Teak Efficiency and Environmental Education Methods

for Batipa

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Panamá Project Center 2018

WPI

Universidad Tecnológica Oteima
Formadores de Líderes

BATIPA
FIELD INSTITUTE

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Teak Efficiency and Environmental Education Methods for Batipa

An Interactive Qualifying Project
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In partial fulfillment of the requirements for the
Degree of Bachelor of Science
by

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Report Submitted to:

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Abstract

We have addressed three issues in this project regarding the Batipa Peninsula and the surrounding areas: solutions for teak by-products, reconnecting wildlife corridors, and the sustainability of the Chiriquí Province through education. Our mission was to create effective and attainable solutions for these issues. We conducted primary research, via interviews and on-site visits, to find low-cost, low-risk solutions for these problems. Our recommendations included new equipment for better teak efficiency, construction of permanent structures for wildlife, planned future projects, proposed classes, critiqued Oteima's online presence, and generated new tourism itineraries for Batipa.

Acknowledgements

Executive Summary

This report provides suggestions on the subjects of teak efficiency and marketing, improving the Altitudinal Biological Corridor of Gualaca, the sharing of agricultural techniques to local farms through Batipa, and new initiatives for both academic and ecotourism. The Universidad Tecnologica Oteima, or Oteima University, is a private university and is affiliated with Batipa. On the Batipa Peninsula, there is a large-scale teak plantation, cattle pastures, and a 600-hectare nature refuge. This combination between profitable agriculture and ecology makes Batipa a one of a kind place.

The Batipa Peninsula is part of the Altitudinal Biological Corridor of Gualaca, this massive stretch of land goes from the Pacific coast to the mountains of Fortuna. There is a variety of ecosystems within this corridor and a large span of flora and fauna. The dream is to have full connectivity between the Pacific and Atlantic Oceans by connecting the Gualacan Corridor to the Mesoamerican Corridor, making it unique in terms of biodiversity.

Initially, 13 projects were delivered to us. Being a four-person team with a short amount of time to complete the project, we needed to look at them all and choose three projects that were the most relevant to the development of Batipa. By looking at the big picture and looking at all 13 projects together, we saw that all of them fell within three subjects. Each would either fall into an economic, ecological, or educational based project. From this we were able to find the three subjects that encompassed multiple other topics so we could produce suggestions to complete these projects. The final three projects were the following:

Economy
- Teak By-Products
- Academic/Eco-tourism

- Biological Corridors
- Soil Erosion Control
- Biodiversity

- Relations with other Field Stations
- Polyculture
- Seed Banks

- Teaching Farming methods to locals

Ecology

Education

1. Teak by-product management
2. Soil erosion control and reconnection of Batipa to the Gualacan Corridor
3. Sharing of knowledge and agricultural techniques utilized at Batipa
4. New initiatives to promote academic and ecotourism
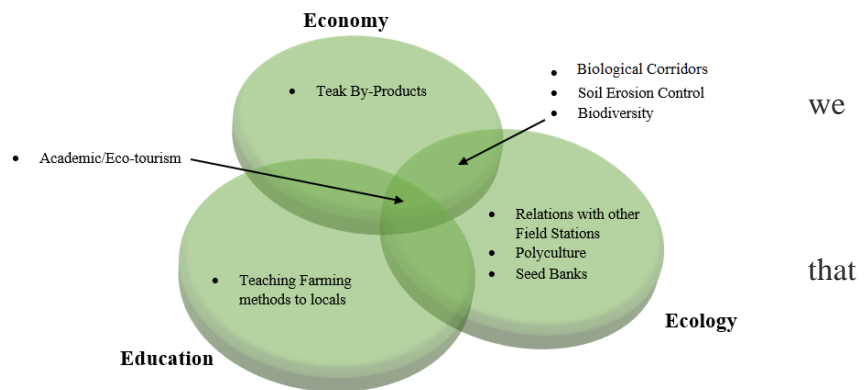
The time span of the project was seven weeks. Of the seven weeks, we spent ten days in the Chiriquí province of Panamá in the city of David. Here we worked at Oteima University and would take trips to Batipa or other areas to evaluate the resources and methods currently implemented to make our suggestions applicable to Batipa. Along with multiple on-site visits, the project team conducted interviews with employees at Batipa to gather information on specific questions we had such as teak milling procedures. After our ten days in David, we spent the remainder of our time researching the topics. We reported to our sponsor to make sure our deliverables still remained viable for Batipa and Oteima. Through extensive research and gathering information on-site, the following suggestions were presented to Oteima.

Teak By-Products

With the loss of the buyer of whole, eight-year-old teak logs, Batipa had to find a new market to sell these trees. Instead of keeping the logs whole, milling was implemented to square off the lumber, which created large quantities of scrap. Nearly 50% of each logs volume was lost. With the squared off wood drying without a buyer and slabs littered along the side of logging roads, Batipa looked into turning these idle pieces of wood into profit. We measured the amount of teak by-product there was, considered what could be done with it, and offered new methods to try in order to sell the lumber faster. We gave two suggestions on how to deal with all the excess lumber. The first suggestion was to mill each piece again, into a more popular dimension. A popular teak dimension is 1"x4", which is primarily used for siding and decking. There is a range of buyers all around the world for this style of teak lumber and if Batipa can mill it on-site, then the profit margin may increase. The second suggestion is to purchase a horizontal wood grinder with a colorizer attachment from a heavy equipment auction. Seeing that our sponsor was discouraged about purchasing a chipper due to its extreme retail price, we still believe a chipper is necessary and older models can be bought for lower prices at auctions. With a chipper on-site, all scrap such as the branches, slabs, and unusable logs can be put through and chipped and with the colorizer attachment colored mulch can be produced and sold for a greater amount to landscapers. As for the slabs, we believed the creation of 'slab racks' would be beneficial to

make the movement and storage of these pieces much easier. There is a market for slabs, but there is a narrow market for the small slabs that Batipa currently has. The best option would be to sell these slabs by the cord and see if they can be sold domestically to cabinet and furniture makers. After harvesting, all the branches and excess wood are left in large brush piles in different locations and left to rot. If a chipper were purchased these could simply get chipped. If a chipper is not purchased, these brush piles should get dispersed along the edges of the freshly cut zone. This would prevent erosion from the now free soil, and will provide nutrients for the biological corridor between zones. The final suggestion we offered was a method to increase the maximum trimming distance of branches. Pole saws are used to trim the branches of the teak trees up to seven meters tall to ensure high quality, knot free wood. With saws maxing out at seven meters, we believe the use of construction staging with adjustable legs would be a cheap and effective way to add another two meters of trimming. With these suggestions, Batipa can gain stability and even a larger profit margin with their teak plantations.

Altitudinal Biological Corridor of Gualaca

Batipa is a crucial part of this biological corridor due to its extreme amounts of mangroves that surround the peninsula. This along with Batipa's 600-hectare nature reserve means there are a lot of animals trapped on the peninsula due to the expansion of the Pan-American Highway. With four lanes of traffic, along with Jersey barriers dividing traffic, it makes it extremely difficult for animals to cross. Either the animals cannot get over the barrier or are struck by vehicles. To combat this, six primate bridges were installed for climbing animals to safely get across the highway in early 2018. As of right now, animals are hesitant to use it due to the fact that there is no vegetation on these bridges, making it unappealing for climbing animals. Our suggestion to speed up that process is to put a number of hanging baskets on the bridge with vines growing out of the basket. These vines will climb up and around the bridge, covering it with vegetation faster and making it more appealing to animals. Along with

the vegetation stimulation, the installation of game cameras on either end of these bridges will help monitor monkey troop movement. With these two suggestions, Batipa will be one step closer to reconnecting with the rest of the Gualacan Corridor and can monitor animal movement in and out of the peninsula.

Future Interdisciplinary & Major Qualifying Projects

With 13 projects put before us throughout our time, in both ID-2050 and Panamá, we did not have the time to invest in all of them. This does not mean that these projects were unsubstantial and should not be forgotten. The project team has come up with a proposal of future WPI Interdisciplinary Qualifying Projects (IQP) and Major Qualifying Projects (MQP) that could be implemented in the coming two years that will provide solutions and suggestions for the remaining projects. Below is the suggested IQP and MQP schedule in order of relevance:
2019-2020:

IQP: *Academic and Ecotourism methods for Batipa.* Project involves the team to create academic courses and catalogues, as well as recreational tourism itineraries and programs.

MQP: *Design of Animal Bridge Across Pan-American Highway.* Project involves civil and architectural engineers in the drafting, design, and rendering of an animal crossing bridge to be installed near Batipa.
2020-2021:

IQP: *Polyculture and Natural Seed Bank Initiative for Batipa*. Project team proposes potential profit plants to cultivate underneath older teak trees. Team also focuses on implementing a seed bank at Batipa to help support the sapling program.

MQP: *Design and Placement of Observational Towers on the Batipa Peninsula*. Project involves civil and mechanical in the design and locations for multiple wildfire and poaching prevention observation towers.

Sharing of Techniques with Local Farmers

One of the key questions presented to us was how Oteima could spread the idea of environmental conservation with other locals in the Gualacan Corridor to improve its' overall health. Oteima University wants to utilize Batipa as an educational center and an outreach for the more remote areas outside of the city of David. In order to spread the ideas of conservation and environmentally conscious farming methods, Oteima University would also like to develop

Batipa into a scientific research station. Batipa prides itself upon its methods of rotational teak logging, its optimization of cattle ranching, and the connectivity of the forests and wildlife. These are all subjects Batipa thinks would benefit the wellbeing of the peninsula through the spreading of knowledge. By spreading more efficient and profitable farming techniques, individual farmers can do more with the land they have and can reserve forests for protection and help the corridor as a whole be healthier. Analyzing the techniques Batipa uses allowed our team to develop feasible teaching methods and programs that Batipa can either directly implement or implement once a learning center has been established on-site. Criteria used to determine the methods and programs depended on simplifying the information into clear, concise rhetoric.

Farmers stray from traditional learning methods such as reading textbooks and attending lectures and prefer to learn using hands-on methods such as demonstrations, farm visits, or tours. Besides establishing educational farm visits or on-site demonstrations at Batipa, we also thought it would be valuable to establish a 'Sapling Program' whose purpose is to reintroduce cover crops to eroded soil so that with time the topsoil can be repaired and repurposed for the planting of profitable crops. The program would be divided into multiple phases beginning with education about erosion and the importance of vegetative cover on topsoil. In the next phase, partnerships with local farmers who are enrolled in the program will be formed and the restoration of erosion damaged areas will begin. Saplings of teak or other trees with the ability to grow in harsh soil would be planted, following the 'Batipa Model' for taking care of the trees. The final two steps occur after there has been significant growth. They involve reintroducing native species once the soil has recovered a significant amount. After the trees matured, they are logged and sold back to Batipa or sold on the farmer's own terms. After establishing these educational programs, Batipa could have a larger presence in the Chiriquí Province and the scientific community. This would help spread the word about Batipa and help it grow as a reputable field institute.

Possible Academic and Ecotourism Initiatives

Being both academic and ecotourists, our group was seen as an opportunity for Batipa and Oteima to receive a first-hand review of the programs and activities Batipa had to offer. Going to Batipa allowed us to experience what they did and did not have. Our group gave feedback on what we, acting as tourists, would look for in a destination and at Batipa.

Oteima and Batipa are partnered with a small number of American universities and would like to be partnered with more in the future. Developing infrastructure pertaining to

tourism would be a beneficial first-step for increasing the number of study abroad students they receive. Infrastructure that would be universal to all tourists includes electricity, internet access, sleeping quarters, and meal plans. Things unique to academic tourists would include the presence of a larger dormitory or a lecture hall as well as a stable internet connection. Things important to ecotourists would be the diversity and availability of the recreational activities offered at Batipa. The environmental sustainability of Batipa as a whole and the unique experience Batipa can offer that separates it from other tourist destinations are also key. We spent a weekend at Batipa and were able to take part in multiple recreational activities. We believe that these few activities are a good starting point for Batipa to focus and build upon. We presented Batipa and Oteima with our ideas and ways we thought the tourism sector of Batipa can be developed.

Throughout our time at Oteima University and Batipa, the project team has provided custom suggestions and recommendations based on extensive background research and on-site resource evaluations. We were able to look at the big picture and divide the 13 projects into three main categories, and from that choose three projects that encompass multiple others. These suggestions gave Oteima and Batipa a foundation of information that can be used to better not only the Batipa Peninsula, but the Gualacan Corridor as well.

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- Executive summary
  - Sharing of Techniques with Local Farmers
  - Possible Academic and Ecotourism Initiatives
- Background
  - Batipa and its Biodiversity
  - Environmental Research Stations
  - Ecotourism
  - Academic Tourism
  - Biological Corridors
- Methodology
  - Objective Three: Finding Possibilities
    - Establishing ways of Sharing Techniques with Local Farmers
- Initial Findings
  - Spreading of Knowledge and Techniques
  - Possible Academic and Ecotourism Initiatives
- Analysis and Recs
  - Spreading of Knowledge and Techniques

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- Introduction
- Background
  - Opening Statement
  - Oteima University
  - Reforestation
  - Biological Corridors
  - Wildlife Crossings
- Methodology
  - Opening Statement
  - Objective Two: Resource and Evaluation
  - Objective Three: Finding Possibilities
    - Teak by-Products
- Initial Findings
  - Opening statement
  - Altitudinal Biological Corridor of Gualaca
- Analysis and Recs
  - Altitudinal Biological Corridor of Gualaca
  - Sapling Program

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- Appendix A: Website Critique

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- Acknowledgements
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  - Altitudinal Biological Corridor of Gualaca
  - Future Major Qualifying / Interdisciplinary Qualifying Projects
- Background
  - Academic Tourism
- Methodology
  - Objective One: Strategic Planning and Prioritization of Needs
  - Objective Three: Finding Possibilities
    - Opening Paragraph
    - Expanding the Altitudinal Biological Corridor of Gualaca
    - Attracting Outside Academic Tourism Sources
    - Attracting Ecotourism
- Initial Findings
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- Analysis and Recs
  - Teak by-Products
  - Future Major Qualifying / Interdisciplinary Qualifying Projects
- Conclusion
- Appendix B: Strategic Visions for Batipa in the Future

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1.0 Introduction

Central America is home to lush tropical forests filled with thousands of different species of animals, birds, insects, and plants. These beautiful and diverse ecosystems have been under threat for the past 50 years. Tropical regions across the globe have been fighting to survive the damaging effects of climate change and deforestation. The international community has since banned together to protect these precious ecosystems.

In affiliation with Oteima University, Batipa is an environmentally conscious farm dedicated to sustainable rural land use, preservation of the site's tropical forest habitat, rehabilitation of biological corridors, and protection of local biodiversity. Batipa is located on a raised peninsula in Chiriquí province, near the city of David in western Panamá. This peninsula is home to a sustainable teak plantation dedicated to reforestation and profit via logging, and a cattle genetics laboratory dedicated to the genetic diversity of cattle.

Batipa is currently looking for solutions to reduce the amount of excess teak that cannot be sold at markets and to manage soil health. Batipa wants to maintain an environmentally friendly presence while manipulating the land so that they can continue towards their goals. By working with local farm owners, Batipa hopes to teach smart farming through technology in order to make the most out of the land while also being sustainable.

Oteima University was recognized in 2005 and has become a reputable private university in Panamá. As the university continues to expand, the administrators of Oteima are looking to expanding their study abroad and volunteer programs at Batipa. By redesigning Batipa's website to entice other students and overhauling their existing infrastructure, Oteima wants to increase the presence of their academic programs. Their overall goal is to increase the number of foreign students and volunteers that visit Oteima University and their off-campus laboratories.

2.0 Background

This section is dedicated to the discussion of land protection and management in Panamá by discussing governing bodies, land uses, and environmental goals. We explain the importance of environmental research stations and ecotourism locations along with the impact they can have on the surrounding area. We also state how Oteima University and Batipa plan to preserve the peninsula's ecology. In addition, we investigate strategies for managing teak zones, monitoring the Altitudinal Biological Corridor of Gualaca, and spreading Batipa's farming methods to others.

