Chapter 14: Control of Invasive Species and Native Pests

Nonnative species, both plants and animals, are a serious concern for managers at Everglades National Park. The warm subtropical climate and changes caused by the Central and Southern Florida Flood Control Project make the area particularly susceptible to invasion by exotic species. In some cases, local residents introduced exotic plants long before the park was authorized. When exotic plants have high reproductive rates, elevated seed production, and longevity, they can easily displace native plants. Park scientists raised a concern over Australian pine within a decade of park establishment. Today, approximately 250 nonnative plant species are known to exist in the park. For many decades, South Florida has supported an exotic pet trade that annually imported or bred thousands of nonnative animals. There have been multiple accidental or deliberate releases of exotic land animals and fish from private owners and pet breeding establishments.[705] Some of these animals have established breeding populations within the park. Park efforts regarding exotics have moved from attempts to control or eradicate them within its boundary to public education efforts aimed at preventing their release outside the park. In addition to attempting to control exotics, the park has had to contend with mosquitoes and other native pests that, unless artificially restrained, can at times make the park unbearable for visitors and staff.

The Pink Bollworm Project

The pink bollworm project, the first known effort to control an exotic species in what became the park, got underway in the early 1930s. The pink bollworm is a larval form of a moth, *Pectinophora gossypiella,* believed to be native to the Indian subcontinent (figure 14-1, pink bollworm). It was first reported as a pest in cultivated cotton in East Africa in 1904 and was found in Mexico in 1916. In 1932, the worm was discovered in experimental cotton plants at the U.S. Department of Agriculture (USDA) station at Chapman Field south of Miami. Investigations soon showed that the worm had found a host in a local variety of wild cotton (*Gossypium hirsutum)*, which grows within five miles of the shore on many Florida keys and along the Gulf Coast. Wanting to keep this pest from affecting cotton crops in the Southeast, the USDA began a program of

705 Robert F. Doren and David T. Jones, "Plant Management in Everglades National Park," in *Strangers in Paradise: Impact and Management of Nonindigenous Species in Florida*, ed. Daniel Simberloff, Don C. Schmitz, and Tom C. Brown (Washington, D.C.: Island Press, 1997), 275-276; Hillary Cooley, "Exotic Vegetation Management Program: Fiscal Year 2012 Report" (Homestead, Fla.: NPS, 2012), 2.

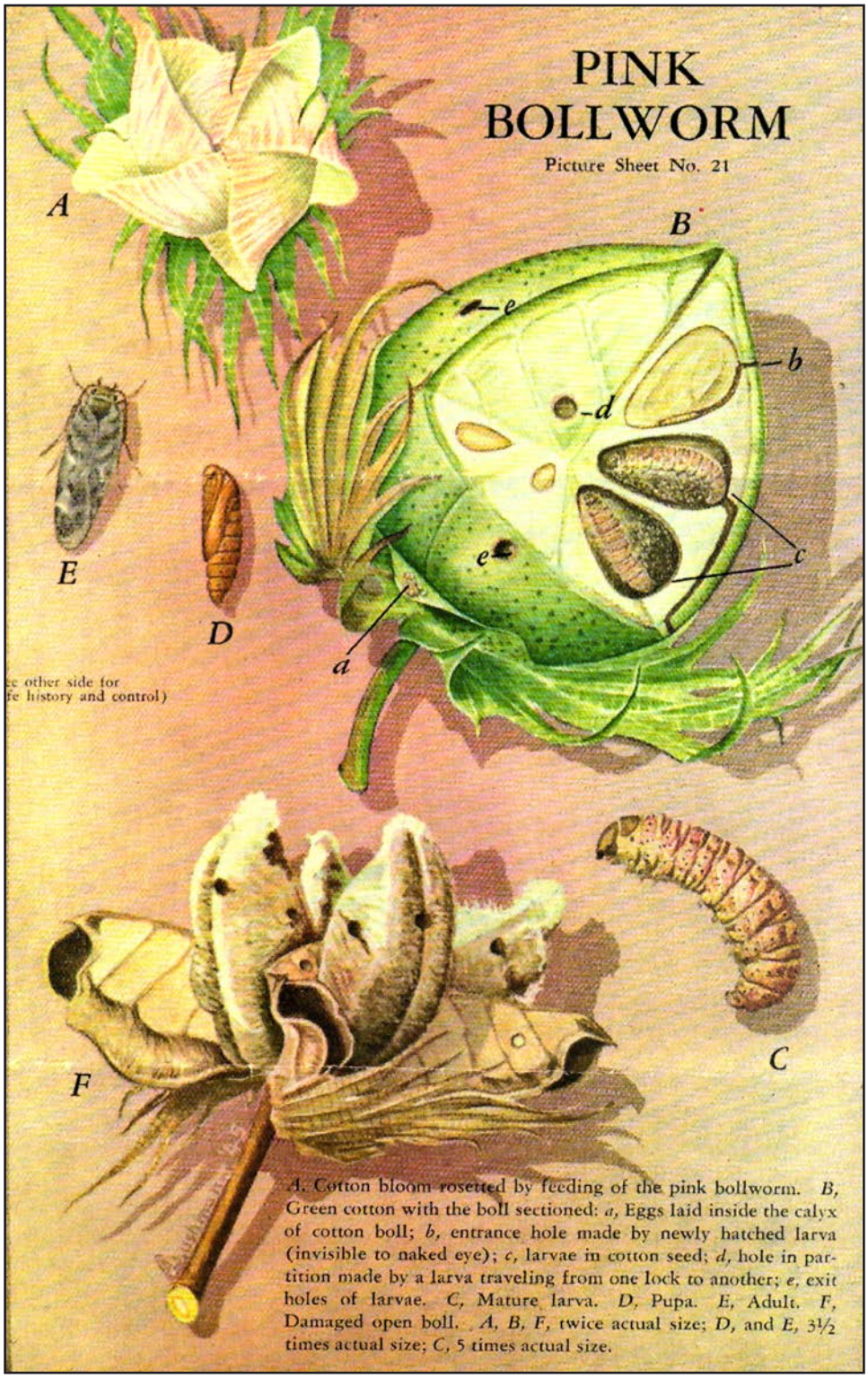

Figure 14-1. Pink bollworm

eradication of the wild cotton host plant in South Florida. Under the program, crews went into the field from late September to May to uproot and burn cotton plants. The USDA found Flamingo an ideal spot to set up a seasonal camp the local black men it hired for this heavy labor. White supervisors of the project apparently commuted from Homestead.[706]

The USDA's Flamingo camp was set up each year from 1932/1933 through 1946/1947 (figure 14-2, Flamingo camp for wild cotton workers). From Flamingo, work crews went by boat to keys and by truck to mainland areas, which required building temporary roads and trails. Congress declined to fund the project for fiscal years 1948 and 1949 (July 1, 1947, to June 30, 1949). Congress restored funding for fiscal year 1950, and the USDA requested permission from the NPS to resume the project. Superintendent Beard opposed restarting the project. As a wildlife technician and refuge manager he had observed damage to plants surrounding the cotton as well as the occasional killing of snakes and harvesting of orchids and mahogany timber by

