Nicholas Institute for Environmental Policy Solutions
Scoping Document
Part 2
Exploratory Analysis of Characteristics and Trends of At-Risk Species in the Southeast U.S.

Spatial Distribution and Characteristics of At-Risk Species in the Southeast U.S.

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Most of the spatial information on species used in this analysis is provided by NatureServe (www.natureserve.org) and its network of natural heritage member programs, a leading source of information about rare and endangered species, and threatened ecosystems.

The National Atlas of the United States also provided some data layers used in this analysis.

This document is the result of an internal scoping and exploratory analysis based on publically available data and has not been peer-reviewed. We hope it will initiate discussion on effective and efficient pre-compliance management for at-risk species in the southeast.

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This section provides an overview of geographic trends and species characteristics for at-risk species. All at-risk species are presented first (listed, candidate, and petitioned), followed by subsections focused on two groups that may be of particular interest to managers: restricted range species (those known to range in only a single county or watershed) and petitioned and candidate species alone (without listed species).

AN OVERVIEW OF ALL AT RISK SPECIES

GEOGRAPHIC TRENDS. Within the southeast, the heaviest concentrations of at-risk species (currently listed, candidates to be listed, and petitioned to be listed) are located along the Appalachian Mountains (particularly northern Alabama), along the Florida panhandle, and throughout central and southern Florida. Only a few counties and watersheds have no known occurrences of at-risk species. This pattern is closely followed by listed and petitioned species (Figures 2 and 3).

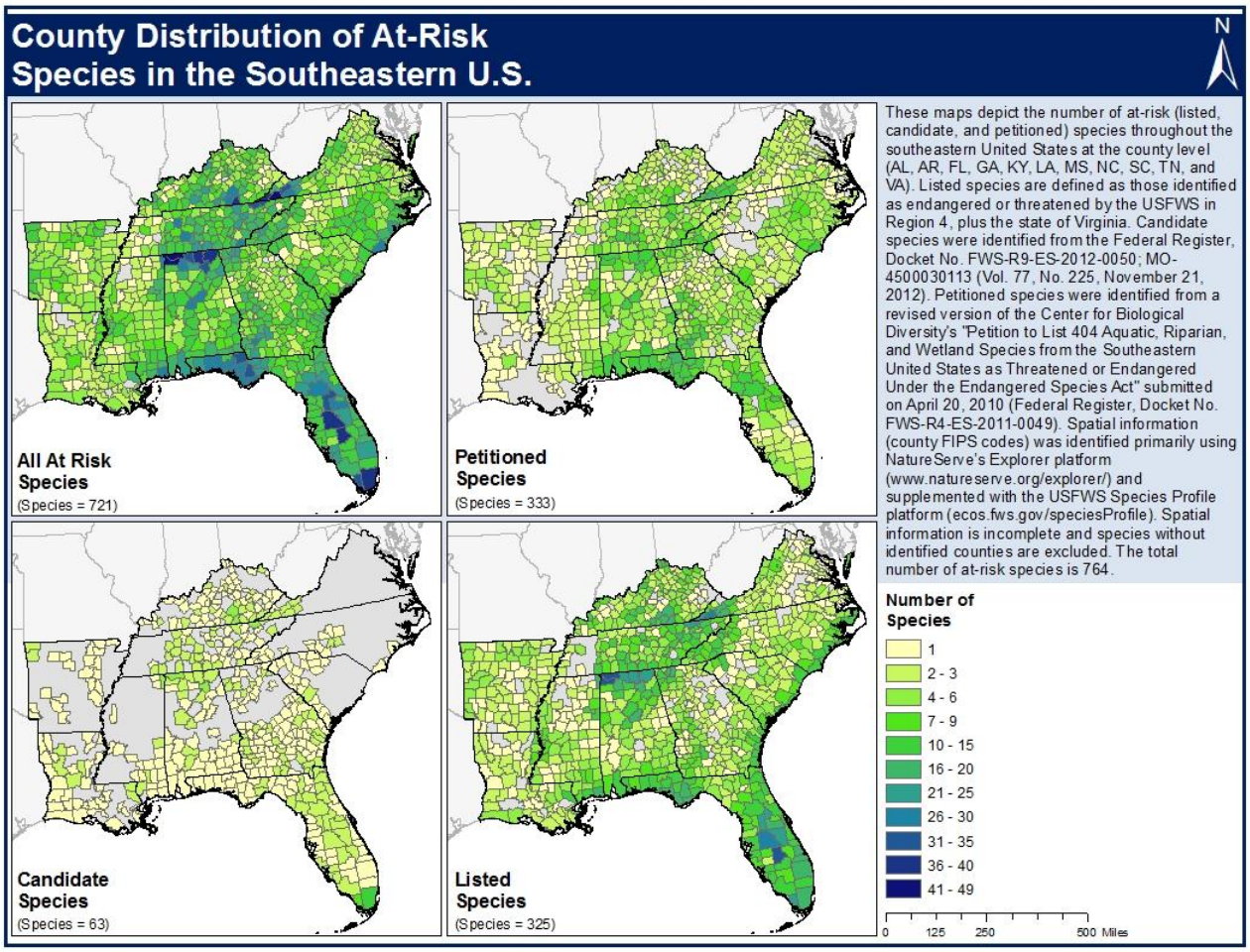


Figure 2: County distribution (presence/absence) of at-risk species throughout the southeastern U.S. Because geographic information is incomplete, the total number of species depicted in this figure is less than the total number of at-risk species.

