CONNECTING PEOPLE WITH RIVERS TO IMPROVE WATER QUALITY AT RIO GRANDE DE AÑASCO WATERSHED, PUERTO RICO

By

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ABSTRACT

CONNECTING PEOPLE WITH RIVERS TO IMPROVE WATER QUALITY AT RIO GRANDE DE ANASCO WATERSHED, PUERTO RICO

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Puerto Rico's water quality is currently in relatively poor conditions. Because many of these impacts are anthropogenic in nature, we need to couple social and natural systems in order to make improvements in land and water use. In this research, I address the nature of water quality issues at a western watershed in Puerto Rico through understanding farmers' behaviors. Specifically, I assessed, using a survey, what motivates local farmers to engage in conservation practices. The survey was implemented in two municipalities (Añasco and Las Marias) of the Rio Grande de Añasco watershed to 31 farmers. The survey demonstrated that farmers at Las Marias have a significantly greater place attachment than those in Añasco. However, the analysis did not depict that there was a significant relationship between "place attachment" and "environmental behaviors" (Spearman correlation (r_s)=-0.06 p-value=0.74). There was a statistical significance between "social bonding" and "pro-environmental behaviors" (r_s=0.32 p=0.08) and between "general connection to nature" and "behavioral intentions" (r_s=0.21 p=0.09). To improve the water quality in Puerto Rico in these predominately farming communities, management agencies should focus on strengthening the social attachments between citizens and educate them about how their actions while farming influences the water quality in nearby rivers; which serves as their primary source of drinking water. Such actions will likely promote peoples motivation to participate in pro-environmental behaviors and therefore enhance water quality in the watershed.

This thesis is dedicated to my parents Carlos and Lillian. This would have not been possible without the constant support from my mother, thanks for being a great field partner, and the moral and loving support of my father.

….. and to my daughter, Lara Sofia, which has and will always be my focus and motivation.

Los amo!

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Water is an importance source of life, and with current anthropogenic stressors many of our surface waters are being threatened for human use and aquatic life. Puerto Rico's water are no exception, with the 305(b)/303(d) 2012 Integrated Report (PREQB 2012) stating that many of the island's surface water (52%) do not meet at least one of the Commonwealth's water quality standard. In this research, I focus on Rio Grande de Añasco watershed, a watershed located in western Puerto Rico, which had been found to not meet turbidity and dissolved oxygen standards regulations in 2010 and 2011. This watershed has been describe by the Puerto Rico Environmental Quality Board to be 1) high priority due to its impairments 2) an important source of potable water for the area, and 3) as it discharges into the Mayaguez bay is influencing the near shore marine water quality.

The USDA NRCS implemented an initiative, National Water Quality Initiative (http://www.pr.nrcs.usda.gov/programs/pubs/CB_NWQI_FactSheet.pdf), which attempts to engage farmers and landowners in conservation practices in order to reduce water quality stressors on high priority rivers in United States and its territories. Due to Rio Grande de Añasco watershed degraded surface water's characteristics, this river was selected for inclusion in this initiative. In this research, I assessed, through a model created using past research, whether place attachment, general connection to nature, and concern about water quality motivates farmers to engage in conservation practices that would improve the watersheds water quality.

This thesis is composed of two primary chapters. In chapter one, I describe water quality in Puerto Rico emphasizing in Rio Grande de

Añasco watershed, how agricultural practices could impacts these waters, and discuss the NRCS USDA Water Quality Initiative. In second chapter, I focus on my findings of the stewardship behavior of the local farmers in the watershed and what are the factors that could motivate people to participate in pro-environmental behaviors, which may improve the water quality of rivers in Puerto Rico.

CHAPTER I

Puerto Rico's general land use and water quality background

"We abuse land because we see it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect" – Aldo Leopold (1949)

Water is an important resource, not only for ecosystems, but also for humans and other organisms. Increase human population numbers and human consumption patterns, coupled with landuse and climate change are major influences on health of these ecosystems. Worldwide, water availability is currently threatened not only due to its scarcity (Vörösmarty, Lévêque, and Revenga 2005) but also due to pollution (Vörösmarty et al. 2010, Vörösmarty et al. 2005). The reduction in water quantity and quality thus not only threaten direct human water use, but also the ecosystem services that freshwater provides, such as recreation, fisheries, aesthetic, transportation, biodiversity, and spirituality (Vörösmarty et al. 2005).

Many current water threats are caused by anthropogenic activities, such as development and agriculture. As such, conservation approaches need to not only be understood in relationship to the direct impacts that these activities have on water, but also on how humans perceive, relate to, and value their ecosystems and ecosystem services. Understanding how humans relate to and value their ecosystems will assist conservation and management programs better engage citizens on the management of their natural resources and address environmental problems (McKinley and Fletcher 2012). Such understanding may shift behavioral intentions to more environmentally responsible behaviors (Kollmuss and

Agyeman 2002; Shofoluwe and Sam 2012) leading to the adoption of practices that will have reduce impact on the environment (Kollmuss and Agyeman 2002).

With increase threats to water there is an interest to reduce future impairments to water resources by incorporating change in land use activities. Protecting water quality in agricultural watersheds is a major concern due to impairments caused, for example, from high nutrient input from fertilizers (Sharpley, Foy, and Whiters 2000, Larsen and Web 2008) and sedimentation (Larsen and Webb 2009). The reduction of water stresses from agricultural activities is generally in the "hands" of farmers and the way they manage their land (Ryan, Erickson, and Young 2003). Because of this, federal and commonwealth agencies have an interest on engaging farmers in conservation practices. For example, in 2012 the United States Department of Agriculture' Natural Resource Conservation Service (USDA NRCS) implemented a new initiative named the National Water Quality Initiative. This Initiative aims to help landowners, farmers, and ranchers participate in conservation efforts, such as providing filtering strips and creating terraces which hopefully shifts behaviors to more sustainable land use practices, and improves water quality in their nearby aquatic ecosystems. The focus of these programs is in watersheds that are considered "impaired" (e.g. do not meet at water quality standards for a designated use) or a "priority" (identified as priority by local partners and state water quality agencies) in the United States or Puerto Rico (USDA n.d.). The initiative shares conservation practices installation costs after visiting the farm and selecting the best conservation practices for that particular farm. In order for this initiative to be successful, individuals living in the watershed need to be willing to adopt new conservation practices that ultimately should improve land and water conservation.

The focus of my research takes place in Puerto Rico, where there are many factors negatively impacting water quality, such as non-existent or damage septic tanks, sanitary sewer overflows, urban runoffs, industrial point sources pollution, animal feeding operations, and agriculture run off. The specific objectives of this study were to (1) describe the agricultural impacts of nutrient input to waterways Puerto Rico, and (2) assess farmer's place attachment and their willingness to participate in conservation practices in a selected watershed in the western side of Puerto Rico, where the major river has been consider to be impaired by the USDA and Puerto Rico Environmental quality board. This, in order to address water quality issues through understanding human behavior

1.1 Puerto Rico's general land use background information

Puerto Rico is the smallest island of the Greater Antilles (Figure 1), measuring 100 x 35 miles. The human population on the island is relatively high, 3.973 million people as determined in the 2010 US census. Most of the human population on the island (70%) lives in coastal municipalities (US Census Bureau 2010).

The topography of Puerto Rico is characterized by having steep and narrow valleys, relatively short stream lengths, and high channel gradients (Lopez and Villanueva 2006, Larsen and Webb 2009). These characteristics when coupled with the intense rainfall that occurs on the island and the land use changes due to the growing populations, promotes sediment and nutrients to runoff from the land into rivers and streams (Larsen and Webb 2009).

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Figure 1. Localization of Puerto Rico in the Caribbean.

Up until late 1950's Puerto Rico's economy was primarily based on crop based agriculture (such as sugar cane, coffee, and tobacco)(Lopez and Villanueva 2006) whose growth caused extensive deforestations on the island. Puerto Rico up to this time had gone through intense deforestation leading the island to have only 6% of its initial forest still standing, the lowest percent of forest cover that has had ever been recorded for Puerto Rico (Lopez and Villanueva 2006). This trend of deforestation and increased agriculture lands decreased after 1950's, when "operation bootstrap", a United States of America program design to enhance Puerto Rico's economy, shifted the agricultural based economy to an industrialize and

manufacturing based economy (Zetterstrand 2001, Hunter and Arbona1995). Relatively cheap labor coupled with tax exemptions and other economic incentives promoted by the new initiative, coupled with relatively low enforcement of environmental protection, were amongst the things that attracted industries to the island (Zetterstrand 2001, Hunter and Arbona1995). In turn, the shift from agriculture to an industrialized economy, promoted the migration of individuals from the rural areas of the island to the developing municipalities (Hunter and Arbona 1995). Coastal urbanization increased rapidly after the 1950's (Figure 2). A result of this urbanization of Puerto Rico has been an increased reforestation rate in the once agricultural lands that were abandoned (Lopez and Villanueva 2006). As such, Puerto Rico has seen almost 60 years of forest regeneration. Nevertheless, urban sprawl has provided a new threat to forest cover in the island by promoting forest fragmentation (Lopez and Villanueva 2006).

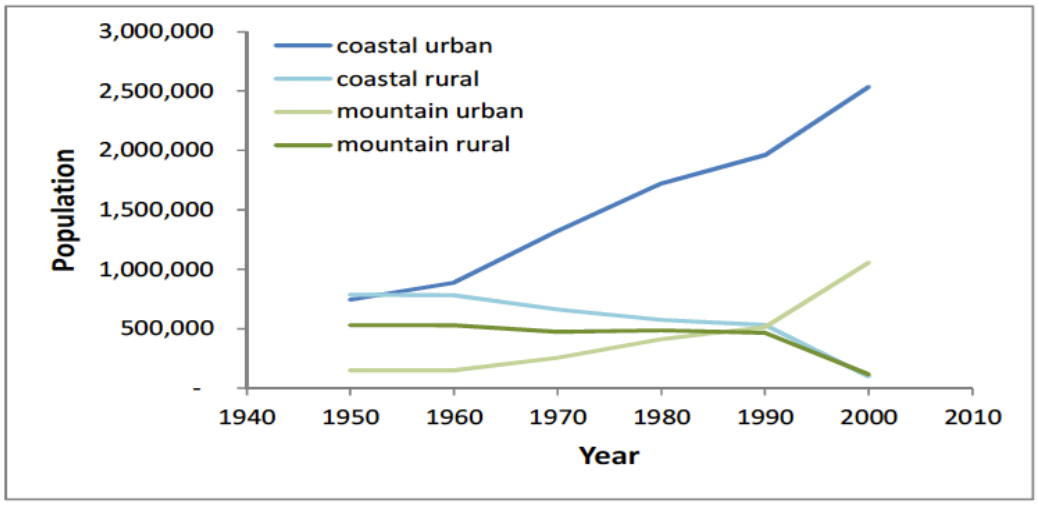
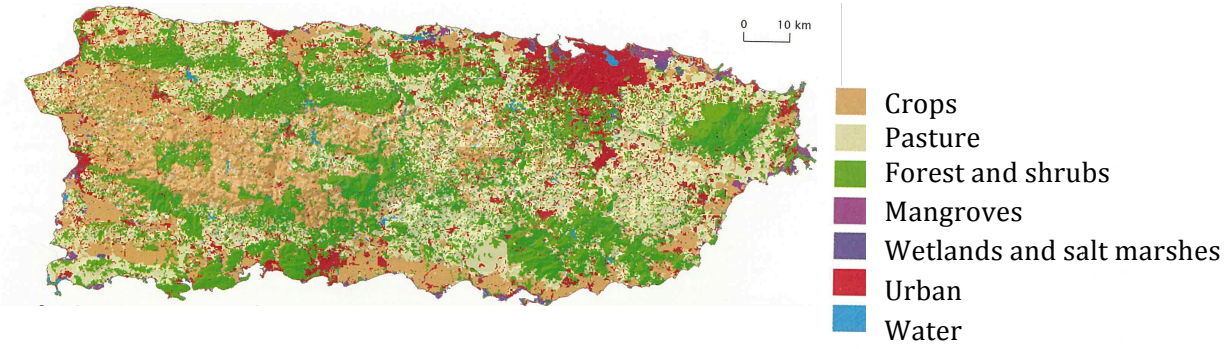


Figure 2. Coastal and mountain population growth from 1950's to 2000

Land use maps (Figure 3) show the increase of both reforestation and urbanization on the island (Lopez and Villanueva 2006). In 2012, compared to 1940 and 1950's, Puerto Rico depends mostly on manufacturing (such as pharmaceuticals, chemicals, machinery, and

electronics) as opposed to agriculture (predominant in the 1940's) followed by the financial, insurance and real estate sectors, (20.6%), service sectors (12.5%) government sector (8.2%), trade (7.6%) transportation and other public services (2.7%) construction and mining (1.5%) and finally agriculture with 0.8% total net income (Puerto Rico Planning Board 2012).

Land use map 1977-1978



Land use map 1991-1992

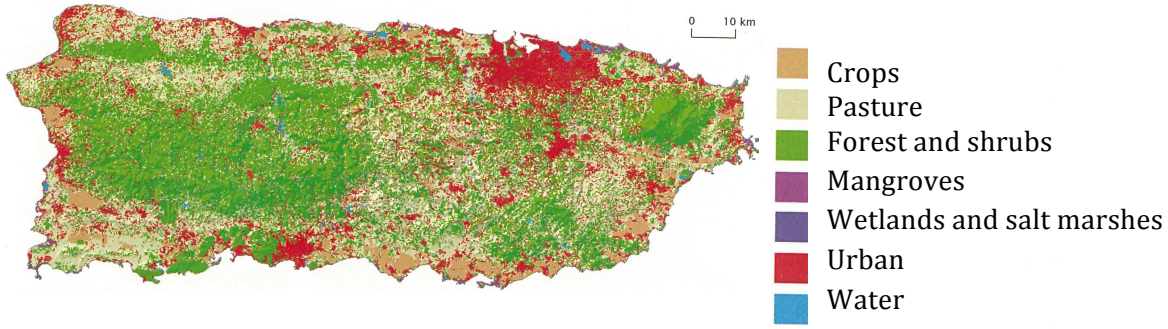


Figure 3. Puerto Rico's land use map 1997-1978 and land use map 1991-1992 (Lopez and Villanueva 2006)

1.2 Puerto Rico's water quality

Puerto Rico's Water Quality Standards Regulations (WQSR) provides the mechanism to maintain, preserve, and increase the water quality in the island in order to meet the requirements established by the Federal Water Pollution Control Act (commonly known as Clean Water Act). This WQSR establishes Puerto Rico's water designated uses that should be

maintained and protected and the standards that needs to be met for every designated use (Table 1).

Table 1. Description of designated used by the Environmental Quality Board

Designated use	Standards
Primary contact recreation (Direct Contact)	Primary contact recreation is considered where human contact is prolonged and direct contact with water, such as swimming and surfing (EPA 1994). To determine if the assessed waters fulfill the requirements for this designated, Fecal Coliform has to be less or equal to 200 colonies/100mL and 20% of the individual samples cannot exceed the value of 400 colonies/100mL. If it doesn't fulfill these requirements then is considered to be impaired for the designated use (Puerto Rico Environmental Quality Board (PREQB) 2012)
Secondary contact recreation (Indirect Contact)	Second contact recreation is considered to be any recreational activity, or other use, where contact is indirect (Eyes, nose, and ears are not immersed in the water), such as fishing or boating (EPA 1994, PREQB 2012). To assess if this waters fulfill the requirements for this designated use, total coliform bacteria is measured and has to be less or equal to 10,000 colonies/100mL or 200 colonies/100mL of fecal coliforms, and not more than 20% of the samples shall exceed 400 colonies/100mL of Fecal Coliforms. If the water does not fulfill the requirements then is considered to be impaired for secondary contact recreation (PREQB 2012).

Table 1 (cont'd)

Designated use	Standards
Aquatic life	Aquatic Life Support is the physical/chemical characteristics needed to support aquatic life. To assess this, various toxic parameters are taken in consideration, such as lead, copper, zinc, ammonia, pesticides, cyanide, amongst others harmful chemicals. The conventional parameters used for the assessment of aquatic life support were, dissolved oxygen, temperature, pH, and turbidity. For these parameters, a single violation of the standard was is enough to classify the segment as non-support for the aquatic life (PREQB 2012)
Raw source of potable water	To asses this, various toxic parameters where measure such as, arsenic, chlorides, mercury, nitrates + nitrites (NO3 + NO 2), total phosphorous, turbidity, amongst others water quality indicators (PREQB 2012)

The WQRS also classifies Puerto Rico's waters in the following classes (PREQB 2012):

1) Class SA: Coastal and estuarine waters of high quality for ecological or recreational values. The conditions present in these waters should be protected and preserved.
2) Class SB: Coastal and estuarine waters with primary and secondary designated uses, and aquatic life. Waters that are not Class SA or SC are considered Class SB.
3) Class SC: Segments of coastal waters designated for aquatic life, primary contact recreation from the zone of mean sea level to 3 miles seaward, and secondary contact recreation from 3 miles seaward to 10.35 miles seaward.

4) Class SD: Surface waters designated as raw source of potable water, aquatic life, and primary and secondary contact recreation.
5) Class SE: Surface water and wetlands with high ecological value. The conditions present in these waters should be protected and preserved.

Puerto Rico has 96 major basins for which twenty-two are constantly monitored by stations operated by the United States Geological Survey. These stations assess key water quality and quantity parameters such as temperature, flow, pH, dissolve oxygen, nutrients, among others water quality parameters. The data is collected in order to monitor the changes in water quality conditions on the island and evaluate current pollution control approaches (PREQB 2012).

Every two years the EPA, in collaboration with the Puerto Rico Environmental Quality Board (PREQB), publishes a document entitled 305(b)/303(d) Integrated Report, where Puerto Rico's water quality is assessed (PREQB 2012). The 2012 report states that 52% of 5,052.8 miles of rivers and streams assessed failed to meet at least one of the quality standards established for designated uses, while only 6% of streams and rivers assessed met all the quality standards for all designated uses (PREQB 2012) (Figure 4). This means that many rivers do not meet the conditions to support primary contact such as swimming, and do not meet the optimal physical or chemical conditions needed for aquatic organism's survival or growth (PREQB 2012). According to this document, these impairments are due primarily to; turbidity, fecal coliforms, and low dissolve oxygen (Figure 5). The sources for these impairments are mostly due to damaged or non-existence septic tanks in the local communities, run off from animal feeding operations, urban runoffs, industrial point source pollution, run off from agriculture lands, sanitary sewer overflows, and municipal point sources (Figure 6)(PREQB 2012).

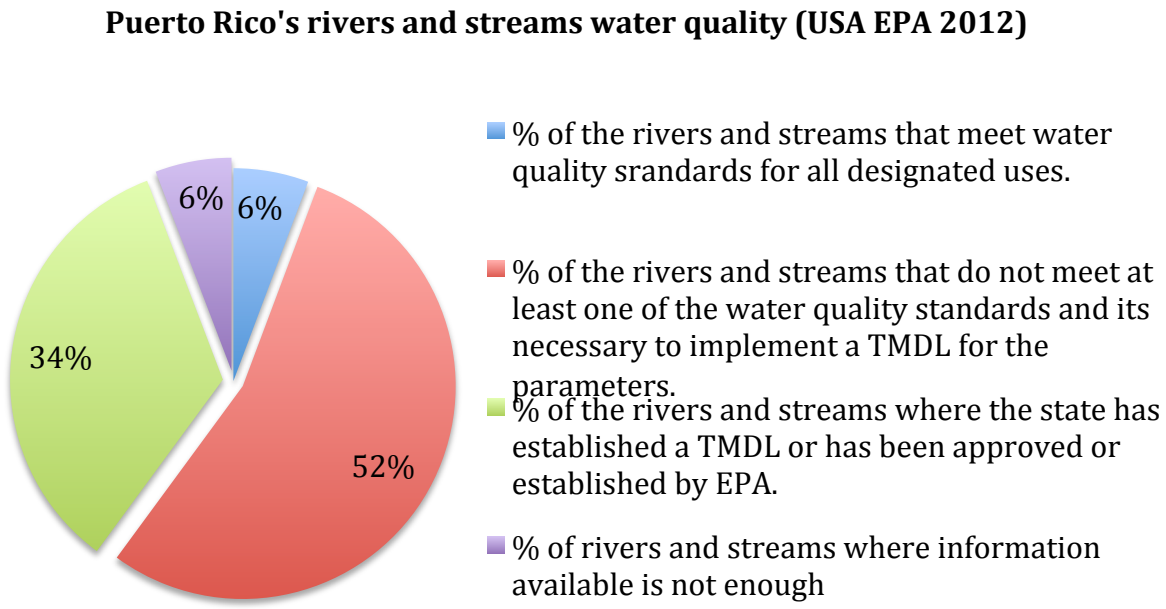


Figure 4. Puerto Rico's general river and streams water quality conditions in 2012.