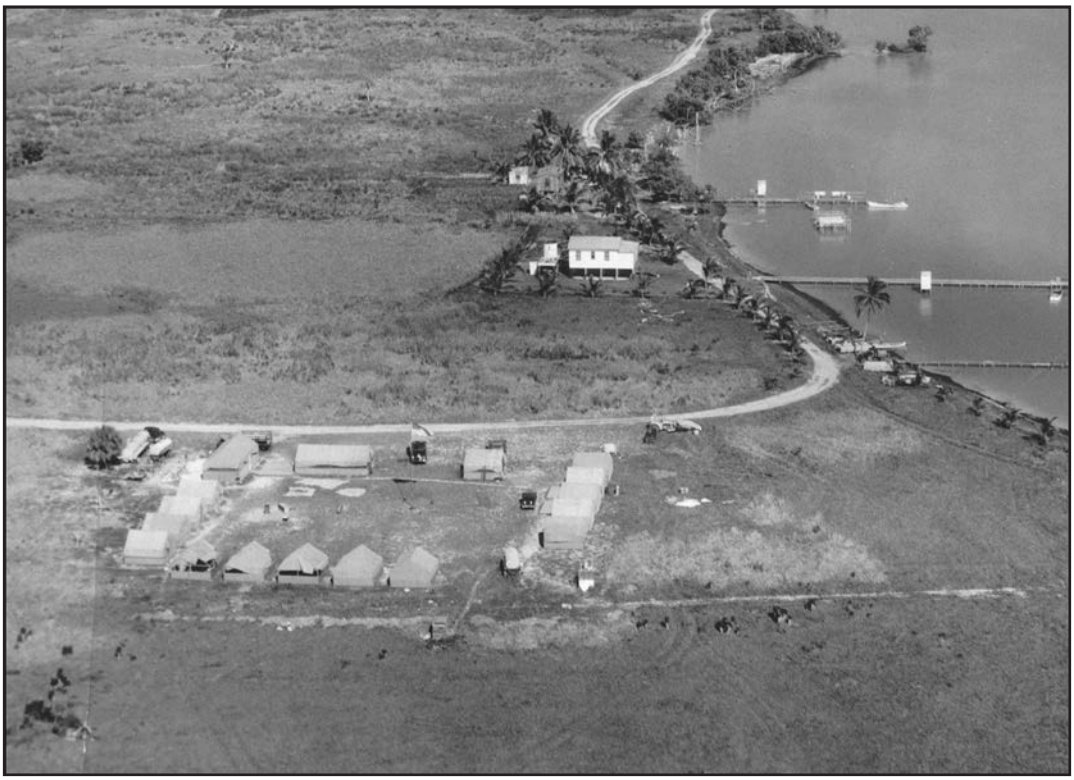

Figure 14-2. Flamingo camp for wild cotton eradication workers

706 Lloyd Noble, *Fifty Years of Research on the Pink Bollworm in the United States,* Agriculture Handbook No. 357 (Washington, D.C.: USDA, 1969), http://babel.hathitrust.org/cgi/pt?id=uiug.30112019254223#page/14/mode/1up.

project workers. None of this seemed appropriate in a national park. Further, Beard questioned the need for the program, given that the only cotton raised commercially in Florida was about 250 miles to the north and the USDA crews could never keep up with the spread of wild cotton. Beard and others suspected the whole program was more about getting federal dollars into South Florida than protecting crops. Beard consulted with Dr. Walter M. Buswell, a botanist at the University of Miami, who observed that Congress could achieve equal benefit to the Florida economy with far less resource damage if it merely put the bollworm workers up in a Miami Beach hotel for a few weeks.[707]

The USDA had enough clout to keep the project going, and the best that Everglades superintendents could do was keep a close watch on the project, prohibit burning of vegetation, and push the USDA to use herbicides rather than machetes in removing the wild cotton. The project went forward under a memorandum of understanding between Interior and Agriculture from 1949/1950 into the early 1970s. By then, the USDA was admitting that it had failed to eradicate wild cotton in South Florida. Dr. Bill Robertson noted that the "program has come under severe question periodically for more than 30 years." Additionally, the "incidence and the mobility of the parasite are both very low" and "control efforts are almost necessarily erratic." He strongly urged the NPS to put an end to the program, which it did in 1972.[708]

Invasive Flora

By the late 1960s, three nonnative trees had emerged as serious problems for Everglades National Park: Australian pine, melaleuca, and Brazilian pepper. Australian pine (*Casuarina equisetifolia*) was the first nonnative that park managers recognized as a potential threat (figure 14-3, Australian pine). The tree, which is not a pine but an evergreen hardwood, was brought to Florida in the late 1800s and planted as windbreaks and for bank stabilization. It reaches heights of 70 to 90 feet and is a prolific producer of seeds, which are spread by birds, wind, and water. In 1956, Dr. Bill Robertson noted individual trees in the park and urged that they be removed before "we have solid stands to contend with." Hurricane Donna in 1960 compounded the problem by widely scattering seeds. [709]

Melaleuca (*Melaleuca quinquenervia*), known variously as paperbark tree, cajeput, and punk tree, is native to Australia (figure 14-4, Melaleuca trees). It was introduced

707 Supt. Beard to RDR1, Jan. 21 and Jan. 28, 1949, NARA II, RG 79, NPS CCF, box 924.

708 Memorandum of Understanding, Dec. 8, 1949, NARA II, RG 79, NPS CCF, box 924; William B. Robertson Jr., Wild Cotton Eradication Project, Dec. 14, 1971; Acting Dir., NPS, to T. W. Edminister, USDA, Aug. 17, 1972, NARA Ph, RG 79, 79-85-8.

709 Biologist Robertson to Chief Ranger Campbell, Feb. 27, 1956, EVER 22970; Draft Exotic Plan Management Fact Sheet, Feb. 12, 2004, EVER 43414.

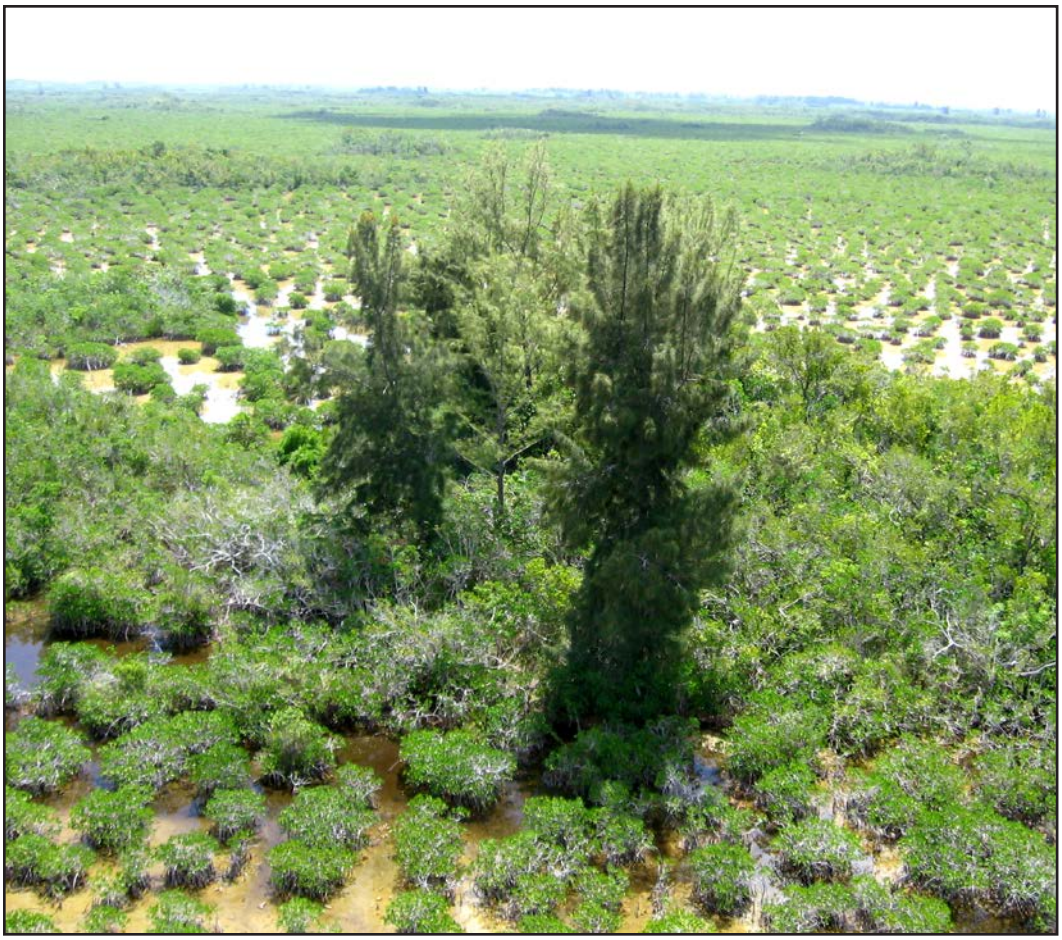

Figure 14-3, Australian pine

in South Florida around 1900 as an ornamental. University of Miami Forester John C. Gifford and others promoted it as an ideal tree for reclaiming wetlands, believing that it drew water from the ground. Ernest Coe recommended planting it on otherwise "useless" land, and the Corps used it to stabilize the levees around Lake Okeechobee in the late 1930s. The tree is an evergreen, grows up to 80 feet, and has a layered, whitish bark that peels easily. Isolated melaleuca trees were first reported in the eastern portions of the park in 1967.[710]

