Chapter 7: Status of Nonindigenous Species

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SUMMARY

Invasive, non-indigenous species present serious threats to ecosystem community structure and function throughout South Florida. As such, controlling invasive species is cited as a critical resource management activity in the South Florida Water Management District (District or SFWMD) Strategic Plan, 2012–2017 (SFWMD 2012). Successfully managing invasive species also is tangentially important to other strategic goals as invasive species have far-reaching effects—from evaluating environmental resource permits to managing the Everglades Stormwater Treatment Areas (STAs) to restoring natural fire regimes. In support of collective activities of the many agencies involved in Everglades restoration, this chapter reviews the broad issues involving invasive, nonindigenous species in South Florida and their relationship to restoration, management, planning, organization, and funding. The report provides updates for many priority invasive species, programmatic overviews of regional invasive species initiatives, and key issues linked to managing and preventing biological invasions in South Florida ecosystems.

While detailed information on many invasive species is not available, this document attempts to provide an update and annotations for priority plant and animal species, including summaries of new research findings. As part of continued efforts to streamline reporting, this year's update emphasizes new information obtained during Fiscal Year 2014-2015 (October 1, 2014–September 30, 2015). During Fiscal Year 2014-2015, the District spent roughly $19 million for overall invasive species prevention, control, and management in South Florida. More supporting information, including general background of the District's invasive species program and further details on nonindigenous species, is also presented in Chapter 9 of the *2011 South Florida Environmental Report* (SFER) – *Volume I* (Rodgers et al. 2011).

In addition to providing the status of nonindigenous species programs and outlining programmatic needs, this document summarizes what, if any, control or management is under way

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for priority nonindigenous species considered to be capable of impacting the resources that the District is mandated to manage or restore.

NONINDIGENOUS PLANTS

- Seventy-five species of nonindigenous plants are District priorities for control. Old World climbing fern (*Lygodium microphyllum*), melaleuca (*Melaleuca quinquenervia*), Brazilian pepper (*Schinus terebinthifolius*), and Australian pine (*Causarina* sp.) continue to be systemwide priorities, while aquatic plants such as hydrilla (*Hydrilla verticillata*), water hyacinth (*Eichhornia crassipe*s), and tropical American water grass (*Luziola subintegra*) are priorities in the Kissimmee Basin and Lake Okeechobee.
- Efforts to control invasive plants continue on District-managed natural areas, STAs, project lands, lakes, and flood control canals and levees. The District has one of the country's largest aquatic plant management programs, managing floating and submerged aquatic vegetation (SAV) systemwide. The interagency melaleuca management program is a national model for regional, interagency invasive plant control programs. Melaleuca has been systematically cleared from Water Conservation Area (WCA) 2 and WCA-3 and Lake Okeechobee and is now under maintenance control in these regions.
- Biological control of several invasive plants is showing promising results, with substantial reductions of melaleuca documented. The Comprehensive Everglades Restoration Plan's (CERP's) Biological Control Implementation Project continues to move forward. The recently completed mass rearing facility at the existing United States Department of Agriculture's Agricultural Research Service biological control laboratory in Davie, Florida now supports biological control agent rearing and field release for melaleuca, Old world climbing fern, water hyacinth, and other invasive nonindigenous plant species.
- Range expansions of invasive non-indigenous plant species into new areas remain a concern for resource managers. Chinese tallow (*Sapium sebiferum*), a Florida noxious weed, continues to expand southward into new areas within the District including the Kissimmee River Basin and Allapattah Ranch.

NONINDIGENOUS ANIMALS

- Considerable numbers of nonindigenous animals are known to occur in South Florida, ranging from approximately 62 species in the Kissimmee Basin to over 130 species in the Greater Everglades. Ranking animals for control is a serious challenge and prioritizing related threats across regulatory agencies is needed.
- The Florida Fish and Wildlife Conservation Commission (FWC) continues to build its nonindigenous animal management program and coordinates closely with the District, National Park Service, and other partners to manage nonnative animal species in South Florida. During 2014, federal, state, local, and tribal partners continued rapid response efforts to control expanding populations of several invasive animal species including northern African pythons (*Python sebae*), Argentine black and white tegus (*Tupinambis merianae*), and the spectacled caiman (*Caiman crocodilus*).
- Burmese pythons (*Python molurus bivittatus*) continue to be observed and removed in the Everglades and surrounding rural areas and the numbers appear to be rising again after cold-induced reductions in 2010–2011. The District remains an active partner in

regional efforts to halt the spread of this invasive reptile by conducting regional search and removal operations.

- The District continues to collaborate with the Everglades Cooperative Invasive Species Management Area (ECISMA), Lake Okeechobee Interagency Aquatic Plant Management Team, and South Florida Ecosystem Restoration Task Force. During this reporting period, these cross-jurisdictional teams facilitated the implementation of regionwide invasive species monitoring programs, rapid response efforts, standardized data management, and outreach initiatives.

PROGRESS TOWARD MANAGEMENT AND CONTROL

The following section provides updates for Fiscal Year 2014-2015 on control, research, monitoring, and coordination activities on invasive nonindigenous species that threaten the success of the mission of the District.

SUMMARY OF INVASIVE SPECIES CONTROL TOOLS

Many different techniques are used to control invasive plants and animals in South Florida (Langeland and Stocker 1997, Wittenberg and Cock 2001). The District and other agencies typically use tools in an integrated fashion with the goal of minimizing impacts of invasive species by the most cost-effective and environmentally sound means. A detailed account of invasive species management tools and strategies is presented in Chapter 9 of the 2006 SFER – Volume I (Ferriter et al. 2006). The following is a brief summary of available management tools for controlling invasive species.

Invasive Plant Control Tools

Tools for controlling invasive plants are well developed and widely utilized although their application in natural areas has limitations. Researchers are refining these control methods to be more effective in natural areas. The following list provides a generalized description of available plant control techniques:

- **Biological controls** include the use of living organisms, such as predators, parasitoids, and pathogens. “Classical” biological control seeks to locate host-specific pests from the plant’s native range and import these species to attack and control the plant in regions where it has become invasive. For example, the alligatorweed flea beetle (*Agasicles hygrophila*) was introduced to North America in 1964 from Argentina to combat alligatorweed (*Alternanthera philoxeroides*). This insect continues to provide excellent alligatorweed control and has not caused damage to any other plants.
- **Herbicides** are pesticides designed to control plants. Herbicides approved for aquatic use or in terrestrial natural areas are a vital component of most control programs and are used extensively for invasive plant management in South Florida. There are over 20 herbicides employed to control invasive plants in South Florida. Commonly used herbicides for control of broadleaf species in wetlands include 2,4-D, triclopyr, imazamox, and metsulfuron-methyl. Glyphosate and imazapyr are non-selective herbicides and are used for a variety of plant types. Fluazifop-p-butyl is used to control perennial grass species specifically. Floating and submerged aquatic plants are controlled with several herbicides with 2,4-D, diquat, fluridone, endothall, and triclopyr being the most commonly used.
- **Manual and mechanical controls** include the use of bulldozers, specialized logging equipment, aquatic plant harvesters, or hand pulling to control invasive plants. While costly, these methods are often used when other control techniques may cause

unacceptable damage to native species or when removal of invasive plant biomass is necessary to achieve restoration objectives.

- **Cultural practices** include the use of prescribed burning, water level manipulation, or native species plantings to control invasive plants. Fire can be used to suppress plant growth and kill both native and nonnative plants that are not fire tolerant. Regulating water levels may reduce invasive plant species in aquatic and wetland habitats. Planting native species may reduce the susceptibility of aquatic and wetland sites in some cases.

Invasive Animal Control Tools

Operational management tools to control invasive animals in Florida's natural areas are poorly developed or, in some cases, developed but not fully implemented. There is not a single agency in the state that has a dedicated program to deal with the operational-type control and management of nonindigenous wildlife or marine species (ISWG 2003). The following list provides a generalized description of techniques for control of nonindigenous animal species:

- **Exclusion** is the use of barriers (e.g., electrical, hydraulic, sound) in terrestrial or aquatic environments to prevent target species from moving into unaffected areas. For example, electrical barriers are currently being utilized to limit movement of Asian carp from the Illinois River into the Great Lakes.
- **Habitat manipulation** is the removal of food and/or water sources or breeding sites, or preventing the use of habitats by target species to reduce species population growth or tendency to occupy an area. For example, the District and FWC recently removed large melaleuca slash piles in and around the area known to harbor the northern African python. These large debris stockpiles were thought to provide nesting habitat for this species.
- **Trapping** is the use of snares, nets, or cage traps to catch individuals of the target species to be relocated or disposed of humanely.
- **Hunting or fishing** is the use of recreational hunting or fishing as a means to reduce populations of the target species. Hunting programs are frequently used to manage nutria (*Myocastor coypus*) populations in Louisiana and other states.
- **Biological control** is the development of biological agents that can be introduced to reduce target species populations. Intentional releases of the Myxoma virus have successfully reduced invasive rabbit populations in Australia.
- **Chemical contro**l is the use of direct chemical application or bait stations to dispatch target species or interrupt breeding.
- **Sterilization** reduces reproduction to phase out populations of the target species in specific areas. For example, new chemical fertility control technologies are being utilized in Australia and Asia to control invasive rodent species.

INVASIVE PLANT MANAGEMENT

The District and other agencies continue to make significant progress toward achieving maintenance control of some invasive, nonindigenous plant species on public conservation lands in South Florida. Large sections of the Greater Everglades and the marshes of Lake Okeechobee have reached or are nearing maintenance-control levels where melaleuca once dominated (**Figure 7-1**). However, remote sections of the southeastern area of Everglades National Park (ENP or Park) and the Arthur R. Marshall Loxahatchee National Wildlife Refuge (LNWR) remain moderately to heavily impacted by difficult-to-control invasive plants. In these areas, the challenges

of invasive plant control are immense due to inadequate financial resources and heavy infestations in difficult-to-access areas. It will likely be decades until these areas are successfully under control.

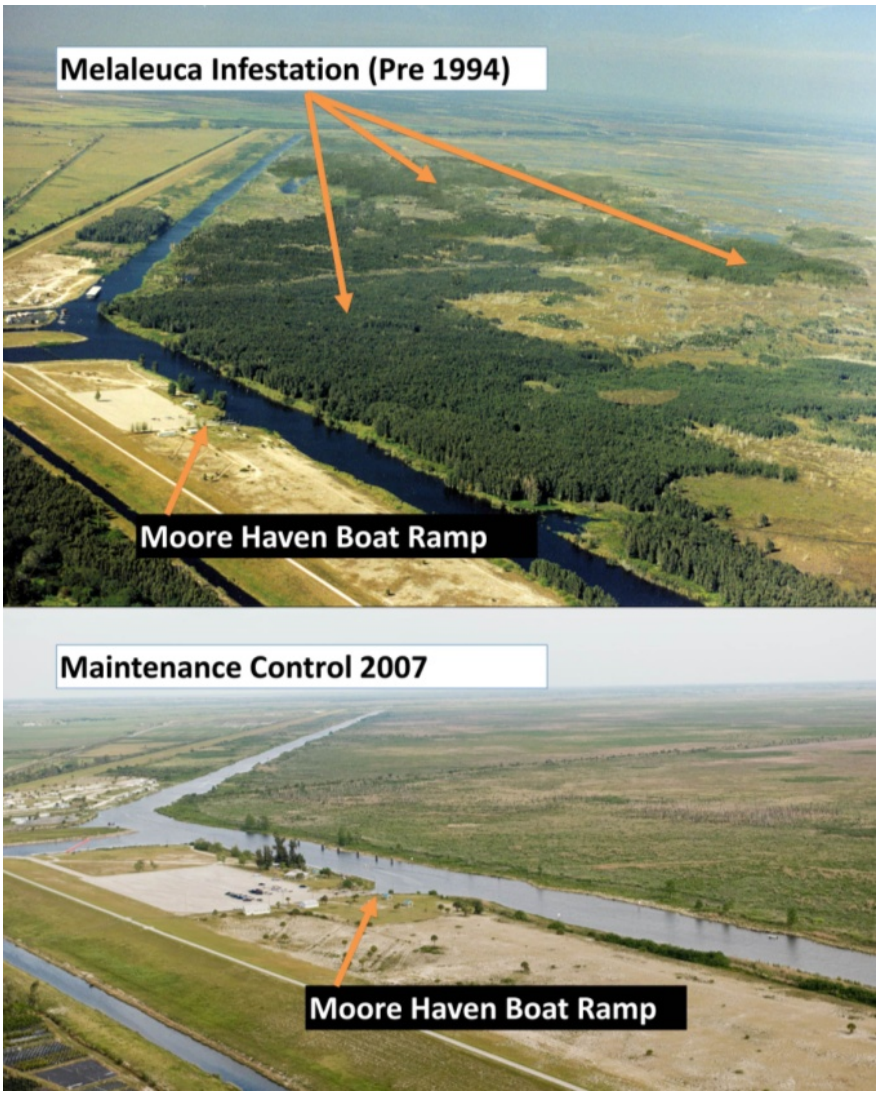


Figure 7-1. The Moore Haven Marsh, Lake Okeechobee, prior to (1993) and after (2007) intensive melaleuca (*M. quinquenervia*) management (photos by SFWMD).

Old World climbing fern continues to present a significant challenge for natural resource managers in the Everglades and the Kissimmee River Basin. This highly invasive plant is proving difficult to control, in part due to its ability to establish and thrive in remote, undisturbed areas. Continued research to develop herbicides, biological controls, and control strategies are needed for successful long-term management of this species.

In **Table 7-1**, the District's Fiscal Year 2014-2015 expenditures for nonindigenous plant control are summarized by land management regions. The purpose of this table is to report expenditures for the most abundant invasive plant species on District managed lands in support of the District's environmental restoration and flood control missions. In addition to these species, the District directs its staff and contractors to control all invasive plant species identified by the Florida Exotic Pest Plant Council (FLEPPC) as Category I species (FLEPPC 2013). These species are

documented to alter native plant communities by displacing native species, change community structures or ecological functions, or hybridize with native species. In Fiscal Year 2014-2015, the District spent more than $19 million for overall invasive species prevention, control, and management in South Florida. In anticipation of continued budget shortfalls, the District reevaluated invasive plant management priorities to assure that gained ground is not lost. Experience has shown that vigilant reconnaissance and retreatment is necessary to maintain low levels of established invasive species. Biological controls are proving to be beneficial in this regard by reducing the rate of reestablishment for some species (Overholt et al. 2009, Rayamajhi et al. 2008). However, successful biological control programs are in place for only a handful of priority species so land managers must persist with frequent monitoring and control efforts.

Table 7-1. Invasive plant species control expenditures by the District in Fiscal Year 2014-2015 organized by land management region.