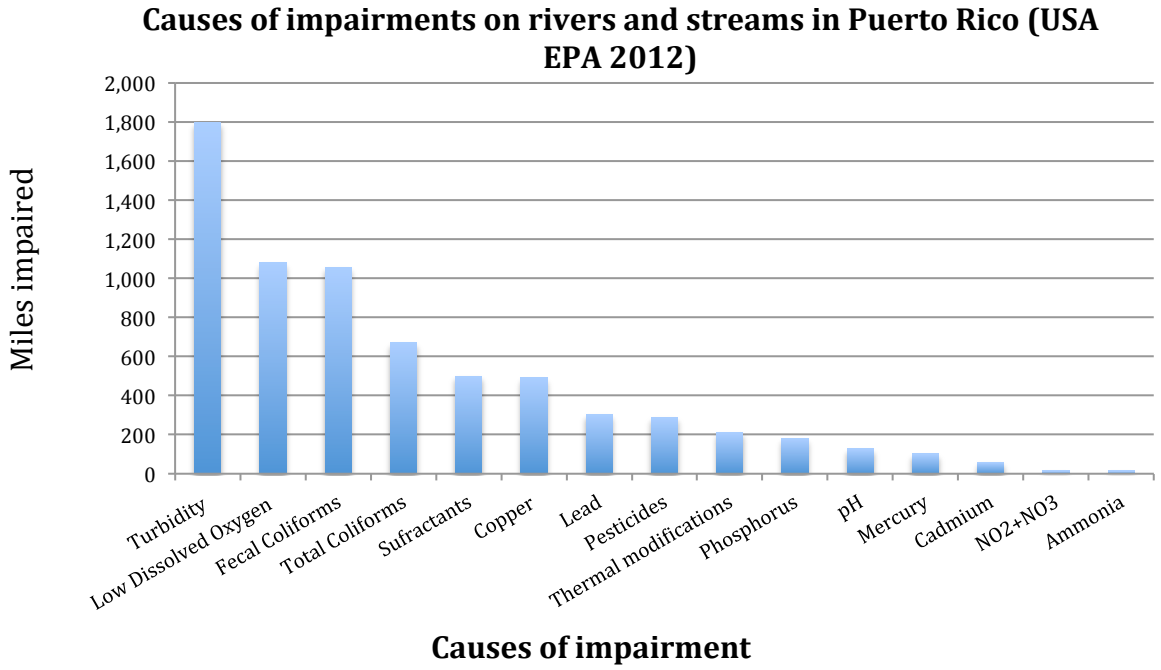


Figure 5. Causes of water quality impairments (miles) on rivers and streams assesses in Puerto Rico (PREQB 2012)

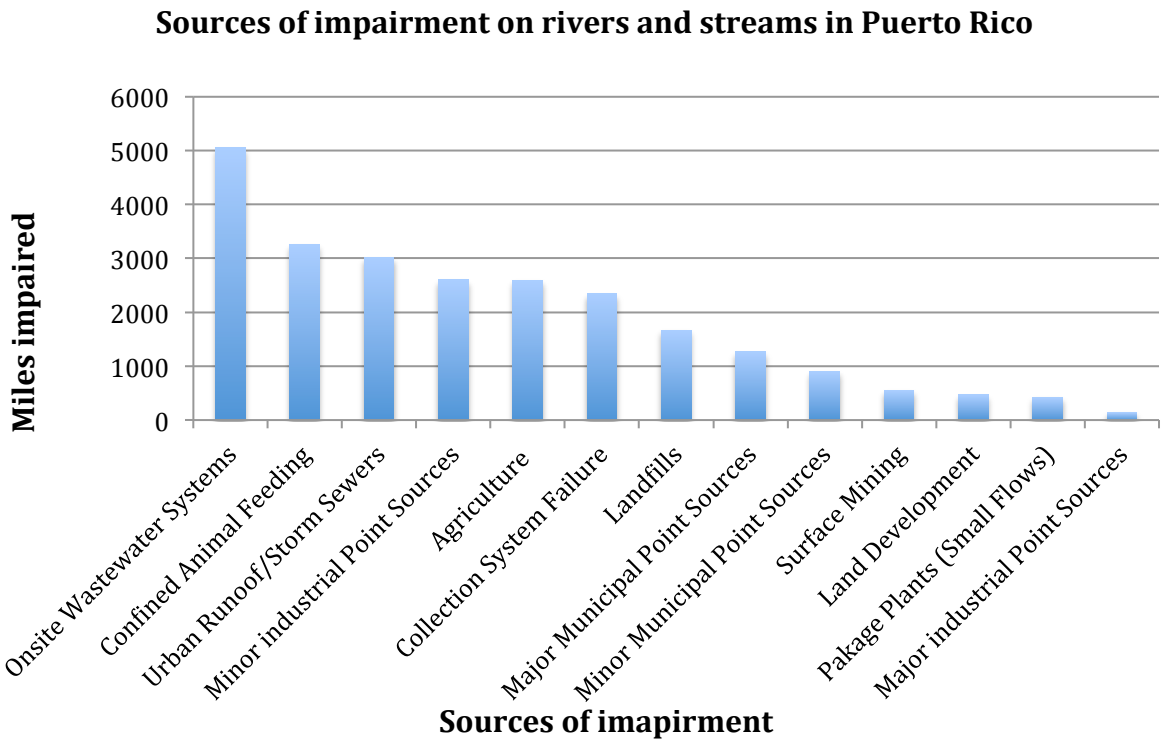


Figure 6. Sources of impairment (miles) on rivers and streams assessed in Puerto Rico (PREQB 2012)

For coastal waters, the 2012 Water Quality Assessment Report states that from 546.63 miles of coastal water 4.45% are designated for all uses, while 44.21% have insufficient data to make any determination for at least one of the designated uses, and 51.34 % are considered to be impaired (Figure 7)**.** The report also stated that the impairments for designated use of primary contact recreation in coastal waters was due to violation to water quality standards of fecal coliform and enterococcus. The impairment for the designated use of aquatic life are due to low dissolved oxygen, turbidity, pH, and temperature (PREQB 2012).

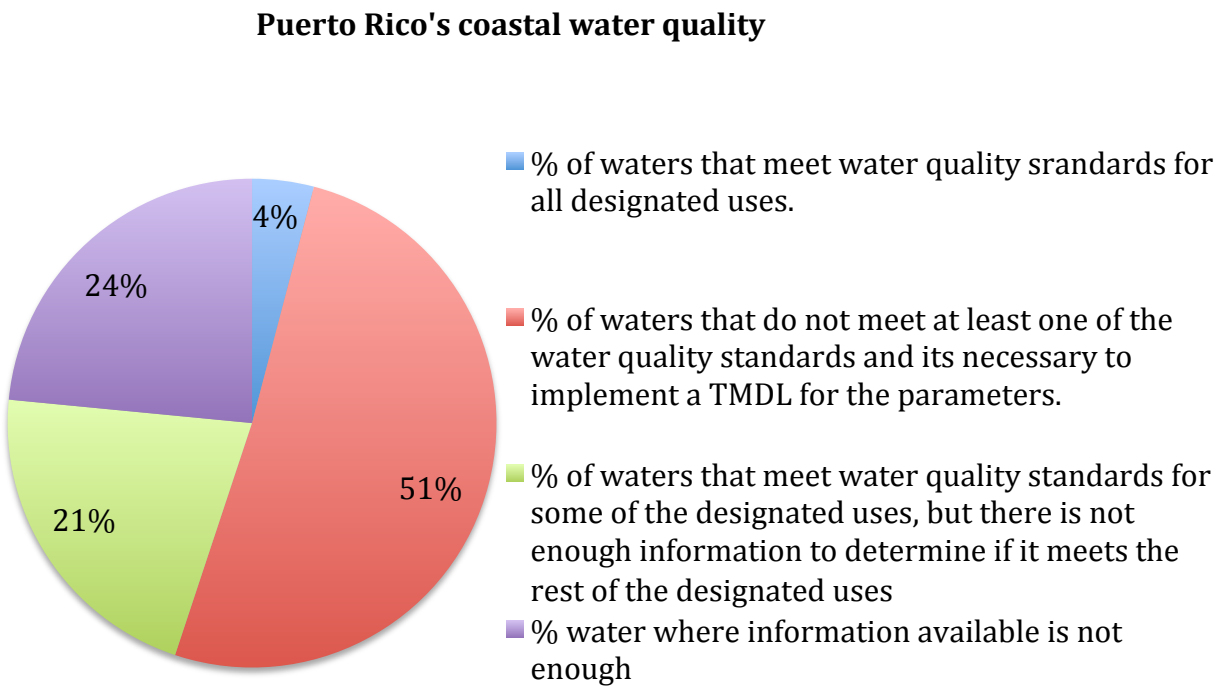


Figure 7. Puerto Rico's general coastal water quality conditions in 2012.

1.3 Puerto Rico's water management

Puerto Rico's water management is overseen by various agencies with different and sometimes overlapping responsibilities. The large number of different agencies, engaging in the island's water management, sometimes, creates difficulties when interagency cooperation is needed. The Puerto Rican Department of Natural Resources and the Environment (DNRE), established in 1972, is in charge of the management and conservation of the island's water (rainwater and runoff, superficial water, ground water, coastal and estuaries), through the Water Law #136 of 1976(Law for the conservation, development, and use of Puerto Rico's water resources) and the Integral Water Plan (DRNA 2007)**.** Although the DNRE is in charge of overseeing the island's water resources, there are other local and federal agencies and laws

that intervene in the management, use, and conservation of the island's water. Some of them include:

- The Environmental Quality Board (EQB) (1970) whose main function, through Law #146 of 2004, is to "protect and conserve the environment using, wisely and judiciously, the necessary resources to prevent and eliminate what may affect it, maintaining a balance between the environment and economic development". This agency is responsible of seeking the attainment of designated uses established in the Puerto Rico's Water Quality Standards Regulations. In collaboration with the United States Environmental Protection Agency (USEPA), they establish laws and regulations to control waste and substance loads that alter water quality (EQB 2014).
- The Aqueduct and Sewer Authority (ASA), established in 1945 through law #40 of 1945, is a public corporation whose role is to provide Puerto Rican communities potable water and sanitary sewer (AAA 2014). They served 97% of the island population. Most of the water produced by the ASA comes from reservoirs. (AAA 2014)
- The Electric Energy Authority (EEA), established in 1941, manages the reservoirs and irrigation systems under their jurisdiction (AEE 2014). By year 2013 they operated 11 reservoirs (DRNE 2004) where neither the ASA nor the DNRE can intervene.
- The Health Department (HD) oversees potable water through delegation of the EPA and Federal Law of Secure Potable Water (1970) and Law # 5 of 1977. They are in charge to establish and monitor the maximum levels of contaminants that potable water can contain (AAA 2014)

- Army Corps of Engineer was established in Puerto Rico in 1905. This agency is in charge of the design, construction, and operations of reservoirs, canals, and coastal zone improvements related to erosion control and navigation in the island. Jointly with the DRNE they regulate and provide permits related to the Clean Water Act (Torres 2004).
- United States Environmental Protection Agency (USEPA), is the agency responsible to ensure that water quality meets the regulation stated by the Water Clean Act of 1977. The agency also overlooks the disposition of solid waste, toxic and dangerous substances, and others.
- Nature Resources Conservation Services (NRCS), previously known as Soil Conservation Service, is part of the US Department of Agriculture. This agency is in charge of providing assistance to land users to deal with natural resource challenges such as erosion control, sedimentation, and flooding, and help them in maintaining and improving their economic viability. (USDA 2014)
- The United States Fish and Wildlife Service (USFWS) and United States Forest Service (USFS) also have indirect measure for the management of water in Puerto Rico, for example; in national reserves such as el Yunque the USFS regulates the use of the waters.
- The United States Geological Survey (USGS) is in charge of operating the long-term water monitoring stations through the island (PREQB 2012).

1.4 Rio Grande de Añasco watershed background and land use information

Rio Grande de Añasco (RGA) watershed, which occupies an area of 181 mi^2 (488.6 miles) (PREQB 2012), is located in central and western Puerto Rico within the municipalities of Lares,

Las Marias, Maricao, Mayaguez, Adjuntas, Yauco , San Sebastian, and Añasco (Figure 8). The highest elevation on the RGA watershed is 1,200 meters above sea level, while the lowest is the river's outlet (DRNE 2010). The watershed is composed of 90% mountainous areas with the remaining terrain being at sea level (Federal Emergency Management Agency 2012)(Figure 9). As is true for the rest of the island, most rainfall in RGA watershed occurs between August and December. Annual precipitation in this watershed varies between 108 inches in the mountainous area to 66 inches on the coastal valley.

Figure 8. Municipalities at Rio Grande de Añasco Watershed

Figure 9. Elevations at Rio Grande de Añasco watershed. We can observe that Añasco has a valley area, while the rest of the watershed has different and higher elevations.

The watershed is the 5th largest watershed on the island measuring 488.6 miles (Figure 10) and consisting of 269,207 inhabitants between the 8 municipalities (Census 2010). Mayaguez has the largest population with 89,080 inhabitants, while Maricao has the smallest population with 6,276 inhabitants (Census 2010). As stated in the 2010 Puerto Rico's Census report, the human population in most of the municipalities in this watershed has decrease since 2000, except with a slight increase of 200 people in Adjuntas and an approximately 1,000 increase in Añasco municipality (census 2010).

Agriculture in this watershed is diverse. In the coastal municipalities of Mayaguez and Añasco, plantain agriculture is the common crop. Meanwhile, in the mountainous areas we can find gourmet coffee plantations, oranges, small plantain farms, amongst other small crops.

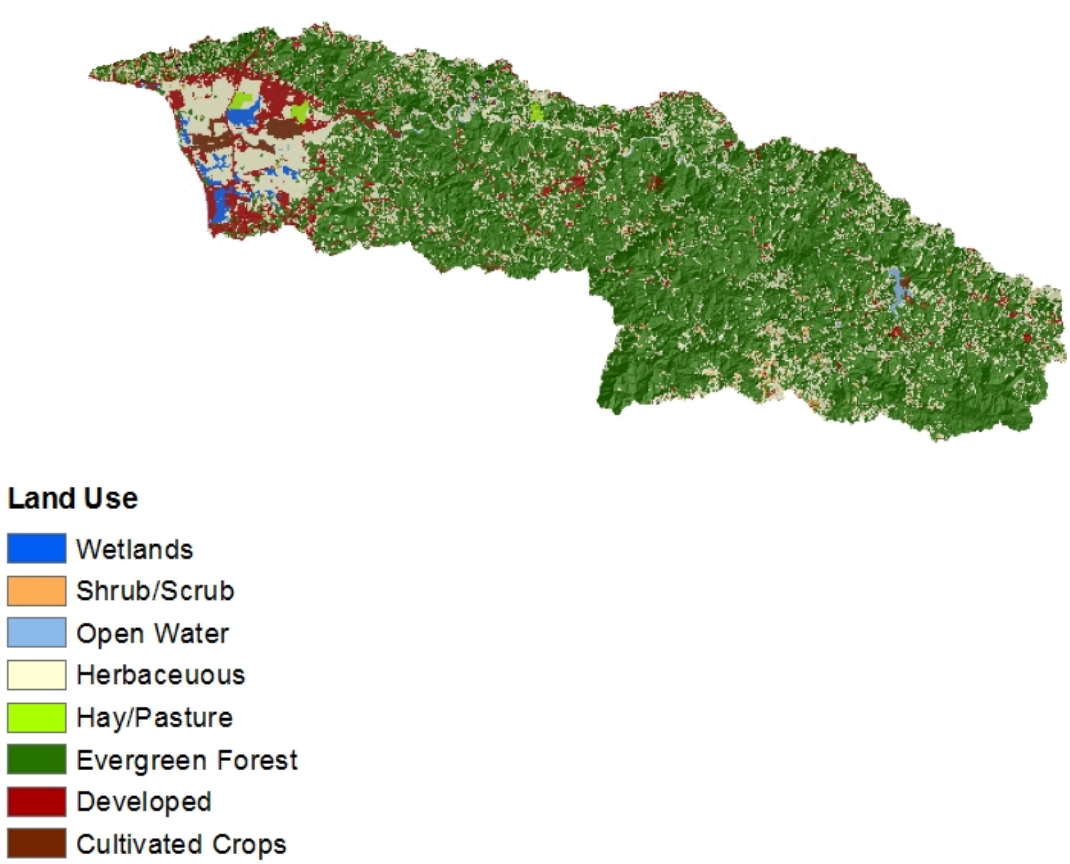


Figure 10. Rio Grande de Añasco Watershed Land Use in 2001.

In this research, I focused on two municipalities from the Rio Grande de Añasco watershed; Añasco and Las Marias. We selected these two municipalities because these are the only two municipalities that are completely within the RGA watershed.

Añasco is the coastal/valley municipality of the Rio Grande de Añasco watershed, which has the outlet of the Rio Grande de Añasco to the Mayaguez bay. This municipality has approximately 29,261 inhabitants (Census 2010), an increase of 1,000 people compared to data reported from the census in 2000. The same trend is seen in the agriculture census, where there was a slight increase in number of farms. The Agriculture Census of 2012 stated that there were 166 farms in 2012 and 146 farms in 2007, this represents a 12.82% increase of farms

in this municipality. The average farm sizes in the coastal valley municipality was 58 acres, with a total of 9,635 acres being farmed in 2012. From the 9,635 acres planted in Añasco in 2012, there were, for example, 473 acres of plantain crops compared to 610 acres in 2007, and 38 acres are of oranges crops; a decrease from 107 acres in 2007. On the other hand, coffee plantations have increase from 140 acres in 2007 to 214 acres in 2012 (Census 2012).

Las Marias municipality, with city slogan "the city of the sweet orange", is located in the mountainous area of the Rio Grande de Añasco watershed. The 2010 Census states that this municipality has approximately 9,881 inhabitants, compared to 11,061 in 2000, a decrease of approximately 2,000 people. The same trend is seen in the agricultural census, with a decrease from 404 farms in 2007 to 299 farms in 2012; a 29.87% decrease of farms. The average farm size in this municipality was 25 acres, with a total of 7,347 acres in 2012. Coffee plantations make up most of the land farmed at Las Marias, although it has decrease from 2,204 acres in 2007 to 1,512 acres in 2012, plantain crops was next most farmed with 470 acres in 2012 while oranges crop farm land increased from 478 acres in 2007 to 756 acres in 2012 (Agricultural Census 2012) (Table 2).

Table 2. 2012 Agriculture census information

	Añasco		**Las Marias**	
	2007	**2012**	**2007**	**2012**
Total farms	146	166	404	299
Total acres	6,492	9,635	7,734	7,347
Acres planted with coffee	140	214	2,204	1,512
Acres planted with plantain	610	473	346	470
Acres planted with oranges	107	38	756	478

1.5 Rio Grande de Añasco Water Quality

The main river in the watershed is named "Río Grande de Añasco" (RGA) (Figure 11), which drains into the Mayaguez Bay and has a strong influence on its water quality. The river is 126 miles long and has 10 major tributaries (Río Humata, Río Arenas, Río Casey, Río Blanco, Río Mayaguecillo, Río Cañas, Río Guaba, Río Prieto, Río Guilarte, and Río Guayo) ranging from 13.3 to 79.9 miles long (PREQB 2012). The NRCS states that this watershed has impaired waters due to many pollutants that are related to agricultural activities, such as fertilizers, pesticides, manure, and pasture lands (NRCS 2012).

Figure 11. Main river at Rio Grande de Añasco Watershed

In the 2012 303(d)/305(b) Water Quality Report, the Rio Grande de Añasco was considered of high priority due to its impairments on primary and secondary contact recreation and aquatic life (Table 3). This river is consider Class SD, which means any surface water used as a raw source of public water supply, also waters that are important for the propagation and preservation of desirable species(including threatened and endangered species), and for primary and secondary contact recreation. In order to meet the Puerto Rico Water Quality standards for all the designated uses in Class SD waters, the river must meet the fallowing criteria (1) Not contain less than 5.0mg/L of Dissolved Oxygen, (2) Coliforms must not exceed 10,00 colonies/100mL of total coliforms or 200colonies/100mL of fecal coliforms, (3) pH should always be between 6.0 and 9.0 standard pH units, (4) Color should not exceed 15 units according to the colorimetric platinum cobalt standard, (5) Turbidity should not exceed 50 nephelometric turbidity units (NTU), (6) Total Dissolved Solids should not exceed 500mg/L and (7) Total Phosphorous should not exceed 1ppm (mg/L) (PREQB 2010). One single violation of

the standard is enough to classify the waters as impaired due to the specific parameter violated.

Table 3. Designated uses in Rio Grande de Añasco and it's 2012 status.

	Designated uses			
	Primary contact recreation	**Secondary contact recreation**	**Aquatic life**	**Raw source of potable water**
Rio Grande de Añasco	4a	4a	5	5

4a: State has established a TMDL or has been approved or established by EPA.
5: Do not meet at least one of the water quality standards and its necessary to implement a TMDL for the parameters.

The data used by the Environmental Quality Board to create the Water Quality Assessment Report is based not only on the USGS gaging stations located in the watershed under study, but also any other information and data available about water quality in the watershed, such as studies done by Universities, and other water related agencies.

In the most recent Water Quality Assessment Report (2012) the Puerto Rico Environmental Quality Board and USDA stated that the principal sources of contamination to the Rio Grande de Añasco, which were causing its impairments, were agricultural runoff, animal confinements runoff, major municipal point sources pollution, small industrial point source pollution, non-existent septic tanks, and urban runoffs. In the Report they state that the result of these impairments were low dissolve oxygen and unacceptable levels of turbidity.