2.1 Oteima University

The *Universidad Tecnológica Formadores de Líderes*, otherwise known as Oteima University, is a leading technical university in Central America. Oteima itself is a Spanish acronym: *Ordenadores, Tecnología, Educación, Investigación, Medio Ambiente, y Argo*. Which translates to 'Computers, Technology, Education, Research, Environment, and Food Security' in English. Recognized as a university in 2005, Oteima has grown to become a reputable private institution in Panamá and an outlet for agricultural studies in the western portion of the country. Oteima's courses have expanded in the last decade to offer a dozen degrees ranging from sustainability to language. Oteima University is partnered with Batipa to provide a remote research facility in western Panamá (Oteima, History, 2017).

2.2 Batipa and its Biodiversity

A long-term goal of Batipa is to become a recognized and trusted source in the academic world both locally and globally. They wish to become part of a 'Conservation Cluster' and to be a model for the people in the Chiriquí province. A Conservation Cluster is a group of region-wide leaders, institutions, and enterprises committed to the development of environmentally responsible choices. Being part of this type of group could be accomplished once a research station is constructed on Coiba Island and is connected to Batipa along with the Smithsonian "Casa Verde" facility at Fortuna. This allows Batipa to further spread their goal of environmental conservation (Mullen, n.d.).

The missions of Batipa include establishing an initiative focusing on the conservation and restoration of biodiversity within Chiriquí forests and improving the accessibility of sustainable

living to lower income, rural communities, along with the development of intercultural scientific exchange. They also look to increase their influence in the scientific community by attracting students, professors, and researchers with experienced academic talent. The goal is to spread the value of their indigenous species and endemic resources to the surrounding communities as well as to the rest of Panamá and abroad (Batipa Field Institute [BFI], n.d.).

2.3 Environmental Research Stations

Batipa plans to build a small and sustainable, environmentally low-impact research station in the Cabimos area of the peninsula using solar energy as the power source. Using the model of the Smithsonian research station at Bocas del Toro, Batipa can implement sensors and systems used at other tropical research stations. Once the Batipa station is established, researchers could take regular measurements of the characteristics of the marine and forest ecosystem such as "weekly and daily measurements of rainfall" (Collin, 2005) as well as air and sea temperature measurements at regular intervals.

Figure 1: Rendering of upgraded cabimos proposed last year

Researchers can measure the height of the tides and the growth rate of mangroves as well as conduct experiments to test the health of the rainforest such as measuring the organic content of the soil, the growth rate of trees, and the number of known species. Other possible things to measure to determine the health of the area would be the pH of the soil and rainwater. These measurements can be done using automated sensors, like the Bocas del Toro station, or through human measurements and record-keeping. Cataloging fauna, flora, and the climate is important for long-term studies of the environment because this data can be used as a baseline for researchers in the future who are faced with problems such as climate change, deforestation, and the extinction of species. In order to recognize these problems in the first-place, scientists would need to compare present day data to the baseline data.

Research stations can prevail as centers of knowledge for not only the scientists and staff, but also visitors locally and from afar (Organization of Biological Field Stations [OBFS], Research, n.d.). Research stations can be the first place a student goes where they are able to apply what they have learned and get firsthand experience from real world problems. Students and tourists could feel more connected to their environment and gain a new perspective on the world around them (OBFS, Education, n.d.). After completing a visit to Batipa, it is hopeful that participants would spread the influence of Batipa to the areas they return to. Batipa would like to become a model for cattle and tree farmers in the Chiriquí province and in the Gualacan Corridor. They would like to share with locals their version of how to farm smarter using technology and science. With the completion of the research station Batipa would be one step closer to establishing themselves as a reliable field institute.

With the creation of a research station it may be possible to connect with other research stations in the western part of the country. This would lead to the establishment of a scientific community, focused on the sustainability and health of western Panamá. A network of research centers allows for the easy exchange of scientific studies and could lead to collaborations on the area. The station would help Batipa build a reputation as a scientific institute and obtain a larger public presence.

2.4 Ecotourism

When thinking of what ecotourism is, one might think that it solely involves travelling to a remote location and exploring the natural landscape. As nature.org states, ecotourism is more than just a nature walk, in fact, "Most tourism in natural areas today is not ecotourism and is not, therefore, sustainable. Ecotourism is distinguished by its emphasis on conservation, education, traveler responsibility and active community participation" (Eco-trips 6, 2018). This means that there is a very small amount of human disturbance that occurs in these ecotourism locations. This cannot be done simply by designating a trail and placing signs that tell hikers not to litter. The process involves management of the area to promote minimal human impact to keep the area as natural as possible so that tourists can experience untouched areas of the world while at the same time to encourage the public to step up and support these conservation measures.

Figures 2 & 3: Tourist enjoying Panamá's natural beauty

The Batipa farm and ranch already brings this to students through their experiential learning program. The program is open to students pursuing a career in sustainability. They attend Batipa and use the scientific knowledge they gain while there to actively apply it to the further growth and development of the institute. These projects are carried out "year-round, on the ground" and provide a unique opportunity to contribute one's skillset to make a difference and participate in real life conservation efforts (BFI, n.d.). With this, along with their growing ecotourism reputation, Batipa will be a key location to experience a genuine look at nature while contributing to conservation efforts.

2.5 Academic Tourism

Academic tourism, or studying abroad as a student, means more than travelling to another country. It is about immersing oneself into a new culture, climate, or language to broaden one's understandings of the world. Alternatively, academic tourism is a big source of revenue to these countries and organizations, especially during times of the year that are unpopular for recreational tourism. Academic tourists pay for room, board, and course registration fees at universities but also stimulate the economy like a recreational tourist would through weekend activities and other extracurricular events. A study done in 2008 showed that the average expenditure per academic tourist was 3,608 euros. With a total of 3,212 students going through their program that year, the total economic impact was 11,589,000 euros only through this one study that involved three universities (Rodriguez, Martínez-Roget, & Pawlowska 4, 2013). Batipa does not need this level of success to stimulate its growth and progress upon its visions. If Batipa achieves only 10% of what the study achieved, 320 students and 1.15 million dollars, the

additional publicity and revenue would satisfy the goals of Oteima and allow for Batipa to grow significantly. Unlike conventional tourists, academic tourists stay for a greater span of time. A study done in 2008 compared the impacts of conventional tourism to academic tourism. Topics of analysis included the number of visitors, expenditure per visitor, and average stay in days. The study showed that academic tourists stay 1800% longer than recreational tourists and account for 6.2% of the total number of tourists. From this it was concluded that one academic tourist is equivalent to 18 conventional tourists (Rodriguez 5, 2013) showing that academic tourism has the potential to be more profitable per person.

With more and more students choosing to study abroad, it is important to create a program that is attractive to universities and students to secure a consistent enrollment each year. Ideally, the program should provide things college students find attractive in a study abroad program. Examples of this include offering classes that provide college credits, designing trips or activities that provide the student with an immersive feeling into the culture, and offering a unique experience exclusive to the study abroad location.

2.6 Reforestation

Batipa follows the guidelines set by the Forest Stewardship Council (FSC). The FSC is an internationally recognized group that sets sustainable lumber practices regarding growing, cutting, selling, and buying. The goal of the FCS is, "[to] promote environmentally appropriate, socially beneficial, and economically viable management of the world's forests" (Forest Stewardship Council [FCS], What, n.d.). The FCS aims to create sustainable foresting using reliable methods. The FCS evaluates all aspects of the foresting industry and establishes regulations to protect all persons involved including farmers, workers, buyers, and sellers.

To earn a FCS certification, the plantation must adhere to the following 10 principles. These principles define methods for the overall organization meaning the plantation and everyone and everything in it.

1. The Organization shall comply with all applicable laws, regulations and nationally-ratified international treaties, conventions and agreements.
2. The Organization shall maintain or enhance the social and economic wellbeing of workers.

3. The Organization shall identify and uphold Indigenous Peoples' legal and customary rights of ownership, use and management of land, territories and resources affected by management activities.

4. The Organization shall contribute to maintaining or enhancing the social and economic wellbeing of local communities.

5. The Organization shall efficiently manage the range of multiple products and services of the Management Unit to maintain or enhance long term economic viability and the range of environmental and social benefits.

6. The Organization shall maintain, conserve and/or restore ecosystem services and environmental values of the Management Unit, and shall avoid, repair or mitigate negative environmental impacts.

7. The Organization shall have a management plan consistent with its policies and objectives and proportionate to scale, intensity and risks of its management activities. The management plan shall be implemented and kept up to date based on monitoring information in order to promote adaptive management. The associated planning and procedural documentation shall be sufficient to guide staff, inform affected stakeholders and interested stakeholders and to justify management decisions.

8. The Organization shall demonstrate that, progress towards achieving the management objectives, the impacts of management activities and the condition of the Management Unit, are monitored and evaluated proportionate to the scale, intensity and risk of management activities, in order to implement adaptive management.

9. The Organization shall maintain and/or enhance the High Conservation Values in the Management Unit through applying the precautionary approach.

10. Management activities conducted by or for The Organization for the Management Unit shall be selected and implemented consistent with The Organization's economic, environmental and social policies and objectives and in compliance with the Principles and Criteria collectively.

After the owner shows compliance with the 10 principles (FCS, the 10, n.d.) they can apply for three different certifications: Forest Management covers sustainable forestry practices, Chain of Custody follows the lumber from seed to consumer, and FCS Controlled Wood encompasses

non-certified practices that are still allowed by other credentials. In the Forest Management certification, there are several criteria under 'restoration actions' that are notable:

I. Rare and threatened species and habitats

II. Water bodies and riparian zones

III. Landscape connectivity, including wildlife corridors

IV. Declared ecosystem services

V. Representative sample areas (of environmental values in their natural conditions)

VI. High conservation values

These six items are present at Batipa. With diverse landscapes filled with plants, animals, and water. Part of Batipa's goal is to maintain wildlife corridors, while having adequate space for teak and cattle (FCS, Forest, n.d.).

2.7 Biological Corridors

In 1997, several nations of Central America created the Mesoamerican Biological Corridor. Together, the nations of Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panamá, and Mexico sought to preserve and protect the plants and animals through low-impact development. The Central American Commission for Environment and Development describes a biological corridor as "a geographically defined area which provides connectivity between landscapes, ecosystems and habitats, natural or modified, and ensures the maintenance of biodiversity and ecological and evolutionary processes" (What, n.d.).
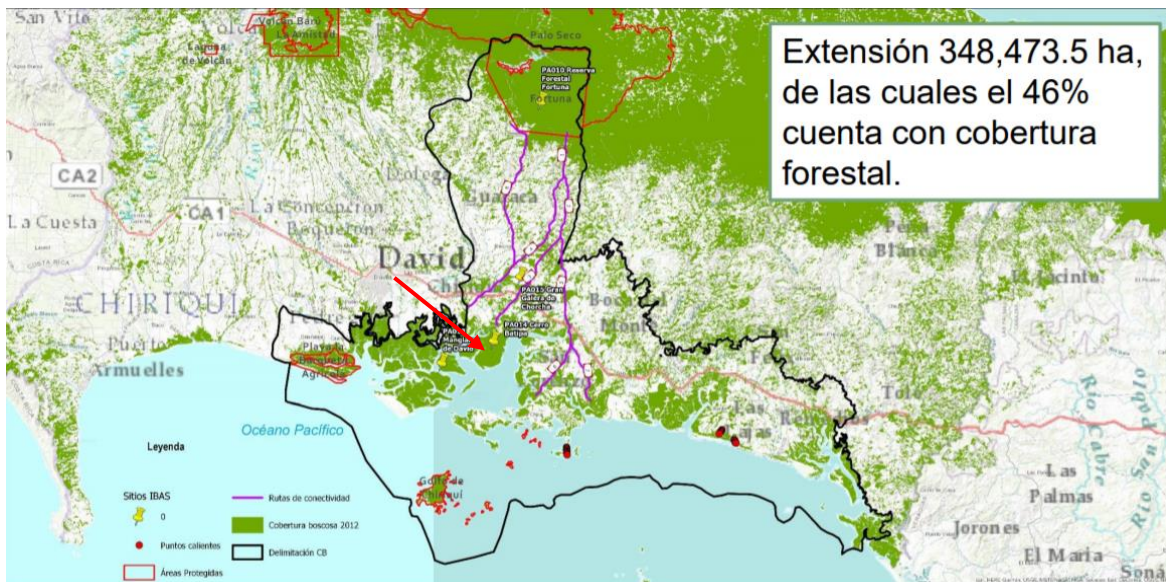
Figure 4: Altitudinal Biological Corridor of Gualaca

Oteima University has worked to create the Gualacan Corridor. The corridor occupies roughly 350,000 hectares of mangroves, grasslands, mountains, and forest from the Bahias de los Muertos in the Pacific to the mountains of Fortuna. Batipa sits on 4,000 hectares of land at the bottom of the corridor (see red arrow on map above). The goal of the corridor is to create a safe-zone for animals to move, without obstruction, from the Pacific Ocean to the Atlantic Ocean.

Establishing why biological corridors are important to an ecosystem can be done by analyzing the response of a species to a change in its habitat. The genetic diversity of a species is important to a species' long-term survival because it allows members to have genetic advantages over a changing environment. A study "on genetic diversity and gene flow of fruit bats in Costa Rica" (Griffin, 2017) was conducted to find to what degree the increase in farming and deforestation in the area had on the bats. This study was conducted in the same climate that Batipa is located in so it is possible the study's conclusions may be directly applicable to Batipa. Researchers found through the study that the establishment of a corridor was "largely successful in maintaining genetic diversity and functional connectivity" for the bats (Griffin, 2017). In the areas of study, there was a direct correlation between the expansion of farms and a decrease in genetic diversity among the bats and thus the possibilities of their ability to adapt and survive. At Batipa, all animals have the daunting challenge of crossing the Pan-American Highway. The highway creates a break in the forest so the animals cannot use the safety of the vegetation to get across. Because both the bats and native animals, such as monkeys, sloths, and ground dwelling animals, lack the ability to move freely from one region of the forest to the other it is possible that in both cases their ability to survive decreases and therefore it is important to make sure all aspects of the forests are connected. The same can be said for farming and forestry outside of Batipa. With limited forest connectivity due to the increase of grasslands, many animals refuse to walk through open fields and are limited to smaller areas of the forest, hence the lack of animal movement in the grasslands and connectedness in the corridor.

2.8 Wildlife Crossings

With the creation and expansion of major roads and highways, the number of roadkill incidents has increased. To deal with this increase, dedicated wildlife crossings have sprung up across the world with the most famous of these being located in Europe and Canada (US, n.d.). A wildlife crossing is any structure that aids animals in crossing a man-made obstacle. Examples of animal crossings include bridges, tunnels, and fish ladders. In North America, there is a company

called Animal Road Crossings Solutions (ARC). They began as an engineering design competition. The challenge was to design an economically plausible solution for large animals, like deer and moose, to safely cross a stretch of highway (Animal Road Crossings [ARC], 2018). Since then, the company has become an advocate for education and providing solutions for animal crossings around the world.

In an insurance study conducted in Montana in 2016, three important facts were discovered: Montana ranked number two in America for animal collisions, there were 211 human fatalities in 2016, and about one billion dollars in annual property damage was caused (US, n.d.). Animal road crossings pose obvious benefits. With animals using these structures, frequency of road incidents are dramatically reduced. In the remote wilderness of Alberta and British Columbia, Canada, several underpasses and overpasses have been installed in the Banff National Park so animals can cross the Trans-Canada Highway. These structures have been used almost 185,000 times by bear, deer, elk, weasels, skunks, and many others (Clevenger, Ford, & Sawaya. 2009) proving their usefulness and benefits in a real-world scenario.

