EXPEDITION REPORT

Expedition dates: 3 February – 1 March 2019

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Authors:

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Enonkishu Conservancy

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Biosphere Expeditions

ABSTRACT

Enonkishu Conservancy is on the northernmost boundary of the Mara-Serengeti Ecosystem (MSE). The conservancy is secured year to year by renting the land from Maasai title-deed owners, who as conservancy members, abide by land-use regulations (restricting permanent structures, arable farming, fences, utilisation of natural resources and regulating the number of livestock). The land rent for Enonkishu was first paid in 2014 and although many wildlife species have re-inhabited the conservancy, monitoring them has been haphazard. Because Enonkishu aims to be a showcase site for sustainable, community-based rangeland management, resource competition between ungulates and livestock is a concern. Enonkishu employs seven rangers who are responsible for protection of wildlife, livestock and people within the conservancy. Rangers are tasked with collecting data on wildlife populations, but their training prior to the involvement of Biosphere Expeditions had been insufficient, resulting in unreliable data.

An inaugural one-month long citizen science wildlife monitoring expedition was organised with Biosphere Expeditions to alleviate this, and took place from 3 February to 1 March 2019. A reliable wildlife monitoring programme was developed for the expedition and to inform livestock owners how many livestock can coexist with the wildlife population, without hindering its growth and establishment on Enonkishu. Monitoring methods used during the expedition included foot and vehicular patrol transects, waterhole observations, a hilltop observation point, and deploying camera traps. Thirty-six mammal species were observed in Enonkishu using these methods: aardvark (*Orycteropus afer*), African elephant (*Loxodonta africana*), African hare (*Lepus microtis*), banded mongoose (*Mungos mungo*), bat-eared fox (*Otocyon megalotis*), black and white colobus monkey (*Colobus angolensis*), black-backed jackal (*Canis mesomelas*), brown greater galago (*Otolemur crassicaudatus*), bushbuck (*Tragelaphus scriptus*), bushpig (*Potamochoerus larvatus*), Cape buffalo (*Syncerus caffer caffer*), caracal (*Caracal caracal*), dik dik (*Madoqua kirkii*), Dwarf mongoose (*Helogale parvula*), eland (*Taurotragus oryx*), giraffe (*Giraffa tippelskirchi*), Grant’s gazelle (*Nanger granti*), Koke’s hartebeest (*Alcelaphus buselaphus*), hippopotamus (*Hippopotamus amphibius*), honey badger (*Mellivora capensis*), impala (*Aepyceros melampus*), klipspringer (*Oreotragus oreotragus*), large spotted genet (*Genetta tigrine*), leopard (*Panthera pardus*), lion (*Panthera leo*), mountain reedbuck (*Redunca fulvorufula*), Olive baboon (*Papio anubis*), spotted hyaena (*Crocuta crocuta*), Thomson’s gazelle (*Eudorcas thomsonii*), topi (*Damaliscus korricum*), vervet monkey (*Chlorocebus pygerythrus*), warthog (*Phacochoerus africanus*), waterbuck (*Kobus ellipsiprymnus*), white-tailed mongoose (*Ichneumia albicauda*), white-bearded wildebeest (*Connochaetes taurinus*) and zebra (*Equus quagga*).

Next to collecting baseline data, another objective of the expedition was to train the rangers to collect accurate data. Rangers supported the expedition throughout and in doing so built their skills, confidence and pride in their work to such an extent that a less intensive version of monitoring can now be conducted in the absence of citizen scientists.

Enonkishu demonstrates how livestock can coexist with wildlife and enhance the ecosystem in such a way that both thrive, resulting in revenue for Maasai members who benefit from a more sustainable alternative to arable farming. The expedition demonstrated how a citizen science expedition at the interface of wildlife monitoring, community training and tourism can support a valuable showcase conservancy to the benefit of wildlife and people.

Enonkishu rangers will continue collecting data using each method of wildlife monitoring monthly with another expedition team contributing to an intensive monitoring programme in February 2020. With a growing collection of data, Enonkishu will be able to track progress in increasing wildlife populations over time.

MUHTASARI

Hifadhi ya Enonkishu iko kaskazini mwa mpaka ya mazingira ya Mara-Serengeti na inapata uhifadhi wake kila mwaka kwa kukodisha ardhi kutoka kwa wenye hati ya umiliki wa ardhi wenye asili ya jamii ya maasai, ambao kama washiriki wa hafidhi hii hufuata kanuni za utumiaji wa ardhi (kutojenga majengo ya kudumu, kilimo endelevu, kutounda vizio, matumizi ya maliasili na kudhibiti idadi ya mifugo). Kodi ya ardhi ya Enonkishu ililipwa kwa mara ya kwanza mnamo 2014, ingawa spishi nyingi za wanyamapori wamerejea kwenye makaazi yao, utafiti haujakuwa na mpangilio unaofaa na kwa sababu Enonkishu inakusudia kuwa kielelezo cha usimamizi wenye misingi ya jamii na wenye uendelevu, ushindani wa rasilimali kati ya wanyama pori na mifugo ni suala nyeti. Enonkishu imewaajiri walinda mbuga ambao wamepewa jukumu na mamlaka ya kuwalinda wanyama pori, mifugo na wakaazi wa Enonkishu pamoja na kukusanya takwimu ya idadi ya wanyama pori. Hata hivyo mafunzo waliopata kwa kujihusisha na harakati za kutafiti na kundi la utafiti ya Biosphere Expeditions ni chache mno kiasi ya kwamba data inayokusanywa siyo yenye dhamana.

Uzinduzi wa msafara wa utafiti wa wanyamapori iliyohusisha raia wa sayansi, uliandaliwa na kikundi cha Biosphere Expeditions nakufanyika kwa mwezi mmoja kutoka 3 Februari hadi 3 Machi 2019. Mpango huu wa utafiti wa wanyapori wenye uaminifu uliundwa na kundi hili ili kuwashauri na kuwajulisha wamiliki wa mifugo ni idadi ipi ya mifungo inaweza kuishi na idadi fulani ya wanyama pori bila kuzuia ukuzaji wake hapa Enonkishu. Baadhi ya njia za utafiti zilizotumika wakati wa utafiti huo ni kunakili takwimu za idadi ya wanyama pori wanapopiga doria kwa miguu na kwenye gari, kupiga doria kwenye bwawa la maji, kileleo cha milima na matumizi ya kamera za mitego zilizotundikwa msituni. Spishi thelathini na saba wakiwemo kiharara (*Orycteropus afer*), ndovu (*Loxodonta africana*), sungura (*Lepus microtis*), nguchiro wenye bendi (*Mungos mungo*), mbweha (*Otocyon megalotis*), mbega (*Colobus angolensis*), mbweha mwenye mngongo-mweusi (*Canis mesomelas*), komba (*Otolemur crassicaudatus*), pongo (*Tragelaphus scriptus*), nguruwe wa msituni (*Potamochoerus larvatus*), nyati (*Syncerus caffer caffer*), simbamangu (*Caracal caracal*), diki diki (*Madoqua kirkii*), nguchiro mbilikimo (*Helogale parvula*), pofu (*Taurotragus oryx*), twiga (*Giraffa tippelskirchi*), swala granti (*Nanger granti*), koke ya kongoni (*Alcelaphus buselaphus*), kiboko (*Hippopotamus amphibius*), cheche (*Mellivora capensis*), paa (*Aepyceros melampus*), ngurunguru (*Oreotragus oreotragus*), kanu mwenye madoadoa kubwa (*Genetta tigrine*), chui (*Panthera pardus*), simba (*Panthera leo*), tohe milima (*Redunca fulvorufula*), nyani (*Papio anubis*), kingubwa (*Crocuta crocuta*), swala wa aina ya thompson (*Eudorcas thomsonii*), nyamera (*Damaliscus korricum*), ngedere (*Chlorocebus pygerythrus*), ngiri (*Phacochoerus africanus*), kuro (*Kobus ellipsiprymnus*), nguchiro mwenye mkia nyeupe (*Ichneumia albicauda*), nyumbu mwenye ndevu nyeupe (*Connochaetes taurinus*), na punda milia (*Equus quagga*) walionekana Enonkishu.

Kando na hayo, lengo lingine la kukusanya takwimu za msingi kwenye utafiti ilikuwa kutoa mafunzo kwa walinzi wa mbuga ili wakusanye data sahihi. Walinzi wa mbuga waliunga mkono na kushiriki kwenye utafiti huu na kwa kufanya hivo kujenga ujuzi wao, ujasiri na majivuno kwa kiasi kwamba wameweza kutekeleza utafiti huu usiowakina bila usaidizi wa raia wa kisayansi.

Enonkishu imefaulu kuonyesha jinsi mifugo zinaweza kuishi kwa pamoja na wanyamapori na kuboresha mazingira kwa njia ambayo wote wanastawi na kuzalisha mapato kwa wanachama ambao wamenufaika kutokana na shuguli za utalii ambayo ni mbadala kwa kilimo. Ziara ya Utafiti huu ulionyesha jinsi raia wasayansi wakitafiti wanyamapori, kuwafunza jamii na shuguli za utalii inaumuhimu kwa kuboresha jamii na wanyama pori.

Walinzi wa mbuga ya Enonkishu wataendelea kukusanya data ya wanyama pori kila mwezi kwa kutumia kila mbinu za kukusanya takwimu hadi wakati ambapo msafara ya wana raia wanasayansi wataiunga na kushiriki katika mpango wa kina wa kukusanya takwimu mwaka ujao wa 2020. Pamoja na ukusanyaji mkubwa wa takwimu, Enonkisu itakuwa na uwezo wa kufuatilia iwapo idadi ya wanyama pori inaongezeka kila mara.

Contents

1. Expedition Review

Matthias Hammer (editor)
Biosphere Expeditions

1.1. Background

Biosphere Expeditions runs wildlife conservation research expeditions to all corners of the Earth. Our projects are not tours, photographic safaris or excursions, but genuine research expeditions placing ordinary people with no research experience alongside scientists who are at the forefront of conservation work. Our expeditions are open to all and there are no special skills (biological or otherwise) required to join. Our expedition team members are people from all walks of life, of all ages, looking for an adventure with a conscience and a sense of purpose. More information about Biosphere Expeditions and its research expeditions can be found at www.biosphere-expeditions.org.

This project report deals with an expedition to Enonkishu Conservancy of the Mara-Serengeti Ecosystem (MSE) that ran from 3 February to 1 March 2019 with the aim of ascertaining population diversity and abundance, and to work with local people on defending this iconic African landscape from encroachment, poaching and destruction.

