ADVANCING HUMANITY in BELIZE

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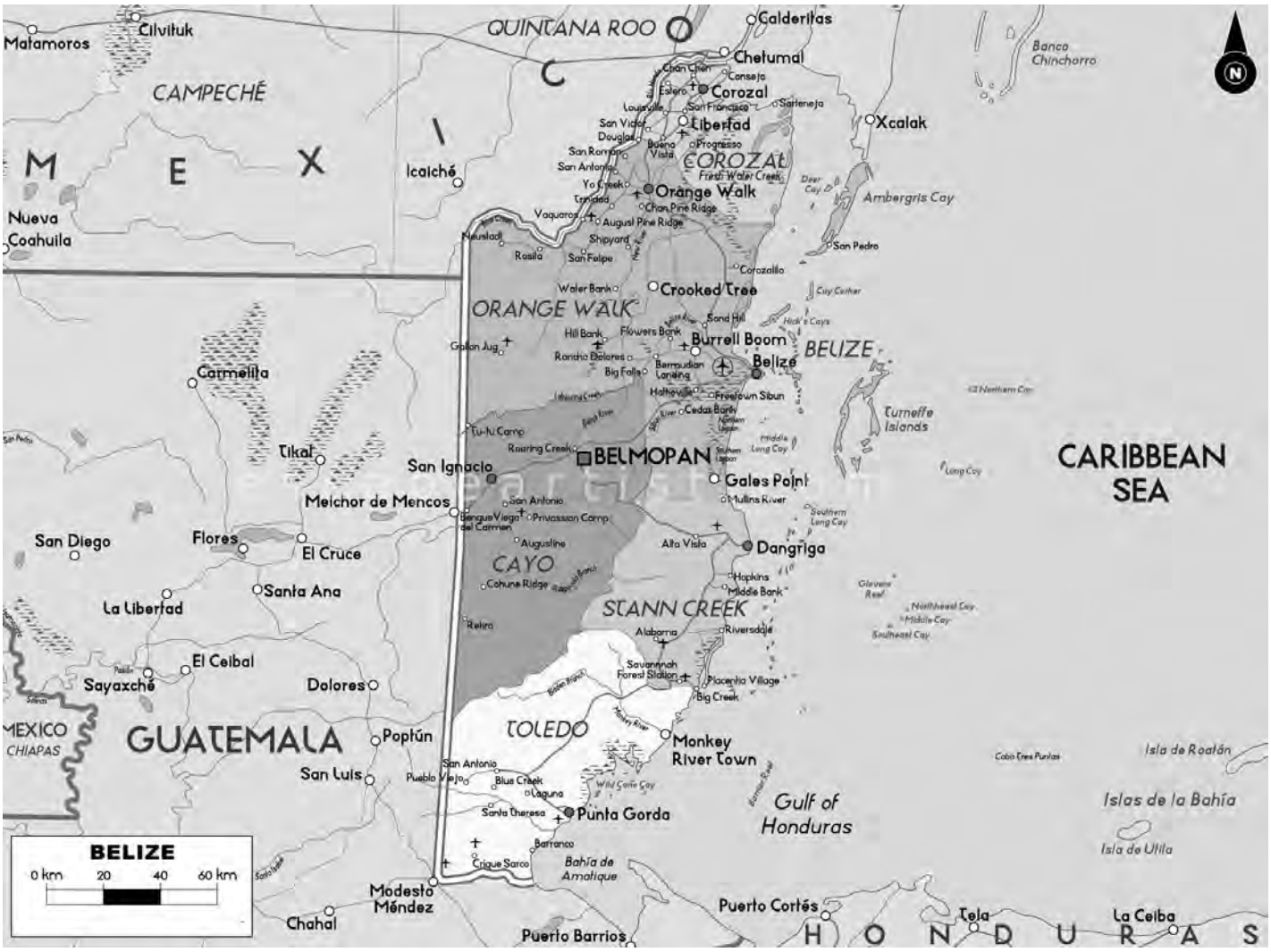

RESEARCH COMING TOGETHER TO EFFECT CHANGE IN NORTHERN BELIZE

Mary Ann Studer, McMaster Fellow, 2012-2014

Enhancing human well-being and productivity, while minimizing the negative impacts human activity can have on the environment, is at the core of the projects that were undertaken in Belize in December 2012, April 2013, and December 2013. While working with communities as they move toward sustainable development, my focus continues to be on: (1) providing information to farmers that supports optimal fertilization and minimizes negative impact on their soils and the environment; and (2) surveying nitrate levels of subsurface water in the New River Lagoon to assess the potential for that body of water to be a viable source of water for the village of San Carlos. These projects may seem diverse, yet they coherently align within the Integrated Natural Resource Management framework proposed by Sanchez Palm and Buol (Sanchez, Palm, & Buol, 2003), as they work to address the issues commonly faced by agricultural communities in developing countries, namely food and water insecurity, poverty, and environmental degradation. The projects I worked on, with the support of the McMaster School for Advancing Humanity in 2012 and 2013, are directly targeted at connecting the agendas of all the stakeholders involved, specifically the conservation mission of Programme for Belize (PFB), managing entity of the Rio Bravo Conservation and Management Area (RBCMA); the sustainable development of the village of San Carlos; and other agricultural communities that lie on the periphery of the preserve.

Soil Macro and Micro Nutrient Analysis Conducted in Agricultural Areas in Northern Belize

The negative consequences of over fertilization of agricultural areas weigh heavy on both the farmers and the neighboring rainforest. These negative impacts include: (1) soil degradation and destruction of the farmers' natural capital, the land; (2) the financial strain and reduced profits for farmers with limited landholdings and subsistence income levels; (3) inorganic chemical runoff into environmental waterways, the subsequent threat to aquatic life, and, perhaps more important, the threat to quality drinking water; and (4) the potential damage to conserved rainforest areas and carbon sequestration plots due to agricultural runoff.

In our meetings each December, PFB Director Edilberto Romero continues to stress that Defiance College's McMaster School for Advancing Humanity teams remain the sole initiative that is working to improve subsistence agriculture on the periphery of the RBCMA. I am working with farmers toward that goal by monitoring soil nutrient levels and promoting strategic agricultural practices that have the potential to minimize the negative impacts of agriculture on the environment. I have documented, through the analyses of soil macro and micro nutrient levels in specific fields, that the information provided by this project in past years has allowed farmers to increase their profits by reducing inorganic fertilizer use and simultaneously decreased the potential for harmful runoff. Data shows, farmers I have partnered with have reduced the amount of inorganic macro nutrient (nitrogen, phosphorus, and potassium) fertilizer they use by an average of over 48% since my initial testing in 2005 (Studer M. , 2010).

The maintenance of optimal nutrient levels in these farmers' fields confirmed in this study evidences that farmers are utilizing the information returned to them on the field sheets I provide to them following each test period. In December 2012, I had one farmer sit down with me and go over each of the field sheets he had received over the past 6 years. He tracked the decreasing levels of inorganic inputs proudly explaining that the yields, while they varied due to weather conditions, had been good at the same time as his costs to achieve those yields had decreased. He was very proud of those results.

The protocols for testing in both 2012 and 2013 mirrored methods utilized since 2005, so as to maintain continuity. Analysis of soil color was completed using the Munsell scale. Texture, pH, and a physical assessment of soil quality was conducted while onsite using a modified version of the schema Observational Approach to Soil Health (Romig, Garlynd, Harris, & McSweeney, 1995). Criteria for the modification have been supported by information provided by the Assessment of Soil Quality by Maurice J. Mausbach and Cathy A. Seybold. (Lal, 1998). All macro and micro soil nutrient analyses were completed using LaMotte Smart2 Electronic Soil analysis apparatus. The following chemical reactions were completed to allow for digital analysis of the soil extract to quantify nutrient levels to hundredths of parts per million or pounds per acre.

Macro-Nutrients (LaMotte, 2004)

Nutrient	Protocol
Nitrate-Nitrogen	Cadmium Reduction Method
Nitrite-Nitrogen	Diazotization Method
Phosphorus	Ascorbic Acid Reduction Method
Potassium	Tetraphenylboron Method
Calcium	Schwarzenbach EDTA Method
Magnesium	Schwarzenbach EDTA Method

Micro-Nutrients (LaMotte, 2004)

Nutrient	Protocol
Manganese	Periodate Method
Iron	Bipyridyl Method
Chloride	Direct Reading Titrator Method
Copper	Diethyzdithiocarbamate Method
Ammonia-N	Nesslerization Method

December, 2012

The soil nutrient analysis for the fields tested in December 2012, showed the farmers previously partnering with this project are maintaining optimal levels of macronutrients in their fields. Levels of potassium, phosphorus, and nitrogen for these farmers were within the medium–low range parts per million (ppm) in all fields sampled. A table showing the ranges for each macro nutrient is as follows:

December, 2012 results for fields farmed by ongoing partners

Nutrient	**Sample range** **ppm**	**Medium (optimal level range ppm** (LaMotte, 2004)
Ammonia Nitrogen	28.7 – 52.2	25.0 – 68.0
Nitrate Nitrogen	10.8 – 21.4	11.0 – 29.0
Nitrite Nitrogen	2.5 – 4.0	2.5 – 4.0
Phosphorus	36.8 – 60.2	35.0 – 67.0
Potassium	82.4 – 130.2	82.0-143.0

December, 2013

Soil analyses on samples collected in December 2013, showed low macro nutrient levels in almost every field tested. This was likely attributable to the extreme rainfall during the rainy season and the rain that continued throughout the time we were on site. Due to the rain, farmers had either not applied fertilizer to their fields or it had been washed away. The notable exception to this was the field owned by Bergen, a mechanized farmer with fields adjacent to the RBCMA. In each of the nutrient ranges listed below, the highest recording was from Bergen's field that I regularly monitor as a control to understand the potential impact it could have on the adjacent carbon sequestration plot managed by PFB.

