The United Republic of Tanzania
Ministry of Natural Resources and Tourism

TANZANIA WILDLIFE CORRIDORS ASSESSMENT, PRIORITIZATION, AND ACTION PLAN

2022 - 2026

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FOREWORD

Tanzania is one of the megadiversity countries in the world. The country's high biodiversity richness arises from a variety of factors such as diversity of habitats and ecosystems, geomorphology, climate and its strategic location in the tropics close to the equator. The diversity of habitats and ecosystems has in turn contributed to large mammals diversity in Tanzania. For example, currently there over 340 large mammals found in in the country.

Wildlife is a source of wonder and revenue through tourism which prior to emergency of COVID-19 pandemic tourism contributed 17% of Tanzania's GDP and 25% of foreign revenue. This means that conservation of wildlife resources is key to economic development in Tanzania. To this end Tanzania has set aside 32.5% of the land surface for wildlife conservation which comprises of National Parks, Game Reserves, Ngorongoro Conservation Area, Game Controlled Areas, Ramsar Sites and Wildlife Management Areas. of high biodiversity value, including water catchments. These wildlife protected areas are connected by corridors that allow wildlife movement and plant dispersion for the purpose of accessing key resources such as water, food, cover, breeding sites, geophagy, and security. Corridors are of fundamental importance to allow for gene flows and colonization of new habitats and ecosystems for revitalizing vigour, population growth and preventing inbreeding for species survival and sustainability. Corridors therefore support the best-known technique for effective biodiversity conservation at a landscape level.

Despite their importance, wildlife corridors are under threat from anthropogenic activties including agriculture, human settlements, infrastructure development, encroachment and other human disturbances. Consequently, some wildlife protected areas are gradually being turned into ecological islands and they may eventually become cut off from each other. This will have dire consequences to the wildlife populations and on the long-term conservation efforts which Tanzania has invested for decades.

In view of the importance of corridors for sustainable conservation of wildlife resources, the Government decided to undertake assessment of wildlife corridors, prioritization and development of an Action Plan as a tool for securing all the wildlife corridors in the country. The Action Plan consists of a detailed assessment and analysis for corridors, priority based on ecological value and vulnerability and a plan for reclaiming and maintaining all the wildlife corridors across the country.

The Government is fully committed to taking a lead in implementing the Action Plan and calls upon all stakeholders to take part in implementing the plan. The Government would wish to thank USAID PROTECT Project for committing resources to prepare this Action Plan and TAWIRI, TANAPA and TAWA for taking an active role in the process. We also thank all experts who have contributed data and information and participated in the process and made the production of the Action Plan possible.

Prof. **Eliamani M. Sedoyeka**
PERMANENT SECRETARY
MINISTRY OF NATURAL RESOURCES AND TOURISM

PREFACE

The Ministry of Natural Resources and Tourism is responsible for the management of natural resources found within and outside protected areas. Tanzania's protected areas and associated landscapes are connected by corridors which facilitate various ecological and functional processes. The Ministry is aware that these protected areas and corridors persistently encounter anthropogenic challenges that threaten their continued existence.

To this effect the Ministry has put in place policy and legal framework for the purpose of safeguarding sustainable existence of the protected landscapes and associated corridors. The Ministry is also aware that many of the corridors are severely encroached to the extent that some are almost impassable by the wildlife that has been utilizing them. The closure of wildlife corridors affects the ecological value of our wildlife protected areas which are critical for developing our tourism industry. In this regard failure to secure corridors will therefore affect wildlife populations and therefore tourism and hence our economy and our long-term sustainable conservation and development goals.

The Ministry is therefore launching this Wildlife Corridors Assessment, Prioritization and Action Plan in order to ensure that all wildlife corridors in the country are secured, degraded habitats in the corridors are restored and structural and functional connectivity of the corridors is restored and maintained.

The Ministry is also aware that corridor management issues are complex especially when it comes to land as most of the lands where wildlife corridors, dispersal areas, and buffer zones occur are in village or the private lands. In this regard, the Ministry will ensure that all relevant stakeholders including sectoral Ministries, Government institutions, agencies, non-governmental organizations, the private sector, communities and all conservation partners are fully engaged in the implementation of this Action Plan.

The Action Plan chronologically outlines steps that will be followed during the implementation of the plan in line with the Wildlife Corridor Regulations of 2018. The Ministry will also ensure that other plans and strategies such as the National Human - Wildlife Conflict Management Strategy will complement the implementation of the Wildlife Corridors Assessment, Prioritization and Action Plan better results.

I appreciate the effort and commitment of various agencies, institutions and individuals who have invested their resources and time to prepare this Action Plan. My promise to all of them is that the Ministry will avail maximum cooperation in implementing the plan and will support all the initiatives and efforts directed towards the full implementation of this Action Plan.

STATEMENT OF ENDORSEMENT

I hereby endorse this Wildlife Corridors Assessment, Prioritization and Action Plan and call upon all stakeholders to support its implementation.

Hon. Ambassador Dr. Pindi H. Chana (MP)
MINISTER FOR NATURAL RESOURCES AND TOURISM

Date: 9th August, 2022

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We would like also to extend our thanks to the Range Wide Conservation Program for Cheetah and African Wild Dogs (RWCP)—a joint project of the Wildlife Conservation Society (WCS) and the Zoological Society of London (ZSL), Oikos East Africa—for financing the northern regional corridors workshop. We further recognize the contribution of data from various individuals and institutions working across Tanzania. In particular, we wish to thank Dr. Jason Riggio at University of California Davis, Dr. Lilian Pintea of Jane Goodall Institute (JGI), Aaron Nicholas of WCS, Dr. Nick Mitchell of the RWCP of WCS and ZSL, Dr. Claire Bracebridge and Dr. Corinne Kendall of North Carolina Zoo, and Dr. Trevor Jones of the Southern Tanzania Elephant Program (STEP). Special thanks also go to all people who were involved in reviewing numerous drafts of this report. Finally, we are immensely grateful for the extraordinary dedication of our lead consultant, Kristeen Penrod of Science and Collaboration for Connected Wildlands (SCW).

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LIST OF ABBREVIATIONS AND ACRONYMS

AESG	Anguillid Eel Specialist Group
ADAP	Association pour le Développement des Aires Protégées
APLIC	Avian Power Line Interaction Committee
ATE	Association of Tanzania Employers
AWF	African Wildlife Foundation
BCI	Borderland Conservation Initiative
BFF	Born Free Foundation
BLI	BirdLife International and Handbook of the Birds of the World (2016-2019)
BTC	Belgian development agency in Tanzania
CAP	Conservation Action Plan
CAWM	College of African Wildlife Management
CBA	Commercial Bank of Africa
CBFM	community-based forest management
CCRO	Certificate of Customary Right of Occupancy
CI	Conservation International
COSTECH	Tanzania Commission for Science and Technology
CRF	Chelonian Research Foundation
DANIDA	Denmark's development cooperation
DC	District Council
DED	District Executive Director
DGO	District Game Officer
EAC	East African Community
EAMCEF	Eastern Arc Mountains Conservation Endowment Fund
ESRI	Environmental Systems Research Institute
FishBase	FishBase team RMCA & Geelhand, D.
FORVAC	Forestry and Value Chains Development
FR	Forest Reserve
FZS	Frankfurt Zoological Society
GCA	Game Controlled Area
GIS	Geographic Information System
GPS	Global Positioning System
GR	Game Reserve
HGF	Honeyguide Foundation
HWC	Human-wildlife conflict
IFAW	International Fund for Animal Welfare
IUCN	International Union for Conservation of Nature
IUCN SSC - SMSG	IUCN Species Survival Commission Small Mammal Specialist Group
IUCN/SSC-AESG	IUCN/Species Survival Commission African Elephant Specialist Group
IUCN/SSC-PSG	IUCN Species Survival Commission Pangolin Specialist Group
JGI	Jane Goodall Institute
JVLUAs	Joint Village Land Use Agreements

JVLUP	Joint Village Land Use Plan
KDU	Wildlife Division Anti-poaching Unit
KWS	Kenya Wildlife Service
LAFR	Local Authority Forest Reserve
LGAs	Local Government Authorities
MCDI	Mpingo Conservation & Development Initiative
MEST	Ministry of Science, Education and Technology
MNRT	Ministry of Natural Resources and Tourism
MOA	Ministry of Agriculture Livestock and Fisheries
MWEKA	College of African Wildlife Management/MWEKA College
MWTC	Ministry of Works, Transport and Communications
NCAA	Ngorongoro Conservation Area
NCZ	North Carolina Zoo
NM-AIST	Nelson Mandela African Institution of Science and Technology
NP	National Park
NR	Nature Reserve
NSAMIS	National Strategy and Action Plan to Manage Invasive Species
NTRI	Northern Tanzania Rangelands Initiative
ODA	Odonata Database Africa
PG	Peter Gerngross
PORALG	President's Office Regional Administration and Local Government
PROTECT	Promoting Tanzania's Environment, Conservation, and Tourism
RAS	Regional Administrative Secretary
REDD	Reducing Emissions from Deforestation and forest Degradation
RLI	Red List Index
RNRO	Regional Natural Resources Officer
RT	Rainforest Trust
SAIAB	South African Institute of Aquatic Biodiversity
SCW	Science & Collaboration for Connected Wildlands
SFS	School for Field Studies
SPANEST	Strengthening the Protected Area Network of Southern Tanzania
STEP	Southern Tanzania Elephant Program
SUA	Sokoine University of Agriculture
TAFORI	Tanzania Forestry Research Institute
TANAPA	Tanzania National Parks
TANESCO	Tanzania Electric Supply Company Limited
TANROADS	Tanzania National Roads Agency
TARURA	Tanzania Rural and Urban Roads Agency
TAWA	Tanzania Wildlife Management Authority
TAWIRI	Tanzania Wildlife Research Institute
TAZARA	Tanzania Zambia Railway Authority
TFCG	Tanzania Forest Conservation Group
TFS	Tanzania Forest Service Agency
TNC	The Nature Conservancy

TNRF	Tanzania Natural Resource Forum
TRC	Tanzania Railways Corporation
TRIAS	Belgium Development Agency
UCRT	Ujamaa Community Resources Team
UDOM	University of Dodoma
UDSM	University of Dar es Salaam
UMNP	Udzungwa Mountains National Park
URT	United Republic of Tanzania
USAID	United States Agency for International Development
VGS	Village Game Scouts
VLFR	Village Land Forest Reserve
VLUP	Village Land Use Plan
WCS	Wildlife Conservation Society
WD	Wildlife Division
WNI	Wild Nature Institute
WWF	World Wide Fund for Nature
ZSL	Zoological Society London

EXECUTIVE SUMMARY

The recent passage of Tanzania's Wildlife Conservation (Wildlife Corridors, Dispersal Areas, Buffer Zones, and Migratory Routes) Regulations (2018), aka the "Corridor Regulations," exemplifies the commitment of the Tanzanian government to maintain and restore critical wildlife corridors to sustain the incredible biodiversity for which Tanzania is world-renowned. The purpose of this report was to delineate, assess, and prioritize wildlife corridors across Tanzania, including critical transboundary corridors to protected areas in neighboring countries, and to develop a "priority action plan," as called for in Tanzania's Corridor Regulations.

The wildlife corridor network delineated for the assessment (ES-1) identifies 61 corridors, including eight transboundary corridors, that are likely important for wildlife movement between targeted protected areas at the countrywide scale based on natural land cover and various human influences on the landscape. The wildlife corridor network was developed to support a systematic assessment and prioritization of wildlife corridors important to maintaining and restoring Tanzania's rich natural heritage. Detailed assessments and ground truthing of the on-the-ground situation in each corridor will be needed in order to prepare robust plans of action to secure these corridors.

The assessment team consisted of representatives from the Tanzania Wildlife Research Institute (TAWIRI) and US Agency for International Development (USAID) Promoting Tanzania's Environment, Conservation, and Tourism (PROTECT) project, along with a senior consultant from Science and Collaboration for Connected Wildlands (SCW). This team consulted extensively with conservation and development stakeholders across Tanzania—including the leaders of previous corridor assessments in Tanzania—to develop a set of 12 stakeholder-endorsed criteria for assessing and prioritizing the corridors. The assessment team applied the 12 stakeholder-endorsed criteria to prioritize all 61 corridors according to two independent rankings: Conservation Value and Vulnerability of the corridors. The assessment was rigorously quantitative and followed a systematic, transparent, and repeatable process. The following sections describe the assessment and prioritization framework, including the 12 criteria for prioritization, and a brief summary of the results of the prioritization analysis for the entire network of corridors in Tanzania.

PRIORITIZATION	CRITERIA	POSSIBLE POINTS
CONSERVATION VALUE	Species of Conservation Value in the Pair of Protected Areas Connected by the Corridor	21
	Globally Important Biodiversity Hotspots and Ecoregions in the Pair of Protected Areas Connected by the Corridor	10
	Size of Protected Areas Connected by the Corridor	15
	Habitat Quality in the Corridor	20
	Corridor Importance to Facilitate Wildlife Movements Driven by Climate Change	10
	Scientific Evidence that Wildlife use the Corridor	15
	Freshwater Features that add Value to the Corridor	9
		=100
VULNERABILITY	Vulnerability of the Corridor to Habitat Conversion	30
	Human Influence on the Corridor	20
	Existing and Planned Infrastructure Density in the Corridor	20
	Threats to the Corridor from Invasive Species	10
	Human-Wildlife Conflict Severity in the Corridor Area	20
		=100

Figure ES-1. Wildlife Corridor Network Assessed

Target Protected Areas

Least Cost Corridors

Less Permeable

More Permeable

This map delineates lands likely important to wildlife movement between protected areas at the countrywide scale based on natural land cover and various human influences on the landscape. This map was used to support the assessment and prioritization of wildlife corridors important to maintaining Tanzania's rich natural heritage. It may be refined in the future by finer-scale analyses and as more data and information becomes available.

0 40 80 160 240 320 Kilometers

THE KEY RESULTS: TANZANIA'S PRIORITIZED WILDLIFE CORRIDORS

The table below provides a prioritized list of the wildlife corridors based on conservation value and vulnerability. The assessment found that all of the corridors assessed have conservation value (range from 40-90 points), with 34 corridors scoring above the mean of 66.9. Highlighted in different shades of green are the top 1-5, 6-10, 11-15, and 16-20 corridors with the highest scores for conservation value. Note that there is a high degree of variation in the vulnerability scores of these 20 corridors. A few of the top 20 corridors for conservation value are also among the most vulnerable, but several of the top 20 for conservation value have much lower vulnerability scores. Vulnerability scores have been color-coded to signify the relative level of threat (red=high, orange=medium, yellow=low) based on the assessment. Note: the term "complex" is used when there are more than two land designations within a target protected area (e.g., Serengeti Complex includes Serengeti NP, Ngorongoro Conservation Area, Lake Natron GR, Maswa GR, Loliondo GCA, and Masai Mara National Reserve).

Wildlife corridors prioritized based on conservation value from highest to lowest with vulnerability scores color-coded to signify relative level of threat (red = high, orange = medium, yellow = low)

Wildlife Corridors Assessed sorted by Conservation Value Score	Conservation Value Score	Vulnerability Score
Ruaha Rungwa - Udzungwa	90	48
Ruaha Rungwa - Katavi Complex	87	17
Serengeti Complex - Tarangire Complex* *completely captures Serengeti – Lake Manyara & Tarangire Complex – Lake Manyara corridors*	86	55
Kilombero - Udzungwa Mountains	85	49
Nyerere Selous - Niassa (Mozambique)	85	37
Nyerere Selous - Wami Mbiki	83	41
Serengeti Complex - Lake Manyara*	82	36
Nyerere Selous - Saadani	80	46
Serengeti Complex - Longido	80	36
Udzungwa - Mikumi	80	36
Kigosi Moyowosi - Burigi Chato	79	45
Kilombero - Uzungwa Scarp	79	26
Mkomazi Tsavo - Handeni	78	53
Mahale Mountains - Ugalla Complex	78	21
Udzungwa - Uzungwa Scarp	77	36
Serengeti Complex - Wembere	76	36
Mahale Mountains - Katavi Complex	76	17
Katavi-Complex - Ugalla Complex	75	17
Ruaha Rungwa - Inyonga	75	21
Nyerere Selous - Liparamba	74	31
Ruaha Rungwa - Wembere	73	21
Amboseli - Mkomazi Tsavo (Kenya)	73	21
Serengeti Complex – Yaeda Chini	73	26
Ugalla Complex - Wembere	73	13
Nyerere Selous - Udzungwa	71	77
Kilimanjaro - Amboseli (Kenya)	71	40
Kigosi Moyowosi - Ugalla Complex	71	31
Tarangire Complex - Mkomazi Tsavo (Kenya)	70	53
Mikumi - Wami Mbiki	69	63
Katavi Complex - Loazi Lungu	69	21
Katavi Complex - Inyonga	69	17

Wildlife Corridors Assessed sorted by Conservation Value Score	Conservation Value Score	Vulnerability Score
Kigosi Moyowosi - Uvinza	68	31
Serengeti Complex - Arusha	68	41
Kilimanjaro - Mkomazi Tsavo (Kenya)	67	75
Mahale Mountains - Gombe Stream	67	45
Ugalla Complex - Uvinza	66	17
Wami Mbiki - Saadani	66	46
Ruaha Rungwa - Yaeda Chini	65	47
Burigi Chato - Akagera (Rwanda)	65	27
Longido - Amboseli (Kenya)	64	26
Tarangire Complex - Lake Manyara*	63	58
Kilimanjaro - Arusha	62	72
Kilimanjaro - Longido	62	35
Loazi - Luanga Musalangu (Zambia)	62	29
Tarangire Complex - Handeni	60	27
Ruaha Rungwa - Kitulo Rungwe	59	55
Arusha - Longido	59	42
Ruaha Rungwa - Swaga Swaga	59	56
Ruaha Rungwa - Mpanga Kipengere	58	49
Wami Mbiki - Handeni	57	45
Gombe Stream - Uvinza	57	53
Tarangire Complex - Arusha	53	63
Amani - Nilo	53	40
Kitulo Rungwe - Mpanga Kipengere	49	36
Tarangire Complex - Swaga Swaga	47	80
Gombe Stream - Mukungu Rukamabasi (Burundi)	46	70
Ibanda - Karagwe Rumanyika	45	56
Akegera (Rwanda) - Karagwe Rumanyika	44	56
Lake Manyara - Yaeda Chini	44	41
Baga - Kisima Gonja	43	68
Msanjesi - Lukwika Lumesure	40	39

As noted, this report prioritizes the corridors quantitatively, but it does not specify a particular number of "top priority corridors" in Tanzania because it is designed for a wide variety of stakeholders with different strategic needs and opportunities—some stakeholders, for example local community groups, might wish to focus on just one or two priority corridors; some might wish to focus on the top five or top 10; still others will aim to form consortia to conserve the top 20 or more. Many stakeholders already have made substantial conservation investments in high-priority corridors, while other stakeholders are looking for opportunities to develop conservation activities in new areas. Accordingly, TAWIRI and its partners developed this corridor assessment, prioritization, and Action Plan for all stakeholders—whether they aim to conserve one priority corridor, 20, or more—and the activities recommended in the Action Plan at the end of this report are applicable to conserving any of the corridors. Regardless of the specific number of top priority corridors that stakeholders aim to conserve, TAWIRI and its partners recommend that all stakeholders should follow the results of the assessment and prioritization when deciding how many and which priority corridors to focus on, and which ones to focus on first.

We highlighted the top five, 10, 15, and 20 priority corridors—ranked according to conservation value—because each set conserves significant landscape connections, with each subsequent priority tier providing greater connectivity. One clear result of the assessment and prioritization is that conserving at least the top 20 corridors—ranked according to conservation value—would maintain a landscape network that connects most of the major protected areas in Tanzania. The top 20 corridors can provide essential north-south and east-west connectivity across the country, and also conserve critical transboundary connections to protected areas in Kenya and Mozambique, which are essential for maintaining large mammal populations within Tanzania but also are continentally important to maintaining connectivity for wide-ranging species like cheetah and African wild dog across East Africa. However, there are still a few key corridors missing from the top 20 that, if included, would help to tie the whole network together. As such, Wildlife Division elevated 7 additional corridors to be among the first corridors to be secured to ensure the ecological integrity of Tanzania's existing protected areas. For example, there is a gap in the eastern part of the network linking the northern parks with those in southern Tanzania, between Wami Mbiki – Handeni.

Although we have highlighted 20 priority corridors in terms of conservation value and the Wildlife Division Priority Corridor Additions, it is important to acknowledge that **all the corridors assessed have conservation value**. Many of the other priority corridors have champions actively working to conserve and restore corridors on the ground (e.g., Nyerere Selous - Udzungwa) that are also essential to maintaining wildlife populations and the ecological integrity of the protected area network.

Corridors outside of the top 20 may also have specific, critical values that do not translate into a high overall score. For example, a number of corridors (e.g., Mikumi – Wami Mbiki, Wami Mbiki – Handeni, Nyerere Selous – Udzungwa) cross areas of high levels of human-wildlife conflict and can be expected to be important for reducing this conflict if restored and protected.

It is important to also highlight the corridors with the highest overall Vulnerability Score, as this likely indicates the corridors most highly threatened by existing or imminent blockage by anthropogenic land use. Given that all the corridors assessed are of value, the Vulnerability Score may also be a primary criterion for stakeholders in selecting corridors for restoration. The five corridors with the highest Vulnerability Score include two international transboundary corridors:

(1) Tarangire Complex - Swaga Swaga
(2) Nyerere Selous – Udzungwa
(3) Kilimanjaro - Mkomazi Tsavo (Kenya)
(4) Kilimanjaro – Arusha
(5) Gombe Stream - Mukungu Rukamabasi (Burundi)

The Action Plan at the end of this report lists activities that TAWIRI and its partners recommend to secure and conserve the corridors. The activities are ranked according to their level of urgency and organized into seven categories:

- Corridor Working Groups & Interagency Coordination
- Land Use Planning and Management
- Community Outreach & Awareness
- Community Improvement & Empowerment
- Mitigating and Remediating Impacts of Roads & Infrastructure
- Research and Conservation Planning Resources
- Habitat Restoration & Stewardship

While all of the activities identified in the seven categories in the action plan are essential to maintain, restore and secure critical wildlife corridors across the country, engaging Local Government Authorities in community outreach and awareness from the inception should always be the first activity carried out in each corridor.

Tanzania's protected area network and the rich biodiversity it sustains are some of the country's most important natural assets. Wildlife corridors must be maintained and restored to conserve Tanzania's rich natural heritage, maintain wildlife populations that generate substantial tourism revenue, and help reduce human-wildlife conflicts. Coordinated and prioritized actions to conserve wildlife corridors are urgently needed to ensure the ecological integrity of Tanzania's protected area system.



1: INTRODUCTION

Tanzania is a globally important mega-biodiversity hotspot, supporting over a third of Africa's total plant species and roughly 20% of the large mammal population (Division of Environment 2015)—one of the most diverse large-mammal communities in the world. However, Tanzania has also become a hotspot for species at risk of extinction with 1,320 threatened species on the IUCN Red List (2020), representing nearly every taxonomic group. In fact, Tanzania is the hottest hotspot on the continent in terms of at-risk species (IUCN 2020). Protected areas may conserve many of these species, but wide-ranging species like elephant, lion, cheetah, wildebeest, and African wild dog may be lost from even the largest natural areas if agricultural land conversion, highways, and urbanization isolate each major protected area and wildland habitat. Movement is essential to wildlife survival (MacArthur and Wilson 1967, Soulé and Terborgh 1999, Forman et al. 2003, Crooks and Sanjayan 2006, Jones et al. 2009, Division of Environment 2015, Masenga et al. 2016, Debonnet and Nindi 2017, Riggio and Caro 2017)—whether it be the day-to-day movements of individuals seeking food, shelter, or mates, dispersal of offspring to new home areas, seasonal migration, healthy mixing of genes among populations, recolonizing unoccupied habitat after a local population goes extinct, or for species to shift their geographic range in response to global climate change (Noe 2003, Forman et al. 2003, Crooks and Sanjayan 2006, Heller and Zavaleta 2009). Disruption of these natural movement patterns can alter essential ecosystem functions and lead to losses of species and critical environmental services such as pollination, seed dispersal, and nutrient cycling.
Habitat loss and fragmentation are the major reasons for the decline of wildlife species in Tanzania. Species that once moved freely through a mosaic of natural vegetation types are now confronted with a man-made labyrinth of barriers that fragment formerly expansive natural landscapes. For example, the Tarangire Ecosystem still supports one of the great long-distance wildebeest migrations (Lamprey 1964, Morrison and Bolger 2012, 2014, Bond et al. 2017), one of only three remaining in Africa (Estes 2014). Historically, the diverse ungulate populations dominated by the wildebeest in the Tarangire migrated along at least 10 routes between their dry- and wet-season ranges (Lamprey 1964); now only two viable migration routes remain due to habitat loss and fragmentation (Morrison and Bolger 2012, 2014, Morrison et al. 2016, Bond et al. 2017). Roads, railroads, and development are major obstacles to wildlife movement, fragmenting large habitat areas into smaller patches that support smaller populations, which are consequently more prone to local extinction.

If Tanzania's protected areas become islands with no connecting landscape to allow movement of species, they will not be able to continue to support the animals and plants that currently reside within them. Populations of many species of concern are becoming increasingly isolated from one another, leading to reduced genetic diversity (Epps et al. 2013, Lohay 2019) and risk of extirpations. African wild dogs have been extirpated from at least 25 countries over the past 50 years largely due to direct persecution and widespread habitat loss and fragmentation (Woodroffe and Ginsberg 1999, Whittington-Jones and Davies-Mostert 2015). Wildlife corridors are essential for carnivores like African wild dog and cheetah and large charismatic species like elephant and giraffe that require large areas to persist and are among the first to be harmed by loss of connectivity, and corridors are also vital for corridor-dwellers, plants and less mobile animals (e.g., small mammals, amphibians, reptiles, invertebrates), who may take generations to move their genes between target protected areas (Beier et al. 2008). All of Tanzania's species conservation action plans (TAWIRI 2010, 2016, 2018, 2019) identify habitat loss and fragmentation as key reasons for the species decline and identify maintaining and restoring wildlife corridors as key to the species' recovery and persistence.

In the last 12 years, researchers have completed at least three nationwide studies of wildlife corridors in Tanzania (Jones et al. 2009; Debonnet and Nindi 2017; Riggio and Caro 2017), but there has still been a critical lack of information to support efficient and effective corridor conservation prior to this Wildlife Corridor Assessment, Prioritization, and Action Plan. In addition, while there have been numerous initiatives underway in Tanzania from various stakeholders to secure some corridors, these efforts have generally been dispersed and not sufficiently coordinated. In 2009, the Tanzania Wildlife Research Institute (TAWIRI) conducted Tanzania's first nationwide assessment of wildlife corridors, which identified, assessed, and called attention to 31 wildlife corridors (Jones et al. 2009). In 2017, an assessment by Debonnet and Nindi (2017) called for scientists and conservation stakeholders in Tanzania to "determine clear priorities" for conserving corridors. The 2017 report recommends that these "priorities should be based on assessing the biological and ecological importance of the different corridors in view of how to best secure the long-term survival of the different ecosystems of Tanzania (including the transboundary ecosystems), the integrity of the Protected Area System, and the conservation of the wildlife populations they harbor." In 2018, Tanzania's government took a major step toward conserving wildlife corridors by approving new regulations—Tanzania's Wildlife Conservation (Wildlife Corridors, Dispersal Areas, Buffer Zones, and Migratory Routes) Regulations—that allow legal designation and management of wildlife corridors, dispersal areas, buffer zones, and migratory routes, as conservation areas (URT 2018). Consistent with recommendations from the Debonnet and Nindi 2017 report, these "corridor regulations" also call for Tanzania's Director of Wildlife, in consultation with TAWIRI and other stakeholders, to prepare a priority corridor action plan for designating areas under the regulations, which "shall take into consideration (i) the biological and ecological importance; (ii) integrity of the Protected Area System; (iii) wildlife population, and (iv) negotiation complexities and related cost." This Wildlife Corridor Assessment, Prioritization, and Action Plan responds to that call. Maintaining and restoring wildlife corridors can help stabilize existing populations, prevent additional species from becoming endangered, and prevent costly long-term recovery efforts. But the benefits go beyond just conserving biodiversity. Maintaining ecological processes also are critical to sustaining human communities and protecting essential ecosystem services such as clean air, clean water, food, nutrients, and other natural resources.

Tanzania's protected area network and the rich biodiversity it sustains are some of the country's most important natural assets, with wildlife-related commerce accounting for ~17% of gross domestic product and wildlife-related industries providing diverse sources of employment (Debonnet and Nindi 2017). Although Tanzania has been exceptional in retaining a considerable diversity and concentration of its wildlife (TAWIRI 2015), conserving well-connected protected area networks will help ensure that natural ecological and evolutionary processes can continue operating over large spatial and temporal scales, as they have for millennia.

1.1 Vision and Objectives

This Wildlife Corridor Assessment, Prioritization, and Action Plan aims to meet the following vision and objectives for corridor conservation, which diverse stakeholders discussed and endorsed at a wildlife corridor assessment and prioritization workshop in 2019 (workshop described below in the Stakeholder Engagement section).

Vision: Tanzania's rich natural heritage is sustained and human wildlife coexistence is restored through the establishment of wildlife corridors linking protected areas and other essential habitats to maintain high ecological integrity and viable wildlife populations that support a thriving economy for the people of Tanzania.

Objective 1: Conserve and restore functional wildlife corridors between protected areas and other essential habitats to maintain viable wildlife populations and restore Tanzania's rich biodiversity.
Working to achieve this objective will help to ensure:

- Movement between protected areas and landscapes for wildlife seeking vital resources, including food, water, shelter, mates, and calving and rearing habitats;
- Dispersal of juveniles to new areas;
- Seasonal migration;
- Recolonization of unoccupied habitat after human induced environmental disturbances or natural stochastic events;
- Gene flow, which supports genetic connectivity between populations and prevents inbreeding;
- Ability of organisms to respond or adapt to environmental stressors, including climate change; and
- Maintenance of community, private sector, national, and global biodiversity commitments.

Objective 2: Maintain sustainable flow of ecosystem services for wildlife and people, including:

- Supporting biodiversity, habitat, photosynthesis, soil formation, and food production;
- Provisioning clean water, fish, wood, pollination, wild food, natural medicines, and fiber;
- Providing cultural and aesthetic values, stewardship, recreation, education, and spiritual renewal; and
- Regulating temperature, flooding, clean air and water, and carbon storage.

Objective 3: Support climate adaptation for wildlife and people
Wildlife corridors support climate adaptation by allowing species and full biological communities to shift their ranges in response to climate change. This enhances the climate resilience of the protected area system, which is a key driver of Tanzania's economic growth and opportunities for its people.

Objective 4: Reduce human-wildlife conflict

For example, by:

- Providing safe passage for wildlife through corridors instead of through areas more heavily used by humans such as farms, schools, and settlements;
- Reducing crop damage and other economic losses;
- Preventing human deaths and injuries;
- Reducing retaliatory killing of wildlife;
- Reducing social disruption, and
- Improving attitudes about human-wildlife coexistence.

Objective 5: Provide tangible benefits, create jobs, and develop alternative livelihoods to build support among local stakeholders for conserving wildlife corridors

Such benefits may include:

- Security for communities and their properties;
- Beekeeping and honey production;
- Jobs in corridor management (e.g., village game scouts, habitat restoration, research and monitoring);
- Jobs in ecotourism and related sectors (e.g., tour guides, lodging, restaurants);
- Cultural tourism (e.g., traditional food, dance, songs, customs, crafts);
- Tourist revenue shared with local communities;
- Carbon projects that contribute funding to improve living conditions for local communities, and for climate adaptation projects;
- Sustainable community-based rangeland management and fishing according to land use plans;
- Other conservation-friendly income generating activities;
- Improving activities compatible with wildlife corridor management; and community-based projects and services.

2. STAKEHOLDER ENGAGEMENT

Diverse stakeholders were engaged from the inception of the project through a series of workshops to develop the wildlife corridor prioritization framework, gather data and information on the status and threats to wildlife corridors, and promote the partnerships needed to conserve connectivity at the landscape scale, across the entire country and beyond to critical wildlife areas in neighboring countries.

On November 6-7, 2019 TAWIRI and the US Agency for International Development (USAID) Promoting Tanzania's Environment, Conservation, and Tourism (PROTECT) project hosted a 2-day stakeholders' workshop in Dodoma to develop a vision, objectives, and criteria for prioritizing conservation of Tanzania's wildlife corridors. This workshop was the launch event for this technical study. The workshop brought together over 45 participants from diverse agencies, organizations, and academic institutions (Appendix A) and had the following specific objectives: (i) Collaboratively identify and reach consensus on a vision and objectives for conserving wildlife corridors; and (ii) Collectively develop criteria for a Corridor Prioritization Framework to assess and prioritize corridors with reference to the agreed-upon vision and objectives for conserving Tanzania's corridors.

Participants crafted and agreed on the vision statement and developed and endorsed the high-level objectives for conserving wildlife corridors in Tanzania provided in Section 1.1. Stakeholders also identified, discussed, and endorsed a set of 12 criteria for assessing and prioritizing the conservation of Tanzania's wildlife corridors based on the conservation value and vulnerability of the corridors to a variety of threats, which are listed in Section 3.

The Northern Region Wildlife Corridor Workshop, held January 31, 2020 in Arusha, was the first in a series of planned regional events to gather local data and information on wildlife corridors. Scientists, land managers, land use planners, and a very wide representation of district leaders from across the region were invited, and the full complement of District Game Officers were invited and attended. The workshop engaged 85 participants (Appendix B) from throughout the region, including representatives from Kenya, to share their knowledge and expertise.

The workshop was designed as a working session to gather data, information, and knowledge about the wildlife corridors to be evaluated. Each table had a large-format map depicting one of the corridors to be evaluated. Participants circulated around the corridor maps where they had knowledge, conversed with colleagues, and completed wildlife corridor description forms (Appendix C). Participants also drew any spatial related information on the maps (e.g., known pathways of target species) based on research data and expert opinion. There was also a large-format map of Tanzania to identify additional corridors, particularly those linking protected areas in northern Tanzania with those in the west and south. The northern region workshop was made possible through the generous support of the Range Wide Conservation Project for Cheetah and African Wild Dogs (a joint project of the Wildlife Conservation Society and the Zoological Society of London) and Oikos East Africa.

Workshops for the southern and western corridors were planned for April 2020 in collaboration with World Wide Fund for Nature and Jane Goodall Institute but were canceled due to the COVID-19 pandemic. TAWIRI sent requests for data and information to people on the invitee lists for both workshops to complete wildlife corridor description forms.

A final 4-hour virtual stakeholder workshop was held 4th of September 2020 to achieve consensus on the prioritized list of corridors and validate the Action Plan. Conserving wildlife corridors across the country, including transboundary corridors to protected areas in neighboring countries, will require collaboration and coordination among numerous agencies, organizations and individuals. Technical plans such as this must be matched by efforts to build and maintain relationships among all the entities necessary to implement a connectivity conservation strategy for Tanzania.

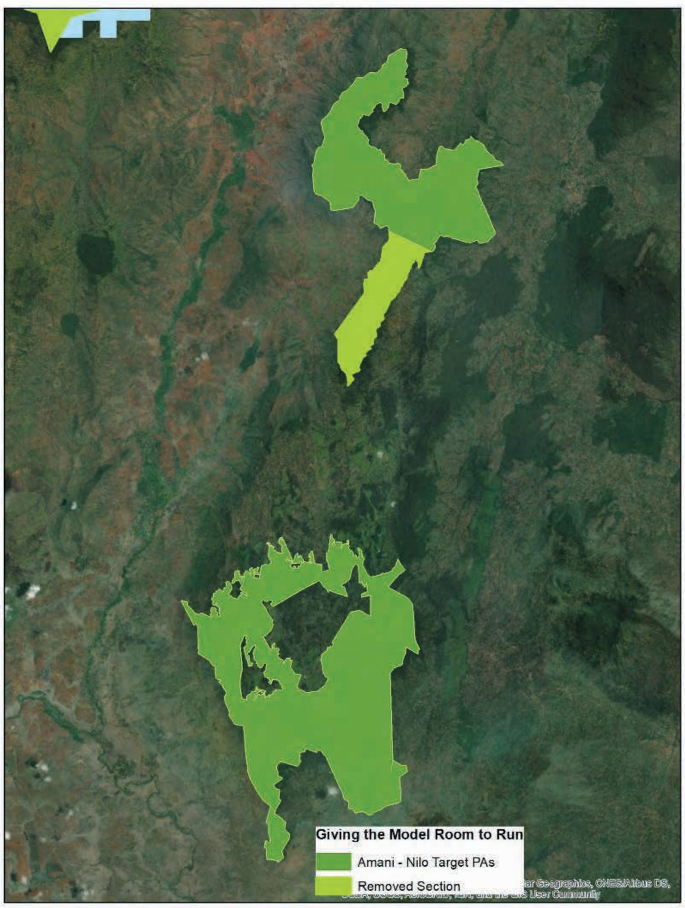
3. WILDLIFE CORRIDOR DELINEATION, ASSESSMENT AND PRIORITIZATION

This countrywide assessment includes 61 corridors, including 8 transboundary corridors that connect protected areas in Tanzania to protected areas in surrounding countries: Kenya, Rwanda, Burundi, Zambia, and Mozambique. Stakeholders at the November 2019 Dodoma workshop and the corridor assessment team initially agreed that this study should focus on 52 corridors identified in a recent paper by Riggio and Caro (2017): Structural Connectivity at a National Scale: Wildlife Corridors in Tanzania. However, TAWIRI expanded the scope of the assessment for three reasons: (1) Tanzania's Wildlife Division requested that the network of protected areas and corridors considered in this assessment include several recently designated National Parks and Game Reserves; (2) TAWIRI wanted to ensure that all the corridors that TAWIRI assessed in its 2009 report, Wildlife Corridors in Tanzania (Jones et al. 2009) were included in this assessment; and (3) Key stakeholders at TAWIRI's Northern Region Wildlife Corridor Workshop in Arusha (January 2020) identified several potential corridors linking protected areas in northern Tanzania with those in the west and south, which were not delineated in Riggio and Caro (2017). Maintaining and restoring habitat connectivity and wildlife movement across central Tanzania is essential to maintaining Tanzania's rich biodiversity, and it also provides a vital link for all of East Africa.

3.1 Delineating Corridor Boundaries for the Assessment

A "least cost path" is the product of a GIS analysis that identifies the route through the corridor where wildlife are expected to encounter the most natural habitat and fewest hazards as they move between protected areas.

The corridor boundaries were delineated by conducting least-cost corridor analyses using Linkage Mapper (McRae and Kavanagh 2011) in ESRI ArcMap v.10.8. One of the first steps in any connectivity analysis is deciding what needs to be connected—whether these are existing reserves, suitable or occupied habitat for particular species, or large areas of relatively natural land cover (Beier et al. 2008). In particular, running the least-cost corridor analysis requires identifying the endpoints to be connected. For the most part, the assessment team used National Parks and Game Reserves—protected areas that have the highest forms of protection in Tanzania—as the termini for the analyses, with the expectation that the corridors would capture other land use designations (e.g., Wildlife Management Areas, Game Controlled Areas, Forest and Nature Reserves, Hunting Blocks) that are largely compatible with wildlife movement. In a few instances, the team included other contiguous land designations in the target protected areas to form complexes. The term "complex" is used when there are more than two land designations within a target protected area. For example, the Tarangire Complex includes Tarangire National Park, Mkungunero Game Reserve, and Lolkisale Game Controlled Area. The team also modeled corridors between other areas in the TAWIRI 2009 report (Jones et al. 2009), such as the Amani Nature Reserve to the Nilo Nature Reserve in the Usambara Mountains.



In a few areas, the termini for the analyses (protected areas) were further constrained to a subset of the target protected areas to give the GIS model “room to run” by selecting only termini well inside the targeted protected areas. For example, the Nilo Nature Reserve has a long peninsula extending south toward the Amani Nature Reserve, and this section was removed so that the model had enough distance between targeted endpoints to make good decisions about which path to take (i.e., the continuous forested path), since shorter corridors may have “less cost” overall but travel through non-habitat, for example, agricultural lands. The assessment team also removed the long peninsula on the Kilombero Valley Game Reserve target protected area for the same reason.

As noted above, least-cost corridor analysis is a GIS technique (Craighead et al. 2001, Singleton et al. 2002) that models the relative cost of movement between target protected areas and will delineate a corridor even if there is a high cost to movement (e.g., Nyerere Selous-Udzungwa). The landscape is portrayed in a GIS as a grid of squares; such a grid is called a raster, and each square is called a pixel. The assessment team used a Human Influence Index (van Bruegel et al. 2015a) as the cost surface to model corridors between target protected areas, which was based on natural land cover and various human influences on the landscape. The cost surface represents the per-pixel cost of movement. The Human Influence raster was on a scale of 0-100, with a pixel with a value of 100 being the highest human influence or highest cost. Resistance values are calculated for each pixel in the raster. Resistance refers to the difficulty of moving through a pixel and cost is the cumulative resistance incurred in moving from the pixel to targeted endpoints, the protected areas. The lowest-cost swath of pixels is the least-cost path, which represents the best potential route between two target areas under the model’s assumptions. A “slice” (or cost contour) of the resulting cost surface was used to delineate least-cost corridors for this assessment.

The network of 61 corridors delineated for this assessment (Figure 1a) identifies lands likely important for wildlife movement between targeted protected areas at the countrywide scale based on natural land cover and human influences on the landscape. The results of the least cost corridor analyses are largely in concurrence with the network delineated by Riggio and Caro (2017). Figure 1b depicts land designations within the target protected areas and serves as a geographic reference map for the wildlife corridor network. Table 1 provides a list of the names used for each of the wildlife corridors delineated and assessed as well as the associated names and numbers of each corridor from the TAWIRI 2009 report (Jones et al. 2009), and any other known alternative corridor names. The wildlife corridor network was developed to support a systematic assessment and prioritization of wildlife corridors important to maintaining and restoring Tanzania’s rich natural heritage. Detailed field assessments and ground truthing of the on-the-ground situation in each corridor will be needed in order to prepare robust plans of action to secure these corridors. Thus, the analyses contained herein may be refined in the future by finer-scale analyses and as more data and information become available.

Although the great majority of the corridors assessed are structurally connected, some of the corridors delineated require habitat restoration to restore connectivity, and a few may be truly lost. For example, the assessment team delineated some corridors for the assessment that were considered severed in Riggio and Caro (2017) but were delineated and assessed because of their vital importance to maintain connected wildlife populations between northern and southern Tanzania and all of East Africa. This includes five corridors linking northern and southern protected areas: (i) Serengeti Complex – Wembere, (ii) Yaeda Chini Valley – Ruaha Rungwa, (iii) Tarangire Complex – Swaga Swaga, (iv) Ruaha Rungwa – Swaga Swaga, and (v) Wami Mbiki – Handeni. The first two of the corridors listed are largely overlapping along the floodplains connecting Lake Eyasi, Lake Kitangiri, and the Sibiti and Wembere Rivers. The assessment team also did not want to preclude the potential for restoring connectivity where habitat may have been converted to agriculture, which is much more possible to restore than corridors converted to towns or settlements. Research on large mammals in Africa has shown that they will reestablish movement patterns between protected areas once barriers are removed and habitat is restored (Bartlam-Brooks et al. 2011, Riggio and Caro 2017).

Figure 1a. Wildlife Corridor Network Assessed

Target Protected Areas

Least Cost Corridors

Less Permeable

More Permeable

Numbers correspond to Map IDs inTable 1

This map delineates lands likely important to wildlife movement between protected areas at the countrywide scale based on natural land cover and various human influences on the landscape. This map was used to support the assessment and prioritization of wildlife corridors important to maintaining Tanzania's rich natural heritage. It may be refined in the future by finer-scale analyses and as more data and information becomes available.

0 40 80 160 240 320 Kilometers

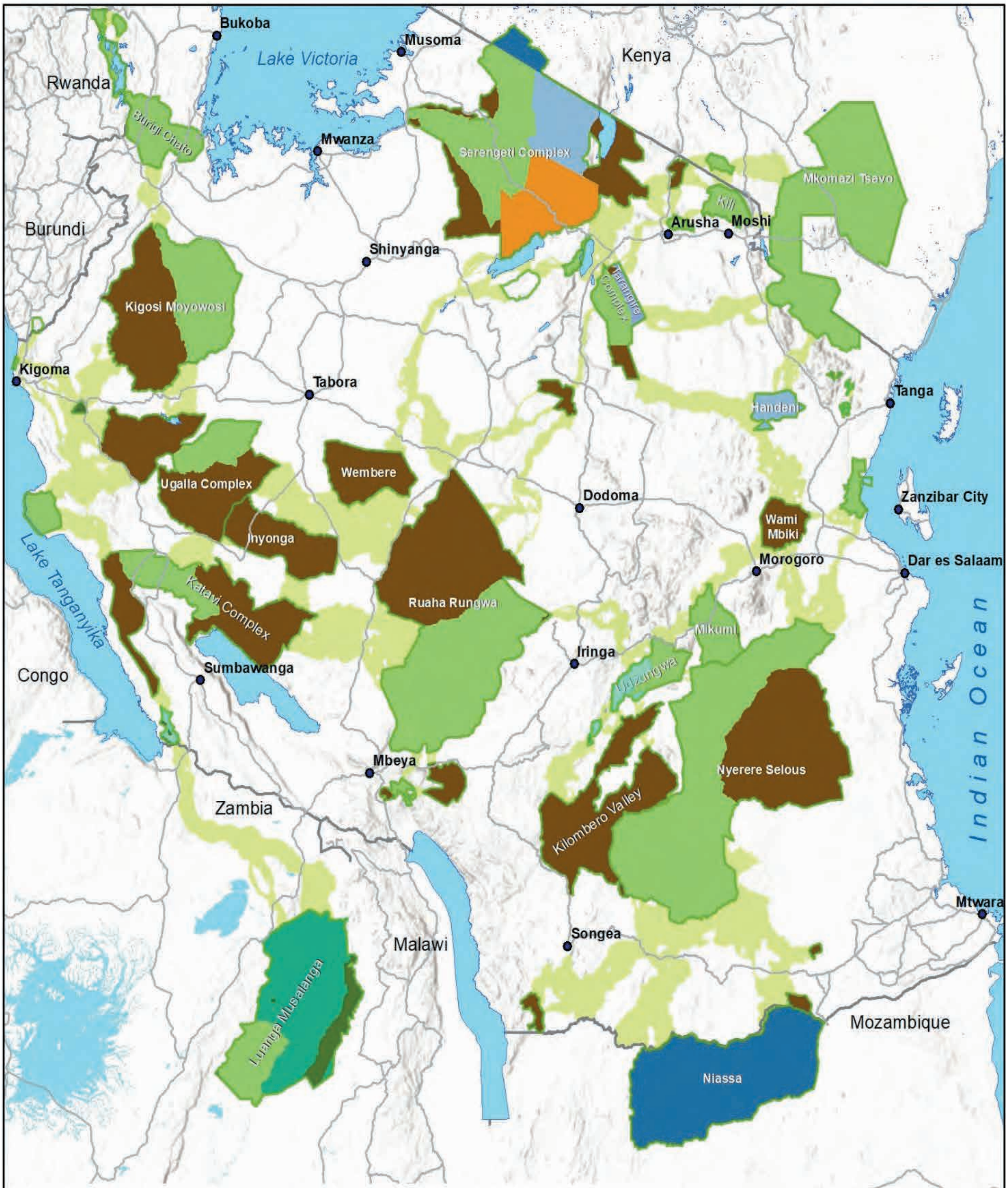


Figure 1b. Wildlife Corridor Network Geographic Reference Map

- National Park
- Conservation Area
- Game reserve
- Game controlled area
- Forest Nature Reserve
- Forest Reserve
- Game Management Area
- National Reserve
- Wildlife Corridor Network
- Target Protected Areas
- City / Town
- Primary Transportation Route (includes primary and trunk roads)
- International Boundary

This map delineates lands likely important to wildlife movement at the countrywide scale based on natural land cover and human influence on the landscape. This map was used to support the assessment and prioritization of wildlife corridors important to maintaining Tanzania's rich natural heritage. It may be refined in the future by finer-scale analyses and as more data and information becomes available.

0 37.5 75 150 225 300 Kilometers

Table 1. List of names for each of the 61 wildlife corridors delineated and assessed and how they relate to the TAWIRI 2009 report (Jones et al. 2009)

Map ID	Wildlife Corridor Assessed	2009 TAWIRI Corridor Name & Number / Alternative Names
1	Akagera (Rwanda) - Rumanyika Karagwe	
2	Amani - Nilo	Usambaras, East / Derema (26)
3	Amboseli - Mkomazi Tsavo (Kenya)	
4	Arusha – Longido	
5	Baga - Kisima Gonja	Usambaras, West (27)
6	Burigi Chato - Akagera (Rwanda)	Burigi-Akagera (Rwanda) (2)
7	Gombe Stream - Mukungu Rukamabasi	Gombe-Mukungu-Rukamabasi (5)
8	Gombe Stream – Uvinza	Greater Gombe Ecosystem-Masito-Ugalla (6); Gombe-Kwitanga (4)
9	Ibanda - Rumanyika Karagwe	
10	Katavi Complex – Inyonga	
11	Katavi Complex - Loazi Lungu	Loazi-Kalambo (11) and Loazi-Lwafi (12)
12	Katavi Complex - Ugalla Complex	
13	Kigosi Moyowosi - Burigi Chato	Burigi-Moyowosi/Kigosi (3)
14	Kigosi Moyowosi - Ugalla Complex	
15	Kigosi Moyowosi – Uvinza	
16	Kilimanjaro - Amboseli (Kenya)	Kilimanjaro-Amboseli (Kenya) / Kitendeni (10)
17	Kilimanjaro - Arusha	
18	Kilimanjaro - Longido	
19	Kilimanjaro - Mkomazi Tsavo (Kenya)	
20	Kilombero - Udzungwa	Ruipa Corridor (X)
21	Kilombero - Uzungwa Scarp	Uzungwa Scarp-Kilombero / Mngeta Corridor (24)
22	Kitulo Rungwe - Mpanga Kipengere	Bujingijila, Mt Rungwe-Livingstone (1)
23	Lake Manyara - Yaeda Chini Valley	
24	Loazi - Luanga Musalangu (Zambia)	
25	Longido - Amboseli (Kenya)	
26	Mahale Mountains - Gombe Stream	
27	Mahale Mountains - Katavi Complex	Katavi-Mahale (8)
28	Mahale Mountains - Ugalla Complex	
29	Mikumi - Wami Mbiki	Wami Mbiki-Mikumi (30)
30	Mkomazi Tsavo - Handeni	
31	Msanjesi - Lukwika-Lumesule	
32	Nyerere Selous - Liparamba	
33	Nyerere Selous - Niassa (Mozambique)	Selous-Niassa (Mozambique) (16)
34	Nyerere Selous - Saadani	
35	Nyerere Selous – Udzungwa	Udzungwa-Selous / Magombera (23); Kilombero Elephant Corridor
36	Nyerere Selous - Wami Mbiki	Wami Mbiki-Jukumu/Gonabis/Northern Selous (29)
37	Ruaha Rungwa – Inyonga	
38	Ruaha Rungwa - Katavi Complex	Katavi-Rungwa (9)
39	Ruaha Rungwa - Kitulo Rungwe	
40	Ruaha Rungwa - Mpanga Kipengere	Igando-Igawa (7)
41	Ruaha Rungwa - Swaga Swaga	Muhezi-Swaga Swaga (15)
42	Ruaha Rungwa - Udzungwa	Udzungwa-Ruaha (22)
43	Ruaha Rungwa – Wembere	
44	Ruaha Rungwa - Yaeda Chini	
45	Serengeti Complex - Arusha	

Map ID	Wildlife Corridor Assessed	2009 TAWIRI Corridor Name & Number / Alternative Names
46	Serengeti Complex - Lake Manyara	Manyara – Ngorongoro / Upper Kitete/Selela (14)
47	Serengeti Complex – Longido	
48	Serengeti Complex - Tarangire Complex	*includes* Manyara-Lake Natron (13) / Makuyuni (17)
49	Serengeti Complex – Wembere	
50	Serengeti Complex - Yaeda Chini	
51	Tarangire Complex – Arusha	
52	Tarangire Complex - Handeni	Tarangire-Mkungunero/Kimotorok (18)
53	Tarangire Complex - Lake Manyara	Tarangire-Manyara / Kwakuchinja (20)
54	Tarangire Complex - Mkomazi Tsavo (Kenya)	Tarangire-Simanjiro Plains (19)
55	Tarangire Complex - Swaga Swaga	
56	Udzungwa - Mikumi	Udzungwa-Mikumi (21)
57	Udzungwa - Uzungwa Scarp	
58	Ugalla Complex – Uvinza	
59	Ugalla Complex – Wembere	
60	Wami Mbiki - Handeni	Wami Mbiki-Handeni/ Southern Masai Steppe (28)
61	Wami Mbiki - Saadani	Wami Mbiki-Saadani (31)
	Note: Uluguru North-South (25) from TAWIRI Report is now contiguous and was not modeled.	

The purpose and intent of the following assessment was to evaluate the conservation value of each corridor and the protected areas it connects, as well as to assess the extent to which the corridors are vulnerable to a variety of threats. The analyses used spatial and non-spatial data, all with inherent limitations.

3.2 Prioritization Framework

The assessment team used the 12 stakeholder-endorsed criteria (mentioned above in Section 2 and listed below in Table 2) to prioritize all 61 corridors according to two independent rankings:

- The **CONSERVATION VALUE** of the corridors, for which the assessment team used criteria that assess the biophysical importance of the corridors and the protected areas they connect, the ecological viability of the corridors, and the amount of scientific and indigenous knowledge demonstrating that wildlife use the corridors; and
- The **VULNERABILITY** of the corridors to a variety of threats, as well as the vulnerability of the protected areas that the corridors connect and the wildlife they support.

