Species Status Assessment Report for White Fringeless Orchid (*Platanthera integrilabia*)

Version 1.0

March 2021

U.S. Fish and Wildlife Service

South Atlantic–Gulf Region

Atlanta, Georgia

ACKNOWLEDGEMENTS

This document was prepared by Kathryn Smith-Hicks (Texas A&M University-Natural Resources Institute [NRI]), Geoff Call (U.S. Fish and Wildlife Service [Service]), and Mike Marshall (NRI). Other species expertise, guidance, and document reviews were provided by Mark Pistrang (U.S. Forest Service [USFS]), Al Schotz (Alabama Heritage Program), David Taylor (USFS), Tara Littlefield (Office of Kentucky Nature Preserves), Michele Elmore (Service), Roger McCoy (TN Division of Natural Areas), Scott Wiggers (Service), Todd Crabtree (TN Division of Natural Areas), and Lawrence Zettler (Illinois College). Cartographic design was provided by Kurt Snider (Service).

Additionally, valuable input into the analysis and reviews of a draft of this document were provided by peer reviewers including Jennifer Boyd, Adam Dattilo, Roger McCoy, James Rickard, Dennis Whigham, and Marion Wiggers. We appreciate their input and comments, which resulted in a more robust status assessment and final report.

Suggested reference:

U.S. Fish and Wildlife Service. 2021. Species status assessment report for *Platanthera integrilabia* (white fringeless orchid), Version 1.0. March 2021. Atlanta, Georgia.

VERSION UPDATES

EXECUTIVE SUMMARY

Platanthera integrilabia (white fringeless orchid) is a perennial herb, which was listed in 2016 as a threatened species under the Endangered Species Act. The species currently occurs in Alabama, Georgia, Kentucky, Mississippi, South Carolina, and Tennessee. *Platanthera integrilabia* habitat has historically been described as partially shaded areas with sandy and acidic soils in wet areas like seeps, bogs, or swamps; however, the species also occurs in areas that differ in light and moisture availability. Like most terrestrial orchids, *P. integrilabia* depends on a symbiotic relationship with mycorrhizal fungi for seed germination and seedling development and establishment. The number of orchids found across occurrences varies greatly, from about a dozen to thousands of individuals. Frequency of flowering also varies and may be absent in some occurrences for several years, presumably in response to environmental variability, but factors regulating growth and reproduction in the species are not well understood. Threats believed to influence *P. integrilabia* populations include logging, invasive species (plants and hogs), herbivory, illegal collection, and land use changes that remove habitat or alter local hydrology or light availability. Many occurrences respond well to management actions (e.g., exclusion fencing, thinning of overstory, seed propagation and transplanting), and such efforts are ongoing for several occurrences across the species' range. We have compiled and analyzed available data, including input from species experts, in preparing this Species Status Assessment (SSA). However, there are many aspects of the species' life history and responses to change that are unknown. Where there was uncertainty in our analysis, we attempted to be clear and explicit in the SSA about where assumptions and estimations were made and why.

Using available occurrence data, we delineated 50 populations (i.e., groups of plants including one or more occurrences believed to be potentially interbreeding) distributed in five ecoregions in the southeast: Blue Ridge, Piedmont, Ridge and Valley, Southwestern Appalachians, and Southeastern Plains. We developed a framework for assessing resilience of these populations using available data on population size, flowering within the population, and connectivity to other populations. First, we assigned one of four baseline resilience levels depending on population size and whether flowering has been observed in the population in the previous decade, as depicted in the table below.

Population Size (# plants)	Flowering	Not Flowering
<100	Low	
100-500	Moderate	Low
501-1000	High	Moderate
>1000	Very High	Moderate

Next, we rated connectivity for each population as either low (no extant populations within 10 km), medium (1 extant population within 10 km), or high (>1 extant population within 10 km) and adjusted the resilience level, as warranted, to account for degree of population isolation. We lowered resilience levels by one step for populations with "low" connectivity and raised resilience levels for populations with "high" connectivity but did not change resilience levels for populations with "medium" connectivity. If a population had not been observed flowering within the previous 10 years, its level remained "low" regardless of connectivity. We used the resulting population resilience levels in our analyses of current and future resilience, redundancy, and representation for white fringeless orchid in this SSA. Based on this resilience classification strategy, there are currently 4 very highly resilient populations, 6 highly resilient populations, 5 moderately resilient populations, and 33 populations with low resilience. Redundancy in the Southwestern Appalachians is high, but redundancy is low in the other ecoregions to the south and west, and resilience levels for most of these populations are low.

After determining the resilience level for each population, we ranked its conservation status with respect to habitat protection and management, as shown in the table below. Over one-third of the populations (n=18) have no protection or management, and the majority (72%) of those have low resilience.

	Protected	
	Yes	No
Managed	High	Medium
Not Managed	Medium	Low

We assessed the future condition of *P. integrilabia* 50 years into the future under 3 scenarios: Status Quo, Reduced Conservation, and Targeted Conservation. These scenarios explored how varying levels of future conservation effort might interact with current population resilience levels and two risk factors affecting the species: (1) residential and commercial development, which can alter local hydrology, fragment habitat, limit pollinator movements, increase invasive species occurrence, or directly remove habitat in areas that are not protected, and (2) logging, which can change light availability, increase invasive plant species, cause direct habitat destruction, and alter local hydrology and soil moisture. Under the Status Quo scenario, no new protected areas are acquired, and no new populations are found or introduced. Ongoing management effort will continue to benefit the targeted populations, assuming that the ability to do so will not be hampered by funding, climate change, or other extraneous factors. Under the Reduced Conservation scenario, management effort on all populations decreases, presumably as an effect of a wide-scale change in priorities, funding, and/or resources. Under the Targeted Conservation scenario, conservation resources are focused on maintaining highly resilient populations and strengthening moderately resilient populations on protected lands.

Resilience Level	Current	Future - Status Quo	Future - Reduced Conservation	Future - Targeted Conservation
Very High	5	7	4	7
High	6	3	4	4
Moderate	6	9	5	14
Low	33	19	24	14
All	50	38	37	39

The number of populations predicted to be extant in 50 years would decline under all scenarios because some populations are predicted to be extirpated as a result of development or logging and/or lack of protection or habitat management. Even under the Targeted Conservation scenario, extirpation is predicted for 11 populations. However, under the Status Quo and Targeted Conservation scenarios, conservation efforts are predicted to improve resilience levels for 11 and 15 populations, respectively, in that time. A majority of populations (66%) would have "low" resilience under the Reduced Conservation scenario indicating that these populations may be at great risk for extinction if the timeline were extended beyond 50 years. Additionally, climate change impacts (i.e., warmer temperatures, droughts) are expected to exacerbate pressures on populations with low resilience. Redundancy is expected to decrease compared to current condition under all scenarios. The main cause for predicted loss of populations under the Status Quo and Reduced Conservation scenarios is high risk of logging on private properties, specifically in the Southeastern Plains and Southwestern Appalachian ecoregions.

Ecoregion	**State**	**Population**	**Resilience**			
			Current	**Status Quo 2070**	**Reduced 2070**	**Targeted 2070**
Blue Ridge	GA	Tallulah Gorge	Low	Low	Low	Low
		Pine Log Mountain	Low	Low	Low	Low
		Big Canoe	Low	Low	Presumed Extirpated	Low
	SC	Greenville	Low	Low	Low	Low
	TN	Starr Mountain	High	Very High	High	Very High
		Sheeds Creek	Low	Moderate	Low	Moderate
Piedmont	AL	Ivory Mountain	Moderate	Moderate	Moderate	Moderate
		Union-Good Hope Delta Rd	Low	Low	Low	Low
	GA	Sawnee Mountain	Low	Presumed Extirpated	Presumed Extirpated	Presumed Extirpated
		Turkey Creek	Low	Presumed Extirpated	Presumed Extirpated	Presumed Extirpated
		Lee Mountain	Low	Moderate	Low	Moderate
		Moore Creek	Low	Moderate	Low	Moderate
		Lyons Landing	Low	Presumed Extirpated	Presumed Extirpated	Presumed Extirpated
Ridge and Valley	AL	Mountain Longleaf NWR	Moderate	High	Moderate	High

Ecoregion	State	Population	Resilience			
			Current	Status Quo 2070	Reduced 2070	Targeted 2070
Southeastern Plains	AL	Clifty Creek	Low	Presumed Extirpated	Presumed Extirpated	Presumed Extirpated
		Bankston	Low	Presumed Extirpated	Presumed Extirpated	Presumed Extirpated
	MS	Itawamba	Low	Low	Low	Moderate
		Bear Creek	Low	Low	Low	Low
		Glasgow	Very High	Very High	Very High	Very High
Southwestern Appalachians	AL	Jock Creek	Low	Presumed Extirpated	Presumed Extirpated	Presumed Extirpated
		Lookout Mountain	Low	Low	Low	Low
		Browns Creek Branch	Low	Low	Low	Low
		Skyline WMA	Low	Low	Low	Low
	GA	Neal Gap	Low	Moderate	Low	Moderate
	KY	Bald Rock Uplands/Marsh Branch	High	Very High	High	Very High
		Hindsfield Ridge	Moderate	Moderate	Moderate	Moderate
		Flatwoods Uplands	High	Presumed Extirpated	Presumed Extirpated	Low
		Pine Creek Gorge	Low	Moderate	Low	Moderate
		Mount Victory Seeps	Very High	Very High	Very High	Very High
		Barren Fork	Low	Low	Low	Moderate
		Pine Knot	Low	Low	Low	Low
		Grove	Very High	Very High	Very High	Very High
	TN	Plantation Pond	Low	Low	Low	Low
		Hwy 111	Moderate	Presumed Extirpated	Presumed Extirpated	Presumed Extirpated
		Meadow Creek	Very High	Very High	Very High	Very High
		Tar Kiln Ridge	High	Very High	High	Very High
		Pitcher Ridge	Low	Low	Low	Low
		Guntersville Lake	Low	Low	Low	Low
		Prentice Cooper SF	Low	Low	Low	Moderate
		N Fork Creek	Low	Low	Low	Moderate
		Duncan Hollow	Low	Moderate	Low	Moderate
		Marion	Moderate	Low	Low	Moderate
		Mooneyham	High	Moderate	Moderate	High
		Southern Pine Plantation	High	Low	Low	Moderate
		Spencer Powerline	Low	Presumed Extirpated	Presumed Extirpated	Presumed Extirpated
		Great Falls	Low	Presumed Extirpated	Presumed Extirpated	Presumed Extirpated

Ecoregion	State	Population	Resilience			
			Current	Status Quo 2070	Reduced 2070	Targeted 2070
Southwestern Appalachians	TN	Lee Farm/Laurel Trail	Low	Presumed Extirpated	Presumed Extirpated	Presumed Extirpated
		Centennial Wilderness WMA	Moderate	High	Moderate	High
		Falls Creek	Low	Presumed Extirpated	Presumed Extirpated	Presumed Extirpated
		Bledsoe Powerline	Very High	High	High	High

TABLE OF CONTENTS

CHAPTER 1 – INTRODUCTION AND ANALYTICAL FRAMEWORK

The Species Status Assessment (SSA) framework (U.S. Fish and Wildlife Service (Service) 2016, entire) summarizes information compiled and reviewed by the Service, incorporating the best available scientific and commercial data, to conduct an in-depth review of a 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.

Platanthera integrilabia (white fringeless orchid) is a perennial herb, which was listed in 2016 as a threatened species under the Endangered Species Act of 1973 (Act) (81 FR 62826, September 13, 2016). The species currently occurs in Alabama, Georgia, Kentucky, Mississippi, South Carolina, and Tennessee. This SSA was prepared to support development of the species Recovery Plan, which must include quantitative recovery criteria, and will also provide a basis for future consultation, classification, and recovery actions taken by the Service.

This SSA provides a review of available information strictly related to the biological status of *P. integrilabia* and its viability. For the purpose of this assessment, we generally define viability as the ability of the species to sustain populations in its range over time. Using the SSA framework (Fig. 1.1), we consider what the species needs to maintain viability by characterizing the status of the species in terms of its resilience, redundancy, and representation (Wolf *et al.* 2015, entire).

- **Resilience** describes the ability of populations to withstand stochastic events (arising from random factors). We can measure resilience 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 resilience, and their distribution (and connectivity), redundancy gauges the probability that the species has a margin of safety to withstand or return 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.

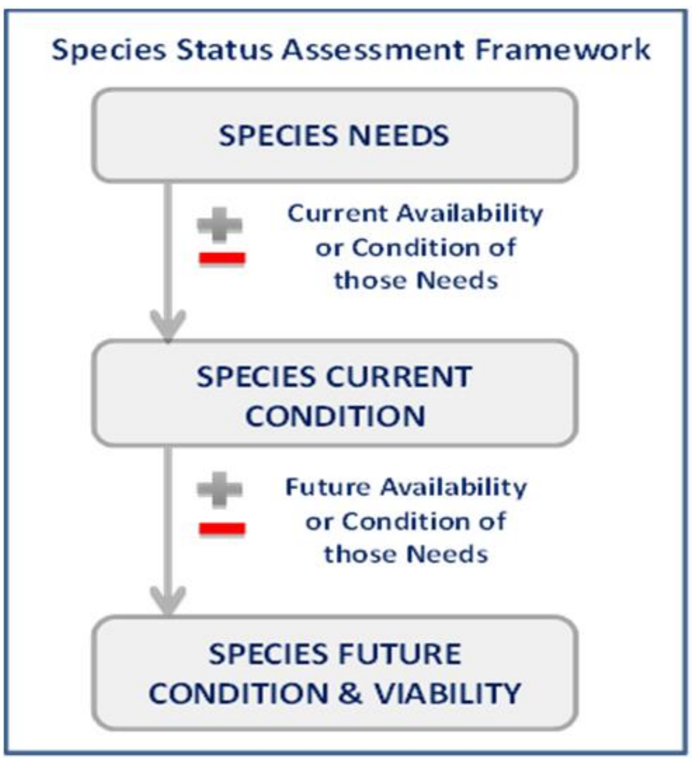

Figure 1.1. Species Status Assessment Framework

To evaluate the biological status of *P. integrilabia* we compiled available information from the literature and species experts about the species' biology and needs and assessed the species' resilience, redundancy, and representation (together, the 3 Rs) under current conditions and multiple plausible future scenarios. This SSA includes the following chapters: 1 – Introduction and Analytical Framework, 2 – Species Biology and Individual Needs, 3 – Species Needs for Viability, 4 – Influences on Viability, 5 – Current Condition, and 6 – Future Condition. 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 *P. integrilabia*. However, there are many aspects of the species' life history and responses to change that are unknown. Where there was uncertainty in our analysis, we attempted to be clear and explicit in the SSA about where assumptions and estimations were made and why.

CHAPTER 2 – SPECIES BIOLOGY AND INDIVIDUAL NEEDS

In this chapter, we provide biological information about *Platanthera integrilabia*, including its taxonomic history, morphological description, historical and current distribution and range, and known life history. We then outline the resources individual plants require to germinate, grow, and reproduce.

2.1 Taxonomy

P. integrilabia was first recognized as a distinct taxon when D.S. Correll (1941 pp. 153-157) described it as a variety of *Habenaria* (*Platanthera*) *blephariglottis.* C.A. Luer (1975, p. 186) elevated the taxon to full species status. The currently accepted binomial for the species is *Platanthera integrilabia* (Correll) Luer. The description of this taxon at the full species level used the common name of "monkey-face" (Luer 1975 p. 186), as have some other publications (Zettler and Fairey 1990, p. 212; Zettler 1994, p. 686; Birchenko 2001, p. 9). A status survey report for the species recognized both "white fringeless orchid" and "monkeyface" as common names (Shea 1992, p. 1).

The currently accepted taxonomy for *P. integrilabia* is described below (Integrated Taxonomic Information System 2019):

Kingdom:	Plantae
Subkingdom:	Viridiplantae
Infrakingdom:	Streptophyta
Superdivision:	Embryophyta
Division:	Tracheophyta
Subdivision:	Spermatophytina
Class:	Magnoliopsida
Superorder:	Lilianae
Order:	Asparagales
Family:	Orchidaceae
Genus:	Platanthera (Rich.)
Species:	*Platanthera integrilabia*
Common name:	white fringeless orchid, monkeyface

2.2 Species Description

P. integrilabia (Fig. 2.1) is a perennial herb with a light green, 60-centimeters (cm) long stem that arises from a tuber (modified underground stem of a plant that is enlarged for nutrient storage). Leaves are alternate with entire margins and are narrowly elliptic to lanceolate (broadest below the middle and tapering toward the apex) in shape. Lower leaves are approximately 20 cm long and 3 cm wide; upper stem leaves are much smaller. White flowers are borne in a loose inflorescence (spike) terminating the stem. The upper two flower petals are about 7 millimeters (mm) long, and the lower petal (the lip) is approximately 13 mm long; nectar spur slender, curved, 4-5 cm long. The epithet "integrilabia" refers to the lack of any prominent fringe on the margin of the lip petal (Fig. 2.1 (a)). The lack of conspicuous fringe on the lip and longer nectar spur are useful characters for discerning *P. integrilabia* from similar appearing congeners. Fruit is an ellipsoid capsule, approximately 1.5 cm long, bearing thousands of dust-like seeds (Luer 1975, p. 186, Zettler *et al.* 1996, p. 20).

(a)

(b)

Figure 2.1. Photographs of *Platanthera integrilabia* (a) inflorescence and (b) growth habit.

2.3 Range and Distribution

Platanthera integrilabia is believed to have historically occurred in 7 southeastern States including Alabama, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee (Fig. 2.2). In addition to the 36 counties where the species is extant, the historical range of *P. integrilabia* also included Cobb County, Georgia; Henderson County, North Carolina; Alcorn County, Mississippi; and Roane County, Tennessee (Shea 1992, p. 15). As of 2021, there were 86 extant element occurrences (EOs), distributed among 36 counties in 6 southeastern States: Alabama, Georgia, Kentucky, Mississippi, South Carolina, and Tennessee (Alabama Natural Heritage Program (ANHP) 2018, Georgia Department of Natural Resources (GDNR) 2018, Office of Kentucky Nature Preserves (OKNP) 2018, Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP) 2014, North Carolina Department of Environment and Natural Resources (NCDENR) 2014, South Carolina Department of Natural Resources (SCDNR) 2012, Tennessee Department of Environment and Conservation (TDEC) 2018; Appendix A). The species has not been observed in North Carolina since 1992 (Appendix A).

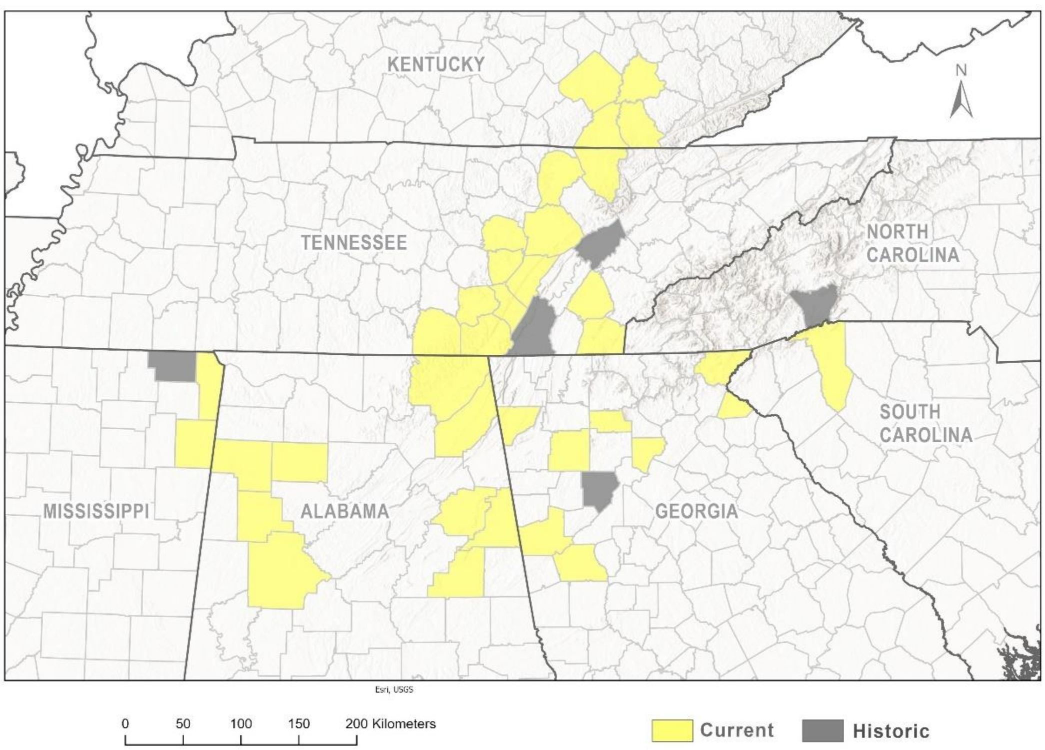

Figure 2.2. Counties currently and historically occupied by *Platanthera integrilabia*.

2.4 Life History

Historically, *P. integrilabia* has been observed flowering from late July through September, and the fruiting capsules matured in October (Shea 1992, p. 23). Recent surveys in Kentucky (last 10 years) indicate flowering is finished by September and that capsules begin to dehisce by October (T. Littlefield 2019, pers. comm.). Orchid seeds are dust-like and lack an endosperm (the tissue produced inside seeds of most flowering plants that provides nutrient reserves) making them dependent upon acquiring carbon from an external source (Yoder *et al.* 2010, p. 7). Like most terrestrial orchids, *P. integrilabia* depends on a symbiotic relationship with mycorrhizal fungi (an association of a fungus and a plant in which the fungus colonizes the host plant's root tissues) for seed germination and seedling development and establishment (Zettler and McInnis 1992, pp. 157-160; Rasmussen and Whigham 1993, p. 1374).

It is nearly universally acknowledged that orchids are dependent on mycorrhizal fungi, which they metabolize as a source of carbon during germination and early developmental stages due to their small seed size (i.e., few stored food reserves) (Smith and Read 1997, pp. 423-450; Bayman *et al.* 2002, p. 1007). In addition to providing a carbon source for seedling development, mycorrhizal fungi enhance germination by promoting increased water uptake by orchid seeds (Yoder *et al*. 2000, p. 149). There is also evidence that orchids use mycorrhiza, in addition to photosynthesis, as a carbon source at all life history stages (i.e., mixotrophy; Lallemand et al. 2019, entire). Their small size permits dispersal of orchid seeds to new environments via wind currents; however, very few of the seeds likely encounter suitable habitats where host fungi are present (Yoder *et al*. 2010, pp. 14-16). This likelihood is further reduced in the case of species such as *P. integrilabia*, which likely relies on a single fungal species, *Epulorhiza inquilina*, to complete its life cycle (Currah *et al.* 1997, p. 340; Zettler 2018, pers. comm.). The distribution and abundance of *E. inquilina* is not known; however, its distribution is believed to be a limiting factor for *P. integrilabia* (Zettler 2018, pers. comm., Currah *et al.* 1997, p. 340).

While *P. integrilabia* has a self-compatible breeding system, allowing individuals to produce seeds using their own pollen, the proportions of fruits produced through self-pollination versus cross-pollination are not known (Zettler and Fairey 1990, p. 214). There is some evidence that self-pollination is infrequent compared to insect pollination (Zettler 2018, pers. comm.). For example, Zettler and McInnis (1992, pp. 157-159) suggested that larger orchid populations have higher rates of seed germination compared to smaller populations, and this may be attributed to outcrossing among different individuals. Rates of fruit set, measured as the proportion of individual flowers that produced capsules, varied in studies of populations in Georgia (6.9 percent), South Carolina (20.3 percent) (Zettler and Fairey 1990, p. 214), Kentucky (41 percent) (Littlefield 2015, p. 12), and Tennessee (56.9 percent) (Zettler *et al.* 1996, p. 20). While these observations were made at these populations in different years, the Tennessee population, where pollination was observed, is considerably larger than the Georgia or South Carolina populations, where no pollination was observed. Zettler *et al.* (1996, p. 22) reasoned that inbreeding depression was a likely cause for the lower fruit set in the smaller populations, noting that in a separate study both germination rates and propagation success were greater in *P. integrilabia* seeds collected from the largest of these populations (Zettler and McInnis 1992, p. 160). They speculated that higher rates of fruit set were probably more typical historically, when larger populations provided greater opportunities for cross-pollination to occur.

P. integrilabia is capable of prodigious seed production, which might help to compensate for the likely dispersal of many seeds into unsuitable habitats. In the Tennessee population studied by Zettler *et al.* (1996, p. 20), more than half of the flowers on inflorescences (the complete flower head of a plant including stems, stalks, bracts, and flowers) set fruit, resulting in a mean of 4.7 capsules per plant. The capsules produced an average of 3,433 seeds each, indicating that each inflorescence averaged over 16,000 seeds. With 577 inflorescences counted in the study area, Zettler *et al.* (1996, p. 20) estimated that over 9,000,000 seeds were produced. However, in separate studies of *in vitro* and *in situ* seedling development, even with fungal inoculation less than 3 percent (not an unusually low number for orchid species) of seeds developed into protocorms (young seedlings) that could be established on soil (Zettler and McInnis 1992, pp. 157-160; Zettler 1994, pp. 65). Unlike its congener *P. leucophaea* (eastern prairie fringed orchid), seeds of *P. integrilabia* do not require cold-moist stratification in order to break dormancy barriers to germination (Zettler 2018, pers. comm.).

Pollinaria are the pollen-bearing structures on orchids, consisting of pollen masses (pollinia) attached to a stalk that has a sticky pad (viscidium), which attaches the pollinaria to pollinators

(Argue 2012, p. 5). Confirmed pollinators for *P. integrilabia* are limited to three diurnal species from two families of butterflies (Lepidoptera): silver spotted skipper (Hesperiidae: *Epargyreus clarus*), spicebush swallowtail (Papilionidae: *Papilio troilus*; Fig. 2.3), and eastern tiger swallowtail (Papilionidae: *P. glaucus*); though, these species have been observed carrying pollinia on only a single compound eye (Zettler *et al.* 1996, p. 16; D. Taylor 2018, pers. comm.; T. Littlefield 2019, pers. comm.). It has been suggested that more effective pollinators for *P. integrilabia*, potentially capable of contacting viscidia and removing pollinaria with both compound eyes simultaneously, exist in the nocturnal sphingid moth family (Lepidoptera: Sphingidae) (Zettler *et al.* 1996, pp. 17-21); though, removal of a single pollinarium per pollinator visit is apparently not unusual in the genus *Platanthera* (Zettler 2018, pers. comm.). Despite the fact that nectar concentrations in *P. integrilabia* flowers did not fluctuate significantly over a 24-hour observation period, Zettler *et al.* (1996, p. 20) noticed the floral

Figure 2.3. Spicebush swallowtail (*Papilio troilus*) visiting *Platanthera integrilabia* in Kentucky.

fragrance produced by a large Tennessee population intensified between the hours of 1900 and 2300, suggesting the species possesses adaptions for attracting nocturnal pollinators. However, the role of sphingid moths as pollinators for *P. integrilabia* has not been confirmed. Nocturnal sphingid moths (species unknown) have been seen approaching *P. integrilabia* in Kentucky;

however, they were never seen taking nectar or pollinia (D. Taylor 2018, pers. comm.). Alternatively, because diurnal Lepidoptera that are known pollinators for the species typically contact viscidia and remove pollinia with one eye, a circumstance that is not unusual in *Platanthera*, it is possible that this pollination mechanism increases potential for outcrossing by requiring multiple insect visitors for removal of both pollinia (Zettler 2018, pers. comm.).