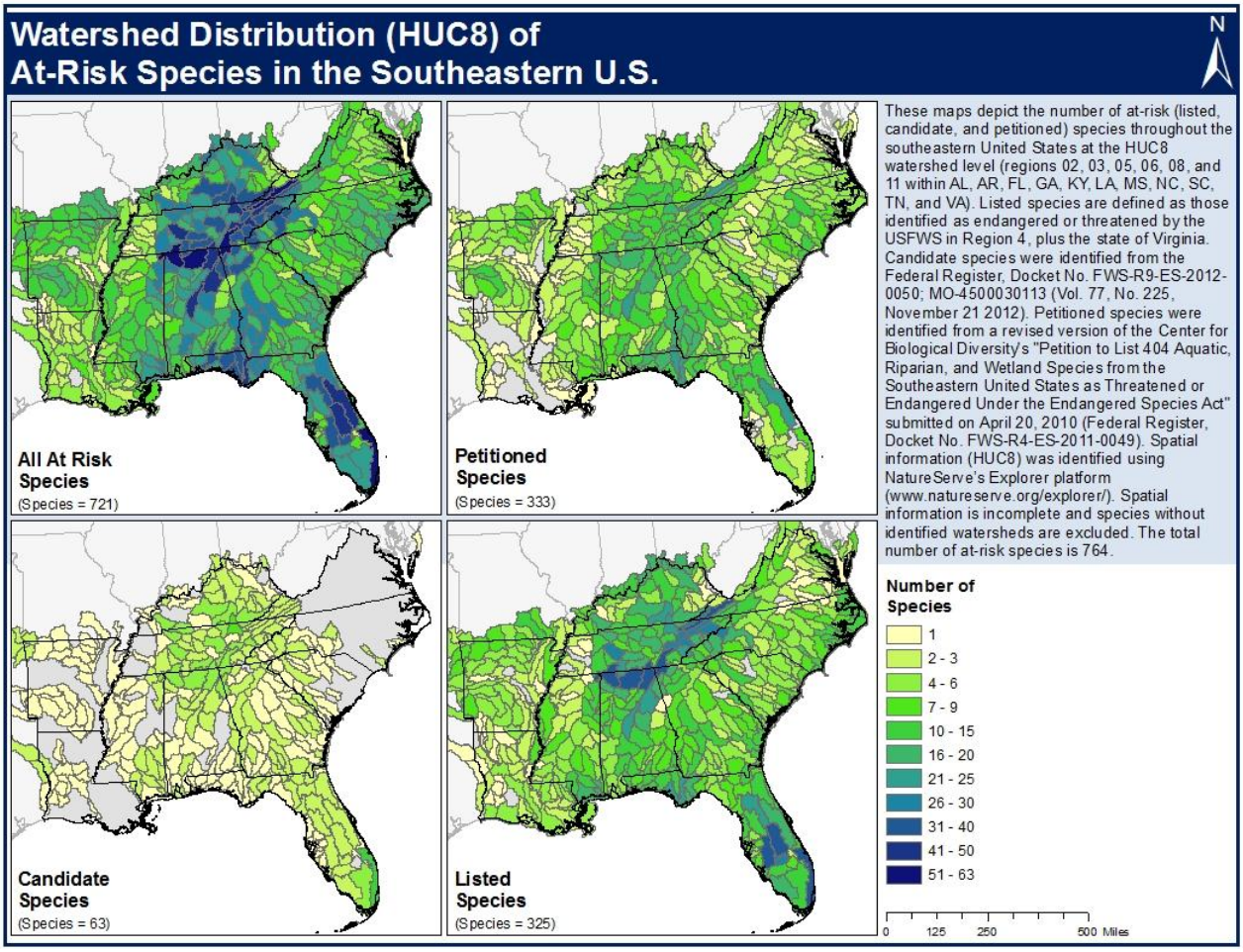


Figure 3: Watershed distribution (presence/absence) of at-risk species throughout the southeastern U.S. Because geographic information is incomplete, the total number of species depicted in this figure is less than the total number of at-risk species.

AT-RISK SPECIES TAXA. The dominant taxon of at-risk species is plants (predominantly vascular), with 220 species. Nearly half of all species are invertebrates – insects, snails, mussels, etc. (351) – and the dominant vertebrate taxon is fish (Figure 4). Predictably, the most charismatic taxa (birds and mammals) contain primarily listed species. Mussels also already have a high proportion of already listed species (approximately 65%) while other invertebrate groups have far more petitioned species (Figure 5).

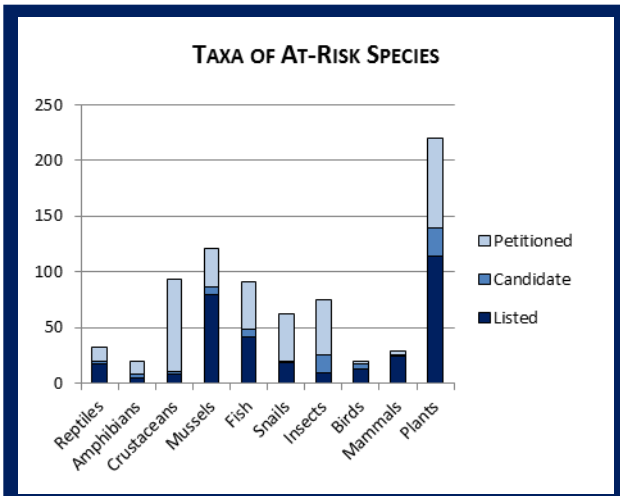


Figure 4: Species counts by taxa and ESA status.*

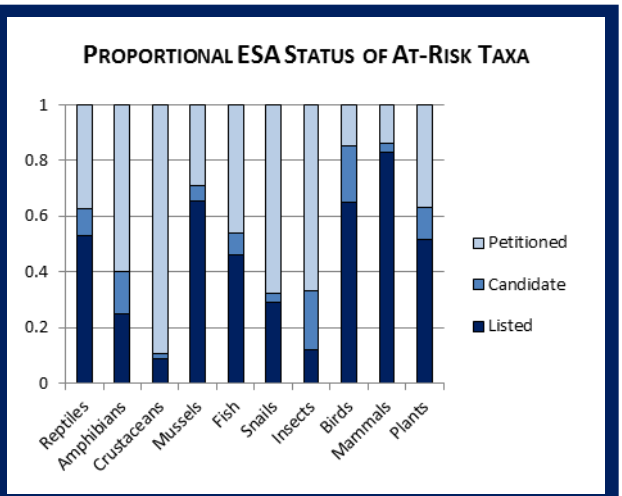


Figure 5: ESA status proportion by taxa.*

* Does not include a single arachnid species (already listed).

