

# Determining Natural Reserves Boundaries in Puerto Rico



A proposal for Ms. Damaris Delgado  
And the Department of Natural and Environmental Resources  
5 March 2010

By  
Russell Austin  
Stephen J. Esposito  
Elizabeth Lapinel

## Table of Contents

<b>List of Figures</b> .....	<b>iv</b>
<b>Chapter 1: Introduction</b> .....	<b>- 1 -</b>
<b>Chapter 2: Background</b> .....	<b>- 4 -</b>
2.1 Natural and Marine Reserves.....	- 4 -
2.1.1 Río Espíritu Santo Natural Reserve .....	- 5 -
2.1.2 Laguna Tortuguero Natural Reserve.....	- 6 -
2.1.3 Puerto Mosquito Natural Reserve .....	- 7 -
2.1.4 Las Piedras del Collado Natural Reserve.....	- 8 -
2.1.5 Caño Tiburones Natural Reserve .....	- 8 -
2.2 Reserve Creation .....	- 9 -
2.2.1 Reserve Designation Process: By way of the Planning Board .....	- 10 -
2.2.2 Special Reserve Designation Process: By way of Legislation.....	- 11 -
2.3 Reserve Regulation and Management .....	- 12 -
2.4 GIS .....	- 13 -
2.4.1. GIS in Coastal Zone Management.....	- 14 -
2.5 Land Use conflicts .....	- 15 -
2.5.1 Land use Conflict in Nicaragua’s Bosawás Reserve .....	- 15 -
2.5.2 Resource Conflict in Vizcaino Biosphere Reserve .....	- 16 -
2.5.3 Management Success in Ecuador Reserve.....	- 17 -
2.6 Summary: Reserves planning in Puerto Rico .....	- 18 -
<b>Chapter 3: Methodology</b> .....	<b>- 20 -</b>
3.1 Researching Documents.....	- 20 -
3.1.1 Archival data.....	- 21 -
3.2 Comparison and Determination of Boundaries.....	- 22 -
3.3 Presentation of Information .....	- 23 -
3.4 Summary .....	- 24 -
<b>Chapter 4: Conclusion</b> .....	<b>- 26 -</b>
<b>References</b> .....	<b>- 27 -</b>
<b>Appendix A: GIS Tutorial</b> .....	<b>- 32 -</b>
Getting Started .....	- 32 -
Adding Data .....	- 33 -
Symbology .....	- 33 -
Layer Files .....	- 35 -
Layout .....	- 36 -
<b>Appendix B: Map of Reserves Locations’</b> .....	<b>- 37 -</b>
<b>Appendix C: Library of Acronyms</b> .....	<b>- 38 -</b>

## List of Figures

Figure 1: Blue Land Crab .....	- 5 -
Figure 2: Freshwater Crocodile .....	- 6 -
Figure 3: Puerto Mosquito .....	- 7 -
Figure 4 Las Piedras de Collado (DRNA, 2010) .....	- 8 -
Figure 5: Common Moorhens .....	- 9 -
Figure 6: Planning Board Designation Process (NOAA 2007) .....	- 11 -
Figure 7: Legislation Designation Process (NOAA, 2007) .....	- 12 -
Figure 8: GIS map of Puerto Mosquito water depth (Mitchell, 2004).....	- 14 -
Figure 9: Project Completion Plan.....	- 24 -
Figure 10: Location of Five Reserves .....	- 37 -

## Chapter 1: Introduction

Puerto Rico's incomparable beaches, coral reefs, forests, lagoons and countless other treasures can be enjoyed by anyone who lives in or visits Puerto Rico. This is greatly due to the preservation efforts of the Department of Natural and Environmental Resources (DNER, or DRNA in Spanish). However, these natural wonders in Puerto Rico can be at risk from many factors. Coral reefs can bleach and die because of overly warm waters and pollution. Forests and beaches can suffer from harvesting of the trees or sand. Nature reserves protect critical natural habitats from the changes that urbanization and agriculture might bring. They also protect the environment through educational and research programs. Reserves safeguard natural areas, while still allowing people to enjoy them.

Despite the benefits offered, there is often public controversy surrounding the creation of nature reserves. Puerto Rico's unemployment has historically been much higher than in the U.S., so any action that is seen as restricting economic growth is met with opposition. The creation of a nature reserve imposes restrictions on land use, which can possibly result in negative economic repercussions for local residents. Specifically, a reserve can restrict use of the coastal area for "construction, mineral development, energy, recreation, transportation, and commercial fishing" (CZMP, 2009). The difficulty in resolving these two competing interests, of protecting nature's beauty and increasing the prosperity of the island, occasionally yields considerable tension between the organizations involved in creating a natural reserve.

A recent example underscores this tension between opposing interests. The Northeast Ecological Corridor, or the NEC, is a stretch of beach along the coast of Puerto Rico. The NEC is home to leatherback turtles, an endangered species that thrives along this stretch of beach (Crescioni, 2010). The NEC was proposed as a nature reserve in the Commonwealth of Puerto Rico House Bill 2105, and had substantial support from environmental groups (Crescioni, 2010). In 2007, the then-Governor of Puerto Rico signed an executive order setting aside 3,107 acres of

coastline of the NEC. In November of 2009, Governor Fortuno, with the support of Planning Board president Hector Morales, revoked the reserve (New York Times, 2009). The governor decided that it would be more to the benefit of Puerto Rico's economic development if resorts were allowed to use the area because this would create jobs. Maintaining balance between economic growth and environmental impact is very important when the DRNA considers designating new land as a nature reserve.

The DRNA works with many other organizations and government agencies to protect the reserves of Puerto Rico. A short list of collaborators includes the Planning Board, National Oceanic and Atmospheric Administration (NOAA), Environmental Quality Board (EQB), Regulations and Permits Administration (RPA), and the United States Fish and Wildlife Service (USFWS). These agencies rely on each other for support, approval, and evaluation. The DRNA complies with policies established by the EQB, and the EQB must submit policies to the Planning Board for approval. All agencies may adopt or develop regulations regarding nature reserves (CZMP 2009). However, the DRNA's regulations do not require formal approval by the other agencies.

To create a new nature reserve, the DRNA drafts a designation document and submits it to the Planning Board for approval. The designation document includes a description of the region and its ecological importance, proposed boundaries, and potential land use conflicts (Delgado, personal communication, 2/4/2010). If approved by the Planning Board, the designation document is submitted to NOAA. If NOAA approves the document, then the Governor must authorize creation of the reserve (CZMP, 2009; Delgado, personal communication, 2/4/2010). Alternatively, the legislators of Puerto Rico can draft a designation document and sign it directly into law. Although several reserves have been created through acts of legislation, it is more common that the DRNA proposes designation of an area to be protected (CZMP, 2009).

Once a reserve is created, through either method, the various agencies are responsible for managing these reserves. The current problem facing the DRNA is that the boundaries outlined in designation documents or other legislative descriptions

of the reserves are not always in agreement with the land deeds and titles. This can lead to reserve boundary issues, such as in La Parguera Natural Reserve, where residents built on public domain lands (CZMP 2009). This project will address these conflicts by looking at reserves like La Parguera and working to determine the location of the reserve boundaries.

Working with the DRNA, we plan to collect data from five reserves in particular. These sites include; Río Espíritu Santo Natural Reserve in the Río Grande Municipality, Laguna Tortuguero Natural Reserve in Manatí Municipality, Puerto Mosquito Natural Reserve in Vieques, Las Piedras del Collado Natural Reserve in Cayey Municipality, and Cano Tiburones Natural Reserve in Arecibo Municipality. The scope of the project will include uncovering designation documents, GIS data, maps, real estate title registries, and land surveys. In addition to this research we will analyze the current disputes concerning reserve boundaries and use presentations, pamphlets, and updated information on websites to aid the DRNA in the clarification and dissemination of our findings.

