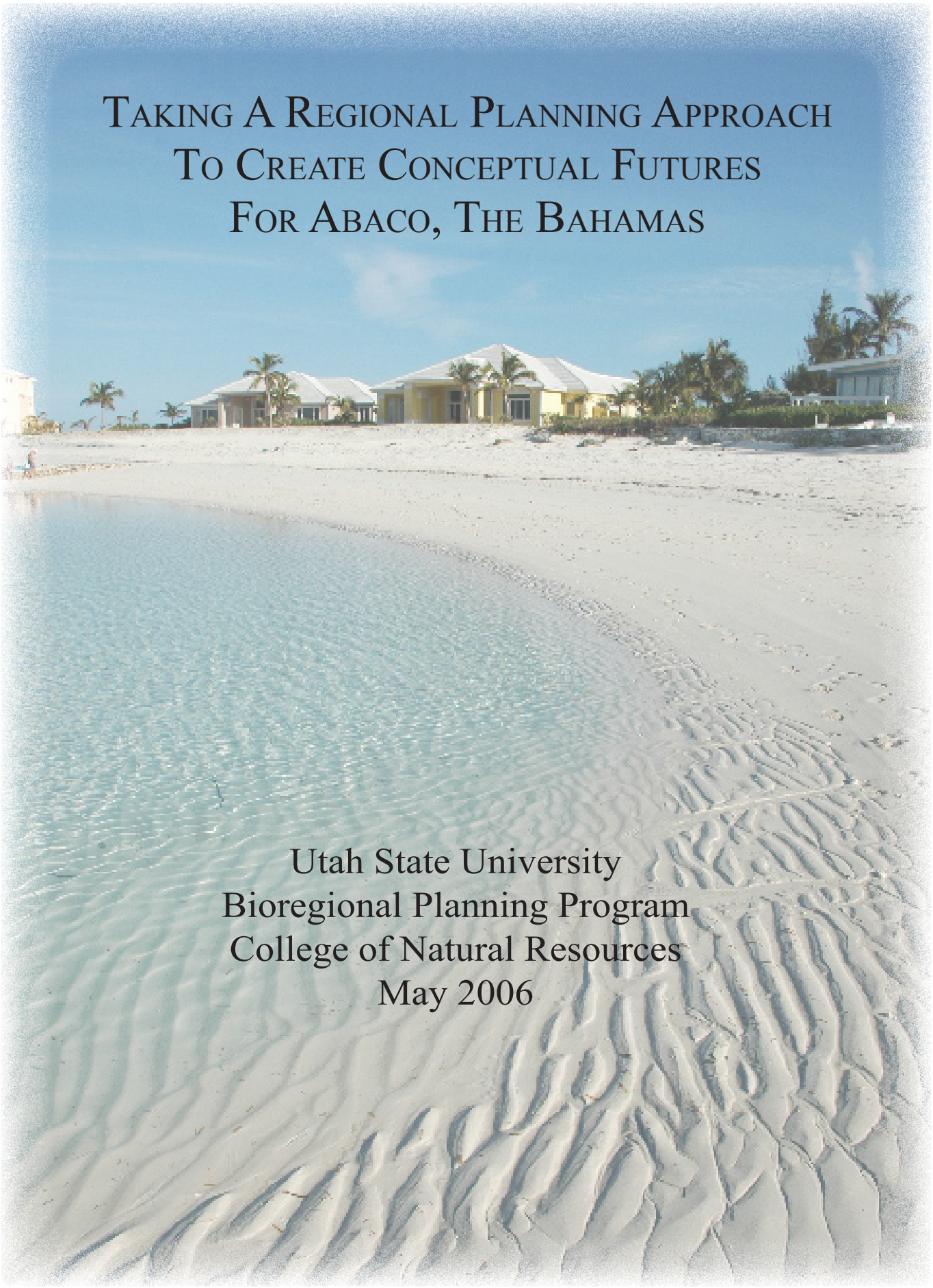
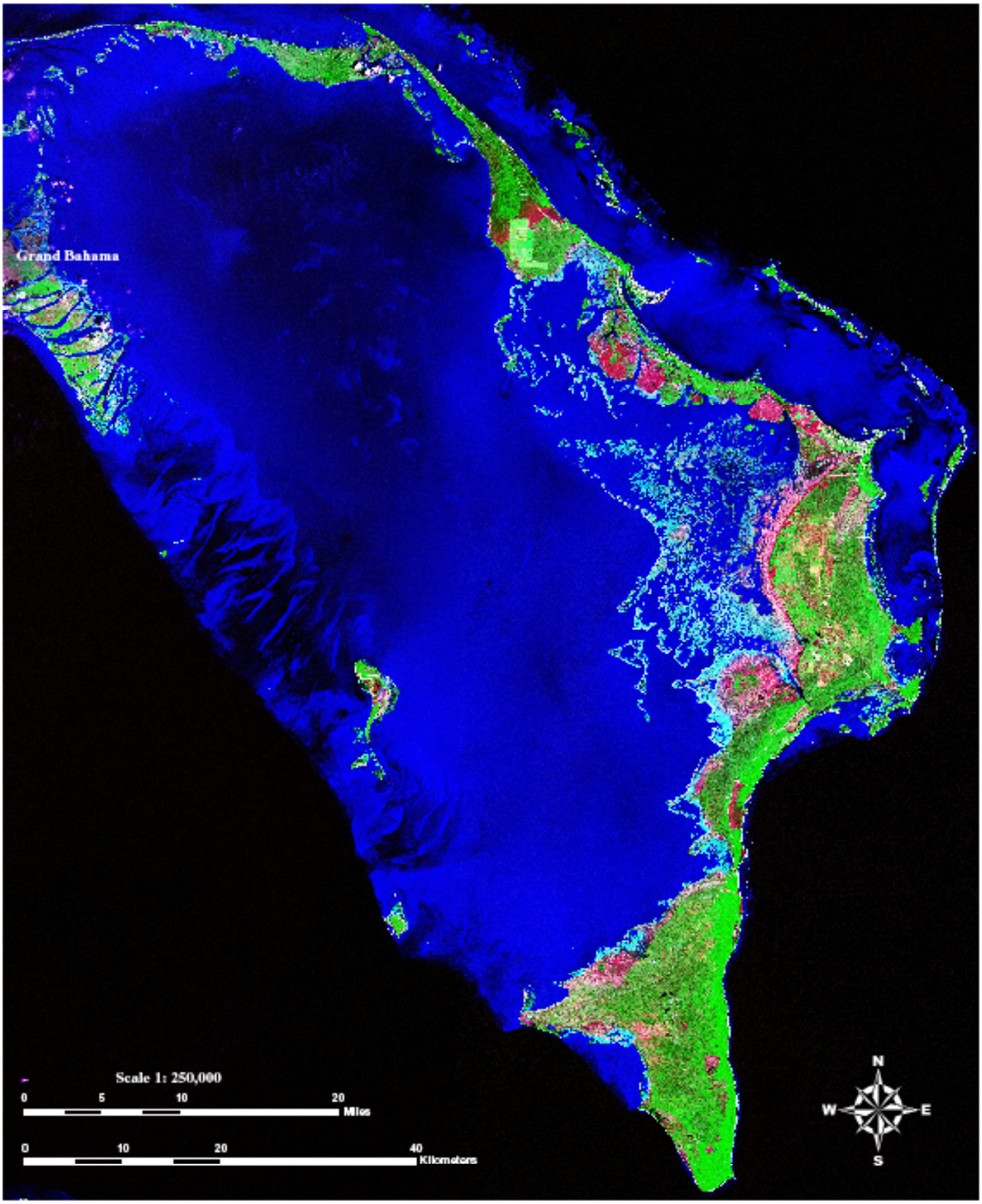
Taking A Regional Planning Approach To Create Conceptual Futures For Abaco, The Bahamas



Utah State University
Bioregional Planning Program
College of Natural Resources
May 2006

Abaco Island, The Bahamas



College of Natural Resources
Utah State University
5275 Old Main Hill
Logan, Utah 84322-5275

15 Meter Landsat circa 2000 image
6,4,2 Band Combination
Source: NASA's Earth Science Enterprise Scientific Data Purchase Program
https://zulu.ssc.nasa.gov/mrsid

Taking a Regional Planning Approach to Create Conceptual Futures for Abaco, The Bahamas

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May 2006 Utah State University, College of Natural Resources, Department of Environment and Society

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Of course we would like to thank members of our thesis committee for their suggestions and guidance along the way: Dick Toth from Utah State University's Department of Environment and Society, Doug Ramsey from Utah State University's Department of Forest, Range, and Wildlife Sciences, and Karen Beard from Utah State University's Department of Forest, Range, and Wildlife Sciences.

Other specific individuals who contributed in one form or another to the project from Utah State University included: John Lowry, Chris McGinty, Cynthia Tyler, and Alan Luce.

We would also like to specifically thank Ethan Fried: University of Tampa, and Craig Layman: Yale University for generously sharing their knowledge of the island of Abaco.

Special thanks should also be given to the individuals in The Bahamas representing various government agencies, stakeholders, and the general public who contributed their own time and knowledge in order to ensure that an accurate study could be conducted in accordance with the values and vision of the people of Abaco.

Left to right: Clark Bryner, Kevin Seegmiller

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AUTHOR'S NOTE

While this study was exciting due to the nature of the area in which it took place, it was also an excellent learning experience because of the variety of challenges which it presented to us. Some of the challenges which had to be overcome were:

1. **Distance**: Physical and cultural distance separating the island of Abaco from us created communication challenges.

2. **Time**: The amount of time allotted for the entire study including data collection/ creation was just under nine months, an incredibly short amount of time to conduct a study of this extent.

3. **Data**: Very little digital data had been created for The Bahamas region and more specifically for the island of Abaco. The little data that was available was very difficult to acquire. Almost all data had to be created from outdated paper maps by us. The digitizing process was very time consuming, laborious, and tedious.

Everything in this report should be considered conceptual. The ideas presented are meant for the purpose of stimulating ideas within the minds of the lawmakers and citizens of Abaco. The data presented is fairly accurate, but does not represent the detailed state of the land, resources, or hazards on any official plots of private or crown land. As such, the study can serve as a starting point from which official zoning ordinances and land-use plans can be derived.

Despite the complications of this study, the methodology and framework used are sound. The planning principles outlined in this document are well documented and can be applied to many regions of the world. As such, time permitting and with the creation of more accurate data, the methodology from this study can be replicated on Abaco or any of the other Bahaman islands to create a regional land-use plan reflecting the vision and values of its people.

Thank You,

Clark Bryner
Kevin Seegmiller

INTRODUCTION

Overview

Abaco and its surrounding cays are a part of the British Commonwealth of The Bahamas. The Bahamas are located off the eastern coast of Florida and extend southward over 500 miles (800 km) almost to the country of Haiti. The island of Abaco is the second largest of the more than 700 islands and 2000 cays which comprise the Bahaman islands, and is located about 100 miles (160 km) directly north of Nassau, the capitol city of The Bahamas (Durrell, 1972).

The island of Abaco and its surrounding cays appear to be relatively uninhabited when compared with the dense settlement experienced in Nassau, New Providence. The island has vast expanses of pine woodlands and mangrove swamps which create an identity for, and characterize Abaco as unique. These same lands are also very appealing to the investor. Abaco's warm climate, and its location in close proximity to the United States, make it a prime target for development. Development brings jobs and economic prosperity to the island. If development is done in the right manner it has the ability to enhance and improve the character of Abaco. But if development is not done in accordance with the shared vision and values of its citizens, and it can become a place unattractive to both citizens and tourists alike.

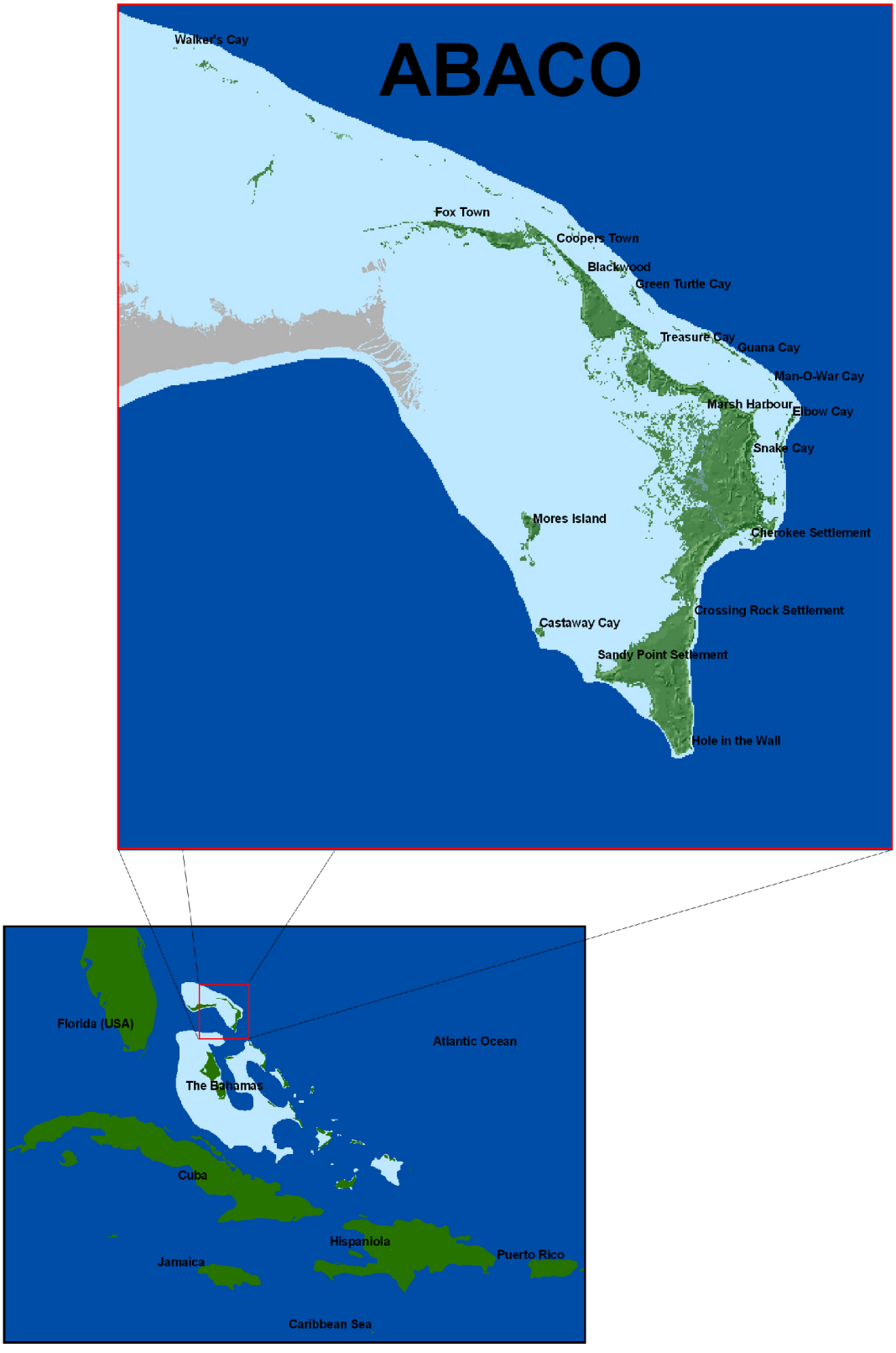
Subdivision on Abaco © Clark Bryner

Economy

The historical economy of Abaco has changed several times, from pirating, to shipbuilding, to subsistence fishing and farming, to shipbuilding, to logging, to agriculture, and finally today, to tourism (Durrell, 1972). Currently tourism is the largest economic contributor to the island. Tourism contributes 60% of the island's gross domestic product each year and employs about half of the total population (United States of America: Central Intelligence Agency, 2006). Fishing however continues to have an impact on the economy, especially in the northern and southern parts of Abaco where the influences of tourism are not so prevalent.

Abaco Quick Facts

- 120 miles (190 km) long from North to South (Durrell, 1972)
- 649 square miles (1680 square km), second largest amongst Bahaman islands (United States Army Corp of Engineers, 2004)
- Subtropical Climate, Mean Annual Temperature - 76˚ F (24.5˚ C), Mean Annual Precipitation - 50" (127 cm) (Bluewater Marketing Services, 2002)
- Settled in 1784 by British Loyalists (Durrell, 1972)
- Total Population 13,174 (Ministry of Finance: Department of Statistics, 2000)
- Principal city is Marsh Harbour, Population 3,211 (Ministry of Finance: Department of Statistics, 2000)
- Growth Rate 3.1% (Ministry of Finance: Department of Statistics, 1990 and 2000)
- Economy: Tourism 60% GDP (United States of America: Central Intelligence Agency, 2006)


ABACO
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Elbow Cay
Snake Cay
Mores Island
Cherokee Settlement
Crossing Rock Settlement
Castaway Cay
Sandy Point Settlement
Hole in the Wall
Florida (USA)
Atlantic Ocean
The Bahamas
Cuba
Hispaniola
Puerto Rico
Jamaica
Caribbean Sea

Tourism

Tourism is the number one economic contributor to Abaco and The Bahamas. So what makes this place so attractive? Abaco is considered the yachting capitol of The Bahamas. The island is surrounded by crystal blue Caribbean waters and some of the best beaches in the world. Apart from the beautiful beaches, hunting and fishing are very popular activities, and in some cases world renown. The pine woodlands of Abaco are home to feral bores, a popular game species. The waters surrounding Abaco and especially in The Marls are world renown for their Bone fishing, a popular species amongst fly-fisherman known for its incredible fight and elusiveness.

Sandy beach on Elbow Cay © Kevin Seegmiller

Abaco is also home to five areas designated as national parks due to their outstanding cultural and environmental resources. These parks include Abaco National Park, Pelican Cays National Park, Black Sound Cay Reserve, Walker's Cay, and Tilloo Cay. These parks are managed by The Bahamas National Trust, and responsible visitors are welcome. Each of these parks affords unique tourist and recreation opportunities in hiking, snorkeling, diving, wildlife viewing, etc.

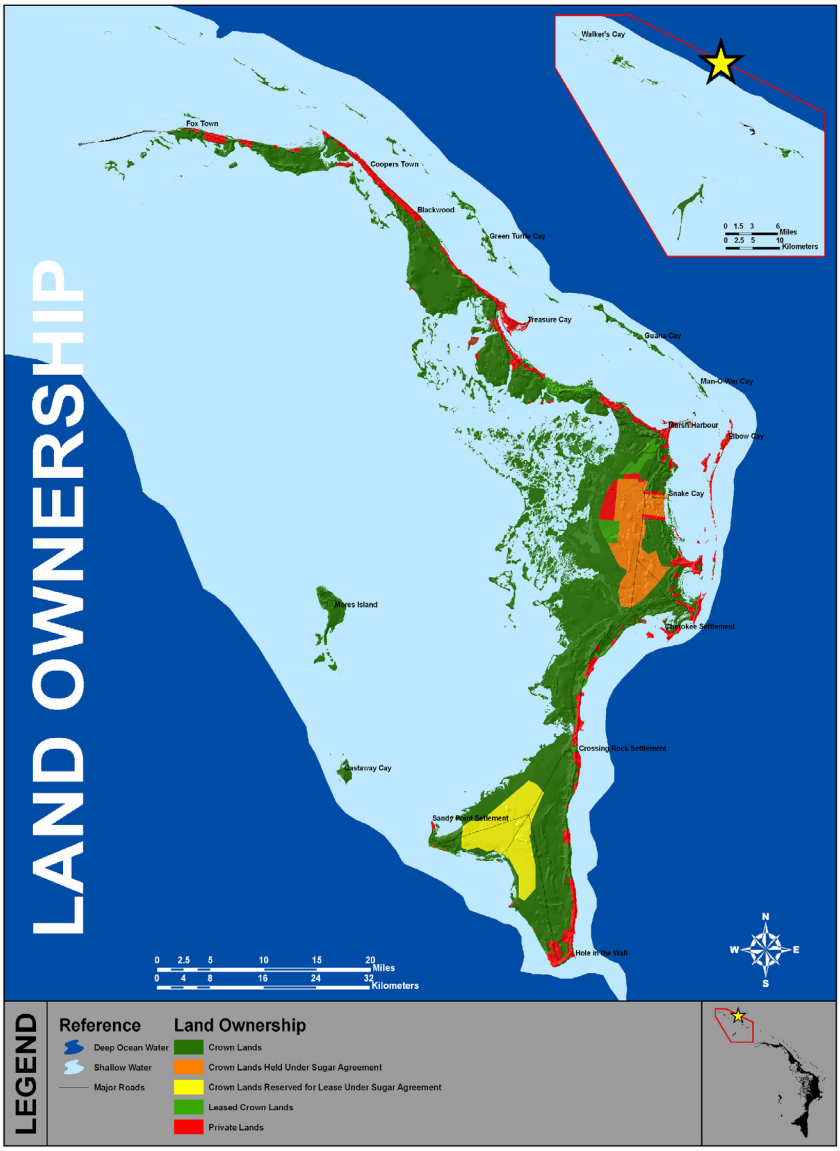
Entrance to Abaco National Park

Values

Abaconians are "fiercely independent" and progressive in comparison with much of The Bahamas (Marshall, 2006). They pride themselves in this. Abaco has enjoyed a small town, community-based lifestyle for more than two-hundred years. For a very long period of time, little outside influence or interaction occurred. The people raised in this small friendly environment have become the perfect hosts for tourists. The citizens of Abaco are enjoying the economic boost tourism has brought to the island, but would not like prosperity to come at the price of sacrificing their traditional values.

Some of the main values identified by residents of Abaco include:

- Small town living
- Beach Access
- Environment
- Hunting/ Fishing



Ownership

There are two basic landowners in Abaco, private owners and government owned lands known as crown lands. There is very little enforced regulation regarding what a private landowner can do with his or her land (Appendix B). As a result, at present a private landowner can do just about whatever they like with their property, regardless of how it affects others in the community. Crown lands, though owned by the government, are not like public lands in the United States. Rather, the government acts in the role of a private landowner, and allows purchase of these lands for development (Appendix B). Data for land ownership was derived from maps with information dating from 1970 and therefore is most likely not entirely accurate. In 1970 private landowners held 32,281 acres (13,063 hectares), and crown land composed 300,492 acres (121,605 hectares) on Abaco.

Demographics and Population Statistics

Abaco has remained relatively unchanged for more than two centuries. The population has grown very slowly. The island was settled by British loyalists who fled the United States during the revolutionary war in the late 1700's. Because the original settlers were of European decent, today Abaco has a much larger proportion of Caucasians than the rest of The Bahamas. About 50% of the people are of European decent, and 50% of the people are of African decent (Durrell, 1972).

In recent decades the island has been discovered in a sense by the outside world. Between 1990 and 2000 the population rose at a steady rate of 3.1% per year (Ministry of Finance: Department of Statistics, 1990 and 2000) versus the national average of 0.64% (United States of America: Central Intelligence Agency, 2006). Abaco is expected to continue to grow in the future, with high immigration of Haitians, increased second home development, and the need for more workers to construct and staff tourism-based resorts (Appendix B).

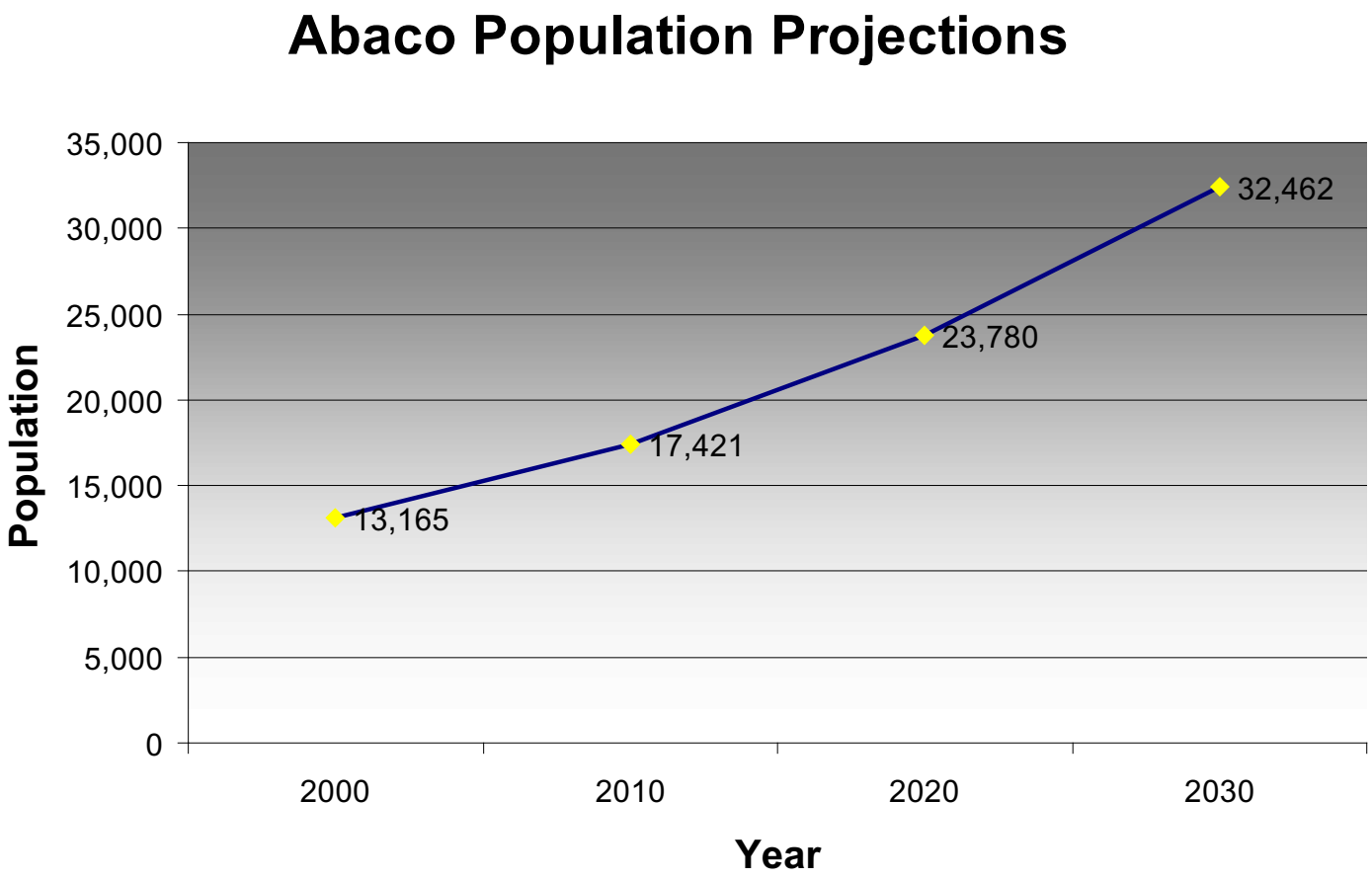


Figure 1 Population Projections

Issues

Through public and stakeholder meetings held February 16 – 21, 2006 in Marsh Harbour, Abaco and Nassau, New Providence the following issues were identified:

- **Water Quality and Quantity** - Will there be enough water for the expected population growth and for possible exportation of water to other growing Bahaman islands, and how will the water quality of the aquifers be affected by the expected growth?
- **Marine Resources** - At current harvest rates and with the destruction of important marine nursery areas, can the marine system remain intact?
- **Solid & Liquid Waste Disposal** – Where will it be stored and how will it effect ecosystem and human health?
- **Access to Public Beaches** - With continued resort development, is there still room for the locals?
- **Economic Opportunities** - How can the island provide sufficient jobs to give its citizens the quality of life they desire?
- **Regulation & Enforcement** - What laws are in place to ensure a quality future for everyone and what is being done to enforce these laws?


Blue Hole © Kevin Seegmiller


Fresh Conch © Kevin Seegmiller


Solid waste © Kevin Seegmiller

Clark Bryner at Beach Access © Kevin Seegmiller

METHODOLOGY

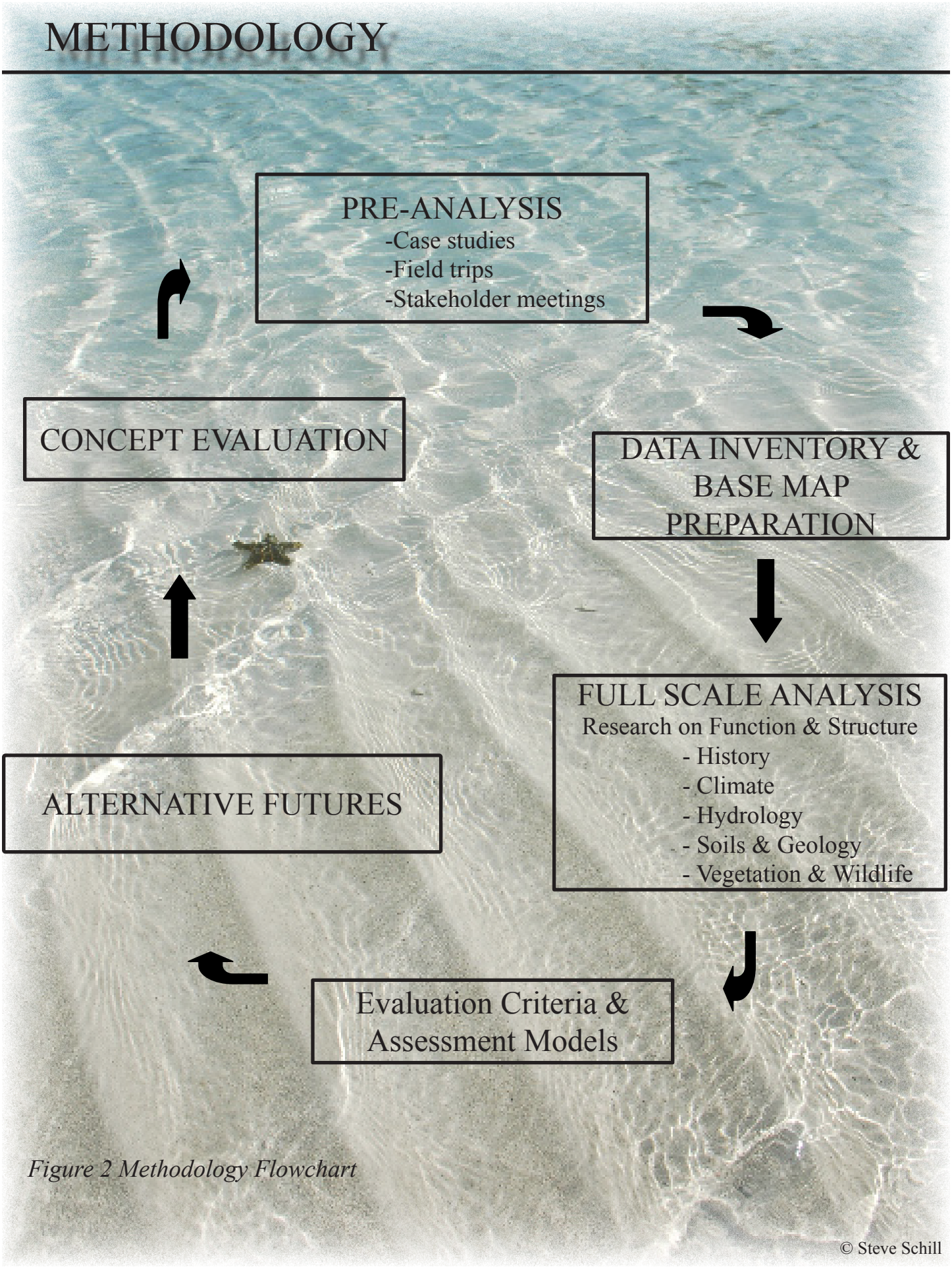


Figure 2 Methodology Flowchart

METHODOLOGY

An outline of the methodology includes six basic phases. These phases should be viewed as a cycle of processes which promote feedback between each other (see Figure 2).

1) Pre-analysis
2) Data inventory/ base map preparation
3) Full scale analysis
4) Evaluation criteria and environmental assessment models
5) Alternative futures
6) Concept evaluation

The methodology used in this study was patterned after a land planning framework outlined by Richard E. Toth (Toth, 1974).

The various decisions made at the pre-analysis stage accomplished the following three objectives:

- Set the context and scale of the study area
- Determined which issues needed to be addresses in the analysis stage of the project
- Identified which types of data were needed for future work

These objectives were accomplished by way of:

- Reviewing past case studies
- Meetings with public and stake holders
- Over-flight and field trip of study area

The analysis phase included separating the study area into its parts in order to describe and understand in a preliminary manner its nature, proportion, function, and structure. Research was conducted on the major biophysical characteristics of the region along with those dealing with settlement and culture. As a result, several issues were identified as being important within the study area (see page 13).

A major part of the project was to digitize all of the Lands and Surveys topographic maps for The Bahamas from the early 1970's. Searching for existing available data was difficult because of governmental issues related to sharing data between agencies and with outside consultants. As a result, most of the data used for analysis was assembled from dated paper maps, Landsat imagery, or GPS data points.

Land-use and environmental assessment models were then created for the purpose of informing the decision making process. The following models established the evaluation criteria for the alternative future models:

- Conflict Assessment
- Conservation Assessment
- Development Assessment
- Infrastructure Assessment
- Marine Resources Assessment
- Protected Areas Assessment
- Public Health, Welfare & Safety Assessment
- Sandy Beaches Assessment
- Tourism Resources Assessment
- Water Resources Assessment
- Wildlife Assessment

Based on the issues and objectives identified during the pre-analysis phase, several future growth scenarios were produced in order to assess their impacts on the island. They were:

- Plan Trend Future
- Double-expected Population Future
- Beach Growth Future
- Population Capacity Future

The final phase in this methodology addresses four important aspects to be considered in planning for the island:

- Assessment of alternative futures for compatibility with the goals and vision Abaconians
- New strategies and/or alternatives
- New tools of implementation (examples used elsewhere)
- New land use activities and evaluation models to be identified for future consideration

METHODOLOGY

It should be noted that as various portions of the region are developed over time, new issues will surface. These issues may vary from biophysical concerns to those dealing with settlement and culture. The approach described here has the capacity to capture these issues over time for future analysis and resolution, either as part of this study, or as a separate analysis. Implementation strategies and mitigation measures may be developed to meet new and emerging issues across the study area.

Neighborhood Gathering © Steve Schill

Beach Development © Clark Bryner

Hope Town Harbour © Kevin Seegmiller

A pre-analysis was conducted at the beginning stages of this project as an initial study of The Bahamas, and more specifically the island of Abaco. The research was carried out in order to learn more about the island before assessment and future models were created.

The components of the pre-analysis were:

- Analysis of previous projects: Critique of case studies for similar projects
- A study of the area through site visits and over-flights: Survey of the land and issues through observation and exploration
- Meetings with public and stakeholders: Issue analysis stemming from interviews and meetings with the public and key stakeholders

Together these factors helped develop a balanced understanding of the elements of the island, and a sense of how these elements work together to create the characteristics of the region.

Case Studies

Two principle case studies were looked at in an attempt to better understand any work that had been conducted in areas facing similar situations as the island of Abaco. "A Delicate Balance: Conservation and Development Scenarios for Panama's Coiba National Park" and "A Sustainable Path?: Deciding the Future of La Paz" which were both studies conducted by Professor Carl Steinitz at the Harvard School of Design. These studies identified issues occurring in their respective parts of the world and outlined planning approaches and methods applicable to each study area. The issues and methods could not be directly applied to Abaco, but the ideas from these studies helped to guide and direct portions of this study.

Site Visit

It was important to experience the island of Abaco and its surrounding cays first hand through site visits. Three and a half days were spent on field trips covering the island from north to south. An over-flight was also completed for the southern part of the island when arriving from Nassau, New Providence. The purpose of the site visit was to gain a direct understanding of the island that could not be achieved through a literature review.

Left to Right: Ethan Fried, Steve Schill, and Clark Bryner conducting field work. © Kevin Seegmiller

Accompanying the research team on the site visit were experts in botany, marine ecology, and geography/ remote sensing. By experiencing the region accompanied by these three experts, it was possible to get a feel for the characteristics of the area and observe the issues being faced currently on the island. From the air it was possible to get a feel for the size, pattern, and more broad issues being faced. The site visits ultimately helped to shape a "sense of place" and provide a realistic perspective about the region.

Stakeholder/ Public Meetings

As part of the site visit and pre-analysis several interviews and meetings were held with key stakeholders and citizens of Abaco.


