1 Displacement of Native Ecosystems by Invasive Alien Plants—The Florida Experience, or How to Destroy an Ecosystem

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Abstract

This discussion will focus attention on some of the factors that permit alien plants to become problems throughout the world by using Florida's introduced species as examples. Sixteen species that may become future problems based on their current distributions and dispersal mechanisms are profiled.

Introduction

Few of the introduced alien (non-native) plants that are established in the United States have succeeded in dominating our native plant communities. Perhaps because a small percentage cause problems and not many people know natives from exotics, laypeople and scientists rarely understand the enormity of the problems these few cause. Only Hawaii has the equal to the ecosystem devastation occurring in Florida as a result of these invasive alien species (McKnight 1993; U.S. Congress 1993; Schmitz and Brown 1994; Simberloff 1994).

Millions of plants are imported into Florida annually. In 1990 alone, 333 million plants passed through the Miami International Airport. This Miami port admits 85% of all plant shipments into the United States (U.S. Congress 1993). About 1% of these imports are inspected, and then usually only as possible carriers of insect pests (Center 1993). This flood of non-native plants into Florida is a result of active agricultural and horticultural industries, $1 billion a year businesses (U.S. Congress 1993). On the opposite side of the economic scale, it costs Florida's citizens many millions of dollars in taxes to combat invasive exotics. To control just one submersed aquatic plant introduced from Sri Lanka, hydrilla (*Hydrilla verticillata* (L. f.) Royle), Florida needed $2.5 million in 1986 and $10 million in 1993 (Schardt

and Ludlow 1993). Exotic plants have caused an economic drain on the United States of over $1 billion per year since 1906 (U.S. Congress 1993). To my knowledge, no one has figured exactly how much money these plants cost Florida taxpayers.

Despite this money, no one has ever compiled a complete statewide list of exotic plants or given attention to the biology and ecology of more than a handful of species. That lack of attention was exactly the approach needed to destroy Florida ecosystems. Surely no one intended that to happen, but it has.

In the middle 1970s, Morton (1976) and Austin (1978), working independently, compiled lists of exotic plants in southern Florida: Morton concentrated on those problem exotics in Miami-Dade and Monroe counties, while Austin examined them in the southeastern counties of Miami-Dade, Broward, Palm Beach, Martin, and St. Lucie. Almost two decades have passed since those lists were published. There is a need to update those compilations because the situation has worsened (see Austin et al. 1979; Johnson and Olmsted 1982; Austin et al. 1990; Austin 1993).

Since these original papers were published, it has become clear that we cannot predict the changes that occur over short time spans. There are now plants naturalized that neither Morton nor Austin listed, e.g., laurel-leaf fig (*Ficus microcarpa* L.f.) and earleaf acacia (*Acacia auriculiformis* Benth.). To draw attention to the problems caused by alien plants, the Florida Exotic Pest Plant Council (FLEPPC), a non-profit organization founded in 1984, has compiled lists of the most invasive non-native species known in the state. Species considered here are taken from the 1997 list (Florida Exotic Pest Plant Council 1997).

Exotics - What is the Problem?

One need not examine the literature or gather careful scientific data to see that alien plants are causing problems in native communities. By simply looking out a car window while driving down the highway, any novice can see that the mass of non-native plants is physically crowding out the natives. Masses of exotic plants often dominate land beyond manicured roadsides throughout Florida.

The idea that exotics cause ecological problems has also begun to appear in national, non-scientific publications (Mack 1990; Quammen 1990; Pankowski 1992; Fisher 1995). In spite of all the publicity given to health and ecological problems caused by exotic organisms, and to the cost of these to the taxpayer (Schardt and Schmitz 1990), some individuals still maintain that they cause no difficulties (Rosen 1990).

The terms "alien" and "exotic" refer to organisms that have been moved into

Florida accidentally or purposefully and have established populations, reproducing either sexually or vegetatively, i.e., have become naturalized in Florida. Not all reports in the literature are reliable since there is often no distinction made between naturalized (reproducing without humans) and persistent (not reproducing) from cultivation. There is, however, often a regional difference between populations. For example, *Bischofia javanica* Blume was not reproducing in Palm Beach County in 1990 but has been reproducing in Miami-Dade and Broward counties since the late 1970s. Each site must be studied individually and may change drastically within short periods of time.

Many factors contribute to the problems of alien plants in Florida. The following are among those thought to be of high importance.

