Assessing Land Use and Land Cover Change Dynamics of Wildlife Ranches in South Africa

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By

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Abstract

Biodiversity conservation requires diverse, context-specific approaches that extend beyond traditional protected areas. In South Africa, wildlife ranches have emerged as dynamic social-ecological systems capable of balancing biodiversity conservation with economic viability. This study examines land use and land cover dynamics within wildlife ranches in the Eastern Cape and Limpopo provinces, focusing on historical transformations, variability across business models, and the drivers shaping these transitions. Using a mixed-methods approach integrating spatial analysis and survey interviews, the findings highlight a significant post-1992 shift from conventional agriculture to wildlife-based land uses, catalysed by legislative reforms such as the Game Theft Act (1991).

Key land use changes included declines in cultivated fields and increases in old fields and rangelands, reflecting transitions to less intensive, more conservation-compatible practices. Wildlife ranches exhibit lower natural land cover loss than protected areas, underscoring their stability and potential as complementary conservation areas. However, variability in conservation outcomes across business models reveals important trade-offs. Some business models' properties align economic priorities with habitat preservation, leveraging natural landscapes and ecological restoration to attract tourism and support game populations. Conversely, other models demonstrate greater challenges in integrating biodiversity objectives with agricultural productivity, often maintaining higher proportions of non-natural land cover.

Old fields play a critical role as transitional habitats, supporting biodiversity recovery and ecological heterogeneity, but their potential is contingent on active management to prevent invasive species encroachment. The motivations driving land use changes are multifaceted, with economic viability, environmental constraints, and historical legacies shaping decisions. While wildlife ranches maintain stable natural land cover and contribute to habitat connectivity, their ecological contributions are influenced by regional dynamics and management practices. This research demonstrates the adaptability of wildlife ranches and their significant role in South Africa's conservation landscape. By integrating biodiversity conservation with economic resilience, wildlife ranches contribute meaningfully to national and global targets, including the Kunming-Montreal Global Biodiversity Framework. Tailored policies and management strategies are necessary to optimise their ecological and socio-economic potential, ensuring their sustainability as complementary conservation areas alongside protected areas.

Keywords: wildlife ranches, biodiversity conservation, land use change, social-ecological systems, business models, natural land cover, South Africa.

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List of abbreviations

Abbreviation	Definition
AIS	Alien Invasive Species
CBD	Convention on Biological Diversity
DFFE	Department of Forestry, Fisheries and Environment
GBF	Kunming-Montreal Global Biodiversity Framework
IPCL	Indigenous People and Local Communities
MLL	Mega Living Landscapes
NAMC	National Agricultural Marketing Council
NLC	Natural Land Cover
OECM	Other Effective Area-Based Conservation Measures
PA	Protected Area
PCA	Private Conservation Area
SANBI	South African National Biodiversity Institute
SANLC	South African National Land Cover
SES	Social-Ecological Systems
SWEP	Sustainable Wildlife Economies Project
WRSA	Wildlife Ranching South Africa

1. General Introduction

1.1 Introduction

To bend the curve on biodiversity loss, conservation must adopt diverse, context-specific approaches that extend beyond traditional models (IPBES, 2019). While protected areas (PAs) remain essential tools for biodiversity preservation, they are increasingly understood within conservation discourse as components of broader social-ecological systems (SES) that involve complex interactions between ecosystems and human communities. Recognising these dynamics, recent global policy processes have emphasised the need for adaptive strategies that include other models and measures for protecting biodiversity (Dudley and Stolton, 2022; Fitzsimons et al., 2024). Most significantly, the Kunming-Montreal Global Biodiversity Framework (GBF) has proposed that other effective area-based conservation measures (OECMs) fulfil a large proportion of Target 3’s 30x30 expansion goal (Cook, 2024).

The push for area-based conservation, including PAs and OECMs, is rooted in global commitments such as the Convention on Biological Diversity (CBD) advocating target-based biodiversity conservation (Bhola et al., 2021). Although PAs are important for protecting endangered species and promoting public awareness, studies show that not all PAs effectively conserve biodiversity and often overlook socio-economic aspects like inclusivity and social justice (Visconti et al., 2019; Watson et al., 2014). Consequently, the CBD supports areas beyond PAs, such as OECMs, to enhance biodiversity through in-situ conservation, ecological connectivity, restoration efforts, and sustainability, thereby expanding the scope of critical conservation areas (Borrini-Feyerabend et al., 2013; CBD, 2022; Diz et al., 2018; Juffe-Bignoli et al., 2016).

Wildlife ranches, particularly in South Africa, reflect this diversification by combining conservation-compatible practices with economic land uses, making them potential candidates for OECMs. Through activities such as ecotourism and sustainable game management, these privately managed landscapes support biodiversity goals while remaining economically viable (Denner et al., 2024). However, despite their potential, key uncertainties remain about the effectiveness of wildlife ranches as reliable, long-term conservation areas (Cousins et al., 2010; Otieno and Muchapondwa, 2015; Taylor et al., 2020). Wildlife ranches are subject to changing market demands, policy shifts, and environmental pressures that may affect their ability to support biodiversity objectives consistently. This variability raises important questions about their role in sustaining biodiversity, especially over the long term (Taylor et al., 2016).

In South Africa, wildlife ranches account for a significant portion of land cover, covering an estimated 17-20% of the country, and have the potential to contribute to conservation through private protection or as biodiversity-compatible economic land uses, such as potential OECMs (African Leadership University School of Wildlife Conservation, 2020; Bothma, 2002; Sungira and Ngwenya, 2016; Taylor et al., 2020). Despite their recognised significance, the overall contribution of wildlife ranches to conservation is still not fully understood and remains contested. On one hand, they are viewed as beneficial to biodiversity by providing alternative habitats for wildlife and alleviating pressure on traditional agricultural lands. On the other hand, criticisms have been raised about practices such as fencing, which can fragment ecosystems, and the prioritisation of economically profitable species at the expense of broader biodiversity goals (Cousins et al., 2010; Taylor et al., 2016).

Two main challenges arise in assessing wildlife ranches. Firstly, they are often perceived as homogeneous, which overlooks the variety of business models employed within wildlife ranching (Denner et al., 2024). Secondly, wildlife ranches are commonly viewed as static, whereas they are dynamic systems that continuously adapt to changing economic and environmental pressures. As part of South Africa's commitment to the 30x30 target, wildlife ranches contribute by integrating biodiversity-compatible practices within private landscapes, supporting conservation and economic activities. However, their long-term viability remains uncertain due to fluctuating market demands, policy changes, and environmental pressures (Clements et al., 2022; Denner et al., 2024). These varied land uses reflect the need for wildlife ranches to adapt their management practices to align with economic objectives, making changes in land use an important feature of the wildlife ranching landscape.

Wildlife ranches operate through various business models that balance conservation with economic goals, including ecotourism, trophy hunting, game meat production, and mixed agriculture-wildlife systems. Each business model incorporates unique land management strategies: for instance, ecotourism relies on preserving natural landscapes to attract visitors, while game meat production focuses on sustainable rangeland management. This business model diversity supports income generation and shapes land use practices in ways that may support or challenge long-term conservation objectives (Clements et al., 2016; Denner et al., 2024). Wildlife ranches, therefore, represent a complex and essential component of South Africa's broader conservation landscape, where adaptive management and diversified business model approaches may help sustain biodiversity in the face of ongoing challenges.

1.2 Land use dynamics

Understanding the impact of wildlife ranches on biodiversity conservation requires a nuanced examination of land use and land cover change. Many wildlife ranches have emerged from historically degraded agricultural lands, where ecological restoration plays a crucial role in facilitating biodiversity recovery (Fedorowick, 1993; Jones and Davidson, 2016). These changes directly influence habitat availability, ecological connectivity, and ecosystem health, which are critical factors for sustaining biodiversity (Serneels, Said and Lambin, 2001; Foley *et al.*, 2005; Lambin and Meyfroidt, 2010). Land use and land cover shifts determine whether wildlife ranches can sustain biodiversity in the long term, particularly in the face of pressures such as agricultural expansion, infrastructure development, and overutilisation of resources (Ellis et al., 2013; Newbold et al., 2015; Tilman et al., 2001).

Evaluating these dynamics helps identify the extent to which wildlife ranches contribute to conservation goals or aggravate ecological degradation. Land use encompasses a range of activities designed to produce goods and services from the land, and it is influenced by both ecological factors and socio-economic market pressures (Lambin and Meyfroidt, 2010; Pérez-Soba et al., 2008). The emergence and growth of wildlife ranches in South Africa have been greatly facilitated by policies that permit the use and ownership of wildlife on private lands (Bond et al., 2004; Cousins et al., 2010; Snijders, 2012; Taylor et al., 2020, 2016). These policies have led to diverse land uses within wildlife ranches, supporting diverse land uses tailored to different business models, with each business model emphasising specific types of land management to generate income (Clements et al., 2022; Parker et al., 2020). For example, ecotourism-focused wildlife ranches often prioritise natural landscapes to enhance visitor experiences, while mixed wildlife-agriculture models incorporate both wildlife and crop cultivation or livestock production within the same landscape (Clements et al., 2022, 2016; Denner et al., 2024).

In wildlife ranching, land use change typically involves transforming land from conventional agricultural or other uses to wildlife-based land uses. This change often includes modifications to cultivated land, conversion of old fields, and other adaptations to accommodate wildlife. Such changes have both ecological and social consequences, affecting not only the functioning of landscapes but also their resilience, biodiversity, and ability to deliver essential goods and services, including species habitat, water regulation, and soil fertility (Cumming et al., 2015; Foley et al., 2005; Tscharntke et al., 2012). Biodiversity responses to these changes can be delayed, with the impacts of past land use changes remaining in ecosystems (Schirpke et al., 2023).

Understanding land use history and change is important for several reasons, such as providing insight into the ecological and social transformations that have shaped the current landscape.

Historical land use patterns influence present-day ecosystem structure and function, and past practices can have long-lasting impacts on biodiversity (Fukasawa and Akasaka, 2019). By examining land use history, researchers can identify legacy effects that may affect current conservation efforts (Foster et al., 2003; Stritih et al., 2024, 2021). This knowledge helps develop strategies that address current land use practices and the remaining effects of past land use activities. Researchers can evaluate how various practices impact biodiversity and ecosystem services by comparing areas with different land use histories.

This comparative approach can highlight best practices and inform policy decisions, ensuring that conservation efforts are based on evidence of what works. In the case of wildlife ranches, understanding how different business models influence land use can guide the development of policies that promote economic viability and conservation goals. Historical knowledge can provide context for current land use conflicts and inform efforts to find common ground among diverse stakeholders (Foster et al., 2003). Many different factors can shape land use change. As mentioned, ranches encompass diverse business models that shape land use differently. These land use patterns are also influenced by climate change, land degradation, natural disasters, economic development, and cultural shifts, all of which can prompt shifts in land management (Zhu, 2013). Despite their importance, the specific motivations and drivers behind land use change within wildlife ranches remain underexplored, presenting challenges for developing effective conservation strategies linked to wildlife ranches.

1.3 Motivations for study

Wildlife ranches play a central role in South Africa's conservation landscape, yet critical research gaps limit our understanding of their long-term impact. A significant gap lies in the lack of detailed knowledge about historical land use patterns on these ranches and how shifts from conventional agriculture to wildlife-based land use affect current conservation efforts. Although many wildlife ranches have transitioned from traditional agricultural uses, systematic research on these changes over time remains limited. Additionally, while diverse land use practices are associated with different business models, there has been no comprehensive assessment categorising and analysing these changes across business models. Understanding how business models influence land use changes and conservation outcomes is essential for evaluating the sector's overall conservation potential.

Land management decisions among wildlife ranchers are shaped by a combination of economic, social, and environmental factors, yet the weight of these drivers across business models remains unexplored. Further investigation into these motivations is critical to identifying broader land use change trends and developing strategies that balance economic viability with ecological goals. The size and age of wildlife ranches are likely to influence land use and conservation outcomes. Larger or older properties may have more resources to allocate toward conservation or may have experienced more substantial land use changes over time. However, how these characteristics vary across different business models and their impact on conservation efforts remains underexplored. In this study, I aim to address this gap by examining the relationships between wildlife ranch size, age, and land use patterns, particularly regarding loss of natural land cover (NLC) and the role of fallowed old fields in ecological restoration. Wildlife ranching, in many instances, represents a transition from traditional agricultural land uses that contributed to degradation, requiring ecological restoration to reestablish biodiversity and ecosystem functionality (Clements et al., 2022; Fedorowick, 1993).

By assessing the extent of non-NLC and its associated challenges, such as the proliferation of fallowed old fields that can introduce alien invasive species (AIS) and other ecological issues (Gaigher et al., 2016; Skowno et al., 2021; Van Wilgen et al., 2010), this research seeks to evaluate the sector's role in ecological restoration critically. Old fields, while sometimes reverting to natural vegetation, often require active management to prevent degradation, highlighting the complexity of land cover dynamics on wildlife ranches (Cramer et al., 2008; Zivec et al., 2021). This research focuses on land use change dynamics within wildlife ranches in South Africa's Eastern Cape and Limpopo provinces, two important areas for wildlife ranching that exemplify diverse ecological and socio-economic contexts. This research forms part of the Sustainable Wildlife Economies Project (SWEP), which explores land use changes and assesses the conservation contributions of wildlife ranching in these areas.

1.3.1 Research aims and objectives.

This study examines land use change within wildlife ranches in South Africa’s Eastern Cape and Limpopo Provinces, key areas for wildlife-based land management. Analysing land use change is essential to understanding how wildlife ranches, such as SES, adapt to diverse pressures over time. This study aims to analyse the patterns and drivers of land use change within these wildlife ranches, focusing on how different business models impact NLC. To achieve this, I use a mixed-methods approach, drawing on interviews with landowners to capture motivations and remote-sensing techniques to assess changes in land use dynamics. My objectives are:

Objective 1: To understand historical changes in land use patterns within wildlife ranches, including their conversion from conventional agriculture to wildlife-based practices and specific land use patterns (e.g., cultivation, planted pastures, rangelands and old fields) within these properties.

Objective 2: To identify and evaluate the motivations and drivers of land use change and to assess their relative importance in influencing these changes. More specifically, this includes:

- Evaluating landowner motivations for land use changes;
- Identifying key drivers of land cover change, particularly property size, age, and business model, as these factors may significantly influence land use decisions; and
- As discussed in the literature, consider broader contextual drivers, such as policy and political changes.

Objective 3: To understand how patterns and drivers of land use change vary across business models, as each business model may emphasise different conservation and economic goals.

Objective 4: To assess the ability of wildlife ranches to maintain NLC over time and to evaluate how NLC loss varies across different business models. Additionally, this objective examines the role of old fields as indicators of historical cultivation and their potential influence on the ecological function of wildlife ranches.

1.4 Thesis structure

This thesis is organised into seven chapters, moving from a contextual foundation to an analysis of the results and their implications for conservation and land use management. The structure is designed to systematically address the research objectives, providing a clear development from background and methods to findings, synthesis, and recommendations. The first chapter, **Introduction**, sets the context for wildlife ranching within global and South African conservation frameworks. It highlights the research problem, the significance of the study, and the specific research objectives, establishing the foundation for the thesis. The second chapter, **Literature Review**, examines key theoretical and empirical studies on wildlife ranching, SES, and private conservation trends. It identifies knowledge gaps in land use transitions, business models, and their integration with national and global conservation strategies, building the conceptual framework that underpins the study.

The third chapter, **Study Context**, provides the socio-political and ecological background of wildlife ranching in South Africa. It explores key policies and legislation and examines their influence on land use. This chapter also outlines regional differences between Limpopo and the Eastern Cape, providing the context needed to interpret the findings within these distinct landscapes. The fourth chapter, **Methodology**, details the mixed-methods approach used in the study, which combines spatial analysis of land use change with interviews conducted with landowners. This chapter explains the analytical tools employed to assess business models and conservation outcomes, linking the methods directly to the research objectives to demonstrate how they support the overall analysis. The fifth chapter, **Results**, presents the study's findings, focusing on patterns of land use change and the drivers behind these transitions. It highlights differences across business models and assesses their impact on retaining NLC. This chapter also examines variations in regional land use dynamics between Limpopo and the Eastern Cape, providing a nuanced understanding of the challenges and opportunities in each region.

The sixth chapter, **Discussion**, synthesises the study's findings, engaging with SES frameworks to highlight key feedbacks, adaptive capacities, and trade-offs in wildlife ranching. It contextualises the results within global conservation practices. The discussion also includes the limitations of the study. The final chapter, **Conclusion**, summarises the key findings and reflects on how they address the research objectives. It revisits the study's aims, evaluates its contributions to understanding wildlife ranches in South Africa's conservation landscape, and outlines directions for future research.

2. Literature Review

2.1 Purpose of the literature review

Addressing biodiversity loss requires conservation strategies that go beyond traditional PAs and integrate conservation goals with broader socio-economic and ecological systems. Recent global frameworks, such as the Kunming-Montreal GBF, emphasise the need for innovative approaches, including private conservation efforts, to complement PAs. These approaches contribute to biodiversity conservation while addressing social and economic challenges, providing a more comprehensive response to the biodiversity crisis. Wildlife ranching offers a convincing example of how conservation goals can interconnect with sustainable land use. Operating as dynamic SES, wildlife ranches can adapt to various pressures, including economic, policy, and environmental factors, while balancing biodiversity objectives with economic viability. Understanding the role of wildlife ranches in conservation requires a closer examination of land use dynamics, including historical and ongoing changes in management practices. In this literature review, I expand on key themes relevant to this study.

2.2 Global context

Biodiversity conservation has become an urgent global priority due to accelerating species extinction and habitat loss driven primarily by human activities. Despite extensive research and policy interventions, biodiversity continues to decline, highlighting the need for more adaptive and innovative conservation strategies (Cardinale et al., 2012; Mace et al., 2018; Weisser et al., 2017). Protected areas have historically formed the cornerstone of conservation efforts, with frameworks such as the Kunming-Montreal GBF calling for protecting 30% of the Earth's surface by 2030 (CBD, 2022). While PAs play a critical role in preserving key habitats and ecological processes, their limitations have become increasingly evident, particularly in addressing socio-economic inequities and ensuring ecological connectivity (Gurney et al., 2023; Visconti et al., 2019).

Recognising these challenges, recent conservation discussions call for more inclusive approaches involving various management systems and land use methods (Cook, 2024; De Vos and Cumming, 2019; Geldmann et al., 2015; Lichtenstein et al., 2022). Such approaches acknowledge that achieving global conservation goals requires integrating biodiversity objectives into multi-functional landscapes. One key innovation in this regard is the recognition of OECMs under the GBF's Target 3. OECMs are defined as "geographically defined spaces, not recognised as PAs, which are governed and managed over the long term in ways that deliver the effective in-situ conservation of biodiversity, with associated ecosystem services and cultural values" (IUCN-WCPA, 2019). Unlike traditional PAs, OECMs often prioritise other land uses, such as agriculture, forestry, or economic activities, while still supporting biodiversity conservation. By integrating conservation into working landscapes, OECMs promote ecological connectivity, enhance sustainability, and expand the scope of conservation initiatives beyond formal PAs (Borrini-Feyerabend et al., 2013; Juffe-Bignoli et al., 2016). This pluralistic approach highlights the importance of private and community-managed conservation initiatives. While some privately or communally managed lands contribute to biodiversity conservation, not all qualify as OECMs under South Africa's current legal and policy frameworks. In South Africa, OECMs primarily consist of biodiversity stewardship areas, which require formal, long-term commitments to conservation. Although wildlife ranches integrate biodiversity conservation into privately or communally managed landscapes by combining ecological stewardship with economic activities such as tourism, trophy hunting, and game meat production (Cousins et al., 2010, 2008), their recognition as OECMs remains uncertain due to the voluntary nature of their conservation commitments and landowners' reluctance to engage in formal agreements Nonetheless, they play a pivotal role in reducing pressure on PAs, protecting biodiversity on private lands, and providing connectivity between fragmented habitats.

Wildlife ranching has emerged as a viable alternative to traditional land uses in areas with challenging environmental conditions. For example, traditional livestock farming has proven unsustainable in countries like Zambia and Namibia, which are characterised by frequent droughts, poor soils, and disease outbreaks (Taylor et al., 2020). Wildlife ranching offers a more resilient and economically viable land use alternative, supported by policies that encourage wildlife utilisation on private land (Bond et al., 2004). In Namibia, limited agricultural subsidies and the lower costs of wildlife production compared to livestock farming have further incentivised this shift, enabling higher economic returns alongside biodiversity conservation (Lindsey et al., 2013; Naidoo et al., 2016).

Countries such as Argentina and Brazil have also incorporated wildlife ranching, facilitated by legislative frameworks supporting private and community-based conservation efforts (Aguilar and Morgera, 2009; Bragagnolo et al., 2019). Wildlife ranching in Namibia has surpassed traditional cattle farming, covering more than double the land area of its PA network and providing significant economic and ecological benefits (Naidoo et al., 2016). However, the effectiveness of private conservation initiatives is often constrained by legal and regulatory barriers in other regions. In Australia, private landowners are restricted from owning endangered indigenous species, limiting the growth of private wildlife conservation (Wilson et al., 2020). Similarly, in Chile, while neoliberal policies allow private land conservation, the lack of formal government recognition and support hinders their full potential (Holmes, 2015).

In South Africa, wildlife ranching occupies a unique position within the conservation framework, covering a significant portion of the country's land surface and showcasing ecological and economic benefits (Taylor et al., 2016). Assessing the potential of South African wildlife ranches to contribute meaningfully to conservation goals provides an opportunity to evaluate their role in addressing biodiversity loss, particularly in dynamic land use and governance systems.

2.3 The potential of South African ranches in conservation

South Africa's wildlife ranches have emerged as potential key contributors in the country's conservation framework, bridging the gap between PAs and broader landscape-level conservation efforts. As multifunctional systems that integrate biodiversity goals with economic activities, wildlife ranches are uniquely positioned to address biodiversity loss. Their vast coverage of private and community-managed lands highlights their potential as OECMs, particularly in areas where PAs are spatially or financially constrained. Wildlife ranching's ability to adapt to changing socio-economic and environmental pressures underscores its importance as a dynamic conservation model. This section examines the opportunities and challenges presented by South African wildlife ranches, focusing on their potential to contribute to long-term conservation outcomes and the broader Kunming-Montreal GBF targets.

Wildlife ranching has become an increasingly significant conservation approach, but its effects on people, economies, and ecosystems must be carefully considered before being presented as a universal model (Denner et al., 2024). Globally, several wildlife ranching initiatives have demonstrated notable successes. These landscapes now cover more than double the size of Namibia's PA network and have proven to be economically, socially, and ecologically advantageous while also providing local communities with direct economic returns, including employment and non-wage benefits, while enhancing wildlife populations and improving rural livelihoods (Lindsey, 2011; Naidoo et al., 2016; Taylor et al., 2016).

In addition to economic benefits, wildlife ranches can play a critical role in biodiversity conservation. They offer habitats supporting megaherbivores and large predators, often incompatible with livestock farming due to space and resource requirements (Clements and Cumming, 2017; Clements et al., 2023). The southern white rhinoceros is among the most widely cited success stories, with wildlife ranching providing secure environments for population growth, supported by income from ecotourism and regulated trophy hunting (Furstenburg et al., 2022; Lindsey et al., 2007). Wildlife ranches have also been shown to protect and conserve more NLC and biodiversity than unprotected areas, reinforcing their ecological value (Shumba et al., 2020).

Wildlife ranching also generates significant economic benefits. In South Africa, studies show that wildlife ranches create more jobs, offer higher wages, and generate greater profits per unit area than traditional livestock farming. They also contribute to food security through game meat production (Child et al., 2012; Taylor et al., 2020). Trophy hunting, ecotourism, and biltong hunting are substantial revenue sources for landowners, with wildlife-based tourism in Africa supporting 3.6 million jobs and contributing US$29 billion annually to local economies (Saayman et al., 2018; Van Der Merwe et al., 2014; World Travel & Tourism Council, 2019). Wildlife ranching offers a compelling alternative to more extractive land use practices by providing economic incentives and ecological benefits.

Another critical advantage of wildlife ranches is their role in improving habitat connectivity. By acting as ecological corridors, ranches facilitate wildlife movement between fragmented PAs, maintaining genetic diversity and enabling species reintroductions in previously degraded areas (Lindsey et al., 2007). These contributions align with global conservation goals, such as the Kunming-Montreal GBF, emphasising the importance of connected and resilient landscapes (CBD, 2022). However, concerns remain regarding wildlife ranching's social, ecological, and ethical implications. Critics have raised issues about deagrarianisation and the motives behind land use changes, questioning the social impacts of wildlife ranching on local communities (Brandt and Spierenburg, 2014). Ethical dilemmas also arise around certain commercial practices, such as captive breeding and hunting, which may prioritise profit over conservation goals. For example, breeding exotic or non-native species poses ecological risks, including the disruption of local ecosystems and genetic pollution of native species (Lindsey et al., 2013). Furthermore, if poorly regulated, the commercialisation of wildlife ranching may lead to overexploitation, illegal poaching, or unsustainable practices driven by market demands for animal products such as ivory or rhino horn (Hiller and 't Sas-Rolfes, 2024; Mozer and Prost, 2023).

The long-term sustainability of wildlife ranching as a conservation-compatible land use depends on addressing these challenges through effective governance, equitable benefit-sharing, and adaptive management practices. Ensuring sustainability is crucial not only for maintaining biodiversity and ecosystem services but also for securing the economic viability of wildlife enterprises and their long-term contributions to conservation goals.. Aligning wildlife ranching activities with conservation objectives and ensuring adequate regulation of commercial activities are critical steps toward mitigating potential risks. Despite these challenges, wildlife ranching remains a promising strategy for biodiversity conservation when managed sustainably and inclusively. By complementing PAs, enhancing habitat connectivity, and supporting rural economies, wildlife ranches have the potential to significantly contribute to conservation in regions where traditional models alone are insufficient

(Cousins et al., 2008). Ultimately, their success will depend on their ability to balance ecological goals with socio-economic benefits for landowners and local communities (Child et al., 2012; Taylor et al., 2016).

2.3.1 Wildlife ranches in the South African context

I am focusing on wildlife ranches in South Africa because they play a pivotal role in the country's conservation framework and offer a unique model for integrating biodiversity conservation with economic development. With over 15 000 private wildlife ranches spanning approximately 17–20% of South Africa's land surface, these properties significantly contribute to biodiversity goals in a landscape where PAs alone are not enough to address the scale of habitat loss and degradation (Child et al., 2012; Taylor et al., 2016). Their widespread implementation and success make them a compelling case study for understanding how private conservation initiatives can complement traditional conservation strategies. South Africa offers a distinctive combination of legislative support, ecological richness, and market-driven conservation. This creates an opportunity to explore how wildlife ranches adapt to environmental and socio-economic pressures while maintaining NLC and contributing to biodiversity conservation. By examining their role in addressing biodiversity loss and promoting sustainable land use, this study aims to generate insights that can inform similar initiatives in other regions facing conservation challenges.

2.4 Wildlife ranches as social-ecological systems

To better understand the sustainability and growth of wildlife ranches, it is essential to recognise them as complex SES. These systems are characterised by dynamic interactions between ecological processes, such as biodiversity conservation and habitat management, and social dimensions, including economic activities, governance structures, and cultural values (Biggs et al., 2021). Viewing wildlife ranches through the lens of SES highlights their adaptability to changing environmental, economic, and policy conditions, which is crucial for their long-term viability. For instance, economic drivers like ecotourism and game meat production are closely linked to ecological health, as wildlife populations and habitat quality underpin financial returns (Clements et al., 2016). Similarly, governance and legislative frameworks, such as South Africa's Game Theft Act, shape landowner incentives to invest in conservation-compatible practices (Cousins et al., 2010). Recognising wildlife ranches as SES also promotes resilience, as these systems can adapt to disturbances like drought, market fluctuations, and policy changes while maintaining ecological integrity and socio-economic benefits (Lindsey et al., 2013). This perspective provides a holistic framework for analysing how wildlife ranches balance ecological sustainability with economic viability, offering insights into their potential to contribute to long-term conservation goals.

Social-ecological systems are interconnected and dynamic systems in which ecological processes and human activities are deeply intertwined, influencing and shaping one another over time (Biggs et al., 2021). This framework provides a holistic approach to understanding the sustainability of wildlife ranches by recognising them as multifunctional landscapes where ecological and social components interact. Wildlife ranches make a perfect example of SES because they integrate biodiversity conservation with economic activities, such as trophy hunting, ecotourism, and game meat production while being influenced by governance structures, market forces, and local cultural values (Clements et al., 2022, 2016). The SES perspective is particularly appropriate for wildlife ranches as it accounts for their adaptability to external pressures, such as environmental changes, policy shifts, or economic fluctuations, and their potential to maintain resilience through these changes (Reyers et al., 2018). By considering wildlife ranches as SES, this framework facilitates a deeper understanding of how these systems balance ecological goals with socio-economic benefits, providing insights into their role in contributing to conservation and sustainable development.

Wildlife ranches represent a dynamic interplay between ecological and social components, where biodiversity conservation and habitat management are tightly linked to economic incentives and community involvement. Ecologically, maintaining NLC and diverse wildlife populations is essential for the functionality of wildlife ranches, as these factors support the success of revenue-generating activities (Shumba et al., 2020). Socially, economic incentives drive landowners to invest in conservation-compatible practices, with financial returns directly tied to the ecological health of the wildlife ranches (Child et al., 2012). Community involvement further enhances these interactions by fostering local stewardship and generating employment opportunities, which in turn incentivise sustainable land use and resource management (Naidoo et al., 2016). These interactions create a feedback loop: ecological success bolsters economic viability, while economic gains provide the resources needed for continued habitat restoration and species conservation. However, the complexity of these interactions also highlights the need for effective governance and unbiassed benefit-sharing to ensure that both ecological and social goals are met sustainably (Clements et al., 2016; Lindsey et al., 2013).

Wildlife ranches in South Africa have evolved from traditional agricultural systems, driven by market dynamics and ecological challenges. Historically, conventional farming faced significant limitations due to poor soils, water scarcity, and vulnerability to drought in many parts of the country (Bond et al., 2004). These environmental pressures and declining profitability in traditional livestock farming prompted landowners to explore alternative land uses that could align better with the region's natural ecological conditions. Legislative reforms, such as the Game Theft Act of 1991, further enabled this transition by granting landowners ownership rights over wildlife, transforming wildlife into a viable economic asset (Cousins et al., 2010). This shift was also supported by growing international and regional demand for wildlife-based activities, such as ecotourism, trophy hunting, and game meat production, which offered higher returns than livestock farming (Clements et al., 2016; Taylor et al., 2016).

Wildlife ranches have demonstrated remarkable adaptability and resilience to external drivers, including market fluctuations, policy changes, and climate variability. These systems are inherently flexible, allowing landowners to modify management practices in response to economic pressures, such as shifts in tourism demand or hunting regulations (Lindsey et al., 2013). For example, during economic recessions, many wildlife ranches diversify their income streams by combining multiple activities, such as ecotourism with game meat production, to buffer against financial losses (Clements and Cumming, 2017; Clements et al., 2016). Climate variability, including prolonged droughts, has also necessitated adaptive measures such as rotational grazing, rewilding degraded areas, and investing in water conservation infrastructure to ensure ecosystem resilience (Shumba et al., 2020). Wildlife ranches maintain their viability and contribute to long-term sustainability in a rapidly changing world by continually adjusting their strategies to align with environmental and economic conditions.