The MSE supports the most diverse migration of grazing mammals on Earth. The Mara, although only a quarter of the total ecosystem area, is crucial to the survival of the entire system, because it is the source of forage for wildlife migrating through the Serengeti during critical points in the dry season. Only 25% of the wildlife habitat in the Mara part of the ecosystem is protected (in the Mara National Reserve); the rest lies within conservancies north of the reserve. These conservancies, which are local associations dedicated to the protection of the environment and its resources, are bearing the brunt of the pressure from recent unprecedented population growth and the subsequent transition in land uses from livestock to crop farming.

Enonkishu Conservancy, the expedition's core study area, is the northernmost conservancy in the MSE and although small at 1,705 hectares (4,224 acres), supports the same wildlife species found throughout the reserve and neighbouring conservancies. The conservancy was founded in 2009, but only began to organise itself properly in 2014. Enonkishu's stated aim is to preserve wildlife in tandem with ancient Maasai cow-herding culture, allowing wildlife and cattle to share the same space in a sustainable way. Enonkishu, often called "the last line of defence", also has a key role to play in defending the Mara from encroachment, as it is the bulwark that separates the wilderness of the Mara in the south from agricultural areas in the north.

Since Enonkishu combines sustainable cow herding with wildlife presence, monitoring wildlife is crucial. This is why Biosphere Expeditions has been asked to provide citizen scientists to assist with data collection in order to establish baseline data and track improvements in wildlife populations as Enonkishu's initiatives gain momentum. With evidence of an increase in wildlife over time and viable populations within its boundaries, Enonkishu has the potential to become a showcase for successful wildlife and cattle management in Kenya and the rest of Africa.

1.2. Research area

Kenya is a country in Africa and a founding member of the East African Community (EAC). Its capital and largest city is Nairobi. Kenya's territory lies on the equator and straddles the East African Rift valley, covering a diverse and expansive terrain that extends roughly from Lake Victoria to Lake Turkana, and further south-east to the Indian Ocean. It is bordered by Tanzania to the south and southwest, Uganda to the west, South Sudan to the north-west, Ethiopia to the north and Somalia to the north-east. Kenya covers 581,309 square km and has a population of approximately 48 million.

Kenya also has considerable land area devoted to wildlife habitats, including the famous Maasai Mara ecosystem, the expedition's study site, where wildebeest and other bovids participate in a large scale annual migration. More than one million wildebeest and 200,000 zebras migrate across the Mara River. The "Big Five" game animals of Africa - that is the lion, leopard, buffalo, rhinoceros and elephant, can all be found in Kenya and in the Maasai Mara in particular.

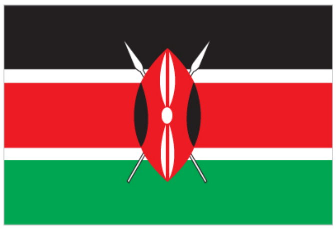

Figure 1.2.a. Flag and location of Kenya and study site.

An overview of Biosphere Expeditions' research sites, assembly points, base camp and office locations is at Google Maps.

Kenya has a warm and humid tropical climate on its Indian Ocean coastline. Thanks to its diverse climate and geography, expansive wildlife reserves and national parks such as the East and West Tsavo National Parks, Amboseli National Park, Maasai Mara, Lake Nakuru National Park, Aberdares National Park and white sand beaches at the coastal region, Kenya is home to the modern safari (in fact 'safari' is a Swahili word meaning 'journey'). It also has several world heritage sites such as Lamu and a number of beaches, including Diani, Bamburi and Kilifi. The Maasai Mara is considered one of the natural wonders of the world and has the world's highest biodiversity of large mammals.

1.3. Dates

The expedition ran over a period of four weeks divided into two twelve-day groups, each composed of a team of international citizen assistants, scientists and an expedition leader. Group dates were:

3 - 15 February | 17 February - 1 March 2019

Expedition participants could join for multiple groups (within the periods specified). Dates have been chosen to coincide with the most favourable weather in the Mara.

1.4. Local conditions & support

Expedition base

The expedition base was a very modern and comfortable field station with large twin or double bed safari cottages with linen, furniture, en suite hot showers and flush toilets. Expedition participants shared a cottage by default, but those who wanted to stay in single accommodation could also stay in a safari tent with linen and furniture, but with hot showers and flush toilets in a campsite style ablution block. The field station also had a large and comfortable chalet-type structure, right by the Mara river, for eating, meeting, relaxing, data entry, etc. There was mains electricity (220V, UK type G sockets).

Figure 1.4a. Expedition base: A two-bed cottage.

Figure 1.4b. Expedition base: Safari tent singles.

Figure 1.4c. Expedition base: Main area for eating.

There was intermittent mobile phone coverage at base and throughout the study area (provider Safaricom) and participants could access the internet through this. All meals were prepared for the team by the camp chef and special diets were catered for by prior arrangement.

Weather

The Kenyan study site is located just south of the equator at an altitude between 1,500 and 1,900 metres. Kenya has a pleasant, tropical climate, but there are large regional climatic variations influenced by several factors, including altitude. As with everywhere else on the planet, the weather is changing in Kenya too and erstwhile reliable weather patterns may no longer apply. In general, however, the expedition months of February and March are near the beginning of the wet season, which has been increasingly unpredictable. Afternoon showers should be expected, but many days are warm and dry. Temperatures are likely to be around 23°C and reaching up to 30°C. Early morning temperatures can be as low as 10°C.

During the expedition in February 2019, Enonkishu had 42.9 mm of rainfall, but December 2018 and January 2019 experienced higher than normal rainfall, contributing to very green conditions. Showers in the afternoon were not uncommon, although there was only one heavy shower that hampered monitoring activities the following morning. The temperature ranged from 10-30°C.

Transport & vehicles

Expedition participants made their own way to the assembly point in Nairobi. From there onwards and back to Nairobi all transport was provided for the expedition team. The expedition used a combination of 4x4 cars provided by Market Car Hire and Enonkishu Conservancy. Surveys were conducted on foot or by vehicle.

Medical support and incidences

The expedition leader was a trained first aider and the expedition carried a comprehensive medical kit. The nearest doctor, hospital and clinic were approximately 45 minutes away. All team members were required to carry adequate travel insurance covering emergency medical evacuation and repatriation. Safety and emergency procedures were in place and had to be invoked for a serious incidence of a bacterial infection of the digestive system, which affected most members of the expedition team. Some had to seek medical help, but all recovered.

1.5. Expedition scientist

Rebekah Karimi, a Kenyan/American, was the expedition lead scientist and is also the manager of Enonkishu Conservancy. Rebekah holds degrees in zoology, animal behaviour and conservation biology, and has worked in Africa since the turn of the millennium. Her work there included six years of instructing field courses in Namibia and Botswana, and her involvement with, and love of, the Mara began on a study trip during her undergraduate degree. Her interests range from squirrels to baboons, elephants and yellow crazy ants.

1.6. Expedition leader

Malika Fettak is half Algerian, but was born and educated in Germany. She majored in Marketing & Communications and worked for more than a decade in both the creative department, and also in PR & marketing of a publishing company. Her love of nature, travelling and the outdoors (and taking part in a couple of Biosphere expeditions) showed her that a change of direction was in order. Joining Biosphere Expeditions in 2008, she runs the German-speaking operations and the German office and leads expeditions all over the world whenever she can. She has travelled extensively, is multilingual, a qualified off-road driver, diver, outdoor first aider, and a keen sportswoman.

1.7. Expedition team

The expedition team was recruited by Biosphere Expeditions and consisted of a mixture of ages, nationalities and backgrounds. They were (in alphabetical order and with country of residence):

3 - 15 February: Klaus Ablaßmeier (Germany), Christine Bernhofer (Germany), Susanne Bollinger (Switzerland), Julia Collins (UK), Andrew Collins (UK), Maria Domingues (Portugal), Cornelia Ernst (Germany), Janice Moore (Australia), Jill Swenson (USA), Eric Swenson (USA), Peter Thoem (Canada), Rebecca Tunstall (UK). Also, Matthias Hammer, executive director of Biosphere Expeditions attended for part of the group.

17 February - 1 March: Valery Collins* (UK), Wendy Eklund (USA), Ellen Haas (USA), Leonard Kinanta** (Kenya), Don Macpherson (Australia), Rose Palmer-Sungail* (USA), Linda Southall (Canada), Chris Taylor* (UK), Peter Thoem (Canada), Rebecca Tunstal (UK), Carrie Visinatainer (USA), Michael von Bose (USA).

Also throughout the expedition: Albanus Mutiso (Mara Training Centre Manager), Musa Kiseer (Enonkishu Monitoring Officer), as well as conservancy rangers Francis Dapash (Head Ranger), Albert Cheruiyot (Monitoring Ranger), Nonyuat Lenkume, Meshack Chepuret, Joseah Langat, Mike Koriata, and Salami Koriata.

*Member of the media
**Placement supported by the Friends of Biosphere Expeditions

1.8. Partners

Biosphere Expeditions' three main partners for this expedition are the Mara Training Centre, Enonkishu Conservancy and the Last Line of Defence Trust.

Mara Training Centre was built with the objective of training conservancy members within the Mara on enhancing their ecological knowledge of cattle husbandry and pastoralism. Enonkishu Conservancy, a local association dedicated to the protection of the environment and its resources, was created to preserve wildlife in tandem with ancient Maasai cow-herding culture. The Last Line of Defence Trust was established in 2015 as the fundraising arm of Enonkishu Conservancy. Its objective is to protect the boundary of the Mara-Serengeti Ecosystem by funding projects that facilitate environmental education and protection along the Mara boundary.

1.9. Expedition budget

Each citizen scientist paid a contribution of €2,580 per person per twelve-day period towards expedition costs. The contribution covered accommodation and meals, supervision and induction, special research equipment and all transport from and to the team assembly point. It did not cover excess luggage charges, travel insurance, personal expenses such as telephone bills, souvenirs etc., or visa and other travel expenses to and from the assembly point (e.g. international flights). Details on how this contribution was spent are given below.

Income	**€**
Expedition contributions	53,028
Expenditure	
Staff Includes local and Biosphere Expeditions staff salaries and travel expenses	9,709
Research Includes equipment and other research expenses	6,915
Transport Includes hire cars, fuel, taxis and other in-country transport	12,358
Expedition base Includes accommodation, food, services & conservancy fees	13,690
Miscellaneous Includes miscellaneous fees & sundries	763
Team recruitment Kenya As estimated % of annual PR costs for Biosphere Expeditions	8,676
Set-up of expedition Includes all costs of reconnaissance visit	3,165
Income – Expenditure	**55,276**
Total percentage spent directly on project*	**104%**

*This means that in 2019, the expedition ran at a loss (of €2,248) and was supported over and above the income from the expedition contributions by Biosphere Expeditions.

