Eastern Indigo Snake
(*Drymarchon couperi*)

5-Year Status Review:
Summary and Evaluation

Eastern Indigo Snake. Photo Credit: Ben Stegenga, The Orianne Society

U.S. Fish and Wildlife Service
Southeast Region
Georgia Ecological Services Field Office
Athens, Georgia

August 2024

5-YEAR STATUS REVIEW
Eastern Indigo Snake (*Drymarchon couperi*)

GENERAL INFORMATION

Current Classification: Threatened

Lead Field Office: Georgia Ecological Services Field Office, Michele Elmore

Reviewers:
Lead Regional Office: Southeast Region, Carrie Straight

Cooperating Field Office(s):
Alabama Ecological Services Field Office, Evan Collins
Florida Ecological Service Field Office, Harold Mitchell
Mississippi Ecological Services Field Office, John Tupy

Cooperating Service Program(s):
Fisheries and Aquatic Conservation Program, Welaka National Fish Hatchery, Ken Blick

Date of original listing: March 3, 1978 (43 FR 4026; January 31, 1978).

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 species or endangered species to determine whether its status has changed and if it should be classified differently or removed from the List of Threatened and Endangered Wildlife and Plants (50 CFR 424.11). The U.S. Fish and Wildlife Service (Service) evaluated the best available information about the eastern indigo snake's biology, habitat, and threats of to inform this status review.

We announced initiation of this review in the Federal Register on May 11, 2023 (88 FR 30324) with a 60-day comment period and received one comment from the National Council for Air and Stream Improvement, Inc. (NCASI). This letter and associated citations discussed managed forests and habitat for listed terrestrial species. Any discussion of impacts of managed forests on eastern indigo snakes is addressed and the comments are incorporated into Threats, Factor A, below. The primary sources of information used in this analysis were the 1978 final listing rule (43 FR 4026), the Recovery Plan for the Eastern Indigo Snake, First Revision (Service 2019a), the Species Status Assessment for the Eastern Indigo Snake (Service 2019b), peer-reviewed literature, agency reports, unpublished survey data and reports, and personal communication with recognized experts. This review was completed by the U.S. Fish and Wildlife Service, Georgia Ecological Services Field Office (GAFO), Athens, Georgia. All literature and documents used for this review are on file at the Field Office. All recommendations resulting from this review are the result of thoroughly reviewing the best available information on the eastern indigo snake.

FR Notice citation announcing the species is under active review:
May 11, 2023 (88 FR 30324)

Species' Recovery Priority Number at start of 5-year review (48 FR 43098): 11C. The eastern indigo snake is a species with a moderate degree of threat and a low recovery potential. The "C" indicates the species recovery effort has some degree of conflict with economic development.

Review History: The two most recent five 5-year reviews, the Service recommended no change in the species' status (Service 2008 and 2019c).

REVIEW ANALYSIS

Listed Entity

Taxonomy and nomenclature

At the time of listing in 1978, the eastern indigo snake was considered a subspecies of indigo snake, *Drymarchon corais couperi* (Service 1978). Post-listing, Collins (1991) elevated this lineage to species status based on geographic isolation and morphology. Subsequent work supported this designation, and the eastern indigo snake was accepted by the scientific community as its own species, *Drymarchon couperi* (Wüster *et al*. 2001, Crother 2012). The Service recommended adopting this change in nomenclature in the 2008 and 2019 5-year reviews (Service 2008, 2019c). This new taxonomy is accepted by the Service and a final rule formally changing the listed entity on the List of Endangered and Threatened Wildlife (50 CFR 17.11) was published February 17, 2022 (87 FR 8960).

Distinct Population Segment (DPS) (61 FR 4722)

The Act defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This species was not listed as a DPS, and we have no new information that would indicate the species should be listed as a DPS under the Service's 1996 DPS Policy.

Recovery Criteria

Recovery Plan or Outline

Recovery Plan for the Eastern Indigo Snake, First Revision, September 26, 2019.

Recovery plans are not regulatory documents and intended to provide guidance to the Service, States, and other partners on methods of minimizing threats to listed species and on criteria that may be used to determine when recovery is achieved. If the recovery criteria defined in the plan are still valid, meeting recovery criteria can indicate that the species no longer requires protections under the Act. However, when recommending whether a listed species should be delisted, the Service must apply the factors in section 4(a) of the Act (84 FR 45020).

RECOVERY CRITERIA:

Criteria for Delisting:

1) At least 14 populations exhibit a stable or increasing trend evidenced by natural recruitment and multiple age classes (addresses Factors A, C, and E).

2) Populations (as defined in criterion 1) are distributed across at least 12 Conservation Focus Areas (CFAs)[1] with at least 2 populations within each of the 4 representative regions (North Florida; Panhandle; Peninsular Florida; Southeast Georgia) (addresses Factors A, C, and E).

3) Populations in the North Florida, Peninsular Florida, and Southeast Georgia regions naturally maintain genetic connectivity and ecological diversity (addresses Factors A, C, and E).

4) Commitments are in place to ensure conservation measures (e.g., habitat protection and management) to manage threats of habitat loss, degradation, and fragmentation such that sufficient habitat quantity and quality exist for the species to remain viable into the foreseeable future (addresses Factors A, C, D and E).

The Service believes these criteria are appropriate and relevant; however, no criteria have currently been met.

Biology and Habitat Summary

For detailed information about life history, biology, and population and species needs, the reader can refer to the Species Status Assessment Report (Service 2019b).

Populations

Historically, the eastern indigo snake occurred throughout Florida and in the coastal plain of Georgia, Alabama, and Mississippi. Today, most natural populations are known to occur in northern and peninsular Florida and southeastern Georgia. The species is extirpated or very rare in southwestern Georgia and the Florida Panhandle and is considered extirpated from Alabama and Mississippi. However, recovery efforts are underway to reestablish populations in Alabama and the Florida Panhandle.

