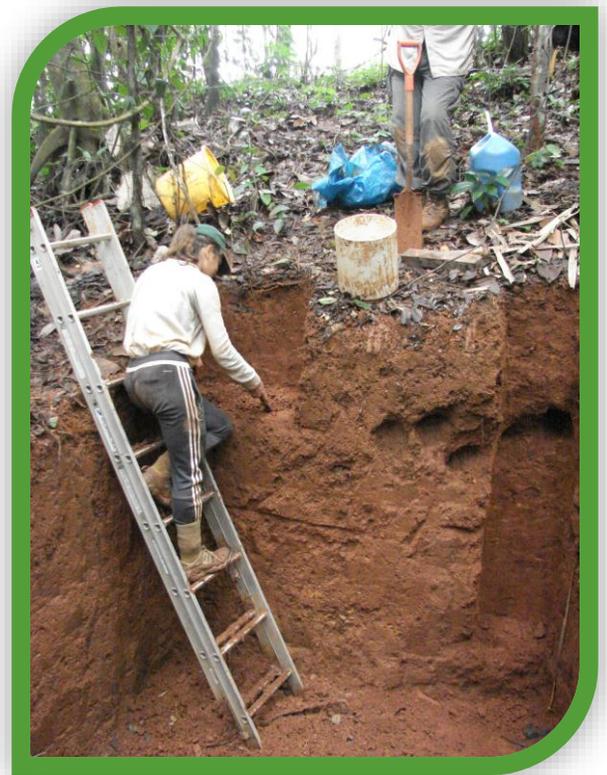


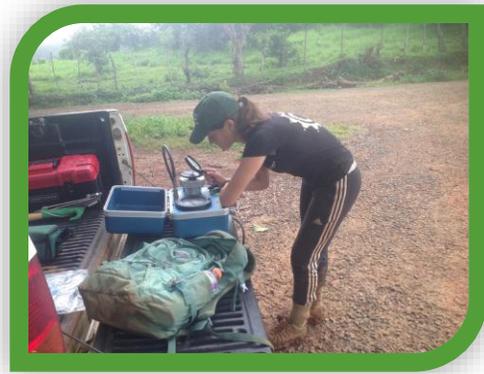
# Agua Salud: An evaluation of hydrologic cycling and land use in Panama



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## Project Overview

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 Location: Panama Canal Watershed  
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 Fellowship Duration: June 6th 2016 - August 8th 2016



## About the McBurney Fellowship Program

Through McGill’s Institute for Health and Social Policy, the McBurney Fellowship Program supports students in international service programs related to health and social policy in Latin America. McBurney Fellows serve abroad in organizations working to meet the basic needs of local populations. One key aspect of this fellowship is its mandate to make a significant contribution to improving the health and social conditions of poor and marginalized populations through the delivery of concrete and measurable interventions. Students and their mentors identify issues, make connections with local organizations, and develop a strategy for the fellowship. The views expressed in this document are the opinions of the fellow, and do not necessarily reflect the opinions of the IHSP.

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# Agua Salud: An evaluation of hydrologic cycling and land use in Panama

## Objectives

For the Summer of 2016 I worked for Agua Salud, a project out of the Smithsonian Tropical Research Institute in Panama. Agua Salud evaluates the ecosystem services provided by the Panama Canal Watershed. Specifically I worked as a research assistant for the hydrology team of the project. The hydrology team focuses on how water movement is affected by different land uses. In other words, how hydrologic ecosystem services are altered when humans change how they utilize a given piece of land. In total there are five sites with five distinct land uses. They are young secondary forest, old secondary forest, pasture, cut catchment and coffee plantation. A secondary forest is a forest that has re-grown after a major disturbance such as fire, natural disaster or intense human activity. Therefore the young secondary forest is only eight years old, while the old secondary forest is 80+ years old. The pasture site is an area where cattle are being raised for consumption and sale. The cut catchment is a young secondary forest that is 25-30 years old. Lastly the coffee plantation is a farm where coffee is being grown and harvested for commercial use. The young secondary forest, the old secondary forest, the pasture and the cut catchment sites are all located in Agua Salud, east of the Panama Canal. The coffee plantation site is the only site located in the western watershed of the Panama Canal. At these sites, various experiments are conducted to measure factors such as sap flow, degree of infiltration, degree of runoff and soil moisture content. By measuring these values from each site, it enables a researcher to gain insight into how land use affects ecosystem services oriented around water cycling systems.

