Lythrum flagellare
(Florida loosestrife)
Species Status Assessment
Version 1.0

Photo by Camille Eckel

December 2022

U.S. Fish and Wildlife Service

Southeast Region

Atlanta, GA

Table of Contents

ACKNOWLEDGEMENTS

This document was prepared by Drew Finn (Texas A&M Natural Resources Institute), Stephanie Martinez-Brewer (Texas A&M Natural Resources Institute), Mike Marshall (Texas A&M Natural Resources Institute), Todd Mecklenborg (Service), Byron Hamilton (Service), and Annie Dziergowski (Service). Substantive information was provided by Hanna Rosner-Katz (Florida Natural Areas Inventory) and Mike Jenkins (Florida Department of Agriculture and Consumer Services). Valuable reviews of a draft of this document were provided by Alan Franck (University of Florida Herbarium) and Aaron David (Archbold Biological Station).

EXECUTIVE SUMMARY

This report summarizes the results of a species status assessment (SSA) conducted for *Lythrum flagellare* (Florida loosestrife), a species that the U.S. Fish and Wildlife Service (Service) determined may warrant listing under the Endangered Species Act of 1973, as amended (Act), on September 27, 2011. The SSA evaluates *L. flagellare*'s viability by characterizing the biological status of the species in terms of its resiliency, redundancy, and representation (together, the 3Rs). For the purpose of this assessment, we generally define viability as the ability of the species to sustain populations in their natural setting over time. In conducting the SSA, we compiled the best available scientific information regarding *L. flagellare*'s biology and ecology (Chapter 2) and factors that influence the species' viability (Chapter 3). We used this information to evaluate and describe the species' current (Chapter 4) and projected future condition (Chapter 5) in terms of the 3Rs.

Lythrum flagellare is a perennial herb endemic to Florida. It occurs in seasonally inundated open areas and can tolerate moderate levels of disturbance. It is a plant of high hydroperiod systems and is confined to mucky or sandy-peat-muck soils. Little is known about *L. flagellare*, but if similar to related species, it likely forms persistent seed banks and germinates in moist to saturated soils. Both the historical and current distribution of *L. flagellare* is not fully known as it is likely an overlooked and under-documented species, however, the Atlas of Florida Plants currently lists twelve counties as vouchered.

Factors influencing the viability of *L. flagellare* include direct and indirect impacts of development, anthropogenic disturbances, invasive plant and animal species, climate change and sea level rise (SLR), and conservation and management. In addition to directly impacting *L. flagellare* by reducing available habitat around the cities of Tampa, St. Petersburg, Bradenton, Lakeland, Port Charlotte, Fort Myers, and others in south-central Florida, development indirectly threatens the species through alteration of natural hydrology and fire patterns. As such, the major influence on viability of *L. flagellare* is direct and indirect impacts of urban and agricultural development. Additionally, because the species often occurs in moderately disturbed open areas such as roadside ditches, rights-of-way, and firebreaks, it is susceptible to anthropogenic disturbances such as road widening, herbicide application, and soil tilling. Invasive plant and animal species occur within *L. flagellare*'s range and have the potential to threaten the species.

Climate change could negatively impact the species depending upon how extreme droughts and heavy rainfall events become, and SLR could potentially cause salt water to intrude or inundate low-lying habitats along the western coast of Florida where *L. flagellare* currently occurs and thus kill off plants since the species is not salt tolerant. *L. flagellare* is currently listed on the State of Florida's Regulated Plant Index as endangered and was recently re-ranked from G2/S2 to G3/S3 by Florida Natural Areas Inventory (FNAI), meaning that it is "Vulnerable—At moderate risk of extirpation in the jurisdiction due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors" (NatureServe 2022). The state listing does little to protect *L. flagellare* on private lands, but the species does occur on several protected lands including Myakka River State Park and Myakka State Forest.

To evaluate the current and future viability of *L. flagellare*, we assessed a range of conditions to allow us to consider the species' resiliency, redundancy, and representation. First, we used element occurrence records from FNAI as well as 12-digit hydrologic unit code subwatersheds as the basis for delineating populations (i.e., analysis units) of *L. flagellare*, resulting in a total of 34 analysis units.

We used a habitat-based approach to assess current resiliency whereby we considered three factors for each analysis unit: percentage of available habitat, percentage of incompatible land use, and habitat protection. *L. flagellare* has not been extensively studied, so we used the data that were available for all analysis units to assess resiliency. We ranked each factor as low, moderate, or high for each analysis unit and assigned a value of 3 to factors ranked high, a value of 2 to factors ranked moderate, and a value of 1 to factors ranked low. To calculate overall resiliency, we added up these values per analysis unit and ranked them on a scale from very high resiliency (total score = 9) to very low resiliency (total score = 3). Overall, 4 analysis units ranked very high, 6 ranked high, 1 ranked moderate-high, 10 ranked moderate, 4 ranked moderate-low, 5 ranked low, and 4 ranked very low.

Redundancy for *L. flagellare* is inherently fairly low due to its restricted distribution because individual catastrophes could potentially impact the species across the entirety or most of its range. However, analysis units that ranked higher in resiliency are spread across the range of the species, providing some protection against catastrophes.

To assess current representation of *L. flagellare*, we used the 12 core attributes of adaptive capacity from Thurman et al. (2020, entire). Overall, one core attribute was assessed as low (extent of occurrence), two as moderately low (dispersal distance and climatic niche breadth), six as moderate (population size, fecundity, reproductive phenology, physiological tolerances, habitat specialization, commensalism with humans), one as moderately high (life span), one as unknown (genetic diversity), and one as not applicable (diet breadth).

To evaluate the future condition of *L. flagellare*, we projected out to the years 2040 and 2070 to get an idea of what conditions might look like for the species in the near future as well as approximately 50 years from now. We expect that the major influences on viability of *L. flagellare* in the future will be direct and indirect impacts of development and climate change, specifically from urban and agricultural development and SLR. As such, we used the forecasting scenarios of land-use change (FORE-SCE) model to predict how developed and cultivated crops land cover classes might change into the future as well as intermediate low and high SLR scenarios for Fort Myers, Florida to predict how SLR might impact *L. flagellare* analysis units in the future. We then developed two plausible future scenarios representing the worst- and best-case outcomes from our analysis of future urban and agricultural development and SLR. Under the worst-case scenario, resiliency is expected to decrease in 14 analysis units by 2040, and in 20 analysis units by 2070. Under the best-case scenario, overall results were the same for 2040 and 2070, with resiliency expected to decrease in 6 analysis units and increase in 1.

Redundancy for *L. flagellare* is expected to decrease under both scenarios and for both timesteps, but only marginally under the best-case scenario. By 2070, analysis units expected to decrease in resiliency could be spread across the range of the species or be mostly clustered along the coast near Sarasota.

To assess future representation of *L. flagellare*, we used the 12 core attributes of adaptive capacity we considered for current condition to predict how well-equipped the species is to adapt to climate change. We determined that *L. flagellare* may be better equipped to persist-in-place than shift-in-space. As such, its future viability may depend on how well it is able to persist-in-place in a changing climate. In the future, annual mean temperature is projected to increase, precipitation is projected to stay approximately the same, and potential evapotranspiration is projected to increase under both lower and higher emissions scenarios. It is difficult to predict exactly how this will impact *L. flagellare* but given that it is a plant of high hydroperiod systems and likely needs moist to saturated soils to germinate, increased temperature and evapotranspiration without an increase in precipitation would likely negatively impact the species.

1 INTRODUCTION

The Species Status Assessment (SSA) framework (USFWS 2016, entire) is intended to support an in-depth review of a species' biology and threats, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain long-term viability. The intent is for the SSA to be easily updated as new information becomes available and to support all functions of the Endangered Species Program from Candidate Assessment to Listing to Consultations to Recovery.

Lythrum flagellare (Florida loosestrife) is a perennial herb endemic to Florida. For the purposes of this document, we will refer to *L. flagellare* as "Florida loosestrife." On April 20, 2010, the U.S. Fish and Wildlife Service (Service) received a petition from the Center for Biological Diversity to list 404 aquatic, riparian, and wetland species from the southeastern United States, including Florida loosestrife, as endangered or threatened under the Endangered Species Act, and on September 27, 2011, the Service determined that listing Florida loosestrife may be warranted (76 FR 59836). As such, this SSA is intended to provide information to support a determination of whether listing the species is warranted. For the purpose of this assessment, we generally define viability as the ability of Florida loosestrife to sustain populations in their natural setting over time. Using the SSA framework (Figure 1), we consider what the species needs to maintain viability by characterizing the status of the species in terms of its resiliency, redundancy, and representation (Wolf et al. 2015, entire). In general, species viability will increase with increases in resiliency, redundancy, and representation (Smith et al. 2018, p. 306).

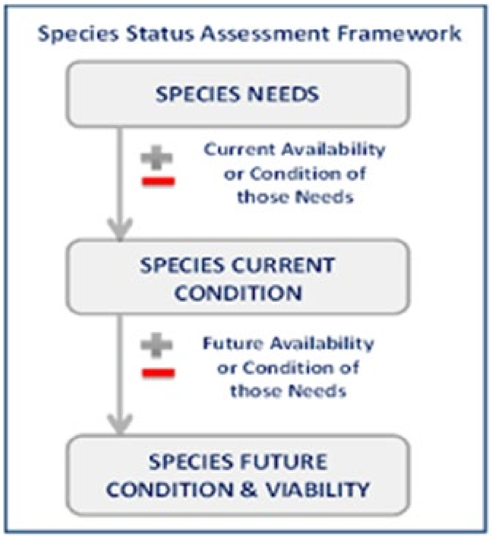

Figure 1. Species Status Assessment framework.

Resiliency is the ability of a species to withstand environmental stochasticity (normal, year-to-year variations in environmental conditions such as temperature and rainfall), periodic disturbances within the normal range of variation (fire, floods, storms), and demographic stochasticity (normal variation in demographic rates such as mortality and fecundity) (Redford et al. 2011, p. 40). Simply stated, resiliency is the ability to sustain populations through the natural range of favorable and unfavorable conditions. We can best gauge resiliency by evaluating population level characteristics such as: demography (abundance and the components of population growth rate—survival, reproduction, and migration), genetic health (effective population size and heterozygosity), connectivity (gene flow and population rescue), and habitat quantity, quality, configuration, and heterogeneity. Also, for species prone to spatial synchrony (regionally correlated fluctuations among populations), distance between populations and degree of spatial heterogeneity (diversity of habitat types or microclimates) are also important considerations.

Redundancy is the ability of a species to withstand catastrophes. Catastrophes are stochastic events that are expected to lead to population collapse regardless of population health and for which adaptation is unlikely (Mangel and Tier 1993, p. 1083). We can best gauge redundancy by analyzing the number and distribution of populations relative to the scale of anticipated species-relevant catastrophic events. The analysis entails assessing the cumulative risk of catastrophes occurring over time. Redundancy can be analyzed at a population or regional scale, or for narrow-ranged species, at the species level. Redundancy is assessed by characterizing the number of resilient populations across a species' range. The more resilient populations the species has, distributed over a larger area, the better the chances that the species can withstand catastrophic events.

Representation is the ability of a species to adapt to both near-term and long-term changes in its physical (climate conditions, habitat conditions, habitat structure, etc.) and biological (pathogens, competitors, predators, etc.) environments. This ability to adapt to new environments—referred to as adaptive capacity—is essential for viability, as species need to continually adapt to their continuously changing environments (Nicotra et al. 2015, p. 1269). Species adapt to novel changes in their environment by either [1] moving to new, suitable environments or [2] by altering their physical or behavioral traits (phenotypes) to match the new environmental conditions through either plasticity or genetic change (Beever et al. 2016, p. 132; Nicotra et al. 2015, p. 1270). The latter (evolution) occurs via the evolutionary processes of natural selection, gene flow, mutations, and genetic drift (Crandall et al. 2000, p. 290–291; Sgrò et al. 2011, p. 327). We can best gauge representation by examining the breadth of genetic, phenotypic, and ecological diversity found within a species and its ability to disperse and colonize new areas. In assessing the breadth of variation, it is important to consider both larger-scale variation (such as morphological, behavioral, or life history differences which might exist across the range and environmental or ecological variation across the range), and smaller-scale variation (which might include measures of inter-population genetic diversity). In assessing the dispersal ability, it is important to evaluate the ability and likelihood of the species to track suitable habitat and climate over time. Lastly, to evaluate the evolutionary processes that contribute to and maintain adaptive capacity, it is important to assess [1] natural levels and patterns of gene flow, [2] degree of ecological diversity occupied, and [3] effective population size.

To evaluate the current and future viability of Florida loosestrife, we assessed a range of conditions to characterize the species' resiliency, redundancy, and representation (together, the 3Rs) as described above. This SSA provides a thorough account of the known biology and natural history of Florida loosestrife and assesses factors likely to influence the future viability of the species.

This SSA includes the following chapters:

1. **Introduction**;
2. **Species Biology and Individual Needs –** a biological description of the species and the resource needs of individuals;

3. **Factors Influencing Viability** – an assessment of the factors contributing to the status of the species and the degree to which these factors influence viability;
4. **Population and Species Needs and Current Condition** – a description of what the species needs across its range for viability, and estimates of the species' current range and condition; and
5. **Future Condition and Viability** – descriptions of plausible future scenarios and predictions of their influence on the species' resiliency, redundancy, and representation.

2 SPECIES BIOLOGY AND INDIVIDUAL NEEDS

In this chapter, we provide biological information about Florida loosestrife, including its taxonomic history, morphological description, life history, habitat needs, and distribution.

2.1 Taxonomy

Dr. A. W. Chapman (1883, p. 620) was the first to formally publish *Lythrum flagellare* as an official species name, although Shuttleworth was the first to use the name distinctly. There was some initial confusion regarding the proper use of the name, as Koehne (1885, p. 274) and others used it as a synonym for *L. ovalifolium* (low loosestrife), from which it is clearly morphologically distinct (Nieuwland 1914, pp. 268–269). Since then, the name has been used correctly and *L. flagellare*'s taxonomic standing is still accepted (Small 1933, p. 931; Graham 1975, p. 88; Weakley 2022, p. 1003; Wunderlin et al. 2022).

The currently accepted taxonomic hierarchy for Florida loosestrife is described below (Integrated Taxonomic Information System 2022).

Kingdom	Plantae
Subkingdom	Viridiplantae
Infrakingdom	Streptophyta
Superdivision	Embryophyta
Division	Tracheophyta
Subdivision	Spermatophytina
Class	Magnoliopsida
Superorder	Rosanae
Order	Myrtales
Family	Lythraceae – loosestrife
Genus	*Lythrum* L. – loosestrife
Species	*Lythrum flagellare* Shuttlew. ex Chapm.
Common name	Florida loosestrife

2.2 Species Description

Florida loosestrife (Figure 2) is a perennial member of the Lythraceae. Its stems are erect to decumbent, 10–40 cm (4–16 in.) tall, and arise from a woody creeping rhizome. Leaves are opposite, sessile or subsessile, oblong to obovate, 5–13 mm (0.2–0.5 in.) long, and 2–6 mm (0.1–0.2 in.) wide. Flowers are solitary and dimorphic with 3–4 mm (0.1–0.2 in.) long pale purple to purple petals (Graham 1975, p. 88). Fruit is a dehiscent capsule 3–4 mm (0.1–0.2 in.) long with numerous seeds. Florida loosestrife can be distinguished from sympatric *Lythrum* species by its creeping habit (Kral 1983, p. 787).