3.0 Methodology

The main objective of this project was to present our sponsor, Oteima University, with recommendations about the following four areas: Teak by-product, Altitudinal Biological Corridor of Gualaca (Corredor Biologico Altitudinal de Gualaca), sharing techniques with local farmers, and finding new academic and ecotourism initiatives. Oteima wishes to use their crown-jewel, Batipa, as an example of how to apply sustainable foresting practices. We spent ten days living in David, roughly 450 kilometers west of Panama City. During our stay, we made multiple trips to Batipa in the Chiriquí province. The remainder of our time was spent at Oteima University analyzing our findings and communicating directly with our sponsor.

We researched other facilities like Batipa to see how they conduct themselves and if their methods can be applied to Batipa. A common practice we found was to promote plant diversity using nurseries as well as conserve water while reducing erosion. Being in constant contact with our sponsor made certain that we were on the same page and ensured that our solutions met their needs. The project followed three objectives as followed:

3.1 Objective One: Strategic Planning and Prioritization of Needs

Our sponsorship on this project included Oteima University, the company that oversees the development of Batipa. By communicating with all parties involved, both at the university as well as on-site, we were able to get an understanding of what exactly our sponsor wanted and what projects were more important than others in terms of depth of solutions. With these plans, we were able to ask comprehensive questions to make certain that we were clear as to what was wanted by workers as well as the administration. With this mutual understanding of the projects, it was assured that whatever research and conclusions we made were relevant to the problems at hand. Through multiple meetings and introductions, each person gave us new project ideas. In total, 13 project ideas were initially put before us. After analyzing all projects using the 'double diamond' method mentioned in Appendix B, we saw an overlap of three main ideas; economy, education, and ecology. With the narrowing of the projects at hand, instead of attempting to do too many projects at once, we can focus on the three main projects that encompass multiple others. The first main focal point, economy, was chosen because in order for Batipa to grow as an organization and a business whose focus is on agricultural sustainability. They require capital

to implement projects and programs that promote environmentally conscious decisions to maintain their ecological self-sufficiency. The second main idea, education, was selected due to the importance Oteima places on education. The university is determined to develop Batipa into an educational hub, spreading the mission and influence of Oteima. Ecology was the third and most important main idea due to its ability to connect all of the projects presented to us to one another, tying in economy, education, and the environment.
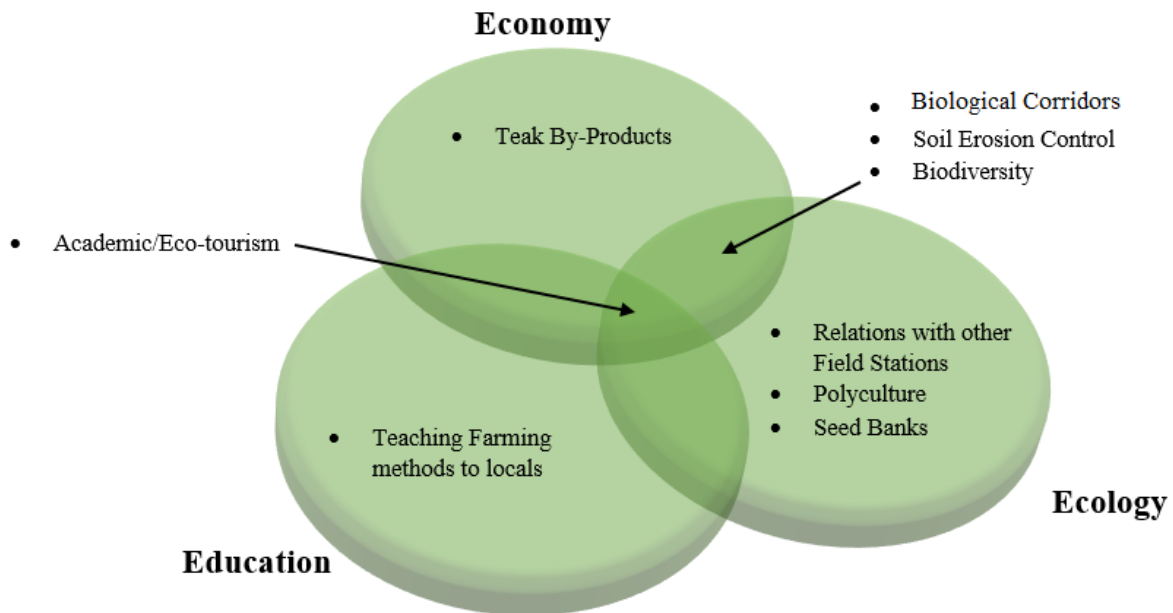
Figure 5: Venn Diagram of three main topics

3.2 Objective Two: Resource Evaluation

Once we determined the project objectives we can begin looking at the resources available to turn these goals into a reality. By remaining cognizant of the resources available we can ensure we make realistic and well guided suggestions that can be implemented. This required multiple trips on-site to Batipa, the recording of specific characteristic of the soil, plantations, headquarters, and corridors. Since these proposals had to compliment the already existing layout of the research center, we had to make certain that the solutions were feasible and could be implemented on-site. The first step once getting on-site was to get a full understanding as to what Batipa looks like and how it operates.
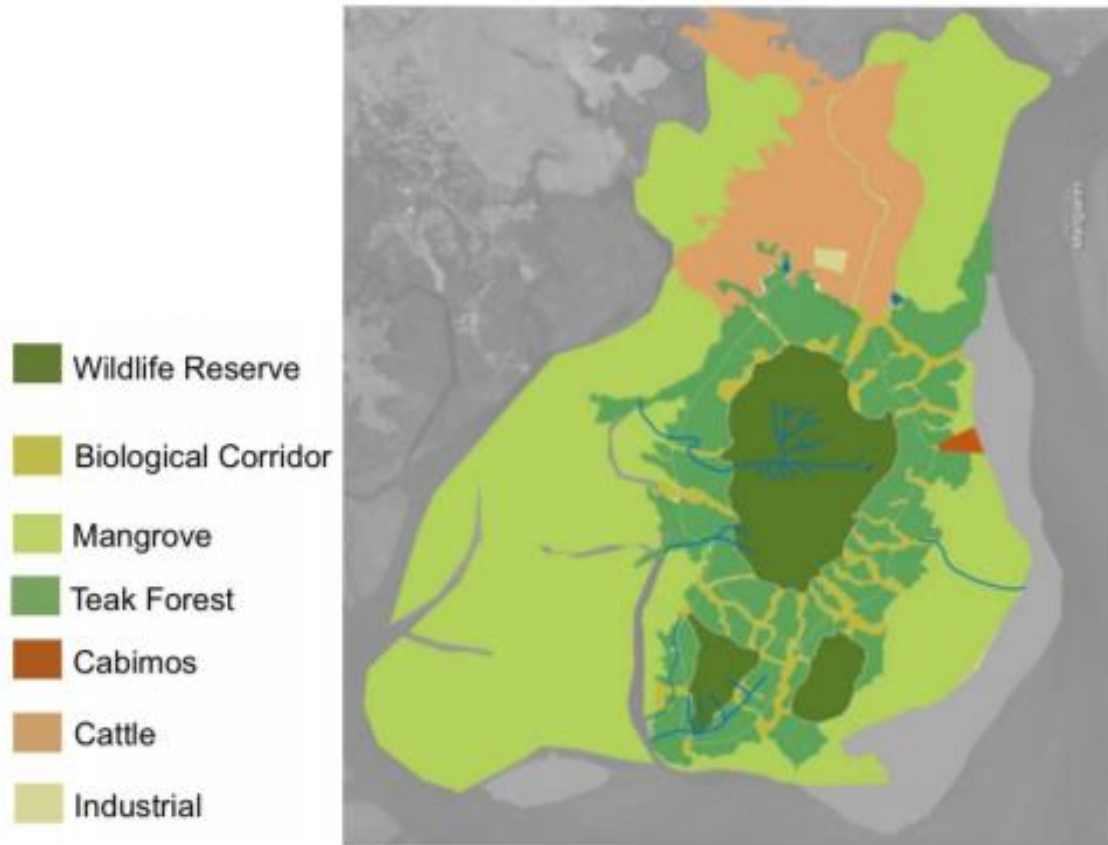
Figure 6: Map displaying land use of Batipa Peninsula (Palacios, 2017)

Evaluation of the current practices at Batipa allowed us to address the issues that were presented to us. Regarding teak by-products, it was key that we evaluated the growth rate of the trees, the frequency of cutting and planting trees, and the total number of trees and waste produced. We also analyzed the cutting methods performed at Batipa and how well maintained the zones were kept. The main corridor of the region is the Altitudinal Biological Corridor of Gualaca. The Corridor is important to evaluate because it provides animals safe routes to move along the different areas. Various maps were analyzed to investigate the areas where Batipa promotes this animal movement. The land in these areas is diverse and connects different ecosystems. However, there were some limitations to the animals' movement due to a lack of connectivity in some areas of the Corridor due to the expansion of the Pan-American Highway. Lastly for education, we evaluated the locations where Batipa could develop a learning center. We also took into consideration the resources available for the learning center and analyzed what would be the most applicable teaching material and the most effective teaching methods.

3.3 Objective Three: Finding Possibilities

Once the scope of our project was refined, along with the evaluation of on-site needs and wants, we were able to construct possibilities for Batipa to consider in the future improvement of the site and biological corridor. Giving multiple timelines and budgets were crucial in making sure our sponsor had options to choose from and knew what was necessary for the immediate solving of the problems and what could be added to improve the quality or magnitude of the solution or proposal.

3.3.1 Analyzing Teak By-Products

Our initial concerns were when and how often the trees were trimmed or cut. With this knowledge, we could estimate how much material we potentially could be working with. We started our research with local reforestation. Two main sources of information came from Mr. John Rolfson, Reservation Director and Ranger at Griswold Scout Reservation, and Mr. Ronald Klemarczyk, Forester for Daniel Webster Council and a New Hampshire certified Forester. Armed with general practices and principles with deciduous forests, we began to see what can be applied to the tropical climate of Panamá.

Mr. Rolfson shared some insight about the milling process. Many places struggle to find uses for cut off slabs. He said many mills chip or burn the excess. He also commented about on-site milling, logging men are different than saw-millers for a reason. He explained the extra work is more strain on the workers and that the introduction of milling equipment and by-products could be damaging to the trees.

Mr. Klemarczyk was concerned about tree and soil health. He explained that trimming the tree and leaving the brush would boost the organic matter in the soil. Evidence of this would be darker color, a richer smell, and a coarser soil. Teak thrives best in calcium rich soil, so undergrowth or fertilizers should enrich the soil with calcium. He also stated that cut teak is resistant to water, insects, weather, and fungus, hence its high desirability. With that in mind, he also shared cut teak has a long shelf life, so it can be stored with little protection until sale.

Both men are businessmen, so they made a point about operating on a budget and sticking to it. We plan to see how Batipa spends their reforestation money and look for improvements, be it change in materials, upgrades in equipment, or change in policy (Klemarczyk & Rolfson, 2018).

3.3.2 Expanding the Altitudinal Biological Corridor of Gualaca

Panamá is an interesting country when it comes to biodiversity. This thin and long country gets both Atlantic and Pacific biological influences, creating many different ecosystems with a wide range of flora and fauna in each. This area is classified as a biological corridor, which is a stretch of land to which animals travel across to get from one region to another, sort of like a highway. Batipa is part of the Altitudinal Biological Corridor of Gualaca, which spans from the Pacific coast up to the mountainous region of Fortuna. This corridor connects to the larger Mesoamerican Corridor that spans across most of the northern part of Panamá into Costa Rica.

There are two problems currently; the cutoff of Batipa from the rest of the corridor due to the construction of the Pan-American Highway, as well as soil erosion that is devastating grazing pastures throughout the region. We investigated possible solutions of reconnecting the Batipa peninsula and mangrove regions to the rest of the corridor by creating animal crossings traversing the four-lane highway. "Monkey bridges" are currently installed, but there are no vines or natural foliage present. We looked at methods to speed up the process of vine production on these bridges as well as the installation of a bridge or tunnel across the highway for larger non-climbing animals such as deer or coati. Modifications to current bridges may be made as well.

Figures 7 & 8: Pan-American Highway bridge spanning a creek

We investigated methods for controlling soil erosion both in Batipa as well as in the surrounding regions of the corridor. This involved looking at methods used in other regions as well as pioneer species seen growing on these erosion banks currently. We came up with the idea of creating a nursery of native species where tree saplings can be introduced to these barren patches of land to start the restoration process.

3.3.3 Establishing Ways of Sharing Techniques with Local Farmers

Part of Batipa's vision includes the spreading of knowledge obtained at Batipa to local farmers. This includes the sharing of sustainable and environmentally conscious methods of farming. Batipa strives to be a center of knowledge in the Chiriquí province for proper agricultural practices. The two main sectors that Batipa would like to share knowledge on are the benefits of wildlife corridors have on cattle and farming, along with how to prevent and fix erosion from improper farming. Analyzing Oteima and Batipa's available combined on-site resources, we plan to develop a handbook or hands-on method of teaching for local farmers. This handbook would focus on how to use technology to their advantage to increase their profits and better the economy of the area, along with decreasing their negative impact on the environment. While choosing demonstration methods for local farmers, we considered the simplest and clearest ways of relaying information from the university or field institute to the farmers. Easy methods to exchange information include concise handbooks or online classes. Other methods include lectures for the farmers at Oteima University that go through the proper practices and methods. Instructors can take the farmers on a tour of Batipa's operation and/or go to the farms of those attending for case studies and specific solutions or recommendations for how the farmer should use their land.

3.3.4 Attracting Outside Academic Tourism Sources

One of Batipa's main challenges is spreading information about the beauty and educational benefits of the peninsula. They wish to share this beautiful place with both domestic and foreign universities. As Oteima's director, Mrs. Nixa del Ríos said, "We have a pearl, but no way for us to show that pearl". This was a challenge because there were no real methods of spreading information about Batipa and its many qualities as both a successful ecological plantation and educational area.

Figure 9: Academic tourist learning about cattle farming at Batipa

With no methods presently being used, this made us think what is necessary for Batipa to look more attractive to academic tourists. Using our experience in researching the field institute before coming here as our example, this led us to look into methods of spreading information about Batipa such as an increase in social media presence, improving their current website or creating a more advanced website, and looking into how universities choose locations to send students to for going abroad and helping Oteima with finding these opportunities and offering their curriculum via Batipa.

3.3.5 Attracting Ecotourism

Another one of Batipa's goals is to establish an ecotourism initiative to attract environmentally conscious visitors who seek to learn more about Batipa. Small packages could be offered for non-academic persons to stay in Batipa and experience the Panamanian countryside. This has never been done at Batipa before and is a new project with a lower priority than other projects of interest at Batipa.

Figure 10: Ecotourist drinking spring water from leaf

To help Oteima and Batipa with thinking about bringing ecotourists around, we analyzed the differences between an academic tourist and an ecotourist, investigated and presented plausible and attractive activities they could offer to ecotourists, and how to alter their existing academic tourism program to fit the needs of traditional recreational tourism.

4.0 Initial Findings

To best collect our data, we took different trips to Oteima University and Batipa to investigate specific issues. As questions were answered, and new ones arose, our sponsor suggested new people to interview and new areas to investigate. With only 10 days to view as much as possible, we tried to limit our topics of discussion and incorporate as many small ideas into a few large topics. For example, soil erosion and methods of prevention and regeneration for areas of erosion, we unearthed information relevant to general teak farming and regenerating the biological corridor.

4.1 Problem One: Teak By-Products

To provide solutions to current problems within the teak plantation at Batipa, we spent multiple days on-site looking at the current operation and interviewed loggers and employees on what they were doing. We explored the organization of this new method of squaring off lumber and calculated how much time and labor is involved as well as the scrap wood that was generated.