1.10. Acknowledgements

We are very grateful to all the expedition citizen scientists, who not only dedicated their spare time to helping but also, through their expedition contributions, funded the research. We would also like to thank our key partners, Enonkishu Conservancy and their rangers Francis Dapash, Albert Cheruiyot, Nonyuat Lenkume, Meshack Chepuret, Joseah Langat, Mike Koriata and Salami Koriata, as well as the Mara Training Centre, especially Albanus Mutiso and Musa Kiseer. Biosphere Expeditions would also like to thank members of the Friends of Biosphere Expeditions and donors for their sponsorship, as well as Tarquin Wood for his help in making the expedition a reality. Last, but not least thanks to Joseph Kosgei, Bernard Cheruiyot, Beatrice Vakwa and Rose Nasimiyu for looking after us and keeping us well fed. Finally a special thanks to Dr. Alan Lee for very helpful comments on this report and for helping with the science for it and for the forthcoming 2020 expedition.

1.10. Further information & enquiries

More background information on Biosphere Expeditions in general and on this expedition in particular including pictures, diary excerpts and a copy of this report can be found on the Biosphere Expeditions website www.biosphere-expeditions.org.

Enquires should be addressed to Biosphere Expeditions at the address given on the website.

2. Monitoring a model of livestock/wildlife coexistence in the Mara-Serengeti ecosystem buffer zone

Rebekah Karimi
Enonkishu Conservancy

2.1. Introduction

The Mara-Serengeti ecosystem (MSE) within Kenya contains 17 conservancies in addition to the Maasai Mara National Reserve (MMNR). In 2006, the wildebeest migration through the MSE was named one of the new Seven Wonders of the World (Bedelian 2012). However, wildlife populations around the MMNR are in decline (Blackburn et al. 2016, Green et al. 2017, Homewood et al. 2001, Ogutu et al. 2011, Veldhuis 2019). In 2009, Tarquin and Lippa Wood began the process of registering Enonkishu Conservancy on the northern edge of the MSE on former agricultural lands. It took four years to fulfill the requirements and attain funding to secure what is now the conservancy. Over those four years, 2,500 of the original 4,000 hectares were converted to arable farming and no longer available to form the conservancy. Since 2014, anecdotal evidence suggests that there have been improvements in wildlife numbers and the ecosystem. However, reliable data to prove this scientifically have been lacking.

Enonkishu has conducted monitoring of the grassland quarterly and has slowly been building a monitoring regime for wildlife. Resources are limited and although the conservancy rangers have been tasked with wildlife monitoring, they had not received sufficient sustained training by the time the expedition started.

As Enonkishu is in such a vulnerable location in an extremely important buffer zone, it also serves as the front line of the conservation of the MSE. As such it is imperative that the conservancy's wildlife is monitored in order to ascertain wildlife and habitat recovery.

Citizen science

Manpower is often the limiting factor in how intensively a landscape can be monitored (Dickinson 2012). Citizen scientists offer an opportunity to have boots on the ground in conservation areas where resources are limited, building a valuable database (Bonney et al. 2014). Data collection by citizen scientists on this expedition was simple and straightforward, for example species identification and counting, and data entry was supervised to ensure quality and transparency between the field team and scientists (Foster-Smith & Evans 2003). In addition to collecting valuable data, citizen science engages a larger community in environmental education, scientific literacy, conservation initiatives, and natural history observation (Evans et al. 2005). In fact, involving citizen scientists with a fresh perspective offers new insights, which may lead to new and improved testable hypotheses (Foster-Smith & Evans 2003).

Fields in which citizen science has been utilised include biological studies of global climate change and in sub-disciplines focused on species (rare and invasive) and ecosystems (Dickinson et al. 2012). By engaging non-career scientists, programmes deploying civilians to ecosystems off the beaten path elevate public understanding and support of science, the environment, and earth stewardship (Dickinson et al. 2012).

Protected areas, buffer zones and tourism

It is predicted that by 2020, protected areas could cover 17% of the world's terrestrial area, but biodiversity continues to decline, as the human population is encroaching on boundary areas and most biodiversity resides in human-modified landscapes (Western et al. 2015, Chape et al. 2005). Biodiversity within increasingly rare wildlife habitats is intrinsically valued by tourists, whilst also enabling essential ecosystem services (Harrison et al. 2014, Turner et al. 2007). Establishing buffer zones and constant assessment of their functionality is essential to the preservation of biodiversity (Veldhuis 2019, Ogutu et al. 2016). The concept of a multi-use buffer zone can bolster the conservation of wildlife habitat along with ecosystem support, and also provides an economic incentive for local impoverished populations (Homewood et al. 2001, Western et al. 2009). Rather than relying solely on tourism ventures, livestock farming if properly managed can serve as an additional source of income while improving the quality of rangelands for wildlife species (Lankester & Davis 2016). The alternative of arable mechanised farming severely degrades the soil and is not compatible with wildlife coexistence (Ogutu et al. 2016, Homewood et al. 2001).

Pastoral lands surrounding protected areas serve as vital extensions of wildlife habitat. Historically, buffer zones have been shaped by restrictive conservation policies, expropriation of land, efforts to include communities in conservation, both positive and negative wildlife/livestock interactions, and political tensions (Lankester & Davis 2016). The coexistence of livestock and wildlife has potential to ease tensions between the tourism industry and traditional local communities, many of whom are more interested in livestock than wildlife conservation. If tourists see the benefits of grazing livestock in wildlife habitat and both wild and domestic species thrive, both factions benefit. The local communities maintain their traditional livelihoods and gain additional income from the livestock. When sustainable rangeland management is employed, it improves resources utilised by wildlife species, promoting healthy ecosystem services, and preserving wildlife habitat (Veldhuis 2019, Lankester & Davis 2016). Recruiting local communities to support conservation has been a challenge since the commencement of protected areas, but adding additional value by encouraging and supporting traditional land use has potential (Reid et al. 2009).

Livestock/wildlife co-existence

Innovative tools and techniques are necessary to maintain and restore resilient biological and social systems (Mooney et al. 2009). The sustainable management of grasslands and rangelands to enhance pastoral livelihoods and the conservation of wildlife habitats is one form of ecosystem-based adaptation that can provide multiple socio-cultural, economic and biodiversity co-benefits (Osano et al. 2013, Tyrell et al. 2017). Shifting from conflict with pastoralists into an integrated land use change that manages livestock grazing in a sustainable manner is one way of providing such benefits.

As species mutualisms shift with the added stress of resource competition, the species interactions and relationships have been disrupted (Mooney et al. 2009). Improving understanding of the key relationships between biodiversity and service provision will help guide effective management and protection strategies (Veldhuis 2019, Harrison et al. 2014).

Investigating inter-species interactions around a resource such as a waterhole could shed some light on the complexity of climate change and its effects within buffer zones, which already experience ample stress from proximity to human encroachment.

Climate change and water availability

Climate change affects the amount of rainfall and causes higher temperatures and greater climate variability (Osano et al. 2015). In East Africa, climate change will make rangelands warmer, increase rainfall unpredictability, reduce plant-available moisture and increase the frequency and severity of extreme climatic events such as droughts and flooding (Lankester & Davis 2016, Osano et al. 2015). Climate change has disrupted the ecosystem base in new ways. Habitats where migrations are necessary for survival are at serious risk as corridors are increasingly fragmented by human settlement (Mooney et al. 2009). Fences could exacerbate the impacts of global warming on wildlife conservation by constraining adaptive responses of wildlife to climate change through adjustments in their spatial distribution (Somers & Haywood 2012), stressing the importance of buffer zones with controlled land-use. Species behaviours are altering and disrupting long-standing mutualisms as resource competition grows more severe (Mooney et al. 2009).

As rainfall variability increases, during certain parts of the year, water availability will become a commodity. Interference competition over water resources will become more apparent in the form of aggressive interactions between and among wildlife species (Valeix 2007). Such competition may be amplified by the presence of livestock (Butt & Turner 2012, Young et al. 2005). However, many protected areas have converted to the use of artificial waterholes built to provide water in safe areas, to preserve natural water sources by reducing wildlife traffic, and to ensure the survival of wildlife species during drought (Epaphras et al. 2007).

Waterhole observations, either directly or remotely using camera traps, have been implemented as part of a monitoring regime (Hayward & Hayward 2012, Stratford & Naholo 2017). If all waterholes within an area are monitored concurrently for 72 hours, the likelihood of quantifying populations of species is enhanced (Stratford & Naholo 2017). Monitoring has become the methodological centrepiece of strategies for management and conservation of biodiversity (Brashares & Sam 2005). Utilising foot patrols, vehicular transects, observation points, and camera trap deployment should paint a solid picture of which species exist in a habitat and ideally, quantify wildlife populations (Mazzoli & Hammer 2013). In an ideal world, monitoring programmes would always be spatially and temporally comprehensive, rigorous in their treatment of sampling error, and sustainable over the time scales necessary to examine population and community level processes. However, managers face difficult trade-offs between precision and sustainability when devising monitoring strategies (Brashares & Sam 2005).

Objectives

The primary objective of the inaugural Biosphere Expeditions project in Enonkishu was to develop an inventory of resident mammals within the conservancy and train the conservancy rangers to collect accurate patrol data to establish baselines for monitoring purposes during their daily activities.

Study site

Enonkishu conservancy is located on the far northern reaches of the Maasai Mara-Serengeti Ecosystem bordering Ol Chorro conservancy, Lemek Conservancy, and on the northern edge, arable commercial farmland (Figure 2.1a). It is comprised of 1721 hectares of land owned by 31 landowners who are paid an annual lease fee for preserving land use within the conservancy boundaries. Restricted land uses include permanent structures, harvesting natural resources (firewood), fences, arable farming, and a regulated number of livestock that must follow the sustainable rangeland management plan implemented by Mara Training Centre. Within the conservancy, there are three main natural wetlands fed by springs. In addition, there are three man-made dams (waterholes) and three water troughs that were constructed to protect the natural springs from overuse. The unfenced portion of the conservancy is divided into nine grazing blocks demarcated by roads and natural landmarks. Two main roads run through Enonkishu, one to Emarti Centre and the other to Aitong Centre (Figure 2.1a). The unique approach is the incorporation of multiple enterprises (forming Enonkishu Stakeholders' Company Limited) supporting Enonkishu, diversifying its financial support to limit vulnerability.