Figure 2. Florida loosestrife (*Lythrum flagellare*). Left photo copyright Jason Sharp (https://www.flickr.com/photos/78235221@N05/7759028960/). Right photo copyright Elizabeth Gandy (https://www.inaturalist.org/photos/194125930).

2.3 Life History

Little is known about the life history of Florida loosestrife. Kral (1983, p. 787) reported that it flowers year-round, but it likely most reliably flowers in spring (Coile and Garland 2003, p. 34). Plants that experience seasonal flooding beginning in late spring to early summer must flower and set seed before they are inundated (Rosner-Katz 2021, pers. comm.). Pollinators are not known, but for the related species *L. alatum* (winged loosestrife) and *L. salicaria* (purple loosestrife) include bees, butterflies, and syrphid flies (Levin 1970, p. 2; Ornduff 1978, p. 1079;

Kinyo 2005, p. 13). Seeds of purple loosestrife do not have any obvious dispersal structures or mechanisms so are likely gravity dispersed (Montague et al. 2008, p. 236); seeds of Florida loosestrife are likely similar and may disperse within floodplains via sheet flow (Rosner-Katz 2022, pers. comm.). If similar to winged loosestrife, Florida loosestrife likely forms persistent seed banks and germinates in moist to saturated soils (Smith et al. 2002, p. 138).

As mentioned above, flowers of Florida loosestrife are dimorphic (i.e., distylous), meaning all flowers on a single plant either have long styles and short stamens (pins) or short styles and long stamens (thrums). Although pollination and seed set are possible between flowers of the same form (Ornduff 1978, p. 1078), the most successful crosses occur between pins and thrums (Graham 1964, p. 244). Thus, populations require plants with both flower types and a means of pollination between the two to be viable long-term. However, vegetative reproduction is possible via the rhizomes plants produce.

2.5 Habitat

Florida loosestrife occurs in seasonally inundated open areas and can tolerate moderate levels of disturbance (Figure 3). Habitat descriptions include pond margins, swamps, marshes, wet prairies, moist roadsides, and disturbed wetlands (Chapman 1883, p. 620; Small 1933, p. 931; Kral 1983, p. 787; Tobe et al. 1998, p. 463; USFWS 1999, p. C-47; Gann et al. 2002, p. 277; Coile and Garland 2003, p. 34; Woodmansee and Green 2006, p. 46; Florida Natural Areas Inventory [FNAI] 2010, p. 142; Weakley 2020, p. 922). It is a plant of high hydroperiod systems and is confined to mucky or sandy-peat-muck soils (Kral 1983, p. 788). Where it is found along roadsides (Figure 4) and rights-of-way, species associates may include *Centella asiatica* (gotu kola), *Hypericum mutilum* (dwarf St. John's wort), *Phyla nodiflora* (turkey tangle frogfruit), *Carex longii* (Long's sedge), *Diodia virginiana* (Virginia buttonweed), *Eryngium baldwinii* (Baldwin's eryngo), *Hydrocotyle umbellata* (manyflower marshpennywort), *Ptilimnium capillaceum* (mock bishopweed), and *Bacopa monnieri* (waterhyssop) (Rosner-Katz 2021, pers. comm.). Florida loosestrife can be very abundant where it occurs, forming dense mats and dominating the groundcover (Rosner-Katz 2021, pers. comm.).

Figure 3. Example of Florida loosestrife (*Lythrum flagellare*) habitat at Deer Prairie Creek Preserve in Sarasota County, Florida. Photo by Camille Eckel, Florida Natural Areas Inventory.

Figure 4. Example of Florida loosestrife (*Lythrum flagellare*) roadside habitat. Photo by Camille Eckel, Florida Natural Areas Inventory.

2.6 Distribution

Both the historical and current distribution of Florida loosestrife is not fully known as it is likely an overlooked and under-documented species; over half of occurrences documented by FNAI were first recorded within the last five years (Rosner-Katz 2021, pers. comm.). The Atlas of Florida Plants lists Charlotte, Collier, DeSoto, Glades, Hardee, Hendry, Hillsborough, Lee, Manatee, Okeechobee, Sarasota, and Seminole counties as vouchered (Wunderlin et al. 2022) (Figure 5). Herbarium specimens from Citrus (Hitchcock 1897, p. 124; link to specimen) and Broward (Jestrow and Bornhorst 2021; link to specimen) counties were misidentified, and reports of the species from Palm Beach County (Gann et al. 2001–2022) and Everglades Wildlife Management Area, where Loveless (1959, p., 2) described it as a “weed species,” should be considered dubious (Franck 2022, pers. comm.). Although disjunct from other vouchered counties, Seminole County does have one confirmed herbarium specimen from 1902 which was before the county was created; as such, the locality of the specimen is listed as Orange County (Franck 2022, pers. comm.). However, no other records of the species from Seminole County exist, including in FNAI’s database.

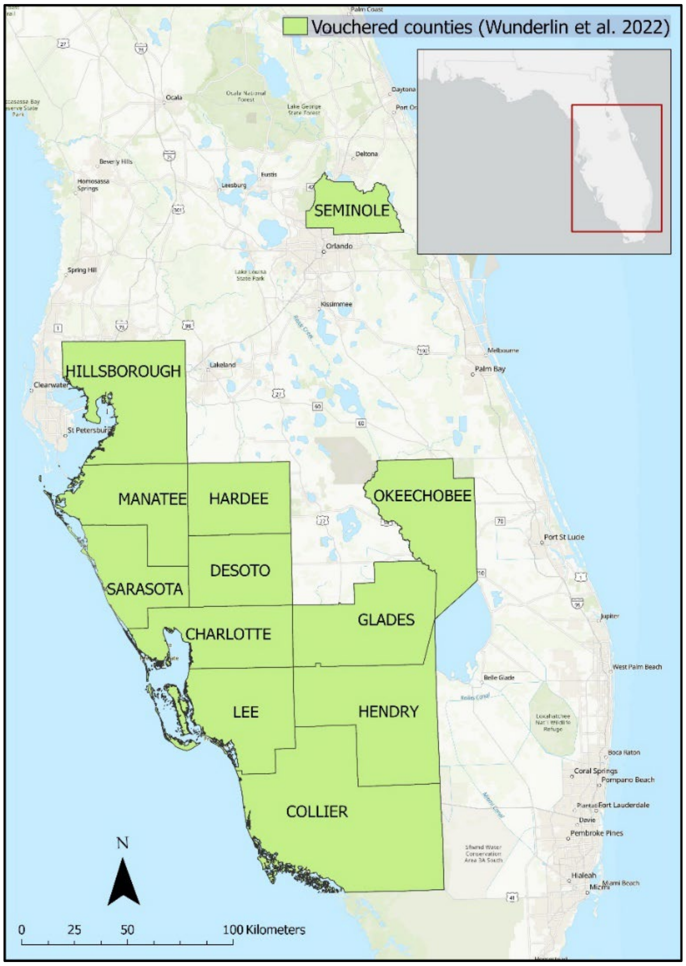

Figure 5. Counties with voucher specimens of Florida loosestrife (*Lythrum flagellare*) according to the Atlas of Florida Plants (Wunderlin et al. 2022).

3 FACTORS INFLUENCING VIABILITY

In this chapter, we provide information on negative and positive influences on viability of Florida loosestrife, including direct and indirect impacts of development, anthropogenic disturbances, invasive plant and animal species, climate change and sea level rise, and conservation and management (Figure 6).

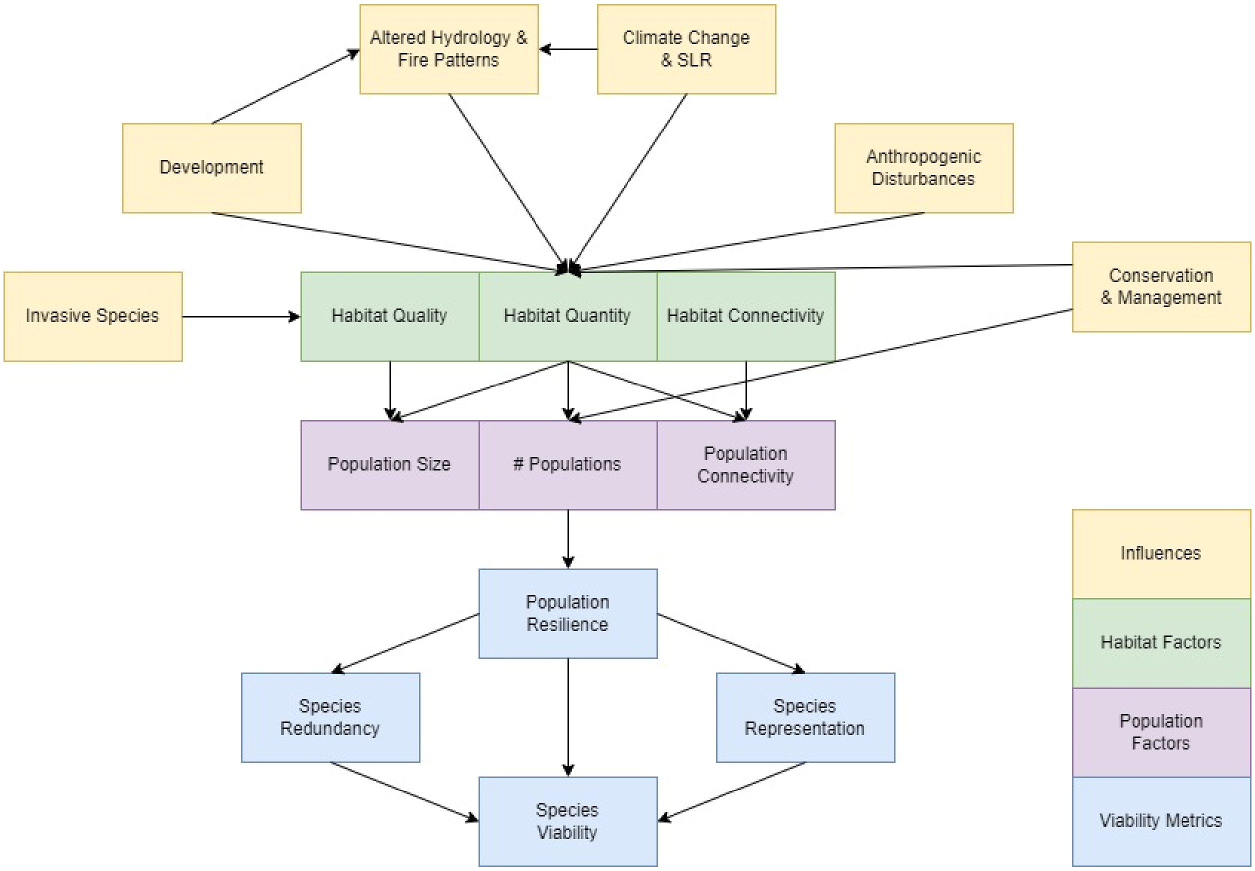

Figure 6. Influence diagram depicting the various potential influences on viability for Florida loosestrife (*Lythrum flagellare*).

3.1 Direct and Indirect Impacts of Development

In addition to directly impacting Florida loosestrife by reducing available habitat around the cities of Tampa, St. Petersburg, Bradenton, Lakeland, Port Charlotte, Fort Myers, and others in south-central Florida, development indirectly threatens the species through alteration of natural hydrology and fire patterns. A large amount of former habitat has been drained and is now dry nearly year-round, rendering it unsuitable for Florida loosestrife (Kral 1983, p. 788). Additionally, the channelization of rivers for flood control has altered natural seasonal flooding patterns and vegetation structure and led to a loss of plant and seed bank diversity (Goodrick and Milleson 1974, pp. 1–3; Toth 1993, p. 31; Wetzel et al. 2001, p. 189). Altered hydrology has also impacted natural fire patterns along with fire suppression. When water levels recede far below the surface of the ground, intense wildfires can occur that destroy peat layers in addition to consuming vegetation, leading to complete transformations of vegetative communities (Loveless 1959, p. 8). In fire-suppressed areas, woody encroachment is a threat to the shade-intolerant Florida loosestrife (Kral 1983, p. 788).

3.2 Anthropogenic Disturbances

Florida loosestrife often occurs in moderately disturbed open areas such as roadside ditches, rights-of-way, and firebreaks, making it susceptible to disturbance factors such as road widening, herbicide application, and soil tilling. Roadside populations additionally face an increased likelihood of extirpation due to stochastic events because they are strictly confined to the ditches in which they occur (Matthies et al. 2004, p. 481). Soil tilling to form firebreaks is believed to have extirpated two populations of the species, and another population was paved over to create a bike path (Rosner-Katz 2021, pers. comm.).

3.3 Invasive Plant and Animal Species

Invasive plant and animal species such as *Panicum repens* (torpedograss), *Ludwigia peruviana* (Peruvian primrose-willow), *Alternanthera philoxeroides* (alligator weed), *Urochloa mutica* (para grass), *Hymenachne amplexicaulis* (West Indian marsh grass), *Urena lobata* (Caesar weed), and feral hogs (*Sus scrofa*) occur in floodplain marsh communities (FNAI 2010, p. 143) and have the potential to threaten Florida loosestrife. Invasive grass dominance may have extirpated at least one population of the species (Rosner-Katz 2021, pers. comm.). Habitat disturbance from feral hogs alters plant communities and soil chemistry (Winchester et al. 1985, p. 116; Arrington et al. 1999, p. 535; Bankovich et al. 2016, p. 45; Gray et al. 2020, p. 739) and could facilitate the establishment of invasive plants along with other disturbances.

3.4 Climate Change and Sea Level Rise

Climatic changes, including sea level rise (SLR) and shifts in seasonal precipitation, temperature, and storm cycles, are projected to impact the southeastern United States over the next century. Under both lower and higher emissions scenarios, temperatures are expected to increase (Carter et al. 2018, pp. 751–752), and climate change is expected to intensify the hydrologic cycle and increase the frequency and severity of extreme events like drought and heavy rainfall (Carter et al. 2018, p. 775). Increases in evaporation of moisture from soils and loss of water by plants in response to warmer temperatures are expected to contribute to increased frequency, duration, and intensity of droughts. Since Florida loosestrife is a plant of high hydroperiod systems and likely needs moist to saturated soils to germinate, this would have a profound negative impact on the species.

Additionally, SLR is a concern for populations located along the western coast of Florida. SLR scenarios for Fort Myers range from 0.6–2.1 m (2.1–6.9 ft.) by 2100 (NOAA 2022). SLR could potentially cause salt water to intrude or inundate low-lying habitats near the coast where Florida loosestrife currently occurs and thus kill off plants since the species is not salt tolerant (Rosner-Katz 2021, pers. comm.). Furthermore, SLR could indirectly impact inland populations through anthropogenic responses to climate change; in addition to increasing the demand for freshwater, SLR could cause coastal-dwelling humans to migrate inland, further reducing available habitat for Florida loosestrife and decreasing soil moisture.