The interplay between economic activities and ecological outcomes creates a complex feedback loop within wildlife ranches. Ecological health directly influences the profitability of ranches, as biodiversity, wildlife abundance, and habitat quality underpin revenue-generating activities such as tourism, hunting, and game meat production (Taylor et al., 2020). Conversely, economic success enables further investment in ecological management, such as habitat restoration, anti-poaching efforts, and the reintroduction of species, thereby enhancing biodiversity outcomes (Naidoo et al., 2016). However, this feedback can also become negative if economic activities, such as overhunting or prioritising profitable species, compromise broader biodiversity goals (Lindsey et al., 2013). Balancing this feedback requires careful management to ensure that short-term economic gains do not undermine long-term ecological sustainability. Effective governance, robust monitoring frameworks, and equitable benefit-sharing mechanisms are essential to maintaining this balance and ensuring that wildlife ranches contribute positively to both conservation and rural development.

In viewing wildlife ranches as SES, it becomes evident that their contribution to conservation is shaped by two critical factors: the management and utilisation of land over time and the economic strategies driving these decisions. Land use and management practices directly influence the ecological outcomes of wildlife ranches, such as maintaining biodiversity, preserving natural habitats, and supporting the recovery of threatened species. By integrating ecological and economic dimensions, the SES framework offers valuable insights into how wildlife ranches navigate competing priorities, adapt to environmental and market pressures, and align conservation objectives with sustainable development goals. This perspective highlights the potential of wildlife ranches to contribute meaningfully to biodiversity conservation.

2.5 Business models

Business models are central to the functioning of wildlife ranches, serving as the mechanisms through which revenue is generated, and land use practices are sustained over the long term. They shape not only the economic viability of wildlife ranches but also their ecological impact, determining how land is utilised, which species are prioritised, and how conservation objectives are balanced with economic interests (Cousins et al., 2010; Lindsey et al., 2013). A variety of business models reflect the diversity of approaches taken by landowners to optimise both financial returns and biodiversity outcomes (Clements et al., 2016). In this review, I examine how economic drivers influence land use decisions and assess the extent to which these decisions align with broader conservation goals. Wildlife ranches in South Africa employ diverse business models, each reflecting unique financial motivations and conservation impacts. These models include ecotourism, trophy hunting, game meat production, mixed wildlife-agriculture practices, and wildlife breeding. Each of these models contributes differently to economic sustainability and biodiversity conservation.

Ecotourism is one of the most prominent business models, providing a stable income while promoting conservation through education and sustainable practices (Clements et al., 2016; Denner et al., 2024). However, ecotourism is not a uniform business model, as wildlife ranches adopt different approaches depending on their target market. Some focus on high-income foreign tourists, offering exclusive experiences that generate substantial revenue but cater to a limited number of visitors (Snyman, 2017). Others prioritise local tourism, which typically attracts larger visitor numbers at lower rates, contributing differently to employment structures, revenue models, and conservation funding (Gumede and Nzama, 2019; Snyman, 2017). These differences influence the financial sustainability of ecotourism ventures and their capacity to reinvest in conservation activities. Ecotourism-focused ranches generate revenue and raise public awareness about biodiversity conservation, contributing to a broader societal understanding of ecological issues (Gumede and Nzama, 2020; Scheyvens, 1999; Snyman and du Preez, 2005). Additionally, these ranches create significant employment opportunities, offering higher job quality and contributing to local economic development (Spenceley, 2008; Van Der Merwe et al., 2014). Ecotourism often fosters community engagement and enhances support for conservation initiatives, thereby increasing the social sustainability of wildlife ranching; however, its reliance on external factors such as tourism demand and economic stability can make it vulnerable to market fluctuations (Samal and Dash, 2023).

Trophy hunting is another significant business model, often generating substantial revenue that is reinvested in habitat management and anti-poaching measures (Lindsey et al., 2007). This model supports conservation by providing financial resources necessary for wildlife management and habitat protection. Trophy hunting-focused ranches typically achieve high operating profit margins, though they rely heavily on foreign clients and are susceptible to seasonal and political fluctuations (Denner et al., 2024). Studies have demonstrated that trophy hunting, when managed sustainably, can contribute positively to species conservation and habitat preservation (Lindsey, 2011; Lindsey et al., 2007). For example, well-regulated trophy hunting operations have facilitated the recovery of species such as black rhinos in Namibia and lions in South Africa (Clements et al., 2023). Despite these benefits, ethical concerns and the potential for mismanagement pose significant challenges to this model. Studies have highlighted issues such as the commodification of wildlife, intensive breeding of high-value species, and selective manipulation of genetics, which can undermine ecological integrity and conservation objectives (Blackmore, 2017; Cousins et al., 2010; Russo et al., 2019). Additionally, poor governance and lack of standardised regulations can lead to unethical practices, including inadequate animal welfare considerations and unsustainable hunting practices (Lindsey et al., 2007; Taylor et al., 2021).

Game meat production offers an alternative revenue stream that supports local economies and provides a sustainable source of protein (Hoffman and Wiklund, 2006). This model is particularly valuable in regions where traditional agriculture is less viable due to environmental constraints. Wildlife ranches integrating meat production with conservation objectives can diversify income sources while contributing to food security and biodiversity goals (Denner et al., 2024). Game meat production complements other wildlife-based activities, enhancing economic resilience while promoting sustainable land use (Taylor et al., 2016). However, the financial viability of this model depends on effective management, market access, and adherence to food safety standards.

Mixed wildlife-agriculture practices combine traditional farming with wildlife conservation, creating a diversified income stream and promoting integrated land use strategies (Child et al., 2012). This model allows landowners to balance agricultural production with biodiversity conservation, potentially improving land health and ecosystem services. For example, integrated systems that combine cattle grazing with wildlife management have demonstrated benefits such as reduced overgrazing and enhanced soil fertility (Bennett et al., 2021). However, a key limitation of this model is the risk of disease transmission, particularly foot-and-mouth disease. In South Africa and Namibia, the presence of this significantly restricts opportunities for keeping certain wildlife species, as well as limits production opportunities such as live sales and the transport of raw meat. Although mixed models are often less profitable than specialised ones, their diversified revenue streams make them more resilient to economic shocks (Denner et al., 2024). This resilience can support long-term sustainability, particularly in regions prone to environmental variability.

Wildlife breeding focuses on the captive breeding and sale of game animals, contributing significantly to the wildlife economy (Fraser, 2008; Snyman and Bothma, 2023). This model often requires substantial investment in infrastructure and management but can yield high returns during favourable market conditions (Denner et al., 2024). Breeding programmes also play a crucial role in conserving endangered species, providing genetic reservoirs and supporting species reintroduction efforts (Fraser, 2008). However, this model has faced criticism for prioritising commercial over ecological goals, especially when breeding practices favour high-value species at the expense of broader biodiversity objectives (Burns et al., 2022). A major concern within this model is the impact of selective and intensive breeding on the genetic integrity of species. This is particularly evident where subspecies are hybridised or where breeding is driven by phenotypic traits such as horn length rather than broader conservation priorities. The colour variant breeding bubble is a well-documented example where intensive breeding compromised biodiversity objectives (van Wyk et al., 2017). Similar risks have been noted in cases of bontebok and blesbok hybridisation (van Wyk et al., 2024), highlighting the potential long-term ecological consequences of prioritising commercial traits over genetic diversity.

2.5.1 Economic drivers

The financial independence of wildlife ranches is vital for their sustainability, particularly given the absence of government funding for private conservation efforts (Cousins et al., 2010; Pienaar et al., 2017). Revenue generation from diverse business models enables ranches to support conservation activities, manage land effectively, and promote sustainable wildlife management (’t Sas-Rolfes et al., 2022). Economic imperatives also drive innovation in land use practices, with landowners constantly adapting to optimise income from their chosen models (Lindsey et al., 2013). For example, ranches initially established for livestock production often transition to wildlife-based land uses, leading to significant changes in land cover and ecosystem services.

While the diversity of business models enhances economic resilience, it also introduces complexities and vulnerabilities. The need to balance conservation and profit can sometimes lead to prioritising short-term financial gains over long-term ecological sustainability (Clements et al., 2016; Parker et al., 2020). For instance, the selective breeding of high-value species for trophy hunting or game sales may compromise ecosystem balance and biodiversity (Lindsey et al., 2007). Similarly, introducing non-native species for commercial purposes can disrupt local ecosystems and lead to unforeseen ecological consequences (Cousins et al., 2008).

2.5.2 Impacts of land use

The impact of business models on land use is profound, influencing how landscapes are managed, restored, and utilised over time. Wildlife ranches often reconfigure land previously used for livestock or crops into habitats supporting wildlife, enhancing biodiversity and ecosystem services (Child et al., 2012). For example, ecotourism ranches may prioritise large, open landscapes to attract tourists, while game breeding facilities might focus on enclosed areas tailored to specific species' needs. This dynamic approach to land use creates a mosaic of habitats within individual ranches, reflecting the diverse objectives of their business models (Clements et al., 2016).

However, these changes in land use also present challenges. Conflicts can arise over resource allocation, such as water and grazing land, particularly in ranches integrating agriculture with wildlife conservation (Clements et al., 2016). Additionally, the coexistence of multiple land uses can lead to fragmented landscapes, affecting wildlife movement and genetic exchange, both of which are critical for maintaining healthy populations (De Vos and Cumming, 2019). Business models ultimately form the strategic foundation for how land is managed on wildlife ranches. The economic activities pursued directly shape habitat management, species priorities, and conservation initiatives. Understanding the land use dynamics arising from these business models is critical for evaluating the adaptive capacity and conservation potential of wildlife ranches.

2.6 Land use dynamics and drivers of change

Land use and land cover are fundamental components of the landscape, significantly influencing the ecological and economic outcomes of wildlife ranches. Land use encompasses human activities that shape and manage land, such as agriculture, conservation, or wildlife utilisation. In contrast, land cover refers to the physical surface characteristics of the land, including grasslands, forests, and cultivated fields (Lambin and Meyfroidt, 2010; Wang et al., 2023). In wildlife ranches, these elements are intricately linked; decisions on land use directly influence land cover, thereby affecting habitat quality and biodiversity potential. Land use dynamics within wildlife ranches reflect continuous adaptations of physical landscapes to various pressures and opportunities. Shifts from traditional agricultural practices to wildlife-based land uses exemplify these dynamics, driven by a complex interplay of ecological conditions, market demands, legislative changes, and economic incentives (Clements et al., 2022). These transformations are central to understanding how wildlife ranches, as social-ecological systems, respond to both local and global conservation challenges.

Understanding these dynamics is essential for assessing the viability of different business models and their contributions to conservation goals. The interplay of economic, policy, and environmental factors not only shapes land management practices but also determines the sustainability of ranch operations and their ability to maintain ecological integrity (Timko and Innes, 2009). By evaluating how land use is managed, converted, or restored over time, we can gain critical insights into the adaptive capacity of wildlife ranches to balance economic development with biodiversity conservation (Cumming et al., 2015).

2.6.1 Historical evolution of land use on wildlife ranches

The history of wildlife ranching in South Africa is deeply intertwined with the country's evolving legal, economic, and social landscapes. The practice gained significant momentum in the latter half of the 20th century, driven by pivotal legislative changes that shifted wildlife management from public to private hands. These developments transformed traditional agricultural landscapes into spaces dedicated to conservation and wildlife utilisation, establishing a foundation for the thriving wildlife ranching industry observed today. Historically, land use in South Africa was dominated by agricultural practices, with livestock farming taking precedence across vast tracts of land. This began to change with legislative reforms in the early 1990s, particularly the introduction of the Game Theft Act of 1991, which granted private landowners the legal right to own and manage wildlife on their properties. This marked a significant departure from earlier policies, where wildlife was considered state property and landowners had limited control over its management (NAMC, 2006). By recognising wildlife as private property, the Act incentivised landowners to convert agricultural fields into wildlife habitats, enabling them to generate revenue through activities such as ecotourism, trophy hunting, and game breeding (Taylor et al., 2016).

The economic viability of wildlife ranching compared to traditional agriculture, especially in regions with marginal agricultural potential, catalysed this shift. Wildlife ranching was perceived as a more sustainable and profitable alternative, capable of generating higher revenues while promoting biodiversity conservation. For instance, by 1980, 399 farms covering 610 000 ha had transitioned to wildlife ranching (Du Toit, 2007). By 1987, this number had grown to 1 760 farms encompassing 6.2 million ha, reflecting a rapid uptake of wildlife-based land uses (Taylor et al., 2016). The trend continued into the 21st century, with the National Agricultural Marketing Council (NAMC) reporting over 9 000 wildlife ranches covering 20.5 million ha by 2006 (NAMC, 2006). Most recently, estimates suggest there are well over 10 000 wildlife ranches in South Africa, covering approximately 17%-20% of the country’s land area (Taylor et al., 2020). These figures highlight the transformative impact of wildlife ranching on South Africa’s land use landscape, driven by a combination of economic incentives and legislative support.

The concept of rewilding old fields (previously cultivated or degraded agricultural lands left fallow) is central to the historical evolution of wildlife ranching. As landowners transitioned from traditional farming to wildlife-based enterprises, these old fields became opportunities for ecological restoration and biodiversity enhancement (Cramer et al., 2008). Through passive or active management, old fields were rewilded to support native vegetation and wildlife, contributing to habitat expansion and ecosystem recovery. Rewilding old fields often involved the re-establishment of native plant species and the creation of habitats for wildlife, including threatened and endangered species. Research by Cumming et al. (2015) highlights the ecological potential of old fields, noting their ability to increase landscape heterogeneity and support biodiversity. In South Africa, these rewilded landscapes have played a critical role in the conservation efforts of wildlife ranches, allowing them to contribute meaningfully to the country's biodiversity goals. This transformation not only enhances the ecological value of wildlife ranches but also improves their economic potential by attracting ecotourists and supporting sustainable hunting practices (Lindsey et al., 2013).

The restoration of old fields aligns closely with the broader goals of NLC conservation. By increasing NLC through rewilding, wildlife ranches contribute to carbon sequestration, soil fertility improvement, and water regulation, addressing some of the pressing environmental challenges associated with agricultural land degradation (Hobbs and Harris, 2001). This dual focus on ecological restoration and economic viability highlights the adaptive capacity of wildlife ranches as SES. The historical evolution of land use on wildlife ranches underscores the adaptive capacity of these landscapes in response to changing socio-economic and environmental conditions. By transitioning from agriculture to wildlife utilisation, South African landowners have created a model that integrates conservation with economic sustainability, offering valuable lessons for biodiversity preservation in working landscapes. This transformation sets the stage for exploring the drivers of land use change and their implications for the future of wildlife ranching in South Africa.

2.6.2 Drivers of land use change

The dynamics of land use change on wildlife ranches are shaped by a complex interplay of economic, environmental, social, and political factors. Understanding these drivers provides critical insight into how and why landowners transition from traditional agriculture to wildlife ranching, as well as the broader implications for biodiversity conservation and sustainable land management.

2.6.2.1 Economic motivations

Economic incentives are among the most significant drivers of land use change on wildlife ranches. Different business models, such as trophy hunting, ecotourism, and game meat production, provide diverse financial opportunities that encourage landowners to transition away from traditional agriculture. Trophy hunting, for example, offers high financial returns, with hunters willing to pay premium prices for unique and exotic species (Lindsey et al., 2007). These profits are often reinvested into land management practices, such as habitat restoration or anti-poaching initiatives, which further incentivise the adoption of wildlife ranching.

Ecotourism has similarly emerged as a lucrative alternative, attracting both domestic and international visitors to experience wildlife in natural settings. The steady income generated through ecotourism supports the diversification of land use while promoting conservation awareness (Kiper, 2013). In regions where traditional agriculture is constrained by marginal soils or unpredictable rainfall, integrating ecotourism into land management allows landowners to generate stable revenues while reducing reliance on conventional farming practices (Kiper, 2013). Game meat production provides another economic driver, offering sustainable protein sources while meeting local and international demand (Hoffman and Wiklund, 2006). These economic opportunities collectively create a strong financial case for transitioning to wildlife ranching. The financial pressures of maintaining viable operations can lead to dynamic land use patterns, where land is continually re-evaluated and repurposed to align with market demands and conservation goals. This adaptability allows wildlife ranches to respond to economic fluctuations but also requires robust management frameworks to ensure that conservation objectives are met (Pienaar et al., 2017). The shift from agriculture to wildlife-based land uses and conservation has not been systematically researched, representing a challenge fundamental to understanding the socio-economic and environmental issues arising from such changes.

2.6.2.2 Environmental drivers

Environmental factors, including climate change, soil degradation, and water scarcity, have significantly influenced the growth of wildlife ranching as a land use. In regions like South Africa, where semi-arid and arid conditions dominate, traditional livestock farming faces increasing challenges. Prolonged droughts, declining soil fertility, and the depletion of water resources make wildlife ranching a more viable and sustainable alternative (Bond et al., 2004). Wildlife species are better adapted to harsh environmental conditions, requiring fewer inputs such as supplemental feeding and intensive veterinary care, which are often necessary for livestock under similar circumstances.

Research has demonstrated that environmental variables play a critical role in driving land use changes (Zhu, 2013). More recent studies continue to support this trend, highlighting how factors such as climate variability, soil degradation, and policy changes influence land use decisions (Adjei et al., 2023; Buckley Biggs, 2022; Dias et al., 2023; Gupta et al., 2024). Climate variability has exacerbated vulnerabilities in traditional agriculture, prompting landowners to adopt land uses that are more resilient to environmental stressors. Wildlife ranches not only support species that are better suited to semi-arid environments but also maintain natural vegetation that enhances ecosystem services, such as carbon sequestration and water regulation (Hobbs and Harris, 2001). For example, degraded lands previously used for agriculture can undergo ecological restoration through wildlife-based land use, contributing to long-term sustainability.

2.6.2.3 Social and political factors

Shifts in societal values and government policies have further accelerated land use changes towards wildlife ranching. In recent decades, growing public awareness of biodiversity loss and the importance of sustainable land management has influenced landowners to adopt conservation-oriented practices. For example, community-led initiatives in Namibia have demonstrated the socio-economic benefits of integrating conservation with land use, setting a precedent for similar efforts in South Africa (Naidoo et al., 2016).

Policy reforms, such as the introduction of the Game Theft Act of 1991, have been pivotal in enabling private landowners to manage and profit from wildlife on their properties. This legal framework incentivised the establishment of wildlife ranches by granting landowners greater autonomy over land use decisions and access to wildlife-related revenue streams (Cousins et al., 2010). Additionally, international agreements like the Kunming-Montreal GBF have encouraged governments to incorporate OECMs, including wildlife ranches, into national conservation strategies. OECMs encompass areas outside formal protected zones that effectively conserve biodiversity through sustained management practices (Marnewick et al., 2021). In South Africa, this includes various land types such as conservancies, community-managed areas, and certain privately-owned lands that contribute to conservation objectives. (ref). Cultural shifts and market dynamics also influence land use change. For instance, the rise of eco-conscious tourism and ethical consumerism has created demand for wildlife products and experiences that align with sustainable and ethical values (Sharpley, 2006). These societal trends reinforce the economic and environmental drivers shaping land use, further supporting the growth of wildlife ranching as a viable alternative to conventional agriculture.

2.6.3 Natural land cover

Natural land cover encompasses ecosystems such as natural forests, grasslands, wetlands, and savannas, which are integral to biodiversity conservation and ecosystem health. These ecosystems provide essential services like carbon sequestration, water filtration, soil stabilisation, and habitat provision for numerous species (Pettorelli et al., 2018). Natural land cover serves as a critical indicator of ecological integrity, directly influencing the resilience of ecosystems to external pressures like climate change and human activities (Wang et al., 2023). However, the global loss of NLC due to agricultural expansion, urbanisation, and industrial development remains a pressing issue. For instance, over 75% of Earth's terrestrial ecosystems have been significantly altered by human-driven land use changes (Newbold et al., 2015). In South Africa, NLC loss is particularly severe, with the grassland biome experiencing nearly 60% transformation due to agricultural activities (Egoh et al., 2011). Such alterations not only reduce habitat availability for species but also fragment landscapes, isolating populations and diminishing genetic diversity. This ongoing biodiversity crisis underscores the importance of protecting and restoring NLC as a cornerstone of conservation strategies.

Wildlife ranches are uniquely positioned to contribute to NLC restoration by adopting innovative land management practices that prioritise biodiversity conservation alongside economic activities. Their flexibility as private conservation areas enables them to rehabilitate degraded lands, creating critical habitats for species while generating financial benefits through ecotourism or game breeding. Understanding NLC within the context of wildlife ranches is important because it directly influences biodiversity, ecosystem resilience, and landscape connectivity. Restoration of NLC contributes to broader conservation networks by facilitating species migration and adaptation, particularly in the face of climate change. This focus on NLC is pivotal for assessing the ecological and economic sustainability of wildlife ranches, as it highlights their potential to harmonise conservation objectives with land use strategies that support long-term environmental and socio-economic benefits.

2.6.3.1 Impact on biodiversity

Restoration of NLC within wildlife ranches offers significant opportunities to counteract biodiversity loss. Wildlife ranches, through practices like rewilding and habitat conservation, create and maintain spaces for native species to thrive. Species that benefit from restored habitats include large predators like cheetahs and herbivores such as kudu, which require expansive natural areas to sustain their populations (Lindsey et al., 2007). Moreover, restoration efforts enhance ecological connectivity, allowing species to move freely between fragmented landscapes, which is critical for maintaining viable populations and genetic diversity. Examples from wildlife ranches globally highlight their role in biodiversity conservation. In Zimbabwe, wildlife ranches have supported the reintroduction of black rhinoceroses, which were previously extirpated due to poaching (Davie and Henry, 2022). Similarly, in South Africa, rewilding efforts on old fields have created habitats for endemic bird species and pollinators, promoting ecosystem functionality (Navarro and Pereira, 2012).

2.6.3.2 Changes in Old Fields

Old fields, areas of previously cultivated or heavily used agricultural lands left fallow, represent unique opportunities for ecological restoration. These areas, when managed effectively, can undergo natural succession, returning to states that closely resemble their original NLC. Research has shown that old fields contribute to increased biodiversity by providing habitats for a wide range of species, including those displaced by agricultural activities (Cumming et al., 2015). Studies in South Africa have demonstrated that old fields can significantly improve landscape heterogeneity, creating ecological niches for both flora and fauna (Cramer et al., 2008). Passive restoration, where old fields are left to regenerate naturally, has been particularly successful in promoting the re-establishment of native vegetation and the recovery of wildlife populations (Cramer et al., 2008). Active restoration efforts, such as replanting indigenous species and controlling invasive plants, further accelerate biodiversity recovery and improve ecosystem services (BenDor et al., 2015).

Old fields also offer tangible ecosystem service benefits, including enhanced carbon sequestration, improved soil fertility, and better water retention. These benefits are critical for increasing ecosystem resilience against climate change and ensuring long-term sustainability (Hobbs and Harris, 2001). However, the success of old field restoration depends on factors such as the degree of prior degradation, surrounding land uses, and the presence of invasive species (Pasmans and Hebinck, 2017). For wildlife ranches, managing old fields aligns conservation goals with economic realities. Restored landscapes attract ecotourism, enhance game quality for hunting, and improve the ecological value of ranch properties (Naidoo et al., 2016).

2.6.4 Temporal dynamics and implications for conservation

The evolution of wildlife ranching in South Africa reflects a dynamic interplay of socio-economic, environmental, and policy-driven forces that continue to shape land use and conservation outcomes. Temporal dynamics in this context refer to the shifts in land use practises and land cover patterns over time, driven by changing market conditions, environmental pressures, and legislative reforms. These dynamics are crucial to understanding how wildlife ranches maintain their viability and adapt to evolving challenges while balancing conservation objectives with economic sustainability. Historically, wildlife ranches emerged as an adaptive response to declining profitability in traditional agriculture, catalysed by enabling legislation such as the Game Theft Act of 1991, which granted private landowners ownership rights over wildlife (NAMC, 2006). This transformative legal reform incentivised landowners to transition from livestock farming to wildlife-based land uses, enabling them to capitalise on economic opportunities (Taylor et al., 2016). Environmental pressures such as climate change, soil degradation, and water scarcity have further accelerated the shift toward wildlife ranching. In semi-arid regions of South Africa, where traditional livestock farming is particularly vulnerable to prolonged droughts and declining soil fertility, wildlife ranching offers a more resilient alternative (Bond et al., 2004).

Economic drivers have played a pivotal role in shaping temporal dynamics within wildlife ranches. The profitability of ecotourism, trophy hunting, and game meat production has incentivised landowners to continuously re-evaluate and repurpose their land in response to market demands (Lindsey et al., 2013). For example, trophy hunting generates substantial revenue, often reinvested into habitat restoration and anti-poaching efforts, while ecotourism supports biodiversity conservation by attracting tourists to restore natural habitats (Snyman and du Preez, 2005; Snyman and Bothma, 2023). The ability to diversify income streams through mixed wildlife-agriculture systems or game meat production enhances the resilience of wildlife ranches to economic fluctuations (Denner et al., 2024). This adaptability highlights the importance of financial imperatives in driving land use decisions, which, in turn, shape ecological outcomes.

Policy reforms have also significantly influenced temporal dynamics. The recognition of OECMs under the Kunming-Montreal Global Biodiversity Framework has provided a framework for integrating private conservation efforts, such as wildlife ranches, into broader conservation strategies (CBD, 2022). These policy shifts encourage landowners to adopt practices that align with international biodiversity goals, ensuring the long-term sustainability of their operations. Namibia's communal conservancy system serves as a regional example, demonstrating how policy-driven initiatives can empower communities to manage wildlife ranches effectively, resulting in enhanced biodiversity and economic benefits (Naidoo et al., 2016).

Temporal dynamics are also evident in the ecological restoration efforts undertaken on wildlife ranches. The rewilding of old fields, previously degraded by intensive agriculture, exemplifies how landowners repurpose and restore landscapes to enhance biodiversity and ecosystem functionality (Cumming et al., 2015). While rewilding often occurs through passive natural regeneration, some old fields exhibit long-term legacy effects, such as altered soil composition, invasive species encroachment, and nutrient imbalances that may hinder recovery (Cramer et al., 2008). In these cases, active restoration interventions, such as controlled grazing, targeted replanting, and soil rehabilitation, may be necessary to facilitate ecosystem recovery and ensure the re-establishment of native biodiversity (Corson et al., 2022; du Toit and Pettorelli, 2019; Svenning, 2020). In South Africa, these rewilded areas have provided habitats for species such as antelope, cheetahs, and endemic birds, contributing to landscape-level conservation goals (Navarro & Pereira, 2012). Passive restoration, which allows old fields to undergo natural succession, and active measures, such as replanting native vegetation and controlling invasive species, have both proven effective in improving habitat quality and ecosystem services (BenDor et al., 2015; Cramer et al., 2008; Hobbs and Cramer, 2007).

2.7 Gaps in existing literature

The existing body of literature on wildlife ranches has made significant contributions to understanding their role in biodiversity conservation and economic sustainability. However, notable gaps remain, particularly concerning the long-term viability of different business models, the temporal dynamics of land use, and the integration of social and ecological outcomes. Addressing these gaps is critical to evaluating the adaptive capacity of wildlife ranches and their reliability as conservation tools. While much research has focused on the economic and conservation benefits of specific business models such as trophy hunting, ecotourism, and game meat production (Lindsey et al., 2007; Snyman and du Preez, 2005), limited studies have assessed their long-term ecological and socio-economic impacts. For instance, the effects of selective breeding for trophy hunting on genetic diversity or the sustainability of game meat production under varying environmental conditions are insufficiently understood (Clements et al., 2016; Parker et al., 2020). Furthermore, there is a lack of comparative analyses across different models, making it difficult to determine which approaches are most effective in achieving both conservation and economic goals over extended periods.

The dynamic nature of land use within wildlife ranches, driven by shifts in market demands, environmental changes, and policy reforms, remains underexplored. Although studies have documented transitions from traditional agriculture to wildlife ranching (Du Toit, 2007; Taylor et al., 2016), there is limited understanding of how these land use practices evolve over time and their cumulative impacts on ecosystems. For example, the long-term implications of rewilding old fields on species recovery and landscape-level biodiversity connectivity remain poorly documented (Cumming et al., 2015; Navarro and Pereira, 2012). Research into how these temporal shifts interact with business models and conservation outcomes is necessary to predict the future trajectory of wildlife ranching.

Current studies often compartmentalise ecological outcomes and socio-economic drivers, resulting in a fragmented understanding of the interactions between these components. The SES framework has been applied to wildlife ranches (Lindsey et al., 2013). However, there is insufficient empirical evidence linking the social and economic drivers, such as market fluctuations and governance structures, to ecological metrics like biodiversity and habitat quality. For example, how do market pressures to maximise profitability influence land use decisions, and what are the cascading effects on species composition or ecosystem resilience? Bridging this gap requires interdisciplinary approaches that integrate ecological, economic, and social dimensions to capture the complexity of wildlife ranches fully.

These gaps in knowledge have significant implications for the role of wildlife ranches as long-term conservation tools. Without comprehensive studies on the sustainability of different business models, policymakers and practitioners lack the evidence needed to design interventions that align economic viability with ecological integrity (Cousins et al., 2010). Similarly, the absence of research on temporal dynamics limits the ability to anticipate and manage the long-term impacts of land use changes, potentially undermining conservation outcomes. Understanding the interplay between social and ecological factors is particularly important for assessing the resilience of wildlife ranches to external pressures such as climate change, economic downturns, and policy shifts (Clements et al., 2016; Denner et al., 2024). For instance, failure to address the socio-economic drivers of land degradation or unsustainable practices may compromise the conservation potential of these areas.

Conversely, identifying strategies that enhance the integration of social and ecological objectives can provide valuable insights into how wildlife ranches can adapt to future challenges while maintaining their dual role as economic enterprises and biodiversity conservation areas. Identifying these gaps highlights the need for targeted research that explores the adaptive capacity, sustainability, and resilience of wildlife ranches as conservation tools. By evaluating the interplay between land use dynamics, business models, and conservation outcomes, I aim to address these knowledge gaps and contribute to a more comprehensive understanding of how wildlife ranches can support biodiversity conservation in the context of socio-economic and environmental change.

2.8 Conclusion

Wildlife ranches represent a dynamic conservation model that integrates biodiversity goals with economic activities, offering a compelling alternative to traditional PAs. However, significant knowledge gaps remain regarding the long-term sustainability of their business models, the temporal dynamics of land use change, and the complex interplay between social and ecological factors. Addressing these gaps is critical to understanding their potential as reliable, long-term conservation tools that complement formal PAs and contribute to global biodiversity targets. The literature review highlights key themes essential to this understanding, including the role of wildlife ranches as SES and their capacity to adapt to diverse pressures.

