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MANAGING NON-NATIVE WILDLIFE IN FLORIDA: STATE PERSPECTIVE, POLICY AND PRACTICE

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Abstract: Florida has more non-native wildlife species than any other state: 439 introduced species of fish, wildlife and marine organisms have been observed and at least 123 are established, i.e., highly unlikely to be extirpated without human intervention. Florida is an epicenter for non-native species with a long established pet industry, major tourist attractions, and major ports, primarily Miami. The large number of established species is due to climate match with that of popular tropical pets, habitat disturbance that facilitates invasion, and a depauperate vertebrate fauna in tropical and subtropical portions of Florida. The Florida Fish and Wildlife Conservation Commission's approach to managing non-native wildlife is based on (1) encouraging responsible pet ownership; (2) a regulated industry is preferable to underground traffic; and (3) most introduced species have negligible environmental impacts. Regulations for captive wildlife and non-native aquatic species, first established in the 1970s, employ risk-based bio-security for problematic species, and prohibition of a limited number of species that posed unacceptable risks to the ecosystem, economy, or human health and safety. Effective January 1, 2008, owners of six large reptile species will be required to implant passive integrated transponders to identify individual animals. Although anecdotal evidence suggests dealers have released inventories to establish source populations, the majority of introductions have resulted from release of pets by owners. To close this pathway, a pet surrender network is in the early stages of development. Within the past five years, capacity to detect and manage terrestrial and semi-aquatic species has improved, including surveillance, rapid assessment and response; examples include the Gambian giant pouched rat (*Cricetomys gambianus*), purple swamphen (*Porphyrio porphyrio*), and Argentine black and white tegu (*Tupinambis merianae*).

Key Words: Florida, invasive species, pathways, rapid response, regulations, surveillance.

Managing Vertebrate Invasive Species: Proceedings of an International Symposium (G. W. Witmer, W. C. Pitt, K. A. Fagerstone, Eds). USDA/APHIS/WS, National Wildlife Research Center, Fort Collins, CO. 2007.

INTRODUCTION

Over 400 species of non-indigenous fish, wildlife and marine organisms have been observed in Florida since its colonization by European settlers in the 16th century. The earliest documented vertebrate introduction dates to 1538 when Hernando de Soto imported European pigs (*Sus scrofa*) as a food source. Apparently, the settlers traded pigs to indigenous humans who allowed these animals to range free, eventually leading to the widespread establishment of one of the more notorious exotic species.

During Florida's long history with non-native species, a \$300 million captive wildlife industry has developed, including importers, breeders, and tourist attractions that prominently feature exotic animals. In 2005-06, 3982 facilities were permitted for captive wildlife. Furthermore, Florida is the epicenter of the freshwater tropical fish industry, growing 95 percent of the nation's cultured tropical

fish on farms primarily in the Tampa Bay area. Over 800 varieties of tropical fish are cultured in Florida.

In the nascent discipline of invasion biology, there is general acceptance of the so-called 'rule of 10s', which posits that roughly 10% of introduced species become established, and roughly 10% of those become invasive (Williamson 1996, Bomford 2005). Florida's experience is consistent with the general boundaries of this rule. The Florida Fish and Wildlife Conservation Commission (FWC) has adopted risk-based regulations that (1) prohibit the unauthorized release of any non-native species; (2) restrict possession of species that pose substantial environmental or economic risks, or harm to human health; and (3) permit possession of species not deemed to present significant consequences to native fish and wildlife.

With the substantial level of pet ownership, as well as an existing industry based on captive

wildlife and aquarium specimens, FWC's approach to non-native species, reflected in its regulatory framework, is to encourage responsible pet ownership. We believe that a regulated pet industry, allowing environmentally benign species and restricting problematic ones, is preferable to indiscriminate underground traffic that would result from legal bans on the majority of non-native organisms.

STATUS OF NON-NATIVE SPECIES IN FLORIDA

There are approximately 123 established non-native species in Florida. Established means unlikely to be extirpated without human intervention. For freshwater fishes and marine species, the definition is a subjective assessment based on collective expert opinion. For wildlife, species are considered established if they have reproduced for five or more years. The list includes 22 non-native freshwater fishes (Shafland et al. In Review), 4 amphibians, 36 reptiles, 12 birds, and 18 mammals. There are at least 31 marine species, although this number is an estimate at best, owing to the difficulty in surveying the marine environment and the fact that global ship travel predated virtually all biological surveys. With the exception of the red lionfish (*Pterois volitans*) that is possibly established along Florida's Atlantic Coast, introduced marine species are invertebrates or algae.

