

# Final Report

## Floristic Assessment of the Karst Belt of Puerto Rico Phase Two

George D. Gann and Keith A. Bradley

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Final report submitted by:  
The Institute for Regional Conservation  
22601 S.W. 152 Avenue; Miami, Florida 33170  
George D. Gann, Executive Director



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## **Introduction**

The Floristic Assessment of Puerto Rico (FAPR) Database has been developed in order to facilitate the conservation of native plants in Puerto Rico. While it was initiated in order to contribute to an ongoing study of the Puerto Rican karst belt by the International Institute of Tropical Forestry in Río Piedras, Puerto Rico, it has wider conservation implications. The FAPR Database builds upon nine years of floristic database development by The Institute for Regional Conservation (IRC) in Florida, and foresees the development of an analog publication to *Rare Plants of South Florida: Their History, Conservation, and Restoration* (Gann et al. 2002) for Puerto Rico. The development of the FAPR will also allow for the development of a website application similar to IRC's Floristic Inventory of South Florida Database Online, which can be viewed at [www.regionalconservation.org](http://www.regionalconservation.org). Phase One of the FAPR was completed in September 2002. Phase Two was initiated in the July 2003 and was completed in February 2004.

## **Methods**

### **Plant Names**

The development of the FAPR Database began with a base list of the Puerto Rican flora derived from Liogier & Martorell's *Flora of Puerto Rico and Adjacent Islands* (2000). After all plant names were entered into an Accepted Names table from this resource other taxonomic sources were reviewed in order to supplement or make changes to this base list. A literature search was conducted to find newly published plant records for Puerto Rico and these were added to the database. The online USDA PLANTS database, <http://plants.usda.gov/>, was used extensively, as was Kartesz (1994). If both of these references used a different name than one used by Liogier & Martorell (2000) then that name was changed. Names in the Orchidaceae generally follow Ackerman (1995). The sources followed for each taxon name are traced in the Authority table. Synonyms have also been entered and are stored in the Synonyms table. Plant names and ancillary data (below) can be viewed in the PLANTS\_PUERTORICO form.

### **False and Doubtful Names**

Significant work was done in Phase Two to identify names that were falsely or doubtfully attributed to the Flora of Puerto Rico. Notes have been included in the database explaining why these designations were given for each species.

### **Ancillary Data**

Liogier & Martorell (2000) was used as a baseline for other types of data for each plant taxon, including global ranges, nativity, and current status in Puerto Rico. Other sources were used to supplement this baseline data and as sources for other data fields, including plant habit, substrate, and perennation. Valuable sources include the *Descriptive Flora of Puerto Rico and Adjacent Islands* by Liogier (1985-1997), *Botany of Porto Rico and the Virgin Islands* by Britton & Wilson (1923-1930), Ackerman (1995), Little & Wadsworth (1964), Little et al. (1974), and Proctor (1989). The baseline data were augmented with information from herbarium labels. Agency lists of species (DRNA, USFWS) were also added. Each taxon is also attached to a HighTax table with data on plant families and groups (monocot, dicot, gymnosperm, pteridophyte). Significant work was done in Phase Two to more accurately determine nativity status. In addition, notes were added for those species thought to be extirpated or historical in Puerto Rico.

### **Herbarium Labels**

Electronic herbarium label data were imported into the database from several sources including A (13 specimens), AMES (7 specimens), FLAS (230 specimens), GH (183 specimens), MO (1,850 specimens), NY (2,378 specimens), SJ (386 specimens), UPRRP (5,098 specimens), and US (1,933 specimens). Specimens from US and UPRRP are entirely from collections by Pedro Acevedo and Franklin Axelrod, respectively. In total, the database has data from 12,078 herbarium labels including 2,633 Acevedo specimens and 5,308 Axelrod specimens. Data from each specimen were entered into the References table, and are linked through the SiteRefs table to localities in the Sites table. Label data for potential names are attached to an accepted taxon name in the Occurrences\_PR table. Data from FLAS and MO were newly entered in Phase Two. Herbarium label data can be viewed in the dataentryHerbarium form.

### **Collection Books**

Data from George Proctor's collection books were hand entered into the database in Phase Two. In total, data from 3,752 specimens were entered – up to specimen number 43588 (May 25, 1987). These data can be viewed using the dataentryCollectionBook form.

### **Other Occurrence Data**

Several literature sources were used for occurrence data within Puerto Rico. Specific locality data for plants in municipalities and conservation areas were entered from Ackerman (1995), Cedeño & Breckon (1996), Little & Wadsworth (1964), Little et al. (1974), Proctor (1989), and several other sources. All plant taxa listed in Acevedo-Rodríguez & Axelrod (1999) for the Río Abajo Forest Reserve were also entered. These data are linked to sites and species as described for herbarium specimens above. Occurrence data from all sources can be viewed in the dataentryOccurrences form.

