Chapter 7: Status of Nonindigenous Species

LeRoy Rodgers, David Black, Mike Bodle and Francois Laroche

Contributors: Paul Pratt[1], Frank Mazzotti[2], Kristina Serbesoff-King[3], Mike Renda[3], Jenny Ketterlin Eckles[4] and Mike Rochford[5]

SUMMARY

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

While detailed information on many invasive species is not available, this document attempts to provide an update and annotations for priority plant and animal species, including summaries of new research findings. As part of continued efforts to streamline reporting, this year's update emphasizes new information obtained during Fiscal Year 2013 (FY2013) (October 1, 2012–September 30, 2013). During FY2013, the District spent roughly $19 million for overall invasive species prevention, control, and management in South Florida. More supporting information, including general background of the District's invasive species program and further details on nonindigenous species, is also presented in Chapter 9 of the *2011 South Florida Environmental Report* (SFER) – *Volume I*.

Acknowledgments: The authors acknowledge Jake Edwards (FWC), Art Roybal (USFWS), Joy Vinci (UF), Tony Pernas and Jed Redwine (USNPS), Jon Lane (USACE), Carrie Beeler (USDOI), and Lou Toth for providing valuable comments and suggestions to this document. The authors are also grateful to Terri Bennett for providing GIS support.

[1] United States Department of Agriculture - Agricultural Research Service, Davie, FL
[2] University of Florida - Ft. Lauderdale Research and Education Center, Davie, FL
[3] The Nature Conservancy - Florida Chapter, Altamonte Springs, FL
[4] Florida Fish and Wildlife Conservation Commission, Tallahassee, FL
[5] The Nature Conservancy -University of Florida Chapter, Altamonte Springs, Gainesville, FL

In addition to providing the status of nonindigenous species programs and outlining programmatic needs, this document summarizes what, if any, control or management is under way for priority nonindigenous species considered to be capable of impacting the resources that the District is mandated to manage or restore.

NONINDIGENOUS PLANTS

- Seventy-five species of nonindigenous plants are District priorities for control. Old World climbing fern, melaleuca, Brazilian pepper, and Australian pine continue to be systemwide priorities, while aquatic plants such as hydrilla, water hyacinth, and tropical American water grass 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 the country's largest aquatic plant management program, managing floating and submerged aquatic vegetation systemwide. The interagency melaleuca management program is a national model for regional, interagency invasive plant control programs. Melaleuca has been systematically cleared from Water Conservation Areas (WCAs) 2 and 3 and Lake Okeechobee and is now under maintenance control in these regions.
- Biological control of several invasive plants is showing promising results, with substantial reductions of melaleuca documented. The Comprehensive Everglades Restoration Plan's Biological Control Implementation Project continues to move forward. Construction of a mass rearing facility at the existing United States Department of Agriculture's Agricultural Research Service biological control laboratory in Davie, FL was completed in 2013. The new facility now supports biological control agent rearing and field release for melaleuca and other invasive nonindigenous plant species.
- New introductions and range expansions of invasive non-indigenous plant species were noted during FY2013. Feathered mosquito fern, a federal noxious weed, expanded into the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge) and WCA-2A.

NONINDIGENOUS ANIMALS

- Considerable numbers of nonindigenous animals are known to occur in South Florida, ranging from approximately 62 species in the Kissimmee Basin to over 129 species in the Greater Everglades. Ranking animals for control is a serious challenge and prioritizing related threats across regulatory agencies is needed.
- The Florida Fish and Wildlife Conservation Commission (FWC) continues to build its nonindigenous animal management program and coordinates closely with the District and other partners to manage nonnative animal species in South Florida. During 2013, federal, state, and tribal partners continued rapid response efforts to control recently discovered or expanding populations of several invasive animal species including northern African pythons and Argentine black and white tegus.
- Burmese pythons continue to be observed and removed in the Everglades and surrounding rural areas, although in fewer numbers than in last year. The District remains an active partner in regional efforts to halt the spread of this invasive reptile by conducting regional search and removal operations.

- The District continues to collaborate with the Everglades Cooperative Invasive Species Management Area, Lake Okeechobee Interagency Aquatic Plant Management Team, and South Florida Ecosystem Restoration Task Force. During 2013, these cross-jurisdictional teams facilitated the implementation of region-wide invasive species monitoring programs, rapid response efforts, standardized data management, and outreach initiatives.

PROGRESS TOWARD MANAGEMENT AND CONTROL

The following section provides updates for FY2013 on control, research, monitoring, and coordination activities on invasive nonindigenous species that threaten the success of the District's mission.

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 (*Melaleuca quinquenervia*) once dominated (**Figure 7-1**). However, remote sections of the southeastern area of Everglades National Park (ENP or Park) and the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge) remain moderately to heavily impacted by difficult-to-control invasive plants. In these areas, the challenges of invasive plant control are immense due to inadequate financial resources and heavy infestations in difficult-to-access areas. It will likely be decades until these areas are successfully under control.

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

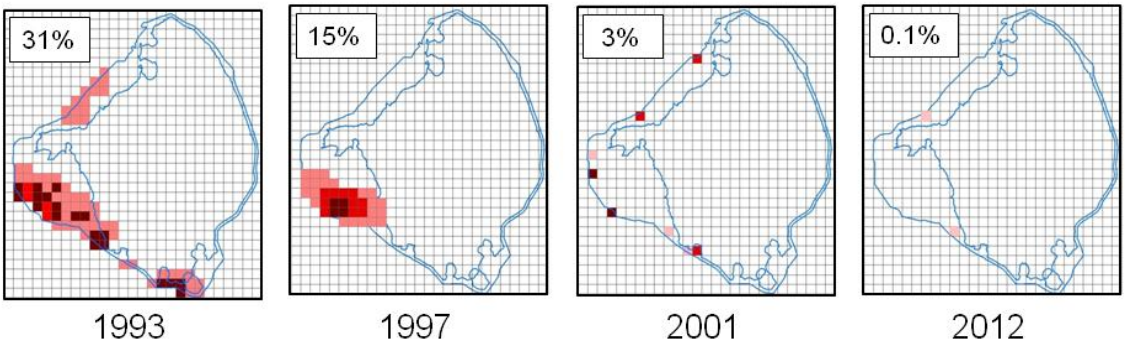


Figure 7-1. Distribution and abundance of melaleuca (*Melaleuca quinquenervia*) on the Lake Okeechobee western marsh between 1993 and 2012. Darker red colors indicate higher densities of melaleuca within 1-km grid cells. Percentage of marsh habitat inhabited by melaleuca indicated in the top right corner for each year.

In **Table 7-1**, the District's FY2013 expenditures for nonindigenous plant control are summarized by land management regions. The purpose of this table is to report expenditures for the most abundant invasive plant species on District managed lands in support of the District's environmental restoration and flood control missions. In addition to these species, the District directs its staff and contractors to control all invasive plant species identified by the Florida Exotic Pest Plant Council (FLEPPC) as Category I species (FLEPPC, 2011). These species are documented to alter native plant communities by displacing native species, change community structures or ecological functions, or hybridize with native species. In FY2013, the District spent more than $19 million for overall invasive species prevention, control, and management in South Florida. In anticipation of continued budget shortfalls, the District reevaluated invasive plant management priorities to assure that gained ground is not lost. Experience has shown that vigilant reconnaissance and retreatment is necessary to maintain low levels of established invasive species. Biological controls are proving to be beneficial in this regard by reducing the rate of reestablishment for some species (Overholt et al., 2009; Rayamajhi et al., 2008). However, successful biological control programs are in place for only a handful of priority species so land managers must persist with frequent monitoring and control efforts.

Table 7-1. Invasive plant species control expenditures by the South Florida Water Management District (SFWMD or District) in Fiscal Year 2013 (FY2013) (October 1, 2012–September 30, 2013), organized by land management region.

Priority Invasive Species	Upper Lakes	Kissimmee/ Okeechobee	Lake Okeechobee	Everglades	East Coast	West Coast	Biocontrol	Total
Australian pine (*Casuarina equisetifolia*)				56,090				56,090
Brazilian pepper (*Schinus terebinthifolius*)	5,717	171,451	37,029	241,925	430,821	220,021		954,964
Cogongrass (*Imperata cylindrica*)	13,048	8,002		333	106,283	45,143		63,775
Hydrilla (*Hydrilla verticillata*)	1,284,975	950		952,434	18,866	169,988		2,427,213
Melaleuca (*Melaleuca quinquenervia*)			86,629	1,309,153	3,430	90,131	150,000	1,485,943
Old World climbing fern (*Lygodium microphyllum*)	642	596	23,340	60,542	6,148	9,734	150,000	40,467
Shoebutton ardisia (*Ardisia elliptica*)				50,424				50,424
Torpedograss (*Panicum repens*)	642	596	23,340	60,542	6,148	9,739		101,277
Floating plants Water hyacinth (*Eichhornia crassipes*) and Water lettuce (*Pistia stratiotes*)	74,071	223,630	1,421	519,955	30,099	5,771		854,947

Biological Control of Invasive Plant Species

Most nonindigenous species in Florida have limited or no predators, parasites, or pathogens. With few natural enemies in their new range, some nonindigenous species are able to grow larger, produce more offspring, spread quickly, and dramatically degrade Florida's sensitive habitats. The objective of classical biological control is to reunite host-specific natural enemies from the nonindigenous species' native range and introduce them into Florida to reestablish a balance in the regulation of the nonindigenous pest population.

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

Biological control research and implementation has yielded great successes in Florida, but it is not a panacea. Detailed and lengthy studies are required to ensure that potential biological control agents will only attack the targeted invasive species and not native or agronomically important species. Biological control agents that are determined to be safe must pass through a lengthy review by state and federal regulatory agencies before they can be introduced. Despite these hurdles, biological control research and implementation has led to important advances in invasive plant management.

Melaleuca

The melaleuca weevil (*Oxyops vitiosa*) was introduced in 1997 and established on melaleuca throughout the region. Feeding by the weevil reduces the tree's reproductive potential as much as 90 percent (Tipping et al., 2008), and the few 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. Data indicates that feeding by psyllids induces leaf drop, eventually resulting in tree defoliation. USDA entomologists have determined that psyllid feeding on melaleuca seedlings results in 60 percent mortality in less than a year (Franks et al., 2006). The combined effect of feeding by the weevil and the psyllid has led to more than 80 percent stem mortality in some stands as well as decreases in melaleuca canopy cover over a 10-year period (1997–2007), resulting in a fourfold increase in plant species diversity following the introduction of biological control agents (Rayamajhi et al., 2009). A recently completed five-year field study found that melaleuca re-invasion 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 (**Figure 7-2**). The melaleuca midge (*Lophodiplosis trifida*) is the most recent biological control agent for melaleuca. The larvae feed on the internal structures of the stem, which damages the flow of nutrients to melaleuca buds and leaves. Feeding by the insect also causes the stems to produce galls that dramatically alter the morphology of melaleuca stems. Feeding damage by larvae can kill small individuals and, in concert with the other melaleuca biological control agents, provides increased control of the invasive tree.

Old World Climbing Fern

The white lygodium moth (*Austromusotima camptozonale*) was the first agent to be released against Old World climbing fern in Florida. Releases of this insect began in 2004 and continued

through 2007, with more than 40,000 individuals being mass reared and released, but no establishment was obtained. During 2011–2012, a second colonization effort with the moth was initiated using insects from a new lab colony. Approximately 18,000 larvae were distributed in series of open releases, but aside from sporadic recoveries of relatively low numbers of progeny, there was no evidence to indicate that populations were establishing in the field.

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). At long-term study sites in Martin County, moth populations have successfully survived four winter seasons without additional insect releases. Subsequent surveys revealed that moths are established in all sites into which they were released with the exception of Everglades National Park (ENP or Park). An additional release of 13,500 larvae was made in May 2013.

The lygodium gall mite, *Floracarus perrepae*, induces leaf roll galls on the leaves of Old World climbing fern. The gall mite was released in 60 plots at five sites in South Florida during 2008 and 2009. Within release sites, the mite marginally established and continues to be present at low numbers and successful gall induction on field plants were much lower than anticipated. However, the mite has shown the ability to undergo long distance dispersal and colonize sites far from the release sites. Recently, a verified *F. perrepae* population was found in Everglades National Park and in Martin County, FL, approximately 230 km and 20 km, respectively, from the release sites in Jonathan Dickinson State Park.

Figure 7-3. The waterhyacinth planthopper (*Megamelus scutellaris*) (photo by the USDA-ARS).

Water Hyacinth

Water hyacinth is an exotic floating plant that aggressively colonizes freshwater ecosystems in the southeastern and southwestern United States including the Everglades. Several biological control agents of water hyacinth introduced during the 1970s have reduced biomass by more than 50 percent and seed production by 90 percent, but additional agents are needed to reduce surface coverage. A new insect, *Megamelus scutellaris*, was developed recently and released into the field in February 2010 (**Figure 7-3**), making it the first new agent on water hyacinth in more than 30 years. To date, more than 40,000 individuals have been released at Stormwater Treatment Area (STA) 1 West for establishment and evaluation. The species is cold tolerant and has overwintered as far north as Gainesville, FL. Several thousand insects from a new population of *M. scutellaris* from Paraguay that is better adapted to higher summer temperatures were released in STA-1 East and West. Another candidate insect, *Eccritotarus catarinensis*, has been imported into quarantine from Peru and is currently undergoing host range testing.

