Chapter 9: The Status of Nonindigenous Species in the South Florida Environment

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SUMMARY

In support of the collective activities of the many agencies involved in Everglades restoration, this chapter reviews the broad issues involving nonindigenous species in South Florida and their relationship to restoration, management, planning, organization, and funding. Previous consolidated reports used an "all-taxa" format for understanding and presenting an inclusive picture of the magnitude of the invasive species threats. This chapter builds on previous years' reports, providing highlights of nonindigenous species programs of importance to the South Florida Water Management District. While detailed information on many nonindigenous species remains unavailable, this document provides a status report and annotations for those species considered serious threats to Everglades restoration. Species impacts and a status report are provided for high-priority species. Supporting background information for many of these species, as well as management tools for controlling invasive species in South Florida, are presented in Chapter 9 of the *2006–2008 South Florida Environmental Reports – Volume I*. Numerous groups and agencies are involved with nonindigenous species management in Florida. A summary of these agencies and their corresponding tasks and responsibilities as they pertain to nonindigenous species is available on the Environmental Law Institute's web site at www.elistore.org/reports_detail.asp?ID=11002&topic=Biodiversity_and_Invasive_Species.

In addition to providing a status of nonindigenous species programs and outlining programmatic needs, this document also summarizes what, if any, control or management is under way for priority species. The stoplight table technique was established through coordination among the Science Coordination Group, the Noxious Exotic Weed Task Team, and the Florida Invasive Animal Task Team of the South Florida Ecosystem Restoration Task Force. Continued collaboration should lead to a coherent and integrated method for evaluating progress.

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INTRODUCTION

Florida, California, and Hawaii are the states with the most introduced invasive species at this time, yet every state is affected. Globally, invasive species – including pest animals, weeds, and pathogenic diseases – are a major cause of biodiversity decline. In particular, non-native animals compete for food and habitat, upset existing predator/prey relationships, degrade environmental quality, spread diseases, and threaten the integrity of flood protection levees and electrical power delivery. Nationally, more than 50,000 species of introduced plants, animals, and microbes cause more than $120 billion in damages and control costs each year (Pimentel, 2005).

There are 192 non-native animal species known to be established in Florida. There is a great need to develop methods to forecast and respond to the potential economic loss, environmental damage, and social stress caused by invasive species, whether they are new introductions or long-established organisms. The state lacks a cohesive program to manage these species, and interagency collaboration related to education, training, and broadening public awareness of these problems is piecemeal. Basic population analyses also are lacking. Several states, including California, Hawaii and Idaho, are devising invasive animal prevention programs and/or prohibited lists. There is a desperate need for federal initiatives to unify and standardize these efforts and provide a critical framework for evaluating existing and potential problems.

The South Florida Water Management District (SFWMD or District) maintains 2,000 miles of flood protection and water management canals in South Florida's 16 counties and is engaged on many ecosystem protection and restoration fronts. The District has a long history of successful invasive plant management and experience, but recently has had to commit resources to emerging populations of non-native invasive animals. Taxpayer-funded resources could instead benefit other important Everglades restoration efforts if effective preventative programs were in place to limit introductions of non-native plants and animals. Effectively preventing additional introductions is the only way to prevent such cost increases.

Managing invasive species is an important issue for the overall ecological health of South Florida's public conservation lands. This is underscored by the great number of plans, reports, statements, and papers written by numerous committees, state and federal agencies, public and private universities, state and federal task forces, and various other organizations. Most of these documents support an "all-taxa" approach. The consensus is that controlling and managing invasive nonindigenous species is a critical component of ecosystem restoration in South Florida. A summary of these efforts and plans is presented in Chapter 9 of the *2008 South Florida Environmental Report – Volume I* (SFER).

Sixteen different federal and state agencies, numerous local agencies, and two Indian tribes are involved in Everglades restoration and, therefore, in one or more activities related to managing, regulating, controlling, interdicting, and preventing invasive species in the region. Collectively, these agencies have management authority for more than 13.7 million acres (about 21,500 square miles) of Florida's natural lands. Individual agencies have identified 32 of the 66 priority plant species as particularly serious and specifically targeted for control (Doren and Ferriter, 2001). Documentation of problems associated with nonindigenous animal species in South Florida began only recently (Goodyear, 2000; A. Roybal, USFWS, personal communication).

KEY ISSUES

NEW LEGISLATIVE INITIATIVES

In 2005, Florida's Fish and Wildlife Conservation Commission (FWC) created an invasive animals management section. This move has led to a new Florida rule limiting commerce in "reptiles of concern" including the world's five largest non-venomous snakes and the carnivorous Nile monitor (*Varanus niloticus*). These animals were selected as most threatening because of their large size and extreme predatory natures. Currently under the Florida Administrative Code, the rule requires $100 annual possession permits and implanting identification microchips in the animals. However, these species were present in Florida's pet trade before the new rule and reportedly are in Florida's wilds. The FWC's exotic animals section remains a tiny, yet stalwart, unit with funding sufficient only to attempt serious management efforts against small populations of species, such as the Gambian pouch rat (*Cricetomys gambianus*), present only in isolated areas. State and local governments across the country are making these types of efforts to regulate deleterious, exotic and/or injurious animals. Efforts at the federal level are long overdue.

Establishing compulsory risk assessments and a "clean list" of approved species at the federal level represents a much-needed shift in the approach to regulating the flow of potentially harmful non-native wildlife into the United States. Specifically:

A national "gray list" of provisionally approved species is needed. Such a list could limit trade in species for which inadequate information exists to call for their complete prohibition. The list could be used to assess their full importation risks. Requirements could mandate that these animals, once imported, remain in special containment. This action would allow fair commerce while not allowing unlimited importation of a potentially harmful species.

A federal Non-Native Wildlife Invasion Prevention Fund is critical to the success of this initiative. Without such a self-funding mechanism, this complex and potentially contentious regulatory program is unlikely to succeed if funding were solely dependent upon annual congressional appropriations.

An emergency rule provision to give the federal government authority to place a species on the unapproved list, temporarily, is a vital component of a comprehensive program. It would prevent establishment of potentially harmful animals while scientific and official processes proceed.

INTRODUCTION PATHWAYS

There are many pathways for the introduction of invasive species. Manmade pathways – unintentional or intentional – are created or expanded by human activity. Examples of unintentional pathways are ballast water discharge (e.g., zebra and quagga mussels), soil associated with nursery stock (e.g., fire ants and nematodes), importation of fruits and vegetables (e.g., plant pests), escaped horticultural plants (e.g. pest plants), and international movement of people (e.g., pathogens). Examples of intentional introductions include the intended movement of living seeds, whole plants, or pets. A summary of invasive species vectors and pathways is provided by the National Invasive Species Information Center (www.invasivespeciesinfo.gov/toolkit/pathways.shtml). To date, Florida's most threatening and

damaging pest species, such as the Burmese python (*Python molurus bivittatus*) (see **Figure 9-1**), have come via the pet trade.

Whether accidentally or intentionally released, when an animal succeeds in establishing a new population, the impacts may be broad and devastating or they may barely be detected. It is difficult to predict. Better predictive methods are needed to gauge the risk posed by specific animals before they are imported, bred, and distributed as pets. Screening and risk assessment methods are imperfect, but must be developed. Several nations, including Australia and New Zealand, already have implemented pre-import screening and risk analysis systems that proscribe import of potentially harmful animals. Furthermore, new research indicates that proactive screening measures can be economically beneficial.

