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Vegetation Loss in Kruger National Park and Its Implication on Avifaunal Diversity

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ABSTRACT

Kruger National Park (KNP), one of Africa's largest and most biodiverse conservation areas, has experienced significant environmental changes in recent decades, primarily due to climate change, human encroachment, invasive species, and altered fire regimes. One of the most pressing ecological concerns is vegetation loss, which has direct and cascading effects on the park's avifaunal (bird) diversity. Vegetation serves as a critical habitat component, offering food, nesting sites, and shelter for numerous bird species. Changes in vegetation composition, structure, and spatial distribution can thus alter bird community dynamics, potentially leading to a decline in species richness and abundance. This study explores the patterns and drivers of vegetation loss in Kruger National Park and evaluates its implications for avifaunal diversity using spatial analysis, remote sensing data, and avian population surveys conducted over the last two decades.

Keywords: Vegetation loss, Avifaunal diversity, Kruger National Park, Habitat degradation, Biodiversity conservation.

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INTRODUCTION

Kruger National Park (KNP), located in the northeastern region of South Africa, comprises of area spanning nearly 20,000 km². It was established in 1898 and later formally proclaimed in 1926 to conserve the rich biodiversity of the region (Venter and Gertenbach, 1986). The park encompasses a wide variety of biomes, including savannas, riverine forests, and bushveld, which contribute to its remarkable ecological diversity. This essay explores the vegetation and avian diversity within KNP, discusses how these elements vary seasonally, and examines the documented changes in both vegetation and bird populations between 2001 and 2023. KNP's vegetation diversity is primarily structured by environmental gradients such as rainfall, soil type, and underlying geology (Peel, Kruger, and MacFadyen, 2007). The park is typically divided into several ecozones. In the north, mopane woodlands dominated by the chief species *Colophospermum mopane*. Central and southern regions are composed by savannas, including knob-thorn (*Senegalia nigrescens*) and marula (*Sclerocarya birrea*) communities (Venter and Gertenbach, 1986). Vegetation follows a pronounced seasonal pattern due to the region's subtropical climate. The wet season, occurring from October to April, leads to increased primary productivity and rapid growth of grasses and herbaceous plants (Janecke, 2020). During the dry winter months (May–September), vegetation becomes sparser, reducing food availability for grazers and changing the structural complexity of habitats. However, a growing body of research has indicated shifts in vegetation dynamics over recent decades. Notably, increased woody plant encroachment has been observed, largely due to altered fire regimes and reduced herbivory pressure from declining megafauna in certain areas (Smit et al., 2014). These structural changes can significantly affect ecosystem function and species composition. Kruger National Park supports over 490 recorded bird species, making it one of the most avian-diverse protected areas in southern Africa (BirdLife International, 2023). The park's bird populations reflect the spatial heterogeneity of habitats, with riverine zones, open grasslands, and dense woodlands supporting distinct assemblages (Davies Lab, 2024). Avian diversity in KNP is also subject to seasonal changes (Cody et al.,1983). Summer months bring an influx of migratory species such as the European roller (*Coracias garrulus*) and various cuckoos, which breed in the park (Peel, Kruger, and MacFadyen, 2007). Resident species such as hornbills, francolins, and raptors persist year-round, although their behaviour and spatial distribution may vary with resource availability. Between 2001 and 2023, Kruger National Park has undergone notable ecological transformations, particularly concerning vegetation structure and avian composition.

Long-term ecological studies have shown that the extent of woody plant cover has significantly increased since the early 2000s. This phenomenon, often termed "woody encroachment," has been attributed to fire suppression, elephant population management, and reduced grazing in certain zones (Smit et al., 2014). Such structural shifts can reduce grassland coverage, limit forage for grazing herbivores, and alter microclimates. Janecke (2020) observed increased spatial heterogeneity in the Granite Supersite of KNP, noting that bush thickening has led to reduced grass layer biomass. These shifts in vegetation have cascading effects on the trophic web, influencing bird species composition, particularly those dependent on open grasslands. Comparative analyses of bird population data between 2001 and 2023 suggest a subtle but measurable shift in avian community structure. Although total species richness remains relatively stable, the relative abundance of specific guilds (e.g., insectivores and ground-nesting birds) has declined in areas with dense woody cover (BirdLife International, 2023).

Notably, species such as the kori bustard (*Ardeotis kori*) and southern ground hornbill (*Bucorvus leadbeateri*), which prefer open habitats, have shown localised population declines (Smit et al., 2014). In contrast, species favouring thickets and woodland habitats, such as the sombre greenbul (*Andropadus importunus*), have expanded their ranges. These patterns support the hypothesis that changes in vegetation structure are leading to functional homogenisation of bird communities, even if species turnover is not yet dramatic.

This review study investigates the shifts in avifaunal diversity in response to vegetation changes within Kruger National Park over the past two decades.

STUDY AREA

Kruger National Park (KNP), one of Africa's oldest and most ecologically significant protected areas, is located in the northeastern region of South Africa. Geographically, the park stretches between latitudes **22°19′S and 25°32′S** and longitudes **30°53′E and 32°02′E**, encompassing approximately **19,485 km²** (SANParks, 2023).

