Chapter 7: Status of Nonindigenous Species

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SUMMARY

Controlling nonindigenous species is cited as an important strategy and success indicator in the South Florida Water Management District's (District or SFWMD) Strategic Plan (SFWMD, 2010). Successfully managing these species also is tangentially key to many other strategic goals as nonindigenous species have far-reaching effects — from evaluating environmental resource permits to managing 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 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 nonindigenous 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 2011 (FY2011) (October 1, 2010–September 30, 2011). During FY2011, the District spent roughly $18 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 detail on nonindigenous species, is also presented in Chapter 9 and Appendix 9-1 of the *2011 South Florida Environmental Report* (SFER) – *Volume I*.

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.

Table 7-1 compiles the many invasive species management activities the District is engaged in and also serves to cross-reference region-specific coverage of invasive species issues of the STAs, Everglades, Lake Okeechobee, Kissimmee Basin, and coastal areas in other chapters of this volume (see Chapters 5, 6, 8, 9, and 10, respectively). Key FY2011 updates on South Florida's nonindigenous species highlighted in this chapter follow.

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NONINDIGENOUS PLANTS

- Sixty-nine species of nonindigenous plants are District priorities for control. Old World climbing fern, melaleuca, and Brazilian pepper 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.
- Widespread efforts to control invasive plants are continuing. The District has the country's largest aquatic plant management program, managing floating and submerged aquatic vegetation systemwide. The agency's successful melaleuca management program has become a national model for regional, interagency invasive plant control programs. Melaleuca has been systematically cleared from Water Conservation Areas 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 Melaleuca Eradication and Other Exotic Plants – Implement Biological Controls project continued 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, Florida is planned to begin this fall. The facility will support implementation of biological control rearing, field release, establishment, and field monitoring for melaleuca and other invasive nonindigenous species.

NONINDIGENOUS ANIMALS

- Considerable numbers of nonindigenous animals are known to occur in South Florida, ranging from approximately 55 species in the Kissimmee Basin to over 150 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 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 2011, federal, state, and tribal partners continued rapid response efforts to control newly discovered or expanding populations of northern African pythons, Nile monitors, and Argentine black and white tegus in the Greater Everglades.
- Burmese pythons continue to be observed and removed in the Everglades and surrounding rural areas, although in fewer numbers than 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 and supporting research for management related research. A 2011 pilot project on using detection dogs for python monitoring and removal demonstrated that they can be an effective tool in regional management efforts.

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 2011, these cross-jurisdictional teams facilitated development of region-wide invasive species monitoring programs, rapid response efforts, standardized data management, and outreach initiatives.

Table 7-1. South Florida Water Management District (District or SFWMD) invasive species management activities in relation to operational mandates during Fiscal Year 2011 (FY2011) (October 1, 2010–September 31, 2011).

Project	Outcomes/Findings	Agency Partners[1]	Mandates[2]
Control Programs			
Systemwide			
Aquatic Plant Control in the Regional Water System	Multiagency management has nearly eliminated water hyacinth (*Eichhornia crassipes*) and water lettuce (*Pistia stratiotes*) from urban canal systems in Broward and Miami-Dade counties. "Newer" nonindigenous aquatic plants, including swamp weed (*Hygrophila polysperma*), toothcup (*Rotala rotundifolia*), marshweed (*Limnophila* spp.), and floating heart (*Nymphoides peltata*), continue to pose management challenges.	FWC local drainage agencies	AWCA
Biological Control of Aquatic Weeds Using Asian Grass Carp	During FY2011, 42,900 Asian grass carp (*Ctenopharyngodon idella*) were released in 11 canals for the control of hydrilla (*Hydrilla verticillata*) and other submerged aquatic vegetation.	FWC local drainage agencies	AWCA
Biological Control Implementation for Invasive Plant Species (see 2011 SFER – Volume 1, Chapter 9)	*Melaleuca:* The most recent biological control agent for melaleuca (*Melaleuca quinquenervia*), the melaleuca midge (*Lophodiplosis trifida*), continues to spread from all 24 release locations. Galls are observed throughout the canopy of even tall trees but preliminary data indicates that flies cause the greatest levels of damage (and mortality) among seedlings and saplings during the summer at sites with long hydroperiods. *Old World climbing fern:* Populations of the brown lygodium moth (*Neomusotima conspurcatalis*) have successfully survived three winter seasons without additional insect releases. The moth populations undergo pronounced seasonal fluctuations in response to low winter temperatures. Quarterly monitoring over the last three years has shown that although regrowth of Old World climbing fern (*Lygodium microphyllum*) occurs during the first half of the year when brown lygodium moth larval populations are low, subsequent larval defoliation during the fall can cause substantial reductions in the weed (35%).	USDA-ARS	EFA CERP INP
CERP – Implement Biological Controls Project	Final design review for the Mass Rearing Facility was completed and the Notice to Proceed for construction was issued in August 2011. Construction of the facility will commence in October 2011 and is scheduled for completion in October 2012.	USACE USDA-ARS	CERP
Kissimmee Chain of Lakes			
Aquatic Plant Control	Ongoing management aims to keep floating weeds at low levels for environmental, navigational, and water management functions. Hydrilla treatments are made in areas of highest priority. Emergent aquatic plant species most frequently controlled include Wright's nutrush (*Scleria lacustris*), West Indian marsh grass (*Hymenachne amplexicaulis*), and para grass (*Urochloa mutica*).	FWC USACE	AWCA
Region-wide Control of Upland Invasive Plants (see Volume II, Chapter 6B)	Aerial surveys for Old World climbing fern are conducted annually and treatments are scheduled as new infestations are identified. There has been significant progress toward control of soda apple (*Solanum viarum*) due to successful biological controls. Control efforts also continue for cogongrass (*Imperata cylindrica*), Chinese tallow (*Sapium sebiferum*), and Brazilian pepper (*Schinus terebinthifolius*).	Osceola County	WRA
Kissimmee/Okeechobee Region			
Invasive Plant Control for the Kissimmee River Restoration Project (see 2010 SFER – Volume I, Chapter 11)	Many priority invasive plant species are being successfully managed, although some difficult-to-control species continue to threaten restoration goals. Research to improve control tools for these species is ongoing.	FWC USACE FDEP	AWCA
Region-wide Control of Upland Invasive Plants (see Volume II, Chapter 6B)	Aerial surveys for Old World climbing fern are conducted annually and treatments scheduled as infestations are found. New infestations of this species are increasing in number, and it is proving difficult to stay ahead of its spread. Additional control efforts during FY2011 focused on dense infestations of Brazilian pepper and cogongrass.	FWC	WRA

Table 7-1. Continued.

Project	Outcomes/Findings	Agency Partners[1]	Mandates[2]
Control Programs (continued)			
Lake Okeechobee			
Invasive Grass Management	Ongoing treatments aim to manage invasive grasses and take advantage of seasons or conditions when best control can be gained. New arrivals to Florida, such as tropical American watergrass (*Luziola subintegra*), Wright's nutrush, and West Indian marsh grass, will likely continue to appear and pose new management problems	FWC USACE	AWCA
East Coast Region			
Region-wide Control of Upland Invasive Plants (see Volume II, Chapter 6B)	The primary nonindigenous plant species targeted in this region are Old World climbing fern, melaleuca, Brazilian pepper, and downy rose myrtle (*Rhodomyrtus tomentosa*). Secondary nonindigenous plant species exotics in this region include cogongrass, tropical soda apple, and primrose willow (*Ludwigia peruviana*).	FWC Martin County NRCS LRPI FDEP	CERP EFA FCT WRA
West Coast Region			
Invasive Plant Control for Corkscrew Regional Ecosystem (see Volume II, Chapter 6B)	Sustained control efforts for priority invasive plant species continue. The focus remains on Old World climbing fern, melaleuca, cogongrass, and downy rose myrtle.	---	WRA
Everglades Region			
Giant Constrictor Snake Management	District staff and agency partners continue to remove live pythons found during routine searches. Between January and October 2011, 130 Burmese pythons (*Python molurus bivittatus*) were removed from Everglades National Park and surrounding areas. Continued interagency rapid response efforts to eradicate northern African pythons (*Python sebae*) resulted in the removal of two adult pythons from the Bird Drive Basin. Since 2002, 22 northern African pythons have been removed from this area.	FWC NPS UF USDA-Wildlife Services	EFA
Everglades Invasive Plant Management	Systematic control of melaleuca, Brazilian pepper, Old World climbing fern, and other species continue in Water Conservation Area (WCA) 2 and WCA-3. Maintenance-level control of priority species is now achieved for large expanses of the WCAs. The District, in close collaboration with Miami-Dade County, continued efforts to control shoebutton ardisia (*Ardisia elliptica*) and restore freshwater marsh and other habitats in the C-111 Project area.	FWC Miami-Dade County	EFA INP
Biscayne Bay Coastal Wetlands Invasive Plant Management	Ten hectares of coastal wetlands in the Biscayne Bay Coastal Wetlands project area were cleared of priority invasive plant species. These included shoebutton ardisia, Australian pine (*Casuarina equisetifolia*), Old World climbing fern, and Brazilian pepper.	---	EFA CERP
Monitoring			
Digital Aerial Sketch Mapping of Invasive Plants	During the reporting period, the District and agency partners mapped invasive plant infestations in WCA-1 and on all District-managed lands along the eastern boundary of the Everglades. The distribution and abundance of melaleuca was mapped for WCA-1, whereas melaleuca, Australian pine, Brazilian pepper, and Old World climbing fern were mapped for the eastern Everglades project lands.	NPS USFWS	EFA
Everglades Invasive Reptile and Amphibian Monitoring Project	An interagency collaboration was initiated in 2010 to monitor priority invasive reptiles and amphibians and their impacts within the Greater Everglades ecosystem. Encounter rates ranged from 0.0 to 0.09 observations per kilometer. Brown anole (*Anolis sagrei*), Mediterranean gecko (*Hemidactylus turcicus*), greenhouse frog (*Eleutherodactylus planirostris*), marine toad (*Bufo marinus*), black rat (*Rattus rattus*), nine-banded armadillo (*Dasypus novemcinctus*), and wild hog (*Sus scrofa*) were the most commonly observed nonindigenous animal species. To date, four Burmese pythons have been detected during these visual surveys.	UF FWC	EFA

