International Elephant Foundation Final Report

HEC Abatement: Deterrents, ecological correlates, and climate smart agriculture practices

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2. Conservation Needs of Project

The Kasigau Corridor REDD+ (Reduce Emissions from Deforestation and forest Degradation) Project Area includes 14 Group Ranches covering an area of ca. 2000 km^2 that is part of the Kasigau Wildlife Corridor between the Tsavo East and Tsavo West NP (Figure 1). These ranches are conserved under a REDD+ scheme that aims to provide financial incentives by tapping into the carbon market to help protect forests. Wildlife Works has pioneered practical REDD+ solutions that are acceptable to both the rural communities and the marketplace. The biological component of the study involve elephant surveys and monitoring and are mainly be undertaken within Rukinga Wildlife Sanctuary (30,000 ha).

Human encroachment and agricultural development have compressed and fragmented the ranges for African elephants. Negative encounters with people result in human elephant conflict (HEC) with consequences that represent the major conservation needs of this project:

(1) Crop raiding is the major form of HEC, and losses to elephants can severely influence livelihoods. Thus, there is a great need to identify sustainable and affordable means to reduce crop raiding by elephants. Rukinga Ranch has no permanent residents, but community owned ranches and villages surround it; thus, negative encounters with wildlife are common. Farmers would benefit from means of deterring elephants that approach their crops and being warned of elephants at a distance heading in the direction of their fields. Initially, we are focusing on experimental examination of deterrents and ecological indicators (see #3 & #4 below) of potential crop raiding. In the near future, we will include aspects of early warning system(s) to alert farmers of impending elephant presence near their farms.

(2) People's poor attitudes towards elephants reduce the effectiveness of conservation initiatives and practices, ultimately resulting in a decline in elephant populations. People often attribute crop raiding to any elephants in the area, but it is possible only particular individuals are the culprits and other species may also be to blame. Many bull elephants we catalogued in the project area have one or more large scars, likely the result of negative encounters with the local people. By determining which elephants and what other species crop raid, we can target solutions and enhance human attitudes towards elephants in general.

(3) Elephant presence in confined areas or recovering ecosystems, such as the wildlife corridor at our study site, can result in extensive damage to canopy trees. Bark striping that results in girdling a tree can lead to mortality. These trees provide habitat (e.g., nesting sites) and cover for other species. In addition, humans use these trees as a resource for lumber, medicinal products, food, and fuel. The project site was formally a cattle ranch and faunal diversity is still recovering from years of overgrazing. Thus, there is a need to maintain these trees in the habitat for elephants, wildlife, and humans. Furthermore, we are determining how the timing and extent of tree use by elephants relates to the probability of crop raiding.

(4) Elephant activities can facilitate biodiversity and enhance ecosystem services. However, elephants confined by human presence or enclosed by fences can overuse a particular habitat resulting in a loss of biodiversity. Elephants and their activities can facilitate enhanced biodiversity but not all species are favored by elephant presence. Thus, highly mobile yet easy to locate species such as larger mammals and predatory birds may be indicators of elephant absence or presence and potentially signal temporal shifts in crop raiding rates as well as elucidating the broader influence of elephants on local biodiversity.

(5) Crop raiding by elephants needs to be considered in perspective of overall crop yield. Previous studies have shown that farmers will attribute crop losses to elephants even when elephants are not the primary reason for crop loss. In order to improve human livelihoods, we need to know the relative importance of various factors on crop survival as well as have good data on the overall prevalence of elephant crop raiding.

3. Goals and Objectives of Project

(1) We are testing **deterrent fences** to reduce elephant intrusion into crop fields with a third and fourth trial. We have demonstrated that the new metallic strip fences (Kasaine fence) singly and in combination have a statistically significant deterrent effect. We now hope to determine if and when habituation to this method occurs, test different iterations and applications of the fence, and in the near future test early warning devices which alert farmers to elephant presence. Journal publications and community outreach programs are planned to disseminate the information to those who would benefit from this new and practical deterrent method. In addition, this year we are planning to erect three more beehive fences in the community for testing in comparison to other deterrents. Our ability to use beehive fences depends on our success at establishing viable hives. We should see a direct benefit to elephants by reducing conflict with local farmers while collecting data that will inform us about deterrent methods that are worth trying on a broader geographic scale.