The assessment team applied all 12 stakeholder-endorsed criteria to every corridor. Specifically, the team used seven criteria for the CONSERVATION VALUE prioritization and five criteria for the VULNERABILITY prioritization.

Importantly, the assessment was rigorously quantitative and followed a systematic, transparent, and repeatable process. Each assessment, according to each criterion, produced a point score for each corridor. The final result is two cumulative scores for each corridor, corresponding to the two prioritization rankings, with a possible maximum score of 100 points for CONSERVATION VALUE and 100 points for VULNERABILITY. Table 2 lists the two prioritization rankings, the criteria that the assessment team used for each prioritization, and a summary of the distribution of possible points.

Table 2. Corridor Prioritization Framework Showing Assessment Criteria and Point Allocations

PRIORITIZATION	CRITERIA	POSSIBLE POINTS
CONSERVATION VALUE	Species of Conservation Value in the Pair of Protected Areas Connected by the Corridor	21
	Globally Important Biodiversity Hotspots and Ecoregions in the Pair of Protected Areas Connected by the Corridor	10
	Size of Protected Areas Connected by the Corridor	15
	Habitat Quality in the Corridor	20
	Corridor Importance to Facilitate Wildlife Movements Driven by Climate Change	10
	Scientific Evidence that Wildlife use the Corridor	15
	Freshwater Features that add Value to the Corridor	9
		=100
VULNERABILITY	Vulnerability of the Corridor to Habitat Conversion	30
	Human Influence on the Corridor	20
	Existing and Planned Infrastructure Density in the Corridor	20
	Threats to the Corridor from Invasive Species	10
	Human-Wildlife Conflict Severity in the Corridor Area	20
		=100

Unless otherwise noted below, the assessment team conducted all analyses using ArcGIS software. The team delineated an assessment area boundary around Tanzania to capture all the target protected areas connected by transboundary corridors. In cases where protected areas are contiguous or comprised of more than one land designation, the assessment team merged those areas and treated them as one protected area for this study. Several of the analyses described below required the results to be classified into groups to allocate points. The assessment team used Jenks Natural Breaks, which is a classification method that identifies natural groups inherent in the data, for all analyses that required classification.

What follows is a discussion of each of the criteria in turn, their significance, the assessment approaches used to evaluate the corridors according to the criteria, and the results of the analyses.

3.3 Prioritizing the Corridors According to their Conservation Value: Approach and Results

3.3.1 Species of Conservation Value in the Pair of Protected Areas Connected by the Corridor

This criterion assesses the number of *at-risk species*, *endemic species*, and *species of national significance* in Tanzania that are known to inhabit the protected areas connected by the corridors.

According to the International Union for Conservation of Nature (IUCN) Red List (2020), Tanzania has 1,320 at-risk species—ranked as Vulnerable, Endangered, and Critically Endangered. Tanzania also has many endemic species; the exact number is not known, but the available lists include mammals, birds, fishes, reptiles, amphibians, butterflies, and thousands of plants. Species of national significance, for the purpose of this analysis, are (i) those species named as conservation priorities in Tanzania's commitments to the international Convention on Biological Diversity and (ii) species for which TAWIRI regularly conducts aerial surveys.

Assessment Approach: The assessment team compiled IUCN terrestrial species range distribution data for Red List species—including Vulnerable, Endangered, Critically Endangered, and Near Threatened species—in Tanzania and surrounding countries, i.e., the entire "assessment area" of this prioritization study for which spatial data were available (https://www.iucnredlist.org/resources/spatial-data-download).

The assessment team also compiled IUCN terrestrial species range distribution data for the following subsets of species in Tanzania:

- Tanzanian endemic species listed at http://lntreasures.com/tanzaniam.html for which spatial data were available, many of which are highlighted in Tanzania's National Biodiversity Strategy and Action Plan (NBSAP) 2015-2020 (Division of Environment 2015), produced as part of Tanzania's commitment to the Convention on Biological Diversity.

- Species of national significance, as listed in Tanzania's fifth and sixth national reports on the implementation of the Convention on Biological Diversity (Division of Environment 2014 and 2019), as follows: black rhinoceros (*Diceros bicornis*), African elephant (*Loxodonta africana*), chimpanzee (*Pan troglodytes*), Colobus monkeys (e.g., *Piliocolobus gordonorum* and *P. kirkii*), Mangabey monkeys (e.g., *Rungwecebus kipunji*, *Cercocebus sanjei*), lion (*Panthera leo*), leopard (*Panthera pardus*), cheetah (*Acinonyx jubatus*), African wild dog (*Lycaon pictus*), shoe-billed stork (*Balaeniceps rex*), and wattled crane (*Bugeranus carunculatus*).

- Species of national significance that TAWIRI regularly monitors via aerial surveys, as follows: Cape buffalo (*Syncerus caffer*), African elephant, giraffe (*Giraffa camelopardalis*), Grant's gazelle (*Nanger granti*), hartebeest (*Alcelaphus buselaphus*), Thompson's gazelle (*Eudorcas thomsonii*), impala (*Aepyceros melampus*), Roan antelope (*Hippotragus equinus*), Sable antelope (*H. niger*), wildebeest (*Connochaetes taurinus*), and zebra (*Equus species*).

The assessment team intersected all the species distribution data described above with a map of the protected areas that are connected by each corridor to generate a list of at-risk species, endemic species, and species of national significance whose ranges overlap each pair of protected areas. Next the assessment team:

(i) Summed the total number of at-risk species, endemic species, and species of national significance whose ranges overlap each pair of protected areas;

(ii) Used the total number of <u>at-risk species</u> for all pairs of protected areas to identify natural breaks in the data and group each pair into one of seven classes (1-7), where:
1 is the group of pairs of protected areas that have the fewest at-risk species
7 is the group of pairs of protected areas that have the most at-risk species

(iii) Used the total number of <u>endemic species</u> for all pairs of protected areas to identify natural breaks in the data and group each pair into one of seven classes (1-7), where:
1 is the group of pairs of protected areas that have the fewest endemic species
7 is the group of pairs of protected areas that have the most endemic species

(iv) Used the total number of <u>species of national significance</u> for all pairs of protected areas to identify natural breaks in the data and group each pair into one of seven classes (1-7), where:
1 is the group of pairs of protected areas that have the fewest species of national significance
7 is the group of pairs of protected areas that have the most species of national significance

(v) Summed the three group scores for each pair of protected areas.

Point scores: Point distribution was determined according to the results of the analysis. The minimum possible score for any pair of protected areas was 3, and the maximum possible score was 21.

Results: All 61 pairs of protected areas assessed support IUCN listed species, endemic species, and species of national significance (Table 3 and Figure 2). Due to the overlapping nature of the pairs of protected areas connected by the corridors (e.g., 8 corridors associated with Ruaha Rungwa) and the spatial data used in these analyses, it is not possible to map the results using the pairs of protected areas. Thus, the results are displayed using the corridors in Figures 2-5 below.

Table 3. Species Conservation Value for Each Pair of Protected Areas Connected by a Corridor

Pair of Protected Areas Assessed	IUCN Count	IUCN Score	Endemic Count	Endemic Score	Nationally Significant Count	Nationally Significant Score	Total Score
Akagera (Rwanda) - Rumanyika Karagwe	58	2	2	1	11	3	6
Amani - Nilo	93	5	48	6	7	1	12
Amboseli - Mkomazi Tsavo (Kenya)	115	7	16	3	16	6	16
Arusha - Longido	71	3	9	2	14	5	10
Baga - Kisima Gonja	87	4	40	6	9	2	12
Burigi Chato - Akagera (Rwanda)	134	7	28	5	12	4	16
Gombe Stream - Mukungu Rukamabasi (Burundi)	68	3	7	2	6	1	6
Gombe Stream - Uvinza	78	3	12	2	11	3	8
Ibanda - Rumanyika Karagwe	58	2	1	1	11	3	6
Katavi Complex - Inyonga	68	3	16	3	15	5	11
Katavi Complex - Loazi Lungu	74	3	17	3	16	6	12
Katavi-Complex - Ugalla Complex	78	3	22	4	15	5	12
Kigosi Moyowosi - Burigi Chato	137	7	31	5	15	5	17
Kigosi Moyowosi - Ugalla Complex	63	2	11	2	15	5	9
Kigosi Moyowosi - Uvinza	58	2	9	2	15	5	9
Kilimanjaro - Amboseli (Kenya)	85	4	14	3	15	5	12
Kilimanjaro - Arusha	83	4	15	3	15	5	12
Kilimanjaro - Longido	84	4	14	3	15	5	12
Kilimanjaro - Mkomazi Tsavo (Kenya)	118	7	24	4	16	6	17
Kilombero - Udzungwa Mountains	99	6	70	7	17	6	19
Kilombero - Uzungwa Scarp	94	5	63	7	15	5	17
Kitulo Rungwe - Mpanga Kipengere	57	2	23	4	9	2	8
Lake Manyara - Yaeda Chini	60	2	8	2	15	5	9
Loazi - Luanga Musalangu (Zambia)	69	3	5	1	16	6	10
Longido - Amboseli (Kenya)	72	3	3	1	15	5	9
Mahale Mountains - Gombe Stream	74	3	5	1	13	4	8
Mahale Mountains - Katavi Complex	90	5	17	3	15	5	13
Mahale Mountains - Ugalla Complex	92	5	14	3	15	5	13
Mikumi - Wami Mbiki	64	2	31	5	14	5	12
Mkomazi Tsavo - Handeni	115	7	24	4	17	6	17
Msanjesi - Lukwika Lumesule	35	1	3	1	9	2	4
Nyerere Selous - Liparamba	78	3	37	6	15	5	14
Nyerere Selous - Niassa (Mozambique)	76	3	37	6	15	5	14
Nyerere Selous - Saadani	90	5	42	6	15	5	16
Nyerere Selous - Udzungwa	107	6	77	7	17	6	19
Nyerere Selous - Wami Mbiki	78	3	41	6	15	5	14
Ruaha Rungwa - Inyonga	76	3	31	5	17	6	14
Ruaha Rungwa - Katavi Complex	90	5	37	6	18	7	18
Ruaha Rungwa - Kitulo Rungwe	86	4	48	6	17	6	16
Ruaha Rungwa - Mpanga Kipengere	82	4	40	6	16	6	16
Ruaha Rungwa - Swaga Swaga	76	3	32	5	16	6	14
Ruaha Rungwa - Udzungwa	117	7	80	7	20	7	21
Ruaha Rungwa - Wembere	76	3	31	5	17	6	14
Ruaha Rungwa - Yaeda Chini	80	4	34	5	16	6	15
Serengeti Complex - Arusha	103	6	20	4	16	6	16
Serengeti Complex - Lake Manyara	98	6	17	3	16	6	15
Serengeti Complex - Longido	100	6	16	3	16	6	15
Serengeti Complex - Tarangire Complex	98	6	18	3	16	6	15
Serengeti Complex - Wembere	99	6	18	3	18	7	16
Serengeti Complex - Yaeda Chini	98	6	16	3	16	6	15
Tarangire Complex - Arusha	75	3	13	3	16	6	12
Tarangire Complex - Handeni	75	3	20	4	17	6	13
Tarangire Complex - Lake Manyara	65	2	8	2	16	6	10
Tarangire Complex - Mkomazi Tsavo (Kenya)	115	7	22	4	17	6	17

Pair of Protected Areas Assessed	IUCN Count	IUCN Score	Endemic Count	Endemic Score	Nationally Significant Count	Nationally Significant Score	Total Score
Tarangire Complex - Swaga Swaga	63	2	11	2	16	6	10
Udzungwa - Mikumi	97	6	73	7	17	6	19
Udzungwa - Uzungwa Scarp	99	6	74	7	16	6	19
Ugalla Complex - Uvinza	62	2	11	2	15	5	9
Ugalla Complex - Wembere	62	2	14	3	15	5	10
Wami Mbiki - Handeni	69	3	26	4	15	5	12
Wami Mbiki - Saadani	72	3	27	5	10	3	11

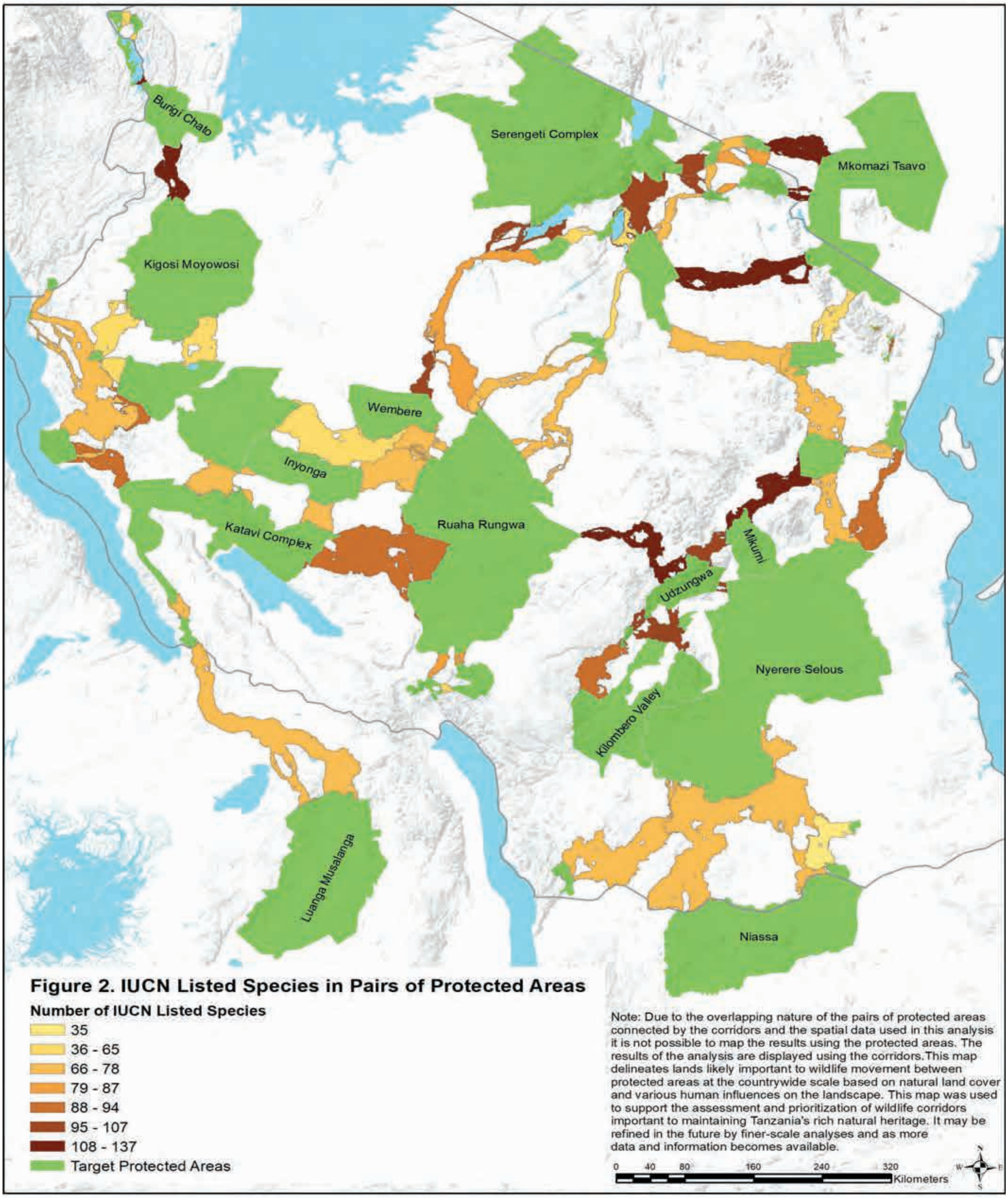


Figure 2. IUCN Listed Species in Pairs of Protected Areas

Each pair of protected areas supports between 35 and 137 species listed by IUCN as either Critically Endangered, Endangered, Vulnerable, or Near Threatened, with most pairs averaging 83 listed species (SD 19.799) (Figure 2). Almost all pairs that captured distributions of over 100 IUCN listed species include at least one large-sized (i.e., ≥ 1,200,000 hectares) protected area, with the exception of Burigi Chato – Akagera (Medium-Small), which supports 134 IUCN listed species, 49% (66/134) of which are cichlid fish in the genus *Haplochromis*. However, size is not everything. The two very smallest pairs of protected areas, Amani – Nilo and Baga – Kisima Gonja, have 93 and 87 IUCN listed species, and both have more endemic species than all but six other pairs.

While the most IUCN listed species per pair of protected areas was 137, the target protected areas all together support a total of 392 IUCN listed species for which spatial data were available (Table 4). Of the 1,320 species on the IUCN Red List (2020-2) for Tanzania, 59% (781/1320) are plants but only 0.02% (18/781) of these species had spatial data available through IUCN, including species in the Liliopsida and Magnoliopsida classes, which are associated with freshwater. Actinopterygii, or ray-finned fish, is the class with the most threatened species known to occur within the targeted protected areas, followed by birds, and then mammals. Species in the genus *Haplochromis*, or cichlid fish, make up 43% (68/159) of the taxa in the Actinopterygii class whose ranges overlap target protected areas, mostly in the East African Rift zone.

Table 4. Class summary of IUCN Red List Species (i.e., Critically Endangered, Endangered, and Vulnerable), and Near Threatened species whose distributions overlap target protected areas

Class	Critically Endangered	Endangered	Vulnerable	Near Threatened	Sum by Class
Actinopterygii	55	13	78	13	**159**
Amphibia	5	18	10	2	**35**
Aves	5	14	23	35	**77**
Bivalvia	0	1	2	1	**4**
Insecta	2	2	3	2	**9**
Liliopsida	1	2	2	3	**8**
Magnoliopsida	1	3	2	4	**10**
Malacostraca		1	6	2	**9**
Mammalia	5	13	17	18	**53**
Reptilia	4	12	9	3	**28**
Sum IUCN Category	**78**	**79**	**152**	**83**	**392**

The number of endemics species ranges from 1 to 80 endemics per pair of protected areas (mean 26; SD 19.459; Figure 3) with 193 endemic species represented across all target protected areas. The Ruaha Rungwa – Udzungwa Mountains pair of protected areas provides habitat for the most endemic species. In fact, all five pairs of protected areas with over 70 endemic species include the Udzungwa Mountains as one of the protected areas. Each pair of protected areas provides habitat for between 6 and 20 species of national significance to Tanzania (mean 14.77; SD 2.66) (Figure 4) with all 23 nationally significant species represented. Tables of IUCN listed species whose range distribution overlaps each corridor are provided in Appendix D. The Ruaha Rungwa – Udzungwa Mountains is also the only pair of protected areas that received all of the possible points for this criterion, though all corridors associated with the Udzungwa Mountains scored in the top tier, as did the Ruaha – Katavi (Figure 5).

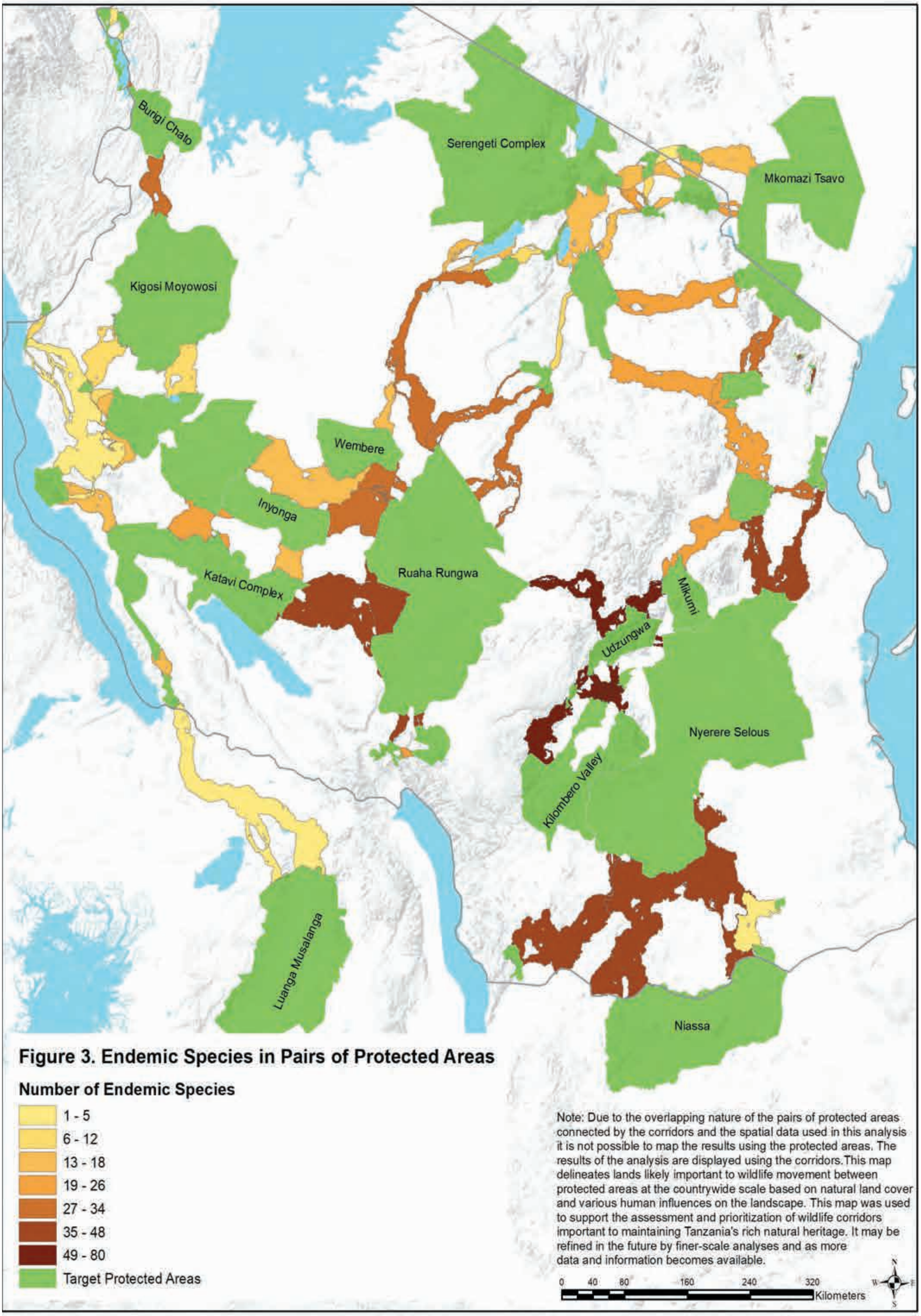


Figure 3. Endemic Species in Pairs of Protected Areas

Note: Due to the overlapping nature of the pairs of protected areas connected by the corridors and the spatial data used in this analysis it is not possible to map the results using the protected areas. The results of the analysis are displayed using the corridors. This map delineates lands likely important to wildlife movement between protected areas at the countrywide scale based on natural land cover and various human influences on the landscape. This map was used to support the assessment and prioritization of wildlife corridors important to maintaining Tanzania's rich natural heritage. It may be refined in the future by finer-scale analyses and as more data and information becomes available.

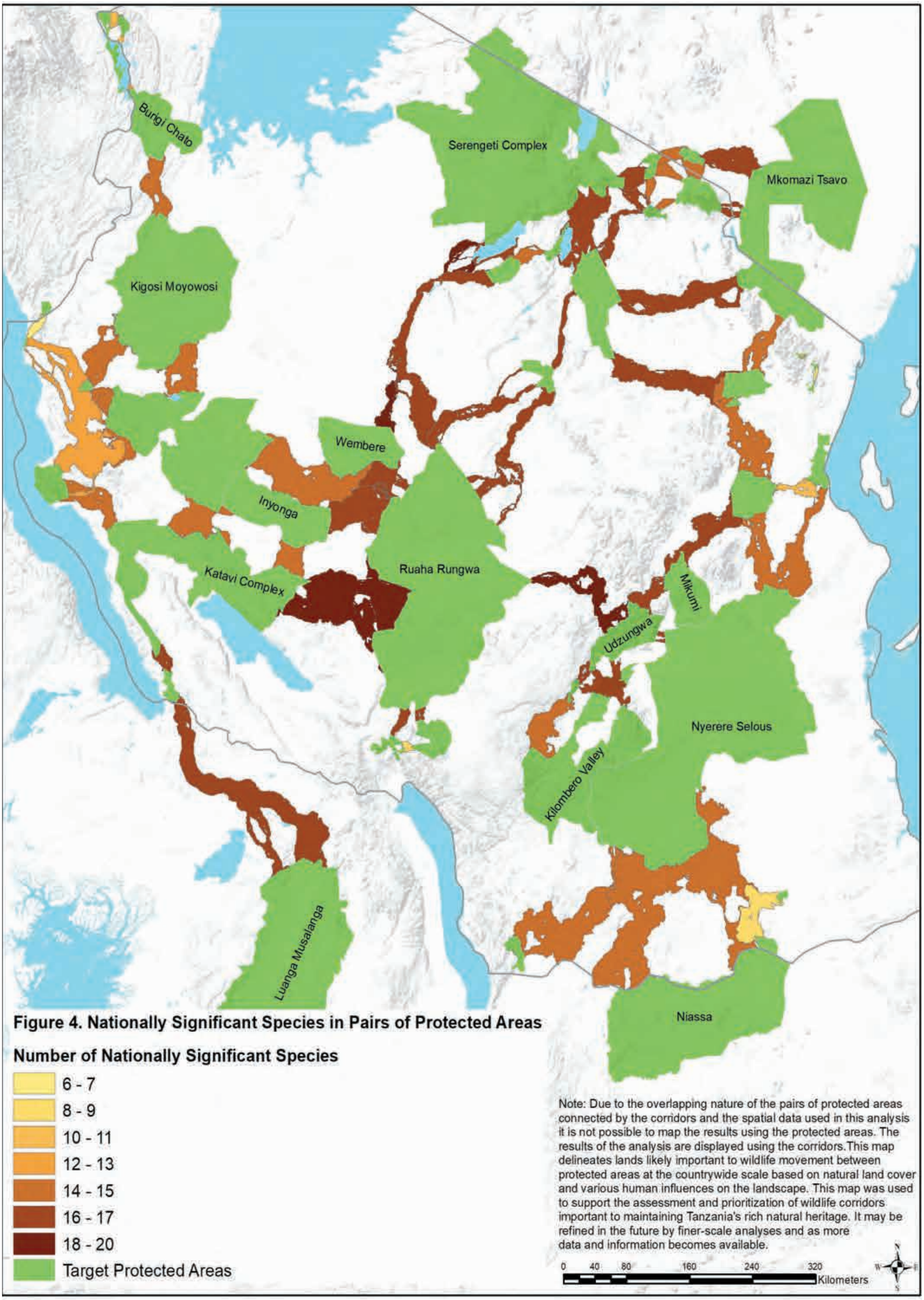


Figure 4. Nationally Significant Species in Pairs of Protected Areas

Note: Due to the overlapping nature of the pairs of protected areas connected by the corridors and the spatial data used in this analysis it is not possible to map the results using the protected areas. The results of the analysis are displayed using the corridors. This map delineates lands likely important to wildlife movement between protected areas at the countrywide scale based on natural land cover and various human influences on the landscape. This map was used to support the assessment and prioritization of wildlife corridors important to maintaining Tanzania's rich natural heritage. It may be refined in the future by finer-scale analyses and as more data and information becomes available.

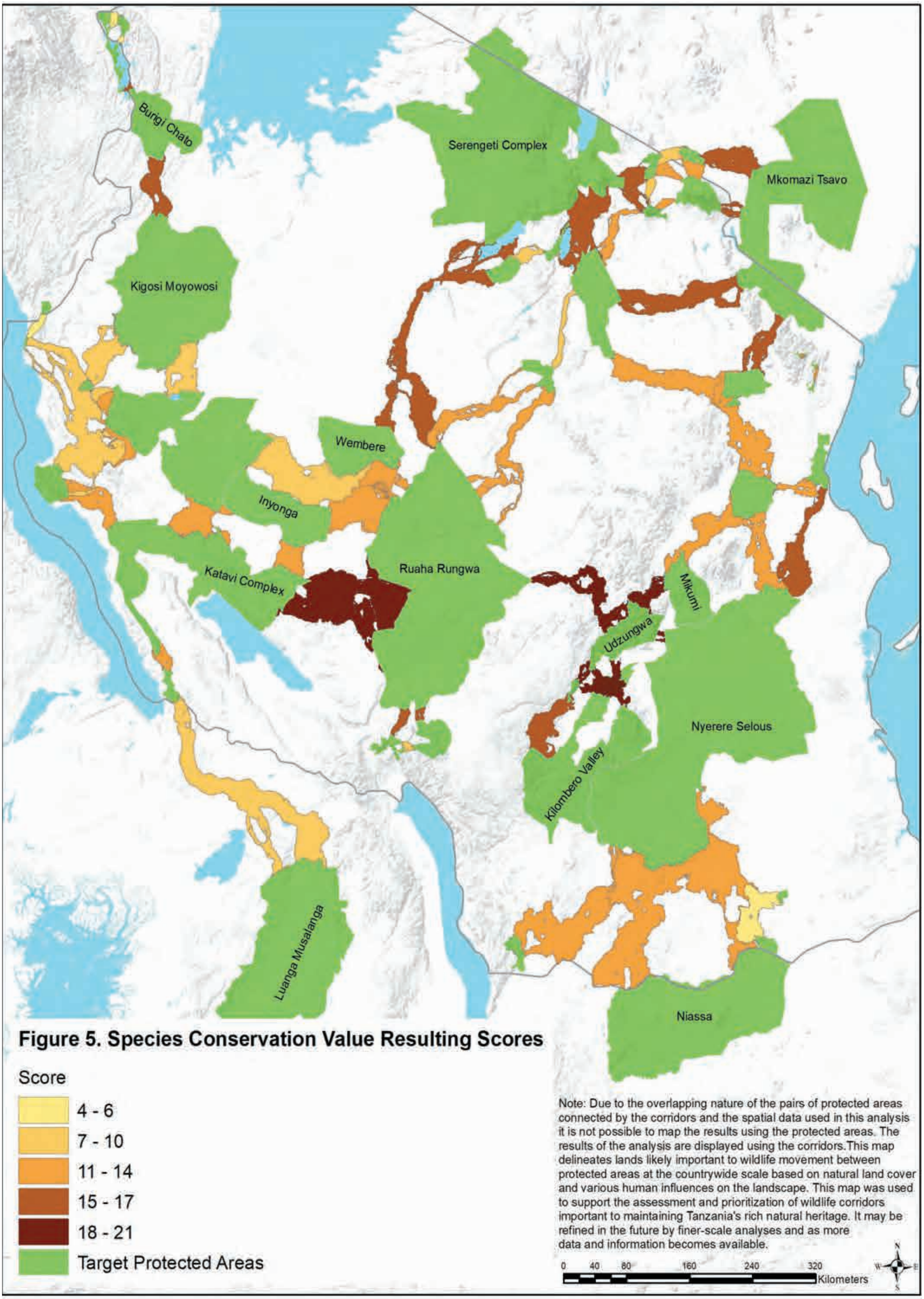


Figure 5. Species Conservation Value Resulting Scores

3.3.2 Globally Important Biodiversity Hotspots and Outstanding Ecoregions in the Pair of Protected Areas Connected by the Corridor

One efficient approach to conserving biodiversity, in Tanzania and around the world, is to focus on biodiversity "hotspots" – areas with especially high species richness and endemism, where conservation success can have an enormous impact in securing biodiversity at national and global levels. According to Conservation International (Hoffman et al. 2016) and the World Wildlife Fund's Conservation Science Program (Olson and Dinerstein 2002), Tanzania has several globally important biodiversity hotspots and outstanding ecoregions, primarily located in the Eastern Arc Mountains and Southern Highlands, coastal forests, western landscapes adjacent to Lake Tanganyika, and in northern Tanzania near Serengeti National Park, Ngorongoro Conservation Area, Tarangire National Park, and other prominent protected areas.

Assessment Approach: The assessment team identified globally important biodiversity hotspots in Tanzania and surrounding countries that are spatially delineated by Conservation International, including Coastal Forests of Eastern Africa and Eastern Afromontane (Hoffman et al. 2016), and six of the globally outstanding ecoregions that are spatially delineated by World Wildlife Fund, i.e., Eastern Arc Montane Forests, Zambian Flooded Savannas, East African Moorlands, Southern Rift Montane Woodlands, Albertine Rift Montane Forests, and East African Mangroves (Olson and Dinerstein 2002). Next, the team intersected these hotspots and ecoregions with a map of the protected areas that are connected by each corridor to determine how much of each pair of protected areas (in hectares) overlaps with one or more biodiversity hotspots or outstanding ecoregions. The team then identified natural breaks in the data to assign each pair of protected areas to one of five classes, with a maximum of 10 possible points for this criterion.

Point scores:
10 = 612,468.812501 – 1,257,831.625000 hectares of overlap
8 = 388,006.281251 – 612,468.812500 hectares of overlap
6 = 197,340.125001 – 388,006.281250 hectares of overlap
4 = 68,007.429689 – 197,340.125000 hectares of overlap
2 = 4,572.862305 – 68,007.429688 hectares of overlap

Results: Tanzania has several globally important biodiversity hotspots and outstanding ecoregions (Figure 6). In fact, 87% (53/61) of the pairs of protected areas have at least some areas of overlap with biodiversity hotspots or outstanding ecoregions (Table 5). Within these Pairs of Protected Areas, the area covered by globally important biodiversity hotspots and outstanding ecoregions ranges from 4,573 to 1,257,830 hectares with an average of 305,767 hectares. The Kigosi-Moyowosi – Ugalla Complex protected areas captured the largest area of biodiversity hotspots and ecoregions, roughly 33% of their total area. The Nyerere Selous – Udzungwa also encompassed over a million hectares of biodiversity hotspots and ecoregions. The entire area of three of the smallest pairs of protected areas, Amani - Nilo, Baga – Kisima Gonja, and Kilimanjaro – Arusha are 100% covered by biodiversity hotspots or outstanding ecoregions, while 96% of Mahale Mountains – Gombe Stream protected areas are hotspots. Overall, the target protected areas capture 4,276,164 hectares of globally important hotspots and ecoregions (Figure 6).

While not a part of this analysis, it is important to note that the wildlife corridor network encompasses an additional 1,952,120 hectares of globally important biodiversity hotspots or outstanding ecoregions across 36/61 of the corridors.

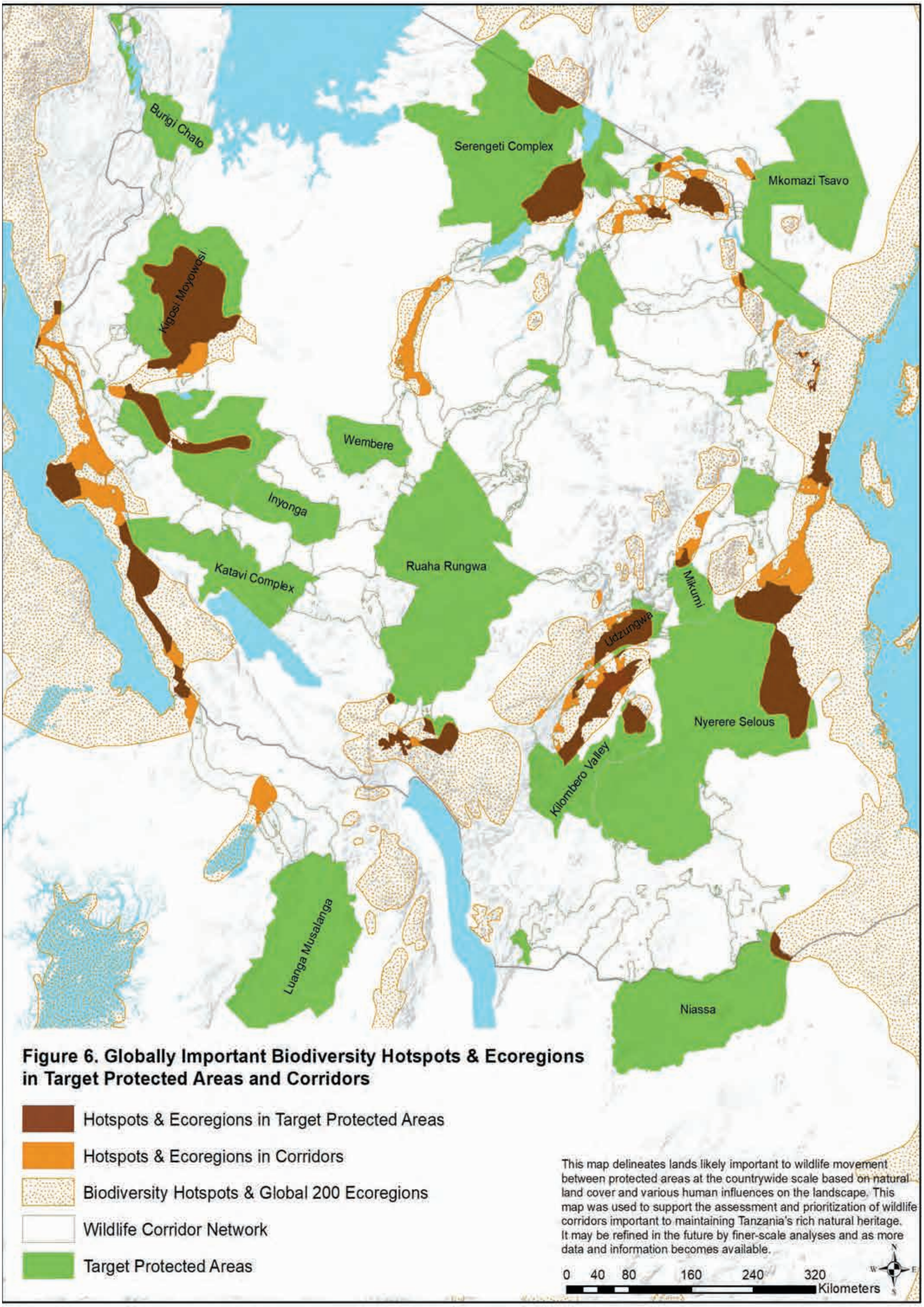


Figure 6. Globally Important Biodiversity Hotspots & Ecoregions in Target Protected Areas and Corridors

Table 5. Summary results of biodiversity hotspots and outstanding ecoregions within pairs of protected areas connected by the corridors and the resulting scores for this criterion

Pairs of Protected Areas Assessed	Hotspot & Ecoregion in Protected Area Pair (hectares)	Total Area of Pair (hectares)	% of Pair	Hotspot Score
Amani - Nilo	15,085	15,085 15,085 2,418,299	100%	2
Amboseli - Mkomazi Tsavo (Kenya)	11,454	2,418,299	0%	2
Arusha - Longido	38,721	78,570	49%	2
Baga - Kisima Gonja	4,797	4,797	100%	2
Gombe Stream - Mukungu Rukamabasi (Burundi)	18,153	24,171	75%	2
Gombe Stream - Uvinza	4,573	22,292	21%	2
Katavi Complex - Inyonga	280,979	2,201,331	13%	6
Katavi Complex – Loazi Lungu	330,371	1,599,132	21%	6
Katavi Complex - Ugalla Complex	559,528	3,277,790	17%	8
Kigosi Moyowosi - Burigi Chato	979,610	2,550,806	38%	10
Kigosi Moyowosi - Ugalla Complex	1,257,830	3,807,440	33%	10
Kigosi Moyowosi - Uvinza	976,137	2,095,875	47%	10
Kilimanjaro - Amboseli (Kenya)	166,054	205,042	81%	4
Kilimanjaro - Arusha	197,340	197,781	100%	6
Kilimanjaro - Longido	173,489	212,897	81%	4
Kilimanjaro - Mkomazi Tsavo (Kenya)	177,498	2,545,364	7%	4
Kilombero - Udzungwa	612,469	1,689,123	36%	10
Kilombero - Uzungwa Scarp	388,006	1,367,021	28%	8
Kitulo Rungwe - Mpanga Kipengere	173,317	220,530	79%	4
Loazi - Luanga Musalangu (Zambia)	49,064	2,286,962	2%	2
Longido - Amboseli (Kenya)	7,435	85,831	9%	2
Mahale Mountains - Gombe Stream	162,187	168,690	96%	4
Mahale Mountains - Katavi Complex	438,740	1,712,623	26%	8
Mahale Mountains - Ugalla Complex	435,655	1,890,893	23%	8
Msanjesi - Lukwika Lumesule	18,386	56,541	33%	2
Mkomazi Tsavo - Handeni	11,454	2,554,270	0%	2
Mikumi - Wami Mbiki	24,039	600,487	4%	2
Nyerere Selous - Liparamba	776,133	4,950,715	16%	10
Nyerere Selous - Niassa (Mozambique)	797,678	7,166,290	11%	10
Nyerere Selous - Saadani	884,906	5,007,925	18%	10
Nyerere Selous - Udzungwa	1,018,000	5,233,013	19%	10
Nyerere Selous - Wami Mbiki	776,133	5,141,417	15%	10
Ruaha Rungwa - Inyonga	9,661	4,400,341	0%	2
Ruaha Rungwa - Katavi Complex	290,967	5,298,530	5%	6
Ruaha Rungwa - Kitulo Rungwe	68,007	3,807,121	2%	4
Ruaha Rungwa - Mpanga Kipengere	124,631	3,910,949	3%	4
Ruaha Rungwa - Swaga Swaga	9,661	3,837,639	0%	2
Ruaha Rungwa - Udzungwa	251,523	4,091,553	6%	6
Ruaha Rungwa - Wembere	9,661	4,292,587	0%	2
Ruaha Rungwa - Yaeda Chini	9,661	3,838,622	0%	2
Serengeti Complex - Arusha	546,711	3,771,967	14%	8
Serengeti Complex - Lake Manyara	515,462	3,779,654	14%	8
Serengeti Complex - Longido	523,060	3,787,083	14%	8
Serengeti Complex – Tarangire Complex	515,462	4,176,493	12%	8

Pairs of Protected Areas Assessed	Hotspot & Ecoregion in Protected Area Pair (hectares)	Total Area of Pair (hectares)	% of Pair	Hotspot Score
Serengeti Complex - Wembere	515,002	4,284,057	12%	8
Serengeti Complex - Yaeda Chini	515,002	3,830,092	13%	8
Tarangire Complex - Arusha	31,249	467,980	7%	2
Tarangire Complex - Mkomazi Tsavo (Kenya)	11,454	2,815,563	0%	2
Udzungwa - Mikumi	265,901	692,083	38%	6
Udzungwa - Uzungwa Scarp	259,262	363,464	71%	6
Ugalla Complex - Uvinza	278,221	1,744,495	16%	6
Ugalla Complex - Wembere	278,221	2,271,847	12%	6
Wami Mbiki - Saadani	108,773	368,882	29%	4

3.3.3 Size of Protected Areas Connected by the Corridor

According to general principles of conservation science, large habitat areas tend to have more species than small ones because large areas typically contain a greater diversity of habitat types and microclimates (MacArthur and Wilson 1967, Tessel et al. 2016). Large protected areas also provide more interior habitat and buffer against edge effects (Brashares et al. 2011); this is vital for fragmentation-sensitive species that require intact high-quality habitat. Large habitat areas are especially important for wide-ranging species such as elephants and African wild dogs (Ngene et al. 2017, O'Neill et al. 2020). However, most individual protected areas in Tanzania are not big enough on their own to support wide-ranging species over the long-term; dispersal corridors between protected areas are therefore essential for healthy populations of wide-ranging species to persist (Epps et al. 2013, O'Neill et al. 2020).

Assessment Approach: The assessment team first calculated the size of each protected area or protected area complex (e.g., Serengeti Complex) and classified it as either "large," "medium," or "small," as described in detail below. The size classes are derived from the various sizes of Tanzania's national parks and game reserves as well as information taken from scientific literature describing home range sizes for some of the wildlife species considered nationally significant in Tanzania.

Large = habitat areas $\geq$ 12,000 km^2 (1,200,000 hectares). For example, large habitat areas have the potential to support healthy populations of species with large home ranges such as cheetah (300,000 hectares), African wild dog (80,000 hectares) (Foley et al. 2014), and elephant (334,000 hectares) (Ngene et al. 2016). The largest target protected area in the assessment area is made up of Nyerere National Park and the Selous Game Reserve (4,890,230 hectares). Other examples of large habitat areas are Ruaha Rungwa (3,748,770 hectares) and the Katavi Complex (1,549,760 hectares).

Medium = habitat areas $\geq$ 2,000 km^2 (200,000 hectares) < 12,000 km^2 (1,200,000 hectares). For example, medium habitat areas have the potential to support a small population of lions (between approximately 10 and 25 prides) based on a home range size estimate of 225 km^2 or 22,500 hectares (Foley et al. 2014) but require connectivity among subpopulations to persist. Examples of medium-sized habitat areas are Udzungwa Mountains National Park (342,783 hectares) and Wembere Game Reserve (543,817 hectares).

Small = habitat areas < 2,000 km^2 (200,000 hectares). For example, small habitat areas such as Mahale National Park (162,863 hectares) are likely to support a population of chimpanzees based on a home range size estimate of 50 km^2 (5,000 hectares) (Foley et al. 2014), but a chimpanzee population in Gombe Stream National Park (5,827 hectares of which 3,572 hectares is on land) is unlikely to persist over the long term without connections to larger habitat areas.

Next, the corridor assessment team grouped each pair of protected areas that are connected by corridors into categories — Large-Large, Large-Medium, Medium-Medium, Large-Small, Medium-Small, and Small-Small—and assigned points, with corridors that connect larger protected areas earning more points.

Point scores:
15 = Large-Large
13 = Large-Medium
11 = Medium-Medium
9 = Large-Small
7 = Medium-Small
5 = Small-Small

Results: The target protected areas connected by the corridors together cover a total of 30,603,950 hectares. This includes several protected areas in surrounding countries that are linked by transboundary corridors to protected areas in Tanzania including Amboseli and Tsavo in Kenya, Akagera in Rwanda, Mukungu Rukamabasi in Burundi, Luanga Musalanga in Zambia, and Niassa in Mozambique.

The 44 target protected areas connected by the wildlife corridors range in size from the 1,585-hectare Baga Reserve to the 4,890,230-hectare Nyerere National Park and Selous Game Reserve (Table 6 and Figure 7). The majority of the target protected areas (27/44) are included in the Small category (< 200,000 hectares), seven in the Medium category (≥ 200,000 hectares < 1,200,000 hectares), and ten in the Large category (> 1,200,000 hectares). Thus, it is not surprising that 70% (43/61) of the wildlife corridors are associated with protected areas in the Small category, including 25% (15/61) linking Small-Small, 13% (8/61) Medium-Small, and 33% (20/61) Large-Small. Overall, 57% (35/61) of the corridors are associated with Large protected areas, including the Large-Small mentioned above, 18% (11/61) Large-Medium, and 7% (4/61) Large-Large.

Table 6. Summary of size class categories of pairs of protected areas connected by the corridors and the resulting scores for this criterion

Pairs of Protected Areas Assessed	Size Class 1 (hectares)	Size Class 2 (hectares)	Size Categories	Score
Msanjesi - Lukwika Lumesule	14,173	42,367	Small - Small	5
Gombe Stream - Mukungu Rukamabasi (Burundi)	5,827	18,345	Small - Small	5
Kitulo Rungwe - Mpanga Kipengere	58,351	162,179	Small - Small	5
Lake Manyara - Yaeda Chini	39,414	89,852	Small - Small	5
Mahale Mountains - Gombe Stream	162,863	5,827 5,827	Small - Small	5
Ibanda - Rumanyika Karagwe	29,866	24,554	Small - Small	5
Akagera (Rwanda) - Rumanyika Karagwe	102,091	24,554	Small - Small	5
Longido - Amboseli (Kenya)	46,843	38,989	Small - Small	5
Kilimanjaro - Amboseli (Kenya)	166,054	38,989	Small - Small	5
Arusha - Longido	31,727	46,843	Small - Small	5
Kilimanjaro - Arusha	166,054	31,727	Small - Small	5
Kilimanjaro - Longido	166,054	46,843	Small - Small	5
Gombe Stream - Uvinza	5,827	16,465	Small - Small	5
Baga - Kisima Gonja	1,585	3,212	Small - Small	5
Amani - Nilo	9,151	5,933	Small - Small	5
Wami Mbiki - Handeni	251,187	174,960	Medium - Small	7
Tarangire Complex - Handeni	436,253	174,960	Medium - Small	7
Tarangire Complex - Swaga Swaga	436,253	88,869	Medium - Small	7
Tarangire Complex - Lake Manyara	436,253	39,414	Medium - Small	7
Tarangire Complex - Arusha	436,253	31,727	Medium - Small	7
Udzungwa - Uzungwa Scarp	342,783	20,681	Medium - Small	7
Wami Mbiki - Saadani	251,187	117,695	Medium - Small	7
Burigi Chato - Akagera (Rwanda)	471,396	102,091	Medium - Small	7
Ugalla Complex - Uvinza	1,728,030	16,465	Large - Small	9

Pairs of Protected Areas Assessed	Size Class 1 (hectares)	Size Class 2 (hectares)	Size Categories	Score
Nyerere Selous - Liparamba	4,890,230	60,485	Large - Small	9
Amboseli - Mkomazi Tsavo (Kenya)	38,989	2,379,310	Large - Small	9
Katavi Complex – Loazi Lungu	1,549,760	49,372	Large - Small	9
Kigosi Moyowosi - Uvinza	2,079,410	16,465	Large - Small	9
Kilimanjaro - Mkomazi Tsavo (Kenya)	166,054	2,379,310	Large - Small	9
Loazi - Luanga Musalangu (Zambia)	49,372	2,237,590	Large - Small	9
Mahale Mountains - Katavi Complex	162,863	1,549,760	Large - Small	9
Mahale Mountains - Ugalla Complex	162,863	1,728,030	Large - Small	9
Mkomazi Tsavo (Kenya) - Handeni	2,379,310	174,960	Large - Small	9
Nyerere Selous - Saadani	4,890,230	117,695	Large - Small	9
Ruaha Rungwa - Kitulo Rungwe	3,748,770	58,351	Large - Small	9
Ruaha Rungwa - Swaga Swaga	3,748,770	88,869	Large - Small	9
Ruaha Rungwa - Mpanga Kipengere	3,748,770	162,179	Large - Small	9
Ruaha Rungwa - Yaeda Chini	3,748,770	89,852	Large - Small	9
Serengeti Complex - Longido	3,740,240	46,843	Large - Small	9
Serengeti Complex - Arusha	3,740,240	31,727	Large - Small	9
Serengeti Complex - Lake Manyara	3,740,240	39,414	Large - Small	9
Kilombero - Uzungwa Scarp	1,346,340	20,681	Large - Small	9
Serengeti Complex - Yaeda Chini	3,740,240	89,852	Large - Small	9
Mikumi - Wami Mbiki	349,300	251,187	Medium - Medium	11
Udzungwa - Mikumi	342,783	349,300	Medium - Medium	11
Kigosi Moyowosi - Burigi Chato	2,079,410	471,396	Large - Medium	13
Kilombero - Udzungwa	1,346,340	342,783	Large - Medium	13
Nyerere Selous - Udzungwa	4,890,230	342,783	Large - Medium	13
Nyerere Selous - Wami Mbiki	4,890,230	251,187	Large - Medium	13
Ruaha Rungwa - Inyonga	3,748,770	651,571	Large - Medium	13
Ruaha Rungwa - Udzungwa	3,748,770	342,783	Large - Medium	13
Ruaha Rungwa - Wembere	3,748,770	543,817	Large - Medium	13
Serengeti Complex - Tarangire Complex	3,740,240	436,253	Large - Medium	13
Serengeti Complex - Wembere	3,740,240	543,817	Large - Medium	13
Tarangire Complex - Mkomazi Tsavo (Kenya)	436,253	2,379,310	Large - Medium	13
Ugalla Complex - Wembere	1,728,030	543,817	Large - Medium	13
Katavi Complex - Inyonga	1,549,760	651,571	Large - Medium	13
Katavi-Complex - Ugalla Complex	1,549,760	1,728,030	Large - Large	15
Kigosi Moyowosi - Ugalla Complex	2,079,410	1,728,030	Large - Large	15
Nyerere Selous - Niassa (Mozambique)	4,890,230	2,276,060	Large - Large	15
Ruaha Rungwa - Katavi Complex	3,748,770	1,549,760	Large - Large	15

Note: Size Class 1 and 2 order follow the name of the pairs of protected areas in column one rather than the size categories in column four.

