Please note that Table 7-1 on page 7-6 was updated on April 17, 2017.

Chapter 7: Status of Nonindigenous Species

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SUMMARY

Invasive nonindigenous species present serious threats to ecosystem community structure and function throughout South Florida. As such, controlling invasive species is a critical resource management activity in the South Florida Water Management District (SFWMD or District) *Strategic Plan, 2012–2017* (SFWMD 2012). Successfully managing invasive species is important to other strategic goals also 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 2015-2016 (October 1, 2015–September 30, 2016). 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 underway for priority nonindigenous species considered to be capable of impacting the resources that the District is mandated to manage or restore. The District continues to collaborate with the regional cooperative invasive species management areas (CISMAs), Lake Okeechobee Interagency Aquatic Plant Management Team, South Florida Ecosystem Restoration Task Force (SFERTF), and other cross-jurisdictional teams. These critical collaborations have facilitated the implementation of regionwide invasive species monitoring programs, rapid response efforts, standardized data management, and outreach initiatives. As such, this report includes a great deal of information and summaries of accomplishments attributed to the efforts of these

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collaborative teams. Active partners in invasive species management within the South Florida ecosystem include the following entities: Broward County, Collier County, Florida Fish and Wildlife Conservation Commission (FWC), Miami-Dade County, Miccosukee Tribe of Indians of Florida, Palm Beach County, The Nature Conservancy, Seminole Tribe of Florida, United States Army Corps of Engineers (USACE), United States Department of Agriculture (USDA), United States Department of the Interior, United States Geological Survey (USGS), National Park Service (NPS), United States Fish and Wildlife Service (USFWS), and University of Florida (UF).

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 (*Casuarina* 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, controlling 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 controlled in Water Conservation Area (WCA) 2 and WCA-3 as well as Lake Okeechobee and is now under maintenance control in these regions.
- Interagency efforts to achieve maintenance control of priority invasive plant species in areas with more severe infestations continue. The USFWS, FWC, and SFWMD are actively engaged in aggressive control efforts in the Arthur R. Marshall Loxahatchee National Wildlife Refuge (LNWR) where melaleuca and Old World climbing fern remain problematic. NPS resource managers are collaborating with FWC and SFWMD invasive species biologists to leverage resources towards achieving maintenance level control of melaleuca, Brazilian pepper, and other aggressive invaders in Everglades National Park (ENP) and Big Cypress National Preserve (BCNP).
- 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 mass rearing facility at the existing USDA's Agricultural Research Service (USDA-ARS) biological control laboratory in Davie, Florida, now supports biological control agent rearing and field release for melaleuca, Old World climbing fern, water hyacinth, air potato (*Dioscorea bulbifera*), and other invasive nonindigenous plant species.
- Range expansions of invasive nonindigenous plant species into new areas remain a concern for resource managers. The District and partner agencies are assessing feasible means of monitoring and controlling expanding populations based on threat prioritization and financial resource availability.

NONINDIGENOUS ANIMALS

- Considerable numbers of nonindigenous animals are known to occur in South Florida, ranging from approximately 62 species in the Kissimmee Basin to more than 130 species in the Greater Everglades. Ranking animals for control is a serious challenge and prioritizing related threats across regulatory agencies is needed.

- Burmese pythons (*Python molurus bivittatus*) continue to be observed and removed in the Everglades and surrounding rural areas. The District is an active partner in regional efforts to halt the spread of this invasive reptile by conducting regional search and removal operations. Ongoing collaboration between UF and FWC has produced a systemwide monitoring and removal program for Burmese pythons and other priority invasive reptiles.
- FWC continues to build its nonindigenous animal management program and coordinates closely with SFWMD, NPS, USFWS, and other partners to manage nonnative animal species in South Florida. During 2016, federal, state, local, and tribal partners continued 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*).

PROGRESS TOWARD MANAGEMENT AND CONTROL

The following section provides updates for Fiscal Year 2015-2016 on control, research, monitoring, and coordination activities on invasive nonindigenous species that threaten the success of SFWMD's mission.

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). SFWMD 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. 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; however, 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. More than 20 herbicides are used in South Florida to control invasive plants. Commonly used herbicides for control of broadleaf species in wetlands include dichlorophenoxyacetic acid (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 specifically to control perennial grass species. Floating and submerged aquatic plants are controlled with several herbicides; 2,4-D, diquat, fluridone, endothall, and triclopyr are 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 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, SFWMD and FWC recently removed large melaleuca slash piles in and around the area known to harbor the northern African python. The 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. However, remote sections of the southeastern area of ENP and 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 likely will be decades until these areas are successfully under control. Since 2014, SFWMD, FWC, and USFWS have collaborated to implement an aggressive control program for melaleuca and Old World climbing fern in the LNWR. Utilizing FWC funding, SFWMD invasive species biologists are working collaboratively with USFWS resource managers to augment existing LNWR control efforts. The strategy involves utilizing SFWMD-managed ground applicators in the southern reaches of the LNWR moving systematically northward while USFWS managed contractors continue control efforts in the northern half of the LNWR where infestations are most severe.

Old World climbing fern presents significant challenges for natural resource managers in the Everglades and Kissimmee River Basin. This highly invasive plant is difficult to control, partly due to its ability to establish and thrive in remote undisturbed areas. Continued research to develop herbicides, biological controls, and control strategies is needed for successful long-term management of the species. SFWMD, in partnership with FWC, executed a multi-year agreement with UF to further expand Old World climbing fern management research. The primary focus of the work will be evaluating new herbicides and refining integrated pest management strategies in areas where the plant is most difficult to control.

In **Table 7-1**, SFWMD's Fiscal Year 2015-2016 expenditures for nonindigenous plant control are summarized by land management regions. The purpose of **Table 7-1** is to report expenditures for the most abundant invasive plant species on District-managed lands in support of SFWMD's environmental restoration and flood control missions. In addition to these species, SFWMD directs staff and contractors to control all invasive plant species identified by the Florida Exotic Pest Plant Council (FLEPPC) as Category I species (FLEPPC 2015). These species are documented to alter native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with native species. In Fiscal Year 2015-2016, SFWMD spent more than $19 million for overall invasive species prevention, control, and management in South Florida. In anticipation of continued budget shortfalls, SFMWD reevaluated invasive plant management priorities to assure that gained ground is not lost. Vigilant reconnaissance and retreatment is necessary to maintain low levels of established invasive species. Biological controls are proving to be beneficial 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. Note: The SFERTF is compiling expenditure information for participating member agencies. This information will be used to create a cross-cut budget for invasive exotic species to increase strategic coordination efforts (SFERTF 2016).

Table 7-1. Invasive plant species control expenditures ($) by SFWMD in Fiscal Year 2015-2016 organized by land management region.

Priority Invasive Species	Upper Lakes	Kissimmee/ Okeechobee	Lake Okeechobee	Everglades	East Coast	West Coast	Biocontrol	Total
Melaleuca (*Melaleuca quinquenervia*)			55,181	2,510,729	40,437	587,592	170,070	3,364,009
Old World climbing fern (*Lygodium microphyllum*)	100,389	285,884		1,609,877	72,572	10,947	170,070	2,231,739
Floating plants Water hyacinth (*Eichhornia crassipes*) and Water lettuce (*Pistia stratiotes*)	6,792	118,861		238,969	117,970	2,353	20,070	505,015
Brazilian pepper (*Schinus terebinthifolius*)	6,969	283,734	64,695	725,581	930,175	655,703		2,666,857
Hydrilla (*Hydrilla verticillata*)	687,259			278	18,641	7,407		713,585
Torpedograss (*Panicum repens*)	60,034			33,211	43,599	34,760		171,604
Shoebutton ardisia (*Ardisia elliptica*)				362,928	23,867			386,795
Australian pine (*Casuarina equisetifolia*)				62,635				62,635

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 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 being 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). The 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 divert the tree's resources away from growth and reproduction (**Figure 7-1**). This agent works with other melaleuca biological control agents in suppressing the tree, rendering it less invasive and easier to control using herbicides and fire. There is a new agent under development in USDA quarantine that galls the leaves; this species likely will receive a release permit within 2 to 3 years.

Figure 7-1. Galls of the melaleuca midge stunt and deform melaleuca stem growth (photo by SFWMD).

Old World Climbing Fern

Figure 7-2. Damage to Old World climbing fern from the brown lygodium moth in the LNWR during winter 2015-2016 (photo by SFWMD).

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; however, despite the release of more than 110,000 individuals, the 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 7-2**). The population densities of the moth vary across the landscape in South Florida. Outbreaks of the moth caused heavy damage to Old World climbing fern in multiple areas in winter 2015-2016. To date, 211,322 brown lygodium moths or larvae have been released in South Florida in Fiscal Year 2015-2016.

The lygodium gall mite (*Floracarus perrepae*) induces leaf roll galls on the leaves of Old World climbing fern. It also damages the apical meristems or new growing tips. First released in 2008 and 2009, the mite continues to be present at low numbers within some 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. Lygodium gall mites recolonized a site after a prescribed burn in ENP and caused heavy damage to Old World climbing fern regrowth. During Fiscal Year 2015-2016, more than 56,000 mites were 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 underway in the USDA-ARS quarantine facility in Fort Lauderdale, Florida, for two candidate biocontrol agents, namely *Lygomusotima stria* (a newly described Cambrid moth) and *Neostrombocerus albicomus* (a sawfly). A new defoliating agent, *Callopistria* sp., has been colonized in quarantine and will soon begin the host range testing process.