December, 2013 results for fields farmed by ongoing partners

Nutrient	**Sample range** **ppm**	**Medium (optimal level range ppm** (LaMotte, 2004)
Ammonia Nitrogen	11.0 – 25.6	25.0 – 68.0
Nitrate Nitrogen	4.0 – 11.1	11.0 – 29.0
Nitrite Nitrogen	0.9 – 2.8	2.5 – 4.0
Phosphorus	21.0 – 35.7	35.0 – 67.0
Potassium	58.5 – 84.5	82.0-143.0

The data collected also supports the premise that rainforest soils fail to retain nutrients once the land is cleared for agricultural use. It has been noted in studies conducted by Ayoub that there is a higher rate of soil nutrient depletion in Latin American and the Caribbean than in Asia or Africa due to the rapid nutrient depletion caused by deforestation (Ayoub, 1999). These soils, which were formerly rainforest, farmed by the Belizean and Mennonite farmers we work with, contain only minimal levels of nutrients beyond inputs applied by farmers. Therefore, the low levels in the fields sampled were likely the result of heavy rains during the rainy season 2013, which prompted a lack of fertilizer application or fertilizer runoff. In December 2012, I was able to expand my connections within the un-mechanized Mennonite community by working with farmers in two distinct camps wherein I had not previously made contacts; and in December 2013, these partnerships were solidified. Agricultural information is generally only disseminated via word of mouth within Mennonite communities ("camps"). Therefore, partnering with a single individual strategically within a camp to provide accurate information regarding soil health has the potential to impact many other family farms in the area. I have seen this happen in past years in local camps such as New Hope Village.

Nitrate Assay of Water Sub-Surface in the New River Lagoon

875 million people worldwide live without clean water (Facts and Statistics, 2014). Evidence shows that 1.76 million deaths could be avoided each year by providing access to clean drinking water, sanitation, and hygiene (Facts and Statistics, 2014). While these facts are worldwide, we hear anecdotally about deaths from undetermined causes in the areas that we work in Belize. We hear comments about prolonged diarrhea leading to premature births, babies that simply weren't strong enough to survive, or that someone died of

the "flus." We have been told by mothers in the village that children are repeatedly given deworming medication when a nurse visits the village, a too infrequent occurrence. We have seen firsthand villagers washing vegetables in the New River Lagoon; where our testing indicated high levels of E.coli (Alexander, 2013). We have seen children's toothbrushes sitting on the edge of a well, known to contain both chemical and biological contaminants (Studer T. , 2012) (Alexander, 2013). This unsafe water is, at minimum, a contributing factor to reoccurring health issues in this community.

I have been focused on finding a source of water that would be safe, once treated for biological contamination by a sustainable water treatment system. The potential for clean water to positively impact the village of San Carlos in terms of decreased health problems and the subsequent increase in productivity is probably the single largest step forward for this village of just over 200 people.
The village of San Carlos had been struggling to access clean drinking water for the past three years. In 2010 and 2011 sources of drinking water in the village showed both high nitrate levels (Hegemier, 2010), the presence of E.coli bacteria, and intestinal parasites (Coates, 2012). In 2012 the nitrate levels had decreased (Studer T. , 2012), but the biological contaminants were still present in nearly every water source in the village (Alexander, 2013). Scholars have provided data to the village, PFB, and the Belizean Government. The latter resulted in the government drilling a new well in the village in 2011. The problem is that there is only one well for a village of over 200 people.

After analyzing the problem for the past three years, it seems that there may be multiple sources of the contaminants. While biological contaminants can be filtered or heated to remove lethal bacteria, chemical contaminants such as nitrates are much more difficult to remove. In December 2011, I began exploring the level of nitrates in the lagoon specifically sampling water at various depths. While the surface water of the New River Lagoon showed elevated levels of nitrates (Studer T. , 2012), water sampled from various depths did not (Studer M. , Community Based Research in Northern Belize, 2012). In an effort to determine a potential unlimited source of potable water for the village, it was decided to test water sampled at depth in the New River Lagoon for nitrates, knowing that any biological contaminates could likely be remediated. The results of this testing proved significant since it was determined that even rainwater had elevated levels of nitrates while the group was on site in December 2011 (Studer T. , 2012). By December 2012, testing showed that the nitrate levels had decreased in the surface waters (Golnick, 2013) and rain water (Adair, 2013); and the nitrate levels at depth remained stable at low levels. A preliminary conclusion would be that, regardless of the source of the contaminants, the sub-surface levels are consistent and need not be remediated for chemical contamination as a precursor to consumption.

Using a Van Dorn tube, testing was conducted at various sites in the New River Lagoon in December of 2012 and 2013. All sites were marked using a Global Positioning System ("GPS"). Nitrate levels are assessed using a *Hach* Pocket Colorimeter II device and nitrate testing protocol (*cadmium reduction method)* to digitally determine nitrate levels. In December 2013, sites were identified as possible springs due to extreme depth. Depth was determined using a Hummingbird® Piranha Max™ 175 PT depth finder. These sites suspected to be direct sources of ground water were tested at depths up to 20m.

December, 2012

The nitrate levels for water sampled at a minimum of 0.5 meter below the surface showed low nitrate levels compared to surface levels and compared to the U.S. Environmental Protection Agency standard of safe levels below 10mg/L. A total of 18 samples were taken from depths ranging from 0.5m to 10m. Samples were taken from sites upstream, downstream, and directly offshore relative to the village of San Carlos. The results for those sites that bracketed the village ranged from 0.0mg/L – 1.7mg/L. The primary source of nitrate contamination is usually linked to agricultural or human/animal waste runoff. The significant distance of San Carlos' agricultural fields from the lagoon, and the fact that similar nitrate levels were found in water drawn from sites both upstream and downstream from the village, seem to indicate that the nitrate levels in the New River Lagoon are not the result of human activity, or at minimum not associated with human activity attributable to the village of San Carlos. In addition, samples were taken at various depths at the mouth of the New River Lagoon and further downstream directly in the New River. The level of nitrates at those sites ranged from 0.2mg/L – 0.3mg/L. The final sites tested included sites upstream from the village of San Carlos nearer the tributary of Irish Creek and analysis indicated nitrate levels no higher than 0.4mg/L. The location of Irish Creek in this water shed would make it likely to be, at least partially, fed by agricultural runoff.

Data confirmed that subsurface water in the New River Lagoon contained minimal to low levels of nitrates and therefore would be suitable as a potable water source after remediation of the biological contaminants. This study provided information necessary to confirm the feasibility of installing a water chlorine generation system that could access water from the New River Lagoon at a subsurface level.

A meeting was held with the residents of the village to see if the community would be willing to use and maintain this viable option for a clean water source. The community agreed that clean water was important and that they desperately needed an unlimited safe water source for their families. The San Carlos Women's Group agreed to maintain the system once it was installed. The proximity of the water chlorine generation system to the Sun Breeze restaurant managed by the women would make this possible because the location is just off shore from the New River Lagoon.

April, 2013

While it is good scholarship to explore and determine all the possible sources for both biological and chemical contamination, it is more critical to solve the problem facing the community and provide a mechanism to provide the village with clean drinking water. In April, 2013, a chlorine generation system was installed just off shore in San Carlos to purify water drawn from depth in the New River Lagoon to remediate the problems we have seen over the last three years. Drawing the low nitrate level subsurface water from the New River Lagoon and then treating it with a sustainable chlorination process was the simplest way to provide the village with a virtually unlimited source of water.

This system consisted of an M-100 Chlorine Generator which has the capacity to purify 10,000 gallons of water per day with the only consumable being a handful of salt (WaterStep). The system was acquired from WaterStep, a non-profit organization based in Louisville, Kentucky. This system produces sodium hydroxide and chlorine as byproducts of the chlorination process, both of which can be diluted and used as disinfectants for water storage containers, dishes, etc. In addition to the water chlorine generator, solar panels and a submersible pump were also installed to move subsurface water from the New River Lagoon to the storage tanks for chlorination. Collectively the system is sustainable for many years.

The entire system was installed in a matter of days, and the Women's Group of San Carlos was trained how to operate and maintain the system. The team that was on-site to install the system included Mike Suzo, Defiance College; John and Lynn Witte, Advanced Distributed Generation, Inc.; Ryan and Evan Witte; Ivan Gillett, PFB; and myself.

In December 2013, we were back in the village to check on the status of the chlorine generator and to see if it was being used by the village residents. The system was not being used at this time due to the abundance of rainfall. Village residents were using rainwater for household and hygiene purposes and as a source of drinking water. This is viable in most cases as the rainwater was currently safe to drink, however, in some cases the cisterns were sources of biological contamination. We were informed that some of the villagers utilized the water chlorination system initially; others thought that the water from Lagoon once chlorinated didn't taste good. The rains began within a month or so after the system was installed so it is inconclusive as to whether the village will utilize the

system during the next dry season in the spring of 2014. It is common practice to revert to that which one is most familiar. Drinking rainwater is commonplace and since it is safe in most cases, rainwater provides a seasonal option to the chlorine purified water. The people in the community would need to use the chlorinated water as their clean water source for 30-90 days in order for them to begin to notice the positive effects that drinking clean water would have on their health. I will be monitoring the system, its use by the village, and continue testing subsurface water in the lagoon as proposed for 2014-2015. In addition, I will oversee and work with a scholar to implement a clean water education program in the village. Change comes slow at times. Education about the importance of clean water and access to clean water over time will be critical to improving the health of the village.

December, 2013

Due to the extensive rainfall throughout the rainy season in the fall, 2013 the water level in the New River Lagoon was higher than it had been anytime during the last 10 years. This was a unique opportunity for us to survey the New River Lagoon more extensively than we had done in past years. To facilitate massive testing (over 40 samples of subsurface water were collected and tested) we sectioned off the Lagoon into five zones. Zone one encompassed the south end of the Lagoon to Tarpon Point and included Ram Goat Creek and Harry Jones Creek. Zone two consisted of the area between Tarpon Point and the mouth of Irish Creek and included Lemonal Creek. Zone three started at the mouth of Irish Creek and went upstream in Irish Creek as far as we could get by boat. Zone four incorporated the entire northern end of the Lagoon including Lamanai Creek and the area of the Lagoon in front of both San Carlos and Lamanai. Zone five included the mouth of the New River and downstream into the New River. This allowed sampling of sub-surface water farther upstream than we have ever been able to access by boat in tributaries previously sampled such as Ram Goat Creek, Harry Jones Creek, Lemonal Creek, and Irish Creek. We were also able to take samples in a tributary not previously accessible – Lamanai Creek. Data confirmed that subsurface water in the New River Lagoon and its tributaries contained minimal to low levels of nitrates; from 0mg/L – 7.48 mg/L. Deep areas of the Lagoon thought to be associated with natural springs were also sampled at 20m depths. Data confirmed that water at these deep sites within the Lagoon, associated with natural springs contained minimal to low levels of nitrates; ranging from 0.44mg/L – 5.28 mg/L. This may indicate that there is minimal transfer of nitrates into the New River Lagoon via ground water.

