Invasive Exotic Species
Strategic Action Framework

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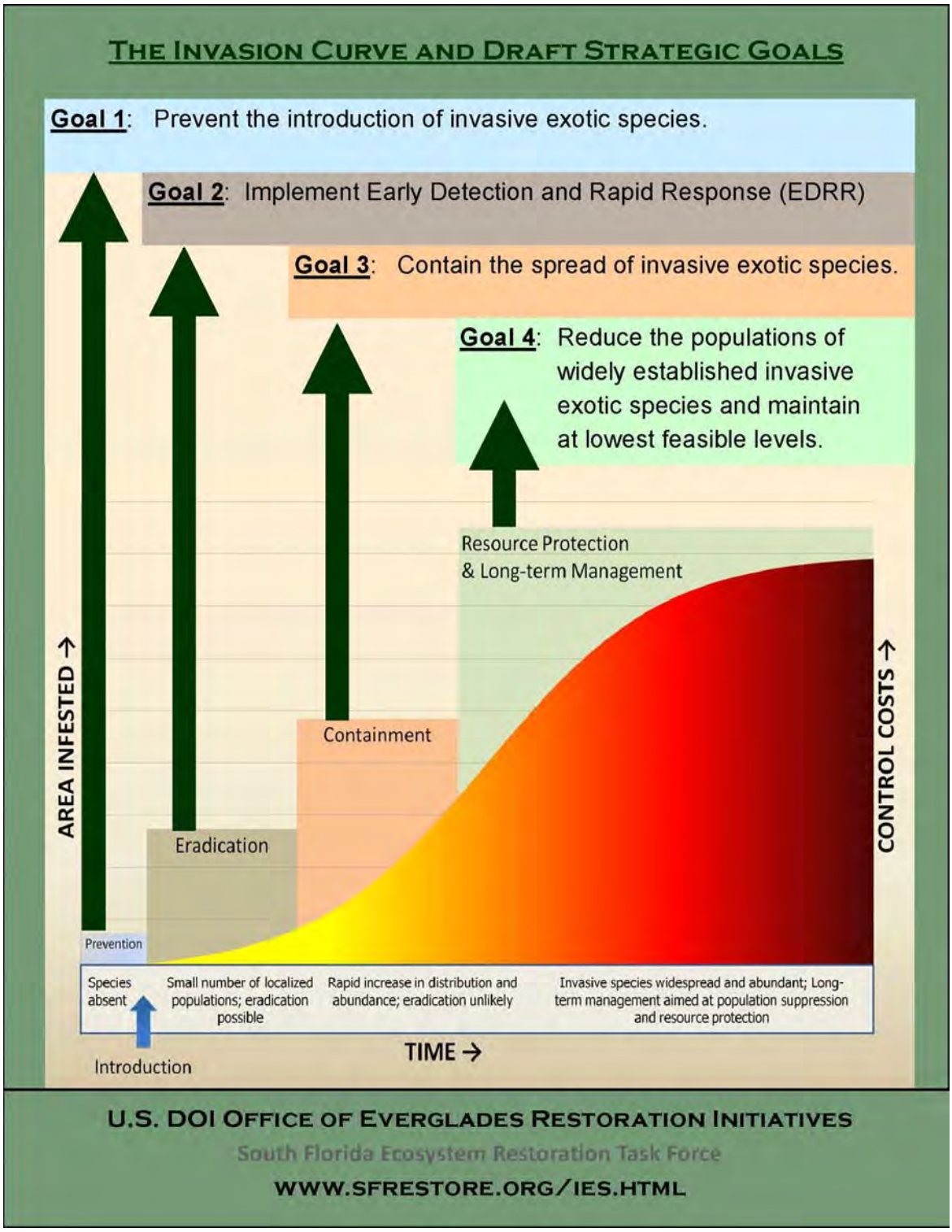
I. Executive Summary

The South Florida Ecosystem Restoration Task Force, along with members of the Everglades Cooperative Invasive Species Management Area (ECISMA) and other partners, has developed this Framework in order to enhance our collective ability to combat invasive exotic species. Florida is second only to Hawaii in the severity of the threat posed by invasive exotic species and is particularly vulnerable to the introduction, invasion, and establishment of non-native species because of its subtropical climate, major ports of entry, and the pet, aquarium, and ornamental plant industries. Invasive exotic plants and animals, including marine and freshwater fish species, are causing rapidly increasing environmental and economic problems in south Florida.

Vision
The South Florida Ecosystem, including America's Everglades, its environmental, economic, and cultural values and human health, is protected from the harmful effects of invasive exotic species.
Key Principles
• Combating invasive exotic species is integral to ecosystem restoration and the sustainability of south Florida.
• The invasion curve is our organizing principle; its four phases mirror our goals of prevention, early detection and rapid response, containment, and resource protection and long-term management.
○ Prevention is the most cost effective strategy and can yield benefits if invested in upfront and if current barriers are addressed.
○ Successful early detection and rapid response (EDRR) requires formal collaboration and dedicated staff and funding.
○ Consistent resources to address containment, resource protection, and long-term management are needed.
• Science, outreach/education, coordination, and funding are vital elements within each goal area.
○ Science should form the foundation for our strategies within every phase of the invasion curve.
○ Invasive exotic species issues are inherently multi-disciplinary.
○ Success will require interagency cooperation, innovative partnerships, and an informed, involved public.
○ A successful invasive exotic species program requires long-term commitment of resources.

A vision statement and set of key principles helped guide development of this Framework (see above). The Invasion Curve (see below) serves as the organizing principle for the Framework. The Invasion Curve graphically depicts the four major categories of actions that may be taken to combat invasive exotic species. **Prevention and early detection and rapid response (EDRR) give the best return on investment in the war on invasive exotic species** (Goals 1 and 2). Over time, the costs and areas infested increase, resulting in containment efforts or development of long-term management programs to best protect the environment and economy (Goals 3 and 4). The four

goals are supported by strategies, actions, and case studies, including implementation tools such as research, outreach/education, and coordination.



II. Introduction

A. Invasive Exotic Species & the South Florida Ecosystem

Invasive exotic species are generally defined as non-native species whose introduction does or is likely to cause economic or environmental harm or harm to human health. They are defined within this document as a non-native species (including its seeds, eggs, spores, or other propagules) whose introduction to the South Florida Ecosystem does or is likely to cause economic, environmental, or cultural harm or harm to human health.

The South Florida Ecosystem includes America's Everglades and is defined by the boundary of the South Florida Water Management District plus the adjacent marine systems. This geographical region includes all or part of sixteen counties and contains a population of almost eight million residents. It is also home to more than 70 threatened and endangered species, three national parks, a national preserve, and 19 national wildlife refuges. The region also includes sovereign and perpetual lease tribal lands, one of the most important agricultural industries in the country, and supports a world renowned tourism and recreational industry.

The South Florida Ecosystem, ecologically unique and imperiled by numerous threats, is the subject of the largest ecosystem scale restoration program in the world. Invasive exotic species diminish the return on ecosystem restoration investment and threaten ecosystem functions and services, cultural values, recreational opportunities, and economic interests vital to the health of the entire state of Florida.

B. Task Force Direction

Combating invasive exotic species is part of the Task Force's *Strategy for Restoration of the South Florida Ecosystem* and has been addressed by past Task Force initiatives including the establishment of specific task teams [Florida Invasive Animal Task Team (FIATT) in 1997; Noxious Exotic Weed Task Team (NEWTT) in 2004] and the development and distribution of *Weeds Won't Wait* (2000) and an *Information Brief on Invasive Exotic Animals* (2010).

In July 2013, the South Florida Ecosystem Restoration Task Force directed its Working Group and Science Coordination Group to develop a *Strategic Action Framework* on invasive exotic species. The Department of Interior's Office of Everglades Restoration Initiatives coordinated the drafting of the Framework in collaboration with an extensive and diverse set of partners, including members of the Task Force, Working Group, Science Coordination Group, and ECISMA.

C. Why a Framework?

There is a large body of work already complete on invasive exotic species and their impacts on the South Florida Ecosystem. Many plans have been written to address specific species and areas of concern. This document is intended to strategically combine these efforts into a single framework that can be utilized by decision-makers, managers, and practitioners to enhance our collective ability to combat invasive exotic species. The intent is to create an overarching framework, and not another individual plan.

This framework aims to provide the following:

- Helps decision-makers understand the connections between goals, strategies, tactics
- Maximizes the extent to which the current capacity for partnership is leveraged to meet common goals
- Helps decision-makers make wise and timely investment decisions in the battle against invasive exotics
- Defines success and provides for accountability

D. Path Forward

Framework vs. Plan

- *Not intended to replace existing projects or species specific plans.*
- *Provides an overarching strategy and draws recommendations from these plans for areas that require additional resources.*
- *Identifies common themes and areas of common interest where increased cooperation can help achieve strategic goals.*
- *Helps present the business case for invasive species prevention and control and can be shared with leaders, decision makers, and natural resource user groups.*

Adapted from Wisconsin's "Statewide Strategic Plan for Invasive Species."

III. Background

A. Definition of Invasive Exotic Species

An Executive Order (EO 13112) was signed in 1999 in order to "prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause." Consistent with EO 13112, invasive exotic species are defined within this document as a non-native species (including its seeds, eggs, spores, or other propagules) whose introduction to the South Florida Ecosystem does or is likely to cause economic, environmental, or cultural harm or harm to human health.

B. Specific Concerns for the South Florida Ecosystem and America's Everglades

1. Environment

The South Florida Ecosystem and America's Everglades are prime habitat for invasive exotic species, proving to be hospitable to many plant and animal species that are native to similar climates throughout the world. Central and South American as well as African and Asian species have found a new home in the humid subtropical climate South Florida offers. The abundant water and food and warm temperature provide perfect conditions for invasive species, giving them a foothold in Florida and the United States. Introduced species are not encumbered by the natural control mechanisms, such as predators, that exist in their native range when they arrive in the South Florida environment. Without any natural mechanisms to keep these introduced populations in check, exotic plant and animal populations can get established and then expand into new areas.

Invasive exotic species are detrimental to the South Florida ecosystem causing 1) physical harm to habitats, such as Old World Climbing Fern which smothers tree islands; 2) direct biological harm to native species, such as Argentine black and white tegu, an avid egg eater; 3) indirect harm by disruption of the food web, such as the loss of small mammals, a food source for the fox and bob cat; 4) and the harm and irreparable loss of threaten and endangered species, such as the Burmese python direct consumption of small mammals, including the marsh rabbit.

2. Economy

Invasive exotic species can have both a directive and indirect economic impact on South Florida. Examples of direct costs are: 1) the interdiction/inspection at the points of entry (airports, ships and mail); 2) the early detection, rapid response efforts (EDRR); 3) the various efforts to control of existing populations. Indirect costs are associated with the loss of ecosystem services, including habitat destruction, reduction in recreational opportunities and the displacement or loss of species.

The interdiction of species is partly under the jurisdiction of the U.S. Customs and Border Protection (CBP). The CBP is responsible protecting our agricultural and economic interests from harmful pests and disease import and have teams that actively inspect cargo at the ports of entry in

Florida. Other agencies, such as the U.S. Fish & Wildlife Service Office of Law Enforcement, and the Florida Fish and Wildlife Commission, have staff that work alongside the CBP to prevent the of import or export of endangered species. At the grassroot level, EDRR is coordinated to coincide with a current need; an example is the effort to control, *Mikania micrantha,* a Florida and Federally-listed noxious weed that is frequently encountered along nursery fence lines and in disturbed areas. The multi-agency ECISMA group voluntarily performs an annually survey when the plant is flowering, thus easier to find and identify, mapping locations needing treatment. Several species are controlled in Florida, such as the water hyacinth. These floating plants can form impenetrable barriers that obstruct water flow and navigation and impact fishing and water sports. Florida spends approximately $3 million per year just for the management of this individual species.