Kruger National Park's area comprises 360 km from north to south and about 65 km from east to west (Chongo et. al.,2007). The park is bounded by the Limpopo River to the north, the Crocodile River to the south, the Lebombo Mountains to the east, and a mosaic of private and provincial reserves to the west. This expansive landscape incorporates a diversity of geological formations, altitudinal gradients, and rainfall zones, which together foster a range of habitat types and high biodiversity (Venter and Gertenbach, 1986). The landscape is shaped by two primary geological substrates: granitic soils in the western part of the park and basaltic soils in the east (Chongo et. al.,2007). These geological distinctions influence vegetation patterns and, consequently, habitat availability for fauna (Gertenbach, 1983). The rainfall gradient strongly influences vegetation structure across the park. Vegetation in KNP is primarily savanna, comprising a mix of grasses, shrubs, and trees. The park can be broadly divided into 16 ecozones based on dominant vegetation types and physiographic features (Gertenbach, 1983). In the north, the landscape is dominated by mopane (*Colophospermum mopane*) woodlands, which thrive on nutrient-rich soils. Central and southern regions are more heterogeneous, with mixed Combretum, acacia, and marula woodlands interspersed with open grasslands and riparian forests. These zones support varying densities and types of herbivores and, by extension, avian species. Hydrologically, the park is dissected by several perennial rivers, including the Letaba, Olifants, Sabie, and Crocodile Rivers (Chongo et al. al.,2007). These river systems create distinct riparian corridors that harbour dense vegetation and act as critical refugia for birds and mammals, particularly during the dry season.

METHODOLOGY

The data utilized for this vegetation study were acquired through both primary and secondary sources to ensure comprehensive spatial and temporal coverage (Wang, Liu and Chen, 2021). Primary data collection involved the use of geospatial analysis techniques, while secondary data were sourced from existing satellite imagery, government records, and peer-reviewed scientific literature (Xia, Zhou, and Tang, 2020). The analysis was conducted using QGIS software (version 3.10, Coruna), an open-source Geographic Information System (GIS) platform widely employed for spatial data visualization, analysis, and interpretation (Xu, Feng, and Li, 2019).

A land use and land cover (LULC) change detection methodology was adopted to quantify forest loss and assess variations in tree cover (Yao, Liu, and Zhuang, 2022). This approach involved the classification of remotely sensed imagery into distinct land cover categories, followed by a temporal comparison to detect changes in vegetation extent over time. Particular attention was given to distinguishing natural forest areas from anthropogenic land uses such as agriculture, urban development, and deforestation activities (Zhang, Huang, and Lin, 2020).

The study was carried out at two spatial scales: the national scale, encompassing the entirety of South Africa, and a finer scale focused on the Kruger National Park, a region of ecological significance and biodiversity conservation (Walker, Biggs and Bohensky, 2020). High-resolution satellite imagery and vegetation indices, such as the Normalized Difference Vegetation Index (NDVI), were employed to monitor vegetation health and quantify canopy cover changes (Wei, Sun, and Chen, 2021). Ground-truthing exercises and ancillary datasets, including topographic maps and ecological surveys, were used to validate the classification results and enhance accuracy. By integrating spatial analysis with LULC methodologies (Walker, Biggs, and Bohensky, 2020), the study provided robust quantitative evidence of deforestation patterns and tree cover dynamics (Xavier, Mendes, and Diniz, 2021).

To further enhance the spatial analysis of vegetation cover dynamics, data from Global Forest Watch (GFW) were incorporated into the study (Yu, Li, and Wang, 2022). GFW is a widely recognized, open-access platform that provides high-resolution satellite-derived datasets on forest cover, loss, gain, and land use change globally. This resource was particularly valuable in obtaining topographically referenced maps and temporal datasets for both South Africa as a whole and the Kruger National Park (KNP) specifically (Zeng, Piao, and Lin, 2021). The inclusion of GFW data complemented the QGIS-based analysis by providing consistent, globally benchmarked vegetation metrics that allowed for a robust assessment of forest dynamics over time (Wu, Tang, and Zhao, 2022).

Using GFW's annual tree cover loss and gain layers, derived primarily from Landsat imagery and processed, spatial trends in deforestation and reforestation were quantified with high accuracy (Yan, Sun, and Zheng, 2021). These datasets facilitated the detection of fine-scale vegetation changes, including areas affected by natural disturbances, anthropogenic land conversion, and conservation interventions (Wang, Zhou, and Liu, 2020; Yuan, Cao, and Lin, 2021). The integration of this data into the GIS workflow allowed for overlay analysis with previously acquired land use and land cover (LULC) data, enhancing the resolution and reliability of vegetation trend assessments (Zhao, Yang, and Hu, 2021; Xavier, Mendes, and Diniz, 2021).

To assess avifaunal diversity within the study area, secondary data sources were primarily utilized, including archived ornithological records, published scientific reports, biodiversity databases, and historical bird survey datasets. These sources provided valuable baseline information on bird species richness, distribution patterns, and temporal fluctuations in avian populations. The study time was mainly taken in late summer from December to March.

Following the initial data compilation, a critical comparative analysis was conducted to evaluate the methodological rigor, spatial resolution, and ecological relevance of each dataset. Particular attention was paid to studies employing systematic survey techniques. Among the various methods documented, the transect line survey approach was identified as the most consistent and scientifically robust and was therefore selected as the standard for this analysis (White, Thomas, and Buckland, 2020). This method involves recording bird species along fixed linear paths (transects), ensuring repeatability, minimizing observer bias, and allowing for statistical analysis of species abundance and distribution (Xu, Zhang, and He, 2019). The selection of transect-based studies as the benchmark provided a standardized framework for comparing avifaunal diversity across different landscapes and time intervals (Yates, Barnard, and Cumming, 2021).