The first day on-site we spent time at the milling site, inspected the area, collected data, and asked questions to the loggers. The first set of data we collected was the time it took for one piece to be completely milled. This was repeated multiple times to create an average.

Piece	Time to fully mill	Time to reload mill
1	2:50	2:00
2	3:35	2:00
3	3:01	2:00
Blade Change	3:00	0:00

Average mill time	3:09
TOTAL TIME	18:26

From this data it can be shown that during a typical 8-hour day, at this pace, a total of 78 pieces can be produced. While on site, we counted how many squared off timbers were present and asked how long it took. There were 150 pieces and it took two days, meaning an average of 75 pieces a day which agrees with our mathematical estimate. To properly mill each piece, five cuts were made, four to remove the bark and square the tree off, and the fifth to correct the first cut to match the other three sides as shown in the figure below.

Figure 11: Five step milling process from log to squared off lumber

From this data we can assume with an average of 75 pieces per day, a total of 375 scrap pieces are created. Three hundred of those would be the slabs with the bark on it and 75 would be the skinny shims created by the last cut. The dimensions of these squared off pieces varies from tree to tree to create the least amount of waste. An example is one log milled had a 9-inch diameter on one end and a 7-inch diameter on the other. After cutting the dimensions were 5⅛" x 4¼". Despite the effort, there is about a 10-30% loss of diameter and nearly 50% loss of volume during the milling process.

Teak is an oily hardwood, and when milling freshly cut green wood which has not had time for all the water and oils to dry, it is difficult to cut through and dulls the band saws blades faster than other woods. In this case, the blade must be changed roughly every three or four pieces. If the blade is kept on too long, it will catch onto the wood causing it to either bend and render unusable or break.

Figure 12: Band saw blade cracked from overuse

After milling, the squared off lumber is brought to a shed to dry and the scrap is left in piles on the side of the road to rot. Currently, nothing is being done with both the lumber or the scrap slabs. We saw this as a problem from the beginning, and everyone we talked to saw it as a problem too. From this, we can find methods to deal with either the selling of both or the possibility of chipping the excess to sell so that it is not just rotting away.

To get the desired look and length of viable lumber, there is a certain protocol to be followed in the growing and harvesting of these trees. The teak clone starts off-site where it is kept until a sapling. Then it is brought on-site to the freshly cut 50-hectare section of the plantation where it is planted in the rainy season. Throughout the first six years of the tree's life, its branches are constantly trimmed off using a pole saw to ensure pristine wood (without knots). These pole saws extend to seven meters, which is the maximum height of trimming. From then on, the tree grows on its own. Starting at age eight, and repeated at age 12, the zones are scanned through and all leaning or unhealthy trees are logged in order for healthy, straight trees to continue to grow without interference.

After 20-22 years, the trees are ready to be logged. This begins in January during the dry season. The cutting of the mature teak trees ideally takes 1½ months, but due to waiting on shipping containers, it takes closer to two or three months. Here workers go through the 50-hectare section and cut down and de-limb all trees by hand, via chainsaw. These felled trees are then moved toward the road using a skid-steer where they will be classified by size. The piles will be placed in either "large" logs or "small" logs. Large logs are classified as straight whole logs with a minimum diameter of 60 cm and a minimum length of 4.5 meters, with the average

length per container being six meters. Small containers are classified as straight logs with a minimum diameter of 60 cm and a length between 2.3 and 4.5 meters with an average length of three meters. A typical harvest contains about a 65% to 35% difference between large and small containers. Any lumber that does not fall within those specifications is put into a brush pile in the zone.

The problems we saw in this process included the stopping of limb cutting at seven meters and the way excess brush is dealt with. With improved methods on cutting older trees above seven meters and the spreading and dispersing of brush piles will cause both a more profitable harvest and more ecologically friendly use of land.

4.2 Problem Two: Altitudinal Biological Corridor of Gualaca

To better understand how the corridor behaves, we were granted a tour by our sponsor. We were driven from David to Fortuna using the Pan-American Highway and other major highways. During this trip, we were able to see what ecosystems were in the corridor and how the major highways affect the wildlife.

To the south by the ocean, the area is dominated by mangroves. Mangroves are a dense network of trees that sit above the rising tides. There is a massive amount of flora and fauna that inhabit the mangroves. From the ocean to the foothills, this area is mostly grasslands. In this area, there are grazing pastures as far as the eye can see. There are small sections of natural vegetation, however most of it has been cleared for farming and grazing. Farmers take advantage of the gentle slope for cattle and horses. The area here is greatly affected by the wet and dry seasons. As the hills turn into mountains, the natural vegetation has a greater presence. The natural rainforests of this area display the beauty of the land. With cooler temperatures, abundant rains, and steep slopes unsuitable for grazing, life explodes up here. During the dry season, the land is more resilient to the heat.

In the grasslands, the land is shallow enough that major erosion is limited. The erosion is mostly from animals treading the vegetation, stripping it away. In the mountains, the land becomes too steep for agricultural purposes. Land that has been cleared shows various signs of soil erosion: from light grass and small amounts of exposed soil to steep declines of barren, rocky soil with zero vegetation. In some steep areas, people have planted pine trees. Our guide stated as an exotic species, pine has a high market value here and it can grow in harsh conditions.

He also explained it is planted with more native species, like small shrubs and grasses (Gonzalez, 2018).

As we were driving in the mountains, we also came across a landslide. A section of cliff about three feet wide and 50 feet high. The land gave away and mud and rocks poured onto the road, damaging the asphalt. On the opposite side, fissures opened in the road because there was no earth underneath it, plants were carried away with the water, and the gutter was full of soil and plant material. The road was still passable, but it was reduced to one-lane. We still had to drive over it slowly because the bumps and rocks in the road.

On all the roads, our guide identified specific man-made structures that positively and negatively impacted the land and animals. Near the top of the mountain, we stopped at *Bella Vista Del Mundo*, which means "most beautiful view of the world".
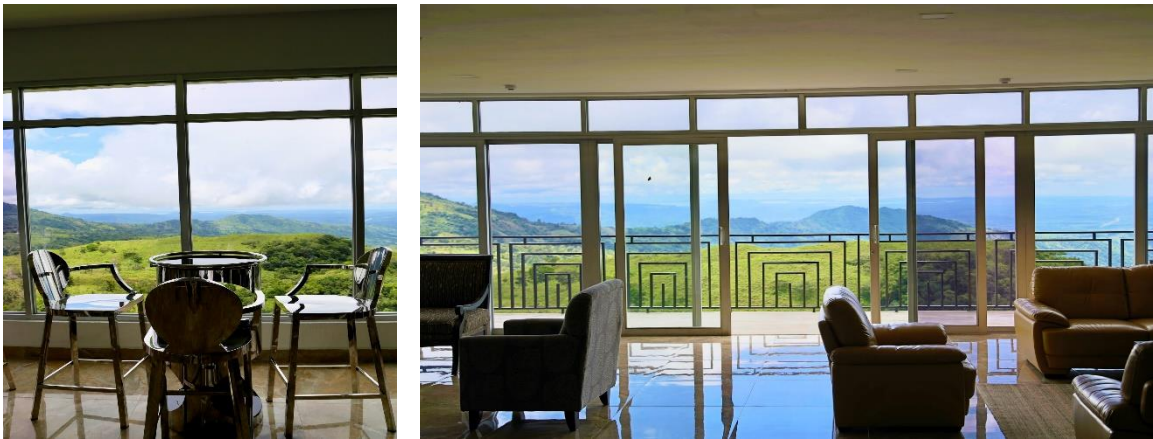
Figures 13 & 14: Views of the Corridor from hotel windows

It is a brand-new hotel and they offer nature tours and scenic views of the Altitudinal Biological Corridor of Gualaca. At the top of the mountain, we saw the *Represa de Embalse Fortuna*. It translates to the Fort Dam Reservoir. It supplies hydroelectric power for the region and creates the *Río Brazo de Hornito*, or the Littlehorn River. As important as the dam is, its presence disqualifies the area for national law protection. It is up to the private landowners to protect the environment. The most extensive obstruction we encountered was the Pan-American Highway. They recently completed an expansion of the highway. It is now two-lanes in either direction with Jersey barriers and turnaround points every few miles. The expansion has created some issues. The Jersey barriers prevent animals from crossing the road, so roadkill incidents have increased. To combat this, Batipa has installed six monkey bridges, a suspended wire bridge about two feet wide.

Figure 15: 1 of 6 monkey bridges spanning the Pan-American Highway

Because the bridges are new, and vegetation free, monkeys are intimidated to use them. Our sponsor also informed us that drainage tunnels are being used by medium and large ground animals (Gonzalez, 2018).

In our initial discussions and observations, some base suggestions were made. To combat soil erosion and regenerate the natural vegetation, a tree sapling program was conceived. The program would include some education of soil erosion, ways to prevent it, and ways to fix it. After that, tree saplings and shrubs could be given to the farmer to plant and rebuild the soil. This would solve two problems, soil erosion and restoration of the Corridor. Additionally, our sponsor talked about seed dropping schemes in other parts of the world. Native and exotic seeds are coated with fertilizers, plant food, and germination chemicals and then cast into the soil. The seeds then grow various plants to rebuild the soil. These seeds can be trees or fruit bearing shrubs to attract wildlife.

4.3 Problem Three: Spreading of Knowledge and Techniques

To understand considerations for teaching local farmers sustainable farming methods, we needed to experience their farms first hand so we could evaluate the health of their land and visualize what could be improved on their farms. In our short time at Batipa we learned about Batipa's farming methods and how and why they can be used as a model for sustainable

agriculture. Additionally, we learned what methods of farming should be conducted and what methods of farming should be avoided.

Traveling to Fortuna from David allowed us to analyze the local farms in the corridor and discuss if there were ways they could be improved. Regarding cattle ranching we saw two main types of land: grassland and steep slopes. With grasslands it was brought up that certain types of grass are better than others for different things. One type of grass can be good for gripping soil, but lack vital nutrients while another type of grass can be more nutritious while not being as sturdy in the soil. It was also brought up that farmers should evaluate the nutritional value of their land and choose the correct breed of cattle. Farms with more nutritious grass can sustain larger breeds of cattle while farms with less nutritious grass can support smaller cattle breeds, so the land's health is not threatened. To prevent the land from being exhausted it is important to rotate cattle from pasture to pasture frequently, giving the grass time to grow and the dirt time to recuperate. For steep sloped land, organic matter in the topsoil is crucial to the health of the land. We learned that exposed, red dirt was a direct result of erosion due to a lack of vegetative cover on the topsoil. The exposed dirt can lead to further erosion downhill and has a greater potential to become a landslide. We learned that to combat the erosion of these steep slopes farmers can plant 'pioneer' plants that can create a root system for other plants to develop and grow from. Pioneer plants include pine trees, construction seed, and fertilizer coated grass seeds.

Oteima would like to spread information to local farmers so they can empower others to what is best for the land. A student at Oteima University, Jason Navarro suggested different types of teaching methods (Navarro, 2018). Combining traditional and modern techniques, a few ways to spread the information from Oteima and Batipa to farmers include:

- Making a short handbook with basic information
    - Possibly go from farm to farm handing out and teaching using the handbook.
- Using a Twitter page with tweets for short information and providing links for more in-depth information
    - Other social media sites such as Facebook
- Offering classes at Oteima for the farmers
- Providing tours of Batipa to the farmers
- Visiting farms and directly consulting with the farmers

It was important to note how Batipa chooses to farm in certain areas and not to farm in others. The locations of the teak plots were chosen so that a significant amount of rainforest was reserved for wildlife, as well as providing a natural path for wildlife to travel from one section of the biological corridor to another section. This is another farming practice that other farmers can learn from.

4.4 Possible Academic and Ecotourism Initiatives

Currently, Oteima and Batipa are partnered with other universities for study abroad programs. These universities include Worcester Polytechnic Institute, Nebraska University, and Tulsa University. There were courses offered at Batipa, but that initiative was terminated in 2015. There were no other efforts made to get other universities both in Panamá and the United States to bring students to Batipa.

As for on-site infrastructure dedicated to academic tourism, there is only a small cabin with a small gazebo, attached via a breezeway. There were plans for a lecture hall and dormitories to be installed, but currently there was just the one building with no electricity or Wi-Fi available. As for cell service, most local companies got between one to three bars of service, enough to make calls, send texts, and use data for apps.

To understand what activities and services that could be offered to potential recreational ecotourism groups, we spent our weekend on-site going around the Batipa Peninsula and close by areas. We found that there was a lot to offer already including fishing, kayaking, and horseback riding. As for sleeping quarters, the current structure was a thatched roof that needed to be replaced every two years. Batipa was in the middle of replacing it during our stay so the ceiling was heavily tarped. The breezeway of the structure was leaning heavily to one side, but not at a dangerous angle. As for food, meals were cooked on-site using a separate pavilion with a small wood fire stove and grills made of bricks and clay. The electricity source was a diesel generator that powered either the lights or a small power strip.

5.0 Analysis and Recommendations

This section details solutions to combat specific issues presented by our sponsors in the following sectors: By-products that come from the various stages of Teak farming, the growing problems within the Altitudinal Biological Corridor of Gualaca, and the spreading of knowledge to create a formal agricultural education. These three main categories link varying issues together and provide a greater overall picture to the initiatives of Oteima University and the practices of Batipa.

5.1 Teak By-Products

One challenge Batipa is currently facing is what to do with the by-products produced by teak milling and harvesting. With the loss of a buyer for the trimmed eight-year-old trees, Batipa is trying to find new methods to sell these logs. In addition to massive brush piles, there are piles of scrap slabs along the side of the road simply rotting away. Through further analysis of the problems the teak plantation within Batipa is facing, the following suggestions were created.

When growing trees for lumber, pruning is an important step in creating the highest grade, knot free lumber for sale. The current strategy implemented at Batipa is the use of pole saws to trim branches of young trees. Due to the limitations of the pole saws, trimming can only be done up to seven meters. This limits the amount of high grade lumber that the tree could produce because without pruning, branches could die on the tree, provoking knots. We looked at this problem and thought of a few ways it could be dealt with. The first idea was the use of a "cherry picker." This option was not a feasible because of the extreme slope in some zones of the plantation and it would require a road in the middle of each row of trees, destroying the opportunity for natural foliage to reclaim the forest floor. The second option we considered was a scissor lift. This machine's wheelbase is narrower than that of a cherry picker truck. This would lead to less disturbance of the natural reclamation in older zones, but yet again the machine would not be able to deal with the extreme slope present in some zones. The third and most environmentally friendly option would be the purchase of construction staging with adjustable legs. The legs of the staging can be adjusted by simply screwing or unscrewing a large wing nut and can compensate for the uneven terrain and steep slopes.
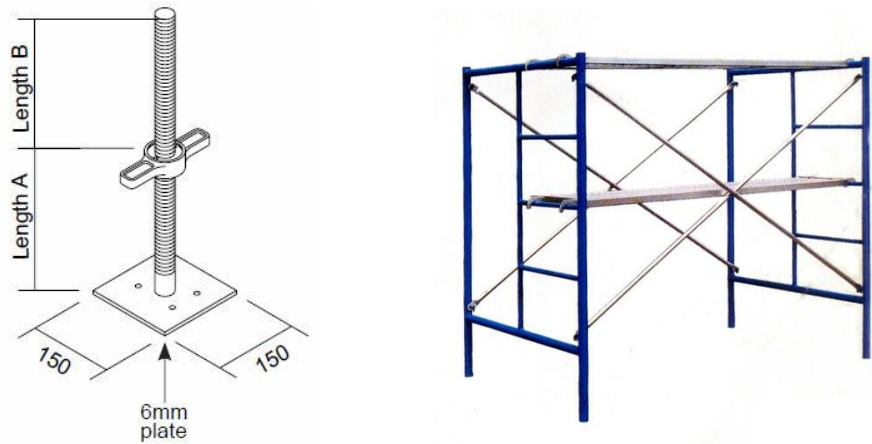
Figures 16 & 17: Diagram of adjustable legs (left) construction staging example (right)

Three sets of staging could suffice per row along with a three-person crew. One person would be walking across the staging with the pole saw while the other two are transferring and adjusting the next set from tree to tree. This is also a viable option due to its minimal impact on the natural species growing underneath the older tree sections. With staging being roughly two meters tall, this would increase the pruned regions to nine meters. Construction staging like the one shown above is relatively cheap, has a long lifespan, and can be bought in bulk. Pieces required for the staging such as planks do not need to be purchased because scrap teak planks can be used. The implementation of these staging routes could lead to more viable lumber and a higher profit margin with minimal equipment and labor costs.