This study builds on these insights by evaluating land use practices and business models within wildlife ranches in South Africa's Eastern Cape and Limpopo Provinces. I examine how these factors influence conservation outcomes over time, focusing on the adaptive capacity of wildlife ranches to balance ecological and economic goals. By integrating landowner perspectives and remote sensing analyses, this study builds on data collected by SWEP while conducting new spatial analyses to explore wildlife ranching transitions. The landowner surveys and historical land use data were collected as part of SWEP, while all land cover change analyses, policy timeline construction, and statistical comparisons were done independently by myself.. Ultimately, seeking to provide actionable insights into the resilience and sustainability of wildlife ranches, reinforcing their potential to support biodiversity conservation and sustainable development in an increasingly dynamic world.

3. Study Context

3.1 Introduction

This study context chapter introduces the Eastern Cape and Limpopo provinces of South Africa as focal areas due to their significant concentration of wildlife ranches and distinct social-ecological dynamics. These provinces represent areas where wildlife-based land use has expanded considerably, driven by economic incentives and conservation initiatives. Their contrasting climates and ecosystems, ranging from Limpopo's warm savannas to the Eastern Cape's diverse coastal and inland biomes, offer an ideal comparative framework for analysing the ecological, economic, and conservation impacts of wildlife ranching. The inclusion of these provinces is further justified by their relevance to SWEP, under which this study was done. SWEP focuses on sustainable wildlife-based land use practices and their social-ecological impacts, aligning with the broader objectives of this research. In this chapter, I provide a foundation for understanding how these landscapes contribute to biodiversity conservation, ecosystem service provision, and rural economic resilience by exploring how wildlife ranching operates within the unique contexts of these provinces.

3.2 Geographical and ecological context

3.2.1 **Study areas overview**

The Eastern Cape and Limpopo provinces are geographically and ecologically diverse, making them ideal for examining the dynamics of wildlife ranching. The Eastern Cape province spans diverse climatic zones, from the arid inland Great Karoo to the coastal forests and thickets along the south-eastern coast (Figure 3-1A). Rainfall varies dramatically, with coastal regions receiving up to 1 000 mm annually, while the interior experiences semi-arid conditions with 250–500 mm of rainfall per year (Mahlalela et al., 2020). The province's complex topography supports a variety of vegetation types, including grasslands, Afromontane forests, and the Albany Thicket biome, which is distinguished for its rich biodiversity but highly vulnerable to overgrazing and land degradation (Cowling et al., 2005; Pasmans and Hebinck, 2017). These geographic and climatic differences shape the opportunities and constraints for land use, providing a comparative framework for analysing how environmental conditions influence wildlife ranching practices.

Limpopo, situated in the northernmost part of South Africa (Figure 3-1B), is characterised by a subtropical climate with distinct wet and dry seasons, receiving an average annual rainfall of 400–600 mm (Tshiala et al., 2011). Limpopo's topography ranges from the flat, low-lying areas of the Lowveld to the mountainous escarpments of the Drakensberg and Soutpansberg, creating varied ecological zones that support savanna ecosystems rich in biodiversity (Scheiter et al., 2018). These ecosystems are well-suited to wildlife-based land use due to seasonal water availability and fertile soils in some areas (Van Wilgen et al., 2010).

3.2.2 Biomes

The provinces' biomes are important in supporting biodiversity and ecological services. In the Eastern Cape, the Albany Thicket biome is particularly significant due to its biodiversity and ecological importance. This semi-arid vegetation type supports numerous endemic plant and animal species but has suffered degradation from historical overgrazing and agricultural expansion (Cowling et al., 2005). Efforts to restore this biome through wildlife ranching have shown promise in reversing ecological damage and enhancing habitat connectivity (Pasmans and Hebinck, 2017). Additional vegetation types, such as coastal forests and grasslands, further contribute to the province's ecological diversity and conservation value.

Limpopo is dominated by savanna ecosystems, which are globally significant for their biodiversity and support a variety of large mammal species (Scheiter et al., 2018). The savannas are adapted to seasonal rainfall patterns, receiving the majority of their precipitation during the hot, wet summers. At the same time, the cooler, dry winters create a natural rhythm that shapes vegetation growth and wildlife behaviour (Sankaran et al., 2004). Fire is a crucial ecological driver in these biomes, playing an essential role in maintaining grassland dominance, reducing encroachment by woody plants, and recycling nutrients into the soil (Van Wilgen et al., 2007). This interplay of fire and rainfall makes the savannas highly resilient and well-suited to wildlife-based land uses, such as grazing by herbivores and habitat for predators (Hoffmann, 2022).

3.2.3 Ecological context and influence on wildlife ranches

The ecological and geographical characteristics of Limpopo and the Eastern Cape provide a foundation for understanding how wildlife ranching responds to varying environmental pressures. Limpopo's savannas and the Eastern Cape's diverse biomes offer contrasting landscapes, enabling the exploration of how wildlife ranching models adapt to different ecological, as well as socio-economic, contexts. This analysis contributes to a broader understanding of the role of wildlife ranching in supporting biodiversity conservation, ecosystem service provision, and rural livelihoods (Cousins et al., 2008; Denner et al., 2024; Taylor et al., 2016).

3.3 Historical and socio-economic context

3.3.1 Historical land use transitions

The transition from livestock farming to wildlife ranching in the Eastern Cape and Limpopo provinces reflects broader land use changes driven by economic and environmental pressures. Historically, livestock farming dominated both provinces, with cattle and sheep ranching prevalent in the semi-arid Karoo and grassland areas of the Eastern Cape and subsistence agriculture and commercial cattle farming widespread in Limpopo's savannas (Goni et al., 2018; Van Wilgen et al., 2010). However, these practices often lead to overgrazing, habitat fragmentation, and biodiversity loss, particularly in vulnerable ecosystems like the Albany Thicket in the Eastern Cape and the savannas of Limpopo (Haddad et al., 2015; Smith et al., 2020).

Droughts, declining soil fertility, and economic pressures in the late 20th century accelerated the shift toward wildlife ranching as a more sustainable alternative (Cousins et al., 2010; Lindsey et al., 2013; Juffe-Bignoli et al., 2016; Pasmans and Hebinck, 2017). Legislative reforms supporting private conservation and market demand for wildlife-based activities like ecotourism and hunting also played a pivotal role in driving this transition (Carruthers, 2008; Lindsey, 2011). In the Eastern Cape, wildlife ranching facilitated the restoration of degraded thicket and grassland ecosystems, while in Limpopo, rewilding efforts addressed challenges such as soil erosion and water scarcity (Cousins et al., 2010; Pasmans and Hebinck, 2017). Despite progress, the legacy of historical land degradation remains a challenge for both provinces. Sustainable management practices are essential to maximise wildlife ranching's conservation potential and align with South Africa's biodiversity goals.

3.3.2 Socio-economic extents

Wildlife ranching has become a vital socio-economic sector in both provinces, creating livelihoods, generating revenue, and supporting conservation (Denner et al., 2024; Taylor et al., 2020, 2016). In rural areas where traditional agriculture has declined, wildlife ranches provide stable income through activities such as ecotourism, trophy hunting, and game breeding (Clements et al., 2016; Denner et al., 2024; Pasmans and Hebinck, 2017). These activities often generate higher economic returns than conventional farming, particularly in marginal areas with low agricultural productivity (Cousins et al., 2010).

In the Eastern Cape, wildlife ranches have contributed to job creation in ecotourism and conservation management, supporting local economies and reducing poverty. Wildlife-based land use has also promoted ecological recovery by restoring degraded lands, particularly in the Albany Thicket biome, which is crucial for biodiversity conservation (Becker et al., 2015; Pasmans and Hebinck, 2017).

The interconnected landscapes managed by wildlife ranches enhance habitat connectivity, allowing for wildlife movement and genetic diversity, further strengthening their conservation impact (Correa Ayram et al., 2016; Sandifer et al., 2015).

In Limpopo, wildlife ranching plays a similarly significant role in rural development and conservation. The province's savanna ecosystems support a thriving wildlife economy, with trophy hunting and ecotourism attracting substantial international revenue (Child et al., 2012; Parker et al., 2020). Income from these activities is often reinvested into conservation measures such as anti-poaching initiatives, water resource management, and habitat restoration (Taylor et al., 2016). Additionally, wildlife ranching supports local employment and entrepreneurship in tourism-related sectors, further stimulating the rural economy (Denner et al., 2024). Both provinces face challenges, including human-wildlife conflict and unequal access to resources. However, wildlife ranching offers a framework for integrating economic opportunities with conservation efforts, encouraging ecological resilience and supporting socio-economic development.

3.4 Key challenges and pressures

Wildlife ranching in the Eastern Cape and Limpopo provinces faces significant pressures, ranging from environmental challenges such as water scarcity and climate variability to socio-economic constraints like market fluctuations and unequal access to resources. These factors collectively impact the sustainability of wildlife-based land use and its ability to balance conservation and economic objectives.

Water scarcity is one of the most pervasive challenges in both provinces, exacerbated by frequent droughts and the growing impacts of climate change. In the Eastern Cape, rainfall is highly variable, particularly in semi-arid areas like the Great Karoo, where prolonged droughts strain water resources needed to sustain both livestock and wildlife (Letsoalo et al., 2023; Mahlalela et al., 2020). Similarly, in Limpopo, water availability relies heavily on seasonal rainfall, which has become increasingly unpredictable due to climate variability (Tshiala et al., 2011). Reduced rainfall, combined with rising temperatures, intensifies stress on vegetation, further limiting ecosystem recovery in degraded areas such as the Albany Thicket and savanna biomes (Rapolaki et al., 2021). These pressures affect biodiversity and challenge landowners and managers' ability to maintain wildlife populations and the ecosystem services they provide. In response, many wildlife ranches have adopted innovative water management strategies, such as rainwater harvesting, artificial waterholes, and selective vegetation management, to enhance water retention and efficiency (Monde et al., 2012). These practices aim to mitigate the effects of water scarcity while building resilience to climate-related challenges. However, the long-term sustainability of these measures depends on broader conservation strategies and collaborative efforts at provincial and national levels to address the root causes of water insecurity and climate stress.

Beyond environmental challenges, socio-economic constraints further complicate the viability of wildlife ranching. Market fluctuations, particularly in sectors such as ecotourism and trophy hunting, introduce financial instability for ranchers reliant on these revenue streams. For example, global economic downturns or travel disruptions can significantly impact international tourism, reducing income and undermining investments in conservation and local employment (Taylor et al., 2016). Unequal access to resources, such as land, water, and financial capital, also limits the ability of smaller landowners and historically disadvantaged communities to participate fully in wildlife-based economies (Cousins et al., 2012). Policy and incentive gaps compound these challenges, particularly for landowners transitioning from traditional livestock farming to wildlife ranching. While provincial wildlife economy strategies aim to promote sustainable land use and economic development, their benefits are not evenly distributed. Smaller landowners and marginalised communities often face barriers to accessing these programmes, such as high upfront costs and limited technical support (Spenceley, 2008; Taylor et al., 2016). Strengthening policy frameworks and expanding financial incentives could be crucial in enabling broader participation in conservation-focused land use, particularly in areas facing significant socio-economic and environmental pressures.

Despite these challenges, wildlife ranching remains vital for promoting conservation and supporting rural livelihoods. By fostering economic opportunities, enhancing ecological resilience, and aligning with national biodiversity goals, wildlife ranches in both provinces demonstrate the potential to address environmental and socio-economic pressures. However, realising this potential requires continued investment in sustainable practices, equitable resource distribution, and adaptive management strategies to mitigate the impacts of water scarcity, climate change, and market instability.

3.5 Policy and legislative framework

The South African Constitution (Section 24) provides the legal framework for environmental governance and the sustainable use of natural resources. This section ensures that everyone has the right to an environment that is not harmful to their well-being. It mandates the state to take legislative and other measures to promote conservation while ensuring sustainable resource use. This principle is fundamental to the governance of the wildlife economy, highlighting policies that facilitate biodiversity conservation and economic viability (Plessis, 2008). One of the key policies emerging from this constitutional framework is the Game Theft Act (1991), which granted private landowners legal ownership rights over game animals under specific conditions (Snijders, 2012; Spierenburg, 2018). By enabling ownership of wildlife, the Act incentivised landowners to transition from traditional agriculture to wildlife-based enterprises, leading to a broader shift towards conservation-compatible land uses (Child et al., 2012; Lindsey et al., 2013; Snijders, 2012).

Beyond the Game Theft Act, more recent policy developments continue to shape the wildlife economy. The White Paper on Biodiversity Conservation and Sustainable Use establishes national strategies to integrate biodiversity conservation with economic opportunities (Wynberg, 2002). Complementary to this, the National Biodiversity Economy Strategy and the Game Meat Strategy outline specific objectives to strengthen the economic viability of wildlife-based industries while ensuring sustainability (Schalkwyk et al., 2010; Taylor et al., 2020). Additionally, the Policy Position on the Conservation and Ecologically Sustainable Use of Elephant, Lion, Leopard, and Rhinoceros sets clear guidelines for managing key species, balancing conservation priorities with responsible economic use (Clements et al., 2016; Hiller and ’t Sas-Rolfes, 2024; ’t Sas-Rolfes et al., 2022). These policies collectively shape the regulatory environment within which wildlife ranches operate, reinforcing the importance of both conservation and economic sustainability.

Another key national framework supporting this integration is the Biodiversity Economy Strategy, developed by the Department of Forestry, Fisheries, and Environment (DFFE). This strategy seeks to enhance the economic potential of biodiversity-based industries, including wildlife ranching, by promoting sustainable use, job creation, and rural development (Denner et al., 2024; Mokotjomela and Nombewu, 2020; Taylor et al., 2020). Wildlife ranches contribute significantly to this vision by generating revenue through ecotourism, game breeding, and sustainable hunting, while also maintaining biodiversity-compatible land uses. The strategy emphasises the role of the wildlife economy in balancing conservation and economic objectives, reinforcing the importance of private landowners in achieving national biodiversity targets.

Wildlife ranching in South Africa is underpinned by a robust policy and legislative framework that integrates conservation with socio-economic development. National and provincial strategies highlight the role of wildlife ranches in achieving biodiversity goals, supporting rural economies, and fostering ecological resilience. At a national level, initiatives such as SANParks’ Mega Living Landscapes (MLL) vision and South Africa’s commitment to the Kunming-Montreal GBF are pivotal in shaping large-scale conservation strategies. While the MLL initiative is still in its early stages, its aim to promote ecological connectivity by integrating private lands, including wildlife ranches, into broader conservation networks highlights the potential role of these areas in supporting biodiversity goals.

Wildlife ranches could arise as potential OECMs due to their capacity to maintain habitats, protect biodiversity, and support critical ecosystem services like carbon storage and water regulation (Dudley and Stolton, 2022; Fitzsimons et al., 2024). However, they have not yet been formally recognised as OECMs, though ongoing discussions and research are evaluating their suitability for this designation (Stevens et al., 2020).In areas like the Eastern Cape, protected environments such as Indalo and areas near Graaff-Reinet demonstrate the potential for private lands to contribute to conservation outcomes (Hayward et al., 2007). These areas play a role in bridging gaps between PAs, fostering biodiversity conservation while aligning with South Africa's broader target of protecting 30% of its land by 2030 under the Kunming-Montreal GBF. These initiatives underline the importance of private and communal lands in South Africa's conservation landscape by fostering sustainable land use practices and contributing to global biodiversity commitments. Provincial policies in the Eastern Cape and Limpopo complement these national strategies by promoting the wildlife economy. These initiatives encourage landowners to adopt sustainable practices like ecotourism, trophy hunting, and game breeding, which generate higher economic returns than traditional agriculture. In the Eastern Cape, these policies aim to restore degraded landscapes, enhance biodiversity, and create employment opportunities in rural communities (Taylor et al., 2016). Similarly, Limpopo's wildlife economy plan emphasises habitat restoration, connectivity conservation, and the integration of private and communal lands into larger conservation networks (Gallo et al., 2009).

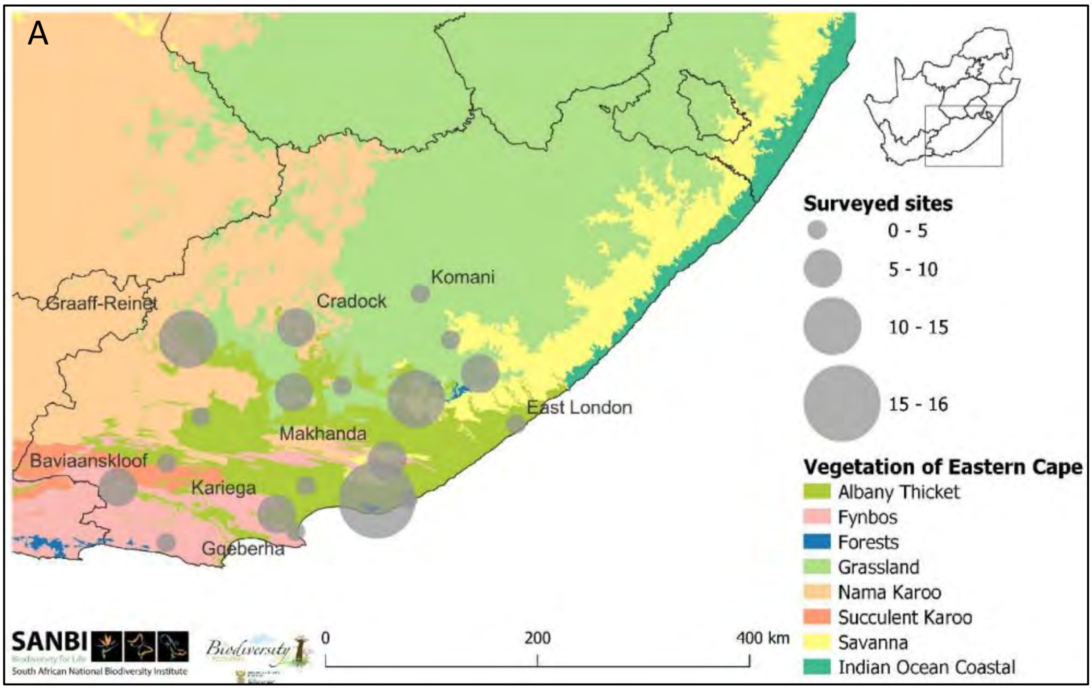
Despite these advancements, challenges remain. Smaller landowners and historically disadvantaged communities often face barriers to accessing financial incentives and technical support needed to participate fully in wildlife-based economies. Addressing these gaps through expanded incentives and more inclusive policy frameworks is essential for achieving equitable and sustainable outcomes. Wildlife ranching represents a practical tool for balancing conservation goals with economic priorities. By aligning with national and provincial policies, these ranches play a vital role in enhancing ecological connectivity, fostering biodiversity, and supporting rural livelihoods, reinforcing South Africa's commitment to sustainable development and global biodiversity targets.

3.6 SWEP

The Sustainable Wildlife Economies Project was initiated to explore the role of wildlife economies in promoting sustainable land use and conservation across South Africa. The project aimed to understand how wildlife-based enterprises, such as ecotourism, game breeding, and hunting, contribute to ecological restoration, biodiversity conservation, and rural livelihoods (SWEP, 2024). By focusing on integrating socio-economic and ecological systems, SWEP sought to align private land management practices with national and global conservation goals, such as those outlined in the Kunming-Montreal GBF.

This research forms part of the SWEP initiative using SWEP-collected data on land use transitions within wildlife ranches in Limpopo and the Eastern Cape. SWEP conducted all landowner surveys and collected historical land-use data, while this study independently analysed these data and performed new spatial analyses. These provinces were selected due to their high concentration of wildlife ranches and the contrasting ecological and socio-economic contexts they present. The research examines how different business models in wildlife ranching influence conservation outcomes, economic sustainability, and community benefits. It also contributes to SWEP's broader objectives by providing insights into how wildlife-based land use can balance biodiversity goals with economic resilience in regions facing environmental and socio-economic pressures.

The maps below illustrate the spatial distribution of the wildlife ranches surveyed as part of this study in Limpopo and the Eastern Cape. These maps highlight the geographical scope of the research, contextualising the findings within the broader SWEP framework. By integrating these findings, this study supports SWEP's mission to identify scalable models for sustainable wildlife economies that enhance ecological connectivity, foster rural development, and align with conservation priorities.



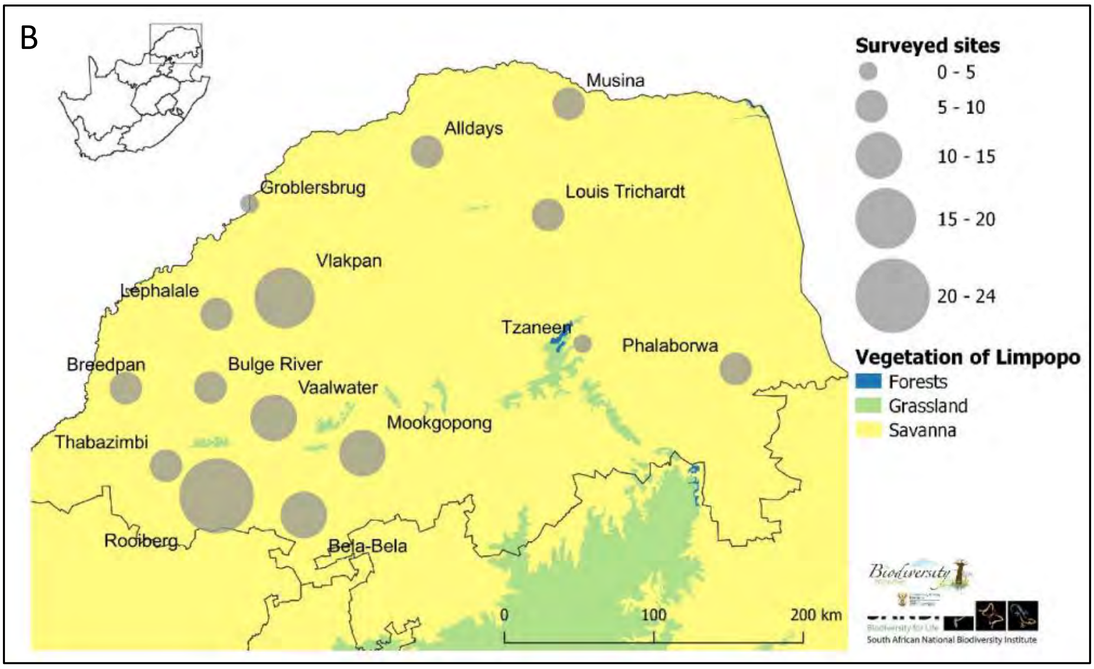


Figure 3-1: Survey sites of private wildlife ranches in South Africa during 2021 and 2022, showing locations in (A) the Eastern Cape (map created by Kyra Lunderstedt) and (B) Limpopo (map created by Cecilia Wagner). Data source: SWEP, 2025.

3.7 Conclusion

This study provides a nuanced understanding of how wildlife ranching shapes land use in the Eastern Cape and Limpopo, illustrating its potential as a sustainable alternative supporting conservation and rural economic development. By examining the distinct environmental and socio-economic contexts of these regions, such as the Eastern Cape's diverse but semi-arid landscapes and Limpopo's savanna ecosystems near PAs—this research underscores the contributions of wildlife ranching to biodiversity conservation and ecological resilience. Provincial policies and economic incentives further enhance the viability of wildlife ranching, positioning it as a critical component in South Africa's conservation framework.

By aligning wildlife ranching with national initiatives like SANParks' MLL and the Biodiversity Economy Strategy, this study highlights the synergy between private conservation efforts and formal PAs, fostering ecological connectivity and strengthening conservation networks. Additionally, the economic and policy dimensions explored here emphasise the value of wildlife ranching in supporting rural livelihoods, engaging communities in conservation, and building resilience to socio-economic and environmental challenges. This research positions wildlife ranching as a promising integrated conservation and sustainable development model, meaningfully contributing to South Africa's biodiversity and land use goals.

4. Methodology

In this research, I used a mixed-methods approach to examine land use and land cover dynamics within wildlife ranches, integrating qualitative and quantitative data to understand this sector comprehensively. The study combines spatial analysis of NLC change with data from surveys and interviews. Data sources include existing surveys conducted as part of SWEP, which, as previously stated, gather information on wildlife ranching practices and socio-economic drivers and targeted interviews with landowners to capture their motivations, perspectives, and decision-making processes. Spatial analysis focuses on assessing land cover changes over time, specifically at land cover gain and loss, while the survey and interview data are used to identify a more in depth history of change and motivations or drivers of change, as well as the variations across business models. The landowner surveys and historical data on wildlife ranching transitions were collected as part of SWEP, while all spatial analyses of land cover change and statistical analyses were conducted independently for this research. This approach enables a nuanced exploration of the interactions between conservation, land use, and economic objectives within wildlife ranches. All data analysis and visualisation were conducted using a combination of ArcGIS Pro (v3.3) and R (v4.3.2). ArcGIS Pro was used for spatial analyses, including land cover change detection. R was used for statistical analysis and data visualisation.

4.1 Landowner surveys (SWEP data source)

From February 2021 to March 2022, as part of SWEP, a comprehensive survey was done with 292 landowners and managers (now referred to as survey participants) of wildlife ranches across the Eastern Cape and Limpopo provinces of South Africa. This survey was a collaborative effort between the South African National Biodiversity Institute (SANBI), the DFFE, Wildlife Ranching South Africa (WRSA), and other industry stakeholders. The collaboration ensured that the survey aligned with policy objectives and addressed practical needs within the wildlife ranching industry, making the data valuable for both policy development and operational insights. SWEP employed trained resource auditor teams to conduct in-depth interviews with survey participants over one to three hours.

Data collection for SWEP began in the Eastern Cape in early 2021 as part of Phase 1. This phase focused on gathering baseline information on land use, sustainable land management, animal population control, and socio-economic activities within wildlife ranches. Although the survey covered multiple aspects, this study exclusively uses the land use data collected, as detailed in Appendix 1. The sampling approach combined opportunistic and snowball sampling methods. WRSA members were first contacted to gauge their interest in participating. An informational video explaining SWEP's objectives and potential impacts was shared with the Eastern Cape wildlife ranching network to expand the sample. Interested participants referred other landowners and ranch managers, broadening the survey's reach. In June 2021, SWEP Phase 2 extended to Limpopo, following the same methodology with minor adjustments to gather more detailed data on fencing, sustainable land management, and financial viability. However, these adjustments did not affect the analyses conducted for this study. The private wildlife industry association disseminated communication materials encouraging participation among Limpopo wildlife ranchers.

In March 2022, I conducted follow-up surveys with 24 original participants from the Eastern Cape to obtain more detailed accounts of land use changes. These interviews focused on understanding the motivations behind land use change, the approximate dates of significant land use changes, and the relative extent of different land uses over time. While participants were asked to provide updated maps of their properties, these maps were ultimately not used in the analyses. The follow-up surveys played an important role in supplementing SWEP data, mainly by providing qualitative insights into land use decision-making and drivers of change. The properties for these follow-ups were selected using a stratified random sampling approach, ensuring representation across different wildlife ranch sizes, business models, and operational contexts. This stratification aimed to provide a balanced cross-section of wildlife ranches to support the study's objectives.

Despite the structured approach, some limitations were encountered during data collection. A notable limitation was the variability in data quality, as multiple individuals were involved in data collection, leading to inconsistencies. Additionally, some potential participants declined to participate due to distrust of government-related initiatives, further affecting sample size and diversity. There is also the potential for recall bias, as participants were required to recount historical land use changes, which could impact the accuracy of the reported data. While the phased data collection approach—starting in the Eastern Cape and moving to Limpopo—was logistically practical, it resulted in regional data being collected at slightly different times. This timing difference could have introduced temporal variability, particularly as the surveys were conducted after the COVID-19 pandemic, a period of significant economic and operational impacts on wildlife ranches (Clements et al., 2022). Despite these challenges, the data collected provides valuable insights into land use dynamics and decision-making within the wildlife ranching sector.

Although the sample may not fully represent the entire wildlife ranching sector, particularly foreign-owned wildlife ranches and those with more questionable management practices, the study offers a detailed and balanced perspective on land use trends. These limitations are discussed further in the context of the broader study limitations in the Discussion chapter.

4.2 Data collection

4.2.1 Historical land use activities (SWEP data)

Survey participants were asked to provide a detailed historical account of land use activities on their properties. To capture this historical perspective, participants were prompted to recall what their land was primarily used for before its current state as a wildlife ranch. Specifically, they were asked to identify the dominant land uses before transitioning to wildlife-based enterprises. Participants were asked to approximate the timeframe for each type of previous land use activity. They were encouraged to provide general dates, where possible, for the start and end of each land use type. Survey participants were also asked about the year they transitioned to wildlife ranching, at least partially.

4.2.2 Land use data (SWEP data)

Survey participants (n = 292 for the original survey and n = 24 for follow-up interviews) were asked to provide approximate proportions of each land use type on their property, both at the start of their current enterprise and in its present state. This information assessed changes in land cover types over time, focusing on cultivated fields, planted pastures, rangeland, and old fields (Table 4.1). These classifications provided a structured framework for exploring shifts in land use, allowing the analysis to assess how various types of land cover correlated with different management decisions or environmental factors.

Table 4-1: Descriptions of land use types within wildlife ranches

Land use	Description
Cultivated land	This refers to land used for the planned cultivation of various agricultural products, such as grains, fruits, or vegetables, employing techniques like planting, irrigating, and ploughing. Within wildlife ranches, cultivated land is marked by ordered rows or fields and is the result of deliberate human involvement in producing agricultural products (Mujuru and Obi, 2020; Pretorius, 2009).
Planted pastures	Planted pastures are specifically created and managed areas designed to provide high-quality feed for both livestock and wildlife. These pastures involve the introduction of selected grasses, legumes, or other forage plants that offer high nutritional value and are suitable for grazing (Tjelele et al., 2021).
Rangeland	Rangelands refer to large areas of mostly undeveloped or semi-natural land on wildlife ranches, often utilised for livestock and wildlife grazing. They include diverse plant communities, such as grasses, shrubs, and scattered trees, that serve as fodder for grazing animals. These landscapes are integral to biodiversity conservation, supporting animal

	populations and sustainable livestock production (Snyman and du Preez, 2005; Vetter, 2013).
Old fields	Old fields are areas of land that were historically used for agricultural activities but have since been abandoned or left fallow. Over time, natural ecological succession enables the colonisation of these areas by various plant species, fostering the formation of new biological communities. Within wildlife ranches, these areas serve as essential habitats that contribute to biodiversity conservation (Cumming et al., 2015; Hobbs and Cramer, 2007).

Survey participants were provided with a land use decision tree to ensure consistency and accuracy in identifying land use types (Figure 4-1). This decision tree served as a cognitive tool, offering specific criteria for categorising different land use types, thereby supporting systematic data reporting and classification.

