**U.S. FISH AND WILDLIFE SERVICE**
**SPECIES ASSESSMENT**
**AND LISTING PRIORITY ASSIGNMENT FORM**
**December 12, 2022**

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SCIENTIFIC NAME: *Dionaea muscipula*

COMMON NAME: Venus flytrap

LEAD REGION: Region 4

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DATE INFORMATION CURRENT AS OF: December 2022

STATUS/ACTION

__X_ Species petitioned for listing which we have determined does not warrant listing (does not meet the definition of a threatened or endangered species)

Petition Information:
___ Non-petitioned
_X__ Petitioned; Date petition received: 10/21/2016
90-day "substantial" finding FR publication date; citation: 12/20/2017 (82 FR 60362)
12-month "warranted but precluded" finding FR publication date; citation:

PREVIOUS FEDERAL ACTIONS:
On October 21, 2016, we received a petition from Donald Waller and 25 other individuals to list the Venus flytrap (*Dionaea muscipula)*, as endangered or threatened species and to designate critical habitat under the Endangered Species Act (Act). On December 20, 2017, we published a 90-day finding (82 FR 60362) that the petition contained substantial information indicating listing may be warranted for the species. This document constitutes our 12-month finding on the October 21, 2016, petition to list Venus flytrap under the Act.

PLANT GROUP, ORDER AND FAMILY:
Flowering plants
Caryophyllales
Droseraceae

BIOLOGICAL INFORMATION
To assess the viability of Venus flytrap, we conducted a species status assessment (SSA) using

the three conservation biology principles of resiliency, redundancy, and representation (Shaffer and Stein 2000, pp. 306–311). Briefly, resiliency supports the ability of the species to withstand environmental and demographic stochasticity (for example, wet or dry, warm or cold years, variation in demographic rates), redundancy supports the ability of the species to withstand catastrophic events (for example, droughts, large pollution events), and representation supports the ability of the species to adapt to both near-term and long-term changes in its physical and biological environment (for example, climate change, disease). A species with a high degree of resiliency, representation, and redundancy is better able to adapt to novel changes and to tolerate environmental stochasticity and catastrophes. In general, species viability will increase with increases in resiliency, redundancy, and representation (Smith et al. 2018, p. 306). Using these principles, we identified the species' ecological requirements for survival and reproduction at the individual, population, and species levels, and described the beneficial and risk factors influencing the species' viability.

We use the SSA framework to assemble the best scientific and commercial data available for this species. The SSA framework consists of three sequential stages. During the first stage, we evaluate the species' needs. The next stage involves an assessment of the historical and current condition of the species' demographics and habitat characteristics, including an explanation of how the species arrived at its current condition (i.e., how threats and conservation actions have influenced the species). The final stage of the SSA framework involves assessing the species' plausible range of future responses to positive and negative environmental and anthropogenic influences. The SSA framework uses the best available information to characterize viability as the ability of a species to sustain populations in the wild over time and is used to inform our regulatory decision.

The SSA Report does not represent a decision by the Service on whether Venus flytrap should be listed under the Act. However, it does provide the scientific basis that informs our regulatory decisions, which involve the further application of standards within the Act and its implementing regulations and policies. The Species Status Assessment Report for the Venus flytrap (*Dionaea muscipula*) – July 2022, version 1.0 (SSA Report) is a summary of the information we have assembled and reviewed, and incorporates the best scientific and commercial data available for this species. Excerpts of the SSA Report are provided in the sections below. For more detailed information, please refer to the SSA Report (Service 2022, entire).

Species Description

As described in Section 2.1 of the SSA Report (Service 2022, p. 11), Venus flytrap is one of the most widely recognized plant species on earth. It is a small, low-growing perennial herb that forms a basal rosette of distinct leaves that are attached to a short rhizome. The leaf blade consists of two somewhat kidney-shaped, hinged, lobes up to 25 mm long with stiff marginal hairs to 8 mm long. When trigger hairs are stimulated, the two lobes snap closed, trapping insects between them.

Venus flytrap (*Dionaea muscipula*), Brunswick County, NC. Photo Credit: Dale Suiter

Taxonomy

As detailed in Section 2.2 of the SSA Report (Service 2022, p. 13), Venus flytrap was first described by John Ellis in September 1768, and further described in more detail in September 1769 (Nelson 1989, p. 250-252; Ellis 1770, entire).

*Dionaea* is monotypic genus in the sundew family (Droseraceae), meaning that there is only one species in the genus. The sundew family consists of three genera of carnivorous plants: *Drosera*, *Dionaea*, and *Aldrovanda*. Members of this plant family are found on all continents except Antarctica. The species name, *muscipula*, derives from the Latin word for "mousetrap." The species, *D. muscipula,* is unique in the plant world and there is no evidence in the literature to suggest that it is not a valid species. Due to its popularity in the horticulture trade, Venus flytrap has been the subject of much selective breeding and there are many named varieties (Bailey and McPherson 2012, pp. 143-333).

Life History and Individual Resource Needs

As detailed in sections 2.3-2.9 of the SSA Report (Service 2022, pp. 13-16), Venus flytrap is a long-lived perennial flowering plant species. Specimens have survived in cultivation for at least 25 years (Bailey and McPherson 2012, p. 105). Seedlings take three to four or more years to reach reproductive maturity, or ability to flower (Bailey and McPherson 2012, p. 105; Roberts and Oosting 1958, p. 202). The life cycle of Venus flytrap consists of four stages: adult (flowering) plant, seed, seedling and juvenile plant. Recent research confirmed that the species is self-compatible, meaning pollen can fertilize an ovary on the same plant. Due to the timing of ripe pollen and receptive stigmas, the species is dependent on pollinators for sexual reproduction (Hamon 2022, p. 84-89).

The availability of abundant sunlight and moisture is important for all life stages of Venus flytrap. Venus flytrap plants are often, but not always associated with sphagnum moss carpets (Hamon et al. 2021a, p. 8; Luken 2005a, p. 581). Venus flytrap plants require wet or moist acidic soils that are low in nutrients (Bailey and McPherson 2012, p. 102; Roberts and Oosting 1958, entire). Abundant sunlight is important for Venus flytrap to complete its life cycle as light suppression reduces flowering and subsequently seed production in Venus flytrap. Vegetative or asexual reproduction occurs from buds that grow from short rhizomes (Hamon et al. 2021a, p. 22). Natural or prescribed fires are critical to Venus flytrap survival as they reduce competition of woody and herbaceous vegetation and keep the forest floor where Venus flytrap plants grow open to sunlight. Frost (1998, p. 78), noted that Venus flytrap plants in research plots at the Green Swamp (North Carolina) die out when not burned at least every three years. He called Venus flytrap "one of the most fire-dependent species." According to Hamon (2021, p. 11) many of the largest and densest populations of Venus flytrap are found in habitat that is burned frequently (at least every three years) (Hamon et al. 2021a, entire). Luken (2007, p. 50) demonstrated that the highest flowering and seedling establishment occurred soon after prescribed fire. Venus flytrap sites with less canopy cover and more exposure to sunlight support more robust populations.

Water is necessary for plant growth. As mentioned in the SSA Report section 2.4 (Habitat), Venus flytrap occurs in wet longleaf pine savannas and associated habitats that contain abundant moisture. This species can tolerate short periods of drought, but it is not tolerant of extended dry conditions.

Venus flytrap has an interesting relationship with arthropods. This carnivorous plant is well known for its ability to trap and digest arthropods, while some insects also play an important role in their reproduction. Venus flytrap reproduces by both sexual and asexual reproduction, the former, also involving insects. Sexual reproduction occurs when Venus flytrap plants produce flowers. The flowers are self-compatible, but insects are required for pollination and seed production (Hamon 2022, p. 84-89). Flowers are visited by a generalist suite of pollinators; however, the primary pollinator is a sweat bee (*Augochlorella gratiosa*) while the longhorned beetle (*Typocerus sinuatus*) and the checkered beetle (*Trichodes apivorus*) are also considered important pollinators (Hamon et al. 2021a, p. 7; Youngsteadt et al. 2018, p. 3-4).

Venus flytrap plants trap insects, spiders and other arthropods using its snap trap shaped leaves. Despite the name "flytrap," studies indicate that spiders, ants and beetles make up the largest groups of arthropods found in the traps of Venus flytrap plants (Youngsteadt et al. 2018, p. 2; Ellison and Gotelli 2009, p. 27). Researchers also determined that there was very little overlap between prey and pollinators, an indication that Venus flytrap rarely traps its pollinators (Youngsteadt et al. 2018, entire). Spatial separation may play a role in partitioning pollinators and prey as flowers are elevated well above the traps and most flower visitors fly, while most prey are not able to fly (Youngsteadt et al. 2018, p. 6). Schulze et al. (2012, p. 1313-1317) deep sequenced cDNA from the traps to identify the proteins secreted during digestion. The results suggest that the plants digestive system evolved from defense-related processes. Hamon (2022, p. 84) conducted prey supplementation experiments in 2020 that showed plants that received supplemental prey produced nearly twice as many flowers as those that received only naturally available prey. This result suggests that prey availability in the field may limit flytrap sexual reproduction.

Habitat

The Venus flytrap has a narrow geographic range in the Cape Fear Arch region of North Carolina and South Carolina, including portions of the Coastal Plain and Sandhills ecoregions. The Cape Fear River Basin, with its underlying geology, soil types and endemic plants, serves as a corridor between the Outer Coastal Plain and the Sandhills and may have served as a migratory corridor to and from refugia during the most recent glacial cycle (LeBlond 2001, pp 94-96). In the Outer Coastal Plain where the species is more common, large patches of Venus flytrap occur in sandy pine savannas and wet pine flatwoods and along their ecotones with pocosins (linear, evergreen shrub bogs along small creeks) and the sandy rims of Carolina bays. These sites are generally flat with wet or moist soils for much of the year, and some sites have Sphagnum moss carpets (Luken 2005, p. 581). In the Sandhills region, Venus flytrap is limited to Sandhill seeps that are narrow, moist ecotones between streamhead pocosins and pine/scrub oak Sandhill uplands. They are also found along the vegetatively similar ecotones between Sandhill seeps and longleaf pine uplands (Hamon et al. 2021a, p. 7-8; Schafale 2012, pp. 167-171; NatureServe 2021, entire; and Schafale 2021, pers. comm.). Venus flytrap grows in acid soils that are low in nutrients (Bailey and McPherson 2012, p. 102; Roberts and Oosting 1958, entire).