## Chapter 2: Background

Puerto Rican natural reserves were first created in 1979, when the Department of Natural Resources was established to protect valuable natural areas in Puerto Rico. Among the first reserves were Bosque Estatal de Piñones and Laguna Tortugero. Bosque Estatal de Piñones contains coral reefs, mangroves, and sea grass beds (DRNA 2006). Laguna Tortugero is one of the largest bodies of freshwater in Puerto Rico, and a popular destination for migrating waterfowl. These reserves marked the beginning of official government involvement in environmental protection in Puerto Rico. The DRNA, which regulates these reserves, was established in compliance with EPA standards. The stated mission of the DRNA is:

“To protect, conserve, administer to the natural reserves and the environment of Puerto Rico in order to create a balance that guarantees the health of the environment for future generations” (DRNA, 2006).

The DRNA continues to fulfill this mission statement today, as it oversees and manages over 50 separate natural reserves in Puerto Rico.

### 2.1 Natural and Marine Reserves

In order to discuss natural reserves and marine reserves and their relationship to the DRNA, we must first define the terms natural and marine reserve. According to the DRNA, natural and marine reserves are

‘Áreas, identificadas por el Departamento de Recursos Naturales y Ambientales (DRNA) y designadas por la Junta de Planificación (JP), que por sus características físicas, ecológicas, geográficas y por el valor social de los recursos naturales existentes en ellas, ameritan su conservación, preservación o restauración a su condición natural’<sup>1</sup>(DRNA, 2006)

A nature reserve in Puerto Rico is owned by the DRNA and is accessible to the public for specific limited activities. Hiking, swimming, boating, camping and scientific observation constitute some of the unrestricted activities permitted. The particulars of

---

<sup>1</sup> “areas identified by the Department of the Environment and Natural Resources (DRNA) and designated by the Planning Board, that for their physical characteristics, ecological or geographical importance, and for the social value of the natural resources that they have, merit their conservation, preservation, or restoration to their natural condition.”

permitted activities at each natural or marine reserve are determined within the reserve's management plan. The needs of a nature or marine reserve can include conservation, preservation, and/or restoration. The management plan is determined by area needs are, and how these needs will be satisfied.

There are five reserves that will be the focus of our project in Puerto Rico. These reserves are either very important ecologically, or controversial because of the restrictions imposed by their designation as a natural reserve. The following is a brief description of each reserve we will investigate in our project.

### 2.1.1 Río Espiritu Santo Natural Reserve

The Río Espiritu Santo Natural Reserve, in the Rio Grande Municipality of Puerto Rico, is home to a rich diversity of life. The area is designated as a subtropical rain forest, with an average of 77 inches of rain per year (Grupo Editorial EPRL, 2009). Río Espiritu Santo is an economically valuable reserve because of the animal species living there, including the Blue Land Crab, Swamp Ghost Crab, and the Blue Crab (Grupo Editorial EPRL, 2009).



Figure 1: Blue Land Crab

The Río Espiritu Santo reserve is also home to mangrove forests, swamps, and coral reefs offshore. The Río Espiritu Santo estuary is also the only river open to the ocean that is navigable by small boats in Puerto Rico, allowing its wealth of natural



resources to be used by fishermen (Grupo Editorial EPRL, 2009). Although the area was designated as a natural reserve, many activities are still allowed in the boundaries including: "...canoeing, diving, day trips, bird watching, scientific studies, swimming, water skiing, boat tours, hunting and fishing" (Grupo Editorial EPRL, 2009). This reserve protects an invaluable natural area, as well as offers sanctuary to many plant and animal species.

### 2.1.2 Laguna Tortuguero Natural Reserve

Laguna Tortuguero, designated in 1979, is one of the very first natural reserves of Puerto Rico. The lagoon is the largest body of freshwater in Puerto Rico (PuertoRico.com, 2009). The reserve is unique because it is fed by freshwater springs, which fill the lagoon and then empty into the sea. This unusual habitat allows many rare plants and animals to live there. There are over 700 species of plants coming from 120 different plant families. Furthermore, 144 species of plants and animals are classified as being "incredibly rare or are even noted as being endangered" (PuertoRico.com, 2009). The lagoon is also a major stop for migrating birds. Although boating and kayaking are allowed in the reserve, camping and swimming are prohibited due to freshwater crocodiles (see Figure 2) (PuertoRico.com, 2009).



Figure 2: Freshwater Crocodile

### 2.1.3 Puerto Mosquito Natural Reserve

The Puerto Mosquito Natural Reserve is home to Puerto Mosquito, which is “... considered to be one of the densest and brightest bioluminescent bays in the world” (Mitchell, 2004). The bioluminescence comes from microscopic algae that live in the bay. Puerto Mosquito is an excellent bioluminescent bay because of its unique characteristics; a narrow inlet from the sea traps much of the algae, and mangrove forests on the edge of the bay that provide food (Mitchell, 2004). The Navy ceded the land around the bay to the DRNA in 2003, which led to increased human development near the bay. The bioluminescent algae are very susceptible to pollution, and therefore “these projects, if not managed properly, can cause irreversible damage to the biobay system” (Mitchell, 2004). Puerto Mosquito is a place of great natural beauty and needs to be protected for future enjoyment. Below is an aerial view of Puerto Mosquito (Gilbes, 2004).

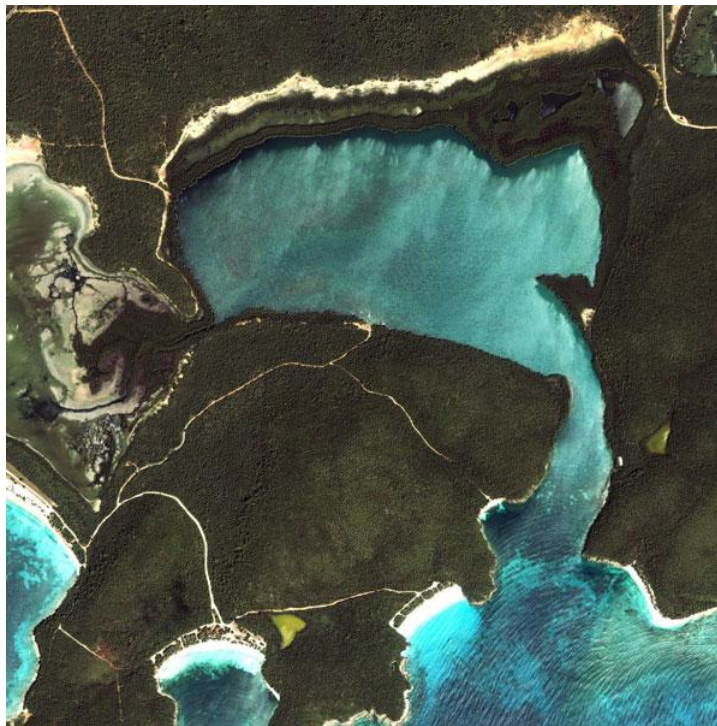


Figure 3: Puerto Mosquito

#### 2.1.4 Las Piedras del Collado Natural Reserve

Las Piedras del Collado Natural Reserve is located on the side of a mountainous system in Collado. This area is post-volcanic, as the twin mountains at the heart of the reserve were once active volcanoes. The reserve contains a vast amount of plant life. Due to the volcanic soil, and location in the valley, the temperature of this area is slightly cooler than the rest of the island, between 64 to 75 degrees Fahrenheit. The volcanic soil in this region houses ten unique species of flora, of which five are endemic to Puerto Rico (DRNA, 2010). According to the DRNA, this reserve is very new, only designated in 2000. Below is a view of the reserve, highlighting one of the rare flowers with the twin mountains in the background.



Figure 4 Las Piedras de Collado (DRNA, 2010)

#### 2.1.5 Caño Tiburones Natural Reserve

Designated in October of 1998, the Caño Tiburones Natural Reserve is home to more than 200 species of bird, and over 40 other animal species. This area encompasses an estuary, which is a partially enclosed body of water that has several different flow points in and out of it (DRNA, 2010). This reserve attracts many species of birds, which feast upon the aquatic life in the estuary. Caño Tiburones is consequently also valuable because of the extensive wetlands protected within the reserve. For many years, wetlands were blamed for mosquito problems and for the spread of diseases, and were not valued for their ecological benefits (DRNA 1998). Caño Tiburones was designated as a reserve in part to protect the wetlands for the

benefits they offer. These benefits include vital habitats for wildlife, and flood mitigation capacity. Common moorhens, one of the many inhabitants of the reserve are seen in Figure 5.