Stakeholder Meeting in Marsh Harbour © Steve Schill

Stakeholders met with included:

- Friends of the Environment
- Interested/Involved Citizens
- The Abaconian Newspaper
- The Bahamas Agricultural Industrial Corporation
- The Bahamas Department of Agriculture
- The Bahamas Department of Environmental Health
- The Bahamas Department of Financial Services and Investments
- The Bahamas Department of Fisheries
- The Bahamas Department of Meteorology
- The Bahamas Department of Physical Planning
- The Bahamas Department of Urban Renewal
- The Bahamas Electric Corporation
- The Bahamas Ministry of Tourism
- The Bahamas Ministry of Works and Utilities
- The Bahamas National GIS Centre
- The Bahamas Port Department
- The Bahamas Water and Sewage Corporation
- The Nature Conservancy

Through the interviews and meetings held with the stakeholders and citizens, many important issues were identified and suggestions were given to make the project more applicable to the people that would be most affected by the future of the island.

Evaluation of Study Area

Landscapes are defined by their structure (the spatial arrangement of landscape elements), their ecological function (how ecological processes operate within that structure), and the dynamics of change (disturbance and recovery) (Gergel & Turner, 2002). In order to understand a large-scale landscape such as the island of Abaco, it is important to examine the biophysical components of the area. The function and structure of the ecology and history of the island was carried out.

The information gathered from the function and structure was used to provide context for the issues surrounding the island throughout the rest of the project. The research was also used to determine what GIS data would be needed to create the assessment models and alternative futures.

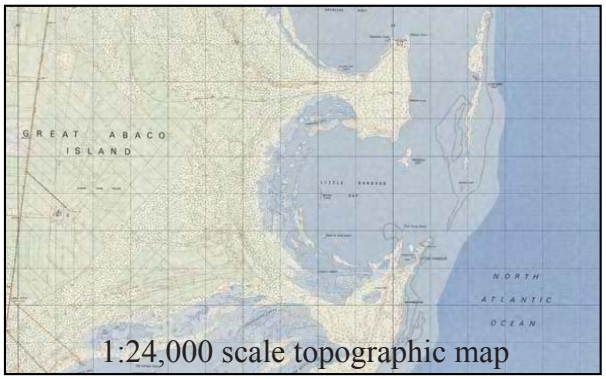
The function and structure components that were researched in order to gain an overall understanding of the island were:

- History
- Hydrology
- Geology
- Soil
- Climate
- Vegetation
- Wildlife

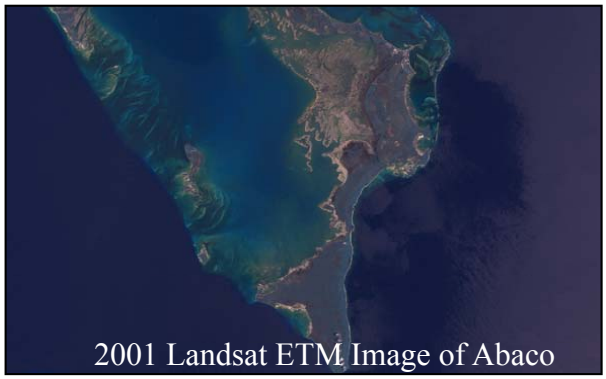
		Water Resources	Marine Resources	Wildlife	Waste Disposal	Regulation & Enforcement	Planning & Zoning	Growth & Development	Beach Health & Access
Central Government	Financial Services							✓	✓
	Physical Planning							✓	✓
	Dept. of Meteorology								
	GIS Centre						✓		
	Water & Sewage	✓			✓	✓	✓	✓	
Local Government	Port Department		✓			✓	✓		✓
	Department of Agriculture	✓						✓	
	Environmental Health	✓			✓		✓	✓	✓
	Electric Company								
	Dept. of Fisheries		✓			✓			
	Ministry of Tourism		✓						✓
Other	Works & Utilities	✓			✓	✓	✓	✓	
	Scientists/ Specialists		✓			✓	✓	✓	
	Stakeholders	✓	✓	✓	✓	✓	✓	✓	✓
	Public	✓	✓	✓	✓	✓	✓	✓	✓

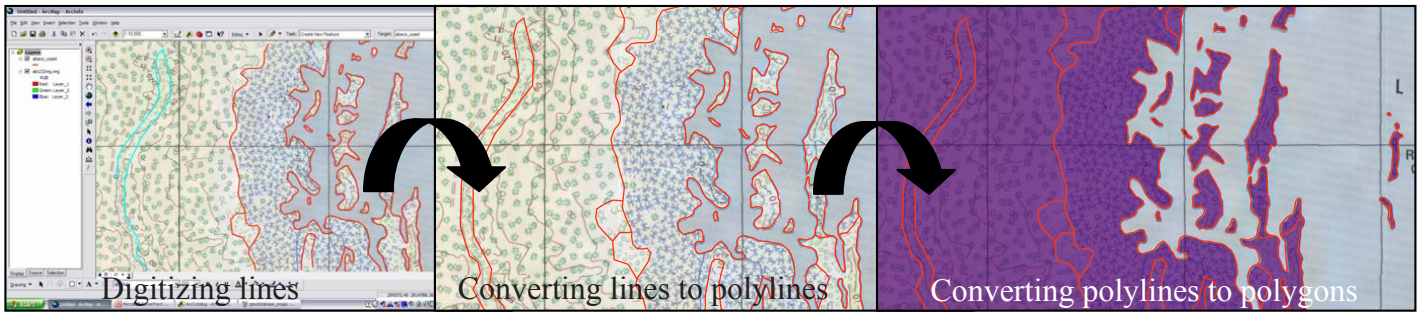
Figure 3 Summary of topics addressed during public and stakeholder meetings.

This Page: Pictures of Pigeon Pea and The Mud communities showing some examples and consequences of unregulated development.



1:24,000 scale topographic map


2001 Landsat ETM Image of Abaco


Digitizing lines

Converting lines to polylines

Converting polylines to polygons

DATA INVENTORY

Data, and especially appropriate GIS data, was important to carrying out the study. Unfortunately GIS data sets are very limited in The Bahamas. The little spatial data that does exist in digital form is not shared freely between government agencies and outside consultants.

In order to perform a proper analysis of the study area, appropriate GIS data had to be created. The creation of GIS data occupied approximately 50% of the entire time spent on this project. Data creation consisted of digitizing 16 land cover classes on over 200 Department of Lands and Surveys topographic maps from 1973, for not only the island of Abaco, but for the entire Bahamas. The digitized land cover data was verified for quality and accuracy using Landsat imagery from the year 2000 and remote sensing techniques.

Other applicable GIS data was gathered or created from existing paper maps based on availability and need.

The digitizing process is illustrated in the graphics above. The process was performed using ESRI's ArcGIS 9.1 software and consisted of the following steps:

1. Acquisition/preparation of digitally scanned maps
2. Georeference/align digital maps within 30m of Landsat imagery
3. Digitize polylines around all attributes
4. Convert polylines into polygons
5. Assign polygons appropriate attribute signature
6. Compile a final GIS database for distribution and use by government agencies

CLIMATE

The climate of The Bahamas like most of the Caribbean is classified as tropical wet-dry (Aw) according to the Köppen climate classification system (Strahler, 1975). The climate in any part of the Caribbean is determined by three things (Blume, 1974):

1. Position in the tropics
2. Insular position surrounded by water whose temperature never falls below 25˚C
3. Relief

The island of Abaco has a maximum altitude of just over 100 feet, so topographic relief does not play a very important role in determining climate in this particular part of the Caribbean. However, the position of Abaco in the tropics and its insular position surrounded by warm waters do largely determine the island's climate.

The Aw climate type experienced throughout Abaco and The Bahamas is characterized by year-round mild temperatures, a wet summer season, and a dry winter season (Strahler, 1975). Temperatures do not vary significantly seasonally, but daily, with the coolest temperatures experienced in the morning and the warmest temperatures experienced in the afternoon (Blume, 1974). Heavy precipitation will occur in either the dry or wet season, but usually comes in the form of short, violent showers. The total amount of yearly precipitation varies greatly from year to year, and droughts are experienced frequently.

Almost constant winds blow throughout Abaco. These winds are known as the trade winds and blow steadily from an easterly direction throughout the year. The constant breeze experienced makes the warm temperatures and high humidity easy to endure (Durrell, 1972).

The trade winds determine the weather in Abaco. During the summer rainy season which extends from May/June – October/November troughs of low pressure become superimposed on the trade wind system. The storms created are known as easterly waves and bring frequent heavy precipitation throughout the season (Blume, 1974).

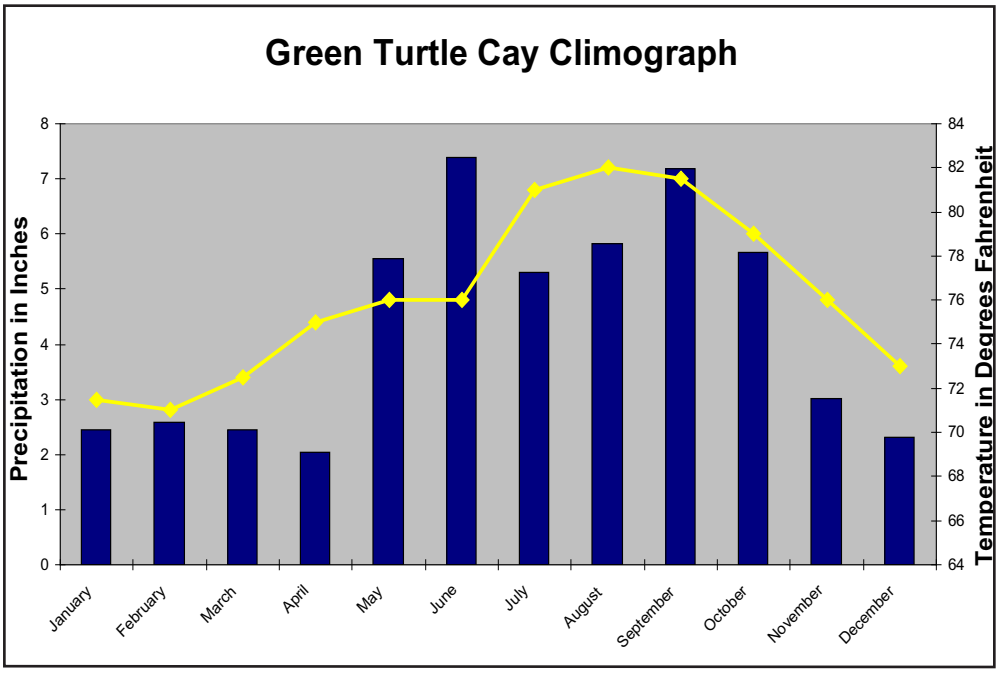


*Figure 4 (*Appendix B)

The easterly wave storm systems can sometimes develop into extremely powerful and destructive tropical storms called hurricanes (Blume, 1974). Hurricanes bring heavy precipitation, constant high winds, and a potentially deadly storm surge (FEMA: Hurricane, n.d.). Hurricane season extends from June to November throughout the Caribbean, but The Bahamas are typically affected by hurricanes at the beginning and the end of the season (Blume, 1974).

GEOLOGY

The Bahamas are composed of oolitic limestone (Blume, 1974) formed over submerged volcanic plateaus over the past 58,000,000 years. The lime is made up of the shells of foraminifera (microscopic animals living by the billions in the warm waters), mollusk remains, and lime-secreting algae (Durrell, 1972). The limestone is up to 4500m thick in places, but manifests itself on the surface as a low lying plateau.

The Bahama Islands are the highest elevations of the limestone plateau known as the Bahama Banks, which lie less than 20m below sea level before descending into the deep ocean (Blume, 1974). Abaco lies on the Little Bahama Bank (Durrell, 1972).

Abaco and the other Bahaman islands are very flat. Physical weathering is almost non-existent due to the lack of relief. Chemical weathering plays a much more important role in shaping the landscape. The limestone on the surface of the islands has been chemically weathered into a formation known as karst topography. Karst topography is made up of caves and their accompanying formations, and unique features known as blue holes.

The outer cays surrounding Abaco differ from the main island and are not composed of limestone, but are made of coral. Limestone and coral are related, but not all limestone is of coral origin. The biggest advantage that comes from an island composed of limestone versus coral is its capacity to store vast amounts of water within the porous rock. (Durrell, 1072). The limestone aquifers on Abaco store a large percentage of the freshwater resources in The Bahamas, and are a big reason the island is habitable.

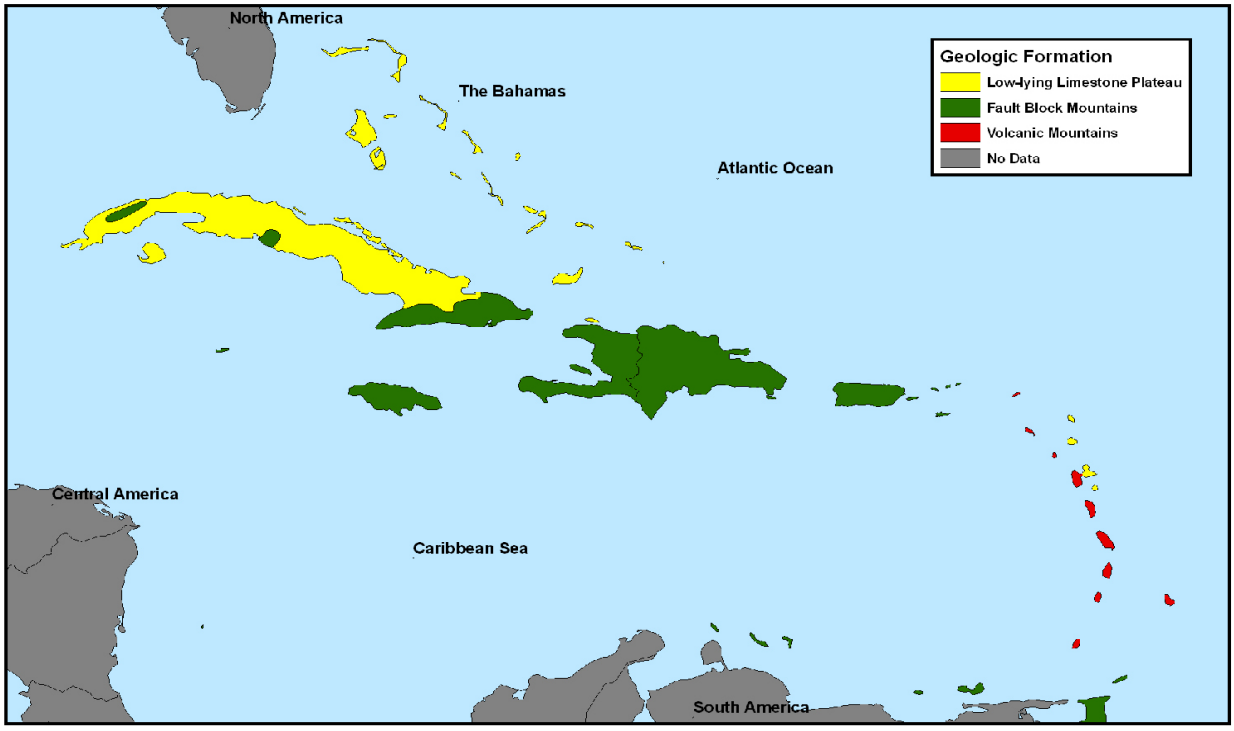


Figure 5 (Blume, 1974)

HISTORY

Prior to the arrival of Columbus to the Bahamas, many of the islands were inhabited by Arawak Indians who called themselves "Lucayans." These people were related to those natives the Spaniards found on present day Cuba, Haiti, Jamaica, and Puerto Rico. By 1550, the Lucayan culture was ultimately destroyed by disease and slavery with the arrival of the Spanish treasure seekers. There are no Bahamians today whose ancestors were there more than three hundred years ago (Durrell, 1972).

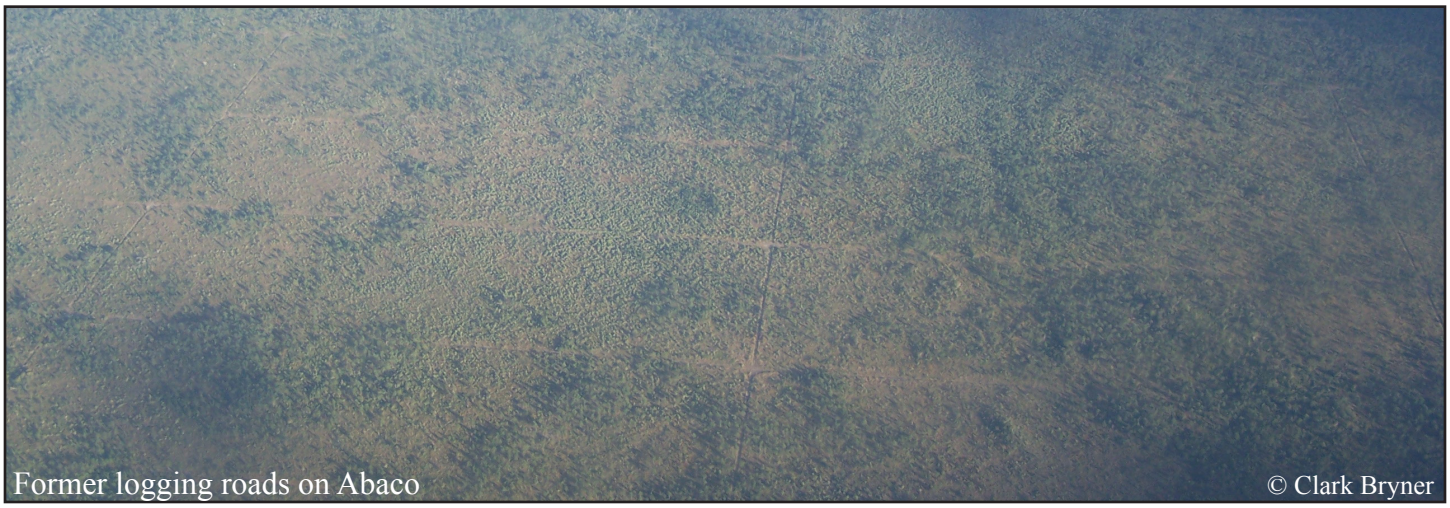
Former slave quarters in Nassau © Kevin Seegmiller

The first settlement on Abaco took place in 1783 as a rebellious group of British loyalists left Carleton, San Salvador and settled in Marsh Harbour. These loyalists originally came from New York shortly after the War of Independence from the United States. For the next one hundred years or so, several loyalist communities were founded throughout Abaco, including: Hope Town, Man-O-War, Guana Cay, Cherokee, and Sandy Point. Additionally, with the emancipation of slaves in 1838, Bluff Point, Cornish Town, and Old Place were established. By 1838, total population on Abaco was less than 1,000.

In the first decades of the 1900's, the Abaco economy was dependent on lumbering, shark fishing, sponging, and boat building. Over time these industries died out and were replaced by different industries. Money was scarce during this time period and most families were lived precariously off the land and sea. By the mid-1900's, agriculture was an important economic industry and major land use. Large agriculture projects grew tomatoes, citrus fruits, and sugar cane.

The arrival of the Owens-Illinois pulpwood operation in 1959 is a key event to Abaco's history. The company not only provided hundreds of direct jobs for locals, it also had positive economic effects on surrounding communities like Marsh Harbour. New supermarkets, garages, drug stores, banks, and service industries developed as the local economy grew.

The pulpwood operation left over 1,600 miles of quality roads, including the Great Abaco Highway that runs the entire length of the island. This network of roads unified the island by connecting remote communities and areas that were previously days apart by sailing routes.



Former logging roads on Abaco © Clark Bryner

In 1966, the Owens-Illinois company left Abaco and moved its 500 employees to harvest timber on Andros. The pulpwood operation was replaced by a sugar cane operation the company established on 20,000 acres of newly cleared land. This gave a big boost to the Cherokee settlement which was a traditional fishing village. For a variety of reasons, the sugar venture eventually failed after several years and was a major blow to the Cherokee employees and the Abaco economy in general.

An economy historically based on fishing, agriculture, and logging is now heavily dependent on tourism. Throughout the Bahamas, tourism represents more than 60 percent of the gross domestic product (GDP) and employs about half of the work force. Most of the tourism on Abaco is created by passing visitors and long term second homeowners.

HYDROLOGY

Abaco obtains its freshwater primarily from large underground aquifers called Gyhben-Hertzberg lenses. The freshwater in these lenses is derived from rainfall which percolates through the surface and forms a freshwater lens on top of the underground saline water (see figure 6). The majority of these lenses are within three to five feet of the surface which makes the water easy to access and also vulnerable to contamination.

Compared to other islands throughout the Bahamas, Abaco possess good freshwater resources based on quality and quantity. It is estimated that Abaco's freshwater reserves will allow close to 80 million gallons to be extracted daily (United States Army Corp of Engineers, 2004).

Water reserves on Andros and Grand Bahama are the only islands that possess more freshwater than Abaco. Many large freshwater lenses are located under extensive pine woodland areas. These woodlands play an important role in absorption and storage of rainwater (Appendix B). According to the U.S. Army Corp of Engineers water assessment report, deforestation due to urbanization over important freshwater lenses can lead to contamination of water resources.

All freshwater reserves stored in lenses are owned by the Commonwealth of The Bahamas. This ownership allows water resources on one island to be used to relieve shortages on other islands. This is currently the situation with Andros supplying 50 percent of Nassau's water. As the population and tourism industry increase throughout the Bahamas, pressure on limited water resources grows. It will become increasingly important for land-use planners and decision makers

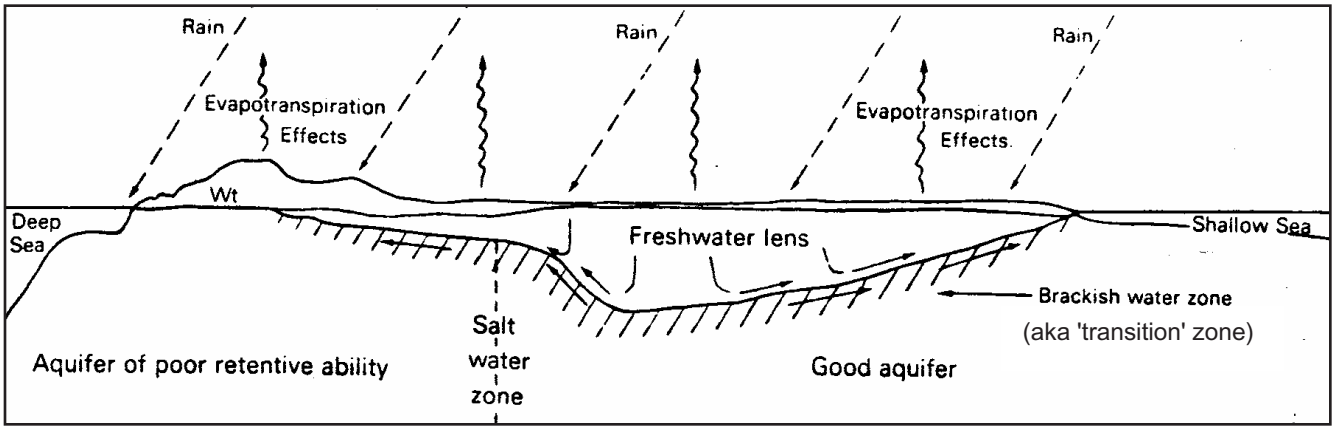


Figure 6 Gyhben-Hertzberg model (United States Army Corp of Engineers, 2004)

to manage for water quality and quantity.

The following concerns have been identified by the Water and Sewage Company that effect water resources in The Bahamas:

1. **Over-abstraction**: pumping groundwater at too high a rate .

2. **Physical disturbance**: salt water invading freshwater areas through the construction of marinas, canals, and waterways connected to the sea.

3. **Point-source pollution**: oil spills, leaks from underground storage tanks at gas stations, engineering workshops, chemical spills, etc.

4. **Solid waste disposal**: pollutants leaking from landfills, sludge disposal, and illegal dumping.

5. **Disposal wells**: pollution from disposal or drainage fields.

6. **Septic tanks**: pollution from septic tanks, cesspits, and latrines.

7. **Abstraction wells**: can cause threat when poorly constructed or sited or drilled to wrong depth.

8. **Diffuse pollution**: pollution from poor use of fertilizers, chemicals, and manures in agricultural or on golf courses.

Although primary water sources are currently obtained from underground aquifers, other methods are becoming popular nationwide, i.e., Reverse Osmosis (RO), other desalination methods. In addition to high costs, RO can potentially have significant negative effects on the environment. Furthermore, because RO is considered a viable alternative source to freshwater, people are becoming less concerned about protecting freshwater lenses.


Garbage Dump © Kevin Seegmiller

Litter © Clark Bryner


Well © Kevin Seegmiller

Blue holes are found on several islands throughout the Bahamas. These unique features are formed when the carbonate bedrock collapses during periods of low sea-level. They are open to the earth's surface and many are connected to submerged cave passages. Blue holes contain water chemistries from fresh to marine.


Blue Hole © Kevin Seegmiller

Soil

"The climate is delightful but the soil so shallow that in a dry season the sun heated the rock underneath and burned up any vegetables that had been planted (Mosley, 1926)."

As a result of the geologic make-up and the relative absence of topographic relief on Abaco, there exist very few soils. Pockets of soil are found in karst depression hollows, but are very thin and infertile (Durrell, 1972).

Attempts at farming on the meager soils have been made since loyalists introduced cotton to Abaco in the early 1800's. Initially the harvest was large, but declined rapidly with the rapid depletion of the soil's nutrients. Cotton farming was abandoned on Abaco after only a few decades (Blume, 1974).

In the early 1970's a second attempt at farming was initiated on Abaco. This time the crop was sugarcane. The story was the same. At first the crop succeeded, but it was soon abandoned because it was not cost effective due to the enormous amount of fertilizer necessary to condition the soil (Durrell, 1972).


Agricultural Fields © Clark Bryner

From the two documented attempts at large-scale agriculture it can be concluded that the soil, though extremely thin, can be made productive with sufficient effort and modern technology. There are three basic soil types that exist on Abaco (Durrell, 1972):

1. White, sandy soil
2. Black soil or decayed matter
3. Reddish clay

Each of the soils present on Abaco are suited for growing different crops. The white, sandy soils will produce coconuts, corn, and some vegetables. The black soil will grow fruits and vegetables. And the reddish clay is excellent for growing pineapples (Durrell, 1972).

Though the meager soils of Abaco have the potential to produce crops, large-scale agricultural attempts are rarely made due to the enormous effort involved and lack of initiative at present.

VEGETATION

Understanding where vegetation occurs and its function within the landscape is critical in order to fully appreciate Abaco's landscape.

Primary vegetation types on Abaco can be summed into the following three categories:

1. Pine Woodlands
2. Dry Broad Leaf Evergreen Formation (DBEF)
3. Mangroves

Pine woodlands

Pine woodland is the predominant land cover type on Abaco. Historically, these woodlands have played a vital role in the local economy as timeber companies harvested the pine for pulp. These woodlands also have other commercial, recreational, and ecological importance.

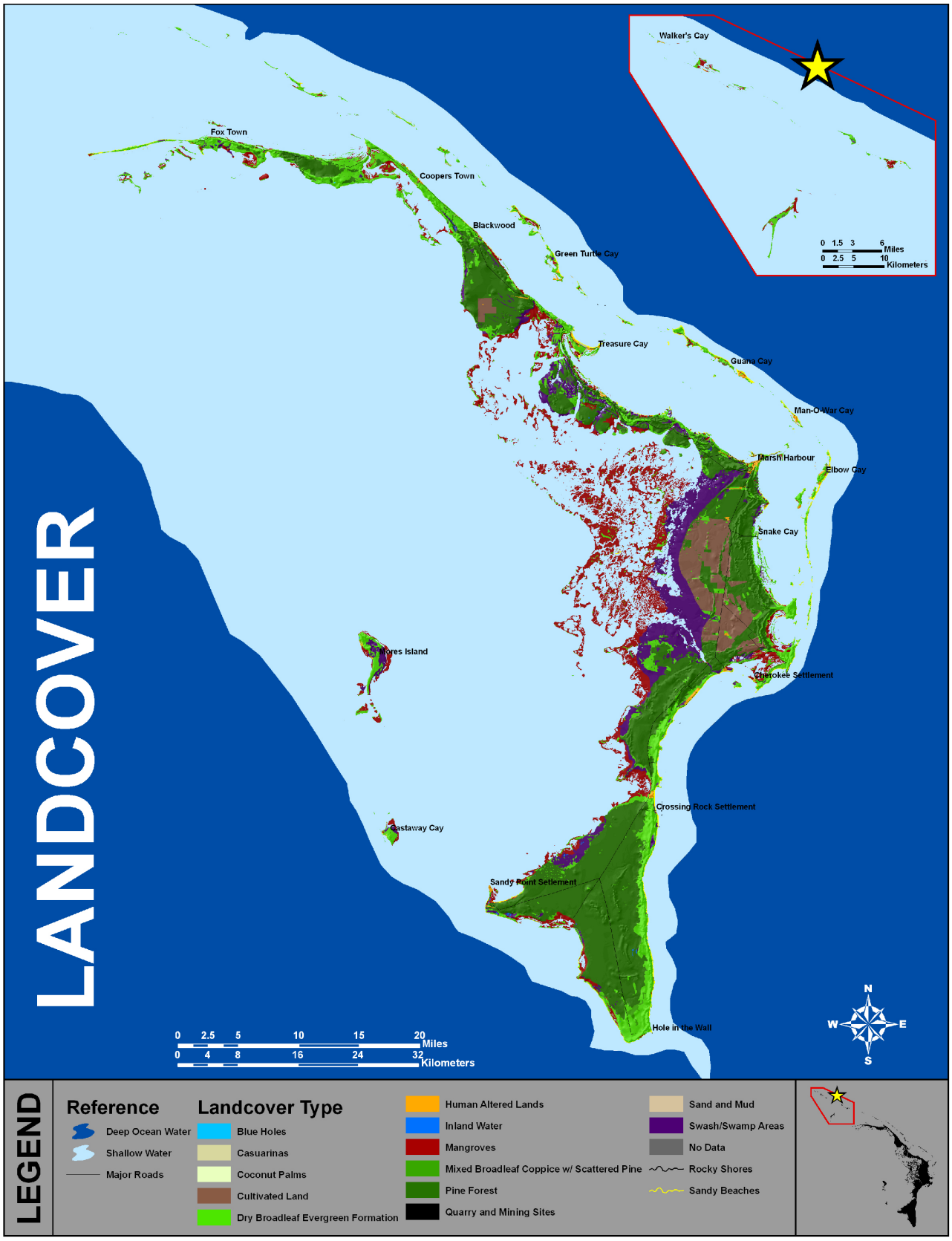
Pine woodlands are dominated by the Caribbean Pine (Pinus Caribaea vs bahamenis) which is endemic to the Bahamas and South Florida. The northern islands of the Bahamas (Abaco, Andros, Grand Bahama, New Providence) contain about 350,000 acres of pine woodlands (Bahamas National Trust 4, n.d.). The southern end of Abaco encompasses the largest pine woodland areas and also includes the Abaco National Park. This park protects 20,500 acres of pine woodland which provides important habitat for many species of Bahamian wildlife including the Bahama Parrot.

Typical understory vegetation that can be found in pinewood stands include various types of orchids, grasses, ferns, and palms.

The majority of the freshwater reserves for the Bahamas are located beneath the pinewoods of the northern islands. It is believed that the cover over these reserves play an important role in absorption and storage of rainwater. Additionally, deforestation over these freshwater lenses due to increased urbanization may lead to contamination of these water resources (United States Army Corp of Engineers, 2004).

Fire plays an important role in sustaining pine woodlands. By removing shading broad leafed plants, fire allows the much needed light to reach the pines. Without fire, broad leafed coppice would eventually take over the pine woodlands. On the other hand, if fire occurs too often, juvenile trees will be killed and understory will become grass dominated (Bahamas National Trust 1, 2000).

Bahamian Pine Woodland © Steve Schill


LANDCOVER
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Elbow Cay
Snake Cay
Moores Island
Cherokee Settlement
Crossing Rock Settlement
Castaway Cay
Sandy Point Settlement
Hole in the Wall
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
0 2.5 5 10 15 20 Miles
0 4 8 16 24 32 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Major Roads
Landcover Type
Blue Holes
Casuarinas
Coconut Palms
Cultivated Land
Dry Broadleaf Evergreen Formation
Human Altered Lands
Inland Water
Mangroves
Mixed Broadleaf Coppice w/ Scattered Pine
Pine Forest
Quarry and Mining Sites
Sand and Mud
Swash/Swamp Areas
No Data
Rocky Shores
Sandy Beaches

Dry Broad Leaf Evergreen Formation (DBEF)

DBEF combines coppice, mixed coppice with scattered pine, and scrubland into one general category. This was done based on the rationale that these cover types essentially comprise the same flora species.

Coppice includes both Blackland and Whitland Coppice. These two coppice types are typically characterized by thick, dense stands of broad leafed trees with a light starved understory.

Blackland Coppice may include plant species such as mahogany, horseflesh, mastic, and cedar. Understory vegetation may include various types of Stoppers (*Eugenia spp.*), Wild Coffee (*Pshchotria spp.*) orchids, bromeliads, and shrubs (Bahamas National Trust 3, 2000).


Dry Broadleaf Evergreen Formation © Steve Schill

Whiteland Coppice areas can be characterized as the impoverished areas of forests often located in close proximity to the sea. The vegetation in these areas is less intense due to salt spray and other natural factors. The soil typically supports rugged and durable plant species such as Brasiletto and Acasia (Bahamas National Trust 2, 2000).

Historically, coppice has been a valuable source for locals, providing them with timber for home and boat building. Additionally, coppice is an important habitat for wildlife, particularly bird life.

Mangroves

Abundant mangrove stands grow throughout much of the coastal wetland areas of Abaco. These trees and scrubs grow in areas that are frequently inundated with saltwater due to tidal activity (Lee County Government, n.d.). These areas include sheltered bays, marshes, lagoons, and tidal mud flats (Gerace 1998).

Limited freshwater inputs coupled with the stresses of exposure to low temperatures and frequent hurricane disturbances, typical mangroves consist of fringe and coastal scrub, with an average height of 4 m (Gerace 1998).


Marine Tidal Creek © Steve Schill

Mangroves thrive salt water inundation due to their specialized rooting structures (prop roots), specialized reproduction (vivipary or live birth) and the ability to exclude or excrete salt.


Craig Layman holding a crab found in a tidal creek. © Steve Schill

Mangrove stands may be dominated by Red (Rhizophora Mangle), Black (Avicennia), White (Laguncularia Racemosa), or Buttonwood Mangrove (Conocarpus Erectus).

Being valued for various reasons, mangroves:

1. prevent shoreline erosion and stabilize low lying coastal lands (Lee County Government, n.d.)

2. shield inland areas from damage from hurricanes and tidal waves (U.S. Environmental Protection Agency, 2006)

3. provide critical nursery habitat for marine food chains (Appendix, B)

4. provide important wetland functions as they trap and cycle various organic materials and chemical elements (Florida Marine Research Institute, 2006)

An estimated 75 percent of fish caught commercially spend some time in mangroves or depend on food chains which can be traced back to mangrove stands (Florida Marine Research Institute, 2006).

The following is a list of a few marine species found throughout Bahamas Islands which utilize mangrove habitats:

- Green Turtle (Chelonia Mydas)
- Hawksbill Turtle (Eretmochelys Imbricata)
- Loggerhead Turtle (Caretta Caretta)
- Leatherback Turtle (Dermochelys Coriacea)
- Snappers (Lutjanus Spp.)
- Grunts (Haemulon Spp.)
- Parrotfishes (Scarus Spp And Sparisoma)
- Mojarra (Gerres Spp. And Eucinostomus Spp.)
- Nassau Grouper (Epinephelus Striatus)
- Bonefish (Albula Vulpes),
- Tarpon (Megalops Atlanticus)
- Barracuda (Sphyraena Barracuda)

List compiled from Burdette, C. (2001).

INVASIVES

The Brazilian-Pepper (Schinus Terebinthifolius) and Australian Pine (Casuarina Equisetfolia) are two invasive plant species on Abaco that threaten native plant and wildlife populations (Friends of the Environment, 2004). These non-natives can out-compete native plants and destroy the balance of the ecosystem. (Friends of the Environment, n.d.).


Australian Pine (Casuarina) © Clark Bryner

WILDLIFE

Abaco is only home to a few "native" species of wildlife. However, because Abaco is isolated from the continent many of the species existing on the island are unique and rare. The most reknown of these unique and threatened species is the Bahama Parrot.

The Bahamas Parrot is one of the most endangered species in the Bahamas (Bahamas National Trust, 1994). When Christopher Columbus arrived in The Bahamas, he recorded in his log, " flocks of parrots darken the sun." Today, there are less than 3,000 Bahama Parrots remaining in the Bahamas. Once found on seven different Bahamian islands, this threatened parrot is now only found on the islands of Abaco and Great Inagua.

On Inagua the parrots live in the coppice areas. On Abaco the parrots live in the pine woodlands, where the birds look for limestone cavities on the ground to nest in (Bahamas National Trust, 1997).

The Bahama Parrot feeds on wild guava, poison wood berries, pigeon berry, and the fruit from gumbo limbo and pond-top palm.

