International Elephant Foundation Final Report 2020

Elephant deterrent effectiveness in light of ecological and agricultural variation

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Final: March 2021

Start: January 2020

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2. Conservation Needs and Progress of Project in 2020

Although the execution of data collection looked much different due to the COVID-19 pandemic, the conservation needs of the project remained the same as in past years. As of 15 February 2021, The World Health Organization reported over 108 million cases globally with nearly 2.4M deaths. Africa has experienced over 2.7M cases with 102,867 cases in Kenya and 1,795 deaths (WHO Dashboard). Kenya has a population of approximately 51 million, thus the rate of cases is quite low (0.2%) compared to the USA with ca. 27 million cases and a population of 328 million (8.2%). However, for Kenya and other countries, the impact of the pandemic is not limited to the internal situation but the overall effect on the global economy. In November 2020, the World Bank estimated a 1-1.5% downturn, the first shrinkage in over a decade (Rosauer 2020). Tourism is a vital component of the Kenyan economy (Nyasuguta 2019), and the cessation of international travel is clearly contributing to this problem. In addition, the lack of tourists has opposing impacts on wildlife. Animals have been reported to be less impeded in their movements and behavior because of the general absence of humans (Marshall 2020). Yet, poaching also has been increasing in some areas, such as Uganda (Maron 2020). Overall, the absence of conservationists and other scientists in the field and the inability for countries to continue to address environmental issues because of COVID-19 are likely to have an overall negative price for wildlife and wild places (Associated Press 2020).

Our study site is situated within the Kasigau Corridor REDD++ (Reduce Emissions from Deforestation and Degradation) Project Area, which includes 14 Group Ranches covering an area of ca. 2000 km^2 that is part of the Kasigau Wildlife Corridor between 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, a process pioneered by Wildlife Works. Most of the biological component of the study takes place within Rukinga Wildlife Sanctuary (30,000 ha).

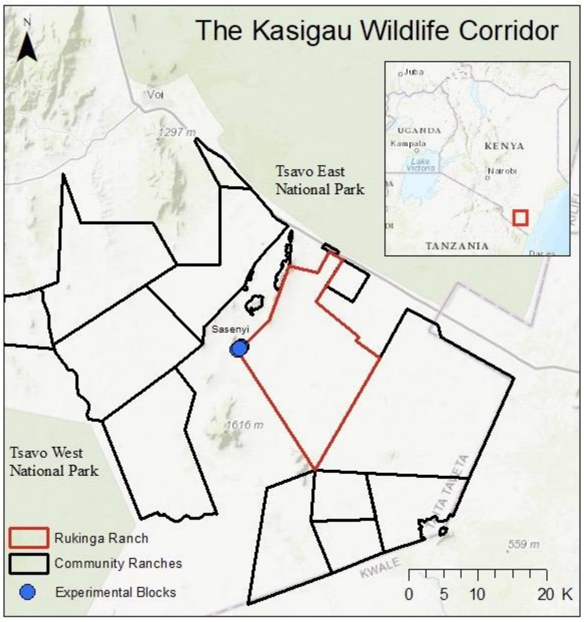

Figure 1. Map of project site location showing Rukinga Ranch and the remainder of the Kasigau Corridor ranches in the REDD+ Project.

3. Goals and Objectives of Project in 2020

(1) Continued testing of existing deterrent fences

a. *Deterrent Fences in Main Experimental Blocks*. For the past three years **we have established and used actual farmers' fields in the Sasenyi community to conduct controlled experiments on deterrent fences.** We have four sets of matched experimental and control fields in the configuration shown in Figure 2. In 2020 we continued testing of the matched control and experimental fields tested in 2019 (see section 4).

Figure 2. An example trial block with crop land in the upper half and wild space (Rukinga) in the lower half with a dirt road between the wild space and the fences (field 8 to right).

b. *Beehive Fences.* In addition to the main experimental blocks, we have four sets of bee fences with matching empty hive controls nearby to the study site. At two of these blocks, we had bee plus metal strip fences. During 2020 we continued testing these fences to increase our sample size and investigate practices that encourage honey harvest.

***(2)* Associated practices to deterrent fences**

a. *Elephant Database*. We are determining **to what extent crop raiding occurs in our area by the same or different elephants** by establishing an identification database

b. *School Visits*. We are making **visits to the local primary school** to facilitate a good relationship with the local community and assist with educational information on elephants and conservation. Because of the pandemic, we were not able to make these visits with our Earthwatch volunteers; however, members of our Kenyan based team did visit the school when it was safe to do so and otherwise stayed in contact with the administrators, teachers, and students. In addition, former volunteers have continued to contribute funds to supply food to the school throughout 2020 and into 2021. Schools returned to in-person learning in 2021.

(3) Crop and Wild Habitat Quality

a. *Climate Smart Agriculture*. Our soil sampling from 2018 by Dr. Urbanus Mutwiwa revealed poor soil nutrients, which can reduce overall crop success. As part of a renewed focus on the drivers of human elephant conflict, the team constructed a test plot with climate smart agricultural (CSA) practices using micro water catchments, zai pits (an agricultural technique that involves digging down to the topsoil and adding manure to improve soil quality), and drought and/or elephant resistance crops accompanied by a control plot. We have conducted CSA plots over two trials with clear results of the success of treated plots versus controls. The CSA plots were maintained in 2020, but because of the pandemic and related fewer personnel to facilitate expansion, additional plots were not initiated.

b. *Tree Damage*. We are **assessing damage caused by elephants to tree species** in the study area. We are using this information to assess the timing and degree of damage relative to crop raiding. We are testing the hypothesis that escalating tree damage could be used as an indicator of impending crop raiding. An 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). Due to the COVID-19 pandemic, we were not able to collect tree damage data in 2020, and instead, we are relying on data collected from 2017 – 2019 to test this hypothesis.

c. *Mammal & Bird Diversity Surveys.* Using **surveys of mammals and higher trophic level birds** (primarily raptors) we are assessing biodiversity of the study region. 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. As with the tree damage, we were not able to collect any new data on mammal and bird diversity in the study site during 2020 due to the COVID-19 pandemic, and are relying on data collected from 2017-2019 to test this hypothesis.

