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Interacting with the Trail: A Comprehensive Approach to Developing an Environmental Education Program for Agnolakely Private Nature Reserve

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SIT Study Abroad

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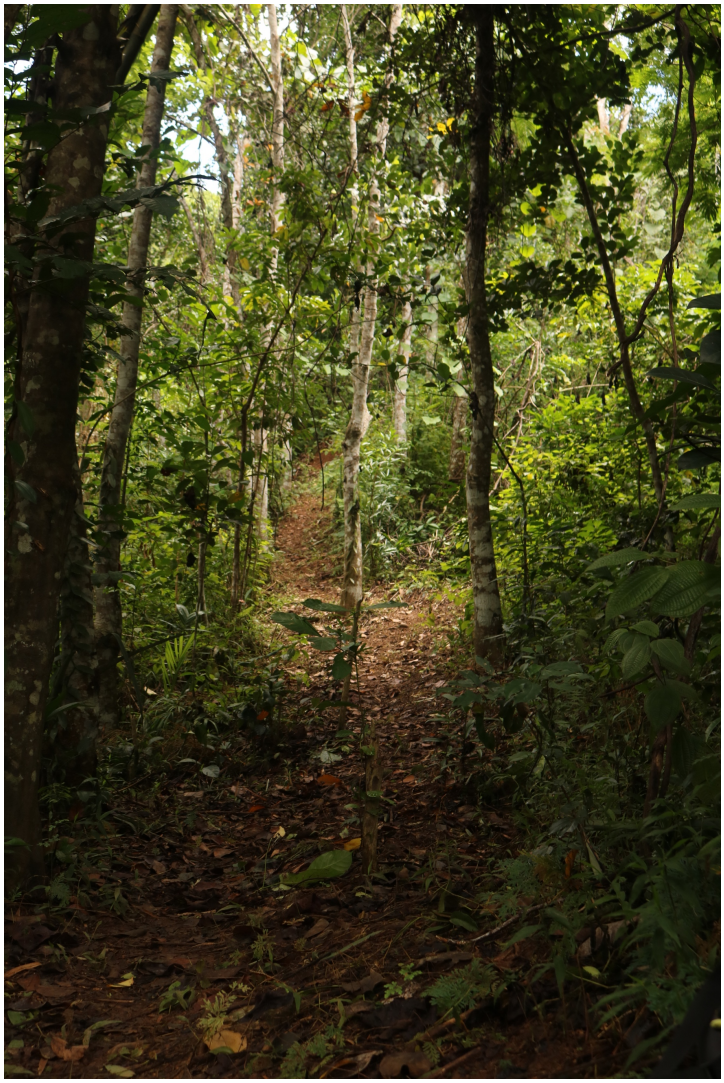

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Abstract

Madagascar is a diverse island, biologically and geographically. This has led to the development of endemic species and high biodiversity within the landscape. Unfortunately, due to poverty, extraction of natural resources, and a growing population, these species have become threatened. Agnolakely, is a private nature reserve, located in eastern Madagascar that is trying to combat these challenges through reforestation projects and land protection. Agnolakely is not only of ecological value, but is also integral in the community structure. As Agnolakely expands it has become essential to implement education and outreach for the reserve. This study was designed to collect biological and social information about Agnolakely and the surrounding area to inform educational and published materials. The development of the educational materials for primary school aged children were based on research supporting experiential learning and links between the environment and the community. Trail activities, pre- and post- lessons for primary schools, a field guide, and a brochure were created using the information from this study.

Introduction

Madagascar is home to a diverse array of animal and plant species. On the island, there are five main biogeographic regions encompassing environments such as humid forest, savannah, deciduous forest, spiny forest, wetlands, and coastline (Behrens & Barnes 2016). Species have evolved to fill the niches within each of these ecosystems. This has led to a high level of endemism. Eighty-five percent of plants, 100% of mammals, 53% of birds, and 95% of frogs are endemic to Madagascar (Rakotomanana, Jenkins, & Ratsimbazafy 2013). Yet, due to the increasing threats of poverty, natural resource extraction, and a population expected to reach over 53.6 million in 2050, these species are constantly in danger of habitat loss (Rakotomanana, Jenkins, & Ratsimbazafy 2013; Rakotovao, Rakotoariseheno, & Andrianarivo 2001). The once

bountiful and plentiful forests of Madagascar now only compose 25% of the terrain (Rakotovao, Rakotoariseheno, & Andrianarivo 2001). These threats combined with the biodiversity on the island has led to its classification as a global hotspot by the World Conservation Monitoring Centre (Rakotovao, Rakotoariseheno, & Andrianarivo 2001).

As the global community recognizes the biological significance of Madagascar, there has been an increase in conservation. Historically, conservation in Madagascar has changed with the ever-evolving political regime and international influences. It was not until the 1990s, that there was a shift for communities to become involved in the conservation process (Rakotomanana, Jenkins, & Ratsimbazafy 2013). Rakotovao, Rakotoariseheno, and Andrianarivo note that to exclude the people from conservation is to ignore a significant principle of biodiversity protection (2001). Essentially, if a program is able to assist the people in a manner which they no longer must resort to unsustainable logging or slash and burn practices the threats to the forest could be diminished. The protection of the forest is linked with the conservation of biodiversity as the loss of primary rainforest is the foremost threat to the island's plants and animals (Harper *et al*. 2007 in Rakotomanana, Jenkins, & Ratsimbazafy 2013).

Agnolakely is an attempt to preserve and restore Madagascar's rainforest. This six hectare private nature reserve located in Manantenina, a village in eastern Madagascar, began as a ½ hectare of ancestral land that has become a home to a diversity of species (J. Tonkasina, personal communication, April 12, 2018). The reserve is situated in the Lokoho valley known for the humid tropical forests in the region and home to the Tsimihety people (Neuvy 1989; Wilson 1971). Agriculture is the main form of subsistence and income for the Tsimihety. This reliance on agriculture and the rising population has increased the prevalence of slash and burn practices which are not only causing deforestation, but water pollution, and erosion (Laney & Turner

2015; Rakotondrabe 2015). Jaques Tonkasina, property owner of Agnolakely, noticed these effects on the landscape and began accumulating more land in 1999 to protect it from the rising threats. It was not until 2014 that Agnolakely was recognized as a private reserve (J. Tonkasina, personal communication, April 12, 2018).

With the continued expansion of the reserve, the need for education, outreach, and support for Agnolakely has heightened. Conservation education can take on two forms as stated by Lehnhardt (2015). The first is to influence the audiences' feelings about the environment. While the second is to spread awareness in efforts to improve natural resource management (Lehnhardt 2015). The environmental educational materials created for Agnolakely embrace these goals with the hopes of shaping positive behaviors in the primary students who visit. This study aimed to take a biological and social approach to assess the value of Agnolakely while developing an interactive trail within the reserve, educational materials for local primary schools, and a brochure. The goals of this study were to identify key species within Agnolakely, the social value of the reserve and the forest in general, and how Agnolakely could promote learning and outreach in primary schools and the community.

Methods

Nine Bushnell Trophy Cam HD camera traps were used in Agnolakely for 14 days beginning on April 2 through April 15, 2018. Each camera location was chosen because it was described as key animal habitat by Tonkasina. The locations were spread out along the trail in a fashion which enabled them to capture more area as advised by Nichols, O'Connell, & Ullas Karanath (2011). The cameras were set to be activated by motion only. GPS points were taken for each camera. Cameras were checked on days: 2, 4, 7, 11, and 14. During each check, all images from the memory card were uploaded to a laptop on-site and the memory cards were re-

inserted immediately after. The images were analyzed out of the field. Images of integrity had evidence of species present. False triggered images were removed from the data set. After the first two days of being active, the detection levels were amplified from normal to high based on recommendations for high temperature conditions from Bushnell Outdoor Products (2012). An advantage of using the camera traps was the non-invasive approach to a 24-hour monitoring system which could detect both nocturnal and diurnal species (Nichols, O'Connell, & Ullas Karanath 2011).