It is difficult to delineate biological populations of the eastern indigo snake due to the species' large home ranges, secretive behavior, low densities, and other challenges associated with identifying population boundaries. However, over the past decade, progress has been made via research and monitoring efforts to better understand the needs of eastern indigo snakes to estimate potential populations across the current range. In the Species Status Assessment (SSA) Report for the Eastern Indigo Snake (Service 2019b), 51 extant populations and 2 reintroduced populations were delineated based on occurrence records buffered by the species' maximum home range width (Figure 1). Furthermore, population resiliency was assessed based on habitat fragmentation, habitat type, road density, and gopher tortoise (*Gopherus polyphemus*) populations[2] (Table 1). An estimated 30 populations are considered extirpated, and the area occupied by (*i.e.*, population extent) the species has declined significantly from the historical distribution (Table 2). Compared to the historical distribution, populations have become smaller and more fragmented (*i.e.*, more, smaller populations rather than fewer, larger connected populations) (Service 2019b). Population areas and resiliency have not been reassessed since the 2019 SSA and therefore it is unclear how many populations are stable or exhibit an increasing population trend at this time. In this review we provide updates since the last 5-year review (Service 2019c) based on monitoring and research efforts. Updates are organized by the

[1] See SSA (Service 2019a) and RIS (Service 2019b) for descriptions of the representative regions and CFAs.
[2] Eastern indigo snakes depend on gopher tortoise burrows for overwintering shelter sites.

Representative Regions and Conservation Focus Areas described in the SSA (2019b) and referenced in the species recovery plan criteria (2019a).

Southeast Georgia

The Southeast Georgia representative region is a stronghold for the species but has 4 extirpated populations and area occupied has declined by 32 percent compared to the known historical distribution (Table 2). This is the only region across the range where there has been consistent long-term monitoring of naturally occurring populations. The Orianne Society has conducted annual surveys for eastern indigo snakes in Southeast Georgia since 2007 across as many as 60 sites (public and private lands). Overall, these monitoring efforts indicate that some sites appear to continue to support viable populations of eastern indigo snakes based on positive detections (*i.e*., recaptured and newly captured snakes) and good habitat quality (including stable gopher tortoise populations). Other sites indicate a decline in occupancy, most likely due to lack of appropriate habitat management (*i.e*., fire) to maintain healthy gopher tortoise populations as well as direct impacts to gopher tortoise burrows from land management (*e.g*. timber harvests) (Stegenga and Chandler 2024). In addition, Fort Stewart monitors the population on their installation annually and data suggests the population is stable (Fort Stewart 2023). Recent eastern indigo snake records have been documented from all five Conservation Focus Areas in this region, however, records from the Cabin Bluff and Okefenokee are scarce (Table 1).

North Florida

The North Florida representative region has 3 extirpated populations and area occupied has declined by 56 percent compared to the known historical distribution (Table 2). This region is important for maintaining population connectivity across all other Representative Regions, especially between the Southeast Georgia and Peninsular Florida regions (Service 2019c, Bauder *et al*. 2022). Eastern indigo snake records from the North Florida region have been sparse since the last 5-year review. Across the region, there have been about 35 opportunistic sightings of eastern indigo snakes reported to the State Florida Fish and Wildlife Commission from the public and other sources since the last review (between 2019-2024). Although these sightings have been verified by the State and provide some information on the species' current distribution, population conditions are unknown at this time. In an effort to better understand population conditions, the State began implementing species-specific surveys in 2022 in this region similar to the occupancy monitoring protocols used by The Orianne Society in Southeast Georgia. Across about 30 sites surveyed from 2022 to 2024, where the species is historically known to occur, only 2 eastern indigo snakes have been detected. Further, these two observations were from the same site (Steen, pers comm. 2024). The lack of observations or evidence of the species at 29 of the sites in the North Florida region that were thought to support eastern indigo snakes is concerning. The survey sites included mostly public lands (including Camp Blanding), but some private lands were also surveyed. Recent eastern indigo snake records have been documented from both Conservation Focus Areas in this region, however, records from the Trail Ridge Conservation Focus Area are scarce (Table 1) with only one recent record (2022) near Camp Blanding.