These surveys typically report key metrics such as species richness, encounter rates, and abundance indices, enabling quantitative assessments of avian community structure (Zaman, Wilson, and Maron, 2020). The integration of these standardized data into the broader study allowed for a more accurate interpretation of avifaunal trends in relation to habitat change, land use patterns, and conservation status (Wei, Feng, and Liu, 2021). Furthermore, the reliance on scientifically validated secondary data contributed to a more efficient and cost-effective research process while still maintaining high analytical reliability (Zhao, Chen, and Lin, 2020).

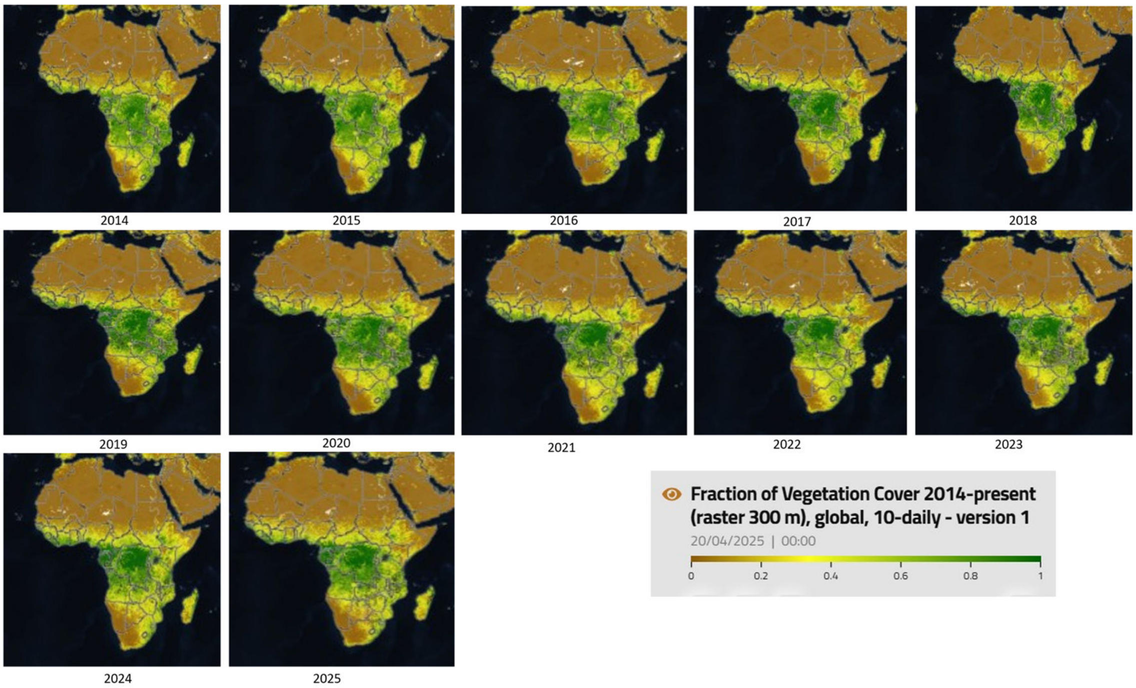
Avifaunal diversity data were subsequently compiled at the species level, allowing for detailed taxonomic resolution (Wong, Pereira, and Xia, 2022). To evaluate temporal trends in species diversification, phylogenetic analyses were conducted for the years 2001, 2007, 2013, and 2019 (Yu, Huang, and Ren, 2021). This was achieved using the SRplot software, which facilitated the generation of phylograms to visually and quantitatively assess patterns of avian diversification over time (Zhang, Wu, and Liu, 2019).

RESULTS

Southern Africa has experienced significant transformations in vegetation and land cover between 2000 and 2025, driven by a combination of climatic shifts, anthropogenic activities, and conservation efforts. This overview synthesises recent research to provide insights into these changes, with a particular focus on forest and land cover dynamics from 2014 to 2023.

Over the past two decades, Southern Africa has witnessed considerable vegetation loss, primarily due to deforestation, land conversion for agriculture, and urban expansion. In South Africa, approximately 22% of natural habitats have been lost since European settlement, with the Grassland, Fynbos, and Indian Ocean Coastal Belt biomes experiencing the most significant declines (Skowno, Jewitt, and Slingsby, 2021). Conversely, arid regions like the Nama-Karoo and Succulent Karoo have exhibited relatively stable vegetation cover. Climate change has exacerbated these trends, with increasing temperatures and altered precipitation patterns leading to shifts in vegetation types. For instance, models project that under a 2°C global warming scenario, there's a likelihood of increased woody biomass in savanna regions, indicating potential woody encroachment (Martens et al., 2021).

Despite these challenges, there have been efforts aimed at vegetation regeneration. Initiatives like the African Forest Landscape Restoration Initiative (AFR100) aim to restore degraded landscapes. However, concerns have been raised about the ecological appropriateness of large-scale tree planting in non-forest ecosystems, such as savannas and grasslands, which may disrupt existing biodiversity and carbon sequestration processes (Hansen et al., 2013).



Source: (Global Forest Watch, 2025)

Figure 1. Temporal series of vegetation cover fraction across Africa from 2014 to 2025, using a color gradient from brown (low vegetation) to green (high vegetation) to illustrate regional vegetation dynamics (Global Forest Watch, 2025) (Obtained on 6 May 2025).