**Figure 5: Common Moorhens**

## **2.2 Reserve Creation**

The DRNA, the Planning Board, the RPA and the EQB can all develop and adopt regulations for the management of natural or marine reserves (CZMP 1978). The DRNA “serves as an advocate and proponent of a natural resources perspective” (CZMP 1978). As an advocate, the Department is allowed to create new areas that should be protected through the creation of new natural reserves. When a nature or marine reserve is created, it can go through one of two processes: the main Planning Board creation process, or the special process by way of legislation (NOAA 2007). The process outlined below is from the 2007 Natural Reserves in Puerto Rico document, published by the National Oceanic and Atmospheric Administration. The process is generally the same, whether the reserve is primarily land or marine, but the approval criteria may vary. Since 1979, when the first natural reserves were created, the Planning Board process was used for the creation of most reserves. In recent years, since 1999, the newer legislative process was used in the creation of certain ecologically valuable reserves.

### **2.2.1 Reserve Designation Process: By way of the Planning Board**

In order for a nature or marine reserve to be created through the process provided by the Planning Board, the proposal has to be presented to the DRNA for consideration. If the DRNA agrees that the specified area should be designated as a natural or marine reserve, they notify NOAA (the National Oceanic and Atmospheric Administration) that they intend to create a National Protected Area. NOAA is a division of the U.S. Department of Commerce, with responsibilities across a range of environmental programs. The Caribbean Field Office in Puerto Rico is among the many programs overseen by this administration. This office analyzes the impacts of any projects in Puerto Rico on species and habitat protected by the Endangered Species Act (NOAA, 2007). NOAA must be notified of all DRNA activities that may impact the environment, but is not further involved in the process. After notifying NOAA, the DRNA drafts a designation document to be submitted to the Planning Board. The Planning Board must comment and collaborate in updating the designation document, and then make the document available for public comment. After an allotted period of time, the public comments are incorporated into the final draft of the designation document. The Planning Board will then endorse a resolution to create the new reserve. The new natural reserve creation is effective 30 days from the official date on the resolution. The diagram below shows the Planning Board reserve creation process, step-by-step.

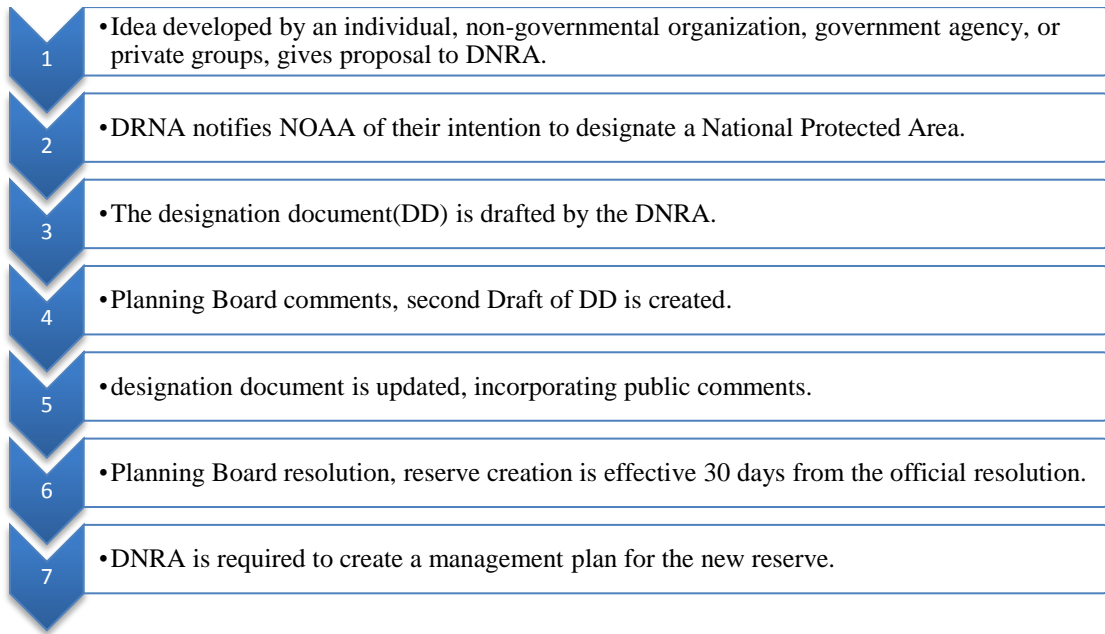


Figure 6: Planning Board Designation Process (NOAA 2007)

### 2.2.2 Special Reserve Designation Process: By way of Legislation

The process of creating a natural reserve through the legislative process differs from a reserve that would go through the Planning Board process depending on the origination of the idea. If the proposed reserve is initiated by a non-governmental organization, an individual, a private group, or a government agency, the route to create the reserve is through the Planning Board process. The reserve designation process will go through the legislation only when the idea originates with a legislator, or within the DRNA. The legislators proposing the reserve draft an Act, which designates the area as a natural reserve. The Act must then be made available for public comment. Subsequently, the legislature approves the Act, and send it to the Governor. Once the Governor ratifies the Act, the DRNA as required by the Act, must manage the natural reserve. The DRNA must also produce a management plan for the reserve. The Governor then directs the Planning Board to consider this new reserve when creating the land use plans for Puerto Rico. The final step of creating the natural reserve is then the same as the other process; the Planning Board endorses a resolution to officially make the natural reserve. The diagram below shows the

## Legislative reserve creation process, step-by-step.

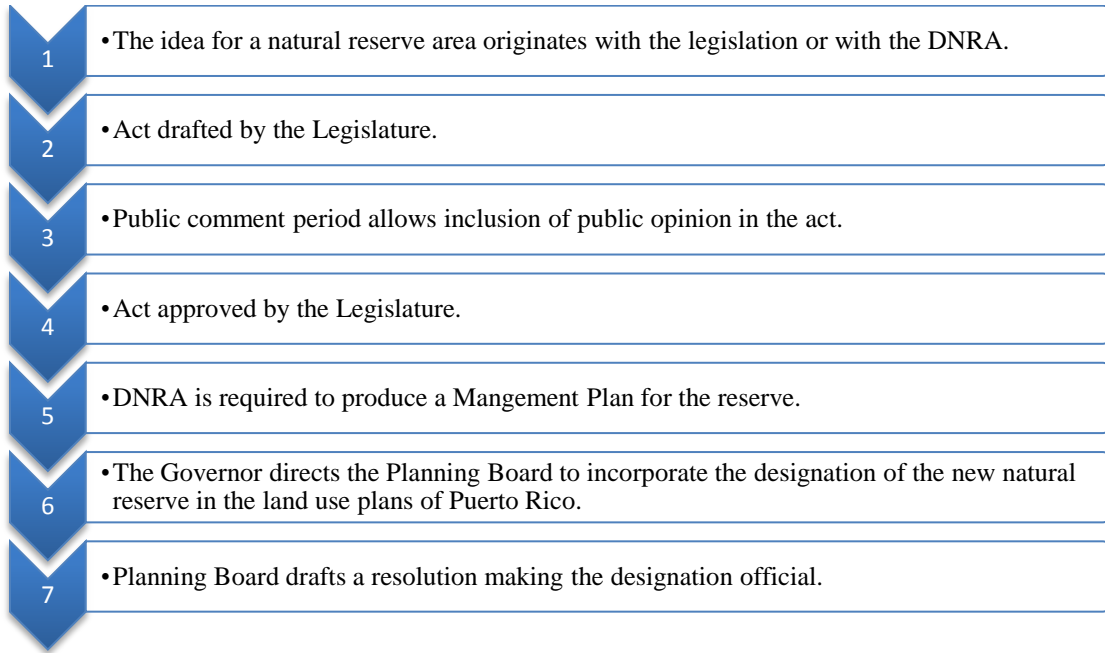


Figure 7: Legislation Designation Process (NOAA, 2007)

### 2.3 Reserve Regulation and Management

Once created, the responsibility for managing the natural reserves lies primarily in the hands of the DRNA. The specific responsibilities for regulation and management of Puerto Rico’s natural and marine reserves are detailed in the Coastal Zone Management Program document, updated in 2009. The Planning Board, RPA, EQB, and the DRNA are the primary organizations responsible for regulations and management of the natural reserves. All the above agencies can adopt or develop regulations. The Planning Board’s land use plans serve as a basis for zoning maps, and their regulations become effective once signed by the Governor of Puerto Rico (CZMP, 2009). The Planning Board has responsibility for overall policymaking and for development plans for all of Puerto Rico’s natural reserves. The other important responsibility of the Planning Board is to reconcile public needs that might conflict with the protection needs of the reserves areas (CZMP, 2009).