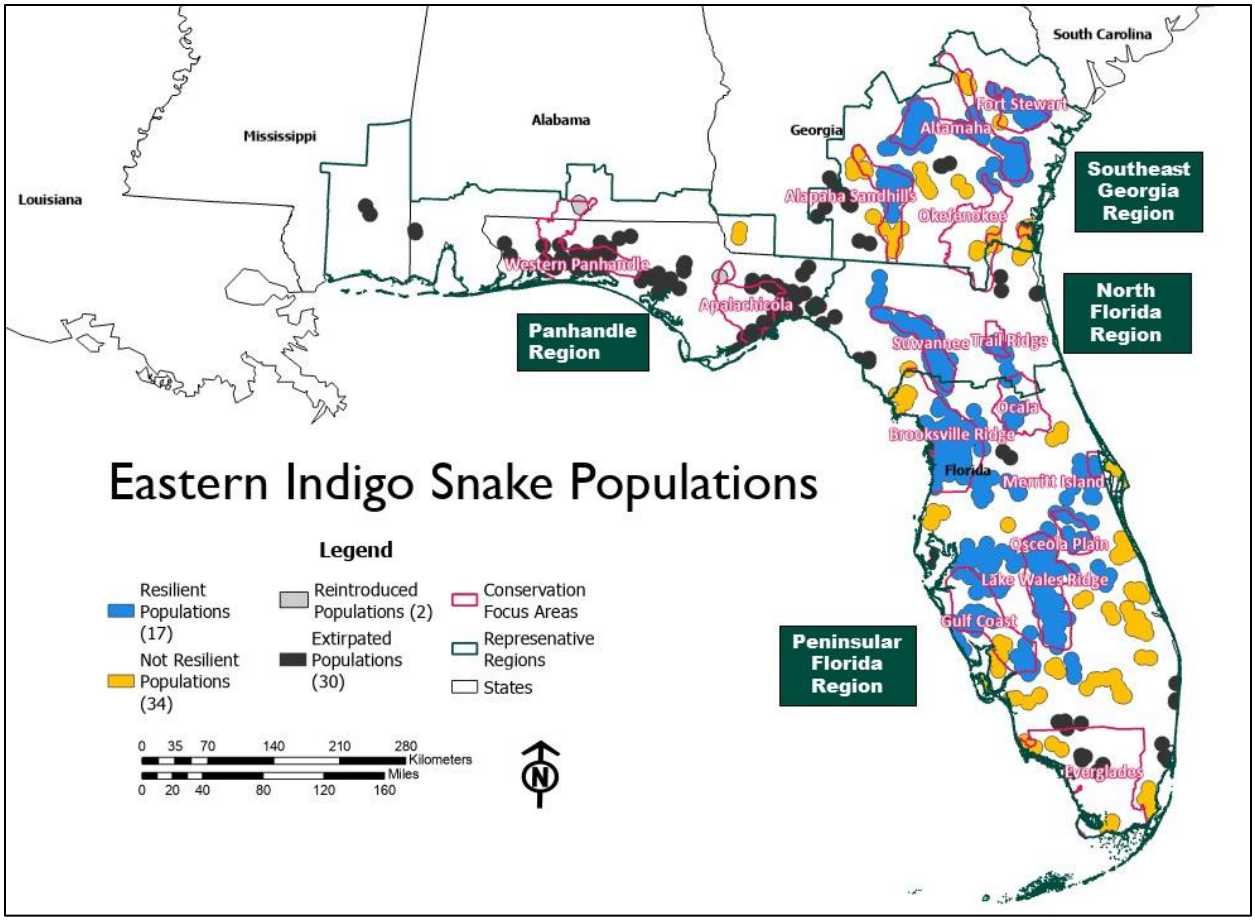

Figure 1. Distribution of eastern indigo snake populations and Conservation Focus Areas within four Representative Regions based on the species status assessment (Service 2019b).

Peninsular Florida

The Peninsular Florida representative region has 11 extirpated populations and area occupied has declined by 42 percent compared to the known historical distribution (Table 2). This region is the southernmost portion of the species' range. For the most part, there are no long-term and consistent monitoring programs in this region. Much like the North Florida region, eastern indigo snake sightings are opportunistically reported to the State. Between 2019-2024, 110 observations have been reported, which provide some information on current distribution (Table 1). Based on the last five years' observations, the extent of the eastern indigo snake distribution continues to include the Florida Keys (Enge *et al*. 2022) and coastal areas in the east (Atlantic) and west (Gulf). The Sanibel-Captiva Conservation Foundation has conducted monitoring of eastern indigo snake populations on North Captiva and Pine Island with 18 of the 110 observations from this area. Some records represent recaptures of previously captured snakes. Overall data indicate a decline in eastern indigo snake observations on North Captiva and Pine Island over time, however, four observations have been reported post Hurricane Ian (*i.e.* post September 2022). Recurring observations also have been reported for Avon Air Force Park and Archbold Biological Station (Lake Wales Ridge Conservation Focus Area). Some populations have been significantly impacted due to habitat loss from development and Everglades restoration efforts

(see threats summary). Recent eastern indigo snake records have been documented from six of seven Conservation Focus Areas in this region, however, records from the Ocala, Osceola Plain, Gulf Coast, and Everglades Conservation Focus Areas are scarce. There are no recent records from the Merritt Island Conservation Focus Area (Table 1).

Panhandle

In the Panhandle representative region, most populations have been extirpated (12) and area occupied has declined by 97 percent compared to the known historical distribution (Table 2) primarily due to the loss of gopher tortoises (Enge *et al*. 2013). Therefore, this region has been the focus of population reestablishment efforts where gopher tortoise populations are protected. There has only been one naturally occurring record from this region over the past five years, from Decatur County, in extreme southwest Georgia in 2020. The observation was a juvenile snake found dead on a road. There is another record from 2013 from nearby Seminole County, Georgia, only the second record from this county and the first since 1955 (Stevenson *et. al.* 2021a). It is assumed that other eastern indigo snakes may occur in this area since the one observed in Decatur County in 2020 was a juvenile, however, abundance and population numbers are believed to be extremely low, and long-term persistence of populations in this area is likely low without additional conservation efforts to preserve and manage habitat. Natural recolonization of this region from adjacent areas is unlikely due to dispersal barriers, distance, and number of snakes necessary to reestablish populations. Therefore, captive propagation and population reintroduction efforts have been underway since 2010 with a goal to reestablish at least two viable populations in this region. Since 2010, 248 snakes have been released on the Forest Service's Conecuh National Forest in Alabama and since 2017, 167 snakes have been released on The Nature Conservancy's Apalachicola Bluffs and Ravines Preserve in Florida. Intensive survey and monitoring efforts are ongoing to assess the success of the effort. While site fidelity of released snakes and successful reproduction in the wild have been documented at both sites (see ADCNR 2024, TNC 2024) and indicates potential for success, the long-term viability of the reintroduced populations has not been achieved (e.g., Folt *et al.* 2020, Chandler *et al.* 2023).

Table 1: Summary of extant and resilient populations across Conservation Focus Areas (CFAs) and Representative Regions. Resilient populations are those assessed as high, medium-high, or medium current resiliency condition class in the species status assessment (Service 2019b). Two populations in the Panhandle Representative Region are reintroduced (shown in parentheses). Recent records are from 2019 to 2024. Recent records (*) from the Western Panhandle and Apalachicola Conservation Focus Areas are from population reintroduction efforts.

