Invasive Exotic Species

Strategic Action Framework

2020

South Florida Ecosystem Restoration Task Force

DRAFT

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INVASIVE EXOTIC SPECIES STRATEGIC ACTION FRAMEWORK

EXECUTIVE SUMMARY

The South Florida Ecosystem Restoration Task Force (Task Force) was established by Congress to coordinate the numerous restoration efforts being planned and implemented throughout the Everglades ecosystem. The Task Force, along with its Florida-based Working Group and Science Coordination Group, brings together federal, state, tribal, and local agencies involved in restoring and protecting the Everglades. The Task Force provides a forum for sharing information, engaging stakeholders, identifying emerging issues, resolving conflicts, and reporting on restoration progress.

The Task Force, recognizing the serious threats to the Everglades posed by invasive exotic plants and animals, has established this Invasive Exotic Species Strategic Action Framework (Framework). The Framework was developed by an extensive and diverse set of partners including members of the Task Force, Working Group, Science Coordination Group, and the Everglades Cooperative Invasive Species Management Area (ECISMA). The Department of the Interior's Office of Everglades Restoration Initiatives (OERI) coordinated the development of the original 2015 Framework as well as this 2020 update.

The Framework seeks to help decision-makers understand the connections between goals, strategies, and tactics; maximize the extent to which the current capacity for partnership is leveraged to meet common goals; and help decision-makers make wise and timely investment decisions in the battle against invasive exotics.

The South Florida Ecosystem is Unique–and Uniquely Vulnerable

The Everglades, ecologically unique and imperiled by numerous threats, is the subject of the world's largest ecosystem restoration program. In addition to its unique natural environment, the South Florida Ecosystem is also characterized by:

- a culturally diverse population of almost 9 million residents, including two Native American tribes,
- world renowned recreational opportunities, and
- a strong agricultural and tourism-based economy.

Florida is particularly vulnerable to the introduction, invasion, and establishment of non-native species because of its subtropical climate; the existence of major ports of entry; already impacted ecosystems; and the large-scale pet, aquarium, and ornamental plant industries active in the region. The threats posed by invasive exotic species are growing,

and if left unaddressed or inadequately addressed, could threaten the success of ecosystem restoration and the sustainability of the region.

Threats are beyond the Ability of any Single Agency or Effort to Address

Combating invasive exotic species in the South Florida Ecosystem is daunting in terms of geographic scale, diversity of invasive exotic species, technical challenges, and required coordination and resources. The 18,000 square mile South Florida Ecosystem is infested with many emerging and widely established invasive exotic species spanning the jurisdictions of multiple agencies, tribes, and private industries.

We Need Swift Action, Vigilant Stewardship, and Adequate Recurring Resources to Succeed

Delay is costly.

- Swift action against newly detected invaders can save significant public resources and substantially reduce impacts to natural resources.
- If the window for swift action is missed, and eradication becomes unlikely, a lasting commitment to the management of the invasive exotic species will be needed.
- The long-term commitment of adequate resources is vitally important, along with strategic and coordinated implementation.

A Strategic Action Framework Enhances our Collective Efforts to Combat Invasive Exotic Species

The Framework builds on the large body of work already completed on invasive exotic species and the many plans that have been written to address individual species and areas of concerns within the South Florida Ecosystem. The Framework delineates our shared goals, objectives, and strategies for successfully combating invasive exotic species. Associated tools, including a comprehensive list of current and needed actions, progress made since 2015, and a snapshot budget, complement this Framework and ensure that we are working in a coordinated way at all levels toward our shared goals and objectives.

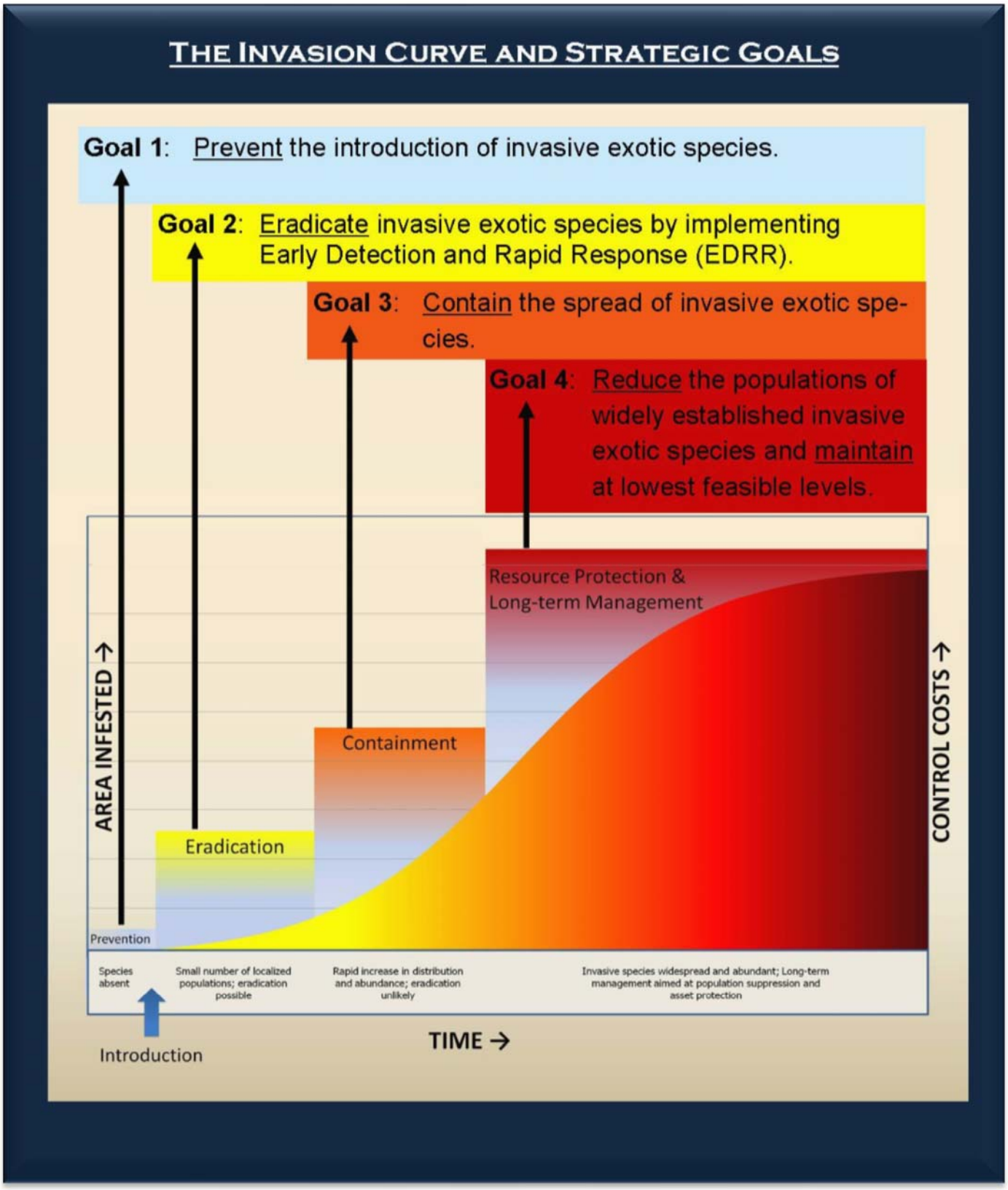
Our Organizing Principle: The Invasion Curve