AT-RISK SPECIES CHARACTERISTICS. Over half of all at-risk species use riverine habitat while approximately 30% are found in palustrine environments (palustrine includes both wetland and riparian areas). Within riverine habitats, more species are found in medium river or creek habitats with moderate to high gradients and almost 75% are benthic (291 of 390). Of those in palustrine habitats, nearly half are found in riparian areas. Dominant terrestrial habitats are forest (more commonly hardwood, if specifically known) and woodland (more commonly conifer, if specifically known).[1] Sixty-six species are subterranean obligates, primarily living in either aquatic or terrestrial cave environments. Most of these species are either crayfish or cave beetles, and have very low to low mobility.

Only five percent of at-risk species exhibit life stage habitat variation. This group includes all caddisflies/stoneflies/dragonflies, some amphibians, and sea turtles (because sea turtles hatch on beaches, but then spend their entire lives off-shore, we categorized them as having life stage habitat variation). Most of these species are found in palustrine environments, but many are also riverine. None of them have interspecific relationships. The vast majority of these species have moderate to very high mobility but are non-migratory. A few are local or long-distance migrants. These species are concentrated in the state of Florida and along the Atlantic coastline, a distribution that is likely influenced by the inclusion of sea turtles in this group. Excluding sea turtles highlights that at-risk species with habitat variation by life stage are still concentrated in northern Florida and southern Georgia (Figure 6).

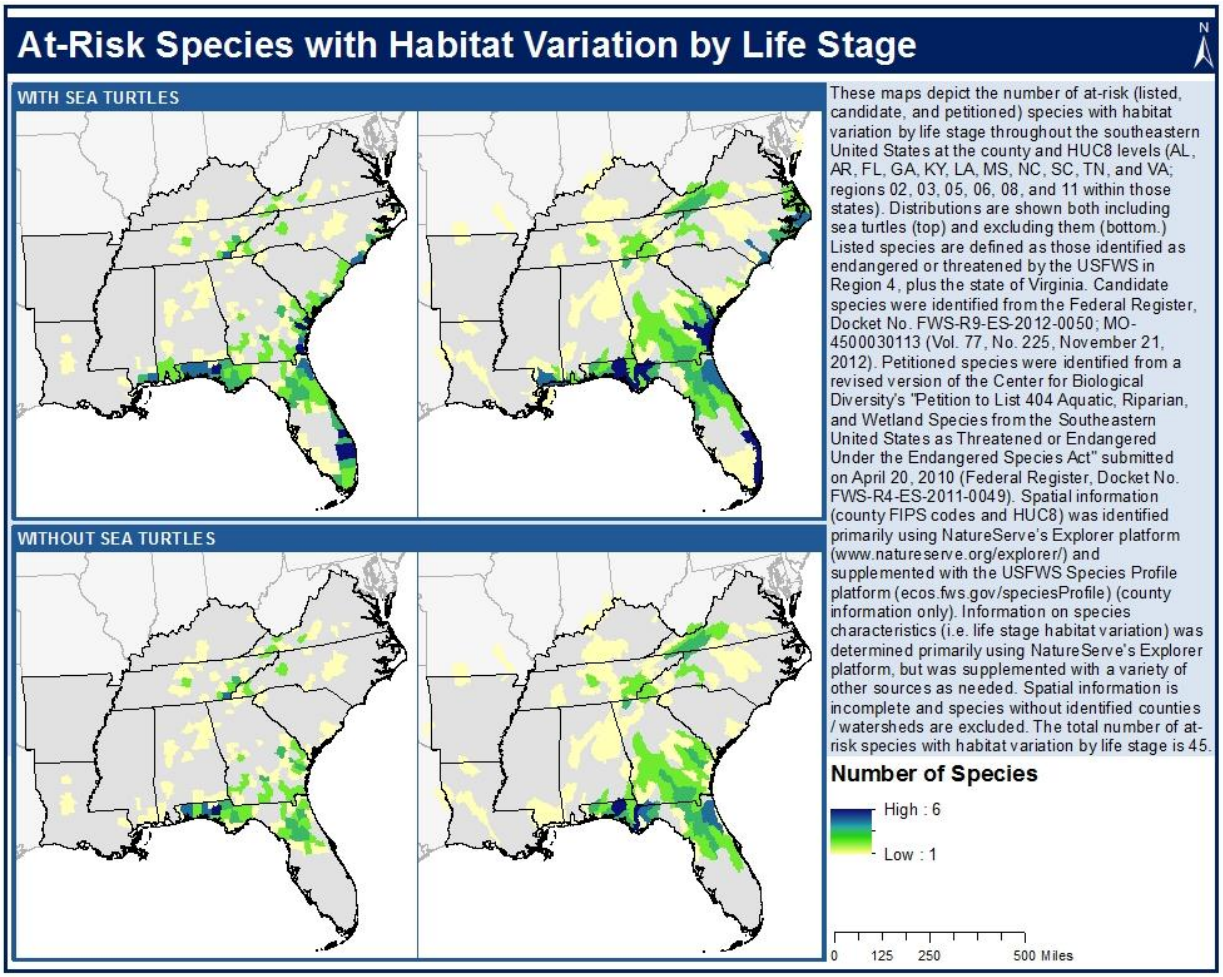


Figure 6: Distribution of species with habitat variation by life stage, both with and without sea turtles.

[1] Habitat categories are not mutually exclusive.