(4) Community Outreach

a. *Village Surveys and HEC Mitigation*. A **community outreach program is part of the PhD thesis of Lynn Von Hagen**. The first step in this process after her initial interviews with chiefs and selection of villages is to conduct an extensive survey of village members in each of the six villages participating in the study. Please see the 2020 final report by Von Hagen et al. (2021) for updated information.

b. *HEC Mitigation.* The results of the survey combined with GIS information will be used to plan the **placement of appropriate mitigation measures** for each of the six villages involved in the surveys (See Von Hagen et al. IEF final report).

4. Specific Actions Taken to Achieve Objectives in 2020

(1) Continued testing of existing deterrent fences

a. *Deterrent Fences in Main Experimental Blocks***.** Because of COVID-19, we were unable to field any Earthwatch Institute citizen science teams in 2020. In addition, the USA team members were not able to travel to Kenya, and our Kenyan team members had restrictions for travel and gathering in groups. Therefore, in 2020 we maintained the same deterrent fences for the T7, the first growing season of 2020, and continued this setup for T8, the second growing season (Nov 2020-April 2021). As part of her MSc project, Ms. Sophia Corde has been analyzing data from all trials while in the USA. Crop failure was high during the first growing season of 2020, and elephant presence around our experimental plots was low, so we did not have a great deal of data emanate from this trial. Currently, we are inputting and analyzing data from the second growing season as it winds down. As we planned from our experimental design, the number of approaches was not related to fence type (figure 3) but more to the number of total approaches per trial, and the total number of field trials a fence was tested, or the number of fields a deterrent was tested in across all trials (figure 4); these can be equated to the number of elephants in the region during the trial. For example, while Acacia and Chili were replicated across 16 fields across trials, they were only tested in trials 1-4 (4 fields per trial) (Tables 1 and 2), two of which had few total approaches to all blocks and fields. In contrast, the deterrents with only 12 field trials were tested during the latter trials (4-7 or 5-7) with the same or greater number of approaches in fewer field trials. When approaches and breaches are adjusted by the number of field trials per field type, most fences were approached only once or less per field trials (figure 5). A breach can only occur after an approach, so the stacked bar graphs in figures 3 and 5 indicate the proportion of all approaches (approach + breach = height of the bar) that result in a breach. The fields surrounded by the Grand Control, Acacia, and Double Metal Strip Control fences had the highest number of approaches that resulted in crop damage due to elephants. The greater the number of breaches to the total bar height, the less effective the deterrent.

Table 1. Experimental (e) deterrent fences tested during trials 1-7 from 2017-2020. Each fence was paired with a matching control (not shown but see Table 2, corresponding number with letter "c"). Eight fields (four experimental, four control) were present in each of the four blocks. See Table 2 for explanation of Fence Type. This table is organized chronologically. Table 2 is organized to align with the Figures x-axis order.

Fence Type	**Trial 1 2017**	**Trial 2 2017**	**Trial 3 2018**	**Trial 4 2018**	**Trial 5 2019**	**Trial 6 2019**	**Trial 7 2020**
1e) MS	X	X	X	X	X	X	X
2e) Chili	X	X	X	X			
3e) Acacia	X	X	X	X			
4e) Chili + MS	X	X					
5e) False C+MS			X	X			
6e) False Color C+MS					X	X	X
7e) DBL MS					X	X	X
1e) MS[1] (grand c)					X	X	X
8e) Active Bee[2]			X	X	X	X	X

[1]The overall experimental control of no fence (only fence posts) was used for this second metal strip fence once the acacia fence was no longer erected. [The 'no fence control' was the matched control for the acacia fence in the early trials.]

[2]Beehive fences were erected in plots separate from the four blocks of eight fields each.

Table 2. Legend of abbreviated deterrent types. Order aligns with Figures x-axis.

Abbreviation	Deterrent Type + Explanation
8e) Active Bee	Active Beehive fence. A single wire holding a yellow painted wooden box beehive strung between fence posts.
8c) Control Bee	Control Beehive fence. A single wire holding up a yellow painted wooden block strung between fence posts.
1e) MS	Metal fence. A single wire with hanging metal strung between fence posts.
3c) Acacia Co 1c) Grand Co	Metal No Control fence. Fence posts, with no wire between them. Used as control when MS erected in two fields per block.
1c) MS Co	Metal Control fence. A single wire strung between fence posts.
6e) False Color C+MS	False color Chili + Metal fence. A single wire and a rope strung between fence posts with colored cloths and metal strips
6c) False Color C+MS CO	False color Chili + Metal fence control. A single wire and a rope strung between fence posts with a plain cloth.
5e) False C+MS	False Chili + Metal fence. A single wire with hanging metal strips and rope with hanging cloths strung between posts.
5c) False C+MS Co	False Chili + Metal Control fence. A single wire and a rope strung between fence posts.
7e) DBL MS	Double Metal fence. Two wires with hanging metal strips strung between fence posts.
7c) DBL MS CO	Double Metal Control fence. Two wires strung between posts.
3e) Acacia	Acacia. A border of acacia placed around the field.
2c) Chili Co	Chili Control Fence. A rope strung between fence posts.
2e) Chili	Chili Fence. A rope strung between fence posts with cloths dipped in motor oil and ground chili peppers.
4e) Chili +MS	Chili + metal fence. A single wire and a rope strung between fence posts with cloths dipped in chili oil and metal strips
4c) Chili +MS Co	Chili + metal fence control. A single wire and a rope strung between fence posts with plain cloths and no metal strips.

