



Eastern Indigo Snake SAFE Program Plan 2022-2024



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Image 1: Eastern indigo snake being released in Conecuh National Forest, Alabama. Photo by Michelle Hoffman

Acronyms Used

ABRP	The Nature Conservancy's Apalachicola Bluffs and Ravines Preserve
ADCNR	Alabama Department of Conservation and Natural Resources
APTR	Automatic PIT tag reader
ARCS	Annual Reports on Conservation and Science
AZA	Association of Zoos and Aquariums
CNF	Concuh National Forest
EIS	Eastern Indigo Snake (<i>Drymarchon couperi</i>)
EISRC	Eastern Indigo Snake Reintroduction Committee
FWC	Florida Fish and Wildlife Conservation Commission
GDNR	Georgia Department of Natural Resources
IUCN	International Union for Conservation of Nature
NGO	Non-Governmental Organization
OCIC	Central Florida Zoo's Orianne Center for Indigo Conservation
PIT	Passive Integrated Transponder (Microchip)
SAFE	Saving Animals From Extinction
SSP	Species Survival Plan
TAG	Taxon Advisory Group
USFWS	United States Fish and Wildlife Service

Eastern Indigo Snake SAFE Species Program Goal

The Return of the Emperor - The Eastern Indigo Snake (*Drymarchon couperi*), hereafter referred to as EIS, is a large-bodied, nonvenomous, diurnal colubrid native to the southeast region of the United States. The scientific name roughly translates to “Emperor of the Forest.” Once found in southeastern Mississippi, southern Alabama, southern Georgia, and all of Florida, the range of EIS has been reduced to southeastern Georgia and peninsular Florida (USFWS 2018). Naturally occurring EIS populations are considered extirpated in Mississippi, Alabama, southwest Georgia and the panhandle of Florida due to habitat loss and fragmentation (Figure 1). This range encompasses much of the 14,000,000 hectare (ha) historic range of the longleaf pine (*Pinus palustris*; Stiles 2013). As such, the preferred habitat for free-ranging EIS is the open-canopy longleaf pine ecosystem. A key component needed to maintain a healthy longleaf pine ecosystem is periodic fire (USFWS 2018).

Another iconic inhabitant and keystone species of the longleaf pine ecosystem is the gopher tortoise (*Gopherus polyphemus*). The gopher tortoise is an environmental engineer, creating deep burrows that provide shelter for over 300 other species, including EIS (USFWS 2018). The Eastern Indigo Snake will use the gopher tortoise burrow for shelter and thermoregulation, especially in the northern extent of its range. The burrows also serve as protection against potential predators as well as wildfires (USFWS 2018).

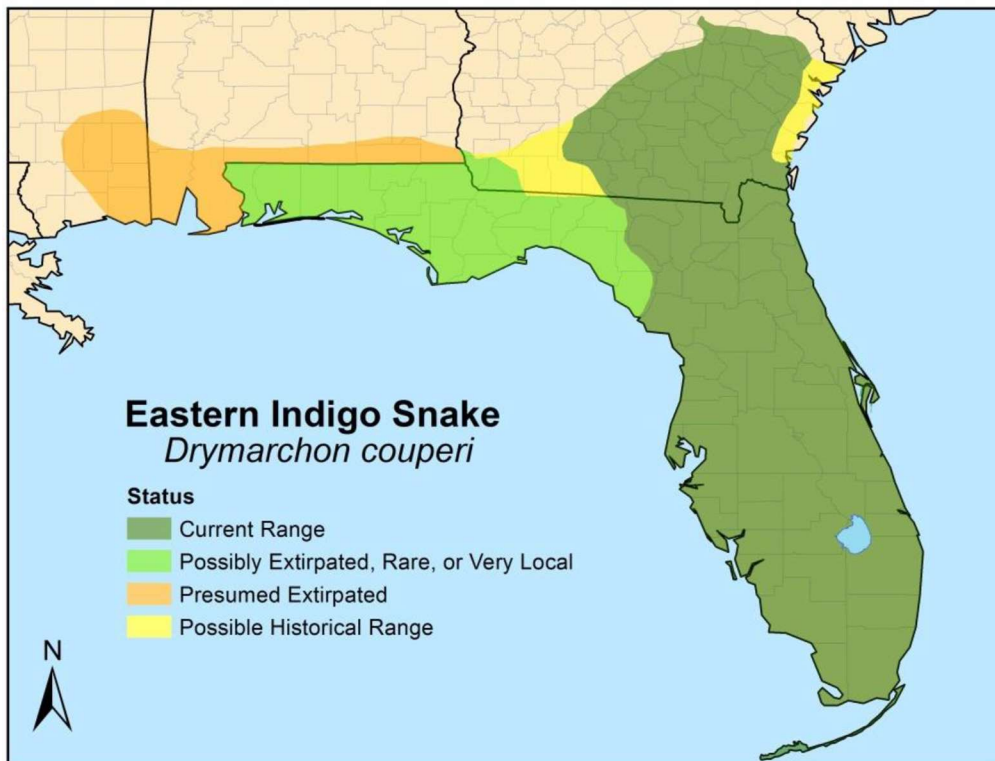


Figure 1: Historic and current range of the Eastern Indigo Snake (USFWS 2018).

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Since listing as a Threatened species in 1978 (USFWS 2019), significant conservation efforts have been made to reestablish this species throughout parts of its historic range in southern Alabama and the Florida Panhandle. The Association of Zoos & Aquariums (AZA): Saving Animals From Extinction (SAFE) Program brings together groups of AZA members with field-based partners to enhance conservation success for threatened species. The SAFE mission is to combine the power of zoo and aquarium visitors with the collective expertise of AZA members and partners to prevent animal extinction (AZA 2018).