Table 7-1. Continued.

Project	Outcomes/Findings	Agency Partners[1]	Mandates[2]
Monitoring (continued)			
Invasive Animal Survey Team	District staff continues periodic exotic animal surveys along levees and roads throughout the region. The effort is intended to augment interagency invasive animal monitoring and control efforts. This fiscal year, the team initiated monitoring and trapping for the Nile monitor (*Varanus niloticus*) on the C-51 canal in central Palm Beach County.	NPS FWC	EFA
Research in Support of Management			
Burmese Python Detection Dog Pilot Program	Location of free-ranging pythons continues to be a limiting factor in control efforts. A pilot project evaluated the feasibility of using detection dogs to locate pythons along canals and levees and in fallow fields. Field test scenarios using live and bagged pythons resulted in 91 percent detection by dogs. The use of detection dogs is recommended for canal and levee searches as well as rapid response efforts when a constrictor has been sighted.	Auburn University NPS	EFA
Herbicide Efficacy and Selectivity of Aquatic Weeds	Research to evaluate herbicide resistance and selectivity among invasive aquatic weeds common in Everglades STAs is ongoing. Seven recently approved aquatic herbicides and three experimental use herbicides are being tested in STA test cell ponds to determine efficacy and selectivity profiles for undesirable invasive plants in STAs.	IFAS	LTP EFA
Development of Biological Controls for Priority Invasive Plant Species	Biological control research conducted by agency partners is focused on developing new control agents for Brazilian pepper, carrotwood (*Cupaniopsis anacardioides*), Chinese tallow, melaleuca, downy rose myrtle, skunkvine (*Paederia foetida*), water hyacinth, water lettuce, wetland nightshade (*Solanum tampicense*), and Jamaican nightshade (*Solanum jamaicense*).	IFAS USDA-ARS	EFA CERP
Control of Tropical American Watergrass	District-sponsored research into seed dynamics of tropical American watergrass has found that the plant produces copious fertile seeds that remain viable for long periods under flooded conditions. Seed fertility quickly declines under nonflooded conditions. Upon maturity, seeds are immediately able to germinate.	IFAS	AWCA EFA CERP
Herbicide Evaluations for the Control of Downy Rose Myrtle	Knowledge gained from both operational experience and recent herbicide trials allows the District to more effectively treat downy rose myrtle with herbicides. Smaller plants can be controlled by foliar application of dicamba, whereas larger bushes are better treated by basal or cut stump application of triclopyr ester. Recent trials showed that use of heavy grinding equipment followed by foliar treatment of resprouts with dicamba is a cost-efficient way to control downy rose myrtle and may result in accelerated recovery of desirable native plants.	---	EFA CERP

[1]**Mandates**

AWCA – Florida Aquatic Weed Control Act, Section 369.20(2), Florida Statutes (F.S.)
CERP – Comprehensive Everglades Restoration Plan
EFA – Everglades Forever Act , Section 373.4592, F.S.
FCT – Florida Communities Trust Act, Section 380.501, F.S.
INP – Invasive Nonnative Plants, Section 369.251, F.S.
LTP – Long-Term Plan for Achieving Water Quality Goals in the Everglades Protection Area
WRA – Water Resources Act, Chapter 373, F.S.

[2]**Agency Partners**

FIU – Florida International University
FDEP – Florida Department of Environmental Protection
FWC – Florida Fish and Wildlife Conservation Commission
IFAS – Institute of Food and Agricultural Sciences (University of Florida)
LRPI – Loxahatchee River Preservation Initiative
NPS – National Park Service
NRCS – Natural Resources Conservation Service (United States Department of Agriculture)
UF – University of Florida
USACE – United States Army Corps of Engineers
USDA-ARS – United States Department of Agriculture, Agricultural Research Service
USGS – United States Geological Survey
USFWS United States Fish and Wildlife Service

PROGRESS TOWARD MANAGEMENT AND CONTROL

The following section provides updates for FY2011 on research and management activities for priority nonindigenous species that threaten the success of the District's mission. These species are presented with a "District-centric" justification for listing. Priority species may differ for other agencies depending on regional factors and agency priorities and goals. The format of this section has changed from previous years to streamline reporting. This year, information related to the status of priority species, including research and management progress, is provided on only those species for which new information is available. This report includes updates on 15 priority non-indigenous species (10 plants and 5 animals), presented according to the species current management status—established species' targeted for long-term control and newly discovered species targeted for eradication.

For more detailed information on a larger compliment of District priority species, see Chapter 9 of the 2010 SFER – Volume I. The 2010 report includes a one-page synopsis for each of the 24 priority species, which highlights key management issues, provides general distribution information, and includes an indicator-based stoplight table that gauged the status of the species in each module designated by the Restoration Verification and Coordination Program (RECOVER), which is the scientific program of the Comprehensive Everglades Restoration Plan (CERP). In addition, Chapter 6 of the 2010 SFER – Volume I, includes a detailed assessment of many priority invasive species occurring in the Greater Everglades region.

INVASIVE PLANT MANAGEMENT

The District and other agencies continue to make significant progress toward achieving maintenance control of invasive, nonindigenous plant species on public conservation lands in South Florida. Large sections of the Greater Everglades have reached or are nearing maintenance-control levels where melaleuca (*Melaleuca quinquenervia*) once dominated sawgrass marsh. Recent funding increases for invasive plant management in the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge) have resulted in substantial reductions in melaleuca infestations. However, remote sections of the southeastern area of Everglades National Park (ENP or Park) and the 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.

In **Table 7-2**, the District's FY2011 expenditures for nonindigenous plant control are summarized by land management regions. The purpose of this table is to report expenditures for the most prominent 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 contractors to control all invasive plant species identified by the Florida Exotic Pest Plant Council **(**FLEPPC) as Category I species (FLEPPC, 2009). 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 FY2011, 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 7-2. Invasive plant species control expenditures by the SFWMD in FY2011, 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*)				$45,712	$1,225	$2,900		$49,800
Brazilian pepper (*Schinus terebinthifolius*)	$29,710	$375,000	$70,924	$529,000	$363,110	$301,157	$125,000	$1,795,000
Cogongrass (*Imperata cylindrica*)	$14,200	$43,200			$550	$240,000		$298,000
Downy rose myrtle (*Rhodomyrtus tomentosa*)					$140,000	$28,300		$168,000
Hydrilla (*Hydrilla verticillata*)	$585,000			$15,800	$40,100	$217,500		$858,400
Melaleuca (*Melaleuca quinquenervia*)	$2,000	$395,000	$35,000	$914,000	$3,400	$159,400	$150,000	$1,510,000
Old World climbing fern (*Lygodium microphyllum*)	$1,720	$396,000		$375,000	$80,000		$150,000	$853,000
Shoebutton ardisia (*Ardisia elliptica*)				$241,000	$2,300			$243,300
Torpedograss (*Panicum repens*)	$47,500		$687,000		$67,875	$3,200		$804,200
Water hyacinth (*Eichhornia crassipes*)	$88,970	$70,000		$54,300	$3,500	$8,500		$225,300
Water lettuce (*Pistia stratiotes*)	$84,000	$9,900		$208,000	$17,900	$7,384		$327,133

Priority Invasive Plant Species

Established Plant Species

Brazilian Pepper

Brazilian pepper (*Schinus terebinthifolius*) is an aggressive weed found throughout most of South and Central Florida. It is the most widespread and abundant nonindigenous plant species in the District, occupying an estimated 283,000 hectares (ha). This large shrub rapidly establishes in disturbed areas and then expands into adjacent natural areas (Cuda et al., 2006). Once established, it severely reduces native plant and animal diversity (Workman, 1979; Curnutt, 1989) and alters fire regimes (Stevens and Beckage, 2009). Some progress has been made in managing this species in more accessible areas, but many remote regions of the Everglades remain infested (2011 SFER – Volume I, Chapter 6).

