

South Florida Ecosystem Restoration Task Force

Invasive Exotic Species Strategic Action Framework

Prevention Case Study: Risk Screenings and Assessments

Calculating Risk

The State of Florida is at risk of invasive exotic species particularly through live animal trade. Nonnative invasive wildlife issues in Florida have increased in frequency and severity over the last decade. Although invasive exotic species are not a problem unique to Florida, Florida's subtropical climate has been conducive to the establishment and expansion of many exotic species including large constrictor snakes like the Burmese python; large lizards, such as monitors, tegus, and iguanas; freshwater fish species like bullseye snakehead; and marine species, such as lionfish. To address these challenges, the Florida Fish and Wildlife Conservation Commission (FWC) has increased management efforts focused on prevention and early detection and rapid response (EDRR) of priority nonindigenous invasive animal species.

Tools for Prevention and Rapid Response

Risk screenings and assessments are key components of the FWC's invasive species prevention efforts. **Risk screenings** are quick evaluations that help gauge a species' potential invasion capabilities in a matter of hours. **Risk assessments** are more comprehensive investigations into a species that can take months to complete. Both screenings and assessments take into account a species' biology including natural history traits such as reproductive rate, history of invasion, ability to spread beyond initial introduction points, and climate suitability. Risk screening and risk assessment results help inform management decisions, including whether to conduct EDRR efforts or develop new regulations.

Multiple tools are available to conduct risk screenings. The FWC primarily uses a go/no-go EDRR tool developed by the University of Florida (UF) to conduct terrestrial species risk screens. For aquatic species, the FWC typically contracts researchers at UF to use the Fish Invasiveness Screening Kit (FISK) and Aquatic Species Invasiveness Screening Kit (AS-ISK). For full risk assessments, the FWC has contracted UF researchers to assess species

using the federal Nuisance Aquatic Species Task Force's Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process. This framework has been accepted and used broadly, including use in the US Geographic Survey's (USGS) 2009 giant constrictor establishment risk assessment conducted to evaluate nine large constrictor snakes as injurious reptiles under provisions of the federal Lacey Act.

Prevention through Regulation

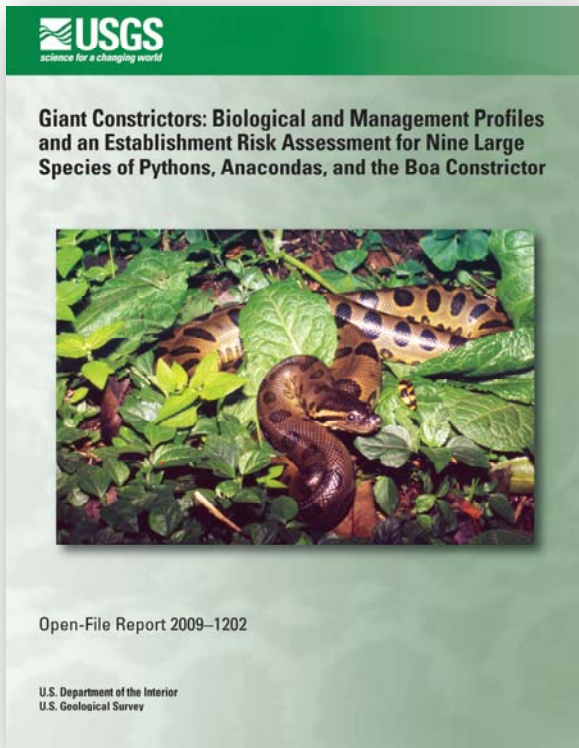
The FWC has used both screenings and assessments in recent years. Most recently, the FWC added a new suite of species to the state's Prohibited list. The species included birds, mammals, and reptiles that were already listed as injurious wildlife under title 18 of the federal Lacey Act. Following a federal court ruling in 2017, injurious wildlife may now be transported between the 49 States within the continental U.S. (the contiguous 48

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Conclusion

Moving forward, the FWC will continue to use risk screenings and assessments to make science-based, informed decisions when deciding whether to regulate a species. The go/no-go tool will also continue to be used in informing EDRR decision making. These tools are vital to the state's continued efforts in preventing the introduction, establishment, and spread of nonnative invasive fish and wildlife.

Additional Resources

Aquatic Nuisance Species Task Force (ANSTF), Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process: https://www.anstaskforce.gov/Documents/ANSTF_Risk_Analysis.pdf

FISK and AS-ISK: <https://www.cefas.co.uk/services/research-advice-and-consultancy/non-native-species/decision-support-tools-for-the-identification-and-management-of-invasive-non-native-aquatic-species/>

Species Currently Listed as Injurious Wildlife under the Federal Lacey Act (18 U.S.C. 42): https://www.fws.gov/injuriouswildlife/pdf_files/Current_Listed_IW.pdf

State of Florida Prohibited Species and Rule Development: <https://myfwc.com/wildlifehabitats/nonnatives/rule-development/>

USGS Giant Constrictor Establishment Risk Assessment: <https://pubs.er.usgs.gov/publication/ofr20091202>

States and Alaska) without the previously required federal permit. Florida relied on the protections that had been in place prior to the ruling to keep these potentially harmful species from entering the state. The FWC used risk screenings and the USGS's 2009 giant constrictor establishment risk assessment to support listing the brown tree snake, yellow anaconda, Beni anaconda, DeS-chauensee's anaconda, Java sparrow, red-whiskered bulbul, dioch, pink starling, brushtail possum, dhole, flying foxes, mongoose, meerkats, and raccoon dog as prohibited state species.

These birds, mammals, and reptiles are all listed as injurious wildlife under the Lacey Act, but previously had no other restrictions in Florida. The FWC Prohibited listing limits their possession to qualifying, licensed facilities for educational exhibition and research use. These species may no longer be possessed as personal pets or for commercial sales in the state. The FWC did allow people who had any of these animals as pets to obtain a grandfathered pet permit to keep those pets for the life of the individual animals. Grandfathered pet permits are offered at no-cost.



Mongoose removed from Port Everglades.
Photo courtesy of FWC.