Wet pine savannas are dominated by longleaf pine trees scattered such that abundant sunlight reaches the ground. These habitats often have a highly diverse herbaceous flora that is adapted to frequent fires. Fire (either natural or prescribed) is important to managing the natural habitat for Venus flytrap and other savanna species (Hamon et al. 2021a, p. 8). Only sites that are well managed with prescribed fire are likely to support Venus flytrap over time (Schafale 2021, pers. comm.; Gray et al. 2003, p. 213). Venus flytrap is well adapted to fire and can be abundant and a major component of the herbaceous understory where favorable conditions exist. Venus flytrap appears to grow best in areas with little competition from other herbaceous or woody species that might create shade (Bailey and McPherson 2012, p. 102).

Historical and Current Range/Distribution

As described in Section 2.7 of the SSA Report (Service 2022, pp. 18-19), Venus flytrap has a narrow historical range within a 161 km (100 mi) radius of Wilmington, North Carolina in 18 North Carolina counties and three counties in South Carolina (Figure 1).

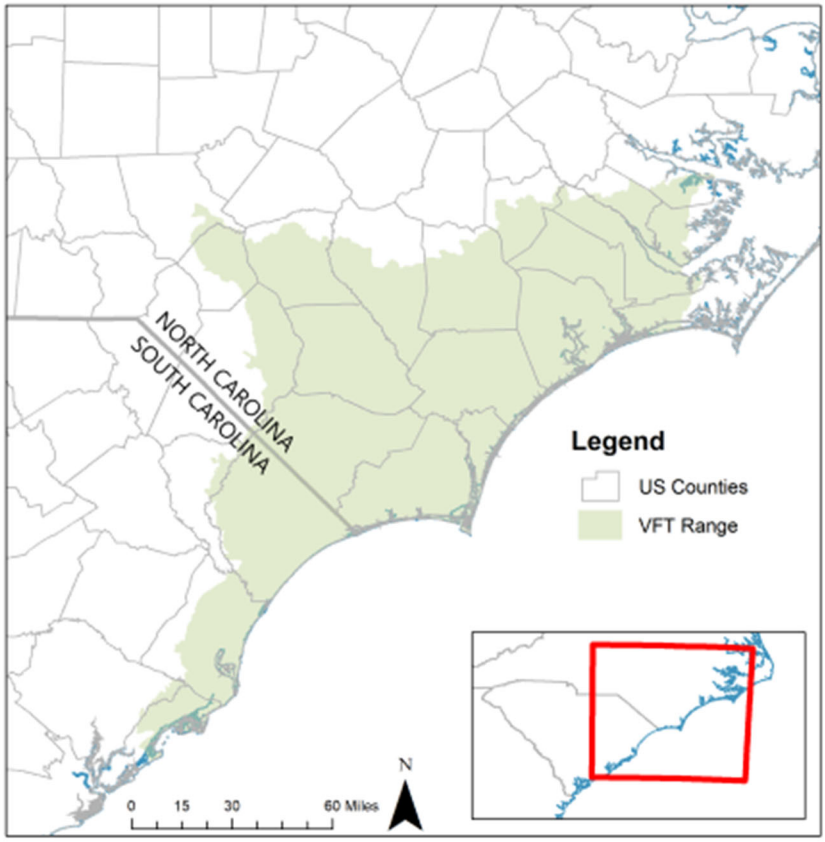


Figure 1. Venus flytrap range.

Population Needs

As described in Section 3.1 of the SSA Report (Service 2022, p. 22), we use two terms to refer to groupings of Venus flytrap plants: population and subpopulation. Following NatureServe guidelines for defining populations, a generic distance of 2 km (1.2 mi) was used to denote separate populations of Venus flytrap. Data analysts buffered the records by 2 km (1.2 mi) and denoted a single population as occurring, if the 2 km buffer overlapped. When occurrences within 2 km (1.2 mi) were disjunct from one another for greater than 1 km (0.6 mi) due unsuitable habitat, the analysts used a 1 km (0.6 mi) separation distance rule to separate populations. A population of Venus flytrap may vary widely in size, ranging from a single cluster of a few individuals to tens of thousands of individuals distributed over several hectares. A subpopulation refers to geographically distinct groups of individuals within a population, meaning a group of plants that are not connected but are within 1 km of other flytraps. The subpopulation designation is somewhat subjective but is broadly a method of distinguishing parts

of a population for the purposes of data management and conservation planning (Hamon et al. 2021a, p. 14; NatureServe 2021, entire).

At the population level, resource needs include the key needs of individuals mentioned above (abundant light, abundant moisture, moist acidic soils, arthropods, and fire) as well as sustainable population size and connectivity between populations. Small population size can increase the risk of genetic drift (changes in allele frequency/disappearance of particular genes) and inbreeding depression (mating of related individuals) (Ellstrand and Elam 1993, pp. 218-219). Small population size and isolated populations can change pollinator behavior by causing less visitation due to the limited resources available to pollinators. Small, isolated populations of rare plant species often receive less pollinator visitation in comparison with larger or more widespread plant species (Ellstrand and Elam 1993, p. 227).

Lastly, populations need suitable habitat within the population area and between populations to create connectivity. Habitat and population connectivity provides higher pollinator visitation rates to flowers in comparison with fragmented habitats or populations (Kearns and Inouye 1997, p. 299). Connected populations can have up to three times higher visitation rates in comparison with isolated populations. Overall, the large Venus flytrap populations on large, protected sites in comparison with the small, isolated populations, often on private land highlight the importance of population size and connectivity in relation to viability.

Species Needs

Regarding the species' needs and viability, there must be adequate redundancy (suitable number of resilient populations, distribution of resilient populations, and connectivity between populations to allow the species to withstand catastrophic events) and representation (suitable genetic and environmental diversity to allow the species to adapt to changing environmental conditions). Redundancy is measured by numbers of populations in medium to high resiliency condition and connectivity among those populations to allow populations to "rescue" each other after catastrophic events. Representation is a measure of genetic diversity and adaptive capacity to changing environmental conditions.

SUMMARY OF BIOLOGICAL INFORMATION FOR FEDERAL REGISTER

Venus flytrap (*Dionaea muscipula*) is a perennial herbaceous vascular plant species endemic to southeastern North Carolina and northeastern South Carolina. It has a historical range within approximately 100 miles (161 kilometers) of Wilmington, North Carolina**.** The carnivorous plant is well known for its ability to trap prey in its distinctive leaves.

A population of Venus flytrap may vary widely in size, ranging from a single cluster of a few individuals to tens of thousands of individuals distributed over several hectares. Venus flytrap occurs in wetland habitats in the Outer and Inner Coastal Plain and Sandhills ecoregions. In the Outer Coastal Plain, where it is more common, large populations of Venus flytrap occur in sandy pine savannas and wet pine flatwoods, and in the Sandhills region, Venus flytrap plants are limited to seeps between evergreen shrub bogs along small creeks and pine/scrub oak uplands.

The species needs abundant light, abundant moisture, moist acidic soils, arthropods, as well as sustainable population size and connectivity between populations. Only sites that are well managed with prescribed fire are likely to support Venus flytrap over time. Venus flytrap is well adapted to fire and can be abundant and a major component of the herbaceous understory where favorable conditions exist.

FACTORS INFLUENCING THE STATUS

The Act directs us to determine whether any species is an endangered species or a threatened species because of any factors (or threats) affecting its continued existence (i.e., whether it meets the definition of a threatened species or an endangered species). We use the term "threat" to refer in general to actions or conditions that are known to or are reasonably likely to negatively affect individuals of a species. The term "threat" includes actions or conditions that have a direct impact on individuals, as well as those that affect individuals through alteration of their habitat or required resources. The term "threat" may encompass—either together or separately—the source of the action or condition, or the action or condition itself.

However, the mere identification of any threat(s) does not necessarily mean that the species meets the statutory definition of an "endangered species" or a "threatened species." In determining whether a species meets either definition, we must evaluate all identified threats by considering the expected response by the species, and the effects of the threats—in light of those actions and conditions that will ameliorate the threats—on an individual, population, and species level. We evaluate each threat and its expected effects on the species, then analyze the cumulative effect of all of the threats on the species as a whole. We also consider the cumulative effect of the threats in light of those actions and conditions that will have positive effects on the species—such as any existing regulatory mechanisms or conservation efforts. The Secretary determines whether the species meets the definition of an "endangered species" or a "threatened species" only after conducting this cumulative analysis and describing the expected effect on the species now and (if evaluating whether a species is a threatened species) in the foreseeable future.

Threats

The primary factors affecting the viability of Venus flytrap are: 1) habitat loss and modification via fire suppression, land conversion, and roadside and utility right-of-way management, 2) poaching and overcollection, and 3) small population size and isolation. Other factors include nonnative invasive species, herbivory, and climate change-associated factors, but these have a lesser effect on current flytrap viability (Figure 2). Prey availability is not known to affect viability, as the flytrap will digest anything that falls/crawls into the traps. See Chapter 4 of the SSA Report (Service 2022, pp. 33-47) for more information.