During the reporting period, the District conducted herbicide applications to control 2889 ha of Brazilian pepper in all land management regions. District and Florida Fish and Wildlife Conservation Commission (FWC) land managers continued herbicide treatments on many tree islands in Water Conservation Area (WCA) 3. Ground-based herbicide application is providing excellent control, but is costly due to difficult access. In addition, repeat visits are necessary to remove recruits from the seed bank, although seed longevity in the seed bank is relatively short for this species (Ewel et al., 1982).

In FY2011, the District and University of Florida collaborated on field evaluations to determine control efficacy of the herbicide imazamox on several species including Brazilian pepper. This herbicide is of interest due to reported control selectivity for Chinese tallow (*Sapium sebiferum*) and cattail (*Typha* spp.). Preliminary results suggest that aerial applications of imazamox do not effectively control Brazilian pepper. The District also continued collaboration with the United States Department of Agriculture–Agriculture Research Service (USDA-ARS) to identify potential biocontrol agents (see the *Biological Control of Invasive Plant Species* section in this chapter).

Downy Rose Myrtle

Downy rose myrtle (*Rhodomyrtus tomentosa*) is an ornamental shrub of Asian origin. It now occurs in natural areas throughout South and Central Florida. This fast growing shrub spreads prolifically, even in the absence of disturbance. Once established, it is capable of forming almost impenetrable dense monospecific stands up to 3.7 meters tall, resulting in local displacement of understory plant communities. This plant typically invades pine flatwoods, coastal scrub, baygalls, and drained cypress strands. It occurs throughout Central and South Florida, particularly in moist sandy habitats. Significant infestations occur on conservation lands in coastal counties on the Atlantic and Gulf coasts. Fire appears to aggravate infestations, which is particularly troublesome since this shrub commonly invades fire-adapted communities.

Knowledge gained from both operational experience and herbicide trials during the past year allows the District to more effectively treat downy rose myrtle with herbicides. Smaller plants can be controlled by foliar application of dicamba, whereas larger bushes are better treated by basal or cut stump application of triclopyr ester. Tall, dense thickets have presented a problem; access is so difficult that treatment has been slow and expensive. Recent trials, however, have shown that use of heavy grinding equipment followed by foliar treatment of resprouts with dicamba (**Figure 7-1**) does the job for less money. Successful herbicide treatment continued this year on the Cypress Creek property in Martin and Palm Beach counties and on the Corkscrew Regional Ecosystem Watershed (CREW) property in Lee and Collier counties. For FY2011, 114 ha of downy rose myrtle were treated on District-managed lands. Completion of initial treatments plus follow-up treatments of any sprouts or seedlings that appear will be required to ensure recovery of the natural wildlife habitat. There are currently no biological controls approved for release for this species, but work continues in this area (Ted Center, USDA–ARS, personal communication).

Figure 7-1. Restoration sequence of pine flatwoods heavily infested with downy rose myrtle (photos by the SFWMD).

Hydrilla

Hydrilla (*Hydrilla verticillata*) is usually treated annually in the primary lakes of the Kissimmee Chain of Lakes because it threatens flood protection, navigation, and environmental quality. During the reporting period, the District conducted herbicide applications to control 1298 ha on public waterways. The herbicide endothall is the primary control agent. However, several products have recently received federal aquatic use labels and are being evaluated as control agents. If any are effective, their use will enable rotation of products; avoiding potential induction of hydrilla resistance to any of them from overuse.

Many public stakeholders hold that hydrilla is a boon to Florida waters for reasons including its perceived benefits to duck hunting and fishing. However, it must be managed in lakes with high priority uses and infrastructures, such as the Kissimmee Chain of Lakes. In these lakes, it has persisted for decades in dense and broad distributions. Interestingly, in Lake Okeechobee no large treatments have ever been made and the plant has come and gone from many areas, usually after rapid water level changes.

Four biological control insects have been released in Florida. Only two of these, both flies, have become established, although only minimal impacts are seen to hydrilla. United States Department of Agriculture (USDA) researchers have found a few hydrilla-feeding insects in Southeast Asia that may have potential as biocontrol agents. However, little funding is available to support this research. An endemic fungal pathogen of hydrilla has shown management potential in lab studies but this has not been replicable in the field.

Melaleuca

After several decades of management, large stands of melaleuca (*Melaleuca quinquenervia*) persist only on private lands. Populations have declined greatly on all public conservation lands within the Everglades Protection Area with the greatest remaining population found in the Refuge. The decline has been achieved via aerial and ground-based herbicide applications. In all areas, patrols continue to manage new seedling plants. On private lands, little has been done to encourage or require removal of the plant, despite the illegality of possessing it. These private stands serve as sources of reinfestation for public lands.

Assessment continues regarding the impacts of three melaleuca-feeding insects now established in Florida. Research also continues into the potential use of several other Australian melaleuca insects. However, the melaleuca biological control program can already be said to be nearing its design goals. Several established agents are inducing damages to the plant causing decreased flowering, seed production, and decline in overall health.

Old World Climbing Fern

Perhaps no other plant species poses a greater threat to South Florida's mesic upland and wetland ecosystems than Old World climbing fern (*Lygodium microphyllum*). This highly invasive vining fern smothers native vegetation, severely compromising plant species composition, destroying tree island canopy cover, and dominating understory communities. Currently, Old World climbing fern occupies an estimated 2,337 ha within the Greater Everglades region (SFER 2011 – Volume I, Chapter 6) where it threatens the biodiversity, structure, and function of Everglades tree islands (Brandt and Black, 2001). Left uncontrolled, this invasive fern is likely to negatively affect restoration performance measures for freshwater vegetation mosaics[1]

[1] Wetland Landscape Patterns – Freshwater and Estuarine Vegetation Mosaics performance measure, http://www.evergladesplan.org/pm/recover/recover_docs/ret/030807_ge_veg_mosaics.pdf.

and ridge and slough community sustainability[1] developed by RECOVER. The fern is also an aggressive invader in floodplain forests of the Kissimmee River Basin and mesic pinelands and swamps throughout the District. A 2007 aerial reconnaissance estimated that Old World climbing fern infests 64,434 ha of public and private lands within the District (2008 SFER– Volume I, Chapter 9).

During the reporting period, the District conducted herbicide applications to control 1298 ha of Old World climbing fern on its conservation lands. Ground-based herbicide treatments were carried out on many tree islands of WCA-3, which is providing some control, but the weed rapidly recovers after initial treatments (Ellen Donlan, SFWMD, personal communication). The District continues with a restrained program of aerial spraying (to limit damage to nontarget native species) along the Kissimmee River, combined with proactive ground treatment of selected infestations to avoid losses of wetland tree species. The District also plans to continue collaboration with USDA-ARS in FY2012 to release approved biological controls and identify new agents for Old World climbing fern (see *Biological Control of Invasive Plant Species* section in this chapter).

Shoebutton Ardisia

Imported as an ornamental shrub as early as 1900 (Gordon and Thomas, 1997), shoebutton ardisia (*Ardisia elliptica*) is thoroughly established in South and Central Florida. It aggressively invades the understory of moist hammocks, tree islands, and disturbed wetlands, especially on calcareous soils. The numerous black fruits contain seeds with a very high germination rate but no viability beyond six months. This ardisia is very shade tolerant, allowing seedlings to grow up under a canopy of mature plants to form dense, dark, multi-layered, single-species stands, resulting in almost complete displacement of native plants (**Figure 7-2**). Early infestations may go unnoticed due to physical similarity to the common native marlberry (*A. escallonioides*) (Invasive Species Specialist Group, Global Invasive Species Database, www.issg.org).

Figure 7-2. Workers hand clear shoebutton ardisia from formerly disturbed marl prairie wetlands (photo by the SFWMD).

The most extensive stands of shoebutton ardisia in Florida occur within a band of mostly exotic vegetation on previously farmed marl soil that fringes the southern edge of the developed areas of south Miami-Dade County. This is a strategic area that extends to the edge of ENP to the west and lies as a buffer between development and large marshes to the south that are part of the Everglades system. The District owns much of this area and during the past year has treated a great deal of shoebutton ardisia and associated exotic vegetation in this area with either chemicals or shredding. Follow up treatments will ensure that the exotics are dead; but additional work will be necessary to promote natural, native vegetation.

