

Biodiversity Recording and Planning: Bermuda

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Introduction

The isolated island chain of Bermuda, the oldest of the UK Overseas Territories, is located in the Western North Atlantic, 965km S.E. of Cape Hatteras. The islands are situated on the southern rim of the largest of three steep-sided mounts. Originating through volcanic activity 110 million years ago, these mounts rise from depths of about 4,000 m to form a total platform area of approximately 1,000 km².

Of great biological interest is the northerly extension of subtropical systems to this latitude, a direct result of the transport of the warm waters of the Gulf Stream. Boasting the northern-most coral reef system in the world Bermuda is biotically linked with the islands of the Caribbean and the south-eastern United States. However, it does support a much reduced species assemblage, with only about one third of the shallow-water coral species recorded from Jamaica and a relatively depauperate terrestrial fauna.

Like many of the islands in the Caribbean, Bermuda's economy, through tourism, recreational activities and international business, is nowadays intrinsically dependent on the health of its natural habitats. However, with a resident population of 60,000 inhabiting a total land mass of 50km², and entertaining 500,000 visitors a year, Bermuda is one of the most densely populated places on earth. Fuelled by strong economic growth, the pressure for further development poses an escalating threat to the fragile ecology of the island.

Bermuda's attractiveness as a natural laboratory explains the wealth of scientific research conducted on the island, particularly over the last century. Over 3,400 scientific documents have described the island's natural history, and over 8,000 species have been recorded. However, with no central clearing house, most of this information is widely scattered and of little use to resource managers, land-planners, conservationists, educators and scientists. In a concerted effort to promote the conservation of Bermuda's natural resources, the Bermuda Aquarium, Natural History Museum and Zoo (BAMZ) and its support agency, the Bermuda

Zoological Society (BZS) have taken the lead in co-ordinating the Bermuda Biodiversity Project (BBP). Launched in 1997, the BBP represents the first attempt to create a comprehensive information management system for Bermuda's natural resources. With this underlying goal, the project is focused on the collation and dissemination of information, promotion of its importance and encouragement of its use.

Partnerships, the vehicle to success!

Conceived and initiated on a shoestring (\$25,000), the BBP has been dependent upon partnerships from the outset. The longstanding, and very successful partnership between the Government Aquarium, established in 1926, and its supporting charity, the Bermuda Zoological Society (established in 1978 to support education, conservation and exhibit development at BAMZ), provided a strong foundation from which to attract other partners. Appeals were made to prospective collaborators highlighting the benefits of working together and sharing information and resources, and, with a shared vision of the value of collaborating, numerous critical partnerships were cemented. These fall into three broad categories:

Information Sources - A series of informal gatherings were held to which the local government and non-governmental organisations were invited to join with local librarians, scientists, naturalists, and photographers in discussing the objectives of the project. This led to many expressions of interest and several commitments for the production of papers to be published as contributions to the BBP. Overseas scientists with a history of local research were also contacted to assist in providing references to literature on Bermuda and experts were invited to collaborate with the production of reviews of the local biota. Museums known to hold Bermuda specimens were solicited for information on their holdings.

Human Resources - Several of the local government departments readily recognised the value of the project to their areas of responsibility and hence committed to

provide manpower to assist. Notable amongst these were those departments responsible for: conservation and parks, agriculture and fisheries, mapping and forward planning. They have all provided significant technical advice and support. Non-governmental sources of manpower have included overseas researchers who agreed to collaborate (often in return for logistic support along with spartan housing and lab space), as well as local experts, amateur naturalists, local dive operators, and students. With a membership comprising almost 17% of the population, the BZS also has a large pool of enthusiastic volunteers, who have assisted with many aspects of the BBP.

Financial - Financial partners include both the Bermuda and the U.K. Governments, local and overseas NGO's, overseas environmental funding agencies, the local business community, as well as individual donors.