Supporting stakeholders

Tourism enterprises include Naretoi Holdings, a 400-hectare fenced real estate property comprised of 34 two-hectare plots on which high-end homes are constructed. The community contributes conservancy fees for access to game routes within the three participating conservancies (Lemek, OlChorro, and Enonkishu). Within Naretoi is House in the Wild, a small safari lodge in which additional visitors pay rates per bed per night for conservancy access.

The Mara Training Centre was built in 2014 with funding from the Africa Enterprise Challenge Fund. It provides training opportunities for communities centred around social cohesion, improving livestock quality and preserving biodiversity. Training courses thus far have focused on the implementation of sustainable rangeland management to enhance landowners' ability to deal with drought emergencies. The training courses fall in line with the Sustainable Development Goal 15 (SDG 15: Life on Land), which aims to protect, restore and promote sustainable use of terrestrial ecosystems by combating desertification, reversing land degradation, and eventually halting biodiversity loss. Enonkishu Conservancy serves as a showcase site for sustainable rangeland management taught and implemented by the Mara Training Centre.

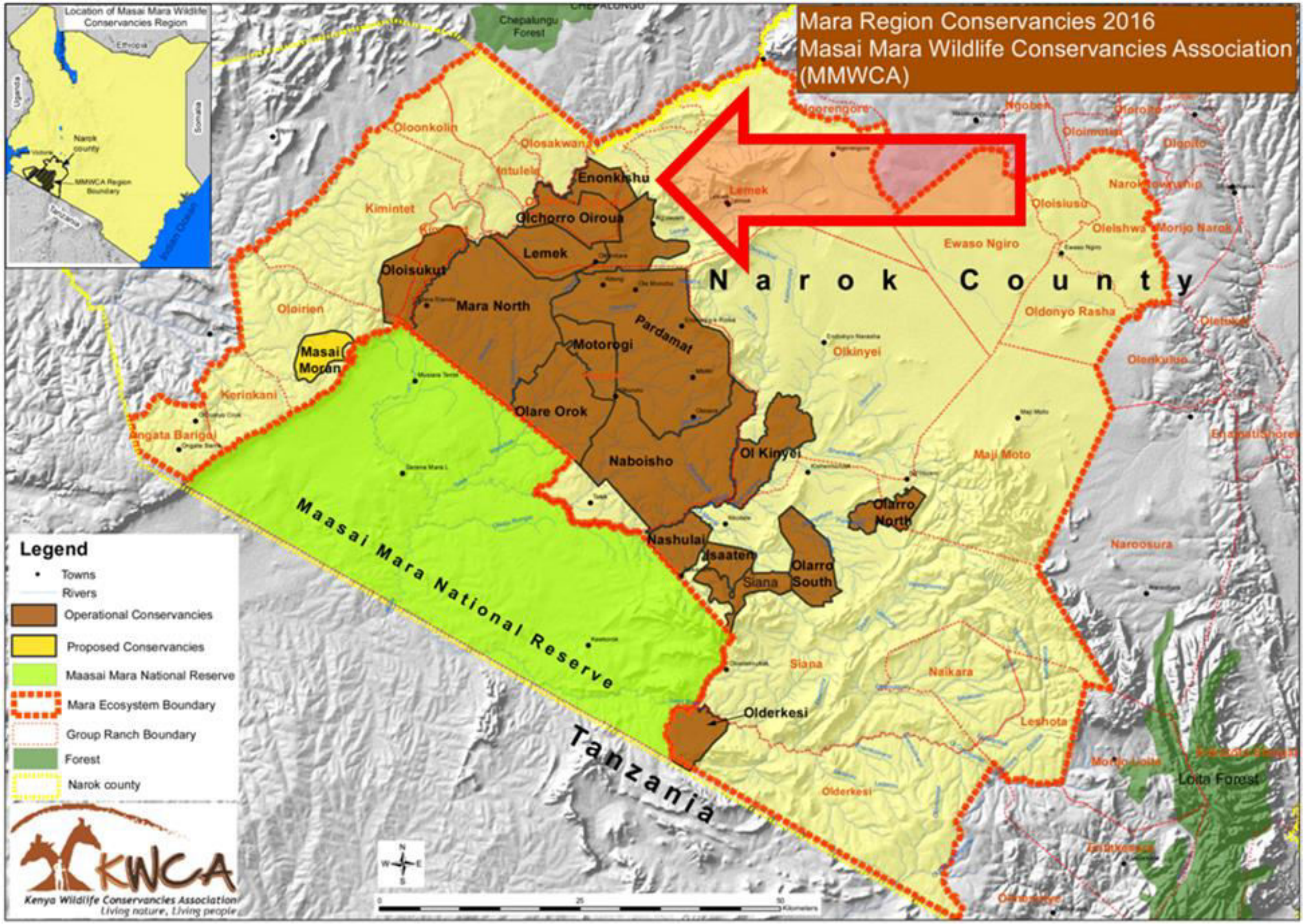

Figure 2.1a. Location of Enonkishu Conservancy, on the northern boundary of the Maasai Mara conservancies (image adapted from Kenya Wildlife Conservancy Association).

2.2. Methods

Five methods were used to monitor wildlife in Enonkishu: (a) vehicle transects (distance sampling), (b) walking patrols (distance sampling), (c) hilltop observation surveys (distance sampling), (d) waterhole observations, (e) camera trapping. There was also an outreach activity with a local school.

Vehicle transects

Four vehicle transects were created within Enonkishu Conservancy ranging from 3.3 to 11.3 km in length (Figure 2.2b). Morning vehicle transects began at 07:00 and were completed by 11:00 to avoid the hottest part of the day when most animals are inactive. The start time for afternoon transects varied due to weather delays and logistical issues, but all were completed by sunset at 18:30. Citizen scientists used binoculars, data sheets, a GPS, rangefinder and compass. Observers sat on a bench in the bed of a double cab Toyota Hilux with a metal cage (Figure 2.2a). The driver of the vehicle drove slowly (<20 km/h) along the transect route waiting for a signal from the observers in the back of the truck when a group of animals was spotted. The GPS location was recorded, along with the species, age/sex composition and group size. An angle from north was taken from the vehicle's position to the animal group. The rangefinder was used to determine the distance to the animal judged to be in the centre of the group. When animals were observed along the road, only the GPS coordinates were recorded.

Figure 2.2a. Citizen scientists counting ungulates on a vehicle transect. Photo courtesy of Chris Taylor.

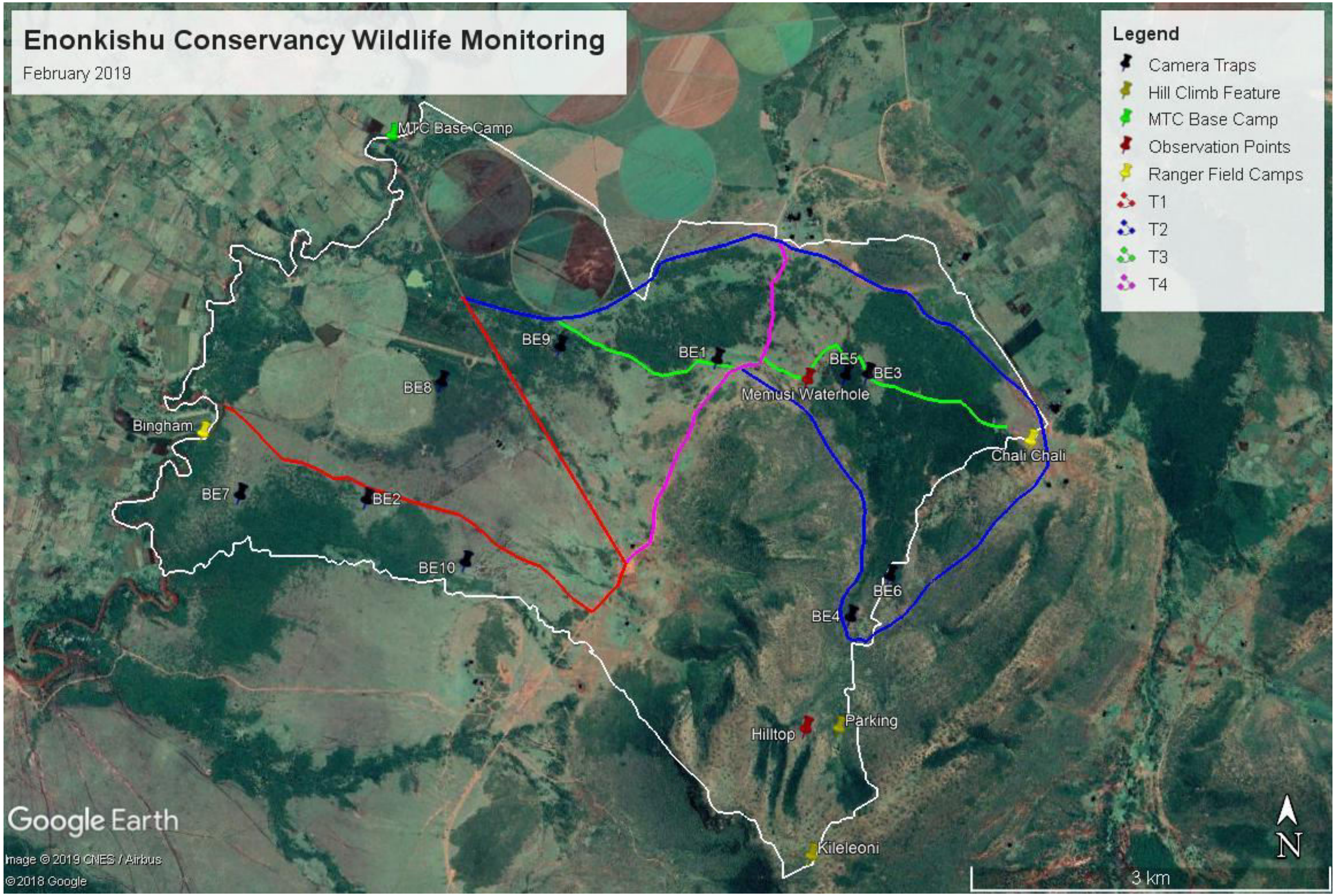

Figure 2.2b. Map of Enonkishu of study routes and sites used by the expedition. T = vehicle transects. MTC base camp = expedition base at Mara Training Centre.