Representative Region	**Conservation Focus Area (CFA)**	**Number of Extant Populations**	**Number of Resilient Populations**	**Recent Records (2019 - 2024)**
Southeast Georgia	Fort Stewart	2	1	Yes
Southeast Georgia	Altamaha	4	3	Yes
Southeast Georgia	Alapaha Sandhills	3	1	Yes
Southeast Georgia	Okefenokee	1	0	Scarce
Southeast Georgia	Cabin Bluff	1	0	Scarce
Southeast Georgia	Non-CFA	2	0	Yes
North Florida	Trail Ridge	1	1	Scarce
North Florida	Suwannee	1	1	Yes
North Florida	Non-CFA	3	0	Yes
Florida Peninsula	Ocala	1	1	Scarce
Florida Peninsula	Brooksville Ridge	2	1	Yes
Florida Peninsula	Merritt Island	2	1	No
Florida Peninsula	Osceola Plain	2	2	Scarce
Florida Peninsula	Lake Wales Ridge	1	1	Yes
Florida Peninsula	Gulf Coast	3	2	Scarce
Florida Peninsula	Everglades	3	0	Scarce
Florida Peninsula	Non-CFA	18	2	Yes
Panhandle	Apalachicola	1(1)	0	Yes*
Panhandle	Western Panhandle	(1)	0	Yes*
Panhandle	Non-CFA	0	0	Scarce
TOTAL		***51(2)***	***17***	***NA***

Table 2: Summary of extirpated populations and percent decline of area occupied by the eastern indigo snake organized by representative region summarized from the Species Status Assessment (Service 2019b). Percent decline is changes in occupancy from 2017 compared to the historical distribution.

Representative Region	**Extirpated Populations**	**Percent Decline**
Southeast Georgia	4	32
North Florida	3	56
Panhandle	12	97
Florida Peninsula	11	42
TOTAL	**30**	NA

Threats (Five-Factor Analysis) Summary

The status of a species is determined from an assessment of factors specified in section 4 (a)(1) of the Act. A summary of this assessment is detailed below.

Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range

Continued destruction, modification, and curtailment of habitat is the primary threat to species viability for the eastern indigo snake. Fragmentation, destruction, and degradation of habitat have discrete effects on habitat suitability. Habitat destruction and conversion reduces the overall amount of suitable habitat available, and degradation reduces resource availability (*e.g.*, gopher tortoise burrows and other refugia) within habitat patches.

Habitat Impacts that Alter Home Range

Eastern indigo snakes have large home ranges (most estimates of home ranges vary from several hundred to several thousand acres (ac) (tens to over a thousand hectares (ha)), move long distances (especially males; maximum long distance linear movements of about 2.4 miles (3.9 km) or greater are common), and generally have little home range overlap (Service 2019b and references therein). Thus, habitat connectivity needs to be maintained to support viable populations (including genetic connectivity) and reduce exposure to threats associated with habitat edges, especially urban edges (Bauder *et al*. 2021). Fragmentation may reduce habitat into patches that become too small and unconnected (isolated) to support snakes and increase the risk of direct mortality (*i.e.*, exposure to roads and other edge effects such as increased human contact) if snakes expand home range in search of resources.

Studies in Peninsular Florida have shown that eastern indigo snakes may reduce their home range size in landscapes with little or no urbanization if habitat diversity (vegetation heterogeneity) is high suggesting individual needs may be met in smaller areas if resource needs are concentrated. However, in more urbanized landscapes home range size may be further restricted to smaller areas due to barriers or restrictions to movement or because snakes can capitalize on human derived resources (*e.g*., shelter sites and prey) (Bauder *et al*. 2020). Nevertheless, urbanizing environments may have little value for the conservation of the species given high mortality rates for eastern indigo snakes found in these environments (Breininger *et al.* 2012).

Habitat Impacts to Resource Availability / Gopher Tortoise Burrows

In the northern part of their range (Southeast Georgia, North Florida, and the Panhandle regions), eastern indigo snakes depend on gopher tortoise burrows and the associated habitat for winter shelter sites, breeding, nesting, and feeding. Eastern indigo snakes rely on active, inactive, and abandoned burrows for shelter and nest sites (Stevenson *et al*. 2021b). Past declines in gopher tortoise populations are linked to negative effects on eastern indigo snake populations across the range, but particularly in the northern regions (Enge *et al*. 2013). Relocation of gopher tortoises off sites that are proposed for development to conservation areas is increasingly common. Augmentation or reintroductions of gopher tortoises to conservation areas may help bolster or recover gopher tortoise populations in areas that are declining. However, eastern indigo snakes are not relocated along with the gopher tortoise because they often are not present at the time of gopher tortoise relocations and are difficult to locate. Further, relocation of eastern indigo snakes is typically not recommended due to increased mortality risk (*e.g.*, increased road mortality) from snakes leaving relocation areas in search of their established home range and/or

intraspecific competition. In Peninsular Florida, eastern indigo snakes are documented to use a wider variety of habitats throughout the year, including winter and do not rely on gopher tortoise burrows for shelter and nesting sites as they will use other types of shelter sites such as mammal holes, root and stump holes, and debris piles; therefore, conservation of undeveloped habitat with few or no gopher tortoises is important to conservation of eastern indigo snakes in this region (Bolt *et al*. 2023). However, gopher tortoises and their burrows, where they co-occur with eastern indigo snakes, are important refugia throughout the species' range (Service 2019c, Metcalf *et al.* 2021)

Development

Residential, urban, and industrial development continue to negatively impact eastern indigo snake habitat and populations, particularly in Florida where population growth and development pressures are high (Bolt *et al*. 2023). Generally, residential and urban development occur near or around already developed areas but has expanded rapidly in some areas. Industrial developments, such as resource mining for sand, limestone, phosphate, and heavy minerals, generally cause intensive land disturbance over relatively large, sometimes rural areas. Some research has shown that eastern indigo snakes are reluctant to disperse or move from preferred habitat areas during intense habitat modification from mining (Durso *et al.* unpublished data), challenging the assumption that snakes move out of harm's way during habitat disturbance. Further, if snakes do move, habitat connectivity is essential to minimize risk of direct mortality from crossing roads and other edge effects.