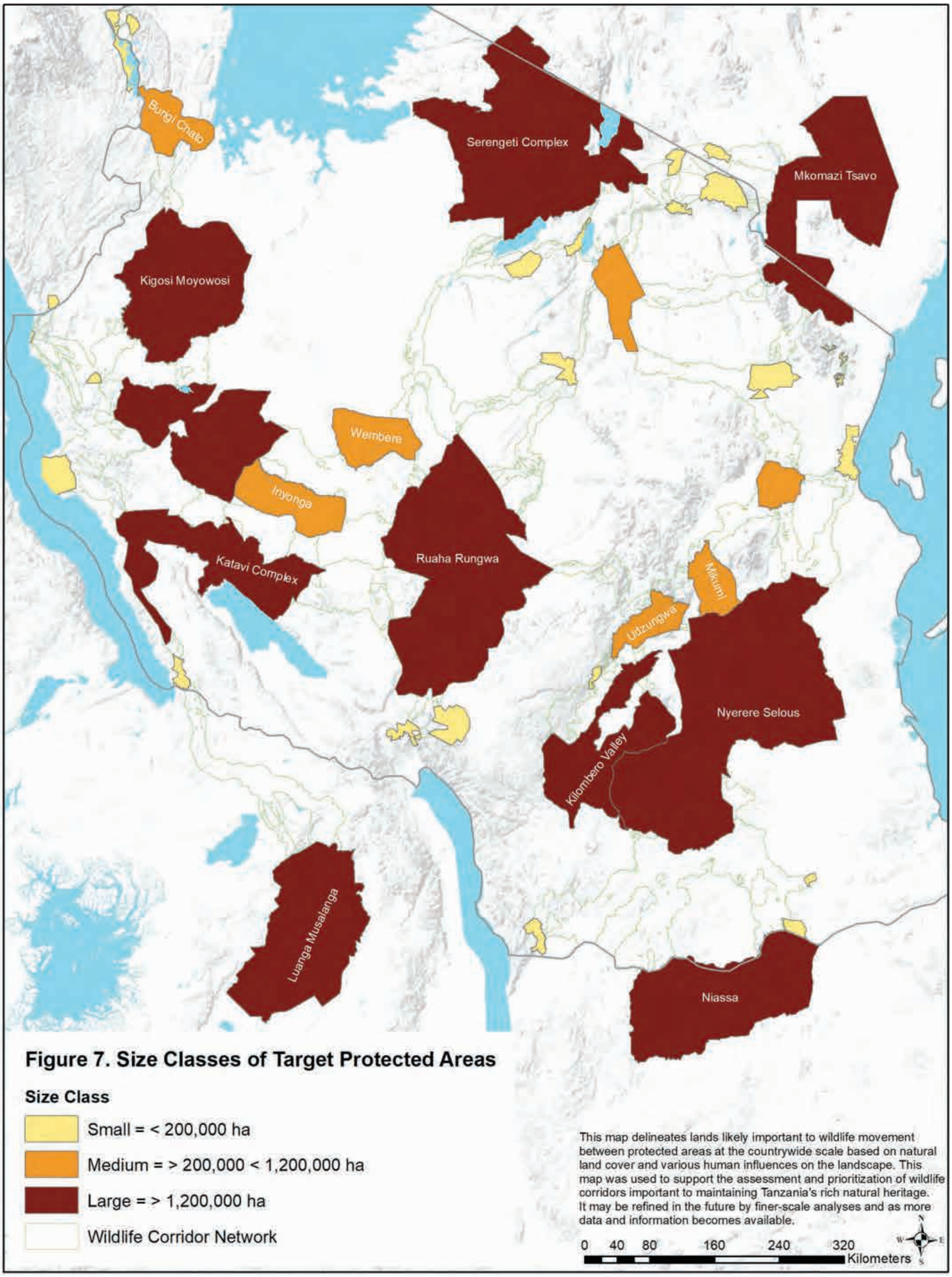


Figure 7. Size Classes of Target Protected Areas

3.3.4 Habitat Quality in the Corridor

Corridors that provide live-in and move-through habitat for wildlife are more likely to maintain ecological integrity and facilitate wildlife movements over time.

Assessment Approach: Using Copernicus Global Land Service 100 m data for agriculture and urban land cover in Africa for 2018 (Buchhorn et al. 2019; https://africa.lcviewer.vito.be/download), the assessment team updated a "potential vegetation map of eastern Africa" developed by van Breugel et al (2015b) (http://vegetationmap4africa.org/Data.html) to account for habitat conversion to agriculture, settlements, and other developed areas. The team then calculated the area and proportion (%) of natural land cover, including water bodies, for each corridor and identified natural breaks in the data to assign each corridor to one of three classes using the following definitions:

Landscape Connectivity / High Quality Habitat = The corridor contains extensive natural land cover/water (≥82%) that wildlife can use as live-in and move-through habitat between protected areas.

Constrained Corridor / Impacted Habitat = The corridor contains moderate natural land cover/water (≥44% but < 82%) that wildlife can use as live-in and move-through habitat between protected areas but also may have areas that are impacted to varying degrees by human use.

Severely Impacted Habitat = The corridor is highly impacted by human use (< 44% natural land cover/water), crisscrossed by roads, railways and other infrastructure, unplanned settlements, logging/charcoal burning, agriculture, mining etc. Although the corridor might be an important historical route for wildlife migration or dispersal, it likely provides only limited connectivity in its current state.

Point scores:
20 = Landscape Connectivity/High Quality Habitat ≥ 82% natural land cover/water
13 = Constrained Corridor/Impacted Habitat ≥ 44% but < 82% natural land cover/water
5 = Missing Link/Severely Impacted Habitat < 44% natural land cover/water

Results: The assessment team updated the *Potential Natural Vegetation of East Africa* by van Bruegel et al. (2015b) to address habitat conversion using urban and agricultural land cover from 2018, which is estimated to be 80% accurate (Buchhorn et al. 2019). Of the 11,553,300 net hectares in the wildlife corridor network, roughly 8% (910,893 ha) was identified as being converted to agriculture and less than 1% (45,627 ha) as being converted to settlement (Figure 8). The percent natural vegetation in the corridors ranged greatly from 4 to 99.995% (Table 7) with an average of 85% natural landcover (SD 18.96). An astounding 56% (34/61) of the corridors have greater than 90% natural land cover. This is due in part to the sheer size of many of the corridors. For example, the Nyerere Selous – Niassa was identified as being 99% natural vegetation, even with over 15,000 ha of agriculture and over 1,000 ha of settlement.

Only 12 of the 61 corridors have less than 75% natural land cover/water (Table 7). The corridor delineated for the Nyerere Selous – Udzungwa was identified as having just 4% natural landcover but the modeled corridor is much broader than what is being implemented on-the-ground. The Ruaha Rungwa – Mpanga Kipengere delineated corridor has just 20% natural land cover. About half of the Baga – Kisima Gonja, Kilimanjaro – Mkomazi Tsavo, and the Tarangire – Swaga Swaga delineated corridors have been converted to agriculture or settlement.

Figure 8. Vegetation & Land Cover Analysis Extent (van Bruegel et al. 2015b, Buchhorn et al. 2019)
See legend next page. Fine-scale vegetation maps and tables are available for each corridor in Appendix D

Legend for Figure 8 Vegetation & Land Cover

- Acacia-Commiphora deciduous wooded grassland
- Afromontane dry transitional forest
- Afromontane forest - grasslands mosaic
- Afromontane rain forest
- Afromontane undifferentiated forest
- Agriculture/Crops
- Bush groups, typically around termitaria, within grassy drainage zones
- Catena of Acacia-Commiphora & Combretum wooded grassland, edaphic grassland seasonally flooded soils
- Catena of North Zambezian Undifferentiated woodland and edaphic grassland on drainage-impeded or seasonally flooded soils
- Coastal mosaic
- Drier miombo woodland
- Dry combretum wooded grassland
- Edaphic grassland on drainage-impeded, seasonally flooded soils or freshwater swamp
- Edaphic grassland on volcanic soils
- Evergreen and semi-evergreen bushland and thicket
- Halophytic vegetation
- Itigi thicket
- Miombo woodland on hills and rocky outcrops
- Montane Ericaceous belt
- Mopane woodland and scrub woodland
- North Zambezian undifferentiated woodland
- Riverine wooded vegetation
- Settlement/Development
- Somalia-Masai Acacia-Commiphora deciduous bushland and thicket
- Swamp forest or riverine wooded vegetation
- Transitional zone of drier miombo woodland and North Zambezian Undifferentiated woodland
- Transitional zone of drier miombo woodland and Somalia-Masai Acacia-Commiphora deciduous bushland and thicket
- Water bodies
- Wetter miombo woodland
- Zambezian chipya woodland
- Zambezian dry deciduous forest and scrub forest
- Zanzibar-Inhambane lowland rain forest
- Zanzibar-Inhambane transitional rain forest
- Target Protected Areas

Table 7. Summary of Quality of Habitat in the Wildlife Corridors assessment and resulting scores for this criterion

Wildlife Corridor Assessed	Corridor Area (hectares)	% Natural	% Converted	Agriculture (hectares)	Settlement (hectares)	Habitat Quality Score
Akagera (Rwanda) - Rumanyika Karagwe	5598	75	25	1398	0	13
Amani - Nilo	5743	91	9	529	0	20
Amboseli - Mkomazi Tsavo (Kenya)	177612	96.5	3.5	6128	118	20
Arusha - Longido	29945	92.5	7.5	1962	284	20
Baga - Kisima Gonja	2273	44	56	1273	1	5
Burigi Chato - Akagera (Rwanda)	6176	89	11	672	0	20
Gombe Stream - Mukungu Rukamabasi (Burundi)	31643	68	32	8354	1894	13
Gombe Stream - Uvinza	86126	93	7	4636	1537	20
Ibanda - Rumanyika Karagwe	18212	82	18	3228	23	20
Katavi Complex - Inyonga	103350	99.995	0.005	5	0	20
Katavi Complex - Loazi Lungu	41029	96.5	3.5	1428	13	20
Katavi Complex - Ugalla Complex	200931	99.4	0.6	1180	28	20
Kigosi Moyowosi - Burigi Chato	141506	81.4	18.6	25496	783	13
Kigosi Moyowosi - Ugalla Complex	183555	78.7	21	39047	599	13
Kigosi Moyowosi - Uvinza	195089	92.7	7.3	13052	614	20
Kilimanjaro - Amboseli (Kenya)	44707	86.7	13.3	5603	166	20
Kilimanjaro - Arusha	19102	64	36	6247	503	13
Kilimanjaro - Longido	45453	93.6	6.4	2590	160	20
Kilimanjaro - Mkomazi Tsavo (Kenya)	32365	44	56	17767	389	5
Kilombero - Udzungwa	141921	73.8	26.2	37392	292	13
Kilombero - Uzungwa Scarp	188479	97	3	5214	48	20
Kitulo Rungwe - Mpanga Kipengere	13320	86	14	1725	184	20
Lake Manyara - Yaeda Chini	46165	68	32	14846	40	13
Loazi - Luanga Musalangu (Zambia)	823585	96	4	24218	9262	20
Longido - Amboseli (Kenya)	43316	98	2	784	10	20
Mahale Mountains - Gombe Stream	681381	95	5	29759	4678	20
Mahale Mountains - Katavi Complex	177213	99.5	0.5	914	40	20
Mahale Mountains - Ugalla Complex	442172	95.7	4.3	19040	1401	20
Mikumi - Wami Mbiki	219186	94.8	5.2	10548	533	20
Mkomazi Tsavo - Handeni	129355	92	7.7	8445	947	20
Msanjesi - Lukwika Lumesule	195189	95.8	4.2	6902	336	20
Nyerere Selous - Liparamba	1030050	98	2.1	16950	1497	20
Nyerere Selous - Niassa (Mozambique)	1659850	99	1	15774	1045	20
Nyerere Selous - Saadani	296910	95.5	0.5	1042	409	20
Nyerere Selous - Udzungwa	8870	4	96	7548	940	5
Nyerere Selous - Wami Mbiki	215890	98	2	3708	183	20
Ruaha Rungwa - Inyonga	311036	97	3	10411	343	20
Ruaha Rungwa - Katavi Complex	814075	99	1.1	7966	1034	20

Wildlife Corridor Assessed	Corridor Area (hectares)	% Natural	% Converted	Agriculture (hectares)	Settlement (hectares)	Habitat Quality Score
Ruaha Rungwa - Kitulo Rungwe	34409	62	38	12478	541	13
Ruaha Rungwa - Mpanga Kipengere	14705	20	80	11045	679	5
Ruaha Rungwa - Swaga Swaga	462120	74	26	115599	3423	13
Ruaha Rungwa - Udzungwa	244725	89	10.75	24608	1626	20
Ruaha Rungwa - Wembere	238844	94	6.2	13981	512	20
Ruaha Rungwa - Yaeda Chini	479767	76	23.7	108852	3138	13
Serengeti Complex - Arusha	67075	93	6.9	4295	614	20
Serengeti Complex - Lake Manyara	121814	91	9	10334	1375	20
Serengeti Complex - Longido	70591	99	1	741	159	20
Serengeti Complex - Tarangire Complex	291830	86.2	13.8	37786	2525	20
Serengeti Complex - Wembere	341207	80	19.5	66316	1583	13
Serengeti Complex - Yaeda Chini	60226	97	3.4	2023	243	20
Tarangire Complex - Arusha	90363	72	27.6	24697	565	13
Tarangire Complex - Handeni	367506	88	12	44746	400	20
Tarangire Complex - Lake Manyara	55575	82	18	9614	556	20
Tarangire Complex - Mkomazi Tsavo (Kenya)	360898	77	23	83098	1189	13
Tarangire Complex - Swaga Swaga	65180	53	47	29213	1001	13
Udzungwa - Mikumi	85292	97.5	2.5	1942	399	20
Udzungwa - Uzungwa Scarp	24213	86	14	3300	4	20
Ugalla Complex - Uvinza	63391	99.6	0.4	5	244	20
Ugalla Complex - Wembere	549850	99	1	3169	25	20
Wami Mbiki - Handeni	328804	94	6	20569	330	20
Wami Mbiki - Saadani	59385	98	2	882	129	20

There are 30 different natural land cover types in the delineated wildlife corridor network (van Brugel et al. 2015b; Figure 8 and Table 8). Vegetation maps and tables are provided for each of the 61 corridors in Appendix D. Drier miombo woodland covers much of the corridors south of the Selous, between Katavi, Ruaha and Wembere, and up through the Wami Mbiki to Handeni corridor. Wetter miombo woodland covers much of the corridors in Western Tanzania and much of the Loazi to Luanga Musalanga transboundary corridor down into Zambia. The Catena of North Zambezian woodland and seasonally flooded grasslands are the major vegetation type in the corridors between Serengeti, Tarangire and Amboseli, while the Somalia-Masai Acacia Commiphora bushland and thicket is the prominent cover in the corridors between the Tarangire Complex and Mkomazi Tsavo and Handeni.

Table 8. Potential Natural Vegetation in the Wildlife Corridors updated to address habitat converted to settlement and agriculture. Data Source: (van Bruegel et al. 2015b, Buchhorn et al. 2019)

Potential Natural Vegetation and Land Cover Type	Hectares
Drier miombo woodland	3,532,010
Wetter miombo woodland	1,703,630
Catena of North Zambezian woodland and edaphic grassland, seasonally flooded	1,483,850
Somalia-Masai Acacia-Commiphora deciduous bushland and thicket	1,016,100
Agriculture/Crops	910,893
Edaphic grassland on drainage-impeded, seasonally flooded soils or freshwater swamp	801,609
Catena of Acacia-Commiphora & Combretum wooded grassland, seasonally flooded soils	483,112
Coastal mosaic	396,623
Edaphic grassland on volcanic soils	239,870
Transitional zone of drier miombo woodland and North Zambezian Undifferentiated woodland	181,366
Bush groups, typically around termitaria, within grassy drainage zones	155,915
Itigi thicket	121,227
Evergreen and semi-evergreen bushland and thicket	68,239
Drier miombo woodland and Somalia-Masai Acacia-Commiphora deciduous bushland and thicket	67,425
Halophytic vegetation	65,521
Settlement/Development	45,627
Dry combretum wooded grassland	44,472
Acacia-Commiphora deciduous wooded grassland	42,212
Afromontane rain forest	37,979
North Zambezian undifferentiated woodland	35,639
Riverine wooded vegetation	30,867
Afromontane undifferentiated forest	29,179
Zambezian chipya woodland	12,206
Afromontane forest - grasslands mosaic	11,316
Zanzibar-Inhambane lowland rain forest	10,208
Afromontane dry transitional forest	7,660
Mopane woodland and scrub woodland	4,489
Zanzibar-Inhambane transitional rain forest	3,942
Swamp forest or riverine wooded vegetation	3,661
Zambezian dry deciduous forest and scrub forest	2,253
Water bodies	223
Miombo woodland on hills and rocky outcrops	93

3.3.5 Corridor Importance to Facilitate Wildlife Movements Driven by Climate Change

Climate change is causing species range shifts in ecosystems around the world, including in Tanzania. As climate conditions such as temperature and precipitation patterns change, the distribution of plant communities will change, and wildlife will need to move to new areas to find suitable habitat. Maintaining and restoring wildlife corridors is one of the most important adaptation strategies to facilitate wildlife movements and conserve biodiversity during climate change (Heller and Zavaleta 2009).

Large protected areas that have high topographic diversity are likely to be important climate refugia in the future for wildlife undergoing climate-driven range shifts (Haight and Hammill 2020). In addition, biodiversity hotspots can serve as climate refugia because they often occur where historic climate changes have been relatively mild and where both topographic diversity and elevational gradients are high (Harrison and Noss 2017). Protecting land along broad elevational gradients may be particularly important for sustaining biodiversity during climate change (Lawler et al. 2015, Elsen et al. 2018). Large protected areas also provide valuable room for wildlife to move in response to climate-change driven extreme weather events.

Assessment Approach: The assessment team analyzed corridors and the protected areas they connect based on weighted combinations of many factors (Diagram 1) to quantify the relative value of each corridor to accommodate species movements driven by climate change. All inputs to the analysis were standardized to a consistent scale from 0 to 100.

The first part of the analysis focused on the protected areas. Using the three factors at the bottom of Diagram 1—potential to serve as a climate refuge, size, and ecological integrity—the assessment team first quantified the relative value of each protected area, as follows:

Potential to serve as a climate refuge: The team used the global biodiversity hotspots (Hoffman et al. 2016) and Global 200 outstanding ecoregions (Olson and Dinerstein 2002) described above as proxy indicators for climate refugia, i.e., protected areas that contain biodiversity hotspots or outstanding ecoregions are considered to have higher potential to serve as climate refugia. The team intersected a map of the biodiversity hotspots and outstanding ecoregions with a map of the protected areas and calculated the area of climate refugia in each protected area (in hectares). The range of areas were then classified into ten size classes using natural breaks, with the largest climate refugia areas having the highest value (100) and protected areas with no refugia having the lowest value (0).

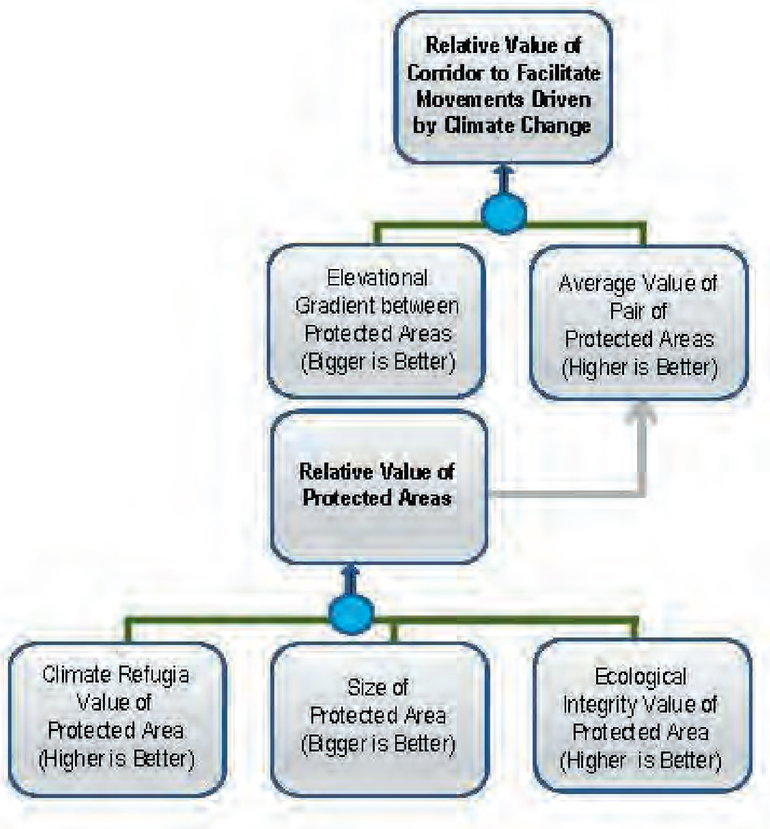


Diagram 1

Size: The team classified the size of all protected areas into ten size classes, again using natural breaks in the dataset, with the largest size class having the highest value (100) and the smallest size class having the lowest value (0).

Ecological Integrity: The team calculated the average ecological integrity value of each protected area using the inverse of van Breugel et al.'s Human Influence Index (2015a). Protected areas with more human influence from things such as development and roads have lower values (0 = very low integrity) and protected areas with no human influence have higher values (100 = very high integrity).

Using the calculated values for these three factors, the assessment team next calculated a single value for each protected area based on a weighted average of the factors, according to the following formula:

(Climate Refugia * .50) + (Size * .25) + (Ecological Integrity * .25) = Relative value of Protected Area

Finally, the assessment team calculated the average value of each pair of protected areas connected by a corridor and combined those average values with another higher-level factor—the elevational gradient between each pair of protected areas. As noted above, corridors linking protected areas that span greater elevational ranges are expected to better facilitate species range shifts. To calculate the elevational gradient, the team plotted elevation versus distance along the least cost path of each corridor, and from the end of the least cost path to the highest elevation in each protected area connected by the corridor. The range of elevational gradients was classified into ten classes using natural breaks in the data, with corridors linking protected areas that span greater elevational ranges having more value (greatest range = 100). Each factor was given equal weight as follows:

(Average Value of Pair of Protected Areas * .50) + (Elevational Gradient * .50) = Relative value of each corridor to accommodate species movements driven by climate change, on a scale of 0 to 100, with higher values receiving more points.

Point Scores:
10 = 80-100
8 = 60-80
6 = 40-60
4 = 20-40
2 = 0-20

Results: All the protected areas have relatively high value in terms of ecological integrity with 44% (27/61) having values of 80 or higher for this factor (Table 9a). Several of the protected areas scored well for the climate refugia factor with two of the protected areas, Nyerere Selous and Kigosi Moyowosi, having the highest values (100). The Serengeti Complex scored 90 for climate refugia, while the Ugalla Complex, Katavi Complex, and the Udzungwa Mountains all had values of 80. Nyerere Selous was identified as having the highest relative value among protected areas (97.5), followed by Kigosi Moyowosi (95), and the Serengeti Complex (90).

Table 9a. Results of the first part of the analysis to assess the protected areas' importance for facilitating movements driven by climate change

Target Protected Area(s)	Protected Area (hectares)	Size of Protected Area	Climate Refugia	Ecological Integrity	Relative value of Protected Area
Baga	1,585	10	10	60	22.5
Kisima Gonja	3,212	10	10	60	22.5
Gombe Stream	5,827	10	20	70	30
Nilo	5,933	10	20	60	27.5
Amani	9,151	10	30	60	32.5
Msanjesi	14,173	20	0	70	22.5
Uvinza	16,465	20	0	80	25
Mukungu Rukamabasi	18,345	20	30	50	32.5
Uzungwa Scarp	20,681	20	40	80	45
Rumanyika Karagwe	24,554	20	0	70	22.5
Ibanda Kyerwa	29,866	30	0	60	22.5
Arusha	31,727	30	50	60	47.5
Amboseli	39,989	30	0	80	27.5
Lake Manyara	39,414	30	0	70	25
Lukwika Lumesule	42,367	30	40	70	45
Longido	46,843	40	20	70	37.5
Loazi Lungu	49,372	40	60	80	60
Kitulo Rungwe	58,351	40	60	70	57.5
Liparamba	60,485	40	0	90	32.5
Swaga Swaga	88,869	50	0	70	30
Yaeda Chini Valley	89,852	50	0	80	32.5
Akagera	102,091	50	0	60	27.5
Saadani	117,695	50	70	80	67.5
Mpanga Kipengere	162,179	60	70	80	70
Mahale Mountains	162,863	60	70	80	70
Kilimanjaro	166,054	60	70	70	67.5
Handeni	174,960	60	0	90	37.5
Wami Mbiki	251,187	60	0	90	37.5
Udzungwa	342,783	70	80	90	80
Mikumi	349,300	70	40	90	60
Tarangire-Mkungunero-Lolkisale Complex	436,253	70	0	80	37.5

Target Protected Area(s)	Protected Area (hectares)	Size of Protected Area	Climate Refugia	Ecological Integrity	Relative value of Protected Area
Burigi Chato	471,396	70	0	90	40
Wembere	543,817	70	0	90	40
Inyonga	651,571	70	0	90	40
Kilombero Valley	1,346,340	80	80	90	82.5
Katavi-Rukwa-Lukwati-Luafi Complex	1,549,760	80	80	90	82.5
Ugalla-Luganzo-Tongwe Complex	1,728,030	80	80	90	82.5
Kigosi Moyowosi	2,079,410	90	100	90	95
Luanga Musalanga	2,237,590	90	0	80	42.5
Niassa	2,276,060	90	40	90	65
Mkomazi Tsavo	2,379,310	90	30	90	60
Serengeti-Ngorongoro-Natron Complex	3,740,240	100	90	80	90
Ruaha Rungwa	3,748,770	100	30	90	62.5
Nyerere Selous	4,890,230	100	100	90	97.5

As noted, the second part of the analysis used the elevation range along the least cost path of each corridor and the two protected areas it connects. Kilimanjaro – Mkomazi Tsavo had the greatest elevational range at 5,612 meters. It is not surprising that all corridors associated with the highest mountain in Africa, Mount Kilimanjaro, have the most extreme elevation ranges (> 4,500 m). Two of the corridors associated with Arusha National Park's Mount Meru, Tarangire Complex – Arusha, and Arusha – Longido, have elevation ranges above 3,000 m. About 75% (46/61) of the corridors have elevational ranges greater than 1,000 meters with 18 of these having ranges greater than 2,000 meters. The elevation range and average value of each pair of protected areas were both given equal weight to calculate the relative value of each corridor to accommodate species movements driven by climate change (Table 9b and Figure 9). Three of the corridors had relative values higher than 80 and received the maximum number of points for this criterion (10), including Kilimanjaro – Mkomazi Tsavo, Nyerere Selous – Udzungwa, and Kilombero Valley – Udzungwa. All of the other corridors associated with Kilimanjaro, Udzungwa and Neyerere Selous received 8 points for this criterion, as did most of the corridors associated with the Ruaha Rungwa, Serengeti Complex, and Arusha target protected areas. The majority of corridors, 59% (36/61), had values over 50.

Table 9b. Summary of corridor importance to facilitate movements driven by climate change and resulting score for this criterion (PA=”protected area”)

Wildlife Corridor Assessed	Relative Value PA1	Relative Value PA2	Average Value PA Pair	Elevation Minimum	Elevation Maximum	Elevation Range	Elevation Value	Relative Value corridor	Climate Change Score
Akagera (Rwanda) - Rumanyika Karagwe	27.5	22.5	25.0	1260	1866	606	10	18	2
Amani - Nilo	32.5	27.5	30.0	230	1384	1154	40	35	4
Amboseli - Mkomazi Tsavo (Kenya)	27.5	60.0	43.8	168	2007	1839	70	57	6
Arusha - Longido	47.5	37.5	42.5	1171	4254	3083	90	66	8
Baga - Kisima Gonja	22.5	22.5	22.5	1208	1944	736	20	21	4
Burigi Chato - Akagera (Rwanda)	40.0	27.5	33.8	1128	1773	645	20	27	4
Gombe Stream - Mukungu Rukamabasi (Burundi)	30.0	32.5	31.3	728	1756	1028	30	31	4
Gombe Stream - Uvinza	30.0	25.0	27.5	728	1482	754	20	24	4

Wildlife Corridor Assessed	Relative Value PA1	Relative Value PA2	Average Value PA Pair	Elevation Minimum	Elevation Maximum	Elevation Range	Elevation Value	Relative Value corridor	Climate Change Score
Ibanda - Rumanyika Karagwe	22.5	22.5	22.5	1260	1866	606	10	16	2
Katavi Complex - Inyonga	82.5	40.0	61.3	798	2001	1203	40	51	6
Katavi Complex - Loazi Lungu	82.5	60.0	71.3	798	2001	1203	40	56	6
Katavi Complex - Ugalla Complex	82.5	82.5	82.5	798	2001	1203	40	61	8
Kigosi Moyowosi - Burigi Chato	95.0	40.0	67.5	1055	1715	660	20	44	6
Kigosi Moyowosi - Ugalla Complex	95.0	82.5	88.8	1044	1691	647	20	54	6
Kigosi Moyowosi - Uvinza	95.0	25.0	60.0	988	1546	558	10	35	4
Kilimanjaro - Amboseli (Kenya)	67.5	27.5	47.5	1124	5780	4656	100	74	8
Kilimanjaro - Arusha	67.5	47.5	57.5	1192	5780	4588	100	79	8
Kilimanjaro - Longido	67.5	37.5	52.5	1134	5780	4646	100	76	8
Kilimanjaro - Mkomazi Tsavo (Kenya)	67.5	60.0	63.8	168	5780	5612	100	82	10
Kilombero - Uzungwa	82.5	80.0	81.3	248	2476	2228	80	81	10
Kilombero - Uzungwa Scarp	82.5	45.0	63.8	248	1883	1635	70	67	8
Kitulo Rungwe - Mpanga Kipengere	57.5	70.0	63.8	1063	2878	1815	70	67	8
Lake Manyara - Yaeda Chini	25.0	32.5	28.8	896	2056	1160	40	34	4
Loazi - Luanga Musalangu (Zambia)	60.0	42.5	51.3	565	2033	1468	60	56	6
Longido - Amboseli (Kenya)	37.5	27.5	32.5	1124	2454	1330	50	41	6
Mahale Mountains - Gombe Stream	70.0	30.0	50.0	728	2402	1674	70	60	6
Mahale Mountains - Katavi Complex	70.0	82.5	76.3	722	2402	1680	70	73	8
Mahale Mountains - Ugalla Complex	70.0	82.5	76.3	733	2402	1669	70	73	8
Mikumi - Wami Mbiki	60.0	37.5	48.8	176	1167	991	30	39	4
Mkomazi Tsavo - Handeni	60.0	37.5	48.8	168	1672	1504	60	54	6
Msanjesi - Lukwika Lumesule	22.5	45.0	33.8	163	572	409	10	22	4
Nyerere Selous - Liparamba	97.5	32.5	65.0	40	1393	1353	50	58	6

Wildlife Corridor Assessed	Relative Value PA1	Relative Value PA2	Average Value PA Pair	Elevation Minimum	Elevation Maximum	Elevation Range	Elevation Value	Relative Value corridor	Climate Change Score
Nyerere Selous - Niassa (Mozambique)	97.5	65.0	81.3	40	1305	1265	50	66	8
Nyerere Selous - Saadani	97.5	67.5	82.5	3	1305	1302	50	66	8
Nyerere Selous - Udzungwa	97.5	80.0	88.8	40	2476	2436	80	84	10
Nyerere Selous - Wami Mbiki	97.5	37.5	67.5	40	1305	1265	50	59	6
Ruaha Rungwa - Inyonga	62.5	40.0	51.3	722	1865	1143	40	46	6
Ruaha Rungwa - Katavi Complex	62.5	82.5	72.5	722	2001	1279	50	61	8
Ruaha Rungwa - Kitulo Rungwe	62.5	57.5	60.0	722	2878	2156	80	70	8
Ruaha Rungwa - Mpanga Kipengere	62.5	70.0	66.3	722	2815	2093	80	73	8
Ruaha Rungwa - Swaga Swaga	62.5	30.0	46.3	722	1865	1143	40	43	6
Ruaha Rungwa - Udzungwa	62.5	80.0	71.3	284	2476	2192	80	76	8
Ruaha Rungwa - Wembere	62.5	40.0	51.3	722	1865	1143	40	46	6
Ruaha Rungwa - Yaeda Chini	62.5	32.5	47.5	722	1900	1178	40	44	6
Serengeti Complex - Arusha	90.0	47.5	68.8	583	1273	690	20	44	6
Serengeti Complex - Lake Manyara	90.0	25.0	57.5	583	3537	2954	90	74	8
Serengeti Complex - Longido	90.0	37.5	63.8	583	3537	2954	90	77	8
Serengeti Complex - Tarangire Complex	90.0	37.5	63.8	583	3537	2954	90	77	8
Serengeti Complex - Wembere	90.0	40.0	65.0	583	3537	2954	90	78	8
Serengeti Complex - Yaeda Chini	90.0	32.5	61.3	583	3537	2954	90	76	8
Tarangire Complex - Arusha	37.5	47.5	42.5	988	4254	3266	90	66	8
Tarangire Complex - Handeni	37.5	37.5	37.5	485	1736	1251	50	44	6
Tarangire Complex - Lake Manyara	37.5	25.0	31.3	896	2056	1160	40	36	4
Tarangire Complex - Mkomazi Tsavo (Kenya)	37.5	60.0	48.8	168	1736	1568	60	54	6
Tarangire Complex - Swaga Swaga	37.5	30.0	33.8	988	2264	1276	50	42	6
Udzungwa - Mikumi	80	60.0	70.0	205	2476	2271	80	75	8
Udzungwa - Uzungwa Scarp	80	45.0	62.5	284	2476	2192	80	71	8

Wildlife Corridor Assessed	Relative Value PA1	Relative Value PA2	Average Value PA Pair	Elevation Minimum	Elevation Maximum	Elevation Range	Elevation Value	Relative Value corridor	Climate Change Score
Ugalla Complex - Uvinza	82.5	25.0	53.8	988	1691	703	20	37	4
Ugalla Complex - Wembere	82.5	40.0	61.3	1044	1691	647	20	41	6
Wami Mbiki - Handeni	37.5	37.5	37.5	176	1003	827	20	29	4
Wami Mbiki - Saadani	37.5	67.5	52.5	3	735	732	20	36	4

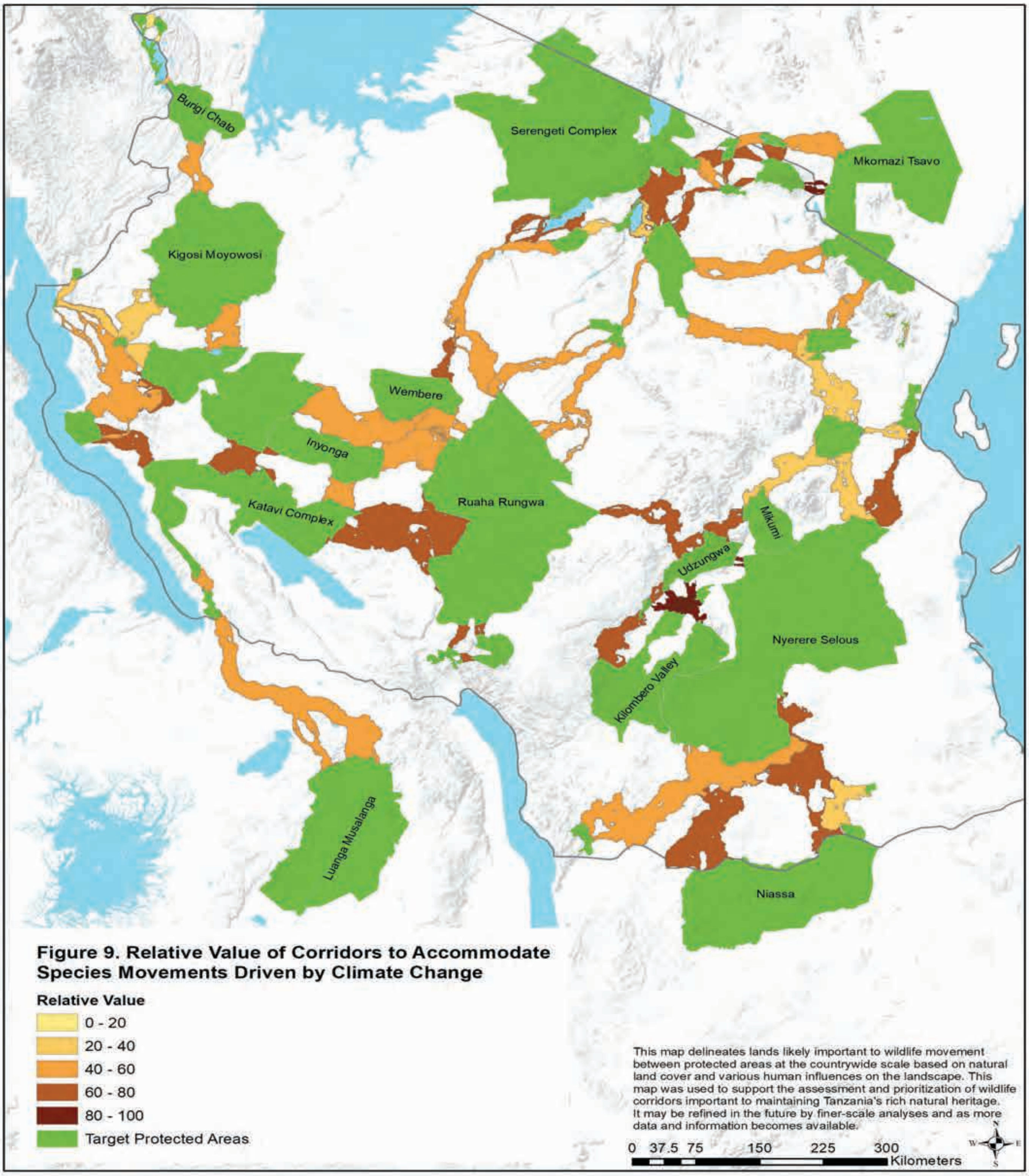


Figure 9. Relative Value of Corridors to Accommodate Species Movements Driven by Climate Change

It is important to note that all three of the corridors that scored the highest for this criterion require habitat restoration to varying degrees if they are to allow species to respond and adapt to climate change without assisted translocation. Maintaining and restoring habitat connectivity is the most important climate adaptation strategy to allow species and full communities to shift their ranges and respond and adapt to climate change.

3.3.6 Scientific Evidence that Wildlife use the Corridor

Corridors that are known to provide wildlife habitat or facilitate wildlife movements received extra points in this prioritization analysis. The reason is that conservation stakeholders can invest in such corridors with "no regrets"—because there is already evidence to demonstrate that these corridors can enhance connectivity between protected areas—whereas corridors for which there is minimal or no evidence demonstrating that wildlife use them require more research. Evidence that corridors facilitate wildlife movement can be obtained, for example, through tracking data from GPS collars, aerial surveys, remote camera stations and track stations, point-count surveys, pitfall traps, bait stations, and other standard wildlife research techniques, as well as from people who have direct local knowledge (such as from District Game Officers) about how wildlife use and move through landscapes.

Assessment Approach: The corridor assessment team determined the number of species known to use each corridor through compiled spatial data describing wildlife abundance, distribution, and movement patterns taken from TAWIRI and IUCN. The IUCN species distribution data formed the foundation of the analysis with additional species from TAWIRI aerial surveys added if not already captured in the IUCN data. The IUCN data don't specify where Black rhino (*Diceros bicornis*) occur in the country for security reasons. Thus, given that rhino may occur in very few of the corridor areas, this species was not included in the analysis. The team calculated the number of species known to use each corridor and sorted the results into five classes using natural breaks. Corridors with a larger number of species earned more points, with a total of 10 points possible. In addition, corridors where there was documentation that species are moving through the corridor between target protected areas received an additional five points.

Documentation that the corridors are used by wildlife to travel between target protected areas came from (i) spatial data or maps provided to the assessment team by researchers and other stakeholders; (ii) TAWIRI aerial survey data that documented species throughout a corridor; (iii) literature searches in research databases such as Research Gate and Web of Science; and (iv) movement documentation (e.g., GPS collar data) provided by workshop participants.

Point Scores:
10 = 76 – 89 IUCN-listed and TAWIRI species known to use the corridors
8 = 60 – 75 IUCN-listed and TAWIRI species known to use the corridors
6 = 53 – 59 IUCN-listed and TAWIRI species known to use the corridors
4 = 42 – 52 IUCN-listed and TAWIRI species known to use the corridors
2 = 31 – 41 IUCN-listed and TAWIRI species known to use the corridors

Add 5 points for corridors known to facilitate movement between target protected areas.
Maximum total point score = 15 points

Results: All the corridors support a number of IUCN species, ranging from 31 to 89, with most corridors supporting an average of 59 IUCN species (SD 11.94; Table 10). Five corridors really stood out in terms of the number of IUCN species they support (Figure 10). One of the very smallest corridors, Amani – Nilo in the Usambara Mountains, had the highest number of IUCN species (89) across all corridors. Baga – Kisima Gonja, another very small corridor in the Usambara Mountains, also supports a very high number (81) of IUCN species. Other corridors with considerable numbers of IUCN species include Mahale Mountains – Gombe Stream (87), Tarangire Complex – Mkomazi Tsavo (84), and Mkomazi Tsavo – Handeni (79).

TAWIRI aerial survey data added to the total number of species in 28 of the corridors. Many of the species that are surveyed by TAWIRI are also IUCN listed species, such as elephant, cape buffalo, giraffe, and zebra, which were not counted in the additional species column in Table 10.

Table 10. Scientific evidence that the corridors are used by species based on IUCN and TAWIRI surveys, with bonus points for movement data

Wildlife Corridor Assessed	# Species IUCN	Additional Species TAWIRI	# Species	Base Score	Bonus Points	Evidence Score	Movement Data Source for Bonus Points
Akagera (Rwanda) - Rumanyika Karagwe	50		50	4	5	9	TANAPA working reports
Amani - Nilo	89		89	10		10	
Amboseli - Mkomazi Tsavo (Kenya)	73		73	8	5	13	Elephant (BCI, ATE, IFAW, KWS, SFS), wild dog (Masenga et al. 2016), TAWIRI report, Ojwang' et al. 2017
Arusha - Longido	64	2	66	8	5	13	TAWIRI Report
Baga - Kisima Gonja	81		81	10	5	15	TAWIRI Report
Burigi Chato - Akagera (Rwanda)	52		52	4	5	9	TAWIRI Report
Gombe Stream - Mukungu Rukamabasi (Burundi)	38		38	2	5	7	Pintea et al. JGI, Mjungu et al. in Debonnet & Nindi 2017
Gombe Stream - Uvinza	44		44	4	5	9	Pintea, Mjungu et al. JGI
Ibanda - Rumanyika Karagwe	54		54	6	5	11	TANAPA Reports and DGO Reports
Katavi Complex - Inyonga	48		48	4		4	
Katavi Complex - Loazi Lungu	50		50	4	5	9	Davenport and Games in Debonnet & Nindi 2017
Katavi Complex - Ugalla Complex	54	5	59	6	5	11	Vultures (Bracebridge and Kendall WCS NCZ)
Kigosi Moyowosi - Burigi Chato	53	3	56	6	5	11	Vultures (Bracebridge and Kendall WCS NCZ)
Kigosi Moyowosi - Ugalla Complex	50	4	54	6	5	11	Vultures (Bracebridge and Kendall WCS NCZ), Kalumanga 2015, Kalumanga and von Oertzen in Debonnet & Nindi 2017
Kigosi Moyowosi - Uvinza	53	1	54	6	5	11	Vultures (Bracebridge and Kendall WCS NCZ)
Kilimanjaro - Amboseli (Kenya)	69		69	8	5	13	Elephant (BCI, Kikoti, TAWIRI, OIKOS, AWF), wild dog (Masenga et al. 2016), Mallya et al. in Debonnet & Nindi 2017, Ojwang' et al. 2017
Kilimanjaro - Arusha	66		66	8	5	13	TANAPA working reports
Kilimanjaro - Longido	64	3	67	8	5	13	Elephant (BCI), TAWIRI, Ojwang' et al. 2017

Wildlife Corridor Assessed	# Species IUCN	Additional Species TAWIRI	# Species	Base Score	Bonus Points	Evidence Score	Movement Data Source for Bonus Points
Kilimanjaro - Mkomazi Tsavo (Kenya)	75		75	8	5	13	TAWIRI Report, TANAPA working reports
Kilombero - Udzungwa	58	1	59	6	5	11	TAWIRI surveys
Kilombero - Uzungwa Scarp	69		69	8		8	
Kitulo Rungwe - Mpanga Kipengere	46		46	4		4	
Lake Manyara - Yaeda Chini	52		52	4		4	
Loazi - Luanga Musalangu (Zambia)	54		54	6		6	
Longido - Amboseli (Kenya)	68	1	69	8	5	13	TAWIRI Report, Kikoti report, wild dog (Masenga et al. 2016), Ojwang' et l. 2017
Mahale Mountains - Gombe Stream	87		87	10	5	15	Pintea, Mjungu et al. JGI
Mahale Mountains - Katavi Complex	48		48	4	5	9	Mosha et al. in Debonnet & Nindi 2017, Kichegwa Connectivity Assessment, Piel et al. GMERC
Mahale Mountains - Ugalla Complex	58		58	6	5	11	Doody et al. in Debonnet & Nindi 2017, Piel et al. GMERC, Pintea, Mjungu et al. JGI
Mikumi - Wami Mbiki	54	2	56	6	5	11	Vultures (Bracebridge & Kendall WCS NCZ)
Mkomazi Tsavo - Handeni	79		79	10	5	15	Wild dog (Masenga et al. 2016)
Msanjesi - Lukwika Lumesule	31		31	2		2	
Nyerere Selous - Liparamba	47	6	53	6		6	
Nyerere Selous - Niassa (Mozambique)	45	7	52	4	5	9	Vultures (Bracebridge & Kendall WCS NCZ), TAWIRI aerial surveys, Kajuni et al. in Debonnet & Nindi 2017, Selous Niassa Wildlife Corridor Project
Nyerere Selous - Saadani	63	3	66	8		8	
Nyerere Selous - Udzungwa	46		46	4	5	9	Jones et al. 2007, 2012, STEP unpublished, Marshall 2008, Jones et al. in Debonnet & Nindi 2017
Nyerere Selous - Wami Mbiki	52	4	56	6	5	11	Vultures (Bracebridge & Kendall WCS NCZ)
Ruaha Rungwa - Inyonga	51	4	55	6	5	11	Vultures (Bracebridge & Kendall WCS NCZ), WCS aerial surveys

Wildlife Corridor Assessed	# Species IUCN	Additional Species TAWIRI	# Species	Base Score	Bonus Points	Evidence Score	Movement Data Source for Bonus Points
Ruaha Rungwa - Katavi Complex	52	4	56	6	5	11	Vultures (Bracebridge & Kendall WCS NCZ), elephant (Epps et al. 2013), TAWIRI aerial surveys, WCS aerial surveys, Lobora 2017, Davenport and Nichols in Debonnet & Nindi 2017
Ruaha Rungwa - Kitulo Rungwe	46		46	4	5	9	SPANEST Reports
Ruaha Rungwa - Mpanga Kipengere	41		41	2	5	7	SPANEST Reports, Davenport & Nichols in Debonnet & Nindi 2017
Ruaha Rungwa - Swaga Swaga	54		54	6		6	
Ruaha Rungwa - Udzungwa	70	2	72	8	5	13	Elephant, multiple species (Epps et al. 2011; 2013), TAWIRI Report, Epps et al. in Debonnet & Nindi 2017
Ruaha Rungwa - Wembere	45	4	49	4	5	9	Vultures (Bracebridge & Kendall WCS NCZ), TAWIRI aerial surveys
Ruaha Rungwa - Yaeda Chini	56	3	59	6	5	11	TAWIRI Report
Serengeti Complex - Arusha	69		69	8		8	
Serengeti Complex - Lake Manyara	67	5	72	8	5	13	Mangewa MSc thesis, Kisui et al. in Debonnet & Nindi 2017
Serengeti Complex - Longido	64		64	8	5	13	Ojwang' et al. 2017
Serengeti Complex - Tarangire Complex	67	5	72	8	5	13	Vultures (Bracebridge & Kendall WCS NCZ), wildebeest (Morrison & Bolger 2014), multiple species (Kiffner et al. 2015), Kissui et al. in Debonnet & Nindi 2017

Wildlife Corridor Assessed	# Species IUCN	Additional Species TAWIRI	# Species	Base Score	Bonus Points	Evidence Score	Movement Data Source for Bonus Points
Serengeti Complex - Wembere	51	1	52	4	5	9	Vultures (Bracebridge & Kendall WCS NCZ)
Serengeti Complex - Yaeda Chini	52		52	4		4	
Tarangire Complex - Arusha	70	3	73	8		8	
Tarangire Complex - Handeni	60	3	63	8	5	13	TAWIRI multiple species
Tarangire Complex - Lake Manyara	62	3	65	8	5	13	Vultures (Bracebridge & Kendall WCS, NCZ), Elephant (BCI, Chem Chem 2020), multiple species (Kiffner et al. 2015), Lee and Bolger 2017, Morrison & Bolger 2014, Mallya et al. in Debonnet & Nindi 2017
Tarangire Complex - Mkomazi Tsavo (Kenya)	79	5	84	10		10	
Tarangire Complex - Swaga Swaga	55	2	57	6		6	
Udzungwa - Mikumi	53		53	6	5	11	Elephant (Epps et al. 2013), Jones et al. in Debonnet & Nindi 2017
Udzungwa - Uzungwa Scarp	71		71	8		8	
Ugalla Complex - Uvinza	50		50	4	5	9	Chimpanzees (Pintea, Mjungu et al. JGI, Piel et al. JGI)
Ugalla Complex - Wembere	45	4	49	4	5	9	Vultures (Bracebridge & Kendall WCS NCZ)
Wami Mbiki - Handeni	63	2	65	8	5	13	Vultures (Bracebridge & Kendall WCS NCZ), Riggio & Caro 2017
Wami Mbiki - Saadani	54		54	6	5	11	Vultures (Bracebridge & Kendall WCS NCZ), Mwakatobe et al. in Debonnet & Nindi 2017

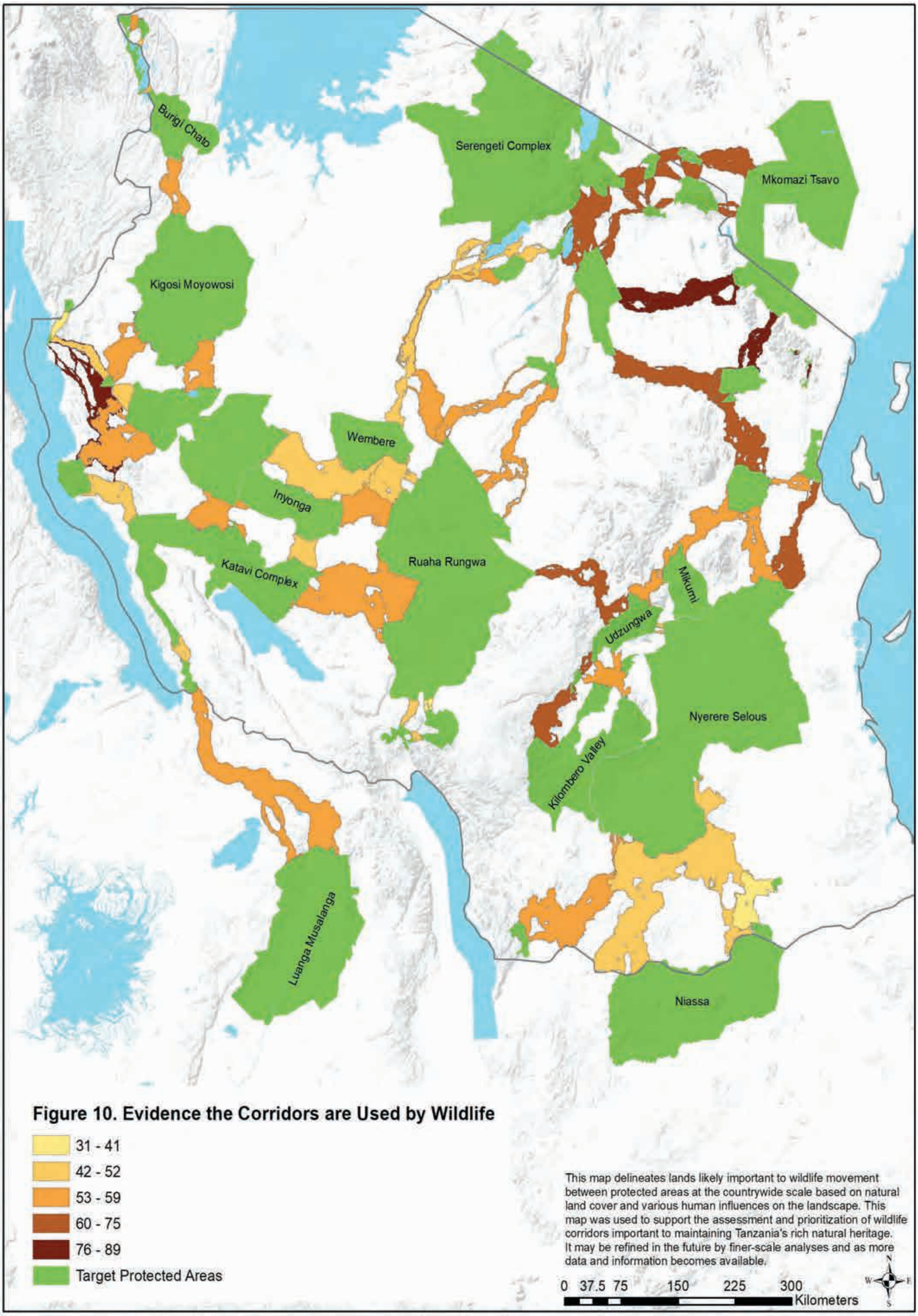


Figure 10. Evidence the Corridors are Used by Wildlife

The assessment team found that 74% (45/61) of the corridors have been documented to support movement by target species (Table 10), which earned bonus points. One of the most compelling datasets documenting movement through the corridors was provided by Dr. Claire Bracebridge and Dr. Corinne Kendall, who have been tracking endangered vultures (Figure 11) since 2015 through a collaboration with Wildlife Conservation Society and North Carolina Zoo (Bracebridge and Kendall 2018, 2019). Movements of three critically endangered vultures are depicted on the map with the White-backed vulture (*Gyps africanus*) being the primary species documented to use several of the delineated wildlife corridors in the network. African White-backed vultures were found to move through about 16 of the delineated wildlife corridors. Tagged Hooded vultures (*Necrosyrtes* monachus) have used the Ruaha – Wembere and Ruaha – Inyonga corridors, while tracked White-headed vultures (*Trigonoceps occipitalis*) are documented using the corridor between the Katavi Complex and Ugalla Complex. Dr. Kendall stated, “vulture movement should provide unique insight into the quality of the habitat in the corridors.” Considering the reluctance of vultures to use non-habitat and their strong preference for natural lands, it is particularly exciting to see movement pathways between two critically important links in the network: Wami Mbiki – Handeni and Serengeti Complex - Wembere. Dr. Bracebridge remarked that “vultures play an important overarching role as a landscape-level species, and the results from our movement data are increasingly making us realize that Tanzanian vulture conservation ultimately needs a country-wide approach.”