The biological inventory was done with assistance from a local guide. All plants within sight of the trail were identified by their local name. Reptiles, amphibians, lemurs, and birds were identified by sight and their calls. Two night hikes were performed in the same manner to monitor for nocturnal species. After the inventory, each local name was matched to the scientific name of the species using Rohwer (2000) and Glaw & Vences (2007) for the reptiles, amphibian, and plant classifications. Species found were put into tables with their local and corresponding scientific names. When the scientific name could not be found an "x" was paired with the local name in the tables.

Trail maps and the limits of Agnolakely were created with a Garmin Etrex 2000-2010 series Global Positioning System. Points were marked beginning at the start of the trail and then at each point where direction changed. Each corner of the boundary was recorded with the help of the property owner, Tonkasina. One GPS point was excluded from the data set as it was located outside of the area observed. Afterwards, Google Earth was utilized to make a map of the trail and boundaries using all of the recorded points.

Forty structured surveys were conducted with twenty individuals from Manantenina and twenty individuals from Mandena. Individuals were chosen at random. Each interviewee was

informed of the purpose of the survey. A translator was used for all interviews. Questions were asked in French translated to Malagasy and the answers were translated from Malagasy to English. There were 8 structured questions asked within 10-15 minute interviews. Graphs and summaries of the responses were used for analysis. The structured surveys were conducted from April 7-10, 2018.

Key stakeholder interviews were held at the Manantenina and Mandena primary schools as well as with the owner of Agnolakely. Four teachers and the head director were present for a focus group in Manantenina. Due to time constraints and school scheduling, only the head director of the primary school was interviewed in the Mandena school district. Both of these meetings were approximately 30 minutes and used a translator. The interview held with Tonkasina, the owner of Agnolakely, was unstructured and conducted in English without the use of a translator.

Ethics

All the interviews and focus groups were anonymous. Each participant was informed the interview was a voluntary activity and asked if their responses could be used in published material. Oral confirmation was obtained for each interview. The individual interviewees were randomly chosen, while the participants of the focus groups were targeted based on their relationship to the local educational system. No names were used in the promotional material or the report except for that of Tonkasina whose ownership of Agnolakely required him to be accessible for future communications. Rapport within Agnolakely consisted of following the "Leave No Trace" policy.

Results

Camera Traps

The locations of the camera traps are shown in Figure 1. Over 300 images were collected from the camera traps. No species were identified in any of the photos from the camera traps. Leaves and tree branches seemed to be the key activators of the camera sensor.

GPS Mapping

Thirty-five GPS points were taken to mark the boundary of Agnolakely (Figure 1). The trails were mapped with 75 GPS points (Figure 2). Trail A, as shown in Figure 2, is the main trail within Agnolakely. While Trail B consists of side trails that were created during the period of this study. The peak elevation recorded was 181 meters.

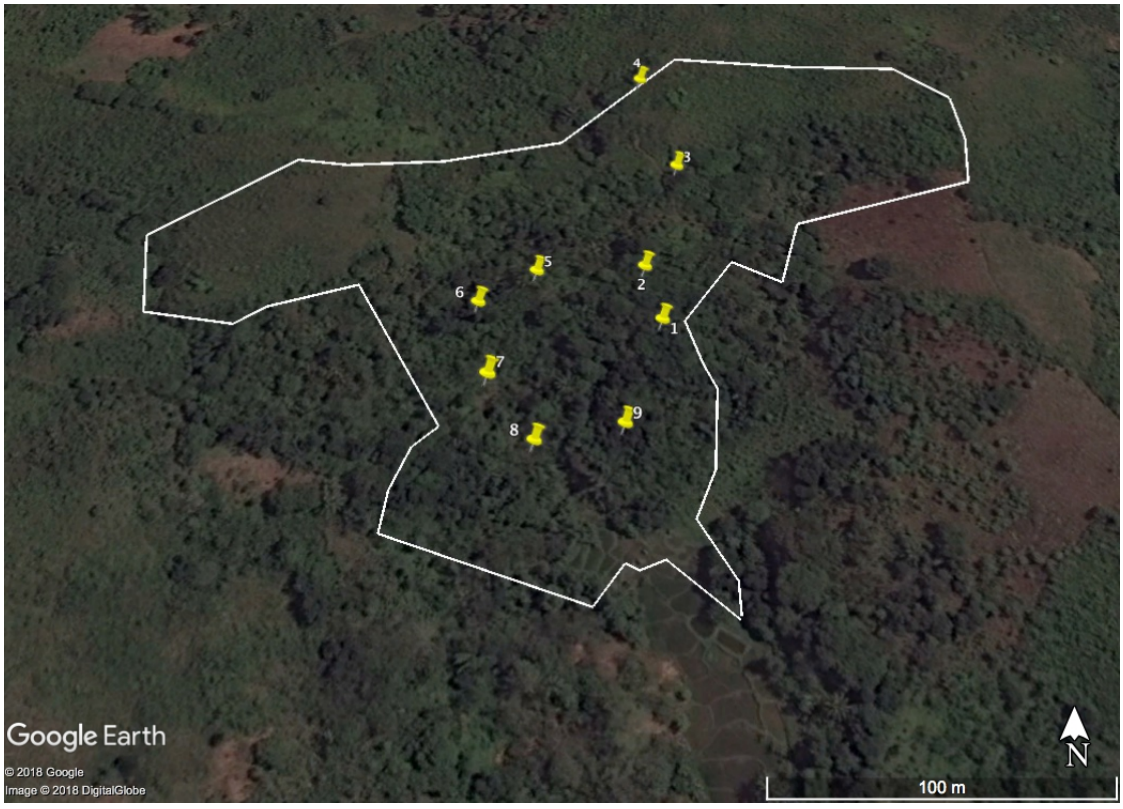

Figure 1. Locations of 9 camera traps within the boundary of Agnolakely Private Nature Reserve from April 2-April 15, 2018 in Manantenina, Madagascar.

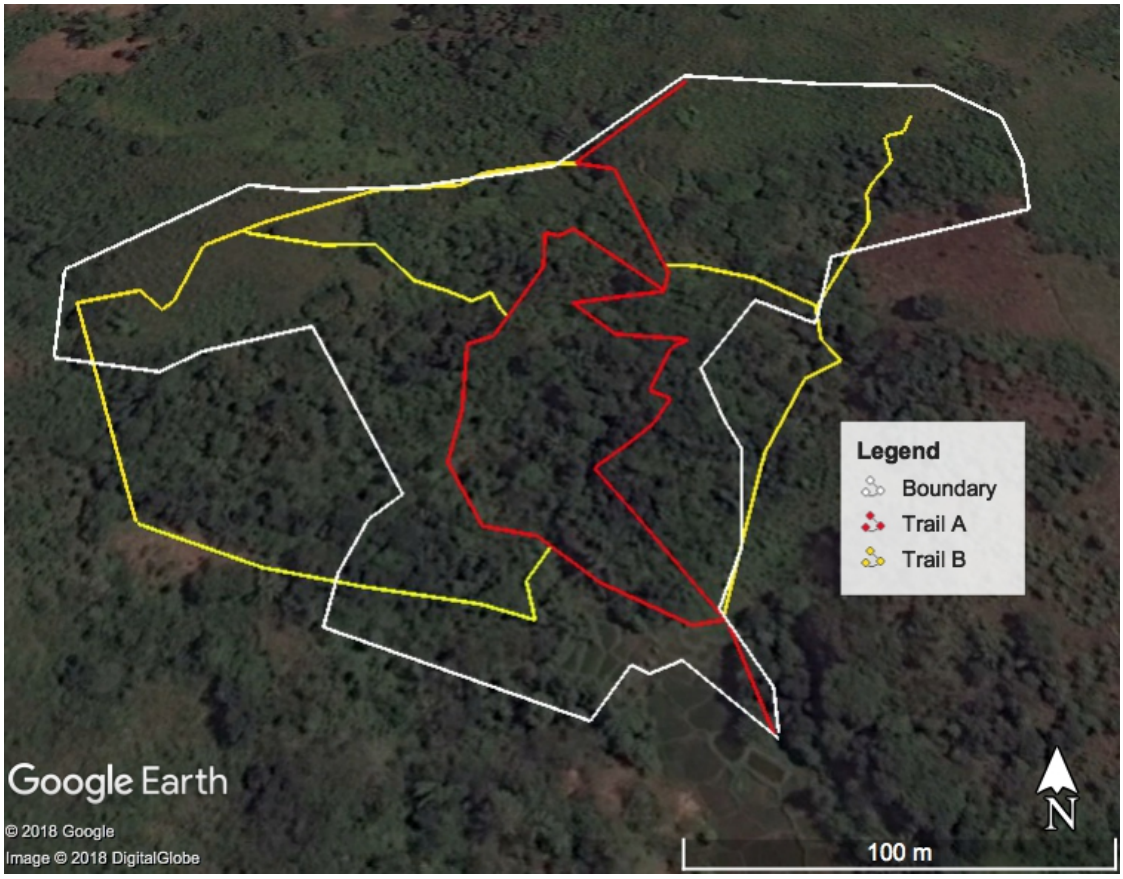

Figure 2. Trails within Agnolakely Private Nature Reserve from April 2-April 15, 2018 in Manantenina, Madagascar.