Priority Invasive Species	Upper Lakes	Kissimmee/ Okeechobee	Lake Okeechobee	Everglades	East Coast	West Coast	Biocontrol	Total
Melaleuca (*Melaleuca quinquenervia*)		$15,488	$31,022	$1,560,476	$1,426	$969,536	$150,000	$2,727,948
Old World climbing fern (*Lygodium microphyllum*)	$101,130	$354,579	$1,229	$536,370	$607,414	$41,576	$150,000	$1,792,298
Floating plants Water hyacinth (*Eichhornia crassipes*) and Water lettuce (*Pistia stratiotes*)	$399,505	$246,523		$597,101	$120,468	$14,609		$1,378,206
Brazilian pepper (*Schinus terebinthifolius*)	$29,793	$32,040	$48,979	$333,082	$215,062	$252,222		$911,178
Hydrilla (*Hydrilla verticillata*)	$492,715			$872	$25,669	$167,463		$686,719
Torpedograss (*Panicum repens*)	$94,877			$14,342	$46,800	$29,339		$185,358
Shoebutton ardisia (*Ardisia elliptica*)				$111,101				$111,101
Australian pine (*Casuarina equisetifolia*)				$81,445				$81,445

Biological Control of Invasive Plant Species

Most non-native plant species in Florida arrived without their specialized natural enemies and, as a result, grow larger, produce more offspring, spread more quickly, and often end up dominating and degrading important habitats in Florida. The objective of classical biological control is to reunite host-specific natural enemies from the native range of the non-natives by introducing and establishing them into Florida in order to reestablish a natural regulation of the pest populations.

Although several biological control projects have been very successful in Florida, this method rarely controls the target completely, rather it complements existing tactics by weakening the target plant and making it less competitive with native plants, while increasing their susceptibility to herbicides and fire. Developing biological control agents is necessarily a long-term process in order to ensure the environmental safety of prospective agents. Overseas and United States quarantine studies are used to confirm the specificity of an agent, which is then subjected to a rigorous and lengthy review by state and federal regulatory agencies before they can be introduced. Despite these

hurdles, biological control research and implementation has led to the permanent transformation of formerly intractable weeds into less invasive forms.

Melaleuca

The melaleuca weevil (*Oxyops vitiosa*) was introduced in 1997 and established on melaleuca throughout the region. Feeding by the weevil can reduce the tree's reproductive potential as much as 99 percent, reduce its rate of growth by more than 80 percent, and shorten its height by half (Tipping et al. 2008). Those trees that do reproduce have smaller flowers containing fewer seeds (Pratt et al. 2005, Rayamajhi et al. 2008). The melaleuca psyllid (*Boreioglycaspis melaleucae)* was released in 2002 and, in conjunction with the weevil, has led to decreases in melaleuca canopy cover over a 10-year period (1997–2007), resulting in a fourfold increase in native plant species diversity at some sites (Rayamajhi et al. 2009). A five-year field study found that melaleuca reinvasion was reduced by 97.8 percent compared to pre-biocontrol population densities despite a large fire that, in the past, would have promoted dense recruitment of seedlings (Tipping et al. 2012). The melaleuca midge (*Lophodiplosis trifida*) is the most recent biological control agent for melaleuca. The larvae feed within the stems, stimulating the formation of galls which diverts the tree's resources away from growth and reproduction (**Figure 7-2**). This agent also works in concert with the other melaleuca biological control agents in suppressing this tree, rendering it less invasive and easier to control using herbicides and fire.

Figure 7-2. Galls of the melaleuca midge (*L. trifida*) stunt and deform melaleuca stem growth (photo by SFWMD).

Old World Climbing Fern

The white lygodium moth (*Austromusotima camptozonale*) was the first agent to be released against Old World climbing fern in Florida. Releases of this insect began in 2004 and continued through 2012 and, despite the release of more than 58,000 individuals, this species did not establish In contrast, a second biocontrol agent, the brown lygodium moth (*Neomusotima conspurcatalis*), was released in Florida in 2008 and rapidly established large field populations at release sites (Boughton and Pemberton 2009) (**Figure 7-3**). At long-term study sites in Martin County, Florida, moth populations have successfully survived five winter seasons without additional insect releases. Subsequent surveys revealed that moths are established in all sites into which they were released with the exception of ENP. To date, 260,640 brown lygodium moths or larvae have been eased in South Florida in Fiscal Year 2014-2015.

Figure 7-3. Larvae of the brown lygodium moth (*N. conspurcatalis*) feed on Old World climbing fern [photo by United States Department of Agriculture, Agricultural Research Service (USDA-ARS)].

The lygodium gall mite, *Floracarus perrepae*, induces leaf roll galls on the leaves of Old World climbing fern. First released in 2008 and 2009, the mite continues to be present at low numbers within some of these sites but successful gall induction on field plants is much lower than anticipated. However, the mite has shown the ability to undergo long distance dispersal and has colonized lygodium populations far from the release sites, including areas within ENP. *F. perrepae* recolonized a site after a prescribed burn in the ENP and caused heavy damage to the Old World climbing fern regrowth. During Fiscal Year 2014-2015, more than 227,202 mites have been released in Florida. Research is under way to identify, test, and introduce better genetic matches between the weed and the mites. Host range testing is also under way in United States Department of Agriculture – Agricultural Research Service (USDA-ARS) quarantine for two candidate biocontrol agents, namely *Lygomusotima stria* (moth) and *Neostrombocerus albicomus* (sawfly).

Water Hyacinth

Water hyacinth is an exotic floating plant that aggressively colonizes freshwater ecosystems in the southeastern and southwestern United States including the Everglades. Several biological control agents of water hyacinth introduced during the 1970s have reduced biomass by more than 50 percent and seed production by 90 percent, but additional agents are needed to reduce surface coverage. A new insect, the water hyacinth planthopper (*Megamelus scutellaris*), was recently approved and released into the field in February 2010 (Tipping et al. 2014) (**Figure 7-4**), making it the first new agent on water hyacinth in more than 30 years. During Fiscal Year 2014-2015, more than 392,000 insects were released in Florida, most of them in the Everglades STAs. The species is cold tolerant and can overwinter at least as far north as Gainesville, Florida. Other biological control agents for water hyacinth and water lettuce (*Pistia stratiotes*) are being evaluated in USDA-ARS quarantine in Davie, Florida.

Figure 7-4. The water hyacinth planthopper (*M. scutellaris*) (photo by USDA-ARS).

CERP Biocontrol Implementation Project

The CERP Melaleuca Eradication and Other Exotic Plants – Implement Biological Controls Project is dedicated to the implementation of biological control agents to address the spread of non-native weeds throughout the CERP area. The project included the construction of a mass rearing annex to the existing USDA-ARS biological control facility in Davie, Florida, to mass rear, release, establish, and monitor approved biological control agents for melaleuca and other non-native weeds in the CERP area. The final project implementation report/environmental assessment (USACE and SFWMD 2010), the project partnership agreement and cooperative agreement on lands, and the design-build contract were all executed in 2010 with the construction of the mass rearing facility completed in 2013. USDA-ARS, in close coordination with the District and United States Army Corps of Engineers (USACE), has begun the operational phase of the project and has released 929,000 insects and mites on three weed species in Fiscal Year 2014-2015. Intensive and extensive field monitoring and evaluation of the biological control agents are under way.

INVASIVE ANIMAL MANAGEMENT

Efforts to develop control tools and management strategies for several priority animal species continued in Fiscal Year 201-2015. These include the Burmese python (**Figure 7-5**) and other giant constrictors, the Nile monitor (*Varanus niloticus*), and the Argentine black and white tegu. Control tools are very limited for free-ranging reptiles, and the application of developed methods is often impracticable in sensitive environments where impacts to non-target species are unacceptable. Available tools for removing reptiles generally include trapping, toxicants, barriers, dogs, and introduced predators (Witmer et al. 2007), as well as visual searching and pheromone attractants. Reed and Rodda (2009) provide a thorough review of primary and secondary control tools that may be considered for giant constrictors.

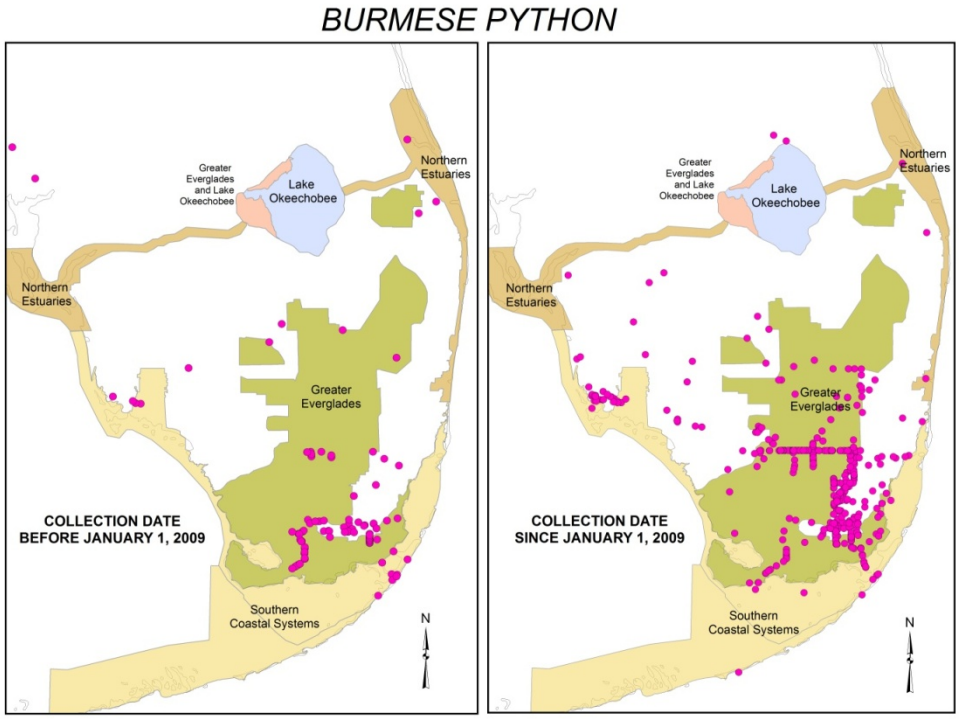


Figure 7-5. Locations of Burmese pythons (*P. molurus bivittatus*) removed from South Florida from 1999 through 2008 (left) and from 2009 to present (right).

Regional invasive biologists associated with the ECISMA have developed a conceptual response framework for establish priority invasive animals in South Florida. Objectives within this framework are classified into three main categories—containment (slow the spread), eradicating incipient populations (remove outliers), and suppression (reduce impact in established areas) (Skip Snow, ENP, personal communication). The resources to implement this strategic framework remain insufficient, but close collaboration between agencies has allowed for some coordinated efforts. For example, multiple agencies are working together to contain the Argentine black and white tegu to determine its population status, develop monitoring and control tools, and better understand the natural history of this invader in South Florida habitats. A significant step toward a more structured and coordinated framework would be the formation of a region-wide early detection rapid response (EDRR) strike team possibly modeled after the National Park Service (NPS) Exotic Plant Management Teams. To date, this strike team has not been formalized although sustained and coordinated efforts continue through the ECISMA and other coordinating groups.

There were several ongoing and new invasive animal initiatives in Fiscal Year 2014-2015, including ongoing monitoring and research efforts for Burmese python, northern African python, Argentine black and white tegu, Nile monitors, Gambian pouched rat (*Cricetomys gambianus*), and Cuban treefrog (*Osteopilus septentrionalis*), among others. Updates on these activities are discussed in the *Invasive Species Status Updates* section in this chapter.

Everglades Invasive Reptile and Amphibian Monitoring Project

In 2010, the University of Florida (UF), FWC, and SFWMD began collaboration on the Everglades Invasive Reptile and Amphibian Monitoring Project. The purpose of the project is to develop a monitoring program for priority invasive reptiles and amphibians and their impacts to South Florida. Specifically, the program seeks to (1) determine the status and spread of existing populations and the occurrence of new populations of invasive reptiles and amphibians, (2) provide additional EDRR capability for removal of invasive reptiles and amphibians, and (3) evaluate the status and trends of populations in native reptiles, amphibians, and mammals. The monitoring program involves visual searches for targeted invasive species on fixed routes along levees and roads within LNWR, WCA-2, WCA-3, Big Cypress National Preserve (BCNP), Southern Glades Wildlife Management Area, ENP, and other areas such as the C-51 canal, US Highway 1, and Card Sound Road. Visual searches and call surveys, in addition to trapping, are conducted to monitor prey species. Twenty-one routes have been established. The encounter rates for targeted invasive species ranged from 0.001 to 0.018 observations per kilometer. Brown anoles (*Norops sagrei*), house geckos (*Hemidactylus* spp.), Burmese pythons, greenhouse frogs (*Eleutherodactylus planirostris*), Cuban treefrogs, cane toads (*Rhinella marina*), domestic cats (*Felis domesticus*), domestic dogs (*Canis familiaris*), and domestic horses (*Equus ferus*) were the most commonly observed nonindigenous species of reptile, amphibian, and mammal, respectively (Frank Mazzotti, UF, unpublished data). Raccoons *(Procyon lotor*), Virginia opossums (*Didelphis virginiana*), and white-tailed deer (*Odocoileus virginianus*) were the most common native mammals observed. To date, 15 Burmese pythons have been detected during these visual surveys. Moving forward, the team plans to refine survey methods to correspond with peak Burmese python movement periods. In addition, the team has an occurrence experiment to evaluate whether the presence of invasive species is related to the absence of native species. In addition to fixed routes, the UF, FWC, and SFWMD team has joined with Zoo Miami and Venom One to provide EDRR capability for invasive reptiles in the ECISMA. The EDRR surveys and trapping have resulted in the removal of 49 Nile monitors, 787 Argentine black and white tegus, 599 Oustalet's chameleons (*Furcifer oustaleti*), 15 veiled chameleons (*Chamaeleo calyptratus*), 96 spectacled caiman, 7 Burmese pythons, 1 white-throated monitor (*Varanus albigularis*), 1 Nile crocodile (*Crocodylus niloticus*), 1 boa constrictor (*Boa constrictor*), 1 ball python (*Python regius*), 1 leopard gecko (*Eublepharus macularius*), and 2 black spinytail iguanas (*Ctenosaura similis*).

INTERAGENCY COORDINATION

This section provides updates on key interagency coordination activities pertaining to invasive, nonindigenous species in South Florida during Fiscal Year 2014-2015. To be successful, regional management of nonindigenous species requires strategic integration of a broad spectrum of control measures across multiple jurisdictions. As such, numerous groups and agencies are necessarily involved with nonindigenous species management in Florida. More information on agency roles and responsibilities pertaining to nonindigenous species in Florida is available at http://www.eli.org/sites/default/files/eli-pubs/fillingthegaps.pdf .

Cooperative Invasive Species Management Areas

Florida has a long history of invasive species organizational cooperation including the FLEPPC, Noxious Exotic Weed Task Team, Florida Invasive Animal Task Team, and Invasive Species Working Group. At more local levels, land managers and invasive species scientists have informally coordinated across the fence line for many years. These regional groups began formalizing their partnerships into cooperative invasive species management areas (CISMAS) to further enhance collaboration and coordination. CISMAs are local organizations, defined by a geographic boundary, that provide a mechanism for sharing invasive plant and animal management information and resources across jurisdictional boundaries to achieve regional invasive species prevention and control (MIPN 2006). Based on the success of CISMAs in Florida and in western states, the Florida Invasive Species Partnership, formerly the Private Lands Incentive subcommittee of the Invasive Species Working Group, expanded its reach to act as a statewide umbrella organization for Florida CISMAs (www.floridainvasives.org). The Florida Invasive Species Partnership is an interagency collaboration of federal, state, and local agencies; nongovernmental organizations; and universities focused on addressing the threat of invasive, nonnative species to Florida's wildlife habitat and natural communities, and working agricultural and forest lands. The Florida Invasive Species Partnership serves Florida's CISMAs by facilitating communication between existing CISMAs, fostering the development of new CISMAs, providing training for invasive species reporting, and providing access to existing online resources and efforts. To date, there are 18 CISMAs in Florida covering roughly 98 percent of the state. Of these 17 CISMAs, seven occur either wholly or partially within the CERP footprint. Additional information on the Florida Invasive Species Partnership and the ongoing cooperative efforts throughout Florida is available at www.floridainvasives.org/cismas.html.