The combination of data from 2011 – 2013 narrows the search for sources of nitrate contaminates, or minimally allows us to speculate more coherently. The high nitrate levels seem to have diminished in surface, rain, and ground water since the high levels recorded during 2009-2012 (Hegemier, 2010) (Studer T. , 2012), (Golnick, 2013) (Alexander, 2013). We are however, unable to conclusively determine the source of the contamination throughout this period. This pattern of data supports the concept that the nitrates might be the result of marsh fire residue that has moved into the ground water and or into the atmosphere, or that the runoff from marshlands is transferring nitrate loaded ash into the waterway. This is an interesting concept and one that is supported in an article by Camargo and Alonso wherein they cite biomass burning (including marsh fires), and land clearing, as nonpoint sources for the infusion of inorganic nitrogen into aquatic ecosystems (Camargo & Alonso, 2006). The dry seasons that preceded our testing in both December of 2010, and December of 2011, were extremely significant in terms of the number of fires in the region. Indeed, I even witnessed massive marsh fires in the spring of 2011. During late April and early May the fires that decimated the savanna areas moved to both the marshes and the high forest. This was a rare occurrence. The fires in the spring of 2012 were not prevalent in the area and preliminary analysis of the nitrate levels for water tested in December of 2012 were lower as well (Golnick, 2013) (Adair, 2013). Continued study of the New River Lagoon, its tributaries, and ground water in its watershed is critical. These efforts, coupled with charting the occurrences of marsh fires in the savannas that lie on the east side of the Lagoon from the village of San Carlos, may provide the information necessary to move this project from simple correlation to causality.

The significant rainfall during the 2013 rainy season allowed environmental water to be sampled far inside of the tributaries that merge with the New River Lagoon. In addition subsurface water samples were tested at some of the deepest locations in the lagoon and provide a good base line for assays in the years to come. While the overall nitrate levels for all subsurface samples were below EPA thresholds and seem to be somewhat stable, the chemical composition of rainwater varies from location to location and is dependent on multiple variables including wind direction, El Nino events, hurricanes and human /industrial emissions (Baez A. P., Belmont, Garcia, Torres, & Padila, 2006) (Baez A. , Belmont, Garcia, Padilla, & Torres, 2007). Thermal circulation patterns of water within various depths in the New River Lagoon is unknown as is the impact of extensive rainfall should the water contain higher than safe levels of any chemical contaminant. Scientific inquiry demands that we keep searching to identify the source of the contaminants. Community-based research however, is first and foremost focused on the solutions that would positively impact community health by providing a reliable and sustainable source of clean water. Having addressed the later the former concern will drive future research into nitrate levels in this region of northern Belize.

Conclusion

The projects summarized above, conducted during 2012 and 2013, worked in partnership with local people, communities, and organizations to: (1) improve the productivity of subsistence farmers and agricultural communities; (2) improve of one community's access to clean water; and (3) to accomplish both goals while simultaneously supporting the preservation of the fragile rainforest and aquatic ecosystems that cradle these communities. As often happens in collaborations between academic scholarship and local expertise and culture, progress, at times, can be characterized as more erratic than forward. Farmers throughout the region trust the soil analyses provided because this project has an extensive successful track record that began in 2006 when the first field sheets were returned to farmers with recommendations to decrease chemical inputs. The water issues are newer and more difficult for the community of San Carlos to appreciate. During village meetings in 2012 and 2013, wherein the results of past and current water testing were conveyed, the residents agreed that they needed to have a source of clean water. They have been living (and dying) with roughly the same access to water for years. Symptoms experienced by village residents could be potentially attributed to water borne disease that has never been documented due to the lack of access to regular adequate medical care. These same symptoms have been incorporated into their everyday concepts of health and hygiene. Proving that they could feel better, have more energy, miss fewer days of school, and perhaps have a better chance to survive infection, viruses, etc. is difficult. Only after several months of exclusively using the purified water for drinking, cooking, dish washing, hand washing and teeth brushing would the community begin to recognize significant improvements in their health. In addition to the habits, cultural norms, and lack of education that negatively impact this project's success, is the fact that the high nitrate levels were only evidenced for a period of a couple of years and have since diminished. Without a documented source of the contamination clearly determined, we can only guess when and if the high levels of chemical contamination might return. Chlorinating water to eliminate the biological contamination from a source that was consistently showing low levels of chemical contamination, even when high nitrate levels were detected elsewhere currently seems to be the best solution to provide clean water to the village. This project will continue to employ the feedback from the village as well as work to educate the community about the benefits that would result from using only a clean water source. Perhaps if we can establish a positive track record over time with individuals who use the clean water source realizing improvements in their health the community as a whole will realize the benefit and change will occur.

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GEOGRAPHIC DISTRIBUTION OF NITRATE LEVELS IN NORTHERN BELIZE

Ken Adair, McMaster Fellow, Belize 2012-2013

Introduction:
Consumption of nitrates, and closely related nitrite ions lead to an elevated risk of developing methemoglobinemia, commonly known as 'blue baby syndrome' in infants (World Health Organization, 2007). This disease occurs when oxygen carrying hemoglobin is oxidized by the non-oxygen binding methemoglobin, and results in a decreased oxygen capacity in the bloodstream. This results in chronic shortness of breath for adults, and in infants, who typically have less developed immune systems, may result in a visible blue discoloration (United States Environmental Protection Agency, 2009). Long term methemogbinemia can be fatal as the blood is no longer capable of carrying a sufficient supply of oxygen to the extremities. People with less developed or those who have compromised immune systems, including the very young and the very elderly, are most at risk for fatal methemoglobinemia. (World Health Organization, 2007). Due to the potential threat of methemoglbinemia, the World Health Organization has recommended a maximum concentration of no more than 10mg/L of nitrate ion in consumable water (World Health Organization, 2011). The World Health Organization's standard is mirrored in drinking water standards set by national regulating agencies such as the United States Environmental Protection Agency (United States Environmental Protection Agency, 2009).

Though there are many ways in which nitrate ion can enter the water supply, the two most significant means are through agricultural runoff and undertreated wastewater (World Health Organization, 2007). Nitrate is a significant component of many chemical fertilizers, and is found in relatively high concentrations in both human and animal wastes, including the manure used to fertilize farm fields. Accordingly, rural populations that rely heavily on agricultural activity and septic systems are particularly at risk when runoff from these systems enters the local water supply. As a result, extra processing may be required before water derived from this supply is safe to consume.

Removal of nitrate ion from the local water supply is a significant challenge because it is water soluble under nearly all conditions, and does not form volatile compounds. Accordingly, the nitrate ion cannot be removed by typical water treatment methods such as precipitation, filtration, or boiling. Though many methods are available for the removal of nitrate ions, they primarily fall into two categories: reduction of the nitrate ion to ammonia or nitrogen, and selective removal of the nitrate ion using an ion selective resin. Of these methods, the latter, which are typically used to treat water at the point of consumption, is easier to install and can be implemented with little knowledge of the underlying source of the nitrate ion. The downside of such systems however, is that a separate filter must be installed at each faucet, and the filters require frequent recharging and maintenance. Reductive methods, on the other hand, are more challenging to implement, but are more broadly applicable and more closely mimic how nitrates are removed naturally. In particular, significant work has been done to reduce the nitrate ions to less harmful species using iron (Ozturk & Bektas, 2004), carbon (Mizuta, Matsumoto, Hatate, Nishihara, & Nakanishi, 2004), bacteria (Kemsley, 2011), and combinations of these materials (Dejournett & Alvarez, 2000). These methods parallel the reduction of nitrate ion that occur from interactions with carbon and bacterial content of soil in nature. Such methods are often challenging to implement as they are typically implemented either in a well or in a holding tank, and are incompatible with the oxidative methods used to treat water for biological contaminants. The best option for reducing the exposure to nitrate ion is to keep nitrate ions from entering the water supply at the source. My work as part of the 2011-12 Belize learning community focused on exploring these options and implementing a solution in cooperation with our community partners in San Carlos, Belize. Though these efforts were successful in that we were able to implement a solution that secured access to nitrate safe drinking water, they gave little understanding or remediation of the underlying problems.

Prior to travel our community partners faced complex and rapidly changing water quality issues. What was discovered however, was that these issues are far more complicated and fluid than anticipated. Elevated nitrate levels in potable water sources in the village of San Carlos were first observed by McMaster Scholar Josh Hegemier during the 2009-10 academic year (Hegemier, 2010), and confirmed by McMaster Scholar Thomas Studer during the 2010-11 and 2011-12 academic years (Studer, 2012). While some wells in the village were below the maximum recommended nitrate concentration of 10mg/L, the majority, including the public well at the school, were not. The fact that many of the wells were determined to also have elevated levels of coliform bacteria further compounded these issues (T. Studer, personal communication, August 29, 2011). It was theorized that the agricultural nature of this community, coupled with the relative low carbon content of tropical soil, and inadequate depth and placement of septic systems were responsible for the elevated nitrate levels observed in the village. To alleviate these problems the government of Belize installed two new and much deeper wells in the village, and residents of the village built a rain catch to collect water free of contamination entering through the soil. Testing of these sources by McMaster Scholar Thomas Studer during the 2011-12 revealed that agricultural activity alone could not explain the presence of nitrates.

The most interesting result of water testing during the 2011 Belize Initiative was that the rainwater in San Carlos contained nitrates at a level of 12mg/L (T. Studer, personal communication, February 12, 2012). This result was subsequently confirmed using rainwater collected from a rain catch constructed at the nearby Hillbank Research Station, and in environmental surface water samples of the New River Lagoon. Significantly lower levels of nitrates however, were observed deeper in the New River Lagoon, which is spring fed, and in one of the wells installed by the Belizean government. This suggests that contrary to our assumptions, the rainwater itself is a significant source of nitrate contamination, and the soil is effective at reducing the nitrate concentration as water passes through. Interestingly, the elevated levels of nitrates observed in surface water were not present in previous years (T. Studer, personal communication, August 29, 2011). This suggests that something had changed in the local environment to introduce such high levels of nitrate ion into the rainwater.

The phenomenon of elevated nitrate concentrations in rainwater is not without precedent. Urban areas with significant factory emissions are particularly susceptible to elevated nitrate levels (Research Watch: Nitrate in Rainwater, 1999). Due to the rural nature of San Carlos, it seems unlikely that industrial output is responsible for the increased levels of nitrates observed in the rainwater. The prevailing winds in northern Belize do, however, blow into San Carlos from more heavily industrialized areas of Belize along the coast. Additionally, the sudden onset of these nitrate levels suggests a single point of origin, rather than a broad environmental change, is the source of elevated nitrate levels. More recently, it has been observed that tropical forests may naturally contain higher concentrations of nitrate ion as a result of complex interactions within the environment (Brookshire, Gerber, Menge, & Hedin, 2012). If the observed nitrate levels are natural, we would expect that they would be broadly observed throughout northern Belize, but would not be able to explain the sudden onset.