## Background/Context

The Panama Canal watershed provides crucial ecosystem services that promotes the economic and social well-being of the country. Water reserves in this area provide freshwater for the millions of Panamanians living the nation's capital, sustain the agricultural enterprises of farmers within the region, and are utilized to move ships through the canal. The proper functioning of the watershed as a macro-ecosystem, in addition to the many micro-ecosystems that encompass the whole, is crucial for the livelihoods of millions of Panamanians.

The Panama Canal is the foundation of the Panamanian economy. The geography of Panama has given the country a comparative advantage that has been realized since the Spanish conquistadors first arrived to the Americas, transporting gold and silver across the isthmus. Eighty percent of the Panamanian economy is based on a well-developed services sector including the Panama Canal and supporting institutions such as the Colon Free Trade Zone, container ports, banking and insurance. Although not every Panamanian is directly involved in

the operations of the Panama Canal, its actions have far reaching and comprehensive implications for the entire country.

The proper functioning of the Panama Canal is dependent on the ecosystem services provided by the tropical forests located within its watershed. A watershed is all of the land and water areas that drain toward a particular river or lake. Therefore the Panama Canal watershed is the area surrounding the canal that through runoff and infiltration, feeds the water supply that allows it to function. The canal allows movement between the Atlantic and Pacific oceans by utilizing a system of three locks. Because sea level at the Atlantic Ocean is tens of meters lower than sea level at the Pacific Ocean, the system of locks allows water to be pumped or removed in the chamber at the three respective locations. Water is taken from nearby Gatun Lake. Many streams and rivers within the Panama Canal watershed feed into Gatun Lake. Therefore activity through the watershed can potentially affect local bodies of water that feed into Gatun Lake, ultimately altering the availability of water needed for commercial use in the Panama Canal.

The Autoridad Canal de Panama (ACP) or the Panama Canal Authority in recent years has noticed decreased water levels in Gatun Lake. In collaboration with the Smithsonian Tropical Research Institute, Agua Salud was created to research water cycling within the Panama Canal watershed. In particular Agua Salud focuses on how the hydrology of an ecosystem is affected by different land uses. For example, is more water cycled in a coffee plantation or in a young secondary forest? The information gathered from Agua Salud is used to influence public policy regarding land incentives throughout Panama. If research conducted by Agua Salud suggests that a certain land use results in greater hydrologic cycling eventually contributing water to Gatun Lake, then the government of Panama can pay farmers to change their land use. Creating land incentive programs can potentially be less expensive than importing water from other sources.

## Activities

There is no typical day as a research assistant for Agua Salud. Despite the dynamic nature of my internship, in general a typical work day falls into one of three categories: collecting data at Agua Salud, working with a professor from out of town, or a laboratory day at Tupper.

When my day included collecting data at Agua Salud, I met at Tupper in the morning. Tupper is the main facility of the Smithsonian Tropical Research Institute (STRI). After packing all necessary items into the STRI truck, we traveled to Agua Salud. Agua Salud is the name of the land owned by the Smithsonian Tropical Research Institute for the purpose of conducting research for the Agua Salud Project. After arriving to Agua Salud, the roads are not accessible by car. Therefore it is necessary to park the car and hike to the various sites where data is being continuously collected. In total there are four sites where sap flow sensors are installed and data download is necessary. They are Cut North, Cut South, young secondary and mature secondary. In addition there are two scintillometers and one eddy flux tower. From each of these sites, data has to be downloaded onto a field laptop. While the data was being downloaded, I was able to

see the values on the computer screen. Often NAN values pop up indicating that an error has occurred. Troubleshooting for NAN values can include repairing wires that have been corroded due to ants, replacing malfunctioning pieces or simply reconnecting items that were accidentally pulled out of place. This process is the same for the Cut N, Cut S, young secondary, mature secondary forests and both scintillometers. For the eddy flux tower, instead of downloading the data onto a laptop, I had to swap out cards that log the data. The same process of troubleshooting applies in that I had to ensure that no NAN values appeared and if they did, I had to resolve the error.

The second category of day, working with a visiting professor, is similar to data collection in that



both take place at Agua Salud. So far I have worked with three different professors on their independent research projects within Agua Salud. The research of Dr. Ed Kempema, of University of Wyoming, is oriented around rainfall simulation technology. My responsibilities when working with him included implementing and recording data for the rainfall simulation. This information

is used in order to assess how infiltration and runoff are affected by different three distinct land uses (young secondary forest, coffee plantation and pasture). The research of Dr. Jan Hendrickx focuses on the structure and water retention capacity of the soils. When working with him, I collected bulk density samples to later analyze at Tupper facility to determine specific characteristics such weight, mass and volume. Lastly, Dr. Bruce Harrison of New Mexico Tech researches the geology of soils. For his research, I dug and analyzed soil pits to distinguish the number and individual lengths of different soil horizons with emphasis on the distance from soil surface to the bedrock layer.