Brazilian pepper (*Schinus terebinthifolius*), native to coastal Brazil, Paraguay, and Argentina, was introduced in Florida as an ornamental plant as early as the 1840s (figure

710 C. E. Turner, T. D. Center, D. W. Burrows, G. R. Buckingham, "Ecology and Management of Melaleuca Quinquenerniva, an Invader of Wetlands in Florida, U.S.A.," *Wetlands Ecology and Management* 5/3 (1997):165-178; "Fast-Spreading Tree Chokes Glades, But Control Programs Are Working," *Miami Herald,* July 3, 2006; Ernest F. Coe to Frederick V. Coville, Botanist, USDA, October 19, 1933, CP, EVER 13650; Status of Exotic Pest Plants/Everglades National Park, n.d. [2004], EVER 43414.

Figure 14-4. Melaleuca trees

14-5, a monotypic stand of Brazilian pepper). It is an evergreen that can grow to about 30 feet, often growing in dense stands that shade out other vegetation. Brazilian pepper produces white flowers and fruit that turn a deep red when ripe. It had already appeared in the park at the time of establishment, and Dr. Frank Craighead Sr. in 1961 predicted that it might become a serious problem. The species was not recognized as a pressing issue until around 1970. The rock-plowed soils of the Hole in the Donut were particularly susceptible to invasion by pepper plants.

Over time, a number of other exotic plant species began to appear in the park. In the 1960s, park staff were alarmed by the rapid growth of water hyacinth (*Eichornia crassipes*) in the L-67 extension canal and adjacent wetlands. In recent decades, old world climbing fern (*Lygodium microphyllum*) and lather leaf (*Colubrina asiatica*) have emerged as troublesome invaders. It was clear that the exotic flora had a number of negative consequences for Everglades ecosystems. These included displacement of native plants, loss of habitat value for wildlife, changes to the water regime, changes to soil characteristics, and changes in fire regimes. The park began a systematic effort to address exotic plants in spring 1968. The first step was to survey the park to learn what inroads had already been made. The park developed an exotic plant control plan in 1973. The plan identified melaleuca control as the top priority. It further observed

that "it will be impossible to completely control the major exotic plants within the Park. The goal will be to maintain a holding action against invasion at as many areas as possible." [711]

In 1963, the park began attacking Australian pine at waterfront areas, especially where the tree threatened to disrupt sea turtle and crocodile nesting areas. By the early 1970s, park staff were using a Hypo-Hatchet® tree injector to inject herbicide into the trees and reporting a very high kill rate. In the 1970s and early 1980s, park staff addressed melaleuca by pulling up seedlings and cutting down trees, then applying herbicides to the stumps. In the early 1970s, the park looked to determine what herbicides were most effective against Brazilian pepper. Fire was used experimentally without success. Herbicides and physical removal were used against water hyacinth. The pine is

Figure 14-5. A monotypic stand of Brazilian pepper in the Hole-in-the-Donut

711 Draft Exotic Plan Management Fact Sheet; Water Hyacinth (*Eichhornia crassipes*) in Everglades National Park, Feb. 1976, EVER 22970; Frank J. Mazzotti, Ted D. Center, F. Allen Dray, and Dan Thayer, "Ecological Consequences of Invasion by *Melaleuca Quinquenervia* in South Florida Wetlands," University of Florida, http://edis.ifas.ufl.edu/uw123; Larry Bancroft, Exotic Plant Control Plan, 1974-1979, July 1973, EVER 42242, ser. IV.

largely under control on keys and coastal areas, but remains in southeastern portions of park.[712]

The park undertook a thorough review of its exotic plant management activities in 1983 and prepared an exotic plant control handbook. The following year it hosted an exotic woody plant workshop. Concern over exotics was becoming more widespread, and the Florida Exotic Pest Plant Council was established in 1984 by concerned state and federal agencies, corporations, and individuals to address invasive flora in a more systematic fashion. Everglades National Park has played an active role with the council since its inception, with park scientists serving on its board. In its early years, the council identified the control of melaleuca as its top priority. Scientists from a wide range of disciplines, land managers, and public officials participate on the council. It publishes a list of invasive plants in the state and has makes available much valuable research and treatment advice. Five years after the council's establishment, the *Wall Street Journal* described the statewide effort against exotics as just getting started.[713]

In November 1988, the park hosted an exotic pest plant symposium organized by park biologist Robert Doren. This was described as the first event concerned with exotics that attracted broad participation from South Florida agencies. The park and others have experimented with biological control methods, the use of an invasive species' natural predators to limit its spread. An example is the introduction of the melaleuca snout beetle (*Oxyops vitiosa*). The beetle is established in the park and is of some help in limiting the spread of melaleuca. The Water Resources Development Act of 2007 included funding for the Department of Agriculture to conduct significant additional work on developing biological control agents for exotic plants in the Everglades. For a number of years, the NPS has partnered with the South Florida Water Management District in conducting systematic overflights of the park to monitor the distribution of exotics. The goal is to do the airborne monitoring every other year, but funding levels do not always allow this. The monitoring is coordinated by the NPS's Exotic Plant Management Team Program.[714]

Melaleuca and Australian pine were well established in the East Everglades expansion area. Prior to the 1989 act that added 109,000 acres of the East Everglades to the park, park managers concentrated on establishing a buffer zone along the eastern

712 Summary of Terrestrial Resource Management in Everglades National Park, 1975; Water Hyacinth (*Eichhornia crassipes*) in Everglades National Park, Feb. 1976, EVER 22970; SAR, 1972, 1975.

713 SAR, 1983, 1984, 1986; Michael J. Bodle and Robert F. Doren, "The Exotic Pest Plant Councils," *Castanea* 61/2 (Sep. 1996):252-254; Eric Morgenthaler "Everglades Park Battles to Stem Invasion of Exotic Foreign Plants," *Wall Street Journal*; Jonathan Taylor, personal communication, Jan. 14, 2013.

714 SAR, 1988, 2000; Jonathan Taylor, personal communication, Jan. 14, 2013; National Research Council, *Progress Toward Restoring the Everglades: The Fifth Biennial Review—2014* (Washington, D.C.: National Academies Press, 2014), 79, http://www.nap.edu/catalog.php?record_id=18809. Hereafter cites as *Progress,* 2014.

park boundary. The aim was to eradicate the two invasive species on both sides of the boundary, with the Park Service and the South Florida Water Management District working in tandem. Once the East Everglades lands became part of the park, eradication of these two species became the park's top exotic plant control priority. Both melaleuca and Australian pine continue to enter the park from seed sources east of the park boundary. The park has attempted to quarantine these species by applying herbicides from the west to the east, attacking the areas of least concentration first. As of 2012, 99 percent of the melaleuca in the park had been treated once, but follow-up treatments are needed. Most of the park's Australian pine had been initially treated by 2012, but approximately 800 acres in the far southeastern portion of the mainland awaited initial treatment. [715]

The South Florida and Caribbean Parks Exotic Plant Management Plan.