(2) We are creating an **elephant identification database** and using trap cameras to identify elephants that crop raid our experimental plots. This is the first time that elephants have been catalogued in the wildlife corridor. We are making visits to the local primary school to facilitate a good relationship with the local community. As part of the larger project, Wildlife Works conducts surveys with people in villages in the study area to examine their attitudes on wildlife, elephant conservation, and sustainable practices to maintain a viable livelihood. We plan to compare these perceptions of crop raiding to our study data, which could give insight as to the level of misperception of elephants as the only or predominant threat to sustainable livelihoods. We also receive funding through Earthwatch who provides citizen scientists to assist with our project. These individuals also visit the local schools and help to spread the conservation message around the globe when they return home.

(3) We are assessing **damage caused by elephants to tree species** in the study area. As all 240 elephant-favored trees were located and tagged in the first year of the project, we plan to perform follow-up inspections for tree damage with the intention to revisit each tree in 2018. We will use this information to assess the timing and degree of damage relative to crop raiding. We will test the hypothesis that escalating tree damage could be used as an indicator of impending crop raiding. The alternative hypothesis is that higher tree damage reflects the preference for browse over crops by elephants (especially in light of the higher costs of raiding when crops are protected). In the future, we will wrap some trees of value with wire to determine if this wrapping reduces tree mortality from elephants (such mortality is primarily the result of bark stripping). A recent study by Osipova et al. (2018, *J. Applied Ecology*) suggests that fences can shift problems rather than solve them, so we need to be aware and concerned about the larger landscape ramifications of deterrent fences or the wrapping of trees.

(4) We are using **surveys of mammals and higher trophic level birds** (primarily raptors) to assess biodiversity, which we have continued in this second year of the project. We are testing the

hypothesis that one or more of these species could serve as indicators of elephant presence and degree of activity, such as impending crop raiding. Thus, such species could provide a biotic early warning system.

(5) We are measuring the damage to our experimental plots from all causes (elephants, other wildlife, domestic animals, insects, and lack of water). We are also **tracking incidents of elephant crop raiding in the farming area** of our experimental plots to determine how commonly elephants are visiting the area. Previous trials indicate elands as potentially important crop raiders; we plan to investigate this further.

4. Specific Actions Taken to Achieve Objectives

(1) Deterrent Fences. In year two, our research team maintained the four agricultural blocks, established in year one. We renewed the leases in each block from one or more farmers and the farmers planted maize primarily, as well as some lentils and/or cowpeas. Within each block, we maintained our treatments with a paired control, randomly without replacement. The treatments were acacia fence (unfenced control), cloth flags without chili mixture (see below) with ropes control, metallic strip (Kasaine) fence (metal wire fence control), and cloths + metallic strip (Kasaine) fence (ropes + metal wire fence control). We erected and monitored twenty-six (26) camera traps in trial 3 (T3) and twenty-two (22) in T4 at the experimental fields in strategic positions near viable crops. We employed locals to assist with fence maintenance and the construction of four new beehive fences and five Earthwatch teams helped with all phases of the process. Data were collected from (T3) and (T4) is currently concluding with analyses pending.

(a) Trial Three: 6/3/18-10/31/18. The four experimental blocks were retained for the third trial and routine maintenance was performed on all deterrents. Results from the first two trials suggested that neither the chili + oil fence nor the motor oil (control) fence were effective at deterring elephants. However, the chili + Kasaine fence was the most effective. Since chili fences have been shown to be very effective in some parts of Africa, it was necessary to isolate the factors attributing toward the success of the combined method but lack of effectiveness when chili fences were used in isolation. Thus, chili + oil and motor oil were not reapplied to the chili pepper fence or the chili + metal fence and their respective controls, and the large cloths that were in the center of each chili fence panel were removed from the motor oil fence (control) and chili + metal control. These modifications should demonstrate if the movement of the cloths and ropes blowing in the wind could have been a factor contributing toward the success of the chili + Kasaine fence instead of the mixtures applied to the fences. The continued success of a chili + Kasaine fence without chili + oil could indicate that any type of physical barrier provides some type of deterrent power even if limited. If these fences are effective without the oil and pepper mixture, then this would reduce costs and greatly simplify their construction. This was the first testing of this modification of deterrents for T3.