Among the freshwater fishes, most introduced species are aquarium releases or escapes from aquaculture, although one species, the pike killifish (*Belanesox belizanus*) escaped from a medical research facility. Of the 22 permanently established species, 13 are in the widely distributed tropical-subtropical Cichlid family and four are South American catfishes. Investigation of introduced fishes in southeast Florida canals has indicated no reductions in absolute abundance or biomass of native species, while the standing crop of all fishes has increased (some due to sterile grass carp [*Ctenopharyngodon idella*] purposefully introduced for vegetation control). Recently, non-native catfishes, sailfin catfish (*Pterygoplythys multiradiatus*) and brown hoplo (*Hoplosternum littorale*) have experienced population expansions over south and central Florida. Study of fish population abundance and diet has not revealed competition or displacement of native fishes. However, sailfin catfish dig spawning burrows, and localized erosion has resulted from this activity. In

2000, a prohibited species, bullseye snakehead (*Channa marulius*) from southeast Asia, were discovered in a canal system in southeast Florida. Six years later, no major changes in fish populations have been observed.

Although only three amphibians are established or potentially established, the Cuban tree frog (*Osteopilus septentrionalis*), introduced in 1931, is now found as far north and west as Tallahassee (with reports in south Georgia). This large, invasive frog is associated with declines attributed to predation in native hylid frogs, including green tree frogs (*Hyla cinerea*) and squirrel tree frogs (*H. squirella*). By contrast, the marine toad (*Bufo marinus*), native to central America and south Texas, garnered much attention following its introduction in 1971, but has had negligible impact on native wildlife and appears to be declining in the southern part of its range in Florida.

Roughly three quarters of the introduced reptiles are now established in Florida. The list of established reptiles is dominated by lizards (31 species), but includes one turtle (red-eared slider [*Trachemys scripta elegans*]), one crocodylian (spectacled caiman [*Caiman crocodiles*]), and three snakes. Of the lizards, most were pet releases from owners or dealers, primarily from the families Iguanidae and Gekkonidae, and have caused minor concern in conservation areas. Several large species are established, including the herbivorous green iguana (*Iguana iguana*) and omnivorous spinytail iguana (*Ctenosaurus similis*) which are considered nuisances by many Floridians, but no evidence exists for ecological damage. The Nile monitor (*Varanus niloticus*), a generalist predator and the largest of the African lizards, is established in a small urban area of southwest Florida, causing concern over potential impacts to a nearby population of burrowing owls (*Athene cunicularia*), a Florida Species of Special Concern. Additionally, Nile monitors are predators of crocodile eggs in Africa, and southward expansion of the Florida population would overlap that of the endangered American crocodile (*Crocodylus acutus*).

In the past decade, considerable attention has been focused on a reproducing population of Burmese pythons (*Python molurus*) in extreme south Florida. The distribution of collected snakes suggests that the population may have been the result of released pets. Other speculation centers on the escape of collections of specimens from dealers during Hurricane Andrew in 1992. Regardless, Burmese pythons span the width of Everglades National Park and are commonly found on adjacent

lands. Although there is no evidence at this time of landscape-level effects, the sociological impact has led to greater restrictions on ownership of this species and several other large reptile species. Less well known is an isolated population of *Boa constrictor* confined to a tropical hammock “habitat island” in Miami. This population has existed since the 1970s with no expansion or other impacts.

Relatively few introduced birds have become established, with 68% having no more than 9 breeding pairs (72 species are not reported breeding), and only 7 species reported from more than 9 of Florida’s 67 counties (B. Pranty, personal communication). The largest group of introduced birds are the Psittacines, with over 70 species reported, undoubtedly pet releases, yet only two species are confirmed established. Noteworthy among resident non-native birds is the monk parakeet (*Myiopsitta monachus*), well established in south Florida, which builds large colony nests in electrical transformers causing significant economic impact from power outages and equipment loss. A recent introduction, the purple swamphen (*Porphyrio porphyrio*), has expanded from coastal southeast Florida into the Everglades Conservation Areas, and has been observed on Lake Okeechobee. Its ecological similarity to the native common moorhen (*Gallinula chloropus*) and purple gallinule (*Porphyryla martinica*) have prompted efforts to eliminate this member of the rail family native to central Europe and Asia. One non-native bird species, cattle egret (*Bubulcus ibis*), arrived without human assistance, apparently blown by hurricane winds from nearby Caribbean islands.