During the breeding season, Bahama Parrots eat the seed from pine trees which provide a rich source of protein, essential for the development of Bahama Parrot chicks (Bahamas National Trust, 1997).

Primary threats to these parrots include: feral cats, feral boars, crabs and snakes, heavy rains during the nesting period, loss of habitat, and the pet trade. These birds are currently protected under the Wild Bird (Protection) Act.

Abaco also provides habitat for several other wildlife including: Quail, Wood doves, White-crowned pigeon, several migratory ducks, turkey vulture, lizards, hummingbirds, and warblers. The Kirtland's Warbler, one of the world's most endangered bird species, migrates from the state if Michigan and nests during winter months in The Bahamas (Bahamas National Trust, 1994).

A few introduced species also thrive on the island; wild horses, feral bore, feral cats, and raccoons. The most notable of these is the feral bore. The bore which lives in the pine woodlands has become a very popular hunting target.

A list of all threatened and endangered wildlife species can be found in Appendix D.

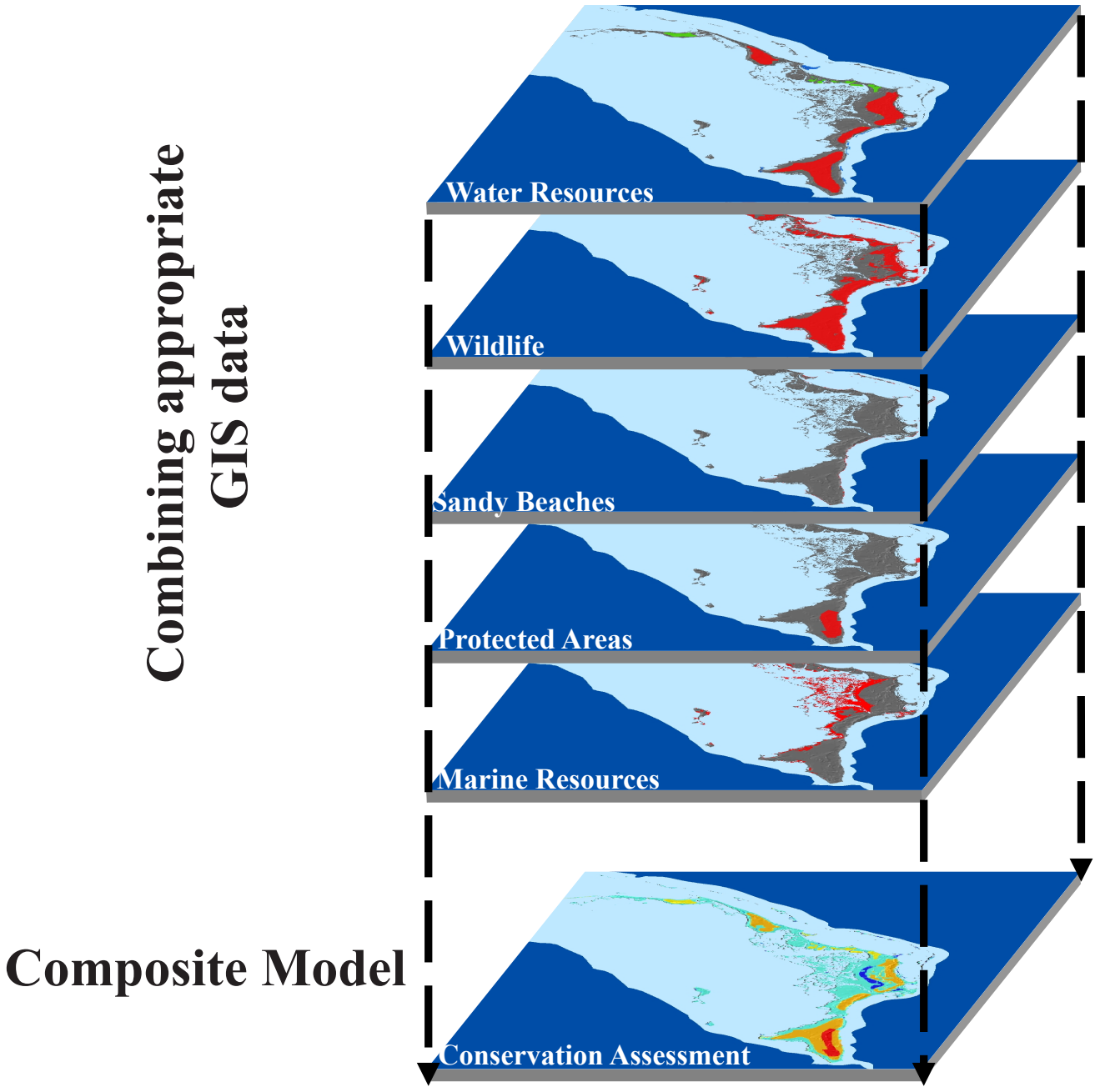
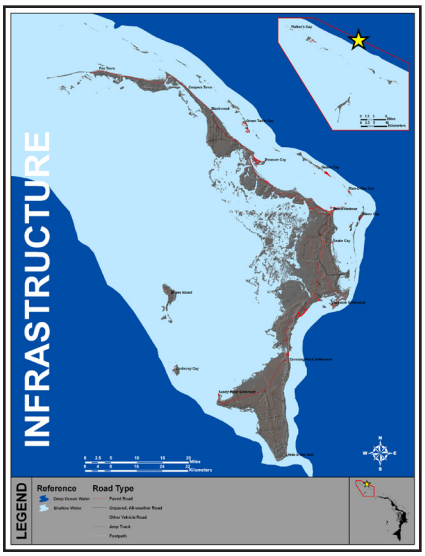


Figure 7 Modelling Process

ASSESSMENTS

An assessment model is a spatial representation of complex dynamic processes using spatial data. The assessment models were created for the purpose of evaluating the impacts of alternative futures on the various resources in question. Each assessment model created illustrates one or more of the resources, attributes, or characteristics identified as possible issues by the people of Abaco.

Each of the GIS-based models demonstrates the spatial location of each of the attributes in question, and in some cases places the attributes on a gradient of low to high. The models can be used by decision-makers to inform the planning process and make better decisions on where growth should be directed. Each of the assessment models can be compared against one of the proposed alternative futures included with this report, or any other proposed plan, to determine the impacts/benefits that particular plan would have on the landscape if implemented. The plan can then be modified as necessary in order to avoid or mitigate any adverse impacts.



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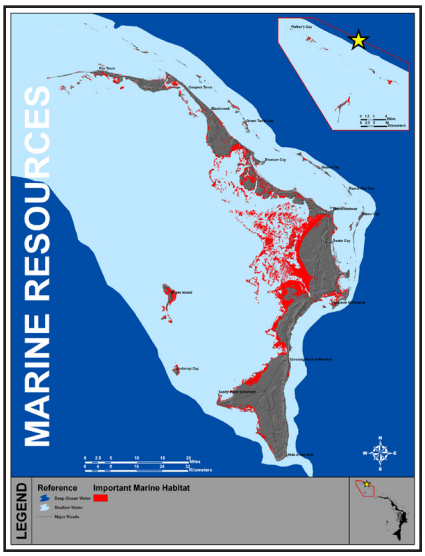

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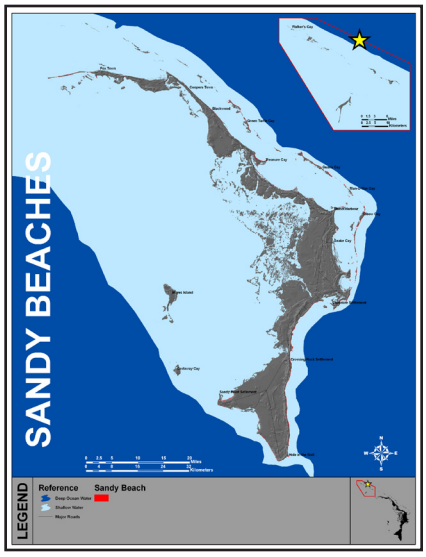

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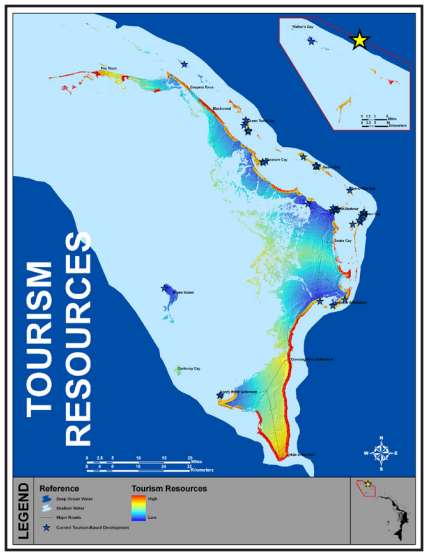

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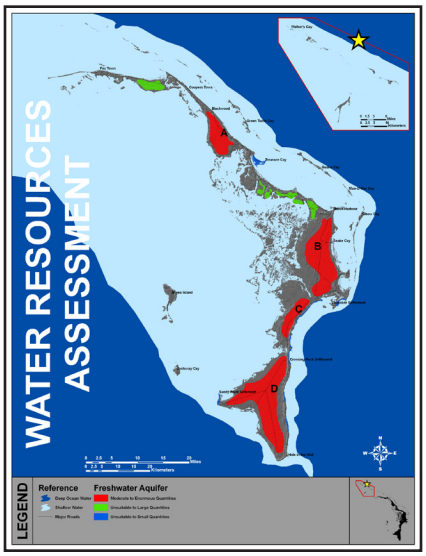
Entrance to Hope Town Harbour © Kevin Seegmiller



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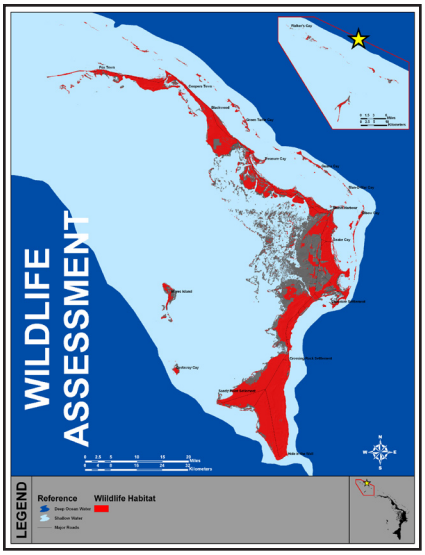

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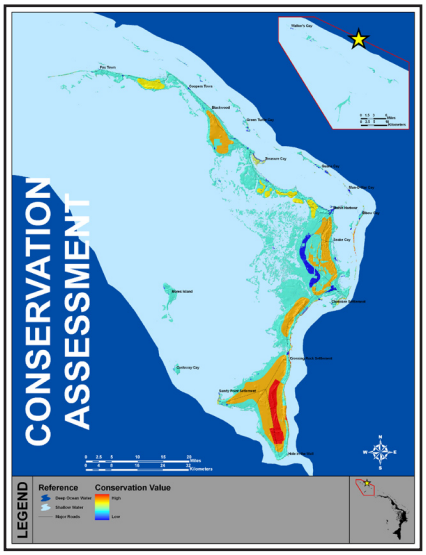

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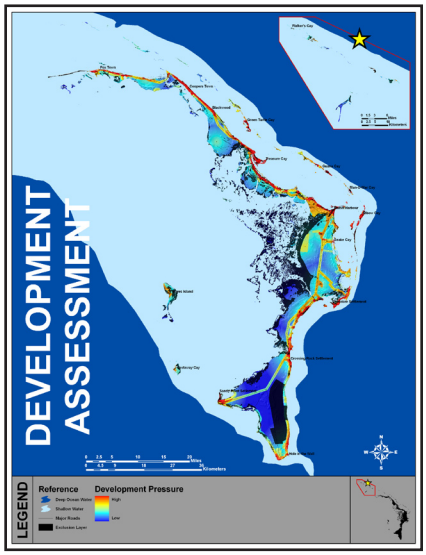

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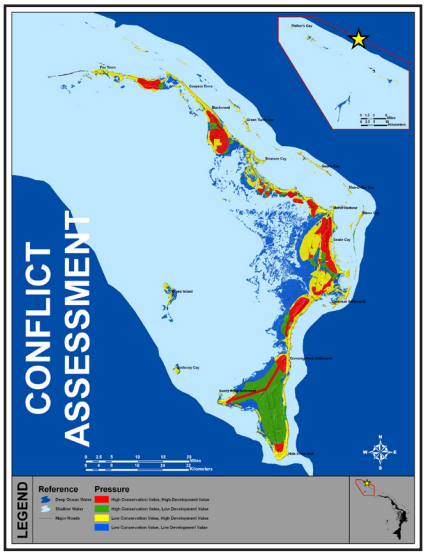

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INFRASTRUCTURE

An assessment of current infrastructure can help to identify areas of cost-efficient development, as well as areas that might be of concern for conservation if infrastructure is present in areas that are environmentally sensitive.

Data considered for use in the infrastructure model was:

- Roads
- Electric Lines
- Sewage Treatment Facilities
- Water Lines
- Phone Lines

The data for roads was derived from 1973 Lands and Surveys Topographic maps. The data was updated using a vague road map, satellite imagery, local knowledge, GPS point data, and the best professional judgment of the digitizers to complete the updated road system.

Data for electricity lines was unavailable, but from a discussion with Michael Wilson of The Bahamas Electric Company February 20, 2006, electric lines generally follow major roads.

Discussions with John Bowleg of The Department of Water and Sewage February 17, 2006 revealed that sewage treatment facilities basically do not exist on Abaco, and almost all people use septic tanks for wastewater disposal.

In the same discussion with the Department of Water and Sewage it was found that central water lines are in place in Marsh Harbour, but anywhere else people draw water from local wells.

Data about areas serviced by phones was unavailable, but serviced areas are assumed to follow major roads. Cell phone towers have recently been erected throughout the island but are currently inoperable.

Criteria

- Roads

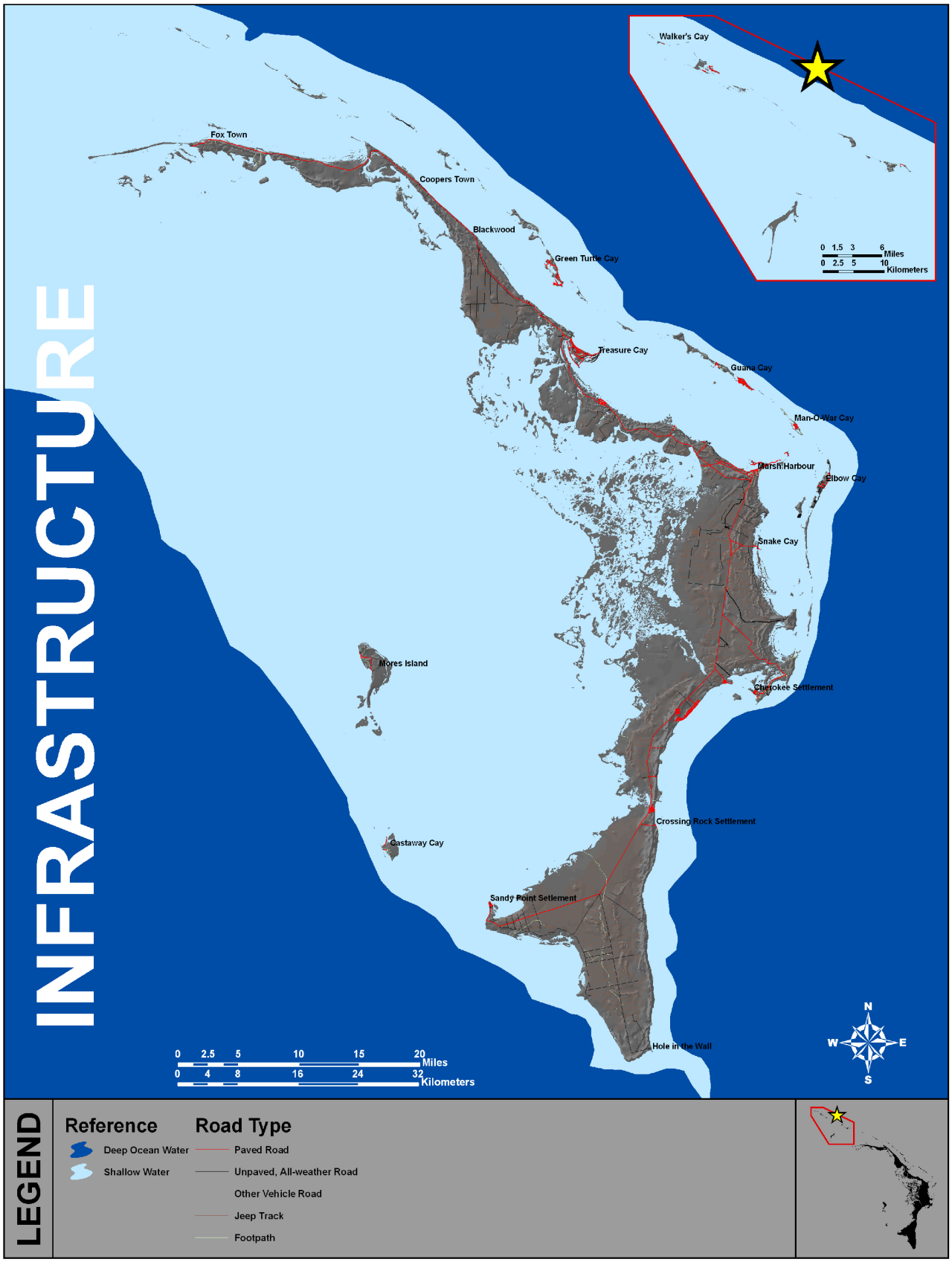
Weaknesses

- Official spatial data on electric lines, water lines, sewage treatment areas and phone lines would make the model a more reliable source for use with planning.

Assessment Benefits

Knowledge of existing infrastructure can help to identify areas of cost-efficient development, as well as areas that might be of concern for conservation if existing infrastructure is in place in areas that are environmentally sensitive.

Great Abaco Highway © Kevin Seegmiller


INFRASTRUCTURE
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Elbow Cay
Snake Cay
Mores Island
Cherokee Settlement
Crossing Rock Settlement
Castaway Cay
Sandy Point Setlement
Hole in the Wall
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
0 2.5 5 10 15 20 Miles
0 4 8 16 24 32 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Road Type
Paved Road
Unpaved, All-weather Road
Other Vehicle Road
Jeep Track
Footpath

MARINE RESOURCES

The Marine Resources Assessment spatially illustrates habitat types important to the health of local fisheries. The following habitat types were identified by marine ecologist Craig Layman and Department of Fisheries expert Jeremy Saunders as being important to local fisheries: mangroves, swash/swamp areas, tidal creeks, estuaries, sea grass beds, and reefs. Based on data availability, this assessment was limited by including only mangroves and swash/swamp areas.

Local fisheries throughout Abaco are suffering severely as a result of:

- Vast over-fishing
- Habitat destruction, particularly aquatic nursery habitat and reproduction areas
- Poaching
- Lack of regulation and enforcement

Faced with a dwindling fish population, local fishermen are forced to travel further offshore to find fish (Appendix B). Additionally, many locals harvest fish, conch, and crab before they reach sexual maturity and therefore destroy future fish populations (Appendix B). These marine resources not only play an important role in the local economy, but equally as important, an important role in the ecosystem. Therefore, protecting these habitats is crucial.

Tall mangrove stands play a particularly important role in sustaining fish populations because these areas provide protection to young fish (Appendix B). Many prime mangrove stands are being destroyed by new developments and road construction. If culverts were installed under these roads, fish could continue to access these areas.


Marine Tidal Creek © Steve Schill

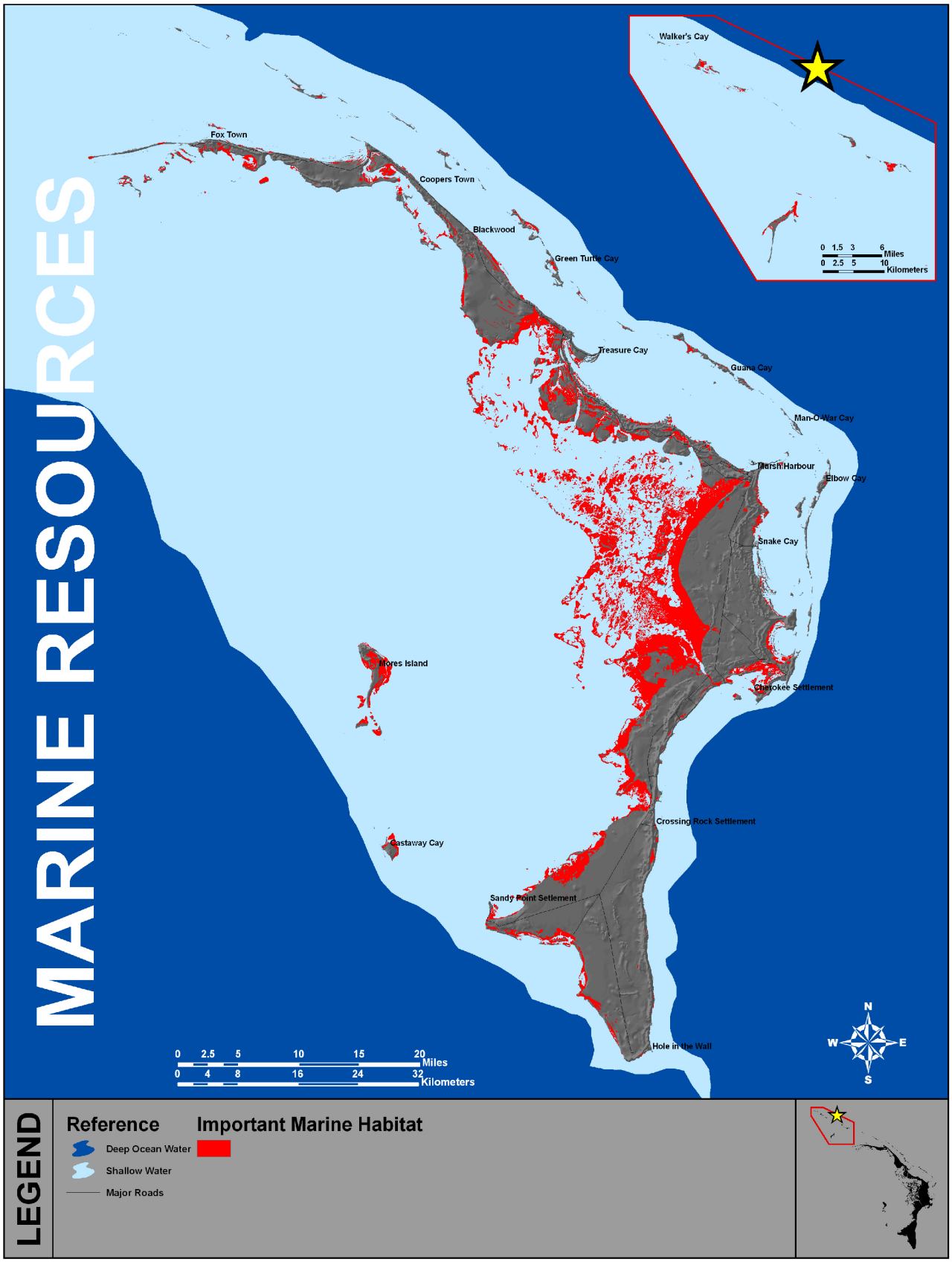
- Mangroves
- Swamp/Swash
- Ocean water less than 10 meters deep

Assessment Benefits

Knowledge of where important fish habitats are will allow land-use planners to spatially identify and manage them.

Weaknesses

This model includes only two of the many habitats important to fish. Additional data to consider includes: tall mangrove stands, estuaries, tidal creeks, reefs, and sea grass beds. Tidal creeks with deep carved channels leading to tall mangrove stands are considered extremely important according to Craig Layman.


MARINE RESOURCES
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Elbow Cay
Snake Cay
Moores Island
Cherokee Settlement
Crossing Rock Settlement
Castaway Cay
Sandy Point Setlement
Hole in the Wall
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
0 2.5 5 10 15 20 Miles
0 4 8 16 24 32 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Major Roads
Important Marine Habitat

PROTECTED AREAS

The Bahamas National Trust has been making an effort for nearly 50 years to protect and conserve unique natural and cultural resources in The Bahamas. Abaco is home to five areas protected under national park status and managed by the Bahamas National Trust.

In order to preserve species biodiversity for future generations the Bahamas National Trust and The Nature Conservancy have a primary goal of protecting 10% of every terrestrial habitat in The Bahamas and a secondary goal of protecting 25% of every terrestrial habitat within The Bahamas.

The national parks in Abaco represent only a portion of the areas throughout the nation that have been set aside for conservation. However, an assessment of the habitats being protected in Abaco currently can give us an idea of the progress being made in order to reach this goal. The assessment can also help to identify which habitats are not being well represented within the current protected areas system and help us identify areas that might be considered for protection in order to conserve a balanced sample of all habitats.

Criteria

- Protected Areas
- Land cover

Weaknesses

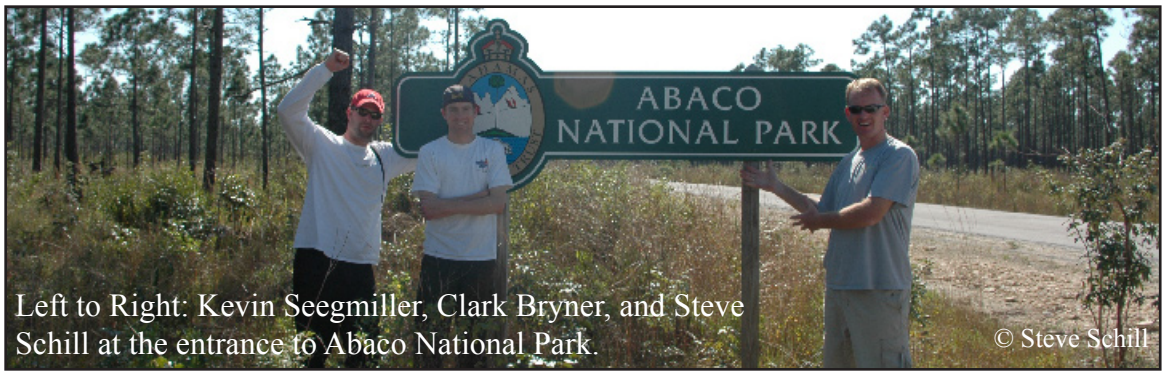
Terrestrial habitats are based on Lands and Surveys topographic maps created 1968-1973 and may not appropriately represent the true state of the land cover.

Assessment Benefits

Identify protected areas and assess their contents in order to identify gaps in protection so that sites can be identified which contain the habitat types lacking in the current protected areas system.

Land Cover	Acres/ Hectares Protected	Acres/ Hectares Total	% Protected
Blue Holes	0/ 0	10/ 4	0
Dry Broadleaf Evergreen Formation (DBEF)	3,069/ 1,242	66,632/ 26,965	5
Mangroves	12/ 5	93,213/ 37,722	0
Pine Woodland	17,535/ 7,096	138,184/ 55,921	12
Sandy Beaches	93	1,443	6

Figure 8 Protected Areas Assessment



Left to Right: Kevin Seegmiller, Clark Bryner, and Steve Schill at the entrance to Abaco National Park.


PROTECTED AREAS ASSESSMENT
Walkers Cay
Walker's Cay
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Black Sound Cay Reserve
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Elbow Cay
Tilloo Cay
Snake Cay
Pelican Cays National Park
Mores Island
Cherokee Settlement
Crossing Rock Settlement
Castaway Cay
Sandy Point Setlement
Abaco National Park
Hole in the Wall
0 2.5 5 10 15 20 Miles
0 4 8 16 24 32 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Major Roads
Protected Areas

PUBLIC, HEALTH, WELFARE & SAFETY

The Public Health, Welfare & Safety Assessment model was created to spatially identify areas that are considered hazardous to the welfare of the citizens and visitors of Abaco and the surrounding cays.

Issues of concern identified by the public and stakeholders are:

- Hurricanes
- Mosquitoes
- Access to Health Clinics

Hurricane forces are frequently experienced on Abaco and the surrounding cays. Hurricanes are powerful tropical storms that are accompanied by heavy rainfall, high winds, and storm surges. All the forces of hurricanes are potentially devastating, but the storm surge accompanying an approaching hurricane can be deadly (FEMA: Hurricane, n.d.).

Through an interview conducted February 16, 2006 with Jeffrey W. Simmons, Deputy Director of The Bahamas Department of Meteorology local hurricane characteristics were identified. Hurricanes will almost always approach from the east throughout The Bahamas. The accompanying storm surge usually averages 8-12', but can be accentuated by +/- 3-6' if the storm surge hits at high or low tide. A rough estimate of storm surge height based on the Saffir-Simpson Hurricane Scale was identified:

- Category 1 – Storm Surge 6'
- Category 2 – Storm Surge 10'
- Category 3 – Storm Surge 15'
- Category 4 – Storm Surge 18' (Hurricane Floyd, September 1999)
- Category 5 – Storm Surge 20'+ (None in recent times)

The hurricane storm surge can be less destructive if an outer bank is present. The reef on the edge of the bank will cause the surge to break and hit land with less force. Nevertheless when Hurricane Floyd hit Marsh Harbour in 1999, the storm surge reached more than 800 meters inland.

Other issues of concern to the health, welfare and safety of Abaconians were identified in a stakeholder meeting held February 20, 2006 in Marsh Harbour. Mosquitoes were a concern due to their potential for the spread of disease. Assuring that everyone had access to a public health clinic within a reasonable distance, and the desire for a hospital on Abaco were also brought up in the meeting as concerns to the well-being of the citizens of Abaco.

Planners, policy makers, and citizens can use the information presented in this model to plan, pass legislation, and make decisions on proposed development. In order to ensure the safety of the people of Abaco, it is recommended that development within areas identified as hazardous should be approached with caution or be avoided altogether.

For modeling purposes, only hurricane storm surges were taken into consideration. All other concerns were not addressed in this model due to insufficient data.

Criteria

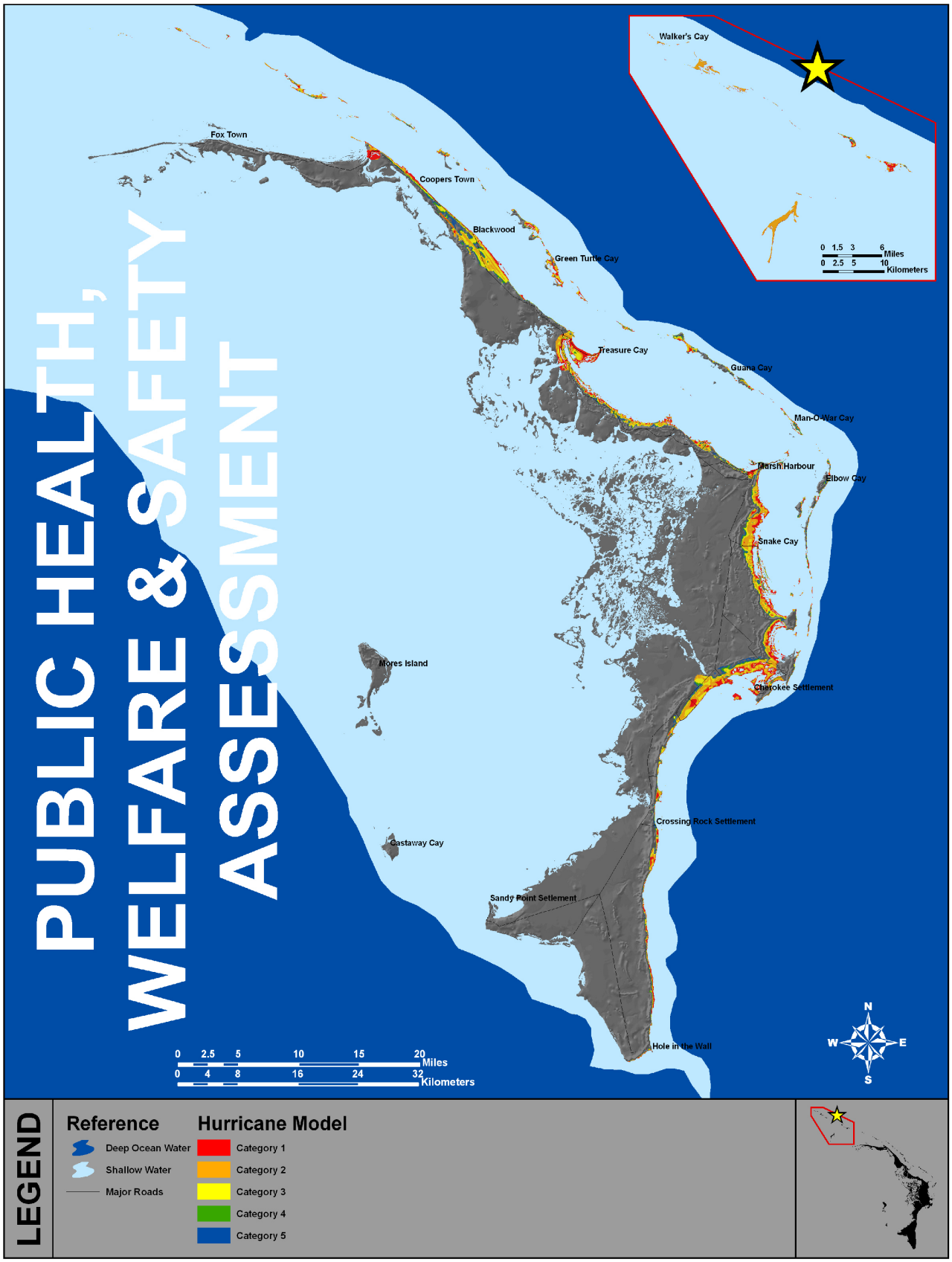
- Hurricane storm surge heights by category on the east side of the island

Strengths

- Illustrates the degree to which specific areas of Abaco are potentially in danger

Weaknesses

- Storm surge heights used in model were based on estimates and not actual field data
- Storm surge modeling does not take into consideration the energy loss of the surge as it moves inland, or the energy loss due to barrier reefs.


PUBLIC HEALTH,
WELFARE & SAFETY
ASSESSMENT
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Elbow Cay
Snake Cay
Moores Island
Cherokee Settlement
Crossing Rock Settlement
Castaway Cay
Sandy Point Setlement
Hole in the Wall
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
0 2.5 5 10 15 20 Miles
0 4 8 16 24 32 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Major Roads
Hurricane Model
Category 1
Category 2
Category 3
Category 4
Category 5

SANDY BEACHES

One primary reason people come to the Bahamas is to enjoy the beaches. Abaco stands as having some of the finest white-sand beach in the world (Bahama Beaches, 2005). In fact, Treasure Cay Beach was recently voted one of the top ten beaches in the Caribbean (Caribbean Travel and Life, n.d.).

Beach front property is facing high development pressure by private resort developers and second home buyers. Public access to beach areas is becoming limited and is an issue with the locals, especially if they've used it for a long time (Appendix B). Some of these beaches are part of crown land which has been sold by central government.

Ethan Fried, who has conducted extensive research in the Bahamas, believes that beaches are high priority conservation areas based on their vulnerability and geographic range. He emphasized that removing native vegetation from beach areas may cause them to erode much faster than normal. There is some difference of opinion among local residents and scientists to whether the Australian Pine (Casuarinas) has a negative or positive effect on beach health (Risk, 2005). Further research is needed in order to make an appropriate management decision.

The Bahamas is also bound by international agreement to preserve habitat for endangered species, such as the sea turtle (Taft, 2003).