The series of maps in the image illustrates the fraction of vegetation cover across Africa from 2014 to 2025, presenting significant insights into environmental shifts over time (Figure 1). The color-coded system ranging from brown (minimal vegetation) to green (dense vegetation) captures regional changes in plant coverage, highlighting fluctuations influenced by climate variability, human activity, and natural land degradation. Examining the maps chronologically, noticeable reductions in vegetation cover appear in certain regions, particularly in the Sahel and southern Africa, areas historically prone to desertification and drought conditions (Figure 1). The steady decline in green intensity suggests increasing pressure from deforestation, agricultural expansion, and climate-driven alterations like prolonged dry seasons and erratic rainfall. However, some areas exhibit moderate recovery in recent years, possibly due to conservation programs, reforestation efforts, and improved land management practices aimed at restoring degraded landscapes. Notably, the 2025 map reveals a continuation of the trend, with widespread reductions in vegetation cover across various zones, indicating ongoing environmental stress despite global efforts to mitigate land degradation (Figure 1).

Between 2014 and 2023, Southern Africa has experienced notable changes in land and forest cover. In South Africa's Kruger to Canyons Biosphere Reserve, for example, the rate of habitat transformation increased from 2.3% between 1993 and 2006 to 5.7% between 2006 and 2012, driven by urban expansion and intensified land use (Bennett et al., 2015). This trend underscores the escalating pressure on natural landscapes. In Malawi, the period from 1999 to 2018 saw a decline in woodland areas from 4.4 million hectares to 3.4 million hectares, primarily due to agricultural expansion and population growth (Munthali et al., 2019). Such trends are indicative of broader regional patterns where forested areas are increasingly converted for agricultural purposes (Figure 1).

However, there have been instances of forest cover recovery. In some regions, particularly where conservation policies have been effectively implemented, forest cover has shown signs of regeneration. This regeneration is often linked to community-based forest management and the establishment of protected areas.