A number of other species have been documented to use the corridors. Several researchers (Epps et al. 2011, 2013, Dr. Kikoti, Dr. Jones, Dr. Kalumanga), land managers and research institutions (TANAPA, TAWIRI), and NGOs (e.g., STEP, AWF, OIKOS), have documented elephant movement through corridors throughout the country, as well as transboundary connections to neighboring countries (Table 10). The Borderland Conservation Initiative (ATE, IFAW, KWS, SFS) organizations have generated and compiled elephant movement data from a number of sources documenting movement in transboundary connections between Tanzania and Kenya. Masenga et al. (2016) has documented movements of dispersing African wild dog groups through several of the northern and transboundary corridors. Morrison and Bolger (2014) have documented long-distance movements of wildebeest migrations in the Tarangire Ecosystem. Additional data documenting wildlife movement between target protected areas surely exist and should be compiled from various sources into a central database.

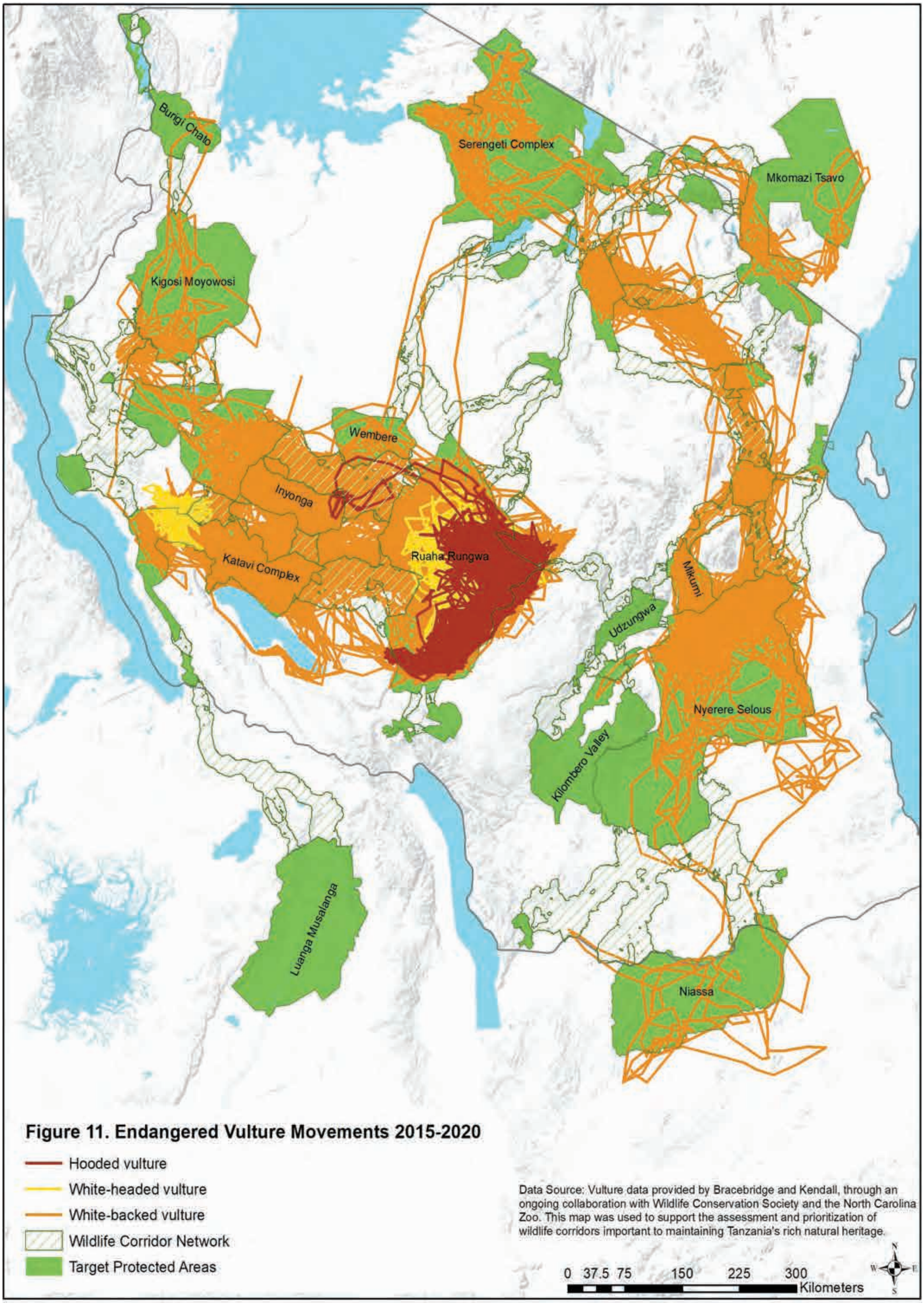


Figure 11. Endangered Vulture Movements 2015-2020

3.3.7 Freshwater Features that add Value to the Corridor

Water is essential for wildlife to survive, and many species are known to use rivers and streams as travel corridors (Sanchez-Montoya et al. 2016, Davis et al. 2017). When freshwater features, e.g., rivers, streams, lakes, or wetlands, are inside a corridor, they can increase its habitat value and help facilitate wildlife movement through the corridor.

Assessment Approach: The assessment team acquired spatial data describing rivers, streams, lakes, and wetlands in Tanzania and surrounding countries from the following data source: OpenStreetMap—Waterways and Water Bodies (http://download.geofabrik.de/africa.html).

For each corridor, the assessment team (i) calculated the length of all rivers and streams within the corridor; (ii) drew a line across all lakes and wetlands in the corridor in a direction parallel to the least cost path (see text box); (iii) calculated the lengths of those lines that traverse lakes and wetlands; (iv) summed the lengths of all freshwater features in each corridor (lengths of all rivers and streams plus lines traversing lakes and wetlands); and (v) compared the result to the length of the least cost path to calculate a proportion.

A "least cost path" is the product of a GIS analysis that identifies the route through the corridor where wildlife are expected to encounter the most natural habitat and fewest hazards as they move between protected areas.

Corridors whose summed lengths of these "water" lines have a higher proportion received more points because water features enhance wildlife habitat and can facilitate movement between protected areas.

Point scores:
9 = > 80% of the least cost path
7 = > 60% - 80% of the least cost path
5 = > 40% - 60% of the least cost path
3 = > 20% - 40% of the least cost path
1 = 0 - 20% of the least cost path

Results: There are significant freshwater resources in the great majority of the delineated wildlife corridors (Figure 12 and Table 11). The proportion of freshwater features compared to the least cost path for roughly half of the corridors (31/61) was over 100%. The proportion of freshwater features for three of the corridors, Burigi Chato – Akagera, Nyerere Selous – Niassa, and Serengeti Complex – Tarangire Complex were over 400%, six corridors were between 300 and 400%, seven were between 200 and 300%, and 15 were between 100 and 200%. Only 11 of the corridors had freshwater proportions to the least cost path that were below 50%, and only 3 of these were below 5%, which include Arusha – Longido, Tarangire Complex – Handeni, and Wami Mbiki – Handeni. While the corridor network captured a great deal of freshwater features, the geospatial algorithms for the least-cost corridor analysis often fail to identify the entirety of important rivers and streams, which are often key movement routes. Rivers and perennial and intermittent streams provide movement corridors for a number of species; breeding habitat for many birds, amphibians, and reptiles; and key resources for countless species. Rivers and streams also span elevation gradients in a way that increases interspersion and promotes ecological processes and flows, such as movement of animals, sediment, water, and nutrients (Cowling et al. 1999, 2003). Segments of key riparian corridors not captured (e.g., Great Ruaha) can complement the corridor network.

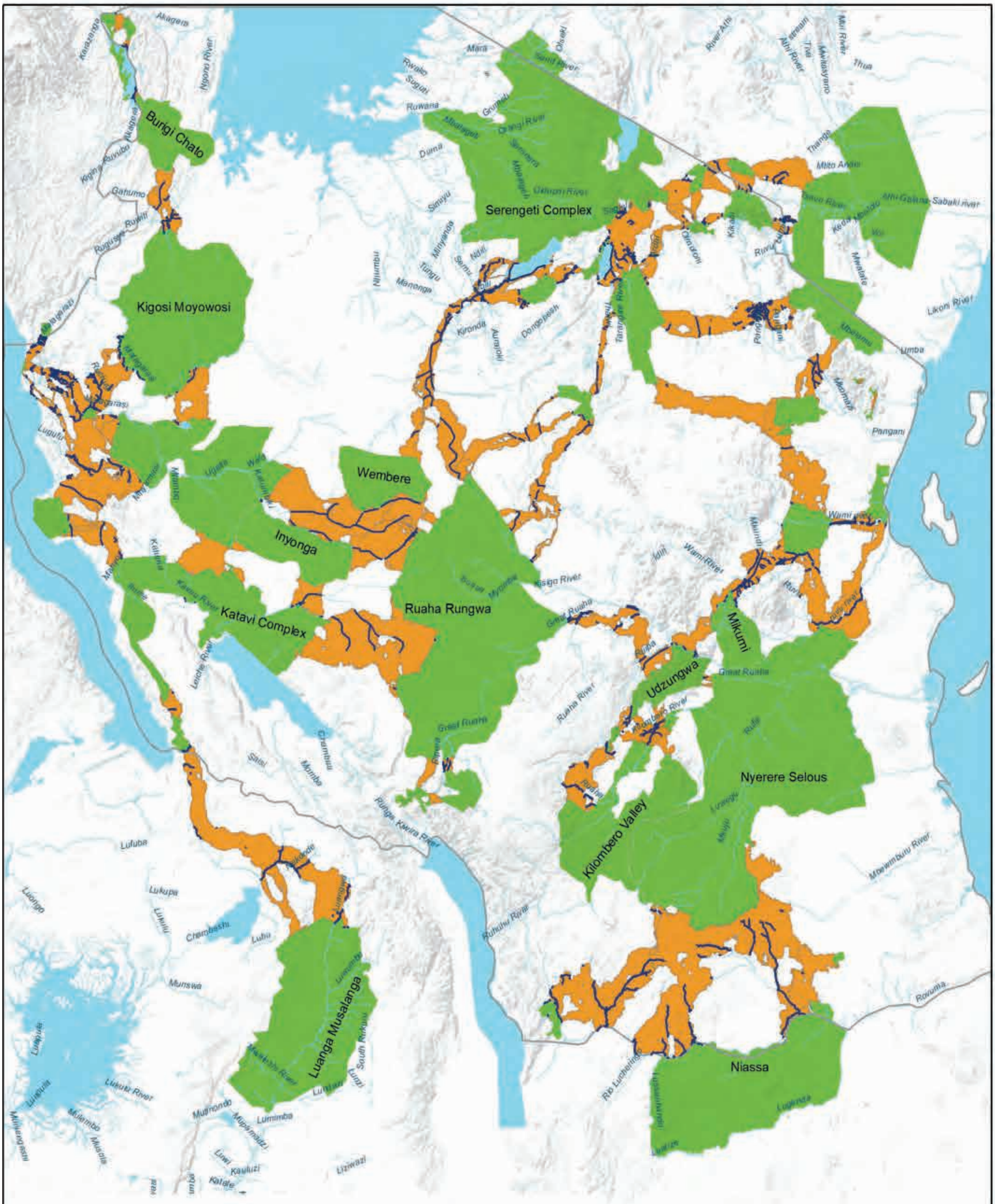


Figure 12. Freshwater Features in the Wildlife Corridors

This map delineates lands likely important to wildlife movement between protected areas at the countrywide scale based on natural land cover and various human influences on the landscape. This map was used to support the assessment and prioritization of wildlife corridors important to maintaining Tanzania's rich natural heritage. It may be refined in the future by finer-scale analyses and as more data and information becomes available.

Table 11. Summary results of freshwater features that add value to the corridors

Wildlife Corridor Assessed	Rivers & Streams length (m)	Lakes & Wetlands length (m)	Freshwater Feature length (m)	LCP Length	Proportion	Freshwater Score
Akagera (Rwanda) - Rumanyika Karagwe	11676	3473	15149	9372	162%	9
Amboseli - Mkomazi Tsavo (Kenya)	60587		60587	78928	77%	7
Arusha - Longido	648		648	33891	2%	1
Kigosi Moyowosi - Burigi Chato	128209		128209	76074	169%	9
Burigi Chato - Akagera (Rwanda)	19673	3880	23553	5245	449%	9
Gombe Stream - Mukungu Rukamabasi (Burundi)	105512	1549	107060	39701	270%	9
Gombe Stream - Uvinza	255041		255041	99202	257%	9
Ibanda - Rumanyika Karagwe	675		675	11172	6%	1
Katavi Complex - Inyonga	48988		48988	31537	155%	9
Katavi Complex - Loazi Lungu	11903		11903	18282	65%	7
Katavi Complex - Ugalla Complex	4490		4490	36436	12%	1
Kigosi-Moyowosi - Ugalla Complex	23563	4722	28285	47055	60%	7
Kigosi-Moyowosi - Uvinza	228963	11581	240544	64720	372%	9
Kilimanjaro - Amboseli	26510		26510	17100	155%	9
Kilimanjaro - Arusha	11327	5133	16461	27873	59%	5
Kilimanjaro - Mkomazi Tsavo (Kenya)	87131		87131	26536	328%	9
Kilombero - Udzungwa	115907		115907	66547	174%	9
Kilombero - Uzungwa Scarp	131005	3264	134269	80766	166%	9
Lake Manyara - Yaeda chini	62620		62620	36346	172%	9
Loazi - Luanga Musalangu (Zambia)	301625	12191	313816	318926	98%	9
Longido - Amboseli (Kenya)	31707		31707	25109	126%	9
Mahale Mountains - Gombe Stream	754062	47280	801343	233505	343%	9
Mahale Mountains - Katavi Complex	66101	4222	70323	77256	91%	9
Mahale Mountains - Ugalla Complex	233947	24584	258531	108884	237%	9
Mikumi - Wami Mbiki	319743	4770	324512	84275	385%	9
Mkomazi Tsavo (Kenya) - Handeni	99246	2435	101681	76947	132%	9
Msanjesi - Lukwika Lumesule	14712		14712	74119	20%	3
Nyerere Selous - Liparamba	534461		534461	241925	221%	9
Nyerere Selous - Niassa (Mozambique)	654745	24698	679443	155104	438%	9
Nyerere Selous - Saadani	117095	2204	119299	149113	80%	9
Nyerere Selous - Udzungwa	3764		3764	9372	40%	5
Nyerere Selous - Wami Mbiki	102812		102812	92119	112%	9
Ruaha Rungwa - Inyonga	157947		157947	74492	212%	9
Ruaha Rungwa - Swaga Swaga	163657	30704	194361	191514	101%	9
Ruaha Rungwa - Udzungwa	205254		205254	171149	120%	9
Ruaha Rungwa - Wembere	134615		134615	43391	310%	9
Ruaha Rungwa - Yaeda chini	500468	21485	521953	326499	160%	9
Ruaha Rungwa - Katavi Complex	160629		160629	186306	86%	9
Ruaha Rungwa - Mpanga Kipengere	46160		46160	14245	324%	9
Seregeti Complex - Arusha	4712		4712	40383	12%	1
Serengeti Complex - Lake Manyara	47053	14507	61559	37773	163%	9
Serengeti Complex - Longido	15808		15808	25945	61%	7
Serengeti Complex - Tarangire Complex	258654	52244	310898	76729	405%	9
Serengeti Complex - Wembere	489838	56615	546453	317062	172%	9
Serengeti Complex - Yaeda chini	13062	70939	84001	88956	94%	9

Wildlife Corridor Assessed	Rivers & Streams length (m)	Lakes & Wetlands length (m)	Freshwater Feature length (m)	LCP Length	Proportion	Freshwater Score
Tarangire Complex - Arusha	33148	625	33772	96774	35%	3
Tarangire Complex - Lake Manyara	54082	52245	106327	68256	156%	9
Tarangire Complex - Swaga Swaga	47841	1707	49548	108383	46%	5
Tarangire Complex - Handeni		3087	3087	157857	2%	1
Tarangire Complex - Mkomazi Tsavo (Kenya)	397058		397058	170649	233%	9
Udzungwa - Mikumi	18673		18673	39328	47%	5
Udzungwa - Uzungwa Scarp	40852		40852	20082	203%	9
Ugalla Complex - Uvinza	19879	6913	26792	28400	94%	9
Ugalla Complex - Wembere	220229		220229	134057	164%	9
Wami Mbiki - Handeni	3710		3710	92402	4%	1
Wami Mbiki - Saadani	137467		137467	64683	213%	9

3.4 Prioritizing the Corridors According to their Vulnerability to a Variety of Threats: Approach and Results

3.4.1 Vulnerability of the Corridor to Habitat Conversion

Habitat loss and fragmentation are leading threats to biodiversity worldwide, and that threat is particularly severe in Tanzania, where habitat conversion is happening at a rapid pace. As people convert native habitats to land for settlements and agriculture, protected areas have become more fragmented and isolated (Ntongani et al. 2009, Estes et al. 2012), human-wildlife conflicts have increased (Lewis et al. 2016, Kissui et al 2019, MNRT 2020), and many wildlife populations have declined (Kiffner et al. 2015, Morrison et al. 2016, Bond et al. 2017).

Assessment Approach: The assessment team used the results of the *Quality of Wildlife Habitat in the Corridor* analysis described above in section 3.3.4 to rank the vulnerability of the corridor to habitat conversion, as follows.

Point Scores:
30 = < 60% natural land cover/water
25 = ≥ 60% but less than 70% natural land cover/water
20 = ≥ 70% but < 80% natural land cover/water
15 = ≥ 80% but < 90% natural land cover/water
10 = ≥ 90% natural land cover/water

Results: The majority of the corridors delineated 57% (35/61) have greater than or equal to 90% natural land cover (See Figure 8 in section 3.3.4). Only five of the corridors received a habitat conversion score of 30, which are the corridors most threatened by habitat conversion (Table 12). These include Tarangire Complex – Swaga Swaga, Ruaha Rungwa – Mpanga Kipengere, Nyerere Selous – Udzungwa, Kilimanjaro – Mkomazi Tsavo, and Baga – Kisima Gonja. While percent natural cover provides a good indication of a corridor's vulnerability to habitat conversion, a corridor could be constrained by settlement or agriculture along a single road. Corridors highlighted with a double asterisk in (**) in Table 12 have, at some point in the corridor, 90% or more of the width converted to agriculture and or settlement. In all the corridors, most of the habitat conversion is to agriculture rather than to settlement, making habitat restoration more feasible.

Table 12. Vulnerability of the corridors to habitat conversion based on percent of natural land cover

Wildlife Corridor Assessed	Corridor Area (hectares)	% Natural	% Converted	Agriculture (hectares)	Settlement (hectares)	Habitat Conversion Score
Akagera (Rwanda) - Rumanyika Karagwe	5598	75	25	1398	0	20
Amani - Nilo	5743	91	9	529	0	10
Amboseli - Mkomazi Tsavo (Kenya)	177612	96.5	3.5	6128	118	10
Arusha – Longido **	29945	92.5	7.5	1962	284	10
Baga - Kisima Gonja **	2273	44	56	1273	1	30
Burigi Chato - Akagera (Rwanda)	6176	89	11	672	0	15
Gombe Stream - Mukungu Rukamabasi **	31643	68	32	8354	1894	25
Gombe Stream - Uvinza	86126	93	7	4636	1537	10
Ibanda - Rumanyika Karagwe	18212	82	18	3228	23	15
Katavi Complex - Inyonga	103350	99.995	0.005	5	0	10
Katavi Complex - Loazi Lungu	41029	96.5	3.5	1428	13	10
Katavi Complex - Ugalla Complex	200931	99.4	0.6	1180	28	10
Kigosi Moyowosi - Burigi Chato	141506	81.4	18.6	25496	783	15
Kigosi Moyowosi - Ugalla Complex	183555	78.7	21	39047	599	20
Kigosi Moyowosi - Uvinza	195089	92.7	7.3	13052	614	10
Kilimanjaro - Amboseli (Kenya)	44707	86.7	13.3	5603	166	15
Kilimanjaro - Arusha **	19102	64	36	6247	503	25
Kilimanjaro - Longido **	45453	93.6	6.4	2590	160	10
Kilimanjaro - Mkomazi Tsavo (Kenya) **	32365	44	56	17767	389	30
Kilombero – Udzungwa **	141921	73.8	26.2	37392	292	20
Kilombero - Uzungwa Scarp	188479	97	3	5214	48	10
Kitulo Rungwe – Mpanga Kipengere	13320	86	14	1725	184	15
Lake Manyara - Yaeda Chini	46165	68	32	14846	40	25
Loazi - Luanga Musalangu (Zambia)	823585	96	4	24218	9262	10
Longido - Amboseli (Kenya)	43316	98	2	784	10	10
Mahale Mountains - Gombe Stream	681381	95	5	29759	4678	10
Mahale Mountains - Katavi Complex	177213	99.5	0.5	914	40	10
Mahale Mountains - Ugalla Complex	442172	95.7	4.3	19040	1401	10
Mikumi - Wami Mbiki	219186	94.8	5.2	10548	533	10
Mkomazi Tsavo - Handeni	129355	92	7.7	8445	947	10
Msanjesi - Lukwika Lumesule	195189	95.8	4.2	6902	336	10
Nyerere Selous - Liparamba	1030050	98	2.1	16950	1497	10
Nyerere Selous - Niassa (Mozambique)	1659850	99	1	15774	1045	10
Nyerere Selous - Saadani	296910	95.5	0.5	1042	409	10

Wildlife Corridor Assessed	Corridor Area (hectares)	% Natural	% Converted	Agriculture (hectares)	Settlement (hectares)	Habitat Conversion Score
Nyerere Selous – Udzungwa **	8870	4	96	7548	940	30
Nyerere Selous - Wami Mbiki	215890	98	2	3708	183	10
Ruaha Rungwa - Inyonga	311036	97	3	10411	343	10
Ruaha Rungwa - Katavi Complex	814075	99	1.1	7966	1034	10
Ruaha Rungwa - Kitulo Rungwe **	34409	62	38	12478	541	25
Ruaha Rungwa - Mpanga Kipengere **	14705	20	80	11045	679	30
Ruaha Rungwa - Swaga Swa-ga **	462120	74	26	115599	3423	20
Ruaha Rungwa - Udzungwa	244725	89	10.75	24608	1626	15
Ruaha Rungwa - Wembere	238844	94	6.2	13981	512	10
Ruaha Rungwa - Yaeda Chini **	479767	76	23.7	108852	3138	20
Serengeti Complex – Arusha **	67075	93	6.9	4295	614	10
Serengeti Complex - Lake Manyara	121814	91	9	10334	1375	10
Serengeti Complex - Longido	70591	99	1	741	159	10
Serengeti Complex - Tarangire Complex	291830	86.2	13.8	37786	2525	15
Serengeti Complex – Wembere **	341207	80	19.5	66316	1583	15
Serengeti Complex - Yaeda Chini	60226	97	3.4	2023	243	10
Tarangire Complex - Arusha **	90363	72	27.6	24697	565	20
Tarangire Complex - Handeni **	367506	88	12	44746	400	15
Tarangire Complex - Lake Manyara	55575	82	18	9614	556	15
Tarangire Complex - Mkomazi Tsavo (Kenya) **	360898	77	23	83098	1189	20
Tarangire Complex - Swaga Swaga **	65180	53	47	29213	1001	30
Udzungwa - Mikumi	85292	97.5	2.5	1942	399	10
Udzungwa - Uzungwa Scarp	24213	86	14	3300	4	15
Ugalla Complex - Uvinza	63391	99.6	0.4	5	244	10
Ugalla Complex - Wembere	549850	99	1	3169	25	10
Wami Mbiki - Handeni	328804	94	6	20569	330	10
Wami Mbiki - Saadani	59385	98	2	882	129	10

3.4.2 Human Influence on the Corridor

Habitat conversion to agriculture, settlements, and urban and industrial land uses creates “edge effects” that threaten wildlife in nearby natural areas. While some edge effects can increase species diversity and richness by increasing habitat heterogeneity, most edge effects are negative for wildlife. Edge effects include the spread of invasive species (D’Amore et al. 2010), artificial night lighting (Longcore and Rich 2016), pesticides and other pollution (Guzha et al. 2018), zoonotic disease transmission (Parsons et al. 2015), noise (Shannon et al. 2016), changes to the frequency and intensity of wildfires (Tarimo et al. 2015), increased water diversion, and increased hunting of wildlife (Holmern et al. 2007). Such edge effects from human land uses often are more pronounced the closer they occur to natural areas. McDonald et al. (2009) conducted a literature review of 163 studies that identified 22 important urban effects on protected areas. For example, car noise from heavily trafficked roads can have an effect on wildlife in protected areas up to a kilometer or more away (Forman and Alexander 1998). Illegal logging has been documented up to 5 km in to protected areas (Yonariza and Webb 2007). Poachers have been known to walk up to 5 hours in the Congo Basin (Wilkie et al. 2000). Disease transmission has been recorded in Sengwa Wildlife Research Area in Zimbabwe, where domestic dogs penetrate 6 km into the parks, bringing rabies, canine distemper, and parvovirus to wild populations (Butler et al. 2004). Light pollution from urban areas may reach protected areas up to 10 km away, affecting birds and insects that are attracted to lights, causing direct mortality and in some cases altering migration patterns (Longcore and Rich 2004).

Human-wildlife conflict, which causes harm to people, property, and crops, also generally increases as people develop and use land near protected areas, corridors, and other natural habitats. Recognizing that human impacts on natural habitats can be a function of distance, the assessment team used a 6 km buffer zone around the corridors, as noted below.

Assessment Approach: To assess the proximity and potential impact of human land use near the corridors, the assessment team used a Human Influence Index dataset (van Breugel et al. 2015a), which is a composite of four factors: (i) human population density (> 20 people/square kilometer is considered high human influence); (ii) travel distances from natural areas to high-population-density areas; (iii) livestock pressure (a measure of livestock density relative to available forage); and (iv) relative vegetation change (a comparison of the historic potential natural vegetation map of eastern Africa (van Breugel et al. 2015b) and current vegetation land cover maps) (Figure 13). The Human Influence Index dataset uses standardized scores for each of these factors, from 0 (no human influence) to 100 (very high influence).

The assessment team (i) created a 6 km buffer zone around each corridor; (ii) overlaid the Human Influence Index data to generate statistics on human impacts in the buffer zone; (iii) calculated the average human influence value in the buffer zone; and (iv) classified the results into natural breaks in the data using five classes to represent potential impacts of human influence on the network of corridors and protected areas. Point scores below correspond to the five classes generated by the results of the analysis.

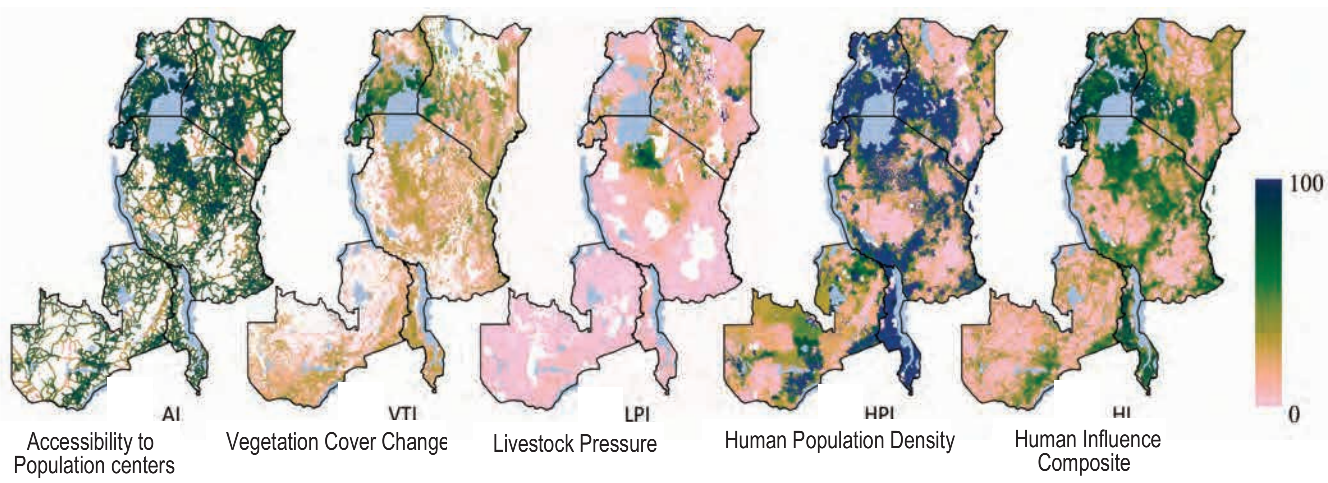


Figure 13. Maps of the individual human influence factors used to create the Human Influence Index composite layer (from van Bruegel et al. 2015a)

Point Scores:

20 = 52.040001 – 66.850000 average Human Influence Index value
15 = 43.600001 – 52.040000 average Human Influence Index value
10 = 33.810001 – 43.600000 average Human Influence Index value
5 = 25.800001 – 33.810000 average Human Influence Index value
1 = 10.700000 – 25.800000 average Human Influence Index value

Results: Vulnerability scores were based on the average Human influence in the buffer zone around the corridors with the greatest amount of human influence in the buffer receiving 20 points. Eight of the corridors had relatively high human influence in the buffer zones and received 20 points for this criterion (Table 13 and Figure 14). Kilimanjaro – Arusha had the highest average human influence in the 6 km buffer (66.668). Kilimanjaro – Mkomazi Tsavo had the second highest average human influence in the buffer zone with 63.501. The Ibanda – Rumanyika Karagwe corridor in northwest Tanzania also had a relatively high average human influence index in the buffer at 61.951. Tarangire – Swaga Swaga, one of the connections through central Tanzania, also not surprisingly had very high human influence in the buffer (61.679). The Gombe Stream – Mukungu Rukamabasi transboundary connection to Burundi, which is important for chimpanzee (*Pan troglodytes*), also appears to be at a critical juncture to maintain that connection with a score of 60.399. The Nyerere Selous – Udzungwa (Magombera) corridor, a critical connection being restored for elephants, also not unexpectedly had a very high human influence value in the buffer (56.195). Amani – Nilo corridor in the Usambara Mountains, which was estimated to have greater than 90% natural land cover in sections 3.3.4 and 3.4.1, also had a very high average Human Influence index at 56.668, as did Baga – Kisima Gonja corridor at 55.296, suggesting that immediate conservation action is necessary to maintain these connections for countless listed and endemic species. Although the average Human Influence Index values do give an indication of the overall picture surrounding the corridors, it is also important to note that the maximum Human Influence Index value for all but two of the corridors was 100, meaning there is high human pressure in at least one area in the buffers surrounding virtually all of the corridors.

Table 13. Average human influence value in the 6 km buffer zone around each corridor (Human Influence Index Source van Breugel et al. 2015a)

Wildlife Corridor Assessed	Minimum	Maximum	Range	Sum	Average	SD	Score
Akagera (Rwanda) - Rumanyika Karagwe	2.13	100	97.87	14035.73	51.984	16.73	15
Amani - Nilo	22.3	81.84	59.54	22723.97	56.668	13.72	20
Amboseli - Mkomazi Tsavo (Kenya)	2.29	100	97.71	61230	43.333	20.24	10
Arusha - Longido	14.08	100	85.92	29721.78	46.512	19.7	15
Baga - Kisima Gonja	25.02	100	74.98	15317.21	55.296	17.04	20
Burigi Chato - Akagera (Rwanda)	3.37	100	96.63	11093.2	41.392	20.57	10
Gombe Stream - Mukungu Rukamabasi (Burundi)	27.14	100	72.86	28085.87	60.399	10.92	20
Gombe Stream - Uvinza	14.83	100	85.17	74825.56	46.591	16.04	15
Ibanda - Rumanyika Karagwe	10.02	100	89.98	23541.53	61.951	17.34	20
Katavi Complex - Inyonga	2.01	100	97.99	7597.63	10.700	9.63	1
Katavi Complex – Loazi Lungu	7.18	100	92.82	22894.07	31.534	16.68	5
Katavi-Complex - Ugalla Complex	2.51	100	97.49	34443.45	21.594	19.43	1
Kigosi Moyowosi - Burigi Chato	5.01	100	94.99	53027.6	35.047	20.48	10
Kigosi Moyowosi - Ugalla Complex	0	68.12	68.12	22281.28	20.784	13.7	1
Kigosi Moyowosi - Uvinza	2.65	100	97.35	57943.04	29.608	17.7	5
Kilimanjaro - Amboseli (Kenya)	7.17	100	92.83	21405	43.595	16.33	10
Kilimanjaro - Arusha	26.7	100	73.3	29144.89	66.846	13.36	20
Kilimanjaro - Longido	12.11	100	87.89	27914.66	42.945	18.3	10
Kilimanjaro - Mkomazi Tsavo (Kenya)	13.18	100	86.82	40323.17	63.501	14.93	20

Wildlife Corridor Assessed	Minimum	Maximum	Range	Sum	Average	SD	Score
Kilombero - Udzungwa	2.35	100	97.65	54636.89	35.158	20.67	10
Kilombero - Uzungwa Scarp	2.63	100	97.37	43179.92	23.265	17.59	1
Kitulo Rungwe - Mpanga Kipengere	14.59	100	85.41	15263.82	39.138	15.05	10
Lake Manyara - Yaeda Chini	6.53	100	93.47	41398.49	41.858	17.74	10
Loazi - Luanga Musalangu (Zambia)	1.88	100	98.12	219819.39	31.255	18.14	5
Longido - Amboseli (Kenya)	8.25	100	91.75	27245.57	37.946	15.28	10
Mahale Mountains - Gombe Stream	2.5	100	99.99	229568.91	33.814	21	10
Mahale Mountains - Katavi Complex	4.2	100	95.8	39597.57	25.796	17.48	1
Mahale Mountains - Ugalla Complex	1.14	100	98.86	69174.85	23.361	17.39	1
Mikumi - Wami Mbiki	2.41	100	97.59	103507.03	44.576	20.25	15
Mkomazi Tsavo (Kenya) - Handeni	4.24	100	95.76	80501.11	48.465	21.46	15
Msanjesi - Lukwika Lumesule	0.5	100	99.49	61878.57	30.587	21.7	5
Nyerere Selous - Liparamba	0.91	100	99.09	149379.81	25.786	17.84	1
Nyerere Selous - Niassa (Mozambique)	0.2	100	99.8	234469.51	28.033	19.81	5
Nyerere Selous - Saadani	3.05	100	96.95	100770.32	36.418	20.41	10
Nyerere Selous - Udzungwa	6.42	100	93.58	14273.71	56.195	14.85	20
Nyerere Selous - Wami Mbiki	1.32	100	98.68	74123.81	38.706	23.32	10
Ruaha Rungwa - Inyonga	5.62	100	94.38	10539.17	22.094	16.36	1
Ruaha Rungwa - Katavi Complex	1.66	100	98.34	62665.61	21.220	19.18	1
Ruaha Rungwa - Kitulo Rungwe	15.41	100	84.59	34492	48.717	15.43	15
Ruaha Rungwa - Mpanga Kipengere	15.37	100	84.63	20561.81	51.404	15.14	15
Ruaha Rungwa - Swaga Swaga	2.5	100	99.99	343104.85	41.669	20.73	10
Ruaha Rungwa - Udzungwa	2.42	100	97.58	115970.73	36.218	18.52	10
Ruaha Rungwa - Wembere	2.15	100	97.85	25764.86	22.462	18.27	1
Ruaha Rungwa - Yaeda Chini	0	100	100	239585.43	41.137	20.64	10
Serengeti Complex - Arusha	8.1	100	91.9	45904.28	41.317	23.44	10
Serengeti Complex - Lake Manyara	0	100	100	42959.07	28.281	20.21	5
Serengeti Complex - Longido	12.11	100	87.89	24285.46	30.741	14.43	5
Serengeti Complex - Tarangire Complex	0	100	100	74616.36	35.684	23.87	10
Serengeti Complex - Wembere	0	100	100	247633.01	40.278	21.71	10
Serengeti Complex - Yaeda Chini	0	100	100	40060.95	23.413	22.9	1
Tarangire Complex - Arusha	9.26	100	90.74	81040.08	49.565	18.48	15
Tarangire Complex - Handeni	3.7	100	96.3	113792.11	35.862	19.98	10
Tarangire Complex - Lake Manyara	0	100	100	20222.75	35.919	25.99	10
Tarangire Complex - Mkomazi Tsavo (Kenya)	2.46	100	97.54	134486.48	39.186	20.13	10
Tarangire Complex - Swaga Swaga	5.76	100	94.24	101092.26	61.679	15.18	20
Udzungwa - Mikumi	3.41	100	96.59	31303.68	32.139	21.53	5
Udzungwa - Uzungwa Scarp	3.92	100	96.08	23627.73	39.844	17.23	10
Ugalla Complex - Uvinza	1.46	100	98.54	13686.15	24.615	17.24	1
Ugalla Complex - Wembere	1.99	100	98	51812.32	22.029	17.98	1
Wami Mbiki - Handeni	2.6	100	97.4	116186.19	42.841	23.17	10
Wami Mbiki - Saadani	4.64	100	95.36	55732.57	52.037	20.8	15

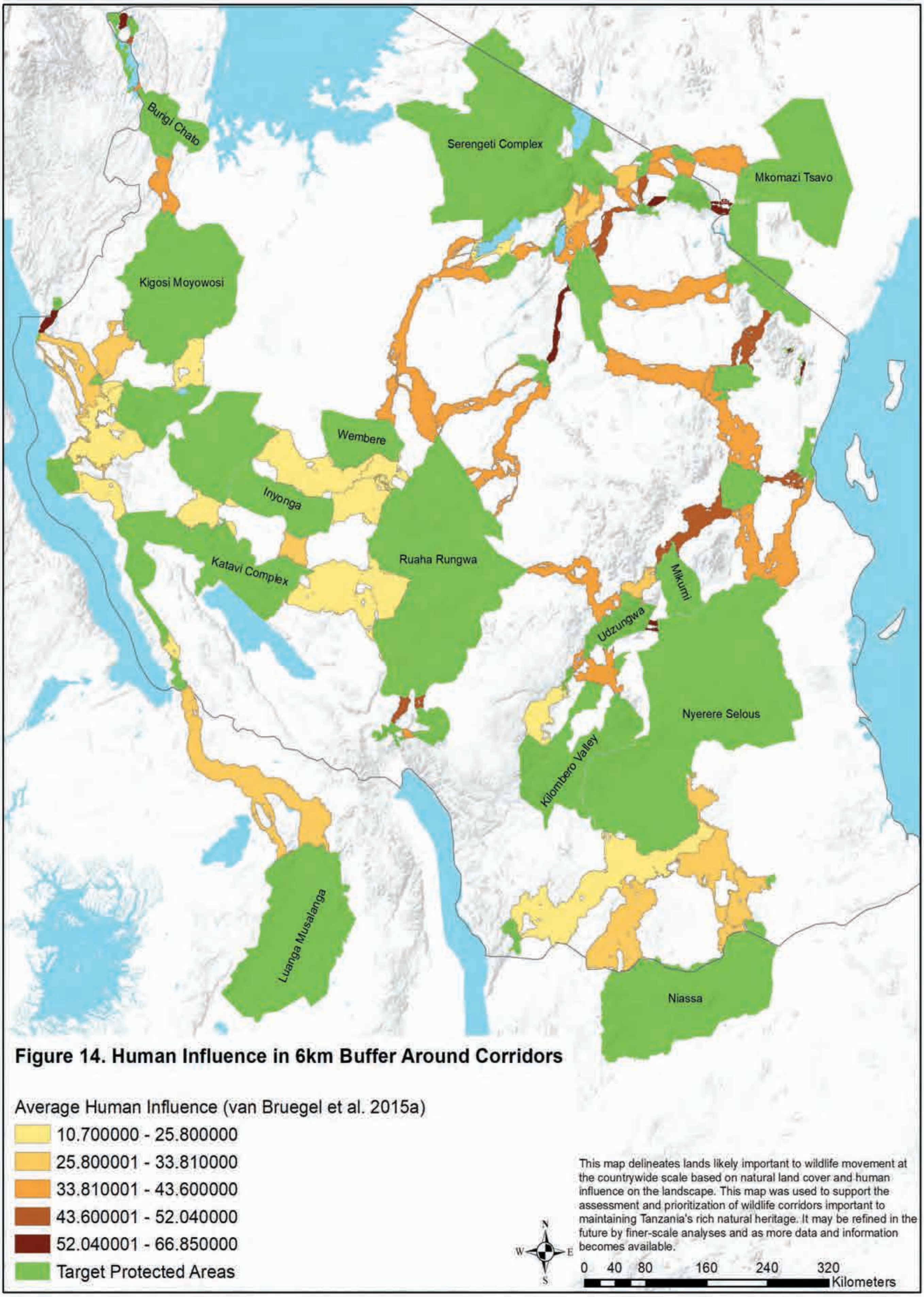


Figure 14. Human Influence in 6km Buffer Around Corridors

3.4.3 Existing and Planned Infrastructure Density in the Corridor

Linear infrastructure such as roads, railways, dams, oil and gas pipelines, and electricity grids are major threats to wildlife. Wildland fragmentation by roads is recognized as one of the greatest threats to biodiversity (Noss 1983, Harris 1984, Wilcox and Murphy 1985, Wilcove et al. 1986, Noss 1987, Reijnen et al. 1997, Trombulak and Frissell 2000, Forman and Deblinger 2000, Jones et al. 2000, Forman et al. 2003). Roads kill animals in vehicle collisions, create discontinuities in natural vegetation, alter animal behavior (due to noise, artificial light, human activity), promote invasion of exotic species, and pollute the environment (Lyon 1983, Noss and Cooperrider 1994, Yanes et al. 1995, Forman and Alexander 1998, Sheppard et al. 2008, Cozzi et al. 2013, Epps et al. 2015).

Direct effects include mortality, habitat fragmentation and loss, and reduced connectivity. The severity of these effects depends on the ecological characteristics of a given species, vegetation and topography near the road, road type, and level of traffic (Clevenger et al. 2001). Direct roadkill affects most taxonomic groups, with severe documented impacts on wide-ranging predators such as the wild dog and cheetah (TAWIRI 2016). High-speed roads within or near protected areas are likely to have the greatest impact on large mammals and primates because of the high concentration of animals in these areas (Drews 1995, Holdo et al. 2011, Epps et al. 2015). Literally thousands of road mortalities of numerous mammals, birds, and reptiles have been documented in Mikumi National Park, which is bisected by the Tanzania-Zambia Highway (Drews 1995, Rugaimukamu 2009, Epps et a. 2015). Many species avoid roads, including elephants (Newmark et al. 1996, Blake et al. 2008), chimpanzees (Olupot & Sheil 2011, Hicks et al. 2012), four species of ungulates and black-backed jackals (Newmark et al. 1996 *in* Epps et al. 2015). Several recent roadkill studies (Kioko et al. 2015a, 2015b, Njovu et al. 2019, Chem Chem Association 2019) have documented significant mortality on the A104 highway that bisects the Kwakuchinja corridor between Tarangire and Lake Manyara National Parks. Roads fragment large habitat areas into smaller, isolated habitat patches, which support fewer individuals. Small isolated populations lose genetic diversity and are at risk of local extinction.

Railroads share many of the deleterious effect of highways (Messenger 1968, Niemi 1969, Klein 1971, Stapleton and Kiviat 1979, Muehlenbach 1979, Lienenbecker and Raabe 1981, Forman 1995, Dorsey et al. 2015, Barrientos and Borda-de-Água 2017), though the full ecological impacts of trains on wildlife are incomplete (Dorsey et al. 2015). Research has focused on quantifying the rates of wildlife-train collisions and the factors influencing it (Seiler & Helldin 2005, Dorsey et al. 2015). Most studies have focused on large mammals, especially species with special conservation status or economic value, such as elephants, that can cause significant damage to trains (Dorsey et al. 2015). Railways can also be significant impediments to smaller species, such as turtles, that are unable to climb over the tracks (e.g., Kornilev et al. 2006, Dorsey et al. 2015).

Other linear infrastructure, such as above-ground pipelines, can also be impediments to wildlife movement. Above-ground pipelines have been documented to exacerbate declines of large-bodied species, such as caribou, by restricting their movements (Curatolo and Murphy 1986, Lawhead et al. 2006, Canada 2012, Muhly et al. 2015). Increased barrier effects have been documented for several species when there are multiple linear impediments (e.g., railways, roads, pipelines) to wildlife movement (Skogland 1986, Vos et al. 2001, Waller and Servheen 2005, Dorsey et al. 2015, Barrientos and Borda-de-Água 2017).

Roads and railways fragment populations by acting as semi-permeable to impermeable barriers for non-flying animals (e.g., insects, fish, amphibians, reptiles, and mammals) and even some flying species (e.g., butterflies and low-flying birds), while above-ground pipelines primarily limit movements of larger species. The resulting demographic and genetic isolation increase the extinction risk for populations (Gilpin and Soulé 1986). For rare species, such as black rhino, cheetah, lion and African wild dog, isolation into separate sub-populations would be detrimental to population persistence (Gadd 2015). Smaller populations are more susceptible to extinction due to demographic and environmental stochasticity.

Roads, railways, or other linear infrastructure can affect long-distance movements, dispersal and seasonal migration, which can have significant and far-reaching consequences (Gadd 2015). This is especially true for wide-ranging species that disperse long distances, such as critically endangered elephants and wild dogs, which are known to traverse roads and are therefore at risk of wildlife-vehicle collisions (Gadd 2015, Whittington-Jones and Davies-Mostert 2015). Elephants still make long-distance movements between the Ruaha, Udzungwa and Selous–Mikumi ecosystems but apparently cross the paved Tanzania–Zambia Highway in only a few locations (Jones et al. 2009, Epps et al. 2011, Epps et al. 2015). Southern Tanzania Elephant Program (2019) has been diligently working with local communities for many years to ensure that development associated with the highway doesn't sever the only known route for dispersal and gene flow across this large region.

Some species may be attracted to roads and railways. Yellow baboons pick up garbage thrown from passing vehicles on the Tanzania–Zambia Highway between Mikumi National Park and Iringa and feed on rice that falls off passing vehicles in the Kilombero Valley (Gupfinger 2012, Epps et al. 2015). Thus, opportunistic species, such as baboons, may be even more affected by roadkill (Drews 1995, Epps et al. 2015). Similarly, agricultural products spilled from trains along railway tracks can increase wildlife collisions with trains (Huber et al. 1998, Wells et al. 1999, Waller & Servheen 2005, and Dorsey et al. 2015). Herbivores are often struck by trains because they tend to be attracted to forage along railway alignments (Andersen et al. 1991, Dorsey et al. 2015). Most documented road impacts on animal movement concern paved roads. Dirt roads may actually facilitate movement of some species, such as wild dog (Whittington-Jones 2011, Whittington-Jones and Davies-Mostert 2015), while adversely impacting other species, such as snakes that sun on them and may be crushed even by infrequent traffic.

In addition to these obvious effects, roads and railways create noise and vibration that can interfere with the ability of reptiles, birds, and mammals to communicate, detect prey, or avoid predators. Roads also increase the spread of exotic plants, promote erosion, create barriers to fish, and pollute water sources with chemicals (Forman et al. 2003). Highway lighting also has important impacts on nocturnally active species (Rich and Longcore 2006).

Human settlement rates typically increase after roads are built, facilitating extraction of bushmeat, charcoal, timber, and other resources (Laurance et al. 2006, Brugiere & Magassouba 2009, Epps et al. 2015). Martin et al. (2019) evaluated land use changes in the Kwakuchinja wildlife corridor between Tarangire and Lake Manyara National Parks and found most of the habitat conversion to agriculture occurred along the A104 road that was paved in 2005. Human–wildlife conflicts also increase and are more common along roads (Sitati et al. 2003, Wato et al. 2006, Maingi et al. 2012, Epps et al. 2015).

Avian collisions with transmission lines are a significant impediment (Jenkins et al. 2010, Quinn et al. 2011, Barrientos et al. 2012, Rioux et al. 2013, Luzenski et al. 2016). Power lines that bisect avian movement corridors can cause substantial avian collisions (Bevanger and Brøseth 2004, Stehn and Wassenich 2008, APLIC 2012), with dramatically increased risks of collision in low light, fog, and inclement weather (Savereno et al. 1996, APLIC 2012, H¨uppop and Hilgerloh 2012, Luzenski et al. 2016). Birds that fly in flocks, or are large heavy-bodied species, such as flamingos, cranes, bustards, waterfowl, shorebirds, gamebirds, and diurnal raptors have a higher risk of collision (Jenkins et al. 2010, APLIC 2012). Birds appear to detect large-diameter energized wires (conductors) on transmission lines and avoid them by adjusting flight altitudes upward, subsequently colliding with smaller-diameter, less-visible overhead shield wires that are used for lightning protection (Jenkins et al. 2010, APLIC 2012). For example, across 3 studies, 72% of 373 observed collisions were with overhead shield wires (Faanes 1987, Pandey et al. 2008, Murphy et al. 2009, Luzenski et al. 2016).

Assessment Approach: The assessment team (i) downloaded and assembled spatial data for roads and railways from OpenStreetMap (http://download.geofabrik.de/africa.html) for Tanzania and each country within the analysis extent (ii) acquired spatial data for Tanzania's electricity grid from Tanzania Electric Supply Company Limited (TANESCO), including data for existing transmission lines and those planned or currently under construction (http://www.tanesco.co.tz/); and (iii) created spatial data to represent two other planned major infrastructure projects, including upgrades and extensions to the Tanzania Standard Gauge Railway (https://www.tanzaniainvest.com/?s=Tanzania+Standard+Gauge+Railway) and the Hoima-Tanga Oil Pipeline (http://eacop.com/the-route/route-description-map/) (Figure 15).

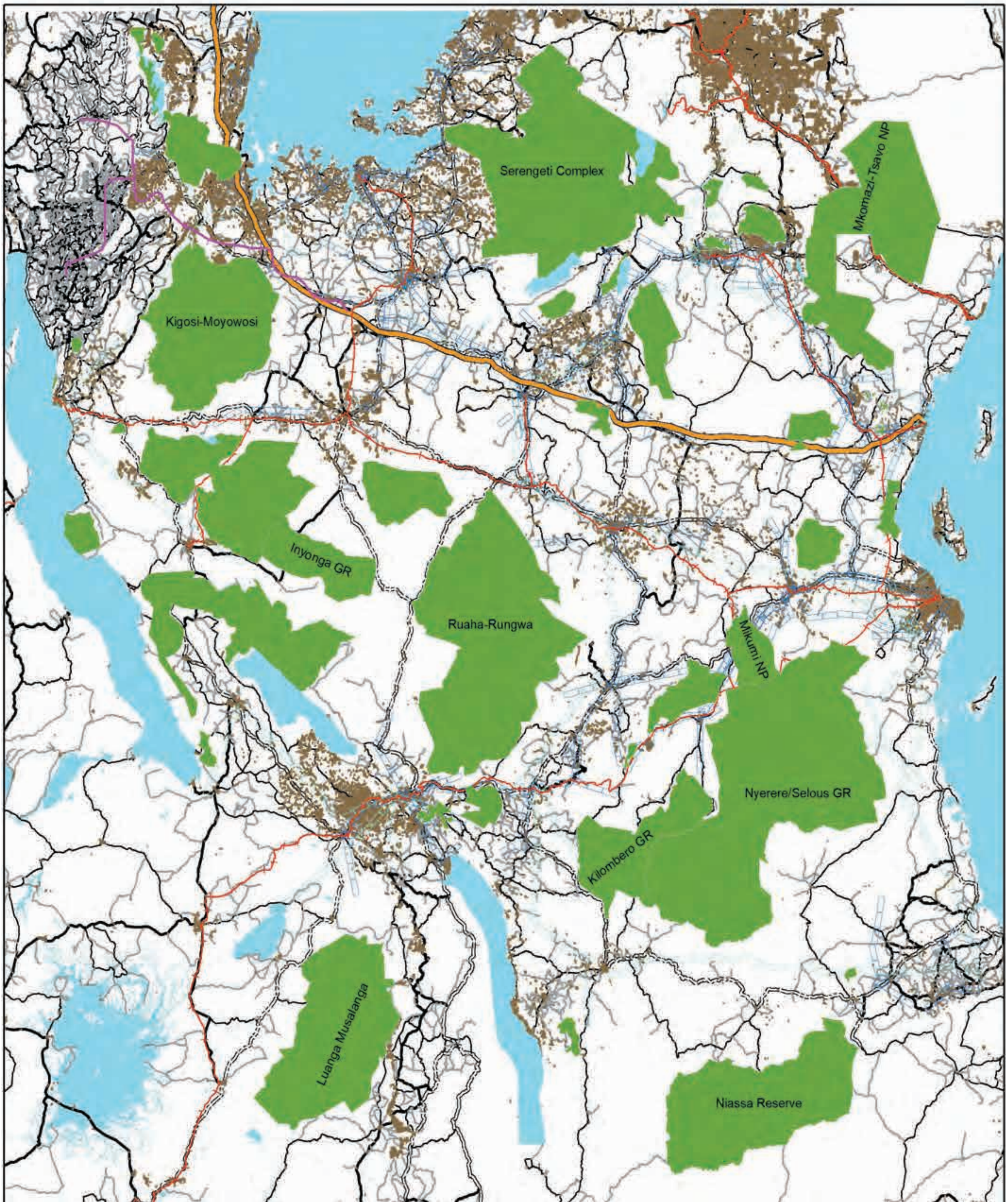


Figure 15. Existing and Planned Infrastructure in the Analysis Extent

- Motorway
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Trunk Roads
- Residential Roads
- Railways
- Railways (Planned)
- Target Protected Areas
- Hoima Tanga Pipeline (Planned)
- Transmission Line Under Construction (Planned)
- Existing Transmission Line

This map was used to support the assessment and prioritization of wildlife corridors important to maintaining Tanzania's rich natural heritage.

