

**Recovery Plan for the
Eastern Indigo Snake
First Revision**



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DISCLAIMER

Recovery plans delineate reasonable actions that are believed necessary to recover and/or protect the species. Plans are prepared by the U.S. Fish and Wildlife Service, sometimes with the assistance of recovery teams, contractors, State agencies, and others. Plans are reviewed by the public and subject to additional peer review before they are adopted by the U.S. Fish and Wildlife Service. Objectives will only be attained and funds expended contingent upon appropriations, priorities, and other budgetary constraints. Recovery plans do not obligate other parties to undertake specific tasks. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks. By approving this document, the Regional Director certifies that the information used in its development represents the best scientific and commercial data available at the time it was written. Copies of all documents reviewed in development of the plan are available in the administrative record, located at the U.S. Fish and Wildlife Service's South Atlantic-Gulf Regional Office, Atlanta, Georgia.

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Recovery Plan for the Eastern Indigo Snake, First Revision

This revised recovery plan describes criteria for determining when the eastern indigo snake should be considered for delisting from the Federal *List of Endangered and Threatened Wildlife* (50 CFR 17.11). It also lists actions that will be necessary to meet those criteria, and estimates the cost for implementing recovery actions. Brief descriptions of the species' status, habitat requirements, and limiting factors are included. A detailed discussion of these and other topics pertinent to the recovery of the eastern indigo snake can be found in the Species Status Assessment (SSA, Service 2019a) and the Recovery Implementation Strategy (RIS, Service 2019b). These supplemental documents are available online at the U.S. Fish and Wildlife Service's Environmental Conservation Online System (ECOS) by searching for the species profile for the eastern indigo snake (<https://ecos.fws.gov/ecp/>). The RIS and SSA are finalized separately from the Recovery Plan and will be updated on a routine basis.

Current Species Status: The eastern indigo snake (*Drymarchon corais couperi*, hereafter recognized by its currently accepted name, *Drymarchon couperi* (Collins 1991, Wüster *et al.* 2001, Crother 2012)) was federally-listed as threatened on March 3, 1978 (Service 1978) under the Endangered Species Act (ESA) due to threats from habitat modification, collections for the pet trade and gassing while in gopher tortoise (*Gopherus polyphemus*) burrows. The species is also state-listed as threatened in Georgia and Florida, and as endangered in Alabama and Mississippi. The first recovery plan was published in 1982 (Service 1982), and since that time progress has been made to better understand the species' life history and to conserve the species. The current distribution for the eastern indigo snake, which includes the coastal plain of Georgia and Florida, has contracted from its historical distribution. Historical records exist for Alabama and Mississippi, but no naturally-occurring populations remain in these states. Since listing under the ESA, the threat of collecting for the pet trade and gassing of burrows has been considerably reduced. However, further range contraction has occurred particularly in the Florida Panhandle due to population declines of the gopher tortoise (Enge *et al.* 2013), whose burrows provide critical winter shelter for eastern indigo snakes. Also, the range has contracted in many parts of the Florida Peninsula mostly due to habitat impacts (Service 2019a). In addition to habitat loss, degradation, and fragmentation, direct mortality by people and their domestic pets and from vehicle strikes on roads is an increasing risk (Service 2019a,c). Conservation efforts are underway to repatriate eastern indigo snake populations in the Florida Panhandle and Alabama and land conservation efforts have increased, particularly in Southeast Georgia. In 2019, overall population resiliency was estimated to be medium to low and was predicted to decline in the future without targeted conservation efforts (Service 2019a).