3.5 Conservation and Management

Florida loosestrife is listed on the State of Florida's Regulated Plant Index as endangered under Chapter 5B-40, Florida Administrative Code. This listing provides little or no habitat protection beyond the state's Development of Regional Impact process, which discloses impacts from projects, but provides no regulatory protection for state-listed plants on private lands. Florida loosestrife was also recently re-ranked from G2/S2 to G3/S3 by FNAI, meaning that it is "Vulnerable—At moderate risk of extirpation in the jurisdiction due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors" (NatureServe 2022).

Florida loosestrife is known to occur on lands owned/managed by the State of Florida, Sarasota County, Charlotte County, Manatee County, Lee County, DeSoto County, the City of Holmes Beach, and the University of South Florida. It has also been reported from the Big Cypress Reservation (Gann et al. 2002, p. 277), Everglades Wildlife Management Area (Loveless 1959, p. 2), and DuPuis Management Area (Gann et al. 2001–2022), but no voucher specimens or confirmed sightings from these locations are known (Franck 2022, pers. comm.). Although populations on these lands are likely afforded more protection than those on private lands, most land managers are either unaware of the presence of the species or do not monitor populations. As such, a first step in conservation and management of this species would be to increase awareness of its presence and encourage regular monitoring. However, existing management plans likely benefit Florida loosestrife even if the species is not explicitly targeted. The Myakka River State Park (MRSP) management plan does mention Florida loosestrife and lists hydrological maintenance/restoration as a management action and a non-targeted monitoring level for the species (MRSP 2019, p. 63). The Myakka State Forest (MSF) management plan does not mention Florida loosestrife but wetland restoration management actions such as road and soil stabilization, water level control structure removal or installation, exotic species control, and site preparation and re-vegetation with native wetland species (MSF 2010, p. 20) likely benefit the species.

Botanic Gardens Conservation International (BGCI 2022) does not list any *ex situ* collections of Florida loosestrife. At the very least, seed banking should be pursued to preserve genetic diversity. Florida loosestrife has been reported to be easy to maintain in planting beds (Huegel 2010).

4 POPULATION AND SPECIES NEEDS AND CURRENT CONDITION

As the population is the basic unit of resiliency, in this chapter we first examine the distribution of Florida loosestrife and define and delineate populations. We then assess the resiliency of each population by synthesizing the best available information about population and habitat conditions. Finally, we describe current redundancy and representation for Florida loosestrife across all populations.

4.1 Delineating Populations

We used element occurrence records from FNAI as the basis for delineating populations (i.e., analysis units) of Florida loosestrife. Element occurrences are areas in which a species or ecological community is or was present and records of each are maintained by state natural heritage programs. Element occurrence records are oftentimes the best data available for rare plant species, as is the case for Florida loosestrife. However, because the species is overlooked and under-documented, we decided to use 12-digit hydrologic unit code subwatersheds where element occurrences are present as our analysis units in an attempt to account for undocumented populations and to enable landscape-level comparisons across the species' range. Where individual element occurrences occupied multiple subwatersheds, we considered the associated subwatersheds part of the same analysis unit. This resulted in a total of 34 analysis units (Figure 7).

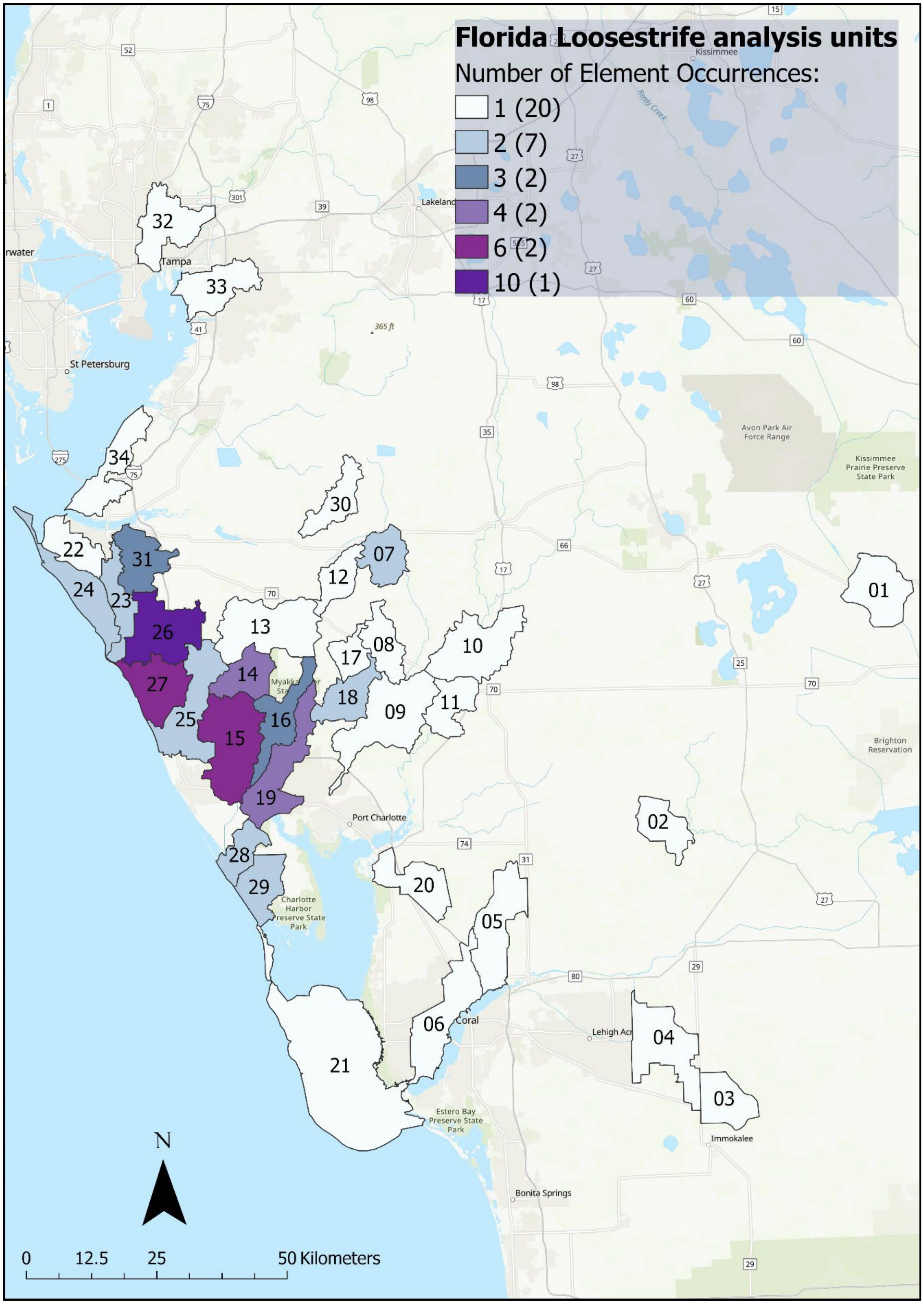

Figure 7. Florida loosestrife (*Lythrum flagellare*) analysis units and number of Florida Natural Areas Inventory element occurrence records in each.

4.2 Current Resiliency

Since recent estimates of population size were not available for most element occurrences, we used a habitat-based approach to assess the resiliency of each analysis unit. Specifically, we considered three factors: percentage of suitable habitat, percentage of incompatible land use, and habitat protection. Again, Florida loosestrife is overlooked and under-documented, so we used the data that were available for all analysis units to assess resiliency. Therefore, our methodology and results for current resiliency should be refined as more information becomes available.

4.2.1 Percentage of Suitable Habitat

Since we do not know how much habitat is actually occupied by Florida loosestrife, we used percentage of suitable habitat within each analysis unit as a proxy. In theory, the more habitat available, the higher the resiliency. We considered any area classified as a freshwater wetland to be suitable for Florida loosestrife and used the 2022 USFWS National Wetlands Inventory to calculate the percentage of wetlands within each analysis unit. We then ranked them as low, moderate, or high using the Jenks natural breaks classification method in ArcGIS Pro 2.9 (Environmental Systems Research Institute, Redlands, CA) (Table 1). Twelve analysis units ranked high, 14 ranked moderate, and 8 ranked low (Figure 8).

4.2.2 Percentage of Incompatible Land Use

Urban and agricultural development threaten Florida loosestrife both directly and indirectly, so we considered percentage of incompatible land use within each analysis unit in addition to percentage of suitable habitat. Because development alters natural hydrology and fire patterns, the greater the percentage of development present on the landscape within close proximity of Florida loosestrife populations, the lower the resiliency of those populations. Using the 2019 National Land Cover Database (NLCD; Dewitz and U.S. Geological Survey 2021), we considered all developed and cultivated crops land cover classes to be incompatible with Florida loosestrife. We calculated the combined percentage of these land cover classes within each analysis unit and ranked them as low, moderate, or high using the Jenks natural breaks classification method in ArcGIS Pro (Table 1). Sixteen analysis units ranked high, 9 ranked moderate, and 9 ranked low (Figure 9).

4.2.3 Habitat Protection

We used habitat protection as a proxy to assess habitat quality. We assumed that protected land was higher quality than unprotected land. We used FNAI's Florida Conservation Lands Florida Managed Areas (FLMA) shapefile from June 2022 to calculate the percentage of protected land within each analysis unit and ranked them as low, moderate, or high using the Jenks natural breaks classification method in ArcGIS Pro (Table 1). Six analysis units ranked high, 10 ranked moderate, and 18 ranked low (Figure 10).

Table 1. Strategy for ranking resiliency factors for Florida loosestrife (*Lythrum flagellare*) analysis units. All values are percentages and cutoffs between ranks were determined using the Jenks natural breaks classification method in ArcGIS Pro.

Resiliency Factor	Ranking		
	Low	**Moderate**	**High**
Percentage of Suitable Habitat	≤10.2	10.3–23.1	>23.1
Percentage of Incompatible Land Use	>53.3	19.2–53.3	≤19.1
Habitat Protection	≤9.5	9.6–43.8	>43.8

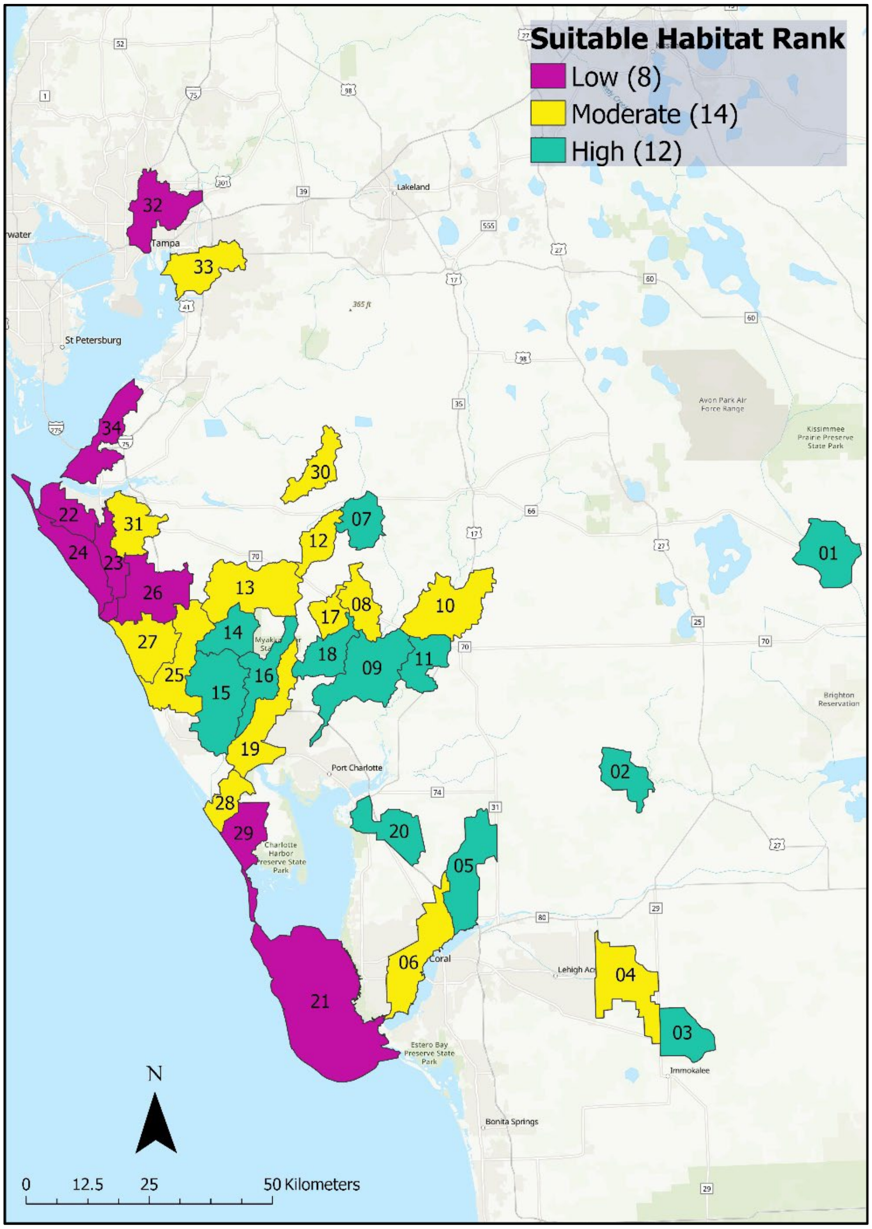

Figure 8. Florida loosestrife (*Lythrum flagellare*) analysis unit rankings for percentage of suitable habitat.

