# Chapter 14: Exotic Species in the Everglades

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## SUMMARY

Invasive exotic species have become one of the most serious global environmental problems today. Florida is listed with California, Hawaii and Louisiana as one of the states with the most non-indigenous species. Currently, more than 26 percent of all animals found in Florida are non-native. Also, one-third of Florida's flora is now composed of exotic plant species.

In compliance with the Everglades Forever Act of 1994, the South Florida Water Management District has a well-established program that monitors the distribution of invasive plants. This program also manages exotic pest plants with emphasis on the Everglades Protection Area. Invasive plant management methods include biological control, herbicide application, physical removal and physical treatments, such as water level manipulation and prescribed burning. Prevention measures should aim to reduce current stands and halt further spread of the nuisance species already established in Florida. However, prevention measures are also needed to halt the introduction of new invasive species. Varied mandates and legislation have supported exotic species management. However, doubts remain whether fully integrated programs can be developed to overcome obstacles currently limiting effective management throughout the region.

Of approximately 220 species of exotic plants recorded in Everglades National Park, very few are major nuisance plants. These include melaleuca (*Melaleuca quinquenervia*), Old World climbing fern (*Lygodium microphyllu*m), Brazilian pepper (*Schinus terebinthifolius*) and Australian pine (*Casuarina* spp.). Melaleuca has long been a major threat to the Everglades; however, aggressive management and continuous funding have successfully reduced the melaleuca population in the past decade. Old World climbing fern has now supplanted melaleuca as the single greatest threat to the greater Everglades ecosystem. A regional approach is essential to effectively contain these pests.

While melaleuca management is proving to be successful on public lands, adjacent private properties continue to harbor the plant. Effective control may require the expenditure of public funds on private lands or incentives for control of plants on private lands, such as property tax breaks. While state and federal mandates and legislation have supported invasive plant management, exotic animal problems are poorly understood and their management efforts suffer from a lack of basic ecological information including

exotic animals' distributions, impacts and possible countermeasures. Such basic information is needed to inform both planning efforts and supportive legislation. For the Fiscal Year 2001 (October 1, 2000, through September 30, 2001) the Science Coordination Team has recommended enhanced funding for the Invasive Species Control Strategy Program under the Critical Ecosystem Studies Initiative. However, funding for exotic animal studies was not included. Information gaps and future research needs remain for dozens of lesser known plant and animal species, none of which are subject to any control at this time. There is a great need to identify those species most likely to develop into serious problems and begin management during their incipient phase of expansion, or, best of all, prior to their introduction.

Generally speaking, the problems facing invasive exotic species managers need to be regionalized. Multifaceted programs must maintain current management efforts, support basic research, encourage management on private lands and establish effective programs to prevent new exotic species introductions.

**Figure 14-1.** Old World climbing fern's fertile fronds are one of many threats in the Everglades. State and federal agencies are working hard to control the most invasive exotic species in the Everglades.

# INTRODUCTION

Invasive exotic species have become one of the most serious global environmental problems today (IUCN, 1998). A recent Cornell University study found that invasive species - plants, mammals, birds amphibians, reptiles, fish, arthropods and mollusks - cost the United States alone about $137 million annually. Such losses and costs will inevitably continue along upward trends, especially if efforts are scattered. Planning, resources and actions must be integrated effectively to turn back the overwhelming invasions of numerous invasive species.

Florida is listed with Hawaii and California, and now also Louisiana, as one of the states with the most non-indigenous species. South Florida contains more introduced animals than any other region in the U.S. With an estimated 26 percent of all resident mammals, birds, reptiles, amphibians and fish not native to the region, South Florida has one of the largest non-indigenous faunal communities in the world (Corn et al., 1999; Ewel, 1986; Gore, 1976; McCann, et al., 1996; OTA, 1993; Shafland, 1996a; Simberloff, 1996). Thirty years ago, a Smithsonian publication described tropical Florida as a "biological cesspool of introduced life" (Lachner et al., 1970).

# INVASIVE SPECIES AND EVERGLADES RESTORATION

The topic of invasive species has been identified as an issue since the beginning of the Everglades restoration effort. Several organized efforts and mandates have highlighted the problems associated with exotic species in the Everglades region. Control and management of invasive exotics are the priorities established by the South Florida Ecosystem Restoration Task Force (SFERTF) in 1993. One of the tasks in the 1993 charter for the former Management Subgroup (December 16, 1993) was to develop a restoration strategy that addresses the spread of invasive exotic plants and animals. The U.S. Fish and Wildlife Service was designated as lead agency for this strategy and submitted a brief strategy report (Carroll, 1994). This report highlighted some of the issues: Only a limited number of species is designated as "nuisance" species and can be prohibited by law; screening processes are deficient; responsibilities remain vague; there is a lack of awareness and knowledge of the harmful impacts; and there is an urgent need for coordination and cooperation to eliminate exotics. The greatest obstacle in combating non-indigenous species was identified as the lack of sufficient funding and manpower to stay ahead of problems.

The first Annual Report of the South Florida Ecosystem Restoration Working Group in 1994 addressed non-indigenous species. The overall objectives for the restoration effort, as stated in the report, are the same for all non-indigenous species, whether plant or animal: (1) to halt or reverse the spread of invasive species already widespread in the environment; (2) eradicate invasive species that are still locally contained; and (3) prevent the introduction of new invasive species to the South Florida environment. The existing Everglades Program (see Chapter 1) also has an exotic component.The Everglades Forever Act of 1994 requires the District to establish a program to monitor

invasive species populations and coordinate with other federal, state and local governmental agencies to manage exotic pest plants with emphasis in the Everglades Protection Area.

The Scientific Information Needs Report (Science Subgroup, 1996) contains a region-wide chapter on harmful non-indigenous species. One of the overall regional science objectives for the restoration is to develop control methods on exotics at entry, distribution and landscape levels. The specific objectives for work on non-indigenous species are to (1) halt and reverse the spread of invasive naturalized exotics, and (2) prevent invasions by new exotic species. The major issues in South Florida are: inadequate funding for scientific investigations to develop effective controls; lack of funding to apply control methods to problem species; and delays and lack of consistency in responses to new problems. Most resources on non-indigenous animals have been focused on agricultural pests, with little on investigations of species that threaten natural areas. Particular information needs are: studies to develop control technology; basic biological and ecological studies to improve understanding of invasive exotic species (e.g., how will water management alterations affect non-indigenous plants and animals; what are the principal controls on expansion of a species; what are the impacts of invasive species on native species and ecosystems; what makes a natural area susceptible to invasion?); and screening and risk assessment technology to help focus on the greatest potential problems. Overall, the major issue is the lack of meaningful information concerning the effect of non-indigenous species on South Florida.

