

Black Pinesnake
(Pituophis melanoleucus lodingi)

**5-Year Review:
Summary and Evaluation**



Photo courtesy of Terry L. Vandeventer

July 2022

**U.S. Fish and Wildlife Service
South Atlantic–Gulf and Mississippi Basin Regions
Mississippi Ecological Services Field Office
Jackson, Mississippi**

5-YEAR REVIEW

Black Pinesnake (*Pituophis melanoleucus lodingi*)

I. GENERAL INFORMATION

A. Methodology used to complete the review

In accordance with section 4(c)(2) of the Endangered Species Act of 1973, as amended (Act), the purpose of a status review is to assess each threatened or endangered species to determine whether its status has changed and if it should be classified differently or removed from the Lists of Threatened and Endangered Wildlife and Plants. In conducting this 5-year review, we relied on the best available information pertaining to historical and current distributions, life history, habitats, and potential threats to this subspecies. We announced initiation of this review and requested information in a published Federal Register notice with a 60-day comment period on March 25, 2020 (85 FR 16951). We did not receive any public comments during this comment period. To acquire the most current information available, we solicited various experts, including State conservation agencies and heritage programs, and knowledgeable individuals associated with Federal and State agencies, academia, and non-governmental conservation organizations. Specific sources used to inform this 5-year review included the final rule listing this subspecies under the ESA; peer reviewed scientific publications; State and other experienced biologists; unpublished studies and survey reports; and notes and communications from other qualified biologists or experts.

B. Reviewers

Lead Region: Atlanta Regional Office, South Atlantic–Gulf Region and Mississippi Basin Regions, Carrie Straight, 404-679-7226

Lead Field Office: Jackson, Mississippi, Ecological Services Field Office, John Tupy, 601-321-1126

Cooperating Field Office: Daphne, Alabama, Ecological Services Field Office, Evan Collins, 251-441-5837

C. Background

1. Federal Register Notice citation announcing initiation of this review

March 25, 2020 (85 FR 16951)

2. Listing history

Original Listing

Federal Register Notice: 80 FR 60468

Federal Register Notice Date: October 6, 2015

Effective listing date: November 5, 2015

Entity listed: Subspecies

Classification: Threatened

3. Associated rulemakings

4(d) Rule: 80 FR 60468, November 5, 2015

Designation of Critical Habitat: 85 FR 11238, February 26, 2020

4. Species' Recovery Priority Number at start of review: 12

The recovery potential is considered low for the black pinesnake because specific threats such as habitat loss, degradation, and road mortality are difficult to alleviate quickly, and endeavors undertaken to address these threats have an uncertain probability of success.

Degree of Threat: Moderate

Recovery Potential: Low

Taxonomy: Subspecies

II. REVIEW ANALYSIS**A. Application of the 1996 Distinct Population Segment (DPS) policy****1. Is the species under review listed as a DPS?**

No

2. Is there relevant new information that would lead you to consider listing this species as a DPS in accordance with the 1996 policy?

No

B. Recovery Criteria**1. Does the species have a final, approved recovery plan containing objective, measurable criteria?**

No. The species does not have a final recovery plan.

C. Updated information and current species status**1. Biology and habitat**

Black pinesnake's biology, life history, taxonomic classification, genetics, population trends, distribution, and habitat are detailed in the species' final listing rule and are still considered current (U.S. Fish and Wildlife Service (Service) 2015). Information related to the current status of black pinesnake is summarized below.

a. Abundance and distribution

The black pinesnake is known from 14 counties in southern Mississippi, 3 counties in southwestern Alabama, and has been extirpated from Louisiana. Multiple independent records exist outside of these populations, but it is unknown whether these represent potential populations or truly isolated individuals. Recently, a black pinesnake was observed in Lawrence County, Mississippi, where the species had not previously been documented (Lee et al. 2017).

However, it is not known whether this snake represents a new extant population due to lack of additional observations and was therefore not included in the population count estimation.

There are 19 extant black pinesnake populations across the current range: 13 in Mississippi and 6 in Alabama. Multiple independent records exist outside of these populations, but it is unknown whether these represent potential populations or truly isolated individuals. Recently, a black pinesnake was observed in Lawrence County, Mississippi, where the species had not previously been documented (Lee et al. 2017). However, it is not known whether this snake represents a new extant population due to lack of additional observations and was therefore not included in the above population count estimation.

The Service assesses the viability of a species to maintain populations in the wild over time using three conservation principles: resiliency, redundancy, and representation (Shaffer and Stein 2000; Service 2016). Resiliency generally represents the ability of a species to withstand normal variation in conditions like changes in environmental conditions, periodic disturbances, and normal variation in demographic rates. Redundancy allows the species to withstand catastrophic events, because of multiple populations or a single large population that may range across a large geographic extent. Lastly, representation is the ability of a species to adapt to both near-term and long-term changes in its physical (e.g., climate conditions, habitat conditions) and biological (e.g., pathogens, predators) environments. Each of these factors are addressed below.