Florida’s non-native mammals include species with cosmopolitan distributions, such as the house mouse (*Mus musculus*), black rat (*Rattus rattus*) and Norway rat (*R. norvegicus*), as well as four feral species: pig, dog (*Canis familiaris*), cat (*Felis catus*), and goat (*Capra hircus*). Three non-native mammals have become established both by human introduction as well as natural migration: nine-banded armadillo (*Dasypus novemcinctus*), red fox (*Vulpes vulpes*), and coyote (*Canis latrans*), although the latter species’ success is at least partially attributed to extirpation of the red wolf (*Canis rufus*) in the early 1900s. Among the more interesting non-native mammals, the rhesus monkey (*Macaca mulatta*) was introduced to a central Florida tourist attraction in the 1930s and now has an established, stable population in river floodplains, as well as a smaller population in south Florida. Similarly, a population of vervet monkeys

(*Chlorocebus atheiops*) has been established without apparent consequence in an isolated tropical hammock area within the highly urbanized corridor of Broward County in southeast Florida for 50 years. The Sambar deer (*Cervus unicolor*) has been established on St. Vincent Island in northwest Florida for 100 years; the National Wildlife Refuge conducts periodic hunts to control this population. In the Florida Keys, Gambian giant pouched rats (*Cricetomys gambianus*) have established a localized, reproducing population and are the subject of a multi-agency eradication effort.

INTRODUCTION PATHWAYS

Florida has had a long history of tourist attractions, many of which featured exotic animals, prior to the establishment of captive wildlife regulations. Several non-native species escaped from these facilities either from lax security or from defunct businesses that abandoned their operations. Florida aquaculture, though well regulated in recent years, has contributed to the release of freshwater non-native species. Anecdotal evidence suggests that a possibly established population of Argentine black and white tegu (*Tupinambis merianae*) may have originated when a dealer released his stock in response to falling market prices. Many non-native lizard observations are in proximity to reptile dealers.

In addition, Florida has three significant ports, and the Port of Miami receives shipments of tens of thousands of imported tropical fish, reptiles, amphibians and plants. Although most specimens have destinations outside Florida, many are consigned to local dealers and breeders.

With the ready availability of non-native pets, it is not surprising that released animals are a major source of introduction. For reptiles, prior to 1950, the few introductions occurred collaterally with freight shipments. Since that time, the volume of introductions has increased sharply, primarily through the pet trade (Figure 1).

Florida’s tropical and subtropical climate further improve the likelihood of success for non-native species, particularly fishes and reptiles. Another aspect conducive to establishment is the relatively depauperate ichthyofauna and herpetofauna in much of peninsular Florida. Unlike most tropical areas of the world, Florida is isolated from land with similar climate. Most native species originated from temperate regions of the southeastern United States, many at the extreme southern end of their

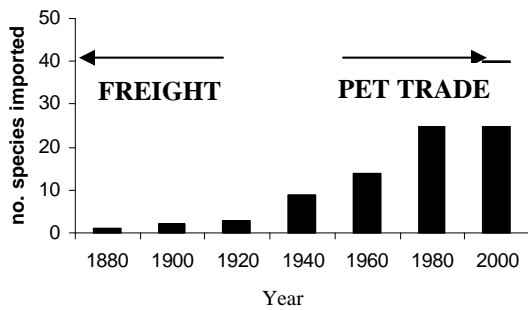


Figure 1. Introduction pathways for non-native reptiles and amphibians in Florida, 1880 - 2000. The Texas horned lizard (*Phrynosoma cornutum*) was imported by the pet trade in 1934, and is the sole exception to the freight pathway prior to 1940.

range. As a result, introduced species find a less species, including one native anole, whereas Cuba has 83 native lizard species, including 54 anoles. South Florida only has 10 native lizards and over three times as many exotic lizard species (K. Enge, FWC, personal communication). Of the 175 species of freshwater fish, many are cyprinids and darters restricted to the temperate streams in north Florida.

Cultural influence appears to have opened new pathways, particularly for non-native fishes. Asian food markets frequently sell live fish, and the bullseye snakehead (*Canna marulius*), and possibly the swamp eel (*Monopterus alba*) originated from such operations. Live northern snakeheads (*C. argus*), a prohibited species, have been confiscated by FWC law enforcement. Brown hoplo (*Hoplosternum littorale*), a small South American catfish prized as food item, may have been spread by immigrants with no knowledge of laws to the contrary. A Venezuelan immigrant confided to an FWC biologist that he regularly placed hoplo in southeast Florida canals to have a readily available food source.