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. The latest biocontrol agent, the water hyacinth planthopper (*Megamelus scutellaris*), was released into the field in February 2010 (Tipping et al. 2014) (**Figure 7-3**), making it the first new agent on water hyacinth in more than 30 years. During Fiscal Year 2015-2016, more than 580,000 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 7-3. The water hyacinth planthopper (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 SFWMD and USACE, began the operational phase of the project and released 912,784 insects and mites on three weed species in Fiscal Year 2015-2016 to date; releases are continuing. Intensive and extensive field monitoring and evaluation of the biological control agents are underway.

Invasive Plant Monitoring

The District maintains a regional monitoring program for priority invasive plant species within the CERP footprint. Objectives of the program include 1) assessing long-term changes in landscape-scale invasive species distribution and abundance, and 2) providing species location information to regional land managers planning control strategies. The District and partner agencies utilize digital aerial sketchmapping (DASM) to obtain distribution data for numerous canopy-dominating invasive plant species. DASM is a remote sensing technique where biologists observe ground conditions from low-flying aircraft and digitally map invasive plant populations with global positioning system (GPS)-linked touch screen computers (Rodgers et al. 2014). Recent SFER volumes have presented detailed analyses of monitoring results for the Greater Everglades region of CERP (see 2015 SFER – Volume I, Chapter 7; Rodgers et al. 2015). This section presents recent monitoring results for the Kissimmee River floodplain and the LNWR.

Kissimmee River

The spatial extent and dominance of priority invasive plant species were mapped within the Kissimmee River floodplain in late December 2015 and early January 2016. Mapping was conducted on District-managed lands between Lake Okeechobee and State Highway 60. Mapped species included Old World climbing fern, Brazilian pepper, and creeping water primroses (*Ludwigia* spp.). Three invasive grass species—paragrass (*Urochloa mutica*), limpograss (*Hemarthria altissima*), and West Indian marsh grass (*Hymenachne amplexicaulis*)—were also mapped. Due to their intermixed distributions, the three grass species were combined in single polygons during mapping. Percent vegetation cover was estimated for each species polygon using a modified Braun Blanquet cover abundance scale: < 1.0 percent, 1.0–2.0 percent, 2.1–5.0 percent, 5.1–15 percent, 15.1–25.0 percent, 25.1–75.0 percent, and > 75 percent. After completing geographic information system (GIS) quality assurance/quality control, polygon data for each species were analyzed using a 500-meter (m) grid using the Esri™ ArcMap™ Zonal Statistics tool. The analysis allows for computation of statistics on percent cover within equal 25-hectare (ha) zones (500 × 500-m grid cell). The mean percent cover in each 25-ha cell is used to visually assess the abundance and distribution for each species. Results from a 2011 DASM survey for Old World climbing fern were used in the analysis to evaluate changes in the species' abundance and distribution over the five-year period.

Figure 7-4 shows the distribution and abundance of Old World climbing fern in 2011 and 2016. The number of 25-ha cells where Old World climbing fern was detected increased from 147 (3,675 ha) in 2011 to 335 (8,375 ha) in 2016, representing a 128 percent increase in area of occurrence within the Kissimmee River floodplain over the five-year period. However, much of the expansion is associated with very low level infestations (**Figure 7-5**). When considering only cells with moderate to high infestation levels (>15 percent mean Old World climbing fern cover), there are an estimated 625 ha of invaded habitat. This represents a 19 percent increase of moderate to high level infestation areas within the mapping area. The expansion of Old World climbing fern during the five-year period is consistent with previously observed expansion patterns in portions of the Greater Everglades. Specifically, populations of the plant can spread rapidly across a large landscape at relatively low densities then become more dominant in localized areas within the expansion area over longer periods of time (Rodgers et al. 2015). This trend suggests further increases in Old World climbing fern density is likely without increased control efforts and improved management strategies in the region.

The data also show that Old World climbing fern is present throughout many of the seasonal marshes and floodplains along the Kissimmee River, primarily in the restored portions where the longer hydroperiod has created favorable conditions for the invasive fern. In the northern and middle sections of the river, Old World climbing fern is frequently found in the broadleaf marshes, growing across the top of the low shrubs. In Blanket Bay, Old World climbing fern has expanded its distribution, but as described earlier, is present at mostly low levels throughout the southern portion of the management area. Old World climbing fern growth is prolific in the Turkey Hammock West floodplain where densities can exceed 50 percent cover over large areas. In the southern stretch of the river, Old World climbing fern dominates portions of Chandler Slough, Seaboard Marsh South, and the S-65E Impoundment where it climbs vertically through the cypress (*Taxodium* spp.) and red maples (*Acer rubrum*), and spreads horizontally through the marsh along the footprint of the historic river.

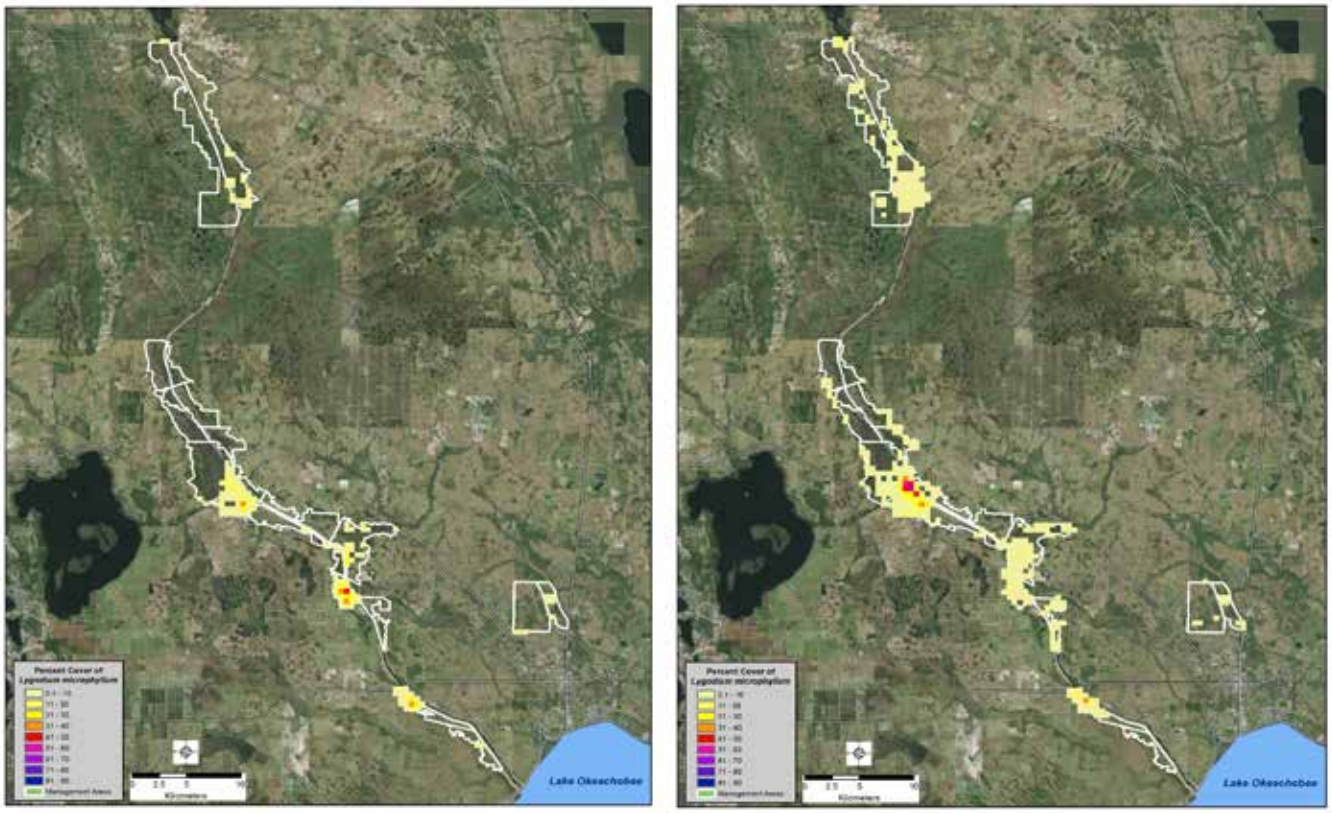

Figure 7-4. Distribution and abundance of Old World climbing fern on District-managed lands in the Kissimmee River Region: 2011 and 2016.

