South African
NATIONAL PARKS

Elephant Management Plan
Kruger National Park
2023-2028

Reference Number:

INFORMATION

Responsible Executive Manager:	Dr Howard Hendricks (CSD) Mr Oscar Mthimkhulu (ME: KNP)
Division/Unit Responsible for Formulation:	Scientific Services Division & Kruger National Park Management
Writer/s:	Sam Ferreira, Cathy Greaver, Danny Govender, Corli Wigley-Coetsee.
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Pam Yako Chair of the SANParks Board Date: 30/09/2025	Nomfundo Tshabalala Director General, DFFE Date: 02/10/2025
Dr. Dion George Minister of the Department of Forestry, Fisheries and the Environment Date: 23/10/2025	

Note that the lifetime of the plan aligns with the Park Management Plan.

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Executive Summary

South African National parks (SANParks) wish to manage elephant impacts on biological, cultural, human and stakeholder values. Kruger National Park (Kruger) is a large conservation area comprising a diversity of landscapes that conserve significant biodiversity assets. Kruger forms the key focus of conservation in the lowveld region as well as the Greater Limpopo Transfrontier Conservation Area (GLTFCA). The region includes a multitude of landscapes and land uses including rural communities, commercial farming, industry, and ecotourism initiatives. Several different stakeholder interests therefore impact on Kruger, and vice versa. This Elephant Management Plan (EMP), compiled in accordance and compliance with the National Norms and Standards for Elephant Management (National Environmental Management Biodiversity Act (NEMBA) 2005: Government Gazette 251 of 29 February 2008), is a supporting document to the Kruger Park Management Plan (PMP) approved by the Department of Forestry, Fisheries and Environment (DFFE).

The Plan provides the strategic context of elephant management, supported by experience and adaptive learning, specifically during implementation of the previous elephant EMPs. The focus is on addressing how elephants influence overall management objectives of Kruger, as defined in the PMP. In this context, four key elephant management objectives have 13 strategic actions, with 29 key activities addressing these influences with 16 performance indicators.

Objective 1 fosters meaningful stakeholder relationships by growing local and regional understanding and support for elephants, improving livelihoods and mitigating conflict with people. Strategic actions focus on (1) aligning with and supporting implementation of the GLTFCA elephant management framework; (2) managing damage causing elephants that leave the Park as well as (3) incidences of problem elephants within the Park; and (4) strengthening co-operative governance arrangements with key South African stakeholders. **Objective 2** seeks to maintain resilient elephant populations by reducing impacts from poaching, poisoning, and snaring. It relies on (1) anti-poaching and conservation law enforcement; (2) investigations and appropriate interventions; and (3) connecting fragmented landscapes within which elephants live. Linked to this is **Objective 3** that seeks to manage the ecological and cultural role of elephants allowing for their dynamic function in ecosystems, while reducing ecological risks and promoting their cultural value. It focuses on (1) restoring and establishing gradients of water, food, comfort and safety resources across landscapes and habitats; (2) managing the ecological impacts to sensitive areas and species; (3) monitoring and influencing the interactions between fire and elephants and their impacts on landscapes; and (4) protecting specific species and individuals that have tourism and cultural values. **Objective 4** facilitates opportunities and benefits associated with elephants while promoting all their various values as well as ecosystem services.

Accountability for overall implementation lies with the Managing Executive: Kruger National Park. The actions set out in the Objectives of this plan are not limited to the timeframe of this plan and may become redundant pending outcomes of actions taken. Changing context including but not limited to changes in resource availability, and unforeseen or emergent opportunities or challenges that may arise during the period for which this plan is active, may lead to some deviation, adding or subtracting from the plan, but these will be carefully considered and the rationale for any deviation will be documented.

1. Rationale

African elephants (*Loxodonta africana*) contribute to ecological features and the existence of biomes[1] while structuring the physical environment that benefits other fauna[2]. People value elephant for many reasons[3], the benefits provided to tourists[4] and rural communities[5]. Elephants, however, threaten biodiversity[6] and cause damages to property and come in conflict with people[7]. Making trade-offs between the positive effects of elephants and the various costs of living with them, both to people and other biodiversity, poses challenges to African-based conservation agencies[8].