Numbers

At least 20% of Florida's southernmost flora (ca. 658 of 1647 species) is exotic (Long and Lakela 1971; Morton 1976; Austin 1978). Some 15.7% or more of the Panhandle flora (ca. 1989 of 2360 species) is exotic (Clewell 1985). The combined lists of Morton (1976), Austin (1978), Wunderlin (1982), Clewell (1985), and Ward (1990) brings the total number of plants introduced to Florida and escaping cultivation to 925 species. Since 1990, more escaped plants have been found and the list now stands at over 1000 alien species in our flora; about half of these are invasive to some degree (D. Austin and D. Ward, unpubl. data). If Ward's conservative number is used, it means that between 21 and 27% of the flora in the state is exotic. The figures are not exact because Wunderlin (1982) and Ward (1990) disagree on the number of Florida plant species (3800 vs. 3448). Whatever the number used, these foreign plants have an overwhelming potential to change the very fabric of Florida's ecosystems. In many areas, the landscape has already changed dramatically. Even worse, data are available only for the numbers of species, not for biomass or numbers of individuals. Furthermore, there is little information on the effects of exotics in most habitat types, particularly community interactions such as food webs, pollination systems, and seed and fruit dispersal.

Time

In preparing their papers, Morton (1976) and Austin (1978) used historical documents, although not always the same: Morton relied heavily on records from the 1900s while Austin also used documents going back to the 1500s.

We know that people have been moving plants here since about 1513 when Florida was officially discovered by Europeans. This movement of plants continues today. The rate of introduction has probably been accelerating since the time of European arrival. Today, large industries are devoted to plant importation.

Sources

As might be expected, the alien floras differ between northern and southern Florida. Southern Florida introductions are mostly from tropical sources, such as tropical America, Africa, Asia, and Australia. Northern Florida introductions tend to be from more temperate areas of Europe, Eurasia, and East Asia. Invasive species in Florida usually thrive under conditions similar to those in their homelands.

Most of the plants considered invasive in Florida are derived either directly or indirectly from cultivation (see Schmitz and Brown 1994) (Appendix). The majority of the species listed in the appendix (ca. 83%) were introduced for ornamental horticulture. A few were brought in as animal fodder and soil stabilizers, or accidentally as contaminants in species introduced for other reasons. This aspect of imported plants has not been addressed by the agricultural agencies responsible for ornamental horticulture. In most cases, these agencies are not aware of the problems they have caused. An education program should be started to make college and university horticultural staff and county extension staff cognizant of the problems already being caused by invasive exotic plants, and to warn about the negative ecological ramifications of their use.

Insular effect

The history of Florida makes the state especially prone to invasion by foreign organisms. Biogeographic theory says that diversity decreases along an insular gradient (MacArthur and Wilson 1967). Because of its geological history, the Florida biota is effectively that of an island chain. Simberloff (1994) contends that the southern third of the peninsula remains a habitat island, "..bounded on three sides by water, the fourth side by frost, and typified, as are oceanic islands, by an impoverished native flora and fauna." Plant diversity therefore, should decrease down the peninsula as does animal diversity (Simberloff 1994). The few data that are available (Fig. 1) indicate a lower species richness in southern than in northern Florida native plants. The fauna and flora of Florida conform to biogeographic theory. Biogeographic theory also states that unsaturated biotas are more prone to invasion from introduced species. This insular effect is at least part of the reason Florida has such a dramatic problem with exotic plants and animals.

Habitat alteration

Simberloff (1994) and others have pointed out that Florida has many habitats created and disturbed by humans. Disturbance has been caused by the lowering of water tables, fires, agriculture, horticulture, urbanization, planted forests, roads, a growing resident population, and an enormous transient tourist population. Florida also has several environments where disturbance is part of the non-human (typically called "natural") order. These habitats are beaches, pinelands, marshes, prairies, and swamps where there is a dramatic wet-dry cycle. In other words, virtually all of Florida's native habitats are maintained by periodic disturbance ranging from a treefall to fires to hurricanes. Gordon (1995) recently elaborated on the im-