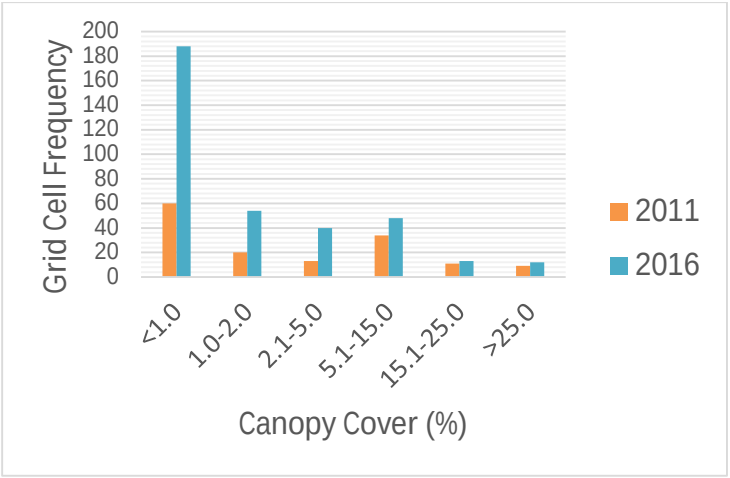

Figure 7-5. Histogram of Old World climbing fern mean percent cover classes in 25-ha grid cells in the Kissimmee River floodplain 2011 and 2016.

Three exotic grass species (paragrass, limpograss, and West Indian marsh grass) have aggressively colonized the central regions of the Kissimmee River floodplain, particularly in the wet prairies extending from No Name Slough south to Hickory Hammock where the C-38 canal is backfilled (**Figure 7-6**). For the entire mapped area, these exotic grass species occur within 260 grid cells (area of occurrence = 6,500 ha). Of this area, 2,275 ha contain moderate to high level infestations (> 25 percent canopy cover). Paragrass grows in dense infestations, in some cases occurring at > 75 percent cover across 1,000 contiguous acres or more. Limpograss and West Indian marsh grass grow amid the paragrass in dense scattered patches. However, field observations suggest recent, dramatic increases in West Indian marsh grass abundance in localized portions of the floodplain. Once dominant, the three species impede reestablishment of native wet prairie plant communities and limit wading bird and waterfowl foraging access (Koebel et al. 2016). SFWMD is developing a strategic control plan for these species within the restoration area. Herbicide trials aimed at developing methods to shift plant populations from dominant exotic grasses to native mixed marsh communities are ongoing. Effective long-term management of these species will require an integrated approach utilizing chemical, mechanical, and cultural (e.g., prescribed fire, hydrologic restoration) control tools.

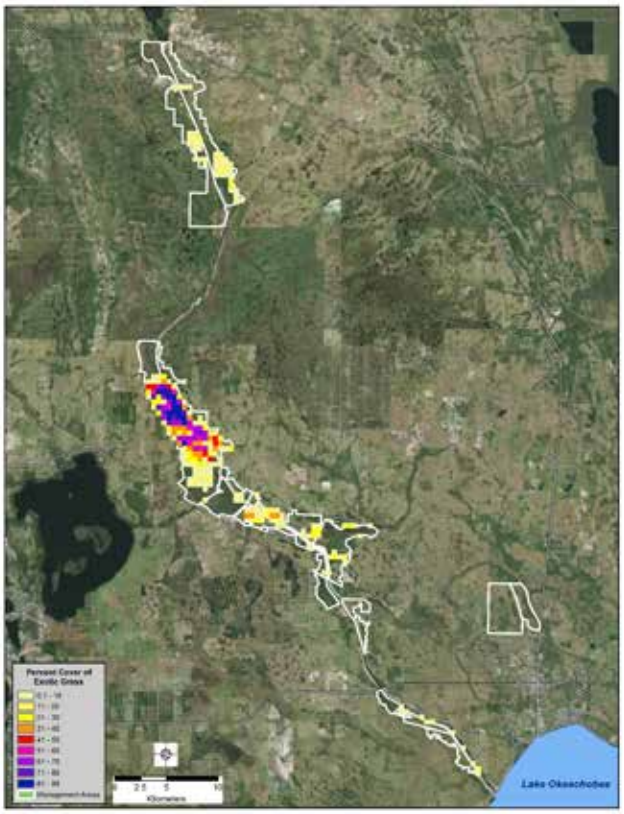

Figure 7-6. Distribution and abundance of invasive exotic grass species on District-managed lands in the Kissimmee River region.

Aggressive non-native species of water primroses (primarily *Ludwigia peruviana)* occur throughout the Kissimmee River floodplain. During the 2016 mapping, the species complex was documented in 315 25-ha grid cells (area of occurrence = 7,875 ha) with 1,275 ha of the area consisting of moderate to high level infestations (> 25 percent mean canopy cover) (**Figure 7-7**). While these species are present in broadleaf marsh and wetland shrub communities throughout the floodplain, most of the large dense stands occur in the central portion of the mapped area. In particular, the transitional marsh found between the long hydroperiod wet prairie and the upland oak hammock appears to be especially conducive to primrose willow (*Ludwigia* spp.) growth. While the majority of primrose willow exists at density levels that are < 50 percent, scattered high-level infestations do occur, especially in Blanket Bay. It is hypothesized that more-variable hydroperiods resulting from revised water regulation schedules will may make conditions less favorable to this species (Spencer and Bousquin 2014).

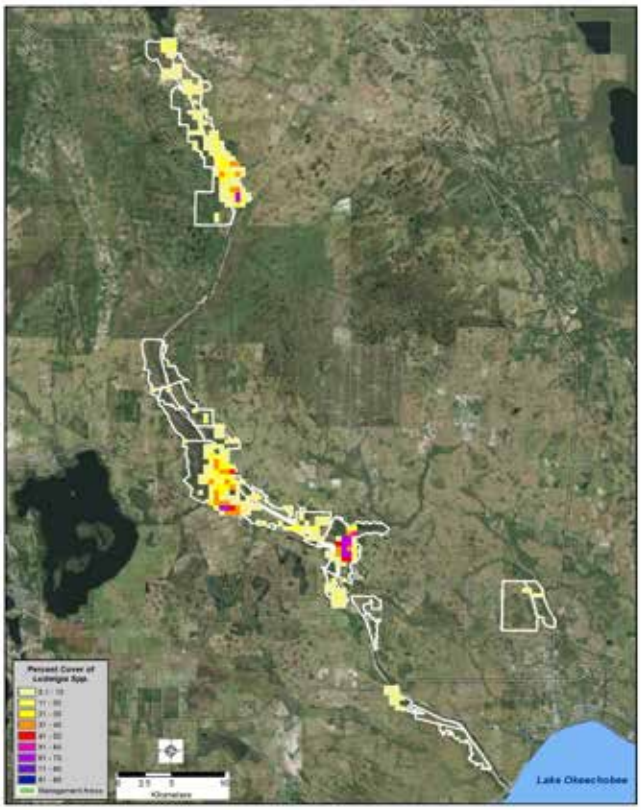

Figure 7-7. Distribution and abundance of invasive water primroses on District-managed lands in the Kissimmee River region.

Brazilian pepper is a common component of the upland forested areas as well as the dry grasslands where it occurs in moderate densities with occasional scattered dense, almost monotypic stands. This invasive large shrub was observed in 506 25-ha grid cells (area of occurrence = 12,650 ha), of which 525 ha contain moderate to high density infestations (> 25 percent mean canopy cover) (**Figure 7-8**). Dechannelization of the C-38 canal would likely eliminate some of the suitable habitat for Brazilian pepper in this portion of the Kissimmee River. In the southern portion of Blanket Bay, low-density pockets of Brazilian pepper persist in the broadleaf marshes, growing among the primrose willow. Widely distributed regions of low-density Brazilian pepper are common in the broadleaf marshes in Hickory Hammock and Turkey Hammock. Moderate- to high-density occurrences of Brazilian pepper are found from Bluff Hammock 2 to Mims Island, most often at the river edge growing with other woody species such as oaks (*Quercus* spp.) and cypress. This opportunistic species easily recruits along berms and roadways and is present on most man-made upland areas from Highway 60 to State Road 78.

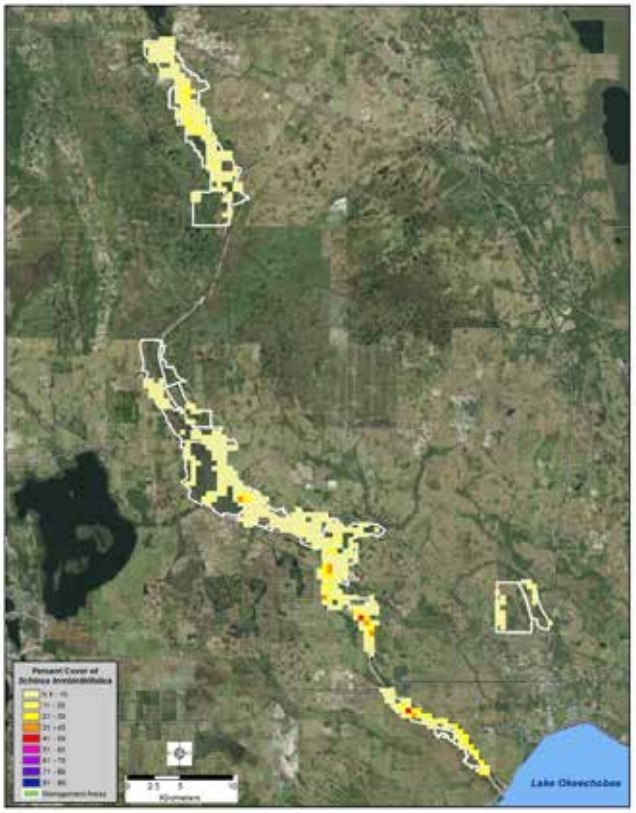

Figure 7-8. Distribution and abundance of invasive Brazilian pepper on District-managed lands in the Kissimmee River region.