South Africa embraced such challenges as opportunities for an inclusive, transformed society where biodiversity conservation and sustainable use ensure healthy ecosystems, with improved benefits that are fairly and equitably shared for present and future generations[9]. In this context, the management of elephants in Kruger seeks to contribute to the national goals of transformed and enhanced biodiversity conservation, sustainable use, and equitable access and benefit sharing within the "*White Paper on Conservation and Sustainable Use of South Africa's Biodiversity*".

The management of elephants, their values and the costs and benefits that they have for people takes guidance from the National Elephant Heritage Strategy[10] that

[1] Skowno AL, Thompson MW, Hiestermann J, Ripley B, West AG, Bond WJ (2017) Woodland expansion in South African grassy biomes based on satellite observations (1990-2013): general patterns and potential drivers. Global Change Biology, 23, 2358–2369
Stevens, N., B. F. N. Erasmus, S. Archibald, and W. J. Bond. 2016. Woody encroachment over 70 years in South African savannahs: overgrazing, global change, or extinction aftershock? Philosophical Transactions of the Royal Society B: Biological Sciences 371:20150437

[2] Pringle, R.M. 2008. Elephants as agents of habitat creation for small vertebrates at the patch scale. Ecology 89:26–33.
Pringle, R.M., Coverdale, T.C., Kartzinel, T.R., Grabowski, K.L., Shriver, R.K., Hassan, A.A., Goheen, J.R. and Palmer, T.M. 2016. Elephants in the understory: opposing direct and indirect effects of consumption and ecosystem engineering by megaherbivores. Ecology. 97(11):3219-3230.
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[3] van de Water, A., Henley, M., Bates, L. and Slotow, R., 2022. The value of elephants: A pluralist approach. *Ecosystem Services*, *58*, p.101488.

[4] Lindsey PA, Roulet, PA, and Romañach, SS. 2007. Economic and conservation significance of the trophy hunting industry in sub-Saharan Africa, Biological Conservation, 134(4): 455-469.

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[6] Cumming, D.H., Fenton, M.B., Rautenbach, I.L., Taylor, R.D., Cumming, G.S., Cumming, M.S., Dunlop, J.M., Ford, A.G., Hovorka, M.D., Johnston, D.S. and Kalcounis, M., 1997. Elephants, woodlands, and biodiversity in southern Africa. South African Journal of Science, 93(5), pp.231-236.
McCleery, R., Monadjem, A., Baiser, B., Fletcher Jr, R., Vickers, K. and Kruger, L. 2018. Animal diversity declines with broad-scale homogenization of canopy cover in African savannas. Biological Conservation, 226, pp.54-62.

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Hoare, R.E. & Du Toit, J. 1999. Coexistence between People and Elephants in African Savannas. Conservation Biology. 13(3),633-639
Hoare, R.E. 2000. Humans and elephants in conflict: the outlook for coexistence. Oryx 34(1):34–38
Hoare, R.E. 2012. Lessons from 15 years of human–elephant conflict mitigation: Management considerations involving biological, physical and governance issues in Africa. Pachyderm. 51. 60-74.

[8] Holling, C.S. (2001). Understanding the Complexity of Economic, Ecological, and Social Systems. Ecosystems. 4, 390-405.
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Venter, F., Naiman, R. J., Biggs, H. and Pienaar, D. (2008). The Evolution of Conservation Management Philosophy: Science, Environmental Change and Social Adjustments in Kruger National Park. Ecosystems. 11, 173-192.

[9] Publication of the white paper on Conservation and sustainable use of South Africa's Biodiversity. Department of Forestry, Fisheries, and the Environment. Government Gazette, No. 48785. 14 June 2023. https://www.gov.za/sites/default/files/gcis_document/202306/48785gon3537.pdf

[10] Developing National Elephant Heritage Strategy, DFFE, humbu.mafumo@dffe.govt.za

envisions thriving elephants contributing to equitable livelihoods, ensured dignity, and secured well-being for present and future generations of South Africans.

South Africa had an estimated 43,884 to 44,775 African savanna elephants by the end of 2021[11]. South Africa's elephant populations are well protected and breed quicker, live longer, and use landscapes more intensely than elsewhere in Africa[12] due to fencing and other landscape constraints. Consequently, the impacts created by elephants can have undesirable outcomes for other values, including biodiversity.

