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ICT and community-based primate conservation in the Burica Peninsula

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Introduction

There are near infinite areas of study in Panama's tropical rainforests, but due to resource constraints and the complex nature of neotropical ecosystems, much meaningful data and academic literature remains to be. Panama is a center for biodiversity on earth, especially in its tropical rainforests, but due to human disturbance many species are rapidly becoming at risk of extinction. In the search for solutions, a largely untapped resource of knowledge is the communities surrounding these biological hotspots, whose intimate daily interactions with their environments leads to a familiarity with the local species that can take outside biologists years of field experience to attain. To this end, our project aims to address both these issues by collecting local, community generated data on three monkey species of concern to the conservation biologists in this area. Due to the recent advent of smartphones, with a high penetration rate even in the rural areas of Panama, there is a possibility of remote data collection by the local residents. This utilization of technology is not only is this an ample opportunity to democratize conservation research in the area, but with exponentially more eyes on the ground, much more data can be collected than if we were to collect this data on our own in the field. Thus, our research question is as follows: Can community-based, Information Communications Technology (ICT) data collection, using the application Open Data Kit, yield useful data on primate populations in the Burica peninsula, and engage the local population in productive conservation efforts? More broadly, our research objectives are tri-fold: to produce a data server using the ICT application Open Data Skit, encourage community members to download and use

the application for data collection on primates, and to produce an educational guide for local youth on these concepts.

Literature Review

In Pimbert and Pretty's paper on community based conservation (1997) they point out the flaws in exclusively academically-based conservation strategies (especially in a Western context), and their inevitable ineffectiveness given that local communities are the active agents in shaping their immediate environments, and their involvement in the conservation of their land is essential for both sustainable and ethical ecosystem management. For a comprehensive assessment of the status and range of a species of interest, consulting and including regional expertise by the inhabitants is the only way to ensure a complete picture of the ecological situation. Armitage defines community-based natural resource management (CBNRM) as an approach to "encourage better resource management outcomes with the full participation of communities and resource users in decision-making activities, and the incorporation of local institutions, customary practices and knowledge systems in management, regulatory, and enforcement processes" (2005).

Waylen et al. (2009) truly drive home this point of how essential it is to integrate community-based conservation into any conservation based research in their systematic review of the success rate of studies of this nature. Their findings, based on 60 studies, significantly supported their hypothesis that "the outcomes of conservation interventions are positively affected by a supportive cultural context and engagement with the local cultural context" (p.

1126). In addition, their study provided less strongly correlated support "for the role of local participation, conservation education, benefit provision, and market integration" (p. 1127). They promote the importance of cultural context in conservation efforts, and warn that the lack of appreciation for the socio-political factors of a region in past research have led to failure. Their break-through analysis is very informative to our research project in its interdisciplinary emphasis on social science and natural science in successful conservation initiatives. This is especially true for our particular study, considering that the primate species of interest in this region are primarily threatened by deforestation and changing land use, and the responsible management of natural resources is integral in their survival as a species, and is intimately tied into local practices and attitudes.

The three monkey species of interest to this paper are *Alouatta palliata* (Gray, 1849), commonly named the Mantled Howler, *Saimiri oerstedii* (Reinhardt, 1872), also called the Central American Squirrel Monkey, and *Cebus capucinus* (Bangs, 1905), or the White-Headed Capuchin. They all fall under the category of the 'New World Monkeys' of South and Central America, and all are important in maintaining the vitality of neotropical ecosystems. These species are all arboreal, and their variety of feeding niches on different seeds and fruits plays a significant role in dispersion and diversity in the tropical forest (Rosenberger et al. 2013). Moreover, the Central American Squirrel Monkey subspecies, chiricano, is solely found in the Pacific wet lowlands of Costa Rica and Panama, making it extremely vulnerable to the prominent threats of habitat loss due to agriculture and development, with the subspecies of this genus being listed as critically endangered (Cropp et al. 2000). Immediate strategies need to be

put in place if the Squirrel Monkey is to persevere, and given the complex interdependence of food-web interactions in Panama's tropical rainforests, it can be expected the the Howler and Capuchin, along with countless other non-monkey species, are also likely to fall down this slippery slope towards extinction.

