Rare Plants of South Florida:

Their History, Conservation, and Restoration

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Cover photos by George D. Gann: Top: mahogany mistletoe (*Phoradendron rubrum*), a tropical species that grows only on Key Largo, and one of South Florida's rarest species. Mahogany poachers and habitat loss in the 1970s brought this species to near extinction in South Florida. Bottom: fuzzywuzzy airplant (*Tillandsia pruinosa*), a tropical epiphyte that grows in several conservation areas in and around the Big Cypress Swamp. This and other rare epiphytes are threatened by poaching, hydrological change, and exotic pest plant invasions.

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Chapter 3
Restoring South Florida's Rare Plant Diversity

In 1929, renowned botanist John Kunkel Small emphatically called attention to the disappearance of South Florida's rare plants and the degradation of their environment (Small, 1929). Nevertheless, in South Florida awareness of native plants and their conservation has lagged behind other environmental initiatives. Despite educational efforts, land acquisition programs, and exotic species control campaigns, we still are losing rare plant populations.

As discussed in Chapter 2, the causes of native plant extirpations are many, but habitat loss is by far the major culprit. Because of the rapid development of the South Florida landscape, it is imperative that viable populations of each native species be protected in at least one publicly-owned conservation area. These populations can be augmented by native plant conservation and restoration projects on private lands. Unfortunately, damage to rare plant populations is occurring even within conservation areas. Factors include poor planning, poaching, drainage, exotic pest plant invasions, and fire suppression, not to mention a lack of funding for rare plant conservation work.

The restoration of rare plant populations in South Florida is best viewed as an element of the larger effort to restore South Florida's damaged ecosystems. The loss of native plant diversity in South Florida is a form of ecosystem degradation, and ecosystems can be considered truly restored only when native plant diversity has recovered. **Yet, ecological restoration cannot succeed unless the causes of ecosystem degradation and rare plant extirpations are identified and managed, and proactive steps are taken to restore viable rare plant populations to the landscape.** These are complex issues, and the effort to restore South Florida's rare plant diversity will be a multi-faceted process requiring the efforts and cooperation of numerous individuals, agencies, and institutions. Our intention in this chapter is to provide both a strategic context and a series of implementation guidelines for the restoration of rare plant populations and their habitats in South Florida. This, we hope, will contribute to the larger effort to restore South Florida's beleaguered ecosystems.

Part 1. Strategies and Recommended Actions.

Eight strategies have been developed that, if implemented, are meant to prevent the continuing extirpation of rare plants, and to restore to the extent possible rare plant populations and habitats in South Florida. Within each strategy actions are identified to accomplish the overarching goal of restoring South Florida's native plant heritage.

Strategy 1. Continue floristic research.

Recommended actions:

- Continue review of scientific literature.
- Continue review of herbarium specimens.
- Continue floristic inventories.
- Voucher rare plant occurrences.
- Survey for rare plants.
- Systematically map and monitor rare plant populations.

Strategy 2. Protect all critically imperiled native plant populations and prevent additional extirpations.

Recommended actions:

- Ensure that each critically imperiled species is protected in at least one conservation area.
- Acquire privately owned sites that contain populations of critically imperiled plants; ideally, protect several species at each site.
- Designate areas with populations of critically imperiled plants within publicly-owned sites as conservation areas.
- Develop conservation agreements with private landowners and non-conservation agencies that own or manage lands containing critically imperiled plants, and provide technical assistance.
- Prevent extirpations of rare plants in conservation areas.
- Prevent poaching of rare plants.
- Control exotic pest plants that threaten rare plants and their habitats.
- Control feral animals that damage rare plants and their habitats.
- Establish and implement fire management programs in fire maintained habitats.

Strategy 3. Develop and manage *ex situ* (off-site) collections of germplasm of critically imperiled plants.

Recommended actions:

- Manage existing *ex situ* collections of germplasm of critically imperiled plants at Fairchild Tropical Garden and other botanical institutions.
- Determine additional critically imperiled species that would benefit from *ex situ* collections of germplasm.

Strategy 4. Determine life history and management needs of rare plants.

Recommended actions:

- Determine the ecological requirements of critically imperiled plants.
- Conduct conservation horticulture studies.
- Determine the effects of fragmentation on rare plant pollination, dispersal, and genetic integrity.
- Conduct research on regional and global changes that may impact rare plant populations including drainage, global warming, sea-level rise, and nutrient enrichment to identify management responses.

Strategy 5. Restore degraded South Florida ecosystems including habitats for rare plants.

Recommended actions:

- Restore key habitats of critically imperiled and extirpated plants.
- Ensure that ecological restoration projects do not unnecessarily harm rare plant populations.

Strategy 6. Restore native plant populations while maintaining natural patterns of genetic variation.

Recommended actions:

- Restore viable populations of critically imperiled taxa in conservation areas.
- Augment populations of critically imperiled plants if necessary to prevent extirpations.

- Reintroduce viable populations of rare plants to conservation areas from which they have been extirpated.
- Restore viable populations of native plant species that have been extirpated from South Florida.
- Consider genetic differentiation and patterns when determining propagule sources for all restoration efforts involving translocation.

Strategy 7. Improve the legal protection of rare plants.

Recommended actions:
- Provide current information on rare plants to listing agencies.
- Improve the listing process so that rare plants that warrant protection can be listed.