### **Site Names**

Site names were imported or entered from locality data sources including herbarium specimens, collection books, and literature. Site names can be viewed in the SITE form.

### **Karst Belt Data**

The karst belt of northwestern Puerto Rico has been described as an important ecological resource (Lugo et al. 2001). Using the herbarium specimens and literature sources described above, a preliminary flora was developed for the karst belt. The boundaries identified for the karst belt are from a GIS layer provided by the IITF (karst\_belt.shp). A taxon was assigned to the karst belt if an herbarium voucher was known to be collected within its boundaries, if it was recorded from one of the four conservation areas located primarily within the karst belt (Río Abajo, Cambalache, Guajataca, and Vega), or if it was recorded from one of the following municipalities that have significant areas of karst: Aguadilla, Isabela, Quebradillas, Camuy, Hatillo, Arecibo, Barceloneta, Florida, Manatí, Vega Baja, Vega Alta, and Dorado. Karst Belt data can be viewed in the KarstNatives table.

### **Municipality Data**

Municipality data were compiled from herbarium labels and literature as described above. They can be viewed in the MUNICIPALITIES form. They were not updated in Phase Two.

### **Conservation Area Data**

Conservation area data were compiled from herbarium labels and literature as described above. They can be viewed in the CONSERVATION\_AREAS form. They were not updated in Phase Two.

### **Substrate Data**

Substrate data were compiled from several sources. These data were used to identify species that grow on certain substrates, such as karst, limestone, or serpentine. Sources included Liogier (1985-1997), Britton & Wilson (1923-1930), Ackerman (1995), Proctor (1989), Cedeño & Breckon (1996), and others. These data are preliminary and can be viewed in the SUBSTRATE form. They were not updated in Phase Two.

### **Elevation Data**

During Phase Two, data from herbarium specimens and Proctor's collection books, along with Ackerman (1995) and Proctor (1989), were used to develop a table with coarse elevation data. Elevation zones of <500 m, 500-1000 m, and >1000 m were created and populated with plant names. These data can be viewed in the ELEVATIONS form.

### **Habitat Data**

During Phase Two, data from herbarium specimens and Proctor's collection books, along with Ackerman (1995) and Proctor (1989), were used to develop a table with coarse habitat data. Habitat designations of Dry Forest, Moist Forest, and Wet Forest were created and populated with plant names. These data can be viewed in the HABITATS form.

### **Literature Review**

A literature search was conducted for plants tracked by the Puerto Rico Department of Natural and Environmental Resources (DRNA). This search yielded 70 unique references. These data can be viewed in the Literature\_DRNA\_Taxa table.

### **Site Visits**

The senior author has made seven trips to the island of Puerto Rico since 1998 to meet collaborators and become familiar with the landscape and flora. In September 2003, both authors attended the second symposium held on karst research at the Interamerican University of Puerto Rico in Bayamón.

## **Results and Discussion**

### **FAPRv2**

Version 2 of the Floristic Assessment of Puerto Rico Database (FAPRv2) has been prepared as a read-only database in Microsoft Access and burned on a CD that can be copied and distributed for review and use.

### **Floristics**

The floristic data contained in version 2 of the Floristic Assessment of Puerto Rico Database (FAPRv2) is summarized in the report SUMMARYrpt. The FAPR Database provides a database form (PLANTS\_PUERTORICO) containing names for all native and naturalized vascular plants in Puerto Rico, as well as many common cultivated plants. In version 1 (FAPRv1), there were 3,906 names, including 617 synonyms. In FAPRv2, there are 4,001 names, including 713 synonyms and 3,287 accepted names. Of these, 50 names have been either falsely attributed to the flora of Puerto

Rico, or represent uncorroborated reports or doubtful records. Additional work is needed to normalize accepted names with work being conducted by Franklin Axelrod at the University of Puerto Rico, Río Piedras.

### **Nativity**

Of the 3,237 plants in the database that are either present in Puerto Rico or were historically documented there, 187 are cultivated plants that are not native to Puerto Rico but which may be encountered persisting from cultivation in forests or conservation areas. The actual flora of Puerto Rico comprises approximately 3,050 kinds of plants, including 646 plants that are either naturalized exotics or are doubtfully native. In FAPRv2, 21% of the flora is non-native as compared to 19% in FAPRv1. In addition, 227 plants have been identified as assumed to be native and are in need of additional review. If half of these species are not native, then about 25% of the flora of Puerto Rico represents naturalized exotics. If all of the assumed natives are actually native, then there are 2,403 taxa native to Puerto Rico. The remaining results and discussion are based upon an assumed 2,403 species of native plants.

