A Multi-Criteria Evaluation Model for Rapid Assessment and GIS Mapping of Ecological Values for Informed Land Use in Small-Island Developing States

A Multi-Criteria Evaluation Model for Rapid Assessment and GIS Mapping of Ecological Values for Informed Land Use in Small-Island Developing States

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Abstract

Small-island developing states (SIDS) contain some of the most biodiverse ecosystems on earth (Churchyard et al., 2014), yet these countries suffer from pandemic sustainable policy failure (Mycoo, 2006), leading to significant losses in ecological assets and ecosystem services (Albuquerque & McElroy, 1992; McElroy, 2003). Many sustainability issues in SIDS arise from uninformed development practices due to a lack of economic and human resources to inform sustainable land use planning (Ghina, 2003; Douglas, 2006; Global Conference on the Sustainable Development of Small Island Developing States, 1994).

I developed a multi-criteria evaluation model (MCEM) to assess biodiversity and ecosystem service values and to address the resource limitations of SIDS. The applied MCEM combined literature review, remote sensing, rapid ecological assessment, GIS mapping and data analysis. Procedures were standardized for ease of implementation and affordability for SIDS. Presence/absence of 16 evaluation criteria, recorded during field studies, provided objective data for the MCEM, which can be applied to any land or marine area and employs readily available open-access software and imagery, thus being particularly relevant to the needs and resource limitations of SIDS.

I implemented the MCEM as a case study on East Caicos, the largest uninhabited island in the Caribbean, located in the Turks and Caicos Islands (TCI) and currently experiencing pressure from proposed tourism development (Turks and Caicos Sun, 2013). Results indicate that the island possesses some of the most significant

conservation interests in the Caribbean region. The entire island and surrounding marine habitats are an intact, landscape-level ecosystem mosaic, with some of the best-preserved coral reefs, estuarine and palustrine wetlands and tropical dry forest, woodland and shrubland formations in the Lucayan Archipelago. Numerous rare, threatened, endangered and endemic species include, but are not limited to, the largest known population of the TCI endemic and IUCN Critically Endangered Caroline's pink *(Stenandrium carolinae);* significant populations of IUCN Endangered and Critically Endangered coral species staghorn *(Acropora cervicornis),* elkhorn *(A. palmata)* and boulder star *(Orbicella annularis* complex); and significant nesting populations of IUCN Critically Endangered and Endangered hawksbill sea turtles *(Eretmochelys imbricata)* and green sea turtles *(Chelonia mydas)*, respectively. Symbolic and experiential cultural values occur throughout the island and include Lucayan archaeological sites, areas of outstanding natural beauty and areas of scientific interest. The East Caicos multi-criteria evaluation also identified wide distributions of all other MCEM criteria.

Results suggest that the best land use for this remote island would be facilitated by the development of a multi-faceted, sustainable ecotourism plan that provides culturally appropriate economic opportunities for local human populations, while at the same time conserving and sustaining the island's outstanding biodiversity and ecosystem values.

Acknowledgements

The implementation of the MCEM at East Caicos has been a collaborative effort and would not have been possible without the unselfish support of various individuals and institutions who have assisted throughout the project process.

The method was developed in association with the Harvard University Extension School's Sustainability and Environmental Management Program. Dr. Mark Leighton advised extensively during the development of the preliminary model, and my Thesis Director, Rafe Boulon, offered technical support and practical wisdom throughout the entire project. The academic quality and rigor of this document would not have been possible without their expertise and guidance.

Although the method is designed to be cost effective, the logistics of undertaking field studies on a remote and difficult-to-access island can be expensive. To alleviate this impediment, the Royal Society for the Protection of Birds (RSPB) generously sponsored all logistical support for the project. Furthermore, RSPB's interest in conserving the ecological assets of East Caicos was instrumental in choosing this location for the case study implementation of the MCEM. RSPB has also tirelessly provided moral and technical support throughout the entire process.

The government of TCI has also offered vital support to the project. The Department of Environment and Maritime Affairs (DEMA) provided research permits and regular technical feedback on the project, in addition to providing existing baseline data. Dr. Eric Salamanca has been stalwart in his support of the project, and Bryan Naqqi

Manco has provided existing data from previous field studies on the island. The Governor of TCI, His Excellency Peter Beckingham, visited the island for a first-hand view of the island's ecological assets. He has supported the research and has taken an active role in promoting the island's conservation values.

Accessing and navigating the treacherous waters surrounding East Caicos is a logistical nightmare, but this impediment was eliminated due to the incomparable maritime knowledge of boat captains Timothy Hamilton, Marley Hamilton and Dolphus Arthur. These men of the sea have been navigating the waters off East Caicos for decades and were able to gracefully avoid the coral heads, reefs and shoals that would otherwise impede access to the island. Their intimate knowledge regarding local use of the island and its surrounding waters was also invaluable to the project.

Accessing the remote interior of East Caicos, which is surrounded by dense thorn bush on the north, east and west perimeters and by extensive tidal flats along the south, would also have been impossible without the use of helicopter service. Mountain Air Helicopters, located on the island of Grand Turk, ably and economically provided support for the project. In particular, Emmet Webb and Dwight Jones provided excellent piloting to ensure the safe delivery of supplies and passengers to some of the most remote areas of the island, with logistical support being provided by Stanley Been (Load Assistant) and Veronica Jones (Project Coordinator). The discovery of remotely located significant populations of rare, threatened, endangered (RTE) and endemic species populations would not have been possible without the assistance of Mountain Air Helicopters.

Big Blue Unlimited, guided by co-owner Mark Parrish, has supported the project since its inception. Mark, who has probably visited East Caicos more than any other

living person, provided important insight and logistical assistance, in addition to pointing me in the right direction for several possible ecological hotspots.

Mike Pienkowski, of the United Kingdom Overseas Territory Conservation Forum (UKOTCF), took time from his busy schedule to offer insight and proofreading of preliminary drafts of this work and has been steadfast in his support for the project. The value of the UKOTCF's on-going and continuous support of TCI's conservation efforts cannot be overstated.

The project would not have been technically possible without the generous support of the U.K. Joint Nature Conservation Committee (JNCC), which sponsored a QGIS (an open access GIS software) mapping workshop in TCI, providing me with the technical foundation to be able to map the ecosystem services being measured. Katie Medcalf of Environment Systems and Ilaria Marengo of the Falkland Islands' Environment Institute were perpetually available to answer questions about QGIS applications. Barbara Brunnick of Taras Oceanographic Foundation provided beautifully crafted existing shape files from a previous JNCC-sponsored TCI terrestrial habitat mapping project, which saved endless hours of creating polygons.

Tireless and brave field assistants John Brander, Simon Wood, Marsha Pardee, Katharine Hart, John Claydon, Mark Parrish, Lynn Robinson and Marta Calosso endured heat, exposure, seasickness, mosquitoes, thorn bushes and other torments for the sake of the project, providing field support and ensuring safety while undertaking the necessary field studies for the project. In particular, Laura Brander was my steadfast companion for treacherous terrestrial field studies. She braved the wrath of feral donkeys and scorpions and spent many a night on a flat air mattress for the sake of the project. It would not have been possible without her (nobody else was willing). For the fearless field assistants, for the others listed above, and for those I have failed to mention due to unintentional oversight, I am truly grateful.

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Chapter I

Introduction

Small-island developing states (SIDS) struggle to foster economic development while simultaneously sustainably managing ecological assets. SIDS share many commonalities, including vulnerability to natural disasters, small economic and natural resource bases, limited land areas and scarce access to expertise to inform sustainable development decisions (Albuquerque, McElroy, & McElroy, 1992; Beukering, Brander, Tomkins, & McKenzie, 2007; Global Conference on the Sustainable Development of Small Island Developing States,1994; Kaffashi & Yavari, 2011). SIDS are also typically areas of high biodiversity. For example, the United Kingdom's Overseas Territories (UKOTs), comprising 14 SIDS, contain an estimated 94 percent of the unique or endemic British species (Churchyard et al., 2014). The Caribbean region has been repeatedly cited as a biodiversity hotspot, defined as being an area with a high proportion of endemism, with biodiversity at risk from environmental degradation (Myers, Mittermeier, Mittermeier, da Fonseca, & Kent, 2000). Because of their ecological values, significant biodiversity and ecosystem service gains can be made by addressing the conservation vulnerabilities of SIDS.

Research Significance and Objectives

To answer the above needs, an easy-to-implement, multi-criteria evaluation model (MCEM) was developed in this study. The MCEM developed here uses objective presence/absence criteria for 16 key biodiversity and ecosystem service values and provides a graphic illustration of measured criteria to inform sustainable land use. The applicability and effectiveness of the model has been tested as a case study at East Caicos in the Turks and Caicos Islands. The MCEM provides a valuable decision tool for informed land use planning and conservation management in SIDS, fulfilling the following specific objectives:

1. Develops an approach for classifying and ranking ecological variables that is objective and easy to use;
2. Based on the above approach, determines evaluation criteria based on accepted practices;
3. Develops a multi-criteria evaluation model incorporating criteria identified above;
4. Develops an inventory of ecological assets on East Caicos, in the Turks and Caicos Islands;
5. Develops a standardized method for rapid environmental assessment of terrestrial, wetland and marine ecosystems;
6. Conducts field studies and imputs field data into a GIS dataset model that graphically illustrates the locations of observed ecological assets at East Caicos, using remote sensing to develop extended polygons of evaluation criteria; and
7. Analyzes and discusses results, making recommendations for sustainable land use, conservation areas and further study.

Background

Traditionally characterized by subsistence agriculture and fisheries, many SIDS have transitioned to economies based on tourism and government employment. With few viable alternatives, tourism development has allowed many SIDS to realize sustained economic growth by banking on the relatively intact ecosystems and cultures that have been preserved by previous subsistence lifestyles. While tourism has been associated with environmental impact, social problems and boom-bust economic cycles, the potential for sustainability in this industry remains feasible when coupled with appropriate and informed development planning (Albuquerque & McElroy, 1992).

In 1994, the Convention on Sustainable Development in Small Island Developing States recognized the needs of SIDS for sustainable planning initiatives, with a focus on the development of human resources and sustainable land use management (Global Conference on the Sustainable Development of Small Island Developing States, 1994); however, in the past 20 years, little progress has been made in this regard. An analysis of tourism development concluded that while the Caribbean is the most tourism-dependent region of the world, with tourism accounting for as much as 70% of GDP in many Caribbean countries, the region suffers from pandemic "sustainable tourism policy failure" (Mycoo, 2006, p. 506). In particular, the study cited failures of land use planning policy and, where appropriate policy exists, inadequate implementation. A 2003 study reviewed the impact of tourism development on 51 islands and found that the vast majority of tourism development was unplanned and intrusive and had resulted in deforestation, erosion, pollution and reef damage. In 2003, at least 30 percent of Caribbean coral reefs were at high risk from impacts due to cruise ship development and pollutants (McElroy, 2003). An estimated ten percent of the Caribbean's original vegetation cover remains intact (Presley & Willig, 2008).

In the Caribbean in particular, few economic options coupled with limited natural resources have driven tourism development, which now accounts for at least 25% of GDP in most Caribbean states (Cameron & Gatewood, 2008). Combined with a lack of informed decision-making, uncontrolled development results in impacts to terrestrial and marine ecosystems and cultural integrity. As the environment becomes despoiled, the fickle tourism industry relocates, leaving behind greater economic hardship and a diminished environmental baseline (Cameron & Gatewood, 2008).

Ecosystem Valuation and Planning

Negative environmental effects can be avoided and/or reduced by developing and implementing sustainable land use management strategies before anthropogenic impacts occur. Ideally, such strategies would foster economic development, while at the same time conserving important ecological and cultural assets. Several evaluation methods for land use conservation planning have been developed.

One approach is to ensure that the ecosystem services nature contributes to human welfare are protected. The European Environment Agency has developed a proposed International Common Classification of Ecosystem Goods and Services (CICES) (Haines-Young & Potschin, 2010, 2011), in which ecosystem services are defined as, "the contributions that ecosystems make to human well-being, and arise from the interaction of biotic and abiotic processes" (Haines-Young & Potschin, 2010, p. 4). CICES recognizes three basic themes of ecosystem services, including provisioning, regulation and maintenance and cultural aspects. Each of these broad divisions is further subdivided into service classes (Table 1).

Table 1. CICES ecosystem services hierarchy (Haines-Young & Potschin, 2010, p. 4).

CICES Theme	**CICES Class**	**Function**
Provisioning	Materials	Resource
	Nutrition	Resource
	Energy	Resource
Regulation and Maintenance	Regulation of Waste	Sink
	Regulation of Flows	Environmental Quality
	Regulation of Abiotic Environment	Environmental Quality
	Regulation of Biotic Environment	Environmental Quality
Cultural	Symbolic	Amenity
	Intellectual and Experiential	Amenity

The Millennium Ecosystem Assessment (MEA) defines ecosystem services as the benefits people derive from ecosystems and found that 15 of 24 ecosystem services assessed were in a state of decline on a global scale (Millennium Ecosystem Assessment, 2005). MEA classifies key ecosystem services under broad categories of supporting, regulating, provisioning and cultural; however, such classifications may fail to take into consideration services that are critical to the maintenance of the behaviors and characteristics of the ecosystems themselves. An effective classification system should include clear definitions, ecosystem characteristics and consideration of the development setting under which the ecosystem exists (Fisher, Turner, & Morling, 2009). Furthermore, conventional classifications of ecosystem services account only for the benefits humans derive from ecosystems and are not immediately inclusive of ecosystem structure and function. Although ecosystem structure and function can provide ecosystem services to humans, they persist independently of anthropocentric utility (Fisher et al., 2009).

The Economics of Ecosystems and Biodiversity (TEEB) Initiative incorporated expertise from 500 specialists across the world to develop a three-step process to incorporating ecosystem values into the decision-making process. The TEEB model three steps are as follows:

- Recognizing the significance of and embedding knowledge of ecosystem and biodiversity values
- Embedding ecosystem and biodiversity values into calculations to inform decisions
- Capturing ecosystem and biodiversity values via market mechanisms to influence economic behavior (Kosmus, Renner, & Ullrich, 2012).

The TEEB process is incorporated into a method called “Integrating Ecosystem Services into Development Planning (IES). The IES approach defines ecosystem services based on MEA and TEEB categories, which include supporting, provisioning, regulating and cultural criteria (Kosmus et al., 2012).

The documentation and classification of ecosystem services is an important and increasing trend, as natural values tend to be underestimated or largely ignored in natural resource decision-making (Wallace, 2007). Considerable research has been dedicated to the classification and management of ecosystem services; however, a comprehensive and practical method for implementation of ecosystem services in the decision-making process has yet to be developed (De Groot, Alkemade, Braat, Hein, & Willemen, 2010).

The CICES criteria are effective for measuring ecosystem services that have value to humans; however, methods that focus exclusively on anthropocentric utility have been criticized for failing to account for ecological values that are important within their own context but may have limited anthropocentric value and also for failing to adequately account for intrinsic values. In the case of East Caicos and other areas with limited direct use by humans, conservation planning, based on the context of ecosystem services, can be particularly detrimental. In such cases, variables that have important ecological features, such as reservoirs of biodiversity on a species level or the provision of critical habitats for threatened species, are not accounted for or are undervalued. Ecological criteria that may not be fully accounted for in typical valuation methods may include endemism, vulnerability to extinction, critical habitats for migration, nesting and spawning and biodiversity.

A method that deals exclusively with biodiversity values for conservation purposes is currently being developed by the International Union for the Conservation of Nature (IUCN). IUCN is the institution recognized globally as an authority on species and biodiversity conservation and has a stated mission of helping "the world find pragmatic solutions to our most pressing environment and development challenges" (IUCN, 2016). The IUCN Species Survival Commission and IUCN World Commission on Protected Areas are in the process of developing standards for the identification of key biodiversity areas (KBAs). A preliminary draft for comment by conservation professionals has been developed (IUCN, 2015).

The IUCN KBA criteria are being developed to help standardize disparate existing methods of identification, to identify new sites for conservation, to be used across all habitats and national spectrums, to be transparent and objective and to elevate capacity and understanding among decision-makers. IUCN has initially established five KBA criteria. Although they recommend site assessment for all criteria (where data are available), the presence of one criteria is sufficient to establish a site as a KBA. The five KBA criteria include the following:

A. Threatened Biodiversity
B. Geographically Restricted Biodiversity
C. Ecological Integrity
D. Biological Processes
E. Irreplaceability Through Quantitative Analysis (IUCN, 2015)

Other methods have been devised that help to balance anthropocentric utility with ecological considerations. The creation of guidelines for the identification of areas of high conservation value (HCV) has been established via the Forest Stewardship Council, Proforest and the HCV Resource Network. Recently, HCV definitions have been broadened to include all ecosystems and include six HCV definitions (Brown et al., 2013). The six high conservation values are as follows:

1. HCV 1 – Species diversity (e.g. rare, threatened, endangered and/or endemic species populations)
2. HCV 2 – Landscape-level ecosystems and mosaics (e.g. viable and significant populations of species occurring naturally across ecosystems)
3. HCV 3 – Ecosystems and habitats (e.g. rare, threatened or endangered ecosystems, habitats or refugia)
4. HCV 4 – Ecosystem services (e.g. watershed protection, erosion control, etc.)

5. HCV 5 – Community needs (e.g. areas that provide for basic human subsistence needs for food, water, livelihoods, etc.)
6. HCV 6 – Cultural values (e.g. areas of cultural, archaeological, religious or traditional importance) (Brown et al., 2013)

HCV assessment involves evaluation of all six HCVs, including stakeholder consultation, and incorporates the potential effects of proposed development. When conducting an HCV assessment, the presence or absence of all six HCVs must be evaluated. The risk of any proposed development must be assessed. The assessment must be undertaken on a wide landscape level, and the precautionary approach must be employed when interpreting findings (Brown et al., 2013).

The above methods provide a useful framework for conservation and land use planning; however, data and resources to inform the use of such methods have often been beyond the means of SIDS. When resources do exist, outcomes can be difficult to understand and use by decision-makers, who are often not scientifically trained. The developed MCEM therefore devises methods for data collection, analysis, interpretation and implementation that are inexpensive, easy to implement and readily understandable by persons of disparate professional backgrounds.

Mapping Conservation Values

Global information system (GIS) technology is one tool that enables information to be readily accessible via graphic illustration and mapping. GIS has revolutionized environmental survey and evaluation processes (Almeida et al., 2014; Joerin, Thériault, & Musy, 2001); however, the use of GIS modeling in environmental applications can be costly and requires a level of expertise that is often not available to SIDS. Consequently, GIS environmental research has had limited application in SIDS. Where it has been implemented, results are often incomplete and/or unusable by decision makers.

For example, a 2014 habitat mapping of Anguilla was conducted by a private company, Environmental Systems Inc., and supported by the U.K. government and the Universities of Newcastle and Aberystwyth. The project mapped habitats and ecosystem services, relying heavily on remote sensing, with a technology known as Earth Observation. Ground-truthing was limited and results were highly generalized. The work was also facilitated by the use of costly WorldView-2 satellite imagery (Medcalf, Bell, Cameron, & Pike, 2014).

Given the cost constraints and expertise involved with the assessment, such a method is difficult to reproduce within the budgetary and human resource constraints of other SIDS without outside funding and assistance. Furthermore, the project was targeted towards valuation of environmental services only and did not take into account ecological criteria, such as endangered species populations, endemic species, critical habitats or other conservation values. Nevertheless, the Anguilla project provided valuable local training, and the evaluation model developed provides an effective framework upon which to build other, less-resource-intensive methods.

Figure 1. The Turks and Caicos Islands (Google, 2015).

The Turks and Caicos as a Case Study

East Caicos is located in the northeastern portion of the larger Caicos Bank (Fig. 1). The Turks and Caicos Islands (TCI) have experienced accelerated development within the past three decades, with associated environmental impacts (Cangialosi, 2011; Carleton & Lawrence, 2005; Pardee, 2014). In a 1971 assessment, TCI's natural environment was described "…as close to the natural state as is likely to be the case for any similar islands within the American tropics due to relatively light utilization by man" (Ray & Sprunt, 1971, p. 6). Ray and Sprunt also forewarned:

"Their [the islands'] value lies in their still retained beauty and relative remoteness. Their ecology and small size makes mandatory that development not violate ecological integrity or natural beauty. Their remoteness makes mandatory that they not imitate or compete with the massive developmental schemes in the more accessible Western Hemisphere tropics. In short, these islands are a special case. They deserve to be treated in a very special way" (Ray & Sprunt, 1971, p. 20).

Unfortunately, development in TCI did not take place in a special way, and the TCI have followed a predictable development path that has been replicated by SIDS across the world (Holder, 1988). Pristine dwarf dry forests and coastal habitats have been clear-cut for hotel development and infrastructure, and diverse mangrove, seagrass meadows and coral reefs have been dredged to create marinas and a cruise ship terminal (Goreau et al., 2007; Johnson, 2002). Uncontrolled and illegal development and a rapid increase in population drives squatting and urban sprawl into undeveloped lands. No sustainable development plan for the country currently exists; therefore, development has largely been driven by investment interests, rather than by informed planning.

The elected government has now indicated that it intends to seek investment to develop transshipping, cruise ship and mega yacht ports on East Caicos (Turks and Caicos Sun, 2013). Such development will require extensive dredging through coral reefs and other marine habitats and significant land clearance for infrastructural development. East Caicos is characterized by myriad biodiversity and ecosystem service values. A UKOT Biodiversity Assessment cited potential development on East Caicos as "most worrying" (Oldfield & Sheppard, 1997, p. 121).

The East Caicos Pre-survey Cultural and Environmental Baseline

The island of East Caicos comprises approximately 47 square kilometers of land area, surrounding by intact tidal estuaries, nearshore seagrass and sand habitats and coral reef ecosystems. As such, the island is included among the largest landscape-level ecosystem mosaics in the Caribbean region. East Caicos is poised on a carbonate platform, known as the Caicos Bank, covering a total area of 6,140 km^2. The Caicos Bank is a shallow bank of oolitic limestone, which grades at its margins by steep relief into deep open-ocean (Rudd, 2003). The Caicos Islands are Pleistocene in origin and are protected by an almost continuous, 130 km northern barrier reef, which extends from East Caicos (in the east) to West Caicos (in the west). Winds are generally in an easterly direction, with tidal flats forming along the southern margins of larger islands (Harris, 1994). East Caicos is located at 21 degrees northern latitude, with annual mean maximum and minimum temperatures of 31°C and 21°, respectively (Doran Jr, 1955). The island is relatively arid with an average rainfall of 711mm, falling largely in the month of October. The island is subject to persistent easterly trade winds with mean average wind speeds of 18 km/hr (Doran, 1958).

East Caicos has a distant history of limited development and use. It was occupied by Lucayan People from approximately the 10th Century, C.E., until the European conquest of the New World. In the late 19th Century, an Irish entrepreneur, John Reynolds, established a sisal (a textile), cattle and guano (bat dung used as fertilizer) plantation. Reynolds's enterprises were short-lived and were completely abandoned in the early 20th Century (Pearce, 2015). Reynolds's legacy lives on in scattered stone ruins across the island and in herds of wild donkeys that were originally imported to transport sisal and guano. Plantation development and the introduction of exotic mammalian species to the island undoubtedly resulted in alterations to the environmental baseline. Donkeys probably continue to shape floral species compositions by selectively foraging on preferred species. Other alien invasive species appear to be limited to scattered floral populations of Australian pine *(Casuarina equisetifolia)* and cow bush *(Leucaena leucocephala)* and lionfish *(Pterois spp.).* These populations are small and do not yet appear to be problematic. The ecological landscapes of East Caicos have had approximately one-hundred years to recover from colonial development and remain largely intact.

Due to the relatively intact nature of existing ecosystems, East Caicos lends itself well to the proposed MCEM case study. Prior to the commencement of this work, quantitative data on the ecological variables of East Caicos were limited. Qualitative data that did exist suggested that the island possesses significant high conservation values.

A 2002 Darwin Initiative project developed a biodiversity management plan for the North, Middle and East Caicos Ramsar Site (Pienkowski, 2002), which encompasses the southeastern portion of East Caicos. The TCI Ramsar site has been described as "the best example of its type in the Caribbean and arguably the most natural wetland amongst" the sites listed under the Ramsar Convention (Pienkowski, 2005, p. 77). Mangrove ecosystems on East Caicos are characterized by low, scrubby development (less than five-meter canopy heights) due to limited freshwater and nutrient inputs and high salinity levels (FAO, 2005).

The North Middle and East Caicos Ramsar Site has also been designated as an Important Bird Area (IBA) (Pienkowski, 2008), based on the presence of populations of the IUCN Vulnerable (VU) West Indian whistling duck *(Dendrocygna arborea)* and Near-Threatened (NT) Kirtland's warbler *(Dendroica kirtlandii)*. The IBA also has populations of waterbirds in excess of 20,000 individuals, including globally significant populations of reddish egret *(Egretta rufescens),* Caribbean flamingo *(Phoenicopterus ruber)* and several shoreline birds. The IBA also possesses significant populations of endemic subspecies of Antillean bullfinch *(Loxigilla violacea ofella)*, in addition to the range restricted Cuban crow *(Corvus nasicus)*. The Ramsar site is also an important juvenile habitat for IUCN Endangered (EN) green turtles *(Chelonia mydas)* and Critically Endangered (CR) hawksbill turtles *(Eretmochelys imbricata)*, in addition to endemic reptile species, including curly-tail lizards *(Leiocephalus psammodromus)*, Caicos Islands reef gecko *(Sphaerodactylus caicosensis)* and the Caicos Islands pigmy boa constrictor *(Tropidophis greenwayi)* (Pienkowski, 2008).

A 2005 review of the existing Ramsar site recommended extending the protected area to include the entire landmass of East Caicos, up to and including the fringing reef and tidal flats surrounding the island. This recommendation was based on 1) annexing habitats not currently represented under protection, 2) adding critical habitats for rare and endangered species, 3) conserving habitat for rare and endemic species, 4) supporting plant and animal species during critical life cycle stages, 5) supporting more than 20,000 waterbirds, 6) supporting more than one percent of the individuals in a species or subspecies of waterbird, 7) possible support for indigenous fish species or subspecies, and 8) providing important foraging, nursery and spawning areas (Pienkowski, 2005). In particular, the 2005 recommendations cited the following ecological assets:

- Important beach areas that support most of the remaining nesting sites for green, hawksbill and possibly loggerhead turtle populations;
- Tidal creek complexes linking mangrove ecosystems to open ocean;
- Global priority cave systems which provide habitat for endemic invertebrates and bats;
- Migratory habitats for piping plover *(Charadrius melodus)* and Kirtland's warbler;
- Breeding habitats for West Indian whistling duck;
- The "best" resource for Lucayan archipelago endemic silver palms *(Coccothrinax inaguensis)*;
- Habitat for breeding common terns *(Sterna hirundo)* comprising about 20% of the Americas summer population; and
- Important cultural and archaeological sites (Pienkowski, 2005).

Apart from the Ramsar Nature Reserve, the other areas of East Caicos have also been designated as an Important Bird Area (IPA) (Pienkowski, 2008); however, the remaining land areas of the island do not have any legal protection status. The East Caicos IBA contains three of four Bahamas Archipelago endemic bird species (thick-billed vireo *(Vireo crassirostris stalagmium)*, Bahama woodstar hummingbird *(Calliphlox evelynae)* and Bahama mockingbird *(Mimus gundlachii)*), in addition to globally significant numbers of reddish egret and common tern. The area also supports endemic Cuban crow and Antillean bullfinch and NT Kirtland's warbler and piping plover (Pienkowski, 2008).

Limited supporting data for the designation of East Caicos as an IBA is provided by Hilton et al., who conducted walking transect surveys of East Caicos and recorded six piping plover along the northern coastline during 2-9 March 2000. A number of other previously unrecorded or rare species for TCI were also recorded during Hilton's study, including roseate spoonbill (*Platalea ajaja*), double-crested cormorant (*Phalacrocorax auritus*), neotropic cormorant (*P. brasilianus*) and American bittern (*Botaurus lentiginosus*) (Hilton, Cleeves, Murray, Hughes, & Williams, 2000b). Additionally, five West Indian whistling ducks were recorded on East Caicos in the vicinity of Jacksonville pond (Hilton, Cleeves, Murray, Hughes, & Williams, 2000a). Population sizes were not measured or estimated and sightings were not tagged with GPS coordinates. Subsequent reports from recreational users has suggested higher population numbers and broader distributions for avian species of interest.

A follow-up investigation to the Darwin Initiative Project explored cave ecosystems on East Caicos. East Caicos caves possess features of geological, ecological and historic interest. Bat populations of *Macrotus waterhousii* and *Erophylla sezekorni* were confirmed and evidence of *Brachyphylla spp.* and *Monophyllus spp.* was also observed (Hutson, McCarthy, & Hart, 2005). Cave petroglyphs that date back to Lucayan Indian habitation at approximately 900-1200 C.E. have also been identified (Booy, 1912; Hutson et al., 2005; Pateman, 2013). The caves of East Caicos are currently not protected.

In 1999, a country-wide Atlantic and Gulf Rapid Reef Assessment (AGRRA) studied benthic reef condition. East Caicos' northern barrier reef and eastern windward patch reefs were not studied for this assessment, with the closest studied areas being south of East Caicos off McCartney Cay and South Caicos. Riegl et al. calculated an average live stony coral cover of 18%, with *Orbicella annularis* complex dominating at most depths and *Porites astreoides* dominating at shallow depths and on patch reefs. (Riegl, Manfrino, Hermoyian, Brandt, & Hoshino, 2003). These figures applied to the overall condition of TCI's coral reefs and not specifically to East Caicos.

A 2006 study assessed coral reef health throughout the Turks and Caicos Islands (Goreau et al., 2007), including East Caicos. The study incorporated extensive, rather than intensive assessment, and the method involved incorporating trained divers swimming over large areas of reef to determine large-scale spatial patterns (Goreau et al., 2007). The study also generalized findings across locations throughout TCI, and East Caicos data from the study were not specified. A personal communication with Goreau, via email on 15th May 2015, confirmed that data for the 2006 study were only collected at two southeastern reef sites off East Caicos. The overall characteristics of the reefs off East Caicos are therefore largely unknown. Given that these areas are at high risk if development takes place, an accounting of the conservation values of these coral reefs was imperative to conservation interests.

Other marine ecological assets include green, hawksbill and loggerhead turtles *(Chelonia mydas, Eretmochelys imbricata* and *Caretta caretta*), which are known to nest on remote beaches in TCI. All species are listed under the IUCN Red List as EN or CR. In 2009, a survey of known sea turtle nesting sites was conducted (Richardson et al., 2009); however, "because of the remote nature of many of the cays and limited resources available for the study, surveys for nesting activity were infrequent and opportunistic" (Richardson et al., 2009, p. 194). Three suspected nesting areas on East Caicos were identified, via aerial surveys, a review of published literature and interviews, on the northern and eastern beaches of East Caicos. Satellite tagging of an adult female hawksbill turtle has subsequently revealed repeated nesting episodes on northern and eastern beaches (Richardson, 2013). To date, no comprehensive survey of turtle nesting sites and activities on East Caicos has been undertaken, but it is believed that the island serves as an important remnant rookery (Richardson et al., 2009).

East Caicos' terrestrial ecological assets are also poorly quantified. In general, the terrestrial environment of East Caicos is characterized by low levels of average rainfall and thin, limestone marl soils. Such variables inhibit vegetative growth in most areas, with resultant dwarfed scrub vegetation (Sears & Sullivan, 1978). In 2010, a terrestrial habitat mapping and classification project identified 32 terrestrial and wetland communities and 41 floral species, two reptile species, five mammal species and one invertebrate species of interest, including rare, threatened, endangered or endemic species (Wood, Brunnick, Harzen, Weinberg, & Kissinger, 2010). The habitat mapping and classification project conducted only limited, non-quantitative field studies. A majority of habitat identification was conducted via remote sensing, and habitats were therefore only classified to a class, sub-class, formation and group level (Cowardin, Carter, Golet, & LaRoe, 1979; Grossman & Conservancy, 1998). Floral alliances and associations were not classified or mapped, and ecological assets were not quantitatively measured. A search for available data for East Caicos was conducted using the Global Biodiversity Information Facility (GBIF, www.gbif.org). The search returned results for only one floral species (*Lepidium filicaule,* a TCI endemic) recorded on East Caicos.

Research Goals, Questions and Specific Aims

The developed MCEM addresses the above limitations by combining a desktop review of existing data with a standardized method for rapid field assessment of terrestrial, wetland and marine habitats that is easy to implement. Collected data is used to develop a GIS digital database that records, maps and highlights biodiversity and ecosystem service values in relation to the subject landscape. Open-access GIS software (QGIS) and imagery (Google Earth) enhance accessibility for resource-limited users. The end product is a GIS dataset that can be incorporated into national databases. The dataset has myriad applications and can be used to:

- Identify priority areas of high ecological value for conservation purposes;
- Develop a sustainable development plan;
- Identify critical areas and populations that merit further scientific research; and
- Inform other conservation priorities.

In order to test the model, a case study focused on the island of East Caicos in the Turks and Caicos Islands. East Caicos is an uninhabited island of approximately 47 square kilometers. As such, it is the largest uninhabited island in the Caribbean region (Pienkowski, 2008). The application of the proposed model demonstrates its practicality and ease of implementation in scenarios where resources are limited, access is constrained by remoteness and environmental conditions and land use planning lacks informed environmental input.

Chapter II

Methods

Evaluation of ecological criteria is generally conducted by applying various scales of importance or "weights" to selected criteria. Such methods are often perceived as subjective, as weighting necessarily introduces the tenets of the evaluator (Smith & Theberge, 1987), making the results of such studies questionable within and among disparate groups with varying conservation priorities. A credible model that will gain acceptance by broad demographics must therefore devise methods that will be viewed across diverse interests as objective. A simple, empirical method involves presence/absence analyses. Presence/absence criteria are by their nature objective. Either a variable exists or it does not. By incorporating desktop and rapid field assessment for the presence/absence of pre-determined criteria, a simple and objective map of ecological significance, using GIS mapping technology was developed. Due to its simplicity and graphic representation, the tool is broadly accessible across a wide range of decision-making disciplines, including those without scientific backgrounds.

The method for the multi-criteria assessment and mapping of East Caicos incorporated the following components:

1. Desktop review of existing methods and data
2. Selection of the MCEM criteria
3. Field studies
4. GIS mapping of data

Desktop Review of Existing Methods and Data

Prior to any other work taking place, a comprehensive literature review was conducted in order to obtain existing information regarding various methods for multi-criteria evaluation, ecological valuation and field sampling techniques. From this review, the MCEM was developed by adapting existing ecological assessment methods for application in SIDS, where resource limitations often constrain large-scale assessment.

In order to identify conservation targets, communities, species and abiotic factors of conservation interest were first identified and classified. On a community level, classification methods were derived from a review of several standardized and accepted classification systems. Classification methods for marine habitats were based on adapted marine classification methods from NOAA (Allee et al., 2000) and regional methods (Mumby & Harborne, 1999). Classification of wetland habitats were based on Cowardin et al. (Cowardin et al., 1979) and the derivation of that method adapted for the conditions of TCI (K. Wood & Brunnick, 2010). Terrestrial classification was based on the Nature Conservancy method (Grossman, 1998) and the derivation of that method adapted for TCI (K. Wood & Brunnick, 2010). Species were identified using accepted taxonomy and standardized text (Correll & Correll, 1982; Humann & Deloach, 2013; Raffaele, Wiley, Garrido, Keith, & Raffaele, 2003; Reynolds, Hailey, Wilson, & Horrocks, 2011). Habitat classifications for East Caicos are attached as Appendix 1.

At a basic level, determining the presence or absence of a species, habitats and ecosystem services at a particular geographical location can be a simple, objective means of determining several environmental parameters, including the identification of habitats of high value (Brotons, Thuiller, Araújo, & Hirzel, 2004; MacKenzie & Vojta, 2005).

Presence-absence methods are therefore widely accepted and applied to a range of environmental management objectives.

A key criticism of presence-absence methods is the likelihood of false negative reporting (Gu & Swihart, 2004). For example, a species may be recorded as absent, when it is actually present, but not observed. Multiple replicates during field studies of each habitat type help to reduce this type of sampling error. In the case of East Caicos, and in order to avoid subjectivity, evaluation criteria were assessed based on presence/absence. Although this method may have resulted in some false negatives, the resultant GIS map of ecological hot spots should be viewed as an accurate estimate of minimum rather than full values.

In order to develop an inventory of ecologically important assets on East Caicos, a desktop review of existing literature and data provided a preliminary list of known ecologically significant species, habitats and services. Interviews with local experts and resource users were also conducted (Hamilton, 2015; Manco, 2015; Pardee, 2015). Based on this collated data, a baseline map was developed, using GIS layers from existing topographical and geological surveys, habitat maps and previous studies (Wood et al., 2010). This map was then used to inform sampling locations and was refined by ground-truthing. A detailed summary of existing information is combined with the data collected during field studies in the Results section of this report.

The MCEM Model Criteria

The various methods for ecosystem assessment outlined in the Introduction section each have benefits and deficiencies. Methods such as CICES and TEEB account for ecosystem values that are important to humans but only marginally assess values that are important for biodiversity conservation and values of ecological importance (Haines-Young & Potschin, 2011; Kosmus et al., 2012). Conversely, IUCN methods are heavily weighted towards biodiversity and ecological conservation but only minimally address ecosystem services that are valuable to humans (IUCN, 2015). The HCV method (Brown et al., 2013) addresses both ecosystem services and ecological values but misses out some components of other methods, such as the inclusion of critical habitats for migration, spawning, etc.