South Florida Ecosystem Restoration Task Force

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Prevention Case Study: Exotic Pet Amnesty Program

Exotic Pets: Pathway for Invasive Species

The Florida Fish and Wildlife Conservation Commission's (FWC) **Exotic Pet Amnesty Program (EPAP)** is an innovative effort that provides exotic pet owners with an opportunity to surrender or re-home their exotic pet. Exotic pets are not native to Florida and are a primary introduction pathway for invasive wildlife in the state. It is illegal to release nonnative wildlife in Florida. Released or escaped exotic pets can present a threat to Florida's native wildlife. The goal of the amnesty program is to reduce the number of nonnative species released into the wild by pet owners by providing a convenient, legal alternative. The program also provides education and outreach regarding responsible pet ownership and exotic species in Florida.

Preventing the Release of Exotic Pets

The EPAP was created in 2006 and codified into law in 2008 (Chapter 68-5, F.A.C.). Through EPAP, pet owners can surrender their unwanted exotic pets, whether kept legally or illegally, without penalty or cost. The FWC also facilitates rehoming these pets with prequalified adopters. To date, over 6,100 exotic pets have been surrendered to the state through this innovative program.

People who can no longer care for their exotic pets are able to surrender these animals, including Conditional species that can no longer be acquired for personal possession in Florida, to the FWC at **Exotic Pet Amnesty Days** held throughout the state. Typically, 3-5 events are held each year. Surrendered pets are given an exam by a veterinarian and healthy animals are made available for adoption to FWC's pre-approved adopters on the same day. Conditional species can be adopted by permitted recipients only. EPAP currently has over 700 active adopters.

Exotic pet owners who cannot attend an Exotic Pet Amnesty Day can contact the FWC's **Exotic Species Hotline** at **888-lve-Got1** (888-483-4681) for year-round assistance in finding their animal a new home.

Another goal of EPAP is to encourage responsible pet ownership through outreach and education at Exotic Pet Amnesty Day events. The FWC and partners strive to spread the "**Don't Let It Loose**" message to prevent release of nonnative wildlife into Florida.

Innovation Yields Success

Florida is the first state to have an established amnesty program to provide options for owners of exotic species. The framework of this program has served as a resource for other states and nations, such as Georgia, Ohio, Arizona, and Australia, working to build similar programs.

There has been continued success with FWC's EPAP. From 2006-2014, FWC held 30 events with over 2,300 exotic pets surrendered. As efforts ramped up since 2015, FWC hosted an additional 19 events with over 3,700 additional exotic pets surrendered. This total since 2015 includes over 430 Conditional animals (species that may only be imported and possessed for research purposes, commercial use, or public exhibition, not as personal pets) that were not released into the wild.



Exotic Pet
Amnesty Program
Great pets. Great homes.

For more information:
MyFWC.com/nonnatives
888-lve-Got1 (888-483-4681)

Interested in Adopting an Animal?

The FWC is always looking for experienced exotic pet owners to be adopters in the Exotic Pet Amnesty Program. It's free - there are no fees to apply or adopt an animal through the program. However, the cost of supporting a pet for the remainder of its life should be taken into account before applying.

In order to adopt an animal through EPAP you must apply and be approved as an adopter. The FWC requires adopters to understand how to properly care for the animals they want to adopt. Approved adopters will receive a letter of acceptance; adopters must bring their letter of acceptance to each Exotic Pet Amnesty Day event that they wish to attend.

Steps:

- Fill out and submit an application at [MyFWC.com/Nonnatives](https://myfwc.com/Nonnatives).
- Complete an Applicant Information Form and at least one Animal Information Form. The Animal Information Form has a drop-down list of animal categories; choose one category per animal form.
- Applicants who are approved as adopters will receive a letter of acceptance from the FWC and will be informed of upcoming Exotic Pet Amnesty Days in their area.
- All adopters must apply and be approved before adopting an animal at an Exotic Pet Amnesty Day event.



Veiled chameleon at an EPAP event.

Photo courtesy of Rebekah Nelson, FWC, [Bugwood.org](https://bugwood.org)

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EDRR Case Study: Exotic Species Hotline

It is imperative to respond quickly and deal with emerging invasive exotic species (IES) while they remain localized. This process is called Early Detection and Rapid Response (EDRR). Eradication through EDRR is the second most cost-effective method to deal with invasive exotic species, after prevention. Early detection requires effective communication between experts, responders, and the public and should seamlessly connect to the assessment and rapid response phases of EDRR.

IES Reporting Tools

In addition to agency monitoring programs and formal detection efforts, easily understood and accessible IES reporting mechanisms for use by the public are vital to EDRR success. Florida's **Exotic Species Hotline** was developed in cooperation with the Nature Conservancy, Everglades National Park, and the Florida Fish and Wildlife Conservation Commission (FWC). The hotline was initially established for Burmese python reporting in the Florida Keys. The success of this hotline was then extended to the mainland in 2009 and transferred to the FWC in 2011 to obtain reports of any nonnative wildlife statewide. Also that year, the hotline merged with the FWC's Exotic Pet Amnesty Program hotline.

To supplement the Exotic Species Hotline, a free smart phone app, **IveGotOne**, was developed so people can report observations and upload photos of the sighted animals online. The "IveGot1" app was developed by the University of Georgia's Center for Invasive Species and Ecosystem Health through a cooperative agreement with the National Park Service. The FWC and the University of Florida Center for Aquatic and Invasive Plants were also part of the app development. Data from all sources are shared across FWC and EddMaps, the web-based Early Detection and Distribution Mapping System for invasive exotic species.