The primary goal of the Eastern Indigo Snake SAFE Program is to contribute to the conservation of the Eastern Indigo Snake as set forth in the reintroduction strategy initiated by the Eastern Indigo Snake Reintroduction Committee (EISRC) and the Eastern Indigo Snake Recovery Plan (USFWS 2019). The reintroduction strategy is, in short, the captive breeding and rearing of EIS for the sole purpose of repatriation of the species into areas where the population is believed to be extirpated. Metrics have been calculated suggesting that a minimum of 30 two-year-old EIS be released annually for ten consecutive years within a predetermined release site in order to ensure population survivability (Folt et al. 2020).



Image 2: Eastern indigo snake housed in an outdoor enclosure at the Central Florida Zoo's Orianne Center for Indigo Conservation. Photo by Sydney Seng

Program Operational Structure

The Eastern Indigo Snake SAFE Program operating structure includes a program leader, a steering committee, and external experts. The description of these roles and associated responsibilities are included in the AZA SAFE Species Handbook (AZA, 2019). The external experts listed in Table 1 are partner institutions and advisors with EIS expertise and participate in the Eastern Indigo Snake Reintroduction Committee (EISRC), a decision-making body overseeing the Eastern Indigo Snake Reintroduction Program.

Affiliation	Representative(s)	Title	Contact Information
Program Leader			
Central Florida Zoo's Orianne Center for Indigo Conservation (OCIC)	James E. Bogan, Jr., DVM, MVS, DABVP, CertAqV	OCIC Director	407-494-9277, jamesb@centralfloridazoo.org
Education Advisor			
St. Augustine Alligator Farm	Trevor Mia	Curator of Education	904-824-337, ext. 129, tmia@alligatorfarm.com
Steering Committee			
Birmingham Zoo	Dan Self	Zoological Manager of Reptiles	205-397-3855, dself@birminghamzoo.com
Central Florida Zoo's Orianne Center for Indigo Conservation (OCIC)	Michelle Hoffman	Field Biologist	386-785-5468, michelleh@centralfloridazoo.org
Florida Fish and Wildlife Conservation - Commission of Wildlife Diversity Conservation	Bradley O'Hanlon	Reptile and Amphibian Conservation Coordinator	850-617-6060, bradley.ohanlon@myfwc.com
North Carolina Zoo	Dustin Smith	Curator of Herpetology	336-879-76620, dustin.smith@nczoo.org
Zoo Atlanta	Robert Hill	Assistant Curator of Herpetology	404-624-5623, rhill@zooatlanta.org
Zoo Tampa at Lowry Park	Dan Costell	Associate Curator of Herps & Aquatics	813-935-8552, ext. 5258 dan.costell@zootampa.org
Program Partners			
Florida Fish and Wildlife Conservation Commission - Fish and Wildlife Institute	David Steen, PhD	Reptile and Amphibian Research Leader	352-334-4216, david.steen@myfwc.com
Oklahoma City Zoo	Brad Lock, DVM, DACZM	Curator of Herpetology and Aquatics	404-200-6973, block@okczoo.org
U.S. Fish and Wildlife Services	Michele Elmore, PhD	Biologist	912-403-1873, michele_elmore@fws.gov

Table 1: Contact information for Eastern Indigo Snake SAFE Program Team.

Additional EIS SAFE Program Partners

Type of organization	Name of Partner	Role (past or present)
Zoological (AZA)	Central Florida Zoo & Botanical Gardens Orianne Center for Indigo Conservation (OCIC)	Captive propagation facility in the reintroduction program built by the Orianne Society and operated by the Central Florida Zoo
	North Carolina Zoo	Staffs the EIS studbook keeper and Species Survival Plan (SSP) coordinator
	Zoo Atlanta	Head start partner responsible for assisting in the rearing of offspring bred and hatched at the OCIC prior to release into the wild
	Birmingham Zoo	Assist with health screening of wild snakes to better inform the reintroduction program; outreach
	Zoo Tampa at Lowry Park	Head start partner responsible for assisting in the rearing of offspring bred and hatched at the OCIC prior to release into the wild
	St. Augustine Alligator Farm Zoological Park	Develop EIS Engagement Toolkit
Landowners/Managers	US Forest Service	Management of the southern Alabama EIS release site in the Conecuh National Forest (CNF)
	The Nature Conservancy	Management of the Florida Panhandle release site at the Apalachicola Bluffs and Ravines Preserve (ABRP)
Universities	Auburn University	Monitoring of snakes post-release at both reintroduction sites
	University of Florida	Perform PCR testing for infectious diseases
NGO	The Orianne Society	Survey for EIS in the wild in Georgia
	The Joseph W. Jones Ecological Research Center	Advise monitoring of snakes post-release
State	Florida Fish and Wildlife Conservation Commission (FWC)	Assist with permits; provide guidance and resources (in-kind and grants) within state jurisdiction; aid in monitoring efforts post-release
	Georgia Department of Natural Resources (GDNR)	Assist with permits; provide guidance and resources (in-kind and grants) within state jurisdiction
	Alabama Department of Conservation and Natural Resources (ADCNR)	Assist with permits; provide guidance and resources (in-kind and grants) within state jurisdiction
Federal	US Fish and Wildlife Service (USFWS)	Assist with federal permits; provide guidance to the project based on the principles of the Endangered Species Act, Species Recovery Plan and related policies such as the captive propagation policy
	Welaka National Fish Hatchery	Head start partner responsible for assisting in the rearing of offspring bred and hatched at the OCIC prior to release into the wild

Table 2: Eastern Indigo Snake SAFE Program Partners.

