TRANSFRONTIER AFRICA

3-Year Research Plan

2023 – 2025

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PART A – STRATEGIC OVERVIEW

1. Strategic overview

This document provides Transfrontier Africa's (TA) Research Plan for the period 2023 – 2025. It sets out the Action and Engagement Plan of TA's Research Department for the next 3 years, which is designed to meet the scientific requirements outlined in the Olifants West Nature Reserve (OWNR) Management Plan, the MoU between TA and OWNR, and to respect and support TA's overall values and objectives.

As a non-profit environmental conservation organisation under contract with OWNR, TA's planning framework is informed by OWNR's Management Plan and aims to improve wildlife conservation and ecosystem sustainability in the reserve. Its actions and contract have recently been extended to Blyde Olifants Confluence Conservation Area (BOCCA), and TA now provides ecological, security and educational services to both areas and surrounding communities.

Research is one of the core functions of Transfrontier Africa and is strongly linked to all the other fields of action of the organisation: volunteers, security and community development and engagement. One of the key objectives of the organisation is to support management in making informed decisions based on scientific evidence. Over time many of the research projects developed have not been able to directly contribute to this need and we spread ourselves very wide and thin in the process of pursuing all the areas we do. It led to a multitude of projects that were initiated but not followed up, with limited benefits to our stakeholders. This document gives structure and direction to the research programme to ensure that our resources are used efficiently and our contractual obligations as well as stakeholder needs are met.

2. Corporate values

Transfrontier Africa fulfils its role as an environmental conservation organisation by operating according to three main corporate values: Wildlife and Ecosystem Conservation, Landscape Security, and Community Development and Engagement in conservation. All the actions undertaken by the organisation, and the behaviour of its employees, shall, at all times, be consistent with these values. The following table reflects these corporate values:

Corporate value	Guiding principle associated with the value
Wildlife and Ecosystem Conservation	TA shall foster wildlife and ecosystem conservation by supporting management in making informed decisions based on scientific evidence, and by implementing the appropriate, pre-determined management measures in its area of operation.
Security	TA shall ensure wildlife and human safety in its area of operation.
Community Development and Engagement	TA shall promote community development and engagement in conservation.
International Collaborations	TA shall promote international collaborations to ensure its contribution to global conservation efforts.

3. Alignment with Olifants West Nature Reserve Management Plan

Transfrontier Africa operates in part in Olifants West Nature Reserve (OWNR), a Big 5 nature reserve within the Greater Kruger National Park and has aligned its Research objectives with the Management Plan of OWNR, as part of its contractual obligations with the reserve (see PART A.4). Indeed, in order to make informed ecological management decisions and to meet the legal requirements with which a nature reserve must comply, OWNR has entrusted Transfrontier Africa to conduct research projects that meet these needs. In light of this agreement, TA's Research Department must ensure that research is focused on applied projects that benefit the stakeholders of the nature reserve and are linked to management objectives.

The following axes were identified as needed research areas by the reserve management plan:

- **Human-wildlife conflict**: understanding the dynamics between humans and wildlife, to limit human pressures on the environment and manage space and resources use. The research projects included in this axis should cover spatial and temporal distribution of animals and vegetation, consumption of natural resources and game counts.
- **Biodiversity:** understanding and monitoring biodiversity to protect and manage the ecological integrity of the reserve and determining the effectiveness of management interventions to develop adaptive management strategies. This involves establishing baseline data to refer to (covered over the past 15 years for weather, flora and fauna – data is lacking for soils and underground water), and studying/monitoring soils, plant communities over time, species diversity and threatened and/or iconic species. Soil surveys are essential to determine the maximum biota that can be sustained by the reserve, and should include monitoring of specific sites, such as sodic sites. Vegetation community monitoring is essential to determine the Ecological Carrying Capacity (ECC) of the reserve, in order to advise management strategies in case of under- or overutilization. The study of species diversity is important for setting biodiversity targets as a nature reserve, measuring the resilience of the system to changes and predicting changes in species composition based on the population dynamics of keystone species. Finally, the monitoring and eventual management of threatened and/or iconic species is essential for global conservation purposes and crucial for the tourism industry within the reserve.
- **Sustainable use of biotic and abiotic resources:** understanding the natural resource requirements of the system to establish sustainable limits for resource use, notably underground water, firewood, animals.
- **Socioeconomics**: understanding the needs of surrounding local communities to ensure their long-term sustainable integration into the development of the nature reserve, both socially and economically.

The results of all research projects conducted on OWNR will be made available to the reserve's stakeholders (see Part C) and, should the results suggest policy changes, will be presented to the reserve's Annual General Meeting (AGM) for potential revisions of management strategies. Annual evaluations of the research framework will be conducted to ensure that the projects are and remain relevant to the management plan.

4. Contractual obligations

Transfrontier Africa's contractual obligations to OWNR, which include those of TA's Research Department, are detailed in the Memorandum of Understanding (MoU) discussed and signed by both parties, available at the following link:

https://ln5.sync.com/dl/499f65e60/nfdp9i5u-s93quqcg-zhu4x79g-m5kuk4pf

5. Development of local talent

While international conservation NGOs are prevalent, the conservation sector needs more South Africans with a vested interest in local/national conservation and research. In order to develop this local talent, TA's Research Department will ensure that priority is given to local applicants when advertising internship opportunities. In order to develop local students' skills in ecology and conservation, training will be provided in the following areas:

- Fieldwork related to the intern's project – and possibly to various projects carried out by Ndlovu Bush Camp (mainly for Bachelor students and below)
- Presentation & communication
- Report and proposal writing
- GIS, biostatistics & database management, depending on the intern's needs and level (mainly for Master students and above)

This research training will enable the students to progress academically during their internship, so as to facilitate their access to a career in research and/or conservation, to related studies and/or to national or international internship or employment opportunities.

PART B – RESEARCH DEVELOPMENT

1. Research axes – long-term goals

TA's Research Department is focusing its efforts on five main research axes, under which the on-going, past, and future research projects fall. These research axes have been selected to meet OWNR's requirements in terms of ecological monitoring, research development, sustainable use of the landscape and wildlife, security, and community empowerment. Indeed, covering all these aspects is essential to ensure that comprehensive and durable conservation and management strategies can be designed and implemented. These five research axes are:

- **RA.1 – Biodiversity and Trophic Interactions**
- **RA.2 – Community Development**
- **RA.3 – Human-Wildlife Conflicts**
- **RA.4 – Criminology**
- **RA.5 – Ecological Monitoring**

The protection of biodiversity is intimately linked with the understanding and management of the relationships between human populations and wildlife, whether these interactions are positive or negative. By ensuring that conservation benefits local populations and that they actively participate in it, sustainable strategies can be developed over time. To achieve this, it is essential to implement awareness campaigns and environmental education programmes and to study the perception and use of biodiversity by local populations, as well as their impact on the environment, before and after these programmes in order to assess their success. These sociological surveys are part of the Research Axis 2, '**Community Development'**, which includes all the research needed to investigate the effects of the Bush Babies and Black Mambas programmes in the surrounding communities and their perception of wildlife, conservation, and poaching as well as the efficacy of the programs themselves.

Understanding conflicts between locals and wildlife, and elaborating solutions to mitigate them and reduce illegal wildlife trade, is also an essential part of conservation, as wildlife can only be protected effectively when local populations can peacefully and sustainably cohabit with it. This aspect is covered by our Research Axes 3, Human-Wildlife conflicts, and 4, Criminology. The axis '**Human-Wildlife Conflicts'** includes all the research needed to mitigate human-wildlife conflicts in the landscape and surrounding areas, and to develop conflict mitigation methods that could be used throughout Africa, or in other continents facing similar human-wildlife conflicts to reduce both human losses/injuries and structure/crops damages caused by wildlife, and the human impact on wildlife populations. This axis includes behavioural studies of species involved in human-wildlife conflicts, pilot studies testing innovative conflict mitigation methods, the monitoring of both human and wildlife spatiotemporal use of the landscape and the impact of human infrastructures, transports, and pollution on wildlife populations demography. The axis '**Criminology'** includes all the research

needed to understand, combat and prevent illegal wildlife trade, with a main focus on the prevention of poaching. This axis includes socioeconomic studies in communities surrounding nature reserves, spatiotemporal studies of poaching patterns, studies to evaluate the effectiveness of anti-poaching methods used and pilot studies to test new methods for detecting and preventing poaching in nature reserves. This axis therefore uses interdisciplinary science, building on sociology, criminology, and biogeography, to provide holistic and comprehensive answers to scientific and security questions.

Finally, biodiversity conservation is a complex process that needs a comprehensive understanding of the structure, functions, and composition of the ecosystem. Ensuring that its inherent functions are maintained is fundamental to the sustainability of the system, and this can be achieved by monitoring, and possibly managing, water availability and use, fire regimes, nutrient cycling, plant communities and the impact of natural and human-induced disturbances. To do so, it is important to know the population dynamics of the species living on the landscape, as their diversity, spatiotemporal distributions and seasonal movements undeniably influence the parameters mentioned above. Furthermore, population dynamics are closely linked to intra- and interspecific interactions, and it is therefore crucial to include them in our attempt to improve our understanding of the system, in order to know the impact of a species' management on its own populations and on the species that interact with it. Finally, these processes can be compromised when biological integrity is lost, due to invasive alien species or extinctions of species or function, for instance, and this aspect must therefore be integrated into any research and monitoring plan. All these aspects are linked and important for the management of a reserve and for conservation as a whole and are therefore covered by our Research Axes 1 and 5. The axis '**Biodiversity and Trophic Interactions'** is focused on research and includes projects related to species diversity, intra- and interspecific interactions, spatiotemporal use of the landscape by animals, and the relationship between wildlife and habitats. The axis '**Ecological Monitoring**' is focused on the monitoring part of biodiversity conservation and includes all the projects needed to ensure the sustainable use of the landscape, assess wildlife and landscape management policies, ensure the development of policies for effective protection of endangered species and monitor wildlife populations over time and their response to biotic and abiotic factors.