A first step to understanding the origin of this problem is to understand the source of nitrate ion in the rainwater that feeds the hydrology of northern Belize. By determining the geographic distribution of this problem we can begin to determine whether the elevated nitrate levels observed in San Carlos are due to a localized source, or are broadly applicable to all water throughout northern Belize. This knowledge will inform future decisions as to how best to manage nitrate exposure risks faced by our community partners.

Procedure:
Polypropylene containers suitable for rainwater collection were distributed to community partners throughout northern Belize. These containers were distributed to ensure a broad geographic distribution within the region while simultaneously respecting existing community partnerships and emphasizing population centers. The latitude and longitude of each site was recorded in addition to a brief description of the collection site and any overhanging vegetation. The containers were allowed to sit outside to collect rainwater for up to two days or until our community partner deemed the container held enough water to sample. The containers were then sealed and stored until retrieved by the research team and transferred to the Hillbank Research Station for analysis. All containers were collected from community partners within four days of rainwater acquisition and tested within twelve hours of retrieval. When possible, new containers were distributed to collect rainwater from subsequent rain events to gauge the variation expected within an acquisition site.

Once transferred to Hillbank Research Station the pH and nitrate concentration, reported as Nitrate-Nitrogen, of each sample were measured using a Hach surface water test kit and pocket colorimeter using protocols established by previous McMaster Fellows and Scholars (Hegemier, 2010). This data was then compared to NOAA HYSPLIT Model 12-hour back trajectories in order to understand the likely geographic origin of the rainwater collected according to the procedure described by Satyanarayana, et al (Satyanarayana, Reddy, Kulshrestha, Rao, & Kulshrestha, 2010). Results of these analyses are presented in table one and the corresponding air mass trajectories are presented in figure one.

Results and Discussion:
A summary of the nitrate levels and corresponding pH of each collected rainwater sample is presented in figure one.

Site or Community Partner:	Region	Lat.	Long.	NO3-N (mg/L)	pH	Notable Features
Community Partner 1	Trinidad	18.0224	-88.6856	0.3	7.7	Private residence, no canopy
Community Partner 2	August Pine Ridge	17.97527	-88.7288	0.3	7.4	Private residence, no canopy
Community Partner 2	August Pine Ridge	17.97527	-88.7288	0.6	7.3	Private residence, no canopy
Community Partner 3	San Felipe	17.87265	-88.7735	0.5	7.4	Private residence, no canopy
Indian Church Roadside	Indian Church	17.7528	-88.657	0.4	8.2	Near dirt road, no canopy
Indian Church Store	Indian Church	17.7528	-88.657	0.8	7.9	Near dirt road, no canopy
Community Partner 4	Indian Creek	17.7524	-88.7892	1.1	8	Farmstead, no canopy
Community Partner 4	Indian Creek	17.7524	-88.7892	0.4	8.1	Farmstead, no canopy
Community Partner 5	Indian Creek	17.75083	-88.737	0.9	8	Farmstead, no canopy
Community Partner 5	Indian Creek	17.75083	-88.737	2.3	8.2	Farmstead, no canopy
San Carlos Site 1 Selected by SC Women's Group	San Carlos	17.71832	-88.6536	1.3	7.8	Within village, some canopy
San Carlos Site 2 Selected by SC Women's Group	San Carlos	17.71832	-88.6536	0.7	7.7	Within village, some canopy
Hillbank Research Station Bergen's Gate	Rio Bravo CMA	17.6666	-88.741	1.1	8.1	Conservation area, heavy canopy
Hillbank Research Station	Rio Bravo CMA	17.5962	-88.6994	0	8.4	Research Station, some canopy
Hillbank Research Station	Rio Bravo CMA	17.5962	-88.6994	0	8.4	Research Station, some canopy
Hillbank Research Station	Rio Bravo CMA	17.5962	-88.6994	0	8.4	Research Station, some canopy
Hillbank Research Station	Rio Bravo CMA	17.5962	-88.6994	0	8.4	Research Station, some canopy

Table 1 - Summary of nitrate concentration and corresponding pH at tested sites.

As seen in table one all collected rainwater samples had nitrate concentrations that were well below the maximum consumption level recommended by the World Health Organization, and those observed by McMaster Scholars in recent years. Additionally, no significant variation was observed either geographically or from one rain event to the next. This suggests the factors that led to the elevated nitrate levels in previous years have either been corrected or dissipated naturally.

In consultation with Edilberto Romero, the Executive Director of Programme for Belize, the organization that oversees the Rio Bravo Conservation Management Area that includes Hillbank Research Station, it was determined the most significant change in this region over previous years was a decrease in the number and severity of marsh fires. This would agree with previously observed patterns of nitrate release following significant forest fires (Riggan, et al., 1994). It is believed that such forest fires produce nitrogen oxides which then react with water in the atmosphere to form nitric and nitrous acids. As such, production of nitrate ion is expected to be accompanied by acidification of the rainwater. Previously, this was not believed to be the case as the pH of rainwater collected during the 2011-12 Belize Learning Community consistently had a pH near seven. Such pH levels are considered to be basic for rainwater, which typically has a pH around 5.6 due to interaction with atmospheric carbon dioxide. This data suggests, however, that the natural pH for rainwater in this region may be closer to eight, and thus the previously observed pH levels may demonstrate acidification of the rainwater coincident with elevated nitrate levels. If marsh fires are the source of the previously observed elevation in nitrate concentration, then the most significant result of this study is the magnitude of the health hazards marsh fires pose to community partners.

Where data can be directly compared, the nitrate concentration of rainwater appears to have been reduced by approximately 10mg/L over previous years. This decrease corresponds to the recommended maximum consumption limit for the nitrate ion, suggesting that marsh fires alone can elevate the concentration of this harmful ion from negligible to dangerous levels. The impact these findings have on community partners is interesting considering the source of rainwater in this region. The rainwater in this region is delivered by winds from the northeast. The area affected by the marsh fires lies along the New River Lagoon, and is located due east of the southernmost locations tested, it is expected that significant variation in nitrate concentration would be observed between these community partners as those that live further to the north that would not receive rainwater from the affected region. Continued monitoring of the geographic variation in the nitrate concentration found in rainwater will likely provide more accurate information as to the risks that such fires pose to our community partners.

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Figure 1 - NOAA HYSPLIT Model 12-hour airmass back trajectories for testing sites during the period of rainwater acquisition.

POTABLE WATER QUALITY ANALYSIS IN RURAL BELIZE

Melina Alexander, McMaster Scholar, Belize 2012-2013

The purpose of this project was to continue the ongoing water quality analysis of the New River Lagoon, its tributaries, and the surrounding potable water sources. Testing consisted of chemical and biological assays. The end goal of these tests is to flag the existence of contaminants so that mechanisms can be implemented that ultimately improve of total water quality of these sources, and thereby improve the drinking water for the San Carlos Community.

Tests were performed to collect data on nitrate nitrogen levels, orthophosphates, free chlorine, pH levels, and bacteria that is harmful to the human body. Testing sites were chosen in accordance with data acquired from former McMaster Scholars. Additionally, I tested new sites requested by community partners. If a site had previously been found to have high nitrate levels, the site was tested again to continue to expand the data. Trends in the collected data were analyzed to understand the variances in contamination levels.

After comparing the data found in December 2012, to previous years' data, I found the high levels of nitrates that were previously documented had returned to normal, safe levels. Further, the values of phosphates, ammonia, pH, and free chlorine remained at normal, safe levels. Biological contaminantes on the other hand, proved to be a major problem. Six of nine potable water sources tested in San Carlos contained harmful biological contaminants. The only three sources that did not contain biological contaminants were wells that were installed by the government. After speaking to community about their overall health, it was observed that several children had illnesses that may be attributable to bacterial sources. This research indicates a permanent water system, capable of providing clean, non-contaminated water, to the community of San Carlos is necessary.

The information that was collected and analyzed was then shared with community partners in San Carlos and with Programme for Belize. When presenting this information to the community in a village meeting, I observed an elderly woman express her support and gratitude for the information and advice the McMaster School for Advancing Humanity has contributed to the community of San Carlos. I feel that my work has assisted the McMaster School for Advancing Humanity fulfill its mission by working with this community, as a partnership, to improve standard of living through education, and sustainable collaborative action.

PREVENTATIVE EDUCATION OF DIABETES, CORONARY HEART DISEASE, AND HYPERTENSION

Evan Allen, McMaster Scholar, Belize 2012-2013

People in developed countries seldom consider diabetes mellitus, coronary heart disease, or hypertension as untreatable life threatening diseases. These diseases do, however, prove to be lethal in some lesser-developed countries, such as Belize. Diabetes mellitus, coronary heart disease, and hypertension rank first, second, and fourth, respectively, as the leading causes of death in Belize (Coronary Heart Disease in Belize, 2012) (Diabetes Mellitus in Belize, 2012). Although preventable and treatable, these diseases are so threatening due to a cultural lack of trust in the health care system and a lack of access to regular preventative health care.

In San Carlos, I provided community members with educational materials that are relevant to the prevention of heart disease, hypertension, and diabetes. The focus of my work was on proper nutrition. Furthermore, I worked to improve the community's understanding of these diseases, and promote preventative measures. The ends of my work were to reduce the prevalence of these diseases in the community.

Due to the remote location of San Carlos, community members have limited access to professional health care. Accordingly, there are insufficient records pertaining to the community's medical history. An adequate medical history can be imperative to the discovery of heart disease, hypertension, and diabetes. In order to maintain adequate medical records, I provided the community with an individual health log to enable the community to better record their individual medical history. This health log will provide professional healthcare providers with a more thorough record of specific symptoms, and a more complete understanding of an individual's overall health. These improvements have the potential to facilitate more effective health care in San Carlos.

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COMPUTER TECHNOLOGY EDUCATION AND WATER SAFETY IN BELIZE

Chelsea Bell, McMaster Scholar, Belize 2012-2013

The goal of this project was to utilize the five laptops that were donated, refurbished and taken to San Carlos to train both teachers and students how to use the technology for educational purposes. There is a barrier to education within the village of San Carlos because the community partners do not have meaningful access to computers. The only technologies the school and library had prior to our work there in December, 2012, were two desktop computers that required a large amount of energy. These computers were not feasible given the limited power provided by the school's solar energy systems, and the equipment's large amount of energy consumption. The laptops that were distributed consume much less energy, and are accordingly much more feasible to implement. Additionally, I worked with teachers and the librarian on methods to instruct students on how to utilize the computers, access academic resources, and communicate with people outside the village via email.