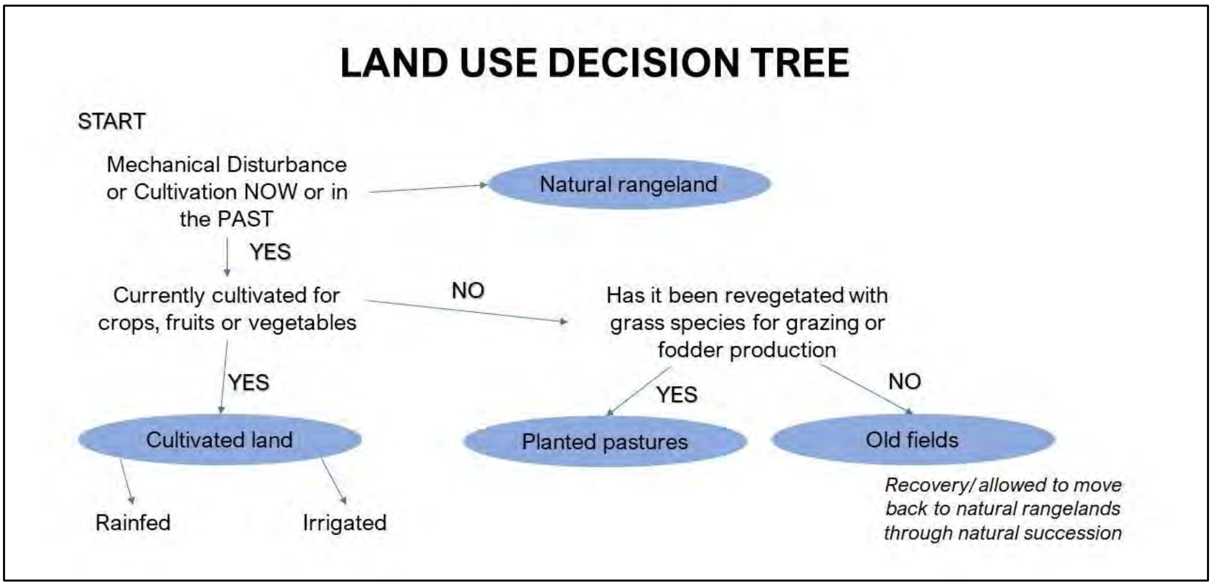


Figure 4-1: Land use decision tree used to help landowners/ managers identify land uses within their properties

4.2.3 Motivations behind land use changes (SWEP data)

Survey participants were asked to explain the specific reasons behind each land use change, detailing economic, social, and environmental factors that influenced these transitions. This information allowed for a thematic analysis of motivations across different business models, providing insights into the challenges, opportunities, and decision-making processes that shaped each property's current land use. The survey highlighted key drivers of land use change within the wildlife ranching sector by capturing these motivations.

4.2.4 Age and size (SWEP data)

The survey gathered foundational data on the age and size of each wildlife ranching enterprise by asking participants to specify the year they transitioned to wildlife ranching. In addition to the year of transition, participants were asked to report the property's size at the time of transition and its current size in hectares. This information facilitated an analysis of how property sizes may have expanded or contracted over time, providing insights into the dynamics of land use and enterprise growth within the wildlife ranching sector.

4.3 Assigning business models to properties (SWEP data)

The specific details and characteristics of each business model, along with their defining operational and income attributes, are discussed comprehensively in Section 2.5. To categorise wildlife ranches into specific business models, this study drew on the classification approach outlined by Clements et al. (2016) and Denner et al. (2024), which identified and classified revenue-generating activities. The methodology explicitly follows the work of Denner et al. (2024), who used principal component analysis to cluster survey responses into distinct business models. This approach enabled the identification of operational characteristics and income sources that defined the primary focus of each property. Based on this methodology, each property was assigned to one of six wildlife-based business models: ecotourism, trophy hunting, wildlife breeding, mixed hunting, mixed wildlife-agriculture, and trophy hunting-game meat. These classifications were determined by evaluating survey responses regarding revenue activities, visitor demographics, and operational priorities, ensuring consistency in model assignment.

In addition to the wildlife-based business models, a small number of surveyed properties fell into the "livestock farming" category. Although livestock farms are not wildlife ranches, they were included in the analysis to serve as a comparative baseline, providing insights into differences in socio-economic impacts and conservation roles. The sample size for livestock farms was small and is discussed as a limitation later in the thesis. Similarly, PAs were included in the survey but were excluded from the analysis in this study to maintain a clear focus on wildlife ranches and livestock farms.

4.4 Thematic analysis

The thematic analysis approach used in this study was adapted from methods outlined by Naeem et al. (2023) and Dawadi (2020) as well as established frameworks widely applied in social-ecological research (Braun and Clarke, 2006; Bryman, 2016). This approach was chosen for its ability to systematically identify and categorise themes, facilitating the exploration of complex social-ecological dynamics. Drawing on Dawadi (2020), the analysis adopted a structured multi-stage process to ensure rigour and transparency. Ban et al. (2019) emphasis on integrating social-ecological dimensions provided a framework to contextualise land use changes within adaptive systems, while Braun and Clarke (2006) focus on the reliability of theme identification ensured the robustness of the analysis.

This method enabled the systematic organisation of qualitative data into themes related to historical land use, transitions, and the motivations driving these changes. By combining SWEP-derived narrative accounts with thematic coding, this study provided nuanced insights into land use dynamics and wildlife ranching transitions. SWEP collected the landowner interviews, while the thematic analysis was independently conducted by the researcher using a manual coding approach, revealing barriers and opportunities for social-ecological adaptation. Thematic analysis helped differentiate between general patterns of change over time and specific transitions in land cover types, such as shifts in old fields, rangelands, and planted pastures.

1. Familiarisation with data: In the initial stage, interview transcripts were reviewed to comprehensively understand the responses' content and context. This familiarisation phase allowed preliminary identification of patterns and recurring topics, establishing an intuitive grasp of each interview narrative.

2. Open coding and theme identification: A systematic open coding process was applied, where text sections corresponding to specific themes were categorised. Each relevant fragment of the responses was labelled with descriptive codes representing thematic areas. This coding approach facilitated capturing nuances in participants' accounts and allowed for categorising recurring topics.

3. Refining and consolidating themes: Finally, coded data were reanalysed to consolidate and refine themes, ensuring they accurately represented key patterns while avoiding redundancy. This iterative refinement helped structure a layered and contextually rich view of each theme, supported by direct statements from survey participants.

Several limitations were identified in the thematic analysis. The reliance on self-reported data introduced potential subjectivity, as participants' recall bias or personal perspectives may have influenced their accounts of historical practices (Braun and Clarke, 2006; Bryman, 2016). Participants may have overlooked key drivers of historical changes or lacked knowledge about past land use decisions, particularly for properties with long operational histories (Ban et al., 2019; Thompson et al., 2013). While the open coding process allowed for flexibility, it also introduced the potential for variability in coding consistency, particularly when interpreting ambiguous or complex responses (Smith et al., 2020).

To address these limitations, efforts were made to cross-check themes during the coding process and to triangulate findings with quantitative data where possible. The implications of these limitations are further reflected in the discussion, particularly regarding the drivers of historical change and their potential underrepresentation due to recall biases or gaps in participants' knowledge (Bryman, 2016; Braun and Clarke, 2006). Despite these challenges, thematic analysis proved to be an effective method for extracting structured insights from complex narratives, providing a robust foundation for understanding land use dynamics in wildlife ranching systems.

4.4.1 Historical change analysis (SWEP data & independent analysis)

A frequency analysis of the coded responses was done to identify themes associated with historical land use changes. These themes were organised by decade, ranging from the pre-1960s to the 2020s, allowing for a temporal perspective on how land use change evolved. A stacked bar graph was created to visualise these trends, with each bar representing a specific decade and segmented by the proportion of each theme. This visual format provided a clear illustration of shifts in land use activities across decades, highlighting how the relative significance of each theme changed over time. To statistically assess the association between land use themes and specific decades, a chi-square test for independence was done, testing whether the distribution of land use themes varied significantly across periods. A cumulative line graph was also developed to depict the overall increase in wildlife ranching conversions over time. Segmented regression analysis was applied to this cumulative data, identifying statistically significant breakpoints to mark key periods of growth in wildlife ranching. This analysis provided a quantitative framework for examining changes in conversion rates, indicating distinct phases in the history of wildlife ranching expansion.

4.4.2 Motivations of land use change (SWEP data & independent analysis)

Using thematic analysis, survey participant responses were reviewed to identify recurring themes representing significant motivations and drivers of land use change. These themes were categorised as distinct motivations: water availability, historical legacy, economic motivations, land rehabilitation, property expansion, and planting for fodder production. Each theme was then organised within data tables, capturing its frequency and illustrating its role in specific land use categories: cultivated fields, planted pastures, old fields, and rangelands. To provide a clear visual representation of how motivations varied across different business models, pie charts were created to illustrate the primary motivations within each business model. This breakdown showed the proportion of each motivation in ecotourism, livestock farming, trophy hunting, wildlife breeding, mixed hunting, and mixed wildlife agriculture.

4.5 Policy and event timeline table (Independent review & compilation)

A timeline table was developed to summarise key policies, organisational milestones, and events relevant to the development of wildlife ranching in South Africa, employing an approach similar to that used by De Vos et al. (2019) in examining key conservation events in PAs. The process for identifying and selecting events for inclusion focused on their significance in shaping wildlife ranching as a socio-political and economic sector. To compile this timeline, an independent review of publicly available legislation, policy documents, and academic literature was conducted. This process involved: (a) conducting keyword searches in online academic databases and government portals to identify relevant legislative and policy documents affecting wildlife ranching. were conducted in Google Scholar, the Southern African Legal Information Institute, and the DFFE online repository. Search terms included "wildlife ranching policy South Africa", "Game Theft Act 1991", and "Biodiversity Economy Strategy South Africa"; (b) reviewing reports and literature from government departments, conservation organisations, and industry bodies. These included documents from DFFE, the Department of Agriculture, Land Reform and Rural Development, and policy briefs from organisations involved in private land conservation, such as the Endangered Wildlife Trust and the South African Hunters and Game Conservation Association; and (c) consulting secondary academic sources that analyse policy changes in the wildlife economy, particularly those detailing legislative shifts and their socio-economic impacts. Where possible, cross-referencing was done to validate the importance of specific events.

Serving as a chronological reference, the table highlights critical socio-political events that likely influenced the growth of wildlife ranching. Key elements include organisational milestones, such as the establishment of conservation bodies that formalised wildlife ranching and conservation practices. Legislative developments, particularly those granting landowners legal rights to wildlife (e.g., the Game Theft Act), are documented as pivotal moments that catalysed private conservation efforts. Additionally, policy reforms and influential events, such as the publication of foundational ecological studies or the implementation of significant land use policies, are included to showcase shifts in regulatory frameworks and societal attitudes toward wildlife management. This timeline provides essential context for understanding the external factors that shaped the motivations and patterns observed in the thematic analysis. By situating the rise of wildlife ranching within a broader socio-political and regulatory landscape, the timeline underscores the role of historical events in shaping current land use and conservation dynamics within the wildlife ranching sector.

4.6 Land use change analysis (SWEP data & independent analysis)

Land use change was calculated to illustrate proportional shifts across cultivated fields, planted pastures, old fields, rangelands, and wetlands, providing a summary of trends within each land use category. Statistical analyses and data visualisation were performed using R (version 4.3.2). The following packages were used for different analytical tasks: tidyverse (Wickham et al., 2019); ggplot2 (Wickham, H, 2016) and dplyr (Wickham and François, 2014). To evaluate the statistical significance of these changes, a series of paired t-tests were applied. Paired t-tests were chosen because they are well-suited for comparing means from related samples, such as proportional changes within each land use category over time, where data points are inherently linked (e.g., the same property at two different time periods). Assumptions for paired t-tests, including normality of differences, were tested prior to analysis.

To assess differences in land use changes across business models, a series of one-way ANOVAs was conducted. This approach was used to compare the means of multiple independent groups (i.e., the business models) and evaluate whether significant differences existed in the magnitude of land use changes among them. Assumptions for ANOVAs, including the homogeneity of variances and normal distribution of residuals, were tested to ensure the validity of the results. A Sankey diagram was created in RStudio using the ggalluvial package to illustrate transitions between specific land use categories over time. This visualisation highlights the flow of land use changes, with widths of the connections proportional to the magnitude of transitions.. This diagram provided a detailed visual representation of how initial land uses were converted into other categories, such as the transition from cultivated fields to rangelands or old fields. The Sankey diagram was used as a descriptive tool and did not involve any statistical testing. Its purpose was to offer qualitative insights into the dynamics of land use transitions, complementing the quantitative analyses.

4.7 Size and age analysis (SWEP data & independent analysis)

The relationship between wildlife ranch age and size was analysed by generating a scatterplot with a trendline to visually assess the potential association. Before performing the regression analysis, the data were checked to ensure they met the assumptions of linear regression. Linearity and homoscedasticity were evaluated using residual plots, and the normality of residuals was tested using the Shapiro-Wilk test. No significant violations of assumptions were detected, validating the use of linear regression for this analysis. A simple linear regression analysis was then conducted, with age as the independent variable and current size as the dependent variable. This regression analysis yielded a line of best fit, allowing for an assessment of any statistically significant association between these two variables. A second scatter plot was created to explore the relationship between enterprise age and property size changes over time, and a linear regression analysis was done. The regression line indicated the trend in size change as a function of enterprise age, with p-values and R-squared values calculated to assess statistical significance and explain variability.

The data were visualised using box plots, which displayed the distribution of property ages and size changes within each business model to investigate variations in property age and size across different business models. To statistically assess these differences, a one-way ANOVA test was initially performed to compare property ages among business models, with a p-value calculated to evaluate statistical significance. Due to variations in data distributions, additional statistical tests were done to ensure robust comparisons. The Kruskal-Wallis test was applied for property age to account for unequal variances and non-parametric data characteristics. Similarly, Kruskal-Wallis tests were done to examine changes in property size across business models to assess differences in mean and median property size changes.

4.8 Land cover change analysis (Independent spatial analysis)

This study utilised the South African National Land Cover (SANLC) datasets from 1990 and 2022, sourced from the DFFE via the E-GIS platform. The South African Protected Area Database (SAPAD) was also obtained from E-GIS for contextual analyses. These datasets provided comprehensive geospatial information on land cover across South Africa, supporting analyses of natural versus non-NLC, the extent of old fields, and other land use categories relevant to wildlife ranching. The SANLC datasets offer standardised classification schemes across years, facilitating reliable comparisons of land cover changes over time. This enabled an examination of both broad trends and specific landscape features within the context of wildlife ranching.

The SANLC datasets were generated using remote sensing technologies integrating satellite imagery with ground-truthing techniques to improve classification accuracy. The 1990 dataset relied on Landsat Thematic Mapper imagery, supplemented by aerial photographs and manual digitisation . The 2022 dataset, developed using more advanced classification methods and higher-resolution imagery, captured nuanced transitions in vegetation cover with improved precision. This methodological consistency across datasets, such as the use of similar classification systems and imaging resolutions—minimised discrepancies that might arise from differing technologies, thereby improving the reliability of cross-temporal comparisons.

The choice to use the 1990 and 2022 SANLC datasets for assessing NLC changes was based on their comparability and alignment with previous studies. Unlike the change product used by Smit et al. (2024), which focused on a specific type of transformation (e.g., expansion of old fields or cultivated areas), this study reclassified and analysed land cover types directly from raw SANLC data to provide a more detailed examination of transitions across a broader range of land use categories. While the Smit et al. (2024) study employed a pixel-based change detection approach, this study prioritised the reclassification of datasets to align with social-ecological questions about natural and modified land cover changes relevant to wildlife ranching. Both approaches share a commitment to consistent temporal and spatial methods, ensuring robust analyses of NLC changes over time. Still, this study aimed to address broader land use transitions beyond those explicitly linked to specific conservation areas. All spatial analyses was done using ArcGIS Pro (version 3.3). The minus tool from the spatial analyst toolbox was used to assess changes in natural land cover between 1990 and 2022. Additionally, land use classifications and transitions were processed using the reclassification tool and raster calculations.

Reclassification was done in ArcGIS Pro to create a consistent framework for comparing land cover across years. Each land cover type was assigned values based on its classification as either natural or human-modified, following definitions used in previous studies (Smit et al., 2024). Natural land cover was defined as areas dominated by indigenous vegetation, including forests, grasslands, and thickets, as these categories are critical for biodiversity conservation and align with definitions in national biodiversity assessments. Non-NLC included areas modified by human activities, such as cultivated fields, planted pastures, residential zones, and industrial sites. Water bodies and dynamic features, such as seasonal rivers and temporary wetlands, were excluded from the analysis to minimise variability over time. To address the issue of fragmented land cover categories, roads and rail networks were dissolved into the surrounding majority land-cover class using a 5x5 moving window filter. This step ensured continuity and reduced artificial fragmentation of landscape data. Reclassification also involved assigning numeric values to each land cover class to standardise the analysis and focus on transformations relevant to NLC.

Tables summarising the 1990 and 2022 SANLC reclassifications (Table 4-2 and Table 4-3) provide a detailed breakdown of each land cover class and its assigned value in this analysis. These reclassifications underpin the subsequent analyses of land cover transitions and their implications for conservation and land use management within wildlife ranches.

Table 4-2: 1990 South African national land cover reclassification for natural and non-NLC

1990 SANLC Reclassification	
Land Cover Class	**Assigned Value**
Indigenous Forest	1
Thicket /Dense bush	1

Woodland/Open bush	1
Low shrubland	1
Plantations / Woodlots	2
Cultivated commercial annual crops non-pivot	2
Cultivated commercial annual crop pivot	2
Cultivated commercial permanent orchards	2
Cultivated commercial permanent vines	2
Cultivated subsistence crops	2
Settlements	2
Wetlands	0
Grasslands	1
Fynbos: forest	1
Fynbos: thicket	1
Fynbos: open bush	1
Fynbos: low shrub	1
Fynbos: grassland	1
Fynbos: bare ground	2
Nama Karoo: forest	1
Nama Karoo: thicket	1
Nama Karoo: open bush	1
Nama Karoo: low shrub	1
Nama Karoo: grassland	1
Nama Karoo: bare ground	2
Succulent Karoo: forest	1
Succulent Karoo: thicket	1
Succulent Karoo: open bush	1
Succulent Karoo: low shrub	1
Succulent Karoo: grassland	1
Succulent Karoo: bare ground	2
Mines	2
Waterbodies	0
Bare Ground	2
Degraded	2

Table 4-3: 2022 South African national land cover reclassification for natural and non-NLC

2022 SANLC Reclassification	
Land Cover Class	**Assigned Value**
Contiguous (indigenous) forest	1
Contiguous low forest & thicket	1
Dense forest & woodland	1
Open woodland	1
Contiguous & dense plantation forest	2
Open & sparse plantation forest	2
Temporary unplanted (clear-felled) plantation forest	2
Low shrubland (other)	1
Low shrubland (fynbos)	1
Low shrubland (succulent karoo)	1
Low shrubland (nama karoo)	1
Sparsely wooded grassland	1
Natural grassland	1
Natural rivers	0
Natural estuaries & lagoons	0
Natural ocean & coastal	0
Natural lakes	0
Natural pans (flooded @ observation times)	0
Artificial dams (including canals)	0
Artificial sewage ponds	0
Artificial flooded mine pits	0
Herbaceous wetlands (currently mapped)	0
Herbaceous wetlands (previously mapped)	0
Mangrove wetlands	0
Natural rock surfaces	1
Dry pans	0
Eroded lands	2
Sand dunes (terrestrial)	1
Coastal sand & dunes	1
Bare riverbed material	0
Other bare	2
Cultivated commercial permanent orchards	2

Cultivated commercial permanent vines	2
Cultivated commercial sugarcane pivot irrigated	2
Cultivated commercial permanent pineapples	2
Cultivated commercial sugarcane non-pivot	2
Cultivated emerging farmer sugarcane non-pivot	2
Commercial annual crops pivot irrigated	2
Commercial annual crops non-pivot irrigated	2
Commercial annual crops rain-fed / dryland	2
Subsistence / small-scale annual crops	2
Fallow land & old fields (trees)	2
Fallow land & old fields (bush)	2
Fallow land & old fields (grass)	2
Fallow land & old fields (bare)	2
Fallow land & old fields (low shrub)	2
Residential formal (tree)	2
Residential formal (bush)	2
Residential formal (low veg / grass)	2
Residential formal (bare)	2
Residential informal (tree)	2
Residential informal (bush)	2
Residential informal (low veg / grass)	2
Residential informal (bare)	2
Village scattered (bare & low veg/ grass combo)	2
Village dense (bare & low veg / grass combo)	2
Smallholdings (tree)	2
Smallholdings (bush)	2
Smallholdings (low veg / grass)	2
Smallholdings (bare)	2
Urban recreational fields (tree)	2
Urban recreational fields (bush)	2
Urban recreational fields (grass)	2
Urban recreational fields (bare)	2
Commercial	2
Industrial	2

Roads & rails (major linear)	2
Mines: surface infrastructure	2
Mines: extraction pits, quarries	2
Mines: salt mines	2
Mine: tailings and resource dumps	2
Land-fills	2
Fallow land & old fields (wetlands)	0

Percentage changes in NLC were calculated by comparing reclassified values between the 1990 and 2022 SANLC datasets using the minus tool in ArcGIS Pro (v3.3). This analysis was done separately for wildlife ranches in the Eastern Cape and Limpopo to assess provincial variations (n = 292 wildlife ranches). Additionally, the same method was applied to PAs within these provincial to facilitate a comparative assessment of NLC loss and gain.. SWEP provided the spatial boundaries for wildlife ranches by extracting cadastral data to create the initial maps, which were then verified through landowner confirmations. As part of this process, I was directly involved in mapping and validating some of these boundaries. Therefore, the final spatial dataset represents a combination of cadastral data and landowner-confirmed property outlines. The analysis began by assessing average NLC loss and gain across properties over this period. Box plots were created to visualise these distributions as percentages of the total property area, showing the median, interquartile range, and outliers for NLC loss and gain. Given the non-parametric nature of the data, a Mann-Whitney U test was applied to statistically compare the distributions of NLC loss and gain, assessing whether land cover loss was significantly higher than gain across wildlife ranch properties.

Further analysis compared NLC loss between the Eastern Cape and Limpopo provinces, with box plots highlighting province variability. A Mann-Whitney U test evaluated the statistical significance of differences between the two provinces. Box plots were generated to illustrate NLC loss distributions across different business models, including protected areas. These plots display the median, interquartile range (IQR), and outliers to highlight variations in land cover change among business models. Data were derived from the reclassified SANLC 1990 and 2022 datasets, with percentage NLC loss calculated for each wildlife ranch.. A Kruskal-Wallis H-test was done to assess the significance of differences in NLC loss across business models, facilitating a non-parametric comparison to determine if specific business models were associated with higher NLC loss rates from 1990 to 2022.

Beyond NLC analysis, the study also examined the contribution of old fields within the non-NLC category across different business models. Since old fields are classified as a non-NLC in the SANLC dataset, an additional step was taken to isolate old fields from other non-NLC categories. This allowed for an assessment of the proportion of non-NLC land cover that consists specifically of old fields.. For each business model, non-NLC and old field proportions were calculated as percentages of total property area. These values were visualised in bar graphs, with separate bars for non-NLC and old fields alongside error bars representing standard error. An ANOVA test was performed separately for non-NLC and old field proportions to assess the significance of differences across business models. This approach provided insights into land restoration patterns within wildlife ranches and highlighted how historical land uses, such as old fields, affect current ecological characteristics across diverse business models.

Several limitations were noted with the SANLC datasets and this classification approach. First, the datasets did not account for invasive species or bush encroachment within natural areas, potentially leading to degraded areas being misclassified as natural vegetation (Thompson *et al.*, 2013). Additionally, old fields in transition to natural vegetation were classified as non-NLC, even though they might be undergoing partial restoration, whether active or passive (Clements et al., 2021; Smit et al., 2024). The binary classification of natural and non-natural cover may oversimplify the complex status of certain lands, particularly those in the process of partial restoration.

The SANLC datasets' static snapshots from 1990 and 2022 further limit this analysis, as they capture land cover at only two points in time, potentially missing shorter-term changes that might influence NLC outcomes (Smit et al., 2024). This temporal gap could omit critical transitions, such as short-term agricultural cycles or rapid restoration efforts, which might provide more detailed insights into land use dynamics. Finally, the broad classification categories used in the SANLC datasets may mask smaller-scale ecological nuances within properties, particularly in mixed land use areas, potentially omitting high-value ecosystems embedded within non-natural areas (Driver et al., 2020).

5. Results

5.1 Land use history

5.1.1 Year to wildlife ranching

The progression of property conversions to wildlife use over time shows an initial gradual adoption followed by an accelerated trend starting around 1990 and continuing through 2020 (Figure 5-1). The cumulative curve illustrates this pattern, with a slow increase in conversions until approximately 1990, after which the rate significantly accelerates, resulting in a steeper upward trend. Segmented regression analysis identifies a statistically significant breakpoint at 1992 (Estimate = 1992.27, SE = 0.26), dividing the timeline into two phases. Before 1992, the conversion rate is slow, at an estimated 0.90 properties per year (Estimate = 0.90, SE = 0.068). After 1992, the rate sharply increases to 6.07 properties per year (Estimate = 6.07, SE = 0.094), highlighting a substantial shift in conversion activity post-breakpoint.

Including wildlife ranch age as a covariate in the model did not significantly influence the cumulative conversion rate (Estimate = -0.024, SE = 0.033, p = 0.47), suggesting that the duration of a ranch's operation does not affect the observed trend. The segmented regression model demonstrates excellent fit (R^2 = 0.991), explaining over 99% of the variation in cumulative conversions, underscoring the robustness of the identified breakpoint and phase-specific trends.

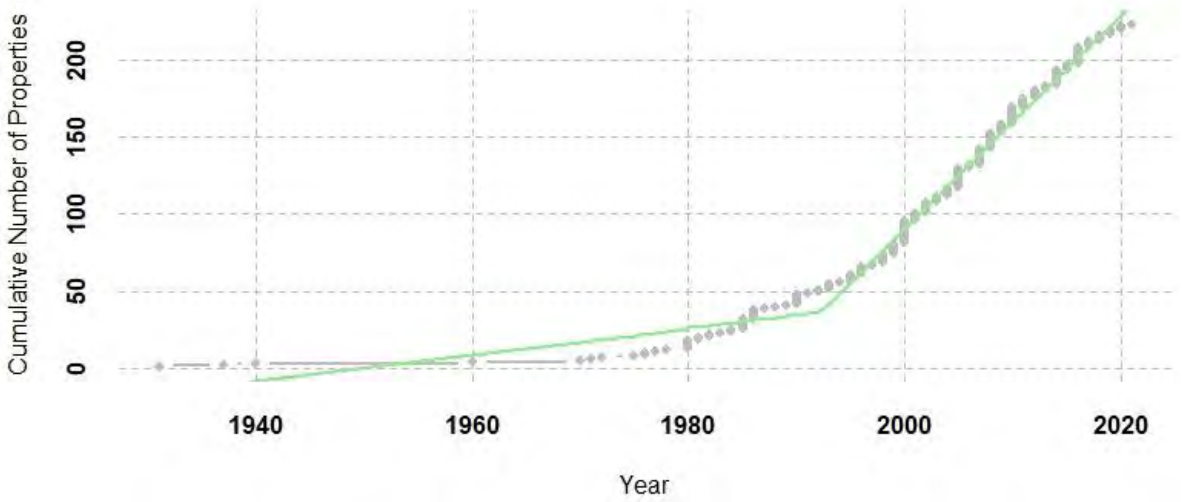


Figure 5-1: Cumulative number of properties converted to wildlife use over time with segmented regression analysis

5.1.2 Land use activity history

The distribution of land use activity themes across wildlife ranches reveals shifting priorities over time, with distinct trends emerging from the pre-1960s to the 2020s (Figure 5-2). Each bar represents a decade, segmented by the relative frequency of themes, including breeding, cultivation of crops, ecotourism, hunting, and livestock farming. The total number of properties surveyed per decade is indicated above each bar. In the pre-1960s (n = 39 properties), livestock farming dominated land use themes (53.8%), followed by traditional livestock farming (35.9%). Other themes, including cultivation of crops, hunting, and breeding, were less frequent, at 2.6%, 5.1%, and 2.6%, respectively. During the 1960s (n = 21 properties), livestock farming further increased to 66.7%, with cultivation of crops comprising the remaining 33.3%.

In the 1970s (n = 31 properties), livestock farming remained significant (32.3%), alongside cultivation of crops (25.8%) and traditional livestock farming (35.5%). Hunting and breeding were minor, at 6.5% and 2.6%, respectively. The 1980s (n = 13 properties) marked a shift, with cultivation of crops rising to 56.4%, surpassing livestock farming (37.5%). Traditional livestock farming dropped to 5.1%, and no mentions were recorded for other themes. The 1990s (n = 39 properties) saw cultivation of crops predominate (69.0%), while hunting (15.4%) and ecotourism (7.7%) emerged. Traditional livestock farming and breeding were absent during this period. In the 2000s (n = 42 properties), livestock farming regained prominence (28.6%), while cultivation of crops remained substantial (50.0%). Hunting and ecotourism were minor, each at 2.4%. In the 2010s (n = 8 properties), cultivation of crops accounted for 33.3%, while livestock farming (38.5%) and traditional livestock farming (12.5%) remained significant. Hunting and breeding each represented 2.4%.

In the 2020s (n = 6 properties), livestock farming remained dominant (50.0%), with hunting, ecotourism, traditional livestock farming, and cultivation of crops each contributing 16.7%. A chi-square test for independence assessed the association between decades and land use themes, yielding a statistic of $\chi^2 = 77.96$ (df = 28, $p < 0.001$). This result indicates that the frequency of land use themes varied markedly across decades, highlighting changes in priorities and practices over time.

Figure 5-2: Proportion of land use activities on wildlife ranches by decade, showing shifts in priority land use activities

5.1.3 Timeline of policies and events associated to changes in wildlife ranches

The timeline table summarises key legislative and policy developments affecting wildlife ranching in South Africa (Table 5-1). The apartheid-era policies, notably the Bantu Homelands Citizenship Act of 1970, entrenched racial segregation by allocating land primarily for privileged uses. This segregation created lasting impacts on land ownership patterns, which were partially addressed by the Restitution of Land Rights Act of 1994 as post-apartheid reforms aimed to rectify historical injustices.

The 1980s and 1990s marked a shift toward formalised conservation on private land. Key legislation, such as the Environmental Conservation Act of 1983 and the Game Theft Act of 1991, empowered private landowners by recognising their rights to conserve, manage, and profit from wildlife. Specifically, the Game Theft Act was instrumental in legitimising wildlife ranching as a viable land use, granting property owners legal ownership over game on their lands and encouraging private conservation initiatives. However, this ownership is only applicable if the property is adequately enclosed, as per the requirements of the Act. Properties that do not meet these enclosure standards remain subject to common law principles, where wildlife remains a ownless resource. Post-apartheid environmental policies further bolstered conservation on private lands, with the National Environmental Management: Biodiversity Act of 2004 establishing regulatory frameworks to ensure biodiversity conservation on private property. This was complemented by the National Environmental Management: Protected Areas Act of 2003, which provided a legal structure for private lands to be declared PAs, thereby integrating private wildlife ranches into the broader conservation landscape. More recent developments, including the Spatial Planning and Land Use Management Act of 2013 and the Land Expropriation Motion of 2018, reflect ongoing efforts to address land reform and ownership issues in South Africa.