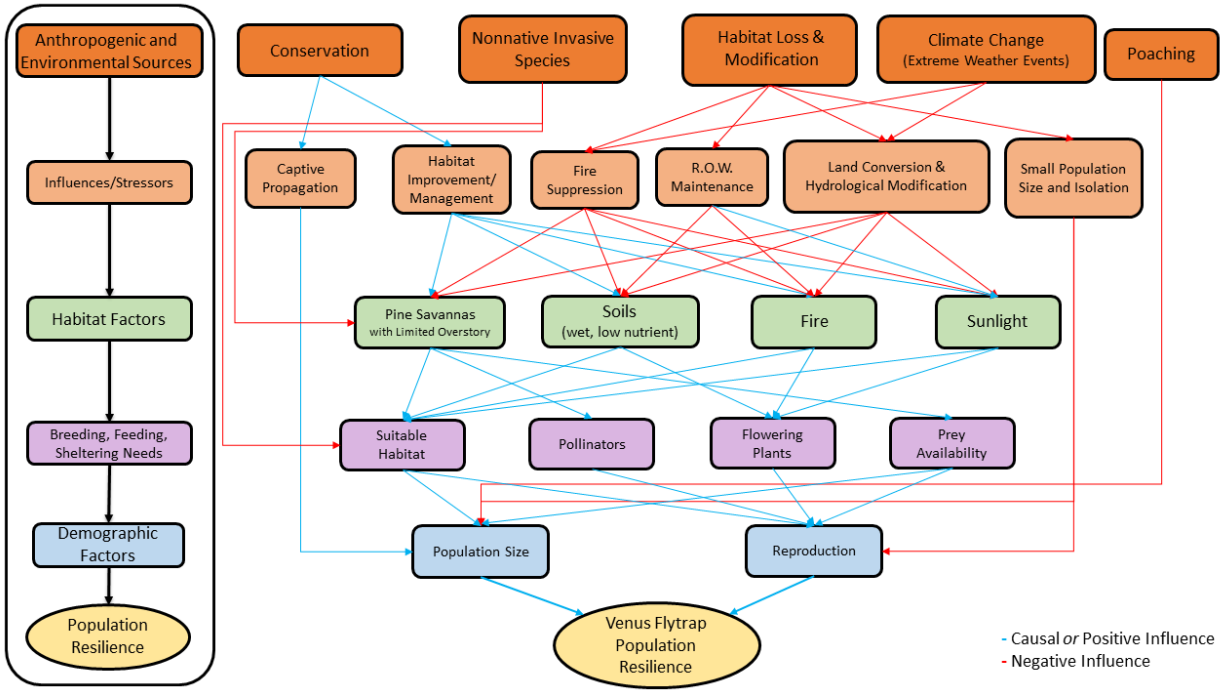


Figure 2. Venus flytrap influence diagram showing relationships between factors and species' viability.

Habitat Loss and Modification

We do not know the range of Venus flytrap prior to European settlement in the Carolinas, but we have no evidence that it was significantly more widespread than its currently known range. The counties where the species is considered historical are at the northern, southern and western edges of its known range, an indication that the range of extant populations is shrinking. Historically, longleaf pine ecosystems occupied 93 million acres (37 million hectares) across the southeastern Atlantic coastal plain and piedmont. Agriculture, open livestock grazing, turpentine production and the elimination of wildfires have reduced the amount of landscape with longleaf pine to less than 3% of what it once was (Frost 1993, pp. 17, 37). As such, the pine savannas and flatwoods that support Venus flytraps have also been reduced.

Venus flytrap habitat may be lost because of fire suppression and land conversion to agriculture, silviculture, residential and commercial development and associated fragmentation, right-of-way (ROW) management, and other factors, discussed briefly, below.

*Fire Suppression*

As discussed above, natural or prescribed fires are critical to Venus flytrap survival as they reduce competition of woody and herbaceous vegetation and keep the forest floor where Venus flytrap plants grow open to sunlight. Natural fires are a regular occurrence in the southeastern coastal plain. The warm, humid climate of the southeast combined with killing frosts and occasional droughts create a condition where there is plenty of volatile fuels to ignite in the

presence of lightning strikes (Finch et al. 2012, p. 105). The southeastern coastal plain has one of the highest lightning frequencies in North America (Finch et al. 2012, p. 105). The ecosystem has therefore adapted to regular fires.

Both natural and prescribed fires are beneficial to the longleaf pine ecosystem where Venus flytrap occurs. Venus flytrap is one of the most fire dependent species; it begins to die out when fire-return intervals become longer than three years (Frost 1998, p. 78). Fire suppression is considered one of the main threats to Venus flytrap as it disrupts natural fire cycles, often resulting in increased shading and competition from woody plants, eventually causing the decline of herbaceous plant species. Venus flytrap plants can persist in a state of dormancy following a period of fire suppression and initiate growth in response to increased light availability (Luken 2021, p. 682); however, over time, shaded plants decline, causing populations to disappear (Roberts and Oosting 1958, p. 217). The longleaf pine forests where currently resilient Venus flytrap populations are found have average fire return intervals of one to four years (Frost 1998, p. 77; Guyette et al. 2012, p. 330). Thus, resilient flytrap populations are not experiencing fire suppression-related impacts.

In addition to the lack of fire, fire suppression techniques such as plowing and bulldozing can be detrimental to herbaceous species. Many Venus flytrap populations occur in wet ecotones where plow lines are often located and serve as fire breaks, but these areas are subject to destruction when the fire breaks are maintained (plowed to expose mineral soil) during an ongoing fire. Approximately 1,000 Venus flytrap plants were destroyed when a power line easement in Onslow County, North Carolina was plowed up to serve as a fire break for the Juniper Creek Fire in June 2011 (NCNHP 2022, unpublished data). There have been two incidents in the Croatan National Forest, where fire plow lines to contain wildfires directly impacted Venus flytrap plants (Walker 2022, pers. comm.).

*Land Conversion*
Other types of habitat loss such as the conversion of land from longleaf pine savannas and associated Venus flytrap habitat to agricultural lands, silviculture (tree farming), or residential and commercial development are more immediate and permanent.

Clearing land for conversion to agriculture and silviculture is destructive to Venus flytrap populations and often has permanent impacts on the landscape (Frost 1993, pp. 17, 37). The physical act of clear cutting destroys Venus flytrap plants. The habitat is further altered to make it suitable for planting additional trees or agricultural crops. Much of land within the range of Venus flytrap has been converted to loblolly pine production (Boyer 1995, p. 18; Gilliam and Platt 2006, p. 8; Hamon 2022, pp. 56, 109, 124). This may involve cutting existing longleaf pine, scraping the ground, and ditching and draining, which changes the hydrology and makes the soil too dry for the moisture-dependent Venus flytrap. Clear cutting also allows the sun to quickly dry out the soil. Conversion to silviculture includes site preparation and herbicide application. A silviculture practice called bedding involves converting flat, poorly drained land into a series of parallel rows and furrows, thus altering hydrology. These actions, along with fast rotation cycles

(less than 25 years), results in stands with reduced species diversity and unsuitable habitat for Venus flytrap.

Residential and commercial development (development) is another type of land conversion that can have direct and indirect negative impacts on Venus flytrap populations. Development typically converts natural areas from forests to residential and commercial spaces for living, shopping and recreation. This type of land conversion is typically irreversible. Development also leads to fragmentation of natural areas, and this fragmentation threatens biodiversity. Fragmentation reduces plants to isolated populations, which face a higher risk of extinction (Matthies et al. 2004, p. 481). Plants in small, isolated patches may receive fewer visits from pollinators, which can reduce fecundity due to insufficient pollination (Matthies et al. 2004, p. 482). Many of the low resiliency flytrap populations are at risk of extirpation because of these types of land conversion.

The human population within the range of Venus flytrap (southeastern North Carolina and northeastern South Carolina) is growing rapidly. Population increases contribute to urban sprawl in the form of residential and commercial development. The construction of residential neighborhoods, golf courses and commercial development may result in the direct loss of Venus flytrap habitat or fragmentation of existing populations. Development also increases the wildland-urban interface, which complicates the management of natural areas with prescribed fire. Such development often precludes the ability to use fire as a management tool for nearby protected flytrap populations because of the threat of fires escaping the natural area or their proximity to Smoke Sensitive Areas (e.g., schools, hospitals, homes, poultry houses, etc.) (NC Forest Service 2020, p. 7).

*Roadside and Utility Right-of-Way Management*

Venus flytrap populations sometimes occur on roadsides and utility line ROW where roads and utility lines intersect suitable habitat for this species. These populations are vulnerable to road maintenance, road widening projects, herbicide application, and mowing. Road maintenance and widening projects can destroy habitat where plants occur. Herbicides, which suppress plant growth, are often used to manage vegetation along road shoulders and in utility ROW. Herbicide damage can be temporary or permanent depending on the type of herbicide used and the rate of application. Dormant season (winter) mowing is generally not problematic for disturbance-dependent species, as it helps reduce competition and maintain sites in an open condition. However, it is important that dormant season mowing be conducted when soils are not too wet to avoid creating ruts that can kill small plants and disrupt the microtopography. Mowing that occurs during the growing season before plants produce mature seeds is harmful to the population because it eliminates seed production/reproductive potential for that year. In general, populations that occur in roadside and utility line ROW are extremely vulnerable to poor management actions.

Poaching and Overcollection

The Venus flytrap is a very popular houseplant, highly sought after for its ability to trap prey. Before species propagation was honed by the horticulture industry, plants were poached from the wild. Poaching is defined as taking plants without permission of the landowner. Poaching is probably most harmful to small populations, which have fewer plants. When a larger percentage of total plants are removed from a population, it is harder for that population to recover to the number of plants present before the poaching event. For many years, Venus flytrap plants have been the subject of illegal collection from the wild. Initially this was done so that plants could be sold at roadside markets and more widescale in the horticulture trade. In more recent years, poaching may also involve the pharmaceutical industry (McManus 2014, p. 4).