Everglades National Park in the early 2000s lacked a comprehensive document on exotic plants that satisfied National Environmental Protection Act criteria. Plant ecologist Jonathan Taylor and others came to realize that a number of NPS units in Florida and the Caribbean had the same deficiency. These parks were known to "have similar goals to preserve and protect park resources, face similar issues related to the presence and spread of exotic plants, and use similar techniques to manage exotic plants." Hoping to share expertise and resources, the NPS developed the *South Florida and Caribbean Parks Exotic Plant Management Plan*. The plan set up a framework for nine NPS units threatened by invasive plants to analyze and evaluate threats and proposed management actions. The preferred alternative in the plan emphasized active restoration of native plants. Initial work on the plan and its associated environmental impact statement began in 2003 and a draft was released for public review in fall 2003. The final version took effect August 30, 2010, and the plan calls for annual reviews.[716]

Brazilian Pepper in the Hole-in-the-Donut

The park faced a particularly difficult battle with Brazilian pepper when farming ended in the Hole-in-the-Donut in the mid-1970s. Before the 1950s, this area

715 SAR, 1991; Cooley, "Fiscal Year 2012 Report," 4-5; Hillary Cooley, personal communication, Sep. 13, 2013.

716 The other NPS units involved were Big Cypress National Preserve, Biscayne National Park, Canaveral National Seashore, Dry Tortugas National Park, Buck Island Reef National Monument, Christiansted National Historic Site, Salt River Bay National Historical Park and Ecological Preserve, and Virgin Islands National Park. Jonathan Taylor, interview by Bonnie Ciolino, Bethany Serafine, and Lu Anne Jones, Nov. 3, 2011; "South Florida Parks Seek Input for the South Florida and Caribbean Parks Exotic Plant Management Plan," NPS media release, Oct. 2, 2006; 75/167 Fed. Reg. 52967-52969 (Aug. 30, 2010).

had been short hydroperiod glades with fingers of pine upland. After World War II, about 9,000 acres in the Hole-in-the-Donut was under cultivation, two-thirds of that acreage being rock plowed (see chapter 6). Once the farmlands were in government ownership, the NPS was eager to reverse the effects of agriculture and restore natural conditions. Immediately upon farming's end, the park planted former fields with slash pine, sedges, and grasses, but without success. In some cases, the park had to drill 18-inch-deep holes in the limestone bedrock to plant saplings. Park staff also established test plots where different treatments of the disturbed area were tried – disking, mowing, bulldozing, and burning. None of the treatments promoted a return to native vegetation. Worse, throughout the abandoned agricultural fields, Brazilian pepper rapidly took over. The drier, more aerated soil and traces of fertilizer left from agriculture proved particularly conducive to the invader. The pepper formed dense stands, known as monotypic stands, that crowded out all other vegetation.[717]

Efforts to remove the pepper trees with herbicides and burning were failures, largely because pepper seeds remaining in the soil survived the treatments. In the late 1980s, resource managers tried a new tactic, attempting to recreate a slough and a hammock landscape by removing all soil material in the slough location, and piling it up to form a hammock. The hardwoods planted on the artificial hammock died, but native wetland plants took hold in the slough. To validate these results, between 1989 and 1992, the park removed soil down to the substrate on 45 acres and partially removed soil on 15 acres. Analysis of the test results showed that only total removal of the soil produced a return to native vegetation (Figure 14-6, Removing soil in the Hole-in-the Donut). The U.S. Army Corps of Engineers and the Dade County Department of Environmental Resources Management participated in these tests.[718]

Although the effort would be very expensive, the park concluded that only total removal of the soil would accomplish restoration goals. In 1993, the NPS, Miami-Dade County and the National Parks Foundation (NPF) entered into an agreement to restore approximately 6,300 acres in the Hole-in-the-Donut. Funding for the project came from a wetlands mitigation trust fund established by Miami-Dade County, and the NPF agreed to accept and hold funds from the county. Developers who were allowed to fill in degraded wetlands in other parts of the county paid up to $19,000 an acre into the fund as mitigation. In 1996, the park was granted permits from the Corps of Engineers and the state of Florida, and the project began in 1997. The environmental assessment conducted by the Corps identified several alternatives for

717 Robert F. Doren and Louis D. Whitaker, Plan for Mitigation and Monitoring of Secondary Successional Communities in Everglades National Park: Hole-in-the-Donut, Dec. 6, 1988, EVER 22965; Taylor interview; SAR, 1991.

718 NPS, "Environmental Assessment, Hole-in-the-Donut Soil Disposal" (Homestead, Fla.: NPS, Aug. 1998), 9.

Figure 14-6, Removing soil in the Hole-in-the-Donut

deposition of up to 17 million cubic yards of removed soil, with trucking it off-site the preferred alternative.[719]

After the Corps issued its permit, there was a growing realization that trucking the soil off-site would be expensive and likely require the park to replace a dozen miles of road every two to four years. The state also decided that the costs of trucking the soil out of the park were not a legitimate mitigation expense, and the NPS would need to find funding for it. As a result, the state's permit allowed the indefinite retention of the soil on-site by piling into mounds within the Hole-in-the-Donut. The NPS prepared a supplemental environmental assessment in 1996 focusing on the issues surrounding soil disposal. This assessment emphasized the damage to roads and degradation of the visitor experience that 12 to 16 thousand truck trips each winter would cause if the soil was removed. Instead, the document called for creating five to 12 soil disposal mounds on 2 to 3 percent of the restored acreage. It was acknowledged by all concerned that piling up the soil in the park was a disruption of the natural environment. Ultimately as

719 Jonathan Taylor, interview by author, Sep. 26, 2013; "A Mountainous Challenge in the Heart of the Everglades," *Miami Herald,* Apr. 20, 1997.

Figure 14-7, Spoil pile in the Hole-in-the-Donut with native vegetation

the project proceeded, six soil mounds totaling 230 acres were created in the park. The mounds were to have been located away from visitor use areas and cultural resources. For reasons that remain murky, one mound was located near the historic route of the Ingraham Highway and a second within sight of the HM-69 missile base.[720]

The issues surrounding soil disposition aroused considerably controversy locally. Some farmers who forced out of the Hole-in-the-Donut in the 1970s expressed outrage that the NPS was creating artificial conditions on a portion of the acreage they had promised to restore. One former farmer, Rosario Strano, complained, "They're not restoring, they're destroying. They're down there digging up good soil." Dr. Murray Mantell, a professor of civil engineering at the University of Miami, had a novel, perhaps tongue-in-cheek, proposal. He suggested that the soil be piled up to form mountains that could be covered with artificial snow for a ski resort within the park.

720 NPS, Decision Notice and Second Finding of No Significant Impact for Restoration of Wetlands in the Hole-in-the-Donut, with attached Supplemental Environmental Assessment (Homestead: NPS, Sep. 18, 1996); Taylor interview.