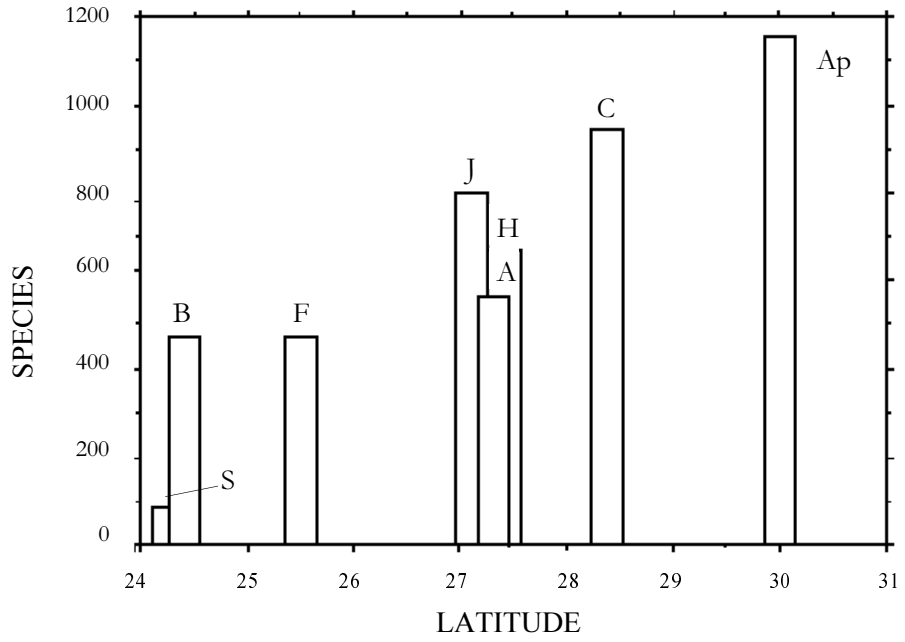

Figure 1. Species abundance by site on the Florida peninsula relative to latitude. Site codes: A, Archbold Biological Station; Ap, Apalachicola National Estuarine region; B, Big Pine Key; C, Cape Canaveral region; F, Fakahatchee Strand State Preserve; H, Highlands Hammock State Park; J, Jonathan Dickinson State Park; S, Sands Key.

pacts of the most invasive exotics in Florida. She found that numerous structural, physiological, and geochemical changes take place before and after alien organisms invade. Exotic plants thrive first on disturbed and created habitat; subsequently, they are prone to invade less disturbed native ecosystems.

Additional complications

Importation of ornamental plants presents another aspect that is little appreciated. Both insect pests and plant pathogens are sometimes accidentally introduced along with these plants. Traditionally, only those organisms with a potential for adverse impact on agriculture have been of concern, but other devastating situations affect native ecosystems. For example, *Cactoblastis cactorum* (Lepidoptera: Pyralidae) is a moth devouring the native cactus *Opuntia*; both our common and endangered species. This pest moth was probably introduced accidentally on imported *Opuntia* brought into Florida on a massive scale by the nursery industry (Pemberton 1995). Another recent example involves the beetle *Metamasius callizona* (Coleoptera: Curculionidae), first discovered in 1989 in a Florida nursery of cultivated Bromeliaceae

(O'Brien et al. 1990). The species has subsequently spread to several counties and ravaged several native species of *Tillandsia*. Both of these insects have the potential to extirpate several species from the flora of Florida.

Problem Categories

Numerous ways have been devised to categorize problem exotic plants. One common way has been to consider them as agricultural and lawn weeds, and health-impairing weeds.

Agricultural and lawn weeds

Some species cause no known problems to native habitats, e.g., day flower (*Commelina diffusa* Burm.f.). Species that are considered benign in native ecosystems are often considered the worst pests by people concerned with agriculture, well-manicured lawns, and ornamental landscapes (Holm et al. 1991). How "bad" any particular species is considered depends on the viewpoint of the observer. People concerned with human-only affairs do not consider the same taxa harmful as those concerned with native ecosystems.

Health-impairing weeds

Scientists have long been writing of the health related and ecological impacts of transporting organisms from one area to another (Laycock 1966; Cuddihy and Stone 1990). For example, *Acacia, Casuarina, Cestrum, Jasminum, Lantana, Ligustrum, Lonicera, Melaleuca, Melia,* and *Schinus* are major sources of respiratory and dermatological problems in people (Perkins and Payne 1978; Lampe and McCann 1985). *Melaleuca* is also crowding out native communities in the Everglades (Center et al. 1991).

The FLEPPC list of invasive species categorizes the species based on ecosystem degradation (Florida Exotic Pest Plant Council 1997). Their Category I rank contains species "that are invading and disrupting native plant communities in Florida." The second group, Category II, contains species that have "shown a potential to invade and disrupt native plant communities [and] have a real potential to become ranked as Category I, but have not yet invaded natural Florida communities."

Some Problem Species

The 1997 FLEPPC "List of Florida's Most Invasive Species" contains 64 species in Category I (Appendix). Space permits comments on only a few "new" problem taxa. These plants were selected for discussion because they may become the

worst problems in the future, possibly eclipsing Florida's famous trio of trees, namely Australian pine (*Casuarina* spp.), Brazilian pepper (*Schinus terebinthifolius* Raddi), and melaleuca (*Melaleuca quinquenervia* (Cav.) S.T. Blake). This trio is specifically excluded here; see Johnson and Olmsted (1982) and Schmitz and Brown (1994) for literature on these.