Until recently, trespass laws and the North Carolina Plant Protection and Conservation Act were the main way to address Venus flytrap poaching. In 2014, the North Carolina Legislature passed a law making it a felony to take Venus flytrap plants from someone else's land without written permission of the landowner (NC Gen Stat § 14-129.3 (2014)). In 2019, the North Carolina Department of Agriculture and Consumer Services (NCDACS) and the North Carolina Wildlife Resources Commission (NCWRC) entered into a Memorandum of Understanding whereby the NCWRC will fully enforce the 2015 North Carolina Plant Protection and Conservation Act and its accompanying regulations (NC Gen Stat § 106-202.19 (2015), which provides limited protection of Venus flytrap from unauthorized collection (uproot, dig, take or otherwise disturb or remove for any purpose from the land of another without written permission from the owner) and trade (sell, barter, trade, exchange, export, etc.), as discussed further below (NCWRC-NCDACS 2019, entire). This state law is also enforced by local and county police. Venus flytrap poaching still occurs, but it appears to happen locally and on a small scale. While there appears to be much talk about poaching among Venus flytrap enthusiasts, conservationists, and the media, the actual number of reported incidents is relatively small. While some large poaching events do occur, overall poaching impacts probably pale in comparison to lack of proper fire management, development, and other land use changes.

South Carolina Code of Laws 16-11-590 (General Bill H*2953), amended on May 19, 1980, makes it unlawful to "collect, cut, break or otherwise destroy Venus's Flytrap plants or any part on public property or on private property without the owner's consent." Anyone violating this law is guilty of a misdemeanor and if convicted, may be fined $10 to $200 per offense and may be imprisoned not more than 30 days. The law also protects sea oats (*Uniola latifolia*) (Justia US Law undated, entire).

Venus flytrap has also been the subject of academic research for many years, some of which involves the collection of parts of plants or entire plants from natural populations. Current research projects focus on genetics, demography, response to drought, nutrient input, prey availability, and pollination ecology. These studies involve the collection of leaves, flowers, traps, and seeds for laboratory and field experiments or the collection of voucher specimens for herbaria. All research projects are permitted by the North Carolina Plant Conservation Program. Prior to issuance of their research permits, each project is evaluated by a team of botanists to

determine that the level of collection was unlikely to pose any potential threat of overutilization for the species.

Small Population Size and Isolation

Small population size can result in loss of genetic diversity due to inbreeding and genetic drift (changes in allele frequency/disappearance of particular genes) and inbreeding depression (mating of related individuals) (Ellstrand and Elam 1993, pp. 218-219). Small population size and isolated populations can change pollinator behavior by causing less visitation due to limited resources available to pollinators. Small, isolated populations of rare plant species often receive less pollinator visitation in comparison with larger or more widespread plant species (Ellstrand and Elam 1993, p. 227). Small populations have lower resiliency and can be vulnerable to stochastic processes (Matthies et al., 2004, pp. 481, 485-486). Matthies et al. (2004, p. 485) determined that very small populations faced a considerable risk of extinction over a 10-year period while the risk for populations greater than 1,000 individuals was very small.

Narrow endemic species whose populations exhibit a high degree of isolation are extremely susceptible to population extirpation from both random and nonrandom catastrophic natural or human-caused events. Species that are restricted to geographically limited areas are inherently more vulnerable to extinction than widespread species because of the increased risk of genetic bottlenecks, random demographic fluctuations, climate change, stochastic events, and localized catastrophes such as hurricanes and disease outbreaks (Pimm et al. 1988, p. 757; Mangel and Tier 1994, p. 607). These problems are further magnified when populations are few and restricted to a very small geographic area, and when the number of individuals is very small. Populations with these characteristics face an increased likelihood of stochastic extinction due to changes in demography, the environment, genetics, or other factors (Gilpin and Soule 1986, pp. 24–34).

Small, isolated populations often exhibit reduced levels of genetic variability, which diminishes the species' capacity to adapt and respond to environmental changes, thereby decreasing the probability of long-term persistence (e.g., Barrett and Kohn 1991, p. 4; Newman and Pilson 1997, p. 361). Very small plant populations may experience reduced reproductive vigor due to ineffective pollination or inbreeding depression. Isolated individuals have difficulty achieving natural pollen exchange, which limits the production of viable seed. The problems associated with small population size and vulnerability to random demographic fluctuations or natural catastrophes are further magnified by synergistic interactions with other threats, such as those discussed above.

Seventy six percent of extant Venus flytrap populations are considered small, and have low resiliency, thus susceptible to the impacts of small population size and isolation. However, the remaining quarter of populations are considered large, some with hundreds of thousands of plants, and are resilient to this threat.

Nonnative Invasive Species

Nonnative invasive plants compete with native plants for space, light, water, and nutrients, and modify native plant communities. Nonnative invasive animals may eat and/or disturb native vegetation. In general, longleaf pine savannas and their associated communities do not have many invasive species. Nonnative invasive species are not considered a significant threat to Venus flytrap at this time; however, land managers at Venus flytrap populations identified three species that may negatively affect this species in the future, including torpedograss, cogongrass, and feral hogs.

Herbivory

White-tailed deer (*Odocoileus virginianus*) have been documented browsing on the flowers and fruiting heads of Venus flytrap, but deer herbivory on the leaves has not been reported.

Venus flytrap is one of the primary hosts for the extremely rare Venus flytrap cutworm moth (*Hemipachnobia subporyphryea*) and is therefore critical to its survival. Based on the best available information at this time, browsing or herbivory by this moth are not causing population-level effects to Venus flytrap (Hamon et al. 2021a, p. 22; 2021b, entire).

Climate Change-Associated Factors

Despite the recognition of potential climate effects on ecosystem processes, there is uncertainty about what the climate future for the Southeast will be and how ecosystems and species in this region will respond. It has been noted that our scientific understanding of the climate system strongly supports the conclusion that large changes in North Carolina's climate, "much larger than at any time in the state's history," are very likely by the end of the century under both the low (RCP 4.5) and high (RCP 8.5) scenarios (Kunkel et al. 2020, p. 5). 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 (Elliot et al. 2014, p. 67 -68). As a result, impacts from land use change might be exacerbated under even a mild to moderate climate future.

Regardless of climate future, the following systematic changes are expected to be realized to varying degrees in the southeastern United States., including southeastern North Carolina and northeastern South Carolina (North Carolina Interagency Leadership Team, NCILT 2012, p.27; Intergovernmental Panel on Climate Change, IPCC 2013, p.7; UNC Communications 2019, entire):

- More frequent drought
- More extreme heat (resulting in increases in air and water temperatures)
- Increased heavy precipitation events (e.g., flooding)
- More intense storms (e.g., frequency of major hurricanes increases)
- Increased fire and fire severity

According to Roberts and Oosting (1958, p. 215) mature Venus flytrap plants can withstand desiccation over short or even extensive periods of time by going into a dormant stage, but

seedlings cannot become established in areas where soil drought is common. In contrast, Louthan et al. (2022, p. 22-27) suggest that flytrap population growth rates could increase under future climate conditions, that they may benefit from a slightly longer fire return interval, and that their sensitivity to fire return interval may change.

Conservation Measures and Existing Regulatory Mechanisms

Venus flytrap has been the subject of much attention and conservation for many years. There are several nature preserves dedicated to the conservation of Venus flytrap and associated species. Several state laws protect Venus flytrap from poaching and the horticulture trade produces and sells responsibly grown plants that were not taken from wild populations.

*Habitat Improvement, Management, and Protection*

Suitable habitat for Venus flytrap is found on State-owned lands, privately owned nature preserves, National Forests, Department of Defense lands, and other conservation areas across the species' range (Service 2022, pp. 43-44). Many of these landowners implement beneficial land management practices (e.g., prescribed burning, mowing, mechanical removal of woody vegetation) to maintain the structure and function of wet pine savannas where Venus flytrap occurs by mimicking natural disturbance regimes (Gilliam and Platt 2006, p. 7). Removing woody vegetation encroachment reduces vegetative competition thereby increasing the availability of water, nutrients, and light which are all important to the growth and reproduction of Venus flytrap. At present, five of the highly resilient Venus flytrap populations occur on protected lands. Conservation lands owned by the US Forest Service, State agencies, and private nature preserves are expected to remain protected and managed for conservation purposes in the future, which would eliminate the risk of direct habitat loss due to urbanization in these areas. Three Department of Defense (DOD) military bases are home to high and medium resilient populations. Department of Defense lands are managed with fire to reduce fuel loads, which benefits the species. However, Venus flytrap is not specifically managed for by these installations, so if land use needs change, these populations could be negatively affected in the future. Therefore, we do not consider them to have the same level of protection as other state and federal lands.

*Integrated Natural Resources Management Plans*

The Sikes Act requires most military installations within the United States to develop and implement comprehensive plans for natural resource conservation and management (e.g., fish and wildlife, forestry, land management, outdoor recreation) on each installation. This conservation plan, known as an Integrated Natural Resource Management Plans (INRMP), focuses on ecosystem-based management with a goal of managing the natural resources to meet stewardship requirements while supporting, and even enhancing, military operations.

Military installations prepare INRMPs in cooperation with the Service and state fish and wildlife agencies, ensuring appropriate consideration of fish, wildlife, and their habitat needs. This collaborative approach to natural resource conservation directly benefits the Service's ability to enhance and conserve fish, wildlife and plants, as well as their habitats. Due to successful natural

resource conservation and management on installations, landscapes can be conserved and enhanced, providing the benefits of healthy ecosystems to wildlife and human communities, while still being used to support military operations and training.

The INRMPs for Camp Lejeune Marine Corps Base, Fort Bragg and Military Ocean Terminal at Sunny Point (MOTSU) list Venus flytrap as Species at Risk (SAR), Federal Species of Concern (FSC) and priority species, respectively and emphasize the importance of protecting and managing this rare species (Camp Lejeune 2015, p. 4-92-95; MOTSU 2018, p. III-1; Ft. Bragg 2018, p. 3). The MOTSU INRMP mentions that the Forest Management Plan will ensure the conservation of natural communities that will benefit Venus flytrap (and other rare species) (MOTSU 2018, p. III-1). The Fort Bragg INRMP commits to using ecosystem management practices to restore and manage natural communities and improve habitat conditions for rare species (Fort Bragg 2018, p. 3). However, if military training needs change over time, non-listed species could be impacted; these changes would likely be discussed with the Service and state fish and wildlife agencies prior to implementation.