The key to tackling a problem as complex as invasive exotic species is to prioritize both threats and solutions, and to identify the relative cost of our prioritization choices. Fortunately, a tool already exists that can be applied to the invasive exotic species problem in the South Florida Ecosystem. The Invasion Curve (Fig. 1), first developed by experts in Australia and broadly accepted and applied, organizes the battle against exotics into four phases: 1) Prevention, 2) Eradication through Early Detection and Rapid Response (EDRR),

3) Containment, and 4) Long-Term Management/Resource Protection. The curve also shows the relationship of each of these phases to the duration and extent of the invasion, and the costs of addressing it. ***The Invasion Curve tells us that the longer we wait to address a particular invasion and the more widespread that invasion becomes, the more expensive it is to address.*** The Invasion Curve also tells us that, in general, the most cost-effective approach to controlling invasive exotic species is to prevent the introduction of the species in the first place. If prevention is not possible, EDRR is the next most cost-effective strategy to employ. If opportunities to prevent or swiftly eradicate the species are missed, costs of addressing the invasion begin to rise very quickly. Once a species has crossed into the yellow and red zones of the Invasion Curve, the costs of management are high and perpetual. For some of south Florida's "red zone" species, like Burmese pythons, even if agencies had unlimited resources with which to address the problem, science cannot yet tell us how to effectively reduce populations, let alone to reduce them to the lowest feasible levels. In such cases, the costs of the invasion include needed research as well as the costs associated with the impact of the invasion such as environmental and agricultural harm, human health risk, and loss of cultural resource values.

The goals of the Framework correspond to the four phases of the Invasion Curve. Each goal is supported by broad strategies and specific actions to meet the goal, as well as case studies to help identify lessons learned. The Framework is also based on the following overarching **key principles**:

- Science should provide the foundation for our strategies within every phase of the Invasion Curve.
- Success will require interagency cooperation, innovative partnerships, and an informed and involved public.
- A successful invasive exotic species program requires the long-term commitment of adequate and consistent resources.