INVASIVE ANIMAL MANAGEMENT

Efforts to develop control tools and management strategies for several priority animal species continued in Fiscal Year 2015-2016, including the Burmese python (**Figure 7-9**) 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 often is 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.

Regional invasive biologists associated with the Everglades CISMA (ECISMA) have developed a conceptual response framework for establishing priority invasive animals in South Florida. Objectives within the framework are classified into three main categories: (1) containment (slow the spread), (2) eradicating incipient populations (remove outliers), and (3) 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 regionwide early detection rapid response (EDRR) strike team possibly modeled after the 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.

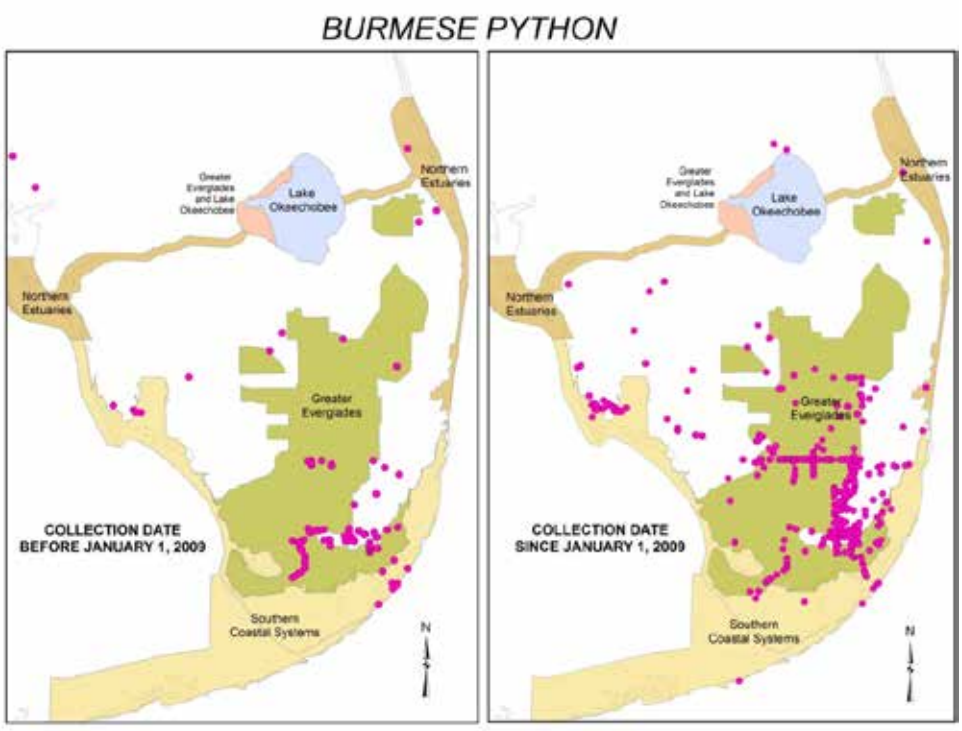

Figure 7-9. Locations of Burmese pythons removed from South Florida from 1999 through 2008 (left) and from 2009 to present (right).

There were several ongoing and new invasive animal initiatives in Fiscal Year 2015-2016, including ongoing monitoring and research efforts for Burmese python, northern African python, Argentine black and white tegu, Nile monitor, 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, UF, FWC, and SFWMD began collaboration on the Everglades Invasive Reptile and Amphibian Monitoring Project (EIRAMP). 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, BCNP, Southern Glades Wildlife Management Area, ENP, Corkscrew Swamp Sanctuary, 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 Burmese pythons ranged from 0.0004 to 0.0351 observations per kilometer. In 2016, brown anoles (*Norops sagrei*), house geckos (*Hemidactylus* spp.), brown basilisks (*Basiliscus vittatus*), Cuban treefrogs, greenhouse frogs (*Eleutherodactylus planirostris*), cane toads (*Rhinella marina*), domestic cats (*Felis domesticus*), domestic dogs (*Canis familiaris*), and black rats (*Rattus rattus*) were the most commonly observed nonindigenous species of reptile, amphibian, and mammal, respectively (Frank Mazzotti, UF, unpublished data). Virginia

opossums (*Didelphis virginiana*), white-tailed deer (*Odocoileus virginianus*), and raccoons *(Procyon lotor*), were the most common native mammals observed. Southern leopard frogs (*Lithobates sphenocephalus*), green treefrogs (*Hyla cinerea*), and pig frogs (*Lithobates grylio*) were the most common native amphibians observed. Cottonmouths (*Agkistrodon piscivorus*), peninsula cooters (*Pseudemys floridana*), and eastern ribbonsnakes (*Thamnophis sauritus*) were the most abundantly observed native reptiles. To date, 105 Burmese pythons have been detected during the visual surveys. Moving forward, the EIRAMP 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 EIRAMP team has joined with Zoo Miami and Venom One to provide EDRR capability for invasive reptiles in the ECISMA. EDRR surveys and trapping have resulted in the removal of 65 Nile monitors; 1,801 Argentine black and white tegus; 600 Oustalet's chameleons (*Furcifer oustaleti*); 17 veiled chameleons (*Chamaeleo calyptratus*); 97 spectacled caimans; 13 Burmese pythons; three black spinytail iguanas (*Ctenosaura similis*); 1 white-throated monitor (*Varanus albigularis*); 1 Nile crocodile (*Crocodylus niloticus*); 1 boa constrictor (*Boa constrictor*); 1 ball python (*Python regius*); and 1 leopard gecko (*Eublepharus macularius*). A small group of volunteers as part of this program has removed 86 Burmese pythons since April 17, 2015.

INTERAGENCY COORDINATION

This section provides updates on key interagency coordination activities pertaining to invasive nonindigenous species in South Florida during Fiscal Year 2015-2016. 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 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 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 (Midwest Invasive Plant Network 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 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, 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

Figure 7-10. Locations of Florida's CISMAs. (Map credit is University of Georgia - Center for Invasive Species and Ecosystem Health)

CISMAs, providing training for invasive species reporting, and providing access to existing online resources and efforts. To date, there are 16 CISMAs in Florida covering approximately 98 percent of the state (**Figure 7-10**). Of the 16 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 ECISMA in 2006 to improve cooperation and information exchange related to invasive species management. The ECISMA partnership was formalized in 2008 with a memorandum of understanding among SFWMD, USACE, FWC, NPS, and USFWS. The memorandum 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 lands within the Everglades Protection Area and Everglades Agricultural Area; Miccosukee and Seminole lands; and Broward, Palm Beach, and Miami-Dade counties.

ECISMA has achieved much progress toward improved coordination and cooperation among those engaged in invasive species management in the Everglades. 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 fiscal year, ECISMA members worked together on several 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, Nile monitors, and spectacled caiman; (2) conduct rapid response efforts to assess populations of potential emerging threats such as Wright's nutrush (*Scleria lacustris*) and bushweed (*Flueggea virosa* subsp. *melanthesoides*); and (3) continue monitoring and treatment of the exotic black mangrove, or kripa (*Lumnitzera racemosa*). ECISMA also coordinated and participated in outreach initiatives aimed at increasing public awareness of invasive species such as the Race Against Invasives 5k Run and the 2016 Non-Native Fish Roundup.

In July 2016, 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 2016–2017 include (1) increasing collaboration between ECISMA land managers and vegetation management teams with Florida Department of Transportation and Florida Power & Light; (2) continued monitoring and trapping efforts for Argentine black and white tegus and Nile monitors;

(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; and (4) updates to the ECISMA Early Detection/Rapid Response Plan. More information about the ECISMA is available online at http://www.evergladescisma.org/.

Treasure Coast CISMA

The Treasure Coast CISMA (TC-CISMA) is a regional partnership established in 2007 to cooperatively address the threats of invasive plants and animals 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.

From October 2015 through September 2016, the TC-CISMA held two steering committee meetings, developed a 2016 annual work plan, continued its private land efforts treating 26 ha of downy rose myrtle (*Rhodomyrtus tomentosa*), strawberry guava (*Psidium cattleianum*), and Old World climbing fern at The Boy Scouts of America's Tanah Keeta Scout Reservation in Martin County. Also at the reservation, the TC-CISMA held a celebration for the five-year partnership. In addition, coastal private invasive work finished at the 1.5-ha Jensen Beach site that benefits the federally listed Lakela's mint (*Dicerandra immaculata*). A new private land scrub site in Tequesta was submitted and accepted for USFWS Partners for Wildlife funding for invasive removal.

Within the TC-CISMA, 10 requests for funding from the FWC Invasive Plant Management Section were approved and others may be approved later. The TC-CISMA also updated and standardized its EDRR plant list with Florida Natural Areas Inventory and FWC involvement, participated in nine 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 invasive removal workday and outreach event in Juno Beach with a new partner, the Loggerhead Marinelife Center. The TC-CISMA improved outreach abilities by creating a stand-up display tabletop, which was used at Naturescape in North Palm Beach, the Oxbow Eco Center in Port St. Lucie, Tanah Keeta Scout Reservation Partnership Celebration, and Loggerhead Marinelife Center.