Conservation Target

The Eastern Indigo Snake (EIS) can reach lengths of over eight feet and are considered one of North America’s largest native snake species (Conant and Collins 1988). Eastern Indigo Snakes are the only species within the genus *Drymarchon* of the family Colubridae that is federally listed as Threatened by the Endangered Species Act (Table 3). Threats to EIS include habitat loss, degradation and fragmentation, gassing of gopher tortoise burrows, collection for the pet trade, and persecution (USFWS 2018).

Common Name	Scientific Name	Endangered Species Act Status	IUCN Red List Status (global)
Spotted-tailed Cribon	<i>Drymarchon caudomaculatus</i>		Least Concern
Yellow-tailed Cribon	<i>Drymarchon corais</i>		Least Concern
Eastern Indigo Snake	<i>Drymarchon couperi</i>	Threatened (USA)	Least Concern
Magarita Island Cribon	<i>Drymarchon margaritae</i>		Least Concern
Black-tailed Cribon	<i>Drymarchon melanurus melanurus</i>		
Texas Indigo Snake	<i>Drymarchon m. erebennus</i>		
Orizaba Cribon	<i>Drymarchon m. orizabensis</i>		
Red-tailed Cribon	<i>Drymarchon m. rubidus</i>		
Unicolored Cribon	<i>Drymarchon m. unicolor</i>		

Table 3: Common and scientific names for *Drymarchon* species.

The Eastern Indigo Snake SAFE Program will focus on some of the most critical field conservation needs while maintaining support for the significant ongoing conservation efforts of AZA member institutions and growing opportunities for public engagement in support of Eastern Indigo Snake conservation.

The overall goal of the reintroduction project is to establish a sustainable population of EIS into regions where the numbers have previously been extirpated. By releasing a minimum of 300 two-year-old EIS at each predetermined release site, a few key conservation needs should be monitored. These conservation needs include wild population surveillance, disease prevalence determination in wild populations, and investigation in decreased reproductive fecundity in captivity.

Wild population surveillance primarily involves pedestrian surveys but also includes drift fence captures, camera trap documentation surveys, and the use of automatic PIT tag readers (APTR) to identify previously captured or released animals. These are labor intensive but vital in determining the population of a cryptic species like EIS. One concern to the success of reintroduction efforts is infectious disease, such as cryptosporidiosis and ophidiomycosis. Surveying wild EIS and collecting samples help determine the effect these infectious agents have on reintroduction efforts. And finally, investigating the known decrease in reproductive fecundity in captive EIS. Studies involving nutrition and artificial insemination techniques are needed to advance the success of captive reproduction efforts.

Status of Taxon within the AZA Community

Eastern Indigo Snakes are represented in multiple AZA facilities and are under the purview of both the AZA's Snake Taxonomic Advisory Group (TAG) and Species Survival Plans (SSP). A care manual has been published through AZA's Snake TAG (AZA 2011). The Eastern Indigo Snake SSP population sustainability ranking has a yellow designation based on the most recent Animal Program sustainability designation. Currently, the following facilities are housing EIS for educational and display purposes: Abilene Zoological Park, North Carolina Zoo, Zoo Atlanta, The Maryland Zoo in Baltimore, Birmingham Zoo, Brevard Zoo, The Buffalo Zoo, Busch Gardens Tampa Bay, The Chattanooga Zoo at Warner Park, Detroit Zoo, Fort Worth Zoo, Fresno Chaffee Zoo, Santa Fe College Teaching Zoo, Greenville Zoo, ZooAmerica, Jacksonville Zoo and Gardens, Naples Zoo at Caribbean Gardens, Louisville Zoo, ZooTampa at Lowry Park, Nashville Zoo at Grassmere, Newport Aquarium, Smithsonian National Zoological Park, Oklahoma City Zoo, Omaha's Henry Doorly Zoo and Aquarium, Central Florida Zoo & Botanical Gardens, South Carolina Aquarium, St. Augustine Alligator Farm Zoological Park, Tulsa Zoo, Chicago Zoological Society's Brookfield Zoo, Los Angeles Zoo, Mote Marine Laboratory and Aquarium. The Central Florida Zoo & Botanical Gardens houses the captive breeding colony for repatriation and Zoo Atlanta is head-starting some of the captive reared offspring.



Image 3: Eastern indigo snake as part of the captive breeding colony.
Photo by Sydney Seng

AZA Conservation Activities

AZA institutions have been reporting coordinated conservation efforts for Eastern Indigo Snakes for over a decade. Several facilities have contributed both financial resources and research efforts toward the conservation of Eastern Indigo Snakes (Table 3). According to AZA’s Annual Reports on Conservation and Science (ARCS), AZA partner facilities have reported, on average, two research projects focused on Eastern Indigo Snakes conservation every year for the last decade. Since the inception of the Eastern Indigo Snake SAFE Program in 2018, AZA reports partner institutions contributing over \$250,000 annually, on average.

Reporting Institutions	Field Conservation	Research
Birmingham Zoo	EIS Reintroduction Committee	
Central Florida Zoo & Botanical Gardens	EIS Reintroduction Committee Population Monitoring	Diet and Husbandry Dystocia Blood Values Venom Resistance Genetics Behaviors Immunity Cryptosporidiosis Stress Artificial Insemination
Clyde Peeling’s Reptiland	Contributor to SAFE	
Disney Animal Kingdom	Habitat Restoration	
Lincoln Park Zoo	Population Viability	
Lion Country Safari	Contributor to SAFE	
Maryland Zoo in Baltimore	Contributor to SAFE	
Memphis Zoo		Immunity
North Carolina Zoo	Contributor to SAFE	
Riverbanks Zoo & Garden	Population Monitoring Overwintering Habitats	
Saginaw Children’s Zoo	Contributor to SAFE	
Smithsonian National Zoological Park		Immunity
St. Augustine Alligator Farm	Fundraising	
Zoo Atlanta	EIS Reintroduction Committee	

Table 4: Reporting institutions identified in the ARCS databases associated with EIS between 2009-2021.