On a regional scale, elephants in Kruger forms a key part of the shared elephant population living in the GLTFCA. The GLTFCA covers roughly 100,000 km^2. It includes Kruger in South Africa, Limpopo National Park (Limpopo) in Mozambique, Gonarezhou National Park (Gonarezhou) in Zimbabwe as the three flagship National Parks providing habitat for robust elephant populations. Several corridors link additional habitat for elephants in the Banhine and Zinave National Parks as well as private conservation areas in the Massingir and Corumana regions in Mozambique. Various privately, community and state-managed protected and conservation areas in South Africa and Zimbabwe provide additional elephant habitat within the GLTFCA footprint.

The African Elephant Specialist Group in 2016 reported 17,086, 11,120 and 1,081 elephants in Kruger, Gonarezhou and Limpopo respectively, while Banhine had five and Zinave no elephants. The other areas within and abutting the GLTFCA had 3,781, 2,733 and 173 elephants in South Africa, Zimbabwe, and Mozambique respectively. In this context, Kruger contributed 47.5% of the 35,979 elephants that lived in the GLTFCA and surrounds during 2016. Elephants in the GLTFCA represented 12% of the 308,604 elephants living in southern Africa and 7% of the 532,555 living on the continent by 2016. Elephants in Kruger are also a major component of South Africa's population contributing 63% to the 27,233 elephants reported to live in the country during 2016[13].

African elephants play key roles in ecosystems. While global concerns focus on poaching[14], elephants can cause habitat change across landscapes of multiple uses[15]. Elephants also harm the well-being of people[16]. Habitat change and conflict with people associate with how intense elephants use landscapes. Elephants are thus ecosystem engineers that carry benefits and costs for people dictated by where and how elephants use landscapes.

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[11] Data provided by Jeanetta Selier (SANBI)
[12] van Aarde, R.J., Ferreira, S.M., Jackson, T., Page, B., de Beer, Y., Gough, K., Guldemond, R., Junker, J., Olivier, P., Ott, T. & Trimble, M. 2009. Elephant population biology and ecology. In: Scholes, R.J. & Mennell, K.G. (eds). Elephant management: A scientific assessment for South Africa. Wits University Press, Johannesburg, South Africa. pp 84-145.
[13] Thouless, C., Dublin, H.T., Blanc, J., Skinner, D.P., Daniel, T.E., Taylor, R., Maisels, F., Frederick, H. and Bouché, P., 2016. African elephant status report 2016. Occasional paper series of the IUCN Species Survival Commission, 60.
[14] Chase, M.J., Schlossberg, S., Griffin, C.R., Bouché, P.J., Djene, S.W., Elkan, P.W., Ferreira, S., Grossman, F., Kohi, E.M., Landen, K. and Omondi, P., 2016. Continent-wide survey reveals massive decline in African savannah elephants. PeerJ, 4, p.e2354.
[15] Cumming, D.H., Fenton, M.B., Rautenbach, I.L., Taylor, R.D., Cumming, G.S., Cumming, M.S., Dunlop, J.M., Ford, A.G., Hovorka, M.D., Johnston, D.S. and Kalcounis, M., 1997. Elephants, woodlands, and biodiversity in southern Africa. South African Journal of Science, 93(5), pp.231-236.
[16] Shaffer, L.J., Khadka, K.K., Van Den Hoek, J. and Naithani, K.J., 2019. Human-elephant conflict: A review of current management strategies and future directions. Frontiers in Ecology and Evolution, 6, p.235.

In this context, SANParks envisage *a resilient*[17] *Kruger elephant population over extensively linked landscapes*[18]*, enhancing biodiversity, improving equitable*[19] *socio-economic benefits, whilst inspiring and connecting diverse cultures*. Kruger has a complexity, richness and diversity of socio-ecological systems and the promotion of conservation in all its complexities is fundamental to SANParks' core biodiversity conservation values[20]. These complexities are addressed through a strategic adaptive management approach[21] within which the management of elephants in Kruger embeds.

2. Elephant contribution to Park objectives[22]

2.1 Key attributes

Kruger covers a large and varied area embedded in a diverse regional setting that stretches across almost 2 million hectares of South Africa's lowveld, bordering Mozambique in the east and Zimbabwe in the north. Its elongated shape is approximately 350 km from north to south and on average 60 km wide, with rivers providing natural boundaries in the south and north and the Lebombo hills bounding the east. To the west, the park is predominantly bordered by private, community and provincial state managed nature reserves, as well as high-density communal areas and commercial agricultural crop areas.