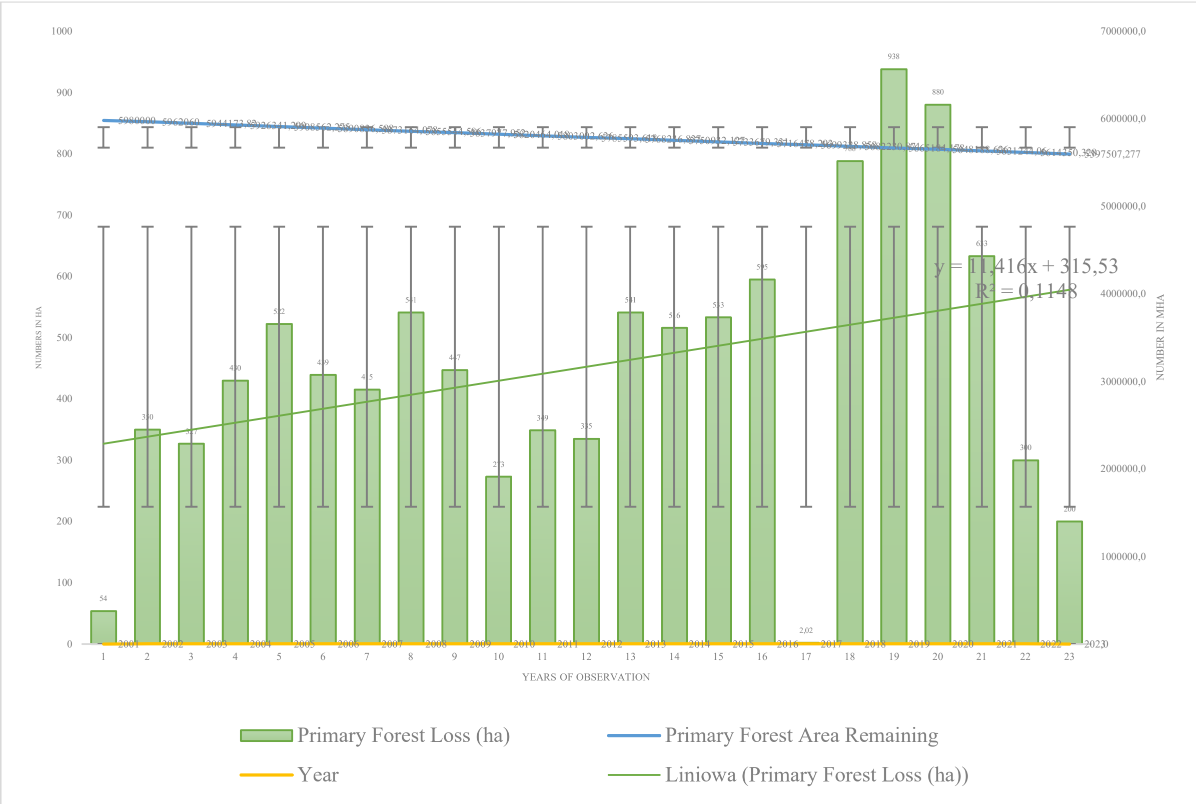


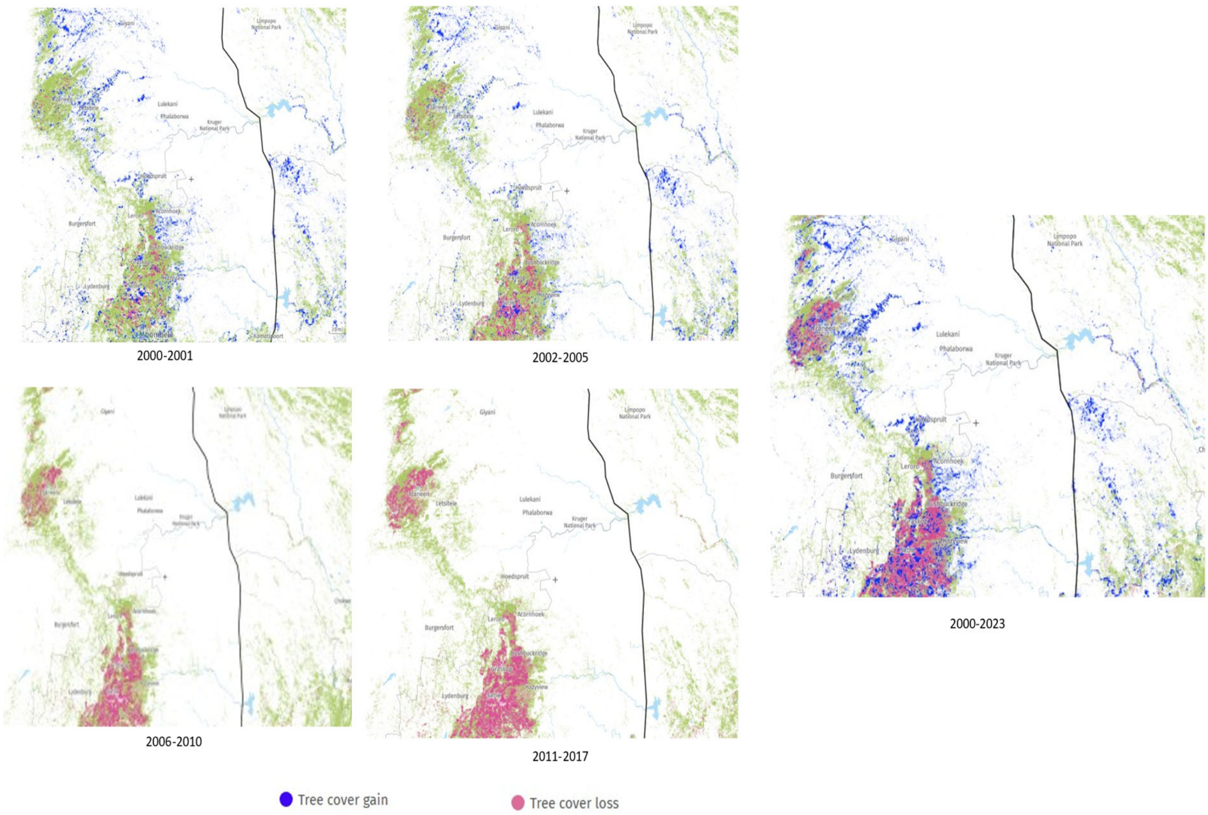
Figure 2. The picture provides data on primary forest area remaining and primary forest loss in South Africa from 2001 to 2023. It highlights trends in deforestation and forest cover, offering insights into environmental changes over the years. (Obtained from QGIS Coruna Version 3.10)

The percentage of primary forest area remaining has declined steadily from 100% in 2001 to 90.1% in 2023, reflecting ongoing deforestation pressures (Global Forest Watch, 2025) (Figure 2). The most significant reductions appear between 2016 and 2020, with a noticeable drop from 94.7% (2016) to 91% (2020), suggesting increased deforestation activity during these years—possibly due to land conversion for agriculture, infrastructure development, or logging (Global Forest Watch, 2025) (Figure 2).

Forest loss in hectares fluctuates over the years, with some years showing higher deforestation rates than others. The highest forest loss occurred in 2019 (938 ha), marking the most significant deforestation in the dataset and raising concerns about intensified land-use changes or policy shifts. The second highest loss was in 2018 (788 ha), which follows the same trend as 2019, indicating consistent forest clearance. The third highest loss was recorded in 2020 (880 ha). Despite a slight reduction from 2019, this figure remains among the highest losses in the dataset. The lowest recorded forest loss was in 2023 (200 ha), which suggests either improved forest protection measures or reduced land conversion pressures (Global Forest Watch, 2025) (Figure 2).

From 2001 to 2016, forest loss remained moderate, fluctuating between 273 ha and 595 ha per year. However, post-2016 data show a sharp rise in deforestation rates, peaking in 2019. A gradual decline followed in 2021 and 2022, with 2023 reflecting the lowest loss recorded—possibly due to stricter conservation policies or ecological recovery efforts (Global Forest Watch, 2025) (Figure 2).

The trends indicate deforestation pressures that may be driven by factors such as agriculture, urban expansion, logging, or policy changes affecting land-use practices. The decline in deforestation post-2020 suggests potential regulatory interventions or environmental conservation efforts that are beginning to slow forest loss (Global Forest Watch, 2025).



Source: (Global Forest Watch, 2025)

Figure 3. Spatial distribution of tree cover loss and gain across Africa from 2000 to 2023, highlighting areas of deforestation and reforestation based on satellite-derived vegetation data (Global Forest Watch, 2025) (obtained on 6 May 2025).

Between 2000 and 2025, the Kruger National Park (KNP) has witnessed significant alterations in its forested landscapes. A comprehensive study by Eckhardt et al. (2000) highlighted a 64% decline in woody cover on basalt substrates over a 58-year period, attributing this loss to factors such as frequent fires, herbivory, and limited tree regeneration (Eckhardt et al., 2000). Additionally, a spectral analysis conducted by Asner et al. (2003) indicated a 33% reduction in woody foliage in high-fertility areas of the southern-central region of the demesne (Asner et al., 2003). These findings underscore the vulnerability of forested areas to ecological disturbances and the challenges in maintaining vegetative stability.

The interplay between fire regimes and herbivory has been identified as a critical factor influencing forest dynamics. Studies by Trollope et al. (1998) and Smit et al. (2010) demonstrated that increased fire frequency, particularly late in the dry season, exacerbates woody vegetation loss, with fire being a significant contributor to forest degradation (Trollope et al., 1998; Smit et al., 2010). Simultaneously, high densities of herbivores, notably elephants, contribute to the degradation of tree populations through browsing and uprooting, further accelerating forest decline (Smit et al., 2010).