Approximately 25% of at-risk species rely on some type of interspecific relationship: butterflies with either obligate larval hosts or feeding plants, mussels with obligate larval fish hosts, and vascular plants that rely on insects or other animals for seed dispersal or pollination. Of the sixty-one plant species, nearly one-third are found in Florida scrub habitat (along with three butterflies). All mussels are riverine, and most are found in medium river habitats (tributaries of big rivers, with coarse to fine sediments and low amounts of shading from vegetation). Habitats for butterflies are varied. Of species with interspecific relationships, the vast majority have low mobility, but a few plants and butterflies have moderate to high mobility (in plants, mobility refers to dispersal capacity). None of these species are migratory. Spatially, these species are scattered throughout the southeast, but concentrations do occur in the Appalachian Mountains, similarly to the distribution of all at-risk species (Figure 7).

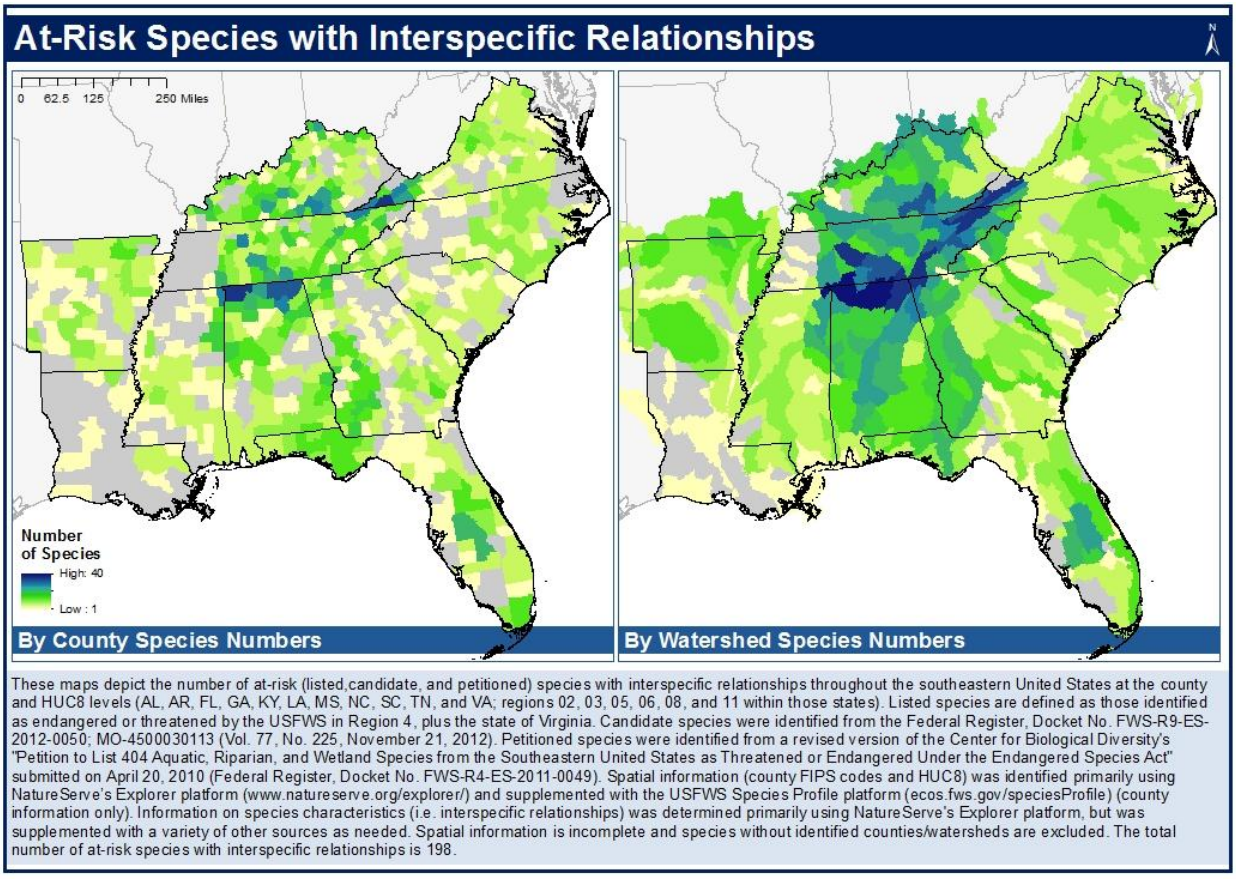


Figure 7: Distribution of species with interspecific relationships.

Over 500 species have low mobility (defined as movements likely less than 100 meters), though 121 are moderately mobile (movements over 100 meters but less than 1 kilometer) and 80 are either highly or very highly mobile (movements over 1 kilometer, with very highly mobile generally used for long-distance migrants). Taxa are varied for species with moderate or high mobility, and include amphibians, birds, fish, insects, mammals, reptiles, and plants. Only five percent of species are migratory (either locally or long-distance, and most of those species are considered highly or very highly mobile.

AN ANALYSIS OF RESTRICTED RANGE SPECIES

Species with severely restricted ranges are usually of particular concern to conservation managers as opportunities for protection are very limited. Fewer locations for a species, and geographically concentrated locations, can also be more susceptible to threats, such as pollution or development.

SPATIAL DISTRIBUTION. Within the southeast, 120 at-risk species range only within a single county, and 161, within a single watershed (based on current known range information). The highest concentration of these species is along the east coast of Florida. However, species are also roughly scattered through the Appalachians into central Alabama. The number of potentially restricted range species within Florida is not surprising given its unique ecosystems (Florida scrub and hammock). A high proportion of the species throughout Florida are petitioned or candidate, highlighting the opportunity for pre-compliance action (Figure 8).