CERP Biocontrol Implementation Project

The Comprehensive Everglades Restoration Plan (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 invasive nonindigenous plants throughout the CERP area. The project includes the construction of a mass rearing annex to the existing U.S. Department of Agriculture – Agricultural Research Service (USDA-ARS) biological control facility in Davie, FL, in support of implementing the mass rearing, field release, establishment,

and field monitoring of approved biological control agents for melaleuca and other invasive nonindigenous species. The Final Project Implementation Report/Environmental Assessment, the Project Partnership Agreement and Cooperative Agreement on Lands, and the design-build contract were all executed in 2010. Construction of the mass rearing facility was completed in 2013. With the completion of the facility, the USDA, in close coordination with the District and U.S. Army Corps of Engineers (USACE), will begin the operational phase of the project, which consists of the rearing, release, and field monitoring of agents approved for release.

Everglades Invasive Plant Monitoring

To address the need for more detailed geospatial information on priority invasive plants and to meet (Section 373.4592, Florida Statutes) requirements to conduct biennial surveys of exotic species within the Everglades Protection Area (EPA), the District and the National Park Service (NPS) are now utilizing digital aerial sketch mapping (DASM) for regional invasive plant surveys. Sketch mapping is a remote sensing technique of observing ground conditions from low-flying aircraft and digitally mapping invasive plant infestations with Global Positioning System-linked touch screen computers. A detailed description of DASM methods is included in Chapter 6 of the 2011 SFER – Volume I.

This section documents results of invasive plant mapping DASM conducted by District and NPS biologists within the EPA between March 2012 and February 2013. Specifically, the spatial extent and dominance of four priority invasive plant species—Australian pine (*Casuarina* spp.), Brazilian pepper (*Schinus terebinthifolius*), melaleuca, and Old World climbing fern (*Lygodium microphyllum*)—were mapped. All management areas within the Everglades Cooperative Invasive Species Management Area (CISMA) were included in the survey. These include the Holey Land, Rotenberger, and Southern Glades Wildlife Management Areas (WMAs); Big Cypress Seminole Indian Reservation; Refuge (WCA-1); Everglades WMA (WCAs 2A/2B, 3A/3B); Miccosukee Indian Reservation; Big Cypress National Preserve (BCNP); ENP; East Coast Buffer Lands; South Dade Wetlands; and other areas. The surveys were conducted over two years during late winter and spring due to the size of the survey area (~2.8 million acres) and short sampling period when canopy species are maximally defoliated (**Figure 7-4**).

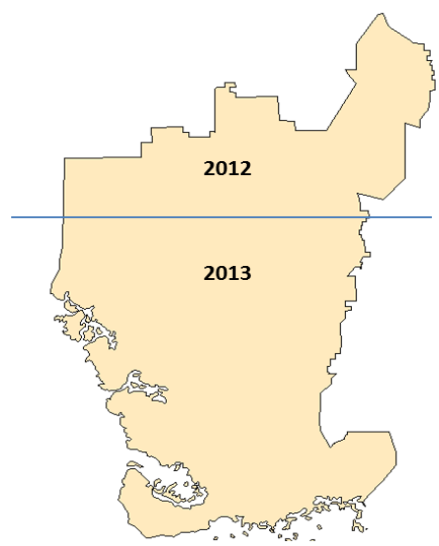


Figure 7 -4. Survey areas for the 2012 and 2013 Everglades invasive plant inventory.

Percent vegetation cover was estimated for each species polygon using a modified Braun-Blanquet cover abundance scale (Mueller-Dombois and Ellenberg, 1974): 1–5 percent, 6–25 percent, 26-51 percent, 51-75 percent, and > 75 percent. After completing Geographic Information System quality assurance/quality control, infestation area and canopy area were calculated. Infested area is the summed area of all polygons for a given species. Canopy area is a percent cover-adjusted calculation for each species using the mid-point of each cover class [$NIA = \sum(.875)H_{dense} + \sum(.675)H_{high} + \sum(.375)H_{moderate} + \sum(.15)H_{low} + \sum(.025)H_{sparse}$, where H is area, in hectares, for a polygon in a given cover class]. To aid in visual interpretation of landscape-level spatial patterns

of the polygon, vector data was transferred to a raster format and analyzed using a 1-km grid system.

2012-2013 Sketch Mapping Results

Australian Pine

Australian pine is the least abundant of the targeted species in the survey area, with a total infestation area of 4,178 ha (10,325 ac) (**Table 7-2**). Percent cover of Australian pine ranged from 0.003–48 percent within 1-km cells (mean=2.3%) (**Figure 7-5**). This species is now at maintenance control levels in most Everglades areas, meaning that continuous low intensity management will keep this species at a low infestation level. The large majority of Australian pine occurs on District and Miami-Dade County lands in the South Dade Wetlands and Model Lands Basin, where it forms dense stands to widely scattered patches in remote mangrove swamps and sawgrass marsh. A comparison between 2013 and 2010 DASM results in these management areas indicates a substantial increase in Australian pine cover over the three-year period without a marked increase in the plant's spatial distribution.

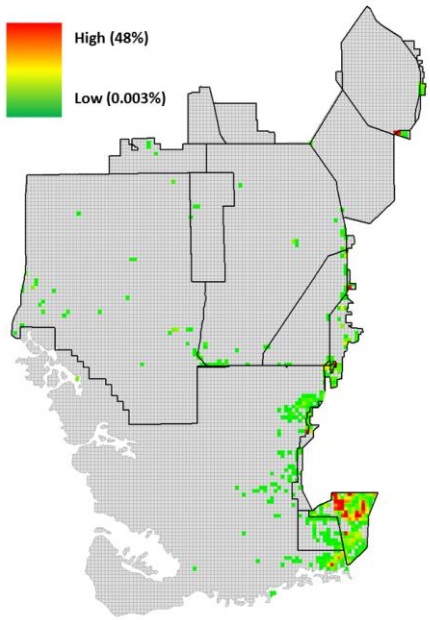


Figure 7-5. Distribution and relative abundance of Australian pine in the Everglades based on aerial surveys conducted between January 2012 and June 2013. Values represent percent cover within 1-km grid cells (range = 0.003 - 48%).

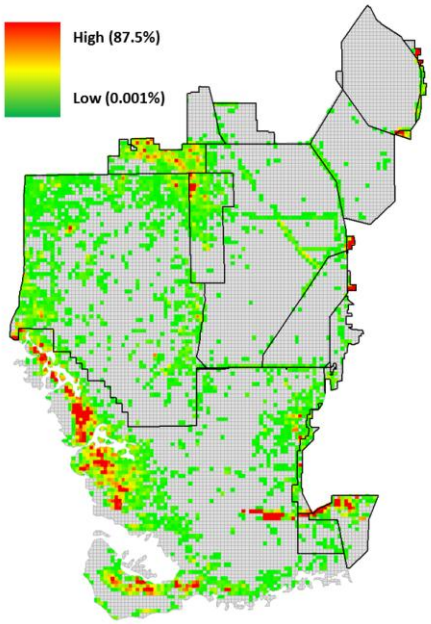


Figure 7-6. Distribution and relative abundance of Brazilian pepper in the Everglades based on aerial surveys conducted between January 2012 and June 2013. Values represent percent cover within 1-km grid cells (range = 0.001 - 87.5%).

Brazilian Pepper

Brazilian pepper is widely distributed throughout the survey area with an estimated infestation area of 30,038 ha (74,225 ac) (**Table 7-2**). Percent cover of Brazilian pepper ranged from 0.001 to 87.5 percent within 1-km cells (mean=3.0%) (**Figure 7-6**). It is a major component of buttonwood (*Conocarpus erectus*) swamps and graminoid marshes along the fringes of southwestern mangrove swamps of the ENP. The most severe infestations extend from the Ten Thousand Islands area to Cape Sable, representing roughly 60 percent of the total infestation area within the survey area. Dense infestations of Brazilian pepper also occur within the Big Cypress Seminole Indian Reservation, primarily on improved pastures and along the fringes of cypress swamps. This

invasive plant was also detected on tree islands throughout the central Everglades region. In some cases, this species is dominant or co-dominant in the canopy. Ground-based observations of tree islands infested with Brazilian pepper revealed that little to no understory native vegetation remains beneath the canopy. Other widely scattered but dense infestations occur in the western Everglades hardwood hammocks within Big Cypress National Preserve.

Melaleuca

Melaleuca occupies an estimated 16,512 ha (40,802 ac) within the survey area (**Table 7-2**). Percent cover of melaleuca ranged from 0.002 to 63.3 percent within 1-km cells (mean=2.1%) (**Figure 7-7**). The most significant infestations occur in project or lease properties within the East Coast Buffer Lands, the Big Cypress Seminole Indian Reservation, and the northern sections of the Refuge. Melaleuca continues to reestablish in previous herbicide treatment within Big Cypress National Park, eastern ENP, and Everglades WMA. For example, a substantial increase in melaleuca cover was observed in south-central Big Cypress National Park between 2010 and 2013.

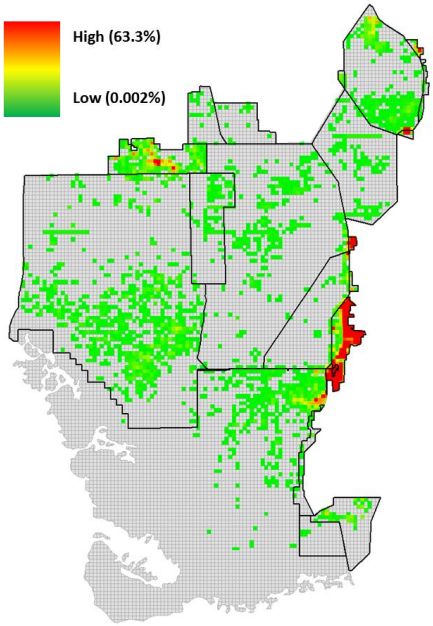


Figure 7-7. Distribution and relative abundance of melaleuca in the Everglades based on aerial surveys conducted between January 2012 and June 2013. Values represent percent cover within 1-km grid cells (range = 0.002 - 63.3%).

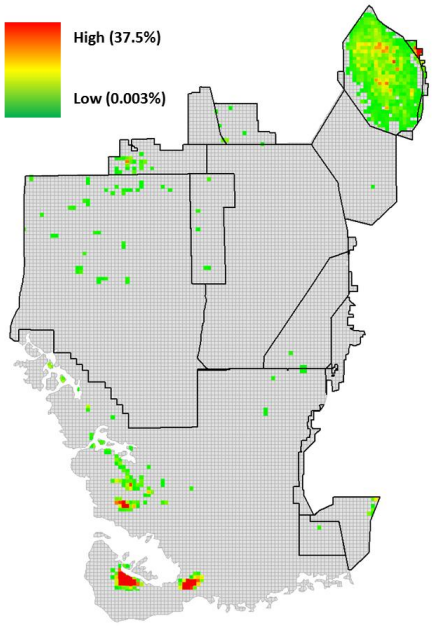


Figure 7-8. Distribution and relative abundance of Old World climbing fern in the Everglades based on aerial surveys conducted between January 2012 and June 2013. Values represent percent cover within 1-km grid cells (range = 0.003 - 37.5%).

Old World Climbing Fern

Old World climbing fern is estimated to occupy 10,367 ha (25,617 ac) within the survey area (**Table 7-2**). Percent cover of Old World climbing fern ranged from 0.003 to 37.5 percent within 1-km cells (mean=3.2%) (**Figure 7-8**). The large majority of Old World climbing fern (~75 percent) mapped in this survey occurs within the Refuge (WCA-1), where it aggressively forms dense mats over tree island canopies. Distribution and abundance estimates for this invasive vine increased in the graminoid marshes of southwestern ENP. Between 2010 and 2013, the infested area within Cape Sable increased from 1250 ha to 3725 ha. Old World climbing fern was infrequently detected eastern

sections of the Everglades. However, observations of sub-canopy infestations in WCA-3A/3B confirm that DASM is ineffective for early detection of this species in sub-canopy strata of tree islands.

Table 7-2. Infested area and canopy area of four priority invasive plant species within the Everglades Cooperative Invasive Species Management Area.

Species	Infested Area (ha)	Canopy Area (ha)
Brazilian pepper	30,038	8,961
Melaleuca	16,512	4,061
Old World climbing fern	10,367	2,398
Australian pine	4,178	756

Laurel Wilt

Laurel wilt is a lethal disease of redbay (*Persea borbonia*) and other members of the Laurel family (Lauraceae), including swamp bay (*P. palustris* = *P. borbonia* var. *pubescens*), an important species of Everglades tree island plant communities. 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). The redbay ambrosia beetle is native to Asia, and was likely introduced into the United States via infested wood used for shipping crates (Harrington et al., 2011). Once infected, susceptible trees rapidly succumb to the pathogen and die. Laurel wilt is causing up to 100 percent mortality of red bay in canopies of mixed forests in northern Florida (Shields et al., 2011).

Since its arrival in 2002, the red bay ambrosia beetle has spread quickly throughout the southeastern U.S. In March 2010, the redbay ambrosia beetle was found in Miami-Dade County in the Bird Drive Basin, less than 5 km from WCA-3B. Laurel wilt disease was subsequently confirmed on swamp bay trees in February 2011. Prior to this, Martin County was the southernmost Florida county where the disease was documented. In March 2011, the District, NPS, and Florida Department of Agricultural and Consumer Services (FDACS) utilized DASM to determine the spatial extent and abundance of laurel wilt in the eastern Everglades. This survey identified 105 symptomatic swamp bay trees scattered throughout the Bird Drive Basin, northward into the Pennsuco Wetland area, and westward into the ENP. Laurel wilt was later found in the central portion of the Refuge at four locations the during the 2012 DASM survey.