Recent research in Alabama indicates that *P. integrilabia* may be visited by *Lasioglossum* spp. (sweat bee) and *Halictus* spp. more often than moth or butterfly species (B. Chowdhury 2018, pers. comm.). *Augochlora pura* (sweat bee) has also been observed visiting *P. integrilabia* flowers in Kentucky (T. Littlefield 2019, pers. comm.; Fig. 2.4). However, none of these species have been confirmed as effective pollinators capable of transferring pollinia among *P. integrilabia* individuals. Further research is needed to better understand *P. integrilabia* pollinators.

Figure 2.4. Sweat bee (*Augochlora pura*) visiting *Platanthera integrilabia* in Kentucky.

2.5 Habitat and Resource Needs

P. integrilabia habitat has historically been described as partially shaded sites with sandy and acidic soils (Shea 1992, p. 19) in wet areas like seeps, seepage slopes, bogs, or swamps (Correll

1941, pp. 156-157; Luer 1975, p. 186; Zettler and Fairey 1990, p. 212; Hoy 2012, p. 53). Some of these terms, used by botanists to describe *P. integrilabia* habitat, have been misapplied from the perspectives of hydrology or wetland classification. For example, hydrology in seepage slopes is predominantly driven by subsurface water sources, whereas hydrology in bogs is largely precipitation-driven with little groundwater inflow (Mitsch and Gosselink 2000, p. 734). The only hydrology study of *P. integrilabia* habitat, conducted in three wetlands in Kentucky, documented hydrology lacking significant groundwater contribution (Hoy 2012, p. 33). The results of this study demonstrated the importance of precipitation in maintaining hydrology in these habitats, but for other reasons they do not meet traditional definitions of bogs. Weakley and Schafale (1994, pp. 360-361) commented on the discrepancy between regional use of the terms "bogs" and "fens" to describe non-alluvial wetlands of the Southern Blue Ridge in which sphagnum moss is prominently featured and more traditional usage of those terms in peatland classifications. Noting that most of the region's non-alluvial wetlands lacked organic soils, these authors nonetheless chose to maintain the regional usage of these terms in their classification, to emphasize differences in sources of hydrology and their effects on water chemistry (nutrient-poor precipitation in "bogs" versus mineral-rich groundwater seepage in "fens"). Like the non-alluvial wetlands of the Southern Blue Ridge, further study is needed to characterize the range of variation in soils, hydrology, physicochemistry, and origin of wetlands throughout the range of *P. integrilabia*.

P. integrilabia has also been associated with a wide range of light availability (Luer 1975, p. 186, Zettler and Fairey 1990, p. 213, Shea 1992, p. 19; Boyd *et al.* 2016, entire). Some observations have noted large increases in growth and reproduction soon after timber harvests occurred (Shea 1992, pp. 26, 96; Appendix B) while other populations collapsed, presumably due to resulting depletion of ground water supply (D. Taylor 2018, pers. comm.). Following timber harvest (5-10 years), *P. integrilabia* populations that initially respond positively can quickly decline due to the surge in young sapling growth in occupied habitat and nearby, which alters light and water availability (T. Littlefield 2019, pers. comm.).

Recent research shows that *P. integrilabia* can tolerate a wide range of light and soil moisture (Boyd *et al.* 2016, p. 1269). For example, *P. integrilabia* sites located in powerline rights-of-way share many of the herbaceous taxa listed below but lack a canopy or well-developed shrub stratum due to vegetation management. Boyd *et al.* (2016, p. 1270) found no clear association between site-level abiotic conditions and *P. integrilabia* density across study sites occurring in forested seeps, experimentally thinned forests, and a powerline corridor right-of-way, an outcome that indicates individual *P. integrilabia* may be capable of acclimating to varying local conditions. In Kentucky, most *P. integrilabia* occurrences are associated with surface depressions, made up of sand covered in a thin layer of silt and organic material, with saturated soils present at depths ranging from the surface to as much as several feet below the surface through the year; the orchids grow within the depressions and between them along shallow, braided channels (D. Taylor 2018, pers. comm.). Increased soil saturation from December through May was noted in three separate wetlands known to be inhabited by *P. integrilabia* or congeners (Hoy 2012, pp. 26-29). This all suggests that the definition of habitat suitable for *P. integrilabia* could be broadened, with suitability influenced as much by the presence or absence of *E. inquilina* as by specific ranges of light and moisture availability. Regardless of the terms used to describe them, further study is needed to characterize the range of variation in soils, hydrology, physicochemistry, and origin of wetlands throughout the range of *P. integrilabia*.

P. integrilabia is associated with sphagnum moss (*Sphagnum* spp), an acidophilic species of moss often found in bogs (Mitsch and Gosselink 2000, p. 41). *P. integrilabia* often occurs in swamps (wetlands dominated by trees or shrubs) dominated by *Acer rubrum* (red maple), *Quercus alba* (white oak), and *Nyssa sylvatica* (blackgum), where common shrubs and woody vines include *Alnus serrulata* (smooth alder), *Decumaria barbara* (climbing hydrangea), *Smilax* spp. (greenbrier), *Ilex verticillata* (winterberry), *Aronia melanocarpa* (chokecherry) and *Viburnum nudum* (possumhaw). Common herbaceous associates of *P. integrilabia* include *P. clavellata* (small green woodland orchid), *Doellingeria umbellata* (parasol flat-top white aster), *Carex* sp. (sedge), *Gymnadeniopsis clavellata* (green woodland orchid), *Lobelia cardinalis* (cardinal flower), *Lycopus virginicus* (Virginia bugleweed), *Osmunda cinnamomea* (cinnamon fern), *O. regalis* (royal fern), *Oxypolis rigidior* (stiff cowbane), *Parnassia asarifolia* (kidneyleaf grass of parnassus), *Platanthera ciliaris* (yellow fringed orchid), *P. cristata* (crested yellow orchid), *Sphagnum* spp. (sphagnum moss), *Thelypteris noveboracensis* (New York fern; typically in dry/degraded conditions) (D. Taylor 2019, pers. comm.), *Viola primulifolia* (primrose-leaf stemless white violet), and *Woodwardia areolata* (chainfern) (Zettler and Fairey 1990, p. 213; Shea 1992, p. 22; T. Patrick 2012, pers. comm.).

2.6 Genetics

Birchenko (2001, pp. 18-23, 47-48) used Inter-Simple Sequence Repeats to analyze genetic structure among 25 *P. integrilabia* populations, distributed across Alabama, Georgia, Tennessee, and Kentucky. The majority (79%) of the genetic variation was present as variation within populations, while 21% of the variation was attributable to differences among populations (Birchenko 2001, p. 29). These results do not demonstrate that genetic variability in *P. integrilabia* populations has been eroded by restricted gene flow but could indicate populations were once larger and have more recently become fragmented (J. Cruse-Sanders 2019, pers. comm.). Birchenko (2001, pp. 34-40) cautioned that interactions between demographic and ecological factors could be a cause for some observed population declines. Allee effects on the small isolated populations of *P. integrilabia* could ultimately cause declines in the species' genetic variation and increase differentiation among *P. integrilabia* populations.

CHAPTER 3 – SPECIES NEEDS FOR VIABILITY

3.1 Individual Level

At the individual level, *Platanthera integrilabia* requires suitable habitat to survive and reproduce (Fig. 3.1). Habitat characteristics and the species' biological requirements were discussed above in Sections 2.4 and 2.5 and are discussed in detail in the next section as they relate to the population scale, but individual plants have similar needs, briefly: acidic sandy soils, minimal organic matter, and suitable levels of soil moisture and light availability (Fig. 3.1). *P. integrilabia* can persist in high canopy cover, or even thrive as observed in the sizeable Starr Mountain population; however, increasing density of trees and shrubs occasionally corresponds with diminished growth and reproduction in some areas (Fig. 3.1). In addition to these habitat characteristics, for *P. integrilabia* to complete its life cycle, habitat where it occurs must also

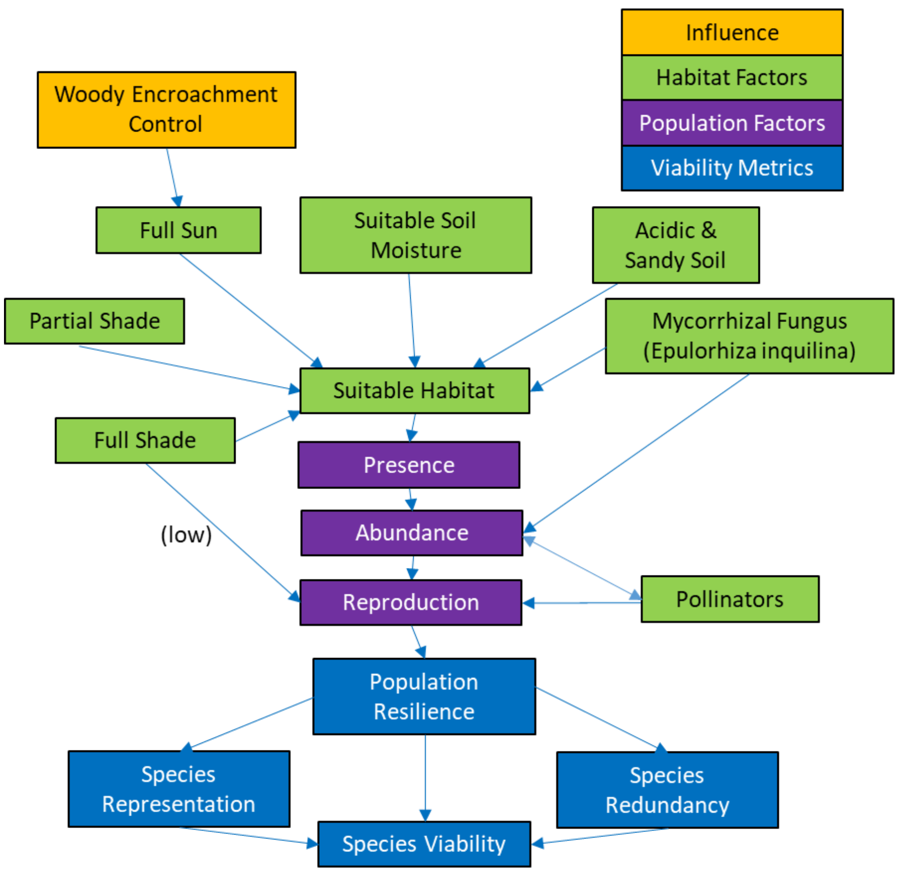

Figure 3.1. Conceptual diagram illustrating connections between population attributes and habitat factors influencing population resilience for *Platanthera integrilabia*.

support the fungal species with which it forms mycorrhiza for seed germination and subsequent growth and establishment of seedlings. Effective pollinators must also be present.

3.2 Population Level

For resilient populations to persist, wet acidic soils must be maintained. Factors that have caused altered hydrology in or near *P. integrilabia* habitat include pond construction (TDEC 2008, p. 4), ditching (Sullivan 2014, pers. comm.), development, logging (Shea 1992, p. 26, Taylor 2014, pers. comm.), removal of beaver dams to facilitate logging (Shea 1992, p. 25), and woody vegetation succession following logging (Hoy 2012, p. 13; D. Taylor 2018, pers. comm). Where populations with low abundance or flower production are in heavily shaded sites, reducing woody vegetation can be beneficial in promoting increased flowering and reproductive output. However, suitable levels of soil moisture and light alone do not ensure that populations will grow or remain stable, as it is likely that *P. integrilabia* population sizes respond to interactions between multiple site factors mentioned above (e.g., soil moisture, fungi, canopy cover, pollinator interactions).

The low number of individuals that have been seen at most *P. integrilabia* occurrences increases the species' vulnerability to threats by diminishing its resilience to recover from demographic reductions caused by various factors (Fig. 3.1). Despite the fact that *P. integrilabia* has been shown to be self-compatible, higher rates of fruit set have been observed in larger populations, presumably due to higher rates of cross-pollination (Zettler and Fairey 1990, p. 214; Zettler *et al.* 1996, p. 20). Zettler *et al.* (1996, p. 22) attributed the lower fruiting rates in the smaller populations to inbreeding depression, noting that in a separate study both germination rates and propagation success were greater in *P. integrilabia* seeds collected from the largest of the three populations they studied (Zettler and McInnis 1992, p. 160). Johnson *et al.* (2009, p. 3) found that higher proportions of self-pollination occurred in smaller populations of a moth-pollinated orchid, *Satyrium longicauda* (blushing bride satyrium), presumably due to pollinators visiting more flowers per plant in smaller populations and more frequently transferring pollen among flowers within a single inflorescence, rather than frequently moving among separate inflorescences on different individuals. To the extent that rates of cross-pollination, fruit set, germination, and propagation success are lower for *P. integrilabia* populations of small size, demographic reductions resulting from other threats place the species at greater risk of localized extinctions (Fig. 3.1).

3.3 Species Level

For the species to be viable, there must be adequate redundancy (suitable number, distribution, and connectivity of populations to allow the species to withstand catastrophic events) and representation (genetic and environmental diversity to allow the species to adapt to changing environmental conditions). Redundancy improves with increasing numbers of populations, and connectivity (either natural or human-facilitated) increases the potential for pollinator-mediated gene flow to occur among populations or for sites to be recolonized via seed dispersal from nearby populations in the event of local extirpation. Representation improves with increased genetic diversity and/or environmental conditions within and among populations.

CHAPTER 4 – INFLUENCES ON VIABILITY

Platanthera integrilabia has been and will continue to be impacted both negatively and positively by a number of anthropogenic and natural influences (Figure 4.1). Historically, the primary negative influences to *P. integrilabia* have been habitat loss as a result of human development (Shea 1992, p. 15) and silviculture practices (Shea 1992, p. 26; Birchenko 2001, p. 33), habitat degradation due to altered hydrology, and direct loss or injury of individual plants from herbivory or pathogens (Zettler and Fairey 1990, p. 214; Shea 1992, pp. 27, 61, 71-77, 95-97) or illegal collection. Resilience to these influences is affected by *P. integrilabia* reproductive limitations, including its dependence on a fungal symbiont (*Epulorhiza inquilina*) (Currah *et al.* 1997, p. 340) and suitable pollinators. Encroaching invasive plant species (e.g., *Microstegium vimineum* (Japanese stiltgrass), *Ligustrum sinense* (Chinese privet), and *Perilla frutescens* (beefsteak plant)) can create over-shaded conditions (Greene and Blossey 2012, p. 143) or alter the acidity of the soil (McGrath and Binkley 2009, pp. 145-153). These threats are likely compounded for small populations that are isolated on the landscape and potentially less likely to attract pollinators or produce seeds. Positive influences associated with viability relate to protection and management (e.g., woody vegetation thinning, hydrology restoration, exclusion fences) of existing *P. integrilabia* populations and, potentially, restoration of historical populations or creation of new populations through translocation. The following discussion provides a summary of the factors that are, or could be, affecting the current and future condition of *P. integrilabia* throughout all or parts of its range.

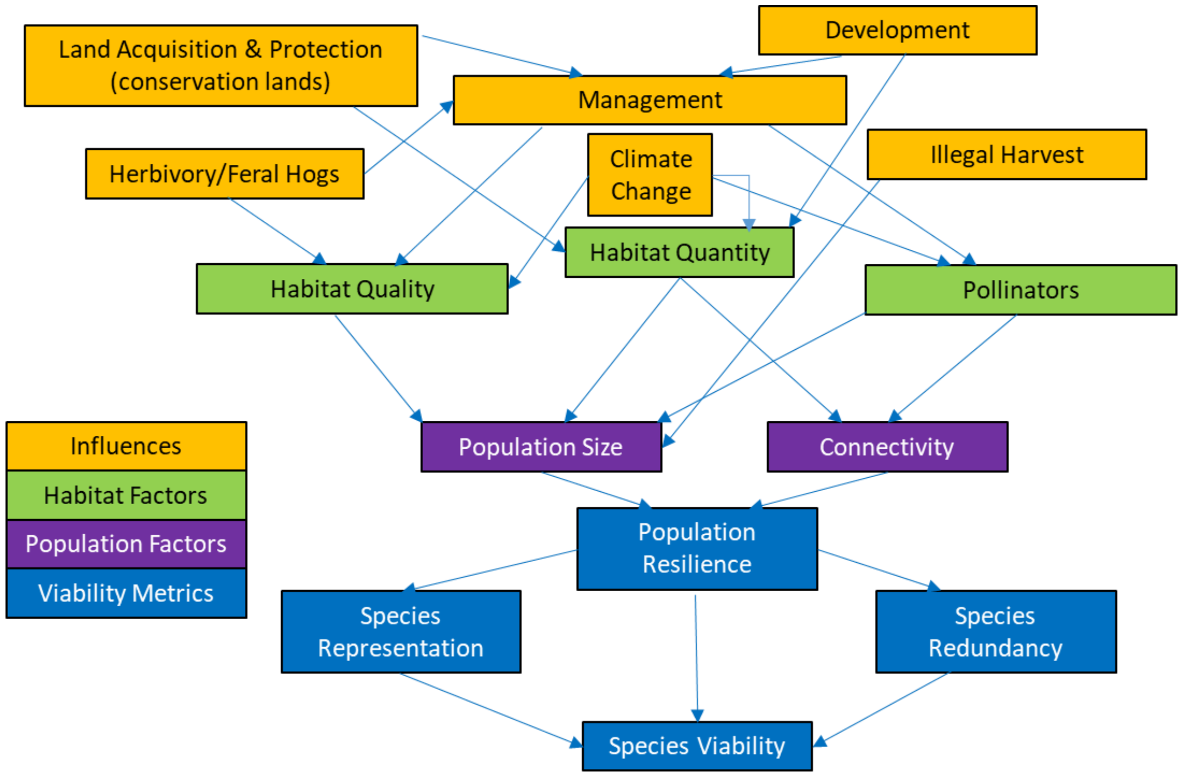

Figure 4.1. Influence diagram illustrating relationships between key habitat and population factors, influences on those factors, and species viability for *Platanthera integrilabia*.

4.1 Silvicultural Practices

Direct and indirect effects of silvicultural practices have adversely affected habitat conditions and abundance of many *P. integrilabia* populations through logging (Shea 1992, p. 26, Birchenko 2001, p. 33), alteration of local hydrological features (Scott 2005, p. 4204), and replacement of native tree species with intensively managed pine plantations (Clatterbuck and Ganus 1999, p. 4). While *P. integrilabia* has sometimes shown short-term increases in flower production following canopy removal, the longer-term response typically is a decline in orchid abundance as vegetation succession ensues (Shea 1992, p. 15, Birchenko 2001, p. 33). Additionally, Hoy (2012, p. 26) suggested that high stem densities that occur during succession following canopy removal shortened the hydroperiod (seasonal pattern of the water level that results from the combination of the water budget and the storage capacity of a wetland) of wetlands at an extant *P. integrilabia* site in Kentucky. This results from increased evapotranspiration, due to greater leaf surface area, causing faster rates of water loss.

Plantation forestry, specifically the clearcutting of native forests surrounding *P. integrilabia* sites and replacement with intensively managed pine plantations consisting solely of *Pinus taeda* (loblolly pine), can affect *P. integrilabia* populations in multiple ways. For example, intensive mechanical or chemical site preparation occurs before planting in order to reduce seedling competition with other tree species (Clatterbuck and Ganus 1999, p. 4). Compounds used for chemical site preparation can harm or kill beneficial mycorrhizal fungi (Estok *et al.* 1989, pp. 836-838, Zaller *et al.* 2014, p. 1) and the building of logging roads can cause direct and indirect impacts to *P. integrilabia* habitat (Shea 1992, p. 32). Additionally, plantation forestry generally causes reductions in streamflow as compared to native forest vegetation (Scott 2005, p. 4204) which could reduce the hydroperiod in wetlands located at the heads of streams, such as those typically occupied by *P. integrilabia*. There is also evidence that the transition from hardwood to mature pine reduces calcium stores which impedes future regrowth of the native oak-hickory forest (McGrath *et al.* 2004, p. 21). Further research is needed to understand the impacts these changes in soil conditions and local tree species diversity and abundance would have on *P. integrilabia* populations.

4.2 Native and Non-native Plant Encroachment

Invasive species, both native and non-native, can affect *P. integrilabia* populations by shading, over-crowding, or changing soil properties. Woody encroachment, stimulated by anthropocentric changes (e.g., urban/suburban development, agriculture, pond/lake construction) in Kentucky has been observed as the strongest predictor of decreases in herbaceous diversity in Appalachian wetland communities (Warren *et al.* 2007, entire). The presence of invasive, nonnative plant species, including *Microstegium vimineum* (Japanese stiltgrass), *Ligustrum sinense* (Chinese privet), and *Perilla frutescens* (beefsteak plant), has been documented at 10 extant *P. integrilabia* occurrences and one of unknown status (USFS 2008, p. 53; Richards 2013, pers. comm.; OKNP 2019; TDEC 2018). The presence of *Ligustrum sinense* (Chinese privet) and *Perilla frutescens* (beefsteak plant) could reduce potential for exposure of seeds to light before being incorporated into the soil, which would impede germination rates (Zettler and McInnis 1994, p. 137). Greene and Blossey (2012, p. 143) determined *L. sinense* to be a major agent of change in Piedmont floodplain forests because it suppresses herbaceous understory and reduces seedling survival and growth. *Lygodium palmatum* (American climbing fern), a native species that has demonstrated invasive tendencies, occurs near multiple *P. integrilabia* populations, and attempts to control its spread have had limited success. *Dicanthelium microcarpon* (small-fruited panic grass) is another native plant believed to compete with *P. integrilabia* (T. Littlefield 2019, pers. comm.) in some sites with higher light levels. Research is needed to investigate the effects of aggressive native and non-native invasive plant species on various life history stages of white fringeless orchid.

Despite *P. integrilabia* habitat typically being described as shaded, excessive shading due to vegetation succession has been suggested as a factor associated with population declines (Shea 1992, p. 19; Richards 2013, pers. comm.; Schotz 2015, p. 4). Woody vegetation succession is believed to be the primary factor in the decline of multiple *P. integrilabia* populations in Tennessee (TDEC 2012, p. 3) and led to the extirpation of at least one *P. integrilabia* occurrence when a nearby powerline was removed, ending regular vegetation management at the site (TDEC 2018). Available data indicate that the threat of excessive shading has been noted at 19 extant occurrences and 5 of unknown status across the species' geographic range (M. Richards 2013 pers. comm.; H. Sullivan 2014, pers. comm.; OKNP 2019; TDEC 2018; Schotz 2015, pp. 10-35). The threat of shading is most often noted in instances where woody succession followed logging in or adjacent to sites occupied by *P. integrilabia*. In contrast to these sites, one of the largest populations of the species, located in McMinn County, Tennessee, thrives in the presence of a well-developed forest canopy (Boyd *et al.* 2016, pp. 1262-1264). More research is needed to understand the dynamics between vegetation structure and local hydrology and how these two factors interact to influence *P. integrilabia* individuals and populations.

Invasive plant species are known to cause major shifts in composition and function of soil communities (Wolfe and Klironomos 2005, entire). For example, Japanese stiltgrass has been shown to increase pH and phosphorous availability in Cumberland Plateau forest soils (McGrath and Binkley 2009, pp. 145-153) and increase abundance of vesicular arbuscular mycorrhiza (mycorrhizal fungi that grow into the roots of host plants and form specialized structures called arbuscules and vesicles) in other sandstone-derived soils (Kourtev *et al.* 2002, p. 3163). While the effect of these soil alterations on *P. integrilabia* has not been investigated, *P. integrilabia* and its symbiotic mycorrhizal fungus, *Epulorhiza inquilina* (see Section 2.4; Currah *et al.* 1997, p. 340), are associated with acidic (i.e., lower pH) soils (Zettler and Fairey 1990, p. 213). The rise in soil pH from Japanese stiltgrass presence might limit habitat available to *P. integrilabia* seed germination as well as seedling development and establishment. Allelopathy from the invasive plant *Alliaria petiolata* (garlic mustard) can also potentially alter the abundance of the mycorrhiza and impact *P. integrilabia* (Wolfe *et al.* 2008, entire).

4.3 Herbivory

High frequencies of inflorescence herbivory, presumably by deer, have been observed at *P. integrilabia* occurrences (Zettler and Fairey 1990, p. 214; Shea 1992, pp. 27, 61, 71-77, 95-97; TDEC 2012, p. 3; OKNP 2019; TDEC 2018). Deer herd increase was implicated in declines of numerous orchid species in the Catoctin Mountains of Frederick County, Maryland (Knapp and Wiegand 2014, entire). Orchid growth is initiated each spring from overwintered buds, like most perennial plants; however, orchids differ from most other plants by lacking the capacity to replace tissues lost to herbivory or other causes until the following year. In addition, in several other species of *Platanthera*, the usual response to loss of the shoot is death of the plant (Sheviak 1990, p. 195). Conversely, in larger populations with relatively high flowering rates, herbivores might positively influence *P. integrilabia* populations by browsing understory that could shade populations provided they do not cause excessive mortality or reductions in reproductive output (T. Littlefield 2019, pers. comm.).

Numerous observers have reported herbivory by white-tailed deer (*Odocoileus virginianus*) as a threat to *P. integrilabia*, specifically removal of inflorescences from *P. integrilabia* (Zettler and Fairey 1990, p. 212; Shea 1992, pp. 27, 61, 71-77, 95-97; TDEC 2012, p. 3). It is likely that this threat affects many *P. integrilabia* occurrences (TDEC 2012, p. 3), despite not having been specifically documented in every instance. In Kentucky, elk (*Cervus canadensis*) herbivory might also threaten *P. integrilabia* as two counties inhabited by *P. integrilabia* (i.e., McCreary and Whitley counties) are within the Elk Zone, an area where elk will not be discouraged and will be managed under separate regulations in ways that enhance elk habitat (D. Taylor 2019, pers. comm). Research is ongoing to investigate effects of herbivory on emergence, growth, flowering, and physiology in an introduced population of *P. integrilabia* in Tennessee. Results of this research should increase understanding of the impacts of herbivory on individual plants and populations. Additional work is needed to document which populations are affected by this threat and to determine where management intervention is needed.