Walking patrols

Citizen scientists accompanied rangers from two field camps in Enonkishu (Bingham and Chali Chali, Figure 2.2b). Participants met the rangers manning the camps by 07:30. Rather than having a set route, rangers traversed portions of the conservancy on a foot patrol as they would normally (Figure 2.2c). Participants collected data pertaining to species encountered on this patrol, recording age/sex composition, angle, distance, and coordinates of direct observations. In addition, during foot patrols, participants collected scat and photographed spoor. Photographs and samples were taken back to Mara Training Centre and identities confirmed before the scat was dried and placed in a container for future reference, thereby creating a reference collection (Figure 2.2d). Foot patrols ended by 10:30, allowing participants to return to camp by 11:00.

Figure 2.2c. On foot patrol with the conservancy rangers. Photo courtesy of Rose Palmer-Sungail.

Figure 2.2d. Scat reference collection.

Hilltop observation surveys

Participants accompanied by two rangers climbed to a vantage point ("Hilltop" on Figure 2.2b) from the base of Kileleoni Hill, parking their vehicle at Nubian Camp "("Parking" on Figure 2.2b) . The group climbed as quietly and vigilantly as possible, passing through dense vegetation. Once the the "Hilltop" location was reached, participants quietly arranged themselves and prepared for the hilltop observation survey (Figure 2.2e). Temperature and time were taken at the beginning and end of an observation period lasting 1-3 hours. When an animal or group of animals were observed using a spotting scope or binoculars, the distance, angle, group size, ages, and sexes of the species were transcribed on a data sheet. At the conclusion of the observation period, participants were given the option of continuing the hike up Kileleoni Hill to capture a spectacular view of Enonkishu and neighboring conservancies. This activity was conducted three times per expedition team.

Figure 2.2e. Observers on the hilltop survey recording data from a vantage point. Photo by Chris Taylor.

Waterhole survey

Citizen scientists were tasked with observing animals that came to drink at Memusi Dam ("Waterhole" on Figure 2.2b and Figure 2.2f). Memusi dam is located at the base of Kileleoni Hill, surrounded on one side by trees and vegetation. A hide was constructed using the branches from the area and some binding wire, and a shade net was installed to minimise shadows and visibility of obvious movements. Citizen scientists carried chairs so that as they observed, only their heads were visible above the hide wall. They brought binoculars, a spotting scope, and for night-time observations, ambient light enhancing goggles, as well as torches with red and green beams. No white light torches were permitted to minimise disturbance. The vehicle was parked 150 m away from the hide and participants walked slowly and quietly to the hide location. Each shift lasted four hours. Throughout the observation period, when an animal was observed, recorders noted the time, number of animals, age, sex, and any interesting observations, prioritising drinking at the waterhole or surrounding springs. Mid-way through February, this methodology was revised to record all animals up to 500 m from the waterhole hide at 15-minute time intervals. This method was added to gauge activity at the waterhole throughout the day.

Figure 2.2f. Vantage from hide at Memusi Dam in Enonkishu. Photo by Rebekah Karimi.

Morning and evening waterhole survey

Citizen scientists, accompanied by rangers, manned the hide at Memusi dam for four hours at a time. Morning observation periods were meant to begin at 06:00 and end at 10:00. However, logistics often interfered with most morning observation periods being cut short to 2-3.5 hours. Observers recorded temperature and time at the beginning and end of each observation period. When an animal or animals were observed approaching the waterhole, their behaviours were transcribed ad libitum to identify any resource competition at the waterhole. Species, age class and sexes were recorded for every identifiable individual. Over the expedition period, data collection was adjusted, as participants were finding it difficult to keep track of individuals and many were confused by unfamiliar behaviours. During the second expedition group and in the future, the data collected at waterhole observations will include a census of animals seen within 500 m of the waterhole every fifteen minutes throughout the survey period.

72-hour waterhole survey

Each expedition group conducted in a 72-hour waterhole survey at Memusi Dam. Two citizen scientists were accompanied by at least one ranger during eighteen four-hour shifts. The survey started at noon and continued until noon on the third day. Observers were instructed to hand over at shift changes, notifying the next team of animals recently observed and their locations. The methodology was revised during the expedition. Initially, observers were only recording interesting behaviours, but due to a lack of activity and lack of experience in identifying and recording important behaviours, the data transitioned to taking a census of all animals visible within 500 m from the hide every 15 minutes throughout the four-hour shift. In addition, participants would note when animals were observed drinking and if they were accompanied by any other noteworthy interactions and behaviours, which could be construed as resource competition. As the data set grows, it may be possible to make conclusions on resource competition, but in the meantime, data will focus on the 15-minute scans.

Camera trapping

Ten Bushnell Trail Cam™ (Model #119837) camera traps were deployed at "hotspots" within Enonkishu, using the rangers' knowledge of areas frequented by wildlife (see Figure 2.2b). This included waterholes or paths through thick vegetation where a concentration of tracks occurred. Cameras were set up during the first expedition group and remained in those locations for the duration of the expedition. Data collected during the initial set-up included GPS coordinates, physical description of the area and citizen scientists involved in the camera set-up. Traps were set up approximately 1 m from the ground, aiming slightly downward. Due to inexperience by operators with camera traps, settings varied, with some capturing images while others captured video. Most camera traps were equipped with a protective case with a lock to secure them from hyaenas and wildlife (Figure 2.2g). For the inaugural expedition, it was not specified if cameras were set to record video or still photographs, contributing to a variety of media collected.

Figure 2.2g. Installing a camera trap.

At the end of the first expedition group and each week of the second expedition group, camera traps were serviced by replacing batteries and switching the SD cards. Expedition participants went through all photos and videos captured, recording species of interest (excluding diurnal ungulates commonly observed by other methods of monitoring). When a species of interest was captured, participants recorded photo number, date, time and species into a spreadsheet. An event was defined as an animal or animal group being present at the camera trap, separated by at least a 30 minute interval before the next event. Images and videos that were recorded in the spreadsheet were copied to a separate folder for easy access. Ambiguous photos and videos were filed for further examination.

Outreach activity

During each expedition group, members of the wildlife club from Emarti Secondary School were invited to Enonkishu and hosted there by the expedition for a day.

2.3. Results

Comprehensive field effort

In 2019, 24 citizen scientists participated in wildlife monitoring in Enonkishu Conservancy through Biosphere Expeditions. Seven Enonkishu rangers accompanied participants on activities ensuring that the methodology was adequately disseminated. Citizen scientists participated in 101 wildlife monitoring activity sessions including vehicle transects, walking transects, hilltop observation surveys, waterhole observations and camera trappping (Table 2.3a). Participants spent 280 hours in the field, excluding travel to and from activities and hours spent entering data and sorting camera trap images.

Table 2.3a. Field effort of wildlife monitoring within Enonkishu throughout February 2019.

Activity	Sessions	Field hours	Species observed	Individuals counted	Number of observations
Vehicle transects	34	68.5	24	8448	1192
Walking transects	9	25.1	22	997	165
Hilltop observations	6	9.9	9	339	55
Waterhole observations	39	153.0	19	2941	475
Camera trapping	13	24.0	13	N/A	N/A
Total	**101**	**280.5**	**36***	**12,725**	**1,887**

*36 species counted in total as some of them were recorded multiple times by the survey methods.

Results from wildlife monitoring activities

During February 2019, 36 wildlife mammal species were observed directly and indirectly through wildlife monitoring activites (Table 2.3b). Although not an objective of the inaugural expedition, several birder created an inventory of birds seen throughout February 2019 (Appendix I). This will be a valuable list that can be compared over time, as birds are often indicator species of changes in the environment.

For wildlife abundance estimates, data collected from multiple vehicle transects, walking transects, and hilltop observations were used to calculate an average number of each species observed for each activity session. For example, vehicle transect T1 recorded a sum of 583 impala observed, which was divided by the number of times T1 was completed (10) resulting in an average of 58.3 impala seen on T1. The waterhole observation and camera trap surveys collected continuous data without resulting in an actual count. While valuable for establishing an inventory of species, such data were excluded from the wildlife abundance analysis.

Table 2.3b. Wildlife abundance estimates of species detected in Enonkishu Conservancy in February 2019.

Common name	Scientific name	Estimated abundance in conservancy	Detection method			
			Vehicle transect	Walking transect	Hilltop survey	Other method*
Impala	*Aepyceros melampus*	291.03	229.85	33.35	27.83	
Zebra	*Equus quagga*	250.30	224.65	25.65	-	
Thomson's gazelle	*Eudorcas thomsonii*	165.90	119.10	46.80	-	
White-bearded wildebeest	*Connochaetes taurinus*	112.70	74.25	36.45	2.00	
Warthog	*Phacochoerus africanus*	71.28	46.25	20.20	4.83	
Vervet monkey	*Chlorocebus pygerythrus*	50.10	46.10	4.00	-	
Eland	*Taurotragus oryx*	46.95	29.10	17.85	-	
Cape buffalo	*Syncerus caffer caffer*	42.07	31.40	2.00	8.67	
Olive baboon	*Papio anubis*	32.85	21.85	4.00	7.00	
Giraffe	*Giraffa tippelskirchi*	25.10	20.10	4.50	0.50	
Grant's gazelle	*Nanger granti*	10.90	7.50	3.40	-	
Banded mongoose	*Mungos mungo*	10.85	8.60	2.25	-	
Topi	*Damaliscus korrigum*	9.95	7.35	2.60	-	
Dik dik	*Madoqua kirkii*	7.40	6.90	0.50	-	
Bat-Eared Fox	*Otocyon megalotis*	3.70	2.30	1.40	-	
Spotted hyaena	*Crocuta Crocuta*	3.45	2.10	1.35	-	
African elephant	*Loxodonta africana*	2.78	0.20	0.75	1.83	
Waterbuck	*Kobus ellipsiprymnus*	2.55	2.10	0.45	-	

* C = camera trap, R= random encounter, S = scat collection.

Common name	Scientific name	Estimated abundance	Detection method			
			Vehicle transect	Walking transect	Hilltop survey	Other method*
Black-backed jackal	*Canis mesomelas*	2.40	1.60	0.80	-	
Black and white colobus monkey	*Colobus angolensis*	2.33	-	-	2.33	
Klipspringer	*Oreotragus oreotragus*	1.50	-	-	1.50	
Dwarf mongoose	*Helogale parvula*	1.25	-	1.25	-	
African Hare	*Lepus microtis*	0.90	0.30	0.60	-	
Bushbuck	*Tragelaphus scriptus*	0.35	0.10	0.25	-	
Hartebeest	*Alcelaphus buselaphus*	0.10	0.10	-	-	
Caracal	*Caracal caracal*	0.10	0.10	-	-	R
Leopard	*Panthera pardus*	0.10	0.10	-	-	R
Honey badger	*Mellivora capensis*	0.10	0.10	-	-	R
Mountain reedbuck	*Redunca fulvorufula*	0	-	-	-	S
Giant forest hog	*Hylochoerus meinertzhageni*	0	-	-	-	C
Brown greater galago	*Otolemur crassicaudatus*	0	-	-	-	C
Large spotted genet	*Genetta tigrina*	0	-	-	-	C
Hippopotamus	*Hippopotamus amphibious*	0	-	-	-	C
Lion	*Panthera leo*	0	-	-	-	C
White tailed mongoose	*Ichneumia albicauda*	0	-	-	-	C
Aardvark	*Orycteropus afer*	0	-	-	-	C, R

* C = camera trap, R= random encounter, S = scat collection.