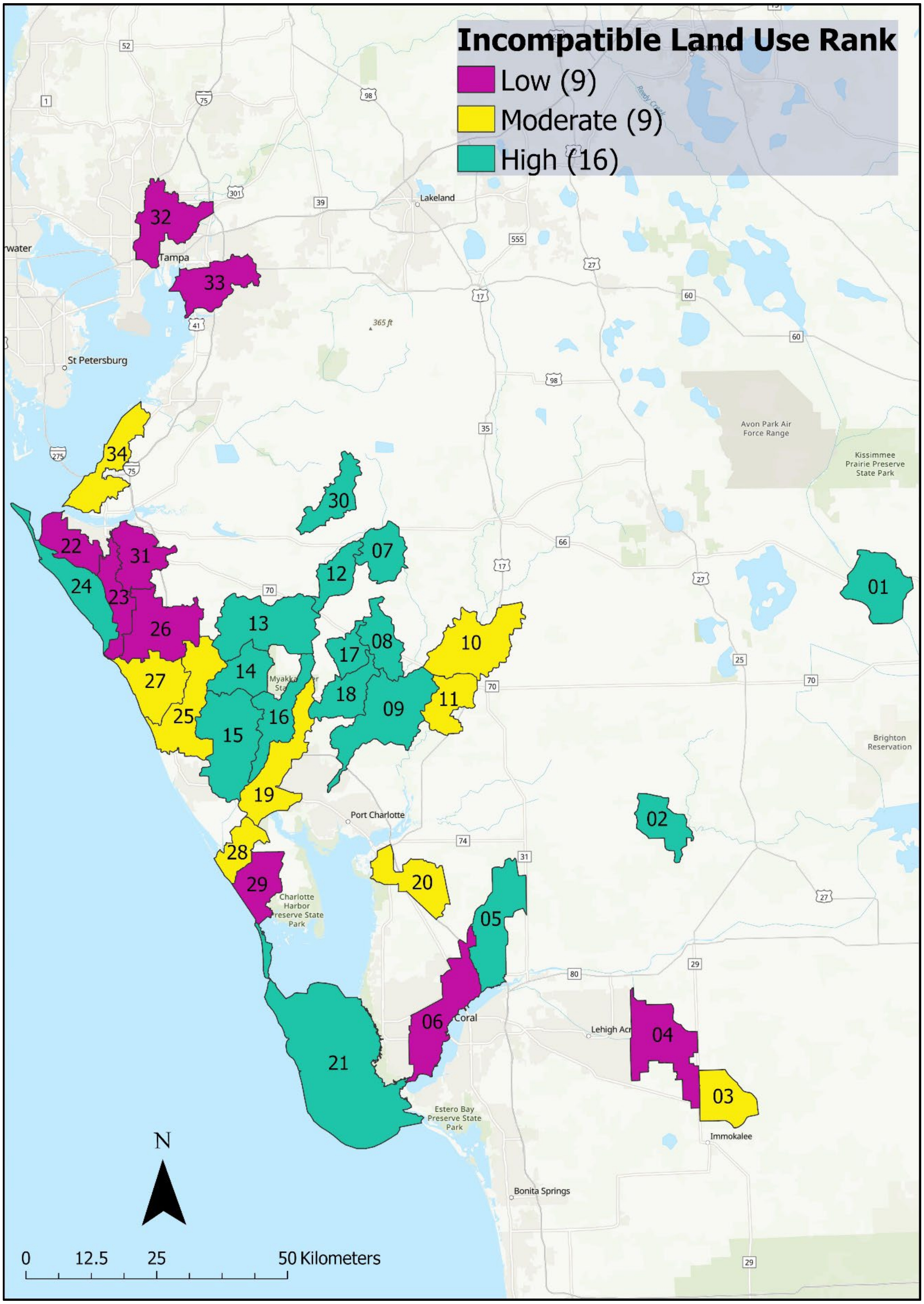

Figure 9. Florida loosestrife (*Lythrum flagellare*) analysis unit rankings for percentage of incompatible land use.

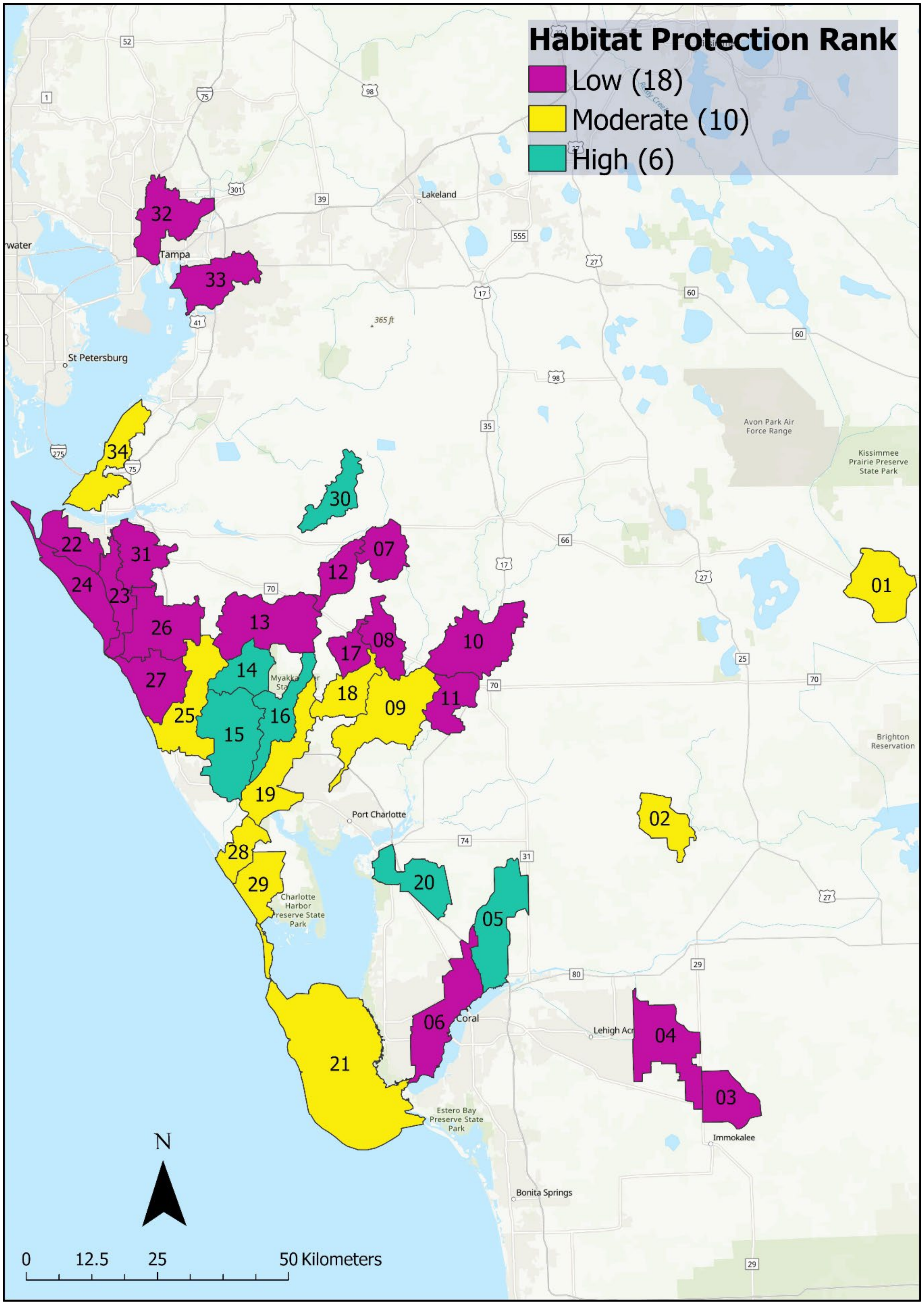

Figure 10. Florida loosestrife (*Lythrum flagellare*) analysis unit rankings for habitat protection.

4.2.4 Classifying Resiliency

Using the classification strategy outlined in Table 1, we ranked each factor per analysis unit (Table 2). To calculate overall resiliency, we assigned a value of 3 to factors ranked high, a value of 2 to factors ranked moderate, and a value of 1 to factors ranked low. We then added up these values per analysis unit and ranked them on a scale from very high resiliency (total score = 9) to very low resiliency (total score = 3). Overall, 4 analysis units ranked very high, 6 ranked high, 1 ranked moderate-high, 10 ranked moderate, 4 ranked moderate-low, 5 ranked low, and 4 ranked very low (Figure 11).

Again, resiliency refers to the ability of populations to withstand stochastic events, i.e., the natural range of favorable and unfavorable conditions. For this species, empirical data are not available to associate resiliency rankings with specific quantitative extinction risks or probabilities of persistence. Rather, we are limited to providing qualitative definitions of each resiliency rank. Populations with lower resiliency are highly vulnerable to stochastic events and face a high risk of extirpation within the next few decades. Populations with moderate resiliency are less likely to be extirpated within the next few decades but require additional growth (with help from regular habitat management and/or restoration) to become more self-sustaining and resilient to stochastic events. Populations with higher resiliency are unlikely to be extirpated within the next few decades in the absence of catastrophes or significant declines in the quality of habitat management. Populations with very high resiliency are the most robust and resistant to stochastic fluctuations.

Table 2. Current resiliency of Florida loosestrife (*Lythrum flagellare*) analysis units. Different colors correspond to different resiliency rankings as outlined in Table 1. To calculate overall resiliency, we assigned a value of 3 to factors ranked high, a value of 2 to factors ranked moderate, and a value of 1 to factors ranked low. We then added up these values per analysis unit and ranked them on a scale from very high resiliency (total score = 9) to very low resiliency (total score = 3).

Analysis Unit	Suitable Habitat (%)	Incompatible Land Use (%)	Habitat Protection (%)	Overall Resiliency
1	23.9	8.7	31.6	High
2	26.7	3.1	15.4	High
3	27.0	47.5	1.4	Moderate
4	16.0	62.1	0.1	Low
5	28.9	10.7	49.4	Very high
6	14.1	75.8	7.7	Low
7	28.9	15.4	0	Moderate-high
8	22.5	10.0	0	Moderate
9	30.1	12.4	25.8	High
10	15.5	31.5	0	Moderate-low
11	24.6	35.7	5.1	Moderate
12	20.6	18.2	9.5	Moderate
13	23.1	14.8	8.2	Moderate
14	47.7	4.2	83.7	Very high
15	33.0	17.0	64.7	Very high
16	34.6	1.5	85.8	Very high
17	22.6	3.6	0	Moderate
18	32.6	5.9	21.2	High
19	16.6	41.8	32.4	Moderate
20	31.7	28.7	49.6	High
21	2.5	9.7	18.1	Moderate
22	7.2	58.3	5.7	Very low
23	3.6	87.8	0.2	Very low
24	0.2	19.1	1.3	Moderate-low
25	19.0	37.4	14.5	Moderate
26	10.2	79.3	0.9	Very low
27	15.0	53.3	7.7	Moderate-low
28	15.7	37.4	34.9	Moderate
29	10.0	61.5	17.0	Low
30	20.8	12.5	64.4	High
31	14.8	72.1	0.4	Low
32	6.2	91.1	0.8	Very low
33	14.3	72.8	0.3	Low
34	10.1	26.1	20.9	Moderate-low

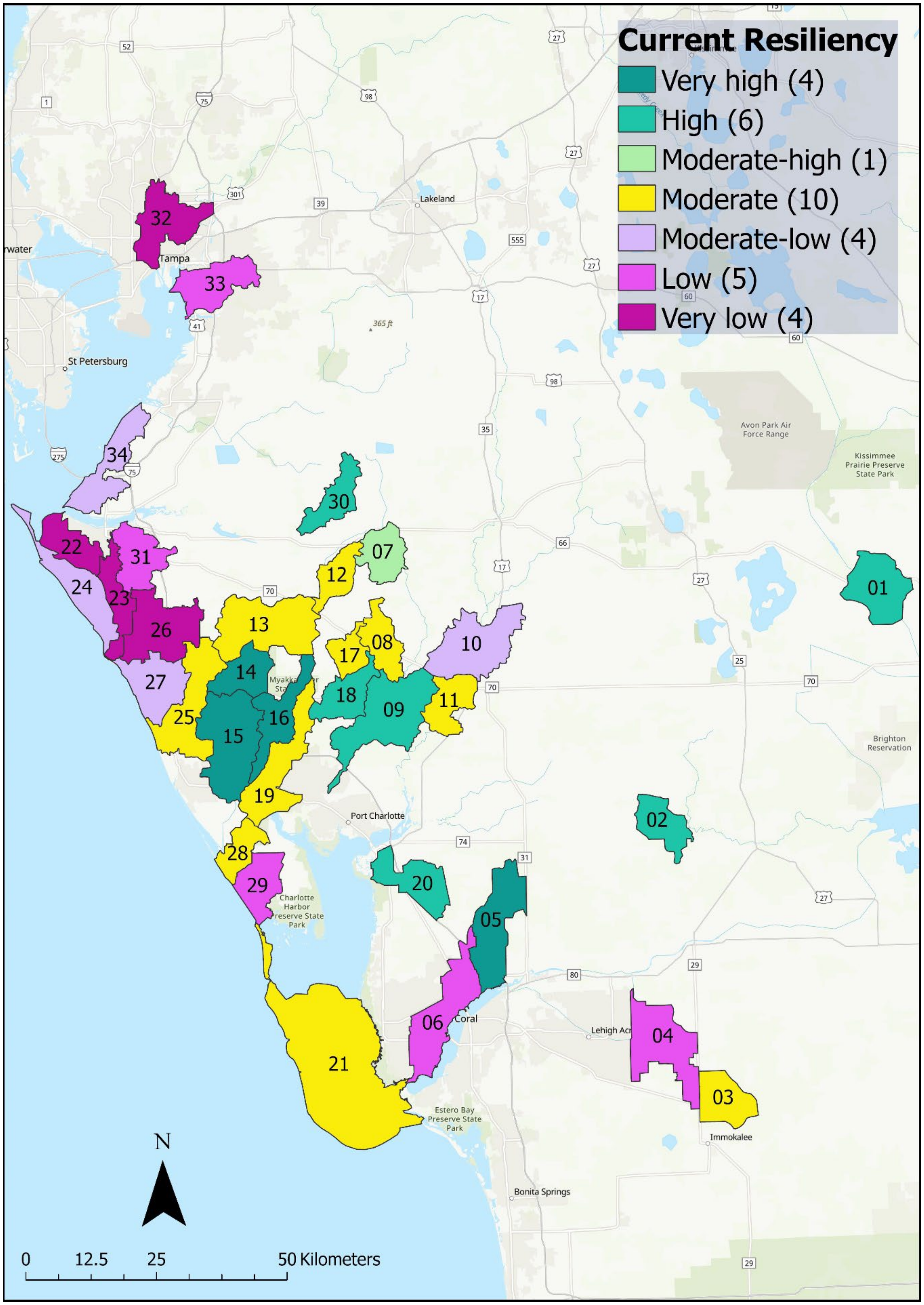

Figure 11. Current resiliency of Florida loosestrife (*Lythrum flagellare*) analysis units.

4.3 Current Redundancy and Representation

Redundancy for Florida loosestrife is inherently fairly low because it is an endemic species. Individual catastrophes could potentially impact the species across the entirety or most of its range. However, analysis units that ranked higher in resiliency are spread across the range of the species, providing some protection against catastrophes. Analysis units that ranked lower in resiliency are mostly clustered around Tampa and Bradenton.