Biological Inventory

During the biological inventory, 10 frog species, 11 reptile species, 4 mammal species, 22 bird species, and 81 plant species were detected within the boundary of Agnolakely (See Appendices Table 2, 3, 4, 5, 6). Both, *Cheirogaleus sp*. and *Hapalemur griseus,* were lemur species found in the reserve.

Structured Surveys

The first question in the structured interview assessed the general values of the community. Interviewees could answer with more than one response; therefore, all responses were grouped into categories based on the number of times issues were mentioned. Most of the people surveyed believed values surrounding the community were highly significant in their lives (Figure 3). Community values included answers related to avoiding stealing, fighting, and

killing. The second highest category was the environment in which common topics were honoring forest etiquette, planting trees, and animal well-being. These were followed by values of health, religion, livelihood, and law.

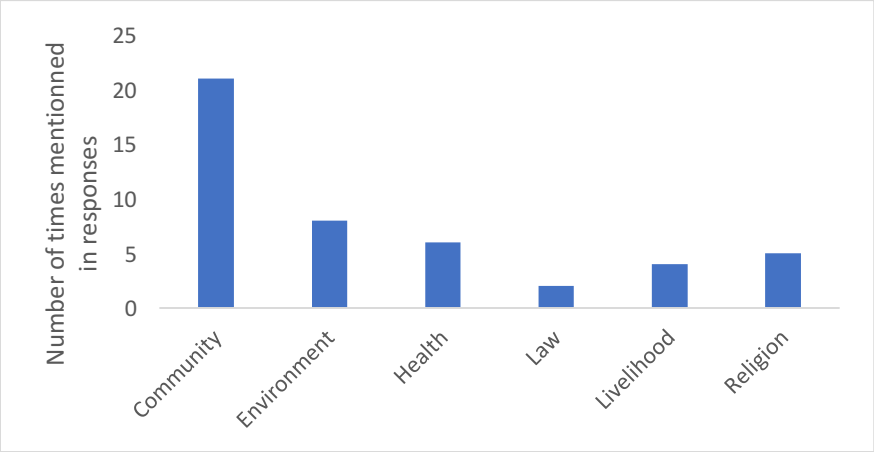

Figure 3. Number of responses for topics relating to core values in Manantenina and Mandena from April 7-10, 2018.

The most dominant issues in the community were grouped into categories based on their prevalence. Environmental issues were mentioned most with eleven of the twenty-one responses pertaining to water quality (Figure 4). It was followed closely by development challenges including isolation from trade, lack of access to a hospital, and poor road conditions.

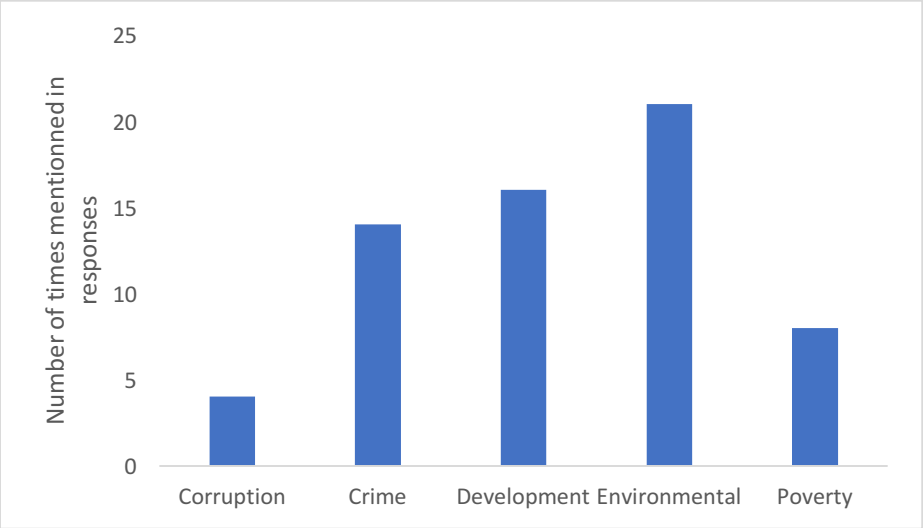

Figure 4. Number of responses to the issues grouped by category in Manantenina and Mandena from April 7-10, 2018.

The third question pertained to how does one interact with the forest. Most people used wood from the forest for construction and charcoal. The primary use of land within the forest was agriculture such as plantations of rice and vanilla. Additionally, some of the plants within the forest have medicinal qualities that the community uses them for. Lastly, one respondent's answer was that by not using the forest it produces clean air and water.

Overall, the majority of children go to the forest according to their parents. Only 5 interviewees said their children did not go to the forest due to them attending school or being too young. One interviewee did not have children. The children who went to the forest were there to work, follow their parents, or collect fruit.

Fadys pertaining to animals restricted the consumption of animals such as zebus without horns, tenrec, certain birds, eels, lemurs, *Fossa fossana*, hooved animals, snakes, lizards, and chameleons. Some of the animal fady were specific. For example, a woman cannot kill a chicken in the forest. Another faday was if an aye-aye comes out during the middle of the day it must be killed. One person did not kill any animals except for livestock.

There were more types of fady concerning forest conduct. For certain people, work in the forest cannot take place on Tuesdays, Thursdays, Saturdays, and Sundays. Other forest fady involved the restriction of places to defecate, not permitting menstruating women to wash in the river, harvesting wood, and disposing of food waste. One individual explained that hurting a chameleon was fady because they do not have ears. Therefore, there is no method to talk to the ancestors through the chameleon. There are also holy places in the forest in which one should not touch or speak in. Some correspondents mentioned there was less fady now than in the past due to the increased number of Christians.

There was a question referring to the traditional stories of the surrounding forest. Eighteen respondents recalled when the forest enveloped their village, a long time ago, and associated this with less disease, clear water, better climate, and more animals. One respondent referred to the changing of Madagascar's name from the green island to the red island as the loss of forest has led to soil erosion. Few tales specifically pertained to family accounts and the history of the forest within Marojejy National Park. Traditionally, one interviewee said, forests are named after things that can be taken from them. Another person told of a place where there was a small tomb for infants where one could walk by and hear the babies cry; however, since the deforestation of the area no one has heard the cries. Additionally, there is one mountain in the region in which no one camps, but people travel there to harvest tobacco which was never planted. Ten people had no knowledge regarding stories about the forest.

All of the forty interviewees said it was necessary to conserve the forest. Water, air, soil quality, climate change, animal habitat and population, and medicinal plants in the forest were mentioned as primary reasons to preserve the forest.

Thirty-three people had heard about Agnolakely, but only 39% of those who had heard about Agnolakely had visited Agnolakely (See Appendices Table 7).