Habitat Requirements and Limiting Factors: Eastern indigo snake habitat consists of a wide range of upland and lowland habitats. Upland habitats in the northern portions, and in some southern portions, of the species' range include xeric longleaf pine (*Pinus palustris*) sandhills and scrub habitats that support gopher tortoise populations. In the northern portion of the range the species depends on gopher tortoises, whose burrows are used by snakes for winter shelter sites. In the southern two-thirds of Peninsular Florida eastern indigo snakes use a wide variety of

natural and human-altered habitats. Across its range, the most important factors limiting the suitability of these environments as habitat for the eastern indigo snake are their quantity and quality. Estimates of good-quality (i.e., low fragmentation, road density and urban land cover with adequate shelter sites) habitat patches needed to support an eastern indigo snake population range from 5,000 to >20,000 acres (2,023 to >8,094 hectares).

Recovery Strategy: The recovery strategy for the eastern indigo snake is to ensure the long-term viability of the species by maintaining and enhancing existing populations via habitat conservation, restoration and management; monitoring the status of extant populations; identifying and securing additional eastern indigo snake populations and habitat; repatriating populations through translocations or reintroductions; and supporting research that guides land management and provides demographic and ecological data. The recovery strategy requires that habitat is protected and managed and that populations are genetically-connected to promote the stability and growth of multiple populations across the species' range.

Recovery (or viability) of the eastern indigo snake is based upon the ecological principles of resiliency, redundancy, and representation (3 R's, Wolf *et al.* 2015). **Resiliency** is positively related to population size and growth and describes the ability of a population to withstand stochastic disturbance. Highly resilient populations are better able to withstand disturbances such as random fluctuations in birth rates (demographic stochasticity), variations in temperatures (environmental stochasticity), or the effects of anthropogenic (human-driven) activities. **Representation** describes the ability of a species to adapt to changing environmental conditions over time as characterized by the breadth of genetic and ecological diversity within and among populations. The more representation, or diversity, a species has, the more it is capable of adapting to changes in its environment. **Redundancy** spreads the risk among multiple populations and describes the ability of a species to withstand catastrophic events. Redundancy gauges the probability that there is a margin of safety for the species to withstand or bounce back from catastrophic events. It is measured by the number of populations and their resiliency, distribution, and connectivity. The 3 R's for the eastern indigo snake are assessed in detail in the SSA (Service 2019a).

The SSA (Service 2019a) estimated 53 extant eastern indigo snake populations based on verified species occurrence records buffered by the snake's estimated maximum home range width (5 miles or 8 kilometers). The SSA highlighted the importance of maintaining large patches of good-quality habitat and of connecting eastern indigo snake populations to support highly resilient populations. Habitat loss, degradation and fragmentation from development and sea level rise were identified as the primary negative factors influencing resiliency of populations. The populations were distributed across 4 geographic regions (North Florida; Panhandle¹; Peninsular Florida; Southeast Georgia) that represented the species' genetic and ecological diversity. Sixteen (16) Conservation Focus Areas (CFAs) (Service 2019a,b), which can maintain or restore sufficient habitat (quantity and quality) and connectivity among populations and across regions, were defined to target recovery criteria and actions.

¹ Panhandle region includes portions for Alabama, Florida and Georgia. See the SSA (Service 2019a) for details.

Habitat protection and management plans should be developed and implemented for all recovery populations. Habitat management includes maintaining corridors with low road density allowing dispersal between occupied upland and lowland habitats; minimizing soil disturbance and loss of native herbaceous ground cover vegetation; conducting prescribed burning, particularly during the growing season; maintaining appropriate lowland habitat; and restoring degraded upland habitat. Habitat on private land that could be managed for eastern indigo snakes need to be identified. Site analyses and habitat management actions that improve the connectivity between upland and lowland habitats utilized by eastern indigo snakes are needed. Long-term monitoring programs and a range-wide population viability analysis (PVA) are needed to track population trends and the response of this species to habitat changes, and to better define populations. Gopher tortoise populations should be regularly monitored and managed in areas where both eastern indigo snakes and tortoises co-occur. Monitoring programs should be critically evaluated and revised as needed. Since recovery of the eastern indigo snake will necessitate finding new or repatriating populations, assessment of potentially suitable habitat within the range of the species and additional presence/absence surveys are needed. Range-wide monitoring and PVAs should be used to evaluate delisting criteria and determine when delisting criteria have been met.