Representation reflects the capability of a species to cope with or adjust to near- and long-term changes in its physical and biological environments. A species' adaptive potential, or capacity, is characterized by the local ecological conditions that influence where it can occur, and can be assessed by evaluating intraspecific genetic, ecological, morphological, and/or behavioral variability that facilitates its either adaptation to these changes in place through the acquisition of new traits or expanded tolerances ("persist-in-place"), or relocating to track suitable bioclimatic conditions ("shift-in-space") as a response to changes in limiting environmental variables (Thurman et al. 2020, entire). Adaptive capacity is a key component in assessing species vulnerability yet is difficult to evaluate and apply in practice. The "adaptive capacity wheel," introduced by Thurman et al. (2020, entire) and recommended by USFWS (2021, entire), focuses on and investigates a species' intrinsic adaptive capacity and acknowledges that many extrinsic factors can act as constraints to the ability of a species to cope with or adjust to changes. This framework identifies and analyzes 36 total attributes grouped within seven general ecological themes, or complexes, of related characteristics (i.e., abiotic niche, demography, distribution, ecological role, evolutionary potential, life history, and movement) and their contribution to a species' ability to adapt to environmental, specifically climatic, conditions (Thurman et al. 2020, entire) (Figure 12). Distribution and movement complexes largely capture the ability of a species to move across the landscape ("shift-in-space"), while life history and demography complexes reflect the ability of a species to accommodate changing climates in situ ("persist-in-place"). Evolutionary potential, ecological role, and abiotic niche complexes are used to inform both response pathways of a species. Of these 36 attributes, 12 are identified as "core" attributes and jointly span the seven complexes, providing a comprehensive approach in assessing a species' adaptive capacity when information for the other attributes is limited or unavailable.

To assess current representation of Florida loosestrife, we used the 12 core attributes represented in the "adaptive capacity wheel" per the methodology outlined in Thurman et al. (2020, entire). We engaged two species experts in an elicitation process in which we asked them to categorize the 12 core attributes into categories of low, moderate, high, unknown, or not applicable based on guidance from Thurman et al. (2020, entire). We also asked experts to indicate their level of uncertainty and provide justification for the way they categorized each core attribute. Below we present the results of this elicitation process.

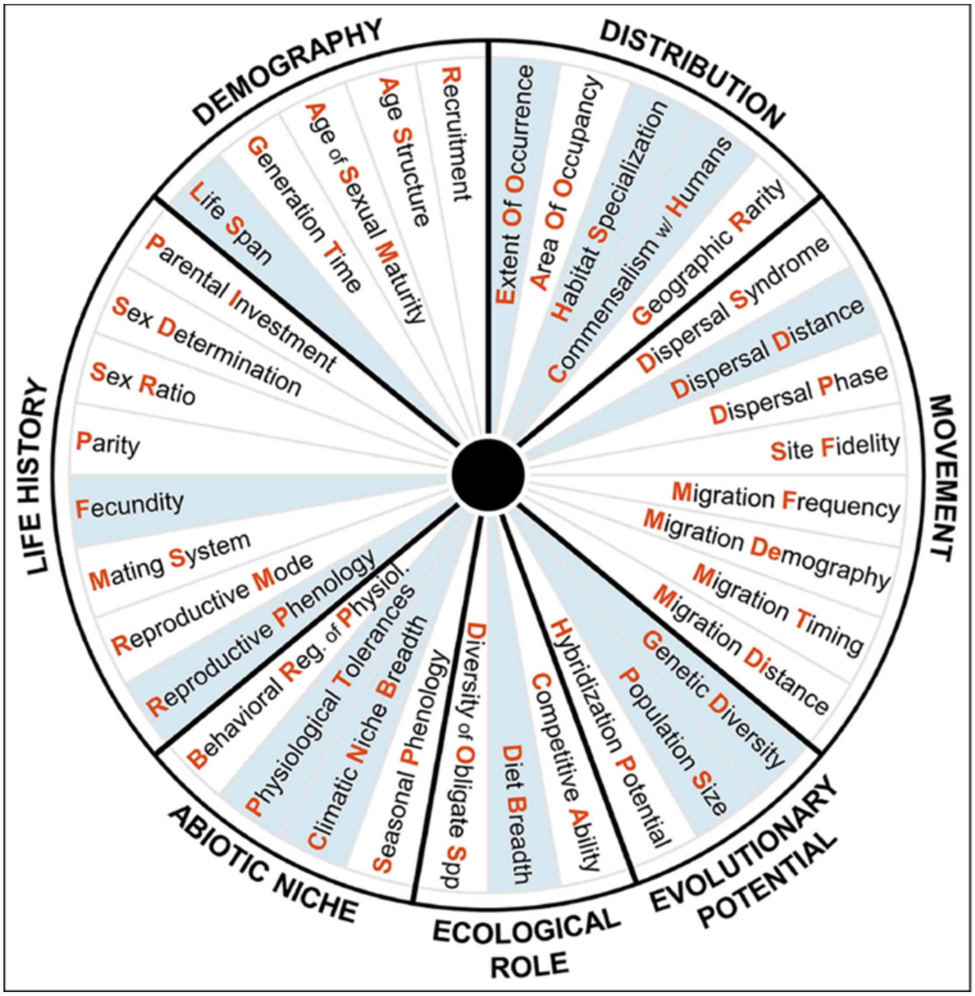

Figure 12. From Thurman et al. (2020, p. 522): “The adaptive capacity (AC) “wheel”, depicting 36 individual attributes organized by ecological complexes (or themes). Twelve core attributes, representing attributes of particular importance and for which data are widely available, are highlighted in light blue.”

Overall, one core attribute was assessed as low, two as moderately low, six as moderate, one as moderately high, one as unknown, and one as not applicable (Figure 13). Genetic diversity is currently unknown for Florida loosestrife, and the only core attribute related to ecological role, diet breadth, is not applicable to plant species.

Species experts describe Florida loosestrife as being “short lived” (life span). It likely most reliably flowers in spring before fluctuating water levels can inundate individuals (reproductive phenology), and its fruits contain numerous seeds (fecundity). With this information, we assessed the core attributes associated with Florida loosestrife’s ability to persist-in-place as moderately high (life span; because species with shorter life spans are presumed to evolve genetic adaptations more quickly than species with longer life spans) and moderate (fecundity and reproductive phenology).

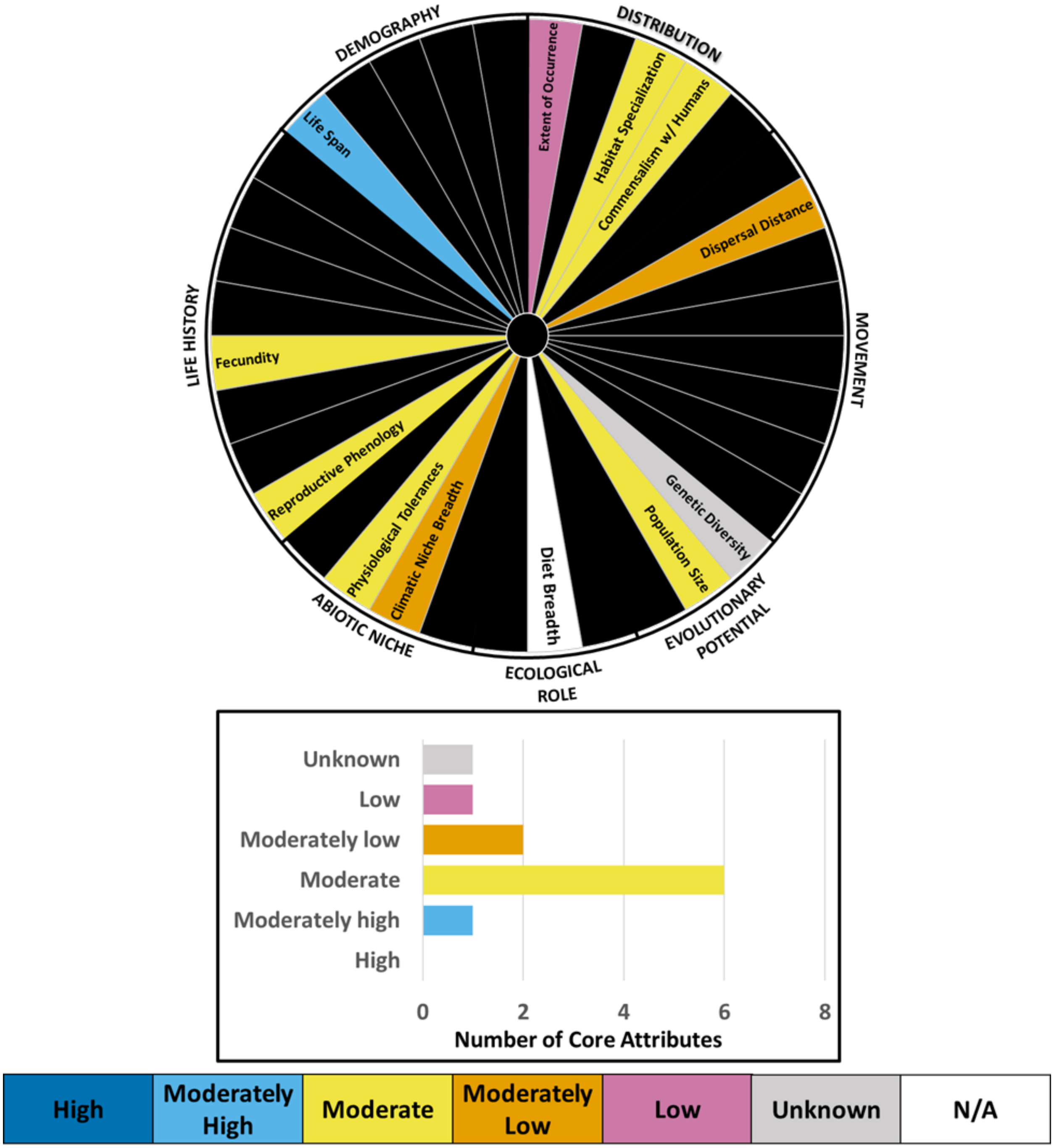

Figure 13. Assessment of adaptive capacity for Florida loosestrife (*Lythrum flagellare*) represented by a color-coded version of the adaptive capacity wheel (top) and summary chart (bottom). Non-core attributes were not assessed thus are blacked out in the wheel.

The core attributes that reflect Florida loosestrife's ability to shift-in-space were assessed as being moderate (habitat specialization and commensalism with humans), moderately low (dispersal distance), and low (extent of occurrence). Species experts consider Florida loosestrife a habitat specialist typically occupying high quality marsh floodplains, but the species has also been reported growing in disturbed human-impacted areas, such as small medians and rights-of-way (habitat specialization). It seems that this species is tolerant of human interaction as it can grow and flower in urban areas, however other types of disturbances such as drainage can be harmful to populations; further, it is unknown if populations in urbanized areas are as healthy as natural populations (commensalism with humans). The dispersal distance core attribute was assessed as moderately low because seeds are likely gravity dispersed but may also disperse within floodplains via sheet flow, and the extent of occurrence core attribute was assessed as low because Florida loosestrife is an endemic species with an occurrence range of ~23,000 km^2.

The remaining core attributes were assessed as moderate (population size and physiological tolerances) and moderately low (climatic niche breadth). While Florida loosestrife has high abundance estimates across its range (in the thousands, often dominating habitats in some locations), population size is difficult to gauge because of uncertainties in defining genetic individuals. Experts described Florida loosestrife's climatic niche breadth and physiological tolerances as limited by narrow hardiness zones and associated soil moisture.

5 FUTURE CONDITION AND VIABILITY

In this chapter we develop plausible future scenarios to assess the future viability of Florida loosestrife in terms of its resiliency, redundancy, and representation.

5.1 Future Considerations and Scenarios

We expect that the major influences on viability of Florida loosestrife in the future will be direct and indirect impacts of development and climate change, specifically from urban and agricultural development and sea level rise (SLR).

5.1.1 Urban and Agricultural Development

We used the forecasting scenarios of land-use change (FORE-SCE) model (Sohl et al. 2014, entire; Sohl et al. 2018) to predict how developed and cultivated crops land cover classes might change into the future. The FORE-SCE dataset we used includes historical baseline land cover data from 1992 to 2005 as well as projected land cover for 2006 to 2100 based on the A1B, A2, B1, and B2 scenarios from the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (Nakićenović et al. 2000, entire). We determined that the A1B and B2 FORE-SCE scenarios would be the worst- and best-case scenarios, respectively, for Florida loosestrife thus retained them for our analyses. The A1B scenario is part of the IPCC A1 storyline, which "describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies" (IPCC 2000, p. 4). The B2 scenario is part of the IPCC B2 storyline, which "describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability" (IPCC 2000, p. 5).

Because FORE-SCE projections are somewhat outdated (the first projected year was 2006), we used the FORE-SCE dataset to calculate percent changes in developed and cropland land cover classes then applied those percent changes to the 2019 NLCD. Specifically, we calculated percent changes in developed and cropland land cover classes from 2005 to 2040 and from 2005 to 2070 using the A1B and B2 FORE-SCE scenarios then applied those percent changes to the developed and cultivated crops land cover classes from the 2019 NLCD. We then estimated the percentage of incompatible land use within each analysis unit under each of the scenarios and used the same cutoffs from our current condition assessment to rank analysis units as low, moderate, or high.

5.1.2 Sea Level Rise

As stated in Section 3.4—Climate Change and Sea Level Rise, SLR could potentially cause salt water to intrude or inundate low-lying habitats near the coast where Florida loosestrife currently occurs and thus kill off plants since the species is not salt tolerant. We used intermediate low and high SLR scenarios for Fort Myers, Florida (NOAA 2022) to predict how SLR might impact Florida loosestrife analysis units in the future. For each scenario, we first removed current suitable habitat expected to be inundated. To incorporate potential saltwater intrusion into the root zone which would trigger complete transformations of vegetative communities prior to direct inundation, we used marsh migration projections from NOAA (2022) and removed additional current suitable habitat expected to transform into brackish/transitional or estuarine marshes. We then calculated the percentage of suitable habitat remaining within each analysis unit under each of the scenarios and used the same cutoffs from our current condition assessment to rank analysis units as low, moderate, or high.

We used 1-foot increment SLR shapefiles and 0.5-foot increment marsh migration rasters from NOAA (2022), thus rounded SLR scenarios for 2040 and 2070 to both the nearest foot and the nearest half-foot (Table 3).

Table 3. Intermediate low and high local sea level rise (SLR) scenarios for Fort Myers, Florida for 2040 and 2070 (NOAA 2022) and SLR shapefile and marsh migration raster used for each.

SLR scenario	Prediction	SLR shapefile	Marsh migration raster
Intermediate low 2040	0.79 ft.	1 ft.	1 ft.
High 2040	1.02 ft.	1 ft.	1 ft.
Intermediate low 2070	1.44 ft.	1 ft.	1.5 ft.
High 2070	3.25 ft.	3 ft.	3.5 ft.

5.1.3 Future Scenarios

We developed two plausible future scenarios representing the worst- and best-case outcomes from our analysis of future urban and agricultural development and SLR. Scenario 1 represents the worst-case outcome and incorporates A1B FORE-SCE and high SLR results, and Scenario 2 represents the best-case outcome and incorporates B2 FORE-SCE and intermediate low SLR results. Together, these scenarios provide the upper and lower bounds of the plausible future condition of the species.

For each scenario, we projected out to the years 2040 and 2070 to get an idea of what conditions might look like for Florida loosestrife in the near future as well as approximately 50 years from now.

5.2 Future Resiliency

We used the future considerations and scenarios described above to assess the future resiliency of Florida loosestrife analysis units. Specifically, we examined the differences between current and future suitable habitat and incompatible land use rankings to determine the expected trend in resiliency for each analysis unit under each scenario. Summarized results are discussed and presented below, and detailed results can be found in the appendix.