The developed MCEM adopts criteria from each of the above methods, accounting for conservation and biodiversity values, as well as anthropocentric ecosystem service values, in order to facilitate a balanced accounting. Criteria are broadly categorized into two groups, including 1) ecosystem service values that are important to humans and 2) biodiversity service values that are important to the conservation of biodiversity. The two groups are further divided into six sub-groups, including the following:

Ecosystem Services

1. Provisioning
2. Materials
3. Regulation and maintenance

Biodiversity Services

1. Species diversity
2. Landscape-level ecosystems and mosaics
3. Rare, Threatened and Endangered ecosystems, habitats or refugia

Provisioning can be defined as "all materials and energetic outputs from ecosystems…that can be exchanged or traded, as well as consumed or used directly by people in manufacture" (Haines-Young & Potschin, 2011, p. 4). Provisioning can include resources that are both biotic and abiotic. Provisioning examples include wild and cultured food, water, raw materials, genetic resources, medicinal resources and ornamental resources. For the purposes of the MCEM, three broad provisioning criteria are assessed for presence/absence, including 1) nutrition, 2) materials and 3) energy. In the case of East Caicos, an uninhabited island, many provisioning resources are extant but unexploited. For the sake of this exercise, they will be counted as present, whether or not they are exploited. In order to qualify for presence, the provisioning resource must be present at a level that would allow sustainable use by nearby human populations for the foreseeable future.

Regulation and maintenance ecosystem services are defined as "the ways in which ecosystems control or modify biotic or abiotic parameters that define the environment of people" (Haines-Young & Potschin, 2011, p. 4). Regulation and maintenance criteria include 1) regulation of wastes, 2) flow regulation and 3) regulation of the physical environment. Factors that regulate the biological environment are addressed in biodiversity services criteria. Examples of regulation and maintenance ecosystem services are air purification, treatment of wastes, regulation of air flows, regulation of water flows, mass flow regulation, atmospheric regulation, water quality regulation and nutrient cycling. As noted previously, as East Caicos is an uninhabited island, many of the regulation and maintenance ecosystem services extant on that island are currently not exploited by humans. For the sake of this analysis, such regulation and maintenance ecosystem services will be counted as present if they exist in sufficient capacity to provide for sustainable use by nearby local populations for the foreseeable future. For example, regulation of flow ecosystem services are determined to be present in all wetland habitats, as these areas serve as floodwater catchment areas. If physical development ever does take place on East Caicos, unaltered wetlands will protect appropriately sited land-based development from flooding.

Cultural ecosystem services are defined as "all non-material ecosystem outputs that have symbolic, cultural or intellectual significance" (Haines-Young & Potschin, 2011, p. 4). MCEM cultural criteria include 1) symbolic and 2) intellectual and experiential. Cultural ecosystem services can be aesthetic, heritage, spiritual, recreational, inspirational and informational. Examples include areas of outstanding natural beauty, areas supporting local identity and sense of place, tourism opportunities, scientific and educational opportunities and sacred places or species.

Species diversity is defined by "concentrations of biological diversity including endemic species, and rare, threatened or endangered species (RTE) that are significant at global, regional or national levels" (Brown et al., 2013). Species diversity criteria include 1) significant populations of RTE species, 2) significant populations of endemic species, 3) geographically restricted species or species assemblages (including rare species) and 4) spatial or temporal concentrations of species.

RTE species are those recognized by international conservation organizations, such as the International Union for the Conservation of Nature (IUCN), Convention on International Trade in Endangered Species (CITES) and the Specially Protected Areas and Wildlife Protocol of the Cartagena Convention (SPAW). For the purposes of this assessment, IUCN Critically Endangered (CR), Endangered (EN), Vulnerable (VU) and Near-threatened (NT) species will qualify for inclusion. CITES Appendices I and II listed species will qualify and SPAW Annexes I, II and III listed species will qualify. Significant populations are defined broadly as being of sufficient size as to measurably affect and contribute to the general population characteristics of the species on a local, regional or global level. Rarity can be on a local, regional or global level and is broadly defined as 1) occurring naturally at low concentrations 2) suffering from significant losses due to anthropocentric activities or 3) occurring at low concentrations due to range limits, although possibly common elsewhere (Brown et al., 2013). A list of RTE species, observed or recorded at East Caicos, is attached as Appendix 2 – Turks and Caicos Rare, Threatened and Endangered Species.

Endemic species include those with distributions that are restricted to national and regional geographic boundaries. For the purposes of this assessment, TCI, Lucayan Archipelago (including the Bahamas and Turks and Caicos Islands) and Caribbean regional endemic species will be considered. A list of endemic species, observed or recorded at East Caicos, is attached as Appendix 3 – Endemic Species.

Although geographic restriction is often equated with endemism, for the purposes of this assessment, geographically restricted species include those that have a global and/or local distribution that is restricted by "range, extent of suitable habitat or area of occupancy, and hence [are] largely or wholly confined to a relatively small portion of the globe, such as a biome, ecoregion or site" (IUCN, 2015, p. 7).

Spatial and temporal concentrations of species are located in varied habitats that species use at different times of the year or at different life stages (Brown et al., 2013).

Spatial concentrations can include nesting and spawning areas and aggregations, source populations, critical juvenile habitats and migration routes and stopover areas. For the purposes of this assessment, areas with any of the above attributes, noted during field studies or determined by personal communication with knowledgeable resource users is noted as present.

Landscape level and ecosystem mosaics are defined as those "that are significant at global, regional or national levels, and that contain viable populations of the great majority of the naturally occurring species in natural patterns of distribution and abundance" (Brown et al., 2013, p. 30). Criteria for landscape level and ecosystem mosaics include 1) viable populations of the great majority of species, 2) irreplaceability and 3) ecological integrity. East Caicos is the largest, uninhabited island in the Caribbean region, with a scant history of human use and limited impacts by invasive species. As such, for the purposes of this assessment, it is assumed that the entire island and surrounding coastal areas would qualify under these three criteria.

Rare, threatened or endangered ecosystems, habitats or refugia are those that "are of special importance because of their rarity or the level of threat that they face or their rare or unique species composition or other characteristics" (Brown et al., 2013, p. 34). Such areas can be RTE on a local, regional or global level and may be naturally rare, rare or threatened due to anthropogenic stresses or classified as such under national or international systems (Brown et al., 2013).

The above variables comprise a total of sixteen criteria which are assessed for presence/absence, including eight ecosystem service criteria and eight biodiversity service criteria, as follows:

Ecosystem Service Criteria

1. Nutrition
2. Materials
3. Energy
4. Regulation of wastes
5. Regulation of flows
6. Regulation of physical environment
7. Cultural symbolic
8. Cultural intellectual and experiential

Biodiversity Service Criteria

1. RTE species
2. Endemic species
3. Geographically restricted species
4. Spatial/Temporal concentrations of species
5. Viable proportions of the great majority of species
6. ecological integrity
7. irreplaceability
8. RTE ecosystems

Field Study Methods

Accessing the island of East Caicos is difficult and costly. The island is surrounded on the northern and eastern boundaries by windward barrier reefs and dense scattered patch reefs. Southern and western areas are comprised of large expanses of shallow mud flats and mangals (habitats with a majority of biomass being attributable to mangrove species and mangrove allied species, including *Rhizophora mangle, Avicennia germinans, Laguncularia racemosa* and *Conocarpus erectus.* The two most-feasible forms of access for the purposes of this assessment were therefore via helicopter and local fishing boats (weather permitting). Given these constraints, and taking into account the economic and resource limitation of SIDS, it was necessary to be able to gather as much information as possible within limited field study time.

The Nature Conservancy has developed a method for rapid field assessment for similar scenarios (Sayre, 2000), and a method adapted from the Nature Conservancy model was employed for terrestrial and wetland surveys. NOAA has developed rapid assessment for marine ecosystems, and an adapted version was used here (Morrison et al., 2012). Field studies incorporated the following aspects:

1. Initial landscape characterization – remote sensing of aerial or satellite imagery to delineate discernable distinctions in landscape attributes. For terrestrial and wetland studies, this work had already been undertaken for the TCI habitat mapping and classification project (Wood et al., 2010), and the imagery developed with that project was used for determining the logistics of the field sampling method.
2. For marine habitats, Google Earth imagery was uploaded to QGIS (open access GIS software), and preliminary polygons were drafted for each discernable habitat type.

3. Field sampling for terrestrial and wetland habitats incorporated a series of pre-determined transects, selected in order to sample every discernable habitat type at several locations throughout the island, with an objective of sampling at least one percent of each discernable habitat. Marine transects were organized around remotely discernable coral reefs, seagrass beds and other known features or habitats of interest.
4. In the field, sampling points were located within each discernable habitat type and were selected based on representativeness and known or suspected biological value. As the rapid assessment was intended to note presence/absence and community characteristics of significant biotic communities, this method is preferable to random sampling, which may not adequately record all features of interest.
5. Locations for transects were loaded into a Garmin GPSMap 78SC handheld GPS device to facilitate field studies.
6. For all survey points, habitats (marine, wetland and terrestrial) were classified to upper and lower hierarchy levels, in accordance with accepted methods (Allee et al., 2000; Cowardin et al., 1979; Grossman & Conservancy, 1998; Mumby & Harborne, 1999).
7. For terrestrial and wetland habitats, at each survey point, all species were identified and counted within a 1 x 1-meter plot surrounding the survey point. 1 x 1 meter plots (as opposed to 10 x 10 plots) were used due to the dwarf nature of vegetation in TCI.

8. All birds, reptiles and other features of interest observed along transect lines, either by voice or vision, were counted and identified, using accepted identification guides (Raffaele et al., 2003; Schwartz, 1991). In particular, sampling protocol was designed to take in critical bird habitats, such as wetlands, ponds and tropical dry forests, during spring, summer and fall migration periods.
9. Marine habitats were measured, using a combination of broad and medium-scale data collection methods (Hill & Wilkinson, 2004).
    a. Broad-scale assessment was undertaken at all selected sites by incorporating "manta tows" (surveys conducted by pulling a team member slowly behind a boat to rapidly record significant habitat features, such as benthic cover and species of interest) for preliminary assessment.
    b. Medium-scale assessment was then undertaken, at areas identified during manta tows as having high conservation value, by incorporating approximate 20 meter transects, with 0.25 x 0.25-meter quadrat samples at one meter intervals along the transect line.
    c. Still photos of marine quadrat samples were recorded for desktop analysis to determine all coral species present, percent coverage and presence/absence of coral disease and/or other aspects of interest. Due to time and resource constraints, separate counts of fish and other species of interest were not conducted, but all species observed during field studies and within still photographs were recorded.

10. Sampling methods for all transects incorporated photographic documentation of all criteria, landscapes, species of interest, habitats and other features, when possible.
11. Along each transect line, additional survey points were implemented if ecosystem service and biodiversity value evaluation criteria were observed.
12. For all terrestrial data points, species density, relative density, frequency, relative frequency and importance values were determined.
13. For all marine data points, species dominance, relative dominance, frequency, relative frequency and importance values were determined for benthic species.

Variables outlined in (12) and (13) are defined by the following formulas:

Density = Number of individuals/area sampled (per habitat type)

Relative density = (density for a species/total density for all species) x 100

Dominance = areal coverage values for a species/area sampled (per habitat type)

Relative dominance = (dominance for a species/total dominance for all species) x 100

Frequency = total number of plots in which a species occurs/total number of plots sampled

Relative frequency = (frequency value for a species/total of frequency values for all species) x 100

Importance value = relative density + relative dominance + relative frequency

Biodiversity values for each sample set was determined using the Shannon Wiener Index, as described by the following formula:

$$H = -\sum_{i=1}^{s} p_i \ln p_i$$

Where H is the measured biodiversity and p_i is the proportion of species (*i*) relative to other species.

In order to determine logistics and time required for field studies, a preliminary map of proposed transects (terrestrial) and polygons (marine) was developed, using Google Earth Pro satellite imagery. This map was modified throughout the field study process, as conditions in the field became apparent through ground-truthing.

A United Kingdom non-governmental organization (NGO), The Royal Society for the Protection of Birds (RSPB), generously provided the funding for the vast majority of logistical support for the research and field assistants were drawn from the TCI Department of Environment and Maritime Affairs (DEMA), local environmental specialists and local educators. Field Studies were undertaken on four separate occasions (Table 2) at representative sites across the island (Fig. 2).

Figure 2. Field study survey points.

Table 2. Field study dates and areas.

Dates	Description
26,27, 28 February and 1 March 2015	North coastal, upland and wetland habitats
4, 6, 7, 8 and 9 June 2015	Western-central upland and wetland habitats Southeastern upland and wetland habitats Eastern-central upland and wetland habitats
14, 17 and 22 August 2015	Eastern and northeastern marine habitats and coastal habitats
24, 25, 26 and 27 October 2015	Southeastern and south-central upland and wetland habitats

GIS Mapping Methods

The proposed method for developing GIS layers that graphically illustrate the biodiversity and ecosystem service values of East Caicos involves the integration of aerial imagery, input of field study data and remote sensing (attribution of habitats visually similar to those assessed during field studies). The GIS shape files for terrestrial habitats, developed by Dr. Barbara Brunnick in association with the Turks and Caicos Islands terrestrial habitat mapping project (Wood et al., 2010), were used as a base for mapping the MCEM. In the habitat mapping project, polygons were developed for all discernable habitats and attributed with vegetation classifications on a Class, Subclass and Formation level. All habitats have a Group classification of “tropical/subtropical”. Using QGIS, an open source graphic information system, additional polygons were developed for marine habitats for this analysis.

Using polygons as a vector layer, an attribute table was developed with columns for each of the MCEM criteria. The criterion for endemism was split into three columns for TCI, Lucayan and Regional endemics. The criterion for RTE species was also split into three columns, IUCN, CITES and SPAW. In total, 20 criteria columns were developed.

All data from desktop and field studies were then analyzed for presence/absence of each of the MCEM criteria. If a criteria was present, it was marked in the criteria column as a value of “1”. If a criteria was absent, it was marked in the respective column as “0”. A final column was developed to provide a total sum of all criteria, ranging from zero to 20.

The data entered into the attribute table was then used to map the ecological features of the landscape, using values mapped on a gradient. The vector layer was converted to a raster layer for each criterion to be mapped individually and collectively. The results of field studies and the GIS mapping analysis appear in the Results section of this report.

The resultant map was analyzed based on identified evaluation criteria. Appropriate land use management strategies are discussed in the Discussion section. Areas for further research are identified, and recommendations for conservation approaches are made. The results were also presented to policy makers as a written report and through a workshop to present results and provide a forum for discussion and feedback.

Chapter III

Results

A review of existing literature and field studies were used to identify and map the biodiversity ecosystem service values of East Caicos. A summary of results, broken down by areas surveyed and habitat types follows.

Northern Coastal, Upland and Palustrine Habitats

Northern terrestrial and wetland areas are comprised of interconnected coastal, upland and palustrine ecosystems. The north coast of East Caicos is protected by a continuous barrier reef that extends from east to west. Barrier reef, coupled with prevailing easterly winds, protects the north shore from high seas and persistent wind. A coastal ridge feature runs approximately east to west for the entire length of the northern portion of the island, and this feature plays a significant role in shaping floral community structure and characteristics. Northern coastal, upland and palustrine survey points were recorded during field studies that took place 26 February 2015 – 1 March 2015 (Fig. 3).

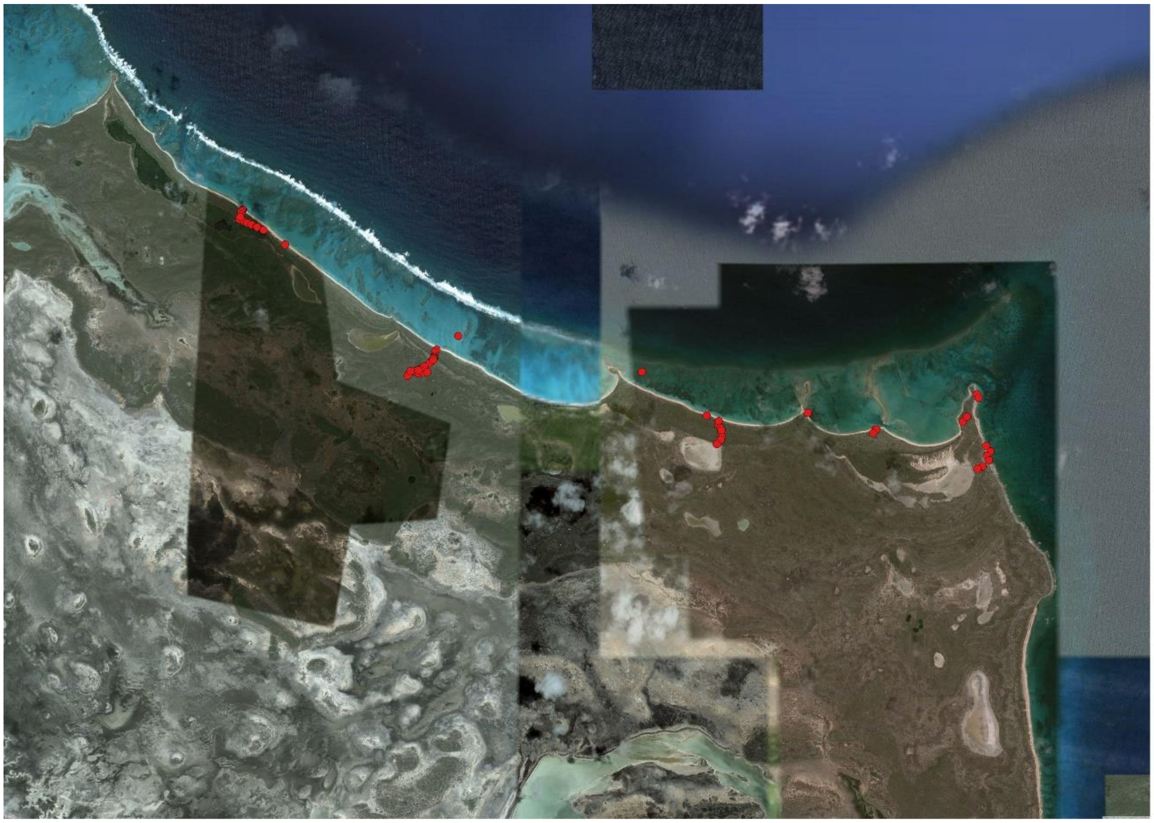

Figure 3. Northern survey points.

Habitats along the northern side of the ridge are directly exposed to coastal elements, and vegetation in these areas takes on coastal characteristics, such as salt tolerance, wind tolerance and xeromorphism (Fig. 4). Vegetation classification in these areas include coastal herbaceous, shrubland and woodland habitats. In northern coastal habitats, a total of 76 floral species were recorded, with a biodiversity value of H = 3.8035 (see Appendix 4 for northern coastal floral species distributions and biodiversity calculations). The species with the highest importance values in northern coastal habitats are wild thyme [*Euphorbia inaguensis* (13.9)], Inagua silver palm [*Coccothrinax inaguensis* (12.8)], black torch [*Erithalis fruticosa* (10.9)] and rong bush [*Wedelia* *bahamense* (9.14)]. Of these species, *E. inaguensis, C. inaguensis* and *W. bahamense* are Lucayan archipelago endemic floral species.

Figure 4. Northern coastal shrubland habitats.

E. inaguensis is a widely distributed floral species; however, the distribution of *W. bahamensis* is limited to intact coastal habitats, making this area an important conservation concern for this species. *C. inaguensis* has a distribution limited to TCI, Inagua and San Salvador. It is widely threatened throughout its range by coastal development and a k-selected life history, coupled with poor transplant success. The significant population of this species across the north coast of East Caicos makes this area an important conservation concern for the species (Fig. 5).

Figure 5. *Coccothrinax inaguensis* woodland habitats.

In addition to frequently occurring species, a number of other species of interest were noted during field studies in northern coastal habitats (Table 3), including the IUCN Endangered and TCI endemic floral species silvery silverbush (*Argythamnia argentea)* and Caicos Islands Encyclia (*Encyclia caicensis).* In addition, TCI endemic floral species, which have not yet been assessed by IUCN, Britton's buttonweed (*Spermacoce brittonii)* and TCI Cynanchum (*Cynanchum stipitatum),* were also recorded in northern coastal habitats. *A. argentea* has only been previously recorded on South Caicos, Grand Turk and Ambergris Cay in TCI (S. Williams, Clubbe, & Hamilton, 2012). *E. caicensis* occurs only in coastal areas in the northeastern islands of TCI and is vulnerable to coastal development pressures and poaching (S. Williams, Clubbe, & Hamilton, 2015). A total of four TCI, 11 Lucayan and 13 regional floral endemic species were observed in northern coastal habitats, in addition to one other floral species of interest [prickly pear *(Opuntia dillenii),* a CITES II listed species and possible TCI endemic sub-species], representing 38% of all floral species observed.

Table 3. Northern coastal floral species of interest.

Common Name	**Species**	**Endemism**	**RTE Status**
Pork and Doughboy	*Acacia acuifera*	Lucayan	
Inagua Agave	*Agave inaguensis*	Lucayan	
Silvery Silverbush	*Argythamnia argentea*	TCI	IUCN EN
Inagua Gumbo Limbo	*Bursera fagaroides*	Regional	
Catesby's Vine	*Catesbaea foliosa*	Lucayan	IUCN NT
Inagua Senna	*Chamaecrista caribaea var. inaguensis*	Regional	IUCN VU
Inagua Silver Palm	*Coccothrinax inaguensis*	Lucayan	IUCN DD
Nash's Tree Cactus	*Consolea nashii*	Lucayan	CITES II
Two-colored Croton	*Croton discolor*	Regional	
Marsh Cynanchum	*Cynanchum callialatum*	Regional	
Egger's Cynanchum	*Cynanchum eggersii*	Regional	
Inagua Cynanchum	*Cynanchum inaguense*	Lucayan	
TCI Cynanchum	*Cynanchum stipitatum*	TCI	Not Assessed
Dogwood	*Dodonaea viscosa*	Regional	
Caicos Encyclia	*Encyclia caicensis*	TCI	IUCN EN, CITESII
Wild Thyme	*Euphorbia inaguaensis*	Lucayan	
One-flowered Milk Pea	*Galactia uniflora*	Regional	
Jamaican Trash	*Gundlachia corymbosa*	Regional	
White Pussley	*Heliotropium nanum*	Lucayan	
Island Jacquemontia	*Jacquemontia cayensis*	Regional	
Berter's Joewood	*Jacquinia berteroi*	Regional	

Bahama Vernonia	*Lepidaploa arbuscula*	Lucayan	
Prickly Pear	*Opuntia dillenii*		CITES II
White Passionflower	*Passiflora pectinata*	Regional	
Swordbush	*Phyllanthus epiphyllanthus*	Regional	
Dildo Cactus	*Pilosocereus royenii*	Regional	CITES II
Bahama Buttonweed	*Spermacoce bahamensis*	Lucayan	
Britton's Buttonweed	*Spermacoce brittonii*	TCI	Not Assessed
Rong Bush	*Wedelia bahamensis*	Lucayan	

Northern coastal areas also provide habitat for a variety of fauna (Table 4), which were observed during field studies. The TCI endemic curly-tailed lizard *Leiocephalus psammodromus* was recorded throughout the area, and locally endemic sub-species thick-billed vireo (*Vireo crassirostris stalagmium)* and Antillean bullfinch *(Loxigilla violacea ofella)* were noted, with *V. crassirostris stalagmium* nesting in these habitats. The Lucayan archipelago endemic Bahama woodstar hummingbird *(Calliphlox evelynae)* was also noted nesting in northern coastal habitats. Populations of regionally endemic Bahama mockingbird (*Mimus gundlachii)* and Cuban crow *(Corvus nasicus)* were also observed in these areas. Bahama mockingbirds are known to avoid human population centers; therefore, uninhabited East Caicos could be an important refuge for this species (Montambault, 2007). In addition, migrant perching birds, such as northern parula (*Parula americana)* and American redstart (*Setophaga ruticilla)* were also recorded. Four IUCN Vulnerable West Indian whistling ducks *(Dendrocygna arborea)* were noted flying overhead during field studies in these areas; however, it is believed they were utilizing palustrine habitats, which are described in further detail in a subsequent section. A promontory, known locally as "Thatch Cay," located in the central portion of the north coast is a noted nesting area for bridled terns (*Sterna anaethetus)* and brown pelicans (*Pelecanus occidentalis)*. Hilton et al. conducted walking transect surveys of East Caicos and recorded six piping plover *(Charadrius melodus)* along the northern coastline during 2-9 March 2000 (Hilton et al., 2000b).

Table 4. Northern coastal fauna.

Common Name	**Species**	**Endemism**	**RTE Status**
Ruddy Turnstone	*Arenaria interpres*		
Bahama Woodstar Hummingbird	*Calliphlox evelynae*	Lucayan	
Piping Plover	*Charadrius melodus*		IUCN NT SPAW II Migrant
Semipalmated Plover	*Charadrius semipalmatus*		
Bananaquit	*Coereba flaveola*		
Cuban Crow	*Corvus nasicus*	Regional	
Smooth-billed Ani	*Crotophaga ani*		
West Indian Whistling Duck	*Dendrocygna arborea*		IUCN VU CITES II SPAW III
American Kestrel	*Falco sparverius*		CITES II
Curly-tailed Lizard	*Leiocephalus psammodromus*	TCI	
Antillean Bullfinch	*Loxigilla violacea ofella*	TCI Sub-species	
Bahama Mockingbird	*Mimus gundlachii*	Regional	
Osprey	*Pandion haliaetus*		CITES II
Northern Parula	*Parula americana*		Migrant
Brown Pelican	*Pelecanus occidentalis*		SPAW II Nesting
West Indian Flamingo	*Phoenicopterus ruber*		CITES II SPAW III
American Redstart	*Setophaga ruticilla*		Migrant
Bridled Tern	*Sterna anaethetus*		Nesting
Thick-billed Vireo	*Vireo crassirostris stalagmium*	TCI Sub-species	Nesting

MCEM ecological criteria in northern coastal habitats (Table 5) vary spatially and temporally across environmental gradients.

Table 5. Northern coastal MCEM criteria.

Criterion	**Description**
Materials	*Coccothrinax inaguensis* thatch for building
Regulation of Flows	Littoral movement of sand
Cultural Symbolic	Area of outstanding natural beauty, naturalness
Cultural Intellectual and Experiential	Tourism potential, educational, scientific research and study
RTE Species	Endangered, Vulnerable and Near Threatened floral species, CITES II floral species, Vulnerable and Near-threatened bird species, CITES II, SPAW II and SPAW III fauna
Endemic Species	TCI, Lucayan and regional endemic floral species, TCI endemic reptile species, TCI endemic bird sub-species, Lucayan and regional endemic bird species
Spatial/Temporal concentrations of species	Nesting bird populations, migrant bird habitat
Landscape-level Ecosystems and Mosaics	Applies to all areas on East Caicos
RTE Ecosystems	*Coccothrinax inaguensis* coastal woodlands are threatened in TCI by coastal tourism development

Habitats along the southern side of the northern coastal ridge receive protection from coastal elements, taking on upland characteristics and generally acquire greater stature and diversity. Vegetation classifications in these areas include upland dry dwarf shrubland, shrubland and forest. Where vegetation is exposed to wind, along ridgetops and other exposed areas, upland shrublands and dwarf shrublands occur. In more sheltered areas, dry forests occur (Fig. 6). A total of 80 floral species were recorded in northern upland habitats, with a biodiversity value of H = 4.0887 (see Appendix 5 for northern upland floral species distributions and biodiversity calculations). Species in the gumbo limbo and lignum vitae genera (*Bursera* and *Guaiacum)* have the highest observed importance values in northern upland habitats (9.66 and 9.17, respectively). Other species with high importance values include fire bush [*Croton lucidus* (7.61)] and dildo cactus [*Pilosocereus royenii* (7.42)]. Of these species, *G. sanctum* and *G. officinale* are IUCN Endangered floral species. While *G. sanctum* is widely disturbed in TCI, *G. officinale* is rare, with only occasional occurrence on North and Middle Caicos. The East Caicos population is the largest known, making this an area of important conservation concern for the species. *Swietenia mahagoni* is also observed here and is also listed as Endangered by IUCN. With rapid tourism development taking place across TCI, East Caicos' isolated populations of these Endangered flora could have significant future conservation value. *P. royenii* and *C. lucidus* are both regionally endemic species.

Figure 6. Northern dry forest formation.

Significant populations of *Pedilanthus bahamensis*, a Lucayan archipelago endemic and CITES Appendix II species with limited distribution in TCI, were also observed in northern upland habitats, making this area an important conservation concern for the species.

A number of other floral species of interest occur in northern upland dry dwarf shrubland, shrubland and forest habitats (Table 6). A total of one TCI, 13 Lucayan and 14 regional endemic species, in addition to three other species of interest comprise 40% of total observed species.

Table 6. Northern upland floral species of interest.

Common Name	**Species**	**Endemism**	**RTE Status**
Pork and Doughboy	*Acacia acuifera*	Lucayan	
Tamarindillo	*Acacia choriophylla*	Regional	
Brace's Agave	*Agave braceana*	Lucayan	
Lucayan Silverbush	*Argythamnia lucayana*	Lucayan	
Inagua Gumbo Limbo	*Bursera fagaroides*	Regional	
Brasiletto	*Caesalpinia bahamensis*	Regional	
Catesby's Vine	*Catesbaea foliosa*	Lucayan	IUCN NT
Tie-tongue	*Coccoloba swartzii*	Regional	
Inagua Silver Palm	*Coccothrinax inaguensis*	Lucayan	IUCN DD
Nash's Tree Cactus	*Consolea nashii*	Lucayan	CITES II
Two-color Croton	*Croton discolor*	Regional	
Fire Bush	*Croton lucidus*	Regional	
Egger's Cynanchum	*Cynanchum eggersii*	Regional	
Bahama Lovegrass	*Eragrostis bahamensis*	Lucayan	
Serrate-leaved Ernodea	*Ernodea serratifolia*	Lucayan	
Broom Bush	*Evolvulus bahamensis*	TCI	Not evaluated
Wild Sisal	*Furcraea hexapetala*	Regional	
Bahama Milk Pea	*Galactia bahamensis*	Lucayan	
Carajo Bush	*Gochnatia paucifloscula*	Regional	
Lignum Vitae	*Guaiacum officinale*		IUCN EN CITES II SPAW III
Lignum Vitae	*Guaiacum sanctum*		IUCN EN CITES II SPAW III
Wild Salve	*Helicteres semitriloba*	Regional	
Berter's Joewood	*Jacquinia berteroi*	Regional	
Bahama Vernonia	*Lepidaploa arbuscula*	Lucayan	
Haul Back	*Mimosa bahamensis*	Lucayan	
White Passionflower	*Passiflora pectinata*	Regional	
Monkey Fiddle	*Pedilanthus bahamensis*	Lucayan	CITES II
Sword Bush	*Phyllanthus epiphyllanthus*	Regional	
Dildo Cactus	*Pilosocereus royenii*	Regional	CITES II
West Indian Mahogany	*Swietenia mahagoni*		IUCN EN CITES II
Rong Bush	*Wedelia bahamensis*	Lucayan	

Northern upland areas also provide habitat for locally resident bird species (Table 7), including nesting habitat for TCI endemic sub-species *Vireo crassirostris stalagmium* and *Loxigilla violacea ofella*.

Table 7. Northern upland fauna.

Common Name	**Species**	**Endemism**	**Other**
Bananaquit	*Coereba flaveola*		Nesting
Antillean Bullfinch	*Loxigilla violacea ofella*	TCI Sub-species	Nesting
Bahama Mockingbird	*Mimus gundlachii*	Regional	
Thick-billed Vireo	*Vireo crassirostris stalagmium*	TCI Sub-species	Nesting

Northern upland habitats exhibit significant conservation values in terms of biodiversity and ecosystem services, and several MCEM criteria were recorded as present during field studies (Table 8).

Table 8. Northern upland MCEM criteria.

Criterion	**Description**
Materials	Genetic reservoir of medicinal and ornamental plants
Regulation of Physical Environment	Carbon sink
Cultural Symbolic	Area of outstanding natural beauty, naturalness,
Cultural Intellectual and Experiential	Tourism potential, educational, scientific research and study
RTE Species	Endangered and Near Threatened floral species, CITES II and SPAW III floral species
Endemic Species	TCI, Lucayan and regional endemic floral species, TCI endemic bird sub-species, regional endemic bird species
Spatial/Temporal concentrations of species	Nesting bird populations
Landscape-level Ecosystems and Mosaics	Applies to all areas on East Caicos
RTE Ecosystems	Upland dry forests are rare habitats in TCI, threatened by development and are considered the most-threatened forest type (Franklin, Ripplinger, Freid, Marcano-Vega, & Steadman, 2015)

Along the southern edge of the northern coastal ridge, seasonal wetlands have formed. These areas collect runoff from the surrounding watersheds during seasonal rainy periods, forming palustrine nonvascular, herbaceous, shrubland, woodland and forests. In TCI, freshwater lenses are known to develop in areas where unconsolidated limestone sands overlay porous bedrock or in low-lying areas that receive runoff from surrounding watersheds. Although East Caicos has never had its hydrological resources mapped, one can assume that the island's hydrological regimens are similar to those on other islands in the archipelago. Therefore, it is likely that fresh ground water exists throughout the northern areas, along the length of the island where rainwater collects in low-lying depressions between ridges. The presence of fresh water within caves throughout the area supports this assumption (Mather, 1988).

A total of 23 floral species were recorded in northern palustrine habitats during field studies, with a calculated biodiversity of H = 2.9177 (see Appendix 6 for floral species distributions and biodiversity calculations in northern palustrine habitats). In palustrine habitats, green buttonwood (*Conocarpus erectus)* is the canopy species with the highest importance value (21.5). *C. erectus* is listed in Appendix III of the SPAW Protocol of the Cartagena Convention due to conservation concerns regarding palustrine wetlands in the Caribbean region. In general, East Caicos' palustrine habitats are an important reservoir for this and allied species. Important understory (herbaceous) species include seashore rush grass [*Sporobolus virginicus* (16.8)], seaside purslane [*Sesuvium portulacastrum* (15.1)] and saltwort [*Batis maritima* (16.8)]. Floral species of interest include some regional endemic species and species listed under Appendix II of CITES and Appendix III of the SPAW Protocol of the Cartagena Convention. Floral species of interest (Table 9) comprise 43.5% of all floral species observed during field studies in northern palustrine areas.

Figure 7. Northern palustrine habitats with West Indian flamingos.

Table 9. Northern palustrine floral species of interest.

Common Name	Species	Endemism	RTE Status
Black Mangrove	*Avicennia germinans*		SPAW III
Green Buttonwood	*Conocarpus erectus*		SPAW III
Two-colored Croton	*Croton discolor*	Regional	
Dogwood	*Dodonaea viscosa*	Regional	
Jamaican Trash	*Gundlachia corymbosa*	Regional	
Island Jacquemontia	*Jacquemontia cayensis*	Regional	
Prickly Pear	*Opuntia dillenii*		CITES II
Red Mangrove	*Rhizophora mangle*		SPAW III
Bushy Salmea	*Salmea petrobioides*	Regional	
Milk Berry	*Sideroxylon americanum*	Regional	

Although floral diversities are relatively low in northern palustrine areas, they provide important habitat for significant populations of waterfowl (Table 10). Within these habitats, West Indian flamingo *(Phoenicopterus ruber)* populations numbering in the several 100's were noted during field studies (Fig. 7), in addition to White-cheeked pintail *(Anas bahamensis),* American coot *(Fulica americana),* pied-billed grebe *(Podilymbus podiceps*) and least grebe *(Tachybaptus dominicus)* populations numbering in the several 10's. Hilton et al. observed West Indian whistling ducks on northern East Caicos ponds during field studies in 2000, and recreational users of East Caicos also report citing these animals. Hilton et al. conclude that the West Indian whistling duck may be genuinely scarce in TCI due to the fact that they are "nomadic opportunists [responding] to unpredictable changes in wetland conditions" (Hilton et al., 2000b, p. 117). The variety and extent of palustrine habitats on East Caicos may therefore be critical to the survival of this species in TCI. It is assumed that the birds observed in coastal habitats during field studies are utilizing these palustrine habitats.

As reservoirs of fresh water, these areas are critical habitats for all waterfowl species, both resident and migratory. American coot and lesser scaup (*Aythya affinis)* are migratory species that are using these habitats as stopover areas. White-cheeked pintail and grebe populations were breeding residents, as juveniles were also noted.

Table 10. Northern palustrine fauna.

Common Name	**Species**	**Endemism**	**RTE Status**	**Other**
White-cheeked Pintail	*Anas bahamensis*	Regional		Breeding
Lesser Scaup	*Aythya affinis*			Migratory
Great White Egret	*Ardea alba*			
West Indian Whistling Duck	*Dendrocygna arborea*		IUCN VU CITES II, SPAW III	
Yellow Warbler	*Dendroica petechia*			
Snowy Egret	*Egretta thula*			
American Coot	*Fulica americana*			Migratory
Neotropic Cormorant	*Phalacrocorax brasilianus*			Locally Rare
West Indian Flamingo	*Phoenicopterus ruber*		CITES II SPAW III	Significant Population
Pied-billed Grebe	*Podilymbus podiceps*			Breeding
Least Grebe	*Tachybaptus dominicus*			Breeding
Thick-billed Vireo	*Vireo crassirostris stalagmium*	TCI Sub-species		

MCEM ecological criteria (Table 11) in northern palustrine habitats are fairly uniform over spatial gradients; however, they vary seasonally with rainfall and migration patterns.

Table 11. Northern palustrine MCEM criteria.