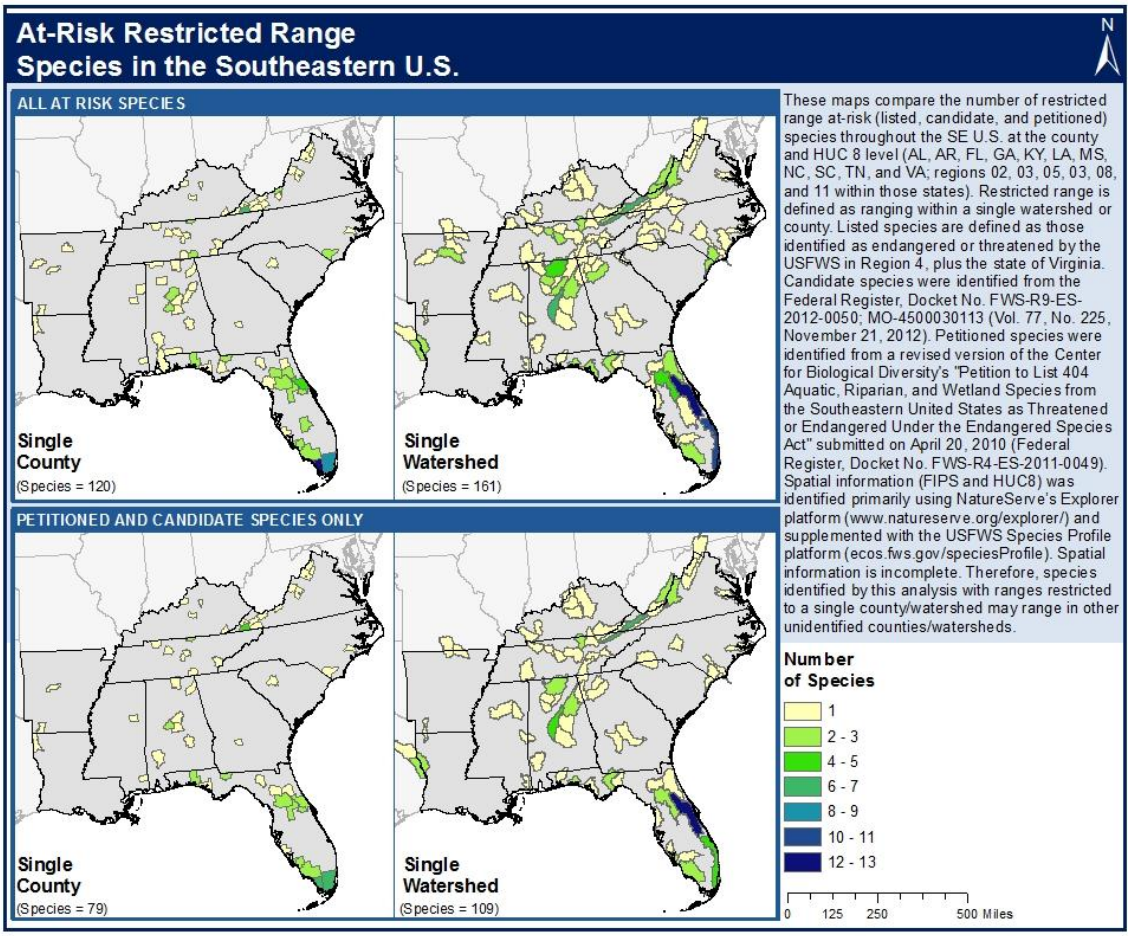


Figure 8: Distribution of restricted range at-risk species (top) and petitioned and candidate species (bottom).

CHARACTERISTICS OF RESTRICTED RANGE SPECIES. The ESA status of approximately half of these restricted range species is petitioned (Figure 9). Invertebrates such as snails, insects, and crustaceans are the dominant taxa, followed by plants (Figure 10). These species are more likely to be associated with aquatic habitats, including riverine, palustrine, and subaquatic, although a number are also subterrestrial (most of them cave beetles). Mobility is generally low and species are primarily non-migratory.

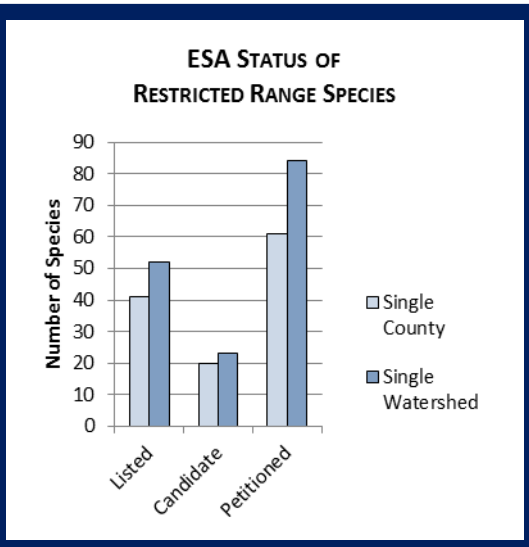


Figure 9: Status of restricted range species.

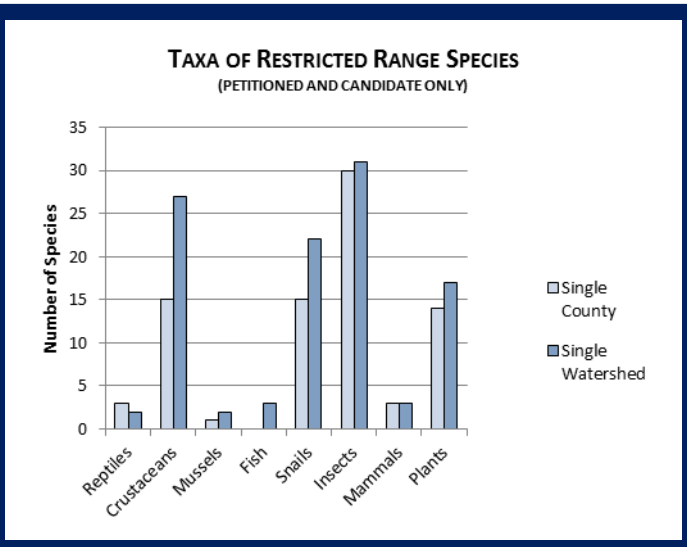


Figure 10: Taxa of restricted range species (includes cave beetles).