Vehicle transects

Four transects were designated within Enonkishu Conservancy (T1-4 on Figure 2.2b). Transects were determined by main tracks within the conservancy and covered 26.1 km in total. Accounting for repeat surveys along transects, a total of 237 km were surveyed by Biosphere Expeditions in February 2019. Twenty-four species were counted along a cumulative distance of 237 km. The nine most commonly recorded species accounted for 94.8% of observations (Burchell's zebra, impala, Thomson's gazelle, warthog, white-bearded wildebeest, Cape buffalo, eland, olive baboon, giraffe).

Of the monitoring methods implemented, vehicle transects were by far the most efficient use of time and resources, covering the largest area and counting the most species (Table 2.3c).

Table 2.3c. Species counted along four vehicle transects in Enonkishu in February 2019. The mean per surveyed kilometre was calculated by dividing the total count of each species by the number of kilometres surveyed (n= 237.0).

Species	Scientific name	Group size	Mean per surveyed km
Impala	*Aepyceros melampus*	1-71	9.25
Burchell's zebra	*Equus quagga burchelli*	1-57	9.01
Thomson's gazelle	*Gazella thomsonii*	1-38	4.81
Warthog	*Phacochoerus africanus*	1-19	3.45
White-bearded wildebeest	*Connochaetes taurinus*	1-34	2.84
Cape buffalo	*Syncerus caffer caffer*	1-31	1.18
Eland	*Taurotragus oryx*	1-39	1.15
Olive baboon	*Papio Anubis*	1-65	0.87
Giraffe	*Giraffa tippelskirchi*	1-12	0.81
Banded mongoose	*Mungos mungo*	1-15	0.36
Grant's gazelle	*Nanger granti*	1-13	0.31
Topi	*Damaliscus korrigum*	1-10	0.29
Dik dik	*Madoqua kirkii*	1-3	0.25
Waterbuck	*Kobus ellipsiprymnus*	1-7	0.23
Bat-eared fox	*Otocyon megalotis*	1-6	0.10
Vervet monkey	*Chlorocebus pygerythrus*	6-10	0.09
Spotted hyaena	*Crocuta crocuta*	1-10	0.09
Black-backed jackal	*Canis mesomelas*	1-2	0.07
African hare	*Lepus microtis*	1	0.01
African elephant	*Loxodonta africana*	1	0.01
Bushbuck	*Tragelaphus scriptus*	1	0.004
Caracal	*Caracal caracal*	1	0.004
Hartebeest	*Alcelaphus buselaphus*	1	0.004
Leopard	*Panthera pardus*	1	0.004

Walking transects

Twenty-two wildlife species were recorded on walking transects. Six species (Thomson's gazelle, white-bearded wildebeest, impala, Burchell's zebra, warthog, and eland) accounted for 85.7% of the observations recorded. Although the walking transects did not produce as much data as the vehicle transects, during the activity citizen scientists also collected and archived photos and samples of scat and tracks, which will be a valuable resource for future citizen scientists.

The habitat differences between the two field camps were apparent through analysis of the data collected. Bingham is located in a thicket along the Mara River, but the majority of time patrolling from the camp is through the open plains on the western side of Enonkishu, resulting in more direct observations (Table 2.3d). Conversely, Chali Chali is on the southeastern boundary where the majority of habitat is dense shrub and forest. There was indeed a large variance between the types of species observed from the two camps (Figure 2.3d). The most dominant species from Bingham foot transects was Thomson's gazelle, which was not even recorded on the Chali Chali transects.

Table 2.3d. A comparison between the two foot transects at Enonkishu in February 2019.

Factor	Bingham	Chali Chali	Cumulative
Species diversity	15	16	22
Sum animals counted	777	220	997
Species <1% observed	5	4	10
Field hours	12:58	12:05	25:03

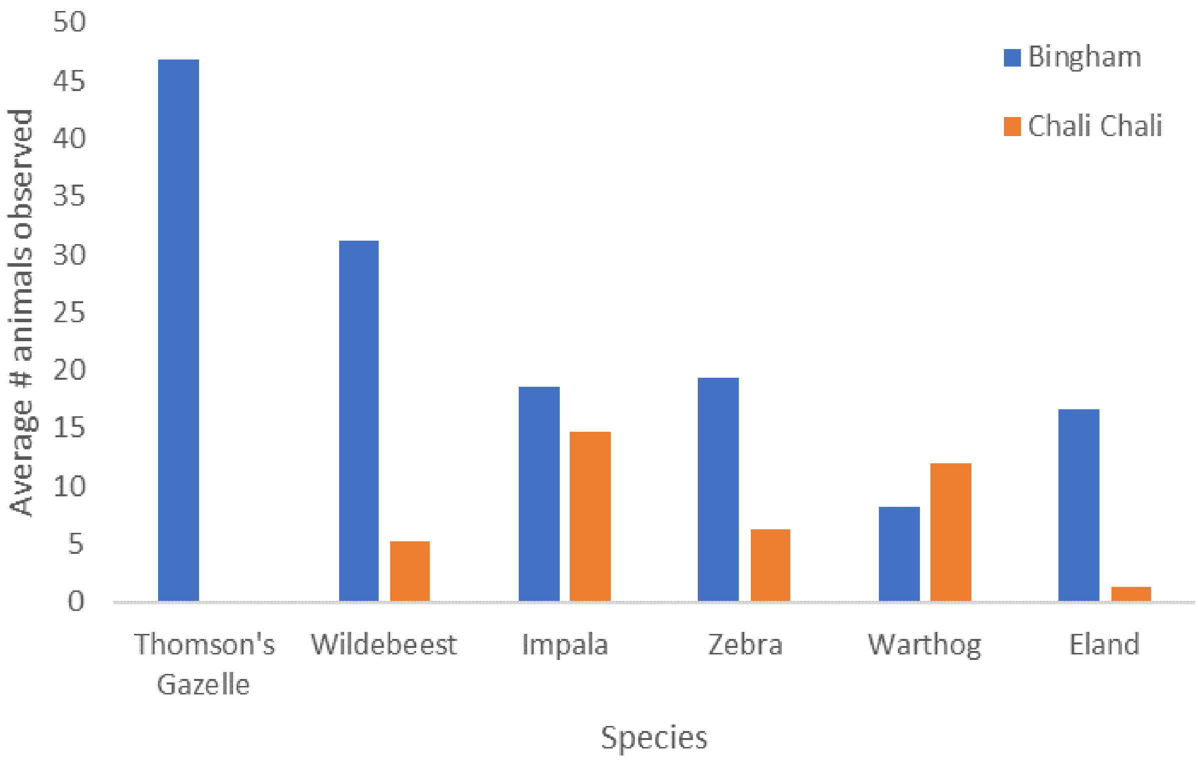

Figure 2.3a. Difference of species abundance
from the two walking transects in Enonkishu throughout February 2019.

Hilltop observation surveys

Nine species were observed during six hilltop observation surveys conducted in February 2019 (impala, Cape buffalo, olive baboon, warthog, colobus monkey, white-bearded wildebeest, elephant, klipspringer, giraffe). Two species, the black and white colobus monkey (*Colobus angolensis*) and klipspringer (*Oreotragus oreotragus*), were only observed through the hilltop survey and no other monitoring method. Participants spent 9.85 hours observing species from one point.

Waterhole surveys

Four dawn/dusk waterhole surveys were conducted. The two 72-hour waterhole observation periods added more value to the objectives of monitoring wildlife within Enonkishu. While recording behaviours regarding resource competition would have been extremely interesting, establishing a standardised methodology for a variety of citizen scientist observers proved to be more complicated than presumed. Throughout the first expedition group, waterhole observations were recorded on a data sheet focused on collecting behavioural data. However, by the second expedition group's 72-hour waterhole observation period, participants were scanning the area around the waterhole every 15 minutes and recording all species within 500 m. Species that were visible from the hide in consecutive scanning periods were knowingly re-counted. Therefore, rather than estimating the species abundance around the waterhole, the data revealed the use of the waterhole and surrounds throughout the day.

Throughout the initial waterhole observation surveys, 13 species were observed during 251 observations over 84 hours spent at the Memusi Dam hide. Four species accounted for 91.2% of animals observed (Burchell's zebra, impala, warthog, giraffe).

The data collected during the census point count during the second 72-hour waterhole observation survey allowed observers to analyse animal activity around Memusi dam throughout a 72-hour period. As expected, the number of species observed roughly correlated with the number of individual animals recorded (Figure 2.3b). Group size varied greatly with a maximum of 57 animals – a mixture of mostly zebra and impala – observed on 26 February at 08:00. Nine scans each counted the maximum number of six species observed in a single scan. Out of 288 scans, animals were counted 57% of the time. The pattern of observations was noticeably higher during daylight hours, from 06:00 to 18:00 with occasional visitors during night time. Therefore, unless powerful night-vision goggles are available, it may not be worth the effort of surveying the waterhole around the clock.