The last category of day is laboratory work at Tupper. Laboratory days at Tupper encompassed transferring data downloaded from the different sites in Agua Salud to the appropriate databases, analyzing information or samples from the field, or preparation for a particularly intense day, or set of days, of field work. For example, Dr. Jan Hendrickx and I collected over 50 bulk density samples from different sites with unique land use allocation, gradient, vegetation etc. Each bulk density sample had to first be weighed within one day of the sampling in order to get the “wet weight”. After this value is determined, the soil sample is put into the heater in

order to dry out at 30 degrees Celsius. After the “wet weight” was recorded, three additional “dry weights” were determined to analyze the rate of water loss. Ultimately this methodology assesses whether the moisture content of a given soil sample can be predicted by characteristics such as land use and depth from soil surface.

### Challenges and Successes

During my time as a research assistant for Agua Salud I accomplished a significant amount of field work. The majority of my time was dedicated to downloading sap flow data and I assisted in the implementation and completion of three separate supplementary research projects. These projects were oriented around rainfall simulation technology, soil moisture content, and vertical soil profiles respectively.

I was able to accomplish everything that I set out to do. Agua Salud has existed since 2006 and because it is not a young organization, it operates as a well-oiled machine. Therefore when I arrived there were predetermined tasks that the supervisors of the project have decided in advance. Because of their extensive experience in conducting research for Agua Salud, all of my tasks were very reasonable and within reach.

### Questions Raised

My fellowship is very effective at measuring ecosystem services. Research oriented around ecosystem services is crucial for the protection and preservation of natural landscapes. By pinpointing how the proper functioning of ecosystems contributes to the economic, social and cultural well-being, humans better understand how the disturbance and destruction of these systems negatively affects human and ecological communities alike. As an extension of this idea, Agua Salud measures the ecosystem services of the Panama Canal watershed and analyzes how different land uses impact these crucial services. Within this mission there is emphasis on how public policy regarding land use incentives can support the transformation of the watershed towards long-term sustainability.

The question arises “What if it is more cost effective to damage the environment, rather than protect it?” A part of the research is funded by the Autoridad de Canal Panama (ACP), or the Panama Canal Authority. As a business and organization, it has a vested interest in ensuring water resources within the watershed. It may prove that it is more cost effective to transport water from abroad, rather than protect the watershed that provides water resources naturally. The Panama Canal is not the only organization dependent on the ecosystem services of the watershed. The infrastructure systems that provide water resources to the urban areas are



dependent on reserves such as Gatun Lake. Rural communities are more directly dependent on the proper water cycling because many individuals orient their livelihoods around the cultivation and sale of crops. My fear is that if the cost-benefit analysis favours the transport of water resources versus the preservation of the watershed, business will operate as usual while millions of Panamanians with fewer economic means will suffer.

### Training and Mentoring

My first week in Panama served as my training period. I arrived, filled out proper paperwork, applied for a driver's license and became acquainted with the Smithsonian Tropical Research Institute's facilities. Field work training mostly occurred instantaneously. Due to the nature of the work, it made most sense to teach me about the different experiments and technologies as data was being collected versus in advance.

My faculty mentor, Dr. Carolyn Begg, played a crucial role during my fellowship. As I was faced with new concepts and terms, Dr. Begg provided me with the necessary resources (e.g. web resources, personal knowledge and academic articles). By increasing my understanding of the topics that my research was assessing, it enriched my experience allowing me to appreciate the data being collected.



### What did you learn?

Next time I would develop my Spanish to a higher level of fluency before arriving in Panama. If I was speaking at a higher proficiency upon arrival to Panama, then I could have connected with the locals I met earlier in my fellowship. While immersed in the culture, my ability to speak the language significantly increased out of necessity. The level of proficiency that I had at the end of my internship, I wish I had from the beginning. I believe this would have increased my ability to understand and appreciate

Panamanian culture.

### Community Implications and Further Work

In the short-run, it is difficult to determine what conclusions can be drawn. Reason being, in research it is difficult to state "it will take X amount of time and Y numbers of values for this experiment in order to be able to draw formidable conclusions". Especially when examining ecosystems there are an incredibly high number of factors that can influence the results. That being said, as repetition of a given experiment increases, the validity or the confidence in conclusions increases as well. Because of this long term applications monitoring proves to be crucial. Agua Salud for example has been collecting data since 2008 and intends to continue

within the foreseeable future. Therefore no definitive conclusions can be determined within the mere nine weeks I worked in Panama.