The District and NPS conducted a second laurel wilt DASM survey in the central portion of the Everglades (WCA-3A/3B, tribal lands, BCNP, and ENP) between May and June 2013. **Figure 7-9** shows the estimated distribution and abundance of diseased swamp bays in the central region of the Greater Everglades in 2011 and 2013 (excluding Refuge sites). As of June 2013, the area of occupancy of laurel wilt within the central Everglades is 133,740 ha. Within this area, 332 tree islands contained symptomatic trees. The estimated percentage of affected canopy ranged from 0.25–50 percent (mean=7.46%). The large majority of tree islands showed very low levels of tree canopy loss (<5%) of tree island canopy affected), though a number of large tree islands experienced substantial loss of tree island canopy (**Figure 7-10**).

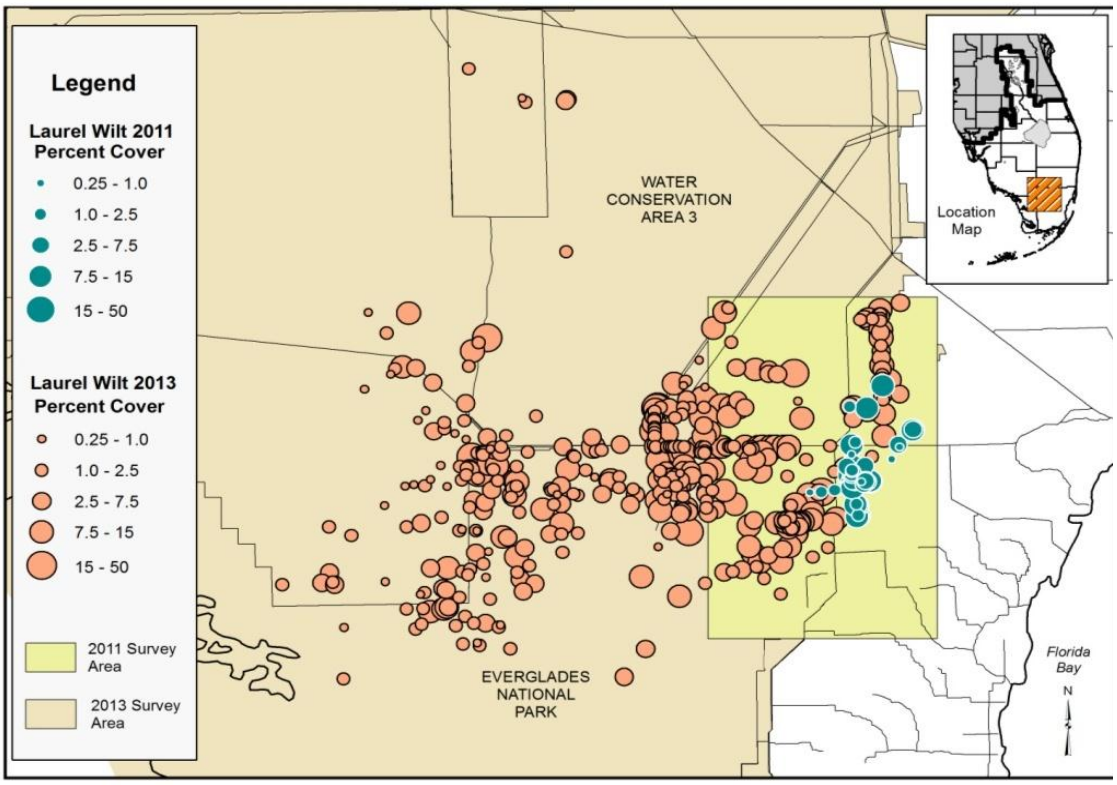


Figure 7-9. Distribution and abundance (as percent cover) of laurel wilt-infected swamp bays (*Persea palustris*) in the central Everglades in 2011 and 2013.

Tree island vegetation data in WCA-3A/3B and ENP indicates that swamp bay is relatively common in tree islands to the north and south of the current laurel wilt distribution (Engel et al., 2009). Additionally, ground truthing of tree islands with laurel wilt-infected trees confirmed that many swamp bays remain non-symptomatic. These observations suggest that the spatial extent of laurel wilt will continue to expand in the Everglades and swamp bay loss within the current area of occupancy is likely to continue. The short- and long-term impacts of canopy loss in tree islands due to laurel wilt are not known. Tree islands with moderate to high canopy loss may become more vulnerable to invasion by Old World climbing fern and Brazilian pepper. District scientists and land managers are developing a management strategy for the most severely impacted tree islands. The strategy includes aerial and ground-based reconnaissance to detect early expansions of these invasive plants. This information will be used to direct rapid response efforts by invasive plant control teams.

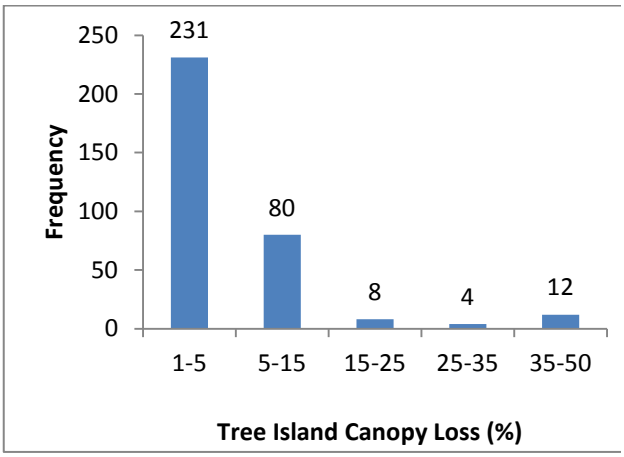


Figure 7-10. Frequency of tree island canopy loss estimates during the 2013 laurel wilt survey.

INVASIVE ANIMAL MANAGEMENT

Efforts to develop control tools and management strategies for several priority species continued in FY2013. These include the Burmese python (*Python molurus bivittatus*) and other giant constrictors, the Nile monitor (*Varanus niloticus*), and the Argentine black and white tegu (*Tupinambis merianae*). Control tools are very limited for free-ranging reptiles, and the application of developed methods is often impracticable in sensitive environments where impacts to non-target species are unacceptable. Available tools for removing reptiles generally include trapping, toxicants, barriers, dogs, and introduced predators (Witmer et al., 2007), as well as visual searching and pheromone attractants. Reed and Rodda (2009) provide a thorough review of primary and secondary control tools that may be considered for giant constrictors.

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

There were several ongoing and new invasive animal initiatives in FY2013, including ongoing monitoring and research efforts for Burmese python, northern African python, Argentine black and white tegu, Nile monitors, Gambian pouched rat (*Cricetomys gambianus*), and Cuban treefrog (*Osteopilus septentrionalis*), among others. Updates on these activities are discussed in the *Invasive Species Status Updates* section in this volume.

Figure 7-11. Burmese pythons continue to be removed from the Everglades (photo by the SFWMD).

Everglades Invasive Reptile and Amphibian Monitoring Project

In 2010, the University of Florida (UF), FWC, and SFWMD began collaboration on the Everglades Invasive Reptile and Amphibian Monitoring Project. The purpose of the project is to develop a monitoring program for priority invasive reptiles and amphibians and their impacts to South Florida. Specifically, the program seeks to (1) determine the status and spread of existing populations and the occurrence of new populations of invasive reptiles and amphibians, (2) provide additional early detection and rapid response 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 the Refuge, WCA-2 and WCA-3, BCNP, Southern Glades WMA, ENP, and other areas such as the C-51, US-1, and Card Sound Road. Visual searches and call surveys, in

addition to trapping, are conducted to monitor prey species. Twenty routes have been established. The encounter rates for targeted invasive species ranged from 0.007 to 0.09 observations per kilometer. House geckos, Brown anoles, Cuban tree frogs, feral cats, feral dogs, and wild hogs were the most commonly observed nonindigenous species (Frank Mazzotti, UF, unpublished data). Opossums and raccoons were the most common native mammals observed. To date, 15 Burmese pythons have been detected during these visual surveys. Moving forward, the team plans to increase sampling frequency and refine survey methods. In addition, the team has an occurrence experiment to evaluate whether the presence of invasive species is related to the absence of native species. In addition to fixed routes, the UF, FWC and SFWMD team has joined with Zoo Miami and Venom One to provide early detection and rapid response (EDRR) capability for invasive reptiles in the ECISMA. The EDRR surveys and trapping have resulted in the removal of 19 Nile monitors, 147 Argentine black and white tegus, and 228 Oustalet's chameleons (*Furcifer oustaleti*).

INTERAGENCY COORDINATION

This section provides updates on key interagency coordination activities pertaining to invasive, nonindigenous species in South Florida during FY2013. To be successful, regional management of nonindigenous species requires strategic integration of a broad spectrum of control measures across multiple jurisdictions. As such, numerous groups and agencies are necessarily involved with nonindigenous species management in Florida. More information on agency roles and responsibilities pertaining to nonindigenous species in Florida is available at www.elistore.org/reports_detail.asp?ID=11002&topic=Biodiversity_and_Invasive_Species.

Cooperative Invasive Species Management Areas

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

Everglades CISMA

Invasive species scientists and Everglades land managers formed the Everglades CISMA in 2006 in order to improve cooperation and information exchange related to invasive species management. The Everglades CISMA partnership was formalized in 2008 with a memorandum of understanding among the District, USACE, FWC, NPS, and United States Fish and Wildlife Service (USFWS). The memorandum of understanding recognizes the need for cooperation in the fight against invasive species and affirms the commitment of signatories to a common goal. Currently, the Everglades CISMA 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 Everglades CISMA includes all state and federal conservation lands within the Everglades Protection Area, Miccosukee and Seminole lands, Broward County, Palm Beach County, and Miami-Dade County (**Figure 7-12**).

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

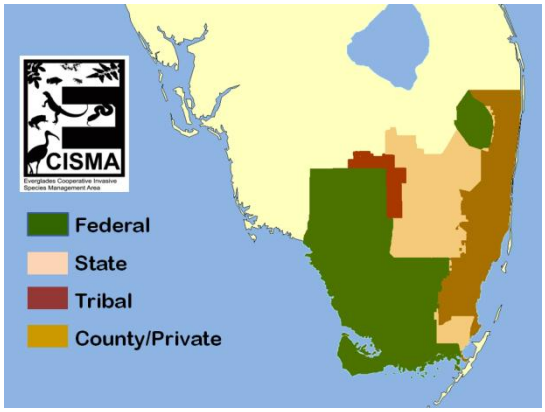


Figure 7-12. The Everglades Cooperative Invasive Species Management Area (ECISMA).

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

The ECISMA also coordinated and participated in a number of outreach initiatives aimed at increasing public awareness of invasive species. ECISMA partners developed a number of outreach publications during 2013, including identification and reporting guides for tegus and pythons. ECISMA partners also participated in 13 outreach events including a Broward County pet amnesty event. The group also hosted the Everglades Nonnative Fish Roundup aimed at increasing awareness of the issue of invasive freshwater fish.

In July 2013, 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 2013 include (1) numerous interagency work days focused on rapid response efforts for mile a minute, exotic black mangrove, northern African pythons, and Oustalet's Chameleon; (2) continued monitoring and

trapping efforts for Argentine black and white tegus and Nile monitors; and (3) several outreach and training initiatives aimed at increasing observations of priority species in the field (e.g., personnel for utility companies, Everglades biologists, law enforcement) and prevention education to the public.

Treasure Coast CISMA

From June 2012–July 2013 land managers, biologists and others along Florida's Treasure Coast held two steering committee meetings and developed an annual work plan as participants in a regional partnership to cooperatively address the threats of invasive plants and animals. Since 2007, the Treasure Coast Cooperative Invasive Species Management Area (TC-CISMA) partnership extends from Indian River County south through St. Lucie, Martin, and northern Palm Beach counties and includes representatives and land managers from local, state, and federal governments. Groups involved include the SFWMD, USFWS, FWC, Florida Park Service, Martin County, The Nature Conservancy, Treasure Coast Resource Conservation & Development Council, Natural Resources Conservation Service, Palm Beach County Environmental Resources Management, UF Institute of Food and Agricultural Sciences (UFAS), St. Lucie County, St. Lucie County Mosquito Control District, Aquatic Vegetation Control Inc., Habitat Specialists Inc., Florida Forest Service, Florida Grazing Land Coalition, Florida Native Plant Society, and Indian River County.

During this past year, the TC-CISMA has continued its priority coastal control efforts on treating 58 acres targeting beach naupaka (*Scaevola taccada*) and other invasive species on public conservation lands. The TC-CISMA also treated *Scaevola* on 1 private landowner's shoreline and held several individual and general outreach efforts on this invasive species. In addition, 12 acres of private scrub lands were treated for invasive species. Financial assistance for these projects has been from the USFWS Coastal Program and Partners for Wildlife Programs. The success of this partnership project was demonstrated by its receipt of the Coastal America Partnership Award for 2010. TC-CISMA also held five multiagency cooperative invasive plant workdays on the Florida Park Service lands, Hobe Sound National Wildlife Refuge, Boy Scouts of America's Tanah Keeta Scout Reservation, and Blowing Rocks Preserve. Within the TC-CISMA, 15 FWC Invasive Plant Management Section projects were submitted and at least 7 were funded.