The NPS declined this solution (figure 14-7, a spoil pile in the Hole-in-the-Donut with native vegetation).[721]

The Hole-in-the-Donut restoration project has been a stunning success. When the limestone is exposed, summer rains flood out any pepper seedlings. Algae and other plant material create a layer of marl, and sawgrass and other native plants rapidly become established, without the need for plantings by park staff. After 15 years, soil accumulations average about 3.7 centimeters, within the range considered optimal for rocky wetlands areas in the Everglades Within a few years, native and migratory birds colonize the reclaimed acreage, and raccoons, deer, panthers, and black bears move in. The project has been expensive, with each reclaimed acre costing between 10 and 15 thousand dollars. As of October 2013, 4,850 of the targeted 6,300 acres had been restored. Early concerns among environmentalists over the soil mounds have largely died away. Interest earned from the mitigation trust fund allows staff to mow the mounds to prevent pepper from being reestablished. One mound has been released to natural succession, with hardwood hammock trees becoming established. The mounds have proven to be good habitat for invertebrates, including rare and endangered butterflies. Bird watchers love the mounds because they are excellent observation platforms. The preferred alternative in the park's draft GMP contemplates constructing spur trails to one or two mounds to be used as overlooks.[722]

Brazilian pepper also covers tens of thousands of acres on the fringes of mangrove forests on the Gulf side of the park. The density of these stands varies, but most are in areas that are very difficult to access. Crews coming in to apply treatments would need to use helicopters. Helicopter landings are problematic in wilderness areas, and there are few landing areas where the pepper grows. To date, the NPS had not identified "a cost-effective strategy for systematically removing Brazilian pepper" from these areas. The best that the park has been able to accomplish with available funds is to spot treat Brazilian pepper at high-priority locations, for example, where impacts of the plant on rare or endangered species is a concern.[723]

Old World Climbing Fern and Lather Leaf

Old world climbing fern was first noticed in Everglades National Park in 1999. It is a twining and climbing perennial that starts on the ground and grows up shrubs and

721 "Schussing through the Everglades?," ***Orlando Sentinel,*** Aug. 17, 1997.

722 Craig S. Smith, Laura Serra, Yuncong Li, Patrick Inglett, and Kankia Inglett, "'Restoration of Disturbed Lands: The Hole-in-the-Donut Restoration in the Everglades," *Critical Reviews in Environmental Science and Technology* 41/6 (2011):723-739; "Reviving 'Hole in the Donut' an Everglades Success Story," *Miami Herald,* June 26, 2001; Taylor interview; Jonathan Taylor, personal communications, Jan. 14 and Sep. 26, 2013; Draft GMP, 67.

723 Cooley, "Fiscal Year 2012 Report," 5.

trees, eventually smothering them. Within the park it is mostly found in remote Gulf coast areas from Cape Sable to Everglades City. In 2010, old world climbing fern was estimated to be growing on at least 2,000 acres in the park. The total could be higher because it is unlikely that all stands of the plant can be observed from aircraft flying at 500 feet. Park scientists believe that the affected area has expanded slightly since then. The park has used herbicides released from the air to control this invasive, but funding has not been available for this treatment since 2008. In 2013, the park released brown Lygodium moths (*Neomusotima conspurcatalis*) in affected park areas. This species feeds on old world climbing fern, and this method of biological control previously has been used with some success in Florida's Jonathan Dickenson State Park. Park scientists will be monitoring the results of the introduction of this moth species.[724]

Park collaborator Frank C. Craighead recognized lather leaf in the park as early as 1954, but it did not become a serious concern until the 1990s. By then, the species was noted as common on upper dunes, coastal strand habitat, buttonwood forests, and coastal hardwood hammocks along Florida Bay and in the Ten Thousand Islands. Lather leaf is difficult to indentify in aerial survey efforts, making it difficult to estimate how much of the park is affected. The plant has been controlled in limited areas by persistent manual removal and herbicide application.[725]

Exotic Flora Introduced by the NPS

The planting plans used during the Mission 66 period in the 1950s and 1960s frequently specified the use of exotic plants. As attitudes within the NPS evolved, this practice was abandoned. In 1979, the park removed several hundred nonnative coconut palms from Flamingo and the headquarters area on Parachute Key.[726]

Invasive Fauna

Various tropical fishes were among the first invasive animals to cause concern in the park. Once the extensive system of canals of the Central and Southern Florida Flood Control Project were built, nonnative fishes (and species native to other parts

724 Jonathan Taylor, "Management of Old World Climbing Fern in Everglades National Park," in *Old World Climbing Fern Management Plan for Florida,* 2d ed., 2006; University of Florida IFAS, http://hillsborough.extension.ufl.edu/homegardening/PDFs/Fact%20Sheets/Invasives_Old%20World%20Climbing%20Fern.pdf; Anthony Boughton and Ted Center, "Biological Control of Old World Climbing Fern, *Lygodium microphyllum,* Recent Progress with the Brown Lygodium Moth," Florida Exotic Pest Plant Council, Apr. 6, 2010, http://www.ars.usda.gov/research/publications/publications.htm?seq_no_115=251047; Hillary Cooley, personal communication, Sep. 13. 2013.

725 Cheryl M. McCormick, compiler, *Columbrian Asiatic* (*Lather Leaf) Management Plan* (N.p.: Florida Exotic Pest Plant Council, 2007), 37-39.

726 SAR, 1979.

of Florida) had an easy route into park waters. As early as December 1969, Everglades rangers received instructions to preserve or photograph any nonnative fishes they encountered. At the time, the so-called walking catfish (*Clarias batrachus*) was creating a media stir. *C. batrachus* was one of a number of nonnative fish brought to Florida for the aquarium trade that were released into the wild and eventually established breeding populations. As described above in chapter 12, park managers had limited information on freshwater fish populations prior to the late 1970s. Once systematic sampling began, it was learned that the walking catfish and the black acaca (*Chilasoma bimaculatum*) were breeding in park waters (figure 14-8, invasive freshwater fish).[727]

The appearance of nonnative fishes in park waters seems to be tied to changes in regional water management practices. Not long after the capacity of canals near the park was expanded and water began being pumped directly from the L-31W Canal into Taylor Slough in 1981, six new nonnative fishes appeared in the eastern section of the park. After 1999, when water managers began delivering more water to the eastern side of the park and water overtopped the banks of the C-111 and L-31W Canals, eight additional nonnative species were found in the park. To date, 17 nonnative species have been detected in park waters. Two of these, the Mozambique tilapia and the banded cichlid, are not believed to be breeding in the park. Ten of the 17 species are from the Cichlidae family, a large family of tropical fishes with members native to Central and South America, Africa, and Asia. Among these are the oscar (*Astronotus ocellatus*), the Mayan cichlid (*Cichlasoma urophthalmus*), the spotted tilapia (*Tilapia mariae*), the blue tilapia (*Oreochromis aureus*), and the African jewelfish (*Hemichromis letourneuxi*). Fish from the Cichlidae family have the ability to adapt to a variety of habitats. Further, they occupy a similar ecological niche to native sunfishes and have the potential to outcompete them. Nonnative fish from other families that have become established in the park include the Asian swamp eel (*Monopterus albus*) and the pike killifish (*Belonesox belizanus*). Some of these invasive species do provide prey for larger native fish, like the largemouth bass (*Micropterus salmoides*), or for wading birds.[728]

The long-term effects of the invaders on the ecosystem are largely unknown. Recent studies indicate that the African jewelfish and the Mayan cichlid may pose a particular threat. When small native fishes seek refuge in the deeper waters of solution holes and creek headwaters in the dry season, they appear to be subject to increased predation by these species. It is generally thought that once a nonnative fish species is

727 Chief Ranger, EVER, to Field, Dec. 19, 1969, EVER 22965; "Catfish That 'Walks' Is Here to Stay, Florida Finds," *New York Times,* Nov. 24, 1968; Jeffrey L. Kline, William F. Loftus, Kevin Kotun, Joel C. Trexler, Jennifer S. Rehage, Jerome J. Lorenz, and Michelle Robinson, "Recent Fish Introductions into Everglades National Park: An Unforeseen Consequence of Water Management?," *Wetlands,* Jan. 17, 2013, DOI 10.1007/s13157-012-0362-0. Loftus interview. Native to Africa and Southeast Asia, *C. batrachus* uses its dorsal fins to wriggle (not actually walk) up to 75 feet from one body of water to another.