Everglades CISMA

Invasive species scientists and Everglades land managers formed the ECISMA in 2006 in order to improve cooperation and information exchange related to invasive species management. The ECISMA partnership was formalized in 2008 with a memorandum of understanding (MOU) among the District, USACE, FWC, NPS, and United States Fish and Wildlife Service (USFWS). The MOU recognizes the need for cooperation in the fight against invasive species and affirms the commitment of signatories to a common goal. Currently, the ECISMA consists of 18 cooperators and partners, spanning the full spectrum of jurisdictions, including tribal, federal, state, local, and nongovernmental conservation organizations. The geographic extent of ECISMA includes all state and federal conservation lands within the Everglades Protection Area (EPA), Miccosukee and Seminole lands, and Broward, Palm Beach, and Miami-Dade counties (**Figure 7-6**).

Since its inception, ECISMA has achieved much progress toward improved coordination and cooperation among those engaged in invasive species management in the Everglades. These accomplishments include development of regional monitoring programs, standardization of data management, completion of numerous rapid response initiatives, and enhanced coordination of management and research activities.

During the last year, ECISMA members worked together on a number of invasive species initiatives. In addition to continued coordination and collaboration on long-term management efforts for melaleuca, Old World climbing fern, Burmese pythons and other widely established species, ECISMA cooperators organized efforts to address recently discovered populations of nonindigenous plant and animal species. These include rapid assessment efforts to (1) determine the current status of tegu lizards, two chameleon species, spectacled caiman, and Nile crocodile in the southeastern region of the Everglades and adjacent developed areas, (2) rapid response efforts to control populations of mile-a-minute (*Mikania micrantha*), and (3) continued monitoring and

treatment of the invasive mangrove species *Lumnitzera racemosa* (Exotic black mangrove or kripa). Updates on these and other species are provided in this chapter.

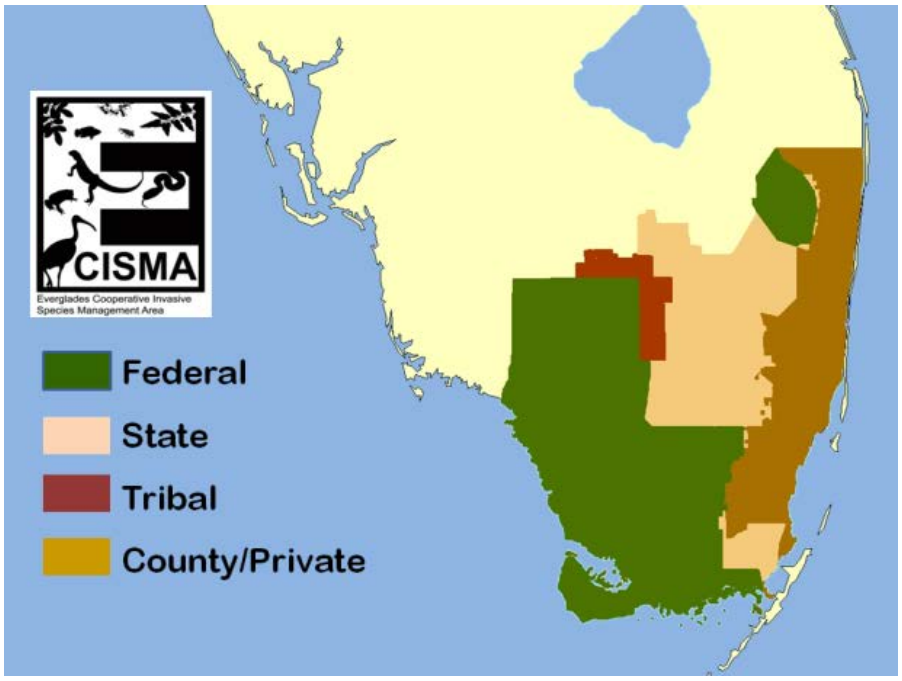


Figure 7-6. The Everglades Cooperative Invasive Species Management Area.

The ECISMA also coordinated and participated in a number of outreach initiatives aimed at increasing public awareness of invasive species. ECISMA partners developed a number of outreach publications during 2014, including identification and reporting guides for tegus and pythons. ECISMA partners also participated in 13 outreach events including a Broward County pet amnesty event. The group also hosted the Everglades Nonnative Fish Roundup aimed at increasing awareness of the issue of invasive freshwater fish.

In July 2014, ECISMA partners convened for a two-day Everglades Invasive Species Summit in Broward County. Updates on invasive species management activities, new research, and outreach efforts were presented to attendees. As with previous summits, attendees worked in multiple breakout sessions to plan collaborative efforts and regional strategies for mutual invasive species priorities during the next year. Planned activities for 2014 include (1) numerous interagency work days focused on rapid response efforts for mile-a-minute, exotic black mangrove, northern African pythons, and Oustalet's chameleon; (2) continued monitoring and trapping efforts for Argentine black and white tegus and Nile monitors; and (3) several outreach and training initiatives aimed at increasing observations of priority species in the field (e.g., personnel for utility companies, Everglades biologists, and law enforcement) and prevention education to the public.

Treasure Coast CISMA

From June 2014 to July 2015, land managers, biologists, and others along Florida's Treasure Coast held two steering committee meetings and developed a 2015 annual work plan as participants in a regional partnership to cooperatively address the threats of invasive plants and animals. Since 2007, the Treasure Coast CISMA (TC-CISMA) partnership extends from Indian River County south through St. Lucie, Martin, and northern Palm Beach counties and includes representatives and land managers from local, state, and federal governments. Current active participants include

SFWMD, USFWS, FWC, Florida Park Service, Martin County, The Nature Conservancy, Treasure Coast Resource Conservation and Development Council, Natural Resources Conservation Service, Palm Beach County Environmental Resources Management, UF Institute of Food and Agricultural Sciences (IFAS), St. Lucie County, Aquatic Vegetation Control Inc., Habitat Specialists Inc., Florida Grazing Land Coalition, and The Florida Native Plant Society.

During this past year, the TC-CISMA has continued its priority private land efforts treating 20 acres of downy rose-myrtle (*Rhodomyrtus tomentosa*), strawberry guava (*Psidium cattleianum*), and Old World climbing fern at The Boy Scouts of America's Camp Tanah Keeta in Tequesta, Martin County. In addition, coastal private land treatments of 2.5 acres occurred on Harbour Island, Jupiter Island, and 0.5 acres in Jensen Beach to support the rare Savannas mint. Within the TC-CISMA, 20 requests for funding from the FWC IPMS program were proposed.

The TC-CISMA also updated and standardized its EDRR plant list with Florida Natural Areas Inventory and FWC involvement, participated in eight statewide Florida Invasive Species Partnership conference calls, and participated in the FLEPPC's Annual Symposium CISMA workshop. The TC-CISMA celebrated National Invasive Species Awareness Week with a multi-agency workday at the Hobe Sound National Wildlife Refuge and a webinar viewed by 496 people on the air potato leaf beetle (*Lilioceris cheni*).

Working within the TC-CISMA, St. Lucie County's Python Patrol held an event with 25 participants and 16 outreach events with 533 participants. St. Lucie County also held the Southern Swines Feral Hog Challenge with 347 participants and five Feral Hog Management events with 230 participants.

Southwest Florida CISMA

The Southwest Florida CISMA (SWF CISMA), founded in 2008, is a partnership between the Florida Forest Service, FWC, Florida Department of Environmental Protection (FDEP), USFWS, Lee County, Collier County, Audubon of Florida, Conservancy of Southwest Florida, Naples Zoo, and others. This past year, members participated in more than 10 festivals and events from September 2014 to April 2015, including World Wetlands Day at Corkscrew Swamp Sanctuary, Panther Day at Naples Zoo, the Swamp Heritage Festival at BCNP, an FWC Pet Amnesty Day, and the 6th Annual Everglades Non-Native Fish Round-up. A representative from SWF CISMA attended the FLEPPC 2015 CISMA session: Strategizing across Boundaries – CISMA EDRR Plant Lists and Statewide Surveys. The group also organized a grass identification workshop with IFAS, a python handling workshop, and the 19th Annual Southwest Florida Exotics Workshop, which reached 180 attendees. SWF CISMA continued their invasive reptile outreach and research efforts in 2014. The group coordinated with the Conservancy of Southwest Florida and Dr. Paul Andreatis in tracking radio-telemetry tagged pythons, the Invasive Animal Subcommittee held a Tegu Strategy Meeting, and the group funded a billboard that was posted on US41 in an area where pythons and tegus have been sighted.

Other CISMAs

In addition to the ECISMA, TC-CISMA, and SWF CISMA, there are four other CISMAs either wholly or partially within the footprint of the Greater Everglades ecosystem: Florida Keys Invasive Species Task Force, Heartland CISMA, Osceola County CISMA, and Central Florida CISMA. These CISMAs have also recognized many successes that have benefitted the Everglades ecosystem by furthering the concept of a landscape-level approach to invasive species management.

Lake Okeechobee Aquatic Plant Management Interagency Task Force

Invasive plant management on Lake Okeechobee is coordinated according to policy contained in the Corps of Engineers Letter of Operating Procedures for Aquatic Plant Management on Lake Okeechobee (USACE 1989), which was adopted by the involved agencies: USACE, SFWMD, Florida Department of Natural Resources, FDEP, and FWC. At semi-monthly meetings, interagency representatives plan treatment species and areas. Also, the group has flown semi-monthly since 1987 to estimate the lake's coverage of water lettuce and water hyacinth. The group's considerations include accounting for the presence of endangered species, conservation of quality fish and wildlife habitat, and navigation. Public stakeholders and nongovernmental organizations are always encouraged to attend and provide input to this process. More information about this task force is available online at http://www.floridainvasives.org/Okeechobee/index.html.

Kissimmee River and Chain of Lakes Coordination

Similar invasive plant treatment events are planned at interagency meetings for the Kissimmee River and Chain of Lakes, though these groups do not have a formal agreement such as the Corps of Engineers Letter of Operating Procedures for Aquatic Plant Management on Lake Okeechobee. Funding from the Florida Aquatic Plant Management Trust Fund, administered by FWC, is available for much of the work in these waters. The primary lakes within the Kissimmee Chain of Lakes are given high state priority for large-scale aquatic plant management treatments, particularly for hydrilla, water lettuce, water hyacinth, Cuban bulrush (*Oxycaryum cubense*) and large-flower primrose-willow (*Ludwigia grandiflora*). The primary lakes are large (1,620–13,800 hectares) and interconnected with flood protection canals, which are navigable with boat locks along the system.

South Florida Ecosystem Restoration Task Force

The South Florida Ecosystem Restoration Task Force was established by section 528(f) of the Water Resources Development Act of 1996. The task force consists of 14 members from four sovereign entities. There are seven federal, two tribal, and five state and local government representatives. The task force coordinates the development of consistent policies, strategies, plans, programs, projects, activities, and priorities addressing the restoration, preservation, and protection of the South Florida ecosystem. It recognizes the significant threat invasive exotic species pose to the goals and objectives of ecosystem restoration programs in South Florida. For more than a decade, task force member agencies have fought the rising tide of invasive exotics and the task force itself has supported those efforts through the coordination work of the Task Force Working Group and Science Coordination Group.

Most recently, these two groups along with the Office of Everglades Restoration Initiatives recommended to the South Florida Ecosystem Restoration Task Force that a comprehensive strategic action framework for invasive species be developed to improve coordination and boost the effectiveness of existing programs. The framework, completed in fall 2014, is a living, web-based document. This initiative has developed four goals organized around the invasion curve (**Figure 7-7**). The curve depicts, at a glance, the ability to combat invasive exotic species in terms of time, resources, and likelihood of eradication or containment. The left-hand side of the invasion curve represents the best chance for long-term success. Since eradication of widely established invasive species is rarely achieved, a long-term commitment to controlling established species is required to protect the natural resource. Long-term suppression of established species is challenging and costly. Thus, early detection and control of new invasive species results in lower overall environmental impact and economic cost along with a higher likelihood for eradication. The strategic action framework lists objectives and actions for each phase of the invasion curve and highlights case studies as examples of the phases. More information on this effort is available at http://www.EvergladesRestoration.gov.

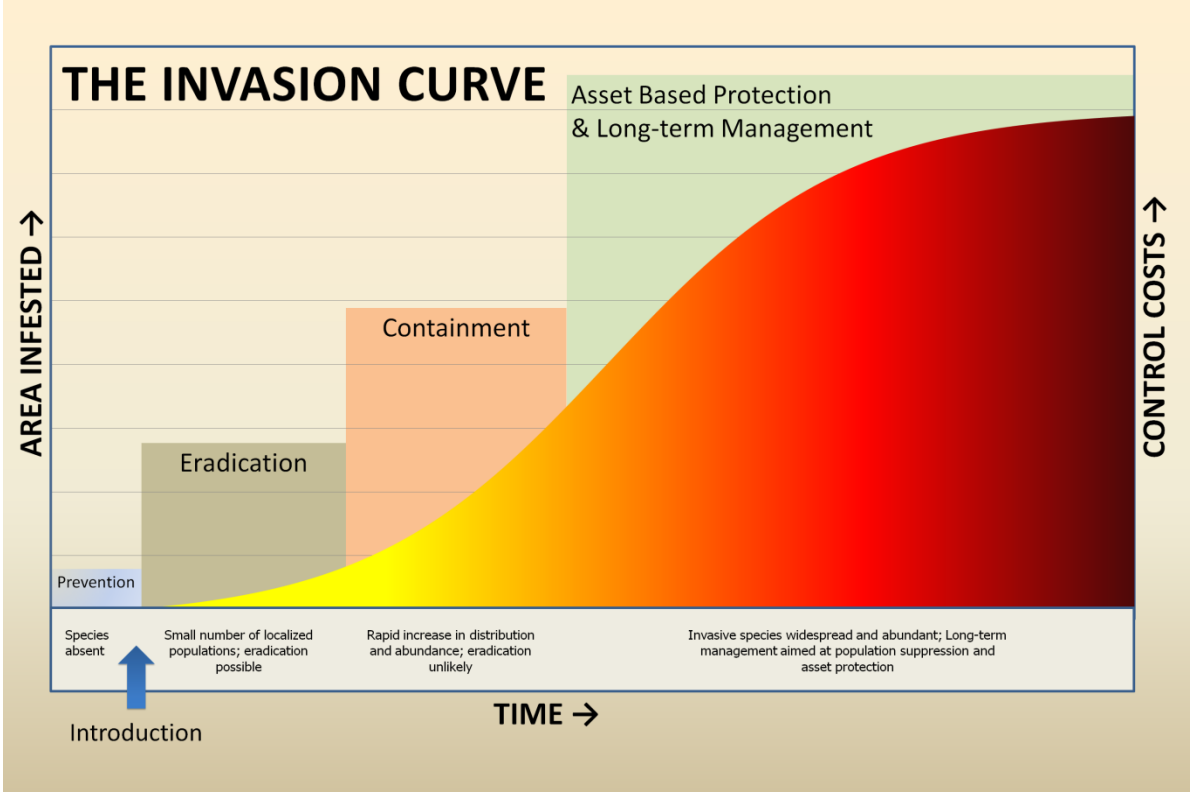


Figure 7-7. The invasion curve depicts the four major categories of management actions that may be taken to combat invasive exotic species as the invasion progresses from initial establishment to widespread dominance on the landscape. Graphic adapted from *Invasive Plants and Animals Policy Framework* (DEPI 2010).