Strategy 8. Create awareness about rare plants, their conservation, and restoration.

Recommended actions:
- Create training opportunities for land managers and restoration practitioners, in both the public and private sectors.
- Provide key information to policy makers.
- Educate the public.
- Improve funding for research and management of rare plants in South Florida.

Part 2. Implementation Guidelines

The following guidelines are intended to assist policy makers, land managers, and restoration practitioners in improving rare plant conservation and restoration in South Florida. These guidelines are not meant to be all-inclusive or complete. In most cases, additional resources are needed to implement a particular element of a conservation or restoration program. Where applicable, these resources are identified.

Floristic Inventories

Current vascular plant inventories are needed for all conservation areas in South Florida. Inventories are also extremely valuable on lands being considered for acquisition and conservation easements and agreements. Inventories are best when all of the natural communities at the site are sampled, as well as disturbed areas such as roadsides and picnic areas, and the site is sampled during all of the major seasons of the year.

In general, we recommend that a vascular plant inventory be completed every ten years. For sites with staff botanists, a working flora can be updated on a constant basis. While a previous list can be used as a reference, we discourage simply adding newly observed taxa to a previously compiled flora. A flora (that is a list of plants at a site) is most helpful if it clearly indicates those taxa known to be present at the time of the inventory. Taxa not found during the current inventory can be included, but are best annotated to indicate that they were not found. For instance, the most recent observer of a species can be noted. Taxa that were not observed during the current inventory can be indicated as extinct, extirpated, historical, doubtfully present, recorded in error, or assumed to be present.

For all species, it is useful to indicate some measurement of abundance. While some floras use qualitative terms, such as “common,” “rare,” etc. we prefer quantitative estimates of abundance using a Log_{10} scale (e.g. 1, 2-10, 11-100, 101-1000, and so on). Furthermore, if 10 or fewer individuals occur, then it is best to count all individuals. If 100 or fewer individuals are present, then it would be beneficial to estimate the number of plants by tens (11-20, 21-30, etc.). In all cases, abundance measurements are based upon numbers of reproductive

individuals. In the case of annuals, the estimate is based upon the number of sexually reproductive individuals present within a period of a year.

If species abundance trends are obvious, they can be indicated. For instance, if managers are intentionally eliminating an exotic species, then the trend could be indicated as declining. Trends are best based upon some relatively long-term time scale, such as five years, to avoid focusing upon short-term changes in population numbers due to weather phenomena or other factors. We usually indicate trends as increasing, decreasing, or stable. We define stable as a population that undergoes a net demographic change of less than 10% during the time period used to indicate trends.

Information on presence by plant community or habitat is very helpful. It is preferable to use the Florida Natural Areas Inventory (FNAI) system whenever possible. In addition to indicating which plants are found in natural habitats, it also is important to indicate if a species is present in disturbed areas. If the plant is cultivated, then it is best to note if it is cultivated only, augmented (native to the site but also cultivated), or introduced (naturalized on the site). Naturalized plants can be indicated as ruderal (confined to disturbed areas and dependent upon disturbance), not invasive (naturalized, but not invading a natural area), invasive (a non-native plant invading a natural area), or potentially invasive (an invasive non-native plant present at the site but not yet established within a natural area). Some authors provide additional information, such as why a species has been cultivated (for instance for ornament or food) or whether it was accidentally introduced.

Ideally, site floras indicate: which taxonomic authority or authorities were used (e.g., Wunderlin, 1998); the author or authors of the plant list; the date the list was completed; the date or dates the data were recorded; the botanists who recorded the data; other individuals present, if pertinent; and contact information. If previous lists, herbarium specimens, or other resources were used as references, then these should be cited clearly on the plant list. If plants are vouchered during the inventory, then it is helpful if the specimens are cited.

The more historical research that is completed as part of the inventory process, the more useful the plant list for the site. Herbaria can be consulted to find herbarium specimens that may have been collected at or near the site. In some cases, herbarium specimens may need to be sent to a specialist for determination. If authors of previous lists for the site are available, then they can be consulted for additional information about species that cannot be located during the current inventory. Field biologists conducting floristic inventories should also be cognizant of species that may be present at the site, but for which no prior record exists. Whenever possible, herbarium vouchers should be collected (see Vouchering in this chapter).

Summary of general recommendations:

- Inventory all conservation areas.
- Sample all habitats, including disturbed sites.
- Sample at different times of year.
- Conduct intensive inventories at a minimum of every 10 years.
- Indicate if a plant is present, or only recorded in the past.
- Indicate if a plant is cultivated, or if a native population has been augmented.
- Indicate if an exotic is invasive, or only a weed of disturbed areas.
- Estimate population abundance (e.g. Log scale).
- Date all inventories and indicate authors.
- Conduct as much historical and taxonomic research as possible.
- Voucher all species when possible.

Resources: The International Working Group on Taxonomic Databases has prepared a Plant Occurrence and Status Scheme, which can be accessed on the Internet at www.tdwg.org.

Vouchering

Vouchering the occurrence of rare plant taxa at each site is extremely important. Without vouchering, reports of historical presence cannot by verified. Preferably, all stations within a large conservation area are vouchered but, at a minimum, at least one station per conservation area should be vouchered. Herbarium specimens are most useful when deposited at a registered herbarium. Many herbaria now require the collection of a

geographic coordinate with the specimen, a good practice even when not required.