Primary School Interviews

The Manantenina primary school has 258 students (See Appendices Table 8). Each class averaged about 44 students. School begins at 7 am through 12 pm each day. The students in the lower classes were reported to be interested in literature and the alphabet. While older students were engaged more in mathematics. All students were interested in French; however, there is less material for French classes. Teachers have blackboards, chalk, Malagasy texts, French literature, science books, pencils, and copy books. Students have their own personal mini-chalkboards. The most challenging problems for the school were the proximity to the road, the lack of fence, and dated materials. Traffic and people caused distractions from learning. Despite these problems, the teachers were still able to integrate environmental education into the classroom, even though it is not officially in the schedule. They have discussed climate change, waste, and water issues. All the teachers were willing to visit Agnolakely. Additionally, they would have time for an hour lesson pre-visit and 30-minute lesson at the end of a visit to the reserve.

In comparison to Manantenina primary school, the Mandena primary school taught 546 children with an average of 110 students per class (See Appendices Table 9). The school start and end time is the same as in Manantenina. Mandena primary school struggles with old material, availability of recreation equipment, and lack of funds. The school is able to supply protractors, rulers, and blackboards for the teachers. According to the director, the students in Mandena were most interested in geography. Teachers have taught about environmental issues on a weekly basis such as how does one live in the region. The school cooperates with the Duke Lemur Center SAVA Conservation, Lemur Conservation Foundation, Marojejy National Park,

and Tonkasina from Agnolakely. The director was very enthusiastic and understands the necessity of environmental education. He plans to have the students visit Agnolakely. Before the field trip to Agnolakely, teachers would have 25 minutes and after the visit only 7 minutes for a lesson.

Key Stakeholder Interview

Tonkasina inherited ½ hectare of land from his parents' parcel. In 1999, he began reforesting the terrain as he saw the need for conservation in the area. It was not until 2012 when Tonkasina began buying more land for reforestation which is now around 6 hectares. Tonkasina said the threats to biodiversity in this area are slash-and-burn agriculture, cyclones, the hunting of tenrecs and lemurs, and stealing wood from the forest. In 2014, he was able to make his plot of secondary forest into a private nature reserve, Agnolakely. The name of the reserve describes its location. Agnolaka is to be hidden and kely means small because it is only after one crosses the Manantenina River and walks along a path surrounded by rice and vanilla fields that one can discover Agnolakely. Tonkasina not only performed reforestation projects within Agnolakely, but also uses it for cultivating vanilla. Within the reserve, he believed there were several key species of plants and animals which are starred in Tables 2-6 in the Appendices. In addition to these species, he has also identified mouse lemurs, mongoose, *Fossa fossana,* fossa, the Madagascar boa, and the Madagascar tree boa in Agnolakely. He felt these animals were significant species to include in the educational materials as well, even though they were not seen during this study. His hopes for Agnolakely were to expand the reserve and make it more accessible for visitors and students. Tonkasina said Agnolakely is a part of his own story that he will leave behind and both stories will continue when the land is inherited by his children.

Analysis

Information from the inventory and the interviews were used as a foundation to what activities and lessons would be most useful and possible given the surrounding environment. As community values and environmental issues were the most significant in the villages, lessons were structured to teach how improving and maintaining one's environment can be beneficial for the community. Minimal supplies are needed for the activities as schools already were challenged to meet the needs of their students. The large class sizes were considered when recommending group size and number of adults present to aid and explain the activities on the trail. The group sizes were set to 8-10 participants for the activities as it is likely there will 40-100 children per visit. Educational materials assumed children had some exposure to the forest or environmental education based off the responses from interviewees, the focus group, and the director of the primary school. Additionally, the lessons for the primary schools were designed to take 30 minutes considering the time both schools had available to allocate to them.

The trail activities and lessons take into account the learning styles and developmental stage of primary school students in order to create age appropriate effective activities. Generally, learning is classified into three different categories: auditory, visual, and action-oriented. By implementing multiple modes of learning into one lesson, educators can reach more students on a deeper level (Domroese & Sterling 1999). Primary school children range from developmental stages of early to middle childhood. Early childhood begins at age 3-6, while middle childhood continues through 7-10 (Domroese & Sterling 1999). Often times role-playing and learning through senses are most beneficial for younger children (Domroese & Sterling 1999). These types of activities can take on a form which encompasses the three types of learning categories mentioned previously. The older children within this age range tend to also have a sense of right

and wrong associated with certain behaviors (Domroese & Sterling 1999). The trail activities were constructed with this in mind. Therefore, during the hike through Agnolakely, the guide is essentially giving an interpretive presentation by leading the students through activities while simultaneously teaching them environmental concepts and human behaviors that can cause or prevent environmental damage. The concepts range from those of general environmental factors to those specific to Agnolakely including: dams, lemurs and animal habitat, biodiversity, deforestation, and rice and vanilla.

Each trail activity includes the general location where it could be performed, a summary, learning objectives, background knowledge of the theme, instructions, a conclusion, and references for the activity (See Appendices Figure 5 and pages 31-35 for map and detailed outline of activities). Along Trail A, one of the first sites the students walk by is the dam. The dam's role as a water source for surrounding rice fields is important for the community. This function as a social tool in addition to the community's concerns about water made it a key educational site. After the dam, students walk through the forest to a small bamboo plantation where it is common to find bamboo lemurs. The presence of lemurs is an essential topic as bamboo lemurs are one of the main species in Agnolakely according to Tonkasina. The lemur and animal activity for the trail includes the retelling of animal fady which were dominant in the interviews and how they can be a way to protect species. Thirdly, an activity regarding conserving biodiversity in a local and global context was constructed for students. In the interviews, all correspondents agreed the forest was necessary to conserve. Therefore, educating the students on how the forest connects to a broader theme of biodiversity allows them to deepen there understanding by knowing "why" the forest is important. Next the students will partake in a game which focuses on issues of erosion and deforestation. Through this activity, students will

learn about the negative social and ecological consequences of deforestation. Lastly, rice and vanilla were chosen as a theme due to agriculture being a primary use of the forest. The activity stresses the different conditions necessary for growing each crop and using natural features of the terrain such as trees and the lowlands. All of these activities were structured using both the social and biological data collected.

Before visiting Agnolakely, a general knowledge about primary and secondary forest will help form building blocks for what the students will see in the reserve; while the lesson after the visit aims to link all the activities and concepts (See Appendices Pre-Visit: Primary and Secondary Forest and Post-Visit: Web of life). The pre-lesson for the primary schools uses guided imagery. The story recounts the history of the surrounding forest and how it has changed through time affecting the animal species and the villagers. Each phrase aims to take the students step by step through what they see and feel throughout the story. The goal of guided imagery is to have listener's go on a journey (Domroese & Sterling 1999). In this case, the students are experiencing a journey through time as well as listening to the history of their region. Additionally, the post-lesson activity is a game which requires students to draw links between all the elements of Agnolakely. The most successful environmental programs are those which can make connections, discuss local and worldly issues, and have a theme (Neal & Palmer 1994). By describing multiple connections between the elements, students will be more likely to remember the environmental and social concepts related to Agnolakely.

Additionally, a small supplemental field guide for students to use on the trail was created (See Appendices Agnolakely Field Guide). The species listed were some of the ones noted by Tonkasina as important to the reserve. Availability of images for the species was also taken into account when designing the field guide. The French names of species were included when

possible as French was a subject the students were interested in learning according to the teachers in Manantenina. If possible the brochure should be laminated as it will be more conducive to the rainforest environment. Additionally, when laminated the back of the second page can be used for notes along with a dry erase marker instead of paper and pencil during the activities. The primary aim of the field guide is to empower the students with knowledge as soon as they begin their trek through Agnolakely by identifying species on their own.

The information on the brochure includes the fundamental facts about the reserve and how it contributes to the surrounding community (See Appendices for brochure). The GPS maps of the trail and the mention of 128 species present in the reserve were included in the brochure to highlight what visitors would see and do at Agnolakely. Tonkasina's accounts of the goals of Agnolakely were also incorporated to show the visitors who and what they would be supporting by coming to Agnolakely. The brochure follows the recommendations from Harford and Baird (1997) who state slimmer pamphlets with more pictures tend to be more effective.

Discussion

> "It is vital to recognize that actively involved people generally undergo far greater development of abilities, understanding and environmental commitment for the future than do passive receivers of information . . ." Malcom (1990 in Neal & Palmer 1994).