Internet was placed on a single laptop to facilitate email communication with Defiance College and to access resources via the Internet. The laptops provided an opportunity for the many of the students of the village to learn and use a computer for the first time. Lesson plans and educational software were used to train the village's librarian and the teachers in the school. The village's librarian will continue to teach both children and adults about technology, typing, and other programs on the laptops. The teachers in the school will work to incorporate technology into the curriculum through the lesson plans I provided. This project is a significant milestone for the McMaster School and our community partners because it enables our community partners to possess a more modernized and relevant understanding of these technologies, and it facilitates a better means of communications for the McMaster School during the times when we are not physically in the village of San Carlos.

WATER TESTING AND ACTIVE LEARNING IN SAN CARLOS

Rachel Davis, McMaster Scholar, Belize 2012-2013

This project focused on improving functional literacy and modeling active learning in the San Carlos Government School. In upper and middle grade levels, demographic questions were utilized to enable a better understanding and usage of the English language. I also presented a brief review lesson on sentence structure and punctuation. Following the review I proceeded with the active learning portion of the lesson.

Students were able to demonstrate their functional literacy and develop their writing skills by writing descriptions of their home in San Carlos. Descriptions were based on a series of prompts. After students responded to their writing prompts they were asked a series of questions to help them to organize the information gathered into various categories or patterns.

The youngest age group learned about the water cycle via an interactive activity where students demonstrated different parts of the water cycle. All age groups had an active part in their lessons. Students were able to physically engage in the lesson prompts which allowed the students to better understanding and enjoy the material. This project served a dual purpose by not only educating the students of San Carlos, but also by modeling the importance and effectiveness of active learning to the teachers. Accordingly, this project will better enable teachers to more meaningfully engage with their students.

ADDRESSING LIMITED ACCESS TO HEALTH CARE IN RURAL BELIZE

Kirsten Frissora, McMaster Scholar, Belize 2012-2013

This project sought to address the limited access to health care in the northern interior of Belize, specifically in the village of San Carlos. My project trained the community members of San Carlos in first aid, CPR, and snakebite management. I also worked to enhance symptom awareness for three major and prevalent health concerns: hypertension (HTN), diabetes (DM), and coronary heart disease (CHD). I accomplished this by going door to door in San Carlos and talking with people about these health conditions.

I sought to improve access to health care through the improvement of the clinic facility in San Carlos by providing supplies and basic equipment, including thermometers and blood pressure cuffs. Then I trained the San Carlos Women's Group how to use the equipment. After I demonstrated how to use each piece of equipment, the women were able to calculate each other's blood pressure. The women were eager and quick to master the use thermometers and blood pressure cuffs. When I explained that there were manuals just in case anyone needed a reference, one woman replied, "We will never forget this!" Furthermore, I began to research the feasibility of establishing a permanent nurse at the San Carlos clinic. Also, through speaking with Maria Luisa, the stand-in health care provider, I was able to document the natural remedies used for various ailments. Ms. Luisa explained how different plants were used, and the symptoms they help treat.

I collaborated with the San Carlos community, specifically the teachers, students, and the San Carlos Women's Group, for the duration of my project. The San Carlos community responded well to all aspects of my project. The community was active in training sessions; helpful as I went door to door asking questions and talking about HTN, DM, and CHD; and quick mastered the use of medical

equipment. The community also informed me of different natural remedies they use, and what they are used for. Furthermore, a man in the village was identified as being interested in becoming the village nurse. The goal of my project was to improve San Carlos' access to health care through emergency response training, health care monitoring, and improving on-site health care capabilities. My project resulted in an increased understanding of appropriate responses to situations requiring first aid, CPR, or snakebite management; a better understanding of three common health conditions; education regarding proper use of medical equipment; and the beginning of a natural remedy project.

ENVIRONMENTAL WATER QUALITY ANALYSIS AND ECOSYSTEM HEALTH INDICATORS IN BELIZE

Phoenix Golnick, McMaster Scholar, Belize 2012-2013

Since 2005, baseline water quality analysis of various nutrients has been performed to monitor the quality of the environmental water sources in northern Belize. In recent years, excess nitrate levels have been documented in the New River Lagoon and its tributaries (Studer, 2012). Accordingly, nitrate levels must be continuously monitored. Concentrations of nitrate, phosphate, dissolved oxygen, ammonia, and free chlorine were determined using a Hach surface water test kit, and were compared with historical data. From early 2010 to late 2011, nitrates were found in extremely high levels that exceeded the US EPA's safety standard of 10 mg/L NO3-N. Prior to 2010, the nitrate levels were relatively low. Also, testing conducted by the McMaster teams each December subsequent to 2011 indicates nitrates, dissolved oxygen, phosphates, and ammonia are at natural and safe levels, at those points in time. Possible explanations include natural phenomena including the mobilization of nutrient reserves due to increased marsh fires, and extreme weather conditions (i.e. hurricanes) that occurred between 2010 and 2011.

I also investigated the possibility of using an index of biotic integrity to assess the overall health of the lagoon. I determined that the most commonly used index using macro-invertebrate indicators would not be a viable option for this location due to the difficulty in seining in the New River Lagoon. Seining is not practical because the bank conditions do not allow a safe access place for the villagers. In order to use an index of biotic integrity, a high diversity of organisms is needed. According to Meerman, the only index that would be practical in the New River Lagoon would be to use dragon or damsel flies, and seining is not a proper methodology for catching dragon and damsel fly nymphs or larvae due to their preferred habitat being under rocks, in aquatic vegetation, or burrowed in the soil on the bottom of the lagoon (2006). Community partners including Programme for Belize, Ivan Gillett, and the village of San Carlos were informed of results and conclusions.

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GREENING IN SAN CARLOS

Stephanie Phillips, McMaster Scholar, Belize 2012-13

San Carlos, Belize is struggling to transition from a subsistence economy to one with the ability to tap into broader markets which would enable this community to grow their economic base. Preparing for more tourists to visit the village to patronize a newly established restaurant necessitates more attention to waste management. My project was to teach our community partners in San Carlos, especially school children, how to reuse and make marketable items out of materials and refuse collected around the village. The benefits of this project are twofold by assisting in the beautification of the area, and providing easy opportunities to sell items for profit to tourists that come to the village. In addition, these handmade materials will be sold through the DC Art Box and will provide more income as well as a more aesthetically pleasing and healthier place to live.

The initial conditions in San Carlos consisted of various types of clutter scattered around the village. This mainly consisted of chip bags, candy wrappers, and bottle caps. This caused little harm to the people of San Carlos, so it has not been a major priority to clean up the surrounding areas. After the cleanup process, the village looked much better and the community members, especially the children, seemed enthusiastic about continuing the process. The children were also eager about continuing the art projects and being creative with whatever materials they can collect. Additionally, I explored the possibility of establishing a beekeeping business. Honeybees provide many necessary resources, such as a healthy sugar substitute to cook, materials to make sellable products as well as honey for medical uses, which are especially helpful to a developing country. I surveyed the San Carlos community regarding their interest in starting a beekeeping practice and explained the economic benefits that it could have on an agricultural community such as San Carlos. The residents I spoke to were somewhat interested and perhaps a bit overwhelmed. This needs to be explored further before taking it to the next step of installing of a beekeeping area in the village.

FIRST AID, CPR, INFECTION PREVENTION, AND REFEREEING/COACHING SEMINAR IN SAN CARLOS

Alec Pribulsky, McMaster Scholar, Belize 2012-2013

The goal of this project was to improve the health and well-being of the village of San Carlos, Belize, and to try to reduce athletic injuries by better training coaches, players and referees through emergency response, cardiopulmonary resuscitation (CPR), infection and wound care, skin infection, and athletic training.

This project sought to build upon the first aid and CPR training provided by previous McMaster Scholars on infection of wounds and proper wound treatment. I discussed skin infections including Methicillin-Resistant Staphlyococcus Aureus, commonly referred to as MRESA, and impetigo. These skin infections pose critical risks that often occur as a result of wound infection. Furthermore, I conducted basic CPR training in the community. Additionally, I provided a review of former trainings held in past years to the people of

San Carlos, and enhanced these trainings in regard to emergency response tactics. Upon request from Ivan Gillett, our community partner from Programme for Belize, I also discussed proper treatment of athletic injuries and how to properly wrap the ankle and knee.

Additionally, I held a refereeing clinic in San Carlos in order to better organize the soccer team which had already been established. The refereeing clinic discussed the basic and advance rules of the game of soccer, or football as it is called in San Carlos. The clinic emphasized that the main objective of refereeing is to control the game from aggressive play and conflict. Furthermore, I discussed simple coaching strategies with Mr. Noel, principal and coach of the soccer team in San Carlos.

RESTAURANT MANAGEMENT

Meghan Spencer, McMaster Scholar, Belize 2012-2013

The purpose of my research was to help the San Carlos Women's Group learn and implement effective restaurant management practices. The Sun Breeze Restaurant in San Carlos was started in 2011 by the Women's Group with the help of the McMaster School for Advancing Humanity. The Women's Group is made up of eight women in San Carlos who have little access to the education necessary to help this restaurant reach its potential as a business. With a better understanding of business principles, the Women's Group will be better equipped to enable the restaurant to reach its full potential.

Almost all small businesses must have a business plan to receive financing and experience growth in the future. Before arriving in San Carlos, the Women's Group did not have a business plan. My research project was focused on creating a business plan with the Women's Group, educating the Women's Group as to the information that should be included in their business plain, and preparing the Women's Group to alter their business plan to accommodate for changing circumstances.

Additionally, I trained the women on basic bookkeeping practices. Keeping track of expenditures, such as food and supplies, is just as important as knowing how much is being sold. Prior to my project, the Women's Group was not keeping records of their income and expenses. The failure to keep proper records could lead to negative results in any business. I educated the Women's Group, especially its treasurer, Maritza Perez, regarding best practices in records keeping, the importance of keeping accurate records, and I provided the Women's Group with all the materials that they would need in order to properly keep their books.

Altogether, this project: (1) set up a business plan for the San Carlos Women's Group; (2) trained the Women's Group on basic bookkeeping practices; (3) created a guest log to track the restaurant's patronage; and (4) educated the Women's Group how to properly draft and distribute receipts. This project enables the Women's Group to operate a more successful restaurant, and has educated the Women's Group on best practices in business.