Resiliency. An estimate of resiliency (high, medium, low) for each of the 19 extant black pinesnake populations was derived from two population factors: population size and population connectivity; and habitat suitability using a Habitat Suitability Model (hereinafter habitat model; depicted in Figure 1). Details on methods can be found in Appendix A. The results of resiliency rankings were: 3 High, 8 Medium, and 7 Low populations (Table 1). The most robust populations appear to be on the De Soto National Forest in Mississippi, which also includes the Camp Shelby Joint Forces Training Center, Mississippi Army National Guard (hereinafter Camp Shelby).

Although some black pinesnake populations had more recent records, they had a lower overall resilience due to a high degree of fragmentation and low availability of suitable habitat. Generally poor habitat conditions at many sites combined with small population sizes and low connectivity resulted in overall lower resilience ranks.

Representation. Current representation, as measured by the number and distribution of resilient populations across the current geographic range has decreased from historical conditions. To have high representation, the species should have highly resilient populations maximizing the species' latitudinal and longitudinal extent. Black pinesnakes have likely become extirpated from Louisiana and have become extremely rare in parts of Mobile County, Alabama,

where they were once abundant (Jennings and Fritts 1983). A spatial analysis of records pre- and post-1990 shows a drastic reduction in numbers of recent records in and around the city of Mobile as urban development and expansion have overtaken much of the natural communities. While robust populations persist in the core of the species' range on the De Soto National Forest (including Camp Shelby), peripheral populations appear to have fewer records in recent years and now face greater fragmentation threats. With few resilient populations across a contracted range, overall representation of the black pinesnake is currently low.

Table 1. Current resilience rankings of the 19 presumed extant black pinesnake populations. Methods are described in detail in Appendix A. Distribution of the 19 populations with resilience rankings are depicted in Figure 3.

Population	State	Number pinesnake records	Other records nearby connected by suitable habitat	Percent highly and moderately suitable habitat	Protected lands	Degree of fragmentation	Resilience
9	MS	100+	Yes	100	Yes	Low	High
14	MS	35	Yes	90	Yes	None	High
17	MS	8	Yes	90	Yes	None	High
1	MS	5	Yes	10	Yes	None	Moderate
10	MS	8	Yes	60	Yes	Medium	Moderate
4	AL	3	Yes	80	No	None	Moderate
5	AL	2	Yes	85	No	None	Moderate
11	MS	2	Yes	50	Yes	None	Moderate
3	MS	2	Yes	35	Yes	None	Moderate
6	AL	2	No	85	No	None	Moderate
2	MS	2	Yes	20	Yes	None	Moderate
15	MS	2	Yes	40	Yes	Low	Moderate
19	AL	2	No	60	No	Low	Low
7	AL	2	No	20	Yes	None	Low
8	MS	2	No	15	Yes	None	Low
13	MS	2	No	30	Yes	Medium	Low
16	MS	2	No	40	No	Medium	Low
18	AL	4	No	10	No	High	Low
12	MS	4	No	10	No	High	Low

Redundancy. A high level of redundancy allows the species to have a higher chance to withstand catastrophic events (such as a rare destructive event that impacts a large geographic area not impacting all populations of the species). Species that have resilient populations spread throughout their full ecological range are less susceptible to extinction (Wolf et al. 2015). Data suggest that the black pinesnake was once more broadly distributed; however, several factors including fire suppression, habitat conversion, and habitat degradation have resulted in loss and fragmentation of habitat and, presumably, populations. The distribution of resilient populations has become clustered as evidenced in the location of the post-1990 observation records of black pinesnakes (Figure 2). Resilient populations are primarily on protected public lands, leaving large portions of the range fragmented and unoccupied. Of the 19 identified presumed extant populations, only 3 show evidence of high resilience, based on larger apparent population sizes, high percentage of suitable habitat, and low

fragmentation. These 3 populations are all in Mississippi and located on the De Soto National Forest (including Camp Shelby). Because most of the black pinesnake populations display low to moderate resilience and distribution is limited, current redundancy for the species is low (Figure 3).