Working within the TC-CISMA, St. Lucie County's UF IFAS Natural Resources Extension Program "Eyes and Ears" invasive reptile training has been provided to 950 utility employees and volunteers. The extension program associates with the UF IFAS St. Lucie County Extension, and the UF IFAS Indian River Research and Education Center worked with program partners at USDA and the Florida Department of Agriculture and Consumer Services (FDACS) on outreach efforts for the air potato leaf beetle (*Lilioceris cheni*). In St. Lucie County, 19,635 beetles were released on 100 sites. More information about the TC-CISMA is available at http://www.floridainvasives.org/treasure/

Southwest Florida CISMA

The Southwest Florida CISMA, founded in 2008, is a partnership of the Florida Forest Service, FWC, Florida Park Service, USFWS, Lee County, Conservation Collier, Audubon of Florida, Conservancy of Southwest Florida, Naples Zoo, and others. The CISMA boundary encompasses 5 counties: Collier, Lee, Charlotte, Hendry, and Glades (added in 2015). This past year, members participated in 10 festivals and events to educate the public about invasive plants and animals. The CISMA also took part in the 7th Annual Everglades Non-Native Fish Round-up and the 2016 FWC Python Challenge. A representative from Southwest Florida CISMA attended the FLEPPC 2016 CISMA session: Outreach Reporting and Leadership Workshop for Cooperative Invasive Species Management Areas in Florida. Southwest Florida CISMA also held a Grass Identification workshop with UF IFAS, and a Burmese Python Strategic Planning Workshop.

The CISMA's 20th Annual Southwest Florida Exotics Workshop was held at Florida Gulf Coast University, and reached 180 attendees. Southwest Florida CISMA continues their invasive reptile outreach and research efforts, and has conducted an EDRR tegu survey and Exotic Animal Training for Private Landowners. Python research continues through the Conservancy of Southwest Florida and Dr. Paul Andreatis in tracking radio-telemetry tagged pythons. More information about Southwest Florida CISMA is available online at http://www.floridainvasives.org/Southwest/.

Other CISMAs

In addition to the ECISMA, TC-CISMA, and Southwest Florida 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 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, Florida Department of Environmental Protection, and FWC. At semi-monthly meetings, interagency representatives plan treatment species and areas. Since 1987, the group has flown over the lake semi-monthly to estimate the 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 encouraged to attend and provide input to this process. More information about the 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 and the Land Acquisition 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 primrose-willow (*Ludwigia spp.*). The primary lakes are large (1,620–13,800 ha) and interconnected with flood protection canals, which are navigable with boat locks along the system.

South Florida Ecosystem Restoration Task Force

SFERTF 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. SFERTF 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 SFERTF 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. The initiative developed four goals organized around the invasion curve (**Figure 7-11**). 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 side of the invasion curve represents the best chance for long-term success. Because 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.

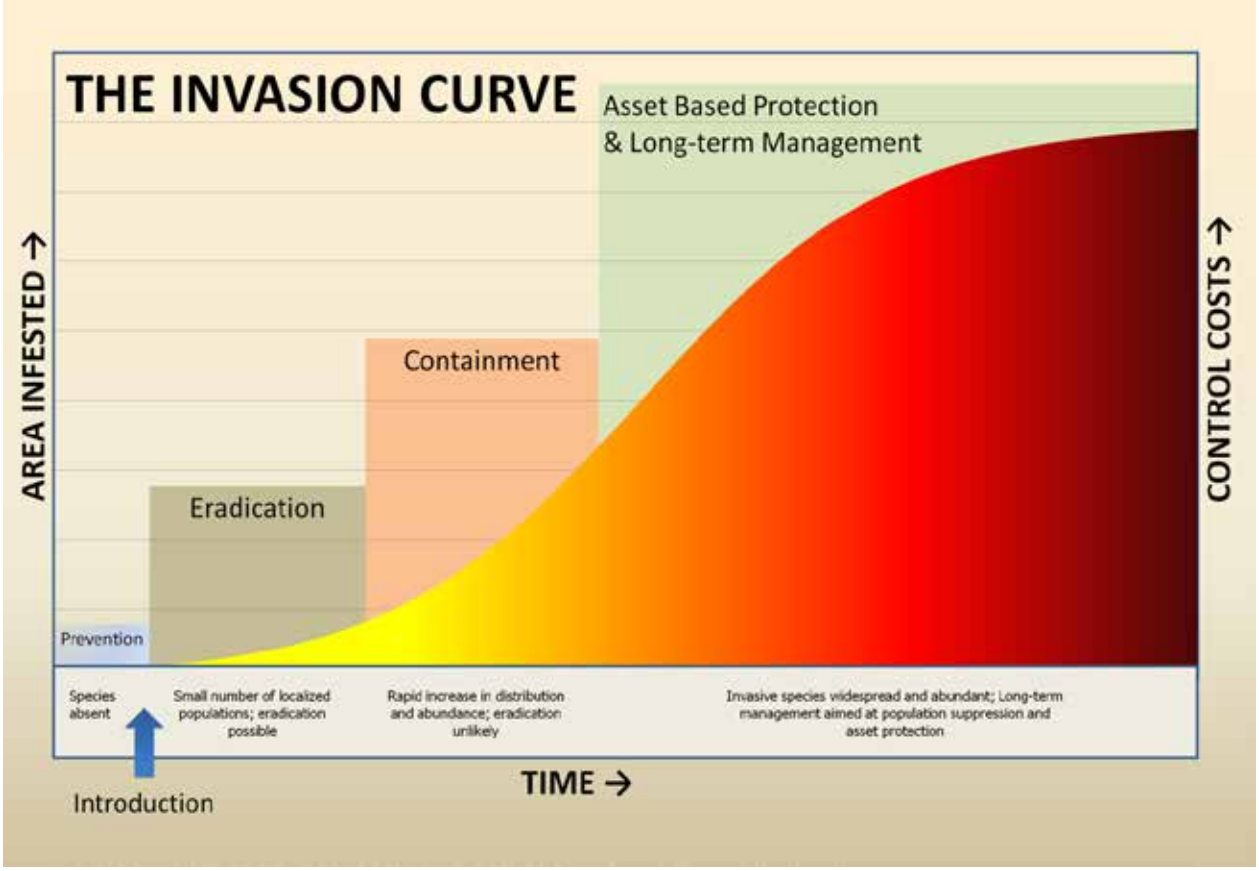

Figure 7-11. The invasion curve depicts the four major categories of management actions that may be taken to combat invasive exotic species as the invasion progresses from initial establishment to widespread dominance on the landscape. Graphic adapted from *Invasive Plants and Animals Policy Framework* (Department of Environment and Primary Industries 2010).

INVASIVE SPECIES STATUS UPDATES

This section provides a summary of nonindigenous species that threaten the success of SFWMD's mission. Species are presented in two groups—established priority species and emerging threats. Twelve established plant species were selected by SFWMD 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 7-2**) 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, the 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/), USGS Nonindigenous Aquatic Species (nas.er.usgs.gov/), and University of South Florida Atlas of Florida Vascular Plants (www.plantatlas.usf.edu/).

Additionally, each species synopsis includes an indicator-based stoplight table that gauges the status of the species in each of SFWMD's land management regions as well as Lake Okeechobee, Florida Bay, and the Florida Keys. These regions closely align with the CERP's Restoration Coordination and Verification Program (RECOVER) modules, but are more inclusive of all conservation and project lands within SFWMD's 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 SFERTF (Doren et al. 2009). Similar to its application in previous reports, the indicator table assesses each species by region according to the following questions: (1) How many hectares does this species occur in within the module? (2) Is the distribution of the species in the module 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 currently is 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 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.

Table 7-2. SFWMD'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 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 cylindrica*)	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 water grass (*Luziola subintegra*)	
*Exotic black mangrove (*Lumnitzera racemosa*)	
*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*)

Finally, updates are provided for eight priority species that currently are the focus of rapid response efforts (**Table 7-2**). For some of these species, agencies are directing resources toward monitoring and removal efforts with the stated objective of eradicating the species in Florida (e.g., Gambian pouched rat). For species whose potential ecological impacts and population status are not sufficiently understood, response efforts are focused on rapid assessments to gather the 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 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 list also indicates whether a species is widely or locally distributed (i.e., occurring in all modules, all but one module, or in only one module). This distribution information indicates the scope of the problem and may help agencies prioritize animal species for regional control and management. Due to limited availability of distribution data, the list 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, are deficient in Florida.

Australian Pine (*Casuarina* spp.)

SUMMARY

Figure 7-12. The dense litter mat of Australian pine inhibits growth of other plants (photo by SFWMD).

Three nonindigenous species in Florida are collectively referred to as Australian pine: *Casuarina equisetifolia*, *C. glauca*, and *C. cunninghamiana*. Australian pine is a large, fast-growing tree that readily colonizes coastal and inland habitats (Morton 1980). Mature plants produce thick litter mats containing plant growth inhibiting compounds (Batish et al. 2001; **Figure 7-12**), making the plant particularly destructive to native plant communities. Australian pine can interfere with sea turtle and American crocodile (*Crocodylus acutus*) nesting (Klukas 1969), and small mammal populations are reportedly lower in habitats dominated by this invader (Mazzotti et al. 1981).