It is with this attitude in mind that this study and the associated materials were designed. As the challenges for conservation in Madagascar escalate, it has become necessary to find an answer which places equal importance to the people who inhabit the island to that of the biodiversity on the island. By including interviews with the community and schools in addition

to a biological and geographical assessment of the land, the materials are representative of all major elements of Agnolakely. People and specifically the students who visit Agnolakely will need to make decisions based on a comprehensive approach and cannot be expected to only make choices based on biodiversity conservation. The objectives of the educational materials are for students to learn on their visit to Agnolakely and have an experience which has a lasting impact on their lives.

It is recognized that after implementing the activities and lessons, they may need to be modified to meet the needs of the students and educators. Over time after assessing the effectiveness of the activities and the children's responses to them, activities may need to be removed or added to enhance the learning experience. These changes should take place at the discretion of the educators who are working on the trail and in the classroom. Educators in both places should communicate about the transfer of knowledge from Agnolakely to the classroom and the conduct of students outside the classroom as past experiences influence people's decisions when faced with new situations (Boud & Miller 1996). Ideally, each student's education about Agnolakely will impact their decisions in the future and will be reflected in their behavior. The success of this program can be assessed by the positive or negative comportment from the students in regards to the environment after their visit.

Investing in education for primary students is only one step for promoting Agnolakely and conservation. Integrating more programs targeting the community as a whole will result in supplementary benefits for the reserve. When a nature reserve makes education a primary objective the benefits of the program outweigh the costs (Tudor 2014). Agnolakely would profit from investing further time and money into education. Furthermore, incorporating and instilling a community centered environmental education program can encourage a sustainable model for

positive environmental change in a region (Andrews, Stevens & Wise 2002). Therefore, the environmental benefits Agnolakely could receive from additional educational programs have potential to make a larger scale impact. The communities of Manantenina and Mandena have already voiced the need for conservation in reference to the changes to water quality, soil fertility, climate, population health, and animal populations and habitat in the region. Programs aiding and educating the adults in addition to the children will target the people who live and use the land now and in the future.

Looking ahead, it is necessary to complete more thorough surveys regarding the biodiversity within and community surrounding Agnolakely. Due to the short time period and the primary objective to create educational materials, a detailed and scientific method for observing plant and animal species was not conducted. Therefore, it is probable some species within the reserve were not identified. Focused studies will provide more complete knowledge on the flora and fauna in the area. Camera traps could also be utilized again in Agnolakely to aid in these studies; however, it is essential the cameras are in the field for a longer period of time and in areas of low interference from tree branches. False triggered images by leaves were primary activators of the cameras' sensors in this study. Likewise, studies which have the capacity to interview children directly about how they view the environment and their learning experiences in nature are essential in tailoring more activities and lessons to their needs. When thinking about creating adult educational programs, more surveys and interviews would need to be performed in the area regarding the logistics and content of a sustainable education program.

This study was successful in developing the needed starting materials for Agnolakely by taking steps to build biological, geographical, and social knowledge about the nature reserve. With continued studies and use of the materials, modifications to the activities, lessons, field

guide, and brochure will need to be made. Moving forward, building an educational program which encompasses the adults in the community has potential to incur more benefits within and around Agnolakely. By making the people active participants of conservation, they will not only have the knowledge to make informed decisions, but experiences to reference them to.

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Appendices

Table 1. Parameter and setting of camera traps in Agnolakely from April 2-April 15, 2018.

Parameter	Setting
Mode	Camera
Image Size	5M Pixel
Image Format	Full Screen
Capture Number	1 Photo
LED Control	Medium
Interval	10 seconds
Sensor Level	High
Time Stamp	On
Field Scan	Off

Table 2. Scientific names of frogs identified in Agnolakely Private Reserve from April 2-15, 2018 in Manantenina, Madagascar. Starred names were identified by Tonkasina as important to include in educational material.

Scientific Name
Boophis sp.
Boophis madagascariensis
*Heterixalus madascareniensis**
Mantidactylus sp.
Mantidactylus albofrenatus
Mantidactylus opiparis
Platypelis barbouri
Platypelis grandis
Pytchadena mascareniensis
Stumpffia tridactyla

Table 3. Scientific names and local Malagasy name of reptiles identified in Agnolakely Private Reserve from April 2-15, 2018 in Manantenina, Madagascar. Starred names were identified by Tonkasina as important to include in educational material.

Scientific Name	**Local Name**
*Brookesia karchei**	Ranovary
*Calumma nasutum**	Ranovary
*Dromicodryas quadrilineatus**	Bibifaly
*Furcifer pardalis**	Amboalava
Ithycyphus perineti	Bibi menatapaka
*Leioheterodon madagascariensis**	Montingora
Paroedura sp.	Antsatsaka
Phelsuma guttata	Antsatsaka
Phelsuma lineata	Antsatsaka
*Phelsuma madagascariensis **	Antsatsaka be
Zonosaurus madagascariensis	Androngo

Table 4. Scientific names and local Malagasy names of mammals identified in Agnolakely Private Reserve from April 2-15, 2018 in Manantenina, Madagascar. Starred names were identified by Tonkasina as important to include in educational material.

Scientific Name	**Local Name**
*Cheirogaleus sp.**	Tsitsihy
*Hapalemur griseus**	Bokombolo
*Setifer setosus**	Sokina
*Tenrec ecaudatus**	Trandraka

Table 5. Scientific names and local Malagasy names of birds identified in Agnolakely Private Reserve from April 2-15, 2018 in Manantenina, Madagascar.

Scientific Name	**Local Name**
Accipiter madagascariensis	Firasa
Apus balstoni	Manavy Andro
Butorides striatus	Voronpantsika
Centropus toulou	Monjo
Corythornis vintsioides	Vintsirano
Dicrurus forficatus	Ehidronga
Falco newtoni	Hitsikitsika
Foudia madagascariensis	Fody
Hypsipetes madagascariensis	Tsokorevena
Ispidina madagascariensis	Vintsyala
Leptosomus discolor	Korombo

Lonchura nana	Antsagireity
Nectainia souimanga	So
Nesillas typica	Boretika
Newtonia brunneicauda	Tentegny
Numida meleagris	Akanga
Otus rutilus	Torotorka
Ploceus nelicourvi	Vorontsaina
Streptopelia picturata	Domohina
Terpsiphone mutata	Sinketry
Vanga curvirostris	Vanga
Zosterops maderaspatanus	Sobery

Table 6. Scientific names and local Malagasy names of plants identified in Agnolakely Private Reserve from April 2-15, 2018 in Manantenina, Madagascar. Starred names were identified by Tonkasina as important to include in educational material. "x" indicates uncertainty of scientific name.

Scientific Name	**Local Name**
Acacia auriculaeformis	Acacia
Aframomum angustipholium	Longoza
Albizia gummifera	Sambalahy
Albizia julbrissin	Albizia
Albizia lebbek	Bonara
Ananas comosus	Ananas
Annona muricata	Voantsokina
Artocarpus altilis	Sahonambo
*Artocarpus integer**	Ampalibe
Asplenium nidum	Ahaka
Barringtonia racemosa (?)	Fotetra
Calophyllum	Ventanana
Canaga odorata	Ylang-Ylang
Ceiba pentandra	Pamba
*Cinnamosma madagascariensis**	Fandravasarotra
Citrus aurantium	Orange
Clitoria	Famihafary
Cocos nucifera	Coco
Cofea arabica	Kafé
Colocasia esculenta	Sahogno
Combretum	Manakobonga
Croton marge	Mongy
Cyathea australis	Fangena