UNDERSTANDING NITRATE IONS OBSERVED IN RAINWATER IN NORTHWEST BELIZE

Ken Adair, McMaster Fellow, 2013-2014

Introduction:

Access to clean drinking water is one of the basic human rights recognized by the United Nations and the World Health Organization (World Health Organization, 2011). Unfortunately, this is a right that many, including our community partners in northwest Belize, do not always possess. For nearly a decade, Defiance College has sponsored student and faculty research seeking to understand the water conditions in Belize's New River Lagoon, its tributaries, and potable water sources in neighboring communities (Mavroidis, Schurter, Johnson, Putman, & Sattler, 2006; Dix, 2007; Kurtz, 2007; Perkins, 2007; Fix, 2007; Mavroidis S. , 2008; Rostocil, 2009; King, 2009; Gibson, 2009; Kleman, 2010). The results of these studies present a very complex situation that seems to suggest both environmental and human stresses on the quality of drinking water throughout this region. Among these challenges, two common threats have emerged: the presence of biological contaminates including intestinal parasites and coliform bacteria (Heaton B. , 2012; Studer, Water Quality Analysis in Belize 2011-2012, 2012; Dix, 2007; Coats, 2012), and the presence of elevated nitrate levels (Hegemier, 2010; Studer, Water Quality Analysis in Belize, 2012; Studer, Water Quality Analysis in Belize 2011-2012, 2012; Adair, 2012; Heaton B. , 2012).

My work during the 2011-12 and 2012-13 academic years focused on developing methods to remediate elevated nitrate levels (Adair, 2012), and understand their origin. Prior to testing performed by the 2009-10 Learning community (Hegemier, 2010), only negligible concentrations of nitrates had been observed (Mavroidis, Schurter, Johnson, Putman, & Sattler, 2006; Fix, 2007; Mavroidis S. , 2008; Kleman, 2010). In that year significant nitrate concentrations were observed in many of the potable and environmental water sources tested; elevated levels that persisted for the following two years (Studer, Water Quality Analysis in Belize, 2012; Studer, Water Quality Analysis in Belize 2011-2012, 2012).

During the 2011-12 Belize learning community it was determined that these elevated nitrate levels could be observed not only in terrestrial water sources, but also in rainwater (Studer, Water Quality Analysis in Belize 2011-2012, 2012). My work during the 2012-13 academic year attempted to develop a geographic profile of nitrate concentrations in Belize's rainwater in order to identify possible sources of nitrate contamination. The results of this study show that nitrate levels in rainwater have returned to levels traditionally associated with water sources in this region, and that these results are consistent over a wide geographic range. This suggests the factors leading to elevated nitrate levels continue to change rapidly. Eddie Romero, Executive Director of Programme for Belize, notes that the most significant change during the years of elevated nitrate levels is the presence of wildfires in the area (personal communication, 21 Dec 2012). Previous work has shown enhanced nitrification of soil following forest fires (Ball, MacKenzie, DeLuca, & Holben Montana, 2010), and nitrification of surface water. These studies however, have not directly linked this to nitrate levels in rainwater. The ability to show a positive correlation between forest fires and nitrate concentrations in rainwater would be a significant step in understanding the issues that threaten water quality in this region.

This project sought to build upon my work during the 2012-13 academic year by continuing baseline measurements of nitrate levels in rainwater, the geographic variation in those nitrate levels, and observing correlations between elevated nitrate levels and their anthropogenic and natural sources. By continuing to monitor the magnitude and variation of nitrate

concentrations in the rainwater of this region, we will continue to develop a better understanding of the water quality challenges of our community partners.

Understanding the factors that affect rainwater quality in this region is more important than ever for our community partners in San Carlos, Belize, because a chlorine generation system was recently installed in the village. This system has the potential to effectively and sustainably solve the biological contamination issues observed within the village by treating water drawn from the New River Lagoon. As this system will draw from a surface water source it will be more susceptible to variations in the rainwater than well water sources. The better we understand the sources and variation of nitrate ion concentration in this region the closer our community partners will be to realizing the basic human right of clean drinking water.

Procedure:
Polypropylene containers suitable for rainwater collection were distributed to community partners throughout northern Belize. These containers were distributed to ensure a broad geographic distribution within the region, and when possible, to sites tested during the 2012-13 academic year. In all cases, testing sites were chosen with respect to existing community partnerships and emphasizing population centers. The latitude and longitude of each site was recorded as was a brief description of the collection site and any overhanging vegetation. The containers were allowed to sit outside to collect rainwater for up to two days, or until the community partner deemed the container held enough water to sample. The containers were then sealed and stored until retrieved by the research team and transferred to the Hillbank Research Station for analysis. All containers were collected from community partners within four days of rainwater acquisition and tested within twelve hours of retrieval. When possible new containers were distributed to collect rainwater from subsequent rain events to gauge the variation expected within an acquisition site.

Once transferred to Hillbank Research Station the pH and nitrate concentration, reported as Nitrate-Nitrogen, of each sample was measured using a Hach surface water test kit and pocket colorimeter using protocols established by previous McMaster Fellows and Scholars (Hegemier, 2010).

Results and Discussion:
A summary of the nitrate levels and corresponding pH of each collected rainwater sample is presented in figure one along with the corresponding average values collected during the 2012-13 Belize learning community when available.

Site or Community Partner:	Region	Lat.	Long.	NO3-N (mg/L)	pH	NO3-N (mg/L) [2012]	pH [2012]	Notable Features
Community Partner 1	Orange Walk Town	18.072683	-88.56985	0.9	8.1			On unpaved road in urban area, no canopy
Community Partner 2	San Lazaro	18.03395	-88.66148	1.1	8.5			On unpaved Road, no canopy. Rock in container
Community Partner 3	Trinidad	18.0224	-88.6856	1.3	7.4	0.3	7.7	Private residence, no canopy
Community Partner 4	August Pine Ridge	17.97527	-88.7288	0.7	7.7	0.45	7.35	Private residence, no canopy
Community Partner 5	Indian Creek	17.7524	-88.7892	0.3	8.3	0.75	8.05	Farmstead, no canopy
Community Partner 6	Indian Creek	17.75083	-88.737	0.5	8.2	1.6	8.1	Farmstead, no canopy
San Carlos Sun Breeze Restaurant	San Carlos	17.71832	-88.6536	0.1	8.5	1.0	7.75	Within village, some canopy
Rio Bravo Bergen's Gate	Rio Bravo CMA	17.6666	-88.741	0.3	7.2	1.1	8.1	Conservation area, heavy canopy
Hillbank Research Station	Rio Bravo CMA	17.5962	-88.6994	0.0	8.0	0	8.4	Research Station, some canopy

Table 1 - Summary of nitrate concentration and corresponding pH at tested sites. Testing sites are sorted by latitude with northernmost sites listed first.

As seen in table 1, the rainwater nitrate levels in this region remained at negligible levels well below the recommended maximum consumption limit. Furthermore, very little regional variation was observed in the nitrate concentrations, though nitrate levels were nominally higher in the northern testing sites than in the southern testing sites. Notably, the pH of the rainwater in this region remained around 8.0. This is significantly more basic than usual for rainwater as well as what was observed during the years of elevated nitrate concentration in the rainwater (Adair, 2012). It is likely that this basification is the result of the close proximity between these testing sites and the Caribbean Sea. The acidification of rainwater concurrent with elevation in nitrate levels observed during the 2010-11 period is consistent with previously observed nitrification of rainwater following forest fires (Beschta, 1990). It again appears that our community partners in northern Belize are not at risk of elevated nitrate concentration at this time. The sudden onset and disappearance of elevated nitrate concentrations in this region, however, suggests that these conditions can change rapidly and may once again pose a risk in the future.

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WATER QUALITY ANALYSIS IN RURAL BELIZE

Melina Alexander, McMaster Scholar, 2013-2014

According to the CIA World Factbook, Belize has 98% access to improved drinking water. Improved access is defined as "piped water into [a] dwelling, yard, or plot; public tap or standpipe; tubewell or borehole; protected dug well; protected spring; or rainwater collection []" (Belize, 2013). The term 'improved access' however, speaks not to the quality of the water but only to the means available to access it. According to data previously collected by former McMaster Scholars, many of the water sources in the village of San Carlos, Belize, are not safe for consumption notwithstanding the fact that the accessibility of the water it improved. Indeed, these water sources were not safe for consumption due to high nitrate levels and biological contaminates. My own experiences on the ground in Belize have confirmed the findings of previous scholars. The purpose of my project was to continue the ongoing water quality analysis of the New River Lagoon, the Lagoon's tributaries, and potable water sources within and surrounding the village of San Carlos. This project will contribute to the data accumulated by former McMaster Scholars and ultimately provide a means to the end of providing a clean and sustainable water source to San Carlos.

My testing consisted of both chemical and biological tests. Tests were completed using Hach water testing kits. Then, I performed analyses to determine nitrate nitrogen levels, orthophosphates, free chlorine, dissolved oxygen, pH levels, ammonia levels, and bacteria that can be harmful to the human body. My testing mirrors protocols used by previous McMaster scholars in years prior. Testing sites included all the sites I tested in the 2012-13 trip, as well as any new sites requested by community partners. The information was collected, compiled, and communicated to community partners including the village of San Carlos and Programme for Belize.

This was an especially important year for environmental testing because there was an above-average amount of rain which caused very high water levels. Accordingly, I was able to test sources that former McMaster Scholars have not had access to. My results indicate the high levels of nitrates found previously have returned to safe levels. Nitrate levels are safe when there is less than 10 ppm. Furthermore, the values of phosphates, ammonia, free chlorine, and pH have remained at safe levels for consumption below 0.1 mg/L, 0 mg/L, below 4 ppm, and between 6.5 and 8.5, respectively. Biological contaminates however, appear to be a major concern. Biological contaminates were found in 17 of 20 potable water sources tested in the village. Additionally, every well tested was positive for biological contaminants. Furthermore, families are drinking out of contaminated potable and environmental water sources as well. Although the village may have access to clean water, such as bottled water, bottled water is not a reasonable alternative for the people of San Carlos. The risk that biological contaminants pose to our community partners evidence the importance of this project and the need for a permanent sustainable solution to this problem.

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ENHANCING ELECTRONIC EDUCATION IN SAN CARLOS, BELIZE

Brock Bell, McMaster Scholar, 2013-2014

In San Carlos, Belize, students do not have access to books that fit the educational curriculum, or that appeal to them. Indeed, students in San Carlos are often without educational content that is relevant to them in the context of their community and their education. Discussions with previous scholar Chelsea Bell indicated that laptops implemented in San Carlos have dramatically increased the learning and skill development of the children in the village. As the curriculum continues to develop and add new material, students in the San Carlos Government School will need the means to have current and relevant information to ensure their success after school.