Building on these foreign successes, U.S. legislation and related funding would enable better information about what is being imported and determine what limits should be imposed on new species. The U.S. pet trade industry is not required to keep records or report importations of species that are not specifically regulated by the federal government. Record keeping and importation reporting is an important first step in understanding the scope of the issue across the nation. These business practices can be developed without tremendous adverse impacts on the pet industry and yield savings to U.S. taxpayers and decreased threats to the environment.

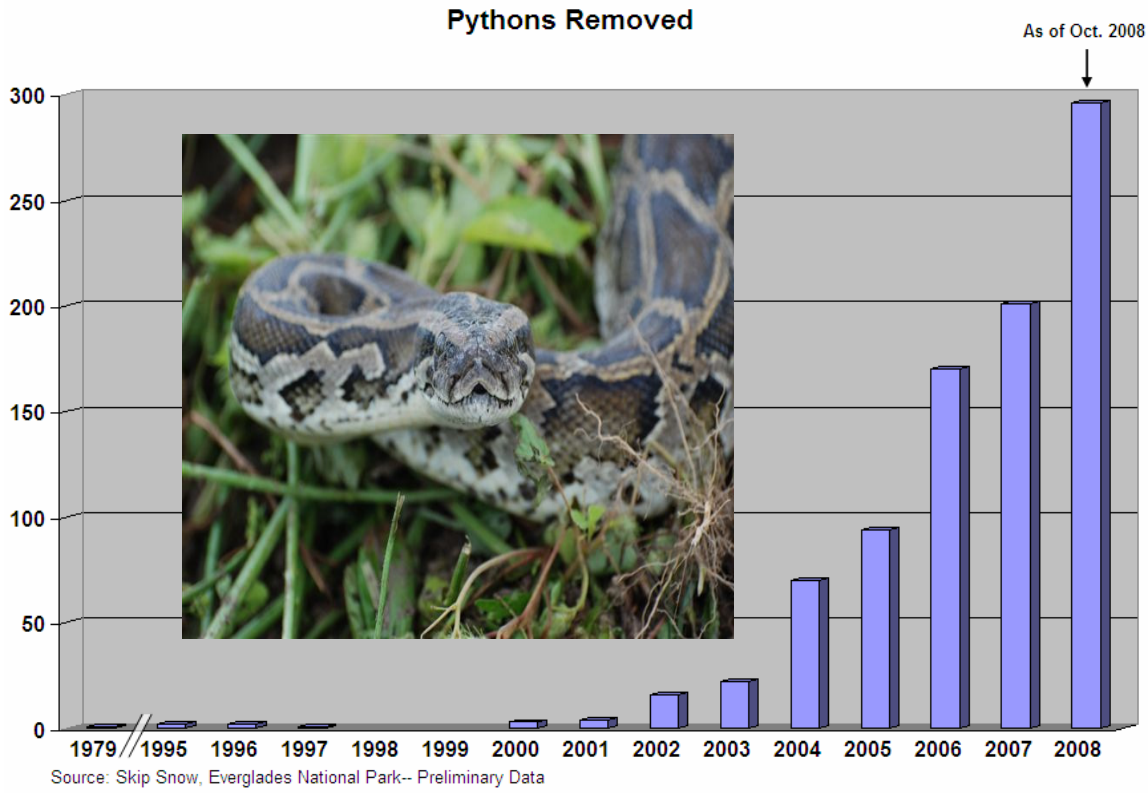

Figure 9-1. Number of Burmese pythons (*Python molurus bivittatus*) removed from Everglades National Park annually since 1979.

LIMITED IMPACTS OF PUBLIC EDUCATION

Public education programs can be creative, such as the nationally branded Habitattitude™ effort led by the Aquatic Nuisance Species Task Force. The program advises the public at pet shops never to release exotic aquatic fish and plants into any U.S. waters. Yet, releases continue regularly as evidenced by frequent appearances of new species in these waters.

Sailfin catfish (*Pterygoplichthys multiradiatus*) from South America appeared only within the past decade in Lake Okeechobee. Commonly sold under the name "plecostomus" as a fish tank "vacuum cleaner," these fish dig deep burrows in sediments and potentially threaten the integrity of canal banks and flood protection levees. They also are overtaking areas of rocky lake bottom, depriving native fish of their preferred spawning sites. The ultimate impacts of the establishment of this species in South Florida remain unknown, but many thousands of the fish already inhabit the District's lakes and canals, disrupting commercial fishing and displacing native species.

With no authority or potential for legal recourse, programs such as these have little proven impact on public behavior. Additional efforts are needed to strongly influence the public to recognize the risk inherent in releasing exotic pets into our natural areas. "Pet Amnesty Days" have been held in larger cities in Florida, and this may be a good way to reach the public and encourage responsible ownership.

PUBLIC HEALTH CONCERNS

Invasive vertebrate pests also may harbor other threatening organisms such as parasites and disease. The Gambian pouch rat has become established in the Florida Keys and serves as a vector for African monkey pox virus. The first human infections from this virus were reported in Africa in the 1970s, arising from contact with monkeys and rodents. In the United States, this virus was first reported infecting humans in 2003 and was traced to contact with pet African pouch rats. This disease spread to our shores directly as a result of importation of the Gambian pouch rat as pets. It is unclear what other species will be imported that carry unwanted diseases or parasites.

INNOVATIONS NEEDED

There may be creative solutions that enable trade in some otherwise invasive species. For instance, Asian grass carp (*Ctenopharyngodon idella*) are legal for use in aquatic weed control in Florida only when the fish are certified as triply chromosomed, sterile varieties created by treatments of the eggs. Research is needed to identify how other species could be rendered unable to establish wild populations. Tropical species could be legal for sale only outside their climate tolerance range, although some northern states such as Idaho have extensive geothermal resources that support nonindigenous tropical aquatic species. It is irresponsible and dangerous to continue trade in pest organisms capable of unlimited spread when, with appropriate research, credible ways can be found to allow responsible trade in some of these species.

THE DISTRICT'S ROLE

The South Florida Water Management District's Strategic Plan provides the agency and the public it serves with a blueprint for meeting the challenges of balancing the needs of the natural environment with the demands of Florida's growing population and important agricultural industries. Controlling nonindigenous species is cited as an important strategy and success indicator in the agency's Strategic Plan. Nonindigenous species management is listed as a deliverable in five of the 11 overall Strategic Plan goals. Successfully managing these species also is tangentially key to many of the other Strategic Plan goals as nonindigenous species impact everything from evaluating Environmental Resource Permits to managing Stormwater Treatment Areas (see **Figure 9-2**) to restoring natural fire regimes.

Figure 9-2. Aerial helicopter spraying for aquatic vegetation control over Stormwater Treatment Area 1 East in summer 2007 (photo by the SFWMD).

The District spent roughly 20 million in Fiscal Year 2008 for overall invasive plant prevention, control, and management in South Florida (**Table 9-1**). The agency has played a key role in the invasive plant management program in Florida for many years. Witness the unparalleled progress made regionally on species such as melaleuca (*Melaleuca quinquenervia*). Once covering hundreds of thousands of acres, this species now is only occasionally spotted by resource managers flying over Lake Okeechobee and the Water Conservation Areas. What seemed to be an insurmountable invasive species now is being successfully managed through sustained interagency commitment. While the importance of invasive plant management has reached mainstream status among local, state, and federal agencies, a similar response is sorely needed for nonindigenous animal species.