The Central Florida Zoo & Botanical Gardens employs a field biologist who monitors EIS activity at one of the release sites, The Nature Conservancy's Apalachicola Bluffs and Ravines Preserve. This monitoring effort employs both the use of pedestrian surveys, camera trap analyses and drift fences. Additionally, the Central Florida Zoo & Botanical Gardens is investigating the use of automatic PIT tag readers (APTR) around gopher tortoise burrows, other winter refugia and strategically placed along drift fence arrays.

The Alabama Natural Heritage Museum at Auburn University assists in the management of the reintroduction efforts taking place in the Conecuh National Forest in southern Alabama. Technicians are employed to conduct field monitoring on site using pedestrian surveys, camera traps, drift fences and APTR's.

Disney's Animal Kingdom is contributing to EIS field conservation through re-establishing a 4,600 hectare longleaf pine ecosystem in a central Florida wilderness preserve located in Osceola County, Florida. The AZA Eastern Indigo Snake SSP and Snake TAG has written the Eastern Indigo Snake (*Drymarchon couperi*) Care Manual (AZA 2011). This manual serves as a guide for the captive care of EIS within the AZA zoological community.

AZA Public Engagement Activities

In the participation of I ♥ Indigo Day and World Snake Day we aim to have guests engage in conversations with our AZA educators and staff about the importance of all snakes, all while using Eastern Indigo Snakes as ambassadors.

Our goal for these days is to spread awareness. The best conservation practices we can convey to our public is to leave Eastern Indigo Snakes and all snakes in their native habitats, always keep at least two arms lengths away, and report any animal to their local wildlife authorities (such as the Florida Fish and Wildlife Conservation Commission) that have become a nuisance individual.

Since the Eastern Indigo Snake SAFE plan is a newer program, AZA public engagement activities are still in their infancy. The Central Florida Zoo's Orianna Center for Indigo Conservation (OCIC) is educating the public through social media outreach as well as scheduled tours of the facility. February 28, 2022 was the OCIC's inaugural date of the annual Indigo Bluegrass Barbecue festival. Local musicians entertained guests as they enjoyed barbecue and learned about the conservation efforts surrounding the Eastern Indigo Snake.

The St. Augustine Alligator Farm is working on creating resources with the Curious Pangolin, a wildlife art and design company, for a toolkit that will be distributed to all facilities with Eastern Indigo Snakes as ambassadors.

The toolkit will include Customer Actions, Ecosystem Actions, and Support Actions that the public can engage in within their own backyard. The purpose of this toolkit is to enhance awareness and increase backyard conservation engagement to promote healthy ecosystems. A formative evaluation will be given to AZA facilities, so front-line staff can gauge their impact with their audience. A summative

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evaluation will be distributed at the end of each calendar year to gauge how these toolkits were utilized and areas where changes can be made.

The “I ♥ Indigo Day” is a recognized SAFE-related species awareness day historically occurring every February 8th. This ongoing annual outreach educates the general public on the important role this iconic species plays in the longleaf pine ecosystem. In addition, this SAFE program will highlight World Snake Day, July 16th, as an additional day of celebration.

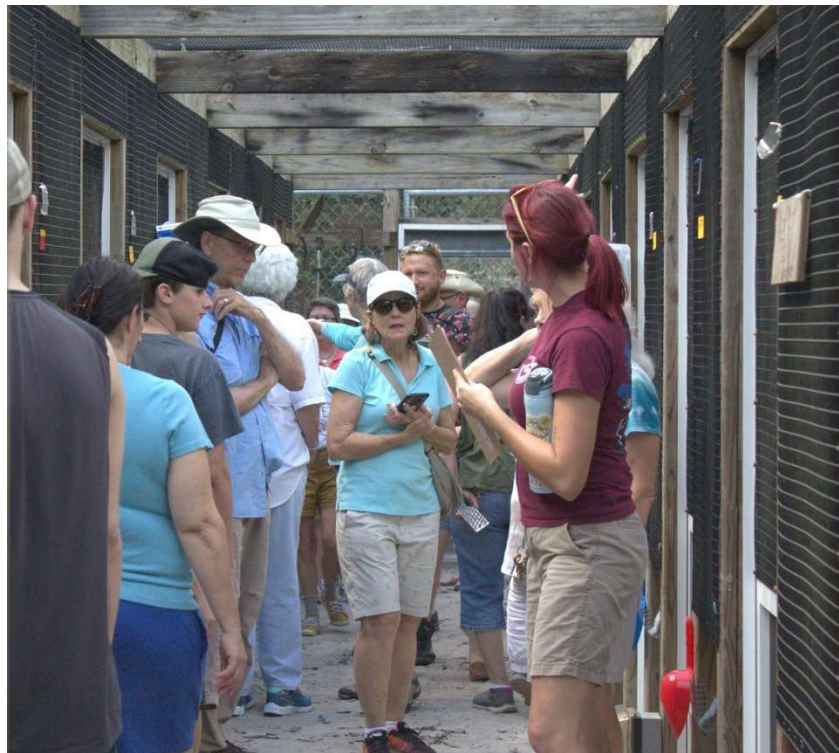


Image 4: Educational tour of Central Florida’s Orianne Center for Indigo Conservation.



Image 5: I ♥ Indigo Day public engagement at the Central Florida Zoo & Botanical Gardens. Photo by Michelle Hoffman

The EIS SAFE Education Advisor is currently assembling an EIS Engagement Toolkit for partner institutions to utilize in these and other EIS outreach programs. Materials will be available for partner institutions by January 2023 with electronic distribution occurring throughout the month in preparation for "I ♥ Indigo Day" in February of 2023. These materials will focus on the EIS conservation status and everyday changes our communities can make to protect this species.