All herbarium specimens must be collected with the appropriate permits, and without causing harm to the rare plant populations being vouchered. In some cases, photographic vouchers may have to suffice, such as when permits cannot be secured, or when a population is too small to collect a herbarium specimen. In other cases, vouchers can consist of a plant fragment, such as a single fertile frond or flower.

In the past, some taxa have been over-collected for herbarium specimens. In the extreme, these collections may have led to the extirpation of the species in South Florida (see ribbon fern [*Nevrodium lanceolatum*] in Chapter 4). Over-collecting may not only have a negative impact upon rare species, but also may waste resources and limited herbarium space. Therefore, we recommend that plants not be re-vouchered at a site unless the most recent collection is at least 10 years old. For most taxa, vouchering every 20 years would be sufficient to ensure a long-term record of a plant's presence at a site. In a few special cases (see lobed croton [*Croton lobatus*] in Chapter 5), a species is ephemeral and is present only in special situations. In these cases, it may be important to collect a voucher each time plants are present.

Summary of general recommendations:

- Collect fertile specimens.
- Ensure that the collection of the specimen does not harm the population.
- Record collector name(s), date, taxon name, habitat and/or associated species, specific location, and geographical coordinate (GPS point).
- Secure permit before vouchering.
- Deposit specimen at a registered herbarium.

Resources: Fairchild Tropical Garden has guidelines for collecting herbarium specimens on their website at www.virtualherbarium.org, and links to other resource sites. The New York Botanical Garden has a list of registered herbaria on their website at www.nybg.org/bsci/ih/.

Rare Plant Surveys

Rare plant surveys are conducted when a historical record exists, but the presence of a species has not been recently verified at the site. Even though decades have passed since a voucher was collected or a species was observed, plants still may persist. Although it may be difficult to obtain precise locality data from herbarium specimens, especially older specimens, an effort must be made to determine the appropriate habitat for the species and conduct reasonable searches before the plant is considered extirpated at a site. Often a plant list for a site will include a species that is within its historical range, but for which there is no herbarium voucher for the county or immediate area. In these cases, surveys are conducted to determine if the species is present.

Surveys are conducted so as to maximize the probability of encountering the target species. Potential habitat is determined and maps of the area reviewed to determine where the appropriate habitat is located. Some species are annuals or may develop aboveground parts for only part of the year. Other species may be difficult or impossible to identify when not in flower. In either case, it is extremely important to establish the time of year when identification can be made and a voucher collected.

Habitats for rare plants are best surveyed on a regular basis. Many species have relatively mobile populations, especially over longer periods of time. These populations may shift in response to fire, hydrological changes, and successional processes. Plants may have gone undetected in prior surveys. In other cases, a site may be largely unexplored.

In some cases reports of rare pants refer to cultivated plants, often planted outside of their historical range. Cultivated populations should be noted and nativity status indicated.

Surveys on private land must be conducted with the permission of the landowner to avoid criminal prosecution for trespass.

Summary of general recommendations:

- Identify which taxa are rare.
- Utilize historical records to determine location and habitats.

- Survey all potential habitats and sites.
- Survey when plants are flowering or otherwise can be identified.
- Re-survey historical localities, if warranted. Survey new localities, if time permits.
- Voucher, map, and estimate abundance of any newly-discovered population.

Rare Plant Mapping

At a minimum, centers of rare plant populations should be mapped, preferably with GPS equipment. Where possible, an outline of plants at each station can be mapped. If warranted, individual plants can be tagged and mapped. Distribution maps can be prepared from GIS data and provided to land managers, park planners, and researchers. For most species covered in this manual, we recommend mapping every three years, although in some cases more frequent mapping may be warranted.

For mapping a centroid, a GPS unit with 10-meter accuracy will suffice, but finer resolution is preferred when mapping boundaries of populations. When mapping individual plants, the use of a GPS recorder with sub-meter accuracy is essential.

Summary of general recommendations:

- At a minimum, map a centroid for each new station.
- If possible, map an outline of plants at each station.
- If warranted, tag and map individual plants.
- Re-map at least every three years.
- If possible, use a GPS recorder with sub-meter accuracy.
- Create GIS coverages and share with agencies and other researchers.

Rare Plant Monitoring

Monitoring rare plant populations is essential to ensure their proper management. In many cases, an annual estimate of population size and population trends is sufficient. In other cases, counting individual plants and recording physical site conditions may be needed. Menges & Gordon (1996) provides a three-level monitoring scheme that can be nested, depending upon the specific needs of a species at the site level. Monitoring varies

from Level 1 (population distribution), to Level 2 (quantitative monitoring of population size/condition), to Level 3 (demographic monitoring of individuals). Each level provides more information, but increases the time and resources needed. Philippi et al. (2001) recommends a multistage approach to the monitoring of rare plant populations, in which demographic monitoring of a subset of each known population is completed in addition to extensive enumeration of all populations. Regardless of which system is used, the key is to design a monitoring program that yields the information needed to properly manage a rare plant population without expending excess resources.

At a minimum, all rare plant populations should be monitored on an annual basis, and mapped every three years. As with floristic inventories, it is useful when population sizes are estimated.