[1] Wetland Landscape Patterns – Ridge and Slough Community Sustainability performance measure, http://www.evergladesplan.org/pm/recover/recover_docs/ret/030807_ge_ridge_slough.pdf.

The fringe area was extensively farmed in the 1920s and the following decades. When it was first abandoned, weedy shrubs invaded, and later Brazilian pepper took over. Eventually, shoebutton ardisia dominated much of it. At this point, native vegetation has been missing from here for the better part of a hundred years, so there is not much of a native seed bank with which to work. A difficult job of fighting weeds and promoting native marl prairie species lies ahead. Planting of desirable species will probably be required in some areas. The crucial location, however, will provide a large benefit when the work is complete. During the reporting period, the District conducted shredding and herbicide applications over 142 ha to control shoebutton ardisia in south Miami-Dade County.

Torpedograss

Torpedograss (*Panicum repens*) was introduced to Gulf coastal states during the first half of the twentieth century to provide wet pasture livestock forage. This Old World native is now a serious weed of the world's tropics and subtropics, overwhelming native plant communities throughout these latitudes. Its deeply-buried rhizomes grow to depths of 50 centimeters and subterranean plant portions constitute a majority of mature plant biomass. Underground portions are protected from extremes such as fires and freezing. Hossain et al. (2001) reported that a single culm emerging from a single rhizome bud produced approximately 23,000 rhizome buds in a single year. Therefore, some level of treatment is likely to be essential to maintain native plant diversity in any infested sites. Any torpedograss surviving treatments will exhibit tremendous clonal regeneration potential by fragmentation and bud production.

In the grass family, biological control is considered untenable for the most part. Tissues and biochemistries of grass species are more uniform than many broadleaf plants groups. Such differences often contribute greatly to whether a biocontrol agent will attack only the target species. Therefore, the Poaceae is generally considered not to contain any species likely to have species-specific control agents or pathogens since host specificity is required for successful biological control.

This year, additional large-scale torpedograss treatments totaling 1,460 ha were made in Lake Okeechobee's marsh. It is present in much of the lake's 40,500 ha of marshlands and by 2001 dominated at least 8,100 ha in the marshlands. Broad expanses of the grass have been brought under control by annual treatments averaging more than a thousand hectares per year. Smaller ground-based torpedograss treatments were made in the Kissimmee Chain of Lakes and Lake Istokpoga, in Osceola and Highlands counties, respectively.

Plant Species Targeted for Eradiation

Lumnitzera (Kripa, Pacific Black Mangrove)

Lumnitzera (*Lumnitzera racemosa*) is an exotic mangrove from Asia that escaped from Fairchild Tropical Botanic 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 there is no evidence concerning the effects of lumnitzera on Florida mangrove swamps diversity and function, 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 in the past three years eliminated many of the invading plants. Areas of invasion were mapped and herbicides were tested for effectiveness. The FWC provided funding for a contractor to work on lumnitzera removal. Few mature specimens remain to release seeds. Great progress has been made and continuation of current efforts holds promise for eradication of this recent introduction to Florida.

Mile-a-Minute

Mile-a-minute (*Mikania micrantha*) is a major 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 to Asia, Australia, Africa, and other warm parts of the world (Holm et al., 1977; Zhang et al., 2004). It rapidly overgrows and smothers cultivated and native plants (**Figure 7-3**), facilitated in part by the release of phytotoxic compounds that inhibit germination and growth of neighboring plants (Shao et al., 2005). This weed was discovered near Homestead in 2008, and an aggressive reconnaissance and eradication effort was begun immediately. Fighting the fast growing pest is challenging; it roots freely from stems, small fragments can grow into new plants, and vast numbers of airborne seeds can spread the infestation.

Figure 7-3. Mile-a-minute rapidly smothers and displaces surrounding vegetation (photo by FWC).

In early growth stages, mile-a-minute may be overlooked because it resembles the native climbing hemp vine (*M. scandens*). Hope for eradication depends on identification of outlier populations quickly enough to destroy them before they spread. The Florida Division of Plant Industry has issued a pest alert to make people aware of this weed and help with identification (available online at http://www.doacs.state.fl.us/pi/pest_alerts/mikania-micrantha-pest-alert.html). Although mile-a-minute is clearly a threat to South Florida, the actual extent of potential damage to the Everglades is uncertain. Using an ecological niche model, Manrique et al. (2011) estimate that mile-a-minute has a high to excellent chance of establishing in various habitat types throughout Central and South Florida, including ENP and Big Cypress National Preserve. In other regions of the world, this weedy vine is reported to invade agricultural lands (Swarmy and Ramakrishnan, 1987), disturbed forest ecosystems (Muniappan and Viraktamath, 1993; Kong et al., 2000), and mangrove forests (Xue, 2000).

Since the known Florida distribution of mile-a-minute is limited to roughly 2,600 ha in the Homestead region (FDACS, 2011a), invasive species scientists hope that this species is eradicable. Towards the goal of eradication, the Everglades Cooperative Invasive Species Management Area (CISMA), in cooperation with the Florida Department of Agriculture and Consumer Services (FDACS), is attempting to initiate an aggressive strategy to control this weed. Elements of the strategy include refinement of herbicide control techniques, expanded monitoring efforts, public outreach, and multiple volunteer work days to treat known infestations. During the reporting period, several volunteer work days were conducted. Herbicidal control appears to be only marginally effective as several infestations recovered from the initial applications (Dennis Giardina, FWC, personal communication). Also, seed viability tests indicate that seeds quickly become viable after flowering (Jane Griffin-Dozier, Miami-Dade County, personal communication), which limits control options since flowers are needed to differentiate mile-a-minute from the native hemp vine.

As with other early detection/rapid response efforts, this collaboration has limited funding and staffing resources. However, regional invasive species biologists and land managers consider eradication of mile-a-minute to be a high priority given the potential long-term cost savings if this species is prevented from spreading into natural and agricultural areas.

Tropical American Watergrass

Tropical American watergrass (*Luziola subintegra*) was first discovered in North America in Lake Okeechobee in 2007. It immediately demonstrated very invasive and overwhelming growth. In 2009, the FLEPPC placed it in the most invasive plant category of its invasive plant list. This perennial South American aquatic grass grows floating or emergent with prostrate creeping culms, and forms stolons and floating mats.

District-sponsored research into seed dynamics of the plant found that the plant produces copious fertile seeds that remain viable for long periods under flooded conditions. Hundreds of seeds per plant are produced annually. Seed fertility quickly declines under non-flooded conditions. Upon maturity, seeds are immediately able to germinate. The plants decline in winter, apparently from combined effects of annual 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 treatments to effectively contact the plants. Managers aim to treat the plants before the onset of annual flowering. During the reporting period, the District conducted herbicide applications over 139 ha to control tropical American watergrass in the western marsh region of Lake Okeechobee.

Little likelihood exists for biological control to be a viable option for tropical American watergrass as discussed regarding grasses under torpedograss. As a grass in the rice tribe (Oryzeae), the importance of rice agriculture could further limit such investigations.

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.

The scope of a biological control program is broad, including foreign exploration, overseas screening, quarantine host range testing, field colonization and redistribution, and performance assessment. The principal objective of the foreign exploration portion of the project is to find effective agents and provide evidence of their safety. This is needed to support requests to the USDA's Animal Plant Health Inspection Service (APHIS) to import superior candidates into United States quarantine facilities. The quarantine process, a continuation of the initial foreign screening procedure, is designed to corroborate the safety of promising candidates, particularly addressing potential risk of collateral damage to nontarget native and economically important plant species. The domestic phase of the project transforms potential biological control agents into actual, usable instruments of control. This step mandates that the agents first be established in nature. Realizing the full potential of the agents necessitates evaluation of their impacts as well as recognition and assessment of their shortcomings.

Biological control of natural area weeds is a relatively new application of this science, as much of the earlier efforts focused on agricultural pests. Recognizing the potential for biological control agents as a component of integrated weed management strategies in Florida, the District, FWC, United States Army Corps of Engineers (USACE), and other agencies began funding biological research for priority invasives with the USDA-ARS, University of Florida, and others with expertise in this area.

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. Biological control agents that are approved and permitted are introduced into Florida but a portion of these individuals may fail to establish due to incompatibilities with the local environment. Despite these hurdles, biological control research and implementation has led to important advances in invasive plant management. Updates on the status of the more recently introduced biological control agents are listed below.

Melaleuca

The melaleuca snout weevil (*Oxyops vitiosa*) was introduced in 1997 and, subsequently, the insect established on melaleuca throughout the region. Adult weevils can live more than a year, and females produce approximately 350 eggs during their lifetime (Wheeler, 2003). Weevils lay eggs on the surface of expanding foliar buds, young leaves, and elongating stems. Weevil larvae feed exclusively on young leaves and have voracious appetites. 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). Recent surveys indicate that the geographic distribution of the melaleuca weevil encompasses 71 percent of the melaleuca infestation (Balentine et al., 2009). Following establishment, common garden experiments confirmed that feeding and development by the melaleuca weevil was restricted to melaleuca species, as predicted in quarantine-based host range testing and posed no threat to native or economically important plants (Pratt et al., 2009).