NATURAL VERSUS HUMAN HABITAT RESTRICTION. While many species have restricted ranges because of human activity, some species have ranges that are restricted naturally. An example of naturally small ranges in this analysis is cave beetles. Twenty-two species of cave beetles are currently petitioned or candidate species, and are known from only a single county or watershed in the southeast U.S. (many within a single cave). However, these species are likely relic populations from the Pleistocene Era and have no means of moving between caves except during excessive flooding (NatureServe). Understanding the reason for range restriction would be key to effective pre-compliance management of these species.

AN ANALYSIS OF PETITIONED AND CANDIDATE SPECIES

Petitioned and candidate species are also of particular interest to managers, as they offer opportunities for pre-compliance management. General spatial distributions of these 434 species were covered previously in this analysis. However, exploring the characteristics of this group highlight some interesting trends, as does evaluating petitioned and candidate species by ecoregion.

TAXA AND CHARACTERISTICS OF PETITIONED AND CANDIDATE SPECIES. As with all at-risk species, the dominant taxa for petitioned and candidate species is plants (100 species or 23% of petitioned and candidate species versus 29% plants for all at-risk species). However, 85 petitioned and candidate species are crustaceans and another 66 are insects, which represents over 90% of all at-risk crustaceans and insects. Only 91 petitioned and candidate species are vertebrates or any taxa (amphibians, birds, fish, mammals, or reptiles).

The Center for Biological Diversity petition focused on those species that are aquatic, riparian, and wetland. Therefore, those habitats are much more prominent within the petitioned and candidate group than terrestrial habitats. Medium river and creek habitats with moderate gradients are more common, and 40% of petitioned and candidate species are benthic. With the broad palustrine habitat category, both herbaceous wetland and forested wetlands are more common, along with riparian areas. A significant percentage (38%) of candidate species use woodland habitat (both mixed and conifer

woodlands). Importantly, detailed habitat information is not known for 21 petitioned and candidate species (compared to 2 for listed species).

Eight percent of petitioned and candidate species have life stage habitat variation, which is slightly higher than all at-risk species. However, only 15% have interspecific relationships, compared to roughly 25% of all at-risk species. Two-thirds of petitioned and candidate species have low mobility, and only 10 have any migratory behavior (either local or long-distance).

DISTRIBUTION BY ECOREGION. The southeast U.S. contains portions of 21 distinct ecoregions as defined by the EPA, and all are home to at least 1 petitioned or candidate species. Generally, ecoregions in the far west of the southeast U.S. have fewer petitioned and candidate species than those in the central and eastern portions. The ecoregion with the highest number of species is the Southeastern Plains. However, the Southeastern Plains ecoregion also has the largest area, nearly double that of the Piedmont, which has the second largest area. Accounting for differences in area highlights that petitioned and candidate species are more concentrated in the Appalachian Mountains rather than the Southeastern Plains and Southern Coastal Plains ecoregions, which have the highest numbers of species (150 and 100 respectively) (Figure 12).

Ecoregion Methods Overview

Species counts are based on watershed presence/absence data from NatureServe. Each watershed was assigned to the ecoregion that contained the majority of its area (this does introduce some error). Each species occurrence by watershed as then labeled according to ecoregion and species counts were summarize by ecoregion. Agriculture and developed areas are calculated based on NLCD 2006 (developed area land classes 21-24 and agriculture land classes 81-82). Protected areas were identified using PAD-US, and only include designated areas