2. Research projects

Each of the five Research Axes includes Research Projects with a wide range of stakeholders involved, project duration and scale of impact. These projects can arise to address local internal needs (*e.g.,* informing management decisions (see Appendix Table A), assessing immediate threats), to develop fundamental knowledge on an innovative ecological or social question, or to address international issues (*e.g.,* human-elephant conflicts). The development of the project, fieldwork, and data analysis are often run by different and numerous parties, from TA's Research Department and TA's director, to interns. Therefore, ensuring that data is collected consistently by field technicians to allow data analysts to conduct adequate analyses is critical. TA's Research Department has the responsibility to produce and distribute Standard Operating Procedures (SOPs) for each project, as well as fieldwork datasheets. The Research Department must also make sure that data is filled in the database regularly and correctly, and that the fieldwork planning and the role distribution are understood.

The Research Department will ensure that each project has:

- Research proposal
- SOP for data collection
- Printed fieldwork datasheets (when necessary)
- SOP for data entry
- Clear database with a detailed 'Legend' spreadsheet
- Clear planning for fieldwork
- Clear role distribution (fieldwork supervisor for the project & associated data analyst – role of interns, volunteers, etc, in the project)
- Clear objectives and methodologies
- Data analysis & Reporting

Regarding the number of projects being conducted simultaneously, hosting interns is critical for TA. The Research Department will therefore advertise internship / Ph.D. opportunities for any project requiring interns and will lead the selection process, along with TA's director, Craig Spencer. This process also has the benefit of providing opportunities for national and international students, networking with universities, and raising awareness of conservation issues in South Africa, with interns acting as nature ambassadors on their return to their hometown/country.

The development of new projects arising from spontaneous opportunities in any of the five Research Axes will be encouraged over the next three years. Long-term sub-projects may be carried out by several trainees or parties, and the Research Department is responsible for ensuring that any transition occurs seamlessly and correctly.

The following table details the projects and their division into sub-projects within each Research Axis, as well as corresponding Internship / Ph.D. opportunities:

Research Axes	Research Projects	Sub-projects	Internship / Ph.D. opportunities[1]
RA.1 - Biodiversity and Trophic Interactions	**RA. 1.1 - Anthropause**	RA.1.1.1 - Human impact on wildlife populations	Master Student
		RA.1.1.2 - Human impact on wildlife spatiotemporal use	Master Student
	RA.1.2 - Marula trees Demography Survey	RA.1.2.1 - Marula Seedlings Predators and Predation Rate Assessment	Ph.D. Student: Chris BANOTAI
	RA.1.3 - Predator Community Surveys	RA.1.3.1 - Predator Diet Determination; Assessment of Abiotic and Biotic drivers	Ph.D. Student
		RA.1.3.2 - Faecal Hairs Analysis *vs* Faecal DNA Metabarcoding – Methods Comparison	Master Student
		RA.1.3.3 - Predator Diet Determination; Temporal patterns	Bachelor Students
		RA.1.3.4 - Identification of individual leopards and of the spatial distribution of their territories: Data collection and Monitoring	Bachelor Students
		RA.1.3.5 - Identification of individual leopards and of the spatial distribution of their territories: Data analysis and Territories mapping	Master Student
		RA.1.3.6 - Spatiotemporal Interactions between Apex and Mesopredators: Trophic Cascades, Avoidance/Attraction Strategies, Community Composition and Dynamics	Ph.D. Student
	RA.1.4 - Rhino Population Dynamics	RA.1.4.1 - Black Rhinos Carrying Capacity Assessment within OWNR	Master Student
		RA.1.4.2 - Biotic and abiotic drivers of Black Rhinos movements and distribution	Master Student
RA.2 - Community Development		**RA.2.1 - Local Community Response to the Black Mambas and Bush Babies Programs**	Research Department – spontaneous applications
		RA.2.2 - Establishing sustainable utilization of natural resources by sangomas[2]	Bachelor Students
RA.3 - Human-Wildlife Conflicts	**RA.3.1 - Anthropogenic Impact**	RA.3.1.1 - Road Density and Traffic Intensity Impact on Wildlife Spatiotemporal Use in OWNR and BOCCA	Master Student (or NASA too?)
		RA.3.1.2 – Human-made Infrastructure Density Impact on Wildlife Occupancy and Spatiotemporal Use in OWNR and BOCCA	Collaboration with the NASA and Pr. David BUNN Ph.D. Students (2) - Colorado State University
	RA.3.2 - Bioproducts usage as Elephants Deterrent	RA.3.2.1 - Bee Pheromones as Elephants Deterrent – Methodology Testing	Associated Researcher – Mark WRIGHT & Master Student
		RA.3.2.2 - Effect of Formicine Ants Presence on Tree Protection against Elephants	Associated Researcher – Mark WRIGHT & Master Student

Research Axes	Research Projects	Sub-projects	Internship / Ph.D. opportunities[1]
		RA.3.2.3 - Formic Acid as Elephants Deterrent – Methodology Testing	Associated Researcher – Mark WRIGHT
	RA.3.3 - Railway Mortality Study	RA.3.3.1 - Impact of Railway Transports on Wildlife Mortality	Project carried by the African Railway Ecology group Post-doctorate
		RA.3.3.2 - Animal Mortality Rate linked to the Railway and Animal Space Use	Master Student – Siboniso THELA
		RA.3.3.3 - Under-path Passages Use by Wildlife as Safe Crossing Ways	Master Student – Hannah DE VILLIERS
		RA.3.3.4 - Elephant Space Use along the Railway	Master Student
		RA.3.3.5 - Buffer zone Mapping and Ecological Assessment of Abiotic Drivers linked to Animal Crossings and Mortality	Collaboration with Transnet Master Student
	RA.3.4 - Tree Wrapping	RA.3.4.1 Tree Wrapping Effectiveness Assessment against Elephants RA.3.4.2 Assessment of Tree Wrapping Effects on Non-Target Species	Bachelor Student Bachelor Student
RA.43 - Criminology	**RA.4.1 – Illegal Wildlife Trade**	RA.4.1.1 - Researching the Live Trade Network of Pangolins	Ph.D. Student
		RA.4.1.2 - Spatiotemporal Evolution of Snaring Trends in the Area	Master Student
	RA.4.2 – Technology Development	RA.4.2.1 - Automation of Security Reports for more Effective and Efficient Response	Master Student
		RA.4.2.2 - Predictive Heatmaps of Rhino Distribution	Master Student
RA.5 - Ecological Monitoring	**RA.5.1 - Alien Vegetation Control**	RA.5.1.1 - Biological control Effectiveness Assessment	Bachelor Student
		RA.5.1.2 - Drone Mapping – Method Testing	Master Student
		RA.5.1.3 - Biocontrol *vs* Chemical – Methods Comparison	Bachelor Student
	RA.5.2 - Boreholes and Subterranean waters	RA.5.2.1 - Water tables level response to human use and rainfalls – Monitoring	Bachelor Students
		RA.5.2.2 - Water tables level response to human use and rainfalls – Solutions	Ph.D. Student
	RA.5.3 - Vegetation community and structure monitoring	RA.5.3.1 - Comparative Analysis of Riparian Zones between Big5 (OWNR) and non-Big5 (BOCCA) Areas	Bachelor Students
		RA.5.3.2 - Ecological Carrying Capacity (ECC) in OWNR and BOCCA	Research Department
		RA.5.3.3 - Grass Community Composition and Rainfalls – Community Changes over time	Bachelor Student
		RA.5.3.4 - Grass Community Composition and Rainfalls – Integrated Modelling using fine-scale Rainfall data	Master Student

Research Axes	Research Projects	Sub-projects	Internship / Ph.D. opportunities[1]
		RA.5.3.5 - Phytomass Assessment	Bachelor Students
		RA.5.3.6 - Protection of indigenous vegetation - firewood availability	Master Student[3]
		RA.5.3.7 - Protection of indigenous vegetation - identification of priority species	Master Student[3]
		RA.5.3.8 - Vegetation Community – Composition, Abundance and Landscape changes over time using Fixed Point Photography	Bachelor Student
		RA.5.3.9 - Woody:herbaceous ratio – monitoring and early detection of species invasions	Master Student[3]
	RA.5.4 - Wildlife Monitoring	RA.5.4.1 - Aerial Annual Game Count in OWNR and BOCCA	Research Department
		RA.5.4.2 - Biweekly Game Count in BushRiver and Ekuthuleni: Spatiotemporal Analyses and Method Comparison with Aerial Game Count	Master Student
		RA.5.5.1 - Black and White Rhino Populations Monitoring within OWNR	Research Department
		RA.5.5.2 - Continuous Wildlife Monitoring – Threatened and/or Iconic Species	Research Department
		RA.5.4.4 - Call-ups for Predators Counting	Research Department
		RA.5.4.5 - Improving the Precision and Accuracy of Aerial Census using Remote Sensing Imagery and Machine Learning	Ph.D. Student
		RA.5.4.3 - LoRa Technology Implementation	Research Department

[1]The projects may be adapted to the level of students may the need arise. [2]Traditional healers. [3]These three projects can be covered by the same master student all at once.