Table 5-1: Key legislative and policy developments influencing wildlife ranching in South Africa

Year / Period	Details
1919	Agricultural Holdings Registration Act - Originally intended to manage agricultural lands, this Act defined land use parameters that later indirectly influenced the transformation of agricultural holdings into wildlife ranches as economic conditions evolved (Claasens and Cousins, 2022).
1962	Animal Protection Act - Established early standards for animal welfare, mandating humane treatment and influencing future wildlife management practices on private ranches, significantly as private game ownership grew.
1970	Bantu Homelands Citizenship Act - Enforced racial segregation by creating designated 'homelands' for black South Africans, leading to mass dispossession of land and impacting future wildlife ranching regions as many were reserved for privileged hunting areas (Worden, 2011).
1983	Environmental Conservation Act - A landmark law for sustainable development. It encouraged conservation by making it a 'duty' of landowners to protect natural resources, supporting emerging private conservation areas (Carruthers, 2008).
1983	Conservation of Agricultural Resources Act (CARA) - Required landowners to prevent soil erosion and maintain natural vegetation, directly impacting wildlife ranchers who needed to balance agricultural and conservation practices.
1990 - 2000	Reduction in Agricultural Subsidies - The gradual reduction in government agricultural subsidies made traditional farming less viable in semi-arid and arid regions, incentivising landowners to shift to wildlife-based enterprises as a more profitable land-use strategy.
1991	Game Theft Act - Enabled private ownership of wildlife. Under Section 2, it declared that 'the ownership of game on land vests in the owner of such land,' allowing ranchers to profit from and protect wildlife. This Act catalysed the growth of the private wildlife ranching industry (De Villiers, 2003).
1994	Restitution of Land Rights Act - Key post-apartheid law for land reform. It allowed dispossessed individuals to reclaim ancestral lands, affecting ownership of conservation areas and wildlife ranches, which had to accommodate land claims.
2003	National Environmental Management: Protected Areas Act - Permitted to establish PAs on private land, allowing wildlife ranchers to benefit from legal protection while contributing to conservation.
2004	National Environmental Management: Biodiversity Act - Aiming to conserve biodiversity, this Act regulated the use of natural resources, influencing ranchers by delegating sustainable wildlife practices (Claasens and Cousins, 2022).
2008	Financial policy change on loss deduction - A new tax policy prevented landowners from deducting losses from one property/business against gains from another, increasing financial pressure and leading many to transition to more profitable wildlife-based business models, such as ecotourism, game breeding, and trophy hunting.
2004	Communal Land Rights Act - Provided communal land ownership rights and aimed to empower local communities with control over conservation land use before it was repealed, briefly impacting wildlife conservation in communal areas (Claasens and Cousins, 2022).

2013	Spatial Planning and Land Use Management Act - Governs land use planning and zoning land for agriculture, conservation, or other uses. This Act gave wildlife ranchers more control over how their land was zoned and used.
2018	Land Expropriation Motion - Sparked national debates on land ownership and use, proposing land expropriation without compensation to rectify historical injustices, including on land designated for wildlife ranching (Kepe and Hall, 2018).
2020-2022	The COVID-19 Pandemic - Created economic challenges for wildlife ranchers as tourism declined, prompting them to diversify income sources and adapt business models to focus on local markets (Clements et al., 2022).

5.2 Land use change

5.2.1 Proportional overall change

The proportional shifts in land use categories, covering cultivated fields, planted pastures, old fields, rangelands, and wetlands, highlight key trends in land management within wildlife ranches (Figure 5-3). The proportional change for cultivated fields shows a statistically significant decrease of approximately 2.48% (p = 0.00001, n = 225). This indicates a notable reduction in land dedicated to cultivated fields over the study period. Planted pastures exhibited a small and statistically non-significant change of approximately 0.18% (p = 0.69, n = 225), suggesting relatively stable land use patterns for this category over time. Old fields experienced a statistically significant proportional increase of about 2.33% (p = 0.002, n = 225), signifying a considerable expansion of land designated as old fields during the study period. Rangelands displayed a moderate proportional change of approximately 1.08% (p = 0.087, n = 225). Lastly, wetlands demonstrated a minor proportional change of approximately 0.29% (p = 0.201, n = 225), indicating minimal alterations in the extent of wetland areas.

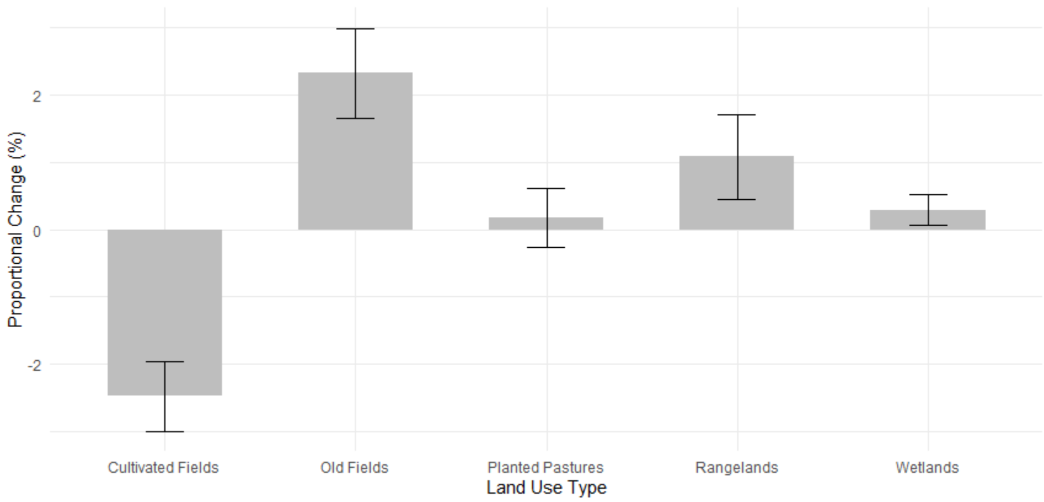


Figure 5-3: Proportional change in different land use types on wildlife ranches

5.2.2 Land use transitions over time

The transitions between land use categories reveal significant shifts in land allocation, illustrating changes from initial to current land use states across various categories (Figure 5-4). Each category initially accounted for 100% of its designated land, with varying proportions transitioning to other uses over time. However, in some cases, the cumulative proportions exceed 100%. This occurs because the transitions are calculated based on the original land allocation compared to its current size. This reflects expansions or reductions in land use categories due to changes in property management, land acquisition, or other factors. Initially, cultivated fields comprised 100% of the land designated for this category. Over time, a substantial portion of this land transitioned to other categories. As a result, 20.18% of cultivated fields remained as cultivated, while 31.86% changed to planted pastures, 45.37% converted to old fields, and 2.59% shifted to rangelands. Planted pastures also began with 100% of its designated land. The transitions observed for this category show that 9.39% of planted pastures changed to cultivated fields, 40.19% remained as planted pastures, and 50.42% transitioned to old fields. For old fields, which initially accounted for 100% of its designated land use, the transitions resulted in 10.71% changing to cultivated fields, 24.51% shifting to planted pastures, 58.13% remaining as old fields, and 6.65% converting to rangelands. Starting at 100%, Rangelands saw most of its land, 92.73%, remaining within the same category. However, there were also transitions, with 1.31% of rangelands changing to cultivated fields and 5.96% shifting to planted pastures.

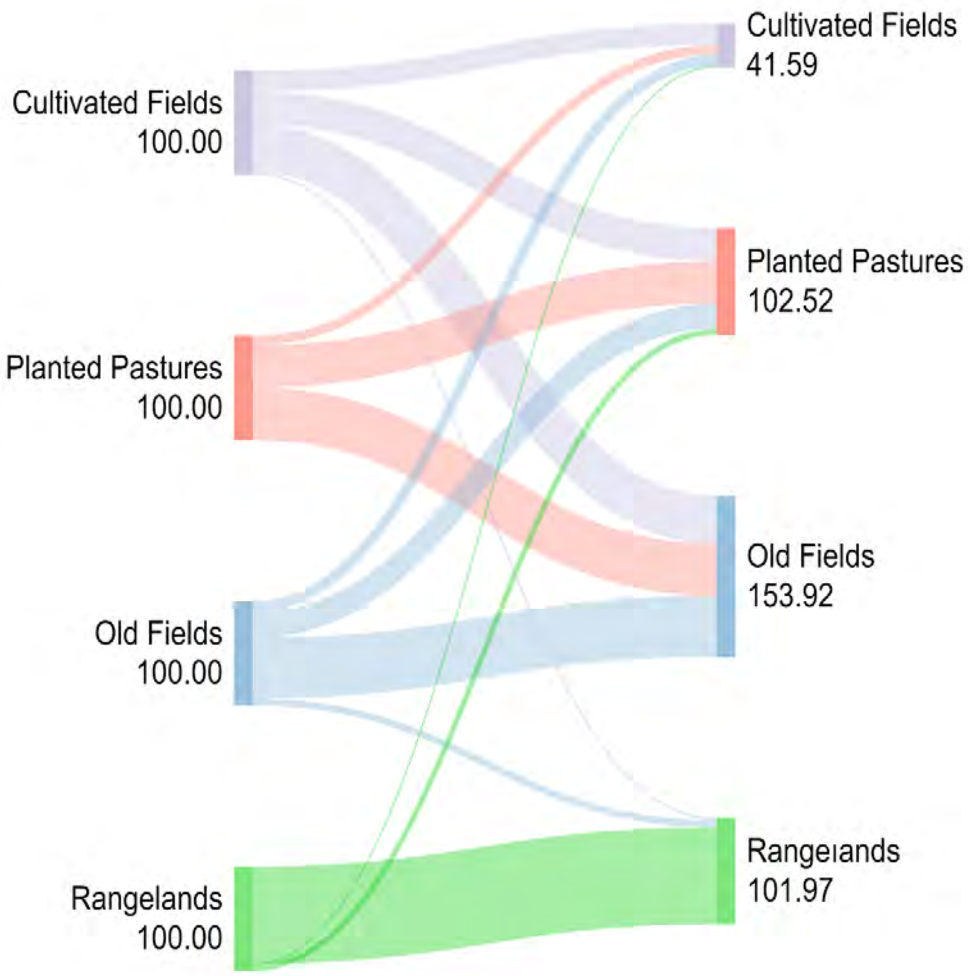


Figure 5-4: Land use transitions across wildlife ranches, showing what each land use changed into over time

5.2.3 Land use change across business models

Analysis of land use changes across different business models indicated distinct trends in the proportions of cultivated fields, planted pastures, old fields, and rangelands (Figure 5-5). Changes in land use proportions were assessed using ANOVA. In the ecotourism model, significant reductions were observed in cultivated fields and planted pastures. Cultivated fields decreased by 5.03% (SE = 2.26, p = 0.008, n = 140), while planted pastures showed a non-significant decrease of 3.34% (SE = 1.69, p = 0.07), approaching statistical significance. Additionally, ecotourism properties experienced a significant increase in old fields, with an 8.31% rise (SE = 3.59, p = 0.004). Rangelands, however, remained stable with a minor and non-significant increase of 0.22% (SE = 0.83, p = 0.92). These findings suggest a shift away from cultivated fields and planted pastures within the ecotourism model, with a corresponding increase in old fields. The livestock properties exhibited distinct changes in both cultivated fields and planted pastures. Cultivated fields showed a significant decrease of 8.82% (SE =

4.22, *p* = 0.004), while planted pastures experienced a significant increase, rising by 6.56% (SE = 2.68, *p* = 0.007). Old fields and rangelands within the livestock model remained relatively stable, with old fields increasing slightly by 2.33% (SE = 1.98, *p* = 0.41) and rangelands showing a negligible change of -0.07% (SE = 0.79, *p* = 0.98).

Mixed hunting model properties did not show significant changes across land use types. Cultivated fields showed a minor decrease of 0.83% (SE = 0.75, p = 0.55), while old fields increased slightly by 1.06% (SE = 0.77, *p* = 0.58). Planted pastures and rangelands also remained stable, with changes of -0.14% (SE = 0.11, *p* = 0.92) and -0.28% (SE = 0.18, *p* = 0.87), respectively. The stability across all land use types suggests that the mixed hunting model maintained a consistent approach to land use without significant shifts in any particular category. The mixed wildlife-agriculture model also displayed relatively minor changes, with no statistically significant shifts across land use types. Cultivated fields showed a slight increase of 0.20% (SE = 0.10, *p* = 0.91), while old fields decreased by 2.54% (SE = 3.63, *p* = 0.33). Planted pastures exhibited a non-significant increase of 2.73% (SE = 3.61, p = 0.13), and rangelands remained almost unchanged with a minor decrease of 0.08% (SE = 0.08, *p* = 0.97). For the trophy hunting model, a significant increase was observed in rangelands, which increased by 4.03% (SE = 3.11, *p* = 0.02). Other land use types within the trophy hunting model did not show significant changes. Cultivated fields decreased by 2.03% (SE = 1.40, *p* = 0.16), while old fields and planted pastures remained stable with changes of +2.94% (SE = 1.46, *p* = 0.14) and +0.09% (SE = 0.28, *p* = 0.95), respectively. The significant increase in rangelands suggests that trophy hunting properties may shift land use towards preserving or expanding rangeland areas, with minimal changes in other types. The wildlife breeding model exhibited no significant changes across land use types. Cultivated fields decreased slightly by 0.46% (SE = 0.37, *p* = 0.75), while old fields showed a small increase of 1.42% (SE = 2.45, *p* = 0.49). Planted pastures decreased by 1.43% (SE = 1.34, *p* = 0.32), and rangelands slightly increased by 0.31% (SE = 1.85, *p* = 0.86).

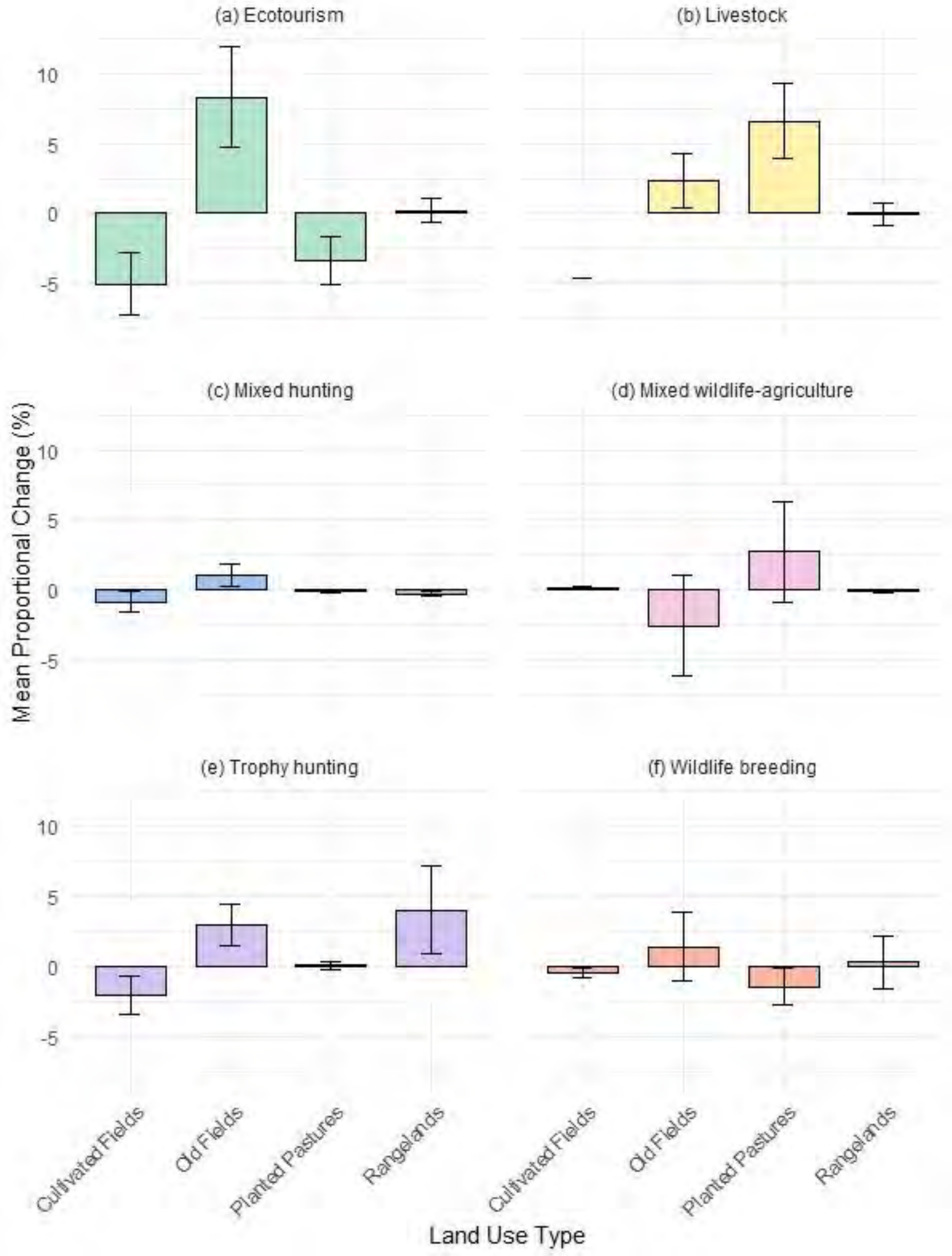


Figure 5-5: Mean proportional change in cultivated fields, old fields, planted pastures, and rangelands across the different business models

5.3 Motivations and drivers behind land use changes

5.3.1 Motivations of land use change per land use

The motivations and drivers behind land cover transitions in wildlife ranches reveal a range of economic, environmental, and historical factors influencing land use decisions (Table 5-2). Key themes were identified across four major land use categories. These themes include water availability, historical legacy, economic motivations, land rehabilitation, property expansion and acquisition, and planting and fodder production.

Water availability emerged as the most frequently mentioned factor, accounting for 31.25% of responses. Drought or insufficient water availability often made cultivation difficult, leading to the abandonment of many fields, resulting in a net loss of cultivated fields. Historical legacy was the second most frequent factor (20.31%), where cultivation ceased before current owners took over, leaving the land fallow. Economic motivations, cited by 20.31% of respondents, included high input costs and the need to diversify income streams, making continued cultivation economically unfeasible. Land rehabilitation accounted for 17.19% of responses, where efforts were made to improve land quality and restore natural vegetation, resulting in a gain. Property expansion and acquisition (3.13%) led to the continuation of cultivation on newly acquired lands, while planting and fodder production (7.81%) indicated that fields were used to produce food for game, showing both gains and losses in cultivated land.

The most significant factors for changes in planted pastures were planting and fodder production, which were mentioned 30% of the time. The increased demand for feed drove the expansion of planted pastures to support livestock and game, resulting in gains. Water availability was the second most frequent factor (27.14%), with changes in pasture management influenced by the need for more grazing land or diversified income due to water scarcity, resulting in both gains and losses. Land rehabilitation, cited by 24.28% of respondents, saw pastures left to recover into natural vegetation, resulting in losses. Property expansion and acquisition (11.43%) involved the acquisition of additional land for planting, leading to gains. Economic motivations were noted in 4.28% of responses, driven by the high cost of purchased fodder. Historical legacy was the least mentioned factor (2.86%), where past decisions to plant pastures were not continued by new landowners, leading to gains.

Land rehabilitation was the most frequently mentioned driver of change in old fields, accounting for 56.25% of responses. Active efforts to restore natural vegetation and improve land quality led to significant gains in this category, suggesting that ranchers are improving old fields. Property expansion and acquisition (16.67%) was the second most frequent factor, where increased property size through land acquisition altered land use patterns, resulting in gains. Water availability (13.54%) was also a notable factor, with drought and water shortages rendering cultivation unfeasible, resulting in the abandonment of fields and gains in old fields. Economic motivations (5.21%) led to fields being left to revert to their natural state due to the unprofitability of crops, resulting in both gains and losses. Planting and fodder production (6.25%) involved converting old fields for agricultural purposes, resulting in losses. Historical legacy accounted for 2.08% of the responses, with past land use decisions leaving fields uncultivated, leading to gains.

Property expansion and acquisition were the most amount drivers of changes in rangelands, mentioned in 56.90% of responses. Expanding property holdings and acquiring neighbouring farms increased the area designated as rangelands, leading to a gain in land cover. Land rehabilitation and natural vegetation growth were also necessary, accounting for 22.41% of responses, where acquired lands were rehabilitated and integrated into larger conservation areas, enhancing natural vegetation. Water availability, cited by 8.62%, influenced rangeland transformations, particularly during drought periods, resulting in gains. Economic motivations (6.90%) also played a role, driven by the unprofitability of crops and the advantages of game farming, leading to both gains and losses. Planting and fodder production (5.17%) involved converting some rangelands into planted pastures to support the nutritional needs of livestock and game, leading to losses. Historical legacy was not mentioned as a factor for rangelands.

Table 5-2: Motivations and drivers behind land use change in wildlife ranches for each land use type

Cultivated Fields				
Key Theme	**Occurrences (%)**	**Reasons for Land Use Change**	**Supporting Statements**	**Change Type**
Water Availability	31.25	Drought or insufficient water availability has made cultivation difficult, leading to the abandonment of cultivated fields.	A5: "Drought." LIM117: "Stopped farming due to drought and high Input costs."	Loss
Historical Legacy	20.31	Cultivation was historically stopped or ceased before the current owners took over, resulting in the land being left fallow.	A1: "Historically Stopped cultivation." LIM107: "Stopped cultivation pre current owners."	Loss
Economic Motivations	20.31	High input costs, such as fertiliser and labour, coupled with the need to diversify income streams and changes in market demand, have made continued cultivation economically unfeasible.	LIM102: “High input costs of fertiliser and labour became too expensive.” LIM117: “Stopped farming due to drought and high Input costs.”	Loss
Land Rehabilitation	17.18	Efforts to rehabilitate the land for natural vegetation or wildlife have been initiated to improve land quality and environmental sustainability.	LIM135: “Didn't want degraded lands - wanted to rehabilitate lands.”	Gain
Planting and Fodder Production	7.81	Cultivated fields have been used to produce food for game and generate revenue, ensuring economic viability.	L125: “Food for game and for revenue generation.”	Gain / Loss
Property Expansion and Acquisition	3.12	The expansion of property size or acquisition of new land that already included cultivated fields has led to continued cultivation on these lands.	L44: “When expanding their property they bought more land which already had cultivated fields, therefore they carried on cultivating these lands.”	Gain
Planted Pastures				
Key Theme	**Occurrences (%)**	**Reasons for Land Use Change**	**Supporting Quotes**	**Change Type**
Planting and Fodder Production	30	Increased demand for feed has led to the expansion of planted pastures to support livestock and game.	CH&: “Planted more pastures for feed.”	Gain
Water Availability	27.14	The need for more grazing land and diversified income due to water scarcity has influenced the use of land for planted pastures.	A6: “Drought since 2015.” L58: “Little water in the area therefore the amount of land they could cultivate became constrained by the little water.”	Gain/ Loss
Land Rehabilitation	24.28	Planted pastures have been left to recover towards natural vegetation, aligning with wildlife-based revenue generation strategies.	P14: “Planted pastures were left to recover towards natural vegetation for wildlife-based revenue.”	Loss
Property Expansion and Acquisition	11.42	The acquisition of additional land has increased the area available for planted pastures.	P89: “Bought more land.”	Gain
Economic Motivations	4.28	Economic pressures, including the high cost of fodder, have driven the need to grow pastures to support livestock and game.	L40: “Diversification due to current game prices.” L94: “Fodder is expensive so had to grow own for the horses and game.”	Gain

Historical Legacy	2.85	Previous tenants' decisions to plant pastures, which were not continued by new owners, resulted in changes in land use.	L26: "Past tenants wanted to plant pastures in this area, however, when enterprise started the new farmers did not see the need for a planted pasture."	Gain
Old Fields				
Key Theme	**Occurrences (%)**	**Reasons for Land Use Change**	**Supporting Quotes**	**Change Type**
Land Rehabilitation	56.25	Active efforts to rehabilitate the land have focused on restoring natural vegetation and improving land quality.	LIM108: "They have rehabilitated well. The quality has improved", LIM135: "Didn't want degraded lands - wanted to rehabilitate lands"	Gain
Property Expansion and Acquisition	16.66	The increase in property size through the acquisition of additional land has altered land use patterns, including the management of old fields.	A3: "Increased property size.", LIM1: "Bought another neighboring farm which mostly comprised of rangeland.s"	Gain
Water Availability	13.54	Persistent drought and water shortages have forced fields to be left fallow, as cultivation was no longer viable.	A5: "Planted pastures abandoned due to drought..", A6: "Lack of water.", LIM112: "Drought forcing lands to go fallow."	Gain
Planting and Fodder Production	6.25	Some old fields have been converted for the planting of pastures or other agricultural uses to support livestock and game.	L144: "Used the land to plant."	Loss
Economic Motivations	5.20	Economic challenges, such as the unprofitability of crops, have led to fields being left to revert to their natural state.	L104: Crops were not profitable back then and it has been left to grow back to their natural state.	Gain/ Loss
Historical Legacy	2.08	Historical cessation of cultivation and changes in land ownership have resulted in fields being left uncultivated.	A2: "Stopped cultivation pre current owner. Rainfall related."	Gain
Rangelands				
Key Theme	**Occurrences (%)**	**Reasons for Land Use Change**	**Supporting Quotes**	**Change Type**
Property Expansion and Acquisition	56.89	Expanding property holdings and acquiring neighboring farms have increased the area designated as rangelands.	A4: "Acquired more land", LIM1: "Bought another neighboring farm which mostly comprised of rangelands"	Gain
Land Rehabilitation/Natural Vegetation Growth	22.41	Acquired lands have been rehabilitated and integrated into larger conservation areas, enhancing the natural vegetation.	LIM57: "Bought up farms to rehabilitate and form part of the park. However, bought up farms had more old fields than natural rangeland."	Gain
Water Availability	8.62	Reduced water availability, particularly during drought periods.	P59: "Drought changing wetlands into rangelands."	Gain
Economic Motivations	6.89	Shifts from crop farming to game farming have been driven by the unprofitability of crops and the economic advantages of game farming.	P125: "Crops were not profitable so we moved to game farming."	Gain / Loss
Planting and Fodder Production	5.17	Some rangelands have been converted to planted pastures to support the nutritional needs of livestock and game.	L116: "Transformation to planted pastures."	Loss
Historical Legacy	0	-	-	-

5.3.2 Motivations of land use change per business model

The primary motivations behind land use changes vary across six business models (Figure 5-6). In ecotourism properties, land rehabilitation and natural vegetation growth are the predominant motivation, accounting for 57.1% of land use changes. Economic motivations contribute 21.4%, while property expansion and acquisition account for 14.3%. Other factors are less prominent in this model. For livestock-oriented properties, the distribution is evener. Land rehabilitation and natural vegetation growth represent 30.0%, while economic motivations, property expansion and acquisition, and water availability each account for 15.0%. Land rehabilitation and natural vegetation growth remain prominent in mixed hunting properties, comprising 40.6% of motivations. Economic motivations account for 21.9%, and water availability is 9.4%. Historical reasons appear at 12.5%, adding to the variety in this model. The mixed wildlife-agriculture model presents a diverse mix of motivations. Land rehabilitation and natural vegetation growth is the most frequent at 26.1%, followed by property expansion and acquisition at 21.7% and economic motivations at 17.4%. Historical reasons and planting and fodder production also contribute 13.0% and 8.7%, respectively.

In trophy hunting properties, land rehabilitation and natural vegetation growth are the leading motivations, comprising 38.5%. Economic motivations follow at 23.1%, and property expansion and acquisition account for 15.4%. Water availability and historical reasons appear at lower percentages, 6.9% and 3.9%, respectively. Wildlife breeding properties show a relatively balanced distribution, with land rehabilitation and natural vegetation growth at 29.4% and economic motivations at 14.7%. Property expansion and acquisition are slightly higher at 20.6%, with water availability at 11.8% and planting and fodder production at 14.7%. Across the different business models, land rehabilitation and natural vegetation growth consistently emerge as the most prominent motivations for land use changes. However, the distribution of other motivations varies. Livestock and mixed-wildlife agriculture properties demonstrate an even distribution across multiple motivations, indicating a balanced approach. In contrast, ecotourism and trophy hunting properties are marked by a clear dominance of ecological motivations, with economic considerations playing a secondary role. Mixed wildlife-agriculture and mixed hunting models display a broader spread of motivations, with historical reasons notably present in mixed hunting properties.

