



DRAFT

Invasive Exotic Species

Strategic Action Framework

8/22/14

The South Florida Ecosystem Restoration Task Force

In 1996 Congress established the South Florida Ecosystem Restoration Task Force (Task Force) to bring together federal, state, tribal, and local agencies involved in restoring and protecting the Everglades. The Task Force coordinates the myriad restoration efforts being planned and implemented throughout the Everglades ecosystem. The Task Force also provides a forum for sharing information, identifying emerging issues, resolving conflicts, and reporting on restoration progress.

Framework Purpose

On July 9, 2013, the South Florida Ecosystem Restoration Task Force directed its Working Group and Science Coordination Group to develop a Strategic Action Framework (Framework) for addressing the serious threats to the Everglades posed by invasive exotic plant and animal species. The Framework was developed by an extensive and diverse set of partners including members of the Task Force, Working Group, Science Coordination Group, Everglades Cooperative Invasive Species Management Area (ECISMA), and the Department of the Interior's Office of Everglades Restoration Initiatives.

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;
- Help decision-makers make wise and timely investment decisions in the battle against invasive exotics; and
- Define success and provide for accountability.

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Executive Summary

The South Florida Ecosystem Restoration Task Force and its advisory bodies, along with members of the Everglades Cooperative Invasive Species Management Area (ECISMA) and other partners, have developed this Framework to enhance collective efforts to combat invasive exotic species.

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 8 million residents, including two Indian tribes,
- world renowned recreational opportunities, and
- a strong agricultural and tourism-based economy.

Florida is second only to Hawaii in the severity of the threats posed by invasive exotic species on U.S. native habitats and species. 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, and the large-scale pet, aquarium, and ornamental plant industries active in the region.

Invasive Exotic Species Pose a Real and Growing Threat to the South Florida Ecosystem

Invasive exotic species like the ambrosia beetle, giant African snail, Brazilian pepper tree, and Burmese python threaten our environment, economy, culture, and human health. 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.

The Threats are Beyond any Single Agency or Effort to Address

It is estimated that ___ non-native species are introduced to south Florida every ___ and of those ___ become established as invasive exotic species. Combined with already established populations of the estimated ___ invasive exotic species in Florida, these numbers quickly overwhelm the ability of any single agency or individual effort to control.

Combating invasive exotic species is daunting in terms of geographic scope (an 18,000 square mile ecosystem with an estimated 1.7 million acres of natural areas already infested), time scale (requiring rapid response to new invaders as well as steady, long-term management of well-established pests), coordination (multiple agencies, tribes, private industries, and the public), and resources (extensive and consistent application of tools, manpower, and funding). Yet inaction or delayed action dramatically increases the time and resources needed to protect the ecosystem from invasive exotic species.

We need Swift Action, Vigilant Stewardship, and Adequate Resources to Succeed

Delay is costly. Melaleuca, an ornamental tree first introduced to Florida in the early 1900's, was allowed to thrive for almost a century and by 1993 infested an estimated 488,000 acres in South

Florida (TAME 2007), far escaping the ability of any single entity to control it. An intensive interagency effort led to the development of a regional, comprehensive strategy that utilized multiple control tools and strategies (including regulatory initiatives) and public outreach. Today, large sections of the Everglades have reached or are nearing maintenance-control levels where melaleuca once dominated. However, some portions of the South Florida Ecosystem, including many private lands, still contain sizable melaleuca infestations. The South Florida melaleuca effort (including biological, mechanical, chemical, and physical control efforts) has cost over \$43 million thus far. To place this in perspective, however, the Florida Department of Environmental Protection estimates that *failing to act* against melaleuca would be even more costly, ultimately costing the region \$161 million annually in lost revenues (FLEPPC 1999).

The high cost of managing this aggressive invader calls attention to three important points. First, swift action against newly detected invaders can save significant public resources and substantially reduce impacts to natural resources. Second, 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. And finally, although the long-term commitment of adequate resources is vitally important, we will only be successful if those resources are invested in a strategic and coordinated way.