The DRNA is responsible for carrying out the management plans for each of the designated natural reserves. Within the DRNA are many sub-units that manage various aspects of the nature reserves. The Survey office manages the plans, maps and drawings of reserve areas. The Real Estate unit manages the deeds to lands owned by the DRNA. Another section of the DRNA, the Designation Process unit, prepares the designation documents (Delgado, personal communication, 2/4/2010). The current problem is with conflicting designation documents and other legal papers. If the deeds to the land making up the natural reserve were not acquired by the time the designation documents are finalized, as was the case in the NEC lands discussed above in Chapter 1, the designation documents would not be legally correct. The DRNA needs to confidently know the boundaries of their reserves, to avoid land use conflicts that can be difficult to solve. The Information Systems Office in the DRNA uses GIS (Geographic Information System) to aid in storing and visualizing the reserve areas. Unless the information is correct, the GIS program will not be an effective tool.

## 2.4 GIS

GIS is mostly associated with the computer program ArcGIS. However, the concepts and technology behind an actual GIS map have been around as long as maps have been drawn. For example, a topographical map of the Worcester Area will not only show the outline of Worcester and the gradient elevation line, but will most likely include items such as towns within the Worcester Area, landmarks, bodies of water, and other information. Each individual item represents a new thought, a new piece of information that reveals characteristics of the region and the map. Today with the aid of computers, maps show geographical trends in many different areas. Figure 8 is an example of a GIS map of Puerto Mosquito, one of the reserves in our investigation. This map shows water depth in the bay.



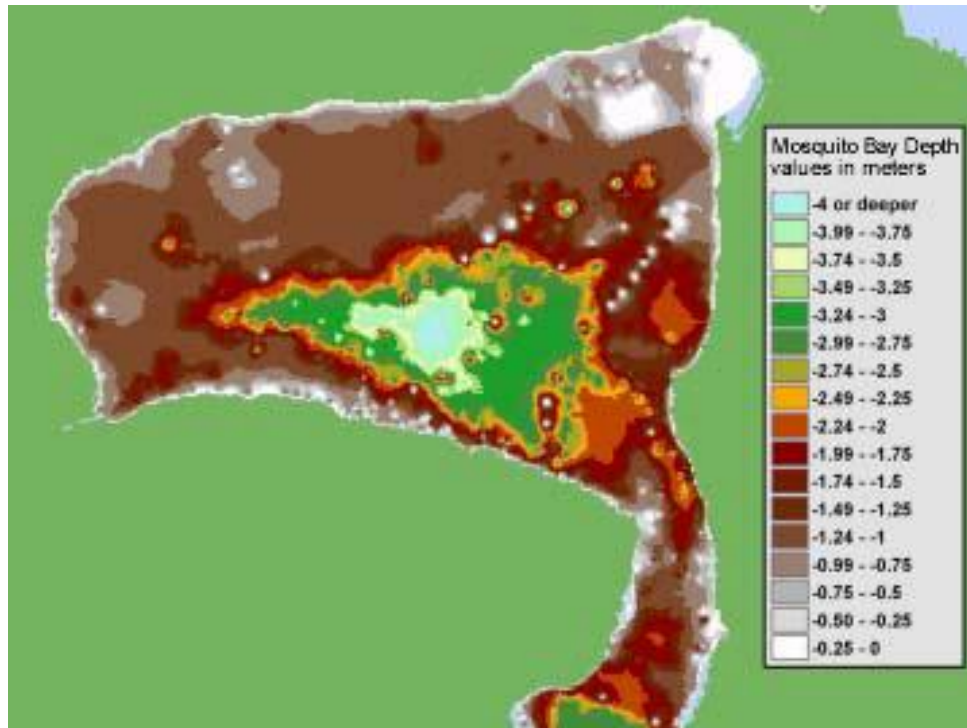


Figure 8: GIS map of Puerto Mosquito water depth (Mitchell, 2004).

#### 2.4.1. GIS in Coastal Zone Management

Our project in Puerto Rico involves many coastal zones, and understanding GIS' role in coastal zone management will be essential. One particular example of coastal zone research shows GIS' function with the United Kingdom assessment of the Norfolk coastline. The case describes GIS' assistance in creating the map data and management of the area. The key assessment of the Norfolk study was the rise in sea level (Jude, Jones, Andrews, & Bateman, 2006). With the data compiled in the study, projections were made about the Norfolk area up until 2100. An original process, detailing many documents and agencies, was described, but with the new GIS "methodology ... different sea level[s can]... be quickly assessed before they were used in the creation of visualizations" (Jude et al., 2006). Those visualizations included maps in a scale of 1:2500 comprised of 1km<sup>2</sup> tiles. That level of granularity would have taken weeks to construct through conventional means, but with the use of GIS, such a map can be created in a matter days (based on data entry into the map assembly itself). Visualizations included 2 and 3D maps of the sea level rise over the

hundred-year span, pointing out key areas that would need to be watched in the future.

Gathering data in the assessment of the Norfolk coastline was a time consuming and arduous task. Often organizations that held the data had only hard copies, requiring the digitization of the information so it could be integrated into the GIS system. Furthermore, it was found that several different types of GIS software were being used between the organizations and the agency. The discrepancy in the software made the data incompatible with one another, requiring extra effort to find a common data format (Jude et al., 2006). As the majority of our data will be in hard copy format, we will need to enter the data manually into GIS, which will take time. However, the visual aid the program produces will be invaluable in discerning of the discrepancies between the designation documents and deeds.

## **2.5 Land Use conflicts**

There are many situations that can lead to land use conflicts around natural reserve areas. Conflicts can be resolved in both beneficial and harmful ways. Land use in and around natural reserves can be controversial because the land could be valuable economically, and/or culturally (DRNA, 2009). Land conflicts have occurred in Puerto Rico in the past. For example, "...in La Parguera Natural Reserve, there is a problem with residences built on assets of maritime public domain..." (CZMP, 2009). Because the DRNA cannot prove that the residents do not own the land, they are struggling to resolve the conflict. The following are examples of other land use conflicts, and their resolution processes.

### **2.5.1 Land use Conflict in Nicaragua's Bosawás Reserve**

An example of land use conflict occurs in the Bosawás National Resource Reserve in Nicaragua. The reserve is home to 8,000-10,000 Mayangna Indians, 4,000 Miskitu Indians and approximately 30,000 Mestizos, people of mixed descent (Howard, 1998). These different cultures conflict politically and economically on the

same reserve. Most of the tension in this reserve is between the Mayangna Indians and the Mestizo population. Howard states,

“Common among national governments is the failure to demarcate indigenous territories, the tendency to draw inappropriate boundaries which undermine indigenous livelihoods, the failure to develop procedures to defend indigenous lands, and the disregard of indigenous land boundaries in favor of more lucrative land uses” (Howard, 1998, p. 20).

The Mayangna peoples received almost no titles in the Harrison-Altamirano Treaty of 1905 (Howard, 1998). All land that was not ceded to the Miskitu and Mayangna Indians was classified as National Land, or state property. This allowed for the encroachment of Mestizos near the Sikilta community in the reserve. During that time, the Mayangna felt that they were bearing the brunt of a prejudice system towards natives. Howard suggests five possible approaches to amend the land dispute problem between the Mestizos and Mayangna in Sikilta. First, the author proposes that the two groups negotiate and work together for a common goal; “...[the] first solution seems to be preferred by the governmental and non-governmental organizations involved, and has the advantage of achieving a peaceful solution at minimum financial cost” (Howard, 1998). The other solutions proposed by Howard include relocating and compensating the Mestizos, relocating without compensation, and taking the case to court. The fifth and final choice the author recommends is evicting the Mestizos by force (Howard, 1998). The examination of these approaches shows it would be the most beneficial for both groups involved to work together peacefully and cohesively.