While the success of laptops in San Carlos was observed by fellow scholar Chelsea Bell, the age and maintenance of equipment continues to present challenges for the community. My project was to not only expand on the use of the laptops, but to also provide supplemental methods of learning for children in San Carlos. In pursuit of that objective, I introduced video distance learning, as well as a set of electronic readers to the village. These technologies addressed the need for improved electronic learning and sustainability of future devices for the village. Electronic readers provide not only a new platform to learn from, but also included features that help facilitate the learning process. The ability to load free books onto the electronic readers, and built in tools, such a dictionary, provide additional means to increase students' reading comprehension.

Distance learning through video conferencing involved the exploration of factors such as data bandwidth, and the consistency of internet connectivity. Research at Defiance College over the availability and strength of the internet access led me to believe such technologies were a possibility and worth following up with further testing on site in Belize. After exploration of the internet connectivity at a nearby site, the Hillbank research station, I determined a distance education program was not feasible at this time. I did however discuss the potential use and outcome of a distance education program with Mr. Zapata, a teacher at the San Carlos school, who was familiar and excited about the potential for this program. As technology advances in the region, the opportunity for video conferencing may become available in the future.

To address the access to relevant books for the students, three electronic readers were taken to San Carlos. Before the electronic readers were introduced, a verbal pre-test was given to help gauge student interest in both the desire to read as well as the content that students were interested in. Following the pre-test, classroom instructions were provided before breaking the students off into groups to begin learning about the functions of the electronic readers. The electronic readers were then placed in the library with the suggestion of using a sign-out system so that the students could further explore and read the books on the devices.

The pre-test revealed that students generally had a low desire to read. About half of the class responded with affirmative answers when questioned whether they enjoy reading. Students however, indicated they largely prefer to read action and adventure books. Those genres of books, action and adventure, were in limited supply at the San Carlos Library. The electronic readers however, have the capacity to store both genres. After receiving instructions, the electronic readers were introduced to the students in the San Carlos Government schools, and they were able to effectively operate the devices and quickly took to reading and exploring the equipment.

This test program for enhanced electronic education provided a foundation for further projects to build off of. Electronic readers provide a feasible and practical method for delivering content to the students in San Carlos. Accordingly, increased access to information can serve to benefit not just the students, but the community as a whole. Coupling the electronic readers with future video conferencing technologies would increase the community's access to information. In the short term, a continued post-test issued to the students next year will provide more concrete feedback on the impact of electronic readers. In the long term, continuing these efforts will increase the community's access to information thereby increasing net opportunities for the community.

INFORMATION TECHNOLOGY AND WATER SAFETY TRAINING IN BELIZE

Chelsea Bell, McMaster Scholar, 2013-2014

Understanding Internet safety, and cost effective Internet usage is imperative to technological education. Furthermore, adding virus protection software and applications is another requirements of internet usage. This project sought to educate Internet users in San Carlos, Belize, in the best practices in internet usage as well as continuing to educate on keyboarding and other computer usage skills.

Internet service in Belize is sold per gigabyte (GB) of data downloaded. Accordingly, some websites will cost more than others (Manohar). A GB is a unit of measurement for data used on computers. Data consumption often depends, in part, on how many graphics and other data-consuming features the website has. Downloading files also can consume large amounts of data and become costly. In San Carlos, laptops were introduced in the 2012-13 Belize McMaster Initiative, and Internet was introduced in a limited fashion to the library.

This project sought to develop a plan to keep Internet operational by appropriately charging for its use, and training in Internet safety. This was accomplished by teaching Internet safety in the schools, to adults, and to the librarian in the village of San Carlos. Posters were created and displayed in the school and library to reminder and provide tips regarding safe practices. Furthermore, a software program called Esafely was downloaded on all laptops to prevent websites with adult content, profane language, and sensitive martial to be accessed. Also, the computers in the library were assessed and necessary repairs were made and additional laptops with new and updated software were implemented in the school.

A survey was taken while teaching in the school and data was collected regarding technology usage. In 2012, only four students had used a computer. In 2013, 25 students had used the laptops in the library on a fairly regular basis. Only 13 students knew what the Internet is, three students had seen others use Internet, and one had used the Internet. Ten students had used a cell phone. The change is likely the result of five laptops that were provided to the library during the 2012-13 initiative.

Notably, younger student in San Carlos had used the laptops more and expressed greater interest during the 2012-13 and 2013-14 initiatives. Starting a new skill at a younger age should result in more laptop usage and a greater proficiency when using the technology. Currently, San Carlos students who go to high school do not have access to the technologies necessary be as successful as their similarly situated peers in communities with better information technologies. With seven working laptops in the library, the community will be better equipped to provide opportunities for students to acquire an adequate education in their community.

Additionally, I continued previous efforts to educate the community regarding water safety. Back boarding was a key element this year to help prevent further injury to anyone who has a head, neck, or back injury. About 20 community partners attended the session held under thatch behind the Sun Breeze Restaurant. I explained and showed how to backboard and deal with head, neck, or back injuries. Community partners practiced the skills and were asked how much skills have been used in the past year. Posters were also provided that gave general rules and guidelines for water safety.

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IMPROVING ACCESS TO HEALTHCARE AND EMERGENCY RESPONSE TRAINING IN RURAL BELIZE

Kirsten Frissora, McMaster Scholar, 2013-2014

Health care, access to, and quality of the same, are imperative internationally; Belize is no exception. Lack of adequate and consistent health care in remote villages has been a problem for some time. In 2006, the Belizean government released an article stating that "[t]he health sector suffered from severe resource imbalances . . . towards cities and towns and away from rural areas[]" (Ministry of Health Belize, 2006, p. 21). Measures intended to remedy this deficiency have been inadequate. The purpose of my project was to improve the means for adequate access to healthcare. In pursuit of this objective, I developed a four-pronged approach to address various aspects of health. This approached was developed from my former projects in this area as well as with the assistance of community partners in the area. The four-pronged approach consisted of: (1) the production of a natural remedies book, (2) education regarding intestinal worms, (3) emergency response training, and (4) a health survey conducted to compile data so as to provide health care providers with medical histories regarding community members. I collaborated with the villagers of San Carlos and Indian Church, and rangers from Programme for Belize (PFB) at Hillbank Research Station. The goal was to improve the overall health in these rural communities which are at least three hours from a hospital or doctor.

The first prong consisted of a natural remedies book which incorporated research largely from the book *Rainforest Remedies: One Hundred Healing Herbs of Belize* written by Rosita Arvigo and Michael Balick (1998). I modified the information from this book to create a resource which concentrated on profiling the plants known to grow specifically in and around the Rio Bravo Conservation and Management Area of Belize, instead of the country as a whole. Ecosystems in Belize change dramatically from location to location, and include mountain regions, coastal areas, and equatorial regions. Accordingly, plants native to one area may be unknown to another area. In response, I developed a natural remedies resource booklet that was comprised of plants accessible and relevant to the community partners we worked with. I also used information collected from community partners including: PFB ranger Ivan Gillett, San Carlos resident Maria Luisa Hernandez, and Indian Church resident and mid-wife Blanca Esquivel to supplement the book. Revisions and additions were implemented before the final product was created and given as a resource to San Carlos and Programme for Belize's Hillbank Research Station. A shortened medicinal plant checklist was created and taken to Hillbank so that visitors would be able to mark which plants they see while there and also add any plants that they find.

The second and third prongs of this project focused on preventative measures and emergency response training. Lessons were conducted at the San Carlos Government School, and with the San Carlos Women's Group, about the dangers of intestinal worms, symptoms that would indicate the presence of intestinal worms, and preventative measures critical to reducing contraction of intestinal worms. I adapted these lessons from WaterStep's 'International Water Training: Hygiene Education' manual which provided techniques and methods for teaching and discussing various health issues in developing countries (WaterStep, 2012). Although preventative measures are necessary, emergency response measures may be the only option at times. McMaster Scholar Chelsea Bell, and I demonstrated emergency response techniques, including: first aid, CPR, the Heimlich maneuver, snakebite management training, and water safety. These demonstrations, which built on information and training conducted in previous years, covered some of the situations and injuries which may be encountered, and how best to remediate them in accordance to the procedures from Mayo Clinic (2012). In the first aid portion, I focused specifically on profuse bleeding, lifts to carry injured people, and what everyday objects could be used in cases where the first aid and snakebite kits were unavailable. In teaching about CPR and the Heimlich maneuver, I covered the basics for adults and infants who are both conscious and unconscious; I also reviewed how to perform the Heimlich maneuver on pregnant women.

While the previous prongs of the project dealt with known health concerns or problems in the community, the health survey I conducted helped identify what other health concerns were prevalent in San Carlos. My survey assessed access to clean water, the usefulness of trainings provided by previous McMaster Scholars, the frequency of professional medical visits to San Carlos, natural remedy use, and cancer awareness. The survey revealed that many villagers still use rain or contaminated water instead of water from an available water filtration system because it is easier to access and they don't realize the full impact of contaminated water on their overall health. The survey also evidenced a need for cancer awareness among everyone, especially the women concerning breast cancer. Additional information was gathered about access to medical professionals, although it is unclear if, how often, and how consistently medical professionals visit San Carlos. These results will help provide a base for future projects.

The San Carlos and Indian Church communities responded well to this project. Community partners were essential in helping document more information about natural remedies; they were active during the emergency response trainings, inquisitive about intestinal worms and their prevention, and open and willing to answer my survey questions. The goal of my project was to improve San Carlos' access to health through the creation of a natural remedy book, intestinal worm lessons, emergency response training, and surveying broad health topics in the village. I was able to create a permanent resource on natural remedies; raise awareness on intestinal worms; educate about how to respond to situations requiring first aid, CPR, or snakebite management; and collected data concerning the different aspects of health in the San Carlos community.

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EMPOWERING INDIVIDUALS THROUGH CONFIDENCE BUILDING AND ATHLETICS

Caroline Hesterman, McMaster Scholar, 2013-2014

In rural Belize, the majority of females do not continue their education past the age of thirteen (Central Intelligence Agency 2014). This is not always a decision of choice, but one out of necessity due to lack of money, difficulty with national tests, and access to education. Secondary education is very expensive and often requires travel hours away from the rural areas of Belize to the more urban areas of the county. The purpose of this project was to build self-esteem and confidence in the young women of the village of San Carlos, Belize. In furtherance of that goal, I spoke with young women in the community, and their mothers, to conduct a variety of confidence building activities, such as journal writing. Journal writing is important because it is one of the best ways for someone to learn and better understand one's self. Additionally, I taught the sport of volleyball to the women in San Carlos. Sports play a very important role in building self-confidence (Bowker 2006). It was my hope that building self-esteem through coaching volleyball and other hands-on activities would provide confidence and motivation to the young women of San Carlos and would enable them to continue their education.