Air potato (*Dioscorea bulbifera* L.; Dioscoreaceae). This vine is a native of southeastern Asia and western Africa; it was sent by the U.S. Department of Agriculture (USDA) to Florida horticulturist Henry Nehrling in 1905 (Morton 1976). According to Nehrling, "with the exception of kudzu vine I have never seen a more aggressive and dangerous weed in Florida" (Morton 1976). Plants are still grown for ornament. The vines are invading wild tracts in Fakahatchee Strand State Preserve (Collier County), Castellow Hammock Nature Center (Miami-Dade County), and many other places in the peninsula and the Panhandle (see Schmitz and Brown 1994, map p. 14).

Bischofia (*Bischofia javanica* Blume; Euphorbiaceae). The trees are native to tropical southeastern Asia, from India, central China, and Malesia eastward to the Pacific**.** Plants were first noted in the wild in Miami-Dade County in the early 1970s (Morton 1976). Trees were planted in Hawaii from the 1930s to 1950s, and are now naturalized and spreading (Wagner et al. 1990).

These trees are now one of the major components of Castellow Hammock Nature Center in Miami-Dade County (Molnar 1990). Birds disperse the fruits (Morton 1976). The trees have recently been found spreading by seed in Broward and Palm Beach counties (Austin, unpubl. data).

Burma reed or **silk reed** (*Neyraudia reynaudiana* (Kunth) Hitchc.; Poaceae). This is a native of southern Asia (Watson and Dallwitz 1992). Even before Hurricane Andrew hit Miami in 1992, these giant grasses were spread across the pinelands of Miami-Dade County. Fire, a normal and essential component of pineland management and maintenance, is suspected of spreading this exotic pest. There are literally square miles of Miami-Dade County park lands where the shrub layer is now dominated by this grass. As the grass proliferates, it shades and out-competes the many endemic and endangered herbs and shrubs in the region. Recently, Burma reed was found on the western border of the Fakahatchee Strand State Preserve (C. DuToit, pers. comm., 1993) and in Big Cypress National Preserve, both in Collier County (see Schmitz and Brown 1994, map p. 15). A study is under way at Florida Atlantic University (FAU), with the cooperation of the Miami-Dade County Department of Environmental Resource Management, to learn more about the species and its possible control.

Carrotwood (*Cupaniopsis anacardioides* (A. Rich.) Radlk.; Sapindaceae). Originally an endemic to northern and eastern Australia, these trees seem to have been in cultivation in Florida since the 1980s (Oliver 1992). No individuals were seen in the

wild until the late 1980s and early 1990s. They have been known from the wild in Martin County since about 1989 and Palm Beach County since 1990. The many large seedlings of carrotwood that occur on Sarasota Bay, Sarasota, threaten to shade out the mangroves within the next few years (E. Freeman, pers. comm.).

Each summer, students at FAU watch fish crows eating the whole fruits, seeds, and arils of carrotwood. Mockingbirds also carry off and consume seeds and arils, and doubtless other birds take them also. Seedlings are now frequent in a growing number of wild areas in southeastern and southwestern Florida. This species is spreading (Lockhart et al. 1999), as *Acacia auriculiformis* Benth. did 10-15 years ago, and promises to be an equivalent of Brazilian pepper (see Schmitz and Brown 1994, map p. 14).

Catclaw mimosa (*Mimosa pigra* L.; Fabaceae). Although there were some old herbarium specimens thought to have come from cultivation, this tropical American species was brought to everyone's attention back in the early 1970s. The first plants were seen where the Florida Turnpike crosses the Loxahatchee River in Martin County. The prickly shrubs were later found scattered down the riverside along the canoe trail leading to Trapper Nelson's old home site in Jonathan Dickinson State Park. When the South Florida Water Management District became involved in the plants control a few years ago, they found several other sites. They have been recorded in distinct foci in five counties (see Schmitz and Brown 1994, map p. 14). This species covered millions of acres in Kakadu National Park, Australia, in only a few years (T. Center, pers. comm., 1991). Without control, it could do the same in Florida.

Chinese tallow tree or **popcorn tree** (*Sapium sebiferum* (L.) Roxb.; Euphorbiaceae). This native of China and Japan is widespread in northern Florida where it has been in cultivation since at least the 1930s (Small 1933). The species was considered a pest in Charleston, South Carolina, and vicinity in 1970. In spite of this reputation, Floridians continued to propagate and promote the tree, purportedly because of its spectacular red fall foliage. In the Carolinas, it is called "popcorn tree" because the fruits open and the white wax-covered seeds are exposed. These seeds are primarily dispersed by birds. A 1995 survey by the Florida Department of Environmental Protection found Chinese tallow tree escaped in 44 of Florida's 67 counties (Jubinsky 1995). Fourteen of these counties have naturalized colonies. The trees have invaded closed canopy forests, bottomland hardwood forests, lake shores, marshes, and other wetlands.