Summary of general recommendations:

- Monitor each station on an annual basis, at a minimum.
- Estimate population sizes (e.g. Log scale).
- If under 100, estimate by 10s; if under 10, count individuals.
- Indicate general health of plants and any threats.
- Determine if more frequent or intensive monitoring is needed.
- Monitor following natural disturbances.
- Monitor before and after management events.

Resources: Menges & Gordon (1996) and Philippi et al. (2001) provide rare plant monitoring guidelines.

Land Acquisition

There are many ongoing acquisition projects in South Florida, from federal programs to state and local initiatives. Despite the fact that more than 50% of South Florida is protected, 16 species of critically imperiled plants are absent from all conservation areas (Appendix 3). Some of these species could possibly be protected through the acquisition of private lands.

Other critically imperiled species are present in one or more conservation areas, but additional populations are found on non-conservation lands. Where possible, these sites should be acquired. Other sites may be considered for acquisition if they contain potential habitat for extirpated, historical, or critically

imperiled species. All sites should be thoroughly surveyed during the acquisition process to determine if they contain any historical or critically imperiled species. Furthermore, sites that are partially degraded may be considered for acquisition if habitat for extirpated or inadequately protected critically imperiled species can be restored. Altogether, 40 sites have been identified for acquisition in South Florida (Appendix 7).

Summary of general recommendations:
Prioritize sites for acquisition as follows:

- Sites that contain critically imperiled plants not known from any conservation area.
- Sites that contain critically imperiled plants known from only one conservation area.
- Sites that contain critically imperiled plants.
- Sites that contain habitat for critically imperiled, historical, or extirpated plants.
- Sites where habitat for critically imperiled, historical, or extirpated plants can be restored.

Resources: Information on State acquisition projects can be obtained on the Internet from the Florida Natural Areas Inventory at www.fnai.org.

Designation and Management of Public Lands as Conservation Areas

Some publicly-owned lands contain populations of rare plants, but are not designated or managed as conservation areas. In some cases, a site is currently designated as a conservation area, but is not managed as such. Nine publicly-owned sites have been identified for designation and management as conservation areas (Appendix 8).

Summary of general recommendations:

- Designate all, or sections of, publicly-owned sites with populations of critically imperiled plants as conservation areas.
- Manage these sites as conservation areas.

Conservation Easements and Agreements

In some cases, it may be impossible, impractical, or inappropriate to acquire a site or to designate a publicly-owned site as a conservation area. In such cases, it may be beneficial to obtain a conservation easement or develop a conservation agreement. In cases where conservation agreements can be developed, technical assistance from a land managing agency should be provided to help manage and monitor populations of rare plants. Incentives may be provided to the landowner to encourage participation in such a program. Twenty-one sites have been identified that would benefit from the development of a conservation agreement and from technical assistance to manage rare plants (Appendix 9).

Summary of general recommendations:

- Obtain conservation easements or develop conservation agreements for sites that are not appropriate for acquisition or designation as conservation areas.
- Identify a source of technical assistance to help with rare plant conservation and restoration efforts.
- Develop a work plan and monitoring schedule.

Preventing Avoidable Extirpations

Unfortunately, rare plant populations are still being extirpated from conservation areas. In some cases, these losses are completely avoidable. In particular, park planners and superintendents need to be informed about populations of rare plants so that park improvements or management activities do not needlessly threaten or destroy rare plant populations. Management plans should include clearly marked maps of rare plant distributions, and articulate methods of monitoring and managing rare plant populations. It is extremely helpful if mapped locations of rare plants are distributed to land stewards who are responsible for implementing management programs. Recreational activities such as off-road vehicle use and equestrian activities must be restricted to avoid impacts to rare plant populations.

Summary of general recommendations:

- Provide land managers, park planners, and superintendents with mapped locations of rare plants.

- Include maps of rare plant populations in management plans.
- Articulate methods of monitoring and managing rare plants populations in management plans.
- Ensure that park improvements do not needlessly extirpate populations of rare plants.
- Prevent off-target damage to rare plant populations from management programs.
- Design recreational activities to avoid impacts to rare plants.

Poaching

Over-collecting and poaching have contributed to the extirpation of numerous rare plants, especially epiphytic orchids and tropical ferns. The State of Florida Department of Agriculture and Consumer Services, Division of Plant Industry (DPI) regulates the collecting of listed plants in the state. Collecting of listed plants without a permit is illegal. Unfortunately, few conservation areas have the resources necessary to combat rare plant poaching. For the survival of many rare plants, it is critical that illegal collecting is halted and that poachers are prosecuted.

Summary of general recommendations:
- Prevent illegal poaching of rare plants.
- Prosecute poachers to the fullest extent of the law.

Resources: The rule regulating the collection of plants in Florida can be obtained at the DPI website at http://doacs.state.fl.us/~pi/5b-40.htm

Exotic (Non-Native) Pest Plants

Exotic pest plants directly and indirectly threaten rare plant populations in South Florida. The Florida Exotic Pest Plant Council (FLEPPC) has identified invasive and potentially invasive exotic pest plants in Florida (FLEPPC, 2001). Every conservation area needs an active exotic pest plant control program to eradicate species identified by FLEPPC. In some cases, exotic pest plants pose a specific threat to critically imperiled plants. In these cases, special eradication programs need to be implemented. In other cases, exotic plants that are not identified by FLEPPC pose a threat to rare species on a site. If a species is documented as being invasive, then it should be eradicated.