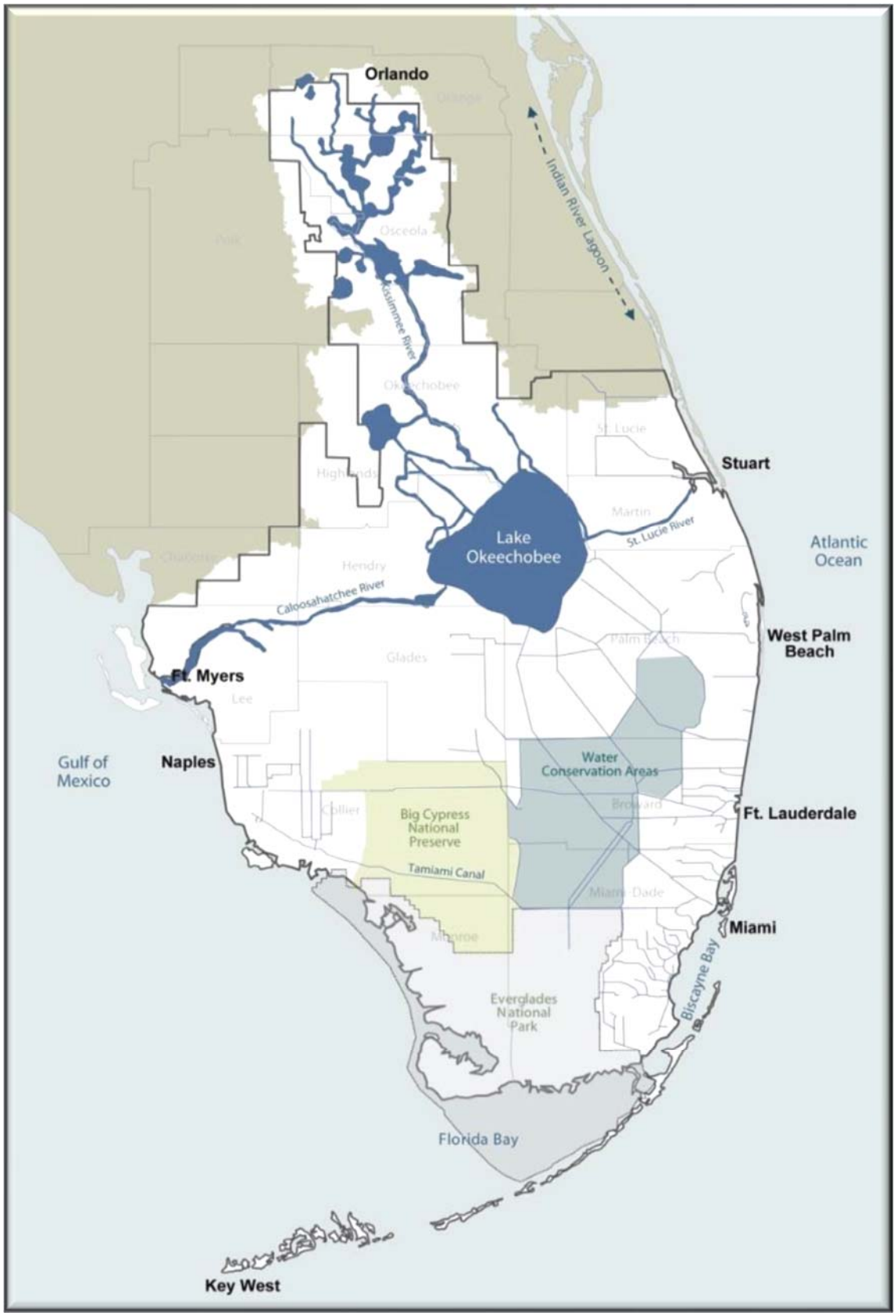


The Invasion Curve. Adapted from: Department of Environment and Primary Industries. 2010. Invasive Plants and Animals Policy Framework. Victoria, Australia.

TABLE OF CONTENTS

Executive Summary ..... **iii**
Introduction **1**
How Invasive Exotic Species Affect the South Florida Ecosystem 1
The Everglades 2
The Regional Economy 3
Native American Culture 4
What are Invasive Exotic Species and How Do They Get Here? 5
The Invasion Curve **6**
Vision, Key Principles, and Strategic Goals **7**
Goal 1: Prevent the Introduction of Invasive Exotic Species. 8
Goal 2: Eradicate Invasive Exotic Species through Early Detection and Rapid Response (EDRR). 10
Goal 3: Contain the Spread of Invasive Exotic Species. 12
Goal 4: Reduce the Populations of Widely Established Invasive Exotic Species and Maintain at Lowest Feasible Levels. 14
Conclusion **17**
Literature Cited **18**

The South Florida Ecosystem



INTRODUCTION

In 1995, Florida Governor Lawton Chiles' Commission for a Sustainable South Florida recognized that the environment and the economy are both pillars of regional sustainability and since then, the term "South Florida Ecosystem" has been recognized as encompassing both the natural and built systems. The South Florida Ecosystem includes many diverse areas, such as the Everglades and Miami; sugar farms and oyster beds; highways and wetlands. This concept is a fundamental tenet of the Task Force and therefore the Framework uses the term South Florida Ecosystem in this inclusive way. The term "Everglades" in the Framework refers solely to the natural system.

The South Florida Ecosystem includes the area encompassed by the boundary of the South Florida Water Management District (SFWMD), as well as the coastal and marine ecosystems that are ecologically connected to the mainland. The region covers more than 18,000 square miles, includes all or part of sixteen counties, and is home to a population of nearly nine million. The South Florida Ecosystem also includes sovereign and perpetual lease tribal lands of two federally recognized Tribes, contains one of the most important agricultural industries in the country, and supports a world-renowned tourism and recreational industry.

The natural habitats in the region, including coastal, estuarine, and reef habitats, are *all* part of the Everglades, a vast, globally renowned and unique watershed that is the subject of the world's largest ecosystem restoration program. The Everglades is divided into several protected areas including three national parks, a national preserve, 18 national wildlife refuges, a national marine sanctuary, and extensive conservation lands managed by state and local government agencies. It is also home to more than 70 threatened and endangered species.

How Invasive Exotic Species Affect the South Florida Ecosystem

With its mild climate, diverse environments, multiple ports of entry, and dense human population centers, the South Florida Ecosystem is particularly vulnerable to the introduction, invasion, and establishment of non-native species. A small number of these non-native species eventually become aggressively invasive and spread into neighborhoods, farms, and natural areas. Once established, the most aggressive invasive species can displace native species, alter ecosystem structure and function, change food web dynamics, degrade critical wildlife habitat, introduce diseases to native species, exert additional pressures on threatened and endangered species, and threaten cultural values, recreational opportunities, and economic interests vital to the health of the entire State of Florida.

The Everglades

America's Everglades is vulnerable to exotic species invasion because it is 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 South Florida climate and in the vast wilderness of the Everglades. The abundant water and food and warm temperatures provide perfect conditions for many species, giving them a foothold in Florida and the United States. In contrast, the natural mechanisms that control species in their native ranges, such as predators, diseases, and environmental conditions, often do not exist in South Florida. Without these mechanisms to keep introduced populations in check, some exotic plant and animal populations can become established and rapidly expand into new areas.

Burmese pythons are generalist predators, capable of eating most 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 (e.g., wood stork, Key Largo wood rat) are at risk of extinction because of their already low population sizes or limited geographic distribution. Evidence suggests that many prey populations (e.g., raccoons, opossums) have declined dramatically since the Burmese python's introduction.
Photo: Roy Wood, ENP.

Invasive exotic species are detrimental to the Everglades causing: 1) direct harm to native species through predation; 2) indirect harm by disruption of the food web and competition for resources; 3) harm and irreparable loss of threatened and endangered species, and 4) physical changes to habitats and ecological processes. The photos on this page illustrate some of these impacts.

An American crocodile, a federally threatened species in Florida, is observed laying eggs by a wildlife camera (left). An invasive exotic Argentine black and white tegu, a species known to predate upon reptile eggs, is later observed on the same camera near the crocodile eggs (right). Photo: Michelle McEachern.