Dalbergia baroni	Hazovola
*Dalbergia louvelli**	Andramena
*Dendrocalamus giganteus**	Valiaha
Dioscorea sp.	Ovy be
Dombeya	Hafotrafotsy
Dracaena reflexa	Hasina mahitso
Dypsis lastellaera	Sera sera
Dypsis sp.	Fontroaka
Elaeis guineensis	Veniveto
Emilia amplexicaulis	Sesia
Ficus	Voarankorevany
Ficus apdocephala	Voara
Ficus politona	Ampaly
Harungana madagascariensis	Harongana
Homalium	Hazombato
Hugonia	Vahintsivory
*Intsia madagascariensi**	Tsararavina
Ixora	Mantalagny
Litchi sinensis	Litchi
*Mangifera indica**	Manga
Manihot esculenta	Mahogo
Melaleuca alternifolia	Ravinbafotsy
*Melicope**	Bilahy
Mimulopsis	Velatra
Musax paradisiaca	Fontsy
Ocotea cymosa (?)	Tsifo
Pandanus sp.	Rambo
Persea americana	Gavoka
Phyllartron madagascariensis	Atoheravina
Pittosporum ochrosiaefolium	Maimbovitska
Psiadia altissima	Dingadinga
Psidium guajava	Gavo
Raphia farinifera	Rafia
*Ravenala madagascariensis**	Ravinala
Rinorea	Hazondamokana
Salacia	Vahy be
Syzygium aromaticum	Jirifo
Syzygium bernieri	Voarotro
Syzygium jambos	Voaseva
Tambourissa amplifolia	Mamoarano
Tambourissa amplifolia	Ambora
*Trachlobium verrucosum**	Mandrorofo

Trema orientalis	Angezoka
Trema orientalis	Angezoka
x	Famahotro akanga
x	Velavelona
x	Ohotro
x	Greselia
x	Mankavia
x	Rangazaha
x	Kakazontainakoho
x	Barabonja
x	Pisitasy kakazo
x	Sakoagnala
x	Maimboloa
x	Sinkaramantingoro
x	Letchi kakazo
x	Kitata

Table 7. Number of individuals who were familiar with Agnolakely pre-interview in a survey in Manantenina and Mandena from April 7-10, 2018.

	Number of Individuals
Familiar	33
Unfamiliar	7

Table 8. Number of boys, girls, and total in each class in Manantenina primary school on April 9, 2018.

	Boys	**Girls**	**Total**
CP1	28	29	57
CP2	24	20	44
CE	31	21	52
CH1	12	21	33
CH2	19	13	32

Table 9. Number of boys, girls, and total in each class in Mandena primary school on April 10, 2018.

	Boys	Girls	Total
CP1	72	71	143
CP2	74	78	152
CE	40	43	83
CH1	45	37	82
CH2	44	42	86

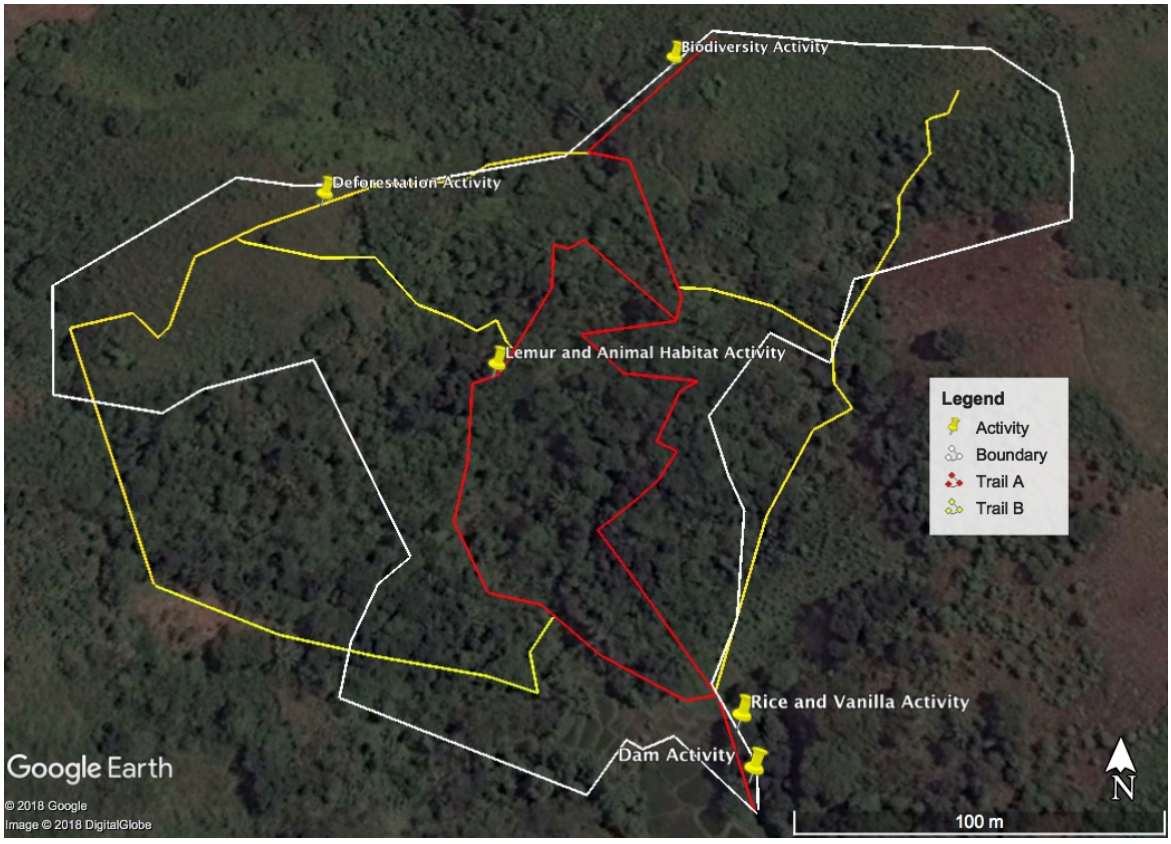

Figure 5. Approximate location of each educational activity in Agnolakely.

1. **Trail Activity:** Dams (Picnic site)
    a. Summary
        i. Students are introduced to the dam in Agnolakely and how it functions.
    b. Learning Objectives
        i. Understand how the dam operates in the rainforest.
        ii. Describe how the dam provides water for rice plantations in the community.
    c. Background Knowledge
        i. The dam, built in 2017, in Agnolakely creates a reservoir for the water from the reserve. Since the rainforest receives high amounts of precipitation, a dam can regulate the water flow from the slope. The reservoir stores water when there is high flow (high precipitation). In times of low flow (low precipitation), the water is gradually released from the dam into the surrounding rice fields.
    d. Activity
        i. Divide students into groups of 8-10. Have two students be the "dam" by holding hands facing each other. The rest of the students will be the "rain water". The other 6-8 students will stand in a line approximately 2 meters from the "dam." The first student will go under the "dam" and the next student will count to 6 before going through. The next students in line will do the same until each student goes through the dam (~5 minutes). Next, have the students repeat the activity, but with only 2 seconds between (~5 minutes). The goal is to have there be a reservoir of students waiting to go through the dam in the second activity.
    e. Conclusion
        i. Discuss how the students who were rain were able to easily go through the dam when there was more time between each student, but when there was less time there was a clump of students waiting to go through the dam. This is how a dam stores water and creates a reservoir in times of high flow. Therefore, surrounding rice fields can be irrigated in both the wet and dry seasons from the dam in Agnolakely.
    f. Reference
        i. Bendewald, M., Born, S., Carlson, D.W., Cooper, L., Dittrich, T.M., Field, K., & Lander, D. (2008). Lesson: Water resources: Why do we build damns?. Retrieved from University of Colorado Boulder, College of Engineering.