Ground disturbance by rooting of feral hogs (*Sus scrofa*) has adversely affected *P. integrilabia* at multiple sites on public lands in Georgia and Tennessee, including the largest occurrence, located in McMinn County, Tennessee (Zettler 1994, p. 687). Though these occurrences are on public lands, feral hog populations are extremely difficult to control and will likely be a continuing threat to *P. integrilabia* populations. Rooting by feral hogs has affected specific microsites where *P. integrilabia* had previously been observed growing, as well as surrounding wetland habitat. Disturbance by feral hogs has been shown to affect plant communities by causing decreases in plant cover, diversity, and regeneration (Barrios-Garcia and Ballari 2012, p. 2295). Feral hogs also eat fungi and their extensive disturbance affects fungi by overturning soil, physically changing habitat characteristics, and modifying resource availability (Vitousek 1990, pp. 183-191; Barrios-Garcia and Ballari 2012, p. 2295). These impacts suggest potential for adverse effects to the mycorrhizal fungi that enhance *P. integrilabia* seed germination and promote seedling development and establishment (Zettler and McInnis 1992, pp. 157-160; Rasmussen and Whigham 1993, p. 1374). Further research is needed to understand impacts of ground disturbance by rooting feral hogs on *P. integrilabia* populations and mycorrhizal fungi on which they depend.

4.4 Small Sub-population Sizes and Connectivity

Southern Appalachian wetlands are generally small (< 5 ha), isolated features on the landscape (Batzer and Sharitz 2006, pp. 1-5; Stine *et al*. 2011, p. 60). Many *P. integrilabia* occurrences within these habitats have a low number of individuals (Fig. 4.2), which decreases their resilience to recover from demographic reductions caused by habitat disturbance or modification, collecting, or herbivory. In general, the smaller a population, the greater the probability that fluctuations in population size from both demographic and environmental stochasticity will lead to extirpation (Sutton and Morgan 2009, pp. 722-733). There are also genetic concerns with small populations, including reduced availability of compatible mates, genetic drift, and inbreeding depression (Willi *et al.* 2005, p. 2260). To the extent that cross-pollination, fruit set,

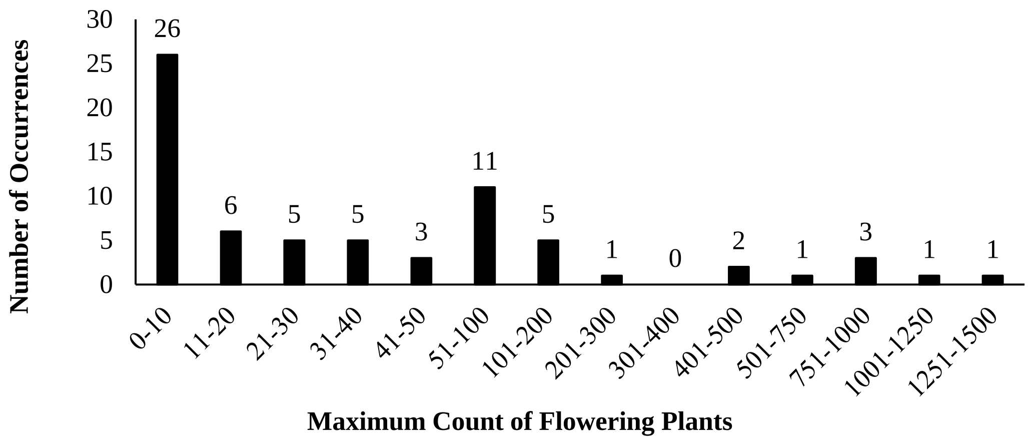

Figure 4.2. Histogram of maximum number of flowering *Platanthera integrilabia* ever recorded during a single observation at 70 extant and uncertain occurrences as of 2016. Specific counts of flowering plants were not available for 10 extant and uncertain occurrences (80 FR 55304).

germination, and recruitment are reduced in *P. integrilabia* populations of small size, demographic reductions resulting from other threats (i.e., herbivory, collection, shading) place the species at greater risk of localized extinctions.

One ecological factor potentially affecting *P. integrilabia* populations is allee effects, a correlation between population size or density and the mean individual fitness of a population or species. Birchenko (2001, pp. 34-38) suggested two ways allee effects may be affecting *P. integrilabia* given their dependence on limited ecological conditions. First, small, isolated populations may not be attracting sufficient numbers of pollinators, which is supported by studies showing larger *P. integrilabia* populations exhibit significantly greater percentages of fruit sets compared to small populations (Zettler and Fairey 1990, p. 214; Zettler *et al.* 1996, p. 20). Zettler *et al.* (1996, p. 22) attributed the lower fruiting rates in the smaller populations to inbreeding depression, noting that in a separate study both germination rates and propagation success were greater in *P. integrilabia* orchid seeds collected from the largest of the three populations they studied (Zettler and McInnis 1992, p. 160). Johnson *et al.* (2009, p. 3) found that higher proportions of self-pollination occurred in smaller populations of a moth-pollinated orchid, *Satyrium longicauda* (no common name), presumably due to pollinators visiting more flowers per plant in smaller populations and more frequently transferring pollen among flowers within a single inflorescence, rather than frequently moving among separate inflorescences on different individuals. Second, growth rates of small populations could be reduced as a result of

P. integrilabia's presumed dependence on a single species of symbiotic fungus, *E. inquilina* (Currah *et al.* 2007, p. 340). At lower densities, fewer seeds are produced, potentially reducing the likelihood that the seeds would be dispersed into microsites where hyphae of the fungal symbiont are present to support germination and recruitment (Birchenko 2001, p. 36). Research is needed to understand how population size influences both pollinator attraction and the likelihood that seeds are dispersed into suitable microsites where mycorrhizal fungi are present to support germination and growth.

As *P. integrilabia* occurrences have become rarer and more isolated across the landscape, the potential for different populations to exchange genetic material also decreases. The ability of populations to adapt to environmental change is dependent upon genetic variation. Small populations occurring in isolation on the landscape can lose genetic variation due to the potentially strong influence of genetic drift, i.e., the random change in allele frequency from generation to generation (Barrett and Kohn 1991, p. 8). Smaller populations experience greater changes in allele frequency due to drift than do larger populations (Allendorf and Luikart 2007, pp. 121-122). Loss of genetic variation due to genetic drift heightens susceptibility of small populations to adverse genetic effects, including inbreeding depression and loss of evolutionary flexibility (Primack 1998, p. 283). Deleterious effects of loss of genetic variation through drift have been termed drift load, which is expressed as a decline in mean population performance of offspring in small populations (Willi *et al.* 2005, p. 2260).

4.5 Climate Change

The Intergovernmental Panel on Climate Change (IPCC) concluded that evidence of warming of the climate system is unequivocal (IPCC 2014, p. 2). Two groups have utilized NatureServe's Climate Change Vulnerability Index (CCVI) (Young *et al.* 2016, entire) to assess the vulnerability of federally listed plants in Tennessee to climate change (Glick *et al*. 2015, entire; C. Kwit 2019, pers. comm.). The CCVI is an assessment tool that combines results of downscaled climate predictions, to characterize potential exposure to projected climate change, with readily available information about a species' natural history, distribution, and landscape circumstances. Together these attributes influence sensitivity to change, to predict whether it will likely suffer a range contraction and/or population reductions because of climate change (Young *et al*. 2016, pp. 7-8). For both the aforementioned assessments using the CCVI, climate change projections were based on ensemble climate predictions, representing a median of 16 major global circulation models, using a "middle of the road" scenario (i.e., emission scenario A1B of the IPCC (IPCC 2000, entire)) for GHG emissions (Young *et al.* 2016, p. 14), instead of a more extreme scenario.

From these two assessments, *P. integrilabia* was ranked as either "highly vulnerable" (Glick *et al.* 2015, p. 39) or "extremely vulnerable" (C. Kwit 2019, UT, pers. comm.), the latter indicating the species' abundance and/or range extent within the geographical area assessed would likely decrease by 2050 (Young *et al.* 2016, p. 45). This is because *P. integrilabia* depends on narrow hydrologic/precipitation conditions, has limited dispersal abilities, and anthropogenic barriers to dispersal limit its ability to move into new locations. As both ranks suggest, *P. integrilabia* is among the most vulnerable to projected climate change of the federally listed plant species in Tennessee, an assessment that would likely extrapolate to a varying degree in other portions of its range.

Data on recent trends and predicted changes for the Southeast United States (Karl *et al.* 2009, pp. 111-122) provide some insight for evaluating the specific threats of climate change to the species. The geographic range of *P. integrilabia* lies within the geographic area included by Karl *et al.* (2009, pp. 111-116) in their summary of regional climate impacts affecting the Southeast region. Since 1970, the average annual temperature across the Southeast has increased by about 2 degrees Fahrenheit (^{o}F), with the greatest increases occurring during winter months. The geographic extent of areas in the Southeast region affected by moderate to severe spring and summer drought has increased over the past three decades by 12 and 14 percent, respectively (Karl *et al.* 2009, p. 111). These trends are expected to increase; however, estimates of the effects of climate change using available climate models largely lack the geographic precision needed to predict the magnitude of effects in all locations.

Depending on timing and intensity of drought events, *P. integrilabia* occurrences could be adversely affected by increased mortality rates, reduced reproductive output due to loss or reduced vigor of mature plants, and reduced rates of seed germination and seedling recruitment. Further, *P. integrilabia* might be dependent upon a limited number of large Lepidoptera for pollination (Zettler *et al.* 1996, pp.16-22) and, potentially, on a single species of mycorrhizal fungi to complete its life cycle (Currah *et al.* 1997, p. 340). These requirements place *P. integrilabia* at higher risk of extinction due to environmental changes that could diminish habitat suitability for these species it depends on for seed germination, growth, and reproduction (Swarts and Dixon 2009, p. 546; Young et al. 2017, p. 14). There is also concern for increased intensity of rain events due to climate change. Intense rainfall events can produce high velocity surface runoff, potentially eroding *P. integrilabia* sites or transporting excessive amounts of sediment from eroded uplands into occupied sites (D. Taylor 2018, pers. comm.).

4.6 Habitat Management and Restoration

P. integrilabia occupies several habitat types (i.e., grassland, wooded, rights-of-way), therefore, management needs will likely vary by site. Management efforts have taken place to restore hydrology, increase light availability by reducing woody vegetation cover, and reduce threats from herbivory and invasive plants. Several restoration programs have been completed in the past few years, are ongoing, or are planned for the near future. Table 4.1 summarizes conservation actions for *P. integrilabia,* and more details can be found in Appendix B.

4.6.1 Restoring Hydrology

Several options have been utilized for restoring altered wetland hydrology in *P. integrilabia* habitat with limited success. Littlefield (2015, entire; 2017, entire) evaluated the impacts on local hydrology of thinning and debris dam construction, intended to slow or reverse the channel forming processes and reestablish lost hydrologic function by reducing energy of flowing water to downstream channels, at Mount Victory Seeps in Kentucky from 2008 to 2015. Management at one of the sites appeared to positively influence the *P. integrilabia* population at the site compared to other sites; however, more years of observations are needed to determine if impacts were due to light levels, hydrology, or both (Littlefield 2015, p. 12; Littlefield 2017, pp. 5-7).

At the Daniel Boone NF in 2005, the USFS installed check dams (small, often temporary, dam constructed across a swale, drainage ditch, or waterway to counteract erosion by reducing water flow velocity) aimed at restoring suitable conditions for *P. integrilabia* at a site where wetland

Table 4.1. Summarized recent, current, and future conservation actions taking place across the range of *Platanthera integrilabia*. Grey highlight indicates completed projects, blue highlight indicates projects in progress, and orange highlight indicates projects planned for the near future.

State	EO ID	Landowner	Site Name	Status	Start Date	Management Actions	Response
Alabama	3830	USFWS[1]	Marchetta Seep	Complete	2016	Veg. management	Increase in flowering
Georgia	1981	Private	Lyons Landing	In progress	2017	Veg. management; Seed collection	Unknown
Georgia	2305	Forsyth Co. Parks	Sawnee Mountain	In progress	2014	Veg. management; Transplant plants to site	Slight increase in *P. integrilabia*; flowering
Georgia	6971	USFS[2]	Lee Mountain	In progress	2016	Veg. management; Seed collection	Unknown
Georgia	11021	GDOT[3]	Lookout Mountain (Neal Gap)	In progress	2014	Veg. management; Transplant plants to site	Initial flowering; site heavily disturbed by incompatible mowing 2017 (and other years not documented)
Georgia	17494	Private	Big Canoe	In progress	2014	Veg. management; Seed collection	Increase in *P. integrilabia*; flowering; subsequent decline with woody regrowth in 2018; poor germination
Georgia	19166	GDNR[4]	Chattahoochee Bend State Park	In progress	2013	Veg. management; Transplant orchids to site	Introduced population; flowering plants observed 2015-2017
Kentucky	9084	USFS[2]	Marsh Branch Powerline-DBNF	In progress	2016	Veg. management	No response
Kentucky	9084	USFS[2]	Marsh Branch Powerline-DBNF	Complete	2018	Signage	Unknown
Kentucky	9084	USFS[2]	Marsh Branch Powerline-DBNF	Complete	2017	Prescribed fire	Initial site improvement
Kentucky	9084	USFS[2]	Marsh Branch Powerline-DBNF	Complete	2016	Prescribed fire	Initial site improvement

State	EO ID	Landowner	Site Name	Status	Start Date	Management Actions	Response
Kentucky	2601	OKNP	Mount Victory Seeps - A (center)	complete	2012/2013	Veg. management; check dam installation.	Increase in flowering
Kentucky	9084	USFS[2]	Marsh Branch Powerline-DBNF	Complete	2012	Prescribed fire	Unknown
Kentucky	12123	USFS[2]	Barren Fork-DBNF	Complete	2006	Check dams	Initial improvement; now declining post dam breech
Kentucky	6901	USFS[2]	Hindsfield Ridge-DBNF	Complete	2015	Check dams	Site wetter; only 3 *P. integrilabia* in 2018
North Carolina	Not yet assigned	NCPCP[5]	Bat Fork Bog	In progress	2018	Veg. management	No response; reintroduction planned
North Carolina	Not yet assigned	NCPCP[5]	Bat Fork Bog	Planned	TBD	Reintroduction of plants produced by Illinois College and/or Atlanta Botanical Garden	Unknown
Tennessee	10896	TSP[6]	Meadow Creek	In progress	2016	Veg. management	Unknown
Tennessee	10896	TSP[6]	Meadow Creek	In progress	2017	Loblolly canopy harvested	Large increase in flowering
Tennessee	10896	TSP[6]	Meadow Creek	Complete	2019	Prescribed fire	Large increase in flowering
Tennessee	17312	TSP[6]	Pigeon Point	Complete	2017	Veg. management	Unknown
Tennessee	9616	USFS[2]	Starr Mountain-CNF	Complete	2018	Seed collection	Unknown
Tennessee	7925	USFS[2]	Sheeds Creek-CNF	Complete	2019	Veg. management	Flowering observed 2019
Tennessee	16515	NPS[7]	Tar Kiln 3	Complete	2015	Hog exclusion fence – following disturbance	Large increase in *P. integrilabia*
Tennessee	16576	NPS[7]	Duncan Hollow	Complete	2015	Hog exclusion fence – preventive	Stable
Tennessee	17611	NPS[7]	Tar Kiln 1 & 2	Complete	2017	Hog exclusion fence - preventive	Stable but drying

State	EO ID	Landowner	Site Name	Status	Start Date	Management Actions	Response
Tennessee	19788	TWRA[8]	Centennial WMA	Complete	2017-2019	Veg. management; transplant orchids to site	Introduced population; research ongoing

[1]U.S. Fish and Wildlife Service (USFWS)
[2]U.S. Forest Service (USFS)
[3]Georgia Department of Transportation (GDOT)
[4]Georgia Department of Natural Resources (GDNR)
[5]North Carolina Plant Conservation Program (NCPCP)
[6]Tennessee State Park (TSP)
[7]National Park Service (NPS)
[8]Tennessee Wildlife Resources Agency (TWRA)

hydrology had been altered from road construction in the 1990s (Table 4.1). As of 2018, most of the check dams have been breached by the stream, diminishing their effectiveness at slowing surface runoff and raising ground water elevation in the site; however, the dams retain sediment in the stream channel, reducing gradient and potential for headcutting in the established channel (Taylor 2018, pers. comm.). While more information on indirect effects of pine plantations on hydroperiods of wetlands occupied by *P. integrilabia* is needed, evidence suggests that restoring native hardwood forest vegetation may be needed to restore wetland hydrology in some sites, and that this would be a challenging and long-term process.

4.6.2 Managing Vegetation Encroachment

Vegetation management (e.g., mechanical, by hand, prescribed fire) is the most common type of *P. integrilabia* habitat management, and *P. integrilabia* response is mixed (Table 4.1). Efforts to control invasion by Japanese stiltgrass by repeatedly weeding at one site on Daniel Boone National Forest (NF) have been hampered by a seed source that exists on private lands upslope of the site (Taylor 2014, pers. comm.). At Mount Victory Seeps in Kentucky, repeated attempts to control Japanese stiltgrass have met little success, likely because the plants are so abundant that some individuals are overlooked during the removal process (T. Littlefield 2019, pers. comm.). At *P. integrilabia* sites on public land where a native species, the American climbing fern, has demonstrated invasive tendencies, the USFS has attempted to control spread of the species with limited success.

Patrick *et al.* (1995, p. 1) also suggested hand thinning as a useful tool for reducing canopy cover and avoiding impacts from heavy equipment disturbing the habitat. This management technique has led to increases in numbers of flowering plants at Meadow Creek in Tennessee, Mount Victory Seeps in Kentucky (Littlefield 2015, p. 12), and Mountain Longleaf NWR (Table 4.1, Appendix B). It has been suggested that fire could play a role in regulating woody vegetation growth in uplands surrounding *P. integrilabia* habitats, allowing greater light penetration into swamps where the species grows creating favorable conditions for *P. integrilabia* (Schotz 2015, p. 4). Fire appears to be a viable option for habitat management (D. Taylor 2018, pers. comm.) but could be challenging on private lands. Following vegetation management during 2017 and 2018, TDEC conducted a prescribed burn in 2019 at the Meadow Creek site, where large increases in numbers of flowering *P. integrilabia* have subsequently been observed (Table 4.1, Appendix B).

Several extant *P. integrilabia* populations occur in rights-of-way (Richards 2013, pers. comm.; OKNP 2019; TDEC 2018). Vegetation management practices in such habitats (i.e., mowing, herbicide application) prevent advanced succession of woody vegetation, which can benefit *P. integrilabia* by periodically reducing shading. On the other hand, mechanical clearing in these habitats can alter hydrology by causing rutting of soils and hastening channel development (e.g., Neal Gap, Table 4.1). These issues can be mitigated with agreements and signage, such as the one implemented in 2018 for a site in Kentucky (i.e., Marsh Branch Powerline, Table 4.1; D. Taylor 2018, pers. comm.). Mowing during the flowering period for *P. integrilabia* is detrimental, given the low flowering rates that have been observed in this species and the fact that individual plants will not regenerate flowers during a growing season once they are lost to herbivory or other causes (Sheviak 1990, p. 195). Indiscriminate herbicide application causes mortality of *P. integrilabia* individuals, but targeted application of only woody plants in the area appears to benefit *P. integrilabia* (Atlanta Botanical Garden 2016, p. 24; D. Taylor 2019, pers. comm.). However, some herbicides (e.g., glyphosate) are known to kill beneficial mycorrhizal fungi (Zaller *et al.* 2014, p. 1), which could be harmful for *P. integrilabia* reproduction and establishment by adversely affecting its mycorrhizal associate *Epulorhiza inquilina* (Currah *et al.* 1997, p. 340). It appears that application of best management practices (BMPs) at rights-of-way occupied by *P. integrilabia* provides an opportunity to increase viability of *P. integrilabia* populations.

Atlanta Botanical Garden (ABG) received a grant from National Fish and Wildlife Foundation to restore wetland habitat at four *P. integrilabia* sites in Georgia and augment or introduce populations using propagated plants (ABG 2016, entire). Working with partners, ABG mapped restoration areas, selectively removed canopy trees and invasive exotic plants, constructed deer fencing, propagated *P. integrilabia*, and outplanted the orchids (see discussion below) into the restored sites. All sites with vegetation management saw an increase in *P. integrilabia* numbers and flowering (Table 4.1).

4.6.3 Managing Herbivory

The USFS has undertaken efforts to restore or protect habitat at several *P. integrilabia* sites located on National Forest (NF) lands. At the Cherokee NF, the USFS constructed fences to exclude feral hogs at two sites, one of which is the largest known occurrence of the species. These fences are effective when maintained; however, only the main concentration of plants is protected at the site. Additionally, the fence at one site fell into disrepair and it was discovered that approximately half the flowering plants had been uprooted in 2002; however, after the fence was repaired the number of flowering plants rebounded to numbers similar to those recorded before the herbivory (USFS 2008, p. 54). Tennessee Department of Environment and Conservation (TDEC) biologists installed plastic deer control fencing around two *P. integrilabia* sites in 2013. During 2014, there were 105 flowering plants at the site, plus 31 plants with browsed inflorescences found outside of the fenced enclosures and one browsed plant inside one of the enclosures where the fence had partially collapsed. Inside of the enclosures were 45 flowering plants that were unharmed. Approximately one-third of the flowering plants outside of the fenced areas suffered inflorescence herbivory (TDEC 2018).

The National Park Service (NPS) installed exclusion fences at three sites in Tennessee, following hog disturbance that was observed in June 2015; one site has seen a marked increase in *P. integrilabia* numbers while the other two have remained stable (Table 4.1; Appendix B). Fencing may be a viable option for protecting *P. integrilabia* from herbivory and hogs if adequate monitoring of the fence condition is realistic; however, the difficulty of accessing many of the remote *P. integrilabia* occurrences may be prohibitive. Additionally, deer exclusion fences may have the unintended effect of increasing shading within *P. integrilabia* habitat and, therefore, the risks need to be weighed against the benefits for the populations. Large populations may be able to withstand some herbivory but could be more impacted over time from decreased sunlight if browsers were excluded from the habitat (T. Littlefield 2019, pers. comm.).

4.6.4 Managing Populations via Translocation, Propagation, and Outplanting

Despite being dependent upon a specific fungus to reproduce in the wild, *P. integrilabia* can be propagated using both symbiotic (Zettler and McInnis 1992, entire) and asymbiotic methods, and seeds and fungal isolates can also retain their viability over long periods under appropriate conditions. For example, Helmich *et al.* (2018, unpublished data) determined that *P. integrilabia* seeds retained their viability after being thoroughly dried and stored for 28 years at -7°C, successfully germinating them on fungal isolate that was collected near the same point in time from a separate site. While successful germination of seeds held in long-term storage under controlled temperature and humidity conditions is not representative of potential for long-term seed viability under field conditions, it raises the possibility that *P. integrilabia* populations could form a soil seed bank. Research is needed to determine whether soil seed bank formation occurs in the wild and whether habitat management could trigger germination and reestablishment in historically occupied sites where habitat has not been destroyed or severely degraded.

The USFS entered a Master Stewardship Agreement with ABG to provide for habitat management, captive propagation, and reintroduction or augmentation of populations on USFS lands in Georgia (ABG 2016, entire). Several restoration and reintroduction efforts are ongoing or planned. Seeds were collected from 3 sites in Georgia in 2014, 2016, and 2017, where vegetation management to reduce shading also occurred, and propagated orchids were later returned to the sites, all of which saw an increase in *P. integrilabia* numbers as well as flowering (Table 4.1). Seed collection (2018) has also occurred at Starr Mountain in Tennessee, and these seeds will be used for propagating plants to restore a population in Henderson County, North Carolina (Table 4.1). Seed collection is planned at Marsh Branch in Kentucky with plans to begin a joint project with state, USFS, and ABG for sites at Mount Victory Seeps (T. Littlefield 2019, pers. comm.).

Two occurrences (EO IDs 19166 and 19788, Appendix A) have been established through introduction of plants into protected sites in Coweta County, Georgia, and White County, Tennessee (Table 4.1). The Coweta County introduced occurrence was established using plants propagated by ABG using seeds collected from privately owned land nearby; 26 individuals were planted in 2013 and 25 in 2014. Prior to planting, managers mechanically reduced canopy and understory cover in the wetlands and adjacent upland habitats. Flowering plants were observed at this site each year during 2015 through 2017. The introduced occurrence in White

County was established using material from an occurrence in a Tennessee Valley Authority (TVA) transmission line right-of-way in Van Buren County, Tennessee. This line was retired from service in 2017, and it was anticipated that the habitat would become unsuitable due to vegetation succession in the absence of maintenance by TVA. In 2016, ABG, TVA, and the Service removed 35 flowering plants from this site, which were held at ABG for safeguarding purposes, and seeds from the plants were used to propagate additional plants to increase the founding population size at the White County location. Approximately 40 more flowering plants were removed from the TVA site during 2017 and directly transplanted into the introduction site, which is in a wildlife management area owned by Tennessee Wildlife Resources Agency. In total, approximately 500 plants have been introduced to this site, mostly within an experimental framework to test effects of light availability and herbivory on emergence, growth, flowering, and physiology of individual *P. integrilabia*.

The results of the White County introduction experiment reveal a complex range of effects from light availability (i.e., woody vegetation thinning) and herbivore access treatments (Wooten *et al*. 2020, pp. 7-10). From cohorts planted in 2018 and 2019, 59 and 70 percent of tubers, respectively, produced emerged plants. Thinning and herbivore access both negatively affected proportions of emerged plants in the 2019 cohort but not the 2018 cohort. Conversely, proportion of flowering stem production among emerged plants was significantly greater in the highest light treatment for the 2019 cohort but did not differ among light treatments for the 2018 cohort or among herbivore access treatments in either year. Survival to peak flowering time did not differ across thinning or herbivore access treatment in either year (approximately 23 and 56 percent for 2018 and 2019 cohorts, respectively).

Vegetation thinning and herbivore access treatments, and the interaction of the two, influenced individual *P. integrilabia* size (i.e., total leaf area) in the 2019 cohort (Wooten *et al*. 2020, p. 8). Individual *P. integrilabia* were larger in the moderately thinned treatment than in the unthinned or heavily thinned treatments and were larger in plots in which herbivores were excluded than in plots where herbivore access was not restricted. Effects of herbivore access treatments were greatest in unthinned or moderately thinned vegetation treatments. Neither vegetation thinning nor herbivore access treatments, or the interaction of the two, affected total leaf area in the 2018 cohort or maximum stem height in either the 2018 or 2019 cohorts.

The results of the White County introduction experiment indicate that transplantation from tubers could be a successful relocation strategy for individuals in *P. integrilabia* populations that are at risk of loss due to factors that reduced habitat suitability. Furthermore, these results indicate that restricting herbivore access when attempting to establish introduced populations could improve the proportion of tubers that are able to produce emerged plants. Vegetation thinning treatments negatively affected tuber emergence in this study but positively influenced flowering stem production. As noted above in 4.6.2 Managing Vegetation Encroachment, thinning of woody vegetation has been observed to increase numbers of flowering plants in wild populations, sometimes stimulating flowering production where it had previously ceased to occur (Table 4.1, Appendix B). Additional research is needed to investigate the effects of vegetation thinning treatments on demography of introduced and natural populations of *P. integrilabia*.