FWC HISTORY

In response to a growing number of introduced freshwater fishes, biological investigations commenced in the early 1960s, and the Non-Native Fish Research Laboratory was established in south Florida in 1966. Based on investigations by Lab staff, in 1976 several freshwater fishes were legally designated for restricted possession, i.e., these could be possessed only under strict biosecurity by research institutions and public exhibitors, and, under more limited circumstances, commercial

producers. This list was re-evaluated in the early 1980s when several species were designated as prohibited, removing the possibility of commercial use. These regulations have been modified periodically, including the addition of aquatic organisms other than fishes, zebra mussel (*Dreissena polymorpha*) in 1993, Australian red claw crayfish (*Cherax quadricarinatus*) in 1996, and Chinese mitten crab (*Eriocheir sinensis*) in 1999, the latter at the suggestion of the aquaculture industry.

The first regulations for the possession of captive wildlife, primarily exotic species, were established in 1970. This was followed by the creation of a specialized law enforcement unit staffed by officers with degrees in biology to inspect facilities and survey ports to intercept restricted and prohibited imports. Florida's captive wildlife regulations, the most comprehensive in the United States, continue to evolve. In 2005, a comprehensive review of the regulations was undertaken in conjunction with stakeholders from affected industries and organizations (Table 1), and the first of a series of modified regulations was approved by FWC in 2006.

In 2004, in response to stakeholder concerns, FWC created a section to provide a seamless and comprehensive approach to non-native species issues. This alignment will increase the agency's capability to respond to terrestrial non-native species. Additional emphasis will be placed on interagency coordination at the local, state and federal level. This cooperative approach is evident in the management examples cited below.

MANAGEMENT APPROACH

The primary tenet in management of non-native species is prevention. There are three aspects of prevention: regulation, outreach, and surveillance.

Regulation

FWC's position toward prevention is reflected in its primary non-native species regulation, which states that it is unlawful to "to possess, transport or otherwise bring into the state or to release or introduce in the state any freshwater fish, aquatic invertebrate, marine plant, marine animal, or wild animal life that is not native to the state unless such person shall first secure a permit from the Commission" (Rule 68-5.001, Florida Administrative Code). Violation of this rule is a first degree misdemeanor, punishable by a fine up

Table 1. Captive wildlife technical assistance representation, Florida Fish and Wildlife Conservation Commission, 2007.

Representative	Organization	Interest
Alexa Strauss	FELD Entertainment, Inc. Ringling Brothers and Barnum & Bailey Circus	Entertainment
Terri Parrot-Nenezian, DVM		Wildlife Rehabilitator
Dan Martinelli	Treasure Coast Wildlife Hospital	Wildlife Rehabilitator
Eugene Bessette	Ophiological Services, Inc.	Pet Industry
Joe Christman	Disney's Animal Kingdom	Entertainment
Leroy Coffman, DVM	Consultant	Pet Industry
Ken Johnson	Humane Society of the US	Animal Welfare
Susan Clubb, DVM	Hurricane Aviaries Parrot Jungle Island	Pet Industry and Entertainment
Bill Armstrong	Hillsborough County Animal Control Florida Animal Control Assoc.	Animal Control
R. Donovan Smith	Close Up Creatures, Inc. NGALA Private Reserve	Pet Industry
Kathy Stearns	Stearns Zoological Rescue and Rehabilitation	Wildlife Rehabilitator

to \$1,000 and imprisonment for as long as one year. However, this general proscription against unauthorized release does not prevent the possession and display of non-native species, which is addressed through risk-based captive wildlife and non-native species regulations.

Captive wildlife regulations deal primarily with species maintained as personal pets and for public exhibition. There are three classes of captive wildlife, based on the potential danger to human safety, each with permitting requirements (Table 2). Caging and confinement requirements reflect concerns over safety as well as for the welfare of the animal.

Prior to 2007, permits were not required to possess non-venomous, non-native reptiles. In response to the established Burmese python and Nile monitor populations, effective January 1, 2008, a \$100 permit will be required to possess five species of large constrictor and one large lizard. Additionally, all specimens of these "reptiles of concern" must be permanently identified with a passive integrated transponder tag. These regulations are designed to discourage impulse purchases, and subsequent illegal release, that may lead to establishment of these large species.