The long-term implications of Agua Salud's research do have potential to revolutionize public policy regarding the Panama Canal Watershed. The hydrology team is one of many teams working within the project. There is also a soils team, a vegetation team, and a socioeconomic team. Eventually the data from the soils, vegetation and hydrology teams will be put into the TREES model which stands for Terrestrial Regional Ecosystem Exchange Simulator. The TREES model allows researchers and academics create a computer simulation of a given ecosystem. Within the model, these individuals manipulate factors commonly associated with climate change such as temperature increase and sea level change. The simulation illustrates how an ecosystem will change due to externalities of climate change. In contrast, the socioeconomic team has been working on gathering data on farmers' willingness to accept different land incentive programs. This information will be juxtaposed with the conclusions gathered from the TREES model. In effect, this will shed light into how the landscape of Panama will change due to climate change and what the government of Panama can do to implement policies that promote proper ecosystem functioning.

#### **How might your fellowship make a difference for the people you worked with?**

Scientific research is increasingly supporting the idea that preserving ecosystems results in provision of ecosystem services that support economic and ecological structures alike. In the example of the Panama Canal watershed, the proper functioning of the watershed supplies water resources for the purpose of drinking, supports farmers' abilities to grow and sell crops, and fosters biodiversity among other positive repercussions. If the research of Agua Salud confirms this, then it promotes the idea that preservation of the watershed does not come at the expense of economic frugality. For example, farmers may be paid by the government to plant coffee versus graze cattle because cattle has increasingly been discovered to disrupt water cycling by compacting soil. The transition from cattle to coffee would result in farmers increasing their annual income while also promote ecological functioning. The cost to pay farmers to transform their land costs the government of Panama funds, but may prove to be cheaper than transporting water from an external source. Therefore, scientific and policy implications of Agua Salud yields potential to have far reaching implications for local communities.

Smithsonian's Agua Salud project evaluates the effects of land use for local communities, or stakeholders, that are not capable to do so themselves. The vast majority of farmers in the Panama Canal watershed work on farms that have been in the family for many generations. It has been found though that the agricultural practices in the watershed have periodically contributed to the decline of tropical forests. Over time the decline of tropical forests has led to the decline of the ecosystem services that they provide. In short, the quality of the agricultural land is decreased because of the degradation of tropical forests. Because these farmers are living harvest-to-harvest, they do not have the means to "experiment" with different land uses

to see which agricultural practices contributes to both the income of the family and the ecosystem that surrounds it. The research that Agua Salud conducts determines which land uses will best contribute to economic and ecological sustainability, taking that burden off local farmers.

Some of Agua Salud’s conclusions have indicated that there is not a trade-off between utilizing land for agricultural use or preserving it as a tropical forest. One does not necessarily have to come at the



expense of the other, as there lies potential for tropical forests and agricultural plots of land to be mutually beneficial. For example, coffee crops need shade in order to grow. Therefore having the presence of trees on coffee plantations doesn’t only promote biodiversity, but also compliments agricultural practices. It is through the work of Agua Salud that many new realizations are being discovered about how agricultural and ecological interests can complement one another. Because of this, the promotion of biodiversity and ecologically sustainable can be integrated into the livelihood strategies of farmers in the Panama Canal Watershed.

### Program Evaluation

This fellowship furthered my academic goals by providing me

an intimate understanding of hydrologic processes in tropical environments. After my undergraduate studies at McGill I intend on pursuing a master's degree in either bioresource engineering or hydrology. This internship has proven to be a crucial stepping stone for my future academic goals. Throughout the nine weeks of my fellowship I had the opportunity to meet countless hydrologists and engineers. It was through meeting and working beside these individuals that I gained crucial knowledge about the schooling involved and the average day for both occupations. My interactions with them cemented my desire to get a master’s in either of those fields.

**What did you value most about the fellowship?**

I absolutely loved being able to work outside the entire summer. Although occasionally I was in the lab, for the vast majority of the time I was in the field. It was unlike many internships that I've had in the past that were in office settings. The experience allowed me to realize how much I valued working outdoors and helped me refine my future career aspirations according to this new realization.

**Any advice for future fellows?**

My advice for future fellows is to be committed to learning Spanish before and during your time in Latin America. Being able to speak the language proved to be a crucial skill not only for navigating, but also for forging meaningful connections with the country's locals.

I would highly recommend working for Agua Salud to other undergraduate and graduate students who are looking for research experience. At the moment, Agua Salud has no expiration date, so the project intends to collect data and conduct research far into the foreseeable future. Therefore there will most likely be many opportunities for students with similar academic backgrounds and experiences to work for Agua Salud.