*State Laws*

There are currently four North Carolina laws that are related to Venus flytrap. North Carolina General Statute §145-22, adopted in 2005, designated this species as the official carnivorous plant of the State of North Carolina. This law is simply a designation and does not provide any protections to the species (North Carolina General Assembly 2005, entire).

North Carolina General Statute §14-129 prohibits the taking of certain species of wild plants from the land of another. Specifically, it states that no person, firm or corporation shall dig up, pull up or take from the land of another or from any public domain, the whole or any part of any Venus flytrap or various other species without permission of the landowner. The full statute is included in Appendix C of the SSA Report (Service 2022, p. 79).

Venus flytrap is currently listed as State Threatened by the North Carolina Department of Agriculture and Consumer Services and is protected by the North Carolina Plant Conservation and Protection Act (North Carolina Code Article 19B, section 106-202.12) (Wichmann 2021, pp. 2, 30). This law provides limited protection of Venus flytrap from unauthorized collection (uproot, dig, take or otherwise disturb or remove for any purpose from the land of another without written permission from the owner) and trade (sell, barter, trade, exchange, export, etc.). It is also unlawful to buy more than 50 Venus flytrap plants for the purpose of resale or trade unless fully compliant with applicable regulations. However, the statute does not protect the species or its habitat from destruction in conjunction with development projects or otherwise legal activities. This law authorizes the NCPCP to establish nature preserves for protected species and their habitats. The Plant Protection and Conservation Act is provided in Appendix C of the SSA Report (Service 2022, pp. 80-89).

In June 2014, the North Carolina General Assembly passed House Bill 1059, which makes it a felony to take Venus flytrap plants or seeds from the land of another. Any person convicted of

taking Venus flytrap plants or seeds from another person's land or from public domain without written permission of the landowner or the owner's authorized agent is guilty of a Class H felony (NC Gen Stat § 14-129.3 (2014)). The complete bill is in Appendix C of the SSA Report (Service 2022, p. 90).

South Carolina Code of Laws 16-11-590 (General Bill H*2953), amended on May 19, 1980, makes it unlawful to "collect, cut, break or otherwise destroy Venus's Flytrap plants or any part on public property or on private property without the owner's consent." Anyone violating this law is guilty of a misdemeanor, and if convicted, may be fined $10 to $200 per offense and may be imprisoned not more than 30 days. This law is in Appendix C of the SSA Report (Service 2022, p. 91).

*Convention on International Trade in Endangered Species of Wild Fauna and Flora*
Venus flytrap is listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), an international agreement between governments to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Because the trade in wild animals and plants crosses international borders, the effort to regulate them requires international cooperation to safeguard certain species from over-exploitation. CITES was conceived in the spirit of such cooperation. Today, it affords varying degrees of protection to more than 35,000 species of animals and plants, including the Venus flytrap, whether they are traded as live specimens, fur coats, or dried herbs. CITES is an international agreement to which countries adhere voluntarily. CITES does not take the place of national laws, but it provides a framework to be respected by each Party, which has to adopt its own domestic legislation to ensure that CITES is implemented at the national level (CITES, undated). Appendix II includes species for which trade must be controlled (i.e., permitted) in order to avoid utilization incompatible with their survival (CITES, undated). Thus, Venus flytrap receives international protection under CITES.

*Horticulture Trade and Commercial Availability*
Venus flytrap plants are now common in cultivation and there are many commercial sources to supply hobby carnivorous plant enthusiasts. Venus flytrap plants have been cultivated using tissue culture techniques for many years. This process allows mass production of plants in a short period of time and at low price. The availability of a large quantity of affordable Venus flytrap plants in the horticulture trade reduces the need to obtain specimens from the wild. The International Carnivorous Plant Society (ICPS or Society) web page lists 130 named cultivars of Venus flytrap (ICPS 2022, entire). According to Bailey and McPherson (2012, p. 146) many additional cultivars have not been formally registered. Bailey and McPherson (2012, pp. 335-345) provide information about several plant nurseries that grow ethically sourced Venus flytrap and other carnivorous plants for the horticulture trade.

*International Carnivorous Plant Society*
According to the International Carnivorous Plant Society's web page, the ICPS (ICPS 2022, entire) "is an organization of horticulturists, conservationists, scientists, and educators all

interested in sharing knowledge and news of carnivorous plants." The ICPS supports a variety of research projects on carnivorous plants and provides funds for management of natural areas that support carnivorous plant species (ICPS, undated). According to their conservation policies online, they condemn collection of plants from the wild and introduction of plants into the wild outside of their natural range and not part of a valid restoration project as unethical (ICPS 2022, entire).

Cumulative Effects

We note that, by using the SSA framework to guide our analysis of the scientific information documented in the SSA Report, we have not only analyzed individual effects on the species, but we have also analyzed their potential cumulative effects. We incorporate the cumulative effects into our SSA analysis when we characterize the current and future condition of the species. Our assessment of the current and future conditions encompasses and incorporates the threats individually and cumulatively. Our assessment of current and future conditions is iterative because it accumulates and evaluates the effects of all the factors that may be influencing the species, including threats and conservation efforts. Because the SSA framework considers not just the presence of the factors, but to what degree they collectively influence risk to the entire species, our assessment integrates the cumulative effects of the factors and replaces a standalone "cumulative effects" analysis.

When potential stressors occur together, one factor may exacerbate the effects of another, causing effects not accounted for when factors are analyzed individually (Brook et al. 2008, entire). Synergistic effects can be observed in a short amount of time. Habitat loss and modification as a result of fire suppression, land conversion, roadside and utility right-of-way maintenance, along with poaching, small isolated populations, nonnative invasive species, and climate change are all factors that may affect the habitat of Venus flytrap.

As described in each of their respective sections above, each of these threats are either *de minimis* threats, occur at a limited number of sites, are actively managed and monitored by Federal and State agencies, or are offset by conservation lands owned by federal, state, or private entities. Furthermore, recent observations have found that the species maintains at least 18 moderate or highly resilient populations, most of which are in protected lands. Fire suppression is by far the biggest threat, but the species is currently being managed such that it maintains many resilient populations. After evaluating the best available scientific and commercial information on potential stressors acting individually or in combination, we found no indication that the combined effects are causing a population-level decline or that the combined effects are likely to do so in the next 50 years, based on the species' response to future stressors (see *Future Conditions* below). Other threats that modify or destroy habitat include right-of-way maintenance and conversion to agriculture (including silviculture) and residential and commercial development. Additional stressors that could have a negative effect on the species include poaching and small population size nonnative invasive species, herbivory, and climate change. While there are several stressors to the species, the largest and most robust populations of Venus flytrap have maintained resiliency in the face of these threats. Furthermore, there are many ongoing positive actions that benefit Venus flytrap such as habitat protection and

management, state laws that protect Venus flytrap, international permitting requirements, and horticultural availability of ethically grown plants.

CURRENT CONDITION
Details of the current condition analysis can be found in Chapter 3 of the SSA Report (Service 2022, pp. 22-32).

A recent status survey of Venus flytrap indicates that there are approximately 880,300 Venus flytrap plants growing in the wild in North Carolina and South Carolina (Hamon 2021, entire). Of 140 known Venus flytrap populations, 74 are considered extant and 66 are considered extirpated. Of the 74 extant Venus Flytrap populations, eight populations (11%) are highly resilient, 10 populations (14%) have medium resiliency, and 56 (76%) have low resiliency. The most resilient populations occur in the Outer Coastal Plain (all eight highly resilient and 8 of the 10 populations with medium resiliency). Venus flytrap was likely never widespread through the Inner Coastal Plain and Sandhills like it is in the Outer Coastal Plain. Approximately two-thirds of all known plants (584,700 of 880,300) occur at the three largest populations. These three populations occur on a preserve owned by The Nature Conservancy, a state-owned game land, and a military base. The populations occurring on the nature preserve and game land are protected from future development and managed with prescribed fire and are expected to remain highly resilient. The third largest Venus flytrap population occurs on a military base where regular fire has maintained this population; however, management of the military base could change so the long-term protection of this population is less certain. While 66 populations are considered extirpated, we do not know the original population sizes, nor do we know the historical resiliency of those populations that no longer exist. With regards to representation, the fact that Venus flytrap is found in different plant communities within the Outer and Inner Coastal Plain and the Sandhills with different environmental conditions between the ecoregions demonstrates moderate adaptive capacity. The large number of low resiliency and extirpated populations indicate reduced representation across ecoregions. Overall, Venus flytrap has multiple medium and high resilient populations in the Outer Coastal Plain and some medium and low resilient populations in the Sandhills, thus enabling the species to withstand catastrophic events.

FUTURE CONDITION
Details of the future conditions analyses can be found in Chapter 5 of the SSA Report (Service 2022, pp. 48-63).

For our future conditions analysis, we measured how the threats of climate change, development, and management (or lack thereof) could affect the resiliency of Venus flytrap populations at decadal intervals up to 50 years into the future. We also examined how management with prescribed fire can affect overall species' viability in the future. We estimated resiliency condition across three different plausible management scenarios; status quo, low management, and high management. Note that management with prescribed fire is ongoing, and the difference in categorization of management scenarios is based on the frequency of fire return intervals (see

section 5.3.3 of SSA Report (Service 2023, pp. 53-55)). Within each management scenario, we estimated resiliency condition for two climate scenarios (Shared Socioeconomic Pathway (SSP) 2 and SSP5) at decadal intervals between 2030-2070. The SSPs are scenarios of projected socioeconomic global changes, with SSP2 representing medium challenges to climate change mitigation and adaptation, and SSP 5 representing high challenges to climate change mitigation and adaptation (Hausfather 2018, p. 2).