An apiary was established in 2017 to recruit bees for use in beehive fence deterrents, as hive occupations in Kenya are opportunistic. In a collaborative effort with the Elephants and Bees Team from Save the Elephants in June, the project erected its first beehive fence to support a farmer from the Sasenyi community. The design was similar to our existing experimental blocks with two fields measuring 16 X 32 m with an alley between and buffers on each end. One active beehive fence was established that alternated active hives with dummy hives so that elephants would potentially perceive each hive to have active bees. This established method allows for higher efficacy with lower

costs. An adjacent plot containing all dummy hives served as the paired control. Four occupied hives were moved from the apiary during the night into the active fence and all existing hives were checked for pests and serviced if needed. This is the first type of testing of this deterrent method with an entire dummy hive control plot. Over the course of T3, two of the established hives moved out as conditions got dryer despite the compliance of farmers. During the remainder of the year three more locations at the Sasenyi border were selected to receive the remaining test plots and four new farmers have received a beehive fence. Five volunteer teams assisted with the lay out and erection of the four experimental beehive blocks. Each new farmer erected sugar water to attract bees and received training on how to maintain and clean the hives. Those farmers selected to participate received the necessary equipment to maintain and service their own fences, training in the skills of apiculture, and will receive any profits from future honey harvests. Save the Elephants has offered to assist with processing any honey harvests for the farmers and hosted an educational day for the farmers. Incorporating beehive fences into our project not only provides information on how this deterrent measure ranks in efficacy to other methods, but also teaches farmers a valuable skill that can positively affect the livelihood of their families. In year 3, we will test beehive fences singly and in combination with the Kasaine fence as long as we can maintain viable hives. The four mixed experimental blocks and the four experimental blocks were all monitored for the third trial. Only the first beehive farmer fields were planted, so monitoring of the beehive fences for this trial was limited.

(b) Trial Four: 11/11/18-ongoing. Trial 4 continued with the same deterrent measures as trial 3, including the modifications to the chili fences. Each beehive farmer was able to plant and establish crops for this trial, giving us the first complete data set on the performance of the beehive fences. However, few hives were established despite attempts to attract bees from each of the experimental blocks. Cameras were deployed and monitored as before. We are evaluating whether to continue the beehive fences in 2019, which will depend on whether we can maintain hives.

(2) Elephant identification database. The database continues to grow, and as of February 2019, over 30 family groups and 100 bulls have been catalogued with minimal analysis still remaining. Transects and opportunistic sightings continued in 2018. Three family groups have been established with all members fully identified as groups that frequents the area with our "C" group being the most common. Eight of the bulls in the catalogue remain identified as crop raiders, but several more individuals have recently been observed on camera trap images from the farms in T3 and T4 and are being compared to the catalog. The current elephant population on the ranch is substantial but starting to decline despite the lack of crops.

(3) Tree damage. During 2018, we successfully relocated and evaluated the 240 trees spread over six transects that were originally identified in 2017. All teams assisted with the tree surveys. The rechecks of each tree were to assess how elephant damage (bark stripping, branch breaking, felling) has changed in the last year. Approximately 75% of these trees have had an increase in damage or additional damage within the last year. This indicates that the selected trees were appropriate choices and that this long-term data set will be useful in determining if elephant foraging is an indicator of changes in crop raiding patterns as well as assessing their overall impact on trees in the study site.

(4) Mammal and bird surveys. We continued to perform surveys along six driving transects over roads that cover the majority of the Rukinga Ranch wildlife corridor through September and reinitiated transects in February with the intention to do monthly transects even when the entire research team

was not present in order to get a more complete picture of wildlife populations and trends. Transects were driven three days per week by each of the Earthwatch teams and scientific personnel. To date, over 50 transects have been performed since February of 2018. We will analyze these data for trends that correlate with elephant activity and crop raiding.