3. Culture

When exotic invasive species displace native species, the environmental and economic impact can be analyzed and quantified, however, the cultural impact may be more elusive. For example, laurel wilt disease threatens to cause the extinction to native redbay trees and swamp bays in the Everglades, and seriously impact commercial avocado groves in South Florida. This has two important cultural implications: 1) the loss of a dominate tree island hardwood plant threatens the structural integrity of tree islands in the Everglades; and 2) bay trees are one of the most important cultural resources to the Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida. Current scientific knowledge indicates that an exotic invasive plant, such as Brazilian Pepper, will rapidly occupy the ecological niche left open by the loss of the swamp bay. This creates the simultaneous loss of both the bay as material of ritual practices for the Tribes and the ecological damage to tree islands that serve as the location for ritual activities.

C. The Invasion Curve

The Invasion Curve has been selected as the organizing principle for the Framework. It depicts, at a glance, the ability to combat invasive exotic species in terms of time, resources, and likelihood of eradication.

Four major categories of actions may be taken to combat invasive exotic species: Prevention, Eradication, Containment, and Resource Protection & Long-term Management. Prevention is the best and only mechanism available prior to the introduction of an invasive exotic species. Once a species is introduced, eradication can be attempted through early detection and rapid response. EDRR is most successful when there are small numbers of localized populations of an invasive exotic species. Once the populations increase and become distributed over a greater area, eradication is far less likely, leading to containment efforts, with the purpose of preventing the spread to new areas. Finally, once invasive exotic species are widespread and abundant, efforts shift to population suppression and resource protection.

Each portion of the Invasion Curve is linked to a specific strategic goal in the Framework (Section IV). Prevention and early detection and rapid response give the best return on investment in the war on invasive exotic species (Goals 1 and 2). Over time, the costs and areas infested increase, resulting in containment efforts or development of long-term

management programs to best protect the environment and economy (Goals 3 and 4). The four goals are supported by objectives, strategic actions, and case studies, including implementation tools such as research, outreach/education, and coordination.

D. Key Principles

The Framework, including the strategic goals in Section IV, is guided by a set of key principles. These principles are core, shared values that help outline the best route(s) for success.

- Combating invasive exotic species is integral to ecosystem restoration and the sustainability of south Florida.
- The invasion curve is our organizing principle; its four phases mirror our goals of prevention, early detection and rapid response, containment, and resource protection and long-term management.
    - Prevention is the most cost effective strategy and can yield benefits if invested in upfront and if current barriers are addressed.
    - Successful early detection and rapid response requires formal collaboration and dedicated staff and funding.
    - Consistent resources to address containment, resource protection, and long-term management are needed.
- Science, outreach/education, coordination, and funding are vital elements within each goal area.
    - Science should form the foundation for our strategies within every phase of the invasion curve.
    - Invasive exotic species issues are inherently multi-disciplinary.
    - Success will require interagency cooperation, innovative partnerships, and an informed, involved public.
    - A successful invasive exotic species program requires long-term commitment of resources.

E. Vision

The Framework's vision statement succinctly describes what success looks like in the battle on invasive exotic species:

> *The South Florida Ecosystem, including America's Everglades, its environmental, economic, and cultural values and human health, is protected from the harmful effects of invasive exotic species.*

This vision is compatible with the Task Force's *Strategy for Restoration of the South Florida Ecosystem*, specifically its Vision Statement and its second goal:

> *Vision: A healthy South Florida Ecosystem that supports diverse and sustainable communities of plants, animals, and people.*
>
> *Goal 2: Restore, preserve, and protect natural habitat and species.*

IV. Strategic Goals

Goal 1: Prevent the introduction of invasive exotic species.

- **Key Principle:** Prevention is the most cost effective strategy and can yield benefits if invested in upfront and if current barriers are addressed.

Preventing the introduction of invasive exotic species into the South Florida Ecosystem protects both the environment and the economy from the deleterious impacts of those species and the high costs associated with eradication and control efforts. Prevention requires both the ability to identify risks and the ability to implement tools that will stop the identified species from entering our region. Prevention is often seen as only a high-level regulatory tool. However, many other tools, including best management practices and public education, are also available.

The ability to **prioritize** prevention efforts will rely on technical expertise and tool development, including ecological risk assessments. Current and future efforts will build on existing resources including the FIATT criteria, the Aquatic Nuisance Species Task Force (ANSTF) template, and the University of Florida's Institute of Food and Agricultural Sciences (UF/IFAS) on-line weed risk assessment.

Preventing the introduction of high priority invasive exotic species will rely upon a cooperative and cohesive multi-jurisdictional approach that aims to fortify the ecosystem from invasion. Better understanding the risks from pathways can help develop robust and more effective biosecurity measures that prevent invasions before they produce significant economic and ecological damages, while simultaneously protecting safe commerce. Securing current and potential pathways will require enhanced import/export screening, full utilization of existing authorities, and development of new authorities.

A Deadly Hitchhiker

Heartwater is an often fatal tick-borne disease historically endemic to sub-Saharan Africa, Madagascar, and more recently several islands in the Caribbean. The potential for Heartwater gaining a foothold in South Florida is increased due to the favorable climate for the ticks and the large volume of African reptiles that are imported into Miami International Airport.

Goal 1: Prevent the introduction of invasive exotic species.

PRIORITIZE

Objective 1A: Prioritize prevention efforts.

- Assemble technical work groups.
- Develop tool(s) to identify invasive exotic species that are the most risky or are most likely to succeed once introduced to the ecosystem.
- Utilize ecological risk assessments.
- Educate and create public acceptance of risk assessment process.

PREVENT

Objective 1B: Prevent high priority invasive exotic species from entering.

- Enhance import/export screening.
- Maximize use of existing authorities.
  - Fully leverage federal, state, and local authorities to manage pathways of introductions of invasive exotic species using both regulatory and voluntary approaches.
- Seek new authorities.
- Enhance domestic bio-security.
- Utilize best management practices (BMPs).
  - Require that all activities that have the potential to introduce or disseminate invasive species on public lands include an analysis to determine the potential for the introduction or movement of invasive species.
  - Develop a prevention plan (e.g. Hazard Analysis and Critical Control Point (HACCP) plan) or appropriate set of prevention and containment practices that will be implemented to mitigate or reduce the potential for invasive species movement onto and off of public lands and privately-owned/publicly managed lands.
- Engage the public and broaden the partnership actively working to prevent the introduction of invasive exotic species.
- Encourage the use of prevention practices in partner agency contracts and by entities working on or on the behalf of all partner agencies.

Goal 2: Implement Early Detection and Rapid Response (EDRR).

- **Key Principle:** Successful early detection and rapid response requires formal collaboration and dedicated staff and funding.

When prevention is not possible, it is imperative to be able to respond quickly and deal with emerging threats while they remain localized. EDRR is the second most cost-effective method to deal with invasive exotics, after prevention.

Prioritization of EDRR efforts should begin before species are identified in the wild. According to ECISMA's EDRR Plan, "in order to respond rapidly and effectively to an invasion, actions should be anticipated and consensus reached on as many response details as possible prior to discovery of an unwanted introduction. Then, when a response is needed, it will be rapid, streamlined, and more effective."

The next step in EDRR is to ensure **early detection.** This requires effective communication between experts, responders, and the public and should seamlessly connect to rapid response and eradication efforts. **Eradication** depends upon dedicated funding and an effective logistical framework in order to be able to quickly respond to threats. Barriers to rapid response, such as permitting issues for responders, must be eliminated.

Interception…

An EDRR Success Story

Sacred ibis are wading birds indigenous to African wetlands that would directly compete with native wading birds if they became established in South Florida. Zoo Miami and the USDA Wildlife Services led a successful interagency EDRR program to eradicate 75 sacred ibis from Miami-Dade and Palm Beach counties.

A Threat to Agriculture

Tephritid fruit flies are considered the most destructive pest of fruits and vegetables, attacking more than 400 different plants, and are the focus of USDA APHIS' cooperative EDRR program that includes efforts offshore, at the border, and within the United States.

Goal 2: Implement Early Detection and Rapid Response (EDRR).

PRIORITIZE

Objective 2A: Prioritize early detection and rapid response (EDRR) efforts.

- Provide the resources (funding and staff) to maintain a team with the full-time responsibility of assessing incipient exotic invasive species populations.
- Assemble technical expert work groups for specific species of concern.
- Utilize ecological risk assessments.

DETECT

Objective 2B: Ensure early reporting of new invasions.

- Expand and implement a systematic, prioritized, all-taxa monitoring and inventory plan.
- Establish and utilize a centralized reporting system.
- Develop an outreach and communication strategy.
- Compile an on-call expert list.

ERADICATE

Objective 2C: Eradicate newly introduced invasive exotic species.

- Update and implement the ECISMA response protocol.
- Establish a rapid response fund in addition to consistent, dedicated resources for early detection.
- Update and provide access to EDRR guidelines, model response plans, and other resources.
- Expand and enhance training programs for rapid responders.
- Establish strike teams.*
- Eliminate barriers to rapid response such as permitting issues for responders.

INTERCEPT

Objective 2D: Prevent new incipient populations with limited distribution.

- ACTIONS

* An 'All-Taxa' Invasive Exotic Species Strike Team could build off of the currently existing National Park Service Florida/Caribbean Exotic Plant Management Team and the U.S. Fish and Wildlife Service Invasive Species Strike Team. A coordinated multi-agency 'All-Taxa' Strike Team could work with partners to address plant and animal species, including terrestrial, freshwater, and marine realms. This Strike Team could better coordinate invasive exotic species management activities on public lands and waters and, in addition, could pool and leverage funding to create and/or strengthen existing partnerships with other federal, state, and local agencies, and non-governmental organizations (NGOs). Key duties would include EDRR for new invasive plant and animal threats on public lands and adjacent lands and waters, and technical assistance to land managers.

Goal 3: Contain the spread of invasive exotic species.

- **Key Principle:** Consistent resources to address containment, resource protection, and long-term management are needed.

Once it is determined that eradication of an invasive exotic species is not possible, we enter the third phase of the Invasion Curve. Control and containment efforts focus on preventing the spread of an invasive exotic species to new areas in order to minimize the damage to the ecosystem. Elements of the containment phase include improving coordination and investing in monitoring and tool development.

Efforts to improve **coordination** at all levels should be enhanced and strengthened to enable better coordinated on-the-ground management activities directed at species, pathways, and high-value assets. There is a need to identify technical, enforcement, or financial assistance for activities needed to eliminate or reduce the environmental, public health, and safety risks associated with invasive exotic species. General containment plans by major taxa should be put in place a priori. These plans should focus on identification of feasible, cost-effective management practices and measures for the cooperating entities to prevent and control invasive exotic infestations. Providing greater support will yield significant leveraging of resources on the ground and actions across-the-board for a variety of invasive exotic species.

CONTAIN

Monitoring, research, and science must remain the foundation of our efforts to address invasive species. Most of our public natural resource management agencies are committed to science-based decision-making, and this should include invasive species. **Investment** in and consistent application of science during risk assessment, methods development, control implementation, and **analysis** of control efforts will provide the justification and support we will need to be successful.

Goal 3: Contain the Spread of Invasive Exotic Species.

COORDINATE

Objective 3A: Standardize containment efforts through enhanced coordination.

- Describe invasive exotic species (flora and fauna) impacting South Florida Ecosystem restoration.
- Develop a shared plan for creating an emergency response fund to help support and increase the capacity of interagency and inter-jurisdictional teams to tackle emerging invasive species issues.
- Ensure that partnership policies, mechanisms, and implementation tools help support and encourage cooperative efforts across agencies, landscapes and jurisdictions.
- Encourage the use of containment practices in contracts and by entities working on or on the behalf of all partner agencies.

CONTAIN

Objective 3B: Utilize existing control tools to contain invasive exotic species.

- Develop and promote best management practices to prevent the inadvertent spread of invasive exotic species.*
- Retreat areas to ensure containment.