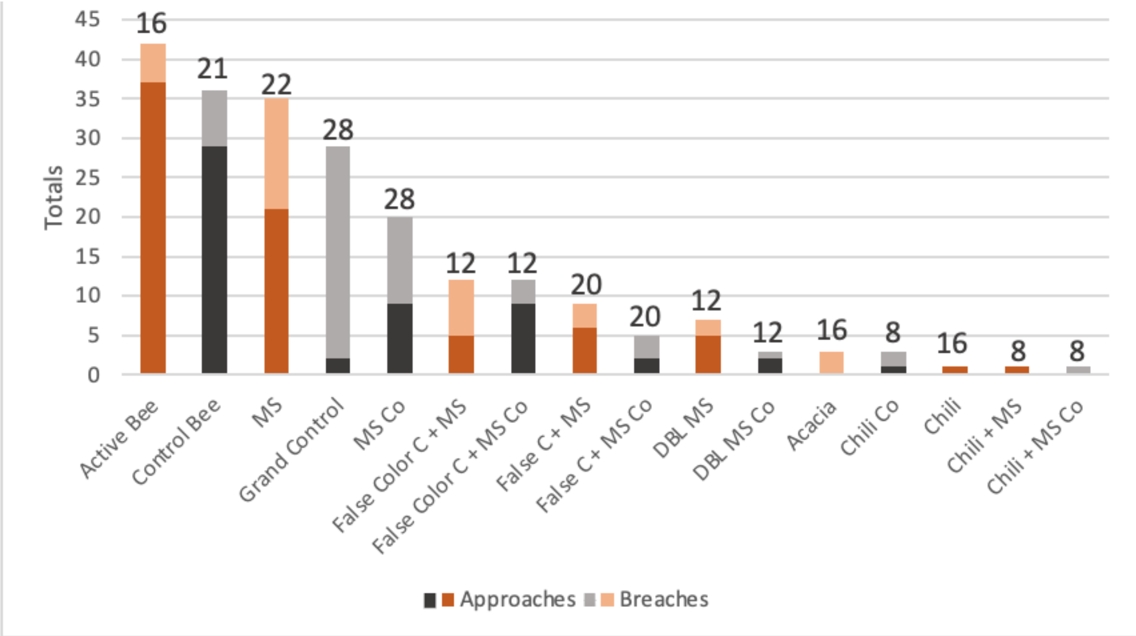

Figure 3. The total number of approaches and breaches that occurred at each deterrent fence over the past 7 trials. The number above the bars represent the number of field trials (= #fields per trial times number of trials) each deterrent type was tested. Bars in brown are deterrent fences, bars in black are control fences.

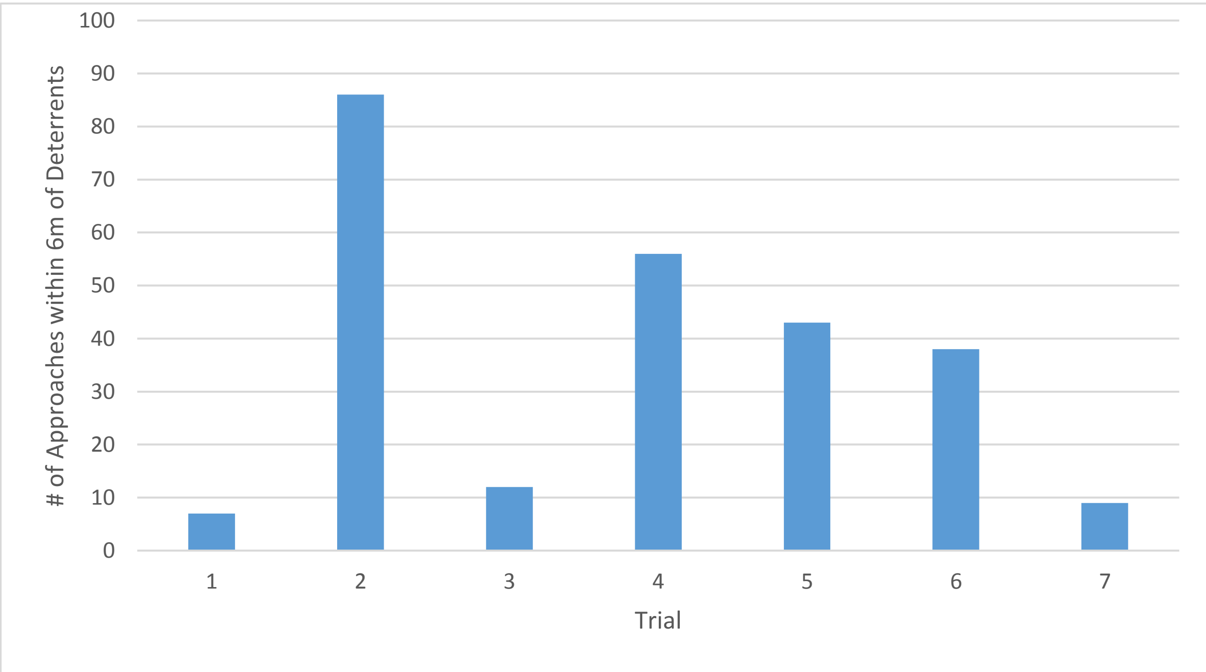

Figure 4. The total number of elephant approaches (within 6 meters of the fences) to active deterrent fences while maize was present over the past 7 trials.