Large-scale solar energy developments are emerging as a significant threat to eastern indigo snake habitat. These large-scale developments (hundreds to thousands of acres in size) are often located in rural areas, sometimes in natural and ecologically sensitive habitats. Specifically, Florida and Georgia have seen a significant increase in this type of development impacting gopher tortoise and eastern indigo snake habitat at much larger scales and frequency than other types of developments. Sandhill habitats that support gopher tortoises, eastern indigo snakes, and other at-risk species have been targeted for this type of development due, in part, to lower land values and revenue opportunities for private landowners to lease (or sell) their land to solar developers. Both state agencies in Georgia and Florida have numerous permits, permit applications, or inquiries for relocating gopher tortoises off sites that are being proposed for solar developments. However, if gopher tortoises are relocated, eastern indigo snakes are left without essential shelter, breeding, and nesting habitat because relocation of snakes is often not a feasible solution. While some efforts have been made to improve siting of future solar developments to avoid impacts to sandhill habitats (see GUSSSI 2024), overall impacts are expected to continue to increase into the future.

Agriculture and Silviculture

Agricultural (cropland) land uses have mixed effects on eastern indigo snake populations. In the northern extent of the species' range (*i.e.*, Southeast Georgia, North Florida, Panhandle regions) where the species relies on gopher tortoise habitat to support essential life functions, intensive agricultural areas (*i.e.*, annually tilled) are not inhabited by gopher tortoises (Herman *et al.* 2012) and therefore may not support eastern indigo snakes. However, gopher tortoises may be attracted to fallow areas after several years of crop abandonment (Service 2022). In general cropland is declining throughout the southeast (USDA 2024) and fallow cropland reinhabited by gopher tortoises may be increasingly important for supporting eastern indigo snake population connectivity or could become population "sinks" if not conserved or restored (*i.e.*, converted to other, incompatible land use). In Peninsular Florida some agricultural areas (*e.g.*, citrus groves

and pastureland) may support eastern indigo snake populations (Jackson 2013, Bauder *et al.* 2018). However, as part of the Everglades hydrological restoration several large agricultural sites (>10,000 acres each) that support eastern indigo snakes are being converted to water reservoirs and stormwater treatment areas which are unsuitable habitat for eastern indigo snakes. Currently, eastern indigo snakes are being displaced during construction and flooding of these areas and snakes may be more likely to develop health issues due to stressful environments, such as habitat conversion (Bogan *et al.* 2023) (see Factor C below). The long-term impact conversion of agricultural lands from Everglades hydrological restoration projects on eastern indigo snake populations is uncertain.

Managed forests (silviculture), especially open pine (*Pinus* spp.) habitats that support gopher tortoises, provide important habitat and habitat corridors for eastern indigo snake populations throughout the species' range. Historically, natural longleaf pine (*Pinus palustris*) habitats with periodic fire to maintain open conditions was a predominate forest type used by gopher tortoises and eastern indigo snakes in the northern portion of the species' ranges. Today most of the longleaf pine ecosystem has been lost to timber harvest, fire exclusion, and land use change. However, longleaf pine ecosystem restoration efforts across the eastern indigo snake range continue to improve habitat on both public and private lands. Other forest types including managed private timberland (*i.e.*, pine plantations) may also provide important habitat for the species. Managed forests may replicate open pine habitat conditions at various stages throughout the management cycle (planting, mid-rotation treatments [fire, herbicides], tree thinning, and timber removal) and may support gopher tortoise and eastern indigo snake populations (Greene *et al.* 2019, Royal *et al.* 2022). However, gopher tortoises may abandon areas due to loss of herbaceous groundcover from increasing midstory and canopy closure (Hermann *et al.* 2002), which may reduce shelter, breeding, and nesting habitat for eastern indigo snakes. Although gopher tortoises may have some flexibility to persist on sites with high tree canopy cover (McIntyre *et al.* 2019) the long-term effects of pine plantation management cycles on eastern indigo snakes are unclear.

Impacts from heavy equipment used in forestry operations and road mortality or deliberate killing within forested recreational areas (*e.g.*, Godley and Moler 2013) is an ongoing concern. At some sites gopher tortoise burrows have been impacted by forestry equipment. Although gopher tortoises have shown ability to dig out of damaged or collapsed burrows, most commensal species like the eastern indigo snake would not be able to dig out and could be entombed. Forestry Best Management Practices, if implemented, can improve wildlife conservation. For example, when using heavy equipment for forestry, Georgia Best Management Practices recommend flagging all tortoise burrows and establishing a buffer of 10 feet (GDNR 2024) and Florida Best Management Practices recommend avoiding burrow impacts and marking concentrations of burrows (FDACS 2024). However, Best Management Practices are not always implemented. Forest certification programs (*e.g.*, American Tree Farm, Sustainable Forestry Initiative, and Forest Stewardship Council may improve wildlife conservation and Best Management Practices monitoring and implementation. While managed forests (pine plantations) likely provide important connectivity among seasonal habitats (*i.e.*, areas occupied by gopher tortoises and wetland areas) used by eastern indigos snakes, forests that are managed for open canopy conditions that support and protect gopher tortoise populations and their burrows are essential for long-term eastern indigo snake species viability.