Criterion	**Description**
Nutrition	Fresh water
Regulation of Flows	Flood water catchment
Regulation of Wastes	Wetland filtration
Regulation of Physical Environment	Carbon sequestration
Cultural Symbolic	Area of outstanding natural beauty, naturalness
Cultural Intellectual and Experiential	Tourism potential, educational, scientific research and study
RTE Species	Vulnerable bird species, near-threatened bird species, CITES II and SPAW III bird species
Endemic Species	Regional endemic floral species, TCI endemic bird sub-species and regional endemic bird species
Spatial/Temporal concentrations of species	Nesting bird populations, migrant bird habitat, congregations of birds (flamingos)
Landscape-level Ecosystems and Mosaics	Applies to all areas on East Caicos
RTE Ecosystems	*Conocarpus erectus* palustrine habitats are threatened throughout TCI by development pressure

MCEM overall scores for northern areas range from a minimum of five to a maximum of nineteen evaluation criteria points (Fig. 8). The areas with greatest ecosystem service and biodiversity values are tropical dry forests, shrublands and woodlands in these areas.

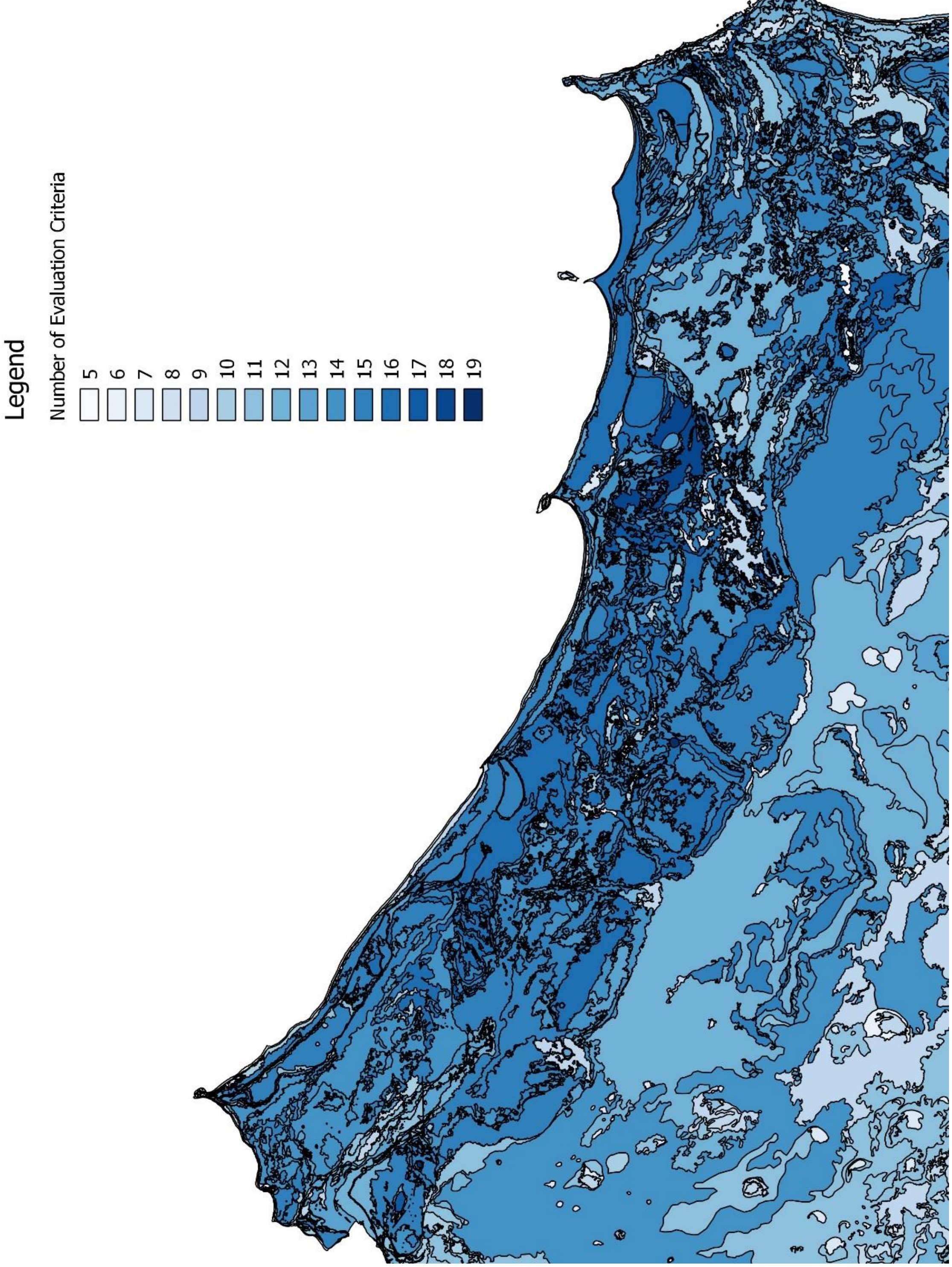

Figure 8. MCEM map for northern areas.

Eastern Coastal, Upland, Palustrine and Estuarine Habitats

Eastern terrestrial and wetland areas form integrated mosaics of coastal, upland, palustrine and estuarine habitats. The eastern shoreline is characterized by a shallow, narrow shelf, with scattered patch reefs, that drops precipitously to 7,000 ft. depths directly offshore at the Columbus Passage. Easterly winds prevail, with speeds averaging approximately 18 kmph (Doran, 1958; USACE, 2012) thus exposing eastern habitats to almost continual wind and wave action. Along the eastern coastline, a coastal ridge runs approximately north to south, and this ridge plays an important role in shaping terrestrial and wetland habitats in eastern areas. Coastal, upland, palustrine and estuarine survey points were taken on 1st March and 7-8th June 2015 (Fig. 9).

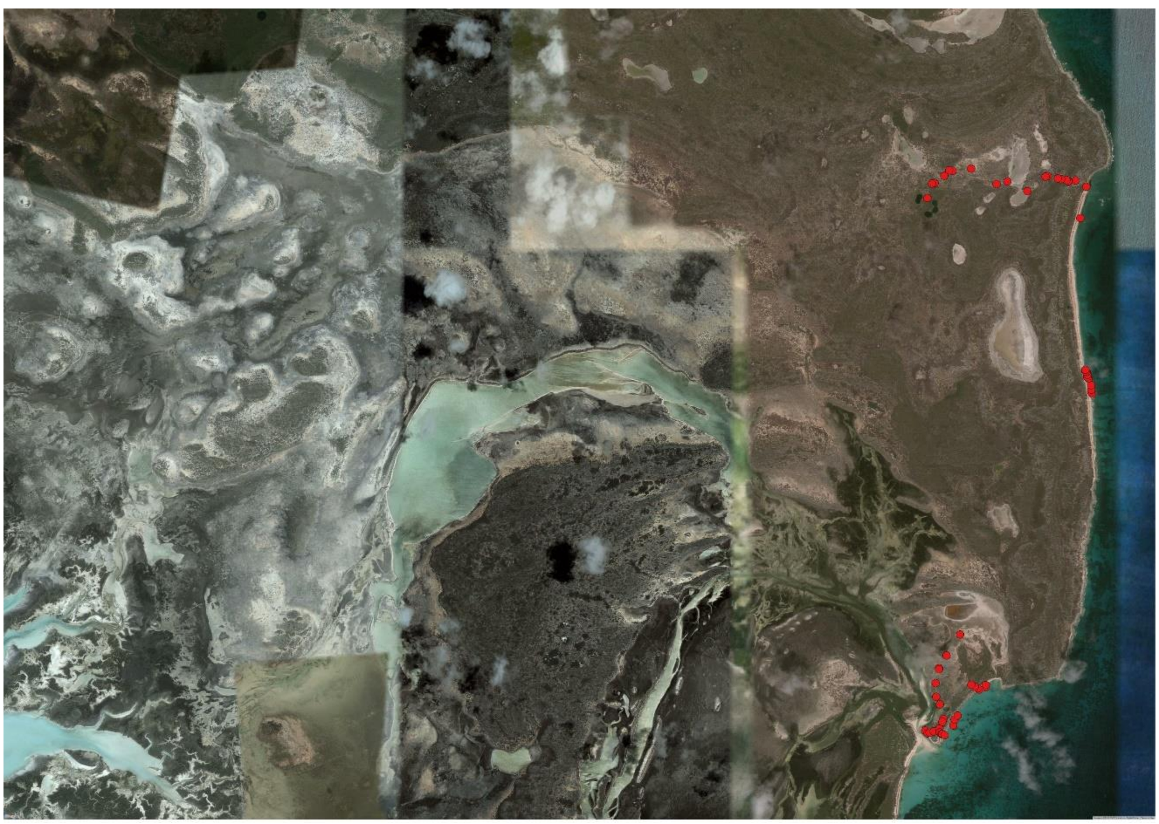

Figure 9. Eastern survey points.

Immediately adjacent to the eastern shoreline, terrestrial habitats are strongly influenced by prevailing wind and wave conditions. Vegetation in these areas has adapted to coastal variables such as salinity, wind and drought, resulting in dwarfed, xeromorphic and salt-tolerant floral species assemblages (Fig. 10). Habitats in these areas include coastal mixed woodlands, shrublands, dwarf shrublands and coastal rock dwarf shrublands. In these habitats, a total of 46 floral species were observed, with a calculated biodiversity of H = 3.56501 (see Appendix 7 for floral species distributions and biodiversity calculations). The species with the highest importance value is wild thyme [*Euphorbia inaguensis* (15.9)]. Other species with the high importance values are sea grape [*Coccoloba uvifera* (10.9)], seven-year apple [*Casasia clusiifolia* (9.34)], jack switch [*Corchorus hirsutus* (10.9)] and two-colored croton [*Croton discolor* (10.1)].

Figure 10. Eastern coastal habitats.

Table 12. Eastern coastal floral species of interest.

Common Name	**Species**	**Endemism**	**RTE Status**
Inagua Agave	*Agave inaguensis*	Lucayan	
Shining Silverbush	*Argythamnia candicans*	Regional	
Black Mangrove	*Avicennia germinans*		SPAW III
Inagua Senna	*Chamaecrista caribaea var. inaguensis*	Regional	IUCN VU
Green Buttonwood	*Conocarpus erectus*		SPAW III
Two-colored Croton	*Croton discolor*	Regional	
Fire Bush	*Croton lucidus*	Regional	
Marsh Cynanchum	*Cynanchum callialatum*	Regional	
Egger's Cynanchum	*Cynanchum eggersii*	Regional	
Dogwood	*Dodonaea viscosa*	Regional	
Wild Thyme	*Euphorbia inaguaensis*	Lucayan	
Sheathed Spurge	*Euphorbia vaginulata*	Lucayan	
Jamaican Trash	*Gundlachia corymbosa*	Regional	
Island Jacquemontia	*Jacquemontia cayensis*	Regional	
Berter's Joewood	*Jacquinia berteroi*	Regional	
Prickly Bush	*Oplonia spinosa*	Regional	
Prickly Pear	*Opuntia dillenii*		CITES II
Dildo Cactus	*Pilosocereus royenii*	Regional	CITES II
Red Mangrove	*Rhizophora mangle*		SPAW III
Bahama Buttonweed	*Spermacoce bahamensis*	Lucayan	
Thyme-like Buttonweed	*Spermacoce thymifolia*	Lucayan	
Rong Bush	*Wedelia bahamensis*	Lucayan	

In addition to numerous Lucayan and Regional endemic floral species, Inagua senna (*Chamaecrista caribaea var. inaguensis)*, a regional endemic species and IUCN Vulnerable species, was also recorded in these areas during field studies. A total of 22 floral species of interest (Table 12) were observed in Eastern coastal habitats during field studies (48% of all observed species), making eastern coastal habitats of significant conservation concern.

Eastern coastal areas also provide significant habitat for a number of faunal species (Table 13). Of particular conservation interest, east coast beaches function as nesting areas for Critically Endangered hawksbill *(Eretmochelys imbricata)* and Endangered green (*Chelonia mydas)* sea turtles. Green (*Chelonia mydas)*, loggerhead *(Caretta caretta)* and hawksbill (*Eretmochelys imbricata)* turtles have remnant localized nesting populations in TCI; however, their numbers have been reduced over time due to traditional fishing and harvest of eggs from nesting beaches (Richardson, 2011). Green and hawksbill turtles are the most abundant, with green turtles largely occurring in seagrass beds and tidal creeks and hawksbills occurring on fringing and patch reefs. Loggerhead and leatherback *(Dermochelys coriacea)* turtles are occasional (Richardson, 2011). A majority of these turtles are from populations originating within the wider Caribbean nesting area and are not of locally born stock (Richardson, 2011). Turtle nests and breeding adults are now protected under the Fisheries Protection Ordinance ("Fisheries Protection Ordinance," 1997); however, harvest of sub-adults for personal consumption is still legal and takes place. Peter Richardson identified East Caicos as a nesting area for “unidentified” species during a rapid aerial survey (Richardson, 2011, p. 133). Given historic harvests of eggs and nesting adults, nesting activities are now mostly limited to uninhabited islands, such as East Caicos (Richardson, 2011, p. 133). Our field data associated with this study indicates that the east coast of East Caicos is more important for turtle nesting than previously estimated. Although the beach was only surveyed on one day, during field studies on 14th August 2015, six green turtle *(Chelonia mydas)* nests and tracks, two hawksbill turtle *(Eretmochelys imbricata)* nests and tracks and one unconfirmed loggerhead (*Caretta caretta)* nest and track were recorded along east coast beaches. The southeastern coastal areas are also providing habitat to a small population of Critically Endangered and locally endemic TCI rock iguanas *(Cyclura carinata)*. This species has been extirpated from all inhabited islands in the archipelago. In addition a number of migrant and breeding bird populations are noted in eastern coastal areas. Drum Point on the northeastern side of East Caicos is serving as a nesting area for Audubon's shearwater. This is one of only two known nesting sites for this species in TCI. A small number (four) of Near Threatened piping plover (*Charadrius melodus)* were also observed foraging along the eastern coastline. Norton and Clarke (1989) reported geographically restricted nesting white-tailed tropicbirds (*Phaethon lepturus)* along the east-facing cliffs of East Caicos (Norton & Clarke, 1989).

Table 13. Eastern coastal fauna.

Common Name	**Species**	**Endemism**	**RTE Status**	**Other**
Green Heron	*Butorides striata*			Breeding
Sanderling	*Calidris alba*			Migratory
Loggerhead Turtle	*Caretta caretta*		IUCN EN CITES I SPAW I	Possible Nesting
Piping Plover	*Charadrius melodus*		IUCN NT CITES II SPAW II	Migratory
Semipalmated plover	*Charadrius semipalmatus*			Migratory
Green Turtle	*Chelonia mydas*		IUCN EN CITES I SPAW I	Nesting
Bananaquit	*Coereba flaveola*			
TCI Rock Iguana	*Cyclura carinata*	TCI	IUCN CR CITES I SPAW II	
Hawksbill Turtle	*Eretmochelys imbricata*		IUCN CR CITES I SPAW I	Nesting
Laughing Gull	*Larus atricilla*			
Osprey	*Pandion haliaetus*		CITES II	
Brown Pelican	*Pelecanus occidentalis*		SPAW II	
White-tailed Tropicbird	*Phaethon lepturus*			Geographic ally restricted
Audubon's shearwater	*Puffinus lherminieri*		SPAW II	Nesting
Least Tern	*Sterna antillarum antillarum*		SPAW II	Migratory

Eastern coastal habitats express a number of MCEM criteria (Table 14), which are spatially and temporally variable, according to environmental variables and seasonality.

Table 14. Eastern coastal MCEM criteria.

Criterion	**Description**
Energy	Constant onshore winds
Regulation of Flows	Dissipation of wave and wind energy
Cultural Symbolic	Area of outstanding natural beauty, naturalness, Lucayan archaeological sites
Cultural Intellectual and Experiential	Tourism potential, educational, scientific research and study
RTE Species	Critically Endangered and Endangered sea turtles Critically Endangered TCI rock iguanas, Vulnerable *Chamaecrista caribae*a *var. inaguensis*, Near Threatened piping plover, SPAW II brown pelican, least tern and Audubon's shearwater
Endemic Species	6 Lucayan endemic plants, 12 regional endemic plants, TCI endemic rock iguana
Spatial/Temporal concentrations of species	Nesting bird populations, migrant bird habitat, nesting sea turtles
Geographically Restricted Species	White-tailed tropicbird (nesting)
Landscape-level Ecosystems and Mosaics	Applies to all areas on East Caicos
RTE Ecosystems	Turtle nesting beaches are threatened by tourism development throughout the TCI archipelago

In areas where the eastern ridge provides shelter from coastal elements, upland shrublands and woodlands are present (Fig. 11). A total of 50 floral species were recorded in eastern upland habitats during field studies, with a calculated biodiversity of H = 3.6692. Appendix 8 lists floral species distributions and biodiversity calculations for eastern upland habitats. Floral species distributions in these habitats are widely mixed; however, the species with the highest importance value for eastern upland habitats is two-color croton [*Croton discolor* (13.7)]. Other species with relatively high importance values include gumbo limbo [*Bursera simaruba* (9.54)], black torch [*Erithalis fruticosa*

(7.63)], naked back [*Euphorbia gymnonota* (7.39)], fire bush [*Croton lucidus* (6.56)] and satinwood [*Zanthoxylum flavum* (6.56)]. Of these species, *E. gymnonota* is a Lucayan archipelago endemic, listed under CITES Appendix II, and *C. lucidus* is a regional endemic. While *C. lucidus* is widely distributed across TCI, *E. gymnonota*'s distribution is limited to small populations on only a few islands of the archipelago, making the East Caicos population an important conservation interest for TCI. Of particular interest is the wide presence of the TCI endemic and IUCN Endangered floral species *Argythamnia argentea* in these habitats. In total, 31 species of interest (62% of all species recorded), including TCI, Lucayan and regional endemic floral species and RTE species were observed in eastern upland habitats, making this an area of significant conservation concern for TCI floral species (Table 15).

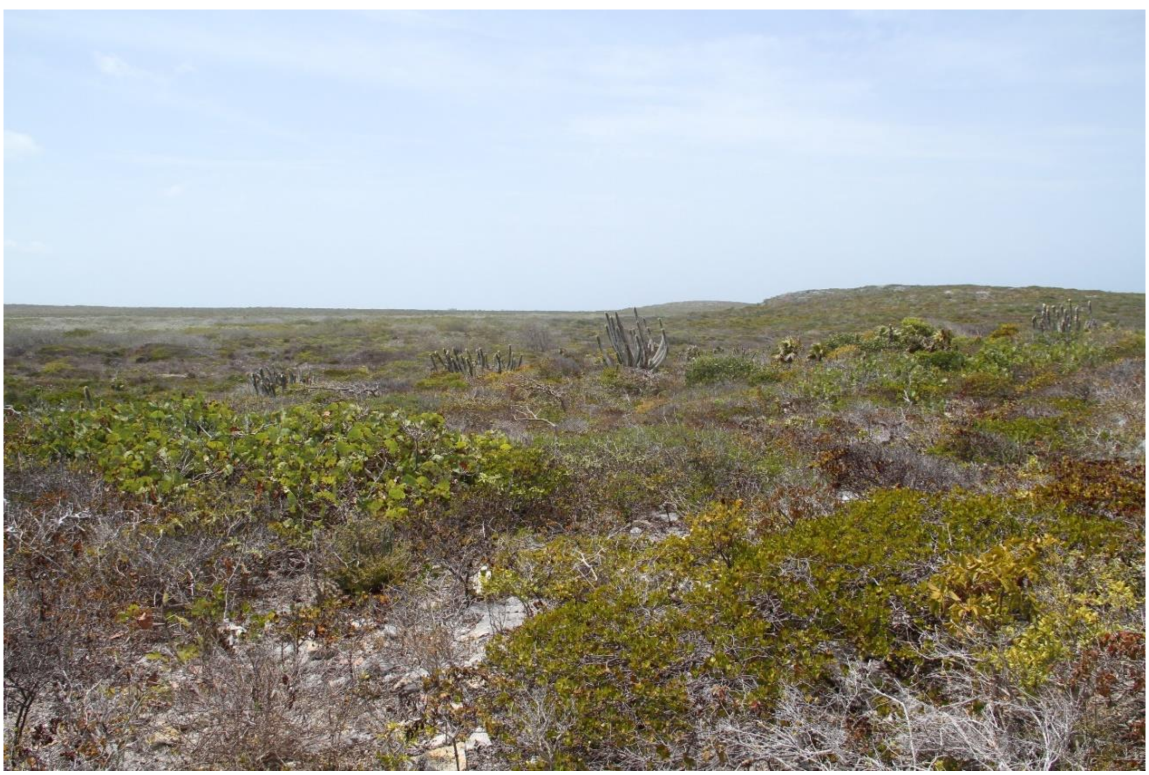

Figure 11. Eastern upland habitats (dry season).

Table 15. Eastern upland species of interest.

Common Name	**Species**	**Endemism**	**RTE Status**
Pork and Doughboy	*Acacia acuifera*	Lucayan	
Brace's Agave	*Agave braceana*	Lucayan	
Inagua Agave	*Agave inaguensis*	Lucayan	
Silvery Silverbush	*Argythamnia argentea*	TCI	
Brasiletto	*Caesalpinia bahamensis*	Regional	
Inagua Senna	*Chamaecrista caribaea var. inaguensis*	Regional	IUCN VU
Green Buttonwood	*Conocarpus erectus*		SPAW III
Two-color Croton	*Croton discolor*	Regional	
Fire Bush	*Croton lucidus*	Regional	
Bahama Spikerush	*Eleocharis bahamensis*	Lucayan	
Inagua Encyclia	*Encyclia inaguensis*	Lucayan	CITES II
Red Encyclia	*Encyclia rufa*	Regional	CITES II
Serrate-leaved Ernodea	*Ernodea serratifolia*	Lucayan	
Naked Back	*Euphorbia gymnonota*	Lucayan	CITES II
Wild Thyme	*Euphorbia inaguaensis*	Lucayan	
Broom Bush	*Evolvulus bahamensis*	TCI	
Spiny Flueggea	*Flueggea acidoton*	Regional	
Lignum Vitae	*Guaiacum sanctum*		IUCN EN CITES II SPAW III
Jamaican Trash	*Gundlachia corymbosa*	Regional	
Bahama Maidenbush	*Heterosavia bahamensis*	Regional	
Island Jacquemontia	*Jacquemontia cayensis*	Regional	
Turks Cap Cactus	*Melocactus intortus*	Regional	CITES II SPAW III
Prickly Bush	*Oplonia spinosa*	Regional	

Bahama Prickly Pear	*Opuntia bahamana*		CITES II
White Passionflower	*Passiflora pectinata*	Regional	
Monkey Fiddle	*Pedilanthus bahamensis*	Lucayan	CITES II
Dildo Cactus	*Pilosocereus royenii*	Regional	CITES II
Bushy Salmea	*Salmea petrobioides*	Regional	
Thyme-like Buttonweed	*Spermacoce thymifolia*	Lucayan	
Rong Bush	*Wedelia bahamensis*	Lucayan	
Bahama Jujube	*Ziziphus taylorii*	Lucayan	

In addition to floral communities, eastern upland habitats also provide habitat to a variety of fauna (Table 16). As surveys in these areas were conducted during the summer months, winter migrant bird species would not have been counted. Nevertheless, nesting activities of three bird species were noted, in addition to two endemic reptile species.

Table 16. Eastern upland fauna.

Common Name	***Species***	***Endemism***	***Other***
Bark Anole	Anolis scriptus scriptus	TCI subspecies Lucayan	
Bahama Woodstar	Calliphlox evelynae	Lucayan	Nesting
Bananaquit	Coereba flaveola		Nesting
Common Ground Dove	Columbina passerina		
Curly-tail Lizard	Leiocephalus psammodromus	TCI	
Blue-gray Gnatcatcher	Polioptila caerulea		Nesting

Eastern upland habitats exhibit a variety of MCEM criteria (Table 17).

Table 17. Eastern upland MCEM criteria.

Criterion	**Description**
Materials	Ornamental floral species (*Agave spp. Euphorbiacea, Encyclia spp.* and *Cactacea)*
Regulation of Physical Environment	Carbon sink
Cultural Symbolic	Area of outstanding natural beauty, naturalness
Cultural Intellectual and Experiential	Tourism potential, educational, scientific research and study
RTE Species	IUCN EN *Guaiacum sanctum*, IUCN VU *Chamaecrista caribaea var. inaguensis*, numerous CITES II and SPAW III listed floral species
Endemic Species	1 TCI endemic plant, 13 Lucayan endemic plants, 15 regional endemic plants, TCI endemic curly tail and Lucayan endemic bark anole
Spatial/Temporal concentrations of species	Nesting bird populations
Landscape-level Ecosystems and Mosaics	Applies to all areas on East Caicos

At the western edge of the eastern coastal ridge, lowlands capture runoff from seasonal rains, forming palustrine wetland habitats. During field studies, a total of 22 floral species were observed within these habitats, with a calculated biodiversity of H = 2.9390. Appendix 9 lists species compositions and biodiversity calculations in eastern palustrine habitats. Eastern palustrine habitats include nonvascular, herbaceous, shrubland and woodland habitats. Green and silver buttonwood (*Conocarpus erectus* and *Conocarpus erectus var. sericeus)* are the species with the highest importance values (total 29.9) recorded in eastern palustrine habitats. Other important species are sea grape [*Coccoloba uvifera* (16.9)], saltwort [*Batis maritima* (12.1)], Inagua agave [*Agave inaguensis* (16.0)] and Jamaican trash [*Gundlachia corymbosa* (18.3)]. Of these species

A. inaguensis is a Lucayan archipelago endemic floral species, with a distribution limited to TCI and Inagua in the Bahamas. The East Caicos eastern population represents the largest known population in TCI and possibly across its range, making this an area of significant conservation concern for this species.

Of particular conservation interest is the occurrence in these areas of fine-leaved buttonweed (*Spermacoce capillaris)*, a TCI endemic floral species and IUCN Endangered species (Fig. 12). *S. capillaris* is restricted to small areas on South Caicos and East Caicos (Barrios & Manco, 2015). With impending development in habitat on South Caicos, the East Caicos population of this species is of significant conservation value. Other floral species of interest were also observed (Table 18).

Figure 12. *Spermacoce capillaris* in eastern palustrine habitat.

Table 18. Eastern palustrine floral species of interest.

Common Name	**Species**	**Endemism**	**RTE Status**
Inagua Agave	*Agave inaguensis*	Lucayan	
Inagua Senna	*Chamaecrista caribaea var. inaguensis*	Regional	IUCN VU
Green Buttonwood	*Conocarpus erectus*		SPAW III
Silver Buttonwood	*Conocarpus erectus var. sericeus*		SPAW III
Egger's Cynanchum	*Cynanchum eggersii*	Regional	
Dogwood	*Dodonaea viscosa*	Regional	
Bahama Lovegrass	*Eragrostis bahamensis*	Lucayan	
Wild Thyme	*Euphorbia inaguaensis*	Lucayan	
Sheathed Spurge	*Euphorbia vaginulata*	Lucayan	
Jamaican Trash	*Gundlachia corymbosa*	Regional	
Island Jacquemontia	*Jacquemontia cayensis*	Regional	
Berter's Joewood	*Jacquinia berteroi*	Regional	
Bushy Salmea	*Salmea petrobioides*	Regional	
Bahama Buttonweed	*Spermacoce bahamensis*	Lucayan	
Fine-leaved Buttonweed	*Spermacoce capillaris*	TCI	IUCN EN

In addition to the occurrence of important floral species, eastern palustrine habitats also provide critical habitat for waterfowl, seabirds and other birds (Table 19). In particular, at least 50 pairs of least tern (*Sterna antillarum antillarum)* were observed nesting within nonvascular palustrine habitats (Fig. 13). Black-necked stilts were also observed with juveniles in these habitats.

Figure 13. Eastern palustrine habitat with least tern hatchlings.

Table 19. Eastern palustrine fauna.

Common Name	**Species**	**Endemism**	**Other**
Bark Anole	*Anolis scriptus scriptus*	TCI subspecies Lucayan	
Bahama Woodstar	*Calliphlox evelynae*	Lucayan	Nesting
Blue Land Crab	*Cardisoma guanhumi*		
Willet	*Tringa semipalmata*		Nesting Migratory
Wilson's Plover	*Charadrius wilsonia*		Migratory
Bananaquit	*Coereba flaveola*		Nesting
Cuban Crow	*Corvus nasicus*	Regional	
American Kestrel	*Falco sparverius*		
Black-necked Stilt	*Himantopus mexicanus*		Nesting
Curly-tail Lizard	*Leiocephalus psammodromus*	TCI	
Brown Pelican	*Pelecanus occidentalis*		SPAW II
Least Tern	*Sterna antillarum antillarum*		Nesting Migratory
Gray Kingbird	*Tyrannus dominicensis*		Migratory

Several MCEM criteria were recorded as present in eastern palustrine habitats (Table 20).

Table 20. Eastern palustrine MCEM criteria.

Criterion	**Description**
Nutrition	Fresh water catchment and storage
Materials	Ornamental floral species (*Agave spp.)*
Regulation of Wastes	Filtering capacity of wetlands
Regulation of Flows	Flood plains and water catchment
Regulation of Physical Environment	Carbon sink
Cultural Symbolic	Area of outstanding natural beauty, naturalness, Lucayan archaeological site
Cultural Intellectual and Experiential	Tourism potential, educational, scientific research and study
RTE Species	IUCN EN *Spermacoce capillaris*, IUCN VU *Chamaecrista caribaea var. inaguensis*, numerous CITES and SPAW listed species
Endemic Species	1 TCI endemic plant, 5 Lucayan endemic plants, 7 regional endemic plants, TCI endemic curly tail and Lucayan endemic bark anole and Bahama woodstar hummingbird, regional endemic Cuban crow.
Spatial/Temporal concentrations of species	Nesting bird populations
Landscape-level Ecosystems and Mosaics	Applies to all areas on East Caicos
RTE Ecosystems	Palustrine habitats are threatened across TCI by dredge and fill activities.

At the southeastern tip of East Caicos, an extensive network of tidal creeks and estuaries connects directly to coastal habitats. Estuarine habitats in these areas include evergreen and mixed non-vascular, herbaceous, dwarf shrubland, shrubland, woodland and forest. Vegetative communities in these areas are limited by salinity and flooding, and species diversity is consequently low. A total of only seven vascular plant species were recorded in estuarine habitats, with a calculated biodiversity of H = 1.906155. Appendix 10 provides a list of floral species distributions and biodiversity calculations for eastern estuarine habitats. The most important species in these habitats is red mangrove *(Rhizophora mangle),* with an importance value of 25. The significance of these habitats lies not in their vascular plant assemblages, but rather in the ecosystem services provided by mangal habitats. These particular tidal creeks and estuaries are likely the most important and best examples of these habitats in TCI. The location of southeastern estuarine habitats, with direct connectivity to coastal and deep ocean areas, is unparalleled in TCI, making them an important nursery and foraging area for a wide variety of marine species (Fig. 14). During field studies a number of juvenile nurse *(Ginglymostoma cirratum)* (IUCN Near-threatened for Western Atlantic subpopulations) and lemon sharks *(Negaprion brevirostris)* (IUCN Near Threatened) were observed foraging within tidal creeks. The presence of neonatal lemon sharks (*Negaprion brevirostris)* with recent umbilical scars in the shallow estuarine areas surrounding East Caicos suggests that the area is an important spawning and nursery habitat for this species (Henderson, McClellan, & Calosso, 2010).

A wide variety of juvenile snappers *(Lutjanus* and *Ocyurus spp.),* grunts *(Haemulon spp.)* and other game fishes were noted within mangal prop root habitats during field studies. The tidal creeks and associated estuarine habitats in this area also appear to be providing habitat for all life phases of queen conch *(Strombus gigas),* a CITES Appendix II species and significant fisheries species in TCI. Marine species observed during field studies are listed in Appendix 14.

In 2009, five IUCN Endangered loggerheads *(Caretta caretta)* were captured near East Caicos. Two of these were foraging in southeastern tidal creeks. The immediate adjacency of these creeks to deep water may indicate that these areas are important foraging area for migrating individuals. One of these individuals, in particular, was an adult female, which may be nesting in the area (Stringell et al., 2010).

Figure 14. Mangal prop root nursery habitat.

In addition to marine species, eastern estuarine habitats are also important areas for seabirds, shoreline birds and other avian species (Table 21). A number of these species are nesting or migratory.

Table 21. Eastern estuarine fauna.

Common Name	**Species**	**Endemism**	**Other**
Great Blue Heron	*Ardea herodias*		Migratory
Green Heron	*Butorides striata*		Nesting
Great Egret	*Ardea alba*		Migratory
Wilson's Plover	*Charadrius wilsonia*		Migratory
White-crowned Pigeon	*Columba leucocephala*		SPAW III
Yellow Warbler	*Dendroica petechia*		Nesting
Reddish Egret	*Egretta rufescens*		IUCN NT Nesting
Magnificent Frigatebird	*Fregata magnificens*		
American Oystercatcher	*Haematopus palliatus*		Nesting
Laughing Gull	*Larus atricilla*		Nesting Migratory
Yellow-crowned Night Heron	*Nyctanassa violacea*		Nesting
Osprey	*Pandion haliaetus*		CITES II
Brown Pelican	*Pelecanus occidentalis*		SPAW II
Least Tern	*Sterna antillarum antillarum*		Nesting Migratory
Royal Tern	*Sterna maximus*		Migratory

A number of MCEM criteria are also present within eastern estuarine habitats (Table 22).

Table 22. Eastern estuarine MCEM criteria.

Criterion	**Description**
Nutrition	Nursery and foraging areas for game fish, *Strombus gigas*.
Regulation of wastes	Filtering capacity of mangals
Regulation of flows	Regulation of sediments, seawater flow
Regulation of Physical Environment	Carbon sink
Cultural Symbolic	Area of outstanding natural beauty, naturalness
Cultural Intellectual and Experiential	Tourism potential, educational, scientific research and study
RTE Species	SPAW III mangrove species, CITES II *Strombus gigas*, IUCN NT nurse and lemon sharks
Spatial/Temporal concentrations of species	Nesting bird populations
Landscape-level Ecosystems and Mosaics	Applies to all areas on East Caicos
RTE Ecosystems	The finest example of tidal creek and estuarine habitat in TCI.

Collectively, MCEM scores in eastern habitats range from a minimum of five to a maximum of 19 evaluation criteria (Fig. 15), with palustrine habitats exhibiting the highest ecosystem service and biodiversity values.

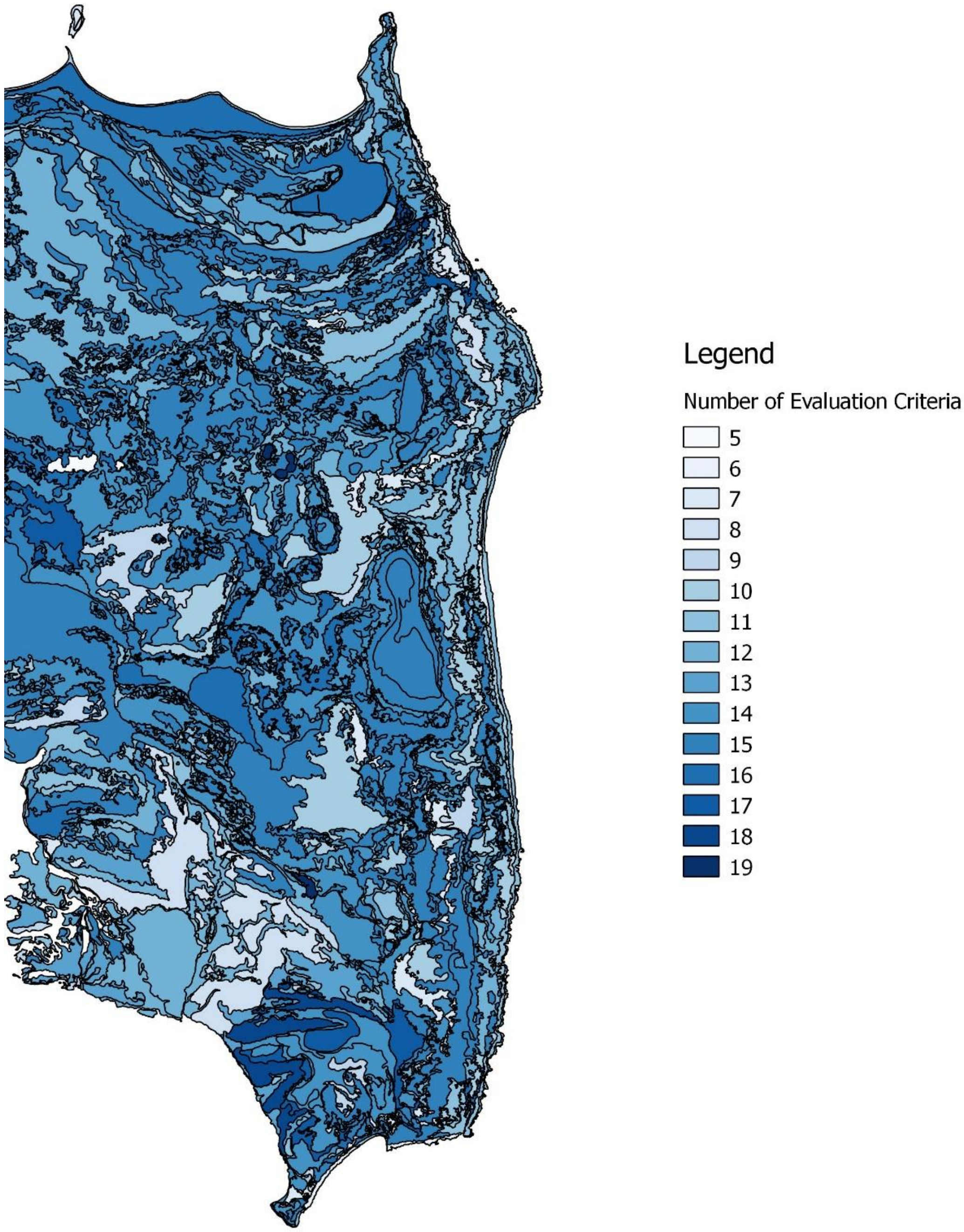

Figure 15. MCEM map for eastern areas.