Downy rose-myrtle (*Rhodomyrtus tomentosus* (Aiton) Hassk.; Myrtaceae). The shrub is native to Asia (from India east through China to the Philippines) and Australia. This plant was introduced into Highland and Lake counties in 1905 and first found in the wild there by 1906. It subsequently spread to Orlando, Bradenton, Oneco, Bonita Springs, Naples, and Estero (Morton 1976; Alexander 1981), and to Palm Beach and Martin counties by 1978 and 1979, respectively. A physician in

Jensen Beach remembered that the shrub was planted at his father's home in Highlands County and spread over a mile around the nearby lake in a year (Stokes, pers. comm., 1981). Birds eat the fleshy fruits and spread the seeds. The species is considered more aggressive in central Florida than Brazilian pepper (J. Layne, pers. comm., 1976). This has been a major pest in Hawaii for some time (Wagner et al. 1990), after having been introduced in 1920.

Ear-leaf acacia (*Acacia auriculiformis* Benth.; Fabaceae). This species was first noted in the wild in Palm Beach County in the late 1970s (Austin 1990). The trees are native to tropical northern Australia (Brock 1988). Birds spread the seeds into native habitats by eating the yellow arils and attached brown seeds. Plants now occur in a variety of sites including landscaped areas, roadsides, dry prairies, and pinelands, usually where there is a good perch nearby for birds. Starlings (introduced from Europe) are among the principal dispersers.

Half flower, **scaevola** or **beach naupaka** (*Scaevola sericea* Vahl.; Goodeniaceae). This herb is native to the islands of the Pacific and Indian Oceans, including Australia (Brock 1988). *Scaevola* began being used commonly in southeastern Florida about 1980. Since that time, it has escaped into the wild in Broward, Palm Beach, and Martin counties on the east coast and Lee County on the west. Birds apparently spread the seeds, and wild individuals appear with regularity in plant nurseries and native habitats in Martin County (M. Hurchalla, pers. comm., 1991). Because the species grows faster and stabilizes our beaches more poorly than our native species (*S. plumieri* (L.) Vahl), it poses an erosional threat if nothing else. Since 1991, the species has begun invading mangroves in Palm Beach County and elsewhere.

Lather leaf (*Colubrina asiatica* (L.) Brongn.; Rhamnaceae). Native to southeastern Asia, this scrambling shrub was first recorded in Florida by Small (1933) as occurring in the southern peninsula and the Keys. The species later started becoming a pest in Miami-Dade and Monroe counties (Long and Lakela 1971), spreading north to Martin County by 1978 (Austin 1978). Saponins in the bark are poisonous and used medicinally by Asians (R. Pemberton, pers. comm., 1996). These plants out-compete native coastal vegetation, reducing diversity. The plants have apparently been cultivated for ornament and may be dispersed by birds. Large colonies are dominating saline sites in The Nature Conservancy's Blowing Rocks Preserve (Martin County) and Big Pine Key National Wildlife Refuge (Monroe County) (see Schmitz and Brown 1994, map p. 14).

Laurel leaf fig (*Ficus microcarpa* L.f.; Moraceae). For years, no one worried about exotic figs in cultivation because of the close relationship between the plants and their pollinators. Late in the 1970s, however, several people began to notice fertile fruits on some of the exotic species, particularly *F. microcarpa* (Strange and Knight 1987).

Trees were first noted in the wild in Palm Beach County in 1979, although they had been seen earlier in Miami-Dade County (Morton 1976; Strange and Knight 1987). The species is native to India, Southeast Asia, the Malay Archipelago, and northern tropical Australia (Brock 1988). It is recorded in the wild in Miami-Dade, Monroe, Broward, and Palm Beach counties, and elsewhere (see Schmitz and Brown 1994, map p. 14). Birds have been spreading the species into a variety of habitats for over a decade (Kaufmann et al. 1991; McKey and Kaufmann 1991). These trees now grow as epiphytes on native and introduced plants, and appear in sidewalk cracks in town and on park boardwalks, e.g., Loxahatchee National Wildlife Refuge.

Mast wood (*Calophyllum antillanum* Britton; Clusiaceae). Native to the Caribbean, these trees have been used in landscaping in southern Florida for some years. These trees were first found naturalized in the 1970s on an old Indian mound and farmstead of more recent origin in Martin County; everyone thought it was an isolated aberrant event. Subsequently, Morton (1976) documented its spread in Miami-Dade and Monroe counties, and it is now invading mangroves in Palm Beach County. Even within Puerto Rico, where the species is native, trees have spread from cultivation into regions where they did not occur naturally (Little et al. 1964).