As presented in this chapter, the District and other regulatory agencies are attempting to contain the documented damage and growing threat of existing invasive animals in Florida. However, the flow of potentially harmful exotic animals into the state continues, while funding and regulations remain stagnant. For example, nearly 1,000 venomous African puff adders (*Bitis arietans*) were imported through Florida's ports between 2000 and 2005 [U.S. Fish and Wildlife Service, Law Enforcement Management Information System (LEMIS) data[. This viper is common in its native range and is one of Africa's most dangerous snakes. The Oriental water dragon (*Physignathus cocincinus)* is another popular imported species with a potential for establishment in South Florida. Between 2000 and 2005, over 210,000 Oriental water dragons were imported through Florida ports (LEMIS data). The District lacks the tools to accurately predict if either of these reptile species will become established in Florida, and there are no import restrictions on the pet trade. Rather than wait for the next Burmese python to become well established in Florida, a proactive approach to nonindigenous animals is urgently needed.

Table 9-1. Summary of invasive plant species control expenditures by the South Florida Water Management District in Fiscal Year 2008.

Plant Species	Lake Okeechobee	Kissimmee	Big Cypress	Greater Everglades	Northern Estuaries East	Northern Estuaries West	Systemwide Biological Control
Australian Pine *(Casuarina equisetifolia)*	--	--	--	$278,568	--	--	$20,000
Brazilian Pepper *(Schinus terebinthifolius)*	$142,004	$323,071		$1,030,065	$630,732	--	$49,000
Shoebutton Ardisia *(Ardisia elliptica)*	--	--	--	$341,509	$7,519	--	--
Old World Climbing Fern *(Lygodium microphyllum)*	--	$687,897	--	$537,071	$575,500	--	$150,000
Bodlegrass *(Luziola subintegra)*	$111,389	--	--	--	--	--	--
Melaleuca *(Melaleuca quinquenervia)*	$1,435	--	--	$3,992,911	$56,180	--	$150,000
Torpedograss *(Panicum repens)*	$1,764,322	--	--	--	--	--	--
Cogongrass (*Imperata cylindrica*)	--	$47,588	--	--	$1,366	--	--

PRIORITY NONINDIGENOUS SPECIES

OVERVIEW

In this chapter, priority nonindigenous species are summarized in species-based indicator tables to demonstrate the use of the indicator tool in gauging progress in overall agency-sponsored nonindigenous species control efforts as related to the restoration initiatives. Tables are presented where agency efforts to deal with the individual species are ongoing, where evidence suggests that these species are causing negative impacts, or to highlight the need for resources or early detection and rapid response efforts. Given differing agency priorities and responsibilities, a definitive "priority nonindigenous species list" may be years from being developed and accepted by resource management agencies in Florida. The following section provides a summary of nonindigenous species which threaten the success of the District's mission. These species were selected by District staff based on potential and current implications to District infrastructure and ecological concerns. These species are presented with a "District-centric" justification for listing, and it should be noted that priorities may differ for other agencies, depending on regional factors and agency priorities and goals. Speces-specific stoplight tables are presented in **Tables 9-2** through **9-14**. Selected species photos are presented in **Figures 9-3** through **9-18**.

Figure 9-3. Close-up of the monk parakeet (photo by the SFWMD).

It is important to note that there are many nonindigenous plant and animal species that occur throughout the region. These species include torpedograss (*Panicum repens*), cogongrass (*Imperata cylindrica*), giant toad (*Bufo marinus*), Cuban brown treefrog (*Osteopilus septentrionallis*), monk parakeet (*Myiopsitta monachus*) (see **Figure 9-3**), and feral dog (*Canis familiaris*). Additionally, the District has the country's largest aquatic plant management program, managing floating and submerged aquatic vegetation regionwide. While not all of these species are described in detail in this document, supporting background information and descriptions of management programs for many of these species are presented in the 2008 SFER – Volume I, Chapter 9.

Omitting specific mention of some of these species in the following priority summaries does not imply that the species are not problematic, or that control is not important. On the contrary, the need is urgent for distribution and biological data for these organisms, given their ubiquitous nature in South Florida. Additional information on those organisms not discussed in detail herein, is available from the University of Florida's extension documents or extension site at http://agronomy.ifas.ufl.edu/class_sites/PCB2441/list%20of%20species.htm. Additionally, information about aquatic plant management is available on the University of Florida's Center for Aquatic and Invasive Plants web site at http://aquat1.ifas.ufl.edu/.

MELALEUCA (*Melaleuca quinquenervia*)

SUMMARY

Before organized state and federal nonindigenous plant control operations were initiated in 1990, melaleuca (*Melaleuca quinquenervia*) was widely distributed throughout the Water Conservation Areas (WCAs), Everglades National Park (ENP or Park), Big Cypress National Preserve (BCNP), Lake Okeechobee, and Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge). Overall, agency efforts to control melaleuca are succeeding in containing and reducing its spread. Melaleuca has been systematically cleared from Lake Okeechobee, WCA-2A, WCA-2B, WCA-3A, WCA-3B, and BCNP; these areas are now under maintenance control.

KEY ISSUES

1) The District spearheaded the interagency Melaleuca Management Plan for Florida in 1990. Since the release of that strategic plan, agencies have worked systematically to control this species regionwide.

2) The first melaleuca biocontrol agent, a melaleuca weevil (*Oxyops vitiosa*), was introduced in 1997 and subsequently established throughout the region. To date, five biocontrol agents have been released against melaleuca in Florida.

3) Melaleuca biological control agents have been successful in decreasing flowering and slowing the spread of melaleuca. Biological controls complement other controls and are key to effective long-term management.

4) Herbicidal, mechanical, and physical controls are critical to controlling existing populations.

5) Florida's melaleuca management program is truly integrated and has become a national model for successful interagency coordination in dealing with a weed species.

Figure 9-4. Before (left) and after (right) of melaleuca-treated areas in the Lake Okeechobee region (photos by the SFWMD).

Table 9-2. Stoplight table for melaleuca (*Melaleuca quinquenervia*).

Management Issue	2008 Status		1-2 Year Prognosis	
Interagency Coordination	Interagency coordination has proven successful regionwide for this species.		Agencies will continue to work together to maintain melaleuca-free areas and bring other areas under maintenance control.	
Integrated Control	The region's melaleuca management program is integrated. Herbicidal, mechanical, physical, and biological controls are all used.		Herbicidal, mechanical, and physical controls continue as biological controls reduce rate of spread.	
Monitoring	Agencies monitor for this species in high priority public lands regionwide. Monitoring critical for long term maintenance control.		Agencies include monitoring in long-term maintenance control plans.	

 Red = Severe Negative Condition, or one is expected in near future, with out-of-control situation that merits serious attention.

 Yellow = Situation is improving due to reasonable control program and either is stable or moving toward stabilizing, or the species is still very localized but is expected to spread if sufficient resources or actions are not continued or provided. The situation could still reverse.

 Green = Situation is under control and has remained under control for several years, particularly where biocontrol is found to be effective. Where chemical maintenance control is in place, continuation of control efforts is essential to maintain green status.