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

Collection of eastern indigo snakes from the wild for the pet trade was a primary reason for listing the species in 1978 (Service 1978). Concerns existed at the time of listing, that publicity from listing of the eastern indigo snake would increase demand for this species in the pet trade, resulting in more collection from the wild. Although some unauthorized wild collection of eastern indigo snakes may still occasionally occur (*e.g.*, Roebuck 2014), it is thought to have negligible impacts on wild populations (Enge *et al*. 2013). However, the high price of legally purchasing adult eastern indigo snakes in the pet trade may incentivize unauthorized/illegal activities associated with take from the wild and sale. Wild collection remains a concern for the species, but State and Federal law enforcement agencies have not reported an increase in cases of illegal take. In addition, activities that will contribute to the species' recovery by enhancing their survival, such as propagation and educational animals, interstate commerce of captive eastern indigo snakes and other recovery actions, may be permitted under Section 10 of the Act. Because cases of illegal take are rare and take for scientific (recovery) purposes are carefully reviewed prior to permitting, overutilization for commercial, recreational, scientific, or educational purposes is not considered to be a substantial threat to the species at this time.

Factor C: Disease or predation

Disease and health concerns continue to increase for the eastern indigo snake. Snake fungal disease (*Ophidiomyces ophiodiicola*) is an emerging disease that has infected snakes throughout the eastern United States, including eastern indigo snakes in Georgia, and has been implicated in population declines of several snake species (Lorch *et al.* 2015, Chandler *et al*. 2019, Allender *et al*. 2020). Snake fungal disease is widely distributed across eastern indigo snake populations in southeastern Georgia. The Orianne Society continues to monitor annually for the disease with snakes testing positive, however, positive detections have been increasing (2019–2020: 50%; 2020–2021: 68%; 2021–2022: 91%) (Chandler 2023). One eastern indigo snake from the reintroduction site in Alabama tested positive for snake fungal disease. In Florida, snake fungal disease has been detected on several native snake species (Glorioso *et al*. 2020), including some on eastern indigo snakes (Bogan, pers. comm. 2024). However, little monitoring has been conducted on eastern indigo snake populations in Florida. Thus, the distribution and impact of this pathogen on eastern indigo snake populations remains unclear.

Cryptoporidium serpentis is a protozoan that can cause a parasitic disease in snakes. Symptomatic snakes infected with *C. serpentis* often have poor growth, weight loss, regurgitation, and gastric hypertrophy leading to a visible mid-body swelling. Severe clinical infections are progressively debilitating and may lead to fatal gastric cryptosporidiosis (Bogan 2019). Reported prevalence and fate of snakes with *C. serpentis* in captive and wild populations are not well studied. An extensive survey of over 500 wild and captive reptiles over three continents found a 3% prevalence of infection with *Cryptosporidium* (Upton *et al*. 1989, entire). However, it seems there is a higher prevalence rate in captive populations (Sevá *et al.* 2011, entire) and infection may be more common in the zoological collections than traditionally thought. In 2016, *C. serpentis* was discovered in captive eastern indigo snakes at the Central Florida Zoo & Botanical Garden's Orianne Center for Indigo Conservation. The Center has since developed strict protocols to minimize the incidence of the disease and all animals are regularly screened using a probe hybridization quantitative test for eastern indigo snakes evaluated by Bogan *et al*. (2022a). Treatment for *C. serpentis* infection in eastern indigo snakes is being evaluated but no effective treatment has been found (Bogan *et al*. 2021a). Surveys to better understand the distribution and prevalence of this disease in the wild within the range of the eastern indigo snake recently were conducted, where 155 free-ranging snakes were sampled at

two sites where eastern indigo snakes are being reintroduced, and 72 free-ranging eastern indigo snakes and other snake species were tested across Georgia and Florida. All tested negative for *C. serpentis* except one eastern indigo snake from south Florida (O'Hanlon *et al.* 2023). However, *C. serpentis* has been detected in more eastern indigo snakes (n=11) from south Florida sites where agricultural lands used by the species are being heavily modified and converted to reservoirs as part of the Everglades hydrologic restoration efforts (Bogan *et al.* 2023, Bogan, pers comm. 2024). Given the increased prevalence of *C. serpentis* at these disturbed sites, snakes that are immunosuppressed by stress or have concurrent illness may be more likely to develop clinical signs and illness due to *C. serpentis* infection (Bogan *et al*. 2023). Therefore, where eastern indigo snakes are subject to stressful environments, such as habitat conversion, impacts from *C. serpentis* is an increasing concern.

In addition to *C. serpentis*, a wide variety of other disease and health concerns were recently detected across two Everglades hydrologic restoration sites in South Florida that may have important conservation implications. Results of this study are detailed in Bogan *et al.* (2023) but are summarized here. The incidence of nematode parasites was found to be consistent with previous studies (Knafo *et al*. 2016) and are generally common in wild snakes and may not be a threat to the species. However, the Asian pentastome (snake lungworm, *Railletiella orientalis*) introduced to North America by the invasive, non-native Burmese python (*Python bivittatus*) was detected in at least 12 eastern indigo snakes (Bogan *et al.* 2023). Previous studies have documented this parasite in 13 native snakes including 2 eastern indigo snakes (Miller *et al.* 2018) and has been a likely contributing factor in the death of at least two *Sistrurus miliarius* (Pygmy rattlesnake) (Farrell *et al.* 2019) and a *Nerodia fasciata* (southern watersnake) (Walden *et al.* 2020). At least one eastern indigo snake has been reported to have died due to infection from *R. orientalis* (Bogan *et al*. 2022b). *Ferlavirus* and adenovirus were also detected in one and three eastern indigo snakes, respectively, and these viruses co-occurred with *C. serpentis* (Bogan *et al.* 2023). Further research is needed regarding whether viral co-infection plays a role in *C. serpentis* infections in eastern indigo snakes.