Another necessary process in lumber farming is crop thinning. This means that after a certain age, trees that are curved, experience a fork at a low height, or dead trees are harvested so that healthy trees will not be affected by them and can continue to grow. The teak trees at Batipa have a 20-22-year cycle, thinning is done at age eight and again at age twelve. The twelve-year-old trees meet the requirements to be shipped to the current client, but the client for the younger and smaller eight-year-old trees no longer does business with Batipa due to the increasing teak market. This leaves Batipa with a large amount of lumber with no buyer.

The current thought is to square off these logs with an on-site mill, and hopefully find a buyer for these sawn logs as is. The current state of the drying milled eight-year-old trees is squared, meaning it has the maximum dimension of lumber that the specific log could offer. An example of this is the piece our team watched get fully milled, its final dimensions were 5⅛" x 4¼". This is not a standard lumber piece, and buyers of sawn wood look for certain specifications. While looking through go4worldbusiness.com, most buyers of sawn teak lumber

required the logs to be high quality meaning no knots and to meet a certain dimension, an example being 1"x4". This would mean that further milling would be required to sell these pieces of lumber.

Figures 18 & 19: Milled lumber at Batipa (left) Example of shiplap style wood plank (right)

A good strategy, especially for such an oily and hardwood such as teak, is to let it dry before milling to expand the life of band saw blades. With further milling being necessary to sell this lumber, it would be ideal to find a permanent location for a sawmill to be established. As more is sold and profits arise, invest in the expansion of the mill and milling equipment so that more custom orders can be produced and sold for a larger amount.
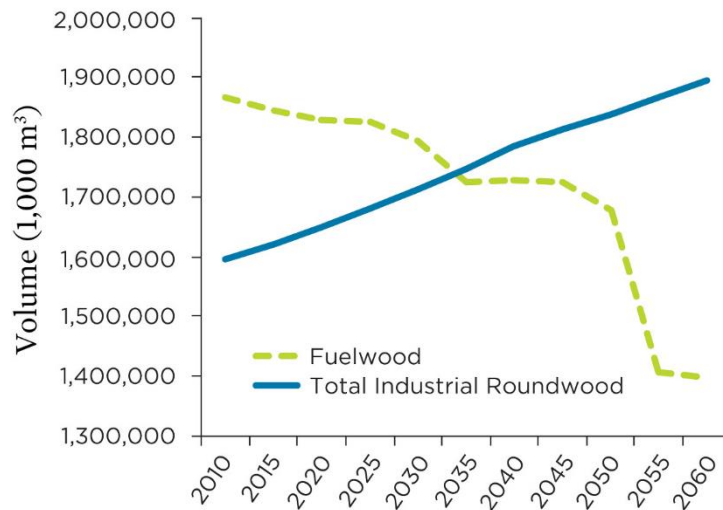

Figure 20: Graph projecting steady market increase for industrial lumber products

Popular uses of teak include ship parts such as decks, contemporary siding, and decking. These pieces, such as shiplap siding, require different milling saws to make, but in the end can be sold for much more money.

Instead of simply squaring off lumber, the precision milling of popular dimensions and styles could prove more profitable. Popular dimensions of teak wood are around 1"x3"x4'. These are sold for a lot of money to the public but selling to an exotic wood supplier or even small lumber yard internationally could prove beneficial. The dimensions created would vary based on what clients would want after a deal was met so that the buyer is committed. Another benefit to this is the fact that no other milling equipment would be necessary unless intricate milling was required for pieces such as shiplap siding, where a separate specialty saw would be necessary.

Another route Batipa could go is to have trees dry prior to cutting based on how much is wanted and the desired dimensions. This would not be an immediate change in the milling process but would be good if Batipa could attempt to reach this step around ten years out. If a permanent milling location is established, a shed could be constructed and the beginnings of a small lumber yard would come into shape. Buyers could express their needs and Batipa could fulfill them. This would in turn need a lot of money to be put into this initiative to buy improved milling equipment, specialty milling equipment, and extra machinery.
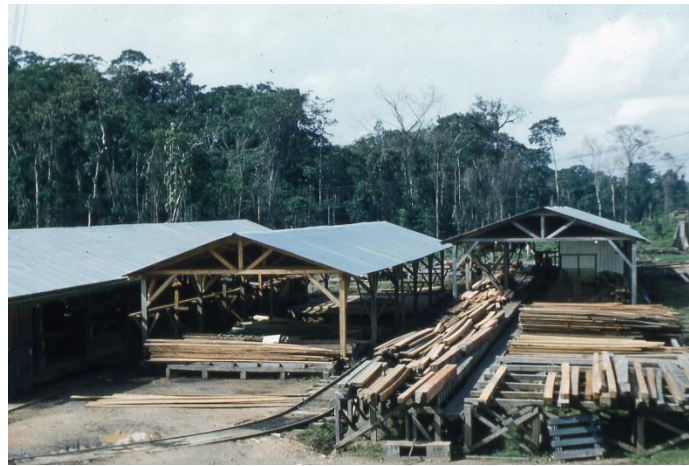
Figure 21: Large scale saw mill with lumber yard

A popular saying in the business world is "you got to spend money to make money" and this is true in Batipa's teak plantations case. There are a lot of different paths that Batipa can go down, each with their own unique benefits and challenges, but if a niche or a group of buyers is found then Batipa can mold to best meet their needs with the selling of the young eight-year-old trees. The lumber business is an ever-changing market with fluctuations in interests. If Batipa can combat these changes by finding what style of lumber is popular with the times, then wood will sell and profits will come in.

With the milling of these younger teak trees, there is the creation of excess slabs. These currently are just littered across the side of logging roads where the mill site was located. In most situations, when a log such as pine is milled, the slabs are cut and chopped into firewood and either sold in cords or in smaller bundles.

Figure 22: Milled slabs along the side of the logging road

We would not advise Batipa doing this with the teak slabs for multiple reasons. The first being that since teak is an oily and dense wood, it would not burn easy even if dried for an extended period. The second being that since teak is such an exotic and valuable wood, there is a market for these slabs. Slabs are typically used for furniture pieces and are a growing style in contemporary buildings. These slabs could be sold as is, with no further adjustment. These could be sold to buyers by the cubic meter, giving average dimensions of the slabs, specifically looking at the minimum width of the slab and the width at either end. As for storage, instead of throwing these slabs into piles on the side of the road, the use of slab racks could both clear away all the clutter of milling and provide a system of measure for these pieces.

Figures 23 & 24: SOLIDWORKS rendering of slab rack (above) Example of slab rack compared to stacked lumber (below)

These slab racks could be made from cheap square stock metal and be light enough to be moved around using the equipment Batipa already has such as the bulldozer or skid steer. A second advantage to the introduction of slab racks is it would be used as a unit of measurement for sale. These racks could be made to fit one cord of lumber which is 4'x4'x8' or 128 cubic feet or 3.62 cubic meters. This makes it easier to measure these uneven pieces of lumber. The third advantage of these racks would be keeping the slabs off the ground. When the rack becomes full, it would be much easier to run straps around the bundle for transportation to an area to dry before sale. With the use of slab racks, the sides of the road would be less cluttered and one step closer to being in a shipping container on its way to a buyer.

An expanding market in lumber involves 'live-edge' slabs. A live-edge slab is when a tree is milled down into 1.5" to 2" thick pieces, not squaring off any sides. These slabs are then sold as is with no further milling or processing necessary. The price of these slabs vary based on a couple of parameters. The first being the minimum width of the slab, followed by the width at either end of the piece.

Figures 25 & 26: Example of live edge lumber & furniture

The quality of lumber is also taken into account when pricing these slabs, meaning pieces with knots or defects will be cheaper than higher quality pieces. These teak slabs are popular in cabinetry and furniture such as dining tables due to them being resistant to water and mold, the ease to apply finishes to, and the fact that it is an exotic wood. Another benefit to switching to live edge slabs is the fact that no extra milling equipment is necessary, just the method of milling would need to change. These young trees may be small, but the creation of live edge slabs instead of squared off lumber may prove to be more profitable if a client is found.

With the rise of urbanization in eastern Panama, landscaping materials such as mulch may be on the rise, and Batipa may be able to fill those needs with the amount of timber that is available to be mulched. This would resolve the issue of excess teak, because all excess would simply be mulched and sold.

Figure 27: Mulch piles of various popular colors

Another option regarding these eight-year-old trees would be to purchase a used chipper. It would be a major purchase for the plantation and would probably involve the separate purchase of another piece of equipment such as a front loader or excavator. If there is no viable market for either the slabs, squared off pieces, or further milled logs, then it would be cost effective to purchase the chipper and every year run the eight-year-old felled trees through the chipper. Along with the eight-year-old trees, any excess wood produced through the harvesting process, such as branches and other unusable logs, can be put through the chipper as well. Ideally, instead of a chipper, a horizontal grinder could be purchased to speed up the mulching process from tree to mulch. Grinders are capable of heavy workloads and come with engines and parts that will withstand a lot of abuse. With proper maintenance such as oiling and greasing components and washing the machinery, chippers can withstand thousands of operating hours. These chips could be sold to a wide variety of markets. One is the biomass industry, which feeds the chips into power plants to provide energy to homes. Another potential market is to be sold for animal and livestock bedding and could possibly be sold domestically and internationally. The third potential market could be the landscape industry by selling raw mulch or going a step further and coloring the mulch to meet popular demands especially within the United States. Popular mulch colors include red, black, and brown.

Figure 28: Horizontal grinder with colorizer

With coloring chips, a specific chipper would need to be bought or a "colorizer" attachment would need to be purchased to spray the ground mulch with pigment to make sure all pieces are

the same color. In an ideal situation, Batipa could make a large investment by purchasing a new machine, but that is currently improbable. At this moment, we would recommend going to auctions around the area, looking at forestry equipment and other equipment such as skid steers, excavators, or a front loader. When looking at recent selling prices of large grinders and chippers, like figured above, a ten-year-old chipper was selling from $50,000-90,000. This is much cheaper than buying new, but the machine has been worked and is more susceptible to mechanical failure. Another thing to be wary of with auctions is the fact that previous owner(s) may not have properly taken care of the machinery. In the end, the amount of money saved buying at auction outweighs the risks of buying used.

Figure 29: Heavy equipment auction block

If a chipper is not purchased, the brush piles created via tree harvesting would still be present. Currently, brush is left in large piles across the freshly cut zone to rot. Teak wood, with its high resistance to water and mold, takes a long time to decompose. A better way to deal with all this brush is to disperse it along the edges of the zone. By spreading these piles out, it makes the decomposition process faster and provides both nutrients to the soil around the zone and retains more water. This will reduce erosion in the now cleared patch of land before the saplings are able to establish a firm root system.

5.2 Altitudinal Biological Corridor of Gualaca

Our sponsor wanted us to mainly focus on teak and education, but we believe the corridor needs to be addressed as well. We want to use the big picture ideas of Batipa and apply their sustainable forestry methods to the larger corridor. The corridor can also involve educational aspects, like erosion control and sapling programs. These solutions are simple, low-budget, and can make a huge impact.

The Pan-American Highway recently opened an expansion in early 2018. It was a simple two-lane highway and was modified into a four-lane highway with a Jersey barrier divider. To combat growing roadkill incidents, Batipa installed six monkey bridges. These bridges are large metal poles supporting a three-foot-wide piece of fence that spans across the highway. Because the bridges are new and lack vegetation, climbing animals are intimidated. To add vegetation faster, hanging baskets can be installed. The baskets would contain vine-like plants. When they are fastened to the bridge, the vines will be woven into the fence and allowed to grow. With these baskets, plant growth can then come from the top of the bridge and meet up with the pre-existing vines growing upward from the ground. Once there is significant coverage, we recommend adding game cameras to monitor usage.

Figures 30 & 31: Additions to "Monkey Bridges" to boost vegetation and monitor animal movement

Additionally, fruit bearing plants can be added to the bridges to attract the animals. However, we recommend adding fruit bearing plants after the vegetation is mildly thick, to prevent fruit being dropped on the passing cars below.

In some areas, the highway structures can be modified from their current state to resemble the figure below. Outside the main entrance to Batipa, there are two bridges that span a small creek. The creek was roughly 45 feet wide, plus the 20 feet of concrete support for the bridge, the entire span was approximately 90 feet long. From the mildew and water marks on the concrete, the flood level was approximately 12 inches up the river bed.
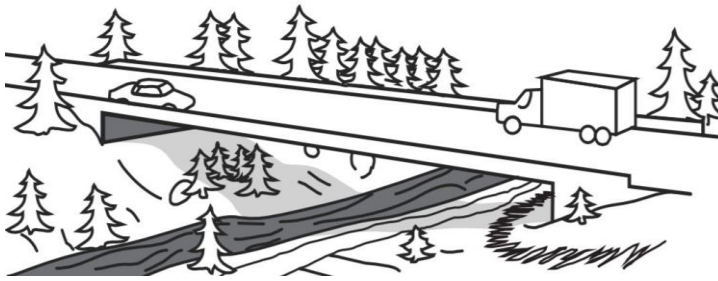
Figures 32 & 33: Concept art for a creek overpass and target overpass

Similar to the figure above, the area at the base of the concrete can be filled with dirt and rocks to allow animals to walk under the bridge near the water (Pennsylvania, n.d.). The added material would restrict the flow of water and make the stream narrower, but the river banks can be reinforced to prevent erosion. The added material would have to be higher than the water mark on the concrete, to compensate for the narrower river, and add a cushion to the soil. Designs like this can be implemented to any bridge along the Pan-American Highway. There is little design work involved, but the biggest appeal is how cheap and simple this solution is.

We are also proposing building large, permanent structures under and over the highway. We believe tunnels have the potential to be more economically feasible than bridges. Bridges appear to be more expensive than tunnels and require more engineering to design and construct. In heavy rainfalls, the tunnels can serve drainage purposes. Also, the effects of water on the bridge would have to be viewed from several aspects: drainage, weight, soil absorption and erosion, and material deterioration. Both tunnels and bridges require the highway to be restricted or closed for installation, but we think tunnels would have a lower impact on the highway closures.

To design these structures, our recommendation is to seek a Major Qualifying Project (MQP) team from WPI. Oteima is aggressively looking to expand their foreign student presence while concentrating relationships between a select group of universities. A MQP team would accomplish both goals. MQP is a better match for designing tunnels and bridges than an IQP team. A Civil Engineering or Architectural Engineering MQP would have the technical prowess to produce a more economically plausible design to present to the Panamanian government.