OLD WORLD CLIMBING FERN (*Lygodium microphyllum*)

SUMMARY

Perhaps no other individual plant species poses a greater threat to the Everglades 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, which are all cited as key parameters in measuring Everglades restoration success. This species could potentially overtake most of the southern peninsula of Florida (Gann et al., 1999; Lott et al., 2003; Volin et al., 2004).

KEY ISSUES

1) When surveys for the species began in the early 1990s, Old World climbing fern occurred on limited tree islands in the northern quarter of the Refuge (Ferriter and Pernas, 2006). Today, it dominates many tree islands, and now occurs, at various levels of density, in virtually every habitat in the region.

2) The District conducted early work to determine Best Management Practices for this species in the late 1990s (Stocker et al., 1997). Several ongoing research initiatives are under way and include (1) determining the effects of fire as a post-treatment strategy on tree islands, (2) assessing post-fire recruitment of Old World climbing fern, and (3) monitoring the effects of repeated aerial herbicide applications on *Lygodium* and native vegetation.

3) Herbicides – either applied aerially or from the ground – are used to control the species in most areas. The District surveys for Old World climbing fern on tree islands and dispatches control contractors in an effort to control small populations of this species in WCA-2 and WCA-3.

4) Land managers statewide agree that biocontrol may be the key to effective long-term regional management of Old World climbing fern. There are two agents currently released; one has established in Florida and shows promise as a control agent.

5) A second *Lygodium*-feeding moth, *Neomusotima conspurcatalis,* was first released in South Florida on January 31, 2008 (see photos). Since its release, this moth has been found to be reproducing successfully in Florida and also is causing significant damage to Old World climbing fern. This was the second insect released as a biocontrol agent of Old World climbing fern. The first insect, *Cataclysta camptozonale,* also a moth, has not established self-sustaining populations in Florida to date.

6) In addition to the released agents, numerous other insects are being studied both in the field abroad and in the laboratory for their biology and host specificity. These include the sawfly (*Neostrombocerus albicomus*), noctuid moth (*Callopistria* spp.), pyralid moth (*Lygomusotima stria*), flea beetle (*Manobia* spp.), and stem-boring moths (*Siamusotima aranea*, *Ambia* spp. "S", and *Ambia* spp. "H".

Table 9-3. Stoplight table for Old World climbing fern (*Lygodium microphyllum*).

Management Issue	2008 Status		1-2 Year Prognosis	
Interagency Coordination	An interagency *Lygodium* Management Plan was developed for this species and agencies are coordinating to some extent.		Improved and expanded interagency coordination is needed.	
Integrated Control	Herbicidal control is effective with persistent monitoring and follow-up treatments for re-growth. Biological controls have been released, although effectiveness is still not documented, this method shows promise.		Herbicidal controls will need to be continued and follow-up treatments are critical for management programs. Effective biological control agents are needed for long-term, regional control.	
Monitoring	Agencies monitor high priority public lands. The District controls outlier populations.		Monitoring of adjacent and private lands will be critical for long-term, effective control.	

Red = Severe Negative Condition, or one is expected in near future, with out-of-control situation that merits serious attention.

Yellow = Situation is improving due to reasonable control program and either is stable or moving toward stabilizing, or the species is still very localized but is expected to spread if sufficient resources or actions are not continued or provided. The situation could still reverse.

Green = Situation is under control and has remained under control for several years, particularly where biocontrol is found to be effective. Where chemical maintenance control is in place, continuation of control efforts is essential to maintain green status.

Figure 9-5. Close-up (left) of *Lygodium*-feeding moth, *Neomusotima conspurcatalis*, released at Jonathan Dickinson State Park (right) (photos by the SFWMD).

AUSTRALIAN PINE (*Casuarina spp.)*

SUMMARY

Australian pine (*Casuarina* spp.) grows quickly; is salt tolerant; fixes nitrogen; readily colonizes rocky coasts, dunes, sandbars, islands; and invades far-inland, moist habitats (Morton, 1980) Efforts to control Australian pine are ongoing, but are not systematic or coordinated in approach. This species is still common along District levee berms, in the District's southern saline glades (C-111 basin), and Biscayne National Park.

KEY ISSUES

1) Australian pine threatens key habitat for the endangered Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis),* which needs the short-hydroperiod marl prairies of the southeastern Everglades to nest.

2) Herbicidal and mechanical control continues for Australian pine regionwide.

3) There are currently no biological controls available for this species in Florida.

4) Effective agency-sponsored Australian pine control is complicated by local and state initiatives to allow additional plantings of this genus in certain situations and/or prevent control of the species for aesthetic reasons. These actions hinder agency abilities to control these species regionally.

Figure 9-6. Australian pine toppled over along South Florida coastline following storm (photo by the SFWMD).

Table 9-4. Stoplight table for Australian pine (*Casuarina spp.*).

Management Issue	2008 Status		1-2 Year Prognosis	
Interagency Coordination	Interagency coordination to control this tree is lacking. Initiatives to plant or prevent control hinder agency success.		Interagency coordination to control this tree is lacking. Additional initiatives to plant or protect this tree will continue to hinder agency success for regionwide control.	
Integrated Control	Herbicidal and physical control continue in an un-systematic manner. However, when implemented, control programs can be very effective. Biological controls are not available.		Herbicidal and physical controls will continue, but program is not integrated and biological controls re not being developed.	
Monitoring	Agencies monitor for this species in high priority public lands.		Agencies monitor for this species in high priority public lands.	

 Red = Severe Negative Condition, or one is expected in near future, with out-of-control situation that merits serious attention.

 Yellow = Situation is improving due to reasonable control program and either is stable or moving toward stabilizing, or the species is still very localized but is expected to spread if sufficient resources or actions are not continued or provided. The situation could still reverse.

 Green = Situation is under control and has remained under control for several years, particularly where biocontrol is found to be effective. Where chemical maintenance control is in place, continuation of control efforts is essential to maintain green status.

BRAZILIAN PEPPER (*Schinus terebinthifolius*)

SUMMARY

Brazilian pepper (*Schinus terebinthifolius*) is the most widespread invasive species in South Florida. Operational control for this species is not systematic in approach on a landscape level, with the exception of the ENP's "Hole in the Donut" Project, where impenetrable monocultures of Brazilian pepper are controlled through the complete removal of previously farmed and rock-plowed substrate. This intensive process results in re-colonization by native wetland vegetation to the exclusion of Brazilian pepper. In contrast, many WCA tree islands and vast areas of the western coastal mangroves and marshes of ENP are dominated by Brazilian pepper. Resource managers face almost insurmountable obstacles in treating these populations due to the breadth and remoteness of the sites. This underscores the need for effective biological controls for this species.

KEY ISSUES

1) Brazilian pepper is the most widespread species in the District, occupying an estimated 700,000 acres (Ferriter and Pernas, 2005).

2) Brazilian pepper is spread by birds and other wildlife that consumes the seed, making it difficult to contain populations.

3) Resource managers control this species through the use of herbicides and physical and mechanical controls, but little region-wide progress has been made.

4) Biological controls have been under development since 1993, but to date there are no effective agents released in the state.

Figure 9-7. Close-up of plentiful berries on Brazilian pepper branch (photo by the SFWMD).

Table 9-5. Stoplight table for Brazilian pepper (*Schinus terebinthifolius*).