INVASIVE SPECIES STATUS UPDATES

The following section provides a summary of nonindigenous species that threaten the success of the District's mission. Species are presented in two sections—established priority species and emerging threats. Twelve established plant species were selected by District staff based on potential and current implications to the District's infrastructure and ecological concerns. These species are presented with a "District-centric" justification for listing, and priority plant species may differ for other agencies, depending on regional factors and agency priorities and goals.

Ten established nonindigenous animal species presented in this section are in close alignment with the species identified by the Florida Invasive Animal Task Team as eradication, control, and research priorities for the state (www.sfrestore.org/issueteams/fiatt/index.html). Omitting specific mention of other nonindigenous species in the following priority summaries does not imply that the species are not problematic or that control is not important. On the contrary, the need is urgent for distribution and biological data for many of these organisms.

In this section, each of the 22 priority established species (**Table 7-3**) is summarized in a one-page synopsis that highlights key management issues and provides general distribution information. The county (or coastline) distribution maps provided for each species were compiled from a variety of resources, but in only a few cases are data from systematic, statewide monitoring efforts. As such, these maps should be viewed as provisional and only intended to give general instruction on species' distribution. Primary data sources for the distribution maps and the module occurrence table found in Appendix 7-1 of the 2014 SFER – Volume I (Rodgers and

Black 2014), include Early Detection and Distribution Mapping System (www.eddmaps.org/distribution/), ECISMA (www.evergladescisma.org/distribution/), FWC Florida's Nonnative Species (http://myfwc.com/wildlifehabitats/nonnatives/invasive-species/), United States Geologic Survey Nonindigenous Aquatic Species (nas.er.usgs.gov/), and University of South Florida Atlas of Florida Vascular Plants (www.plantatlas.usf.edu/).

Table 7-3. The District's priority species ranked by taxonomic group and then alphabetically by common name. An asterisk indicates species presumed to have a limited distribution and is the current focus of rapid assessment and rapid response efforts.

Plants	Reptiles
Australian pine (*Casuarina* spp.)	Argentine black and white tegu (*Salvator merianae*)
Brazilian pepper (*Schinus terebinthifolius*)	Burmese python (*Python molurus bivittatus*)
Cogongrass (*Imperata cylindrical*)	Nile monitor (*Varanus niloticus*)
Downy rose myrtle (*Rhodomyrtus tomentosa)*	*Northern African python (*Python sebae*)
Hydrilla (*Hydrilla verticillata*)	*Oustalet's chameleon (*Furcifer oustaleti*)
Melaleuca (*Melaleuca quinquenervia*)	*Spectacled caiman (*Caiman crocodilus fuscus*)
Old World climbing fern (*Lygodium microphyllum*)	*Veiled chameleon (*Chamaeleo calyptratus*)
Shoebutton ardisia (*Ardisia elliptica*)	
Torpedograss (*Panicum repens*)	
Tropical American watergrass (*Luziola subintegra*)	
*Exotic black mangrove (*Lumnitzera*)	
*Mile-a-Minute (*Mikania micrantha*)	
Water lettuce (*Pistia stratiotes*)	
Water hyacinth (*Eichhornia crassipes*)	
Mollusks	**Birds**
*Giant African land snail (*Lissachatina fulica*)	Purple swamphen (*Porphyrio porphyrio*)
Island applesnail (*Pomacea maculata*)	
Insects	**Amphibians**
Laurel wilt (*Raffaelea lauricola*)	Cuban treefrog (*Osteopilus septentrionalis*)
Mexican bromeliad weevil (*Metamasius callizona*)	
Fishes	**Mammals**
Asian swamp eel (*Monopterus albus*)	Feral hog (*Sus scrofa*)
	*Gambian pouched rat (*Cricetomys gambianus*)

*Species is currently targeted for possible eradication.

Additionally, each species synopsis includes an indicator-based stoplight table that gauges the status of the species in each of the District's land management regions, as well as Lake Okeechobee, Florida Bay and the Florida Keys. These regions closely align with the RECOVER modules, but are more inclusive of all conservation and project lands within the District boundary. The stoplight table technique was established through coordination among the Science Coordination Group, Noxious Exotic Weed Task Team, and Florida Invasive Animal Task Team of the South Florida Ecosystem Restoration Task Force (Doren et al. 2009). Similar to its application in previous reports (e.g., 2012 SFER – Volume I, Chapter 9; Ferriter et al. 2012), the indicator table assesses each species by region according to the following questions: (1) How many acres within the module does this species occur in? (2) Are the acres of the species in the module documented to be increasing, decreasing, or static? and (3) If the species is decreasing in coverage, is it a direct result of an active biocontrol or chemical/mechanical control program? While the development of an assessment and monitoring program specifically designed for this purpose would be ideal, the exotic species indicator is currently constrained to data from existing monitoring and research

programs. A brief explanation of stoplight indicators provided for each priority species in the following species summaries is as follows:

- Red – Severe negative condition, or expected in near future, with out-of-control situation meriting serious attention
- Yellow – Situation is improving due to control program and is stable or moving toward stabilizing, or species is very localized but expected to spread if sufficient resources or actions are not continued or provided.
- Green – Situation is under control and has remained under control for several years.

Finally, updates are provided for eight priority species that are currently the focus of rapid response efforts (**Table 7-3**). For some of these species, agencies are currently directing resources toward monitoring and removal efforts with the stated objective of eradicating the species in Florida (e.g., Gambian pouched rat). For other species whose potential ecological impacts and population status are not sufficiently understood, response efforts are focused on rapid assessments to gather information necessary for informed decision making as to whether the species should be a priority for eradication attempts.

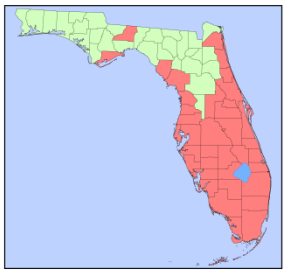
A more complete list of nonindigenous plant and animal taxa known to be established in each Restoration Coordination and Verification Program (RECOVER) module is included in the 2014 SFER – Volume I, Appendix 7-1 (Rodgers and Black 2014). Within the geographic areas, animal species are divided into broad taxonomic groups of amphibians, reptiles, birds, mammals, fish, and invertebrates. The animal table also indicates whether a species is widely or locally distributed (i.e., occurring in all modules or all but one module, or in only one module). This distribution information indicates the scope of the problem and, in the future, may help agencies prioritize animal species for regional control and management. Due to limited availability of distribution data, the appendix may not be comprehensive or entirely accurate. For instance, some nonindigenous species listed for a module may occur outside of the module noted because the listing relies on incomplete county data as the most specific location data available. The lists have been developed and refined through peer review by taxonomic experts and land managers to reflect regional considerations (such as coastal versus inland habitats), but should be used with the knowledge that animal distribution data, especially across taxa, is deficient in Florida.

Australian Pine (*Casuarina* spp.)

Figure 7-8. The dense litter mat of Australian pine (*Causarina* sp.) inhibits growth of other plants (photo by SFWMD).

SUMMARY: Three nonindigenous species in Florida are commonly and collectively referred to as Australian pine: *Casuarina equisetifolia*, *C. glauca*, and *C. cunninghamiana*. Australian pine is a fast growing tree that readily colonizes rocky coasts, dunes, sandbars, islands, and inland habitats (Morton 1980). This large tree produces a thick litter mat and compounds that inhibit growth of other plant species (Batish et al. 2001; **Figure 7-8**). These characteristics make Australian pine particularly destructive to native plant communities and can also interfere with sea turtle and American crocodile (*Crocodylus acutus*) nesting (Klukas 1969). Mazzotti et al. (1981) found that small mammal populations are significantly lower in habitats dominated by Australian pine.

KEY MANAGEMENT ISSUES



Distribution: Australian pine is still common in northeastern ENP, in the District's southern saline glades (C-111 Basin), the Model Lands, and Biscayne Bay National Park. While maintenance control is achieved throughout most of the EPA and most District-managed conservation lands, recent monitoring in the Southern Glades and Model Lands suggests a slight increase in abundance of Australian pine (see *Everglades Invasive Plant Monitoring* section in this chapter for more information).

Control Tools: Herbicide controls are well established for this species although access to remote infestations in mangroves makes control challenging. Recent research confirms hybridization of *Casuarina* in Florida (Gaskin et al. 2009), which may present challenges for future biological control efforts.

Monitoring: Agencies monitor for this species in high priority public lands region-wide. Digital aerial sketch mapping (DASM) is conducted biennially within the Greater Everglades and on all District-owned lands.

Interagency Coordination: Agency-sponsored control efforts are ongoing but are complicated by local and state initiatives to allow plantings of this genus in certain situations or prevent control of the species for aesthetic reasons.

Regulatory Tools: *Casuarina* species are designated as Florida Prohibited Aquatic Plants. *C. equisetifolia* and *C. glauca* are designated as Florida Noxious Weeds. Florida law allows plantings of *C. cunninghamiana* for windbreaks in commercial citrus groves.

Critical Needs: State and local restrictions on planting and maintaining *Casuarina* species and statewide private lands initiatives to reduce propagule pressure on conservation lands. Research into potential biological control agents is also needed.

2014 Status of Australian Pine by Management Region

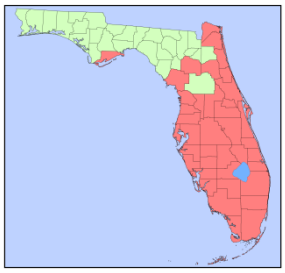
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Brazilian Pepper (*Schinus terebinthifolius*)

SUMMARY: Brazilian pepper (**Figure 7-9**) is an aggressive weed found throughout most of South and Central Florida. This shrub rapidly establishes in disturbed areas and then expands into adjacent natural areas (Cuda et al. 2006). Once established, Brazilian pepper severely reduces native plant and animal diversity (Workman 1979, Curnutt 1989) and alters fire regimes (Stevens and Beckage 2009). The invasiveness of Brazilian pepper is partly explained by hybrid vigor. Florida's Brazilian pepper originated from multiple genetic strains (Mukherjee et al. 2012). The Florida hybrids were recently found to have greater fitness (germination rate and seedling survival) relative to their progenitors (Geiger et al. 2011).

Figure 7-9. Left untreated, Brazilian pepper (*S. terebinthifolius*) outcompetes virtually all other plant species (photo by SFWMD).

KEY MANAGEMENT ISSUES



Distribution: Brazilian pepper is the most widespread and abundant nonindigenous species in the District (Ferriter and Pernas 2005). This prolific seed producer is a dominant component of southwestern ENP and invades tree islands throughout the Greater Everglades region (see *Everglades Invasive Plant Monitoring* in this chapter for more information). Brazilian pepper also remains abundant on rights-of-way and adjacent private lands, facilitating constant reestablishment on conservation lands.

Control Tools: Managers use herbicides, and physical and mechanical controls. Wide distribution on private lands and rapid colonization via bird dispersal make it difficult to achieve sustained control in management areas. Some management progress has been made but many remote regions of the Everglades remain infested. The severe cuts to the budget of the United States Department of Agriculture (USDA) lab in Fort Pierce will dramatically slow the development and release of biocontrol agents for Brazilian pepper.

Monitoring: Agencies monitor for this species in high priority public lands region-wide. DASM is conducted biennially within the Greater Everglades and on all District-owned lands

Interagency Coordination: An interagency management plan was developed that called for the need for coordination but little progress has been made.

Regulatory Tools: Brazilian pepper is designated a Florida Noxious Weed and Florida Prohibited Aquatic Plant. There are no federal regulations regarding this species.

Critical Needs: Successes in biological control efforts and statewide private lands initiatives to reduce propagule pressure on conservation lands.

2014 Status of Brazilian Pepper by Management Region

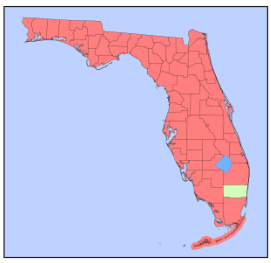
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Cogongrass (*Imperata cylindrica*)

Figure 7-10. Once established, cogongrass (*I. cylindrica*) quickly dominates pineland understories (photo by University of Georgia).

SUMMARY: Cogongrass is a fast-growing perennial grass native to southeastern Asia and is among the top worst weeds internationally (Holm et al. 1977). Widely planted for forage in the early twentieth century, it is now estimated to infest 1,000,000 acres in Florida (Miller 2007). Cogongrass aggressively invades pine flatwoods (**Figure 7-10**), disturbed sites, and marshes where it often displaces entire understory plant communities and alters ecosystem processes such as fire regimes (Lippincott 2000) and biogeochemical cycling (Daneshgar and Jose 2009, Holly et al. 2009).

KEY MANAGEMENT ISSUES



Distribution: Cogongrass is documented in natural areas throughout Florida. Within the District boundaries, cogongrass is most prevalent in the Kissimmee and Caloosahatchee watersheds, but in recent years it has spread in the BCNP and in the DuPuis Management Area. Cogongrass has been estimated to infest about 6,900 acres in the District (Ferriter et al. 2008).

Control Tools: This species is difficult to control and requires judicious implementation of integrated controls. These include repeated herbicide applications in conjunction with prescribed fire, mechanical controls, and in some cases, native revegetation efforts (IFAS 2013). No biocontrol agents have been approved for release.

Monitoring: Agencies monitor for this species in high priority public lands regionwide. DASM is conducted biennially within the Greater Everglades and on all District-owned lands.

Interagency Coordination: A strategy to address management of cogongrass throughout the southern United States was developed at the Regional Cogongrass Conference in 2007. The outcome of this meeting was a cogongrass management guide that provides guidance for control strategies, research priorities, and approaches to regional coordination. The Florida Department of Agriculture and Consumer Services (FDACS) with USDA has provided a cost-share program to reduce the spread of cogongrass to new areas by helping private landowners control or eradicate existing infestations.

Regulatory Tools: Cogongrass is designated as both a Federal and Florida noxious weed.

Critical Needs: Development of biological control agents would greatly improve regional control of this species. Additional coordination between governmental and private entities would be useful. Increased control efforts on linear utilities (e.g., power line corridors) are needed. A selective herbicide, which kills cogongrass but spares some native species would be useful in natural areas. Fluazifop has some selective activity and should be investigated (IFAS 2013).

2014 Status of Cogongrass by Management Region

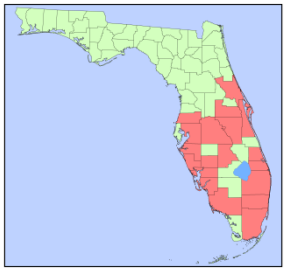
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Downy Rose Myrtle (*Rhodomyrtus tomentosa*)

SUMMARY: Downy rose myrtle (**Figure 7-11**) is an ornamental shrub of Asian origin. Introduced to Florida in the late 1800s, the plant now occurs in natural areas throughout South and Central Florida. This fast-growing shrub spreads into pine flatwoods and drained cypress strands, even in the absence of disturbance, and can form dense thickets that crowd out native vegetation. It is very fire tolerant. Successful control of downy rose myrtle with herbicides is being accomplished where adequate resources are available. Large cost per acre to clear advanced invasions shows the value of detecting and eliminating downy rose myrtle before it dominates a natural area.

Figure 7-11. Downy rose myrtle (*R. tomentosa*) displaces understory plant communities in pine flatwoods (photo by USDA-ARS).