Under Scenario 1, resiliency is expected to decrease in 14 analysis units by 2040, and in 20 analysis units by 2070 (Tables 4–5, Figures 14–15). Under Scenario 2, overall results were the same for 2040 and 2070, with resiliency expected to decrease in 6 analysis units and increase in 1 (Tables 4–5, Figure 16). Although SLR is projected to impact several analysis units, the main driver of changes in resiliency for both scenarios and both timesteps was the percentage of incompatible land use brought about by changes in developed and cropland land cover classes (see appendix).

Table 4. Current and projected change in resiliency of Florida loosestrife (*Lythrum flagellare*) analysis units under worst- and best-case scenarios for 2040 and 2070. Single down arrows indicate the incompatible land use ranking for an analysis unit is expected to decrease one category from current, double down arrows indicate it's expected to decrease two categories, and single up arrows indicate it's expected to increase one category from current.

Analysis Unit	**Current Resiliency**	**Resiliency Trend**			
		Scenario 1 2040	**Scenario 2 2040**	**Scenario 1 2070**	**Scenario 2 2070**
1	High	No change	No change	↓	No change
2	High	No change	No change	No change	No change
3	Moderate	No change	No change	No change	No change
4	Low	No change	↑	No change	↑
5	Very high	↓	↓	↓	↓
6	Low	No change	No change	No change	No change
7	Moderate-high	No change	No change	↓	No change
8	Moderate	No change	No change	No change	No change
9	High	↓	No change	↓	No change
10	Moderate-low	↓	No change	↓	No change

11	Moderate	No change	No change	↓	No change
12	Moderate	↓	No change	↓	No change
13	Moderate	↓	↓	↓	↓
14	Very high	↓	No change	↓	No change
15	Very high	↓	↓	↓↓	↓
16	Very high	↓	No change	↓	No change
17	Moderate	No change	No change	No change	No change
18	High	No change	No change	↓	No change
19	Moderate	↓	No change	↓	No change
20	High	No change	No change	No change	No change
21	Moderate	↓	No change	↓	No change
22	Very low	No change	No change	No change	No change
23	Very low	No change	No change	No change	No change
24	Moderate-low	↓	↓	↓	↓
25	Moderate	↓	↓	↓	↓
26	Very low	No change	No change	No change	No change
27	Moderate-low	↓	↓	↓	↓
28	Moderate	↓	No change	↓	No change
29	Low	No change	No change	No change	No change
30	High	No change	No change	↓	No change
31	Low	No change	No change	No change	No change
32	Very low	No change	No change	No change	No change
33	Low	No change	No change	No change	No change
34	Moderate-low	No change	No change	↓	No change

Table 5. Number of Florida loosestrife (*Lythrum flagellare*) analysis units expected to increase, have no change, or decrease in resiliency under worst- and best-case scenarios for 2040 and 2070.

Resiliency Trend	**Scenario 1 2040**	**Scenario 2 2040**	**Scenario 1 2070**	**Scenario 2 2070**
Increase	0	1	0	1
No change	20	27	14	27
Decrease	14	6	20	6

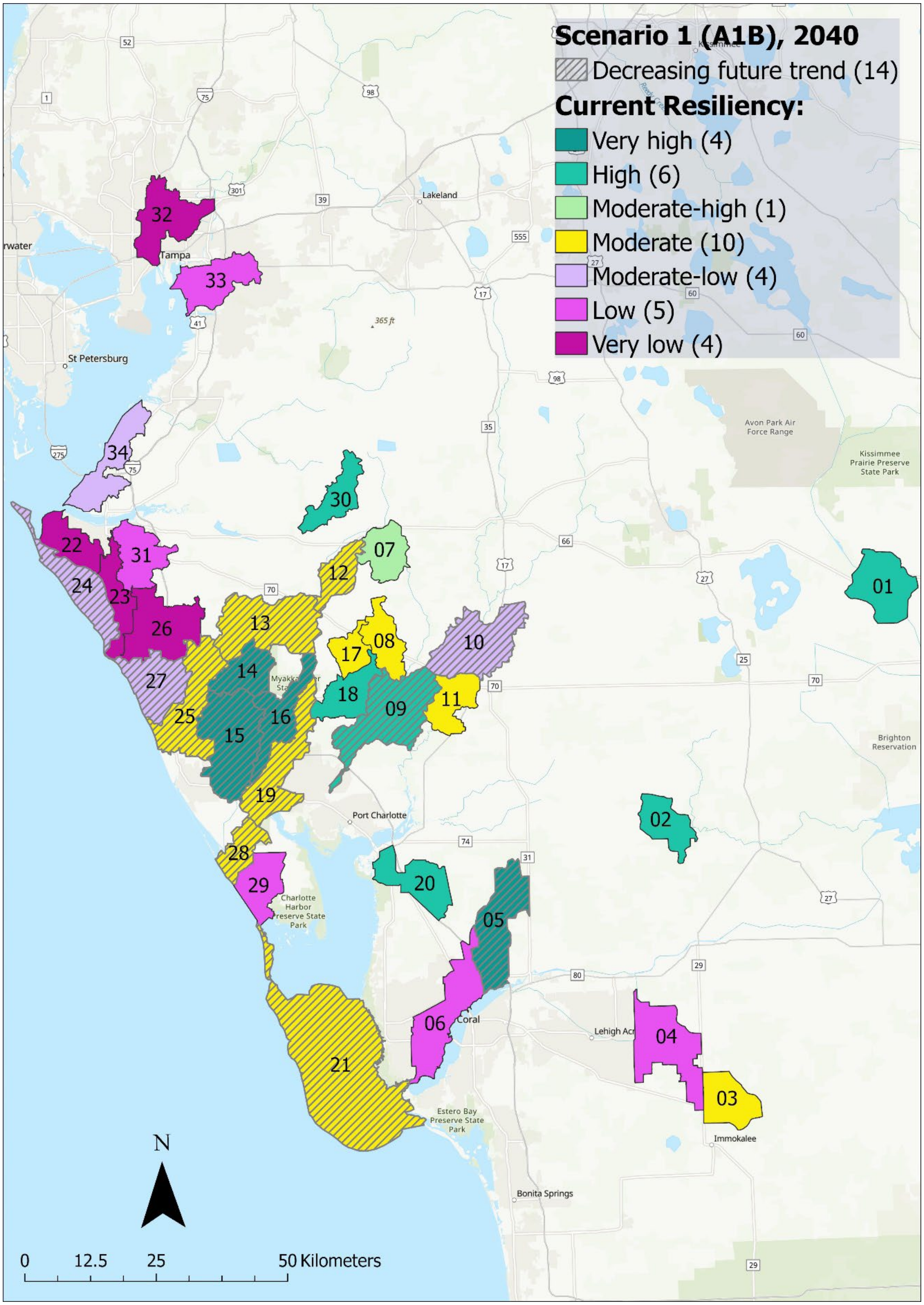

Figure 14. Current and projected change in resiliency of Florida loosestrife (*Lythrum flagellare*) analysis units under Scenario 1 for 2040.

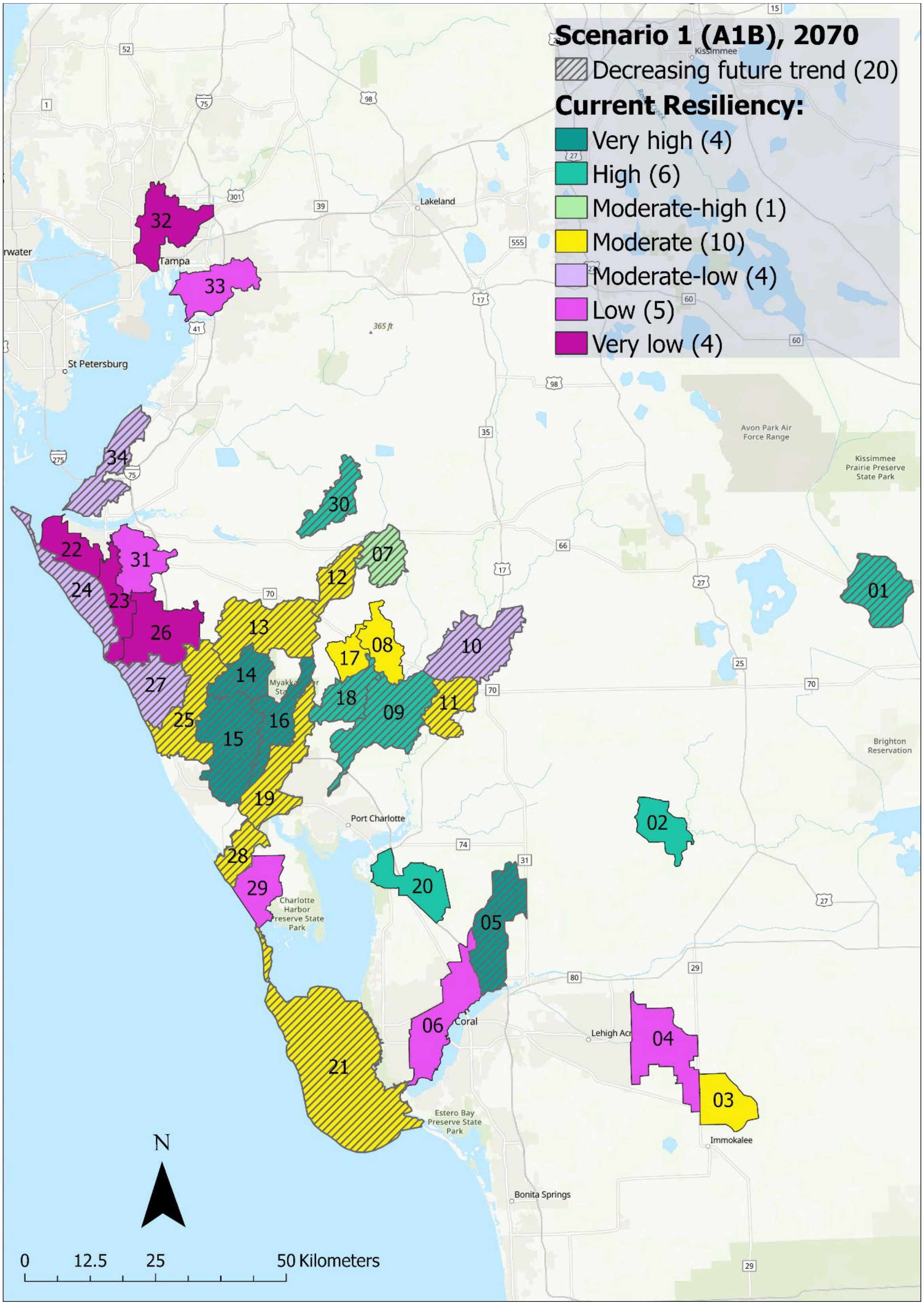

Figure 15. Current and projected change in resiliency of Florida loosestrife (*Lythrum flagellare*) analysis units under Scenario 1 for 2070.

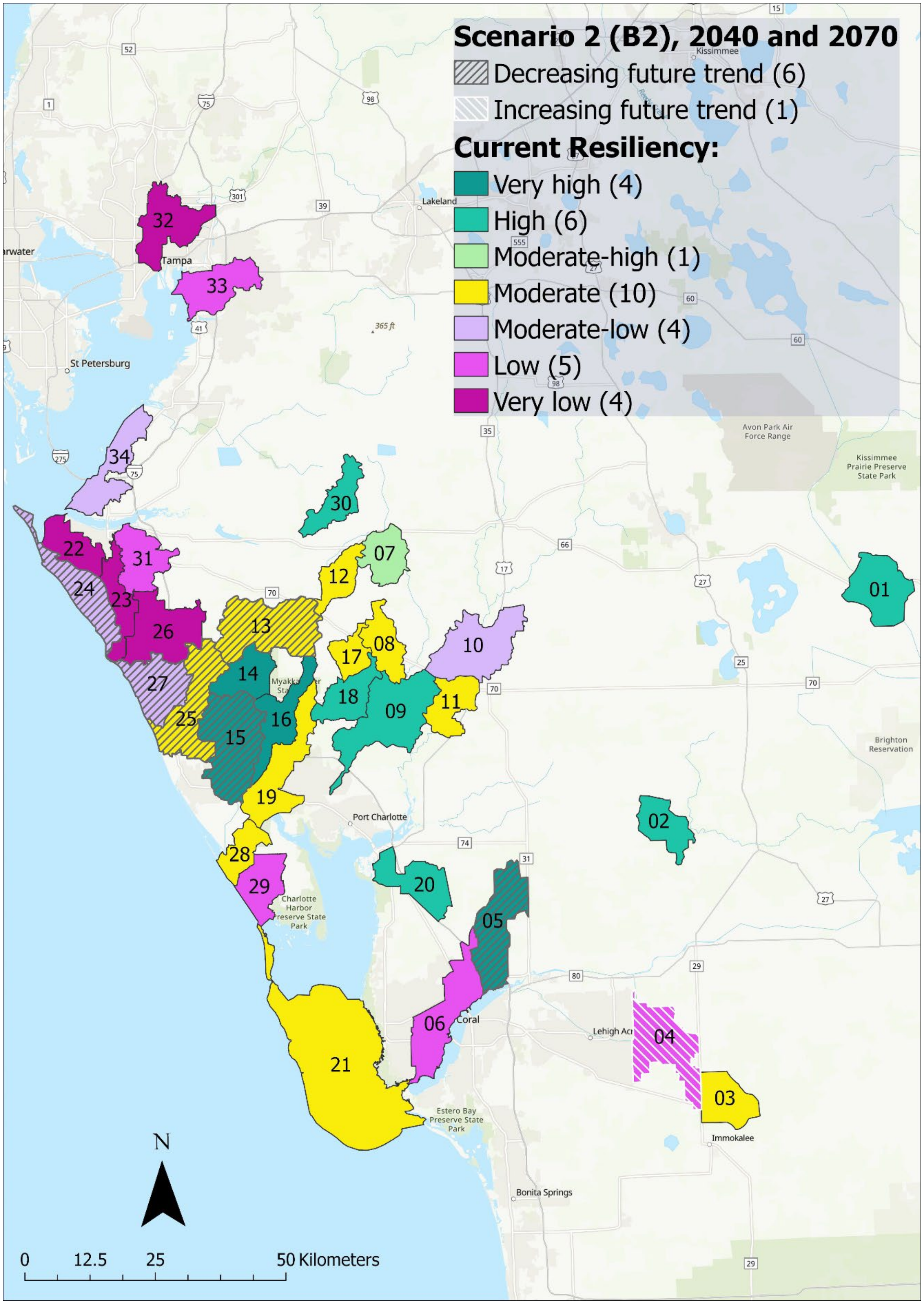

Figure 16. Current and projected change in resiliency of Florida loosestrife (*Lythrum flagellare*) analysis units under Scenario 2 for 2040 and 2070.