728 Kline et al.; Jeffrey Kline, personal communication, June 28, 2013.

Figure 14-8. Invasive freshwater fish

established in the park, it is highly impractical, if not impossible, to eradicate it. Current NPS management efforts therefore are directed to stopping invaders before they reach the park. If nonnative fishes are detected in canals bounded by levees before they can enter the park, there is a better chance of eradicating them. The park has stepped up efforts to educate the public about the dangers of releasing nonnative fish, encourage responsible practices by breeders of aquarium fishes, and achieve water management practices that are favorable to native species. The park is an active

participant in the Everglades Cooperative Invasive Species Management Area (CISMA) effort, described further below.[729]

Nonnative Land Animals

Over the decades, a number of nonnative land animals became resident in the park, including feral hogs, armadillos, and iguanas. The Spanish brought domesticated swine (*Sus scrofa*) with them on their invasions of the Southeast in the 1500s, and feral populations have existed in Florida ever since. The main threat from hogs is the damage to native vegetation caused by their foraging. In 1930, a group of U.S. senators scouting the proposed park area saw wild hogs in the area. Ranger Erwin Winte in 1960 noted evidence of hog rooting on a tree island in the Shark River Slough. Wild hogs today are found in every county in Florida, with a statewide population estimated at 500,000 to two million. In 2012, some Florida hunters began the practice of shooting hogs from the air using chartered helicopters. This occurred on a large private ranch in the north Everglades, well away from the park. In the park, hogs are confined mostly to upland areas. The nine-banded armadillo (*Dasypus novemcinctus*) is native to South Texas and Mexico, but rapidly expanded its range in the twentieth century. This armored mammal has been in Everglades National Park since the early 1970s, if not earlier. Both hogs and armadillos have emerged as good food sources for panthers.[730]

A number of lizards from the exotic animal trade have established themselves in the park. These include the brown anole (*Anolis sagrei*), knight anole (*Anolis equestris*), common green iguana (*Iguana iguana*), and three species of gecko. To date, these lizards appear not to have caused serious damage. A more recent reptilian invader, the Argentine tegu lizard (*Tupinambis merianae*), has caused more concern. The tegu is omnivorous and can tolerate temperatures approaching freezing. A host of other exotic animals are present in Florida, not far from the park's boundary. Many could in future

729 J. S. Rehage, S. E. Liston, K. J. Dunker, and W. F. Loftus, "Fish Community Responses to the Combined Effects of Decreased Hydroperiod and Nonnative Fish Invasions in a Karst Wetland: Are Everglades Solution Holes Sinks for Native Fishes?," *Wetlands*, Jan. 17, 2013, DOI 10.1007/s13157-012-0361-1; E. J. Harrison, J. J. Lorenz, and J. C. Trexler, "Per Capita Effects of Nonnative Mayan Cichlids (*Cichlasoma urophthalmus*; Gunther) on Native Fish in the Estuarine Southern Everglades," *Copeia* 2013/1, 80-96; Jeffrey Kline, personal communication, June 28, 2013.

730 "New Territory Seen by Senate Group in Blimp," *Miami Daily News,* Dec. 30, 1930; "Wild Hogs: Nuisance or Hunting Opportunity?," Florida Fish and Wildlife Conservation Commission, http://myfwc.com/news/news-releases/2012/january/03/outta-jan/; "Hunters Use Helicopters to Target Nuisance Wild Pigs on Florida Ranch," *Miami Herald,* Mar. 25, 2012; Joseph M. Schaeffer and Mark E. Hostetler, "The Nine-Banded Armadillo (*Dasypus novemcintus*)," University of Florida IFAS, http://edis.ifas.ufl.edu/uw082; Wes Phillips to Larry Bancroft, May 8, 1973, EVER 22965.

become park residents. The Burmese python is the invader that aroused the greatest concern in the 2000s.[731]

Burmese Pythons and Other Constrictors

For decades, several python species have been imported into and bred in Florida for those who crave unusual pets. Two subspecies of *Python molurus,* the Burmese python (*Python molurus bivittatas*) and the Indian python (*Python molurus molurus*) have become a large problem for the Everglades National Park (figure 14-9, Burmese py-

Figure 14-9. Burmese python

thon).[732] Several other python species, including the African rock python, are also of concern. The Burmese python is one of the largest snakes in the world; females can

731 "Hunt is on for Tegu Lizards in South Florida," *Miami Herald,* Sep. 26; 2013; Everglades National Park Exotic Species List, http://www.nps.gov/ever/forteachers/upload/BackgroundInformation.pdf.

732 Other large snakes including the northern African python (or African rock python) (*Python sebae)*, common boa (*Boa constrictor*), reticulated python (*Python reticulator*), and green anaconda (*Eunectus murinus*) have been found in the wild in the Everglades, but only the Burmese python is known to have a significant breeding population. The northern African python does appear to be breeding in a localized area just southeast of the intersection of Tamiami Trail and Krome Avenue, not far from the park boundary. Florida Museum of Natural History website, http://www.flmnh.ufl.edu/herpetology/fl-guide/Pythonsebae.htm.

reach more than 20 feet in length and weights of 200 pounds. Burmese pythons are tan with distinctive brown and black markings on the back and sides. They kill by first gripping the victim with their teeth and then wrapping their body around it and smothering it. The species is semiaquatic, known to hunt on dry land and in water, and needs only a slightly elevated hammock for nesting. It was known for some time that Florida owners were releasing pythons when they became unmanageably large. The first confirmed capture of a Burmese python in the park came in 1979. Hurricane Andrew in 1992 demolished a number of exotic pet warehouses, releasing an unknown number of pythons into the wild. Until the year 2000, only about a dozen had been found in the wild throughout South Florida. From that point, sightings and captures skyrocketed. By 2007, 250 to 300 individuals annually were being captured or found dead within the park or on adjacent South Florida Water Management District land. [733]

Burmese pythons pose a particular threat in the Everglades because they can adapt to a variety of habitats, consume a wide variety of prey, live 15 to 25 years, can move great distances, and are prolific breeders. Analysis of the stomachs of these serpents has shown that they eat mice, rats, rabbits, muskrats, raccoons, opossums, deer, bobcats, egrets, and more. A study published in early 2012 documented a decrease in populations of raccoons, opossums, rabbits, and bobcats observed at night in the park from 2003 to 2011. Although the authors cautioned that this is not proof that predation by pythons is the cause, the results are suggestive. Beginning in late 2005, scientists from the University of Florida and the park began surgically implanting radio transmitters in a few pythons, to better track their movements. Radiotelemetry led to the discovery in May 2006 of the first nest of python eggs in Everglades National Park, confirming that the giant snake was indeed breeding in the park.[734]

The invasion of the Everglades by giant pythons that squeeze the life out of their prey was a story that few media outlets could resist, especially after video of "gator vs. python" went viral. This epic, 24-hour struggle started on a Sunday morning in January 2003, when visitors on the Anhinga Trail observed a full-grown alligator and a large python in a clinch. The gator had bitten down on the snake, which then wrapped itself around the gator. Deputy Superintendent John Benjamin happened to be there to photograph a section of the boardwalk that needed repair. His son, also John, who was with him, shot video and placed it on the web, causing a sensation. Media outlets

733 Rebecca G. Harvey, Matthew L. Brien, Michael S. Cherkiss, Michael Dorcas, Mike Rochford, Ray W. Snow, and Frank J. Mazzotti, "Burmese Pythons in South Florida" (Gainesville, Fla.: University of Florida IFAS, July 2008), http://edis.ifas.ufl.edu/uw286.