0 45 90 180 270 360 Kilometers

To analyze the data, the team (i) combined spatial features for planned and existing infrastructure and (ii) conducted a linear infrastructure density analysis for all corridors by calculating the number of kilometers of paved roads/railways/pipelines/etc. per square kilometer inside each corridor. The team then used Jenks natural breaks to classify the results across all corridors into five classes and assigned points as follows.

Point Scores:
20 = 0.502977 - 0.827647 kilometers of linear infrastructure per square kilometer
15 = 0.210401 - 0.298975 kilometers of linear infrastructure per square kilometer
10 = 0.099154 - 0.144486 kilometers of linear infrastructure per square kilometer
5 = 0.044493 - 0.081795 kilometers of linear infrastructure per square kilometer
1 = 0 – 0.036104 kilometers of linear infrastructure per square kilometer

Results: Several transportation and infrastructure projects are planned in Tanzania that have the potential to impact wildlife movement. The assessment team conducted a linear infrastructure density analyses that included not only existing roads, railways, and transmission lines but also proposed infrastructure projects. For railways, there are planned improvements to the existing Standard Gauge Railway from Dar es Salaam to Tabora and north to Isaka, and then a new railway route from Isaka to Keza. The team created spatial data to represent the Standard Gauge Railway extension to Keza, as well as the Hoima Tanga Pipeline which is expected to bisect several wildlife corridors. In addition to Tanzania's locally planned transportation improvement efforts, the East African Community (EAC) has identified five strategic transportation corridors (a total length of about 12,000 km) that require rehabilitation and upgrading (https://www.eac.int/infrastructure/road-transport-sub-sector). Two of the five major transport corridors in East Africa are in Tanzania: (1) Dar es Salaam - Rusumo with branches to Kigali, Bujumbura and Masaka; and (2) Tunduma - Dodoma - Namanga - Isiolo – Moyale, which is part of the Trans African Highway – from Cairo to Gaborone (Cape Town) passes through Tanzania. Tanzania also hosts one of only two primary transit corridors that facilitate import and export activities in East Africa, the Central Corridor (1,300 km long), which begins at the port of Dar es Salaam and serves Tanzania, Zambia, Rwanda, Burundi, Uganda and Eastern Democratic Republic of Congo. Figure 15 depicts the linear infrastructure features that were factored into our analysis, including many trunk roads that are currently unpaved but are shown as planned for upgrades on the EAC site.

The purpose of this analysis was to evaluate the relative ecological integrity of the delineated wildlife corridors with respect to linear infrastructure. Since roadways into wildlands typically encourage further habitat conversion, and are a key signature of the human imprint on the natural environment, it was important to take a snapshot of current infrastructure in the corridors as part of the assessment to gauge overall threat to habitat integrity.

The team conducted a linear infrastructure density analysis across the entire analysis extent and calculated the number of kilometers of existing or proposed paved roads, railways, pipelines, and transmission lines per square kilometer inside each corridor (Figure 16 and Table 14). While the average road density for all 61 corridors is less than 1 km per square kilometer, there are several corridors that have quite high road density in some areas. For example, all three major corridors leading to Gombe Stream have maximum road densities above 6 km per square kilometer (km/km^2). Mahale Mountains – Gombe Stream has the highest max at 11.7847 km per square kilometer, followed by Gombe Stream – Uvinza at 8.4213 km/km^2, and Gombe Stream – Rukamabasi at 6.4308 km/km^2**.** Other corridors with max densities above 6 km/km2 include Burigi Chato – Kigosi Moyowosi (6.0887 km/km^2), Loazi – Luanga Musalanga (7.8437 km/km^2), and Akagera – Rumanyika (8.8290 km/km^2).

For the most part, the great majority of the corridors in the network have fairly low road densities (Table 14). However, most corridors are bisected by at least one or two major roads creating significant impediments to wildlife movement. Several roadkill studies have been conducted in the wildlife corridor between Tarangire Complex and Lake Manyara and have documented several hotspots with multiple wildlife-vehicle collisions (Chem Chem 2019, Njovu et al. 2019). While the great majority of the corridors have relatively low road and infrastructure density, all it takes is one high-speed route to create an impediment to wildlife passage for wide-ranging species and or barrier-sensitive species.

Since the opening of the first section of tarmac on the road from Koga to Inyonga, ADAP has recorded roadkill of a leopard and African wild dog.

As noted, transportation improvement projects are planned for several unpaved trunk roads that pass through critical wildlife movement corridors (URT 2016). Some of these projects are already being implemented, such as the trunk road from Koga to Inyonga. Roadkill of two wide-ranging species, African wild dog and leopard, has already been documented on this recently paved trunk road. This transportation project was implemented without factoring in wildlife movement or safe passage for wildlife or motorists through the corridors between Ruaha Rungwa – Wembere, Ruaha Rungwa – Inyonga, and Ruaha Rungwa – Katavi Complex, and requires remediation (see section 5.5 Mitigating and Remediating Impact of Roads and Infrastructure). While the best time to factor in wildlife crossings is during the design and construction phases of a project, a series of speed bumps, signage, and camera traps along this stretch of road could remedy this situation for relatively low cost.

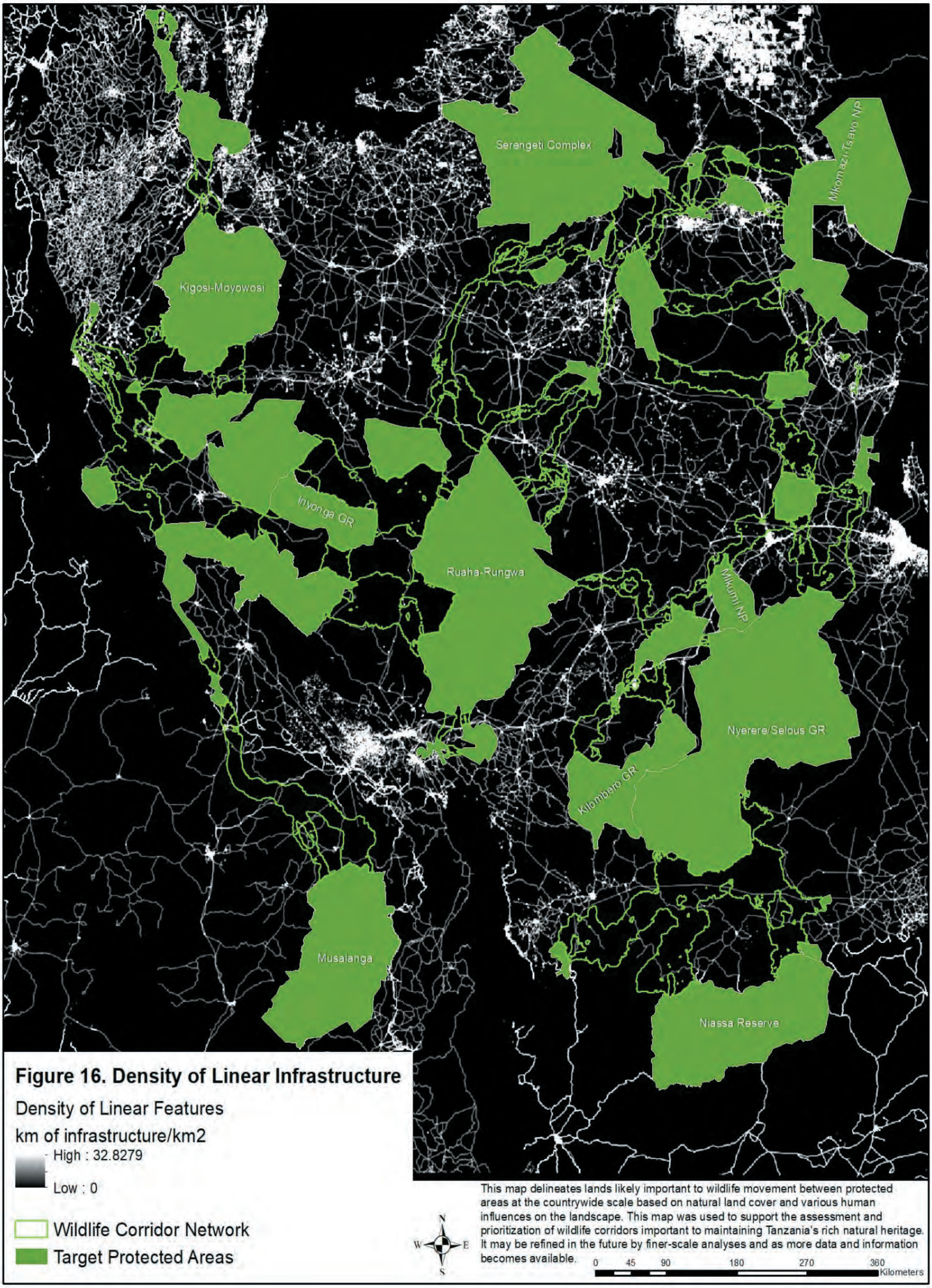


Figure 16. Density of Linear Infrastructure

Table 14. Results of linear infrastructure density analysis and resulting threat scores for this criterion

Wildlife Corridor Assessed	Corridor Area km^2	Kilometers of linear infrastructure	Kilometers of linear infrastructure per km2	Average Density	Median	Maxi-mum	Range	Linear Density Score
Akagera - Rumanyika Karagwe	55.98	31.812	0.5683	0.503	0	8.829	8.829	20
Amani - Nilo	57.43	2.515	0.0438	0.0361	0	0.7267	0.7267	1
Amboseli - Mkomazi Tsavo	1776.12	31.154	0.0175	0.0192	0	1.3042	1.3042	1
Arusha - Longido	299.45	37.548	0.1254	0.1315	0	1.2271	1.2271	10
Baga – Kisima Gonja	22.73	5.588	0.2458	0.2943	0	1.0308	1.0308	15
Burigi Chato - Akagera	61.76	0.183	0.0030	0	0	0	0	1
Gombe Stream - Rukamabasi	316.43	254.083	0.8030	0.8276	0.3155	6.4308	6.4308	20
Gombe Stream - Uvinza	861.26	228.409	0.2652	0.2606	0	8.4213	8.4213	15
Ibanda - Rumanyika Karagwe	182.12	112.389	0.6171	0.6313	0.2867	3.9843	3.9843	20
Katavi Complex - Inyonga	1033.5	0.000	0.0000	0	0	0	0	1
Katavi Complex – Loazi Lungu	410.29	9.024	0.0220	0.0232	0	0.9064	0.9064	1
Katavi Complex - Ugalla Complex	2009.31	76.399	0.0380	0.0458	0	1.2755	1.2755	5
Kigosi Moyowosi – Burigi Chato	1415.06	312.053	0.2205	0.2329	0	6.0887	6.0887	15
Kigosi-Moyowosi - Ugalla Complex	1835.55	101.397	0.0552	0.0565	0	1.82	1.82	5
Kigosi-Moyowosi - Uvinza	1950.89	113.501	0.0582	0.0594	0	3.8524	3.8524	5
Kilimanjaro - Amboseli	447.07	32.703	0.0732	0.0694	0	2.0482	2.0482	5
Kilimanjaro - Arusha	191.03	39.243	0.2054	0.2104	0	1.0598	1.0598	15
Kilimanjaro - Longido	454.53	34.502	0.0759	0.0756	0	1.189	1.189	5
Kilimanjaro – Mkomazi Tsavo	323.65	160.602	0.4962	0.5036	0.0111	3.7708	3.7708	20
Kilombero - Udzungwa	1419.21	97.468	0.0687	0.0716	0	2.634	2.634	5
Kilombero - Uzungwa Scarp	1884.8	155.841	0.0827	0.0804	0	1.9101	1.9101	5
Kitulo Rungwe – Mpanga Kipengere	133.2	19.976	0.1500	0.1445	0	1.2702	1.2702	10
Lake Manyara - Yaeda chini	461.65	9.779	0.0212	0.0232	0	1.137	1.137	1
Loazi – Luanga Musalanga	8235.86	429.127	0.0521	0.0519	0	7.8437	7.8437	5
Longido - Amboseli	433.16	26.646	0.0615	0.0546	0	0.9548	0.9548	5
Mahale Mountains - Gombe Stream	6813.81	719.619	0.1056	0.1094	0	11.785	11.785	10
Mahale Mountains - Katavi Complex	1772.13	48.162	0.0272	0.0283	0	0.8064	0.8064	1
Mahale Mountains - Ugalla Complex	4421.71	309.946	0.0701	0.068	0	1.9333	1.9333	5
Mikumi - Wami Mbiki	2191.86	272.706	0.1244	0.1254	0	3.7326	3.7326	10
Mkomazi-Tsavo - Handeni	1293.55	166.597	0.1288	0.1272	0	2.4067	2.4067	10
Msanjesi – Lukwika Lumsule	1951.89	106.286	0.0545	0.0535	0	1.2618	1.2618	5
Nyerere Selous - Liparamba	10300.5	315.787	0.0307	0.0315	0	1.144	1.144	1
Nyerere Selous - Niassa	16598.5	431.200	0.0260	0.0265	0	1.7695	1.7695	1

Wildlife Corridor Assessed	Corridor Area km^2	Kilometers of linear infrastructure	Kilometers of linear infrastructure per km2	Average Density	Median	Maxi-mum	Range	Linear Density Score
Nyerere Selous - Saadani	2969.1	296.445	0.0998	0.0992	0	1.9282	1.9282	10
Nyerere-Selous - Udzungwa	121.03	26.659	0.2203	0.299	0	2.2293	2.2293	15
Nyerere-Selous - Wami Mbiki	2158.9	169.568	0.0785	0.0818	0	1.8099	1.8099	5
Ruaha Rungwa - Inyonga	3110.35	66.934	0.0215	0.0173	0	0.9018	0.9018	1
Ruaha-Rungwa - Katavi Complex	8140.75	95.733	0.0118	0.0116	0	1.1886	1.1886	1
Ruaha-Rungwa – Kitulo Rungwe	344.09	51.163	0.1487	0.1436	0	2.4184	2.4184	10
Ruaha-Rungwa - Mpanga-Kipengere	147.05	1.364	0.0093	0.0151	0	1.6141	1.6141	1
Ruaha Rungwa - Swaga Swaga	4621.2	268.907	0.0582	0.0584	0	2.3329	2.3329	5
Ruaha Rungwa - Udzungwa	2447.25	129.284	0.0528	0.052	0	1.8076	1.8076	5
Ruaha Rungwa - Wembere	2388.44	28.107	0.0118	0.0107	0	0.6476	0.6476	1
Ruaha Rungwa - Yaeda chini	4797.68	211.774	0.0441	0.0445	0	1.7541	1.7541	5
Serengeti Complex - Arusha	670.75	48.719	0.0726	0.0755	0	1.1037	1.1037	5
Serengeti Complex - Lake Manyara	1218.14	92.587	0.0760	0.074	0	2.6693	2.6693	5
Serengeti Complex - Longido	705.91	50.652	0.0718	0.0758	0	1.2589	1.2589	5
Serengeti Complex - Ta-rangire Complex	2918.31	288.264	0.0988	0.0966	0	3.1644	3.1644	5
Serengeti Complex - Wembere	3412.07	115.660	0.0339	0.0332	0	1.2748	1.2748	1
Serengeti Complex - Yae-da chini	602.26	27.398	0.0455	0.0491	0	0.6617	0.6617	5
Tarangire Complex - Arusha	903.63	102.270	0.1132	0.111	0	1.2854	1.2854	10
Tarangire Complex - Handeni	3675.07	124.342	0.0338	0.034	0	1.242	1.242	1
Tarangire Complex- Lake Manyara	555.75	59.262	0.1066	0.1131	0	3.0174	3.0174	10
Tarangire Complex - Mkomazi-Tsavo	3608.98	216.399	0.0600	0.0611	0	2.6651	2.6651	5
Tarangire Complex - Swa-ga Swaga	651.8	184.612	0.2832	0.276	0	3.8623	3.8623	15
Udzungwa – Mikumi	852.93	44.192	0.0518	0.0508	0	0.8192	0.8192	5
Udzungwa - Uzungwa Scarp	242.13	4.274	0.0176	0.0346	0	1.604	1.604	1
Ugalla Complex - Uvinza	633.91	2.823	0.0045	0.013	0	0.7007	0.7007	1
Ugalla Complex - Wembere	5498.5	85.623	0.0156	0.0154	0	0.6837	0.6837	1
Wami Mbiki - Handeni	3288.04	151.368	0.0460	0.0478	0	1.6685	1.6685	5
Wami Mbiki - Saadani	593.85	29.170	0.0491	0.0523	0	1.409	1.409	5

3.4.4 Threats to the Corridor from Invasive Species

Invasive species are non-native organisms that spread quickly in natural habitats. They threaten wildlife and native ecosystems in many ways. The ecosystems they invade often do not have natural predators or other controls that can keep their populations in check, so they frequently outcompete native plants and animals for food and other resources. Invasive species also may prey on native species, prevent native species from reproducing, and spread diseases among native populations. In addition, invasive species can significantly alter fundamental processes in an ecosystem. They can alter food webs—e.g., destroying or replacing native food sources—change the chemistry of the soil, and change the frequency and intensity of wildfires (Molles 2008).

Recognizing the many threats that invasive species pose to wildlife and native ecosystems, Tanzania's national government convened experts from across the country in 2018-2019 and produced a National Strategy and Action Plan to Manage Invasive Species (NSAMIS) (Vice President's Office 2019). The NSAMIS lists more than 200 invasive species that have the potential to threaten the country's economy, biodiversity, and physical environment, and it identifies species that are the highest priority for management in various sectors.

Assessment Approach: The NSAMIS lists 38 priority invasive species that are known to threaten wildlife and forest ecosystems in Tanzania. Using this list of 38 species and a dataset from the Centre for Agriculture and Biosciences International focused on Africa Invasive and Alien species (Witt and Beal 2018), the assessment team (i) imported spatially explicit occurrence data for 35 of the 38 species for which spatial data were available, (ii) overlaid that data layer with a map of all the corridors buffered by 2 kilometers in this study, and (iii) summed the total number of invasive species occurrences for each corridor. The team classified the results into five classes using natural breaks in the data. Corridors where invasive species are more prevalent received higher scores.

Point Scores:
10 = 52 – 80 invasive species occurrences
8 = 27 – 51 invasive species occurrences
6 = 11 – 26 invasive species occurrences
4 = 4 – 10 invasive species occurrences
2 = 0 – 3 invasive species occurrences

Results: The priority invasive species have not been recorded in all the delineated wildlife corridors in the network. They have been documented in 61% (37/61) of the corridors. Mahale Mountains – Gombe Stream had the absolute highest invasive species count (80), far and above all the other corridors. The next five corridors with the highest recorded occurrences of these priority invasive species include all corridors associated with the Tarangire Complex (Figure 17 and Table 15).

It should be noted that the invasive species survey data included in this analysis were almost exclusively collected along major roadways. While roadways are one of the main pathways for invasive species invasions, the available dataset does not capture the full extent of these non-native species distributions in Tanzania. The assessment team sought to incorporate plant occurrence data from Tanzania's Biodiversity Information Management Tool into this analysis but was not able to attain the spatial data. Future efforts to assess threats from invasive species in the wildlife corridor network should seek to connect with local botanists to attain a more comprehensive dataset of recorded occurrences of invasive species.

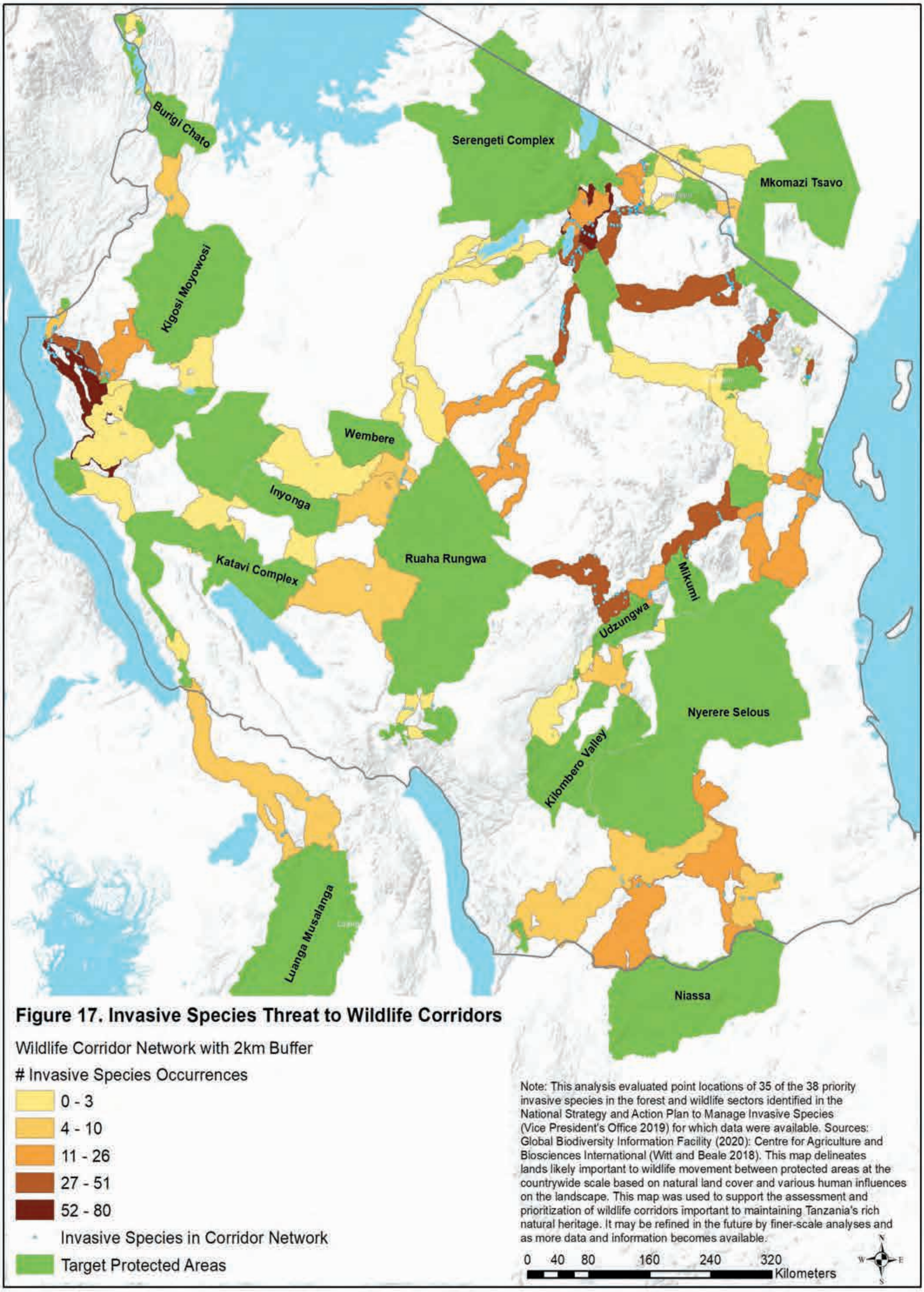


Figure 17. Invasive Species Threat to Wildlife Corridors

Table 15. Occurrences of priority invasive species in the corridors

Wildlife Corridor Assessed	Invasives Count	Invasives Score
Arusha - Longido	3	2
Baga - Kisima Gonja	1	2
Kilimanjaro - Arusha	1	2
Nyerere Selous - Udzungwa	3	2
Ruaha Rungwa - Mpanga Kipengere	1	2
Ruaha Rungwa - Yaeda chini	2	2
Gombe Stream - Mukungu Rukamabasi (Burundi)	10	4
Kigosi Moyowosi - Burigi Chato	6	4
Kilimanjaro - Mkomazi Tsavo (Kenya)	6	4
Kilombero - Udzungwa	4	4
Loazi - Luanga Musalangu (Zambia)	10	4
Msanjesi - Lukwika Lumesure	6	4
Nyerere Selous - Liparamba	10	4
Ruaha Rungwa - Inyonga	6	4
Ruaha Rungwa - Kitulo Rungwe	5	4
Ruaha Rungwa - Wembere	10	4
Kigosi Moyowosi - Uvinza	19	6
Nyerere Selous - Niassa (Mozambique)	21	6
Nyerere Selous - Wami Mbiki	26	6
Nyerere Selous - Saadani	22	6
Ruaha Rungwa - Swaga Swaga	25	6
Serengeti Complex - Arusha	20	6
Serengeti Complex - Lake Manyara	17	6
Serengeti Complex - Longido	21	6
Udzungwa - Mikumi	19	6
Wami Mbiki - Saadani	16	6
Amani - Nilo	33	8
Gombe Stream - Uvinza	29	8
Mikumi - Wami Mbiki	30	8
Mkomazi Tsavo (Kenya) - Handeni	32	8
Ruaha Rungwa - Udzungwa	33	8
Tarangire Complex - Arusha	43	8
Tarangire Complex - Swaga Swaga	37	8
Tarangire Complex- Lake Manyara	37	8
Tarangire Complex - Mkomazi Tsavo (Kenya)	51	8
Mahale Mountains - Gombe Stream	80	10
Serengeti Complex - Tarangire Complex	64	10

3.4.5 Human-Wildlife Conflict Severity in the Corridor Area

The majority of Tanzania's growing population lives in rural areas and are dependent on subsistence farming, resulting in a growing demand for agricultural and grazing land, expanding settlement into formerly wild areas, and increasing human-wildlife conflicts (HWC). HWC are most prevalent within or directly adjacent to wildlife habitats, such as protected areas, wildlife corridors, dispersal areas, and along waterways. According to the National HWC Strategy (MNRT 2020), "Impacts of HWC on people include crop loss, livestock depredation, injury and loss of life, damage to property such as fishing gear and water sources, and social costs such as increased time spent guarding farms, limitations on mobility, and reduced school attendance (Hoare 2000, Lamarque et al. 2009). Impacts of HWC on wildlife include retaliatory or problem-animal-control killing of wildlife, reduced community support for conservation, tolerance for poaching, and disputes between protected area managers and communities (Hoare 2000, Treves et al. 2006, Lamarque et al. 2009)." HWC can have important implications for conservation of the wildlife involved, especially carnivores and large herbivores, as their survival is increasingly dependent on their tolerance by people (Treves et al. 2006, MNRT 2020).

Tanzania's National Human-Wildlife Conflict Management Strategy (MNRT 2020) further states that wildlife corridors are an "essential tool for enhancing human-wildlife coexistence over the long term. Complex land tenure arrangements and lack of management of wildlife corridors are some of the key drivers of human-wildlife conflicts. Unregulated or poorly planned development in wildlife corridors inevitably leads to increased crop losses, livestock losses, endangerment of human lives, and other economic and social disruption. Species such as elephants have knowledge of migratory routes that are passed down from generation to generation, and continue to attempt to move along these paths even when they are blocked by farmland, settlements or infrastructure, creating conflict hotspots."

Assessment Approach: Tanzania Wildlife Management Authority (TAWA) collects data on HWC throughout the country. The TAWA HWC data may not capture the full extent of HWC incidences across Tanzania but it was the best available countrywide dataset. Using this dataset from TAWA, supplemented by HWC data from the Southern Tanzania Elephant Program (STEP) for Kilombero District not captured in the TAWA data, the assessment team (i) summed the total number of HWC incidents from 2017 through 2020 by District, (ii) joined this data to the spatial boundaries of the Districts to create a HWC data layer (Figure 18), (iii) overlaid that data layer with a map of all the corridors in this study, and (iii) generated a list of Districts that intersect each corridor and calculated the total number of HWC incidents across all overlapping Districts. For example, if there were three Districts that overlap a particular corridor, the analysis generated a list of the names of those Districts and the total number of HWC incidents across those 3 Districts. The team classified the results into five classes using natural breaks in the data. Corridors where HWC are more severe received higher scores.

Point Scores:
20 = 2229 – 3100 HWC incidents
15 = 2228 – 813 HWC incidents
10 = 117 – 812 HWC incidents
5 = 44 – 116 HWC incidents
1 = 0 – 43 HWC incidents

Results: The total number of HWC incidents between 2017 and 2020 was 29,798 incidents across all Districts that intersect the wildlife corridor network. All but seven of the wildlife corridors had at least one HWC incident. The two corridors that overlap Districts with the highest number of incidents are Mikumi – Wami Mbiki with 3,100 and Wami Mbiki – Handeni with 2,769 incidents (Figure 19 and Table 16). Other corridors that overlap Districts with significant human-wildlife conflict are the three connections to the south of Nyerere Selous with the corridor to Niassa having 2,228 incidents, the corridor to Liparamba having 2,201 incidents, and corridor between Msanjesi - Lukwika Lumesule having 1,784 incidents. Further north, two corridors that largely overlap one another, Serengeti Complex – Tarangire Complex and Tarangire Complex – Lake Manyara, also overlap Districts that have considerable numbers of human-wildlife conflicts. The Ruaha Rungwa – Swaga Swaga, a highly constrained corridor through the central part of the country, also overlaps Districts with significant numbers of HWC.

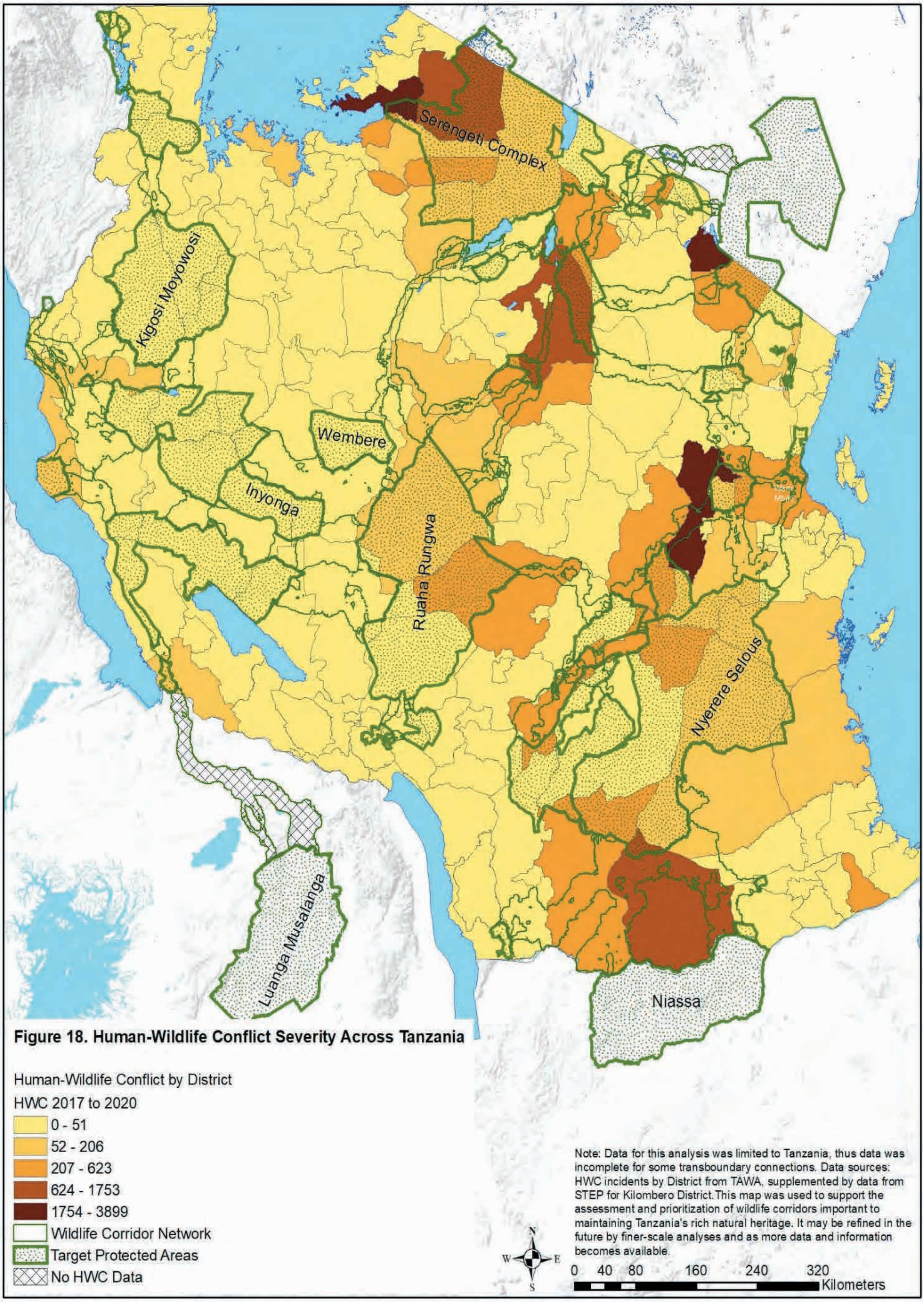


Figure 18. Human-Wildlife Conflict Severity Across Tanzania

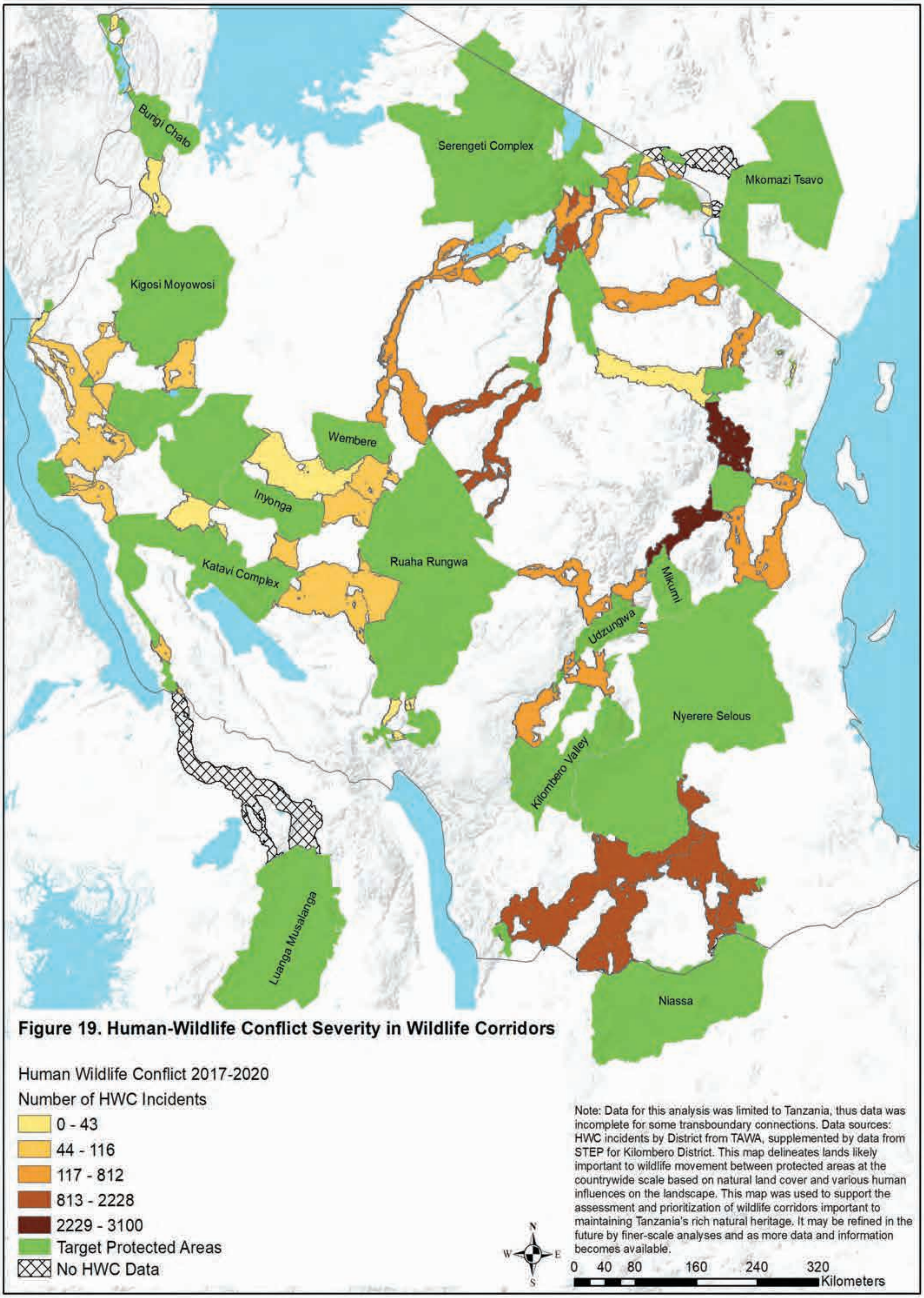


Figure 19. Human-Wildlife Conflict Severity in Wildlife Corridors

Table 16. Human-Wildlife Conflict Incidents by District 2017-2020 (source: TAWA, STEP)

Wildlife Corridor Assessed	HWC Incidents 2017-2020	HWC Threat Score	# of Districts
Akagera (Rwanda) - Rumanyika Karagwe	0	1	1
Amani - Nilo	0	1	2
Arusha - Longido	58	5	3
Baga - Kisima Gonja	0	1	1
Burigi Chato - Akagera (Rwanda)	6	1	1
Gombe Stream - Mukungu Rukamabasi (Burundi)	0	1	2
Gombe Stream - Uvinza	79	5	5
Ibanda - Rumanyika Karagwe	0	1	1
Katavi Complex - Inyonga	63	5	3
Katavi Complex - Loazi Lungu	84	5	2
Katavi Complex - Ugalla Complex	36	1	2
Kigosi Moyowosi - Burigi Chato	0	1	3
Kigosi Moyowosi - Ugalla Complex	79	5	3
Kigosi Moyowosi - Uvinza	93	5	4
Kilimanjaro - Amboseli (Kenya)	437	10	3
Kilimanjaro - Arusha	408	10	2
Kilimanjaro - Longido	394	10	2
Kilimanjaro - Mkomazi Tsavo (Kenya)	43	1	2
Kilombero - Udzungwa	408	10	1
Kilombero - Uzungwa Scarp	388	10	3
Kitulo Rungwe - Mpanga Kipengere	0	1	1
Lake Manyara - Yaeda Chini	76	5	2
Loazi - Luanga Musalangu (Zambia)	63	5	1
Longido - Amboseli (Kenya)	19	1	1
Mahale Mountains - Gombe Stream	95	5	7
Mahale Mountains - Katavi Complex	93	5	2
Mahale Mountains - Ugalla Complex	93	5	2
Mikumi - Wami Mbiki	3100	20	4
Mkomazi Tsavo - Handeni	512	10	5
Msanjesi - Lukwika Lumesule	1784	15	4
Nyerere Selous - Liparamba	2201	15	6
Nyerere Selous - Niassa (Mozambique)	2228	15	5
Nyerere Selous - Saadani	541	10	4
Nyerere Selous - Udzungwa	388	10	1
Nyerere Selous - Wami Mbiki	538	10	3
Ruaha Rungwa - Inyonga	83	5	2
Ruaha Rungwa - Katavi Complex	116	5	4
Ruaha Rungwa - Kitulo Rungwe	33	1	3
Ruaha Rungwa - Mpanga Kipengere	33	1	1
Ruaha Rungwa - Swaga Swaga	1399	15	6
Ruaha Rungwa - Udzungwa	812	10	4
Ruaha Rungwa - Wembere	83	5	2
Ruaha Rungwa - Yaeda Chini	407	10	10
Serengeti Complex - Arusha	675	10	4
Serengeti Complex - Lake Manyara	674	10	2
Serengeti Complex - Longido	642	10	2
Serengeti Complex - Tarangire Complex	1865	15	5
Serengeti Complex - Wembere	418	10	10
Serengeti Complex - Yaeda Chini	310	10	4
Tarangire Complex - Arusha	623	10	2
Tarangire Complex - Handeni	11	1	4
Tarangire Complex - Lake Manyara	1781	15	3

Wildlife Corridor Assessed	HWC Incidents 2017-2020	HWC Threat Score	# of Districts
Tarangire Complex - Mkomazi Tsavo (Kenya)	385	10	2
Tarangire Complex - Swaga Swaga	2124	15	3
Udzungwa - Mikumi	549	10	2
Udzungwa - Uzungwa Scarp	437	10	2
Ugalla Complex - Uvinza	93	5	2
Ugalla Complex - Wembere	36	1	2
Wami Mbiki - Handeni	2769	20	5
Wami Mbiki - Saadani	353	10	1

3.5 Prioritized Wildlife Corridors List and Summary

Table 17 provides a prioritized list of all 61 wildlife corridors considered for this assessment, based on conservation value and vulnerability. Highlighted in different shades of green are the top 1-5, 6-10, 11-15, and 16-20 corridors with the highest scores for conservation value. According to the assessment, based on stakeholder-determined criteria for conservation value, these are the top 20 corridors (Figure 20). Note that there is a high degree of variation in the vulnerability scores of the top 20 corridors (Table 17). A few of the top 20 for conservation value are also among the most vulnerable, but several of the top 20 for conservation value have much lower vulnerability scores. Vulnerability scores in Table 17 have been color-coded to signify relative level of threat (red=high, orange=medium, yellow=low). It should be noted that the Serengeti Complex - Lake Manyara corridor, which ranked 7th in terms of conservation value, is entirely encompassed within the corridor delineated between the Serengeti Complex – Tarangire Complex; thus, an additional corridor was added to the top 20, as explained below. Table 17 and Figure 20 also highlight 7 additional corridors that were elevated by Wildlife Division to be among the first corridors to be secured to ensure the ecological integrity of Tanzania's existing protected areas.

Table 17. Wildlife corridors prioritized based on conservation value from highest to lowest with vulnerability scores color-coded to signify relative level of threat (red = high, orange = medium, yellow = low). Wildlife Division Priority Corridor Additions highlighted in green text.

Wildlife Corridors Assessed sorted by Conservation Value Score	Conservation Value Score	Vulnerability Score
Ruaha Rungwa - Udzungwa	90	48
Ruaha Rungwa - Katavi Complex	87	17
Serengeti Complex - Tarangire Complex* *completely captures Serengeti – Lake Manyara & Tarangire Complex – Lake Manyara corridors*	86	55
Kilombero - Udzungwa Mountains	85	49
Nyerere Selous - Niassa (Mozambique)	85	37
Nyerere Selous - Wami Mbiki	83	41
Serengeti Complex - Lake Manyara*	82	36
Nyerere Selous - Saadani	80	46
Serengeti Complex - Longido	80	36
Udzungwa - Mikumi	80	36
Kigosi Moyowosi - Burigi Chato	79	45
Kilombero - Uzungwa Scarp	79	26
Mkomazi Tsavo - Handeni	78	53
Mahale Mountains - Ugalla Complex	78	21
Udzungwa - Uzungwa Scarp	77	36
Serengeti Complex - Wembere	76	36
Mahale Mountains - Katavi Complex	76	17
Katavi-Complex - Ugalla Complex	75	17
Ruaha Rungwa - Inyonga	75	21
Nyerere Selous - Liparamba	74	31
Ruaha Rungwa - Wembere	73	21

Wildlife Corridors Assessed sorted by Conservation Value Score	Conservation Value Score	Vulnerability Score
Amboseli - Mkomazi Tsavo (Kenya)	73	21
Serengeti Complex - Yaeda Chini	73	26
Ugalla Complex - Wembere	73	13
Nyerere Selous - Udzungwa	71	77
Kilimanjaro - Amboseli (Kenya)	71	40
Kigosi Moyowosi - Ugalla Complex	71	31
Tarangire Complex - Mkomazi Tsavo (Kenya)	70	53
Mikumi - Wami Mbiki	69	63
Katavi Complex - Loazi Lungu	69	21
Katavi Complex - Inyonga	69	17
Kigosi Moyowosi - Uvinza	68	31
Serengeti Complex - Arusha	68	41
Kilimanjaro - Mkomazi Tsavo (Kenya)	67	75
Mahale Mountains - Gombe Stream	67	45
Ugalla Complex - Uvinza	66	17
Wami Mbiki - Saadani	66	46
Ruaha Rungwa - Yaeda Chini	65	47
Burigi Chato - Akagera (Rwanda)	65	27
Longido - Amboseli (Kenya)	64	26
Tarangire Complex - Lake Manyara*	63	58
Kilimanjaro - Arusha	62	72
Kilimanjaro - Longido	62	35
Loazi - Luanga Musalangu (Zambia)	62	29
Tarangire Complex - Handeni	60	27
Ruaha Rungwa - Kitulo Rungwe	59	55
Arusha - Longido	59	42
Ruaha Rungwa - Swaga Swaga	59	56
Ruaha Rungwa - Mpanga Kipengere	58	49
Wami Mbiki - Handeni	57	45
Gombe Stream - Uvinza	57	53
Tarangire Complex - Arusha	53	63
Amani - Nilo	53	40
Kitulo Rungwe - Mpanga Kipengere	49	36
Tarangire Complex - Swaga Swaga	47	80
Gombe Stream - Mukungu Rukamabasi (Burundi)	46	70
Ibanda - Karagwe Rumanyika	45	56
Akegera (Rwanda) - Karagwe Rumanyika	44	56
Lake Manyara - Yaeda Chini	44	41
Baga - Kisima Gonja	43	68
Msanjesi - Lukwika Lumesure	40	39

As shown in Figure 20, conserving the top five priority corridors would connect all the largest southern parks, including the critical Selous – Niassa Transboundary Connection down into Mozambique, with the Ruaha Rungwa and Katavi Complex protected areas in western Tanzania. The top five priority corridors also connect two of the most ecologically important protected areas in the northern circuit, Serengeti Complex – Tarangire Complex, with the Serengeti Complex encompassing Serengeti National Park, Ngorongoro Conservation Area, and the recently designated Lake Natron Game Reserve. The Serengeti Complex – Tarangire Complex corridor also entirely encompasses two other corridors: Serengeti Complex – Lake Manyara, which ranked 7th, and Tarangire Complex – Lake Manyara.

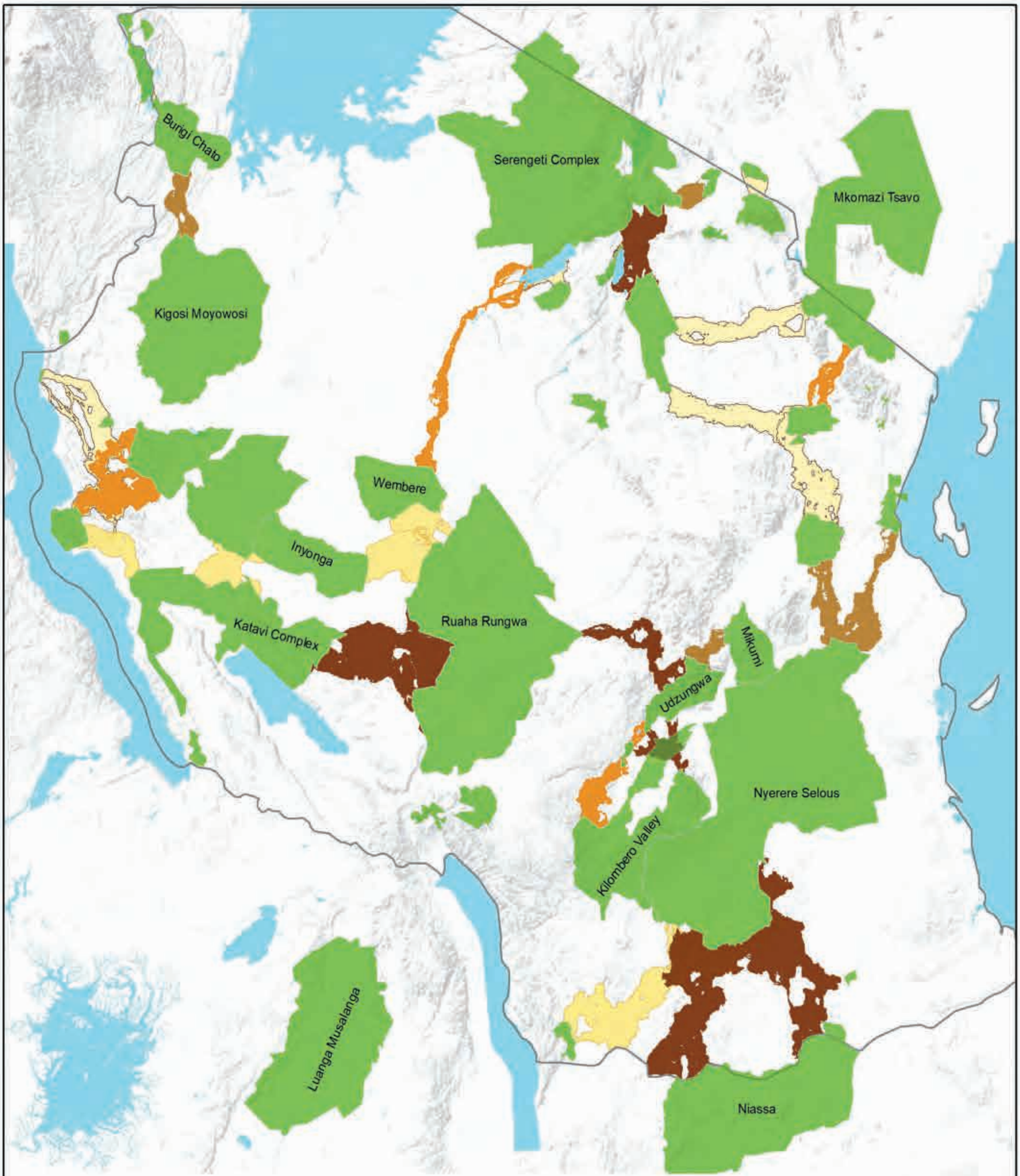


Figure 20. Top 20 Priority Wildlife Corridors in Tanzania in Terms of Conservation Value

- Top 1-5 Priority Wildlife Corridors
- Top 6-10 Priority Wildlife Corridors
- Top 11-15 Priority Wildlife Corridors
- Top 16-20 Priority Wildlife Corridors
- Wildlife Division Priority Corridor Additions
- Target Protected Areas

This map delineates lands likely important to wildlife movement between protected areas at the countrywide scale based on natural land cover and various human influences on the landscape. This map was used to support the assessment and prioritization of wildlife corridors important to maintaining Tanzania's rich natural heritage. It may be refined in the future by finer-scale analyses and as more data and information becomes available.

N W E S

0 40 80 160 240 320 Kilometers

Conserving the top 10 priority corridors would further solidify the wildlife corridor network in the southern part of the country, adding two other corridors that connect to the Nyerere Selous (Wami Mbiki and Saadani) and the Mikumi – Udzungwa corridor, which also links to the constellation of protected areas and corridors in southern Tanzania. The Serengeti Complex – Longido in the north and Burigi Chato - Kigosi Moyowosi in the west are also among the top 10 priority corridors.

Adding the next five priority corridors for conservation value—conserving the top 15 corridors—would provide a critical connection through central Tanzania, Serengeti Complex – Wembere, that would connect the northern parks with those in the west and south. This tier would also connect the Mahale Mountains to the Ugalla Complex, and with the newly designated Igombe Game Reserve connecting the Ugalla Complex to Kigosi Moyowosi, would provide connectivity between protected areas in the west from Mahale all the way to Burigi Chato. Also included in this tier are two more corridors in the south that connect to the Uzungwa Scarp, Udzungwa Mountains and Kilombero Valley. This tier also includes a transboundary connection to Kenya, the Mkomazi Tsavo – Handeni corridor.

Although the top five, 10, and 15 priority corridors conserve significant landscape connections, with each subsequent priority tier providing additional connectivity, Figure 20 clearly shows that a countrywide network is enhanced if all 20 of the top priority corridors for conservation value can be secured. Conserving at least the top 20 corridors would maintain a landscape network that connects most of the major protected areas in Tanzania, forming the backbone of a countrywide conservation strategy to maintain Tanzania's iconic wildlife and the ecological integrity of the network of protected areas. These 20 corridors can provide essential north-south and east-west connectivity across the country, and also conserve critical transboundary connections to protected areas in Kenya and Mozambique, which are essential for maintaining large mammal populations within Tanzania but are also continentally important to maintaining connectivity for wide-ranging species like cheetah and African wild dog across East Africa. It is for these reasons that the assessment team has highlighted the top 20 corridors in Table 17 and mapped them in Figure 20.

It should also be noted that corridors ranked 20-23 all scored 73 in terms of conservation value (Table 17). The assessment team reviewed the vulnerability scores for these four corridors and their overall contribution to connectivity in the network to identify which corridor to include in the top 20. The Ruaha Rungwa – Wembere was considered essential to overall connectivity in the network, since Ruaha Rungwa – Wembere is a critical link to Serengeti Complex – Wembere linking the southern and northern parks.

Half of the top 20 corridors were identified in the 2009 TAWIRI report (Jones et al.), six were assessed in Riggio and Caro (2017), and four were associated with newly designated Game Reserves. The top 20 corridors associated with newly designated Game Reserves include Serengeti Complex – Longido, Serengeti Complex – Wembere, Ruaha Rungwa – Inyonga, and Ruaha Rungwa – Wembere, and were therefore not identified in either Jones et al. (2009 TAWIRI), Debonnet and Nindi (2017), or Riggio and Caro (2017).

There is scientific evidence documenting that wildlife use 16 of the top 20 corridors (see Table 10). The three top 20 corridors where research data was not found to document use of the corridors by wildlife include Nyerere Selous – Saadani, Nyerere Selous – Liparamba, Kilombero – Uzungwa Scarp, and Udzungwa Mountains – Uzungwa Scarp. We caution that just because we did not find recent data documenting wildlife movement between protected areas, does not mean it's not happening. If there are natural habitats between protected areas, it is highly likely that the intervening habitat is providing live-in or move-through habitat for some species, even if not documented by researchers or local communities. Debonnet and Nindi (2017) correctly noted that the level of information available on the corridors assessed is highly variable, even eleven years after the publication of the ground-breaking 2009 TAWIRI report calling attention to Tanzania's vanishing corridors (Jones et al. 2009). For example, there is no recent documentation that wildlife uses the number one ranked corridor, Ruaha Rungwa – Udzungwa, which is considered to a be a critical connection between two of the three elephant metapopulations in Tanzania (Debonnet and Nindi 2017), with the most recent documentation of wildlife movement from Epps et al. 2011 and 2013. Wildlife movement has been documented in the great majority of the corridors assessed (69%) but a central database is lacking, and most of the research has been conducted where researchers live and work (i.e., the northern parks).