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

The Invasive and Exotic Species (IES) Strategic Action Framework (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 and impacts on the South Florida Ecosystem. This Framework prioritizes a combined comprehensive list of current activities, with needed efforts, recommends a governance structure, and presents a new crosscut budgeting tool to ensure that governments are working in a coordinated way at all levels toward 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 (Figure 1), developed by experts in

Australia, organizes the battle against exotics into four phases: Prevention, Eradication through Early Detection and Rapid Response (EDRR), Containment, and Resource Protection and Long-Term Management. 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 generally speaking the most cost effective approach to 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 both opportunities to prevent or swiftly eradicate 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 we had all the resources we could hope for to throw at the problem, science cannot yet tell us how to reduce populations let alone to reduce them to the lowest feasible levels. In such cases, the costs of the invasion include research, but they also include the costs associated with the impact of the invasion such as environmental and agricultural harm, human health risk, or loss to 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 resources.

THE INVASION CURVE AND STRATEGIC GOALS

Goal 1: Prevent the introduction of invasive exotic species.

Goal 2: Eradicate invasive exotic species by implementing Early Detection and Rapid Response (EDRR).

Goal 3: Contain the spread of invasive exotic species.

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

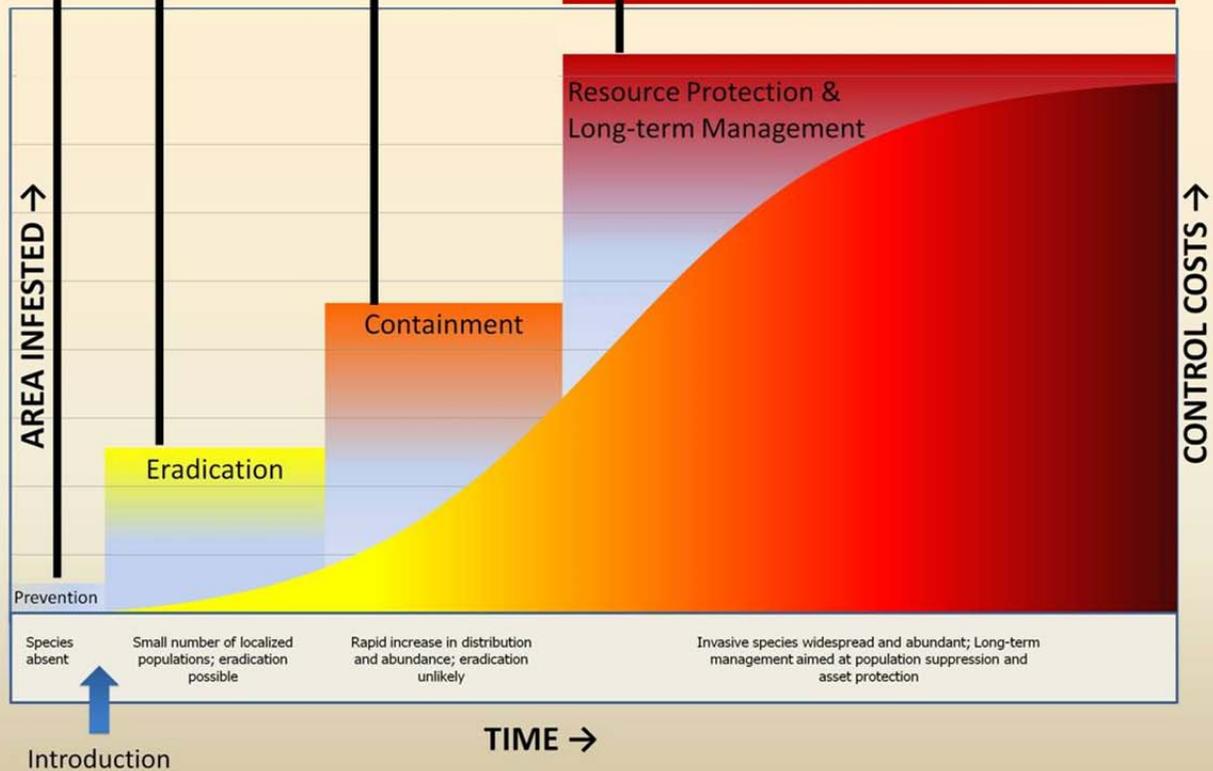


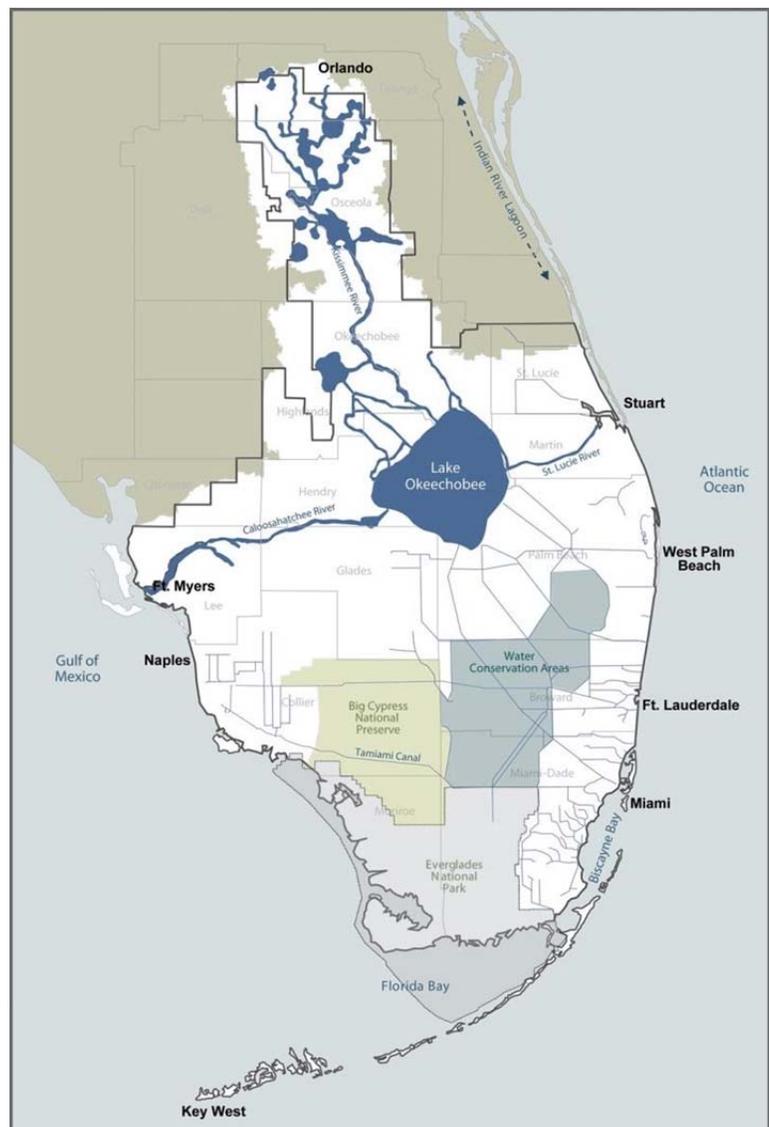
Figure 1: The Invasion Curve and Goals. Adapted from Invasive Plants and Animals Policy Framework, 2010, Department of Environment and Primary Industries, Victoria Australia.

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 the Everglades and Miami; sugar farms and oyster beds; highways and wetlands. This concept is a fundamental tenet of the South Florida Ecosystem Restoration Task Force and therefore the Invasive Exotic Species Strategic Action Framework will use the term "South Florida Ecosystem" in this inclusive way. The Framework will use "Everglades" when referring solely to the natural system.

The South Florida Ecosystem includes the area encompassed by the boundary of the South Florida Water Management District 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 eight 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 greater Everglades, a vast, globally renowned and unique watershed and natural ecosystem that is the subject of the world's largest ecosystem restoration program. The Everglades is divided into a number of protected areas including three national parks, a national preserve, 18 national wildlife refuges, a National Marine Sanctuary, and extensive conservation lands managed by state, county, and local governments, and is home to more than 70 threatened and endangered species.