Management Issue	2008 Status		1-2 Year Prognosis	
Interagency Coordination	An interagency Brazilian pepper management plan was developed that called for the need for coordination, but to date little progress has been made.		There is a need to coordinate agency control programs if effective long-term control is to be achieved.	
Integrated Control	Herbicidal, physical, and mechanical controls continue in an unsystematic property by property approach. No effective biological controls.		Unless effective biological controls are released for this species, long-term control will be unachievable.	
Monitoring	Agencies monitor for this species in high priority public lands.		Agencies monitor for this species in high priority public lands. Adjacent private lands need to be surveyed as control is achieved on public lands.	

 Red = Severe Negative Condition, or one is expected in near future, with out-of-control situation that merits serious attention.

 Yellow = Situation is improving due to reasonable control program and either is stable or moving toward stabilizing, or the species is still very localized but is expected to spread if sufficient resources or actions are not continued or provided. The situation could still reverse.

 Green = Situation is under control and has remained under control for several years, particularly where biocontrol is found to be effective. Where chemical maintenance control is in place, continuation of control efforts is essential to maintain green status.

DOWNY ROSE MYRTLE (*Rhodomyrtus tomentosa)*

SUMMARY

Downy rose myrtle (*Rhodomyrtus tomentosa*) is a landscape shrub of Asian origin that now occurs throughout South Florida, overtaking native pinelands' understory. This fast-growing shrub spreads more prolifically than other nonindigenous plant species currently of concern. Consequently, this species was added to the priority plant list. Little is known about its biology and it is challenging to control with conventional methods. This plant is rapidly expanding in range.

Figure 9-8. Ground view of downy rose myrtle (photo by the SFWMD).

KEY ISSUES

1) This species is difficult to control. Recent herbicide trials show some promise in effectively controlling the species while showing selectivity in pine flatwood communities. Herbicide label changes related to where this product may be used in Florida will be required to manage this pest in natural areas.

2) Grows in extremely dense understory thickets. Information is needed related to its basic biology in order to develop an effective control program.

3) Wildlife consumes the fruit, exacerbating its spread.

4) The potential for biological control is being evaluated in its native range.

Table 9-6. Stoplight table for downy rose myrtle (*Rhodomyrtus tomentosa)*

Management Issue	2008 Status		1-2 Year Prognosis	
Interagency Coordination	Interagency coordination and systematic control are lacking.		Interagency coordination and systematic control are lacking.	
Integrated Control	Control of this species is poorly-understood.		Control technologies are being investigated, but unless integrated control is initiated, this species will continue to spread. Biological controls need to be investigated.	
Monitoring	There are no monitoring programs for this species regionwide.		There are no monitoring programs for this species regionwide.	

 Red = Severe Negative Condition, or one is expected in near future, with out-of-control situation that merits serious attention.

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BODLEGRASS (*Luziola subintegra*)

SUMMARY

In December 2007, a District biologist discovered a population of an unknown grass in Fisheating Bay on Lake Okeechobee during a routine lake inspection (Kunzer and Bodle, 2008). The population consisted of two large, near-monoculture mats in a portion of the lake bed that during the record low-water level of early June 2007 was completely exposed and bare of all vegetation. The grass was also found as both an emergent aquatic and a terrestrial inside the mouth of Fisheating Creek. Botanists at the University of South Florida identified the species, bodlegrass (*Luziola subintegra*), as new (and non-native) to Florida and North America. *L. subintegra* has a known distribution from Mexico southward through Central America and South America southward to Argentina, and the Caribbean basin. The District immediately began work to evaluate herbicidal controls for this species as a rapid response to this early detection in Lake Okeechobee.

KEY ISSUES

1) *Luziola subintegra* is unlike any other *Luziola* currently known to the United States. It is robust, with large, thick culms, and has leaves with inflated, spongy sheaths and long, broad blades. All of our other *Luziola* taxa can be described as delicate, slender plants with narrow culms, and shorter, narrower leaves (Kunzer and Bodle, 2008).

2) Given the extent of the current population and the plant's apparent fecundity, biologists have nominated this species for listing by the Florida Exotic Pest Plant Council.

3) District staff continues to screen herbicides to manage this grass species, which has proven difficult to control.

4) The Department of Environmental Protection and the District's Lake Okeecobee Division allocated money for this control program in an effort to prevent the grass from becoming more widespread in Lake Okeechobee.

5) Ecological research is needed to determine the potential impact of this species on Florida's natural systems, and to determine how widespread the infestation is.

Figure 9-9. Aerial view of bodlegrass in Lake Okeechobee (photo by the SFWMD).

Table 9-7. Stoplight table for bodlegrass (*Luziola subintegra*).

Management Issue	2008 Status		1-2 Year Prognosis	
Interagency Coordination	The Lake Okeechobee interagency group is actively involved in this early detection and rapid response project.		Continued interagency support is expected.	
Integrated Control	Herbicides are the only control option being evaluated at this point.		Herbicides will most likely be the only control technique used to control this limited population.	
Monitoring	Aquatic plant biologists are aware of the species on Lake Okeechobee and District staff continues to monitor known populations.		Populations will continue to be monitored by District staff throughout control operations. Follow-up monitoring will ensure long-term control.	

Red = Severe Negative Condition, or one is expected in near future, with out-of-control situation that merits serious attention.

Yellow = Situation is improving due to reasonable control program and either is stable or moving toward stabilizing, or the species is still very localized but is expected to spread if sufficient resources or actions are not continued or provided. The situation could still reverse.

Green = Situation is under control and has remained under control for several years, particularly where biocontrol is found to be effective. Where chemical maintenance control is in place, continuation of control efforts is essential to maintain green status.

Figure 9-10. Close-up of bodlegrass flowering in Lake Okeechobee (photo by the SFWMD).

BURMESE PYTHON (*Python molurus bivittatus*)

SUMMARY

The Burmese python (*Python molurus bivittatus*) is a top predator that is known to prey upon more than 20 native Florida species. Notable among these are the federally listed Key Largo wood rat, white tailed deer, American alligator, bobcat, and numerous wading birds common to the Everglades. The python also threatens agricultural interests as small livestock are also likely prey. In 2008, the U.S. Geological Survey published a climate tolerance model predicting that this snake will likely survive throughout most southeastern states and westward across the southern reaches of the country to the Pacific.

Figure 9-11. Close-up of the Burmese python (photo by the SFWMD).

KEY ISSUES

1) The pathway of invasion for the Burmese python is through the pet industry; pythons are still commonly sold in pet stores. Roughly 6,000 Burmese pythons were imported through the Port of Miami between 2003 and 2005. It is unknown how many Burmese pythons are bred in the United States. In an attempt to "cork the bottle," the District's Governing Board petitioned the U.S. Fish and Wildlife Service (USFWS) to list the Burmese python as an injurious species under the Lacey Act (42 U.S.C. § 18). The USFWS regulates international wildlife trade and addresses threats to native wildlife resources. A 1981 amendment to the Lacey Act allows for the regulation of importation or interstate commerce of animals that have been determined to be injurious to U.S. wildlife resources or humans. To date, no decision on this request has been made.