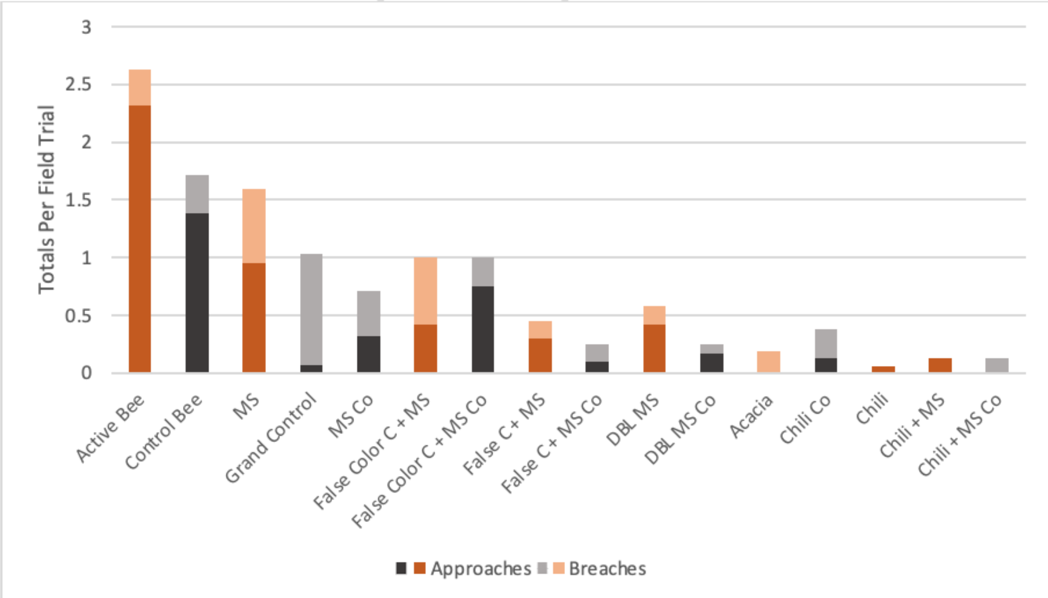

Figure 5. The total number of approaches and breaches that occurred at each deterrent fence over the past 7 trials corrected per field trial. Bars in brown are deterrent fences and bars in black are control fences.

b. *Beehive Fences.* As with the main experimental blocks, we asked the same farmers to continue to establish and care for the beehive fences at their farms as was done in 2019. Hive occupancy was highest in 2019 with 33% of hives occupied, yet honey production was still quite low, and no farmers have received a harvest of honey. Thus, we are instituting cleaning and other practices that can encourage higher honey yields, which was overseen by our Kenya colleagues in our absence.

c. *Aeolian Harp Design*. A component that Ms. Corde proposed to add to the beehive fences is a modified Aeolian Harp. The Aeolian harp is a musical string instrument that is played through the vibration of strings due to wind blowing against them (Figure 3). This vibration is then amplified through a larger body. Ms. Corde postulates that these harps can be tuned to a similar frequency to that of an agitated beehive, and then added to the dummy hives. This acoustic effect coupled with the presence of the beehives would function as visual and auditory cues to alert elephants that bees are in the area. To avoid the sound being emitted continuously from the box, a pressure activated mechanism is being tested to be added to the dummy hives.

Figure 6. An example of an Aeolian harp built by Ms. Corde using 50 lb. test fishing line, scraps of plywood, and an old gutter pipe. _{NOTE: photograph is proprietary; please do not distribute or otherwise share publicly}._

(2) Associated practices to deterrent fences

a. *Elephant Database.* We have created an elephant identification database using photos taken in elephant encounters on the ranch and camera trap images to identify elephants. This is the first time that elephants have been catalogued in the wildlife corridor and our catalog continues to grow. As of December 2019, we have cataloged 241 elephants in the region with the largest proportion (46%) comprised of adult males (Figure 7). Age class, sex, and identification are determined through analysis of photographs taken by researchers and volunteers while on the ranch. Age and age class are determined by comparing the height of the individual in question to that of the average height of an elephant in that age and age class. The decision of age and age class of an individual typically follows the guidelines of a calf being 0-4 years old, juveniles being 5-9 years, young adults being 10-14 years, subadults being 15-19 years, and adults being 20 years and above. The identification of the individual is then determined based on physical characteristics such as scars, tusk shape and markings, and variety in the ears. Due to the COVID-19 pandemic, we were not able to photograph and catalog any new elephants during 2020 but continue to input data from the exorbitant number of photos in 2019 .

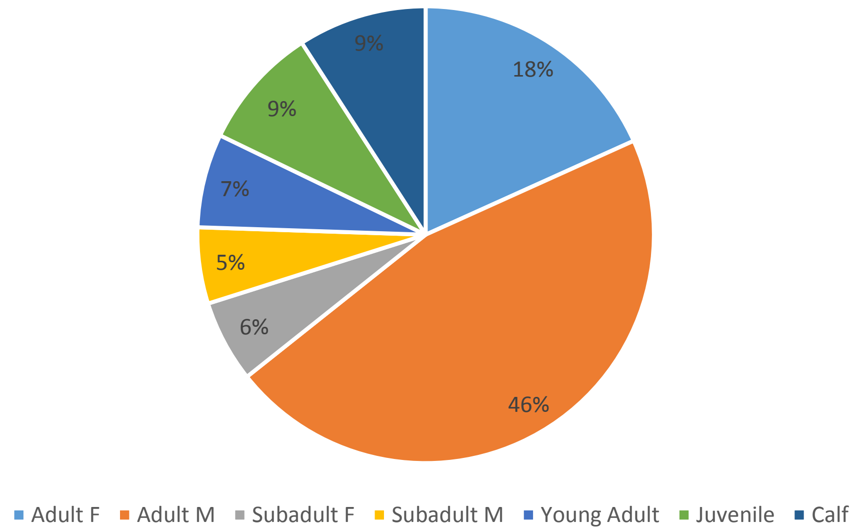

Figure 7. Percentage of adult (age ≥ 20 y) and sub-adult (15-19 y) male and female, as well as young adult (10-14 y), juvenile (5-9 y), and calf (0-4 y) elephants in the database to date.