Central and Western Upland, Palustrine and Estuarine Habitats

Central and western areas on East Caicos are in the lee of prevailing winds, allowing for greater vegetative growth and diversity. To the north, these areas are sheltered by northern coastal ridges, running approximately east to west. To the east, these areas are sheltered by the eastern ridge that runs north to south. To the south and west, these areas are surrounded by large expanses of tidal flats, creeks and estuaries associated with the Ramsar Nature Reserve. Central and western habitats include upland. Survey points were sampled within central and western areas on 4 June and 24 – 27 October 2015 (Figure 16).

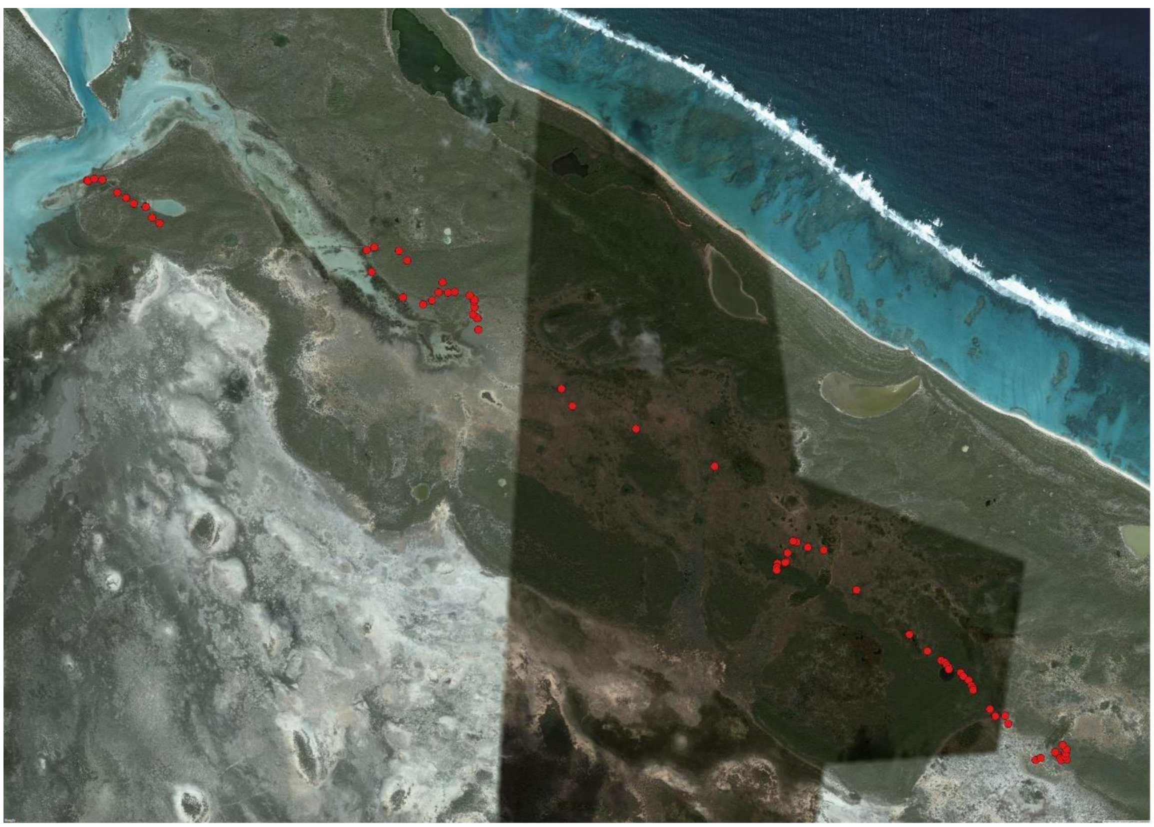

Figure 16. Central and western survey points.

Central and western upland habitats occur in areas that are of necessary elevation to avoid seasonal flooding and at sufficient proximity from coastal influences to preclude coastal characteristics. Because of the sheltered nature of western and central portions of the island, these habitats have the greatest floral diversities of all habitats surveyed and include upland shrublands, woodlands and forests. Tropical dry forests are considered to be the "most threatened tropical forest ecosystems" (Franklin et al., 2015). In particular, dry forests within the Lucayan archipelago are considered globally rare and endangered ecosystems, threatened by land clearance for agriculture, charcoal manufacturing urban sprawl and tourism development (Franklin et al., 2015).

A total of 98 floral species were observed in these habitats during field studies, with a calculated biodiversity of H = 4.2723. High floral diversities preclude dominance by any particular species; however, the floral species with the highest importance values in these habitats include fire bush [*Croton lucidus* (9.54)], frangipani [*Plumeria obtusa* (7.18)] and white torch [*Amyris elemifera* (8.77)]. See Appendix 11 for a complete species list, biodiversity calculations and species compositions. Of these species, *C. lucidus* is a regional endemic and *P. obtusa* is an ornamental floral species.

Central and western habitats are also areas that contain high concentrations of RTE and endemic floral species (Table 23). Of note is a significant population of Caroline's pink (*Stenandrium carolinae),* a TCI endemic floral species that is listed as Critically Endangered by IUCN (Fig. 17). Previously, this species had only been observed in small populations on North and Middle Caicos. The population observed during the field studies associated with this project is the largest recorded to date and may represent as much as 75% of the known global population, making these habitats an important conservation interest. Other TCI floral endemic species observed in these habitats include TCI Cynanchum (*Cynanchum stipitatum),* Lucayan prickly pear *(Opuntia lucayana)* and Caicos Encyclia (*Encyclia caicensis).* Of these, *E. caicensis* is listed as Endangered by the IUCN. *O. lucayana* and *C. stipitatum* have not yet been evaluated by IUCN but meet the criteria for RTE status. Significant populations of IUCN Endangered *Guaiacum sanctum, G. officinale* and *Swietenia mahagoni* were also recorded in western and central upland habitats. Significant populations of *Euphorbia articulata* were also observed in western central upland habitats. This species is only reported from one other location on Middle Caicos in TCI. A total of four TCI, 15 Lucayan, 22 regional endemics and six other species of interest, representing 48 percent of all recorded flora, were observed in western and central upland habitats during field studies.

Figure 17. *Stenandrium carolinae* in central and western upland habitat.

Table 23. Central and western upland floral species of interest.

Common Name	**Species**	**Endemism**	**RTE Status**
Pork and Doughboy	*Acacia acuifera*	Lucayan	
Anomaly Agave	*Agave anomala*	Regional	
Millspaugh's Agave	*Agave millspaughii*	Lucayan	
Forked Bernardia	*Bernardia dichotoma*	Regional	
Inagua Gumbo Limbo	*Bursera fagaroides*	Regional	
Bahama Boxwood	*Buxus bahamensis*	Regional	
Brasiletto	*Caesalpinia bahamensis*	Regional	
Catesby's Vine	*Catesbaea foliosa*	Lucayan	IUCN NT
Inagua Senna	*Chamaecrista caribaea var. inaguensis*	Regional	IUCN VU
Crabwood	*Coccoloba krugii*	Regional	
Tie-tongue	*Coccoloba swartzii*	Regional	
Inagua Silver Palm	*Coccothrinax inaguensis*	Lucayan	IUCN DD
Green Buttonwood	*Conocarpus erectus*		SPAW III
Nash's Tree Cactus	*Consolea nashii*	Lucayan	CITES II
Two-colored Croton	*Croton discolor*	Regional	
Fire Bush	*Croton lucidus*	Regional	
Egger's Cynanchum	*Cynanchum eggersii*	Regional	
TCI Cynanchum	*Cynanchum stipitatum*	TCI	
Dogwood	*Dodonaea viscosa*	Regional	
Caicos Encyclia	*Encyclia caicensis*	TCI	IUCN EN CITES II
Red Encyclia	*Encyclia rufa*	Regional	CITES II
Bushy Spurge	*Euphorbia atriculata*	Regional	Rare
Naked Back	*Euphorbia gymnonota*	Lucayan	CITES II
Wild Thyme	*Euphorbia inaguaensis*	Lucayan	
Bahama Milk Pea	*Galactia bahamensis*	Lucayan	
Candlewood	*Gochnatia paucifloscula*	Regional	
Lignum Vitae	*Guaiacum officinale*		IUCN EN CITES II SPAW III
Lignum Vitae	*Guaiacum sanctum*		IUCN EN CITES II SPAW III
Jamaican Trash	*Gundlachia corymbosa*	Regional	
Wild Salve	*Helicteres semitriloba*	Regional	
Bahama Maidenbush	*Heterosavia bahamensis*	Regional	
Bahama Lantana	*Lantana bahamensis*	Regional	
Bahama Vernonia	*Lepidaploa arbuscula*	Lucayan	

Haul Back	*Mimosa bahamensis*	Lucayan	
Prickly Bush	*Oplonia spinosa*	Regional	
Bahama Prickly Pear	*Opuntia bahamana*	Lucayan	CITES II
Prickly Pear	*Opuntia dillenii*		CITES II
Lucayan Prickly Pear	*Opuntia lucayana*	TCI	CITES II
Monkey Fiddle	*Pedilanthus bahamensis*	Lucayan	CITES II
Sword Bush	*Phyllanthus epiphyllanthus*	Regional	
Dildo Cactus	*Pilosocereus royenii*	Regional	CITES II
Ladies Tresses	*Spiranthes polyantha*		CITES II
Caroline's Pink	*Stenandrium carolinae*	TCI	IUCN CR
West Indian Mahogany	*Swietenia mahagoni*		IUCN EN CITES II
Ironwood	*Thouinia discolor*	Lucayan	
Rong Bush	*Wedelia bahamensis*	Lucayan	
White Calliandra	*Zapoteca formosa*	Regional	
Bahama Jujube	*Ziziphus taylorii*	Lucayan	

In addition to floral species of interest, central and western upland habitats also provide critical habitat for a wide variety of fauna (Table 24). Of interest is the presence of *Spondylurus caicosae* within these habitats. This species is a TCI endemic, which has not been previously recorded on East Caicos. Significant populations of nesting birds, including Bahama woodstar, bananaquit, blue-gray gnatcatcher and thick-billed vireo (a TCI endemic sub-species) were also observed.

Table 24. Central and western upland fauna.

Common Name	**Species**	**Endemism**	**RTE Status**	**Other**
Bark Anole	*Anolis scriptus*	Lucayan		TCI sub-species
Bahama Woodstar	*Calliphlox evelynae*	Lucayan		Nesting
Bananaquit	*Coereba flaveola*			Nesting
Cuban Crow	*Corvus nasicus*	Regional		
Northern Mockingbird	*Mimus polyglottos*			
Blue-gray Gnatcatcher	*Polioptila caerulea*			Nesting
Thick-billed Vireo	*Vireo crassirostris*	Regional		TCI sub-species
Caicos Islands Skink	*Spondylurus caicosae*	TCI		

Central and western upland habitats are areas with significant conservation values and several MCEM criteria were observed during field studies (Table 25).

Table 25. Central and western upland MCEM criteria.

Criterion	Description
Materials	Traditional medicinal and ornamental floral species
Regulation of Physical Environment	Carbon sink
Cultural Symbolic	Areas of outstanding natural beauty, naturalness, cultural identity
Cultural Intellectual and Experiential	Tourism potential, educational, scientific research and study
RTE Species	CR, EN, VU and NT floral species, CITES II and SPAW III floral species, rare floral species
Endemic Species	4 TCI, 15 Lucayan and 22 regional floral species. 1 TCI, 2 TCI sub-species and 1 regional faunal species
Spatial/Temporal concentrations of species	Nesting bird populations
Landscape-level Ecosystems and Mosaics	Applies to all areas on East Caicos
RTE Ecosystems	Tropical dry forests are considered endangered on a global scale (Franklin et al., 2015)

Low-lying areas in western and central habitats function as flood plains for surrounding ridges. In these areas seasonal rains collect from adjacent watersheds, creating palustrine forests, woodlands, shrublands, dwarf shrublands, herbaceous and non-vascular habitats. Western and central palustrine habitats are dominated by flood, saline and drought-resistant species that can tolerate wide ranges of flooding, drought and saltwater inundation. Such environmental variables limit vegetative diversity to an extent; however, this effect is marginally tempered by variations in the landscape, such as elevation, on a micro-scale. A total of 40 floral species, with a calculated biodiversity of H = 3.378694 were recorded in western and central palustrine habitats during field studies. The most important floral species in these habitats are the varieties of buttonwood *(C. erectus* and *C. erectus var. sericeus),* which collectively have an importance value of 30.8. Other species with high importance values include seaside dropseed grass [*Sporobolus virginicus* (15.7)], sea ox eye [*Borrichia arborescens* (10.1)], sandfly bush [*Rachicallis americana* (9.62)] and wild thyme [*Euphorbia inaguensis* (9.62)]. Of these species, *E. inaguensis* is a Lucayan archipelago endemic species. Floral species, distributions and biodiversity calculations for western and central palustrine habitats are attached as Appendix 12.

Species of interest include significant populations of endemic floral species, including six regional, four Lucayan and three TCI (*Evolvulus bahamensis* being doubtfully endemic), observed in western and central palustrine habitats during field studies or previously recorded. Two rare species *(Euphorbia articulata* and *Turnera diffusa)* were also observed. A search for available data for East Caicos was conducted using the Global Biodiversity Information Facility (GBIF, www.gbif.org). The search returned one result for the TCI endemic and endangered species peppergrass *(Lepidium filicaule),* recorded within central palustrine habitats on East Caicos. The TCI endemic and Endangered *Limonium bahamensis* was not observed during field studies for this project, but has been recorded in central and western palustrine habitats previously by this author and local flora expert Bryan Naqqi Manco (Manco, 2015). A total of three TCI, four Lucayan and four regional endemic floral species, in addition to five other species of interest, account for 42.9% of all floral species observed or recorded in central and western palustrine habitats during field studies (Table 26).

Table 26. Central and western palustrine floral species of interest.

Common Name	**Species**	**Endemism**	**RTE Status**
Black Mangrove	*Avicennia germinans*		SPAW III
Brasiletto	*Caesalpinia bahamensis*	Regional	
Green Buttonwood	*Conocarpus erectus*		SPAW III
Dogwood	*Dodonaea viscosa*	Regional	
Bushy Spurge	*Euphorbia articulata*	Regional	Rare
Naked Back	*Euphorbia gymnonota*	Lucayan	CITES II
Wild Thyme	*Euphorbia inaguaensis*	Lucayan	
Sheathed Spurge	*Euphorbia vaginulata*	Lucayan	
Broom Bush	*Evolvulus bahamensis*	TCI	
Jamaican Trash	*Gundlachia corymbosa*	Regional	
Berter's Joewood	*Jacquinia berteroi*	Regional	
Peppergrass	*Lepidium filicaule*	TCI	IUCN EN
Heather	*Limonium bahamensis*	TCI	IUCN EN
Haul Back	*Mimosa bahamensis*	Lucayan	
Sword Bush	*Phyllanthus epiphyllanthus*	Regional	
Brown-seeded Portulaca	*Portulaca rubricaulis*		Rare
West Indian Mahogany	*Swietenia mahagoni*		IUCN EN CITES II
Spreading Turnera	*Turnera diffusa*		Rare

In addition to floral species of interest, western and central palustrine areas provide habitat for a wide variety of fauna (Table 27). Of particular interest is a population of Cuban cave shrimp *(Barbouria cubensis),* which were observed in a saline palustrine pond feature during field studies. This species is considered Critically Endangered, in addition to being a regional endemic species. Cuban cave shrimp are threatened due to their geographic restriction to small ponds and caves. Pupfish *(Cyprinodon spp.)* were also noted throughout palustrine habitats. Pupfish are also geographically restricted to palustrine ponds, which has resulted in significant genotypic variation among populations (C. H. Martin & Wainwright, 2011, 2013). Dr. Christopher

Martin of the University of North Carolina at Chapel Hill has hypothesized that TCI pupfish populations may also display high genetic variation and may constitute a previously undescribed species. Specimens collected during field studies are currently being sequenced (C. Martin, 2015). Other faunal species of interest include nesting Bahama mockingbirds *(Mimus gundlachii),* a regional endemic species and Bahama woodstar hummingbird *(Calliphlox evelynae),* a Lucayan endemic species. TCI endemic curly-tail lizards *(Leiocephalus psammodromus)* were also abundant in western and central palustrine habitats.

Table 27. Central and western palustrine fauna.

Common Name	***Species***	***Endemism***	***RTE Status***	***Other***
Cuban Cave Shrimp	Barbouria cubensis	Regional	IUCN CR	
Sanderling	Calidris alba			
Bahama Woodstar Hummingbird	Calliphlox evelynae	Lucayan		Nesting
Bananaquit	Coereba flaveola			Nesting
Cuban Crow	Corvus nasicus	Regional		
Smooth-billed Ani	Crotophaga ani			
Pupfish	Cyprinodon spp.	TCI	Possible Endemic	
American Kestrel	Falco sparverius		CITES II	
Common Snipe	Gallinago gallinago			
Curly-tail Lizard	Leiocephalus psammodromus	TCI		
Bahama Mockingbird	Mimus gundlachii	Regional		Nesting
Yellow-crowned Night Heron	Nyctanassa violacea			Nesting

Central and western palustrine habitats are areas with high conservation values. Several MCEM criteria were observed during field studies in central and western palustrine habitats (Table 28).

Table 28. Central and western palustrine MCEM criteria.

Criterion	**Description**
Nutrition	Fresh water catchment and storage
Regulation of Wastes	Filtering capacity of wetlands
Regulation of Flows	Floodplains
Regulation of Physical Environment	Carbon sink
Cultural Symbolic	Areas of outstanding natural beauty, naturalness, Colonial era archaeological sites
Cultural Intellectual and Experiential	Tourism potential, educational, scientific research and study
RTE Species	EN floral species, CITES II and SPAW III floral species, rare floral species, CR faunal species, CITES II faunal species, rare floral species
Endemic Species	2 TCI, 4 Lucayan and 6 regional floral species. 2 TCI, 1 Lucayan and 3 regional faunal species
Geographically restricted species	Cuban cave shrimp and pupfish
Spatial/Temporal concentrations of species	Nesting bird populations, breeding populations of Cuban cave shrimp and pupfish
Landscape-level Ecosystems and Mosaics	Applies to all areas on East Caicos

In low-lying areas that are exposed to tidal influences, estuarine habitats are present in western locations on East Caicos. These habitats are part of the North, Middle and East Caicos Ramsar site, the East Caicos portion of which has been only marginally studied. A 2002 Darwin Initiative project developed a biodiversity management plan for the North, Middle and East Caicos Ramsar Site (Pienkowski, 2002). The TCI Ramsar site has been described as “the best example of its type in the Caribbean and arguably the most natural wetland amongst” the sites listed under the Ramsar Convention (Pienkowski, 2005, p. 77). Mangrove ecosystems on East Caicos are characterized by low, scrubby development (less than five-meter canopy heights) due to limited freshwater inputs and high salinity levels (FAO, 2005).

Floral diversity in these areas is limited by exposure to seawater, which creates conditions which are favorable for only salt-tolerant species. Western estuarine habitats surveyed during field studies contained eight floral species with a calculated biodiversity of H = 1.9080 (see Appendix 13 for western estuarine floral species and biodiversity calculations). Important species in western estuarine habitats include glasswort [*Salicornia depressa* (38.4)], seashore dropseed grass [*Sporobolus virginicus* (38.4)], and green buttonwood [*Conocarpus erectus* (29.7)]. It should be noted that these figures are derived from a small sample size and that red mangrove (*Rhizophora mangle)* is actually the dominant species in these habitats. Floral species of interest observed during field studies in western estuarine habitats include wild thyme (*Euphorbia inaguensis),* a Lucayan archipelago endemic species, and SPAW III species green buttonwood (*Conocarpus erectus)* and red mangrove (*Rhizophora mangle).*

Western estuarine habitats provide valuable habitat for a wide variety of fauna (Table 29). The North Middle and East Caicos Ramsar Site has also been designated as an Important Bird Area (IBA) (Pienkowski, 2008), based on the presence of populations of the IUCN Vulnerable West Indian whistling duck (*Dendrocygna arborea)* and Near-Threatened Kirtland’s warbler *(Dendroica kirtlandii)*. The IBA also has populations of waterbirds in excess of 20,000 individuals, including globally significant populations of reddish egret *(Egretta rufescens),* brown pelican *(Pelecanus occidentalis)*, Wilson's plover *(Charadrius wilsonia)*, laughing gull *(Larus atricilla),* gull-billed tern *(Sterna nilotica),* royal tern *(Sterna maxima),* least tern *(Sterna antillarum)* and common tern *(Sterna hirundo)*. Endemic species and sub-species Bahama woodstar *(Calliphlox evelynae)*, thick-billed vireo *(Vireo crassirostris stalagmium)*, and Bahama mockingbird *(Mimus gundlachii)* have also been observed (Pienkowski, 2008). Hilton et al. observed TCI rare birds roseate spoonbill (*Platalea ajaja)*, double-crested cormorant *(Phalacrocorax auritus)*, neotropic cormorant *(Phalacrocorax brasilianus)* and American bittern *(Botaurus lentiginosus)* in western estuarine habitats during field studies in 2000 (Hilton et al., 2000b). Additionally, five West Indian whistling ducks *(Dendrocygna arborea)* were recorded in the vicinity of Jacksonville Creek (Hilton et al., 2000a). Subsequent reports from recreational users has suggested higher population numbers of West Indian whistling duck. Western estuarine tidal creeks are also an important juvenile habitat for IUCN Endangered green turtles *(Chelonia mydas)* and Critically Endangered hawksbill turtles *(Eretmochelys imbricata)*, in addition to endemic reptile species, including curly-tail lizards *(Leiocephalus psammodromus)*, Caicos Islands reef gecko *(Sphaerodactylus caicosensis)* and the Caicos Islands pigmy boa constrictor *(Tropidophis greenwayi)* (Pienkowski, 2008).

Table 29. Western estuarine fauna.

Common Name	**Species**	**Endemism**	**RTE Status**	**Other**
American Bittern	*Botaurus lentiginosus*			Rare Migrant
Green Heron	*Butorides striata*			Nesting
Bahama Woodstar Hummingbird	*Calliphlox evelynae*			
Wilson's Plover	*Charadrius wilsonia*			Nesting
Green Turtle	*Chelonia mydas*		IUCN EN	Juvenile habitat
West Indian Whistling Duck	*Dendrocygna arborea*		IUCN VU	
Yellow Warbler	*Dendroica petechia*			Nesting
Reddish Egret	*Egretta rufescens*		IUCN NT	Nesting
Hawksbill Turtle	*Eretmochelys imbricata*		IUCN CR	Juvenile habitat
Magnificent Frigatebird	*Fregata magnificens*			
Laughing Gull	*Larus atricilla*			Nesting
Curly-tail lizard	*Leiocephalus psammodromus*	TCI	Not evaluated	
Bahama mockingbird	*Mimus gundlachii*			Nesting
Brown Pelican	*Pelecanus occidentalis*		CITES II	Nesting
Double-crested Cormorant	*Phalacrocorax auritus*			Rare Migrant
Neotropic Cormorant	*Phalacrocorax brasilianus*			Rare Migrant
Caicos Islands Reef Gecko	*Sphaerodactylus caicosensis*	TCI	Not evaluated	
Least Tern	*Sterna antillarum*			Nesting
Common Tern	*Sterna hirundo*			Nesting
Royal Tern	*Sterna maximus*			Nesting
Gull-billed Tern	*Sterna nilotica*			Nesting
Caicos Islands Pygmy Boa Constrictor	*Tropidophis greenwayi*	TCI	Not evaluated	
Thick-billed Vireo	*Vireo crassirostris*	TCI		Endemic sub-species

Western estuarine habitats have significant conservation values, as reflected by international protection under Ramsar and designation as an IBA, and several MCEM criteria were recorded as present in these areas (Table 30).

Table 30. Western estuarine MCEM criteria.

Criterion	**Description**
Nutrition	Spawning and nursery areas for juvenile fisheries species
Regulation of Wastes	Filtering capacity of mangals
Regulation of Flows	Coastal protection, control of sediments
Regulation of Physical Environment	Carbon sink
Cultural Symbolic	Areas of outstanding natural beauty, naturalness
Cultural Intellectual and Experiential	Tourism potential, educational, scientific research and study
RTE Species	IUCN CR, EN, VU and NT species, CITES II and SPAW III species
Endemic Species	Lucayan floral species, TCI reptile species
Spatial/Temporal concentrations of species	Nesting bird populations, spawning habitat
Landscape-level Ecosystems and Mosaics	Applies to all areas on East Caicos

Collectively, MCEM scores for central and western habitats range from five to 19 evaluation criteria points (Fig. 18), with tropical dry forests, karst features and some palustrine habitats exhibiting the highest ecosystem service and biodiversity values.

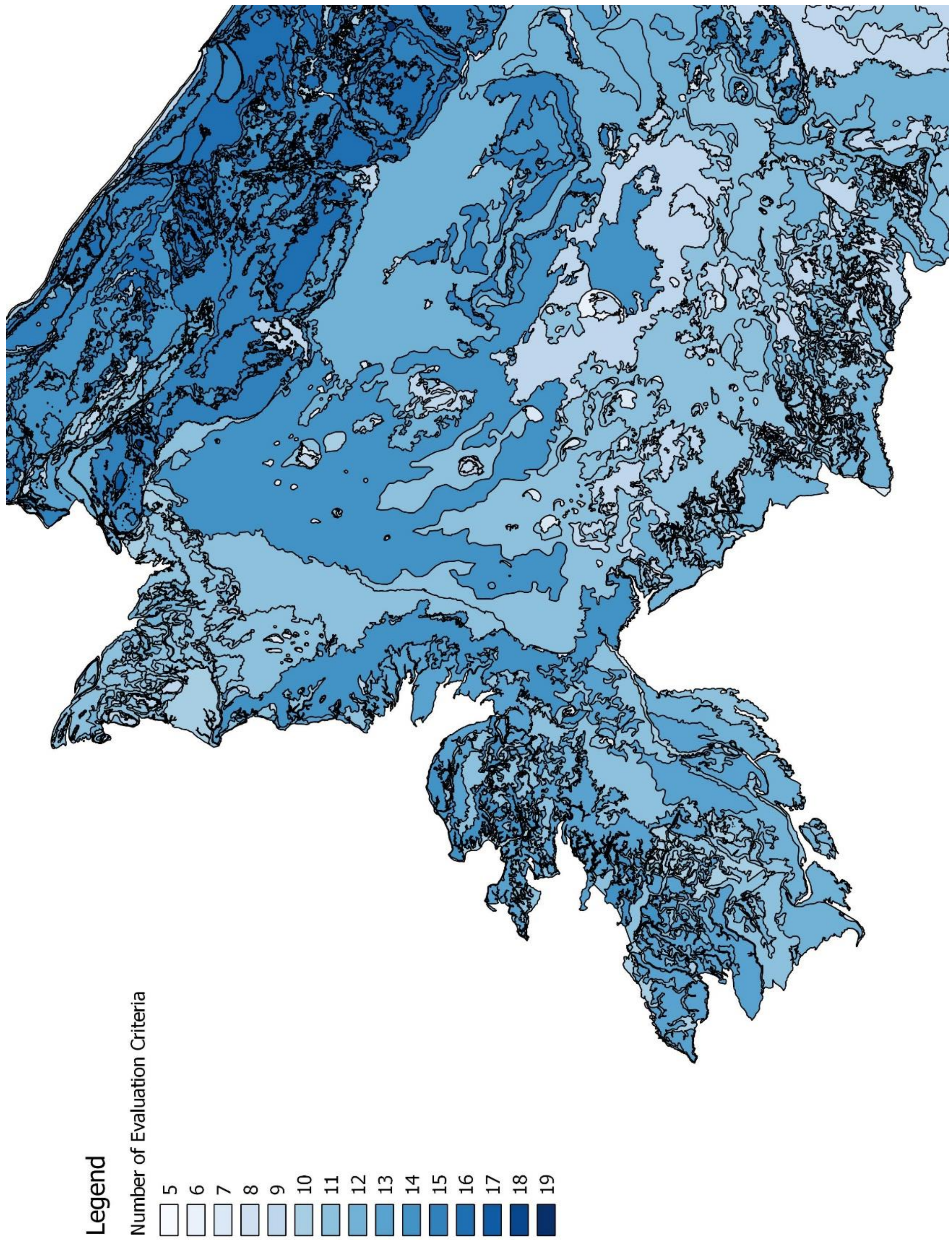

Figure 18. MCEM map for central and western areas.

Cave and Karst Features

Cave and karst features are located throughout the island of East Caicos and include solution sink holes, dry and wet caves and blue holes. These habitats are poorly studied, and a comprehensive analysis of their ecology is beyond the scope of this study. During field studies, cave and karst features were observed in all areas studied and included cave features in the western areas of the island and wet solution sinkholes and blue holes in other areas studied. A brief description of the cave and karst features encountered during field studies is given below, along with a review of existing data and MCEM criteria noted during the assessment period.

A large network of caves occurs throughout the western portion of East Caicos. These caves have a long history of human use. Cave petroglyphs date back to Lucayan habitation at approximately 900-1200 C.E. (Booy, 1912; Hutson et al., 2005; Pateman, 2013) (Fig. 19). East Caicos caves were also mined for guano (bat dung, used as fertilizer), during the late 19th and early 20th Centuries C.E. (Sadler, 1986).

Figure 19. Lucayan petroglyph.

The caves of East Caicos provide habitat for a variety of geographically restricted, endemic and rare species. Waterhouse's big-eared bat *(Macrotus waterhousii),* buffy flower bat *(Erophylla sezekorni)* and the Antillean fruit-eating bat *(Brachyphylla nana)*, considered a Caribbean endemic species, have been recorded (Buden, 1986). Evidence of Antillean long-tongued bat *(Monophyllus spp.)* has also been observed (Hutson et al., 2005). In 1931 Shamel described the buffy flower bat *Erophylla planifrons mariguanensis*, a Lucayan endemic sub-species, from sixteen species in a cave cited as "Stubbs Guano Cave" on East Caicos (Shamel, 1931). It should be noted that this sub-species is not currently recognized as valid. Caves in TCI are notable for the high degree of endemism exhibited by crustacean populations, including endemic higher taxa (Koenemann, Iliffe, & van der Ham, 2007; Koenemann, Iliffe, & Yager, 2004; Kornicker, Iliffe, & Harrison-Nelson, 2008). Crustacean populations within the caves of East Caicos have yet to be studied; however, based on data from other cave systems within TCI, the presence of endemic crustaceans within East Caicos caves is highly probable. Geographically restricted barn owls *(Tyto alba)* and evidence of roosting barn owls (middens) were also observed during field studies within East Caicos caves.

Wet solution sink holes and blue holes were encountered in northwestern, western central and central locations on East Caicos (Fig. 20). The water contained within them ranged in salinity [(18 ppt (northwestern), 28 ppt (western central) and 30 ppt (central)]. Water depths also varied greatly [<5 meters (northwestern), <10 meters (western central) and unmeasurable due to excessive depth (central)]. All solution sink holes contained pupfish (*Cyprinodon spp.)*, which are possibly endemic (Martin, 2015).

Figure 20. Central blue hole.

Several MCEM criteria for East Caicos caves, solution sink holes and blue holes were recorded from the literature review and during field studies (Table 31).

Table 31. Cave and karst feature MCEM criteria.

Criterion	Description
Materials	Guano
Regulation of Flows	Water catchment
Regulation of Physical Environment	"Living" caves
Cultural Symbolic	Naturalness, cultural identity, Lucayan archaeological sites/petroglyphs
Cultural Intellectual and Experiential	Tourism potential, archaeological interest, educational, scientific research and study
RTE Species	Bat populations are rare in TCI. CITES II bark owls.
Endemic Species	Cave crustaceans
Geographically restricted species	Cave crustaceans, barn owl, bat populations and pupfish
Spatial/Temporal concentrations of species	Breeding populations of bats, cave crustaceans and pupfish
Landscape-level Ecosystems and Mosaics	Applies to all areas on East Caicos
RTE Ecosystems	Caves and blue holes are rare habitats in TCI and globally.

MCEM criteria for cave and karst features are illustrated within area maps (Figs. 8, 15 and 18).

Nearshore Marine Habitats

Due to resource, time and accessibility constraints, only eastern and northeastern marine areas were surveyed in association with this project. Eastern marine habitats were surveyed on 9th June and 14th August 2015, and northeastern marine habitats were surveyed on 17th and 22nd August (Fig. 21). All marine species observed during field studies are listed in Appendix 14 (Marine Species). Marine species distributions and biodiversity, calculated from quantitative survey data, are attached as Appendix 15 (Marine Species Distributions and Biodiversity).

Figure 21. Marine survey areas.

Eastern Marine Habitats

As noted previously, the east side of East Caicos is the windward side of the island, receiving direct onshore winds with mean average wind speeds of 18 km/hr throughout the year (Fig. 22).

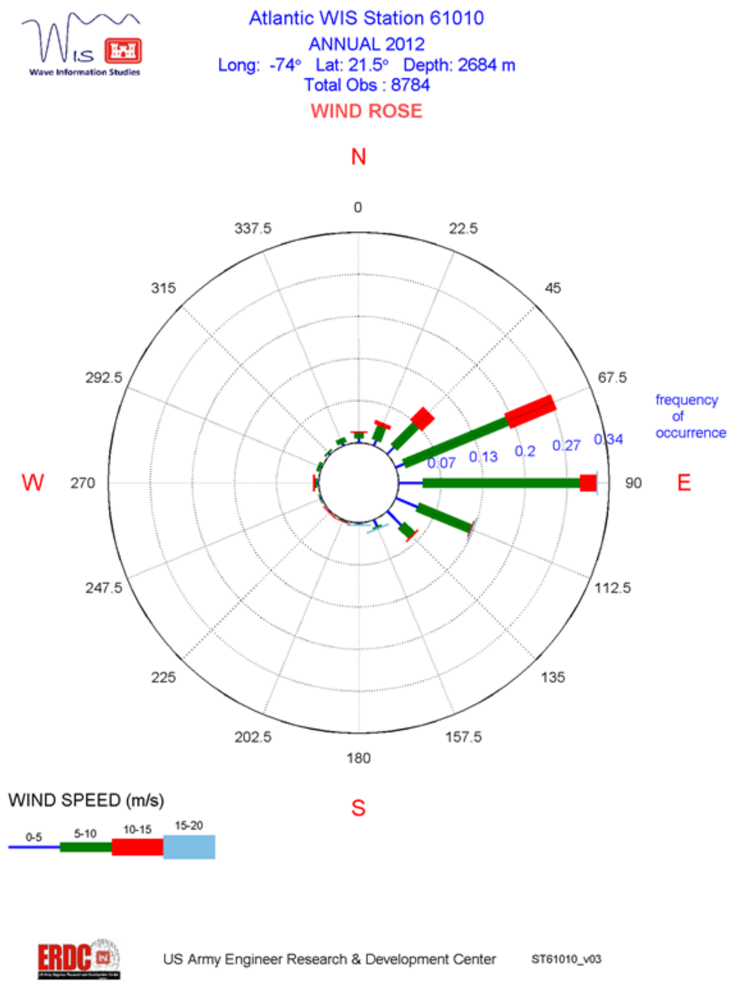

Figure 22. Wind rose WIS 61010 (USACE, 2012).

Marine habitats at this location are therefore shaped by almost constant exposure to wind and wave surge. These habitats were not surveyed quantitatively, but they were assessed for habitat type and presence/absence of MCEM criteria. Nearshore habitats are mosaics of bare sand, sand with seagrass and algal, non-reefal hardbottom. With distance from the shoreline, patch reefs, intermixed with bare sand and bare hardbottom, occur, with patch reefs increasing in density with depth. Collectively, the patch reefs function as a fringing reef, aiding in the protection of the adjacent eastern shoreline beaches from waves and swells. These beaches are observed turtle nesting areas. At a depth of approximately 20 meters and within a kilometer of the shoreline, shallow nearshore habitats grade precipitously into the 2,200-meter-deep Columbus Passage, a major migration corridor for marine mammals, sea turtles and other marine organisms. The proximity of the coastal and estuarine habitats to deep oceanic water, makes this area important in terms of connectivity for spawning and juvenile habitat for oceanic species.

The nearshore eastern coastal waters of East Caicos have a greenish hue that is not generally characteristic of other areas in TCI. Such coloration indicates high chlorophyll content and is indicative of nutrient loads. Such nutrient loads may be attributable to upwelling, as the east coast of East Caicos has typical wind/current conditions that could lead to upwelling (e.g. shore perpendicular currents and winds along a deep ocean area). Nutrient loads may also be contributed by the vast network of mangal ecosystems along the southern boundaries of East Caicos. These areas flush tidally directly into the eastern coastal areas at various locations, particularly at the southeastern tip of the island. It is not believed that nutrient loads are from anthropogenic sources, as there are no land-based pollutant sources on the uninhabited island of East Caicos. The adjacent Columbus Passage is a shipping lane; however, it is not believed that any illegal dumping of wastes in the area would lead to such large-spread and apparently permanent nutrient loads.

Goreau et al. incorporated extensive coral reef habitat surveys, assessing 26 different criteria at 47 sites across TCI, including East Caicos (Goreau et al., 2007). Goreau attributes high algal coverages in eastern areas off East Caicos to “localized upwelling of cold, deep, nutrient-rich water offshore” (Goreau, 2015; Goreau et al., 2007). Goreau also suggests that TCI has many areas where deep ocean upwelling contribute to nutrient loads and benthic dominance of algal species, rather than coral. He contends that these areas "are not dead reef that has been recently overgrown by algae, instead they are made of older limestone, subject to very high wave stress, and have never had constructional coral reefs growing on them. Their widespread distribution suggests that the green water and algae dominated conditions at these sites has a long and continuous historic past and is not a recent phenomenon" (Goreau et al., 2007, p. 36). Goreau identifies the east coast of East Caicos as one such area of upwelling (Goreau et al.., 2007).