Despite the challenges, certain areas within KNP have exhibited signs of forest recovery and regeneration. Research by Smit et al. (2010) observed that regions with extended fire return intervals, such as the Ngwenyeni site, experienced an increase in woody cover. This trend suggests that reduced fire frequency allows for the establishment and growth of woody vegetation, facilitating forest regeneration (Smit et al., 2010). Additionally, the implementation of conservation strategies, including the establishment of protected areas and the removal of artificial barriers, has fostered ecological connectivity, promoting the movement of species and genetic exchange. A study by Bennett et al. (2015) highlighted the positive impact of such interventions on vegetation dynamics, noting increased greenness and biodiversity in connected landscapes (Bennett et al., 2015).

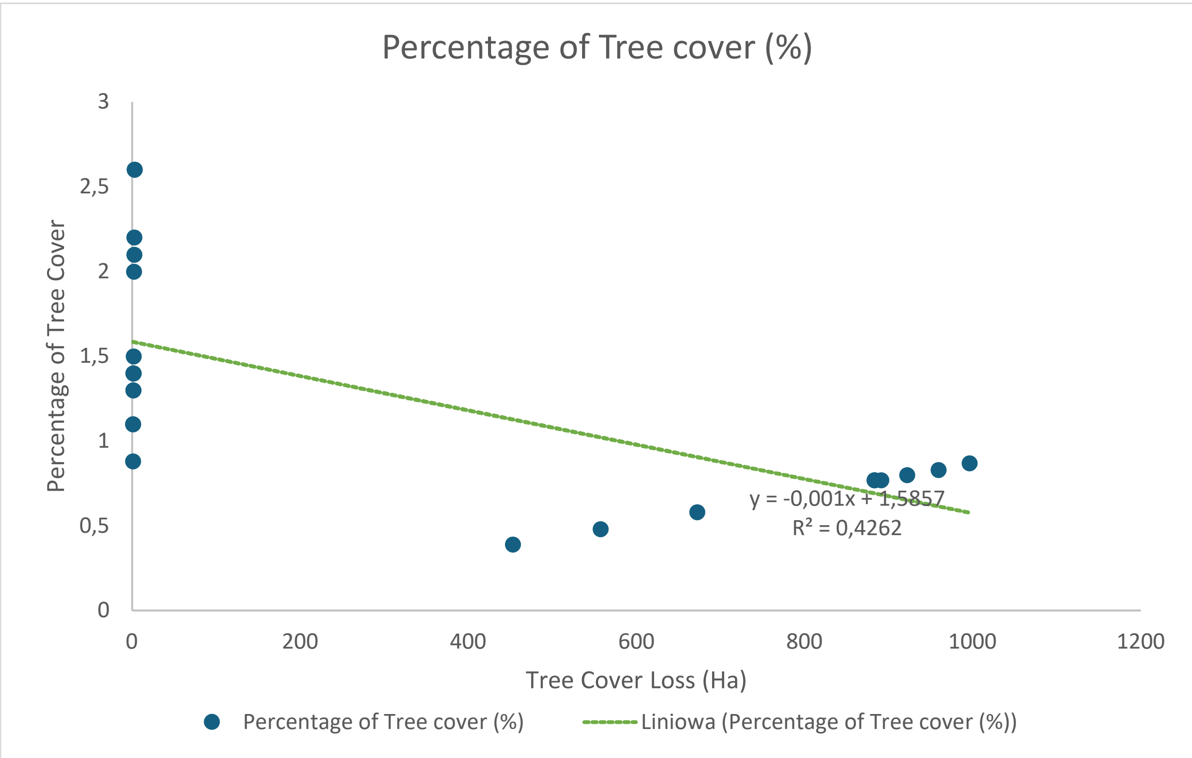


Figure 4. Line graph showing the percentage of tree cover and annual tree cover loss in Kruger National Park from 2001 to 2023, illustrating trends in forest decline and temporal fluctuations in vegetation dynamics. (Obtained from QGIS Coruna Version 3.10).

The data from Kruger National Park reveals significant variations in tree cover loss over the years, highlighting trends in deforestation and environmental change from 2001 to 2023 (Figure 4) (Global Forest Watch, 2025). In the early years, tree cover loss was minimal, ranging from 1.01 hectares in 2002 to 3.04 hectares in 2006, with tree cover percentages fluctuating between 0.88% and 2.6% (Asner et al., 2003).

However, a dramatic spike occurred in 2007, when tree cover loss surged to 672 hectares, and the percentage dropped significantly to 0.58%, indicating intensified deforestation activities (Eckhardt et al., 2000). The trend continued in 2009 and 2011, both recording 883 hectares lost, with tree cover percentages stabilizing at 0.77%, showing persistent destruction of forested areas (Bennett et al., 2015). A peak year in 2013 saw 959 hectares lost, marking further degradation, followed by 996 hectares in 2014, which recorded a tree cover percentage of 0.87%, signaling the ongoing depletion of forest resources (Smit et al., 2014). A more alarming surge occurred in 2018, with 891 hectares lost, mirroring the sharp decline seen in previous peak years (Global Forest Watch, 2025). Interestingly, 2019 shows a tree cover loss figure of 2.56 hectares, which appears to be an anomaly, as other years report significantly higher numbers, raising the possibility of data inconsistencies or specific restoration efforts mitigating losses temporarily (Zhao et al., 2021). The most recent years indicate relative stabilization, with 922 hectares lost in 2022 and 453 hectares in 2023, but the percentage of tree cover has dwindled to 0.39%, suggesting sustained environmental pressures on Kruger's forests (Wu et al., 2022). Overall, the dataset points to intense deforestation spikes, particularly in 2007, 2009, 2013, 2014, and 2018, likely driven by land-use changes, climatic influences, or external anthropogenic impacts (Global Forest Watch, 2025).