In order to evaluate the water quality impairments at Rio Grande de Añasco watershed, I examined the water quality data from the three USGS gaging stations (50143000, 50144000, 50146000), located in the Rio Grande de Añasco Watershed (Figure 12), to see the changes in nutrient load and dissolve oxygen from approximately 1980 to 2013.

- Station “50143000” is located near Lares at Lat 18º 15’ 26”, long 66º 55’ 00”, at bridge on Highway 124.
- Station 50144000 is located near San Sebastián at Lat 18º 17’ 05”, long 67º 03’ 05”, on left bank, at downstream side of bridge on Highway 108.
- Station 50146000 is located near Añasco at Lat 18º 16’ 00”, long 67º 08’ 05”, at bridge on Highway 430.

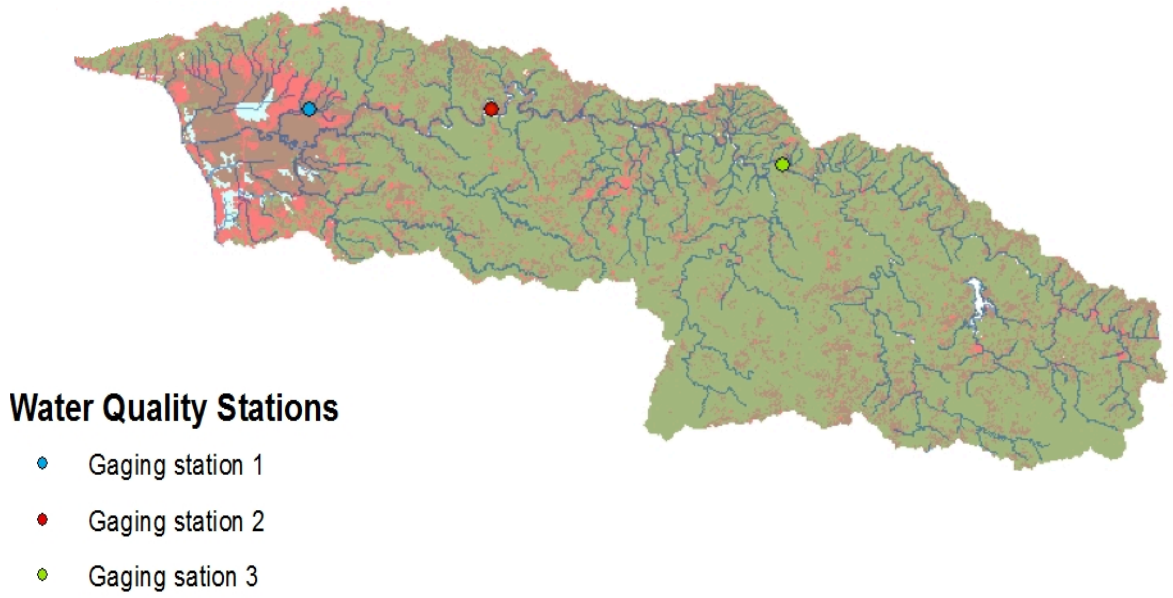


Figure 12. Water Quality Gaging Stations at Rio Grande de Añasco watershed. Blue dot: Station 50146000, Red dot: station 50144000, Green dot: 50143000

From the data obtain from all three USGS gaging station we observed that the phosphorous measurements has been steady since 1980 (Figure 13, 14, and 15) as was the dissolved oxygen levels (Figure 16, 17, and 18).

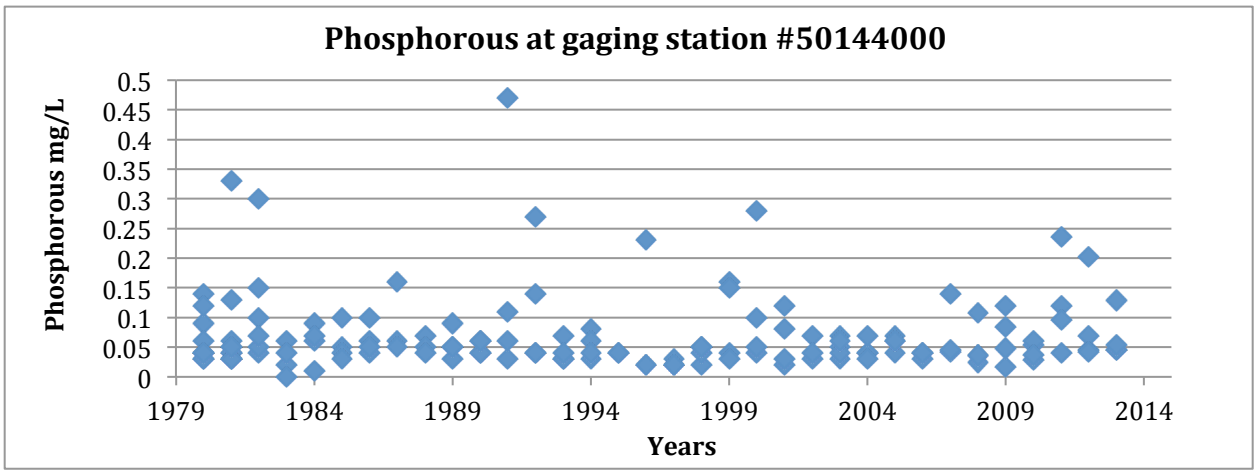


Figure 13. Phosphorous concentration (mg/L) at USGS gaging station #5014400 at RGA

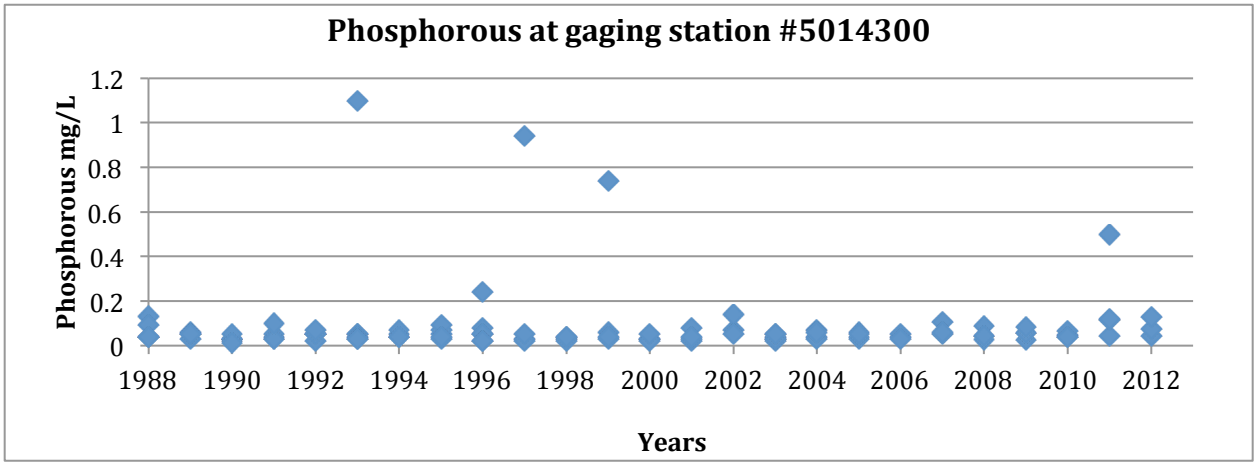


Figure 14. Phosphorous concentration (mg/L) at USGS gaging station #5014300 at RGA

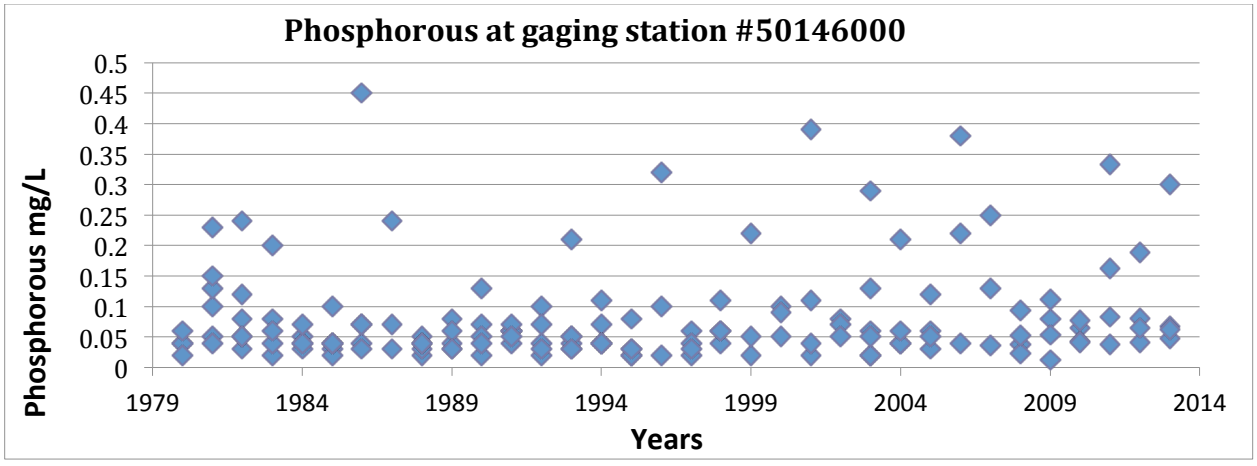


Figure 15. Phosphorous concentration (mg/L) at USGS gaging station #5014600 at RGA

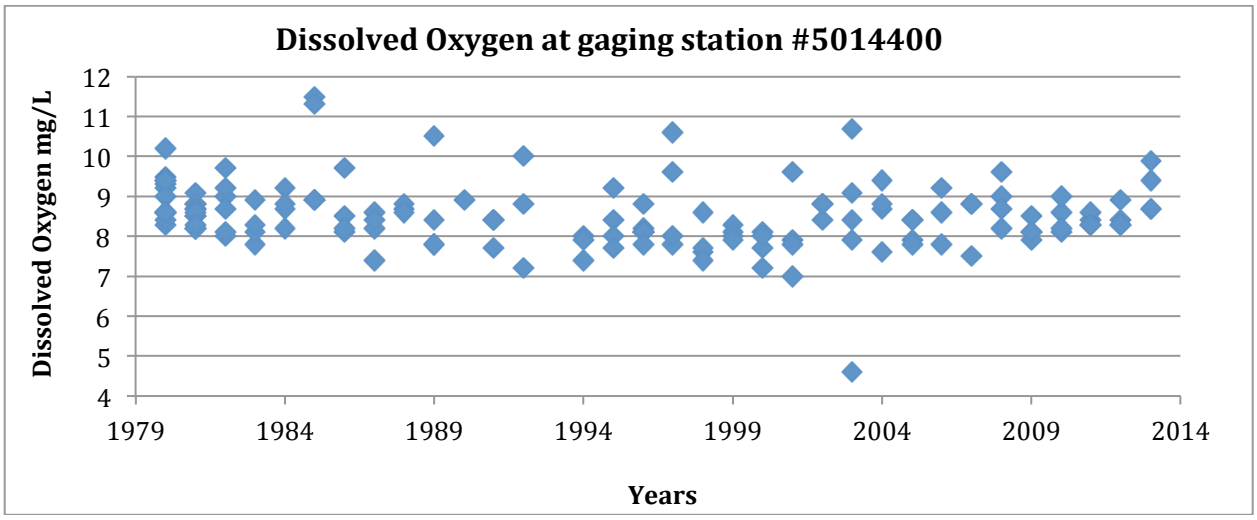


Figure 16. Dissolved oxygen concentration (mg/L) at USGS gaging station #5014400 at RGA.

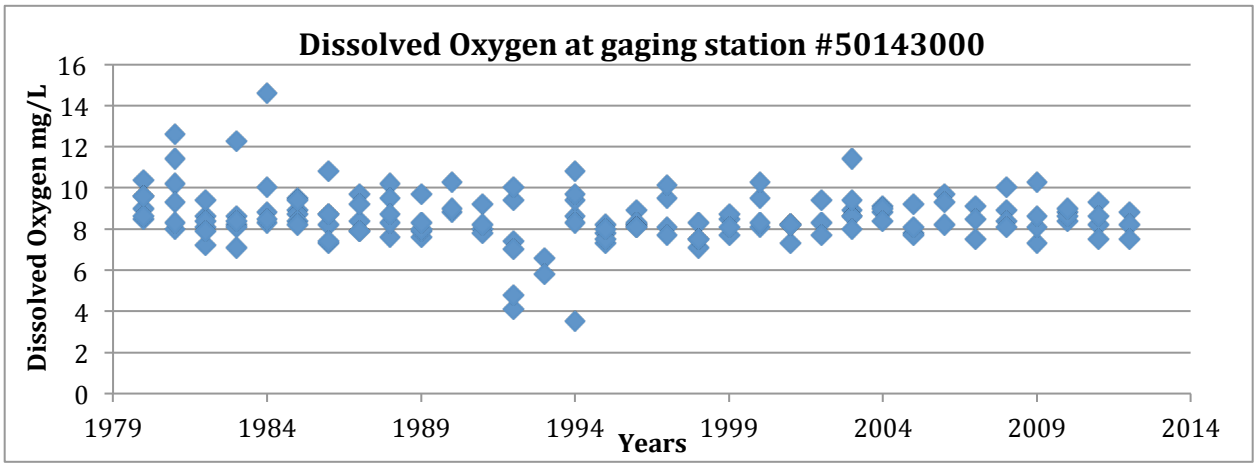


Figure 17. Dissolved oxygen concentration (mg/L) at USGS gaging station #5014300 at RGA.

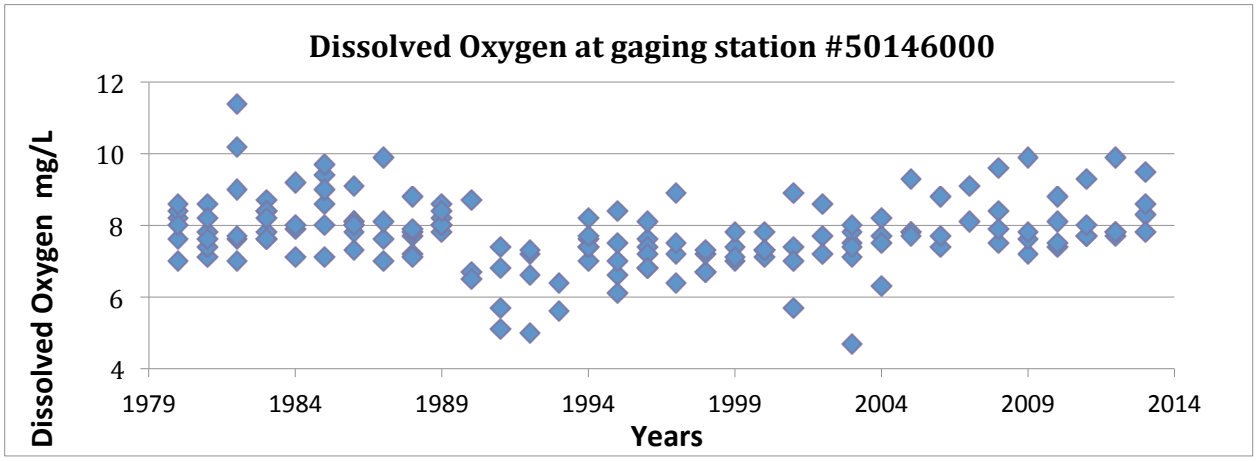


Figure 18. Dissolved oxygen concentration (mg/L) at USGS gaging station #5014600 at RGA.

Turbidity, meanwhile, violated the standard regulation (0.03 NTU) at least once in all three USGS gaging stations (50143000, 50144000, 50146000) during the study period as seen in Table 4. Therefore, Rio Grande de Añasco was determined to be impaired due to its turbidity levels.

Table 4. Turbidity at USGS gaging stations

Gaging Station	Year	**Turbidity (NTU)**
50143000	2010	2
50143000	2010	8.52
50143000	2010	14.8
50143000	2010	11.1
50143000	2011	2
50143000	2011	1174
50143000	2011	36.8
50144000	2010	5.76
50144000	2010	5.29
50144000	2010	16.8
50144000	2010	2.6
50144000	2011	2.33
50144000	2011	176
50144000	2011	83.3
50146000	2010	15.1
50146000	2010	12.6
50146000	2010	32.4
50146000	2010	7.77
50146000	2011	3.03
50146000	2011	252
50146000	2011	136

Apart from the USGS gaging stations the EQB used, for the 2012 water quality assessment report, data from a 2011 synoptic study was used. In this study surface waters in the south east and west side of the island were monitored. In this synoptic study they collected data during the rainy and dry season for additional water quality parameters (fecal coliforms surfactants, pH, temperature, dissolved oxygen, specific conductivity, flow, metal traces, pesticides, and nutrients). Rio Grande de Añasco was included in this study and 13 monitors stations where established along the river. In this synoptic study it was determined that

dissolved oxygen did not meet standard regulation (Table 5) in gaging station 50146120 and therefore Rio Grande de Añasco was impaired not only due to turbidity, but also due to low dissolved oxygen.

Table 5. Dissolved oxygen data from synoptic study at Rio Grande de Añasco

Gaging Station	Year	**Dissolved Oxygen (mg/L)**
50146120	2010	1.95
50146120	2011	2.02

In addition to these impairments affecting inland fresh waters it also had an impact on near shore coastal ones, such as the Mayaguez Bay.(Rodriguez 2002, Gilbes et al 2002). For instance, Mayaguez bay, which encloses an area of 47 km2, is a semi-enclosed bay with large sediment input (Gilbes et al 2002)(Figure19). This bay is an example of how the impact of inland activity affects different coastal characteristics, such as sediment input (Rodriguez 2002, Gilbes et al 2002), and phytoplankton presence (Figure 20) (Gilbes et al 2002).

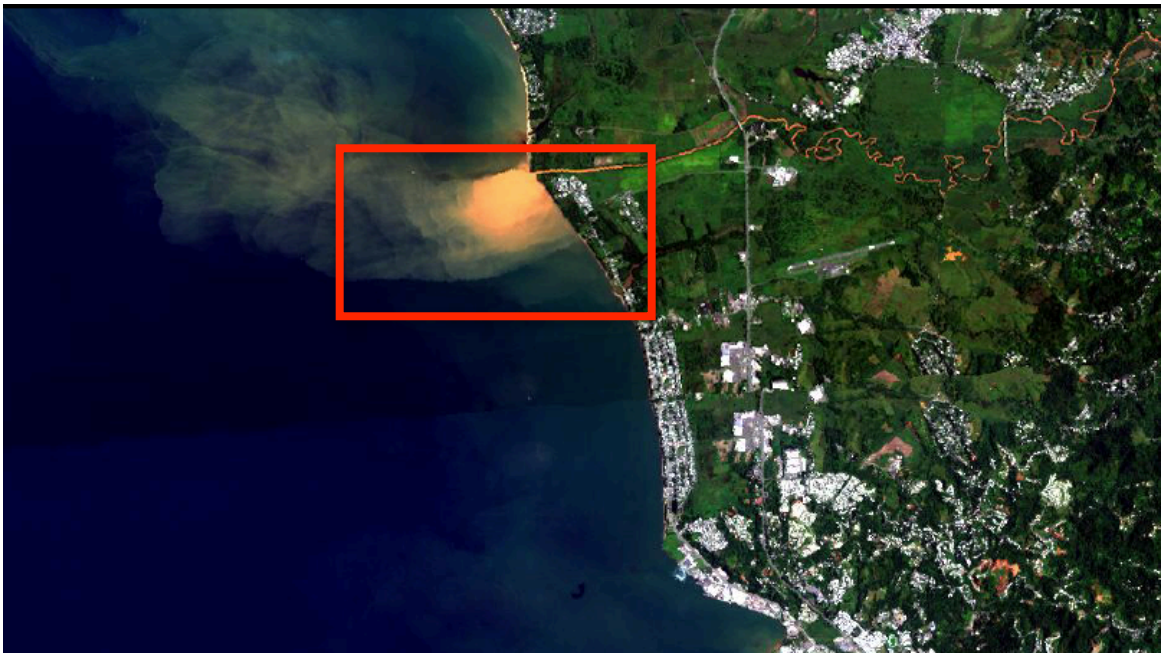


Figure 19. Rio Grande de Añasco river mouth, sediment input to Mayaguez bay detected by AVIRIS sensor (Gilbes et al 2002)

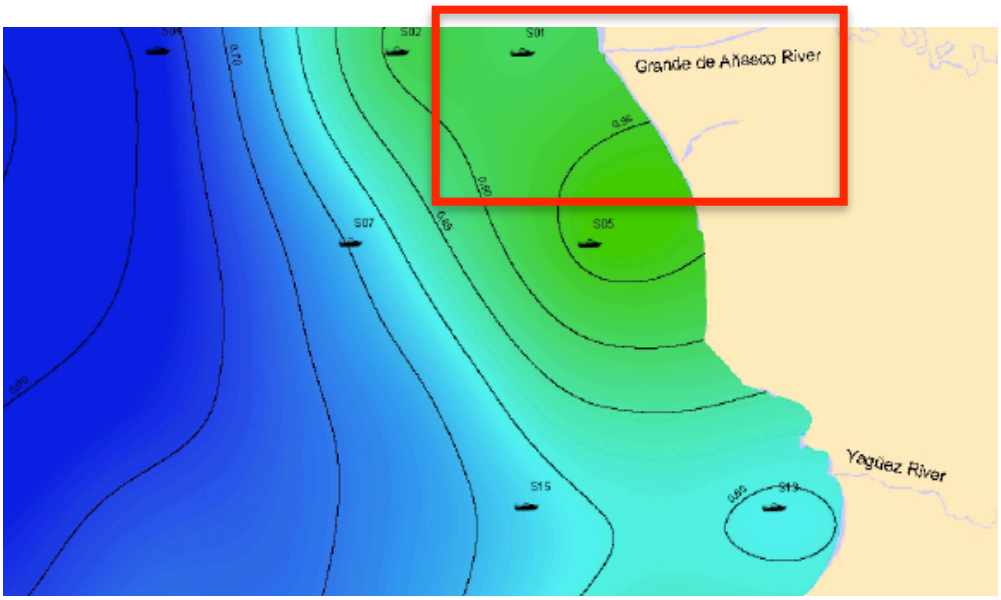


Figure 20. Phytoplankton biomass in the rainy season, shown by presence of Chlorophyll-a, which causes higher fluorescence (green) (Gilbes et al 2002)

1.6 Non point sources pollution and agriculture

With 85% of the food consumed in Puerto Rico being imported (USDA 2014) there is increased interest from Puerto Rican government to purchase of locally grown foods (Caribbean Journal 2013). This increased interest on local agriculture production should come with an increased interest on practices that do not further influence or stress water quality in rivers, streams, and coastal ecosystems in the island. Agricultural practices and cattle ranching, while necessary to feed an increasing human population, can increase nutrient and sediment loading to Puerto Rico's waterways. This increase loading leads to different impacts such as eutrophication, which can increases algae and aquatic weeds growth and reduces dissolved oxygen due to algae death and decomposition (Sharpley, Foy, and Whiters 2000). This type of runoff, not only impairs water availability for drinking, but also impacts other ecosystems characteristics that provide services for the human such as fisheries or recreation (Sharpley et

al. 2000).