During field studies, significant algal growth was observed on patch reefs throughout eastern coastal areas, with macro-algal coverages on patch reefs greater than 60% in most areas. Patch reefs at this location are dominated by fan leaf algae *(Lobophora variegata).* In spite of high nutrient loads, live coral communities continue to grow in these areas, and several areas of IUCN Endangered boulder star coral *(Orbicella annularis)* complex and Critically Endangered elkhorn coral *(Acropora palmata)* were observed throughout the area. Abundant populations of large herbivores, such as parrotfish *(Scaridae)* were also noted, in addition to IUCN Endangered green turtles *(Chelonia mydas)*, which were grazing on macro-algae.

Deep water areas near the drop off into the Columbus Passage do not appear to have well-developed coral communities and are characterized by bare rock, coralline algae and macro algae benthos. These areas were not surveyed extensively during field studies due to poor visibility and time constraints; however, the lack of coral development along the eastern wall was confirmed in a personal communication with the Director of the School for Field Studies, Heidi Hertler, and Environmental Officers from the TCI Department of Environment and Maritime Affairs (DEMA), Luc Clerveaux and Alexander McLeod, all of whom have dived in the area and report similar findings (Hertler, 2015; McLeod & Clerveaux, 2015).

Due to permanent high nutrient loads in this area, reefs are predominantly developed from the skeletal structures of coralline algae *(Porolithon pachydermum*), rather than coral species (Pardee, 2015). These organisms are important reef builders, particularly in areas of high surf and current conditions, such as those prevalent along the windward eastern coastal areas of East Caicos. Reefs dominated by coralline algae are important carbon and nutrient sinks. Adey surmised that under windward conditions and constant wave action, calcareous algae can dominate reefs as the major framework builders (Adey, 1978). High chlorophyll content of the water creates moderate visibility conditions and a greenish hue, and the reef is dominated by macro algae with some live coral populations (Fig. 23).

Figure 23. Typical eastern patch reef with *Acropora palmata.*

In spite of domination by algal species, eastern marine habitats have significant ecological, cultural and ecosystem values, and several MCEM criteria were recorded as present during field studies (Table 32).

Table 32. Eastern marine MCEM criteria.

Criterion	**Description**
Nutrition	Traditional fishing area for artisanal fishers from the adjacent island of South Caicos
Energy	Constant, onshore winds
Regulation of flows	Regulation of wind and wave energy
Regulation of wastes	Nutrient sink
Regulation of physical environment	Carbon Dioxide sink
Cultural symbolic	Areas of outstanding natural beauty, cultural identity
Cultural intellectual and experiential	Recreation, scientific research
RTE Species	EN Nassau grouper, green turtle, loggerhead turtle, *Orbicella annularis* complex, CR hawksbill turtle, *Acropora palmata*, numerous CITES and SPAW listed coral species.
Spatial/temporal concentrations of species	Sea turtle nesting (adjacent) and foraging habitat, spawning aggregation for Nassau grouper
Landscape-level Ecosystem Mosaics	Applies to all areas on East Caicos
RTE Ecosystems	Coralline algae reefs are a rare habitat type in TCI. Reef ecosystems are threatened globally.

MCEM scores within eastern marine habitats range from five to 15 evaluation criteria (Fig. 24), with reefal hardbottom habitats demonstrating the highest ecosystem service and biodiversity values.

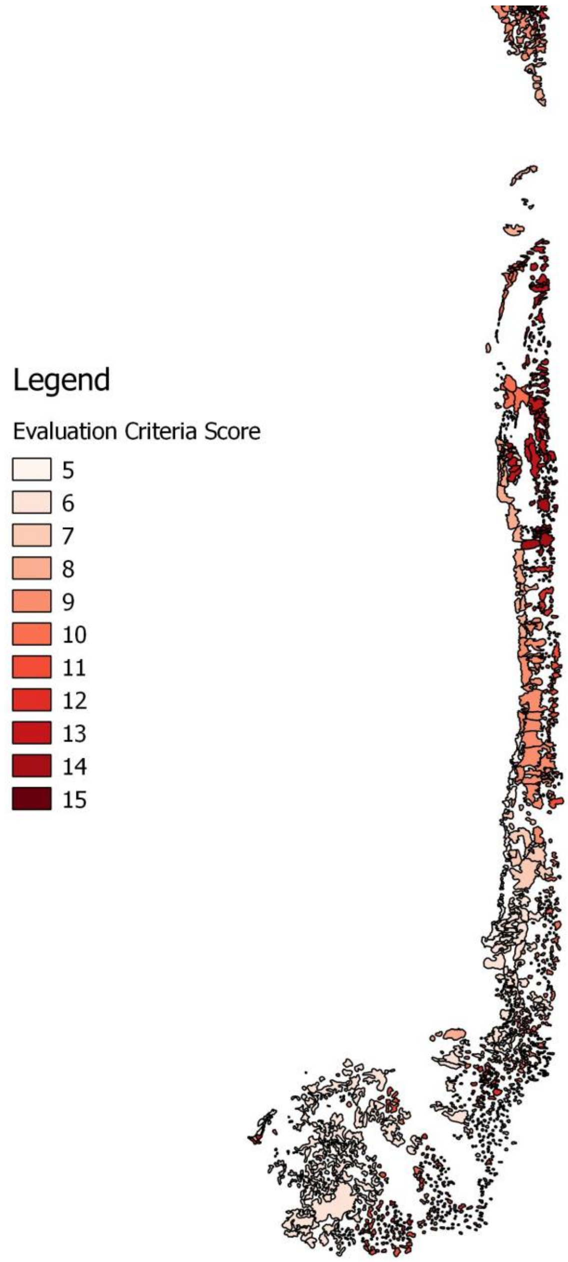

Figure 24. MCEM map for eastern marine areas.

Northeastern Marine Habitats

Northern marine habitats have slightly less exposure to prevailing winds than eastern marine habitats on East Caicos, as prevailing winds tend to run parallel to these areas, rather than directly onshore. Nearshore habitats are further protected by a continuous fringing reef along the north shore that runs approximately east to west. The fringing reef has well defined slope, crest and flat formations. Turks and Caicos coral reefs have been extensively surveyed; however, the remoteness and climactic factors of East Caicos have thus far limited the collection of data here, particularly along the fringing reefs of the northeastern coastline, which are remote and relatively inaccessible under northeasterly wind conditions.

The reef crest occurs approximately at sea level, with some exposure of coral during extreme low tides. Reef crest communities are dominated by dead and living populations of elkhorn coral *Acropora palmata,* an IUCN Critically Endangered Species. The reef slope initially grades gradually northward, away from the crest for variable distances of less than one kilometer before plunging sharply into precipitous depths offshore, as described previously. Reef slope areas include non-reefal hardbottom habitats dominated by algae and sea fans *(Gorgonia spp.)*, spur and groove formations dominated by boulder star coral (*Orbicella annularis* complex, an IUCN Endangered species), and spur and groove formations dominated by elkhorn coral and staghorn coral (*Acropora palmata* and *A. cervicornis,* IUCN Critically Endangered species).

The reef slope communities surveyed during field studies had calculated mean live coral coverages of 22.92 percent, with maximum values of 57.19 percent and minimum values of 4.95% (see Appendix 15). These values are considered high for the

Caribbean, although consideration should be given to the fact that sites for the survey were pre-selected based on observed high coral coverages in some cases. The Future of Reefs in a Changing Environment (FORCE) project determined that Caribbean reefs averaged approximately 20% coverage. A previous study by Gardiner et al. (2003) determined average Caribbean coverage as ten percent. FORCE also determined that the Turks and Caicos Islands had an average live coral coverage in the low range, around ten percent (Williams, 2013). The dominant and most important species on surveyed reefs are boulder star coral (*Orbicella annularis* complex) and mustard hill coral *(Porites astreoides),* with importance values of 63.33 and 27.27, respectively. Calculated biodiversity, with coral species as indicators, is H = 2.4442.

In addition to high live coral coverages, the reefs on the northeastern coast of East Caicos contain a high percentage of IUCN E and CR species, such as *Acropora palmata* (Fig. 25)*, A. cervicornis* (Fig. 26), *Montastraea cavernosa* and *Orbicella annularis* (Fig. 27). A large area of living *A. cervicornis,* measuring at least 500 square meters and with at least 50% live coverage was identified during the survey. Given time restrictions associated with marine field studies, only a small area was surveyed, and a larger area of this species is likely to exist. The East Caicos population is the largest known remaining area of this size of *A. cervicornis* in TCI and one of few remaining within the wider Caribbean. Larger stands of CR *A. palmata* were also observed. Other species of interest noted during field studies included Endangered Nassau grouper *(Epinephelus striatus)* and loggerhead turtle *(Caretta caretta)* and Vulnerable hogfish *(Lachnolaimus maximus),* rough cactus coral *(Mycetophyllia ferox),* whitestar sheet coral *(Agaricia lamarcki),* elliptical star coral *(Dichocoenia stokesi)* and pillar coral *(Dendrogyra cylindrus)*.

Figure 25. Population of *Acropora palmata.*

Figure 26. Population of *Acropora cervicornis.*

Figure 27. Population of *Orbicella annularis* complex.

Northeastern reef flat communities are largely comprised of bare sand, seagrass and non-reefal hardbottom habitats, with scattered patch reefs. Seagrass beds provide important foraging areas for queen conch (*Strombus gigas),* in addition to being important for juvenile life stages of a wide variety of marine organisms. In addition, Caribbean spiny lobster *(Panulirus argus)* were abundant on patch reefs. Northern reef flat communities are important traditional fishing areas for these species.

As with east coast patch reefs, northeastern patch reefs are largely dominated by microalgae species (Figs. 28 and 29); however, coral species of interest, including Endangered *Orbicella annularis* complex and Critically Endangered *Acropora palmata* were observed in these locations. Northeastern beaches are also cited as nesting habitat for sea turtles (Richardson, 2011).

Figure 28. Northeastern patch reef dominated by macro-algae.

Figure 29. Northeastern seagrass bed.

In summary, northeastern marine habitats exhibit a number of important ecological, cultural and ecosystem services, and several MCEM criteria for these areas were recorded as present during field studies (Table 33).

Table 33. Northeastern marine MCEM criteria.

Criterion	**Description**
Nutrition	Traditional fishing area for artisanal fishers from the adjacent island of South Caicos
Materials	Significant source of sand for the east-west littoral system in TCI
Regulation of flows	Regulation of wind and wave energy, flow of sand
Cultural Symbolic	Areas of outstanding natural beauty, cultural identity
Cultural Intellectual and Experiential	Recreation and scientific research
RTE Species	VU *Agaricia lamarcki, Dendrogyra cylindrus, Dichocoenia stokesi, Mycetophyllia lamarckiana,* EN Nassau grouper, loggerhead turtle, *Orbicella annularis* complex, *Montastraea cavernosa,* CR hawksbill turtle, *Acropora palmata*, *A. cervicornis. N*umerous CITES and SPAW listed species.
Spatial/temporal concentrations of species	Sea turtle nesting (adjacent) and foraging habitat, spawning aggregation for Nassau grouper and other fisheries species, important juvenile habitat
Landscape-level Ecosystem Mosaics	Applies to all areas on East Caicos
RTE Ecosystems	Living and healthy *Acropora palmata* and *A. cervicornis* reef formations are regionally rare. Reef ecosystems are threatened globally.

Northeastern marine habitats have MCEM scores ranging from five to 15 (Fig. 30). Reefal hardbottom exhibits the highest ecosystem service and biodiversity values.

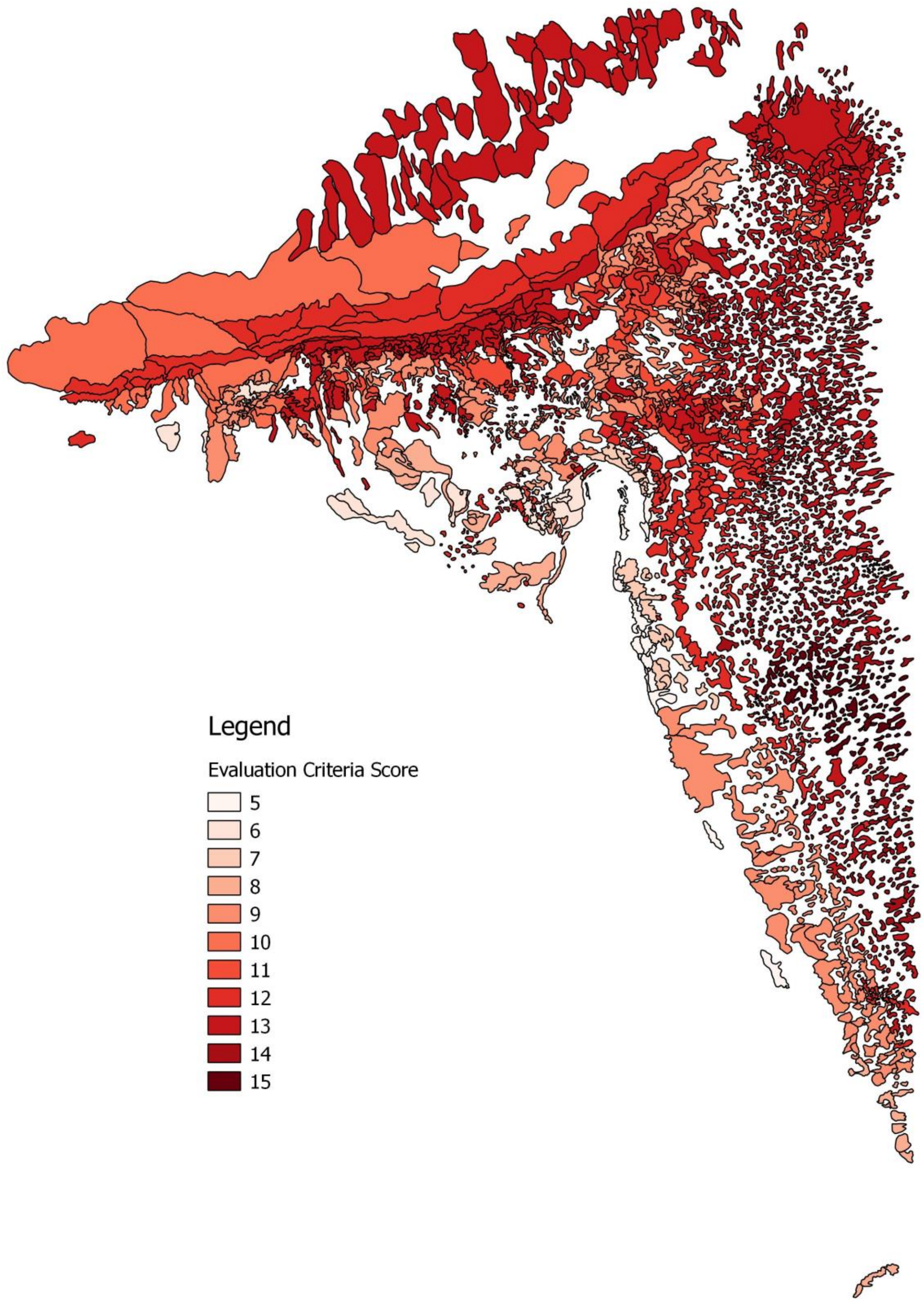

Figure 30. MCEM map for northeastern marine habitats.

Chapter IV

Discussion

The application of the MCEM at East Caicos confirms that the island serves as a reservoir for biodiversity and ecosystem service values. Each of the MCEM criteria are represented broadly across the island. Criteria significance at East Caicos, within TCI, across the wider Caribbean region and within a global context are discussed below. A discussion of MCEM potentials, limitations and conclusions follow.

MCEM Criteria Significance

Nutrition. Nutrition ecosystem services for East Caicos and surrounding marine habitats include fisheries, fresh water and the potential for grazing livestock (Fig. 31). Patch and fringing reefs, seagrass beds and mangals support an artisanal fisheries industry, which harvests finfish, lobster and conch.

Fresh water resources are collected, purified and transported to groundwater aquifers, within palustrine habitats. Although they are currently untapped, East Caicos fresh groundwater resources could prove to be valuable in the future, as standing fresh water is only available on the island seasonally in palustrine wetlands. On a global scale, groundwater resources have been diminished by as much as 35% (Millennium Ecosystem Assessment, 2005).

No agriculture or ranching currently takes place on East Caicos, although historically cattle were grazed at East Caicos, primarily within palustrine herbaceous habitats (Pearce, 2015).

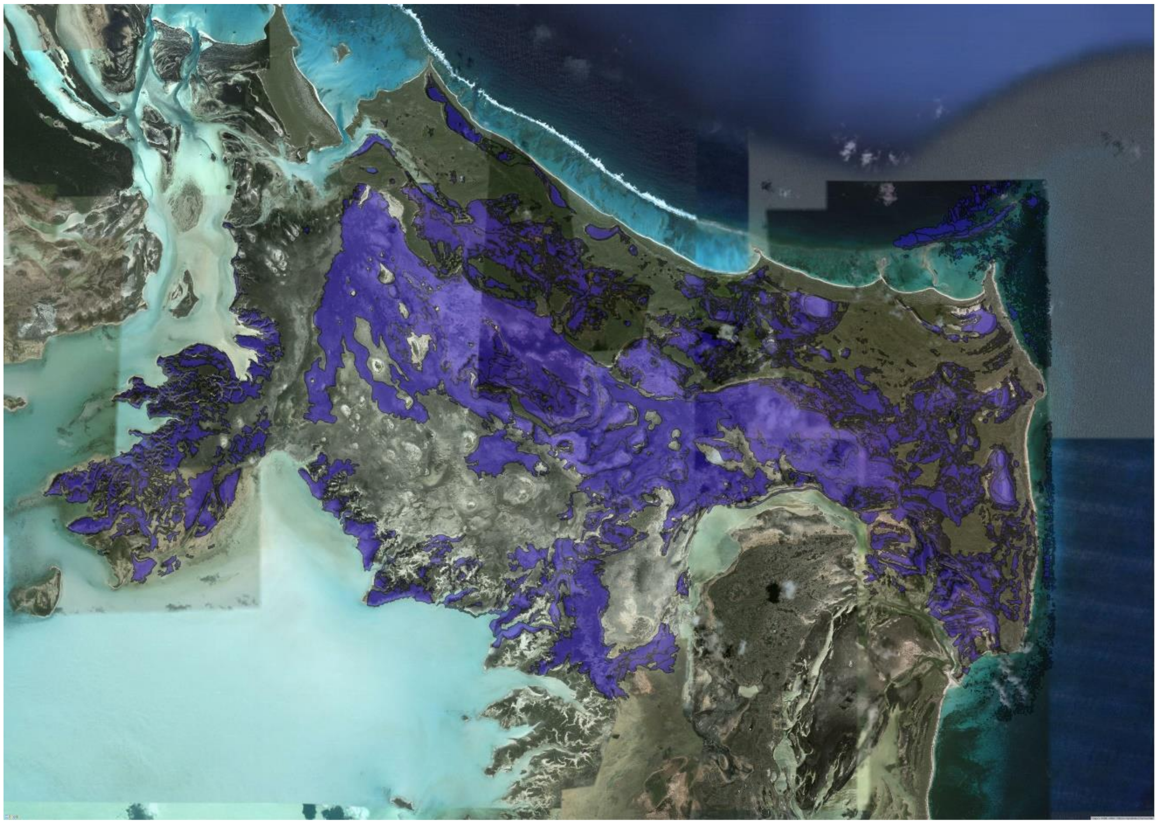

Figure 31. Nutrition ecosystem services.

Materials. Materials ecosystem services on East Caicos include raw materials, such as sand, thatch, wood, traditional medicinal floral species and ornamental floral species (Fig. 32). Sand is produced by calcareous algae and coral reefs and by precipitation of calcium carbonate oolite from the water column. The prevailing currents in the Caicos Islands move along the northern shorelines from the east to the west. Therefore, sand produced within the coastal waters surrounding East Caicos significantly contribute to the available sand resources across the Caicos Islands. Given that white-sand beaches are a prominent feature of TCI's tourism product, these resources are considered to be of considerable economic benefit, although an estimation of this value is beyond the scope of this study. Local sand is also used in TCI in the construction industry.

In addition to mineral resources, East Caicos is a genetic reservoir of the vast majority of TCI floral species, including those used for materials. The Inagua silver palm *(Coccothrinax inaguensis)* and thatch palm *(Leucothrinax morrisii)* have been used historically for roofing thatch and as textiles for weaving. The wood of several hardwood species, including lignum vitae *(Guaiacum sanctum, G. officinale),* mahogany *(Swietenia mahagoni),* wild tamarind *(Lysiloma latisiliquum),* satinwood *(Zanthoxylum flavum)* and others have been used as lumber for traditional sloop building, wagon wheels and building construction (Morton, 1977; Sadler, 1986; Wood, 2003).

Bay tansy *(Ambrosia hispida),* love vine *(Cassytha filiformis),* granny bush *(Croton discolor),* fire bush *(Croton lucidus),* mauby *(Erythroxylum rotundifolium),* salve bush *(Helicteres semitriloba),* sea sage *(Lantana involucrata),* sword bush *(Phyllanthus epiphyllanthus),* mahogany *(Swietenia mahagoni)* and numerous other floral species have traditionally been used for medicinal purposes (Morton, 1977; Wood, 2003).

Ornamental species include prickly pear species (*Opuntia spp.),* Agave species *(Agave spp.),* frangipani *(Plumeria obtusa),* Encyclia orchid species *(Encyclia spp.),* monkey fiddle (*Pedilanthus bahamensis),* false frangipani (*Euphorbia gymnonota),* dildo cactus (*Pilosocereus royenii),* Turk's cap cactus *(Melocactus intortus)* and others. Materials floral species mentioned above are broadly distributed across upland, coastal and wetland habitats throughout East Caicos.

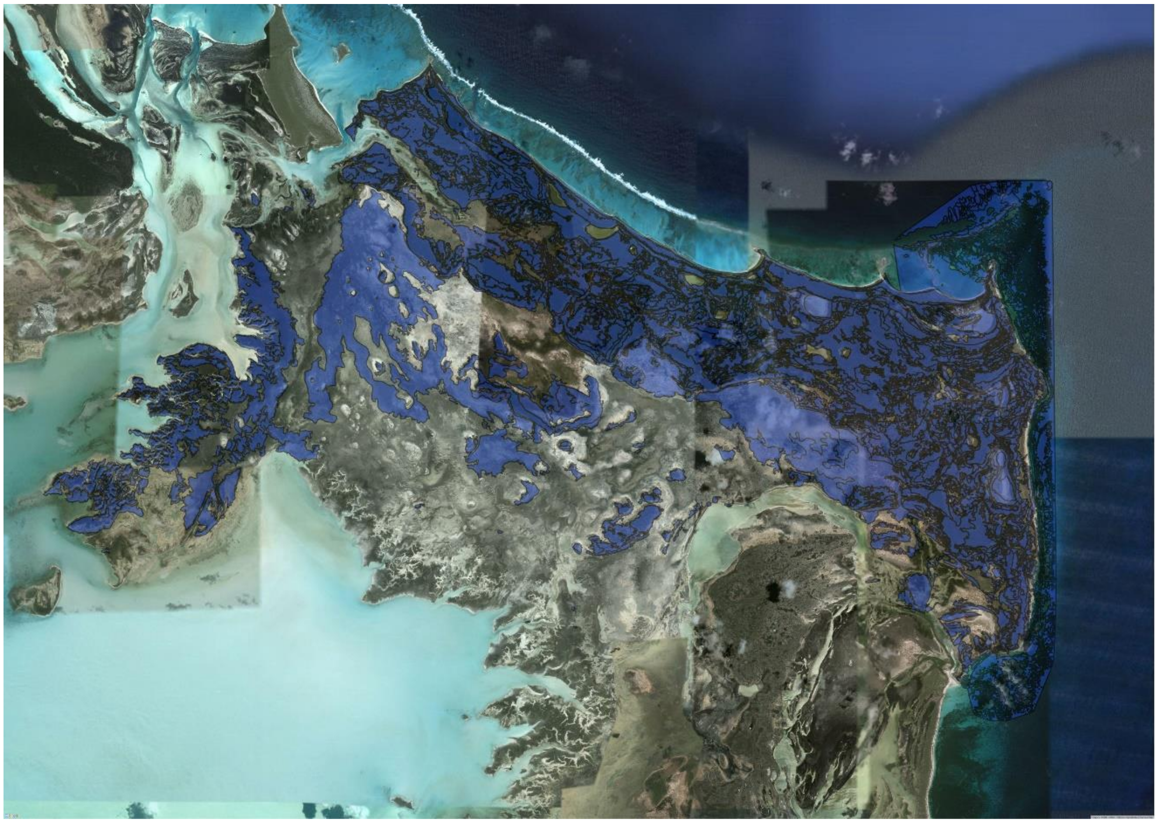

Figure 32. Materials ecosystem services.

Energy. Existing energy ecosystem services at East Caicos are provided by constant easterly trade winds, which could be harnessed along the east coast to provide significant electrical resources for the country (Fig. 33). Easterly trade winds across the region are typical and have generally not been tapped for their potential. Wind energy resources are renewable and are not threatened by environmental degradation or loss; however, site selection and feasibility will need to account for bird and bat populations, which may be at risk from wind turbines.

Intact tropical dry forests are also a potential energy source, as these are harvested on a regional and global scale for fuel wood and charcoal manufacturing. The use of tropical dry forest resources for fuel is considered the leading cause of deforestation in these habitats (Aide et al., 2013). Illegal charcoal manufacturing is a major threat on the inhabited islands of TCI, wherever forested areas become accessible via roads infrastructure. The unfragmented forested areas of East Caicos therefore represent a reservoir of this habitat type and an untapped energy resource, although such use is not recommended.

Figure 33. Energy ecosystem services.

Regulation of wastes. Wastes on East Caicos are currently regulated via the absorption of nutrients within algal reef ecosystems, seagrass meadows and estuarine and palustrine wetland ecosystems (Fig. 34). All wetland habitats at East Caicos also provide regulation of wastes ecosystem services. Although no anthropogenic waste is currently produced at East Caicos, the habitats that provide this ecosystem service process nutrient loads from coastal upwelling and potential upland runoff from nutrient loads in soils, ensuring that downstream sensitive habitats, such as coral reefs, are less vulnerable to the effects of these compounds. Such processing is particularly critical for the ongoing resilience of RTE coral populations, located in the marine habitats northeast of East Caicos.

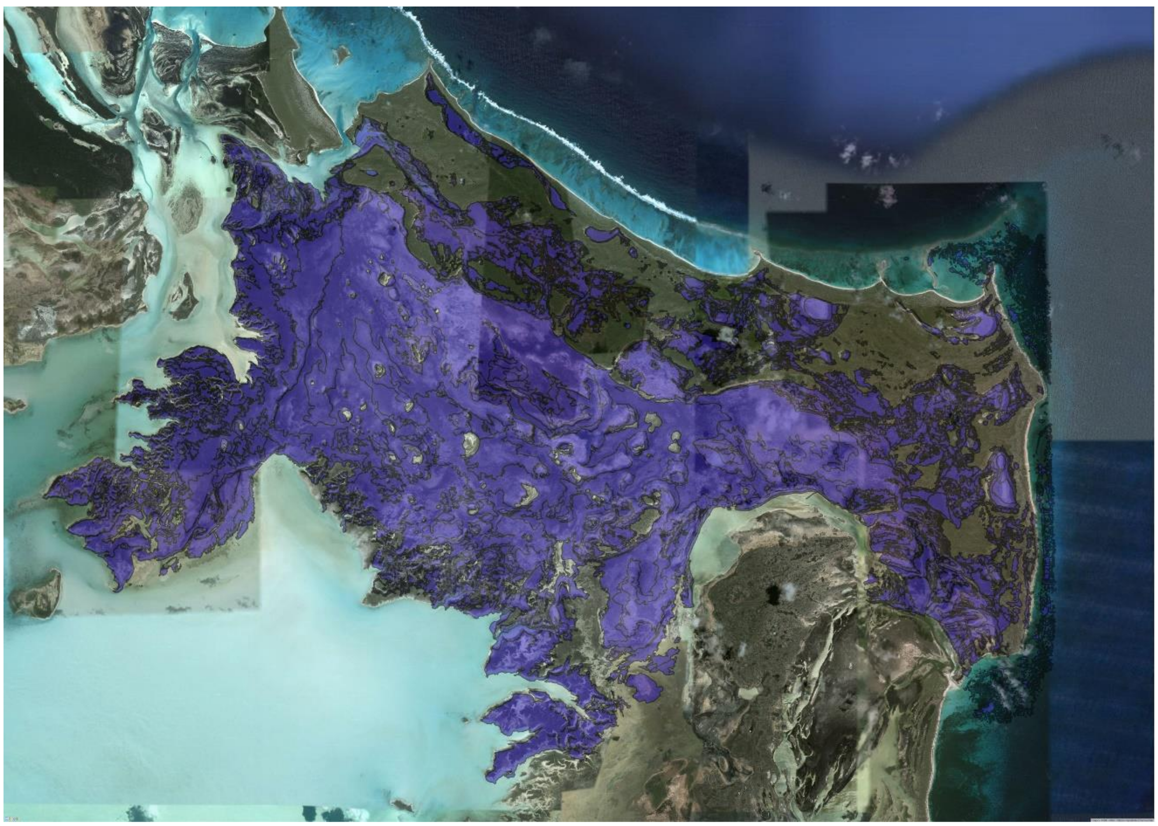

Figure 34. Regulation of wastes ecosystem services.

Regulation of flows. Flows are regulated at East Caicos by several mechanisms (Fig. 35). Palustrine habitats and associated cave and karst features function as flood plains, regulating the flow of runoff from seasonal rains and storms and recharging subterranean aquifers. Coral and algal reef complexes regulate wave, wind and current flows, protecting shorelines from erosion. Estuarine mangal communities regulate tide and storm surge flows and trap sediments, protecting shorelines from erosion and sensitive habitats, such as coral reefs, from sedimentation. Coastal beach and dune complexes regulate sand, wave and littoral flows.

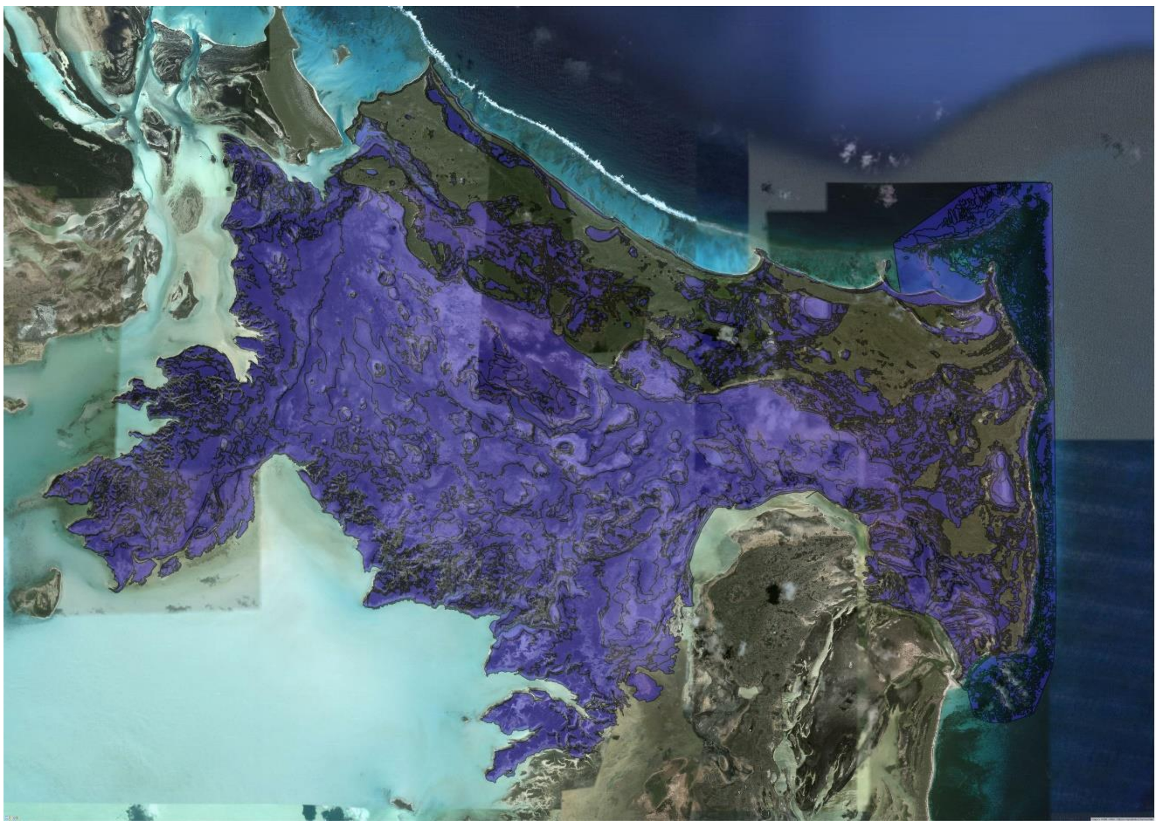

Figure 35. Flow regulation ecosystem services.

Regulation of physical environment. The physical environment at East Caicos is regulated via the sequestration of carbon dioxide (Fig. 36). The regulation of carbon dioxide by natural ecosystems helps to reduce atmospheric concentrations, thus helping to mitigate against global climate change. Tropical dry forests, woodlands and shrublands sequester carbon dioxide within tree and shrub biomass and within biogenic soils. Palustrine and estuarine ecosystems also serve as carbon sinks, as carbon is sequestered in plant biomass and a peat layer that forms in these habitats. Carbon dioxide is also sequestered in coral and coralline algal reef structures, carbonate sand and oolitic precipitation.

Figure 36. Physical environment regulation ecosystem services.

Cultural symbolic. Cultural symbolic ecosystem service values are located throughout East Caicos and the island's surrounding marine ecosystems. These values include areas of outstanding natural beauty, traditional artisanal fishing grounds, wilderness, tranquility, isolation, and sacred and archaeological spaces, including Lucayan archaeological sites and Colonial era ruins. As the island is uninhabited and undeveloped, areas of outstanding natural beauty, wildness, tranquility and isolation are considered to be present for all areas. Traditional artisanal fishing grounds are located within all northern and eastern marine habitats and estuarine tidal creeks. Lucayan and colonial archaeological sites are also located at various locations across the island, particularly within cave and karst habitats.

Cultural intellectual and experiential. Cultural intellectual and experiential ecosystem service values at East Caicos include charismatic and iconic wildlife (sea turtles, rock iguanas, flamingos and others), sport fishing venues, tourism values, areas for scientific research and educational values. Charismatic and iconic wildlife are located along eastern beaches, shorelines and nearshore marine areas (sea turtles and rock iguanas) and within palustrine ponds (flamingos). The extensive area of tidal creeks and flats, located along the southern side of East Caicos are used for sport fishing of bonefish *(Albula vulpes).* Given the island's natural beauty and significant populations of RTE and endemic species, tourism values and areas for scientific research and education are distributed across all habitat types on East Caicos.

Rare, threatened and endangered species. Myriad significant RTE species populations are extant at East Caicos as described previously in the Results section (Fig. 37). Refer to Appendix 2 for a comprehensive listing. In particular, upland terrestrial ecosystems provide habitat for IUCN CR Caroline's pink *(Stenandrium carolinae),* IUCN EN lignum vitae *(Guaiacum sanctum* and *G. officinale),* West Indian mahogany *(Swietenia mahagoni),* Caicos Islands Encyclia *(Encyclia caicensis)*, IUCN VU Inagua senna

(Chamaecrista caribaea var. inaguensis) and other species listed under CITES and SPAW. The East Caicos population of *Stenandrium carolinae* is the largest recorded to date and is estimated to comprise approximately 75% of the known population for this species.

Coastal habitats support populations of IUCN EN silvery silverbush *(Argythamnia argentea)* and Caicos Islands Encyclia *(Encyclia caicensis),* IUCN VU Inagua senna *(Chamaecrista caribaea var. inaguensis)* and other species listed under CITES and SPAW.

IUCN EN thin-leaved buttonweed *(Spermacoce capillaris),* peppergrass *(Lepidium filicaule),* heather *(Limonium bahamense)* and other species listed under CITES and SPAW occur in palustrine habitats. The population of *Spermacoce capillaris* in East Caicos palustrine habitats is one of only two known populations of this species (Barrios & Manco, 2015).

RTE terrestrial and wetland fauna include IUCN CR TCI rock iguana *(Cyclura carinata)* and Cuban cave shrimp *(Barbouria cubensis),* IUCN VU West Indian whistling duck *(Dendrocygna arborea),* IUCN NT piping plover *(Charadrius melodus)* and reddish egret *(Egretta rufescens)* and other species listed under CITES and SPAW.

East and northeast coast beaches and nearshore coral reefs and seagrass beds provide nesting and foraging habitats for IUCN EN and CR sea turtles *(Chelonia mydas, Caretta caretta* and *Eretmochelys imbricata).* Estuarine ecosystems are also important nursery areas for IUCN NT lemon sharks.

IUCN CR elkhorn coral *(Acropora palmata)* and staghorn coral *(A. cervicornis),* IUCN EN boulder star coral complex *(Orbicella annularis),* mountainous star coral

(Montastraea cavernosa) and Nassau grouper *(Epinephelus striatus*), IUCN VU hogfish *(Lachnolaimus maximus),* rough cactus coral *(Mycetophyllia ferox),* whitestar sheet coral *(Agaricia lamarcki),* elliptical star coral *(Dichocoenia stokesi)* and pillar coral *(Dendrogyra cylindrus)* and numerous CITES and SPAW listed species are located in northeastern coral reef communities and at some eastern algal reef locations. In particular, populations of CR *Acropora palmata* and *A. cervicornis* are the most significant populations of these species currently known in TCI and may represent a significant population for the wider Caribbean region.