b. *School Visits*. Because of the pandemic, no school visits involving our Earthwatch citizen scientists occurred in 2020. One of our team (Simon Kasaine) kept in steady contact with the Sasenyi School administrators. We established a fund to help feed school children and provide school supplies to assist in improving the relationship between the local community and scientists/conservation managers. As stated in the 2019 final report, "volunteers donated enough money to feed lunch to over 700 students in 2019 through March 2020." Donations from 2020 ($6984.55) enabled students to receive meals until the school was closed because of the pandemic. We currently have funds in reserve to transfer to the schools once they are back in session after the pandemic. The school often runs out of water during the drought season, as water douser trucks cannot make it up the badly eroded road, and so the storage tanks at the school dry up. Donations by the volunteers facilitated the connection of the school's storage tanks to the municipal water system. Now the school will have water year-round. This outreach has made a lasting and positive impression of our project on the people of Sasenyi.

(3) Crop and Wild Habitat Quality

a. *Climate Smart Agriculture.* Test plots in zai pits in the Sasenyi farms have continued during the pandemic. Control plots with no interventions continue to perform poorly compared to treatment plots.
b. *Tree Damage.* All 240 elephant-favored trees were located and tagged in the first year of the project and rechecked in the second and third years (2018 and 2019). The rechecks of each tree were to assess how elephant damage (bark stripping, branch breaking, felling) has changed since the inception of the monitoring. Because of the pandemic, we have been unable to re-check the trees in 2020, however, we evaluate data collected through 2019 and found that there may be a slight correlation between the increase in tree damage and the increase in the number of crops damaged per year (Figure 8).

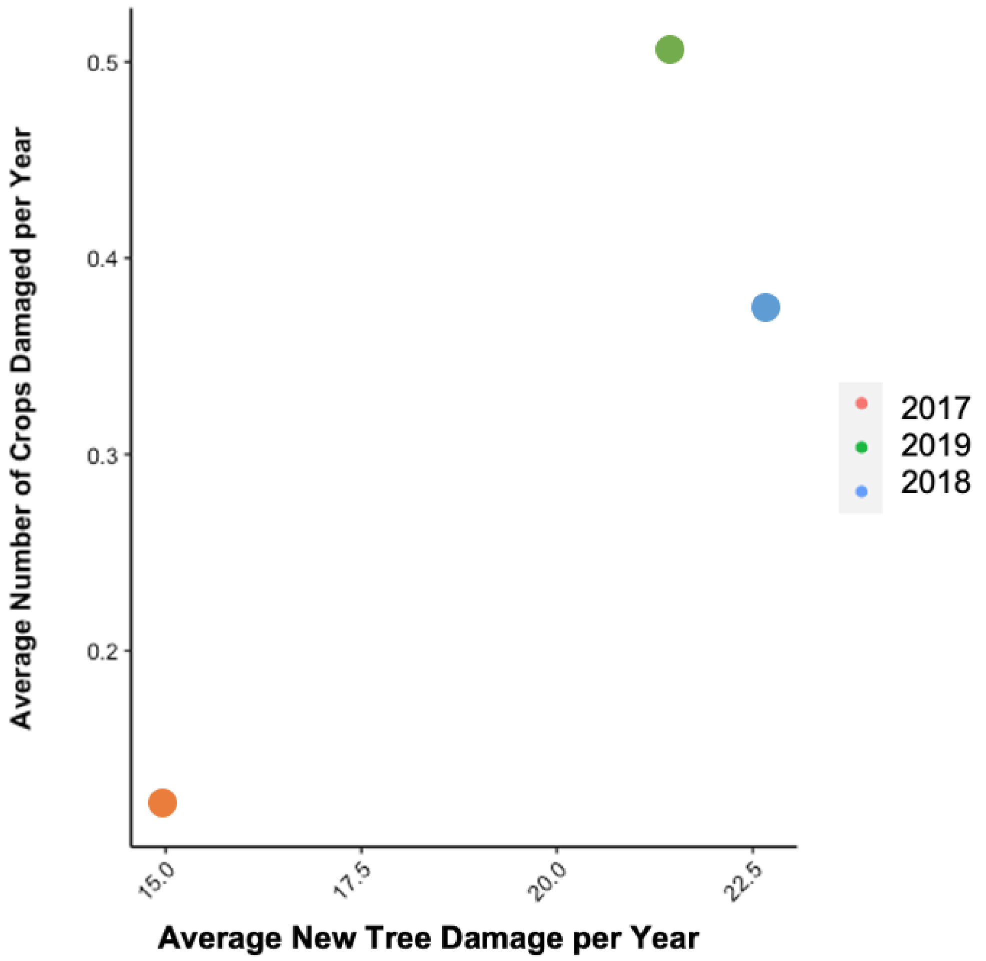

Figure 8. Average number of new elephant damage done to the trees per year in relation to the average number of crops damaged per year by elephants.

c. *Wildlife Surveys.* Because of the pandemic, we were unable to run wildlife surveys in 2020 but hope to resume these in 2021. We are evaluating data collected through 2019. Over the past three years of wildlife surveys, the most common wildlife found on transect were Cape buffalo, yellow baboon, and common zebra. These three species made up over 50% of all wildlife recorded since 2017. The occurrence of these species decreased as incidents of crop raiding by elephants increased (Figure 9). Few transects were conducted between the months of January and March due to the USA team not being on sight, leading to the low averages during those months. Further analysis needs to be completed to compare the crop raiding events to a wider range of wildlife spotted on transects.