(5) Crop raiding incidences and causes of crop damage. The two Wildlife Works employees who are dedicated fence attendants continued to record daily information on crop raiding in the area. We deployed twenty-nine (26) camera traps in T3 and T4 at strategic locations across the front line of farms. We checked these weekly for signs of wildlife and crop raiding. Each crop raiding incident was recorded in an elephant database and records were kept of crop raids elsewhere in the community. As elephants in this area are blamed for the majority of crop losses, it is important to understand if poor soil quality also contributes towards crop failure. For the first time in 2018, we initiated soil sampling at four different sites across the experimental area and volunteers assisted under the guidance of Dr. Urbanus Mutwiwa. Those analyses suggest that poor soils also contribute to the lack of crop success and so soil conditions and care need to be addressed.

5. Modifications of Actions

The largest modification was the erection of four beehive fence experimental blocks in T3 with the first complete monitoring of these blocks in T4. For upcoming trials, we will consult with STE to determine some methods in which we can attract more bees for establishment in hives, as well as combine some blocks with the metal strip fence.

Another modification to the project in trial three was to the chili fences as outlined in Section 4 “Deterrent Fences” above. In T4, several cloths had to be replaced due to degradation from the environment. Since this modified technique underwent two trials of testing, in future trials we will replace chili fences with a different deterrent fence (possible some type of bee pheromone technique) and replace cloths in the chili + metal fence with a lighter layer of metal creating a double metal fence.

6. Conservation Outcomes to Date

Since statistical analyses from the first two trials showed that the chili + Kasaine fence and the stand-alone Kasaine fence had a significant deterrent effect, we are in the final preparation stages of a manuscript to report these results. *This is exciting news for the conservation of elephants as new, practical, and effective deterrents are rare.* We are also planning a workshop outreach program for local villages to demonstrate the different types of effective deterrents that are available and how to construct and maintain them. In addition, it is important to investigate if elephants habituate to this type of fencing over time, if additions of Kasaine fence strips to other fencing types such as beehive fences might increase the efficacy, and if the Kasaine fence is useful in neighboring regions.

The hypothesis for the stand-alone chili fence was that it should perform similarly to the Kasaine fence, as it has been very successful in many studies throughout Africa. However, our study revealed poor performance as a deterrent (6^{th} in efficacy of 8 deterrent measures) with the motor oil control even performing slightly better than the active chili fence. Thus, we modified the deterrents containing chili

cloths to test if the movement and physical barrier rather than chili potency was responsible for past efficacy (see above). As T4 concludes, we will have two trials of these modified deterrents to be able to statistically compare the results. Testing of this hypothesis could reveal that chili fences, which are high in maintenance and low in practicality, could be replaced with a more effective method such as cloths and/or ropes that move with the wind, or double barriers.

For the entire study to date, we have monitored all species entering farms and/or damaging crops. From the onset of the trials, it was observed that elands were commonly present and doing damage in experimental fields. Analysis from the first three trials demonstrated that elands were frequent visitors in two of the tree trials, sometimes as often as elephants. However, elephants did considerably more damage. Though deterrents were designed to prevent elephants from entering, analysis also revealed that all active deterrents (except acacia) were effective against elands, despite their amazing jumping prowess. As elands are renowned for their "skittishness," this suggests that the movement of these barriers in the wind may be effective in preventing crop damage by elands. However, unprotected farms may incur significant damage from elands, which could be misattributed to elephants. Since farmers have erected home-made wind socks long before our study, we can capitalize on knowledge of indigenous people, experimentally evaluate their means of deterrence, and add viable deterrent methods to the catalog of defenses against crop raiding.

Additional data obtained from the crop raiding study also provided valuable conservation information. As hypothesized, the acacia fences and its control did not provide much of a deterrent for elephants, but the acacia control or no deterrent method performed well as a master control for comparison. Analysis also revealed that all deterrent methods were approached equally across the four experimental blocks. This validates the experimental design, which could be adapted by other scientists to test a variety of deterrent methods in other locations.

Elephant damage to farms usually consists of a combination of dung deposition, trampling, and consumption, yet through year two of our study, we still found no elephant dung in the experimental fields. Consumption was responsible for the majority of crop mortality from elephants, but farmers only lost 5% of their overall yield because of elephant raids. Maize is widely known as one of the preferred crops by elephants, but of the three crops planted within our experiment 27% of cowpeas were damaged, while only 7% of lentils and 6% of maize were destroyed by elephants in our experimental fields. This indicates that cowpeas may need to be defended to a greater extent than other crops, and future studies could determine if this crop acts as attractant for elephants.