Impact of Public Reporting

The Exotic Species Hotline, IveGot1.org, and the IveGot1 smartphone app reporting tools are instrumental in EDRR and have helped determine new areas where pop-

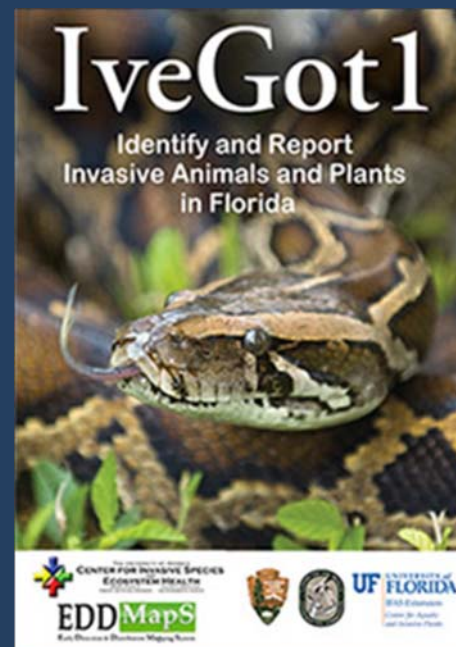
ulations may be establishing. For example, reports from these sources led to the discovery of an emergent Argentine black and white tegu population in Charlotte County in 2018 where over 100 tegus have now been removed to date.

Conclusion

The exotic species hotline, currently managed by the FWC, has received 12,153 reports since its statewide inception in 2011. An additional 5,611 reports have been received via Ivegot1.org and the smart phone application. This equates to a combined total of 17,764 reports in Florida, building an extensive geospatial database where snakes are located and have been introduced on the landscape, increasing knowledge of the spread of invasive exotic species in Florida, and enabling rapid response to eradicate emerging invaders.

TO REPORT INVASIVE EXOTIC SPECIES

Call 888-IveGotOne, (888) 483-4681,
Visit IveGotOne.org, or
Download the app:



Details on next page.

Report Sightings of Invasive Exotic Species to the FWC

[From MyFWC.com/wildlifehabitats/nonnatives/report/](http://MyFWC.com/wildlifehabitats/nonnatives/report/)

Reporting observations helps us manage nonnative species. The best reports of nonnative species are credible reports. These are reports that the species in question can be verified and all necessary data has been included.

Credible reports contain 3 elements:

- 1) A photograph showing the animal in question that is not blurry and has a high enough resolution so that it can be enlarged to ensure species identification
- 2) The location where the animal was seen. GPS coordinates are best, but the location can also be a street address or detailed description of the area.
- 3) The date when the animal was seen.

You can report any other information that you think is valuable.

Smartphone App

You can quickly and easily report sightings of nonnative species by using the free IveGot1 app, which was developed by The University of Georgia's Center for Invasive Species and Ecosystem Health. The app is available for iPhone and Android phones by searching for "IveGot1" at the appropriate app store. Reporting nonnatives using the IveGot1 app or the IveGot1 website is preferred for **lower priority species**, such as small nonnative lizards and iguanas.

Online

You can use the web form at IveGot1.org to report nonnatives. The form will prompt you for the information and has a map where you can select the location if you do not have the GPS coordinates. You will need to create a free account the first time you report a sighting online. Reporting nonnatives using the IveGot1 app or the IveGot1 website is preferred for **lower priority species**, such as small nonnative lizards and iguanas.

Exotic Species Hotline

You can call the FWC's Exotic Species Hotline at 888-Ive-Got1 (483-4681) to report nonnative species. The FWC asks the public to call the Hotline to report **high priority species**, which include all nonnative snakes, monitor lizards, tegus, and chameleons. The Hotline is answered part-time 7 days per week by a live operator and has a voicemail system that will prompt you for information about your sighting and your contact information if the operator is unable to answer the call.

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EDRR Case Study: New World Screwworm Fly

The **New World screwworm fly** (NWSF), endemic to South America, poses a significant threat to livestock and other mammals. These invasive exotic flies lay larvae in open wounds; the resulting screwworms then feed on the animal's flesh, causing serious discomfort and itching. If left untreated, screwworm infestations can be fatal. A known parasitic pest, a recent occurrence of the NWSF in the Florida Keys spurred a successful Early Detection and Rapid Response (EDRR) interagency effort.

A Coordinated EDRR Effort

In September 2016, a multi-agency rapid response was initiated due to a positive detection of NWSF in an endangered key deer on the National Key Deer Refuge. NWSF had previously been eradicated in the southeast United States, including Florida, by 1960 (Novy 1991). Following its detection in the Lower Keys, a unified Incident Command System (ICS) structure was established between four primary agencies that included the Florida Department of Agriculture and Consumer Services (FDACS), the US Department of Agriculture's Animal and Plant Health Inspection Service (USDA-APHIS), Monroe County, and the US Fish and Wildlife Service (USFWS). It was later determined that the ICS strategy was essential to effectively managing the outbreak (Hennessey et. al. 2019).

Successful Eradication

Eradication was ultimately achieved using a multi-faceted approach that included mass sterile male fly releases (to reduce the likelihood that a fertile male fly will mate with a fertile female fly thus reducing the population); monitoring for disease spread; quarantine check points that included health inspections for domestic animals; containment and treatment of infected Key deer; euthanizing afflicted deer; proper disposal of deer carcasses; and community education and engagement (Hennessey et. al. 2019). Local volunteers provided invaluable assistance during the response.

The NWSF was declared eradicated on March 31, 2017, a mere seven months after its initial detection. Over 200

million sterile male flies were released on remote islands and in strategic locations on the mainland and over 17,000 animals received health checks (FDACS 2017). Roughly 15% of the endangered key deer population was lost (Hennessey et. al. 2019). Response costs likely exceeded \$5 million (Skoda et. al. 2018).

Conclusion

The coordinated effort was an excellent example of EDRR to a newly detected, highly invasive species, and the response met all criteria in the federal definition for an invasive species: 'an introduced species that is likely to cause economic or ecological harm, or is a threat to public safety'. There were direct risks to the Florida livestock industry, threatened and endangered species, and, although rare, cases of NWSF have been documented in humans. The source of the infestation remains unclear.



New World Screwworm Fly (top) and mature larvae (bottom).

Photos courtesy of USDA-APHIS.

New World Screwworm Infestation: Before and After Treatment



Above, an active open wound infestation in an endangered Key deer.

Right, post-treatment with topical antibiotics.

Photos courtesy of USFWS.