How Invasive Exotic Species Affect the South Florida Ecosystem

With its mild climate, diverse environments, 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 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 provides prime habitat for invasive exotic species because it is hospitable to many plant and animal species that are native to similar climates throughout the world. In particular, 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. Often the natural mechanisms that control species in their native ranges, such as predators, diseases, and environmental conditions, do not exist in south Florida. Without these mechanisms to keep introduced populations in check, some exotic plant and animal populations can establish and expand into new areas. Approximately 1.7 million acres of Florida's natural areas have become infested (NPS & FWC 2008).

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



Figure 2: An Everglades marsh overtaken by melaleuca.
Photo:



Figure 3: Burmese pythons are food 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. Photo: Roy Wood.



Figure 4: After an American crocodile, a federally threatened species, is captured laying eggs by a wildlife camera, an Argentine black and white Tegu is caught by the same camera feeding on the eggs. Photo:

The Regional Economy

Agriculture, tourism and recreation are among Florida's important economic sectors, collectively making up approximately 20% of the economic activities in the state. All three sectors face both direct and indirect threats from invasive exotic species.

Agriculture: Florida agriculture covers over 9 million acres within the state and contributes more than \$104 billion annually to the state's economy (FDACS 2013). The estimated economic loss due to invasive exotic species, with direct, indirect, and induced costs to crops and livestock, may exceed \$8 billion (Evans 2013), roughly 8% of the entire sector. This represents a significant challenge to the agricultural sector of Florida's economy. These pests range from weeds to feral pigs, insects and mites, plant pathogens, microbes, and parasites. In addition to the financial costs, food security, trade, human health, markets and pricing, and domestic production are all impacted by invasive exotics. An example of just the direct costs associated from selected pests is illustrated in [Table XXX](#).

Estimates of Control and Damage Costs in Florida Agriculture		
Plant/Animal Pest/Disease	Ind. Control Cost/yr (\$'M)	Potential Sales Loss/yr (\$'M)
Citrus Canker & Citrus Greening	29	750
Thrips palmi	20	3.5
Brown Citrus Aphid	30	5.2
Citrus Leaf miner	32	5.5
Leatherleaf Fern Anthracnose	33	20.0
Others	27	727.8
Total	171	1,512

Roberts, 2005

One of the newest threats is Laurel wilt disease, spread by the invasive exotic ambrosia beetle ([see Case Study...](#)), has the potential to cause a direct loss of \$183-356 million to the avocado industry, Florida's second-largest fruit industry (after citrus) (American Society for Horticultural Science 2010).

Tourism/Recreation: Florida is forecasted to exceed 100 million tourists annually by 2015 and many explore the natural beauty of the state creating approximately \$70 billion in economic activity (Florida TaxWatch 2014). The Florida Outdoor Recreation Participation Survey (DEP 2011) showed that 98% of visitors believe that outdoor recreation is important to them with

fishing and wildlife viewing important outdoor recreational activities, along with beach activities. With its abundance of both freshwater and saltwater habitats, Florida is known as the “Fishing Capital of the World,” with over 57 million person-days of recreational fishing (Florida TaxWatch 2011). Collectively, wildlife-based recreational activities provide over \$8 billion in economic activity in Florida.

Total EXPENDITURES of US Citizens in 2011 in Florida on wildlife-economic activity, in order of magnitude		PARTICIPANTS in Wildlife-Related Recreation in Florida in 2011 (U.S. residents 16 years old and older)	
1. Fishing	\$4.6 billion	1. Wildlife Watching	4.3 million
2. Wildlife Watching	\$3 billion	2. Anglers	3.1 million
3. Hunting	\$716 million	3. Hunters	242 thousand

Source: Source: U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

Invasive exotics can significantly diminish these opportunities that are enjoyed by the public, ranging from disruption of active recreational activities to diminished availability of passive recreational opportunities such as bird watching. Venomous lionfish invasions may make certain areas unsafe for divers, impacting tour providers. The prevalence of pythons in the news media has made some members of the public wary of even visiting the Everglades. A more calculable direct impact involves water hyacinth, a non-native floating aquatic plant that 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 and more than \$50 million annually just to treat invasive exotics weeds in canals, places, rivers, fields, pastures, and greens (NPS & FWC 2008).