During 2018 we collected the first soil samples from four different areas in Sasenyi to determine soil quality. Results obtained in 2019 showed that all soil samples were lacking in the vital nutrients nitrogen and carbon, which could be a factor in low crop yields. Future trials may incorporate education and/or outreach programs to find ways for farmers to maintain healthier soils.

Other research in our project continued to shed light on ecological correlates relating to elephant conservation. The elephant ID database continues to grow with additional family groups, bull groups, and associations recorded. This is the first time that elephants have been catalogued on Rukinga Ranch; future analysis could reveal how movement of individuals varies seasonally and in response to the recently built Standard Gauge Railway (SGR) train, which has caused modification of natural migration through the wildlife corridor. In addition, wildlife transects continue to reveal the distribution and density of a variety of wildlife, including species of high conservation interest such as endangered Grevy's zebra and all vulture species. Now that year two is completed, we will be assessing

the wildlife transects as a comparative data opportunity to search for indicator species that coincide with crop raiding rates. We also have noted that crop raiding rates tend to rise in conjunction with elephant density on the ranch. Data from Wildlife Works aerial patrols, which keeps track of the relative abundance of elephants in the surrounding areas, may also reveal that elephant density is related to crop raiding frequency. Further research into this potential correlation provides an opportunity to explore if an early warning system can be developed based on an awareness of elephant population numbers. As over 75% of the trees currently undergoing re-checks for damage have seen an escalation in damage, this data set will provide information on how elephant foraging changes over time and if crop raiding fluctuations can be predicted by these changes.

The established Facebook page has grown to over 200 followers, and some shared posts reach over 2,000 people. We update this site frequently. It provides a means to thank supporters of the project and direct them to places (such as the IEF donation page) where they can contribute to our efforts. At the request of volunteers we have also established a fund to support the children of Sasenyi Primary School directly adjacent to the study area. This fund will be accessible for donations through the IEF website, hopefully creating more traffic and awareness of its projects. This also keeps elephant conservation in the forefront.

7. Numerical Impact on Humans and Elephants

Based on the 2009 National Census, the human population in Buguta sub-location was ca. 7,000 in 1,200 households. This is the area closest to our experimental fields. The region around the Wildlife Works wildlife corridor has a population of some 90,000 people. Tsavo National Park has an estimated elephant population of 12,000 (ca. one-third of the Kenyan elephant population). Hundreds of elephants are known to move through the Kasigau Wildlife Corridor, but reliable population estimates have not been determined prior to the present study; however, during the November-December months of 2017, the population of the elephants on the ranch was estimated at 700-800 from aerial surveys conducted by Wildlife Works pilot Keith Hellyer. During T3 in 2018, elephant numbers were about 1/6 of this amount, but the seasonal migration of elephants back into the ranch area during T4 showed numbers close to 2017 levels. The four experimental farm blocks that we established had eight different families benefit from the leasing of their farms and the protection of their crops. Four additional farmers received beehive fences and also participated in a workshop teaching apiculture, a skill that can be passed to future generations. All participating farmers yielded harvests in T3 (smaller) and T4 (larger).

8. Problems during the Project Period

Elephants continued to uproot poles in the second year of the project. These poles need to be replaced periodically, which adds to our expenses. We maintained materials for broken fences. In addition, several cloths had to be replaced due to exposure to the environment. The field vehicle continued to have some mechanical issues, but the majority have been resolved. Fourteen cameras have been stolen over the length of the project, with four of those between T3 and T4. A set of suspects were questioned, and we are working with Wildlife Works security to determine if there is a way to disguise the cameras. We plan to host another community meeting to remind villagers of the importance of the project to their livelihoods. Guarding and fire burning were reduced in the third and fourth trials, and our experimental areas were excluded from these community based defense practices, which

gives us a better of idea of how the deterrents work. To date, we have solved or are addressing problems that have arisen. We anticipate continued success of the project.