INVEST

Objective 3C: Invest in monitoring, research, science, and tool development.**

- Develop tools to assist in the containment and control of invasive exotic species.***
- Conduct inventory and monitoring to improve understanding of population dynamics.****

ANALYZE

Objective 3D: Analyze to determine effectiveness of control efforts on invasive exotic species' populations.

- Report successes/failures and lessons learned for each species and/or geographic region.
- Augment public dissemination of control efforts to bolster support, understanding and cooperation.
- Conduct low level impact analyses.
- Conduct economic impact analyses.

* Examples include the US FWS BMPs for decontamination and agriculture's canker program. Should include marinas and boats. Transporting plant fragments on boats, trailers, and in live wells is the main introduction route to new waterbodies.

** Monitoring the effects of invasive species on ecosystems, native species, and natural processes is important to justify the significant efforts and costs associated with developing invasive species controls. Understanding impacts of invasive species through monitoring may also provide key insights into interactions with native species/ecosystems and help identify or improve control methods.

Research on the basic life history of invasive species can identify key life stages that are most vulnerable to control methods, and understanding demographic characteristics and population growth of invasive species will also help identify the appropriate scale of control efforts and accurately assess risk from each species.

Development of effective control tools may also be best conducted through targeted studies. Rapid experiments to determine interactions of invasives with their environment and native species can provide key insights to develop and improve control methods. However, delaying control to conduct studies may exacerbate problems, and applying control methods while conducting studies may be the best approach to prevent delays that may increase control costs.

Documenting the effectiveness of control methods and measuring changes in the abundance and occurrence of invasive species is also essential because even applying the best available control methods with high levels of effort may ultimately be insufficient in some cases. Scientific assessment of species detection probabilities, our abilities to detect/measure changes in their populations in response to controls, and responses of native species/populations may all be essential to evaluating the effectiveness of our efforts.

*** Tools for successful control of invasive species are usually not "off-the-shelf." For each new species that is detected, removal and control methods must be developed that allow for efficient control and containment. For invasive plants, development of chemical control methods may require testing to identify cost-effective methods that minimize damage to native species. For animals, identification of appropriate traps, baits, and detection methods must be developed, and even after feasible methods have been identified, refinement of these methods may significantly improve performance and reduce costs. Control efforts may be best viewed as ongoing experiments during which method development can occur in conjunction with removal.

Developing second-tier specialized methods may also be essential for improving long-term control and combating established species. Biological controls, pheromone attractants, and other similar highly specific methods generally require extensive development, testing and review, but may be key factors that first allow for real control of some invasive species. Despite large up-front costs and uncertain likelihood of success, endeavors to develop such tools may be cost effective in the long run, and maintaining capacity to develop these methods is important.

**** Establishing and conducting inventory and monitoring of both native and invasive species is an important component of effective invasive species control. Inventory and monitoring programs that are designed to detect incipient populations of invasive species early may significantly improve the outcomes of rapid response, eradication and containment efforts. Similarly, inventory and monitoring of native communities can help to document impacts of invasive species to ecological communities and accurately assess risk that invasive species may pose. These programs may also contribute to assessment of invasive species control efforts by providing reference conditions that can be compared at various stages in control efforts.

Goal 4: Reduce the populations of widely established invasive exotic species and maintain at lowest feasible levels.

- **Key Principle:** Consistent resources to address containment, resource protection, and long-term management are needed.

The final stage of the Invasion Curve is resource protection and long-term management. This phase endeavors to reduce the population and impact of an invasive exotic species so it is no longer plays a dominant role in the ecosystem. This can be accomplished by using control tools to reduce the population densities of a species within a specific area and by strengthening the resilience of natural areas through restoration efforts.

COMBAT

RESTORE

INVEST

ANALYZE

Goal 4: Reduce the populations of widely established invasive exotic species and maintain at lowest feasible levels.

COMBAT

Objective 4A: Reduce population of established invasive exotic species through new controls or increased utilization of existing control tools.

- Eliminate, to the extent possible, invasive exotic plants and animals from natural areas by reducing invasive exotic species densities, reducing reproductive capacities of invasive exotic species, and employing a variety of control measures.
- Ensure that control measures are not deleterious to native species.
- Continue to review and update invasive species management techniques.
- Conduct routine surveys to detect new infestations and new species.
- Evaluate effectiveness of different treatment techniques and treatment intervals on invasive plants.
- To the extent practical, integrate federal, state, and local agency invasive exotic plant and animal control programs.

RESTORE

Objective 4B: Reduce impacts of invasive exotic species through restoration of native habitats and species.

- Support efforts to increase the total spatial extent of natural areas and restore natural hydrology.
- Coordinate invasive species management activities with monitoring of existing rare plant and animal species and to minimize unintended impacts to rare species.
- Coordinate invasive species management with restoration activities to prevent degradation of habitat.
- Reintroduce populations of extirpated and rare species, and augment existing populations where appropriate to improve native plant and animal species abundance and diversity.
- For listed species, use USFWS Recovery Plans as guides.

INVEST

Objective 4C: Invest in monitoring, research, science, and tool development.

- Develop tools to assist in the containment and control of invasive exotic species.
- Conduct inventory and monitoring to improve understanding of population dynamics.

ANALYZE

Objective 4D: Analyze to determine effectiveness of control efforts on invasive exotic species' populations.

- Report successes/failures and lessons learned for each species and/or geographic region.
- Conduct low level impact analyses.
- Conduct economic impact analyses.

V. Case Studies

Prevention:

- ~~South African Python~~Yellow Anaconda (Lacey Act) - Art Roybal
- Ticks (Heart Water Disease) - Carlos Pages

Eradication:

- Sacred Ibis - Tony Pernas, John Humphrey, Frank Ridgely
- Fruit Fly - David Munyon PHOTOS

Containment:

- Tegus - Jenny Eckles, Tylan Dean
- Gambian Pouched Rats - Jenny Eckles PHOTOS

Management:

- Lionfish - Tom Jackson
- Melaleuca (success story; highlight funding tool) - LeRoy Rodgers, Tony Pernas, Don Schmidt, Dan Thayer, Paul Pratt, Francois Laroche
- Burmese Python - Michelle McEachern and Bryan Falk PHOTOS
- Ambrosia Beetle/Laurel Wilt – Rory Feeney, Barry Rosen, and Jim Snyder
- Feral hog – USDA ???
- Shoebutton Ardisia – Cynthia Guerra and Gwen Burzycki

Other Topics:

Funding, Hawaii Cargo - Phil Andreozzi
Amnesty Days – Jenny Eckles
Habitattitude – Tom Jackson

PREVENTION: Heartwater Disease Case Study

Introduction

Heartwater is a tick-borne disease of domestic (cattle, sheep, goats) and wild ruminants (deer, antelope, giraffe) caused by a rickettsial bacteria (*Ehrlichia ruminantium*) transmitted via the saliva of twelve species of ticks belonging to the genus *Amblyomma*. The most important of these vectors is the tropical bont tick (*Amblyomma variegatum*) due to its widespread distribution. Heartwater is historically endemic to sub-Saharan Africa, Madagascar and more recently several islands in the Caribbean (Antigua, Guadeloupe, and Marie-Galante). Other carriers of these ticks are birds and reptiles. This case study reviews the potential devastating impact that Heartwater can inflict on the Florida Ecosystem and agricultural industry.

Case Presentation

In countries where Heartwater is established, indigenous wild and domestic ruminants have had many years of exposure to the disease therefore gaining resistance to its effects. The concern lies in geographic areas in which Heartwater was never present.

Species that contract Heartwater experience symptoms that include prolonged high fever, listlessness, diarrhea, shortness of breath and death. Heartwater disease is often fatal with mortality rates of up to 80% in non-African cattle, sheep and goats. The white-tail deer population has also been shown to be very susceptible to the disease in laboratory settings and can also serve as a reservoir in the wild.

If the disease becomes established in the US, there are 2 species of *Amblyomma* tick (*A. maculatum* and *A. cajennense*) that are native and have proven to be able to transmit the disease in laboratory settings.

The potential for Heartwater gaining a foothold in South Florida is further increased due to the favorable climate for the vector (*Amblyomma* ticks) and the large volume of African reptiles that are imported weekly into Miami International Airport. The reptiles prone to carrying the ticks include land tortoises, monitor lizards, and snakes (pythons and old world boas). Another risk of introduction comes from the proximity of the Caribbean islands and the migration patterns of cattle egrets.

Management Actions and Outcome

In 2000, the USDA passed two emergency rules banning the import (9 CFR 93.701(c)) and the interstate movement (9 CFR 74.1) of 3 species of African land tortoises: African spurred tortoise (*Geochelone sulcata*), Leopard Tortoise (*Stigmochelys pardalis*), and Bell's Hingeback tortoise (*Kinixys belliana*). The interstate movement rule was later amended to allow these tortoises to travel between states with a health certificate endorsed by an accredited veterinarian. These emergency rulings were in response to the discovery that there was evidence of the causative agent for heartwater disease in a tick collected from a Leopard tortoise and the interstate movement of leopard tortoises from infested premises to noninfested premises. The African spurred and bell's

hingeback tortoises were included in these rulings due to the prevalence of Amblyomma ticks found on them upon importation.

USDA received appropriated funds to create two positions that would be responsible for inspecting reptile shipments imported into the US. In 2003, USDA APHIS VS created the Pest Management Officer (PMO) position. There is currently only one PMO in the country (stationed at Miami International Airport). The PMO relies on USFWS for notification and inspections of reptile shipments imported into the airport (with an emphasis on inspections for shipments of African origin).

This officer collaborates with USFWS Wildlife inspectors on reptile shipment inspections. Upon discovery of tick infestation in a reptile shipment, the USDA PMO places the importers facility under USDA Quarantine and notifies the State Agriculture agency of the infestation so that the quarantine can be enforced until all ticks have been identified. If the identification of the tick comes back as a heartwater carrier species, the state agricultural agency directs the importer to treat the reptiles for ectoparasites and follows up with site inspections.

To date there have been two recent importations of reptiles from Africa (Ghana) that have had *A. variegatum* identified in the shipment. Both times the same reptile importer's facility was quarantined and the animals were treated for ectoparasites. In both cases the wildlife infested were savannah monitor lizards (*Varanus exanthematicus*). In both situations, the quarantines were lifted after confirmation by Florida Department of Agriculture that facility was tick free.

USDA APHIS VS has had several workshops/meetings with the reptile industry in light to the two infested shipments. The reptile industry has expressed concern over possible future bans on imports of specific species and has taken a constructive approach by becoming proactive. Several reptile importers have traveled to Africa and have put pressure on their suppliers to treat their stock for ectoparasites and improve their animal husbandry practices to prevent tick infestations in their facilities.

Key Recommendations

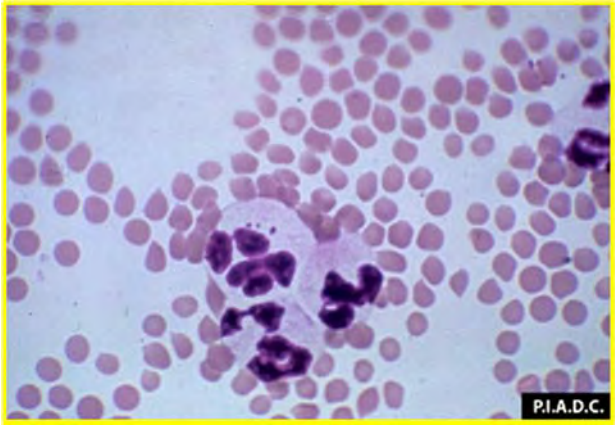
Future recommendations:

- Hire more Pest Management Officers.
- Amend current regulations to add inspection authority for USDA Pest Management Officers. Currently they can only inspect reptile shipment when USFWS is present.
- Continue to engage and include the Reptile industry. They have more influence overseas and can correct the issue before it arrives in the US.
- Continue to monitor cattle egret populations and expand by conducting random trapping and sampling of ectoparasites.