The control of exotic pest plants must be implemented without harming rare plants. Control efforts need to be as specific as possible and avoid off-target damage to native vegetation. Maps of rare plant locations may be provided to exotic plant control crews along with photographs of rare plants and their identifying characteristics. In some cases, rare plant populations can be demarcated in the field prior to the initiation of exotic plant control programs. Supervisors of control efforts should understand both the control methods and the identity of the invasive and native species of concern. Once initial exotic species control efforts are concluded, a long-term monitoring and management program is needed to control new infestations of exotic plants. Where possible, invasive exotic pest plants should be extirpated from conservation areas in South Florida.

Some species of exotic pest plants have small populations that could be extirpated from South Florida before they become major regional problems. Land managers can work with local governments, industry, and others to ensure that these species are eliminated from the landscape before they invade further.

Summary of general recommendations:

- Implement an ongoing exotic pest plant control program at every conservation area.
- Provide maps of rare plant locations to control crews.
- Provide educational materials to control crews and train them to avoid impacts to rare plants.
- Establish long-term monitoring and management programs after initial control efforts are concluded.
- Eliminate invasive exotic pest plants from conservation areas in South Florida.
- Extirpate exotic pest plant species from South Florida whenever possible.

Resources: A current FLEPPC list can be obtained at www.fleppc.org.

Feral Animals

Feral hogs, and possibly other feral animals, threaten populations of rare plants. Wild hogs are aggressive rooters of tubers and

other litter and belowground sources of food. Wild hogs are especially damaging to rare plant habitats such as hydric hammocks and the edges of depression marshes. In some cases, wild hogs can completely destroy the aboveground vegetation and disturb all the soil in an area where they are feeding.

Unfortunately, populations of wild hogs are tolerated or even promoted on some conservation lands as game species. Hogs also travel freely from one site to another, making them difficult to control even when control efforts are implemented on conservation lands. Furthermore, there is often public resistance to control efforts from those concerned about either hunting or animal rights. If wild hogs are not eradicated, all other management efforts to protect rare plant species may meet with failure in conservation areas affected by wild hog activity.

Summary of general recommendations:

- Control wild hogs.
- Educate the public about the effects of wild hog damage.
- Document the effects of wild hogs on rare plants.

Fire

Many plant communities in South Florida are fire adapted (Myers & Ewel, 1990), and the use of natural and prescribed fire as a management tool is extremely critical for the protection of many rare plants. Some conservation areas, such as Everglades National Park, have sophisticated fire management programs; others still need to develop and implement such programs. An important issue is the difficulty of using prescribed fire in smaller, fragmented conservation areas in urban and suburban communities. Health and property concerns and public misunderstanding can lead to political pressure to reduce or suppress the use of fire in conservation areas. In some cases, managers have attempted to mimic the effects of fire using mechanical treatments, but there are scarce data on the long-term effects of these practices on rare plants. Without the proper use of fire, many species of critically imperiled plants will be lost from South Florida.

Prescribed fire is important for the maintenance of many native plant habitats, and the application of prescribed fire is best conducted in such a way that it mimics the historical ecological

role of fire in the ecosystem being burned. Sites are best divided so that the entire site is not burned during the same year. The effects of fire on rare plant populations should be monitored following a prescribed burn.

The Florida Department of Agriculture and Consumer Services, Division of Forestry regulates the use of prescribed fire in Florida. County and municipal fire departments also have regulatory authority, and permits are required for any prescribed burn in Florida. Prescribed fire training is provided by the Florida Division of Forestry. The Florida Prescribed Burn Law releases burners from liability in case unintended damage occurs if the appropriate training, planning, permits, and equipment are obtained, and the fire is conducted within the prescription of the permit.

Summary of general recommendations:

- Establish and implement fire management programs at conservation areas with fire maintained habitats.
- Ensure that each conservation area has at least two burn units.
- Monitor effects of prescribed fire on rare plants.
- Provide fire training to land managers.

Resources: The University of Florida Cooperative Extension Service has a web page on prescribed burning regulations in Florida at http://edis.ufl.edu/BODY_FRO55.

Ex Situ Collections

The establishment and management of *ex situ* collections of rare plants is an expensive and resource intensive process. However, in some cases, the development of an *ex situ* collection of plant germplasm may be necessary to prevent the loss of a species or the loss of important genetic material (Falk & Holsinger, 1991). *Ex situ* collections can be comprised of seeds or clonal material (Eberhart et al., 1991). Except in special situations, *ex situ* collections are best managed by institutions affiliated with the Center for Plant Conservation, such as Fairchild Tropical Garden. Fairchild Tropical Garden already maintains *ex situ* collections of several species discussed in this manual (e.g. semaphore cactus [*Opuntia corallicola*] in Chapter 5).

Falk & Holsinger (1991) provides background on rare plant genetics and the use of *ex situ* collections of rare plants as a conservation strategy. One important consideration is that the initial cost of collecting germplasm may be eclipsed by the long-term cost of management of the collection (Falk & Holsinger, 1991). Because of limited resources, *ex situ* collections should be limited to critically imperiled endemic species or species with disjunct populations in South Florida. In some cases, *ex situ* collections have been established for species that are now known to be more common than was originally thought. In these cases, it may be worthwhile to end the management of these collections to free up resources for rarer species. Conversely, some species could easily be extirpated from South Florida, and would be better protected by the establishment of an *ex situ* collection of germplasm (e.g. fragrant maidenhair [*Adiantum melanoleucum*] in Chapter 5).