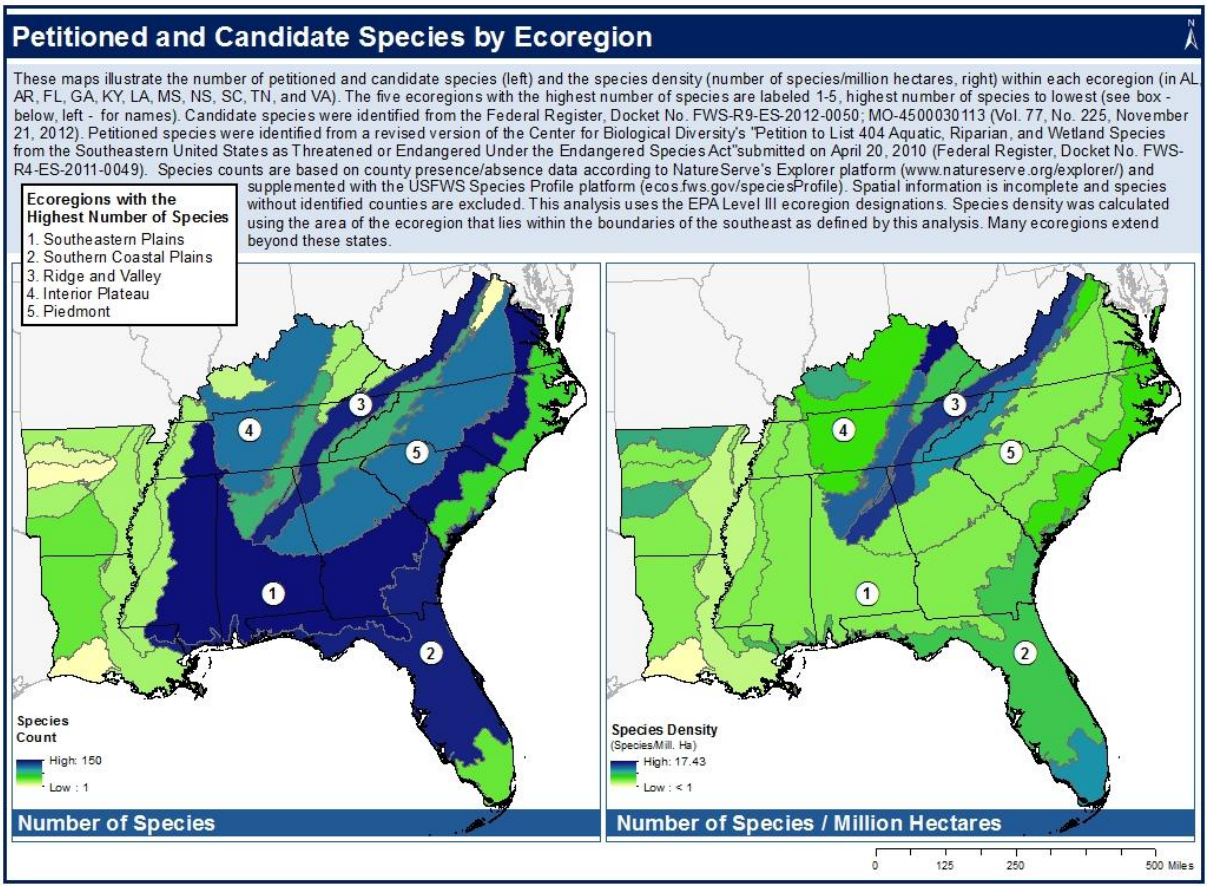


Figure 12: Distribution of petitioned and candidate species by ecoregion.

OVERALL LAND USE PATTERNS BY ECOREGION. Understanding the characteristics of species by ecoregion, as well as land use patterns within that ecoregion could highlight some opportunities for targeted management. We overlaid maps of land use to identify potential risk factors for species and what kinds of opportunities might exist for species protection, those typical of agricultural areas or those more likely to work in urbanizing landscapes, and where existing protected areas might be important (percentages of land area by ecoregion summarized in Table 3).

LAND COVER / LAND USE	PERCENTAGE (Approx.) OF LAND AREA BY ECOREGION		
	Average	Minimum	Maximum
Developed (NLCD Open Space, Low, Medium, and High)	11	4	25
Agriculture	23.5	3	52
Modified Land (Developed + Agriculture)	34	10	66
Protected Areas (Biodiversity and Multiple Use)	14	2	58
Protected Areas (Biodiversity Only)	8	< 1	40 *

Table 3: Average, minimum, and maximum percent of land area per ecoregion by different LULC groups.
* This value is for the Southern Florida Coastal Plains ecoregion, which contains the Everglades.

CHARACTERISTICS OF ECOREGIONS WITH HIGH NUMBERS OF PETITIONED AND CANDIDATE SPECIES. This section presents information on the top five ecoregions with the most petitioned and candidate species as these ecoregions could be prioritized based on high species numbers (listed from highest number of species to lowest). However, species numbers is only one way to visualize species distributions; alternatively, species density could be used, which would suggest targeting a different suite of ecoregions (Figure 13 compares these five ecoregions).

Southeastern Plains. The Southeastern Plains has both the highest number of petitioned and candidate species (150), but also the highest area. Therefore, the number of species per million hectares is approximately 4, which is a relatively low species density (ranked 15th out of 21).). Plants are the dominant taxa for this ecoregion and it has more petitioned and candidate plant species than any other ecoregion (50 species, compared to a total of 106 petitioned and candidate plant species for the entire southeast). Furthermore, the Southeastern Plains has more species of most taxa than any other ecoregion (insects and fish being the primary exceptions), a result likely related to its sheer size. Just under 8% of the total land area is developed and just over 20% of the land is devoted to agriculture. Both of these percentages are slighter lower than average for ecoregions in the southeast. However, a very low percentage of land is protected, either for multiple-use management (i.e. wildlife and timber harvest, approximately 3%) or for biodiversity only (less than 1%).

Southern Coastal Plains. The Southern Coastal Plains has the second highest number of petitioned and candidate species (100), and like the Southeastern Plains ecoregion, approximately one-third of those species are plants. Seventeen of these species are crustaceans (only the Southeastern Plains ecoregion has more crustacean species). This ecoregion has approximately 7 species per million hectares, which is close to the average for all ecoregions in the southeast. Approximately 32% of the land is modified (17% developed – one of the highest development percentages in the southeast - and 15% agriculture). However, along with higher levels of development, the Southern Coastal Plains also has higher percentages of protected areas, with 21.5% protected for biodiversity or multiple-use and 10.5% protected strictly for biodiversity.

Ridge and Valley. The Ridge and Valley ecoregion of the Appalachian Mountains has one of the highest species/unit area ratios of the southeast, at 15 species/million hectares (only the Western Allegheny Plateau has a higher number). This value is nearly twice that of the other ecoregions in the top five for petitioned and candidate species count. This ecoregion has a total of 98 petitioned and candidate species with mussels and insects being the dominant taxa (22 and 23 species respectively). Only the

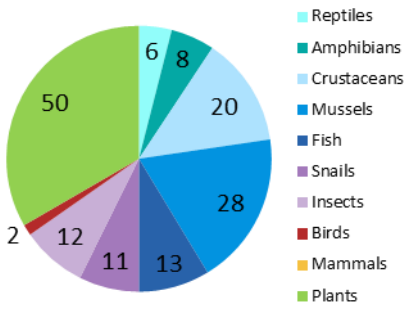
Southeastern Plains ecoregion has a higher number of mussel species and the Ridge and Valley ecoregion has the highest number of insect species by far. Nearly 40% of the land is modified (approximately 13% developed and 25% for agriculture). The percentage of land protected for biodiversity is approximately 4%, and adding in protected areas managed for multiple use increases that percentage to almost 12%.

Interior Plateau. The Interior Plateau ecoregion is home to 72 species, with approximate 7 species per million hectares. Dominant taxa are fish and mussels, with this ecoregion having more fish species than any other southeast ecoregion. This ecoregion is also heavily modified, with just over 10% of land area developed (roughly equivalent to the average for the southeast), but nearly 40% converted for agriculture (only 3 ecoregions have higher agriculture percentages). Percent protected areas are also exceptionally low, with less than 1% protected for biodiversity and only just over 2% protected for both biodiversity and multiple-use.