While the top 20 corridors would maintain connectivity between most of the major protected areas both within Tanzania and to protected areas in neighboring countries, there are a few key corridors missing from the top 20 that, if included, would tie the whole network together. As such, Wildlife Division elevated 7 additional corridors to be among the first corridors to be secured to ensure the ecological integrity of Tanzania's existing protected areas. These include: Serengeti - Yaeda Chini, Tarangire - Handeni, Wami Mbiki - Handeni, Tarangire – Mkomazi Tsavo, Burugi Chato - Akagera, Kilimanjaro - Amboseli, and Mahale – Gombe Stream (Figure 20). The first four Wildlife Division Priority Corridor Additions were elevated due to their high conservation value as critical corridors linking the central and southern ecosystems with northern ecosystems. Of particular note is the Wami Mbiki – Handeni corridor, which has been identified as the forgotten link between northern and southern Tanzania (Riggio et al. 2018), which should not be forgotten. The Burigi Chato – Akagera Corridor was elevated as a priority due to its importance as the only transboundary corridor to the west of Tanzania, which is important for facilitating cross border tourism with Rwanda, conservation of iconic species of eland and facilitating gene flow. Tarangire – Mkomazi Tsavo and Kilimanjaro – Amboseli Corridors were also elevated as transboundary corridors to the north with Kenya for similar reasons, serving iconic species such as elephant, giraffe, and wild dog. The Mahale – Gombe Stream Corridor was elevated because the landscape harbors over 75% of extant chimpanzee populations, a critically endangered species, which is vital for great apes tourism. Finally, a great deal of the Kigosi Moyowosi – Ugalla Complex corridor was recently designated as the Igombe Game Reserve, providing a continuous connection between these two target protected areas.

Even outside of the top 20 and the Wildlife Division Priority Corridor Additions, we found that **all the corridors assessed have conservation value**. Many of the other priority corridors have champions actively working to conserve and restore corridors on-the-ground (e.g., Nyerere Selous–Udzungwa) that are also essential to maintaining wildlife populations and the ecological integrity of the protected area network. Other corridors have specific value that do not translate into a high overall score. For example, a number of corridors (e.g., Mikumi–Wami Mbiki, Wami Mbiki–Handeni, Nyerere Selous–Udzungwa) cross areas of high levels of human-wildlife conflict and can be expected to be important for reducing this conflict if restored and protected.

It is important to also highlight the corridors with the highest Vulnerability Score, as this likely indicates the corridors most highly threatened by existing or imminent blockage by anthropogenic land use, and may also be a primary criterion for stakeholders in selecting corridors for restoration. The five corridors with the highest Vulnerability Score include two international transboundary corridors: Tarangire Complex - Swaga Swaga; Nyerere Selous – Udzungwa; Kilimanjaro - Mkomazi Tsavo (Kenya); Kilimanjaro – Arusha; and Gombe Stream - Mukungu Rukamabasi (Burundi).

The following chapter focuses on the feasibility of conserving the corridors, and highlights that many of the priority corridors, including those not captured in the top 20, already have land governing instruments in place that are largely compatible with conserving connectivity. Maps for each wildlife corridor and other detailed information that may assist with implementation are provided in Appendix D.

4. CONSIDERING THE FEASIBILITY OF CONSERVING THE CORRIDORS

At the November 2019 workshop hosted by USAID PROTECT and TAWIRI, stakeholders also recommended that the assessment team consider the feasibility of conserving corridors across Tanzania. Stakeholders were especially interested in three questions: (1) Does land-use governance in the corridor increase the feasibility of conserving it? (2) Are there are any ongoing conservation initiatives in or near the corridor? And (3) What are the costs associated with conserving a corridor, and what economic benefits and opportunities for local communities might be associated with conserving it?

These questions are distinguished from the prioritization criteria listed above because they primarily address political, economic, and social issues. The prioritization criteria are essentially questions of ecology and conservation science—the conservation value of the corridors; and the vulnerability of the corridors, protected areas, and the wildlife they support to a variety of threats—while considerations of feasibility are primarily relevant to the implementation of conservation efforts. In addition, although the assessment team found extensive data to assess and prioritize corridors according to their conservation value and vulnerability to a variety of threats, the team found only minimal data to address the governance question above; and the team found almost no data that they could use to systematically quantify costs and benefits of conserving corridors across Tanzania. Answering these questions will require additional research.

Nonetheless, the team did assess corridors (without assigning prioritization points) according to questions of local land-use governance, ongoing conservation initiatives, and costs and benefits associated with conserving corridors, because some data were available to answer these questions, and the assessments might help stakeholders implement conservation activities.

4.1 Review of Policy and legal frameworks

Tanzania's policy and legal frameworks provide several options for community engagement to secure critical wildlife corridors. Most of these corridors are found in areas that are categorized as village or general land. Therefore, community engagement to address land use and tenure using the existing policy and legal frameworks is key to achieving corridor protection.

From a policy perspective the National Land Policy 1995 (under review), National Environment Policy 1997 (revised in 2021), National Forest Policy 1998, National Water Policy 2002, National Wildlife Policy 2007, and the National Land Use Framework Plan 2013-2033, Guidelines for Participatory Village Land Use Planning 2013 (second edition), and National Forest Policy Implementation Strategy 2021-2023 all support corridor protection and maintaining connectivity. Other policies that have a critical but indirect impact on the protection of corridors include the National Human Settlements Policy 2000 and National Livestock Policy of 2006. At the international level, Tanzania has signed and ratified regional and global conventions aimed at conserving and protecting biodiversity and wildlife, including the Convention on Biological Diversity, Ramsar Convention on Wetlands, the World Heritage Convention, several endangered species conventions and climate change protocols (Tanzania National Environment Policy 2021). These agreements and policy instruments complement Government efforts towards conserving wildlife habitats and biological diversity and can also provide opportunities to organize diverse efforts including personnel, technological and financial resources that are pertinent in securing corridors (Debonnet and Nindi 2017; Tanzania National Environment Policy 2021).

The existing legal framework also provides laws and institutional structures for the protection of corridors. These laws include the Local Government (District Authorities) Act 1982, Land Act 1999, the Village Land Act 1999, Forest Act 2002, Environmental Management Act 2004, Land Use Planning Act 2007, Wildlife Conservation Act 2009, Grazing Land and Animal Feed Resources Act 2009, Water Resource Management Act 2009 and the corresponding regulations. Whereas the Wildlife Conservation Act addresses wildlife conservation in general, these other acts have implications on the sustainability of wildlife corridors, dispersal areas and migratory routes. Most wildlife corridors are situated on village lands whereby village registration and administration are dispensed under the Local Government Act of 1982, while land surveys and demarcations are implemented under the Village Land Act No. 5 of 1999. Thus, demarcation, restoration and management of corridors in village lands need joint concerted efforts not only from the MNRT but also from other ministries, departments and agencies such as Regional Administration and Local Government Authorities and Ministry of Lands, Housing and Human Settlements Development, Agriculture, Livestock and Fisheries and Mining and Energy (Debonnet and Nindi 2017).

Most notably, the Wildlife Corridors Regulations of 2018 was developed to address Section 22(1) in the Wildlife Conservation Act, No. 5 of 2009 which required the Minister in consultation with local communities to designate wildlife corridors, dispersal areas, buffer zones and migratory routes (URT 2018). The Wildlife Corridor Regulations recognize that community survival depends greatly on the goods and ecosystem services provided by protected areas; and addresses the need to strike a balance between development and conservation of biodiversity. However, the Wildlife Corridor Regulations are not a "one size fits all" remedy for protecting corridors and ensuring that localcommunities benefit from their protection.

Collectively, the overarching policy and legal frameworks provide several mechanisms and tools to secure corridors while providing benefits to local communities. The other legal options and tools for securing and protecting corridors includes Certificate of Customary Right of Occupancy (CCRO) Wildlife Captive Facilities (Wildlife Farms, Ranches, Zoos, Breeding Facilities, Orphanage Facility, Sanctuary), Environmental/Conservation Easements and Joint Village Land Use Agreements (JVLUA), Village Land Forest Reserves and other Community Based Forest Management (CBFM) models. Some of these options are covered under **section 4.2** of this report. To secure corridors and ensure proper benefits and incentives for the communities, different situations will require different approaches. However, land use planning at the local, regional, and national level should be developed and implemented as the most effective approach to maintain connectivity at the landscape level.

4.2 Land Use Governance in the Corridor

While the corridors were delineated irrespective of land tenure, many corridors in Tanzania contain areas that are governed according to land use designations and agreements designed to conserve wildlife, enhance natural resource management, and prevent unchecked development and conversion of natural habitats, e.g., Wildlife Management Areas, or Forest Reserves. When a corridor contains land areas that are governed according to land use designations and agreements that have the potential to sustain wildlife and natural resources, stakeholders might be able to use those governing instruments to promote corridor conservation. The presence of good governance, oriented toward wildlife conservation and natural resource management, should make it more feasible to conserve the corridor.

Assessment Approach: The assessment team identified a list of local-level and national-level governing instruments for Tanzania that may increase the feasibility of corridor conservation. The local-level list includes Certificates of Customary Right of Occupancy, Wildlife Management Areas, and Local Authority Forest Reserves. The national-level list includes Conservation Areas, Forest Reserves, Nature Reserves, Game Controlled Areas, Game Reserves, and hunting blocks outside of target protected areas.

Certificates of Customary Right of Occupancy (CCROs) formally designate and zone communal land rights for sustainable local natural resource management and use through village land use plans to secure equal access and ownership, thereby reducing conflicts over land. CCROS are developed at the community level; passed by the Village Council, Assembly and District, and are issued by the Ministry of Lands under Tanzania's Land and Village Acts.

Wildlife Management Areas (WMAs) are formally set aside village lands for the sole purpose of sustainable conservation and utilization of wildlife resources. WMAs provide a legal framework for communities to protect, manage, and benefit from wildlife and other natural resources on village land outside of protected areas under the Wildlife Conservation Act (WCA).

The Wildlife Division facilitates the establishment of WMAs, creates awareness and disseminates information about wildlife management and policy to communities, and determines if and where segregated settlements, farming or pastoralism, is permitted.

Local Authority Forest Reserves are gazetted forests managed at the district council level under the local government as either protection or production forest reserves. Production forests use inventory-based management according to National Forest Policy to improve forest condition and local livelihoods.

Conservation Areas are similar to National Parks with the highest levels of protection that only allow photographic tourism but allows grazing by indigenous Maasai pastoralists.

Forest Reserves (FR) are gazetted forests state-owned and managed by TFS under the National Forest Act. There are protection FRs managed for conservation purposes to maintain ecosystem functions and biodiversity, and there are production FRs including natural and plantation forests that are managed using inventory-based management and allow selective logging, if permitted.

Nature Reserves (NR) are designated under the National Forest Act of Tanzania,and provide the highest level of protection for all aspects of native flora and fauna of an area. Activities are generally restricted to research, education, and nature-based tourism; no extractive activities are permitted. NRs are state-owned and managed by TFS.
Game Controlled Areas (GCA) are another type of protected area provided for in the WCA but in GCAs human settlement, farming, and grazing were somewhat unrestricted until 2009 and are now prohibited, while hunting of wildlife is only permitted under license. TAWA is responsible for day-to-day management of GCAs with MNRT overseeing wildlife hunting activities and revenue generated in GCAs.

Game Reserves (GR) also known as wildlife preserves or game parks, offer one of the highest levels of protection afforded under the Wildlife Conservation Act, and generally focus on large mammals. No settlements, farming, wood cutting, or pastoralism are allowed in GRs without permission, while permitted hunting is allowed by tourists. TAWA is responsible for day-to-day management of GRs with MNRT providing oversight of wildlife hunting activities and revenue generated.

Hunting Blocks are specific areas designated outside of protected areas that allow hunting of certain species by permit, which is overseen by Wildlife Division. Hunters are accompanied by Government Game Scouts to ensure laws and regulations are adhered to (e.g., age and size requirements).

The team obtained spatial data for the local-level governing instruments from Tanzania's Wildlife Division and Ujamaa Community Resource Team, and spatial data for the national-level governing instruments from TAWIRI. Data from the World Database on Protected Areas (https://www.protectedplanet.net/) was used for the surrounding countries. The team then merged these datasets, intersected a map of lands governed according to these instruments with a map of the corridors, and calculated the proportion (%) of each corridor's total land area (in hectares) that is governed according to any of these instruments.

Results: The wildlife corridor network covers 11,553,300 net hectares and roughly 44% (5,075,620 hectares) of land in the corridor network have governing instruments that may make it more feasible to conserve the corridors. While the corridors were delineated irrespective of land tenure, the corridors captured all of the local- and national-level governing instruments identified above. This was largely expected since these land designations are highly compatible with providing live-in and move-through habitat for multiple taxa. Although these land designations may improve opportunities for conserving connectivity, the quality of habitat in the various designations may vary significantly, even within the same type of governing instrument. Governance is essential, whether it be a national park, WMA, or other category of protected or governed land.

Four of the 61 wildlife corridors assessed are 100% covered by these land designations (Table 18). Three of these occur in southwestern Tanzania and include Ugalla Complex – Uvinza, Ugalla Complex – Wembere, and Katavi Complex – Inyonga. The other occurs in the north, Serengeti Complex – Longido, which was also ranked in the top 20 in terms of conservation value.

Five more of the corridors have greater than or equal to 90% of land in the delineated corridor covered by these land governing instruments, and three of these were ranked in the top 20, including Udzungwa – Mikumi in the south, and Ruaha Rungwa – Inyonga, and Katavi Complex – Ugalla Complex in the west. The other two corridors with compatible land governing instruments covering greater than 80% of land in the corridor include Kilimanjaro – Longido and Tarangire Complex – Handeni.

Seven more of the corridors have greater than or equal to 80% of land covered by these governing instruments, and four of these were ranked in the top 20, including Ruaha Rungwa – Katavi Complex, Ruaha Rungwa – Wembere Serengeti Complex – Lake Manyara, and Kilombero – Udzungwa. The other three corridors with greater than 80% of the land in the corridors covered by these instruments include Tarangire Complex – Lake Manyara, Arusha – Longido, and Kigosi Moyowosi – Ugalla Complex.

This means that 40% of the top 20 priority corridors have land governing instruments that cover between 80—100% of land in the corridors, and 26% (16/61) of the corridors overall have greater than 80% of land governed by these instruments (Table 18). This is excellent news indeed but not all the corridors are quite so fortunate. In fact, there were also 8 of the 61 corridors that registered 1% or less in terms of land governing instruments (Table 18 and Figure 21). This includes some corridors linking world renowned protected areas, such as Gombe Stream and Mahale Mountains National Parks, which are critical to maintain and restore healthy chimpanzee populations, as identified in the Chimpanzee Action Plan (2018). Mahale – Katavi Complex and Gombe Stream – Rukamabasi corridors both have less than 1% of the land governing instruments used to assess the corridors, while Mahale – Ugalla Complex has 50%, Mahale – Gombe Stream 52%, and Gombe Stream – Uvinza with the most at 55%. Two of these corridors, Mahale – Katavi Complex and Mahale – Ugalla Complex were ranked in the top 20 corridors in terms of conservation value and should be a focus for corridor implementation. The Jane Goodall Institute has been working tirelessly for decades to conserve habitat for chimpanzees and other species in the Greater Gombe Ecosystem, by working with over 50 villages to link various types of village reserves together. This includes working with 12 different villages in the Gombe Stream – Rukamabasi corridor to stitch together continuous Village Forest Reserves, River Forest Reserves and Woodlots that cover 27% (8,497 hectares) of this corridor. This type of spatial data was not available at the countrywide scale and was thus not included in this analysis.

There are two other top 20 priority corridors that have less than 10% of the land within them governed by these instruments, including the number one corridor in terms of conservation value, the Ruaha Rungwa – Udzungwa, which has only 9% of its land conserved by these designations. Kilombero – Uzungwa Scarp also has just 8% of its land formally conserved. About half of the top 20 corridors have less than 50% of the land covered by these governing instruments.

Table 18. Overall proportion of each corridor with land designations that may be compatible with conserving connectivity, with top 20 corridors and Wildlife Division priority corridor additions denoted with an asterisk

Wildlife Corridor Assessed	Corridor Area (hectares)	Land Governing Instruments in Corridor (hectares)	% with Governance
Ruaha Rungwa - Yaeda chini	479,768	32	0.01%
Gombe Stream - Mukungu Rukamabasi (Burundi)	31,643	10	0.03%
Mahale Mountains - Katavi Complex*	177,213	88	0.05%
Lake Manyara - Yaeda chini	46,165	47	0.10%
Serengeti Complex - Yaeda chini*	60,226	349	1%
Wami Mbiki - Saadani	59,385	372	1%
Burigi Chato - Akagera (Rwanda)*	6,176	46	1%
Ruaha Rungwa - Swaga Swaga	462,120	5,481	1%
Ibanda - Rumanyika Karagwe	18,212	310	2%
Loazi - Luanga Musalanga (Zambia)	823,586	16,141	2%
Ruaha Rungwa - Mpanga Kipengere	14,705	332	2%
Akagera (Rwanda) - Rumanyika Karagwe	5,598	153	3%
Kilimanjaro - Mkomazi Tsavo (Kenya)	32,365	1,192	4%
Nyerere Selous - Udzungwa	8,870	384	4%
Msanjesi - Lukwika Lumesule	195,189	8,706	4%
Kilombero - Uzungwa Scarp*	188,480	15,815	8%
Mikumi - Wami Mbiki	219,186	18,540	8%
Ruaha Rungwa - Udzungwa*	244,725	21,703	9%
Baga - Kisima Gonja	2,273	211	9%
Nyerere Selous - Saadani*	296,910	30,444	10%
Serengeti Complex - Wembere*	341,207	49,893	15%
Wami Mbiki – Handeni*	328,804	53,701	16%
Kigosi Moyowosi - Burigi Chato*	141,506	26,569	19%
Amboseli - Mkomazi Tsavo (Kenya)	177,612	36,805	21%
Katavi Complex - Loazi Lungu	41,029	8,968	22%
Tarangire Complex - Swaga Swaga	65,180	14,652	22%
Kilimanjaro - Amboseli (Kenya)*	44,707	11,194	25%
Longido - Amboseli (Kenya)	43,316	11,688	27%
Amani – Nilo	5,743	1,669	29%
Ruaha Rungwa – Kitulo Rungwe	34,409	10,267	30%
Nyerere Selous – Liparamba*	1,030,050	323,288	31%
Kitulo Rungwe - Mpanga Kipengere	13,320	4,315	32%
Kilimanjaro - Arusha	19,103	6,392	33%
Mkomazi Tsavo (Kenya) - Handeni*	129,355	43,891	34%
Nyerere Selous – Niassa (Mozambique)*	1,659,850	634,481	38%
Nyerere Selous - Wami Mbiki*	215,890	107,539	50%
Mahale Mountains - Ugalla Complex*	442,171	221,577	50%
Tarangire Complex - Arusha	90,363	46,111	51%
Mahale Mountains - Gombe Stream*	681,381	354,297	52%
Gombe Stream - Uvinza	86,126	47,661	55%
Udzungwa - Uzungwa Scarp*	24,213	14,027	58%
Kigosi Moyowosi - Uvinza	195,089	139,673	72%
Seregeti Complex - Arusha	67,075	51,589	77%
Serengeti Complex - Tarangire Complex*	291,831	225,638	77%
Tarangire Complex - Mkomazi Tsavo*	360,898	282,332	78%
Kigosi Moyowosi - Ugalla Complex	183,555	147,912	81%
Kilombero - Udzungwa*	141,921	116,593	82%
Ruaha Rungwa - Wembere*	238,844	198,985	83%
Serengeti Complex - Lake Manyara*	121,814	101,750	84%
Ruaha Rungwa - Katavi Complex*	814,075	688,305	85%
Arusha - Longido	29,945	26,007	87%
Tarangire Complex - Lake Manyara	55,575	48,464	87%
Ruaha Rungwa - Inyonga*	311,036	280,320	90%

Wildlife Corridor Assessed	Corridor Area (hectares)	Land Governing Instruments in Corridor (hectares)	% with Governance
Tarangire Complex – Handeni*	367,507	336,928	92%
Katavi Complex - Ugalla Complex*	200,931	189,401	94%
Kilimanjaro - Longido	45,453	43,561	96%
Udzungwa - Mikumi*	85,293	82,251	96%
Serengeti Complex - Longido*	70,591	70,405	100%
Katavi Complex - Inyonga	103,350	103,146	100%
Ugalla Complex - Wembere	549,850	549,614	100%
Ugalla Complex - Uvinza	63,391	63,391	100%

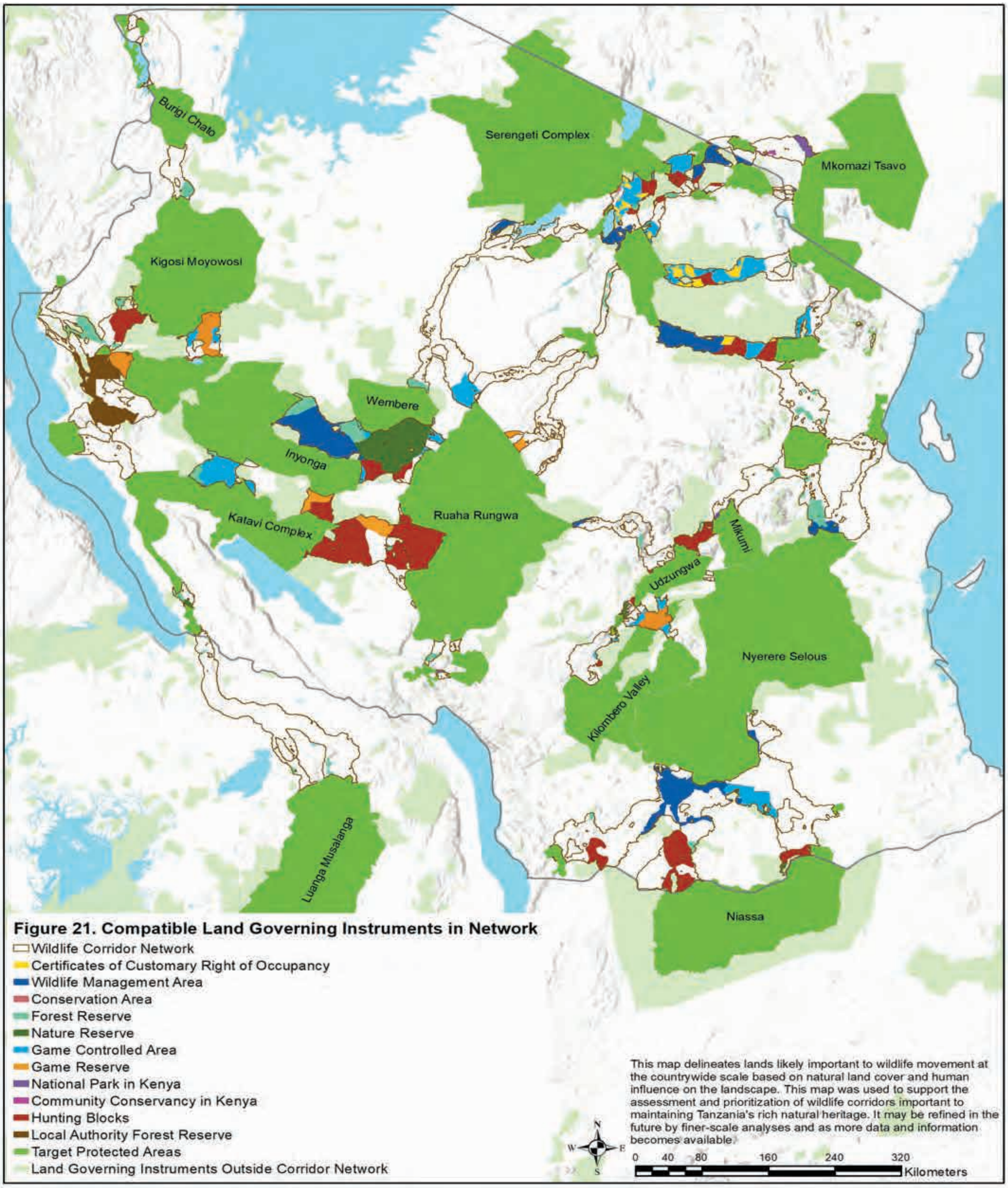


Figure 21. Compatible Land Governing Instruments in Network

4.3 Ongoing Conservation Initiatives in or near the Corridor

It should also be more feasible to conserve corridors where stakeholders are already working toward conservation because new efforts can build upon the resources and activities of ongoing initiatives.

Assessment approach: The assessment team (i) consulted stakeholders who have specific knowledge about the corridors in this study and used standard datasheets to collect information about ongoing conservation initiatives, and (ii) conducted a search on the Internet for information about ongoing initiatives that are working in or could contribute to conserving the corridors.

Results: There are a number of initiatives that support connectivity conservation in Tanzania. Table 19 provides current or recent activities and initiatives for some but not all of the corridors. In addition to the activities in the corridors, there are several other conservation initiatives that support corridor conservation, such as Wildlife Conservation Society and Zoological Society of London's Range Wide Conservation Program for Cheetah and African Wild Dog, African People & Wildlife's Northern Tanzania Big Cats Conservation Initiative; the Ruaha Carnivore Project, World Wide Fund for Nature's Wildlife Connect Initiative, and the Borderland Conservation Initiative.

Table 19. Activities, Actions, and Existing Conservation Initiatives in the Corridors

Corridor or Region	Who	What activities or initiatives
Amani - Nilo	Eastern Arc Mountains Conservation Endowment Fund (EAMCEF); Amani Nature Reserve	Forest and habitat restoration, community forests, community engagement, alternative livelihoods
Gombe Stream - Mukungu Rukumabasi (Burundi)	JGI	VLUP, establishment of Village Forest Reserves, River Forest Reserves, and Woodlots with 12 different villages; livelihood, development, education, and capacity building efforts at village, District and regional levels; chimpanzee surveys
Gombe Stream - Ugalla Complex	JGI	VLUP and Village Forest Reserve; Masito and Tongwe East Local Authority Forest Reserve approved 2019 and 2020; livelihood, development, education, and capacity building efforts at village, District and regional levels; chimpanzee surveys
Gombe Stream - Uvinza	JGI	Previous efforts to secure the corridor through VLUP and village forest reserves but resistance from some villages; livelihood, development, education, and capacity building efforts at village, District and regional levels; chimpanzee surveys
Katavi Complex - Loazi Lungu	WCS, TFS and Nkansi District	Environmental education and stakeholder involvement (village environmental committees); Fire management, livelihoods. Immediate action: TFS and Nkansi District to resurvey Loazi forest and villages area; VLUP for adjacent villages; Engaging Kalambo Ranch management in conservation of the corridor. Actions taken: environmental awareness in communities adjacent to the corridor; HWC mitigation. Chimpanzee surveys
Kigosi Moyowosi - Ugalla Complex	DANIDA	DANIDA project support land use planning, village forest reserves, WMA but currently no activities

Corridor or Region	Who	What activities or initiatives
Kilimanjaro Corridors	Oikos	Greater Kilimanjaro initiatives to enhance community participation in sustainable conservation of the trans frontier ecosystem and wildlife; Resilient Villages ECOBOMA; Investing in Maasai Women
Kilimanjaro – Amboseli (Kenya)	AWF, TNC, HGF, and BFF	WMA, VLUPs, Easement, land (ranch) acquisition, Patrols. AWF and BFF have partnered to address the human-predator conflict problem in Amboseli Kenya and West Kilimanjaro in Tanzania by upgrading traditional Maasai bomas to a predator-proof status
Kilombero - Udzungwa	BTC, AWF, Mjumita, Districts of Ulanga, Kilombero and Malinyi of Morogoro region and of Rufiji of Coast region	Redefinition of GCA with VLUP including looking at re-opening the Ruipa corridor. Kilombero and Lower Rufiji Ecosystem Management Project
Kilombero - Uzungwa Scarp	TFCG and WWF	Development and management of village forest reserves; Proposal for the creation of a forest reserve (status?)
Lake Manyara - Yaeda Chini	Carbon Tanzania and UCRT	Yaeda Valley REDD Project. Carbon Tanzania and UCRT working to expand REDD Project and CCROs, and connect to Ngorongoro CA.
Loazi – Luanga Musalanga (Zambia)	WCS	Immediate action: TFS and Nkansi District to resurvey the forest and villages area; Village Land Use plans for this villages. Action taken: Environmental awareness in communities adjacent to the corridor; human activities within the area; HWC mitigation; Chimpanzee surveys; Elephant recce survey in Lwafi/Loazi/Kalambo; Community fire management plans
Mahale Mountains - Gombe Stream	JGI	Established Masito Forest Reserve
Mahale Mountains - Katavi Complex	FZS, TNC, Mahale and Katavi NP; and Carbon Tanzania	VLUP and establishment village forest reserves; Creation of District forest reserve on general land; improving livelihoods; sensitizing community on the importance of villages forests and how they are going to benefit. Providing the village environmental committees with tools and equipments in order to protect the forests; Supporting environmentally friendly projects such as tree planting, bee keeping. Ntakata Mountains REDD Carbon Project
Mahale Mountains - Ugalla Complex	JGI, FZS, TNC, and Carbon Tanzania	VLUP, establishment of village forest reserves, creation of District forest reserve on general land; livelihood, development, education, and capacity building efforts at village, District and regional levels; chimpanzee surveys; carbon project Ntakata Mountains REDD Project

Corridor or Region	Who	What activities or initiatives
Nyerere Selous – Niassa (Mozambique)	WWF and PAMS -	VLUPs; Support WMA; CBFM in Village Forest Reserves; law enforcement; FOVAC (Finnish embassy / government) are doing some forest restoration in the region.WWF and PAMS are working in the WMAs. There is an investor in Nalika WMA. There are VLFRs that also lie inside the corridor, including Sautimoja. MCDI and FOVAC are also present in some of these areas. SWISS AID is also working on Agro-ecology and improved farming in the region.
Nyerere Selous - Udzungwa	STEP, MNRT-DW office, NLUPC, TANAPA, UMNP, TAWA, DGO, DED, DC, RNRO, RAS, Reforest Africa, Association Mazingira, TFS, and TFCG	STEP is facilitating Kilombero Elephant Corridor restoration project working closely with NLUPC and multiple other stakeholders at National, Regional, District, and local levels. First Elephant Underpass in TZ. JVLUP in progress
Ruaha Rungwa - Katavi Complex; Ruaha Rungwa - Inyonga; and Ruaha Rungwa - Wembere	WCS, TFS, TAWA, and NCZ	Aerial wildlife surveys, tracking vultures, working with villages; Identifying the best options for the open areas connecting the two ecosystems. Securing corridor management on village lands through: - VLUPs in 4 villages (approved by village councils, assemblies and district councils and now with NLUPC for final ratification). - VGS unit established, trained, mobilized - Conservation education program initiated - Aerial monitoring and support - Joint patrols with KDU and districts - Wildlife monitoring - Conservation performance bonus system in place Wider corridor management support including: - Corridor protection forum initiated - Aerial monitoring and support to various partners - Engagement initiated with other corridor partners (TFS, TAWA etc.) - Long-term finance options being explored
Ruaha Rungwa - Mpanga Kipengere	WCS	Previous Support to establish WMA but lack of interest from some villages; no ongoing activities
Saadani	tara@carewithaview.com david@carewithaview.com	Saadani Elephant Project collaring 2014
Serengeti Complex - Tarangire Complex (Includes Tarangire Complex - Lake Manyara, and Serengeti Complex – Lake Manyara)	TNC, UCRT, TRIAS, HGF, NCAA, WCS, WD, and WNI	VLUPs and issuance of Customary Certificates of Right of Occupancy (CCROs), Easement but complex, alternative livelihoods; Patrols, GCA, improvement of village management; WMA, VLUPs, Zonal and General Management Plans, VLUPs, Governance, coaching VGS, patrols, Biodiversity conservation Projects

Corridor or Region	Who	What activities or initiatives
Serengeti Complex - Yaeda Chini	Carbon Tanzania	Yaeda Valley REDD Project
Tarangire Complex - Handeni	WCS, TNC, WD, and Carbon Tanzania	Makame Savannah REDD Project
Tarangire Complex - Mkomazi Tsavo (Kenya)	UCRT, Dorobo, TNC, WCS, and WD	GCA, WMA, support village governance, VLUPs, CCROs
Kenya borderlands	Soralo	South Rift Association of Land Owners, community- based land trusts in transboundary connections
SOKNOT	WWF	Transboundary initiative to link over 40 NP, FR, and community conservation areas from Serengeti-Mara to Mkomazi Tsavo, focus area also include Usambara Mountains
Katavi, Ugalla, Mahale, Ruaha Rungwa regions	Landscape and Conservation Mentors Organisation	WASIMA Program Human-Lion Conflict
Southern Corridors	TANAPA	Strengthening the protected area system in southern TZ (SPANEST); project focused on conserving the landscape of southern circuit parks, included connectivity; project ended 2019
Across Tanzania	PAMS	HWC; Conservation Education; Ranger Support
Across Tanzania	Mjumita	Sustainable forestry, 400 villages across Tanzania. Provide technical assistance regarding forest management, governance, and advocacy.

Figure 22 provides a visual representation of the data in Tables 18 and 19 for the 27 Priority Wildlife Corridors, including the top 20 in terms of conservation value and the 7 corridors elevated by Wildlife Division, in order to highlight which corridors are in particular need of attention. There are no existing conservation initiatives for 11 of the Priority Wildlife Corridors including three corridors, Ruaha Rungwa – Udzungwa, Burigi Chato-Akagera, Nyerere Selous-Saadani, with less than 10% of the area covered by land governing instruments that could help conserve the corridors. This includes the number one corridor in terms of conservation value, the Ruaha Rungwa – Udzungwa, which is considered to a be a critical connection between two of the three elephant metapopulations in Tanzania (Epps et al. 2011, 2013, Debonnet and Nindi 2017). The Ruaha Rungwa – Udzungwa is also the only connection in the network linking protected areas in the southwest with those in the southeast of the country; capacity and attention are urgently needed here. The Burigi Chato - Akagera is a critical transboundary connection to Rwanda; only 1% of this relatively small corridor currently has land governing instruments that can help conserve it. The Nyerre Selous-Saadani is the only corridor in the entire network that provides connectivity to the coast, which may be important for some species to adapt to climate change. Four of the other 11 corridors with no existing conservation initiatives are critical for north-south connectivity in the network, including Serengeti-Wembere which has instruments covering 15% of the corridor, Wami Mbiki-Handeni that has 16%, Nyerere Selous-Wami Mbiki that has 50%, and Kigosi Moyowosi-Burigi Chato with 19% of the corridor covered. Udzungwa-Uzungwa Scarp has instruments covering 58% of the corridor, providing a nearly continuous connection between target areas. Nyerere Selous-Liparamba is 31% covered and there may be opportunities to add this corridor to the Nyerere Selous-Niassa initiative. The other two corridors identified as having no existing conservation initiatives have land governing instruments which cover virtually all of the corridor, Udzungwa-Mikumi with 96% and Serengeti-Longido with 100% covered. It will be essential to initiate Wildlife Corridor Working Groups, described below in Section 5.1 of the action plan, as soon as possible for the 9 corridors which are not yet well-covered by existing land governing instruments. For the other 16 Priority Corridors with existing conservation initiatives, agencies or organizations spearheading those efforts should take the lead in Wildlife Corridor Working Groups for those corridors, where possible.

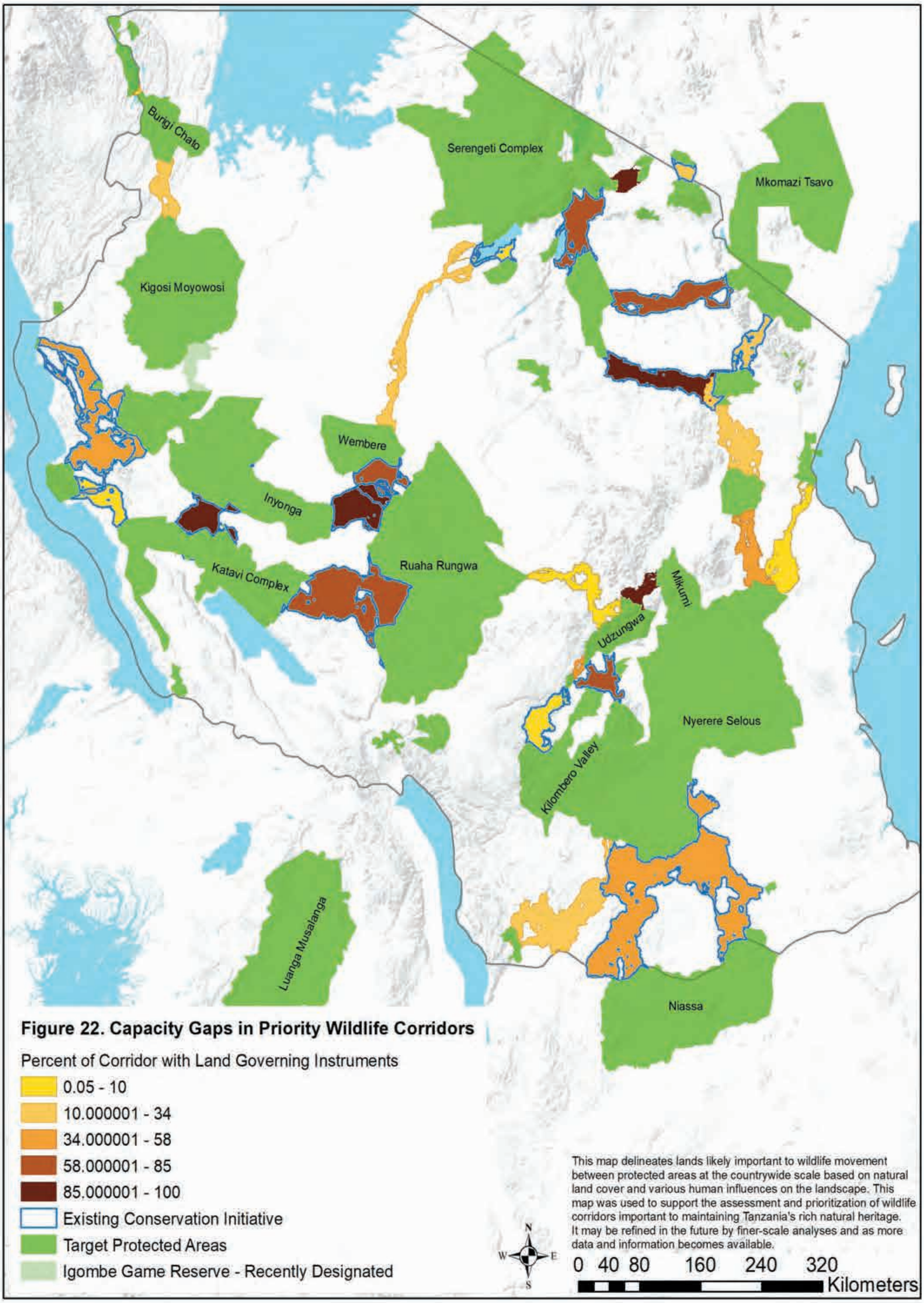


Figure 22. Capacity Gaps in Priority Wildlife Corridors

4.4 Economic Benefits and Opportunities for Local Communities

Successful solutions to conserve wildlife corridors must be beneficial not only to wildlife but also to people living near corridors and the protected areas they connect (Holmes 2013, Mutanga et al. 2014). Providing tangible benefits to local communities can build the local support necessary for conserving corridors. Such benefits may include:

- Security for communities and their properties;
- Beekeeping and honey production;
- Jobs in corridor management (e.g., village game scouts, habitat restoration, research and monitoring);
- Jobs in ecotourism and related sectors (e.g., lodging, restaurants);
- Cultural tourism (e.g., traditional food, dance, songs, customs, crafts);
- Tourist revenue shared with local communities;
- Carbon projects that contribute funding to improve living conditions for local communities, and for climate adaptation projects;
- Sustainable community-based rangeland management and fishing according to land use plans;
- Other conservation-friendly income generating activities;
- Improving activities compatible with wildlife corridor management; and community-based projects and services.

Assessment approach: The assessment team consulted stakeholders who have specific knowledge about the corridors and used standard datasheets to collect information about possible economic benefits and opportunities for local communities in or near the corridors, and conducted literature searches for information on successful conservation strategies that provide community benefits. Datasheets were completed for 31 of the corridors assessed.

Stakeholders were asked to identify possible economic benefits and opportunities to improve the lives of locals and help build support for connectivity conservation (e.g., jobs in corridor management, ecotourism, cultural tourism, beekeeping, sustainable grazing, and fishing).

Results: Stakeholders provided information on existing or potential economic benefits and opportunities for communities in 31 of the corridors (Table 20). Beekeeping was identified as the number one potential opportunity in 68% (21/31) of the corridors for which datasheets were collected. Ecotourism and cultural tourism followed closely being identified as an economic benefit or opportunity in 65% (20/31) of the corridors. Sustainable grazing was also identified as a potential economic benefit in 52% of the corridors. Fishing was identified as a monetary benefit in 35% (11/31) of the corridors. Jobs in corridor management, licensed hunting, and tourist lodges were recognized as a potential economic opportunity in roughly half of the 48% (14/31) of the corridors. Income from Wildlife Management Areas (WMA) was identified as an economic benefit or opportunity in 16% (5/31) of the wildlife corridors. Small-scale agriculture of cash and food crops was identified as a potential financial opportunity or benefit in 16% of the corridors. Carbon Projects were identified as an existing or potential economic benefit or opportunity in 3 of the corridors. Other benefits identified, which are likely to apply to several of the corridors are reduced crop damage, increased value of livings, improved education, and health facilities.

Table 20. Potential Economic Benefits and Opportunities

Wildlife Corridor Assessed	Bee-keeping	Sustainable grazing	Fishing	Agriculture cash/food crops	Ecotourism/cultural tourism	Jobs in corridor management	Job in licenced hunting	Jobs in tourists lodges	Income from WMA	Carbon Project	Salt Mining	Improved Education & Health facilities	Increased value of livings	Reducing Crop Damage
Amboseli -Mkomazi Tsavo					X									
Baga - Kisima Gonja	X	X			X									
Gombe Stream - Ugalla Complex	X		X		X		X							
Handeni - Saadani														
Katavi Complex - Ugalla Complex	X		X				X							
Kilimanjaro - Amboseli	X	X			X	X		X						
Kilimanjaro - Arusha														
Longido - Amboseli		X			X				X	X				
Mahale - Katavi Complex	X	X			X									
Mkomazi Tsavo - Handeni	X	X	X	X	X	X								
Nyerere Selous - Liparamba														
Nyerere Selous - Niassa														
Nyerere Selous - Udzungwa	X				X	X						X	X	X
Ruaha Rungwa - Inyonga	X		X				X							
Ruaha Rungwa - Katavi Complex	X					X								
Ruaha Rungwa - Mpanga Kipengere				X	X			X						
Ruaha Rungwa - Swaga Swaga	X		X		X		X							
Ruaha Rungwa - Udzungwa	X	X	X											
Serengeti Complex - Lake Manyara	X	X	X		X	X								
Serengeti Complex - Longido		X			X				X	X				
Serengeti Complex - Tarangire Complex	X	X	X		X	X			X					
Serengeti Complex - Wembere	X		X	X	X									
Tarangire - Swagaswaga - Ruaha														
Tarangire Complex - Handeni	X	X			X	X				X				
Tarangire Complex - Lake Manyara	X	X	X		X			X						
Tarangire Complex - Lake Natron	X	X			X				X					
Tarangire Complex - Mkomazi Tsavo	X	X	X	X	X	X								
Udzungwa - Mikumi					X				X					
Ugalla Complex - Unvinza	X	X		X							X			
Ugalla Complex - Wembere	X	X			X									
Wami Mbiki - Handeni	X	X												

5. PRIORITY CORRIDOR ACTION PLAN

This Action Plan lists activities that The Government of Tanzania and its partners recommend to secure and conserve the corridors. Like the assessment and prioritization discussed above, and consistent with Tanzania's Corridor Regulations, The Government of Tanzania and its partners created the Action Plan to serve as a decision tool that the Government of Tanzania and other stakeholders can use to design and augment conservation activities in the priority corridors over the next five years (2022-2026). This Action Plan does not specify a particular number of "top priority corridors" in Tanzania because it is designed for a wide variety of stakeholders with different strategic needs and opportunities—some stakeholders, for example local community groups, might wish to focus on just one or two priority corridors; some might wish to focus on the top five or top ten; still others will aim to form consortia to conserve the top twenty or more. Many stakeholders already have made substantial conservation investments in high-priority corridors, while others are looking for opportunities to develop new conservation activities in new areas. Accordingly, The Government of Tanzania and its partners developed this Action Plan for all stakeholders—whether they aim to conserve one priority corridor, 20, or more—and the activities listed below are applicable to conserving any of the corridors. Regardless of the specific number of top priority corridors that stakeholders aim to conserve, TAWIRI and its partners recommend that all stakeholders should follow the results of the assessment and prioritization discussed above when deciding how many and which priority corridors to focus on, and which ones to focus on first by taking the actions listed in this Action Plan.

As noted, one clear result of the assessment and prioritization is that conserving at least the top 20 corridors—ranked according to conservation value—would maintain a landscape network that connects most of the major Protected Areas in Tanzania, provides essential north-south and east-west connectivity across the country, and also conserves critical transboundary connections to Kenya and Mozambique. Although the Government of Tanzania might choose to focus on five, 10, 15, 20 or more priority corridors for official designation under the Corridor Regulations, international development donors, NGOs, local community groups, and other organizations might focus on conserving a larger or smaller set of priority corridors—depending on their own strategic priorities, levels of investment, etc. The assessment and prioritization discussed above, coupled with the Action Plan that follows, can help align the activities and investments of all conservation stakeholders in Tanzania to more effectively conserve the corridors that have the highest conservation value and are the most vulnerable. If the Government of Tanzania and other stakeholders focus on conserving at least the 20 corridors that have the highest conservation value plus the Wildlife Division Priority Corridor Additions, that would help conserve not only those individual corridors but also network connectivity for highly mobile species across East Africa. The Goverenment of Tanzania is therefore inviting all development partners to support activities identified in this action plan.

This policy document is intended to provide guidance on conserving critical wildlife corridors across the country. It is expected that Wildlife Corridor Working Group members (described below) and other partners will conduct detailed on-the-ground assessments to refine the boundaries of each corridor, as needed.

Finally, engaging Local Government Authorities in community outreach and awareness in each corridor from the inception is a top priority and should be the first activity carried out of all of the activities outlined in the action plan.

To help align the conservation activities and investments of all stakeholders, the activities listed below are ranked according to their level of urgency:

Activities highlighted in green are considered the most urgent

Activities highlighted in blue are considered the next most urgent

Activities highlighted in yellow are considered the least urgent

5.1 Corridor Working Groups and Interagency Coordination

Collaboration, Coordination & Learning

- Achieve landscape connectivity through collaboration and coordination within and beyond jurisdictional boundaries
- Develop a common vision and compelling story for conserving priority wildlife corridors
- Develop strategies and resources that support local communities and private landowners to maintain and enhance connectivity across working landscapes
- Influence regional land use planning and infrastructure decisions to make projects more valuable, strategic, and beneficial to wildlife connectivity
- Facilitate timely implementation of wildlife corridors and integrate connectivity into existing and future planning efforts
- Incorporate best science to protect lands with "multiple benefits"
- Learn from the experience of diverse stakeholders through focused, intentional reflection and communication about what works to conserve corridors, what the key challenges are to implementation, and how to manage adaptively

Conserving connectivity at the landscape scale, across the country and beyond to wildlands in neighboring countries will require government agencies, NGOs, academic institutions, the private sector, DGOs, and other individuals from across diverse sectors to collaborate, coordinate, and learn from each other's experience. No single entity can do it alone. Accordingly, Wildlife Corridor Working Groups should be formed for each of the priority corridors with some level of regional coordination to tie them together. The working groups are envisioned as a group of diverse members who would collaborate on research, conservation, land use, policy, stewardship, and outreach in individual corridors to identify implementation opportunities, challenges, and strategies for conserving each corridor. These working groups should link to and collaborate closely with the Coexistence LUP Committee that is planned under the National Human-Wildlife Conflict Management Strategy (MNRT 2020).

Working groups will not only facilitate collaboration but also help stakeholders learn from experience and manage corridor conservation adaptively. All agencies with jurisdictions that overlap the geographic boundaries of a given corridor, organizations, and academic institutions with a conservation interest in the area should be invited to participate. Importantly, the working groups should make a concerted effort to reach out to partners beyond the traditional stakeholders in conservation efforts. Effective strategies to conserve and restore wildlife corridors need to involve the local communities living in or near the corridors.

For example, working group members could assist with research needed to identify critical wildlife crossing locations, conduct outreach to local communities, and assist with fundraising to design and build wildlife crossing structures. At least two highly successful collaborations between diverse stakeholders have implemented wildlife crossings in Kenya that involved local communities. An elephant corridor between Mount Kenya and Ngare Forest Reserve involved not only a wildlife crossing but also substantial fencing to guide elephants safely to the structure to cross the A2 highway (Weeks 2015). This effort was championed by Mount Kenya Trust with two large farms donating land to the corridor, and assistance from Lewa Wildlife Conservancy, Ngare Ngare Forest Trust and other NGOs (Weeks 2015). Colobus Conservation spearheaded an effort to install 28 bridges along a 10 km stretch of Diani Beach Road to reduce vehicle collisions with colobus monkeys, which was funded by the local community and international donors (Donaldson and Cunneyworth 2015). A similar effort is underway in the Magombera Corridor between the Selous and Udzungwa Mountains, which also involves fencing of the corridor and the first wildlife crossing structure specifically designed for elephants in Tanzania.

Working group members also could serve on the Wildlife Corridor Technical Advisory Panel (described in Section 5.5) to ensure that data and information they've gathered on wildlife movement is applied to conserve wildlife corridors on the ground. Technical Advisors can support not only integration of wildlife crossing structures into infrastructure projects, but also coordinate with conservation NGOs and NLUPLC to engage with local communities to support the development of Village Land Use Plans.

Active and regular communication both within and among the wildlife corridor working groups is critical to achieving connectivity at the landscape scale. Working groups should have regularly scheduled meetings, perhaps once a quarter, to share information, ensure their actions are coordinated, and learn from each other's experiences. Hundreds of researchers come together for the TAWIRI Scientific Conference every other year, and it may be possible to have wildlife corridors as a topic at this conference to provide an opportunity for working groups around the country to connect and learn from each other.

The importance of investing in, building, and maintaining relationships within and among the wildlife corridor working groups cannot be over-emphasized. Efforts to maintain and restore wildlife corridors and landscape connectivity must be matched by efforts to build and maintain connections among people from diverse sectors. Wildlife Corridor Working Groups will help focus disparate conservation efforts on coordinated regional plans and promote the partnerships needed to implement wildlife corridors and connectivity at the landscape scale.

Strategic Objective: Collaborate among diverse sectors to coordinate activities necessary to conserve wildlife corridors, learn from experience, and manage corridor conservation adaptively.

Target: Wildlife Corridor Working Groups are established for priority corridors.

Activities (National or Local)	Actors (Lead in Bold)	Target Date	Indicators
Activity 5.1.1 (Local): Establish Wildlife Corridor Working Groups for priority corridors.	**TAWIRI/TAFORI,** WD, TAWA, TFS, TANAPA, NCA, NLUPC, LGAs, NGOs, academic institutions, and community organizations	2022 and onward	Number of working groups established and meeting regularly to coordinate actions to conserve priority corridors
Activity 5.1.2 (Local): Working groups develop workplans for coordinated actions to conserve individual priority corridors, including actions listed in this Action Plan, i.e., land-use planning and management to officially recognize corridor areas and prevent activities that destroy wildlife habitat in the corridors; community outreach and awareness; community development programs; conducting research on target species and further developing conservation planning resource needs; and developing learning agendas to articulate and share lessons learned, collaborate among stakeholders, and manage adaptively.	**WD,** TAWIRI, TAWA, TFS, TANAPA, NCA, NLUPC, LGAs, NGOs, and academic institutions, community organizations	2022 and onward	Number of workplans developed by working groups for individual priority corridors
Activity 5.1.3 (National): Establish an interdisciplinary Wildlife Corridors Coordination Unit at Ministerial/National level to support effective coordination, partitioning of activities and resources, and prevent replication**.** This Unit will coordinate all corridor activities (e.g., research, management, restoration, monitoring).	**WD,** TAWA, TANAPA, NCA, TAWIRI, TFS, NLUPC, PORALG, research and academic institutions	2022 and onward	List of institutions and individuals working on corridors and types of activities undertaken is created and maintained. Corridor database where all information on corridors is stored is created and maintained.
Activity 5.1.4 (National & Local): Establish and maintain international collaborations for transboundary corridors and hold annual conferences.	**WD,** TAWIRI, TAWA, TANAPA, NGOs, and community organizations	2023 and onward	Number of transboundary forums established, and annual conferences held

Activities (National or Local)	Actors (Lead in Bold)	Target Date	Indicators
Activity 5.1.5 (National & Local): Develop transboundary wildlife corridor management plans.	**WD,** TAWIRI, TAWA, TANAPA, NGOs, and community organizations	2023 and onward	Number of transboundary Wildlife Corridor Management Plans developed

5.2 Land Use Planning and Management

More than a decade after the 2009 TAWIRI report on wildlife corridors was released, opportunities still remain to maintain and restore a functional network of wildlife corridors between existing protected areas and to safeguard the tremendous investment in conserving Tanzania's rich natural heritage. Nevertheless, time is running out. Landscape connectivity is being rapidly eroded as habitat in corridors is being converted to settlement and agriculture and used for grazing livestock (Riggio and Caro 2017), and Human-Wildlife Conflicts in wildlife corridors and migration routes are increasing (MNRT 2020). Some historic migration routes no longer exist. For example, ungulate populations in the Tarangire Ecosystem historically migrated along at least ten routes between their dry season range and wet-season calving grounds (Lamprey 1964) but only two of these historic migration routes remain due to habitat loss and fragmentation from settlement, agriculture, and industrial development (Morrison and Bolger 2012, 2014, Morrison et al. 2016, Bond et al. 2017). Unlike road barriers, which can be modified with fencing and wildlife crossing structures (section 4.3), development of settlements and towns creates barriers to movement that cannot easily be removed, restored, or otherwise mitigated. Time is of the essence to formally establish priority wildlife corridors and migration routes to maintain functional connectivity for wildlife populations in Tanzania.