The projects presented above are detailed below:

RA.1 – Biodiversity and Trophic Interactions

RA. 1.1 - Anthropause

Assessing the effects of human activity on wildlife is one of the main scientific challenges of the Anthropocene, and particularly in natural reserves where this impact is meant to be minimized. The Anthropause, term introduced by Rutz et al. (2020) and referring to the reduction of human activity during the COVID-19 lockdown, offers an important, yet tragic, opportunity to study human-wildlife interactions around the world. Tracking changes in animal biology and behaviour during this period of reduced human activity in natural reserves, could provide great insights into the effects of human disturbances on wildlife populations and spatiotemporal activity patterns, providing guidelines for future management decisions. Camera traps have been placed in Olifants West before the lockdown and were still serviced during and after this period, providing the necessary data to study such changes or absence of changes. Similarly, aerial game counts were carried before, throughout and after the Anthropause, providing data on mammal populations.

RA.1.2 - Marula trees Demography Survey

“The bushveld savanna of places such as Olifants West Nature Reserve (OWNR) in the Kruger area of South Africa, is suffering from both a decrease in abundance of older trees and a marked decrease in the recruitment of seedlings. This is especially true for marula (*Sclerocarya birrea*), a keystone and indicator species for the South African Lowveld (Helm & Witkowski, 2012[A], Helm & Witkowski, 2012[B]). Beyond its ecological importance, marulas are also economically and culturally important in the region.

Much of the decline in marula populations in the Greater Kruger Ecosystem is due to a lack of recruitment of new trees into the populations. There is a shortage of small and intermediate sized trees, which is not fully understood. This lack of recruitment is unlikely caused by elephants, as they do not browse on seedlings and are unlikely to target small trees. Previous research conducted in OWNR confirmed that, under the correct circumstances, rodents will feed on the seeds and seedlings of marula as well as several other bushveld savanna tree species. There are many other species that may feed on marula seeds and seedlings in addition to spatial and environmental factors that may be reducing the lack of marula recruitment into the population. Understanding these factors is pivotal when making management and conservation decisions.” – Chris Banotai, Ph.D. candidate

RA.1.3 – Predator Community Surveys

“Interspecific interactions are major driving forces in the organisation and dynamics of ecological communities (Bertness and Callaway, 1994; Thompson, 1997; Codron et al., 2018). Placed at the top of the food webs and exerting top-down controls within and across trophic levels, apex predators indeed have a tremendous impact on prey and predator communities (Prugh et al., 2009; Estes et al., 2011; Wallach et al., 2015). Through predation, and the eventual establishment of a landscape of fear, i.e., spatiotemporal heterogeneity of risks prompting other animals to make trade-offs between food and safety (Bleicher, 2017), apex predators influence the dynamics and densities of prey species, leading to cascading effects on the landscape (Roemer et al., 2009; Prugh et al., 2009; Estes et al., 2011; Ripple et al., 2014). During the past decades, researchers have demonstrated that apex predators exert similar controls within their own guild, on smaller predator species (Ritchie and Johnson, 2009; Prugh et al., 2009; Ripple et al., 2014). Through exploitative and interference competition, expressed as direct suppression, intraguild predation, and kleptoparasitism (i.e., stealing food), apex predators control the diversity and densities of smaller and subordinate predators (Ritchie and Johnson, 2009; Wallach et al., 2015; Prugh and Sivy, 2020). Overall, predator-prey and predator-predator interactions induce trophic cascades that are essential for ecosystem structure, functionality, stability, and resilience, and their thorough understanding and integration into conservation strategies are therefore critical (Ritchie and Johnson, 2009; Yarnell et al., 2013; Ripple et al., 2014; Wallach et al., 2015).” – Elwenn Le Magoarou, Master thesis

To that end, several surveys focusing on apex predators' diet, population dynamics, spatiotemporal distributions and interspecific interactions are conducted in OWNR and BOCCA.

RA.1.4 - Rhino Population Dynamics

Black (*Diceros bicornis*) and white rhinoceros (*Ceratotherium simum*) populations are both threatened by habitat loss and poaching (illegal trade of rhino horn), and are classified as Critically Endangered and Near Threatened, respectively, on the IUCN Red List. In this global context, local monitoring of their population and global collaboration are essential. The Black Rhino Range Expansion Project (BRREP), which was founded in 2003 by World Wildlife Fund (WWF), Ezemvelo KZN Wildlife, Eastern Cape Parks, and Tourism Board, is one of these attempts to join local and global forces to counter the drastic decline in rhino populations. Its aim was to increase black rhino populations by reintroducing them in suitable protected areas to create new breeding populations. As Olifants West Nature Reserve offers suitable protected black rhino habitat, it was included in the project in 2011, when 19 black rhinos were introduced from Great Fish River Nature Reserve.

However, little is known about OWNR's ecological carrying capacity (ECC) for black and white rhinos, and its potential evolution in the coming years and decades. Using our historical database on individual sightings, and the historical data from OWNR's weather station, and vegetation community assessments, we intend to develop models to predict the ECC for black and white rhinos in OWNR and to build predictive models based on weather and vegetation trends.

RA.2 – Community Development

Projects to define.

RA.3 – Human-Wildlife Conflicts

RA.3.1 - Anthropogenic Impact

Man-made infrastructures, such as roads, buildings, powerlines, or artificial waterpoints, are largely represented in OWNR and likely to have a significantly influence on wildlife population dynamics. Indeed, such artificial infrastructures are widely recognised for having detrimental ecological consequences, such as habitat fragmentation, spread of alien invasive species, increased animal mortality, changes in animal behaviour or animal spatiotemporal distribution (Jackson 2000: Lopez et al. 2010; Raman, 2011; Torres et al. 2016; Chester et al. 2019). The creation of buffer zones of disturbed areas around these infrastructures can also tremendously reduced the available space for wildlife and therefore affect the Ecological Carrying Capacity of the reserve (Lopez et al. 2010; Rizzuto 2017). Understanding to what extend and in what way the infrastructures in OWNR and BOCCA affect the ecosystem is therefore

crucial to adapt our wildlife management and landscape use policies and identify mitigation solutions to limit the anthropogenic impact within the reserves.

RA.3.2 - Bioproducts usage as Elephants Deterrent

“Human-elephant conflict (HEC) and HWC have risen due to an increase in urbanisation which decreases the size of their habitats and fragments them (Hoare, 2015). Consequently, both the communities and animals, such as elephants, are competing for the finite land and water resources (King et al. 2011) and therefore the wildlife are raiding crops and breaking into protected areas which in turn amplifies the level of poverty in agriculturally dominated areas (Ngama et al. 2016). HWC is a problem for not just the community but also the economy (Anthony et al. 2010).

There are already a few mitigation measures to stop animals such as elephants from trespassing into agricultural areas, but these are either not 100% effective, or not economically viable. These efforts include fires, dogs, electric fences, beehives and wire wrapping trees, which are mainly short-term measures. However, this project is looking at a sustainable long- term way to change the faunas spatial and temporal access to resources, such as the community’s crops (Cook, 2018).

Following on from the study we helped Wright (2018) execute, we are researching whether bioproducts, such as bee pheromones or formic acid, have a notable impact on a wide array of wildlife species, especially those that cause conflict. This research aims to establish if, and for which species, bee pheromones and eventually formic acid could be used as a viable tool to mitigate HWC.” – Paul Allin, research coordinator

RA.3.3 - Railway Mortality Study

“Globally, it is well-established that roads have extensive ecological impacts on the landscapes through which they transect (e.g. van der Ree et al., 2015). Given the similarities between roads and railways – linear transportation corridors, that fragment habitat, and introduce mortality threats, light, noise, and vibration into their surrounding landscapes – it stands to reason that railways have equally as detrimental impacts on the landscape (Barrientos et al., 2019). However, given the lack of research focus, the ecological impacts of railways often go unquantified (Borda-de-Água et al., 2017; Popp et al., 2017).

Mortality and barrier to movement impacts are amongst the predominate impacts of railways on wildlife (Borda-de-Água et al., 2017). These impacts can have severe detrimental impacts on wildlife and can threaten the extinction of localized populations. When considering species of conservation concern, this is particularly harmful, as loss of local populations may in fact result in the loss of the species overall. In recent years, the threat of railways on native South African fauna has received more recognition. For example, studies along the railway through Balule Nature Reserve have demonstrated a loss of at least 503 individuals to railway collisions over a 25 year period (Allin, 2019). Since studying the impacts of railways on wildlife is not often on the agenda, data on collisions between wildlife and trains are often collected opportunistically rather than

systematically, which makes it difficult to draw clear conclusions and determine the large-scale effective on the landscape or on the population's viability. Thus, a scientific research program to evaluate the impacts of railways on wildlife is necessary in order to better understand these impacts and protect and conserve local fauna.

In this proposal, we outline a research program designed to evaluate the mortality and barrier impacts of railways on native South African fauna. We focus on mortality impacts, and barrier to movement impacts as these are the strongest/largest impacts of railways on wildlife, and because these impacts have the most options to mitigate and reduce impacts (Barrientos et al., 2019). As such, our research program is designed not only to evaluate the impacts of railways on South African fauna, but also designed to evaluate methods to reduce these impacts to create a safer, better-connected landscape for the fauna to thrive in.