In light of the importance of primate conservation in this area, and the need to represent local communities in academic and scientific studies, appropriate methodology that is accessible and practical in this context is necessary for the research to proceed. In this age of exponential technological advancement, it is essential to adapt environmental practices and data collection to fit into new models, and 'Information and Communications Technology' (ICT) has the potential to be a powerful tool that does this in an attainable manner. ICT is essentially utilizing technology to store and exchange information, with an emphasis on the role of unified communications and active user participation and accessibility. Arts et al. (2015) break down the intersection of ICT and conservation into five key categories: data on nature, data on people, participatory governance, communication and experience, and data analysis and integration. Together they label this fusion as "digital conservation", and stress the importance of democratizing this information and steering clear of the classic extractionist power dynamics. (Arts et al. 2015). The benefits of this approach, when carried out correctly, are plentiful. More frequent monitoring of the natural environment on a larger spatial scale, via more hands and eyes, and the encouragement of classically 'untrained' individuals and communities to engage in biological data collection. This last point is of particular importance of our research in Chiriqui, as although local community members may not have academic degrees in biology, they possess a

different nature of knowledge about the local ecosystems that could prove to be extremely valuable, but has lacked an outlet until now.

Synthesizing community-based conservation and ICT can be assisted by one powerful tool: the youth. There are numerous studies citing the importance of youth in ICT, where these important individuals can act as the missing link between technology and older generations or traditional communities. In conservation, the power of young people is only amplified in gravity, as environmental issues are primarily problems that we will experience the effects of in the future. Thackeray et al. (2010) highlight the need to make strategic decisions that combine technology with youth advocacy, in order to properly arm these young policy-makers of the future with the educational tools they need to flourish and make better decisions for our world. This is of particular importance in the future of conservation, especially as we are experiencing a disconnect with nature in the 21st century, where there is a simultaneous increase in usage of technological devices and in apathy toward nature. Alienation from the 'great outdoors' leads to a loss of support and understanding toward conservation in many cases, and therefore if tech-based devices could be reimagined to incorporate, and even appreciate, natural environments, incredible strides could be made in the conservation movement (Lopoukhine et al. 2014). Acknowledgement of the role smartphone applications play in environmental conservation is growing, and a few studies have commented on their enormous potential. Applications that promote bird-watching, star-gazing, weather-monitoring, plant-identification and more are all already available to students, young astronomers, agriculturists, and scientists in general (Bartlett et al. (2015); Burr et al. (2014), Dogbey et al. (2014); Dorward et al. (2017)).

As it seems there is no going back with the penetration of smartphones into modern culture, this may be the most modern and youth-focused strategy for the future of conservation that is currently known.

Methods

Study Sites & Species

Our research was focused in two communities at the Southern tip of the Burica Peninsula, Panama: Limones and Bella Vista. The Burica Peninsula is a very remote region in the province of Chiriqui, Panama, and is only accessible by one main road and a few smaller dirt roads, although development is rapidly expanding, and construction was occuring throughout the duration of our study. The peninsula protrudes into the Pacific ocean as a narrow strip, down which the border with Costa Rica runs, and is partially covered in disturbed, lowland secondary tropical moist forest (Boinski et al. 1998). It is characterized by its jungles and beaches lying parallel to each other, with expansive volcanic reefs between the beach and ocean. We chose to only focus on these two communities in order to limit excessive transport time, as it already takes around 12 hours to arrive at these communities when travelling from Panama City. Each community is home to around 200 - 500 residents, most of whom are employed in agriculture or fishing, and are approximately 45 minutes away from each other via local transport. Interestingly, we were informed (and observed) that almost every community member has a smartphone, usually a Samsung, which is one of the main reasons for the ICT component of our research, as Open Data Kit is capable of running on all Android smartphones.