Non-native species regulations originated from freshwater fish investigations and list species as 'conditional' or 'prohibited' based on risks posed to native fish and wildlife, economic impacts, or human health and safety (Table 3). In 2007, two species of personal pets were added to the list, based on ecological and economic risks. The red-eared slider was designated as conditional due to its intergradation with the native yellow-bellied slider (*T. s. scripta*). African giant pouched rats (*Cricetomys* spp.) were designated as prohibited based on risks to Florida agriculture, native listed rodent species, and to human health.

Outreach

Legal restrictions serve as guidance for owners of non-native animals but are ineffective for those unaware of regulations, or individuals who do not understand their rationale. Many residents have moved only recently to Florida, and have no appreciation of native species and habitats. Accordingly, outreach has substantial preventive value and FWC has endeavored to more fully embrace this management tool. The FWC website has a second level page dedicated to non-native species (www.myfwc.com/nonnatives).

Table 2. Regulatory classes of wildlife in Florida.

Species/Group	Class I (for exhibition only; no personal possession, except for those owned prior to 1980; \$250 permit fee)	Class II (permit fee \$140; applicant must demonstrate one year or 1000 hours experience for each species possessed)	Class III (no cost permit; applicant must be at least 16 years old) Other Wildlife not classified as I or II or exempt fall into this class.
Primates	Chimpanzees (<i>Pan</i>), Gorillas (<i>Gorilla</i>), Gibbons (<i>Hylobates</i>), Drills and mandrills (<i>Mandrillus</i>), Orangutans (<i>Pongo</i>), Baboons (<i>Papio</i>), Siamangs (<i>Symphalangus</i>), Gelada baboons (<i>Theropithecus</i>)	Howler monkeys (<i>Alouatta</i>), Uakaris (<i>Cacajao</i>), Mangabeys (<i>Cercocebus</i>), Guenons (<i>Ceropithecus</i>), Bearded sakis (<i>Chiropotes</i>), Guereza monkeys (<i>Colobus</i>), Celebes black apes (<i>Cynopithecus</i>), Idris (<i>Indri</i>), Macaques (<i>Macaca</i>), Langurs (<i>Presbytis</i>), Douc langurs (<i>Pygathrix</i>), Snub-nosed langurs	
Felids	Snow leopards (<i>Panthera uncia</i>), Leopards (<i>Panthera pardus</i>), Jaguars (<i>Panthera onca</i>), Tigers (<i>Panthera tigris</i>), Lions (<i>Panthera leo</i>)	Servals (<i>Leptailurus serval</i>), European and Canadian lynx (<i>Lynx lynx</i>), Cougars & panthers (<i>Puma concolor</i>), Bobcats (<i>L. rufus</i>), Cheetahs	
Canids		Coyotes (<i>Canis latrans</i>), Gray wolves (<i>C. lupus</i>), Red wolves (<i>C. niger</i>), Asiatic jackals (<i>C. aureus</i>), Black-backed jackals (<i>C. mesomelas</i>), Side-striped jackals (<i>C. adustus</i>), Indian dholes (<i>Cuon alpinus</i>), African hunting dogs (<i>Lycaon pictus</i>)	
Mustelids		Wolverines (<i>Gulo gulo</i>), Honey badgers	
Other	Bears (Ursidae), Rhinoceros (Rhinocerotidae), Elephants (Elephantidae), Hippopotamuses (Hippopotamidae), Cape buffalos (<i>Syncerus caffer caffer</i>)	Binturongs (<i>Arctictis binturong</i>), Hyenas (Hyaenidae)	
Reptiles	Crocodiles, except dwarf and Congo (Crocodylidae), Gavials (Gavialidae), Black caimans (<i>Melanosuchus niger</i>), Komodo dragons (<i>Varanus komodoensis</i>)	Dwarf crocodiles (<i>Osteolaemus tetraspis</i>), Alligators, caimans (except American alligator), (Alligatoridae)	
Rattites		Ostrich (<i>Struthio camelus</i>), Cassowary (<i>Casuaris</i>)	

Table 3. Non-native species with restrictions on possession in Florida. Refer to regulations in the Florida Administrative Code for more details.