The Comprehensive Review Study Final Feasibility Report and PEIS (COE & SFWMD, 1999) addresses the presence of exotic animals as one of several factors that preclude any serious consideration of achieving true restoration of the natural system, one in which exotic species are not present. It discusses how removal of canals and levees, which act as deepwater refugia for exotic fish and conduits into interior marshes for other species, is expected to help control exotic species by slowing further movement into relatively pristine areas. On the other hand, restoration of lower salinities in Florida Bay might result in increases of reproductively viable populations of exotic fishes, such as the Mayan cichlid, in the freshwater transition zone, and this must be addressed during detailed design.

The Department of the Interior's (DOI's) Fish and Wildlife Coordination Act Report (FWS, 1999a) for the Comprehensive Everglades Restoration Plan (CERP) considers control and management of non-indigenous species, a critical aspect of ecosystem restoration in South Florida and discusses the effects of the present canal and levee system and of the preferred alternative on the distribution of non-indigenous animals. Some components of the Comprehensive Plan involve construction of canals and reservoirs, which could provide additional conduits from points of introduction into the Everglades for species such as fish, amphibians, and snails; other components involve removal or partial removal of canals, which should reduce the spread of exotic fishes. Removal of levees, which act as artificial terrestrial corridors into the wetland landscape, should reduce the spread of species such as the fire ant. The DOI recommended establishment of an Exotic Animal Task Team to work on the issue during detailed planning for removal of existing structures or construction of new facilities as part of CERP. This team should have the goal of developing an exotic animal plan of action in the next five years. In relation to planned water preserve areas and flow-ways, it was recommended that an aggressive plan be developed for the perpetual removal of invasive exotics, both plants and animals. It was also recommended that existing control measures

should be accelerated, more effective techniques should be developed, and regulations should be revised and better enforced to prevent additional introductions of exotic species (FWS, 1999a). The U.S. Army Corps of Engineers and the District (SFWMD, 1999) responded that in CERP that this recommendation [team] should be presented to the South Florida Ecosystem Restoration Task Force.

Several other plans and reports also include exotics. The Coordination Act Reports (GFC, 1999) from the Florida Game and Fresh Water Fish Commission (now the Florida Fish and Wildlife Conservation Commission) emphasize that the extent of the canal system's role in the spread of exotic fishes into natural marshes, as opposed to the fish remaining primarily in the disturbed areas, is debatable. The draft report, A New Look at Agriculture in Florida (Evans, 1999), discusses the introduction of exotic pests and diseases as a serious obstacle to sustainable agriculture and the importance of exclusion and control strategies.The South Florida Multi-Species Recovery Plan (FWS, 1999a) identifies exotic animal control as a restoration need for two-thirds of the ecological communities and the individual species covered in the plan. In addition, the South Florida Regional Planning Council's 1991 and 1995 regional plans for South Florida list the removal of exotic plants and animals and discouragement of introductions as regional policies (SFRPC 1991, 1995).

The Science Coordination Team has recommended enhanced funding of $500,000 for the Invasive Species Control Strategy program under the Critical Ecosystem Studies Initiative for Fiscal Year 2001. This work would have included exotic animals (SCT, 1999). The final initiative request, however, was for $95,000; present funding is $150,000 (W. Perry, NPS, pers. comm.).

On a national level, President Clinton's 1999 Executive Order on Invasive Species (EOIS) further recognizes the threats posed by invasive species and authorizes a national invasive species council which shall, among other duties, prepare a national management plan for invasive species.

## NOXIOUS EXOTIC WEED TASK TEAM

As a result of the priorities established by the South Florida Ecosystem Restoration Task Force and Working Group, the Noxious Exotic Weed Task Team (NEWTT) was established and funded in 1999. NEWTT is a direct working team of the South Florida Ecosystem Restoration Task Force and Working Group. NEWTT has two main directives. The first is the development of an assessment to characterize the current problems with invasive exotic plants in southern Florida, and to identify the highest priority invasive species for control. The second directive calls for the development of a comprehensive interagency strategy for elimination or control of the highest priority species and management to control and minimize the spread of other pest plant species.

## NON-INDIGENOUS ANIMAL SPECIES

The task team is made up only of government agencies—federal, state and local. In order to comply with the Federal Advisory Committee Act and Florida's Sunshine laws, all NEWTT meetings are open to the public. While non-governmental organizations (NGOs) are not an official part of NEWTT, Florida's Exotic Pest Plant Council provides advice and peer review. Task team members are land managers and scientists from key federal, state and local government agencies that deal with exotic pest plant issues.

NEWTT has been charged with developing a comprehensive strategic plan covering the issues and problems of exotic pest plants in Florida with programmatic and management focus on the Everglades. However, a statewide perspective has been used in developing this strategic plan because any plan that addresses the issues of exotic pest plants cannot do so in a fragmented geographic or political framework. Federal, state and local governmental policies affect, interact and sometimes contradict one another, and must be addressed synthetically. In addition, the issues and experiences learned regionally (regarding control method development, research results, public education, technology transfer, policy, regulation and funding) affect all agencies and programs throughout the state. In turn, national level issues related to exotic pest plants affect state and local policies and programs.

The effort to address exotic animals in the Everglades has lagged behind that of invasive plants. While it is relatively easy to determine the extent to which nonindigenous plants invade native areas, the impact of nonindigenous animals on native communities and on those species with which they compete directly is frequently less obvious (Schmitz and Brown, 1994). Several reports have highlighted this difficulty.

- The Multispecies Recovery Plan (FWS, 1999b) states:

> *"It is probably safe to say that the most severe exotic species threats to the South Florida Ecosystem come from plants, rather than animals. Therefore, the emphasis on exotics in Florida has been on flora, rather than fauna."*

- The Scientific Information Needs report (SSG, 1996) stated the problem this way:

*"The role of nonindigenous animals in South Florida natural areas is so poorly documented that it is difficult to design and mount an effective effort to control those that are harmful to native plant and animal communities."*

- In the book *Everglades, the Ecosystem and its Restoration,* Robertson and Frederick (1994) are more blunt and state:

*"Although biologists were quick to anticipate the developing problem, their concerns and pleas for regulation have been thoroughly overrun by events…Any present attempt to assess the overall threat posed by nonnative animals to the integrity of the Everglades ecosystem seems futile…In addition, thought may tend to become paralyzed by the obvious, perhaps insurmountable, difficulty of effective countermeasures."*

In spite of the daunting conclusions above, the SFERTF Working Group has been gathering information that is available as a basis for an assessment of the problem. In February 1998, the Working Group established an *ad hoc* interagency team to focus on South Florida and evaluate the status of nonindigenous animals in all habitats (freshwater, marine and terrestrial), describe efforts underway to deal with them, and identify agency needs and problems (Goodyear, in prep.).