9. Evaluation of Success to Date

To date, the project has accomplished one of its main objectives by statistically demonstrating the deterrent effectiveness of the Kasaine strip fence alone and in combination with another deterrent. In addition, we have shown that chili fences are not successful in this area and after the conclusion of two trials of data on cloths without chili, results may suggest that movement and not potency were responsible for the widespread efficacy of this deterrent. However, results could vary based on geography as Sasenyi is an extremely windy area. The frequency of elands in our experimental area was an unexpected but important outcome, and further work is needed to assess the threat of elands to crop security. Additionally, the possibility that fences with mobile components (e.g., cloths or metal strips) may be effective against elands is also important information for farmers and elephants, as elephants are predominantly blamed for the majority of crop raiding in this area. Additional trials are needed to increase sample sizes, potentially validating results and allowing us to improve efficacy by trying new methods and combinations. As we continue to build the tree and the animal transect databases, we will investigate the relationship between these data sets and the presence of elephants and the prevalence of crop raiding. We will analyze whether damage to trees or the prevalence of particular birds or mammals can serve as indicators of elephant presence and activity. Transects continue to gather a considerable amount of information towards this goal. We successfully reevaluated 100% of surveyed trees, and showed that approx. 75% showed additional or new types of damage. The elephant identification catalogues continue to grow, with several new individuals and families added, and we added unknown elephants from crop raiding incidents, which should be identifiable as the known individuals increase. We are delighted with the construction of four new beehive fences that add a new dimension to the deterrent study, as well as improves our reputation with and support from the community. At the qualitative level, we hope to help facilitate greater awareness (and action) on how to deter elephants, and construct and maintain deterrents and assess whether community perceptions of elephants improve over time (i.e., we also can examine this quantitatively through surveys conducted by Wildlife Works in conjunction with this study). All five Earthwatch teams from 2018 were extremely satisfied with their expedition and all have expressed interested in staying current on developments within the project, especially the addition of new beehive fences. The establishment of the Sasenyi School Fund was just one way that former team members have demonstrated this willingness to stay engaged with the team's efforts.

10. Next Step

There is unlikely to be an affordable, sustainable, and ecologically friendly 'silver bullet' to reduce or eliminate crop raiding by elephants. Field experiments are time and energy consuming, but they are the only means to demonstrate scientifically that a particular deterrent or set of deterrents is successful and economically viable for rural farmers, who must contend with elephants and other causes of crop depredation. A clear benefit of a continued presence and commitment to reducing HEC is the conservation pay-off. People who live with elephants often see little value to elephants. By working with these people and their children and by incorporating a climate smart agriculture approach, we can change them from opponents to proponents of elephant conservation.

Our next goals for the deterrent study in 2019 will be to continue monitoring beehive fences with farmers and replace the modified chili fences with a new deterrent such as bee pheromones. In trial five (beginning May/June 2019), we would like to design and test new iterations of the Kasaine fence, likely a double metal fence, and possibly adding strips to beehive fences in trial six. We also seek to determine if habituation is a factor for the Kasaine fences and to disseminate information on how to build and maintain these fences for local communities through workshop programs. We are planning to design early warning systems to alert the community that elephants are in the area and we have two separate collaborations towards this objective.

We will continue to grow the elephant ID database and determine how many elephants repeatedly crop raid into our experimental blocks. We are still identifying elephants from the last trial, while gathering data on movements and group associations in the area. Over the longer term, we are building a collaboration with Dr. Lucy King of Save the Elephants and may have access to some of the data from a recent collaring of 20 elephants in the area, exploring the movements of crop raiding elephants as part of a PhD thesis for Lynn Von Hagen.

As we continue to build the tree and the animal transect databases, we will investigate the relationship between these data sets and the presence of elephants and the prevalence of crop raiding. Working with climate-smart agricultural practices will also be one of our main priorities, as we now know that soil quality is poor in the Sasenyi area, as well as improving our experimental techniques and data collection.