2) The 2007 Florida legislature passed Senate Bill 2766 which increases regulations for the capture, possession, transportation, or exhibition of reptiles of concern. The revised regulations increase the penalties for releasing pythons, anacondas, or other nonnative reptiles into the wild. The bill also authorizes the FWC to require annual registration fees for owners of listed reptiles, thereby limiting "impulse buys" that often lead to unlawful releases when large snakes become difficult to care for. In addition, the measure also increases the $1,000 bond required to exhibit reptiles or certain wildlife to $10,000.

3) Non-native Burmese python populations are continuing to expand at an alarming rate in the Greater Everglades, as documented in previous SFERs. As of October 2008, nearly 300 pythons were removed from the ENP and surrounding areas over the past year (see **Figure 9-1**). Currently, it is estimated that 5,000 to 180,000 Burmese pythons free range in the Everglades (Skip Snow, ENP, personal communication).

4) Observations of pythons exist primarily from three locations in the ENP: (1) along the Main Park Road in the saline and freshwater glades and mangroves between Pay-hay-okee and Flamingo, (2) in the greater Long Pine Key area (including Hole-in-the-Donut), and (3) in the greater Shark Valley area along the Tamiami Trail (including L-67 Ext.). The pythons have also been repeatedly observed on the eastern Park boundary, along canal levees, in the remote mangrove backcountry, and in BCNP. In recent years (2003–2007), individuals of all size classes, including fertile egg bearing females, have been seen with increasing regularity in and around the ENP.

Table 9-8. Stoplight table for the Burmese python (*Python molurus bivittatus*).

Management Issue	2008 Status		1-2 Year Prognosis	
Biology	Progress is being made to understand the biology of this species in order to develop better control technologies.		Dedicated funding is needed to support work in this area.	
Monitoring	Park and District staff began monitoring this species in 2004. This work was initiated without a formal program to deal with nonindigenous animals.		Dedicated funding and staff are needed to support this work to monitor the spread of this species and determine effective control options.	
Management Options	Work to develop management options has been slow to develop.		Resources and biological information are needed to develop an effective management program for this species regionally.	
Regulatory Tools	Federal regulations are ineffective in dealing with this and other animal species. It was not until 2007 that state regulations addressed the issues associated with this species.		State and local initiatives regulate this species; federal initiatives are needed.	

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 Yellow = Situation is improving due to reasonable control program and either is stable or moving toward stabilizing, or the species is still very localized but is expected to spread if sufficient resources or actions are not continued or provided. The situation could still reverse.

 Green = Situation is under control and has remained under control for several years, particularly where biocontrol is found to be effective. Where chemical maintenance control is in place, continuation of control efforts is essential to maintain green status.

Figure 9-12. Burmese python nest uncovered along the L-29 levee (photo by the SFWMD).

GAMBIAN POUCH RAT (*Cricetomys gambianus*)

SUMMARY

Gambian pouch rats (*Cricetomys gambianus*), native to Africa, were bred in captivity on Grassy Key in the Florida Keys. It is believed eight rats escaped between 1999 and 2002 and established a reproducing population. Its large size makes this species popular in the exotic pet trade, although the U.S. Food and Drug Administration (USDA) has banned their transport and sale because they are a carrier of monkey pox. Scientists are concerned that if this species is not eradicated, it will move onto adjacent keys, and then to Florida's mainland.

Figure 9-13. Ground view of the Gambian pouch rat (photo by the SFWMD).

KEY ISSUES

1) In February 2006, a pilot eradication project was initiated on Crawl Key where Gambian rat photographs were recorded in 2005. In June 2006, USDA-APHIS Wildlife Services deployed 94 bait stations. Supplemental trapping was done to obtain rats for radio telemetry.

2) From January to May, 2007, 1,000 bait stations were placed throughout Grassy Key hammock and residential areas. In March 2007, 20 Gambian pouched rats were trapped for the USDA APHIS National Wildlife Research Center for studies of more effective attractants and third generation rodenticides.

3) Intensive surveys using remote cameras and trapping were conducted in July and September 2007 to detect and eliminate any surviving Gambian pouch rats.

4) The program to control this species is a model for early detection and rapid response.

Table 9-9. Stoplight table for the Gambian pouch rat (*Cricetomys gambianus*).

Management Issue	2008 Status		1-2 Year Prognosis	
Biology	The biology of this species is fairly well understood.		The biology of this species is fairly well understood.	
Monitoring	This species was detected early, and monitoring is adequate for an effective and coordinated control program.		Monitoring for this species will continue indefinitely in the eradication zone.	
Management Options	Management options were developed through an effective interagency consortium.		Management options are effective for this species.	
Regulatory Tools	This species is regulated by the federal government and many state agencies.		This species is regulated by the federal government and many state agencies.	

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 Yellow = Situation is improving due to reasonable control program and either is stable or moving toward stabilizing, or the species is still very localized but is expected to spread if sufficient resources or actions are not continued or provided. The situation could still reverse.

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PURPLE SWAMPHEN (*Porphyrio porphyrio*)

SUMMARY

The purple swamphen (*Porphyrio porphyrio*) is a rail native to Australia, Europe, Africa, and Asia. They may have escaped from Miami Metrozoo after Hurricane Andrew in 1992 or from avicultural hobbyists (Pranty et al., 2000). Purple swamphens feed on shoots and reeds, invertebrates, small mollusks and the eggs and young of waterfowl. The original South Florida purple swamphen population is believed to have established in Pembroke Pines in 1996 (S. Hardin, FWC, personal communication). In recent years, purple swamphens have been sighted in WCAs and adjacent to the Everglades in STA-1W, STA-1E, STA-5, and STA-3/4. Numerous varieties of purple swamphen occur throughout the world with some separated as distinct subspecies. Florida has two varieties, one with blue head plumage, the other gray, although it is unclear whether they represent genetically different varieties or subspecies.

KEY ISSUES

1) Little is known about purple swamphens in Florida; most information comes from overseas research. Large concentrations of the purple swamphen could impact native water birds through competition for food and space and through direct predation. Most state and federal agencies view this non-native bird species as a potential threat to native water bird populations.

2) The consensus among land management agencies in Florida is that this species could be effectively controlled and possibly eradicated as part of an early detection and rapid response program, pending appropriate funding and expeditious implementation of a management and control program.

3) A cooperative removal program is under way in the STAs between the FWC and the District. Control of purple swamphens in the Refuge is coordinated through the USFWS Region 4 Invasive Species Strike Team. The FWC conducted a survey to document the absence/presence of this species on Florida's conservation lands, also producing a combination identification/fact sheet as a component of the initial survey package. To date, removal efforts have resulted in the removal of about 2, 000 individuals.

Figure 9-14. Ground view of purple swamphen (photo by Tony Wellington, used with permission).

Table 9-10. Stoplight table for the purple swamphen (*Porphyrio porphyrio*).

Management Issue	2008 Status		1-2 Year Prognosis	
Biology	Resource managers are learning more about the biology of the species to develop control programs.		Biological information for this species is improving as control efforts continue.	
Monitoring	District staff and other state and federal agencies are monitoring the Everglades for this species.		Monitoring efforts will continue in an effort to eradicate this species from the Everglades.	
Management Options	Agency staff dispatches this species as part of eradication efforts.		Management options will likely improve as the program progresses.	
Regulatory Tools	Potential for federal protection of this species under the Migratory Bird Treaty Act may hinder control options.		Federal and state regulations to restrict the ability to possess this species are needed to avoid future releases.	