Non-point sources of pollution are those that come from extensive areas and not a particular place (NRCS 2000), making this source of pollution difficult to measure and control. In non-point sources of pollution, contaminants are transported from the soil by rainwater into the river, streams, lakes, and eventually the coast and oceans. Some examples of non-point sources of pollution are agriculture lands, construction sites, and runoff from urban areas (NRCS 2000).

Agriculture and many of its practices are a major source of non-point pollution (Table 6) as farming practices often result in runoffs these lands increasing the chemical and nutrient inputs to the waters such as: phosphorous, nitrogen, metals, pathogens, pesticides, salts, sediments, and trace elements such as selenium (Ongley 1996)

Table 6. Examples of agricultural activity's impacts on water (Ongley 1996)

Agricultural activity	Surface water
Tillage/ploughing	Tillage is the agricultural preparation of soil by mechanical agitation, such as digging, stirring, and overturning. This type of practice not only affect the sediments, but also every land where the water runoff/discharge too (NRCS 2000). This practice causes siltation, which at the same time could also carry nutrients and chemicals embedded in the sediment particles that runoff to the nearby waterways. This result on river beds impact and loss of habitat, spawning ground, decreases of dissolve oxygen and others (Ongley 1996).

Table 6 (cont'd)

Agricultural activity	**Surface water**
Commercial Fertilizing and Organic fertilizing	Excessive use of fertilizers promotes runoff of nutrients, phosphorus and nitrogen, leading to eutrophication which is knows as fertilization of surface waters. Eutrophication causes explosive growth of algae which causes disruptive changes to the biological equilibrium to inland waters and coastal waters, by reducing dissolved oxygen in the water body. This decrease in oxygen leads to suffocation of fish and other aquatic species. (Ongley 2006, Weiderholt 2005)
Pesticides	Pesticides are substances or chemicals (insecticides, herbicides, rodenticides, fungicides) used to prevent, destroy, or repel pests including diseases, insects, and weeds. Excessive use of pesticides leads to contamination of surface water and biota (Onlgey 1996)

Agricultural major nutrient inputs to surface water are Nitrogen and Phosphorous. The addition of these nutrients in water can cause major impairments altering the biological life of waterways.. After rains, runoffs of these agricultural lands could result in excess inputs of these nutrients to surface water. Increase amount of nitrogen and especially phosphorous leads to algae growth and eventually decrease in dissolved oxygen (Ongley 1996). This results from algae dying and decomposing, which is a process that consumes dissolved oxygen. When

dissolve oxygen levels decrease dramatically, it often impacts aquatic life. This is further aggravated due to combine wastewater treatment failures and non-existent septic tanks, common situation around the island.

Sediment runoff to the waterways, due to erosion, is a major source of water impairment. Sedimentation is a bigger problem in places, like Puerto Rico, where steep elevation due to mountainous and hilly terrain are common. This type of contaminant decreases rivers and lakes capacity to store water, impacts aquatic life habitats, and increases the cost of processing potable water (NRCS 2000). High turbidity from either soil particles, algae, plankton, microbes, and other substances, increases water temperature due to the absorption of more heat from the suspended sediments. Warmer waters lead to less dissolve oxygen (DO) in the waterways. Moreover, the decrease of light penetration reduces photosynthesis activity and therefore production of DO. Direct impact to aquatic life occurs due to these suspended sediments, such as clogging of fish gills, reducing resistance to disease in fish, lowering grow rates, and affecting egg and larval development and survival

These activities and inputs are not only having direct impact on freshwater ecosystems and local drinking waters, but are also extending to other ecosystems and ecosystems services such as coastal habitats and coastal fisheries (Larsen and Webb 2009). This is a major concern, since coastal habitats in Puerto Rico are big contributors to local economy by promoting tourism.

1.7 USDA-NRCS and land practices to reduce impacts to waterways

Most of pollutants on Rio Grande Añasco comes from land management practices, and could be reduce if this is controlled or mitigated via land conservation practices. There are a

number of agricultural practices that could be employed by local farmers to reduce contamination to nearby waterways and, such as crop rotation, conservation tillage and the use of terraces (USDA 2000).

In order to improve water quality, many initiatives have been created in order to promote people's awareness and participation in these conservation practices. Because the main focus in this research is agricultural nonpoint sources of pollution, I focused on an initiative created by the U.S. Department of Agriculture's Natural Resource Conservation Service in 2012, which focuses on improving farmers agricultural land management practices to reduce erosion and pollution to local waterways. The ultimate goal of the initiative is to remove streams and other water bodies from the 303(d) list. This relatively new initiative aims to help farmers, ranchers and forest landowners improve water quality and aquatic habitats in impaired streams in priority watersheds. Considered priority due to its water quality impairments, and for being a source of potable water. This is accomplished by helping people implement conservation and management practices that prevent nutrient, sediment, and manure loading to nearby freshwater ecosystem (United States Department of Agriculture n.d). People that qualify for this program obtain economic help, primarily from the EQIP (Environmental Quality Incentive Program) funds and state conservationists, to engage in the best conservation practice that will lead to healthier water quality through improved land management practices (USDA n.d). Some of these practices include a comprehensive nutrient management program, use of appropriate cover crops, filter strips, terraces and other land based conservations practices which reduces the flow of sediments and land based pollutants to the waterways (USDA n.d).

The priority watersheds are selected with help of local partnerships and state water quality agencies providing the needed financial assistance and guidance needed for the success of this initiative (USDA n.d). This overall goal of this initiative was to create a better understanding by local agriculture producers that well managed farms limit pollution from runoff, benefiting not only the ecosystems and organisms that depend on them, but also their future profitability and community health by creating land that will remain productive into the future and providing clean water for other numerous ecosystem services (USDA n.d)

For FY 2012, 157 watersheds were selected within the 50 states and Puerto Rico with one of these watersheds being the Rio Grande de Añasco; one of the largest watersheds on the island.

CHAPTER II

Evaluating the possibilities to increase farmer's participation in conservation practices, based on a "place attachment perspective"

With increased urban sprawl, agriculture, and other anthropogenic influences on the landscape, Puerto Rico's inland surface waters are generally in poor quality. Although agricultural activities on the island are relative small, the Rio Grande de Añasco watershed is consider to be an agricultural watershed and a region where sediment runoff from land use practices are relatively high. In order to enhance water quality in this watershed, farmers need to be willing to engage in conservation practices, which will reduce surface runoff. In this research, I assess farmers willingness to adopt better stewardship behaviors in order to reduce local water stresses, using a "place attachment" theory.

Previous researchers have found that the willingness of people to engage in conservation practices or in pro-environmental behavior may be influenced by a range of physical, psychological factors such as locus of control or your belief on you ability to bring change, ideological world views, perceive risks of change, individuals sense of responsibility amongst others (Gifford 2011, Kollmuss and Agyeman 2002). While farmers have been observed to engage in behaviors to increase profitability, they have also been noted to adopt conservation practices based on a more personal relationship with the land and others in the community (De Young 1996). One of these factors is known by researchers as "place attachment", or the functional and emotional bond a person has with a place (Payton, Fulton, and Anderson 2005, Halpenny 2007). For Example, a person's feeling toward a place influences their environmental concern (Vining et al. 2008), and environmental concern or attitude

increase peoples participation on conservation practices. An example of this behavior was shown by Schrader (1995) in a study where farmers who acknowledge that riparian management was important for environmental quality were more prone to participate on conservation practices than those farmers that saw riparian management solely for the economic benefit. Thus, in order to increase conservation support, we need to understand not only economic aspect but also the non-economic motivation of people to adopt conservation practices.

In this research I attempt to answer the specific research question of how the farming communities place attachment, general view of nature, and environmental concern influences their willingness to participate in current pro-environmental behaviors The research question was based on the cognitive hierarchy model (figure 21) or value-attitude model, which indicates that attitudes and norms influence behaviors, and these attitudes are linked to a more basic value system. I therefore, used place attachment to assess people's feelings and connection to their watershed, and how it influences their environmental concern, and willingness to protect or participate in pro-environmental behaviors that would improves water quality (Figure 22). The answers to this question would benefit conservation initiatives, such as the NRCS initiative, in understanding community's values towards the watershed, and to target specific areas that would help the program to be more successful on motivating farmers to engage in conservation practices, moving toward achieving the goal of better water quality in this watershed.

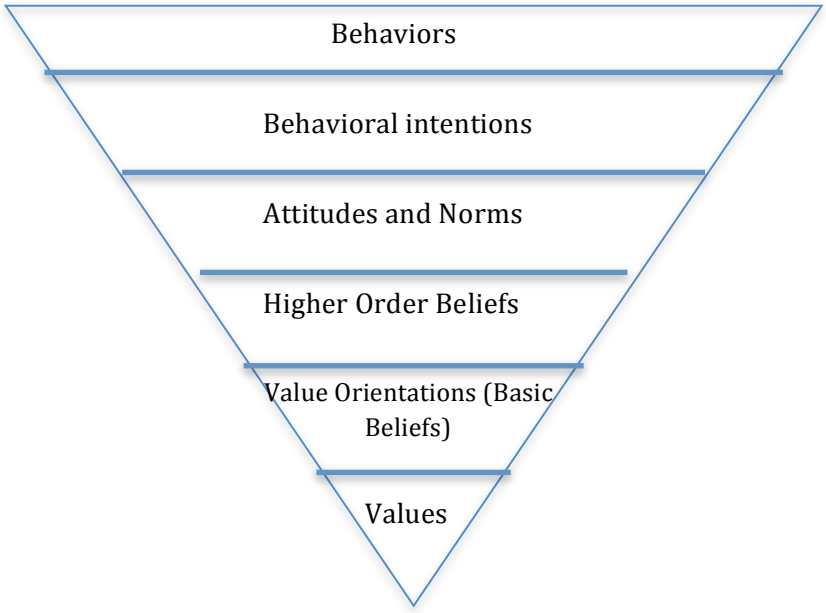


Figure 21. Cognitive hierarchy pyramid, which shows values as the base of the pyramid.

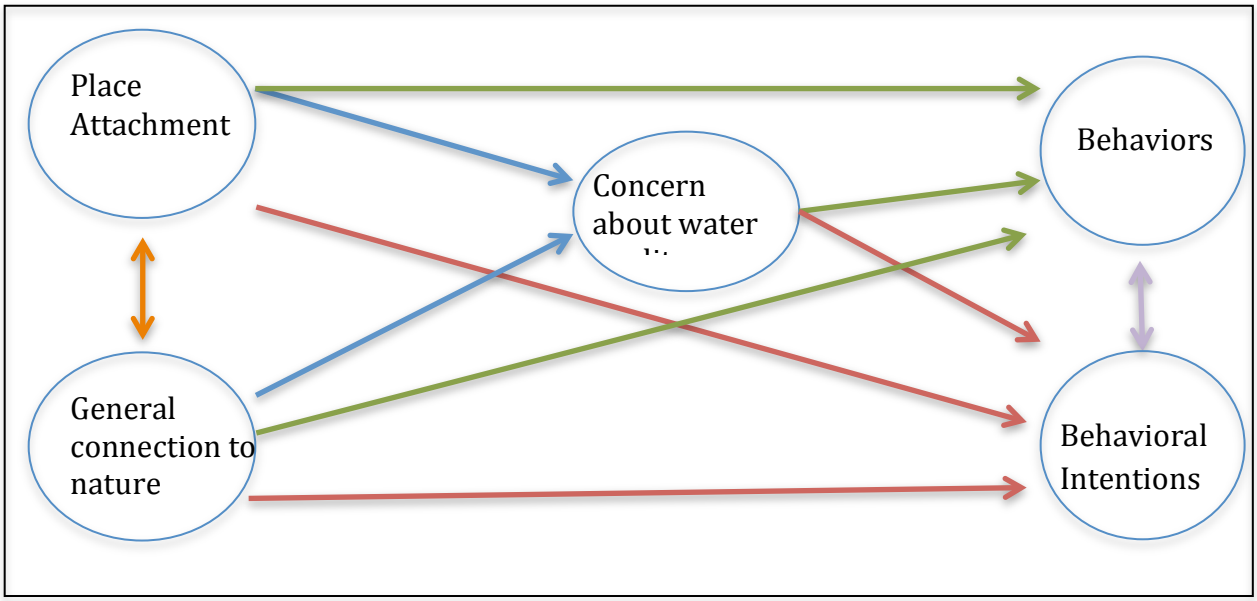


Figure 22. Diagram the Cognitive hierarchy model used in the study of farmers in Rio Grande de Añasco watershed, Puerto Rio to assess how their general connection to nature and place attachment influences the farming communities environmental concern and how that influences their behavioral intentions and behaviors.

The goals of this research were (1) to inform local farmers of the connection between their activities and the health of nearby waters, (2) increase stewardship behavior of local people to promote land use practices which decrease degradation of water quality, and (3) enhance success of conservation programs through culturally sensitive outreach approaches that increase local community understanding of the impact of land-based actions on water resources.

2.1 Theoretical foundation; Place attachment

There is an increasing desire to promote pro-environmental behaviors and stewardship within communities, worldwide, in order to achieve conservation goals (Shofoluwe and Sam 2012) by reducing anthropogenic stressors to the environment. While many efforts focus on increasing awareness, some studies find that increasing environmental awareness while it can change people's attitudes does not necessarily influence people's behaviors (Kollmuss and Agyeman 2002, Hungerford and Volk 1990). I focus on better understanding the role of place attachment in behavioral change related to the environment, since previous studies show that an individual's place attachment has a strong influence on their performance of environmentally responsible behavior (Vaske and Kobrin 2001, Scannell and Gifford 2010, Payton et al. 2005, Halpenny 2007). This influence is thought to be due to a relationship between a close relationship to the land and a sense of belonging, ownership, and pride that makes a person feel responsible of their behaviors and the health of their local environment (Vaske and Kobrin 2001). Other researchers (Scannell and Gifford 2010) state that individuals with a strong place attachment tend to have positive emotions such as love and respect, toward a place, which promotes and influences their willingness to protect the place. Similarly,

Stedman (2002) found that people that are more place attached were more willing to participate in place-protective behaviors toward that particular place. Understanding how a person's place attachment mediates the values that lead to pro-environmental behavioral intentions is a step toward engaging them in being stewards of their resources and achieving conservation goals.

For this research I used Payton et al.'s (2005) definition of "Place attachment", which state that place attachment is the physical and emotional bond of a person with a place. There are numerous theories on the different bonds that promote attachment to a place. Some researchers state that place attachment develops due to individual's place identity bond, which are the physical and symbolic connections that define who we are, or a result of an individual's place dependence bond, which identifies a place attributes for a specific use or need (Williams & Vaske, 2003, Vaske and Kobrin 2001, Raymond et al 2010). Others researchers have further more specific classifications that take into consideration a variety of factors including social and physical relationships between and individual and their environment (Leweika 2011). For the purpose of this study I use Raymond's et al. (2010) research to classify and measure place attachment of the farming community on the watershed under study. Based on his findings, place attachment can be divided into place identity, place dependence, nature bonding, friend bonding, and family bonding (figure 23). All of these interact to create place attachment that can influence individual behaviors

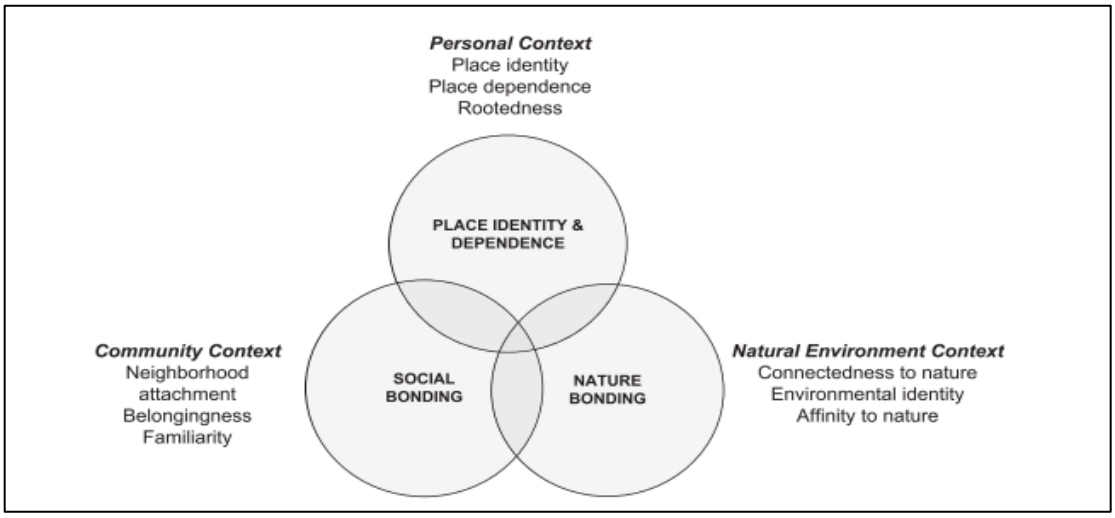


Figure 23. Factors affecting the development of place attachment.

Place attachment studies have been done in many parts of the world and within different communities, trying to understand the link between it and certain behavior attributes. For example, researchers have looked at how place attachment influences the attribution of non-economic values (Brown 2005, Brown et al 2002), and how it influences environmental concern (Brehm et al. 2006, Vorkinn and Riese 2001). The direct influence of place attachment on behavioral intention has also been studied with the findings that it has a positive relationship (Vaske and Kobrin 2001, Scannell and Gifford 2010, Payton et al. 2005; Halpenny 2007). It has also been reported that communities with higher place attachment are more cohesive, and tend to have higher values to the land and a higher number of special places (Brown et al. 2002). Studies on the influence of place attachment on environmental concern also show this positive relationship, finding that a higher environmental and social attachment to a place increases environmental concern (Brehm et al. 2006).

Studying place attachment's influence on farmers' decisions to engage in conservation practices is interesting due to farmers' relationship with the land. It has been seen that farmers'

relationship with the land and the time spent on the place promotes a sense of place amongst them (Curry, 2000) , which motivates their interest toward making decisions base on the non-economic value of their land. For example, Gosling and Williams (2010) found that higher place attachment amongst farmers tend to increase their participation in conservation activities. Understanding how place attachment may influence farmers' decision on how to behave environmentally is important and understanding whether this relationship influences their social institution towards conservation. Social institution are the way people coordinate (informal or formally) to use information and environmental resources cooperatively (Hanna and Jentoft 1996, Vatn 2009). As such studying the role of place attachment on social institutions is an important aspect to integrate in the understanding of peoples' motivations to adopt conservation practices.

It is important to acknowledge that while place attachment can be a strong predictor of pro-environmental behavioral intentions and an important aspect on the development of social institutions, there are many variables (cultural, social, and economic) that act as barriers preventing people from participating or willing to adopt certain practices. Fujisaka (1994) describes how farmers do not easily participate in new technologies aimed to increasing agricultural sustainability due to several reasons, such as 1) the new technology does not address the issues important to their success, 2) the farmers already engage in practices that address the issue attempting to be solved, 3) the new technology creates new issues 4) the information doesn't easily transfer or it was targeted to the wrong groups of people or farmers, 5) the new technology is to costly economically and time wise, and 6) social factors issues such as insecure tenure, could influence their interest on engaging on a new activity or behavior..