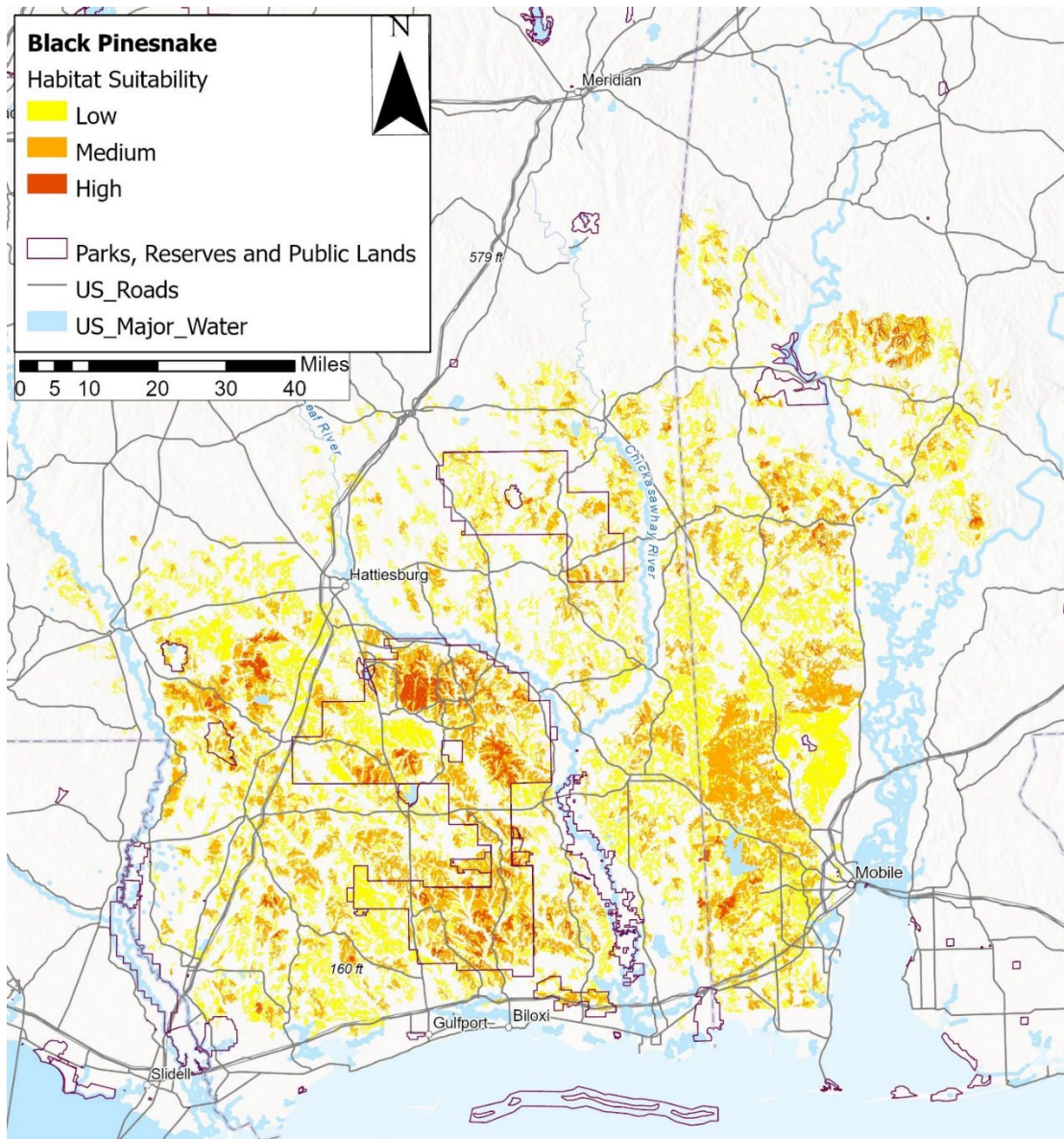


Figure 1. Map showing the GIS layers used to measure resiliency of black pinesnake populations throughout the current range (mid-west and southwest Alabama and south Mississippi). In addition to analyzing rivers, roads, and urban areas as fragmentation sources, we also analyzed to what extent the populations overlapped with suitable habitat (Crawford et al. 2020) and/or protected areas (USGS Protected Areas Database, Version 2.0, 2018).