### **2.5.2 Resource Conflict in Vizcaino Biosphere Reserve**

In the Vizcaino Biosphere Reserve, as in the Bosawás National Resource Reserve, the locals fear they are being marginalized. Young states that, “Although local involvement in conservation endeavors is critical, it is also highly problematic” (Young, 1999). The people living in the reserve in Laguna San Ignacio

fall victim to the nature preservation that was originally meant to promote natural resource protection (Young, 1999). Locals living inside the reserve depend on fishing for their livelihood. With the restrictions imposed upon them by the reserve designation, the local community struggled to get by. This situation is exacerbated by the fact that staff members of the reserve must work with the inhabitants of this remote site from Guerrero Negro (Young, 1999). Young gives another example of the marginalization of the locals, “No one notified the residents, for example, that their presence was required at a meeting held in December 1993 at the reserve’s regional headquarters in La Paz” (Young, 1999). Reserve managers did manage to make the community more involved by making more visits to the reserve in 1994 (Young, 1999). Young suggests that future conservation efforts will be much more successful if indigenous peoples are included and provided for in legal mechanisms (Young, 1999). As stated in the 2009 CZMP document, “. . .protection of the environment and economic sustainability cannot take place at the cost of the population” (CZMP, 2009).

### **2.5.3 Management Success in Ecuador Reserve**

Although we will experience a mostly governmentally managed environmental program in Puerto Rico, it is still important to study different management styles. For this case, we will examine two different “Bosque Protectors,” or protected forests in Ecuador. The BPMN (Bosque Protector Mindo y Nambillo) reserve in Ecuador is an example of self-governed reserve management. Throughout the history of the reserve, it was managed by a local group, known as the “Amigos de la Naturaleza de Mindo” (Perreault, 1996). In contrast to this management style, the Bosque Protector Pasochoa was host to a “top-down capital investment approach” type of management (Perreault, 1996). As Perreault stated, “Policies that ignore the socioeconomic needs of local residents will be difficult or impossible to maintain over time” (Perreault, 1996).

There was skepticism from the beginning as the Amigos de la Naturaleza de Mindo group formed to manage the BPMN (Perreault, 1996). This organization was formed in a “grassroots” fashion, meaning it had nothing to do with the government,

receiving help only from NGO's (Non-Governmental Organizations). NGO's play their part in natural resource management by "...undertaking projects more efficiently than state bureaucracies and, in the long run, their involvement may be less expensive than funding or creation of a government agency" (Perreault, 1996). Even though the government does not manage this organization, a majority of the funding for a NGO may come from government sources. The Amigos reserve management group was at first very successful because they managed the use of land very efficiently. Unification soon turned to disaster when locals living inside the BPMN became discontent. Perrault states that "Sixty-four percent of the people in the area are landless and the BPMN is perceived as eliminating the possibility for economic gain by limiting their access to land and resources" (Perreault, 1996). Community involvement in the reserve became minimal because of the Amigos one-sided representation of needs.

## **2.6 Summary: Reserves planning in Puerto Rico**

This investigation will inter-operate in Puerto Rico with the "top-down" management approach of natural reserves. This style of management uses a bureaucratic system controlled by a major government agency, with little control available to the locals of the reserve. In the case of the Bosque Protector Pasochoa reserve, there were large amounts of funds and managerial services available due to the nature of a top-down system (Perreault, 1996). The downside to this management style is that the local community sees few benefits from the designation of the reserve. The top-down resource management approach seems to be more practical in places like Puerto Rico, where there are sufficient funds and government agencies dedicated to environmental protection.

As shown by the information gathered, to make a successful natural reserve, the people located in and around the reserves must be accommodated. For the best possible relationship between the agency governing the reserve and the local community, there should be very clear boundaries of the reserve. To create the most beneficial study, we must gather all the available information in the various

government agencies including designation documents, and GIS data. Clarifying the documentation of natural reserves will enable more accurate boundary descriptions by the DRNA. This will lead to better communication with local communities living around reserves and within the DRNA itself.

From this research, we will gain insight regarding the processes used to create a reserve, as well as the processes in place to acquire land for use as natural reserves. The case studies we researched contributed to our understanding of land use disputes in nature reserves, which can occur as a result of unclear boundaries. We also explored the functions of several units within the DRNA, including the Real Estate Division, Terrestrial Reserves Planning Division, and the Information Systems Office. Investigating the DRNA, the units within the DRNA, and other governing agencies will allow us to begin our analysis with a solid understanding of the reserves and the regulations. Such an understanding can determine the origin of the discrepancies between documents, the documents that should be researched, and how the correct information can be determined.

## Chapter 3: Methodology

The goal of this project is to conduct an in-depth analysis of the current boundary discrepancies for five natural reserves in Puerto Rico. This project will examine the bigger arena of reserve regulation in Puerto Rico; then narrowing its focus on boundary determination and inconsistencies within the legal documents associated with the reserves. The specific objectives of our project include researching the process for creating natural and marine reserves, and researching the acquisition process for land to create reserves. We then will find designation documents, deeds, surveys and maps for each of the five reserves our project will focus on. By comparing these documents for each reserve, the project team will determine discrepancies in boundary delineation, and determine the legally correct boundary for each reserve. Because both designation documents and deeds are legal items, we will need expert advice to determine which document gives the correct boundary. The team will then present our research outcomes to the DRNA, rangers and neighbors of the reserves.

### 3.1 Researching Documents

To find these documents, we will work with several units within the DRNA, including the División de Bienes Inmuebles<sup>2</sup>, División de Planificación de Recursos Terrestres<sup>3</sup>, and the Oficina de Informática<sup>4</sup>. The first step of the process will be finding designation documents, laws, regulations, land ownership titles, management plans, surveys, and maps. The operational units within the organization will assist us in finding the documents. This project will focus on five reserves: Río Espíritu Santo, Laguna Tortuguero, Puerto Mosquito, Las Piedras del Collado, and Cano Tiburones. Once the documents for these reserves are gathered, the deeds will be compared to the designation documents and management plans. The exact discrepancies about the

---

<sup>2</sup> Real Estate Division

<sup>3</sup> Terrestrial Reserve Planning Division

<sup>4</sup> Information Systems Office

boundaries will be compared to determine the most valid boundaries. Advice to establish which boundaries are correct will come from the experts in the DRNA.

### **3.1.1 Archival data**

Finding documents will take the most time, once we are in Puerto Rico. To gather the most correct and updated designation documents, surveys, maps, and management plans, we must contact the previously mentioned units within the DRNA (Delgado, personal communication, 2/4/10). These departments have delegated responsibility over specific areas of reserve regulation and management, or over reserve creation. Searching within these units is the most direct way to find the documents.

Ms. Damaris Delgado is the director of the Division of Reserves and Refuges within the DRNA. This office advises the Secretary of the DRNA in formulating public policy on natural resources. Through this department, we will have access to varied records for each of the reserves, possibly including descriptions of the reserves and regulations. Working through the Library will also be an effective way to access the documents we need. The DRNA Library is custodian of the records of the DRNA. According to the laws that regulate the DRNA, the Library must keep all laws regulations and related documents (DRNA, 2002). The Library allows individuals to request access to all documents, with some privacy exceptions.

Ms. Mabel Rivera is the director of the Real Estate Division, the DRNA department that attains property for reserves (Delgado, personal communication, 2/4/10). This unit negotiates purchases, accepts donations, bargains to trade land, and if necessary, acquires land by force (a procedure similar to Eminent Domain)(DRNA, 2004). Since this unit secures ownership of reserve lands, we should be able to obtain deeds from this department. If the deeds cannot be located within this reserve, we will contact the municipalities where each reserve is located, in the Río Grande, Manatí and Vega Baja, Vieques, Cayey, and Arecibo. Requesting the deeds from each municipality can contribute more problems that we have not anticipated. Working with so many government departments might cause delays, which could jeopardize the subsequent stages of our project.