The melaleuca psyllid (*Boreioglycaspis melaleucae)* was released in 2002. Individuals in the first immature stage of this insect are active, but later stages are more sessile and congregate on leaves or stems, secreting copious amounts of white, waxy filaments from dorsal glands (Pratt et al., 2004). Adults and nymphs feed by inserting their needle-like mouthparts through stomatal pores in melaleuca leaves to gain access to the phloem (Purcell et al., 1997). Both adults and nymphs feed on expanding buds and leaves, but also exploit mature, fully expanded leaves. Initial field data indicate that feeding by psyllids induces leaf drop, eventually resulting in tree defoliation (Morath et al., 2006). USDA entomologists have determined that psyllid feeding on melaleuca seedlings results in 60 percent mortality in less than a year (Franks et al., 2006). Psyllids also disperse rapidly, spreading an average of 4.7 kilometers per year but ranging as high as 10 kilometers per year (Center et al., 2006). Field surveys indicate that the distribution of the melaleuca psyllid is slightly greater than that of the weevil, with a range that includes 78 percent of the melaleuca stands in Florida.

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

Figure 7-4. Post-fire recovery of melaleuca with biological controls present (left) and with biological controls removed (right) (photo by the USDA-ARS).

compared to pre-biocontrol population densities despite a large fire that, in the past, would have promoted dense recruitment of seedlings (**Figure 7-4**). Seedling/sapling recruits were reduced in height by more than 63 percent over the course of this study because of weevil and psyllid feeding, and appeared unlikely to reproduce. To facilitate the landscape-level impacts of these biological control agents, state and federally supported collection and redistribution efforts have released over 1.9 million insects at 319 locations across 15 counties in South Florida (Balentine et al., 2009). The strategy concentrated on insect releases in environmentally sensitive restoration sites or melaleuca-dominated areas that were not currently slated for herbicide treatments. This approach aims to use biological control agents to reduce re-invasion of managed sites and halt continued melaleuca spread in untreated sites.

The melaleuca gall fly (*Fergusonina turneri*) and its obligate mutualistic nematode *Fergusobia quinquenerviae*, was the third insect released against melaleuca. A permit for the gall fly was acquired in 2005, and releases were made at six sites in South Florida shortly thereafter (Blackwood et al., 2005). These initial releases did not result in the establishment of the fly; therefore, additional efforts were made in winter 2007, which culminated in three generations of the insect before the population went extinct. To date, additional releases of the gall fly are not planned.

The melaleuca midge (*Lophodiplosis trifida*) is the most recent biological control agent for melaleuca. Adults live less than a week but can lay over 200 eggs in their short life spans. Larvae hatch from eggs and quickly burrow into tender green stems of melaleuca branches. 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 or abnormal growths 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. The midge was introduced to 24 locations in Florida during summer 2008 and successfully established at all sites regardless of the number of individuals released. Galls are observed throughout the canopy of even tall trees but preliminary data indicates that flies cause the greatest levels of damage and mortality among seedlings and saplings during the hot summer months at sites with long hydroperiods. The melaleuca midge is widely established in the Greater Everglades.

Old World Climbing Fern

The brown lygodium moth (*Neomusotima conspurcatalis*) was first 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 three winter seasons without additional insect releases. Although populations of this moth undergo pronounced seasonal declines at the end of the calendar year, apparently in response to low temperatures during Florida's cool winter season, the insect has remained present and consistently detectable since the time the initial releases were conducted in early 2008. Typically, populations of the moth recover during the summer, and increase to very high levels by

Figure 7-5. Old World climbing fern damage caused by the brown lygodium moth (photo by the USDA-ARS).

the fall, which are sufficient to cause significant defoliation and measurable declines in Old World climbing fern cover at field sites (**Figure 7-5**). Censuses of moth larvae on Old World climbing fern foliage conducted during fall 2010 indicated that densities of 100–300 larvae per square meter of ground area were typical at sites, and that in areas of population outbreak, larval densities on foliage could exceed 16,000 individuals per square meter of ground area.

Vegetation monitoring data from long-term sites has shown that ground cover of Old World climbing fern was reduced by about half during the first six months after the brown lygodium moth was first released, from an average of about 50 percent cover, down to an average of about 25 percent cover. Quarterly monitoring over the last three years has shown that although regrowth of Old World climbing fern occurs during the first half of the year when larval populations are low, subsequent larval defoliation during the fall can cause substantial reductions in the weed. Together these processes have resulted in annual oscillations in Old World climbing fern ground cover, ranging from 20 to 35 percent at long-term study sites. These average cover levels are lower than amounts present before moth was released.

Parasitism of larvae of the brown lygodium moth was first detected during fall 2008 (Kula et al., 2010). Six species of parasitoid have so far been recovered from field-collected larvae, but most parasitoid individuals belong to a single species in the hymenopteran family Braconidae. Parasitism rates have generally remained low, although peaks in parasitism of up to 30 percent have been observed in brown lygodium moth collections from localized areas. Although it appears that the predominant parasitoid species may be able to regulate localized population outbreaks of this moth, there is little evidence to suggest that parasitoids are increasing across the landscape as a whole, because peaks and subsequent declines in parasitism rates across research sites occurred at different times of the year.

Releases of the moth have been made in Palm Beach, Martin, Monroe, Highlands, and Manatee counties in South Florida. Establishment of field populations has been confirmed in Palm Beach and Martin counties. Efforts to release field-collected insects in Manatee County during fall 2010 apparently resulted in the establishment of small, insipient populations at two lygodium-infested sites, but an unusually harsh winter and several hard frosts that killed above-ground Old World climbing fern foliage appear to have caused the extinction of these founder populations. The moth has shown an ability to disperse on its own, and during 2010 was found to have colonized new patches of Old World climbing fern located 11.3 kilometers from the closest moth release site.

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 (Boughton and Pemberton, 2008), but no establishment was obtained. Exclusion studies conducted at field sites demonstrated significant reductions in the numbers of "unprotected" larvae from Old World climbing fern foliage, suggesting that predation might have been a factor, hampering establishment (Boughton and Pemberton, 2008). During 2010, 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 through the end of 2010, but aside from sporadic recoveries of relatively low numbers of progeny, there was no evidence to indicate that populations were establishing in the field. To address the possibility that surviving adult moths of the release generation were dispersing away from release sites prematurely before they had a chance to mate, release protocols were changed in 2011, so that lab-reared larvae were released at field sites into large screen cages. Following adult emergence and mating, cages would be opened to allow dispersal of mated female moths into the adjacent habitat. As of summer 2011, approximately 24,000 larvae have been released into field cages. Observations indicate that survival of the lab-reared larvae is much improved inside the cages, since subsequent monitoring of released insects

has revealed much higher numbers of later developing larvae and emerging adults inside cages than were ever observed in open releases. However, persistent moth populations do not appear to have established or increased in the immediate vicinity of the field cages suggesting that the main benefit of the cages may be in providing protection from predation, which continues to be a problem once insects are released into the wider environment.

The lygodium gall mite, *Floracarus perrepae*, induces leaf roll galls on the leaves of Old World climbing fern. These galls become swollen with sap and sugars, which diverts photosynthetic production away from plant growth and reproduction. In prerelease studies in Australia, gall mites were shown to significantly reduce growth of Old World climbing fern plants (Goolsby et al., 2004). The gall mite was released in 60 plots at five sites in South Florida during 2008 and 2009, and although the mite has marginally established and continues to be present at low numbers at some sites, rates of successful gall induction on field plants were much lower than anticipated. Data from these field colonization studies and several years of colony maintenance in Fort Lauderdale indicate that a large proportion of Florida Old World climbing fern plants are not susceptible to gall induction by the introduced strain of the mite, suggesting that Florida Old World climbing fern populations may be more genetically diverse than was previously assumed. Similar problems of host plant resistance have been encountered with other eriophyid mites that have been released as weed biocontrol agents.

Biocontrol Agents in Development

One additional biological control agent is awaiting a permit: *Neostromboceros albicomus*, a Thai sawfly that attacks Old World climbing fern. Recent testing of *Liliocerus cheni*, a leaf beetle from Nepal that causes serious defoliation of air potato (*Dioscorea bulbifera*) vines, suggest that this insect is highly specific to air potato and is likely to be approved for release in the near future. Release efforts are expected to be underway during 2011. In addition to these weed targets, biological control research is focused on Brazilian pepper, hydrilla, carrotwood (*Cupaniopsis anacardioides*), skunk vine (*Paederia foetida*), water hyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratiotes*), wetland nightshade (*Solanum tampicense*), Jamaican nightshade (*Solanum jamaicense*), lobate lac scale (*Paratachardina pseudolobata*), and the bromeliad weevil (*Metamasius callizona*).