Conditional Species (may be possessed for the purpose of public exhibition, research, or commercial purposes)	
Freshwater fishes	Grass carp (<i>Ctenopharyngodon idella</i>), Bighead carp (<i>Aristichthys nobilis</i>), Silver carp (<i>Hypophthalmichthys molitrix</i>), Snail or black carp (<i>Mylopharyngodon piceus</i>), Dorados (<i>Salminus</i> spp.), Nile perches (<i>Lates</i> spp.), Blue tilapia (<i>Oreochromis aureus</i>), Wami tilapia (<i>O. hornorum</i>), Mozambique tilapia (<i>O. mossambicus</i>), Nile tilapia (<i>O. niloticus</i>), Walking catfish (<i>Clarias batrachus</i>), Blue catfish (<i>Ictalurus furcatus</i>), Freshwater stingrays (<i>Potamotrygonidae</i>), and Bony-tongue fishes (<i>Osteoglossidae</i>) (except silver arowana [<i>Osteoglossum bicirrhosum</i>])
Freshwater Invertebrates	Australian red claw crayfish (<i>Cherax quadricarinatus</i>), Red swamp crayfish (<i>Procambarus clarkii</i>), and White river crayfish (<i>Procambarus zonangulus</i>)
Reptiles	Red-eared slider (<i>Trachemys scripta elegans</i>)
Mammals	Nutria (<i>Myocastor coypu</i>)
Prohibited Species (may be possessed only by accredited public exhibitors or by research institutions with an approved research plan)	
Freshwater fishes	African electric catfishes (<i>Malapteruridae</i>), African tigerfishes (<i>Hydrocyninae</i>), Airbreathing catfishes (<i>Clariidae</i>) (except Walking catfish [<i>Clarias batrachus</i>]), Candiru catfishes (<i>Trichomycteridae</i>), Freshwater electric eels (<i>Electrophoridae</i>), Lampreys (<i>Petromyzonidae</i>), Piranhas and pirambebas (<i>Serrasalminae</i>), Snakeheads (<i>Channidae</i>), Tilapias (<i>Tilapia</i> spp., <i>Sarotherodon</i> spp., <i>Oreochromis</i> spp.) (except conditional <i>Oreochromis</i> species), Trahiras or tigerfishes (<i>Erythrinidae</i>), Airsac catfishes (<i>Heteropneustidae</i>), and Green sunfish (<i>Lepomis cyanellus</i>)
Freshwater Invertebrates	Australian crayfish (<i>Cherax</i> spp.), except <i>C. quadricarinatus</i> in a closed tank system, Zebra mussels (<i>Dreissena polymorpha</i>)
Mammals	African giant pouched rats (<i>Cricetomys</i> spp.)
Marine species	Mitten crabs (<i>Eriocheir</i>), Sea snakes (<i>Hydrophiidae</i>), Weeverfishes (<i>Trachinidae</i>), Stone fishes (<i>Synanceia</i> spp.)

To close the personal pet release pathway, FWC has initiated a Non-native Pet Amnesty program. Conducted on weekends, these well-publicized events provide an opportunity to surrender non-native pets without penalty. The format calls for multi-agency involvement with substantial focus on outreach. Two events have been conducted with a third planned for February 2008 in Miami. A major concern of pet owners is the welfare of their animal, and arrangements are made for adopters to be at events to minimize the possibility that animals will be euthanized. All pets have been successfully adopted, with the exception of two specimens that were unhealthy at the time of surrender.

The volume of animals surrendered at one-day events is miniscule compared to the number of exotic pets in the state, and the principal value of the weekend Amnesty program is to increase awareness of the problem of non-native species in Florida. The decision to release a pet is based on the circumstances at hand, and we have no illusion that owners will postpone their choice to discard a non-native animal until an event occurs. FWC's ultimate objective is to develop a pet surrender network, with qualified adopters ready to accept animals on an ongoing basis. The network will be mediated through the website.

Other outreach efforts target specific audiences and leverage exposure. FWC developed a poster highlighting several non-native freshwater fishes, their native continent and their pathway to Florida. This will be distributed at county nature centers, museums, and science classrooms. FWC has pursued a cooperative, rather than adversarial, relationship with the pet industry, and agency attendance at trade shows provides an opportunity to efficiently reach out to dealers as well as potential pet owners.

Florida's diverse socioeconomic profile presents significant challenges for outreach and education. Extensive Cuban, Mexican, Haitian, and Vietnamese communities, among others, present language as well as cultural barriers. Simple translation of English-language media will be inadequate, and research is needed to determine effective methods to overcome these cultural challenges.