Summary of general recommendations:

- Manage existing *ex situ* collections at Fairchild Tropical Garden and other botanical institutions unless species are now known to be more common than was originally thought.
- Consider development of *ex situ* collections of germplasm of critically imperiled plants threatened with immediate extirpation.

Resources: Falk and Holsinger (1991) provides sampling guidelines for the conservation of endangered plants. The Center for Plant Conservation maintains a list of participating institutions and other information on the internet at www.cpc.org

Rare Plant Research

Little is known about the basic biology of most rare plants in South Florida. Because of limited resources, researchers at Fairchild Tropical Garden, Florida International University, and other institutions have conducted research on a relatively small suite of species. Most research has been conducted on species listed by the U.S. Fish and Wildlife Service (see USFWS, 2000) and a few tropical species at the northern end of their ranges (e.g. Sargent's cherry palm [*Pseudophoenix sargentii*] in Chapter 5). More recently, the Florida Department of Agriculture and Consumer Services, Division of Plant Industry has provided funding to Fairchild Tropical Garden for work on more species.

Nevertheless, limited funding for rare plant research is a major obstacle to rare plant conservation in South Florida.

Abundant research questions on the biology and ecology of rare plants in South Florida can be identified. Basic questions about pollination, dispersal, and ecological tolerances are just a few of the issues that need to be addressed. Genetic studies on most rare species are just beginning. Information is also needed on rare plant responses to management activities, such as prescribed fire. Horticulture studies are needed to determine how to propagate rare plants and the best methods of out-planting them in restoration project sites.

Summary of general recommendations:

- Improve funding for rare plant research.
- Conduct research to determine the basic biology of rare plants, including reproduction and ecological tolerances.
- Conduct genetic studies.
- Conduct studies on rare plant propagation.
- Conduct studies on best methods of out-planting rare plants.

Fragmentation

Many rare plants in South Florida are contained within small conservation areas located in a matrix of urban and rural landscapes. The effects of fragmentation on organisms and ecosystems have been much discussed (Davies et al., 2001) and fragmentation is considered a major research priority of conservation biology for the next decade (Soulé and Orians, 2001). Effects of fragmentation on rare plants are complex, but potentially include genetic isolation, loss of pollinators, and reduced dispersal ability in response to climatic change or sea-level rise. While there has been much speculation about these effects over the long-term, research on minimum viable populations (Menges, 1991), pollination, and dispersal is needed before we will better understand the management of fragmented populations of rare plants.

Summary of general recommendations:

- Determine the minimum viable population sizes of the rarest plants in South Florida.

- Study the effects of fragmentation on pollination, dispersal, and other natural processes critical to the viability of rare plant populations.
- Develop management strategies to minimize the effects of fragmentation on rare plants.

Regional and Global Impacts

While some impacts to rare plants are localized, others are of a regional or global nature. We have already discussed regional impacts caused by invasive species, fire suppression, and fragmentation. Additional impacts include the historical lowering of the freshwater table and the current plans to restore the Everglades. Global impacts include climate change and sea-level rise. In some cases, rare plant populations cannot be managed successfully or restored unless current conditions are changed. This may be the case for many lithophytic ferns that need moist conditions and have declined due to the lowering of the freshwater table in southeastern Florida. However, we cannot assume that regional change from projects such as the Everglades restoration will automatically benefit rare plants. The Everglades restoration could cause a decline in some species that already have been reduced in range and numbers. Continuing coastal erosion and nutrient enrichment from contaminated water and atmospheric deposition are other regional impacts that may complicate efforts to manage and restore rare plant populations.

Climate change is likely to have important impacts on rare plants in the future, and Florida is one of the states that may be most impacted (Kutner & Morse, 1996). A large number of native species are at the southernmost limit of their ranges in Florida (Kutner & Morse, 1996; Crumpacker et al., 2001a; Crumpacker et al., 2001b). South Florida is isolated from natural sources of tropical plant species by open water. Because of this, tropical plants cannot easily fill niches vacated by temperate species retreating to the north and South Florida may suffer a net loss of native plant species. These losses are expected to be exacerbated by sea-level rise that threatens many tropical species confined to low-elevation coastal habitats such as beaches and coastal berms.

Summary of general recommendations:

- Determine those rare plants most likely to have been impacted by regional drainage and examine management options.
- Evaluate the potential effects of the Everglades restoration on rare plants.
- Monitor the effects of the Everglades restoration on rare plants.
- Continue studies on the effects of climatic change on native plants in South Florida.
- Identify those South Florida plants likely to be impacted by climate change.

Habitat Restoration

The restoration of rare plant habitats is a critical component of the overarching goal of restoring South Florida's degraded ecosystems. For purposes of this manual, we have concentrated on identifying key habitats for critically imperiled, historical, and extirpated plants in South Florida. These habitats were identified by reviewing all of the known historical localities for this group of species. In some cases, such as in the Fort Myers area, numerous species have been collected, but they occupied myriad habitats and no clear restoration objective could be determined. In other cases, clear groupings of species in areas of potential restoration were found. As a result, ten ecological restoration areas have been identified (Appendix 10).