INVASIVE ANIMAL MANAGEMENT

Intensified efforts to develop control tools and management strategies for several priority species continued in FY2011. 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 nontarget species are unacceptable. Additionally, scant information on the species' natural history in its introduced range often prevents effective use of existing control methods. 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.

Programs and Research in Support of Management

Invasive Reptile Removal Permits

The FWC began its python removal program in 2009. Since its inception, 23 qualified individuals have been permitted to search for and remove Burmese pythons, as well as other

specified nonnative snakes and lizards, on four FWC wildlife management areas. More than sixty pythons of all sizes were killed in the first two years. The purpose of the program is to provide data to scientists on the distribution, size, and gut contents of Burmese pythons, and help determine the extent of python range, which would assist stopping its spread in Florida.

In June 2011, the District executed a memorandum of agreement with the FWC establishing a modified permitting program that continues to be administered by the FWC. New permits are designed to make exotic reptile removal easier and more effective by opening additional land owned by the District, providing better access, and allowing use of a greater range of weapons, including guns, for the first time. Nine areas totaling more than 24,300 ha of District property are covered by new permits. This land lies between developed areas of Miami-Dade and Broward counties and Everglades restoration lands. Python populations in this crucial strip threaten both people and the ecological integrity of the Everglades. Agencies involved are confident the new program will significantly increase collection of python data and elimination of the snakes.

Python Trap Development

Collaborative research to develop an effective trapping program for free-ranging pythons and other giant constrictor snakes is ongoing. District-funded research by the University of Florida has culminated in a trap capable of capturing free-ranging pythons, but capture rates are low (Cherkiss et al., 2009). The current focus is on developing effective attractants to draw these ambush predators to the traps. Concurrent with these efforts, the District is evaluating the use of artificial refugia in combination with scent attractants and self-baiting with rodent feed. To date, these methods have not resulted in python captures, but are likely confounded by freeze-induced declines in python densities. To improve knowledge of fine-scale movements and habitat use of Burmese pythons, researchers are developing methods for implanting satellite transmitters in adult pythons. If successful, this innovation will greatly enhance currently established remote tracking programs that rely on the "Judas snake" approach to locating new snakes.

Canine Detection for Python Management

During 2010–2011, a collaborative effort involving the ENP, Auburn University, the District, and others sought to evaluate canine detection as a potential tool for python management. This collaboration resulted in the training of three python dogs, which demonstrated highly accurate olfactory detection of Burmese pythons in a field setting and the capture of 19 Burmese pythons (Christina Romagosa, Auburn University, personal communication). A proof of concept study was carried out in early 2011 to determine situations best suited for detection dogs and to compare detection dog efficacy to current human search team methods. The approach to the study was to create controlled search conditions in which dog teams competed with human search teams. Paired searches were conducted in field plots and along canal levees. In field plots, radio-tagged pythons were released in marked plots prior to arrival of search teams. Each team was allowed to sweep the plot once. For canal searches, dogs searched for bagged live pythons that were hidden in dense vegetation adjacent on the levee slope. Human search teams were sent to locate dead pythons (frozen specimens), which were strategically placed in vegetation. Detection dogs outperformed human search teams in both search scenarios, but at a much wider margin on the levees with a 91 percent versus 63 percent detection rate for dogs and humans, respectively (Romagosa et al., 2011). While the results of this study were predictable, the evaluation provides important information regarding the cost and benefits of a detection dog program for python management. Specifically, the study demonstrated that detection dogs are a time- and cost-efficient tool for python detection on levees and at known locations. The next challenge for agencies involved with python management is to determine a means of implementing a detection dog program in the Everglades across multiple jurisdictions.

Everglades Invasive Reptile and Amphibian Monitoring Project

In 2010, the University of Florida, 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 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 WCA-3, Big Cypress National Preserve, and ENP. Visual searches and call surveys, in addition to trapping, are conducted to monitor prey species. To date, 10 routes have been established. The encounter rates for targeted invasive species ranged from 0.0 to 0.09 observations per kilometer. Brown anoles (*Anolis sagrei*), Mediterranean geckos (*Hemidactylus turcicus*), greenhouse frog (*Eleutherodactylus planirostris*), marine toad (*Bufo marinus*), black rat (*Rattus rattus*), nine-banded armadillo (*Dasypus novemcinctus*), and wild hogs (*Sus scrofa*) were the most commonly observed nonindigenous animal species (Frank Mazzotti, University of Florida, unpublished data). To date, four Burmese pythons have been detected during these visual surveys. Moving forward, the team plans to expand routes, increase sampling frequency, and refine survey methods. In addition, the team will begin an occurrence experiment to evaluate whether the presence of invasive species is related to the absence of native species.

Priority Invasive Animal Species

Established Animal Species

Burmese Python

The Burmese python (*Python molurus bivittatus*) is a large constrictor snake now estimated to be established over thousands of square kilometers in South Florida (**Figure 7-6**). This generalist predator is known to prey upon more than 20 native Florida species (Snow et al., 2007), including the federally endangered Key Largo wood rat (*Neotoma floridana*) and wood stork (*Mycteria americana*). The dramatic increase in observations of free-ranging Burmese pythons in South Florida since 2002 has raised concern among regional land managers and restoration scientists and has led to state and federal policy initiatives to limit the ecological harm of this and other giant constrictor snakes.

Figure 7-6. Removing a Burmese python from a rookery adjacent to the Tamiami Trail bridge construction site (photo by the SFWMD).

To date, 1,748 documented Burmese pythons have been removed from South Florida (source: ENP). The record cold temperatures of 2010 caused widespread mortality of Burmese pythons in South Florida (Mazzotti et al., 2010), leading to the first decrease in removed pythons since 2000 (**Figure 7-7**). As of October 30, 2011, only 130 Burmese pythons have been removed. The relatively low genetic differentiation of Burmese pythons in South Florida (Collins et al., 2008) has led to speculation that the South Florida Burmese python population is more vulnerable to environmental changes (Avery et al., 2010).

Control of this species remains a top priority among agencies and policy makers. However, control options are limited. Reed and Rodda (2009) reviewed control tools and their applicability to large constrictors in Florida. Potential controls include visual searching, traps, detection dogs, Judas snakes, pheromone attractants, and toxicants. Research and development for many of these tools is ongoing. For example, the ENP, FWC, United States Geological Survey, University of Florida, USDA Wildlife Service, SFWMD, and other agencies have worked to develop an effective trapping program since 2004. Although a trap has been designed that is documented to successfully capture free-ranging pythons (Reed et al., 2011), capture rates are low and, currently, insufficient resources are available to deploy these traps on a large scale. Agencies continue to pursue refinements to trapping designs and deployment strategies.

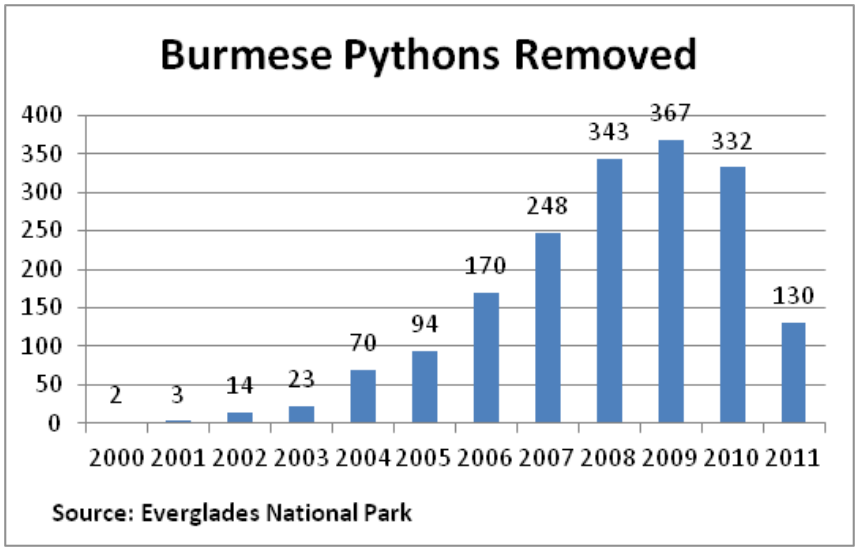

Figure 7-7. Number of Burmese pythons removed from South Florida since 2000. Data for 2011 is from January 1–October 5, 2011 (source: ENP, http://www.nps.gov/ever/naturescience/burmesepython.htm).