5.3 Future Redundancy and Representation

Redundancy for Florida loosestrife is expected to decrease under both scenarios and for both timesteps, but only marginally under Scenario 2. Under Scenario 1 by 2070, resiliency is expected to decrease in 8 of the 10 analysis units currently ranked as very high or high, in 12 of the 15 analysis units currently ranked as moderate-high, moderate, or moderate-low, and in none of the 9 analysis units currently ranked as low or very low. Under Scenario 2 by 2070, resiliency is expected to decrease in 2 of the 10 analysis units currently ranked as very high or high, in 4 of the 16 analysis units currently ranked as moderate-high, moderate, or moderate-low, and in none of the 9 analysis units currently ranked as low or very low (1 ranked as low is expected to increase). By 2070, analysis units expected to decrease in resiliency could be spread across the range of the species (Figure 15) or be mostly clustered along the coast near Sarasota (Figure 16).

To assess the future viability of Florida loosestrife in terms of its representation, we used the 12 core attributes of adaptive capacity identified in Section 4.3 to predict how well-equipped the species is to adapt to climate change. Core attributes relating to the ability of Florida loosestrife to persist-in-place were assessed as moderately high (life span) and moderate (fecundity and reproductive phenology), and those relating to its ability to shift-in-space were assessed as moderate (habitat specialization and commensalism with humans), moderately low (dispersal distance), and low (extent of occurrence). Additional core attributes were assessed as moderate (population size and physiological tolerances) and moderately low (climatic niche breadth). These results suggest that Florida loosestrife may be better equipped to persist-in-place than shift-in-space. As such, its future viability may depend on how well it is able to persist-in-place in a changing climate.

As stated in Section 3.4, temperatures are expected to increase, and climate change is expected to intensify the hydrologic cycle and increase the frequency and severity of extreme events like drought and heavy rainfall. For MRSP, annual mean temperature is projected to increase, precipitation is projected to stay approximately the same, and potential evapotranspiration is projected to increase under both lower and higher emissions scenarios (Table 6). It is difficult to predict exactly how this will impact Florida loosestrife but given that it is a plant of high hydroperiod systems and likely needs moist to saturated soils to germinate, increased temperature and evapotranspiration without an increase in precipitation would likely negatively impact the species.

Table 6. Historical (1971–2000) and projected (2040–2069) annual mean temperature, precipitation, and potential evapotranspiration for Myakka River State Park, Florida. Climate variables projected under Representative Concentration Pathways (RCP) 4.5 and 8.5. Source: Hegewisch et al. (2018).

Climate Variable	Historical (1971–2000)	RCP 4.5 2040–2069	RCP 8.5 2040–2069
Mean temperature (°F)	73.3	76.2	77.3
Precipitation (in.)	57.7	58.6	57.3
Potential evapotranspiration (in.)	62.7	66.4	67.9

LITERATURE CITED

Arrington, D. A., L. A. Toth, and J. K. Koebel, Jr. 1999. Effects of rooting by feral hogs *Sus scrofa* L. on the structure of a floodplain vegetation assemblage. Wetlands 19:535–544.

Bankovich, B., E. Boughton, R. Boughton, M. L. Avery, and S. M. Wisely. 2016. Plant community shifts caused by feral swine rooting devalue Florida rangeland. Agriculture, Ecosystems and Environment 220:45–54.

Beever, E. A., J. O'Leary, C. Mengelt, J. M. West, S. Julius, N. Green, D. Magness, L. Petes, B. Stein, A. B. Nicotra, J. J. Hellmann, A. L. Robertson, M. D. Staudinger, A. A. Rosenberg, E. Babij, J. Brennan, G. W. Schuurman, and G. E. Hofmann. 2016. Improving conservation outcomes with a new paradigm for understanding species' fundamental and realized adaptive capacity. Conservation Letters 9:131–137.

BGCI. 2022. PlantSearch online database. Botanic Gardens Conservation International, Richmond, U.K. https://tools.bgci.org/plant_search.php. Accessed 14 February 2022.

Carter, L., A. Terando, K. Dow, K. Hiers, K. E. Kunkel, A. Lascurain, D. Marcy, M. Osland, and P. Schramm. 2018. Chapter 19: Southeast. In: Reidmiller, D. R., C. W. Avery, D. R. Easterling, K. E. Kunkel, K. L. M. Lewis, T. K. Maycock, and B. C. Stewart (Eds.). Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II. U.S. Global Change Research Program, Washington, D.C.

Chapman, A. W. 1883. Flora of the Southern United States: Containing an Abridged Description of the Flowering Plants and Ferns of Tennessee, North and South Carolina, Georgia, Alabama, Mississippi, and Florida: Arranged According to the Natural System. Second Edition. Ivison, Blakeman, Taylor, and Co., New York, NY.

Coile, N. C., and M. A. Garland. 2003. Notes on Florida's Endangered and Threatened Plants. Florida Department of Agriculture and Consumer Services Division of Plant Industry, Gainesville, FL.

Crandall, K. A., O. R. P. Bininda-Emonds, G. M. Mace, and R. K. Wayne. 2000. Considering evolutionary processes in conservation biology. Trends in Ecology & Evolution 15:290–295.

Dewitz, J., and U.S. Geological Survey. 2021. National Land Cover Database (NLCD) 2019 Products (ver. 2.0, June 2021). U.S. Geological Survey data release, https://doi.org/10.5066/P9KZCM54

Florida Natural Areas Inventory. 2010. Guide to the Natural Communities of Florida: 2010 Edition. Florida Natural Areas Inventory, Tallahassee, FL.

Gann, G. D., K. A. Bradley, and S. W. Woodmansee. 2002. Rare Plants of South Florida: Their History, Conservation, and Restoration. Institute for Regional Conservation, Miami, FL.

Gann, G. D., C. G. Stocking, and Collaborators. 2001–2022. Floristic Inventory of South Florida Database Online. The Institute for Regional Conservation, Delray Beach, FL.

Goodrick, R. L., and J. F. Milleson. 1974. Studies of Floodplain Vegetation and Water Level Fluctuation in the Kissimmee River Valley. Technical Publication 74-2. Central and Southern Florida Flood Control District, West Palm Beach, FL.

Graham, S. A. 1964. The genera of Lythraceae in the southeastern United States. Journal of the Arnold Arboretum 45:235–250.

Graham, S. A. 1975. Taxonomy of the Lythraceae in the southeastern United States. SIDA 6:80–103.

Gray, S. M., G. J. Roloff, D. B. Kramer, D. R. Etter, K. C. Vercauteren, and R. A. Montgomery. 2020. Effects of wild pig disturbance on forest vegetation and soils. Journal of Wildlife Management 84:739–748.

Hegewisch, K. C., J. T. Abatzoglou, O. Chegwidden, and B. Nijssen. 2018. 'Climate Mapper' web tool. Climate Toolbox (https://climatetoolbox.org/). Accessed 16 August 2022.

Hitchcock, A. S. 1897. List of plants in my Florida herbarium. Transactions of the Annual Meetings of the Kansas Academy of Science 16:108–157.

Huegel, C. N. 2010. Florida Loosestrife - *Lythrum flagellare*. Native Florida Wildflowers blog, 3 January 2010. http://hawthornhillwildflowers.blogspot.com/2010/01/florida-loosestrife-lythrum-flagellare.html. Accessed 14 February 2022.

Integrated Taxonomic Information System (ITIS). 2022. ITIS standard report page: *Lythrum flagellare*. https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=27084#null. Accessed 24 January 2022.

IPCC. 2000. IPCC Special Report: Emissions Scenarios; Summary for Policymakers. https://www.ipcc.ch/site/assets/uploads/2018/03/sres-en.pdf

Jestrow, B., and K. Bornhorst. 2021. Fairchild Tropical Botanic Garden (FTG). Occurrence dataset https://doi.org/10.15468/hdpruf. https://www.gbif.org/occurrence/122970728. Accessed 7 February 2022.

Kinyo, A. S. 2005. Effects of distance from invasive *Lythrum salicaria* on pollinator visitation rate and reporoductive success in native *Lythrum alatum*. Thesis, University of Akron, Akron, OH.

Koehne, E. 1885. The Lythraceae of the United States. Botanical Gazette 10:269–277.

Kral, R. 1983. A Report on Some Rare, Threatened, or Endangered Forest-Related Vascular Plants of the South, Volume II: Aquifoliaceae through Asteraceae and Glossary. Technical Publication R8-TP 2. USDA Forest Service Southern Region, Atlanta, GA.

Levin, D. A. 1970. Assortative pollination in *Lythrum*. American Journal of Botany 57:1–5.

Loveless, C. M. 1959. A study of the vegetation in the Florida Everglades. Ecology 40:1–9.

Mangel, M., and C. Tier. 1993. A simple direct method for finding persistence times of populations and application to conservation problems. Proceedings of the National Academy of Sciences of the USA 90:1083–1086.

Matthies, D., I. Bräuer, W. Maibom, and T. Tscharntke. 2004. Population size and the risk of local extinction: Empirical evidence from rare plants. Oikos 105:481–488.

Montague, J. L., S. C. H. Barrett, and C. G. Eckert. 2008. Re-establishment of clinal variation in flowering time among introduced populations of purple loosestrife (*Lythrum salicaria*, Lythraceae). Journal of Evolutionary Biology 21:234–245.

MRSP. 2019. Myakka River State Park Unit Management Plan June 2019 Approved Plan. Florida Department of Environmental Protection, Tallahassee, FL.

MSF. 2010. Ten-Year Resource Management Plan for the Myakka State Forest. Florida Department of Agriculture and Consmer Services Division of Forestry, Tallahassee, FL.

Nakićenović, N., et al. 2000. Special Report on Emissions Scenarios. Published for the Intergovernmental Panel on Climate Change by Cambridge University Press, Cambridge, UK.

NatureServe. 2022. *Lythrum flagellare*. NatureServe Explorer. https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.139430/Lythrum_flagellare. Accessed 14 February 2022.

Nicotra, A.B., E. A. Beever, A. L. Robertson, G. E. Hofmann, and J. O'Leary. 2015. Assessing the components of adaptive capacity to improve conservation and management efforts under global change. Conservation Biology 29:1268-1278.

Nieuwland, J. A. 1914. Some new American Lythra. The American Midland Naturalist 3:265–270.

NOAA. 2022. Sea level rise and coastal flooding impacts. https://coast.noaa.gov/slr/. Accessed 6 June 2022.

Ornduff, R. 1978. Features of pollen flow in dimorphic species of *Lythrum* section Euhyssopifolia. American Journal of Botany 65:1077–1083.

Redford, K. H., G. Amato, J. Baillie, P. Beldomenico, E. L. Bennett, N. Clum, R. Cook, G. Fonseca, S. Hedges, F. Launay, S. Lieberman, G. M. Mace, A. Murayama, A. Putnam, J. G. Robinson, H. Rosenbaum, E. W. Sanderson, S. N. Stuart, P. Thomas, and J. Thorbjarnarson. 2011. What does it mean to successfully conserve a (vertebrate) species? BioScience 61:39–48.

Sgrò, C. M., A. J. Lowe, and A. A. Hoffmann. 2011. Building evolutionary resilience for conserving biodiversity under climate change. Evolutionary Applications 4:326–337.

Small, J. K. 1933. Manual of the Southeastern Flora: Being Descriptions of the Seed Plants Growing Naturally in Florida, Alabama, Mississippi, eastern Louisiana, Tennessee, North Carolina, South Carolina, and Georgia. University of North Carolina Press, Chapel Hill, NC.

Smith, S. M., P. V. McCormick, J. A. Leeds, and P. B. Garrett. 2002. Constraints of seed bank species composition and water depth for restoring vegetation in the Florida Everglades, U.S.A. Restoration Ecology 10:138–145.

Smith, D. R., N. L. Allan, C. P. McGowan, J. A. Szymanski, S. R. Oetker, and H. M. Bell. 2018. Development of a species status assessment process for decisions under the U.S. Endangered Species Act. Journal of Fish and Wildlife Management 9:302–320.

Sohl, T. L., K. L. Slayer, M. A. Bouchard, R. R. Reker, A. M. Friesz, S. L. Bennett, B. M. Sleeter, R. R. Sleeter, T. Wilson, C. Soulard, M. Knuppe, and T. Van Hofwegen. 2014. Spatially explicit modeling of 1992–2100 land cover and forest stand age for the conterminous United States. Ecological Applications 24:1015–1036.

Sohl, T. L., K. L. Slayer, M. A. Bouchard, R. R. Reker, A. M. Freisz, S. L. Bennett, B. M. Sleeter, R. R. Sleeter, T. Wilson, C. Soulard, M. Knuppe, and T. Van Hofwegen. 2018. Conterminous United States Land Cover Projections - 1992 to 2100: U.S. Geological Survey data release, https://doi.org/10.5066/P95AK9HP

Thurman, L. L., B. A. Stein, E. A. Beever, W. Foden, S. R. Geange, N. Green, J. E. Gross, D. J. Lawrence, O. LeDee, J. D. Olden, L. M. Thompson, and B. E. Young. 2020. Persist in place or shift in space? Evaluating the adaptive capacity of species to climate change. Frontiers in Ecology and the Environment 18:520–528.

Tobe, J. D., K. Craddock Burks, R. W. Cantrell, M. A. Garland, M. E. Sweeley, D. W. Hall, P. Wallace, G. Anglin, G. Nelson, J. R. Cooper, D. Bickner, K. Gilbert, N. Aymond, K. Greenwood, and N Raymond. 1998. Florida Wetland Plants: An Identification Manual. Florida Department of Environmental Protection, Tallahassee, FL.

Toth, L. A. 1993. The ecological basis of the Kissimmee River Restoration Plan. Florida Scientist 56:25–51.

USFWS. 1999. South Florida Multi-Species Recovery Plan. USFWS Southeast Region, Atlanta, GA.

USFWS. 2016. USFWS Species Status Assessment Framework: An Integrated Analytical Framework for Conservation. Version 3.4, August 2016.

USFWS. 2021. Linking Adaptive Capacity to Species Status Assessments. Version 1.0, September 2021.

Weakley, A. S. 2022. Flora of the Southeastern United States. University of North Carolina Herbarium, North Carolina Botanical Garden, Chapel Hill, NC.

Wetzel, P. R., A. G. van der Valk, and L. A. Toth. 2001. Restoration of wetland vegetation on the Kissimmee River floodplain: Potential role of seed banks. Wetlands 21:189–198.

Winchester, B. H., J. S. Bays, J. C. Higman, and R. L. Knight. 1985. Physiography and vegetation zonation of shallow emergent marshes in southwestern Florida. Wetlands 5:99–118.

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.

Woodmansee, S. W., and S. E. Green. 2006. A Floristic Survey and Rare Plant Assessment of Caloosahatchee Creeks Preserve, Lee County, Florida Final Report (Abridged Online Version). Institute for Regional Conservation, Miami, FL.

Wunderlin, R. P., B. F. Hansen, A. R. Franck, and F. B. Essig. 2022. Atlas of Florida Plants: *Lythrum flagellare*. Institute for Systematic Botany, University of South Florida, Tampa, FL. https://florida.plantatlas.usf.edu/plant.aspx?id=1257. Accessed 24 January 2022.