KEY MANAGEMENT ISSUES



Distribution: Downy rose myrtle occurs throughout Central and South Florida.

Control Tools: This species is difficult to combat, but recent improvements in herbicide control show promise. A mix of glyphosate and imazapyr is effective but kills native plants and inhibits revegetation. Dicamba provides good control of downy rose myrtle and spares many native flatwoods plants. This selectivity is an advantage for use in natural areas, although follow-up treatment is required. Tall dense growth of downy rose myrtle is hard to kill. Shredding with heavy equipment and treating regrowth is effective but expensive. Not only are herbicides more effective on regrowth after shredding, but fresh growth appears in the field to be very susceptible to rust *Puccinia psidii* (Rayamajhi et al. 2013), which slows growth. Two candidate biological control agents have been imported into quarantine for testing and other insects are being evaluated overseas (Philip Tipping, USDA–ARS, personal communication). Additionally control of feral hogs (*Sus scrofa*) may assist with management of this species by reducing seed distribution and soil disturbance.

Monitoring: Because downy rose myrtle is difficult to detect from the air, monitoring is currently limited to observations by land managers. Predictive models are needed to identify ground-based monitoring priorities.

Interagency Coordination: TC-CISMA makes this species a priority for regional coordination.

Regulatory Tools: Downy rose myrtle is designated a Florida Noxious Weed.

Critical Needs: Statewide private lands initiatives to reduce propagule pressure on conservation lands; plans to guide regional, integrated management; and monitoring to support early detection.

2014 Status of Downy Rose Myrtle by Management Region

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Hydrilla (*Hydrilla verticillata*)

Figure 7-12. Dense hydrilla (*H. verticillata*) mats aggressively overtake native aquatic vegetation (photo by USDA).

SUMMARY: Hydrilla is a rooted submerged plant that can grow to the surface and form dense mats (**Figure 7-12**). It is native to the Old World and Indo-Pacific. Hydrilla was likely first introduced to Florida in the 1950s as an aquarium plant and has since spread throughout the state. Hydrilla overwhelms Florida's native aquatic plant communities, displacing valued native plants. This aggressive weed spreads to new waters mainly as fragments on boats and trailers. By the 1990s, hydrilla was widely distributed in the state, occupying more than 140,000 acres of public lakes and rivers.

KEY MANAGEMENT ISSUES

Distribution: Hydrilla is found in all types of waterbodies in Florida. Since the 1980s, it has often dominated much of the Kissimmee Chain of Lakes. Hydrilla has been in Lake Okeechobee for about 20 years, but has not been a consistent problem. In some years, hydrilla rapidly covered thousands of acres and required mechanical harvesting. Also, hydrilla in Florida has developed resistance to the herbicide fluridone, which was a primary control agent beginning in the 1990s.

Control Tools: Hydrilla management has primarily depended on herbicide applications. This weed developed resistance to a commonly used systemic herbicide, so agencies now use a contact herbicide. Of several newly-labeled aquatic herbicides, CLIPPER (flumioxazin) and GALLEON (penoxsulam) are controlling hydrilla especially when treatments are combined with long-used herbicides such as diquat, dibromide, and endothall. Several additional herbicides may receive aquatic labels soon. The availability of these new herbicides and their use in combinations and rotations will hopefully prevent hydrilla from developing further resistance to herbicides.

Monitoring: The FWC monitors hydrilla throughout Florida's public waters and ranks these waters according to environmental and societal factors to prioritize funding distribution for treatment.

Interagency Coordination: The FWC coordinates management of hydrilla by allocating funds from the Florida Invasive Plant Management Control Trust Fund to local agencies for control.

Regulatory Tools: Hydrilla is designated a Federal Noxious Weed and a Florida Prohibited Aquatic Plant.

Critical Needs: Continued research on effective systemic herbicides. Decades of research have failed to produce a successful biological control agent for this species although the weevil *Bagous hydrilla* (Coleoptera: Curculionidae) has established in Florida (Center et al. 2013). This element of integrated management is needed for long-term control.

2014 Status of Hydrilla by Management Region

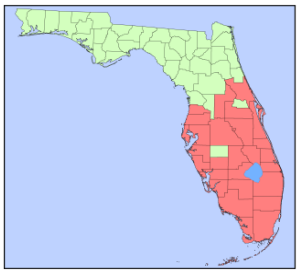
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Melaleuca (*Melaleuca quinquenervia*)

Figure 7-13. A former sawgrass marsh now dominated by melaleuca (photo by SFWMD).

SUMMARY: Before organized state and federal nonindigenous plant control operations were initiated in 1990, melaleuca (**Figure 7-13**) was widely distributed throughout the WCAs, ENP, BCNP, Lake Okeechobee, and LNWR. Overall, agency efforts to control melaleuca are succeeding in containing and reducing its spread. Still, melaleuca remains widely distributed on private lands throughout South and Central Florida, but the successful biological control program has reduced its rate of spread (Pratt et al. 2005). Melaleuca infests an estimated 273,000 acres of public and private lands within the District (Ferriter et al. 2008).

KEY MANAGEMENT ISSUES



Distribution: Melaleuca has been systematically cleared from Lake Okeechobee, WCA-2, WCA-3, and BCNP. These areas are now under maintenance control, but melaleuca continues to reestablish in cleared areas. Land managers do report slower reinfestation rates as a result of biological control. Unfortunately, significant infestations still remain in LNWR, eastern sections of ENP, and East Coast Buffer Lands.

Control Tools: The region's melaleuca management program is integrated. Herbicidal, mechanical, physical, and biological controls are all used. There are now three established biological control agents exerting substantial control on melaleuca (see *Biological Control of Invasive Plant Species* in this chapter).

Monitoring: Agencies monitor for this species in high priority public lands regionwide. DASM is conducted biennially within the Greater Everglades and on all District-owned lands (see *Everglades Invasive Plant Monitoring* section for more information).

Interagency Coordination: Interagency coordination has proven successful for this species.

Regulatory Tools: Melaleuca is listed as a Federal Noxious Weed, a Florida Noxious Weed, and Florida Prohibited Aquatic Plant.

Critical Needs: Private land initiatives to reduce remaining infestations near conservation lands.

2014 Status of Melaleuca by Management Region

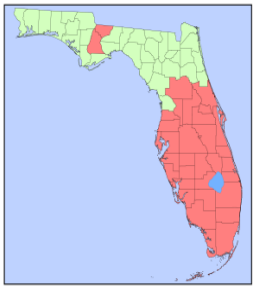
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Old World Climbing Fern (*Lygodium microphyllum*)

SUMMARY: Perhaps no other plant species poses a greater threat to South Florida's mesic upland and wetland ecosystems than Old World climbing fern (**Figure 7-14**). This highly invasive fern smothers native vegetation, severely compromising plant species composition, destroying tree island canopy cover, and dominating understory communities. This species could potentially overtake most of South Florida's mesic and hydric forested plant communities (Gann et al. 1999, Lott et al. 2003, Volin et al. 2004).

Figure 7-14. Old World climbing fern (*L. microphyllum*) overtaking a cypress swamp (photo by USDA-ARS).

KEY MANAGEMENT ISSUES



Distribution: Old World climbing fern dominates many tree islands, strand swamps, mesic to wet flatwoods, and other forested wetlands throughout South and Central Florida. First collected in Martin County, this species has now expanded as far north as Volusia County. Old World climbing fern infests an estimated 159,220 acres of public and private lands within the District (Ferriter et al. 2008).

Control Tools: Herbicides are used to control this species, but rapid reestablishment from abundant spores makes herbicide control costly and unlikely to succeed alone in regional control. Biological control is a critical component to effective long-term management of Old World climbing fern. Three agents have been released in Florida; one is becoming established, exhibiting localized reductions in the invasive fern (Boughton and Pemberton 2009) (see the *Biological Control of Invasive Plant Species* section of this chapter).

Monitoring: Agencies monitor for this species in high priority public lands regionwide. DASM is conducted biennially within the Greater Everglades and on all District-owned lands (see *Everglades Invasive Plant Monitoring* section for more information).

Interagency Coordination: An interagency management plan was developed for this species and agencies are coordinating control and monitoring efforts.

Regulatory Tools: Old World climbing fern is designated a Florida Noxious Weed.

Critical Needs: Successes in biological control efforts, ground-based monitoring programs, and private lands initiatives to reduce propagule pressure on conservation lands.

2014 Status of Old World Climbing Fern by Management Region

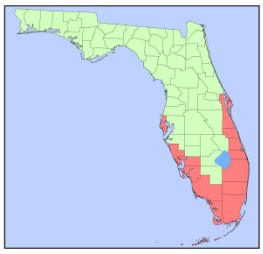
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Shoebutton Ardisia (*Ardisia elliptica*)

Figure 7-15. Large shoebutton ardisia (*A. elliptica*) are prolific seed producers, which allows for rapid colonization of multiple strata in forested areas (photo by SFWMD).

SUMMARY: Shoebutton ardisia (**Figure 7-15**) was imported as an ornamental shrub as early as 1900 (Gordon and Thomas 1997). It aggressively invades understories of hammocks, tree islands, and disturbed wetlands. This species often forms single-species stands, resulting in local displacement of native plants. There is a tendency for reinvasion by shoebutton ardisia or other exotic plants following removal of dense thickets of this species. Early infestations may go unnoticed due to this species' physical similarity to the common native marlberry (*A. escallonioides*).

KEY MANAGEMENT ISSUES



Distribution: Shoebutton is established in natural areas in southeastern Florida, particularly in the southern Glades and eastern portions of ENP.

Control Tools: There are currently no biological controls or investigations into possible biological controls for this species. Individual plants or light infestations can be treated by cut stump herbicide application. This approach is prohibitively expensive for tall, dense thickets. The most efficient approach so far has been shredding with heavy equipment followed by herbicide application to stumps and soil or to regrowth. Several herbicides have been used with moderate success, and evaluations are being made. Over 100 acres of District land have been cleared of dense shoebutton ardisia and herbicide treated in the past four years. This land is now in various stages of restoration to native vegetation. Aerial treatments with herbicides that selectively kill broadleaf plants are being used to convert areas mechanically cleared of dense Ardisia to grass-dominated habitat that can be maintained under a fire regime.

Monitoring: Shoebutton is difficult to detect from the air. Monitoring is currently limited to ground-based observations by land managers.

Interagency Coordination: While there is no regionwide strategic coordination for this species, biologists from the District, Miami-Dade County, and ENP are working closely to address major infestations in the southern Glades region.

Regulatory Tools: Shoebutton ardisia is listed as a Florida Noxious Weed.

Critical Needs: Increased funding to remove dense infestations in eastern Everglades region; improved methods for revegetating southern Glades marl soils with native vegetation after removal of shoebutton ardisia; and monitoring to identify new populations.

2014 Status of Shoebutton Ardisia by Management Region

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

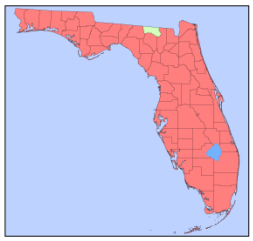
Torpedograss (*Panicum repens*)

Figure 7-16. Torpedograss (*P. repens*) forms dense, impenetrable mats in littoral zones (photo by UF IFAS).

SUMMARY: Torpedograss (**Figure 7-16**), an Old World grass originally introduced to Florida for forage, forms dense, stands that out-compete native plants. Rhizomes make up the majority of the plant's mass storing nutrients that enable the plant to recover from fire, drought, herbicide application and frost (Langeland et al. 1998). Although no viable seed has been proven to have been produced in Florida, torpedograss readily spreads vegetatively to new sites.

KEY MANAGEMENT ISSUES

Distribution: Torpedograss is ubiquitous in most regions of South Florida, but is most dominant in disturbed wetlands (Langeland et al. 1998). More than 20,000 acres of torpedograss recently infested Lake Okeechobee's marshes. Treatments have reduced its coverage to an estimated 6,000 acres on the lake today. However, 2012–2013 treatment funding was severely curtailed but has begun to increase in recent years.



Control Tools: Torpedograss control on Lake Okeechobee aims to limit the plant's further expansion into new areas of the lake. Annually from 2003 to 2012, between 2,500 and 5,000 acres of torpedograss were treated in the lake's 100,000-acre marsh via aerial and ground herbicide application. Some treatments have provided years of control while others have been less effective. Ongoing evaluations aim to reduce this variability. Treatments on Lake Okeechobee are coordinated through the Lake Okeechobee Interagency Aquatic Plant Management Group with funding from the FWC Invasive Plant Management Control Trust Fund. It is hoped that alternative herbicide tools could be found to prevent the possible development of torpedograss resistance to current herbicides. Development of selective biological control of torpedograss is not likely to succeed because of the broad similarities of grasses. Some newly registered aquatic herbicide may have activity on grasses, hopefully including torpedograss. Trials are under way.

Monitoring: The District and FWC have tracked the expansion of torpedograss in Lake Okeechobee since the 1980s. Outside of the lake, there is no systematic monitoring program for this species, and monitoring is limited to observations by land managers.

Regulatory Tools: There are no federal or state prohibitions for this species.

Critical Needs: Effective alternative treatments need to be developed to prevent possible induction of torpedograss resistance to the repeated applications of current herbicide mixture.

2014 Status of Torpedo Grass by Management Region

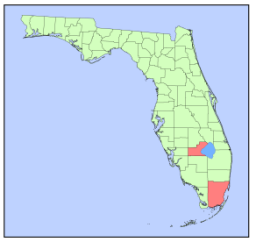
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Tropical American Watergrass (*Luziola subintegra*)

SUMMARY: Tropical American watergrass was first discovered in North America in 2007 in Lake Okeechobee (Kunzer and Bodle 2007). This perennial South American grass grows floating or emergent with prostrate creeping culms that form dense mats (**Figure 7-17**). UF researchers found that plants annually produces hundreds fertile seeds, which remain viable for long periods. Plants decline in winter, new spring and summer growth occurs from seed and surviving rhizomes. Managers aim to treat the plants before the onset of fall flowering. In 2013, the District treated 800 acres of tropical American watergrass in Lake Okeechobee. Everglade snail kite (*Rostrhamus sociabilis*) activity has halted treatments for months. Failure to treat in these areas enables the plant to expand until treatments can resume.

Figure 7-17. Dense floating mats of tropical American watergrass *L. subintegra* (photo by FWC).

KEY MANAGEMENT ISSUES



Distribution: To date, the plant has been found in only two locations—Lake Okeechobee and one site in Miami-Dade County. The latter was eradicated. In Lake Okeechobee, the plant has spread well beyond its initial establishment area, although still within the lake's levee system. Continued treatments may not contain the plant much longer. It is likely that the plant will be transported outside the lake via wildlife or water releases.

Control Tools: Herbicides are the only control tool currently available. Trials with several of the newly-labeled aquatic herbicides, separately and in combinations, may provide more control methods and prevent possible development of herbicide resistance to currently used herbicides. Little likelihood exists for biological control of tropical American watergrass. As a grass in the rice tribe (Oryzeae), the importance of rice agriculture could limit biological control investigations.

Monitoring: Interagency inspectors continue to monitor the plant and recommend control areas. Treatment funding has been available from the Florida Invasive Species Management Trust Fund.

Interagency Coordination: Within the Lake Okeechobee Watershed, large property owners have been contacted to look out for the plant. Also, the Sanibel-Captive Conservation Foundation has been notified in order to look for the plant in their role as Caloosahatchee River Riverkeeper.