Our outcome for these toolkits will be to increase the participating guests through ecosystem, consumer, and support actions. We will measure this through formative evaluations that front line educators will conduct when utilizing these resources. A summative evaluation will be given out at the end of each year which will look at the success/ failure of the formative evaluations given out over the course of the year.

To aid in the creation of these materials and toolkit, a public survey will be distributed to EIS Program Partners to distribute to their local community and visitors. Survey will address the participant's current knowledge of EIS, empathy towards native snake species, and level of motivation to protect these species. Survey will be distributed to Program Partners May of 2022, with all results due back by September of 2022.

Conservation Status of the Eastern Indigo Snake

The Eastern Indigo Snake (EIS) is designated as a Threatened species by US Federal Endangered Species Act. The International Union for Conservation of Nature (IUCN) lists the status of Eastern Indigo Snake as Least Concern. Additionally, Eastern Indigo Snakes are protected by state law in Alabama, Georgia, and Florida.

Each state within the historical range of the Eastern Indigo Snake provides some protection for the species. In Alabama, the Eastern Indigo Snake is listed as a nongame species protected by regulation (Alabama Department of Conservation and Natural Resources (ADCNR) 2018); in Florida and Georgia it is listed as threatened (FWC 2017, Georgia Department of Natural Resources (GDNR) 2018), and in Mississippi as endangered (Mississippi Natural Heritage Program 2015). The protections provided by each state vary. However, most state laws focus on prohibitions against taking Eastern Indigo Snakes from the wild and possessing, killing, exporting, or selling them, although Georgia regulations protect the habitat of listed species on public land (GDNR 2018). *From USFWS 2018.*



Image 6: EIS Breeding at the St Augustine Alligator Farm, January 2021.
Photo by Trevor Mia

SAFE Recovery Plan

The Eastern Indigo Snake SAFE Program welcomes all interested AZA aquariums and zoos to become program partners.

A recovery plan for the Eastern Indigo Snake (EIS) has been formulated under the direction of the Eastern Indigo Snake Reintroduction Committee (EISRC), comprised of AZA zoos, universities, non-governmental organizations (NGO), and governmental bodies involved with EIS conservation including Central Florida Zoo & Botanical Gardens, Zoo Atlanta, Auburn University, University of Florida, The Orianne Society, The Nature Conservancy, Welaka National Fish Hatchery, US Fish and Wildlife Services, Florida Fish and Wildlife Conservation Commission, Georgia Department of Natural Resources, and Alabama Department of Conservation and Natural Resources. Key factors in the recovery plan include captive breeding Eastern Indigo Snakes, head-starting the offspring, and release site management (USFWS 2018, 2019). The Orianne Center for Indigo Conservation (OCIC) was established in 2010 and is the sole captive propagation colony for the Eastern Indigo Snake reintroduction program. The OCIC works closely with EISRC and multiple government agencies to ensure proper management of the captive Eastern Indigo Snake for breeding and reintroduction. Several key facilities assist in the reintroduction efforts by head-starting the offspring prior to release into the wild.

Release site selection for reintroductions were determined based on several factors. The sites are within the natural historical range for Eastern Indigo Snakes, are at least 5,000 hectares of connected, suitable habitat with a mixture of upland and lowland/wetland habitats, support a viable population of gopher tortoises (*Gopherus polyphemus*), have minimal fragmentation by roads, and proper land management to ensure the long-term survival of the species (USFWS 2016). The two release sites that have met these parameters are the Conecuh National Forest in Covington County, Alabama and The Nature Conservancy's Apalachicola Bluffs and Ravines Preserves in Liberty County, Florida.

The current reintroduction efforts began in 2008 when 21 gravid female Eastern Indigo Snakes were collected in southeast Georgia as part of a study conducted by Auburn University and to initiate the Eastern Indigo Snake captive propagation and reintroduction program. Many of the offspring that hatched from these wild collected females in Georgia remain in the captive propagation colony at the OCIC. The OCIC houses over 100 snakes to aid in reintroduction efforts and aid in the demand for Eastern Indigo Snakes within zoological facilities.

The first reintroduction site, located in the Conecuh National Forest, has received 191 snakes between 2010 and 2020 while the second reintroduction site, located at the Apalachicola Bluffs and Ravines Preserve, has received 69 snakes between 2017 and 2020. These reintroduction sites were established by partners in the EISRC which includes individuals responsible for habitat restoration, population monitoring, captive propagation, regulation and other necessary contributors and advisors. These partners represent state and federal agencies, universities, and NGO's. The program leaders report to the EISRC and governmental agencies annually.



Image 7: Captive bred and reared EIS released at Conecuh National Forest. Photo by James Bogan

AZA program partners can help spread awareness through Eastern Indigo Snake ambassador animals. The gentle nature of these large, charismatic snakes can facilitate the message presented through I ♥ Indigo Day, World Snake Day, and use of the upcoming EIS Engagement Toolkit.

Eastern Indigo Snake Threats

The primary threat to Eastern Indigo Snake (EIS) survival is habitat loss, degradation, and fragmentation (USFWS 2018). Land development, silviculture, and urbanization have decreased the longleaf pine ecosystem to less than 3% of its presettlement extent (Frost 2006). Fire suppression allows for oak canopies and invasive flora to overgrow and choke out the longleaf pine (USFWS 2018). Habitat fragmentation by roads contribute to vehicular strikes causing the death of many wild EIS as they travel throughout their large home range (USFWS 2018).