4.7 Collection and Observation

Collection for various purposes has historically threatened *P. integrilabia* in several locations throughout their range (Ettman and McAdoo 1978 cited in Zettler and Fairey 1990, P. 212; Shea 1992, P. 27). The proposed listing rule (80 FR 55304) for the species also notes recent incidents of collection of *P. integrilabia*. Due to the species' rarity, the small sizes of most known populations, and the fact that most of the populations are located in remote sites that are infrequently monitored by conservation organizations or law enforcement, collection is a threat to *P. integrilabia*. In small populations, the collection of even a few individuals would diminish reproductive output and likely reduce genetic diversity. Photographers and curious observers can also impact heavily visited *P. integrilabia* sites by trampling plants (D. Taylor 2018, pers. comm.; T. Littlefield 2019, pers. comm.).

CHAPTER 5 – CURRENT CONDITION

Below we assess current resilience, redundancy, and representation as they relate to population and habitat factors thought to be important for species viability. Historical *Platanthera integrilabia* (white fringeless orchid) data consists of 122 Element Occurrences (EOs) distributed across Alabama, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee (Appendix A). For any occurrence where *P. integrilabia* had been identified based on presence of flowering individuals at some point in time, we considered observations recorded within the 20 years preceding our analysis (i.e., since 1998) to be *P. integrilabia*, regardless of whether flowering had been observed during that time. EOs for which observations since 1998 are lacking were treated as historical unless available data indicated they had been extirpated.

The number of EOs included in this SSA differs from the listing rule (81 FR 62826) for *P. integrilabia* for the following reasons. Observations lacking recent confirmation based on presence of flowering individuals were considered "uncertain" in the listing rule. There is a risk that plants observed during this time were congeners (i.e., members of the same taxonomic genus) but not *P. integrilabia*. Given that this SSA was developed for the initial purpose of supporting recovery planning, we did not want to exclude any EOs that had an acceptable potential to be extant at this time. Also, in the listing rule, EOs were considered extant only if they had been seen since 2000, which is 2 years later than the cut-off used in this SSA. Finally, there are 12 EOs that were discovered and 1 established by introduction after analyses were completed for the listing rule. For these reasons, we used data from 86 extant EOs to delineate populations and assess current conditions for *P. integrilabia*; whereas, the listing rule reported 57 occurrences were extant, as of 2016, and the status of 23 EOs was uncertain. We excluded 36 occurrences, which we treated as historical or extirpated based on available data, from our analysis. Excluded occurrences include 32 EOs, one of which Shea (1992, p. 18) reported was based on a misidentification, and 4 occurrences reported in Shea (1992) as historical or uncertain and which were not represented in databases maintained by state conservation agencies. The status of each EO in this SSA and its status under the listing rule are noted in Appendix A.

5.1 Delineating Populations

Populations (i.e., plants in EOs that are likely interbreeding) are composed of either multiple EOs or stand-alone EO records, using only those EOs where *P. integrilabia* had been observed in that location in 1998 or later (within ~20 years of surveys). We delineated populations using the Habitat-based Plant Element Occurrence Delimitation Guidance (NatureServe 2004), resulting in 50 populations across 6 states and 36 counties (Table 5.3). For *P. integrilabia*, we used the EO Data Standard which provides a Default Separation Distance of 1 to 10 km (~0.62 to 6.2 miles) for plant elements that lack EO specs, noting that situations involving dispersal barriers could involve even shorter distances. While gene flow declines over distance at different rates for different taxa, the minimum default EO separation distance of 1 km has been accepted as the most suitable round-number metric-system approximation broadly applicable to many (but not all) situations. While the team of species experts providing input on this SSA suspected that 1 km is a somewhat arbitrary distance and that gene flow can regularly occur via pollination, there is not enough information regarding the movements of insect pollinators of *P. integrilabia* to make conclusions regarding foraging distances (NatureServe 2004). However, the NatureServe EO guidance allowed us to evaluate the interactions of EOs by examining distances and suitability of habitat between known occurrences to assess the likelihood of genetic interaction using a standardized, scientifically accepted process.

5.2 Classifying Resilience

Information was not available to directly assess habitat quality for each *P. integrilabia* population, as site-specific data were not available for each population. Therefore, we used other factors as a proxy for habitat quality. Resilience was assessed for each population using three factors: population size, flowering within the population, and connectivity of a population to other populations on the landscape. Additionally, we assessed resilience of each population in the context of the level of habitat protection and management it receives. Other factors were considered that likely contribute to population resilience, but data were not available to assess them over all or most of the populations. Examples of these factors not included in the final resilience classification strategy are explicit measures of habitat quality (e.g., vegetation composition or structure, hydrologic conditions) and whether there is a land management plan in place that is being followed. We considered using population trend as a factor to assess resilience; population growth indicates conditions (that we cannot explicitly assess) that favor population persistence, while conditions that negatively influence populations (e.g., lack of or improper habitat management) would be expected to generate population declines. While some past survey data are available for many populations, species experts were not comfortable comparing population counts across time periods. In many cases, differences in reported population sizes could not be precisely interpreted as true population changes due to differences in survey methodology, number of surveyors, and/or areas searched.

5.2.1 Population Size

Population size is both a direct contributor to and an indirect indicator of resilience. Small populations are more susceptible to demographic and environmental stochasticity than larger populations. Small populations are also more likely to suffer from Allee effects or decreased fitness as a result of low genetic diversity from inbreeding or genetic drift (Willi *et al.* 2005, p. 2260). Large populations are more buffered from the effects of herbivory or other disturbances and, indirectly, large population sizes are presumably indicative of other conditions that contribute to population resilience but cannot be objectively assessed due to lack of data, e.g., habitat quality.

For the purposes of this SSA, we only used EOs that have been observed since 1998 and occur on sites that have not been altered such that they are uninhabitable for *P. integrilabia*. We did this for several reasons. First, we did not want to use outdated information in assuming a population was still present. Second, we wanted to be consistent in what we considered "current" for categorizing resilience. Also, experts agreed that EOs as old as 20 years are likely to persist, even if declining, despite not having been observed on more recent surveys. Based on historical survey records (1927 – 2018), *P. integrilabia* may not be visible at a site for several years and then reappear when habitat conditions improve. It is important to note that many of the populations that we excluded from our analysis could persist on the landscape (see Appendix A). Regardless, we conservatively limited our assessment of current condition to those populations for which data are available from 1998 or later.

Based on these criteria (excluding EOs only observed prior to 1998), there are currently 50 populations distributed across the range of *P. integrilabia*. We synthesized the population size information and created four abundance 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 501-1,000 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, and moderate-high probability of extirpation for 20-30 years at or above the current population size.

The population size threshold between high and very high resilience of 1,000 individuals was chosen because it is the typical population size used to rank EOs as having "excellent viability" and likely to persist for the next 20 – 30 years (NatureServe 2008). This is a generic population size limit that is not specifically tailored to *P. integrilabia* with empirical data. The other threshold population sizes for this SSA were chosen with guidance from other plant SSAs (e.g., whorled sunflower, dwarf-flowered heartleaf, and Florida golden aster) and EO ranking criteria (NatureServe 2008). Populations with fewer than 1,000 but greater than 500 individuals were still considered to have high resilience, as there is evidence from historical survey data of populations with fewer than 1,000 individuals persisting for decades. There are presently no empirical estimates of minimum viable population sizes for *P. integrilabia*; however, there are examples of small populations of *P. integrilabia* persisting for decades. This may be because of habitat limitations such as size of the habitat itself (i.e., habitat types for *P. integrilabia* are generally limited by extent of proper site hydrology and soil type) or limits on the presence of symbiotic fungus.

We obtained current population size data for all populations, using the most recent available data collected between 1998 and 2020. Sizes of populations that have not been surveyed in the last 5 years have likely changed, as abundance fluctuates in response to management actions, time since management, environmental events, stochastic demographic processes, and other factors.

Thus, the reported numbers reflect best available estimates for population sizes, rather than precise counts of actual current population sizes. For the purposes of this SSA, population sizes included all plants counted, whether flowering or not. Survey data for some populations provided separate counts for each life stage, but for many populations, survey data were simply numbers recorded with no indication of separate counts for vegetative or reproductive plants.

5.2.2 Flowering within Populations

The second factor used in estimating population resilience is whether the population has exhibited flowering in the past 10 years. The factors related to *P. integrilabia* flowering are complex, largely unknown, and presumably are affected by temporal variations in habitat conditions. Additionally, monitoring of populations has occurred at varying frequencies, negatively biasing potential for recent flowering to have been documented in less frequently visited occurrences. Therefore, flowering within a population in the past decade provides a proxy for the complex characteristics of a site (e.g., herbivory, presence of symbiotic fungus, proper sunlight, soil moisture, soil temperature) that interact to influence flowering at each EO. Flowers are also important indicators for resilience because populations that are not flowering are not exchanging genetic material or sexually reproducing, placing them at greater risk of decline. Because data were not available regarding the numbers or proportions of flowering plants observed over time at most populations, we simplified this factor by determining whether available data indicated that any flowers were observed at each population within the past 10 years. Future revisions to this SSA would benefit from data that include stage specific counts of *P. integrilabia* individuals present during monitoring visits at each occurrence, so that resilience could be assessed based on both number and proportion of flowering plants in a population.

5.2.3 Connectivity

The next factor that contributed to overall resilience was connectivity of the population to other populations. Connections between populations increase availability of mates for cross-pollination, helping to maintain levels of genetic diversity sufficient to prevent harmful consequences from inbreeding depression and genetic drift. Populations in close proximity to one another are at lower risk of experiencing genetic bottlenecks (i.e., loss of genetic variation resulting from extreme reduction in the size of a population) following catastrophic events or, in the event of local extinction, could potentially be reestablished via infrequent long-distance seed dispersal from a neighboring population. For these reasons, proximity to other nearby populations increases the overall resilience of *P. integrilabia* populations. Orchid seeds are very light, small, and abundant. Despite their small size, orchid seeds typically only disperse to within a few meters of the parent plant (Brzosko *et al.* 2005, p. 5; Chung *et al.* 2005, p. 212). However, extreme weather events can lead to orchid seed dispersal over large distances (Nathan 2006, entire). There are no data regarding seed dispersal distances for *P. integrilabia*. Seed dispersal distances for orchids with similar seed size have been seen up to hundreds of kilometers, mostly in open environments and islands (Arditti and Ghani 2000; p. 407). Accordingly, we used a maximum distance of 10 km as a potential dispersal distance for *P. integrilabia* seeds during extreme wind events, without consideration of land use between occurrences. Using GIS, we rated connectivity for defined populations (see Section 5.1) as Low (no extant populations within 10 km), Medium (1 extant population within 10 km), and High (>1 extant population within 10 km).

5.2.4 Resilience Levels

Populations were assigned a baseline resilience level associated with their population size (low, moderate, high, or very high) and whether the population has been observed flowering since 1998. The resulting resilience classes are shown in Table 5.1. This baseline level could then be lowered by connectivity being classified as "low"; "medium" connectivity remained unchanged, and populations with "high" connectivity were raised a resilience level. If the population had not been observed flowering with the previous 10 years, its level remained "low" regardless of connectivity.

Table 5.1. Strategy for assigning current baseline resilience levels to *Platanthera integrilabia* populations based on population size and whether flowering has been observed within the prior decade.

Population Size (# plants)	Flowering	Not Flowering
<100	Low	
100-500	Moderate	Low
501-1000	High	Moderate
>1000	Very High	Moderate

5.2.5 Conservation Rank

After assigning population resilience levels, we assigned a conservation rank of "low", "medium", or "high" to each population in order to characterize the degree to which habitat supporting the population is currently protected or being managed to benefit *P. integrilabia*. The conservation rank does not alter the population resilience level but is useful for evaluating how previous management might influence current or future resilience and how future actions can be strategically applied. Conservation rank in this SSA can be influenced in two ways: (1) direct protection from changes in land use (e.g., logging, roads, recreation) and (2) through management of the habitat to prevent or mediate the effects of invasive species (native and non-native), shading, herbivory, soil disturbance, and, potentially, alteration of local hydrology. It is inferred that Federal- and State-owned *P. integrilabia* habitats provide more assurances of protection in the long term; however, private or local municipality lands that are under conservation agreements can provide protection also. Therefore, we treated all populations occurring on these properties as "protected", including instances where one or more occurrences in the population were not on protected lands. "Managed" populations referred to those currently under a management/restoration plan, regardless of type of management or outcome. As more is learned about the needs of this species, collecting data about habitat management actions and outcomes can refine future assessments of habitat and management quality. Table 5.2 indicates how conservation ranks were determined for each population using available data on both protection and management of the habitat.

Table 5.2 Strategy for assigning conservation ranks based on level of protection and management of *Platanthera integrilabia* populations.

	Protected	
	Yes	**No**
Managed	High	Medium
Not Managed	Medium	Low

5.3 Current Resilience

Resilience refers to the ability of populations to withstand stochastic events, whether demographic, environmental, or anthropogenic. For this SSA, empirical data are not available to associate resilience categories with specific quantitative extinction risks or probabilities of persistence. Rather, we are limited to providing qualitative definitions of each resilience category based upon assumptions about population size, flowering, and connectivity, which are based on general plant population dynamics rather than actual research on *P. integrilabia*. Populations with low resilience are highly vulnerable to stochastic events and face a high risk of extirpation within the next few decades. Populations with moderate resilience are less likely to be extirpated within the next few decades, but require additional population increases (with help of regular habitat management and/or restoration) to become more self-sustaining and resilient to stochastic events. Populations with high resilience are unlikely to be extirpated within the next few decades in the absence of catastrophes or significant declines in habitat quality. Populations with very high resilience are the most robust and resistant to stochastic fluctuations. Summaries of the 50 delineated populations and their resilience categories are provided in Table 5.3.

Table 5.3. Summary of *Platanthera integrilabia* (white fringeless orchid) populations, including population name and Element Occurrence (EO) ID; state; county; last observation of the population; population size class during the last observation; flowering status; connectivity rank; current resilience level; owner of the habitat; whether or not the habitat is being managed for *P. integrilabia*, and conservation rank.

Population	EO ID	State	County	Last Observed	Population Size Class (# plants)	Flowering	Connectivity	Resilience	Owner	Habitat Managed	Conservation Rank
Ivory Mountain	637, 10657	AL	Cleburne	2020	100-500	Yes	Medium	Moderate	USFS	No	Medium
Clifty Creek	3900, 9580	AL	Marion	2014	100 - 500	No	Low	Low	Private	No	Low
Jock Creek	4384	AL	Tuscaloosa	2014	<100	Yes	Low	Low	Private	No	Low
Lookout Mountain	9579	AL	Dekalb	2014	<100	Yes	Low	Low	TVA	No	Low
Browns Creek Branch	8716	AL	Winston	2013	<100	Yes	Low	Low	Private	No	Low
Mountain Longleaf NWR	2257, 3830^	AL	Calhoun	2020	100 - 500	Yes	Medium	Moderate	USFWS	Yes	High
Union-Good Hope Delta Rd	9405, 10558	AL	Clay	2020	<100	Yes*	Medium	Low	USFS/ Private	No	Medium
Skyline WMA	10559, 10562	AL	Jackson	2020	100 - 500	Yes*	Low	Low	State/ Private	No	Medium
Bankston	10658, 10659, 10660	AL	Fayette	2020	<100	Yes	Low	Low	Private	No	Low
Sawnee Mountain	2305^	GA	Forsyth	2017	<100	Yes	Low	Low	Private/ County	Yes	High
Tallulah Gorge	11258	GA	Rabun	2014	<100	Yes	Low	Low	State	No	Medium
Turkey Creek	3687	GA	Carroll	2013	<100	Yes	Low	Low	Private	No	Low
Lee Mountain	6971^	GA	Stephens	2013	<100	No	Low	Low	USFS	Yes	High
Moore Creek	8813, 19166^+	GA	Coweta	2017	<100	Yes	Low	Low	Private/ State	Yes	High
Neal Gap	11021^	GA	Chattooga	2016	<100	Yes	Low	Low	Private-C.E.	Yes	High

Population	EO ID	State	County	Last Observed	Population Size Class (# plants)	Flowering	Connectivity	Resilience	Owner	Habitat Managed	Conservation Rank
Pine Log Mountain	16659	GA	Bartow	2016	<100	Yes*	Low	Low	Private/ State	No	Low
Big Canoe	17494^	GA	Pickens	2017	<100	Yes	Low	Low	Private-C.E.	Yes	High
Lyons Landing	1981	GA	Carroll	2016	<100	Yes	Low	Low	Private	Yes	Medium
Bald Rock Uplands/ Marsh Branch	9084^	KY	Laurel	2018	100 - 500	Yes	High	High	USFS/ Private-C.E.	Yes	High
Hindsfield Ridge	6901^, 6576	KY	Pulaski	2018	<100	Yes	High	Moderate	USFS/ Private	Yes	High
Flatwoods Uplands	586	KY	Laurel	2015	100 - 500	Yes	High	High	Private	No	Low
Pine Creek Gorge	4656	KY	Laurel	2013	<100	No	Low	Low	USFS	Yes	High
Mount Victory Seeps	2601	KY	Pulaski	2018	>1,000	Yes	Medium	Very High	State	Yes	High
Barren Fork	12123^	KY	McCreary	2018	<100	No	Medium	Low	USFS	Yes	High
Pine Knot	974	KY	McCreary	2018	100 - 500	No	Medium	Low	USFS	No	Medium
Grove	8989	KY	Whitley	2018	>1,000	Yes*	Medium	Very High	USFS	No	Medium
Itawamba	10442, 10402, 10403	MS	Itawamba	2014	100 - 500	Yes	Low	Low	Private/ State	No	Medium
Bear Creek	10075	MS	Tishomingo	2010	100 - 500	No	Medium	Low	Private	No	Low
Glasgow	9106	MS	Tishomingo	2013	>1000	Yes	Medium	Very High	Private	No	Low
Greenville	8961	SC	Greenville	2002	<100	Yes	Low	Low	State	No	Medium
Plantation Pond	3112	TN	Grundy	2000	<100 (likely extirpated)	No	High	Low	Private-C.E.	No	Medium
Hwy 111	3621	TN	Sequatchie	2017	<100	Yes	High	Moderate	Private	No	Low
Meadow Creek	10896^, 14096, 19785	TN	Grundy	2020	>1,000	Yes	High	Very High	State	Yes	High
Starr Mountain	9616^	TN	McMinn	2019	>1,000	Yes	Low	High	USFS	Yes	High

Population	EO ID	State	County	Last Observed	Population Size Class (# plants)	Flowering	Connectivity	Resilience	Owner	Habitat Managed	Conservation Rank
Tar Kiln Ridge	16515^, 17611^	TN	Fentress	2018	>1,000	Yes	Low	High	NPS	Yes	High
Pitcher Ridge	4657, 12612, 809, 2828	TN	Franklin	2017	100 - 500	Yes	Low	Low	Private	No	Low
Guntersville Lake	16275, 16274, 17612, 15366, 15368, 5927, 15367	TN	Franklin, Marion	2017	<100	No	Low	Low	Private/ State	No	Medium
Sheeds Creek	7925^	TN	Polk	2018	100 - 500	No	Low	Low	USFS	Yes	High
Prentice Cooper SF	8853	TN	Marion	2018	100 - 500	Yes	Low	Low	State	No	Medium
N Fork Creek	8854	TN	Cumberland	2018	100 - 500	Yes	Low	Low	State	No	Medium
Duncan Hollow	16576^	TN	Scott	2018	100 - 500	Yes	Low	Low	NPS	Yes	High
Marion	13119, 11697, 628, 7632, 17312, 4561	TN	Marion/ Grundy	2018	501 - 1,000	Yes	Low	Moderate	TVA/State/ Private	No	Medium
Mooneyham	18913, 17604	TN	Van Buren	2018	501 - 1,000	Yes	Medium	High	TVA/State	No	Medium
Southern Pine Plantation	3192, 958	TN	Van Buren	2017	501 - 1,000	Yes	Medium	High	Private	No	Low
Spencer Powerline	12960, 2195	TN	Van Buren	2018	<100	Yes	Medium	Low	Private	No	Low
Great Falls	19789	TN	Van Buren	2015	<100	Yes	Medium	Low	Private	No	Low

Population	EO ID	State	County	Last Observed	Population Size Class (# plants)	Flowering	Connectivity	Resilience	Owner	Habitat Managed	Conservation Rank
Lee Farm/Laurel Trail	6669, 12466	TN	Grundy	2017	<100	Yes	Medium	Low	Private/ State	No	Medium
Centennial Wilderness WMA	19788^+	TN	White	2018	100-500	Yes	Medium	Moderate	State	Yes	High
Falls Creek	6355	TN	Bledsoe	2011	<100	No	Medium	Low	Private	No	Low
Bledsoe Powerline	17618, 5928^	TN	Bledsoe	2018	>1,000	Yes	Medium	Very High	State/TVA	Yes	High

*Indicates populations where only a few plants are flowering.

^Indicates EOs under a management and restoration program.

+Indicates EOs established through introduction.

Twenty-two percent of the assessed populations were classified as having high or very high resilience while 66 percent of the populations were classified as having low resilience (Table 5.4). Approximately one third of the populations have no protection or management and the majority (76 percent) of those have low resilience (Table 5.4).

Table 5.4. Summary of resilience levels tallied across all *Platanthera integrilabia* populations and habitat conservation level.

Resilience Level	All Populations	Habitat Conservation		
		Low	Medium	High
Very High	5	1	1	3
High	6	2	1	3
Moderate	6	2	1	3
Low	33	13	11	9
Total	50	18	14	18

5.4 Current Redundancy and Representation

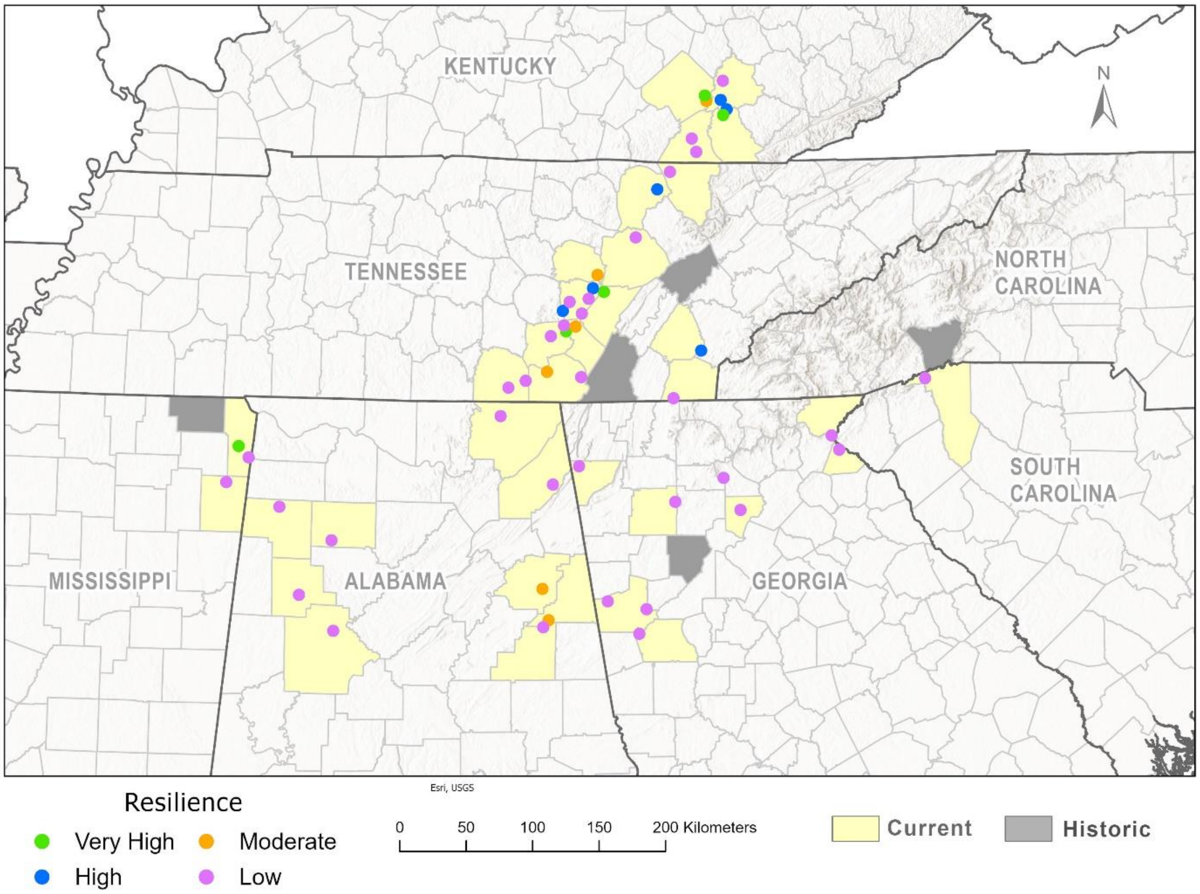

Figure 5.1. *Platanthera integrilabia* populations by current resilience level, with currently and historically occupied counties.

5.4.1 Redundancy

Redundancy describes the ability of a species to withstand catastrophic events. Measured by the number of populations, their resilience, and their distribution, redundancy gauges the probability that the species has a margin of safety to withstand or recover from catastrophic events (such as a rare destructive natural event or episode involving many populations). Catastrophic events could include, among others, frequent or severe fires, droughts, disease outbreaks, or prolonged flooding, each of which cause impacts at different spatial scales. It is worth noting that no information is currently available about soil seedbank formation or resilience for this species; lacking such data, it is difficult to predict long-term impacts of catastrophes.

For *P. integrilabia* to maintain viability in the long term, the species needs to exhibit some degree of redundancy. As stated previously, there are 50 populations of *P. integrilabia* that have been observed within the past 20 years, and resilience of these populations is as follows: 5 – Very High; 6 – High; 6 – Moderate; and 33 – Low. The populations are spread across the range, although the majority are distributed in Tennessee and Kentucky (Fig. 5.1). *P. integrilabia* still occurs in most of the counties from which it is historically known. However, there are many low resilience populations in the eastern and southern parts of its range which may lead to reductions in the future redundancy (Fig. 5.1). Birchenko (2001, p. 37) determined there is currently no current indication of restricted gene flow between populations. However, genetic exchange between populations may be constrained in the future for a couple of reasons: (1) 54 percent of the populations exhibit low connectivity with other populations (i.e., no other populations within 10 kilometers) and (2) 30 percent of the populations have low or no flowering. Given the low numbers of individuals already occurring in many of these populations, especially in the southern and eastern populations (Fig. 5.1), it is far less likely that these populations can withstand acute catastrophic events. Redundancy is further threatened due to the lack of habitat protection for many of the populations occurring in the southwestern portion of the species range (Fig. 5.2).