Old World climbing fern (*Lygodium microphyllum* (Cav.) R.Br.; Schizaeaceae). Native to Africa, Asia, and Australia (Brock 1988), this climber was first found in Florida in the late 1960s (Beckner 1968). The expanded range was discussed by Nauman and Austin (1978). The fern was perhaps first introduced, either accidentally or purposefully, with other cultivated material near the Palm Beach-Martin County line. *Lygodium* continues to be spread as a weed in potted horticultural plants. Since the 1970s, the species has moved north and south (see Schmitz and Brown 1994, map p. 14). These ferns climb tens of meters into the margins of cypress swamps and other forested wetlands. Once established, they shade out native species and reduce diversity.

This plant is comparable to kudzu vine (*Pueraria montana* (Lour.) Merr.) of southern Florida, even though that species recently was found south of Lake Okeechobee (Bodle 1993). Another climbing fern species, *Lygodium japonicum* (Thunb.) Sw., is causing similar problems in central and northern Florida (Wunderlin 1982; Clewell 1985).

Queensland umbrella tree (*Schefflera actinophylla* (Endl.) Harms; Araliaceae). This tree is native to northern Queensland, Australia (Brock 1988). Officially introduced in 1927, this tree was first noted in the wild in Miami-Dade County (Morton 1976). Plants were later recorded from Pinellas (Wunderlin 1982) and Palm Beach counties (Austin 1990). Birds, including native crows and mockingbirds, and exotic starlings, eat the fruits of these trees in Palm Beach County and spread the seeds into the wild. Starlings regularly feed on the fruits. Wild plants have appeared with

greater frequency on the campus of FAU and in wild areas in Boca Raton ever since starlings drove the house sparrows out of their nesting cavities in the Biological Sciences Building at FAU.

Shoebutton ardisia (*Ardisia elliptica* Thunb.; Myrsinaceae). These shrubs, native to the East Indies, first appeared in southern Miami-Dade County (Morton 1976). From there, they spread to other areas by animals, probably mostly birds due to their fleshy fruits. Plants are now known in Palm Beach, Broward, and Monroe counties. Shoebutton ardisia comprises a dominant shrub layer in sites where it occurs, as in the "Hole-in-the-Donut", Everglades National Park (Krauss 1987), and Secret Woods County Park (Broward County). In such sites, shoebutton ardisia eliminates or suppresses natives; it thrives within dense Brazilian pepper (*Schinus terebinthifolius)* stands (Krauss 1987). A related species, *A. crenata* Sims (coral ardisia), is invading hardwood forests in northern Florida.

Skunk vine (*Paederia foetida* L.; Rubiaceae). These climbers are native in the Indian Himalayas, China, the Philippines, and the Malay Peninsula (Puff 1991). The species was introduced for use as a fiber crop and as an ornamental (Pankowski 1992; Hall 1993), and surely as a curiosity also. The binomial refers to the plant's bad smell and is the least vulgar of the names used for the plant. In China, one name means "chicken excrement plant"; in the Malay Peninsula, *akar sekentut* refers to its fecal smell; a related species in Okinawa is called *hekuso-kazura,* or the flatulent vine. These plants are cultivated from at least Tallahassee south to Miami and have been recorded as escaped in less than half of the intervening counties (see Schmitz and Brown 1994, map p. 15). Where it does occur in moist to wet native landscapes, or even in cultivation, the vine often covers vast areas (Pankowski 1992). Dispersal is by animal vectors carrying the fleshy, colored drupes. Once established, the long runners allow single plants to cover several acres.

Conclusions

The 1997 FLEPPC list of Category I species is composed of 72% animal dispersed taxa, and 28% wind- and water-dispersed species (Appendix). Dispersal mechanisms are unknown for almost 20% of the species in Category II (not included here). This lack of information on dispersal in species in Category II emphasizes a major problem in the introduction of foreign organisms into the United States - we rarely know much, if anything, about their life histories. We do not have many data on exact ecological changes, but the sheer mass of invasive non-indigenous plants is overshadowing Florida's native plants. Data on our current, most invasive plants and from other studies, e.g., Bazzaz 1986, suggest a few of the things that should be known about species before they are introduced into new regions.

Florida's most invasive alien plants are often species that (1) are easily and widely dispersed, (2) increase their biomass rapidly without cultivation through high rates

of photosynthesis, respiration, transpiration, and growth, (3) have high fecundity (reproductive allocation), (4) are adapted to environmental disturbance or cyclic variation in conditions (fire, drought, flood, salt intrusion, etc), (5) are hardy, i.e., difficult to kill or control, (6) originate from similar climates, (7) have high population growth rates, (8) have comparatively short life cycles, (9) have early reproductive maturity, (10) are self-fertile, autogamous, wind pollinated, or pollinated by generalists, (11) are broad-niched, i.e., generalists in resource use, (12) can acclimate rapidly to new habitats, and (13) show a rapid response to resource availability.