The decline of gopher tortoises is another key factor in the decline of EIS. Gopher tortoise burrow gassing used to be commonplace but is now illegal in both Florida and Georgia (USFWS 2018). In the panhandle region of Florida, gopher tortoises were regularly harvested for food leading to a decline in both the tortoise and EIS populations (Enge et al. 2013). In addition, EIS were often collected from the wild for the pet trade, although this practice has lessened (Enge et al. 2013; USFWS 2018).

Eastern Indigo Snakes have been known to be preyed upon by large carnivores, such as the American alligator (*Alligator mississippiensis*) (S. Piccolomini pers comm). Additional potential predators contributing to the decline of EIS include fire ants (*Solenopsis*), skunks (*Mephitis*), coyotes (*Canis*), foxes (*Vulpes*), opossums (*Didelphis*), raccoons (*Procyon*), crows (*Corvus*), and even other snakes (USFWS 2018). Additional concerns for the native EIS population in the southern regions of Florida are invasive species. Invasive Burmese pythons (*Python bivittatus*) fill a similar niche as the Eastern Indigo Snake which may be outcompeted by the larger snake (Lovgren 2004). The invasive black spiny-tailed iguana (*Ctenosaura similis*) has also been known to consume gopher tortoises (*Gopherus polyphemus*) and kill southern black racers (*Coluber constrictor priapus*) and may pose additional predator threats to wild Eastern Indigo Snakes (Engeman et al. 2011).

Additionally, these invasive pythons have been implicated in spreading novel parasites to the indigenous snake population in southern Florida (Miller et al., 2017), such as the pentastomid, *Raillietiella orientalis*, which has been implicated in the death of wild caught EIS (Bogan et al. 2022). Other disease concerns include fungal dermatitis caused by *Ophidiomyces ophidiocola* (Chandler et al. 2019) and pesticides (USFWS 2018).



Image 8: EIS collected by FWC from a construction site in south Florida.
Photo by Ashley Kelley

Eastern Indigo Snake SAFE Objectives

The primary goal of the Eastern Indigo Snake SAFE Program is to contribute to the conservation of the Eastern Indigo Snake as set forth in the reintroduction strategy initiated by the Eastern Indigo Snake Reintroduction Committee (EISRC) and the Eastern Indigo Snake Recovery Plan (USFWS 2019).

Conservation	Bolster Eastern Indigo Snake populations in the wild
	Improve Eastern Indigo Snake reproductive output
	Prevent infectious disease transfer from captive populations to the wild
	Determine wild Eastern Indigo Snake population viability
Public/Stakeholder Engagement	Increase awareness with local governments
	Increase awareness with local businesses
Communication/Public Awareness	Increase awareness with the general public
Funding	Raise funds to support captive breeding efforts
	Raise funds for research
	Raise funds for wild EIS monitoring

Table 5: Summary of Eastern Indigo Snake SAFE Objectives.

Eastern Indigo Snake SAFE Actions

Conservation	Release captive bred Eastern Indigo Snakes into regions where populations are believed to be extirpated
	Screen captive bred Eastern Indigo Snakes for infectious diseases of concern
	Monitor wild populations for infectious disease
	Monitor reintroduced populations to gauge success of reintroduction efforts
	Investigate nutritional needs
	Investigate reproductive hormone levels
	Investigate artificial insemination techniques
Public/Stakeholder Engagement	Build a toolkit
	Participate in local chambers of commerce
	Provide facility tours
Communication/Public Awareness	Participate in I ♥ Indigo Day!
	Display ambassador Eastern Indigo Snakes
	Utilization of social media
Funding	Request donations during Public Engagement/Awareness activities
	Host fund-raising events

Table 6: Summary of Eastern Indigo Snake SAFE Actions.

Conservation Actions

Success of creating a sustainable wild population using captive reared snakes depends on many factors. To ensure the establishment of a sustainable population, the appropriate number of snakes need to be released in the defined release site. To mitigate this extinction risk, it has been determined that at least 30 two-year-old Eastern Indigo Snakes should be released per year for ten years for each reintroduction site (Folt et al. 2019). All captive breeding for this reintroduction is done at the Central Florida Zoo’s Orianna Center for Indigo Conservation and primarily funded by the Central Florida Zoo & Botanical Gardens.