### **Rarity**

Based upon data entered in FAPRv1, 543 native plants are tracked by DRNA, representing about 23% of the native flora. Of these, 10 are ranked as historical, 143 are ranked as critically imperiled, and 341 are ranked as of an unknown status. As part of the development of the FAPR, we have identified 83 species that may be extirpated or extinct in Puerto Rico, although two of these (*Pseudophoenix sargentii*, *Caesalpinia coriaria*) are only assumed to be native. These represent about 3.5% of the native flora. From a preliminary search of the occurrence data, it appears that more historical and extirpated plants would be identified by reviewing occurrence data for the remainder of the plants tracked by DRNA. Places such as Tortuguero Lagoon may represent restricted habitats where long-term disturbance may have resulted in numerous extirpations. DRNA tracking data needs to be updated in the next version of the FAPR.

### **Occurrence Data**

33,005 occurrence records have been downloaded or entered into the FAPRv2. Of these, accepted names have been applied to 32,184 records. Herbarium label data from the University of Puerto Rico, Mayagüez and other herbaria are needed to complement the dataset. Electronic data from University of Puerto Rico, Mayagüez has been received but needs reformatting before it can be downloaded into the database. While we have entered all Proctor collection book data provided to us by Pedro Acevedo, it appears that Proctor continued to collect in Puerto Rico after May 25, 1987. Any additional collection books need to be obtained and the data entered. Finally, site names need to be normalized, both in terms of replications due to minor differences in imported site names as well as sites identified in both English and Spanish or with multiple vernacular names.

### **GIS Data**

Site names for occurrences of endemic species collected by Proctor have been provided to Danilo China at the University of Puerto Rico, Mayagüez who has agreed to attach GIS coordinates to each unique site name. Upon receipt of FAPRv2, China will begin attaching coordinates for all unique site names in the database.

### **Karst Belt Data**

A total of 1,039 native plant species have been documented to be historically present in the karst belt, representing about 43% of all native plant species in Puerto Rico. Of these, 893 have been

documented to be present in one or more of the existing conservation areas in the karst region, an increase in 54 species from the FAPRv1. Other pertinent results include:

- 19 native plant species in the karst belt are listed as endangered or threatened by the U.S. Fish & Wildlife Service, which represents about 40% of the federally-listed plants in Puerto Rico. Fourteen of these species are documented to be present in one of the existing conservation areas in the karst belt. We have no data from conservation areas in the karst belt for the following federally-listed species that have been recorded there: *Adiantum vivesii*, *Auerodendron pauciflorum*, *Banara vanderbiltii*, *Buxus vablii*, *Thelypteris verecunda*.
- The DRNA tracks 143 native plant species that have been documented in the karst belt or 26% of all the native species tracked in Puerto Rico. 108 of the tracked species are documented for one of the region's conservation areas.
- Of the 83 species of plants that may be extinct in Puerto Rico, only seven have been documented to be historically present within the karst belt.

GIS data on the proposed acquisition area and vegetation of the karst belt are still needed to generate additional results. Comprehensive plant lists are needed for several conservation areas in the karst belt, and rare plant surveys are needed to validate historical records and determine the present status of the rarest species. The relatively low number of DRNA tracked plants in the region suggest that critical data are missing and that extensive field work is needed to document rare plants in the region.

### **Publication of the Data**

Version 3 of the FAPR should yield data sufficiently complete to publish an online database for Puerto Rico similar to IRC's Floristic Inventory of South Florida Database Online. Significant additional work is needed before a peer-reviewed synopsis of the flora, a paper on extinctions and extirpations, or a paper on the status of native plants in the karst belt can be published.

### **Recommendations for Future Work**

1. Normalize nomenclature with work being conducted by Franklin Axelrod at the University of Puerto Rico, Río Piedras.
2. Conduct additional work on nativity status for those species identified as assumed to be native.
3. Update DRNA tracking ranks.
4. Review occurrence data for all native taxa tracked by DRNA.
5. Import additional electronic herbarium label data.
6. Finish Proctor data entry.
7. Normalize site names.
8. Support Danilo China's work to attach GIS coordinates to each unique locality.
9. Develop web application similar to IRC's Floristic Inventory of South Florida Database Online.
10. Prepare floristic inventories for Cambalache, Guajataca, and Vega, similar to that done for Río Abajo.
11. Conduct surveys for all species preliminarily identified as extirpated, historical, or critically imperiled.
12. Continue supporting Gary Breckon in the databasing of herbarium specimens at University of Puerto Rico, Mayagüez and other Puerto Rican herbaria.

13. Update municipality, conservation area, substrate, elevation, habitat, and karst tables using new occurrence data imported or entered into the database.
14. Analyze data by occurrences of natives in proposed karst acquisition area.

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