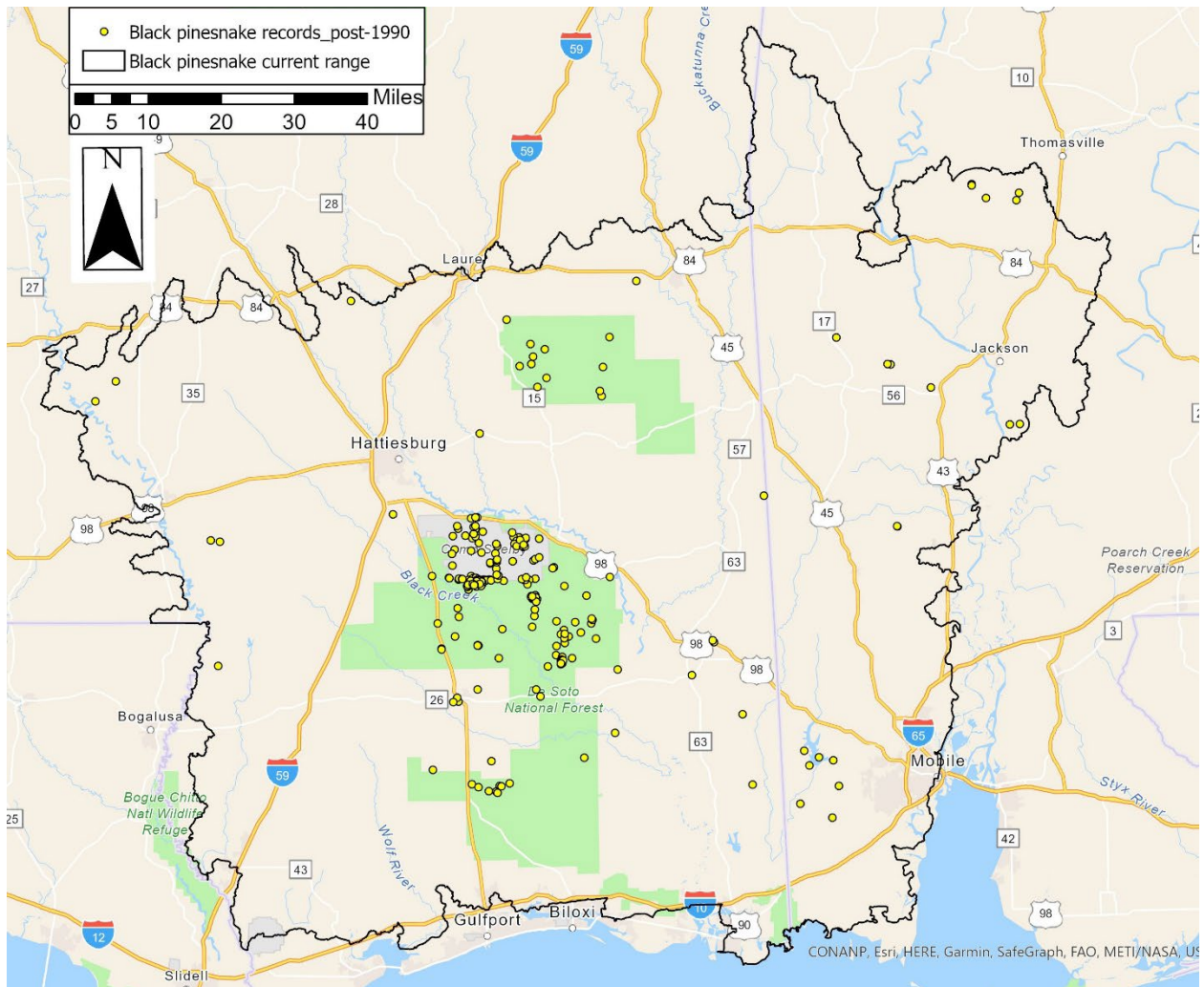


Figure 2. Yellow dots are most recent, post-1990, black pinesnake records (elemental occurrences). The black pinesnake is considered extirpated in Louisiana. Two or more overlapping yellow dots represents a potential black pinesnake population. Multiple independent records exist outside of these populations, but it is unknown whether these represent potential populations or truly isolated individuals