Corridor conservation in Tanzania depends critically on effective land-use planning and management (MNRT 2020), but land-use planning is often beset with numerous challenges. Common challenges associated with land-use planning for corridor conservation include: (i) establishing clear and secure land-use rights, which the land-use planning process itself can help to address; (ii) obtaining and developing accurate information about land boundaries and resources in and near corridors to design land-use plans that optimize the various uses for which available land can be allocated (much of the required information is described below as "research and conservation planning resource needs"); (iii) developing technical and managerial capacity to design and implement land-use plans; (iv) dedicating adequate funding to design and implement land-use plans and to compensate landowners and land users if necessary to implement land-use plans; and (v) ensuring broad participation in the land-use planning process so that landowners, land users, and other stakeholders who will be affected by land-use plans recognize and share the benefits of land-use planning for corridor conservation. The activities listed below and elsewhere in this action plan seek to address these common challenges and facilitate corridor conservation through effective land-use planning.

The assessment and prioritization analyses above take the form of 'benefit targeting' – a ranking of corridors by the magnitude of their potential ecological benefits in order to prioritize the most beneficial investments. However, a consideration of costs of each potential investment is critical - since conservation funds are limited. Conservation planners must optimize outcomes within budget constraints, seeking the greatest return on investment in terms of conservation outcomes for every dollar spent (Ferraro and Pattanayak 2006, Murdoch et al. 2007). There are growing calls for greater consideration of costs in order to conduct more cost-effective conservation (Naidoo et al. 2006, Grand et al. 2017). Different projects targeting similar outcomes can vary wildly in their costs (Balmford et al 2003, Bode et al. 2008). Numerous studies have shown that benefit targeting alone can result in highly inefficient resource allocations, with far more efficient outcomes being achieved when costs are included in the analysis (Ando et al. 1998, Palasky et al. 2001, Cullen et al. 2005).

Strategic Objective: Conserve connectivity and reduce habitat loss and fragmentation of priority corridors through collaborative, participatory land-use planning and implementation of land-use plans.

Target: Wildlife corridors are integrated into Village, District, Regional, and National Land Use Plans.

Activities (National or Local)	Actors (Lead in Bold)	Target date	Indicators
Activity 5.2.1 (Local): For villages within or on the edge of priority corridors, conduct outreach meetings to engage and consult with respective districts, villages, community organizations, and other stakeholders in a collaborative planning process to identify land uses through the corridors that are compatible with wildlife movement and beneficial to local communities. This might not be needed in all villages and Districts, but it is high priority where it is currently lacking.	**NLUPC**, DCs and NGOs, corridor working group members, and community organizations	2022 and onward	Number of collaborative land use planning processes initiated through stakeholder engagement and consultation
Activity 5.2.2 (Local): Conduct comprehensive stakeholder mapping and analysis for corridor conservation to identify: (i) the number of people and villages in each priority corridor; (ii) the types of community support required; (iii) the correct implementing partners; and (iv) the key local influencers in the land-use planning process for priority corridors. Include Power-Interest Grid Model in stakeholder mapping to determine appropriate ways to engage various stakeholders for better results. This might not be needed in all villages and Districts, but it is high priority where it is currently lacking.	**NLUPC**, NGOs, Individual Researchers, corridor working group members, and community organizations	2022 and onward	Stakeholder mapping and analysis completed for communities with land-use claims in or adjacent to priority corridors
Activity 5.2.3 (Local): Develop Village LUPs in collaboration with local communities for villages in or on the edge of priority corridors (Joint Land-Use Plans where there are multiple villages).	**NLUPC**, DCs, RASs, and NGOs	2022 and onward	Number of LUPs approved by Village Assemblies and land is demarcated, surveyed, and registered
Activity 5.2.4 (National): National Land Use Information System in use to include spatially explicit information (in GIS), or links to the information, that this assessment and prioritization project has produced for each corridor; collate land use data in corridor and upload to system to make sure it's available to people working in corridors.	**NLUPC** and NGOs	2022	National Land Use Information System includes information on priority corridors
Activity 5.2.5 (Local): As part of the village-level land-use planning process, design on-the-ground corridor boundaries. Propose boundaries, develop management plans with relevant authorities, and shepherd the plans through the appropriate approval processes.	**NLUPC**, WD, TAWIRI, TAWA, TANAPA, TFS, academics, and corridor working group members	2022 and onward	Number of areas identified, on-the-ground corridor boundaries designated in VLUPs, management plans drafted, proposals drafted and approved
Activity 5.2.6 (National & Local): Fully designate and gazette corridors under appropriate legal tool or otherwise secure official recognition for the corridors.	**WD**, TAWIRI, TAWA, TANAPA, and NGOs	2023 and onward	Number of corridors fully designated and gazette under the corridor regulations or otherwise officially recognized

Activities (National or Local)	Actors (Lead in Bold)	Target date	Indicators
Activity 5.2.7 (Local): Collect wildlife movement, biodiversity, and socioeconomic baseline data necessary for integrating wildlife corridors into Village, District, Regional, and National Plans, as needed. This might not be needed in all villages and Districts, but it is important to complete where it is currently lacking.	**TAWIRI**, NLUPC, DCs, RASs, TANAPA, TAWA, NGOs, SUA, UDSM, NM-AIST and MWEKA, COSTECH, and Individual Researchers	2023 and onward	Movement, biodiversity, and socioeconomic baseline data and maps developed for priority corridors
Activity 5.2.8 (National & Local): Conduct detailed Ecological and Social Impact Assessments in priority corridors as appropriate and also to comply with the laws governing land management.	**TAWIRI**, NGOs, and Individual Researchers	2024 and onward	Number of ESIAs completed for priority corridors
Activity 5.2.9 (National): Integrate corridor conservation into government agencies' regional and national plans (e.g., strategic plans, transportation plans, energy plans, natural resource management plans).	**WD**, DCs, RASs, TANROADS, TAWA, and TANAPA	2025	Number of regional and / or national plans that integrate conservation of priority corridors

Strategic Objective: Reduce human-wildlife conflict by providing safe passage for wildlife through priority corridors instead of through areas more heavily used by humans such as farms, schools, and settlements.

Target: Align activities to reduce human-wildlife conflict in priority corridors with the recommendations in the National Human-Wildlife Conflict Management Strategy (2020-2024), which describes wildlife corridor conservation as an "essential tool for enhancing human-wildlife coexistence over the long term."

5.3 Community Outreach and Awareness

Reaching out to communities and raising awareness about wildlife corridors are vital to conservation – both to modify land-use activities that increase human-wildlife conflict and threaten wildlife movement, and to generate appreciation for the importance of the corridors and the wildland network and ecosystem services they will sustain. As such, engaging Local Government Authorities in community outreach and awareness from the inception should be the first activity carried out in each corridor. Conducting outreach in communities in and adjacent to the corridors will raise awareness of the benefits of conserving connectivity for wildlife, opportunities to reduce human-wildlife conflict, and ecosystem benefits those corridors can provide. Outreach also can help build support for corridor conservation by describing the types of jobs that will be available to local community members to manage and implement specific projects in the corridors. Outreach and education targeted to children and young adults, in particular, is essential to develop the next generation of wildlife corridor stewards. It will take a sustained effort to conserve connectivity across the country and across political boundaries to protected areas in neighboring countries.

There are at least four over-arching compelling messages for corridor conservation: prosperity; health and safety; accountability; and quality of life. Ideally, members of each Corridor Working Group, described in section 5.1, will act as ambassadors to reach out to local Village and District decision makers about how corridor conservation can benefit local communities.

Example Prosperity messages:

Protecting wildlife corridors protects important ecological services for local Tanzanians. It is economically impossible to recreate the services nature provides for free. By protecting wildlife corridors, we also protect pathways for seed dispersers and pollinators that are essential to our food supplies, clean water, healthy soil, and purification of our air.

Wildlife corridors are essential to sustain populations of migratory ungulates such as wildebeest, whose seasonal movements are critical to keeping rangelands healthy. Healthy rangelands = healthy grazing.

Tanzania is world-renowned for its incredibly rich diversity of wildlife and natural beauty. The economic value of our protected areas and the charismatic species they support is in the billions, and their emotional value to people around the world is priceless. By protecting wildlife corridors, we protect the tourist dollars our economy depends on.

We need to protect our investments in the natural treasures that surround us by assuring the continued viability of key wildlife corridors.

Example Quality of Life Messages:

Protecting and restoring corridors is critical to sustain wildlife populations that attract tourists and new businesses, which can provide jobs to improve the livelihoods of people in local communities.

Connected wildlands maintain the health and quality of Tanzania's natural areas that we depend on for jobs, recreation, education, tranquility, and inspiration.

Example Health and Safety Messages:

Protecting and restoring wildlife corridors can reduce human-wildlife conflicts and keep our children and communities safe.

Protected wildlife corridors = reduced conflicts with wildlife.

Protecting and restoring wildlife corridors promotes the long-term health of natural areas, including healthy watersheds and air quality, and makes natural areas more resilient to climate change and disturbance such as fires and floods.

Protecting and restoring wildlife corridors helps protect the quality of our water and air, and makes our natural areas more resilient. Healthy forests = healthy water supplies and clean air.

Example Accountability Messages:

Protecting wildlife corridors will allow species and communities to shift their ranges in response to climate change, thereby protecting our precious and valuable resources.

Protecting and restoring wildlife corridors is required for the long-term health of existing protected natural areas (including the plants and animals that depend on them), so it protects the investment we have already made in establishing and protecting these areas.

Every child in Tanzania should know that they live in a biodiversity hotspot that is cherished throughout the world. NGOs and other groups in Tanzania have already developed a variety of useful books, videos, and school curricula and learning activities. While outreach and education are critical at villages and towns in and around the wildlife corridors, it could eventually expand nationally with a natural heritage curriculum in schools across the country.

Strategic Objective: Create awareness and build support for conserving wildlife corridors at the local level.

Target: Public support for and participation in wildlife corridor conservation, management, and stewardship is improved through outreach and education.

Activities (National or Local)	Actors (Lead in Bold)	Target Date	Indicators
Activity 5.3.1 (Local): Develop and implement community outreach campaigns on the connection between maintaining and restoring wildlife corridors, improving livelihoods, and reducing human-wildlife conflicts.	TAWIRI, TANAPA, TAWA, NGOs**,** PORALG, **corridor working group members**, and community organizations	2022 and onward	Number of community outreach campaigns carried out in priority corridors
Activity 5.3.2 (Local): Develop educational materials for all grade levels on Tanzania's unique ecosystems that include information on the importance of wildlife corridors to maintaining our natural heritage and reducing human-wildlife conflict.	NGOs, academic institutions, **corridor working group members**, and community organizations	2022 and onward	Number of education materials developed, printed, and distributed in communities in or near priority corridors
Activity 5.3.3 (National & Local): Integrate materials developed in 5.3.2 into a National Natural Heritage Curriculum.	NGOs, **corridor working group members**, and academic institutions	2026	Number of schools using National Natural Heritage Curriculum materials
Activity 5.3.4 (National): Develop a documentary on Tanzania's wildlife corridor network and great migrations; host special showings in communities in or near wildlife corridors; broadcast the documentary on major television networks. Documentary should feature stories to show how communities benefit from corridor conservation.	**NGOs**, TAWIRI, WD, TAWA, TANROADS, and PORALG	2026	Documentary produced

5.4 Community Improvements and Empowerment

Community-based mechanisms to safeguard wildlife corridors will be fundamental to assuring conservation success. Despite promises of conservation to deliver benefits to local communities, however, rural poverty continues to show a correlation with the richest biodiversity hotspots (Pearce 2011). Community involvement in, support of, and benefits from wildlife conservation is essential to maintain and restore wildlife corridors and connectivity at the landscape-scale. Sibanda and Omwega (1996) identified four critical issues that relate to local community benefits that require consideration:

(1) *The conflict between wildlife and humans should be minimized and allow for coexistence through greater involvement and participation of local communities in wildlife management.*
(2) *The benefits of wildlife conservation should be directed to those who bear the costs of wildlife conservation and are directly involved in wildlife conservation, forego other types of land use, and suffer inconvenience.*
(3) *Ownership and sharing of benefits are central to sustainable resource management. Local communities' have a legitimate claim to both.*
(4) *Mechanisms are needed for the international community to help pay the actual cost of conserving wildlife for sharing this resource and to channel funding to affected local communities and wildlife conservation efforts*

One of the objectives of Tanzania's Wildlife Policy of 1998 was to transfer management of Wildlife Management Areas in corridors, migration routes, and buffer zones to local communities to ensure that they receive tangible benefits from conserving wildlife (URT, 1998, Kangalawe and Noe 2012). While there are examples of successful implementation of this objective, there are many instances where local communities have not reaped the benefits and poverty alleviation has still not been realized (Mbarang'andu 2003, Ghezae et al. 2009, Pearce 2011, Masozera et al. 2013; Abade et al. 2014, Kiwango et al. 2017). In addition to not receiving tangible benefits from conservation, sometimes local people actually pay a high cost when protected areas are established, such as being excluded from accessing previously available land and utilizing natural resources for sustenance or income, which can lead to conflicts between local communities and wildlife (Sibanda and Omwega 1996). Conserving wildlife corridors, migration routes, and buffer zones requires considerable community involvement of men and women in decision making, management, and implementation.

Strategic Objective: Provide tangible benefits, create jobs, and develop alternative livelihoods to build support among local communities for conserving wildlife corridors.
Target: Livelihoods of people living alongside wildlife corridors are improved through community improvement projects and economic development activities.

Activities (National or Local)	Actors (Lead in Bold)	Target Date	Indicators
Activity 5.4.1 (Local): Facilitate community-level workshops to collaboratively identify community improvement projects and sustainable economic development activities and ventures that are compatible with wildlife movement. The legal and strategic mechanisms to conserve each corridor should be based largely on likely community benefits.	**TASAF**, TAWA TANAPA, TFS, NLUPC, PORALG, NGOs, corridor working group members, and community organizations	2022 and onward	Number of workshops conducted in priority corridors
Activity 5.4.2 (Local): Create jobs in corridor management, ecotourism, cultural tourism, and related sectors (e.g., village game scouts, habitat restoration, research and monitoring, customs, crafts, lodging, restaurants).	**TAWA**, TANAPA, TFS, DCs, research institutions, investors and NGOs, corridor working group members, and community organizations	2022 and onward	Number of jobs created in communities in and near priority corridors
Activity 5.4.3 (National & Local): Develop and promote alternative fuel sources to prevent illegal tree-cutting for charcoal.	**NGOs**, corridor working group members, and community organizations	2023-2026	Number of villages in and near priority corridors where alternative fuel sources are adopted
Activity 5.4.4 (Local): Develop other forms of community financial benefits for conservation, e.g., through payments for ecosystem services (PES) programs.	**TAWA**, TANAPA, TFS, Investors, NGOs, corridor working group members, and community organizations	2024-2026	Number of PES programs developed in villages in and near priority corridors
Activity 5.4.5 (National & Local): Develop opportunities for sustainable community-based rangeland management, hunting, and fishing according to land use plans.	**TAWA**, TANAPA, DCs, TFS, Investors and NGOs, corridor working group members, and community organizations	2024-2026	Number of villages in and around priority corridors where sustainable rangeland, hunting and fishing opportunities are integrated into village land-use plans
Activity 5.4.6 (Local): Establish carbon projects that contribute funding to improve living conditions for local communities, and for climate adaptation projects.	TFS, **Carbon Tanzania,** and NGOs	2026	Number of carbon projects in priority corridors

5.5 Mitigating and Remediating Impacts of Roads, Railways, and Other Infrastructure on Wildlife

Wildlife crossing structures to facilitate movement through landscapes fragmented by roads, railways, and other linear infrastructure are becoming more common throughout the world, including in Tanzania. Wildlife crossing structures are varied, some have been designed with specific taxa in mind (e.g., colobridges for colobus monkeys), but the more common structures include wildlife overpasses, viaducts, bridges, culverts, and pipes. Although many of these structures were not originally constructed with ecological connectivity in mind, many species benefit from them (Clevenger et al. 2001, Forman et al. 2003). No single type of crossing structure will allow all species to cross a road. For example, a concrete box culvert may be readily accepted by carnivores but most ungulates prefer vegetated overpasses or open terrain below high bridges or viaducts, while small mammals, such as deer mice and voles, prefer pipes and small culverts (McDonald and St Clair 2004). Multiple types of structures with a range of sizes and designs are required to provide safe passage for many different species (Mata et al. 2008, Clevenger and Huijser 2011, Grilo et al. 2015). This is especially true in a biodiversity hotspot such as Tanzania, with thousands of species across diverse ecosystems that have very different body sizes, habits, behaviors, and modes of locomotion, which will require equally diverse crossing structures.

Current practices to limit wildlife-vehicle collisions on paved highways in East Africa and Tanzania have largely relied on installing signage and speed bumps and reducing speed limits in key locations (e.g., Mikumi National Park) to alert drivers to watch out for wildlife (Epps et al. 2015). These low-cost methods have shown some success, and are certainly the only viable options for certain species. As Gadd (2015) stated, “Given the unpredictable direction and fluidity of the migration, it would be impossible to design (much less enforce) crossings that would successfully convey 1.5 million unruly wildebeest and zebras from one side of the road to the other, twice per year”. While Gadd (2015) was referring to a now dead project to put a highway through the Serengeti, Morrison and Bolger’s (2014) GPS collar data for wildebeest indicated they moved north from Manyara Ranch, often traveling at night through bottlenecks and across high-traffic roads (*in* Bond et al. 2017). Speed bumps installed near Jozani-Chwaka Bay National Park for Zanzibar red colobus, which prefers terrestrial movement, have also been shown to be highly successful, reducing colobus deaths by greater than 80% (Tom Struhsaker, personal communication, 2012 *in* Epps et al. 2015).

Wildlife overpasses are most often designed to improve opportunities for large mammals to cross busy highways but are used by a wide diversity of species (Brodziewska 2005, Smith et al. 2015, Grilo et al. 2015). Overpasses are typically about 50 m (164 ft) wide, but can be as large as 200 m (656 ft) wide. In Banff National Park, grizzly bears, wolves, and all ungulates (including bighorn sheep, deer, elk, and moose) prefer overpasses to underpasses, while species such as mountain lions prefer underpasses (Clevenger and Waltho 2005). Other research indicates overpasses may encourage birds and butterflies to cross roads (Forman et al. 2003). Wildlife overpasses have numerous advantages over underpasses including ambient conditions of rainfall, temperature, and light, and providing continuous vegetated cover across the highway (Jackson and Griffin 2000, Glista et al. 2009).

Wildlife underpasses include viaducts, bridges, culverts, and pipes. Many such structures were designed and built to ensure adequate drainage beneath highways but many are also used by wildlife. The best bridges, termed *viaducts*, are elevated roadways or railways that span entire wetlands, valleys, or gorges (Evink 2002), such as the one across the Mpanga River in Tanzania. Bridges over waterways are also effective crossing structures, especially if wide enough to permit growth of both riparian and upland vegetation along both river or stream banks (Jackson and Griffin 2000, Evink 2002, Forman et al. 2003). Bridges with greater openness ratios are generally more successful than low bridges and culverts for ungulates (Veenbaas and Brandjes 1999, Jackson and Griffin 2000, Ng et al. 2004).

Viaduct across the Mpanga River in Tanzania, which is 160 feet high (David Brossard/Wiki Commons).

An underpass constructed to allow elephant movements between Ngare Ndare Forest Reserve and Mt. Kenya National Park proved sufficiently large (12 m long, 4.5 m high and 6 m wide) with over 300 crossings by multiple elephants the first year (Mount Kenya Trust, unpublished data, *in* Weeks 2015. The location of the elephant crossing across the A2 highway was identified by GPS collar data from one elephant (Weeks 2015). To encourage use of the underpass, dung was placed in the vicinity the day the underpass and fencing was completed, and it was used the following day (Weeks 2015). The project cost was relatively modest at roughly one million in US dollars (2011), which included design and construction of the underpass, 28 km of elephant-proof fencing, and housing for the corridor maintenance team with ongoing maintenance costs raised each year (Weeks 2015). A similar elephant crossing and associated fencing are being built in Tanzania, as part of upgrades to the Kidatu-Ifakara highway through Kilombero Valley that will help to maintain connectivity between Udzungwa Mountains National Park and Magombera Nature Reserve and the contiguous Nyerere National Park.

Africa's first dedicated elephant crossing near the slopes of Mt. Kenya (Jason Straziuso | Associated Press).

To increase the utility of bridges over rivers or streams, bridges should span not just the waterway but extend to include upland habitats beyond the scour zone of the stream, and should be high enough to allow enough light for vegetation to grow underneath. The most important difference between bridges and culverts is that the streambed under a bridge is mostly earthen flooring while concrete or corrugated metal are more typical in a culvert and the area under a bridge is large enough that a semblance of a natural stream channel returns a few years after construction. Stream morphology and hydrology usually return to near-natural conditions in bridged streams, and vegetation often grows under bridges. In contrast, vegetation does not typically grow inside a culvert, and hydrology and stream morphology are usually permanently altered not only within the culvert, but for some distance up and downstream.

Despite their disadvantages, well-designed and located culverts can mitigate the effects of busy roads for small and medium sized mammals (Clevenger et al. 2001, McDonald and St. Clair 2004). Culverts are used by many species, including mammals, ground-dwelling birds, amphibians, and reptiles (Yanes et al. 1995, Brudin 2003, Dodd et al. 2004, Ng et al. 2004). Culvert usage can be enhanced by providing a natural substrate bottom (Cain et al. 2003). In locations where the floor of a culvert is persistently covered with water, dry ledges or shelves can be installed on the wall of the underpass above the water level to provide passage for terrestrial species (Cain et al. 2003, Grilo et al. 2015). It is important for the lower end of the culvert to be flush with the surrounding terrain. Many culverts are built with a concrete pour-off and others develop a pour-off lip due to scouring action of water. A sheer pour-off of several inches makes it unlikely that most small mammals, snakes, and amphibians will find or use the culvert.

For rodents, pipe culverts about 0.30 m (1 ft) in diameter without standing water are superior to large culverts because it makes them feel secure against predators (Clevenger et al. 2001, Forman et al. 2003). Special crossing structures that allow light and water to enter have been designed to accommodate amphibians. Retaining walls should be installed to deter small mammals, amphibians, and reptiles from accessing roads and guide them to crossings. Because most reptiles, small mammals, and amphibians have small home ranges, metal or cement box culverts should be installed at intervals of 150-300 m (Clevenger et al. 2001).

Colobus Conservation installed and maintains 28 colobridges along 10 km of Diani Beach Road in Kenya

In Kenya, Colobus Conservation installed 28 'colobridges' to reduce vehicle collisions with colobus monkeys along a 10 km stretch of Diani Beach Road. The 'colobridges' average 800 primate crossings per day, with Sykes' monkeys using the bridges most (673 crossings/day), followed by ground-foraging vervets (91 crossings/day) and the arboreal colobus (35 crossings/day) (Colobus Conservation, unpublished data 2011 *in* Donaldson and Cunneyworth 2015).

Existing structures can be substantially improved with little investment by installing wildlife fencing and vegetation to direct animals to passageways (Forman et al. 2003). Fencing should direct animals towards crossing structures (Yanes et al. 1995). In Florida, construction of a barrier wall to guide animals into a culvert system resulted in 93.5% reduction in roadkill, and also increased the total number of species using the culvert from 28 to 42 (Dodd et al. 2004). Fences, guard rails, and embankments at least 2 m high can discourage animals from crossing roads (Barnum 2003, Cain et al. 2003, Malo et al. 2004). Suitable habitat for species should occur on both sides of the crossing structure (Ruediger 2001, Barnum 2003, Cain et al. 2003, Ng et al. 2004), and within the structure if possible.

At least one crossing structure should be located within an individual's home range. For large mammals, crossing structures should be located no more than 1.5 km apart (Mata et al. 2005, Clevenger and Wierzchowski 2006).

Wildlife crossings can also help to mitigate impediments to wildlife movement for other linear infrastructure, such as above ground pipelines. Over-pipeline and under-pipeline crossings can facilitate wildlife movement across pipelines. Under-pipeline wildlife crossings are preferred but must be factored in at the design stage of the project (Government of Alberta 2014). Research has documented caribou using wildlife crossings over and under above-ground pipelines (Curatolo and Murphy 1986, Lawhead et al. 2006, Muhly et al. 2015). Minimum clearance for under-pipeline crossings will be more of a challenge in Tanzania to facilitate movement of taller target species (e.g., elephants). Four crossings per 1000 m of continuous above-ground pipeline are required for caribou movement (Government of Alberta 2014).

Africa's first dedicated elephant crossing near the slopes of Mt. Kenya (Jason Straziuso | Associated Press).

Caribou walking along Trans-Alaska Pipeline (Stan Sheb).

The most effective way to prevent avian collisions with powerlines are either to bury the lines underground or to route transmission lines away from known avian corridors and flyways and areas known to support collision-prone species (Hunting 2002, Drewitt and Langston 2008, Jenkins et al. 2010). Routing transmission lines well away from lakes, wetlands and other bodies of water and topographic features, such as valleys and ridge tops can lower the risk of avian collisions (Jenkins et al. 2010, Avian Power Line Interaction Committee (APLIC) 2012). Other options to reduce avian collision risks include (1) marking the lines to increase their visibility; (2) removing the shield wire if lighting isn't an issue or if lighting arresters can be used instead; (3) increasing the diameter or changing the configuration of wires when a line is rebuilt (APLIC 2012).

A 2016 Ministry of Works, Transport and Communications infrastructure investment opportunity publication included the following targets: (i) Paving all trunk roads by 2018; (ii) Improving urban mobility and accessibility as well as rural transport and travel; and (iii) Linking of Regional Centers with paved roads and all District Headquarters with all-weather roads by 2018. The document lists several specific trunk roads for upgrading but as of today, most have not yet been implemented providing opportunities to integrate safe passage for wildlife into the design and construction of these transportation improvement projects. Trunk roads already paved should be evaluated to improve safe passage for wildlife and reduce dangerous wildlife-vehicle collisions.

Strategic Objective: Make existing and new roads, railways, and other infrastructure permeable to wildlife movement, particularly in key locations in priority corridors, to maintain viable wildlife populations, reduce wildlife-vehicle/rail collisions, and improve driver safety.

Target: New roads, rail, and other linear infrastructure avoids protected areas, buffer zones, dispersal areas, movement corridors, and migratory routes to the greatest extent possible. When existing roads are paved or enlarged, or new roads, railways, or other infrastructure are built, appropriate wildlife crossings for target species are integrated into the design.

Activities (National or Local)	Actors (Lead in Bold)	Target Date	Indicators
Activity 5.5.1 (National & Local): Reduce vehicle traffic speeds in sensitive locations in wildlife corridors by using speed bumps, curves, artificial constrictions, and other traffic calming devices.	**TANROADS**, TARURA and TAWIRI	2022 and onward	Number of traffic speed reduction zones designated and speed bumps installed in roadkill hotspots of priority corridor areas
Activity 5.5.2 (Local): Install signage or billboards on major roads on the outskirts of wildlife corridors in both directions to alert drivers that they are entering a wildlife corridor and should watch out for wildlife crossing the road to reduce dangerous roadway interactions and collisions.	**TANROADS**, TARURA, TAWA, TAWIRI and NGOs	2022 and onward	Number of signs or billboards installed in roadkill hotspots of priority corridor areas
Activity 5.5.3 (National & Local): Prioritize existing barriers to wildlife movement (roads, railways, and other infrastructure) for remediation. The initial prioritization of barriers for remediation should focus on existing roadkill hotspots that are known to pose a threat to the safety of motorists and wildlife.	**TAWIRI**, TANROADS, TANAPA, TAWA and NGOs	2022 and onward	Prioritized list of top barriers for remediation to conserve priority corridors
Activity 5.5.4 (National & Local): Identify currently planned transportation and infrastructure projects that intersect wildlife corridors and develop a plan of action to integrate wildlife crossing considerations into project design.	**TAWIRI** WD, TANROADS, TARURA, TAZARA, TRC and NGOs	2022 and onward	Action plan to integrate wildlife crossing into currently planned projects Number of projects considering wildlife movement in their plans.
Activity 5.5.5 (National): Strengthen the regulatory framework to evaluate direct, indirect, and cumulative impacts of roads, rail and other infrastructure on wildlife movement, and implement avoidance, minimization or mitigation measures in Environmental and Social Impact Assessments (ESIAs).	**TAWIRI**, WD, TAWA, TANAPA, MWTC, TAN-ROADS, and TARURA	2022 and onward	Regulatory framework strengthened to address wildlife movement
Activity 5.5.6 (National & Local): Integrate research data on wildlife movement and roadkill into road, rail, and infrastructure planning projects.	**TAWIRI**, WD, TAWA, TANAPA, MWTC, TAN-ROADS, and TARURA	2022 and onward	Number of infrastructure projects that integrate design features for wildlife passage

Activities (National or Local)	Actors (Lead in Bold)	Target Date	Indicators
Activity 5.5.7 (Local): Conduct field studies of existing major highways and roads in each wildlife corridor to document structures, identify structures that could be modified to enhance wildlife movement, and identify areas where structures should be installed.	**TAWIRI,** TANROADS, and Individual Researchers	2023-2026	Number of field studies of major infrastructure completed for priority corridors
Activity 5.5.8 (National): Establish a Road Ecology Coordination Unit between Ministry of Works, Transport and Communications and the Ministry of Natural Resources and Tourism to coordinate on any new or existing transportation and infrastructure improvement projects inside wildlife corridors; address mitigation and remediation planning; the design of mitigation and remediation infrastructure (overpasses, underpasses, speed bumps, etc.); and post-construction monitoring.	**MWTC**, MNRT, WD, TAWIRI, and TANROADS	2023	Road Ecology Coordination Unit established
Activity 5.5.9 (National): Conduct outreach with major funders of road, rail, and other infrastructure projects (e.g., development banks) to communicate the importance of providing project-specific funding for integrating wildlife crossings into infrastructure projects to minimize wildlife-vehicle collisions, improve driver safety, and maintain viable wildlife populations.	**WD,** TAWIRI, TANROADS, TAWA and TANAPA	2023 and onward	Number of meetings with agencies and institutions that fund infrastructure projects at national and regional levels
Activity 5.5.10 (National): Develop Tanzania's environmental impact assessment (EIA) policy and guidelines to require infrastructure project proponents to (i) conduct research to identify critical points where wildlife cross infrastructure and (ii) design and implement crossing structures for target species in all potential migratory routes and wildlife corridors as mitigation.	**TAWIRI**, WD, TAWA and TANAPA	2024	EIA Policy modified to require infrastructure projects to identify, design, and implement wildlife crossings.
Activity 5.5.11 (National): Establish a Wildlife Corridor Technical Advisory Group to review all Environmental and Social Impact Assessments (ESIAs) for infrastructure projects in wildlife corridors to ensure that planned mitigation addresses potential impacts to wildlife movement, maintains landscape permeability, and contributes to regional connectivity goals.	**WD**, TAWA, TAWIRI, TANAPA, and TFS	2023	Wildlife Corridor Technical Advisory Panel established
Activity 5.5.12 (National): Develop and maintain a Database of Known and Potential Wildlife Crossing Structures (e.g., bridges and culverts) that exist in the corridors to help researchers study wildlife movement in these key locations. Database attributes: type of structure (e.g., bridge, culvert); dimensions; visibility through structure; flooring (e.g., natural, concrete); habitat type on either side of structure; river or stream; photos of structure and surroundings; notes on wildlife use or sign, observer.	TANROADS, WD, **TAWIRI**, academic institutions, and NGOs.	2024	Wildlife Crossing Structure Database developed and maintained
Activity 5.5.13 (National & Local): Develop a standardized protocol to detect and record roadkill in corridors across Tanzania (Collinson et al. 2014, 2015).	**TAWIRI**, SUA, UDSM, NM-AIST and MWEKA, COSTECH and NGOs	2024	Standardized protocol developed to detect and record roadkill

Activities (National or Local)	Actors (Lead in Bold)	Target Date	Indicators
Activity 5.5.14 (National & Local): Develop a National Roadkill mobile application and associated database of wildlife-vehicle collisions to identify and document hotspots for remediation; could be crowd-sourced by citizen scientists.	**TAWIRI,** TAWA, TANAPA, NGO, and academic institutions	2025	Roadkill application and database developed, deployed, and publicized
Activity 5.5.15 (National & Local): Integrate wildlife crossings either over or under the Hoima-Tanga Pipeline in any above-ground sections that bisect wildlife corridors.	DW, MoE, TAWIRI, and **WD**	2022 and onward	Number and type of wildlife crossings integrated into the design and construction of the pipeline
Activity 5.5.16 (National & Local): Ensure biological monitors provide oversight on construction sites to enhance compliance with mitigation measures, reduce biological impacts, and minimize the construction footprint.	**TAWIRI**, WD, Individual Researchers, and Environmental Consulting Firms	2023 and onward	Biological monitors in place on infrastructure construction projects
Activity 5.5.17 (National & Local): Conduct avian collision risk assessment and spatial analysis to prioritize existing transmission lines for modification and design future transmission line segments to avoid and minimize risk.	**TAWIRI**, NGOs, and energy sector	2023 and onward	Avian collision risk assessments and analyses completed
Activity 5.5.18 (National & Local): Working with a multidisciplinary team of biologists, engineers, planners, designers, and policymakers, develop a Tanzania Wildlife Crossing Structure Handbook (see Clevenger and Huijser 2011) using best-practice guidelines for road, rail, and other linear infrastructure design, mitigation and remediation. The handbook should guide users through the entire planning process, from evaluating alternative road alignments to post-construction effectiveness monitoring.	**WD**, TAWA, TANAPA, TANROADS, and TARURA	2024	Wildlife Crossing Structure Handbook for Tanzania is developed and distributed

5.6 Research and Conservation Planning Resource Needs

Focal Species: A set of species that collectively serve as an umbrella for all native species and ecological processes of interest in a wildlife corridor

Area-Sensitive or Passage Species: Species that need connectivity for dispersal, seasonal migration and / or home range connectivity.

Barrier-Sensitive: Species most reluctant to traverse roads, canals, urban areas or other barriers.

Corridor-Dwellers: Species with limited dispersal, may take multiple generations to move between target areas.

Habitat Specialists: Species strongly associated with specific habitat types or topographical elements.

Ecological Indicator: Species tied to important ecological process whose presence indicates the health of the system.

Like Riggio and Caro (2017), many of the corridors delineated by this assessment identify areas between protected areas that are structurally connected and potentially important for wildlife movement, while other delineated corridors have been documented to provide functional connectivity for certain target species (e.g., elephants, vultures). However, as Caro et al. (2009) pointed out, long-distance movements and dispersal routes are poorly understood in East Africa, even for well-studied species (*in* Epps et al. 2015). Additional research is needed to document use of the corridors by a variety of species, track land use changes that could sever connectivity, and project future settlement patterns and infrastructure needs to ensure that connectivity is maintained. In addition, numerous conservation planning resources—e.g., centralized databases, interactive online maps, and other digital resources—should be further developed to facilitate corridor conservation.

The focal species approach (Beier and Loe 1992, Lambeck 1997, Beier et al. 2008) recognizes that species move through and utilize habitat in a wide variety of ways. Because large charismatic species like elephant and giraffe and carnivores like cheetah and wild dog need such large areas to persist and are among the first to be harmed by loss of connectivity, they can serve as “umbrella species” for other native species of interest. However, the umbrella species conservation approach is not perfect; it might not identify habitat needs for all native species that require landscape connectivity. The umbrella species approach best serves biodiversity if umbrella species are part of a wildlife corridor designed for a suite of focal species, including not only umbrella species but also a diverse collection of mammals, amphibians, reptiles, fish, birds, invertebrates, and plants. Researchers and other stakeholders familiar with individual corridors can identify the umbrella species and other focal species for which connectivity is essential in each corridor. Ideally, each corridor can support the habitat and movement needs of area-sensitive species, barrier-sensitive species, corridor-dwellers, habitat specialists, and ecological indicator species.

Landscape-level wildlife corridors should support movements by passage species that need connectivity for dispersal, seasonal migration, and or home range connectivity, while also providing for corridor-dwellers or resident species that persist within the corridors (Beier et al.2008, Epps et al.2011). Elephants are a key ‘passage’ species for corridor planning at regional and landscape-scales (Epps et al.2011). However, because elephants will move through non-habitat such as cropland, at least over short distances, some barriers are semi-permeable to elephant movement (Riggio and Caro 2017) but may be a complete barrier for other species, such as corridor dwellers or habitat specialists. Live-in habitat for corridor-dwellers is especially important to maintain the ecological integrity of the corridors over time. Thus, additional research is needed to document use of the corridors by a full suite of focal species that are representative of Tanzania’s rich biodiversity.

Finally, Cost-benefit analysis (Activity 5.6.1), a full appraisal of the net economic value of restoring and protecting a corridor compared to not doing so, is an undervalued tool for corridor conservation. Development of a sound corridor Cost-benefit analysis methodology, followed by the analysis for each corridor, will not only help to ensure sound conservation investments. Being able to demonstrate the financial benefits of connectivity – including at the household level, for example through mitigation of crop losses – has great potential for helping to build consensus among communities and other key stakeholders for the importance of conserving a wildlife corridor.

Although this Priority Corridor Action Plan provides an extensive assessment to prioritize the corridors, additional research and conservation planning resources are needed to target and refine conservation efforts of priority corridors. **Strategic Objective:** Wildlife corridor research and conservation planning resources are further developed to aid conservation of priority corridors.

Target: Conduct additional research to document whether and how wildlife corridors provide functional connectivity for key focal species in each priority corridor.

Activities (National or Local)	Actors (Lead in Bold)	Target Date	Indicators
Activity 5.6.1. (National & Local): Analyze costs and benefits associated with acquiring and conserving land in priority corridors, including compensating landowners when necessary; develop a corridor cost-benefit analysis (CBA) methodology that can be applied widely in Tanzania to target investments that represent the greatest value for money in terms of conservation and development outcomes. To consider land conservation costs and related complexities, CBA methodology should account for both financial and opportunity costs (e.g., reduced productivity of land spared for conservation), and market and non-market benefits (e.g., likely impact on tourism revenues, 'existence' or 'non-use' values of conserved species, changes in ecosystem services, and potential impact on human-wildlife conflict).	**NLUPC**, Academic Institutions, NGOs, and Individual Researchers	2023 and onward	Corridor cost-benefit analysis methodology developed; Number of comprehensive analyses of costs and benefits conducted for priority corridors
Activity 5.6.2 (National & Local): Use existing research and conduct additional research as needed to further document the functionality of priority wildlife corridors for multiple taxonomic groups (e.g., with GPS collars, telemetry, population genetics, tracking, remote cameras, visual counts, roadkill documentation, interviews with District Game Officers (DGOs) and local community members.	**TAWIRI**, NGOs, SUA, UDSM, UDOM, NM-AIST and MWEKA, SFS, other higher education and academic research institutions, LGAs, and local communities	2022 and onward	Number of priority corridors for which data is collected to document species movement; distribution and abundance of corridor dwellers, and demographic data
Activity 5.6.3 (Local): Convene stakeholders with knowledge of priority corridors to refine the delineation of the corridor boundaries as needed to ensure that corridors adequately provide movement pathways for key focal species by (i) identifying the key focal species for each corridor, (ii) modeling the habitat and movement needs of those focal species, and (iii) conducting multi-species connectivity assessments in the corridors.	**TAWIRI**, WD, NGOs, higher education and academic research institutions, corridor working groups, local communities	2022 and onward	Comprehensive connectivity assessments completed for stakeholder-identified focal species in priority corridors
Activity 5.6.4 (National & Local): Use existing research and conduct additional research as needed on the effects, and severity of effects, of linear infrastructure such as railways and co-aligned roads on wildlife, especially key focal species for priority corridors.	**TAWIRI**, NGOs, SUA, UDSM, NM-AIST, MWEKA, SFS, other higher education and academic research institutions, and Individual researchers	2023 and onward	Number of priority corridors for which barriers and passageways across transportation features are identified
Activity 5.6.5 (National & Local): Identify areas with the highest frequencies of wildlife-vehicle collisions to help determine where potential improvements may be needed to improve roadway safety for motorists and safe passage for wildlife.	**TAWIRI,** TAN-ROADS, TANAPA, TAWA, higher education and academic research institutions, and NGOs	2023	Number of roadkill hotspots identified

Activities (National or Local)	Actors (Lead in Bold)	Target Date	Indicators
Activity 5.6.6 (National): Create and maintain an online, interactive Tanzania Wildlife Corridor Atlas to help corridor conservation practitioners, donors, and other stakeholders access the results of this assessment and prioritization project (GIS files and other data that are essential for conservation planning) and the results of future studies and corridor conservation efforts; link Corridor Atlas website to other online repositories of corridor information for Tanzania and around the world.	**TAWIRI** and NGOs	2023 and onward	Tanzania Wildlife Corridor Atlas launched and accessible online containing 2020 corridor assessment and prioritization results. Results of future studies and corridor conservation efforts online as they become available
Activity 5.6.7 (National): Compile and maintain a National Biodiversity Database for wildlife research and for land use and infrastructure planning and environmental impact assessments. Include a category in the database for wildlife movement studies to guide conservation planning for priority corridors.	**TAWIRI**, higher education and academic research institutions, and NGOs	2024	National Biodiversity Database launched and accessible online
Activity 5.6.8 (National): Compile and maintain a Tanzania Protected Areas Database of land use designations compatible with wildlife movement.	**TAWIRI**, WD, TAWA, TANAPA, TFS, TAAFORI, and NGOs	2023	Protected Areas Database launched and accessible online
Activity 5.6.9 (National): Compile and maintain a central digital library / server of TAWIRI GIS resources.	**TAWIRI**	2023- and onward	GIS library of spatial data developed
Activity 5.6.10 (Local): Continue to conduct threats assessments in the corridors to further identify the types and levels of threats (e.g., habitat conversion to agriculture, expanding settlements, HWC, poaching, invasive species), as needed.	**TAWIRI**, NGOs, SUA, UDSM, NM-AIST and MWEKA, COSTECH, other higher education and academic research institutions, and Individual Researchers	2022 and onward	Number of priority corridors for which threats assessments are conducted
Activity 5.6.11 (Local): Conduct research to monitor land use and land cover changes and evaluate how changes affect wildlife movement as needed.	**TAWIRI**, NLUPC, NGOs, SUA, UDSM, NM-AIST and MWEKA, COSTECH, other higher education and academic research institutions, and Individual Researchers	2022 and onward	Number of priority corridors for which land use/cover change studies are completed
Activity 5.6.12 (Local): Conduct development projection models to evaluate how growth may create future threats to corridors.	**TAWIRI**, higher education and academic research institutions, and Individual Researchers	2024-2026	Number of priority corridors for which development projection models are completed

5.7 Habitat Restoration and Stewardship

Although many of the wildlife corridors in Tanzania are currently viable, others require restoration to restore functional connectivity. Agriculture land practices are not always compatible with biodiversity values, but many agricultural lands still provide move-through habitat and other resources for wildlife. For example, riparian corridors (Hilty and Merenlender 2004) and windbreaks (Johnson et al. 1994) through agricultural landscapes have been shown to provide cover for wildlife movement.

Most riparian systems have been altered by human activity (Stromberg 2000) in ways that increase fragmentation. For animals associated with rivers and streams, impediments are presented by road crossings, vegetation clearing, invasion of non-native species, accumulation of trash and pollutants in streambeds, farming in channels, gravel mining, and high intensity livestock grazing. Groundwater pumping, upland development, water recharge basins, dams, and concrete structures to stabilize banks and channels change natural flow regimes, and this negatively impacts riparian systems. Increased runoff from urban development not only scours native vegetation but also can create permanent flow or pools in areas that were formerly ephemeral streams. Invasive species can displace native species in some permanent waters. Maintaining and restoring riparian systems will enhance the functionality of the wildlife corridors.

Riparian systems evolved under grazing and browsing pressure from highly mobile wildlife. High intensity livestock grazing in particular locations for long periods can be a major stressor for riparian systems, and livestock should be temporarily excluded from stressed or degraded riparian areas (Belsky et al. 1999, National Academy of Sciences 2002). In healthy riparian zones, grazing pressure should not exceed the historic grazing intensity of native grazing wildlife (Stromberg 2000).

Healthy riparian vegetation can protect and improve water quality and provide habitat and connectivity for a number of species. Continuity between upland and riparian vegetation is also important to maintaining water quality and healthy riparian communities (Brosofske et al.1997, Wilson and Dorcas 2003). Many species commonly found in riparian areas depend on upland habitats during some portion of their lifecycle. Examples include butterflies that use larval host plants in upland habitat and drink water as adults, and toads that summer in upland burrows. Buffers of sufficient width protect edge sensitive species from negative impacts like predation and parasitism.

In addition, because riparian systems provide connectivity between habitats and across elevational zones, conserving and restoring riparian systems will be especially important to allow species to respond and adapt to climate change (Seavy et al. 2009). In an era of climate change, riparian areas can provide cool, shady areas as refugia from increasing temperatures and connect many ecological zones, giving plants and animals room to move.

Strategic Objective: Maintain and restore ecosystem functions by restoring stream and riparian habitat, establishing stewardship buffer zones along streams and rivers, and restoring degraded areas of priority corridors.

Target: Key rivers, streams, and upland habitat in priority wildlife corridors are maintained and restored.

Activities (National or Local)	Actors (Lead in Bold)	Target Date	Indicators
Activity 5.7.1 (Local): Restore habitat converted to cropland or excessively intensive grazing areas to provide minimum corridor width for wildlife movement. Minimum widths can be established through activity 5.6.3.	**VCs**, TAWA, TANAPA, NGOs, and community organizations	2022 and onward	Number of priority corridors for which habitat restoration is completed
Activity 5.7.2 (Local): Restore riparian vegetation along rivers and streams as needed in the wildlife corridor network.	**TAWA,** TANA-PA, NGOs, and commu-nity organiza-tions	2023-2026	Number of priority corridors for which riparian vegetation is restored
Activity 5.7.3 (Local): Retain natural fluvial processes. Maintain or restore natural timing, magnitude, frequency, and duration of surface flows to sustain functional riparian ecosystems in wildlife corridors, to the greatest extent possible.	**Energy sector** and TAWIRI	2024-2026	Number of priority corridors affected by water releases from dams to sustain natural fluvial processes
Activity 5.7.4 (Local): Increase and maintain high water quality standards. Establish use of Best Management Practices (BMPs) for agricultural and rural communities in the wildlife corridor network and surrounding communities.	**DCs**, WD, MOA, TAWA, NGOs, and community organizations	2025	Number of priority corridors for which BMPs are established and in use
Activity 5.7.5 (National & Local): Develop incentives and educational programs to encourage farming practices that improve and maintain water quality, deter farming in floodplains, and protect water catchments and riparian areas.	**MEST,** MOA, NGOs, and community organizations	2025	Number of incentives and education programs developed and shared with villages
Activity 5.7.6 (National & Local): Enforce regulations restricting dumping of, agricultural waste, and trash in streams; farming, gravel mining, and building in streams and floodplains; and use of harmful chemicals such as mercury in water catchment areas.	**WD**, TAWA, MOA and NGOs	2024-2026	Number of annual enforcement visits
Activity 5.7.7 (Local): Remediate barriers to fish migration, restore stream channel complexity, and secure seasonal water releases below dams – vital to the restoration of healthy assemblages of native fish and amphibian populations.	**WD**, TAWA, MOA and NGOs	2026	Number of fish barriers remediated in priority corridor areas
Activity 5.7.8 (Local): Map current and historical pastoral rangelands and designate and protect them. CCROs, for example, provide one potential mechanism for protection.	**NLUPC**, UCRT, TNC, and NTRI	2024-2026	Number of pastoral rangelands mapped and designated

6. LITERATURE CITED

Abade L., D. Macdonald and A. Dickman. 2014. Assessing the relative importance of landscape and husbandry factors in determining large carnivore depredation risk in Tanzania's Ruaha landscape. Biological Conservation 180:241–248.

Andersen, R., B. Wiseth, P.H. Pedersen, and V. Jaren. 1991. Moose-train collisions: effects of environmental conditions. Alces 27:79–84.

Ando, A. J. Camm, S. Polasky, and A. Solow. 1998. Species distributions, land values, and efficient conservation. Science 279:2126-2128.

Avian Power Line Interaction Committee (APLIC). 2012. Reducing Avian Collisions with Power Lines: The State of the Art in 2012. Edison Electric Institute and APLIC. Washington, D.C. 159 pp.

Balmford, A. K.J. Gaston, S. Blyth, A. James, and V. Kapos. 2003. Global variation in terrestrial conservation costs, conservation benefits, and unmet conservation needs. Proceedings of the National Academy of Sciences of the United States of America 100:1046-1050.

Barnum, S.A. 2003. Identifying the best locations along highways to provide safe crossing opportunities for wildlife: a handbook for highway planners and designers. Colorado Department of Transportation.

Barrientos, R. and L. Borda-de-Agua. 2017. Chapter 4 Railways as Barriers for Wildlife: Current Knowledge. Pages 43-64 in L. Borda-de-Água et al. (eds.), Railway Ecology, DOI 10.1007/978-3-319-57496-7_4.

Barrientos, R., C. Ponce, C. Palac´ın, C. A. Mart´ın, B. Mart´ın, and J. C. Alonso. 2012. Wire marking results in a small but significant reduction in avian mortality at power lines: A BACI designed study. PLOS One 7:e32569. doi:10.1371/journal.pone.0032569.

Barrientos, R., J.C. Alonso, C. Ponce, and C. Palacin. 2011. Meta-analysis of the effectiveness of marked wire in reducing avian collisions with power lines. Conservation Biology, *25*, 893–903.

Bartlam-Brooks, H.L.A., M.C. Bonyongo, and S. Harris. Will reconnecting ecosystems allow long-distance mammal migrations to resume? A case study of a zebra Equus burchelli migration in Botswana. Oryx. 2011; 45:210-6.

Beier, P., D. R. Majka, and W. D. Spencer. 2008. Forks in the road: choices in procedures for designing wildland linkages. Conservation Biology 22:836-851.

Beier, P., and S. Loe. 1992. A checklist for evaluating impacts to wildlife movement corridors. Wildlife Society Bulletin 20:434-440.

Belsky, A.J., A. Matzke, and S. Uselman. 1999. Survey of livestock influences on stream and riparian ecosystems in the western United States. Journal of Soil and Water Conservation 54: 419-431.

Bevanger, K. and H. Brøseth. 2004. Impact of power lines on bird mortality in a subalpine area. Animal Biodiversity and Conservation 27:67–77.

Blake, S., S. L. Deem, S. Strindberg, F. Maisels, L. Momont, I.B. Isia, I. Douglas-Hamilton, W. B. Karesh, and M. D. Kock. 2008. Roadless wilderness area determines forest elephant movements in the Congo Basin. PLoS One 3: e3546.

Bode, M. K.A. Wilson, T.M. Brooks, W.R. Turner, R.A. Mittermeier, M.F. McBride, E.C. Underwood, and H.P. Possingham. 2008. Cost-effective global conservation spending is robust to taxonomic group. Proceedings of the National Academy of Sciences United States of America 105:6498-6501.

Bond, M.L., C.M. Bradley, C. Kiffner, T.A. Morrison, and D.E. Lee. 2017. A multi-method approach to delineate and validate migratory corridors. Landscape Ecology 32:1705–1721.

Bracebridge, C and C. Kendall. 2019. Southern Tanzania Vulture Research, Monitoring and Conservation Annual Report 2019. North Carolina Zoo. 34 pp.

Bracebridge, C and C. Kendall. 2018. Southern Tanzania Vulture Research, Monitoring and Conservation Annual Report 2018. North Carolina Zoo. 31 pp.

Brashares, J.S. P. Arcese, and M.K. Sam. 2011. Human demography and reserve size predict wildlife extinction in West Africa. Proceedings of the Royal Society London Biological Sciences 268, 2473-2478.

Brodziewska, J. 2005. Wildlife tunnels and fauna bridges In Poland: past, present and future, 1997–2013. In: International Conference on Ecology and Transportation. 2005 San Diego proceedings. Center for Transportation and the Environment: North Carolina State University, 2006. Raleigh, NC, pp. 448–460.

Brosofske, K.D., J. Chen, R.J. Naiman, and J.R. Franklin. 1997. Harvesting effects on microclimatic gradients from small streams to uplands in western Washington. Ecological Applications 7:1188-1200.

Brudin III, C.O. 2003. Wildlife use of existing culverts and bridges in north central Pennsylvania. ICOET 2003.

Buchhorn, M., B. Smets, L. Bertels, M. Lesiv, N.E. Tsendbazar, D. Masiliunas, M. Herold, and S. Fritz. 2019. Copernicus Global Land Service: Land Cover 100m, epoch 2018, Africa Demo (Version V2.1.1) [Dataset]. Zenodo. DOI: 10.5281/zenodo.3518087

Brugiere, D. and B. Magassouba. 2009. Pattern and sustainability of the bushmeat trade in the Haut Niger National Park, Republic of Guinea. African Journal of Ecology 47:630–639.