Photo 1: Tropical Bont Tick

Photo 2: *Ehrlichia ruminantium (*The bacteria that causes heartwater)

Photo 3: Savannah Monitor (Varanus albigularis) with an Amblyomma tick



EDRR: Sacred Ibis Case Study

Introduction

Sacred ibis (*Threskiornis aethiopicus)* are colonial wading birds indigenous to African wetland regions that are classified as invasive species in other parts of the world. The presence of sacred ibis in South Florida may threaten the integrity of the Everglades ecosystem by directly competing with native wading bird populations. Their opportunistic feeding habits, ability to colonize numerous habitats, and tendency to compete with native species in Europe illustrate that sacred ibis' potential to establish viable invasive populations in other regions of the world, including South Florida (Herring & Gawlik 2008).

Sacred ibis escaped captivity following the devastating effects of Hurricane Andrew in 1992. In the following years, numerous sightings of sacred ibis were reported throughout the region. The Everglades Cooperative Invasive Species Management Area initiated the Sacred Ibis Project and developed a sacred ibis Early Detection/Rapid Response plan to incorporate a thorough and efficient detection system, a monitoring network, coordinated invasive species control programs, a trained team of rapid responders, and continuing prevention and education plans.

Case Presentation

Staff at Zoo Miami (formerly Miami Metrozoo) began live-trapping birds at the Zoo and USDA Wildlife Services (WS) began lethal take on Zoo grounds and in the surrounding regions. Live trapping techniques utilized a variety of methodologies that exploited the birds' habituation to people and open exhibit feeding practices that the ibises were utilizing to outcompete the zoo collection animals. Baiting existing covered holding pens, erecting enclosures around feeding stations, and oral drug administration to induce sedation were all successful in capturing birds in different situations. USDA WS equipped four live-captured ibis with solar-powered GPS satellite transmitters, as shown in (Figure 1). Two ibises outfitted with transmitters were tracked by WS team members to detect if either bird would locate and join other populations of sacred ibis remaining in the area (Figure 2). This monitoring strategy was particularly successful at tracking individuals and tracing additional roosting areas located outside of Zoo Miami. The work of the monitoring network and rapid response team also led to the detection and eradication of sacred ibis at landfills in both Palm Beach and Miami-Dade counties by the trained WS response team.

Figure 1. A transmitter is secured to a sacred ibis using a backpack style harness.

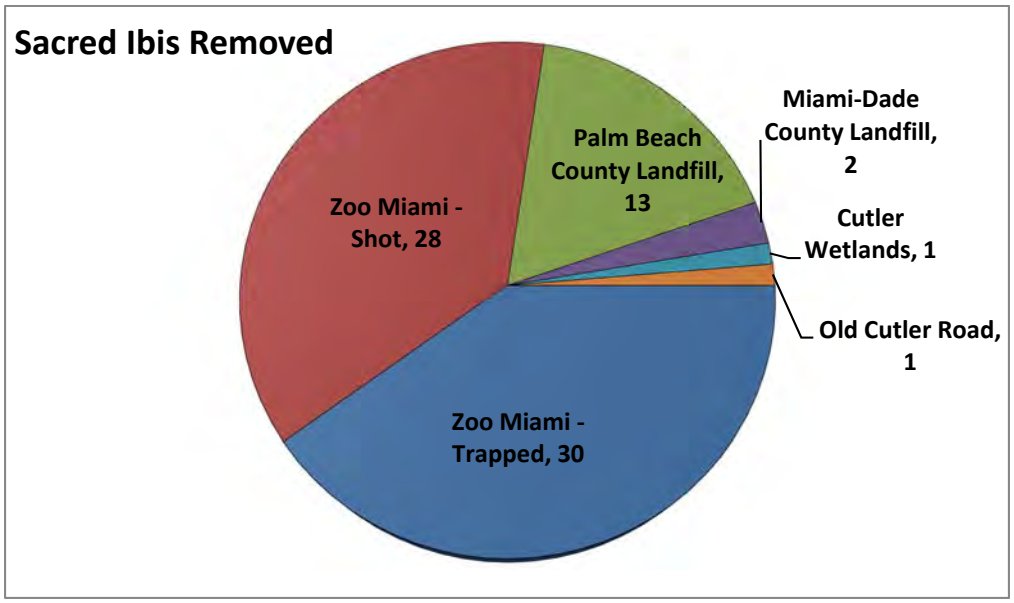
Figure 2. Two sacred ibis with wing tags and satellite transmitters.

All birds trapped by Zoo Miami were surgically pinioned, measured, sexed, and held for placement with other accredited facilities with a signed understanding of their invasive potential and containment. Carcasses from birds that were shot were used for scientific and research purposes.

The early detection and rapid response framework used in the Sacred Ibis Project yielded positive results in terms of identifying a newly introduced invasive species, developing a thorough and efficient detection system, implementing control/eradication measures, effectively coordinating action among multiple government agencies, achieving short-term eradication goals, and promoting scientific research and public education.

Management Outcomes and Actions

The Sacred Ibis Project, funded by the Everglades Foundation, USDA WS, and Zoo Miami, prevented sacred ibis range expansions and successfully controlled populations while they remained localized and extirpation was still feasible. Threats posed by the sacred ibis to native flora and fauna, particularly to endangered wetland species, have declined. Considerable progress was made in determining habitat preference, geographic distribution, and daily routines of the sacred ibis. Overall, 75 sacred ibis were located and removed from the wild by USDA WS and Zoo Miami staff during the project.



Satellite tracking sacred ibis helped determine that the population of ibis living at the zoo never left the immediate area. They followed a general daily routine, moving from feeding to loafing and roosting areas located around the zoo (Figure 3). While the transmittered birds being used for tracking purposes continued to utilize the zoo as their main base, they were visiting wetland areas located in close proximity to the zoo, including a mixed-species rookery site at the Calusa Country Club about 7 miles north of the zoo (Figure 4).

WS members continued to monitor bird networks in the region for sacred ibis sightings. As a result of the Sacred Ibis Project, the threat of extensive sacred ibis colonization across the region has greatly diminished. Success was made in terms of rapid, localized containment of a recently established invasive in a highly efficient, relatively low-cost manner.

In order to establish an observational network for sacred ibis sightings, partnerships were created with several groups and individuals. Educators at Key Largo School agreed to monitor the area for sacred ibis, as a sighting was reported in that location in 2008. After contact, one teacher indicated sightings along the 18-mile stretch between Key Largo and Homestead. Furthermore, personnel with the South Florida Water Management District assisted with the project in the investigation of sightings in Boynton Beach. Additional surveys were conducted by USDA WS and USFWS personnel at Loxahatchie National Wildlife Refuge to investigate reports of possible sacred ibis sightings throughout the refuge. And collaboration between USDA WS and the Florida Fish and Wildlife Conservation Commission (FWC) provided many ibis locations for the project.

The rapid response paradigm is best illustrated by the two most recent sacred ibis removals. On 8 May 2011, FWC contacted WS in Gainesville with photos of a single adult sacred ibis at the Palm Beach County Landfill. A biologist was dispatched and on 11 May 2011 he collected a single adult sacred ibis from that location. On 2 November 2011, a single adult sacred ibis was sighted at the National Park Service building on Old Cutler Road, Palmetto Bay, Florida. As before, this information was relayed to USDA WS biologists, and 2 hours later the bird was collected.

Much of the success of the program relied on multiple agencies and landowners granting access to property and voluntarily monitoring and reporting any sightings. For successful lethal take, the birds had to be located in open and accessible locations where firearms could be safely discharged. A large factor of the removal of the Zoo Miami population was due to the birds having been habituated to the close proximity of people, aggressive scavenging behavior at feeding areas for the collection, and existing infrastructure that aided capture. Satellite tracking allowed for the

discovery of roosting locations, daily migration patterns, and a rookery site for continued monitoring and evaluation of removal efforts.

Challenges included misidentification of similar looking endemic juvenile white ibis and wood storks. Adaptation was exhibited by individual birds to develop aversion to roost locations and trap areas, types, and techniques if a capture was unsuccessful or lethal take had occurred in the proximity.

Key Recommendations/Issues

1. Inter-agency communication and cooperation is essential for efficient, timely response to control invasive species.
2. Availability of trained competent personnel greatly increases chances for success.
3. Telemetry is a useful tool for helping to define the scope of the problem, at least for birds.
4. In south Florida, there is abundant habitat for a mobile species like the sacred ibis. There is little doubt that remnant individuals remain in the wild. On-going vigilance is needed to ensure that there is no resurgence of this species.

Literature Cited

Herring, G., & D. E. Gawlik. 2008. Potential for Successful Population Establishment of the Non-Indigenous Sacred Ibis in the Florida Everglades. *Biological Invasions* 10(7): 969-976.

EDRR: Fruit Fly Case Study

Since 1997, the Tephritidae species of fruit flies has been detected in Florida 22 times. Early detection and rapid response activities conducted jointly by the United States Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) and the Florida Department of Agriculture and Consumer Services (FDACS) have successfully eradicated each introduction.

Tephritid Fruit Flies: A Severe Threat to U.S. Agriculture

Fruit flies in the family Tephritidae are considered the most destructive pests of fruits and vegetables, attacking more than 400 different plants. The genera, *Anastrepha*, *Bactrocera*, and *Ceratitis,* pose the greatest risk to U.S. agriculture and are the focus of APHIS' Exotic Fruit Fly Strategic Plan and Fruit Fly Exclusion and Detection cooperative programs. The permanent establishment of these pests in the United States could cause significant economic losses as a result of the destruction and spoilage of a number of commodities, the costs associated with implementing control measures, and loss of market share due to restrictions on domestic and export shipment of affected commodities. In addition, the establishment of exotic fruit flies in Florida could indirectly impact natural systems as a result of an increased need for treatments to control established infestations in agricultural and/or urban areas near wild lands, and/or tribal lands. APHIS employs a number of regulatory and non-regulatory actions to prevent the entry of fruit fly species and to address outbreaks when outbreaks occur.

Recent History of Detections and Emergency Response in Florida

APHIS' emergency response to fruit fly detections involves two actions: delimitation and eradication. Delimitation includes early detection of a new population and ongoing monitoring to ensure permanent establishment does not occur. Eradication includes measures to control or eliminate the population. A number of factors trigger eradication activities, including the total number of adult fruit flies detected during delimitation, the number or type of life stages detected, or the presence of a pregnant female fruit fly, for example.

Below is a summary of the outbreaks in Florida since 1997 and subsequent actions taken (delimitation and/or eradication).

- Mediterranean Fruit Fly (*Ceratitis capitata*) – Since the major outbreak and subsequent eradication in 1997-98 in Hillsborough, Polk, Manatee, Highlands, Orange, Sarasota, Miami-Dade, Lake and Marion counties, detections have occurred in Sarasota County in 1999 (delimitation), Broward County in 2007 (delimitation), Palm Beach County in 2010 (eradication) and in Broward County in 2011 (eradication).
- Oriental Fruit Fly (*Bactrocera dorsalis*) was detected in Hillsborough (eradication) and Volusia (delimitation) counties in 1999, Manatee County in 2000 (delimitation), Osceola (delimitation) and Sarasota counties (eradication) in 2001, and in Orange and Broward counties in 2002 (delimitation), Hillsborough and Orange Counties in 2007 (delimitation), Orange County 2008 (delimitation) and Pinellas County in 2010 (delimitation).

- Guava Fruit Fly (*Bactrocera correcta*) was detected in Miami-Dade, Pinellas and Seminole counties in 2002 (delimitation), Orange County in 2008 and 2011 (delimitation) and Sarasota County in 2013 (delimitation).
- Peach Fruit Fly (*Bactrocera zonata*) was detected in Miami-Dade County in 2010 (delimitation).
- Mexican Fruit Fly (*Anastrepha ludens*) was detected in Orange County in 2003 (delimitation).