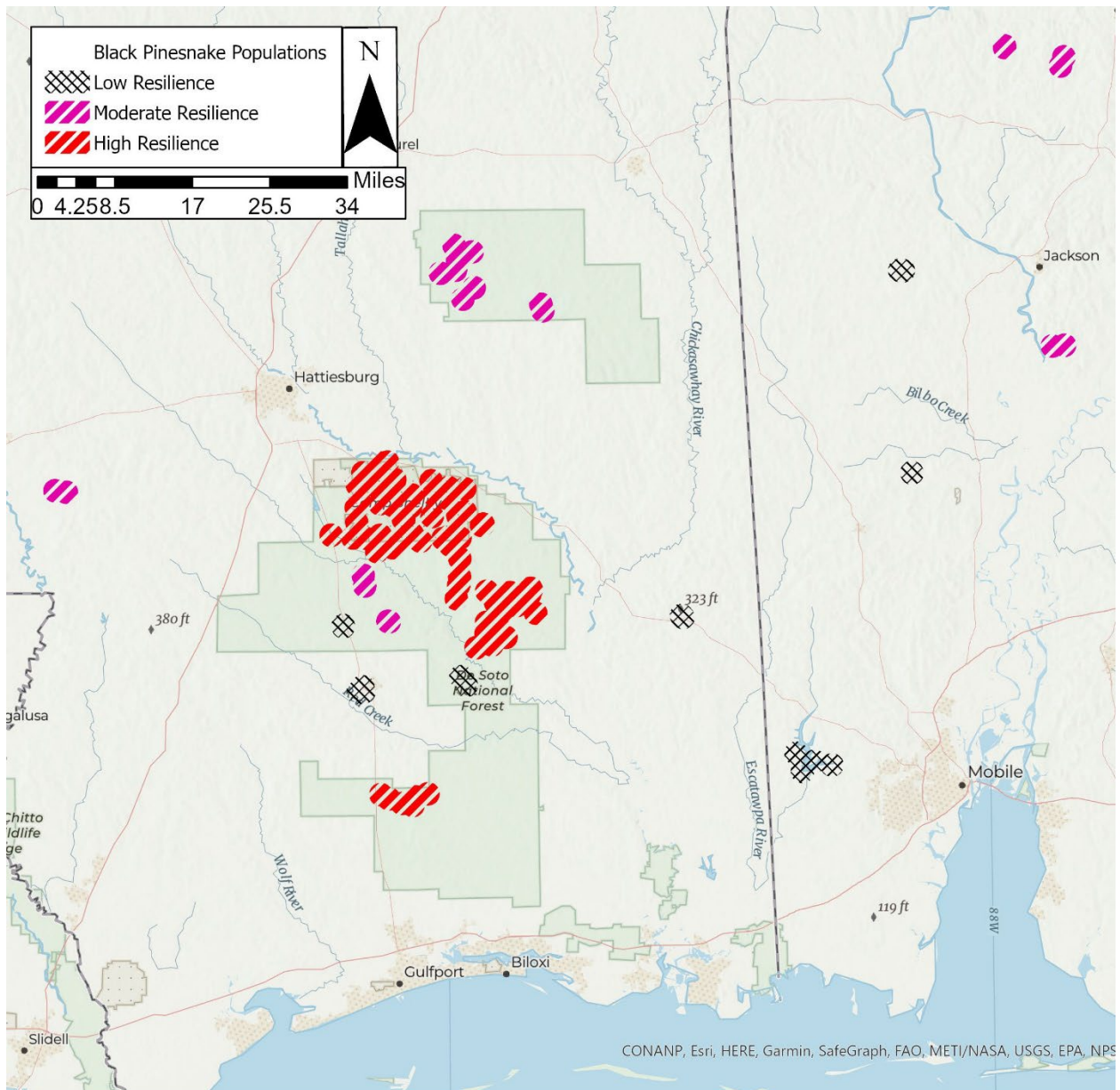


Figure 3. There are 19 extant black pinesnake populations across the current range: 13 in Mississippi and 6 in Alabama. Most of the populations display low to moderate resilience and limited distribution. Only 3 populations show evidence of high resilience, based on larger apparent population sizes, high percentage of suitable habitat, and low fragmentation. The three highly resilient populations are all located in the central part of the range and within the De Soto National Forest and/or Camp Shelby.

2. Five-factor analysis (threats, conservation measures, and regulatory mechanisms)

All threats, conservation measures, and regulatory mechanisms identified that are discussed in the final listing rule for black pinesnake (Service 2015) remain applicable. The Service is unaware of any other new threats to the black pinesnake. The current threats are summarized below.

a. Present or threatened destruction, modification or curtailment of its habitat or range (Factor A)

Currently, and at the time of listing, loss and degradation of habitat represent the greatest threat to the black pinesnake through changes in land use to incompatible forestry practices, conversion to agriculture, urban, or other incompatible uses, and lack of habitat management through fire or other means which results in increasing fragmentation of remaining habitats. These threats have contributed to a reduction in overall range, and the fragmentation and degradation of remaining suitable habitat.

Conservation efforts implemented or planned on Camp Shelby and the De Soto National Forest should help maintain black pinesnake habitat; however, these areas represent a small fraction of the current range of the subspecies.

b. Overutilization for commercial, recreational, scientific, or educational purposes (Factor B)

Not currently considered to be a significant threat.

c. Disease and predation (Factor C)

Red imported fire ants (*Solenopsis invicta*), a non-native invasive species, are potential predators of black pinesnake eggs, especially in disturbed areas (Todd et al. 2008), and have been documented predating snake eggs under experimental conditions (Diffie et al. 2010). They have also been implicated in trap mortalities of black pinesnakes during field studies (Baxley 2007). Anecdotally, in 2010 and 2011, trapping for black pinesnakes was conducted in several areas that were expected to support the subspecies; however, no black pinesnakes were found, but high densities of fire ants were reported (Smith 2011). At this time, the severity and magnitude of effects, as well as the long-term effects, of fire ants on black pinesnake populations are currently unknown.

Other potential predators of pinesnakes include red-tailed hawks, raccoons, skunks, red foxes, and feral cats (Ernst and Ernst 2003, Yager et al. 2005). Lyman et al. (2007) reported an attack on a black pinesnake by a stray domestic dog, which resulted in the snake's death. Several of these mammalian predators are anthropogenically enhanced (urban predators); that is, their numbers often increase with human development adjacent to natural areas (Fischer et al. 2012). However, the severity and magnitude of predation by these species are unknown.

An emerging and potential threat to the black pinesnake is *Ophidiomyces ophiodiicola*, a fungus that causes Snake Fungal Disease (SFD). Although SFD has not been determined as the cause of death in any black pinesnakes to date, a roadkill specimen was found in Perry County, Mississippi, with skin lesions diagnosed as an *O. ophiodiicola* infection (Niedringhaus 2017). This fungus grows well on a variety of common decaying substrates and may be opportunistically infecting snakes in a wide variety of ecosystems (Lorch et al. 2016). There is still uncertainty of the significance of SFD as a potential threat to black pinesnakes, as skin lesions like those associated with SFD have been

documented on snakes for decades (i.e., “hibernation sores”) and infected snakes are often able to shed the fungus through successive moltings (T. Vandeventer 2018, pers. comm.). However, *Ophidiomyces* infections have been identified as the primary cause of mortality in infected timber rattlesnakes (*Crotalus horridus*; Clark et al. 2011) and eastern massasaugas (*Sistrus catenatus*; Allender et al. 2011). This disease has been found on at least five Louisiana pinesnakes (*P. ruthveni*), a closely related species to the black pinesnake. The causative fungus of SFD has been found in two Louisiana pinesnake populations, SFD has caused severe negative impacts to at least two individuals, and SFD has caused morbidity and mortality in several other snake species; therefore, the Service has concluded that disease (SFD) is now considered a potential threat to the Louisiana pinesnake (Service 2018). Because of the close relationship between the Louisiana pinesnake and black pinesnake (i.e., the species belong to the same genus) and the fungal pathogen causing SFD is also found in black pinesnakes, the Service considers SFD a potential threat to black pinesnake.

d. Inadequacy of existing regulatory mechanisms (Factor D)

In Mississippi, the black pinesnake is classified as endangered by the Mississippi Department of Wildlife, Fisheries, and Parks (Mississippi Museum of Natural Science 2001). In Alabama, the pinesnake (*Pituophis melanoleucus* spp.) is protected as a non-game animal (Regulation 220-2-.92), and in the Alabama Comprehensive Wildlife Conservation Strategy, the black pinesnake is identified as a Priority 1, Species of Greatest Conservation Need (ADCNR 2016), however, it is unknown at this time what direct benefit it will have on black pinesnake conservation and recovery in Alabama. In Louisiana, the black pinesnake is considered extirpated (Louisiana Department of Wildlife and Fisheries [LDWF] 2014); however, Louisiana Revised Statutes for Wildlife and Fisheries were recently amended to prohibit killing black pinesnakes or removing them from the wild without a permit from the LDWF (Louisiana Administrative Code 2014), should they be found in the State again. Both Mississippi and Alabama have regulations that restrict collecting, killing, or selling of the subspecies, but do not have regulations addressing habitat loss, which has been the primary cause of decline of this subspecies.