Non-native animal species of concern include insects, marine and freshwater fish and invertebrates, reptiles and amphibians, mammals and birds. Species currently held to be of the greatest concern include: feral pigs (*Sus scrofa*), Norway and black rats (*Rattus norvegicus* and *R. rattus*), nine-banded armadillo (*Dasypus novemcinctus*), European starling (*Sturnus vulgaris*), brown caiman (*Caiman crocodilus*), Tokay gecko (*Gecko gecko*), spinytail iguanas (*Ctenosaura pectinata*, *C. similis*), Cuban knight anole (*Anolis equestis*), brown anole (*Anolis sagrei*), Boa constrictor (*Boa constrictor*), Burmese python (*Python molurus*), Cuban treefrog (*Osteopilus septentrionalis*), Asian swamp eel (*Monopterus albus*), bromeliad weevil (*Metamasius callizona*), Diaprepes weevil (*Diaprepes abbreviatus*), brown citrus aphid (*Toxopotera citricida*), red fire ant (*Solenopsis invicta*), Pacific whiteleg shrimp (*Liptopinaeus vannamei*), zebra mussel (*Dresseina polymorpha*), red-rimmed melania aquatic snail (*Melanoides tuberculata*) and banded tree snail (*Orthalicus floridensis*).

The SFERTF non-native animals report is being developed to provide a broad picture of the status of non-indigenous animal species in South Florida. It will focus on the agencies, along with their respective departments, that are represented on the Working Group. This report is to be used as a basis for the Working Group to: (1) evaluate its members' priorities relative to nonindigenous animals; and (2) determine if and how it might assist the work of individual agencies, enhance interagency collaboration, and integrate South Florida efforts into state, regional, or national programs. The ultimate goal of any further efforts would be to develop a system-wide action plan to address nonindigenous animals in the South Florida ecosystem.

# INVASIVE EXOTIC PLANTS OF THE EVERGLADES PROTECTION AREA

Management and coordination efforts for invasive exotic plant species have been in place for more than a decade in the Everglades Protection Area. The Exotic Pest Plant Council (EPPC) was formed in South Florida in 1984 in response to the increasingly severe problems caused by exotic plants in the Everglades region. Florida EPPC is a professional organization made up of public and private sector members from over 40 different agencies and corporations and includes botanists, ecologists, biocontrol researchers, entomologists, chemists, plant physiologists, land managers and others. The wide-ranging backgrounds of the members have allowed EPPC to facilitate communication and education, provide a forum for discussion, provide advice on research, management and control, and serve as an advisory body to other groups or agencies.

From the beginning, the number one enemy of Florida EPPC was melaleuca (*Melaleuca quinquenervia*) in the Everglades. Much of the initial progress made in controlling melaleuca in South Florida stemmed from the coordination provided by EPPC. A successful effort led by EPPC resulted in the listing of melaleuca as a federal noxious weed by the USDA; EPPC petitioned the USDA to begin research on the use of biological control agents to control melaleuca; and perhaps most importantly, EPPC led the charge in developing a statewide management plan for melaleuca.

In early 1990, EPPC and the District jointly convened a task force of federal, state and local land managers, scientists and others. The goal of this "Melaleuca Task Force" was to develop a comprehensive plan for managing melaleuca. The Melaleuca Management Plan for Florida (1990) was a first in the field of exotic plant management in the state. It serves as a framework for facilitating interagency cooperation and coordination of control efforts, improving resource sharing, enhancing public awareness, and has inspired legislative support. By bringing agencies and organizations together, EPPC provided an unparalleled forum for the development of this species-based management plan. Based on the success achieved through the Melaleuca Management Plan, a Brazilian Pepper (*Schinus terebinthifolius*) Management Plan for Florida has been developed (1997), and a statewide management plan for lygodium (*Lygodium* spp.) is under development. These plans are key to successful species-specific regional management efforts.

EPPC has developed a list of Florida's most invasive plant species to help resource managers focus and prioritize management efforts related to natural area weeds (Langeland and Burks, 1998). The list is made up of two categories of plants. Category I plants are non-native species known to have invaded Florida natural areas - they are displacing native plants or otherwise disrupting the natural community structure and/or function. Placement in this category is derived from observed ecological damage and does not depend on economic severity of the problem or its geographic extent. Category II species are plants that are considered to have a real potential to become Category I problems, but are not yet known to be disrupting natural area communities. The list is revised every two years by consensus of the committee members.

The 1999 EPPC list includes 65 Category I plants. Some of these plants have only been observed as invasive in regional areas. Chinese tallow (*Sapium sebiferum*), for example, is a major pest in Central and Northern Florida, but it has not been reported as widespread in natural areas in South Florida. In contrast, melaleuca is generally regarded – almost exclusively - as a South Florida problem.

In the entire Everglades region, there are hundreds of exotic plant species. In WCA-2, 52 exotic plant species have been identified as naturalized (Bradley et al., 1997). Of the approximately 220 species of exotic plant species recorded in Everglades National Park (the Park) today (Whiteaker and Doren, 1989; McCormick, C.M., 1999), nearly 50 species (23 percent) belong to EPPC's Categories I and II. The majority of these species occurs in limited areas, and do not pose a direct threat to native plant communities. However, plants like melaleuca, Brazilian pepper, Australian pine (*Casuarina* spp.), and Old World climbing fern (*Lygodium microphyllum*) are causing widespread damage to native communities throughout South Florida, and are considered species of primary concern because they have invaded a widespread area and have the potential to severely disrupt native plant communities and/or water delivery systems. EPPC's determinations of a plant's native status are derived from the best available taxonomic information. Species are determined to be invasive or non-invasive based upon experience of natural areas managers. Thousands of their field observations of invasive plants occurrence and growth habits are chronicled in EPPC's invasive species reports database.

The biannual publication of EPPC's list of Florida's most invasive plant species (begun in the 1980s), the Park's list of exotic pest plants in prioritized categories by Whiteaker and Doren (1989), and exotic plant surveys have resulted in greater interagency efforts to manage exotic species regionally. Through increases in funding, volunteers in the field (e.g., the Park's Volunteers-in-the-Parks Program, Miami-Dade County Service Corps Program, and the Student Conservation Association's Americorps Program), the availability of improved mapping and remote sensing work, and regional cooperation among government agencies and non-governmental organizations, some of the most disruptive and potentially disruptive species known to occur in the Everglades region are being controlled and/or monitored to some degree today.