Actions to Prevent the Introduction or Establishment of Fruit Flies in Florida

The ever-growing volume of international trade and travel places constant pressure on the safeguarding system designed to prevent the introduction of fruit flies in Florida. The APHIS/FDACS Cooperative Fruit Fly Exclusion and Detection Program (FFED) addresses the potential risk of fruit fly introductions associated with global commerce and travel through continual pest monitoring and sterile insect release. With approximately 56,000 traps distributed in 43 Florida counties covering more than 8,354 square miles, the FFED continuously monitors the environment to detect new populations.

Under the Medfly Sterile Insect Technique Preventative Release Program, FFED releases sterile medflies by air over the highest-risk urban areas of the state (approximately 633 square miles). The release rate is 125,000 flies per square mile per week. These sterile male flies compete with wild male flies from a potential exotic incursion to cause the new wild population to die out. In addition, new traps, lures, and protocols are always in development to increase efficiencies in an ever increasing risk situation compounded by globalization, liberalized trade, and increase passenger traffic.

A World-Class Safeguarding System

The United States has developed a world-class safeguarding system that uses a number exclusion and response strategies to mitigate the plant health risks that come with global trade and international travel. From risk assessment and analysis to permitting, inspections and pest identification, from treatment and mitigation protocols to policy development and administration, our safeguarding system is a dynamic, data-driven operation that considers and addresses risk not only at ports of entry, but at every point in the risk spectrum - from the countries where commodities originate to the U.S. interior where international products enter the marketplace. The following strategies and tools are used to respond to the risk of fruit fly introduction offshore, at the border, and inside the United States.

Offshore, we:

- Monitor pest data from around the world to uncover new pathways that might bring exotic fruit flies to our shores;
- Harmonize quarantines, exclusion strategies and other safeguarding initiatives with countries in the Greater Caribbean Region to guard against the introduction of high-risk pests;

- Maintain a line of defense along Mexico's southern border to prevent the northern movement of fruit flies from this region through the production and release of sterile flies and the development and use of natural parasites and organic bait sprays ;
- Inspect and treat commodities in their country of origin to mitigate pest risks prior to export to the United States; and
- Conduct trapping programs with countries that export commodities known to host fruit flies.

At the border, we:

- Conduct pest and commodity risk assessments to determine the level of risk associated with specific commodities and the measures that can be used to mitigate the risk;
- Assess and analyze risks through our Port Risk Committees (which include representatives from USDA APHIS, U.S. Department of Homeland Security's Customs and Border Protection, and FDACS) to focus port-of-entry inspection activities to target what is truly risky in an ever-changing global trade environment;
- Develop import policies and procedures to ensure that adequate safeguards, such as inspections or treatments, are applied to prevent the introduction of plant pests and diseases;
- Inspect live plants and propagative plant material and direct the inspections of commercial vessels, trucks, aircraft, railcars, cargo, international passenger baggage (conducted by the U.S. Department of Homeland Security's Customs and Border Protection) to intercept pests before they can enter the United States;
- Develop, conduct and monitor treatments to eliminate viable pests from agricultural goods and commodities entering the United States;
- Provide high-quality and time-sensitive identifications of fruit fly specimens found during port-of-entry inspections;
- Develop molecular diagnostics for fruit fly specimens that may allow us to better identify the source of incursions so we can work with trading partners to minimize risk; and
- Develop methods with key partners to expand the tools available to us to mitigate risk from fruit fly pests.

Inside the United States, we

- Conduct joint USDA and FDACS trapping programs in accordance with the USDA APHIS National Fruit Fly Strategic Plan;
- Release sterile insects to prevent incursions from becoming established;
- Collect and manage trapping data to focus trapping on the highest risk areas and manage eradication activities in an efficient manner;
- Provide high-quality and time-sensitive identifications of fruit fly specimens found during delimitation or eradication programs;
- Conduct aggressive and coordinated emergency and eradication responses based on the USDA New Pest Response Guidelines when a wild fruit fly is detected; and

- Coordinate public communications between FDACS Public Information and USDA Public Affairs staffs to ensure public awareness and cooperation during responses to fruit fly incursions.

In fiscal year 2013, the cost to operate the Fruit Fly Exclusion and Detection program and the Sterile Insect Technique Preventative Release Program was $9.5 million. From an internal APHIS report, each dollar APHIS invested in these programs yielded approximately $120 in cost benefits to the U.S. citrus industry alone. This cost benefit ratio increases significantly when you consider the fact that fruit flies affect a wide variety of fruits and vegetables. Benefits of an aggressive and proactive fruit fly exclusion and eradication program include sustainable crop yields, continued access to domestic and foreign markets, and lower production costs for producers who don't have to implement additional pest management measures. On a larger scale, society benefits from the abundant availability of a wide array of fruits and vegetables at a reasonable cost.

Containment: Tegu Case Study

The Argentine black and white tegu (*Tupinambis merianae*) is a large, invasive lizard native to South America that has become established 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 fecundity (30 - 40 eggs per year) and adaptability to a wide variety of food sources, habitats, and environmental conditions pose a threat to a Florida's wildlife and environment. From their current location, tegus are dispersing west towards the sensitive habitats in Everglades National Park, south toward the Florida Keys, and east towards Biscayne National Park and crocodile nesting habitat in Turkey Point. The goal is to contain them to their current range and decrease the population.

Case Presentation

Tegus were discovered to be breeding in Florida City, a town just west of Everglades National Park, in 2008 after they were observed and photographed by members of the Everglades Cooperative Invasive Species Management Area (ECISMA) investigating reports of Nile monitors in the area. The following year, more investigation and limited trapping efforts confirmed multiple size classes present in the area. At the time, no dedicated staff from any agency were available to trap animals full time in multiple locations or fully assess the range of the population. The National Park Service and FWC were able to hire one trapper and utilize members of their fire crew to develop trapping methods and track five telemetered animals, including one female that led to the discovery of the first tegu nest in Florida. The stomach contents of 30 animals 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 these are re-sold into the pet trade. Information on numbers of tegus removed by private trappers and their ultimate fate is not available; however, the general number given by at least one trapper is in the hundreds of individuals that have been taken out of the wild to bring back into the pet trade.

From the first reports of tegus in 2008 in Florida City through 2013, the tegu population has continued to grow and expand its range, despite 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 objective. No permit is required to possess tegus in Florida.

Management Actions and Outcome

After their discovery, ECISMA members and partners quickly put together whatever resources they could to begin trapping and removing tegus. Members of the Miami-Dade County Venom One team began responding to calls in residential areas and provided traps to neighborhood associations that citizens could use.

Different traps and baits were tested, and telemetry was conducted to learn about dispersal patterns and behavior. Stomach contents were analyzed to determine what native species might be at risk. These initial efforts to assess the population and develop capture methods led to relatively rapid determination of effective trapping methods, confirmation that the tegu may represent a significant threat to wildlife. These studies were conducted within 1-2 years of discovery of a 'population."

What started as a rapid response effort turned to an assessment as it became apparent that tegus were widespread and likely established. In 2012, only three years after a determination that tegus were breeding in the wild, it may be that eradication probability is low because the population is established and widespread.

In 2012, a brochure was created to inform citizens living in areas with tegus on how to prevent them from taking up residence on their property and on how to report their sightings. FWC and Venom One have given several community presentations to inform the public and media outreach has improved awareness. The IVE-GOT1 hotline and EDDMapS website have also been advertised to improve tegu reporting. These outreach efforts have increased public awareness and reporting of tegus, leading to documentation across a broader area of south Florida.

After initial trapping efforts, researchers expanded on previous efforts by increasing trapping locations and season, more animals were tracked using radio telemetry, and new methods for monitoring were added including camera trapping and driving surveys. The University of Florida, Zoo Miami, and USGS 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. DOI provided support for this effort and ENP and NPS provided additional volunteers in the field. This containment effort, coordinated among many partners, is being expanded in 2014. It still lacks dedicated funding, and each participating organization is contributing available resources. This approach, while laudable, does not ensure the consistency or the level of effort that will be required to effectively contain the population.

ECISMA members and cooperators have recognized the threat of an expanding tegu population in the Greater Everglades since they were discovered. Overall, the dedication and persistence of this group has led to increased efforts and larger numbers of tegus removed every year. Our knowledge base about the species and control options and methods is significantly improved due to these efforts, and the tegu population may have been even more widespread and large without these efforts. These efforts were "volunteer" efforts (i.e. conducted in addition to regular duties) and many more resources were needed to implement successful rapid response in this case. As more agencies began to work on tegu issues, their efforts were not always coordinated, and management and research strategies were not discussed ahead of time. More coordination in 2013 led to a more collaborative effort that we hope will also be more focused and successful.

This case study illustrates several important factors in invasive species management:

1) Outreach to the public to promote early reporting could lead to more discoveries of newly established populations, possibly in time to eradicate them.
2) Dedicated resources are needed to be able to successfully respond, and resources must be consistent with the scale of the threat. Potentially significant threats warrant application of all available resources.
3) A pre-existing coordination framework among agencies, researchers, and partners would be helpful.
4) When new species are identified, it is possible to prioritize removal/eradication while still collecting valuable research information.
5) If eradication is not possible, an assessment should be conducted to determine possible impacts.
6) 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.
7) Volunteer efforts are valuable but dedicated staff/work would likely be more effective.

Eradication: Gambian Pouched Rats Case Study

Gambian pouched rats (GPR) are large rodents native to Africa, weighing an average of 3 pounds and measuring 20-35 inches from the head to the tip of the tail. GPR primarily eat fruit and grains, but they have been known to eat insects, crabs and snails. GPR are a vector of a number of serious diseases, including monkey pox; however, several GPR captured in Florid have been tested and all were negative for this zoonotic disease. Due to the somewhat isolated nature of the infestation, it was determined that eradication is possible and remains the ultimate goal.

Case Presentation

GPR were bred in captivity by an individual on Grassy Key, north of Marathon, in the Florida Keys. Between 1999 and 2001, eight rats apparently escaped and subsequently established a reproducing population, which was reported to the US Fish and Wildlife Service (US FWS) in 2004. The state of Florida is concerned about potential impacts to agriculture should they spread to the mainland south Florida, as well as potential interactions with native Florida rodents in the Keys and elsewhere.

The GPR infestation is currently centered around the escape location on a key that is mixed residential, hardwood hammock, and salt marsh. The population had also spread west to Crawl Key where eradication efforts seem to have been successful. The majority of management activities take place on private properties and require coordination between multiple state and federal agencies and the city of Marathon. A number of innovative control measures have been employed and success was even declared in 2010 after trapping had produced no rats for one year. Unfortunately, this declaration was premature and in 2011, Florida Fish and Wildlife Conservation Commission (FWC) received a credible rat report by a reliable citizen in the area and subsequent trapping confirmed a hold-out population remained.

The Exotic Species Coordination Section (ESC) of FWC continues to lead efforts to eradicate this species by conducting monitoring and trapping activities, both in-house and by contracting with USDA-Wildlife Services. FWC is currently funding these activities with both state funds and with a Florida Wildife Foundation Conserve Wildlife Tag Grant issued to ESC. The project will be considered a success after two years of monitoring and trapping have passed with no credible sightings or captures.

Management Actions and Outcome

The US FWS, FWC, and a student at Texas A&M began trapping efforts soon after GPRs were reported to US FWS in 2004. In 2005, FWC held a multi-agency meeting to create an eradication plan. The pilot eradication project began on Crawl Key in June 2006 with US FWS and FWC funding USDA Wildlife Services to conduct trapping and toxic baiting for GPRs. Rats were also tracked using radio telemetry to determine regular movement patterns. A large-scale eradication effort began in January 2007 consisting of the deployment of 1,000 toxic bait stations, live trapping, and further testing of toxicants. Remote cameras were used for monitoring throughout the project. Initial efforts attempted to saturate the area with traps and bait stations and as the project continued, trapping and baiting efforts became more targeted based on results of monitoring.