Establishing the Framework

The backbone of the BBP is the development of a GIS-interactive, relational, event-centred database, pooling information on Bermuda's flora and fauna. The primary function of the database is to record the occurrence in time and distribution of species (and higher taxa) in Bermuda. The secondary function of the database is to manage four "collections", which themselves serve as

the data sources for biodiversity events. These are: Museum lots (biological and geological specimens and artefacts); the Bermuda Natural History Bibliography (a collection of over 3,400 scientific documents describing the Islands' natural history); Images (comprising over 12,000 slides and photographic images); and Field Logs (data collected but not published). A "biodiversity event" is minimally defined by a person (collector, photographer, author) documenting the occurrence, at a specified locality and on a given date, of a species. Additional information about the environment in which it was found, and about the actual specimen itself, may accompany the record.

Additional databases serve as "dictionaries", and include Species, People, Institutions and Localities, the latter being represented in nested levels of accuracy to allow for less precise locality information available in historical records.

We have chosen a Microsoft SQL Server as the backend of this database, with a web-enabled front end, which will allow users to update and retrieve data using a custom-built web-interface. The SQL Server offers a robust database environment, capable of handling large numbers of records, a large amount of data, as well as colour images, sounds and video. The web front end will allow historical data to be kept on-line, with no performance impact for the system users.

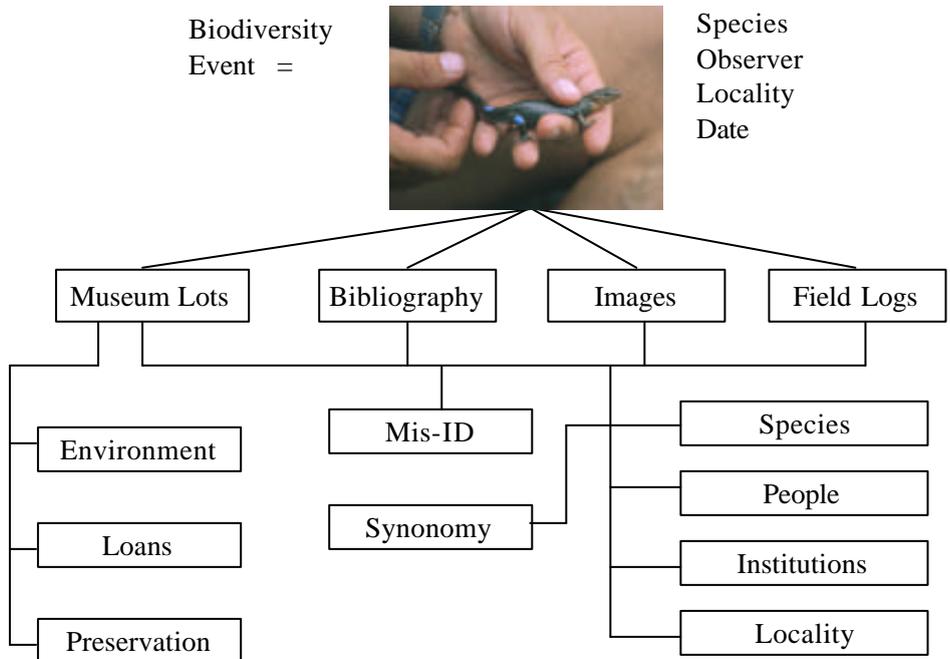


Figure1. The basic structure of the Bermuda Biodiversity Database

Locality data are being linked to the Government Geographic Information System (GIS). Digitised ordnance survey maps currently serve as the base layer for the GIS. However, the recent production of an accurately georeferenced aerial photomosaic is proving to be a much more useful base layer on to which biodiversity data can be superimposed. This is an excellent example of the collaborative nature of the BBP. In April 1997, the BZS and BAMZ partnered with the Ministry of Works and Engineering and the Bermuda Land Development Company to support the aerial photographic survey of Bermuda and the surrounding marine platform.

Data Collection

a) What is already known?

As one of the best-studied islands on Earth, one of the principle aims of the project has been to collate, and make readily available, existing biodiversity information. The Bermuda Natural History Bibliography (a component of the Biodiversity database, and currently available as a searchable database on the BAMZ/BZS web page www.bamz.org) houses over 3,400 scientific documents. This includes unpublished student theses and technical reports. The BAMZ Natural History Museum houses over 5,000 lots and over 12,000 slides of Bermuda's flora and fauna, whilst surveys of overseas institutions have uncovered additional publications and specimens from Bermuda.

b) Filling in the information gaps

A review of the historical data has nevertheless revealed many information gaps. Priorities were therefore established. Efforts to encourage collaborators to help fill these gaps have, to date, resulted in over forty ongoing scientific studies. These have been focused primarily at the taxonomic level, but have also included population studies of threatened endemic and

native species, or invasive species. A BBP Scientific Contribution Series has been established that currently has 35 manuscripts (either published, or accepted for publication) with assigned numbers.

At the outset of the BBP, there was a recognised need for a baseline habitat survey to be conducted, both to provide a broader framework on to which species-specific information could be added, as well as to provide a benchmark against which future changes could be monitored. The timely development of the Government GIS provided an added incentive to launch an intensive mapping survey of Bermuda's terrestrial and marine habitats. It was realised that integration of the habitat data into the GIS would allow for both qualitative and quantitative analysis and would serve as a powerful vehicle for information management and decision support. Additionally, we have discovered that GIS is also a powerful presentation tool, as the information presented is intuitive, and otherwise obscure relationships are easily clarified. It is a very effective way to display scientific findings to non-scientists.

To date, over 1,200 randomly selected points have been surveyed across Bermuda's open spaces by the BBP team. Data have been collected on both canopy and understorey plant species, as well as saplings, enabling some predictions to be made about the future canopy species.