Detection of relatively new (not widespread) invasive species or small infestations of invasive exotic plants is key to developing successful management plans. The Everglades Forever Act (Act) mandates that the District conduct biannual surveys of exotic plants in the Everglades region. Since 1993, the District has tracked four target species regionally. This program attempts to document the status, distribution, rates of expansion, and habitat preferences of Old World climbing fern, melaleuca, Brazilian pepper and Australian pine region-wide (excepting large metropolitan areas). Aerial transects are flown across the state, and the presence of the primary exotic species, these four primary species' relative density, and the presence of other exotic species, if any are recorded. Observers also note areas where treatment programs have been implemented. Surveying large regional areas allows resource managers to establish trends in exotic plant populations. These data can be used to prioritize the allocation of management funds and assess management success for the entire South Florida region.

The first Parkwide distribution maps of major exotic plant species – melaleuca, Brazilian pepper, Australian pine, and latherleaf (*Colubrina asiatica*) – were produced in 1988 using color infrared photographs (1:10,000 scale) recorded in 1987 (Rose and Doren 1988). A recent effort to map these same species, with the addition of shoebutton ardisia (*Ardisia elliptica*), uses 1994-95 color infrared photography (1:40,000 scale) and

is part of a cooperative vegetation classification and mapping effort between the National Park Service and The University of Georgia (McCormick, C.M., 1999). Seventy percent of the park has been mapped; mapping is in progress for the northern portion of the Northwest District, parts of Shark River Slough and the Whitewater Bay area, and eastern portions of the Park.

## MANAGEMENT EFFORTS

Other exotic species have not been tracked regionally because their population sizes, densities, spatial extents, and environmental impacts are significantly lower or unknown. Based on field observations and published information, particularly Whiteaker and Doren (1989), these species are widely scattered and are represented by everything from single individuals to dense, generally localized populations of varying size and occur in natural, cultural (artificial), disturbed, and undisturbed landscapes. The most widespread (on both local and regional scales) and disruptive of these species have received the greatest attention. Similarly, the Act further requires that the District's program give highest priority to the species affecting the largest areal extent within the Everglades Protection Area. The Act also requires that the District coordinate with federal, state and other Government entities the control of exotic species within the Everglades Protection Area.

The District has been closely coordinating all vegetation management efforts with other agencies within the Everglades Protection Area since 1990. The primary forum for this coordination has been through the Florida Exotic Pest Plant Council. This close coordination has resulted in detailed species-based management plans (Melaleuca Management Plan, Brazilian Pepper Management Plan, Lygodium Emergency Action Plan), and a maximization of all available management resources. In addition, the District has been required to get a permit from the Florida Department of Environmental Protection (Department) for all vegetation management activities in public waters since 1979. The permit process has helped to bring peer review and consistency to management approaches Statewide. Within the Everglades Protection Area, floating aquatic plant control in canals has been coordinated with the U.S. Fish and Wildlife Service and Everglades National Park since the early 1970s. Specifically, as it relates to water hyacinth and water lettuce spraying and/or harvesting in and around the S-10 and S-12 structures, and within the L-7, L-39, L-40 and the L-29 canals.

### Priority Species

As required by the Act, the District assembled a meeting with representatives from the Department, the U.S. Army Corps of Engineers (USACOE), the U.S. Fish and Wildlife Service (USFWS), and the National Park Service (Everglades National Park and the Big Cypress National Preserve) in 1996. This list is not derived from the Florida EPPC list Category I invasive plant list. Rather, it is a collective list of "priority species" for the Everglades Protection Area. Melaleuca, Brazilian pepper, and Australian pine are problematic throughout the Everglades Protection Area and are a collective top three problematic plants. Melaleuca has long been recognized as a major threat to the Everglades; however, aggressive management efforts in recent years have reduced the melaleuca population on public lands resulting in a shift in concern to Old World climbing fern. There is consensus among South Florida land managers that Old World climbing fern now represents the single greatest threat to the greater Everglades ecosystem (Ferriter, 1999).

Old World climbing fern was first noted in the Arthur R. Marshall Loxahatchee National Wildlife Refuge in the early 1990s. A 1993 survey found the fern on a few localized tree islands in the central to north-central portion of the Refuge. By 1995, aerial surveys revealed that the fern occupied approximately 17,500 acres; by 1997, this number had risen to 22,000 acres. The fern readily invades tree islands. It is capable of completely overtaking a large tree island in less than 5 years. Refuge staff estimates that the fern is now present - at various stages of development - on 85 percent of the tree islands in the Refuge. In 1999, resource managers began treating populations of Old World climbing fern on small tree islands in the Refuge's interior. On the Refuge, ground crews cut fern stems, leaving aerial material to wither, and treat fern growth on the ground with herbicides.

Large, widespread infestations of Old World climbing fern were discovered throughout the Ten Thousand Islands area of Everglades National Park in early 2000. The fern is concentrated in short hydroperiod coastal marshes dominated by low elevation woody vegetation (predominantly wax myrtle) adjacent to buttonwood/mangrove communities. The populations appear to be relatively new, as no rachis main stem material was present. As the fern colonies develop, stem material develops into dense blankets, which have reached depths of more than one meter in other south Florida infestations.

Although newly established, the plant is extremely widespread and covers a substantial area. Proximity to mangrove communities is alarming because this species is a common component of mangrove communities in parts of its native range (i.e., Thailand). Through a cooperative effort, the District and the Park aerially treated more then 700 acres of Old World climbing fern in the western sections of the Park. An extensive follow-up effort will be necessary.

Water hyacinth and water lettuce are primarily confined to canals and around water control structures. As such, these two floating exotic aquatic plants are mostly a water conveyance issue and are only priority species for the USFWS and the District. While these aquatic weeds can be found downstream of the S-12 structures within Everglades National Park (the Park), they have not expanded their range and are not currently being managed there. Latherleaf is considered a high priority species for the Park, but is not presently found in the greater Everglades ecosystem.

Smaller populations of other invasive exotic species are also treated when discovered. For example, a highly-invasive vine, kudzu (*Pueraria montana*) was identified growing on the L-36 levee in Broward County in 1992 (Bodle, 1994). An eradication program was immediately implemented by the District and appears to have been successful.

The ecological effects of exotic pest plants on native areas are generally known to include: alteration of species composition and community structure; diminishment of natural habitats and food sources of native animals; and interference with ecological and geological processes such as water and nutrient cycling, and, commonly, multi-species interactions. Unfortunately, most resource managers are typically not afforded the opportunity to record these changes. Minimally, determining the responses of native plant communities to exotic pest plant removal, by sampling before and after control treatments, is desirable, but this too often falls beyond the time and resource capabilities of most management programs. Most resource managers are resigned to conducting only

control actions. For every exotic control project successfully completed, there are a dozen more to replace it.