Criteria

- Sandy beaches

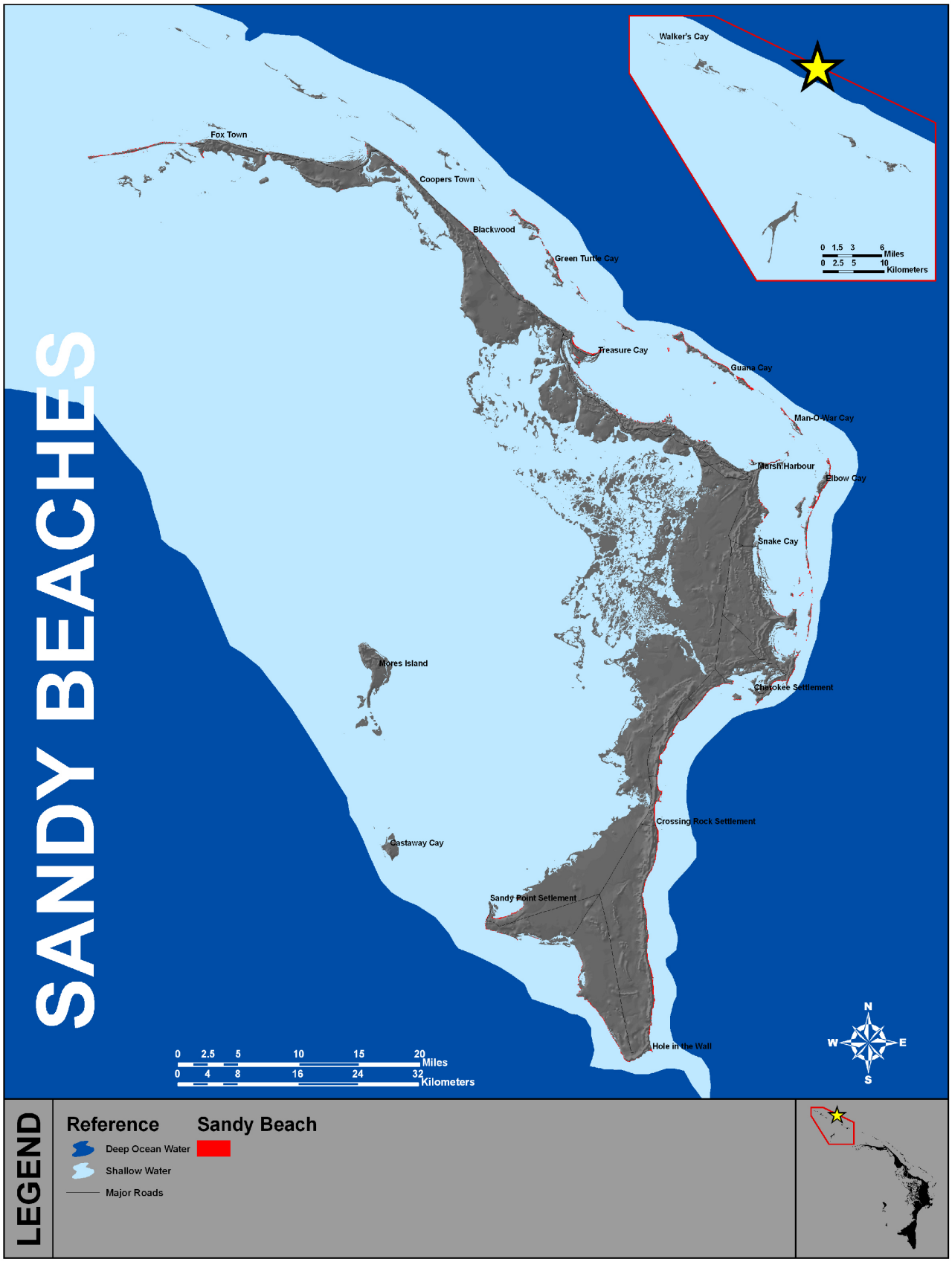
Benefits

Knowing where sandy beaches are will help decision makers identify where development pressure will likely occur and where effort is needed to protect beach areas.

Weaknesses

Data was derived from Landsat ETM imagery using remote sensing techniques and may misrepresent actual sandy beaches in some areas.

Sandy Beach in Southern Abaco


SANDY BEACHES
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Elbow Cay
Snake Cay
Moores Island
Cherokee Settlement
Crossing Rock Settlement
Castaway Cay
Sandy Point Setlement
Hole in the Wall
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
0 2.5 5 10 15 20 Miles
0 4 8 16 24 32 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Major Roads
Sandy Beach

TOURISM RESOURCES

The economy of The Bahamas and the Abacos is based almost entirely on tourism. Therefore it is crucial that there are sufficient tourism-based developments to provide employment opportunities to the hundreds of Abaconians seeking work.

Resort Entrance © Kevin Seegmiller

In a public meeting held February 20, 2006 in Marsh Harbour concerns were expressed that there were not sufficient existing tourism related developments near Little Abaco in the north, or down south near Sandy Point to provide employment to the residents of these regions. The situation in these areas has forced many to either commute up to 60 miles into Marsh Harbour each day, or abandon their homes and communities and move closer to Marsh Harbour or Nassau, New Providence in search of employment.

This model illustrates areas that present good opportunities and ideal sites for future tourism-based development, based on proximity to good quality sandy beaches and distance from existing development. The model can help investors, developers, and planners to identify the best sites to place new development in order to help bolster the island's economy.

An alternative future could potentially be based around this model. If a new site were selected for a major resort in the north and another in the south it would affect growth patterns on the island as a whole. The areas in close proximity to the resorts would likely grow at a much quicker rate than predicted, and other areas of the island might grow more slowly as a consequence. All of these factors should be considered with a development proposal that has the potential to change the historical character of the island.

Criteria

- Existing and proposed Tourism-based Development
- Proximity to Sandy Beaches
- Proximity to Existing and proposed Tourism-based Development

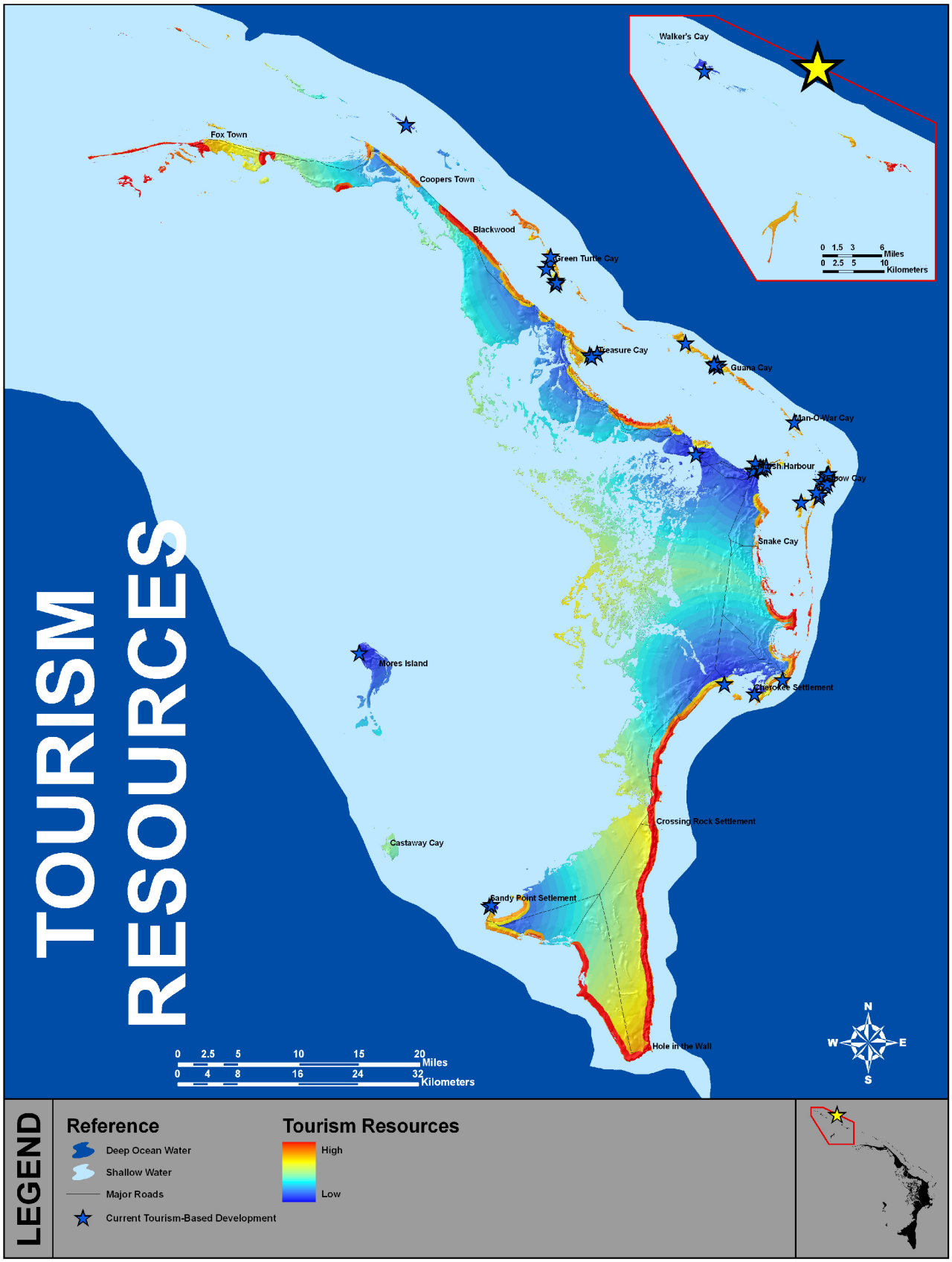

Hope Town Lighthouse © Kevin Seegmiller

Weaknesses

Data for existing tourism-based development was obtained from travel brochures, public meetings, and interviews, and may not reflect a comprehensive list of existing or planned development.

Assessment Benefits

The tourism resources model can be used to identify areas on the island that are ideal for new tourism-based development based on proximity to sandy beaches and distance from existing tourism-based developments.


TOURISM RESOURCES
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Snake Cay
Mores Island
Cherokee Settlement
Crossing Rock Settlement
Castaway Cay
Sandy Point Setlement
Hole in the Wall
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
0 2.5 5 10 15 20 Miles
0 4 8 16 24 32 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Major Roads
Current Tourism-Based Development
Tourism Resources
High
Low

WATER RESOURCES

The Water Resources Assessment spatially illustrates the location of fresh underground water resources. Abaco currently possesses good fresh water resources but they are extremely finite and fragile (U.S. Army Corps of Engineers, 2004). Although Abaco's water resources currently meet local demand, they may be used to help meet water demand on other islands (Appendix B). This is currently happening in the Bahamas as Andros is supplying large quantities of water to Nassau. As water demand increases with a growing population and strong tourism market, it will become increasingly important for land-use planners and decision makers to manage for water quality and quantity.

Water resources are very susceptible to:

- Saltwater inundation from overdrawing
- Saltwater inundation from storm surges
- Contamination from septic tanks and other pollutants

Data used in this assessment is based from the 2004 Water Resources Assessment of the Bahamas, conducted by the U.S. Army Corps of Engineers.

	Quantitative Terms (L/s)
Moderate to Enormous Quantities	.6 to > 6
Unsuitable to Large Quantities	.25 to .6
Unsuitable to Small Quantities	Less than .25

Figure 9 Water Resources Key

Criteria

- Fresh ground water

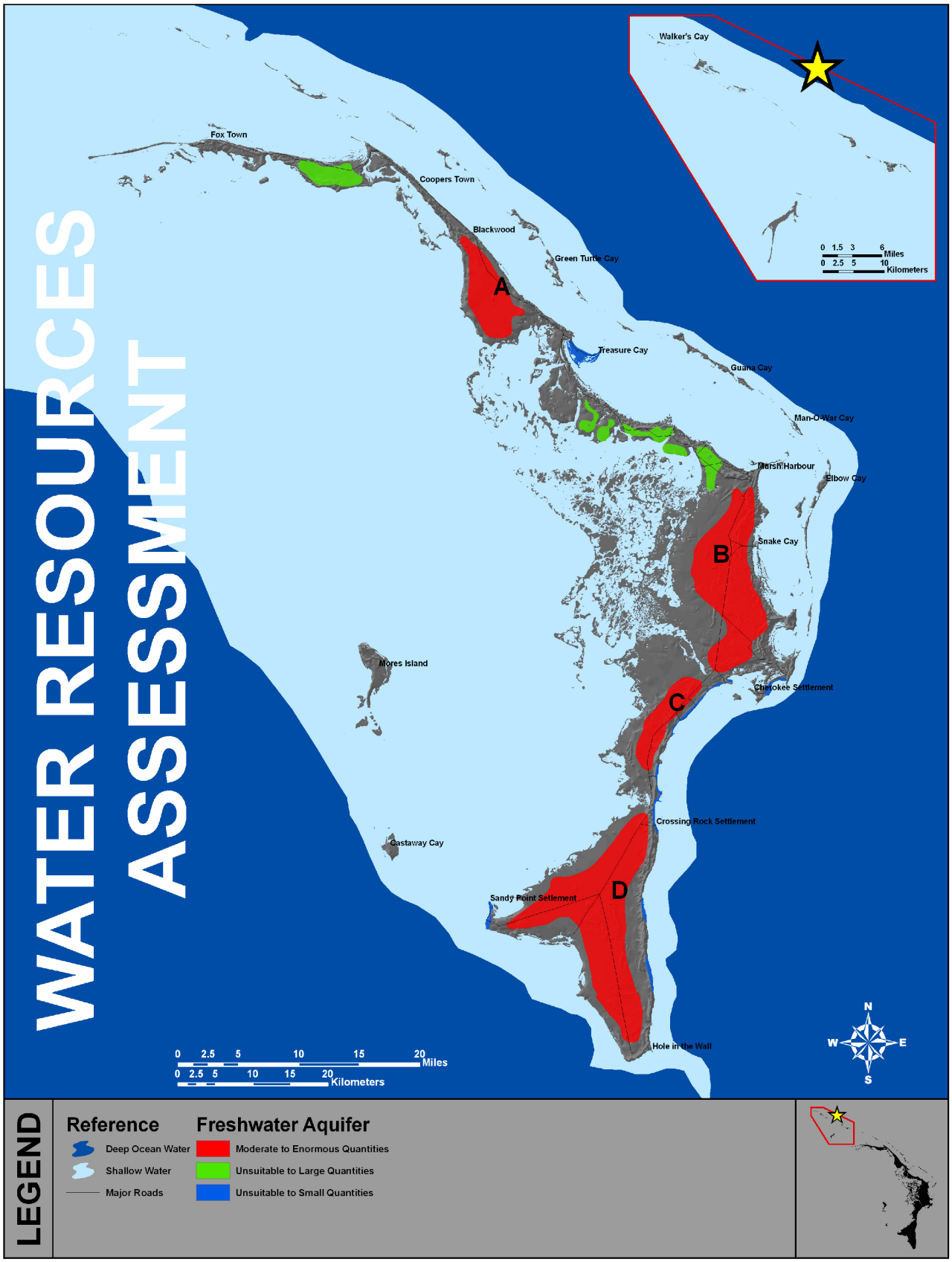
Assessment Benefits

Identifying these areas should help decision makers create wise zoning ordinances and policies in order to protect water quantity and quality.

Weakness

Fresh groundwater aquifers are the only data used in this model. The following data could improve this assessment: blue holes, dump sites, cemeteries, septic tanks, gas stations, inland fresh water, developed areas, and well sites.

Blue Hole © Kevin Seegmiller


WATER RESOURCES ASSESSMENT
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
A
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Elbow Cay
Snake Cay
B
Mores Island
Cherokee Settlement
C
Crossing Rock Settlement
Castaway Cay
Sandy Point Settlement
D
Hole in the Wall
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
0 2.5 5 10 15 20 Miles
0 2.5 5 10 15 20 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Major Roads
Freshwater Aquifer
Moderate to Enormous Quantities
Unsuitable to Large Quantities
Unsuitable to Small Quantities

WILDLIFE

The Wildlife Resources Assessment spatially illustrates and predicts habitat types important to the survival of wildlife. The endangered Bahama Parrot was identified by local residents as being important on the island. Because a complete list of wildlife species on Abaco does not exist, the parrot was used as an umbrella species which can help identify other wildlife habitats as well.


Bahama Parrot
© Friends of the Environment

Pine Woodland and Dry Broadleaf Evergreen Formation (DBEF) make up the major habitat for the Bahama Parrot. Pine woodland is particularly important during breeding season. These parrots will feed on pine seeds which provide a rich source of protein essential for the development of chicks (RARE, 1997). During winter months, DBEF areas will also be used (Appendix B). It is estimated that less than 3,000 Bahama Parrots exist today.

Pine woodlands and DBEF are also home to Wild Boar which is a popular game species on the island. Other wildlife species that may be found in these areas include: raccoons, multiple bird species, and small reptiles (Thompson, 2000).

Criteria

- Dry Broadleaf Evergreen Formation (DBEF), includes: Coppice, Mixed Coppice/Pine, Scrubland, Whiteland
- Pine Woodland

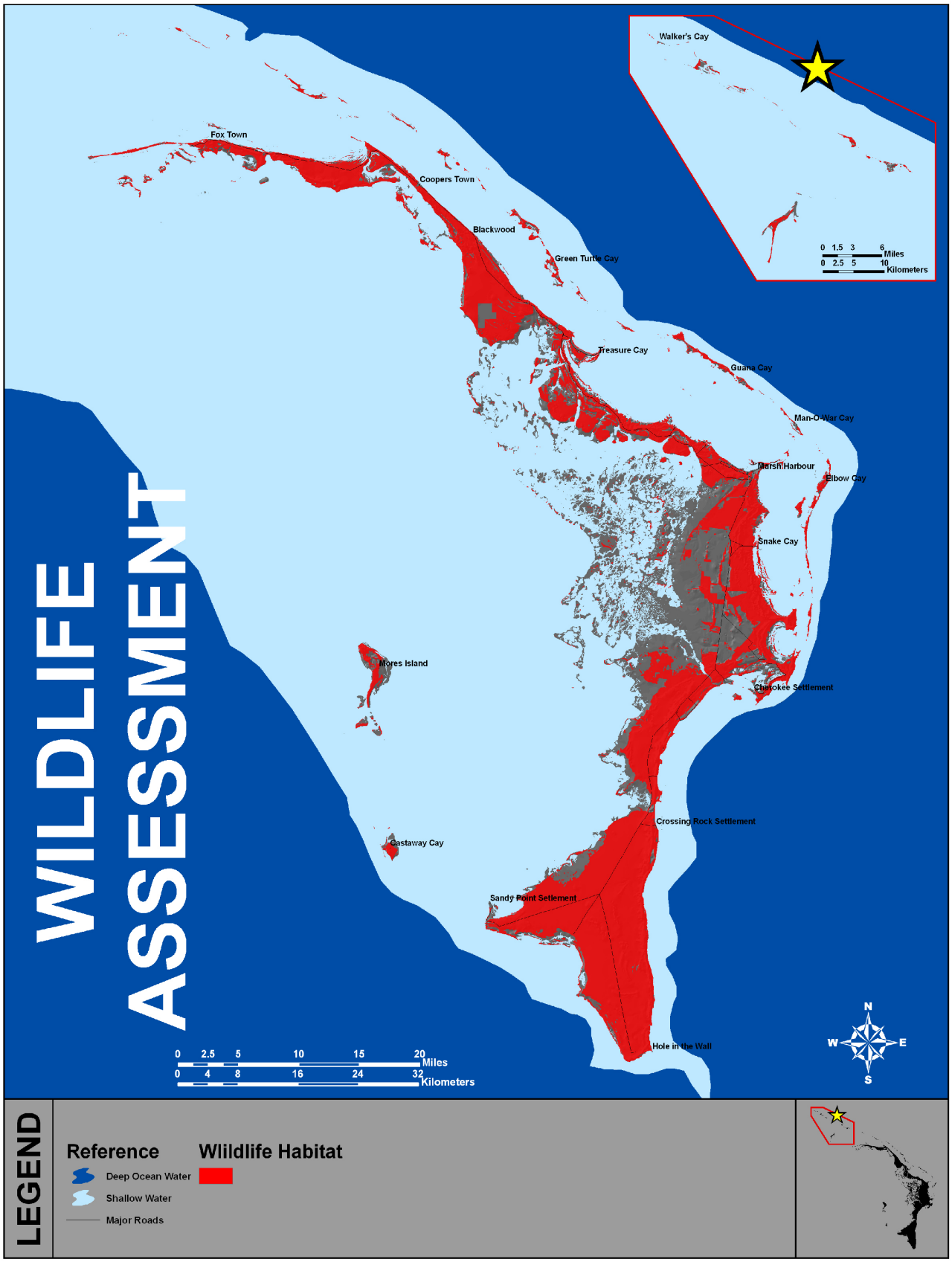
Assessment Benefits

Spatially identifies areas that are critical to the endangered Bahama Parrot. It also identifies other species' habitats. This assessment will allow decision makers to consider critical wildlife habitat when they make land use decisions.

Weaknesses

Research is needed to identify other endemic, threatened/endangered, or important species, i.e., bats, turtles, etc.


Ethan Fried studying a mixed Coppice/Pine Woodland.
© Clark Bryner


WILDLIFE ASSESSMENT
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Elbow Cay
Snake Cay
Moores Island
Cherokee Settlement
Crossing Rock Settlement
Castaway Cay
Sandy Point Setlement
Hole in the Wall
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
0 2.5 5 10 15 20 Miles
0 4 8 16 24 32 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Major Roads
Wlildlife Habitat

CONSERVATION

Abaco has many areas that can be considered critical for conservation. The Conservation Assessment was designed to provide the user with the ability to select certain values they think are worth conserving. This assessment, therefore, can be used as a tool to highlight conservation values based on priority or preference. The following five components were chosen to be incorporated into this assessment: current protected areas, ground water resources, beach areas, marine resources, and wildlife resources. These five components were chosen based on information provided at local stakeholder meetings.

Each component was weighted equally before adding them together. Areas that include the most overlap from among the criteria will show up as having a higher conservation value. As the assessment illustrates, areas in the southern portion of the island have the highest conservation value.

Criteria

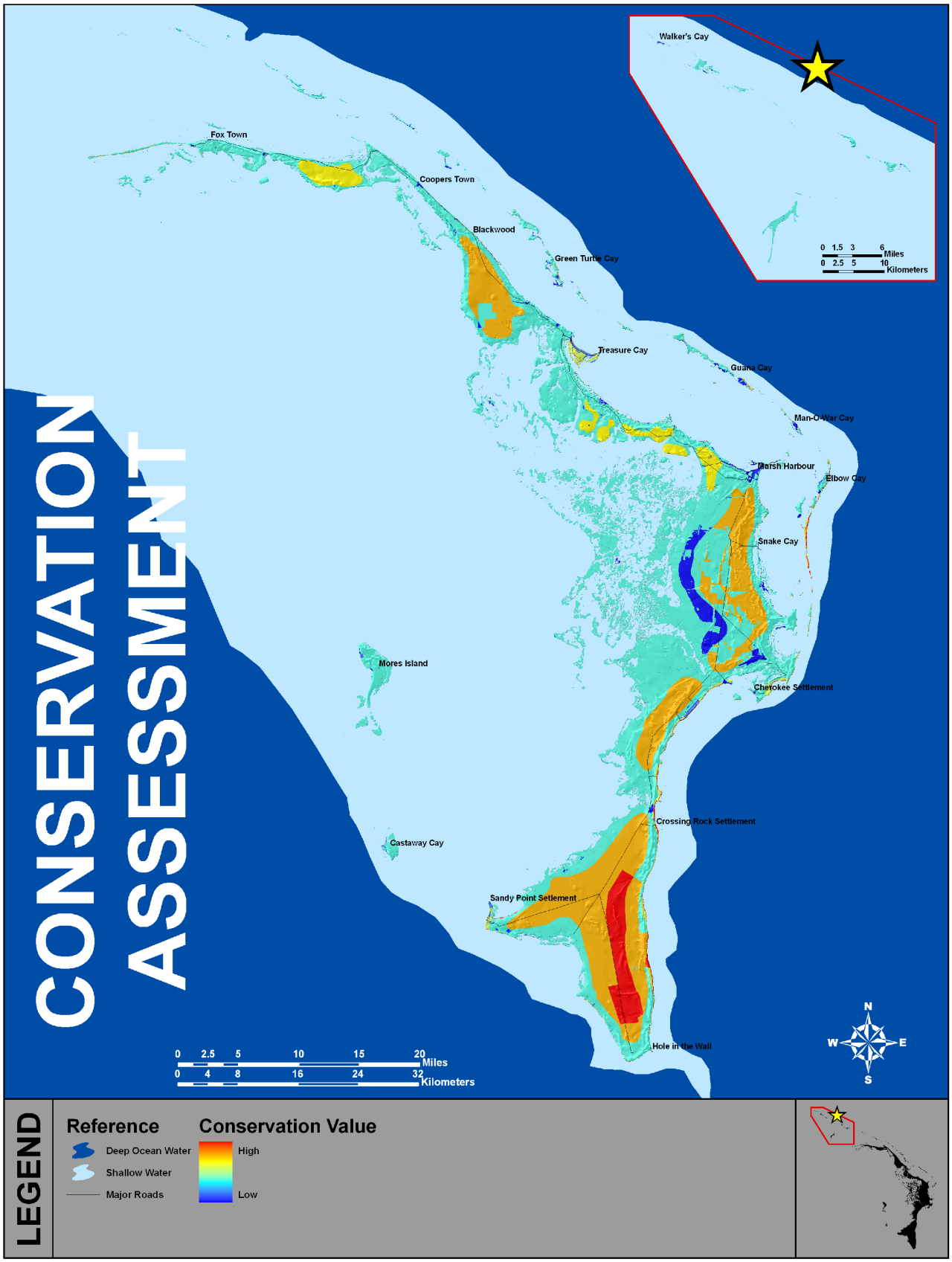
Refer to the abstracts for each specific assessment for a more detailed report of how the data was obtained.

- Protected Areas
- Water Resources
- Beach Assessment
- Marine Resources
- Wildlife Resources

Assessment Benefits

If someone is only interested in preserving water and wildlife resources, this assessment can demonstrate which areas have both water and wildlife conservation value. The flexibility of components in this model is valuable if someone has limited funding but wants to preserve important water and wildlife resource areas. Additionally, the components can be given more or less weight so as to emphasize its importance.

Beach Dune Vegetation © Steve Schill


CONSERVATION ASSESSMENT
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Elbow Cay
Snake Cay
Mores Island
Cherokee Settlement
Crossing Rock Settlement
Castaway Cay
Sandy Point Setlement
Hole in the Wall
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
0 2.5 5 10 15 20 Miles
0 4 8 16 24 32 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Major Roads
Conservation Value
High
Low

DEVELOPMENT

The population of Abaco has grown steadily at a rate of 3.1% per year between 1990 and 2000 according to census data obtained from the Ministry of Finance: Department of Statistics. Population increase has largely been a result of Haitian migration to the island as well as an increase in new second home developments.


Development in Marsh Harbour © Clark Bryner

It is very useful to be able to identify what areas are experiencing the greatest pressure to develop in order to accommodate the growing population. The development assessment model identifies areas that are experiencing the greatest development pressure. The areas identified are also prioritized, so that individual 30m x 30m pixels can be placed specifically in the order in which they will most likely be developed. The predictability of the model makes it a very useful tool in allocating future projected populations on the land.

Some areas of the island should be excluded from development because of cost, ecosystem importance, or human health risk. Areas considered for exclusion were mangroves, swash/swamp areas, and existing protected areas. It is recommended that policies be established to prohibit development in these areas.

Criteria

- Proximity to Main Roads – Infrastructure generally follows the main roads
- Proximity to Urban Areas – Infrastructure is generally existing
- Proximity to Sandy Beaches – Areas most desirable for development
- Land Ownership – Private vs. Crown Lands
- Mangroves (Exclusion Layer)
- Swash/Swamp Areas (Exclusion Layer)
- Protected Areas (Exclusion Layer)

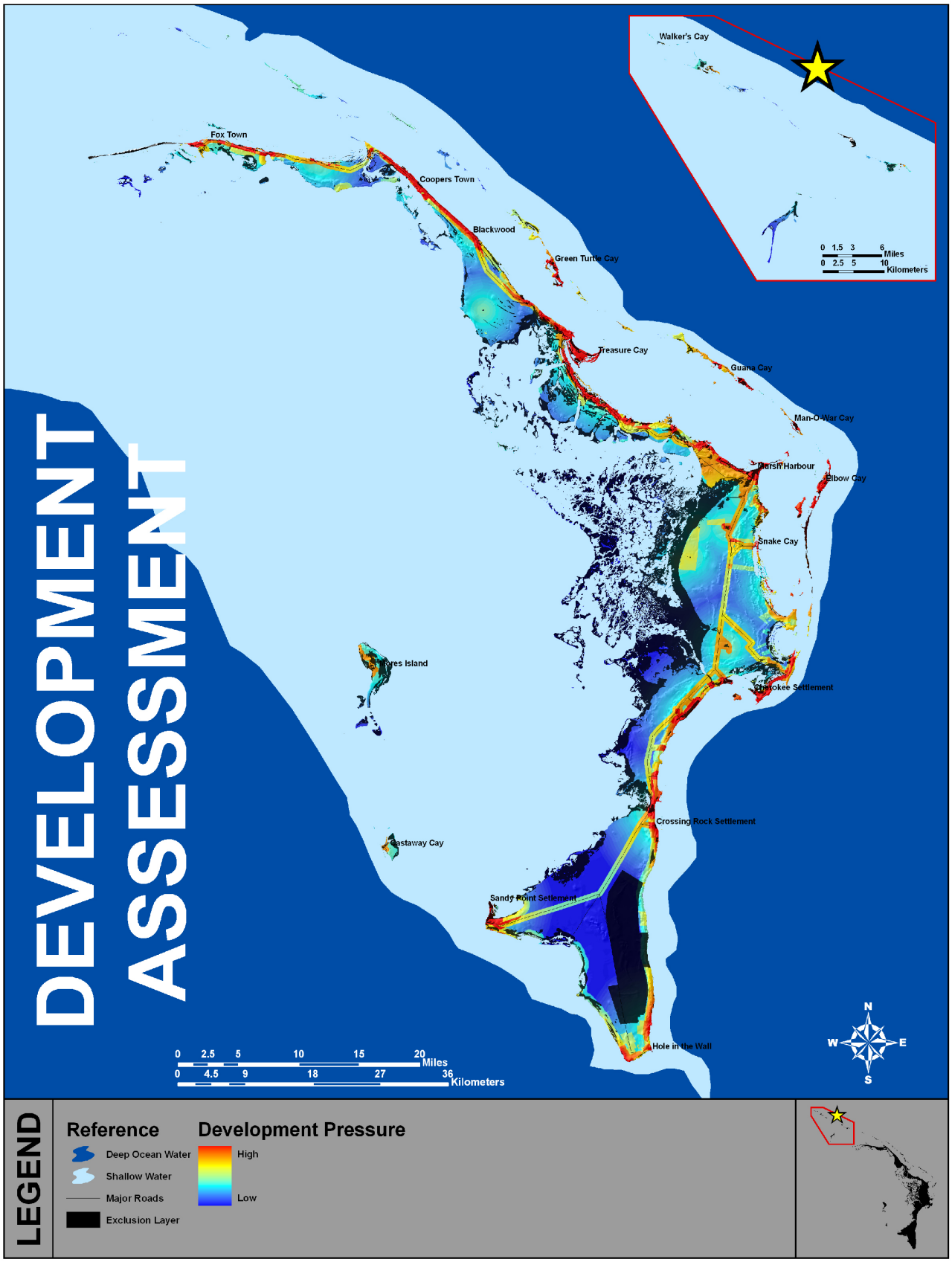
Weaknesses

- Infrastructure data is not precise and should be upgraded as soon as possible.
- Urban Areas are based on 1968-1973 topographic maps - needs updating.

Strengths

- Good prediction model based on available data


Land Build-up © Kevin Seegmiller


DEVELOPMENT ASSESSMENT
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Elbow Cay
Snake Cay
Cherokee Settlement
Crossing Rock Settlement
Sandy Point Setlement
Hole in the Wall
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
0 2.5 5 10 15 20 Miles
0 4.5 9 18 27 36 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Major Roads
Exclusion Layer
Development Pressure
High
Low

COMPATABILITY AND CONFLICT

The Conservation Assessment is compared to the Development Assessment in order to identify where conflicts will likely occur assuming current trends. By placing the values of each assessment model along each axis in the following diagram, different classifications of overlap emerge between priority conservation areas and development areas (Toth, 2002).

Assessment Benefits

This information will help identify positive and negative areas for growth. This will assist planners in making decisions where conservation should take place and where development should occur.