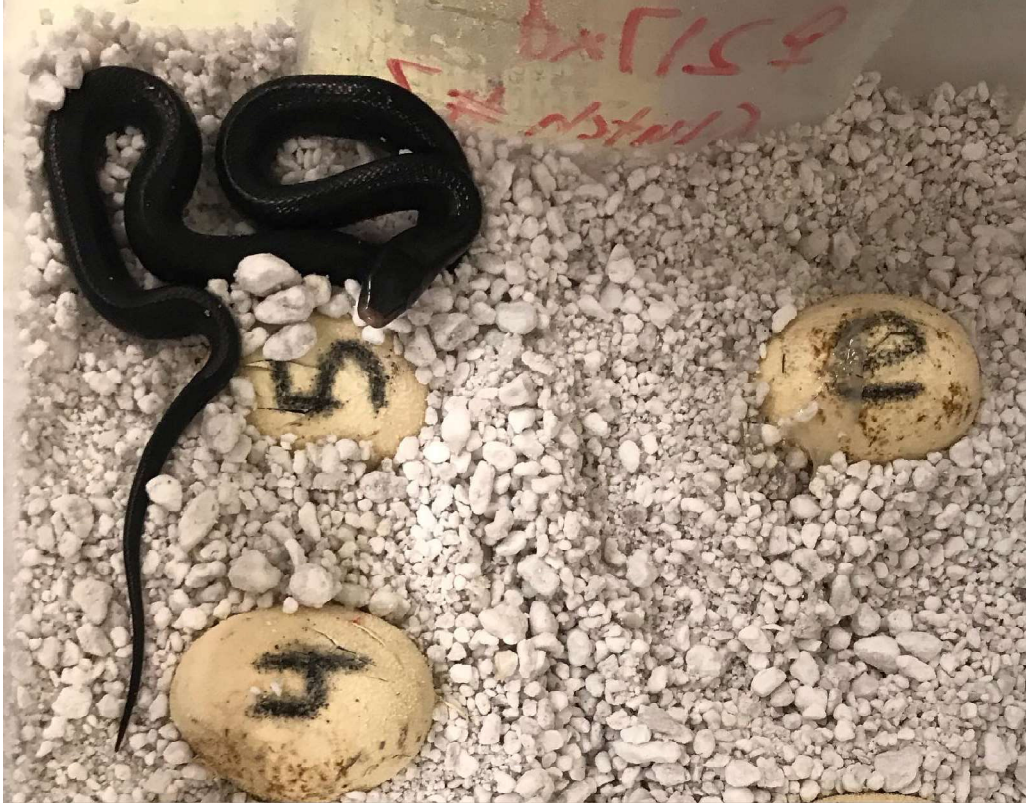


Image 9: Recently hatched EIS within captive breeding colony housed at Central Florida Zoo's Orianne Center for Indigo Conservation. Photo by Fred Antonio

The first conservation action initiated should be the continuation of monitoring of Eastern Indigo Snake populations at the designated release sites. Additionally, these sites will need to be maintained as set forth by the governmental guidelines (USFWS 2019). Monitoring existing Eastern Indigo Snake populations within Georgia and peninsular Florida helps provide information on existing population density and disease conditions.

Currently, the limitations to fulfilling the objective set forth in the Eastern Indigo Snake Recovery Plan are due, in part, to reproductive fecundity in captivity and decreasing genetic diversity in the captive collection. To address these shortcomings, actions should focus on acquiring additional snakes to replace those animals that have left the program due to reproductive fecundity or senescence. To evaluate underlying causes of reproductive fecundity additional studies are needed. Since captive Eastern Indigo Snakes are fed a variety of thawed frozen prey items (rodents, chicks, quail, fish, and frog legs) that do not match the nutrient profile of wild Eastern Indigo Snake prey items (primarily snakes and amphibians), more research into alternative diets and their effect on reproductive output is warranted (Dierenfeld et al. 2002, 2015; Stevenson et al. 2003, 2010; Steen et al. 2016; Bogan et al. 2021).

A better understanding of the reproductive cycle for the Eastern Indigo Snake may also help reduce reproductive fecundity. Research is needed to better understand the hormonal cycles in both male and female Eastern Indigo Snakes. Additionally, establishing a reliable semen collection and storage process can help facilitate reproductive efforts laying a foundation for artificial insemination techniques.



Image 10: Hatchling EIS reared at OCIC. Photo by Sydney Seng

The continued monitoring of medical conditions such as dystocia and cryptosporidiosis are needed to better inform reintroduction efforts. Several medical conditions are known to affect the captive propagation of Eastern Indigo Snakes. Dystocia, or egg binding, has been a well-documented condition in captive Eastern Indigo Snakes (Shatford 1992; Godwin et al. 2008; AZA Snake TAG 2011; Wines et al. 2015; Bogan et al. 2021). While many snakes afflicted with dystocia will continue to have reproductive complications in subsequent breeding seasons, this is not always the case in Eastern Indigo Snakes as many with previous dystocia will successfully breed in subsequent breeding seasons without complication (Bogan et al. 2021). Further investigation into possible causes of dystocia is paramount in order to prevent future cases of dystocia and ensuring a successful captive breeding program.

Captive Eastern Indigo Snakes have also been documented to have gastric cryptosporidiosis, a parasitic infection with the protozoa *Cryptosporidium serpentis* (Bogan 2019). Although it is not uncommon for Eastern Indigo Snakes to develop clinical disease from *C. serpentis*, many are sub-clinical carriers of this parasite and exhibit no clinical signs. This parasite is difficult to control as it is resistant to most disinfectants and all known parasite medications (Bogan 2019). The disease is often spread through contaminated food sources, so proper quarantine and husbandry practices need to be followed to prevent the spread of *C. serpentis*. Treatment options and disease prevalence in wild populations are key research topics to better inform reintroduction efforts.

Public/Stakeholder Engagement Actions

The presence of Eastern Indigo Snakes in zoological facilities increases conservation messaging around the species. Eastern Indigo Snakes that have unknown genetics or are unsuitable breeders are distributed throughout several AZA zoos across the country. These large, charismatic snakes make excellent ambassadors for the Eastern Indigo Snake reintroduction project, due to their agreeable nature. With ambassadors at multiple AZA zoos (Table 7), these snakes can easily bring awareness to the general public for the reintroduction program. Through Eastern Indigo Snake ambassadors, we wish to increase empathy towards snakes and create behavior changes when the public confronts a native snake in their backyard.

Birmingham Zoo
Central Florida Zoo & Botanical Gardens
Fort Worth Zoo
Jacksonville Zoo and Gardens
Newport Aquarium
North Carolina Zoo
Oklahoma City Zoo and Botanical Gardens
St. Augustine Alligator Farm
The Greenville Zoo
The Maryland Zoo in Baltimore
Zoo Atlanta
Zoo Tampa

Table 7: List of AZA facilities with Eastern Indigo Snake Ambassadors.

The EIS SAFE Education Advisor is currently assembling an EIS Engagement Toolkit for partner institutions to utilize in these and other EIS outreach programs. Materials will be available for partner institutions by January 2023 with electronic distribution occurring throughout the month in preparation for “I ♥ Indigo Day” in February of 2023. These materials will focus on the EIS conservation status and everyday changes our communities can make to protect this species.