As the director of the Terrestrial Reserve Planning Division, Ms. Clarimar Diaz is responsible for carrying out the laws and regulations specifically about on-land reserves. The documents that regulate the reserves are management plans and designation documents. Ms. Diaz's department has the updated management plans and designation documents to manage these reserves. We will work with this department in our efforts to locate designation documents and management plans for the five reserves.

The Information Systems Office, under direction of William Mercados, holds all the GIS databases and website data (Delgado, personal communication, 2/4/2010). They are responsible for updating information on the DRNA website and for maintaining computer systems within the agency itself. The Information Systems Office uses a GIS system to keep track of and format all of the data regarding their natural reserves. We will be using the available maps within the DRNA databases to assess the conflicts between the designation documents and legal land deeds. An updated map can be constructed for the reserves, showing the exact overlap of the two documents. In order to use the GIS database run by the DRNA, we will use a computer on their network with the ArcGIS program. We will also need guidance in navigating the DRNA's thirteen databases, to discover surveys and maps pertinent to the project's five reserves.

Some challenges in the process include the location of the documents, which we may not know until we arrive in Puerto Rico. The designation documents are not available online, and they might be difficult to locate. Because of the two separate methods of reserve designation, it is also possible that the legislatively designated reserve designation documents are not located in the departments of the DRNA. By searching within the DRNA divisions, the municipalities where the deeds are stored, and the DRNA's library, we will work around any research setbacks we may encounter.

### **3.2 Comparison and Determination of Boundaries**

Each of the documents we will find has a description of the reserve boundaries. The primary documents that determine boundaries of a reserve are the

designation document and the deed. We will first compare the land described in the designation document with the description in the deed. If either cannot be found, we will also compare management plans, surveys and maps. Then we will clearly state the discrepancies in a separate document. Determining the correct boundaries will depend on advice from the DRNA's managers.

There are many potential complications that we will resolve in this phase of our project. We know that all the documents we are comparing are available only in Spanish. Two members of the team do not read Spanish well enough to compare documents in Spanish. In addition, if the documents are not available in digital formats, translation software will be very difficult to use. A solution for the language barrier would be to work with a student from the University of Puerto Rico, who would assist with translations. An alternative would be to work with managers in the DRNA to translate the documents.

### **3.3 Presentation of Information**

Once the correct boundaries for each of the five reserves are determined, the boundaries will be presented to managers in the DRNA, rangers who work on the reserves, and individuals whose land borders the reserves. These presentations will be an overview of the situation of the five chosen reserves, an explanation of the conflicts that exist between documents, and an explanation of which boundaries are correct. The corrected boundaries will be available to anyone interested through a pamphlet we will compile that explains the conflicts between documents, states the correct boundaries of the five reserves, and includes a description of each reserve. We will also work with the Information Systems Division to post the updated boundary information on their website.

### 3.4 Summary

We will be working with the DRNA in San Juan, Puerto Rico from March 15<sup>th</sup> until May 7<sup>th</sup>. Our tentative plan for completing the project while in Puerto Rico is outlined in the Gantt Chart below; Figure 9: Project completion plan.

Tentative Tasks	PQP	1	2	3	4	5	6	7
Research reserve creation process	■	■						
Research acquisition process								
Find specific documents		■	■	■	■			
Compare documents				■	■	■		
Determine correct information					■	■		
Present to DRNA and others							■	
Complete IQP report								■

Figure 9: Project completion plan

The Gantt chart above represents the schedule of our project. In the PQP we researched natural reserve creation and the land acquisition process used by the DRNA in Puerto Rico. That research will continue into the first week in Puerto Rico, in the form of contacting the DRNA more directly to clarify any questions we may have. During the first four weeks in San Juan, we will be accessing all available documents for each of the five reserves Comparing and deciding which documents show discrepancies will take place during the fifth week of our project. Preparation during the final two weeks of the term will culminate in presentations and a finished report.

The approach we take when working in Puerto Rico will have a direct effect on the success of our project in the long run. The careful prioritization of the tasks will allow us to approach the work with clear and organized objectives. By carefully researching the laws that govern the DRNA, we have learned which departments should be responsible for certain portions of reserve management. But because the daily functions of each department might be very different than was detailed in the laws and the DRNA website, we may encounter a different set of resources than was planned for. Though the resources and locations we search for the documents might change, the basic steps of the methodology will remain unchanged. Wherever the documents are located, we will need to collect them in order to compare them within

the first few weeks, and determine the valid boundaries shortly thereafter. By carrying out this methodology, we will achieve the stated goals of our project; to conduct an in-depth analysis of boundaries for the five reserves, and present the correct boundaries to the DRNA.

## Chapter 4: Conclusion

Natural reserves in Puerto Rico protect immeasurably valuable wonders of nature. Increasingly rare wetlands, endangered coral reefs, volcanic rock formations, and bioluminescent bays are just a short list of the amazing features of the many reserves found in Puerto Rico. The five reserves we will work with also feature many remarkable sights and experiences. Río Espíritu Santo is an estuary in the Río Grande Municipality, with a unique ecological community that results from the mix of freshwater and saltwater from the river and ocean. The Laguna Tortuguero reserve in Manatí and Vega Baja Municipality is the only freshwater lagoon in Puerto Rico, which boasts rare plant life and freshwater marshes. The Puerto Mosquito reserve, in Vieques, is a pristine bioluminescent bay offering an increasingly rare experience. Las Piedras del Collado, in Cayey Municipality, is made up of rocky outcroppings in the natural volcanic mountains in central Puerto Rico. Cano Tiburones natural reserve is in Arecibo Municipality, and is the most extensive wetland estuary in Puerto Rico. The DRNA manages these reserves and makes decisions in order to balance the demands of society with the needs of the natural reserves. An obstacle that prevents the DRNA from optimally regulating and managing the reserves is the occasion when they cannot prove ownership of the land that makes up each reserve. Our team's project will compile the regulating documents surrounding each reserve in order to clarify the correct boundaries of the reserve.

Thus far, we have completed an initial reading of the laws and regulations surrounding the DRNA and have come away with an understanding of how we can find the documents relevant to our project. Our project team is prepared to accommodate many possible situations. Upon completion of this project, we will have verified the correct boundaries for each of our project's five reserves. We will present these findings and work with the Information Systems division to post the clarified boundaries on the DNRA website. By clarifying the boundaries in these important natural areas of Puerto Rico, we hope to assist the DRNA in their commitment to protect these reserves.

## References

- Aaron E. Putnam, David E. Putnam. (2009). Inactive and Relict Rock Glaciers of the Deboullie Lakes Ecological Reserve, Northern Maine, USA. *Journal of Quaternary Science*, 24, 773-784.
- Bengtsson, J., Angelstam, P., Elmqvist, T., Emanuelsson, U., Folke, C., Ihse, M., Moberg, F., & Nyström, M. (2003). Reserves, Resilience and Dynamic Landscapes. *Ambio*, 32(6), 389-396.
- Botsford, L. W., Micheli, F., & Hastings, A. (2003). Principles for the Design of Marine Reserves. *Ecological Applications*, 13(1, Supplement: The Science of Marine Reserves), S25-S31.
- Britaldo Silveira Soares-Filho, Daniel Curtis Nepstad, Lisa M. Curran, Gustavo Coutinho Cerqueira, Ricardo Alexandrino Garcia, Claudia Azevedo Ramos, Eliane Voll, Alice McDonald, Paul Lefebvre, & Peter Schlesinger. Modeling Conservation in the Amazon Basin. *Nature*, 440.
- Callum M. Roberts, James A. Bohnsack, Fiona Gell, Julie P. Hawkins, and Renata Goodridge. (2001). REPORTS: Effects of Marine Reserves on Adjacent Fisheries. *Science*, 2940, 1920-1925.
- The Constitution of the Commonwealth of Puerto Rico, (1952).
- Cox, P. A., & Elmqvist, T. (1991). Indigenous control of tropical rain-forest reserves: An alternative strategy for conservation. *Ambio*, 20(7), 317-321.
- Crescioni, X. N. (2010, Appellate decision could open up NEC to construction. *Puerto Rico Daily Sun*,
- Delgado, D. (2010). *Interview with Ms. Delgado. Feb 4 2010*
- DNER. (2006). *Compounds by DNER acquires land nature reserve Las Piedras del Collado*. Retrieved Feb. 22, 2010, from <http://www.drna.gobierno.pr/oficinas/oficina-de-prensa-y-comunicaciones/comunicados-de-prensa/comunicados-de-prensa-2009/enero-2009/drna-adquiere-terrenos-compuestos-por-la-reserva-natural-las-piedras-del-collado>
- DNER. (2006). *Hojas De Nuestro Ambiente* No. p-007). San Juan, PR: Departamento de Recursos Naturales y Ambientales.
- DRNA. (1978) Puerto Rico Coastal Zone Management Program
- DRNA. (2009) Puerto Rico Coastal Zone Management Program, (September 9, 2009)