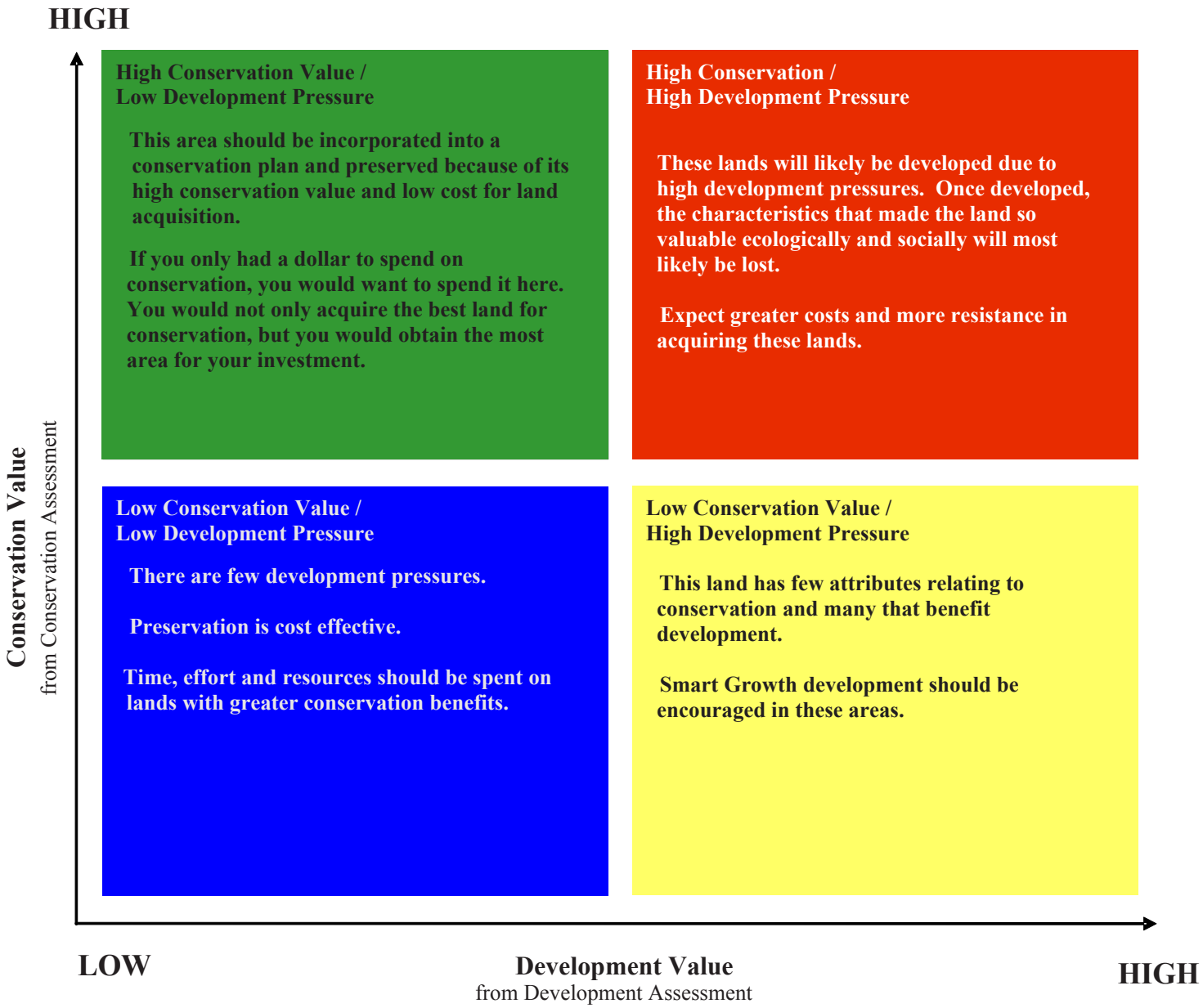
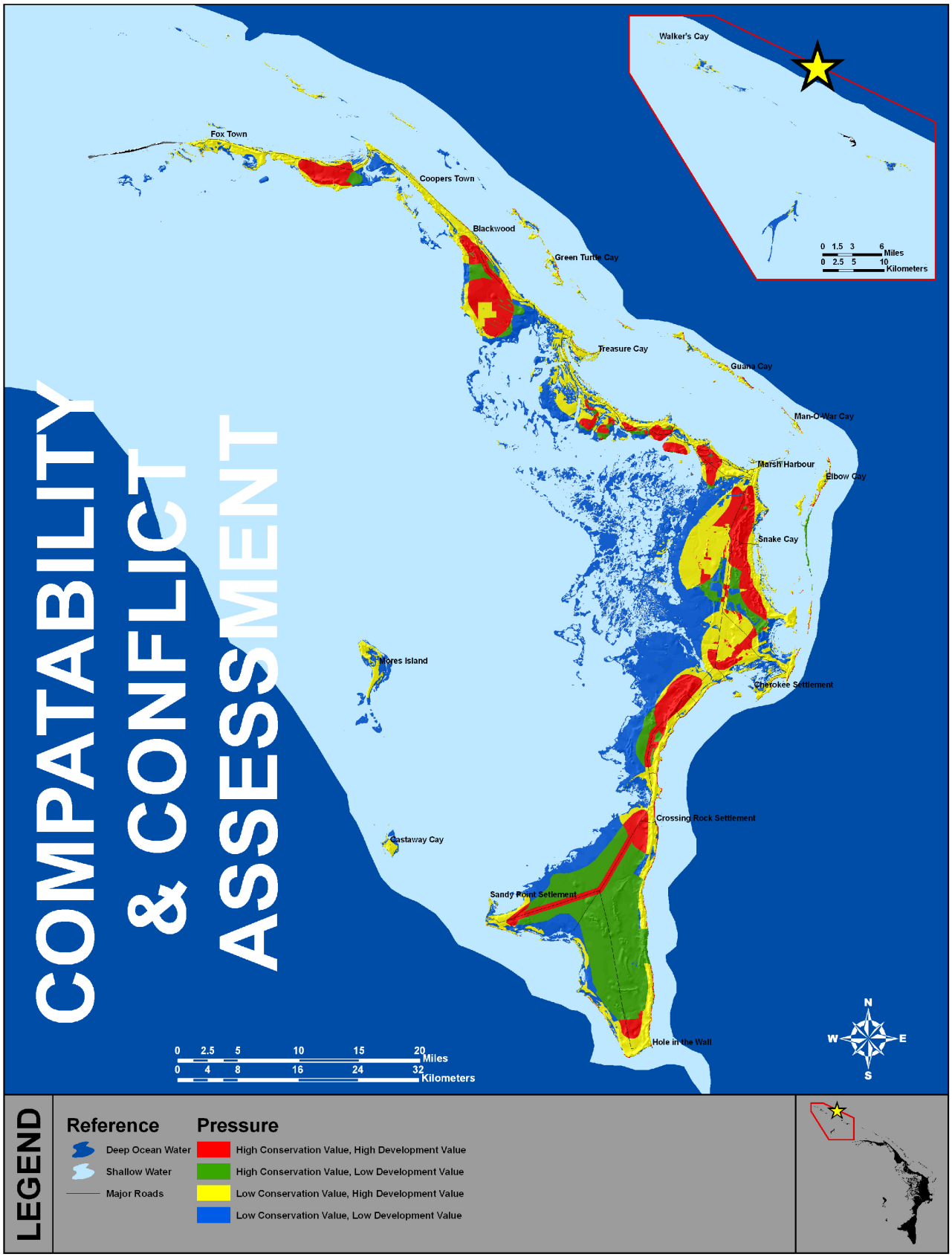
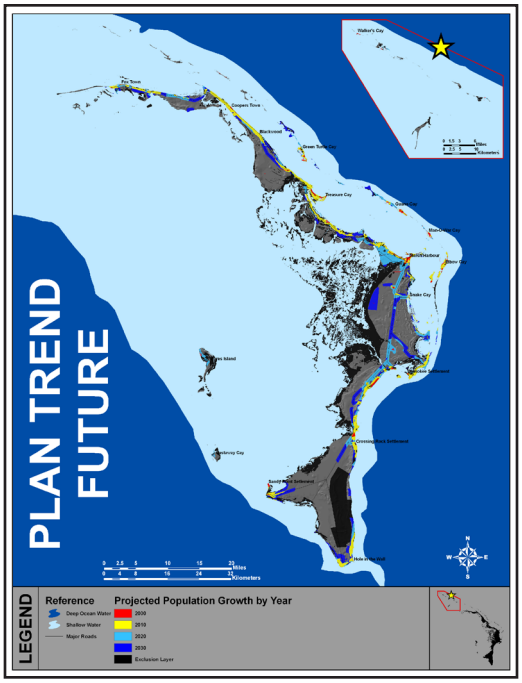


Figure 10 Compatability and Conflict Matrix

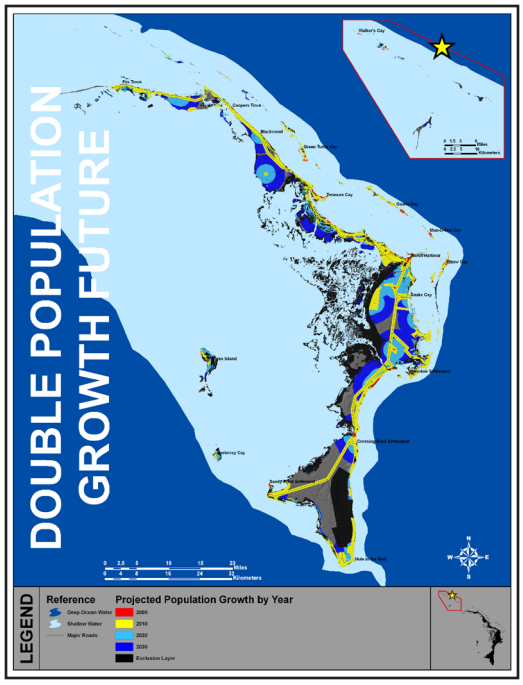

COMPATABILITY & CONFLICT ASSESSMENT
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Elbow Cay
Snake Cay
Moores Island
Cherokee Settlement
Crossing Rock Settlement
Castaway Cay
Sandy Point Settlement
Hole in the Wall
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
0 2.5 5 10 15 20 Miles
0 4 8 16 24 32 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Major Roads
Pressure
High Conservation Value, High Development Value
High Conservation Value, Low Development Value
Low Conservation Value, High Development Value
Low Conservation Value, Low Development Value

Futures

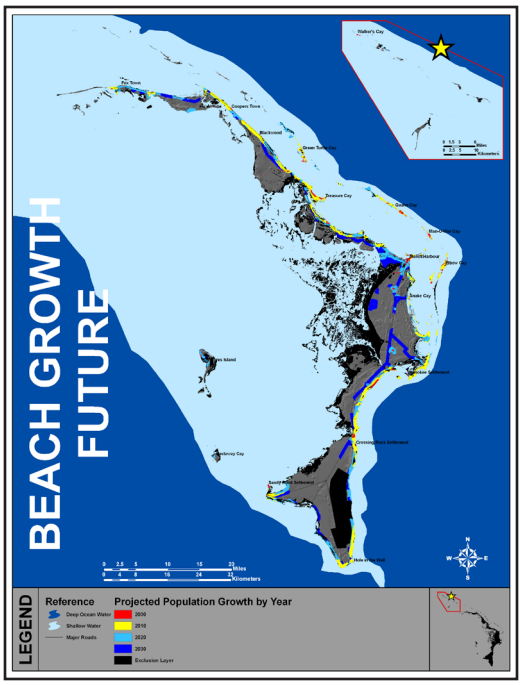
The alternative future models were created for the purpose of illustrating various growth scenarios, based on different assumptions. The various criteria used define the growth patterns possible throughout the island. The possible futures are, but not limited to: Plan Trend, Double Population Growth, Beach Growth, and Population Capacity.



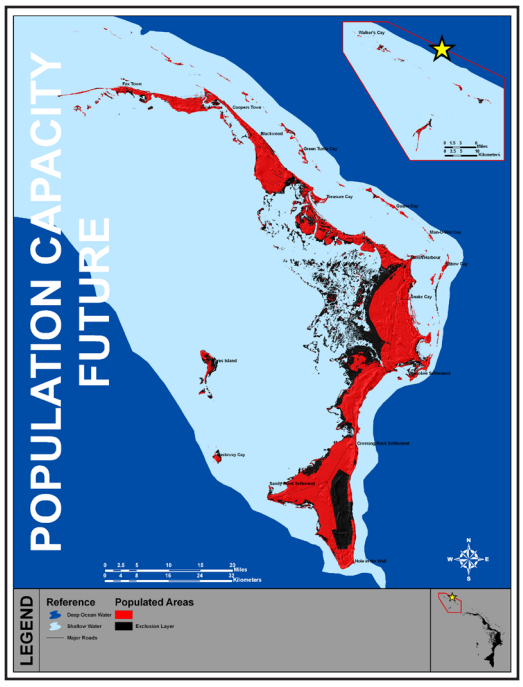
Pg. 61



Pg. 63



Pg. 65



Pg. 67

Nassau, New Providence

PLAN TREND

The Plan Trend Future illustrates the areas that would be built out if growth continues under the same policies that it has in the past.

The factors that influence future growth in the Plan Trend future are the same as those identified in the Development Assessment model. These are:

- Proximity to Main Roads – Infrastructure generally follows the main roads
- Proximity to Urban Areas – Infrastructure is generally existing
- Proximity to Sandy Beaches – Areas most desirable for development
- Land Ownership – Private vs. Crown Lands

There are several areas that were excluded from the model such as mangroves, swash/swamp areas, and existing protected areas. These are areas that should not be developed regardless of development pressure, but should be reserved to ensure human and ecosystem health. It is recommended that laws and/or policies be passed to prohibit development in these areas.

The model can help decision-makers and citizens decide if the manner in which growth is occurring in the region is consistent with the future they have envisioned for the area. If it is, then little should be changed. If it is not, it is important to consider changing the way growth occurs through zoning and other forms of legislation.

The model uses the predictive abilities of the development pressure model to allocate the expected population increase spatially onto the land for the years 2010, 2020, and 2030. The current development footprint on Abaco was determined to be 3.5 persons/acre. For modeling purposes the density was kept consistent with past trends throughout the simulation.

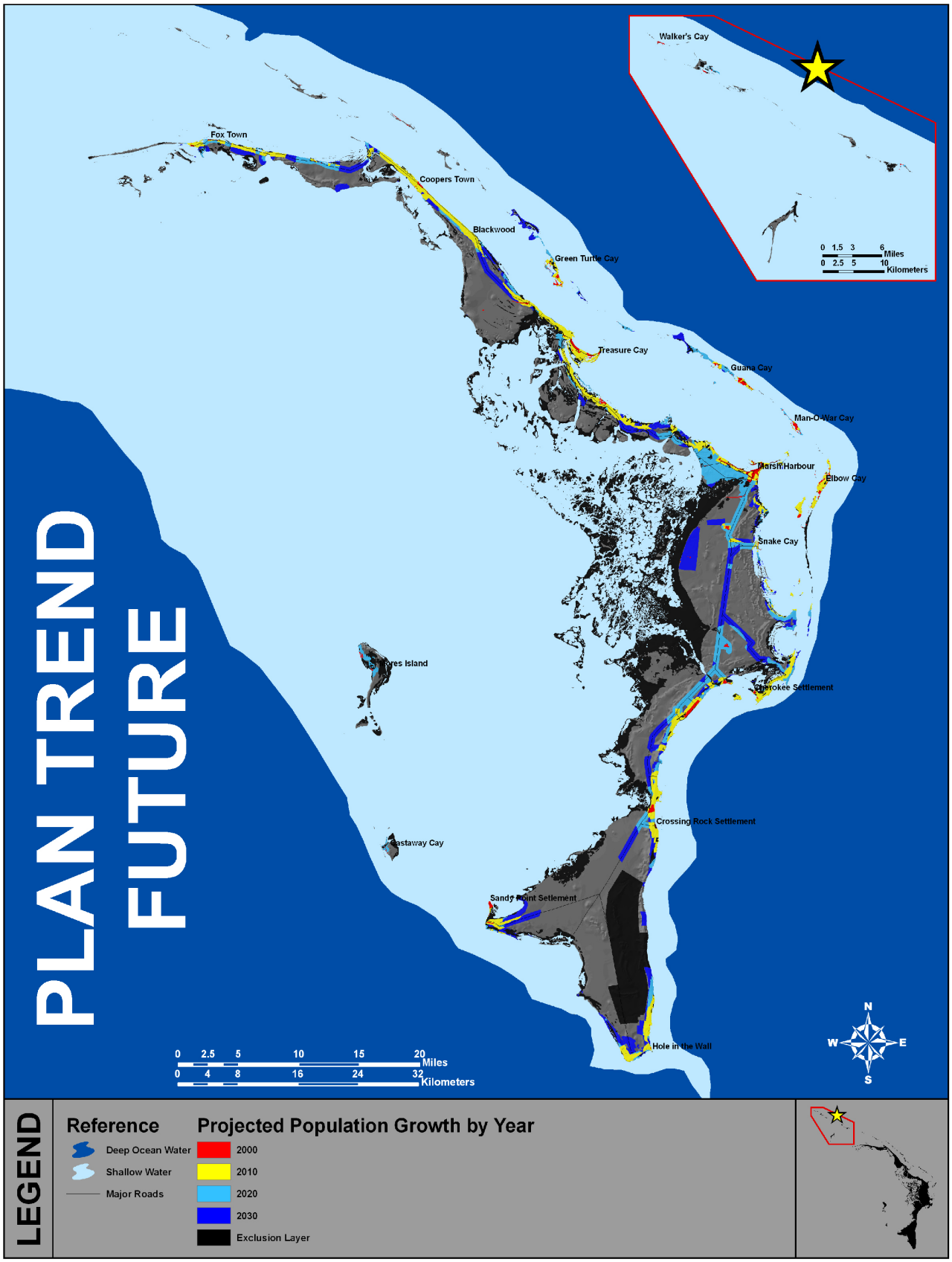
Criteria

- Population Projections for 2010, 2020, and 2030
- Development Assessment Model
- Mangroves (Exclusion Layer)
- Swash/Swamp Areas (Exclusion Layer)
- Protected Areas (Exclusion Layer)

Weaknesses

The population projections used are based on the island as a whole between 1990 and 2000, versus population growth by individual settlements which might reveal varying growth rates. The model is numerically accurate in acres consumed by future growth, but may not be spatially accurate with respect to individual communities.

Nassau, New Providence


PLAN TREND FUTURE
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Elbow Cay
Snake Cay
Cherokee Settlement
Crossing Rock Settlement
Sandy Point Setlement
Hole in the Wall
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
0 2.5 5 10 15 20 Miles
0 4 8 16 24 32 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Major Roads
Projected Population Growth by Year
2000
2010
2020
2030
Exclusion Layer

DOUBLE POPULATION

This model uses a hypothetical population projection that is double that of what is expected. This scenario should be examined as a possibility if unexpected growth occurs.

The factors that influence future growth in the Double Expected Population future are the same as those identified in the Development Assessment model. These are:

- Proximity to Main Roads – Infrastructure generally follows the main roads
- Proximity to Urban Areas – Infrastructure is generally existing
- Proximity to Sandy Beaches – Areas most desirable for development
- Land Ownership – Private vs. Crown Lands

There are several areas that were excluded from the model such as mangroves, swash/swamp areas, and existing protected areas. These are areas that should not be developed regardless of development pressure, but should be reserved to ensure human and ecosystem health. It is recommended that laws and/or policies be passed to prohibit development in these areas.

Decision-makers should use this alternative future like that of the other proposed futures, and decide if it is appealing or undesirable. Laws and policies should then be made to direct growth in one direction or the other.

The model uses the predictive abilities of the development pressure model to allocate double the expected population increase spatially onto the land for the years 2010, 2020, and 2030. The current development footprint on Abaco was determined to be 3.5 persons/ acre. For modeling purposes the density was kept consistent with past trends throughout the simulation.

Criteria

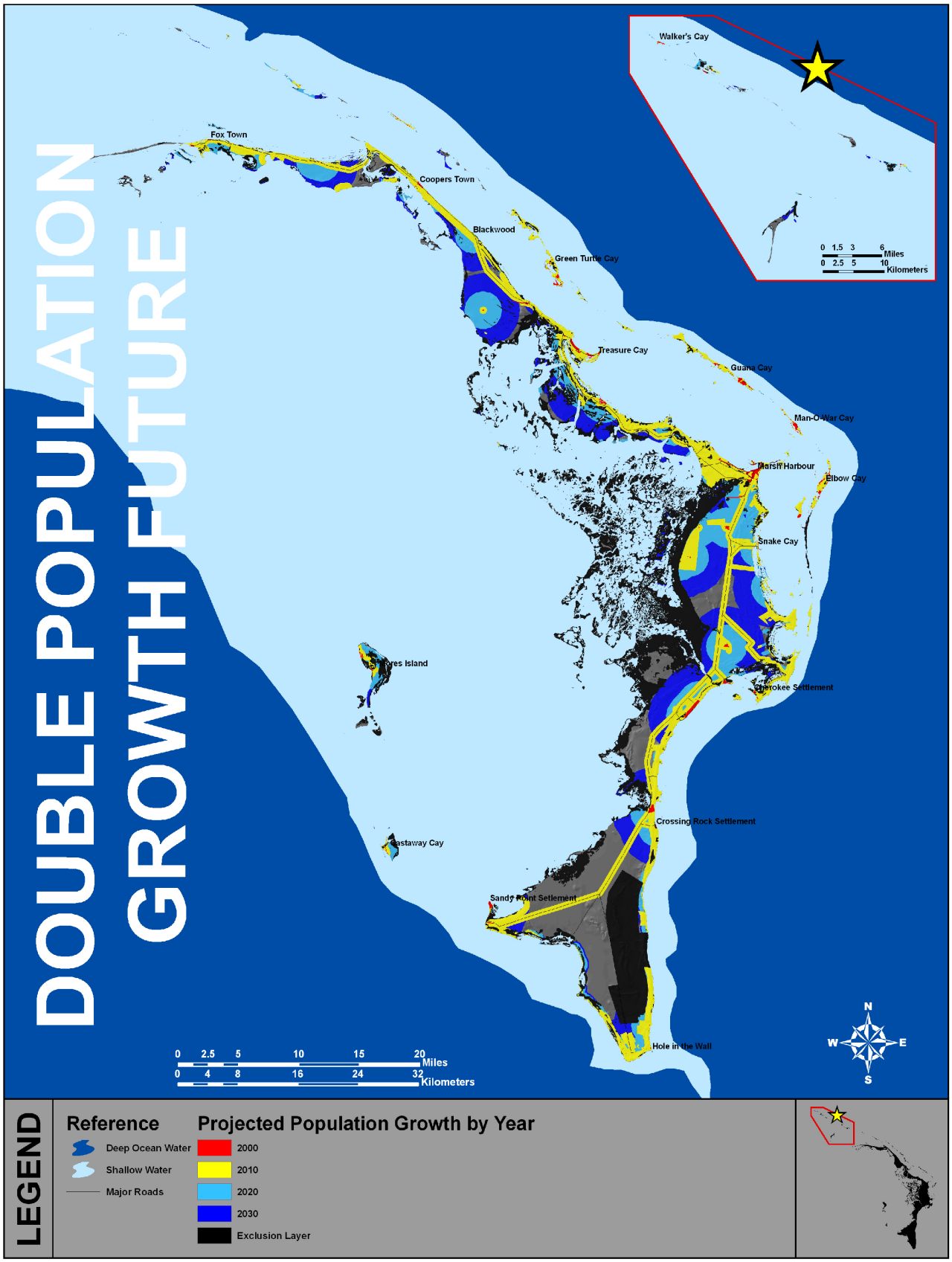
- Double Expected Population Projections for 2010, 2020, and 2030
- Development Assessment Model
- Mangroves (Exclusion Layer)
- Swash/Swamp Areas (Exclusion Layer)
- Protected Areas (Exclusion Layer)

Weaknesses

The population projections used are based on the island as a whole between 1990 and 2000, versus population growth by individual settlements which might reveal varying growth rates. The model is numerically accurate in acres consumed by future growth, but may not be spatially accurate with respect to individual communities.

Projections based on Abaco as a whole, 3.1%/Year	2000	2010	2020	2030
Abaco Total Population	13,165	17,421	23,780	32,462
Abaco Pop. @ Double Expected Population	13,165	34,842	47,560	64,924

Figure 11 Table of Population Projections


DOUBLE POPULATION GROWTH FUTURE
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Elbow Cay
Snake Cay
Cherokee Settlement
Crossing Rock Settlement
Sandy Point Setlement
Hole in the Wall
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
0 2.5 5 10 15 20 Miles
0 4 8 16 24 32 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Major Roads
Projected Population Growth by Year
2000
2010
2020
2030
Exclusion Layer

BEACH DEVELOPMENT

Because beach front property has both conservation and development value (Appendix B), a future which illustrates development along beach areas seems worthy of attention.

The factors that influence development in this future are similar to those identified in the Development Assessment model. The only difference is that sandy beaches were emphasized to be developed first. These are:

- Proximity to Main Roads – Infrastructure generally follows the main roads
- Proximity to Urban Areas – Infrastructure is generally existing
- Proximity to Sandy Beaches – Areas most desirable for development (weighed heavily)
- Land Ownership – Private vs. Crown Lands

The model uses the predictive abilities of the development pressure model to allocate the expected population increase spatially onto the land for the years 2010, 2020, and 2030. The current development footprint on Abaco was determined to be 3.5 persons/acre. For modeling purposes the density was kept consistent with past trends throughout the simulation.

There are several areas that were excluded from the model such as mangroves, swash/swamp areas, and existing protected areas. These are areas that should not be developed regardless of development pressure, but should be reserved to ensure human and ecosystem health. It is recommended that laws and/or policies be passed to prohibit development in these areas.

Criteria

- Sandy Beaches
- Population Projections for 2010, 2020, and 2030
- Development Assessment Model
- Mangroves (Exclusion Layer)
- Swash/Swamp Areas (Exclusion Layer)
- Protected Areas (Exclusion Layer)

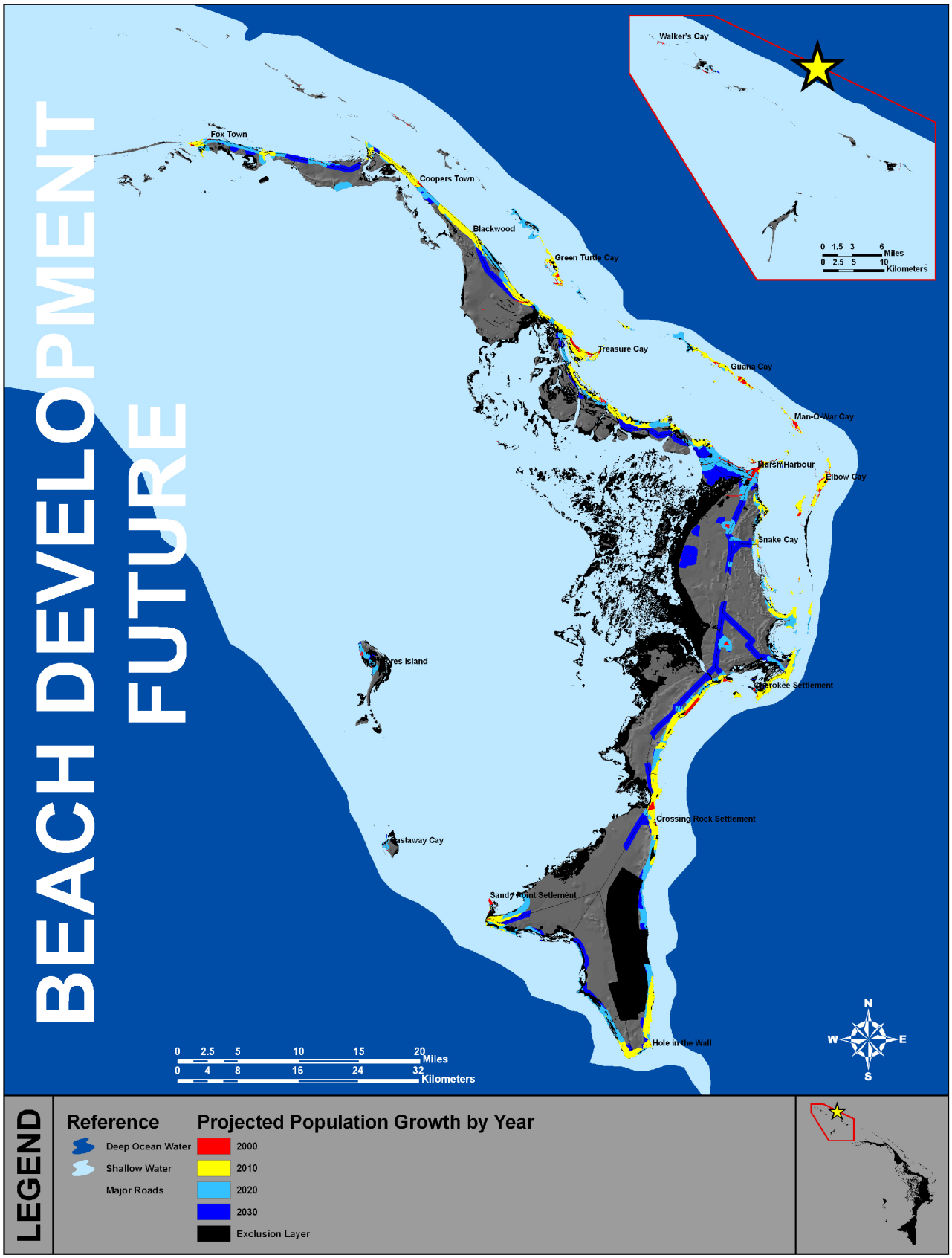
Benefits

The model can help decision-makers and citizens visualize how the island will look if development is taking place primarily along beach front property.

Weaknesses

- Beach information needs to be updated.
- The population projections used are based on the island as a whole between 1990 and 2000, versus population growth by individual settlements which might reveal varying growth rates. The model is numerically accurate in acres consumed by future growth, but may not be spatially accurate with respect to individual communities.

Beach Development


BEACH DEVELOPMENT FUTURE
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Elbow Cay
Snake Cay
Cherokee Settlement
Crossing Rock Settlement
Sandy Point Setlement
Hole in the Wall
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
0 2.5 5 10 15 20 Miles
0 4 8 16 24 32 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Major Roads
Projected Population Growth by Year
2000
2010
2020
2030
Exclusion Layer

POPULATION CAPACITY

The Population Capacity Future model is a build out model of all developable land based on current population density. The current development footprint on Abaco was determined to be 3.5 persons/ acre. For modeling purposes the density was kept consistent with past trends throughout the simulation.

There are several areas that were excluded from the model such as mangroves, swash/swamp areas, and existing protected areas. These are areas that should not be developed regardless of development pressure, but should be reserved to ensure human and ecosystem health. It is recommended that laws and/or policies be passed to prohibit development in these areas.

The result of the model indicates a population of around 72,300 people will fit on the landscape at current density. It should be noted that although this model illustrates build out capacity, it does not take into account other important issues that will likely surface with such a large population on the island. Some of these issues may include: waste disposal, sewer treatment, water quality and quantity, air quality, wildland/urban interface, and transportation.

Criteria

- Entire island
- Mangroves (Exclusion Layer)
- Swash/Swamp Areas (Exclusion Layer)
- Protected Areas (Exclusion Layer)

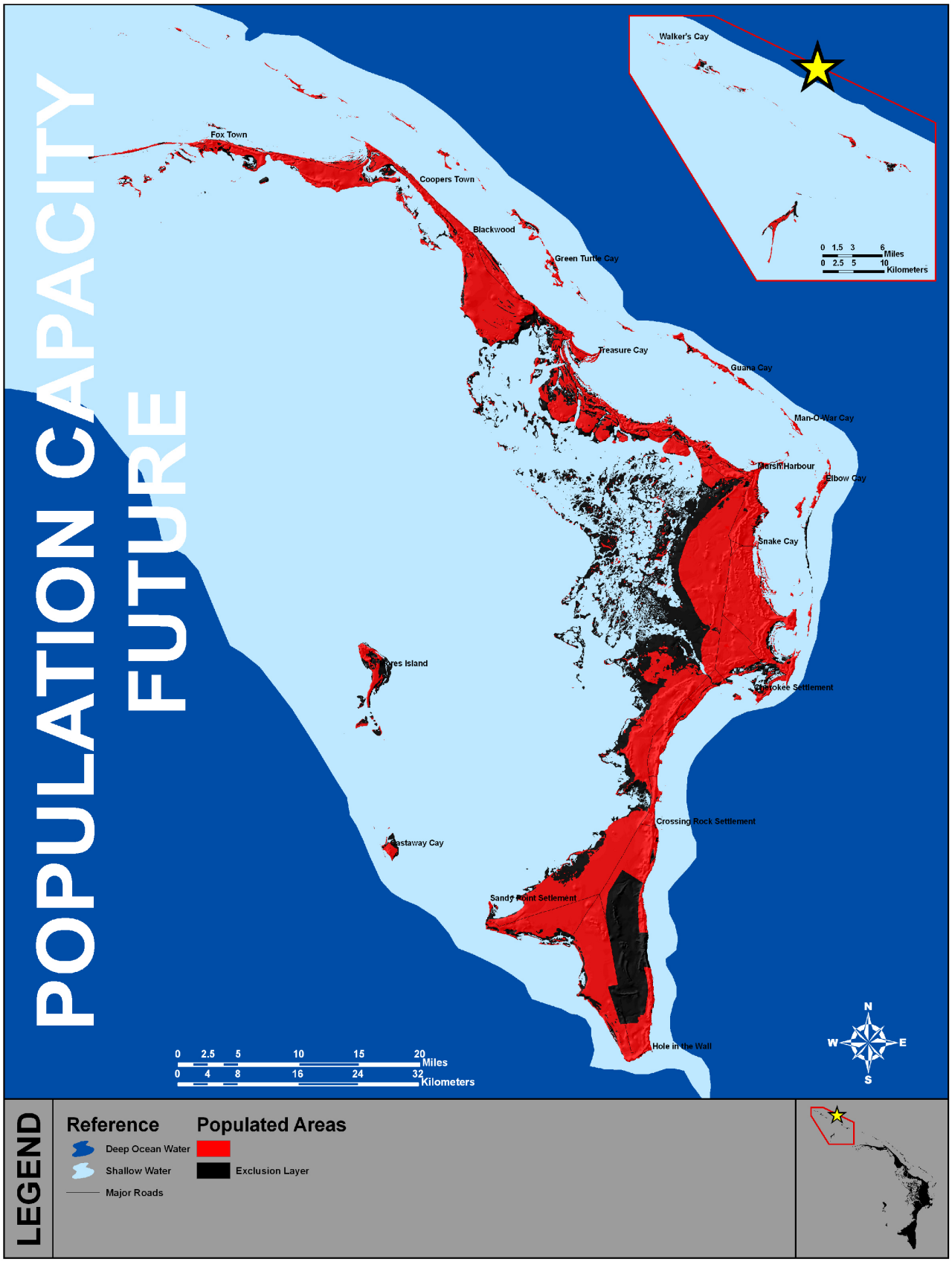
Benefits

This model will help local citizens and decision-makers visualize what the island will look like if all developable land is built on. It will also identify areas that will be lost to development and give insight to zoning and density ordinances.

Weaknesses

Does not take into consideration waste disposal, water resources, environmental impacts, etc.

Nassau, New Providence © Steve Schill


POPULATION CAPACITY
FUTURE
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
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0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
0 2.5 5 10 15 20 Miles
0 4 8 16 24 32 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Major Roads
Populated Areas
Exclusion Layer

CONCEPT EVALUATION

The concept evaluation phase of the methodology was meant to determine if a plan had been created that was consistent with the values of the people of Abaco, and that adequately addressed the issues of concern. The concept evaluation phase can be performed in two ways:

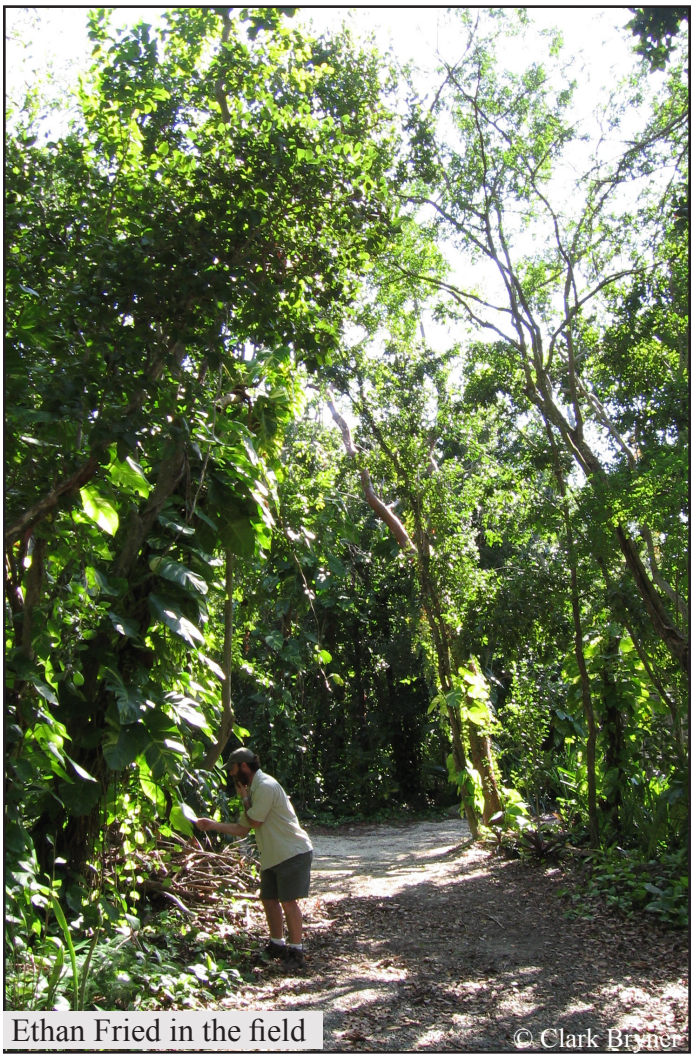
1. Groundtruthing
2. Assessment Models

Groundtruthing consists of going out into the field and visually verifying points identified by the future models on the land. For example, if the model illustrates that an area will likely be built out in the near future. When this area is verified on the land, it becomes apparent that it not only lies in an area that is very vulnerable to hurricanes but also serves as important wildlife habitat. It should be noted from the analysis that this part of that future is not in accordance with the desires of the people. Laws and restrictions should then be put into place in order to prevent the area from being built out.

The use of assessment models as evaluation tools is much more practical than groundtruthing due to the extent of the study area and the time it would take to verify the area physically. Assessment models can be overlain over the top of the future models using GIS techniques. This method will identify areas of overlap and calculate area. Each model is capable of presenting different information, some of it positive and some of it negative. If the future models predict growth to occur in undesirable areas, laws and regulations should be put in place to prevent such actions. If the future models predict growth to occur in areas that are desirable for growth and do not impact other resources valuable to the people of Abaco, this is a good future and laws and regulations should be put in place to ensure that it occurs.

The assessments may determine what parts of different futures are desirable, while others don't address the wishes of Abaco's citizens. The approach used in this study allows for refinements and revisions to take place if needed. The important thing is determining exactly what is desired by the people of Abaco, and then ensuring that this is the future created by zoning ordinances and other land-use regulations.

Three assessment models were chosen to perform an evaluation of the four alternative futures. These were; Conservation, Compatability and Conflict, and Public Health, Welfare and Safety. These models were chosen because they represented the major issues of concern identified by stakeholders. The evaluation is based on acres affected by predicted future growth. When making a final decision however on which future most adequately achieves the desired vision of Abaco residents, a cumulative assessment of all the models should be used.