Black pinesnake habitat is afforded some protection and management under the National Forest Management Act (NFMA; 16 U.S.C. 1600 *et seq.*) where it occurs on lands managed by the Forest Service for the longleaf pine ecosystem. The subspecies co-occurs with other federally listed species such as the gopher tortoise (*Gopherus polyphemus*) and the red-cockaded woodpecker (*Picoides borealis*). Habitat management and protections intended for these other species can also benefit the black pinesnake where they overlap.

The Mississippi Army National Guard (MANG; 2014) has updated their integrated natural resources management plan (INRMP) on Camp Shelby to provide for the protection, management, and impact minimization of the black pinesnake and its habitat. For example, the MANG has designated over 800 acres

as “conservation areas” within their Cantonment Area, which entails restoration and management of longleaf pine habitat (J. Lee, pers. comm, 2022).

e. Other natural or manmade factors affecting its continued existence (Factor E)

A variety of other natural or manmade factors currently threaten the black pinesnake. Fire suppression has historically been considered a primary reason for degradation of the longleaf pine ecosystem. Fire is the preferred management technique to maintain the longleaf pine ecosystem, and fire suppression and/or the inadequate use of prescribed fire continues to be considered a primary reason for the degradation of remnant longleaf pine forest. It is a contributing factor in reducing the quality and quantity of available habitat for the black pinesnake. According to Wear and Greis (2013), southern forests are likely to see increasing challenges to prescribed burning in the future as land use changes, involving fuels management, increased urban interface, and revised safety and health regulations will continue to constrain prescribed fire efforts. Some of these constraints could be in the form of reduced fire intervals or reductions in average area burned per fire event (strategies often used in management of pine plantations), which may not provide adequate fire intensity or frequency to suppress the overgrown understory and mid-story conditions that black pinesnakes avoid (Duran 1998b).

Additionally, non-native invasive species such as cogongrass (*Imperata cylindrica*) can greatly reduce the habitat quality for prey species of the black pinesnake. Cogongrass is known to spread and proliferate through disturbance due to human activities such as land clearing and development.

Isolation of populations beyond the dispersal range of the subspecies is a serious threat due to the fragmentation of available habitat. Private landowners hold more than 86 percent of forests in the South and produce nearly all of the forest investment and timber harvesting in the region (Wear and Greis 2013). Private forest ownership dynamics in the South are trending towards increased parcellation (e.g., the splitting up of large tracts of land), which could lead to greater fragmentation through estate disposal and urbanization (Wear and Greis 2013). Roads surrounding and traversing the remaining black pinesnake habitat pose a direct threat to the subspecies. Dodd et al. (2004) determined that roads fragment habitat for wildlife. Population viability analyses indicate that road mortality estimates in some snake species greatly increase extinction probabilities (Row et al. 2007). The high percentage of radio-tracked black pinesnakes killed while trying to cross roads (Baxley 2007, Lyman et al. 2011, 2012) supports our conclusion that this is a serious threat, while peoples’ fear and dislike of snakes represent another source of mortality.

Stochastic threats such as drought also have the potential to threaten black pinesnake populations, especially considering the possibility of more drastic thermal extremes due to climate change, and the suspected low reproductive rate of the subspecies could exacerbate other threats and limit population viability. See Service 2015 for more details on other natural or manmade threats. Overall, the

threats under Factor E may act in combination with other threats listed above and increase their severity.

D. Synthesis

The black pinesnake is a large, non-venomous snake native to the longleaf pine ecosystem and is currently restricted to 19 known populations in Mississippi and Alabama. The species is currently considered extirpated from Louisiana. Populations vary in size, but most are relatively small and isolated, making it more difficult for the species to withstand and recover from stochastic or catastrophic events. Out of 19 identified presumed extant populations, only 3 show evidence of having high resilience, based on larger apparent population sizes, high percentage of suitable habitat, and low fragmentation. These 3 populations are all in Mississippi and located on the De Soto National Forest, including Camp Shelby. Although additional black pinesnake populations have been identified since completion of the final listing rule, these new populations did not improve the overall condition of the species because most of the black pinesnake populations display low to moderate resilience, distribution is limited, and current redundancy for the species is low. With few resilient populations across a contracted range, overall representation of the black pinesnake is currently low. Threats to remaining black pinesnake populations exist primarily from habitat loss and degradation, limitations in the ability to manage habitat, invasive species, and the fragmentation of the remaining habitat. Snake fungal disease may be an emerging threat to the species. Most of the black pinesnake's original habitat has been either converted from forests to other uses or is highly fragmented. Populations outside of the National Forest and Camp Shelby appear to be small and isolated on islands of suitable longleaf pine habitat making them more vulnerable to other threats. Across the current range of the black pinesnake, degree of threat to the species is moderate and populations are small and fragmented which increases extinction risk, therefore the species' still meets the definition of a threatened species.