- LEY 314 24 DE DICIEMBRE DE 1998, 854 (1998).
- LEY NUM. 147 17 DE OCTUBRE DE 2001, Ley para declarar la reserva U.S.C. 423 (2001).
- Reglamento Para El Cobro De Derechos Por Concepto De Venta De Documentos Y Publicaciones Del Departamento De Recursos Naturales Y Ambientales, 6443 (2002).
- Departamento De Recursos Naturales y Ambientales, Division De Bienes Inmuebles Reglamento Para La Adquisición De Bienes Inmuebles y Derechos Reales, (2004).
- Fernando Gilbes, & Roy Armstrong. (2004). Contaminant and Erosion Control Baseline Database for the Puerto Mosquito Watershed, Vieques, PR.
- Gilbert, F. S. (1980). The Equilibrium Theory of Island Biogeography: Fact or Fiction? *Journal of Biogeography*, 7(3), 209-235.
- Grupo Editorial EPRL. (May 27, 2009). *Espíritu Santo River*. Retrieved 02/24, 2010, from <http://www.encyclopediapr.org/ing/article.cfm?ref=08032808>
- Gurd, D. B., Nudds, T. D., & Rivard, D. H. (2001). Conservation of Mammals in Eastern North American Wildlife Reserves: How Small is Too Small? *Conservation Biology*, 15(5), 1355-1363.
- Halt to Puerto Rico's Northeastern Nature Preserve. (2009, November 2, 2009). *New York Times*, pp. A12.
- Higgs, A. J. (1981). Island Biogeography Theory and Nature Reserve Design. *Journal of Biogeography*, 8(2), 117-124.
- Holt, J. W., Desmarais, R. B., Aull, M. E., Trimbur, J., & Demetry, C. (2002). WPI IQP Report. PR06-44 *Land Use Recommendations and Feasibility Study for Punto Verde PT* <http://library.wpi.edu:7008/vwebv/holdingsInfo?bibId=251086>
- Howard, S. M. (1998). Land Conflict and Mayangna Territorial Rights in Nicaragua's Bosawás Reserve. *Bulletin of Latin American Research*, 17(1), 17-34.
- Jankowski, P., & Nyerges, T. (2001). GIS-supported Collaborative Decision Making: Results of an Experiment. *Annals of the Association of American Geographers*, 91(1), 48-70.
- Justo, S. (2005). A Critical Evaluation of Challenges to Marine Protected Areas in Puerto Rico.

- Jude, S., Jones, A. P., Andrews, J. E., & Bateman, I. J. (2006). Visualisation for Participatory Coastal Zone Management: A Case Study of the Norfolk coast, England. *Journal of Coastal Research*, 22(6), 1527-1538.
- Kerkvliet, J., & Langpap, C. (2007). Learning from Endangered and Threatened Species Recovery Programs: A Case Study Using U.S. Endangered Species Act Recovery Scores. *Ecological Economics*, 63(2-3), 499-510.
- Kingsland, S. E. (2002). *Creating a Science of Nature Reserve Design: Perspectives From History*. Netherlands: Kluwer Academic Publishers.
- Lawson, J., Davenport, J., & Whitaker, A. (2004). Barnacle distribution in Lough Hyne Marine Nature Reserve: A New Baseline and an Account of Invasion by the Introduced Australasian Species *Elminius Modestus* Darwin. *Estuarine, Coastal and Shelf Science*, 60(4), 729-735.
- Lomolino, M. V. (1994). An Evaluation of Alternative Strategies for Building Networks of Nature Reserves. *Biological Conservation*, 69(3), 243-249.
- Lubchenco, J. NOAA-National Oceanic and Atmospheric Administration - about NOAA. Retrieved 2/10, 2010, from <http://www.noaa.gov/about-noaa.html>
- Lugo, A. E. (1994). Preservation of Primary Forests in the Luquillo Mountains, Puerto Rico. *Conservation Biology*, 8(4), 1122-1131.
- McAlary, J. N., Kuzsma, R. C., Kling, M. T., Greene, C. G., Gerstenfeld, A., & Vernon-Gerstenfeld, S. (2001). *Biological corridors -- Promoting and Maintaining Biodiversity in Puerto Rico*
- Miller, R. I., Bratton, S. P., & White, P. S. (1987). A Regional Strategy for Reserve Design and Placement Based on an Analysis of Rare and Endangered Species' Distribution Patterns. *Biological Conservation*, 39(4), 255-268.
- Mitchell, Lee E. *Developing a GIS of the Bioluminescent Bays on Vieques, Puerto Rico* National Geospatial-Intelligence Agency. Retrieved from <http://proceedings.esri.com/library/userconf/proc04/docs/pap1018.pdf>
- Moilanen, A. (2006). Uncertainty Analysis Favours Selection of Spatially Aggregated Reserve Networks. *Biological Conservation*, 129(3), 427-434.
- NOAA. (2007). *Caribbean Coral Reef Fisheries Management Theme: Natural Reserves in Puerto Rico and USVINOAA*.
- NOAA. (2010). NOAA in your territory.



- Önal, H., & Yanprechaset, P. (2007). Site Accessibility and Prioritization of Nature Reserves. *Ecological Economics*, 60(4), 763-773.
- Paquette, A. M., Mezzone, C., McLaughlin, B. J., Levesque, I. A., Peet, R. C., & Garvin, A. (2006). *Conservation Analysis in The Municipality of Toa Baja, Puerto Rico*. Worcester, MA: Worcester Polytechnic Institute.
- Perreault, T. (1996). Nature Preserves and Community Conflict: A Case Study in Highland Ecuador. *Mountain Research and Development*, 16(2), 167-175.
- Pringle, C. M. (2001). Hydrologic Connectivity and The Management of Biological Reserves: A Global Perspective. *Ecological Applications*, 11(4), 981-998.
- PuertoRico.com. (2009). *Stunning Tortuguero Lagoon Nature Reserve*. Retrieved 02/24, 2010, from [www.puertorico.com](http://www.puertorico.com)
- R. Axelsson, & P. Angelstam. *Biosphere Reserve and Model Forest: A Study of Two Concepts for Integrated Natural Resource Management* Retrieved from <http://www.bmatlantida.org/documents/modelforestsbiospherereserves.pdf>
- Rhind, D. W. (2002). The History of GIS. *Geographic Information Systems and Science* (1st ed., pp. 21-22-43)
- Roberts, C. M., Bohnsack, J. A., Gell, F., Hawkins, J. P., & Goodridge, R. (2001). Effects of Marine Reserves on Adjacent Fisheries. *Science*, 294(5548), 1920-1923.
- Roberts, C. M., Hawkins, J. P., & Gell, F. R. (2005). The Role of Marine Reserves in Achieving Sustainable Fisheries. *Philosophical Transactions: Biological Sciences*, 360(1453, Fisheries: A Future?), 123-132.
- Robinson, E. G., Pelligrino, J., Filipe, D. V., Cleveland, B., DeMarco, A. J., & Peet, R. C. (2006). *Ecosystem-based Management in Puerto Rico*
- Russ, G. R., & Alcalá, A. C. (2004). Marine reserves: Long-term Protection is Required for Full Recovery of Predatory Fish Populations. *Oecologia*, 138(4), 622-627.
- Schulte, L. A., Mitchell, R. J., Hunter Jr., M. L., Franklin, J. F., Kevin McIntyre, R., & Palik, B. J. (2006). Evaluating the Conceptual Tools for Forest Biodiversity Conservation and Their Implementation in the U.S. *Forest Ecology and Management*, 232(1-3), 1-11.
- Slocombe, D. S. (1992). The Kluane/Wrangell-St. Elias national parks, Yukon and Alaska: Seeking Sustainability Through Biosphere Reserves. *Mountain Research and Development*, 12(1), 87-96.