Ethan Fried in the field

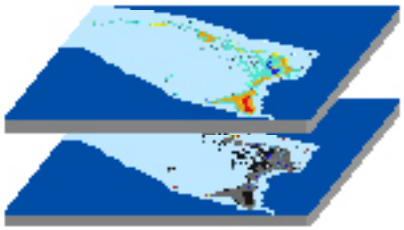
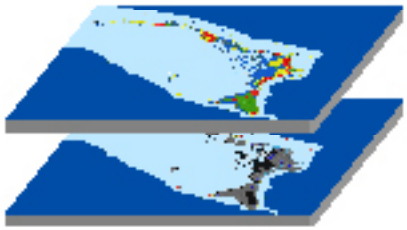
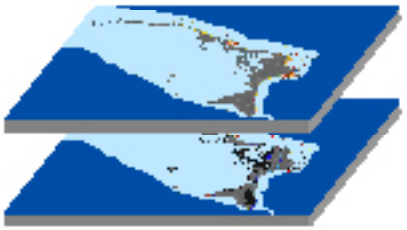




FIGURE 12: PLAN TREND FUTURE ASSESSMENT						
ASSESSMENT MODEL	**2010**		**2020**		**2030**	
CONSERVATION	**Acres**	**% of Pop. Area**	**Acres**	**% of Pop. Area**	**Acres**	**% of Pop. Area**
High	0.20	0.01	0.24	0.01	0.29	0.00
Medium-High	33.87	1.45	42.99	0.99	45.72	0.68
Medium	144.85	6.21	875.84	20.24	1,694.34	25.26
Medium-Low	1,871.10	80.24	3,070.07	70.94	4,406.15	65.69
Low	278.02	11.92	332.37	7.68	553.18	8.25
COMPATABILITY & CONFLICT						
High Conservation/High Development	178.92	7.67	919.07	21.24	1,740.35	25.95
High Conservation/Low Development	0.00	0.00	0.00	0.00	0.00	0.00
Low Conservation/Low Development	2,149.11	92.16	3,402.44	78.62	4,959.34	73.94
Low Conservation/High Development	0.00	0.00	0.00	0.00	0.00	0.00
PUBLIC HEALTH, WELFARE & SAFETY						
Category 1	271.21	11.63	348.43	8.05	412.05	6.14
Category 2	597.64	25.63	818.68	18.92	1,028.00	15.33
Category 3	873.32	37.45	1,210.47	27.97	1,558.43	23.23
Category 4	976.74	41.89	1,355.30	31.32	1,735.52	25.87
Category 5	1,094.63	46.94	1,520.47	35.13	1,932.72	28.81

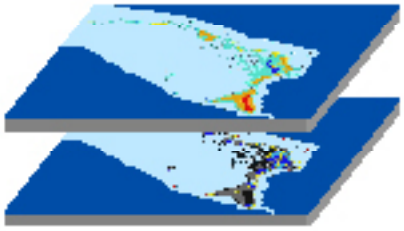
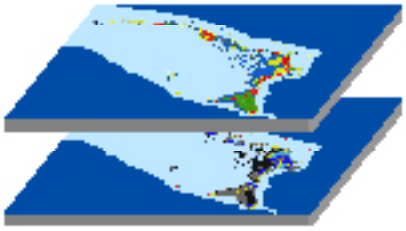
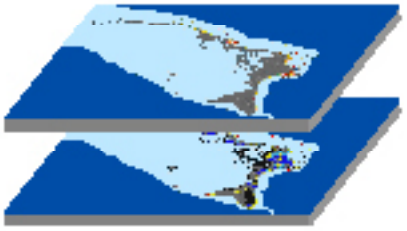




FIGURE 13: DOUBLE POPULATION FUTURE ASSESSMENT						
ASSESSMENT MODEL	**2010**		**2020**		**2030**	
CONSERVATION	**Acres**	**% of Pop. Area**	**Acres**	**% of Pop. Area**	**Acres**	**% of Pop. Area**
High	0.36	0.00	0.78	0.01	2.38	0.02
Medium-High	47.73	0.64	48.02	0.44	48.02	0.30
Medium	2,085.82	27.97	3,534.08	32.06	5,882.97	37.13
Medium-Low	4,754.33	63.74	6,710.74	60.87	8,937.63	56.41
Low	561.66	7.53	720.11	6.53	959.54	6.06
COMPATABILITY & CONFLICT						
High Conservation/High Development	2,133.90	28.61	3,582.87	32.50	5,261.51	33.21
High Conservation/Low Development	0.00	0.00	0.00	0.00	671.99	4.24
Low Conservation/Low Development	5,315.99	71.27	7,430.86	67.40	9,044.58	57.08
Low Conservation/High Development	0.00	0.00	0.00	0.00	852.60	5.38
PUBLIC HEALTH, WELFARE & SAFETY						
Category 1	432.45	5.80	492.92	4.47	513.69	3.24
Category 2	1,077.30	14.44	1,359.46	12.33	1,475.61	9.31
Category 3	1,637.38	21.95	2,062.60	18.71	2,234.00	14.10
Category 4	1,824.86	24.47	2,301.21	20.87	2,492.82	15.73
Category 5	2,028.69	27.20	2,556.87	23.19	2,773.29	17.50

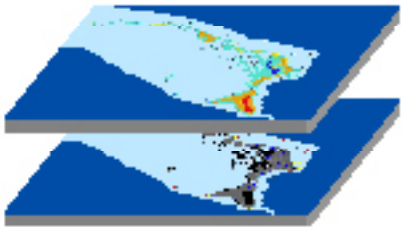
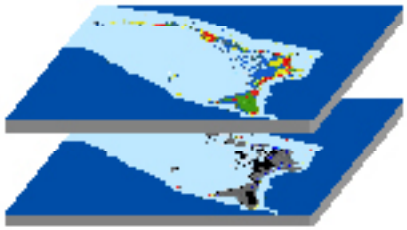
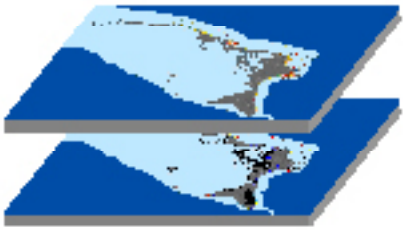




FIGURE 14: BEACH GROWTH FUTURE ASSESSMENT						
ASSESSMENT MODEL	**2010**		**2020**		**2030**	
CONSERVATION	**Acres**	**% of Pop. Area**	**Acres**	**% of Pop. Area**	**Acres**	**% of Pop. Area**
High	0.22	0.01	0.33	0.01	0.33	0.01
Medium-High	47.68	1.99	47.68	1.07	47.73	0.72
Medium	130.08	5.43	476.81	10.70	1,512.00	22.77
Medium-Low	1,937.26	80.90	3,604.60	80.92	4,568.15	68.79
Low	280.06	11.69	316.85	7.11	504.06	7.59
COMPATABILITY & CONFLICT						
High Conservation/High Development	172.36	7.20	524.83	11.78	1,560.06	23.49
High Conservation/Low Development	0.00	0.00	0.00	0.00	0.00	0.00
Low Conservation/Low Development	2,217.32	92.59	3,921.44	88.04	5,072.20	76.38
Low Conservation/High Development	0.00	0.00	0.00	0.00	0.00	0.00
PUBLIC HEALTH, WELFARE & SAFETY						
Category 1	299.61	12.51	411.88	9.25	422.04	6.36
Category 2	654.69	27.34	951.38	21.36	1,035.51	15.59
Category 3	955.36	39.89	1,413.25	31.73	1,576.22	23.74
Category 4	1,061.16	44.31	1,573.96	35.34	1,756.25	26.45
Category 5	1,179.58	49.26	1,746.84	39.22	1,954.56	29.43

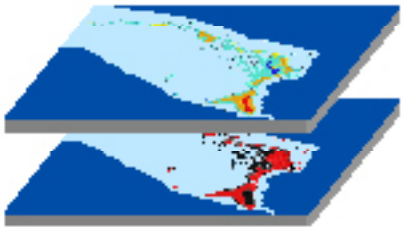
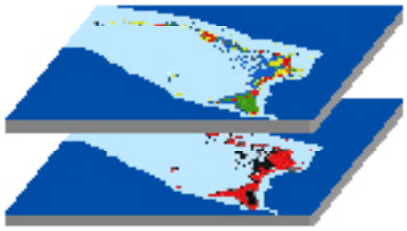
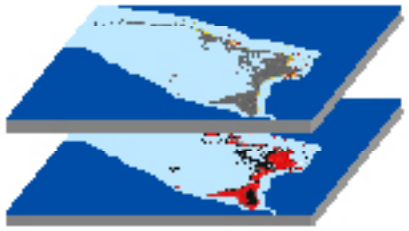




FIGURE 15: POPULATION CAPACITY ASSESSMENT		
ASSESSMENT MODEL	**CAPACITY**	
CONSERVATION	**Acres**	**% of Pop. Area**
High	6.69	0.03
Medium-High	41.50	0.20
Medium	8,718.57	42.17
Medium-Low	11,105.80	53.72
Low	874.83	4.23
COMPATABILITY & CONFLICT		
High Conservation/High Development	5,244.54	25.37
High Conservation/Low Development	3,510.84	16.98
Low Conservation/Low Development	8,805.52	42.59
Low Conservation/High Development	3,094.98	14.97
PUBLIC HEALTH, WELFARE & SAFETY		
Category 1	495.27	2.40
Category 2	1,526.25	7.38
Category 3	2,278.35	11.02
Category 4	2,537.04	12.27
Category 5	2,812.23	13.60

CONCLUSION

The ultimate goal of this report is to promote discussions that will guide planning efforts to create an educated, informed, and publicly supported plan for the future of Abaco. Additionally, it is meant as an information source and tool to be used by elected officials, citizens, and planners to make informed decisions about the future of the area they call home.


Family in Sandypoint © Steve Schill

The models illustrated in this study are conceptual and are dependent on good data. Never the less, they can still be useful. By illustrating and evaluating various future alternatives, elected officials, citizens, and planners will be able to see if their values and visions of Abaco will be maintained in 10, 20, or 50 years.


Restaurant in Hope Town © Kevin Seegmiller

Over the past few decades, tourism developments and second home residents have altered land use and shifted a large part of the local economy. All indications suggest that the trend is likely to continue into the foreseeable future. As such, proactive planning will become increasingly important in the next few years to address many complex and controversial issues such as water quality and quantity, solid and liquid waste disposal, marine resource protection, zoning ordinances, and enforcement.


Beach Development in Hope Town © Clark Bryner

CONCLUSION

For the purpose of providing guidance to the planning process, the following suggestions are recommended:

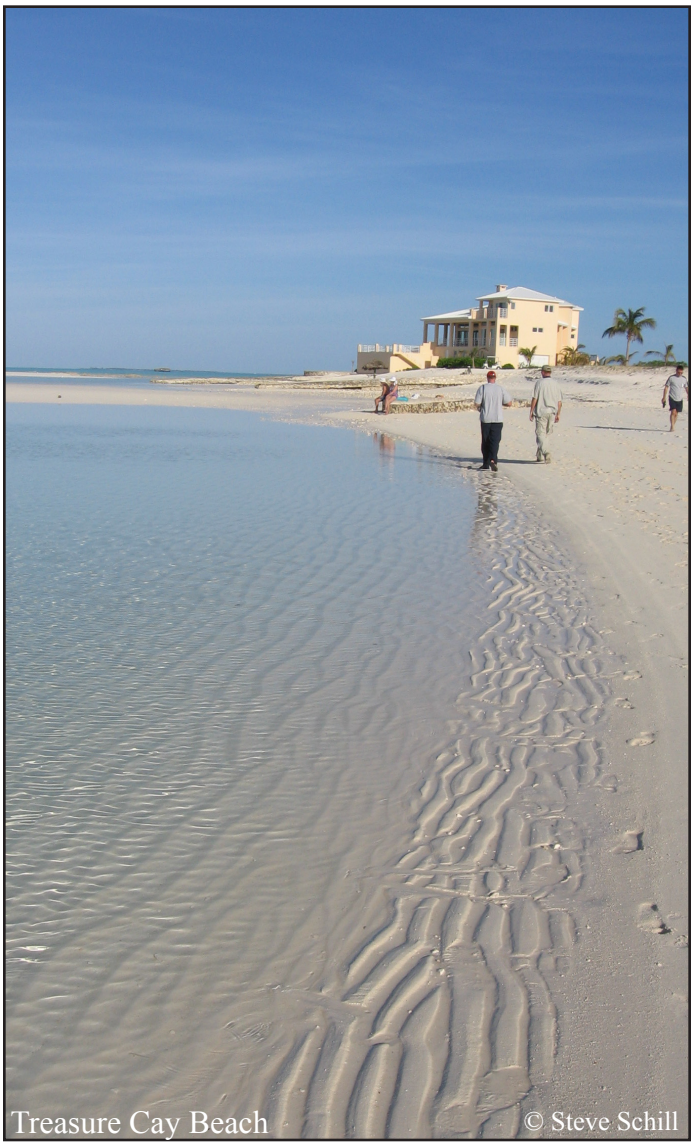
1. **Invest in good, accurate data.** Data should include not only biophysical data, but also social and demographic information.

2. **Share the data.** Once collected, create a data sharing network between various government agencies, stakeholders, and the citizens.


Public Planning Meeting © Steve Schill

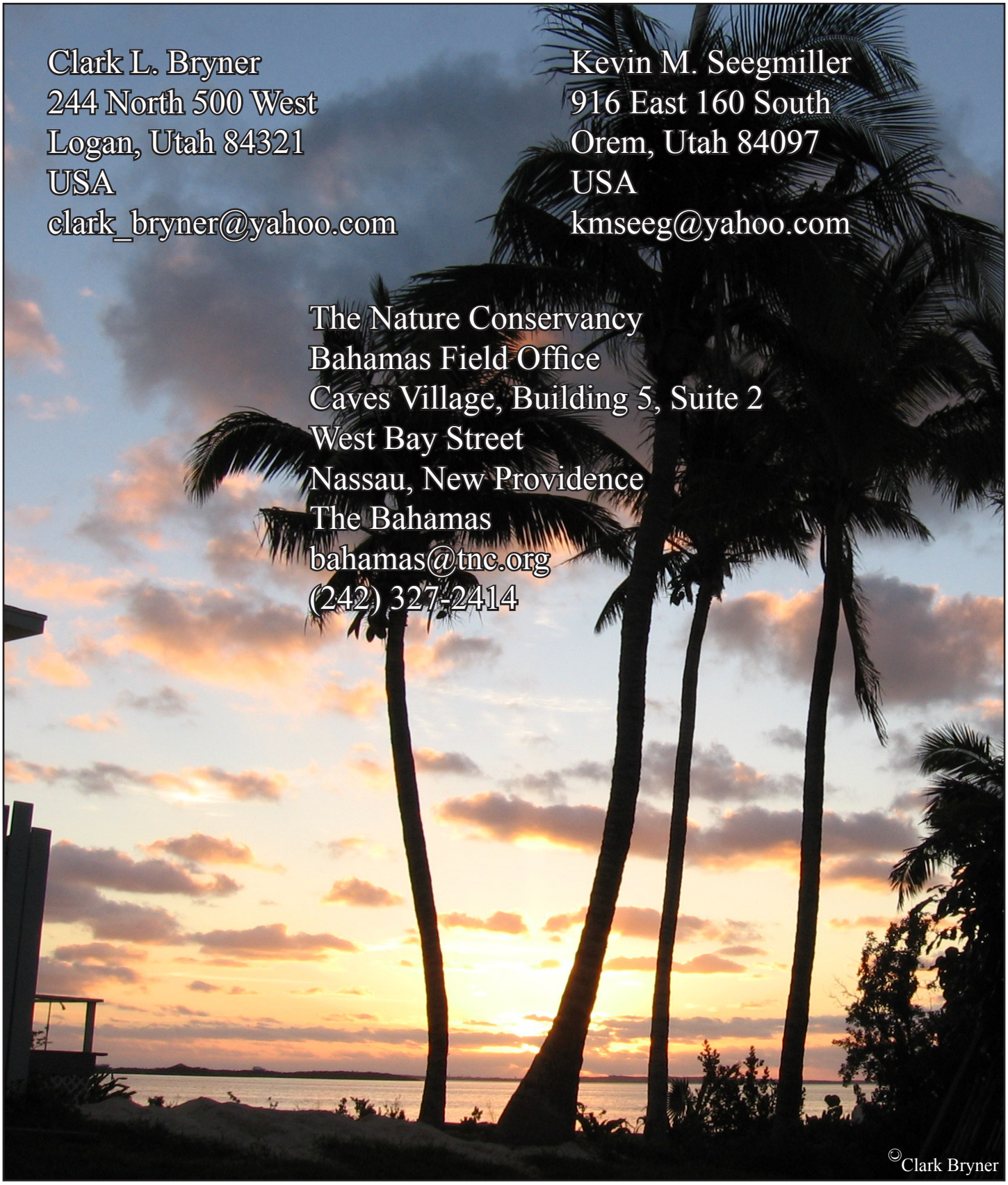
3. **Involve the public.** Include public input (Surveys) in the decision making process. Public meetings should be held before decisions are made and implemented. Discuss the issues. Find out which aspects of the area should be preserved for future generations.

4. **Create plans**. Once the data has been collected and the issues identified, implement urban/regional planning principles to create zoning ordinances and policies to guide planning efforts. The public must support these plans in order for them to be successful.


Treasure Cay Beach © Steve Schill

Abaco and The Bahamas are to be commended for their desire to plan for the future. This study is one of the first of its kind to be carried out in The Bahamas and is only a stepping stone to a better future. Planning for the future today will result in a healthier environment, smarter development and a higher quality of life for many generations to come.

CONTACT INFORMATION



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APPENDICES

IMPLEMENTATION TOOLS AVAILABLE FOR LAND-USE PLANNING IN THE INTERMOUNTAIN WEST OF THE UNITED STATES OF AMERICA

Tools Available to the Public

This report has presented a variety of alternative futures. One of these plans may be desirable by the people of Abaco and its decision makers. If one of these futures is not desirable however, a future which is in accordance with the vision of Abaco's future should be decided upon.

Once a plan has been decided upon, there are a variety of tools which can ensure that the plan is carried out. For the most part the tools outlined in this appendix are not currently available for use on the island of Abaco. These tools and laws have been used effectively in the intermountain west of the United States of America. Each of these tools is meant to compliment existing land-use policy and have been included in this report to stimulate new ideas within the minds of local lawmakers. Some of these policies and tools may or may not be directly applicable to Abaco, as such, they should be taken for what they are worth.

The following list and description of tools was derived mainly from Mechanisms for Protecting Open Space in Utah (Lilieholm and Faulsold, 1999).

Implementation Tools available to Individuals, Governmental Agencies and Non-Governmental Agencies

Conservation Easements

A conservation easement (or conservation restriction) is a legal agreement between a landowner and a land trust or government agency that permanently limits uses of the land in order to protect its conservation values. It allows you to continue to own and use your land and to sell it or pass it on to heirs.

When you donate a conservation easement to a land trust, you give up some of the rights associated with the land. For example, you might give up the right to build additional structures, while retaining the right to grow crops. Future owners also will be bound by the easement's terms. The land trust is responsible for making sure the easement's terms are followed.

Conservation easements offer great flexibility. An easement on property containing rare wildlife habitat might prohibit any development, for example, while one on a farm might allow continued farming and the building of additional agricultural structures. An easement may apply to just a portion of the property, and need not require public access.
A landowner sometimes sells a conservation easement, but usually easements are donated. If the donation benefits the public by permanently protecting important conservation resources and meets other federal tax code requirements—it can qualify as a tax-deductible charitable donation. The amount of the donation is the difference between the land's value with the easement and its value without the easement.

Placing an easement on your property may also result in property tax savings.

Perhaps most important, a conservation easement can be essential for passing land on to the next generation. By removing the land's development potential, the easement lowers its market value, which in turn lowers estate tax. Whether the easement is donated during life or by will, it can make a critical difference in the heirs' ability to keep the land intact
(Land Trust Alliance, 2002).
See the Utah State code for further details.

Purchase of Development Rights

PDR is a voluntary program, where a land trust (see OSU Extension Fact Sheet CDFS 1262-98, Land Trusts) or some other agency usually linked to local government, makes an offer to a landowner to buy the development rights on the parcel. The landowner is free

to turn down the offer, or to try to negotiate a higher price. Once an agreement is made, a permanent deed restriction is placed on the property, which restricts the type of activities that may take place on the land in perpetuity. In this way, a legally binding guarantee is achieved to ensure that the parcel will remain agricultural, or as open (green) space forever. This is because the agency involved retires the development rights upon purchase. The deed restriction may also be referred to as a conservation easement, or, since most PDR programs are designed to preserve agricultural use, an agricultural conservation easement (The Ohio State University, 2002).

Right of First Refusal

A landowner may grant or sell a right of first refusal. The holder of such a right is given the opportunity to purchase the property when it becomes available. This right continues without time limit. When the property is offered for sale, the holder either buys or declines, at which point the property is placed on the open market. This is a common practice in many different arenas of business and the rules are well understood.

Fee Simple Acquisitions

While simply purchasing the land for conservation seems the simplest, it is not without problems. If the land is purchased by a government agency, it is removed from the tax rolls. The agency is also responsible for maintenance and management of the property. It is expensive in terms of money because the agency is purchasing all the rights to the land including those that are not in the public interest. The development rights to the land are still available and at some future time, the owner may decide to develop the land. However, for lands of high development potential and high conservation value, this may well be the best option.

Purchase Options

Somewhat similar to Right of First Refusal, this allows an interested agency to raise the money to purchase land that has become available. The option is usually for a set time, and if not exercised, the option may expire and the money spent on it is lost.

Bargain Sale

A bargain sale represents a compromise between outright donation and fee simple purchase. An agency or organization buys the land or perhaps just the development rights at less than "full market value" after negotiation with the landowner. The difference between full market value and the purchase price is a tax-deductible donation by the owner. Often the tax deduction results the same net financial gain to the seller as if they had sold the property at full market value and the buying organization gains the land for conservation purposes. As with all these tools, the advice of professionals is a wise investment.

Purchase and Sell-Back

After a government or conservation group purchases a property, it severs certain rights-of-development and then sells the land. This removes the development potential of the land and avoids the costs of land management.

Purchase and Lease-Back

Similar to purchase and sell-back, this option allows the owner to draw rent as income on the property. These methods are subject to many provisions of the tax code and the advice of professionals is strongly encouraged.

TOOLS AVAILABLE ONLY TO LOCAL GOVERNMENTS

Special Areas Preservation/Mitigation Programs

These are used in some states to identify important natural resource areas like watersheds. Mitigation measures are defined to ensure that land uses are compatible with the area's ecological function. In Alberta Canada, local volunteer committees examine candidate crown lands for suitable sites to preserve. They help draft management plans including boundary options, management objectives and appropriate land uses for the Minister's approval to ensure ecosystem protection.

Sensitive Land Overlays

Overlay zoning implement specialized standards for unique areas. The purpose of these zoning regulations is the mitigation of natural hazards that may cause loss of life or property. Natural phenomena which could threaten new development include: flooding, ground rupture, slope failure, rock fall, compaction/ consolidation, liquefaction, ground water interception, earthquake damage, and fires. Natural phenomena which could be aggravated by new development include: ground water recharge problems, flooding, soil erosion, wildlife/fisheries habitat reduction, fires, losses of visual quality, and impediments to public access to public resources (Governor's Office of Planning and Budget, 2002).

Exactions and Dedications

Local governments can require land dedications or assess impact fees for the purpose of land conservation. These requirements need to meet certain legal requirements such as proportionality and reasonableness. As you can imagine, these terms have been through the courts in some detail and the advice of legal professionals is highly desirable. See Exactions, Dedications And Impact Fees: Applicability Of Nollan-Dolan Rough Proportionality Requirements To Non-Possessory Exactions And Exactions Imposed By Legislative Enactment for a more complete discussion.

Intergovernmental Agreements

Some states allow jurisdictions to join together to plan and protect open spaces. In Utah, cross-county planning is restricted to the activities of the state's Association of Governments (Lilieholm and Fausold, 1999). Other states recognize that land use planning and open space preservation frequently cross local jurisdictional boundaries and require local government cooperation.

Cluster Zoning and Conservation Subdivisions

Cluster zoning sets a maximum per-acre density for dwellings but allows for closer spacing between homes to encourage open space in other parts of the development. This can reduce infrastructure and maintenance costs as well as increase the value of the homes because of their proximity to open space (Lilieholm and Fausold, 1999; Trust for Public Land, 1999).

Agriculture Land/Open Space Zoning

Open space zoning and exclusive agricultural zoning are two of the most promising method of preserving agricultural land. Open space zoning relies on the principal of cluster development, whereby new homes are clustered onto part of the development parcel. Clustering allows the remainder to be preserved as productive farmland or unbuilt open space. Since only the density and not the number of houses is changed, open space zoning can permanently protect a substantial portion of every development tract's agricultural productivity without decreasing the development potential for both landowner and developer.

Exclusive agricultural zoning is less frequently used than non exclusive zoning such as open space zoning, because it prohibits non agricultural use of the land

within the district. The main advantage is that it ensures there will be no conflict between residential and agricultural uses. However, the ordinances are more difficult to adopt because the farmland owners must forego (often reluctantly) the opportunity to sell their land to residential developers.

A more landowner friendly form of exclusive agricultural zoning is the voluntary creation of agricultural districts. The benefits that farmers obtain by voluntarily joining an agricultural district may include differential assessment, protection against nuisance ordinances, and limits on public investments for nonfarm improvements. Basic standards for reviewing district petitions should be outlined in the County Zoning Ordinance, if not at the state level. Like any zoning ordinance, however, its effectiveness can be undermined by a zoning authority's lax supervision of rezoning and variance requests
(Carver and Yahner, 1996).

The state of Utah has provisions for creating agricultural districts. See http://www.le.state.ut.us/~code/TITLE17/17_21.htm for details.

Impact Fees

Impact fees are gaining in popularity with local governments as a way to finance infrastructure without placing a large burden on existing taxpayers. The fees can be used for basic services such as water, roads, and sewers directly connected with a development or more non-connected projects such as fire stations, parks and other recreational facilities. The fees must meet several standards including reasonableness, fairness and appropriateness (Kolo and Dicker, 1993).

Agriculture Protection Areas

See the discussion for Agriculture Land/Open Space Zoning. The primary difference is that protection areas include protection for farmers from nuisance suits related to their farm activities by local residents. This is not an absolute protection and farmers still need to use Best Management Practices as well as good judgment in their farming operations.

Limited Development

Limited Development is usually associated with a conservation easement. The property owner works together with the holder of the easement to develop plans for the property that will allow limited use compatible with the purpose of the easement. This process has the potential for both income and tax benefits to the property owner (Brandywine Conservancy, 2002).

Land and Mitigation Banking

Land Banking is a way to comply with federal regulations requiring "no net loss" of wetlands or historical function lands. Developers or government agencies purchase land in advance of development projects, construct the necessary wetlands ecosystem and then use the land as an acre-for-acre exchange with properties that result in wetlands loss as they develop. The land banks should be in the same ecosystem as the property they are replacing. The process is subject to a wide range of federal regulations.

Transfer of Development Rights

Transfer of Development Rights uses market forces to help protect land. It is a process that requires significant expertise by the administering agency as well as education of developers and property owners. The process requires a governmental agency to identify land that they desire for conservation (the sending area) as well as land that can be developed to higher density (the receiving area) than would otherwise be allowed. Property owners in the sending area are given development rights that can be sold to developers for use in the receiving area. Boulder Colorado, Maryland, and New Jersey have working programs that have protected over 45,000 acres since 1980.

Urban Growth Boundaries

Urban growth boundaries establish a line around a city within which growth is permitted and outside of which development is prohibited or severely restricted. The reasoning behind the boundary is to control growth to reduce open space loss, sub urbanization and escalating costs of infrastructure. The UGBs can be established by state legislatures as in Oregon, Tennessee and Washington or by local governments as in California (Staley and Milder, 1999). Like any tool to control growth, the boundaries need to be revised from time to time as development occurs. UGBs can be implemented through zoning which is reversible or by conservation easements that are permanent.

Performance Zoning

Performance Zoning seeks to specify the intensity of use of land rather than the permitted uses of a parcel. The intent is to preserve the community vision of the area while allowing developers to be innovative in how the vision is carried out.
The process is more flexible and more judgment intensive on the part of the zoning administrators (Eastern Michigan University, 2002).

Preferential Tax Assessments

Preferential Tax assessments base tax levies on current use rather than "highest and best use". This encourages land to stay in agriculture or open space rather than be developed to pay for the higher taxes. Iowa began such a program in 1955. As experience accumulated, they noticed that while farmers did receive the tax break, land conversion to development did not slow down. After some experimentation, a new process was developed. Land is placed in restrictive agreements where owners agree not to develop the land for ten years. Each year the land remains in the agreement, the time period is automatically extended another year. The result is that if a developer buys the land, they must hold it for ten years before developing it, a generally prohibitive arrangement. Under this program, farmland conversion has slowed substantially in Iowa (Edelman, 1998).

Building Moratorium

Building moratoriums are frequently used to allow planners to "catch up" with growth. Local governments generally impose the moratoriums when the current building permit process is inadequate to control development or when general plans for the area are being developed or revised. Unfortunately, moratoriums do nothing to prevent previously issued building permits or approved plans. Developers will frequently rush through a mass of projects if they get wind that a moratorium is planned. The Supreme Court (U.S. Supreme Court, 2001) recently ruled that moratoriums do not constitute a "taking" under the Constitution and are a legal and sometimes appropriate means of controlling growth. Utah limits moratoriums to six months, whereas other states have limits that vary.

Transfer Development Taxes/Conversion Taxes

This type of tax is focused on land conversion and development. Taxes are assessed and paid when open space land is developed. They are intended to discourage land conversion and can be used to pay for the increased municipal cost of development. They are not currently available in Utah (Lilieholm and Fausold, 1999).

Abaco Field Trip, Over-Flight, and Public/ Stakeholder Meetings
February 15-22, 2006

Summary

In order to gain a better understanding of the how the landscape of Abaco works, what its components are, and how they interact, it was important to experience the study area firsthand through a site visit. The trip began with two days in Nassau where we interviewed various government officials and presented the results of our digitizing efforts. The next four days we spent on Abaco (actual study area) where we traveled the island and met with key stakeholders. Visiting the Bahamas accomplished the following objectives:

1. set the context and scale of the study area
2. determined which issues needed to be addressed in the analysis stage of the project
3. identified which types of data were needed for future work
4. relax on the beach and go snorkeling

The following outlines the trip.

Wednesday 15th

Arrival to Nassau

Thursday 16th

I. Meeting with Financial Services and Investments

- Approved projects and proposals are identified in investment newspaper/ magazine
- Policies that guide development found at investbahamas.org
- Most projects are from foreign investors; primarily hotels and second home development
- Investors look for beach front properties and areas to put in marinas
- Crown land is most likely given to large projects (not easy to do); land transfer governed through Department of Lands and Surveys
- Numerous small developments on Cay areas, maybe faster than inland except for Treasure Cay area
- Passerine and Bakers Bay project held up in court; majority of protestors are local residents
- Politics, losing money, and overstaffing forcing government out of hotel/resort business
- Infrastructure expansion run by a government cooperation; cost is negotiated between investor and government
- At least 20 resorts in Marsh Harbor and 12 in Treasure Cay and surrounding area
- Many high end developments; clubs may not be open to public
- All land sales and building permits go through central government if foreign investment is involved
- Stamp tax of 10% applies to all foreign land exchanges

Issues

- Even with all the development, need to bring in foreign labor; hard to get qualified employees (unemployment is 10%)
- Public access to beach areas is becoming limited and is an issue with the locals, especially if they've used it for a long time
- Affordable housing for native, normal working people
- Extensive building on Cays
- Abaco currently has enough people to man resorts, but may not in the future.

What needs to change?

- Planning efforts
- Take infrastructure and other things into consideration with planning

II. Meeting with Director of Physical Planning, Nassau

- Include an inset of northern cays in study and map (Walkers Cay and Scottland Cay)
- Bahamas Land Use Planning Act of 1961 controls land
- Environmental Impact Assessment (EIA) is required on sensitive land; application process reviewed by BEST committee
- Abaco will continue to grow; northern cays threat for development
- Listing of subdivisions

Issues

- Public access to beaches is a big issue
- All decisions are made on a case by case basis; no real zoning on Abaco

III. Meeting with Botanist from University of Tampa

- Heavy pine woodland cutting in 1960's; left two or three seedlings; hurricane blew over and killed seedlings
- Recommended combining coppice, whiteland, and scrubland into a Dry Broadleaf Evergreen Formation (DBEF) because they encompass the same species
- Bahama Parrot primarily use pine woodlands; coppice in winter
- Horse issue: non-native, non-indigenous, health issues, rough terrain
- No red list of endangered or endemic species; very little quantitative data
- Only native mammal is hutia; other animals include feral pigs (valuable resources for hunters) inhabit coppice and perhaps pine areas, snakes (few subspecies), parrots (threats from feral cats and raccoons).
- Dune and coastal areas are most likely to be altered; being invade by casuarinas
- Mangroves are being blocked by roads and causeways
- Boar (non-native) is valuable resource to hunters; coppice habitat and maybe pine
- Kirtland's Warbler- endangered, need DBEF
- Mangroves- red (right in water or submerged in brackish to full saline); most common is red sprinkled with black
- Priority areas based on vulnerability and geographic range include: beaches, mangrove, coppice, pineland
  Preservation of dunes (beach)
- High density, not scattered
- Place structures on stilts in vicinity of dune
- Only remove vegetation within perimeter of house
- Only use native plants

IV. Meeting with Department of Meteorology

- Marsh Harbor flooded ½ mile inland and five feet high
- Average storm surge is 8-12', up to 18-20' above mean sea level
- East side of island will have highest storm surge
- Wind damage from hurricanes
- Concerned with sea level rising
- Hurricane insurance- no benefit/consideration given to those who protect house (buy hurricane shutters); if one does and neighbor doesn't, cost is split and premium goes up.
- Currently working on SLOSH models
- Category 5 – Storm surge estimate: 20+ (none in recent years)
- Category 4 - Storm surge estimate; 15-20' (Floyd in 1990)
- Category 2 or 3- Storm surge estimate: 10-15'

- Category 1 - Storm surge estimate: minimal to 6'
- Add 3-6' to storm surge at high tide
- Contact insurance clearing house to identify hazardous areas

Ideas

- Hurricane Surge Model – Map elevation of surge with DEM and surge occurring on east side of island

Friday 17th

V. Meeting with Bakers Bay Development

- Abaconians are considered by other islands as being extreme loyalists; very homogenous and "fiercely independent."
- If protesters go to court, they are heard
- Development brings impacts which can be mitigated, but there are trade-offs.
- U.S. immigration to Guana Cay; okay we're here, let's not anyone else come
- Bakers Bay has already spent $2 million on beach restoration
- Lawsuit on Guana Cay is basically coming from three "street" people
- Bakers Bay- low density 1.16 acres/lot, with 350 lots on 600 acres, 70 acres placed in reserve; local politics are changing
- Technical expertise is lacking
- Using the Florida codes for building and design. Florida building code 2004 edition and Palm Beach amendment codes 2004 edition
- Hurricane mitigation used: 1) restore dunes 2) maintain coppice and pine 3) don't clear all vegetation 4) concrete construction

VI. Meeting with Director at the Bahamas National GIS Centre

- We shared the results of our digitizing effort; overviewed the project at Utah State; discussed plans for Abaco
- Desire to coordinate data acquisition and sharing
- Frustrated lack of planning

Models Desired

- Land Suitability
- Critical resources
- Wetlands

VII. Meeting with Water and Sewage Corporation

- Water recharge zones are everywhere but specifically at the toe of slopes
- Ground water within 3-5 feet from surface; same as septic tanks
- Freshwater lens is very fragmented
- Most of the freshwater lens is under pine barrens
- Andros provides water for New Providence but if something happened, Abaco would be the provider
- All fresh water lens is owned by the government

Issues

- If Bahamas goes strictly RO people may feel it's not important to protect fresh water lens
- Overdrawing will pull in saltwater
- Contamination from septic tanks
- Saltwater and waste contamination from storm surges

Concerns of Abaco

- Absence of ground water protection regulations
- No forestry act
- Septic tanks and other environmental concerns

- Sea water inundation
- Over extraction
- Development

Saturday 18th

VIII. Day in the field

- Get a better feel for the terrestrial environment
- Collect data points for major habitat types to be mapped using Landsat
-

Sunday 19th

IX. Day in the field

- Get a better feel for the terrestrial environment, tidal creeks, and mangroves
- Collect data points for major habitat types to be mapped using Landsat
- Look at areas with free flowing creeks and others that have been blocked due to poor road and general development practices
- Valuable to identify tall mangrove areas (most important)
- Vastly over fished
- Anytime you get a carved out deep channel, you'll get better mangrove growth
- Dwarf mangrove experience more shallow sheet flooding
- Limiting factors include tidal flow disturbance and over fishing

Monday 20th

X. Meeting with Key Stakeholders

Department of Agriculture

- Water resources
- How agriculture lands have changed?
- Has forestry health/area changed?
- What areas of forest should we be concerned with protected?

Bahamas Agriculture Industrial Corporation (BAIC)

- Concerned about what types of areas should be preserved for the future (wetlands and mangroves)
- Bakers Bay Development is too large
- Would like to see more development in northern Abaco, to provide economic stability and jobs to this region

Department of Environmental Health

- Want input in government decisions about development
- Want to be able to access data and give data freely
- Want areas near beach to be mapped
- Map large developments
- Map infrastructure
- Want gas stations, graveyards, and dump sites mapped to know if they affect water quality
- Health clinics accessible to all
- Which wetlands are the most important; also mosquito problems
- Wants government to build landfill

Bahamas Electric Company

- Can get us information on distribution systems, underwater cable to Cays, location for new power station

Port of Department

- Problems with dock development
- Don't understand how docks effect beach development
- No regulation
- Concern of beach erosion caused by development
- If you own property, you have a right to build a dock

- Both sides of any dock will erode

Department of Fisheries

- Mangroves extremely important for fisheries
- Interested in any sort of mangrove and wetland destruction
- Where underwater electrical lines are laid to see if lines are damaging reef areas
- Effects of development on coral reefs
- Identified main fishing areas
- 95% of all commercial fishermen fish in waters less than 30 feet
- No plans for a Marine Protected Areas (MPA); BNT-Pelican Cay areas and waters are protected
- Looked at Bite of Oral Robinson for putting a Marine Park – has mangroves, sea grass beds, deep water, pools: very good for MAP
- Proposal looked good to scientists, local support, opposition from those who fished there
- Serious problems with poachers
- Enforcement a big problem

The Abaconian

- People want a reserve but NIMBY (Not In My Backyard)
- Problem with different government agencies not talking to each other; lack of effort and thought in planning
- Concern about water conservation, at the moment there's a lot but what about in 50 years
- Coastal lands important for fish, habitat, and also development
- Infrastructure, water lines, electricity lines, ferry boats, fire hydrants, fire in slums – 150 people displaced, beach erosion, fish conservation areas
- There is a proposed park North of Hope Town

Ministry of Tourism

- Importance of all coastal and marine areas
- Entire economy is based on sun, sand, and sea

Riviere & Associates

- Works with award programs for kids
- Like to hike on trails
- Wants access to map with all roads

Public

- Concerned with development in critical lands
- Islands are fragile because they're small
- Very little monitoring
- Towns up north would like to see large grocery store, hardware stores
- Want a hospital in Marsh Harbor
- Most homes are on .5 acre lots but are being divided because of $
- Want to stay low density
- Concerned about sewage disposal, garbage disposal, water supply
- Once a fire starts, it burns until it stops; lack of resources to fight fire
- Big need for coastal management
- Enforcement a huge issues
- Education a massive issue

Ministry of Works and Utilities

- Can't build within 100-300 feet of high water mark
- 200 foot buffer around wetlands
- Drill 100-150 feet for liquid waste disposal, should be below fresh water table; he's never seen a drill rig on Abaco
- Water contamination problem
- Wetlands need to be protected; people start filling wetlands and building on them
- If you have a wetland on your property, you can do anything you like with it

Hope Town District Commissioner

- Local government only 12 years old
- White paper plan for sustainable development
- Working on wetland and coastal protection, waste management
- Hope Town District would regulate
- Need to maintain historic and cultural heritage
- Abaco wants to provide a different vacation opportunity than Nassau
- Abaco is the boating capital of the Bahamas
- Open discussions regarding zoning within the community
- There is no law that truly says what you can and can't do with mangroves, wetlands. Legislation is vague and broad in some areas.