5.4.2 Representation

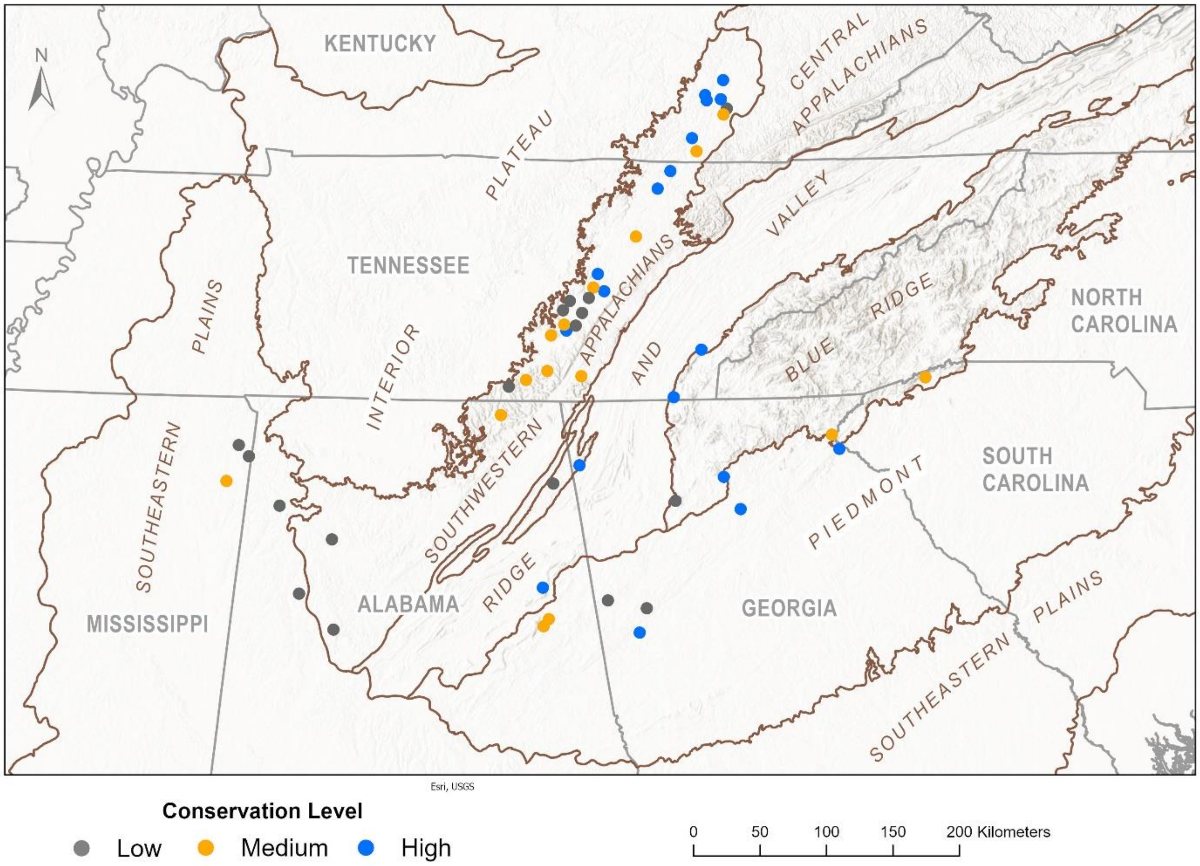

Figure 5.2. ***Platanthera integrilabia*** **populations by level of conservation and Level III Ecoregion.**

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 and/or acclimating to environmental changes. The more representation, or diversity, a species has, the more capable it is 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. To do this, we evaluated representation of *P. integrilabia* using EPA Level III Ecoregions (Omernik 1987, entire). Ecoregions are delineated based upon areas with similar biotic and abiotic phenomena including geology, landforms, soils, vegetation, climate, land use, and hierarchical level.

P. integrilabia populations occur in five Level III Ecoregions: Blue Ridge (6); Piedmont (7); Ridge and Valley (1); Southeastern Plains (5); and Southwestern Appalachians (31) (Fig. 5.1; Table 5.5). Redundancy is greatest in the Southwestern Appalachians, which includes the Cumberland Plateau where the majority of *P. integrilabia* populations occur. Redundancy in the other ecoregions is comparatively lower; however, it is unclear how much this distribution has changed compared to the historical distribution of *P. integrilabia*. In addition to the low number of populations in the Blue Ridge, Piedmont, and Ridge and Valley ecoregions, all but three of these populations have low resilience; populations in the Southeastern Plains generally have low resilience and lack habitat protection with few exceptions (Figs. 5.1 and 5.2; Table 5.5).

Table 5.5. Summary of resilience level tallied across all *Platanthera integrilabia* populations, grouped by conservation rank and Level III ecoregion.

Resilience Level	All Populations	Level III Ecoregion				
		Blue Ridge	Piedmont	Ridge and Valley	Southeastern Plains	Southwestern Appalachians
	Conservation Rank = High					
Very High	3	0	0	0	0	3
High	3	1	0	0	0	2
Moderate	3	0	0	1	0	2
Low	9	2	3	0	0	4
	Conservation Rank = Medium					
Very High	1	0	0	0	0	1
High	1	0	0	0	0	1
Moderate	2	0	1	0	0	1
Low	11	2	1	0	1	7
	Conservation Rank = Low					
Very High	1	0	0	0	1	0
High	2	0	0	0	0	2
Moderate	1	0	0	0	0	1
Low	13	1	2	0	3	7
Total	**50**	**6**	**7**	**1**	**5**	**31**

Limited redundancy of populations outside of the Southwestern Appalachians, many of which have low levels of resilience, suggests there is a greater risk of losing representation within these geographic regions, along with any potentially unique genetic or morphological traits these populations possess that might not be present in populations of the Southwestern Appalachians. Populations in these regions with conservation ranks of medium or higher could provide opportunities for focusing habitat and population management efforts to increase their resilience, reducing the relatively higher level of extinction risk facing *P. integrilabia* at the edges of its geographic range.

CHAPTER 6 – FUTURE CONDITION

6.1 Future Considerations

Our analysis of the past, current, and future influences on what *Platanthera integrilabia* needs for long-term viability revealed several risk factors likely to influence the future viability of the species. The most important factors identified by species experts to consider into the future were population size, habitat conditions, habitat management, and climate change. The risks to *P. integrilabia* populations are primarily related to small population size as well as habitat changes from residential and commercial development (e.g., habitat removal, invasive species, hydrological changes, pollinator access) and logging practices (e.g., soil disturbance, hydrological changes, pollinator access, invasive species). Habitat management has been shown to effectively mitigate many of the risks to *P. integrilabia* populations through management of invasive species and encroaching native vegetation, exclusion fencing to inhibit herbivory and feral hog disturbance, and overstory management. We used projections of urban development to assess potential direct habitat loss, as well as indirect risks from further fragmentation and loss of connectivity between populations associated with urbanization. We also used recent changes in land cover (i.e., forest cover loss) to assess the potential risk of forest alterations within the vicinity of each population. Using a narrative approach, we also considered how climate change may exacerbate the impacts of development and forest change in a qualitative fashion. Habitat restoration and enhancement practices have a notable impact on populations by increasing abundance and flowering (see Table 4.1); therefore, we included habitat management when considering future scenarios for *P. integrilabia*.

We developed three future scenarios to assess the future viability of *P. integrilabia* in terms of resilience, redundancy and representation: Status Quo, Reduced Conservation, and Targeted Conservation. We chose to project populations 50 years into the future in 10-year increments under each scenario. This timeframe was based on expert input and the ability to clearly encapsulate the potential threat of urbanization to *P. integrilabia* in the foreseeable future.

6.1.1 Urban Development Risk

Urban development can influence future habitat conditions for *P. integrilabia* by altering local hydrology, fragmenting habitat, limiting pollinator movements, increasing invasive species occurrence, or by directly removing habitat in areas that are not protected. In order to limit our analysis to areas close enough to impact *P. integrilabia* occurrences, we assessed urban development within 5 km of each population. Within the 5-km radius around *P. integrilabia* populations, we used GIS to examine current and projected urbanization. Projected urbanization data came from the SLEUTH model (Slope, Land use, Excluded, Urban, Transportation and Hillshade; Jantz *et al.* 2010, entire). The SLEUTH model has previously been used to predict probabilities of urbanization across the southeastern US in 10-year increments, and the resulting GIS data are freely available (Belyea and Terrando 2013, entire). To predict rates of urbanization, we used the SLEUTH model which simulates patterns of urban expansion based on observations of past urban growth and transportation networks, including the sprawling, fragmented, "leapfrog" development that has been the dominant form of development in the Southeast (Terrando *et al.* 2014, entire). The SLEUTH model predicts the probability of urbanization ranging from 0-100%, with the higher the percentage, the more likely it is to be developed. For our 50-year future projection, we used the SLEUTH data sets from the years 2030, 2040, 2050, 2060, and 2070 (closest to 50 years in the future). 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.

Our assessment was quantitative, calculating the area within the 5-km buffer surrounding each population that was urbanized at each 10-year time interval. These numbers were then added to the current urbanization of the 5-km buffer to give an estimated total percentage of the area predicted to be developed for each time interval. With this quantitative and qualitative assessment, we categorized populations as having either "low", "moderate", or "high" risk of development impacting the population.

In order to assess what percentage urbanization would potentially begin to impact a population, we determined current percent urbanization in the vicinity of three EOs thought to have been extirpated due to effects of urbanization and development (Table 6.1). We also determined percent urbanization of areas surrounding extant populations and evaluated whether there were differences in these data for unprotected versus protected/managed populations. Current populations occurring on private (i.e., unprotected and unmanaged) lands all have less than 7% urbanization within a 5-km buffer. There is one occurrence on protected lands where urbanization has occurred in 38% of the 5-km buffer; however, all other protected populations have <15% urbanization within a 5-km buffer (see Table 6.5). This indicates that populations occurring on protected lands may be more resilient to slightly higher levels of local urbanization than those that are unprotected and unmanaged. Reasons for this could include effects of protected lands at buffering populations within them from adverse effects of urbanization, such as increased abundance of invasive plants, or implementation of appropriate management actions to counter the effects of habitat degradation. Based on these data, we categorized extant populations as having "low", "medium", or "high" risk from development at each 10-year time interval (Table 6.2).

Table 6.1. *Platanthera integrilabia* element Occurrences (EOs) thought to have been extirpated due to effects from urbanization and development along with the current amount of urbanization within 5 km.

EO Number	Last Known Extant	County, State	% Current Urban Land Cover (2011)*
11656	1992	Henderson County, NC	90.6
10836	1984	Grundy/Sequatchie Counties, TN	34.8
10047	1988	Roane, TN	18.8

*National Land Cover Database (NLCD 2011)

Table 6.2. Qualitative rank of risk incurred by amount of urbanization within 5 km of *Platanthera integrilabia* population for unprotected and protected populations.

% Urbanized	Risk	
	Unprotected	Protected
<15%	Low	Low
15-40%	Medium	Low
40-75%	High	Medium
>75%	High	High

6.1.2 Logging Risk

Logging is a risk to *P. integrilabia* populations because it changes canopy cover, increases likelihood of invasive plant species encroachment, causes direct habitat destruction, and alters local hydrology and soil moisture. In order to assess the risk of logging to each *P. integrilabia* population, we summed loss of forest cover (i.e., deciduous, mixed, and woody wetlands) in each county occupied by *P. integrilabia* using National Land Cover Database (NLCD) change, a raster data set which displays changes in major land cover class from 2006 to 2011 (NLCD 2011). In order to avoid double counting potential impacts from urbanization (see above), we did not include any change from forest cover that occurred due to urban development.

In order to determine what level of logging threat increases the likelihood of a population being affected by logging, we examined counties with and without extirpated *P. integrilabia* populations. Counties with at least one EO extirpated due to logging averaged 3.4% (range: 3.1% to 3.8%) loss of forest cover from 2006 to 2011 while counties with no known loss of EOs due to logging averaged 1.5% (range: 0.1% to 3.9%) loss of forest cover in the same period (Table 6.3). Based on these data, we used a conservative approach and divided risk of logging to populations into two categories: (1) populations at "low" risk occur in counties with < 3.1% forest cover loss and (2) populations at "high" risk occur in counties with ≥ 3.1% forest cover loss from 2006 to 2011. Logging would not be a risk to populations on protected lands, unless the EO was near the edge of the property line; therefore, we included type of ownership/management when classifying logging risk to a population (Table 6.4). Based on these data, we categorized extant populations as having "low", "medium", or "high" risk from logging depending on logging risk and level of protection and management (Table 6.5).

Table 6.3. Percent decrease of deciduous forests, mixed forest, and woody wetland in counties with extant *Platanthera integrilabia* populations. Blue shading indicates high risk of logging and grey shading indicates low risk.

Population	EO ID	State	County	Ownership	% County Logged 2006-2011	% County Logged 2006 - 2011 Minus Development	County Size (sq. km)
Ivory Mountain	637, 10657	AL	Cleburne	USFS	3.6	1.2	1453
Clifty Creek	3900, 9580	AL	Marion*	Private	5.7	3.3	1925
Jock Creek	4384	AL	Tuscaloosa	Private	5.8	3.2	3497
Lookout Mountain	9579	AL	Dekalb	TVA	1.9	1.4	2016
Browns Creek Branch	8716	AL	Winston	Private	4.3	2.2	1635
Mountain Longleaf NWR	2257, 3830^	AL	Calhoun	USFWS	2.1	1.0	1585
Union-Good Hope Delta Rd	9405, 10558	AL	Clay	USFS/Private	4.1	1.6	1569
Skyline WMA	10559, 10562	AL	Jackson	State/Private	0.7	0.7	2918
Bankston	10658, 10659, 10660	AL	Fayette	Private	n/a	4.2	1630
Sawnee Mountain	2305^	GA	Forsyth	Private/ County	2.0	0.7	641
Tallulah Gorge	11258	GA	Rabun	State	0.2	0.1	978
Turkey Creek	3687	GA	Carroll	Private	3.8	1.3	1305
Lee Mountain	6971^	GA	Stephens	USFS	0.9	0.5	478
Moore Creek	8813^, 19166^	GA	Coweta	Private/ State	3.8	1.3	1155
Neal Gap	11021^	GA	Chattooga	Private-C.E.	2.7	1.7	812
Pine Log Mountain	16659	GA	Bartow	Private/ State	3.4	1.4	1218
Big Canoe	17494^	GA	Pickens	Private-C.E.	2.7	0.8	603
Lyons Landing	1981	GA	Carroll	Private	3.8	1.3	1305
Bald Rock Uplands/Marsh Branch	9084^	KY	Laurel	USFS/ Private-C.E.	0.4	0.3	1150
Hindsfield Ridge	6901^, 6576	KY	Pulaski	USFS/ Private	0.4	0.3	1754
Flatwoods Uplands	586	KY	Laurel	Private	0.4	0.3	1150
Pine Creek Gorge	4656	KY	Laurel	USFS	0.4	0.3	1150

Population	EO ID	State	County	Ownership	% County Logged 2006-2011	% County Logged 2006 - 2011 Minus Development	County Size (sq. km)
Mount Victory Seeps	2601	KY	Pulaski	State	0.4	0.3	1754
Barren Fork	12123^	KY	McCreary	USFS	0.4	0.3	1117
Pine Knot	974	KY	McCreary	USFS	0.4	0.3	1117
Grove	8989	KY	Whitley	USFS	0.5	0.5	1154
Itawamba	10442, 10402, 10403	MS	Itawamba	Private/ State	4.9	2.9	1399
Bear Creek	10075	MS	Tishomingo	Private	4.7	2.4	1151
Glasgow	9106	MS	Tishomingo	Private	4.7	2.4	1151
Greenville	8961	SC	Greenville	State	0.9	0.6	2066
Plantation Pond	3112	TN	Grundy*	Private-C.E.	4.9	3.5	935
Hwy 111	3621	TN	Sequatchie*	Private	4.8	3.8	689
Meadow Creek	10896^, 14096, 19785	TN	Grundy*	State	4.9	3.5	935
Starr Mountain	9616^	TN	McMinn	USFS	1.7	0.7	1120
Tar Kiln Ridge	16515^, 17611^	TN	Fentress	NPS	1.2	0.9	1292
Pitcher Ridge	4657, 12612, 809, 2828	TN	Franklin	Private	0.3	0.3	1490
Guntersville Lake	16275, 16274, 17612, 15366, 15368, 5927, 15367	TN	Franklin / Marion	Private/ State	0.3 / 2.3	.3 / 1.9	1490, 1326
Sheeds Creek	7925^	TN	Polk	USFS	0.6	0.2	1146
Prentice Cooper SF	8853	TN	Marion	State	2.3	1.9	1326
N Fork Creek	8854	TN	Cumberland	State	2.2	1.7	1774
Duncan Hollow	16576^	TN	Scott	NPS	1.0	0.9	1382
Marion	13119, 11697, 628, 7632, 17312, 4561	TN	Marion/ Grundy*	TVA/State/ Private	2.3, 4.9	1.9, 3.8	1326, 935

Population	EO ID	State	County	Ownership	% County Logged 2006-2011	% County Logged 2006 - 2011 Minus Development	County Size (sq. km)
Mooneyham	18913, 17604	TN	Van Buren*	TVA/ State	3.9	3.1	711
Southern Pine Plantation	3192, 958	TN	Van Buren*	Private	3.9	3.1	711
Spencer Powerline	12960, 2195	TN	Van Buren*	Private	3.9	3.1	711
Great Falls	19789	TN	Van Buren*	Private	3.9	3.1	711
Lee Farm/Laurel Trail	6669, 12466	TN	Grundy	Private/ State	4.9	3.8	935
Centennial Wilderness WMA	19788	TN	White	State	0.8	0.4	982
Falls Creek	6355	TN	Bledsoe	Private	4.9	3.9	1053
Bledsoe Powerline	17618, 5928	TN	Bledsoe	State	4.9	3.9	1053

*Indicates counties where EOs have been extirpated because of logging.

Table 6.4. Property type where *Platanthera integrilabia* populations occur and associated risk from logging.

Property Type	Low Logging Risk (<3.1%)	High Logging Risk (≥3.1%)	Adjacent to High Logging Risk
Private	Low	High	High
Private-Conservation Easement	Low	Low	Medium
State Park	Low	Low	Medium
State Natural Area	Low	Low	Medium
National Wildlife Refuge (Federal)	Low	Low	Medium
National Park (Federal)	Low	Low	Medium
State Forest	Low	Medium	Medium
National Forest (Federal)	Low	Medium	Medium
Wildlife Management Area (State)	Low	Medium	Medium
Protected and Private	Low	Medium	Medium
County	Low	Medium	Medium
Tennessee Valley Authority (Federal)	Low	Low	Medium

6.1.3 Conservation and Management

Habitat quality for some *P. integrilabia* populations is heavily influenced by active management and restoration to maintain suitable canopy cover, control invasive plant species, protect plants from herbivory or soil disturbance by installing fencing, and maintenance of appropriate hydrological conditions. We currently lack data to analyze past or ongoing management efforts by type of management or duration and link them with predicted outcomes. However, ongoing habitat management projects alongside *ex situ* propagation have shown positive results on sites occupied by *P. integrilabia*, both as an increase in plants observed and flowering (see Table 4.1). Therefore, we considered any type of management of *P. integrilabia* or its habitat to have a positive influence on the future population conditions and increase its resilience.

Populations can grow or decline very rapidly, but we do not fully understand what drives these dynamics and do not have reliable estimates of population growth rates to use to better project population sizes into the future. Thus, we are conservative in the magnitude of our projections, but more confident in the direction (i.e., increase or decrease) of the change. In our scenarios, populations that are currently managed or are expected to be managed in the future (Table 4.1) were assumed an increase of one resilience level throughout the entire 50-year predicted time period. Management could also keep a population from being extirpated if logging and urbanization risks were high.

6.2 Future Scenarios

Below we present three future scenarios for assessing viability for *P. integrilabia*. In constructing scenarios, we considered three main influences by which species viability could be affected: protection and management of current populations (positive influences) and habitat loss and fragmentation due to urban development and logging (negative influences). Development or land use change can negatively influence habitat quality and quantity while land acquisition, habitat management/enhancement, and/or introductions into unoccupied sites that already have suitable habitat have a positive impact. We used the flow chart in Fig. 6.1 to make decisions regarding changes in resilience level based on management, logging risk, and urban risk.

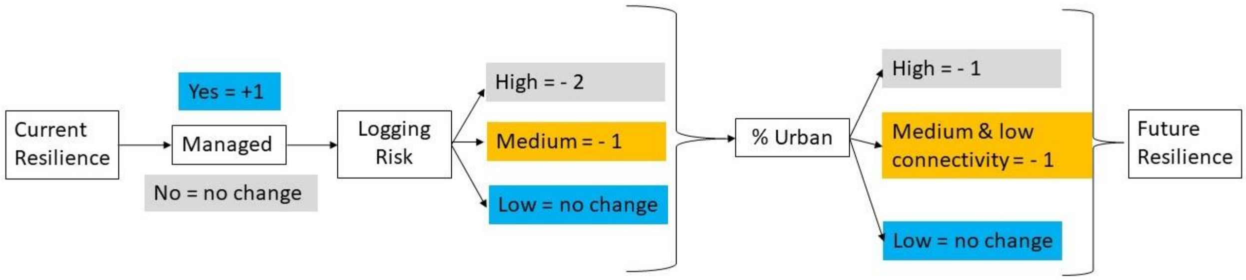

Figure 6.1. Flow chart detailing how resilience level changed based on management, logging risk, and urban risk for *Platanthera integrilabia* population in the three future scenarios.

6.2.1 Status Quo

Under the Status Quo scenario, no new protected areas are acquired, and no new populations are found or introduced. Ongoing management effort will continue to benefit currently targeted populations, assuming that the ability to do so will not be hampered by funding, climate change, or other extraneous factors. Populations with conservation and management efforts have shown signs of increased abundance and flowering (Table 4.1) and are expected to increase in resilience as long as urban development does not impede their connectivity. As a result, resilience levels will increase for managed populations.

6.2.2 Reduced Conservation

Under the Reduced Conservation scenario, management effort on all populations decreases, presumably as an effect of a wide-scale change in priorities and/or resources. Additionally, there is uncertainty in whether populations on non-protected lands will be managed in a way that is compatible with continued *P. integrilabia* persistence.

6.2.3 Targeted Conservation

Under the Targeted Conservation scenario, conservation resources are focused on keeping highly resilient populations highly resilient by ensuring they are protected and strengthening moderately resilient populations on protected lands by enhancing habitat through appropriate management actions.

6.3 Future Resilience

Data used to calculate future resilience in 10-year intervals out to the year 2070 for *P. integrilabia* populations under the three scenarios described above are shown in Table 6.5.

Table 6.5. ***Platanthera integrilabia*** **populations and associated current resilience, current urban land cover, predicted 80% probability of urbanization within a 5-km radius in 10-year increments for 50 years, current and future connectivity to other populations, and percent of county logged from 2006 to 2011. Values that are beneficial to resilience are shaded blue, values that are detrimental are shaded gray, and orange values have undetermined influence on population resilience. Blue shading on population names indicates populations with current management.**

Population	EO ID	State	Ownership	Current Resilience	% Current Urban Land Cover (2011)	% Urban 2030	% Urban 2040	% Urban 2050	% Urban 2060	% Urban 2070	Current Connectivity	Future Connectivity	% County Logged 2006-2011
Ivory Mountain	637	AL	USFS	Moderate	3	3	3	3	3	3	Medium	Medium	1.2
Clifty Creek	3900, 9580	AL	Private	Low	6	7	8	10	12	14	Low	Low	3.3
Jock Creek	4384	AL	Private	Low	1	1	1	1	1	1	Low	Low	3.2
Lookout Mountain	9579	AL	TVA	Low	8	12	16	21	27	35	Low	Low	1.4
Browns Creek Branch	8716	AL	Private	Low	4	5	5	6	7	8	Low	Low	2.2
Mountain Longleaf NWR	2257, 3830^	AL	USFWS	Moderate	12	17	18	19	20	21	Medium	Low*	1.0
Union-Good Hope Delta Rd	9405, 10558	AL	USFS/Private	Low	3	3	3	3	3	3	Medium	Medium	1.6
Skyline WMA	10559, 10562	AL	State/Private	Low	2	3	3	4	6	8	Low	Low	0.7
Bankston	10658, 10659, 10660	AL	Private	Low	5	7	8	9	11	12	Low	Low	4.2
Sawnee Mountain	2305^	GA	Private/County	Low	38	60	77	88	93	96	Low	Low	0.7
Tallulah Gorge	11258	GA	State	Low	7	9	10	11	11	12	Low	Low	0.1
Turkey Creek	3687	GA	Private	Low	6	15	26	40	55	66	Low	Low	1.3
Lee Mountain	6971^	GA	USFS	Low	7	9	10	12	14	15	Low	Low	0.5
Moore Creek	8813^, 19166^	GA	Private/State	Low	2	3	5	7	10	14	Low	Low	1.3
Neal Gap	11021^	GA	Private-C.E.	Low	5	5	5	5	6	7	Low	Low	1.7

Population	EO ID	State	Ownership	Current Resilience	% Current Urban Land Cover (2011)	% Urban 2030	% Urban 2040	% Urban 2050	% Urban 2060	% Urban 2070	Current Connectivity	Future Connectivity	% County Logged 2006-2011
Pine Log Mountain	16659	GA	Private/State	Low	5	6	7	9	10	11	Low	Low	1.4
Big Canoe	17494^	GA	Private-C.E.	Low	9	11	12	14	15	16	Low	Low	0.8
Lyons Landing	1981	GA	Private	Low	6	9	14	19	23	28	Low	Low	1.3
Bald Rock Uplands/Marsh Branch	9084^	KY	USFS/Private-C.E.	High	5	5	6	6	6	6	High	High	0.3
Hindsfield Ridge	6901^, 6576	KY	USFS/Private	Moderate	3	3	3	4	4	4	High	High	0.3
Flatwoods Uplands	586	KY	Private	High	7	16	23	54	64	71	High	Medium*	0.3
Pine Creek Gorge	4656	KY	USFS	Low	8	10	12	14	15	16	Low	Low	0.3
Mount Victory Seeps	2601	KY	State	Very High	3	4	4	4	4	5	Medium	Medium	0.3
Barren Fork	12123^	KY	USFS	Low	9	10	10	10	10	10	Medium	Low*	0.3
Pine Knot	974	KY	USFS	Low	14	24	28	32	34	35	Medium	Low*	0.3
Grove	8989	KY	USFS	Very High	7	16	22	42	55	61	Medium	Medium	0.5
Itawamba	10442, 10402, 10403	MS	Private/State	Low	3	3	3	4	4	4	Low	Low	2.9
Bear Creek	10075	MS	Private	Low	4	4	4	4	4	4	Medium	Low*	2.4
Glasgow	9106	MS	Private	Very High	7	7	7	8	8	8	Medium	Low*	2.4
Greenville	8961	SC	State	Low	5	5	6	7	8	10	Low	Low	0.6
Plantation Pond	3112	TN	Private-C.E.	Low	1	1	1	1	1	1	High	High	3.5
Hwy 111	3621	TN	Private	Moderate	3	4	5	7	8	9	High	High	3.8
Meadow Creek	10896^, 14096, 19785	TN	State	Very High	2	2	2	2	2	2	High	High	3.5
Starr Mountain	9616^	TN	USFS	High	4	4	5	5	5	6	Low	Low	0.7
Tar Kiln Ridge	16515^, 17611^	TN	NPS	High	4	4	4	4	4	4	Low	Low	0.9

Population	EO ID	State	Ownership	Current Resilience	% Current Urban Land Cover (2011)	% Urban 2030	% Urban 2040	% Urban 2050	% Urban 2060	% Urban 2070	Current Connectivity	Future Connectivity	% County Logged 2006-2011
Pitcher Ridge	4657, 12612, 809, 2828	TN	Private	Low	1	1	1	1	1	1	Low	Low	0.3
Guntersville Lake	16275, 16274, 17612, 15366, 15368, 5927, 15367	TN	Private/State	Low	2	4	5	6	8	11	Low	Low	.3, 1.9
Sheeds Creek	7925^	TN	USFS	Low	2	2	2	2	2	2	Low	Low	0.2
Prentice Cooper SF	8853	TN	State	Low	2	2	2	2	3	4	Low	Low	1.9
N Fork Creek	8854	TN	State	Low	3	3	3	3	4	4	Low	Low	1.7
Duncan Hollow	16576^	TN	NPS	Low	1	1	1	1	1	1	Low	Low	0.9
Marion	13119, 11697, 628, 7632, 17312, 4561	TN	TVA/State/ Private	Moderate	2	2	2	2	2	2	Low	Low	1.9, 3.8
Mooneyham	18913, 17604	TN	TVA/State	High	6	7	8	9	10	11	Medium	Medium	3.1
Southern Pine Plantation	3192, 958	TN	Private	High	3	4	6	9	13	17	Medium	Medium	3.1
Spencer Powerline	12960, 2195	TN	Private	Moderate	2	3	4	6	9	13	Medium	Medium	3.1
Great Falls	19789	TN	Private	Low	3	7	10	14	19	25	Medium	Medium	3.1
Lee Farm/Laurel Trail	6669, 12466	TN	Private/State	Low	5	7	9	12	16	22	Medium	Medium	3.8

Population	EO ID	State	Ownership	Current Resilience	% Current Urban Land Cover (2011)	% Urban 2030	% Urban 2040	% Urban 2050	% Urban 2060	% Urban 2070	Current Connectivity	Future Connectivity	% County Logged 2006-2011
Centennial Wilderness WMA	19788	TN	State	Moderate	5	5	5	6	6	7	Medium	Medium	0.4
Falls Creek	6355	TN	Private	Low	2	3	3	4	9	14	Medium	Medium	3.9
Bledsoe Powerline	17618, 5928^	TN	State	Very High	7	10	12	15	20	25	Medium	Low*	3.9

^Indicates EOs which are currently being managed or restored.