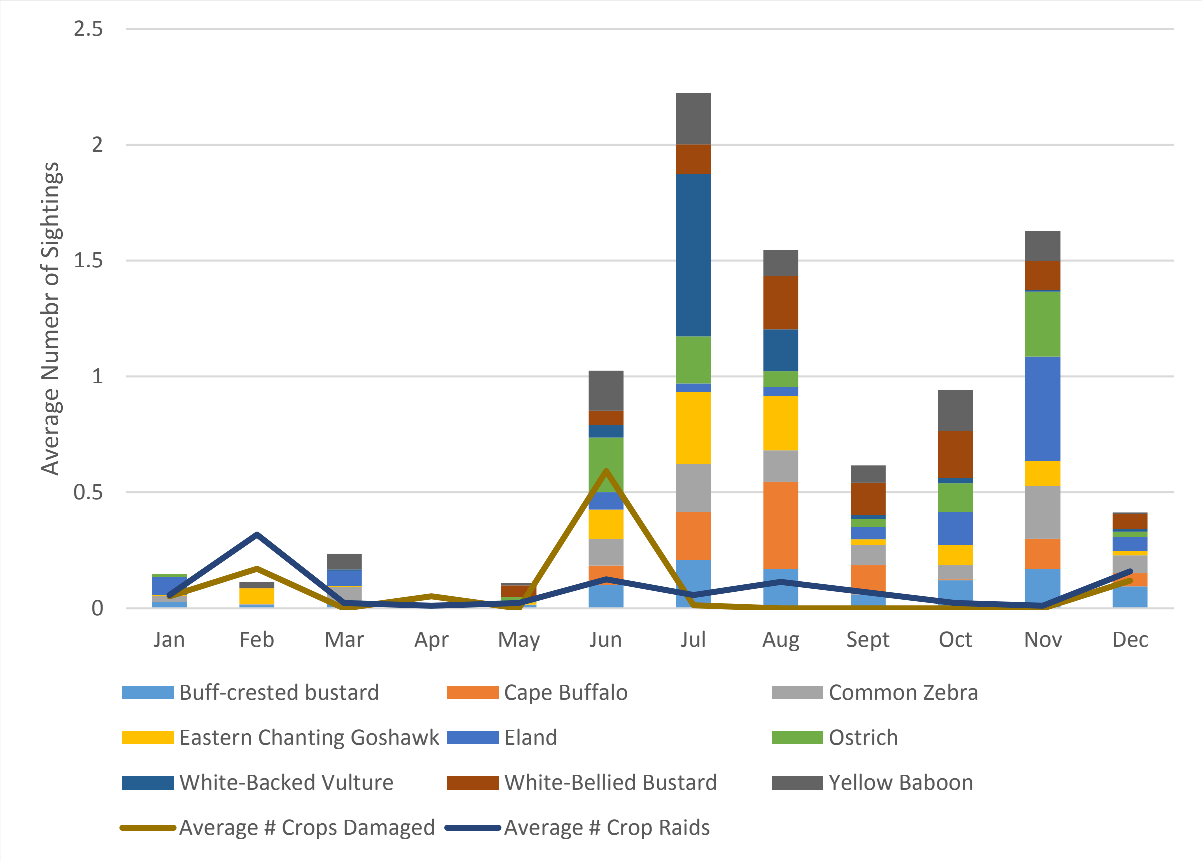

Figure 9. Average number of sightings per month of each most sighted and recorded large mammal and bird species on wildlife transect in relation to the average number of crop raiding events and crops damaged that occurred during those months. *Note: Few transects were conducted from January – March.*

(5) Community Outreach

a. *Village Surveys* Initial interviews were conducted in 2019 as part of the planning process for **workshop programs and community surveys** and participatory modeling. Please see the IEF interim report by Von Hagen et al. (2021) for additional information.

b. *HEC Mitigation*. A **community outreach program is part of the PhD thesis of Lynn Von Hagen** which will evaluate the attitudes and behaviors of villagers towards elephants and overall conservation (see Von Hagen et al. 2021 final IEF report).

5. Modifications of Actions

The COVID-19 pandemic completely modified our plans for 2020. Ms. Sophia Corde, Bruce Schulte, and Lynn Von Hagen were at the study site in December 2019. The multi-week visit by Corde and Schulte (and the final 2019 weeks in the field for Ms. Von Hagen) were conducted to familiarize Ms. Corde with the field and procedures in anticipation of the 2020 field season (May 2020 – January 2021). The experience also helped her composed a realistic thesis proposal for her Master of Science degree at WKU. Little did we suspect at the time that this would our last visit for at least a year! The Kenyan team has been able to keep the deterrent fences repaired and operational for 2020; however, we have suspended data collection on the other objectives because of the lack of personnel.

6. Conservation Outcomes to Date

(1) HEC

a. *Deterrent Fences.* In 2019 (trials 5 and 6), two combination deterrent fences were tested, namely the double metal fence and the false chili plus metal fence, along with two fields with the metal strip fence (one with the wire without metal strips control and the other with the overall no fence controls (Table 1). Because of the pandemic and our inability to be in the field, we continued to test these same fences in 2020. Increasing sample size will be helpful because the double metal strip fence appeared to be quite effective in these trials. Unfortunately, crops did not fare well in the first season in 2020 (trial 7), and subsequently, elephants were not very abundant in the area. As this present crop season concludes (trial 8), we are adding these data into our dataset.

b. *Elephant Database.* The elephant identification database has been continually updated through all trials, and more individuals are being added with over 140 bulls as well as recurring individuals in the area. Further analysis into the elephant database, and cross referencing it with camera trap images of crop raiders has already revealed that Rukinga Ranch has 8+ repeat crop raiders. This could provide insight into what deterrents work best against recurring crop raiders. Helping both the farmers, as well as the elephants by keeping them both out of dangerous situations.

c. & d. *Community Outreach & School Visits.* There was no way to conduct in-person outreach or school visits during 2020. However, repeated community outreach has improved our standing in the community and our feeding program has been highly successful.

e. *Track Crop Damage.* Local monitors have been noting elephant presence and have maintained deterrent fencing. Crop raiding was low this year due to the majority of crops being lost. Though minimal data are available, we have added this to our databases. With our continued experiments, we have acquired a great team of farmers who along with our local field assistants are providing important information on crop damage and success.