Native American Culture: The Miccosukee Tribe of Indians of Florida and Seminole Tribe of Florida are both federally recognized Indian Tribes residing in the Everglades; their presence predates Columbus. The Everglades is not only home, 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, a loss of medicinal and ceremonial plants, and the loss of traditional foods.

Many invasive exotic plants physically disrupt and can even replace the native vegetation. Exotic vegetation such as melaleuca (*Melaleuca quinquenervia*) and Brazilian pepper (*Schinus terebinthifolia*), form thick stands that crowd out native vegetation. Old-World climbing fern (*Lygodium microphyllum*) produces a canopy that smothers native trees.

Tree islands are a particularly important resource used by tribes for ceremonial purposes. Swamp and red bay trees are keystone species that are important to the structure of many tree islands. These trees are currently under attack from Laurel Wilt disease (see Case study), altering the historic Everglades tree islands and 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 and native areas. Pastures and agricultural practices on tribal lands are also greatly impacted by exotic species of vegetation such as Cogon grass (*Imperata cylindrica*), Tropical Soda Apple (*Solanum viarum*), and Brazilian pepper infestations. These exotic species can significantly reduce the grazing capacities of pastures.



Figure 6: Laurel wilt disease. Source: okeechobee.ifas.ufl.edu/News%20columns/Red.Bay.htm



Figure 5: 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 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.**

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 deliberate and unintentional importation of plants and animals through international commerce or transport. 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.