734 Harvey, et al.; Michael E. Dorcas, John D. Willson, Robert N. Reed, Ray W. Snow, Michael R. Rochford, Melissa A. Miller, Walter E. Meshaka Jr., Paul T. Andreadis, Frank J. Mazzotti, Christina M. Romagosa, and Kristen M. Hart, "Severe Mammal Declines Coincide with Proliferation of Invasive Burmese Pythons in Everglades National Park," *Proceedings of the National Academy of Science* 109/7 (Feb. 14, 2012), http://www.pnas.org/content/109/7/2418.full?sid=42030396-df1f-4b93-be77-fbfade00a499.

from the *National Examiner* to *National Geographic* picked up the story. In 2009, *The New Yorker* ran a nine-page feature on exotic animals in Florida, featuring the python prominently and quoting park biologist Ray W. "Skip" Snow extensively. Reality television was not far behind. The National Geographic Channel debuted "Python Hunters" in July 2010. Public television's highly regarded *Nature* series produced an episode "Invasion of the Giant Pythons." Since 2003, video of other python/alligator encounters has been posted.[735]

As land managers became aware of the python threat, a number of steps were taken. Following an invasive reptile management workshop in 2005, the NPS joined with several other institutions to form the Python Science Support Team. The support team has been focusing on ways to capture and remove pythons. Scientists have no present hope of eliminating pythons from the park. A key concern is to insulate bird rookeries from predation by pythons, perhaps by trapping and relocating or euthanizing pythons in the immediate vicinity. It will also be important to try and keep pythons out of the Florida keys. The keys are home to small populations of several endangered species like the Key Largo cotton mouse (*Peromyscus gossypinus allapaticola*), Lower Keys marsh rabbit (*Sylvilagus palustris hefneri*), and the key deer (*Odocoileus virginianus clavium*) that would be particularly vulnerable to pythons.[736]

In 2007, the Florida legislature passed legislation addressing "reptiles of concern." The law directed the Florida Fish and Game Conservation Commission (FWC) to draw up a list of nonnative venomous reptiles and other reptiles of concern. Anyone keeping an animal on the list was required to obtain a $100 annual permit. The commission was given the authority to inspect the premises of any permit holder and revoke the permit if violations were detected. The law also provided penalties for releasing such animals into the wild. The FWC identified four python species (Burmese, articulated, African rock, and amethystine or scrub), the green anaconda, and the Nile monitor lizard as reptiles of concern. It also required that owners implant an identifying microchip in each animal and prepare a critical incident and disaster plan detailing how animals would be secured or evacuated in an emergency. After a Burmese python killed a two-year-old Florida girl in 2009, the legislature in 2010 banned the possession, importation, sale, trading, or breeding of the five species. Existing owners of such animals were exempted, and Florida breeders of these reptiles were permitted to continue operating.[737]

735 Burkhard Bilger, "Swamp Things," *The New Yorker,* Apr. 20, 2009, 83; John Benjamin, interview by author, July 20, 2012; National Geographic Channel, http://www.nationalgeographic.com/wild/shows-python-hunters/; http://www.pbs.org/wnet/nature/episodes/invasion-of-the-giant-pythons/introduction/5532/.

736 Harvey, et al., Bilger, 87.

737 Florida statutes 2007-239 and 2010-185; State Representative Ralph Poppell, "Florida is Proactive about Exotic Reptiles," *Gainesville Sun*, July 24, 2009; Responsible Exotic Animal Ownership website, http://www.rexano.org/StatePages/FloridaFrame.htm.

Effective March 23, 2012, the U.S. Fish and Wildlife Service declared the Burmese python, Indian python, Northern African Python, Southern African python, and yellow anaconda to be injurious reptiles. This action brought the five species under the provisions of the Lacey Act and made it a federal offense to import these snakes and their eggs into the United States or to transport them across state lines.[738] Although these state and federal laws were well-intentioned, they came too late to do much good for the Everglades.

Efforts to control invasive pythons have assumed some very creative dimensions. From 2010 through 2013, the Florida Fish and Wildlife Conservation Commission sponsored an annual sanctioned hunt of Burmese pythons and other injurious reptiles on state land. A much-ballyhooed "Python Challenge" in 2013 drew 1,500 participants, but resulted in the capture of just 68 pythons. The event failed to significantly reduce python populations, but scientists who performed necropsies on the animals gained insights into their diets. Given the meager results, the state has no current plans to repeat the event. The state continues to train and license python hunters, who then have a better chance of locating the elusive beasts than the average hunter. Everglades National Park also has about 30 authorized agents who track and try to capture pythons in the park for research purposes.[739]

The detection of pythons by specially trained dogs has shown some promise. In winter 2010/2011, two black Labrador retrievers from Auburn University, part of a program known as EcoDogs, were in the park with their trainers and university scientists. The dogs covered more ground and were more than twice as accurate as human searchers in detecting pythons. Tracking pythons with dogs is expensive—they require at least six months of specialized training and must work with skilled handlers. The use of tracking dogs is one tool among several that will likely be used in the future to address the python issue.[740]

An Invasive Insect Species: The Red Imported Fire Ant (*Solenopsis invicta*)

The red imported fire ant arrived in the American South from South America in the 1930s and is well established throughout Florida, including Everglades National Park. The ant has aggressive foraging behaviors, with individuals stinging their prey

738 77 Fed. Reg. 3329-3330 (Jan. 23, 2012).

739 "Hunters Unleashed on Florida Python Problem," *Chicago Tribune,* Feb. 24, 2010; "Officials Give Up on Evicting Pythons," *Washington Post,* Mar. 22, 2014; "The Python Invasion Project: Meet the Hunters, *Miami Herald,* June 9, 2014.

740 "A Giant Battle: Auburn Canines Help in Search for Everglades' Pythons," Auburn University press release, Feb. 15, 2012, http://ocm.auburn.edu/featured_story/pythons_dogs.html; "Snake-Sniffing Dogs Help Find Pythons in the Park," *Washington Post,* May 3, 2012.

en masse. In the American South, fire ants frequently become the dominant ant species because of a lack of predators and competitors. Research and observations have shown the fire ant to be a direct and indirect threat to a number of animals found in the Everglades, notably the Florida tree snail, loggerhead turtle, and alligator. In areas of Florida outside Everglades National Park, researchers have observed fire ants killing tree snails and hatchling loggerhead turtles. Research also has shown that both turtle and alligator nests that are infested by fire ants have lower success rates. Fire ants may also adversely affect the foraging behavior of small mammals where fire ant mounds are plentiful. The effect of fire ants on native animals in Everglades National Park is largely conjectural at the moment, pending research efforts specifically targeting the park.[741]

Cooperative Efforts and Public Awareness

Everglades National Park has pursued a number of cooperative efforts to combat invasive species. The park's involvement with the Florida Exotic Pest Plant Council has already been mentioned. In late 2008, the park joined with USFWS, the Corps, the SFWMD, and the Florida Fish and Wildlife Conservation Commission to form the Everglades Cooperative Invasive Species Management Area (CISMA). Miami-Dade County later affiliated with the CISMA. The Everglades CISMA was created to provide a framework for interagency cooperation on invasive species issues and facilitate coordination with the CERP as individual restoration projects went forward.[742]

A major focus of the interagency effort has been educating the public about the issues with invasive species and getting the public's cooperation in preventing future problems. The park and the Florida Fish and Wildlife Conservation Commission produced *Florida Invaders*, an eight-page color brochure. The piece emphasizes the economic and ecological costs of invasives and touts the advantages of education, prevention, early detection, and rapid response. Readers are urged to be responsible pet owners and gardeners. The park has helped fund and staff Nonnative Pet Amnesty Days at Zoo Miami. Owners may bring unwanted exotic pets to the zoo on these days, no questions asked. The FFWCC lines up responsible adopters for these animals, and the event gives people an alternative to releasing them into the wild.[743]

741 C. R. Allen, D. M. Epperson, and A. S. Garmestani, "Red Imported Fire Ant Impacts on Wildlife: A Decade of Research," *American Midland Naturalist* 152 (July 2004):88-103; B. Smith, "A Partial Survey of Florida Tree Snail (*Liguus fasciatus*) Distribution in Big Cypress National Preserve," report submitted to NPS, 1997.