(2) Tree Damage and Mammal & Bird Surveys

a. *Tree Damage.* We are still analyzing the best way to provide a visual representation of tree damage in relation to elephant sightings and crop raiding incidents. We were not able to collect tree damage information during 2020, so our sample size of 3 years is small, however, a slight correlation can be seen between the average amount of new tree damage and the average number of crops damaged.

b. *Mammal and bird surveys.* Analysis of the mammal and bird surveys have shown a slight positive correlation between crop raiding events and sightings of zebra and ostrich on transect. Zebras were more prevalent when grasses are in bloom. The transect data will be analyzed further to better understand this apparent relationship and to examine other species. If through these analyses an indicator species can be found, it will further help the mitigation of HEC.

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 Parks have an estimated elephant population of 12,000-14,000 (ca. one-third of the Kenyan elephant population). Thousands 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. Elephant numbers in T5 started at about 150 elephants on the ranch, and several new-born elephants have been sighted. However, the population escalated to over 600 when the drought lasted through October, and the ranch was one of the only sources of water in the area. In 2019, elephant numbers were high on the ranch during May through early November due to the drought and the ranch being one of the only sources of water. Staff and volunteers were regularly seeing 100+ elephants per day and we received our greatest number of sightings for cataloging during this time. As soon as the rains arrived in November, elephant numbers plummeted.

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. In addition, the community of Ngambenyi has received a front-line Kasaine fence, another area with high crop raiding in the corridor. Monitors have noted adverse reactions from elephants, and some farmers behind the fence are planting crops again for the first time in years. Most participating farmers had failed harvests in T5 due to unusual rain patterns and drought, but all farmers (except those in a portion of block 4) are currently expecting near record harvests. Most farmers received a harvest from the short rains of 2019/2020 (T6). However, most farmers had total losses after the long rains of 2020 and the subsequent drought (T7).

8. Problems during the Project Period

See Section 5.

9. Evaluation of Success to Date

Under the circumstance, our project is surviving surprisingly well. Ms. Corde has made the most of her time in the USA by analyzing data and constructing prototype Aeolian harp fences at her home in Connecticut. Ms. Von Hagen has been diligent about manuscript writing, submission, and revision. Dr. Schulte has assisted with all of these endeavors. Dr. Schulte and Ms. Von Hagen gave a webinar for the Earthwatch Institute that was well received, and we received numerous interesting questions.

10. Next Steps

We will keep the deterrent aspect of the project going in 2021. Ms. Corde and Von Hagen hope to be in Kenya starting in April 2021. We had our first of six 2021 Earthwatch teams scheduled in June. Recently, Earthwatch announced the cancellation of all teams through June 2021. If teams start back up again in July, travel may still be restricted, or travelers may be reticent, which will affect the number of volunteers for our project and our funding. Nevertheless, we are optimistic that we can continue the main components of our project to further amiable coexistence between humans and elephants in rural Kenya.

11. Human Interest Story

Figure 10. Simon Kasaine and Mr. Maasai (the head teacher) in front of the new school water

The ESAK project has had the pleasure of hosting volunteer citizen scientists from across the globe through its involvement with Earthwatch since 2017. For each of the six teams hosted yearly, we visit Sasenyi Primary School where over 700 students attend. Many students walk several kilometers to school every day where the resources are scarce and the infrastructure rudimentary. In Kenya, there are school fees for each child which can create hardship for impoverished families, but one of the benefits is a meal provided mid-day. There are few things sadder than explaining to volunteers that the students sometimes eat a few bites and then take the remainder of their meal home to their younger siblings. Unfortunately, however, with so many students at Sasenyi, food supplies run out sometimes mid-way through the school year. This leaves students having to learn for an entire day with only a small bowl of porridge for breakfast. After a few teams, we quickly began receiving questions from volunteers on how they could support the school after their return to their home countries. Some volunteers began transferring money to purchase foods to help the school. Former volunteer Ellen Sass helped develop a network of potential supporters, and our project turned to IEF to see if they could provide a means to help facilitate since our group does not have non-profit status. Thankfully, IEF offered to provide a pathway for people to donate to the school which allows donors to deduct their donations and easily donate online. Researcher Simon Kasaine helps to facilitate the acquisitions and distribution of food supplies. Since its beginning the program has raised over $25K to support the school! Now students do not go hungry and can learn with full bellies, and the donations also employ two cooks from the local community to create and serve the meals each day. The school was also having issues with being able to provide any water during drought season. The school collects water by funneling rainwater through gutters into large tanks. Other organizations facilitated by Wildlife Works had recently provided a means to filter this water. However, when harsh droughts hit, the water simply runs out. In this area, dowser trucks often move around and distribute water where needed but the poor roads don't allow the trucks to reach the school. So once kids were receiving regular meals, some of the donations were allocated to hook the school into the county water system. Now there is fresh water for drinking year-round. In addition, funding has also helped add an additional teacher from the community. All of this work has been very well received by the community and goes a long way towards building trust when conservation programs such as our research project show an interest in the welfare and resilience of the community in addition to preservation of wildlife. We hope our work inspires other research projects to reach out to communities living with elephants to help build bridges at the socio-ecological interface.