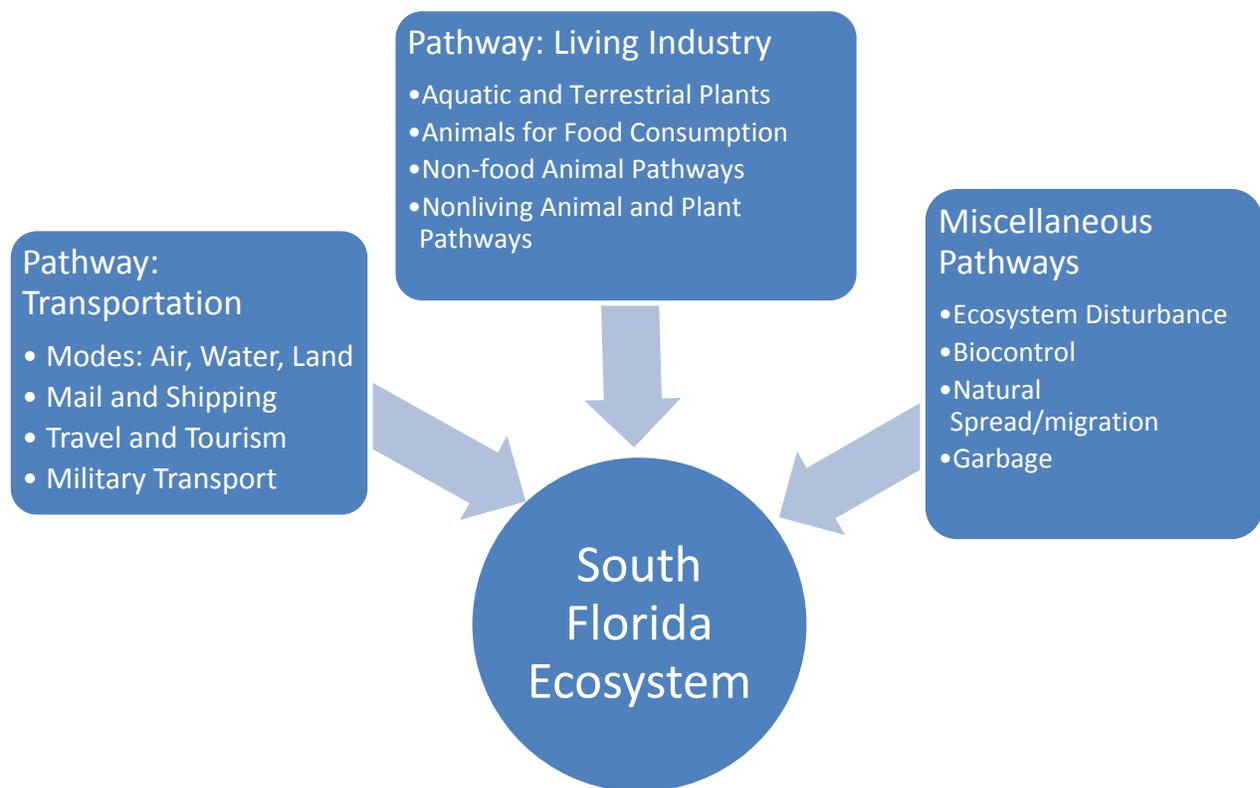


Figure 7: Invasive Exotic Species' Pathways. Adapted from the National Invasive Species Council and Aquatic Nuisance Species Task Force Pathways Ranking Guide (2005).

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. In short, costs increase the longer a species is established and the greater geographical extent of the invasion. **The left-hand side of the Invasion Curve represents the best chance for long-term success.** 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.