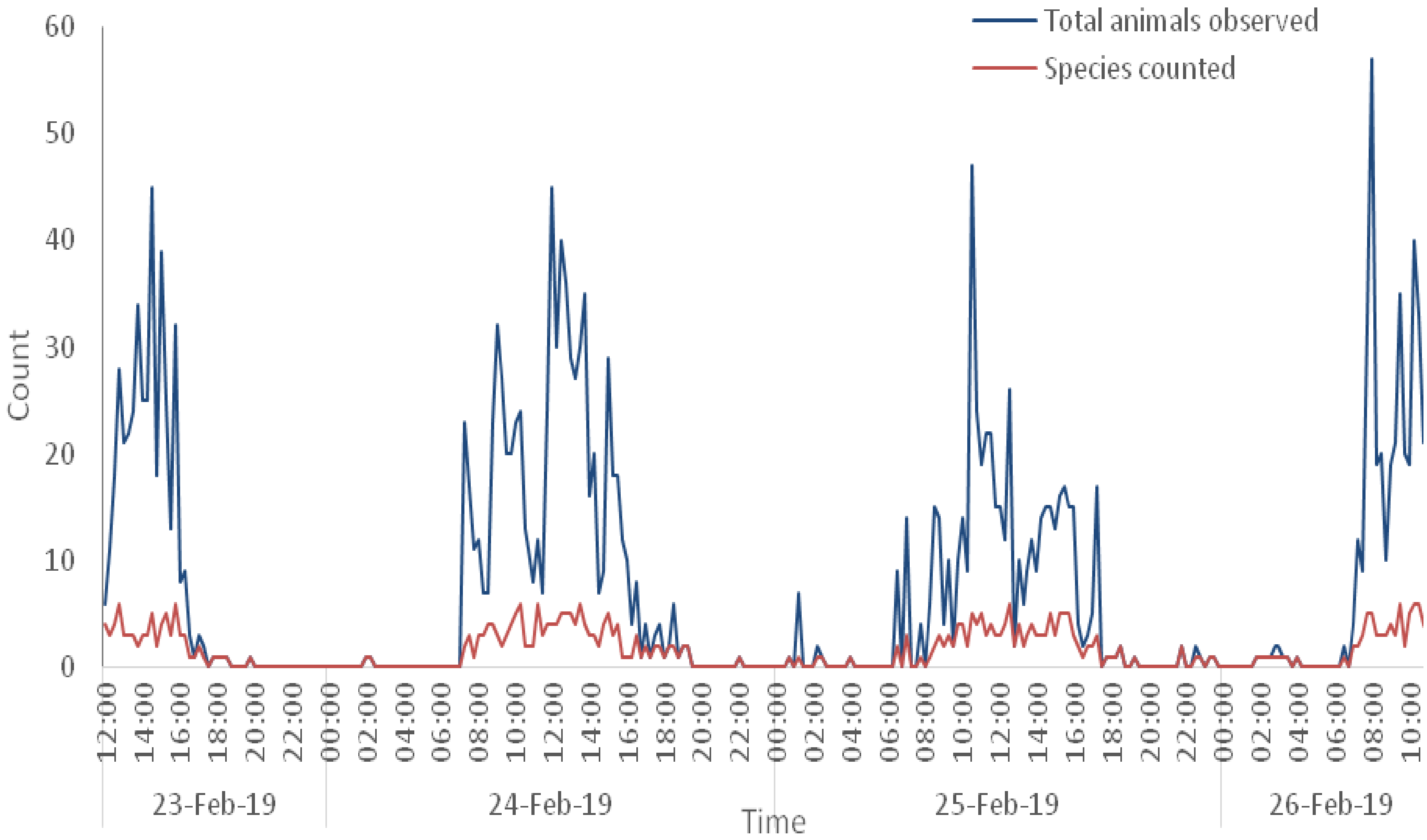

Figure 2.3b. Total animals observed and species counted at Memusi dam during scans every 15 minutes from noon on 23 February to noon on 26 February 2019.

Camera trapping

Ten camera traps were deployed in Enonkishu for 21 days, taking a mixture of videos and photos. Four SD cards did not collect images or videos while one camera was destroyed by a hyaena during its first deployment, resulting in 147 camera trap nights in which cameras were collecting images. While sorting through the images and videos, citizen scientists avoided species commonly seen during the day. Cameras collected 5,074 videos and 6,071 images that were sorted to account for 123 visits by 13 species of interest (Table 2.3e). Only one video remains unclassified, but was likely to be an impala or bushbuck disappearing into a thicket. Importantly, data from this camera trap survey were only used to confirm the presence of species, rather than estimate abundance.

Table 2.3e. Species captured on camera traps placed in hotspots within Enonkishu during February 2019.

Species	Scientific name	Visits
Spotted hyaena	*Crocuta crocuta*	58
African elephant	*Loxodonta africana*	18
Cape buffalo	*Syncerus caffer caffer*	13
Hippopotamus	*Hippopotamus amphibious*	10
White-tailed mongoose	*Ichneumia albicauda*	10
Leopard	*Panthera pardus*	5
Bat-eared fox	*Otocyon megalotis*	2
Brown greater galago	*Otolemur crassicaudatus*	2
Aardvark	*Orycteropus afer*	1
Bushpig	*Potamochoerus larvatus*	1
Bushbuck	*Tragelaphus scriptus*	1
Large spotted genet	*Genetta tigrine*	1
Lion	*Panthera leo*	1
TOTAL		**123**

Although tracks and signs of bushpig had been observed in the past, during the expedition some images were captured of bushpig (Figure 2.3f). Another interesting find was a young spotted hyaena with a mane like a striped hyaena (Figure 2.3g). The hotspot cameras captured one video of a female lioness with two cubs playing with their mother (Figure 2.3h). Five images of leopard (Figure 2.3i), two images of brown greater galago (Figure 2.3j) and one aardvark (Figure 2.3k) were catalogued.

Figure 2.3f. Two bushpigs captured on the camera trap near Nubian Dam in Enonkishu (BE6 on Figure 2.2b).

Figure 2.3g. Uncommon mane on a young spotted hyaena captured at Nubian Dam (BE6 on Figure 2.2b).

Figure 2.3h. Female lioness with two cubs captured on a camera trap in Block 13 (BE7 on Figure 2.2b). See also video.

Figure 2.3i. One of five leopard images captured on camera traps (BE7 on Figure 2.2b).

Figure 2.3j. A brown greater galago pouncing along the ground (BE3 & 2 on Figure 2.2b), one of two brown greater galagos captured with camera traps in February 2019.

Figure 2.3k. The only aardvark (BE9 on Figure 2.2b) captured with camera traps in February 2019.

Outreach activity

During each expedition group, members of the wildlife club from Emarti Secondary School were invited to Enonkishu and hosted there for the day as part of an outreach activity. 18 students were hosted by expedition group 1 and 20 students by expedition group 2. Citizen scientists collected the students in vehicles and took them through the conservancy on a game drive (Figure 2.3l). Despite their close proximity, many of the students had not seen wildlife in that context before. The students were fascinated with the identification charts and pamphlets brought by Biosphere Expeditions. After lunch at Mara Training Centre, citizen scientists led activities focused on disseminating their enthusiasm for the wildlife of the Maasai Mara. After hearing about the conservancy from Dapash and Albert, the first group worked on a project to show what they had learned that day. During the second group, students participated in different activites such as a lesson on how to get involved in conservation, viewing photos and videos of wildlife collected at camera trap stations (Figure 2.3l), looking through all of the wildlife books utilised by the expedition, and observing a drone in action.

Figure 2.3l. Students on a game drive, trying out research equipment (left) and viewing camera trap photos (right).

2.4. Discussion

Expedition results and baseline data

Thirty-six mammal species were recorded in the conservancy throughout February 2019. The presence of the giant forest hog as confirmed through a camera trap image was the most surprising piece of data. However, several species are known to be present within Enonkishu that were not observed throughout a month of intensive wildlife monitoring. The African wild cat, African civet, zorilla, marsh mongoose and African crested porcupine are a few of the species that have been casually observed by visitors without being officially recorded. Therefore, it is essential that Enonkishu continues to use various methods of wildlife monitoring to collect an evidence-based comprehensive inventory of mammals present within the conservancy.

Monitoring methods: successes and challenges

The variety of monitoring methods employed during the expedition is essential to capture the highest variety of species possible. For example, two species (klipspringer & black and white colobus) were recorded during the hilltop survey that were not accounted for elsewhere in the data. Images of six species (white tailed mongoose, brown greater galago, giant forest hog, bushbuck, large spotted genet & lion) were captured on the camera traps only and were not recorded during other monitoring activities. During waterhole observation surveys, valuable data were collected during transit to the waterhole for shift changes. Caracal, aardvark and a few leopards were recorded under these circumstances. Taking into account the strain on citizen scientists to man the waterhole hide 24 hours a day, it is suggested that future expeditions observe the waterhole during all daylight hours including dawn and dusk (04:00 - 22:00) only, unless (extremely expensive) high-powered night-vision equipment can be made available.

Ranger training and application of acquired survey skills

The objective of training the conservancy rangers was achieved by integrating them into the expedition to ensure reliable data collection and to train them in survey methods at the same time. A byproduct of intensively training the rangers to collect data together with a group of citizen scientists from all over the world who took great interest in their work is that it instilled the rangers with a sense of pride for their work and confidence in data collection. Citizen scientists were well suited for this job, as they would have just learned the methods of collecting patrol data and as they work through any issues or questions that arise, the information can be transferred to the rangers, a popular method for disseminating knowledge (Reid et al. 2009).

Enonkishu rangers have continued to conduct each monitoring activity (excluding the 72-hour waterhole survey) once per month since April 2019. The expedition was instrumental in bringing this about; establishing a baseline of wildlife abundance in February 2019 helped the conservancy to recognise important changes in wildlife abundance and composition over time. As the wildlife monitoring within Enonkishu continues and the dataset grows, distance sampling methodology will be used for a more robust estimate of wildlife abundance. Using distance sampling will enable Enonkishu to calculate carrying capacity based on animal units occupying the rangeland. When the carrying capacity is established, the conservancy will be better equipped to adjust the number of livestock in the conservancy to ensure adequate resources for wildlife and livestock alike. Adaptive management is at the core of Enonkishu's ethos and gaining a better understanding of wildlife fluctuations will allow for more informed decision-making regarding livestock-wildlife coexistence. Evidence-based information will also improve livestock husbandry practices and interactions with wildlife across the Maasai Mara and put to rest the notion that livestock is the sole factor affecting wildlife populations.

Enonkishu Conservancy supports a variety of habitats from dense forest, high elevation habitats and the iconic grasslands of the Mara-Serengeti ecosystem. It is essential to monitor all these habitats in a comprehensive manner, which is another reason why the variety of monitoring methodologies was employed. While large-mouthed grazers such as cape buffalo and wildebeest rely on large areas of grassland, small-mouthed ungulates thrive in densely forested areas, and specialists occupy Kileleoni Hill (Flynn et al. 2016). As monitoring activities spread to other Mara conservancies, the habitats within each conservancy will be considered to ensure all wildlife species are represented.

Future wildlife modelling and its implications for management and conservation

Developing a model of wildlife monitoring that can be adapted to similar landscapes in the Mara Serengeti Ecosystem is critical to understanding the resource use of wildlife and livestock. The next step of determining carrying capacity for each conservancy is essential to efficiently utilise each conservancy's resources and ensure a healthy balance in wildlife and livestock in the ecosystem. Presenting evidence of wildlife estimates can better inform managers on the resources available for livestock within the conservancies. Diversifying the revenue from conservation in a sustainable manner will gain support from both Maasai conservancy members and tourism operators.