Detailed summaries of agency management efforts are provided in **Appendix 14**.

### Secondary Species

Other exotic species of concern in the WCAs are mainly restricted to the levee berms. These plants include: Java plum (*Syzygium cumini*), earleaf acacia, (*Acacia auriculforms*), ficus (*Ficus microcarpa*), bishopwood (*Bischofia javanica*), guava (*Psidium guajava*), Surinam cherry (*Eugenia uniflora*), lead tree (*Leucaena leucocephala*), climbing cassia (*Senna pendula*), wild taro (*Colocasia esculenta*), lantana (*Lantana camara*), Burma reed (*Neyraudia reynaudiana*), napiergrass (*Pennisetum purpureum*), kudzu (*Pueraria montana*), schefflera (*Schefflera actinophylla*) and torpedograss (*Panicum repens*). Hydrilla and hygrophila are submersed aquatic plants that are found mainly in canals and around water control structures.

Shoebutton ardisia is a shade-loving shrub that was originally reported from the Hole-in-the-Doughnut, a 14,280-hectare area within Everglades National Park. This area was once cleared for farming only to sprout forth densely in Brazilian pepper and a few other exotic species when agricultural activity halted. It has spread into adjacent tropical hardwood hammocks in the Long Pine Key area of the Park (Seavey and Seavey, 1994) and was observed to have spread to the Flamingo area in 1995 (Doren and Jones, 1997). Other species of concern in the Park are less widespread and extremely variable in their distributions, the habitats they invade, and the sizes of their infestations. Several of these species have persisted from cultivation and have shown the ability to spread from their points of introduction: sisal hemp (*Agave sisalana*), woman's tongue (*Albizia lebbeck*), orchid tree (*Bauhinia variegata*), mast wood (*Calophyllum antillanum*), Surinam cherry, lantana, lead tree, tuberous sword fern (*Nephrolepis cordifolia*), half flower (*Scaevola taccada*), ground orchid (*Oeceoclades maculata*), guava, oyster plant (*Rhoeo spathacea*), bowstring hemp (*Sansevieria hyacinthoides*), shefflera, arrowhead vine (*Syngonium podophyllum*), and tropical almond (*Terminalia catappa*). Infestations consist of scattered individuals, except in the case of sisal hemp, tuberous sword fern, ground orchid, oyster plant, bowstring hemp, and arrowhead vine - all species that spread vegetatively and produce locally dense populations. The coastal species, mahoe (*Hibiscus tiliaceus*) and seaside mahoe (*Thespesia populnea*), and the grasses, cogongrass (*Imperata cylindrica*), Burma reed and napiergrass, have reached the Park by natural expansion from outside sources and are represented by single plants and dense clones.

## INVASIVE PLANT MANAGEMENT TOOLS

### Biological Control

Plants are often prevented from becoming serious weeds in their native range by a complex assortment of insects and other herbivorous organisms. When a plant is brought into the United States, the associated pests are thoroughly screened by government regulations on plant pest importation. Favorable growing conditions and the absence of these associated pest species have allowed some plants to become serious weeds outside their native range.

"Classical" biological control seeks to locate such insects and import host-specific species to attack and control the plant in regions where it has become a weed. The "classical" approach has a proven safety record (none of the approximately 300 insect species imported specifically for this purpose have ever become pests themselves) and has been effective in controlling almost 50 species of weeds.

The following are the performance steps of a classical biological control investigation:

1. Identify target pest and prepare a report outlining the problem conflicts, potential for successful program, etc.
2. Survey and identify the pest's native range for list of herbivores that attack the pest plant.
3. Identify the best potential biocontrol agents based on field observations, preliminary lab tests, and information from local scientists.
4. Conduct preliminary host-range tests on most promising candidate in native country to obtain permission to import to U.S. quarantine.
5. Complete host-range tests in U.S. quarantine to ensure safety of the organism relative to local native plants, agricultural crops, and ornamental.
6. Petition Technical Advisory Group of USDA for permission to release in the U.S. Also, obtain permission from necessary state agencies.
7. Culture agents that are approved to have sufficient numbers to release at field sites. Test release strategies to determine best method.
8. Monitor field populations of pest plants to:
    a) Determine if biocontrol agent establishes self-perpetuating field populations
    b) Understand plant population dynamics to have baseline to measure bioagent effects, especially if they are sublethal and subtle and to know what portions of life history to watch.
9. Study effectiveness of the agents for controlling the target plant. Monitor plant populations with and without the agent and without to determine impacts of agent.
10. Study means of integrating biocontrol into overall management plans for the target plant.

In Florida, classical biological control of invasive non-native plants in non-agricultural areas has focused on aquatic weeds. The first biocontrol agent introduced was the alligatorweed flea beetle (*Agasicles hygrophila*) in 1964 for control of alligatorweed (*Alternanthera philoxeroides*). Subsequently, the alligatorweed thrips (*Aminothrips andersoni*) was released in 1967 and the alligatorweed stem borer (*Vogtia malloi*) in 1971. The flea beetle and stem borer proved to be fairly effective for suppressing growth of alligatorweed, although harsh winters can reduce their populations. Less effective have been introductions of the waterhyacinth weevils (*Neochotina eichhorniae* and *N. bruchi*), released in 1972 and 1974, and the water hyacinth borer, released in 1977 (*Sameodes albigutalis*) for waterhyacinth control. Likewise, effectiveness of a weevil (*Neohydronomous affinis*) and a moth (*Namangama pectinicornis*) released for control of waterlettuce has been unpredictable. Water hyacinth and water lettuce continue to be problems that require management by other methods.

Current biological control research is focused on hydrilla, water hyacinth, melaleuca, Brazilian pepper, and Old World climbing fern. Melaleuca snout beetles are damaging melaleuca stands and showing signs of range expansion after initial releases in 1999. The first Brazilian pepper insects and other melaleuca-feeding insects may be approved for release in Florida within a period of years. Overseas surveys for insects found feeding upon the Old World climbing fern remains in its native range remain in the beginning phases.

Introduction of animals such as cattle, sheep, goats, or weed-eating fish may also be used to control certain invasive plants. However, environmental impacts of using such nonselective herbivores in natural areas should be carefully considered before implementation.