*Indicates change from current connectivity to future connectivity based on location of predicted urbanization between populations.

6.3.1 Status Quo Scenario

In the Status Quo scenario, we predict 41 and 38 extant populations by 2030 and 2070, respectively (Table 6.6). The predicted resilience of the extant populations in 2070 are as follows: very high (7); high (3); moderate (9); and low (19) (Fig. 6.2). When comparing future population resilience to current condition, 1 population drops from very high to high, 1 high to low, 1 high to moderate, 1 moderate to low, and 12 would be extirpated. Eleven populations also improve in resilience due to management efforts and low risk: six low to moderate, two moderate to high, and three high to very high.

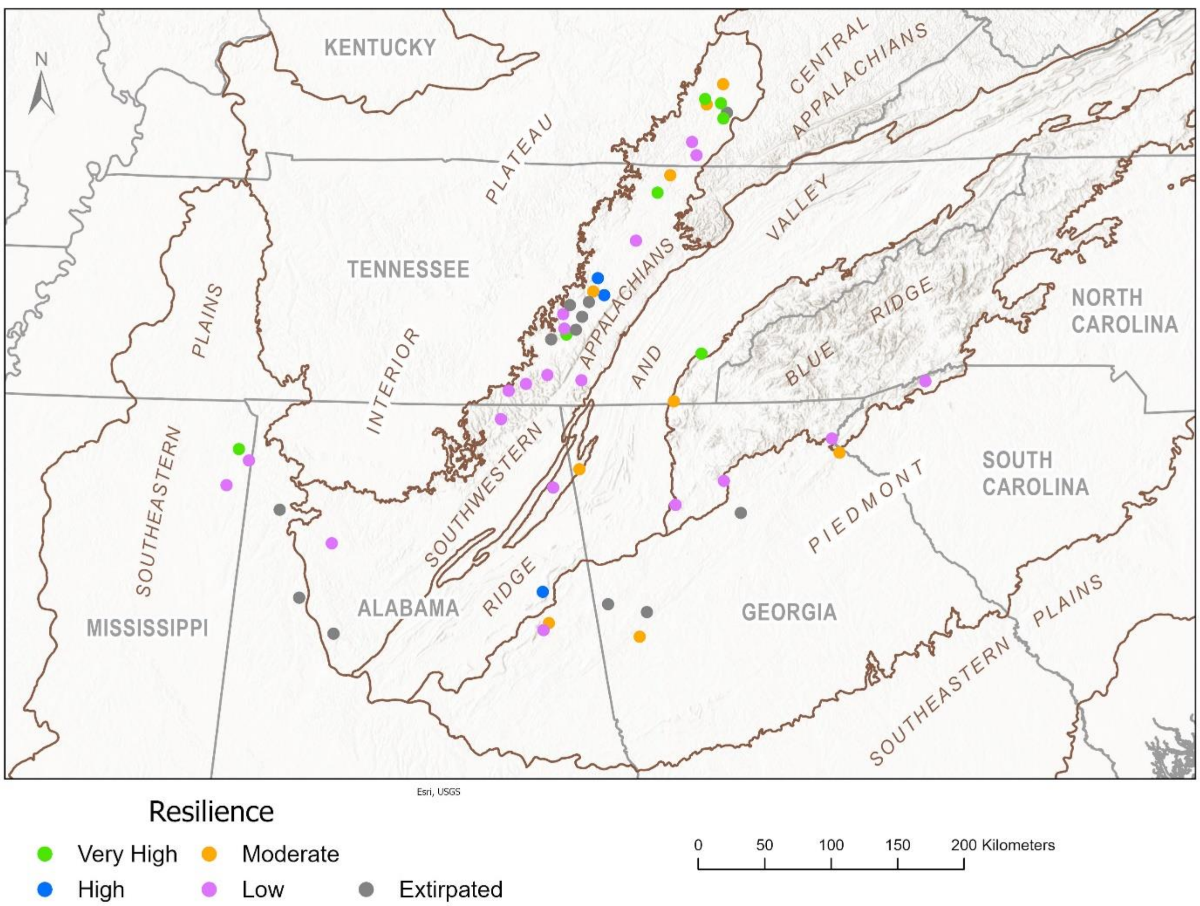

Figure 6.2. Predicted resilience levels of *Platanthera integrilabia* populations in 2070 using the Status Quo scenario.

Table 6.6. Predicted resilience categories for the next 50 years for *Platanthera integrilabia* populations under the Status Quo scenario compared to current resilience. Blue shading on population name indicates populations with current and future management.

Population	Current Resilience	Resilience after Management	Resilience after Logging	Resilience 2030	Resilience 2040	Resilience 2050	Resilience 2060	Resilience 2070
Ivory Mountain	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Clifty Creek	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Jock Creek	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Lookout Mountain	Low	Low	Low	Low	Low	Low	Low	Low
Browns Creek Branch	Low	Low	Low	Low	Low	Low	Low	Low
Mountain Longleaf NWR	Moderate	High	High	High	High	High	High	High
Union-Good Hope Delta Rd	Low	Low	Low	Low	Low	Low	Low	Low
Skyline WMA	Low	Low	Low	Low	Low	Low	Low	Low
Bankston	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Sawnee Mountain	Low	Moderate	Moderate	Low	Extirpated	Extirpated	Extirpated	Extirpated
Tallulah Gorge	Low	Low	Low	Low	Low	Low	Low	Low
Turkey Creek	Low	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Lee Mountain	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Moore Creek	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Neal Gap	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Pine Log Mountain	Low	Low	Low	Low	Low	Low	Low	Low
Big Canoe	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Low	Low
Lyons Landing	Low	Moderate	Moderate	Moderate	Moderate	Low	Extirpated	Extirpated
Bald Rock Uplands/ Marsh Branch	High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Hindsfield Ridge	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Flatwoods Uplands	High	High	High	High	High	Moderate	Low	Extirpated
Pine Creek Gorge	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Mount Victory Seeps	Very High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Barren Fork	Low	Low	Low	Low	Low	Low	Low	Low

Population	Current Resilience	Resilience after Management	Resilience after Logging	Resilience 2030	Resilience 2040	Resilience 2050	Resilience 2060	Resilience 2070
Pine Knot	Low	Low	Low	Low	Low	Low	Low	Low
Grove	Very High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Itawamba	Low	Low	Low	Low	Low	Low	Low	Low
Bear Creek	Low	Low	Low	Low	Low	Low	Low	Low
Glasgow	Very High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Greenville	Low	Low	Low	Low	Low	Low	Low	Low
Plantation Pond	Low	Low	Low	Low	Low	Low	Low	Low
Hwy 111	Moderate	Moderate	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Meadow Creek	Very High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Starr Mountain	High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Tar Kiln Ridge	High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Pitcher Ridge	Low	Low	Low	Low	Low	Low	Low	Low
Guntersville Lake	Low	Low	Low	Low	Low	Low	Low	Low
Sheeds Creek	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Prentice Cooper SF	Low	Low	Low	Low	Low	Low	Low	Low
N Fork Creek	Low	Low	Low	Low	Low	Low	Low	Low
Duncan Hollow	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Marion	Moderate	Moderate	Low	Low	Low	Low	Low	Low
Mooneyham	High	High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Southern Pine Plantation	High	High	Moderate	Moderate	Moderate	Moderate	Moderate	Low
Spencer Powerline	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Great Falls	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Lee Farm/Laurel Trail	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Centennial Wilderness WMA	Moderate	High	High	High	High	High	High	High
Falls Creek	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Bledsoe Powerline	Very High	Very High	High	High	High	High	High	High

6.3.2 Reduced Conservation Scenario

In the Reduced Conservation scenario, we predict 40 and 37 extant *P. integrilabia* populations in 2030 and 2070, respectively (Table 6.7). The predicted resilience of the extant populations in 2070 are as follows: Very High (4); High (4); Moderate (5); and Low (24) (Fig. 6.3). Number of extirpated populations exceeds status quo by only one; however, there are five more low resilience populations predicted in 2070 for Reduced Conservation scenario than for Status Quo scenario.

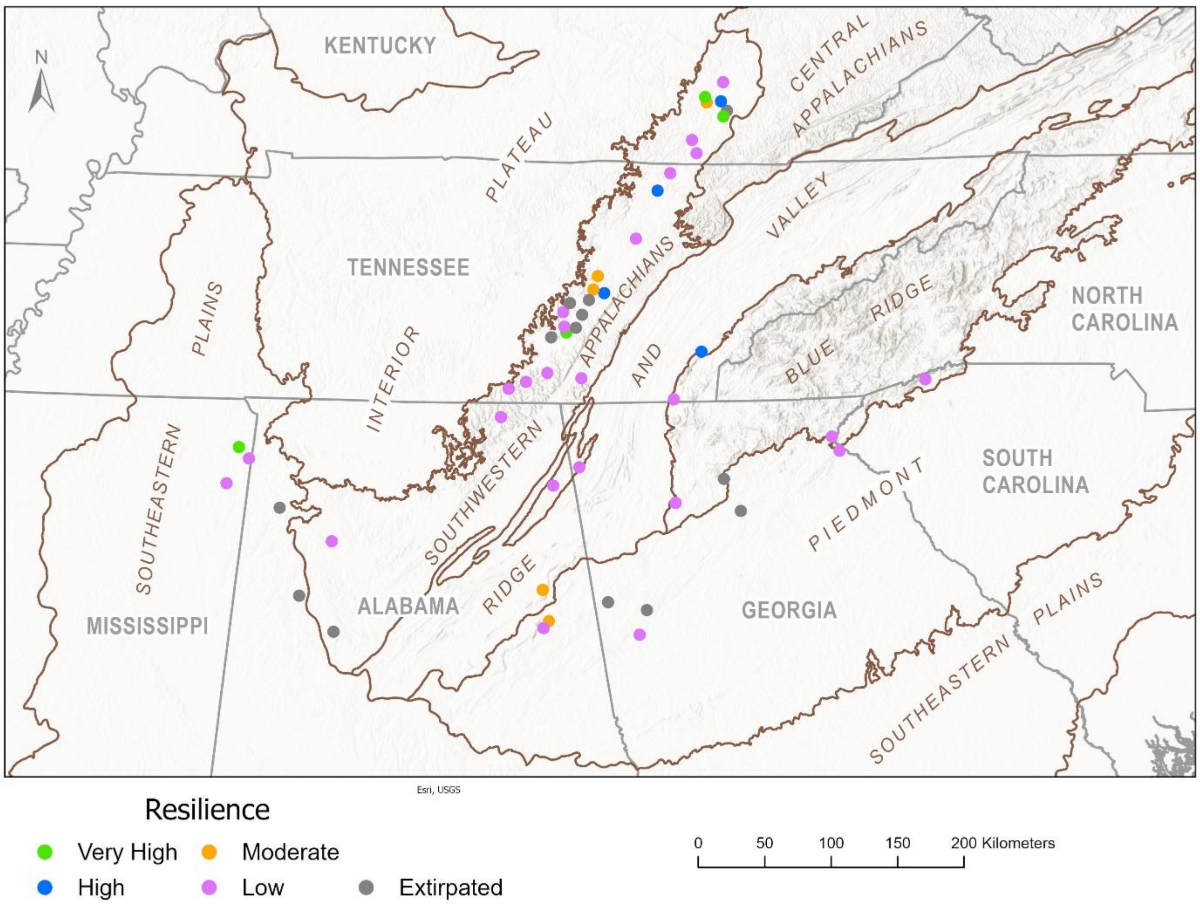

Figure 6.3. Predicted resilience levels of *Platanthera integrilabia* populations in 2070 using the Reduced Conservation scenario.

Table 6.7. Predicted resilience categories for the next 50 years for *Platanthera integrilabia* populations under the Reduced Conservation scenario compared to current resilience.

Population	Current Resilience	Resilience after Management	Resilience after Logging	Resilience 2030	Resilience 2040	Resilience 2050	Resilience 2060	Resilience 2070
Ivory Mountain	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Clifty Creek	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Jock Creek	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Lookout Mountain	Low	Low	Low	Low	Low	Low	Low	Low
Browns Creek Branch	Low	Low	Low	Low	Low	Low	Low	Low
Mountain Longleaf NWR	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Union-Good Hope Delta Rd	Low	Low	Low	Low	Low	Low	Low	Low
Skyline WMA	Low	Low	Low	Low	Low	Low	Low	Low
Bankston	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Sawnee Mountain	Low	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Tallulah Gorge	Low	Low	Low	Low	Low	Low	Low	Low
Turkey Creek	Low	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Lee Mountain	Low	Low	Low	Low	Low	Low	Low	Low
Moore Creek	Low	Low	Low	Low	Low	Low	Low	Low
Neal Gap	Low	Low	Low	Low	Low	Low	Low	Low
Pine Log Mountain	Low	Low	Low	Low	Low	Low	Low	Low
Big Canoe	Low	Low	Low	Low	Low	Low	Extirpated	Extirpated
Lyons Landing	Low	Low	Low	Low	Low	Extirpated	Extirpated	Extirpated
Bald Rock Uplands/Marsh Branch	High	High	High	High	High	High	High	High
Hindsfield Ridge	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Flatwoods Uplands	High	High	High	Moderate	Low	Extirpated	Extirpated	Extirpated
Pine Creek Gorge	Low	Low	Low	Low	Low	Low	Low	Low
Mount Victory Seeps	Very High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Barren Fork	Low	Low	Low	Low	Low	Low	Low	Low

Population	Current Resilience	Resilience after Management	Resilience after Logging	Resilience 2030	Resilience 2040	Resilience 2050	Resilience 2060	Resilience 2070
Pine Knot	Low	Low	Low	Low	Low	Low	Low	Low
Grove	Very High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Itawamba	Low	Low	Low	Low	Low	Low	Low	Low
Bear Creek	Low	Low	Low	Low	Low	Low	Low	Low
Glasgow	Very High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Greenville	Low	Low	Low	Low	Low	Low	Low	Low
Plantation Pond	Low	Low	Low	Low	Low	Low	Low	Low
Hwy 111	Moderate	Moderate	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Meadow Creek	Very High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Starr Mountain	High	High	High	High	High	High	High	High
Tar Kiln Ridge	High	High	High	High	High	High	High	High
Pitcher Ridge	Low	Low	Low	Low	Low	Low	Low	Low
Guntersville Lake	Low	Low	Low	Low	Low	Low	Low	Low
Sheeds Creek	Low	Low	Low	Low	Low	Low	Low	Low
Prentice Cooper SF	Low	Low	Low	Low	Low	Low	Low	Low
N Fork Creek	Low	Low	Low	Low	Low	Low	Low	Low
Duncan Hollow	Low	Low	Low	Low	Low	Low	Low	Low
Marion	Moderate	Moderate	Low	Low	Low	Low	Low	Low
Mooneyham	High	High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Southern Pine Plantation	High	High	Moderate	Moderate	Moderate	Moderate	Moderate	Low
Spencer Powerline	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Great Falls	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Lee Farm/Laurel Trail	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Centennial Wilderness WMA	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Falls Creek	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Bledsoe Powerline	Very High	Very High	High	High	High	High	High	High

6.3.3 Targeted Conservation Scenario

In the Targeted Conservation scenario, we predict 41 and 39 extant *P. integrilabia* populations in 2030 and 2070, respectively (Table 6.8). The predicted resilience of the extant populations in 2070 are as follows: Very High (7); High (4); Moderate (14); and Low (14) (Fig. 6.4). When comparing future population resilience to current condition 12 populations remain unchanged, 11 populations are extirpated, and 3 populations decrease in resilience: 1 high to low, 1 high to moderate, and 1 very high to high. Several populations improve in resilience: 3 high to very high, 2 moderate to high, and 10 low to moderate.

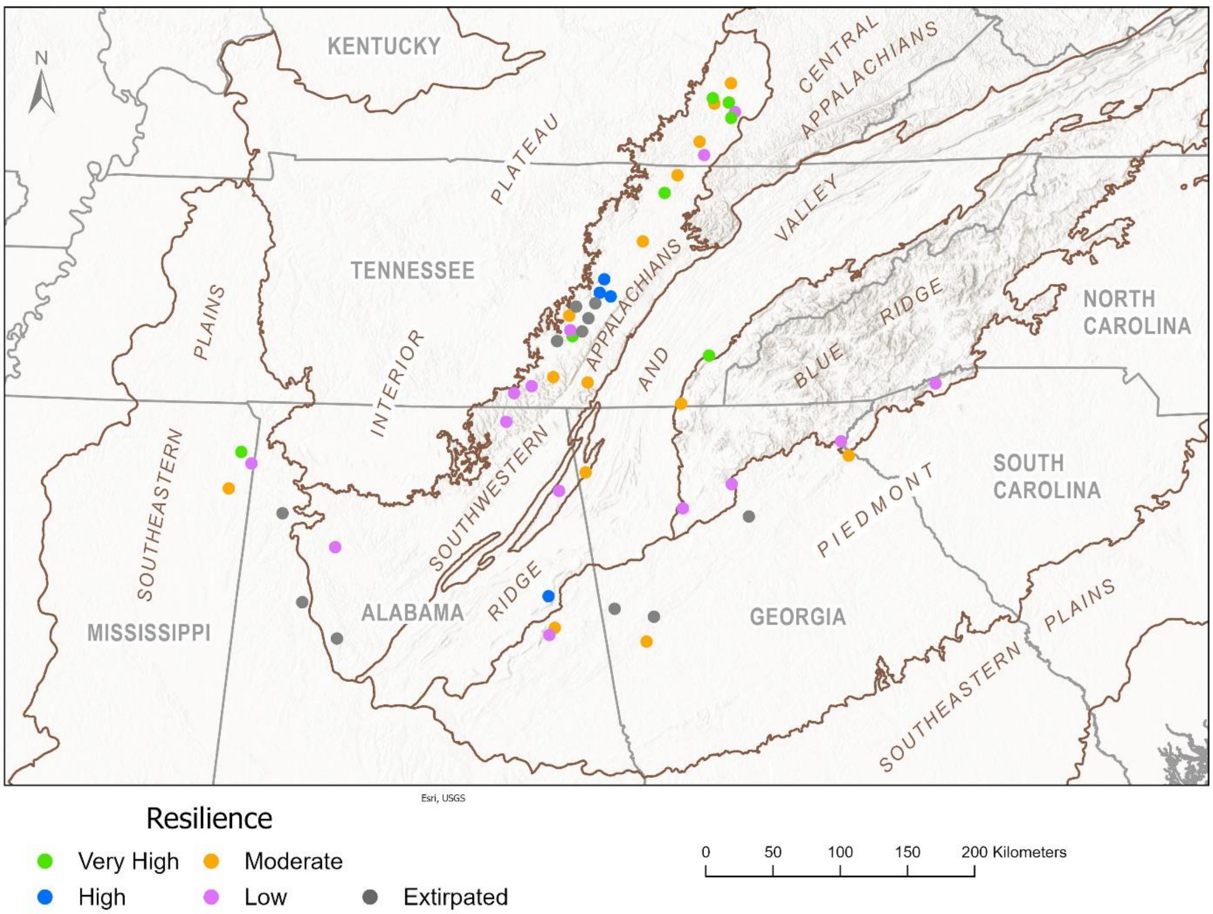

Figure 6.4. Predicted resilience levels of *Platanthera integrilabia* populations in 2070 using the Targeted Conservation scenario.

Table 6.8. Predicted resilience categories for the next 50 years for *Platanthera. integrilabia* populations under the Targeted Conservation scenario compared to current resilience. Blue shading on population names indicates populations with current (light blue) and predicted future (dark blue) management. Blacked out boxes indicated populations that are predicted to be extirpated.

Population	Current Resilience	Resilience after Management	Resilience after Logging	Resilience 2030	Resilience 2040	Resilience 2050	Resilience 2060	Resilience 2070
Ivory Mountain	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Clifty Creek	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Jock Creek	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Lookout Mountain	Low	Low	Low	Low	Low	Low	Low	Low
Browns Creek Branch	Low	Low	Low	Low	Low	Low	Low	Low
Mountain Longleaf NWR	Moderate	High	High	High	High	High	High	High
Union-Good Hope Delta Rd	Low	Low	Low	Low	Low	Low	Low	Low
Skyline WMA	Low	Low	Low	Low	Low	Low	Low	Low
Bankston	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Sawnee Mountain	Low	Moderate	Moderate	Low	Extirpated	Extirpated	Extirpated	Extirpated
Tallulah Gorge	Low	Low	Low	Low	Low	Low	Low	Low
Turkey Creek	Low	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Lee Mountain	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Moore Creek	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Neal Gap	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Pine Log Mountain	Low	Low	Low	Low	Low	Low	Low	Low
Big Canoe	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Low	Low
Lyons Landing	Low	Moderate	Moderate	Moderate	Moderate	Low	Extirpated	Extirpated
Bald Rock Uplands/Marsh Branch	High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Hindsfield Ridge	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Flatwoods Uplands	High	Very High	Very High	High	Moderate	Low	Low	Low
Pine Creek Gorge	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Mount Victory Seeps	Very High	Very High	Very High	Very High	Very High	Very High	Very High	Very High

Population	Current Resilience	Resilience after Management	Resilience after Logging	Resilience 2030	Resilience 2040	Resilience 2050	Resilience 2060	Resilience 2070
Barren Fork	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Pine Knot	Low	Low	Low	Low	Low	Low	Low	Low
Grove	Very High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Itawamba	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Bear Creek	Low	Low	Low	Low	Low	Low	Low	Low
Glasgow	Very High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Greenville	Low	Low	Low	Low	Low	Low	Low	Low
Plantation Pond	Low	Low	Low	Low	Low	Low	Low	Low
Hwy 111	Moderate	Moderate	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Meadow Creek	Very High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Starr Mountain	High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Tar Kiln Ridge	High	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Pitcher Ridge	Low	Low	Low	Low	Low	Low	Low	Low
Guntersville Lake	Low	Low	Low	Low	Low	Low	Low	Low
Sheeds Creek	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Prentice Cooper SF	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
N Fork Creek	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Duncan Hollow	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Marion	Moderate	High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Mooneyham	High	Very High	High	High	High	High	High	High
Southern Pine Plantation	High	Very High	High	High	High	High	High	Moderate
Spencer Powerline	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Great Falls	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Lee Farm/Laurel Trail	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Centennial Wilderness WMA	Moderate	High	High	High	High	High	High	High
Falls Creek	Low	Low	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated
Bledsoe Powerline	Very High	Very High	High	High	High	High	High	High

6.3.4 Summary: Future Scenarios

There are differences between future scenarios in the overall number of populations expected to be extant in 50 years; however, conservation efforts, if implemented, would likely improve resiliency levels for several populations in that time (Table 6.9). For example, the number of *P. integrilabia* populations with very high or high resilience levels increases and the number with low resilience decrease substantially for both Status Quo and Targeted Conservation scenarios (Table 6.9). Conversely, a majority of populations will have low resilience levels under the Reduced Conservation scenario (66%; Table 6.9) indicating that these populations may be at great risk for extinction if the timeline was extended beyond 50 years. Additionally, climate change impacts (e.g., warmer temperatures) will exacerbate pressures on populations with low resilience.

Table 6.9. Summary of resilience levels tallied across all *Platanthera integrilabia* populations for the current condition and future condition (in 50 years) under 3 future scenarios: Status Quo, Reduced Conservation, and Targeted Conservation.

Resilience Level	Current	Future - Status Quo	Future - Reduced Conservation	Future - Targeted Conservation
Very High	5	7	4	7
High	6	3	4	4
Moderate	6	9	5	14
Low	33	19	24	14
All	50	38	37	39

Even under Targeted Conservation, eight populations which occur at least partially on private lands are exposed to a high risk of logging and are projected to have low resilience levels or be extirpated in the future, particularly in Alabama and Tennessee (Fig. 6.5). In order to maintain connectivity and limit fragmentation of existing populations, populations on private property and protected lands in areas with a high risk of logging could be protected or managed to mediate the effects of nearby logging. Urban development risk is predicted to extirpate several *P. integrilabia* populations in Georgia under all future scenarios we considered (Figs. 6.2, 6.3, 6.4), despite ongoing management. It is unclear if the effects of urban encroachment (e.g., invasive species, altered hydrology, pollinator access) can be mediated given the predicted level of future urbanization for these areas; however, there are ongoing management efforts in many of the locations threatened by urbanization, particularly in Georgia (Table 4.1; Appendix B), which may mitigate future habitat degradation.