5.2.1 Future Major Qualifying / Interdisciplinary Qualifying Projects

Throughout the span of the project, we were presented more ideas and problems. Being only a four-person team with seven weeks to complete the project, we made the decision to pick

three problems with the highest importance and focus on them. This does not mean that these other projects are unsubstantial, but instead of dealing with them all at once, we have devised a schedule that could help Oteima and Batipa organize their projects and approach them one at a time. A benefit to this approach is the return of future IQP teams and now potentially MQP teams. Oteima is looking to apply for a 1.5 million dollar grant over five years. This could fund these projects, and possibly more. In order to complete these projects, with Oteima and Batipa's busy schedule, we have created a proposed timeline of projects that could be offered to future WPI students. The project teams suggest the following:

2017-2018

IQP: *Sustainable Design Solutions for Batipa Field Institute*. Project covers improvements to existing Cabimos, architectural designs for the entrance and lecture hall, rainwater catching structure design, and methods to deal with excess teak from harvesting. Project makes Batipa Field Institute ready for tourism initiative.
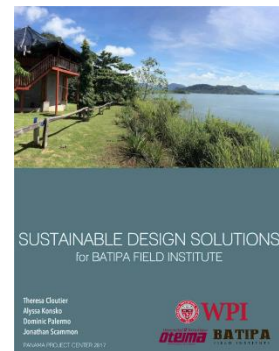
2018-2019

IQP: *Teak Efficiency and Environmental Education Methods for Batipa*. Project focuses on teak milling methods to meet market demands and ways to deal with milling entrails, soil erosion control throughout the Gualacan Corridor, and methods to spread Batipa's agricultural techniques to local farms. Project provides website critique and new methods to make potential profits on lumber.
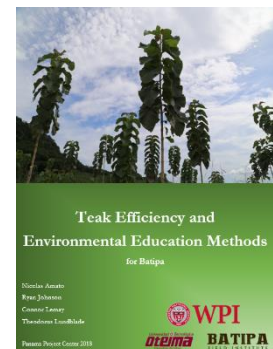
2019-2020

MQP: *Design of Animal Bridge Across Pan-American Highway*. Project involves team of four civil or architectural engineers. Project will design, analyze, and deliver a plausible bridge following drafting standards. Project provides basis for start of reconnection of Batipa to the rest of the corridor.

IQP: *Academic and Ecotourism methods for Batipa*. Project focuses strictly on tourism curriculum to be offered as well as academic courses and volunteering opportunities to be offered at Batipa, especially if lecture hall is built within this time.

2020-2021

MQP: *Design and Placement of Observational Towers on the Batipa Peninsula*. Project involves two civil engineers and two mechanical engineers. Team focuses on design of these observation towers and provides the ideal location for these towers. Project helps Batipa find where the best location for wildfire and poacher observation is and general structure for tower.

IQP: *Polyculture and Natural Seed Bank Initiative for Batipa*. Project focuses on increasing polyculture under older teak plantations, including potential fruiting trees or shrubs that improve the soil condition for improved teak growth. Team also focuses on increasing biodiversity within the peninsula, including animal movement and health. Project suggests methods to produce seed bank at Batipa to boost sapling program suggested in 2018 project.

With all of these projects at hand with such a short amount of time, we believe that this is the most effective way for Batipa and Oteima to look at these projects. If a set of two or three projects is set in front of them, they can spend more time on finding specific data for that certain project. If the next project team is able to spend ten days focusing on three distinct project subjects, there will be higher quality deliverables at the end of these upcoming projects.

5.3 Spreading of Knowledge and Techniques

Oteima University would like to establish Batipa as an educational hub for local farmers in the Chiriquí Province. Through a combination of educational programs, Oteima would use Batipa as a model for managing erosion and maximizing profits during farming to improve the economy of the province as well as to increase the longevity and environmental sustainability of the region. The responsibility of these programs can be split between Oteima and Batipa. Batipa can focus on the hands-on learning while Oteima could focus on conventional learning. Web-based courses can be created by computer science majors while open lectures can be offered at Oteima that focus on the agricultural development in Chiriquí. Batipa on the other hand, can offer hands-on projects and demonstrations that attempt to establish a basic knowledge of sustainable agriculture with local farmers. Additional things include how the trees reach maturity at around 20-22 years and are fast growing hardwoods. The benefits of crop and landscape diversity are that ecosystems will be less vulnerable to disease and reduce the risk of erosion. There could be demonstrations on how to plant teak, how to determine the carrying capacity of grazing land, why teak is great for growing in Panamanian soil, and why environmental conservation would be beneficial for the farmers to adopt. Batipa and Oteima can also set up consultations with local farmers to analyze their practices, equipment, and land. The goal of this

is to present the farmers with personalized solutions and plans they can take to improve their sustainability and profits.

Batipa would get the word out about their program using word of mouth, which may be slow but also the most effective for connecting with older generations. To reach younger generations, social medias sites such as Twitter or Facebook would be faster but less effective for rural farmers. According to a study conducted at Virginia Tech and Virginia State University it was concluded that farmers do prefer certain methods of learning over others (Franz, 2009).

It should be considered that Oteima and Batipa only share their information with farmers who want to learn and not force them into learning. It is important that educators do not invalidate farmers' own ways of farming, but instead present them with better methods they should not turn down.

Figure 34: Worker explaining Batipa's cattle farming techniques

Doing so will promote farmers to be more open to learning if they feel that their honors, goals, and lifestyles valued.

5.3.1 Sapling Program

The overall purpose of this program to regenerate the soil to a level where natural vegetation can flourish. Some areas are badly damaged from erosion and will need years to be healthy again. The Sapling Program would be made up of three phases. Each phase would be years, but the exact timing of each phase would be at the discretion of the farmer.

Phase I would be education. The seminar would start with plant life cycles and participants would visit the school nursery and plant seeds. When these seeds are matured, they

will be gifted to the graduates of the seminar. After, information about how erosion is caused, how and why it affects the environment, and then how to repair it is given. The saplings would be planted in areas of erosion to begin the healing process. These seminars can be taught to large or small groups. Oteima can host these seminars or they could be held in local towns, where they visit specific erosion sites. There are two benefits of gifting sapling trees instead of fresh seeds. First, saplings are easier to maintain, Batipa uses the same practice for their trees. Second, if the farmer wishes to sell the tree for lumber afterward, the sapling would reduce the wait time.

Phase II would be the planting. Using the "Batipa Model" for growing, trimming branches to achieve knot free wood, letting natural vegetation grow around trees, and leaving brush. The species of planted tree would have two requirements: be a "juggernaut" plant and have a logging market. A "juggernaut" plant would be a species that can handle harsh growing conditions. With year-round heat and sun exposure, coupled with long spans of drought and flooding, the trees need to be nigh invincible. Trees like pine and teak would be ideal for this region.

Figure 35: Tree life cycle from seed to full tree

The purpose of these juggernauts is to develop a root system to grip the soil, prevent run off, and to boost the nutrients in the soil for later use. Once the trees are of selling age, they can be cut, removed, and replaced with other trees. Like a financial aid package, the participants can receive the knowledge and the trees with promise of selling back to Batipa.

There would be a small overlap of phases II and III. Phase III would be the introduction of native species into the soil. Participants should plant a combination of food bearing and non-food bearing plants. For a more sustainable income, cash crops like bananas, coffee, plantains, coconuts, and papayas can be used. Not only will these plants feed people, but they can be used for animals as well. With cash crops and timber, natural vegetation should be introduced as well. The natural vegetation needs the longest time to grow, so some nutrients in the soil need to be

present. These trees will also not be removed, so placing them strategically is very important. The natural vegetation should be placed together in path-like pastures and allowed to grow without interruption.

5.4 Possible Academic and Ecotourism Initiatives

Oteima once offered courses for credit at Batipa. Domestic and international students were able to apply to take these classes. These courses were no longer offered after 2015 due to lack of popularity, mainly due to the lack of advertisement for the program. With the updating of the website (see Appendix A), these courses may be re-established and offered again. The following are the project team's suggestions on what courses would have the highest popularity between domestic and international students.

There are two potential categories for courses, those for academic tourists and those focused more on locals. We believe the greater goal of these courses are to instill ecologic appreciation of Panamá. Courses are also intended to promote local economic growth while being ecologically responsible. With these classes, it is our hope people will return home with a new found love for the environment and spread the new practices they discovered here. Additionally, we wish to address the method of teaching. It is our fear that local people will take this information as scolding, instead of sharing. These classes are intended to share the most effective and most sustainable method(s) of agriculture and to share and explain the benefits of environmentally conscious farming.

It would be beneficial for Batipa to adopt agricultural educational programs and hands-on agricultural learning that would be directly applicable to spreading knowledge to farmers. Batipa can look to other institutes or organizations as a guide making the process of developing Batipa's own courses more efficient. The agriculture program at Fort Hays State University is unique and focuses on hands-on teaching as their main method. Interesting things to think about implementing are sending Oteima University students to local farms for three reasons: To allow the students to gain hands-on experience, give aid to the farmers, and allow the students to create reports on each of the local farms. Possible projects to improve local farms include simple but impactful things such as "making and distributing rain barrels" (Fort, n.d.), planting trees, and establishing pioneer crops in erosion-prone areas.

Currently, Oteima is partnered with a few universities and have strong study abroad programs with them. These universities include Nebraska University, Tulsa University, and Worcester Polytechnic Institute.

Figure 36: Academic Tourism group at Oteima

The courses suggested below can be taught by many means, but we recommend multiple classes a week, with hands-on and interactive demonstrations. Depending on the complexity of the teaching material, classes can be combined to cover a semester, or they can be offered as seminars that span over three, five, or eight weeks. These courses can run at different times of the year, to accommodate foreign academic schedules. Majors that could get beneficial field practice from these courses would be Agriculture, Biology, Environmental Engineering, Business, and Management. Courses that could be offered for credit at Oteima include teak farming, sustainable cattle ranching, nature conservation, wildlife tracking, and jungle construction.

- Teak farming would explain the teak life cycle and the farming practices from seed to logging. In this class, students would learn tree and plant biology, how plants are vital to prevent soil erosion, and the environmental impacts of large scale teak plantations.

- Sustainable cattle ranching would include the importance of genetic diversity among cattle, sustainable, yet effective practices, and dry season strategies for managing pastures.

- Nature conservation varies between farmers. With little environmental regulations, it is up to landowners to practice good habits. This course would cover climate change, rudimentary environmental science, and soil and water conservation.

- Wildlife tracking is an important aspect of biological corridors. Being able to monitor the movement of animals is key to analyze rural land use and for people to better respect wildlife. This course would discuss various types of indigenous animals and ways to identify them. Wilderness expeditions could also be incorporated into this course to apply tracking skills.
- Jungle Construction needs serious thought. Looking past simple occupational hazards, health of workers should be the number one priority. This course will cover topics including transportation, materials, weather, and environmental regulations.

Another popular program that was discontinued around 2015 was the wildlife rehabilitation volunteer program. Originally, volunteers would come in, care for, and rehabilitate primates. The lack of primates caused the termination of the program. Now, Oteima has an idea to do a volunteer program that would be focused on tracking animal movement through all biological corridors located within the Batipa Peninsula. This would require the installment of game cameras, planting of fruit bearing trees, and monitoring specific animal movements. The goal is to measure the diversity and general health of all species caught on camera. This is a viable volunteer program because there will constantly be productive tasks available for volunteers to work on.

With the re-establishment of academic courses along with a volunteer program offered at Batipa, more international students may come down to Batipa and Oteima to study. The construction of a lecture hall will make these courses have a good balance of on-site lab work and lectures. With a viable easy to navigate website, popularity of these courses should increase if the right audiences are targeted in the STEM and agricultural majors.

Figure 37: Recreational tourism activity available at Batipa

Batipa is an ideal tourist location because it is secluded in the rainforest but also only a short drive to the nearest city of David. Tourists don't necessarily need a lot to be content with their living situation for a short stay. They do not need regular power or Wi-Fi and some tourists value being unplugged from technology and will see the lack of power and Wi-Fi as part of the experience so long as they have prior warning.

There are definite improvements that would make tourists happier. Currently Batipa could offer more activities, which would increase the number of things people could do during their stay at Batipa. Examples of these proposed activities include:

- Rope swing into the water
- Hiking trails
- Sport fields or courts
- Ziplines
- Fishing

Those improvements would bring out more of the potential in the activities already at Batipa and make them even better. A rope swing and more fishing equipment would make the already available swimming and kayaking more enjoyable. Ziplines and Hiking trails would make animal and bird watching easier as well as nature photography.

Generally, there is commonality between all tourists. They want a new experience that is unique to the place they are visiting. For example, Panamá has flora and fauna specific to subtropical regions. Other areas of the world, like the United States and Europe, simply do not have the biodiversity that is present in Central America.

Figure 38: Typical meal offered at Batipa

Another important topic to consider is that some tourists or volunteers may want to take part in projects at Batipa. Supplying food and housing to volunteers in exchange for their efforts may be a great program. The offer of inexpensive travel to a beautiful tropical country for an extended period of time would be appealing to many university-age people. Many people would be excited to come to Batipa, given the opportunity to engage and learn about agricultural sustainability. Another thing to consider is to encourage feedback from visiting tourists. At the end of our stay, we filled out a survey about our time in David and our activities at Batipa. Something like this would be useful to give to recreational or academic tourists. It could be filled out by hand or digitally. With these surveys, Batipa can shape their program to meet the general wants and needs of the public.

6.0 Conclusion

Throughout the span of the project, many problems were discussed, but after further investigation, we found three problems that encompassed some of the other projects. By looking at these three overlapping problems, we were able to suggest actions to achieve the desired goal. These solutions were based off of multiple on-site visits and interviews with workers at Batipa. From this and extensive background research, we were able to provide the following solutions.

The first problem we analyzed was teak efficiency and marketing. We looked at their current trimming, thinning, harvesting processes, and interviewed staff members. The big problem was the buildup of scrap due to milling of eight-year-old trimmed trees. We suggested the building of racks that would organize these piles of scrap and make it easier for them to be moved around and out of the way. We also looked into extending the trimming of trees to increase the amount of knot free, high quality lumber produced. After exploring multiple options, we found the cheapest and most effective way would be to implement adjustable leg staging for trimmers to stand an extra two meters in the air. The third part of this problem was finding a market for their youngest, trimmed trees. We researched popular teak markets and gave suggestions on potential paths they could take when dealing with this lumber, including a list of equipment that would be necessary.

The second problem involved the biological corridor that Batipa falls within and methods to increase safe animal traffic across the newly expanded Pan-American Highway. Here we looked at the already existing primate bridges and gave suggestions on how to increase vegetation across the bridge in a faster time frame. We also discussed the possibility of a future MQP team to produce an animal crossing bridge instead because they could produce plausible deliverables that follow certain codes and formats.

The third problem the project team faced was creating a foundation for a curriculum to spread the knowledge Batipa has regarding the balance between agriculture and ecology. This initiative will both improve the condition of livestock and of the surrounding ecosystems. We looked into the best methods to deliver these ideas to farmers and produced a sapling program to initiate natural recession on barren, eroded banks.

The fourth problem we analyzed was the installation of new methods regarding academic and ecotourism. By developing action plans to entice new students, faculty, and staff, along with

the creation of recreational tourism itineraries, we sought to boost Oteima's international presence. Improving Batipa's website would provide them with a greater potential for tourism and would make it easier for visitors to obtain information. To further strengthen the relationship between WPI and Oteima, we propose several future IQP and MQP projects based on the project ideas we were unable to complete.

The suggestions delivered were important to Oteima University as well as Batipa in figuring out how to deal with the list of projects they are currently facing. With the help of the workers along with tours around the Batipa Peninsula and La Fortuna areas, we were able to provide specific courses of action to solve these problems or achieve these goals. With the suggestions we provided, Batipa and Oteima now have a guideline on how to approach these projects as well as the other projects at hand.

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Appendix A: Website Critique

Batipa's online presence is an important step in increasing academic and ecotourism programs and initiatives. Throughout this appendix general online etiquettes are explained along with a detailed critique and breakdown of the 'batipafieldinstitute.org' site. Currently there are two web domains titled "batipafieldinstitute", one ending with '.com' and the other with '.org'. Batipa also has a third domain, batiparefugio.org, which is an outdated volunteer program site. Multiple "Lucidchart" diagrams are used as visual aids. They can be viewed in their entirety online, and be accessed in the *Reference* section of this paper.

There is one major difference between the extensions '.org' and '.com'. '.org' is held by an organization, typically a non-profit, and has different legal ramifications than a '.com'. In general, '.org' typically provides educational material or free information. The extension '.com' is used for advertising, persuading, selling products and services, or general information. Depending on the direction Batipa takes in the future, either one may be possible. If Batipa is a non-profit organization, then '.org' is better. However, if Batipa seeks to profit from the website, '.com' would be better (Marsan, 2018).