In spite of this long list, comparatively little is known about why many organisms become pests in areas foreign to their homelands (Bazzaz 1986; Simberloff 1994). We know that removal of species from their predators and diseases may allow them to proliferate, but this does not always happen. Clearly, a number of factors not fully known are involved in the nature of invasive organisms. Until these factors are understood and more complete data are used by those responsible for screening introductions, our natural areas will continue to have new problems. At present, the USDA and U.S. Customs are dominated by the demands of the agricultural and horticultural industries. Ecological impacts of exotic weeds and the well-being of the environment are not on these institutional agendas, although there are members in each of the federal agencies who advocate considering these factors. The missions of these agencies should be modernized and broadened beyond immediate economic productivity.

If these changes in our approaches to the movements of non-native organisms around the world are not made, we will continue to destroy the ecosystems that support our lives and the lives of myriad other organisms that share our planet. The history of our past actions along these lines is now becoming known (Cuddihy and Stone 1990; Ward 1994). Historical data show that we are in the midst of an extinction that dwarfs those we have formerly considered massive (Raup 1991; Wilson 1992; Ward 1994). Destruction of ecosystems by movement of alien organisms plays an important part in this current extinction. Regardless of how vigorously we deny the facts that we now have, we will eventually have to come to the realization that we live in an incomprehensibly complex world where our actions have far-reaching consequences. Introduced alien plants DO destroy ecosystems when they escape cultivation.

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Appendix. List of Category I invasive exotic species from the 1997 FLEPPC "List of Florida's Most Invasive Species." Reason for introduction based largely on Gordon and Thomas (1997). Where additional data are available, they have been added. Dates of introduction are mostly those listed in Miami by the U.S. Department of Agriculture; these are not necessarily the dates of first introduction.

Scientific name	Common name	Area of origin	Reason for introduction	Date of introduction	Dispersal method	Dispersion in Florida
Abrus precatorius	rosary pea	India	ornamental	before 1933	animal	peninsula cos.
Acacia auriculiformis	earleaf acacia	Australia	ornamental	by 1932	animal	southeastern cos.
Albizia lebbeck	woman's tongue	Asia	ornamental	?	wind, water	peninsula cos.
Ardisia crenata	coral ardisia	India to Japan	ornamental	before 1949	animal	panhandle, n. peninsula
Ardisia elliptica	shoebutton ardisia	Sri Lanka	ornamental	before 1933	animal	southern cos.
Asparagus densiflorus	asparagus fern	? Africa	ornamental	before 1949	animal	southern cos.
Bauhinia variegata	orchid tree	Asia	ornamental	1936		
Bischofia javanica	bischofia	Indo-Malaysia	ornamental	?	animal	southern cos.
Brachiaria mutica	Pará grass	Africa	used as camouflage during WWII	before 1943	animal	throughout
Calophyllum antillanum	santa maria	Caribbean		?		
Calophyllum calaba	mast wood, Alexandrian laurel	Indo-Malaysia	ornamental	before 1964	water	southern cos.
Cassia coluteoides	climbing cassia, Christmas cassia, Christmas senna	Americas	ornamental	before 1933	animal	s. half of peninsula
Casuarina equisetifolia	Australian pine	Indo-Pacific	ornamental	1887	wind, water	coastal peninsular cos.
Casuarina glauca	suckering Australian pine	Australia	ornamental	1890	wind, water	s. half of peninsula
Cestrum diurnum	day jasmine	W Indies	ornamental	before 1933	animal	southern cos.

Appendix. *continued*

Scientific name	Common name	Area of origin	Reason for introduction	Date of introduction	Dispersal method	Dispersion in Florida
Cinnamomum camphora	camphor-tree	China, Japan	ornamental	before 1933	animal	n. peninsula
Colocasia esculenta	taro	Asia	ornamental, food	1910	animal	peninsula
Colubrina asiatica	lather leaf	SE Asia	ornamental	before 1933	animal	se. peninsula cos.
Cupaniopsis anacardioides	carrotwood	Australia	ornamental	1968	animal	s. peninsula cos.
Dioscorea alata	winged yam	Asia		?		
Dioscorea bulbifera	air-potato	Asia, Africa	ornamental, food	1905	animal	peninsula cos.
Eichhornia crassipes	water hyacinth	Americas	ornamental	1884	water	throughout
Eugenia uniflora	Surinam cherry	Americas	ornamental, fruit	1931	animal	s. peninsula cos.
Ficus microcarpa	laurel fig	India to Australia	ornamental	before 1912; wasp ca. 1975	animal	s. peninsula cos.
Hydrilla verticillata	hydrilla	Old World	aquarium ornamental	1950-1951	water	throughout
Hygrophila polysperma	green hygro	India	aquarium ornamental	1950s	water	scattered peninsula cos.
Hymenachne amplexicaulis	West Indian marsh grass	?	cultivated as forage grass	between 1970-1978	animal	sw. peninsula cos.
Imperata brasiliensis	cogon grass	Old World	ornamental , contaminant	1905	wind, water	throughout
Ipomoea aquatica	water spinach	India	food	before 1933	animal	e. & central peninsula cos.
Jasminum dichotomum	Gold Coast jasmine	Africa	ornamental	before 1949	animal	s. peninsula cos.
Jasminum fluminense	jasmine	Africa	ornamental	1923	animal	s. peninsula cos.
Lantana camara	lantana	Americas	ornamental	1804	animal	throughout
Ligustrum sinense	hedge privet	S China	ornamental	before 1947 in SC	animal	panhandle
Lonicera japonica	Japanese honeysuckle	NE Asia	ornamental	1875	animal	n. peninsula cos.