## THE USE OF HERBICIDES

Herbicides are pesticides designed to control plants. They are a vital component of most control programs and are used extensively for exotic plant species management in South Florida. Herbicides can be applied in several ways:

### Herbicide Application Methods

***Foliar applications.*** A herbicide is diluted in water and applied to the leaves with aerial or ground equipment. Foliar applications can either be directed, to minimize damage to non-target vegetation, or broadcast. Broadcast applications are used where damage to nontarget vegetation is not a concern or where a selective herbicide is used.

***Basal bark applications.*** A herbicide is applied, commonly with a backpack sprayer, directly to the bark around the circumference of each stem/tree up to 15 inches above the ground.

***Frill or girdle (sometimes called hack-and-squirt) applications.*** Cuts into the cambium are made completely around the circumference of the tree with no more than 3-inch intervals between cut edges. Continuous cuts (girdle) are sometimes used for difficult-to-control species and large trees. Herbicide (concentrated or diluted) is applied to each cut until the exposed area is thoroughly wet. Frill or girdle treatments are slow and labor intensive, but sometimes necessary in mixed communities to kill target vegetation and minimize impact to desirable vegetation.

***Stump treatments.*** After cutting and removing large trees or brush, a herbicide (concentrated or diluted) is sprayed or painted on to the cut surface. The herbicide is usually concentrated on the cambium layer on large stumps, especially when using concentrated herbicide solutions. The cambium is next to the bark around the entire circumference of the stump. When using dilute solutions the entire stump is sometimes flooded (depending on label instructions) with herbicide solution.

***Soil applications.*** Granular herbicide formulations are applied by hand-held spreaders, by specially designed blowers, or aerially.

A pesticide, or some of its uses, is classified as restricted if it could cause harm to humans or to the environment unless it is applied by certified applicators who have the knowledge to use these pesticides safely and effectively. Although none of the herbicides commonly used for invasive plant control in the Everglades is classified as restricted-use, the basic knowledge of herbicide technology and application techniques that are needed for safe handling and effective use of any herbicides can be obtained from restricted use pesticide certification training. All District applicators and contractor supervisors are required to obtain this certification before they apply herbicides in the Everglades Protection Area.

### *Where Herbicides Can Be Used*

No pesticide may be sold in the United States until the U.S. Environmental Protection Agency (USEPA) has reviewed the manufacturer's application for registration and determined that the use of the product will not present unreasonable risk to humans or the environment.

The USEPA approves use of pesticides on specific sites, i.e., for use on individual crops, terrestrial non-crop areas or aquatic settings. Only those herbicides registered by the USEPA specifically for use in aquatic sites can be applied to plants growing in lakes, rivers, canals, etc. For terrestrial uses, USEPA requires herbicide labels to have the statement: "Do not apply directly to water, to areas where surface water is present, or to intertidal areas below the mean high-water mark." Rodeo® is registered for aquatic use and can be applied directly to water. Certain but not all products that contain 2,4-D can also be applied directly to water. The state supplemental special local need label for the imazapyr-containing product, Arsenal® (EPA SLN NO. FL-940004) allows Government agencies and their contractors to use it for injection, frill/girdle or cut stump applications to control melaleuca and Brazilian pepper growing in water.

### *Active Ingredients and Formulations*

A herbicide formulation, or product, consists of the herbicide active ingredient dissolved in a solvent (e.g., oil, water or alcohol), or adsorbed to a solid, such as clay. Formulations often include an adjuvant that facilitates spreading, sticking, wetting and other modifying characteristics of the spray solution. Special ingredients may also improve the safety, handling, measuring and application of the herbicide.

The active ingredients 2,4-D amine, triclopyr amine, imazapyr, and hexazinone are formulated as water-soluble liquids. They are not compatible with oil based diluents and are diluted in water for foliar applications and diluted in water or applied in their concentrated form for cut stump applications. They are not normally used for basal bark applications, but may be applied to the cut stump of many woody species, such as Australian pine, Brazilian pepper and earleaf acacia.

Triclopyr ester, imazapyr, and fluazifop are formulated as emulsifiable concentrates. Emulsifiable concentrates are compatible with oil based diluents and also contain emulsifiers that allow the formulation to mix with water. They may be diluted in water for foliar applications or mixed with oil based diluents for low volume applications (e.g., basal bark). Water/herbicide mixtures for foliar applications can effectively control shrubs and perennial forbs. Basal bark applications of oil/herbicide mixtures may be

effective on thin-barked trees such as Brazilian pepper, earleaf acacia and Australian pine.

Hexazinone is also formulated as an ultra low weight soluble granule formulation. This formulation is broadcast with specialized ground or aerial equipment.

### *Absorption Characteristics*

Systemic herbicides move within the plant to the site where they are active after being absorbed by foliage, roots, or bark. Triclopyr, 2,4-D, imazapyr, and glyphosate can be absorbed by plant leaves and are effective for foliar applications. Triclopyr, 2,4-D, and glyphosate are adsorbed by soils or broken down quickly in soil and are not absorbed effectively by plant roots, whereas imazapyr and hexazinone are readily absorbed by plant roots. Only oil soluble herbicide formulations, i.e., emulsifiable concentrates, are absorbed readily through tree bark.

### *Behavior in Soils*

Herbicides used for invasive plant control vary in their persistence and sorption to soils. The most important factor is the ability of various soil types to chemically bind herbicides. Soil applied herbicides, such as hexazinone, have label recommendations that vary the application rate for different types of soils. In general, soils with more organic matter and/or clay have greater capacities for binding herbicides than coarse, sandy soils and require higher application rates.

### *Selectivity*

The ability to selectively control target vegetation with herbicides without harming nontarget plants is related to the relative sensitivities of target and nontarget plants, absorption and chemical characteristics of the herbicides, and placement.Herbicides vary in their potential to damage non-target vegetation, and unwanted results can be prevented or minimized by making the best choice of herbicides in conjunction with careful application. Fluazifop, which kills many grasses, can be used to selectively manage invasive grass species among non-target broad-leaf plant species. Formulations that contain the active ingredients 2,4-D or triclopyr can often be used selectively because many broad-leaf species are more sensitive to them than are perennial grasses.

Because 2,4-D, triclopyr and glyhosate have negligible root activity and break down quickly, they have little potential for causing non-target damage due to root absorption, when carefully applied to target vegetation. In contrast, caution must be used with root-active herbicides (i.e., hexazinone and imazapyr) to minimize damage to non-target vegetation by root absorption.

Care must be taken to avoid unwanted contact of herbicide spray (drift) to foliage of nontarget plants when broadcast applications of the foliar active herbicides, 2,4-D, triclopyr, glyphosate, or imazapyr are made. Particulate drift can be minimized by avoiding windy conditions when spraying and using low pressures and large nozzle orifices. Volatile compounds such as ester formulations may cause nontarget damage due to vapor drift when applied on very hot days. This damage, which may be observed as

wilting or curling leaves, has been minimal and has not caused permanent harm to woody nontarget plants.