This region is something of a biological hotspot, playing host to the three species of monkey that are of interest to this paper and were mentioned in the introduction. The Mantled Howler, White Headed Capuchin, and Central American Squirrel Monkey all make their home in the fragmented jungles of this area. The Mantled Howler and White Headed Capuchin are designated as "least concern" for extinction by the IUCN, while the Central American Squirrel Monkey is listed as "vulnerable" (Cuarón and Wong 2008), with its subspecies (in the Burica Peninsula) being critically endangered, and the status of all three monkeys has been deteriorating rapidly over the past decade since this classification. Land use change is driving habitat loss and fragmentation among these populations, and it is therefore crucial to identify which areas they frequent (especially roads), the sexual composition of populations, and the troop sizes. To this end, data collected by local residents of the time, location, sex, species, and numbers of monkeys seen in their day to day lives can greatly improve our understanding of these populations, and is valuable in the implementation of further conservation efforts. Dr. Rodriguez and his team are actively working on a project building monkey bridges in this region, and this data could assist in informing them of the ideal locations to build the bridges based on where the monkeys most frequently cross roads, and are at risk of being killed by cars. Creating an accessible platform for residents to record this data, and generally increasing awareness about conservation and the importance the community plays in the life history of these species, are both of equal importance to the data collection.

Thus we had three main objectives in this project, two of which involve ICT data set creation and collection (using Open Data Kit), and one of which is solely focused on

community-based conservation. We completed this project over a timeline of four months, from January to April 2018.

Objective 1:

Our first objective was to produce a method of obtaining data on the three species of monkey populations in the Burica peninsula, specifically around the communities of Limones and Bella Vista. We sought to use cutting edge open-access software, pioneered by Google developers to improve the ease with which data could be collected and the volume of total data able to be collected.

Traditionally, Dr. Rodriguez has used research assistants to go into the community and walk transects to monitor the local monkey population. This methodology has some limitations, and this is one of the reasons for the design of this project. The first limitation is the logistics of getting university students from Universidad Autónoma de Chiriquí (UNACHI) to the area to conduct the surveys. David, where UNACHI is located, is a three hour bus from Puerto Armuelles, the most Northern and highest populated city in the Burica Peninsula. Other than time constraints, there is also the need for lodging and food. Food has to be brought in with the researchers from Puerto Armuelles, adding to expense and difficulty of carrying out this fieldwork. In addition, with this methodology it is not possible to consistently monitor troops, or to record deaths and births in a timely manner, hurting the capacity to successfully observe the monkeys and continuously update their conservation status.

OpenDataKit (ODK) was created as a passion project of Google data scientists, realizing the gap in accessible options to collect data through mobile application platforms. The concept is simple; the researcher needs to establish a server on his computer, and create a survey. The potential responder needs to download the ODK application from the Google "playstore" where applications for android devices are downloaded. This is advantageous because it does not require a separate application for each research project, but instead forms a centralised system where multiple projects can be accessed by a single user, at their convenience. The user then downloads the survey they wish to fill out and it is added to their collection. Another interesting feature is that once the survey is downloaded, it can be filled out and saved while offline, and the data will be sent automatically the next time the user has access to a network. This allows implementation even in areas without strong mobile network connections, aside from the initial need for wifi to download the application.

In our specific case, we setup the server on a laptop. Google App Engine is a cloud-based service for development and hosting of web applications. The server can also be run on Amazon Web Services, or on a personal server, however it is recommended that you use the Google App Engine unless you need highly specialized optics for data management and/or storage. It is run on a freemium model, meaning that it is free, until you start having large volumes of traffic on your platform, an added benefit to researchers already on a limited budget. After creating an account on the app engine, we created a new project. The language is set to Java, unless you require a personalized add-on, but this necessitates more advanced computer skills that were out of our ability. We then chose the datacenter for our data to run through (the closest to our user