Understanding the relationship between resource availability and the herbivores (wildlife and livestock) which depend on those resources has the potential to rehabilitate habitats that have been lost from overgrazing, deforestation and erosion across Kenya (Allan et al. 2017). Adaptive management must be employed to work with the resources available and adjust livestock numbers to accommodate wildlife to ensure adequate habitat for Kenya's top industry, wildlife tourism (Bedelian 2012, Korir et al. 2013, Ogutu et al. 2016).

Outreach

The way to make real changes in society is by influencing children through awareness and education to be advocates for the environment. In Kenya, higher educated adults often migrate to larger cities to pursue their careers. However, rural students are able to influence their families and establish their behaviour and priorities for when they are making environmental decisions as adults. Environmentally-conscious citizen scientists shared the reasons they came to Kenya to instill a sense of pride in the ecosystem the students live in and encouraged them to take small actions, such as not littering, to appreciate their local environment. Biosphere Expeditions also hosted Leonard Kinanta, an early career Kenyan conservationist (and Maasai) on the second expedition group as part of its placement programme. In the future, well-educated local conservationists could play a vital role in a more sustainable future for the Maasai Mara ecosystem.

The expedition as a showcase at the interface of monitoring, training and tourism

The data collected in the inaugural year of Biosphere Expeditions' participation in wildlife monitoring within Enonkishu will be a valuable baseline to compare similar data during future intensive wildlife monitoring periods. The expedition is also a showcase of how wildlife monitoring, community training and tourism can work hand-in-hand for the benefit of all.

Recommendations for future expeditions

1. Surveys should be continued to add to the baseline established. Modifications to surveys should be made as indicated.

2. In the absence of very expensive high-power night time monitoring equipment, waterhole observations should be limited to dawn, dusk and daylight hours (04:00-22:00 for three consecutive days). Late night activity should be monitored instead through strategically placed camera traps.

3. Camera trap surveys could entail servicing already functioning camera trap stations throughout a grid in Naretoi, Enonkishu and Ol Chorro. Camera traps provided by Biosphere Expeditions could extend the grid in place and be functional year-round to maximise available resources. Ideally, Biosphere Expeditions should contribute 10 camera traps.

4. Revision of data sheets and citizen scientist training on how to collect and enter information, to allow efficient analysis of data and report writing after the expedition.

5. Observations of nocturnal species (including hippopotamus) on night game drives should be recorded in the same manner as driving transects to represent commonality of certain animals.

6. Continue outreach programmes to involve local, early career conservationists as well as students from different schools in the neighboring village of Emarti. Potentially, the most promising students could join activities during the weekend to fully immerse themselves in monitoring work within their neighboring conservancy.

7. Expedition participants should record livestock in the same manner they record wildlife during all methods of monitoring. This will enable us to cross check the accuracy of wildlife counts, as the number of livestock is known.

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Appendix I: Bird list compiled by the expedition

SPECIES	SCIENTIFIC NAME	CONSERVATION STATUS
Ostriches		
Common Ostrich	*Struthio camelus*	
Guineafowls		
Helmeted guineafowl	*Numida Meleagris*	
Ducks & geese		
Egyptian goose	*Alophchen aegyptiaca*	
Spur-winged goose	*Plectropterus gambensis*	
White-faced whistling duck	*Dendrocygna viduata*	
Red-billed teal	*Anas erythrorhyncha*	
Grebes		
Little grebe	*Tachybaptus ruficollis*	
Storks		
Abdim's stork	*Ciconia abdimii*	
Black stork	*Ciconia nigra*	
White stork	*Ciconia ciconia*	
Yellow-billed stork	*Mycteria ibis*	
Ibises & spoonbills		
Hadada ibis	*Bostrychia hagedash*	
Sacred ibis	*Threskiornis aethiopicus*	
African spoonbill	*Platalea alba*	
Herons & egrets		
Black-headed heron	*Ardea melanocephala*	
Grey heron	*Ardea cinerea*	
Squacco heron	*Ardeola ralloides*	
Cattle egret	*Bubulcus ibis*	
Great egret	*Ardea alba*	
Hamerkop		
Hamerkop	*Scopus umbretta*	
Secretary bird		
Secretary bird	*Sagittarius serpentarius*	Vulnerable
Eagles, vultures, hawks, buzzards, harriers & kites		
Black kite	*Milvus migrans*	
Bateleur	*Terathopius ecaudatus*	Near threatened
African goshawk	*Accipiter tachiro*	
Augur buzzard	*Buteo augur*	
Tawny eagle	*Awuila rapax*	
Verreaux's eagle	*Aquila verreauxii*	
Falcons & kestrels		
Lanner falcon	*Falco biarmicus*	
Common kestrel	*Falco tinnunculus*	
Bustards		
Kori bustard	*Ardeotis kori*	
Crakes & rails		
Red-knobbed coot	*Fulica cristata*	
Common moorhen	*Gallinula chloropus*	

SPECIES	SCIENTIFIC NAME	CONSERVATION STATUS
Cranes		
Grey crowned crane	*Balearica regulorum*	Endangered
Thick-knees		
Water thick-knee	*Burhinus vermiculatus*	
Stilts & avocets		
Black-winged stilt	*Himantopus himantopus*	
Jacana		
African jacana	*Actophilornis africanus*	
Plovers & lapwings		
Three-banded plover	*Charadrius tricollaris*	
African wattled lapwing	*Vanellus senegallus*	
Blacksmith lapwing	*Vanellus armatus*	
Spur-winged lapwing	*Vanellus spinosus*	
Sandpipers & snipes		
Common sandpiper	*Actitis hypoleucos*	
Green sandpiper	*Tringa ochropus*	
Little stint	*Calidris minuta*	
Doves & pigeons		
Red-eyed dove	*Streptopelia semitorquata*	
Ring-necked dove	*Streptopelia capicola*	
African green pigeon	*Treron calvus*	
Turacos & go-away birds		
Hartlaub's turaco	*Tauraco hartlaubi*	
Bare-faced go-away bird	*Corythaixoides personatus*	
Cuckoos & coucals		
White-browed coucal	*Centropus superciliosus*	
Nightjars		
Square-tailed nightjar	*Caprimulgus fossii*	
Mousebirds		
Speckled mousebird	*Colius striatus*	
Rollers		
Broad-billed roller	*Eurystomus glaucurus*	
European roller	*Coracias garrulus*	Near-threatened
Lilac-breasted roller	*Coracias caudatus*	
Kingfishers		
Giant kingfisher	*Megaceryle maxima*	
Malachite kingfisher	*Corythornis cristatus*	
Bee-eaters		
Cinnamon-chested bee eater	*Merops oreobates*	
White-fronted bee eater	*Merops bullockoides*	
Hornbills		
Southern ground hornbill	*Bucorvus leadbeateri*	
African barbets		
Yellow-rumped tinkerbird	*Pogoniulus bilineatus*	
D'Arnaud's barbet	*Trachyphonus darnaudii*	
Batises & wattle-eyes		
Eastern black-headed batis	*Batis minor*	

SPECIES	SCIENTIFIC NAME	CONSERVATION STATUS
Bushshrikes		
Sulphur-breasted bush shrike	*Chlorophoneus sulfureopectus*	
Tropical boubou	*Laniarius major*	
True shrikes		
Lesser grey shrike	*Lanius minor*	
Common fiscal	*Lanius humeralis*	
Orioles		
African black-headed oriole	*Oriolus larvatus*	
Monarch flycatchers		
African paradise flycatcher	*Terpsiphone viridis*	
African blue flycatcher	*Elminia longicauda*	
Crows & ravens		
Pied crow	*Corvus albus*	
Larks		
Fawn-coloured lark	*Mirafra africanoides*	
Rufous-naped lark	*Mirafra Africana*	
Bulbuls, brownbuls & greenbuls		
Common bulbul	*Pycnonotus barbatus*	
Swallows & martins		
Black saw-wing	*Psalidoprocne pristoptera*	
Barn swallow	*Hirundo rustica*	
Wire-tailed swallow	*Hirundo smithii*	
Common house martin	*Delichon urbicum*	
Rock martin	*Ptyonoprogne fuligula*	
Cisticolas, prinias & apalises		
Singing cisticola	*Cisticola cantans*	
White-eyes		
Yellow white eye	*Zosterops senegalensis*	
Starlings		
Greater blue-eared starling	*Lamprotornis chalybaeus*	
Superb starling	*Lamprotornis superbus*	
Oxpeckers		
Red-billed oxpecker	*Buphagus erythrorhynchus*	
Fly-catchers, robin-chats & wheatears		
Spotted flycatcher	*Muscicapa striata*	
White-eyed slaty flycatcher	*Dioptrornis fischeri*	
African grey flycatcher	*Bradornis microrhynchus*	
African dusky flycatcher	*Muscicapa adusta*	
White-browed robin chat	*Cossypha heuglini*	
Northern wheatear	*Oenanthe Oenanthe*	
Northern anteater chat	*Myrmecocichla aethiops*	
Sunbirds		
Collared sunbird	*Hedydipna collaris*	
Scarlet-chested sunbird	*Chalcomitra senegalensis*	
Sparrows		
Rufous sparrow	*Passer rufocinctus*	

SPECIES	SCIENTIFIC NAME	CONSERVATION STATUS
Weavers		
Baglafecht weaver	*Ploceus baglafecht*	
Red-headed weaver	*Anaplectes rubricepts*	
Black bishop	*Euplectes gierowii*	
Waxbills, mannikins & firefinches		
Bronze mannikin	*Lonchura cucullata*	
Red-billed firefinch	*Lagonosticta senegala*	
Southern citril	*Crithagra hyposticta*	
Purple grenadier	*Uraeginthus ianthinogaster*	
Whydahs & indigobirds		
Pin-tailed whydah	*Vidua macroura*	
Village indigo bird	*Vidua chalybeata*	
Wagtails, longclaws & pipits		
African pied wagtail	*Motacilla aguimp*	
Grassland pipit	*Anthus cinnamomeus*	
Trogons		
Narina trogon	*Apaloderma narina*	

Appendix II: Expedition diary and reports

A multimedia expedition diary is available on https://blog.biosphere-expeditions.org/category/expedition-blogs/kenya-2019/.

All expedition reports, including this and previous expedition reports, are available on www.biosphere-expeditions.org/reports.

More pictures, videos, media coverage of the expedition are available via www.biosphere-expeditions.org/kenya.