Red Bay Ambrosia Beetle and Laurel Wilt

Laurel wilt is a lethal disease of redbay (*Persea borbonia*) and other member of the Laurel family (Lauraceae) (**Figure 7-8**). The disease is caused by a fungus (*Raffaelea lauricola*) that is introduced into trees by the wood-boring redbay ambrosia beetle (*Xyleborus glabratus*) (FDACS, 2011b). 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. It is causing up to 100 percent mortality of redbay in canopies of mixed forests in northern Florida (Shields et al., 2011). It also impacts other native and nonnative members of the family Lauraceae (Hanula et al., 2009) including swamp bay (*P. palustris*), an important species of Everglades tree island plant communities. Two other native members of the Lauraceae, pondspice (*Litsea aestivalis*) and pondberry (*Lindera melissifolia*), are on

Figure 7-8. The initial stages of laurel wilt disease on red bay. (photo by the USDA)

state endangered and federal critically endangered lists, respectively, and may face extinction if laurel wilt spreads to these populations (Smith et al., 2010).

In Florida, laurel wilt is now documented in 30 Florida counties (FDACS, 2011b). In March 2010, the redbay ambrosia beetle was found in Miami-Dade County in the Bird Drive Basin, less than five kilometers from WCA-3B. Laurel wilt disease was subsequently confirmed on swamp bay trees in February 2011. Aerial reconnaissance conducted by the District, NPS, and FDACS in spring 2011 identified 105 symptomatic swamp bay trees scattered throughout the Bird Drive Basin, northward into the Pennsuco Wetland area, and westward into ENP. Its spread into the Everglades landscape represents a major threat to the structure and diversity of Everglades tree islands. Restoration performance measures that may be affected by this invasion include those for freshwater vegetation mosaics[1], and ridge and slough community sustainability[2] developed by RECOVER.

The District hosted an interagency meeting in May 2011 to discuss implications of the outbreak in the Everglades and to explore potential management strategies. As there is no feasible method for controlling this pest or its associated disease in natural areas (Mayfield et al., 2008), the group explored monitoring and conservation strategies. Removal of infected trees may reduce the rate of spread across the Everglades, but this effort would require frequent monitoring and costly deployments of vegetation management crews in remote areas with little guarantee that the spread would be contained. The interagency group concluded that the only feasible response will be to (1) continue monitoring the spread of laurel wilt, (2) investigate vegetation responses following swamp bay mortality, (3) evaluate feasibility and need for replanting efforts, and (4) participate in germplasm conservation for swamp bay and other impacted species of the Lauraceae.

Animal Species Targeted for Containment and Eradication

Argentine Black and White Tegu

The Argentine black and white tegu (*Tupinambis merianae*) is a large, omnivorous lizard (**Figure 7-9**) 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 (Tony Pernas, ENP, personal communication), both of which are suspected to have resulted from deliberate releases by pet dealers or breeders (Hardin, 2007). This species is an emerging threat and little information is available on species or ecological impacts in Florida. As an egg predator, it now threatens shorebirds and sea

Figure 7-9. Numbers of captured black and white Argentine tegus are on the rise in South Florida (photo by the FWC).

[1] Wetland Landscape Patterns – Freshwater and Estuarine Vegetation Mosaics performance measure, http://www.evergladesplan.org/pm/recover/recover_docs/ret/030807_ge_veg_mosaics.pdf

[2] Wetland Landscape Patterns – Ridge and Slough Community Sustainability performance measure, http://www.evergladesplan.org/pm/recover/recover_docs/ret/030807_ge_ridge_slough.pdf

turtles on the island of Fernando de Noronha where it was intentionally released to control rats (Ramalho et al., 2009). The spread of this species in Florida has the potential to significantly 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.

As such, this species has become a priority species for early detection and rapid response by regional invasive species biologists. Since 2008, interagency members of the Everglades CISMA have conducted ad hoc monitoring, assessment, and control efforts, but dedicated funding and staffing resources are lacking for this effort. Beginning in 2009, FWC and National Park Service (NPS) biologists have deployed traps and conducted visual surveys south of Florida City adjacent to the ENP. A total of 109 individuals have been removed from South Florida since July 2009 (Tony Pernas, ENP, personal communication). Of them, 75 were removed in 2011. Tegus was a primary focus at the 2011 Everglades Invasive Species Summit, where Everglades CISMA members collaborated to develop a management plan, scheduled volunteer monitoring work days, and identified future research and development needs for detection and control (see http://www.evergladescisma.org/). Critical research needs identified by the interagency team included continuation of gut content analyses, trapping refinements, and telemetry studies as well as new initiatives to assess population genetics and reproductive habits.

Given the increasing likelihood that this species is well established on the eastern boundary of ENP and that control tools are not yet fully developed, eradication from Florida may soon be unachievable (Kevin Enge, FWC, personal communication). To help curtail the spread in Florida, this species should be considered for Conditional Reptile designation by the State of Florida. Given its popularity in the pet trade, federal importation regulations are needed to further curtail releases.

Nile Monitor

The Nile monitor (*Varanus niloticus*) 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 gopher tortoises (*Gopherus polyphemus*), sea turtles, burrowing owls (*Athene* spp.), Florida gopher frogs (*Lithobates capito*), and other ground-nesting species (Meshaka, 2006; Hardin, 2007).

Established populations are documented in and around Cape Coral in Lee County (Enge et al., 2004) and Homestead Air Force Base in Miami-Dade County. Repeated sightings of adults and juveniles along the C-51 canal in central Palm Beach County have led biologists to conclude that a population is also established there (Jenny Ketterlin-Eckles, FWC, personal communication). The spread of this species into the Everglades has the potential to significantly impact restoration efforts. The Nile monitor has the potential to prey on threatened and endangered species and alter trophic dynamics by competing with native predators for habitat and food. Potentially affected RECOVER restoration performance measures include those for juvenile American crocodile[1] and American alligator[1] (*Alligator mississippiensis*) survival.

[1] American Crocodile - Juvenile Growth and Survival performance measure, http://www.evergladesplan.org/pm/recover/recover_docs/ret/pm_ge_alligator.pdf.

During the reporting period, the FWC and SFWMD initiated monitoring and trapping efforts along the C-51 canal to better understand the status of this population. Three boat surveys during spring and summer 2011 resulted in nine Nile monitor observations, including a mating pair. To date the coordinated trapping effort has not resulted in captured monitors, although two Nile monitors were trapped by homeowners adjacent to the canal. The FWC and the District will continue to coordinate monitoring and trapping activities in this area during 2011, but refinements to trapping methodologies are needed to make this a cost-effective monitoring and management tool. The City of Cape Coral continues to conduct limited Nile monitor trapping in response to citizen reports. The number of reports is down substantially this year (four collected since January 1, 2011). It is unclear if this is caused by record cold temperatures or reductions in citizen reports due to the local housing downturn (Harry Philips, City of Cape Coral, personal communication). Unfortunately, there continues to be little to no funding for the development of control tools or organized monitoring programs for the Nile monitor. Without resources for such initiatives, populations will continue to spread and the likelihood of eradication or containment will decrease (Engeman et al., 2011).

Northern African Python

Since 2002, 22 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. As previously reported in the 2011 SFER – Volume I, Chapter 6, the FWC and District regularly deploy trained python surveyors to the area and have worked to remove artificial nesting habitat created from stockpiling cut melaleuca trees. All captured pythons are transported to the ENP or USDA Wildlife Service's laboratories where they are either euthanized or utilized for telemetry or trap development research.

Between December 2010 and March 2011, Everglades CISMA partners organized five volunteer surveys in the Bird Drive Basin. In addition, USDA Wildlife Service teams conducted thirteen independent surveys in the area through a cooperative agreement with the District. Combined, these surveys resulted in the removal of two northern African pythons and the discovery of an old nest with 19 hatched eggs (Jenny Ketterlin-Eckles, FWC, personal communication). Two Burmese pythons were also detected and removed from the area during these visual searches. The interagency response team, led by the FWC, will continue to conduct surveys in the Bird Drive Basin with the stated objective of eradicating northern African pythons from South Florida. 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.

[1] Wetland Trophic Relationships - American Alligator Distribution, Size, Nesting and Condition performance measure, http://www.evergladesplan.org/pm/recover/recover_docs/ret/pm_ge_alligator.pdf.