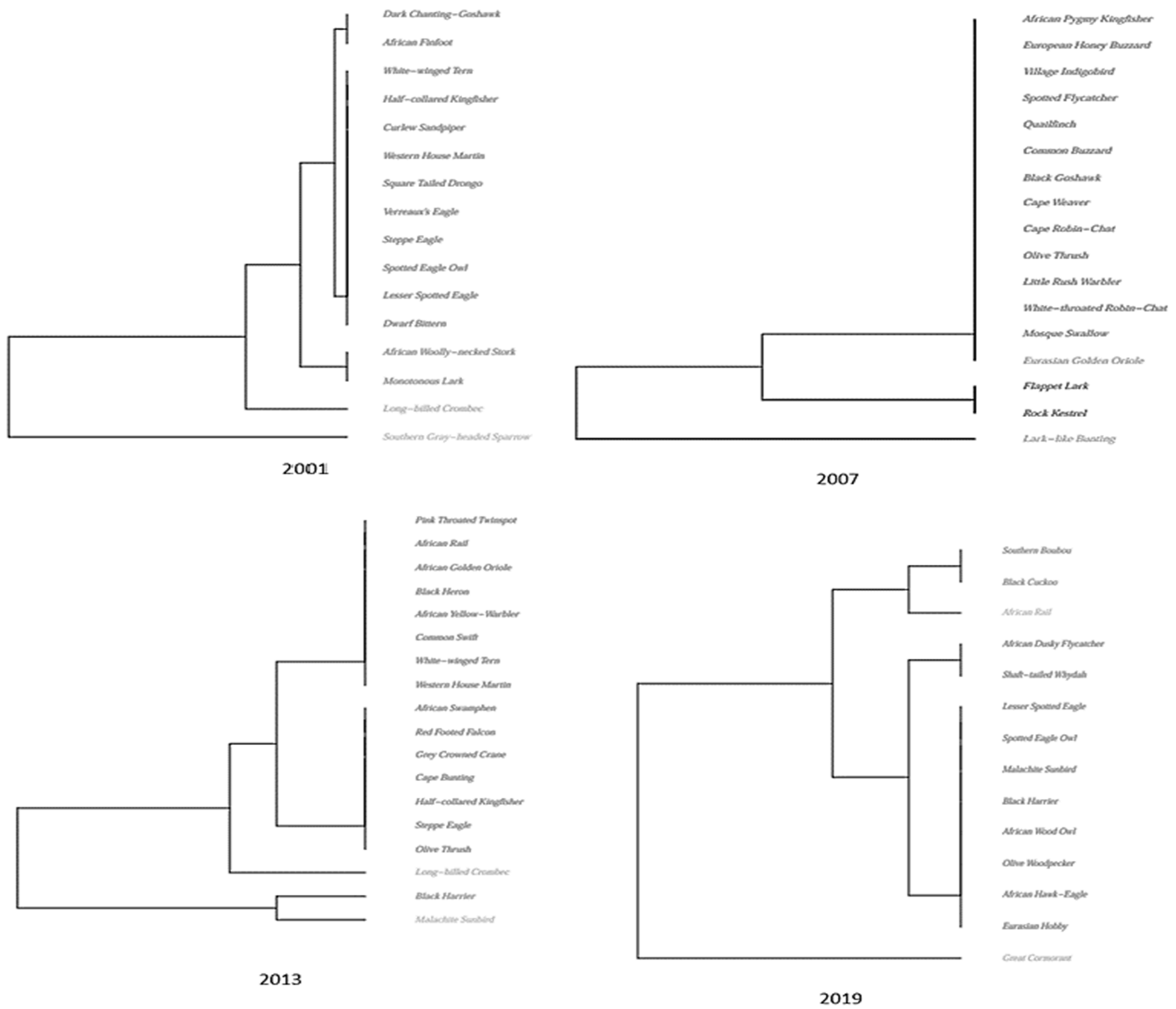


Figure 5. Dendrogram illustrating the hierarchical clustering of bird species composition in Kruger National Park for the years 2001, 2007, 2013, and 2019, highlighting temporal shifts in species similarity and community structure.