Some researchers talk about how economic benefits, such as an increase in land value or crop value, are one of the predictors of conservation practices adoption (Barbier 1990, Sain and Barreto 1996). Others talk about how physical characteristics of the land, such as the size of the farm, and steepness of a slope, have also been found to affect farmers decision on participating in different conservations practices (Barbier, 1990; Huszar and Cochrane 1990), predicated on the time or effort cost compared to the benefits or gains in engaging on the practice that the farmer perceives. Community cohesion and social norms are another important factor influencing people's decision to adopt a new practice. Relationship with other members of the community or other farmers could be either positive or a negative. While positive relationships between community members could promote adoption in conservation practice, a negative relationship or a lack of communication or trust could decrease their interest in participating in conservation practices. For example, Burton (et al 1999) mentions that individuals' participation in community groups increases the probability of individual to engage in new practices. On the other hand, examples of "the prisoners dilemma" demonstrate that individuals that do not trust others and which do not communicate with others will likely behave solely based on individual interest (Vatn 2009).

Knowledge about an ecosystem has to be coupled with knowledge about the social institutions and economic aspects that promote the use and abuse to the ecosystem. Understanding how place attachment influences cooperation and how it motivates peoples' interest and willingness to participate in pro-environmental behaviors is one step toward achieving conservation goals. Managers and decision makers need to be able to not only understand how the resource behaves but also how humans use the resource and value it in

order to be able to better design and target conservation messages and promote effective stewardship behaviors.

2.2 Methodology

In order to answer my research question, I conducted face-to-face surveys from August 2013 to January 2014, where farmers from the Rio Grande de Añasco watershed in Puerto Rico were approached with the survey and were asked to either take it using face to face interview techniques or to complete the survey and return it to me within a week . Face-to Face survey methodology was the preferred method due to suggestion by the director of the NRCS initiative and concerns about mailing facilities and literacy of the respondents.

Farmers were surveyed in two municipalities of Rio Grande de Añasco watershed; Las Marias municipality and Añasco municipality. Before providing the surveys to farmers on the municipalities selected, I conducted a "pilot" project in a farmer's market in western Puerto Rico, Rincon municipality. A total of 6 farmers participated in the pilot study and were requested to write down what they did not understand. This pilot study provided me with insight into how much time farmers would need to take to answer the survey, and to clarify sentences intent and make needed wording changes for clarity of survey questions. The pilot study participants were included with survey respondents on the $300 drawing to be conducted at random at the end of the research period. The pilot participants were between age 27-45 and consisted of 5 men and 1 woman.

The final version of the survey (Appendix A) was approved in 2013 by Michigan State University Social Science/Behavioral/Education Institutional Review Board (IRB # i043721). The survey was developed around 4 main topics, assessing variables about each respondent to such

things as their 1) general connection to nature, 2) place attachment, 3) environmental concern, and 4) and environmental behaviors. These sections are distributed in a nine-page survey (see Appendix A). The first page of the survey titled "Living at Rio Grande de Añasco watershed" had my and my advisor's contact information, and brief introduction to the survey being completely voluntary and anonymous. Second page gave a brief summary explaining what is a watershed and Rio Grande de Añasco watershed's localization. In a separate page a consent form was provided, approved by the IRB in 2013, which let the farmers know about the research, the time it would take to complete the survey, and that the survey was completely voluntary and anonymous.

The survey was targeted individuals older than 18 and focused especially on those that made decision related to land management practices on their farms.

The survey, consisted of questions related to the following general areas:

I. General connection to nature

People's general connection to nature is a measure of environmental attitude, which influences peoples environmental concern (Brehm et al. 2006) and desire to protect the environment (Scanell and Gifford 2010, Dunlap et al 2000). The more people value or have a deeper connection to nature the more concerned and willing they would be to protect it. In order to measure farmer's general connection to nature, I used the New Ecological Paradigm (NEP) measurement. NEP measures a general belief about human-nature interaction which influences environmental attitudes, beliefs and behaviors (Stern et al 1995). There are several group of questions used to measure NEP; in this research I used the original 15 questions developed by Dunlap and van Liere in 1978 (Dunlap et al 2000). These questions are measured

using a Likert scale that ranged from totally disagree =1, disagree= 2, unsure=3, agree=4, to totally agree =5.

I chose to work with the New Ecological Paradigm because 1) it is believed that your worldview influences attitudes and beliefs toward more specific environmental issues (Dalton et al 1999), 2) the NEP uses different questions to assess how you attribute value to nature, which helped me assess if it influenced the way people are connected to their surroundings (place attachment) and 3) has been subjected to many field trials and thus has considerable validity (Dunlap et al 2000).

In order to measure general connection to nature I requested farmers to think about the relationship between humans and nature and classify if they agree or disagree with a given statements (Section 1 in survey). The questions were divided in two groups; 1) questions supporting the endorsement of the NEP and 2) questions supporting the Dominant Social Paradigm (DSP). Some people have a more ecocentric view of nature, where they perceive themselves as part of nature and value nature by itself. These people would support the NEP. Meanwhile, other people have more of an anthropocentric view, where they see themselves apart from nature or that nature exist for human use and has no value by itself. People with the latter belief /view would support the Dominant Social Paradigm (DSP), where humans and nature are separated (Dunlap et al. 2000).

I hypothesized that farmer's who are more connected to nature or who support the NEP would be more place attached and more concern about water quality at Rio Grande de Añasco watershed than those that had a different value system.

II. Place attachment

Place attachment can be attributed to either or both physical and social attributes. For example, a physical cause of place attachment is enjoying the beauty of their surrounding, or doing certain recreation activity in the watershed. A more social influence on place attachment is the relationship with neighbors, and sense of community. In this research, I focused on understanding how physical and social attributes influence the relationship toward the watershed, and how this may influence their concern toward water quality and their participation or willingness to participate in conservation practices. Also, I assessed if general connection to nature has any influence on how farmers relate to their surroundings.

In the survey, place attachment was measured by asking farmers to think about their physical, social, and nature connection to the watershed and classify if they agree or disagree with the premise presented in each question (Section 2 in survey). The questions were based on past research, where William and Vaske (2003) state that asking questions on the social, physical, identity, and dependence bonding will assess people's general place attachment on the watershed under study. I therefore assessed physical attachment by asking questions on and individuals bonds to nature, social bonding (by asking questions on family and friend bonding), place identification (by asking emotional and personal bonding), and place dependence (by asking utilitarian questions or ways you use the resource)

I hypothesized that farmers who are more prone to participate in conservation practices would have a stronger place attachment than farmers who are less place attached.

III. Attitude: Environmental concern

My research is based on the Cognitive Hierarchy Model, for which I assessed how values influence attitudes and willingness to participate in pro-environmental behaviors. I focused on environmental concern as an attitude, which would likely influence their environmental behaviors (actual or willingness).

I measure environmental concern by asking farmers to reflect on their opinions about water and water quality (See section 3 in survey). Based on Xiao and Dunlap's (2007) model, I used different facets to assess concern toward water quality; 1) water quality conditions at a watershed, island and global level, 2) importance of water quality to themself, and 3) policy support. In their study, Xiao and Dunlap (2007) used willingness to pay, which I address in my research as behavioral intentions (willingness to behave pro-environmentally), and behaviors (participation on pro-environmental behaviors).

I hypothesized that farmers who are more willing to participate in conservation practices would have more concern towards water quality than farmers that were less willing to engage in conservation practices.

IV. Environmental behaviors and willingness to participate in conservation practices or pro-environmental behaviors.

In this section I asks farmers to respond to statement related to conservation practices and other pro-environmental behaviors (See section 4 in survey). To measure environmental behaviors, I used the Likert-type scale of past behaviors, where I ask if they agree or disagree that they had participated in the last 12 months in behaviors such as recycling, water conservation, participation in pro-environmental organizations and others environmentally

related questions. Also, I asked about their willingness to participate in specific pro-environmental behaviors.

Due to my focus on the NRCS National Water Quality Initiative, I asked specific questions regarding their participation or willingness to participate in the initiative (See section 5 in survey).

Farmers' selection

In order to assess my model, I decided to give the survey only to farm owners, who made the ultimate decisions on land conservation practices on their farm. To give the survey to the farmer, I needed to contact the farmers and be able to meet with them. In order to do this, I requested a list of farmers from the State Department of Agriculture office, in charge of the municipalities that were the subjects of this research program. I also approached the University Agricultural Extension's Agronomist for an up-to-date list of all farmers in these municipalities.

For Añasco municipality we were able to obtain an up-to-date list of all farmers, which allowed us to contact each farmers and establish their prefer method of meeting. I did not have the same success for Las Marias municipality. When we noticed the difficulties at obtaining an up to date list from Extension Agronomist for this municipality, we tried to drop-in at farms houses in Las Marias. Drop-ins were unsuccessful due to differences on working hours between farmers and myself; I had to travel 3 hours to get to the watershed arriving around 8-9 am and heading back at 4-5pm, which could have conflicted with their working hours.

Sample size:

Añasco farmers, compared to Las Marias' farmers, are considered to be more commercial, have bigger farms (average of 58 acres), and generally do not live on the farm.

Most of the farmers were males (163), while there were only few female farmers (8). At Anasco 26 of the farmers had an elementary education, 21 some secondary education, 38 a high school diploma, 21 some collage education, 39 a bachelors degree, and 21 had a Master's or PhD. On my sampled population I had 17 males and 3 females. From the 20 individuals sampled 1 had secondary education, 7 had high school diploma, 4 had some collage, 6 had bachelor's degree, and 2 had a Master's.

The 2012 agricultural census reports that there are 171 farmers in Añasco. We gather a list of 31 farmer's phone numbers from the Department of Agriculture, which was later updated by the University agricultural extension's agronomist comprising a final list of 48 farmers phone numbers plus 3 additional farmers that I contacted onsite for a total of 51 farmers. From these 51 farmers, 34 answered the phone, 30 accepted to participate, 27 actually participated, and 20 completed surveys (39%) (table 1).

Las Marias farmers have smaller farms (average of 25 acres), and do not only live on the farms, but generally have had families that have lived on the farm for several generations. Most of the farmers in this municipality were males (270), while only a few are female (14). From this population we found that 12 farmers had no formal education, 77 had some elementary education, 78 had some secondary education, 53 had a high school diploma, 44 had some college education, 27 had a bachelor's degree, and 8 had a Master's or PhD. On my sampled population I had 11 males and no females. From the 11 participants 4 had some elementary education, 1 had some secondary education, 1 had a high school diploma, 2 had some collage education, 2 had a bachelors, 1 Master's or PhD.

From the 2012 agricultural census they estimated that there were 284 farmers in Las

Marias. From the Department of Agriculture we obtained a list of 59 farmers' phone numbers; but we were unable to receive a listing of current phone numbers from the local agronomist, making contacting these farmers very difficult. Apart from the farmers on the list I contacted 4 other farmers onsite. From the total of 63 farmers listed, 22 answered the phone , 21 accepted to participate, 19 actually participated, and 11 completed surveys 17% (table 1).

Table 7. Response rate of farmers from Añasco and Las Marias to survey instrument on farmers and environmental behaviors

	Total farmers on the list	% Farmers answered the phone from the total list	% Farmers accepted to participate from the total list	% Actually participated from the total list	**% Farmers completed the survey** from the total list(response rate)
Añasco	51	67%	59%	53%	**39%**
Las Marias	63	35%	33%	30%	**17%**

2.3 Data Analysis

Descriptive analysis were performed on each variable. This was done by first coding the data on an excel sheet. A single or global measure for each section was created in those questions that allowed it. After coding all the questions and having a single measure per individual in each question, I use this to see if a relationship existed between the variables using correlation analysis in the R statistical program.

2.4 Results

Descriptive statistics

I. General connection to nature

To measure farmer's general connection to nature I asked question measuring New Ecological Paradigm (NEP) (odd numbers) and questions measuring Dominant Social Paradigm (DSP) (even numbers).

From this section I found that 79% of farmers agree or strongly agree with NEP views, while 32% agree or strongly agree with DSP views. At Las Marias municipality we observed a similar trend with farmers having a stronger NEP view (89%) than a DSP view (46%)(Figure 24).

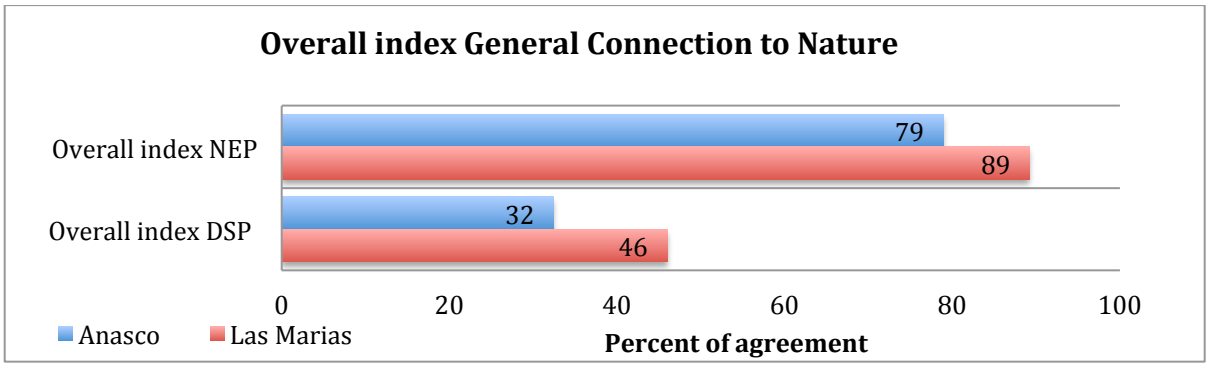


Figure 24. Overall index on section about farmer's general connection to nature at Añasco and Las Marias

When I closely evaluated the different statements I gathered during the survey, I noted, a high percent of Añasco farmers agree or strongly agreed that humans are not only abusing the environment (95%) but that also they believed that when they modify the environment it produced disastrous consequences (85%), while only 55% of farmers agreed or strongly agreed that the environment could be easily destroyed. We found that all farmers at Las Marias also agreed or strongly agreed that humans are abusing the environment and 91% that when they intervene it produces disastrous consequences. All Añasco farmers believed that the environment could be easily destroyed(Figure 25).

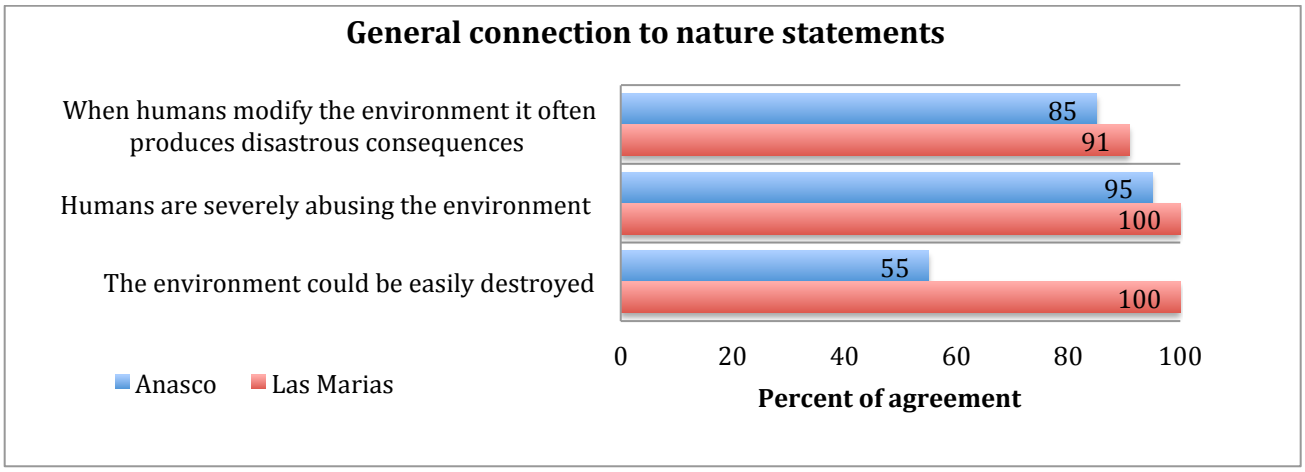


Figure 25. Frequency distribution for some statements on farmer's general connection to nature.

While in both municipalities farmers believe that earth is like a spaceship with limited room and resources, they also agreed or strongly agreed that there are plenty of resources and what we need is to learn how to develop them. A relatively low percent of farmers in Añasco believe that humans have the right to modify the natural environment to suit their needs, while at Las Marias a much higher percent of farmers believe humans have this right (Figure 26).

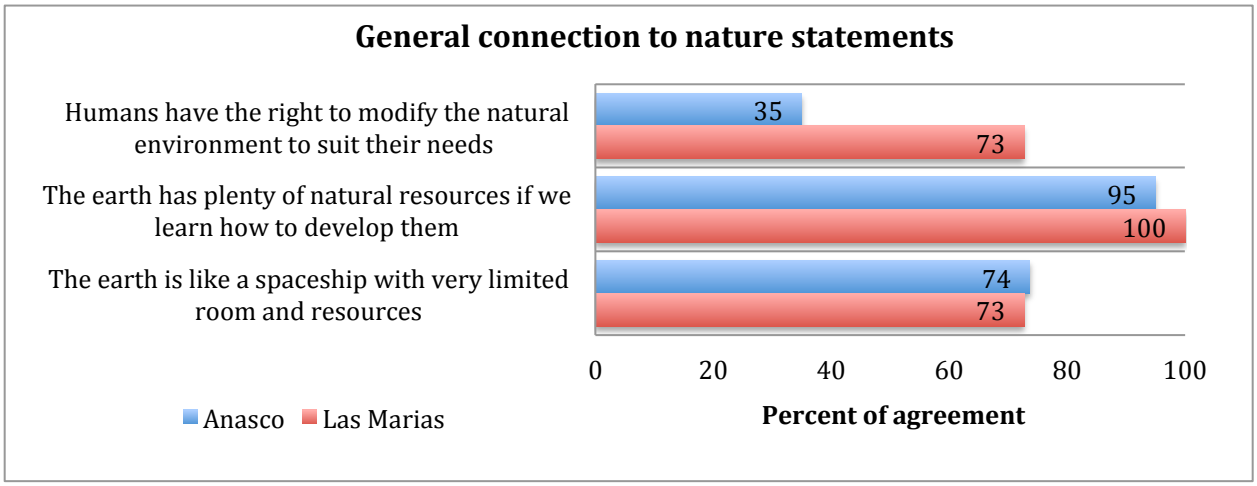


Figure 26. Frequency distribution for some statements on farmer's general connection to nature.

When I statistically compared each NEP statement between municipalities we see that there is no statistical difference between them, except for statement "the environment could

be easily destroyed" were p=0.004 (Table 3).

When we compare each DSP statement between municipalities we found that there was no statistically significant differences between them, expect for statement "Humans have the right to modify the natural environment to suit their needs" (p=0.044)(Table 2).

Table 8. Percent distribution of Agree and Strongly agree of each statement on general connection to nature for both municipalities.

View	**Statement**	**% Distribution (Agree + Strongly Agree)**	
Municipality		Anasco	Las Marias
NEP	We are approaching the limit of the number of people the earth can support	58	50
NEP	When humans modify the environment it often produces disastrous consequences	85	90
NEP	Humans are severely abusing the environment	95	100
NEP	Plants and animals have as much right as humans to exist	95	100
NEP	Despite our special abilities humans are still subject to the laws of nature	85	100
NEP	The earth is like a spaceship with very limited room and resources	74	73
NEP	The environment could be easily destroyed	55	100˚
NEP	If things continue on their present course, we will soon experience a major environmental catastrophe	85	100
DSP	Humans have the right to modify the natural environment to suit their needs	35	73˚
DSP	Human ingenuity will insure that we do NOT make the earth unlivable	32	27
DSP	The earth has plenty of natural resources if we learn how to develop them	95	100
DSP	The environment is strong enough to cope with the impacts of modern industrial nations.	0	18
DSP	The so-called "environmental crisis" facing humankind has been greatly exaggerated	25	40
DSP	Humans were meant to rule over the rest of nature	10	27
DSP	Humans will eventually learn enough about how nature works to be able to control it	30	36

˚ $p<0.05$

The overall NEP mean score for Anasco and Las Marias was 3.96(SD= 0.46) and 4.28 (SD=0.51), respectively. As the score is out of a scale of 5, the results indicate a relatively strong NEP view for both municipalities. The overall DSP mean score was 3.39(SD=0.86) for Anasco and 3.13(SD=0.93) for Las Marias. This DSP score was inverted in order to have "disagreeing" with DSP statement mean there was a stronger connection to nature (closer to 5). When I statistically compare NEP overall mean score between municipalities I found that there was no significant difference between municipalities ($t(13.86)=1.32$, $p=0.2098$), with regards to their DSP view ($t(11.914)=0.5368$, $p=0.6013$)

II. Place attachment

Place attachment was measured through 4 types of attachment; 1) place dependence, 2) place identity, 3) bonds to nature, and 4) social bonding (family bonding and friend bonding).

Place dependence is feeling that the place you live is the best place for the activities you do. In order to measure place dependence three statements were asked (Figure 27). From the three statements we gathered (overall index = sum % agree of all three statements/3)+ (sum % of strongly agree of all three statements/3.)) The majority of farmers (62.7%) in Añasco felt that the watershed they lived in was the best place for the activities they perform (Figure 27), while at Las Marias 73.9% of the farmers felt their watershed was the best place for the activities they perform.