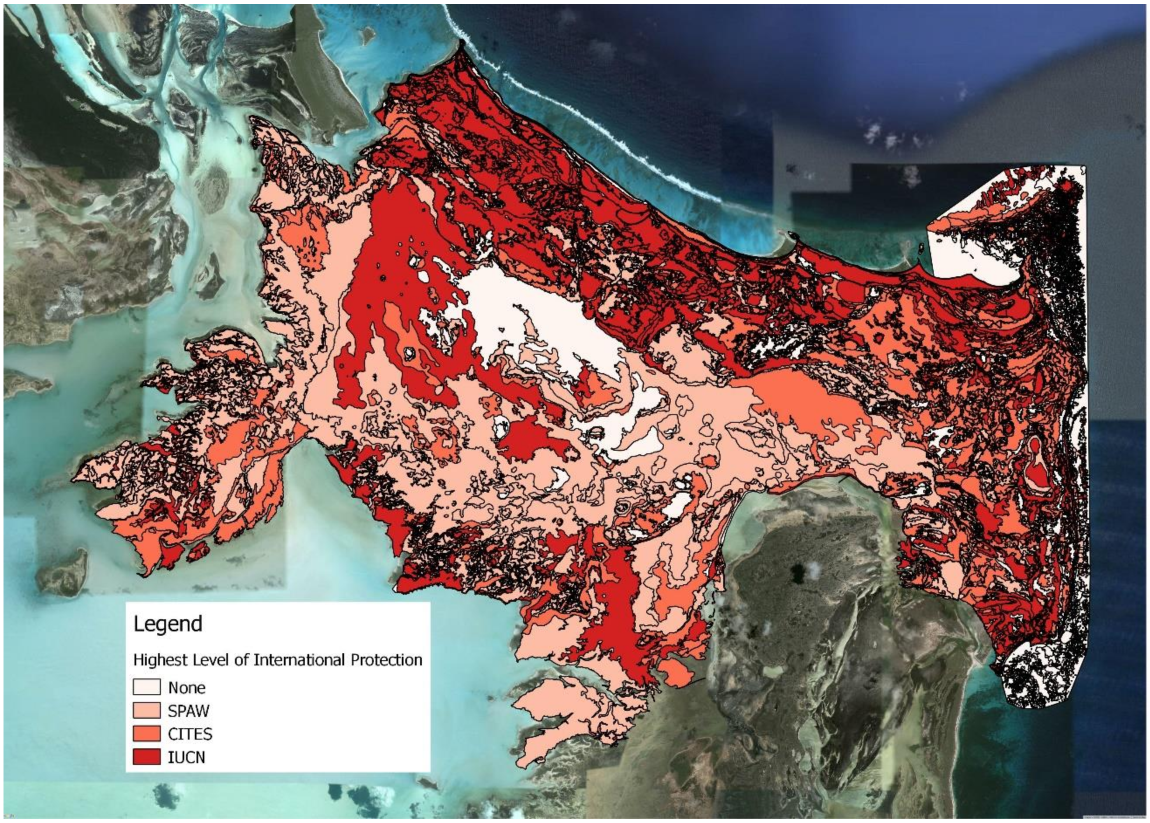

Figure 37. RTE species biodiversity service values.

Endemic species. Myriad significant endemic species populations are extant at East Caicos as described previously in the Results section (Fig. 38). Refer to Appendix 3 for a comprehensive listing. Coastal, upland and palustrine habitats contain all known TCI endemic floral species, including silvery silverbush *(Argythamnia argentea),* TCI heather *(Limonium bahamensis),* TCI milkweed vine *(Cynanchum stipitatum),* Caicos Islands Encyclia *(Encyclia caicensis),* broom bush *(Evolvulus bahamensis,* doubtfully endemic*),* Britton's buttonweed *(Spermacoce brittonii),* fine-leaved buttonweed *(Spermacoce capillaris),* Lucayan prickly pear *(Opuntia lucayana),* Caroline's pink *(Stenandrium carolinae)* and peppergrass *(Lepidium filicaule).* Note that East Caicos is the only island within the TCI archipelago where all ten TCI endemic floral species have been recorded.

Numerous other Lucayan and regional endemic floral species are also located within these habitats.

Endemic birds, including endemic sub-species Antillean bullfinch *(Loxigilla violacea ofella)* and thick-billed vireo *(Vireo crassirostris stalagmium)*, Lucayan archipelago endemic bird species Bahama woodstar hummingbird *(Calliphlox evelynae)* and regional endemic species Cuban crow *(Corvus nasicus)* and Bahama mockingbird *(Mimus gundlachii)* occur in terrestrial ecosystems. The regionally endemic white-cheeked pintail *(Anas bahamensis)* occurs in palustrine ecosystems.

Reptiles, including TCI endemic species curly-tail lizard *(Leiocephalus psammodromus),* TCI rock iguana *(Cyclura carinata),* Caicos Islands skink *(Spondylurus caicosae),* Caicos Islands reef gecko *(Sphaerodactylus caicosensis),* TCI endemic pygmy boa constrictor *(Tropidophis greenwayi)* and TCI endemic sub-species bark anole *(Anolis scriptus scriptus)* occur in terrestrial and some wetland ecosystems. The TCI endemic species Caicos Islands barking gecko *(Aristelliger hechti),* Lucayan archipelago endemic species southern Bahamas rainbow boa *(Chilabothrus chrysogaster)* and Mayaguana gecko *(Sphaerodactylus mariguanae)* and regional endemic blind-eye snake *(Typhlops richardi)* were not recorded during field studies; however, these species are also likely present.

Regionally endemic Cuban cave shrimp *(Barbouria cubensis)* are located in inland saline ponds, and potentially endemic TCI pupfish *(Cyprinodon spp.)* occur in ponds and palustrine habitats across a broad salinity gradient.

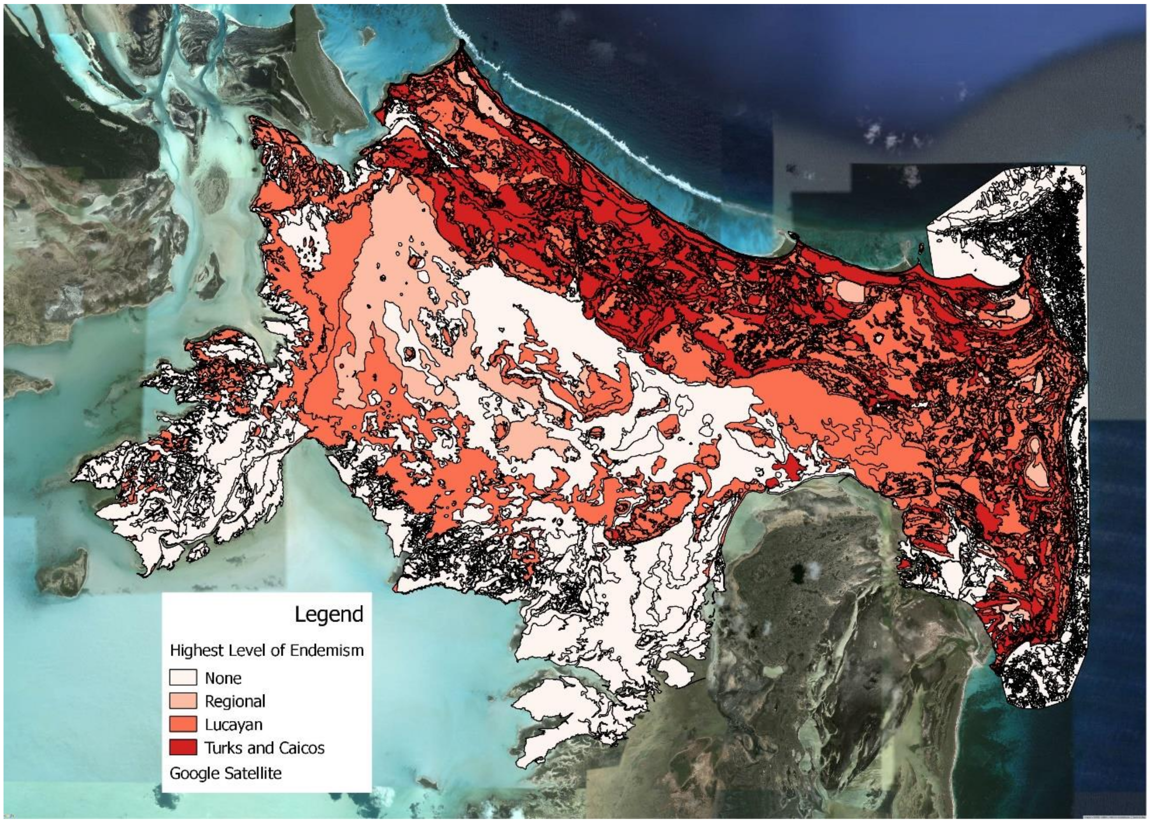

Figure 38. Endemic species biodiversity service values.

Geographically restricted species. Geographically restricted species at East Caicos are those whose populations are restricted to specific biomes or are otherwise restricted in their range (Fig. 39). They include biome restricted nesting bird populations, bats, cave invertebrates and potentially other species. Eastern and northeastern cliffs serve as nesting habitat for geographically restricted white-tailed tropicbird and Audubon shearwater. Bat *(Brachyphylla cavernarum, Brachyphylla nana* and *Tadarida brasiliensis)* and barn owl *(Tyto alba)* populations are rare in TCI and are geographically restricted to cave habitats. Cave invertebrates, such as Cuban cave shrimp *(Barbouria cubensis)* are geographically restricted to karst features and cave habitats.

Figure 39. Geographically restricted species biodiversity service values.

Spatial/temporal concentrations of species. Spatial and temporal concentrations of species at East Caicos include nesting bird populations, migratory species populations, spawning aggregations for marine species, juvenile habitat for marine species, nesting and foraging habitat for sea turtles and others (Fig. 40). Nesting habitat for perching birds is found within tropical dry forests, woodlands and shrublands. These areas are also frequented by migratory perching bird populations. Estuarine and palustrine habitats are important nesting areas for waterfowl, wading birds, shoreline birds and seabird populations. Coral reefs off East Caicos are spawning areas for IUCN EN Nassau grouper *(Epinephelus striatus)* and other fish species. Seagrass beds and mangals are important spawning and nursery habitat for a wide variety of marine organisms.

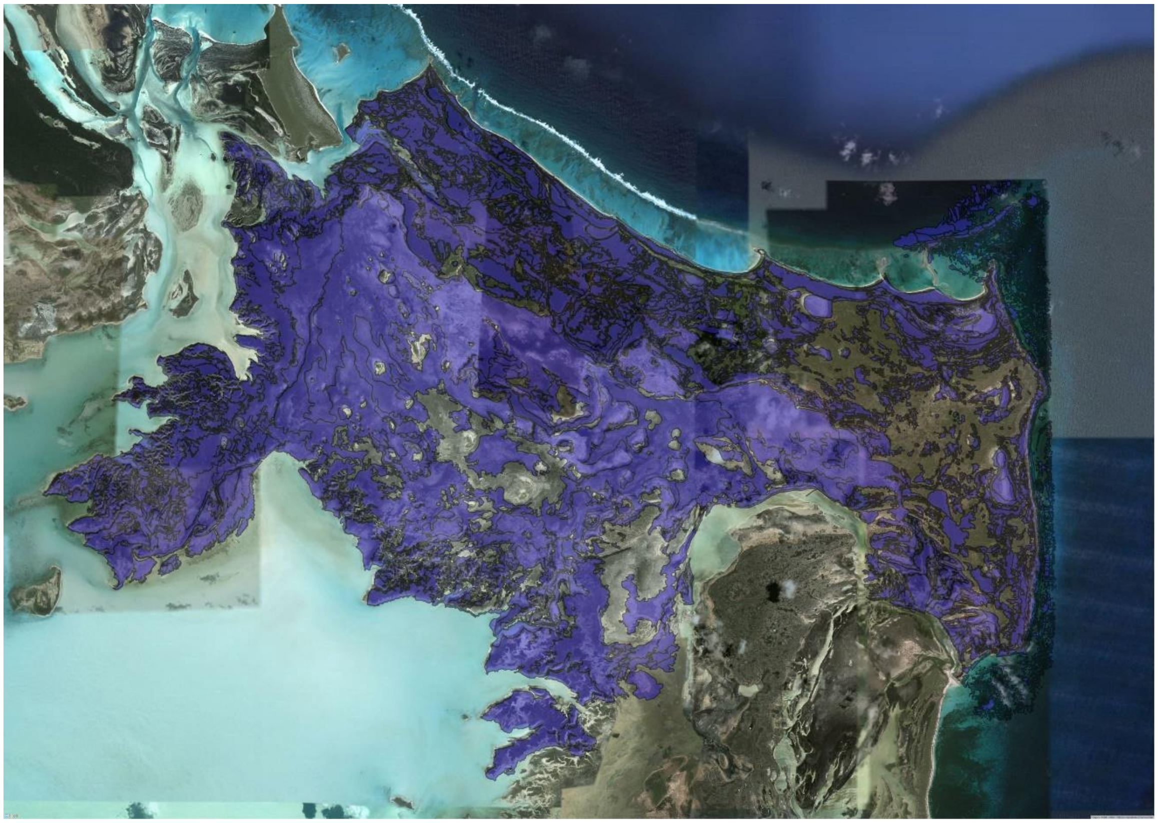

Figure 40. Spatial and temporal concentrations of species biodiversity service values.

Landscape-level ecosystems and mosaics. The island of East Caicos and surrounding marine ecosystems are currently unfragmented and intact, with a history of relatively light human use. The entire study area is therefore considered to be a landscape-level ecosystem mosaic.

Rare, threatened and endangered ecosystems. A large proportion of the habitats and ecosystems represented on East Caicos are rare, threatened or endangered, based on IUCN's criteria currently being developed for RTE ecosystems (Keith et al., 2013; Rodríguez et al., 2011) (Fig. 41). Tropical dry forests are considered the most-threatened forest type on a global scale (Franklin et al., 2015). Coral reef ecosystems and seagrass meadows are threatened on a global scale by global climate change, land-based pollutant sources and other impacts. Mangal and other estuarine habitats are threatened globally by aquaculture, fuel pressures and other impacts. Cave and karst habitats are rare in TCI. Coastal habitats in TCI are threatened by tourism development, and palustrine habitats in TCI and other Caribbean countries are threatened by filling-in due to development pressures and land scarcity.

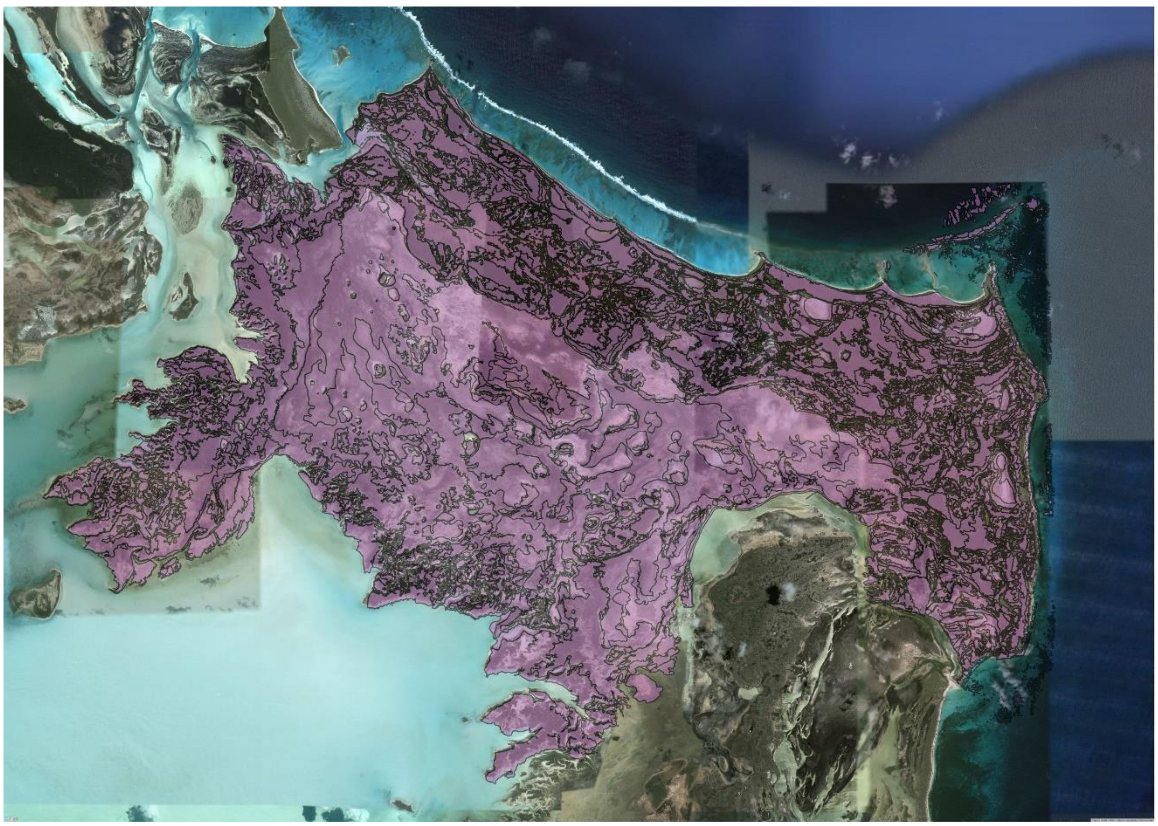

Figure 41. RTE ecosystem biodiversity service values.

Local, Regional and Global Perspectives

Biodiversity and ecosystem service values are discussed below, including local, regional and global perspectives. For discussion purposes, values below are discussed within the context of broad ecosystem types, including coral and algal reef complexes, seagrass meadows, estuarine and palustrine wetlands, tropical dry forests, woodlands and shrublands and cave and karst features.

Coral and algal reefs. As noted previously, coral and algal reefs at East Caicos are critical habitats, supporting nutrition, materials, regulation of flows, regulation of wastes, regulation of physical environment, cultural symbolic, cultural intellectual and experiential, RTE species, spatial/temporal concentrations of species, landscape level ecosystem mosaic and RTE ecosystem biodiversity and ecosystem service values.

Coral reefs are highly productive and biologically diverse ecosystems (Moberg & Folke, 1999). One square kilometer of living coral reef is estimated to sustainably provide the necessary protein for 300 people (Jennings & Polunin, 1996), and the fisheries products harvested from coral reefs provide between nine and twelve percent of the world's fisheries products (Moberg & Folke, 1999).

On a global scale, however, coral reef ecosystems are threatened by myriad stressors, including runoff of sediment and pollutants from coastal development, overfishing and other destructive fishing practices, ocean acidification, boat groundings, climate change and other impacts (Hughes, 2014; Jackson, 2014). Correlations between coastal development and declines in the biomass of fish and coral mortality have been made (Mora, 2008).

Over the past two decades, it is estimated that as much as 80% of live coral cover in the Caribbean region has been lost, with live coverage averages declining from 50% to 10% over the same period (Agard et al., 2007).

Sand is a key material resource produced by algal and coral reefs at East Caicos. Tourism is the leading economic activity in TCI and across the Caribbean, accounting for as much as one-third to one-half of Gross Domestic Product (GDP) in a majority states across the region. In TCI it accounts for an estimated forty percent of GDP (Brough & Sartori, 2015). The Caribbean tourism product is characterized by what is known as the "three "S's": "sun", "sea" and "sand". A recent tourist exit survey in TCI indicated that sun, sea and sand were the purpose of their visit for a majority of visitors (50.9%) (Brough & Sartori, 2015).

Most beaches in the Caribbean are less than 30 meters wide, and these beaches are vulnerable to erosion from climate change and poor development practices. About 70 percent of beaches in the region are suffering from erosion, due to an estimated 19 centimeter sea level rise over the past century (Church, 2013). These losses are likely exacerbated by the declining health of coral reefs and associated losses of coastal protection (Agard et al., 2007). Sand resources in the Caribbean region are further threatened by the removal of mangroves, which protect shorelines and act as sediment traps, mining, physical damages and poorly conceived coastal engineering projects (Gable, 1997). Beach erosion is expected to accelerate with increased temperatures and sealevel rise associated with global climate change (Gable, 1997).

In order to remain productive, coral reefs must balance the production of calcium carbonate structure with erosional effects from bioerosion, ocean acidification and other influences. It is estimated that 21% of Caribbean coral reefs are in a state of decline and have been experiencing a net loss of structure since 1970 (Kennedy, 2013). The current rate of loss of structure is the greatest recorded over approximately the past 8,000 years (Kennedy et al., 2013). Collectively, land-based pollutant runoff, poor fishing practices, ocean acidification and climate-changed induced bleaching will result in significant net losses of reef structure throughout the next several decades (Kennedy et al., 2013).

At East Caicos, coral reefs may be resilient to the above impacts for a variety of reasons. High rates of production on Caribbean coral reefs are correlated with the IUCN CR species *Acropora palmata* and *A. cervicornis* (Kennedy et al., 2013). Regional populations of these two species experienced significant decline due to an epidemic of white band disease in the 1980s and a major bleaching event in 2005, followed by disease outbreak in 2006 (Kennedy et al., 2013). This coral bleaching, followed by disease outbreak is estimated to have resulted in a 60% decline in live coral coverage in the US Virgin Islands (Randall, 2014). Populations measuring greater than 100's of square meters of both species were observed in areas surveyed during field studies at East Caicos.

High coral coverages (greater than 20%), coupled with conservation of parrotfish are also believed to increase resilience in coral reefs and prolonged their resilience to climate change (Kennedy et al., 2013). Parrotfishes *(Scaridae)* were observed in abundance at East Caicos reefs, although the quantification of these populations was beyond the scope of this assessment.

Coral and algal reefs and their biodiversity and ecosystem service values at East Caicos are also protected from many of the above outlined impacts due to a lack of land-based development and limited use. At East Caicos, an existing estimated baseline of 21.58 – 26.2% average coral cover, significant herbivore populations, significant populations of *Acropora spp.,* colder water temperatures from upwelling (and associated nutrients), protection from intense fishing pressures due to climactic conditions and a complete lack of runoff from land-based pollutant sources makes the area an important refuge for coral reefs and their associated biodiversity and ecosystem values within the Caribbean region.

Seagrass habitats. Seagrass beds are ecosystems that provide critical biodiversity and ecosystem services at East Caicos, in the wider Caribbean region and at a global scale. Seagrass beds are important spawning and juvenile habitat (spatial/temporal concentrations of species) for a wide variety of marine organisms, with most reef organisms using these habitats for at least one life phase. They also aid in the protection of shorelines by dissipating wave energy and trapping sand and stabilizing the sea bottom, which in turn contributes to the maintenance of water clarity required for photosynthesis (regulation of flows) (Agard et al., 2007). IUCN EN green sea turtles *(Chelonia mydas),* CITES II-listed queen conch *(Strombus gigas)* and a wide variety of other organisms depend on seagrass beds for foraging and grazing (RTE species habitats) (Agard et al., 2007). As photosynthetic plants, seagrass ecosystems are areas of high productivity, also adding oxygen to the water column. As they absorb carbon dioxide and nutrients from the water column, converting them to biomass, they act as a sink for these compounds (regulation of physical environment and regulation of wastes). As much as a kilogram per square meter of carbon is converted to biomass by seagrass meadows on an annual basis (Agard et al., 2007). Although they are not the direct producers of sand, seagrass beds provide habitat for a wide variety of mollusks, crustaceans and calcareous algae, thus contributing to the production of sand in the littoral systems in which they occur (materials) (Agard et al., 2007). In addition to these criteria, unfragmented and unspoiled seagrass beds (cultural symbolic) at East Caicos are also integrated into landscape-level ecosystem mosaics and have scientific research and ecotourism values (cultural intellectual and experiential).

Caribbean seagrass meadows are under threat from land-based pollutant sources, such as petroleum-based pollutants, pesticides and nutrient loads associated with coastal tourism development. Tourism development also threatens these ecosystems, as they are often dredged in order to create sandy swimming areas that are perceived as more attractive. Seagrass beds are also often dredged in association with shipping and cruise ports, marinas and other nearshore-based developments (Agard et al., 2007). Dredging and pollutant loads can further impact seagrass beds by reducing water clarity, thereby impairing the plants' ability to photosynthesize (Short & Wyllie-Echeverria, 1996). Increased human activity around seagrass beds, such as boating, also leads to degradation and loss from physical damage associated with trampling anchor/chain scars (leading to localized "blowouts") and boat propeller strikes. (Short & Wyllie-Echeverria, 1996).

Although there are many anthropogenic causes of seagrass ecosystem losses, eutrophication is believed to have the most significant deleterious effect (Ralph, Tomasko, Moore, Seddon, & Macinnis-Ng, 2007). Coastal development and associated pollutant and nutrient contamination from poor watershed management can result in the complete loss of seagrass meadows in adjacent nearshore habitats (Ralph et al., 2007). For example, seagrass beds off the coast of Tampa Bay, Florida completely disappeared over the fifty year period from 1948 to 1998, associated with rapid coastal development (Ralph et al., 2007). The seagrass ecosystems at East Caicos are currently protected from major impacts due to relatively light use and a lack of runoff from land-based development, making these areas important reservoirs for biodiversity and ecosystem service values in TCI.

Estuarine and palustrine wetlands. Estuarine and palustrine wetland habitats at East Caicos and across the Caribbean region provide important biodiversity and ecosystem service functions, including, but not limited to shoreline protection (regulation of flows), sequestration of wastes (regulation of wastes) and carbon dioxide (regulation of physical environment) and migratory, nesting, nursery and juvenile habitat for birds, important fisheries species and RTE species (spatial/temporal concentrations of species and RTE species concentrations) (Lomelí, Vazquez, Galavíz, Yáñez-Arancibia, & Arriaga, 1999). At East Caicos, vast areas of unfragmented estuarine and palustrine ecosystems (landscape-level ecosystem mosaics) are also areas of outstanding natural beauty, archaeological sites (cultural symbolic), ecotourism venues and areas of scientific interest (cultural intellectual and experiential) (Agard et al., 2007).

Wetland ecosystems are threatened on a global and regional scale by a variety of anthropogenic activities. Oil production in the Gulf of Mexico, Trinidad and Tobago, the Mexican Caribbean and other areas has resulted in contamination of mangal ecosystems from hydrocarbons. In many areas, wetlands are destroyed, via dredging, canalization and filling, to open areas for oil production, for charcoal manufacturing and to create additional land areas for development (Agard et al., 2007; Lomelí et al., 1999). Land-based activities such as agriculture, urbanization and industry are also a source of pollutants in many wetlands (Lomelí et al., 1999). Reclamation for agriculture and land development accounts for the most significant proportion of palustrine wetland losses (Maltby, 2013). Climate change presents a significant threat to coastal wetlands due to increased hurricane events and sea level rise (D. E. Austin, 2006; Zedler & Kercher, 2005).

It is estimated that as much as 50% of the world's wetlands have been lost, and what remains is often fragmented or otherwise compromised (Maltby, 2013; Zedler & Kercher, 2005). In the Caribbean, an average of one percent of the region's mangal habitats are lost per year amounting to a total loss of 413,000 hectares over the region's development history (Agard et al., 2007; Ellison & Farnsworth, 1996).

All wetland ecosystems on East Caicos remain intact, with the southwestern portion of the island protected under the Ramsar Convention. A proposed amendment to the TCI National Parks Ordinance, if successful, will extend the Ramsar site to include all wetlands on East Caicos (DEMA, 2015). A lack of land-based development, coupled with landscape-level protections for the wetland ecosystems of East Caicos make this area an important conservation interest, locally, regionally and globally.

Tropical dry forests, woodlands and shrublands. Tropical and subtropical dry forests, woodlands and shrublands are included in assessments of the conservation status of tropical dry forests (TDFs) (Miles et al., 2006). At East Caicos, TDFs include all shrubland, woodland and forest types in coastal and upland ecosystems. These habitats provide significant biodiversity and ecosystem service values. East Caicos TDFs are floral genetic reservoirs of traditional medicinal, endemic, RTE and ornamental species (materials, RTE species populations and endemic species populations). Although not recommended, East Caicos TDFs are also a potential energy resource for fuel wood. They also regulate the physical environment via sequestration of carbon into biomass and soils and are areas of outstanding natural beauty, cultural significance and scientific interest, with potential tourism value. East Caicos TDFs provide critical habitat for nesting bird populations, migratory birds and other fauna (spatial/temporal concentration of species). The mosaics of unimpacted and unfragmented TDF forest types on East Caicos represents the largest landscape-level TDF ecosystem in TCI and is one of few remaining in the wider Caribbean region.

In 1988, tropical dry forests were recognized as the most-threatened of all forest types (RTE ecosystems), with an estimated two percent of original areas remaining ecologically intact (Janzen, 1988). In recent years, this status has only declined. Upland dry forests continue to be considered the most-threatened forest type on a global scale (Franklin et al., 2015). 97% of remaining tropical dry forests are considered at risk from a variety of factors, including, but not limited to, climate change, agricultural development, land clearance and other human activity (Miles et al., 2006).

Few contiguous TDFs remain within the North and Central American region, including the Caribbean. In the Caribbean region, human population densities are high, resulting in significant deforestation of TDFs. Slash and burn agriculture, charcoal manufacturing, land clearance for tourism development, introduction of nuisance exotic species and timber harvest are the primary causes of Caribbean TDF degradation (S. Austin, 2016). Pressures on TDFs are exacerbated by a cultural apathy towards conservation ethics (Raffaele et al., 2003). TDFs in the Caribbean region have been reduced by an estimated 66% (Portillo-Quintero & Sánchez-Azofeifa, 2010, p. 150), and those that do remain are at high risk, as only 5.7% are located within protected areas. This represents the smallest proportion of protected TDFs in any region globally (Miles et al., 2006).

Although similar in species compositions to other Caribbean dry forests (Franklin et al., 2015), the dry forests of TCI and the Bahamas in particular are considered to be a globally rare and Critical/Endangered ecosystem (S. Austin, 2016), threatened across their range by land-based development, land clearance and alien invasive species (Franklin et al., 2015). The TDFs at East Caicos therefore represent an important genetic reservoir of the vast majority of Lucayan archipelago upland species. As such, they are an important conservation interest locally, regionally and on a global scale.

Cave and karst features. Cave and karst feature habitats are distributed across the landscape at East Caicos. These habitats are rare (less than one percent of all habitat types) and provide a number of critical biodiversity and ecosystem services. The vast majority of cave and karst habitats are archaeological sites, with significant scientific research and tourism value (cultural symbolic and cultural intellectual and experiential). They are important features in controlling flood water and recharging underground aquifers (regulation of flows). At the interface of water and limestone, cave and karst features are shaping the underground world (regulation of physical environment). East Caicos caves, blue holes and solution sink holes are also habitat for spatial and temporal concentrations of locally and regionally endemic invertebrates and other geographically restricted organisms, such as bats and barn owls. The fragile ecological balances of caves are at risk on a global scale (RTE ecosystems) (Boulton, 2005).

In addition to physical impacts, subterranean ecosystems suffer impacts from pollution, groundwater extraction and changes in surface land use (Boulton, 2005). Changes in above-ground vegetation cover due to development can also alter hydrological regimes, resulting in significant impacts to geographically restricted cave fauna (Boulton, 2005). Given the restriction of light in cave ecosystems, primary production via photosynthesis is limited in these habitats. In response to limited food resources, cave organisms have adapted unique strategies, including chemoautotrophy. Nutrient loading from pollutant sources can therefore be detrimental and significant. Light pollution, which may result in algal blooms can also be problematic (Wood, Gunn, & Perkins, 2002). Given the fragile ecological balances achieved in caves, they can be particularly vulnerable to pollution and disruptions of any kind (Cigna, 1993).

The cave and karst habitats at East Caicos are currently free from ground water extraction, developmental and other negative pressures. They are largely unexplored and unstudied, representing a unique opportunity for scientific study.

Sustainable Eco- and Heritage Tourism

Development pressure may result in the loss of critical biodiversity and ecosystem values at East Caicos, unless viable economic alternatives can be found. The conservation values at East Caicos outlined throughout this document can be conserved, while at the same time supporting alternative livelihoods through the development of culturally and ecologically sustainable ecotourism projects. Through such projects, existing baselines can be maintained and even improved upon (e.g. feral donkeys and other invasive alien species can be eradicated). Some appropriate ecotourism and other development activities could include the following:

- Guided turtle watching activities along turtle nesting beaches can be coupled with turtle conservation initiatives, such as satellite tagging, rescue and rehabilitation and on-going scientific research. Culturally appropriate livelihoods can be generated by training the fisherfolk, who currently work in the area, as tour guides. Turtle watching is considered a high-end ecotourism activity (Wilson & Tisdell, 2003) and could result in improved livelihoods for TCI's fisherfolk. An ongoing conservation program could generate revenues in the form of local spending by research teams. Volunteerism programs (e.g. engaging volunteers who pay to participate in conservation activities) can also be developed to raise revenue to cover ongoing costs of conservation activities.
- High-end eco-camping (colloquially known as "glamping") cam be developed with low to no impact. Solar powered, no-discharge campsites can be elevated and incorporate boardwalks to avoid disruption of vegetation and soil and can generate livelihoods and revenues in the form of small business opportunities for provision of camping supplies and support services, including but not limited to transportation to and from East Caicos, catering, laundry, accommodation, etc.
- Energy from wind in eastern coastal areas could provide electricity for a majority of the electrical needs of the country. All utility-provided electricity in TCI is currently generated via diesel generators, at a significant cost, both economically and environmentally. The average cost of electricity to consumers is $0.46 per

kWh (Castalia, 2011), and an estimated 22.38 pounds of greenhouse gas is produced for every gallon of diesel fuel burned (Fankhauser, 1994). Given the high cost of electricity in TCI, wind-generated electricity is a viable economic alternative; however, such economic benefits will need to be weighed against potential threats to bird and bat populations caused by wind turbines

- Ongoing scientific research to assess and monitor characteristics of RTE and endemic species populations could be supported economically via the introduction of volunteerism programs as outlined above in reference to sea turtle monitoring, generating appropriate livelihoods and revenues in the form of support services and local spending.
- The development of guided hiking trails and tours could be based on several conservation themes, such as medicinal plant tours, endemic flora and fauna tours, seasonal bird watching tours, among other themes. Guided tours could generate livelihoods and revenues in the form of small business opportunities for local tour guides and support services.
- Sustainable harvest and propagation of tropical dry forest products, such as traditional medicines and ornamental plants for landscaping, could generate small business opportunities and increase public awareness about these resources.
- Fresh ground water resources, regulated by palustrine habitats, could be sustainably harvested and managed in order to support various ecotourism activities.
- The development of guided kayaking and snorkeling tours to estuarine wetlands for bird watching, turtle watching, shark watching, educational purposes, etc.

could generate livelihoods and revenues in the form of small business opportunities for local tour guides and support services.

- Spelunking, cave diving and guided cave tours and scientific research could generate livelihoods and revenues for small business opportunities for local tour guides and support services. Such activities will need to take place under strict oversight to ensure that archaeological and biotic resources in caves are not compromised.

In addition to the above activities, other culturally appropriate ecotourism projects could be developed via consultation with local stakeholders.

Project Potentials, Limitations and Conclusions

The MCEM study was not intended to be a comprehensive analysis. As the analysis is based on observed presence/absence, it must be considered that a number of features are unreported when they are actually present. Many areas were not surveyed. Seasonal migration patterns were only opportunistically observed. Investigations of endemism in invertebrate species were not undertaken. Some fauna are reclusive and avoided detection, and many other possible factors likely skewed results towards false negatives. The values reported here should therefore be considered minimum values, rather than an average or maximum.

Another limitation of the study method was the reliance on sub-optimal, open-access, Google Earth aerial imagery. Image clarity was compromised in some areas by a lack of available imagery, cloud cover, opacity of coastal water and poor resolution. Whenever possible, best guess assumptions were made regarding groundcover. In other areas where such assumptions could not reliably be made, undiscernible habitats were simply left blank.

The model incorporated here did not apply weighting or thresholds to any criteria. This was primarily done in order to maintain objectivity; however, the model could be easily altered to include algorithms that apply various weights to different criteria. For example, minimum density and population size requirements could be introduced into the model, in addition to increased values for IUCN CR organisms as compared to less vulnerable species.

This research should therefore be viewed as a preliminary effort to describe the biodiversity and ecosystem service values of East Caicos, rather than as a final conclusive product. Some aspects in particular that would benefit from further analyses include the following:

- Quantification of population characteristics for all RTE and endemic species
- Classification of invertebrate populations to determine the presence/absence of RTE and endemic species
- Quantification and monitoring of RTE nesting sea turtle populations
- Quantitative mapping and monitoring of all coral reef ecosystems
- Mapping and ecological surveying of cave and other karst ecosystems
- Archaeological surveys to determine the extent and characteristics of Lucayan and colonial archaeological remnants
- Population characteristics quantification and further genome study into pupfish *(Cyprinodon spp.)*
- Economic valuation of resources, such as sand, fisheries and tourism potential

The Millennium Ecosystem Assessment estimates that 60% of all ecosystem services are in the process of being exploited unsustainably on a global scale (Layke, Mapendembe, Brown, Walpole, & Winn, 2012). Due to relatively light historic use by humans, East Caicos is one of few locations within the Caribbean region that maintains high biodiversity and ecosystem service values. Although further research is required to fully quantify these values, preliminary results from the MCEM indicate that the island and its surrounding marine ecosystems is among the few remaining intact landscape-level ecosystem mosaics in the Caribbean region. Appropriate use and conservation of the island's environmental values will ensure that biodiversity and ecosystem service values are sustainably maintained for posterity.