Surveillance and Rapid Detection

When preventive measures fail, it is important to detect non-native species as soon as possible to improve the likelihood of eradication or containment. Florida has an interagency working group to coordinate efforts to prevent and manage

non-native and invasive plants and animals. Recognizing that many agencies have staff in the field, Florida state agencies are attempting to utilize this resource to improve surveillance. An initial attempt to map the distribution of exotic applesnails (*Pomacea* spp.) by providing reporting forms to field staff had limited success, likely due to competition with internal priorities.

The vast majority of introduced species are reported by the public, frequently well after their initial discovery. Accordingly, FWC is in the initial stages of developing a web-based reporting system. The difficulty is in finding the balance of providing adequate information to limit bogus reporting while not overwhelming the non-professional. A simplified version has been employed to solicit reports on Gambian giant pouched rat sightings in the vicinity of their distribution in Grassy Key, Florida (myfwc.com/nonnatives/gambianRat.htm), using photographs to help the public distinguish similar species. This effort has not been widely publicized and has yielded few submissions, including some from areas hundreds of miles from the putative Florida distribution of this species.

Unlike the simple on-line reporting format, a more complex reporting process is in place for non-native applesnails, capitalizing on the visibility and distinctiveness of their eggs. The web document provides background on biology, potential impacts, control, and federal regulations, accompanied by photos of eggs and snails (myfwc.com/nonnatives/Docs/FWC_applesnails_FLMS_handout.pdf). The reporting process calls for the observer to complete a one-page form and submit via facsimile. We have not had an opportunity to assess the quality of reports to date. A reporting format for Reptiles of Concern is under development.

RAPID RESPONSE

FWC's approach calls for elimination of non-native species populations where practical. The majority of introduced species will not become invasive. Regardless, FWC would prefer to eradicate incipient populations rather than risk ecological or economic damage, or harm to human health. Upon detection of a non-native species, a rapid assessment is recommended to determine if eradication is practical, i.e., within financial means, without unacceptable impacts to native species, and commensurate with the potential impact of the introduced organism.

Prior to 2004, several isolated non-native fishes were eradicated by rotenone poisoning of the water

body. Since 2004, four rapid assessments have been conducted to gauge the potential for eradication. In one instance a limited number of an exotic aquarium species, silver dollar (*Metynnis* spp., Characidae), were discovered in an isolated 40-ha lake, including evidence of reproduction. Based on the cost of applying rotenone to this water body, the presence of native predatory fish, and the small number of silver dollar encountered, a decision was made to continue sampling rather than pursue eradication. Subsequent observations indicate this introduced species has been eliminated by natural causes.

In 2004, a population of Gambian giant pouched rats in Grassy Key was reported to the U.S. Fish and Wildlife Service (USFWS). Following preliminary investigations by that agency and USDA APHIS Wildlife Services (WS), FWC organized a multi-agency planning effort in March 2005, which led to an initial abundance index conducted by WS, along with live trapping and camera surveys to delineate the range of the population. Funding for eradication was unavailable, so FWC obtained a \$20,000 grant matched by WS to conduct a pilot eradication project on a portion of the range in June 2006. Subsequently, FWC and WS committed internal funds, along with a grant from USFWS, and in-kind contributions from the South Florida Water Management District (SFWMD) and the Florida Department of Environmental Protection, to initiate an eradication project in early 2007. The first full-scale operation to eliminate this population occurred over two years after the initial report. However, based on field observations, this did not decrease the likelihood of success. As of this writing, the first of several periodic surveys to assess survival of Gambian giant pouched rats was underway.

Purple swamphens were first observed in urban southeast Florida in 1996, likely having escaped from a local aviculturist. Over the next several years, this population increased to over 200 birds but remained confined to developed areas. In early 2006, SFWMD vegetation management contractors reported purple swamphens in the Everglades Conservation Areas. Subsequently, SFWMD staff observed these birds in some of their water treatment areas. In May 2006, FWC and SFWMD conducted a survey of the areas, which indicated a population of approximately 100 birds. In August 2006, night capture methods were evaluated and found to be ineffective. In October 2006, FWC and SFWMD initiated an eradication effort using

shotguns and actively pursuing purple swamphens from airboats. As of March 2007, 601 purple swamphens had been killed, leaving a casual estimate of about 50 birds. Subsequent observations have been limited by extremely low water, but additional removal efforts were scheduled for summer 2007, and both agencies remain guardedly optimistic that, at the least, potential impact to native wildlife and vegetation can be minimized.