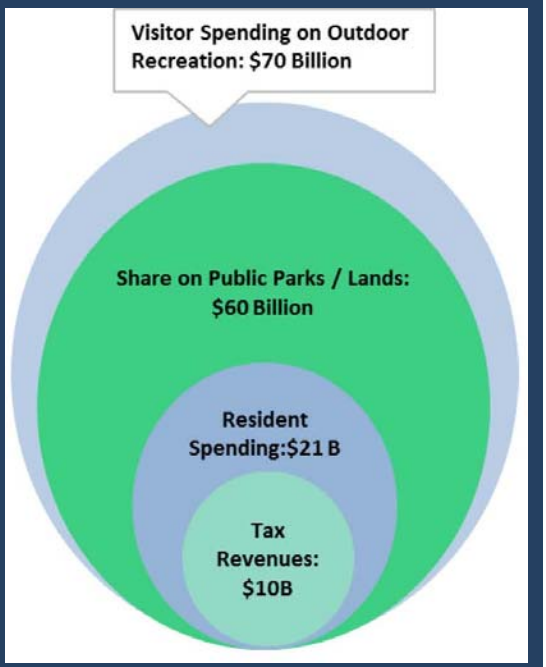
The Regional Economy

Agriculture, tourism, and recreation are among Florida's most important economic sectors and each face both direct and indirect threats from invasive exotic species.

Agriculture: Florida agriculture covers over nine million acres within the state and generates more than $120 billion in annual economic impact for the state (FDACS 2016). Economic losses due to invasive exotic species include direct, indirect, and induced costs to crops and livestock and represent a significant challenge to the agricultural sector of Florida's economy. These pests range from weeds to pathogens, insects, and feral pigs. In addition to the financial costs, food security, trade, human health, markets and pricing, and domestic production are all impacted by invasive exotics.

Laurel wilt disease (LWD), a deadly disease affecting trees in the Laurel family, was first detected in the southeastern U.S. in 2002 and is now found throughout Florida. Spread by the invasive exotic redbay ambrosia beetle, LWD is also impacting Florida's $100 million avocado industry, which is primarily based in Miami-Dade County. Of the 7,400 acres in production in 2012, 1,200 acres (120,000 trees) have been lost to LWD. This equates to $42 million in lost trees in addition to the associated losses in crop production and grower costs for ongoing LWD treatment, management, and research (Ballen and Evans 2019).

Spending and Tax Revenues Generated by Florida Outdoor Recreation



Source: Seidel, et. al. 2017.

Tourism/Recreation: A record 126 million tourists visited Florida in 2018, contributing $91.4 billion to Florida's Gross State Product (Rockport Analytics 2020). The Florida Outdoor Recreation Participation Survey (Magnini and Wyatt 2017) showed that a vast majority of both residents (95%) and visitors (98%) believe that outdoor recreation is important to them, with wildlife viewing and hiking ranked in the top six outdoor recreational activities, along with beach activities. A recent study on the economic impact of outdoor recreation found that $145 billion in total economic output was produced by outdoor recreation in Florida over a twelve-month period (Seidel, et al. 2017).

Invasive exotic species can significantly diminish both active and passive recreational opportunities, thereby causing economic impacts. Venomous lionfish invasions may make certain areas unsafe for divers, impacting tour providers. The prevalence of python coverage in the news media has made some members of the public wary of even visiting the Everglades. A more calculable direct impact involves non-native aquatic plants that can form impenetrable barriers that obstruct water flow and navigation and impact fishing and water sports. Almost $125 million was spent between 2008 and 2015 on aquatic plant management. Over half of those funds ($66 million)

were used for the invasive hydrilla, a particularly aggressive rooted submerged plant (Gettys and Enloe 2019).

Native American Culture

The Miccosukee Tribe of Indians of Florida and Seminole Tribe of Florida are federally recognized Native American tribes residing in the Everglades; their presence predates Columbus. The Everglades is not only a home to the people of these tribes, but the source of spiritual and cultural wellbeing. Invasive exotic species have a direct impact on that wellbeing by the displacement or destruction of traditional physical settings, the loss of medicinal and ceremonial plants, and the loss of traditional foods.

Many invasive exotic plants physically disrupt and can even replace native vegetation. Exotic plants such as melaleuca, Brazilian pepper tree, and Old World climbing fern form thick stands that crowd out native vegetation and degrade important wildlife habitat. Tree islands are a particularly important resource used by tribes for ceremonial purposes. Swamp bay trees are keystone species meaning that other species in the ecosystem depend upon them. Swamp bays are critically important to the structure of many tree islands. These trees are currently under attack from laurel wilt disease which alters many Everglades tree islands and opens the canopy up to further invasion by other exotic species, severely impacting one of the tribes' most important cultural resources.

Significant tribal resources are expended on an annual basis to treat heavily infested areas and manage levels of exotic vegetation within community areas and native habitats used for cultural and medicinal practices. Pastures and agricultural practices on tribal lands are also greatly impacted by invasive exotic plants such as cogon grass, tropical soda apple, and Brazilian pepper tree. Without active management, these invasive exotic species can significantly reduce the grazing capacities of pastures.

Laurel wilt disease. Source: okeechobee.ifas.ufl.edu/News%20columns/Red.Bay.htm

Seminole Elder. Source: Cover of the Florida Folk Arts Apprenticeship Program 1984-1985.

What are invasive exotic species and how do they get here?

A Presidential Executive Order (EO 13112) was signed in 1999 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 the Framework 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.**

Pathways are the means by which species are transported from one location to another. These include natural pathways, such as wind and currents, and man-made pathways, such as the deliberate or unintentional importation of plants and animals through international commerce or transport (Fig. 1). Globalization of trade and advances in transportation technology have dramatically increased the movement of live organisms across oceans, continental divides, and other natural migration barriers. Some of these species are well-adapted to their introduced environment and are able to proliferate and cause significant changes to their new environment.