III. RESULTS

A. Recommended classification

No change needed.

IV. RECOMMENDATIONS FOR FUTURE ACTIVITIES

The following actions are recommended to support and promote recovery of the black pinesnake. Use of a numbered list for these recommendations is for convenient reference and does not necessarily imply prioritization of any activity over others.

1. Work with partners and stakeholders to develop and implement a black pinesnake survey and monitoring strategy for all populations including a standardized survey method.
2. Work with State and Federal Agencies, non-governmental conservation organizations, and private landowners to obtain protections and/or conservation commitments (e.g., Safe Harbor Agreements, Partners for Fish and Wildlife Program, Natural Resources Conservation Service-Working Lands for Wildlife, Conservation Easements, etc.) for black pinesnake populations on privately-owned lands.

3. Develop and implement management plans for all populations.
4. Work with partners and land managers to expand and prioritize prescribed fire programs, emphasizing recommendations on fire intensity, size, frequency, and seasonality.
5. Facilitate and support surveys to identify new populations.
6. Conduct and support research that enhances knowledge of black pinesnakes, including population viability models, habitat suitability models, improved management strategies, radio-telemetry studies, and species/habitat distribution models.
7. Expand outreach efforts, especially education for private landowners, youth, hunters, foresters, contractors, and outdoors enthusiasts and identify innovative ways to increase public awareness of the need to protect this subspecies and its habitat.
8. Identify potential interpopulation habitat corridor locations and secure agreements to protect and restore suitable habitat in those areas.

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**U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Black Pinesnake (*Pituophis melanoleucus lodingi*)**

Current Classification: Threatened

Recommendation resulting from the 5-Year Review:

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change needed

Review Conducted By: John Tupy, Mississippi Ecological Services Field Office.

APPROVALS

FIELD OFFICE APPROVAL

Lead Field Supervisor, Mississippi Ecological Services Field Office, Fish and Wildlife Service

Approve _____

LEAD REGIONAL OFFICE APPROVAL:

Assistant Regional Director – Ecological Services, Fish and Wildlife Service

Approve _____

APPENDIX A

Habitat Analysis

Recently, Habitat Suitability Models (HSMs) have been created for several longleaf pine specialist reptile species, and one of the species modeled was the gopher tortoise (Crawford et al. 2020, entire). The HSM for the gopher tortoise was used for this black pinesnake assessment since the two species have highly similar habitat attributes (Duran 1998a, p. 15; Baxley and Qualls 2009, p. 289) and overlapping ranges. An analysis of the Mississippi Natural Heritage Program database shows a high degree of overlap in areas where both species have multiple records. The HSMs identify habitat features that best predict species presence and also estimate the amount and distribution of potential suitable habitat across a species' range under current conditions at the time of the analysis (2018). The predictors of highly suitable habitat, verified and supported by documented location coordinates and expert opinion, included variables such as geographic ecoregion, soils, vegetation, disturbance and connectivity, wetlands, climate, topography, and fire frequency. One limitation of this model is that current landcover/landuse status may differ from the data displayed in the analysis. Actual, on-the-ground, quality and/or condition of mapped covertypes is not addressed. However, accurately defining stand condition, in some production pine forests for example, can be extremely difficult due to the dynamic nature of the stand and cycles of deforestation and afforestation; therefore, suitability can be very challenging to categorize. While this model wasn't specifically created for the black pinesnake, we feel that the HSM for the gopher tortoise represents the best available method of categorizing and quantifying available suitable habitat for black pinesnakes. The HSM was specifically built to show suitable habitat in >250-acre patches, in order to highlight larger areas that could theoretically support a more viable population, and therefore be of higher conservation value (Crawford et al. 2020, entire). Results of this model are presented as a Habitat Suitability Index showing areas of low, medium, and high suitability that will be used to assess the current and future resilience of black pinesnake populations.

Abundance and Distribution

For estimation of abundance and distribution of black pinesnake populations, we first examined all verified records across the range since 1990. This year was used as it coincides with dates chosen by black pinesnake researchers who conducted habitat assessments at what were considered recently and historically occupied locations (Duran and Givens 2001, pp. 5–9). At the time of that study, the authors determined that about 61 percent of historical black pinesnake population segments (*i.e.*, the portions of populations located in a contiguous area of suitable habitat) had been extirpated or were in imminent danger of extirpation (Duran and Givens 2001, p. 31). As this study represents one of the most comprehensive range-wide habitat and population assessments to date, we chose to use the data that was used to inform that study, in addition to all verified locations documented since then. Our data sources for black pinesnake locations included the Alabama Department of Conservation and Natural Resources; Alabama Natural Heritage Program; Mississippi Department of Wildlife, Fisheries, and Parks Natural

Heritage Program; verifiable online species tracking websites (www.inaturalist.org); and peer-reviewed scientific literature.