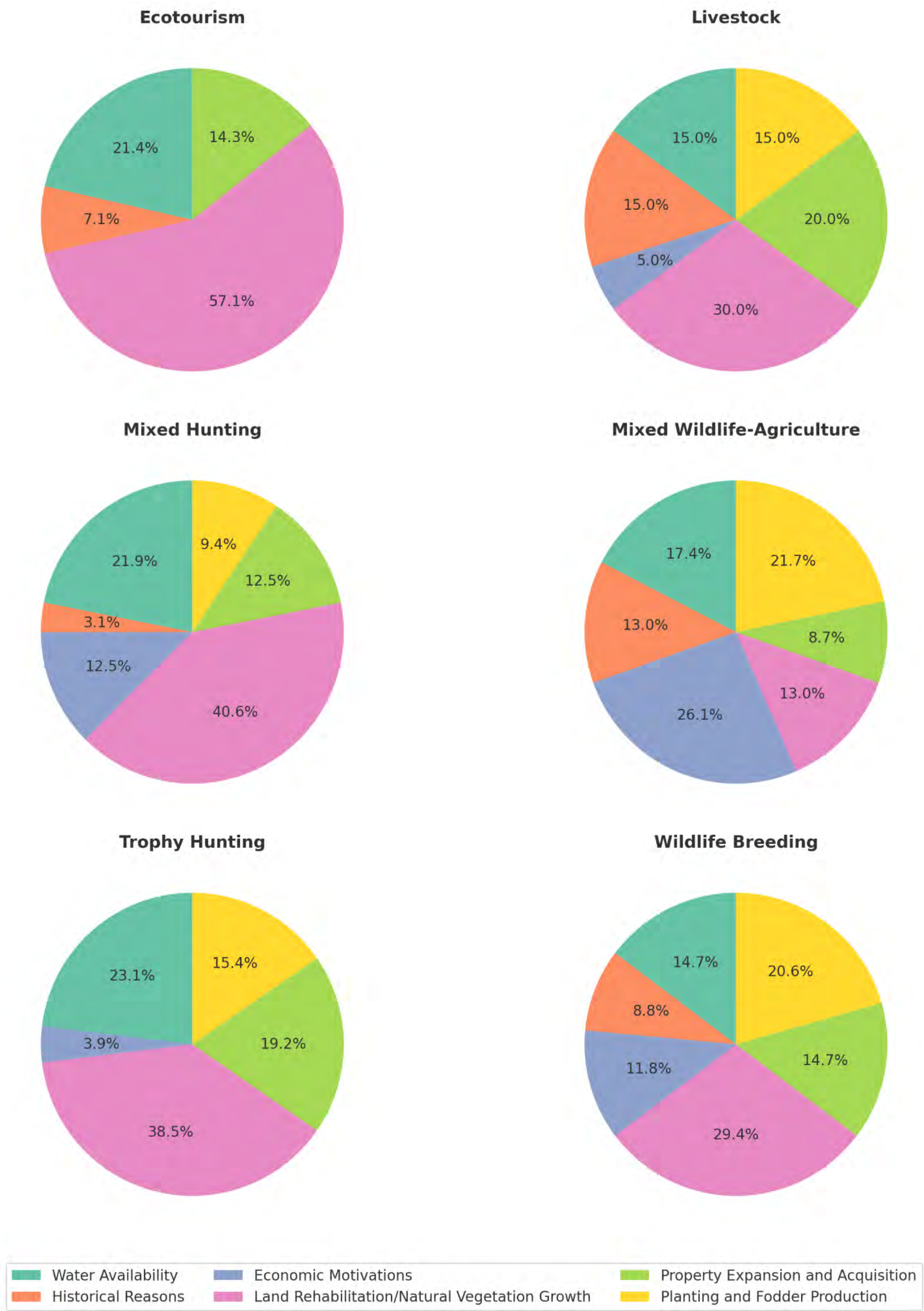


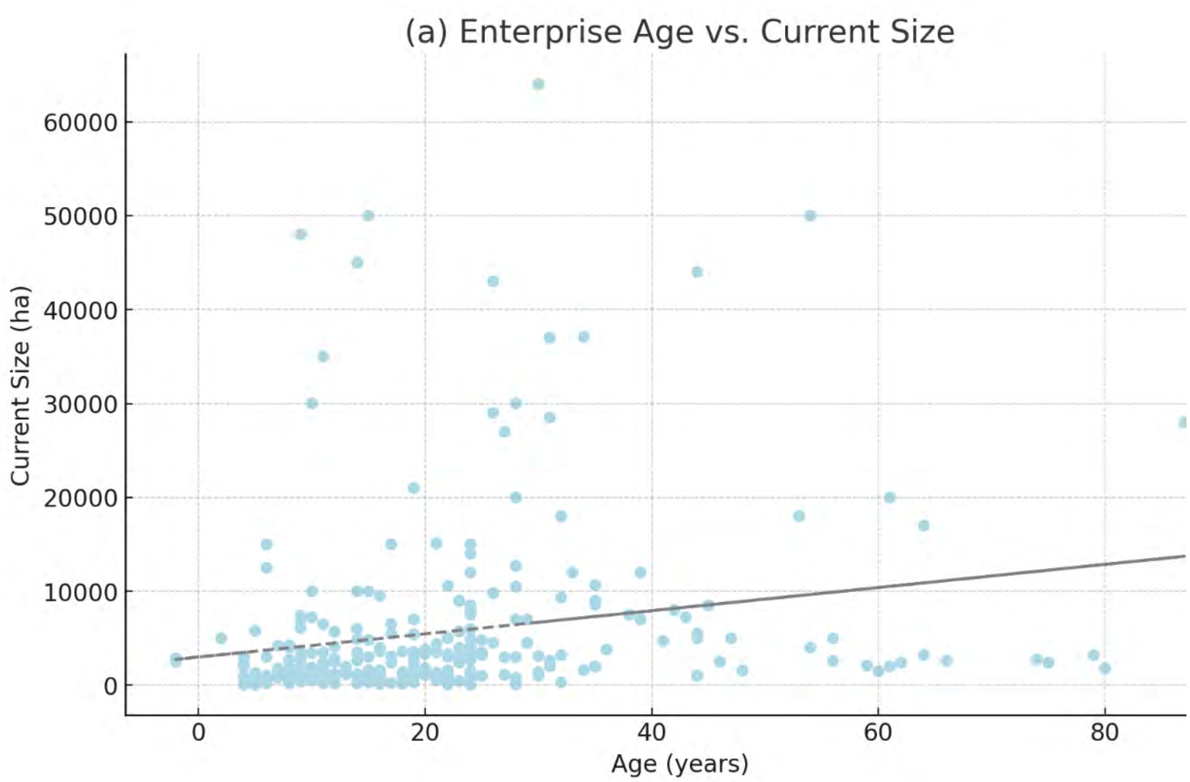
Figure 5-6: Proportions of motivations and drivers for land use change across business models

5.4 Size and age

5.4.1 Overall size and age per business model

Figure 5-7(a) shows the relationship between the age of wildlife ranching enterprises and their current property size. The scatter plot reveals a weak positive trend, where older enterprises tend to have larger current sizes, though with considerable variability. Linear regression analysis indicates a modest slope of 123.36 and an intercept of 3003.53, with low explanatory power ($R^2 = 0.039$). Despite the weak association, the relationship is statistically significant ($p = 0.0011$). The substantial spread of data points around the regression line suggests that factors beyond age likely influence current property size.

Figure 5-7(b) illustrates the relationship between enterprise age and size change, calculated as the difference between current and initial property sizes. The scatter plot and regression line indicate a slightly positive trend, with a slope of 101.37 and an intercept of -94.37 ($R^2 = 0.062$). While the explanatory power is low, the association is statistically significant ($p < 0.001$). The variability in size change across the age range suggests that size change does not consistently increase with age. Some younger enterprises have expanded substantially, while some older enterprises have remained stable or even decreased in size.



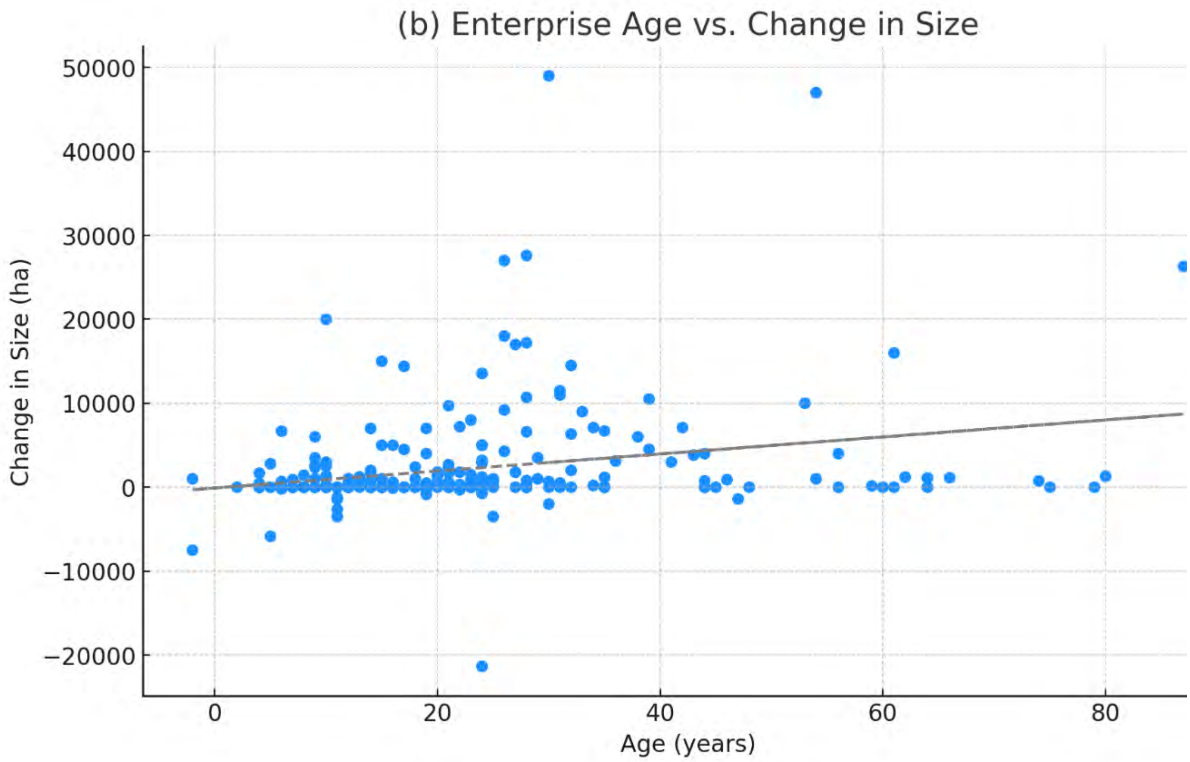


Figure 5-7: Relationship between enterprise age and property size: current size and change in size over time

5.4.2 Property ages and sizes per business model

Figure 5-9 displays the distribution of property ages across business models, revealing some variation but with substantial overlap in the age ranges. Median property ages range from 10 years (IQR = 5–25, n = 36) for trophy hunting properties to 24 years (IQR = 15–40, n = 24) for ecotourism properties. Median ages for other business models are 20 years (IQR = 15–30, n = 17) for livestock, 15 years (IQR = 8–25, n = 40) for mixed hunting, and 18 years (IQR = 10–28, n = 20) for mixed wildlife-agriculture. A Kruskal-Wallis test, used to assess differences in property ages across business models, yielded a chi-square statistic of 2.49 with 4 degrees of freedom (p = 0.812, n = 115). This non-significant result suggests no meaningful differences in median property ages between business models, likely reflecting the observed overlap. Despite this, the ranges of medians, IQRs, and sample sizes highlight the typical property ages within each business model and provide context for understanding variability. These findings suggest that property age is not a distinguishing factor among business models.

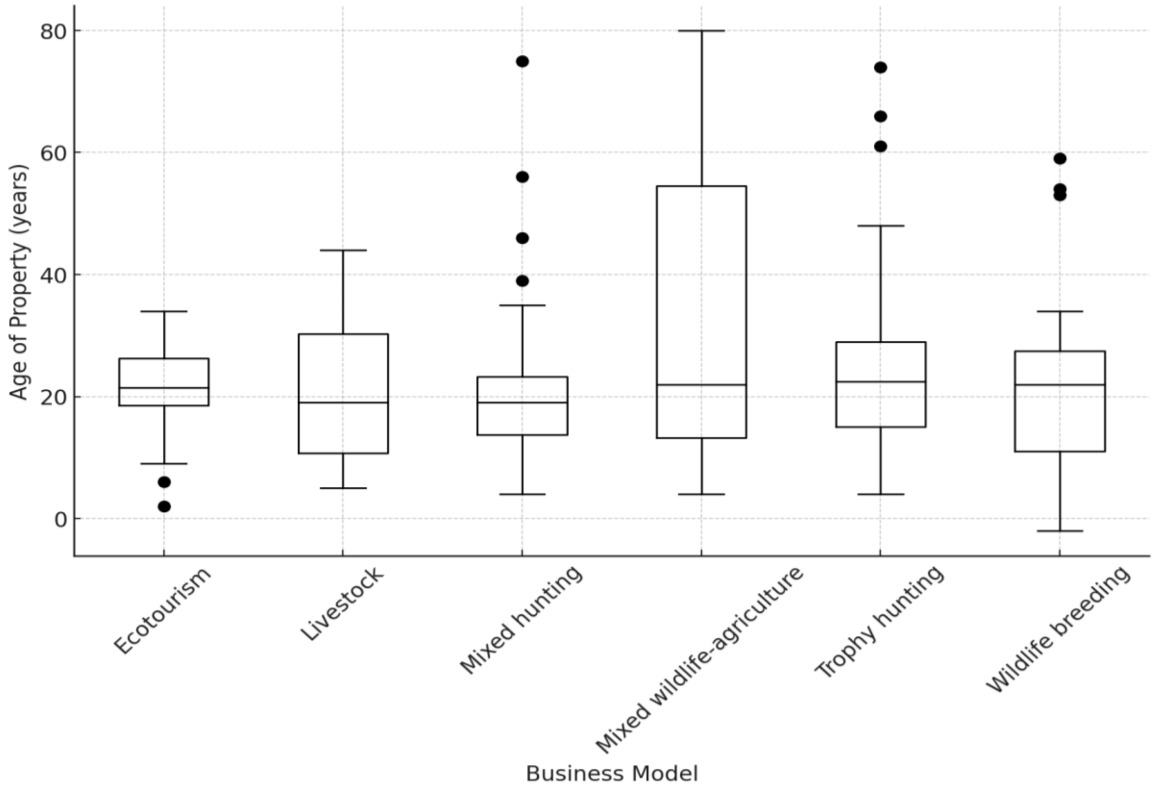


Figure 5-8: Comparison of property age across different business models in wildlife ranches

Figure 5-9 shows the distribution of property size changes across business models, illustrating the median and IQR. Median size changes vary across models, with ecotourism properties showing the largest increase (985 ha, IQR = 300–4,500, n = 24), followed by trophy hunting properties (475 ha, IQR = 100–3,850, n = 36). In contrast, livestock, mixed hunting, and mixed wildlife-agriculture properties all exhibited negligible median changes of 0 ha, with IQRs of -200 to 800 (n = 17), -100 to 950 (n = 40), and -200 to 800 (n = 20), respectively. While a Welch's ANOVA test revealed a statistically significant difference in mean size changes among business models (p = 0.028), suggesting variation driven by specific groups, a Kruskal-Wallis test assessing medians found no statistically significant difference (χ^2 = 6.25, df = 4, p = 0.192). These results highlight the influence of outliers and skewed distributions in the data, as well as the substantial overlap in size changes across business models. Overall, the findings suggest that property size changes are generally similar, with some exceptions in specific models like ecotourism and trophy hunting.

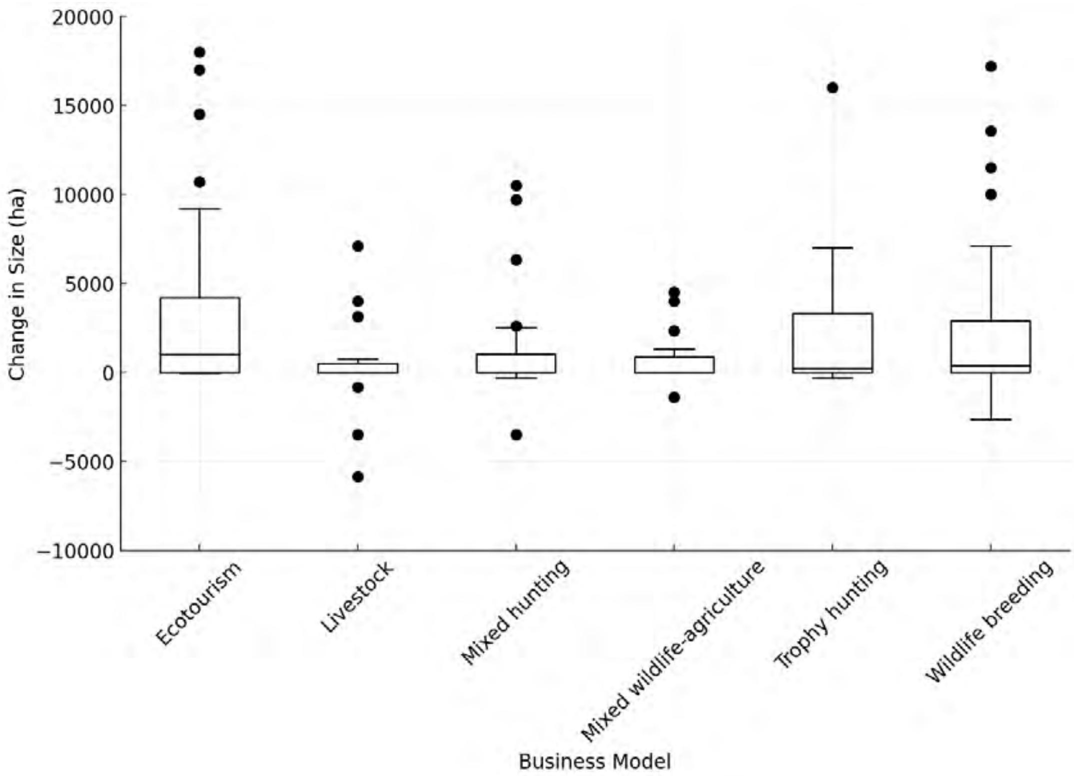


Figure 5-9: Comparison of average property size across different business models in wildlife ranches

5.5 Natural land cover

5.5.1 Average natural land cover

Between 1990 and 2022, patterns of NLC and gain differed notably between wildlife ranches and PAs (Figure 5-10). Wildlife ranches demonstrated a lower median percentage of NLC loss (0.75%, IQR = 2.18%, mean = 1.81%), compared to PAs, which had a higher median NLC loss of 1.39% (IQR = 3.99%, mean = 4.43%). Similarly, NLC gains were more limited on wildlife ranches, with a median gain of 0.12% (IQR = 0.35%, mean = 0.41%), compared to PAs, which exhibited a higher median NLC gain of 0.35% (IQR = 0.99%, mean = 1.47%). These differences suggest that wildlife ranches generally experienced more consistent, modest changes in NLC, whereas PAs exhibited greater variability, as evidenced by larger IQRs and notable outliers. Statistical analyses confirmed these differences. A Kruskal-Wallis test revealed significant differences in both NLC loss (χ^2 = 14.67, df = 1, p = 0.00013) and NLC gain (χ^2 = 48.12, df = 1, p < 0.00001) between wildlife ranches and PAs. Pairwise comparisons using the Wilcoxon rank-sum test with Bonferroni correction supported these findings. For NLC loss, PAs had significantly higher values than wildlife ranches (p = 0.00013). Similarly, for NLC gain, PAs exhibited significantly higher percentages than wildlife ranches (p < 0.00001). These results underscore the differing trajectories of NLC change, with PAs showing greater losses and gains than the more stable patterns observed on wildlife ranches.

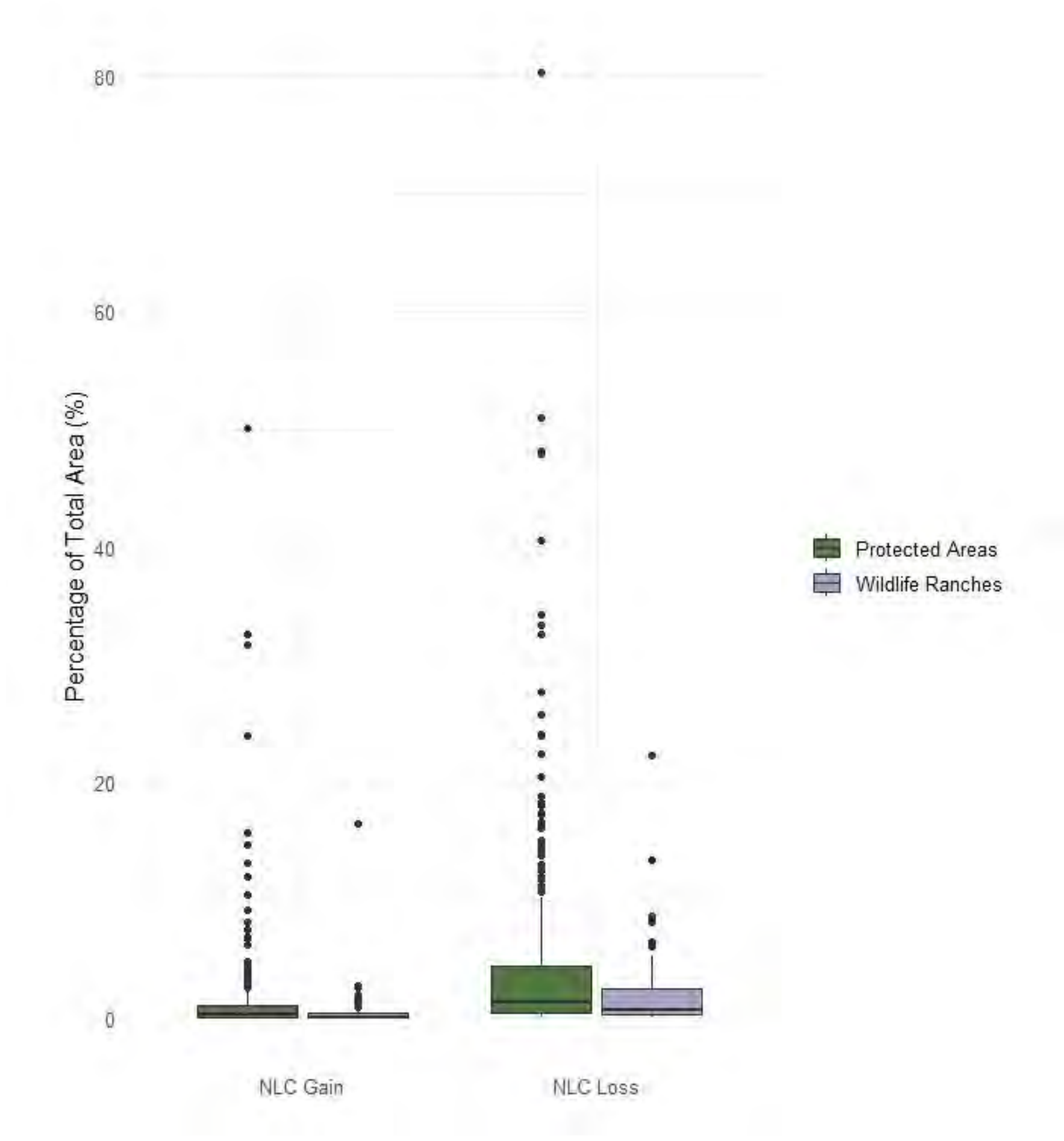


Figure 5-10: Distribution of natural land cover loss and gain (from 1990 to 2022) as a percentage of the total area

The analysis of NLC loss percentages across different land use types and provinces revealed distinct patterns (Figure 5-11). For PAs in the Eastern Cape, the median NLC loss percentage was 1.05% (mean = 4.30%, IQR = 3.21%), while PAs in Limpopo had a slightly higher median loss of 1.48% (mean = 4.46%, IQR = 4.08%), indicating greater variability in Limpopo compared to the Eastern Cape. Wildlife ranches generally exhibited lower NLC loss percentages than PAs. In the Eastern Cape, wildlife ranches had a median NLC loss percentage of 0.43% (mean = 1.34%, IQR = 1.51%). Limpopo wildlife ranches showed a higher median NLC loss percentage of 1.08% (mean = 2.20%, IQR = 2.80%), reflecting more variability in NLC loss in Limpopo compared to the Eastern Cape.

Outliers were present across all groups, particularly within PAs, where some properties exhibited NLC loss percentages exceeding 60%. These outliers highlight that certain PAs experienced substantial losses relative to the broader dataset. In contrast, wildlife ranches had fewer extreme values and displayed more consistent NLC loss percentages within each province, suggesting better stability in maintaining NLC. A Kruskal-Wallis test revealed statistically significant differences in NLC loss percentages among the four groups ($\chi^2 = 20.97$, df = 3, $p = 0.0001$). Pairwise comparisons using the Wilcoxon rank-sum test with Bonferroni correction showed that PAs in Limpopo differed significantly from wildlife ranches in the Eastern Cape ($p < 0.001$), indicating a distinct pattern of NLC loss between these groups. However, no other pairwise comparisons were statistically significant after Bonferroni correction, suggesting that while median differences exist, they were not statistically distinct for the remaining comparisons. These findings underscore the variability in NLC loss across land use types and provinces, with notable distinctions in PAs and Limpopo wildlife ranches.

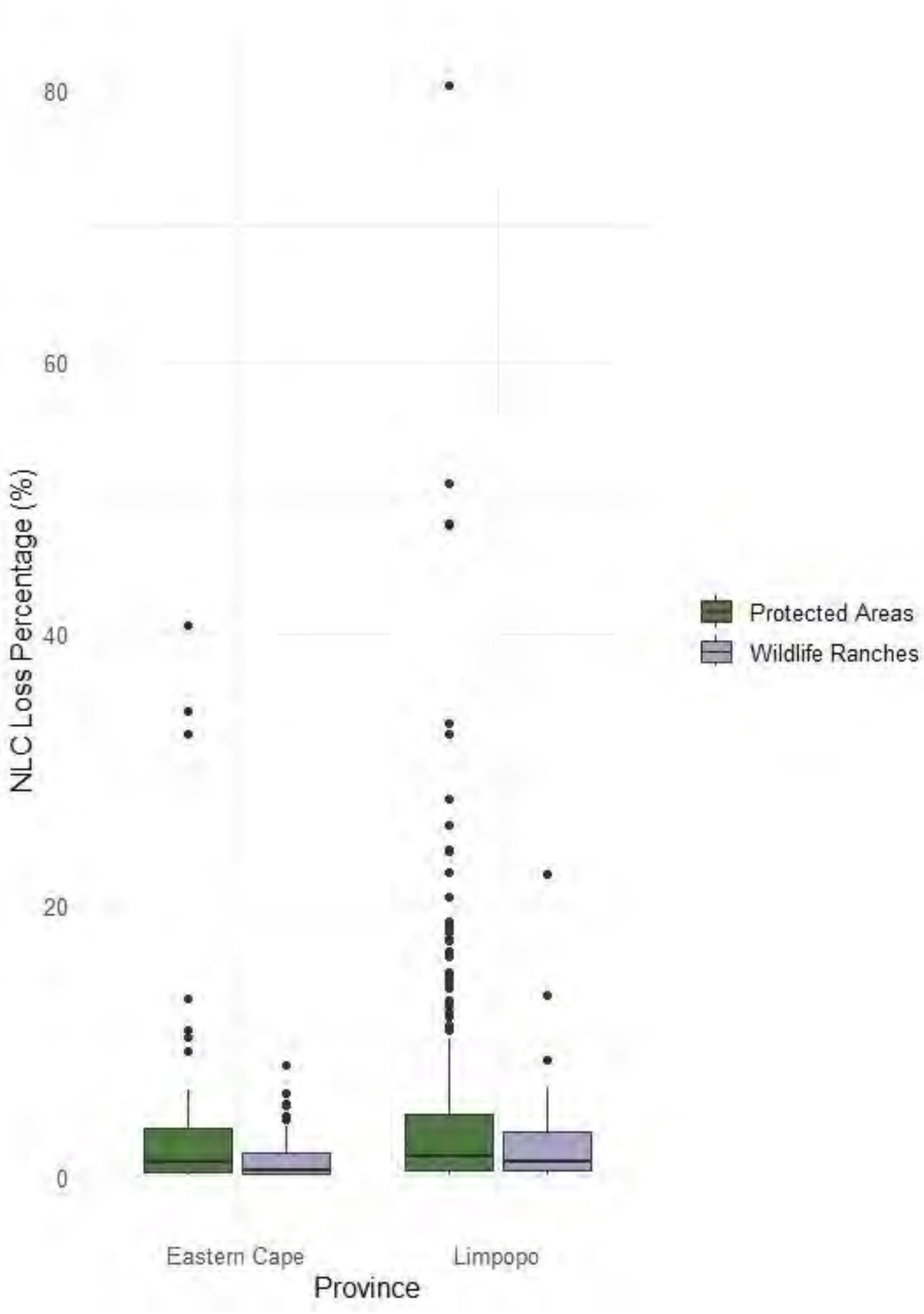


Figure 5-11: Comparison of NLC loss as a percentage of the total area in wildlife ranches: Eastern Cape vs Limpopo (1990-2022)

5.5.2 Natural land cover loss across business models

The analysis of NLC loss percentages across business models revealed notable variability, as shown in Figure 5-12. Box and whisker plots illustrate the distribution of NLC loss for each business model, highlighting medians, IQR, and outliers. Wildlife breeding properties demonstrated a median NLC loss of 0.97% (IQR = 2.51%, n = 41), reflecting moderate variability. Mixed wildlife-agriculture properties had a slightly higher median loss of 1.03% with a broader IQR of 2.68% (n = 20).

Trophy hunting properties exhibited a lower median loss of 0.65% with a narrower IQR of 1.55% (n = 33), suggesting less variability. Mixed hunting showed the lowest median NLC loss at 0.47% (IQR = 1.78%, n = 38), indicating consistent trends in this category. Ecotourism properties presented a median loss of 1.34% (IQR = 2.23%, n = 27), slightly higher than mixed hunting but with less variability than other models. Livestock properties had a median loss of 1.25%, the widest IQR at 3.62% (n = 17), indicating significant variability within this group. Protected areas displayed a median loss of 0.65% (IQR = 2.83%, n = 539), with moderate variability across the group. To determine whether these differences in NLC loss percentages among business models were statistically significant, a Kruskal-Wallis H-test was performed. The results (H = 10.485, p = 0.1056) indicated no statistically significant differences in NLC loss percentages across business models, including PAs.

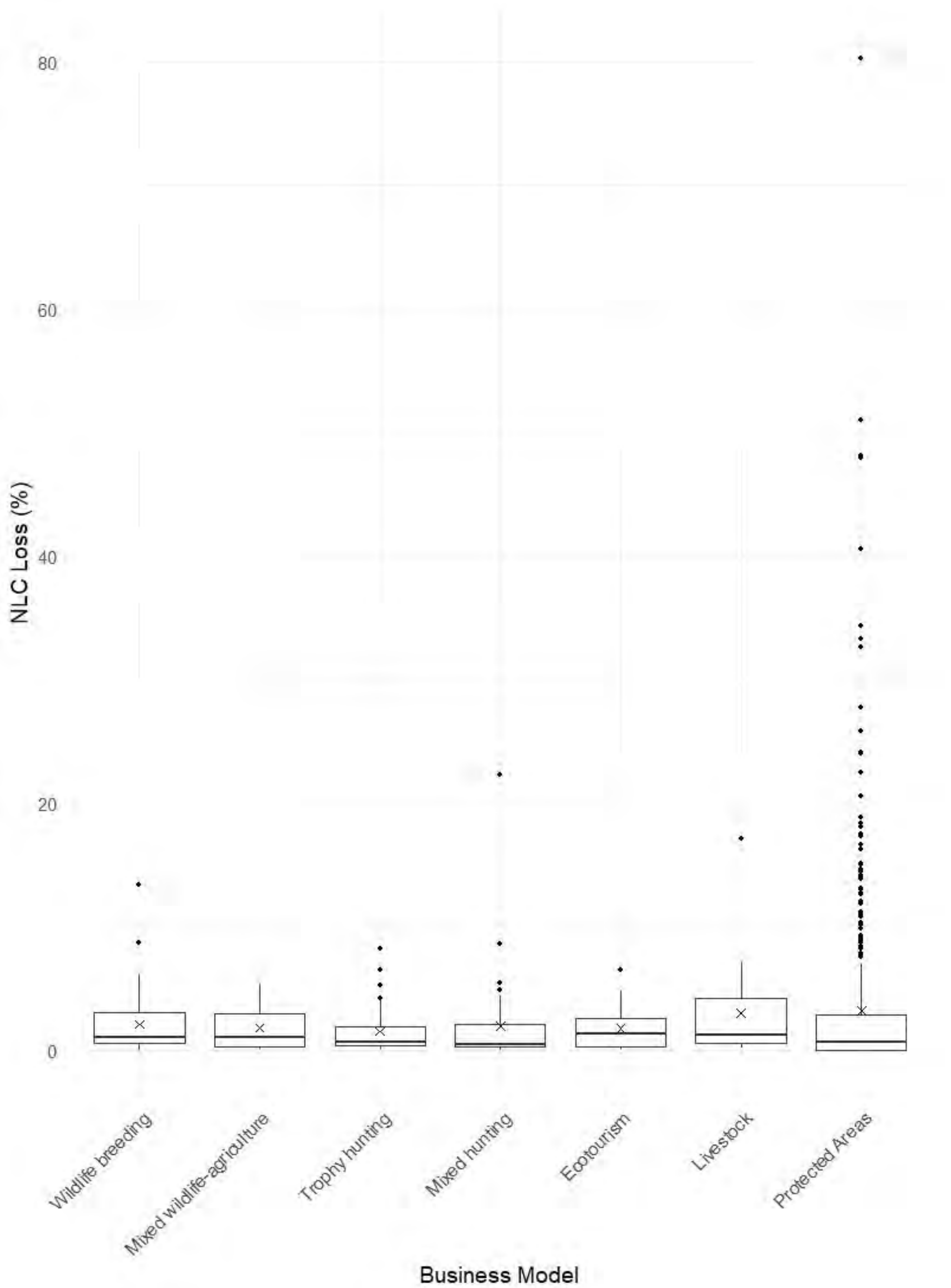


Figure 5-12: Comparison of natural land cover loss as a percentage of total area across different business models, including protected areas (1990–2022)

5.5.3 Non-natural land cover and old fields across business models in 2022

The proportions of non-NLC and old fields as percentages of total property area are shown across various business models in Figure 5-13. The mixed wildlife-agriculture model has the highest average proportion of old fields (13.26%) and a moderate proportion of non-NLC (15.19%). In contrast, the ecotourism model shows notably lower averages for both categories, with a non-NLC proportion of 8.79% and old fields at 2.11%. The livestock model exhibits a relatively high proportion of non-NLC (17.86%) but a much lower presence of old fields (2.25%). The mixed hunting model has a similar proportion of old fields (3.35%) but a lower average for non-NLC (6.67%). Lastly, trophy hunting properties demonstrate a more balanced distribution, with non-NLC at 8.48% and old fields at 6.17%.