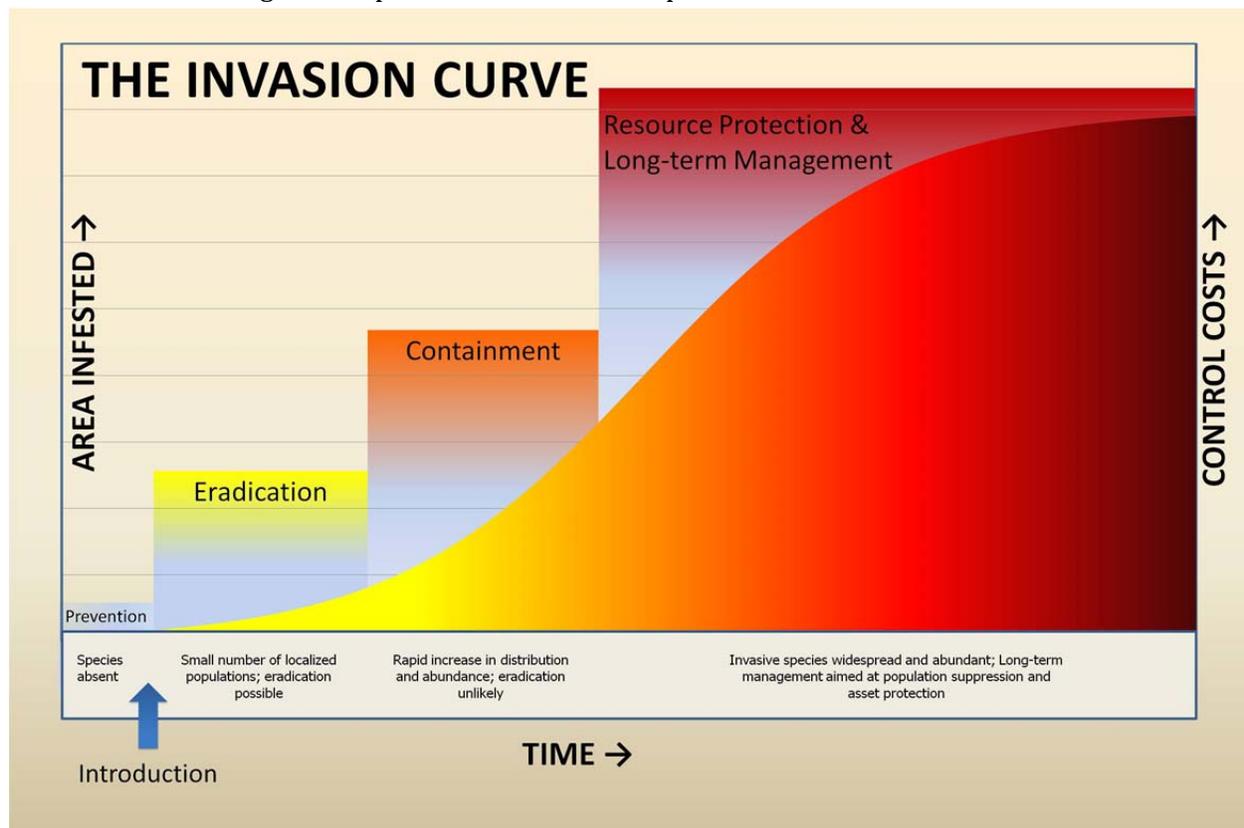


Figure 8: The Invasion Curve. Adapted from *Invasive Plants and Animals Policy Framework, 2010*, Department of Environment and Primary Industries, Victoria Australia.

The Invasion Curve identifies four major categories of management actions to combat invasive exotic species: Prevention, Eradication, Containment, and Resource Protection & Long Term Management. The first opportunity to combat an invitation is to prevent it in the first place. Preventions 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 Rapid Response (EDRR). Eradication through EDRR is the second most cost-effective way to address invasive species. Once the populations increase and become distributed over a greater 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, strategic 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, involved public.
- A successful invasive exotic species program requires long-term commitment of resources.

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

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 assessment.

Preventing the introduction of high priority 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, 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.

Exotic Pet Amnesty Program

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.

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, often carrying ticks, that are imported into Miami International Airport.



Hawaii's Cargo Fee

The State of Hawaii currently imposes an inspection fee on marine freight coming into the State which provides millions of dollars to their biosecurity efforts every year. Invasive species are a very serious problem on Hawaii and receive extensive media coverage and attention in the Hawaii legislature every year. The Hawaii model of an inspection fee on incoming freight may soon be attempted on Guam and could be a template for similar efforts in other States.

Goal 1: Prevent the introduction of invasive exotic species.

PREPARE & PRIORITIZE

Objective 1A: Prepare for and prioritize prevention efforts.

- Identify pathways and prioritize potential threats and invasive exotic species.
- Engage stakeholders and the public to support prevention efforts.

PREVENT

Objective 1B: Prevent entry of invasive exotic species.

- Enhance and improve the pathway inspection/screening process.
- Develop new and utilize existing voluntary and regulatory tools.
- 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 actively 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 of import or export of endangered species. These agencies coordinate when interdiction falls in another agency's jurisdiction.

The scale of the job these agencies face is staggering. Over 6 million tons of perishable cargo enter Florida each year. Over 85% of the plants imported to the U.S. go through Miami (Dixon 2008) and agricultural trade and pest interceptions at Florida's ports of entry have been doubling every 5-6 years (UF/IFAS).

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.

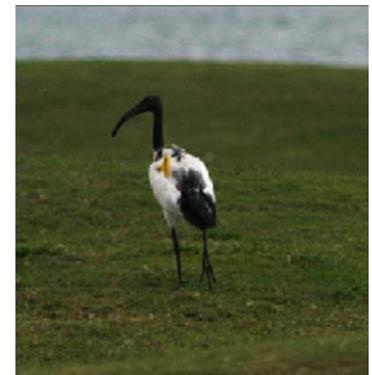
It is imperative to be able to respond quickly and deal with emerging threats while they remain localized. Eradication through EDRR is the second most cost-effective method to deal with invasive exotics, after prevention.

EDRR efforts should begin before species are identified in the South Florida Ecosystem. 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." **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

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. (Photo: Zoo Miami)



Gambian Pouched Rats

Gambian Pouched rats are large rodents native to Africa that are a vector for serious diseases, including monkey pox. Efforts to eradicate this species from the Florida Keys are being led by the Florida Fish and Wildlife Conservation Commission. (Photo: FWC)

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

PREPARE & MONITOR

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

- Implement a systematic, prioritized, multi-species monitoring and inventory plan.
- Utilize existing and develop needed regional monitoring/reporting networks to increase likelihood of detection.
- Employ science and technology for development of early detection tools, e.g., surveys, traps, inspections.
- Engage the public and provide invasive exotic species reporting mechanisms.
- Establish rapid assessment and response programs/processes/cooperatives/tools that allow for nimble attempts at eradication.