### *Wildlife Toxicity*

Invasive plant management is often conducted in natural areas with the purpose of maintaining or restoring wildlife habitat. Therefore, it is essential that the herbicides themselves are not toxic to wildlife. Risk assessment to wildlife is conducted as part of the registration procedure for herbicides and is determined as the product of hazard and exposure. Hazard is measured as the toxicity of the herbicide to test animals and exposure depends on the use and persistence of the compound. Herbicides used for invasive plant control in the Everglades have shown very low toxicity to wildlife that they have been tested on, with the exception of the relatively low $LC_{50}$ (0.87 ppm) of triclopyr ester and fluazifop (0.57 ppm) for fish, neither of which can be applied directly to water. Ester formulations are toxic to fish because of irritation to fishes' gill surfaces. However, because triclopyr ester and fluazifop are not applied directly to water, are adsorbed by soil particles, and have low persistence, exposure is low, which results in low risk when properly used.

## Manual and Mechanical Removal

Manual removal is very time consuming, but often a major component of effective invasive plant control. Seedlings and small saplings can sometimes be pulled from the ground, but even small seedlings of some plants have tenacious roots that will prevent extraction or cause them to break at the root collar. Plants that break off at the ground will often resprout and even small root fragments left in the ground may sprout. Repeated hand pulling or follow-up with herbicide applications are often necessary. Removal of uprooted plant material is important. Stems and branches of certain species (i.e., melaleuca) that are laid on the ground can sprout roots, and attached seeds can germinate. If material cannot be destroyed by methods such as burning, it should be piled in a secure area that can be monitored and new plants killed as they appear.

Mechanical removal involves the use of bulldozers, or specialized logging equipment to remove woody plants. Intense follow up with other control methods is essential after the use of heavy equipment because disturbance of the soil creates favorable conditions for regrowth from seeds and root fragments, and re-colonization by invasive non-native plants. Mechanical removal may not be appropriate in natural areas because of disturbance to soils and non-target vegetation caused by heavy equipment.

In aquatic environments, mechanical controls include self-propelled harvesting machines, draglines, cutting boats and other machines, most of which remove vegetation from the waterbody. These systems generally are used for clearing boat trails, high-use areas, or locations where immediate control is required, like flood control canals and around water control structures.

## Cultural Practices

Prescribed burning and water level manipulation are cultural practices that are used in management of pastures, rangeland and commercial forests, and may be appropriate for vegetation management in natural areas in some situations. Land use history is critical

in understanding the effects of fire and flooding on the resulting plant species composition. Past practices affect soil structure, organic content, seed bank (both native and invasive exotic species), and species composition. While there is evidence that past farming and timber management practices will greatly influence the outcome of cultural management, very little is known about effects of specific historical practices. Similar management practices conducted in areas with dissimilar histories may achieve very different results. Even less is known about the effects of invasives entering these communities, and the subsequent management effects of fire on the altered communities.

Understanding the reproductive biology of the target and non-target plant species is critical to effective use of any control methods but particularly so with methods such as fire management, that often require significant preparation time. Important opportunities exist when management tools can be applied to habitats when non-native invasive species flower or set seed at different times than the native species.

### *Prescribed Burning*

Fire is a normal part of most of Florida's ecosystems and native species have evolved varying degrees of fire tolerance. Throughout much of the Everglades, suppression of fire has altered historical plant communities. Within these communities, the fire-tolerant woody species have lingered in smaller numbers, and less fire-tolerant species have replaced ephemeral herbs. Little is known about the amount, frequency, timing, and intensity of fire that would best enhance the historically fire tolerant plant species, and less is known about how such a fire management regime could be best used to suppress invasive species. Single fires in areas with many years of fire suppression are unlikely to restore historical species composition. Periodic fires in frequently burned areas do little to alter native species composition.

Invasion of tree stands by exotic vines and other climbing plants – such as Old World climbing fern on Everglades tree islands - has greatly increased the danger of canopy (crown) fires and the resulting death to mature trees. The added biomass by invasive plants can result in hotter fires, and can greatly increase the risk of fires spreading to inhabited areas. In these situations, use of fire to reduce standing biomass of invasive species may better protect the remaining plant populations than doing nothing, even though impacts to non-target native species will occur. Under these conditions, the expense of reducing standing biomass of invasive plant species might be justified by the savings on subsequent fire suppression.

### *Water Level Manipulation*

Some success has been achieved by regulating water levels to reduce invasive plant species in aquatic and wetland habitats. De-watering aquatic sites reduces standing biomass, but little else is usually achieved unless the site is rendered less susceptible to repeated invasion when re-watered. Planting native species may reduce the susceptibility of aquatic and wetland sites in some cases.

In most situations, water level manipulation in reservoirs has not provided the level of invasive plant control that was once thought achievable. Ponds and reservoirs can be constructed with steep sides to reduce invadable habitat, and levels can be avoided that promote invasive species, but rarely are these management options adaptable to natural areas.

Carefully timed water level increases following herbicide treatments, mechanical removal or fire management of invasive species can sometimes control subsequent germination, and, with some exotic species, resprouting.

# INFORMATION GAPS AND FUTURE NEEDS

Rudimentary elements of a good invasive exotic plant management strategy—legislation, coordination, planning, research, education, training, and resource input—have been in place in Florida for many years. The plants that are recognized as primary species in the Everglades region are all being controlled to some extent by state or federal agencies. Unfortunately, there are dozens of other exotic species in the Everglades with unknown distributions and invasive potentials. Funding and coordination for a comparable non-indigenous animal management program are badly needed. Little can be done without a committed effort to develop ecological understanding of the spread, effects and behaviors of exotic animals in the Everglades.

Regardless of taxa, the invasiveness of a species is often somewhat slow to develop. Species that appear benign for many years - or even decades - can suddenly spread rapidly following certain events; such as flood, fire, drought, long-term commercial availability, or some other factor. There is a need to recognize these species during their incipient phase or even prior to introduction to maximize available management resources.