Sources:

Hennessey, M.J., Hsi, D.J., Davis, J.S., Delgado, A.H., Allen, H.A., Jandegian, C.M., Skoda, S.R., Watts, K.G., Gibbs, S.J., Powell, B., Welch, J.B., Phillips, P.L., Kitchen, D.L., Christy, G.S. and D.L. Bonilla. 2019. Special Report: Use of a multi-agency approach to eradicate New World screwworm flies from Big Pine Key, Florida, following an outbreak of screwworm infestation (September 2016-March 2017). *Journal of the American Veterinary Medical Association* 255 (8): 908-914.

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EDRR Case Study: Lumnitzera

The mangrove tree lumnitzera (*Lumnitzera racemosa*) was introduced to the United States in 1964 when two specimens obtained from Taiwan were planted in Fairchild Tropical Botanic Garden in Coral Gables, Florida. From these plants, Fairchild staff propagated more. Eventually 14 individuals were planted at Fairchild and six additional plants were sold to garden members in the 1970s. The fate of the sold plants is unknown. Lumnitzera was discovered to have escaped from cultivation at Fairchild in late 2008. Surveys conducted in 2009 found that the species had spread to approximately 19 acres of mangrove habitat in Fairchild and neighboring Matheson Hammock Park, a Miami-Dade County Park with natural areas managed by the County's Environmentally Endangered Lands (EEL) Program. The aggressive growth of the plant in native mangrove habitat raised concern among regional invasive species specialists who initiated a concerted effort to respond rapidly with monitoring and removal efforts. Field observations and scientific literature were provided to the University of Florida Institute of Food and Agricultural Sciences for a risk assessment using the Assessment of Non-native Plants in Florida's Natural Areas Predictive Tool. Lumnitzera was determined to have a high invasion risk. The US Department of Agriculture's Animal and Plant Health Inspection Service (USDA-APHIS) lists lumnitzera as "Not Authorized Pending Risk Analysis." Ongoing management efforts are aimed at eradication due to the localized distribution of the plant in Florida.

Case Presentation

The discovery of the lumnitzera invasion happened to co-occur with formation of the Everglades Cooperative Invasive Species Management Area (ECISMA). Through ECISMA, biologists from multiple agencies across South Florida participated in monitoring and removal workdays. These efforts not only resulted in the removal of an estimated 4,500 plants, but also served to train biologists throughout the region to identify this species, which can be very difficult to tell apart from co-occurring native mangroves. Some of the agencies participating in the

efforts included Miami-Dade County Natural Areas Management, Miami-Dade County EEL, Miami-Dade County Department of Environmental Resources Management, US Fish and Wildlife Service, Florida Fish and Wildlife Conservation Commission (FWC), the National Park Service, The Nature Conservancy, Broward County Parks, the Miccosukee Tribe of Indians of Florida, the National Oceanic and Atmospheric Administration, the US Army Corps of Engineers, USDA, South Florida Water Management District, private vegetation management companies, and Fairchild Tropical Botanic Garden.



Finding lumnitzera amongst native mangroves can be like looking for a needle in a haystack. Photo: Brian Harding, Fairchild Tropical Botanic Garden.

Management Actions and Outcome

Though no formal rapid response program was in place at the time, collaborative efforts between Fairchild Garden, Miami-Dade County EEL, and other members of ECISMA resulted in significant progress toward eradication. However, the plant has proven to be challenging to eradicate from its very localized distribution. The greatest strides toward eradication were achieved when funding was obtained through FWC's Invasive Plant Management Uplands Program and contractors were hired to remove lumnitzera from the infested areas. To date, it is estimated that more than 50,000 stems have been removed by contractors and volunteers.

More than a decade after its spread was discovered, the complete eradication of lumnitzera continues to pose challenges. Academic research has shed some light on



More than 50,000 lumnitzera stems have been removed by volunteers and contractors since eradication began. Contracted work ceased in 2016 but annual volunteer workdays continue. Source: Fairchild Tropical Botanic Garden.

the species' ecology and biology. Its ability to colonize established, undisturbed mangrove communities was unsettling in part because these communities were previously thought to be somewhat immune to alien plant invasions. Fourqurean et al. (2009) explored the possibility that neotropical mangrove forests, with just four species, may be vulnerable to invasion by Old World mangrove species, where there are more than one dozen different species. Studies of cultivated plants by Dangremond (2015) revealed lumnitzera to be tolerant of a very wide range of environmental conditions. And Ye et al. (2004) showed that lumnitzera seeds exhibit true dormancy, unlike most other mangrove species. This last factor especially is a major stumbling block toward eradication since year after year, new seedlings appear in areas where eradication was thought to have been achieved. Currently, efforts are at the level of containment, however, there is hope that complete eradication of lumnitzera is not too far in the future. The success of the eradication efforts is attributed to close collaboration between stakeholders, availability of risk assessment tools, dedicated rapid response funding, management-relevant research, and sustained control efforts.

Key Recommendations

- Continued aggressive monitoring and removal efforts should continue until lumnitzera is determined to be eradicated from Florida.
- Expanded, systematic monitoring for new species introductions is needed to increase the likelihood of early detection in the South Florida Ecosystem.
- The experiences and lessons learned from the lumnitzera eradication initiative provide valuable insight for future rapid response efforts toward other invasive species. After action analysis should be developed and used to improve regional rapid response partnerships.

References

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Containment Case Study: Argentine Black and White Tegu

The Argentine black and white tegu is a large lizard native to South America and popular in the pet trade, and several invasive populations are now established in the southeastern USA, including in southern Miami-Dade County. In their native range, tegus are habitat generalists and eat a wide variety of fruits, insects, small vertebrates, and specialize in eating the eggs of ground-nesting animals. Their high reproductive capacity, lack of potential predators, and adaptability to a wide variety of resources and environmental conditions make them a threat to Florida's wildlife and environment. From their current location in Miami-Dade County, tegus are dispersing west towards the sensitive habitats in Everglades National Park (ENP), south toward the Florida Keys, east towards Biscayne National Park and American crocodile nesting habitat at Florida Power and Light's Turkey Point power plant, and north into residential and agricultural areas. Since they are already widely established, the goal is to contain them to their current range and decrease the population size.