KEY MANAGEMENT ISSUES

Distribution: Australian pine is common in northeastern ENP, SFWMD's East Coast Buffer Lands, C-111 Basin, and Biscayne Bay National Park. While maintenance control is achieved throughout most of the Everglades Protection Area and District-managed conservation lands, recent monitoring in the Southern Glades and Model Lands suggests a slight increase in abundance of Australian pine.

Control Tools: Herbicide controls are well established for this species; however, access to remote infestations makes control challenging. 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 regionwide. Aerial mapping is conducted biennially within the Greater Everglades and on most 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 Australian pine are required. 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 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 found to have greater fitness (germination rate and seedling survival) relative to their progenitors (Geiger et al. 2011).

Figure 7-13. Leaf galls produced by *Calophya latiforceps* on a Brazilian pepper leaf. These galls reduce leaf performance and overall growth.

KEY MANAGEMENT ISSUES

Distribution: Brazilian pepper is the most widespread and abundant nonindigenous species within SFWMD's boundary. This prolific seed producer is a dominant component of southwestern ENP and invades tree islands throughout the Greater Everglades region (Rodgers et al. 2014). Brazilian pepper also remains abundant on right-of-ways and adjacent private lands, facilitating constant reestablishment on conservation lands.

Control Tools: Managers use herbicidal, mechanical, and cultural controls. The first biological control agent for field release against this weed may be permitted in 2017 by the USDA-ARS Invasive Plant Lab in Davie, Florida (**Figure 7-13**).

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: An interagency management plan was developed that called for coordination. ECISMA partners have begun to coordinate control efforts on adjacent lands in the Everglades. More coordination between major land holders is needed.

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: Development and implementation of statewide private lands initiatives is needed 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 7-14. Once established, cogongrass quickly dominates pineland understories (photo by University of Georgia).

SUMMARY

Cogongrass is among the worst weeds internationally (Holm et al. 1977). Widely planted for forage in the early 1900s, this fast-growing perennial Asian grass currently infests an estimated 400,000 ha in Florida (Miller 2007). Cogongrass invades pine flatwoods (**Figure 7-14**), disturbed sites, and marshes where it often displaces 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 SFWMD boundaries, cogongrass is most prevalent in the Kissimmee and Caloosahatchee watersheds, but it has spread in the Lake Okeechobee marsh, BCNP, Dupuis Management Area, and East Coast Buffer Lands. The plant appears to be spreading throughout the District along levees where it is easily spread by mowers.

Control Tools: This species is difficult to control and requires judicious implementation of integrated controls, including 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.

Interagency Coordination: The 2007 Regional Cogongrass Conference produced a comprehensive cogongrass management guide for the southeastern United States. FDACS with USDA has provided a cost-share program to reduce the spread of cogongrass by helping private landowners control existing infestations.

Regulatory Tools: Cogongrass is designated as a Federal Noxious Weed and a Florida Noxious Weed.

Critical Needs: Development of biological control agents would greatly improve regional control of this species. Increased control efforts on utility corridors are needed. A selective herbicide that kills cogongrass but spares some native species would be useful in natural areas. Fluazifop has some selective activity and should be investigated further (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 7-15**) 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. The high cost per hectare to clear advanced invasions shows the value of detecting and eliminating downy rose myrtle before it dominates a natural area.

Figure 7-15. Downy rose myrtle 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 control, but recent improvements in herbicide control show promise. Glyphosate and imazapyr are effective but kill native plants and inhibit revegetation. Dicamba provides good control of downy rose myrtle and spares many native plants. This selectivity is an advantage for use in natural areas. 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 (Philip Tipping, USDA-ARS, personal communication).

Monitoring: Because downy rose myrtle is difficult to detect from the air, monitoring is limited to observations by land managers.

Interagency Coordination: TC-CISMA has made 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 are needed.

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*)

SUMMARY

Hydrilla is a rooted submerged plant that forms dense mats through the water column (**Figure 7-16**), displacing native plant communities. It is native to the Old World and Indo-Pacific and was likely introduced to Florida in the 1950s as an aquarium plant. By the 1990s, hydrilla was widely distributed in the state, occupying more than 56,000 ha of public lakes and rivers. Hydrilla supports the growth of a cyanobacterial epiphyte (*Aetokthonos hydrillicola*) that produces an avian toxin affecting herbivorous waterbirds and their avian predators (e.g., coots [*Fulica americana*] and bald eagles [*Haliaeetus leucocephalus*]) (Wilde 2005, 2014, Martin 2015).

Figure 7-16. Dense hydrilla mats aggressively overtake native aquatic vegetation (photo by USDA).

KEY MANAGEMENT ISSUES

Distribution: Hydrilla is found in all types of Florida waterbodies. It often dominates much of the Kissimmee Chain of Lakes. Hydrilla has been in Lake Okeechobee for approximately 20 years but has not been a consistent problem.

Control Tools: Hydrilla management primarily depends 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. Additional herbicides may receive aquatic labels soon.

Monitoring: 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: 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 in needed. Decades of research have failed to produce successful biological controls for this species. 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
							

Creeping Water Primroses (*Ludwigia* spp.)

SUMMARY

A complex of invasive aquatic *Ludwigia* species (*L. grandiflora*, *L. hexapetala*, *L. uruguayensis*, and *L. peploides*) native to South and Central America, commonly known as creeping water primroses, are causing problems in Florida. Young plants of the creeping water primroses, grow horizontally across the surface spreading into other plant communities. When mature, some grow upright to form dense stands up to 6 feet tall, and the densely tangled rhizome mats fill the water column. In the Kissimmee Chain of Lakes, creeping water primrose overwhelms populations of valued emergent native plants, including giant bulrush (*Schoenoplectus* spp.), Kissimmeegrass (*Paspalidium geminatum*), and maidencane (*Panicum hemitomon*). Allelopathic effects further contribute to the plant's invasiveness (Dandelot et al. 2008). In California, record numbers of mosquitos collected adjacent to creeping water primrose stands have heightened concerns for spread of mosquito-borne diseases (Meisler 2009). Genetic analysis has shown hybridization between *L. grandiflora* and *L. hexapetala* on Lake Tohopekaliga, yielding unknown changes in plant growth and invasive characteristics (M.D. Netherland, personal communication, July 26, 2016).

Distribution: Creeping water primroses are found from Kissimmee to Lake Okeechobee. They are reported in many other Florida waters as well, including the St. Johns River system.

Control Tools: Young surface growth of creeping water primroses can be controlled with herbicides. However, herbicides have little effect on mature dense stands. The USDA-ARS is evaluating numerous insects from South America for possible biocontrol use in the United States (Paul Pratt, USDA-ARS, personal communication, July 29, 2016).

Monitoring: There is no comprehensive monitoring program for creeping water primroses, but involved agencies share information regarding populations.

Interagency Coordination: The Florida Aquatic Plant Management and Land Acquisition trust funds, as administered by FWC, fund control of creeping water primroses.

Regulatory Tools: None of the creeping water primrose species are listed as Federal Noxious Weeds or Florida Prohibited Plants.

Critical Needs: Continued funding and effort are essential to maintain pressure on new and previously treated creeping water primrose populations. Communication continues to be important as trials are made with promising new methods and materials. Containment is unlikely as propagules and seeds move with flows and as contaminants from boating and other activities.

2014 Status of Creeping Water Primroses 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 7-17. 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 7-17**) 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. 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 110,000 ha 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 report slower reinfestation rates as a result of biological control. Significant infestations remain in LNWR, eastern sections of ENP, East Coast Buffer Lands, and many west coast properties. However, significant progress has been made toward control in Broward County East Coast Buffer lands, and several west coast properties over the past few years.

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.

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: Interagency coordination has proven successful for this species.

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

Critical Needs: Private land initiatives are needed 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 7-18**). This highly invasive fern smothers native vegetation, severely compromising plant species composition, destroying tree island canopy cover, and dominating understory communities. This species could 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 7-18. Old World climbing fern overtaking a cypress swamp (photo by USDA-ARS).

KEY MANAGEMENT ISSUES

Distribution: Old World climbing fern dominates many tree islands, strand swamps, pine flatwoods, and other forested wetlands throughout South and Central Florida. First collected in Martin County, this species has expanded as far north as Duval County. Dense infestations are particularly widespread in southwestern ENP, LNWR, and Kissimmee River Region.

Control Tools: Herbicides are used to control Old World climbing fern, but rapid reestablishment makes herbicide control costly and unlikely to succeed alone. Biological control is a critical component to effective long-term management of this plant. Three agents have been released in Florida; two are now established and spreading naturally with help from mass-rearing and release programs (Boughton and Pemberton 2009, Lake et al. 2014, Smith et al. 2014).

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: 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 are needed.

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 7-19. Multiple age classes of shoebutton ardisia dominate the under and mid-stories of this Biscayne Bay Coastal Wetlands mangrove (photo by SFWMD).

SUMMARY

Shoebutton ardisia (**Figure 7-19**) 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 ardisia is established in natural areas in southeastern Florida, particularly in the Southern Glades and eastern portions of ENP.