11. Human Interest Story

For the first time in 2018, our research team was delighted to host volunteers from countries in Latin and South America such as Brazil, Costa Rica, and Mexico. Karla was our first visitor from Mexico and like many volunteers had a life-long obsession and love for elephants. You could bear witness to this love staring back at you from the eyes of a bull emblazoned across her back in an intricate tattoo. Karla was a wonderfully modern role model for women, riding motorcycles and holding a high-level corporate position in her home country. It is always special when you get to experience volunteers seeing elephants for the first time in the wild or on their first trip to Africa; with Karla, we got both. She was missing her childhood sweetheart turned husband, but Karla thrived and was ready to participate and lead the way whenever we called upon her. The trip was an emotional roller coaster as it is for most: spending time with the children in an impoverished community, seeing large elephant groups, and bonding with the farmers while helping build fences to protect their livelihood. She even taught us some useful Spanish and helped her team members in every way. While one of our favorite things about our Earthwatch project is interacting with people from other cultures and learning about their home countries, it is also thrilling to watch the same thing happen with our volunteers as they develop friendships that transcend the miles between them.

12. Project Progress Summary (500 words)

Human encroachment and agricultural development have compressed and fragmented the ranges for African elephants. Negative encounters with people result in Human Elephant Conflict (HEC) with consequences including loss of biodiversity, damage to canopy trees, poor relations between local peoples and wildlife officials, loss of livelihoods, and injury or death to people and elephants. The most

common form of HEC is crop raiding, which is devastating for subsistence farmers. Our project has five main objectives: 1) experimentally test the effectiveness of specific deterrents for reducing crop raiding by elephants; 2) create an elephant identification database to identify crop raiders; 3) measure the damage to trees in the Rukinga wildlife corridor as a means to assess elephant activity and for future protection of trees that have high wildlife and human value; 4) perform animal surveys from vehicles along dirt roads in Rukinga to measure biodiversity and evaluate if any species can serve as indicators of elephant activity; 5) document levels of crop raiding in the community and causes of crop damage to our experimental blocks of crops. This project is part of a larger study involving Earthwatch volunteers on climate smart agriculture practices for sustainable farming and the perpetuation of wilderness in the Kasigau corridor between Tsavo East and West National Parks, Kenya. In year two, we maintained four experimental blocks of eight fields each with deterrent fences and corresponding controls in each block. All four blocks had crops in the third and fourth trials. We added four beehive fence blocks to the experimental area with matching controls, which also meant protection of fields for four new farmers and training in apiculture. Results from combined trials one and two showed that the Kasaine fence was significantly effective at deterring elephants alone and combined with a chili fence. Elands emerged as potentially important crop raiders and deterrents designed for elephants were effective at repelling elands. Soil sampling revealed that key nutrients were lacking in the experimental area, which could contribute towards crop failures. In 2018 we hosted five Earthwatch team of volunteers and are currently preparing for the 2019 season. All teams of volunteers helped process camera images from the crop raiding experiment, performed wildlife transects, located and documented elephants, and assisted with tree rechecks. We have made excellent progress on all five objectives, and WKU graduate student R. Lynn Von Hagen received her MSc degree in August, 2018. She has also presented the results at the WKU Research Conference and has a seminar speech scheduled at her alma mater, Austin Peay State University in April 2019. Dr. Schulte spoke about the project at the 2018 Animal Behavior Society meeting and at Tufts and Lenoir-Rhyne Universities. Based on our results, experimental protocols and treatments were modified for a second year of field study, which began in March 2018 and completed in February 2019. Mr. Bernard Amakobe and Simon Kasaine, employees of Wildlife Works under the direction of Dr. Mwangi Githiru have been invaluable collaborators in the success of the project to date.

13. Project Progress Summary (50 words)

Elephant crop raiding is the most pervasive and economically damaging interaction between humans and elephants. We experimentally tested several deterrent methods for effectiveness while also creating an elephant database, assessing tree damage caused by elephants, measuring biodiversity, and tracking crop raiding incidents in the Kasigau wildlife corridor of Kenya.

14. Organizations involved

The International Elephant Foundation (https://elephantconservation.org/), the Richard Lounsbery Foundation (https://www.rlounsbery.org/), the Earthwatch Institute (http://earthwatch.org/), Save the Elephants', Elephants and Bees Project (http://elephantsandbees.com/), Western Kentucky University (https://www.wku.edu/), Wildlife Works (http://www.wildlifeworks.com/saveforests/forests_kasigau.php), and Jomo Kenyatta University (http://www.jkuat.ac.ke/).