Case Presentation

A population of tegus was discovered in Florida City, a town just east of ENP, in 2008 by members of the Everglades Cooperative Invasive Species Management Area (ECISMA), an interagency group dedicated to cross-jurisdictional collaboration on invasive species management efforts. The following year, more investigation and limited trapping efforts confirmed that the tegus were breeding. There were no dedicated staff from any agency to initiate a rapid assessment and response effort at that time. The National Park Service (NPS) and Florida Fish and Wildlife Conservation Commission (FWC) were able to hire one trapper and redirect limited staff resources to develop trapping methods and track five telemetered tegus, including one female that led to the discovery of the first tegu nest in Florida. The stomach contents of tegus were analyzed to determine diet. During subsequent years, volunteer trapping efforts by more ECISMA partners enabled the continued assessment of tegus but did not appear to limit the expansion of the tegu population.

There was no dedicated funding for trapping efforts until 2011. Private trappers have also become involved with trapping tegus, and many of their captured tegus are re-sold into the pet trade. The exact number of tegus removed by private trappers and their ultimate fate is not available; nonetheless, the general number given by at least one trapper is that hundreds of individuals have been taken out of the wild and placed back into the pet trade. No permit is required to possess pet tegus in Florida at this time. People selling nonnative wildlife must have a valid License to Possess Class III Wildlife for Exhibition or Public Sale from FWC that authorizes the sale of Class III reptiles. Any sales to out-of-state entities must be conducted in compliance with any applicable federal or state rules.

From the first reports of tegus in 2008 in Florida City through 2019, the tegu population has continued to

The Tegu Curtain

The Argentine black and white tegu is a large, invasive lizard native to South America that has become established in southern Miami-Dade County. The goal is to protect sensitive habitats, including nearby national parks and crocodile nesting areas, by containing them within their current range and decreasing the population size.



Photo: Dennis Giardina.

grow and expand its range, despite increasing trapping efforts. Currently, tegus occur across over 100 square miles, including many natural areas and conservation lands. Despite being readily trappable, there is a consensus that eradication now appears unlikely, and containment is the appropriate objective.

Management Actions and Outcome

After their discovery, ECISMA quickly coordinated tegu trapping and removal efforts following the group's rapid response protocol, though limited staff and financial resources prevented an aggressive response. Alongside the efforts to remove tegus from natural areas, this included public outreach to facilitate removals from private lands and research to assess tegu biology and impacts and improve management practices. These initial efforts, which began within two years of discovery, led to relatively rapid determination of effective trapping methods and confirmation that the tegu may represent a significant threat to wildlife. The University of Florida, Zoo Miami, South Florida Water Management District, and the U.S. Geological Survey began providing staff to trap and track tegus starting in 2011, with FWC providing staff specifically to support tegu removal in 2012. In 2013, the idea of creating a "Tegu Curtain" was proposed, which includes utilizing camera traps and driving surveys to monitor the perimeter of the population and conduct intensive trapping in core areas that would expand to correspond with seasonal dispersal. The U.S. Department of the Interior provided support for this effort and NPS provided additional staff and volunteers in the field. This containment effort, coordinated among many partners, was expanded in 2014 and has undergone incremental changes in subsequent years. Although each participating organization is contributing available resources, existing funding and staffing levels appear insufficient to meet the containment objective, as tegus are now regularly observed in areas that were unoccupied just four years ago. Tegus are now occasionally removed just inside ENP, though in low numbers and there is not yet evidence that tegus are

reproducing there. Nonetheless, the dedication and persistence of ECISMA members and cooperators has led to increased efforts and larger numbers of tegus removed every year, and the tegu population may well have been larger and more widespread without these efforts. The knowledge base about the species and control options and methods has also significantly improved, and this knowledge will be important to the long-term management of tegus.

Key Recommendations

- Outreach to the public promoting early reporting can lead to more discoveries of newly established populations, possibly in time to contain further spread.
- Dedicated resources are needed to successfully respond, and resources must be consistent with the scale of the threat. Potentially significant threats warrant application of all available resources.
- Time is of the essence – developing methods and initial assessments should be quick, because incipient populations may grow rapidly, leading to larger costs and effort.
- Though the response to a newly established population should be quick, efforts may need to be sustained over multiple years to achieve eradication and future cost savings.
- A pre-existing coordination and decision-making framework among agencies, researchers, and partners would be helpful to expedite and improve the containment response.
- If containment of tegus is not possible, assessments should be conducted to quantify impacts and inform next steps and develop long-term strategies to protect key resources.
- Volunteer efforts are valuable, but dedicated staff are more effective.
- As invasive-animal populations move into long-term management, control efforts may shift from agency or university staff to contracted work, similar to how invasive plants are managed.

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Long-term Management Case Study: Burmese Pythons

Burmese pythons are giant constricting snakes, native to Asia, that have established extensive populations in southern Florida. Adult pythons are large predators with little risk of predation themselves, and the Florida population has the potential to negatively impact a multitude of native wildlife species. This issue spans a vast area across south Florida and crosses geopolitical boundaries. Interagency collaboration and continued research and tool development are critical for successful management of this invasive exotic species.

Interagency Coordination

In 2016, the Florida Fish and Wildlife Conservation Commission (FWC) developed an Interagency Python Management Coordinator position with support from Everglades National Park to develop an Interagency Python Management Plan (IPMP). The first three years were spent sharing information from researchers and managers, determining which land managing agencies, tribes, and organizations would be included in the written plan development, and creating goals and strategies pertaining to python management. In 2019, the first interagency team meeting, including 15 partner agencies, tribes, and organizations, was held in Fort Lauderdale and an outline for what would be included in the IPMP was developed. The IPMP will center around identifying goals and management strategies among agencies and Cooperative Invasive Species Management Areas (CISMAs) to optimize resources, prioritize, and align management strategies and actions for Burmese pythons. To date, four meetings have been held with this interagency team and a full draft is expected to be finished by the end of 2020.

This interagency team uses a multi-faceted approach to control this invasive constrictor:

Prevention through Regulation

- The FWC listed the Burmese python as a Conditional species as of August 23, 2010, meaning that an individual can no longer acquire a Burmese python in the state for personal use.
- In 2012, the U.S. Fish and Wildlife Service (FWS) placed Burmese pythons on the injurious species list,

which prohibits the importation of this species from outside the continental United States without a federal permit.