The website 'batipafieldinstitute.org' generally looks professional and there is no need for elaborate graphics and animations. A good idea would be to have an English and Spanish translation button that uses flags to denote language. Another note is that on the *Homepage*, the orange text of the navigation bar is on top of the images, making it difficult to see. Adding a white bar around the text would make it stand out. Additionally, the bar and text could fade out entirely when not in use. The lack of maps makes it difficult for viewers to get an understanding of what Batipa looks like and includes. In our research, we greatly desired maps and we feel they can be useful to other people (BFI, n.d.).

The Face of the Website, the *Homepage*

The *Homepage* is the first page that visitors interact with and should allow easy navigation to other parts of the website. One of the first things on the *Homepage* should be an introductory paragraph about Batipa. This paragraph should explain where Batipa is located, its partnership with Oteima University, and what the site is used for. Adding a map of Batipa to the *Homepage* would be a great visual aid to see how Batipa looks and operates. This way people are

given a general understanding of what Batipa is in a short paragraph and interest them to learn more. The following is an example *Homepage*:

In the Chiriquí province of Panamá, located 40 kilometers from David, the Batipa Field Institute [BFI] sits on a peninsula of roughly 4,000 hectares on the Chiriquí gulf. Two thousand hectares are mangroves along the coast and 1,400 hectares of teak plantation and cattle ranching. The land is used for growing teak, raising cattle, wildlife preserves, and tourism. At BFI we strive to improve our farming techniques, increase environmental awareness, and further ecological research. BFI seeks to promote ecologically minded farming, educate international academic tourists in Panamanian conservation, and boosting cultural awareness.

Batipa is the base of the Altitudinal Biological Corridor of Gualaca, which connects the Pacific Ocean to the mountains of Fortuna. The dream is to have full continuity to the Atlantic Ocean and the nearby Mesoamerican Biological Corridor that connects North and South America. This makes Batipa an important ecological resource. Currently, the Gaulacan Corridor is not fully connected because it is not protected by law. It is up to the local landowners to protect the land however, farmers have cut natural vegetation to expand their grazing pastures, reducing natural animal passageways. BFI seeks to encourage those landowners to protect the land by explaining the benefits of leaving small corridors of natural vegetation for animals to travel through.

Currently, the *Homepage* is written like an academic paper, which is difficult and uninteresting to read for the average person. The *Homepage* can be organized like a Wikipedia page. All Wikipedia pages are designed with multiple subheadings and a content box, similar to the one listed below. The example below is from the *Corcovado National Park* page (Wikipedia, 2018). This page was used as an example because of its relative shortness.

Figure: Content box to quickly navigate through lengthy page

The majority of the information is on one long page. Navigation of the page is done through scrolling or the Contents box, which simply jumps down the page to the requested section. The page also links to other Wikipedia pages where more specific and detailed information can be found. We do not recommend the visual style of Wikipedia for Batipa. Our suggestion is to use the navigation techniques to extend the *Homepage* with short summaries about other pages on the website and provide links to the detailed pages. Using studio19glass.weebly.com as an example, the main page links to nearly all other pages on the site in a clean, simple way that can direct unknowledgeable visitors to the location of the information they seek quickly and easily (Lundblade, 2016). The figure below displays tangible examples of seamless navigation.
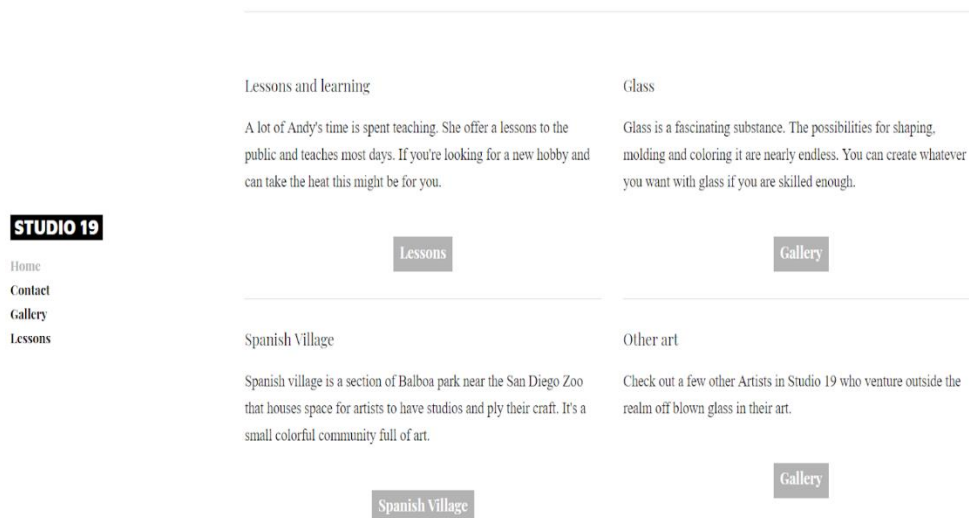
Figure: Quick selection menu example

Currently, there are several pages in the navigation menu of the website that do not have functioning links because the pages do not exist. Boeing's website is a good example of what Batipa's could be like (Boeing, n.d.). Hovering over the *Commercial* tab brings up the drop down menu but it can also be clicked on. Clicking on the tab leads to a page with links to all the drop down menu options. Additionally, it has some general information which provides a nice overview. Note how the figure below illustrates this point, how the mouse pointer can click *Commercial* tab.

Figure: Clickable drop down page

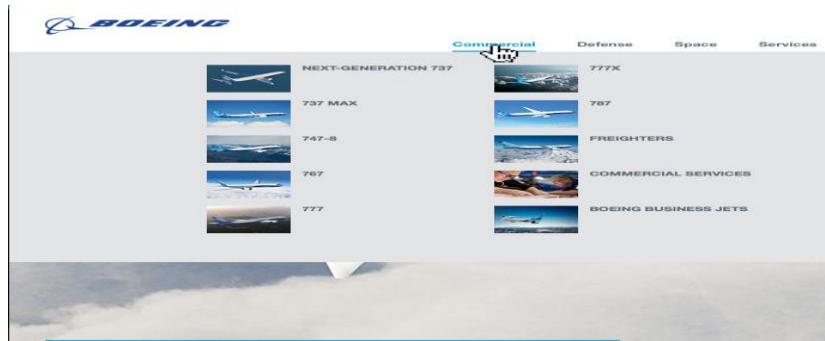The website should display the experiences people should expect from Batipa. There should be a section where tourist's experiences are explained in detail. This should include both academic and recreational tourism. Separately, a section should showcase the different wildlife at Batipa. Pictures with labels, descriptions and sound bites could be included for the fullest experience. Logistical concerns need to be addressed somewhere: transportation methods, check-in and check-out procedures, meeting points, and rental car recommendations. Information about the facilities at Batipa should also be included: What to expect for sleeping accommodations, food, water, hygiene, etc. The more information Batipa can provide, the better. A detailed map of the Cabimos area would be incredibly valuable.

We created a site map of the existing website utilizing Lucidcharts (Lundblade, 2018). After that was completed, we created a new version, adding our suggestions and what we would like to see changed. Pages will continue to exist in the top navigation bar, however now they will be a clickable link that leads to a separate page detailing that topic(s). The drop down menu will include these topics and subpages attached to a larger page. Clicking on those topics will function similar to the Wikipedia content box, jumping down the page to the appropriate location. Also, short summaries should be written about larger, more detailed pages with links to those pages for fast navigation of the site. The drop down menu in the case of subpages should link straight to the separate page.
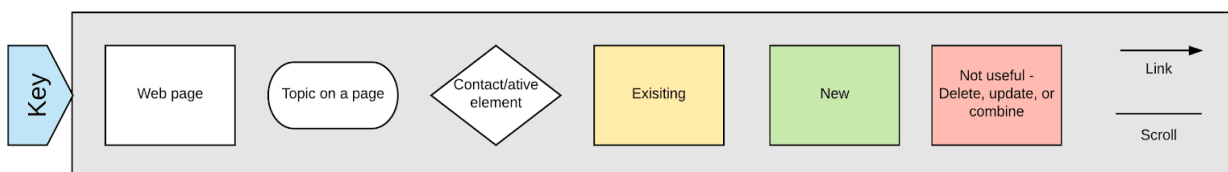
Site Map Key

We also added a key to the site maps see *Figure: Site Map Key* (above) and *Figure: Chart of Redesigned Website* (below). Here is an explanation of the Key and site map notations. Rectangles represent *Webpages*. They are separate, distinct webpages that must be clicked on to visit. Rounded bubbles mean *Topic on a page*. Rounded bubbles are sub-topics or content on the webpage they are on. They can be reached by scrolling down on the webpage. Some sub-topics may have been pre-existing webpages but we believe they need to be reformatted and condensed into a single, long webpage. For example, *History* was its own page but it works better as a subtopic placed under *About*. Diamonds depict *Contact & Active Elements*. Active elements, or ways for people to contact Batipa, like dialogue boxes where people can sign up, register for programs, ask questions, or write reviews. Color denotes the status of webpages: Green is new content, Red is something that needs to be deleted or updated, and Yellow is already existing content that needs cosmetic work or relocation. In this diagram there are two types of lines. A line with an arrowhead means there is a small summary with a link to a separate, fully detailed page and a plain line means the content is on the same page, just farther down.
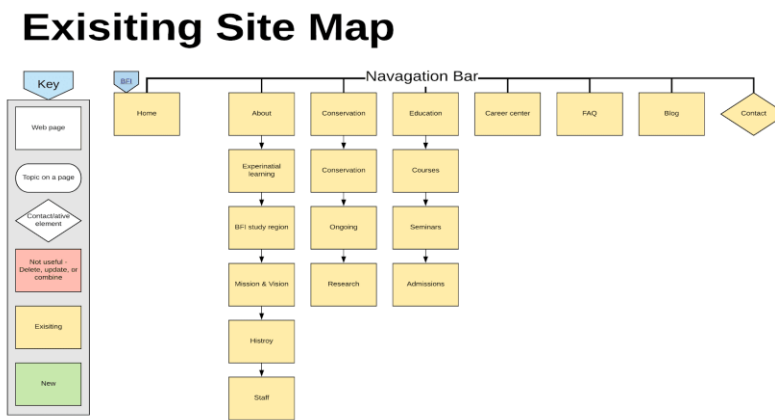

Figure: Chart of existing batipafieldinstitute.org

Suggested Site Map

Navagation Bar

Key

Key elements:
- Web page
- Topic on a page
- Contact or active element
- Not useful – Delete, update, or combine
- Existing
- New
- Link
- Scroll

Blog

Contact & staff
- Staff
- Contact

FAQ's
- FAQ's & Reviews
- FAQ's
- Reviews

Education
- Academic Tourism
- Experiential learning
- BFI study region
- Career center
- Research
- Courses
- Seminars
- Programs
- Events
- Admissions

Tourism & visiting
- Academic Summary
- Map & Facilities
- Experiences & things to do
- Recommendations & Rules
- Packages
- Contact for visitation

About
- What is Balipa
- What goes on at Balipa
- History
- Gallery
- Conservation
- Sustainable Livelihoods
- Ongoing

Home
- Mission & Vision
- Tourism Summary
- Education Summary
- More summaries

(Note) See page 2 for Existing Site Map

(Note) Consider attempting to combine these more so there are less topics in the drop down menu

(Note) These could be that same portal or page they just need to let people apply or sign up and contact someone to take of them. Depends on who's responsible for the different groups.

(Note) Add as many summaries as needed for this page to feel like it can guide someone easily to all key information

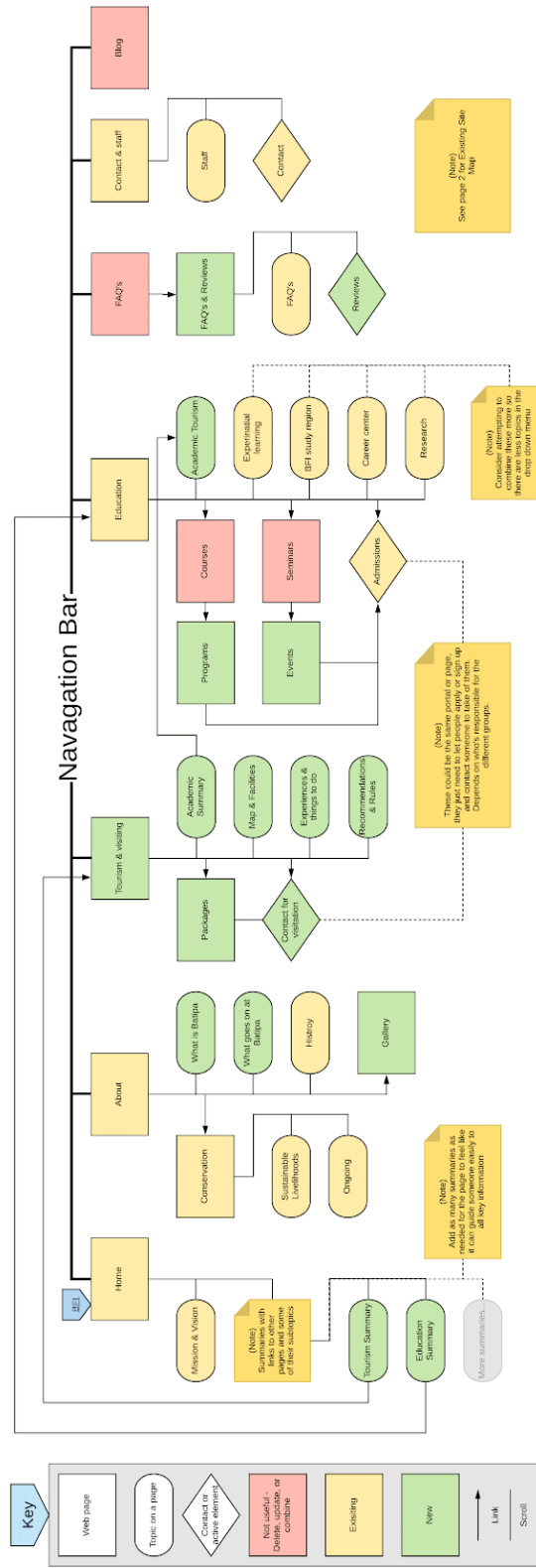(Note) Summaries with links to other pages and some of their subtopics

Figure: Chart of Redesigned Website (see below for zoomed in images)

Site Map Breakdowns

In this section we'll take a closer look at the suggestions to the *Home* and *About* pages. Each of these sections have access to all other sections of the website through linked descriptions. The figure below illustrates a potential navigation for the *Home* and *About* pages.
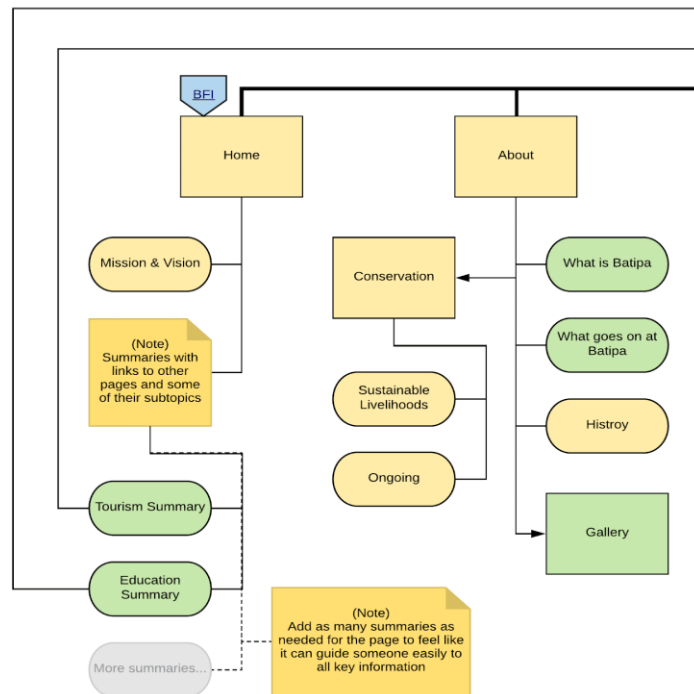

Figure: Cropped site map: Home & About

The *Homepage* should begin with shortened versions of Batipa's mission and vision statements before going into a series of short summaries of other important pages and topics. These summaries should be complemented with pictures. The *About* page should be updated and condensed, combining multiple pages into one, while adding new topics. A *Gallery* page should be curated to house a library of photos relevant to Batipa and Oteima. The pictures are there for documentation and for people to envision themselves at Batipa.