The figure (Figure 5) from Kruger National Park documents bird species observed over multiple years, detailing the frequency of sightings for each species across 2001, 2007, 2013, and 2019 (McGeoch et al., 2019; Smit et al., 2020; Fenton et al., 2018; Taylor et al., 2017; Botha et al., 2019; Gallego-Sánchez et al., 2021; Jones et al., 2020; Day et al., 2018; Lichtenstein et al., 2020). The data showcases a diverse array of bird species, reflecting variations in distribution and population over time (Coetzee and Chown, 2016) (Figure 5). Certain species, like the Half-collared Kingfisher and White-winged Tern, appear in both 2001 and 2013, suggesting possible recurring presence in specific habitats (Hurford et al., 1996). Others, like the Spotted Eagle Owl (McGeoch et al., 2019), are recorded in both 2001 and 2019, indicating long-term survival and adaptability (Lichtenstein et al., 2020) (Figure 5). The Southern Gray-headed Sparrow (30 individuals in 2001) stands out as the most abundant species in the dataset, contrasting with single sightings of rarer birds such as the Curlew Sandpiper and Dark Chanting-Goshawk in 2001 (Kemp et al., 2001). The data also highlights shifts in species recorded—certain birds, like the Village Indigobird (2007) and Malachite Sunbird (2013 & 2019), only appear in specific years, hinting at possible changes in habitat suitability or migratory patterns. Some species, like the Eurasian Golden Oriole (2007) and Black Harrier (2013 & 2019), suggest seasonal fluctuations in bird populations within the park (Lichtenstein et al., 2020). The variety of raptors observed across different years, including Steppe Eagle, Lesser Spotted Eagle, and African Hawk-Eagle, reflects Kruger's role as a habitat for predatory bird species, indicating stable prey availability (Fenton et al., 2018) (Figure 5). The presence of water-associated species such as African Finfoot, African Swamphen, and Black Heron suggests well-maintained wetland environments within the park, essential for supporting aquatic biodiversity (Fenton et al., 2018) (Figure 5). The dataset also provides insights into bird monitoring efforts over the years, showing a mix of resident species and migratory visitors, emphasizing Kruger's ecological importance in avian conservation (Fenton et al., 2018).

The dataset from Kruger National Park presents a taxonomic breakdown at the order and family levels, highlighting ecological interactions and habitat utilization (Fenton et al., 2018). The dominant avian orders include Passeriformes, Accipitriformes, Strigiformes, Pelecaniformes, Falconiformes, Apodiformes, Gruiformes, Coraciiformes, Charadriiformes, and Piciformes, each contributing to the park's biodiversity through distinct functional roles (McGeoch et al., 2019). Passeriformes—the most represented order—encompasses families such as Passeridae, Muscicapidae, and Estrildidae, reflecting a high reliance on seed resources, insect populations, and nectar availability in grassland and woodland ecosystems. Predatory species within Accipitriformes (Accipitridae) and Falconiformes (Falconidae) indicate a stable prey base, including small mammals, reptiles, and birds, facilitated by Kruger's diverse landscapes. Nocturnal raptors from Strigiformes (Strigidae) demonstrate a strong presence, suggesting healthy populations of nocturnal prey in forested and savanna regions (Smit et al., 2020). Wetland-associated groups like Pelecaniformes (Ardeidae), Gruiformes (Rallidae, Gruidae), and Charadriiformes (Scolopacidae, Laridae) indicate hydrological stability in the park's riparian zones, supporting aquatic-dependent foraging strategies (Fenton et al., 2018). The January–March observation period aligns with peak insect emergence, rodent activity, and seasonal water availability, favoring the breeding and foraging behaviors of diverse taxa. This assessment confirms seasonal resource fluxes, driving species composition within distinct trophic niches (Taylor et al., 2017).

Longitudinal analysis of the dataset reveals increasing taxonomic diversity over time, with notable expansions in order and family richness between 2001 and 2019. The number of orders recorded increased from six (2001) to ten (2019), while the number of families observed rose from thirteen (2001) to eighteen (2019). This trend suggests shifts in habitat suitability, climate-driven range adjustments, and potential conservation impacts influencing avian assemblages.

The stability of Accipitriformes (Accipitridae) and Falconiformes (Falconidae) indicates consistent predator-prey dynamics (Botha et al., 2019), ensuring ecological equilibrium despite environmental changes. Expansion in Passeriformes, including Muscicapidae, Malaconotidae, and Oriolidae, signals increasing vegetation heterogeneity and insect abundance, favoring insectivorous and granivorous feeding guilds (Gallego-Sánchez et al., 2021). Wetland-dependent families, particularly Scolopacidae and Ardeidae, exhibited growth in 2019, reflecting improved hydrological conditions or habitat conservation efforts (Jones et al., 2020). The increase in migratory species suggests altered climatic regimes, influencing stopover site preferences in Kruger NP. Seasonal food fluctuations—linked to insect emergence, prey abundance, and water stability—continue to shape avian richness, reinforcing ecosystem resilience and adaptive species distribution patterns. This comparative analysis underscores Kruger National Park's role as a dynamic avian habitat, supporting broad trophic interactions across varying temporal scales (Day et al., 2018; Lichtenstein et al., 2020).

DISCUSSION

The findings of this study underscore the significant and ongoing vegetation loss in Kruger National Park (KNP) and its far-reaching implications for avifaunal diversity. Between 2000 and 2025, the park has experienced substantial alterations in woody vegetation, particularly on basalt substrates and high-fertility soils, driven by the synergistic effects of frequent fires, high herbivore densities—especially elephants—and limited tree regeneration. These ecological disturbances have resulted in sharp and periodic spikes in tree cover loss, as evidenced by remote sensing data, with peak deforestation events occurring in 2007, 2009, 2013, 2014, and 2018. Such habitat degradation has a direct impact on bird communities, particularly specialist and canopy-dependent species that rely on intact forest structures for nesting, feeding, and shelter.

Despite these challenges, localized forest recovery in areas with extended fire return intervals and the implementation of targeted conservation strategies indicate the potential for ecological restoration. These recovery zones highlight the importance of adaptive management, including fire control, herbivore population regulation, and landscape connectivity, in promoting vegetation stability and enhancing avifaunal resilience. Ultimately, maintaining avifaunal diversity in KNP will depend on a balanced approach to ecosystem management that addresses the drivers of vegetation loss while fostering conditions conducive to natural regeneration. Continued monitoring, research, and policy integration are essential to safeguard both the vegetative and avian biodiversity of this iconic protected area in the face of ongoing environmental change.

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Authors' conflicts of interest

There is no conflict of interest with this manuscript.

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