*Climate Change*
When taking into account future climate predictions, we considered the climate futures under SSP2 and SSP5 out to 2070, with SSP5 ("Higher Emissions") projects a possible future in which global emissions of heat-trapping gases continue to increase through the 21st century, whereas SSP2 ("Lower Emissions") projects a possible future in which the global emissions of heat-trapping gasses peak around 2040 and then decline (U.S. Climate Resilience Toolkit 2019, entire).

*Future Land Use Change*
We measured future land use and land cover change using the U.S. EPA Integrated Climate and Land-Use Scenarios (ICLUS) dataset. This dataset provides spatially explicit projections of population and land use based on the IPCC scenarios and pathways approach, as described above (USEPA, undated). We assessed two future scenarios using the SSP2 and SSP5 storylines. The SSP storylines represent different trajectories of population and land use change that stem from global population and urbanization assumptions (explained above). SSP2 represents a 'business as usual' trajectory in which social, economic, and technological trends do not shift markedly from historical patterns and is similar to the RCP 4.5 emissions scenario. SSP5 represents a trajectory with rapid population and economic growth and is similar to the RCP 8.5 emissions scenario.

*Future Suitable Prescribed Burning Windows*
Prescribed fire management for the Venus flytrap aims to mimic the activity of natural wildfires, which are usually caused by lightning strikes during the summer months, or the growing season for Venus flytrap. Burn timing depends on meeting a range of suitable weather and fuel conditions, known as the prescription burn window, to allow safe and effective fire management outcomes (Kupfer et al. 2020, p. 764). Climate change is expected to impact factors such as temperature, relative humidity, and wind speed, which will affect the ability to engage in prescribed burning management in the future. To measure future changes in prescribed burning suitability, the USGS developed the Historical and Future Prescribed Burns Windows for the Southeast United States dataset (Kupfer et al. 2021, entire). This dataset assesses the impact of future climate change on burn window criteria (maximum daily temperature, daily average relative humidity, and daily average wind speed) that will affect suitable prescribed burn windows. Changes in the burn window criteria were assessed using projections from an ensemble of Global Climate Models (GCMs) under two greenhouse gas emissions, RCP 4.5 and RCP 8.5 (Kupfer et al. 2021, entire).

*Protection Status*

The permanent protection of Venus flytrap populations is important to the species' resiliency. Protected populations (that are also managed) provide the best refugia for this species. Sites currently in private conservation organization ownership (conservation organizations and land trusts), public ownership (national forests, state-owned parks, plant conservation preserves, game lands and forests, and local government) or private lands under permanent conservation easement will likely remain in protected status in the future. For the purposes of analyzing the future condition of Venus flytrap, we considered populations owned entirely by government agencies with a conservation focus (US Forest Service, NCDPR, NC Plant Conservation Program, NC Wildlife Resources Commission, NC Forest Service, NCNHP Dedicated Nature Preserves and New Hanover County Parks and Recreation) or private conservation organizations (The Nature Conservancy, Horry County Conservation Foundation and NC Coastal Land Trust) to have a high level of protection. Populations that occur on mixed ownership lands, meaning both conservation lands and private lands (non-conservation focused lands or NCNHP Registered Natural Areas) are considered to have a moderate level of protection. We also determined that populations occurring on military bases have a moderate protection level due to potential impacts from future training activities or land use changes. All other populations occurring on privately owned land with no conservation easement or other protection likely are considered to have a low level of protection.

*Future Conditions Analysis Methodology*

Maintaining and managing Venus flytrap habitat with prescribed fire is essential to maintaining species viability over time. We performed spatial analyses to project changes in land cover under various levels of development over time to assess potential habitat loss due to urbanization and development. To characterize future prescribed fire management potential, we considered factors that affect fire management likelihood: (1) suitable prescribed burning windows during the growing season (June-Aug), (2) burn concern, which equates to proximity of developed areas to where prescribed burning takes place, and (3) burn feasibility, which is based on the combination of the area occupied by the Venus flytrap population, the protection status of the population, and management levels. For more details, see section 5.3 of the SSA Report (Service 2022, pp. 52-55).

*Future Resiliency*

Resilience scores were calculated for three different management scenarios (status quo, low, high) and development scenarios (SSP2 and SSP5) at decadal intervals between 2030-2070. Management with prescribed fire is critical to species' viability. We assumed that if a population is protected and is surrounded by <25% of developed area then it will be managed with prescribed fire.

The results of our future conditions analysis indicate no change in the future resiliency of Venus flytrap populations that are currently in high resiliency condition, regardless of management

scenario, climate scenario, and year (Table 1; Figure 3). Within management scenarios, the total resiliency conditions remained the same in 2050 and 2070 for SSP2. SSP5 showed greater variation within management scenarios and time steps. The eight populations currently in high resiliency condition are all predicted to remain in high resiliency condition 30 and 50 years into the future. This is primarily because these populations are currently protected and managed, and those conditions are not likely to change in the future. These highly resilient populations represent 92% of the area occupied by populations on the landscape (Figure 4).

Table 1. Summary of population resiliency across three management scenarios (high, status quo, low) and two development scenarios (SSP2 and SSP5) for 2050 and 2070.

| Resiliency Class | Current Condition | Status Quo Management | | | | Low Management | | | | High Management | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SSP 2 | | SSP 5 | | SSP 2 | | SSP 5 | | SSP 2 | | SSP 5 | |
| | | 2050 | 2070 | 2050 | 2070 | 2050 | 2070 | 2050 | 2070 | 2050 | 2070 | 2050 | 2070 |
| **High** | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| **Medium** | 10 | 12 | 12 | 12 | 12 | 10 | 10 | 10 | 10 | 16 | 16 | 16 | 16 |
| **Low** | 56 | 46 | 46 | 41 | 37 | 27 | 27 | 25 | 23 | 47 | 47 | 44 | 40 |
| **Very Low** | 0 | 8 | 8 | 13 | 17 | 29 | 29 | 31 | 33 | 3 | 3 | 6 | 10 |

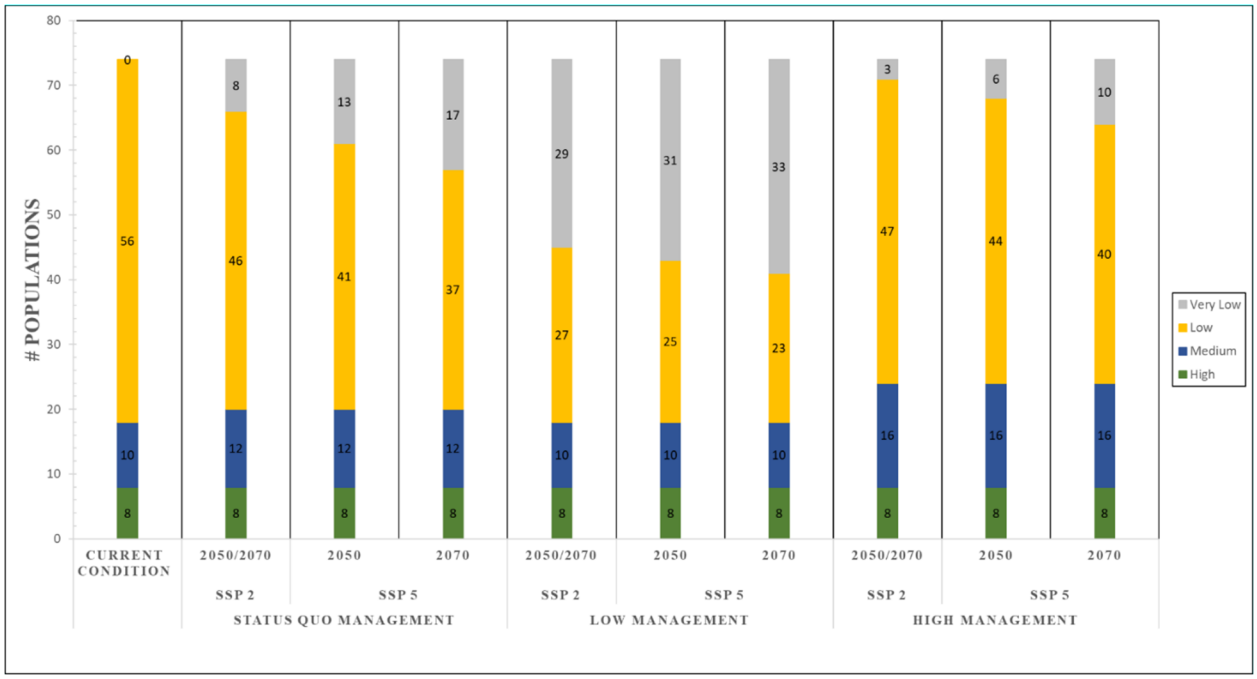


Figure 3. Overall resiliency of Venus flytrap populations under current condition and predicted future condition at 2050 and 2070, under three management scenarios and two climate scenarios.