base), and proceeded to download the ODK Aggregate. After opening the installer, Google App Engine must be used as the platform. After authenticating the usership, we were able able to call forward our project. Following this, it was possible to access our project's essential statistics page through the app engine page. To design a form, it was first built in another external form designer. The most common is XLSForm, but depending on the specifications needed from the form, it can be built in various others, or built from scratch with some more advanced programming skill. XLSForm is especially useful because it allows for forms built in Microsoft Excel to be imported seamlessly into its framework. The form itself can incorporate a variety of useful tools for data collection. Particularly useful in our case was the ability to have the form offer multiple choice questions of the type of monkey seen and how many, making it very user friendly. In addition, its option to have a question record the GPS location of a user and send it with the data proved very helpful in our study design. This would provide to us a measurement of where the monkeys are sighted with a probable margin of error of 50m or less. This allowed for a solid measure of where the troops of monkeys might approach major roads that divide their habitats and for optimization of monkey-bridge placement so as to seamlessly move them between habitat fragments with minimal disturbances to the community and the animals themselves. Because Open Data Kit is run through the cloud, a part of the final product will be to give the access information to Dr. Rodriguez, so he and his lab can continue to use and expand the data collection as they continue to work in the Burica Peninsula.

Objective 2:

Our second objective was to produce a data set on the server produced in Objective 1, with comprehensive information regarding the primate populations of our study region. Our methodology for this objective was repeatedly adapted as we encountered unforeseen issues. We went to the communities of Bella Vista and Limones and attempted to first inform residents about our project, assist them in downloading the application, and encourage them to use the application ODK to record data when they encounter a monkey. Initially, we had been informed that the bus station in the community of Bella Vista had wifi which we could use for downloading the application on resident's phones. From our previous visit, we knew this was a social hub in the community, so we approached community members who were at the stop to talk to them about downloading the application. We quickly realized that the wifi at the station did not have a strong enough bandwidth to download applications, and so we resorted to going door to door, handing out informative flyers about how to download the application and the purpose of our study. The double-sided flyers were created using Microsoft Word, and contained information and images previously used by Dr. Ariel Rodriguez, as well as detailed (but simple) Spanish instructions on downloading and using the application. To test the comprehensibility of the instructions, we asked a Panamanian peer (in Panama City) to follow them from start to finish, and she was successful in downloading and using the application to log test data. When distributing our flyers, we tried to target youth who would be attending school soon. The local school in Limones, which students from both communities attend, only resumed class in mid-March. We had planned to try and raise awareness about the research and the application as much as possible, and then once school was in session host a brief lecture about the monkeys and

conservation, after which we would help the students download the application. Again, we were informed that the school had wifi strong enough to download the application. Once the students had downloaded the application, whenever they saw a monkey all they had to do was open it, answer the multiple choice questions, and then the time and location stamped data would be sent to the server when they were connected to wifi.

The statistical analysis that was planned to be carried out was to compare the results obtained with the data that the Universidad Autónoma de Chiriquí already had on the monkey locations and troop sizes, and determine whether our findings were significant. Also by correlating the data against that found in similar studies using ICT, to determine whether the volume of data generated was sufficient to even statistically analyze.

Objective 3:

The third and final objective of this project was to produce a physical guide in Spanish that can be distributed to the youth in the Limones and Bella Vista communities, which serves as an accessible and informative source for young students to consult concerning scientific research, community-based conservation, and the importance of their local biodiversity. This will serve as a non-technological resource, which when paired with the Open Data Kit data, allows for a well-rounded product for our host institution, including both virtual and non-virtual conservation resources.

The information for this guide was primarily collated through research on the academic databases Scopus, Google Scholar, and Web of Science. Keyword searches concerning primate conservation, scientific education, ICT, and the Burica Peninsula were conducted to retrieve relevant articles. Inclusion criteria for information to be in the guide was that it was readable for ages as low as 12 (no technical jargon), was translatable into Spanish (if it was originally in English), and that it was relevant to the monkey species of concern, and the geographic region of interest. Dr. Ariel Rodriguez and Dra. Laura Patiño were also essential resources, as they provided us with information that was specific to the region and that they had uncovered in their previous research. All sources for the guide are cited at the end of this paper. The guide was produced using a template on Microsoft Word, to make it professional and aesthetic for classroom use. The guide will be sent to Dr. Ariel Rodriguez and the principal of the Limones school to distribute to the communities and students, as it is too expensive (~120 USD) and time consuming for us to travel to Chiriqui solely for its distribution.

All of the research detailed here was done under the supervision of Dr. Ariel Rodriguez at the Universidad Autónoma de Chiriquí, and Hector Barrios as the McGill liaison at the Smithsonian Tropical Research Institute. Both researchers, Cody Kane and Maja Pitcairn followed the McGill University Code of Ethics and completed a course in research ethics. (See Appendix A).