- Since 2006, 114 Burmese pythons have been surrendered to the Exotic Pet Amnesty Program.
- The FWC signed Executive Order (EO) 20-17 in 2020 that authorizes the lethal take of nonnative reptiles without a permit or hunting license requirement, including pythons, on 25 Commission-managed properties in south Florida. The FWC continues to look for opportunities to expand upon this EO and remove regulatory barriers for invasive species removal efforts.

Early Detection/Rapid Response to New Sightings

- FWC's Exotic Species Hotline receives reports from the public regarding nonnative wildlife.
- From 2015 to April 2020, this hotline received 469 calls about pythons. An additional 537 reports were submitted online and through the IveGot1 smartphone app.

Control Tools

- Expert human searchers: Visual searches by local experts continues to be the most effective means of detecting and removing pythons from the wild. The FWC and South Florida Water Management District (SFWMD) contractor programs have removed over 5,000 pythons from public lands since 2017. The National Park Service (NPS) has 69 authorized agents that remove pythons from NPS properties.
- Detection dogs
- eDNA
- Python specific traps
- Pheromone and other attractants
- Sentinel or scout snakes (telemetered animals)

Research

- Development and refinement of innovative tools and techniques to improve our ability to detect and remove pythons from the wild.

Public Engagement

- Python Patrol – Participants learn how to identify and safely capture pythons. To date, over 3,000 people have been trained at 215 workshops.
- Annual Python Challenge™ – The FWC and SFWMD conduct events that provide awards for the most and largest pythons captured. The 2020 Python Bowl removed 80 pythons in just 10 days.

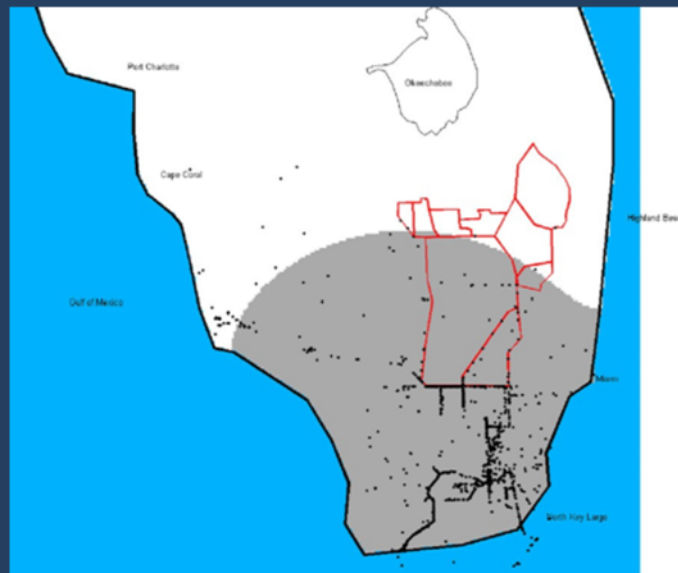
The Role of Science in Long-term Management: The Burmese Python Structured Decision Making (SDM) Workshop

In June 2014, in response to the growing Burmese python threat to the Arthur R. Marshall Loxahatchee NWR (Refuge), the FWS and key stakeholders participated in a U.S. Geological Survey (USGS)-funded python Structured Decision Making (SDM) workshop at the FWS National Conservation Training Center (NCTC). Other agencies represented included the FWC, NPS, University of Florida, and USGS. The purpose of the SDM workshop was “to determine the most efficient allocation of resources for surveillance (detection with intent to eliminate the threat) and control (removal) activities in order to minimize ecological damage from pythons once they become established on the Refuge (Gibble et al. 2014)”.

A specific outcome from the workshop included the development of a predictive model that would determine the current location and expected arrival of the northward-moving python front to the southern end of the Refuge. The model predicted that the northward-moving python front was less than 20 kilometers from the Refuge and that pythons were expected to be established and breeding by 2020 (Bonneau et. al. 2016). In addition, numerous control actions and research tools were discussed or further refined. These included expanding the Everglades Invasive Reptile and Amphibian Monitoring Program (EIRAMP) survey coverage, utilizing detection dogs and sentinel snakes, trap modifications with real-time monitoring capabilities, implementing additional mammal studies to monitor trends, and enhancing capture and monitoring training for agency staff.

In the end, a USGS-funded eDNA study (2014) confirmed the presence of python DNA in water samples collected on the Refuge. Subsequently, in 2016, a refuge law enforcement officer on routine night patrol ran over and killed a 10-foot Burmese python on the L-40 levee. It was the first documented Burmese python recovered on the Refuge following several unconfirmed reports.

Predicting the Python: Modeling its Northward Expansion towards Loxahatchee NWR



Burmese python invasion front and proximity to the Refuge as generated by a reaction-diffusion model developed by Bonneau, Johnson, and Romagosa (2016) – an end product of the NCTC Inter-agency Loxahatchee Python SDM Workshop held in June 2014.

Source (s):

Bonneau, M., Johnson, F., and C.M. Romagosa. 2016. Spatially explicit control of an invasive species using a reaction-diffusion model. *Ecological Modeling* 337: 15-24.

Gibble, R., Kapsch, M., Bonneau, M., Brandt, L., Hart, K., Irik, K., Ketterlin-Eckles, J., Klug, P., Mitchell, C., Olson, R., Romagosa, C., Waddle, H., Adams, A.Y., Hauser, C., Johnson, F., Brewer, D., and S. Converse. 2014. Management response to the threat of Burmese pythons in Arthur R. Marshall Loxahatchee National Wildlife Refuge: A case study from the Structured Decision Making Workshop, June 2 – 6, 2014, National Conservation Training Center, Shepherdstown, WV, 27 pp.

South Florida Ecosystem Restoration Task Force

Invasive Exotic Species Strategic Action Framework

Long-term Management Case Study: Lionfish

Lionfish, predatory reef fish with venomous spines native to the Indo-Pacific, have invaded and established breeding populations in the waters off Florida. Since first observed off Florida in the 1980s, two lionfish species (*Pterois volitans* and *Pterois miles*) have populated the Caribbean, Gulf of Mexico, the Southeastern U.S. coastline, and the Bermuda coastline. Lionfish pose a threat to the integrity of the food web and are capable of impacting commercial fisheries, tourism, and overall coral reef health. Affecting a vast area and crossing geopolitical boundaries, continued interagency and partner collaboration and coordination are key to successful management of this invasive marine species.