To assess whether these differences in land cover proportions were statistically significant, separate ANOVA tests were performed for non-NLC and old fields. These results indicate no statistically significant differences in the proportions of non-NLC or old fields across business models at a typical significance level (non-NLC: p = 0.083; old fields: p = 0.173). Although differences are evident in the proportions of land cover types among business models, these variations are not statistically significant within the context of this dataset.

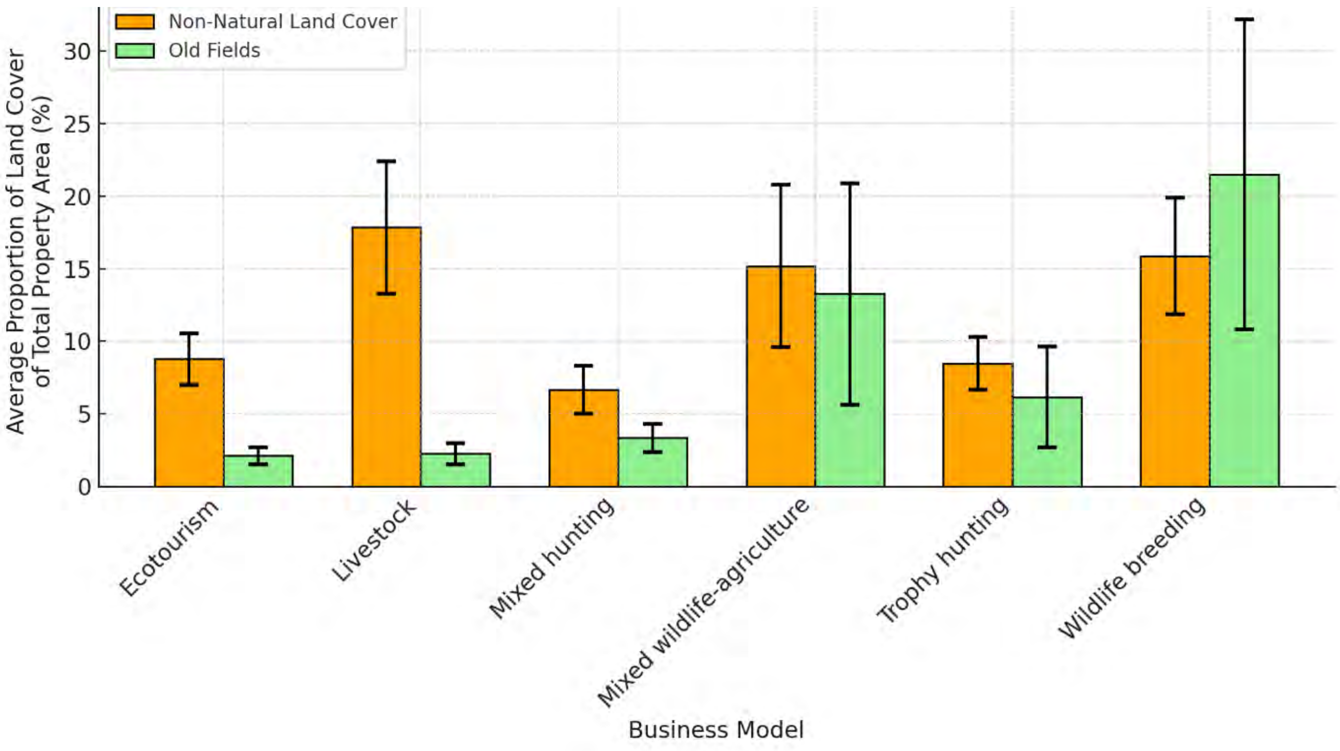


Figure 5-13: Proportional distribution of non-NLC and old fields across business models in 2022

6. Discussion

6.1 Introduction

The primary aim of this thesis was to analyse the patterns and drivers of land use and land cover change within wildlife ranches in South Africa, with a focus on how different business models influence these dynamics. This study highlighted a significant acceleration in the conversion of properties to wildlife ranching after 1992, driven by historical policies and shifting socio-economic conditions. While some notable transitions in land use were observed, such as declines in cultivated fields and increases in old fields, another noteworthy result was the relative stability of rangelands, with minimal conversion apart from a small proportion transitioning to planted pastures. Business models exhibited variable patterns of land use and management, demonstrating both distinct differences and notable similarities across models. Wildlife ranches generally showed lower NLC loss compared to PAs, highlighting their potential as valuable pluralistic conservation areas.

Building on these findings, this chapter explores four interconnected themes critical to understanding the dynamics of wildlife ranching: the historical evolution of wildlife ranching and its role in land use transitions; the motivations driving these changes; the diversity of business models and their ecological and economic implications; and regional differences in land use patterns and outcomes. Together, these themes shed light on how wildlife ranches function as SES, underlining the importance of integrating historical context, economic strategies, and spatial variability into conservation planning. By addressing these aspects, this chapter identifies opportunities to adapt land management and biodiversity strategies, ultimately enhancing the role of wildlife ranches in achieving broader conservation goals.

6.2 The evolution of wildlife ranches

My results reveal a marked acceleration in the conversion of properties to wildlife ranching after 1992, with a statistically significant breakpoint identified during this period (Figure 5-1). This shift can be attributed to the introduction of the Game Theft Act in 1991, which legally recognised private ownership of wildlife within enclosed areas. This legislation transformed wildlife into a marketable asset, enabling landowners to generate economic returns through game farming, trophy hunting, and ecotourism (De Villiers, 2003). The Game Theft Act, combined with broader socio-economic shifts and policy changes, drove the rapid transition from traditional farming to wildlife-based enterprises.

Before 1992, land use on private properties was predominantly shaped by apartheid-era policies that prioritised agricultural productivity through subsidies and economic support mechanisms (Kepe and

Hall, 2018). Livestock farming dominated, accounting for over 50% of activities (Figure 5-2). Cultivation gained prominence during the 1980s and early 1990s, supported by diversification programmes aimed at stabilising rural economies (Kepe and Hall, 2018). However, by the late 1990s, wildlife-based land uses such as trophy hunting and ecotourism emerged as dominant, driven by legislative incentives and increasing international demand for sustainable tourism (Lindsey et al., 2007; Lindsey, 2011). The rise of these activities is evident in the decline in cultivated fields and the increasing adoption of wildlife-based practices across properties.

Socio-economic shifts accompanying South Africa's democratic transition further reinforced these changes. The removal of agricultural subsidies and the globalisation of markets placed economic pressure on traditional farming systems, especially for small-scale and marginal landowners (Kepe and Hall, 2018). Rising costs of inputs, such as fertilisers, water, and labour, rendered conventional farming less viable (Taylor et al., 2016). Many landowners highlighted these challenges in interviews (Table 5-2), emphasising the appeal of wildlife-based enterprises to provide higher returns with lower input costs. Land reform policies, including the Restitution of Land Rights Act (1994) and the Land Expropriation Motion (2018), added further uncertainty around land tenure, especially for large agricultural properties. These uncertainties motivated landowners to transition to wildlife enterprises, perceived as more adaptable and financially sustainable in the context of potential redistribution or tenure insecurity.

Earlier policies, such as the Environmental Conservation Act (1983) and CARA (1983), created a foundation for sustainable land management by mandating soil erosion prevention and vegetation maintenance (Carruthers, 2008). Subsequent policies, like NEMBA (2004), further prioritised biodiversity conservation by introducing mechanisms for protecting threatened ecosystems. However, while NEMBA incentivised sustainable practices, it did not necessarily encourage private land designation as PAs, although this remains a legal possibility under the Protected Areas Act (2003). These land use transitions align with broader trends in Southern Africa and internationally, where legislative reforms and economic incentives have promoted conservation-compatible land uses. In Zambia, Namibia, and Zimbabwe, legislative reforms and community-based models, such as conservancies and private reserves, have promoted conservation-compatible land uses, particularly through initiatives like trophy hunting and ecotourism (Lindsey et al., 2007, 2013; Child et al., 2012; Naidoo et al., 2016). Globally, programmes like the Conservation Reserve Program in the United States have incentivised landowners to shift from agriculture to habitat restoration (Claasens and Cousins, 2022). While South Africa's private ownership model differs, these examples illustrate how market-based conservation mechanisms and legislative frameworks can drive land use change and support biodiversity goals.

6.3 Land use changes and motivations

The patterns of land use change observed in wildlife ranches (Figure 5-3) align closely with broader trends outlined in Chapter 2. These transitions are driven by economic, environmental, and policy factors, highlighting how legislative reforms and market-based incentives have enabled landowners to adapt their strategies and leverage wildlife resources effectively. This section explores these transitions through the lens of cultivated fields, planted pastures, old fields, and rangelands while addressing motivations that drive these changes.

6.3.1 Cultivated Fields

The decline in cultivated fields, with only 20.18% remaining unchanged, reflects the combined effects of economic pressures, environmental challenges, and historical over-cultivation. However, the overall proportional change shows a decrease of only 2.48% (Figure 5-3). This difference arises because Figure 5.3 captures net proportional change across all wildlife ranches, while Figure 5.4 illustrates land use transitions at the category level. In some cases, previously uncultivated areas were brought into cultivation, offsetting a portion of the total decline. Therefore, while individual transitions resulted in a large portion of cultivated fields converting to other uses, the proportional decrease appears smaller due to balancing effects from properties where cultivation increased. A substantial proportion of these areas transitioned into old fields (45.37%) and planted pastures (31.86%). High input costs (20.31%) and water scarcity (31.25%), frequently cited by landowners (Table 5-2), illustrate barriers to sustained agricultural practices, particularly in semi-arid regions with limited irrigation infrastructure. These findings are similar to global trends of agricultural abandonment, as noted by Hobbs and Cramer (2007) and Brandt and Spierenburg (2014), with similar patterns of declining profitability and environmental constraints.

Historical over-cultivation has left many soils degraded, fostering a path dependency that renders these lands unsuitable for traditional farming practices (Cramer et al., 2008). This degradation corresponds with transitions observed where cultivated fields frequently become old fields due to their unsuitability for continued use (Figure 5-4). These degraded fields often transitioned into passive recovery phases, aligning with broader ecological patterns of abandoned croplands undergoing secondary succession (Archer et al., 2017). However, AIS frequently hinder this natural recovery process, presenting a challenge for ecological restoration efforts (Skowno et al., 2021). Interviews revealed landowner motivations for transitioning away from cultivation varied. For example, some landowners cited rehabilitation efforts (Table 5-2) that align with conservation goals and ecological restoration trends (Clements et al., 2016). Others were driven by economic necessity, with declining profitability of crop farming as a significant driver, particularly due to rising costs of fertilisers and labour, as also noted by Kepe & Hall (2018).

6.3.2 Planted Pastures

Planted pastures exhibited dynamic transitions, with only 40.19% remaining in their initial category. A significant 50.42% transitioned into old fields, reflecting landowners' efforts to rehabilitate degraded pastures into natural vegetation (Figure 5-4). Droughts and water scarcity (27.14%) were key drivers of these changes (Table 5-2), as landowners prioritised sustainability and ecological health. However, planted pastures also played a multifunctional role within wildlife ranching systems, supporting grazing for livestock and game. Fodder production (30%) was the most frequently cited motivation, underscoring the economic importance of planted pastures in balancing grazing needs with wildlife management (Godde et al., 2021), noting that planted pastures often serve dual ecological and economic purposes. Jakobsson et al. (2024) similarly highlighted the expansion of planted pastures to support biodiversity and grazing systems, though economic motivations played a relatively minor role in this study (4.28%).

6.3.3 Old fields

Old fields increased in proportion by 2.33% during the study period (Figure 5-3). These areas often serve as transitional zones, with 58.13% remaining unchanged, while smaller proportions transitioned into cultivated fields (10.71%), planted pastures (24.51%), or rangelands (6.65%). However, minor inconsistencies in how land use transitions were recorded during the interviews led to some variation in classification. Although the "rangeland" category was only supposed to be assigned to historically uncultivated areas, in a few cases, old fields were reported as transitioning into rangelands. This likely reflects differences in interpretation rather than actual large-scale land use changes. While these discrepancies should be noted, they do not undermine the overall stability argument. This aligns with NLC findings, which indicate that old fields generally persisted over time rather than undergoing widespread conversion to rangelands. The observed discrepancies likely stem from differences in interpretation rather than substantial land use changes and should be interpreted with caution due to variability in landowner classifications. Importantly, these inconsistencies do not undermine the overall stability argument but instead highlight variations in how land use transitions were recorded.

Cramer et al. (2008) and Peddle et al. (2024) emphasised the role of abandoned fields in enhancing habitat heterogeneity and supporting biodiversity. However, most old fields in this study did not show clear evidence of active rehabilitation, and ecological recovery often remained incomplete due to soil degradation and invasive species. These findings were derived from landowner interviews, where few participants indicated active soil restoration efforts, as well as spatial data, which showed limited transitions from old fields to natural vegetation or rangelands. This highlights the importance of distinguishing between passive and active restoration when evaluating the ecological contributions of old fields. Land rehabilitation (56.25%) and water availability (13.54%) were the primary drivers behind the emergence of old fields (Table 5-2). Landowners reported efforts to restore degraded soils and re-establish natural vegetation, aligning with global findings that PCAs often invest in ecological restoration to improve biodiversity and land value (Hoffmann, 2022; Holmes, 2015). However, motivations for maintaining old fields varied. For some, they represented opportunities to enhance conservation-based activities such as ecotourism and hunting. For others, they were simply by-products of reduced agricultural viability.

6.3.4 Rangelands

The stability of rangelands, with 92.73% of land remaining unchanged (Figure 5-3), highlights their resilience and multifunctionality. SWEP interviews revealed that increases in rangeland areas (56.89%) were primarily the result of property expansion rather than ecological transitions (Table 5-2). This finding highlights the importance of contiguous rangelands in supporting grazing systems and wildlife habitats (Krausman et al., 2009). The stability of rangelands is linked to the NLC analysis, which recorded minimal losses (see "6.4 Natural land cover"). Rangelands are critical for balancing biodiversity goals with revenue-generating activities such as ecotourism and trophy hunting (Holechek & Valdez, 2017). Landowner motivations often centred on maintaining these landscapes for their economic viability and ecological value, particularly through property expansion to support larger contiguous habitats.

6.3.5 Broader implications

While rangelands within wildlife ranches contribute to biodiversity, these areas are primarily businesses with biodiversity-compatible land uses, where ecological outcomes often support, rather than drive, economic objectives. Wildlife ranches can mitigate habitat loss and support biodiversity across a range of business models, as nearly all models inherently prioritise conservation-compatible practices, given their reliance on healthy ecosystems to generate economic returns. However, my results show that their role in biodiversity conservation varies and is influenced by policy frameworks, economic incentives, and landowner motivations.

6.4 Natural land cover

The analysis of NLC changes highlights critical differences between wildlife ranches and PAs, providing insights into their conservation effectiveness and land management strategies. Wildlife ranches displayed lower median NLC loss percentages compared to PAs, with a more consistent distribution and fewer extreme outliers (Figure 5-10). This stability aligns with studies highlighting the role of private conservation models, such as ecotourism, trophy hunting, and game breeding, in encouraging landowners to preserve natural habitats as critical assets (Lindsey et al., 2013). This consistency also aligns with findings from (Gallo et al., 2009), which demonstrate the complementary role of PCAs in achieving biodiversity targets, particularly in underrepresented biomes and lower elevations.

PAs showed higher variability in NLC loss and gain, particularly in smaller reserves, where changes in land cover were more pronounced relative to total area (Figure 5-11). Studies such as Smit et al. (2024) and (Skowno et al., 2021) have noted that transformation in PAs is often driven by agricultural expansion, urbanisation, and resource extraction. Variability in PAs also reflects challenges in governance and enforcement, which exacerbate their vulnerability to external pressures (Jewitt et al., 2015). In contrast, wildlife ranches maintain natural habitats as economic assets, which reinforces their stability and ecological resilience (De Vos and Cumming, 2019).

The transitions observed within wildlife ranches reflect complex interactions between economic motivations and ecological dynamics. Old fields, for example, often serve as transitional zones, with passive regeneration leading to secondary natural cover (Figure 5-4 and Section 6.3.3). However, the ecological value of these areas is mixed, as they can also become hotspots for AIS encroachment, complicating their role in habitat recovery (Skowno et al., 2021). This duality was also highlighted by (Gallo et al., 2009), who noted similar challenges in lowland biodiversity conservation. Rangelands exhibited notable stability, with changes primarily attributed to property expansions rather than ecological transitions (Table 5-2 and section 6.3.4), a pattern consistent with findings on land use priorities in arid and semi-arid biomes (Shumba et al., 2020; Venter et al., 2020). This finding aligns with Clements and Cumming (2017), who reported that rangelands in PCAs are often managed for resilience, balancing short-term economic objectives with long-term ecosystem stability.

The patterns of NLC gains and losses require nuanced interpretation. Gains in PAs may result from restoration efforts such as reforestation but can also indicate AIS expansion, undermining biodiversity objectives (Skowno, Jewitt and Slingsby, 2021). Similarly, secondary natural cover within wildlife ranches likely represents a combination of passive regeneration and alien encroachment, highlighting the need for refined classification methods and context-specific analyses. This interpretation aligns with broader findings by Clements et al., (2016) and De Vos and Cumming (2019), who highlight the importance of management practices that integrate economic and ecological goals.

6.5 Business models

The dynamics of land use change within wildlife ranches are interconnected and tied closely to their underlying business models, each reflecting distinct priorities in balancing ecological and economic goals. In this section, I explore how different business models influence land use changes, providing insights into their social-ecological dimensions. For comparative purposes, livestock farms are included in the analysis but are not considered wildlife ranches due to their distinct management objectives and limited focus on biodiversity conservation. Table 6-1 summarises the main results across business models for easy reference.

Table 6-1: A summary of key results across business models within wildlife ranches

Business Model	Land Use Changes (%)	Top Motivations	Property Age	Size Change (ha)	NLC Loss (%)	Average Non-NLC; Old Field Cover (%)
Ecotourism	Decrease in cultivated fields (-5.03%) and planted pastures (-3.34%). Increase in old fields (+8.31%). Rangelands stable (+0.22%).	Land rehabilitation and vegetation growth (57.1%), economic motivations (21.4%), property expansion (14.3%).	Median: 21.5 years. IQR: 7.75 years.	Median: 985 ha. IQR: 4200 ha.	Median: 1.34%. IQR: 2.23%.	8.79%.; 2.11%.
Livestock	Decrease in cultivated fields (-8.82%). Increase in planted pastures (+6.56%). Old fields stable (+2.33%).	Balanced motivations: land rehabilitation (30%), economic factors (15%), property expansion (15%).	Median: 19 years. IQR: 19.5 years.	Median: 0 ha. IQR: 500 ha.	Median: 1.25%. IQR: 3.62%.	17.86%; 2.25%.
Mixed Hunting	Minimal changes: slight decrease in cultivated fields (-0.83%) and increases in old fields (+1.06%). Planted pastures (-0.14%) and rangelands (-0.28%) stable.	Land rehabilitation (40.6%), economic factors (21.9%), historical reasons (12.5%).	Median: 19.0 years. IQR: 9.50 years.	Median: 0 ha. IQR: 968.5 ha.	Median: 0.47%. IQR: 1.78%.	6.67%; 3.35%.
Mixed Wildlife-Agriculture	Slight increase in cultivated fields (+0.20%) and planted pastures (+2.73%). Old fields decrease (-2.54%). Rangelands stable (-0.08%).	Mixed: land rehabilitation (26.1%), property expansion (21.7%), economic motivations (17.4%).	Median: 22 years. IQR: 41.25 years.	Median: 0 ha. IQR: 1000 ha.	Median: 1.03%. IQR: 2.68%.	15.19%; 13.26%
Trophy Hunting	Increase in rangelands (+4.03%). Cultivated fields (-2.03%) and planted pastures (+0.09%) stable.	Land rehabilitation (38.5%), economic motivations (23.1%), property expansion (15.4%).	Median: 22.5 years. IQR: 14 years.	Median: 475 ha. IQR: 3750 ha.	Median: 0.65%. IQR: 1.55%.	8.48%; 6.17%
Wildlife Breeding	Small decreases in cultivated fields (-0.46%) and planted pastures (-1.43%). Old fields increase (+1.42%). Rangelands (+0.31%) stable.	Balanced: land rehabilitation (29.4%), property expansion (20.6%), economic factors (14.7%).	Median: 22 years. IQR: 16.5 years.	Median: 357.5 ha. IQR: 2896.5 ha.	Median: 0.97%. IQR: 2.51%.	12.35%; 1.42%

6.5.1 Land use and change dynamics across business models

The analysis of land use change, motivations and NLC loss across business models within the wildlife ranching sector highlights distinct patterns reflecting economic imperatives, ecological priorities, and integrated social-ecological strategies. My results demonstrate how each business model's unique land use patterns and underlying motivations highlight the interaction and relationship between conservation and profitability.

6.5.1.1 Ecotourism Model

Ecotourism properties exhibit a shift from agricultural land uses, such as cultivated fields and planted pastures, toward ecological restoration, as evidenced by an increase in old fields and stable rangelands (Figure 5-5). This transition reflects economic motivations to enhance biodiversity-compatible landscapes and generate revenue while supporting ecological functionality. Restoration efforts often involve rehabilitating degraded lands and promoting ecosystem services such as carbon sequestration and water retention, which align with the ecotourism model's dual focus on economic sustainability and conservation (Spenceley, 2008). Land use changes within this ecotourism are predominantly driven by motivations such as land rehabilitation (57.1%) and property expansion to create contiguous habitats that support both wildlife conservation and visitor experiences (Figure 5-6). These findings align with studies emphasising the synergy between ecological restoration and economic imperatives in ecotourism (Clements et al., 2016; Taylor et al., 2016). However, variability in the outcomes of these changes indicates that while some ecotourism properties actively prioritise ecological restoration, others balance natural and non-natural landscapes to accommodate tourism infrastructure, such as lodges and roads (Kiper, 2013; Samal and Dash, 2023; Sharpley, 2006).

Despite these conservation-compatible practices, ecotourism properties exhibit higher median NLC loss and greater variability compared to other business models (Figure 5-12). This suggests that the ecological motivations underpinning the ecotourism model do not always translate into reduced land cover loss. The diversity of land management strategies reflects the complexity of aligning economic priorities with conservation outcomes. High-end ecotourism operations, which cater to affluent tourists, often exhibit stronger commitments to conservation, leveraging ecological restoration to enhance biodiversity and aesthetic appeal (Spenceley, 2008; Lindsey et al., 2013). In contrast, low-end operations may prioritise cost efficiency, resulting in mixed ecological outcomes. Old fields within ecotourism properties, although limited in extent, represent a key component of land use dynamics. These areas often undergo passive or active restoration, but their potential contribution to biodiversity and habitat heterogeneity (Morrison and Lindell, 2010), depends on effective management to prevent AIS encroachment (Skowno et al., 2021). This highlights the variability in ecological strategies within the model, influenced by the balance between restoration efforts and infrastructure development.

6.5.1.2 Trophy Hunting Model

Trophy hunting properties displayed minimal land use change, reflecting their focus on stable management practices that prioritise the maintenance of natural habitats. The trophy hunting model aligns closely with strategies designed to minimise disturbance and maintain ecological functionality, which are foundational to the profitability and long-term sustainability of hunting enterprises (Lindsey et al., 2007; Taylor et al., 2020). This stability supports the essential wildlife populations needed for trophy hunting while simultaneously reducing anthropogenic impacts on the land (De Vos and Cumming, 2019). Land use motivations in this model included property expansion (37.4%) and targeted land rehabilitation (45.8%), aimed at maintaining suitable habitats for game species (Figure 5-6). These findings align with broader literature that highlights the model's dual capacity to drive conservation outcomes and generate significant economic returns (Bothma, 2002; Denner et al., 2024).

Properties under this model exhibited some of the lowest levels of NLC loss, with patterns resembling those observed in PAs. This trend reinforces the view that trophy hunting properties, like formal conservation areas, can achieve conservation-compatible outcomes, especially in biomes underrepresented in traditional PAs (Gallo et al., 2009; Shumba et al., 2020). The minimal variability in NLC loss may highlight consistent management approaches and prioritisation of extensive rangelands. Trophy hunting are notable for their ability to generate substantial revenues while simultaneously contributing to biodiversity conservation (Johanisová and Mauerhofer, 2023). These properties frequently achieve profitability margins exceeding 30%, second only to specialised wildlife breeding operations (Denner et al., 2024). The reliance on natural habitats for sustainable hunting operations drives landowners to preserve ecological integrity while supporting biodiversity (Lindsey et al., 2013; Taylor et al., 2020). The economic success of trophy hunting properties often enables reinvestment into habitat restoration and anti-poaching initiatives, creating positive feedback loops for both biodiversity and profitability (Lindsey et al., 2013; Taylor et al., 2020). Old fields play an integral part in this dynamic by serving as transitional landscapes that support biodiversity recovery while remaining economically viable through their contribution to game farming and hunting operations (Coetzer and Coetzer, 2023; Hobbs and Cramer, 2007; Knieter, 2020).

6.5.1.3 Mixed Wildlife-Agriculture Model

The mixed wildlife-agriculture model shows moderate land use changes, with increases in cultivated fields and planted pastures suggesting continued reliance on agricultural outputs for economic stability (Figure 5-5). Simultaneously, the stability of rangelands and old fields highlights efforts to integrate biodiversity-compatible land uses, reinforcing the dual objectives of production and conservation. Land use transitions within this model often result from diverse motivations, including land rehabilitation (26.1%) and property expansion (21.7%), as these systems adapt to changing market and environmental conditions (Figure 5-6). Old fields are particularly significant (Figure 5-13). These areas serve as transitional landscapes, enhancing habitat heterogeneity and supporting ecosystem services, such as carbon sequestration and water retention. However, the dual role of old fields, both as sites of ecological recovery and as potential sources of invasive species if poorly managed, underlines the complexity of managing these areas within multifunctional systems. Studies like Holmes et al. (2020) and Skowno et al. (2021) provide further evidence of these dynamics, emphasising the need for effective rehabilitation to maximise ecological benefits while mitigating risks such as AIS encroachment.

Natural land cover loss within mixed wildlife-agriculture properties demonstrates significant variability, reflecting the model's adaptability to a range of ecological and economic pressures. Some properties prioritise the retention of natural vegetation, achieving lower NLC loss, while others convert rangelands or old fields into more intensive agricultural uses, increasing habitat transformation. This variability is consistent with the heterogeneity observed in similar systems, where individual management goals and resource availability shape land use patterns (Cousins et al., 2010; Tefera and Sterk, 2010; Tjelele et al., 2021). However, the coexistence of agricultural production and wildlife-oriented practices can lead to trade-offs, as agricultural intensification may compromise long-term ecological resilience if not carefully managed. By balancing these competing demands, mixed wildlife-agriculture systems exemplify the challenges and opportunities of multifunctional landscapes.

6.5.1.4 Wildlife Breeding Model

Wildlife breeding properties exhibit stable land use patterns, reflecting a focus on maintaining existing land use proportions through intensive management practices. These properties are typically small and prioritise operational efficiency over large-scale ecological restoration, aligning land use with the economic demands of breeding operations (Snyman and Bothma, 2023). Controlled agricultural practices, such as planting and fodder production, are central to supporting breeding activities, highlighting the economic orientation of this model. Motivations for land use change within wildlife breeding properties primarily include land rehabilitation (29.4%) to sustain breeding operations and economic considerations driven by market demands (Figure 5-6). Unlike other models that integrate broader conservation objectives, wildlife breeding properties emphasise functionality and profitability, which limits their engagement with large-scale restoration (Krausman et al., 2009;

Mossman and Mossman, 1976). These motivations are consistent with the economic imperatives of the model, which prioritises consistent production outputs over dynamic land use transitions (Denner et al., 2024).

Natural land cover loss in wildlife breeding properties is minimal, reflecting the tightly controlled environments needed for game production. This contrasts with models like ecotourism or mixed wildlife-agriculture, where more dynamic land use changes are observed (Figure 5-5). The limited variability in land management strategies within the wildlife breeding model emphasises its focus on stability and operational efficiency. The restricted extent of old fields further illustrates the model's economic focus, as these areas are often rehabilitated into planted pastures or maintained as controlled habitats. While this approach supports economic objectives, it limits opportunities for ecological restoration and biodiversity enhancement. Clements and Cumming (2017) and Cousins et al. (2008) caution against the ecological trade-offs associated with intensive management practices common to wildlife breeding properties. These practices, including supplemental feeding, water provisioning, and vegetation control, can reduce habitat quality and strain natural resources over time. While the controlled nature of land use ensures profitability and supports breeding activities, it also raises concerns about the long-term ecological sustainability of this model. Targeted incentives and policy frameworks could help encourage sustainable practices, ensuring that economic objectives are balanced with ecological integrity.

6.5.1.5 Mixed Hunting

The mixed hunting model combines elements of trophy hunting and subsistence hunting, creating a land use system that balances economic goals with the preservation of natural habitats. This model is characterised by stable land use patterns, with minimal conversion of cultivated fields or rangelands and a strong emphasis on maintaining extensive, undisturbed landscapes (Figure 5-5). Mixed hunting properties rely on functional rangelands to support diverse game species, which are integral to their economic operations and ecological management. Land use changes in this model reflect a dual focus on sustainability and profitability. The stability of rangelands highlights their role as multifunctional landscapes, providing critical habitats for wildlife while supporting economic activities such as hunting and ecotourism. Motivations for land use change within mixed hunting properties include land rehabilitation, property expansion, and the need to enhance habitat quality for game species (Figure 5-6). These findings align with other studies that emphasise the ecological and economic importance of maintaining large, contiguous rangelands in hunting operations (du Toit et al., 2017; Lindsey et al., 2007; Teague et al., 2009).