From a floristic standpoint, several elements are critical for the successful restoration of rare plant habitats, or for any ecological restoration project that involves the translocation of native plants: (1) identify a reference ecosystem; (2) use species (taxa) of plants native to the immediate locality of the project area, and to the ecosystem being restored; (3) utilize propagules (seeds, cuttings, etc.) collected as close as possible to the restoration site and from the ecosystem being restored; (4) use propagules from many individual plants. Depending upon the circumstances, rare plants may be planted out during the initial stages of the project, or at later stages after some degree of ecosystem maturity has been attained. Clewell et al. (2000) provides guidelines for conceiving, organizing, conducting, and assessing ecological restoration projects. Falk et al. (1996) provides guidelines for the

reintroduction of rare plants (see also Translocations in this chapter).

Another consideration is the integration of rare plant conservation and floristic elements into existing ecological restoration projects. Unfortunately, many restoration projects fail to incorporate rare plant conservation into their designs and, in some cases, rare plants may be harmed. Other projects have loose criteria for the selection of plant species or genetic stock, and these projects may ultimately contaminate conservation areas already stressed by exotic pest plants and other anthropogenic disturbances. Large ecological restoration projects such as the Everglades restoration need protocols for the monitoring of rare plant populations to ensure that the restoration does not inadvertently harm rare plant populations.

Summary of general recommendations:

- Identify and restore key habitat areas for critically imperiled, historical, and extirpated plants.
- Restore populations of rare plants.
- Follow good principles of floristic design in restoration projects.
- Integrate rare plant conservation and restoration into existing and future ecological restoration projects.
- Monitor the effects of large restoration projects on rare plants.
- Develop a strategy to ameliorate damage to rare plants caused by climate change, sea-level rise, and other phenomena.

Resources: The Society for Ecological Restoration website (www.ser.org) has an Adobe Acrobat version of the restoration guidelines by Clewell et al. (2000). The IRC website (www.regionalconservation.org) has floristic data from conservation areas that will assist in the compilation of floristic reference data. Egan & Howell (2001) provides a guide to reference ecosystems.

Increasing Population Sizes of Rare Plants

In many cases, rare plant populations have been reduced within a conservation area due to collecting, exotic pest plant invasions, fire exclusion, and so on. In some cases, these populations can

be restored by eliminating the causes of decline. Poaching can be prevented, exotics plants can be controlled, and fire can be reintroduced. In such cases, a monitoring program should be developed to ensure that restoration activities do not harm critically imperiled plants, and that the populations of critically imperiled plants respond in a favorable way.

Summary of general recommendations:

- Identify and remove stressors from populations of critically imperiled plants
- Ensure that management activities do not negatively impact rare plant populations.
- Monitor long-term management effects to determine whether or not populations of critically imperiled plants respond by increasing abundance and reproductive success.

Translocations

Translocations include the augmentation, reintroduction, and introduction of rare plants (Gordon, 1994; Falk et al., 1996). The translocation of a rare plant into a conservation area is a management strategy that must be approached cautiously. Issues of concern include whether or not a translocation is appropriate, the genetic composition of the propagules, the establishment of a monitoring protocol, and long-term management of the population. Falk et al. (1996) suggests that all translocations be treated as experiments.

In some cases, the population of a rare plant has become so small in a conservation area that the risk of local extinction is extremely high (see mahogany mistletoe [*Phoradendron rubrum*] in Chapter 5). In such cases, augmentation of populations must be considered. In other cases, rare plant populations have been lost from conservation areas in South Florida due to poaching, exotic pest plant invasions, or other factors. These conservation areas may be considered candidate sites for rare species reintroduction. Introductions of rare plants may also be considered if a rare plant was collected in the vicinity of a site. When introducing a rare plant into a conservation area, one must be careful to ensure that the introduced population does not have a negative impact upon other native species present at the site. As such, introductions might be best considered at sites where previous disturbance necessitates the restoration of rare plant habitats. We discourage

the translocation of any species, rare or not, to a conservation area outside of that species' historical range.

Summary of general recommendations:

- Document historical presence at or within the vicinity of the recipient site.
- Determine that the causes of population loss or extirpation have been removed.
- Determine that the appropriate habitat is present and that management will facilitate the success of the project.
- Establish if translocation is appropriate.
- Implement augmentation or reintroduction if these actions will not threaten other native plants or their habitats.
- Use local germplasm from the same habitat as the recipient site.
- Collect germplasm according to rigorous scientific standards.
- Treat the translocation project as a scientific experiment.
- Map all translocated plants and develop GIS coverages.
- Develop a monitoring protocol that will determine success of the project.
- Develop a long-term management plan.

Resources: Gordon (1994) provides guidelines for rare plant translocations into conservation areas. Falk et al. (1996) provides guidelines for rare plant reintroductions.

Reintroducing Populations of Extirpated Plants

Over 100 species of native plants apparently have been lost from South Florida due to human actions in the last 100 years. To the extent possible, populations of these species should be reintroduced to South Florida. Generally, we have recommended consideration of reintroductions to South Florida when sufficient information is present to document: (1) that the plant was a persistent element in the flora, (2) its habitat(s), and (3) a specific historical location.