Challenges to Long-term Management

Lionfish, a popular marine aquarium fish, represent the first invasive marine fish species establishing itself in the Western North Atlantic/Caribbean. The first lionfish sighting in the U.S. was in 1985, however, it wasn't until the early 2000s that they became established in the South Atlantic and 2010 when they became established in the Gulf of Mexico. As of May 20, 2020, the established range for invasive lionfish spans from Venezuela to North Carolina, however, lionfish sightings have been as far north as Massachusetts and as far south as Brazil. Lionfish can withstand low salinity and a wide range of temperatures for long periods of time, which may result in more sightings within the Everglades region. Lionfish have already been found in the more brackish waters of the Loxahatchee River, St. Lucie River, some inland canals, the Florida Intercoastal Waterway, and Florida Bay within Everglades National Park.

Lionfish have few predators and represent a threat to native fish species, many of which have economic importance, in addition to those that have ecological importance by helping keep our reefs clean, allowing for coral recruitment. Lionfish also reproduce rapidly. Sexually mature within one year, lionfish can spawn as often as every four days, year-round, with a larval sac that floats on the currents and can survive approximately one

month. Combatting this ever-growing invasion requires effective interagency coordination and multiple management approaches.

Management Strategies

Removal studies have shown that regular, targeted removals of lionfish are successful. Fortunately, while having venom in their spine, lionfish are not poisonous to eat, providing another avenue for removal. Current management strategies include strengthening (and easing some) regulations, targeted removal, and public engagement.

Prevention Through Regulation

- Strengthening regulations on importation and breeding: In 2014, the Florida Fish and Wildlife Conservation Commission (FWC) prohibited the importation of live lionfish into Florida, the intentional breeding of lionfish in captivity in Florida, and the

An Invasion Below

Since first observed in the 1980s, two predatory species of lionfish have populated the Caribbean, Gulf of Mexico, the Southeastern US coastline, and the Bermuda coastline.



Photo: Cory Walter, Mote Marine Laboratory.

harvest or possession of lionfish eggs or larvae in Florida for any purpose other than destruction. Two lionfish have since been surrendered to the FWC Exotic Pet Amnesty Program.

- Easing of state and federal regulations to allow more lionfish harvesting. Some of these measures include the State of Florida removing size and bag limits for recreational or commercial harvest and the National Oceanic and Atmospheric Administration (NOAA) Office of National Marine Sanctuaries (ONMS) issuing permits to allow spears in sanctuary no-fishing zones to specifically harvest lionfish.

Response and Control Plans

- Multiple plans have been developed to address lionfish, including the Intergovernmental Aquatic Nuisance Species Task Force National Invasive Lionfish Prevention and Management Plan, FWC's Lionfish Control Plan, NOAA's ONMS Lionfish Response Plan, and NOAA's Invasive Lionfish Action Plan.

Control Tools and Long-Term Management

- Targeted removal efforts are conducted by the National Park Service (NPS), FWC, NOAA ONMS, and Mote Marine Laboratory.
- The commercial and recreational harvest of lionfish is ongoing, encouraged by the "Eat 'em to Beat 'em" campaign.
- Lionfish derbies and tournaments are conducted by multiple agencies and entities. The FWC provides monetary assistance for tournaments that remove lionfish.
- Removal Incentive Programs: FWC "pays back" charter fishermen and/or dive shop expenses for trips that are specifically completed as lionfish harvest and education trips. FWC also allows an additional spiny lobster over the recreational season bag limit if 10 or more lionfish have also been removed.

Research Support

- Many federal and state grants provide for lionfish research.
- Lionfish specific trap development research ongoing.

Juvenile Lionfish

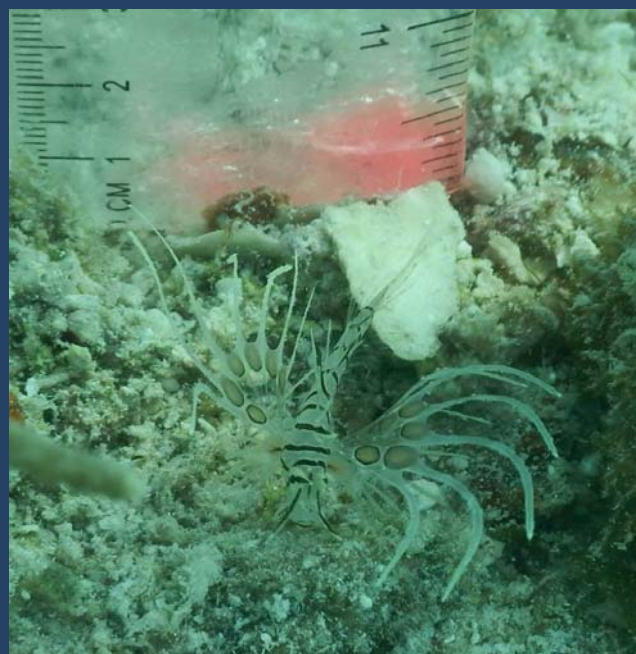


Photo: Kelli O'Donnell, NOAA Fisheries.

- NOAA Fisheries and ONMS completed a Programmatic Environmental Assessment in 2018 that allows for the testing of various trap types and design modifications across multiple areas to determine their effectiveness at catching lionfish in the Gulf of Mexico and South Atlantic, including within the Florida Keys National Marine Sanctuary.

Public Engagement and Targeted Recreational Removal Efforts

- The FWC and other agencies conduct public outreach and recreational removal events targeting lionfish. These include FWC's Lionfish Removal and Awareness Day, Lionfish Challenge, "Become the Predator" workshops, Lionfish Classroom Invasion, Reef Rangers program, and Lionfish Summit Workshops. The NOAA ONMS also hosts a Lionfish Invitational.
- Citizen scientists are also engaged in reporting lionfish sightings to the US Geological Survey, NPS, and FWC.