Regulatory Tools: Tropical American watergrass is not a Federal or Florida noxious weed.

Critical Needs: Additional herbicide research and funding for monitoring and rapid response efforts.

2014 Status of Tropical American Watergrass by Management Region

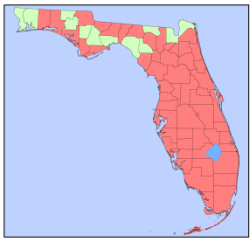
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Water Lettuce (*Pistia stratiotes*)

Figure 7-18. Dense floating mat of water lettuce, *P. stratiotes* (photo by SFWMD).

SUMMARY: Water lettuce (**Figure 7-18**) is a floating aquatic plant native to South America, although now found throughout the tropics and subtropics. Rapid production of vegetative daughter plants occurs during all but the coolest months. New plants are also readily produced from seed and found to be up to 80 percent viable (Dray and Center 1989). Water lettuce was reported by William Bartram in 1765 as forming dense mats on the St. Johns River. These mats continue to occur, clogging waterways and water management structures.

KEY MANAGEMENT ISSUES



Distribution: Water lettuce inhabits all waterbody types in South Florida. Herbicide control efforts have virtually eliminated water lettuce from many canal systems, including urban Miami-Dade and Broward counties. However, most large lakes continue to harbor significant populations requiring frequent control. Also, on lakes in the Kissimmee Chain and Lake Okeechobee, water lettuce populations have expanded when treatments have ceased to accommodate snail kite foraging and nesting. When treatments can resume, treatment costs have increased since greater amounts of the plants are present.

Control Tools: Water lettuce is readily controlled by herbicides, but rapid reestablishment of this species in some waterbodies necessitates frequent retreatments. Newly-labeled products including GALLEON (penoxsulam) and CLIPPER (flumioxazin), are showing promise as additional control agents for water lettuce. Biocontrol agents for this species have been released in Florida, but none have significantly controlled the plant. Of these, the South American water lettuce weevil, *Neohydronymus affinis*, is widely established yet causes only numerous minute holes in the leaves of the plant.

Monitoring: The FWC monitors water lettuce in all public waters, and the District routinely monitors its canals for large populations of this and other floating aquatic weeds.

Interagency Coordination: The FWC coordinates interagency management of water lettuce and other aquatic plants via solicitation of annual work plans from local public agencies and then allocates funds from the FWC Invasive Plant Management Control Trust Fund.

Regulatory Tools: Water lettuce is listed as a Florida Prohibited Aquatic Plant.

Critical Needs: Continued development of biological controls is needed to complement regional herbicide control programs.

2014 Status of Water Lettuce by Management Region

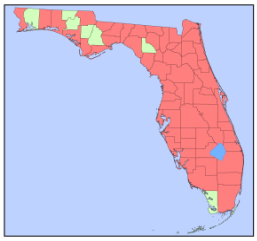
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Water Hyacinth (*Eichhornia crassipes*)

SUMMARY: Water hyacinth (**Figure 7-19**), a floating plant native to tropical South America, was brought to Florida in 1884. It quickly blocked navigation on the St. Johns River. Vegetative reproduction occurs rapidly during all but the coolest months. New plants are also produced from seed, which germinate copiously on exposed moist soils. Low nutrient needs and wide tolerance for water conditions enable its persistence and spread.

Figure 7-19. Dense floating mat of water hyacinth, *E. crassipes* (photo by SFWMD).

KEY MANAGEMENT ISSUES



Distribution: Water hyacinth inhabits all water body types in South Florida. Herbicide treatments have virtually eliminated it from many canal systems, including urban Miami-Dade and Broward counties. However, most large lakes continue to harbor significant populations requiring frequent control. On lakes in the Kissimmee Chain and Lake Okeechobee, populations have expanded when treatments are suspended to accommodate snail kite foraging and nesting. When treatments resume, expanded populations are much more costly to control.

Control Tools: Water hyacinth is readily controlled by herbicides, but rapid reestablishment of this species in some waterbodies necessitates frequent retreatments. Newly-labeled products including GALLEON (penoxsulam) and CLIPPER (flumioxazin), are showing promise as additional control agents for water hyacinth. The USDA has released several water hyacinth biocontrol insects in Florida, including two weevils of the genus *Neochetina*. Despite reports of these weevils effectively limiting water hyacinth populations elsewhere in the world, no such decreases have occurred in Florida. In 2010, a new water hyacinth-feeding insect was released in Florida, the water hyacinth planthopper. USDA-ARS researchers found that this South American insect thoroughly controlled water hyacinths in quarantine trials. It has been shown to reduce water hyacinth growth and biomass production in South America (Sacco 2013). Releases continue in Florida waters. Whether it will establish throughout Florida and exert control on the plant remains to be seen.

Monitoring: FWC monitors water hyacinth in all Florida public waters. The District routinely monitors its canals for large populations of this and other floating aquatic weeds.

Interagency Coordination: FWC coordinates interagency management of water hyacinth and other aquatic plants via solicitation of annual work plans from local public agencies and then allocates funds from the FWC Invasive Plant Management Control Trust Fund.

Regulatory Tools: Water hyacinth is listed as a Florida Prohibited Aquatic Plant.

Critical Needs: Continued development of biological controls is needed.

2014 Status of Water Hyacinth by Management Region

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Island Applesnail (*Pomacea maculata*)

Figure 7-20. The island applesnail, *P. maculata* (photo by FWC).

SUMMARY: The island applesnail (**Figure 7-20**) is a large (up to 10 centimeters) South American freshwater mollusk now established in Florida. It was introduced globally through intentional releases from aquaria and as a food crop. Likely impacts in Florida include destruction of native aquatic vegetation and competition with native aquatic fauna. However, feeding trials suggest the snail has a slight feeding preference for non-native plants including torpedograss and hydrilla (Baker et al. 2010). The island applesnail may continue to spread and out-compete the native applesnail, *P. paludosa*, which is the primary food of the endangered Everglade snail kite. Juvenile snail kites have difficulty handling mature island applesnails and experienced significantly lower net daily energy balances when feeding on nonindigenous snails (Cattau et al. 2010). Recently, an undescribed cyanobacterium was documented on SAV in Lake Tohopekaliga. This species is associated with a lethal neurologic disease that affects bald eagles (*Haliaeetus leucocephalus*) and American coots (*Fulica americana*) in the southeast United States (Wilde et al. 2005). There is evidence that these snails may transport cyanotoxins in freshwater food webs (Robertson 2012).

KEY MANAGEMENT ISSUES

Distribution: The island applesnail has been reported widely throughout Florida and much of the southeast United States (Rawlings 2007). It is found in most waterbodies including marshes, canals, lakes, and rivers. Monitoring by ENP and the Miccosukee Tribe indicate that this species' abundance is increasing in many canals near or within the Everglades, and distributions may be expanding into open marsh habitats. In 2013, a tremendous increase in snails in one section of STA-1 East decimated SAV. This vegetation decline was associated with a decrease in phosphorus uptake in the treatment cell (Lou Toth, SFWMD, personal communication, 2013).

Control Tools: There are few control tools for this species with applicability in large natural areas. State and federal agencies could dedicate resources to develop control strategies.

Monitoring: State and federal monitoring programs are either limited to focused geographic areas or participatory monitoring through outreach. State and federal agencies need to coordinate monitoring programs in support of a comprehensive management strategy.

Interagency Coordination: Limited interagency coordination has yielded little information and few attempts to understand this species' distribution, potential impacts, and possible control.

Regulatory Tools: This species is widely sold in the aquarium trade. Additional regulations are needed to curb the release of this and other nonnative *Pomacea* species.

Critical Needs: Development of control tools; research to better understand impacts of this species; and continued and expanded regional monitoring efforts.

2014 Status of Island Applesnail by Management Region

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Mexican Bromeliad Weevil (*Metamasius callizona*)

SUMMARY: The Mexican bromeliad weevil was originally introduced to Florida via a shipment of bromeliads imported from Mexico. It was first detected in 1989, and is now found in many parts of South and Central Florida (Frank and Cave 2005). Larvae of the weevil destroy bromeliads by mining into their stems (**Figure 7-21**). This damaging insect is documented to attack 12 native bromeliad species, 10 of which are state-listed as threatened or endangered, and one of which occurs naturally only in Florida. Two of these bromeliad species were listed due to damage done to their populations by the weevil. The bromeliads that are at risk are a prominent part of many South Florida woodlands from swamps to dry scrubs. Among the contributions of bromeliads to wildlife is that they catch rainwater, making is available to a variety of animals during dry periods.

Figure 7-21. A Tillandsia plant heavily damaged by larva of the Mexican bromeliad weevil, *M. callizon* (photo by UF).

KEY MANAGEMENT ISSUES

Distribution: The Mexican bromeliad weevil now infests bromeliads in the Sebastian, St. Lucie, Loxahatchee, Caloosahatchee, Peace, Myakka, and Manatee river systems as well as non-riverine sites. It is in BCNP, Rookery Bay National Estuarine Preserve, LNWR, Fakahatchee Strand Preserve State Park, Myakka River State Park, and several other state parks (Howard Frank, UF, personal communication).

Control Tools: The only practicable control tools for this species are biological control and prevention of new introductions. One agent, a parasitic fly (*Lixadmontia franki*), has been approved for release in the United States, but the insect has yet to become established. Facilities for rearing have been improved and additional fly releases are anticipated (Cooper et al. 2013). UF scientists continue to explore other potential biological control agents.

Monitoring: Regional monitoring of this species is limited to under-funded but determined efforts of university scientists engaged in biological control research.

Interagency Coordination: Interagency coordination is limited to exchange of reporting information and some coordinated research.

Regulatory Tools: Federal screening needs improvement to prevent new introductions. Additionally, improved export screening is needed to prevent transport from Florida to other vulnerable regions (e.g., Puerto Rico).

Critical Needs: Development of biological controls; continued monitoring of weevil spread and its effect on bromeliad populations; and conservation measures for impacted native bromeliads.

2014 Status of Mexican Bromeliad Weevil by Management Region

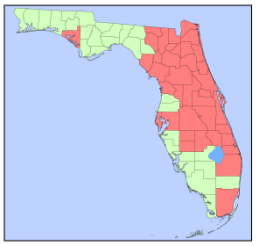
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Laurel Wilt (*Raffaelea lauricola*)

SUMMARY: Laurel wilt is a lethal disease of red bay (*Persea borbonia*; **Figure 7-22**) and other members of the Laurel family (Lauraceae). The disease is caused by a fungus (*Raffaelea lauricola*) that is introduced into trees by the wood-boring redbay ambrosia beetle (*Xyleborus glabratus*) (FDACS 2011). A native of Asia, the beetle was likely introduced into the United States via infested wood used for shipping crates (Harrington et al. 2011). Once infected, susceptible trees rapidly succumb to the pathogen and die. It also impacts other native and nonnative members of the Lauraceae (Hanula et al. 2009) including swamp bay (*P. palustris*), an important species of many Everglades plant communities.

Figure 7-22. Dying red bay (*P. borbonia*) trees in a mixed hardwood forest (photo by FDACS).

KEY MANAGEMENT ISSUES



Distribution: Laurel wilt disease is now found throughout Florida. Since the 2010 detection of the redbay ambrosia beetle in Miami-Dade County, laurel wilt has spread across 372,052 hectares of the central Everglades (Rodgers and Pernas 2015) and is also present in LNWR. Laurel wilt is also widespread throughout the District's East Coast land management region and the Kissimmee River Basin.

Control Tools: There is currently no feasible method for controlling this pest or associated disease in natural areas. A systemic fungicide (propiconazole) can protect individual trees for up to one year, but widespread utilization in natural areas is impractical (Mayfield et al. 2008). Biological control and development of laurel wilt resistant strains of swamp bay are proposed areas for research.

Monitoring: State and federal agencies are monitoring the spread of laurel wilt disease and the redbay ambrosia beetle through the Cooperative Agricultural Pest Survey Program. There is little to no research under way to assess the ecological impacts of laurel wilt disease.

Interagency Coordination: Interagency and tribal coordination has begun. Workshops were conducted during 2013 to identify research and management strategies.

Regulatory Tools: The red bay ambrosia beetle is considered a plant pest, so screening for additional introductions is carried out but is inadequate.

Critical Needs: Critical research areas include (1) evaluating *Persea* resistance, (2) *Persea* seed/genetic conservation efforts, (3) potential chemical or biological control tools, (4) impacts on native plant communities, and (5) impacts on the Palamedes swallowtail butterfly (*Papilio palamedes*) and other host-specific commensals.

2014 Status of Laurel Wilt by Management Region

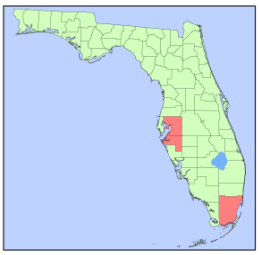
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys
		not applicable				not applicable	

Asian Swamp Eel (*Monopterus albus*)

Figure 7-23. Asian swamp eel (*M. albus*) (photo by NPS).

SUMMARY: Asian swamp eels (**Figure 7-23**) are versatile animals, capable of living in extremely shallow water, traveling over land when necessary, and burrowing into mud to survive periods of drought. The eels are generalist predators with a voracious appetite for invertebrates, frogs, and fishes. Wild populations in Florida originated as escapes or releases associated with aquaculture, the pet trade, or live food markets. Regional biologists are concerned that this species may become widely established, since the diverse wetland habitats of the Greater Everglades may be suitable for the species. Additionally, Asian swamp eels have a broad salinity tolerance giving concern that this species could also establish populations in estuaries (Schofield and Nico 2009).

KEY MANAGEMENT ISSUES



Distribution: During the late 1990s, three reproducing populations of Asian swamp eel were discovered in Florida: North Miami canals, canal networks near Homestead adjacent to ENP, and in waterbodies near Tampa (Fuller et al. 1999; L.G. Nico, United States Geological Survey, personal communication). Unfortunately, recent monitoring efforts confirm the spread of this species into ENP from adjacent canal systems (Jeff Kline, ENP, personal communication).

Control Tools: Given the abundance and wide distribution of swamp eels in Florida's canals, eradication is probably impossible; however, various control methods, such as electrofishing, are currently under investigation.

Monitoring: There is no regional, coordinated monitoring program for Asian swamp eels, but USFWS and NPS biologist conduct periodic surveys in the eastern Everglades region.

Interagency Coordination: No significant interagency coordination presently aims to manage this species.

Regulatory Tools: There are currently no regulations that prohibit the importation or possession of this species in Florida.

Critical Needs: Research to better determine potential species' impacts and spread; research and development of control techniques; and increased collaboration with CERP planners to integrate prevention measures for this and other aquatic invasive species in CERP-related projects.

2014 Status of Asian Swamp Eel by Management Region

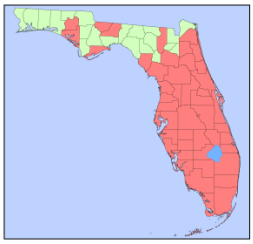
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Cuban Treefrog (*Osteopilus septentrionalis*)

Figure 7-24. The Cuban treefrog (*O. septentionalis*) is now widely dispersed throughout Florida (photo by UGA).