12. Project Progress Summary (500 words)

Our Elephants and Sustainable Agriculture in Kenya (ESAK) project began in 2017 with experiments to compare the effectiveness of deterrent fences for abating crop raiding by elephants. To assess habitat quality and elephant impact, we surveyed large birds and mammals and measured elephant damage to trees. We also started an elephant identification database to ID crop raiders. We have made advances on all fronts. Lynn Von Hagen completed her MS at WKU in 2018 and is pursuing a doctorate at Auburn University. For 2020, we submitted complementary applications. Lynn is conducting community workshops and expanding our elephant behavior and crop raiding data collection beyond our initial study area. To better determine the practicality and affordability of our initiatives, our 2020 IEF project had intended to continue with the experimental deterrents, surveys, investigating early warning systems, and assessing climate smart agriculture practices. Unfortunately, the COVID-19 pandemic has prevented the USA-based team from traveling to Kenya. Furthermore, our 2020 Earthwatch Institute Citizen Science Volunteer teams have been canceled, reducing our project funding and number of field assistants. Restrictions in Kenya have delayed community surveys and other procedures that require gathering individuals together. Fortunately, we have been able to keep our deterrent fence study going. The climate was not kind to crops at our study site in the first growing season this year. Much of the maize has not survived, and overall elephant presence in the region has been low. We are hopeful for a more successful second growing season. Nevertheless, we have made the most of our time. Ms. Sophia Corde, candidate for the MS in Biology at WKU, spent 2020 analyzing data from past trials and developing a new deterrent based on an Aeolian harp for field testing in 2021. Her field season has been moved from May 2020-January 2021 to 2021-August 2021 in the hope that travel from the USA to Kenya will be possible during this time. In 2021, Earthwatch teams will occur no sooner than July. Earthwatch provides research funds only when teams are present, so we have not spent our 2020 IEF budget with the expectation that we will need the funds in 2021. We will require some additional funds as well because our 2020 budget was reduced by 30% and Earthwatch funds will be less in 2021 than projected for 2020. Overall, we are hopeful that our project and the complementary study by Ms. Von Hagen will be fully operational in 2021. In the meantime, we are analyzing our data and preparing means to disseminate our findings. We continue to be highly appreciative of the support from the International Elephant Foundation.

13. Project Progress Summary (50 words)

Our project suffered setbacks from the COVID-19 pandemic. We collected data on deterrent fences in the first and second growing seasons, although poor crop survival and limited elephant numbers have hindered efforts. We are analyzing past data, and preparing for a return to the field in April 2021.

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), Jomo Kenyatta University (http://www.jkuat.ac.ke/), and Auburn University (www.auburn.edu).

15. Financial Report – Final (February 2021)

The 2020 proposal to IEF by Schulte et al. was funded at a reduced amount (original request of $10,000). Thus, the budget had to be revised, and all equipment / visa expenses were eliminated (Table 3). Because travel has not been possible, the IEF funds have not been used to date. In addition, because no Earthwatch Institute groups traveled, the project also did not have access to any of these funds.

Table 3. IEF budget for 2020 – February 2021.

Item	Budget	Expenditures	Cost
Travel	$7000.00	Housing – Rukinga Ranch Company Ltd	$0.00
		Board (per diem)	$0.00
		In Country travel	$0.00
Total	$7000.00	All Expenses to date	$0.00
Remaining	$7,000.00		$0.00

16. Digital Images

Figure 11. Elephant approaching fence in experimental plot.

Figure 12. Elephant sniffing road as travels near experimental plots.

Figure 13. Heavy crop growth at CSA plot.

Figure 14. Delivering maize and beans to the Sasenyi school for student meals.

17. Video Clip

Submitted via Dropbox: PPPS file

18. Presentation / Publication Plans

Conferences:
None in-person because of pandemic (some intended ones were canceled or postponed).

Von Hagen, R.L., Norris, P., Githiru, M., Kasaine, S., Amakobe, B., Lepczyk, C., Schulte, B. A. Conversations on conservation: The human dimensions of elephant conservation in the Kasigau Wildlife Corridor of Kenya. British Ecological Society online Festival of Ecology. December 2020.

Von Hagen, R.L., Norris, P., Githiru, M., Kasaine, S., Amakobe, B. Schulte, B. A. Opportunities for collaborative approaches to crop raiding prevention can advance elephant conservation. Elephant Managers Association Conference (online), October 2020.

Von Hagen, R.L. Invited Guest Lecturer, Brandeis University, Boston USA. Animal Behavior class.

Published:
Von Hagen, R.L., Kasaine, S., Githiru, M., Mutwiwa, U., Amakobe, B., Schulte, B.A. **2020.** Metal strip fences for preventing African elephant (*Loxodonta africana*) crop foraging in the Kasigau Wildlife Corridor, Kenya. *African Journal of Ecology.* DOI: 10.1111/aje.12821

Von Hagen, R.L. **2020**. Chai, Chapati & Coexistence: The Essential Role of Community Engagement in Elephant Conservation. *Journal of Elephant Managers Association.* (**31**)3, 102-106.

Von Hagen RL, Norris P, Schulte BA. **2020.** Quantifying capsaicinoids from chili pepper and motor oil mixtures used in elephant deterrent fences. Chromatographia 83: 1153-1157. https://doi.org/10.1007/s10337-020-03934-8

In Preparation:
Von Hagen, RL, N Norris P, Schulte BA. Capsaicin degradation and alternative solvents for chili fences used to deter African elephant (*Loxodonta africana*) crop raiding.

19. Website, Blogs, Social Media Accounts

https://www.facebook.com/ElesKenya
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=
https://www.youtube.com/watch?v=fi0LFk6Vp5g&t=31s
https://earthwatch.org/science-matters-webinar-series/elephants-sustainable-agriculture
https://lvonhagen.wixsite.com/website

20. Tentative 2021-2022 Schedule

Dates	Activity	Personnel
January – March 2021	Data analysis	Corde, Von Hagen, Schulte
April - December 2021	Deterrent preparation and data collection on all aspects	Both teams, EW volunteers if possible
January - February 2022	Data collection on deterrents Data transfer, analysis, & reporting	Kenyan field team Both teams