Recovery Goal: The goal of this recovery plan is to assure the long-term viability of the eastern indigo snake and to facilitate its removal from the *List of Endangered and Threatened Wildlife* (50 CFR 17.11). Therefore, this recovery plan establishes delisting criteria for the species. Criteria should be reevaluated as new relevant information becomes available.

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)² 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).

Justification for Delisting Criteria: The delisting recovery criteria reflect the best available and most up-to-date information on the eastern indigo snake. These criteria address the five factors

² See SSA (Service 2019a) and RIS (Service 2019b) for descriptions of CFAs.

described in section 4(a)(1) of the ESA and incorporate the conservation biology principles of representation, resiliency, and redundancy (Wolf *et al.* 2015).

Criterion 1: For the eastern indigo snake, assessing population resiliency can be used to estimate if populations are stable or increasing. Resilient eastern indigo snake populations are those that have a relatively large population extent and are genetically-connected to other populations. Resilient populations also have adequate natural habitat with low fragmentation, road density and urban land cover and provide adequate shelter sites (i.e., good-quality habitat, Service 2019a). Medium to highly resilient populations are expected to persist into the foreseeable future (see the SSA, Service 2019a) and therefore assumed to be stable or increasing. The SSA estimated 17 medium to highly resilient populations, but in 30 to 50 years (i.e., the foreseeable future) resilient populations are significantly reduced without targeted conservation actions due to development and sea level rise. To maintain medium to high resiliency, populations need to be of sufficient geographic extent and genetically-connected to adjacent populations. As such, the spatial distribution of populations influences population resiliency; thus, more than 14 populations may be needed to maintain resiliency. Also, resilient populations need adequate habitat quantity and quality to be medium to highly resilient (i.e., stable or increasing). The 16 CFAs address these resiliency factors. Therefore, at least 14 resilient populations should be distributed across 12 of the 16 CFAs. Further explanation for the 14 populations is provided in Criterion 2 justification below. Number of recovery populations (14) may be revised if new relevant information becomes available, such as changes to the definition of a population and resiliency (viability) metrics. This criterion addresses Factors A, C, and E.

Criterion 2: This criterion addresses resiliency, representation, and redundancy by ensuring multiple populations are distributed across the species' range and within representative units (ecological and genetic). Multiple (2 or more) populations in the 4 geographic representative regions will ensure that the species' ecological and genetic diversity (representation) is maintained across the historical distribution of the species. Populations in the Panhandle region will need to be repatriated via captive propagation and reintroduction efforts. Because source populations for the repatriated Panhandle populations are from other representative units, populations in this region primarily support redundancy of populations across a broader geographic range within the species' historical distribution. At least 2 populations within each region provide the minimum threshold for redundancy within each representative unit. The CFAs address population resiliency. Summarized here from the SSA and RIS (Service 2019a,b), CFAs contain potentially resilient populations and/or they contribute to the connectivity of occupied eastern indigo snake habitat and thus increase dispersal potential and improve opportunities for new population establishment. The primary factors used in delineating boundaries of CFAs (inclusive of the same factors that support medium to highly resilient populations) were presence of: (1) intact, unfragmented (by major roads or river systems), naturally-functioning habitat representative of that area's physiographic province; (2) areas that contain multiple, large acreages (greater than 2,500 acres (1,000 hectares)) of conservation land such as public lands or property with conservation easements capable of undergoing adequate management; and (3) diverse natural habitat types (e.g., scrub, sandhills, riverine, sand ridges, etc.). The rationale for requiring only 12 of the 16 CFAs to have resilient populations provides flexibility should some (up to 4) CFAs not support resilient populations in the foreseeable future

due to challenges with conservation efforts (e.g., land protection and management) or unavoidable impacts (e.g., sea level rise and invasive species). However, large CFAs should support more than one resilient population, therefore the minimum number of resilient populations for recovery is 14. These 14 populations within at least 12 CFAs, which are widely distributed across the historical range and within the 4 representative units, will support genetic and ecological integrity of the species. This criterion addresses Factors A, C, and E.