In the past year, the TC-CISMA has also provided plant and animal invasive species outreach at the Martin County Fair, NatureScape at MacArthur Beach State Park, FireFest at Jonathan Dickinson State Park, Florida Sportman's Association Show, Jupiter Island Floral Show, FWC's Pet Amnesty Day event, and through involvement with UF/IFAS educational programs and trainings in Martin and St. Lucie counties. The TC-CISMA also participated in 7 statewide Florida Invasive Species Partnership conference calls, participated in the Florida Exotic Pest Plant Council's Annual Symposium CISMA workshop, created a TC-CISMA logo, and outreach table apron. Working with the TC-CISMA, St. Lucie County developed a Python Patrol outreach program, created displays and educational materials, and coordinated two herbicide license trainings and one feral hog management training.

Other CISMAs

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

Lake Okeechobee Aquatic Plant Management Interagency Task Force

Invasive plant management on Lake Okeechobee is coordinated according to policy contained in a Lake Okeechobee Letter of Operating Procedures (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. Also, the group has flown semi-monthly since 1987 to estimate the lake's coverage of water lettuce and water hyacinth. The group's considerations include accounting for the presence of endangered species, conservation of quality fish and wildlife habitat, and navigation. Public stakeholders and nongovernmental organizations are always encouraged to attend and provide input to this process. More information about this task force is available 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 Letter of Operating Procedures for Lake Okeechobee. Funding from the Florida Aquatic Plant Management Trust Fund, administered by the 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. 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

The South Florida Ecosystem Restoration Task Force (Task Force) was established by section 528(f) of the Water Resources Development Act of 1996. The Task Force consists of 14 members from four sovereign entities. There are seven federal, two tribal, and five state and local government representatives. The Task Force coordinates the development of consistent policies, strategies, plans, programs, projects, activities, and priorities addressing the restoration, preservation, and protection of the South Florida ecosystem. It recognizes the significant threat invasive exotic species pose to the goals and objectives of ecosystem restoration programs in south Florida. For more than a decade, Task Force member agencies have fought the rising tide of invasive exotics and the Task Force itself has supported those efforts through the coordination work of the Task Force Working Group (WG) and Science Coordination Group (SCG). Most recently, these two groups along with the Office of Everglades Restoration Initiatives recommended to the Task Force that a comprehensive Strategic Action Framework for invasive species be developed to improve coordination and boost the effectiveness of existing programs. Development of the Strategic Action Framework is expected to begin in September 2013. More information on this effort is available at http://www.sfrestore.org/tf.html.

INVASIVE SPECIES STATUS UPDATES

The following section provides a summary of nonindigenous species that threaten the success of the District's mission. Species are presented in two sections—established priority species and emerging threats. Twelve established plant species were selected by District staff based on potential and current implications to the District's infrastructure and ecological concerns. These species are presented with a "District-centric" justification for listing, and priority plant species may differ for other agencies, depending on regional factors and agency priorities and goals. Tropical American watergrass (*Luziola subintegra*) is new to this year's list of priority established plants. This relatively recent arrival to Florida is now firmly established in the western marshes of Lake Okeechobee and has quickly become a District priority for control.

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

In this section, each of the 22 priority established species (**Table 7-3**) is summarized in a one-page synopsis that highlights key management issues and provides general distribution information. The county (or coastline) distribution maps provided for each species were compiled from a variety of resources, but in only a few cases are data from systematic, statewide monitoring efforts. As such, these maps should be viewed as provisional and only intended to give general instruction on a species' distribution. Primary data sources for the distribution maps and the module occurrence table in Appendix 7-1 include Early Detection and Distribution Mapping System (www.eddmaps.org/distribution/), ECISMA (www.evergladescisma.org/distribution/), FWC Florida's Nonnative Species (myfwc.com/WildlifeHabitats/Nonnative_index.htm), U.S. Geologic Survey 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 the District's land management regions, as well as Lake Okeechobee, Florida Bay, and the Florida Keys. These regions closely align with the RECOVER modules, but are more inclusive of all conservation and project lands within the District boundary. The stoplight table technique was established through coordination among the Science Coordination Group, Noxious Exotic Weed Task Team, and Florida Invasive Animal Task Team of the South Florida Ecosystem Restoration Task Force (see Doren et al., 2009). Similar to its application in previous reports (e.g., 2012 SFER – Volume I, Chapter 7), the indicator table assesses each species by region according to the following questions: (1) How many acres within the module does this species occur in? (2) Are the acres of the species in the module documented to be increasing, decreasing, or static? and (3) If the species is decreasing in coverage, is it a direct result of an active biocontrol or chemical/mechanical control program? While the development of an assessment and monitoring program specifically designed for this purpose would be ideal, the exotic species indicator is currently constrained to data from existing monitoring and research programs. The table below provides a brief explanation of stoplight indicators provided for each priority species in the following species summaries.

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

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

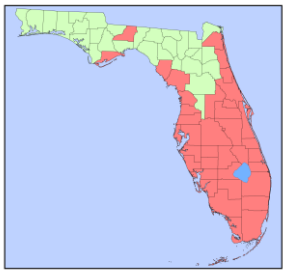
A more complete list of nonindigenous plant and animal taxa known to be established in each RECOVER module is included in Appendix 7-1. Within the geographic areas, animal species are divided into broad taxonomic groups of amphibians, reptiles, birds, mammals, fish, and invertebrates. The animal table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

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

Plants	**Reptiles**
Australian pine	Argentine black and white tegu
Brazilian pepper	Burmese python
Cogongrass	Nile monitor
Downy rose myrtle	*Northern African python
Hydrilla	*Oustalet's chameleon
Melaleuca	*Spectacled caiman
Old World climbing fern	*Veiled chameleon
Shoebutton Ardisia	
Torpedograss	
Tropical American Watergrass	
*Lumnitzera	
*Mile-a-Minute	
Water lettuce	
Water hyacinth	
Mollusks	**Birds**
*Giant African land snail	Purple swamphen
Island applesnail	
Insects	**Amphibians**
Mexican bromeliad weevil	Cuban treefrog
Red bay ambrosia beetle (Laurel Wilt)	
Fishes	**Mammals**
Asian swamp eel	Feral hog
	*Gambian pouched rat

*Species is currently targeted for possible eradication.

Australian Pine (*Casuarina* spp.)



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

Figure 7-13. Australian pine can aggravate coastal erosion and reduce sea turtle nesting habitat (photo by the NOAA).

KEY MANAGEMENT ISSUES

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

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

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

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

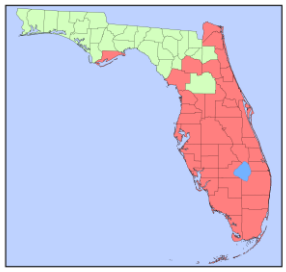
Regulatory Tools: *Casuarina* species are designated as Florida Prohibited Aquatic Plants. *C. equisetifolia* and *C. glauca* are designated as Florida Noxious Weeds. Florida law allows plantings of *C. cunninghamiana* for windbreaks in commercial citrus groves.

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

2013 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 recently found to have greater fitness (germination rate, seedling survival) relative to their progenitors (Geiger et al., 2011).

KEY MANAGEMENT ISSUES

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

Figure 7-14. Brazilian pepper is a prolific seed producer (photo by the USDA-ARS).

Control Tools: Managers use herbicides and physical and mechanical controls. Wide distribution on private lands and rapid colonization via bird dispersal make it difficult to achieve sustained control in management areas. Some progress has been made in managing this species in more accessible areas, but many remote regions of the Everglades remain infested. Biological controls have been under development since 1993 but no effective agents have been released in the state. Recent state budget reductions have slowed research to identify control agents for this species.

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

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

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

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

2013 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

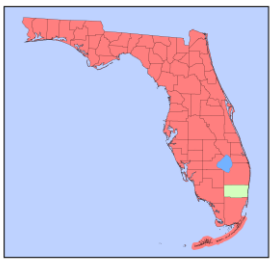
Cogongrass (*Imperata cylindrica*)

Figure 7-15. Once established, cogongrass quickly dominates pineland understories (photo by the UGA).

SUMMARY: Cogongrass is a fast-growing perennial grass native to southeastern Asia and is among the top worst weeds internationally (Holm et al., 1977). Widely planted for forage in the early 20th century, it is now estimated to infest 1,000,000 acres in Florida (Miller, 2007). Cogongrass aggressively invades pine flatwoods, disturbed sites, and marshes where it often displaces entire understory plant communities and alters ecosystem processes such as fire regimes (Lippincott, 2000) and biogeochemical cycling (Daneshgar and Jose, 2009; Holly et al., 2009).

KEY MANAGEMENT ISSUES

Distribution: Cogongrass is documented in natural areas throughout most of Florida. Within the District boundaries, cogongrass is most prevalent in the Kissimmee and Caloosahatchee watersheds, but in recent years it has spread in the Big Cypress National Preserve and in the DuPuis Management Area. Cogongrass has been estimated to infest about 6900 acres in the District (SFWMD, 2008).



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

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

Interagency Coordination: A strategy to address management of cogongrass throughout the southern United States was developed at the Regional Cogongrass Conference in 2007. The outcome of this meeting was a cogongrass management guide that provides guidance for control strategies, research priorities, and approaches to regional coordination.

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

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

2013 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*)

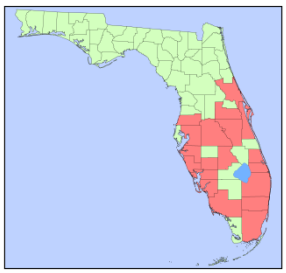
SUMMARY: Downy rose myrtle is an ornamental shrub of Asian origin. It now occurs in natural areas throughout South and Central Florida. This fast-growing shrub spreads into pine flatwoods and drained cypress strands, even in the absence of disturbance, and can form dense thickets that crowd out native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

Figure 7-16. Downy rose myrtle displaces understory plant communities in pine flatwoods (photo by the USDA-ARS).

KEY MANAGEMENT ISSUES

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

Control Tools: This species is difficult to combat, but recent improvements in herbicide control show promise. A mix of glyphosate and imazapyr is effective but kills native plants and inhibits re-vegetation. Dicamba provides good control of downy rose myrtle and spares many native flatwoods plants. This selectivity is an advantage for use in natural areas, although follow-up treatment is required. Tall dense growth of downy rose myrtle is hard to kill. Shredding with heavy equipment and treating regrowth is effective but expensive. Not only are herbicides more effective on regrowth after shredding, but fresh growth appears in the field to be very susceptible to rust *Puccinia psidii* (Rayamajhi et al., in press), which slows growth. A candidate biological control agent has been imported into quarantine for testing and other insects are being evaluated overseas (Ted Center, USDA–ARS, personal communication).



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

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

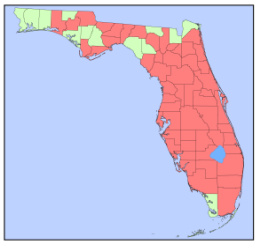
Regulatory Tools: Downy rose myrtle is designated a Florida Noxious Weed.

Critical Needs: Feasibility studies for biological control; statewide private lands initiatives to reduce propagule pressure on conservation lands; plans to guide regional, integrated management; monitoring to support early detection and elimination.

2013 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 can grow to the surface and form dense mats. It has a broad native distribution in the Old World and Indo-Pacific. Hydrilla was likely first introduced to Florida in the 1950s as an aquarium plant and has since spread throughout the state. Hydrilla overwhelms Florida's native aquatic plant communities, displacing valued native aquatic plants. This aggressive weed spreads to new waters mainly as fragments on boat trailers and boat parts. By the 1990s, hydrilla was widely distributed in the state, occupying more than 140,000 acres of public lakes and rivers.

Figure 7-17. Dense hydrilla mats aggressively overtake native aquatic vegetation (photo by the USDA).

KEY MANAGEMENT ISSUES

Distribution: Hydrilla is found in all types of water bodies in Florida. Since the 1980s, it has often dominated much of the Kissimmee Chain of Lakes. Hydrilla has been in Lake Okeechobee for about 20 years, but has not been a consistent problem. In some years, hydrilla has expanded rapidly to cover thousands of acres and required mechanical harvesting to open up boat trails.

Control Tools:

Hydrilla management has primarily depended on herbicide applications. This weed developed resistance to a commonly used systemic herbicide, so agencies now use a contact herbicide. Several newly aquatic-labeled systemic herbicides show promising control both alone and in combinations. Several additional herbicides may receive aquatic labels soon. Several hydrilla biocontrol agents have been released in Florida, but none have exerted significant control.

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.

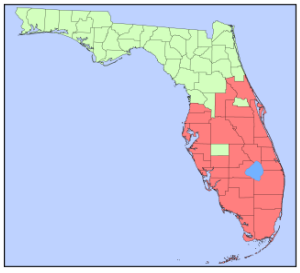
Regulatory Tools: Hydrilla is listed as a Federal Noxious Weed and a Florida Prohibited Aquatic Plant.

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

2013 Status of Hydrilla by Management Region

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

Melaleuca (*Melaleuca quinquenervia*)



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

KEY MANAGEMENT ISSUES

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

Figure 7-18. A former sawgrass marsh now dominated by melaleuca (photo by the USFWS).

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

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

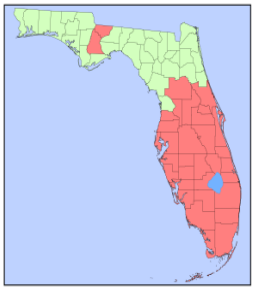
Interagency Coordination: Interagency coordination has proven successful for this species.