Butler, J.R.A., J.T. du Toit, and J. Bingham. 2004. Free-ranging domestic dogs (Canis familiaris) as predators and prey in rural Zimbabwe: threats of competition and disease to large wild carnivores. Biological Conservation 115(3), 369–378.

Cain, A.T., V.R. Tuovila, D.G. Hewitt, and M.E. Tewes. 2003. Effects of a highway and mitigation projects on bobcats in Southern Texas. Biological Conservation 114:189-197.

Canada E. Recovery Strategy for the Woodland Caribou (Rangifer tarandus caribou), Boreal population, in Canada. Ottawa: Environment Canada, 2012.

Caro T., T. Jones, and T.R.B. Davenport. 2009. Realities of documenting wildlife corridors in tropical countries. Biological Conservation 142:2807±11.

Chem Chem Association, 2019. Tarangire-Manyara Kwakuchinja Corridor Project: To Operationalize the Wildlife Corridor between Tarangire and Manyara National Parks. Quarterly report oct-Dec 2019.Prepared for PROTECT Activity in Tanzania. (USAID). 43 pp.

Clevenger, A. P. and M.P. Huijser. 2011. Wildlife crossing structure handbook design and evaluation in North America. Federal Highway Administration, Lakewood CO, 211 pp.

]Clevenger, A.P. and J. Wierzchowski. 2006. Maintaining and restoring connectivity in landscapes fragmented by roads. Pages 502-535. In Connectivity Conservation (Eds. K. Crooks, M. Sanjayan). Cambridge University Press.

Clevenger, A.P. and N. Waltho. 2005. Performance indices to identify attributes of highway crossing structures facilitating movement of large mammals. Biological Conservation 121:453-464.

Clevenger, A.P., B. Chruszcz, and K. Gunson. 2001. Drainage culverts as habitat linkages and factors affecting passage by mammals. Journal of Applied Ecology 38: 1340-1349.

Clevenger, A.P., and N. Waltho. 2000. Factors influencing the effectiveness of wildlife underpasses in Banff National Park, Alberta, Canada. Conservation Biology 14: 47-56.

Collinson, W., D. Parker, C. Patterson-Abrolat, G. Alexander, and H. Davies-Mostert. 2015. Chapter 54 Setjhaba Sa, South Afrika: A South African Perspective of an Emerging Transport Infrastructure. Pages 439-446 in Handbook of Road Ecology, First Edition. Edited by Rodney van der Ree, Daniel J. Smith and Clara Grilo. © 2015 John Wiley & Sons, Ltd. Published 2015 by John Wiley & Sons, Ltd.

Cozzi G., F. Broekhuis, J.W. McNutt, and B. Schmid. 2013. Comparison of the effects of artificial and natural barriers on large African carnivores: implication for interspecific relationships and connectivity. Journal of Animal Ecology 82:707±715. https://doi.org/10.1111/1365-2656.12039 PMID: 23402594.

Crooks and MA Sanjayan, editors, Connectivity Conservation. Cambridge University Press. 712pp.

Cullen, R., K.F.D. Hughey, G. Fairburn, and E. Moran. 2005. Economic analyses to aid nature conservation decision making. Oryx 39:327-334.

Curatolo, J.A. and S.M. Murphy. 1986. The effects of pipelines, roads, and traffic on the movements of caribou, Rangifer tarandus. Canadian field-naturalist Ottawa Ontario 100(2):218–24.

D'Amore, A., V. Hemingway, and K. Wasson. 2010. Do a threatened native amphibian and its invasive congener differ in response to human alteration of the landscape? Biological Invasions 12:145–154.

Davis, C.D., C.W. Epps, R.L. Flitcroft, and M.A. Banks. 2017. Refining and defining riverscape genetics: How rivers influence population genetic structure. WIREs Water. 2018; e1269.wires.wiley.com/water https://doi.org/10.1002/wat2.1269.

Debonnet, G. and S. Nindi. 2017. Technical Study on Land Use and Tenure Options and Status of Wildlife Corridors in Tanzania an Input to the Preparation of Corridor Regulations. Prepared for United States Agency for International Development (USAID). Prepared by PROTECT. 106pp.

Division of Environment. 2014. Fifth National Report on the Implementation of the Convention on Biological Diversity. Published by the Vice President's Office, United Republic of Tanzania, Dar es Salaam. 64 pp.

Division of Environment. 2015. National Biodiversity Strategy and Action Plan (NBSAP). Published by the Vice President's Office, United Republic of Tanzania, Dar es Salaam. 154 pp.

Division of Environment. 2019. Sixth National Report on the Implementation of the Convention on Biological Diversity. Published by the Vice President's Office, United Republic of Tanzania, Dar es Salaam. 89 pp.

Division of Environment. 2019. A National Invasive Species Strategy and Action Plan (2019). Division of Environment, Vice President's Office; United Republic of Tanzania - Vice President's Office, Dodoma, Tanzania. 155 pp.

Dodd, C.K, W.J. Barichivich, and L.L. Smith. 2004. Effectiveness of a barrier wall and culverts in reducing wildlife mortality on a heavily traveled highway in Florida. Biological Conservation 118: 619-631.

Donaldson, A. and P. Cunneyworth. 2015. Chapter 41 Case Study: Canopy Bridges for Primate Conservation. Pages 341-343 in Handbook of Road Ecology, First Edition. Edited by Rodney van der Ree, Daniel J. Smith, and Clara Grilo. © 2015 John Wiley & Sons, Ltd. Published 2015 by John Wiley & Sons, Ltd.

Dorsey, B., M. Olsson and, L.J. Rew. 2015. Chapter 26 Ecological effects of railways on wildlife. Pages 219-227 in Handbook of Road Ecology, First Edition. Edited by Rodney van der Ree, Daniel J. Smith and Clara Grilo. © 2015 John Wiley & Sons, Ltd. Published 2015 by John Wiley & Sons, Ltd.

Drewitt, A. L. and Langston, R. H. W. (2008). Collision effects of wind-power generators and other obstacles on birds. Annals of the New York Academy of Sciences 1134: 233–266.

Drews, C. 1995. Road kills of animals by public traffic in Mikumi National Park, Tanzania, with notes on baboon mortality. African Journal of Ecology 33: 89–100.

Elsen, P.R., W.B. Monahan, and A.M. Merenlender. 2018. Global patterns of protection of elevational gradients in mountain ranges. www.pnas.org/cgi/doi/10.1073/pnas.1720141115. 6 pp.

Epps, C.W., K. Nowak, and B. Mutayoba. 2015. Chapter 55 Unfenced Reserves, Unparalleled Biodiversity and a Rapidly Changing Landscape: Roadways and Wildlife in East Africa. Pages 448-453 in Handbook of Road Ecology, First Edition. Edited by Rodney van der Ree, Daniel J. Smith and Clara Grilo. © 2015 John Wiley & Sons, Ltd. Published 2015 by John Wiley & Sons, Ltd.

Epps, C.W., S.K. Wasser, J.L. Keim, B.M. Mutayoba, and J.S. Brashares. 2013. Quantifying past and present connectivity illuminates a rapidly changing landscape for the African elephant. Molecular Ecology (2013) 22, 1574–1588.

Epps, C.W., B.M. Mutayoba, L. Gwin, and J.S. Brashares. 2011. An empirical evaluation of the African elephant as a focal species for connectivity planning in East Africa. Diversity and Distributions 17:603–612.

Estes, R.D. 2014. The Gnu'sWorld: Serengeti wildebeest ecology and life history. University of California Press, Berkeley.

Estes, A.B., T. Kuemmerle, H. Kushnir, V.C. Radeloff, and H.H. Shugart. 2012. Land cover change and human population trends in the greater Serengeti ecosystem 1984-2003. Biological Conservation 147 (1)255-263.

Evink, G.L. 2002. Interaction between roadways and wildlife ecology. National Academy Press, Washington, D.C.

Faanes, C. A. 1987. Bird behaviour and mortality in relation to power lines in prairie habitats. U.S. Fish and Wildlife Service Technical Report 7: 1–24.

Ferraro, P.J. and S.K. Pattanayak. 2006. Money for nothing? A call for empirical evaluation of biodiversity investments. PLoS Biology 4:482-488.

Foley, C. L. Foley, A. Lobora, D. De Luca, M. Msuha, T.R.B. Davenport, and S. Durant. 2014. A field guide to the larger mammals of Tanzania. 320 pp.

Forman, R.T.T., D. Sperling, J.A. Bissonette, A.P. Clevenger, C.D. Cutshall, V.H. Dale, L. Fahrig, R. France, C.R. Goldman, K. Heanue, J.A. Jones, F.J. Swanson, T. Turrentine, and T.C. Winter. 2003. Road Ecology: Science and Solutions. Island Press, Washington, D.C.

Forman, R.T.T., and R.D. Deblinger. 2000. The ecological road-effect zone of a Massachusetts (U.S.A) suburban highway. Conservation Biology 14:36-46.

Forman, R.T.T., and L.E. Alexander. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics 29:207-231.

Forman, R.T.T. 1995. Land Mosaics: The Ecology of Landscapes and Regions. Cambridge University Press, Cambridge, England.

Gadd, M.E. 2015. Chapter 56 Expected effects of a road across the Serengeti. Pages 455-464 in Handbook of Road Ecology, First Edition. Edited by Rodney van der Ree, Daniel J. Smith and Clara Grilo. © 2015 John Wiley & Sons, Ltd. Published 2015 by John Wiley & Sons, Ltd.

Ghezae, N., M. Berlekom, L. Engström, M.L. Eriksson, G. Gallardo, K. Gerhardt, P. Knutsson, P. Malmer, E. Stephansson, and S. von Walter. 2009. Natural resource tenure – a crucial aspect of poverty reduction and human rights. Swedish Inter-national Development Cooperation Agency (Sida), Stockholm, Sida Studies No. 23.

Gilpin M. E. and M. E. Soulé 1986. Minimum viable populations: processes of species extinction. Pages 19-34 in Conservation biology: the science of scarcity and diversity. M.E. Soule (ed), Sinauer Associates, Inc. Sunderland, Mass.

Glista, D.J., T.L. DeVault, and J.A. DeWoody. 2009. A review of mitigation measures for reducing wildlife mortality on roadways. Landscape and Urban Planning 91: 1–7.

Government of Alberta. 2014. Above ground pipeline wildlife crossing directive. Environment and Sustainable Resource Development, Public Land Management, 2014, No. 7. 6 pp.

Grand, L., K.D. Messer, and W. Allen. 2017. Understanding and overcoming barriers for cost-effective conservation. Ecological Economics 138:139-144. Elsevier B.V. Available from http://dx.doi.org/10.1016.j.ecolecon.2017.03.027.

Grilo, C., D.J. Smith, and N. Klar. 2015. Chapter 35 Carnivores: Struggling for survival in roaded landscapes. Pages 300-312 in Handbook of Road Ecology, First Edition. Edited by Rodney van der Ree, Daniel J. Smith and Clara Grilo. © 2015 John Wiley & Sons, Ltd. Published 2015 by John Wiley & Sons, Ltd.

Gupfinger, C. 2012. A behavioral analysis of primate polyspecific associations in relation to the park boundary of Udzungwa Mountains National Park, Tanzania. Senior thesis. Princeton University, Princeton, NJ.

Guzha, A.C., M.C. Rufino, S. Okoth, S. Jacobs, and R.L.B. Nóbrega. 2018. Impacts of land use and land cover change on surface runoff, discharge and low flows: Evidence from East Africa. Journal of Hydrology: Regional Studies 15, 49–67.

Haight, J. and E. Hammill. 2020. Protected areas as potential refugia for biodiversity under climatic change. Biological Conservation. 241. pp. 1-11. https://doi.org/10.1016/j.biocon.2019.108258.

Hanski, I. and M. Gilpin. 1991. Metapopulation Dynamics. Academic Press, London.

Harris, L.D. 1984. The fragmented forest: island biogeography theory and the preservation of biotic diversity. University of Chicago Press, Chicago, Illinois.

Harrison, S. and R. Noss. 2017. Endemism hotspots are linked to stable climatic refugia. Annals of Botany 0: 1–8, 2017.

Heller, N.E. and E.S. Zavaleta. 2009. Biodiversity management in the face of climate change: a review of 22 years of recommendations. Biological Conservation 142:14-32.

Hicks, T.C., P. Roessingh, and S.B.J. Menken. 2012. Reactions of Bili-Uele chimpanzees to humans in relation to their distance from roads and villages. American Journal of Primatology 74: 721–733.

Hilty, J.A. and A.M. Merenlender. 2004. Use of riparian corridors and vineyards by mammalian predators in northern California. Conservation Biology 18(1): 126-135.

Hoare, R. 2000. African elephants and humans in conflict: the outlook for co-existence. Oryx 34(1), 34-38.

Hoffman, M., K. Koenig, G. Bunting, J. Costanza, and K.J. Williams. 2016. Biodiversity Hotspots (version 2016.1) [Dataset]. Zenodo. http://doi.org/10.5281/zenodo.3261807.

Holdo, R.M., J.M. Fryxell, A.R.E. Sinclair, A. Dobson, and R.D. Holt. 2011. Predicted impact of barriers to migration on the Serengeti wildebeest population. PLoS One 6: e16370.

Holmern, T., J. Muya, R. Oslash, and E. Skaft. 2007. Local law enforcement and illegal bushmeat hunting outside the Serengeti National Park, Tanzania. Environmental Conservation. 34, 55.

Holmes, G. 2013. Exploring the relationship between local support and the success of protected areas. Conservation and Society, 11, 72–82.

Huber, D., J. Kusak, and A. Frkovic. 1998. Traffic kills of brown bears in Gorski Kotar, Croatia. Ursus 10:167–171.

Hunting, K. 2002. A roadmap for PIER research on avian collisions with power lines in California. Sacramento, CA: Prepared for the California Energy Commission, Public Interest Energy Research Program. Report No. P500-02-071F.

H¨uppop, O. and G. Hilgerloh. 2012. Flight call rates of migrating thrushes: Effects of wind conditions, humidity and time of day at an illuminated offshore platform. Journal of Avian Biology 43:85–90.

International Union for Conservation of Nature (IUCN). 2020. The IUCN Red List of Threatened Species. Version 2020-2. https://www.iucnredlist.org. Downloaded on 23 August 2020.

IUCN. 2020. The *IUCN Red List of Threatened Species: Spatial Data Terrestrial Mammals, Amphibians, Reptiles, and Freshwater Polygons.* Red List Version 6.2; 19 March 2020. https://www.iucnredlist.org. Downloaded on 3 April 2020.

Jackson, S.D. and C.R. Griffin. 2000. A Strategy for Mitigating Highway Impacts on Wildlife. Pp. 143-159 In Messmer, T.A., and B. West (eds.). Wildlife and Highways: Seeking Solutions to an Ecological and Socio-economic Dilemma. The Wildlife Society.

Jenkins, A.R., J.J. Smallie, and M. Diamond. 2010. Avian collisions with power lines: a global review of causes and mitigation with a South African perspective. Bird Conservation International (2010) 20:263–278. BirdLife International, 2010 doi:10.1017/S0959270910000122.

Johnson, C.G., Jr., R.R., Clausnitzer, P.J. Mehringer, and C.D. Oliver. 1994. Biotic and abiotic processes of Eastside ecosystems: the effects of management on plant and community ecology and on stand and landscape vegetation dynamics. Gen. Tech. Rep. PNW-GTR-322. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 66 pp.

Jones T., A.J. Bamford, D. Ferrol-Schulte, P. Hieronimo, N. McWilliam, and F. Rovero. 2012. Vanishing wildlife corridors and options for restoration: a case study from Tanzania. Tropical Conservation Science 5:463-74.

Jones, T., T. Caro and, T.R.B. Davenport (Eds.). 2009. Wildlife Corridors in Tanzania. Unpublished report. Tanzania Wildlife Research Institute (TAWIRI), Arusha. 60pp.

Jones, J.A., F.J. Swanson, B.C. Wemple, and K.U. Snyder. 2000. Effects of roads on hydrology, geomorphology, and disturbance patches in stream networks. Conservation Biology 14:76-85.

Kalumanga, E. 2015. How elephants utilize a miombo wetland ecosystem in Ugalla landscape Western Tanzania. Doctoral dissertation, Department of Physical Geography Stockholm University.

Kangalawe, R.Y.M. and C. Noe. 2012. Biodiversity conservation and poverty alleviation in Namtumbo District, Tanzania. Agriculture, Ecosystems and Environment 162 (2012) 90–100.

Kiffner, C., C. Wenner, A. LaViolet, K. Yeh, and J. Kioko. 2015. From savannah to farmland: effects of land-use on mammal communities in the Tarangire-Manyara ecosystem, Tanzania. African Journal of Ecology 53:156-166.

Kikoti A.P., C.R. Griffin, and L. Pamphil. 2010. Elephant use and conflict leads to Tanzania's first wildlife conservation corridor. Pachyderm 48:57-66.

Kioko, J., C. Kiffner, N. Jenkins, and W.J. Collinson. 2015a. Wildlife road kill patterns on a major highway in northern Tanzania. African Zoology, 50, 17–22. https://doi.org/10.1080/15627020.2015.1021161.

Kioko, J., C. Kiffner, P. Phillips, C. Patterson-Abrolat, W. Collinson, and S. Katers. 2015b. Driver knowledge and attitudes on animal vehicle collisions in northern Tanzania. Tropical Conservation Science 8:352–366. https://doi.org/10.1177/194008291500800206.

Kissui, B.M., C. Kiffner, H.J. König, and R.A. Montgomery. 2019. Patterns of livestock depredation and cost-effectiveness of fortified livestock enclosures in northern Tanzania. Ecology and Evolution 00:1–14.

Kiwango W.A., H.C. Komakech, T.M.C. Tarimo, and L. Martz. 2017. Levels of community participation and satisfaction with decentralized wildlife management in Idodi-Pawaga Wildlife Management Area, Tanzania. International Journal of Sustainable Development & World Ecology. 11 pp.

Klein, D.R. 1971. Reaction of reindeer to obstructions and disturbances. Science 173:393-398.

Kornilev, Y., S. Price and M. Dorcas. 2006. Between a rock and a hard place: responses of eastern box turtles (*Terrapene carolina*) when trapped between railroad tracks. Herpetological Review 37:145–148.

Lamarque, F., J. Anderson, R. Fergusson, M. Lagrange, Y. Osei-Owusu, and L. Bakker. 2009. Human-wildlife conflict in Africa: causes, consequences and management strategies (No. 157). Food and Agriculture Organization of the United Nations (FAO).

Lambeck, R. 1997. Focal species: a multi-species umbrella for nature conservation. Conservation Biology 11: 849-856.

Lamprey, H.F. 1964. Estimation of the large mammal densities, biomass and energy exchange in the Tarangire Game Reserve and the Masai Steppe in Tanganyika. East African Wildlife Journal 2:1–46.

Laurance, W. F., B. M. Croes, L. Tchignoumba, S. A. Lahm, A. Alonso, M. E. Lee, P. Campbell, and C. Ondzeano. 2006. Impacts of roads and hunting on central African rainforest mammals. Conservation Biology 20: 1251–1261.

Lawhead B.E., J.P. Parrett, A.K. Prichard, and D.A. Yokel. A literature review and synthesis on the effect of pipeline height on caribou crossing success. In: U. S. Department of the Interior Bureau of Land Management, editor. 2006.

Lawler J.J., D.D. Ackerly, C.M. Albano, M.G. Anderson, S.Z. Dobrowski, J.L. Gill, N.E. Heller, R.L. Pressey, E.W. Sanderson, and S.B. Weiss. 2015. The theory behind, and the challenges of, conserving nature's stage in a time of rapid change. Conservation Biology 29:618–629.

Levins, R. 1970. Extinction. Pages 77-107 in M. Gerstenhaber, ed. Some Mathematical Questions in Biology. Lectures on Mathematics in the Life Sciences, Vol. 2. American Mathematical Society, Providence, RI.

Lee D.E., and D.T. Bolger. 2017. Movements and source–sink dynamics of a Masai giraffe metapopulation. The Society of Population Ecology and Springer Japan 2017. http://dx.doi.org/10.1007/s10144-017-0580-7.

Lewis, A.L., T.D. Baird, and M.G. Sorice. 2016. Mobile Phone Use and Human–Wildlife Conflict in Northern Tanzania. Environmental Management. Springer Science+Business Media New York 2016. DOI 10.1007/s00267-016-0694-2.

Lienenbecker, H. and U. Raabe. 1981. Veg auf Bahnhofen des Ost-Munsterlandes. Berichte naturw. Ver. Bielefeld 25:129-41.

Lohay. G.M.G. 2019. Elephants without borders: historical and contemporary genetic connectivity in Tanzania. A Dissertation in Biology, Penn State University. 215 pp.

Longcore, T., and C. Rich. 2016. Artificial night lighting and protected lands: Ecological effects and management approaches. Natural Resource Report NPS/NRSS/NSNS/NRR—2016/1213. National Park Service, Fort Collins, Colorado.

Lotz, M.A.; E.D. Land, and K.G. Johnson. 1996. Evaluation of state road 29 wildlife crossings. Final report, study no. 7583. Florida Game and Freshwater Fish Commission. Tallahassee, Florida. 15pp.

Luzenski, J., C.E. Rocca, R.E. Harness, J.L. Cummings, D.D. Austin, M.A. Landon and J.F. Dwyer. 2016. Collision avoidance by migrating raptors encountering a new electric power transmission line. The Condor Ornithological Applications. Volume 118, 2016, pp. 402–410 DOI: 10.1650/CONDOR-15-55.1

Lyon, L.J. 1983. Road density models describing habitat effectiveness for elk. Journal of Forestry 81:592-5.

Martin, E.H., R.R. Jensen, P.J. Hardin, A.W. Kisingo, R.A. Shoo and A. Eustace. 2019. Assessing changes in Tanzania's Kwakuchinja Wildlife Corridor using multitemporal satellite imagery and open source tools. Applied Geography 110 (2019) 102051.

MacArthur, R.H., and E.O. Wilson. 1967. The Theory of Island Biogeography. Princeton University Press, Princeton, NJ.

Mahulu, A., A. Lugelo, S. Mtoka, and K. Ngongolo. 2019. Conservation Education, Alternative Livelihood and Habitat Restoration: The Best Strategies for Conservation of Magombera Forest Reserve. Asian Journal of Environment & Ecology 9(4): 1-9, 2019; Article no.AJEE.50158 ISSN: 2456-690X.

Maingi, J. K., J. M. Mukeka, D. M. Kyale, and R. M. Muasya. 2012. Spatiotemporal patterns of elephant poaching in south-eastern Kenya. Wildlife Research 39: 234–249.

Malo, J.E., F. Suarez, and A. Diez. 2004. Can we mitigate animal-vehicle accidents using predictive models. Journal of Applied Ecology 41: 701-710.

Marshall, A.R. 2008. Ecological report on Magombera forest. Unpublished report to WWFTPO. Retrieved from http:// www. easternarc. or. tz/MagomberaEcologicalReport2008. pdf.

Masenga, E., C. Jackson, E. Mjingo, A. Jacobson, J. Riggio, R. Lyamuya, R. Fyumagwa, M. Borner, and E. Røskaft. 2016. Insights into long-distance dispersal by African wild dogs in East Africa. African Journal of Ecology. 54. 95-98. 10.1111/aje.12244.

Masozera M., J.D. Erickson, D. Clifford, P. Coppolillo, H.G. Sadiki, and J.K. Mazet. 2013. Integrating the management of Ruaha Landscape of Tanzania with local needs and preferences. Environmental Management. 52:1533–1546.

Mata, C., I. Hervas, J. Herranz, F. Suarez, and J.E. Malo. 2008. Are motorway wildlife passages worth building? Vertebrate use of road-crossing structures on a Spanish motorway. Journal of Environmental Management88, 407–415. doi:10.1016/j.jenvman.2007.03.014.

Mata, C., I. Hervas, J. Herranz, F. Suarez, and J.E. Malo. 2005. Complementary use by vertebrates of crossing structures along a fenced Spanish motorway. Biological Conservation 124: 397-405.

Mbarang'andu, 2003. Katiba ya Jumuiya ya Hifadhi na Matumizi Endelevu ya Maliasili Mbarang'andu. Wilaya ya Namtumbo, Namtumbo.

McDonald, R.I. R.T.T. Forman, P. Kareiva, R. Neugarten, D. Salzer, and J. Fisher. 2009. Urban effects, distance, and protected areas in an urbanizing world. Landscape and Urban Planning 93:63–75.

McDonald, W. and C.C. St Clair. 2004. Elements that promote highway crossing structure use by small mammals in Banff National Park. Journal of Applied Ecology 41:82-93.

McRae, B.H., and D.M. Kavanagh. Linkage Mapper Connectivity Analysis Software. Seattle (WA): The Nature Conservancy; 2011. Available from: http://www.circuitscape.org/linkagemapper.

Messenger, K.G. 1968. A railway flora of Rutland. Proceedings of the Botanical Society of the British Isles 7:325-344.

Mills, L.S., and P.E. Smouse. 1994. Demographic consequences of inbreeding in remnant populations. American Naturalist 144:412-431.

Ministry of Natural Resources and Tourism (MNRT). 2020. National Human-Wildlife Conflict Management Strategy 2020-2024. Ministry of Natural Resources and Tourism, United Republic of Tanzania.

Molles, M.C. 2008. Ecology: Concepts and Applications, Fourth Edition. McGraw-Hill. New York.

Morrison, T.A., W.A. Link, W.D. Newmark, C.A. Foley, and D.T. Bolger. 2016. Tarangire revisited: Consequences of declining connectivity in a tropical ungulate population. Biological Conservation 197:53-60.

Morrison, T.A. and D.T. Bolger. 2014. Connectivity and bottlenecks in a migratory wildebeest *Connochaetes taurinus* population. Oryx 48(4):613–621.

Morrison, T.A., and D.T. Bolger. 2012. Wet season range fidelity in a tropical migratory ungulate. Journal of Animal Ecology 81:543–552.

Muehlenbach, V. 1979. Contributions to the synanthropic (adventive) flora of the railroads in St. Louis, Missouri, USA. Annals of the Missouri Botanical Garden 66:1-108.

Muhly T., R. Serrouya, E. Neilson, H. Li, and S. Boutin. 2015. Influence of In-Situ Oil Sands Development on Caribou (*Rangifer tarandus*) Movement. PLoS ONE 10(9): e0136933. doi:10.1371/ journal.pone.0136933.

Murdoch, W., S. Polasky, K.A. Wilson, H.P. Possingham, P. Kareiva, and R. Shaw. 2007. Maximizing return on investment in conservation. Biological Conservation 139:375-388.

Murphy, R. K., S. M. McPherron, G. D. Wright, and K. L. Serbousek. 2009. Effectiveness of avian collision averters in preventing migratory bird mortality from power line strikes in the Central Platte River, Nebraska. 2008–2009 Final Report. 30 September 2009, Dept. of Biology, University of Nebraska- Kearney, Kearney, NE. 32 pp.

Mutanga, C.N., S. Vengesayia, N. Mubokob, E. Gandiwa. 2015. Towards harmonious conservation relationships: A framework for understanding protected area staff-local community relationships in developing countries. Journal for Nature Conservation 25 (2015) 8–16.

Naidoo, R., A. Balmford, P.J. Ferraro, S. Polasky, T.H. Rickets, and M. Rouget. 2006. Integrating economic costs into conservation planning. Trends in Ecology and Evolution 21:681-687.

National Academy of Sciences. 2002. Riparian areas: functions and strategies for management. National Academy Press. Washington D. C. 436 pp.

Newmark, W. D., J. I. Boshe, H. I. Sariko, and G. K. Makumbule. 1996. Effects of a highway on large mammals in Mikumi National Park, Tanzania. African Journal of Ecology 34:15–31.

Ng, S.J., J.W. Dole, R.M. Sauvajot, S.P.D. Riley, and T.J. Valone. 2004. Use of highway undercrossings by wildlife in southern California. Biological Conservation 115:499-507.

Ngene, S., M.M. Okello, J. Mukeka, S. Muya, S. Njumbi, and J. Isiche. 2017. Home range sizes and space use of African elephants (Loxodonta africana) in the Southern Kenya and Northern Tanzania borderland landscape. International Journal of Biodiversity and Conservation Vol. 9(1), pp. 9-26.

Niemi, A. 1969. On the railway vegetation and flora between Esbo and Inga, southern Finland. Acta Botanica Fennica 83:1-28.

Njovu, H.K., A.W. Kisingo, T. Hesselberg, and A. Eustace. 2019. The spatial and temporal distribution of mammal roadkills in the Kwakuchinja Wildlife Corridor in Tanzania. African Journal of Ecology 2019;1–6. © 2019 John Wiley & Sons Ltd. wileyonlinelibrary.com/journal/aje.

Noe, C. 2003. The dynamics of land use changes and their impacts on the wildlife corridor between Mt. Kilimanjaro and Amboseli National Park, Tanzania.

Noss, R.F., and A.Y. Cooperrider. 1994. Saving nature's legacy: protecting and restoring biodiversity. Island Press, Washington, D.C.

Noss, R. F. 1987. Protecting natural areas in fragmented landscapes. Natural Areas Journal 7:2-13.

Noss, R. F. 1983. A regional landscape approach to maintain diversity. Bioscience 33:700-706.

Ntongani, W.A., P.K.T. Munishi, and B.P. Mbilinyi. 2009. Land use changes and conservation threats in the eastern Selous-Niassa wildlife corridor, Nachingwea, Tanzania. African Journal of Ecology 48:880-887.

Ojwang', G.O., P.W. Wargute, M.Y. Said, J.S. Worden, Z. Davidson, P. Muruthi, E. Kanga, F. Ihwagi and B. Okita-Ouma. 2017. Wildlife Migratory Corridors and Dispersal Areas: Kenya Rangelands and Coastal Terrestrial Ecosystems. 217 pp.

Olson, D. M., and E. Dinerstein. 2002. The Global 200: Priority ecoregions for global conservation. Annals of the Missouri Botanical Garden 89(2): 199-224. [Dataset] https://www.worldwildlife.org/publications/terrestrial-ecoregions-of-the-world.

Olupot, W. and D. Sheil. 2011. A preliminary assessment of large mammal and bird use of different habitats in Bwindi Impenetrable National Park. African Journal of Ecology 49: 21–30.

O'Neill, H.M.K., S.M. Durant, and R. Woodroffe. 2020. What wild dogs want: Habitat selection differs across life stages and orders of selection in a wide-ranging carnivore. BMC Zoology (2020) 5:1-11. https://doi.org/10.1186/s40850-019-0050-0.

OpenStreetMap Contributors. 2020. Road, Rail, Waterways and Water bodies layers is made available under the Open Database License: http://opendatacommons.org/licenses/odbl/1.0/. OpenStreetMap is open data, licensed under the Open Data Commons Open Database License (ODbL) by the OpenStreetMap Foundation (OSMF) openstreetmap.org. Downloaded from http://download.geofabrik.de/africa.html.

Pandey, A. K., R. E. Harness, and M. K. Schriner. 2008. Bird strike indicator field deployment at the Audubon National Wildlife Refuge in North Dakota: phase two. California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2008-020.

Parsons M.B, D. Travis, E.V. Lonsdorf, I. Lipende, D.M.A. Roellig, S. Kamenya, H. Zhang, L. Xiao, and T.R. Gillespie. 2015. Epidemiology and Molecular Characterization of *Cryptosporidium* spp. in Humans, Wild Primates, and Domesticated Animals in the Greater Gombe Ecosystem, Tanzania. PLoS Negl Trop Dis 9(2): e0003529. https://doi.org/10.1371/journal.pntd.0003529.

Pearce, F., 2011. Conservation and Poverty Reduction. Conservation Magazine. http://www.conservationmagazine.org/2011/03/conservation-and-poverty/.

Polasky, S., J.D. Camm, and B. Garber-Yonts. 2001. Selecting biological reserves cost-effectively: An application to terrestrial vertebrate conservation in Oregon. Land Economics 77:68-78.

Quinn, M., S. Alexander, N. Heck, and G. Chernoff. 2011. Identification of bird collision hotspots along transmission power lines in Alberta: An expert-based geographic information system (GIS) approach. Journal of Environmental Informatics 18:12–21.

Reijnen, R., R. Foppen, and G. Veenbaas. 1997. Disturbance by traffic of breeding birds: Evaluation of the effect and considerations in planning and managing road corridors. Biodiversity and Conservation 6:567-581.

Rich, C. and T. Longcore (eds). 2006. Ecological Consequences of Artificial Night Lighting. Island Press, Washington D.C.

Riggio. J., F. Mbwilo, F. Van de Perre, and T. Caro. 2018. The forgotten link between northern and southern Tanzania. African Journal of Ecology 2018;1–5.© 2018 John Wiley & Sons Ltd; wileyonlinelibrary.com/journal/aje.

Riggio J., and T. Caro. 2017. Structural connectivity at a national scale: Wildlife corridors in Tanzania. PLoS ONE 12(11): e0187407. https://doi.org/10.1371/journal.pone.0187407.

Rioux, S., J-P. L. Savard, and A. A. Gerick. 2013. Avian mortalities due to transmission line collisions: A review of current estimates and field methods with an emphasis on applications to the Canadian electric network. Avian Conservation and Ecology 8:7. http://dx.doi.org/10.5751/ACE-00614-080207.

Ruediger, B. 2001. High, wide, and handsome: designing more effective wildlife and fish crossings for roads and highways. ICOET 2001.

Rugaimukamu, E. 2009. Studies on Road Kill Dynamics and Its Potential for Wild Animal Health Investigations: A Case Study of Mikumi National Park. Sokoine University of Agriculture, Morogoro, Tanzania.

Sanchez-Montoya, M. M., M. Meleon, J.A. Sanchez-Zapatp, and K. Tockner. 2016. Dry riverbeds: Corridors for terrestrial vertebrate. Ecosphere (7) 10 pp.

Savereno, A. J., L.A. Savereno, R. Boettcher, and S.M. Haig. 1996. Avian behaviour and mortality at power lines in coastal South Carolina. Wildlife Society Bulletin 24: 636–648.

Schonewald-Cox, C.M. 1983. Conclusions. Guidelines to management: A beginning attempt. Pages 141-145 in C.M. Schonewald-Cox, S.M. Chambers, B. MacBryde, and W.L. Thomas, eds. Genetics and Conservation: A Reference for Managing Wild Animal and Plant Populations. Benjamin/Cummings, Menlo Park, CA.

Seavy, N.E., T. Gardali, G.H. Golet, F.T. Griggs, C.A. Howell, R. Kelsey, S.L. Small, J.H. Viers and J.F. Weigand. 2009. Why Climate Change Makes Riparian Restoration More Important than Ever: Recommendations for Practices and Research. Ecological Restoration 27(3): 330-338.

Seiler, A. and J.O. Helldin. 2005. Mortality in wildlife due to transportation. In J. Davenport and J.L. Davenport (eds). The ecology of transportation: managing mobility for the environment. Springer, Dordrecht, the Netherlands.

Shaffer, M.L. 1981. Minimum population sizes for species conservation. BioScience 31:131- 134.

Shannon, G., M.F. McKenna, L.M. Angeloni, K.R. Crooks, K.M. Fristrup, E. Brown, K.A. Warner, M.D. Nelson, C. White, and J. Briggs. 2016. A synthesis of two decades of research documenting the effects of noise on wildlife. Biological reviews of the Cambridge Philosophical Society. 91:982–1005.

Shepard, D.B., A.R. Kuhns, M.J. Dreslik, and C.A. Phillips. 2008. Roads as barriers to animal movement in fragmented landscapes. Animal Conservation 11:288-96.

Sibanda, B.M.C. and A.K. Omwega. 1996. Some reflections on conservation, sustainable development and equitable sharing of benefits from wildlife in Africa: the case of Kenya and Zimbabwe. South African Journal of Wildlife Research 26(4)175-181.

Sinclair, A.R., S.A. Mduma, and P. Arcese. 2002. “Protected areas as biodiversity benchmarks for human impact: agriculture and the Serengeti avifauna.” Proceedings of the Royal Society of London. Series B: Biological Sciences 269(1508): 2401-2405.

Sitati, N.W., M.J. Walpole, R.J. Smith, and N. Leader-Williams. 2003. Predicting spatial aspects of human–elephant conflict. Journal of Applied Ecology 40: 667–677.

Skogland, T. 1986. Movements of tagged and radio-instrumented wild reindeer in relation to habitat alteration in the Snøhetta region, Norway. Rangifer 1:267–272.

Smith, D.J., R. van der Ree and C. Rosell. 2015. Chapter 21 Wildlife Crossing Structures: An Effective Strategy to Restore or Maintain Wildlife Connectivity Across Roads. Pages 172-182 in in Handbook of Road Ecology, First Edition. Edited by Rodney van der Ree, Daniel J. Smith and Clara Grilo. © 2015 John Wiley & Sons, Ltd. Published 2015 by John Wiley & Sons, Ltd.

Soulé, M.E., and J. Terborgh, eds. 1999. Continental conservation: scientific foundations of regional reserve networks. Island Press, Washington, D.C.

Soulé, M.E., ed. 1987. Viable Populations for Conservation. Cambridge University Press, Cambridge, UK.

Southern Tanzania Elephant Program (STEP) 2019. Towards Restoring the Selous to Udzungwa Wildlife Corridor Quarterly Report. Produced by STEP for the USAID PROTECT Project in Tanzania. 21 pp.

Stapleton, J. and E. Kiviat. 1979. Rights of birds and rights of way. American Birds 33:7-10.

Stehn, T. and T. Wassenich. 2008. Whooping Crane collisions with power lines: an issue paper. Proceedings of the 10th North American Crane Workshop.

Stromberg, J. 2000. Parts 1-3: Restoration of riparian vegetation in the arid Southwest: challenges and opportunities. Arizona Riparian Council Newsletter vol. 13 no. 1-3. Arizona Riparian Council. Tempe, Arizona. Available online: http://azriparian.asu.edu/newsletters.htm.

Tanzania Wildlife Research Institute (TAWIRI). 2019. National Giraffe Conservation Action Plan 2020-2024. 49 pp.

Tanzania Wildlife Research Institute (TAWIRI). 2018. Tanzania Chimpanzee Conservation Action Plan 2018-2023. 60 pp.

Tanzania Wildlife Research Institute (TAWIRI). 2016. National Action Plan for the Conservation of Cheetahs and African Wild Dogs in Tanzania, Arusha, Tanzania. 48 pp.

Tanzania Wildlife Research Institute (TAWIRI). 2015. Elephant and Buffalo Counts in the Serengeti – Mara Ecosystem.

Tanzania Wildlife Research Institute (TAWIRI). 2010. Eds. Mduma, S.R., A.L. Lobora, C. Foley and T. Jones. Tanzania Elephant Management Plan 2010-2015. 104 pp.

Tarimo, B.B.D. Øystein, T. Gobakken and Ø. Totland. 2015. Spatial distribution of temporal dynamics in anthropogenic fires in miombo savanna woodlands of Tanzania. Carbon Balance Manage (2015) 10:18.

Taylor, A.D. 1990. Metapopulation structure in predator-prey systems: an overview. Ecology 71:429-433.

Tessel, S.M., K.A. Palmquist, and R.K. Peet. 2016. "Species-area Relationships." In Oxford Bibliographies in Ecology. Ed. David Gibson. New York: Oxford University Press.

Treves, A., R.B. Wallace, L. Naughton-Treves, and A. Morales. 2006. Co-Managing Human–Wildlife Conflicts: A Review, Human Dimensions of Wildlife: An International Journal, 11:6, 383-396, DOI: 10.1080/10871200600984265.

Trombulak, S.C., and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18-30.

UN Environment World Conservation Monitoring Centre (UNEP-WCMC). 2020. World Database on Protected Areas. [dataset] https://www.protectedplanet.net/.

United Republic of Tanzania. 2018. Wildlife Conservation (Wildlife Corridors, Dispersal Areas, Buffer Zones, and Migratory Routes) Regulations (2018). Subsidiary Legislation to the Gazette of the United Republic of Tanzania No. 11 Vol. 99 dated 16th March, 2018. Printed by the Government Printer, Dar es Salaam, by Order of Government. Supplement No. 10 16th March, 2018. ISSN 0856 – 034X. 32pp.

United Republic of Tanzania. 2016. Ministry of Works, Transport, and Communication. Investment Opportunity in Roads, Bridges/Roads Intersection, Ferries, Public Housing, Road Safety Projects. Works Sector, Dar Es Salaam. 31 pp.

United Republic of Tanzania. The Wildlife Act, 2009. Dar es Salaam, Tanzania: Ministry of Natural Resources and Tourism, Wildlife Division; 2009.

United Republic of Tanzania – URT, 1998. Tanzania Wildlife Policy. Ministry of Natural Resources and Tourism, Government Printer, Dar es Salaam.

United Republic of Tanzania, 2013. Participatory Land Use Management (PLUM) Guidelines, policies and legal frameworks in Tanzania, Second Edition (2013).

USAID, 2020. Report on Legal Options for Rangelands and Habitat Protection in Tanzania.

van Breugel, P., R. Kindt, J-PB Lillesø, and M. van Breugel. 2015a. Human Influence Index GIS data from Environmental Gap Analysis to Prioritize Conservation Efforts in Eastern Africa. PLoS ONE 10(4): e0121444. doi:10.1371/journal.pone.0121444.

van Breugel, P., R. Kindt, J.B. Lillesø, M. Bingham, S. Demissew, C. Dudley, I. Friis, F. Gachathi, J. Kalema, F. Mbago, H. Moshi, J. Mulumba, M. Namaganda, H. Ndangalasi, C. Ruffo, M. Védaste, R. Jamnadass, and L.O.V. Graudal. 2015b. Potential Natural Vegetation Map of Eastern Africa (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Version 2.0 Forest and landscape (Denmark) and World Agroforestry Center (ICRAF). URL http://vegetationmap4africa.org/.

Veenbaas, G. and J. Brandjes. 1999. Use of fauna passages along waterways under highways. In: Proceedings of the third international conference on wildlife ecology and transportation, edited by G.L. Evink, P. Garrett, and D. Zeigler. FL-ER-73-99. Florida Department of Transportation, Tallahassee, Florida.

Vice President's Office. 2019. Tanzania National Strategy and Action Plan to Manage Invasive Species (2019-2029).

Vos, C.C., A.G. Antonisse-De Jong, P.W. Goedhart and M.J. Smulders. 2001. Genetic similarity as a measure for connectivity between fragmented populations of the moor frog (*Rana arvalis*). Heredity 86:598–608.

Waller, J.S. and C. Servheen. 2005. Effects of transportation infrastructure on grizzly bears in northwestern Montana. Journal of Wildlife Management 69:985–1000.

Wato, Y. A., G. M. Wahungu, and M. M. Okello. 2006. Correlates of wildlife snaring patterns in Tsavo West National Park, Kenya. Biological Conservation 132: 500–509.

Weeks, S. 2015. Chapter 43 CASE STUDY: THE MOUNT KENYA ELEPHANT CORRIDOR AND UNDERPASS. Pages 353-356 in Handbook of Road Ecology, First Edition. Edited by Rodney van der Ree, Daniel J. Smith and Clara Grilo. © 2015 John Wiley & Sons, Ltd. Published 2015 by John Wiley & Sons, Ltd.

Wells, P., J.G. Woods, G. Bridgewater and H. Morrison. 1999. Wildlife mortalities on railways; monitoring methods and mitigation strategies. In G. Evink, P. Garrett and D. Zeigler (eds). Proceedings of the Third International Conference on Wildlife Ecology and Transportation, pp. 237–246. Florida Department of Transportation, Tallahassee, FL.

Whittington-Jones, B. and H. Davies-Mostert. 2015. Chapter 38 Case study: African wild dogs and the fragmentation menace. Pages 322-324 in Handbook of Road Ecology, First Edition. Edited by Rodney van der Ree, Daniel J. Smith and Clara Grilo. © 2015 John Wiley & Sons, Ltd. Published 2015 by John Wiley & Sons, Ltd.

Whittington-Jones, B.M. 2011. The dispersal of African Wild Dogs *Lycaon pictus* from protected areas in the northern KwaZulu-Natal province, South Africa. MSc Thesis, Rhodes University, Grahamstown.

Wilkie, D., E. Shaw, F. Rotberg, G. Morelli and P. Auzel. 2000. Roads, development, and conservation in the Congo Basin. Conservation Biology 14:1614–1622.

Wilson, J.D. and M.E. Dorcas. 2003. Effects of habitat disturbance on stream salamanders: Implications for buffer zones and watershed management. Conservation Biology 17:763-771.

Witt A. and T. Beale. 2018. CABI Africa Invasive and Alien Species data. Centre for Agriculture and Biosciences International. Occurrence dataset https://doi.org/10.15468/pkgevu. Accessed via GBIF.org on 2020-03-25.

Wilcove, D.S., C.H. McLellan, and A.P. Dobson. 1986. Habitat fragmentation in the temperate zone. Pages 879-887 In: M.E. Soulé, ed. Conservation Biology. Sinauer Associates, Sunderland, Massachusetts, USA.

Wilcox, B.A., and D.D. Murphy. 1985. Conservation Strategy: the effects of fragmentation on extinction. American Naturalist 125:879-887.

Woodroffe, R. & J.R. Ginsberg. 1999. Conserving the African wild dog *Lycaon pictus*. I. Diagnosing and treating causes of decline. Oryx 33: 132–142.

Yanes, M., J.M. Velasco, and F. Suárez. 1995. Permeability of roads and railways to vertebrates: the importance of culverts. Biological Conservation 71:217-222.

Yonariza and E.L. Webb. 2007. Rural household participation in illegal timber felling in a protected area of west Sumatra, Indonesia. Environmental Conservation 34(1)73-82.

Zhao, N. 2019. Tanzania Electric Supply Company Limited (TANESCO) existing, under construction and proposed power stations for hydro, thermal and substations, as well as existing and under construction transmission lines [datasets] http://www.tanesco.co.tz/.

APPENDIXES

Appendix A. Participant List Corridor Prioritization Workshop

Participant List Corridor Prioritization Workshop November 6-7, 2019

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Appendix B. Participant List Northern Region Workshop

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Appendix C. Tanzania Wildlife Corridor Description Form

General Information

Wildlife corridor name/ID# - name and number of wildlife corridor as labeled on large format map

Key contact information for this wildlife corridor – participant/s filling out datasheet and other people that are most knowledgeable of this particular wildlife corridor.

Specific Information

1) **Type of Wildlife Corridor** - Landscape Linkage, Constrained Corridor, Missing Link

Below are definitions of each wildlife corridor type. We recognize that these labels fall within a continuum of wildlife corridor types, from large relatively intact connections to highly constricted choke-points. The purpose of this question is to classify the type of corridor.

1. **Landscape Linkage** = Large, regional connections between protected areas ("core areas") meant to facilitate animal movements and other essential flows between different sections of the landscape (Soulé and Terborgh 1999). Corridor is basically an extension of core habitat connecting two or more habitat blocks; and/or the corridor contains extensive habitat (≥ 75% natural land cover/water).

2. **Constrained Corridor** = A narrow, impacted, or otherwise tenuous wildlife corridor connecting two or more habitat blocks ("core areas") that is essential to maintain landscape-level connectivity but is in danger of losing connectivity function. A constrained corridor contains moderate habitat (≥ 35% but < 75% natural land cover/water) that may be facilitating wildlife movement but also has significant non-native areas impacted by human use.

3. **Missing link** = A highly impacted area currently providing limited to no connectivity function (due to intervening development, roadways, etc.), but based on location one that is critical to restore connectivity function. Relatively little cover/habitat for wildlife remains (< 35% natural land cover/water), corridor is crisscrossed by roads, unplanned settlement, logging/charcoal burning, agriculture, mining etc.

2) Species or ecological process considered

List the key focal species/ecological processes used to identify this wildlife corridor.

You should <u>not</u> list all focal species that might use this wildlife corridor. Rather, please list the key (or unique) species that were used to identify this wildlife corridor and that would be indicative of its connectivity.

3) Threat to connectivity function

Intended to provide a relative, qualitative score of the immediacy of the overall threat to connectivity function and the identity and severity of the most important threat/s. Also to identify known imminent threats of planned or approved projects that could impact the corridor, for example, future infrastructure development. Is the wildlife corridor in need of habitat restoration to restore connectivity function? How?

4) Feasibility of conservation opportunity

Intended to provide a relative, qualitative score of opportunities for conservation/management at this wildlife corridor. For example, if funding is available for on-the-ground corridor or connectivity projects, how important/ feasible/effective would it be to direct funding at this particular wildlife corridor?

Is there local community support, existing conservation initiatives, or a formal conservation plan or land use plan to protect the wildlife corridor?

What are existing land uses, land-use trends, and management plans?

5) Provide a brief description of the wildlife corridor to help establish the ecological significance and viability of the corridor.

Is the corridor essential to seasonal migrations, and/or movements driven by climate change? Does the corridor contain or connect seasonally important resources, broad environmental gradients, or major life zones?

What vegetation types and habitats are present within the wildlife corridor?

What other types of land cover besides natural vegetation (e.g., cropland/irrigated agricultural, low density residential, etc.) are within and immediately adjacent to the wildlife movement corridor?

6) Significant impediments/barriers

Identify primary barriers that are impediments to wildlife movement. Be as specific as possible (e.g., particular roads, infrastructure development, agricultural fields).

7) Existing features that facilitate wildlife movement through the corridor

Please list these features, for example, a river or stream that helps to connect protected areas, continual habitat coverage, specific underpasses/bridges across transportation barriers.

8) Scientific Evidence & Indigenous Knowledge

What evidence exists to demonstrate the use of the wildlife corridor? Evidence can be obtained through tracking data from GPS collars, aerial surveys, remote camera stations, track stations, local knowledge, such as District Game Officers, about wildlife movements, data on species composition and abundance, or habitat suitability or connectivity analyses that have been conducted to demonstrate the suitability of the wildlife corridor for target species. Provide any citations

9) Data Gaps & Research Needs

What are the key data gaps and research needs in the corridor? For example, to document use of the corridor by target species, develop detailed vegetation maps, .

10) Economic Benefits and Opportunities for Local Communities

Identify possible economic benefits and opportunities to improve the lives of locals and help build support for connectivity conservation.

EXPECTED FINAL PRODUCTS AT END OF BREAKOUT SESSION

1) Refine the maps of draft delineated wildlife corridors based on research data and expert opinion.

2) We want to have completed description form(s) for each wildlife corridor.

Tanzania Wildlife Corridor Data Sheet

Wildlife Corridor Name/ID#:____

Key contact/s for this wildlife corridor____

Email:______________________________Telephone #:_________________________

1. Type of Wildlife Corridor (Check one)

☐ Landscape Linkage
☐ Missing Link
☐ Constrained Corridor
Other__________________________

2. What are the key species or ecological processes that the wildlife corridor supports and that are indicative of its connectivity?

3. Score the overall degree of threat to connectivity function (circle one):

1	2	3	4	5
No threat/secure		Moderate threat		Severe threat/loss imminent

Identify the most important threat/s to connectivity function (e.g. urbanization, agriculture, roadways, mining or other infrastructure development, exotic plant invasion) and score the severity of each threat (Fill in chart):

Type of Threat	**Severity: 1 (Not severe) - 5 (Extremely Severe)**
Urbanization	4
Exotic Plants	2

Are there any known proposed or approved future developments that could sever or severely constrain a corridor (e.g., mining or oil exploration or pipelines, large scale industrial developments, hydro-power dams, roads)?

What, if any, are the most important restoration needs to restore connectivity function? Describe types of habitat, invasive species issues, degree of restoration needed.

4. Score the feasibility of the wildlife corridor as a conservation priority (circle one):

1	2	3	4	5
Not feasible		Moderate opportunity		Good opportunity

What opportunities exist to establish/protect this wildlife corridor? (Check all that apply, explain below)

- ☐ local community support
- ☐ existing conservation initiative/s
- ☐ education/outreach programs
- ☐ Village Land Use Plan, CCRO, VLFR or similar
- ☐ part of formal conservation plan
- ☐ Other ____________________________

Other opportunities and details, (or information from check items):

What is the current land use and tenure situation in the corridor (e.g., General Land, Village Land [e.g., Wildlife Management Area, Village Land Forest Reserve]), or Reserved Land? Are there any updates to the 2017 (Debonnet and Nindi) report?

What are existing land uses, land-use trends, and management plans for land in and adjacent to the corridor?

5. Provide a brief description of the wildlife corridor to help establish the ecological significance and viability of the corridor.

Is the corridor essential to seasonal migrations (e.g., wildebeest), and/or movements driven by climate change? Does the corridor contain or connect seasonally important resources, broad environmental gradients, or major life zones?

What is known about major vegetation types and habitats within the wildlife corridor?

What other types of land cover besides natural vegetation (eg. agricultural, low/high density communities, mining, roads, etc.) are within and immediately adjacent to the wildlife corridor?

6. What are the most significant impediments/barriers to animal movement within the wildlife corridor? (ex.: roadway, linear obstructions, gaps in habitat cover [how big?], topography)?

7. What existing features facilitate wildlife movement through the corridor (e.g., a river or stream that helps to connected protected areas, continual habitat coverage, underpasses/bridges)?

8. What target focal species have been documented to use the corridor? For example, tracking data (e.g., GPS collars, aerial surveys, camera stations, track stations) that exists for particular species, or local DGO knowledge. Please provide citations and/or contact information.

What research data exists to document the biological importance of this corridor (e.g., connectivity assessments or habitat suitability analyses for particular species)? Please provide citations and/or contact information.

9. What are the most important data gaps and research needs in this corridor (e.g., to document use of corridor by target species, to design it, to evaluate its success, etc.)?

10. What economic benefits and opportunities for local communities are available or possible in the corridor (e.g, jobs in corridor management, ecotourism, cultural tourism, beekeeping, sustainable grazing and fishing)?

For more information please Contact:
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