SUMMARY: The Cuban treefrog (**Figure 7-24**) is native to Cuba, the Cayman Islands, and the Bahamas. It was first reported in Florida in the 1920s, and was likely transported in cargo or ornamental plant shipments. Cuban treefrogs consume a variety of invertebrates and native treefrog species (Maskell et al. 2003). Native green (*Hyla cinerea*) and squirrel (*Hyla squirella*) tree frogs are less likely to be found when Cuban treefrogs are present (Waddle et al. 2010), and when Cuban treefrogs are removed from an area, the abundance of native tree frogs increases (Rice et al. 2011). Given the Cuban treefrog's wide distribution and habitat tolerances, mounting evidence of direct impacts to native anuran species, and the lack of regional monitoring and control programs, the status of this species is red in all RECOVER modules.

KEY MANAGEMENT ISSUES



Distribution: Cuban treefrogs inhabit natural and human-modified habitats throughout most of South and Central Florida. Natural habitats invaded by this species include pine forests, hardwood hammocks, and swamps. In urban and suburban settings, they are most commonly found on and around homes and buildings, and in gardens and landscape plants. They also occur in agricultural settings, orange groves, and plant nurseries (Johnson 2007).

Control Tools: There are currently no agency-sponsored, coordinated control efforts for the Cuban treefrog in South Florida.

Monitoring: The UF and District are continuing a monitoring program for Cuban treefrogs and other priority invasive animals in the Everglades. Cuban treefrogs are found on all Everglades Invasive Reptile and Amphibian Monitoring Program survey routes and are the second most frequently encountered invasive exotic amphibian. In addition, the UF IFAS maintains a small monitoring and outreach program, but state and federal agencies need to assist with coordinating a statewide monitoring and management program.

Interagency Coordination: No significant interagency coordination presently aims to manage this species.

Regulatory Tools: There are currently no regulations that prohibit the importation or possession of this species in Florida.

Critical Needs: Basic research on extent and severity of impacts to native species and development of control techniques.

2014 Status of the Cuban Treefrog by Management Region

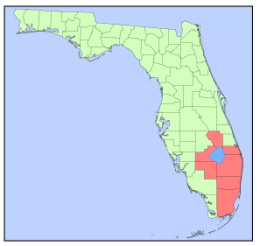
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Purple Swamphen (*Porphyrio porphyrio*)

Figure 7-25. The purple swamphen (*P. porphyrio*) (photo by SFWMD).

SUMMARY: The purple swamphen (**Figure 7-25**) is a rail native to Australia, Europe, Africa, and Asia. Its introduction was likely due to escapes from the Miami Zoo and private aviculturists in Broward County. The purple swamphen feeds on shoots and reeds, invertebrates, small mollusks, fish, snakes, and the eggs and young waterfowl (Pranty et al. 2000). Known to be highly aggressive and territorial, the purple swamphen could impact native water birds through competition for food and space and through direct predation. Rapid response efforts between 2006 and 2009 did not successfully reduce the abundance or distribution of this species. The management goal for this species has shifted from eradication to monitoring (Jenny Ketterlin Eckles, FWC, personal communication).

KEY MANAGEMENT ISSUES



Distribution: The original Florida purple swamphen population is believed to have established in Pembroke Pines in 1996 (Scott Hardin, FWC, personal communication). In recent years, purple swamphens have been sighted in the WCAs, Lake Okeechobee, and in all Everglades STAs.

Control Tools: Previous efforts to remove birds by hunting did not significantly deplete the population. No other control tools are currently developed for this species. This year, FWC contracted researchers from Florida Atlantic University to conduct diet and habitat analyses to inform a risk assessment, which will guide future management strategies.

Monitoring: Agencies rely on reports from the public and agency personnel to track the spread of this species.

Interagency Coordination: Local and state agencies have attempted to analyze this species' population and implement control. However, efforts to date have not halted the further spread of the species, and eradication is no longer considered feasible. FWC have removed over 3,000 purple swamphens to date, mostly from the STAs and WCA-2B (Johnson and McGarrity 2009). Florida Atlantic University is currently studying habitat use and diets of purple swamphens in order to collect information that will help FWC develop a long-term management plan.

Regulatory Tools: There are currently no regulations that prohibit the importation or possession of this species in Florida. Federal and state regulations to restrict the possession of this species are needed to avoid future releases. Purple swamphens are listed on the Migratory Bird Treaty Act, preventing the take by hunters.

Critical Needs: Additional monitoring to assess population expansion; basic information on impacts of this species on native species; and regulations to restrict possession of this species.

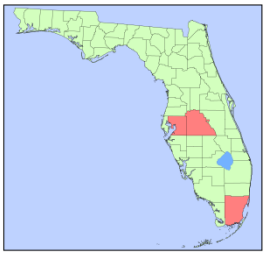
2014 Status of Purple Swamphen by Management Region

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Argentine Black and White Tegu (*Salvator merianae*)

Figure 7-26. An Argentine black and white tegu (*S. merianae*) (photo by Miami-Dade County).

SUMMARY: The Argentine black and white tegu (**Figure 7-26**) is a large, omnivorous lizard filling a niche similar to that of the Nile monitor. In its native range, it prefers open grassy areas and nests in burrows (Winck and Cechin 2008). Two established populations are known in Florida—Hillsborough and Polk counties (Enge et al. 2006), and southern Miami-Dade County (Pernas et al. 2012)—both of which are suspected to have resulted from deliberate releases by pet dealers or breeders (Hardin 2007). Recent sighting of this species in southwestern Florida may indicate another population but establishment has not been confirmed. The spread of this species has the potential to impact Everglades restoration efforts by increasing predation on threatened and endangered species, including the American crocodile (*Crocodylus acutus*) and the Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) (Kevin Enge, FWC, unpublished data), ecologically important species such as the American alligator (*Alligator mississippiensis*; Mazzotti et al 2015), as well as all other ground-nesting birds and reptiles. Given the expanding range of this species and lack of effective control tools, eradication from Florida is unlikely, but containment may still be possible.



KEY MANAGEMENT ISSUES

Distribution: Two established populations are known—Hillsborough and Polk counties (Enge et al. 2006) and southern Miami-Dade County. Data from monitoring efforts and reported sightings in the last year suggest that the South Florida population is expanding (Jake Edwards, FWC, personal communication), particularly south of Florida City in the Model Lands region. Surveys conducted by UF, FWC, the District, United States Geological Survey (USGS), Miami-Dade County, and NPS resulted in the removal of over 500 tegus between January 1 and July 31, 2015.

Control Tools: Trapping may be an effective control tool. Firearms are becoming also a viable compliment to trapping.

Monitoring: Interagency members of the ECISMA initiated monitoring, assessment, and control efforts in 2011. These efforts are ongoing and have expanded to include deployment of 103 camera traps, 130 live traps, and telemetry of 15 tegus in 2015.

Interagency Coordination: There is some interagency monitoring and trapping coordination. However, a fully funded rapid response team is needed if containment is to be achieved.

Regulatory Tools: This species should be considered for Conditional Reptile designation by the State of Florida.

Critical Needs: Dedicated funding for rapid response initiatives; research on severity of impacts; federal and state regulations to restrict possession of this species.

2014 Status of the Argentine Black and White Tegu by Management Region

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys
						not applicable	

Burmese Python (*Python molurus bivittatus*)

Figure 7-27. Burmese pythons being removed from the Everglades (photo by the USGS).

SUMMARY: The Burmese python is widely established in the southern Everglades (Snow et al. 2007). This large constrictor is a top predator known to prey upon more than 20 native Florida species and is implicated in substantial declines of mammal populations in ENP (Dorcas et al. 2012). Control of this species is a top priority among agencies and policy makers. Record cold temperatures during January 2010 caused widespread mortality of Burmese pythons in South Florida (Mazzotti et al. 2010). However, Burmese pythons of all age classes continue to be removed from the Everglades (**Figure 7-27**). Approximately 75 Burmese pythons are reported as removed from in and around ENP between January and July 2015 (Jenny Ketterlin Eckles, FWC, and Bryan Falk, USGS, personal communications).

KEY MANAGEMENT ISSUES

Distribution: The Burmese python is found throughout the southern Everglades, particularly in ENP and adjacent lands (e.g., East Coast Buffer Lands; north ENP boundary along Tamiami Trail; and L-67 canal).

Control Tools: Control options for this species are limited. Reed and Rodda (2009) review control tools and their applicability to large constrictors in Florida. Potential controls include visual searching, traps, detection dogs, "Judas snakes," pheromone attractants, and toxicants. Research and development for many of these tools is ongoing.

Monitoring: A regional python monitoring network of agency staff, reptile enthusiasts, and other interested parties continues to develop and expand in South Florida. Pythons are monitored as part of Everglades Invasive Reptile and Amphibian Monitoring Program.

Interagency Coordination: There is excellent interagency coordination for this species, but efforts to implement controls are constrained by limited resources and few control tools. An interagency workshop on biology and management of large constrictors on Department of Interior lands was held in October 2014 and a structured decision making workshop on Burmese pythons was held in June 2014. Partners are now working together to create an interagency python management plan.

Regulatory Tools: The Burmese python is listed as a Conditional Reptile by the State of Florida. A federal ban on importation of this species was instated in January 2012.

Critical Needs: Development of effective technology to improve detection in the field; implementation of a Judas snake program; protect vulnerable resources such as bird rookeries; implementation of detection dog program; increased understanding of fine-scale movement patterns to improve search protocols; and federal regulations to restrict possession of this species to limit new releases.

2014 Status of the Burmese Python by Management Region

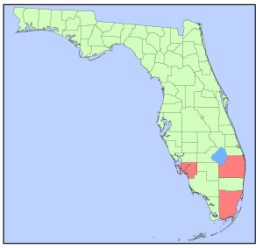
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Nile Monitor (*Varanus niloticus*)

Figure 7-28. Nile monitor (*V. niloticus*) on the C-51 canal in West Palm Beach (photo by FWC).

SUMMARY: The Nile monitor (**Figure 7-28**) is a large, predatory lizard known for its intelligence and adaptability (Bennett 1998). It is a generalist feeder (Losos and Greene 1988) that commonly preys on crocodile eggs and hatchlings in Africa (Lenz 2004). The impact of Nile monitors on Florida fauna is unknown, but their potential to eliminate or significantly reduce native species through competition and predation is high (Enge et al. 2004). In particular, wildlife biologists consider the Nile monitor to be a serious threat to American crocodile, American alligator, gopher tortoises (*Gopherus polyphemus*), sea turtles, burrowing owls (*Athene* spp.), Florida gopher frogs (*Lithobates capito*), and other ground-nesting species (Meshaka 2006, Hardin 2007). Diet studies performed by UF have found 50 percent of Nile monitor removed had food in their stomachs, with 81 percent of those with food in their stomachs having more than one prey item. Insects, snails, and reptiles were the most commonly consumed prey.

KEY MANAGEMENT ISSUES



Distribution: Established populations are documented in and around Cape Coral in Lee County (Enge et al. 2004), Homestead Air Force Base in Miami-Dade County, and the C-51 canal in central Palm Beach County (Jenny Ketterlin-Eckles, FWC, personal communication). Numerous sightings have also been reported in suburban Broward County, approximately 1.5 miles from WCA-3B. Beginning in September 2011, 41 surveys conducted on the C-51 canal resulted in removal of 48 Nile monitors and one was removed from Southwest Ranches in Broward County in 2015.

Control Tools: Snares, traps, and hunting are the only immediately available control tools for this species. Control efforts are piecemeal, consisting of citizen reporting programs (Cape Coral) and limited efforts by agency biologists involved with the ECISMA Rapid Response Team.

Monitoring: The District, FWC, and UF are currently monitoring for, and when possible, removing Nile monitors in central Palm Beach County. FWC will continue survey and removal efforts in the area and will institute monthly monitoring for the species in Broward County.

Interagency Coordination: Agency biologists are coordinating to some degree, but higher-level coordination to develop an interagency control program is needed.

Regulatory Tools: The Nile monitor is listed as a Conditional Reptile by the State of Florida. Federal regulations are needed to further curtail releases of this invasive species.

Critical Needs: Dedicated funding for aggressive control measures and federal regulations to restrict possession of this species to avoid additional releases.

2014 Status of the Nile Monitor by Management Region

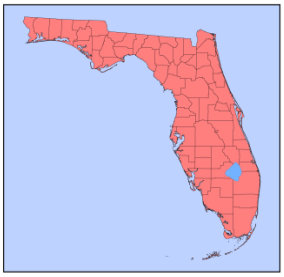
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Feral Hog (*Sus scrofa*)

SUMMARY: Feral hogs (**Figure 7-29**) have existed on the Florida landscape since their introduction by Spanish explorers four centuries ago. Feral hogs consume a variety of vegetation, invertebrates, insects, reptiles, frogs, bird eggs, rodents, small mammals, and carrion (Laycock 1966, Baber and Coblentz 1987). This invasive mammal is also known to prey on sea turtles, gopher tortoises, and other at-risk wildlife (Singer 2005). Rooting by feral hogs can damage plant communities and may facilitate establishment of invasive plant species (Belden and Pelton 1975, Duever et al. 1986). Damage to archeological sites by feral hogs has also been documented (Engeman et al. 2013). Although ecological impacts of this species are apparent, proposals for aggressive hog control are controversial because they are a valued game species.

Figure 7-29. A pair of feral hogs (*S. scrofa*) at Lake Okeechobee (photo by FWC).

KEY MANAGEMENT ISSUES



Distribution: Wild hogs are reported in all 67 Florida counties. Within the District, feral hog populations are particularly high in the counties immediately north and west of Lake Okeechobee, and in the Big Cypress and East Coast regions.

Control Tools: Hunting, trapping, and toxicants may be used to control feral hogs. The District has improved contract procedures for hog control. Hog removal agents can use almost any method to take hogs, including trapping, shooting from trucks or boats, dogs, and lights at night. Permittees who do not remove enough hogs will not be renewed. In the first 10 months of this program (beginning September 2012), 19 agents removed 1,800 hogs from District lands. Hog removal contracts are no cost; the incentive is that the permittee keeps the hogs.

Monitoring: There is no regional, coordinated monitoring program for hogs. Monitoring is limited to efforts associated with trapping programs and game management.

Interagency Coordination: Agencies coordinate control efforts to varying degrees at the local level. Scientists and land managers also exchange information related to control techniques. However, higher-level coordination is necessary to direct regional strategies for maintaining feral hog populations at the lowest feasible level.

Regulatory Tools: Hunting regulations could be modified to better control hog populations

Critical Needs: Development of target specific toxicants or contraceptives and initiatives for control on private lands.

2014 Status of Feral Hogs by Management Region

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

SPECIES TARGETED FOR CONTAINMENT OR ERADIATION

Exotic Black Mangrove (*Lumnitzera racemose*)

The exotic black mangrove (also kripa) is native to Asia and Australia but escaped cultivation from Fairchild Tropical Botanic Garden and was discovered to be rapidly proliferating in neighboring Matheson Hammock Preserve in 2008. This plant aggressively out-competes native mangrove species. Although the full effects of a major invasion of *Lumnitzera* on Florida mangrove swamp diversity and function cannot be predicted, the stakes are high. Contributions of mangroves to marine productivity and the economy of South Florida have been well documented (Hamilton and Snedaker 1984). A response was launched almost immediately after the invasion was detected. Several cooperative interagency workdays eliminated many of the invading plants, but this approach seemed inadequate for eradication.

During the past year, funding from FWC supported a Miami-Dade County work crew that removed 1,380 seedlings and saplings. The plants removed were almost entirely small seedlings and saplings, generated from the diminishing seed bank. In 2010 contractors removed 20,000 plants and the last known reproductive *Lumnitzera* tree was removed in 2011. With no known reproductive trees left in the 20-acre area, eradication of the exotic black mangrove *Lumnitzera* in Florida is possible. A precise prediction of time until elimination is not possible because seed bank dynamics for this species are unknown but apparently long-lived and vigorous. Consistent aggressive control work is crucial. If a major tropical storm or other mechanism spreads seeds to a wider area, then the opportunity for eradication may quickly be lost.