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

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

2013 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. This highly invasive fern smothers native vegetation, severely compromising plant species composition, destroying tree island canopy cover, and dominating understory communities. This species could potentially overtake most of South Florida's mesic and hydric forested plant communities (Gann et al., 1999; Lott et al., 2003; Volin et al., 2004).

KEY MANAGEMENT ISSUES

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

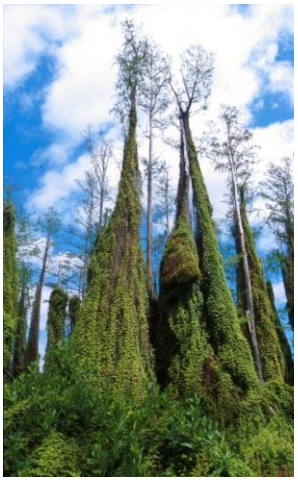


Figure 7-19. Old World climbing fern overtaking a cypress swamp (photo by the USDA-ARS).

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

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

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

Regulatory Tools: Old World climbing fern is listed as Federal and 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.

2013 Status of Old World Climbing Fern by Management Region

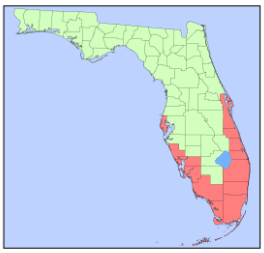
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Shoebutton Ardisia (*Ardisia elliptica*)

SUMMARY: Shoebutton ardisia 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 re-invasion 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 (*Ardisia escallonioides*).

Figure 7-20. Young shoebutton ardisia thicket in the southern Glades region (photo by the SFWMD).

KEY MANAGEMENT ISSUES



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

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

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

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

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

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

2013 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*)

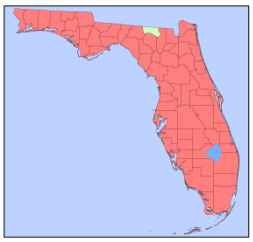
SUMMARY: Torpedograss is an Old World grass originally introduced to Florida as a forage crop. This species forms dense, single-species stands that easily out-compete native plants. Rhizomes, in which the plant accumulates significant energy reserves, make up the majority of this species' mass. These nutrient stores enable the plant to recover from disturbance events including 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 to new sites and within water bodies by vegetative means.

Figure 7-21. Torpedograss forms dense, impenetrable mats in littoral zones (photo by the SFWMD).

KEY MANAGEMENT ISSUES

Distribution: Torpedograss is ubiquitous in most regions of South Florida, but is most dominant in disturbed wetlands (Langeland et al., 1998). More than 20,000 acres torpedograss recently infested Lake Okeechobee's marshes. Treatments have reduced its coverage to an estimated 9,000 acres on the lake today (see Chapter 10 of this volume). However, 2012 treatment funding was severely curtailed and the plant is strongly rebounding.

Control Tools: The District's initial control efforts on Lake Okeechobee aim to limit the plant's further expansion into new areas of the lake. Annually from 2003 to 2009, between 2,500 and 5,000 acres of torpedograss were treated in the lake's 100,000-acre marsh via aerial and ground herbicide application. Some treatments have provided years of control while others have been less effective. Ongoing evaluations aim to reduce this variability. Treatments on Lake Okeechobee are coordinated through the Lake Okeechobee Interagency Aquatic Plant Management Group and performed by the SFWMD with funding from the FWC Invasive Plant Management Control Trust Fund. Development of selective biological control of torpedograss is not likely to be successful because of the broad similarities of grass species. Numerous herbicides have recently received approval from EPA for use in aquatic sites. Some are expected to have activity on grasses, hopefully including torpedograss. Trials are planned for the immediate future.



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

2013 Status of Torpedo Grass by Management Region

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

Tropical American Watergrass (*Luziola subintegra*)

SUMMARY: Tropical American watergrass was first discovered in North America in Lake Okeechobee in 2007 (Kunzer and Bodle, 2007). This perennial South American grass grows floating or emergent with prostrate creeping culms and forms dense floating mats. District-sponsored research found that the plant produces copious fertile seeds, which remain viable for long periods under flooded conditions. Hundreds of seeds per plant are produced annually. The plants decline in winter, apparently from combined effects of herbicide treatments and winter conditions. In spring and summer, plants grow from seed and from surviving rhizomes. Only by late summer are they tall enough for herbicide treatments. Managers aim to treat the plants before the onset of fall flowering. During the reporting period, the District conducted herbicide applications over 595 acres to control tropical American watergrass in Lake Okeechobee. Foraging and nesting of the endangered Everglade snail kite (*Rostrhamus sociabilis*) resulted in the establishment of human activity-free zones. Failure to treat in these zones has facilitated the expansion of the plant in Lake Okeechobee.

Figure 7-22. Dense floating mats of tropical American watergrass (photo by the SFWMD).

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 likely transported contractors' equipment used at both locations. The Miami-Dade Co. population has been eradicated. In Lake Okeechobee, the plant has spread well beyond its initial establishment area, although still remaining within the lake levee system. Continued treatments may not contain the plant much longer. It is likely that the plant will be transported outside the lake via wildlife or water releases.

Control Tools: Herbicides are the only control tool available. Little likelihood exists for biological control of tropical American watergrass. As a grass in the rice tribe (Oryzeae), the importance of rice agriculture could limit biological control investigations.

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

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

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

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

2013 Status of Tropical American Watergrass by Management Region

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

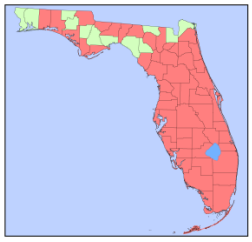
Water Lettuce (*Pistia stratiotes*)

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

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

KEY MANAGEMENT ISSUES

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



Control Tools: Water lettuce is readily controlled by herbicides, but rapid reestablishment of this species in some water bodies necessitates frequent re-treatments. Biocontrol agents for this species have been released in Florida, but none have significantly controlled the plant. Of these, the South American water lettuce weevil, *Neohydronymus affinis*, is widely established yet causes only numerous minute holes in the leaves of the plant.

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

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

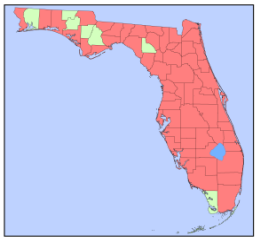
Regulatory Tools: Water lettuce is listed as a Florida Prohibited Aquatic Plant.

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

2013 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 is a floating plant native to tropical South America. Introduced into Florida in 1884, the plant quickly filled miles of the St. Johns River, halting navigation and waterborne commerce. Daughter plants are produced vegetatively by budding and stolon production. Rapid production of daughter plants occurs during all but the coolest months. New plants are also readily produced from seed, which often germinate copiously on moist soils as water bodies refill following drawdowns. Water hyacinth reproductive capacities, adaptability, low nutritional requirements, and resistance to adverse environments make it impossible to eradicate and difficult to control.

KEY MANAGEMENT ISSUES

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

Figure 7-24. Dense floating mat of water hyacinth (photo by the SFWMD).

Control Tools: Water hyacinth is readily controlled by herbicides, but rapid reestablishment of this species in some water bodies necessitates frequent re-treatments. The USDA has released several water hyacinth biocontrol insects in Florida, including two weevils of the genus *Neochetina*. Despite reports of these weevils effectively limiting water hyacinth populations elsewhere in the world, no such decreases have occurred in Florida. In 2010, a new water hyacinth-feeding insect was released in Florida, the water hyacinth plant hopper. USDA-ARS researchers found that this South American insect thoroughly controlled water hyacinths in quarantine trials. It has been shown to reduce water hyacinth growth and biomass production in South America (Sacco, 2013). Whether it establishes in Florida and exerts control on the plant remains to be seen.

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

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

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

Critical Needs: Continued development of biological controls is needed.

2013 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 Apple Snail (*Pomacea maculata*)

Figure 7-25. The island apple snail (photo by the FWC).

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

KEY MANAGEMENT ISSUES

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

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

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

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

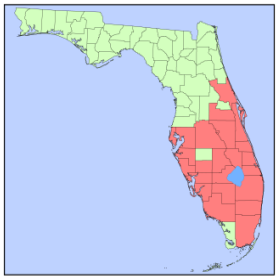
Regulatory Tools: This species is widely sold in the aquarium trade. Additional regulations are needed to curb the release of this and other nonnative *Pomacea* species.

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

2013 Status of Island Apple Snail by Management Region

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

Mexican Bromeliad Weevil (*Metamasius callizona*)



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

Figure 7-26. A Tillandsia plant heavily damaged by larva of *M. callizona* (photo by UF).

KEY MANAGEMENT ISSUES

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

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

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

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

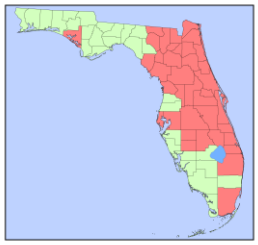
Regulatory Tools: Federal screening needs improvement to prevent new introductions. Additionally, improved export screening is needed to prevent transport from Florida to other vulnerable regions (e.g., Puerto Rico).

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

2013 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



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

KEY MANAGEMENT ISSUES

Figure 7-27. Dying red bay trees in a mixed hardwood forest (photo by the FDACS).

Distribution: Laurel wilt disease is now found throughout Florida. Since the 2010 detection of the redbay ambrosia beetle in Miami-Dade County, laurel wilt has spread across 133,740 ha of the central Everglades (see discussion above under invasive plant monitoring) and is also present in the Loxahatchee Refuge. Laurel wilt is also widespread throughout the District's East Coast land management region and the Kissimmee River Basin.

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

Monitoring: State and federal agencies are monitoring the spread of laurel wilt disease and the red bay 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 during 2013 to identify research and management strategies.

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

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

2013 Status of Laurel Wilt by Management Region

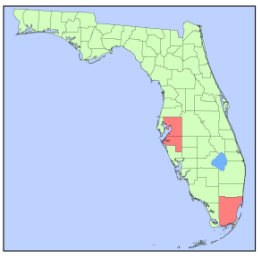
Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys
		N/A				N/A	

Asian Swamp Eel (*Monopterus albus*)

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

Figure 7-28. Asian swamp eel (photo by the USFWS).

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 the ENP, and in water bodies near Tampa (Fuller et al., 1999; L.G. Nico, USGS, personal communication). Unfortunately, recent monitoring efforts confirm the spread of this species into the ENP from adjacent canal systems (Jeff Kline, ENP, personal communication).

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

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

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

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

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

2013 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*)

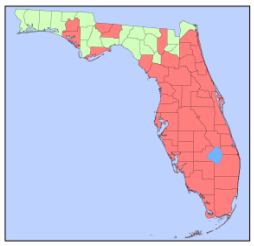
SUMMARY: The Cuban treefrog is native to Cuba, the Cayman Islands, and the Bahamas. It was first reported in Florida in the 1920s, and was likely transported in cargo or ornamental plant shipments. Cuban treefrogs consume a variety of invertebrates and native treefrog species (Maskell et al., 2003).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

Figure 7-29. The Cuban treefrog is now widely dispersed throughout Florida (photo by UGA).

KEY MANAGEMENT ISSUES

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

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



Monitoring: The UF and District are continuing a monitoring program for Cuban tree frogs and other priority invasive animals in the Everglades (see Everglades Invasive Reptile and Amphibian Monitoring Project update in this chapter). In addition, the UF/IFAS maintains a small monitoring and outreach program, but state and federal agencies need to assist with coordinating a statewide monitoring and management program.

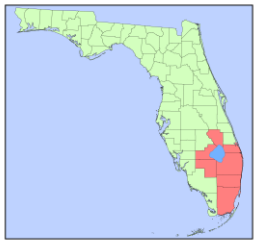
Interagency Coordination: No significant interagency coordination presently aims to manage this species.

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

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

2013 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 is a rail native to Australia, Europe, Africa, and Asia. Its introduction was likely due to escapes from the Miami zoo and private aviculturists in Broward Co. The purple swamphen feeds on shoots and reeds, invertebrates, small mollusks, fish, snakes, and the eggs and young of waterfowl (Pranty et al., 2000). Known to be highly aggressive and territorial, the purple swamphen could impact native water birds through competition for food and space and through direct predation. Rapid response efforts between 2006 and 2009 did not successfully reduce the abundance or distribution of this species. The management goal for this species has shifted from eradication to suppression (Jenny Ketterlin Eckles, FWC, personal communication).

Figure 7-30. Purple swamphens are now well-established in South Florida (photo by the SFWMD).

KEY MANAGEMENT ISSUES

Distribution: The original southern Florida purple swamphen population is believed to have established in Pembroke Pines in 1996 (Scott Hardin, FWC, personal communication). In recent years, purple swamphens have been sighted in the WCAs, Everglades National Park, Big Cypress National Preserve, Lake Okeechobee, and in all Everglades stormwater treatment areas.

Control Tools: Previous efforts to remove birds by hunting did not significantly deplete the population. No other control tools are currently developed for this species. FWC is currently conducting prey and habitat analyses to inform a risk assessment, which will guide future management strategies (Jenny Ketterlin Eckles, FWC, personal communication).

Monitoring: There are currently no coordinated monitoring efforts for this species.

Interagency Coordination: Local and state agencies have attempted to analyze this species' population and implement control. However, efforts to date have not halted the further spread of the species, and eradication is no longer considered feasible. The FWC have removed over 3000 purple swamphens to date, mostly from STA's and WCA 2B (Johnson and McGarrity, 2009). The FWC is currently studying habitat use and diets of purple swamphens in order to collect information that will help to develop a long-term management plan.