ASSESS

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

- Rapidly assess the status and potential threat of newly detected incipient invasive exotic species populations and develop a response/no response plan.

RESPOND

Objective 2C: Rapidly respond to identified threats.

- Initiate rapid response based upon the plan of action developed during the assessment phase.

Goal 3: **Contain** the spread of invasive exotic species.

Consistent resources to address containment, resource protection, and long-term management 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.

The Tegu Curtain

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



Goal 3: Contain the Spread of Invasive Exotic Species.

CONTROL

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

- Implement best management practices to prevent the inadvertent spread of invasive exotic species.
- Implement control efforts at containment boundaries and known pathways.
- Retreat or reassess areas to ensure containment of invasive exotic species.
- Develop an EDRR approach outside containment areas that eliminates incipient populations.
- Enforce existing laws regarding transporting and releasing exotic species to prevent spread.

IMPROVE

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

- Invest in science-based containment methods.
- Assess effectiveness of containment efforts and adapt to improve success.
- Standardize containment efforts through enhanced coordination.
- Improve public awareness of the need for ongoing containment efforts.

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

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 ecological and financial impact of 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** invasive exotic species in order to move efforts left along the Invasion Curve 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. EPA, 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.”

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 dramatically 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. For example, there has been good investment in research related to the expansion of pythons in Everglades National Park. With additional resources, this research could be expanded to non-impacted areas, such as the Water Conservation Areas and the A.R.M. Loxahatchee National Wildlife Refuge.

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.

Ambrosia Beetle

Laurel wilt disease threatens to cause the extinction of native redbay trees, swamp bays 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 one of the most important cultural resources to the Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida. (Photo: Courtesy of Sun Sentinel.)



Shoebuttan Ardisia

An evergreen shrub/small tree that is native to Asia has invaded short hydroperiod wetlands, hammocks, and tree islands in south Florida. It impacts both the community structure and ecological function of native habitats. Miami-Dade County’s Environmentally Endangered Lands (EEL) Program is working to identify cost-effective controls to manage this invasive species. (Photo: Miami-Dade County EEL Program)



Lionfish

Lionfish (*Pterois volitans* and *P. miles*) are the only reproducing examples of 32 ornamental marine fish observed on Florida reefs since the 1980's. Within 40 years, these two predatory lionfish species populated the Caribbean, Gulf of Mexico, the Southeastern US coastline, and the Bermuda coastline. Loss of herbivorous fish species on reefs is resulting in dominance by algae and coral death. There are no suitable traps ready for deployment, nor any other cost effective collection strategy for control.



An infested Bahamian reef. Photo: REEF/ Rich Carey. <http://www.reef.org/enews/articles/noaa-coral-reef->

Burmese Python

Burmese pythons are giant constricting snakes 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. (Photo: ENP)



Melaleuca

Melaleuca is a fast-growing evergreen tree native to eastern Australia. The plant is a prolific seed producer, is fire-adapted, and is able to thrive in both flooded and well drained soils. First introduced to Florida in the early 1900's as an ornamental tree and soil stabilizer, melaleuca quickly spread. Large sections of the Greater Everglades have reached or are nearing maintenance-control levels where melaleuca once dominated. However, some portions of the South Florida Ecosystem still contain sizable melaleuca infestations. (Photo: Vic Ramey, UF/IFAS)



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.

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

- Support efforts to increase the total spatial extent of natural areas and restore natural hydrology.
- Coordinate invasive exotic 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.
- Recover ecological and natural system functions and ecosystem services.

IMPROVE

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

- Assess effectiveness of long-term management efforts and adapt to improve success.
- Conduct inventory and monitoring to improve understanding of population growth of invasive exotic species in order to develop better control methods.
- Develop and improve tools to assist in the long-term control of invasive exotic species.
- Integrate federal, state, and local agency invasive exotic species control programs.