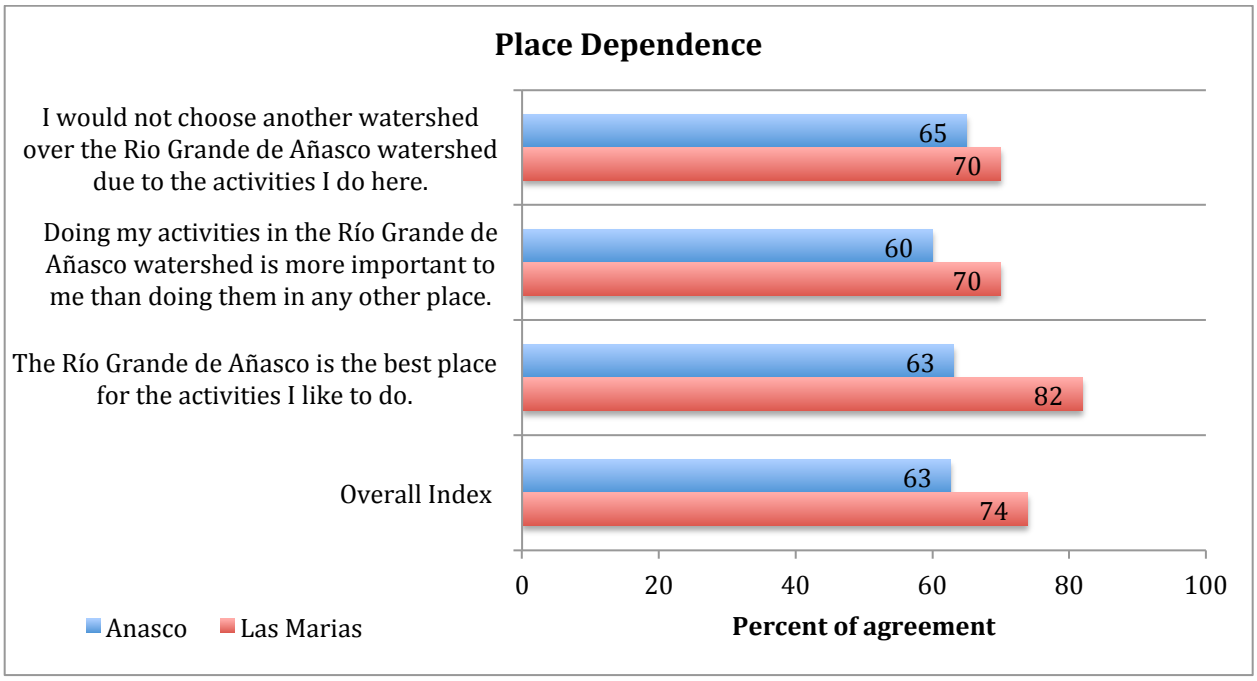


Figure 27. Frequency distribution for statements on farmer's place dependence to nature.

When I statistically compared each statement between municipalities, I found that there was no statistical difference between them. However, when I statistically compare Place Dependence overall between municipalities I found there was a statistic difference ($t(2.013) = -8.2922$, $p = 0.01396$)

Place identity is feeling identified with the watershed that makes one believe that the place is special for them or a part of their identity. Six statements were used in order to measure place identity. When I calculated the overall index from these six statements I found that 72.3% of farmers feel their watershed was special for them and that they feel its part of them while only 13.4% felt that it was not (Figure 28). At Las Marias I found that 81.8% farmers agreed or strongly agreed with the statements related to place identity while only 7.6% did not agree (Figure 28).

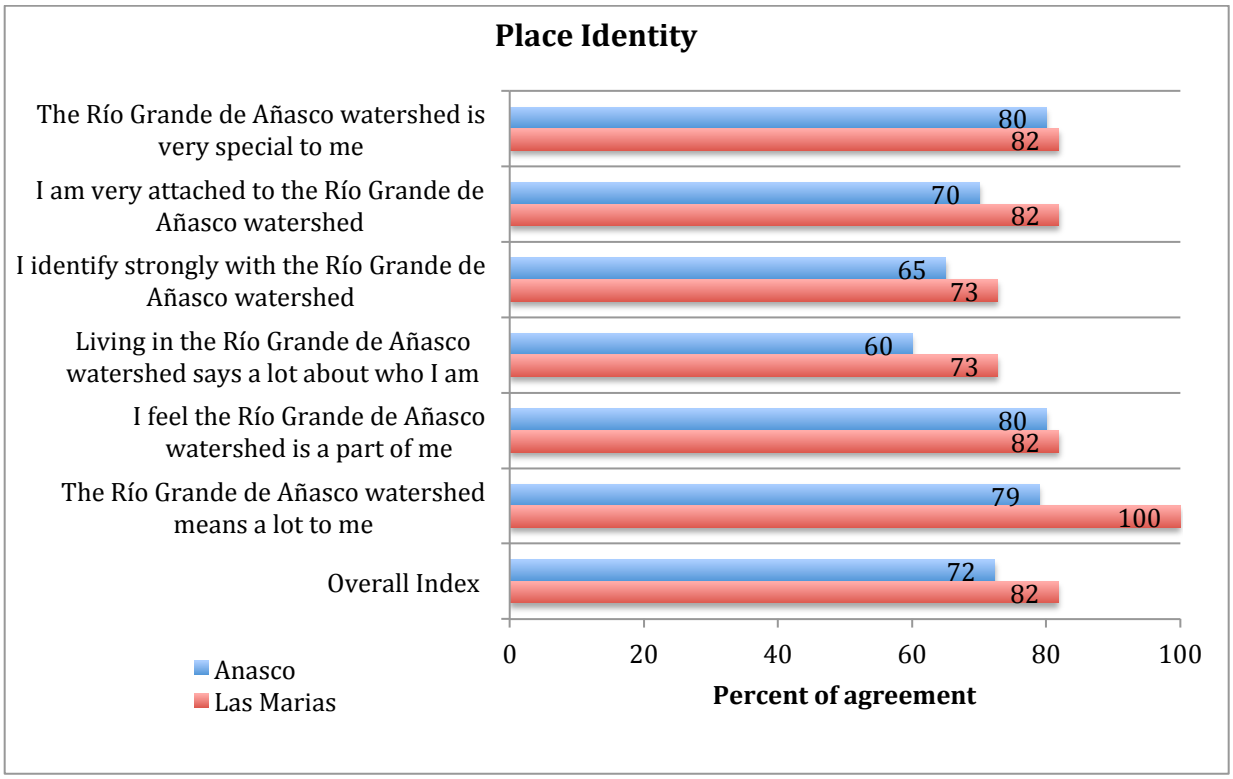
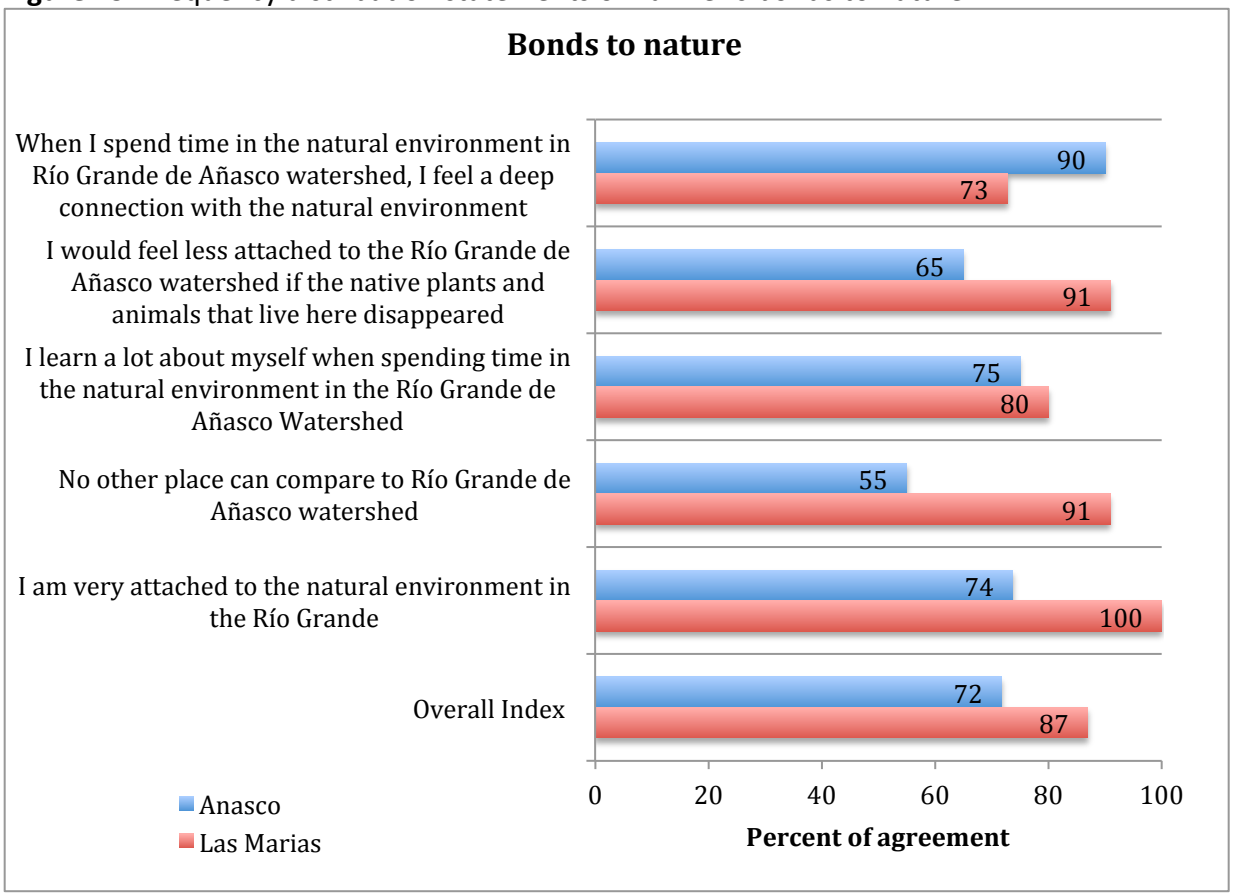


Figure 28. Frequency distribution for statements on farmer's place identity.

When I statistically compared each statement between municipalities, I found there was no statistical difference between them. However, when I statistically compared overall place identity between municipalities I found that there was statistical difference between municipalities ($t(7.504) = -2.1225$, $p= 0.06883$), being Las Marias farmer's more place identified than Añasco farmers.

Bonds to nature is another measure of place attachment, which is the level of connection people have with nature where they live. Six statements were used to measure farmers bonds to nature. From the results of this study I found that there was a stronger and more stable bonds to nature in Las Marias than in Añasco farmers. I noted that farmers in Añasco exhibited high variability responses to different statements ranging from 55% to 91% agreement (Figure 29).

Figure 29. Frequency distribution statements on farmer's bonds to nature.



When I statistically compared the statements between municipalities I found that three of the statements were not statistically different between the farming communities I studied, while the following three were statistically different between municipalities:

1) No other place compares to Rio Grande de Anasco watershed (t(27.818)=2.8743, P=0.01)

2) I am very attached to the natural environment in Rio Grande de Anasco watershed (t(26.965)=2.2203, p=0.03), and

3) I would feel less attached to the Rio Grande de Anasco if the native plats and animals that live here disappeared (t(28.734)=2.5925,p=0.01)

When I compare bonds to nature overall mean between municipalities we found that there

was a statistical difference between them (t(7.199) = -2.8832, p= 0.02284)

Social bonding is another measure of place attachment, which was divided into family and friend bonding. Each was measured with three statements. The social bonding responses showed the lowest levels of agreement of all the place attachment items by farmers in both municipalities. At Anasco 48.3% felt attached to the watershed due to family bonding while 36.7% did not feel attached due to family (Figure 30). I also found that friendship bonding was relatively not important, with 43.3% of farmers being attached due to friendship bonding, while 35.0% did not felt attached to their place due to friendships (Figure 10).

At Las Marias social bonding was also observed to be relatively low, but when compared to farmers values in Añasco it was higher, with 66.6% feeling attached to the watershed due to family bonding (Figure 31) and 48.8% due to friend bonding (Figure 31).

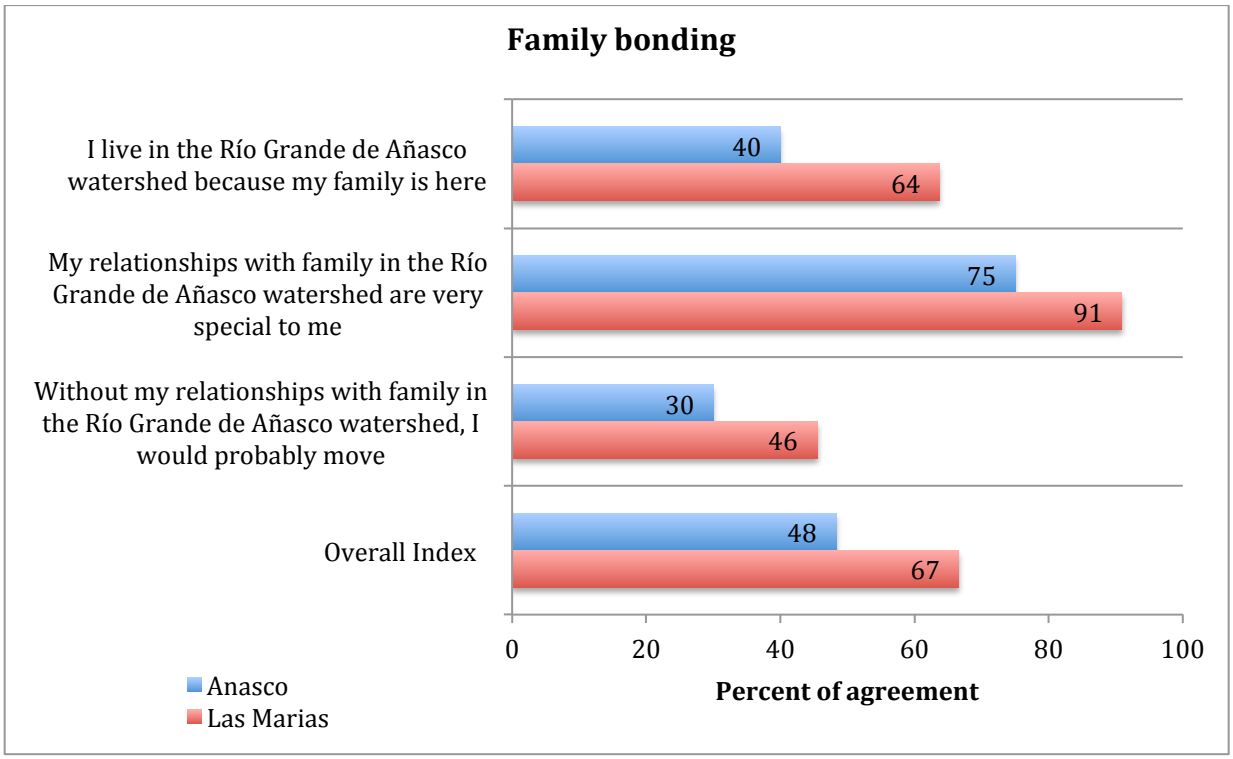


Figure 30. Frequency distribution for statements on farmer's family bonding.

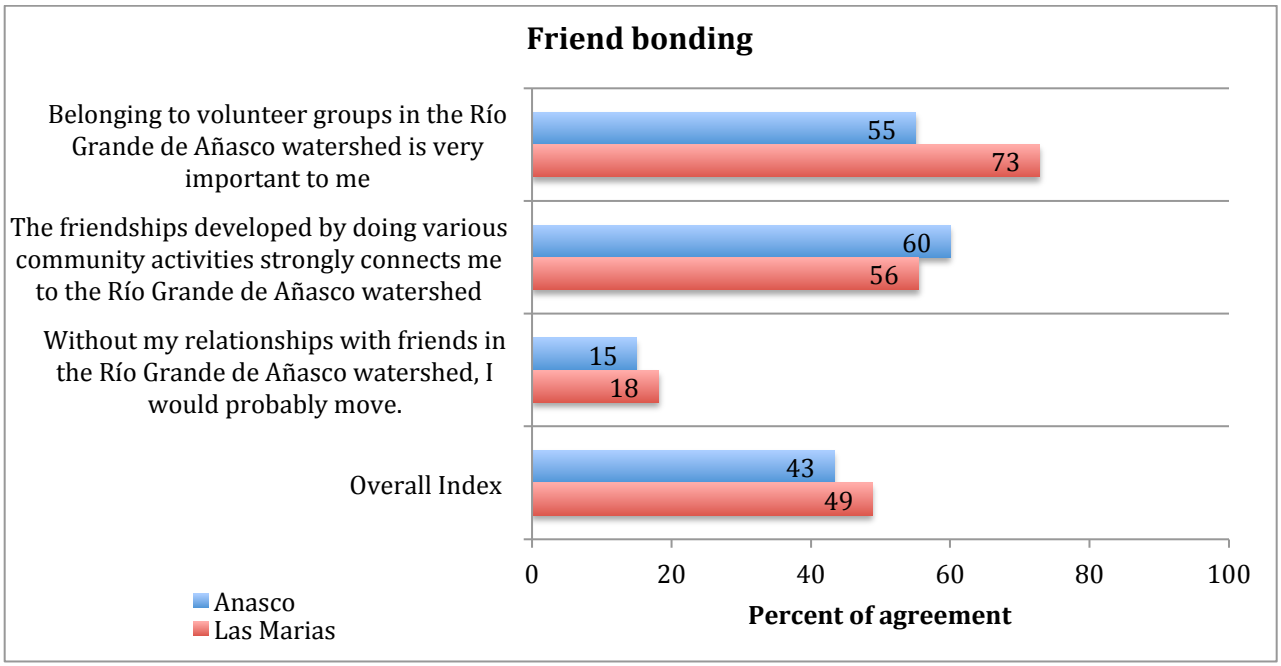


Figure 31. Frequency distribution for statements on farmer's friend bonding.

When I statistically compared each statement between municipalities, for both family bonding and friend bonding, I found that there was no statistical difference between municipalities. When I statistically compare social bonding between municipalities I also found no statistical difference ($t(9.971)= -1.0183$, $p = 0.3326$) between the farming community respondents.

The overall mean score of place attachment (sum mean of each statement/20 statements) at Añasco was 3.58 and at Las Marias was 3.99. When I statistically compared means of both municipalities I found that there was a statistical difference between municipalities ($t(462.472)=-4.3039$, $p=2.05e-05$), with the Las Marias' farmers being more attached than Anasco's farmers to their watersheds.

III. Environmental concern

Concern about water quality was measured by asking farmers 1) how important "Water quality at Rio Grande de Anasco watershed" and "Water quality overall" was for them, and if

they were in 2) support of water quality policies.

The same results were found in both municipalities on water quality importance, with anoverall of 95% of the farmers at Añasco and 100% of the farmers at Las Marias feeling water quality was important for them (Figure 32)

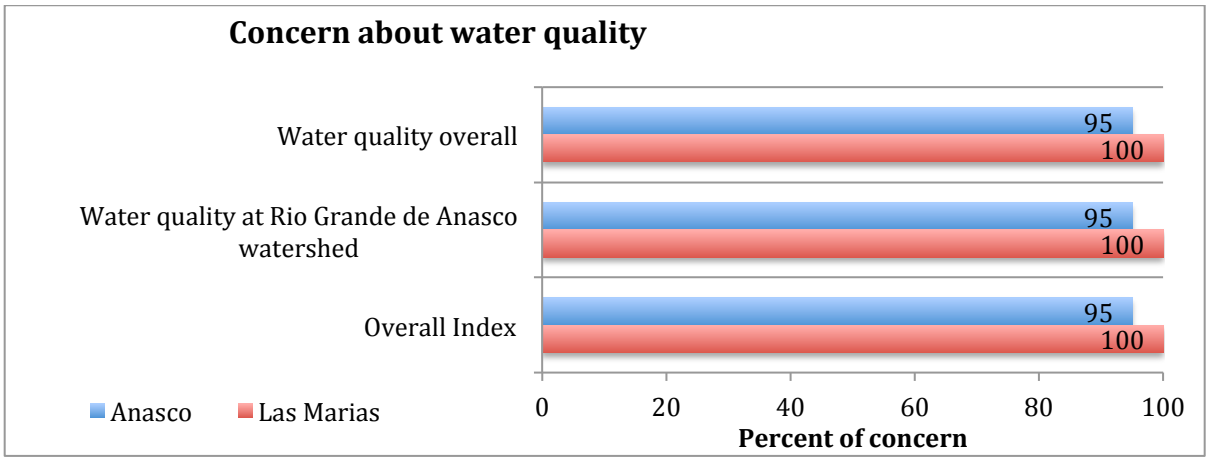


Figure 32. Frequency distribution for questions on farmer's concern about water quality.

When I compared water quality importance between both municipalities, I found that there was no statistical difference between municipalities (t(13.9)= 0.077 , P=0.94).

I also measured farmers' support for water quality policies and found that 95% of farmers at Anasco support to strongly support policies, while 81% of Las Marias farmers support and strongly support policies to protect water quality.

When I compared concern about water quality overall means between municipalities I found that there was no statistical difference between these two farming communities (t(7.854)=0.7385, p-value=0.4817)

IV. Behaviors

Behaviors were measured in my research by asking farmers if they participated in 6 pro-environmental behaviors (1) participating in any environmental group, organization and/or

program, (2) recycle, (3) store rainwater, (4) have solar panels, (5) have bathing rules, and (6) perform conservation practices in the land.