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ISLAND APPLE SNAIL (*Pomacea insularum*)

SUMMARY

The island apple snail (*Pomacea insularum*) is a large (up to 10 cm) South American freshwater mollusk established in California, Texas, and Florida through the aquarium trade. This species has been nominated as one of the "100 World's Worst Invaders." Since its establishment in Southeast Asia and Hawaii in the 1980s, it has become the number one rice and taro pest, causing large economic losses. It has also been implicated in the decline of native apple snails in Southeast Asia. Likely impacts in Florida include destruction of native aquatic vegetation and serious habitat modification in addition to competition with native aquatic fauna. The continued spread of the island apple snail may be a problem for the endangered Everglades snail kite (*Rostrhamus sociabilis)*, in particular, if it outcompetes the native apple snail, *P. paludosa*, which is the primary food of the everglades kite. The snail serves as a vector for disease and parasites. Spread has commonly occurred as intentional introductions to wetlands, as discards from aquaria or, as reported in Asia, as releases to establish a food crop.

KEY ISSUES

1) Several species of South American apple snail are established in South Florida waters. The largest of these is the island apple snail reaching tennis ball size and producing many times more eggs than the smaller, native Florida apple snail. In Asia, these voracious mollusks are known to strip rice fields and wetlands of vegetation.

2) Recent taxonomic work (Tim Collins, Florida International University) indicates that the nonindigenous species previously known as the channeled apple snail (*P. canaliculata*) was incorrectly named and is in all actuality the island apple snail (*P. insularum*). The biology, distribution, and impact of this species remain the same; only the taxonomy has changed.

3) They are displacing the native Florida apple snail with sheer overwhelming numbers and reported predation upon the native snail. Apple snails are the sole food of the federally endangered Everglade snail kite. Lake Tohopekaliga, an 18,000-acre lake located in Central Florida, now harbors thousands of island apple snails. During recent years of drought, this lake has been a critical refuge for snail kites. Because the exotic snails are larger, heavier, and stronger than the native snail young snail kites have difficulty lifting and opening them to extract their meat. As a result, many young kites are not surviving to maturity there. Rice crops in South Florida and the vast wetlands of the Everglades may become fodder to this rapidly spreading, readily reproducing pest snail.

4) The USFWS has contracted for snail populations to be monitored in the future, although little work has been done to outline a control strategy for this nonindigenous species. Studies conducted to date by the University of Florida suggest that any molluscicide that will be toxic to the island apple snail will also be toxic to the native apple snail. The only possibility for differential control between the two snails would be to apply toxicants directly to the easily recognized bright pink exotic apple snail eggs (W. Haller, University of Florida, personal communication).

Table 9-11. Stoplight table for island apple snail (*Pomacea insularum*).

Management Issue	2008 Status		1-2 Year Prognosis	
Biology	The species is a notorious pest throughout the world. Information on its biology is available, although Florida-based work is needed.		Additional work is needed to understand this species' biology in Florida in order to develop effective control programs.	
Monitoring	To date, little comprehensive monitoring has been done to determine the distribution of this species.		State and federal agencies need to coordinate monitoring programs in order to develop a comprehensive management program.	
Management Options	University of Florida researchers are working to develop targeted controls for this species.		Additional work is needed to understand how to use control technologies on a regional basis. State and federal agencies need to dedicate additional resources to develop effective control strategies.	
Regulatory Tools	This genus is widely sold in the aquarium trade. Additional regulations are needed to curb the release of this and other Pomacea species.		Regulation of this genus is needed to prevent future releases while agency control efforts are under way.	

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Figure 9-15. Cluster of island apple snails (photo by Jesse Van Dyke, used with permission).

MONITOR LIZARD (*Varanus niloticus*)

SUMMARY

The African Nile monitor lizard (*Varanus niloticus*) was first noted in Cape Coral in 1990 (Enge et al., 2004). It is now established in a 20-square-mile area around Cape Coral, Florida. The lizard grows to seven feet and is highly aquatic, climbs well and runs quickly. Stomach content analyses indicate that the Nile monitor is a voracious egg eater, raising serious alarm for many of Florida's threatened native animals which are egg-bearing and/or occupy burrows. Wildlife biologists consider the Nile monitor to be a serious threat to gopher tortoises, burrowing owls, Florida gopher frogs and other ground nesting species. Although this large reptile species is an ill-suited pet, it is a popular novelty in the exotic pet trade. According to the USFWS Law Enforcement Management Information System (LEMIS), there were over 60,000 Nile monitors imported through Florida's ports between 2000 and 2004. The source of the Cape Coral population is undocumented, but researchers believe that several monitor lizards were either intentionally or accidentally introduced.

KEY ISSUES

1) This species has dispersed to nearby islands such as Pine Island (G.S. Player, USFWS, personnel communication), Sanibel Island (Brad Smith, SCCF, personnel communication) and the mainland, and has recently been observed in the sawgrass prairies in extreme southern Miami-Dade County (K. Krysko, Florida Museum of Natural History, personal communication). A number of individuals have been observed in a lake north of Orlando, and also along a canal in Palm Beach County, indicating that additional populations may be established around the state (T. Campbell, University of Tampa, personal communication).

Figure 9-16. Close-up of the monitor lizard (photo by the SFWMD).

2) The University of Tampa initiated an aggressive trapping program on Cape Coral. Unfortunately, funding for this program is not adequate. The Cape Coral population is now estimated at well over 1,000 individuals of various size classes and is increasing.

3) One of the biggest concerns is an impact to the "Ding" Darling Refuge on Sanibel Island, one of the most important bird sanctuaries in the state. Given the lack of funding to eradicate Nile monitors from Cape Coral and the surrounding area, land managers are trying to obtain funding to at least keep them off of neighboring Sanibel Island (T. Campbell, University of Tampa, personal communication).

4) A flier was produced and distributed with contact information to report Sanibel sightings in an effort to rapidly respond and remove the animals.

5) Research at the University of Tampa and the University of Florida aims to understand the basic biology – feeding habits, activity patterns, and reproductive cycle – of the species, information that is critical to developing an effective management plan for this reptile, which appears to be approaching an exponential rate of expansion in Southwest Florida.

Table 9-12. Stoplight table for the monitor lizard (*Varanus niloticus*).

Management Issue	2008 Status		1-2 Year Prognosis	
Biology	University research aims to understand the basic biology – feeding habits, activity patterns, and reproductive cycle – of the species.		Additional work is needed to understand the biology of this species. Funding is not adequate.	
Monitoring	University researchers have been working to monitor this species in the Cape Coral area.		Funding for the monitoring program is not adequate. Additional monitoring is needed in other areas of the state given recent sightings.	
Management Options	Local control programs are working to manage this species, but they are not well-funded.		Improved management options are badly needed and only active management in areas of the state where the species is spreading will contain the animal.	
Regulatory Tools	Popular pet novelty and sold widely to hobbyists. Regulation at the federal level needed.		Without regulation, this animal will contnue to be sold in the pet trade and releases will continue to occur.	

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BROMELIAD WEEVIL (*Metamasius callizona*)

SUMMARY

The Mexican bromeliad weevil (*Metamasius callizona*) was originally introduced to Florida via a shipment of bromeliads imported from Mexico. It was first detected in 1989, and is now found in 22 counties in South Florida (Frank and Thomas, 1994, Frank and Thomas, 2003, H. Frank, University of Florida, personal communication). The weevil is now attacking epiphytes in Big Cypress National Preserve, Florida Panther National Wildlife Refuge, and Fakahatchee Strand Preserve State Park. The weevil attacks native bromeliad species, including 10 that are state-listed as threatened and endangered, and one endemic species. Two of these bromeliad species were listed due to damage done to their populations by the weevil (F.A.C., 2000).