Vision of Abaco

- Don't want Abaco to be like Nassau
- Each community will have a different long range plans
- More protected areas, wetlands, good forested lands
- More economic growth in North Abaco to empower the people of the north with financial prosperity.


ABACO:
POINTS OF INTEREST
Walker's Cay
Fox Town
Coopers Town
Blackwood
Green Turtle Cay
Treasure Cay
Guana Cay
Man-O-War Cay
Marsh Harbour
Elbow Cay
Snake Cay
Moores Island
Cherokee Settlement
Crossing Rock Settlement
Castaway Cay
Sandy Point Setlement
Hole in the Wall
0 1.5 3 6 Miles
0 2.5 5 10 Kilometers
0 2.5 5 10 15 20 Miles
0 4 8 16 24 32 Kilometers
N
W
E
S
LEGEND
Reference
Deep Ocean Water
Shallow Water
Major Roads
Cemetery
Garbage Dump
Gas Station
Health Clinic

BAHAMAS TERRESTRIAL THREATENED AND ENDANGERED SPECIES

Amazona leucocephala CUBAN PARROT (E)

Ammodramus caudacutus SALTMARSH SHARP-TAILED SPARROW (E)

Anthus spragueii SPRAGUE'S PIPIT (E)

Brachyphylla nana CUBAN FRUIT-EATING BAT (E)

Caretta caretta LOGGERHEAD (E)

Cesonia irvingi KEY GNAPHOSID SPIDER (E)

Chelonia mydas GREEN TURTLE (E)

Chlorostilbon bracei BRACE'S EMERALD (E)

Chlorostilbon elegans GOULD'S EMERALD (E)

Coccothrinax inaguensis THATCH PALM (E)

Cyclura carinata BAHAMAS ROCK IGUANA (E)

Cyclura cychlura NORTHERN BAHAMIAN ROCK IGUANA (E)

Cyclura rileyi ACKLIN'S GROUND IGUANA (E)

Dendroica cerulea CERULEAN WARBLER (E)

Dendroica kirtlandii KIRTLAND'S WARBLER (E)

Dermochelys coriacea LEATHERBACK (E)

Eretmochelys imbricata HAWKSBILL TURTLE (E)

Geocapromys ingrahami BAHAMIAN HUTIA (E)

Guaiacum officinale COMMONER LIGNUM VITAE (E)

Guaiacum sanctum HOLYWOOD LIGNUM VITAE (E)

Mellisuga helenae BEE HUMMINGBIRD (E)

Monachus tropicalis CARIBBEAN MONK SEAL (E)

Natalus tumidifrons BAHAMAN FUNNEL-EARED BAT (E)

Nyctiellus lepidus GERVAIS'S FUNNEL-EARED BAT (E)

Passerina ciris PAINTED BUNTING (E)

Patagioenas leucocephala WHITE-CROWNED PIGEON (E)

Procyon maynardi BAHAMAN RACCOON (E)

Pterodroma cahow BERMUDA PETREL (E)

Pterodroma hasitata BLACK-CAPPED PETREL (E)

Swietenia mahagoni AMERICAN MAHOGANY (E)

Tachycineta cyaneoviridis BAHAMA SWALLOW (E)

Tadarida brasiliensis BRAZILIAN FREE-TAILED BAT (E)

Trachemys stejnegeri CENTRAL ANTILLEAN SLIDER (E)

Tryngites subruficollis BUFF-BREASTED SANDPIPER (E)

Tyrannus cubensis GIANT KINGBIRD (E)

Vermivora bachmanii BACHMAN'S WARBLER (E)

Vermivora chrysoptera GOLDEN-WINGED WARBLER (E)

Zanthoxylum flavum WEST INDIAN SATINWOOD (E)

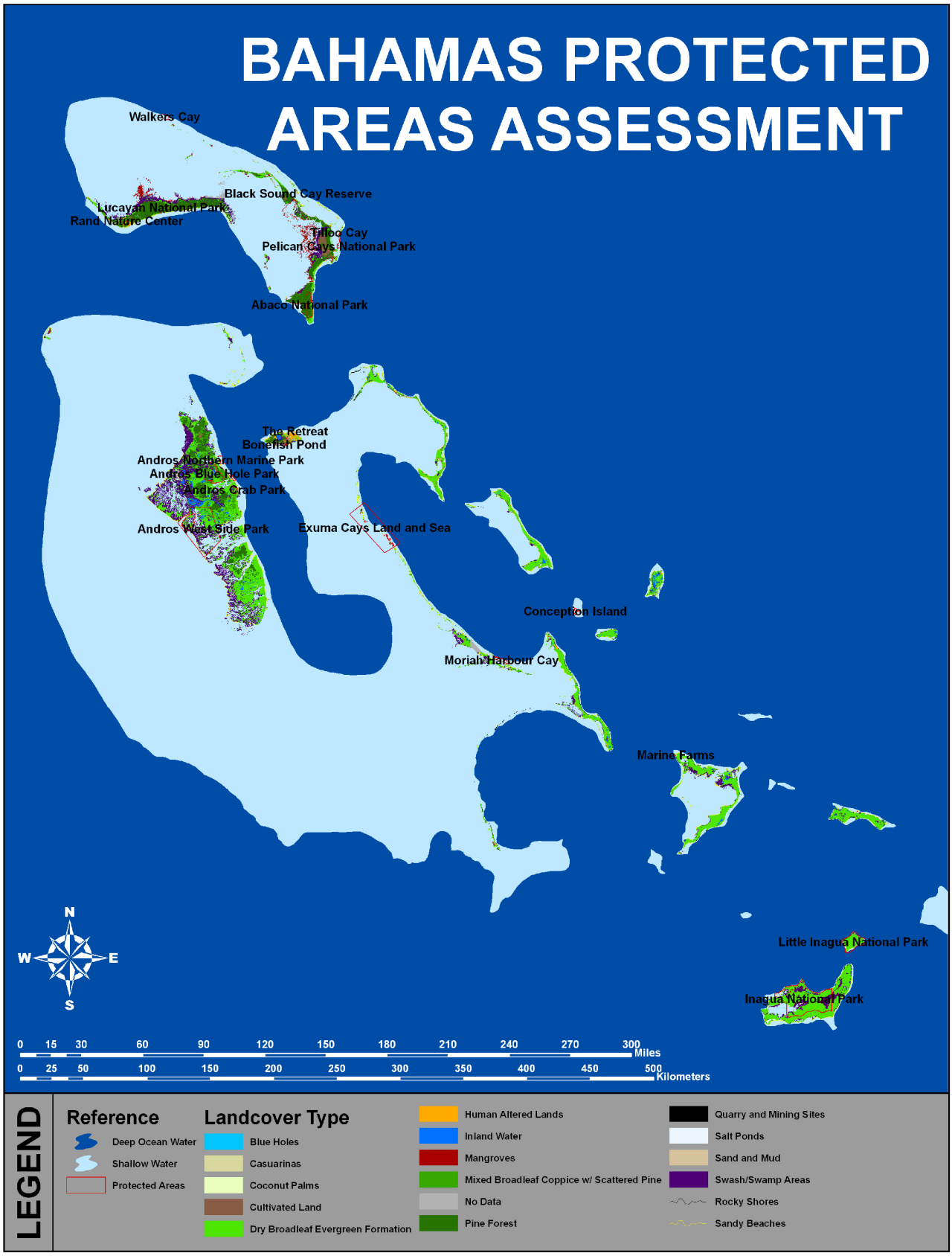
Citation: IUCN 2006. 2006 IUCN Red List of Threatened Species. <www.iucnredlist.org>. Downloaded on 09 May 2006.

In order to preserve species biodiversity for future generations the Bahamas National Trust and The Nature Conservancy have a primary goal of protecting 10% of every terrestrial habitat in The Bahamas and a secondary goal of protecting 25% of every terrestrial habitat within The Bahamas.

The national parks in Abaco represent only a portion of the areas throughout the nation that have been set aside for conservation. An assessment of all of the habitats being protected in The Bahamas currently can inform us of the progress being made in order to reach this goal. The assessment of protected areas can help identify which habitats are not being well represented within the current protected areas system in order to identify new areas that might be considered for protection in order to conserve a balanced sample of all habitats.

NATIONAL PARK NAME	LOCATION	MARINE	ESTABLISHED	MANAGEMENT	HECTARES	ACRES
Andros West Side Park	Andros	Y	2002	Bahamas National Trust	68,257	168,667
Bonefish Pond	New Providence	Y	2002	Bahamas National Trust	440	1,086
Exuma Cays Land and Sea	Exuma	Y	1958	Bahamas National Trust	59,545	147,139
Conception Island	North of Rum Cay	Y	1971	Bahamas National Trust	937	2,315
Conception Island	North of Rum Cay	Y	1971	Bahamas National Trust	30	75
Little Inagua National Park	Inagua	Y	2002	Bahamas National Trust	16,854	41,646
Harold and Wilson Pond	New Providence	N	2002	Bahamas National Trust	81	200
The Retreat	New Providence	N	1977	Bahamas National Trust	6	15
Peterson Cay	Grand Bahama	N	1968	Bahamas National Trust	1	3
Pelican Cays National Park	Abaco	Y	1972	Bahamas National Trust	878	2,169
Andros Northern Marine Park	Andros	Y	2002	Bahamas National Trust	1,666	4,118
Andros Southern Marine Park	Andros	Y	2002	Bahamas National Trust	1,170	2,892
Andros Crab Park	Andros	N	2002	Bahamas National Trust	1,372	3,390
Andros Blue Hole Park	Andros	N	2002	Bahamas National Trust	13,469	33,283
Abaco National Park	Abaco	N	1994	Bahamas National Trust	8,179	20,211
Black Sound Cay Reserve	Abaco	Y	1988	Bahamas National Trust	1	2
Inagua National Park	Inagua	Y	1965	Bahamas National Trust	78,018	192,785
Great Hope House	Crooked Island	N	2002	Bahamas National Trust	2	4
Marine Farms	Crooked Island	N	2002	Bahamas National Trust	2	5
Moriah Harbour Cay	Exuma	Y	2002	Bahamas National Trust	2,388	5,900
Primeval Forest	New Providence	N	2002	Bahamas National Trust	1	2
Rand Nature Center	Grand Bahama	N	1992	Bahamas National Trust	40	99
Lucayan National Park	Grand Bahama	Y	1977	Bahamas National Trust	25	61
Walkers Cay	Abaco	Y	2002	Bahamas National Trust	1,866	4,612
Tilloo Cay	Abaco	N	1990	Bahamas National Trust	1	2

LAND COVER	Acres/ Hectares Protected	Acres/ Hectares Total	% Protected
Blue Holes	125/ 51	1050/ 425	11.905
Dry Broadleaf Evergreen Formation (DBEF)	221,012/ 89,440	1,438,270/ 582,047	15.367
Mangroves	4,998/ 2,023	90,643/ 36,682	5.514
Pine Woodland	20,029/ 8,106	442,204/ 178,954	4.529
Sandy Beaches	N/A	N/A	N/A


BAHAMAS PROTECTED AREAS ASSESSMENT
Walkers Cay
Black Sound Cay Reserve
Lucayan National Park
Rand Nature Center
Tilloo Cay
Pelican Cays National Park
Abaco National Park
The Retreat
Bonefish Pond
Andros Northern Marine Park
Andros Blue Hole Park
Andros Crab Park
Andros West Side Park
Exuma Cays Land and Sea
Conception Island
Moriah Harbour Cay
Marine Farms
Little Inagua National Park
Inagua National Park
N
W
E
S
0 15 30 60 90 120 150 180 210 240 270 300 Miles
0 25 50 100 150 200 250 300 350 400 450 500 Kilometers
LEGEND
Reference
Deep Ocean Water
Shallow Water
Protected Areas
Landcover Type
Blue Holes
Casuarinas
Coconut Palms
Cultivated Land
Dry Broadleaf Evergreen Formation
Human Altered Lands
Inland Water
Mangroves
Mixed Broadleaf Coppice w/ Scattered Pine
No Data
Pine Forest
Quarry and Mining Sites
Salt Ponds
Sand and Mud
Swash/Swamp Areas
Rocky Shores
Sandy Beaches

The following is a time line of notable dates and events which related Abaco's history:

- 1492 Columbus encounters the Bahamas while looking for a route to India.
- 1550 Lucayan Indians no longer in evidence in The Bahamas; decimated by disease and slavery by Spanish.
- 1783 Loyalists arrived at Carleton, San Salvador, having left New York.
- 1718 Charles Van, "Vane the Great Pirate" headed for Green Turtle after plundering two ships.
- 1784 A rebellious group from Carleton, settled in Marsh Harbor; total population reported to be 658 with two thirds in Marsh Harbor.
- 1785 Hope Town Settled by Wyannie Malone.
- 1820 Man-O-War founded; economy based on fishing and farming. Boat building began in mid-century.
- 1820 Guana Cay and Cherokee believed founded.
- 1838 Emancipation of slaves; Abaco population was 499 white, 61 free blacks, 351 black slaves.
- 1870 Sandy Point settled within a year or two of this date.
- 1895 Population of Hope Town District was almost 1200.
- 1912 Wilson city lumber employed 540 persons.
- 1920 First wireless telegraph on Abaco in Hope Town.
- 1925 Norman's Castle lumber mill had 400 employees and 250 houses.
- 1926 October hurricane surge flooded Marsh Harbor, 6ft followed by 20 feet, many drowned.
- 1959 Snake Cay Owens-Illinois pulpwood operation moves in fall to Snake Cay from Riding Point, Grand Bahama.
- 1959 Abaco road network began by Owens-Illinois reputed to total 1600 miles including wood logging roads.
- 1964 Pigeon Pea Haitian settlement in Marsh Harbor settled in early 60's as worker housing for S & M Farms.
- 1967 Owens Illinois sugar mill began operating, exchanged logging lease for 20,000 acres of cane fields.
- 1969 Public water system installed in Marsh Harbor
- 1973 Independence from Great Britain, July 10

Timeline source compiled from Ralph, 2001.

We used Marxan spatial optimization software to select a set of sites on the landscape that most efficiently represent terrestrial conservation features ("targets"). The Marxan software allows us to identify a near-optimal spatial solution to the complex problem of simultaneously meeting representation goals for multiple targets, while minimizing the total area of the landscape required doing so.

Marxan software requires the user to specify multiple parameters that control the model output. The parameters that were specified for the Abaco analyses include: number of repeat model runs, boundary length modifier ("BLM", influences spatial contiguity of the model results), algorithm type (and additional parameters specific to the chosen algorithm), status of input planning units (whether a planning unit is a model seed, locked in, locked out, or unconstrained), the "cost" of selecting any particular planning unit for inclusion in the final portfolio), and the specific representation goals for each conservation target. A Human Activity Surface (HAS) was created for Abaco Island using the following "threat" sources and modeling an intensity value and distance of influence. The resultant surface was summarized by planning unit (mean value) and used as "cost" in the MARXAN model.

Threat Source	Distance of Influence	Intensity
Roads; main	120m	25
Casuarina	120m	5
Human Altered - AG	210m	17
Urban	210m	17
Hotels; >16 rooms	150m	17 and 25
Landfill Sites	120m	25
Airport	120m	35
Mining	210m	30
Gas Stations	120m	35
Marinas	210m	35
Golf Courses	210m	35

Below is a list of the major parameters that were specified for the terrestrial Marxan model runs:

GOAL: 10% and Adaptive for all targets
PROTECTED AREAS locked in
BLM 100 (cost surface ranged from 26-130, thus required a high BLM)
TARGETS for the following habitats that were mapped from the 2001 Landsat imagery:

TARGET NAME	HECTARES	GOAL 10	GOAL Adaptive	Adaptive %
Dense Pine	35288	3529	7058	20
Tall Mangrove	3312	331	662	20
Freshwater Marsh	1835	184	367	20
Rocky Shores	86	9	21	25
Sandy Beaches	292	29	87	30
Blue Hole	8	1	3	40
DBEF	12789	1279	3837	30
Dwarf Mangrove	19332	1933	3866	20

One of these parameters in particular, the Boundary Length Modifier (BLM), strongly influences the spatial configuration of the planning units that are selected as the solution set of the model. High BLM values force the clustering of the solution set, whereas low BLM values allow for a more fragmented set of planning units to be selected as a model solution. This parameter has been the subject of much discussion regarding the proper values to specify for a given analysis. There is no hard rule as to what BLM value makes the most sense in a given situation. The level of clustering that makes the most sense depends on the objectives of the analysis. Some features of interest for conservation may be best protected in many disjoint reserves, where as others are best protected in large contiguous areas on the landscape. The actual value that is specified for the BLM parameter is somewhat arbitrary and must be decided upon through a process of trial and error. The following is a brief discussion of the rationale behind the use of BLM values for these terrestrial Marxan runs.

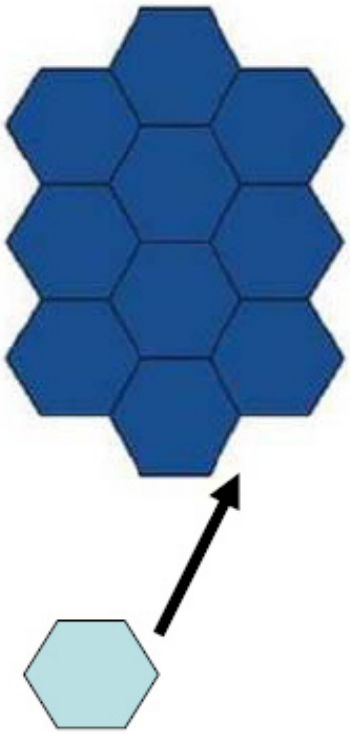
The Marxan objective function is to minimize the overall "cost" of a "portfolio" of planning units, where cost is measured as:

Σ (boundary length cost * BLM) + Σ(planning unit cost) + Σ(target penalty cost)

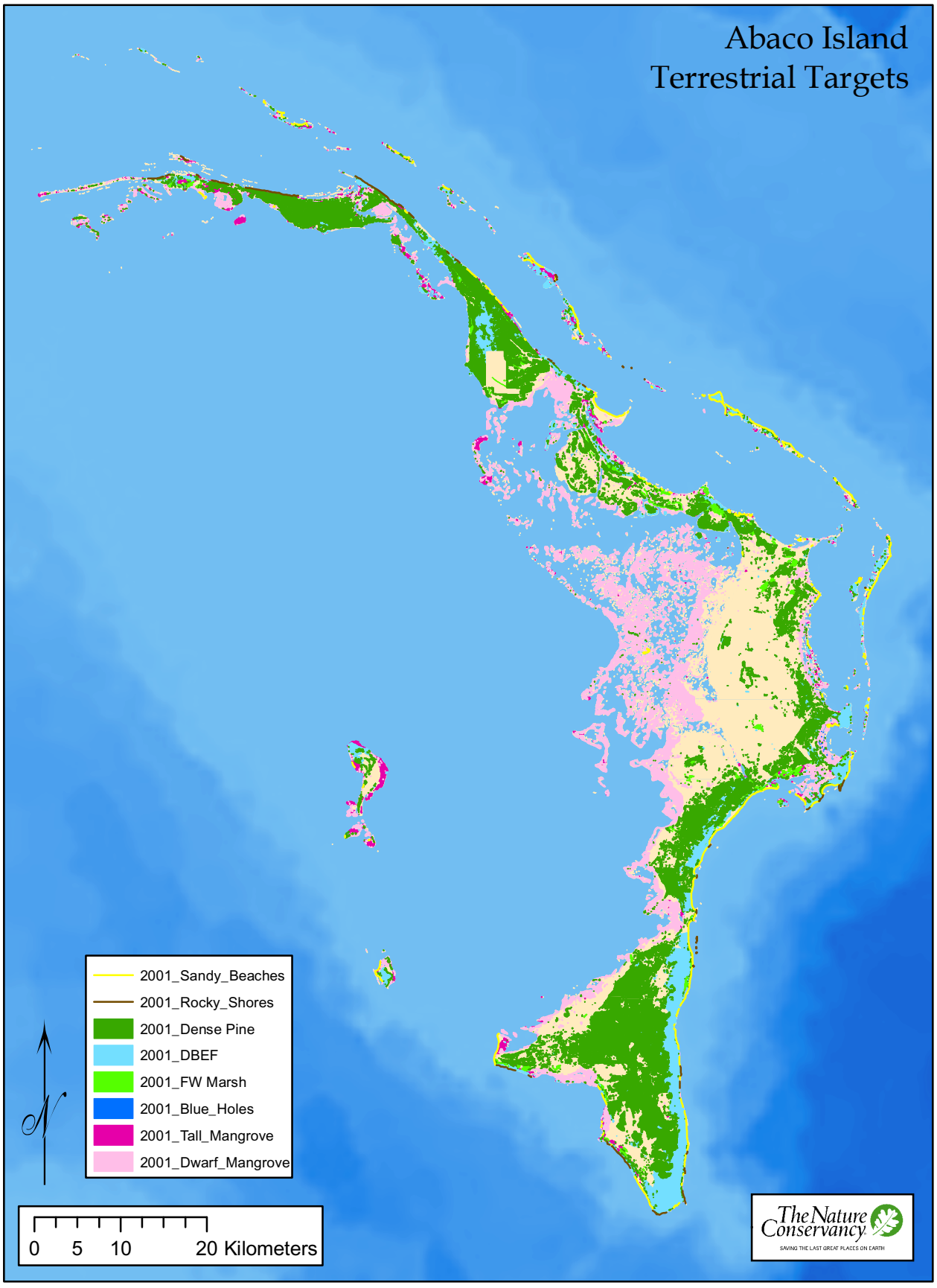
Theoretically, Marxan will choose the set of planning units that best minimize all of these types of cost, while simultaneously solving for the various target representation goals. The BLM (boundary length modifier) parameter is the multiplicative factor that is used in order to convert units of boundary length to a range that more closely matches the other cost units in the model. If the units of boundary length are much larger than the units of planning unit (PU) cost, then the Marxan output will appear spatially clustered. In this scenario, selecting a solution set that minimizes total boundary length more efficiently reduces the overall cost of the solution than does simply minimizing the selection of planning units that have PU costs associated with them. One side effect of forcing a clustered result through the application of a high BLM is that many planning units that have

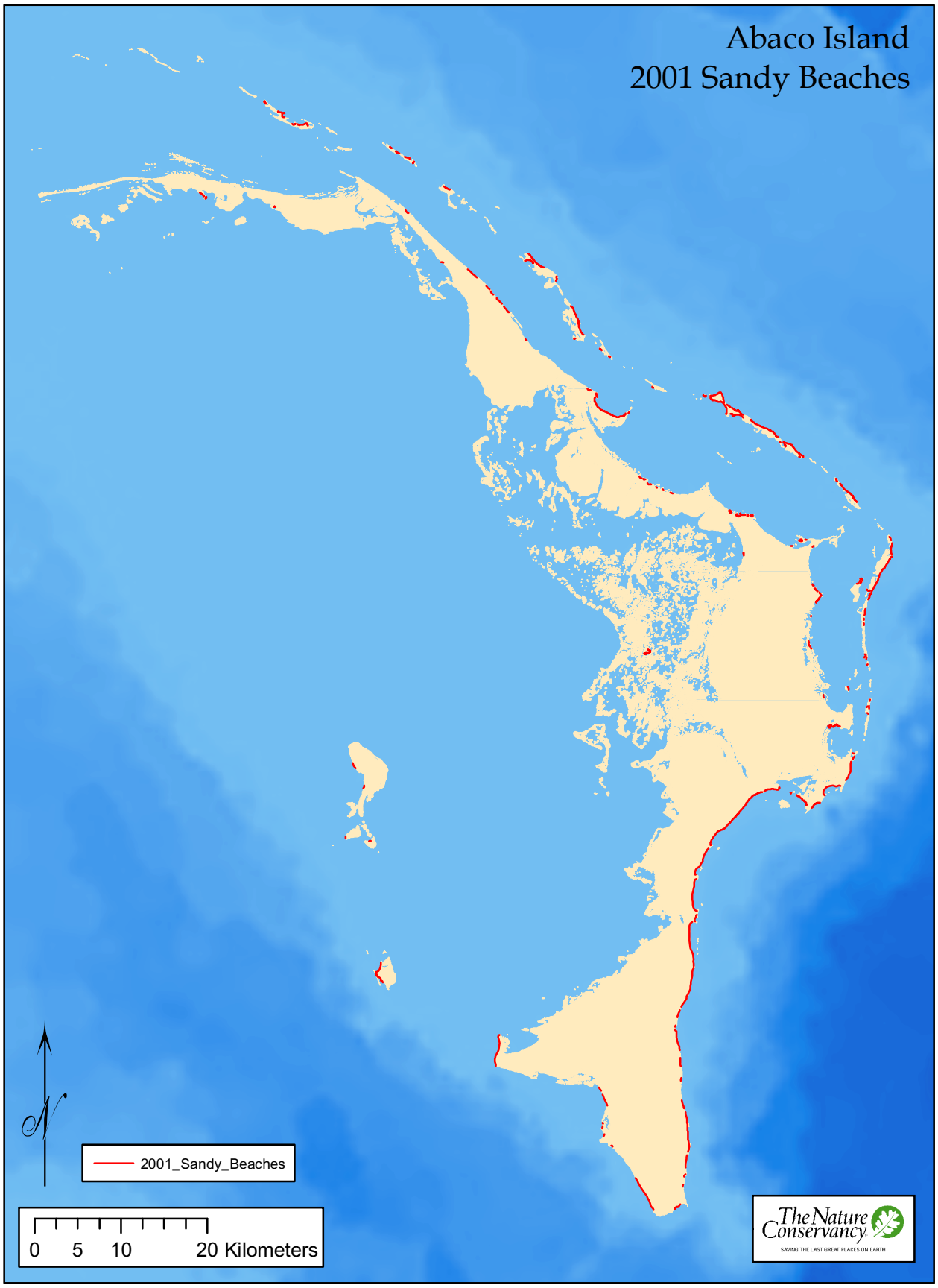
high PU cost may also be included in the solution set. Conversely, if the units of PU cost are much larger than the units of boundary length, then Marxan will get a better reduction in overall cost by minimizing the number of units that have high levels of PU cost. The PU cost would then override any potential clustering effect from the BLM, and the solution may be more fragmented spatially (this may or may not be the case, depending on the spatial configuration of the units with high PU cost).

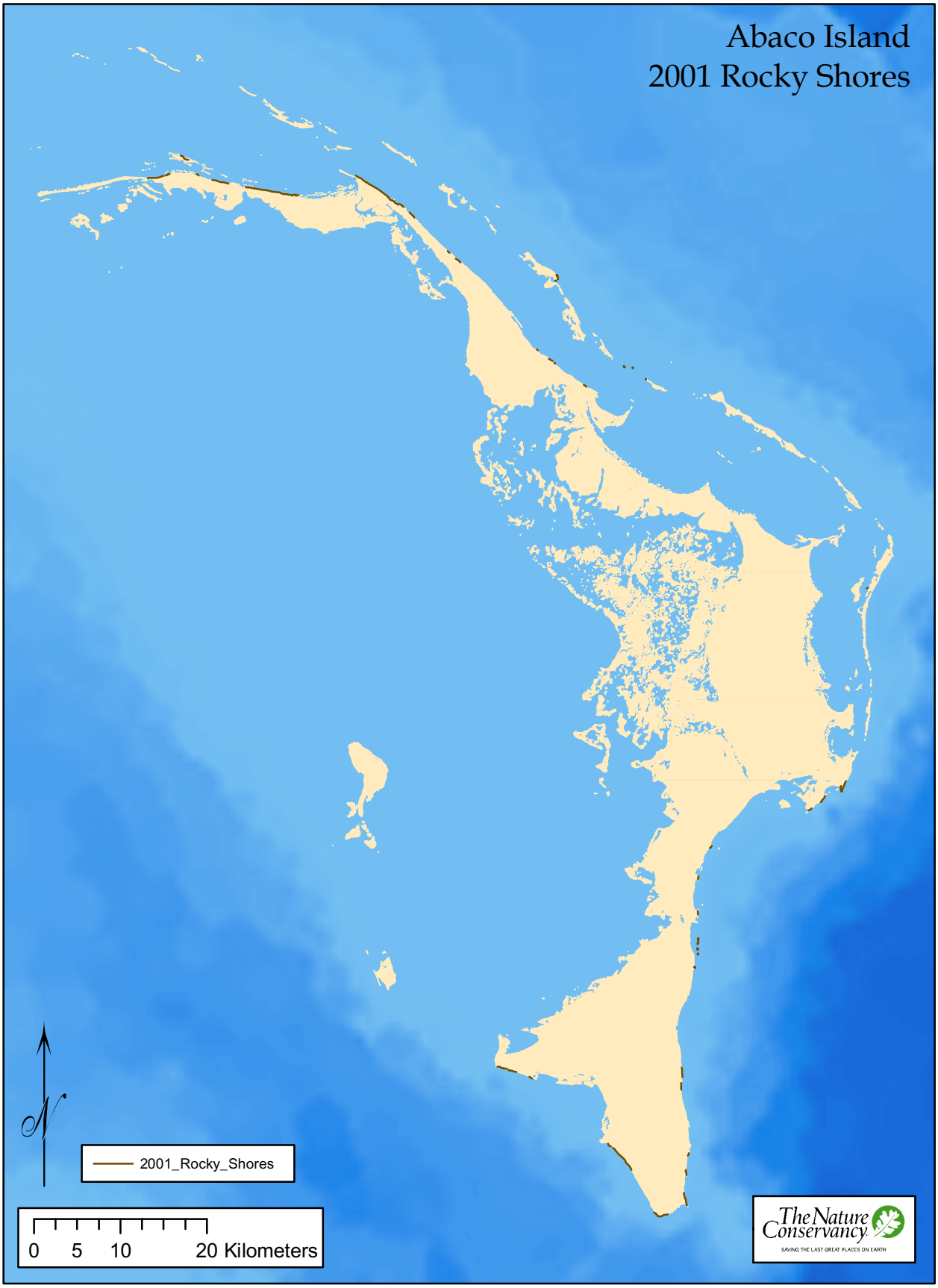
The relationship between the size of the boundary length units and the units of PU cost determines whether the model will strongly avoid solutions with high boundary cost, or avoid solutions with high PU cost. Since the actual PU cost values may be non-intuitive, the decision of how best to scale these units relative to each other can be difficult to make, and generally involves trial and error. We assumed that, in most cases, a PU that is added to an existing cluster of 2 or more PUs will share two edges with the existing cluster, as shown below.

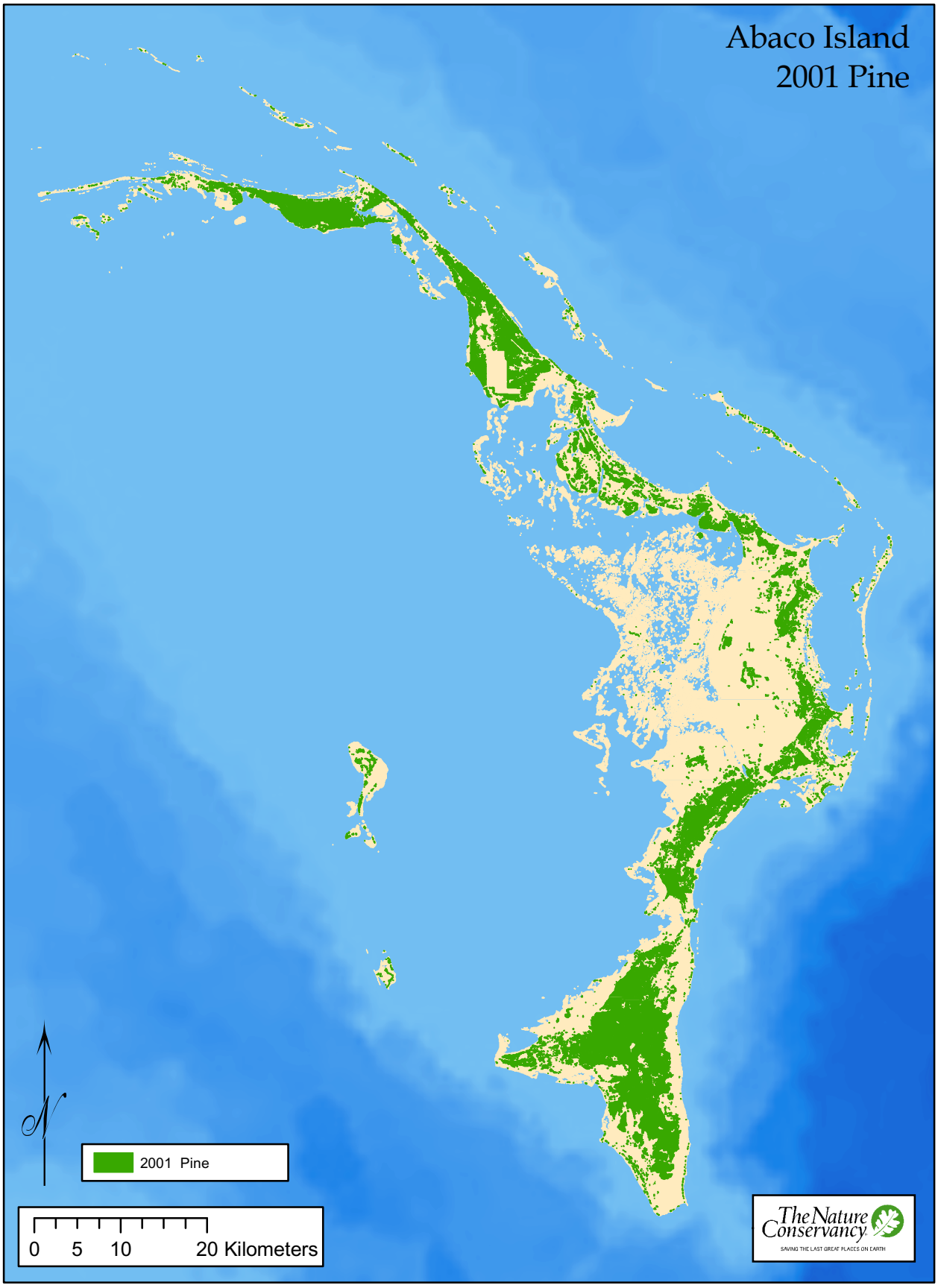


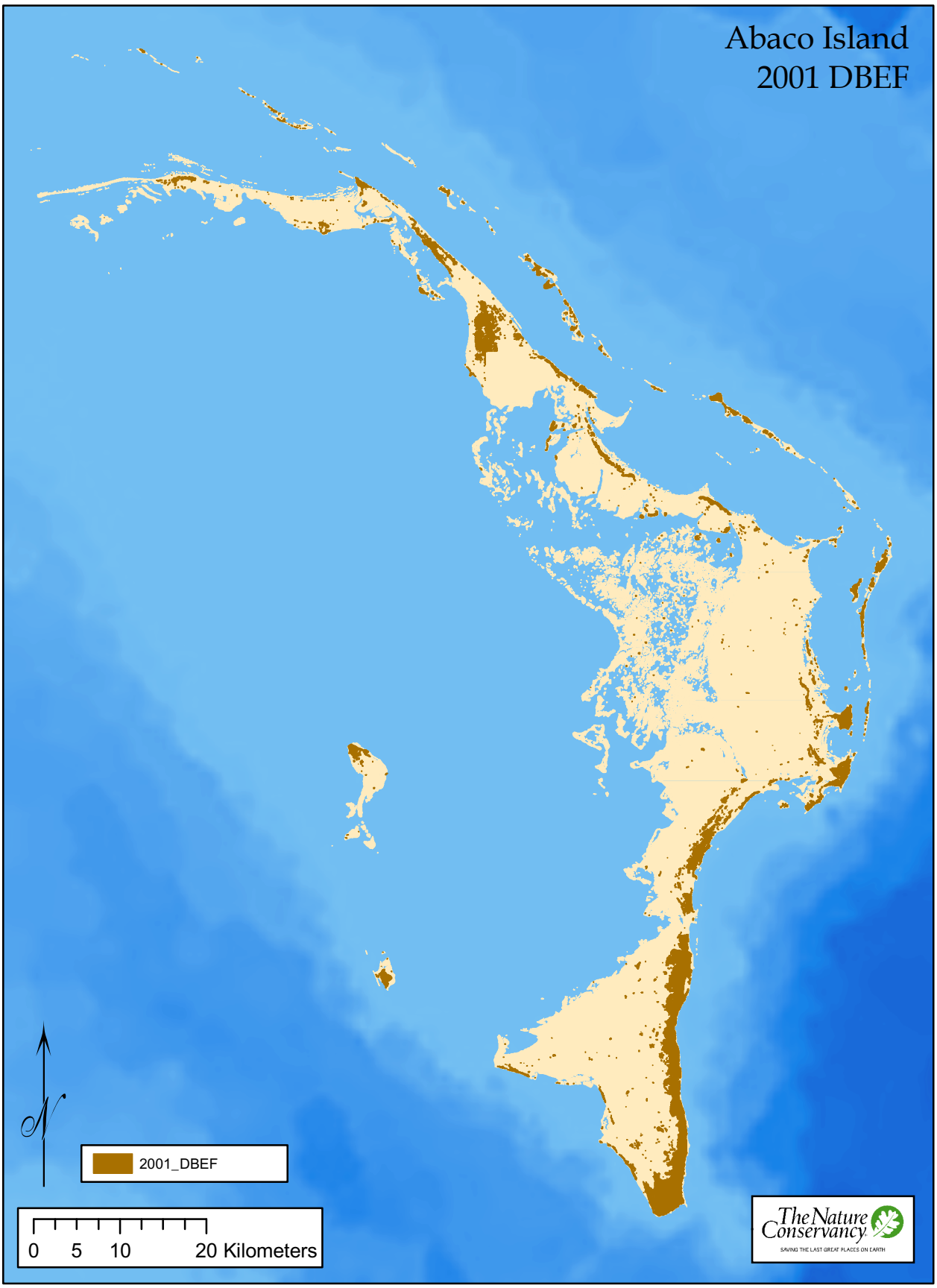
If that planning unit has PU cost associated with it that is much greater than 2 edges worth of boundary length, then the model may avoid that PU regardless of the potential loss of 2 edges worth of boundary cost. It may be less costly to choose a stand-alone PU that adds 6 edges worth of cost, but has less PU cost. The approach we took was to initially parameterize the Marxan runs using a BLM that balances 2 edges of boundary length to the median PU cost (human impacts) found across all of the planning units. The assumption is that 1/2 of the units will have enough cost to override the clustering effect, and 1/2 of the units have too little cost to override the clustering effect. This BLM level should yield a result that balances the efficient representation of targets (at the desired goal levels) with the avoidance of planning units that have high PU cost, while generating a solution set that is made up of contiguous groups of planning units. The optimal BLM for this analysis was 100 and was selected based on multiple trial and error runs. Maps are included in this appendix showing all input targets, Human Activity Surface (HAS), and MARXAN results for the two goal scenarios.