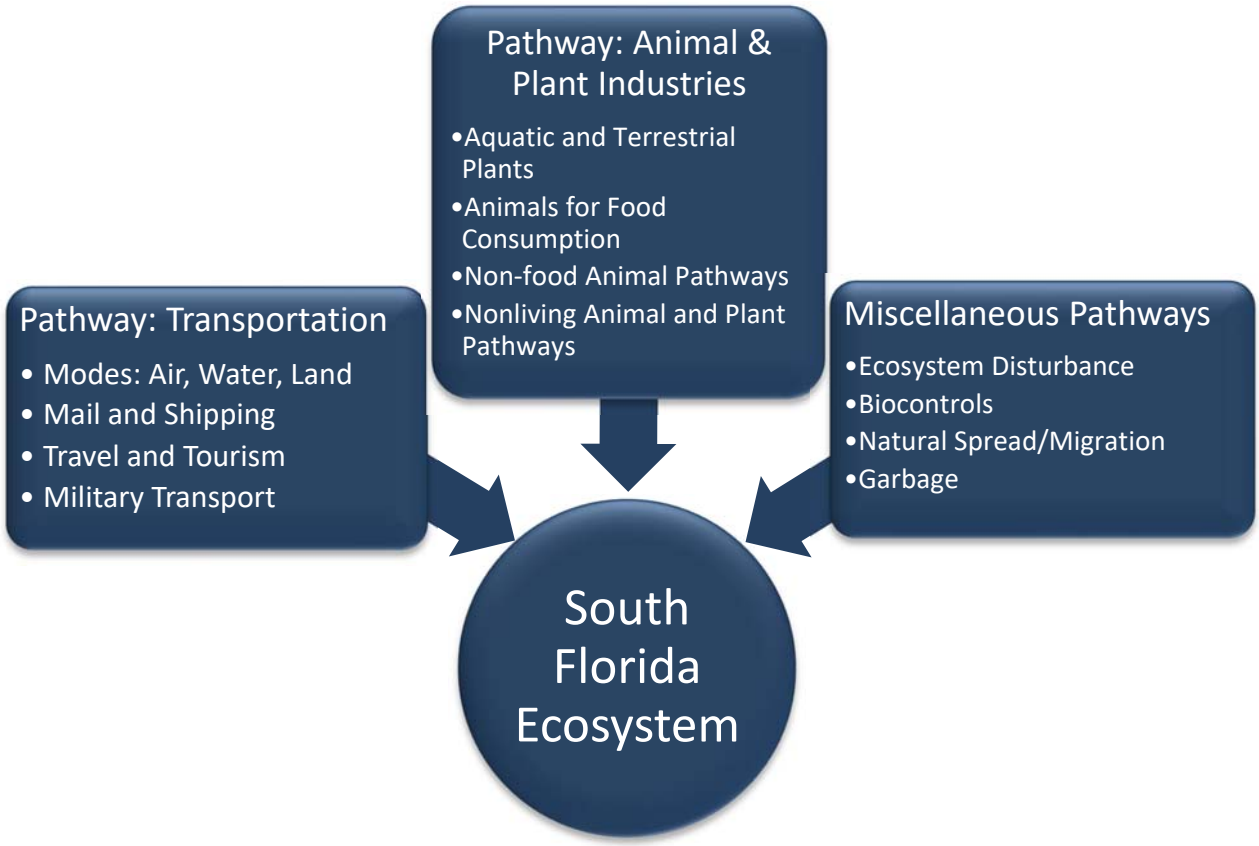


Figure 1. Invasive Exotic Species Pathways. Adapted from the National Invasive Species Council Pathways Work Team's Ranking Guide (2005).

THE INVASION CURVE

The Invasion Curve has been selected as the organizing principle for the Framework. It depicts, at a glance, the costs and benefits associated with combating invasive exotic species across time and geography (Fig. 2). In short, costs increase the longer a species is established and the greater the geographical extent of the invasion. **The left-hand side of the Invasion Curve represents the most cost effective and environmentally sound approach to invasive species management.** Since eradication of widely established invasive exotic species is rarely achieved, a long-term commitment to controlling established species is required to protect the natural resource. Long-term suppression of these established species is a challenge and is costly. Thus, early detection of new invasive species results in lower overall environmental impact and economic cost along with a higher likelihood for eradication. Variations of the Invasion Curve have also been used to portray actions to be taken against a specific invasive exotic species.