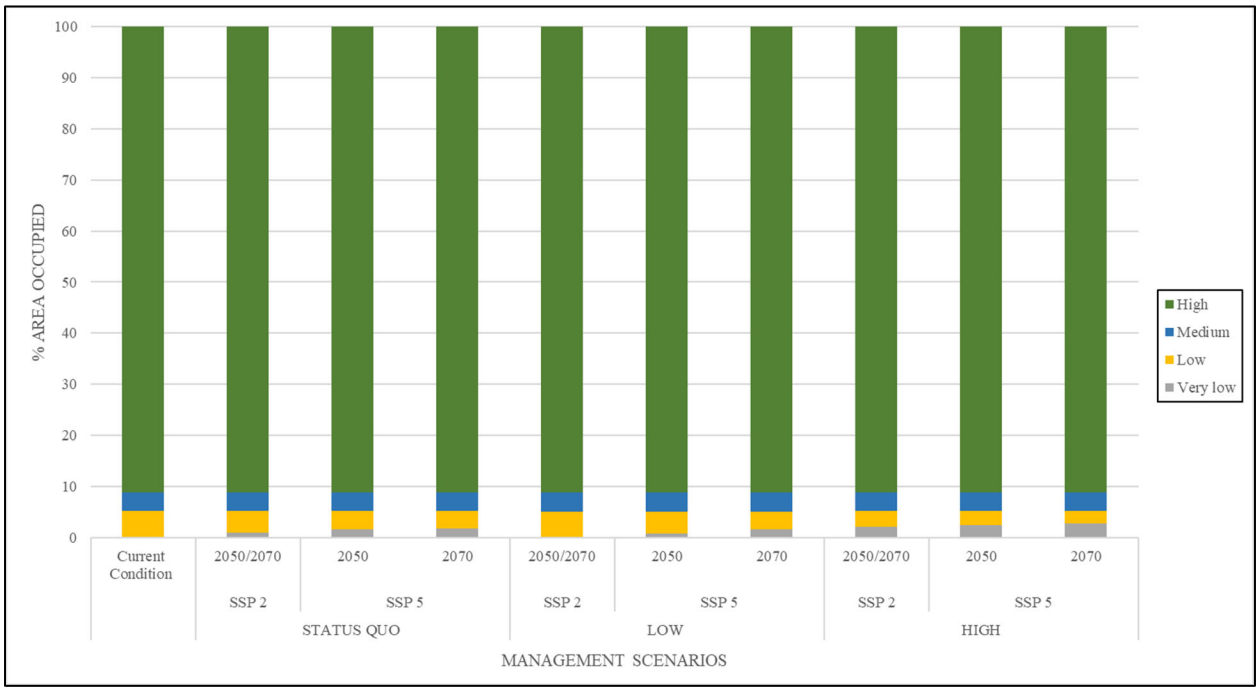

Figure 4. Percentage of area in different resiliency conditions for total area occupied under current condition, 2050, and 2070, for three management scenarios and two climate scenarios.

The populations that are currently in medium resiliency condition represent 3.6% of the area occupied by populations on the landscape (Figure 4). In the future, they either stay in medium resiliency condition under a low management scenario or show a slight increase under the status quo or high management scenarios (Table 1; Figure 3). These increases are primarily due to the potential for improvement of low resiliency populations with high management potential and low risk of habitat loss.

The populations currently in low resiliency condition represent 5% of the area occupied by populations on the landscape (Figure 4). In the future, these populations are predicted to remain in low resiliency condition, increase to medium resiliency, or drop to a very low resiliency condition. While there are many populations that are predicted to be in low condition (23 to 46 populations, representing approximately 3% of future populations by area on the landscape, depending on future management scenario; Figure 4) or very low condition (8 to 31 populations, representing 2% of the future populations by area on the landscape, depending on future management scenario; Figure 4), it is important to note that these populations are currently small (in terms of number of plants and area), isolated, not protected, and are not managed with fire, and therefore not likely to be managed in the future. It is uncertain whether these populations will remain on the landscape in the future.

*Future Redundancy*

The number and distribution of high resiliency populations of Venus flytrap are not predicted to change over the next 50 years (Figure 4). In 2070, regardless of climate future SSP2 or SSP5,

there will likely be eight highly resilient Venus flytrap populations on the landscape, distributed throughout the known range in the Outer Coastal Plain of North Carolina and South Carolina.

Future medium resiliency Venus flytrap populations are predicted to remain well distributed across the Outer Coastal Plain. There is a predicted increase in both the number and distribution of these medium resiliency populations under high and status quo management (see Figures 5-4 and 5-5 in SSA Report (Service 2022, pp. 59-60).

Five percent of the area occupied by current Venus flytrap populations are in low condition; for our analyses, these low condition populations were not considered to currently contribute to overall redundancy nor the ability to rescue the species from a catastrophic event. In the future, the low and very low resiliency populations are also not expected to contribute to redundancy for the species. There will likely be small, isolated populations in low/very low condition throughout the range, comprising 72% of the populations under status quo management conditions and 75% of the populations under low management conditions in the future. Unless they are managed, there is a high probability of extirpation of these populations in the future. However, again, these populations comprise a small portion of the species' range.

*Future Representation*

Venus flytrap populations are known to occur in three ecoregions of North Carolina and South Carolina, but we do not know whether the species was historically distributed evenly throughout these ecoregions. We assume that the species was more widespread in the Outer Coastal Plain, as it is now, and it is predicted to remain so 50 years into the future.

The Venus flytrap's historical and current occupancy within a narrow range of the Coastal Plain ultimately limits aspects of its adaptive capacity, as it is unlikely to move across the landscape outside of its required habitat type to other suitable conditions, thus it is unable to "shift in space" (Thurman et al. 2020, p. 522). As described earlier in the document, Venus flytrap is subject to anthropogenic and climatic stressors that require a "persist in place" strategy, which it currently exhibits the ability to withstand, at least in some portions of its range. However, depending on future management, the species could lose representation in the Sandhills ecoregion.

Each ecoregion where Venus flytrap is found provides different geology, topography, climatic variability, soils, and other characteristics that drive biotic and abiotic environmental diversity and adaptive pressures. As long as management with fire enables species' persistence in these areas, the Venus flytrap's adaptive capacity will sustain the species into the future.

*Future Conditions Summary*

For our future conditions analysis, we measured how the threats of development, climate change, and management could affect the resiliency of Venus flytrap populations at decadal intervals up to 50 years into the future. We also examined how management with prescribed fire can affect overall species' viability in the future. We estimated resiliency condition across three different

management scenarios; status quo, low management, and high management. Within each management scenario, we estimated resiliency condition for two climate scenarios (SSP2 and SSP5) at decadal intervals between 2030-2070. There were declines in the number of low resiliency populations across status quo and low management scenarios to a condition of very low. In the status quo and high management scenarios, there was an increase in the number of medium resiliency populations. Within scenarios, we found a slight difference between climate scenarios (SSP2 or SSP5) and years (2050 or 2070). Management with prescribed fire is critical to species' viability. We assumed that if a population is protected and is surrounded by <25% of developed area then it will be managed with prescribed fire. Five out of eight highly resilient populations are located in protected areas and three are located on moderately protected military lands, containing 95% of the estimated known number of plants, and will likely be managed with prescribed fire and maintain resiliency into the future. Our analysis indicated slight changes to the number and distribution of medium resiliency populations when management with prescribed fire changes in the future, with opportunities for some of the small, low resiliency populations to increase due to high management potential and low risk of habitat loss. There are many populations that fall into the low or very low resiliency categories in the future, however these populations are small, isolated, and consist of only 5% of the area occupied by the species. The best available information does not indicate these small, isolated populations provide a genetic contribution to the species overall.

Eight (11%) out of 74 extant Venus flytrap populations are predicted to remain highly resilient both 30 and 50 years into the future regardless of future scenario, and 10 to 16 (13%-21%) of the populations are predicted to remain in medium resiliency condition in the future depending on scenario, indicating that at least 24% of the populations are predicted to maintain resiliency into the future. These medium and highly resilient populations represent over 98% of the known plants and 95% of the total area currently occupied by the species (Figure 4). Species' redundancy may be reduced if the populations in the Sandhills are not managed adequately in the future, thus limiting the species range entirely to the Outer Coastal Plain. While the Venus flytrap occupies a narrow geographic range, species' representation, or adaptive capacity, is predicted to remain constant, provided that the protected populations remain managed with prescribed fire into the future. Management with prescribed fire is the key to maintaining Venus flytrap viability into the future.

FINDING

Regulatory Framework

Section 4 of the Act (16 U.S.C. 1533) and its implementing regulations (50 CFR part 424) set forth the procedures for determining whether a species is an "endangered species" or a "threatened species." The Act defines an endangered species as a species that is "in danger of extinction throughout all or a significant portion of its range," and a threatened species as a species that is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The Act requires that we determine whether any species is an "endangered species" or a "threatened species" because of any one or a combination of the following factors:

(A) The present or threatened destruction, modification, or curtailment of its habitat or range;
(B) Overutilization for commercial, recreational, scientific, or educational purposes;
(C) Disease or predation;
(D) The inadequacy of existing regulatory mechanisms; or
(E) Other natural or manmade factors affecting its continued existence.

These factors represent broad categories of natural or human-caused actions or conditions that could have an effect on a species' continued existence. In evaluating these actions and conditions, we look for those that may have a negative effect on individuals of the species, as well as other actions or conditions that may ameliorate any negative effects or may have positive effects.

The Act does not define the term "foreseeable future, which appears in the statutory definition of "threatened species." Our implementing regulations at 50 CFR 424.11(d), as revised in 2019, set forth a framework for evaluating the foreseeable future on a case-by-case basis. The term "foreseeable future" extends only so far into the future as we can reasonably determine that both the future threats and the species' responses to those threats are likely. In other words, the foreseeable future is the period of time in which we can make reliable predictions. "Reliable" does not mean "certain"; it means sufficient to provide a reasonable degree of confidence in the prediction. Thus, a prediction is reliable if it is reasonable to depend on it when making decisions.

It is not always possible or necessary to define the foreseeable future as a particular number of years. Analysis of the foreseeable future uses the best scientific and commercial data available and should consider the timeframes applicable to the relevant threats and to the species' likely responses to those threats in view of its life-history characteristics. Data that are typically relevant to assessing the species' biological response include species-specific factors such as lifespan, reproductive rates or productivity, certain behaviors, and other demographic factors.

Status Assessment

The biological information that serves as the basis for our finding is presented in detail in our SSA Report for Venus flytrap (Service 2022, entire) and is summarized above under the **BIOLOGICAL INFORMATION** section of this Species Assessment Form. In our SSA, we evaluated all threats to Venus flytrap, which we generally identified as falling under Factor A of section 4(a)(1) of the Act and include activities that result in habitat loss and modification. We evaluated the impacts of collection (Factor B) and the effects of climate change (Factors A and E) and determined that they had little to no measurable impact on the species over the time period analyzed.