2. **Trail Activity:** Lemurs and Animal Habitat (Replanting of bamboo)
    a. Summary
        i. Students will be able to understand the relationship between conserving the forest and animals, especially in the case of bamboo lemurs and the bamboo trees in Agnolakely.
    b. Learning Objectives
        i. Interpret how bamboo lemurs use the forest within Agnolakely.
        ii. Recognize how planting trees and preserving the existing forest is beneficial for the species who live in Agnolakely.
    c. Background Knowledge
        i. In Agnolakely, the Grey Bamboo Lemur uses the bamboo in the forest for a food source. These lemurs are active during the day and can be found in eastern Madagascar as well as dry forest in the west.
        ii. Additionally, mouse lemurs and dwarf lemurs are two nocturnal species of lemur found throughout Agnolakely. Mouse lemurs feed on fruit and are small with a long tail. In comparison, dwarf lemurs are larger than mouse lemurs. These types of lemurs also go into hibernation from May to September during dry season and survive off of fat reserves. Both lemurs can be found in secondary forest like Agnolakely.
    d. Activity
        i. Guide will explain how bamboo lemurs use bamboo trees. If possible will find a bamboo pith to show how lemurs eat the pith of the bamboo stems. Next the guide will demonstrate a bamboo lemur's grunt and help the students mimic the call (~10 minutes).
    e. Conclusion
        i. Without the bamboo in Agnolakely, the lemurs would not have food or a place to live. Conserving the forest not only means there are more trees in the community, but also more animals. Explain how the community also has fady about the consumption of animals such as lemurs. These fadys help preserve animal species and biodiversity.
    f. Reference
        i. Barnes, K. & K. Behrens. (2016). Wildlife of Madagascar. *Princeton University Press*. Retrieved April 16, 2018 from http://www.Jstor.org/stable/j.ctt18z4g0f.13.

3. **Trail Activity:** Biodiversity (Peak of trail)
    g. Summary
        i. Students can explain why biodiversity is important in a global context and why Madagascar has many types of species.
    h. Learning Objectives
        i. Understand the meaning of biodiversity and significance within the rainforest.
        ii. Identify the origins of biodiversity in Madagascar.
    i. Background Knowledge
        i. Biodiversity is the variety of plants and animals that can be found in an area. Through the conservation of biodiversity there is greater chance of medical treatments, economic development, ecosystem services, and adaptive responses being discovered as the world experiences problems such as climate change and poverty.
        ii. Madagascar is known as a global hotspot for the diversity of species it hosts and the threats against them. The combined factors of isolation and a warm humid climate have created an environment for endemic (native or restricted to a certain region) species to fill niches on the island.
    j. Activity
        i. Introduce the concept of biodiversity. Ask the students how their families use plants within the forest. Next, have students sit individually spread out in a small area of the forest. Each student will listen and record (on a piece of paper if available of laminated field guide) how many and what types of animal sounds they hear and draw or describe the plants they see. After ~7 minutes, have students discuss in partners about what they heard and saw (~3 minutes). Then discuss in entire group (~3-4 minutes).
    k. Conclusion
        i. Guide points out and describes the major plant species present, their medicinal uses (if applicable), and sounds in the forest (ex. Types of birds singing). Explain why there are many species present in Madagascar and concept of endemism. Then relate how preserving and reforesting Agnolakely is a part of conserving biodiversity.
    l. Reference
        i. Shah, A. (2014). *Why is biodiversity important? Who cares?*. Retrieved from http://www.globalissues.org/article/170/why-is-biodiversity-important-who-cares
        ii. Godfrey, L. *Isolation and biodiversity*. Retrieved from http://www.pbs.org/edens/madagascar/eden.htm

4. **Trail Activity:** Deforestation (Mango reforestation overlooking slash and burned fields)
    m. Summary
        i. Students will recognize the relationship between slash and burn practices, erosion, and water quality.
    n. Learning Objectives
        i. Observe the impacts of erosion on the landscape and water sources.
        ii. Comprehend how forests and reforestation projects can prevent erosion.
    o. Background Knowledge
        i. Erosion is the process of being degraded by wind, water, or other natural means. In the rainforest, trees help prevent the process of erosion by securing the soil with their roots decreasing the amount of soil loss which pollutes water sources. When trees are removed from the forest the soil is left bare and can more easily erode. The heavy rains cause the soil to wash into the rivers and oceans. High sedimentation in these water bodies impact fish populations and coral reefs. Madagascar is nicknamed the Great Red Island due to the deforestation and exposure of the soil.
    p. Activity
        i. Students will be divided into groups of 8-10. Each group will have one or two people acting as a source of water. In the first part of the activity, the other 6-8 students will be "soil particles". Explain that this is mimicking the process of erosion in areas which have been deforested. Have the students who are soil walk in a line towards the students who are water. Describe how the water has now become dirty. Next repeat the activity and have 3-4 students from the soil group become trees and stand still spaced out in a straight line (~ 1-1.5 meters apart) on the trail between the students who are water and those who are soil. Then have the soil students try to reach the water source by walking on the trail. This second activity should be more difficult and few if any students should reach the water source. A time limit may have to be set for the second activity.
    q. Conclusion
        i. Explain the importance of trees and the forest in the context of water quality for the surrounding community.
    r. Reference
        i. Butler, R. (2012). *Soil erosion and its effects*. Retrieved from https://rainforests.mongabay.com/0903.htm

5. **Trail Activity:** Rice and Vanilla (Picnic site)
    a. Summary
        i. Students will be able to describe how people in their community use the forest strategically to conserve the land and cultivate crops.
    b. Learning Objectives
        i. Understand the different conditions needed to cultivate lowland rice and vanilla in the forest.
        ii. Interpret the benefits of growing vanilla in the forest and rice in the lowlands.
    c. Background Knowledge
        i. Vanilla is a perennial plant which yields after three years. High humidity, shade, and warm temperatures are required for cultivating vanilla. Madagascar is the top producer of vanilla in the world.
        ii. Rice can be grown in various manners. Lowland irrigated rice is grown in Agnolakely. The rice fields should be kept flooded with water in full sunlight. In Madagascar, rice is normally cultivated twice a year.
        iii. Both these crops are grown in and around Agnolakely and are important uses of the forest in this region. People export the vanilla for income and use the rice for subsistence.
    d. Activity
        i. Divide into two groups, one to observe the vanilla and one who observes the rice. Have students note (on paper or laminated field guide if available) the difference in location, surrounding plants, soil, and water needs of each crop for approximately 5 minutes. Then discuss in a large group the similarities and differences (~5-10 minutes).
    e. Conclusion
        i. Summarize group discussion. If not mentioned in the discussion, include the details from the background readings. Explain how planting rice in the lowlands and vanilla on the forest slopes is beneficial because it does not require further deforestation. Describe how each crop supports different needs for the community (ex. Vanilla is income; Rice is nutrition)
    f. Reference
        i. Food and Agriculture Organization of the United Nations. (2018). *What are sustainable rice systems?*. Retrieved from http://www.fao.org/agriculture/crops/thematic-sitemap/theme/spi/scpi-home/managing-ecosystems/sustainable-rice-systems/rice-what/en/
        ii. AgriFarming. (2018). *Vanilla cultivation guide*. Retrieved from http://www.agrifarming.in/vanilla-cultivation/

Pre-Visit: Primary and Secondary Forest

- Definitions:
    - Primary forest: untouched forest that exists in its original condition without impact from human activities
    - Secondary forest: rainforest which has been disturbed (slash and burn, logging, etc.) and woody successional plants have replaced the original plants

- Objectives
    - Students will be able to understand the difference between primary and secondary forest
    - Students can describe why preserving primary forest and reforesting in secondary forests is important
- Resources
    - Paper
    - pencil

- Background:
    - In this region, there are both primary and secondary forest. Marojejy National Park is an example of a primary forest which has been protected. Agnolakely, the private reserve located in Manantenina, is classified as a secondary forest. Reforestation projects within Agnolakely are improving animal habitat for lemurs, amphibians, and reptiles. Primary forest tends to have a wider diversity of species compared to those of secondary forest. However, only 17.6% of Madagascar was covered with primary forest as of 2005.

- Procedure
    - Explain the definition of primary and secondary forests
    - Ask the students if they know any examples of primary and secondary forests in their region, if not give the example of Marojejy National Park and Agnolakely
    - Then read the following text to the students. Read slowly to allow time for them to visualize.
        - Close your eyes and imagine, a long time ago, the rainforest surrounding the village. Smell the ripe mangoes hanging on the trees. As you reach for the mango, you watch the bamboo lemurs and silky sifakas leaping from tree to tree. On the ground, your feet have just stepped on a snake. It feels slimy and you take a step backwards only to find geckos and lizards in your path. You have to be careful as you walk because they are all around the village. In an instant, you see a tenrec sneak under a house. You are very thirsty from you walk and now drink the clean clear water from the river.
        - Now fast forward to today. You can no longer see the rainforest as it is further from the village. Cultivators were forced to cut down and burn the forest to have food for their families. Lemurs cannot be seen from out your window anymore. You haven't seen a snake or tenrec for a month in your

village. Additionally, the water is not safe to drink now, as it has been polluted.