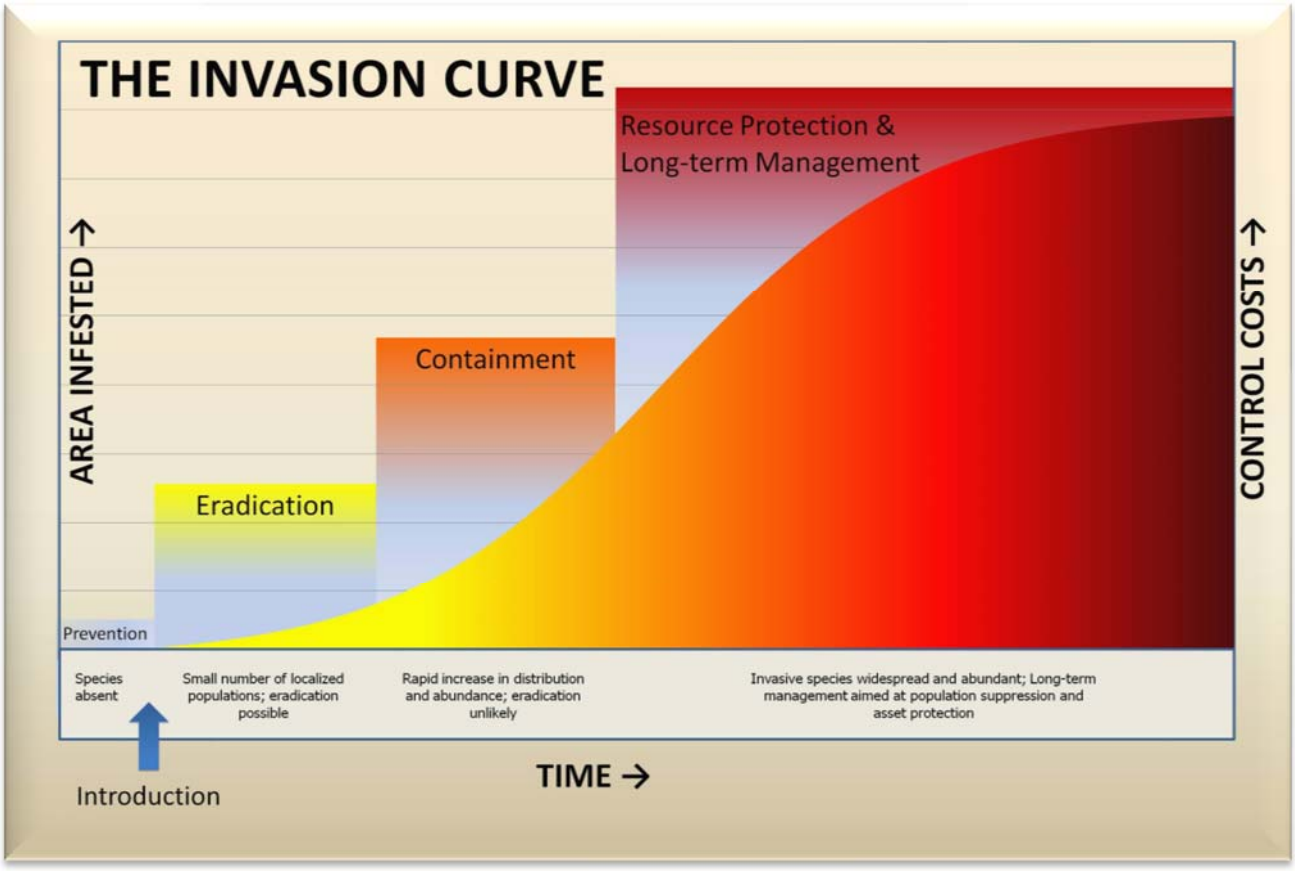


Figure 2. The Invasion Curve. Adapted from: Department of Environment and Primary Industries. 2010. Invasive Plants and Animals Policy Framework. Victoria, Australia.

The Invasion Curve identifies four major categories of management actions to combat invasive exotic species: Prevention, Eradication, Containment, and Long-Term Management/ Resource Protection. The first opportunity to combat an invasion is to prevent it in the first place. Prevention strategies include regulation, border protection, public engagement, and public-private partnerships. If prevention is not possible or the opportunity to prevent an invasion is missed, the next approach is eradication. Eradication requires that the species be detected early in the invasion process, that the risk it poses is assessed quickly, and that sufficient tools and resources are available to respond rapidly to the invasion. This process is known formally as Early Detection and Rapid Response (EDRR). Eradication through EDRR is the second most cost-effective way to address invasive exotic species. Once the populations increase and become distributed over a large area, eradication is far less feasible. At this point, natural resource managers generally shift their management strategy 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 to lowest feasible levels in order to mitigate the impacts of the invader on natural resources, economic interests, and human health.

Each portion of the Invasion Curve is linked to a specific strategic goal in the Framework. The four goals are supported by objectives, strategies, actions, and case studies, including implementation tools such as research, outreach/education, and coordination.

VISION, KEY PRINCIPLES, AND STRATEGIC GOALS

The Framework is guided by a vision statement that succinctly defines success 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.

Underlying this vision are three **key principles**:

- Science should form the foundation for our strategies within every phase of the Invasion Curve.
- Success will require interagency cooperation, innovative partnerships, and an informed and involved public.
- A successful invasive exotic species program requires long-term commitment of adequate resources.

From the vision statement and key principles, four strategic goals were developed based on the four phases of the Invasion Curve: Prevention, Eradication, Containment, and Long-term Management/Resource Protection.

Goal 1: Prevent the Introduction of Invasive Exotic Species.

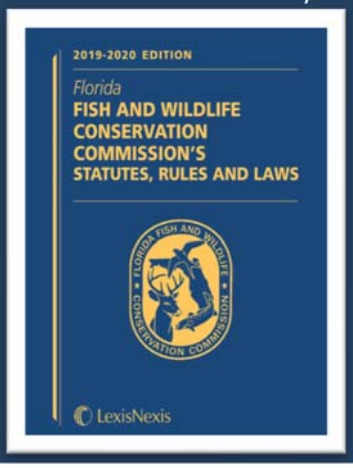
Preventing introductions of new invasive exotic species is the most cost-effective strategy and can yield benefits provided funding and current barriers are addressed up front.

Preventing the introduction of invasive exotic species protects the South Florida Ecosystem from the negative ecological and economic impacts of those species and the subsequent high costs associated with long-term control efforts. Prevention requires the ability to identify pathways and **prepare** for risks in order to stop the identified species from entering the South Florida Ecosystem. A better understanding of pathways can lead to more robust and effective measures that prevent introductions before they produce significant economic and ecological damages, while simultaneously protecting safe commerce. The ability to **prioritize** prevention efforts will rely on technical expertise and tool development, including an effective system of risk screening and assessment.

Preventing the introduction of potential harmful invasive exotic species will rely upon a cooperative and cohesive multi-jurisdictional approach to fortify the ecosystem from invasion. Securing current and potential pathways will require enhanced import screening and risk assessment tools, development of new voluntary and regulatory tools, and maximum utilization of existing voluntary and regulatory tools. Engaging the public, through such programs as *Don't Pack a Pest*, is also key to successful prevention.

Prevention through Regulation

Risk screenings and assessments are important tools for invasive species prevention. The Florida Fish and Wildlife Conservation Commission (FWC) utilizes these tools to identify high-risk nonnative wildlife species that pose a high-risk to Florida if introduced into the state. In 2020, the FWC added several species to the state's Prohibited list, including three anacondas. These species are also regulated by the U.S. Fish and Wildlife Service as Injurious Species under the federal Lacey Act.



Exotic Pet Amnesty Program

The FWC's Exotic Pet Amnesty Program is an innovative effort that provides exotic pet owners with a legal opportunity to surrender or re-home their exotic pets without cost or penalty. The goals of the Exotic Pet Amnesty Program are to reduce the number of exotic pets released in Florida and provide amnesty for pet owners that have exotic pets they can no longer keep, whether or not they are kept legally. Species that require permits to possess, including species such as the Burmese python, can be surrendered through this program. The program also serves to provide education and outreach regarding responsible pet ownership and invasive exotic species in Florida.

Goal 1: Prevent the Introduction of Invasive Exotic Species.

PREPARE & PRIORITIZE

Objective 1A: Prepare for and prioritize prevention efforts.

Strategy 1A1: Identify pathways and prioritize potential threats and invasive exotic species.

Strategy 1A2: Engage stakeholders and the public to support prevention efforts.