This project involves collaboration with researchers, NGOs such as Endangered Wildlife Trust, protected area managers, land use managers, and governmental bodies such as TransNet. The project also involves international collaborations between South African and Swedish-based (Manisha Bhardwaj). The research team also collaborate with and exchange knowledge with other researchers from the USA, Canada, Germany, and Australia." - From: South African Railway Ecology Program, Manisha Bhardwaj, Paul Allin, Craig Spencer and Wendy Collinson.

RA.3.4 - Tree Wrapping

African savanna elephants (*Loxodonta Africana*) are believed to be one of the primary forces contributing to the conversion of savanna woodlands to grasslands (Shannon et al., 2008). By pushing the trees over to feed on their roots, or ring barking them to feed on the cambium, i.e., bark removal around the entire circumference of the tree, causing its death by interrupting water and nutrients exchanges between the roots and the leaves, elephants represent an important factor of mortality for savanna trees (Shannon et al., 2008; Herrera & Pellmyr, 2009).

Trees play an important role in savannas by limiting soil erosion, stabilizing ground temperatures, providing refuges, shade and food resources to wildlife and influencing nutrient cycle and water availability (Belsky 1994, Lindenmayer et al., 2012). While elephant-driven tree mortality is a natural process, the establishment of fenced nature reserves coupled with an increase in artificial perennial water resources, can lead to an increase in this mortality rate due to an increase in elephant density (Derham, 2016). To reduce this rate, reserve managers can either reduce elephant population size (*e.g.,* culling or reduction of water availability), or protect the trees from being damaged (Derham, 2016). There are numerous solutions, including surrounding the tree with rocks to limit its access to elephants, and wrapping them in meshed wire to limit the access to the cambium, i.e., debarking opportunities (Derham, 2016). This solution has been implemented in Olifants West Nature Reserve since 2021 to protect marulas (*Sclerocarya birrea*) and knobthorns (*Senegalia nigrescens*) from elephants, and its efficiency is monitored by revisiting wrapped trees.

RA.4 – Criminology

RA.4.1 – Illegal Wildlife Trade

The main form of illegal human activity reported in OWNR and BOCCA is snaring, i.e., the intentional trespassing and setting of wire or cable snares to catch game. Snares are commonly used by poachers to capture wild animals for muti (traditional medicine) or bushmeat, as their use is low risk for poachers who can set them quickly, limiting the risk of being caught. Made from wire or cable, attached to a tree in the bush and characterised by a deadly noose, snares are non-selective weapons that trap and kill or injure any animal that passes through them. This implies that non-target species, such as wild dogs, hyaenas, elephants or hippos, are also affected by this threat, which can result in injuries, loss of limbs or death. This threat is compounded by the fact that poachers sometimes forget the location of snares that have not caught animals during initial checks, leaving snares in the landscape long after they have gone. To control this ongoing threat, the Black Mamba APU conducts daily snare sweeps in both OWNR and BOCCA and monitors areas where snares have previously been found to remove any potential new ones. By covering the landscape in such a way, they gather information on snaring hotspots and high-risk areas, such as the vicinity of building sites, where the movements of construction workers are also regularly monitored. This information can then be used to investigate spatiotemporal trends to further elucidate drivers, locate high risks areas and adapt our use of resources and efforts accordingly.

Poaching can also target specific species to sell live or dead animals or parts on the international black market. These species are often facing critical decline due to high market demand, and therefore require special attention and efforts. In this context, Transfrontier Africa is involved in the recovery, rehabilitation, and poaching prevention of target species, such as black and white rhinos and ground pangolins. One of the main threats to ground pangolins (*Smutsia temminckii*), also known as Temminck's pangolins and listed as Vulnerable by the IUCN Red List, is indeed the illegal wildlife trade. Although sting operations, i.e., localised reactive actions, are necessary to limit the loss of individuals at national level, the conservation of the species can only be ensured by understanding the pangolin trade network and developing sustainable solutions to combat the observed poaching trend and reduce demand.

RA.4.2 – Technology development

Since 2022, Transfrontier Africa has partnered with Sensing Clues, a secure and innovative platform providing data-driven tools and solutions to support conservation professionals. This allows TA to gather security-related information from the Black Mamba APU and to relay it to the command-and-control centre for record keeping, potential further investigations and predictions to prevent poaching and the arising of future security issues. It also allows TA’s Research Department to gather information related to research and ecological monitoring projects from the field technicians and managers for record keeping, data management and analyses. The security- and research-related information gathered will also assist the Research Department and the Security Department in writing performance reviews and analysing the effectiveness of the methodologies implemented, to allow for adaptive management.

To that end, TA's Research Department has committed to co-supervise interns from Sensing Clues to develop tailored automated tools to improve the deployment of our resources for security and rhino monitoring purposes, by targeting high risks areas in priority (*e.g.,* high risks of poaching combined to rhino presence).

RA.5 – Ecological Monitoring

RA.4.1 - Alien Vegetation Control

Human movements across the world have promoted the spread of species outside their native biogeographical ranges, intentionally or accidentally, leading in some cases to biological invasion (Lockwood, 2005; Alpert, 2006). Invasive alien species are able to invade new ecosystems thanks to their highly competitive and adaptive abilities and represents a threat to ecosystems and native species across the world (Sinclair and Walker, 2003; He et al., 2011). These invaders can notably exclude less competitive native species from a system, and eventually disrupt ecological functions and interspecific interactions (He et al., 2011).

Invasive alien plant species are well known and studied in South Africa and management measures have been established across the country to control and monitor their spread (Lotter and Hoffmann, 1998). According to the Conservation of Agriculture Resources Act of 1983 (CARA), invasive alien plant species can be classified in different categories depending on their invasive status in South Africa and the threats they represent for the ecosystem:

- **Category 1**: Invader plants must be removed & destroyed immediately.
- **Category 2**: Invader plants may be grown under controlled conditions only.
- **Category 3**: Invader plants may no longer be planted.

In OWNR and BOCCA, 14 species have been identified as invasive alien plant species and are the object of management measures. While lodges and private landowners have the responsibility to manage their populations on their land, Transfrontier Africa is responsible for the remaining parts of the reserve, assisting the lodges and landowners in detecting and treating the invaders, and managing their population on Ekuthuleni (BOCCA). These species can be separated into two categories, which are managed differently: the cacti species can be found everywhere in the reserves and are mostly treated with biocontrol agents and chemical products, and the drainage line species are mostly found in drainage lines and removed manually (mechanical removal).

Cochineal bugs (*Dactylopius coccus*) are used as biocontrol agents for the Prickly pear (*Opuntia* sp.) and bred in a controlled nursery located in Ekuthuleni. These agents feed on the cactus' moisture and nutrients, damaging and eventually killing the host plant. Cochineal bugs naturally disperse with the wind and can also be purposedly placed on target plants by adding an infected cladode on it. The insects will then spread from the infected cladode to the new host plant and establish a new generation on it.

Monosodium Acid Methane Arsonate (MSMA) is a selective herbicide which is sprayed on the cacti using a hand-pump sprayer. Both types of treatments are applied during the dry season, to increase their efficiency and durability, as rains tend to wash off the cochineal insects and chemical products.

Investigating the effectiveness of each treatment and detection methods is crucial to ensuring that the population is controlled as effectively as possible and will therefore be one of the objectives of TA's Research Department.

RA.5.2 - Boreholes and Subterranean waters

Olifants West Nature Reserve is categorised as a hot, semi-arid, granite lowveld savanna (Mucina et al., 2006), with a long-term average annual rainfall of 421 mm (since 1985). Monitoring the water table level is therefore essential to ensure the sustainable water use by landowners and lodges present on the landscape. To do so, the depth of the water tables has been monitored weekly since 2019 in 7 boreholes, i.e., holes bored vertically in the ground to extract water, in Olifants West. The trend in depth of the water table is monitored over time and is linked to annual rainfalls, to establish recharge and consumption rates and propose management measures.

Following the presentation by Mike Holloway in 2022, Transfrontier Africa is in the process of establishing its own water monitoring committee on OWNR to monitor and advise the reserve on how to manage this precious resource. As the development of a strong El Niño event is expected in the coming months and years (Lian et al. 2023), with the associated risks of droughts, the water table levels will be monitored closely, and management will be advised accordingly, to ensure that the water resources are used sustainably.

RA.5.3 - Vegetation Community and Structure Monitoring

In any ecosystem, the vegetation forms one of the pillars on which the complex food-web rests. A healthy ecosystem is not sustainable without a healthy vegetation base and monitoring it is therefore essential, and can reveal many pieces of vital information on various aspects of an area under observation. Where possible annual vegetation surveys should be conducted across the managed area. This will allow for the detection of changes over time and enable management to make informed decisions. Indeed, changes in the vegetation structure or composition can have disastrous impacts on an ecosystem, such as a reduction in the Ecological Carrying Capacity, species loss, bush encroachment, or increased fire risks. Multiple complementary methods are available to approach these various aspects of vegetation monitoring and should be used in conjunction with one another, to better understand the full extent of the changes occurring and their causes.