- Weaver, P. L. (1994). *Baño de Oro Natural Area Luquillo Mountains, Puerto Rico* No. SO-111). New Orleans, Louisiana: United States Department of Agriculture, Southern Forest Experiment Station.
- Wright, D. J., Goodchild, M. F., & Proctor, J. D. (1997). GIS: Tool or Science? Demystifying the Persistent Ambiguity of GIS as "Tool" Versus "Science". *Annals of the Association of American Geographers*, 87(2), 346-362.
- Wright, S. J., Sanchez-Azofeifa, G. A., Portillo-Quintero, C., & Davies, D. (2007). Poverty and Corruption Compromise Tropical Forest Reserves. *Ecological Applications*, 17(5), 1259-1266.
- Young, E. (1999). Local People and Conservation in Mexico's El Vizcaino Biosphere Reserve. *Geographical Review*, 89(3), 364-390.

## Appendix A: GIS Tutorial

GIS Tutorial:

The Basics

By, Stephen J. Esposito

This document was created using tutorial videos provided by Professor LePage of the CEE Department and on version 9.3.1 of ArcMap

### Getting Started

To begin using the GIS ArcMap program, locate it within the programs file under the start menu, or if there is a desktop icon double click that. A note to students that may wish to look at the program before going to Puerto Rico; make sure to use one of the computers lining the wall in Kaven 216. The other computers do not have the program installed. Upon opening the program you will be presented with three options. Those options are as follows; start a new map, open a template, or open an existing project. You may find that your employer may have several templates set up already on your topic, but that information can only be found out through contact with those who work with GIS in Puerto Rico.

No matter what option you choose it is important to understand what the program will do for you. Somewhere, usually as a pop up, a tools toolbar will open up. That toolbar is very self explanatory. Some things to note are the button below the back arrow. This allows you to select specific portions of the map, and using shift click will allow you to select multiple. This will also select that information within the attributes table. In the table a button called selected will narrow the table down to the areas selected. The Identify tool under the features tool, will give specific information for that part of the graph as described by the file opened. To apply labels to your map, right click on the file name and click on label features. To change which column is labeled, you must go into the properties of the file. That will be described later. At the top of the screen, or at least in version 9.3.1, there will be a large drop down menu with a button next to it. Should you be starting a new map that menu will

be deactivated. The button next to it will allow you to add data to your map. It is very possible that that button may not be mapped to the correct storage location within the servers. Should that happen contact someone within the department. On campus should you wish to look at the program beforehand that location is \\student\courses\CE\_GIS\Project Files.

## **Adding Data**

Where ever you happen to connect that folder to there will be two types of files that you will be mainly looking for. Those are shape, .shp, or layer, .lyr, files. A shape file will create the map. For instance the shape file in the TIGER Town Boundaries folder at WPI will create a map of Massachusetts and the townships within it. That file then becomes a layer in the GIS program, which can be seen and organized on the left most part of the screen. The layer files and how to use the layers will be discussed later.

The shape file actually contains another file within it. That file is a .dbf file, which is like an excel file. To access the dbf file right click on the name of the shape file and click open attributes table. This will access the dbf file within the shape file. It is very possible that you will have to create these files and the tutorial will only cover how to edit those files. Creation of a dbf file will require further training that you may or may not be able to acquire before leaving for Puerto Rico. You can see that there are many columns of data in this file. Each one is an attribute and means something toward the map created. In the shape file discussed you will be looking at census data, town size, etc.

## **Symbology**

The main reason to use GIS is the symbology function. This is what will display the data you collect and show how it is mapped and divided over the geography. The tutorial adds a second layer to the current map. You can have many layers on a map, but not all of them have to be active. For this tutorial the new layer

can be found in project files under Census 2000 Block Groups. You should notice that the new data covers up the old data, replacing the color pink with yellow. If not then it was changed and you can change the color by double clicking the color box under the file.

The layer that appears on the top of the layer list on the left side of the screen is the layer that will be shown. To see one layer on top of another, such as with the map just opened, you can click on that color box, make the color hallow, and then add an outline to the data. Here the new data is changed to hallow with a red outline. Now you can see the blocks outlines with the bottom layer. What this has done is divided the map further into new areas, with more data within that shape file. To turn a layer off, you can click the check box next to the data you want to remove. You can remove a layer completely but you may wish to use it later, so best to leave it turned off.

To specify certain data within your dbf, or table of data that makes up your map, you have to go into the properties of the file. There is a tab labeled symbology. Here you will see that the data for the pink data is listed as having a single symbol. What this tutorial talks about is the categories feature in that tab. Here the program will sort the map based on the data within the dbf file. This tutorial sorts the data by population change from 1990 to 2000. Select that value field and hit add all values. This shows a few things. One is that it tallies up the number of data points, showing that there are 351 communities within Mass. It gives automatic colors to data but you can customize any data with any color you wish. The problem here is that each color relates to a specific value and is not helpful. To rectify this there are a couple of options. By selecting the gradient color ramp, green to red, the data is sorted by similarities. This allows the data to be viewed and understood much better, suggesting that the greener areas are losing population, and the redder areas are growing. However this is still vague. By going down the quantities selection we can organize the data through ranges. Again select the pop change from 90-00 and use the red to blue color ramp. This will break up the data into 5 or so ranges, and reveal a greater amount of information about the population growth. This may be useful in Puerto

Rico, while you may not be using population, you may have a density, which is what population looks at.

The ranges that the data takes are suggestions; this can be changed at anytime by you. Click on the range you wish to change and edit its upper limit. Here the red range is changed to -2000. This will automatically edit the lower limit on the range below it. The second range was changed to have a upper limit of 0. Now the red and yellow show decrease in population, while the greens and blue show varying levels of increase. All of these changes and data can be seen under the file on the side bar. This acts as your legend, and will not only describe the map to you but people who work with your map. The tutorial then edits the upper limits of the next 3 ranges to be 5000, 10000, and the upper limit of the data 14674.

There are other ways to look at data, but these are the most popular. You may be required to do more, but this tutorial does not cover that. It is important to note that this tutorial uses all census data because the data is unified. Once you begin to start mixing data from different sources, there may be gaps and incomplete information in your map, which will lead to problems. Your employers should have their own library of information, and would be better able to guide you toward which data is incompatible.

## Layer Files

Now this tutorial adds in the TIGER roads layer along with the shape file that is in the folder. The purpose of this is to show how to import a symbol. In the symbolgy tab in the properties of the roads shape file you will see an import option above the box where the color, or line in this case is. There are 2 options here, the second is for data from older versions of ArcGIS, versions 3 and below I believe. If you wish to look at multiple fasciitis of information from you dbf file you can copy the file, add that as another layer, and make a new symbology using other data within that same file, while not losing the old map and layer. Should you wish to edit or add data to an existing dbf, you must click on tools, then edit, then select the file you wish

to edit. You can do this manually, or if you have an excel file set up you can copy values over to ArcGIS.

## **Layout**

The layout view will allow you to see what the map will look like when printed, add a scale for the map, and a title for the map. It is important to note that these tutorials are designed to get the CE 3070 class of A09 through specific homework assignments, but the information provided will give you a basic understanding of how the program functions and what it produces. Your employer will better be able to show you what they are expecting, where to find it, and how you should go about making such a map.

## Appendix B: Map of Reserves Locations'

This map shows the location of the five reserves out group will be concentrating on. It was created using Google Earth.



Figure 10: Location of Five Reserves



## **Appendix C: Library of Acronyms**

DRNA: Department of Natural and Environmental Resources

CZMP: Coastal Zone Management Plan

NEC: North Eastern Ecological Corridor

NOAA: National Oceanic and Atmospheric Administration

EQB: Environmental Quality Board

RPA: Regulations and Permits Administration

USFWS: United States Fish and Wildlife Service

GIS: Graphical Information System

BPMN: Bosque Protector Mindo y Nambillo

NGO: Non-Governmental Organizations

PRPB: Puerto Rico Planning Board

EPA: Environmental Protection Act