742 Everglades CISMA website, http://www.evergladescisma.org/about.cfm; Ray W. "Skip" Snow, interview by author, Oct. 5, 2011.

743 Snow interview; NPS, *Florida Invaders*, http://www.nps.gov/ever/naturescience/upload/2008%20Florida%20Invaders%20For%20Web.pdf.

Mosquito Control

Mosquitoes present a severe challenge for humans attempting to live and work in the Everglades in the warmer months. Some 13 of the 43 mosquito species found in the Everglades bite humans. Mosquitoes carry diseases like West Nile disease and St. Louis encephalitis and can cause accidents when droves of them attack drivers or operators of power tools. Former residents of the fishing village of Flamingo told of their various attempts to keep the pests at bay. Some houses had a "losing room" where a smudge fire and palmetto fronds were used to shed the insects before one entered the house. Mothers wrapped their children's' limbs in newspaper before they ventured outdoors in summer. With the park's establishment and the development of employee residences and maintenance facilities at Flamingo and Pine Island, the NPS faced the challenge of making these areas habitable with the least damage to the environment. The reality is that any chemical that is toxic to mosquitoes will adversely affect other creatures under some circumstances. On the other hand, as the park put it in 1961, "abatement or reduction of the mosquito nuisance [at developed areas] is recognized as essential to the welfare of visitors and employees." [744]

The park has used a number of insecticides against mosquitoes through the decades (figure 14-10, mosquito fogging at Flamingo, June 1965). DDT (dichlorodiphenyltrichloroethane) was used at the park's 1947 dedication and up through the early 1960s. In May 1961, the *Miami Herald* reported that mosquito fogging was done daily at Flamingo. Rachel Carson's *Silent Spring* came out in 1962, touching off a campaign against DDT that led to its near total ban in the U.S. effective January 1, 1973. As of 1966, Everglades National Park had already switched to malathion for mosquito abatement. Malathion is an organophosphate insecticide known to be toxic to insects and some fishes and can cause altered behavior and loss of motor control in birds and reptiles. In 1970, Secretary of the Interior Walter Hickel instituted a systemwide ban on the use of DDT and 15 other pesticides. In the mid-1980s, the park was still employing malathion, but also experimenting with Scourge®, with active ingredients of resmethrin and piperonyl butoxide. By the late 2000s, the park was primarily using Anvil® 10+10 and Duet®. Both products contain d-phenothrin (trade name, Sumithrin®) and piperonyl butoxide as active ingredients. Resmethrin and sumithrin are synthetic pyrethroids, while piperonyl butoxide is a synergist, a chemical that enhances the effectiveness of other compounds. Duet® also contains prallethrin (trade name,

744 Barbara L. Pettit, "A Short History of the Everglades and Surrounding Areas," typescript draft, Apr. 1981, EVER 22965; Park Master Plan, Mission 66 Edition, 1961, HFC, box 3; Draft White Paper: Mosquito Control and Pesticide Use at Everglades National Park, n.d. [circa Aug. 2007].

Figure 14-10. Mosquito fogging at Flamingo, June 1965

ETOC®), which has the ability to draw mosquitoes from a resting state, thus increasing their exposure to the insecticide.[745]

Since 1980, mosquito control in NPS areas has been governed by the Integrated Pest Management (IPM) program as well as general NPS management policies. The management policies provide that native pests may be suppressed to "manage a human health hazard when advised to do so by the U. S. Public Health Service (which includes the Centers for Disease Control and the NPS public health program); or to otherwise protect against a significant threat to human safety." Currently, Everglades and other NPS units make annual requests for the use of pesticides via an internet-based application called PUPS (Pesticide Use Proposal System). Depending on the requested use, park requests are approved by the regional or national IMP program manager. Since the implementation of the IPM program, Everglades has received authorization to use mosquito adulticides at the developed areas at Flamingo

745 "Tourist Trade Slump Hits Everglades Park," *Miami Herald,* May 12, 1961; Leslie D. Beadle, U.S. Public Health Service, Report of a Mosquito Survey at the Everglades National Park, Florida, Oct. 1966, EVER 22970; "News Briefs," *National Parks Magazine,* Aug. 1970, 30; "Farewell, DDT," *Miami Herald*, Dec. 31, 1972; National Resource Defense Council, http://www.getipm.com/articles/malathion.htm; Bayer Environmental Sciences, http://www.backedbybayer.com/system/product/product_label_pdf/59/SCOURGE-Insecticide-With-Resmethrin-Piperonyl-Butoxide-18_-Plus-54_-MF-Formula-II.pdf; SAR, 1985; "Synthetic Pyrethroids," Beyond Pesticides, http://www.beyondpesticides.org/pesticides/factsheets/Synthetic%20Pyrethroids.pdf; material safety data sheets for Anvil® 10+10 and Duet®; Hillary Cooley, personal communication, Sep. 13, 2013.

and Pine Island and at nonwilderness work sites for health and safety purposes. The areas actually treated each year varied depending on the severity of the mosquito presence. Thresholds for the use of pesticides were established based on the number of recorded mosquito landings per minute (landing counts). When thresholds were exceeded, suppression measures were authorized. Pesticide application was generally made through ultra-low-volume spraying.[746]

Two developments in 2007 caused the park to review its mosquito control procedures. NPS staff required to live in the park had begun to purchase backpack sprayers and insecticides on their own to combat what they saw as an unbearable mosquito problem. These actions were not sanctioned through the IMP review process. In that same year, the North American Butterfly Association raised concerns over the effects of mosquito adulticides on rare butterflies in the park. Park managers concluded that its existing 1985 Mosquito Control Plan was no longer adequate. The park formed a Mosquito Interdisciplinary Team, which began work on a Mosquito Risk Reduction Plan in Everglades National Park Developed Areas. Through 2008 and 2009, the team worked to draft a new plan that would allow mosquito suppression when thresholds were exceeded. In summer 2008, ecologists Marc C. and Maria Minno observed butterflies before and after insecticide spraying at Flamingo. They observed neither mortality nor changed behavior in the butterflies, although they were not equipped to measure any sublethal effects on butterflies. Focus groups were also conducted with park employees to learn more about the physical and psychological effects of mosquitoes Among other things, the Mosquito Interdisciplinary Team's recommendations called for incorporating adaptive management principles into the new plan; that is, adjustments would be made to spraying and other procedures as experience was gained. The team's recommendations were circulated in early 2010. To date a new plan has not been adopted, largely because of the press of other business and lack of funding.[747]

746 Jerry McCrea and Carol L. J. DiSalvo, "Integrated Pest Management: What Is It? What Has It Done for the National Park System?," in *Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,* ed. David Harmon (Hancock, Mich.: The George Wright Society, 2001), 393-398; Draft NPS Fact Sheet: Managing Pesticides, July 2007, http://www.nps.gov/sustainability/documents/Waste/Pesticide-Management.pdf; NPS Servicewide IPM Coordinator to IPM Program Files (draft), Feb. 8, 2010; *NPS Management Policies*, 2006, http://www.nps.gov/policy/mp2006.pdf; Hillary Cooley, personal communication, Sep. 13, 2013.

747 IPM Coordinator to IPM Program Files (draft), Feb. 8, 2010; Marc C. Minno and Maria Minno, "An Assessment of the Risk of Harm to Butterflies in the Flamingo Area of Everglades National Park Due to Mosquito Control Spraying around Staff Housing and Maintenance Facilities," July 5, 2008, "Everglades National Park Mosquito Risk Assessment Pilot: Results of Focus Group Interviews," Apr. 2010, National Resource Report NPS/BRMD/NRR—2010/189, ENP IPM files; Hillary Cooley, personal communication, Sep. 13, 2013.