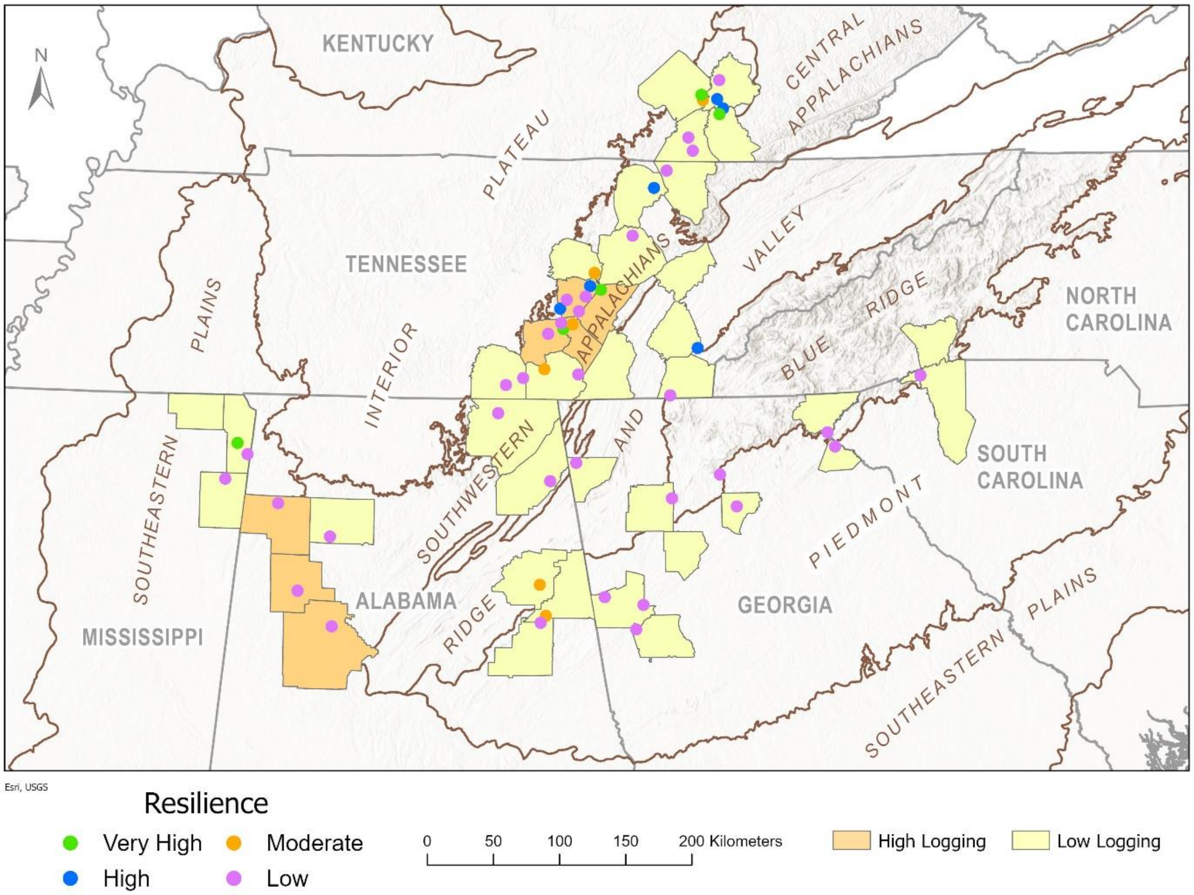

Figure 6.5. Current resilience level of *Platanthera integrilabia* populations and risk of logging within county.

6.4 Future Redundancy and Representation

Redundancy is expected to decrease compared to current condition under all scenarios (Table 6.10). Under the Reduced Conservation scenario, the number of extant populations decreases in the future compared to other scenarios and most of the remaining populations (65%) would have low resilience levels, decreasing redundancy compared to current conditions. The main cause for predicted loss of populations under the Status Quo and Reduced Conservation scenarios is the high risk of logging on private properties, specifically in the Southeastern Plains and Southwestern Appalachian ecoregions (Fig. 6.5).

Table 6.10. Number of extant *Platanthera integrilabia* populations in Level III Ecoregions in the current condition and three hypothetical future scenarios.

Ecoregion	Current	Future - Status Quo	Future - Reduced Conservation	Future - Targeted Conservation
Blue Ridge	6	6	5	6
Piedmont	7	4	4	4
Ridge and Valley	1	1	1	1
Southeastern Plains	5	3	3	3
Southwestern Appalachians	31	24	24	25
All	50	38	37	39

Climate assessments predict higher temperature, more drought events, and increasing occurrences of extreme rain events (i.e., flooding) across the range of *P. integrilabia* (*see* Section 4.5 for details). *P. integrilabia* are considered 'Extremely' or 'Highly vulnerable' to climate impacts in the next 50 years due to their dependence on narrowly defined hydrologic conditions as well as natural and anthropogenic barriers to dispersal (C. Kwit 2019, UT, pers. comm.; Glick *et al.* 2015, p. 16). These impacts will likely impact populations in the Piedmont, Southeastern Plains, and Blue Ridge the most due to low resilience of the majority of the populations that occur in those ecoregions, where representation could be lost if more protection and management are not implemented to increase population resiliency.

Many of the EOs included in the future condition scenarios may not be currently viable (see Section 5 and Appendix A) but were included to be conservative for recovery planning. Several EOs classified as "uncertain" in the listing rule (81 FR 62826) were grouped with extant EOs when delineating populations for this SSA, perhaps indicating a higher probability that *P. integrilabia* could be reconfirmed at the "uncertain" locations. For example, in Kentucky several EOs in the Bald Rock Uplands sites were considered "uncertain" in the listing rule but occur within close proximity to confirmed extant EOs (Appendix A). Those EOs considered "uncertain" in the listing rule because no flowering plants had been observed in recent history (i.e., basal leaves only) and that occur in ecoregions with lower levels of redundancy (i.e., Ridge and Valley, Piedmont, Southeastern Plains) could be prioritized for determining their definite status and, as needed, management to induce flowering. Populations encompassing these uncertain EOs in less represented ecoregions include: Clifty Creek (AL), Bear Creek (MS), Itawamba (MS), Greenville (SC), and Sawnee Mountain (GA).

This concludes our assessment of *P. integrilabia* needs, current condition, and future condition under three plausible scenarios. As *P. integrilabia* is a recently listed species, this SSA will follow the species through its ESA life cycle, including recovery planning, consultations, and all policy-related decision-making until recovery and eventual delisting. To better assess the status of the species in the future, regular monitoring of populations and habitat is needed, and this SSA should be updated as new information becomes available. A monitoring protocol should be developed to ensure consistent methods are used across the species' range, including collection of data on threats, management, and habitat conditions, to enable analysis of population growth rates and factors influencing them.   New research regarding pollinators and their behavior, seed ecology, mycorrhizal fungus specificity and distribution, and best management practices for *P. integrilabia* populations would greatly enhance future conservation efforts and inform management needed to hasten the recovery of the species.

LITERATURE CITED

Atlanta Botanical Garden. 2016. Urban Atlanta wetland restoration and rare species recovery. Unpublished report to National Fish and Wildlife Foundation, Five Star Restoration Grant Program. 75 pp.

Alabama Natural Heritage Program (ANHP). 2018. Element occurrence data for white fringeless orchid. Unpublished GIS data from Alabama Natural Heritage Program, Auburn University. Update received December 19, 2018.

Allendorf, F. W., and G. Luikart. 2007. *Conservation and the Genetics of Populations.* Blackwell Publishing, Malden, Massachusetts. 642 pp.

Arditti, J. and A. K. A. Ghani. 2000. Numerical and physical properties of orchid seeds and their biological implications. New Phytology 145:367-421.

Argue, C. L. 2012. The Pollination Biology of North American Orchids: Volume 1, North of Florida and Mexico. Springer, New York, New York. 228 pp.

Barrett, S. C. H and J. R. Kohn. 1991. Genetic and evolutionary consequences of small population size in plants: implications for conservation. pp. 3-30 In: *Genetics and Conservation of Rare Plants,* D. A. Falk and K. E. Holsinger (eds.). Oxford University Press, New York, New York. 283 pp.

Barrios-Garcia, M. N. and S. A. Ballari. 2012. Impact of wild boar (*Sus scrofa*) in its introduced and native range: a review. Biological Invasions 14:2283-2300.

Batzer, D. P. and R. R. Sharitz. 2006. An Introduction. In: Batzer, D. P. and R. R. Sharitz (ed) Ecology of Freshwater and Estuarine Wetlands, 1st ed. University of California Press, Berkley, California pp.1-5.

Bayman, P., E. J. Gonzalez, J. J. Fumero, and R. L. Tremblay. 2002. Are fungi necessary? How fungicides affect growth and survival of the orchid *Lepanthes rupestris* in the field. Journal of Ecology 90:1002-1008.

Belyea, C. M. and A. J. Terrando. 2013. Urban growth modeling for the SAMBI Designing Sustainable Landscapes Project. North Carolina State University. http://www.basic.ncsu.edu/dsl/urb.html. Accessed 10 January 2019.

Birchenko, I. V. 2001. Genetic diversity and microsite characterization of the rare "Monkeyface Orchid", *Platanthera integrilabia* (Orchidaceae), in the southeastern United States. *Thesis.* Ohio University, Athens, Ohio. 61 pp.

Boyd, J. N., G. A. Raymond, G. P. Call, and M. J. Pistrang. 2016. Ecophysiological performance of the rare terrestrial orchid *Platanthera integrilabia* across contrasting habitats. Plant Ecology 217:1259-1272.

Brzosko, E., B. Ostrowiecka, J. Kotowicz, M. Bolesta, A. Gromotowicz, M. Gromotowicz, A. Orzechowska, J. Orzoloek, and M. Wojdalska. 2017. Seed dispersal in six species of terrestrial orchids in Biebrza National Park (NE Polan). Acta Societatis Botanicorum Poloniae 86:1-14.

Chowdhury, B. 2018. Email correspondence with Geoff Call, Biologist, U.S. Fish and Wildlife Service, re: pollinator research with listed species. December 18, 2018.

Chung, M. Y., J. D. Nason, and M. G. Chung. 2005. Spatial genetic structure in populations of the terrestrial orchid *Orchis cyclochila* (Orchidaceae). Plant Systematics and Evolution 254:209-219.

Clatterbuck, W. K. and L. Ganus. 1999. Tree Crops for Marginal Farmland – Loblolly Pine, With a Financial Analysis. Agricultural Extension Service, University of Tennessee, Publication 1466. Knoxville, Tennessee. 18 pp.

Correll, D. S. 1941. Two new American orchids. Harvard University Botanical Museum Leaflet 9:152-157.

Cruse-Sanders, J. 2019. Peer review comments for Draft SSA for White Fringeless Orchid (*Platanthera integrilabia*). Director, State Botanical Garden of Georgia, Athens, Georgia. Received July 27, 2019.

Currah, R. S., L. W. Zettler, and T. M. McInnis. 1997. *Epulorhiza inquilina* sp. nov. from *Platanthera* (Orchidaceae) and a key to *Epulorhiza* species. Mycotaxon 61:335-342.

Estok, D., B. Freedman, and D. Boyle. 1989. Effects of the herbicide 2,4-D, glyphosate, hexazinone, and triclopyr on the growth of three species of ectomycorrhizal fungi. Bulleting of Environmental Contamination and Toxicology 42:835-839.

Fenneman, N. M. 1938. *Physiography of the Eastern United States*. McGraw-Hill Book Company, New York, New York. 714 pp.

Georgia Department of Natural Resources (GDNR). 2018. Element occurrence data for white fringeless orchid. Unpublished GIS data from Georgia Department of Natural Resources, Wildlife Resources Division. Received December 20, 2018.

Glick, P., S. R. Palmer, and J. P. Wisby. 2015. *Climate Change Vulnerability Assessment for Tennessee Wildlife and Habitats*. Report prepared by the National Wildlife Federation and The Nature Conservancy – Tennessee for the Tennessee Wildlife Resources Agency, Nashville, Tennessee. 108 pp.

Greene, B. T., and B. Blossey. 2012. Lost in the weeds: *Ligustrum sinense* reduces native plant growth and survival. Biological Invasions 14:139-150.

Helmich, R. E., E. E. Bahler, and L. W. Zettler. 2017. Viability of orchid endophytes in prolonged cool (4-6°C) storage. Poster presentation of unpublished data.

Hoy, C. 2012. A hydrologic characterization of three headwater mountain wetlands in eastern Kentucky, USA. Theses and Dissertations—Forestry, Paper 5, University of Kentucky. April 9, 2012. 85 pp. http://unkowledge.uky.edu/forestry_etds/5.

Integrated Taxonomic Information System. 2019. ITIS standard report page: *Platanthera integrilabia*. Retrieved online August 7, 2019 at https://www.itis.gov.

IPCC. 2007. Fourth Assessment Report, Climate Change 2007: Synthesis Report Summary for Policymakers. Released on 17 November 2007/ Available online at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

Jantz, C. A., S. J. Goetz, D. Donato and P. Claggett. 2010. Designing and Implementing a Regional Urban Modeling System Using the SLEUTH Cellular Urban Model. Computers, Environment and Urban Systems 34:1-16.

Johnson, S. D., E. Torninger, and J. Agren. 2009. Relationships between population size and pollen fates in a moth-pollinated orchid. Biology Letters 5:282-285.

Karl, T. R., J. M. Melillo, and T. C. Peterson (eds.). 2009. Global Climate Change Impacts in the United States. Cambridge University Press. 190 pp. Available online at http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/full-report.

Knapp, W.M. and R. Wiegand. 2014. Orchid (Orchidaceae) decline in the Catoctin Mountains, Frederick County, Maryland as documented by a long-term dataset. Biodiversity and Conservation 23:1965-1976.

Kourtev, P. S., J. G. Eherenfeld, and M. Häggblom. 2002. Exotic plant species alter the microbial community structure and function in the soil. Ecology 83:3152-3166.

Kunkel, K. E., L. E. Stevens, S. E. Stevens, L. Sun, E. Janssen, D. Weubbles, C. E. Konrad, C. M. Fuhrmann, B. D. Keim, M. C. Kruk, A. Billot, H. Needham, M. Shafer, and J. G. Dobson. 2013. Regional climate trends and scenarios for the U.S. national climate assessment. Part 2: climate of the southeast United States. NOAA Technical Report NESDIS 142-2. 103 pp.

Kwit, C. 2018. Email to Geoff Call, Biologist, U.S. Fish and Wildlife Service re: CCVI for Cumberland sandwort (including information on other listed plants in Tennessee). Assistant Professor, Department of Forestry, Wildlife and Fisheries, University of Tennessee. June 26, 2018.

Lallemand, F., T. Figura, C. Damesin, C. Fresneau, C. Griveau, N. Fontaine, B. Zeller, and M. Selosse. 2019. Mixotrophic orchids do not use photosynthates for perennial underground organs. New Phytologist 221: 12-17.

Littlefield, T. 2015. White Fringeless Orchid (*Platanthera integrilabia*) monitoring and searching for new populations. Unpublished report to the U.S. Fish and Wildlife Service, Federal Aid Office, Region 4, Atlanta, Georgia. 17 pp.

Littlefield, T. 2017. Monitoring of the federally threatened *Platanthera integrilabia* (white fringeless orchid); and select at risk-globally rare species [*Cypripedium kentuckiense* (Kentucky ladyslipper)]. Section 6 Program Report to U.S. Fish and Wildlife Service, Atlanta, Georgia, Project# - KY-E-F16AP0844 (E-1-31). Prepared by Kentucky State Nature Preserves Commission, Frankfort, Kentucky. 9 pp.

Littlefield, T. 2019. Email to Kathryn N. Smith, Texas A&M University-Natural Resources Institute, re: SSA Review. Botanist, Kentucky Energy and Environment. March 20, 2019.

Luer, C. A. 1975. The Native Orchids of the United States and Canada excluding Florida. The New York Botanical Garden. New York, New York.

McGrath, D. A., and M. A. Binkley. 2009. *Microstegium vimineum* invasion changes soil chemistry and soil microarthropod communities in Cumberland Plateau forests. Southeastern Naturalist 8:141-156.

McGrath, D. A., J. P. Evans, C. K. Smith, D. G. Haskell, N. W. Pelkey, R. R. Gottfried, C. D. Brockett, M. D. Lane, and E. D. Williams. 2004. Mapping land-use change and monitoring the impacts of hardwood-to-pine conversion on the southern Cumberland Plateau in Tennessee. Earth Interactions 8:1-24.

Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP). 2014. Element occurrence data for white fringeless orchid. Unpublished GIS data from Mississippi Department of Wildlife, Fisheries, and Parks, Natural Heritage Program. Received November 20, 2014.

Mitsch, W. J. and J. G. Gosselink. 2000. *Wetlands*. Third Edition. John Wiley & Sons, New York, New York. 920 pp.

Nathan, R. 2006. Long-distance dispersal of plants. Science 313:786-788.

National Land Cover Data (NLCD). 2011. U.S. Geological Survey, Sioux Falls, South Dakota. Available https://www.mrlc.gov/data. Accessed 22 January 2019.

NatureServe. 2004. A habitat-based strategy for delimiting plant element occurrences: Guidance from the 2004 working group. Available http://www.natureserve.org/library/deliminting_plant_eos_Oct_2004.pdf. Accessed 15 November 2018.

NatureServe. 2008. Ranking species occurrences- A generic approach. Available http://explorer.natureserve.org/eorankguide.htm. Accessed 13 December 2018.

North Carolina Department of Environment and Natural Resources (NCDENR). 2014. Element occurrence data for white fringeless orchid. Unpublished GIS data from North Carolina Department of Environment and Natural Resources, Natural Heritage Program.

Office of Kentucky Nature Preserves (OKNP). 2019. Element occurrence data for white fringeless orchid. Unpublished GIS data from Office of Kentucky Nature Preserves, Natural Heritage Program. Received February 19, 2019.

Omernik, J. M. 1987. Ecoregions of the conterminous United States. Map (scale 1:7,500,00). Annals of the Association of American Geographers 77:118-125.

Patrick, T. S., J. R. Allison, and G. A. Krakow. 1995. Protected Plants of Georgia: An information manual on plants designated by the State of Georgia as endangered, threatened, rare, or unusual. Georgia Department of Natural Resources, Wildlife Resources Division.

Patrick, T. 2012. Email to Geoff Call, Biologist, U.S. Fish and Wildlife Service re: updates for white fringeless orchid Candidate Notice of Review. Botanist, Georgia Department of Natural Resources. February 15, 2012.

Primack, R. B. 1998. *Essentials of Conservation Biology*. Sinauer Associates, Sunderland, Massachusetts. 660 pp.

Rasmussen H. N. and D. F. Whigham. 1993. Seed ecology of dust seeds in situ: a new study technique and its application in terrestrial orchids. American Journal of Botany 80:1374-1378.

Richards, M. 2013. Email to Mincy Moffett, Biologist, Georgia Department of Natural Resources re: annual request for data to update status of *Platanthera integrilabia*. Conservation Coordinator, Atlanta Botanical Garden, April 03, 2013.

Schotz, A. 2015. An update on the status of *Platanthera integrilabia (*Correll) Luer (Orchidaceae), the white fringeless orchid, in Alabama. Unpublished report from Alabama Natural Heritage Program to the U.S. Fish and Wildlife Service, Cookeville, Tennessee. 38 pp.

Scott, D. F. 2005. On the hydrology of industrial timber plantations. Hydrological Processes 19:4203-4206.

Shea, M. 1992. Status Survey Report on *Platanthera integrilabia*. Unpublished report to the U.S. Fish and Wildlife Service, Southeast Region. 152 pp.

Sheviak, C. J. 1990. Biological considerations in the management of temperate terrestrial orchids. Pages 194-196 in R. S. Mitchell, C. J. Sheviak, and D. J. Leopold, editors. *Ecosystem Management: Rare Species and Significant Habitats.* New York State Museum Bulletin Number 471.

Smith, S. E. and D. J. Read. 2008. Mycorrhizal Symbiosis. Third edition. Academic Press, Cambridge. 803 pp.

South Carolina Department of Natural Resources (SCDNR). 2012. Element occurrence data for white fringeless orchid. Unpublished GIS data from South Carolina Department of Natural Resources, Natural Heritage Program. Received March 2012.

Sullivan, H. 2014. Email to Geoff Call, Biologist, U.S. Fish and Wildlife Service, re: white fringeless orchid in Mississippi. Botanist, Mississippi Natural Heritage Program. November 20, 2014.

Sutton, F. M. and J. W. Morgan. 2009. Functional traits and prior abundance explain native plant extirpation in a fragmented woodland landscape. Journal of Ecology 97:718-727.

Stine, M. B., L. M. Resler, and J. B. Campbell. 2011. Ecotone characteristics of a southern Appalachian mountain wetland. Catena 86:57-65.

Swartz, N. D. and K. W. Dixon. 2009. Terrestrial orchid conservation in the age of extinction. Annals of Botany 104:543-556.

Taylor, D. 2014. Email to Geoff Call, Biologist, U.S. Fish and Wildlife Service, re: white fringeless orchid at Daniel Boone National Forest. Botanist, U.S. Forest Service. September 22, 2014.

Taylor, D. 2018. Email to Kathryn N. Smith, Texas A&M University-Natural Resources Institute. re: White Fringeless Orchid draft biology/species needs. November 29, 2018.

Taylor, D. 2019. Email to Kathryn N. Smith, Texas A&M University-Natural Resources Institute. re: Full Draft WFO SSA. March 4, 2019.

Tennessee Department of Environment and Conservation (TDEC). 2008. Present status of the known *Platanthera integrilabia* occurrences in Tennessee. Unpublished report from Tennessee Department of Environment and Conservation, Division of Natural Areas, to U.S. Fish and Wildlife Service, Cookeville, Tennessee. 18 pp.

Tennessee Department of Environment and Conservation. 2012. Monitoring of select *Platanthera integrilabia* (white fringeless orchid) populations in Tennessee. Unpublished report from Tennessee Department of Environment and Conservation, Division of Resource Management, to U.S. Fish and Wildlife Service, Cookeville, Tennessee. November 2012. 8 pp.

Tennessee Department of Environment and Conservation. 2018. Element occurrence data for white fringeless orchid. Unpublished GIS data from Tennessee Department of Environment and Conservation, Division of Natural Areas, Natural Heritage Program. Received November 11, 2018.

Terando, A. J., J. Costanza, C. Belyea, R. R. Dunn, A. McKerrow, and J. A. Collzo. 2014. The southern megalopolis: using the past to predict the future of urban sprawl in the southeast U.S. PLOS ONE 9:e102261 doi:10.1371/journal.pone.0102261

United States Forest Service. 2008. Fiscal Year 2007 Monitoring and Evaluation Annual Report for the Revised Land and Resource Management Plan, Cherokee National Forest. Unpublished report by U.S. Department of Agriculture, Forest Service, Southern Region. September 2008. 95 pp.

U.S. Fish and Wildlife Service. 2016. USFWS species status assessment framework: an integrated analytical framework for conservation. Version 3.4.8, August 2016.

Vitousek, P.M. 1990. Biological invasions and ecosystem processes: towards an integration of population biology and ecosystem studies. In: *Ecosystem Management* Springer, New York, New York pp. 183-191.

Warren II, R.J, I.M. Rossell, K.K. Moorhead, and J.D. Pittillo. 2007. The influence of woody encroachment upon herbaceous vegetation in a southern Appalachian wetland complex. American Midland Naturalist 157:39-51.

Weakley, A.S. and M.P. Schafale. 1994. Non-alluvial wetlands of the southern Blue Ridge—diversity in a threatened ecosystem. Water, Air, and Soil Pollution 77:359-383.

Willi, Y., J. Van Buskirk, and M. Fischer. 2005. A threefold genetic Allee effect: population size affects cross-compatibility, inbreeding depression and drift load in the self-incompatible *Ranunculus reptans*. Genetics 169: 2255-2265.

Wolfe, B.E. and J.N. Klironomos. 2005. Breaking new ground: soil communities and exotic plant invasion. BioScience 55:477-487.

Wolfe, B.E., V.L. Rodgers, K.A. Stinson, and A. Pringle. 2008. The invasive plant *Alliaria petiolata* (garlic mustard) inhibits ectomycorrhizal fungi in its introduced range. Journal of Ecology 96:777-783.

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.

Wooten, S., G. Call, A. Dattilo, J. Cruse-Sanders, and J. N. Boyd. 2020. Impacts of forest thinning and white-tailed deer herbivory on translocation of the rare terrestrial orchid *Platanthera integrilabia*. Diversity 12:412-428.

Yoder, J.A., S.M. Imfeld, D.J. Heydinger, C.E. Hart, M.H. Collier, K.M. Gribbins, and L.W. Zettler. 2010. Comparative water balance profiles of Orchidaceae seeds for epiphytic and terrestrial taxa endemic to North America. Plant Ecology 211:7-17.

Young, B., E. Byers, K. Gravuer, K. Hall, G. Hammerson, and A. Redder. 2011. Guidelines for using NatureServe Climate Change Vulnerability Index, Release 2.1. NatureServe Arlington, Virginia 63 pp.

Young, B.E., S. Auer, M. Ormes, G. Rapacciuolo, D. Schweitzer, and N. Sears. 2017. Are pollinating hawk moths declining in the northeastern United States? An analysis of collection records. PLOS One 12:1-20.

Zaller, J.G., F. Heigl, L. Ruess, and A. Grabmaier. 2014. Glyphosate herbicide affects belowground interactions between earthworms and symbiotic mycorrhizal fungi in a model system. Scientific Reports 4:5634.

Zettler, L. W. 1994. Extinction in our own back yard. American Orchid Society Bulletin 1994:686-688.

Zettler, L.W. 2018. Email to Kathryn N. Smith, Texas A&M University-Natural Resources Institute. Re: White Fringeless Orchid draft biology/species needs. December 10, 2018.

Zettler, L. W. and J. E. Fairey, III. 1990. The status of *Platanthera integrilabia*, an endangered terrestrial orchid. Lindleyana 5:212-217.

Zettler, L. W. and T. M. McInnis, Jr. 1992. Propagation of *Platanthera integrilabia* (Correll) Luer, an endangered terrestrial orchid through symbiotic seed germination. Lindleyana 7:154-161.

Zettler, L. W., T. M. McInnis, Jr., and J. S. Ahuja. 1996. Insect pollination of the endangered monkey-face orchid (*Platanthera integrilabia*) in McMinn County, Tennessee: one last glimpse of a once common spectacle. Castanea 61:14-24.

APPENDIX A.
Platanthera integrilabia element occurrences (EOs), assigned population, location, EO Rank, and most recent (i.e., last recorded) dates on which the EO was ranked, visited, observed with plants extant, observed with plants flowering, and status in the listing Rule (81 FR 62826). Green EOs indicate those included in Species Status Assessment analyses.