Appendix. *continued*

Scientific name	Common name	Area of origin	Reason for introduction	Date of introduction	Dispersal method	Dispersion in Florida
Lygodium japonicum	Japanese climbing fern	SE Asia	ornamental	1932	wind, water	n. peninsula cos.
Lygodium microphyllum	Old World climbing fern	SE Asia	?weed in cultigens	before 1965	wind, water	s. peninsula cos.
Macfadyena unguis-cati	cat's claw	Americas	ornamental	before 1947	wind, water	s. peninsula cos.
Melaleuca quinquenervia	melaleuca	Australia	ornamental	1906	wind, water	s. peninsula cos.
Melia azedarach	Chinaberry	Asia to Australia	ornamental	ca. 1830	animal	throughout
Mimosa pigra	catclaw mimosa	Americas	ornamental	1926	water	se. peninsula cos.
Nandina domestica	nandina, heavenly bamboo	India to Japan	ornamental	before 1949	animal	panhandle
Nephrolepis cordifolia	sword fern	tropics	ornamental	before 1949	wind, water	s. peninsula cos.
Neyraudia reynaudiana	Burma reed; cane grass	India, Java	ornamental	1916	animal	s. peninsula cos.
Paederia foetida	skunk vine	India, Japan	ornamental, fiber	1897	animal	scattered throughout
Panicum repens	torpedo grass	tropics	forage	1920s	animal	throughout
Paspalum notatum	Bahia grass	Americas	ornamental	1945	animal	throughout
Pennisetum purpureum	Napier grass	Africa	forage, ornamental	1915	animal	throughout
Pistia stratiotes	water lettuce	tropics	accidental contaminant	before 1765	water	throughout
Psidium guajava	guava	Americas	fruit	before 1765	animal	s. peninsula cos.
Psidium littorale	strawberry guava	Brazil	ornamental, fruit	1887	animal	se. peninsula cos.
Pueraria montana	kudzu	NE Asia	ornamental, fruit	1899	animal	throughout
Rhodomyrtus tomentosa	downy myrtle	Indo-Malaysia	ornamental, fruit	1905	animal	s. peninsula cos.

Appendix. *concluded.*

Scientific name	Common name	Area of origin	Reason for introduction	Date of introduction	Dispersal method	Dispersion in Florida
Rhoeo spathacea	oyster plant	Americas	ornamental	before 1933	animal	s. peninsula cos.
Sapium sebiferum	popcorn tree, Chinese tallow tree	China, Korea	soap/oil from seed, ornamental	1900s in FL, before 1784 in SC	animal	panhandle, n. peninsula cos.
Scaevola sericea	scaevola, half-flower, beach naupaka	Indo-Pacific	ornamental	before 1976	animal	s. peninsula cos.
Schefflera actinophylla	schefflera	Australia	ornamental	1927	animal	se. peninsula cos.
Schinus terebinthifolius	Brazilian pepper	Brazil, Argentina	ornamental	1840s	animal	most peninsula cos.
Solanum tampincense	aquatic soda apple	Mexico				
Solanum torvum	turkey berry	tropics	ornamental?	before 1899	animal	s. peninsula cos.
Solanum viarum	tropical soda apple	Brazil	weed in livestock feed	ca. 1985	animal	s. peninsula cos.
Syzygium cumini	jambolan, Java plum	Asia	ornamental, fruit	1920	animal	s. peninsula cos.
Tectaria incisa	incised halberd fern	American tropics	ornamental	1929	wind, water	s. peninsula cos.
Thespesia populnea	seaside mahoe	Asia	ornamental	before 1928	water	s. peninsula cos.
Tradescantia fluminensis	white-flowered wandering Jew	Americas	ornamental	before 1933	animal	n. peninsula