For extirpated or historical plants with widespread historical records, we have generally limited our reintroduction recommendations to those species in those areas where more than one record exists. For those historical or extirpated plants with a single historical record, we have generally not

recommended reintroduction at this time. The exception would be those plants that would be reintroduced into restored areas in urban or suburban habitats, where risks of contamination to nearby conservation areas are low (Gordon, 1994). This would also apply to intensive agricultural areas, such as in the Everglades Agricultural Area. In some of these cases, we have recommended consideration of reintroduction. We also have not recommended reintroduction of an extirpated or historical species if it appears that the plant was extirpated due to natural causes (see purple tiger orchid [*Maxillaria parviflora*] in Chapter 4).

The main concern about the reintroduction of a plant that has been extirpated from South Florida is where to obtain the genetic material to be used in the restoration. In a few cases, the original genetic material from South Florida plants still exists, and propagules could be obtained from living plants (see spiny black olive [*Bucida spinosa*] in Chapter 4). In some cases, the genetic material is comprised of a single living tree. In other cases, no South Florida material exists whatsoever. If the extirpated species is present to the north of our area, this may not be a stumbling block. But if the plant is a tropical species at the northern limit of its range, this can be a major problem. This is the case for many tropical ferns and orchids that have been extirpated from South Florida. These tropical species almost certainly arrived in South Florida from the Bahamas and Cuba (there are a few South Florida plants that apparently arrived from southern Texas or Mexico), and Bahamian or Cuban germplasm would have to be considered as sources of propagules.

Another consideration is the potential weediness of some extirpated species if reintroduced (see slimbristle sandbur [*Cenchrus brownii*] in Chapter 4). Some of these species could become pests given the extreme disturbance in today's South Florida landscape. In this case, caution is advised, and perhaps no action should be taken at the present time.

Summary of general recommendations:

- Document historical presence in South Florida.
- Document presence at or in the vicinity of the recipient site.
- Determine source(s) of germplasm.
- Follow guidelines for translocations.

Legal Protection of Rare Plants

The Florida Department of Agriculture and Consumer Services, Division of Plant Industry (FDACS) and the U.S. Fish and Wildlife Service (USFWS) both list rare plant species found in South Florida. FDACS lists plants as endangered, threatened, or commercially exploited in Florida. FDACS does not list hybrids or infraspecific taxa (subspecies or varieties). The USFWS lists only those species that are endangered or threatened with endangerment within all or a significant portion of their ranges. In some cases, lack of information about rare plants in Cuba or the Bahamas may slow or stop the listing of species that warrant protection under the Endangered Species Act. In addition, political and legal processes have encumbered the USFWS listing process for many years, and many species that warrant federal protection remain unlisted. Finally, the Florida Natural Areas Inventory tracks rare plants in Florida, but this listing does not provide any legal protection.

Although the listing of plants does not provide the same legal weight as the listing of animals, listing is important because it focuses attention to the plight of rare plants, provides a legal and administrative basis for requiring the protection of rare species on public lands, and, in some cases, secures funding for surveys, mapping, monitoring, or scientific research. Several plants covered in this manual are in need of review for listing by one or more agency, or the current listing is in need of revision. These needs are indicated in the species accounts in Chapter 4 and Chapter 5.

Summary of general recommendations:

- Ensure that the most current information is available to listing agencies.
- Conduct research on the status of rare plants found only in South Florida, Cuba, and the Bahamas that may influence listings by the USFWS.
- Encourage the USFWS to develop and implement objective, biologically-based listing procedures and speed the listing process.
- Encourage FDACS to develop and implement listing procedures to include subspecies, varieties, and hybrids.

Creating Awareness

Awareness of the need for rare plant conservation and restoration lags behind other environmental initiatives. Yet communicating the needs of rare plants and their habitats is critical to their restoration. At the top of the list is the education of land managers and restoration practitioners, so that restoration projects and management efforts can benefit rare plants. IRC initiated this process with a rare plant workshop convened at Fairchild Tropical Garden in 2001, and has another six workshops planned for 2002. Fairchild Tropical Garden has organized state-wide rare plant meetings from time to time, including one at Archbold Biological Station in 2001.

It is important to build awareness within the research community, as there is far more work to do than those currently conducting rare plant research can manage. In particular, graduate students should be encouraged to work on rare plant biology. Funding sources need to be augmented and improved as discussed in Rare Plant Research in this chapter.

Many critical people need more information about the conservation needs of rare plants. These include policy makers, park superintendents, park planners, acquisition specialists, and those responsible for funding conservation programs. Unfortunately, native plants play a minor role in society's thinking about conservation, and have suffered from administrative and political neglect. Finally, without the support of the public, rare plant conservation and restoration will continue to lag behind other environmental activities in South Florida. The Florida Native Plant Society and its local chapters have done an exemplary job in educating the public, but public advocacy for rare plant conservation is critical if we are to move forward with the restoration of South Florida's native plant heritage.

Summary of general recommendations:

- Create training opportunities for land managers and restoration practitioners in the identification, conservation, and restoration or rare plants.
- Encourage graduate student studies on rare plants.
- Provide information to policy makers, park superintendents, park planners, acquisition specialists, and other key people.

- Educate the public and gain support for rare plant conservation and restoration.

Resources: The Florida Native Plant Society website (www.fnps.org) is an excellent resource. The IRC website (www.regionalconservation.org) has information on rare plants, including most of the contents of this manual.