Criterion 3: This criterion addresses resiliency, representation, and redundancy. Connectivity among populations ensures the species can withstand stochastic and catastrophic events. This would maintain genetic connectivity for large populations and reduce the risk of extirpation (i.e., genetic rescue and recolonization after extirpation) for smaller populations. Because gene flow is driven by the movements of individuals and eastern indigo snakes are influenced by landscape condition (Breininger *et al.* 2011, Bauder *et al.* 2018), conservation of suitable habitat corridors among populations will support genetic connectivity. Spatially-explicit population viability models may be developed to inform recovery efforts (e.g. Bauder 2018). The North Florida, Peninsular Florida, and Southeast Georgia regions represent the current ecological and genetic diversity of the species; therefore, maintaining connectivity among populations and across these regions is essential for long-term viability. Populations in the Panhandle region will need to be repatriated using source populations from the other regions. Panhandle populations provide important redundancy for the species but are geographically disconnected from the other regions. Populations in the Panhandle will need to be of sufficient size to maintain stable or increasing populations over time. Because detection probability for eastern indigo snakes is low, especially during the early phases of repatriation, population models may be used to inform release strategies to achieve acceptably low extinction rates (e.g., Folt *et al.* 2019). This criterion addresses Factors A, B, C, and E.

Criterion 4: Abatement of threats to the eastern indigo snake will allow populations to become stable and contribute to the recovery of the species into the foreseeable future. Management plans will need to require maintenance, enhancement, and monitoring procedures so that threats are alleviated. This criterion addresses Factors A, C, D and E.

Actions Needed: The recovery actions identified below (Table 1) are those that, based on the best available science, we believe are necessary to recover the eastern indigo snake.

Table 1. Recovery actions with Estimated Cost and Priority Number³.

Recovery Action	Estimated Cost	Priority Number
1. Protect existing eastern indigo snake populations via land protection and using appropriate habitat management and conservation techniques identified in site-specific management plans.	\$18,250,000	1
2. Monitor known eastern indigo snake populations and the habitat that supports them, includes development of survey and monitoring techniques.	\$1,650,000	1
3. Expand knowledge of basic ecology and demography of eastern indigo snakes, includes development of a range-wide Population Viability Analysis (PVA).	\$1,550,000	1
4. Develop range-wide habitat suitability models.	\$175,000	1
5. Repatriate populations within habitat historically occupied by eastern indigo snakes where appropriate.	\$3,520,000	1
6. Establish a centralized range-wide Geographic Information System (GIS) database for data storage, analyses, and recovery review.	\$180,000	2
7. Develop and distribute public educational materials and outreach programs supporting eastern indigo snake recovery.	\$150,000	3
8. Coordinate all recovery activities, evaluate success, and revise recovery plan as appropriate.	Costs under existing State and Federal programs	3
Total Estimated Cost: \$25,475,000		

Estimated Cost of Recovery: The cost to recover and ultimately delist the eastern indigo snake will total approximately \$25,475,000 (Table 1). Some costs for recovery actions are not determinable at this time (e.g., land protection); therefore, the total cost for recovery will be higher than this estimate.

Date of Recovery: If all actions are fully funded and implemented, including full cooperation of all partners needed to achieve recovery, delisting could be met by 2050. Repatriation of populations is likely to take at least 10 years. Additionally, recovery requires that eastern indigo snake populations be stable or increasing into the foreseeable future. Therefore, a 20-year

³ Recovery actions are assigned numerical priorities to highlight the relative contribution they may make toward species recovery (48 FR 43098):

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.

Priority 2 – An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3 – All other actions necessary to provide for full recovery of the species.

monitoring period is recommended to cover multiple generations (4 to 6) to provide a reliable estimate of population change.