Also throughout the project, different baits were tested and attempts were made to get access to more properties throughout the neighborhood. Adjustments were made to the bait station designs and toxicants to increase effectiveness and limit effects on non-targets. As this project took place both within and in close proximity to private homes, the concerns of residents were a constant consideration. Residents were especially concerned about impacting non-targets, including raccoons and feral cats. Live trapping was used more around private homes to address this concern.

In general, live trapping GPRs is not difficult and does not require sophisticated baits. However, there were some individuals who refused access to their property and that may have contributed to the lack of complete success. Radio telemetry confirmed that rats were frequently traveling to these "no access" properties. More mature rats also seemed to become trap-shy.

There was an attempt to create a "Judas rat" with a mature female that was trapped, sterilized, and released with an implanted transmitter. It was hoped that she would attract breeding males but this did not seem to be the case and it was discovered that live trapping around the coral island was difficult due to the false signals given when the signal was bouncing off of the hard coral formations.

Overall this project demonstrated excellent inter-agency coordination and cooperation with local government and private residents. A declaration of success was premature but the number of rats observed and trapped on Grassy Island has been very low in recent years and FWC is pursuing a renewed contract with USDA WS to conduct more large-scale trapping in 2014. Over the course of the project funds have been made available through grants, operational budgets, and in-kind services both from agencies directly involved with management activities and agencies with a vested interest in the success of the project.

GPRs have since been listed as Prohibited by FWC making personal possession illegal although they are still allowed as pets in much of the United States.

Key Recommendations/Issues

As with other rapid response projects, early action, significant efforts and funding, and a directed plan were needed to assess and target eradication efforts. Follow up assessment was important even after the initial findings were concluded. In this case, agencies were able to find available monies to do this work, aided by the fact that a large agricultural interest was involved. However, funding has not been consistent and this case illustrates the need for a dedicated source of funding to be available for rapid-response efforts and follow-up.

Management: Lionfish Case Study

Introduction

Pterois volitans, and *P. miles* are the only reproducing examples of 32 ornamental marine fish observed on Florida reefs since the 1980's (USGS NAS / BEST Commission (Bahamas), (23; 21; 13; 10). Within 40 years these 2 lionfish species populated the Caribbean, Gulf of Mexico, the Southeastern US coastline, and the Bermuda coastline to over 300 m depth in salinities ranging from oceanic (35 ppt) to estuarine (8 ppt). The invaded range includes habitats for every non pelagic commercial species at some point in their life cycles. The projected future range includes the northeast coast of South America southeast to Uruguay. Densities in some locations are significantly higher than in the native range, and ecosystem level impacts have been documented. Lionfish pose a threat to the integrity of the food web and are capable of impacting commercial fisheries, tourism, and overall coral reef health (19). Control is problematic, and extirpation in the invaded range is unlikely. Removals are done by hand by divers, or are caught as a chance bycatch of fisheries. Targeting fisheries strategies include designing lionfish traps that limit native bycatch and developing local markets. There are no suitable traps ready for deployment, nor any other cost effective collection strategy for control. This is a pinnacle "bad example" case study, and bar some unforeseen emerging technique or natural control, lionfish are a permanent neighbor with new impacts documented every year since their invasion in direct conflict with restoration goals.

Case Presentation

In 1758, "*Gasterosteus volitans*" (Linnaeus), later renamed *Pterois volitans*, was the first described lionfish, one of 16 "lionfish" species (Family Scorpaenidae) having venomous spines that are painful but not life threatening. A related species, *P. ruselli*, came to US public aquaria in the 1930's. Lionfish entered the ornamental trade in numbers in the 1970's, and two species, *Pterois volitans (97%),* and *P. miles (3%)*, were released as pets into the tropical Atlantic in the 80s, to become invasives in the 1990's. Lionfish are important ornamental taxa; thousands are imported annually to Florida, alone (21). Despite knowing about *P. volitans* for over 200 years, very little life history information has been produced. This was due to lack of economic incentive prior to the invasion, and was only aggressively pursued post invasion due to impacts of shared concern.

Lionfish have specialized reproduction, including a novel blood supply system to each ova, year round reproduction of up to 20,000 eggs every three days, and a release method aiding in dispersal and transport over great distances (18,16). Local cohorts are probably not from local sources (17), and more than two individuals survive from each set of parents. Their native-range early life history controls are absent or ineffective in the tropical Atlantic. Except for two predation records (5, 4) controls are completely undocumented. Now found from 8 ppt water, to over 300 m depth, lionfish are double their home range size, such are all unpredictable from pre-invasion documentation. Lionfish invasions have direct and indirect impacts, from local to ecosystem level effects. Invasion densities can be eight times those of native range populations. Lionfish are efficient predators in direct competition with many recreational and commercial native species, and those of special concern. Lionfish affect community structure by reducing biodiversity consuming over 130 commercial and noncommercial species, primarily fish, crustaceans, and mollusks (cephalopods) (20). Lionfish eat juvenile and adult fish small enough to fit into their mouths, as well as settlement stages of all species including larger species like goliath groupers. Lionfish caused a 65% decline in biomass of 42 species over a two year Bahamas study (12) and have reduced small native fish populations up to 95% in some locations (7). They outcompete local predators, growing six times faster in same conditions (3), which could be significant if true for their larvae. Cascading effects include trophic changes on reefs from reducing herbivores, causing

algal proliferation on both shallow habitats (< 30 m), (2) to deep 30 m to 150 m "mesophotic reefs" (15). Algal proliferation reduces habitat for settlement and space for existing coral colonies, in direct conflict with restoration goals (16). Lionfish impacts are the most significant change since the advent of industrialized fishing (2).

Management Actions and Outcome

Lionfish are now a management issue for 6 Central America countries, 28 Caribbean countries, and 2 South American countries, as well as Bermuda, and the United States, with US coastlines of Texas, Louisiana, Mississippi, Alabama, Florida, Georgia, South and North Carolina affected (22). This includes an area of 7.3 million km^2 (7). Lionfish are compromising protected areas in the greater invaded range, including coastal national parks and marine protected areas in and outside the US. The focus of management is marine protected areas and other areas of special concern relating to commercial species or species of special concern. Alliances are developing among the nations and between resource managers and non-governmental conservation organizations. Cooperators have included the UN, US government agencies such as NOAA (NMFS/NOS), USGS, NPS, USFWS, and many corresponding organizations in impacted countries. US management actions have included the development of strategies by Federal and State agencies with a number of nongovernmental entities like REEF who have been a means of furthering research, coordination, and outreach in the greater invaded area. Several Caribbean countries issue species permits easing restrictions and promoting the removal of lionfish. Similar easing of permitting requirements for their capture in the US (Florida) include 1) removing the need for a recreational fishing license for those targeting lionfish by pole or hand spear, and 2) removing any recreational or commercial limits to facilitate the reduction of lionfish populations (9).

Strategies for control include 1) developing effective capture method/designs and 2) developing local markets and market strategies for export. Local control has been promoted as a practical and beneficial strategy. However control efforts will need to be continuous and long term because well-nourished and fecund lionfish are much deeper (> 300 m) than present diving removal methods can target (< 50 m), and new arrivals from outside sources, traveling on currents, will be recruiting to local populations possibly continuously depending upon circulation patterns.

Lionfish trap development is the most promising control strategy, allowing removal of deeper populations. Lionfish are not widely motile if food is present, and a high trap density might be needed for effective control, possibly impacting bottom habitat. Furthermore present trap designs allow significant native bycatch. All are currently in development; none are available at this time. Research and funding is needed to promote trap design and devise attractants or other capture methods that would allow the reduction of lionfish at depths. Given the rapidity and scale of the invasion, it is unlikely that any natural control will emerge in time to make intervention unnecessary.

Most invaded countries are involved with artisanal and bycatch capture of lionfish as a food fish. In Florida, lionfish is the second most common bycatch of the spiny lobster fishery; Florida 2012 commercial lionfish landings were ~ 5,000 kg, (11). Bermuda's spiny lobster fishery also has significant bycatch of lionfish, which is sold in market or to restaurants. Belize and Mexico have developing commercial markets for lionfish with product already in local markets. In 2013, Belize started exports of processed filets collected from various local divers after the local marketing cooperative, Placencia Producers' Cooperative Society Ltd, organized the local collectors and received US FDA certification allowing export to the US. "Commercial control" seems to be on the upswing.

Many countries are safely consuming lionfish as direct catch and bycatch. NOAA has partnered with REEF for "EAT LIONFISH EAT SUSTAINABLE", a project to promote consumption of lionfish and commercial development of a lionfish fishing industry. In some locations the bio-accumulated neurotoxin ciguatera has been found in lionfish. One hotspot, St Thomas, has recorded ciguatera in lionfish, even though lionfish landings are numbering 30,000/year as bycatch, lionfish are not being eaten. Being a stationary, site specific predator, lionfish might be an ideal target for spatial mapping of ciguatera. Florida studies into bioaccumulation of methylmercury document lionfish under maximum allowed WHO levels (14).

Biocontrols have not yet been successful in marine environments. Lack of sufficient life history information (parasites, pathogens, predators) hinders development of an effective biocontrol. Furthermore, biocontrols are more difficult to administer effectively in the ocean because of dilution factors and the inability to contain the subjects within specific areas.

Key Recommendations/Issues

Lionfish are impacting the tropical Atlantic including up to ecosystem levels. Developing commercial fisheries (effective controls) are stymied by; lionfish depths, densities, reproduction / early survival success, as well as problems limiting native bycatch.

Unpredictable, *P volitans* invasives are found from estuaries to 300 m, from 8ppt to seawater, at twice their (prior) recorded size. The lack of economic incentive for life history data, common in animal imports, debilitates risk assessments. Prevention necessitates judgments comparing expenditures on invasives to their dollars produced in trade, and should guide more aggressive discussions and action of what should, and should not, be imported.

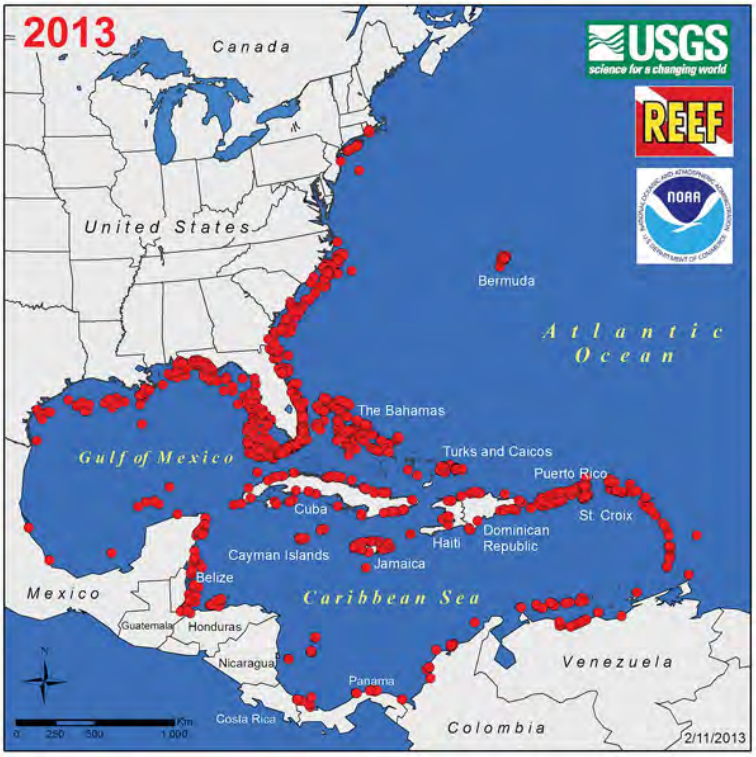
A lionfish captured at the Flower Garden Banks National Marine Sanctuary 2011
(IMAGE (1800 X 1360): NOAA)

URL: http://flowergarden.noaa.gov/education/invasivelionfish.html

An infested Bahamian reef: (IMAGE (1200 X 800): REEF/ Rich Carey)
URL: http://www.reef.org/enews/articles/noaa-coral-reef-conservation-program-and-conservation-foundations-support-reefsfu-lio

An infested rocky habitat off South Carolina in > 40 m depth
(IMAGE: (2048 X 1536) NOAA)
URL:

http://teacheratsea.wordpress.com/2012/07/11/marsha-skoczek-lionfish-groupers-and-bigeye-oh-my-july-11-2012/



02/11/2013 USGS NAS cumulative lionfish sightings (SOURCE: USGS NAS)

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Management: Burmese Python Case Study

Introduction

Burmese pythons are giant constricting snakes with a wide native distribution in Asia, and which have an established invasive population in southern Florida. The pythons are large predators with little risk of predation themselves, and have the potential to negatively impact a multitude of native species. Management of the invasive python population has proven very difficult, and the population continues to grow despite an increasingly coordinated effort of several governmental and academic agencies. Burmese pythons are an unfortunate yet apt example of how eradication of established invasive populations is costly and problematic.