Argentine black and white tegus were reported from west central Florida in 2006 by Hillsborough County Environmental Services staff, as well as by private land managers in neighboring Polk County. Initial surveys in summer 2006 indicated usage by juvenile tegus of gopher tortoise (*Gopherus polyphemus*) burrows on public land, corroborating observations by consultants conducting habitat reclamation projects on disturbed lands. Posters were developed to solicit public observations in an attempt to delineate the range of this introduced lizard. Based on credible public reports, it appears that this tegu species occurs over at least 100 km², although its distribution and habitat preference are not well understood. A member of the Teiidae family, tegus were presumed to enter hibernation in late summer, delaying further sampling or removal. A lack of funding and staffing have hampered further efforts at gathering the data requisite to determining if eradication is feasible, and FWC is not optimistic that this species will be eliminated.

ASSESSMENT

In the event that extirpation of an introduced species is deemed to be impractical, assessment of its ecological role is in order to determine appropriate management. Among the factors to be considered are age and growth, diet, reproduction, limiting factors (e.g., temperature, habitat, salinity), and population abundance and composition of introduced and native species. These data may be used to estimate impact, and, consequently the appropriate level of intervention. At the outset, intensity of these studies is high, followed by a reduced level of effort over an extended period.

Most FWC assessments have been of freshwater exotic fishes, focused primarily in the canals of southeast Florida where the greatest number of introductions have occurred. Studies over the past three decades have documented no impacts to native fishes exclusively attributed to introduced species, contrary to our original suppositions. Similar longitudinal studies have not been conducted for non-native terrestrial wildlife, and

FWC will be pursuing research in this area to determine if the response is similar to our observations from the aquatic environment.

CONCLUSION

Fortunately, very few of Florida's established non-native species have resulted in significant adverse ecological or economic impacts. However, the minority of problematic introductions can exact substantial ecological or economic damage and it is incumbent upon natural resource agencies to take all reasonable measures to discourage release and escape of non-indigenous fish and wildlife. FWC has chosen to encourage responsible pet ownership rather than adopt a prohibitionist approach, which they believe would be ineffective with the substantial level of pet ownership and the industry that services this demand.

There is a suggestion that the pace of vertebrate introductions or establishment in Florida is slowing in the current decade following an increase during the 1990s (Figure 2). This may be due to increased

agency focus at the state and national level. However, the pattern of explosive population growth, including diverse cultural influences will continue to be a challenge to natural resource managers. The most effective barrier to the introduction of non-native organisms is to identify species that pose the greatest risks and limit their possession. Since the development of FWC's non-native species rules, only two fishes have become permanently established, along with two possibly established species. One of the established species, spotted tilapia (*Tilapia mariea*) may have been present yet not observed at the time of its listing. Better screening (i.e., risk analyses) are needed to aid in this process, and this should be a focus of research.

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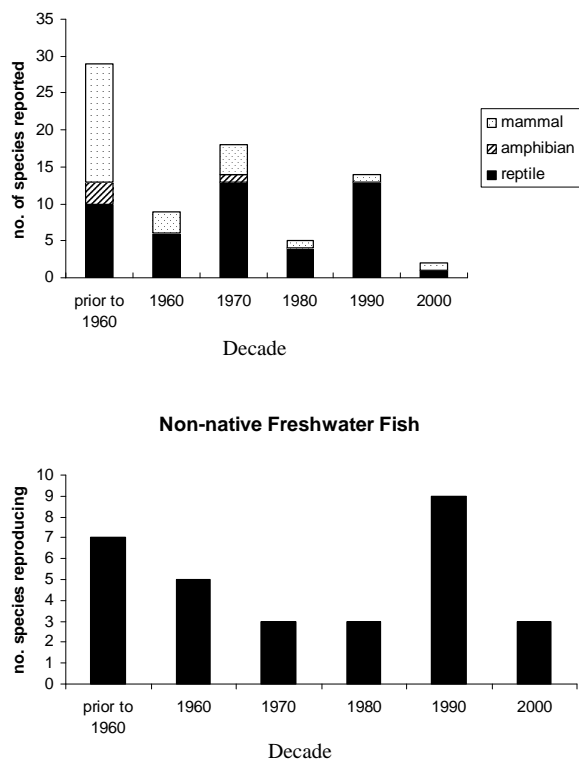


Figure 2. Introduction of non-native vertebrates in Florida by decade.