Literature cited:

Bauder, J.M. 2018. Population viability and connectivity of the federally threatened eastern indigo snake in central peninsular Florida. PhD dissertation. Department of Environmental Conservation Wildlife, Fish, and Conservation Biology. University of Massachusetts Amherst.

Bauder, J.M., Breininger, D. R., M.R. Bolt, R. Breininger, M.L. Legare, C.L. Jenkins, B.B. Rothermel, K. McGarigal. 2018. Multi-level, multi-scale habitat selection by a wide-ranging, federally threatened snake. *Landscape Ecology* 33:743-763.

Breininger, D.R., M.R. Bolt, M.L. Legare, J.H. Dreese, and E.D. Stolen. 2011. Factors influencing home-range sizes of eastern indigo snakes in central Florida. *Journal of Herpetology* 45:484-490.

Collins, J.T. 1991. Viewpoint: A new taxonomic arrangement for some North American amphibians and reptiles. *Herpetological Review* 22:42-43.

Crother, B. I. (ed.). 2012. Scientific and standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding. Society for the Study of Amphibians and Reptiles, Herpetological Circular No. 39. Shoreview, Minnesota. Iv + 92 pp.

Enge, K.M., D. J. Stevenson, M.J. Elliott, and J.M. Bauder. 2013. The historical and current distribution of the eastern indigo snake (*Drymarchon couperi*). *Herpetological Conservation and Biology* 8:288–307.

Folt, B., McGowan, C.P., Steen, D.A., Piccolomini, S., Hoffman, M. Godwin, J.C., and Guyer, C. 2019. Modeling strategies and evaluating success during repatriation of elusive and endangered species. *Animal Conservation*. Published online 12 September 2019. <https://doi.org/10.1111/acv.12537>

U.S. Fish and Wildlife Service (Service). 1978. Endangered and Threatened Wildlife and Plants. Listing of the eastern indigo snake as a threatened species. *Federal Register* 43:4026.

–. 1982. Eastern indigo snake recovery plan. Atlanta, GA. 23 pp.

–. 2019a. Species status assessment report for the eastern indigo snake (*Drymarchon couperi*). Version 1.1 July, 2019. Atlanta, GA.

–. 2019b. Eastern Indigo Snake Recovery Implementation Strategy. Atlanta, Georgia.

–. 2019c. Eastern indigo snake *Drymarchon corais couperi*. 5-Year Review: Summary and Evaluation. 51 pp.

Wolf, S., B. Hartl, C. Carroll, M. C. Neel, and D. N. Greenwald. 2015. Beyond PVA: why recovery under the Endangered Species Act is more than population viability. *BioScience* 65:200-207.

Wuster, W., J.L. Yrausquin, and A. Mijares-Urrutia. 2001. A new species of indigo snake from north-western Venezuela (Serpentes: Colubridae: *Drymarchon*). *Herpetological Journal* 11:157-165.

APPENDIX. SUMMARY OF PUBLIC AND PARTNER COMMENTS RECEIVED

Summary of Public Comments We published a notice of availability in the *Federal Register* on August 6, 2019 ([84 FR 38284](#)) to announce that the Draft Revised Recovery Plan for the Eastern Indigo Snake was available for public review, and to solicit comments by the scientific community, State and Federal agencies, Tribal governments, and other interested parties on the general information base, assumptions, and conclusions presented in the draft revision. An electronic version of the draft plan was posted on our Species Profile website (https://ecos.fws.gov/docs/recovery_plan/Eastern%20Indigo%20Snake%20Draft%20Revised%20Recovery%20Plan.pdf). A Species Status Assessment (SSA, Service 2019a) and Draft Recovery Implementation Strategy (RIS, Service 2019b) were provided as supplemental information to the recovery plan. Specific notifications regarding the public comment opportunity and availability of the Draft Revised Recovery Plan for the Eastern Indigo Snake were sent to key stakeholders in conservation and recovery efforts.