PREVENT

Objective 1B: Prevent entry of invasive exotic species.

Strategy 1B1: Enhance and improve the pathway inspection/screening process.

Strategy 1B2: Develop new, and utilize existing, voluntary and regulatory tools.

Strategy 1B3: Improve pathway awareness and engage the public in prevention efforts.

Prevention through Border Inspection/Interdiction

The interdiction of invasive exotic species is partly under the jurisdiction of the U.S. Customs and Border Protection (CBP) and the U.S. Department of Agriculture (USDA). The CBP and USDA are responsible for protecting our agricultural and economic interests from harmful pests and disease import and have teams that inspect cargo at the ports of entry in Florida. The U.S. Fish & Wildlife Service Office of Law Enforcement and the Florida Fish and Wildlife Conservation Commission have staff that work to prevent the import or export of endangered species and the illegal import of nonnative species. These agencies coordinate when interdiction falls in another agency's jurisdiction.

The scale of the job these agencies face is staggering. Over six million tons of perishable cargo enter Florida each year. Over 85% of the plants imported to the U.S. go through Miami (Dixon 2009) and agricultural trade and pest interceptions at Florida's ports of entry have been doubling every five to six years (Klassen 2005). Photo: CBP.

Don't Let it Loose

The US Army Corps of Engineers has been working with the Don't Let it Loose campaign to create posters, handouts, and stickers specifically for Florida to educate pet owners about the importance of responsible pet ownership. More information will soon be available on DontLetItLoose.com, under the Florida tab.

Goal 2: Eradicate Invasive Exotic Species by Implementing Early Detection and Rapid Response (EDRR).

Successful early detection and rapid response (EDRR) of newly established invaders requires formal collaboration and dedicated staff and funding.

It is imperative to respond quickly and deal with emerging threats while they remain localized**.** Eradication through EDRR is the second most cost-effective method to deal with invasive exotic species, after prevention.

EDRR efforts should begin before species are identified in the South Florida Ecosystem. According to the Everglades Cooperative Invasive Species Management Area'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." **Preparation and monitoring** are conducted in order to identify invasions as early as possible. Early detection requires effective communication between experts, responders, and the public and should seamlessly connect to the assessment and rapid response phases of EDRR.

Once a new invader is detected, **rapid assessment** should occur so that the response priority can be determined. All of the prior steps should enable a **rapid response** to identified threats. Eradication depends upon dedicated funding and an effective logistical framework in order to be able to quickly respond to threats. Barriers, such as permitting issues and authorities for responders, must be identified and solutions found to ensure rapid response and increase our ability to eradicate the species.

An EDRR Success Story

The **New World screwworm fly**, poses a significant threat to livestock and other mammals. If left untreated, screwworm infestations can be fatal. A recent occurrence of the fly in the Florida Keys spurred a successful, interagency EDRR effort. The outbreak impacted endangered key deer on the National Key Deer Refuge. The coordinated effort was an excellent example of EDRR to a newly detected, highly invasive species. A main reason for success was the establishment of a unified Incident Command System (ICS) structure between four primary agencies: Florida Department of Agriculture and Consumer Services, the US Department of Agriculture's Animal and Plant Health Inspection Service, Monroe County, and the US Fish and Wildlife Service.

New World Screwworm Fly (top) and mature larvae (bottom). Photos: USDA-APHIS.

Goal 2: Eradicate Invasive Exotic Species by Implementing Early Detection and Rapid Response (EDRR).

PREPARE & MONITOR

Objective 2A: Prepare and monitor to enhance early detection.

Strategy 2A1: Implement a systematic, prioritized, multi-species monitoring and inventory plan.

Strategy 2A2: Utilize existing and develop needed regional monitoring/reporting networks to increase likelihood of detection.

Strategy 2A3: Employ science and technology for development of early detection tools, e.g., surveys, traps, inspections.

Strategy 2A4: Engage the public and provide invasive exotic species reporting mechanisms.

Strategy 2A5: Establish rapid assessment and response programs/processes/cooperatives/ tools that allow for nimble reactions aimed at eradication.

ASSESS

Objective 2B: Ensure rapid assessment of newly detected species.

Strategy 2B1: Rapidly assess the status and potential threat of newly detected invasive exotic species populations and develop a response/no response plan.

RESPOND

Objective 2C: Rapidly respond to identified threats.

Strategy 2C1: Initiate rapid response based upon the plan of action developed during the assessment phase.

Exotic Species Hotline: 888-IveGot1

The exotic species hotline, currently managed by the FWC, has received 12,153 reports of nonnative fish and wildlife since its statewide inception in 2011. An additional 5,611 reports have been received via Ivegot1.org and the IveGot1 smart phone app. This equates to a combined total of 17,764 reports through these reporting mechanisms, building an extensive database, increasing knowledge of the spread of invasive exotic wildlife in Florida, and enabling rapid response to eradicate emerging invaders.

Eradication Efforts Underway: Lumnitzera

An invasive mangrove is the subject of continued eradication efforts. Risk assessments indicated a high invasion risk of this plant in native mangrove habitat. Collaborative efforts are underway by Fairchild Tropical Botanic Garden, Miami-Dade County, and other members of the Everglades Cooperative Invasive Species Management Area (ECISMA). Ongoing efforts are aimed at eradication due to the localized distribution of the plant in Florida.

Goal 3: Contain the Spread of Invasive Exotic Species.

Consistent resources to address containment are needed.

Once it is determined that eradication is not possible, we enter the third phase of the Invasion Curve. Containment efforts focus on preventing the spread of an invasive exotic species to new areas in order to minimize the damage to the ecosystem and reduce long-term control costs. The containment phase focuses on the utilization and often rapid deployment of **control** tools at containment boundaries and known pathways. Technical expertise, enforcement mechanisms, and financial assistance are needed to successfully contain expanding populations of priority species. 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. Assessment and adaptation of current methodologies, investment in monitoring and science-based containment methods, and a supportive and engaged public will **improve** containment success.

Argentine black and white tegu. Photo: Dennis Giardina.

Goal 3: Contain the Spread of Invasive Exotic Species.