One of the key aspects of this project is to evaluate on an annual basis the Ecological carrying capacity (ECC), i.e., the largest population size an ecosystem is able to support without long-term degradation of the ecosystem. To a certain extent, population numbers are self-regulating because deaths increase when a population

exceeds its carrying capacity. Resource use, drought, competition, predator-prey interaction, disease, and the number of populations in an ecosystem all affect carrying capacity. The smaller the area managed the greater the impact is of small disturbances and therefore it is essential to monitor the condition regularly, to enable timely intervention when needed. The objectives of this annual project are to calculate the Veld Condition Score and ECC, determine whether a change in species composition has occurred during the past year, determine whether the ratio of plant species has changed and assess whether any changes to the ratio of decreasers to increasers has occurred.

Another key aspect of this project is to monitor the woody:herbaceous ratio, to prevent the development of invasive woody species that could lead to bush encroachment, a reduced ECC and the loss of key herbaceous species, and to identify native species that should be prioritize by conservation action (e.g., endangered species declining in the reserve). Indeed, vegetation monitoring in the bushveld needs to include both the woody and the herbaceous layers (Eckhardt, 2010), which makes the monitoring much more complex and very little practical methods had been available so far. The rise of advanced software however allowed the development of simple and efficient methods, such as fixed-point photography. Fixed-point photography is a method of data collection which requires recording images at a predefined location, at regular intervals, over a long period of time. Each picture is taken from the same position and angle so that the recorded data is of the same physical area in every picture. Each picture can be analysed to determine structure and composition of the vegetation (Trollope et al. 1998, Masubelele et al. 2015), estimating phytomass, animal impact (Masubelele et al. 2013), erosion, bush encroachment (Ward et al. 2014), and tree recruitment. By correlating this data with rainfall data, shifts and trends in phenology can be detected (Sparks et al. 2006). This method has been implemented in Olifants West Nature Reserve and its bufferzone since 2019, with pictures being taken monthly at 20 locations (18 in OWNR and 2 in the bufferzone). The repeated pictures can then be compared using an image-processing software, such as Adobe Photoshop, to detect changes by overlaying photosets (Millington et al., 2009), or using convolutional neural networks for automated detection of changes (Bayr and Puschmann 2019).

Finally, riparian zones are key areas in semi-arid savanna systems, providing water throughout the year, constituting ecological corridors and essential breeding and feeding habitats for many species, including endangered species and keystone species (*e.g.,* vultures), and harbouring animal and plant species specialised to these areas (Monadjem & Garcelon 2005; Monadjem & Reside 2008; Monadjem et al. 2016; Gonzalez et al. 2017). Riparian zones are also highly sensitive to environmental changes and their response to anthropogenic and natural disturbances (*e.g.,* fires, pollution) should therefore be monitored closely to protect associated species. Implementing comprehensive monitoring efforts in these areas can therefore provide valuable insights and a holistic understanding of the phenomena affecting the ecosystem at the local level.

RA.5.5 - Wildlife Monitoring

Wildlife monitoring in nature reserves is crucial for maintaining biodiversity, preserving ecosystems, mitigating threats, understanding the impacts of climate change and human activities, and ultimately ensuring the long-term protection and sustainability of these vital natural areas. Therefore, annual game counts are conducted in order to obtain the most accurate representation of the species within OWNR. For many years the same methodology has been employed allowing for consistency in the data and the ability to detect trends over time. Historically, we would compare figures within the whole of the APNR, as an open system is subject to much internal movement. Changes in densities of animals that are known to be highly mobile, such as elephant and buffalo, are much less easy to interpret. Furthermore, the size of the reserve changes over time, as is the case in OWNR with York 7 joining. For this purpose, it is key to look at densities per ha and biomass per ha across as much of the system as possible. These data can then be compared to primary vegetation production to help understand why species increase or decrease in a given year. However, certain species are difficult to detect during aerial game counts (e.g., small mammals, nocturnal species, rare or elusive species, arboreal mammals), Therefore, the Research Department plans on developing or using additional methods or technology to monitor the wildlife, both inside OWNR but also its bufferzone and BOCCA, by using driving game counts, predator call-ups and exploring the use of drones.

Certain species also require more regular monitoring and more specific attention (e.g., poached species, endangered species, iconic species, conflict species). Black (*Diceros bicornis*) and white rhinoceros (*Ceratotherium simum*) populations are both threatened by habitat loss and poaching (illegal trade of rhino horn), and are classified as Critically Endangered and Near Threatened, respectively, on the IUCN Red List. In this global context, local monitoring of their population and global collaboration are essential. The Black Rhino Range Expansion Project (BRREP), which was founded in 2003 by World Wildlife Fund (WWF), Ezemvelo KZN Wildlife, Eastern Cape Parks, and Tourism Board, is one of these attempts to join local and global forces to counter the drastic decline in rhino populations. Its aim was to increase black rhino populations by reintroducing them in suitable protected areas to create new breeding populations. As Olifants West Nature Reserve offers suitable protected black rhino habitat, it was included in the project in 2011, when 19 black rhinos were introduced from Great Fish River Nature Reserve. To monitor the success of this project, Transfrontier Africa has committed to gather all the sightings of both species in OWNR, and to share this data on a monthly basis with Balule Nature Reserve, which is in charge of relaying it to WWF. To this end, landowners, lodges, and TA staff members are encouraged to relay any sightings, and camera traps are placed at key locations in the landscape (*e.g.,* waterholes, active rhino midden). Where possible, the individual rhinos are identified based on their specific ear notches, and their species, sex, age class, location (coordinates), number of individuals, behaviour (activity, direction), and body condition are recorded. It also allows us to build a consistent database over time that can be used to monitor their population dynamic, their temporal activity pattern, and their spatial distribution in the reserve, as well as their health condition (especially in times of drought).

Finally, other threatened and iconic species, such as African wild dogs (*Lycaon pictus*), Southern ground-hornbills (*Bucorvus leadbeateri*), cheetahs (*Acinonyx jubatus*) and vultures (e.g., white-headed vultures – *Trigonoceps occipitalis*), are also closely monitored in OWNR, and the data is shared to global or regional conservation programs. The data collected for Southern ground-hornbills is shared with the APNR Ground-Hornbill Research & Conservation Project (https://apnrgroundhornbillproject.com/), run by the FitzPatrick Institute of African Ornithology and which investigates southern ground-hornbills' habitat use, reproductive success, and behaviour. Their research has for objectives to (1) better understand the ecology of this species, and (2) use this knowledge for conservation purposes, as ground-hornbills are listed as 'Vulnerable' on the IUCN Red list. Vulture sightings, especially of rare and elusive species such as white-headed vultures, are shared with Endangered Wildlife Trust (EWT), and integrated in the EWT's Vultures for Africa Program (https://ewt.org.za/what-we-do/saving-species/vultures/), which aims at protecting vulture species from human impact, such as poisoning, raising public awareness, engaging governments to implement conservation actions, and improving our understanding of the different species to enhance our conservation strategies.

3. Provisional timetable

The following table details provisional planning of the aforementioned research projects and sub-projects within each Research Axis, per quarter, between January 2023 and December 2026:

RESEARCH PROJECTS	2023 - 2024				2024 - 2025				2025 - 2026			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
RA.1 - Biodiversity and Trophic Interactions												
RA. 1.1 - Anthropause												
RA.1.1.1 - Human impact on wildlife populations					x	x						
RA.1.1.2 - Human impact on wildlife spatiotemporal use					x	x						
RA.1.2 - Marula trees Demography Survey												
RA.1.2.2 - Marula Seedlings Predators and Predation Rate Assessment			x									
RA.1.3 - Predator Community Surveys												
RA.1.3.1 - Predator Diet Determination; Assessment of Abiotic and Biotic drivers			x				x		x	x	x	
RA.1.3.2 - Faecal Hairs Analysis vs Faecal DNA Metabarcoding – Methods Comparison							x	x				
RA.1.3.3 - Predator Diet Determination; Temporal patterns				x	x							
RA.1.3.4 - Identification of individual leopards and of the spatial distribution of their territories: Data collection and Monitoring			x	x	x	x	x	x	x	x	x	x
RA.1.3.5 - Identification of individual leopards and of the spatial distribution of their territories: Data analysis and Territories mapping					x	x			x	x		
RA.1.3.6 - Spatiotemporal Interactions between Apex and Mesopredators: Trophic Cascades, Avoidance/Attraction Strategies, Community Composition and Dynamics		x	x	x								
RA.1.4 - Rhino Population Dynamics												
RA.1.4.1 - Black Rhinos Carrying Capacity Assessment within OWNR							x	x				
RA.2 - Community Development												
RA.2.1. - Local Community Response to the Black Mambas and Bush Babies Programs	x	x	x	x	x	x	x	x	x	x	x	x
RA.2.2 - Establishing sustainable utilization of natural resources by sangomas			x			x	x			x	x	
RA.3 - Human-Wildlife Conflicts												
RA.3.1 - Anthropogenic Impact												
RA.3.1.1 - Road Density and Traffic Intensity Impact on Wildlife Spatiotemporal Use in OWNR and BOCCA									x	x		
RA.3.1.2 – Human-made Infrastructure Density Impact on Wildlife Occupancy and Spatiotemporal Use in OWNR and BOCCA											x	x
RA.3.2 - Bioproducts usage as Elephants Deterrent												
RA.3.2.1 - Bee Pheromones as Elephants Deterrent – Methodology Testing	x	x	x	x								
RA.3.2.2 - Effect of Crematogaster Ants Presence on Tree Protection against Elephants	x	x										
RA.3.2.3 - Formic Acid as Elephants Deterrent – Methodology Testing					x	x						
RA.3.3 - Railway Mortality Study												