Over the course of this McMaster trip, I collected information from the young men and women of San Carlos, as well the women from the restaurant via informational interviews with community members. I began by developing an understanding of the word confidence by associating it with the word leader/leadership. This was accomplished through implementing some of the various activities I prepared. The upper level classroom had an articulate understanding of what confidence meant to them. They expressed to me that a leader is someone who guides you and knows what to do. The comparison of a soccer player was used as an example. The leader on the field is someone who is smart not only on, but off the field as well. Some of the leaders mentioned in both the upper and middle classes included their teachers, principal, and parents. When comparing the example to superheroes it was found to be humorous because leaders to them are those who are present in everyday life. These results showed me that an understanding of confidence and leadership is there and that the activities that the young men and women participated in were beneficial.

When talking to the women of the Sun Breeze Restaurant, I inquired about students that had or are currently attending secondary school. I learned that there are now seven students from San Carlos attending secondary school in Orange Walk. This is a very high amount from past years. Most of these young men and women have family there, but unfortunately not all of them do, making it

very expensive. Although money is a major limitation on access to education, transportation also substantially limits San Carlos' access to education. Buses do not travel all the way into or out of San Carlos. Additionally, students in the community have difficulty passing the entrance exams necessary to be accepted to secondary school. These are all problems that substantially limit children from continuing their education. Further research would be beneficial to observe the retention rate of young women in high school.

Building a relationship with the young women and mothers in the village was imperative to this project's success. Through my background in psychology, I was quickly able to build these relationships. I spent the first day building relationship with the young women by establishing a rapport with the community. The young women and mothers made this very easy due to their willingness to meet and talk with me. Instead of pushing my teachings and project on them, I listened, responded to, and participated in their agenda. When they realized I was enjoying the time I spent with them, they in turn were very attentive when I began my project over the next two days.

The young women of San Carlos have shown they have an understanding and a sense of self-confidence. My work indicates that incorporating more activities about self-confidence and self-awareness would be very beneficial in the coming years. This is a perfect time to focus on confidence and leadership especially with the young girls watching their mothers successfully run the Sun Breeze Restaurant. While we were able to make great strides in instilling confidence in these young women, this project is a long term investment, the return on which will be realized when these young women are better able to achieve their potential in accordance with their aspirations. Charting the amount of children that continue on to secondary education is one way of tracking the impact of this investment.

Overall, having a higher self-confidence and self-esteem is one of the drives that will push young women to continue their education. There is great importance in continuing this project and the reaction from the young women and mothers was anything but negative. This project has just barely scratched the surface, and there are many more ways to expand upon the first layer that has been laid out in San Carlos.

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LEARNING ABOUT SAN CARLOS

Zachary Lopez, McMaster Scholar, Belize 2012-2014

The purpose of this project was to compile accurate information about the demographics of the community of San Carlos in order to help the community apply for grants that require this information. A project completed by previous McMaster Scholar, Bryant Green, uncovered potential grant opportunities for people living in San Carlos, and the surrounding areas. The village, however, did not have the basic demographic information compiled that was needed to apply for these grants. My work will create opportunities for the people living in these areas by compiling the necessary data to apply for these awards.

In addition, I assessed the attitudes of periphery populations toward Programme for Belize (PFB), the Rio Bravo Conservation and Management Area (RBCMA), and the conservation as a whole. This project is a follow-up to an impact study conducted in 2005, by former McMaster Scholar, Jordan Plant (Plant, 2007). His project focused on chronicling the attitudes of these communities toward the RBCMA; its managing entity, PFB; the conservation in general; and assessed the positive and negative impacts the reserve has had on their lives. In my subsequent research, villages were selected due to their proximity to the Rio Bravo. Interviews were conducted with the people of the areas and the results of those interviews were analyzed: (1) to gain an appreciation for current conditions and attitudes; (2) to document any change in the formerly negative perceptions of the periphery communities toward PFB; and (3) to give these communities a forum to have their collective voices heard.

In 2012-13, I was able to collect a large amount of demographic information on the community of San Carlos. The average amount time that families had lived in the village was 15.87 years. Of those who reported information about their families, I found that 70% of the families in the village have children. The average number of children in a household was four, but the number of children ranged from one to twelve. Furthermore, the village of San Carlos is heavily dependent on agriculture. Of the 32 households who reported their employment, 81% of the people reported that he or she was engaged in farming. Eight women in the village ran the Sun Breeze Restaurant, while five women worked outside the village. Of 71 people who were over 18 years of age, 17% reported of having some type of educational experience. Continued analysis of the data collected will help to inform future McMaster projects to the site. In 2013-2014, my studies showed that of the 18 people interviewed only 27% of people accurately articulated the purpose of PFB. This is important because it indicates that the local villages have limited exposure to PFB. This limited interaction is limiting the context of which individuals understand the PFB.

The information that was gathered as part of the impact survey was used to determine how the village of San Carlos felt about the PFB and Defiance College. The results indicate that of those who were interviewed, people tend to be very pleased with the partnership between San Carlos, Defiance College, and PFB. Community partners recognize many of the changes in the village since the McMaster teams had been collaborating with them, namely the solar energy initiative that provided power to the school and library, the development of a restaurant which provided additional employment opportunities, and they were excited about the work the group has done with the residents to understand CPR, water safety, and snake bite response. Our community partners indicate however, that it is difficult for people who get ill to get medical help because there is such a long drive to get to the nearest professional health care provider. Having increased access to a nurse, perhaps daily, would solve the problem for many villagers who do not have a car and cannot drive to seek medical attention. Another common theme that people in the village stressed was the need for system that provides clean water to the people in the village. This information will provide future McMaster teams direction when designing and proposing projects. This was the first year of an ongoing attempt to characterize attitudes of periphery populations toward the conservation organization PFB and how the perceptions of our community partners have changed due to the continued partnership with Defiance College.

REFERENCE

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PRESCHOOL EDUCATION IN SAN CARLOS, BELIZE

Hallie Sullivan, McMaster Scholar, 2013-2014

The goals of this project sought to develop a preschool program in the San Carlos library to expose students to the English language and to help children develop school readiness. This will allow the teacher, Miss Sarah, who educates the youngest children in the San Carlos Government School (Infant I), to focus more on teaching the prepared the curriculum rather than combating language barriers and school readiness issues. A child needs a good quality start to begin their schooling career. In Belize, English is the primary language of the school's educational instruction, but often the first language children learn at home is Spanish. As a result, the first few years of a child's education are significantly difficult. Furthermore, teachers are responsible for educating multiple grade levels at one time, which compounds these difficulties. Accordingly, the difficulties associated with learning a new language in order to receive a formal education, and the want of individualized age-appropriate attention for the communities' younger students creates significant challenges for the community of San Carlos.

By developing a preschool education program we can help ease the transition of children in San Carlos, Belize, as they interact with the Spanish-speaking families and their English-speaking educators. Preschool will help students learn the basics of reading, writing, and will develop school readiness. In accordance with my research, lesson plans were created to help develop school readiness including exposure to the English language, and writing. Some of the lessons I developed can be used every day to help the development of the English language. For example, I used a phonics dance to model one way of teaching phonics and exposure to the English language.

Furthermore, I brought materials to put in the library, such as children's books, art material, a teaching calendar, and a number and alphabet line. This helps the environment become more friendly and appealing to the students, and helps get them excited about learning. Wendy, the librarian, will be in charge of the preschool center. When working with Wendy, I showed the sample lesson plans and presented ideas on how to expose students to English. Wendy, Miss Sarah, and I collaborated to develop further ideas regarding what to cover in the preschool in order to help the students prepare for Infant I. Starting this preschool center should help students become more successful in their educational career and prevent students from falling behind. "[A] child who is having difficulty reading at the end of first grade has an 88% probability of still having the difficulty in the fourth grade" (Morrow & Asubry, 2003). Accordingly, it is important to introduce children to reading early due to the significant effect it could have on the child's learning potential. Preschool is an opportunity for students to grow, develop, and shape their academic development as well as themselves.

The village of San Carlos has limited resources when it comes to education. By developing a preschool center by using, and perhaps repurposing, resources already available to the community as well as some additional contributions, a preschool program should be successful if implemented. The preschool run by the librarian should help prepare students to be more productive in Infant I. The positive responses from the village, the Infant I teacher, and the librarian give me confidence that the community will be successful in implementing a part time preschool center for the students who are not yet in school. Our collaborative contributions will not only help children in San Carlos advance in their education, but also will enable future teachers that continue this project as well.

REFERENCE

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MARKETING OF THE SUN BREEZE RESTAURANT

Alyssa Turton, McMaster Scholar, 2013-2014

The purpose of this project was to enhance the marketing capabilities of the San Carlos Women's Group, in regard to their operation of the Sun Breeze Restaurant. Over the past nine years, McMaster Scholars have noticed that the lack of infrastructure and remote location of the village limits the economic development of San Carlos. In 2011, women in San Carlos articulated to the McMaster team that they were interested in new opportunities for employment within the village. By 2012, with the help of the McMaster School for Advancing Humanity, the San Carlos Sun Breeze Restaurant was established by the San Carlos Women's Group to further that goal. Eventually, the women hope that the restaurant becomes a tourist attraction offering authentic Belizean home-cooked meals. Additionally, the Women's Group has explored the possibility of opening an artisan craft store. Marketing will be critical to the future success of the Sun Breeze Restaurant. The purpose of my project was to help establish marketing techniques to maximize the group's profitability.

As the restaurant continues to expand, it is slowly bringing in more revenue. I compiled a basic marketing strategy in collaboration with the San Carlos Women's Group. Working with the women we designed and chose colors for an appealing crossroads signs to place just outside the neighboring village of Indian Church and within the village itself. Furthermore, I was able to collect the recipes for all the dishes they cooked for us throughout the week. Using those recipes, the women and I were able to construct a weekly menu for the restaurant. This menu contains a set dish for Sunday through Saturday. This menu will be finalized and taken to the Women's Group by the McMaster Belize team in December 2014.

My project effectively demonstrated to the Women's Group, the importance of best practices in marketing, and how these best practices can be applied to a newly established small business in a small community. The women are now prepared to use the marketing plan that was established and to modify it as they see fit as the business evolves. Marketing will have a huge impact on the success and growth of Sun Breeze, and I predict that the Women's Group will establish an artisan craft shop in the near future.