Mile-a-Minute (*Mikania micrantha*)

Mile-a-minute is a federally-listed noxious weed that has recently appeared in South Florida (**Figure 7-30**). This vine, which is native to parts of tropical and subtropical America, has turned into a disastrous weed where it was introduced in Asia, Australia, Africa, and other warm parts of the world (Holm et al. 1977, Zhang et al. 2004). This weed was discovered near Homestead in 2008, and an aggressive reconnaissance and eradication effort began immediately. With the exception of a single site discovered in 2014 in Broward County, the infestation has been contained to the Homestead area. However, fighting the fast growing pest is challenging and efforts are not close to eradication. It roots freely from stems and small fragments and vast numbers of tiny airborne seeds can spread the infestation. Most of the major infestations exist in plant nurseries. The threat of quarantine is an incentive for nursery owners to eliminate the weed. Unfortunately, it can be virtually impossible for enforcement agents to track down the owners of abandoned nurseries that continue to act as a local seed source. Infestations also exist on land associated with residences where mile-a-minute twines among shrubbery and hedges making removal challenging because herbicide treatment severely damages the ornamental plantings. Although most residents are cooperative, some are not and avoid contact (Dozier 2012). Because of serious consequences if mile-a-minute becomes permanently established, strong eradication efforts will continue.

Figure 7-30. Mile-a-minute (*M. micrantha*) is a prolific seed producer and quickly overtakes native vegetation (photo by FDACS).

Although the site in Broward County was dealt with successfully, it serves as a warning. It appears that mile-a-minute may have escaped from Miami-Dade County when a nursery in Collier County bought burlap from Homestead that was contaminated with seed. The burlap was used to wrap palm root balls that were sold to a nursery in Broward County. The seeds germinated and an FDACS inspector recognized mile-a-minute growing up the trunks of the palms. If the seeds had not germinated yet and the plants had been shipped outside of Florida, the mile-a-minute would probably not have been recognized until it was spreading rapidly and producing seeds.

In 2014, FWC provided funding to employ a Miami-Dade County exotic weed control crew to search for and remove mile-a-minute wherever possible and document properties where it was present but where access was not possible. FDACS agents continue inspections and report that citations in 2015 have dropped to a third of what they were in 2014, indicating that nursery owners are finding success in treating the vine. However, concerns remain for undeveloped commercial properties. Eradication at this point seems unlikely but the objective remains to continue official and volunteer suppression efforts to prevent it from colonizing large natural areas like the South Dade Wetlands and ENP.

Giant African Land Snail (*Lissachatina fulica*)

A population of the giant African land snail was discovered in 2011 in an area of Miami (FDACS-DPI 2011, USDA 2013). The giant African land snail is known to eat a great variety of vegetation, including crop plants, horticultural plants, and environmentally valuable plants. This species has invaded other places outside its native range in Africa, often causing substantial damage. Another negative aspect of this invasive snail is that it is an intermediate host of the rat lungworm (*Angiostrongylus cantonensis*; **Figure 7-31**), which can infect humans and cause meningitis (Cowie 2013). This parasite, which has been almost unknown in the mainland United States, has recently been detected in giant African land snails collected in Miami (Iwanowicz et al. 2015). A previous infestation of this snail occurred in Miami in 1966. The Florida state eradication effort took 10 years at a cost of $1 million (USDA 2013). An aggressive federal-state cooperative program is now under way to eliminate the existing population. There are currently over 4,500 parcels under survey in the cooperative program.

Figure 7-31. The giant African land snail (*L. fulica*) is an intermediate host of the rat lungworm (photo by FDACS).

Eradication is challenging and requires public support and education. Hand collection (wearing gloves) and snail toxicants are being used. Special care is required with poisons because many children live in the area involved. Toxicants containing iron phosphate or borax were initially used because of low toxicity to other animals. Toxicants containing metadehyde are now being used because they are more effective, although more toxic. Such products are available in retail outlets and are commonly used in home gardens (FDACS 2013). Poisoning of pets and people is typically the result of misuse, such as not securing open containers or applying an excessive quantity of granules to a small area where they can be picked up and eaten (NIH 2013). When correctly used by trained applicators, these products are quite safe (FDACS 2013). There are indications that control efforts are having an effect, as fewer large snails are being seen. Roughly 50 percent of surveyed properties have not had a detection for more than a year (Andrew Derksen, FDACS, personal communication). In spite of obstacles, the snail eradication program seems likely

to succeed because there is an appreciation of the high cost of failure to agriculture, gardening, and public health.

Gambian Pouched Rat (*Cricetomys gambianus*)

The Gambian pouched rat is a large, omnivorous rodent of African origin. Once popular in the exotic pet trade, the Centers for Disease Control banned their importation in 2003 because they are a carrier of monkey pox. Prior to this ban, numerous Gambian rats escaped captivity in the Florida Keys (Grassy Key) and established a reproducing population. This species is considered likely to invade the Florida mainland and is viewed as a significant threat to endangered rodents and other fauna, agriculture, and human health (Engeman et al. 2006). These concerns prompted agencies to initiate rapid response measures in 2005. Toxicant baits were effectively used to control large populations (Engeman et al. 2007). Control efforts for remaining animals involve baited traps. The rapid response efforts appeared to have been successful, and in 2009 FWC biologists cautiously declared that the population was eradicated while continuing periodic monitoring for the rodent. Then in 2011, the Gambian pouched rat was again found on Grassy Key. USDA and FWC biologists reinitiated trapping efforts in early 2011 and have removed 31 rats to date. The FWC and USDA plan to continue trapping and monitoring efforts to the extent that funding and staffing resources allow. The rediscovery of this invasive species after it was presumed eradicated suggests that standards for eradication be reassessed for this species.

Figure 7-32. Gambian pouched rats (*C. gambianus*) continue to occur in the Florida Keys, despite years of trapping (photo by USDA).

Northern African Python (*Python sebae*)

Figure 7-33. The northern African python (*P. sebae*) (photo by FWC).

Since 2001, almost 40 northern African pythons have been found in the Bird Drive Basin in Miami-Dade County (Jenny Ketterlin-Eckles, FWC, personal communication), including multiple large adults, a pregnant female, and two hatchlings. This giant constrictor (**Figure 7-33**) shares many natural history traits with the Burmese python and is considered a high risk for establishment and expansion throughout southern Florida (Reed and Rodda 2009). Rapid response efforts to delineate and eradicate this population are now of highest priority to local, state, and federal agencies. The District, Miccosukee Tribe of Indians, and Miami-Dade County, the primary landowners within the Bird Drive Basin, are working closely with FWC and other agencies to address this emerging threat.

Between December 2013 and March 2014, FWC and ECISMA partners organized three volunteer surveys in the Bird Drive Basin. No Northern African pythons were found during these searches but a recently shed skin was recovered. Surveying was increased by the UF and FWC in late 2014 and early 2015 but additional snakes were not found until July 25, 2015, when one was found dead at SW 144th Avenue and Bird Road. Throughout the next year, the interagency team will be continuing survey efforts in this area with the objective of eradicating this species from South Florida natural areas.

As with the Burmese python, a special permit is now required to possess, import, sell, or breed the northern African python in Florida (Chapter 68-5.002, Florida Administrative Code). This permit is available only to licensed dealers, public exhibitors, or researchers that meet certain bio-security measures. Additionally, a federal ban on importation of this species was instated in January 2012.

Chameleons

A reproducing population of the Oustalet's chameleon was discovered in rural Miami-Dade County in early 2010. This large chameleon is native to Madagascar where it utilizes a wide variety of habitats, including human-altered environments (D'Cruze et al. 2007). An interagency team, led by FWC, began a rapid assessment monitoring project in July 2011. Between July 2011 and July 2015, biologists removed 599 Oustalet's chameleons from a 122-acre site (Jenny Ketterlin Eckles, FWC, and Mike Rochford, UF, personal communications). Preliminary diet analysis indicates that this chameleon population consumes a variety of insect and anole species. The interagency team is continuing periodic surveys in the known population area in order to better understand the extent of the population and natural history of this species in Florida. This species does not appear to be spreading without human assistance and the number of chameleons per survey has decreased, indicating eradication may be possible.

The veiled chameleon (*Chamaeleo calyptratus*) naturally occurs in mountain and coastal regions of Yemen, the United Arab Emirates, and Saudi Arabia. Males reach a length of 2 feet; females get about half that size. Like the previous species, the veiled chameleon is notable for the wide range of habitats it uses in its native countries. A breeding population of the veiled chameleon was documented in a low density residential area of Lee County (northwest estuaries) in 2002 and more than 100 of these lizards were captured (FWC 2013). Scattered individual sightings have been made in the same general area. Recently, a significant population was discovered 100 miles across the Everglades in an agricultural area in southern Miami-Dade County near the area invaded by Oustalet's chameleons. A second (sub-) population was located on the boundary between the agricultural area and the Everglades wetlands, less than 4 miles from the ENP boundary. In 2014, FWC and UF discovered another population in Broward County. More than 50 specimens of veiled chameleon have now been removed from Miami-Dade populations. Biologists studying Oustalet's chameleon are also investigating the veiled chameleon with the same concerns and objectives. Florida populations of both species are suspected to have been established through intentional releases by reptile enthusiasts. If chameleons demonstrate the ability to spread from suburban and agricultural land and build up populations in native Florida habitats, then the argument for an aggressive eradication program will be strong.

Figure 7-34. The spectacled caiman (*C. crocodilus fuscus*) (photo by SFWMD).

Spectacled Caiman (*Caiman crocodilus fuscus*)

Spectacled caiman from the exotic pet trade were first reported from canals at the Homestead Air Force Base as early as 1960 (Ellis 1980). Currently, their range includes parts of Miami-Dade and Monroe counties with most records located in Homestead, Florida City, along US-41 (including the northern part of ENP), and along Loop Road in BCNP (**Figure 7-34**). Spectacled caiman have been captured or observed in Southwest Ranches and Everglades Holiday Park in Broward County, as well as one in Palm Beach County suggesting that the

original population may have spread northward or that other introductions have occurred. In Florida, spectacled caiman are most commonly encountered in ditches, canals, and disturbed wetlands but are occasionally found in relatively undisturbed marshes. A small population of caimans has recently been discovered within the footprint of the Biscayne Bay Wetlands Complex near the L-31 canal between 268th and 320th streets. Increased freshwater flow may encourage that population to expand into Biscayne National Park. Eradication is possible if immediate action is taken.

FUTURE NEEDS IN MANAGEMENT AND CONTROL

The elements of a comprehensive management program for some nonindigenous plant species—legislation, coordination, planning, research, education, training, and funding—have been in place in Florida for many years. The majority of plants identified in this chapter as priority species are being managed on public lands by local, state, or federal agencies. This is not true for most nonindigenous animal species. The threat of nonindigenous animals is becoming an important ecological and restoration issue for many agencies in Florida. Meaningful legislation to significantly limit new invasions, funding for control programs, and coordination at all levels are needed for a comprehensive nonindigenous animal management program for Florida. The number of nonindigenous animals is overwhelming, and agencies charged with managing natural systems have a responsibility to understand the distribution and impacts of these species and either initiate management operations or accept their occurrence and consequences in natural areas.

Given the documented impacts of nonindigenous organisms in South Florida, scientists are obliged to factor these species and their impacts into restoration models. Research is needed to understand the distribution, biology, and impacts of these nonindigenous organisms. Controlling and managing nonindigenous organisms in an all-taxa approach is a new idea, even among ecologists, but it is sure to emerge as an important field of science given global trade and the virtual "open-barn" situation. Organisms will continue arriving and establishing breeding populations in new environments, especially in South Florida.

Regardless of taxa, the process of biological invasion—from introduction to establishment to ecosystem engineer—is complex, involves many environmental factors, and may take many decades to complete. Relatively few nonindigenous species become invasive in their new environments, but a very few species can wreak major economic and ecologic havoc. Species that appear benign for many years or even decades may suddenly spread rapidly following floods, fires, droughts, hurricanes, long-term commercial availability, or other factors. Resource managers must recognize these species during the early, incipient phase to maximize the potential for containing or eradicating them. As part of this effort, an applied monitoring program and a tracking system for nonindigenous plant and animal species are needed before their introduction.

Species like the purple swamphen in the Everglades and Gambian pouched rat in the Florida Keys illustrate the need for agencies to act quickly to contain and attempt to eradicate animals that have the potential to become widespread and difficult to control. While definitive research is lacking to support the immediate management of these particular species, it is widely accepted in the invasive species literature that catching a species in its incipient phase is advantageous, even where research may be inadequate or lacking. This is one of the most important reasons to develop a biological risk assessment "tool box" for nonindigenous species to help discern which species are most likely to become invasive both prior to introduction and during the earliest phases of their establishment when eradication is most feasible.

The use of an EDRR program increases the likelihood that invasions will be controlled while the species is still localized and population levels are so low that eradication is possible (National Invasive Species Council 2003). Once populations of an invasive species are widely established,

eradication becomes virtually impossible and perpetual control is the only option. Implementing an EDRR program is also typically much less expensive than a long-term management program. Given the risks associated with waiting for research and long-term monitoring to catch up, some agencies have opted to initiate control programs concurrently with biological or ecological research programs. Prompt cooperative action to eliminate emerging populations of sacred ibis (*Threskiornis aethiopicus)* and the invasive mangrove species *Lumnitzera racemosa* have been successful. These EDRR efforts may have prevented widespread ecological harm by these new invaders and also saved significant public resources required to manage more widespread invasions. Biological risk assessments are being developed to enable agencies to determine which species are most likely to become problems (Gordon et al. 2006, Simons and De Poorter 2009). Many states struggle with how to implement an EDRR approach because awareness and funding often lag, preventing a real rapid response. For South Florida, groups such as the ECISMA are attempting to initiate additional EDRR efforts.

An overarching theme in this chapter is describing the alarming extent and impacts of some nonindigenous species and stating the need for increased coordination and control. While these observations are valid, control efforts against certain nonindigenous species have proven successful and demonstrate that effective management is possible with effective interagency support and adequate funding. For instance, melaleuca once was thought to be unmanageable in the state because it was so widespread and difficult to control. The District-led melaleuca management program is entering its twentieth year. Resource management agencies estimate this program has cost nearly $41 million to date. However, melaleuca is now under maintenance control on Lake Okeechobee and in the majority of the Everglades and Florida's melaleuca management program is a model for invasive species management nationally. The success of this program is largely attributed to integrated management approaches, sustained funding, and close interagency coordination, all of which foster information and technology transfer, regional strategic planning, increased financial efficiency, and improved public awareness.

For the nonindigenous species that are already widely established, long-term commitments to integrated control programs are the only feasible means of containing and reversing impacts. Effective management of other entrenched and difficult-to-control species, such as Old World climbing fern and the Burmese python, will require sustained resource allocation for development and implementation of control programs, similar to that used for the management of melaleuca, if Everglades restoration is to be successful. Further, many biological invasions are likely to be permanent and may easily reestablish dominance if maintenance and control management is not sustained. For this reason, preventing importation of potentially invasive species through improved regulatory programs and regional monitoring programs should be a priority focus of policy makers, regulators, scientists, and land managers moving forward.

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