RESEARCH PROJECTS	2023 - 2024				2024 - 2025				2025 - 2026			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
RA.3.3.1 - Impact of Railway Transports on Wildlife Mortality	x	x	x	x	x	x	x	x	x	x	x	x
RA.3.3.2 - Animal Mortality Rate linked to the Railway and Animal Space Use						x	x	x	x			
RA.3.3.3 - Under-path Passages Use by Wildlife as Safe Crossing Ways	x											
RA.3.3.4 - Elephant Space Use along the Railway	x	x										
RA.3.3.5 - Buffer zone Mapping and Ecological Assessment of Abiotic Drivers linked to Animal Crossings and Mortality		x	x				x	x				
RA.3.4 - Tree Wrapping												
RA.3.4.1 Tree Wrapping Effectiveness Assessment against Elephants	x	x										
RA.3.4.2 Assessment of Tree Wrapping Effects on Non-Target Species					x	x						
RA.4 - Criminology												
RA.4.1. - Illegal Wildlife Trade												
RA.4.1.1 - Researching the Live Trade Network of Pangolins					x	x	x	x	x	x	x	x
RA.4.1.2 - Spatiotemporal Evolution of Snaring Trends in the Area							x	x				
RA.4.2 – Technology Development												
RA.4.2.1 - Automation of Security Reports for more Effective and Efficient Response	x	x										
RA.4.2.2 - Predictive Heatmaps of Rhino Distribution		x	x									
RA.5 - Biodiversity and Trophic Interactions												
RA.5.1 - Alien vegetation control												
RA.5.1.1 - Biological control Effectiveness Assessment	x	x										
RA.5.1.2 - Drone Mapping – Method Testing							x	x				
RA.5.1.3 - Biocontrol vs Chemical – Methods Comparison	x	x										
RA.5.2 - Boreholes and Subterranean waters												
RA.5.2.1 - Water tables level response to human use and rainfalls – Monitoring	x	x	x	x	x	x	x	x	x	x	x	x
RA.5.2.2 - Water tables level response to human use and rainfalls – Solutions									x	x		
RA.5.3 - Vegetation Community and Structure Monitoring												
RA.5.3.1 - Comparative Analysis of Riparian Zones between Big5 (OWNR) and non-Big5 (BOCCA) Areas										x	x	
RA.5.3.2 - Ecological Carrying Capacity (ECC) in OWNR and BOCCA	x				x				x			
RA.5.3.3 - Grass Community Composition and Rainfalls – Community Changes over time	x	x										
RA.5.3.4 - Grass Community Composition and Rainfalls – Integrated Modelling using fine-scale Rainfall data					x	x						
RA.5.3.5 - Phytomass Assessment			x				x				x	
RA.5.3.6 - Protection of indigenous vegetation - firewood availability									x	x		
RA.5.3.7 - Protection of indigenous vegetation - identification of priority species									x	x		
RA.5.3.8 - Vegetation Community – Composition and Abundance changes over time							x	x				
RA.5.3.9 - Woody-herbaceous ratio - monitoring and early detection of species invasions									x	x		
RA.5.4 - Wildlife Monitoring												

RESEARCH PROJECTS	2023 - 2024				2024 - 2025				2025 - 2026			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
RA.5.4.1 - Aerial Annual Game Count in OWNR and BOCCA			x				x				x	
RA.5.4.2 - Biweekly Game Count in BushRiver and Ekuthuleni: Spatiotemporal Analyses and Method Comparison with Aerial Game Count	x	x	x	x	x	x	x	x	x	x	x	x
RA.5.4.3 - Black and White Rhino Populations Monitoring within OWNR	x	x	x	x	x	x	x	x	x	x	x	x
RA.5.4.4 - Call-ups for Predators Counting			x				x				x	
RA.5.4.5 - Continuous Wildlife Monitoring – Endangered and/or Iconic Species	x	x	x	x	x	x	x	x	x	x	x	x
RA.5.4.6 - Improving the Precision and Accuracy of Aerial Census using Remote Sensing Imagery and Machine Learning	x	x	x	x	x	x	x	x	x	x	x	x
RA.5.4.7 - LoRa Technology Implementation					x	x						
Contractual obligations												
Annual performance reports		x		x		x		x		x		x
Quarterly reports	x		x		x		x		x		x	
Budget revision				x				x				x
3-year Research Plan	x	x										
Annual Research Plans			x		x				x			
External communication												
Presentation to the landowners		x				x				x		
SSNM conference	x				x				x			
SAWMA conference			x				x				x	

*Q1 runs from January to March, Q2 from April to June, Q3 from July to September, and Q4 from October to December.

4. External participants

Transfrontier Africa's Research Department work in collaboration with national and international universities, researchers, institutions, organisations, and hosts and supervises interns from undergraduate to Ph.D. students.

4.a. Collaborations

Collaborations with universities, researchers, institutions, and organisations encompass common larger research projects, for which methodology, data, and results are shared, new tools development and new methodology testing.

TA's Research Department's current collaborations are detailed in the document available at the following link:

https://ln5.sync.com/dl/4097c4970/57t57gwr-tv2d7688-p4e2tnmv-4u7fjaef

New collaborations that are in line with the objectives of the research programme detailed in this document are encouraged. All collaboration is governed by an agreement signed by both parties prior to the start of the project, in the form of a Research MoU, available at the following link:

https://ln5.sync.com/dl/eaf6b79a0/ekpvrhv4-476ps3pp-3jcfmtcp-khjqku34

4.b. Internships policies

Until 2023, the selection process of interns has been mainly reactive to spontaneous applications. The Research Department intends to move towards a proactive selection process, to actively recruit interns whose profiles meet the requirements of our on-going and planned research projects. The internship opportunities will be forwarded to partnering universities and posted on TA's website and media platforms. In the future, the Research Department intends to expend the range of students reached by creating a LinkedIn account for Transfrontier Africa Research Department and by posting internship opportunities on advertising platforms (e.g., Conservation Careers, Conservation Job Board, SFE[2]), providing reasonable membership rates and depending on funds:

Internship opportunities will be advertised using a standardized document presenting the organisation's goals and values, the internship project, as well as the requirements to be selected (*e.g.,* academic level, duration, submission protocol).

Applications will be received and assessed by the Research Department, and shortlisted candidates will be contacted for an online interview. By using a proactive approach to the recruitment of interns, the Research Department will ensure that the selected candidates have the necessary skills and motivation to carry out short-term or long-term research projects and that the results will be beneficial both to TA and to the interns. Spontaneous applications will be considered on a case-by-case basis, and candidates offering valuable contributions in line with the objectives of the research programme detailed in this document will be considered.

A Memorandum of Understanding (MoU) will be signed by all parties involved before the start of any internship, to ensure that the rights and obligations of all parties to each other are fully established and understood. The MoU will notably cover intellectual property rights, field and scientific assistance to the interns, equipment usage agreement, accommodation conditions, and publication policies.

Interns will be supervised by the Research Coordinator and the Research Assistant, who will provide regular academic support and field assistance to ensure successful research and academic development.

Finally, an internship package detailing the living and internship conditions will be provided to all potential interns and will be available on TA's website and at the following link:

https://ln5.sync.com/dl/f608400b0/djtt4sfe-vnc2d4yq-62wssuwd-keg3ywwe

5. Risk management

Research-related risks cannot always be avoided and therefore their management should be planned in advance, where possible, to limit their impact on research projects and the parties involved. The most common risks include intellectual property litigation, political, financial or material obstacles to the completion of a project and data loss.

To avoid any conflicts related to intellectual property rights, TA's Research Department will require the prior signature of a MoU by all parties (see Part C.4). Agreements with the relevant landowners will be concluded prior to the start of any projects in order to outline the objectives of the project, the type and frequency of the planned fieldwork, and the expected duration of the project. For each project, a provisional budget will be drawn up and the missing equipment will be purchased. Data will be saved on personal/professional computers, as well as on an online cloud accessible by all parties involved (Sync), to avoid any loss and centralize the data (as required by the item 16.1 defined in OWNR's Management plan).

In the event of a budget overrun, the research department will seek new sources of funding (*e.g.,* national or international grants, public or private partnerships, external researchers fundings) independently of TA, in order to avoid exhausting the organisation's resources. In the event that the planned budget was not fully used, the research department would reallocate the resources to another project. In the event that the research equipment was to be damaged by an external party, immediate replacement of the product would be required, except in cases of unavoidable damage (*e.g.,* camera traps damaged by wildlife, wear and tear over time). Details of the responsibilities of the different parties in case of damage to the equipment will be included in the MoU signed at the beginning of the partnership/internship.

6. Publications

TA's Research Department aims to publish the results of at least three of the research projects carried out each year in regional, national, or international peer-reviewed scientific journals as co-authors or lead authors. The impact factor (IF), target audience (*e.g.,* applied projects should target reserve managers as a priority) and field of interest will be used as criteria for selecting scientific journals, which will also be adapted according to the scope of the project, the research topic and the relevance of the methods applied, and the results obtained. In accordance with the agreement (MoU) signed by each student and partner researcher, TA's Research Department is co-owner of all data collected and is legally entitled to publish any work, if no publication or intention to publish is made by the student/researcher within one year of the end of a project.

The results of all research projects will be systematically published in at least one of the following resources:

- Reports (quarterly, annual, project-specific reports)
- Bachelor's thesis
- Master's thesis
- Ph.D. thesis
- Peer-reviewed scientific journal

Some of the most innovative research projects may be presented at national or international scientific conferences, with the agreement of all the students and researchers involved.