The *About* section will feature a section titled *What is Batipa?* This section should explain all the beautiful assets of Batipa. Whether it is the corridors, the fellow research centers, or the mangroves. It should also include at least one map of the area, preferably more. *What Happens at Batipa* should be another section. This section would showcase what people do at Batipa rather than the land itself. It would detail tourism activities, research initiatives, farming techniques, and anything else Batipa is being used for.
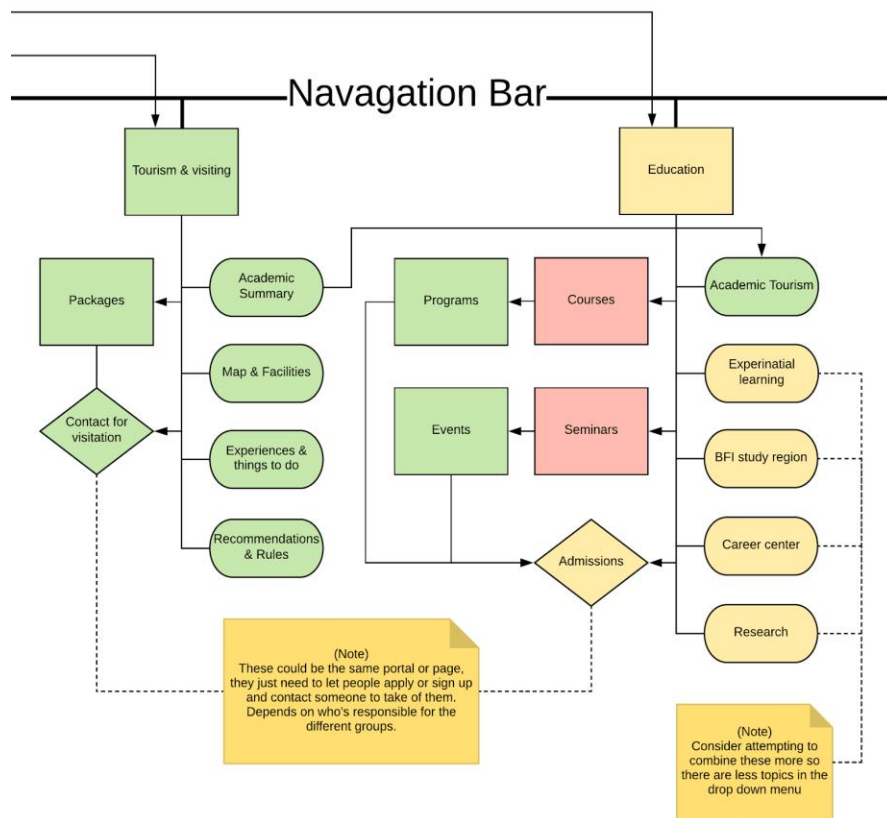
Figure: Cropped site map: Tourism & Visiting & Education

Tourism & Visiting is an entirely new, major webpage that will need to be built from scratch. Under this page, there will be several subsections and collectively, they will contain the most information. The following subsections will be listed under *Tourism & Visiting*.

Academic Summary should be a short summary of what academic tourism is and how it is implemented at Batipa. It should also have a link that sends the reader to *Education* where more information can be found.

Map & Facilities should cover any logistical details. Information and pictures should explain and detail sleeping accommodations, facilities, and other guest related infrastructure. Maps should be provided to detail the layout of the area and provide references for tourists.

Figure: Example of facilities

Experiences & Things to Do should depict activities that are at Batipa. Recreational activities such as kayaking, volleyball, hiking, bird watching, and fishing could be included with brief descriptions, locations, and pictures. This section should also entice people to stay at Batipa. This page should list examples of things to do in and near Batipa, focusing on David and nearby islands.

Recommendations & Rules would be split. Under *Recommendations*, there would be lists of what to bring and what not to bring. The *Rules* section would explicitly state the guidelines and expectations for visitors. It is also a good place to remind visitors to be ecologically minded and take care of the environment while staying at Batipa.

The *Packages* webpage would a separate webpage under *Tourism & Visiting*. This link should be presented at the end of *Experiences & Things to Do.* This page would further describe tourist attractions available at Batipa. These descriptions should include a full itinerary and prices. One potential example would be, "Island Package: 5 days with included meals, horseback riding, and 6 hours at Gamez (or a similar island) at $X per person".

Contact for Visitation should be form near the bottom of the *Package* webpage. Several dialogue boxes that include, number of guests, age of guests, length and dates of stay, bonus activities, and potentially more. People may have questions about trips or may request special accommodations, and there needs to be a way for them to contact Batipa. Payment methods can be determined here as well. Some businesses do not accept electronic payments and require payment in cash, upon arrival.

Education would be a major web page with several sections. Together these sections will characterize the academic atmosphere of Batipa. This section will become the new home for many currently existing pages. The largest changes are to *Academic Tourism* and *Admissions* pages, and other suggestions are mostly cosmetic. The following subsections will be listed under *Education.*

Academic Tourism is not a common phrase in the United States and most people may not have a concrete idea of what it means in this context. This section should list offered courses, current projects, and research initiatives. Financial questions should be answered here as well. To better entice students, Oteima could offer financial aid packages or even work-study opportunities. Batipa should also explicitly welcome new ideas for courses, projects, and research initiatives.

Like other college websites, *Admissions* should be its own page that contains active elements and dialogue boxes that allow people to apply for courses, projects, or research initiatives. A drop down menu of the programs and events should be included. These would be links to the *Programs* and *Events* webpages. *Admissions* could also be a link to Oteima's course webpage.

The *Programs* and *Events* webpages are updated names for *Courses* and *Seminars*, respectfully. People generally assume courses are longer and for students, whereas programs can be various lengths and be offered to anyone. These are simple syntax changes, but words have powerful meanings.
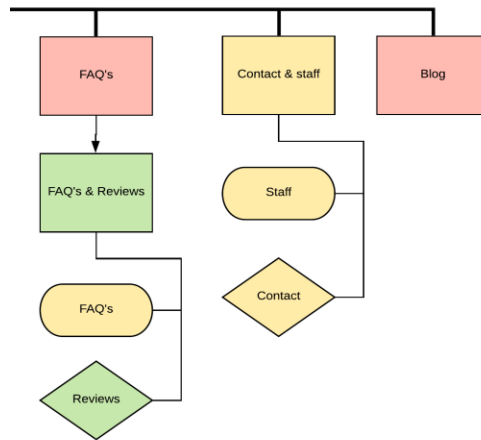
Figure: Cropped site map: FAQ's & Reviews, Contact & Staff, and Blog

The final zoomed in section concerns *FAQ's & Reviews*, *Contact & Staff*, *and Blog*. *FAQ's & Reviews* is an updated version of *FAQ's* that now contains reviews. Reviews have the potential to be valuable because, if positive, they instill confidence in tourists and can identify areas of improvement. Addressing negative reviews not only shows initiative to make customers happy, but improves the experience of future visitors. A one to five-star rating system could be implemented. Not only is it simple and effective, most people understand it without explanation. One of Amazon's greatest assets is thousands of customer reviews on different products, showing how good or bad a product is (Amazon, n.d.).

Contact & Staff is a combination of two already existing pages. *Staff* could go under *Education* but this is a more general location.

Blog should either be updated and used or it should be deleted.

Appendix B: Strategic Visions for Batipa in the Future

The goal of this appendix is to provide insights into general business principles to assist Batipa. It will be a breakdown of the processes we used in brainstorming for Batipa. This hopes to be a reference for Oteima and its students in dealing with issue priority and management in an organized manner.

Strategies

The kernel of a strategy contains three elements: (1) a diagnosis that defines or explains the nature of the challenge, (2) a guiding-policy for dealing with the challenge, and (3) a set of coherent-actions that are designed to carry out the guiding-policy. Only one solution idea is usually produced. The challenge is to find multiple ways to solve the problem, which requires deeper consideration of the problem at hand (Rumelt, 2017).
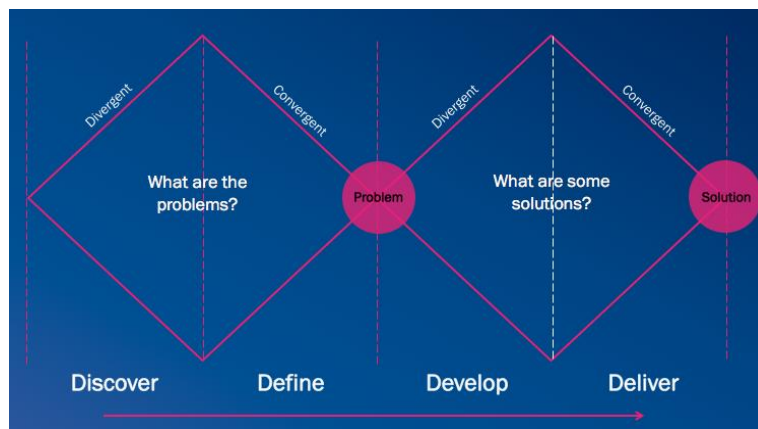

Figure: "Double diamond" strategy

The double diamond is another method for brainstorming, focusing on discovering problems, and finding solutions to those challenges. In general, each problem follows a three steps process; analyzing a goal or problem, developing a strategy, and applying it.

The *Discover* phase, which is an expansion phase, is the addition of all information on relevant subjects to the project. After all information is gathered, begin narrowing it down in the *Convergent* phase. This is the *Define* phase where the problem will have crystalized into one topic.

The next step is the *Develop* phase, which is the creation of possible solutions. This is the secondary expansion phase. Here is when a list of possible solutions is produced, even solutions that may be considered "bad ideas" have possible merit. As soon as a large list is produced,

begin narrowing down the solutions. This is the *Deliver* phase. After discussing and narrowing the list down, there should be one solution that everyone agrees upon and is the most practical and useful.

This process can be done multiple times on the same subject, if necessary. It may become unproductive and pointless if done too many times. Take a break, try again next week, leave the subject entirely, or find a new way of presenting the issue. It's not recommend to treat the subject like "beating a dead horse". This may feel like a slow and cumbersome method, however it is effective at generating non-standard solutions and can prove very effective. Consider inviting students or other people to participate for new perspectives (Heffernan, 2017).

Another strategy implemented was the creation of S.M.A.R.T goals. These are methods of organizing coherent-actions and general processes to move the organization forward. SMART is an acronym of the following:

- **S**pecific (*simple, sensible, significant*).
- **M**easurable (*meaningful, motivating*).
- **A**chievable (*agreed, attainable*).
- **R**elevant (*reasonable, realistic and resourced, results-based*).
- **T**ime bound (*time-based, time limited, time/cost limited, timely, time-sensitive*).

This strategic style has recently become popular in United States corporations as an effective tool for business and management. It is a focused goal that targets one small section at a time. This strategy is not for large projects, but rather for smaller projects. "Promoting education in the Chiriquí province" is not an example of a S.M.A.R.T. goal, due to the fact that it is too broad, making it difficult to measure. "Informing 10% of farmers in a five kilometer radius of Batipa about the benefits of ecological farming and how it could improve their land to be done by 10/29/2019" is an example of a S.M.A.R.T. goal because it has a specific area, is a measurable goal, and is time dependent. Achievability, relevance, and reasonability also play a role to see if the solution is viable (Mindtools, n.d).

Batipa in the Future

Currently at Batipa, there is only a small cabin with a small gazebo, attached via a breezeway. There is one building whose electricity is powered by a generator and lacks Wi-Fi. However, there are plans for the construction of a lecture hall and dormitories. As for cell

service, most local providers cover the area and receive either three or four bars of 4G connection.

With a large list of projects and aspirations, Batipa will go through a lot of changes and improvements over the next 25 years. Although it would be great to complete all projects immediately, that simply cannot happen. Here is the direction our project team believes Batipa can go over the next 5, 10, and 25 years. These are just generalizations and involve ideal circumstances, of course if further problems and projects emerge then the list will change.

Here is where we would like to see happen at Batipa over the next five years. The first is a good word of mouth reputation for all enterprises on the peninsula. This would be important in attracting local farmers to learn Batipa's techniques and begin the sapling program. Another thing we want to see is a stable market found for the young, trimmed trees involving further milling to customer's demands. This would involve the mill to have a permanent location, ideally in the center of all growing zones. Within five years the project team would like to see Batipa purchase a new/used chipper and begin chipping all brush after harvesting and selling all created chips/mulch to a domestic buyer. Another proposal is to see that the Cabimos are overhauled, including a new clay tile roof and strengthening of unbalanced posts in the breezeway. Along with those, we would like to see hard wired lights and outlets installed in the Cabimos, powered by the on-site generator. We would like to see the monkey bridges fully grown with vegetation and troop movement being monitored by the corridor volunteer program that would be re-initiated. After a successful 2019-2020 MQP involving the design of an animal crossing bridge, within five years we would like to see a passed motion to construct the designed bridge across the Pan-American Highway at a location of a complete, natural passageway. And lastly, within five years the project team would like to see the website completely redesigned including small ecotourism packages and academic courses available. We would like to see the consolidation of the Batipa websites into a single site that contains important information, to make it easier to reach and research Batipa Field Institute.

Within 10 years, the project team would like to see massive improvements, as the five-year plan would improve the infrastructure of Batipa and lay down a foundation for the new recreational ecotourism initiatives. In 10 years, through the sapling program, we would like to see "partner farms" showing up to Batipa. With this, it would mean better soil health along the Gualacan Corridor with fewer landslides damaging roads and structures. With an increasing

reputation as an ideal example of ecologically friendly agriculture, relationships between Batipa and other domestic and international research stations have formed, exchanging information and inviting research teams to the peninsula. As for teak milling, in 10 years we would like to see full milling on-site with more specialized equipment being ordered and utilized, such as a large scale automatic mill or skid steers to move mulch. The project team believes that within a 10-year time frame, the animal crossing bridge would be fully constructed with foliage starting to grow along it. The Cabimos should be powered by solar energy and have available Wi-Fi within 10 years, being used for tourist activities, which now involves larger packages such as three day or one week itineraries. Besides the Cabimos, the lecture hall and dormitories are being built on-site.

This is where we would like to see Batipa in 25 years in an ideal situation. This would be the third cycle of teak tree harvesting of certain zones, so by now there is a healthy cloning process with good genetics throughout the plantation. When it comes to harvesting and milling, there is a full mill on-site with custom milling orders being fulfilled along with a full lumberyard of milled pieces and various mulches present. As for the Gualacan Corridor in 25 years, there is minimal erosion caused by pasture creation and there are more complete, natural passageways present from Batipa to Fortuna. Local partner farms would now be harvesting their saplings of teak and pine, and either selling the wood to Batipa or giving Batipa a small portion of their profits back to Batipa. In 25 years, the project team believed that the dormitories and lecture hall be built and used to house academic tourists and hold courses and seminars in. By 25 years, there should be a steady stream of both academic and ecotourism at Batipa.

Even though these are suggestions in an ideal situation, even if half of the recommendations above would prove substantial to the improvement of Batipa, both on-site and reputation. By using strategies to focus and accomplish a smaller number of projects, the challenges will be solved more quickly than spreading resources too thin and getting bogged down by the increasing list.