From the survey, provided to farmers at Añasco municipality, I found that there were 5% of the farmers in this region that did not participate in any environmental behavior, 35% who participated in two behaviors, 10% engaged in 5 behaviors, while 5% participated in all six behaviors (Figure 33). Overall most of the farmers (75%) in this region were currently engaged in some conservation practices on their farms (Figure 34).

At Las Marias I found that 9% of the farmers were not participating in any conservation behaviors, 9% participated in one behavior, 18% participated in two behaviors, 55% participated in three behaviors, and 9% participated in four behaviors; none said that they participated in five or six behaviors (Figure 33). Overall most of the farmers (73%) in this region were currently engaged in some conservation practices on their farms (Figure 34).

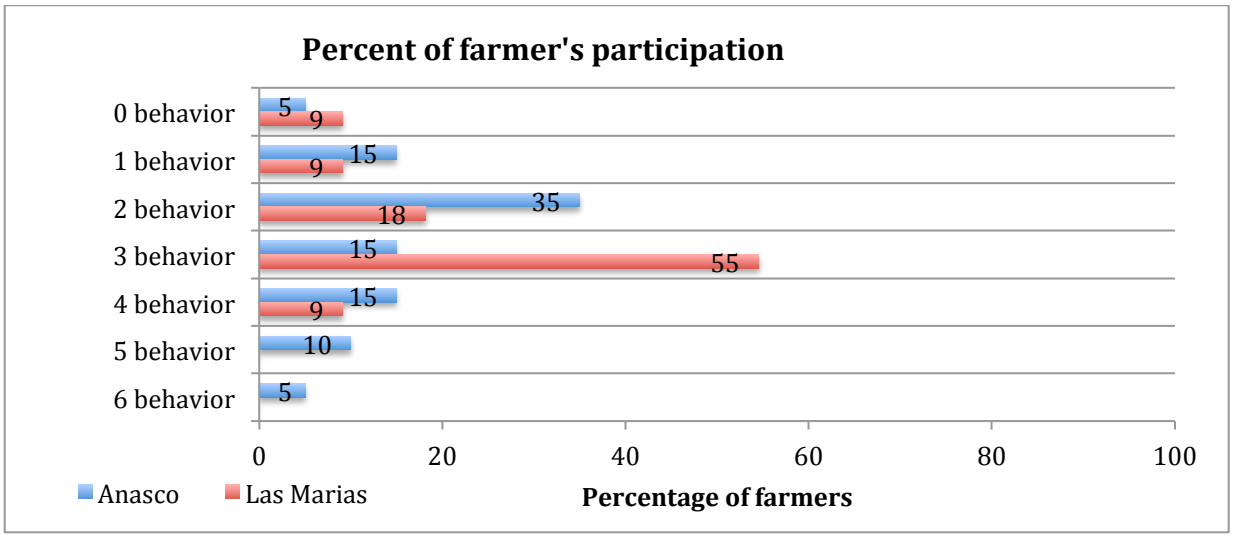


Figure 33. Percent of farmers that participated in different amount of behaviors.

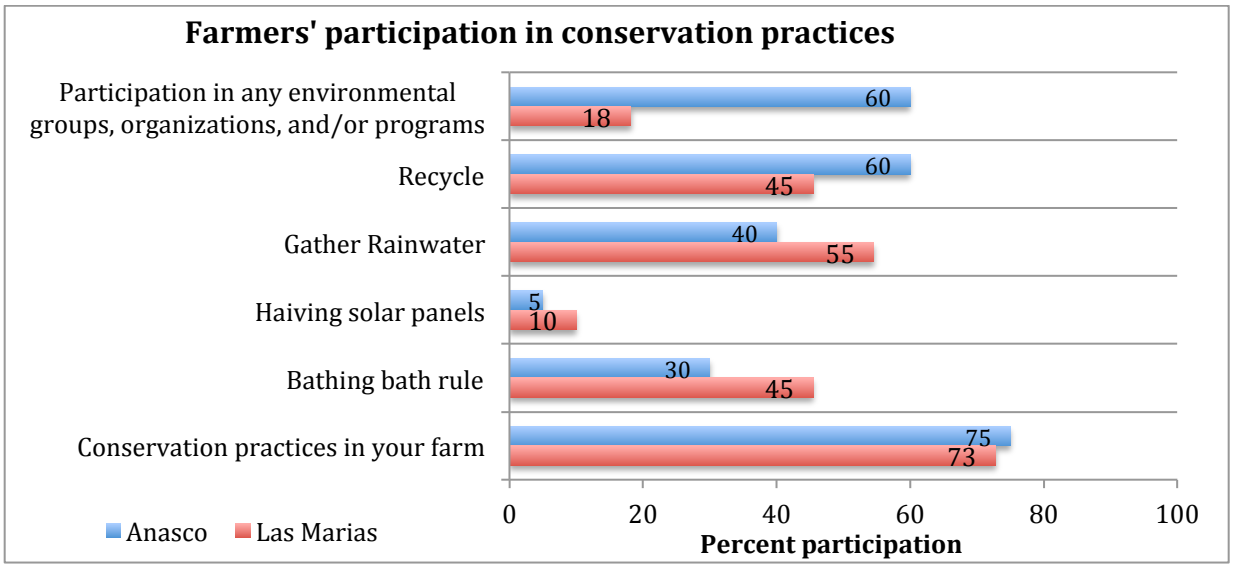


Figure 34. Frequency distribution for questions on farmer's participation in conservation practices.

When I statistically compared farmer's participation in the different behaviors I found that only "participation in any environmental group, organization, and/or program" was statistical significant difference (t(24.787)=2.5214, p-value=0.02)

The mean value of participation at Añasco was 2.70 while it was 2.45 at Las Marias, Farmers, thus, currently engage in 2 to 3 pro-environmental practices in each of these municipalities.

V. Behavioral intentions

Behavioral intentions were measured in my research by asking farmers their willingness to engage in 6 conservation practices during the next 12 months: (1) participating in any environmental group, organization and/or program, (2) recycling, (3) store rainwater, (4) install solar panels, (5) have bathing rules, or (6) implement conservation practices in the land. From Añasco farmers I found that 90% of farmers said that they will likely or very likely participate in at least one conservation practices with 80% indicating that they will likely or very likely recycle,

(Figure 35)

At Las Marias municipality 72.7% of farmers said that they will likely to very likely engage in conservation practices on their land, while 81.8% will store rainwater, and 54.6% said they will likely to very likely recycle (Figure 35).

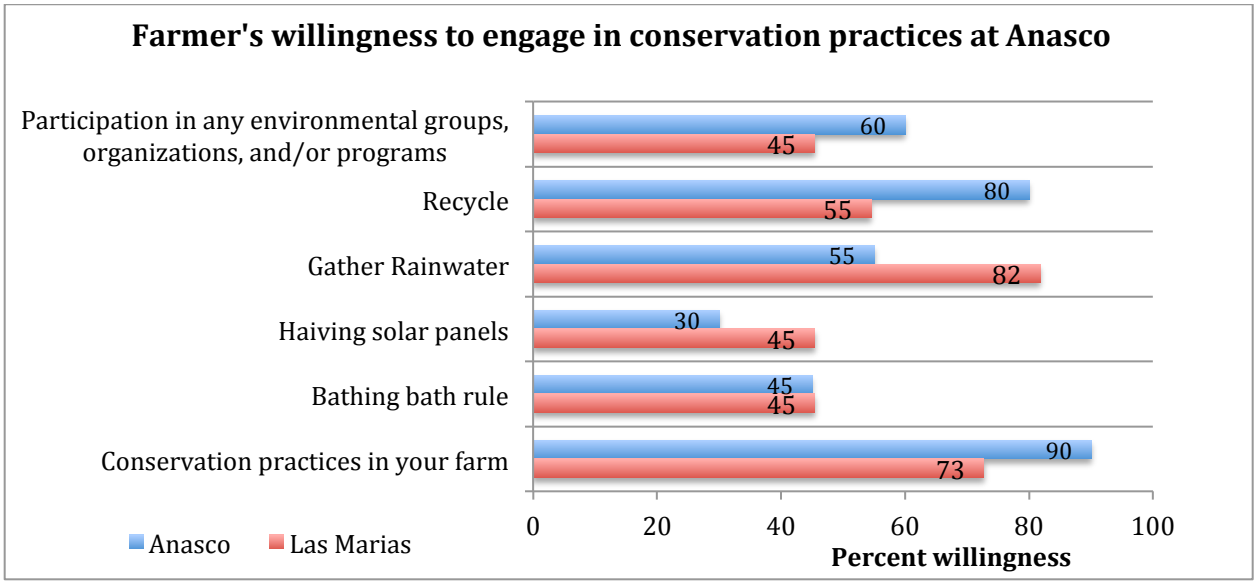


Figure 15. Frequency distribution for questions on farmer's willingness to engage in conservation practices.

When statistically comparing the means of both municipalities I found that there was no significant difference ($t(9.86)=1.0622$, $p=0.3135$) between these farming communities and thus concluded that farmers from both municipalities on average have the same willingness to engage in conservation practices.

VI. Participation in the NRCS

Participation in the NRCS water quality initiative is another measures of behavior that I used in my research to gauge stewardship engagement by farmers in these municipalities. I chose this because this initiative aims to engage farmers in conservation practices in order to reduce water quality stressors. One single question was used to measure farmers participation in NRCS

initiative: Are you currently participating in the NRCS National Water Quality Initiative?

At both municipalities, most surveyed farmers' do not participate in NRCS initiative. At Añasco only 10% out of 20 were participating in the NRCS initiative while 20% out of 10 were participating in Las Marias.

At Añasco most of the farmers do not participate due to the fact that they already are participating in conservation practices, while at Las Marias most of the farmers do not participate because they have little to no information on conservation practices (Figure 36).

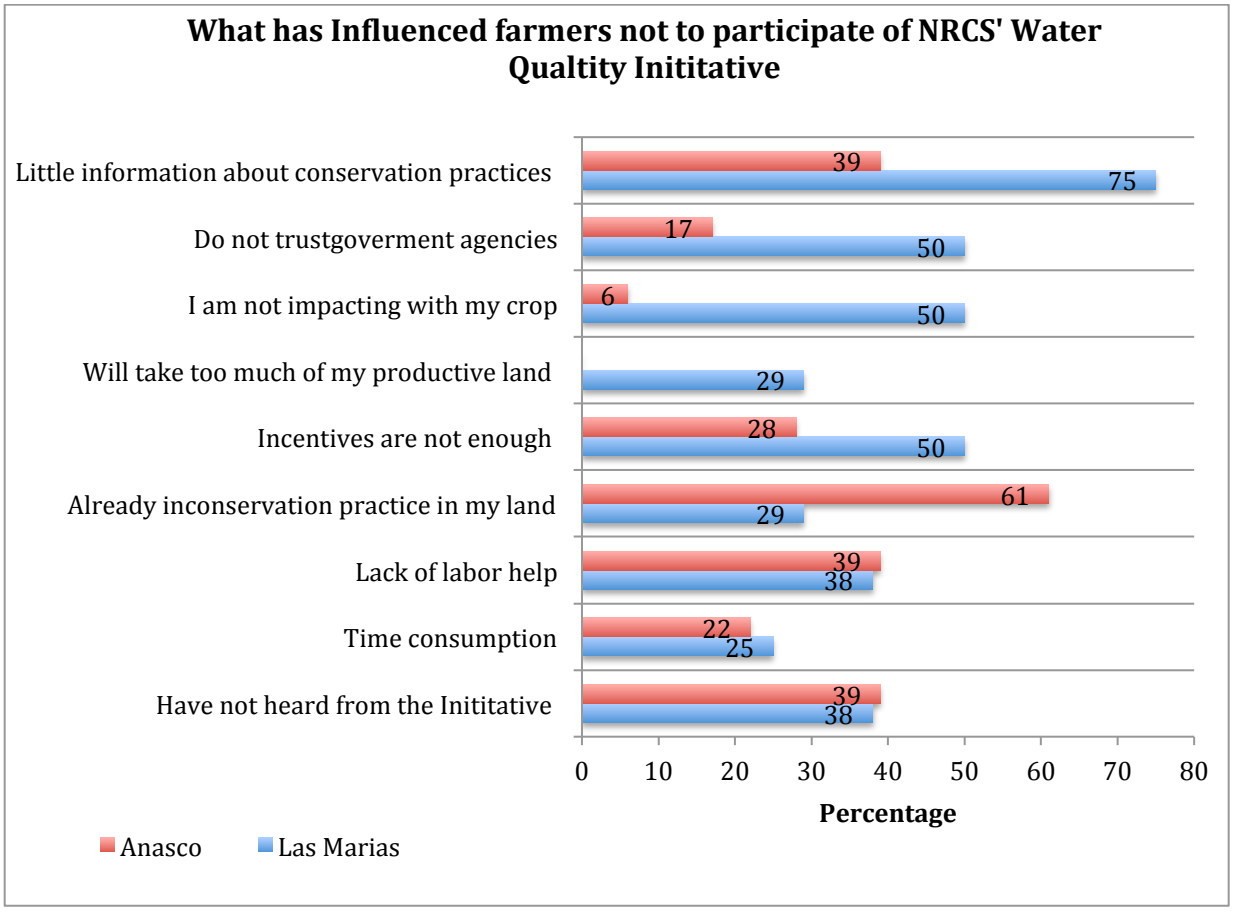


Figure 36. Frequency distribution for reasons farmers did not participated in NRCS initiative

Testing the model

In this research I created a model (Figure 37), from past research, to assess if different variables influenced behavioral intentions and behaviors. In the model, general connection to nature can influence and be influenced by place attachment. Additionally this relationship can influence degree of concern about the environment (water quality), an individual's behavioral intentions, and actual behaviors. Place attachment can also influence concern about the environment, behavioral intentions, and behaviors. Concern about the environment can also influence behavioral intentions and behaviors. In order to test this model I conducted a correlation analysis between the different variables of the model. From the correlation analysis we found that there was a statistical significant positive correlation between "place attachment" and "water quality concern"(r_s=0.31 p=0.09), "behavioral intentions" (willingness to behave) and "behaviors" (r_s=0.43 p=0.01), and "general connection to nature" and "behavioral intentions" (r_s=0.21 p=0.09) for the farming communities studied in Puerto Rico.

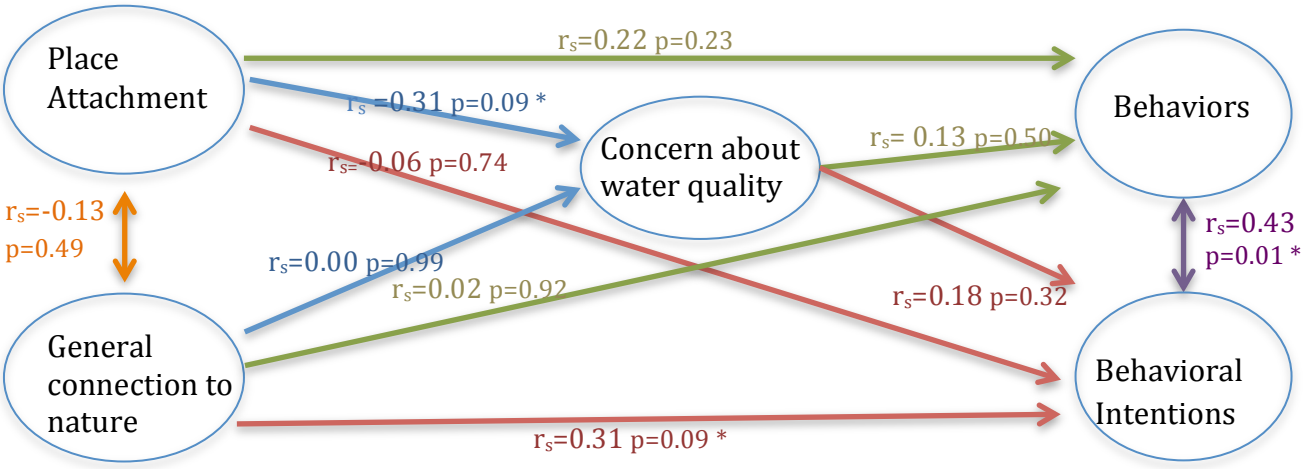


Figure 37. Model diagram with correlation coefficients between variables. *statistical significant

I also analyzed the data to see how the different measurements of "place attachment"

influenced other variables. I found that there was a strong and significant relationship between "social bonding" and "behaviors" (r_s=0.32 p=0.08).

2.5 Discussion

In "general connection to nature" part of my survey (Section 1), the more a person agreed with statements that support the New Ecological Paradigm the greater their concern about the environment, while when a person supports the Dominant Social Paradigm they do not. In my research, when I looked at general connection I found that farmers, at both municipalities, overall have more of an NEP view than a DSP view. For example, farmers from both municipalities agree to statements such as "humans are abusing the environment" or "when humans modify the environment it often produces disastrous consequences". From these results it appears that 1) farmers believe they can produce disastrous consequences while farming 2) they are unaware that farmers modify the environment, or 3) they are thinking of a more global and not local issues.

A contradictory result found in this section, in both municipalities, is the agreement with the statement "earth is like a spaceship with limited room and resources" versus "the earth has plenty of resources and what we need to do is learn how to develop them". This could be because farmers, even though they believe there are limited resources on Earth, if they use them wisely it will not be limited. This is a type of belief that is generally consistent with a view of local versus global environments. I believe farmers in these two municipalities think that globally there are many resources, but in terms of them using it (locally) they have plenty if they know how to use them.

In this same section I found two statements with statistical difference between

municipalities; 1) “Humans have the right to modify the natural environment to suit their needs”, and 2) “The environment could be easily destroyed”. For the statement “the environment could be easily destroyed” 55% of Añasco’s farmers agreed, as opposed to 100% of farmers at Las Marias. From my observations, when visiting the farms and interviewing the farmers, I found this results because mostly farmers at Las Marias 1) are generally small scale/subsistence farmers 2) live on the land, and 3) have lived on the land for many generations, while Añasco’s farmers are 1) more commercial in scale 2) the farmers generally do not generally live on the land, and 3) most have only been linked to this area for only one or two generations. These differences could influence farmers’ perspective due to difference in experiences living in the area.

At Añasco 35% of farmers agreed to the statement “Humans have the right to modify the natural environment to suit their needs”, while at Las Marias 73% agreed. Thus, while all farmers at Las Marias believe that “the environment could be easily destroyed”, 73% believe they “have the right to modify the environment to suit their needs”. I could be getting this results due to the fact that farmers at Las Marias usually are small scale farmers and subsistence farmers and they could believe that while the environment could be easily destroyed they know how to modify it in a way that it would not be threatening and would be useful in order to suit their needs. The fact that they depend on their land makes them believe they have the right to take advantage of it, but because they know it could be easily destroyed they do it in a way that would not only not harm it but would not jeopardize future production. When I evaluated the answers to the statement “when humans modify the environment it often produces disastrous consequences” it may be that the farmers were externalizing it and

not necessarily thinking about their own actions.

General connection to nature has been shown to influence people's concern about their environment (Brehm et al 2006) and their environmental behaviors (Stern et al 1995, Scanell and Grifford 2010). In this study, although farmers have more of an ecological view, I found in that there was no relationship between "general connection" to nature and actual "behaviors". I did find however a strong relationship between "general connection" and "behavioral intentions". This means that while general connection influences peoples behavioral intentions it does not necessarily influence their actual behaviors, likely because there are other behaviors that are more influential For example, the results I found might be observed because compared to past research behaviors, my research options were generally more time consuming or costly which can makes the relationship between attitudinal factors weaker. Behaviors measured in past research (recycling, turning lights off) are less time consuming and less costly than behaviors measured in my research (buying solar planes, collecting rain water, or participating in any environmental group, organization or program), which would explain the lack of relationship between general connection to nature and behavioral that I observed.

I also found no relationship between general connection and environmental concern contrary to what Gosling and Williams (2010) found in their study. This could be do to the fact that environmental concern was more specific and not general. Also, people might have a strong general view on human/nature relationship, but not necessary mean that this would translate to local water quality concern. In other words, a general view on how human and nature relate does not translate to your specific feeling about a certain local issue

When I evaluated the results of the place attachment section (section 2 in the survey) I

found that the only measure that was statistically different between municipalities was the section related to “bonds to nature”. Here three out of six statements presented statistically significant difference. From this three, the statement “No other place can compare to Rio Grande de Añasco watershed” was the biggest difference between municipalities. This is likely a function that most farmers at Añasco did not live on the land, while most of farmers at Las Marias did and past generations of their relatives had farmed the same lands. I found that farmers at Las Marias had a stronger bond to nature than Añasco’s farmers with an overall index of agreement of 87% compared to 72% at Añasco.

When I assessed place attachment overall between municipalities I found that there was a statistical difference, with farmers at Las Marias being more” place attached” than farmers at Añasco. I expected to see this results since farmers at Las Marias are small-scale, mostly subsistence farmers, that had lived in the watershed for several generations. Meanwhile Añasco farmers were more commercial in nature, do not live near the farm (rent or have another house somewhere else), nor have been member of the watershed and their communities for several generations.

When evaluating the overall results, the model I developed demonstrated that there was a statistical significant relationship between “place attachment” and “concern about water quality”. This means that people that are more attached have a stronger concern toward water quality than people that are not attached. When we look at the model with municipalities separated we can see that there is a stronger relationship between Las Marias farmer’s place attachment and concern about water quality than the farmers in Añasco.