15. Financial Report – Final (February 28th, 2019)

Item	Budget	Expenditures	Cost
Travel	$8500	Board & Room	8449.03
Equipment, Supplies, Vehicle	$3500	Camera traps and accessories, materials for deterrent fences, field vehicle maintenance	3480.71
Total	$12000.00	All Expenses to date	11929.74

We have $70.26 remaining in the 2018 budget. We have requested that this be rolled into the 2019 award budget.

16. Digital Images

1. A new adult male elephant added to the catalog in 2018.

2. The four newly added farmers who received beehive fences pictured after their training with Dr. Lucy King and her colleagues at Save the Elephants' Elephants and Bees Research Center in nearby Sagalla.

3. Farmer Nzangi assists volunteers is obtaining soil sample to test for composition.

4. Volunteers were treated to a sighting of four different species of African vultures (all endangered) in one locale after completing a transecting and finding a fresh zebra kill from the previous evenings lion hunt.

5. A herd of elephants retreats after entering the experimental area and contacting a deterrent method.

17. Video Clip

We submitted a 4-minute video for the IEF Video Award contest.

18. Presentation / Publication Plans

Conferences

- 2019 Animal Behavior Society
- 2019 International Elephant Foundation

Planned Manuscripts

- One publication on eland as substantial crop raiders (peer-reviewed)
- One publication on results from crop raiding deterrent study (peer-reviewed)
- One 'popular' article

19. Website, Blogs, Social Media Accounts

https://www.facebook.com/ElephantsandSustainableAgricultureinKenya/
https://wkunews.wordpress.com/2017/02/08/elephant-research-kenya/
http://www.bgdailynews.com/news/wku-professor-gets-funding-to-study-human-elephant-conflict/article_c65bfb09-dfa3-5e3a-b21a-c978229dbe10.html
https://www.facebook.com/permalink.php?id=108627465679&story_fbid=10155055396185680
https://elephantsinkenya.wordpress.com/
http://earthwatch.org/expeditions/elephants-and-sustainable-agriculture-in-kenya
http://wkuherald.com/news/professor-to-research-elephants/article_195bd418-35eb-5a07-ba30-a701a6ceea93.html
http://targetednews.com/nl_disp.php?nl_date_id=833129
http://www.epagepub.com/publication/index.php?i=419814&m=&l=&p=42&pre=

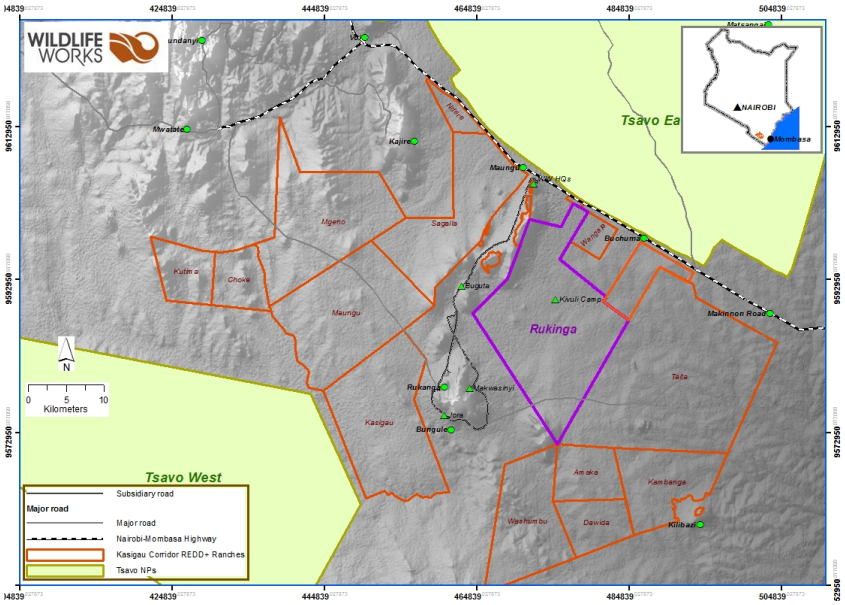

Figure 1. Map of project site location showing Rukinga Ranch as well as the rest of the Kasigau Corridor ranches in the REDD+ Project. (NB: Kivuli Camp will be Earthwatch project's main base.)