Figure 9-17. Close-up of the bromeliad weevil (photo by the SFWMD).

KEY ISSUES

1) Pesticides are used to effectively keep these weevils in check in cultivated bromeliads, but the use of insecticides is not feasible in natural areas due to the epiphytic nature of wild bromeliads and the potential for impacting native insects.

2) The University of Florida is working to track the spread of this insect and develop biological controls for the weevil. A biocontrol agent (the Honduran fly *Lixadmontia franki*) has been released. Baited traps will be monitored to determine whether the second generation of flies can find and parasitize the weevil (J. Frank, University of Florida, personal communication).

3) Additional field explorations have been and will continue to be conducted in Central America in search of supplementary biocontrol agents. Given the mounting obstacles in managing this pest with traditional chemical control methods, biological controls hold the only hope in controlling this species in Florida's wildlands.

Table 9-13. Stoplight table for the bromeliad weevil (*Metamasius callizona*).

Management Issue	2008 Status		1-2 Year Prognosis	
Biology	Work to understand the biology of this species is conducted as part of the biological control program. Funding is not adequate.		Additional work is needed to develop a comprehensive program to control this insect pest.	
Monitoring	The University of Florida is monitoring the species as part of ongoing work. Additional resources are needed.		Monitoring will continue, but without adequate resources, this work will not provide comprehensive distribution data.	
Management Options	Pesticides are used in horticultural operations, but are not practical in natural areas. A biological control agent has been released and is being monitored.		Effective biological controls will be key to the management of this insect. Additional agents are being investigated.	
Regulatory Tools	Considered a plant pest, so screening for additional introductions is done but inadequate.		Federal screening needs to improved to prevent this and other plant pests from being introduced and becoming established.	

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GREEN IGUANA (*Iguana iguana*)

SUMMARY

Central American green iguanas (*Iguana iguana*) already number in the hundreds of thousands in South Florida. High densities (up to 626 iguanas/km^2 have been reported for managed natural areas in South Florida (Smith et al., 2006; Smith et al., 2007; Smith et al., in press). Green iguanas prefer riparian sites where they dig extensive burrows on slopes such as highway embankments, canal banks and flood protection levees. The resulting erosion is very threatening to the District's water management canals and levees and countless other sites such as road and bridge embankments. Their burgeoning numbers in South Florida have recently spurred Palm Beach county commissioners to petition the Florida Fish and Wildlife Conservation Commission to add them to the state list of regulated "reptiles of concern."

KEY ISSUES

1) Green iguanas are popular in the pet trade and frequently escape or are released, although it is illegal to release iguanas and other non-native wildlife in Florida per Chapter 39-4.005, Florida Administrative Code.

2) District field observations of large groups of this species have increased dramatically in recent years and many canals and levees are now peppered with green iguana burrows. This extensive burrowing presents a maintenance liability to surface water infrastructure important to the C&SF and theEverglades restoration effort. Waterways and water structures with notably high numbers of green iguanas include the C-7, C-11 and C-1 West canals. Iguanas burrow into canal banks, leading to bank instability and bank erosion. District and NPS biologists have completed preliminary surveys of burrow characteristics to evaluate their impact on bank stability. Burrows tend to extend horizontally into the banks, ranging from 0.3 to 2.4 meters deep and generally from 10 to 20 centimeters in diameter. Recent evaluations demonstrate that moderate densities of green iguanas have definite economic impacts on bank integrity and maintenance costs (Sementelli et al., in review).

3) Green iguanas prey on tree snails, especially *Drymaeus multilineatus* in Key Biscayne (Townsend, 2005). In the Florida Keys, iguana feeding could have serious implications for populations of other snail species, such as the stock island tree snail (*Orthalicus reses*), federally designated as a threatened species, and the Florida tree snail (*Liguus fasciatus*), a state-listed species of special concern.

4) There are currently no agency-sponsored, coordinated control efforts for the green iguana in South Florida. Small-scale removal projects are in place (e.g., through a "Parknership" collaboration with the USDA-WS and Florida Park Service). Future controls likely will be implemented. However, given the region's expanding green iguana populations, impacts to water management operations and potential impacts of this nonindigenous species on native species such as the Florida burrowing owl are expected (Makie et al., 2005; Smith et al., in press).

Table 9-14. Stoplight table for the green iguana (*Iguana iguana*).

Management Issue	2008 Status		1-2 Year Prognosis	
Biology	The biology of the species is fairly well understood, mainly due to its popularity in the pet trade. Ecological impacts are not well documented.		Work is needed to understand the biology of the species in its introduced range. Ecological impacts need to be evaluated.	
Monitoring	This species is so ubiquitous that it is not monitored.		There are no plans to monitor this species regionally.	
Management Options	Management options are limited. Species is so widespread that control and management is problematic.		Management options are not likely to improve given the scope of the problem. Agency staff will be forced to prioritize areas where control is necessary.	
Regulatory Tools	Local governments are considering regulation of this species, although it is still widely available in the pet trade. These species are illegal to release in Florida. There are no federal regulations to address this issue.		Local governments will be forced to regulate this species due to the lack of federal initiatives.	

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Figure 9-18. Erosion by green iguana burrows along the C-7 canal (photo by the SFWMD).

CONCLUSIONS

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 document as priority species are being managed on public lands by local, state, or federal agencies. Unfortunately, that is not true of nonindigenous animal species. There are hundreds of nonindigenous organisms in South Florida with unknown distributions and invasive potentials. The threat of nonindigenous animals is becoming an important ecological and restoration issue for many agencies in Florida. Funding and coordinating are needed for a comprehensive nonindigenous animal management plan 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 control 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, and 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 nascent 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 South Florida.

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

Species like the purple swamphen in the Everglades and the Gambian pouch rat in the Florida Keys illustrate the need for state and federal 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 non-native wildlife rules (now housed in Chapter 68-5, F.A.C.) increase the scope of existing rules (limiting the trade of the red-eared slider, for example). However, many more restrictions are called for 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 in order 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 feasible.

The use of an early detection and rapid response (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. In addition, implementing EDRR programs is typically much less expensive than a long-term invasive species 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. Biological risk assessments are being developed (particularly for plants) to enable agencies to determine which species are most likely to become problems. 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 Noxious Exotic Weed Task Team and Florida Invasive Animal Task Team are attempting to initiate EDRR efforts. Species chosen by the Florida Invasive Animal Task Team as EDRR candidates are noted in Table 9-2 of the 2007 SFER – Volume I, Chapter 9, and include organisms such as the red palm mite (*Raoiella indica*) and redbay ambrosia beetle (*Xyleborus glabratus*), both of which do not currently occur in South Florida but present extreme risks if they establish.

An overarching theme in this document 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 and resource management agencies estimate this program has cost nearly $40 million to date. However, melaleuca now is under maintenance control on Lake Okeechobee and in the majority of the Everglades. Florida's melaleuca management program is a model for invasive species management nationally. Few states can point to species-based management efforts that are as well planned and executed.

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