CONTROL

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

Strategy 3A1: Implement best management practices to prevent the inadvertent spread of invasive exotic species.

Strategy 3A2: Implement control efforts at containment boundaries and known pathways.

Strategy 3A3: Retreat or reassess areas to ensure containment of invasive exotic species.

Strategy 3A4: Develop an EDRR approach outside containment areas that eliminates incipient populations.

Strategy 3A5: Enforce existing laws regarding transporting and releasing invasive exotic species to prevent spread.

IMPROVE

Objective 3B: Improve effectiveness of containment efforts on invasive exotic species populations.

Strategy 3B1: Invest in science-based containment methods.

Strategy 3B2: Assess effectiveness of containment efforts and adapt to improve success.

Strategy 3B3: Standardize containment efforts through enhanced coordination.

Strategy 3B4: Improve public awareness of the need for ongoing containment efforts.

The Tegu Curtain

The Argentine black and white tegu is a large, invasive lizard native to South America that has become established in southern Miami-Dade County. The hatchling, seen at right, can grow to over 4' in length as an adult. The goal is to protect sensitive habitats, including nearby national parks and crocodile nesting areas, by containing them within their current range and decreasing the population. Tegus are now occasionally removed just inside Everglades National Park, though in low numbers and there is not yet evidence that tegus are reproducing there. Tool development and interagency containment efforts are continuing.

Photo: Dustin Smith.

Goal 4: Reduce the Populations of Widely Established Invasive Exotic Species and Maintain at Lowest Feasible Levels.

Consistent resources to address long-term management/resource protection are needed.

The final stage of the Invasion Curve is long-term management and resource protection. This phase endeavors to reduce the ecological and financial impact of wide-spread invasive exotic species so they no longer play a dominant role in the ecosystem. This can be accomplished by developing and 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** of native habitats and **recovery** of ecosystem functions.

The underlying concept of this goal is to continue to **combat** well established invasive exotic species in order to shift efforts to the left along the Invasion Curve (e.g., containment) and to bring invasive exotic species to a minimum cost and impact on the ecosystem (known as maintenance control). The approach utilized in this endeavor is Integrated Pest Management (IPM). According to the U.S. Environmental Protection Agency, IPM programs "use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment."

Burmese Python

Burmese pythons are large constrictor snakes that have an established invasive population in southern Florida. Adult 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 south Florida python population has proven very difficult, and the population may still be spreading despite an increasingly coordinated effort of several governmental agencies and academic institutions. Photo: ENP.

Improvements in long-term management effectiveness will stem from a combination of investment in science, development of new tools, and enhanced coordination. Investment in research and monitoring may yield future tools that could reduce the population and extent of invasive exotic species that are well established today. These investments need to be expanded and implemented throughout the region through coordinated efforts.

In addition, continual assessment and adaptation based on lessons learned may also yield great improvements in long-term management. One of the most difficult assessments is the area of ecosystem services. Impacts to natural areas and native species by invasive exotics have ripple effects throughout the economy. It is generally understood that long-term management is costly and quantifying ecosystem services benefits is challenging. However, assessing these effects is an important tool to ensuring that more resources could be secured for long-term management and control of invasive exotic species.

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

COMBAT

Objective 4A: Reduce population and extent of established invasive exotic species through Integrated Pest Management approaches.

Strategy 4A1: Strive to eliminate the impact of invasive exotic species on natural areas by implementing an Integrated Pest Management approach.

Strategy 4A1: Conduct routine surveys of widely established species to determine status of populations.

RESTORE & RECOVER

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

Strategy 4B1: Support efforts to increase the total spatial extent of natural areas and restore natural hydrology.

Strategy 4B2: Coordinate invasive exotic species management with restoration activities to prevent degradation of habitat.

Strategy 4B3: Reintroduce populations of extirpated and rare species, and augment existing populations where appropriate, to improve native plant and animal species abundance and diversity.

Strategy 4B4: Recover ecological and natural system functions and ecosystem services.

IMPROVE

Objective 4C: Improve effectiveness of long-term management efforts on invasive exotic species populations.

Strategy 4C1: Assess effectiveness of long-term management efforts and adapt to improve success.

Strategy 4C2: Conduct inventory and monitoring to improve understanding of population growth of invasive exotic species in order to develop better control methods.

Strategy 4C3: Develop and improve tools to assist in the long-term control of invasive exotic species.

Strategy 4C4: Integrate federal, state, and local agency invasive exotic species control programs.

Lionfish

Since first observed in the 1980s, two predatory species of lionfish have populated the Caribbean, Gulf of Mexico, the Southeastern US coastline, and the Bermuda coastline. Lionfish pose a threat to the integrity of the food web and are capable of impacting commercial fisheries, tourism, and overall coral reef health. Affecting a vast area and crossing geopolitical boundaries, continued interagency and partner collaboration and coordination are key to successful management of this invasive marine species. Regulations, research, development of control tools, public engagement, and targeted recreational removal efforts all play an important role. Photos: Cory Walter, Mote Marine Laboratory (left) and Kelli O'Donnell, NOAA Fisheries (right).

Long-term Management of Invasive Plants

Combatting established invasive plants requires achievement of maintenance control through sequential control efforts, long-term resource commitment, and extensive interagency coordination. Currently, there are 76 priority invasive plant species established within the South Florida Ecosystem.

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

Due to the complexities of implementing landscape-level control strategies across numerous jurisdictions, local, state, and federal agencies are working closely in the South Florida Ecosystem to coordinate efforts and improve our collective ability to achieve maintenance control of the ecosystem's priority invasive plants.

CONCLUSION

Combating invasive exotic species is integral to successful ecosystem restoration and to the sustainability of South Florida. Inaction, or delayed action, is costly and this Framework delineates how we can protect both our economic and natural resources by focusing on rapid, coordinated, and strategic action.

The Task Force website (evergladesrestoration.gov) contains complementary tools and additional resources to accompany this Framework, including detailed case studies and an interagency snapshot budget for invasive exotic species. This suite of documents and tools will be updated as needed to provide access to the most current information on our collective efforts to combat invasive exotic species in the South Florida Ecosystem.

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