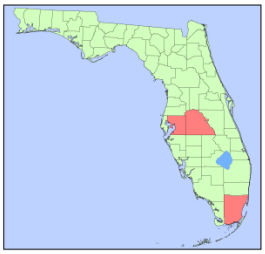
Regulatory Tools: There are currently no regulations that prohibit the importation or possession of this species in Florida. Federal and state regulations to restrict the possession of this species are needed to avoid future releases.

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

2013 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 (*Tupinambis merianae*)



SUMMARY: The Argentine black and white tegu is a large, omnivorous lizard filling a niche similar to that of the Nile monitor. In its native range, it prefers savannas and other 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 (*Crocodylus acutus*) and the Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) (Kevin Enge, FWC, unpublished data), 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.

KEY MANAGEMENT ISSUES

Distribution: Two established populations are known—Hillsborough and Polk counties (Enge et al., 2006) and southern Miami-Dade County. Data from monitoring efforts and reported sightings in the last year suggest that the South Florida population is expanding (Jake Edwards, FWC, personal communication), particularly south of Florida City in the Model Lands region. Surveys conducted by the UF, FWC, the District, USGS, Miami-Dade County, and NPS resulted in the removal of 180 tegus between January 1–September 19, 2013.

Figure 7-31. An Argentine black and white tegu (~50 cm) (photo by the UGA).

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

Monitoring: Interagency members of the Everglades CISMA initiated monitoring, assessment, and control efforts in 2011. These efforts are ongoing and have expanded to include deployment of 54 camera traps and telemetry of 15 tegus in 2013.

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

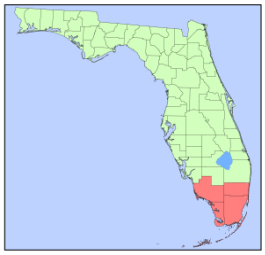
Regulatory Tools: This species should be considered for Conditional Reptile designation by the State of Florida.

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

2013 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
						N/A	

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 upon more than 20 native Florida species and is implicated in substantial declines of mammal populations in the ENP (Dorcas et al., 2011). 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), leading to a 52 percent reduction in the number of Burmese pythons removed in 2011. However, Burmese pythons of all age classes continue to be removed from the Everglades. Approximately 145 Burmese pythons are reported as removed from in and around Everglades National Park between January–October 2013 (Jenny Ketterlin Eckles, FWC, personal communication).

KEY MANAGEMENT ISSUES

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

Figure 7-32. Burmese pythons continue to be removed from the Everglades (photo by the SFWMD).

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

Monitoring: A regional python monitoring network of agency staff, reptile enthusiasts, and other interested parties continues to develop and expand in South Florida.

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 inter research advisory panel convened in August 2012 to facilitate prioritization and coordination.

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

Critical Needs: Development of effective attractants for trapping; technology to improve detection in the field; implementation of detection dog program; increased understanding of fine-scale movement patterns to improve search protocols; federal regulations to restrict possession of this species to limit new releases.

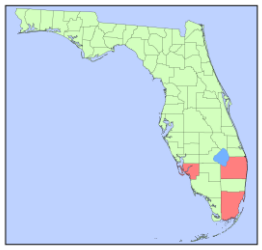
2013 Status of the Burmese Python by Management Region

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

Nile Monitor (*Varanus niloticus*)

Figure 7-33. Nile monitor at Homestead Air Force Base (photo by the Homestead Air Reserve Base).

SUMMARY: The Nile monitor is a large, predatory lizard known for its intelligence and adaptability (Bennett, 1998). It is a generalist feeder (Losos and Greene, 1988) that commonly preys on crocodile eggs and hatchlings in Africa (Lenz, 2004). The impact of Nile monitors on Florida fauna is unknown, but their potential to eliminate or significantly reduce native species through competition and predation is high (Enge et al., 2004). In particular, wildlife biologists consider the Nile monitor to be a serious threat to American crocodile, American alligator (*Alligator mississippiensis*), gopher tortoises (*Gopherus polyphemus*), sea turtles, burrowing owls (*Athene* spp.), Florida gopher frogs (*Lithobates capito*), and other ground-nesting species (Meshaka, 2006; Hardin, 2007).



KEY MANAGEMENT ISSUES

Distribution: Established populations are documented in and around Cape Coral in Lee County (Enge et al., 2004), Homestead Air Force Base in Miami-Dade County, and the C-51 canal in central Palm Beach County (Jenny Ketterlin-Eckles, FWC, personal communication). Numerous sightings have also been reported in suburban Broward County, approximately 1.5 miles from WCA-3B. In 2013, 12 surveys conducted on the C-51 canal resulted in the removal of 19 Nile monitors.

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

Monitoring: The District and FWC are currently monitoring for, and when possible, removing Nile monitors in central Palm Beach County.

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

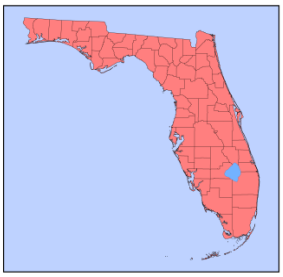
Regulatory Tools: The Nile monitor is listed as a Conditional Reptile by the State of Florida. Federal importation regulations are needed to further curtail releases of this invasive species.

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

2013 Status of the Nile Monitor by Management Region

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

Feral Hog (*Sus scrofa*)



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

Figure 7-34. A pair of feral hogs at Lake Okeechobee (photo by the FWC).

KEY MANAGEMENT ISSUES

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

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

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

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

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

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

2013 Status of Feral Hogs by Management Region

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

SPECIES TARGETED FOR CONTAINMENT OR ERADIATION

Lumnitzera (Exotic Black Mangrove, Kripa)

Exotic black mangrove (also kripa) (*Lumnitzera racemosa*) is native to Asia but escaped from Fairchild Tropical Garden and was discovered to be rapidly proliferating in the vicinity of the Garden in 2008. This plant aggressively competes with native mangrove species. Although the full effects of a major invasion of exotic black mangrove on Florida mangrove swamp diversity and function can't be predicted, the stakes are large. 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 invasion was detected. Several cooperative interagency workdays eliminated many of the invading plants, but this approach seemed inadequate for eradication.

During the last year, funding from the FWC supported a crew of three professional workers who removed 18,000 exotic black mangrove stems over 4 weeks, covering the entire known range of the introduction. The plants removed were almost entirely small seedlings coming up from the seed bank. The last flowering plant was observed in 2011. A volunteer event removed 900 seedlings in January 2013. The FWC has funding for a third crew scheduled before the end of 2013. Very few, if any, plants are producing seeds on the site. Because the infestation is apparently still restricted to a small area entirely accessible for control efforts, eradication of exotic black mangrove in Florida within a few years is possible. A more precise prediction of time until elimination is not possible because seed bank dynamics for this species are unknown. Consistent aggressive control work is crucial. If a major tropical storm or other mechanism spreads seeds to a wider area, then the opportunity for eradication may quickly be lost.

Mile-a-Minute

Mile-a-minute (*Mikania micrantha*) is an environmental and agricultural threat that has recently appeared in South Florida. This vine, which is native to parts of tropical and subtropical America, has turned into a disastrous weed where it was introduced in Asia, Australia, Africa, and other warm parts of the world (Holm et al., 1977; Zhang et al., 2004). This weed was discovered near Homestead in 2008, and an aggressive reconnaissance and eradication effort was begun immediately. With the exception of a recently reported single site in Broward County, the infestation has been contained to the Homestead area. However, fighting the fast growing pest is challenging and efforts are not close to eradication. It roots freely from stems and small fragments can grow into new plants, and vast numbers of tiny airborne seeds can spread the infestation. Major infestations exist in plant nurseries. The threat of quarantine is an incentive for nursery owners to eliminate the weed. Unfortunately, there are heavily infested abandoned nurseries. In many cases, contact with owners has not been possible. Infestations also exist on land associated with residences. Mile-a-minute twines among shrubbery and hedges. Herbicide treatment severely damages the ornamental plantings. Although most residents are cooperative, some are not and avoid contact. (Dozier, 2012) Because of serious consequences if mile-a-minute becomes permanently established, strong eradication efforts will continue. Limited access to infested areas in

Figure 7-35. Mile-a-minute rapidly establishes and covers surrounding vegetation (photo by the FWC).

conjunction with the weed's production of airborne seeds makes the outcome of these efforts uncertain.

Although the new site in Broward County has been dealt with successfully, it serves as a warning. It appears that mile-a-minute may have escaped from Miami-Dade County when a nursery in Collier County bought burlap from Homestead that was contaminated with seed. The burlap was used to wrap palm root balls. The palms were sold to a nursery in Broward Co. which tried to export them. The seeds had germinated and an inspector recognized *M. micrantha* growing up the trunks of the palms. If the seeds had not germinated yet and the plants had been shipped outside of Florida, then the mile-a-minute would probably not have been recognized until it was spreading rapidly and producing seeds. This could have created an environmental problem and triggered quarantine.

Giant African Land Snail

A population of the giant African land snail (*Lissachatina fulica*) was discovered in 2011 in an area of Miami (FDACS-DPI, 2011; USDA, 2013). The giant African land snail is known to eat a great variety of vegetation, including crop plants, horticultural plants and environmentally valuable plants. This species has invaded other places outside its native range in Africa, often causing substantial damage. Another negative aspect of this invasive snail is that it is an intermediate host of the rat lungworm, which can infect humans and cause meningitis (Cowie, 2013). This parasite, which has been almost unknown in the mainland United States, has recently been detected in giant African land snails collected in Miami (FDACS, 2012). A previous infestation of this snail occurred in Miami in 1966. The Florida state eradication effort took 10 years at a cost of $1 million (USDA, 2013). An aggressive federal/state cooperative program is now under way to eliminate the existing population. Although a fully grown giant African land snail is up to 8 inches long and may attract attention, smaller specimens resemble various native snails and can easily be overlooked and accidentally transported.

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

Figure 7-36. The giant African land snail is an intermediate host of the rat lungworm (photo by the FDACS).

Gambian Pouched Rat

Figure 7-37. Gambian pouched rats continue to occur in the Florida Keys, despite years of trapping (photo by the 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. 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 removed 28 rats over a 10-month period. The FWC and USDA plan to continue trapping and monitoring efforts to the extent that funding and staffing resources allow. The rediscovery of this invasive species after it was presumed eradicated suggests that standards for eradication be reassessed for this species.

Northern African Python

Since 2002, 36 northern African pythons (*Python sebae*) 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 shares many natural history traits with the Burmese python and is considered a high risk for establishment and expansion throughout southern Florida (Reed and Rodda, 2009). Rapid response efforts to delineate and eradicate this population are now of highest priority to local, state, and federal agencies. The District, Miccosukee Tribe of Indians, and Miami-Dade County, the primary land owners within the Bird Drive Basin, are working closely with the FWC and other agencies to address this emerging threat. The FWC, District, and other partnering agencies regularly deploy trained python surveyors to the area and have worked to remove artificial nesting habitat created from stockpiling cut melaleuca trees.

Figure 7-38. The northern African python (photo by the FWC).

Between December 2011 and March 2012, FWC and ECISMA partners organized three volunteer surveys in the Bird Drive Basin. No northern African pythons, skin sheds, or eggs were found in these searches. However, four pythons were removed during this time through rapid response efforts to citizen reports and by amateur snake hunters. In August, a 60 lb Siberian husky was killed in its backyard by a Northern African python. The interagency team will

continue to conduct northern African python surveys 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 [F.A.C.]). This permit is available only to licensed dealers, public exhibitors, or researchers that meet certain bio-security measures. Additionally, a federal ban on importation of this species was instated in January 2012.

Chameleons

A reproducing population of the Oustalet's chameleon (*F. oustaleti*) 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 the FWC, began a rapid assessment monitoring project in July 2011. Between July 2011 and May 2013, biologists removed over 400 Oustalet's chameleons from a 122-acre site (Jenny Ketterlin Eckles, FWC, personal communication). Preliminary diet analysis indicates that this chameleon population consumes a variety of insect and anole species. The interagency team is continuing periodic surveys in the known population area in order to better understand the extent of the population and natural history of this species in Florida. Through these efforts biologists hope to determine the potential ecological impact of Oustalet's chameleon and whether the population is expanding without human assistance. This information will help scientists prioritize this species as candidate for eradication.

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

FUTURE NEEDS IN MANAGEMENT AND CONTROL

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

have a responsibility to understand the distribution and impacts of these species and either initiate management operations or accept their occurrence and consequences in natural areas.

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

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

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

The use of an EDRR program increases the likelihood that invasions will be controlled while the species is still localized and population levels are so low that eradication is possible (National Invasive Species Council, 2003). Once populations of an invasive species are widely established, eradication becomes virtually impossible and perpetual control is the only option. Implementing an EDRR program is also typically much less expensive than a long-term management program. Given the risks associated with waiting for research and long-term monitoring to catch up, some agencies have opted to initiate control programs concurrently with biological or ecological research programs. Prompt cooperative action to eliminate emerging populations of sacred ibis (*Threskiornis aethiopicus)* and the invasive mangrove species *Lumnitzera racemosa* have been successful. These EDRR efforts may have prevented widespread ecological harm by these new invaders and also saved significant public resources required to manage more widespread invasions. Biological risk assessments are being developed to enable agencies to determine which species are most likely to become problems (Gordon et al., 2006; Simons and De Poorter, 2009). Many states struggle with how to implement an EDRR approach because awareness and funding often lag, preventing a real rapid response. For South Florida, groups such as the Everglades CISMA are attempting to initiate additional EDRR efforts.