When I evaluated the model to determine how the different measurements of place

attachment (Place identity, place dependence, bonds to nature, social bonding) influenced the other variables, I found that "social bonding" had a strong and meaningful relationship with "behaviors" (r_s=0.32 p=0.08). Thus, the strong relationship between social bonding and behaviors could demonstrate that people's connection to other people motivates their participations. The relationship between social bonds to nature and environmental quality concern is logical since a stronger relationship with the natural place in the watershed likely increases people's interest in protecting it.

Farmer's concern about the environment (Section 3 of survey) in both municipalities was seen to be very high (95 and 100% concern), but there is no relationship between "concern about the environment" and "actual behavior" or "behavioral intentions". The lack of relationship between environmental concern and behavioral intentions or behaviors tells me that there are other things, such as the behavior being too costly or time consuming, or that people are more concern on land productivity than environmental problems, thereby diminishing the farmers interest to participate in pro-environmental behaviors.

From this research, I also found that although there is a high water quality concern this is inconsistent with people's knowledge of current water quality conditions. At Añasco 40% of farmers believed that water quality at Rio Grande de Añasco is average, the same trend is seen in Las Marias with 45% believing is average. Importantly, at Las Marias a relatively high number (25%) admitted not knowing the water quality's condition in their watershed, while at Añasco only 5% said they did not know. Interestingly, 15% and 18% of farmers at Añasco and Las Marias, respectively, said water quality at Añasco is excellent. This inconsistency between concern about water quality and actual knowledge of the status of their water quality could be

due to that farmers are not being informed of the current status of their water quality and reasons for its degradation.

I found that a relatively high number of farmers are and are willing to participate in conservation practices in their land (section 4 and 5 in survey) in both municipalities, but only 10% in Añasco and 20% in Las Marias were participating in the National Water Quality Initiative from the NRCS (Section 6 in survey). Farmers at Las Marias (75%) were not participating and stated that they do not participate as they have little information about conservation practices, while at Añasco 61% of those that are not participating in NRCS initiative are not participating due to the fact that they are already participating in other conservation practices on their lands. The high number of people not participating in the NRCS initiative could be due to a lack of communication and interactions between farmers and the NRCS regarding possible conservation programs available to them.

Due to lack of an updated list of farmers and the relatively low numbers of farmers that participated in this research I had a limited sample of the demographic make up of the farming community. As such, I chose, to eliminate demographic analysis from further analysis.

Participants phone numbers was gathered from a list of the state Department of Agriculture and the list of Agricultural Extension's agronomist. This may have promoted us to have collected biased data due to a selected interview pool of farmers in each region. The fact all of the farmers at Añasco and most of the farmers at Las Marias were selected from this list could have biased our selection to people that already were1) more willing to participate in different practices and the survey 2) trust government agencies 3) already engage in conservation practices promoted by the department or Agricultural Extension, among others. For future

research there should be from a more representative pool of the farming community in each municipality.

2.6 Conclusion

Surface water quality in Puerto Rico is in relatively poor conditions due to levels of impairments such as turbidity, fecal coliforms, and low dissolve oxygen (PREQB 2012). There are several sources of impairment, but for this researched we focused on the impact of agricultural communities on water quality. In western Puerto Rico, Rio Grande de Añasco watershed is considered mostly agricultural and ranked as high priority watershed for conservation practices to be undertaken by the USDA due to its water quality impairments. This was thus an ideal study site for evaluation of conservation behaviors and the agricultural community and further was emphasized by the USDA NRCS having a new initiative that aimed to engage farmers in conservation practices to reduce water quality impacts in this watershed.

Water resource in the island is managed, regulated, and conserved by different agencies. Due to its numerous agencies managing water quality in Puerto Rico it's a challenge that not only needs inter agency communication but citizen involvement. In order for citizen to be stewards, they need first to acknowledge current water quality conditions and understand the causes for its degradation, in order to engage in pro-environmental behaviors to reduce stressors to water quality.

In this research I selected a group of citizens, farmers, in westerner Puerto Rico in order to assess how their connection to the land (place attachment) influence their interest in participating in environmental behaviors. From my results I found that farmers at Las Marias have greater place attachment than Añasco's farmers, this might be due to owning and living

for more than one generation on the municipality. I did find statistical significance between overall “place attachment” and “environmental concern” but no significant relationship with environmental behaviors. Moreover, I did find a statistical significance between “social bonding” and “pro-environmental behaviors”, and between “bonds to nature” and “concern about water quality” . I also found a statistical significance relationship between “general connection” and “behavioral intentions” (r_s=0.32, p=0.08) and a strong and significant relationship between “behavioral intentions” and “behaviors”.

From my experience in the field and trying to contact the farmers, there is a need to be able to send information to farmers in a better way. The lack of cooperation and sometimes-conflicting information from several federal and commonwealth agencies with the farmers makes getting to the goal of environmental stewardship behavior difficult at the local level.

For future research a larger, more representative group of individuals from the Puerto Rican population should be surveyed. For future research I also believe that increasing the quantity of behaviors and making it a broader scope would be more meaningful in the correlation with other variables. In my research, environmental concern was measured as “concern towards water quality”(specific issue). For future research I recommend that one have a bigger scope of environmental issues, making it not only relevant on local issues but also global ones; allowing for great comparisons with the rest of the world.

Farmers represent a small segment of the Puerto Rican population, but this survey could be used as a guide for future, more extensive and inclusive research. Due to the farmer’s current engagement in conservation practices and interest in future participation we recommend that other questions, that could be promoting their engagement, should be

included in the survey, such as economic benefits and cost and time allocation.

Understanding citizen's motivation to engage in pro-environmental behaviors is a key aspect of natural resource conservation and protection. This research aimed to identify how emotional bonds to nature and the place they live influences their interest in participating in certain conservation oriented practices. I believe that by engaging farmers in conservation practices, we will be able to promote healthier waters by reducing water pollution. This increase in healthy waters will enhance ecosystems not only for aquatic life in the local regions but for all ecosystems services which humans benefit from that are effected from the deterioration of the waterways in Puerto Rico (eg, coastal ecosystems) .

APPENDIX

A Survey of Farmers in the Río Grande de Añasco Watershed
About

Living in Río Grande de Añasco watershed

ENTER TO WIN $300!

By participating your name will be collected to participate on the drawn

YOUR RIGHTS AS A PARTICIPANT

Your participation is completely voluntary.

You may choose not to participate at all, refuse to answer some questions, or stop at any time.

You will remain anonymous.

You will not be identified by name, address, or any other unique characteristic in any written document that results from this research. While your privacy will be protected to the maximum extent allowable by law, there is always the possibility of unforeseeable risks.

Follow-up questions/comments?

Contact me (Marielle Peschiera) at (787) 528-2828 or email: peschie2@msu.edu
or my academic advisor Dr. William W. Taylor at (517) 353-3048 or email: Taylorw@msu.edu

Questions/concerns regarding your right as a study participant?
Dissatisfied at any time with any aspect of this study?

Contact Harry McGee Director of the Human Research Protection Program by phone: (517) 355-2180, email: irb@msu.edu, or mail: 202 Olds Hall, East Lansing, MI 48824

By completing this survey you indicate your voluntary agree to participate in this research and have your answers included in the anonymous dataset

Thank you for agreeing to complete this survey about place attachment and water quality. Please read each question carefully before responding. Your responses will help in the fulfillment of a local students Master's thesis research. Before you begin the survey we want to offer the fallowing definitions:

Watershed: A watershed is the area of land where all of the water that is under it or drains off of it goes to the same place.

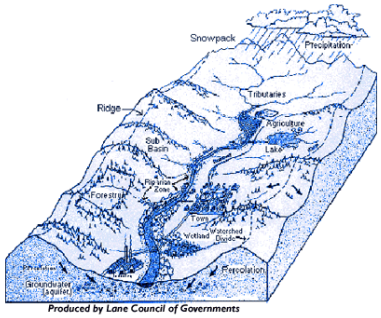


Figure 38. Watershed description

Río Grande de Añasco watershed: This is where you live! Río Grande de Añasco watershed occupies an area of 181 mi² in central and western Puerto Rico, including the municipalities of Lares, Adjuntas, Yauco, Las Marias, Maricao, San Sebastian, Añasco y Mayaguez. The primary river is Río Grande de Añasco where all the other tributaries drains to.

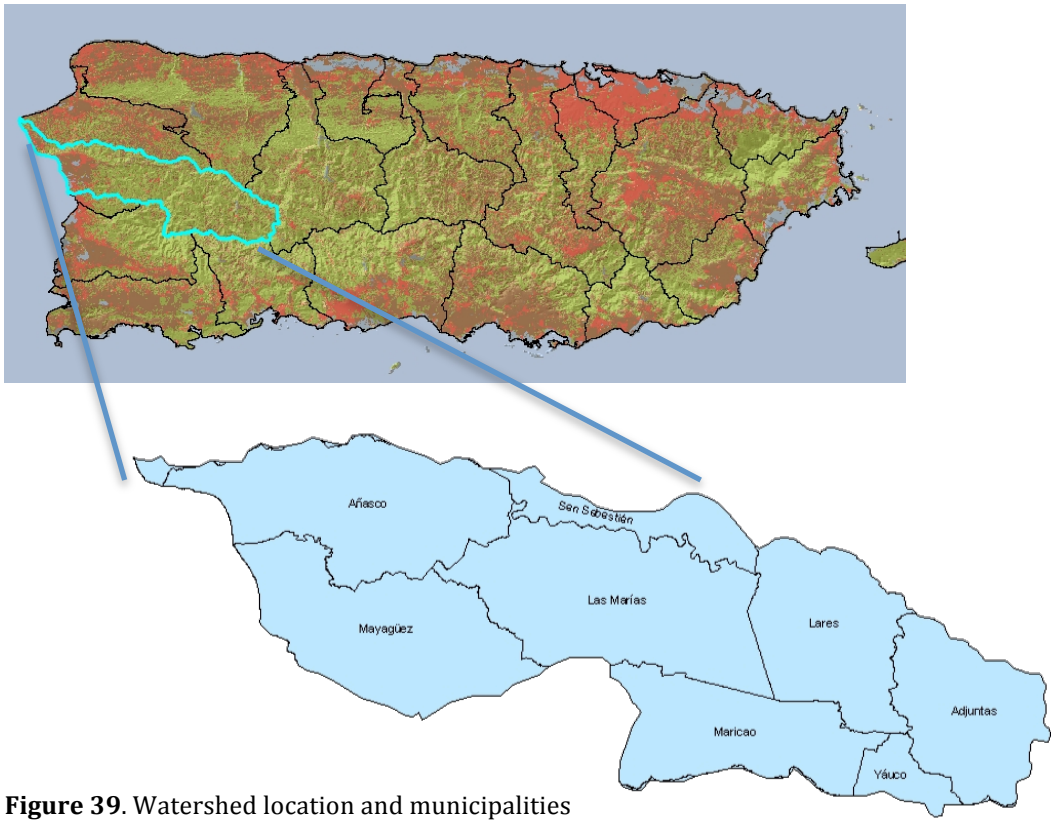


Figure 39. Watershed location and municipalities

Face to face____ Left_____

Section 1. In this section think about the relationship between human and nature and rate how much you agree or disagree with the statement

	Strongly disagree	Disagree	Agree	Strongly agree	I'm not sure
We are approaching the limit of the number of people the earth can support	☐	☐	☐	☐	☐
Humans have the right to modify the natural environment to suit their needs	☐	☐	☐	☐	☐
When humans modify the environment it often produces disastrous consequences	☐	☐	☐	☐	☐
Human ingenuity will insure that we do NOT make the earth unlivable	☐	☐	☐	☐	☐
Humans are severely abusing the environment	☐	☐	☐	☐	☐
The earth has plenty of natural resources if we learn how to develop them	☐	☐	☐	☐	☐
Plants and animals have as much right as humans to exist	☐	☐	☐	☐	☐
The environment is strong enough to cope with the impacts of modern industrial nations.	☐	☐	☐	☐	☐
Despite our special abilities humans are still subject to the laws of nature	☐	☐	☐	☐	☐
The so-called "environmental crisis" facing humankind has been greatly exaggerated	☐	☐	☐	☐	☐
The earth is like a spaceship with very limited room and resources	☐	☐	☐	☐	☐
Humans were meant to rule over the rest of nature	☐	☐	☐	☐	☐
The environment could be easily destroyed	☐	☐	☐	☐	☐
Humans will eventually learn enough about how nature works to be able to control it	☐	☐	☐	☐	☐
If things continue on their present course, we will soon experience a major environmental catastrophe	☐	☐	☐	☐	☐

Section 2. In this section think about your physical, social, and nature connections with your watershed and answer if you agree or disagree with the statement

	Strongly agree	Disagree	Agree	Strongly agree	I'm not sure
I would not choose another watershed over the Rio Grande de Añasco watershed due to the activities I do here.	☐	☐	☐	☐	☐
Without my relationships with friends in the Río Grande de Añasco watershed, I would probably move.	☐	☐	☐	☐	☐
I feel the Río Grande de Añasco watershed is a part of me	☐	☐	☐	☐	☐
The Río Grande de Añasco watershed is very special to me	☐	☐	☐	☐	☐
The Río Grande de Añasco is the best place for the activities I like to do.	☐	☐	☐	☐	☐
I am very attached to the Río Grande de Añasco watershed	☐	☐	☐	☐	☐
Belonging to volunteer groups in the Río Grande de Añasco watershed is very important to me	☐	☐	☐	☐	☐
Living in the Río Grande de Añasco watershed says a lot about who I am	☐	☐	☐	☐	☐
Without my relationships with family in the Río Grande de Añasco watershed, I would probably move	☐	☐	☐	☐	☐
When I spend time in the natural environment in Río Grande de Añasco watershed, I feel a deep connection with the natural environment	☐	☐	☐	☐	☐
I identify strongly with the Río Grande de Añasco watershed	☐	☐	☐	☐	☐
I learn a lot about myself when spending time in the natural environment in the Río Grande de Añasco Watershed	☐	☐	☐	☐	☐
No other place can compare to Río Grande de Añasco watershed	☐	☐	☐	☐	☐
I am very attached to the natural environment in the Río Grande de Añasco watershed	☐	☐	☐	☐	☐
I live in the Río Grande de Añasco watershed because my family is here	☐	☐	☐	☐	☐
My relationships with family in the Río Grande de Añasco watershed are very special to me	☐	☐	☐	☐	☐
The Río Grande de Añasco watershed means a lot to me	☐	☐	☐	☐	☐
I would feel less attached to the Río Grande de Añasco watershed if the native plants and animals that live here disappeared	☐	☐	☐	☐	☐
The friendships developed by doing various community activities strongly connects me to the Río Grande de Añasco watershed	☐	☐	☐	☐	☐
Doing my activities in the Río Grande de Añasco watershed is more important to me than doing them in any other place.	☐	☐	☐	☐	☐

Section 3. In this section think about water and water quality

Based on your knowledge, in the fallowing statements please rate water quality from poor to excellent.

	Poor	Below average	Average	Above Average	Excellent	I'm not sure
Current water quality conditions at Río Grande de Añasco watershed	☐	☐	☐	☐	☐	☐
Current water quality conditions in Puerto Rico	☐	☐	☐	☐	☐	☐
Current water quality conditions globally	☐	☐	☐	☐	☐	☐
Future water quality conditions at Río Grande de Añasco watershed	☐	☐	☐	☐	☐	☐
Future water quality conditions at Puerto Rico	☐	☐	☐	☐	☐	☐
Future water quality conditions globally	☐	☐	☐	☐	☐	☐

Please rate <u>how important or unimportant</u> is for you the following statements

	Very unimportant	Unimportant	Important	Very Important	I'm not sure
Water quality overall	☐	☐	☐	☐	☐
Water quality in Río Grande de Añasco watershed	☐	☐	☐	☐	☐
Environmental problems	☐	☐	☐	☐	☐

Please state <u>if you oppose or support</u> what the following statements say

	Strongly opposed	Opposed	Support	Very supportive	I'm not sure
There is a need for stronger environmental protection laws for business and industry	☐	☐	☐	☐	☐
Laws requiring that all citizens conserve resources and reduce water pollution	☐	☐	☐	☐	☐
Support for scientific research to help find new ways to control water pollution	☐	☐	☐	☐	☐

Section 4. In this section think about conservation practices and other pro-environmental activities

Please indicate in the activities you <u>have engaged</u> in the following activities in the last 12 months

	Yes	No
Participated in any environmental groups, organizations and/or programs	☐	☐
Recycled	☐	☐
Gathered rainwater	☐	☐
Have solar panels	☐	☐
Bathing time rule	☐	☐
Clean your car more than once in a month	☐	☐
Do you have a filled pool on the house	☐	☐
Conservation practices in your farm such as creating terraces or covering crops	☐	☐

To what extent has each of the following influenced your household's actions to NOT <u>participate in conservation practices</u> in your land?

	Not influenced				Influenced
Don't believe is necessary	1	2	3	4	5
Its expensive to participate in conservation practices	1	2	3	4	5
Do not have information on how to start	1	2	3	4	5
Do not know the cost of participating in conservation practices.	1	2	3	4	5
Do not know what conservation practices are	1	2	3	4	5
Do not how where to go in order to start conservation practices	1	2	3	4	5
I have little time in this land	1	2	3	4	5
My land is too small to engage in conservation practices	1	2	3	4	5

Please respond <u>how likely or not likely you are to participate</u> in the following activities in the next 12 months?

	Not likely	Somewhat likely	Likely	Very likely	I'm not sure
Conservation practices in your farm such as creating terraces or covering crops	☐	☐	☐	☐	☐
Be part of and environmental group, program and/or organization	☐	☐	☐	☐	☐
Recycle	☐	☐	☐	☐	☐
Have solar panels	☐	☐	☐	☐	☐
Build a pool	☐	☐	☐	☐	☐
Gathered rainwater	☐	☐	☐	☐	☐
Time rule for bathing?	☐	☐	☐	☐	☐
Clean your car more than once in a month	☐	☐	☐	☐	☐

Section 5. NRCS National Water Quality Initiative

Are you participating of the NRCS National Water Initiative? Yes / No *(Please circle one)*

If you are NOT currently participating of the NRCS Initiative how likely or not likely the fallowing <u>influenced your decision not to participate</u>

	Not likely	Somewhat likely	Likely	Very likely	I'm not sure
Have not heard about it	☐	☐	☐	☐	☐
Time consumption	☐	☐	☐	☐	☐
Lack of labor help	☐	☐	☐	☐	☐
Already have conservation practice in the land	☐	☐	☐	☐	☐
Incentives are not enough	☐	☐	☐	☐	☐
Will take too much of my productive land	☐	☐	☐	☐	☐
I am not impacting water quality with my crop	☐	☐	☐	☐	☐
Do not trust government agencies	☐	☐	☐	☐	☐
Little information of impacts of participating in conservation practice	☐	☐	☐	☐	☐

If you are currently participating of the NRCS initiative how likely one of <u>this influenced your decision to participate</u>

	Not likely	Somewhat likely	Likely	Very likely	I'm not sure
Incentive to participate	☐	☐	☐	☐	☐
Reduce impact to water ways	☐	☐	☐	☐	☐
Neighbor already participating	☐	☐	☐	☐	☐
Reduce impact to other ecosystem services	☐	☐	☐	☐	☐
Would not lose anything by participating	☐	☐	☐	☐	☐

Section 6. In this section please provide personal background information by selecting the option that best describes you

What is your gender? Female / Male

How long have you lived in the Río Grande de Añasco watershed? _____

Do you own or rent the farm? _____

What is your approximate annual gross household income *(before taxes) (please check one response)*

- ☐ Less than 10,000
- ☐ 10,000-29,999
- ☐ 30,000- 49,999
- ☐ 50,000-79,999
- ☐ 80,000-99,999
- ☐ 100,000-ormore
- ☐ No answer

Name the sources of your income *(please type all that apply)*

_____

Percent of income earn from farming *(please check one response)*

- ☐ Less than 25 percent
- ☐ 25 to 49 percent
- ☐ 50 to 74 percent
- ☐ 75 percent or more
- ☐ No answer

Highest grade? *(please check one response)*

- ☐ None
- ☐ Elementary school
- ☐ Secondary school
- ☐ High school diploma or GED
- ☐ Some college
- ☐ College Bachelor's degree
- ☐ Master's or PhD
- ☐ No answer

Years operating the farm *(please check one response)*

- ☐ Less than 2 years
- ☐ 2 to 4 years
- ☐ 5 to 9 years
- ☐ 10 years or more
- ☐ No answer

¿Do you live at Rio Grande de Añasco watershed? ¿Which municipality?

_____

¿Which crops do you have in your farm?

_____

Size of your farm _____

Age group *(please check one response)*

- ☐ Under 25 years old
- ☐ 25 to 34 years old
- ☐ 35 to 44 years old
- ☐ 45 to 54 years old
- ☐ 55 to 64 years old
- ☐ 65 years old and over
- ☐ No answer

Hispanic origin

- ☐ Not of Hispanic origin or Latino origin
- ☐ Of Hispanic or Latino origin
- ☐ No answer

Any comments?

_____ _____

_____ _____

_____ _____ _____

_____ _____

Thanks for participating and stay alert for the drawn prize winner!

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