Appendix 1

East Caicos Habitat Classifications

Table 34. East Caicos habitat classifications.

Terrestrial and Wetland					
Code	*Class*	*Code*	*Subclass*	*Code*	*Formation*
100	Forest	10	Broadleaf Evergreen	1	Upland
		20	Broadleaf Drought Deciduous	2	Coastal
		30	Broadleaf Mixed	3	Estuarine
				4	Palustrine
200	Woodland	10	Broadleaf Evergreen	1	Upland
		20	Broadleaf Drought Deciduous	2	Coastal
		30	Broadleaf Mixed	3	Estuarine
				4	Palustrine
300	Shrubland	10	Broadleaf Evergreen	1	Upland
		20	Broadleaf Drought Deciduous	2	Coastal
		30	Broadleaf Mixed	3	Estuarine
				4	Palustrine
400	Dwarf Shrubland	10	Broadleaf Evergreen	1	Upland
		20	Broadleaf Drought Deciduous	2	Coastal
		30	Broadleaf Mixed	3	Estuarine
		40	Dwarf Rockland	4	Palustrine
500	Herbaceous	10	Graminoid	1	Upland
		20	Forb	2	Coastal
		30	Mixed	3	Estuarine

				4	Palustrine
600	Non-Vascular	10	Algae	1	Upland
				2	Coastal
				3	Estuarine
				4	Palustrine
				5	Karst Feature
700	Sparse	10	Human Altered		
		60	Archaeological Artifact		
		50	Cave		
Marine					
	Formation		*Benthos*		*Secondary Formation*
1000	Hard Bottom Reef	100	Coral	1	Patch Reef
2000	Hard Bottom Non-reef	200	Algae	2	Reef Crest
3000	Sand	300	Gorgonian	3	Back-reef/Flat
4000	Rubble	400	Seagrass	4	Fore-reef
5000	Mud	500	Mixed	5	Spur and Groove
		600	Bare		

Appendix 2

East Caicos Rare, Threatened and Endangered Species

Table 35. East Caicos rare, threatened and endangered species.

Species	**Common Name**	**RTE Status**
Flora		
Argythamnia argentea	Silvery Silverbush	IUCN EN
Avicennia germinans	Black Mangrove	SPAW Annex III
Catesbaea foliosa	Catesby's Vine	IUCN NT
Chamaecrista caribaea var. inaguensis	Inagua Senna	ICUN VU
Conocarpus erectus	Green Buttonwood	SPAW Annex III
Encyclia altissima	Tall Encyclia	CITES Appendix II
Encyclia caicensis	Caicos Islands Orchid	IUCN EN CITES Appendix II
Encyclia inaguensis	Inagua Encyclia	CITES Appendix II
Encyclia rufa	Red Orchid	CITES Appendix II
Guaiacum officinale	Lignum Vitae	IUCN EN CITES Appendix II SPAW Annex III
Guaiacum sanctum	Lignum Vitae	IUCN EN SPAW Annex III
Halodule wrightii	Shoal Seagrass	SPAW Annex III
Laguncularia racemosa	White Mangrove	SPAW Annex III
Lepidium filicaule	Peppergrass	IUCN EN
Limonium bahamense	Heather	IUCN EN
Melocactus intortus	Turk's Cap Cactus	CITES Appendix II, SPAW Annex III
Opuntia bahamana	Bahama Prickly Pear	CITES Appendix II
Opuntia dillenii	Prickly Pear	CITES Appendix II
Opuntia lucayana	Lucayan Prickly Pear	CITES Appendix II
Opuntia nashii	Nash's Tree Cactus	CITES Appendix II
Pilosocereus royenii	Dildo Cactus	CITES Appendix II
Rhizophora mangle	Red Mangrove	SPAW Annex III
Ruppia maritima	Widgeon Grass	SPAW Annex III
Spermacoce capillaris	Thin-leaved Buttonweed	IUCN EN

Stenandrium carolinae	Caroline's Pink	IUCN CR
Swietenia mahagoni	West Indian Mahogany	IUCN EN CITES Appendix II
Syringodium filiforme	Manatee Grass	SPAW Annex III
Thalassia testudinum	Turtle Grass	SPAW Annex III
Fauna		
Phylum: Invertebrata		
Acropora cervicornis	Staghorn Coral	IUCN CR CITES Appendix II SPAW Annex II
Acropora palmata	Elkhorn Coral	IUCN CR CITES Appendix II SPAW Annex II
Agaricia agaricites	Lettuce Coral	CITES Appendix II SPAW Annex III
Agaricia fragilis	Fragile Saucer Coral	CITES Appendix II SPAW Annex III
Agaricia humilis	Low Relief Lettuce Coral	CITES Appendix II SPAW Annex III
Agaricia lamarcki	Lamarck's Sheet Coral	IUCN VU CITES Appendix II SPAW Annex III
Agaricia tenuifolia	Thin Leave Lettuce Coral	CITES Appendix II SPAW Annex III
Antillogoria spp.	Sea Plume	CITES Appendix II SPAW Annex III
Briareum asbestinum	Corky Sea Finger	CITES Appendix II SPAW Annex III
Colpophyllia natans	Boulder Brain Coral	CITES Appendix II SPAW Annex III
Dendrogyra cylindrus	Pillar Coral	IUCN VU CITES Appendix II SPAW Annex III
Dichocoenia stokesii	Elliptical Star Coral	IUCN VU CITES Appendix II SPAW Annex III
Diploria labyrinthiformis	Grooved Brain Coral	CITES Appendix II SPAW Annex III
Erythropodium caribaeorum	Encrusting Gorgonian	CITES Appendix II SPAW Annex III
Eunicea spp.	Sea Rod	CITES Appendix II SPAW Annex III
Eusmilia fastigiata	Smooth Flower Coral	CITES Appendix II SPAW Annex III
Favia fragum	Golfball Coral	CITES Appendix II

		SPAW Annex III
Gorgonia flabellum	Venus Sea Fan	CITES Appendix II SPAW Annex III
Gorgonia ventalina	Common Sea Fan	CITES Appendix II SPAW Annex III
Isophyllia sinuosa	Sinuous Cactus Coral	CITES Appendix II SPAW Annex III
Madracis aurentenra	Yellow Pencil Coral	CITES Appendix II SPAW Annex III
Madracis decactis	Ten-ray Star Coral	CITES Appendix II SPAW Annex III
Madracis formosa	Eight-ray Finger Coral	CITES Appendix II SPAW Annex III
Manicina areolata	Rose Coral	CITES Appendix II SPAW Annex III
Meandrina danae	Butterprint Rose Coral	CITES Appendix II SPAW Annex III
Meandrina meandrites	Maze Coral	CITES Appendix II SPAW Annex III
Millepora alcicornis	Branching Fire Coral	CITES Appendix II SPAW Annex III
Millepora complanata	Blade Fire Coral	CITES Appendix II SPAW Annex III
Montastraea cavernosa	Cavernous Star Coral	CITES Appendix II SPAW Annex III
Muricea laxa	Delicate Spiny Sea Rod	CITES Appendix II SPAW Annex III
Mussa angulosa	Large Flower Coral	CITES Appendix II SPAW Annex III
Mycetophyllia ferox	Rough Cactus Coral	IUCN VU CITES Appendix II SPAW Annex III
Mycetophyllia lamarckiana	Ridged Cactus Coral	CITES Appendix II SPAW Annex III
Mycetophyllia reesi	Ridgeless Cactus Coral	CITES Appendix II SPAW Annex III
Oculina diffusa	Diffuse Ivory Bush Coral	CITES Appendix II SPAW Annex III
Orbicella annularis complex	Boulder Star Coral	IUCN EN CITES Appendix II SPAW Annex II
Plexaurella spp.	Sea Rod	CITES Appendix II SPAW Annex III
Porites astreoides	Mustard Hill Coral	CITES Appendix II SPAW Annex III

Porites colonensis	Honeycomb Plate Coral	CITES Appendix II SPAW Annex III
Porites divaricata	Thin Finger Coral	CITES Appendix II SPAW Annex III
Porites furcata	Branching Finger Coral	CITES Appendix II SPAW Annex III
Porites porites	Club Finger Coral	CITES Appendix II SPAW Annex III
Pseudodiploria clivosa	Knobby Brain Coral	CITES Appendix II SPAW Annex III
Pseudodiploria strigosa	Symmetrical Brain Coral	CITES Appendix II SPAW Annex III
Pseudoplexaura spp.	Porous Sea Rods	CITES Appendix II SPAW Annex III
Pterogorgia anceps	Angular Sea Whip	CITES Appendix II SPAW Annex III
Scolymia wellsi	Solitary Disk Coral	CITES Appendix II SPAW Annex III
Siderastrea radians	Lesser Starlet Coral	CITES Appendix II SPAW Annex III
Siderastrea siderea	Massive Starlet Coral	CITES Appendix II SPAW Annex III
Solenastrea bournoni	Smooth Star Coral	CITES Appendix II SPAW Annex III
Stephanocoenia intersepta	Blushing Star Coral	CITES Appendix II SPAW Annex III
Strombus gigas	Queen Conch	CITES Appendix II, SPAW Annex III
Stylaster roseus	Rose Lace Coral	CITES Appendix II SPAW Annex III
Tubastraea coccinea	Orange Cup Coral	CITES Appendix II SPAW Annex III
Class: AVES	Birds	
Calliphlox evelynae	Bahama Woodstar	CITES Appendix II
Charadrius melodus	Piping Plover	IUCN NT SPAW Annex II
Columba leucocephala	White-crowned Pigeon	SPAW Annex III
Dendrocygna arborea	West Indian Whistling Duck	IUCN VU CITES Appendix II SPAW Annex III
Dendroica kirtlandii	Kirtland's Warbler	IUCN VU SPAW Annex II
Falco sparverius	American Kestrel	CITES Appendix II
Pandion haliaetus	Osprey	IUCN NT CITES Appendix II

Pelecanus occidentalis	Brown Pelican	SPAW Annex II
Phoenicopterus ruber	West Indian Flamingo	CITES Appendix II, SPAW Annex III
Puffinus lherminieri	Audubon's Shearwater	SPAW Annex II
Sterna antillarum	Least Tern	SPAW Annex II
Sterna dougallii dougallii	Roseate Tern	SPAW Annex II
Tyto alba	Barn Owl	CITES Appendix II
Class: CHONCRICHTHYES	Sharks	
Aetobatus narinari	Spotted Eagle Ray	IUCN NT
Ginglymostoma cirratum	Nurse Shark	IUCN NT (Western Atlantic sub-population)
Negaprion brevirostris	Lemon Shark	IUCN NT
Class: MAMMALIA	Mammals	
Brachyphylla cavernarum	Antillean Fruit-eating Bat	SPAW Annex II
Brachyphylla nana	Cuban Fruit-eating Bat	IUCN NT locally and regionally rare SPAW Annex II
Tadarida brasiliensis	Brazilian Free-tailed Bat	SPAW Annex II
Class: REPTILIA	Reptiles	
Caretta caretta	Loggerhead Turtle	IUCN EN CITES Appendix I SPAW Annex II
Chelonia mydas	Green Turtle	IUCN EN CITES Appendix I SPAW Annex II
Chilabothrus chrysogaster	Bahamas Islands Boa	CITES Appendix II
Cyclura carinata	TCI Rock Iguana	IUCN CR CITES Appendix I SPAW Annex II
Eretmochelys imbricata	Hawksbill Turtle	IUCN CR CITES Appendix I SPAW Annex II
Spondylurus caicosae	Caicos Islands Skink	IUCN VU
Tropidophis greenwayi	TCI Dwarf Boa	CITES Appendix II
Class: CRUSTACEA	Crustaceans	
Panulirus argus	Caribbean Spiny Lobster	SPAW Annex III
Class: ACTINOPTERUGII	Bony Fishes	
Balistes vetula	Queen Triggerfish	IUCN VU

Epinephelus striatus	Nassau Grouper	IUCN EN
Lachnolaimus maximus	Hogfish	IUCN VU
Lutjanus analis	Mutton Snapper	IUCN VU

Appendix 3

East Caicos Endemic Species

Table 36. East Caicos endemic species.

Species	Common Name	Endemism Status
Flora		
Acacia acuifera	Pork and Doughboy	Lucayan Endemic
Acacia choriophylla	Tamarindillo	Regional Endemic
Agave anomala	San Salvador Century Plant	Regional Endemic
Agave braceana	Century Plant	Lucayan Endemic
Agave inaguensis	Inagua Century Plant	Lucayan Endemic
Agave millspaughii	Millspaugh’s Century Plant	Lucayan Endemic
Argythamnia argentea	Silvery Silverbush	TCI Endemic
Argythamnia lucayana	Lucayan Argythamnia	Lucayan Endemic
Argythamnia candicans	Shining Silverbush	Regional Endemic
Argythamnia sericea	Shiny Argythamnia	Lucayan Endemic
Bernardia dichotoma	Caribbean Myrtlecroton	Regional Endemic
Bursera fagaroides	Fragrant Gumbo Limbo	Regional Endemic
Buxus bahamensis	Bahama Boxwood	Regional Endemic
Caesalpinia bahamensis	Brasiletto	Regional Endemic
Catesbaea foliosa	Catesby's Vine	Lucayan Endemic
Chamaecrista caribaea	Inagua Senna	Regional Endemic
Coccoloba krugii	Krug’s Coccoloba	Regional Endemic
Coccoloba swartzii	Swartz’s Coccoloba	Regional Endemic
Coccothrinax inaguensis var. inaguensis	Inagua Silver Palm	Lucayan Endemic
Conocarpus erectus var. sericeus	Silver Buttonwood	Lucayan Endemic
Consolea nashii	Nash’s Tree Cactus	Lucayan Endemic
Croton discolor	Sweetwood	Regional Endemic
Croton lucidus	Firebush	Regional Endemic
Cynanchum callialatum	Marsh Milkweed Vine	Regional Endemic
Cynanchum eggersii	Eggers’ Milkweed Vine	Regional Endemic
Cynanchum inaguense	Inagua Milkweed Vine	Lucayan Endemic
Cynanchum stipitatum	TCI Milkweed Vine	TCI Endemic
Dodonaea viscosa	Swamp Bush	Regional Endemic
Drypetes mucronata	False Holly	Regional Endemic

Eleocharis bahamensis	Bahama Spike Rush	Lucayan Endemic
Encyclia caicensis	Caicos Islands Encyclia Orchid	TCI Endemic
Encyclia inaguensis	Inagua Encyclia	Lucayan Endemic
Encyclia rufa	Red Encyclia	Regional Endemic
Eragrostis bahamensis	Bahama Love Grass	Lucayan Endemic
Ernodea serratifolia	Serrate-leaved Ernodea	Lucayan Endemic
Euphorbia articulata	Bushy Spurge	Regional Endemic
Euphorbia gymnonota	Milk tree, False Frangipani	Lucayan Endemic
Euphorbia inaguensis	Inagua Wild Thyme	Lucayan Endemic
Euphorbia lecheoides	Pinweed Spurge	Lucayan Endemic
Euphorbia vaginulata	Sheathed Spurge	Lucayan Endemic
Evolvulus bahamensis	Broom Bush	Doubtful TCI Endemic
Flueggea acidoton	Simpleleaf Bushweed	Regional Endemic
Furcraea hexapetala	Wild Sisal	Regional Endemic
Galactia bahamensis	Bahama Milk Pea	Lucayan Endemic
Galactia uniflora	One-flowered Milk Pea	Regional Endemic
Gochnatia paucifloscula	Carrajo Bush	Regional Endemic
Gundlachia corymbosa	Jamaican Trash	Regional Endemic
Helicteres semitriloba	Wild Salve	Regional Endemic
Heliotropium nanum	Small Heliotrope	Lucayan Endemic
Heterosavia bahamensis	Bahama Maidenbush	Regional Endemic
Jacquemontia cayensis	Island Jacquemontia	Regional Endemic
Jacquinia berteroi	Berter's Joewood	Regional Endemic
Lantana bahamensis	Bahama Lantana	Regional Endemic
Lepidaploa arbuscula	Bahama Vernonia	Lucayan Endemic
Lepidium filicaule	Peppergrass	TCI Endemic
Limonium bahamensis	TCI Heather	TCI Endemic
Melocactus intortus	Turk's Cap Cactus	Regional Endemic
Mimosa bahamensis	Bahama Mimosa	Lucayan Endemic
Oplonia spinosa	Prickly Pricklebush	Regional Endemic
Opuntia bahamana	Bahama Prickly Pear	Lucayan Endemic
Opuntia lucayana	Lucayan Prickly Pear	TCI Endemic
Passiflora pectinata	White Passionflower	Regional Endemic
Pedilanthus bahamensis	Monkey Fiddle	Lucayan Endemic
Phyllanthus epiphyllanthus	Swordbush	Regional Endemic
Pilosocereus royenii	Dildo Cactus	Regional Endemic
Salmea petrobioides	Bushy Salmea	Regional Endemic
Sideroxylon americanum	Milkberry	Regional Endemic
Spermacoce bahamensis	Bahama Buttonweed	Lucayan Endemic
Spermacoce brittonii	Britton's Buttonweed	TCI Endemic

Spermacoce capillaris	Fine-leaved Buttonweed	TCI Endemic
Spermacoce thymifolia	Thyme-like Buttonweed	Lucayan Endemic
Stenandrium carolinae	Caroline's Pink	TCI Endemic
Thouinia discolor	Nakedwood	Lucayan Endemic
Wedelia bahamensis	Bahama Wedelia	Lucayan Endemic
Zapoteca formosa	White Calliandra	Regional Endemic
Ziziphus taylorii	Bahama Jujube	Lucayan Endemic
Fauna		
Class Aves		
Anas bahamensis	White-cheeked Pintail	Regional Endemic
Calliphlox evelynae	Bahama Woodstar Hummingbird	Lucayan Endemic
Corvus nasicus	Cuban Crow	Regional Endemic
Loxigilla violacea ofella	Greater Antillean Bullfinch	TCI Endemic Sub-species
Mimus gundlachii	Bahama Mockingbird	Regional Endemic
Vireo crassirostris stalagmium	Thick-billed Vireo	TCI Endemic Sub-species
Class Reptilia		
Anolis scriptus	Bahama Bark Anole	Lucayan Endemic
Aristelliger hechti	Caicos Islands Barking Gecko	TCI Endemic
Chilabothrus chrysogaster	Southern Bahamas Rainbow Boa	Lucayan Endemic
Cyclura carinata	TCI Rock Iguana	TCI Endemic
Leiocephalus psammodromus	Curly-tail Lizard	TCI Endemic
Sphaerodactylus mariguanae	Mayaguana Gecko	Lucayan Endemic
Spondylurus caicosae	Caicos Islands Skink	TCI Endemic
Tropidophis greenwayi	Pygmy Boa Constrictor	TCI Endemic
Phylum: Invertebrata		
Barbouria cubensis	Cuban Cave Shrimp	Regional Endemic

Appendix 4

Northern Coastal Floral Species and Biodiversity

Table 37. Northern coastal floral species and biodiversity.

#	Species	Total	D*	RD*	O*	F*	RF*	IV*	pi(lnpi)
1	*Acacia acuifera*	5	0.14	1.04	11	0.31	2	3.04	0.04739
2	*Agave inaguensis*	2	0.06	0.41	7	0.2	1.28	1.69	0.02276
3	*Ambrosia hispida*	15	0.43	3.11	9	0.26	1.64	4.75	0.10798
4	*Amyris elemifera*	1	0.03	0.21	18	0.51	3.28	3.49	0.01282
5	*Argythamnia argentea*	10	0.29	2.07	7	0.2	1.28	3.35	0.0804
6	*Bourreria ovata*	1	0.03	0.21	6	0.17	1.09	1.3	0.01282
7	*Bursera fagaroides*	1	0.03	0.21	14	0.4	2.55	2.76	0.01282
8	*Bursera simaruba*	1	0.03	0.21	16	0.46	2.91	3.12	0.01282
9	*Cakile lanceolata*	7	0.2	1.45	3	0.09	0.55	2	0.06146
10	*Capraria biflora*	1	0.03	0.21	1	0.03	0.18	0.39	0.01282
11	*Casasia clusiifolia*	3	0.09	0.62	8	0.23	1.46	2.08	0.03161
12	*Cassytha filiformis*	7	0.2	1.45	5	0.14	0.91	2.36	0.06146
13	*Casuarina equisetifolia*	2	0.06	0.41	2	0.06	0.36	0.78	0.02276
14	*Catesbaea foliosa*	1	0.03	0.21	8	0.23	1.46	1.66	0.01282
15	*Cenchrus spinifex*	2	0.06	0.41	1	0.03	0.18	0.6	0.02276
16	*Chamaecrista caribaea var. inaguensis*	4	0.11	0.83	12	0.34	2.19	3.02	0.03976
17	*Coccoloba uvifera*	11	0.31	2.28	28	0.8	5.1	7.38	0.08627
18	*Coccothrinax inaguensis*	37	1.06	7.68	28	0.8	5.1	12.8	0.19705
19	*Conocarpus erectus*	3	0.09	0.62	26	0.74	4.74	5.36	0.03161
20	*Consolea nashii*	1	0.03	0.21	4	0.11	0.73	0.94	0.01282
21	*Corchorus hirsutus*	20	0.57	4.15	18	0.51	3.28	7.43	0.13204
22	*Cordia bahamensis*	10	0.29	2.07	13	0.37	2.37	4.44	0.0804
23	*Crossopetalum rhacoma*	3	0.09	0.62	5	0.14	0.91	1.53	0.03161
24	*Croton discolor*	7	0.2	1.45	21	0.6	3.83	5.28	0.06146
25	*Croton linearis*	20	0.57	4.15	19	0.54	3.46	7.61	0.13204

26	*Cynanchum callialatum*	1	0.03	0.21	2	0.06	0.36	0.57	0.01282
27	*Cynanchum eggersii*	23	0.66	4.77	21	0.6	3.83	8.6	0.14518
28	*Cynanchum inaguense*	4	0.11	0.83	5	0.14	0.91	1.74	0.03976
29	*Cynanchum stipitatum*	2	0.06	0.41	3	0.09	0.55	0.96	0.02276
30	*Dodonaea viscosa*	4	0.11	0.83	12	0.34	2.19	3.02	0.03976
31	*Echites umbellatus*	1	0.03	0.21	1	0.03	0.18	0.39	0.01282
32	*Encyclia caicensis*	7	0.2	1.45	4	0.11	0.73	2.18	0.06146
33	*Erithalis fruticosa*	19	0.54	3.94	38	1.09	6.92	10.9	0.12746
34	*Ernodea littoralis*	3	0.09	0.62	2	0.06	0.36	0.99	0.03161
35	*Euphorbia charleswilsoniana*	3	0.09	0.62	1	0.03	0.18	0.8	0.03161
36	*Euphorbia inaguaensis*	39	1.11	8.09	32	0.91	5.83	13.9	0.20345
37	*Euphorbia mesembryanthemifolia*	5	0.14	1.04	3	0.09	0.55	1.58	0.04739
38	*Galactia uniflora*	1	0.03	0.21	1	0.03	0.18	0.39	0.01282
39	*Gundlachia corymbosa*	4	0.11	0.83	4	0.11	0.73	1.56	0.03976
40	*Heliotropium nanum*	9	0.26	1.87	5	0.14	0.91	2.78	0.07433
41	*Ipomoea pes-caprae*	1	0.03	0.21	1	0.03	0.18	0.39	0.01282
42	*Jacquemontia cayensis*	9	0.26	1.87	7	0.2	1.28	3.14	0.07433
43	*Jacquemontia havanensis*	6	0.17	1.24	4	0.11	0.73	1.97	0.0546
44	*Jacquinia berteroi*	2	0.06	0.41	2	0.06	0.36	0.78	0.02276
45	*Jacquinia keyensis*	4	0.11	0.83	4	0.11	0.73	1.56	0.03976
46	*Lantana involucrata*	15	0.43	3.11	9	0.26	1.64	4.75	0.10798
47	*Lepidaploa arbuscula*	14	0.4	2.9	9	0.26	1.64	4.54	0.10279
48	*Lycium tweedianum*	2	0.06	0.41	2	0.06	0.36	0.78	0.02276
49	*Manilkara jaimiqui emarginata*	3	0.09	0.62	3	0.09	0.55	1.17	0.03161
50	*Opuntia dillenii*	6	0.17	1.24	6	0.17	1.09	2.34	0.0546
51	*Passiflora pectinata*	6	0.17	1.24	4	0.11	0.73	1.97	0.0546

52	*Phyllanthus epiphyllanthus*	3	0.09	0.62	2	0.06	0.36	0.99	0.03161
53	*Pilosocereus royenii*	5	0.14	1.04	3	0.09	0.55	1.58	0.04739
54	*Pithecellobium keyense*	2	0.06	0.41	1	0.03	0.18	0.6	0.02276
55	*Pithecellobium unguis-cati*	1	0.03	0.21	1	0.03	0.18	0.39	0.01282
56	*Plumeria obtusa*	1	0.03	0.21	1	0.03	0.18	0.39	0.01282
57	*Quadrella cynophallophora*	1	0.03	0.21	1	0.03	0.18	0.39	0.01282
58	*Randia aculeata*	4	0.11	0.83	3	0.09	0.55	1.38	0.03976
59	*Reynosia septentrionalis*	8	0.23	1.66	6	0.17	1.09	2.75	0.06802
60	*Rachicallis americana*	1	0.03	0.21	1	0.03	0.18	0.39	0.01282
61	*Rhynchospora colorata*	3	0.09	0.62	1	0.03	0.18	0.8	0.03161
62	*Salmea petrobioides*	1	0.03	0.21	1	0.03	0.18	0.39	0.01282
63	*Scaevola plumieri*	5	0.14	1.04	5	0.14	0.91	1.95	0.04739
64	*Sideroxylon americanum*	1	0.03	0.21	1	0.03	0.18	0.39	0.01282
65	*Spermacoce bahamensis*	9	0.26	1.87	6	0.17	1.09	2.96	0.07433
66	*Spermacoce brittonii*	3	0.09	0.62	1	0.03	0.18	0.8	0.03161
67	*Sporobolus virginicus*	7	0.2	1.45	3	0.09	0.55	2	0.06146
68	*Strumpfia maritima*	1	0.03	0.21	1	0.03	0.18	0.39	0.01282
69	*Stylosanthes hamata*	3	0.09	0.62	1	0.03	0.18	0.8	0.03161
70	*Suriana maritima*	1	0.03	0.21	1	0.03	0.18	0.39	0.01282
71	*Tournefortia gnaphalodes*	3	0.09	0.62	3	0.09	0.55	1.17	0.03161
72	*Turnera ulmifolia*	3	0.09	0.62	2	0.06	0.36	0.99	0.03161
73	*Uniola paniculata*	3	0.09	0.62	1	0.03	0.18	0.8	0.03161
74	*Wedelia bahamensis*	30	0.86	6.22	16	0.46	2.91	9.14	0.17283
75	*Ximenia americana*	3	0.09	0.62	3	0.09	0.55	1.17	0.03161
76	*Zanthoxylum flavum*	12	0.34	2.49	9	0.26	1.64	4.13	0.09194

	Totals	482	13.8	100	54 9	15.7	100	**H* =**	**3.8035**

* D = Density, RD = Relative Density, O = Occurrence, F = Frequency, RF = Relative Frequency, H = Shannon Weaver Index Biodiversity Score

Appendix 5

Northern Upland Floral Species and Biodiversity

Table 38. Northern upland floral species and biodiversity.

#	Species	Total	D	RD	O	F	RF	IV	pi(lnpi)
1	Acacia acuifera	3	0.14	1.17	3	0.14	1.46	2.64	0.052108
2	Acacia choriophylla	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
3	Agave braceana	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
4	Agave sisalana	3	0.14	1.17	2	0.1	0.98	2.15	0.052108
5	Amyris elemifera	5	0.24	1.95	5	0.24	2.44	4.39	0.07687
6	Argythamnia lucayana	3	0.14	1.17	3	0.14	1.46	2.64	0.052108
7	Bursera fagaroides	6	0.29	2.34	6	0.29	2.93	5.27	0.087971
8	Bursera simaruba	5	0.24	1.95	5	0.24	2.44	4.39	0.07687
9	Caesalpinia bahamensis	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
10	Catesbaea foliosa	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
11	Chamaecrista nictitans var. diffusa	2	0.1	0.78	2	0.1	0.98	1.76	0.037906
12	Citharexylum spinosum	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
13	Coccoloba diversifolia	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
14	Coccoloba swartzii	2	0.1	0.78	2	0.1	0.98	1.76	0.037906
15	Coccoloba uvifera	2	0.1	0.78	2	0.1	0.98	1.76	0.037906
16	Coccothrinax inaguensis	5	0.24	1.95	3	0.14	1.46	3.42	0.07687
17	Colubrina elliptica	3	0.14	1.17	3	0.14	1.46	2.64	0.052108
18	Conocarpus erectus	1	0.05	0.39	1	0.05	0.49	0.88	0.021661

19	Consolea nashii	2	0.1	0.78	2	0.1	0.98	1.76	0.037906
20	Cordia bahamensis	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
21	Crossopetalum rhacoma	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
22	Croton discolor	4	0.19	1.56	3	0.14	1.46	3.03	0.064983
23	Croton linearis	9	0.43	3.52	3	0.14	1.46	4.98	0.117701
24	Croton lucidus	12	0.57	4.69	6	0.29	2.93	7.61	0.14345
25	Cynanchum eggersii	2	0.1	0.78	2	0.1	0.98	1.76	0.037906
26	Drypetes diversifolia	5	0.24	1.95	3	0.14	1.46	3.42	0.07687
27	Drypetes mucronata	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
28	Eragrostis bahamensis	3	0.14	1.17	3	0.14	1.46	2.64	0.052108
29	Erithalis fruticosa	6	0.29	2.34	5	0.24	2.44	4.78	0.087971
30	Ernodea serratifolia	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
31	Erythroxylum rotundifolium	3	0.14	1.17	3	0.14	1.46	2.64	0.052108
32	Eugenia axillaris	5	0.24	1.95	5	0.24	2.44	4.39	0.07687
33	Eugenia foetida	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
34	Evolvulus bahamensis	7	0.33	2.73	4	0.19	1.95	4.69	0.098417
35	Ficus citrifolia	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
36	Furcraea hexapetala	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
37	Galactia bahamensis	2	0.1	0.78	1	0.05	0.49	1.27	0.037906
38	Gochnatia paucifloscula	5	0.24	1.95	2	0.1	0.98	2.93	0.07687
39	Guaiacum officinale	4	0.19	1.56	4	0.19	1.95	3.51	0.064983
40	Guaiacum sanctum	7	0.33	2.73	6	0.29	2.93	5.66	0.098417
41	Guettarda elliptica	3	0.14	1.17	3	0.14	1.46	2.64	0.052108
42	Guettarda scabra	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
43	Gymnanthes lucida	4	0.19	1.56	4	0.19	1.95	3.51	0.064983

44	Gyminda latifolia	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
45	Helicteres semitriloba	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
46	Hippomane mancinella	2	0.1	0.78	2	0.1	0.98	1.76	0.037906
47	Hypelate trifoliata	2	0.1	0.78	2	0.1	0.98	1.76	0.037906
48	Jacquinia berteroi	2	0.1	0.78	2	0.1	0.98	1.76	0.037906
49	Jacquinia keyensis	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
50	Krugiodendron ferreum	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
51	Lantana involucrata	4	0.19	1.56	3	0.14	1.46	3.03	0.064983
52	Lasiacis divaricata	2	0.1	0.78	2	0.1	0.98	1.76	0.037906
53	Lepidaploa arbuscula	2	0.1	0.78	2	0.1	0.98	1.76	0.037906
54	Leucaena leucocephala	2	0.1	0.78	1	0.05	0.49	1.27	0.037906
55	Manilkara jaimiqui emarginata	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
56	Melochia tomentosa	6	0.29	2.34	4	0.19	1.95	4.29	0.087971
57	Metopium toxiferum	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
58	Mimosa bahamensis	5	0.24	1.95	5	0.24	2.44	4.39	0.07687
59	Morella cerifera	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
60	Myrcianthes fragrans	3	0.14	1.17	3	0.14	1.46	2.64	0.052108
61	Oplonia spinosa	4	0.19	1.56	2	0.1	0.98	2.54	0.064983
62	Opuntia bahamana	2	0.1	0.78	2	0.1	0.98	1.76	0.037906
63	Opuntia dillenii	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
64	Opuntia lucayana	2	0.1	0.78	2	0.1	0.98	1.76	0.037906
65	Passiflora pectinata	2	0.1	0.78	2	0.1	0.98	1.76	0.037906
66	Pedilanthus bahamensis	10	0.48	3.91	4	0.19	1.95	5.86	0.126664

67	Phyllanthus epiphyllanthus	9	0.43	3.52	6	0.29	2.93	6.44	0.117701
68	Pilosocereus royenii	9	0.43	3.52	8	0.38	3.9	7.42	0.117701
69	Pithecellobium keyense	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
70	Pithecellobium unguis-cati	4	0.19	1.56	3	0.14	1.46	3.03	0.064983
71	Plumeria obtusa	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
72	Quadrella cynophallophora	2	0.1	0.78	2	0.1	0.98	1.76	0.037906
73	Randia aculeata	11	0.52	4.3	8	0.38	3.9	8.2	0.135235
74	Reynosia septentrionalis	5	0.24	1.95	4	0.19	1.95	3.9	0.07687
75	Smilax havanensis	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
76	Strumpfia maritima	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
77	Swietenia mahagoni	4	0.19	1.56	3	0.14	1.46	3.03	0.064983
78	Wedelia bahamensis	3	0.14	1.17	3	0.14	1.46	2.64	0.052108
79	Zanthoxylum flavum	9	0.43	3.52	7	0.33	3.41	6.93	0.117701
80	Zapoteca formosa	1	0.05	0.39	1	0.05	0.49	0.88	0.021661
	Totals	256	12.2	100	205	9.76	100	**H =**	**4.08872**

Appendix 6

Northern Palustrine Floral Species and Biodiversity

Table 39. Northern palustrine floral species and biodiversity.

#	Species	Total	D	RD	O	F	RF	IV	pi(lnpi)
1	Avicennia germinans	2	0.4	3.45	2	0.4	6.45	9.9	0.1161
2	Batis maritima	6	1.2	10.3	2	0.4	6.45	16.8	0.2347
3	Borrichia arborescens	2	0.4	3.45	1	0.2	3.23	6.67	0.1161
4	Capraria biflora	1	0.2	1.72	1	0.2	3.23	4.95	0.07
5	Conocarpus erectus	5	1	8.62	4	0.8	12.9	21.5	0.2113
6	Croton discolor	2	0.4	3.45	1	0.2	3.23	6.67	0.1161
7	Dodonaea viscosa	1	0.2	1.72	1	0.2	3.23	4.95	0.07
8	Euphorbia charleswilsoniana	3	0.6	5.17	1	0.2	3.23	8.4	0.1532
9	Gundlachia corymbosa	5	1	8.62	1	0.2	3.23	11.8	0.2113
10	Jacquemontia cayensis	1	0.2	1.72	1	0.2	3.23	4.95	0.07
11	Jacquinia keyensis	1	0.2	1.72	1	0.2	3.23	4.95	0.07
12	Lycium tweedianum	1	0.2	1.72	1	0.2	3.23	4.95	0.07
13	Manilkara jaimiqui emarginata	1	0.2	1.72	1	0.2	3.23	4.95	0.07
14	Najas marina	3	0.6	5.17	1	0.2	3.23	8.4	0.1532
15	Opuntia dillenii	1	0.2	1.72	1	0.2	3.23	4.95	0.07
16	Randia aculeata	1	0.2	1.72	1	0.2	3.23	4.95	0.07
17	Rhizophora mangle	3	0.6	5.17	2	0.4	6.45	11.6	0.1532
18	Salicornia depressa	3	0.6	5.17	1	0.2	3.23	8.4	0.1532
19	Salmea petrobioides	1	0.2	1.72	1	0.2	3.23	4.95	0.07

20	Sesuvium portulacastrum	5	1	8.62	2	0.4	6.45	15.1	0.2113
21	Sideroxylon americanum	1	0.2	1.72	1	0.2	3.23	4.95	0.07
22	Sporobolus virginicus	6	1.2	10.3	2	0.4	6.45	16.8	0.2347
23	Stylosanthes hamata	3	0.6	5.17	1	0.2	3.23	8.4	0.1532
	Totals	58	11.6	100	31	6.2	100		**2.9177**

Appendix 7

Eastern Coastal Floral Species and Biodiversity

Table 40. Eastern coastal floral species and biodiversity.