PART C – COMMUNICATION

1. Annual performance reports

Annual performance plans are produced every year by TA to report on the activities conducted during the year, assess the results obtained and the budget used and to set up the objectives and budget for the following year. TA's Research Department is responsible for producing the Research part of the Annual Performance Report, which include all the research projects and ecological monitoring projects.

Annual performance reports are due every year and should be submitted to TA's founder and managing director, Craig Spencer in June (end of the financial year) and December (end of the administrative year).

2. Quarterly reports

TA's founder and managing director, Craig Spencer, entrusted the Research Department with the responsibility of producing TA's Quarterly Reports. These reports include all activities carried out by the organisation in terms of Security, Bush Babies' Activities, Ndlovu camp Activities, Ecological Monitoring, Research and Networking Events and collaborations.

Quarterly Reports are due every quarter of the year and should be submitted to TA's founder and managing director, Craig Spencer. They will be used to provide regular and comprehensive feedbacks to all stakeholders involved.

Comprehensive reports of specific research projects that were completed during the quarter (*e.g.,* annual ecological monitoring project; master thesis) will be mentioned in the quarterly reports, and available in a public folder in TA's Sync, along with the quarterly report.

https://ln5.sync.com/dl/71a755cd0/q2fjvymj-rchfajxb-pwkerwux-eqh3kgzm

3. External communication – stakeholders, landowners & collaborators

TA's Research Department is responsible for sharing the results of the various research projects conducted in OWNR to the stakeholders and landowners. To that end, a bi-annual presentation will be held in OWNR's office, after the submission of the two annual reports, in July and January. These presentations will present the results of the completed and on-going projects and will also present the projects that will be conducted during the year. Questions will be taken to ensure clarity and transparency about all projects, and mutual comprehension with the landowners and stakeholders. The presentation will be filmed and available online for stakeholders who could not be present and will be posted on Transfrontier Africa's medias and websites. The projects will be presented by the Research Department, and eventually by interns, for long-term internships (6 months and more). All the landowners and stakeholders will also have

permanent access to the quarterly and annual reports, and to any report produced at the end of a research project (available on the link provided in Part C.2).

TA's Research Department will broaden the scope of partnership with national and international collaborators by presenting and/or attending conferences related to our field of study in South Africa, and online events. In particular, the results and/or methodology of innovative research projects will be presented, when possible, at the Southern African Wildlife Management Association (SAWMA) conference, held every September, and at the Savanna Science Network Meeting (SSNM), held every March, in Southern Africa, which represent a great opportunity for networking and idea sharing with fellow scientists. Promising interns will be offered the opportunity to present at these events when judged relevant, and where possible. Relevant online events will be attended by the Research Department, when possible, and submissions of abstracts will be considered on a case-by-case basis.

TA's Research Department will opportunistically provide tailored presentations about the organisation and/or specific research projects to partner universities and Professors.

4. Internal communication – field technicians, interns & volunteers

On-going research projects conducted by interns are presented monthly to all the members of Transfrontier Africa during a presentation evening. Each intern presents the project she/he is working on in a 10 min format presentation with a PowerPoint. TA's volunteers and staff members then have the opportunity to ask questions and engage with the intern about the project. Each intern is also asked to take notes during the other interns' presentations, in order to give them feedback afterwards. The Research Department also provides feedback to each intern about the length of their presentation, its content and format, and the intern's presentation skills. The aim of this exercise is not only to communicate about the research projects for the volunteers and staff members, but also to give an opportunity to the interns to practice presenting their research in front of an audience with heterogeneous background and knowledge in ecology and conservation.

Communication between the Research Department and the Ndlovu Bush Camp, which hosts volunteers who conduct part of the fieldwork under the supervision of a camp manager and assistants, is crucial to ensure consistent and accurate data collection and fieldwork planning. Therefore, the Research Department will provide, on a weekly basis, a fieldwork planning for the week ahead. SOPs with detailed instructions, as well as fieldwork datasheets, are provided to ensure the correct collection of data. The data is collected by the Research Assistant daily and incorporated into the general database. In some cases, this is done by bachelor interns who work on specific on-going projects, who are taught beforehand how to manage the database and supervise the fieldwork.

The Research Department is responsible for communicating the results of the various research projects to Transfrontier Africa's Managing Director, who can then inform the different stakeholders, such as Olifants West Nature Reserve's board and funders.

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APPENDIX

Table A. OWNR Management Plan – Operational Framework.

Section	Ref. Number	Specific objective	Action
11.2 - Governance	**Overall Objective**: To ensure that appropriate administrative structures are in place to effectively manage OWNR		
	1.1.1	To ensure that adequate human resources are in place to manage the reserve	Identify manpower and skills required to meet operational objectives
	1.1.2		Implement skills training as necessary
	1.2.1	To ensure that appropriate facilities and equipment are available to support effective management	Identify facilities and equipment required to enable staff to perform their duties
	1.2.2		Prepare and implement a scheduled maintenance programme for key facilities and equipment
	1.3	To ensure that adequate financial resources are available to meet requirements	Prepare an annual plan of operation, including detailed budget requirements
11.3 - Land Use	**Overall Objective**: To ensure that OWNR maintains its status as a Nature Reserve declared in terms of Section 23 of NEMPAA, and remains a part of the open system		
	2.1	To add undeclared properties within OWNR to the protected area	Negotiate with relevant landowners
	2.2	To ensure that buffer zone considerations for OWNR are captured in local and regional plans	Make inputs into district and municipal development policies, by-laws and land-use applications to ensure compatible land use in the areas around the reserve
	2.3	To protect right of access	Develop a servitude register for the reserve
11.4.1.1 - Invasive Species	**Overall Objective**: To control or eliminate invasive species and to conserve as wide a variety of habitats occurring in the reserve as possible		
	3.1.1	To systematically control, and eradicate if practicable, plants which are alien to the reserve, particularly those which threaten the indigenous vegetation and/or other natural resources (e,g. water).	Map location and extent of existing alien plant infestation
	3.1.2		Identify sites for treatment, prioritising species which invade rapidly and have a wide distribution
	3.1.3		Maintain biological control nursery populations where practical
	3.1.4		Treat affected sites and revisit to monitor effectiveness of treatment

Section	Ref. Number	Specific objective	Action
	3.1.5		Compile and distribute information sheets for landowners to enable them to manage alien invasive vegetation on their properties
	3.1.6		Monitor results and report
	3.2.1	To protect the herbaceous layer from invasive indigenous woody species	Monitor woody:herbaceous ratio and identify woody species that might become invasive
	3.2.2		Reduce density of invasive woody species, if necessary
11.4.1.2 - Consumptive Utilisation of Flora	**Overall Objective**: To manage the harvesting of indigenous vegetation		
	4.1	To protect indigenous vegetation from over-utilisation and/or unauthorised removal from the reserve.	Identify key species, their conservation status, and the extent to which they can be harvested sustainably
	4.2		Determine the amount of firewood available from the habitat rehabilitation programme or any sacrificed areas
	4.3		Make available sustainable firewood from external sources as required
	4.4		Prepare a policy for sustainable harvesting of natural vegetation, including firewood and reeds
	4.5		Ensure that gate security checks include scrutiny for illegal removal of wood and plants.
11.4.1.3 - Vegetation Protection	**Overall Objective**: To protect vegetation from damage by wildlife or development and to mitigate the effects		
	5.1.1	To protect iconic trees from elephant damage and encourage replacement of lost trees	Wrap selected trees with wire meshing to prevent bark stripping
	5.1.2		Develop a nursery for seedlings
	5.1.3		Encourage landowners to plant seedlings
	5.2.1	To protect vegetation along rivers, drainage lines and sodic soil areas	Identify excessive human activities in sensitive areas
	5.2.2		Identify waterholes within close proximity to sodic areas that encourage herbivore traffic
	5.2.3		Develop and implement a plan to reduce human and herbivore activity in sensitive areas
11.4.2 - Wildlife Management	**Overall Objective**: To conserve a wide diversity of naturally occurring animal species in the reserve without causing long-term ecological deterioration		
	6.1.1	To quantify presence, absence and relative abundance of key species	Report sightings of key species to Warden
	6.1.2		Identify species of concern
	6.2	To quantify other population parameters, such as sex and age structure, that will help in understanding the population dynamics of key species	Conduct an annual game census
	6.3.1	To identify, reduce and mitigate conflict between wildlife and landowners	Identify potential attractions for wild animals and offer solutions that empower landowners to manage conflict