Perimeter fencing varies considerably along Kruger's boundaries, ranging from standard electrified fences, standard game fences and cabled veterinary fences to no fences where the park is open to other protected areas. Kruger forms part of the GLTFCA, a large contiguous area of varied land uses. Kruger lies in the low-lying savannas of north-eastern South Africa, with the climate tropical to subtropical and high mean summer temperatures and mild, generally frost-free winters. Rainfall from October to April is across a gradient with an annual mean of 750 mm in the south-west, to 350 mm in the north. Geologically, Kruger comprises a western granitic half and an eastern clayey basaltic and rhyolitic half. There are close on 2000 plant species in the park, including about 400 trees and shrubs, and 220 grasses. Fauna is very diverse, with about 150 species of mammals, 50 fish, just over 500 bird, 34 amphibian and 116 reptile species. In addition, there are about 375 alien species, mostly plants, although typically with restricted distributions and densities[23].

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[17] Resilient refers to ability to resist or recover from disturbance
[18] Lived-in regional landscape- large mixed land-uses that are compatible with elephant presence over 3 countries that make up the GLTFCA.
[19] Equitable acknowledges that not all stakeholders are equal, and that stakeholders directly impacted and affected by elephants should have access to more benefits.
[20] Kruger National Park Management Plan 2018-2028. https://www.sanparks.org/assets/docs/conservation/park_man/knp/knp-approved-plan.pdf
[21] Roux, D.J. and Foxcroft, L.C., 2011. The development and application of strategic adaptive management within South African National Parks. *Koedoe: African Protected Area Conservation and Science*, *53*(2), pp.1-5.
[22] Extracted from Section 6, Paragraph 9
(i) description of the elephant population. (ii) the objectives of the property to which the management plan relates. (iii) the contribution of the objectives referred to in subitem (ii) to the national conservation objectives. (iv) risks or constraints to achieve the objectives referred to in subitem (ii). (v) extent or success in achieving the objectives referred to in subitem (b)(ii).(vi) maximising the contribution of the elephant population to the objectives referred to in item (b)(ii). (vii) risks related to management interventions involving the elephant population; and (viii) mitigation of the intervention risks referred to in subitem (vii).
[23] Kruger National Park Management Plan 2018-2028. https://www.sanparks.org/assets/docs/conservation/park_man/knp/knp-approved-plan.pdf

Kruger acts as a *de facto* hub of economic development, especially tourism and the wildlife economy. The Park provides employment opportunities, a market outlet, and source of business for local communities. Adjacent land uses impact in various ways on Kruger and vice versa, and damage causing animals (DCAs), employment issues and insufficient interaction with the Park affect neighbours.

Kruger's early management history went from exploitative to command-and-control by the mid-1990s followed by strategic adaptive management through learning-by-doing in recent times[24]. The Park has well-developed infrastructure, human capacity and a long history of research and management. Strong national legislation protects the Park, which carries widespread national and international sentiment.

2.2 The influence of elephants on objectives of the Kruger Park Management Plan

The summarised key attributes[25] direct the Park's mission through objectives focusing on biodiversity linked values (biodiversity, and wilderness), social aspects (socio-economic development and constituency building), responsible tourism, cultural heritage, regional integration, and effective park management. Elephants contribute to or influence all these objectives.

2.2.1. Elephant influence on biodiversity linked objectives

Elephants influence biodiversity. Evidence biases towards research that considered elephant effects on plant species. With reference to plant diversity, no plant species appear to have become extinct in the park because of elephant impacts, some appear to not be recruiting (e.g., palms and baobabs). However, this should not be considered in isolation of other interactions with other factors, including impact by other meso-herbivores, drought, seed predation, etc. that, may also influence recruitment, and would require specific monitoring.

Elephants respond to gradients of water availability[26], food accessibility[27], comfort[28] and safety[29] over time and space. Local elephant densities and environmental limitations, however, modify the response[30]. These constraints affect how elephants use landscapes over time that could be either too intensely or too sparsely[31], both potentially affecting other values and biodiversity components.