#	Species	Total	D	RD	O	F	RF	IV	pi(lnpi)
1	Agave inaguensis	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
2	Ambrosia hispida	4	0.2	3.13	2	0.1	2.17	5.3	0.1083
3	Argythamnia candicans	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
4	Avicennia germinans	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
5	Borrichia arborescens	5	0.25	3.91	2	0.1	2.17	6.08	0.12666
6	Borrichia frutescens	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
7	Bursera simaruba	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
8	Caesalpinia bonduc	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
9	Casasia clusiifolia	5	0.25	3.91	5	0.25	5.43	9.34	0.12666
10	Cassytha filiformis	2	0.1	1.56	1	0.05	1.09	2.65	0.06498
11	Chamaecrista caribaea var. inaguensis	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
12	Coccoloba uvifera	7	0.35	5.47	5	0.25	5.43	10.9	0.15893
13	Conocarpus erectus	2	0.1	1.56	2	0.1	2.17	3.74	0.06498
14	Corchorus hirsutus	7	0.35	5.47	5	0.25	5.43	10.9	0.15893
15	Cordia sebestena	4	0.2	3.13	2	0.1	2.17	5.3	0.1083
16	Croton discolor	6	0.3	4.69	5	0.25	5.43	10.1	0.14345
17	Croton lucidus	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
18	Cynanchum callialatum	1	0.05	0.78	1	0.05	1.09	1.87	0.03791

19	Cynanchum eggersii	3	0.15	2.34	2	0.1	2.17	4.52	0.08797
20	Dodonaea viscosa	2	0.1	1.56	2	0.1	2.17	3.74	0.06498
21	Erithalis fruticosa	5	0.25	3.91	4	0.2	4.35	8.25	0.12666
22	Euphorbia inaguaensis	12	0.6	9.38	6	0.3	6.52	15.9	0.22192
23	Euphorbia vaginulata	2	0.1	1.56	1	0.05	1.09	2.65	0.06498
24	Euphorbia mesembryanthemifolia	3	0.15	2.34	1	0.05	1.09	3.43	0.08797
25	Gundlachia corymbosa	5	0.25	3.91	2	0.1	2.17	6.08	0.12666
26	Ipomoea pes-caprae	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
27	Jacquemontia cayensis	4	0.2	3.13	4	0.2	4.35	7.47	0.1083
28	Jacquinia berteroi	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
29	Jacquinia keyensis	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
30	Lantana involucrata	3	0.15	2.34	2	0.1	2.17	4.52	0.08797
31	Oplonia spinosa	2	0.1	1.56	1	0.05	1.09	2.65	0.06498
32	Opuntia dillenii	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
33	Pilosocereus royenii	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
34	Reynosia septentrionalis	3	0.15	2.34	2	0.1	2.17	4.52	0.08797
35	Rachicallis americana	4	0.2	3.13	3	0.15	3.26	6.39	0.1083
36	Rhizophora mangle	2	0.1	1.56	2	0.1	2.17	3.74	0.06498
37	Scaevola plumieri	2	0.1	1.56	2	0.1	2.17	3.74	0.06498
38	Sesuvium portulacastrum	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
39	Spermacoce bahamensis	2	0.1	1.56	1	0.05	1.09	2.65	0.06498
40	Spermacoce thymifolia	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
41	Sporobolus virginicus	5	0.25	3.91	2	0.1	2.17	6.08	0.12666

42	Strumpfia maritima	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
43	Suriana maritima	3	0.15	2.34	3	0.15	3.26	5.6	0.08797
44	Tournefortia gnaphalodes	2	0.1	1.56	2	0.1	2.17	3.74	0.06498
45	Wedelia bahamensis	4	0.2	3.13	3	0.15	3.26	6.39	0.1083
46	Zanthoxylum flavum	1	0.05	0.78	1	0.05	1.09	1.87	0.03791
	Totals	128	6.4	100	92	4.6	100		**3.56508**

Appendix 8

Eastern Upland Floral Species and Biodiversity

Table 41. Eastern upland floral species and biodiversity.

#	**Species**	**Total**	**D**	**RD**	**O**	**F**	**RF**	**IV**	**pi(lnpi)**
1	Acacia acuifera	2	0.2	1.67	2	0.2	2.15	3.82	0.0682
2	Agave braceana	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
3	Agave inaguensis	3	0.3	2.5	2	0.2	2.15	4.65	0.0922
4	Agave sisalana	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
5	Amyris elemifera	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
6	Argythamnia argentea	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
7	Bourreria ovata	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
8	Bursera simaruba	5	0.5	4.17	5	0.5	5.38	9.54	0.1324
9	Caesalpinia bahamensis	3	0.3	2.5	3	0.3	3.23	5.73	0.0922
10	Chamaecrista caribaea var. inaguensis	3	0.3	2.5	3	0.3	3.23	5.73	0.0922
11	Coccoloba uvifera	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
12	Conocarpus erectus	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
13	Corchorus hirsutus	3	0.3	2.5	3	0.3	3.23	5.73	0.0922
14	Crossopetalum rhacoma	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
15	Croton discolor	10	1	8.33	5	0.5	5.38	13.7	0.2071
16	Croton lucidus	4	0.4	3.33	3	0.3	3.23	6.56	0.1134
17	Eleocharis bahamensis	3	0.3	2.5	1	0.1	1.08	3.58	0.0922
18	Encyclia inaguensis	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
19	Encyclia rufa	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
20	Erithalis fruticosa	4	0.4	3.33	4	0.4	4.3	7.63	0.1134
21	Ernodea serratifolia	3	0.3	2.5	2	0.2	2.15	4.65	0.0922

22	Euphorbia gymnonota	5	0.5	4.17	3	0.3	3.23	7.39	0.1324
23	Euphorbia inaguaensis	3	0.3	2.5	2	0.2	2.15	4.65	0.0922
24	Evolvulus bahamensis	2	0.2	1.67	1	0.1	1.08	2.74	0.0682
25	Flueggea acidoton	2	0.2	1.67	2	0.2	2.15	3.82	0.0682
26	Guaiacum sanctum	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
27	Gundlachia corymbosa	4	0.4	3.33	2	0.2	2.15	5.48	0.1134
28	Helicteres jamaicensis	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
29	Heterosavia bahamensis	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
30	Jacquemontia cayensis	3	0.3	2.5	3	0.3	3.23	5.73	0.0922
31	Jacquinia keyensis	2	0.2	1.67	2	0.2	2.15	3.82	0.0682
32	Lantana involucrata	3	0.3	2.5	2	0.2	2.15	4.65	0.0922
33	Leucothrinax morrisii	2	0.2	1.67	2	0.2	2.15	3.82	0.0682
34	Melocactus intortus	5	0.5	4.17	1	0.1	1.08	5.24	0.1324
35	Oplonia spinosa	2	0.2	1.67	2	0.2	2.15	3.82	0.0682
36	Opuntia bahamana	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
37	Passiflora pectinata	4	0.4	3.33	3	0.3	3.23	6.56	0.1134
38	Pedilanthus bahamensis	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
39	Pentalinon luteum	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
40	Pilosocereus royenii	3	0.3	2.5	3	0.3	3.23	5.73	0.0922
41	Pithecellobium unguis-cati	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
42	Plumeria obtusa	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
43	Randia aculeata	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
44	Salmea petrobioides	1	0.1	0.83	1	0.1	1.08	1.91	0.0399

45	Spermacoce thymifolia	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
46	Tillandsia flexuosa	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
47	Tillandsia streptophylla	2	0.2	1.67	1	0.1	1.08	2.74	0.0682
48	Wedelia bahamensis	8	0.8	6.67	5	0.5	5.38	12	0.1805
49	Zanthoxylum flavum	4	0.4	3.33	3	0.3	3.23	6.56	0.1134
50	Ziziphus taylorii	1	0.1	0.83	1	0.1	1.08	1.91	0.0399
	Totals	120	12	100	93	9.3	100	**H =**	**3.669**

Appendix 9

Eastern Palustrine Floral Species and Biodiversity

Table 42. Eastern palustrine floral species and biodiversity.

#	Species	Total	D	RD	O	F	RF	IV	pi(lnpi)
1	Agave inaguensis	6	0.46	8.82	3	0.23	7.14	16	0.2142
2	Batis maritima	5	0.38	7.35	2	0.15	4.76	12.1	0.1919
3	Chamaecrista caribaea var. inaguensis	2	0.15	2.94	1	0.08	2.38	5.32	0.1037
4	Coccoloba uvifera	5	0.38	7.35	4	0.31	9.52	16.9	0.1919
5	Conocarpus erectus	4	0.31	5.88	3	0.23	7.14	13	0.1667
6	Conocarpus erectus var. sericeus	5	0.38	7.35	4	0.31	9.52	16.9	0.1919
7	Crossopetalum rhacoma	1	0.08	1.47	1	0.08	2.38	3.85	0.0621
8	Cynanchum eggersii	1	0.08	1.47	1	0.08	2.38	3.85	0.0621
9	Dodonaea viscosa	3	0.23	4.41	2	0.15	4.76	9.17	0.1377
10	Eragrostis bahamensis	3	0.23	4.41	1	0.08	2.38	6.79	0.1377
11	Euphorbia inaguaensis	2	0.15	2.94	1	0.08	2.38	5.32	0.1037
12	Euphorbia vaginulata	3	0.23	4.41	1	0.08	2.38	6.79	0.1377
13	Gundlachia corymbosa	6	0.46	8.82	4	0.31	9.52	18.3	0.2142
14	Jacquemontia cayensis	3	0.23	4.41	2	0.15	4.76	9.17	0.1377
15	Jacquinia berteroi	1	0.08	1.47	1	0.08	2.38	3.85	0.0621
16	Leucothrinax morrisii	1	0.08	1.47	1	0.08	2.38	3.85	0.0621

17	Salicornia depressa	3	0.23	4.41	1	0.08	2.38	6.79	0.1377
18	Salmea petrobioides	1	0.08	1.47	1	0.08	2.38	3.85	0.0621
19	Sesuvium portulacastrum	4	0.31	5.88	3	0.23	7.14	13	0.1667
20	Spermacoce bahamensis	4	0.31	5.88	2	0.15	4.76	10.6	0.1667
21	Spermacoce capillaris	4	0.31	5.88	2	0.15	4.76	10.6	0.1667
22	Suaeda conferta	1	0.08	1.47	1	0.08	2.38	3.85	0.0621
	Totals	68	5.23	100	42	3.23	100	**H =**	**2.939**

Appendix 10

Eastern Estuarine Floral Species and Biodiversity

Table 43. Eastern estuarine floral species and biodiversity.

#	**Species**	**Total**	**D**	**RD**	**O**	**F**	**RF**	**IV**	**pi(lnpi)**
1	Avicennia germinans	1	0.33	12.5	1	0.33	12.5	25	0.2599
2	Borrichia arborescens	1	0.33	12.5	1	0.33	12.5	25	0.2599
3	Conocarpus erectus	1	0.33	12.5	1	0.33	12.5	25	0.2599
4	Gundlachia corymbosa	1	0.33	12.5	1	0.33	12.5	25	0.2599
5	Laguncularia racemosa	1	0.33	12.5	1	0.33	12.5	25	0.2599
6	Rhizophora mangle	2	0.67	25	2	0.67	25	50	0.3466
7	Sporobolus virginicus	1	0.33	12.5	1	0.33	12.5	25	0.2599
	Totals	8	2.67	100	8	2.67	100	**H =**	**1.906**

Appendix 11

Central and Western Upland Floral Species and Biodiversity

Table 44. Central and western upland floral species and biodiversity.

#	**Species**	**Total**	**D**	**RD**	**O**	**F**	**RF**	**IV**	**H=**
1	Acacia acuifera	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
2	Agave anomala	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
3	Agave millspaughii	2	0.06	0.5	2	0.06	0.61	1.11	0.0264
4	Agave sisalana	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
5	Amyris elemifera	13	0.39	3.24	18	0.55	5.5	8.75	0.1112
6	Bernardia dichotoma	2	0.06	0.5	2	0.06	0.61	1.11	0.0264
7	Bourreria ovata	4	0.12	1	4	0.12	1.22	2.22	0.046
8	Bursera fagaroides	7	0.21	1.75	7	0.21	2.14	3.89	0.0707
9	Bursera simaruba	3	0.09	0.75	3	0.09	0.92	1.67	0.0366
10	Buxus bahamensis	2	0.06	0.5	2	0.06	0.61	1.11	0.0264
11	Byrsonima lucida	5	0.15	1.25	5	0.15	1.53	2.78	0.0547
12	Caesalpinia bahamensis	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
13	Catesbaea foliosa	6	0.18	1.5	6	0.18	1.83	3.33	0.0629
14	Chamaecrista caribaea var. inaguensis	3	0.09	0.75	3	0.09	0.92	1.67	0.0366
15	Coccoloba diversifolia	2	0.06	0.5	2	0.06	0.61	1.11	0.0264
16	Coccoloba krugii	2	0.06	0.5	2	0.06	0.61	1.11	0.0264
17	Coccoloba swartzii	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
18	Coccoloba uvifera	4	0.12	1	3	0.09	0.92	1.91	0.046

19	Coccothrinax inaguensis	7	0.21	1.75	5	0.15	1.53	3.27	0.0707
20	Colubrina elliptica	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
21	Conocarpus erectus	3	0.09	0.75	3	0.09	0.92	1.67	0.0366
22	Consolea nashii	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
23	Cordia bahamensis	2	0.06	0.5	2	0.06	0.61	1.11	0.0264
24	Croton discolor	6	0.18	1.5	3	0.09	0.92	2.41	0.0629
25	Croton linearis	7	0.21	1.75	5	0.15	1.53	3.27	0.0707
26	Croton lucidus	21	0.64	5.24	14	0.42	4.28	9.52	0.1545
27	Cuscuta americana	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
28	Cynanchum eggersii	2	0.06	0.5	1	0.03	0.31	0.8	0.0264
29	Cynanchum stipitatum	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
30	Dodonaea viscosa	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
31	Drypetes diversifolia	3	0.09	0.75	3	0.09	0.92	1.67	0.0366
32	Encyclia caicensis	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
33	Encyclia rufa	4	0.12	1	3	0.09	0.92	1.91	0.046
34	Erithalis fruticosa	7	0.21	1.75	7	0.21	2.14	3.89	0.0707
35	Erythroxylum rotundifolium	5	0.15	1.25	5	0.15	1.53	2.78	0.0547
36	Eugenia axillaris	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
37	Eugenia foetida	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
38	Euphorbia articulata	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
39	Euphorbia gymnonota	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
40	Euphorbia inaguaensis	2	0.06	0.5	1	0.03	0.31	0.8	0.0264
41	Ficus citrifolia	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
42	Galactia bahamensis	7	0.21	1.75	6	0.18	1.83	3.58	0.0707
43	Galactia rudolphioides	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
44	Gochnatia paucifloscula	3	0.09	0.75	2	0.06	0.61	1.36	0.0366

45	Guaiacum officinale	2	0.06	0.5	2	0.06	0.61	1.11	0.0264
46	Guaiacum sanctum	9	0.27	2.24	7	0.21	2.14	4.39	0.0852
47	Guapira discolor	5	0.15	1.25	3	0.09	0.92	2.16	0.0547
48	Guapira obtusata	3	0.09	0.75	3	0.09	0.92	1.67	0.0366
49	Guettarda elliptica	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
50	Guettarda scabra	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
51	Gundlachia corymbosa	3	0.09	0.75	2	0.06	0.61	1.36	0.0366
52	Gymnanthes lucida	13	0.39	3.24	11	0.33	3.36	6.61	0.1112
53	Helicteres semitriloba	4	0.12	1	4	0.12	1.22	2.22	0.046
54	Herissantia crispa	3	0.09	0.75	1	0.03	0.31	1.05	0.0366
55	Heterosavia bahamensis	2	0.06	0.5	2	0.06	0.61	1.11	0.0264
56	Hippomane mancinella	3	0.09	0.75	3	0.09	0.92	1.67	0.0366
57	Jacquemontia havanensis	5	0.15	1.25	4	0.12	1.22	2.47	0.0547
58	Jacquinia keyensis	6	0.18	1.5	5	0.15	1.53	3.03	0.0629
59	Krugiodendron ferreum	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
60	Lantana bahamensis	3	0.09	0.75	3	0.09	0.92	1.67	0.0366
61	Lantana involucrata	6	0.18	1.5	4	0.12	1.22	2.72	0.0629
62	Lepidaploa arbuscula	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
63	Leucaena leucocephala	2	0.06	0.5	1	0.03	0.31	0.8	0.0264
64	Lysiloma latisiliquum	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
65	Manilkara jaimiqui emarginata	3	0.09	0.75	3	0.09	0.92	1.67	0.0366
66	Melochia pyramidata	3	0.09	0.75	2	0.06	0.61	1.36	0.0366

67	Melochia tomentosa	4	0.12	1	3	0.09	0.92	1.91	0.046
68	Metopium toxiferum	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
69	Mimosa bahamensis	6	0.18	1.5	5	0.15	1.53	3.03	0.0629
70	Myrcianthes fragrans	2	0.06	0.5	2	0.06	0.61	1.11	0.0264
71	Oplonia spinosa	10	0.3	2.49	6	0.18	1.83	4.33	0.0921
72	Opuntia bahamana	2	0.06	0.5	2	0.06	0.61	1.11	0.0264
73	Opuntia dillenii	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
74	Opuntia lucayana	2	0.06	0.5	2	0.06	0.61	1.11	0.0264
75	Pedilanthus bahamensis	6	0.18	1.5	3	0.09	0.92	2.41	0.0629
76	Phyllanthus amarus	4	0.12	1	4	0.12	1.22	2.22	0.046
77	Phyllanthus epiphyllanthus	7	0.21	1.75	6	0.18	1.83	3.58	0.0707
78	Pilosocereus royenii	7	0.21	1.75	7	0.21	2.14	3.89	0.0707
79	Pithecellobium keyense	5	0.15	1.25	4	0.12	1.22	2.47	0.0547
80	Pithecellobium unguis-cati	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
81	Plumeria obtusa	14	0.42	3.49	12	0.36	3.67	7.16	0.1171
82	Quadrella cynophallophora	3	0.09	0.75	3	0.09	0.92	1.67	0.0366
83	Randia aculeata	12	0.36	2.99	9	0.27	2.75	5.74	0.105
84	Reynosia septentrionalis	7	0.21	1.75	6	0.18	1.83	3.58	0.0707
85	Schaefferia frutescens	7	0.21	1.75	6	0.18	1.83	3.58	0.0707
86	Smilax auriculata	1	0.03	0.25	1	0.03	0.31	0.56	0.0149
87	Sophora tomentosa	2	0.06	0.5	2	0.06	0.61	1.11	0.0264
88	Spiranthes polyantha	2	0.06	0.5	1	0.03	0.31	0.8	0.0264
89	Stenandrium carolinae	9	0.27	2.24	3	0.09	0.92	3.16	0.0852
90	Swietenia mahagoni	4	0.12	1	3	0.09	0.92	1.91	0.046

91	Thouinia discolor	3	0.09	0.75	3	0.09	0.92	1.67	0.0366
92	Tillandsia flexuosa	8	0.24	2	5	0.15	1.53	3.52	0.0781
93	Tillandsia streptophylla	10	0.3	2.49	5	0.15	1.53	4.02	0.0921
94	Wedelia bahamensis	6	0.18	1.5	3	0.09	0.92	2.41	0.0629
95	Zanthoxylum coriaceum	2	0.06	0.5	2	0.06	0.61	1.11	0.0264
96	Zanthoxylum flavum	9	0.27	2.24	6	0.18	1.83	4.08	0.0852
97	Zapoteca formosa	7	0.21	1.75	4	0.12	1.22	2.97	0.0707
98	Ziziphus taylorii	6	0.18	1.5	5	0.15	1.53	3.03	0.0629
	Totals	401	12.2	100	327	9.91	100		**4.2723**

Appendix 12

Central and Western Palustrine Floral Species and Biodiversity

Table 45. Central and western palustrine floral species and biodiversity.

#	Species	Total	D	RD	O	F	RF	IV	pi(lnpi)
1	Avicennia germinans	1	0.07	0.65	1	0.07	1.1	1.75	0.03288
2	Bontia daphnoides	1	0.07	0.65	1	0.07	1.1	1.75	0.03288
3	Borrichia arborescens	7	0.47	4.58	5	0.33	5.49	10.1	0.14112
4	Borrichia frutescens	1	0.07	0.65	1	0.07	1.1	1.75	0.03288
5	Bursera simaruba	1	0.07	0.65	1	0.07	1.1	1.75	0.03288
6	Caesalpinia bahamensis	2	0.13	1.31	2	0.13	2.2	3.5	0.0567
7	Coccoloba uvifera	4	0.27	2.61	4	0.27	4.4	7.01	0.09527
8	Conocarpus erectus	12	0.8	7.84	8	0.53	8.79	16.6	0.19965
9	Conocarpus erectus var. sericeus	10	0.67	6.54	7	0.47	7.69	14.2	0.17829
10	Cuscuta umbellata	2	0.13	1.31	1	0.07	1.1	2.41	0.0567
11	Dodonaea viscosa	2	0.13	1.31	2	0.13	2.2	3.5	0.0567
12	Eleocharis geniculata	3	0.2	1.96	1	0.07	1.1	3.06	0.07709
13	Erithalis fruticosa	4	0.27	2.61	4	0.27	4.4	7.01	0.09527
14	Euphorbia articulata	1	0.07	0.65	1	0.07	1.1	1.75	0.03288
15	Euphorbia gymnonota	3	0.2	1.96	1	0.07	1.1	3.06	0.07709
16	Euphorbia inaguaensis	8	0.53	5.23	4	0.27	4.4	9.62	0.1543
17	Euphorbia vaginulata	3	0.2	1.96	1	0.07	1.1	3.06	0.07709

18	Evolvulus bahamensis	1	0.07	0.65	1	0.07	1.1	1.75	0.03288
19	Evolvulus nummularius	1	0.07	0.65	1	0.07	1.1	1.75	0.03288
20	Gundlachia corymbosa	8	0.53	5.23	2	0.13	2.2	7.43	0.1543
21	Hippomane mancinella	3	0.2	1.96	2	0.13	2.2	4.16	0.07709
22	Jacquinia berteroi	2	0.13	1.31	2	0.13	2.2	3.5	0.0567
23	Jacquinia keyensis	1	0.07	0.65	1	0.07	1.1	1.75	0.03288
24	Lycium tweedianum	4	0.27	2.61	4	0.27	4.4	7.01	0.09527
25	Manilkara jaimiqui emarginata	4	0.27	2.61	3	0.2	3.3	5.91	0.09527
26	Mimosa bahamensis	2	0.13	1.31	2	0.13	2.2	3.5	0.0567
27	Pentalinon luteum	2	0.13	1.31	2	0.13	2.2	3.5	0.0567
28	Phyllanthus epiphyllanthus	1	0.07	0.65	1	0.07	1.1	1.75	0.03288
29	Portulaca rubricaulis	2	0.13	1.31	1	0.07	1.1	2.41	0.0567
30	Rachicallis americana	8	0.53	5.23	4	0.27	4.4	9.62	0.1543
31	Salicornia bigelovii	2	0.13	1.31	1	0.07	1.1	2.41	0.0567
32	Salicornia depressa	10	0.67	6.54	1	0.07	1.1	7.63	0.17829
33	Sesuvium portulacastrum	7	0.47	4.58	3	0.2	3.3	7.87	0.14112
34	Sophora tomentosa	4	0.27	2.61	3	0.2	3.3	5.91	0.09527
35	Sporobolus virginicus	14	0.93	9.15	6	0.4	6.59	15.7	0.21882
36	Suaeda conferta	2	0.13	1.31	1	0.07	1.1	2.41	0.0567
37	Swietenia mahagoni	2	0.13	1.31	2	0.13	2.2	3.5	0.0567
38	Tillandsia flexuosa	3	0.2	1.96	1	0.07	1.1	3.06	0.07709
39	Tillandsia streptophylla	3	0.2	1.96	1	0.07	1.1	3.06	0.07709
40	Turnera diffusa	2	0.13	1.31	1	0.07	1.1	2.41	0.0567
	Totals	153	10.2	100	91	6.07	100	**H =**	**3.3787**

Appendix 13

Western Estuarine Floral Species and Biodiversity

Table 46. Western estuarine floral species and biodiversity.

#	**Species**	**Total**	**D**	**RD**	**O**	**F**	**RF**	**IV**	**pi(lnpi)**
1	Batis maritima	3	1	13	1	0.33	8.33	21.4	0.2657
2	Borrichia arborescens	4	1.33	17.4	2	0.67	16.7	34.1	0.3042
3	Conocarpus erectus	3	1	13	2	0.67	16.7	29.7	0.2657
4	Euphorbia inaguaensis	1	0.33	4.35	1	0.33	8.33	12.7	0.1363
5	Rhizophora mangle	1	0.33	4.35	1	0.33	8.33	12.7	0.1363
6	Salicornia depressa	5	1.67	21.7	2	0.67	16.7	38.4	0.3318
7	Sesuvium portulacastrum	1	0.33	4.35	1	0.33	8.33	12.7	0.1363
8	Sporobolus virginicus	5	1.67	21.7	2	0.67	16.7	38.4	0.3318
	Totals	23	7.67	100	12	4	100	**H =**	**1.908**

Appendix 14

Marine Species

Table 47. Marine species.

#	Species	Common Name	Comments
	Invertebrates		
1	Acropora cervicornis	Staghorn Coral	
2	Acropora palmata	Elkhorn Coral	
3	Agaricia agaricites	Lettuce Coral	
4	Agaricia fragilis	Fragile Saucer Coral	
5	Agaricia humilis	Low Relief Lettuce Coral	
6	Agaricia lamarcki	Whitestar Sheet Coral	
7	Agaricia tenuifolia	Thin Leaf Lettuce Coral	
8	Anthosigmella varians	Brown Variable Sponge	
9	Antillogorgia spp.	Sea Plume	
10	Briareum asbestinum	Corky Sea Finger	
11	Cassiopea spp.	Upside-down Jellyfish	
12	Cliona spp.	Encrusting Sponge	
13	Colpophyllia natans	Boulder Brain Coral	
14	Dendrogyra cylindrus	Pillar Coral	
15	Dichocoenia stokesi	Elliptical Star Coral	
16	Diploria labyrinthiformis	Grooved Brain Coral	
17	Ecteinascidia turbinata	Mangrove Tunicate	
18	Erythropodium caribaeorum	Encrusting Gorgonian	
19	Eunicea spp.	Sea Rod	
20	Eusmilia fastigiata	Smooth Flower Coral	
21	Favia fragum	Golfball Coral	
22	Gorgonia flabellum	Venus Sea Fan	
23	Gorgonia ventalina	Common Sea Fan	
24	Isophyllia sinuosa	Sinuous Cactus Coral	
25	Madracis auretenra	Yellow Pencil Coral	
26	Madracis decactis	Ten-Ray Star Coral	
27	Madracis formosa	Eight-Ray Finger Coral	
28	Manicina areolata	Rose Coral	
29	Meandrina danae	Butterprint Rose Coral	
30	Meandrina meandrites	Maze Coral	

31	Millepora alcicornis	Branching Fire Coral	
32	Millepora complanata	Blade Fire Coral	
33	Montastraea cavernosa	Great Star Coral	
34	Muricea laxa	Delicate Spiny Sea Rod	
35	Mussa angulosa	Spiny Flower Coral	
36	Mycetophyllia ferox	Rough Cactus Coral	
37	Mycetophyllia lamarckiana	Ridged Cactus Coral	
38	Mycetophyllia reesi	Ridgeless Cactus Coral	
39	Oculina diffusa	Diffuse Ivory Bush Coral	
40	Orbicella spp.	Boulder Star Coral (complex)	
41	Plexaurella spp.	Bent Sea Rod	
42	Porites astreoides	Mustard Hill Coral	
43	Porites colonensis	Honeycomb Plate Coral	
44	Porites divaricata	Thin Finger Coral	
45	Porites furcata	Branching Finger Coral	
46	Porites porites	Clubtip Finger Coral	
47	Pseudodiploria clivosa	Knobby Brain Coral	
48	Pseudodiploria strigosa	Symmetrical Brain Coral	
49	Pseudoplexaura spp.	Porous Sea Rod	
50	Pterogorgia anceps	Angular Sea Whip	
51	Scolymia wellsi	Solitary Disk Coral	
52	Siderastrea radians	Lesser Starlet Coral	
53	Siderastrea siderea	Massive Starlet Coral	
54	Solenastrea bournoni	Smooth Star Coral	
55	Stephanocoenia intersepta	Blushing Star Coral	
56	Stylaster roseus	Rose Lace Coral	
57	Tubastraea coccinea	Orange Cup Coral	
	Fish		
1	Abudefduf saxatilis	Sergeant Major	
2	Acanthurus coeruleus	Blue Tang	
3	Acanthurus tractus	Ocean Surgeonfish	
4	Albula vulpes	Bonefish	
5	Aulostomus maculatus	Atlantic Trumpetfish	
6	Balistes vetula	Queen Triggerfish	
7	Caranx latus	Horse-eye Jack	
8	Caranx ruber	Bar Jack	
9	Carcharhinus perezi	Reef Shark	
10	Cephalopholis cruentata	Graysby	
11	Cephalopholis fulva	Coney	
12	Chaetodipterus faber	Atlantic Spadefish	

13	Chaetodon capistratus	Foureye Butterflyfish	
14	Chromis cyanea	Blue Chromis	
15	Diodon hystrix	Porcupine Fish	
16	Epinephelus adscensionis	Rock Hind	
17	Epinephelus guttatus	Red Hind	
18	Epinephelus striatus	Nassau Grouper	Spawning
19	Gerres cinereus	Yellowfin Mojarra	
20	Ginglymostoma cirratum	Nurse Shark	Mating
21	Haemulon sciurus	Bluestriped Grunt	Spawning
22	Halichoeres bivittatus	Slippery Dick	
23	Halichoeres garnoti	Yellowhead Wrasse	
24	Holacanthus bermudensis	Blue Anglefish	
25	Holacanthus ciliaris	Queen Angelfish	
26	Holocentrus adscensionis	Squirrelfish	
27	Holocentrus rufus	Longspine Squirrelfish	
28	Kyphosus bigibbus	Gray Chub	
29	Lachnolaimus maximus	Hogfish	
30	Lutjanus analis	Mutton Snapper	Spawning
31	Lutjanus apodus	Schoolmaster	Spawning
32	Lutjanus cyanopterus	Cubera Snapper	
33	Lutjanus griseus	Gray Snapper	
34	Malacanthus plumieri	Sand Tilefish	
35	Melichthys niger	Black Triggerfish	
36	Microspathodon chrysurus	Yellowtail Damselfish	
37	Mulloidichthys martinicus	Yellow Goatfish	
38	Mycteroperca tigris	Tiger Grouper	
39	Negaprion brevirostris	Lemon Shark	Mating
40	Ocyurus chrysurus	Yellowtail Snapper	Spawning
41	Pomacanthus arcuatus	Gray Angelfish	
42	Pomacanthus paru	French Angelfish	
43	Pterois volitans	Lionfish	Invasive Alien
44	Scarus guacamaia	Rainbow Parrotfish	
45	Scarus vetula	Queen Parrotfish	
46	Sparisoma viride	Stoplight Parrotfish	
47	Sphyraena barracuda	Great Barracuda	
48	Stegastes diencaeus	Longfin Damselfish	
49	Stegastes leucostictus	Beaugregory	
50	Stegastes partitus	Bicolor Damselfish	
51	Stegastes planifrons	Threespot Damselfish	
52	Thalassoma bifasciatum	Bluehead Wrasse	
53	Trachinotus falcatus	Permit	

	Reptiles		
1	Caretta caretta	Loggerhead Turtle	Possibly Nesting
2	Chelonia mydas	Green Turtle	Nesting
3	Eretmochelys imbricata	Hawksbill Turtle	Nesting
	Crustaceans		
1	Panulirus argus	Spiny Lobster	
2	Panulirus guttatus	Spotted Spiny Lobster	
	Mollusks		
1	Cyphoma gibbosum	Flamingo Tongue	
2	Pinna carnea	Amber Penshell	
3	Strombus gigas	Queen Conch	
	Flora		
1	Acetabularia calyculus	Umbrella Algae	
2	Acetabularia crenulata	Mermaid's Wine Glass	
3	Amphiroa rigida	Branching Coralline Algae	
4	Batophora oerstedii	Common Green Algae	
5	Dasycladus vermicularis	False Batophora	
6	Dictyota spp.	Y-branched Algae	
7	Halimeda opuntia	Watercress Algae	
8	Halodule beaudettei	Shoal Grass	
9	Laurencia intricata	Laurencia	
10	Lobophora variegata	Fan-leaf Algae	
11	Ochtodes secundiramea	Bushy Red Algae	
12	Padina sanctae-crucis	White Scroll Algae	
13	Penicillus dumetosus	Bristle Ball Brush	
14	Porolithon pachydermum	Reef Cement	
15	Sargassum fluitans	Sargassum	
16	Sargassum natans	Sargassum Weed	
17	Syringodium filiforme	Manatee Grass	
18	Thalassia testudinum	Turtle Grass	
19	Turbinaria spp.	Turbinweed	

Appendix 15

Marine Species Distributions and Biodiversity

Table 48. Marine species distributions and biodiversity.

#	**Species**	**Total**	**D**	**RD**	**O**	**F**	**RF**	**IV**	**pi(lnpi)***
1	Acropora cervicornis	67	0.11	1.91	18	0.03	1.04	2.95	0.07565
2	Acropora palmata	168.3	0.26	4.8	23	0.04	1.33	6.13	0.14577
3	Agaricia agaricites	50.1	0.08	1.43	55	0.09	3.18	4.6	0.06072
4	Agaricia fragilis	7.25	0.01	0.21	10	0.02	0.58	0.78	0.01279
5	Agaricia humilis	26.6	0.04	0.76	60	0.09	3.46	4.22	0.03704
6	Agaricia lamarcki	3	0	0.09	4	0.01	0.23	0.32	0.00605
7	Agaricia tenuifolia	88.05	0.14	2.51	66	0.1	3.81	6.32	0.09255
8	Antillogorgia spp.	76.25	0.12	2.18	45	0.07	2.6	4.77	0.08328
9	Briareum asbestinum	50.1	0.08	1.43	74	0.12	4.27	5.7	0.06072
10	Colpophyllia natans	53.75	0.08	1.53	27	0.04	1.56	3.09	0.06407
11	Dendrogyra cylindrus	60	0.09	1.71	24	0.04	1.39	3.1	0.06963
12	Dichocoenia stokesi	2.75	0	0.08	3	0	0.17	0.25	0.00561
13	Diploria labyrinthiformis	150.8	0.24	4.3	69	0.11	3.98	8.29	0.13533
14	Erythropodium caribaeorum	3.75	0.01	0.11	3	0	0.17	0.28	0.00732
15	Eunicea spp.	2	0	0.06	3	0	0.17	0.23	0.00426
16	Eusmilia fastigiata	13.75	0.02	0.39	21	0.03	1.21	1.6	0.02174
17	Favia fragum	1.75	0	0.05	5	0.01	0.29	0.34	0.0038
18	Gorgonia flabellum	2.5	0	0.07	3	0	0.17	0.24	0.00517

19	Gorgonia ventalina	3.75	0.01	0.11	3	0	0.17	0.28	0.00732
20	Isophyllia sinuosa	4.75	0.01	0.14	8	0.01	0.46	0.6	0.00895
21	Madracis auretenra	77	0.12	2.2	72	0.11	4.16	6.35	0.08388
22	Madracis decactis	17.5	0.03	0.5	26	0.04	1.5	2	0.02646
23	Madracis formosa	0.5	0	0.01	1	0	0.06	0.07	0.00126
24	Manicina areolata	21.45	0.03	0.61	24	0.04	1.39	2	0.03119
25	Meandrina danae	6.6	0.01	0.19	5	0.01	0.29	0.48	0.01182
26	Meandrina meandrites	3	0	0.09	7	0.01	0.4	0.49	0.00605
27	Millepora alcicornis	39.1	0.06	1.12	102	0.16	5.89	7	0.05016
28	Millepora complanata	69	0.11	1.97	43	0.07	2.48	4.45	0.07733
29	Montastraea cavernosa	82.25	0.13	2.35	27	0.04	1.56	3.91	0.08805
30	Muricea laxa	20.5	0.03	0.58	2	0	0.12	0.7	0.03007
31	Mussa angulosa	0.5	0	0.01	1	0	0.06	0.07	0.00126
32	Mycetophyllia ferox	0.5	0	0.01	1	0	0.06	0.07	0.00126
33	Mycetophyllia lamarckiana	14	0.02	0.4	10	0.02	0.58	0.98	0.02206
34	Mycetophyllia reesi	3.75	0.01	0.11	4	0.01	0.23	0.34	0.00732
35	Oculina diffusa	10	0.02	0.29	3	0	0.17	0.46	0.01672
36	Orbicella spp.	1445	2.27	41.2	383	0.6	22.1	63.3	0.36532
37	Plexaurella spp.	57	0.09	1.63	45	0.07	2.6	4.22	0.06699
38	Porites astreoides	445.9	0.7	12.7	252	0.4	14.5	27.3	0.26231
39	Porites colonensis	0.25	0	0.01	1	0	0.06	0.06	0.00068
40	Porites divaricata	1	0	0.03	1	0	0.06	0.09	0.00233
41	Porites furcata	92.5	0.15	2.64	45	0.07	2.6	5.24	0.09593
42	Porites porites	162.5	0.26	4.64	77	0.12	4.45	9.08	0.1424
43	Pseudodiploria clivosa	0.75	0	0.02	1	0	0.06	0.08	0.00181
44	Pseudodiploria strigosa	29.9	0.05	0.85	18	0.03	1.04	1.89	0.04064

45	Pseudoplexaura spp.	12.75	0.02	0.36	12	0.02	0.69	1.06	0.02043
46	Pterogorgia anceps	0.25	0	0.01	1	0	0.06	0.06	0.00068
47	Scolymia wellsi	0.25	0	0.01	1	0	0.06	0.06	0.00068
48	Siderastrea radians	4.25	0.01	0.12	9	0.01	0.52	0.64	0.00814
49	Siderastrea siderea	39.25	0.06	1.12	22	0.03	1.27	2.39	0.0503
50	Solenastrea bournoni	3	0	0.09	2	0	0.12	0.2	0.00605
51	Stephanocoenia intersepta	1.75	0	0.05	2	0	0.12	0.17	0.0038
52	Stylaster roseus	7	0.01	0.2	7	0.01	0.4	0.6	0.01241
53	Tubastraea coccinea	0.25	0	0.01	1	0	0.06	0.06	0.00068
	Total	3505	5.52	100		2.73	100	**H =**	**2.44423**

* D = Dominance, RD = Relative Dominance, O = Occurrence, F = Frequency, RF = Relative Frequency, IV = Importance Value, H = Shannon Weaver Index Value

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