Very few formal surveys for black pinesnakes have been completed primarily due to the cryptic nature of the species, low detection probability, and lack of an established survey protocol. The areas within the range that have had the most extensive population evaluation are on Camp Shelby and DNF; several areas with pinesnakes on Camp Shelby have been trapped and/or radio-tracked during multiple research projects over a period of more than 20 years (Duran 1998b, entire; and Yager et al. 2005, pp. 23-33), and at a smaller scale on other properties off the installation (Baxley et al. 2011, pp. 155-160). Pinesnakes records also have been documented during gopher tortoise surveys, timber stand improvement activities, and opportunistic sightings.

We plotted all records (post-1990) of black pinesnakes using Geographic Information Systems (GIS) software (ArcMap v10.6), then digitized a circular buffer around each record with a radius equal to the maximum movement distance reported in the literature (1.3 miles; Baxley and Qualls 2009, pp. 287-288) to be considered that pinesnake's maximum activity range, because there was no other information available about black pinesnake homerange. We made assumptions using this model that where the pinesnake was documented is the center of its activity range, and that all ranges are circular. Where at least two of these circular activity ranges overlapped, we made reasonable assumptions that: 1) this was not the same individual pinesnake being recorded more than once; 2) these individuals may be in contact with each other; 3) there are other pinesnakes in the vicinity occupying connected suitable habitat; and 4) this is our best indication of the presence of a potential population. For our analyses, we took the same approach as was done for eastern massasaugas and assumed populations with unknown status are extant, and collectively referred to these extant and unknown populations as "presumed extant" populations (Szymanski et al., 2016, p. 4).

There were 19 presumed extant populations identified using this method: 13 in Mississippi and 6 in Alabama. Multiple independent records exist outside of these populations, but it is unknown whether these represent potential populations or truly isolated individuals. Many populations were digitized with just 2 overlapping records, and the largest population was on Camp Shelby where there is potentially one extensive population with unrestricted gene flow consisting of hundreds of pinesnakes. Populations extended across the geographic range of the species, occurring in 12 of the 16 counties known to have black pinesnake records.

Current Population Resiliency

Population resiliency for the black pinesnake was derived from two population factors (population size and population connectivity) and habitat suitability using the HSM model. For each population, resiliency was determined by grading all factors, with greater weight given to apparent population size, overall habitat suitability, and degree of fragmentation. Other factors included whether there are nearby records or populations connected by suitable habitat, and whether the population is on protected land (Table A.1). These are important factors in measuring the overall growth potential of a population but did not rise to the same importance as

the primary factors. Metrics such as growth rate, hatching success, and survival of the various age classes are unknown for these populations. Once each factor was graded, those grades were tallied to give an overall resiliency classification, ranked as either Low (score 0–4), Moderate (score 5–8), or High (score \leq 9; Table 1, in main text).

True population sizes for black pinesnakes are not currently known but have been ranked based on verified records to represent quantitative estimates. The minimum number of records allowable to be considered a presumed extant population was two, so this was set as the lowest grade in terms of population size. The HSM was used to not only evaluate available habitat within the population polygons, but also between the polygons and other nearby records to determine habitat connectivity. Percentages of the polygon covered by either highly- or moderately-suitable habitat were combined to give an overall suitability estimate for the area. Connectivity was evaluated from several factors: the existence of other pinesnake records nearby, the habitat suitability, and the degree of fragmentation within the polygon. All presumed extant populations were assessed in regard to impacts from nearby fragmentation sources: major roads, wetlands and open water, and incompatible land use such as agricultural and urban development. To analyze road impacts, we overlaid Class 1 and 2 Roads in GIS: Class 1 roads are hard surface highways including Interstate and U.S. numbered highways and primary State routes; and Class 2 roads include secondary State routes, primary county routes, and other highways that connect principal cities and towns. For other fragmentation sources we used the 2016 National Land Cover Database (NLCD) and National Wetlands Inventory (NWI) data layers. Locations of developed areas, cultivated crops, and open water from NLCD and NWI were verified via current aerial imagery. Once all the above layers were added to ArcMap, fragmentation impacts of each population was assessed (Figure 1 in main text). A population was considered to have “No/None” fragmentation if the majority of the habitat contained very few Class 2 roads, no Class 1 roads, no developed areas, no cultivated crop areas, and no open water but may contain secondary or tertiary wetland systems; “Low ” fragmentation if the majority of the habitat contained no Class 2 roads, no Class 1 roads, no developed areas, no cultivated crop areas, and no open water but may contain secondary or tertiary wetland systems; “Moderate” fragmentation if many Class 2 roads, may / may not contain Class 1 roads, some developed areas, some cultivated crop areas, no open water, and a range of wetland systems; and “High” fragmentation if many Class 2 and/or Class 1 roads, developed areas, cultivated drop areas, open water and/or major wetland systems.

Table A.1. Population resiliency was derived from two population factors: population size and population connectivity. Habitat suitability was another resiliency factor graded, derived from each population location and surrounding areas by using a habitat model. Other factors included whether there were nearby records or populations connected by suitable habitat, and whether the population is on protected land.

Grade	Number of pine snake records	Other records nearby connected by suitable habitat?	Percent of highly / moderately suitable habitat	Protected Lands?	Degree of fragmentation
3	≥ 100	n/a	≥ 90	n/a	None
2	99 – 8	n/a	89 – 40	n/a	Low
1	≤ 7	Y	≤ 40	Y	Moderate
0	n/a	N	n/a	N	High