There is an increasing incidence of dystocia (egg binding or retention) in captive eastern indigo snake populations that support the captive breeding and reintroduction recovery program (Bogan *et al.* 2021b). Dystocia can be life-threatening, often requiring medical intervention. Dystocia has been a limiting factor for the eastern indigo snake captive propagation program that supports the population reintroduction recovery program. However, modified husbandry approaches (such as diet, exercise, and types of enclosures) are being implemented to help reduced incidence of dystocia. Risk factors for developing dystocia are not well-understood but have been linked to first time breeders and body weight (smaller snakes) in eastern indigo snakes. Dystocia is believed to be a risk factor primarily for captive populations, however, one eastern indigo snake captured from the wild developed dystocia. This snake originated from the captive propagation recovery program but was in the wild for more than a year where it bred naturally. The snake was recaptured as part of the monitoring program and shortly after recapture laid eggs but retained two eggs. Dystocia in this snake may have been due to the stress of capture or related to its history in from prior captivity and therefore may not be representative of a true wild eastern indigo snake (Bogan *et al*., 2021b). At this time, dystocia appears to be a health risk primarily of captive eastern indigo snakes and is not likely to have significant effects on wild populations. However, monitoring and research are ongoing to better understand and manage this health issue.

Factor D: The inadequacy of existing regulatory mechanisms

The eastern indigo snake was listed due to population decline caused by habitat loss, over-collecting for the pet trade, and mortality from gassing gopher tortoise burrows to collect rattlesnakes (Service 1978). The Lacey Act, as amended in 1981 and 2008, (18 U.S.C. 42), generally prohibits the illegal trade in any fish or wildlife or plant. As a result of effective law enforcement and the Lacey Act, exploitation for the pet trade has declined but remains a concern. Gassing of gopher tortoise burrows to collect eastern diamond-backed rattlesnakes (*Crotalus adamanteus*) is illegal in both Florida and Georgia, but likely still occurs to some extent. Although still a threat, it is unlikely that gassing currently has a large negative impact on most eastern indigo snake populations (Enge *et al*. 2013). Although the Lacey Act provides protection against removal from the wild for the pet trade it does not provide sufficient protection to justify removal of this snake from the Federal List of Endangered and Threatened Species.

While the Act does afford the eastern indigo snake protection from unauthorized direct or indirect take under section 9, incidental take that may occur as a result of a project or activity that does not have a federal nexus (*i.e.*, federal funding, on federal land, federal permit) are not required to consult with the Service on the potential for adverse impacts to the species. While impacts to federally listed species from non-federal projects are not exempt from section 9, it is the responsibility of the project proponent to coordinate with the Service under section 10 of the Act. Exercising this responsibility can be highly variable and therefore, it is likely that impacts to eastern indigo snakes and unauthorized take continue to be a concern.

Each state within the historical range of the eastern indigo snake provides some protection for the species. In Alabama, the eastern indigo snake is a nongame species protected by State regulation (Alabama Department of Conservation and Natural Resources (ADCNR 2018 (AL Code § 220-2-.92)). In Florida and Georgia, it is listed as threatened (FWC 2017, GDNR 2018 (FL Code § 68A-27.003, GA Code § 391-4-10)). In Mississippi it is listed as endangered (MNHP 2015, (MS Code § 49-5-107)).

The protections provided by each state vary. However, most state laws focus on prohibitions against direct take of eastern indigo snakes, such as removing snakes from the wild and possessing, killing, exporting, or selling them, although Georgia regulations also protect the habitat of listed species on public land (GDNR 2018). State regulatory mechanisms are not adequate to protect the species, because they do not prohibit take of eastern indigo snakes as an incidental consequence of incompatible land use or development. However, in Florida, permits must be obtained before any land clearing or development takes place where gopher tortoises occur, which may provide some benefits in the northern parts of Florida but limit benefits in southern Florida areas where eastern indigo snakes are not as reliant on burrows. In Alabama and Georgia, state permits must be obtained to relocate gopher tortoises from impacted sites. These requirements may offer some indirect protection for eastern indigo snakes as a federally listed commensal species. However, given the significant recent, ongoing, and expected future incidence of gopher tortoise relocations in Florida and Georgia due to land use changes, the loss of gopher tortoise burrows in these habitats are likely negatively impacting eastern indigo snakes in those areas, and state regulations are inadequate for protecting eastern indigo snakes where they co-occur with gopher tortoise.

The current regulatory mechanisms outside of the Act are inadequate to protect the species from existing threats.

Factor E: Other natural or manmade factors affecting its continued existence

Road and Direct Mortality

Loss of eastern indigo snakes due to road mortality continues to be a significant threat to the species. As road density and traffic density continue to increase within eastern indigo snake populations, the risk of road mortality also increases. Eastern indigo snakes are active foragers and will move long distances to find food and mates. They may also expand their home ranges and cross roads to find resources when habitat quality decreases. This, along with their large body size makes them susceptible to unintentional and intentional vehicle strikes. Many eastern indigo snake records are from sightings on roads most of which are reported as dead on road. Further, despite federal listing status deliberate killing of eastern indigo snakes is still a risk factor for the species (*e.g.*, Jones 2021).

Climate Conditions

Temperatures and the frequency and intensity of drought and extreme precipitation events in Georgia and Florida, the core indigo state range, have increased and are expected to increase in the future (Frankson *et al.* 2022, Runkle *et al.* 2022). These changes have a potential to impact individuals through changes in species' feeding, breeding, and sheltering needs.