EO ID	EO Number	Population	State	County	Owner	Site Name	EO Rank	EO Rank Date	Last Visited	Last Time Observed	Last Observed Flowering	Status in Listing Rule
637	8	Ivory Mountain	AL	Cleburne	USFS	Ivory Mountain	B	2014	2014	2014	2014	Extant
2257	6	Mountain Longleaf NWR	AL	Calhoun	DoD	Caffey Hill	D	2012	2017	2012	2012	Extant
3830	5	Mountain Longleaf NWR	AL	Calhoun	DoD	Marchetta Seep	E	1993	2018	2018	2018	Extant
3900	1	Clifty Creek	AL	Marion	Private	Dry Branch	C	1991	2014	2014	1991	Uncertain
4384	2	Jock Creek	AL	Tuscaloosa	Private	Jock Creek	C	1991	2014	2014	2014	Extant
8314	4		AL	Jackson	Alabama	Skyline WMA	F	2013	2013	1992	1992	Uncertain
8716	3	Browns Creek Branch	AL	Winston	Private	Browns Creek Branch	C	2013	2013	2013	2013	Extant
9405	9	Union-Good Hope Delta Rd	AL	Clay	Private	Union-Good Hope Delta Rd	C	2013	2015	2015	2015	Extant
9578	10		AL	Marion		Bear Creek	H	2012	2012	1957		Uncertain
9579	11	Lookout Mountain	AL	DeKalb	Federal (TVA)	Lookout Mnt TVA powerline ROW	C	2014	2014	2014	2014	Extant
9580	12	Clifty Creek	AL	Marion	Private	Clear Running Branch Bog	B	2014	2014	2014	2005	Extant
9831	13		AL	Clay	USFS	Lake Chinnabee	H	1982	1982	1982		N/A
10558	14	Union-Good Hope Delta Rd	AL	Clay	USFS	County Rd 512	B	2020	2020	2020	2020	N/A
10559	15	Skyline WMA	AL	Jackson	ADCNR	Skyline WMA	C	2020	2020	2020	2020	N/A
10562	16	Skyline WMA	AL	Jackson	Private	Hytop	C	2020	2020	2020	2020	N/A
10657	17	Ivory Mountain	AL	Cleburne	USFS	Ivory Mountain 2	C	2020	2020	2020	2020	N/A
10658	18	Bankston	AL	Fayette	Private	Boxes Creek	B	2020	2020	2020	2020	N/A
10659	19	Bankston	AL	Fayette	Private	Davis Creek	C	2020	2020	2020	2020	N/A
10660	20	Bankston	AL	Fayette	Private	Bankston	B	2020	2020	2020	2020	N/A
132	7		GA	Carroll		Wolf Creek	H	1992	1990	1990		Historical
1981	9	Lyons Landing	GA	Carroll	Private	Lyons Landing	BC	1992	2016	2016	2016	Extant
2305	5	Sawnee Mountain	GA	Forsyth	Private and Forsyth Co	Sawnee Mountain	D	2011	2017	2017	2017	Uncertain

EO ID	EO Number	Population	State	County	Owner	Site Name	EO Rank	EO Rank Date	Last Visited	Last Time Observed	Last Observed Flowering	Status in Listing Rule
3687	1	Turkey Creek	GA	Carroll	Private	Turkey Creek	C	2013	2013	2013	2013	Extant
6971	3	Lee Mountain	GA	Stephens	USFS	Lee Mountain	D	2013	2013	2013	1990	Extant
8813	6	Moore Creek	GA	Coweta	Private	Moore Creek	CD	2013	2017	2017	2017	Extant
10400	4		GA	Cobb		Blackjack Mountain	X	1992	1989	1989	1989	Extirpated
11021	8	Neal Gap	GA	Chattooga	GA DOT	Lookout Mountain (Neal Gap)	D	1992	2017	2016	2016	Extant
11258	2	Tallulah Gorge	GA	Rabun		Tallulah Gorge	AB	1992	2014	2014	2014	Extant
16659	10	Pine Log Mountain	GA	Bartow		Pine Log Mountain	C	2014	2016	2016	2014 (low flowering)	Extant
19166	12	Moore Creek	GA	Coweta	GA DNR	Chattahoochee Bend State Park			2017	2017	2017	Introduced in 2013
17494	11	Big Canoe	GA	Pickens	Private	Big Canoe	C	2012	2018	2017	2017	Extant
12123	001A	Barren Fork	KY	McCreary	USFS	Barren Fork/Big Creek Streamheads-A	C	2013	1997	1997	1991	Uncertain
12123	001C	Barren Fork	KY	McCreary	USFS	Barren Fork/Big Creek Streamheads-C	CD	2013	2018	2018	2007	Uncertain
12123	001B		KY	McCreary	USFS	Barren Fork/Big Creek Streamheads-B	H	2013				Extant
6901	002A	Hindsfield Ridge	KY	Pulaski	USFS	Hindsfield Ridge-A	H	2008	2015	2015		Uncertain
6901	002B	Hindsfield Ridge	KY	Pulaski	USFS	Hindsfield Ridge-B	CD	2008	2018	2018	2015	Extant
3459	003A		KY	McCreary/ Whitley	Kentucky	Cumberland Falls	H	1949		1949		Historical
9722	004A		KY	McCreary		Isham Streamheads	F	2010	2018	1927		Historical
6576	005A	Hindsfield Ridge	KY	Pulaski	Powerline	Hindsfield Ridge-C	X	2008	2007	1998	1998	Extirpated
9084	006A	Bald Rock Uplands/Marsh Branch	KY	Laurel	USFS	Bald Rock Uplands-A	B	2008	2018	2018	2018 (low flowering)	Extant
9084	006B	Bald Rock Uplands/Marsh Branch	KY	Laurel	USFS	Bald Rock Uplands-B	B	2008	2018	2018		Uncertain
9084	006C	Bald Rock Uplands/Marsh Branch	KY	Laurel	Powerline	Bald Rock Uplands-C	B	2008	2018	2018	2018	Extant
9084	006D	Bald Rock Uplands/Marsh Branch	KY	Laurel	USFS	Bald Rock Uplands-D	B	2008	2018	2018	1998	Uncertain
9084	006E	Bald Rock Uplands/Marsh Branch	KY	Laurel	USFS	Bald Rock Uplands-E	B	2008	2018	2018	1995	Uncertain
9084	006F	Bald Rock Uplands/Marsh Branch	KY	Laurel	USFS	Bald Rock Uplands-F	B	2008	2018	1998	1998	Uncertain

EO ID	EO Number	Population	State	County	Owner	Site Name	EO Rank	EO Rank Date	Last Visited	Last Time Observed	Last Observed Flowering	Status in Listing Rule
9084	006G	Bald Rock Uplands/Marsh Branch	KY	Laurel	USFS	Bald Rock Uplands-G	B	2008	2018	2018	2007	Extant
974	007A	Pine Knot	KY	McCreary		Pine Knot Job Corps Streamheads-A	C	2008	2018	2018	2007	Extant
974	007B	Pine Knot	KY	McCreary		Pine Knot Job Corps Streamheads-B	C	2008	2018	2018	2013 (low flowering)	Extant
5488	011A		KY	Pulaski	USFS	Hindsfield Ridge	X	1998	2007	1992		Extirpated
4656	014A	Pine Creek Gorge	KY	Laurel		Pine Creek Gorge	D	2010	2013	2013	1997	Uncertain
7423	016A		KY	Laurel		Flatwoods Uplands-A	F	1997	2013	1997	1997 (low flowering)	Extirpated
586	017A	Flatwoods Upland	KY	Laurel		Flatwoods Uplands-B	BC	2010	2015	2015	2015	Extant
8989	018A	Grove	KY	Whitley		Grove-A	B	2008	2018	2018	2018 (low flowering)	Extant
8989	018B	Grove	KY	Whitley		Grove-B	B	2008	2008	2008	2004	Extant
2601	019A	Mount Victory Seeps	KY	Pulaski		Mount Victory Seeps-A	A	2008	2018	2018	2018	Extant
2601	019B	Mount Victory Seeps	KY	Pulaski		Mount Victory Seeps-B	A	2008	2018	2018	2018	Extant
2601	019C	Mount Victory Seeps	KY	Pulaski		Mount Victory Seeps-C	B	2008	2018	1998	1998	Uncertain
5611	2		MS	Alcorn	Private		H	1995	1863	1863		Uncertain
9106	3	Glasgow	MS	Tishomingo	Private	Glasgow	B	1995	1995	1995	1995	Extant
10075	4	Bear Creek	MS	Tishomingo	Private	Bear Creek	unavailable		2010	2010		Uncertain
10402	5	Itawamba	MS	Itawamba	Private	Mud Branch	unavailable		2014	2011	2011	Uncertain
10403	6	Itawamba	MS	Itawamba	Powerline ROW	Saucer Creek	unavailable		2013	2013	2013	Extant
10442	7	Itawamba	MS	Itawamba	Mississippi	John Bell Williams WMA	N/A		2014	2014	2014	Extant
8703	1		MS	Tishomingo	Private	Yellow Creek Nuclear Power Plant Site	H	1974	1974	1974		Extirpated
14024	1		NC	Henderson		East Flat Rock Bog	X	1989	1937	1937		Extirpated
4575	2		NC	Cherokee		Pocosin Bog	X	1935	1935	1935		N/A
11656	3		NC	Henderson	Private	Bat Fork Bog	X	1992	1992	1992		Extirpated
6732	4		NC	Henderson	North Carolina	Laurel Branch	H	1966	1966	1966		Historical
8961	1	Greenville	SC	Greenville			U		2002	2002		Uncertain
5981	1		TN	Grundy	Private	Cordell Woodlot	H	2011	2011	2000		Historical

EO ID	EO Number	Population	State	County	Owner	Site Name	EO Rank	EO Rank Date	Last Visited	Last Time Observed	Last Observed Flowering	Status in Listing Rule
12102	2		TN	Grundy	Tennessee	Caruenger Creek Site	E	2014	2014	1980		Uncertain
5233	3		TN	Marion	TVA	Robinson Cove at Foster Falls	H	2014	2014	1980		Extirpated
10035	4		TN	Sequatchie	Private	Grundy Line Low Woods	D	2008	1991	1991		Uncertain
6355	5	Falls Creek	TN	Bledsoe	Private	Meadow Creek Branch	CD	2011	2011	2011	unknown	Uncertain
9616	6	Starr Mountain	TN	McMinn/ Monroe	USFS	Starr Mountain	A	2018	2016	2016	2016	Extant
3112	7	Plantation Pond	TN	Grundy	Private	Plantation Pond	X (likely)	2011	2012	2000		Uncertain
4958	8		TN	Grundy	Tennessee	Savage Gulf Swamp	H	2011	2011	1980		Historical
13416	9		TN	Cumberland		Mayland	H	2008	2008	1934		Historical
13417	10		TN	Cumberland	Private	Frances Lake	H	1991	1951	1951		Historical
7883	11		TN	Fentress		Clarkrange Bog	H	1991	1991	1951		Historical
4193	12		TN	Franklin		Otter Falls Rd	X (likely)	2008	2008	1947		Extirpated
2689	13		TN	Grundy/ Marion		Scott Creek	H	1991	1947	1947		Historical
38	15		TN	Sequatchie	Private	Issac Hill Spring and Pond	H	2011	2011	1983		Historical
12960	16	Spencer Powerline	TN	Van Buren	Tennessee	Spencer Powerline #1	D	2011	2018	2018	2018	Extant
2195	17	Spencer Powerline	TN	Van Buren	Private	Spencer Powerline #2	X (likely)	2011	2011	2004	2004	Extirpated
10836	18		TN	Grundy/ Sequatchie		Shoal Creek	X	2008	2008	1984		Historical
5927	19	Guntersville Lake	TN	Franklin	Private	St Mary's Spring Lot	F	2008	2008	2000	2000?	Uncertain
5928	20	Bledsoe Powerline	TN	Bledsoe	Tennessee	Taft Youth Center Powerline	BC	2018	2018	2018	2018	Extant
5954	22		TN	Franklin	Private	Yeatmans's Orchid Swale	F	2000	2000	1990		Extirpated
3192	23	Southern Pine Plantation	TN	Van Buren/ Warren	Private	Curtistown Seep Forest	CD	2011	2011	2011	2011	Extant
10896	24	Meadow Creek	TN	Grundy	Private	Meadow Creek Seep	B	2018	2018	2018	2018	Extant
12466	26	Lee Farm/Laurel Trail	TN	Grundy	Tennessee	Laurel Trail #2 (multiple sites)	C	2018	2017	2017	2017	Extant
4561	27	Marion	TN	Grundy	Private	Werner Farm	D	2008	2008	2000		Uncertain
13119	28	Marion	TN	Marion	Private	Laurel Branch	D	2018	2018	2018	2018	Extant
7925	29	Sheeds Creek	TN	Polk	USFS	Sheeds Creek Rd	CD	2018	2018	2018	2004	Extant

EO ID	EO Number	Population	State	County	Owner	Site Name	EO Rank	EO Rank Date	Last Visited	Last Time Observed	Last Observed Flowering	Status in Listing Rule
7926	30		TN	Franklin	Private	Keith Springs Rd at Three Forks	D	2014	2000	1990		Uncertain
12612	31	Guntersville Lake	TN	Franklin	Private	Deercheck Station	BC	2017	2017	2017	2017	Extant
8746	33		TN	Grundy	Private	McAlloyd Branch	X	2008	2008	1996		Extirpated
809	34	Pitcher Ridge	TN	Franklin	Private	Cold Springs Pond	F	2014	2014	2012	1996	Uncertain
3621	36	Hwy 111	TN	Sequatchie	Private	Hwy 111 at Cagle	D	2017	2017	2017	2017	Extant
6669	37	Lee Farm/Laurel Trail	TN	Grundy	Private	Lee Farm	B	2011	2011	2011	2000	Extant
958	39	Southern Pine Plantation	TN	Van Buren	Private	Harper Road - Sycamore Branch	C	2017	2017	2017	2017	Extant
959	40		TN	Van Buren	Private	Harper Road - Clearcut	F	2011	2011	1997		Uncertain
14096	41	Meadow Creek	TN	Grundy	State	Stocker Road	BC	2018	2018	2018	2018	Extant
628	44	Marion	TN	Marion	TVA	Foster Falls Powerline	D	2017	2017	2016	2016	Extant
10047	45		TN	Roan	Private	Clifty Creek	X	2008	2008	1988		Extirpated
11697	47	Marion	TN	Marion	Private	Werner SMZ	D	2018	2018	2018	2008	Extant
7632	48	Marion	TN	Marion		Goads Stream Head	ABC	2018	2018	2018	2018	Extant
8853	49	Prentice Cooper SF	TN	Marion	Tennessee	Prentice Cooper State Forest	BC	2018	2018	2018	2018	Extant
8854	50	N Fork Creek	TN	Cumberland	Tennessee	Tributary to North Fork Creek	BC	2018	2018	2018	2018	Extant
4657	52	Pitcher Ridge	TN	Franklin		Old Turnpike Rd	BC	2017	2017	2017	2017	Extant
2828	53	Pitcher Ridge	TN	Franklin		Old Turnpike Rd	CD	2017	2017	2017	2017	Extant
15366	54	Guntersville Lake	TN	Marion	Tennessee	Franklin State Forest	D	2018	2018	2012	2008	Extant
15367	55	Guntersville Lake	TN	Marion	Tennessee	Franklin State Forest	D	2017	2011	2011	2006?	Extant
15368	56	Guntersville Lake	TN	Franklin	Tennessee	Franklin State Forest	C	2018	2018	2017	2014 (few)	Extant
16274	57	Guntersville Lake	TN	Franklin		McBee Woods	D	2011	2011	2011		Uncertain
16275	58	Guntersville Lake	TN	Franklin		Eva Lake	F	2008	2008	2006		Uncertain
16515	59	Tar Kiln Ridge	TN	Fentress	NPS	Tar Kiln Ridge	AB	2018	2018	2018	2018	Extant
16576	60	Duncan Hollow	TN	Scott	NPS	Duncan Hollow Trail	BC	2018	2018	2018	2018	Extant
17005	61		TN	Grundy		Summerfield Rd	H	2014	2014	1987		Uncertain
17312	63	Marion	TN	Marion		Fiery Gizzard Cove/Pigeon Point	B	2012	2018	2018	2018	Extant

EO ID	EO Number	Population	State	County	Owner	Site Name	EO Rank	EO Rank Date	Last Visited	Last Time Observed	Last Observed Flowering	Status in Listing Rule
17604	64	Mooneyham	TN	Van Buren		Bridgestone-Firestone WMA - Mooneyham Road Powerline	A	2018	2018	2018	2018	Extant
17611	65	Tar Kiln Ridge	TN	Fentress		Tar Kiln Ridge	CD	2018	2018	2018	2018	Extant
17612	65	Guntersville Lake	TN	Franklin	Tennessee	Franklin State Forest	D	2017	2017	2017	2011	Extant
17618	67	Bledsoe Powerline	TN	Bledsoe	Tennessee	Bledsoe SF - Powerline at Mill Creek	CD	2017	2017	2017	2017	Extant
19785	71	Meadow Creek	TN	Grundy	Tennessee	Savage Gulf SNA	C	2018	2018	2018	2018	N/A
18913	68	Mooneyham	TN	Van Buren	Private		CD	2014	2013	2013	2013	Extant
19789	73	Great Falls	TN	Van Buren	Private	Great Falls Hydro Plant ROW	E	2018	2015	2015	2015	N/A
19788	72	Centennial Wilderness WMA	TN	White	Tennessee	Centennial Wilderness WMA	CD	2018	2018	2018	2018	Introduced in 2017

APPENDIX B.
Detailed *Platanthera integrilabia* management actions, status (i.e., complete (grey), in progress (blue)) and observed responses.

Owner	Site Name	Status	Start Date	Action Taken	Observed Response (if documented)
USFWS	Marchetta Seeps	Complete	2016	Midstory woody vegetation removal repeated annually or biennially after initially completed for unexploded ordnance (UXO) removal.	Flowering individuals: 2017 - 3; 2018 - 37; 2019 - 161; 2020 - 212
Private	Lyons Landing*	In progress	2017	USFWS Partners program- Mechanical veg. treatment, Chemical invasive treatments. Seed collected in 2018 and sown at ABG for propagation	Flowering occurred following veg. treatment and seed collected. Timing and results of augmentation from propagated plants not yet known.
Forsyth Co. Parks	Sawnee Mountain	In progress	2014	NFWF 5 Star grant. Mechanical and chemical treatments of understory and canopy, site cleanup. Only one clump of plants remained and have never been observed to flower. 30 plants grown from seed donor site in Bartow County (Pine Log WMA) were planted into the site in 2015.	Plants were observed flowering in 2016 and 2017.
USFS - CONF	Lee Mountain	In progress	2016	Mechanical treatment of understory and canopy. Plants collected and flowered at ABG for seed production and propagation.	Awaiting monitoring in 2019. Awaiting germination at ABG.

Owner	Site Name	Status	Start Date	Action Taken	Observed Response (if documented)
GADOT	Lookout Mountain (Neal Gap)	In progress	2014	NFWF 5 Star grant. Cleaned roadside of trash/debris, annual mechanical treatment by hand to eliminate woodies and reduce herbaceous competition. About 30 plants grown from seed at ABG and outplanted into site	Plants were observed flowering in 2016. Site was destroyed by heavy mowing equipment in 2017. Have not monitored since.
Big Canoe HOA	Big Canoe	In progress	2014	NFWF 5 Star grant. Mechanical and chemical treatments of understory and canopy, site cleanup. Chemical treatment of canopy trees. Seed collected and stored/sowed for propagation at ABG	Poor germination on seed sown, attempting again. Excellent response in flowering numbers from 2014-2017, with nearly 40 flowering plants in 2017. Herbaceous and understory growth is coming back, and flowering numbers were significantly lower in 2018
GDNR	Chattahoochee Bend State Park	In progress	2013	NFWF 5 Star grant. Mechanical treatment of understory and canopy in wetlands and uplands. Outplanted plants grown from seed collected at Moore's Creek.	26 plants introduced in 2013; 25 introduced in 2014. Plants were observed flowering in 2015, 2016, and 2017.
USFS - DBNF	Marsh Branch Powerline	In progress	2016	Shrub/sapling removal by hand	No response observed in 2017 or 2018
USFS - DBNF	Marsh Branch Powerline	Complete	2018	Site posted with no machinery, no herbicide signs	Two utility companies acknowledged sign presence; one paid for signs
USFS - DBNF	Marsh Branch Powerline	Complete	2017	Prescribed burn--fire entered site in a couple of areas and wet out	Observation only: reduced *Lygodium palmatum* presence at edge of site for part of a growing season
USFS - DBNF	Marsh Branch Powerline	Complete	2016	Prescribed burn--fire did not enter site	Observation only: reduced *Lygodium palmatum* presence at edge of site for part of a growing season
USFS - DBNF	Marsh Branch Powerline	Complete	2012	Prescribed burn--fire did not enter site	Observation only: reduced *Lygodium palmatum* presence at edge of site for part of a growing season
OKNP	Mount Victory Seeps - A (center)	Complete	2012	Mechanical treatment of understory and canopy. Check dam installation.	Increase in number of flowering plants from <15 per year during 2008-2013 to the following: 2014 - 18, 2015 - 6, 2016 - 71, 2017 - 101, 2018 - 137. Nearby seeps that did not undergo management continued to exhibit low flowering numbers during years of increase at this site.

Owner	Site Name	Status	Start Date	Action Taken	Observed Response (if documented)
USFS - DBNF	Barren Fork	Complete	2006	Check dams installed in stream below orchids to slow head/down cutting	Slowed head/down cutting; by 2016 created saturated area at lower end of system in which sphagnum began to colonize--potential for orchid growth; by 2018, most check dams had been breached (around an end), lower end drying out; sediment still in system and drastic step drops in elevation of stream channel still softened and stream still more resilient to flash flooding than was in 2006
USFS - DBNF	Hindsfield Ridge	Complete	2015	Large ground water dam below site experiencing heavy down cutting/head cutting	Site became wetter within 1 year and continues to stay wet. Only three WFO leaves found 2017-18.
NCPCP	Bat Fork Bog*	In progress	2018	Invasive vegetation treatments on 2.5 acres using stump-cut and spray treatments on woody species as well as hand-pulling invasive grasses.	There are no P. integrilabia at the site at present. This work is preparatory work for a planned reintroduction in 2019.
NCPCP	Bat Fork Bog*	In progress	TBD	Reintroduction	Seeds being propagated from TN EO6, by two entities: Larry Zettler at Illinois College is propagating plants from seed collected during 1990s, using mycorrhizal fungus strain from SC site also collected during 1990s. ABG propagating plants from seed collected during 2018. Outplanting anticipated during 2021.
TSP	Meadow Creek	Complete	2016	Midstory woody vegetation removal using stump-cut treatment.	Positive response by P. integrilabia not evident during 2017 growing season.
TSP	Meadow Creek	Complete	2017	Mature, planted loblolly canopy harvested by American Forest Management.	Number of flowering plants increased from 25 during 2017 to 1,125 during 2018.
TSP	Meadow Creek	Complete	2019	Prescribed burn conducted January 9, 2019	Flowering plants increased to 1,650 in 2019 and 1,796 in 2020.

Owner	Site Name	Status	Start Date	Action Taken	Observed Response (if documented)
TSP	Pigeon Point E	Complete	2017	Reduce shrub / sapling density using stump-cut treatment	2018: 2 Platanthera integrilabia flowering (decrease from high of 39) but not in the zone of management. Parks and Natural Areas staff reduced woody plant density and treated the stumps in October 2017. No sprouting observed, but no flowering P. integrilabia within the management zone. Site not nearly as wet as the western bog that was also managed in October 2017.
TSP	Pigeon Point W	Complete	2017	Reduce shrub / sapling density using stump-cut treatment	2018: 17 flowering plants observed in managed zone (up from 1 in 2017) and 3 outside open area in wetter section of woods. Site managed in October 2017 and area is more open. From center of open site, the N area of the bog has the greatest concentration of plants and is the wettest area. This area could use more thinning and removal of the debris piles.
USFS - CNF	Starr Mtn	Complete	2018	Collected 1-2 seed capsules each from 207 plants. All seeds transported to ABG to be germinated for reintroduction project at NC's Bat Fork Bog.	Seeds viability results are not available currently.
USFS - CNF	Starr Mtn	In progress	2016	Germination and plant holding for reintroduction work at Bat Fork Bog.	Approximately 12 seedlings were germinated from stored seeds (Starr Mt origin) with stored mycorrhizal fungus (*Epulorhiza inquilina*) from SC in lab at Illinois College. Additional seeds were inoculated and are being grown for reintroduction purposes totaling ~30 seedlings.
USFS - CNF	Sheeds Creek	Complete	2019	Create canopy gap by felling a few trees in immediate vicinity of site.	Flowering observed 2019

Owner	Site Name	Status	Start Date	Action Taken	Observed Response (if documented)
NPS	Tar Kiln 3	Complete	2015	Hog-exclusion fence built around plants and all suitable habitat surrounding plants	This site has been monitored annually since 2011 (periodically prior to that). It was highly disturbed by wild hogs in early 2015. In 2018, three years after the site was fenced to exclude hogs, the number of Platanthera species strap leaves counted was the highest ever and the number of flowering P. integrilabia was within the expected range (based on monitoring before hog damage). In addition, the stream (altered severely by hogs in some places) was showing signs of improvement, i.e. it is slowly regaining depth and sinuosity in sites where hog wallows flattened out the area. The site seems to be getting drier overall. NPS is considering removing small successional forest trees to regain water balance. NPS will continue to monitor the site annually and repair fencing as needed.
NPS	Duncan Hollow	Complete	2015	Hog-exclusion fence built around plants and all suitable habitat surrounding plants	This site seems stable. NPS will continue to monitor the site annually and repair fencing as needed.
NPS	Tar Kiln 1 & 2	Complete	2017	Site expanded to include additional plants to north of EO-65: hog-exclusion fence built around plants and all suitable habitat surround plants; one fence built around original site and one around additional plants north of the site	This site seems stable but seems to be drying out. NPS is considering removing small successional forest trees to regain water balance. NPS will continue to monitor the site annually and repair fencing as needed.
TWRA	Centennial WMA	Complete	2017-2019	Vegetation management. Transplanting of orchid seeds to site.	Introduced population. Research of outcome ongoing.
TWRA	Centennial WMA	Ongoing	2017 - TDB	Prescribed fire including uplands surrounding orchid habitat	Fire effects and population response not known

APPENDIX C. ABBREVIATIONS

Agencies, Organizations, and Institutions:

ABG – Atlanta Botanical Garden
ADCNR – Alabama Department of Conservation and Natural Resources
ANHP – Alabama Natural Heritage Program
DoD – Department of Defense
GDNR – Georgia Department of Natural Resources
GDOT – Georgia Department of Transportation
OKNP – Office of Kentucky Nature Preserves
MDWFP – Mississippi Department of Wildlife, Fisheries, and Parks
NCDENR – North Carolina Department of Environment and Natural Resources
NCPCP – North Carolina Plant Conservation Program
NFWF – National Fish and Wildlife Foundation
NPS – National Park Service
SCDNR – South Carolina Department of Natural Resources
Service – U.S. Fish and Wildlife Service
TDEC – Tennessee Department of Environment and Conservation
TSP – Tennessee State Parks
TVA – Tennessee Valley Authority
TWRA – Tennessee Wildlife Resources Agency
USDA – U.S. Department of Agriculture
USFS – U.S. Forest Service
USFWS – U.S. Fish and Wildlife Service
UT – University of Tennessee

Other Terms:

3Rs – resilience, redundancy, representation
C.E. – conservation easement
CNF – Cherokee National Forest
CONF – Chattahoochee-Oconee National Forest
DBNF – Daniel Boone National Forest
EO – element occurrence
ESA – Endangered Species Act of 1973
FR – Federal Register
NF – National Forest
ROW – right-of-way
SF – State Forest
SMZ – Streamside Management Zone
SNA – State Natural Area
SSA – Species Status Assessment
WMA – Wildlife Management Area