Natural land cover loss in mixed hunting properties is among the lowest across all business models, comparable to that observed in trophy hunting properties. This stability reflects the model's reliance on natural habitats for sustainable hunting operations and its integration of conservation objectives with land management practices. The minimal NLC loss also underscores the potential of mixed hunting properties to contribute to broader conservation goals by preserving biodiversity and ecosystem functionality (Figure 5-12). Old fields in mixed hunting properties are often rehabilitated into rangelands or maintained as transitional habitats that enhance biodiversity. These areas provide opportunities for passive restoration and the recovery of ecosystem services, such as carbon sequestration and water retention (Gusha et al., 2024; Pyke and Boyd, 2023). The presence of old fields in this model supports habitat heterogeneity, which is essential for sustaining diverse game populations and promoting ecological resilience.

6.5.1.6 Livestock Model

The livestock model is characterised by a strong focus on agricultural productivity, with land use decisions prioritising planted pastures and cultivated fields to support grazing systems and fodder production. This model demonstrates notable reductions in cultivated fields and increases in planted pastures, reflecting a shift toward more intensive agricultural practices aimed at sustaining profitability. These changes are primarily driven by economic imperatives (Figure 5-6), with limited integration of ecological restoration or biodiversity-compatible practices, as similarly found by other studies Cumming and Atkinson, 2012; du Toit et al., 2017).

Natural land cover loss is the highest among all business models, highlighting the trade-offs inherent in agricultural systems that prioritise productivity over conservation objectives. Livestock properties often convert natural habitats into agricultural land to sustain operations, resulting in significant ecological transformations. These findings are consistent with those of Galindo et al. (2022), who observed similar patterns of habitat conversion in other economically driven agricultural systems. Old fields are relatively scarce within livestock properties, reflecting a limited focus on ecological recovery or passive restoration. When present, old fields are often rehabilitated for agricultural purposes, such as conversion into planted pastures to support grazing. This prioritisation of agricultural productivity sharply contrasts with wildlife-based models, which tend to integrate economic and ecological goals more holistically. The limited presence of old fields also reduces opportunities for habitat recovery but may mitigate risks associated with invasive species colonisation in unmanaged areas, as noted by Skowno et al., (2021). The intensive land use practices within the livestock model, such as high input costs for water, fertilisers, and labour, underscore the economic pressures faced by these operations, particularly in semi-arid regions (Sekaran et al., 2021). While this model prioritises agricultural output, its operational focus limits its contribution to biodiversity conservation. However, the small sample size for livestock properties in this study may constrain the generalisability of these findings, underscoring the need for further research to explore the broader dynamics of livestock-based land use systems.

6.5.1.7 Synthesis

Across all models, land rehabilitation and natural vegetation growth emerge as consistent motivations, reflecting the growing recognition of the ecological and economic value of restored landscapes. Ecotourism and trophy hunting models prioritise biodiversity-compatible land uses, where economic incentives align with conservation outcomes. In contrast, livestock and wildlife breeding models focus on agricultural and operational productivity, with limited integration of conservation practices. The differences across business models highlight the need for context-specific management strategies that balance economic viability with ecological sustainability. By aligning motivations with land use practices, wildlife ranches can optimise their potential as social-ecological systems (Mace et al., 2014). Tailored incentives and support frameworks, such as tax benefits or extension services, can further enhance the integration of conservation and production objectives, ensuring the long-term sustainability of these landscapes.

6.5.2 Property ages and sizes changes

Age and size are fundamental characteristics shaping the dynamics of wildlife ranching properties in South Africa. These factors influence land management strategies, business model transitions, and responses to socio-economic and ecological pressures. Examining their interplay across business models offers insights into the structural and operational diversity within the sector while shedding light on broader drivers such as market demands, policy changes, and historical land use patterns. The relationship between property age and business models indicates that adopting a specific business model is not strongly tied to how long a property has been established. This lack of differences in median ages across models suggests that external socio-economic and legislative drivers play a more prominent role in shaping business model adoption. For instance, the Game Theft Act of 1991 catalysed growth in wildlife ranching, providing incentives for both older and newer properties to diversify and align with evolving market demands (Snyman and Bothma, 2023).

The concept of "path dependency," as described by Clements et al. (2016), provides a useful framework for understanding these dynamics. Historical investments, existing infrastructure, and financial constraints often lock properties into particular models, limiting flexibility for transitions. Even within the ecotourism model, there is notable diversity, ranging from high-end, expansive operations to smaller, low-cost enterprises (Clements et al., 2019). This distinction underscores the need for nuanced policy approaches that account for variations within business models, ensuring that support mechanisms address both large-scale and smaller-scale operations. Such differentiation could help maximise the ecological and economic contributions of ecotourism properties.

Property size varies across business models, with larger sizes associated with trophy hunting and ecotourism. These models often require expansive tracts of land to optimise operations and align with ecological and economic goals. Trophy hunting properties benefit from large, contiguous rangelands to support viable game populations and ensure sustainable hunting practices (Lindsey et al., 2007). Similarly, ecotourism properties prioritise larger landscapes to maintain undisturbed habitats that enhance biodiversity value and visitor experiences (Spenceley, 2008). Conversely, smaller properties are often linked to intensive wildlife breeding operations, where land management focuses on high-value, controlled production systems. These properties rely less on extensive landscapes and more on targeted resource management, reflecting a divergence in land use strategies. Despite these differences, the continuum of size changes highlights the flexibility of landowners in adapting property dimensions to meet the operational demands of their chosen models. Size adjustments are particularly evident in ecotourism and trophy hunting properties, which have shown greater capacity for expansion in response to market opportunities and policy shifts. For instance, the growth of ecotourism and trophy hunting markets has provided financial incentives for landowners to increase property sizes, enhance habitat quality, and diversify revenue streams (Taylor et al., 2016).

The modest relationship between property age and size suggests older properties may benefit from historical opportunities for land acquisition and expansion, such as during economic downturns or under incentivising policies like the Game Theft Act (Schirmer, 2017). However, the low explanatory power indicates that external factors, such as market demands and policy shifts, more strongly influence size changes (Figure 5-7). While some older properties remain stable due to constraints like land claims or financial limitations (Kepe and Hall, 2018), younger properties often adapt more rapidly, leveraging contemporary opportunities in ecotourism and wildlife markets (Clements et al., 2022). Transitions between business models are relatively rare, reflecting path dependency where historical investments and infrastructure limit shifts (Clements et al., 2022). Trophy hunting and ecotourism properties, with their need for expansive landscapes, show greater tendencies for size increases, while smaller models like wildlife breeding remain relatively static. These patterns underscore the importance of external drivers in shaping size changes rather than age alone.

6.6 Regional differences

Both business models and provinces contribute to variations in land use and NLC loss. However, regional differences appear more pronounced in shaping these patterns due to ecological and socio-economic factors (Figure 5-9). However, while NLC loss was analysed across provinces, land use transitions were not explicitly assessed at a provincial level in this study. The observed differences in NLC loss between Eastern Cape and Limpopo may be influenced by ecological and socio-economic factors, but further research is needed to explore these regional trends in greater depth. The Eastern Cape shows a notable transition of cultivated fields into old fields. This pattern aligns with historical land use trends reported in previous research, which highlight the province's milder climate, mixed-use land management history, and biomes like Thicket and Grassland that balance agricultural use with natural cover retention (Lubke et al., 1986; Smit et al., 2024). These factors contribute to the region's lower and more consistent NLC loss and suggest a stable landscape with higher recovery potential. In Limpopo, greater variability in land use transitions—persistent cultivated fields and uneven growth in old fields—highlights the province's dependence on agriculture and challenging ecological context. Frequent droughts, soil degradation, and the pressure on Savanna biomes for agricultural production contribute to higher median NLC loss and greater transformation potential, even within PAs (Bai and Dent, 2007; Smit et al., 2024). While business models also influence NLC loss, these results suggest that regional ecological and socio-economic conditions play a larger role in shaping land cover dynamics. The Eastern Cape's relative stability contrasts with Limpopo's variability, underscoring the importance of tailored, region-specific approaches to address unique environmental and management challenges.

6.7 Wildlife ranches as social-ecological systems

The drivers of land use change within South African wildlife ranches align with global patterns, where environmental constraints, economic pressures, and restoration efforts shape land management decisions. Wildlife ranches, as SES, integrate ecological and social dimensions, balancing biodiversity conservation with economic and social needs. This study highlights the dynamic nature of wildlife ranches, shaped by both local and global forces. Transitions observed—such as declines in cultivated fields driven by water scarcity and economic pressures and gains in old fields and rangelands through rehabilitation and property expansion, reflect adaptive strategies supporting ecological and economic viability. These changes demonstrate the interplay of environmental, economic, and historical factors, shaped by immediate needs and broader socio-political contexts, reinforcing wildlife ranches' role as complex and adaptive SES.

6.7.1 Feedbacks driving land use and land cover change dynamics

Feedback loops are critical in understanding wildlife ranching as SESs. These loops describe the reciprocal relationships between ecological, economic, and social factors, where changes in one component drive responses in others, either reinforcing or counteracting the initial change. Wildlife ranches demonstrate clear feedback loops between economic activities and ecological outcomes.

6.7.1.1 Economic Incentives

Economic activities, such as ecotourism and trophy hunting, create reinforcing feedback loops that support biodiversity conservation. Revenue from these activities funds habitat restoration, invasive species management, and species conservation, enhancing land's ecological value. For example, ecotourism properties prioritise restoring old fields to boost biodiversity and attract visitors, reinforcing the link between ecological recovery and economic growth (Clements et al., 2016; Samal and Dash, 2023). However, overreliance on high-value species can create imbalances, neglecting less profitable species (Taylor et al., 2016). Furthermore, market fluctuations, such as reduced tourism demand, may disrupt these feedbacks, prompting landowners to revert to less sustainable practices like agriculture or resource extraction. Integrated strategies balancing economic and ecological priorities are essential for maintaining long-term conservation outcomes (Liu et al., 2023; Mtapuri et al., 2023).

6.7.1.2 Policy support and adaptive management

Policies like the Game Theft Act (1991) and the National Environmental Management: Biodiversity Act (2004) have facilitated the transition from traditional agriculture to wildlife-based enterprises by granting ownership rights over wildlife and incentivising private conservation (Carruthers, 2008; Lindsey et al., 2007). Adaptive practices, such as rotational grazing and habitat restoration, enhance resilience. However, gaps in policy implementation, particularly for smaller or marginal ranches, limit adaptive capacity. External pressures, such as global economic recessions, can further undermine stability, highlighting the need for policies that address socio-economic variability while supporting long-term conservation.

6.7.1.3 Regional and environmental pressures

Environmental pressures, especially drought, significantly influence wildlife ranching dynamics, particularly in semi-arid regions like Limpopo. Drought has driven landowners to adopt resilient practices, such as expanding rangelands and reducing cultivation, reinforcing the viability of wildlife ranching in these regions (Table 6-1). These practices improve resilience to climate variability but pose risks if carrying capacities are exceeded, potentially leading to habitat degradation. Effective region-specific strategies are crucial to balance these dynamics while maintaining ecological and economic sustainability (van Niekerk, 2020).

6.7.2 Adaptive capacity and resilience

Wildlife ranches' ability to adapt to changing environmental, economic, and social pressures highlights their resilience as SES. Mixed-income strategies, such as combining ecotourism with game meat production, enhance economic flexibility, enabling landowners to navigate market fluctuations or environmental challenges (Clements et al.,2022). Environmental adaptations, such as old-field restoration and rotational grazing, improve resilience to soil degradation and water scarcity (Bilotta et al., 2007; Slayi et al., 2024). However, resilience varies across business models. Trophy hunting exhibits greater economic stability due to its niche market focus, while ecotourism is more vulnerable to global downturns (Taylor et al., 2016).

6.7.3 Path dependency

Wildlife ranches operate within thresholds that, if crossed, could lead to irreversible changes. Market crashes in ecotourism could prompt shifts to less sustainable land uses, such as intensive agriculture, undermining biodiversity gains. Similarly, ecological tipping points, such as invasive species proliferation in unmanaged old fields, could compromise restoration efforts (Skowno et al., 2021). Historical land use practices, like agricultural intensification, also constrain restoration efforts, particularly in regions like Limpopo with degraded soils (Cramer et al., 2008). Flexible, adaptive strategies are crucial to maintaining the ecological and economic viability of wildlife ranches as SES.

6.8 Implications for policy and practice

The observed trends in land use changes, such as the widespread decline in cultivated fields and the stability of rangelands, highlight the importance of policies that incentivise ecological restoration while maintaining economic viability. One potential avenue is the recognition of certain wildlife ranches as OECMs, given their role in habitat protection and biodiversity conservation. However, under current OECM regulations and guidelines, most wildlife ranches in South Africa do not meet the necessary criteria for formal recognition (Marnewick et al., 2021). OECMs require long-term, legally binding conservation commitments, which many private landowners are unwilling or unable to adopt. While OECMs do not provide direct economic benefits, biodiversity stewardship programmes remain a more viable mechanism for integrating wildlife ranches into national conservation planning. Stewardship agreements offer structured support and incentives, making them a more practical approach for recognising conservation efforts on private land. Supporting models like ecotourism and trophy hunting through targeted infrastructure investments and market development can enhance their ecological contributions. Meanwhile, mixed-use systems require tailored support to maximise their multifunctional potential, as reflected in the coexistence of old fields and cultivated areas within these properties.

The patterns of land use change observed—such as the rehabilitation of old fields in ecotourism and the stability of rangelands in trophy hunting—highlight the effectiveness of aligning financial incentives with biodiversity goals. Certification schemes or tax benefits could incentivise conservation-compatible practices while mitigating the risks associated with economic fluctuations. For livestock and wildlife breeding systems, addressing barriers like high input costs and limited restoration funding will be critical to enhancing sustainability. The diversity of business models and their associated land use patterns, such as the integration of grazing and conservation in mixed-use systems, highlights the sector's adaptive potential. Policies that foster innovation, such as supporting younger enterprises in adopting ecotourism or trophy hunting models, can enhance the ecological and economic contributions of wildlife ranches. Recognising regional differences, such as the stable landscapes in the Eastern Cape versus the variable transitions in Limpopo, will be essential for crafting context-specific strategies that address both conservation and production goals.

Policies that foster innovation, such as supporting younger enterprises in adopting ecotourism or trophy hunting models, can enhance the ecological and economic contributions of wildlife ranches. Recognising regional differences, such as the stable landscapes in the Eastern Cape versus the variable transitions in Limpopo, will be essential for crafting context-specific strategies that address both conservation and production goals. The patterns of land use change observed—such as the rehabilitation of old fields in ecotourism and the stability of rangelands in trophy hunting—highlight the effectiveness of aligning financial incentives with biodiversity goals. Biodiversity stewardship programmes and conservation policies should recognise the biodiversity contributions of wildlife ranches and consider incentive structures that support sustainable land use practices. While formal PA status alone may not necessarily enhance conservation outcomes, many wildlife ranches already contribute to long-term ecological stability through their land management practices. Ensuring that policies acknowledge these contributions and provide appropriate incentives could encourage further investment in restoration and habitat conservation. Rather than focusing on short-term profit, these incentives should be designed to support long-term ecological and economic sustainability, enhancing landowners' capacity to sustain biodiversity-compatible land uses while ensuring long-term economic resilience.

6.9 Limitations

This study provides valuable insights into the dynamics of land use and land cover change within South Africa's wildlife ranching sector, but several limitations warrant consideration. First, the dataset used in this research revealed gaps and inconsistencies, particularly in self-reported land use classifications and transitions. Variability in how landowners interpreted and reported categories such as rangelands or old fields may have affected the accuracy of the analysis. Future studies should address these issues through standardised methodologies and the integration of remote sensing data with field validations to ensure consistent and reliable classifications. Similarly, the temporal constraints of this study, which offers a snapshot of land use transitions, limit its ability to capture long-term trends and delayed ecological responses. Longitudinal monitoring is necessary to understand how land use changes unfold over time, particularly in relation to biodiversity and ecosystem services.

A notable limitation was the lack of fine-scale biodiversity data. The absence of detailed ecological surveys precluded an assessment of how land use changes impact species diversity, genetic resilience, or habitat quality across wildlife ranches. Incorporating field-based biodiversity monitoring in future research would enable a more comprehensive evaluation of the ecological consequences of different land use practices. Similarly, while landowner interviews provided insights into land use transitions, there was limited evidence of active restoration efforts on old fields. The study was unable to confirm whether passive recovery processes will lead to full ecological restoration, as many old fields showed signs of persistent soil degradation and invasive species encroachment. Future studies should incorporate long-term monitoring to assess restoration trajectories and identify the key factors influencing successful land rehabilitation.

Additionally, while this study examined general patterns across business models, the findings may not fully generalise due to context-specific drivers. For example, regional ecological conditions and socio-economic contexts may shape land use dynamics differently. Expanding the geographic scope and including a broader range of models, such as subdividing ecotourism into distinct types, would provide a more nuanced understanding of wildlife ranching practices. Another limitation of this study was that land use and land cover change dynamics were not explicitly assessed at the provincial level. While Eastern Cape and Limpopo were included in the study, comparisons between these provinces were not made. Provincial variations in climate, policy frameworks, and land tenure systems may influence land use transitions, and future research could explore these differences more explicitly.

Finally, socio-economic factors, particularly the interplay between ecological outcomes and community-level benefits, were underexplored. While some landowners noted challenges such as labour shortages or water scarcity, the broader socio-economic impacts of wildlife ranching on rural communities—such as income stability, equitable benefit-sharing, or local perceptions of conservation—require deeper qualitative research. Bias in self-reported data also presents a potential limitation, as landowner perceptions and experiential knowledge, while valuable, may not always align with independent economic or ecological analyses. However, these perceptions are an important form of practitioner knowledge and should not be disregarded but rather complemented by triangulating self-reported data with external sources. Addressing these limitations in future studies will help refine the understanding of wildlife ranching as a dynamic SES, ensuring that its contributions to conservation and rural development are optimised.

7. Conclusion

The findings highlight a significant transition within wildlife ranches from traditional agriculture to wildlife-based land uses, driven by economic, environmental, and legislative factors. Economic factors such as rising agricultural input costs and the profitability of wildlife enterprises have been key drivers of this shift, further compounded by environmental constraints like water scarcity and land degradation, which have reduced the viability of conventional agriculture (Lindsey et al., 2013; Cousins et al., 2010). Legislative frameworks, particularly the Game Theft Act (1991), have facilitated this transition by granting landowners economic incentives to adopt conservation-compatible practices (Snyman and Bothma, 2023). These changes reflect the adaptive responses of landowners to evolving economic and environmental pressures, highlighting the social-ecological resilience of wildlife ranching systems.

Wildlife ranches have emerged as stable conservation actors, maintaining lower NLC loss compared to PAs. Their capacity to balance economic incentives with ecological integrity highlights their complementary role in South Africa's broader conservation landscape. Ecotourism and trophy hunting models particularly align with conservation objectives, leveraging habitat restoration and preservation to sustain both biodiversity and economic viability (Spenceley, 2008; Taylor et al., 2016). Meanwhile, livestock-oriented and mixed-use systems face challenges in balancing agricultural productivity with conservation, demonstrating the diverse social-ecological dynamics within these systems (Alary et al., 2022; Duru and Therond, 2015; Valbuena et al., 2012). Wildlife ranches play a role in maintaining natural land cover and supporting biodiversity conservation through sustainable land use practices. The stability of rangelands and the rehabilitation of old fields within certain business models demonstrate how these areas can sustain ecological functions over time. While this study did not explicitly assess habitat connectivity or the direct contribution of wildlife ranches to the protected area network, the patterns of land cover retention observed suggest that they may serve as important buffers or corridors between formally protected areas. Further research is needed to quantify their broader landscape contributions. These findings affirm the potential of wildlife ranches to play a critical role in sustainable land management and biodiversity conservation.

7.1 Review of objectives and synthesis of findings

The findings of this study provide critical insights into the patterns and drivers of land use change within wildlife ranches, addressing the study's objectives and revealing the complex social-ecological dynamics at play.

7.1.1 Objective 1: Historical changes in land use patterns

Transitioning from conventional agriculture to wildlife-based land use significantly transforms South Africa's land management history. The reduction in cultivated fields planted pastures and the corresponding increases in rangelands and old fields underscore a shift towards less intensive land uses. These patterns reflect the growing economic viability and ecological relevance of wildlife ranching as landowners move away from traditional agricultural practices constrained by high input costs and environmental degradation. Legislative reforms, particularly the Game Theft Act (1991), were pivotal in facilitating this shift by granting landowners legal rights to benefit economically from wildlife. This policy catalysed the growth of wildlife-based enterprises, aligning private economic incentives with conservation goals and fostering the expansion of wildlife ranching as a dominant land use. The historical legacy of intensive agricultural practices continues to influence current landscapes, mainly through the presence of old fields, which serve as both markers of past cultivation and opportunities for ecological recovery.

7.1.2 Objective 2: Motivations and drivers of land use change

The motivations driving land use change within wildlife ranches are multifaceted, reflecting a blend of economic, environmental, and historical factors. Economic viability emerged as a central driver, with landowners transitioning to wildlife-based models in response to the profitability of ecotourism and trophy hunting and the high costs of traditional farming. Environmental constraints, such as water scarcity and soil degradation, further reinforced this transition. Broader contextual drivers, including policy changes and regional socio-political dynamics, also shaped land use decisions. Land reform policies and shifts in market conditions influenced how landowners adapted their management strategies, highlighting the dynamic interplay between external pressures and individual motivations. Property size and age added another layer of complexity, with older and larger properties often exhibiting more conservation-friendly practices, likely due to accumulated resources and established infrastructure. However, the diversity of outcomes across enterprises shows the variability in how these drivers manifest within different contexts.

7.1.3 Objective 3: Patterns and drivers across business models

The distinct land use trends observed across business models highlight wildlife ranches' diverse strategies to balance economic and conservation goals. Ecotourism and trophy hunting models prioritise habitat preservation, aligning with their reliance on intact natural landscapes for tourism or game species. These models exhibit lower proportions of non-NLC and higher rates of land rehabilitation, reflecting their focus on long-term ecological benefits. In contrast, mixed-use and livestock models face greater challenges in integrating conservation into their operations. Higher proportions of non-NLC in these models indicate a continued emphasis on agricultural productivity, which often competes with conservation objectives. This balance between production and preservation illustrates the nuanced trade-offs landowners face in these systems. The diversity in land use strategies across business models reflects their adaptability within a social-ecological framework, responding to market demands and ecological constraints.

7.1.4 Objective 4: Natural land cover changes

Wildlife ranches demonstrate a strong capacity to maintain NLC over time. This stability suggests that private land management practices, driven by economic incentives and focused on sustainability, complement state-managed conservation efforts. While PAs experience higher variability in NLC loss, wildlife ranches maintain more consistent outcomes, contributing to habitat connectivity and biodiversity conservation. Old fields are critical in these dynamics, serving as transitional zones that enhance habitat heterogeneity and facilitate ecological recovery. Ecotourism and trophy hunting models, in particular, leverage old fields for passive restoration, supporting rewilding and biodiversity gains. These findings underscore the importance of integrating restoration efforts into land management strategies, particularly in systems with a history of agricultural degradation. Wildlife ranches thus exemplify the potential of private conservation initiatives to balance ecological integrity with economic viability.

7.2 Significance of study

This thesis highlights the transformative role of wildlife ranches in South Africa's conservation landscape, showing their potential to address pressing ecological and socio-economic challenges. By examining the patterns and drivers of land use change, the research contributes to a deeper understanding of how wildlife ranches function as social-ecological systems. The findings illuminate the capacity of wildlife ranches to maintain stable NLC while simultaneously contributing to economic resilience, demonstrating a model that integrates biodiversity conservation with sustainable livelihoods. The emphasis on business models and regional dynamics provides novel insights into the diverse strategies landowners employ to navigate economic, environmental, and historical pressures.

By showing how ecotourism and trophy hunting models align economic incentives with habitat preservation, this research strengthens the case for private conservation as a complement to state-managed PAs. The study also highlights challenges in mixed-use and livestock-oriented models, emphasising the need for targeted policies to enhance their ecological contributions.

7.3 Research and future directions

While this study offers valuable insights into the social-ecological role of wildlife ranching in South Africa, further research is crucial to address ongoing conservation challenges and support sustainable land management. Addressing these knowledge gaps will be essential to optimise wildlife ranching's contributions to biodiversity and rural development. Long-term studies tracking changes in land use, biodiversity, and ecosystem services across wildlife ranching models are essential to understanding their ecological and socio-economic trajectories. Investigating how shifts in market dynamics, climate conditions, and policy incentives shape these transitions over time will provide insights into their adaptive capacity. Comparative analyses across South Africa's provinces and internationally (e.g., Namibia, Botswana) can uncover how regional social-ecological contexts influence the success of various business models. Such analyses will help identify best practices and region-specific strategies to enhance conservation outcomes and economic sustainability.

The ecological trajectories of old fields represent a key area for further research. Assessing their potential for passive or active restoration, alongside risks such as AIS proliferation, can provide practical recommendations for cost-effective rehabilitation strategies. Linking this research to property-level management practices will help guide landowners in maximising biodiversity benefits while minimising ecological risks. Wildlife ranches have the potential to function as critical connectors within broader conservation landscapes. Research should explore how they can act as corridors, buffer zones, or stepping stones for wildlife movement and genetic diversity, especially within initiatives like SANParks' MLL vision. Evaluating their compatibility with conservation frameworks such as OECMs will ensure they complement formal PAs in achieving biodiversity goals. Climate change resilience must also be a priority for future research. Investigating adaptive management practices such as drought-resistant vegetation, soil moisture retention, and diversified grazing strategies will help wildlife ranches cope with increasing climatic variability. Wildlife ranches could also serve as refugia for vulnerable species, making them critical in South Africa's climate adaptation strategies.

Further research is needed to explore the socio-economic impacts of wildlife ranching on rural communities, including employment opportunities, income stability, and livelihood diversification, as well as understanding how economic benefits are distributed among landowners, employees, and neighbouring communities. Integrating wildlife ranching into South Africa's land reform agenda offers opportunities for inclusive conservation practices, addressing equity concerns while enhancing community support for biodiversity goals. Evaluating the financial sustainability of different wildlife ranching models, including their responses to market fluctuations, economic downturns, and regulatory changes, is also crucial. Exploring financing options such as conservation grants, tax benefits, and public-private partnerships will guide landowners adopting sustainable practices. The legal and policy frameworks supporting wildlife ranching require critical evaluation, with a focus on how existing policies influence landowner behaviour and conservation outcomes. By addressing these interconnected research priorities, future studies can provide actionable insights to optimise the role of wildlife ranching in biodiversity conservation, rural development, and sustainable land management, strengthening its contribution as a dynamic component of South Africa's conservation landscape.

7.4 Conclusion

This study demonstrates that wildlife ranches, as dynamic SES, play a pivotal role in balancing conservation and economic priorities in South Africa. By transitioning from traditional agricultural practices to wildlife-based land uses, ranches have contributed to habitat preservation while addressing rural land management's economic and environmental challenges. The distinct patterns of land use and the varying conservation outcomes across business models emphasise the diversity and adaptability of these systems. Business models like ecotourism and trophy hunting align with conservation goals, prioritising natural landscapes and ecological restoration. At the same time, mixed-use and livestock systems highlight the complexities of integrating agricultural productivity with biodiversity objectives. Wildlife ranches consistently maintain lower NLC loss than PAs, highlighting their stability and resilience in conservation efforts. These findings reveal the potential of private conservation initiatives to complement PAs by maintaining habitat connectivity, reducing fragmentation, and supporting biodiversity at a landscape scale. As South Africa navigates the dual challenges of biodiversity loss and rural development, wildlife ranches emerge as critical contributors to sustainable land management. Integrating ecological integrity with economic viability positions them as essential players in advancing conservation outcomes and fostering socio-economic resilience across landscapes.

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Appendix 1

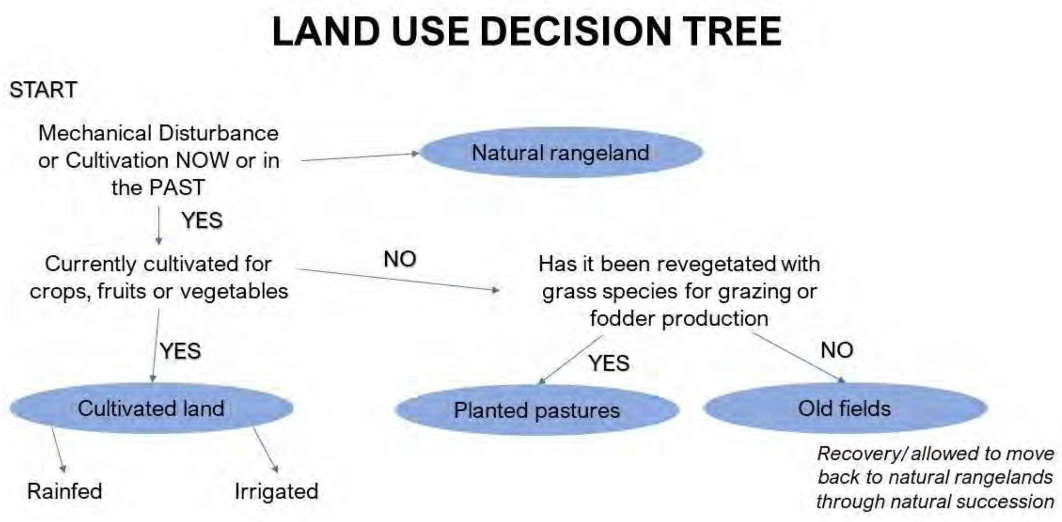
Section 1: Land Use and Land Use Change section

We will talk about current land uses on the property (Table 1). To simplify the responses, we are classifying the following broad land uses…

Land-use name	Definition
Cultivation	Irrigated and dry crops
Planted pasture	Fodder and standing grazing fields
Old fields / fallow land	Abandoned cultivated fields
Rangeland (natural vegetation)	Extensive areas of 'natural habitat'
Wetlands	Naturally occurring inland water bodies and vleis.
Streams and rivers	Any river or stream running through the property

1. **Please indicate on the map where, on the property, the relevant land uses are**

[pull out the map again and ask the landowner to indicate where each land-use is. We will use this as a tool to help the landowner think through the following questions.]



2. ***What crops are grown in your cultivated areas?***
3. ***What was the rough proportion of these land uses just before the current enterprise started?***
4. ***What are they now?***

[Note: For the Streams and Rivers category, this is recorded in km, not %]

5. *Why have these changes happened?*

When asking why a particular land-use has changed in extent this is a free form question so just record the reasons. For example, ' we wanted to diversify economically' or 'increasing fodder for our game species'.

Land-use name	16. Crop types	17. Initial % area	18. Current % area	19. Reason for change
Cultivation				
Planted pasture				
Old fields / fallow land	NA			
Rangeland (e.g. natural vegetation)	NA			
Wetlands (e.g. limestone depressions)	NA			
Rivers and streams	NA	……………(km)	NA	NA