Section	Ref. Number	Specific objective	Action
	6.3.2		Conduct annual audit of private property electric fencing and entrance gates, etc.
	6.3.3		Investigate all incidents and keep detailed records and follow-up actions recommended
	6.4	To protect indigenous fauna from the risk of predation, genetic pollution, or the introduction of disease by domestic animals.	Develop a policy regarding the presence of domestic animals on the reserve.
11.4.2.1 - Sustainable Utilisation of Fauna	**Overall Objective**: To manage sustainable utilisation of game without impacting on the objectives of OWNR		
	7.1	To identify the proportion of selected species available for utilization	Assess population dynamics of relevant animals by analysis of annual game count
	7.2		Assess the ecological carrying capacity via annual vegetation survey
	7.3		Assess predator/ prey relationships
11.4.3 - Fire Management	**Overall Objective**: To provide guidance on how to manage the role of fire as an ecosystem driver as well as to evaluate and respond to fire threats		
	8.1.1	To utilise fire as an ecosystem process, where necessary	Conduct annual vegetation survey to assess fuel load
	8.1.2		Evaluate whether a programme of controlled burning should be implemented
	8.2.1	To promote fire safety and reduce wildfire risks	Identify and map roads, rivers and powerlines as firebreaks
	8.2.2		Map water sources for fire suppression
	8.2.3		Encourage cleared areas around infrastructure and private buildings
	8.2.4		Prepare an emergency fire plan to address unplanned fires and distribute to landowners
	8.2.5		Maintain membership of the Greater Kruger Fire Protection Association
11.4.4 - Water Resource Management	**Overall Objective**: To maintain natural water bodies in such a condition as to support naturally occurring game species		
	9.1.1	To provide water for animals in places and for periods which approximate, as closely as possible, the past natural distribution of water without affecting adversely hydrology and consequent ecology	Map natural perennial and non-perennial water sources
	9.1.2		Take necessary management actions to manage water points
	9.2.1	To monitor the effect of rainfall on the vegetation of the reserve	Set up a network of weather stations
	9.2.2		Record rainfall data on a regular basis
	9.2.3		Analyse rainfall and vegetation data
	9.3	To monitor the extent of human water usage	Determine sustainable extraction rates and set targets in terms of human consumption
	9.4.1	To comply with national legislation	Register river and borehole abstraction and discharge with the Department of Water Affairs

Section	Ref. Number	Specific objective	Action
	9.4.2		Keep a database of registered boreholes
	9.5.1	To monitor and protect the quality and quantity of natural water sources, both above and below ground	Identify aquifers and determine their recharge rates
	9.5.2		Test water quality, both standing and subterranean.
	9.5.3		Identify and remove sources of pollution to the reserve's water
	9.5.4		Develop guidelines to landowners regarding water usage. To include recommendations regarding use of grey water, harvesting of rainfall, etc.
11.4.5 - Road Management	**Overall Objective**: To manage the road network in such a way as to balance the ecological needs of the reserve with the needs of landowners		
	10.1.1	Maintain the servitude roads in good condition	Monitor the condition of the roads on a regular basis, especially after rains
	10.1.2		Arrange maintenance as and when needed, ensuring that the impact of the roads on flanking properties is minimised
	10.2.1	Reduce the number of private tracks within the reserve as a whole	Establish guidelines for desired road density, taking account of the requirements of commercial tourism
	10.2.2		Identify areas with high road density, particularly where tracks run close together and could be consolidated
	10.2.3		Communicate with relevant landowners and agree measures to reduce density and rehabilitate closed tracks
	10.3.1	Assess and manage proposed new roads	Establish an internal process whereby application must be made to the Management Authority for approval of any proposed new roads or resurfacing/concreting of existing roads
	10.3.2		Monitor and manage development once approved
11.4.6 - Soil Erosion Management	**Overall Objective**: To protect and manage soils and, where necessary, rehabilitate areas impacted by erosion		
	11.1.1	To identify and attend to erosion that is threatening unique, valuable or sensitive habitat	Identify and map extensive sheet-eroded areas and erosion from sodic patches
	11.1.2		Identify and map gulley erosion in bottomlands
	11.1.3		Draw up a programme for erosion reclamation
	11.1.4		Reduce water runoff and increase infiltration on sodic patches and sheet-eroded areas
	11.2.1	To identify areas of active erosion resulting from the road and track network and (if	Map areas of active erosion and recommend appropriate measures to minimise erosion

Section	Ref. Number	Specific objective	Action
	11.2.2	practicable) to prevent, or at least minimise, such erosion	Identify roads and tracks that are placed on sodic areas, other erodible soils and on active seep lines and re-route
	11.2.3		Prioritise roads and tracks for erosion reclamation measures
	11.2.4		Maintain all tracks in a state that minimises their impact on surrounding hydrology, soil erosion, and biologically sensitive areas
11.4.7 - Waste Management	**Overall Objective**: To minimise pollution and its effects on the reserve		
	12.1.1	To effectively manage and dispose of waste	Prepare a waste-management policy
	12.1.2		Refine and maintain an efficient refuse removal system that is animal-proof
	12.1.3		Monitor waste storage area
11.5 - Socio-Economic Benefits	**Overall Objective**: To support economic, educational and social upliftment in nearby communities		
	13.1	To support economic and social upliftment	Encourage employers to draw their staff from local communities and develop staff skills
	13.2.1	To raise awareness about the ecological and conservation value of OWNR and the Greater Kruger with local communities and visitors to the reserve	Identify and support selected initiatives which promote these objectives.
	13.2.2		Facilitate information programs on community initiatives for commercial guests
11.6 - Safety and Security	**Overall Objective**: To ensure the safety and security of natural resources, people and property on OWNR		
	14.1.1	To provide protection for natural resources and reserve infrastructure	Develop Standard Operating Procedures for all aspects of security.
	14.1.2		Review SOP's annually and update where necessary.
	14.1.3		Provide a 24hr reporting structure for residents to report any suspicious or noteworthy activities
	14.1.4		Ensure rapid reaction capability
	14.2.1	To prevent and detect illegal access to OWNR	Use access control technology to record and monitor entries and exits.
	14.2.2		Monitor boundary fences, servitude roads, and strategic positions within the reserve
	14.3	To detect signs of poaching or other illegal activity within the reserve and buffer areas	Conduct patrols and snare sweeps within OWNR and the adjoining buffer area
	14.4	To maintain a high level of integrity among reserve and security staff	Establish and implement a deception testing (polygraph) policy
	14.5.1	To integrate security procedures and	Establish communication links and co-operation with local initiatives such as Farm Watch

Section	Ref. Number	Specific objective	Action
		communication with other external initiatives on the landscape	
	14.5.2		Ensure that all security policies and Standard Operating Procedures comply with GLTFCA requirements and are coordinated with neighbouring regions.
11.7 - Land Inclusion	**Overall Objective**: To undertake any expansion of OWNR in accordance with the requirements of the reserve's constitution and the GLTFCA Co-Operative Agreement		
	15.1.1	To determine whether the proposed land inclusion will contribute to or enhance the reserve and Greater Kruger open system	Assess the contribution the land will make towards: · The ecological viability of the reserve · Protection of a habitat or species · The enhancement of ecological connectivity across the landscape
	15.1.2		Assess the following: · The ownership and governance of the land, and whether it will enhance, maintain or undermine the governance of the reserve · The legal status of the land in terms of planning, zoning, land claims and any other relevant issues · Activities undertaken on the land, and whether they are compatible with those conducted on the reserve, and are compliant with the constitution and regulations, or would pose any reputational risk to the reserve
	15.2.1	To ensure compliance with formal processes for inclusion of land in OWNR	Landowner to apply for membership of OWNR in accordance with requirements of the constitution
	15.2.2		Land to be declared as an addition to OWNR in accordance with NEMPAA, and title deeds to be endorsed
	15.2.3		Management Plan to be amended to reflect inclusion of the land
11.8.2 - Research and Monitoring	**Overall Objective:** To provide broad-based scientific support to guide management actions, decision-making and communication		
	16.1.1	To develop and manage an effective system to store, share and report on data	Maintain a repository of electronic files that ensures effective and simple data sharing and access
	16.1.2		Upload current and historical field reports
	16.2.1	To conduct and facilitate appropriate research and monitoring that support OWNR's objectives and have clearly defined goals	Generate an annual plan of relevant key issues for monitoring and research
	16.2.2		Approve research proposals
	16.2.3		Collaborate with projects conducted on the broader open-system landscape
	16.2.4		Detect and warn of environmental changes that detract from management objectives

Section	Ref. Number	Specific objective	Action
11.8.3 - Reporting Requirements for OWNR		**Overall Objective:** To meet the requirements for monitoring and evaluation in key performance areas	
		KEY PERFORMANCE AREA	**AREAS TO BE MONITORED AND REPORTED ON**
		Governance	· OWNR involvement in the Greater Kruger open system
			· Annual plan of operation
			· Annual budget
			· Human resources
			· Facilities, infrastructure and equipment
			· Compliance with environmental authorisation requirements
		Land Use	· Progress on declaration status of any undeclared portions on OWNR
			· Progress on the endorsement of title deeds
			· Inputs into municipal and regional plans regarding buffer zones
		Ecological Management	· Animal and vegetation monitoring projects, and their key findings
			· Animal population control, either through hunting or culling
			· Status of key species (eg. rhinos, elephants)
			· Water resources
			· Invasive species control
			· Soil erosion control
		Socio-economic Benefits	· Income derived from hunting and tourism activities
			· Social support programmes
		Safety and Security	· Illegal incidents and measures taken to address them
		Land Inclusion	· Progress towards the inclusion of any properties in OWNR

The actions falling under the responsibility of TA's Research Department are highlighted in grey.

BUDGET

	Budget 2023/2024	Budget 2024/2025
Income		
Internships	1017250	1162500
Presentations to student groups	18000	20700
Total	**1035250**	**1183200**

Expenditure		
Staff costs, incl. accommodation	346200	597229
Transports	107840	121016
Networking	32000	35200
Equipment & Software	147120	177000
Fieldwork	42000	50000
Intern accommodation	120000	132000
Supporting research	35000	40000
Miscellaneous	3000	27000
Total	**833160**	**1179445**

Net Surplus	**202090**	**3755**