An overarching theme in this chapter is describing the alarming extent and impacts of some nonindigenous species and stating the need for increased coordination and control. While these observations are valid, control efforts against certain nonindigenous species have proven successful and demonstrate that effective management is possible with effective interagency support and adequate funding. For instance, melaleuca once was thought to be unmanageable in the state because it was so widespread and difficult to control. The District-led melaleuca

management program is entering its twentieth year. Resource management agencies estimate this program has cost nearly $41 million to date. However, melaleuca is now under maintenance control on Lake Okeechobee and in the majority of the Everglades and Florida's melaleuca management program is a model for invasive species management nationally. The success of this program is largely attributed to integrated management approaches, sustained funding, and close interagency coordination, all of which foster information and technology transfer, regional strategic planning, increased financial efficiency, and improved public awareness.

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

LITERATURE CITED

Baber, D.W. and B.E. Coblentz. 1987. Diet, Nutrition, and Conception in Feral Pigs on Santa Catalina Island. *Journal of Wildlife Management*, 51:306-317.

Baker, P., F. Zimmanck and S.M. Baker. 2010. Feeding rates of an introduced freshwater gastropod Pomacea insularum on native and nonindigenous aquatic plants in Florida. *Journal of Molluscan Studies*, 76(2):138-143.

Batish, D.R., H.P. Singh and R.K. Kohli. 2001. Vegetation exclusion under *Casuarina equisetifolia* L.: Does allelopathy play a role? *Community Ecology*, 2:93-100.

Belden, R.C. and M.R. Pelton. 1975. European Wild Hog Rooting in the Mountains of Eastern Tennessee. *Proceeding of the Annual Conference of the Southeastern Association of Game and Fish Commissioners*, 29:665-671.

Bennett, D. 1998. *Monitor Lizards, Natural History, Biology and Husbandry*. Edition Chimaira (Andreas S. Brahm), Frankfurt am Main.

Boughton, A.J. and R.W. Pemberton. 2009. Establishment of an imported natural enemy, *Neomusotima conspurcatalis* (Lepidoptera; Crambidae) against an invasive weed, Old World climbing fern, *Lygodium microphyllum*, in Florida. *Biocontrol Science and Technology*, 19:769–772.

Cattau, C., J. Martin and W.M. Kitchens. 2010. Effects of an Exotic Prey Species on a Native Specialist: Example of the Snail Kite. *Biological Conservation*, 143:513-520.

Center, T.D., K. Parys, M. Grodowitz, G.S. Wheeler, F.A. Dray, C.W. O'Brien, A. Cofrancesco and S.J. Johnson. 2013. Evidence of Establishment of *Bagous hydrillae* (Coleoptera: Curculionidae), a Biological Control Agent of *Hydrilla verticillata (Hydrocharitales: Hydrocharitaceae)* in North America? Florida Entomologist 96(1):180-186.

Cooper, T.M., J.H. Frank and R.D. Cave. 2013. Loss of phytotelmata due to an invasive bromeliad-eating weevil and its potential effects on faunal diversity and biogeochemical cycles. *Acta Oecologica*. http://dx.doi.org/10.1016/j.actao.2013.01.016.

Cowie, R.H. 2013. Biology, Systematics, Life Cycle, and Distribution of Angiostrongylus cantonensis, the Cause of Rat Lungworm Disease. *Hawaii Journal of Medicine and Public Health*, 72(2).

Cuda, J.P., A.P. Ferriter, V. Manrique and J.C. Medal. 2006. *Interagency Brazilian Peppertree (*Schinus terebinthifolius*) Management Plan for Florida*. Second Edition. Florida Exotic Pest Plant Council (http://www.fleppc.org/).

Curnutt, J.L. 1989. Breeding bird use of a mature stand of Brazilian pepper. *Florida Field Naturalist*, 17(3):53-76.

Daneshgar, P. and S. Jose. 2009. Imperata Cylindrica, an Alien Invasive Grass, Maintains Control Over Nitrogen Availability in an Establishing Pine Forest. *Plant and Soil*, 320(1-2):209-218.

D'Cruze, N. J. Sabel, K. Green, J. Dawson, C. Gardner, J. Robinson, G. Starkie, M. Vences and F. Glaw. 2007. The first comprehensive survey of amphibians and reptiles at Montagne des Français, Madagascar. *Herpetological Conservation and Biology*, 2:87-99.

Dorcas, M. E., J. D. Willson, R. N. Reed, R.W. Snow, M. R. Rochford, M.A. Miller and K.M. Hart. 2012. Severe mammal declines coincide with proliferation of invasive Burmese pythons in Everglades National Park. *Proceedings of the National Academy of Sciences*, 109:2418-2422.

Doren, R.F., J.C. Volin and J.H. Richards. 2009. Invasive Exotic Plant Indicators for Ecosystem Restoration: An Example from the Everglades Restoration Program. *Ecological Indicators*, 9S:S29-S36.

Dozier, J. 2012 The Mikania micrantha wrap up. Everglades Cooperative Invasive Species Management Area Newsletter, Vol. 3, Issue 1, March.

DPI. 2010. Weed of the Month, May, 2010. Available online at http://www.freshfromflorida.com/pi/weed-of-the-month/0510-rhodomyrtus-tomentosa.html as of August 15, 2013.

Dray, Jr., F.A. and T.D. Center. 1989. Seed Production by *Pistia stratiotes* L. (Water Lettuce) in the United States. *Aquatic Botany*, 33(1-2):155-160.

Duever, M.J., J.E. Carlson, J.F. Meeder, L.C. Duever, L.H. Gunderson, L.A. Riopelle, T.R. Alexander, R.L. Myers and D.P. Spangler. 1986. *The Big Cypress National Preserve*. Research Report 8, National Audubon Society, New York, NY.

Enge, K.M., B.W. Kaiser and R.B. Dickerson. 2006. Another Large Exotic Lizard in Florida, the Argentine Black and White Tegu. *Proceedings of the 28th Annual Gopher Tortoise Council Meeting*, October 26–29, 2006, Valdosta, GA. Gopher Tortoise Council.

Enge, K.M., K.L. Krysko, K.R. Hankins, T.S. Campbell and F.W. King. 2004. Status of the Nile monitor (*Varanus niloticus*) in southwestern Florida. *Southeastern Naturalist*, 3(4):571-582.

Engel, V., A. Renshaw, M. Ross, J. Say, C. Coronado and J. Mellein. 2009. Tree island composition, elevation, and hydrologic tolerances of the dominant species: Implications for the Decomp physical model. Unpublished data from the National Park Service, Everglades

National Park, Homestead, FL; Florida International University, Miami, FL; and South Florida Water Management District, West Palm Beach, FL.

Engeman, R.G., J.W. Woolard, N.D. Perry, G. Witmer, S. Hardin, L. Brashears, H. Smith, B. Muiznieks and B. Constantin. 2006. Rapid Assessment for a New Invasive Species Threat: The Case of the Gambian Giant Pouched Rat in Florida. *Wildlife Research*, 33: 439-448.

Engeman, R.M., K.J. Couturier, R.K. Felix and M.L. Avery. 2013. Feral swine disturbance at important archeological sites. *Environmental Pollution Research*, 20:4093-4098.

Engeman, R.M., G.W. Witmer, J.B. Bourassa, J.W. Woolard, B. Constantin, P.T. Hall, S. Hardin and N.D Perry. 2007. The Path to Eradication of the Gambian Giant Pouched Rat in Florida. G.W. Witmer, W.C. Pitt and K.A. Fagerstone, eds. Pp 305-311. In: *Managing vertebrate invasive species: Proceedings of an international symposium*, USDA/APHIS Wildlife Services, National Wildlife Research Center, Fort Collins, CO.

FDACS. 2011. Laurel Wilt/Redbay Ambrosia Beetle Detection Update. Available online at http://www.freshfromflorida.com/Divisions-Offices/Plant-Industry/Pests-Diseases/Laurel-Wilt-Disease, as of August 1, 2013.

FDACS. 2012. Rat Lungworm Confirmed in Giant African Land Snail Sample Collected in Miami-Dade County. Available online at http://www.freshfromflorida.com/News-Events/Press-Releases/2012-Press-Releases/Rat-Lungworm-Confirmed-in-Giant-African-Land-Snail-Sample-Collected-in-Miami-Dade-County, as of August 15, 2013.

FDACS. 2013. Frequently asked questions about metaldehyde for controling snails and slugs. Available online at www.freshfromflorida.com/pi/gals/docs/Metaldehyde-QA.pdf as of August 15, 2013.

FDACS-DPI. 2011. Giant African land snail. Available on-line at http://www.freshfromflorida.com/Divisions-Offices/Plant-Industry/Pests-Diseases/Giant-African-Land-Snail, as of August 15, 2013.

Ferriter, A.P. and A.J. Pernas. 2005. Systematic Reconnaissance Flight Data. South Florida Water Management District, West Palm Beach, FL. Available online at tame.ifas.ufl.edu/tame_project/index.shtml as of August 15, 2013.

FWC. 2013. Species Profiles: Nonnatives – Veiled Chameleon. Florida Fish and Wildlife Conservation Commission, Tallahassee, FL. Available online at http://myfwc.com/wildlifehabitats/nonnatives/reptiles/veiled-chameleon/ as of August 15, 2013.

FLEPPC. 2011. Florida Exotic Pest Plant Council's 2011 list of invasive plant species. *Wildland Weeds*, 14(3-4):11-17.

Frank, J.H. and M.C. Thomas. 1994. *Metamasius callizona*, an immigrant pest, destroys bromeliads in Florida. *Canadian Entomol*., 126:673-682.

Frank, J.H. and R.D. Cave. 2005. *Metamasius callizona* is Destroying Florida's Native Bromeliads. M.S. Hoddle, ed. Pp. 91-101. In: *Second International Symposium on Biological Control of Arthropods*, September 12-16, 2005, Davos, Switzerland. USDA Forest Service publication FHTET-2005-08. Vol. 1, Washington, D.C.

Franks, S.J., A.M. Kral and P.D. Pratt. 2006. Herbivory by introduced insects reduces growth and survival of *Melaleuca quinquenervia* seedlings. *Environmental Entomology*, 35:366–372.

Fuller, P., L.G. Nico and J.D. Williams. 1999. Nonindigenous Fishes Introduced to Inland Waters of the United States. American Fisheries Society Special Publication 27, Bethesda, MD.

Gann, G.D., K.A. Bradley and S.W. Woodmansee. 1999. Initial Report: Long-term Monitoring of L. microphyllum *(Lygodium microphyllum* (Cav.) R. Br.) in Southeastern Florida. Unpublished report prepared by the Institute for Regional Conservation, Miami, FL, for the South Florida Water Management District, West Palm Beach, FL.

Gaskin, J.F., G.S. Wheeler, M.F. Purcell and G.S. Taylor. 2009. Molecular evidence of hybridization in Florida's sheoak (*Casuarina* spp.) invasion. *Molecular Ecology*, 18:3216-3226.

Geiger, J.H., P.D. Pratt and G.S. Wheeler. 2011. Hybrid vigor for the invasive exotic Brazilian peppertree (*Schinus terebinthifolius* Raddi., Anacardiaceae) in Florida. *International Journal of Plant Science*, 172(5):655-663.

Gordon, D.R. and K.P. Thomas. 1997. Florida's invasion by nonindigenous plants: history, screening, and regulation. D. Simberloff, D.C. Schmitz and T.C. Brown, eds. Pp. 21–37. In: *Strangers in Paradise: Impact and Management of Nonindigenous Species in Florida*, Island Press, Washington, D.C.

Gordon, R., A.M. Fox and R.K. Stocker. 2006. Testing a Predictive Screening Tool for Reducing the Introduction of Invasive Plants to Florida. Submitted by The Nature Conservancy, Arlington, VA, and University of Florida, Gainesville, FL, to the United States Department of Agriculture, Animal Plant Health Inspection Service, Washington, D.C.

Hamilton, L.S. and S.C. Snedaker (eds). 1984. *Handbook for Mangrove Area Management.* IUCN/UNESCO/UNEP. Honolulu, Hawaii, East-West Center.

Hanula, J., A. Mayfield, S. Fraedrich and R. Rabaglia. 2009. Biology and Host Associations of Redbay Ambrosia Beetle, Exotic Vector of Laurel Wilt Killing Redbay Trees in the Southeastern United States. Page 33 in K.A. McManus and K.W. Gottschalk (eds.), *Proceedings, 19th U.S. Department of Agriculture Interagency Research Forum on Invasive Species 2008*, General Technical Publication NRS-P-36, United States Department of Agriculture, Forest Service, Northern Research Station, Newtown Square, PA.

Hardin S. 2007. Managing non-native wildlife in Florida: state perspective, policy and practice. G. Witmer, W. Pitt and K. Fagerstone (eds.). Pp. 43–52. In: *Managing Vertebrate Invasive Species: Proceedings of an International Symposium*, Fort Collins, CO, August 7–9, 2007, United States Department of Agriculture, Animal Plant Health Inspection Service Wildlife Services, National Wildlife Research Center, Fort Collins, CO.

Harrington, T.C., H.Y. Yun, S. Lu, H. Goto, D. Aghayeva and S. Fraedrich. 2011. Isolations from the redbay ambrosia beetle, *Xyleborus glabratus*, confirm that the laurel wilt pathogen, *Raffaelea lauricola*, originated in Asia. *Mycologia*, 103:1028-1036.