We received 10 responses in total. These included multiple comments from interested citizens as well as non-governmental organizations and interest groups. Public comments ranged from providing minor editorial suggestions to specific recommendations on recovery plan content. We have considered all substantive comments. We thank the reviewers for these comments and to the extent appropriate, we have incorporated the applicable information or suggested changes into the final revised recovery plan. In general, changes provided clarification of recovery criteria justifications. Comments were also provided on the SSA and RIS; however, here we considered all substantive comments specific to the Draft Revised Recovery Plan for the Eastern Indigo Snake. Revision of the SSA and RIS will be finalized separately from the Recovery Plan and comments specific to the SSA and RIS will be addressed at that time. Below, we provide a summary of public comments received on the draft recovery plan; however, some of the comments that we incorporated as changes into the recovery plan revision did not warrant an explicit response and, thus, are not presented here.

Comment (1): The following summarizes multiple comments received regarding criterion 1: Why are 14 populations enough for recovery; not including criteria for a larger percentage of the existing populations is likely insufficient to maintain connectivity across the species' range; it seems counter-intuitive that a criterion for delisting would allow for a species to have fewer high-quality populations at delisting than when that species was listed under the Endangered Species Act; and, the designation of 14 populations as a goal for delisting is premature due to limited data and models to assess distinct populations and their status.

Response: Clarification was added to the Criteria 1 and 2 justifications regarding the number of populations needed for recovery. The criteria were developed based on the best scientific and commercial data available at the time they were written and were supported by a peer-reviewed species status assessment (Service 2019a). However, a recovery plan should be a living document, reflecting meaningful change when new substantive information becomes available. Keeping a recovery plan current increases its usefulness in recovering a species by ensuring that

the species benefits through timely, partner-coordinated implementation based on the best available information.

Comment (2): Add spatially-explicit descriptions of where stable or increasing populations should occur.

Response: The CFAs provide general guidance on where, spatially, recovery populations should occur. However, developing more specific spatially-explicit descriptions of where populations should occur within the CFAs could be addressed by a range-wide Population Viability Analysis (PVA) which has been added to the Recovery Action table. As described above, recovery criteria may be amended when new information becomes available, such as a range-wide spatially-explicit population model.

Comment (3): Amend criterion 3 to explicitly include genetic connectivity.

Response: Criterion 3 was amended to include genetic connectivity.

Comment (4): Criterion 3 does not address uncertainty surrounding population data, specifically for repatriated populations and what constitutes a stable enough to persist into the future.

Response: Population models have been developed and used to guide repatriation and release strategies to achieve a low extinction rate (e.g., Folt *et al.* 2019). These models combined with long-term monitoring of repatriated populations help reduce uncertainty surrounding limited population data.

Comment (5): Criterion 4 does not require conservation commitments as currently worded.

Response: Criterion 4 was revised to clarify required conservation commitments.

Comment (6): The \$1.7 million for Recovery Action 1 is very low.

Response: Some costs, such as land protection and some types of management, are not determinable at this time and therefore are not included in the estimate. We acknowledge that recovery costs will be higher than our estimate. However, we adjusted the cost to include estimated cost of fire management of upland habitat within CFAs.

Comment (7): For the date of recovery, do you mean a self-sustaining population to be established for the repatriation of populations in 10 years?

Response: The 10 years described is the minimum amount of time needed to propagate and release enough snakes to achieve an acceptably low extinction rate (Folt *et al.* 2019). The additional 20 years of monitoring is needed to provide time for natural reproduction to occur over multiple generations which could potentially be measured.

Comment (8): Criteria 3 and 4 don't appear to be quantifiable.

Response: Ecological diversity is quantified using the representative regions described in the plan. To determine if genetic connectivity is being maintained, a PVA may be one tool that can be used. We added the development of a region-wide PVA to the Recovery Actions. For

criterion 4, compiling current conservation measures and identifying additional measures needed to meet recovery is part of Recovery Action 1 and is a task further described in the Recovery Implementation Strategy (Service 2019b).