APPENDIX

Table A1. Current and projected change in resiliency of Florida loosestrife (*Lythrum flagellare*) analysis units based on suitable habitat lost due to 1 foot of sea level rise (SLR) and percent changes in developed and cropland land cover classes from 2005 to 2040 calculated using the A1B FORE-SCE scenario.

Analysis Unit	Current Resiliency	Suitable Habitat Lost due to SLR (ac)	Suitable Habitat (%)		% Change Developed	% Change Cropland	Incompatible Land Use (%)		Resiliency Trend
			Current	Future			Current	Future	
1	High	0	23.9	23.9	-0.7	115.3	8.7	15.8	No change
2	High	0	26.7	26.7	0	138.2	3.1	4.1	No change
3	Moderate	0	27.0	27.0	Undefined[1]	-10.9	47.5	47.8	No change
4	Low	0	16.0	16.0	277.8	-25.1	62.1	56.5	No change
5	Very high	26.0	28.9	28.9	179.7	-47.8	10.7	29.4	↓
6	Low	77.6	14.1	13.9	20.2	-84.3	75.8	91.2	No change
7	Moderate-high	0	28.9	28.9	0	26.2	15.4	19.0	No change
8	Moderate	0	22.5	22.5	Undeveloped	63.3	10.0	14.6	No change
9	High	0	30.1	30.1	193.7	44.6	12.4	29.2	↓
10	Moderate-low	0	15.5	15.5	185.7	26.1	31.5	55.1	↓
11	Moderate	0	24.6	24.6	71.6	-1.2	35.7	52.2	No change
12	Moderate	0	20.6	20.6	0	13.0	18.2	20.1	↓
13	Moderate	0	23.1	23.1	171.7	-1.9	14.8	37.1	↓
14	Very high	0	47.7	47.7	1261.9	-39.1	4.2	30.4	↓
15	Very high	616.2	33.0	31.7	521.3	12.1	17.0	49.7	↓
16	Very high	19.4	34.6	34.5	2065.8	388.9	1.5	23.3	↓
17	Moderate	0	22.6	22.6	Undeveloped	41.8	3.6	3.9	No change
18	High	0	32.6	32.6	Undefined[2]	30.6	5.9	10.1	No change
19	Moderate	161.6	16.6	16.2	128.8	26.8	41.8	68.4	↓
20	High	123.6	31.7	31.2	114.2	-94.4	28.7	48.6	No change
21	Moderate	1845.2	2.5	1.1	205.5	-87.2	9.7	29.5	↓
22	Very low	418.2	7.2	5.0	37.9	-100	58.3	80.6	No change
23	Very low	29.1	3.6	3.4	4.8	-100	87.8	92.0	No change

24	Moderate-low	19.4	0.2	0.2	41.6	-100	19.1	21.8	↓
25	Moderate	94.5	19.0	18.8	218.5	-98.2	37.4	83.6	↓
26	Very low	29.8	10.2	10.2	31.1	-99.2	79.3	96.6	No change
27	Moderate-low	30.9	15.0	14.9	101.7	-98.4	53.3	88.7	↓
28	Moderate	79.3	15.7	15.2	96.5	Uncultivated	37.4	73.1	↓
29	Low	725.5	10.0	6.5	56.4	-100	61.5	81.7	No change
30	High	0	20.8	20.8	0	56.1	12.5	18.5	No change
31	Low	488.2	14.8	12.7	32.3	-100	72.1	94.1	No change
32	Very low	401.4	6.2	4.9	5.2	-100	91.1	95.9	No change
33	Low	331.1	14.3	13.0	11.5	-100	72.8	81.2	No change
34	Moderate-low	815.1	10.1	7.2	182.1	-91.7	26.1	50.2	No change

[1] FORE-SCE acreage for 2005 was 0 and for 2040 was 838.1

[2] FORE-SCE acreage for 2005 was 0 and for 2040 was 315.1

Table A2. Current and projected change in resiliency of Florida loosestrife (*Lythrum flagellare*) analysis units based on suitable habitat lost due to 1 foot of sea level rise (SLR) and percent changes in developed and cropland land cover classes from 2005 to 2040 calculated using the B2 FORE-SCE scenario.

Analysis Unit	**Current Resiliency**	**Suitable Habitat Lost due to SLR (ac)**	**Suitable Habitat (%)**		**% Change Developed**	**% Change Cropland**	**Incompatible Land Use (%)**		**Resiliency Trend**
			Current	**Future**			**Current**	**Future**	
1	High	0	23.9	23.9	0	12.9	8.7	9.6	No change
2	High	0	26.7	26.7	0	-31.8	3.1	2.9	No change
3	Moderate	0	27.0	27.0	Undefined[1]	-46.0	47.5	38.4	No change
4	Low	0	16.0	16.0	89.7	-51.0	62.1	48.4	↑
5	Very high	26.0	28.9	28.9	93.4	-40.1	10.7	20.4	↓
6	Low	77.6	14.1	13.9	8.5	-62.2	75.8	82.4	No change
7	Moderate-high	0	28.9	28.9	0	-19.3	15.4	12.9	No change
8	Moderate	0	22.5	22.5	Undeveloped	-27.2	10.0	6.5	No change
9	High	0	30.1	30.1	62.0	-18.9	12.4	16.2	No change

10	Moderate-low	0	15.5	15.5	24.3	-28.5	31.5	27.6	No change
11	Moderate	0	24.6	24.6	14.9	-16.9	35.7	37.1	No change
12	Moderate	0	20.6	20.6	0	-24.6	18.2	14.9	No change
13	Moderate	0	23.1	23.1	70.4	-33.3	14.8	23.4	↓
14	Very high	0	47.7	47.7	222.4	-21.6	4.2	13.4	No change
15	Very high	616.2	33.0	31.7	117.0	0	17.0	27.6	↓
16	Very high	19.4	34.6	34.5	144.7	0	1.5	3.3	No change
17	Moderate	0	22.6	22.6	Undeveloped	-29.2	3.6	3.5	No change
18	High	0	32.6	32.6	Undeveloped	-27.8	5.9	4.5	No change
19	Moderate	161.6	16.6	16.2	47.0	-18.0	41.8	44.0	No change
20	High	123.6	31.7	31.2	65.6	-89.2	28.7	34.7	No change
21	Moderate	1845.2	2.5	1.1	68.5	-85.9	9.7	16.3	No change
22	Very low	418.2	7.2	5.0	16.1	-100	58.3	67.9	No change
23	Very low	29.1	3.6	3.4	3.0	-100	87.8	90.4	No change
24	Moderate-low	19.4	0.2	0.2	26.0	-100	19.1	20.2	↓
25	Moderate	94.5	19.0	18.8	102.0	-70.1	37.4	59.7	↓
26	Very low	29.8	10.2	10.2	20.6	-82.9	79.3	89.0	No change
27	Moderate-low	30.9	15.0	14.9	53.8	-98.4	53.3	69.9	↓
28	Moderate	79.3	15.7	15.2	30.0	Uncultivated	37.4	48.3	No change
29	Low	725.5	10.0	6.5	18.9	-100	61.5	67.7	No change
30	High	0	20.8	20.8	0	-13.3	12.5	11.1	No change
31	Low	488.2	14.8	12.7	16.9	-100	72.1	75.1	No change
32	Very low	401.4	6.2	4.9	4.2	-100	91.1	95.0	No change
33	Low	331.1	14.3	13.0	6.9	-100	72.8	77.9	No change
34	Moderate-low	815.1	10.1	7.2	70.5	-52.5	26.1	33.0	No change

[1] FORE-SCE acreage for 2005 was 0 and for 2040 was 30.9

Table A3. Current and projected change in resiliency of Florida loosestrife (*Lythrum flagellare*) analysis units based on suitable habitat lost due to 3.25 feet of sea level rise (SLR) and percent changes in developed and cropland land cover classes from 2005 to 2070 calculated using the A1B FORE-SCE scenario.

Analysis Unit	**Current Resiliency**	**Suitable Habitat Lost due to SLR (ac)**	**Suitable Habitat (%)**		**% Change Developed**	**% Change Cropland**	**Incompatible Land Use (%)**		**Resiliency Trend**
			Current	**Future**			**Current**	**Future**	
1	High	0	23.9	23.9	-0.7	241.7	8.7	23.4	↓
2	High	0	26.7	26.7	0	261.8	3.1	4.9	No change
3	Moderate	0	27.0	27.0	Undefined[1]	-16.8	47.5	51.3	No change
4	Low	0	16.0	16.0	448.1	-39.9	62.1	53.5	No change
5	Very high	68.9	28.9	28.8	238.1	-63.2	10.7	35.4	↓
6	Low	254.0	14.1	13.4	22.8	-94.3	75.8	93.2	No change
7	Moderate-high	0	28.9	28.9	0	49.4	15.4	22.1	↓
8	Moderate	0	22.5	22.5	Undeveloped	102.8	10.0	18.1	No change
9	High	0	30.1	30.1	394.4	80.6	12.4	46.2	↓
10	Moderate-low	0	15.5	15.5	407.6	22.1	31.5	75.4	↓
11	Moderate	0	24.6	24.6	180.2	-51.6	35.7	71.1	↓
12	Moderate	0	20.6	20.6	0	56.9	18.2	26.1	↓
13	Moderate	0	23.1	23.1	294.6	1.1	14.8	53.1	↓
14	Very high	0	47.7	47.7	2912.0	-43.8	4.2	49.6	↓
15	Very high	1361.1	33.0	30.1	852.6	-48.9	17.0	66.4	↓↓
16	Very high	61.4	34.6	34.4	3992.6	832.7	1.5	36.9	↓
17	Moderate	0	22.6	22.6	Undeveloped	140.7	3.6	4.4	No change
18	High	0	32.6	32.6	Undefined[2]	92.3	5.9	24.5	↓
19	Moderate	578.0	16.6	14.9	167.1	61.0	41.8	75.3	↓
20	High	242.1	31.7	30.7	127.4	-97.0	28.7	50.6	No change
21	Moderate	2674.1	2.5	0.4	283.1	-88.5	9.7	37.0	↓
22	Very low	332.2	7.2	5.5	39.7	-100	58.3	81.6	No change
23	Very low	16.5	3.6	3.5	5.4	-100	87.8	92.5	No change
24	Moderate-low	39.0	0.2	0.1	45.5	-100	19.1	22.0	↓
25	Moderate	178.8	19.0	18.6	288.1	-100	37.4	91.5	↓

26	Very low	43.8	10.2	10.1	35.0	-100	79.3	98.0	No change
27	Moderate-low	66.3	15.0	14.8	116.4	-98.4	53.3	90.2	↓
28	Moderate	189.4	15.7	14.4	111.0	Uncultivated	37.4	78.5	↓
29	Low	1208.6	10.0	4.2	69.4	-100	61.5	85.4	No change
30	High	0	20.8	20.8	0	120.1	12.5	25.3	↓
31	Low	549.0	14.8	12.5	33.7	-100	72.1	94.8	No change
32	Very low	308.5	6.2	5.3	5.1	-100	91.1	95.9	No change
33	Low	337.6	14.3	13.0	12.4	-100	72.8	81.9	No change
34	Moderate-low	1151.9	10.1	6.1	269.9	-99.6	26.1	66.8	↓

[1] FORE-SCE acreage for 2005 was 0 and for 2070 was 2542.1

[2] FORE-SCE acreage for 2005 was 0 and for 2070 was 814.2

Table A4. Current and projected change in resiliency of Florida loosestrife (*Lythrum flagellare*) analysis units based on suitable habitat lost due to 1.5 feet of sea level rise (SLR) and percent changes in developed and cropland land cover classes from 2005 to 2070 calculated using the B2 FORE-SCE scenario.

Analysis Unit	**Current Resiliency**	**Suitable Habitat Lost due to SLR (ac)**	**Suitable Habitat (%)**		**% Change Developed**	**% Change Cropland**	**Incompatible Land Use (%)**		**Resiliency Trend**
			Current	**Future**			**Current**	**Future**	
1	High	0	23.9	23.9	0	8.1	8.7	9.3	No change
2	High	0	26.7	26.7	0	-32.1	3.1	2.9	No change
3	Moderate	0	27.0	27.0	Undefined[1]	-71.1	47.5	34.9	No change
4	Low	0	16.0	16.0	159.1	-69.5	62.1	46.3	↑
5	Very high	34.8	28.9	28.8	106.0	-48.6	10.7	21.7	↓
6	Low	117.5	14.1	13.8	9.1	-72.4	75.8	82.8	No change
7	Moderate-high	0	28.9	28.9	0	-40.9	15.4	10.0	No change
8	Moderate	0	22.5	22.5	Undeveloped	-44.4	10.0	5.0	No change
9	High	0	30.1	30.1	83.3	-40.0	12.4	16.8	No change
10	Moderate-low	0	15.5	15.5	64.3	-46.3	31.5	27.5	No change
11	Moderate	0	24.6	24.6	38.9	-37.3	35.7	40.1	No change
12	Moderate	0	20.6	20.6	0	-36.8	18.2	13.2	No change

13	Moderate	0	23.1	23.1	114.5	-46.5	14.8	28.8	↓
14	Very high	0	47.7	47.7	287.2	-51.4	4.2	16.1	No change
15	Very high	750.0	33.0	31.4	137.2	-13.5	17.0	28.1	↓
16	Very high	24.1	34.6	34.5	153.2	0	1.5	3.4	No change
17	Moderate	0	22.6	22.6	Undeveloped	-52.5	3.6	3.4	No change
18	High	0	32.6	32.6	Undefined[2]	-45.0	5.9	3.7	No change
19	Moderate	210.6	16.6	16.0	53.1	-30.0	41.8	42.0	No change
20	High	132.4	31.7	31.2	69.6	-91.8	28.7	34.7	No change
21	Moderate	2182.6	2.5	0.8	78.2	-87.2	9.7	17.2	No change
22	Very low	241.0	7.2	5.9	17.2	-100	58.3	68.5	No change
23	Very low	11.5	3.6	3.5	3.2	-100	87.8	90.5	No change
24	Moderate-low	11.9	0.2	0.2	27.2	-100	19.1	20.2	↓
25	Moderate	111.0	19.0	18.8	119.8	-80.0	37.4	60.8	↓
26	Very low	30.7	10.2	10.2	22.3	-90.2	79.3	89.3	No change
27	Moderate-low	31.2	15.0	14.9	58.7	-100	53.3	70.3	↓
28	Moderate	93.3	15.7	15.1	30.8	Uncultivated	37.4	48.7	No change
29	Low	814.6	10.0	6.1	23.7	-100	61.5	67.8	No change
30	High	0	20.8	20.8	0	-24.2	12.5	10.0	No change
31	Low	439.6	14.8	13.0	17.3	-100	72.1	75.3	No change
32	Very low	322.2	6.2	5.2	4.1	-100	91.1	95.0	No change
33	Low	328.2	14.3	13.0	7.2	-100	72.8	78.1	No change
34	Moderate-low	763.0	10.1	7.4	91.2	-72.1	26.1	33.6	No change

[1] FORE-SCE acreage for 2005 was 0 and for 2070 was 99.2

[2] FORE-SCE acreage for 2005 was 0 and for 2070 was 15.4