South Florida Ecosystem Restoration Task Force

Invasive Exotic Species Strategic Action Framework

Long-term Management Case Study: Invasive Plant Coordination and Funding

Combatting established invasive plants requires achievement of maintenance control through sequential control efforts, long-term resource commitment, and extensive interagency coordination. Currently, there are 80 invasive plant species within the South Florida Ecosystem that are priorities for control (SFWMD 2020). Due to the complexities of implementing landscape-level control strategies across numerous jurisdictions, local, state, and federal agencies are working closely in the South Florida Ecosystem to coordinate efforts and improve our collective ability to achieve maintenance control of these priority invasive plants.

Maintenance Control

Management for widely established invasive plant species typically begins with controlling small incipient populations and then moves toward the most heavily infested habitats. As control efforts proceed, retreatment is invariably needed due to regrowth from seed banks and other propagule sources. As the number of sequential control efforts increases for an area, the slower the regrowth and spreading of the invasive plant. Control techniques are utilized in a coordinated manner on a continuous basis in order to maintain invasive plant populations at the lowest feasible level. This method of invasive plant management is known as maintenance control.

Challenges to Achieving Maintenance Control

Coordination and collaboration are critical for natural resource managers due to the large number of invasive plant species, vast and remote natural areas, and numerous jurisdictions within the South Florida Ecosystem. The maintenance control strategy, first described in Florida's Exotic Pest Plant Council's (FLEPPC) 1990 Melaleuca Management Plan, is used by most natural resource managers in Florida today. Ideally, this control process should progress across the landscape in a systematic manner, but varying resource availability for control across jurisdictions and untreated infestations on adjacent private lands present challenges. In addition, short term deviations from the strategy are sometimes neces-

sary to protect critical natural resources (e.g., endangered species). Another obstacle to achieving maintenance control is simply the magnitude of infestations that cover thousands to tens of thousands of acres.

Planning for Maintenance Control

Most agencies in the South Florida Ecosystem have developed individual conceptual plans for their management areas and, through decades of collaboration, have developed statewide species-specific management plans for the most problematic invasive plant species. Basic principles for a sound strategy include:

- Reserve adequate resources for follow-up control at the most cost-effective interval;
- Follow a containment plan (i.e., systematic inward progress across the landscape);
- Address "triage" needs for rapidly expanding infestations that are not scheduled for treatment but threaten conservation priorities (e.g., threatened and endangered species); and
- Seek maximum efficiency through integrative management that combines chemical, mechanical, cultural, and biological control methods.

Every strategy should also consider how a specific infestation fits into the conservation landscape and what opportunities are available to collaborate with other agencies on a regional level. This regional approach encourages individual managers to cooperate on funding proposals that will provide multiple benefits. Through ongoing collaboration with the Florida Fish and Wildlife Conservation Commission's (FWC) Invasive Species Regional Working Groups, the Everglades Cooperative Invasive Species Management Area (ECISMA), FLEPPC, and other partnerships, agencies in south Florida coordinate invasive plant management activities such as:

- Developing integrated weed management techniques to ensure cost-effective and environmentally sound practices;
- Using innovative procurement specifications to improve cost-efficiency;

- Integrating an adaptive response to events such as wildfires, droughts, hurricanes, and extreme flooding; and,
- Funding research on effective and safe herbicides and biological control agents.

Consistent Funding for Maintenance Control

Despite advancements made toward achieving maintenance control statewide, many of South Florida's largest conservation lands have not reached the maintenance control phase for all 80 priority invasive plants. Several factors explain this deviation from the state-wide trend: large, inaccessible landscapes, aggressive subtropical invasive plants, and inconsistent or insufficient funding. While the large spatial scale faced by natural resource managers is unchangeable, strategies to address resource limitations have emerged. Past efforts relied on natural resource managers requesting funds for invasive plant management on individual sites, with the amount of money received determining what could be accomplished in a given year. This minimal, often non-recurring, funding model did not result in cost-effective or sustainable success. In the recent past, federal management funding continually decreased. State funding fluctuated, but to a lesser degree. Sustained funding, even when insufficient, allows development of a long-term treatment strategy. For large conservation lands where infestations are significant, landscape-level planning and continuous, sufficient funding are paramount.

One method to overcome the lack of sufficient recurring funds is to form cost- and resource-sharing cooperative agreements between land managing agencies. Such agreements can include the sharing of personnel, equipment, chemicals, biocontrol agents, computer technology, inventory and monitoring data, and educational materials. Cooperators also share the knowledge and skills of available experts and technicians, sponsor joint training, and convene technical workshops and informational meetings. Successful cooperative agreements also help to reduce parochial conflicts and institutional barriers

that limit the most efficient use of public management resources.

In south Florida, federal, state, and regional agencies do cooperate and combine resources. The FWC, South Florida Water Management District (SFWMD), U.S. Fish and Wildlife Service, National Park Service, Florida Forest Service, and Florida Park Service have collaborated on operational management and funding of single and connected conservation lands. This collaboration has resulted in the successful maintenance control of millions of acres of invasive plant species.

Key Recommendations

Achieving maintenance control of priority invasive plant species is a priority for all agencies responsible for invasive species management in the South Florida Ecosystem. To that end, here are some key recommendations:

- Allocate sufficient resources to invasive plant programs to ensure agencies can achieve and maintain maintenance control rotations.
- Continue close coordination and technology exchange to maximize program optimization.
- Conduct research to improve control tools for natural area invasive plant management and maximize integrated pest management strategies. Key areas of research include herbicide evaluations and new biological controls.
- Review procurement strategies to ensure competitive pricing for contractual services while maintaining high standards for work in sensitive natural areas.
- Expand incentives for invasive plant management on private lands to reduce off-site sources of re-infestations on public lands.

Resources

FLEPPC Melaleuca Management Plan: https://www.fleppc.org/Manage_Plans/mplan.pdf

SFWMD 2020 South Florida Environmental Report: https://apps.sfwmd.gov/sfwmd/SFER/2020_sfer_final/v1/chapters/