Holly, C.D., G. Ervin, C.R. Jackson, S.V. Diehl and G.T. Kirker. 2009. Effect of an Invasive Grass on Ambient Rates of Decomposition and Microbial Community Structure: A Search for Causality. *Biological Invasions*, 11(8):1855-1868.

Holm, L.G., D.L. Plucknett, J.V. Pancho and J.P. Herberger. 1977. *The World's Worst Weeds: Distribution and Biology*. University Press of Hawaii, Honolulu, HI.

IFAS 2013. Cogongrass. Center for Aquatic and Invasive Plants. University of Florida. http://plants.ifas.ufl.edu/node/199, accessed September 8, 2013.

Johnson, S. 2007. The Cuban Treefrog (*Osteopilus septentrionalis*) in Florida. Publication WEC 218, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL. Available online at edis.ifas.ufl.edu/UW259, as of August 21, 2013.

Johnson, S.A. and M. McGarrity, 2009, Florida's Introduced Birds: Purple Swamp Hen (*Porphyrio porphyrio*), Publication WEC 270, Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, FL.

Klukas, R.W. 1969. The Australian Pine Problem in Everglades National Park: Part 1. The Problem and Some Solutions. Internal report, South Florida Research Center, Everglades National Park, Homestead, FL.

Krysko, K.L., K.M. Enge and F.W. King. 2004. The Veiled Chameleon, Chamaeleo calyptratus: a New Exotic Lizard Species in Florida. *Florida Scientist*, 67:249-253.

Kunzer, J.M. and M.J. Bodle. 2008. *Luziola subintegra* (Poaceae: Oryzeae), New to Florida and the United States. *Journal of the Botanical Research Institute of Texas*, 2(1): 633-638.

Langeland, K., B. Smith and C. Hanlon. 1998. Torpedograss–forage gone wild. Wildland Weeds, Summer 1998. http://www.se-eppc.org/wildlandweeds/pdf/su98-langeland-p4-6.pdf, accessed September 8, 2013.

Laycock, G. 1966. *The Alien Animals*. Natural History Press, Garden City, N.Y.

Lenz, S. 2004. *Varanus niloticus*. E.R. Pianka, D.R. King and R.A. King (eds.). Pp. 133–138. In: *Varanoid Lizards of the World*, Indiana University Press, Bloomington and Indianapolis, IN.

Lippincott, C.L. 2000. Effects of *Imperata cylindrica* (L.) Beauv. (Cogongrass) Invasion on Fire Regime in Florida Sandhill. *Natural Areas Journal*, 20:140-149.

Losos, J.B. and H.W. Greene. 1988. Ecological and evolutionary implications of diet in monitor lizards. *Biological Journal of the Linnean Society*, 35(4):379-407.

Lott, M.S., J.C. Volin, R.W. Pemberton and D.F. Austin. 2003. The Reproductive Biology of the Invasive Ferns *Lygodium microphyllum* and *L. japonicum* (Schizaeaceae): Implications for Invasive Potential. *American Journal of Botany*, 90:1144-1152.

Maskell, A.J., J.H. Waddle and K.G. Rice. 2003. *Osteopilus septentrionalis*: Diet. *Herpetological Review*, 34:137.

Mayfield, A.E., E.L. Barnard, J.A. Smith, S.C. Bernick, J.M. Eickwort and T.J. Dreaden. 2008. Effect of propiconazole on laurel wilt disease development in redbay trees and on the pathogen in vitro. *Arboriculture and Urban Forestry*, 34(5):317–324.

Mazzotti, F. J., W. Ostrenko and A.T. Smith. 1981. Effects of the exotic plants *Melaleuca quinquenervia* and *Casuarina equisetifolia* on small mammal populations in the eastern Florida Everglades. *Florida Science*, 44.

Mazzotti, F.J., M.S. Cherkiss, K.M. Hart, R.W. Snow, M.R. Rochford, M.E. Dorcas and R.N. Reed. 2010. Cold-induced mortality of invasive Burmese pythons in South Florida. *Biological Invasions*, published online June 15, 2010. Available at www.springerlink.com/content/mj838265763h4w17/fulltext.pdf as of August 15, 2013.

Meshaka, W.E., Jr. 2006. An update on the list of Florida's exotic amphibian and reptile species. *Journal of Kansas Herpetology*, 19:16-17.

Miller, J.H. 2007. The Context of the South's Cogongrass Crisis. N.J. Loewenstein and J.H. Miller, eds. In: *A Cogongrass Management Guide: Confronting the Cogongrass Crisis Across the South*. November 7-8, 2007, Mobile, AL.

MIPN. 2006. *CWMA Cookbook: A Recipe for Success.* Midwest Invasive Plant Network, www.mipn.orgwww.mipn.org, September 2006.

Morton, J.F. 1980. The Australian Pine or Beefwood (*Casuarina equisetifolia* L.), an Invasive "Weed" Tree in Florida. *Proceedings of the Florida State Horticulture Society*, 93:87-95.

Mueller-Dombois, D. and H. Ellenberg. 1974. *Aims and Methods of Vegetation Ecology*. John Wiley and Sons, New York, NY.

Mukherjee, A., D.A. Williams, G.S. Wheeler, J.P. Cuda, S. Pal and W. A. Overholt. 2012. Brazilian peppertree (Schinus terebinthifolius) in Florida and South America: evidence of a possible niche shift driven by hybridization. *Biological Invasions*, 14(7):1415-1430.

National Invasive Species Council. 2003. *General Guidelines for the Establishment and Evaluation of Invasive Species Early Detection and Rapid Response Systems*. Department of the Interior, Office of the Secretary, Washington, D.C. Version 1, June 2003. Available online at http://digitalcommons.unl.edu/natlinvasive/18/, as of August 15, 2013.

NIH, 2013. United States National Institutes of Health TOXNET: metaldehyde. http://toxnet.nlm.nih.gov/cgi-bin/sis/search/a?dbs+hsdb:@term+@DOCNO+1735, available on-line as of August 15, 2013.

Overholt, W., L. Markle, E.N. Rosskopf, V. Manrique, J.P. Albano, E. Cave and S.T. Adkins. 2009. The interactions of tropical soda apple mosaic tobamovirus and *Gratiana boliviana* (Coleoptera: Chrysomelidae), an introduced biological control agent of tropical soda apple (*Solanum viarum*). *Biological Control*, 48:294-300.

Pernas, T., D.G. Giardina, A. McKinley, A. Parns and F.J. Mazzotti. 2012. First Observations of Nesting by the Argentine Black and White Tegu, *Tupinambis merianae*, in South Florida. *Southeastern Naturalist*, 11:765-770

Pranty, B., K. Schnitzius, K. Schnitzius and H. W. Lovell. 2000. Discovery, origin, and current distribution of the purple swamphen (*Porphyrio porphyrio*) in Florida. *Florida Field Naturalist*, 28:1-40.

Pratt P.D., M.B. Rayamajhi, T.K. Van, T.D. Center and P.W. Tipping. 2005. Herbivory alters resource allocation and compensation in the invasive tree *Melaleuca quinquenervia*. *Ecological Entomology*, 30:316-326.

Rawlings, T.A., K.A.Hayes, R.H. Cowie and T.M. Collins. 2007. The identity, distribution and impacts of non-native snails in the continental United States. *BMC Evol. Biol*., 7:97.

Rayamajhi M.B., P.D. Pratt, T.D. Center, P.W. Tipping and T.K. Van. 2008. Aboveground biomass of the invasive tree melaleuca (*Melaleuca quinquenervia*) before and after herbivory by adventive and introduced natural enemies: a temporal case study in Florida. *Weed Science*, 56:451-456.

Rayamajhi, M.B., P.D. Pratt, N. Klopfenstein, A. Ross-Davis and L. Rodgers. 2013. First report of *Puccinia psidii* caused rust-disease epiphytotic on the invasive shrub *Rhodomyrtus tomentosa* in Florida. *Plant Disease*, (in press).

Rayamajhi, M.B., P.D. Pratt, T.D. Center, P.W. Tipping and T.K. Van. 2009. Decline in exotic tree density facilitates increased plant diversity: The experience from *Melaleuca quinquenervia* invaded wetlands. *Wetlands Ecology and Management*, 17:455-467.

Reed, R.N. and G.H. Rodda. 2009. Giant Constrictors: Biological and Management Profiles and an Establishment Risk Assessment for Nine Large Species of Pythons, Anacondas, and the Boa Constrictor. Open-File Report 2009-1202, United States Geological Survey. Washington, D.C.

Rice, K.G., J.H. Waddle, M.W. Miller, M.E. Crockett, F.J. Mazzotti and H.F. Percival. 2011. Recovery of native treefrogs after removal of nonindigenous Cuban treefrogs, *Osteopilus septentrionalis*. *Herpetologica*, 67:105-117.

Robertson, S.M. 2012. Potential threats of the exotic apple snail *Pomacea insularum* to aquatic ecosystems in Georgia and Florida. M.S. thesis, University of Georgia, Athens, GA.

Sacco, J., G. Cabrera Walsh, M.C. Hernández, A.J. Sosa, M.V. Cardo and G. Elsesser. 2013. Feeding impact of the plant hopper Taosa longula (Hemiptera: Dictyopharidae) on water hyacinth *Eichhornia crasssipes* (Pontederiaceae). *Biocontrol Science and Technology*, 2:160-169.

Schofield, P.J. and L.G. Nico. 2009. Salinity Tolerance of Non-native Asian Swamp Eels (Teleostei: Synbranchidae) in Florida, USA: Comparison of Three Populations and Implications for Dispersal. *Environmental Biology of Fishes*, 85:51-59.

SFWMD. 2008. Chapter 9: The Status of Nonindigenous Species in the South Florida Environment. In: *2008 South Florida Environmental Report – Volume I*, South Florida Water Management District, West Palm Beach, FL.

SFWMD. 2012. Strategic Plan, 2012–2017. South Florida Water Management District, West Palm Beach, FL.

Shields, J., S. Jose, J. Freeman, M. Bunyan, G. Celis, D. Hagan, M. Morgan, C.C. Pieterson and J. Zak. 2011. Short-term impacts of laurel wilt on redbay (Persea borbonia [L.] Spreng.) in a mixed evergreen-deciduous forest in northern Florida. *Journal of Forestry*, 109(2):82-88.

Simons, S.A. and M. De Poorter (eds.). 2009. Proceedings of an Expert Workshop on Preventing Biological Invasions: Best Practices in Pre-Import Risk Screening for Species of Live Animals in International Trade, University of Notre Dame, Indiana, USA, April 9-11, 2008. Global Invasive Species Programme, Nairobi, Kenya.

Singer, F.J. 2005. Wild Pig Populations in the National Parks. *Environmental Management*, 5:263-270.

Snow, R.W., K.L. Krysko, K.M. Enge, L. Oberhofer, A. Warren-Bradley and L. Wilkins. 2007. Introduced populations of *Boa constrictor* (Boidae) and *Python molurus bivittatus* (Pythonidae) in southern Florida. R.W. Henderson and R. Powell (eds.). Pp. 416–438. In: *The Biology of Boas and Pythons*, Eagle Mountain Publishing, Eagle Mountain, UT.

Stevens, J. and B. Beckage. 2009. Fire feedbacks facilitate invasion of pine savannas by Brazilian pepper (*Schinus terebinthifolius*). *New Phytologist*, 184:365-375.

Tipping, P.W., M.R. Martin, P.D. Pratt, T.D. Center and M.B. Rayamajhi. 2008. Suppression of growth and reproduction of an exotic invasive tree by two introduced insects. *Biological Control*, 44:235-241.

USDA 2013. Plant pest information. Giant African snail. http://www.aphis.usda.gov/plant_health/plant_pest_info/gas/index.shtml , available on-line as of August 15, 2013.

Volin, J.C., M.S. Lott, J.D. Muss and D. Owen. 2004. Predicting Rapid Invasion of the Florida Everglades by Old World Climbing Fern (*Lygodium microphyllum*). *Diversity and Distributions*, 10:439-446.

Waddle, J. H., R.M. Dorazio, S.C. Walls, K.G. Rice, J. Beauchamp, M.J. Schuman and F. J. Mazzotti. 2010. A New Parameterization for Estimating Co-occurrence of interacting Species. *Ecological Applications*, 20(5):1467-1475.

Wilde, S.B., T.M. Murphy, C.P. Hope, S.K. Habrun, J. Kempton, A. Birrenkott, F. Wiley, W.W. Bowerman and A.J. Lewitus. 2005. Avian vacuolar myelinopathy of the central nervous system of bald eagles and American coots. *Veterinary Pathology*, 35:479-487.

Winck G. and S. Cechin. 2008. Hibernation and emergence pattern of *Tupinambis merianae* (Squamata : Teiidae) in the Taim Ecological Station, Southern Brazil. *Journal of Natural History*, 42(3-4):239-247.

Witmer, G.W., W.C. Pitt and K.A. Fagerstone (eds.). 2007. *Managing Vertebrate Invasive Species: Proceedings of an International Symposium*, Fort Collins, CO, August 7–9, 2007. United States Department of Agriculture, Animal Plant Health Inspection Service Wildlife Services, National Wildlife Research Center, Fort Collins, CO.

Workman, R. 1979. Schinus, Technical Proceedings of Techniques for Control of Schinus in South Florida: A Workshop for Natural Area Managers. Sanibel-Captiva Conservation Foundation, Sanibel, FL.

Zhang, L.Y., W.H. Ye, H.L. Cao and H.L. Feng. 2004. *Mikania micrantha* H.B.K. in China—an overview. *Weed Research*, 44:42-49.