## EVERGLADES RESTORATION AND INVASIVE EXOTIC SPECIES

It is tempting to assume that, once restoration efforts are achieved, results will include reduced needs to control exotic species in the Everglades. However, although it is true that the spread of some exotic species can be reduced by increasing hydroperiods (i.e., Brazilian pepper), there has been little or no research done to determine what effects long range hydrologic changes will have on most of the other exotic species throughout the system. Ongoing tree island research has focused on the effects of high water but has completely ignored the effects of exotic plants like Old World climbing fern. Old World climbing fern, melaleuca and Brazilian pepper have successfully invaded those areas with the least apparent human alterations, including the mangrove zones of southwest Florida and Big Cypress National Preserve. Exotic plant communities in the Everglades Stormwater Treatment Areas (STAs) will need to be monitored and measured as changes to the hydrology are made. A more comprehensive approach needs to be taken when looking at the long-term restoration process in regard to the exotic plant species composition response.

Also, as previously mentioned, management of invasive animals remains a nascent field of study in the region, with little or no published material available to guide planners and resource managers.

### Coordination Efforts

There is a clear need for more a comprehensive plan that incorporates broad and consistent strategies, reduces agency inconsistencies, and takes into account differing

agency mandates to achieve the goal of controlling invasive species. This would result in a strategy that is appropriate and applicable to and coordinated with the broader state and federal efforts to manage invasive species, both plants and animals, and supports each agency in carrying-out their role(s) in the broader program of invasive species control. It is hoped that when complete, the NEWTT Assessment and Strategy will fill this need in the area of invasive plants. A similar effort is needed for non-indigenous animals in the Everglades Protection Area.

## MANAGEMENT EFFORTS

Economic impacts of invasive species in the Everglades Protection Area cannot be directly drawn from the literature. Studies documenting the expansion of some species imply that control would be cheaper when populations are small (Laroche and Ferriter, 1992). But no direct analyses of the environmental and cultural costs and benefits of invasive plant control in the Everglades are available in the literature. The lack of such background information limits the strength of arguments supporting to control these pest species. Further, it might be argued that there should be no need to study obvious catastrophes; you know a train wreck when you see one. Yet, basic foundational research is often needed to construct convincing arguments. A few citations quantify the costs, impacts, and benefits resulting from control of aquatic weeds in a few Florida waterbodies (Colle et al., 1987; Milon, et al., 1986) but none for wetlands like the Everglades Protection Area

For many of upland exotic plants, research has not focused upon the most effective and current control methods. Specific controls for melaleuca, Brazilian pepper and a very few others have been the subject of formal and informal research. For the majority of other species, only general guidelines of herbicide use or physical attack apply. A wide range of unknowns remains for each species. Research might show, as examples, how best to control each plant in different settings, how to minimize non-target damage, or whether treatments during different seasons or stages of growth of each plant will affect results.

## ECOLOGICAL IMPACTS OF INVASIVE SPECIES

Relatively little work has been done investigating the ecological impacts of invasive species in the Everglades Protection Area. Without specific published proof, resource managers can be somewhat “out on a limb” when arguing for support to manage invasive plants.

While melaleuca (O’Hare et al., 1997; Sowder and Woodall, 1985; Ostrenko and Mazzotti, 1981) and Brazilian pepper (Curnutt, 1989; Gogue, 1974) have been found to decrease wildlife species diversity, such studies are rare in the literature published on these species. More publications have come from management, monitoring, or botanical investigations (Ferriter, 1997; Laroche, 1999). For most of the other invasive plants found in the Everglades Protection Area, very few publications are available of even a general nature, and, of these, virtually none formally assess ecological impacts of each species.

## MANAGEMENT AUTHORITIES AND REGULATIONS

Although U.S. regulations on the import of exotic species in general are extensive, there is virtually no regulation against bringing many exotic plant species into the United States. Barring the primarily agricultural weeds on the federal noxious weed list, importation laws focus on plant pests, not pest plants. Insects and pathogens are screened extensively at ports of entry, but plants are allowed to enter this country virtually unimpeded. Upfront screening methods need to be developed for new plant species. In Australia and New Zealand, there are strict regulations regarding exotic plant importation. These countries have developed comprehensive "white lists" of plants that are permitted for import. If the plant is not on the list, it can not enter the country without a Risk Assessment. At a minimum, state and federal agencies importing plants for food, fiber, or forage evaluation should have a protocol, which screens for invasiveness prior to recommending new plant species for cultivation.

On the state level, The Department of Agriculture and Consumer Services Division of Plant Industry's staff does much to assist in the control of invasive exotic plants in natural areas. However, in a regulatory context, plants on the FDACS noxious weed list are primarily listed because of their threat to agriculture, not to native ecosystems. While FDACS (Division of Forestry) fights a whole host of invasive exotic plants in its State forests, most of the plants they control are not even on their own agency's list.

In the Summer 1999, FDACS amended their list to include 11 new species which are threats to natural areas: carrotwood (*Cupaniopsis anacardioides*), dioscorea (*Dioscorea alata* and Dioscorea *bulbifera*), Japanese climbing fern, Old World climbing fern, Burma reed, sewer vine (*Paederia cruddasiana*), skunkvine (*Paederia foetida*), kudzu, downy myrtle (*Rhodomyrtus tomentosa*) and wetland nightshade (*Solanum tampicense)*. The addition of these plants is a good indicator of a growing shift in agricultural rules and regulations to incorporate the protection of natural areas in their regulatory focus.

## BIOLOGICAL CONTROL

Isolating, testing and releasing a host-specific insect to control an invasive exotic plant in the United States can take more than a decade as in the case of the melaleuca snout beetle. Once an insect has been properly selected and screened, it must be approved by a federal Technical Advisory Group (TAG) and, in Florida, a State Arthopod Committee. Although the process is necessary, it can be extremely slow, as there are no deadlines for review set by the committee(s), and the review process for each request for release does not seem to be a priority for staff at participating agencies—especially in the case of agents that target natural area weeds. The process needs to be streamlined and formalized.

Compounding the problem is a lack of specific biological control quarantine facility space in Florida for environmental weeds. The only quarantine facility currently available for this work in Florida is a small, outdated lab located in Gainesville. Available space is shared with researchers screening biological controls for agricultural pests. This space limitation has restricted the number of agents the researchers can study, creating a serious bottleneck.

## PUBLIC/PRIVATE PARTNERSHIPS

Invasive exotic species recognize no political boundaries. Natural resource managers increasingly recognize that parochial management approaches to these problems are ineffective. Without a regional approach, effective containment of a pest plant is impossible. This strategy has proven successful with the management of melaleuca on public lands. However, adjacent privately-held lands continue to harbor melaleuca. Without incentives for private landowners to remove melaleuca, these contaminated lands will be a seed source for neighboring public lands for years to come. This issue needs to be addressed when dealing with plants like Old World climbing fern. Spores of this plant can easily be spread from the source for miles. Until control efforts effectively involve all of the affected populace, control will not be practicable. This may require the expenditure of public monies on private lands or property tax breaks that provide a financial incentive for control.

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