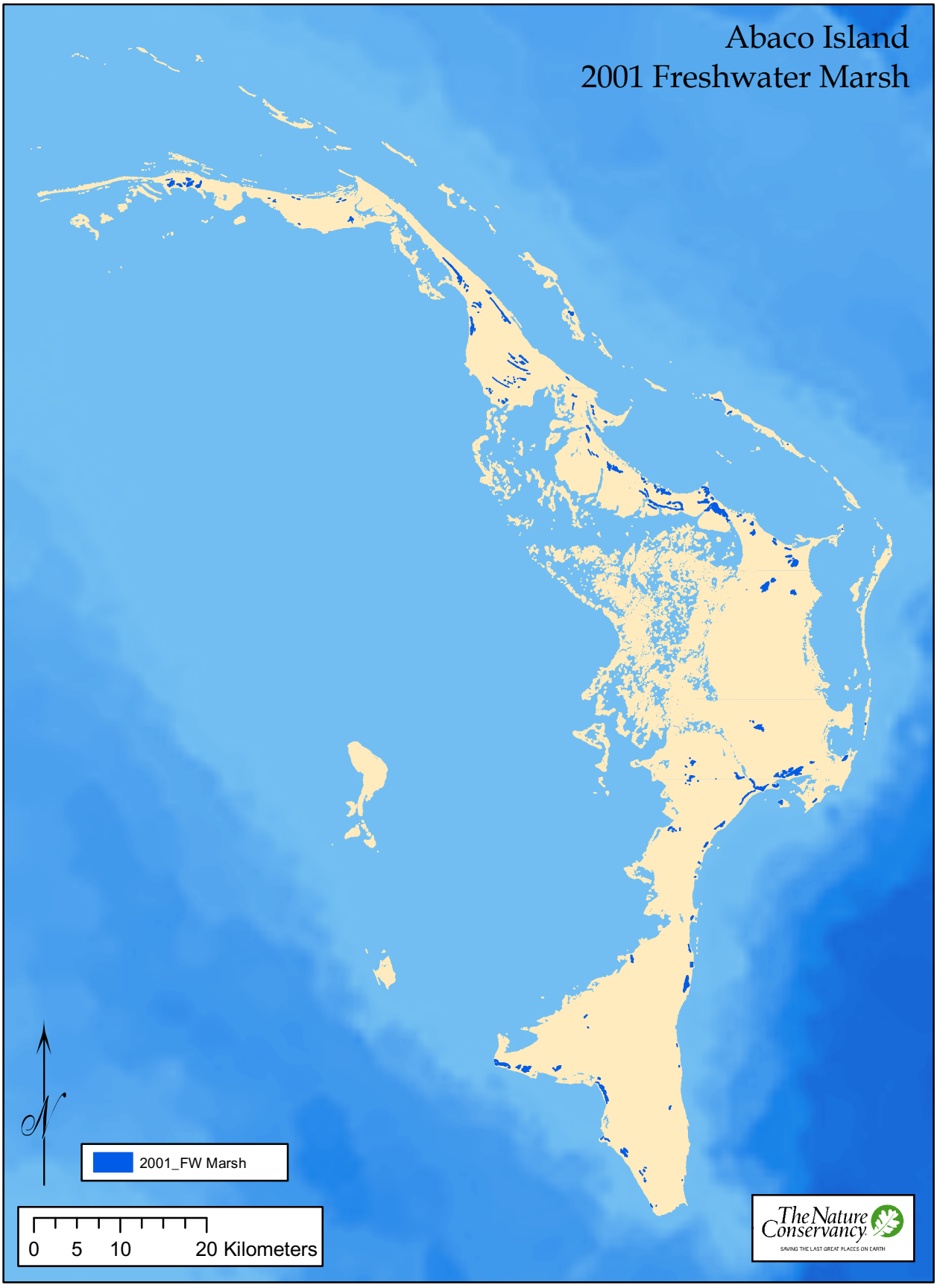

Abaco Island
Terrestrial Targets
2001_Sandy_Beaches
2001_Rocky_Shores
2001_Dense Pine
2001_DBEF
2001_FW Marsh
2001_Blue_Holes
2001_Tall_Mangrove
2001_Dwarf_Mangrove
N
0 5 10 20 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

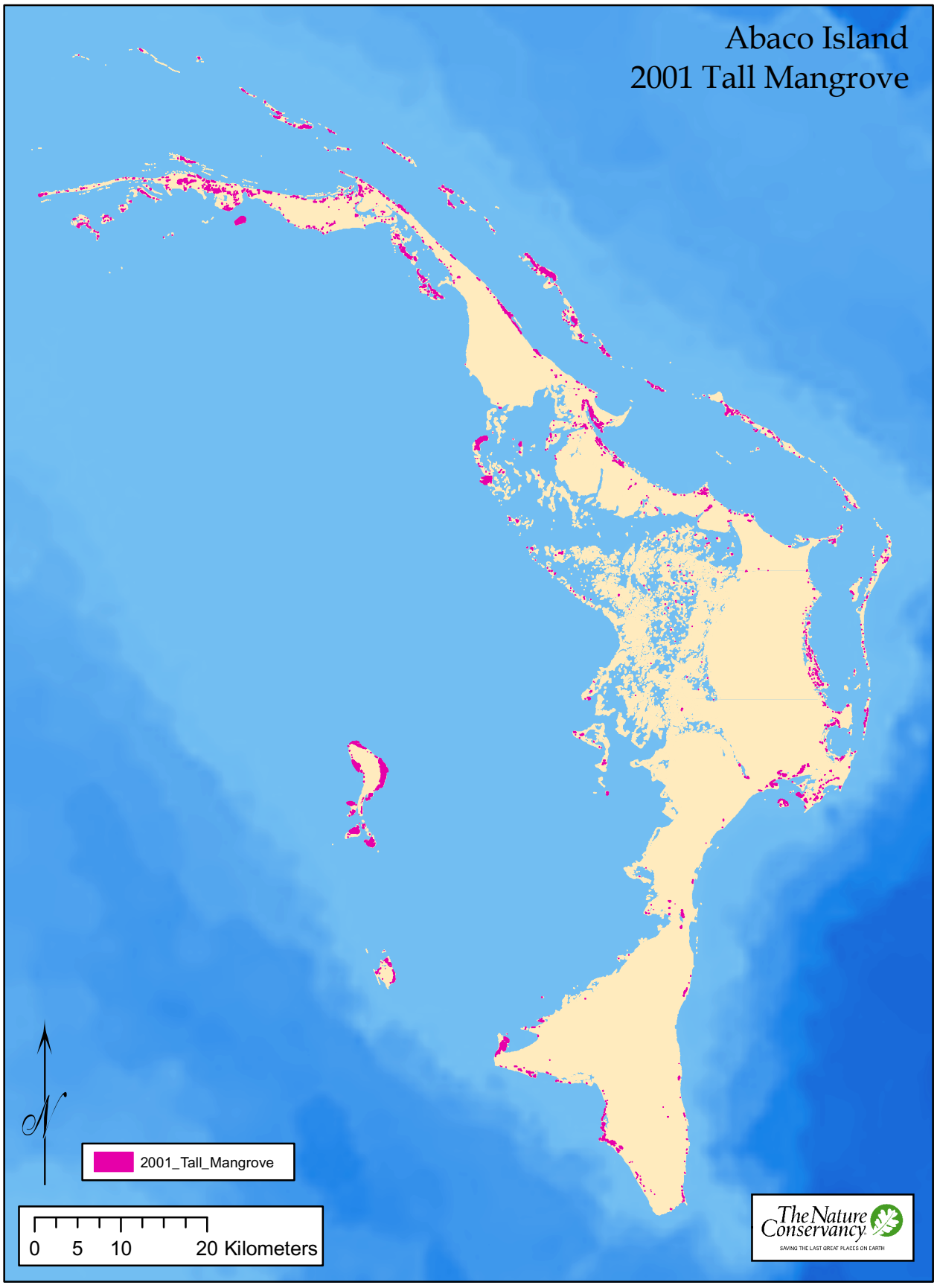

Abaco Island
2001 Sandy Beaches
2001_Sandy_Beaches
0 5 10 20 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

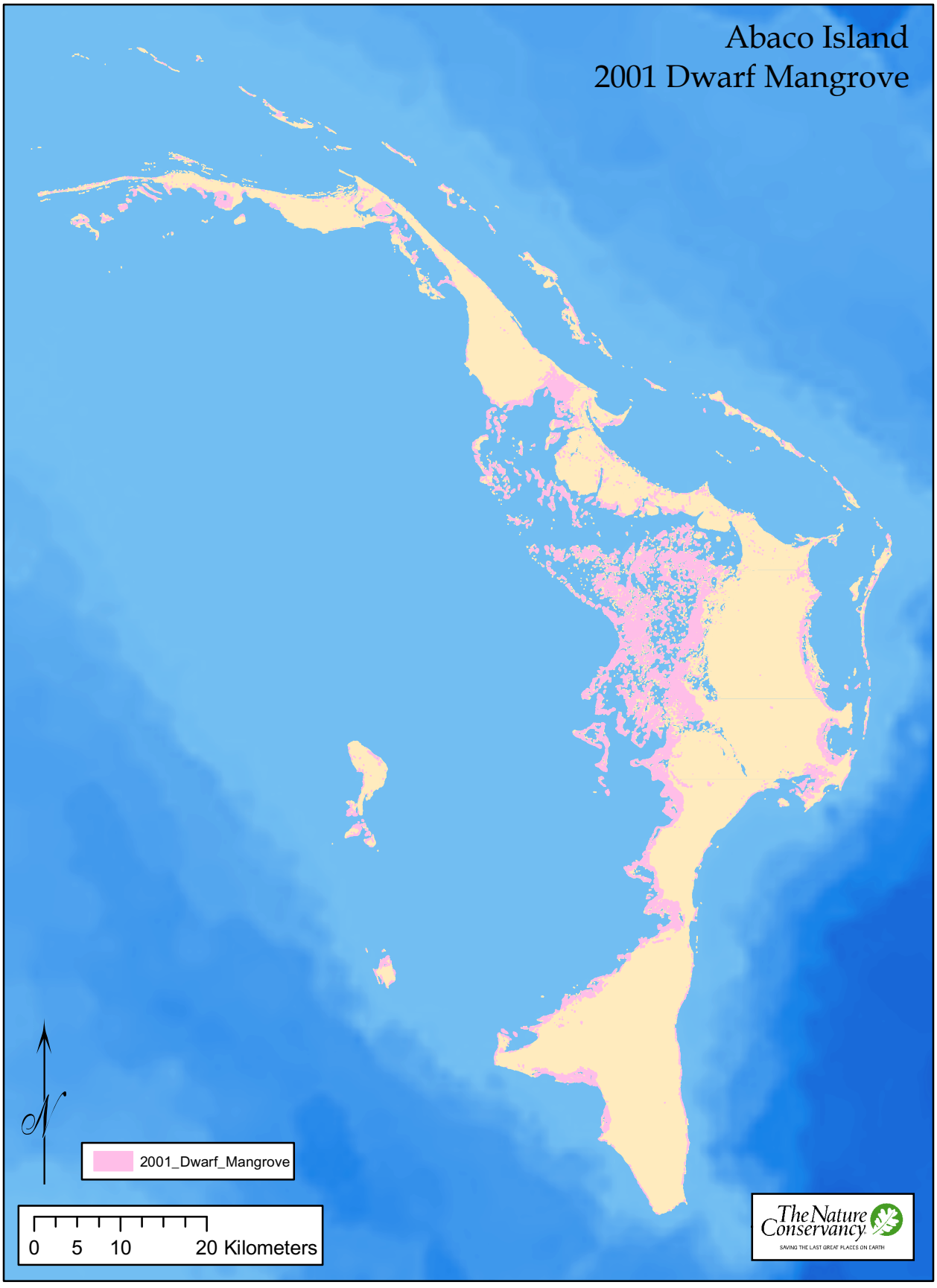

Abaco Island
2001 Rocky Shores
N
2001_Rocky_Shores
0 5 10 20 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

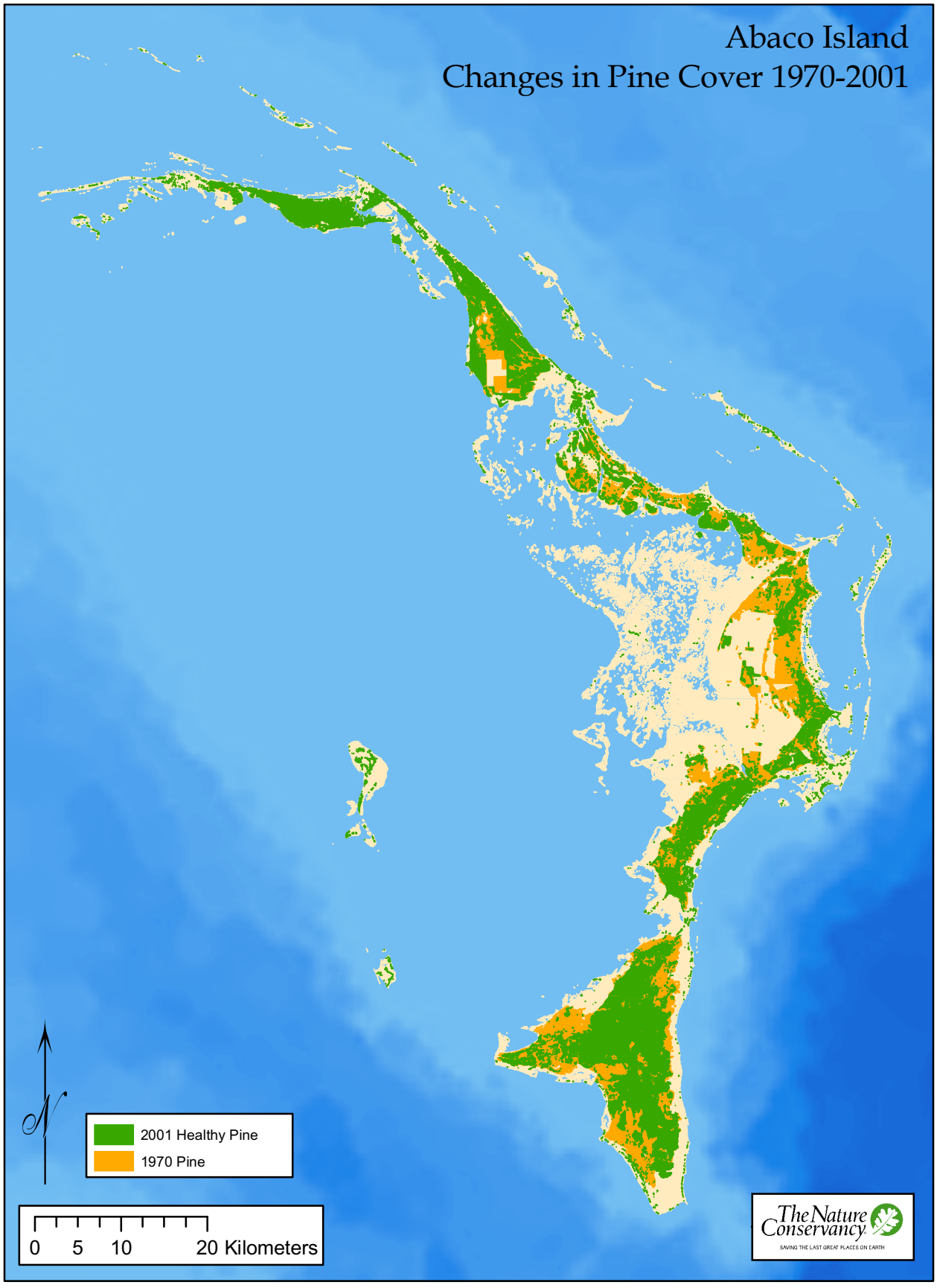

Abaco Island
2001 Pine
N
2001 Pine
0 5 10 20 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

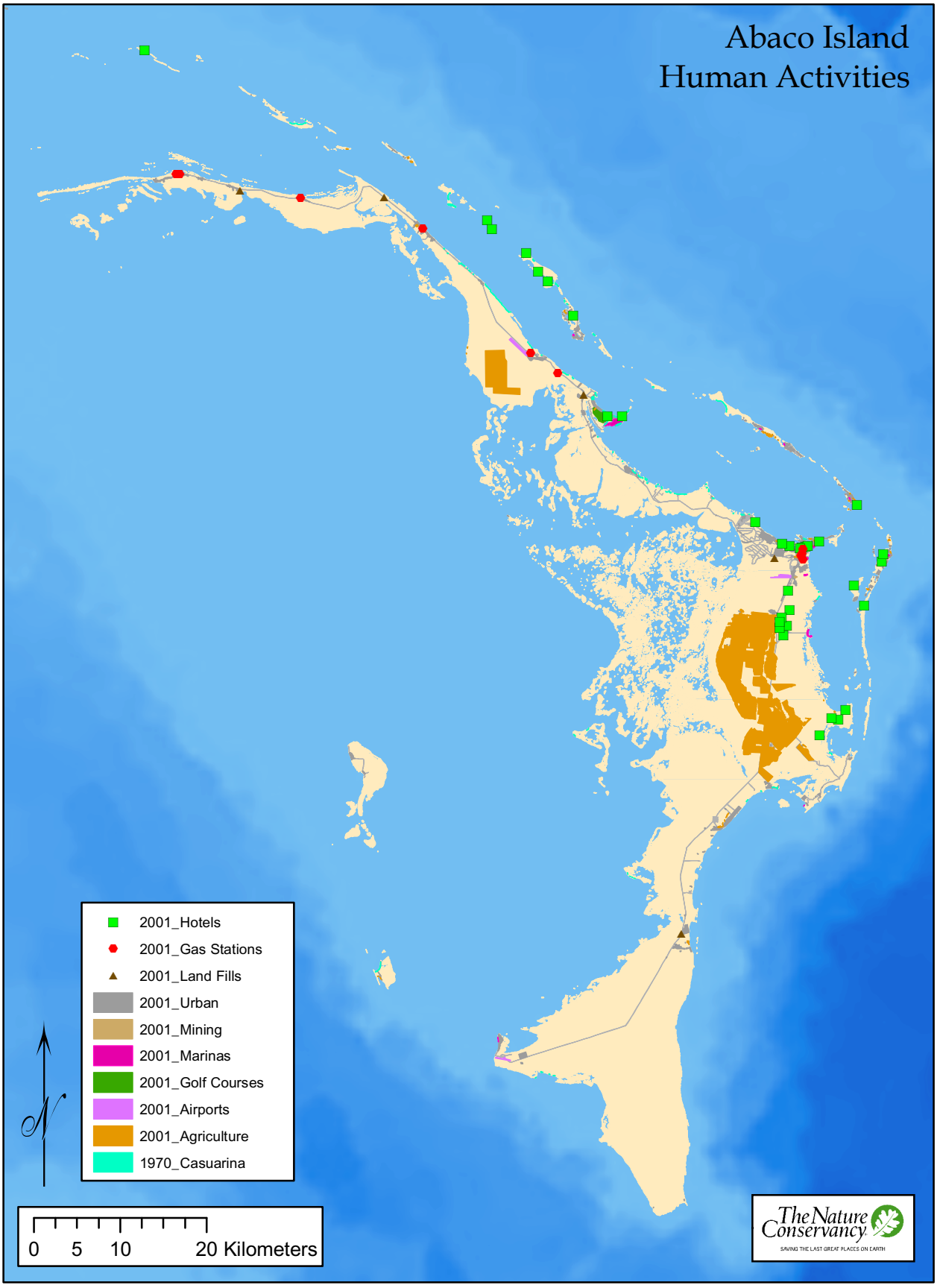

Abaco Island
2001 DBEF
N
2001_DBEF
0 5 10 20 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

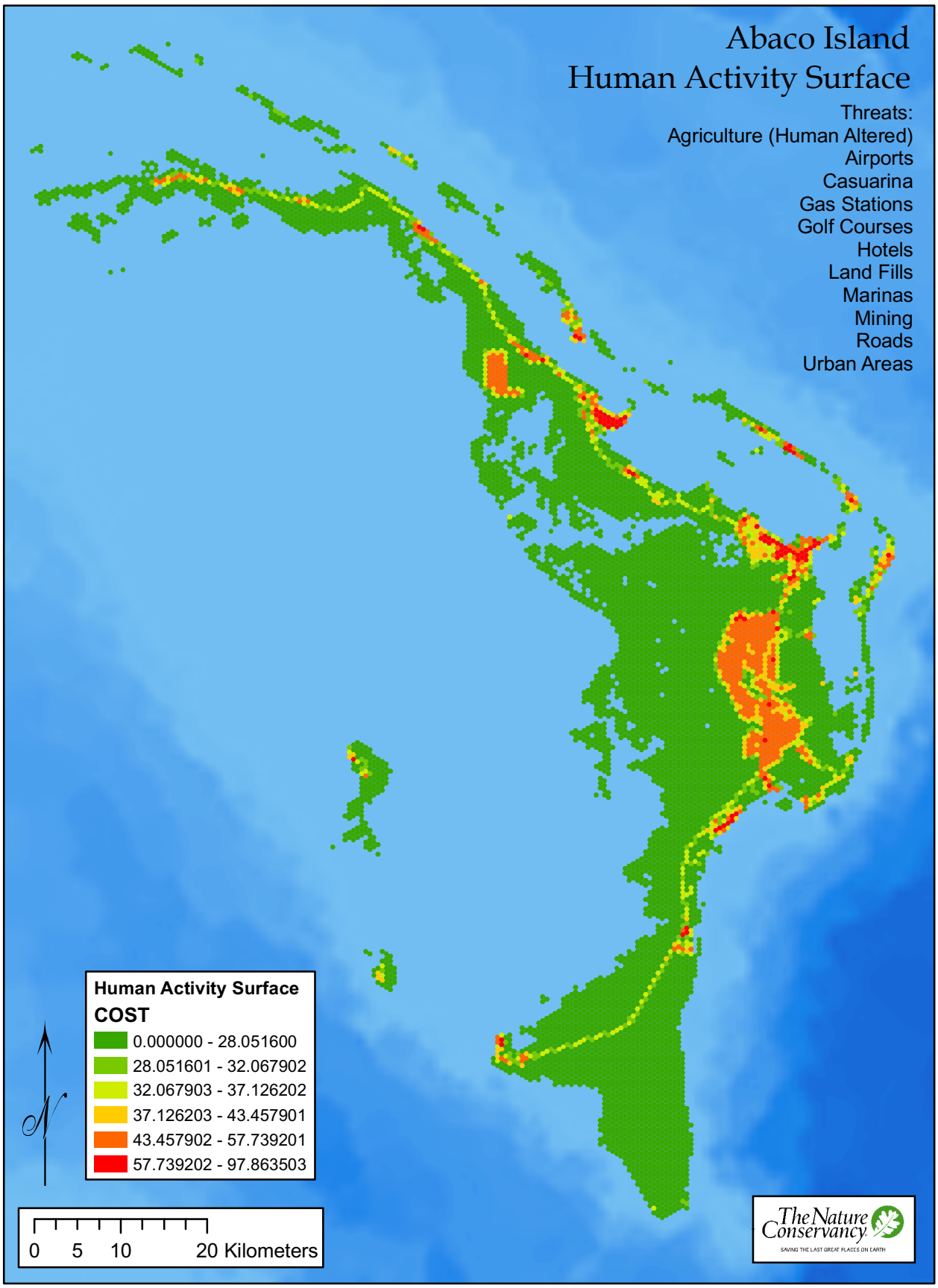

Abaco Island
2001 Freshwater Marsh
N
2001_FW Marsh
0 5 10 20 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

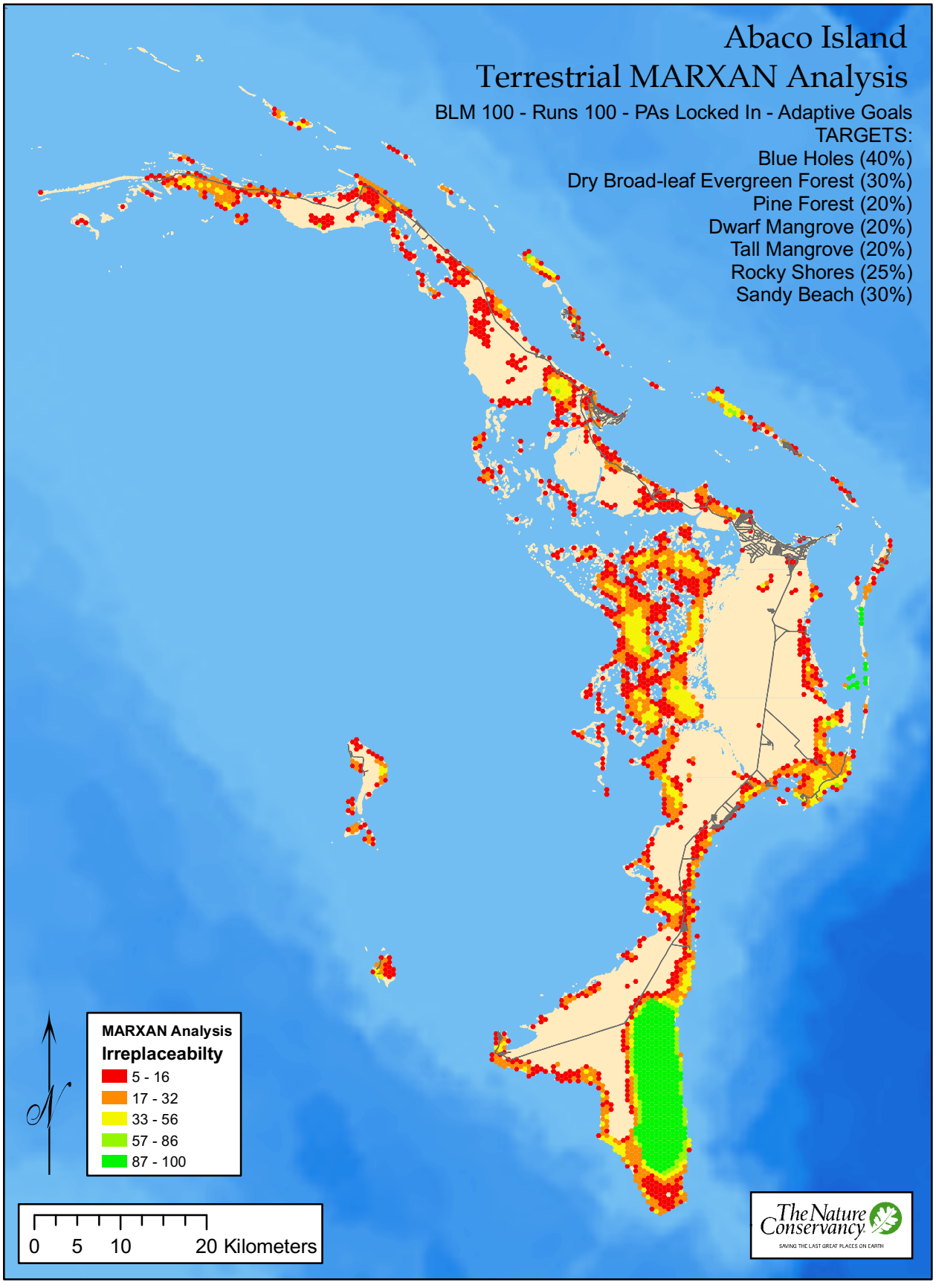

Abaco Island
2001 Tall Mangrove
2001_Tall_Mangrove
0 5 10 20 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

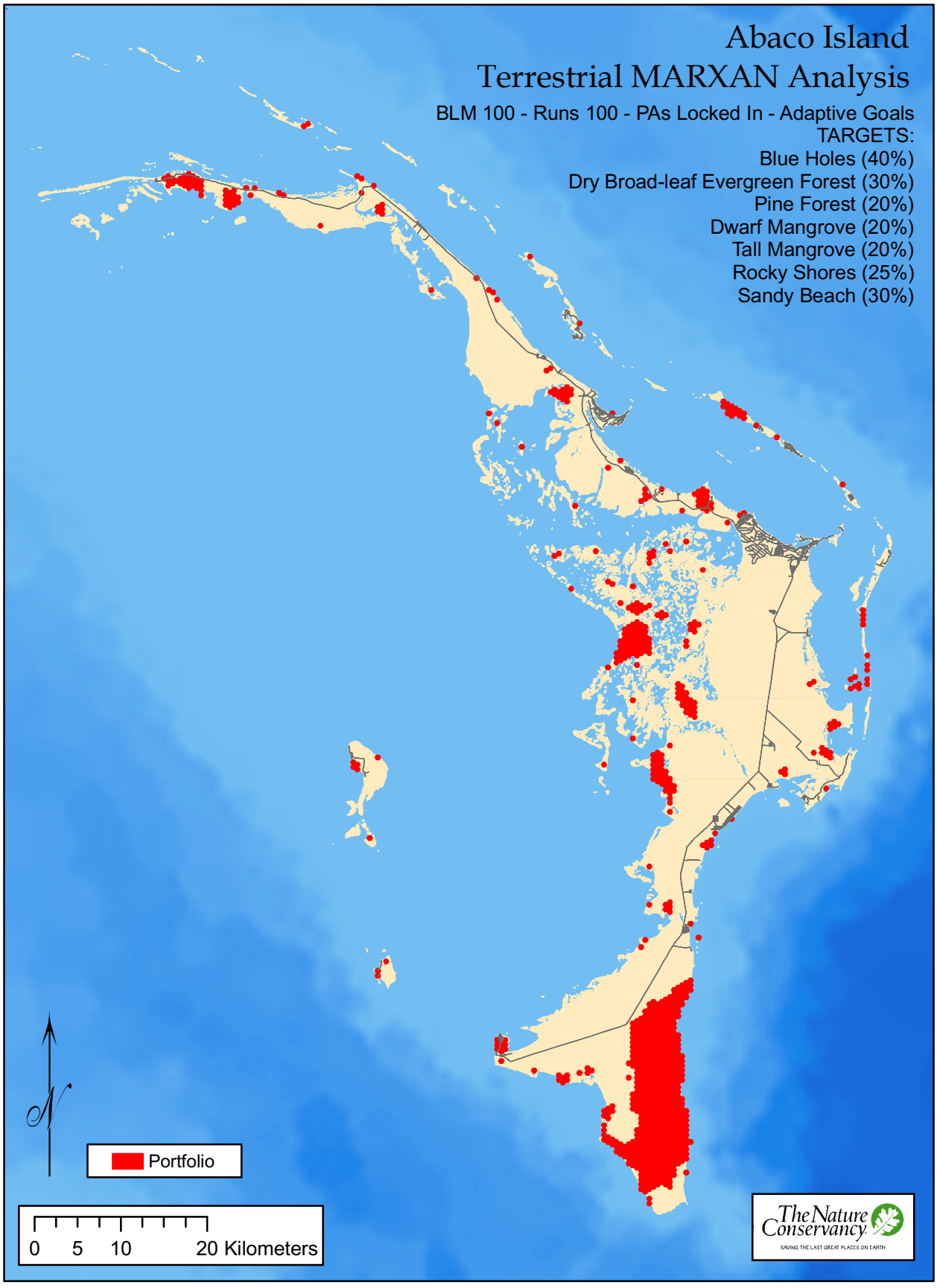

Abaco Island
2001 Dwarf Mangrove
N
2001_Dwarf_Mangrove
0 5 10 20 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH


Abaco Island
Changes in Pine Cover 1970-2001
2001 Healthy Pine
1970 Pine
0 5 10 20 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH


Abaco Island
Human Activities
2001_Hotels
2001_Gas Stations
2001_Land Fills
2001_Urban
2001_Mining
2001_Marinas
2001_Golf Courses
2001_Airports
2001_Agriculture
1970_Casuarina
0 5 10 20 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH


Abaco Island
Human Activity Surface
Threats:
Agriculture (Human Altered)
Airports
Casuarina
Gas Stations
Golf Courses
Hotels
Land Fills
Marinas
Mining
Roads
Urban Areas
Human Activity Surface
COST
0.000000 - 28.051600
28.051601 - 32.067902
32.067903 - 37.126202
37.126203 - 43.457901
43.457902 - 57.739201
57.739202 - 97.863503
N
0 5 10 20 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH


Abaco Island
Terrestrial MARXAN Analysis
BLM 100 - Runs 100 - PAs Locked In - Adaptive Goals
TARGETS:
Blue Holes (40%)
Dry Broad-leaf Evergreen Forest (30%)
Pine Forest (20%)
Dwarf Mangrove (20%)
Tall Mangrove (20%)
Rocky Shores (25%)
Sandy Beach (30%)
MARXAN Analysis
Irreplaceabilty
5 - 16
17 - 32
33 - 56
57 - 86
87 - 100
0 5 10 20 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH


Abaco Island
Terrestrial MARXAN Analysis
BLM 100 - Runs 100 - PAs Locked In - Adaptive Goals
TARGETS:
Blue Holes (40%)
Dry Broad-leaf Evergreen Forest (30%)
Pine Forest (20%)
Dwarf Mangrove (20%)
Tall Mangrove (20%)
Rocky Shores (25%)
Sandy Beach (30%)
N
Portfolio
0 5 10 20 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH