PROCEEDINGS
OF THE
SIXTH SYMPOSIUM
ON THE
NATURAL HISTORY OF THE BAHAMAS

Edited by
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Bahamian Field Station, Ltd.
San Salvador, Bahamas
1996

Cover Photo: Dr. Lynn Margulis, Symposium Keynote Speaker, describes the structure and ecology of living stromatolites. Some, visible as grayish mounds near her feet, line the shore of Storrs Lake whereas others occur farther out in deep water. (See paper by D. C. Edwards, this volume).

Back Cover Photo: Group photo of the 6th Symposium participants and speakers.

Photos by Paul Godfrey (Computer processed prints by Lanny Miller).

Printed in USA by Don Heuer

ISBN 0-935909-60-5

ON THE NEED TO CONSERVE BAHAMIAN FLORAL BIODIVERSITY

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ABSTRACT

The Bahamas has undergone a number of changes since discovery. Yet changes in the natural vegetation of the Bahamas predates the Colombian exchange and began with the activities of the Amerindians called Lucayans ("Lukku-caire"). The Lucayans were probably driven into the Bahamas by Carib Amerindians (Randolph 1994). However, it is only in the late twentieth century that change has accelerated to the point that community and species alteration and extinction has become a potential reality. Both Andros Island and San Salvador serve as models of what the Bahamas face from planned and unplanned development. This paper examines current environmental problems, the status of several plant communities and species, and possible approaches for addressing conservation biology problems now facing the Bahamas.

INTRODUCTION

Eshbaugh first visited San Salvador in 1972 while collecting chili pepper germplasm as a part of a continuing investigation of the genus *Capsicum*. In 1976 Wilson was at Forfar Field Station, Andros Island, on a trip sponsored by the Center of Science and Industry in Columbus, Ohio. This began our long association with field studies in the Bahamas.

An outgrowth of these early experiences in the Bahamas was the development of a course, The Tropical Flora of the Bahamas, that has been taught at the Forfar Field Station for the past nineteen years. What began as a teaching enterprise soon developed into a research endeavor, embracing both our studies and those of our students, focusing primarily on ecological and systematic investigations (see for example Wilson 1986; Eshbaugh 1987; Regan and Wilson 1987; Shoffeitt and Wilson 1987; Eshbaugh and Wilson 1990; Kass and Eshbaugh 1993, and 1994; Block and Wilson 1994; and papers in this volume).

These studies have taken us and our students throughout the Bahamas with research trips to the Abacos, Andros Island, the Exumas, New Providence, Long Island, Great Inagua, and San Salvador. In the course of our travels and these investigations, we have become increasingly concerned that Bahamian floral diversity is in jeopardy, both at the community and species levels, mainly from invasive introduced species and degradation and loss of habitats. Using two model systems, we want to outline the basis of our concerns.

SAN SALVADOR

It has been argued that San Salvador was the first landfall Columbus encountered (Gerace 1987; Obregon 1987; Taviani 1987) in the New World. Although others dispute this (Molander 1981), it is clear that the exploitation of the Bahamas began soon after Columbus arrived in the Caribbean. Descriptions by the chroniclers of Columbus' voyages suggest that forests were formerly much more extensive. The degradation of these forests is well documented in the records of the eighteenth and nineteenth centuries. San Salvador is a small island, approximately twenty kilometers long and 10 kilometers wide. It has suffered development pressure from the time of its discovery. For example, Smith (personal communication) notes that Mahogany (*Swietenia mahagoni*) was undoubtedly formerly abundant on the island but only three naturally occurring specimens survive in the interior of the island, and these will likely disappear because of the harvesting of bark for medicinal purposes.

On San Salvador, subsistence farming and two more recent developments, Columbus

Landings and Club Mediterranean, have had a major impact on plant communities. Traditional plantation and subsistence farming were practiced throughout San Salvador during the past three hundred years. Wherever one walks, walls that defined the limits of properties are encountered even into the more remote reaches of the island. These walls indicate that the vegetation has been continuously altered as farming shifted from one site to another over the centuries. Clearly, the vegetation has recovered over time, but it has been highly modified and is often in a diminutive state when compared to models of the original vegetation.

In the 1960s a development known as Columbus Landings began on the southern end of San Salvador. This was a real estate endeavor designed to provide home sites for foreigners, especially from the United States. In an effort to sell building lots, an extensive network of roads was cut across the landscape. A few homes were built, but ultimately this development failed; remnants of its impact remain as the Riding Rock Resort and the extensive road system. The result of this development scheme is a fragmented landscape that has placed several native species under pressure or, at worst, in danger of extinction. *Rochefortia bahamensis* (Bignoniaceae) is a rare Bahamian endemic confined to regions 3 and 5 (Correll and Correll 1982) that grows on the southern end of San Salvador in the area of the original Columbus Landings development. It has been particularly jeopardized at this location. Black Willow (*Capparis cynophallophora*) (Capparidaceae) is another rare plant on San Salvador that grows primarily in sink holes in the Columbus Landings site. The habit of becoming established in the soil of these sink holes has certainly enhanced the chance of survival in an area that has been cleared of most large trees. These two species are characteristic of what Smith (1993) refers to as the scrublands, a community on San Salvador clearly being impacted by human activity, if these taxa are representative.

In 1992, Club Mediterranean opened near the airport on the lands of the former Bahamian Teachers College. One aspect of the Club Mediterranean operation is to develop a magnificent tourist setting. Inevitably this site will be a focal point for the introduction of exotics that pose a very real danger of some species escaping and displacing or at least co-mingling with the native flora. The implications of such introductions are generally negative, but the long term effect remains to be seen and documented in future years.

ANDROS ISLAND

On Andros Island the activities of AUTEC (Allied Underwater Test and Evaluation Center) and BARC (Bahamian Agricultural Research Center) and recent agricultural development have threatened Bahamian biodiversity. However, earlier endeavors had an impact on the vegetation. For example the Sisal plantation operation initiated by Neville Chamberlain cleared large areas around Mastic Point that have now returned to a more natural assemblage of secondary growth. In the twentieth century North Andros has been continually impacted by human activity. As with San Salvador, a significant development scheme sold off acreage as home sites to individuals from Canada, the United States, and Europe. This led to a network of roads cutting across the central section of North Andros Island.

In the 1960s a major lumbering enterprise undertaken by Owens-Illinois cut and processed most of the pine on North Andros. "The logging operation required construction of thousands of miles of roads. The largest number of these are secondary roads - but the total includes several hundred miles of primary highways - 40 feet wide and made of solidly packed limestone that will endure for decades" (Anonymous 1974). This operation ceased in the early 1970s, but the logging roads persist to this day. "Owens-Illinois presence on Andros...is still very apparent. It will continue for many years to come" (Anonymous 1974). The remnants of Owenstown, a company town, persist in the interior of the island with many escaped exotics established in the area. Thus, subdivisions and logging practices have contributed directly to the fragmentation of the pineland on North Andros. In contrast South Andros pinelands remain largely undisturbed. A land resource study (Henry 1974) on the pine forests of the Bahamas

suggested that these forests represented a valuable economic resource and that Andros Island pinelands required a management plan for the sustainable production of pulpwood for export. The summary recommendations in this report are both interesting and instructive, but unfortunately have been largely ignored.

In the 1960s BARC established a major agricultural presence on North Andros. An attempt was made to introduce cattle ranching on the island and to farm with certain crops for the commercial market. At BARC the government subsidized land clearing. Initially, alfalfa was planted and used as a green manure crop to increase nutrients. The typical planting cycle saw cucumber and onions planted in the second year to be followed by cabbage, cantaloupe, tomatoes, watermelon, etc. in the third and subsequent years. The land was generally not very productive after five years in cultivation. Mr. Lightborne, at one time the director of BARC, estimated that at its peak there were 20,000 acres being tilled on an annual basis with a potential of 200,000 tillable acres (Schmidt 1987). Certain forage crops were introduced for cattle feed. One plant, Wild Bush Bean (*Macroptilium lathyroides*) escaped and became established at Staniard Creek, far outside the original cattle raising area. The last cattle were removed from the island in the 1990s, but Wild Bush Bean is now found in several locations.

The Bahamian Agricultural Research Center ceased to exist in the late 1980s, but in the 1990s a new agricultural threat manifested itself in a joint enterprise between the Bahamian Government, Carnival Cruise Lines, and Israel. The Bahamian Government made a land grant to Carnival Cruise Lines, who later subcontracted with Israel to farm various agricultural crops, including cucumbers and tomatoes on approximately 2450 hectares. Another 1620 hectares was to provide the necessary land to access water to irrigate the crops. A large block of land was cleared adjacent to the San Andros Airport and south to London Creek. Not only was the land cleared, it was pulverized, destroying the original limestone structure and changing the landscape forever so that once abandoned it is unlikely that the original vegetation can be reestablished in anything like the former plant communities.

AUTEC, with its mission to test underwater munitions, has a continuing impact on the coastal plant communities. One of the more significant problems is the jetsam resulting from these tests that washes up on the beaches and into the beach strand and mangrove communities. In addition to the visual pollution, this jetsam load can be heavy enough to affect the underwater animals associated with the mangrove community. Furthermore, AUTEC facilities occupy areas of unique plant communities on North and South Andros. On North Andros one of the more interesting xeric, hard limestone plant associations is found just west of the main gate to the base.

If there is a limiting resource in the Bahamas it is fresh water. Andros Island is the largest of the Bahamas, approximately 3709 sq km in area. Sealey (1994) points out that rainfall is the only source of fresh water in the Bahamas. Furthermore, as the largest of the Bahamas, Andros can generate the most overland heat and create the largest convection currents during the summer, thereby receiving the most rainfall. The fate of this rainfall is evaporation, transpiration, and run off, some of which is captured in fresh water lenses. These lenses are 3-6 meters thick in the smaller islands, while on the larger islands they range from 15-30 meters and exceed 30 meters on Andros.

Because Andros is large, with a series of fresh water lenses and in close proximity to Nassau, it has been viewed as a water resource for New Providence. Today, approximately 3,000,000 gallons a day are barged from North Andros to Nassau to meet the water demand in New Providence. Previous hydrological studies have suggested that agricultural use alone of ground water may put a strain on the fresh water lens. Furthermore, it is critical that an "approximate dynamic equilibrium be established" (Johnson and McWhorter 1977). In other words it is important that evaporation and transpiration not exceed the ability of the lens to meet the demands of all other water uses and be able to recharge itself. Shipping 3,000,000 gallons a day to Nassau taxes the system, especially when coupled with the agricultural practices anticipated if another commercial venture arises. Another concern is the effect of pesticide and herbicide runoff on

the fresh water lens.

Johnson and McWhorter (1977) provided data that indicated that pumping of water has increased the salinity by 25-30 percent over the pre-pumping value in some test sites. Excessive water draw off impinges on the freshwater lens and leads to a draw down on the depth of the fresh-saline interface (e.g., interface pre draw down = 12.5 m, post draw down = 10.4 m). The greatest concern is the potential of the fresh water lens being ruptured due to excessive draw off with subsequent salt water intrusion into the fresh water lens. A number of issues need to be considered when evaluating the impact of water use on Andros and San Salvador islands. These include, but are not limited to, 1) increasing salinity and 2) chemical intrusion into the fresh water lens. The impact of any change in land use on the fresh water supply is critical and should be continuously monitored.

Eshbaugh and Wilson (1990) indicated that Andros Island contains approximately 60 percent of the total flora for the Archipelago. Within the flora, two plant groups, the orchids and ferns, are especially vulnerable because of the specialized habitats, sinkholes and trees (epiphytes), that they occupy. The orchid flora of the Bahamas encompasses 52 species, of which 47 (90%) occur on Andros; while the fern flora includes 36 species, of which 26 (72%) occur on Andros (n.b.: recently a new fern for Andros, *Schizaea poeppigiana*, was discovered by R. James Hickey). Andros Island has a number of taxa found nowhere else in the Bahamas, including *Anemia wrightii* (Schizeaceae), *Thelypteris cordata* (Polypodiaceae), *Tectaria coriandrifolia* (Polypodiaceae), *Psidium androsianum* (Myrtaceae), *Pseudocarpidium wrightii* (Verbenaceae), *Encyclia withneri* (Orchidaceae). South Andros Island, with its several unique Cuban outliers, e.g *Celtis iguanaea* (Ulmaceae), *Catalpa punctata* (Bignoniaceae), etc. represents a special area of concern.

DISCUSSION

Correll and Correll (1982) offered a dire forecast for the long term prospects of Bahamian vegetation. They noted that they do not agree with Byrne's conclusion that in spite of man's activities no extinction of species has occurred. The Corrells indicated "that where shifting agriculture practices have taken place during the past 200 years... the less competitive species have been gradually eliminated and the general flora has become stabilized *with the* more aggressive and competitive species." They also noted that "there is no way to tell how many indigenous species might have been eliminated from our flora, but the absence in coppices of ground species, such as orchids and ferns, is quite evident in many islands." The Corrells indicated that with the passing of time, weeds (exotics) become more common. They noted that Australian Pine or Beefwood (*Casuarina*) is the most successful exotic. Older residents on Andros can recall when this plant was absent from the island. Now it dominates the beach strand community, where it forms dense shade and leaches out an exudate that is allelopathic and inhibits the growth of native plants. A more recent introduction, *Scaevolataccada* (Goodeniaceae), introduced sometime around 1980, has been so successful on North Andros that it has completely changed the structure of the beach strand community (Eshbaugh and Wilson 1986; Koontz et al. this volume).

Gillis (1977) provided another view of the situation. "On the whole, the effect of human interference (cutting, burning, selective felling, grazing, etc.) has been to effect a reduction in height of the woodland and a decrease in the number of species. The word depauperate is used specifically to describe this condition..." What has saved the vegetation in some areas is that the land is unproductive or remote. Gillis (1977) indicated that the slow regeneration of vegetation in areas cleared for farming, especially in the drier areas of the Bahamas, should be a caution to "haphazard or wanton clearing."

Understanding how to put a conservation strategy into place to preserve floral biodiversity and plant communities in the Bahamas requires returning to the theory of island biogeography as originally outlined by MacArthur and Wilson (1967) and more recently as articulated by Shafer (1990). First and foremost it must be recognized that island systems are much more fragile than continental landscapes. The Bahamian archipelago is large in geographic extent but the individual cays

and islands are mostly small in area, low in elevation, relatively young in age, and far from neighboring large land areas. Thus, each of these circumstances contributes to a low diversity index. From a conservation viewpoint the smaller Bahamian Islands such as San Salvador are at greater risk for loss of species and plant communities than are the larger islands such as Andros. These smaller islands cannot withstand fragmentation into small plots of forest without an accompanying loss of species diversity, both plant and animal.

A planning approach is needed that is both community and ecosystem based (Risser 1995; Walker 1995). Using Andros Island as a model, it is apparent that first and foremost there needs to be an inventory of species and communities with a teasing out of what represents truly rare occurrences on these islands. Plotting of rare species distributions would also contribute to identifying areas that need preservation. Such an approach would quickly indicate, for example, that freshwater blue holes are relatively rare and therefore in need of conservation. High coppice communities contain certain unique species, as do the sinkholes found within them. Thus some of the areas in which these communities occur need to be preserved. All the land areas cannot be preserved, but at least some representative examples of each unique community and areas of especially rare species should be set aside for conservation and restricted from development. This is critical for some islands (San Salvador) and less urgent for others (Andros Island), but the time to start the process is now rather than later.

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