INTERAGENCY COORDINATION

This section provides updates on key interagency coordination activities pertaining to invasive, nonindigenous species in South Florida during FY2011. 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 (FLEPPC), Noxious Exotic Weed Task Team, Florida Invasive Animal Task Team, and Invasive Species Working Group. At more local levels, land managers and invasive species scientists have informally coordinated "across the fence line" for many years. These regional groups recently began formalizing their partnerships into Cooperative Invasive Species Management Areas (CISMAs) to further enhance collaboration and coordination. CISMAs are local organizations, defined by a geographic boundary, that provide a mechanism for sharing invasive plant and animal management information and resources across jurisdictional boundaries to achieve regional invasive species prevention and control (MIPN, 2006). Based on the success of CISMAs in Florida and in western states, the Florida Invasive Species Partnership, formerly the Private Lands Incentive subcommittee of the Invasive Species Working Group, expanded its reach to act as a statewide umbrella organization for Florida CISMAs (www.floridainvasives.org). The Florida Invasive Species Partnership is an interagency collaboration, made up of federal, state, and local agencies, nongovernmental organizations and universities, focused on addressing the threat of invasive, nonnative species to Florida's wildlife habitat, natural communities, and working agricultural and forest lands. The Florida Invasive Species Partnership serves Florida's CISMAs by facilitating communication between existing CISMAs, fostering the development of new 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 93 percent of the state (**Figure 7-10**). Of these 18 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 can be found at www.floridainvasives.org/cismas.html.

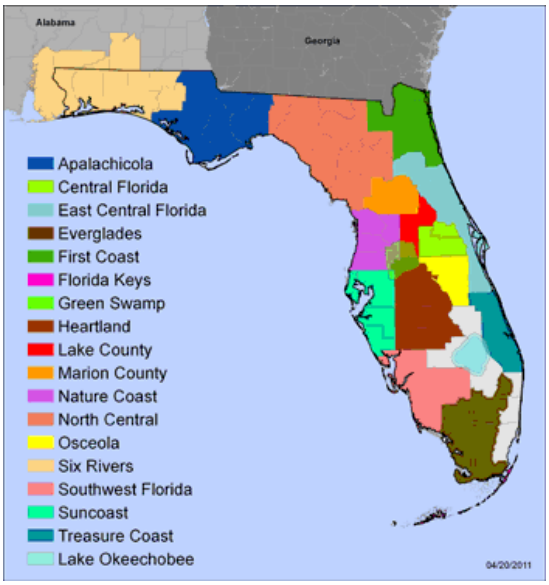

Figure 7-10. CISMAs and other regional coordinating groups cover over 90 percent of Florida.

Everglades CISMA

The Everglades CISMA was formed in 2006. That year, the District and NPS co-hosted the Everglades Invasive Species Summit, an annual invasive species coordination meeting. The Everglades CISMA was established at the summit because attendees recognized the need for a more defined commitment to cooperation among agencies and organizations. 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 19 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, and Miami-Dade County (**Figure 7-**).

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

During the last year, members of the Everglades CISMA 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, and other widely established species, Everglades CISMA cooperators organized efforts to address recently discovered populations of nonindigenous plant and animal species. These include rapid assessment efforts to determine the current status of tegu lizards in the southeastern region of the Everglades, rapid response efforts to control populations of mile-a-minute, and continued monitoring and treatment of the invasive mangrove species *Lumnitzera racemosa*. Updates on these and other species are provided in this chapter.

Everglades CISMA members also worked with the Science Coordination Group of the South Florida Ecosystem Restoration Task Force during 2010 to discuss next steps for addressing the impacts of nonindigenous, invasive species in the Everglades restoration footprint. Recommendations were presented to the task force on October 28, 2010. These recommendations focused on four main areas: (1) promoting federal prevention initiatives for nonnative wildlife, (2) establishing a position for an Everglades Early Detection/Rapid Response (EDRR) coordinator and dedicated EDRR funding, (3) coordinating development of a cross-cut budget for invasive species, and (4) promoting continued improvements to coordination. More information about the Everglades CISMA is available at www.evergladescisma.org.

Treasure Coast CISMA

Land managers and biologists along Florida's Treasure Coast have been participating in a regional partnership to cooperatively address the threats of invasive plants and animals. The Treasure Coast CISMA partnership was formed in 2007. It 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 District, Florida Division of Forestry, Florida Grazing Land Coalition, Florida Native Plant Society, Florida Park Service, FWC, Indian River County, Martin County, Natural Resources Conservation Service, Palm Beach County Environmental Resources Management, Palm Beach State College, St. Lucie County, St. Lucie County Mosquito Control District, The Nature Conservancy, Treasure Coast Resource Conservation and Development, USFWS, University of

Florida's Institute of Food and Agricultural Sciences (IFAS), Aquatic Vegetation Control, Inc., and Habitat Specialists, Inc.

The Treasure Coast CISMA has established goals centered around cross-jurisdictional efforts to (1) reduce and control the spread of existing invasive species, (2) prevent the establishment and spread of new invasive species, (3) build working relationships between public and private stakeholders to foster cost-effective control of invasive species, (4) provide education and information exchange about invasive species among stakeholders, and (5) promote applied research in invasive species management.

During this past year, the Treasure Coast CISMA has continued its priority coastal control efforts by treating 26 ha along eight shoreline kilometers targeting beach naupaka (*Scaevola taccada*) on public conservation lands. In addition, they treated 0.8 ha of beach naupaka on private lands and held several individual and general outreach efforts on this invasive species. Financial assistance for this project has been from the USFWS coastal program. The success of this partnership project was demonstrated with it receiving the Coastal America Partnership Award for 2010.

Also during this past year, they held eight multiagency cooperative workdays on Florida Park Service, USFWS, Martin County, and private lands. The Treasure Coast CISMA completed the ranking of potential early detection rapid response invasive species and began developing field identification cards for the top ten species. Two workdays focusing on Chinese tallow resulted from these efforts. The Treasure Coast CISMA has also provided plant and animal invasive species outreach at county fairs, state park events, Earth Day events, and through involvement with IFAS educational programs and training. More information about the Treasure Coast CISMA is available at www.floridainvasives.org/Treasure/.

Other CISMAs

In addition to 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 Cooperative Weed Management Area, and the 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 semimonthly meetings, agency representatives plan treatment species and areas. Consideration includes 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 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.

LEGISLATIVE AND POLICY INITIATIVES

NEW IMPORTATION RESTRICTION

The USDA Animal and Plant Health Inspection Service (APHIS) is changing the way it regulates importations of nursery stock into the United States. Formerly, some plants have been termed either fully prohibited or restricted (allowed under certain conditions). A new category, "Not Authorized Pending Pest Risk Analysis" (NAPPRA) took effect on June 27, 2011. This regulation restricts importations of species included on a list of plants USDA considers to be quarantine pests or hosts of quarantine pests. Such plants will not be allowed to be imported until a pest risk analysis has been completed.

A "quarantine pest" is defined as a plant pest or noxious weed that is of potential economic importance and not yet present in the United States, or present but not widely distributed and under official control. The new regulations authorize APHIS to add plants to the NAPPRA category based on scientific evidence that indicates that their importation poses a risk of introducing a quarantine pest into the United States. APHIS will request public comment through a public notice before adding any plants to the new NAPPRA category. The NAPPRA lists are expected to be posted online once available.

LACEY ACT CHANGES

The Lacey Act attempts to regulate the importation and transport of species, including offspring and eggs, that are determined to be injurious to the health and welfare of humans; interests of agriculture, horticulture, or forestry; and welfare and survival of wildlife resources of the United States. Proposed changes by the USFWS to the Lacey Act would classify the following large constrictors as injurious species: Indian or Burmese python, reticulated python (*Broghammerus reticulatus* or *Python reticulatus*), northern African python, southern African python (*Python natalensis*), boa constrictor (*Boa constrictor*), yellow anaconda (*Eunectes notaeus*), DeSchauensee's anaconda (*Eunectes deschauenseei*), green anaconda (*Eunectes murinus*), and Beni anaconda (*Eunectes beniensis*). Of these nine species, the Burmese python, northern African python, and boa constrictor are documented to have established populations in South Florida (Snow et al. 2007, Reed et al. 2010). Additionally, the green anaconda, yellow anaconda, and reticulated python have been collected in the wild in various parts of Florida (Krysko et al. 2011).

FUTURE NEEDS IN MANAGEMENT AND CONTROL

The elements of a comprehensive management program for 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 (*Porphyrio porphyrio*) in the Everglades and Gambian pouched rat (*Cricetomys gambianus*) 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. Recent additions to nonnative wildlife rules (Chapter 68-5, F.A.C.) increase the scope of existing rules, such as limiting the trade of the red-eared slider (*Trachemys scripta elegans*). However, more restrictions are needed to curb the purposeful and accidental release of nonindigenous animals into the South Florida environment. 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 Gambian pouched rats, sacred ibis (*Threskiornis aethiopicus*), and the invasive mangrove species *Lumnitzera racemosa* also appear to be 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, Noxious Exotic Weed Task Team, and Florida Invasive Animal Task Team 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 nineteenth year. Resource management agencies estimate this program has cost nearly $40 million to date. However, melaleuca is now under maintenance control on Lake Okeechobee and in the majority of the Everglades and Florida's melaleuca management program is a model for invasive species management nationally. The success of this program is largely attributed to integrated management approaches, sustained funding, and close interagency coordination, all of which foster information and technology transfer, regional strategic planning, increased financial efficiency, and improved public awareness.

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

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