Case Presentation

Founded by animals from the pet trade, a population of Burmese pythons colonized Everglades National Park roughly 30 years ago. The population has since increased in both geographic size and number of individual pythons. The snakes have spread well beyond the park to become established in at least two counties, and most population-size estimates suggest a minimum of 10,000 individual pythons, though the actual number of snakes may be much higher.

Burmese pythons have a remarkable potential for reproduction and growth. Females lay a single clutch of typically 30-50 eggs in the spring, though clutch sizes of over 80 eggs have been recorded in Florida. Like many other python species, the female tends to her nest, protecting her eggs from predation and keeping them warm via a process called shivering thermogenesis. The self-sufficient young are roughly 50-80cm in length upon emerging, and exhibit growth rates of up to 20cm/month. Most pythons collected in Florida are reproductive adults and 3.0-3.25m in length, with few individuals exceeding 5m.

The size and eating habits of these giant constrictors lead to a potentially giant ecological impact. The pythons are feeding generalists, capable of eating most appropriately sized terrestrial vertebrate species, with larger snakes eating larger prey. Documented prey items include over 40 species of mammals and birds, as well as American alligators. Some of these prey items, for example the wood stork and the Key Largo wood rat, are at risk of extinction because of their already low population sizes or limited geographic distribution, and it is unclear how their populations will respond to increased predation pressure. Evidence suggests that many prey populations (e.g., raccoons, opossums) have declined dramatically since the python's introduction, and further research into the effect of the pythons on their prey populations - and the effect of competition on other predator populations - is ongoing.

Management Actions and Outcome

Currently, there is no evidence to suggest that the Burmese python population in Florida can be eradicated by management activities. Each potentially promising management tool has limitations, and primary among these is a high financial investment into research and/or high maintenance costs. Nonetheless, a suite of well-researched management tools may control the geographic spread and density of these snakes.

A major hurdle for Burmese python research and management is that the pythons are exceedingly difficult to find. Most estimates of detection probability (i.e., the probability that a human who is searching for pythons will actually observe a python when within viewing distance) range 0-1%. Furthermore, visual searching is labor-intensive (i.e., costly) and constrained to human-accessible terrain. Whereas some approaches may improve detection probabilities, each of these has limitations. For example, dogs improve detection probabilities, but training and maintenance is expensive and time-consuming. Moreover, detector dogs may show aversion to pythons after a negative interaction (i.e., an attempted or successful snake bite), which also increases costs if a trained dog can no longer be used to search for pythons. Likewise, employing Forward Looking InfraRed (i.e., heat vision) is of limited benefit because the snakes generally have a similar thermal profile as their surrounding environments. Overall, the factors that contribute to detection probability - and the ways in which it may be improved - are poorly understood, and research in this area is ongoing.

Approaches to locate snakes other than visualization have also been employed, but again with limited success. The use of "Judas" snakes (where a captured individual is fitted with a radio transmitter, released, and tracked in order to find other pythons) is an example. Judas-snake activities generally recover only a few additional individuals at a substantially increased cost in both labor and equipment. Trapping is another common management tool, and has been successfully used in the control of other invasive species. Trapping Burmese pythons presents several challenges, however, and principal among these is that the pythons are ambush predators (i.e., they sit-and-wait for food, as opposed to active foraging). Since they don't forage, it's unlikely that they would enter a trap baited with prey. Thus far, strategies to compel the pythons to move (e.g., drift fences, noise deterrents), and thereby increase the probability of trapping success have been, by and large, impractical or ineffective.

Some management tools show great potential, but the underlying science is particularly underdeveloped and in need of much additional research. Pheromone attractants are a good example. Male pythons congregate around females in relatively large numbers during the breeding season, and are presumably signaled to do so via pheromones. Such an attractant may be an effective bait for trapping pythons (at least adult male pythons), but, unfortunately, the science of chemical signaling in snakes is in its infancy. The isolation and synthesis of python pheromones for use in management, while potentially effective, may be a long way off.

Key Recommendations/Issues

Whereas eradication of the Burmese python population in Florida may be impossible, and effective management is costly, the lessons learned may help prevent the establishment of other invasive species. Other giant, non-native constrictors (e.g., African rock pythons, reticulated pythons) are imported to Florida via the pet trade, and have a similar potential for establishment with a large ecological impact. Given what we know about the difficulties in managing Burmese pythons, any steps taken to prevent the establishment of other giant constrictors are steps well-taken.

Management: Ambrosia Beetle/Laurel Wilt Case Study

Brief Species Description and Unique Challenges

Laurel wilt disease threatens to cause the extinction to the native redbay trees (*Persea borbonia*) swamp bay (*Persea palustris*) in the Everglades, and seriously impact commercial avocado (*Persea americana*) groves in South Florida. This has implications for the structural integrity of tree islands in the Everglades and bay trees are one of the most important cultural resources to the Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida.

The disease is caused by a fungus (*Raffaelea lauricola*) transmitted by an exotic insect, the redbay ambrosia beetle (RAB- *Xyleborus glabratus*). The beetle bores into healthy trees creating tunnels in the wood and inoculating with the fungus. Only trees that have a diameter of approximately 4 inches or greater attract the beetle. The tree's reaction to the fungus blocks water flow and results in wilting of leaves and quickly leads to the death of the tree. The beetle was introduced in Port Wentworth, Georgia, in 2002, spread rapidly down into Florida, and was first detected in Miami-Dade County in March 2010. Laurel wilt disease was discovered in swamp bays in February 2011 and by late 2013 dead swamp bays were observed throughout the southern Everglades.

Swamp bay is shrub or small tree that is a major component of many Everglades tree islands and is found in swamp forests, hammocks, and pinelands throughout the region. Swamp bay fruits are consumed by bears, deer, and many songbirds and the foliage is the larval food plant for the palamedes swallowtail butterfly. While the mammalian and avian frugivores are generalists, the only host plants for the swallowtail larvae are swamp bay and red bay, both of which are very susceptible to laurel wilt.

In areas with RAB, populations of red bay and swamp bay have experienced almost 100% mortality of mature trees within a few years of first appearance of laurel wilt symptoms. Given the rate of spread, it is expected that within a few years most, if not all, mature swamp bays within the Everglades ecosystem may be killed. Although the mature trees are likely to be killed, swamp bay often reacts to injury by basal sprouting, which should lead to young trees that initially won't attract the RAB. It is possible that the basal sprouting of swamp bays will create shoots from its roots that will allow the species to survive for an extended period, much like the American chestnut continues to survive as small resprouts.

Can the Issue be Resolved by Management?

Management of RAB and laurel wilt in the Everglades will not be easy, and may not be possible. Only one beetle is necessary to inoculate a tree with the fungi it hat is responsible for the death of a tree. Insect control, such as preventative insecticides, might be effective in an agricultural setting, but is not feasible in the Everglades. Given the current abundance of dead and dying bay trees already in the Everglades, it can be assumed that a large numbers of beetles are already finding their way to uninfected trees. Given enough time, the chances are that a beetle will find all the existing bay trees. Therefore, it seems that no practical way can prevent the spread of redbay

ambrosia beetle in or any feasible way to treat plants in the natural areas against the fungal pathogen.

What Would be the Facilitating Factors Needed for Success?

Success in the sense of slowing or reversing the effects of this exotic invasive are not likely, however, efforts can be focused on developing a recovery strategy. The first important step in a recovery strategy would be to find individual trees that are resistant to the RAB. This effort is underway for the red bay and needs to be extended to swamp bay. Two hypothesize are: 1) the tree may not be producing the appropriate chemical signal to attract the RAB; or 2) the tree is resistant to the fungal pathogen.

A recovery strategy would include efforts to document the spread of laurel wilt by aerial surveys and reporting from individuals in the field. It is recommended that a network of permanent plots be established throughout the Everglades to follow the progression of laurel wilt and search for resistant individuals that can potentially be cultivated.

Key Recommendations/Issues

We recommend that efforts to locate and propagate individual swamp bay trees that show resistance to the RAB and/or the laurel wilt fungus. Resident populations of swamp bay in the field will almost certainly disappear and the best chance to reestablish the species in the wild should be addressed through a comprehensive recovery plan.

Most Important Points (Lessons Learned)

The Everglades has begun to experience bay tree mortality that will impact tree islands and Tribal cultural uses. This needs to be documented and research initiated to understand the impacts to the natural system, including the response by individual trees, the species in general, and the implementation of the Comprehensive Everglades Restoration Plan.

The RAB has spread rapidly over the past decade and has led to the mortality of approximately five hundred million trees. Better communications across state, county and agency boundaries may have provided more awareness of this important invasive exotic species.

It is important to develop a comprehensive recovery plan that involves propagating resistant organisms and reestablishing them into the wild.

Photographer: Handout photo, courtesy of Sun Sentinel

http://okeechobee.ifas.ufl.edu/News%20columns/Red.Bay.htm

http://okeechobee.ifas.ufl.edu/News%20columns/Red.Bay.htm

Managing at the Wrong End of the Invasion Curve: Shoebutton Ardisia in the Miami-Dade County South Dade Wetlands Preserve

Introduction

Shoebutton ardisia (*Ardisia elliptica*) is an evergreen shrub/small tree native to Asia. Originally imported as an ornamental plant in the early 1900s, it has become a prolific invasive species that is very expensive to control. *A. elliptica* is now commonly found in short hydroperiod wetlands, hammocks and tree islands in Miami-Dade, Broward, West Palm, St. Lucie and Brevard Counties.[1] In the 1980s, *A. elliptica* was found in to be invasive within Everglades National Park. Since then, the extent and range of *A. elliptica* has expanded as it displaces both native and invasive exotic plant species. Because it impacts community structure and ecological function of native habitats, *A. elliptica* is a Category 1 invasive on the Florida Exotic Pest Plan Council Invasive Plant Lists. The desired outcome in managing this invasive species is to find and implement a cost-effective control.

Case Presentation

A. elliptica is a summer-flowering, fall-fruiting species that is closely related to the native marlberry (*Ardisia escallonioides*), an uncommon shrub found in South Florida hammocks. The native marlberry is not abundant because there is a native seed predator which renders up to 90% of its seed non-viable. There is no known seed predator in South Florida for *A. elliptica*. *A. elliptica* seeds are known to be dispersed by birds and raccoons.

First spotted outside Everglades National Park during vegetation mapping in 1990, *A. elliptica* expanded to several hundred acres by 1996. Today, there is approximately 4,000 acres of *A. elliptica* within and adjacent to the Miami-Dade County South Dade Wetlands Preserve, an important wetland system in the southern part of the County. Land in this area is targeted for acquisition and management by the County's Environmentally Endangered Lands (EEL) Program because of its strategic location between two national parks (Everglades and Biscayne National Parks) and within the watersheds of Florida Bay, Biscayne Bay and Card and Barnes Sounds. *A. elliptica* is also known to extend up the coast within Miami-Dade County, especially in coastal wetlands that are already impacted by Brazilian pepper or in areas that have been farmed in the past. A. elliptica spreads rapidly in nutrient enriched soils such as those that have been altered by farming, and also tolerates longer hydroperiods than Brazilian pepper.