Piedmont. The Piedmont ecoregion has a similar number of species as the Interior Plateau ecoregion (71 and 72 respectively), but covers a much larger area and therefore has just over 4 species per million hectares (compared to 7 for the Interior Plateau). Dominant taxa for the Piedmont are mussels and plants. Just over 14% of the land is developed while approximately 17% is used for agriculture. Like the Interior Plateau and Southeastern Plains ecoregions, the Piedmont has less than 1% area protected for biodiversity and less than 4% protected for biodiversity or multiple-use.

1. Southeastern Plains

Species Taxa

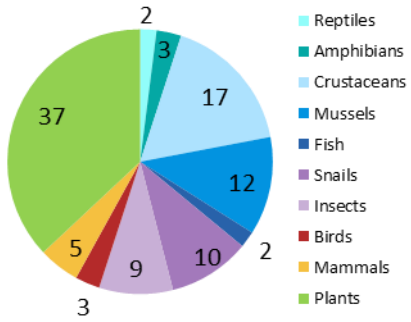


Region Characteristics

Number of Species	150
Species/Million Hectares	4.64
% Area Developed	7.81
% Area for Agriculture	20.69
% Area Protected (All Levels)	3.16
% Area Protected (Biodiversity)	0.84

2. Southern Coastal Plains

Species Taxa

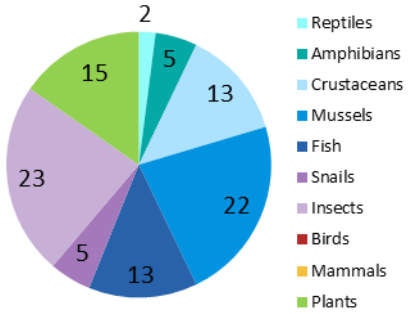


Region Characteristics

Number of Species	100
Species/Million Hectares	7.1
% Area Developed	16.96
% Area for Agriculture	14.51
% Area Protected (All Levels)	21.5
% Area Protected (Biodiversity)	10.5

3. Ridge and Valley

Species Taxa

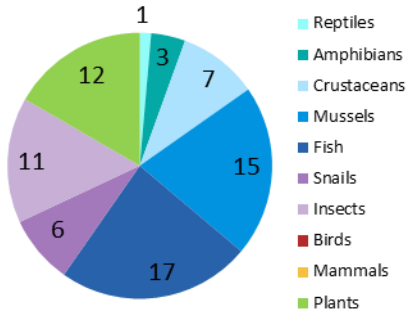


Region Characteristics

Number of Species	98
Species/Million Hectares	15.04
% Area Developed	13.69
% Area for Agriculture	25.2
% Area Protected (All Levels)	11.84
% Area Protected (Biodiversity)	4.23

4. Interior Plateau

Species Taxa

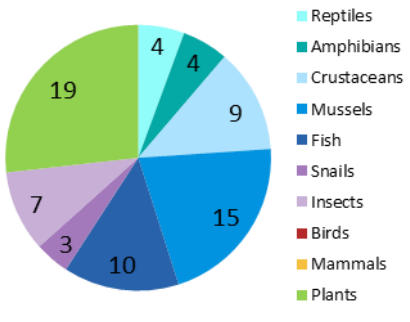


Region Characteristics

Number of Species	72
Species/Million Hectares	7.00
% Area Developed	10.54
% Area for Agriculture	39.06
% Area Protected (All Levels)	2.10
% Area Protected (Biodiversity)	0.93

5. Piedmont

Species Taxa



Region Characteristics

Number of Species	71
Species/Million Hectares	4.27
% Area Developed	14.17
% Area for Agriculture	17.34
% Area Protected (All Levels)	3.47
% Area Protected (Biodiversity)	0.83

Figure 13: Distribution of species taxa plus land cover characteristics for the top six ecoregions (by petitioned and candidate species numbers).

Methods: This analysis only considers the portion of the ecoregion that falls within the borders of the southeast region as defined in this analysis. Species/million hectares is calculated as the number of petitioned and candidate species divided by the total area of the ecoregion within the analysis scope. Developed and agricultural areas were identified using NLCD 2006 (classification categories 21, 22, 23, and 24 for developed and 81 and 82 for agricultural). Protected areas are calculated from US Protected Areas Database, and include classifications 1-3 for percent protected (all levels) and classifications 1-2 for percent protected (biodiversity). Level 3 areas are managed for multiple uses, including both biodiversity protection and resource extraction.

CONCLUSIONS

Within the southeast U.S., at-risk species are widely dispersed, but with concentrations in the Appalachian Mountains and the state of Florida. The distribution of petitioned and candidate species is similar to that of already listed species. Fifteen to twenty percent of species range within a single county or watershed and therefore could be of particular concern to conservation managers. However, these species may be naturally restricted (i.e. cave species) and therefore may be of lesser concern to conservation practitioners than species that have restricted ranges because of human activity.

The dominant taxon of at-risk species is plants (220 of 764 species); of the animal taxa, mussels, crustaceans, and fish have the most species, but nearly half of all at-risk species are invertebrates (351 of 764). The majority of mammal species are already listed, but almost all at-risk crustaceans and insects are petitioned or candidate. Because the majority of at-risk species are currently petitioned, and the petition focused on aquatic, riparian, and wetland species, it is hardly surprising that over 50% of species use riverine habitats and 30%, palustrine habitats. In general, at-risk species have low mobility and are non-migratory, suggesting that these species may have difficulty benefitting from off-site conservation measures. When considering only petitioned and candidate species, the Southeast Plains ecoregion has the highest number of species, but the Ridge and Valley ecoregion of the Appalachians has a much higher species per unit area, suggesting that this ecoregion may be of higher conservation priority.