Control Tools: There are 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 costly in tall, dense thickets and only employed in sensitive mangrove communities where other removal methods are not feasible. The most efficient approach so far for impenetrable thickets of shoebutton ardisia has been mechanical shredding followed by herbicide application. Several herbicides have been used with moderate success, and evaluations are ongoing. More than 52 ha of SFWMD land have been cleared of dense shoebutton ardisia and treated with herbicide in the past four years. This land is now in various stages of restoration to native vegetation. Within the C-111 Basin, follow-up work by ground crews continues to transform the previously infested area into grass-dominated habitat that can be maintained under a fire regime.

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

Interagency Coordination: While there is no regionwide strategic coordination for this species, biologists from SFWMD, 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: A comprehensive feasibility study on the potential for biological control is needed. Increased funding to remove dense infestations in eastern Everglades region, improved revegetation methods after removal of shoebutton ardisia, development of a biological control agent, and monitoring to identify new populations also are required.

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*)

SUMMARY

Torpedograss (**Figure 7-20**), 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.

Figure 7-20. Torpedograss forms dense, impenetrable mats in littoral zones (photo by UF IFAS).

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 8,000 ha of torpedograss originally infested Lake Okeechobee's marshes. Treatments have reduced its coverage to an estimated 2,400 ha on the lake today. Treatment funding was severely curtailed in 2012–2013 but has increased in recent years.

Control Tools: Torpedograss control on Lake Okeechobee aims to limit the plant's expansion into new areas of the lake. From 2003 to 2012, 1,000 to 2,000 ha of torpedograss were treated annually in the lake's 40,400-ha marsh via aerial and ground herbicide application. In 2014, 650 ha of torpedograss were treated by aerial 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 and Land Acquisition trust funds. The goal is to find alternative herbicide tools to prevent development of torpedograss resistance to current herbicides. Development of selective biological control agents for 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 underway.

Monitoring: SFWMD 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 Water Grass (*Luziola subintegra*)

SUMMARY

Tropical American water grass was first discovered in North America in 2007 in Lake Okeechobee (Kunzer and Bodle 2008). This perennial South American grass grows floating or emergent with prostrate creeping culms that form dense mats (**Figure 7-21**). UF researchers found that plants annually produce hundreds of fertile seeds, which remain viable for long periods. Plants decline in winter; new spring and summer growth occurs from seeds and surviving rhizomes. Managers aim to treat the plants before the onset of fall flowering. In 2013, SFWMD treated 320 ha of tropical American water grass in Lake Okeechobee. Everglade snail kite (*Rostrhamus sociabilis*) activity has halted treatments for months. Failure to treat in these areas allows the plant to expand until treatments can resume.

Figure 7-21. Dense floating mats of tropical American water grass (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 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 newly labeled aquatic herbicides, separately and in combination, 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 water grass. As a grass in the rice tribe (Oryzeae), the importance of rice agriculture probably will limit biological control as an option.

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. The Sanibel-Captive Conservation Foundation has been notified to look for the plant in their role as Caloosahatchee River Riverkeeper.

Regulatory Tools: Tropical American water grass is not a Federal or Florida Noxious Weed.

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

2014 Status of Tropical American Water Grass 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 7-22. Dense floating mat of water lettuce (photo by SFWMD).

SUMMARY

Water lettuce (**Figure 7-22**) is a floating aquatic plant native to South America that is now found throughout the tropics and subtropics. Rapid production of vegetative daughter plants occurs during all but the coolest months. New plants are 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 water body types in South Florida. Herbicide control efforts have 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, in the Kissimmee Chain of Lakes and Lake Okeechobee, water lettuce populations have expanded when treatments have ceased to accommodate Everglade snail kite foraging and nesting. When treatments can resume, treatment costs have increased because greater amounts of the plants are present.

Control Tools: Water lettuce is readily controlled by herbicides, but rapid reestablishment of the species in some waterbodies necessitates frequent retreatments. Newly labeled products, including GALLEON (penoxsulam) and CLIPPER (flumioxazin), show promise as additional control agents for water lettuce. A single biocontrol agent, *Neohydronymus affinis,* is established in Florida, but its suppressive effects on the plant do not meet management standards.

Monitoring: 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: 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 7-23**), 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 produced from seed, which germinate copiously on exposed moist soils (Perez et al. 2011). Low nutrient needs and wide tolerance for water conditions enable its persistence and spread.

Figure 7-23. Dense floating mat of water hyacinth (photo by SFWMD).

KEY MANAGEMENT ISSUES

Distribution: Water hyacinth inhabits all water body types in South Florida. Herbicide treatments have 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. In the Kissimmee Chain of Lakes and Lake Okeechobee, populations have expanded when treatments are suspended to accommodate Everglade 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 the species in some waterbodies necessitates frequent re-treatments. Newly labeled products, including GALLEON (penoxsulam) and CLIPPER (flumioxazin), show promise as additional control agents for water hyacinth. USDA released and established four water hyacinth biocontrol insects in Florida, including two weevils of the genus *Neochetina*. These agents reduce biomass by up to two-thirds and seed production by up to 90 percent, but do not reduce surface coverage enough to meet management standards. Herbivory by these agents makes the plant more susceptible to herbicides. In 2010, a new water hyacinth-feeding insect, *Megamelus scutellaris*, was released in Florida. This planthopper is now established in Florida and can be more readily integrated with herbicides than the previously released agents.

Monitoring: FWC monitors water hyacinth in all Florida public waters. SFWMD 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*)

SUMMARY

The island applesnail (**Figure 7-24**) 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 nonnative 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 Everglade 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 and American coots in the southeast United States (Wilde et al. 2005). There is evidence that these snails may transport cyanotoxins in freshwater food webs (Robertson 2012).

Figure 7-24. The island applesnail (photo by FWC).

KEY MANAGEMENT ISSUES

Distribution: The island applesnail has been reported throughout Florida and much of the southeast United States (Rawlings et al. 2007). It is found in most waterbodies, including marshes, canals, lakes, and rivers. Monitoring by ENP and the Miccosukee Tribe indicate that the 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 small 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 are needed.

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 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 7-25**). 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. Among the contributions of bromeliads to wildlife is that they catch rainwater, making water available to a variety of animals during dry periods.

Figure 7-25. A Tillandsia plant heavily damaged by larvae of the Mexican bromeliad weevil (photo by UF).

KEY MANAGEMENT ISSUES

Distribution: The Mexican bromeliad weevil 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 has yet to become established. Facilities for rearing have improved and additional fly releases are anticipated (Cooper et al. 2013).

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 are needed.

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 7-26**) 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 to 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 laurel family (Hanula et al. 2009), including swamp bay (*P. palustris*), an important species of many Everglades plant communities.

Figure 7-26. Dying red bay trees in a mixed hardwood forest (photo by FDACS).

KEY MANAGEMENT ISSUES

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

Control Tools: There is 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 underway to assess the ecological impacts of laurel wilt disease.

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

Regulatory Tools: The redbay ambrosia beetle is considered a plant pest, so screening for additional introductions is carried out but 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*)

SUMMARY

Asian swamp eels (**Figure 7-27**) 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 because the diverse wetland habitats of the Greater Everglades may be suitable for the species. Asian swamp eels have a broad salinity tolerance giving concern that this species could establish populations in estuaries (Schofield and Nico 2009).

Figure 7-27. Asian swamp eel (photo by NPS).

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 waterbodies near Tampa (Fuller et al. 1999; L.G. Nico, USGS, 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 under investigation.

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

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

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

Critical Needs: Research to better determine potential 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 is needed.

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*)

SUMMARY

The Cuban treefrog (**Figure 7-28**) 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 treefrogs and squirrel treefrogs (*Hyla squirella*) 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 treefrogs 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.

Figure 7-28. The Cuban treefrog is widely dispersed throughout Florida (photo by University of Georgia).

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

Monitoring: UF and SFWMD 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, 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 currently are 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 is needed.

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*)

SUMMARY

The purple swamphen (**Figure 7-29**) is a rail native to Australia, Europe, Africa, and Asia. Its introduction was likely due to escapes from Zoo Miami and private aviculturists in Broward County. The purple swamphen feeds on shoots and reeds, invertebrates, small mollusks, fish, snakes, and waterfowl eggs and young (Pranty et al. 2000). Known to be highly aggressive and territorial, the purple swamphen could impact native water birds through competition for food, destruction of habitat and space, and 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).

Figure 7-29.
The purple swamphen (photo by SFWMD).

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). Purple swamphens have been sighted in the WCAs, Lake Okeechobee, and all Everglades STAs; they continue to expand into wetlands to the north and west.

Control Tools: Previous efforts to remove birds by hunting did not significantly deplete the population. No other control tools currently are developed for this species. At this time, control of this species is planned.

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 spread of the species, and eradication is no longer considered feasible. FWC has removed more than 3,000 purple swamphens to date, mostly from STAs and WCA-2B (Johnson and McGarrity 2009). Florida Atlantic University has studied 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 currently are 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 are needed.

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*)

SUMMARY

The Argentine black and white tegu (**Figure 7-30**) 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). 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 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.

Figure 7-30. An Argentine black and white tegu (photo by Miami-Dade County).

KEY MANAGEMENT ISSUES

Distribution: 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 and trapping conducted by UF, FWC, SFWMD, USGS, Miami-Dade County, and NPS resulted in the removal of more than 357 tegus between January 1 and May 31, 2016 (FWC, UF, USGS, unpublished data).