Beginning in 2002, the EEL Program implemented a concerted effort to treat *A. elliptica* within the South Dade Wetlands Preserve, and that work continues today. The control effort is limited because not all of the land with the Preserve has been acquired, and invasive species present on private lands (including *A. elliptica*) are not being treated, so the private parcels act as a seed source. Control of *A. elliptica* is further complicated because field identification is difficult as the invasive strongly resembles the native marlberry and dahoon holly (*Ilex cassine*). Field crews must undergo training and gain practical experience so they properly identify species to treat.

Management Actions

In controlled studies, Garlon 3A® (triclopyr, amine salt form) was over 90% effective at reducing cover of *A. elliptica* with one application. The effectiveness rate of Garlon 3A is diminished in the field when plants in dense stands are inadvertently missed during treatment. Resprouting plants and massive seed germination with increased light after initial treatment requires repeated follow-up treatments. Arsenal® (imazapyr) has been used as an alternative supplement to Garlon 3A®, but Arsenal® is not appropriate for all habitats and can result in high non-target damage to some plants like buttonwood (*Conocarpus erectus*) and white mangrove (*Laguincularia racemosa*).

Detection of *A. elliptica* by aerial review is not effective, so finding infestations can be difficult in remote areas and requires ground verification.

On average, initial control of *A. elliptica* has cost up to $11,000 per acre for selective hand treatment by a crew of 6 individuals walking an area looking for and treating seedlings, saplings and trees. After initial treatment opens up the canopy, the *A. elliptica* seed bank responds to increased light levels and second year treatments can cost up to $9,000 per acre to address all the new seedlings. By the third year, most of the seed bank is being exhausted and the cost decreases to less than $6,000 per acre, with subsequent annual maintenance treatments averaging between $1,000 to $1500 per acre. In native dominated wetlands, treatments must occur every three to four years because the *A. elliptica* is co-located with listed and rare species that will be displaced if the habitat is not maintained free of invasive species. The EEL Program has treated over 350 acres through selective hand treatment and follow-up maintenance activities.

With selective hand treatment by crews, the control costs for *A. elliptica* were too high to be sustainable over 4,000 acres. To reduce costs in areas that are dominated by invasive vegetation, treatment efforts are now being used to manipulate the habitat to make it less suitable for *A. elliptica*. In dense stands of *A. elliptica*, the current strategy is use a gyrotrack or brontosaurus mulcher to mulch both native and exotic woody material, with follow up mowing and aerial spraying. The land is allowed to convert to prairie, which then can be maintained through the application of prescribed fire. The EEL Program has successfully converted 26 acres to prairie, with another 22 acres in process. This treatment method has averaged about $3,000 per acre for mulching, and not more than $300 acre for mowing or aerial spraying. In three years, there has been significant recruitment of native grasses. While not yet applied, prescribed fire is expected to cost less than $100 per acre. As a side note, it is important to use proper phytosanitation/equipment decontamination practices when bringing in heavy equipment. Some exotic grasses can be brought in unintentionally, especially on mowers. Additionally, mulching is preferable to land clearing and grubbing because soil disturbance may also result in new infestations of nuisance species like cattails (*Typha sp.)*.

A primary management goal of the EEL Program is to reduce the amount of exotics-dominated forested wetlands to provide for a diverse ecological community, including habitat for listed ferns, bromeliads and orchids. A critical component of this management goal is to reduce coverage of *A. elliptica* to make control cost-effective and feasible in the long-term. This is especially important because there is no biocontrol currently being developed, and development of a biocontrol would be complicated by the presence of an uncommon native in the same genus. In total, the EEL Program has spent almost $5 million to control *A. elliptica* and other associated invasive species in the South Dade Wetlands since 2000.

Key Recommendations

More research on the demographics and life cycle of *A. elliptica* is needed. Specific information on the relationship to soil nutrient characteristics, response to prescribed fire, seed banks and vectors can all inform management decisions and help to reduce management costs. Most importantly, consistent and sustained funding is needed to help bring this species under permanent control. Funding comes in cycles, but the invasion doesn't stop or slow without active management. Lacking sustained and sufficient funding, land managers are forced to prioritize their management strategies, which often means choosing whether to maintain what has already been restored or respond to new or expanding threats.

1. Shoebutton ardisia (*Ardisia elliptica)*, University of Florida – IFAS
http://plants.ifas.ufl.edu/node/43

Grass prairie recruitment after brontosaurus treatment of A elliptica in Miami-Dade County.

3 Hand treatment of A elliptica by Miami-Dade County crew.

4 Brontosaurus treatment of A elliptica in Miami-Dade County

FWC Amnesty Program

Introduction

The Florida Fish and Wildlife Conservation Commission's Exotic Pet Amnesty Program is an innovative effort that provides exotic pet owners with an opportunity to surrender or re-home their exotic pet. The goals of the Exotic Pet Amnesty Program is to reduce the number of exotic pets released in Florida and provide amnesty for animals that require permits, including conditional species such as the Burmese python. The program also serves to provide education and outreach to regarding responsible pet ownership and exotic species in Florida.

Case Presentation

The Exotic Pet Amnesty Program was started in 2006 as periodic one-day-only events across the state of Florida where people could come and surrender their exotic animals, no questions asked. Surrendered animals were then looked over by volunteer veterinarians and all healthy animals were held for adoptions later that same day. These events were linked with multiple exhibitors providing people with the opportunity to learn more about exotic species and animal care. In later years, events were combined with existing festivals and outreach events. Avoiding the responsibility of long-term housing of the animals allows the Exotic Pet Amnesty Program to be successful with a low budget. This program also relies heavily on volunteers from outside organizations.

The occurrence of Exotic Pet Amnesty Program events has been increased over the last few years with 15 of the 25 total events taking place in the last 3 years. Additionally, the distribution of the events has been expanded with the first Florida panhandle event in 2013. With the increased number and location of Exotic Pet Amnesty Program events, the number of animals placed into new homes through the program has also increased. In total, from 2006 – 2013, 1705 animals have been placed into new homes through the Exotic Pet Amnesty Program. Over 1,000 of those animals were placed within the last 3 years.

Also, the increase in event number and location has allowed the Exotic Pet Amnesty Program to act as a catalyst to inform the public about the dangers of releasing nonnative animals into the wild. The ability to reach the public through this program has been widely successful.

Management Actions and Outcomes

The Exotic Pet Amnesty Program has evolved and improved over the program's history. For instance, at early events, animals were adopted by people vetted that same day, as the program has grown the adopter application process has become more sophisticated. Now a database is kept of approved Exotic Pet Amnesty Program adopters across the state of Florida. This database allows us to search specific counties for adopters interested in specific categories of animals and helps to make adoptions outside of amnesty events possible. By having online applications and time to vet adopters before events allows us to verify their permits and check for any wildlife violations prior to approving them as an adopter with our program.

Additionally, in October of 2010, a grant from the National Park Service (NPS) increased dedicated funding to the Exotic Pet Amnesty Program which facilitated the introduction or improvement of key factors including the hiring of a new staff member and the purchase of an amnesty specific trailer.

Using funding from the NPS grant, a part time (20 hours per week) operator was hired to answer the Exotic Species Reporting Hotline (1-888-Ive-Got1). As part of the program, the operator would also facilitate amnesty adoptions through the hotline as they were received. With the addition of the hotline, and staffing to monitor the hotline, the number of animals placed through the program increased dramatically. 469 animals have been placed into new homes through the hotline since it has been in operation as an Exotic Pet Amnesty Program tool. It should be noted that during this same time period 593 animals were placed into new homes through Exotic Pet Amnesty Program Events. Thus, the effectiveness of the program was nearly doubled with the addition of the hotline and staff to facilitate adoptions through the hotline.

Using grant funding, a trailer was purchased to comfortably house surrendered animals safely and securely during an event. This trailer was created specifically for the Exotic Pet Amnesty Program making it very useful for the programs unique needs. The trailer contains multiple 'snake racks' along one wall which can be used to house animals in a low stress and comfortable environment throughout an event. On the opposite wall the trailer has shelving which allows space for larger cages to be stored during the event. The rear door of the trailer becomes a ramp so people can enter through the rear and exit through the front side door, improving the flow of an event during the adoption period. The trailer also has aero roof vents and a quiet, induction generator which allows the vehicle to be cooled and heated as needed to keep the animals comfortable during an event. The trailer is mobile and can be transported across the state to be used at all Exotic Pet Amnesty Day Events. Additionally, the size of the trailer makes it a usable billboard to promote the program while it is being transported from one event to another.

Key Recommendations/Issues

The Exotic Pet Amnesty Program has been successful as a tool for preventing the release of exotic pets in Florida by facilitating the adoption of 1,705 animals since 2006. Additionally, 87 conditional constrictors were placed into permitted facilities though this program, including 79 Burmese pythons. As with all programs and projects, improvement would be possible particularly with the addition of dedicated staff and increased outreach campaigns to attract potential adopters and educate areas that haven't yet hosted an Exotic Pet Amnesty Day event.

VI. Authorities Matrix

Invasive Species Function	Authorities	Agencies	Responsibilities
Prevention	Miami-Dade County Comprehensive Development Master Plan, Conservation, Aquifer Recharge and Drainage Element and Coastal Management Element Miami-Dade County Code, Chapter 8CC Code Enforcement; Chapter 18A Landscape Ordinance; Chapter 18B, Right-of-Way Landscape Ordinance; and Chapter 24, Environmental Protection; Chapter 26 Park and Recreation Department Rules and Regulations; and Chapter 33B Areas of Critical Environmental Concern		
EDRR	Miami-Dade County Comprehensive Development Master Plan, Conservation, Aquifer Recharge and Drainage Element and Coastal Management Element Miami-Dade County Code, Chapter 8CC Code Enforcement; Chapter 18A	Miami-Dade County	As formal ECISMA partner (signatory to the ECISMA MOU), County staff from various departments participate in various EDRR initiatives throughout the ECISMA region

	Landscape Ordinance; Chapter 18B, Right-of-Way Landscape Ordinance; and Chapter 24, Environmental Protection; Chapter 26 Park and Recreation Department Rules and Regulations; and Chapter 33B Areas of Critical Environmental Concern		
Containment	Miami-Dade County Comprehensive Development Master Plan, Conservation, Aquifer Recharge and Drainage Element and Coastal Management Element Miami-Dade County Code, Chapter 8CC Code Enforcement; Chapter 18A Landscape Ordinance; Chapter 18B, Right-of-Way Landscape Ordinance; and Chapter 24, Environmental Protection; Chapter 26 Park and Recreation Department Rules and Regulations; and Chapter 33B Areas of Critical Environmental Concern	Miami-Dade County Division of Environmental Resources Management Environmentally Endangered Lands Program and Miami-Dade County Parks Recreation and Open Spaces Department, Natural Areas Management; and Miami-Dade County Fire Department, Venom One Unit	As formal ECISMA partner (signatory to the ECISMA MOU), County staff from various departments participate in various EDRR initiatives throughout the ECISMA region Additionally, within Miami-Dade County, the listed agencies actively work to prevent the spread of invasive exotics on almost 25,000 acres of public lands.
Management	Miami-Dade County Comprehensive Development Master Plan, Conservation, Aquifer Recharge and Drainage Element and Coastal	Miami-Dade County Division of Environmental Resources Management Environmentally Endangered Lands	Within Miami-Dade County, the listed agencies actively work to reduce the populations of widely established invasive exotics to the lowest levels allowable

	Management Element Miami-Dade County Code, Chapter 8CC Code Enforcement; Chapter 18A Landscape Ordinance; Chapter 18B, Right-of-Way Landscape Ordinance; and Chapter 24, Environmental Protection; Chapter 26 Park and Recreation Department Rules and Regulations; and Chapter 33B Areas of Critical Environmental Concern	Program and Miami-Dade County Parks Recreation and Open Spaces Department, Natural Areas Management	given available resources spread over almost 25,000 acres of public lands.