Sea level rise due to climate change continues to be a significant risk to eastern indigo snake habitat and populations that occur along the coasts in Florida. In addition, hurricanes may exacerbate already stressed coastal populations. For example, the eastern indigo snake population on the barrier islands of Lee County, Florida on the Gulf Coast was hit by the highly destructive (category 5) Hurricane Ian in September 2022. Impacts to the eastern indigo snake populations are unclear at this time, however, post-hurricane, three eastern indigos have been observed on North Captiva, but none have been observed on Pine Island which sustained more severe damage from the hurricane and had more heavy truck traffic from storm clean-up crews, which may have exacerbated the overall impacts of the storm on the eastern indigo snake population.

Chlorinated Pesticides

Because the eastern indigo snake is an apex predator, pesticides that bioaccumulate through the food chain may present a potential hazard (Lawler 1977). Recently, the presence of chlorinated pesticides in tissue samples of necropsied eastern indigo snakes was found to be higher at one of the Everglades restoration sites (Bogan *et al*. 2023) than previously reported in for agricultural sites in Georgia (Knafo *et al.* 2016). One individual exhibited lethal levels and died, while others exhibited much lower, likely non-lethal levels (Bogan *et al.* 2023). Past and present pesticide use in agricultural areas continue to be a concern for eastern indigo snakes. Additional surveillance and monitoring are needed to better understand the impact residual pesticides may have at population levels.

Synthesis

The eastern indigo snake is a non-venomous, bluish-black colored snake, reaching up to 8.6 feet (2.63 meters) in total length, and is native to Alabama, Florida, Georgia, and Mississippi. Since listing under the Act its natural distribution has contracted, particularly in the Florida Panhandle due to the decline of gopher tortoise populations. Naturally occurring eastern indigo snake populations have been extirpated in Alabama and Mississippi, but population reintroduction efforts are underway restore populations in Alabama and the Florida Panhandle. Reintroductions at the two sites are showing signs of success, but long-term population viability and overall success remains uncertain. Occupancy of indigo snakes within the four geographic regions has

declined (32-97%) compared to historical estimates. We estimate that there are currently approximately 51 extant populations, however, it is unknown how many of the extant populations are stable or increasing in size. Range-wide, eastern indigo snakes continue to be impacted by loss and degradation of habitat. Across Georgia and Florida, habitat loss and degradation continue to increase, particularly due to increasing development (*e.g.*, large-scale solar energy, mining projects, and urbanization) and lack of habitat management. In the North Florida region, lack of observations or evidence of the species on about 30 sites that were thought to support eastern indigo snakes is concerning. In Peninsular Florida, habitat loss from landscape-scale hydrological restoration sites (Everglades restoration) continue to impact the species in this region. Snake fungal disease, disease from a parasitic protozoan, *Cryptoporidium serpentis*, and other health concerns are emerging threats that are impacting eastern indigo snakes and could pose significant population-level threats due to decreasing health or mortality. In addition, road mortality and changes in climate still pose significant threats throughout the species' range. Based on ongoing threats and the current condition of the species, eastern indigo snake continues to meet the definition of a threatened species.

RECOMMENDED FUTURE ACTIVITIES

A detailed discussion of recovery actions and criteria are presented in the Recovery Plan (Service 2019a) and Recovery Implementation Strategy (Service 2019d). In the course of this status review new and/or targeted potential recovery activities were identified and are included below.

Recovery Activities

- Protect existing eastern indigo snake populations on public lands through appropriate habitat management and conservation techniques identified in site-specific management plans.
- Protect habitat via land acquisition along corridors of known occupied habitats, such as the river corridors of southeastern Georgia and the central ridge systems of Florida.
- Protect and develop appropriate management plans for sites on privately owned lands.
- Continue population reestablishment efforts in areas where the species has been extirpated.
- Develop a range-wide conservation action plan that provides appropriate avoidance, minimization, and compensation recommendations to reduce impacts to eastern indigo snakes.
- Revise population (conservation) units and Conservation Focus Areas using updated population viability and habitat suitability models.
- Continue to engage with the Department of Defense and other partners to implement the Recovery And Sustainment Program (RASP) Initiative in support of eastern indigo snake recovery.

Monitoring and Research Activities

- Study and implement long term monitoring of eastern indigo snake populations on selected sites across the range of the species.
- Continue efforts to develop reliable survey methods.
- Complete and apply species-specific population viability model using an updated habitat suitability model (Chandler *et al.* 2022) and conservation units (Bauder *et al.* 2022) to reassess populations and their condition range wide.

- Expand on the initial efforts by Breininger *et al*. (2004), Bauder *et al*. (2018), and others to determine the appropriate size, acceptable fragmentation level, habitat types, and geographic location for eastern indigo snake reserves across the species' range.
- Determine measures of success and what constitutes successful population reestablishment.
- Study the effects and feasibly of wildlife fencing (permeable and exclusion) on eastern indigo snake populations.
- Assess the extent, magnitude, and population effects of ongoing and emerging health and disease issues (e.g., snake fungal disease, *C. serpentis*, *R. orientalis* infections, chlorinated pesticides).

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RESULTS / SIGNATURES

U.S. Fish and Wildlife Service
Status Review of eastern indigo snake (*Drymarchon couperi*)

Status Recommendation:

On the basis of this review, we recommend the following status for this species. A 5-year review presents a recommendation of the species status. Any change to the status requires a separate rulemaking process that includes public review and comment, as defined in the Act.

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist:
____ *The species is extinct*
____ *The species does not meet the definition of an endangered or threatened species*
____ *The listed entity does not meet the statutory definition of a species*
_X_ No change needed

SIGNATURES / APPROVAL:

Field Supervisor, Georgia Ecological Services Field Office, Fish and Wildlife Service

Approve PETER MAHOLLAND Digitally signed by PETER MAHOLLAND Date: 2024.08.28 10:04:04 -04'00'