Results

Results from Objective 1:

We were successful in designing a functioning server for data collection purposes using the ODK application. Now, anyone who has the application and instructions to join the server can participate in remote data collection. When someone who is registered to the server sees a monkey, all they need to do is open the application and will see a very easy and user friendly multiple choice survey. Here they click through five questions, and the next time they have internet the time and location stamped data will be sent back to the main server. The user key to access the server and potential data has been given to Dr. Rodriguez.

Results from Objective 2:

Unfortunately, we did not obtain any data on the server produced in Objective 1, as no community members downloaded the application to our knowledge, and we were unable to meet with the students at the school. Thus our second objective was largely unsuccessful. Many of the technological problems that contributed to this were unavoidable and will be discussed later in this paper. We were successful in making our flyer and distributing around 50 copies to community members and posting them in common spaces. ***Figure 1*** shows our final flyer that was designed, printed, and distributed.

Results from Objective 3:

We were successful in researching, condensing, and designing a readable guide for the Limones school. *Figure 2* shows a snapshot of the guide design and breadth. Our results from our research and discussions with Dr. Rodriguez were productive and yielded very applicable information for the guide. As the purpose of this objective was to produce an accessible (non-ICT) educational tool, we decided to include four main components in the guide: the monkeys and their conservation status in the Burica peninsula, the scientific method as a way to formulate their own studies, using Open Data Kit for their own data collection needs, and how to use Open Data Kit to submit data on the monkeys of Burica (of our own design).

Final Product for Host Institution

From our results and the initiatives that were successful during this research, we have compiled a final product for Dr. Rodriguez and the communities of Limones and Bella Vista. Firstly, from Objective 1, we have the server created on Open Data Kit, and we have handed over the password and user key for the Universidad Autónoma de Chiriquí team to use in future projects or however they see fit. From our second objective, we do not have any community-generated data to present, but we do have the flyer with information on how to download and use app that was distributed to the communities, and can hopefully be used in conjunction with the server in future endeavours. Finally, our main product produced is that from our third objective, which is a professional, aesthetic, and informative school guide in Spanish, detailed above, that will be distributed to the communities of Limones and Bella Vista. We recommend laminating it for durability.

Figure 1: Double-sided application informational flyer distributed in Limones and Bella Vista

Instrucciones para usar la aplicación Open Data Kit

Para instalar el programa

1. Va al 'Playstore'
2. Buscar la aplicación 'Open Data Kit' (es gratis).
3. Descárgalo

Para configurar el programa

4. Para conectar con el servidor, toque los tres puntos en la esquina superior derecha → Elija 'Cambiar la configuración' → Servidor → Elija 'ODK Agregate' como el tipo (si todavía no es) → Cambia el URL a https://burica-monos.appspot.com
5. En el menú principal, toque 'Obtener Formulario en Blanco' → Elija 'Monos_Burica' → toque 'Obtener los seleccionados'

Para usar el programa

6. Ahora está preparado para grabar los monos! Cuando vea un mono, abre la app y elija 'Llenar nuevo formulario' → Monos_Burica. Responde a las preguntas, y deslizar la pantalla a la derecha cuando ha respondido cada una.
7. Para enviar los formularios finalizados, selecciona 'Enviar Formulario Enviados' (si no quiere usar data, puedes enviarlo después).

Figure 2: Educational guide on conservation for the students of Limones and Bella Vista

Discussion

Despite numerous hiccups in our efforts to conduct this research, we believe that the lessons learned are very productive for future conservation efforts in the Burica Peninsula, and that the absence of results for our second objective is a result in itself. The reasons for which we were unsuccessful in obtaining community-generated data are productive in considering the future of community-based conservation, and the use of ICT in developing regions. To discuss these reasons, and expand on what exactly went wrong, we will break them down into three main categories:

Community engagement

Community engagement in our research project was varied, with different residents expressing mixed levels of interest and commitment to primate conservation in this region. Part of our objectives were to empower community members to be active agents in the conservation of their land, and we experienced most of our success in this aspect with the younger residents. Based on casual discussions with community members while raising awareness and distributing flyers about our application, we noticed a lot of adults seemed to think of the monkeys as pests, and saw them as too abundant in this region. Getting the message across that this species of Squirrel Monkey is endemic to their larger geographic area, and even though it may seem like there are a lot of them, that they are in fact endangered, proved difficult. This makes sense, as the majority of the adults there are engaged in peasant farming, and are first and foremost concerned with their livelihoods (which the monkeys interfere with by eating their crops), and not

conservation. Many of the members live in "Techos de Esperanza" government houses, and have large families to feed, and they see the monkeys as providing very little to them. Another subtle message we received concerning community disinterest was when our flyers that we put up at the bus station in Bella Vista were ripped down, which did not indicate positive feedback to our project on a whole.

However, the impression we got from the younger teenagers that were more invested and excited about what we were doing is why we chose to focus in on the youth and the local school for the remainder of our project. Hopefully, our pamphlet (the product of objective 3) will assist these teenagers in learning more about science, conservation, and empower them to actively work with Dr. Rodriguez and his future projects in this area.

Physical Infrastructure

The physical infrastructure (or lack thereof) in the Burica Peninsula has been touched on in our methods, but it was a major limitation throughout our research process. To get to Bella Vista, the Southernmost community of the Burica Peninsula, we would take a bus from Panama City to David, which is 6-7 hours, and then a bus from David to Puerto Armuelles, around 3-4 hours, and then from Puerto Armuelles to Limones, 1-2 hours, and then Limones to Bella Vista, about 45 minutes - 1 hour. Once in Bella Vista, we would have to hike about 2 hours to our hostel by the beach. We tried our best to plan our research accordingly around the estimated travel times, but as there is no bus schedule there, it was very difficult to know when a bus would arrive and how long it would take to arrive to our destination. An example where the transport

directly affected our ability to proceed with our research, was when we hiked to the bus stop early one morning to take the 45 minute bus from Bella Vista to Limones, to meet with students at the school about the application. We waited 7 hours at the bus stop until a bus arrived, which is the only form of transportation in this area. As there is no service in this region (which will be expanded on later), it was very difficult to contact the school, or anyone, and we were unable to meet with the students, as the school day had ended by the time we arrived.

This aspect of our research region is very interesting as it poses a conundrum. We are engaged in conservation based research, but for our research to have been successful, the Burica Peninsula would likely have to be more developed. Development in physical infrastructure such as roads and organized public transport almost always involves some kind of deforestation or natural habitat loss, which is a major threat to the monkey species we are interested in conserving. Of course, this would not be as necessary if we had access to funding, where the research could have been facilitated by having our own vehicle and many of our problems avoided. But in the restricted scope of our research project, it was very difficult to achieve all of our objectives within a physical infrastructure that was very limited, expensive, and time-consuming to navigate.

Technological infrastructure

Technological infrastructure (or again, lack thereof) was the largest barrier, in our opinion, to collecting data via the server. This is also linked to community engagement and

physical infrastructure, where we were misinformed about the technological accessibility of the area in the beginning stages of our project. As mentioned in the methods, the project became drawn out as we were repeatedly told that different areas would have wifi with a bandwidth able to download the application, and upon arriving at this location we would realize this was not true. Other gaps in information, such as the fact that students are not allowed to bring their phones to school, also put a lot of roadblocks in our methodology and research time. The Burica Peninsula does not have service in almost every area we visited, making it very difficult to contact people when we encountered an issue, and limiting us in our access to materials to engage in some other aspect of research while we were there. This is an very important point for future studies in this area, as in our experience, this region of Panama is not ready for ICT conservation strategies, because it simply does not have the technological infrastructure available. In addition, due to the lack of representation in academic studies of these communities and the Burica Peninsula, the only way information about the area can be obtained is from word of mouth, and a lot of this information can be unreliable and with no way to fact check it. This provides an interesting commentary on the technological infrastructure of Panama as a whole, which has a very skewed spectrum of development dependent on the region. When we were testing our server in Panama City, it functioned perfectly, where peers who downloaded the app used it with no issues, and we were able to receive (fake) data to the server as expected. This contrasts heavily with our experiences in the Limones and Bella Vista, where people were not even able to download the application in the first place.