To make the determination whether Venus flytrap warrants protection as an endangered or threatened species under the Act, we evaluated the current condition of the species and future conditions using future scenarios analyses in which we predicted the effects of a range of plausible projected future threat scenarios on the species. As described below, we first evaluated whether Venus flytrap is in danger of extinction throughout its range (an endangered species).

Second, we evaluated whether the species is likely to become in danger of extinction throughout its range within the foreseeable future (a threatened species). Third and finally, we considered whether Venus flytrap is an endangered or threatened species throughout a significant portion of its range.

*Status Throughout All of Its Range*
After evaluating threats to the species and assessing the cumulative effect of the threats under the section 4(a)(1) factors, we assessed the status of Venus flytrap to determine if it meets the definition of an endangered species. Venus flytrap has multiple medium to high resiliency populations found in wetlands in the Coastal Plain and Sandhills of southeastern North Carolina and northeastern South Carolina, which is an indication that the species has redundancy. Habitat loss and modification is the primary factor influencing the species rangewide, however 18 populations comprising 92% of the land within the range of the species are currently in moderate to high condition. The Venus flytrap has maintained robust populations over decades, which supports the idea that the species can withstand stochastic events and indicates population resiliency. Thus, the threats appear to have low imminence and magnitude such that they are not significantly affecting the species' current viability. The SSA Report describes some of the future uncertainties; but, considering the available data, the risk of extinction is low. Therefore, we conclude that Venus flytrap is not in danger of extinction throughout all of its range and does not meet the definition of an endangered species. Therefore, we proceed with determining whether Venus flytrap is likely to become endangered within the foreseeable future throughout all of its range.

In considering the foreseeable future as it relates to the status of Venus flytrap, we considered the relevant risk factors (threats/stressors) acting on the species and whether we could draw reliable predictions about the species' response to these factors. We considered whether we could reliably assess the risk posed by the threats to the species, recognizing that our ability to assess risk is limited by the variable quantity and quality of available data about effects to Venus flytrap and its response to those effects.

The SSA Report's analysis of future scenarios over a 50-year timeframe encompasses the best available information for future projections of habitat loss (i.e., development) under two different climate change futures (SSP2 and SSP5), as well as burn concern (i.e., inability to burn because of proximity to development), and fire management potential. We determined this 50-year timeframe enabled us to consider the threats/stressors acting on the species and draw reliable predictions about the species' response to these factors because it is a long lived plant that requires several generations before showing response to threats. Considering land use changes caused by development in the future scenarios, the threat of habitat loss would not change the conditions of most of Venus flytrap populations by the year 2070. In fact, the results of our future conditions analysis indicate no change in the future resiliency of Venus flytrap populations that are currently in high resiliency condition, regardless of fire management scenario, climate scenario, and year. Within fire management scenarios, the total resiliency conditions remained the same in 2050 and 2070 for SSP2. SSP5 showed greater variation within management scenarios and time steps. The eight populations currently in high resiliency

condition are all predicted to remain in high resiliency condition 30 and 50 years into the future. This is primarily because these populations are currently protected and managed, and those conditions are not likely to change in the future. These highly resilient populations represent 92% of the area occupied by populations on the landscape. Therefore, after assessing the best available information, we determine that Venus flytrap is not in danger of extinction now or likely to become so in the foreseeable future throughout all of its range.

*Status Throughout a Significant Portion of Its Range*

Under the Act and our implementing regulations, a species may warrant listing if it is in danger of extinction or likely to become so in the foreseeable future throughout all or a significant portion of its range. Having determined that the Venus flytrap is not in danger of extinction or likely to become so in the foreseeable future throughout all of its range, we next considered whether it may be in danger of extinction or likely to become so in the foreseeable future in a significant portion of its range—that is, whether there is any portion of the species' range for which it is true that both (1) the portion is significant; and (2) the species is in danger of extinction now or likely to become so in the foreseeable future in that portion. Depending on the case, it might be more efficient for us to address the "significance" question or the "status" question first. We can choose to address either question first. Regardless of which question we address first, if we reach a negative answer with respect to the first question that we address, we do not need to evaluate the other question for that portion of the species' range.

In undertaking this analysis for Venus flytrap, we chose to address the status question first. We began by identifying portions of the range where the biological status of the species may be different from its biological status elsewhere in its range. For this purpose, we considered information pertaining to the geographic distribution of (a) individuals of the species, (b) the threats that the species faces, and (c) the resiliency of populations.

We evaluated the range of the Venus flytrap to determine if the species is in danger of extinction now or likely to become so in the foreseeable future in any portion of its range. Because the range of a species can theoretically be divided into portions in an infinite number of ways, we focused our analysis on portions of the species' range that contribute to the conservation of the species in a biologically meaningful way. For Venus flytrap, we considered whether the threats or their effects on the species are greater in any biologically meaningful portion of the species' range than in other portions such that the species is in danger of extinction now or likely to become so in the foreseeable future in that portion. We examined the following threats: habitat loss or modification due to development and fire suppression, and small population size and isolation, including cumulative effects.

We identified three portions of the range to consider – the Outer Coastal Plain, the Inner Coastal Plain, and the Sandhills. The Outer Coastal Plain is considered a biologically meaningful portion of the species' range, as it contains the majority of extant populations and is considered the core of the range. However, as discussed above, this portion contains the majority of populations with high and medium resiliency. Further, these populations are largely on lands that are protected and managed for conservation For these reasons, the Outer Coastal Plain portion was not

determined to have a different status that the species' range as a whole.

The Inner Coastal Plain portion contains one low resiliency population of Venus flytrap, indicating that this small and isolated population is currently at risk of extirpation, primarily because the lack of resiliency makes the population susceptible to both stochastic and catastrophic events. Threats to this small population could have a disproportionate impact in this portion. Therefore, this portion does have a different status than the species' range as a whole, and the species is in danger of extinction now in the Inner Coastal Plain.

The Sandhills portion contains two medium resiliency populations and seven low resiliency populations of Venus flytrap. The two medium resiliency populations are considered protected in habitat managed with fire by the military and are predicted to maintain resiliency over the next 50 years. However, the high number of low resiliency populations, which are small and isolated, indicates some susceptibility to extirpation from stochastic and catastrophic events. The timing of whether any or all of these populations could be extirpated is uncertain, but is considered possible in the foreseeable future, and these losses in this portion could potentially put the species at risk of extirpation in the future. With the potential loss of populations in this portion, we determined that it is possible for this portion to have a different status than the species' range as a whole, and thus consider the species in danger of extinction in the foreseeable future in the Sandhills.

We next evaluated whether either of these two portions – the Inner Coastal Plain and the Sandhills – represent a significant portion of the range. To determine this, we considered whether the portion constitutes a large geographic area relative to the range of the species as a whole, whether the portion constitutes habitat of high quality relative to the remaining portions of the range, or whether the portion constitutes high or unique value habitat for the species.

The Inner Coastal Plain is comprised of primarily agricultural land, and most sites where the species occurred historically and the one site where it currently exists are considered marginal habitat. This habitat does not meet the criteria of providing high value to the species, nor is the habitat considered to have unique value, as it is marginal and not overly conducive to species survival. In addition, the Inner Coastal Plain makes up a very small portion (less than 0.01%) of the overall species' range and was mostly present in the narrow corridor along the Cape Fear River connecting the Outer Coastal Plain and the Sandhills populations. For these reasons, we do not consider the Inner Coastal Plain to be a significant portion.

The habitat that supports Venus flytrap in the Sandhills is different than in other parts of the range. Because of their requirement for moist soils, Venus flytrap in the Sandhills is limited to seeps that are narrow, moist ecotones between streamhead pocosins (linear, evergreen shrub bogs along small creeks) and pine/scrub oak uplands. These seeps are likely the only areas in the Sandhills that provide conditions suitable for Venus flytrap to grow. However, they do not represent unique value habitat, as they are simply the wetter ecotones that provide suitable conditions for flytraps to grow. These areas are also not high value relative to habitat in the

remaining portions of the range, particularly when compared to habitat in the Outer Coastal Plain that continues to be the stronghold for the range of the species. Furthermore, the Sandhills make up only 0.4% of the total area of the range of the species. For these reasons, we determined that the Sandhills is not a significant portion.

These areas do not represent a significant portion of the range; therefore, we find that the species is not in danger of extinction now or likely to become so in the foreseeable future in any significant portion of its range. This does not conflict with the courts' holdings in *Desert Survivors v. Department of the Interior*, 321 F. Supp. 3d 1011, 1070-74 (N.D. Cal. 2018), and *Center for Biological Diversity v. Jewell*, 248 F. Supp. 3d 946, 959 (D. Ariz. 2017) because, in reaching this conclusion, we did not apply the aspects of the Final Policy on Interpretation of the Phrase "Significant Portion of Its Range" in the Endangered Species Act's Definitions of "Endangered Species" and "Threatened Species" (79 FR 37578; July 1, 2014), including the definition of "significant" that those court decisions held to be invalid.

*Determination of Status*
Our review of the best available scientific and commercial information indicates that the Venus flytrap does not meet the definition of an endangered species or a threatened species in accordance with sections 3(6) and 3(20) of the Act. Therefore, we find that listing the Venus flytrap is not warranted at this time.

COORDINATION WITH STATES
While conducting the SSA for Venus flytrap, we closely coordinated with both NC and SC Natural Heritage Programs as well as the NC Plant Conservation Program. We received and incorporated valuable feedback from the NC Natural Heritage Program, SC Heritage Trust Program, NC State University, NC Botanical Garden, and private consultants for The Nature Conservancy into the SSA. All reviewers were supportive of the conclusions drawn from the scientific analyses presented in the SSA Report.

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All SAFs supporting 12-month findings or candidate notices of review will be signed by the Director. SAFs should continue to be surnamed by Regional and Headquarters staff and leadership.

Digitally signed by MARTHA WILLIAMS
Date: 2023.07.17 19:34:07 -04'00'

Date:
Martha Williams,
Director,
U.S. Fish and Wildlife Service

Date of annual review: 12/12/2022
Conducted by: Sarah McRae