- Instruct the students to open their eyes. State that this story is true and has happened in this region. The first forest was a primary forest like Marojejy National Park.
- Have the students draw a picture of before and after the deforestation around the village
- Ask them if there is a way to reverse the loss of forest and help the animals.

- Conclusion
  - Describe how secondary forests can reduce the impact of deforestation by providing more habitat for animals and decrease water pollution. Additionally, protecting primary forests from extraction like creating national parks can deter further loss of forests.
- Reference
  - Butler, R. (2012). *Types of rainforest*. Retrieved from https://rainforests.mongabay.com/0103.htm

Post-Visit: Web of life

- Resources:
  - ball of string or rope
  - 15 labels: river, soil, tree, dam, frog, bird, lemur, bamboo, chameleon, snakes, lizards, rain, vanilla, rice, person (roles can be added or subtracted based on the number of students)

- Procedure
  - Each student is given a label to hold.
  - Each group is given a string or rope.
  - One student (e.g. the tree) holds the end of the string, then hands the ball to another student (e.g. soil) while stating the relationship between the two labels. The "tree" student is still holding the end of the string while the "soil" student holds the remain ball of rope or string.
  - Next, the "soil" student passes the ball to the third child, making another statement while still holding the string.
  - The rope continues to be passed back and forth to all students with a statement being made after each pass.
  - Children can be passed the ball multiple times as their label will have multiple connections.
  - A web will be created in the end.
    *it is important to hold the web tautly

- Conclusion
  Explain how all these elements are a part of Agnolakely and how if one of these elements are removed from the web the other elements will be impacted as well.

- Extension
  - One child can be instructed to release string after a scenario such as, "The river has been polluted because an oak tree was cut down." The web will then be slack and no longer as strong as it was when all elements were present.
  - Or ask the students to make statements about what would happen if elements were removed from the web.

- Reference
  - This activity was modified from WORKSHEET – Web of life made by Foundation for Environmental Education: Learning about forests
  - Foundation for Environmental Education: Learning about Forests. *Worksheet – Web of life*. Retrieved from http://www.leaf.global/our-resources/

Agnolakely Field Guide

	Ampalibe Jacquier *Artocarpus integer*		Bilahy *Melicope*
	Andramena Bois de rose *Dalbergia louvelli*		Ravinala *Ravenala madagascariensis*
	Valiaha Bambou *Dendrocalamus giganteus*		Mandrorofo *Trachlobium verrucosum*
	Tsararavina *Intsia madagascariensis*		Fandravasarotra *Cinnamosma madagascariensis*
	Manga Mangue Mangifera indica		Antsatsaka be Gecko *Phelsuma madagascariensis*

Agnolakely Field Guide

	Ranovary Caméléon *Brookesia karchei*		Montingora Serpent *Leioheterodon madagascariensis*
	Amboalava Caméléon *Furcifer pardalis*		Mandotra Serpent *Sanzinia m. madagascariensis*
	Sahona Grenouille *Heterixalus madascareniensis*		Tsitsihy Chirogales *Cheirogaleus sp.*
	Do Boa *Acrantophis madagascariensis*		Bokombo Hapalémur *Hapalemur griseus*
	Bibifaly Serpent *Dromicodryas quadrilineatus*		Tsidy Microcèbes *Microcebus sp.*

Agnolakely Field Guide

	Vontsira Mangouste *Galidia elegans*		Fossa *Cryptoprocta Ferox*
	Sokina Tenrec *Setifer setosus*		Jabady *Fossa fossana*
	Trandraka Tenrec *Tenrec ecaudatus*		

Phelsuma madagascariensis climbing a mango tree within the reserve.

Agnolakely

Come spend a morning or afternoon enjoying iconic species and scenic views within Agnolakely.

- Over 128 species of plants, animals, and birds.
- Multiple hiking routes taking you through bamboo plantings, reforestation projects, and streams.
- Guided tours describing the biodiversity and history of the reserve.

Tonkasina, the owner, amidst a reforested mango and rosewood in Agnolakely.

About Us

Agnolakely is a small private nature reserve started by a man with a mission. Beginning with just ½ hectare of ancestral land, Jacques Tonkasina has expanded the reserve to just over 6 hectares of diverse secondary forest for visitors, students, and families to enjoy.

Contact Us

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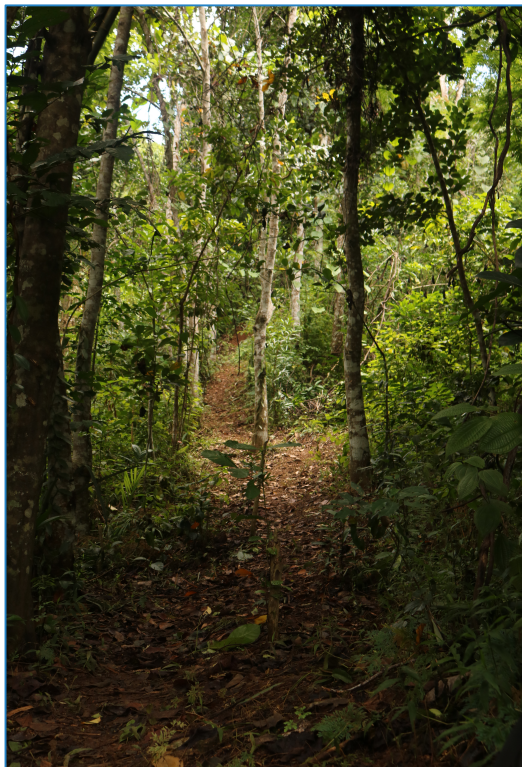


AGNOLAKELY

Private Nature Reserve

Dam constructed in 2017 with the help of Duke Lemur Center SAVA Conservation

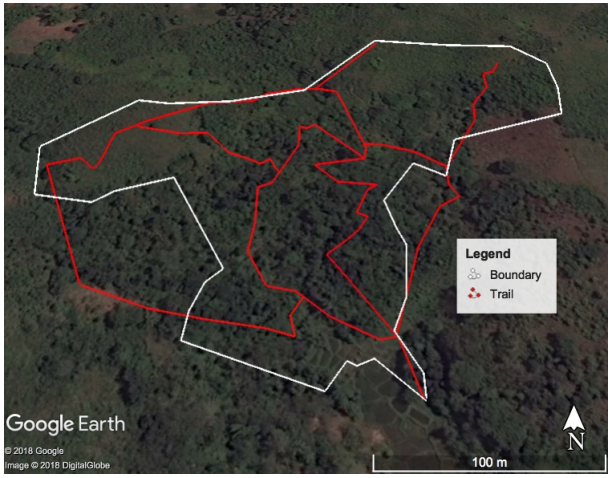
Projects

- Reforestation of rosewood, acacia, and mango trees
- Cooperation and promotion of environmental education in near-by primary schools
- Collaboration with local and international organizations such as Duke Lemur Center SAVA Conservation and Lemur Conservation Foundation

Enjoy the overlook of Mandena from the highest point of Agnolakely.

Hiking Trails

Agnolakely has trails running throughout the reserve. Hike from the lowlands to the peak, 181 meters above sea level, where you are met with a beautiful view of the valley and Marojejy National Park.



A Multi-Dimensional Space

Agnolakely is not just a place for animals and plants to thrive, but also people.

- A dam located in Agnolakely irrigates surrounding rice fields.
- Children are taught about the importance of forests within the reserve.
- Fruit trees and vanilla in Agnolakely provide income and nutrition for the Tonkasina family.

Bamboo lemur perched in bamboo at Agnolakely.

Living within the secondary forest of Agnolakely resides a diversity of species such as bamboo lemurs, mouse lemurs, dwarf lemurs, chameleons, geckos, lizards, and snakes.

Furcifer pardalis, panther chameleon, resting on a peanut tree.