Future implications

To return to our original research question of: Can community-based, Information Communications Technology (ICT) data collection, using the application Open Data Kit, yield useful data on primate populations in the Burica peninsula, and engage the local population in productive conservation efforts? Our experiences trying to implement this form of data collection have been largely unsuccessful, but not exactly for the reasons we expected, and therefore we cannot concretely answer yes or no. We had discussed early on that it was likely that community members would not use the application to actually record data when they saw monkeys (mainly due to lack of incentive), but did not expect that no member would actually be able to download the application at all. This suggests that the answer to our research question is no, community-based ICT data collection is not an effective tool in this area, but it is actually impossible to answer this question when we were never even able to test the data it could potentially generate. Instead we have realized that in the Burica Peninsula, it may be too soon to attempt a study of this nature involving ICT at all. Encouraging and engaging community-based conservation however, has been successful to some degree with the youth, and the product for our host institution reflects our desire to continue to support this in the coming years.

Our fieldwork has succeeded in completing two of our objectives, and has laid groundwork for future research in this area. It is clear that for ICT to be a useful tool in this region, there will have to be much development in the technological infrastructure of the peninsula. Accessibility to conservation and conservation tools has become an interesting theme of this project, and begs the question of what takes priority: people or conservation. With our

limited resources, we were unable to collect all the data we had aimed to, but perhaps with funding and resources data collection on these monkeys could be achieved. But even then, as we found in our interactions with the local people from this area, they are looking out for themselves long before they are concerned with the health of monkey populations, and perhaps the same should apply to researchers.

On a local scale, we hope that with the products produced for Dr. Ariel Rodriguez and his team at the Universidad Autónoma de Chiriquí, that the server could be used in the future for helpful and productive data generation, once a more developed technological system is in place. Until that point, hopefully our educational guide can act as a resource and tool for students at the school in Limones who expressed interest in pursuing science and conservation, and empower them to work with Dr. Rodriguez in future projects.

On a larger, more global scale, we hope that this research has helped fill a gap in the literature concerning this region, but moreso concerning ICT, community-based conservation, and the resource constraints that come into play during a study that fuses these concepts. For ICT to be an effective conservation tool, the community requires a certain level of technological infrastructure, which inevitably comes with development. This does not mean that communities without access to this infrastructure are not of equal importance in community-based conservation, and in fact, we believe this is a huge limitation of ICT. A study of this nature is designed for communities in between stages of development, and the Burica Peninsula initially appeared an ideal example. The lessons we have learned show that this area is not ready for this

technology in the way we might have hoped, and that for other communities that are similar, we suggest conservation is put on the back-burner while the people of the region are helped first and foremost. This is not to say that conservation should be ignored, but community-based conservation is only effective when the community itself is stable and its members living healthy, sustainable lives. It is essential to incorporate community perceptions and needs into environmental and conservation initiatives, and thus longer studies are needed to move through every stage of this process with communities like Limones and Bella Vista, slowly integrating sustainable practices into their development. This type of study is beyond the scope of what our research had the time and resources to achieve, but we hope that our findings are productive in informing future projects, and that the importance of community-based conservation- with or without ICT- has been emphasized.

Conclusion

While we maintain that ICT, community-based solutions can be beneficial to conservation research, it is clear that in the case of monkeys of the Burica Peninsula, the infrastructure is not at the point to make this kind of project feasible. However, our research has hopefully laid the groundwork for future studies in this area, and highlighted some issues with working in this area of Panama that should be kept in mind. As Panama is modernizing at a breakneck pace, we believe this project could be successful in the near future, as residents have the devices necessary but just lack the connections. This also reveals the structural inequality in Panamanian society, as a project of this nature would be easily implementable in the more

urbanized parts of the country. While this project could be considered a failure, in many ways a negative result is just as revealing as a positive one. More than anything, as researchers we have gained a deeper understanding as to how the limitations of geography, infrastructure and technology can limit methodologies, and how cultural context is essential in ethical and effective conservation management.

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Appendix A

PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

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