Control Tools: Trapping may be an effective control tool. Firearms also are becoming a viable complement 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 79 camera traps, 251 live traps, and telemetry of 48 tegus in 2015 (FWC, UF, USGS, unpublished data).

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, and federal and state regulations to restrict possession of this species are needed.

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*)

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 on 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 7-31**). Approximately 167 Burmese pythons were reported as removed from within and around ENP between January 1 and May 31, 2016 (FWC, UF, USGS, unpublished data). FWC held the 2016 Python Challenge™ that resulted in the removal of 106 Burmese pythons. Volunteers managed by SFWMD and UF removed 86 pythons since April 17, 2015.

Figure 7-31. Burmese pythons being removed from the Everglades (photo by the USGS).

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, L-67 canal).

Control Tools: Control options for this species are limited. Reed and Rodda (2009) reviewed 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 United States Department of the Interior lands was held in October 2014 and a structured decision-making workshop on Burmese pythons was held in June 2014. Partners are 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: Critical needs include development of effective technology to improve detection in the field; implementation of a Judas snake program; protection for 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*)

SUMMARY

The Nile monitor (**Figure 7-32**) 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 crocodiles, American alligators, 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 monitors 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.

Figure 7-32. Nile monitor on the C-51 canal in West Palm Beach (photo by FWC).

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 been reported in suburban Broward County, approximately 2.4 kilometers 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: SFWMD, FWC, and UF are 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 is needed.

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

Figure 7-33. A pair of feral hogs at Lake Okeechobee (photo by FWC).

Feral hogs (**Figure 7-33**) 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 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 been documented also (Engeman et al. 2013). UF research has estimated $2 million losses to Florida cattle production due to feral hog impacts. This estimate does not include costs of lost forage, invasive plant management, and range restoration, so the cost is suspected to be nearly an order of magnitude higher (Bankovich et al. 2016). Plans are to document impacts more fully in future work (Wisely 2016). Damage from feral hogs in the United States is conservatively estimated at $1.5 billion in annual costs (Mississippi State Univ. Ext. Svc. 2014).

Key Management Issues

Distribution: Wild hogs are reported in all 67 Florida counties. Within SFWMD boundaries, 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. SFWMD has improved contract procedures for feral hog control. In the first 10 months of the program (beginning September 2012), 19 agents removed 1,800 hogs from SFWMD lands. Feral hog removal contracts are no cost; the incentive is that the permittee keeps the hogs.

Monitoring: There is no regional coordinated monitoring program for feral 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. 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 are needed.

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 ERADICATION

Exotic Black Mangrove (*Lumnitzera racemosa*)

The exotic black mangrove (also called 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.

The number of plants removed annually from the 8-ha area continues to decline (**Figure 7-34**) and are almost entirely seedlings and saplings, indicating that the seed bank is diminishing. Miami-Dade County work crews, funded by FWC, removed 226 plants this year. In addition, 224 plants were pulled during ECISMA volunteer work days. In 2015, a total of 1,380 seedlings and saplings were removed. 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 area, eradication of the exotic black mangrove *Lumnitzera* in Florida is likely. 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. Continued surveys for outlier plants and 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 be lost.

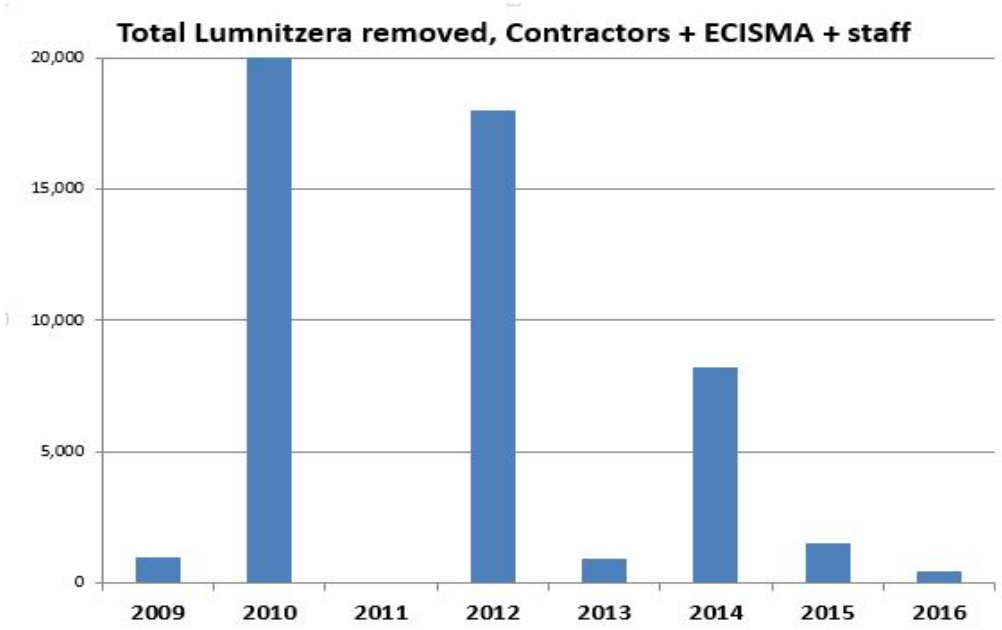

Figure 7-34. The exotic black mangrove population continues to decline as a result of intense control efforts (data provided by Fairchild Gardens).

Mile-a-Minute (*Mikania micrantha*)

Mile-a-minute is a federally listed noxious weed that recently appeared in South Florida. Native to parts of tropical and subtropical America, the vine has become 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). Mile-a-minute 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 Broward County in 2014 that appears to have been eradicated, 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.

Mile-a-minute weed was treated by Miami-Dade County crews in 2016 on 32 properties, including three nature preserves. Occurrences and densities vary, from single plants along the roadside, to much larger infestations that create problems in disturbed areas of hardwood hammocks. After several years of herbicide treatment, it appears that mile-a-minute weed may be eradicated in many locations. However, in other sites, including the Castellow Hammock Preserve, control is extremely difficult. At Castellow Hammock Preserve, the vine is growing within endangered and imperiled plant species. On private properties, the vine persists in ornamental hedges (Dozier 2012). Control with herbicide is only moderately successful in these situations because treating the entire vine without harming desired plants is not possible. 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 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-Division of Plant Industry 2011, USDA 2013). The giant African land snail is known to eat a wide 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 7-35**), which can infect humans and cause meningitis (Cowie 2013). This parasite, which has been almost unknown in the mainland United States, was detected in giant African land snails collected in Miami (Iwanowicz et al. 2015). A previous infestation of the 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 underway to eliminate the existing population. There currently are more than 4,500 parcels under survey in the cooperative program.

Figure 7-35. The giant African land snail 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 children live in the area involved. Toxicants containing iron phosphate or borax initially were used because of low toxicity to other animals. Toxicants containing metadehyde are being used now 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 typically is 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 (National Institutes of

Health 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. Approximately 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*)

Figure 7-36. Gambian pouched rats continue to occur in the Florida Keys, despite years of trapping (photo by USDA).

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 (**Figure 7-36**). 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. 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.

Northern African Python (*Python sebae*)

Figure 7-37. The northern African python (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 7-37**) 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. SFWMD, the 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 the 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 the searches but a recently shed skin was recovered. Surveying was increased by 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. Additional pythons have not been detected during surveys or under refuges placed in appropriate habitat through July 2016. 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 biosecurity 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 2016, biologists removed 600 Oustalet's chameleons from a 49-ha site (Jenny Ketterlin Eckles, FWC, and Mike Rochford, UF, personal communication). Preliminary diet analysis indicates that this chameleon population consumes a variety of insect and anole species. FWC is continuing periodic surveys in the known population area to better understand the extent of the population and natural history of the 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 naturally occurs in mountain and coastal regions of Yemen, the United Arab Emirates, and Saudi Arabia. Males reach a length of 0.6 m; 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 chameleons were captured (FWC 2013). Scattered individual sightings have been made in the same general area. Recently, a significant population was discovered 160 kilometers 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 6.5 kilometers 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. Reports of veiled chameleons are now common from Buckingham, Alva, Cape Coral, Marco Island, and Lutz, Florida. 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.

Spectacled Caiman (*Caiman crocodilus fuscus*)

Spectacled caimans 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 7-38**). Spectacled caimans have been captured or observed in Southwest Ranches and Everglades Holiday Park

Figure 7-38. The spectacled caiman (photo by SFWMD).

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 caimans are most commonly encountered in ditches, canals, and disturbed wetlands but are occasionally found in relatively undisturbed marshes. A small population of caimans recently was 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. Efforts by FWC, SFWMD, and UF have resulted in the removal of 97 caimans since 2011. Eradication may be 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 must factor these species and their impacts into restoration planning and models. Research is needed to understand the distribution, biology, and impacts of 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 insufficient regulatory controls. 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 decades to complete. Relatively few nonindigenous species become invasive in their new environments, but a 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 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 Argentine black and white tegu 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 could 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 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 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 typically is 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; Christina Romagosa, UF, personal communication). 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 CISMAs and SFERTF 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 SFWMD-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 the 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 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. Furthermore, 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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