To aid in the creation of these materials and toolkit, a public survey will be distributed to EIS Program Partners to distribute to their local community and visitors. The survey will address the participant’s current knowledge of Eastern Indigo Snakes, empathy towards native snake species, and level of motivation to protect these species. The survey will be distributed to Program Partners May of 2022, with all results due back by September of 2022. The front-end evaluation will only occur once; the summative evaluation will be conducted annually. A formative evaluation will occur anytime a toolkit is utilized.

Objective 1: Through the EIS toolkit, over 50% of the participants will sign a pledge to make their “backyard” a wildlife save space or obtain a backyard habitat certification. This pledge will be both within the toolkit and for each AZA facility hold onto until the end of the year, when they complete and report their activities via the summative evaluation.

Objective 2: AZA staff will engage with over 100 households with the provided toolkit on native snakes and Eastern Indigo Snake awareness. In the formative survey sent with the toolkit, each educator will gauge how many households will alter their consumer actions after their visit and engagement with an Eastern Indigo Snake or other native snake species. Over 50% of these households will agree to make some sustainable change when it comes to recycling or consuming products.

Objective 3: Through I ♥ Indigo Day, EIS SAFE will fundraise \$500 directly through the supportive donations from participants.

Communications/Public Awareness Actions

The main goal of this program is to increase empathy for Eastern Indigo Snakes and other native snakes in North America. Through an increase in empathy, we hope to see our audiences make changes in their behavior and attitude towards a species that is commonly feared. We will evaluate our effectiveness via a toolkit that will both connect our audiences to these species and their scaly relatives.

EIS SAFE will utilize the AZA education professionals in collaboration with fellow Snake TAG Education Advisors to create educational materials that will educate our facilities visitors and those who may live within the prehistoric and extant ranges of the EIS. These materials will provide new educational opportunities and public outreach through AZA partners. An example of one such activity is the SAFE-Related Species Awareness Day, I ♥ Indigo Day. The St. Augustine Alligator Farm also supports the OCIC with a bi-annual fund-raising event, Raptor Run.

1. Engage the AZA community with a survey in 2022 to determine where the public would like to see Eastern Indigo Snake conservation efforts heading towards in the future.
2. Utilize AZA facilities to reach communities within the current and historic EIS ranges over the course of World Snake Day (2022-2024).
3. Develop a toolkit, in collaboration with Snake TAG Education Advisor, and have distributed to AZA facilities by February 2023, I ♥ Indigo Day.
4. Have 5 – 10 facilities actively participate in I ♥ Indigo Day by 2024.
5. St. Augustine Alligator Farm's Raptor Run is a conservation-based event that directly supports infectious disease testing and reintroduction of Eastern Indigo Snakes. This bi-annual event will raise over \$10,000 in support of this species. This event also occurs in Florida and will utilize the toolkit and Eastern Indigo Snakes as ambassadors both before and after the race.



Image 11: Ambassador EIS at the St Augustine Alligator Farm Raptor Run, May 2021. Photo by Trevor Mia

The target audience are households with native snakes in or around their backyard. To further define our audience, we are targeting households who may be near or in the Eastern Indigo Snake historic or current ranges.

1. Create baseline of understanding and conservation education activities within AZA partner organizations regarding EIS conservation.
2. Increase awareness within AZA partner organizations and their public about the threats EIS face locally.
3. Increase awareness within AZA partner organizations and their public about EIS role within ecosystems.
4. Increase awareness within the general public of EIS status within habitats where EIS currently reside (Image 12).



Image 12: Example of signage for public awareness of EIS status.
Photo by James Bogan

Funding Actions

1. Increase the amount of funding for Eastern Indigo Snake conservation in line with the Strategic Objectives for this SAFE Program Plan by 10% annually.
2. Provide opportunities for AZA members to support the funding and implementation of conservation action plans being developed by the EISRC.
3. Provide opportunities for AZA members to support long-term sustainability building partnerships being championed with organizations such as the OCIC.
4. Provide technical advice and peer review opportunities for Principal Investigator grant applications from range countries that aligns with the strategic objectives of this SAFE Program Plan.



Image 13: Educational outreach program at OCIC. Photo by Daphne Keys

Solicit Eastern Indigo Snake SAFE Program Partners. Eastern Indigo Snake SAFE Program Partners are expected to contribute a minimum of \$1,500 annually in direct financial or in-kind support.

Eastern Indigo Snake SAFE Program Plan 2022-2024

Strategies	Actions	Timeframe	Institutions	Field Partners	Budgetary Needs
In south Alabama and northwest Florida, EIS SAFE will provide funding for the testing of <i>Cryptosporidium serpentis</i> in releasable candidates.	EIS SAFE Program Partners will fundraise and provide individually \$1,000 annually in support towards testing.	2022-2024	St. Augustine Alligator Farm, Central Florida Zoo & Botanical Gardens, ZooTampa, ZooAtlanta, Birmingham Zoo	Eastern Indigo Snake Reintroduction Committee	\$5,000 each year
Support operational costs for the captive breeding program	St. Augustine Alligator Farm will host a biennial conservation fundraiser for the EIS and supporting reintroduction efforts.	2023 2025	St. Augustine Alligator Farm	Central Florida Zoo's Orianne Center for Indigo Conservation	\$10,000
	Central Florida Zoo's Orianne Center for Indigo Conservation will host an annual conservation fundraiser for the EIS and supporting reintroduction efforts.	2022-2024	Central Florida Zoo's Orianne Center for Indigo Conservation		\$10,000
Support Field Biologist Surveys	EIS SAFE Program Partners will fundraise and provide individually \$1,500 annually in support towards testing and population monitoring.	2022-2024	All	Central Florida Zoo's Orianne Center for Indigo Conservation	\$25,000 each year

Table 8: Funding Strategies for Eastern Indigo Snake Conservation.

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