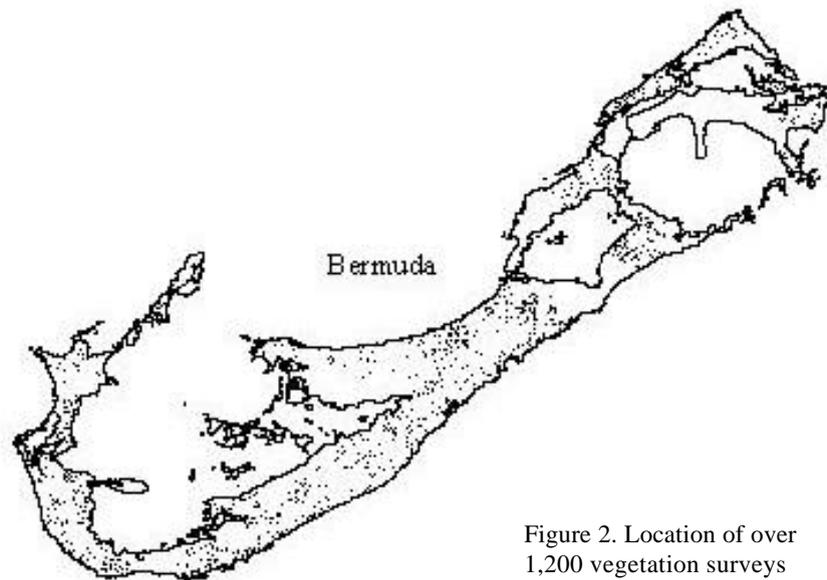


Figure 2. Location of over 1,200 vegetation surveys conducted across Bermuda

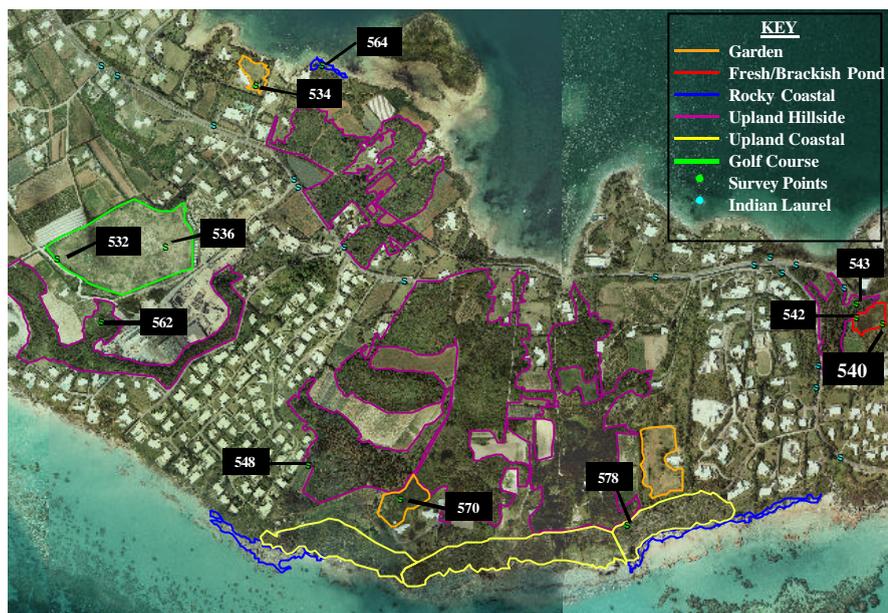


Plate 1. Example of terrestrial habitat digitization using 1:10,000 high resolution aerial photos, and also showing the location of some of the vegetation survey points

Courtesy of the Ministry of Works & Engineering

This information has been used, in conjunction with the high resolution 1:10,000 aerial photos, to develop a terrestrial habitat map for the island (see Plate 1). It is particularly encouraging that the Department of Planning, charged with the production of forward planning statements to direct land-based development and with a mandate of protecting the natural amenities of the islands, will incorporate the information from these surveys in the next Development Plan.

Prompted largely by the 1997 International Year of the Reef, and in recognition of the need for environmental sensitivity maps to guide pollution abatement and coastal development decisions, similar efforts to map Bermuda's shallow water marine habitats are being undertaken through the BBP. 300 transect surveys have been completed across the Platform. Priority is being given to the mapping and assessment of coral and seagrass habitats and inshore areas which are most threatened by coastal development and pollution. Interpretation of a set of 1:15,000 marine orthophotos currently being developed will be supported by extensive ground truthing of bathymetric and benthic features.

Community Involvement

The importance of including the community in the BBP has been a firm goal from the start. By including the wider community, it was hoped that we could promote a sense of ownership and thereby encourage environmental stewardship. Additionally, we recognised

that the public could provide extremely valuable, cost-effective information.

Community participation in the collection of biodiversity data, has included: school groups assisting with the terrestrial vegetation surveys; local recreational and professional divers conducting coral and fish surveys; local amateur photographers providing photographs (often the only record of a particular species); and the general public providing information of species sightings. The latter has proven particularly successful with regard to gathering information on Bermuda's only terrestrial endemic vertebrate, the Bermuda Skink. Flagged as a priority species since the inception of the BBP, in 1998 a questionnaire was inserted in the local utility company's monthly billings, requesting information about Skink sightings across Bermuda. This partnership saved us nearly \$10,000 in postage alone and resulted in nearly 200 responses. The information provided was invaluable, and indicated that the Skink was more widespread on the mainland than originally thought. Follow-up surveys by a Bermudian doctoral candidate are planned over the next year.

Efforts to expand data collection in the marine environment have also been met with enthusiasm by the local dive community. We have adopted the protocol designed by the Reef Environmental Educational Fund for engaging local divers in collecting reef fish data, whilst a small group of volunteers have been trained in the AGRRA (Atlantic Gulf Rapid Reef Assessment) protocol for assessing coral reef health.