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[24] Carruthers, J., 2017. *National Park Science: a century of research in South Africa.* Cambridge University Press.
[25] Kruger National Park Management Plan 2018-2028. https://www.sanparks.org/assets/docs/conservation/park_man/knp/knp-approved-plan.pdf
[26] *e.g.*, Smit, I.P.J., Grant, C.C., and Whyte, I.J., 2007. Elephants and water provision: what are the management links? *Diversity and Distributions*, *13*(6), pp.666-669.
[27] *e.g.*, Young, K.D., Ferreira, S.M. and van Aarde, R.J., 2009. The influence of increasing population size and vegetation productivity on elephant distribution in the Kruger National Park. *Austral Ecology*, *34*(3), pp.329-342.
[28] *e.g.*, Kinahan, A.A., Pimm, S.L. and Van Aarde, R.J., 2007. Ambient temperature as a determinant of landscape use in the savanna elephant, *Loxodonta africana*. *Journal of Thermal Biology*, *32*(1), pp.47-58.
[29] *e.g.*, Wittemyer, G., Keating, L.M., Vollrath, F. and Douglas-Hamilton, I., 2017. Graph theory illustrates spatial and temporal features that structure elephant rest locations and reflect risk perception. *Ecography*, *40*(5), pp.598-605.
[30] Abraham, Joel O., et al. "Heterogeneity in African savanna elephant distributions and their impacts on trees in Kruger National Park, South Africa." Ecology and evolution 11.10 (2021): 5624-5634.
[31] Harris, G.M., Russell, G.J., van Aarde, R.J. & Pimm, S.L. 2008. Habitat use of savanna elephants in southern Africa. *Oryx* 42: 66-75. Trollope, W.S.W., Trollope, L.A., Biggs, H.C., Pienaar, D. & Potgieter, A.L.P. 1998. Long-term changes in the woody vegetation of the Kruger National Park with special reference to the effects of elephants and fire. *Koedoe* 41: 103-112.

Limiting the elephant population size at the scale of Kruger did not prevent a decline in the structural diversity of the woody vegetation in specific areas of Kruger[32]. Some interpret this as evidence that there should be only a few thousand elephants. The assumption that elephant impact is directly related to the number of elephants[33], however, receives little evidence-based support[34]. Elephant impact in Kruger may link to how intensely elephants use landscapes and localities within landscapes. This primarily associate with how elephants move and use habitats in response to resources that they need.

Elephants respond to spatial and temporal resource variation with short- to medium-term movements[35]. In Kruger, however, fences (both historic and current), as well as water provisioning and the effect of missing species such as the presence of humans[36] have influenced elephant space use and natural population regulating mechanisms. The implications are that managing the resources that elephants require, will influence the intensity with which they use landscapes. Elephant demographic responses to such resource gradients, however, may realise over longer time frames[37] by affecting demography[38].

2.2.2. Elephant influence on social linked objectives

Damage caused by elephants to humans outside the park, and their livelihoods is a key consideration in informing how SANParks manages elephants. In Africa, specifically southern Africa, local people, and indigenous communities incur substantial costs when living near elephants. Incidences of damage caused by elephants, however, may not be clearly related to how many elephants there are[39]. Even so, damage causing elephants, both directly through realised losses and indirectly through perceptions, erode relationships between conservation areas and their neighbours[40], and management responses in this regard need to also address the need to restore relationships.

Elephants, however, link to other socio-economic aspects. For instance, elephants may indirectly affect disease dynamics through fence breakages which allow key disease maintenance hosts such as buffalo to encounter livestock[41]. Elephants may therefore be enabling increased human-wildlife-livestock-disease interactions through fence breakages. Perceptions regarding the role of KNP buffalo in ongoing foot-and-

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32 Trollope, W.S.W., Trollope, L.A., Biggs, H.C., Pienaar, D. & Potgieter, A.L.P. 1998. Long-term changes in the woody vegetation of the Kruger National Park with special reference to the effects of elephants and fire. Koedoe 41: 103-112.
33 e.g., Cumming, D.H., Fenton, M.B., Rautenbach, I.L., Taylor, R.D., Cumming, G.S., Cumming, M.S., Dunlop, J.M., Ford, A.G., Hovorka, M.D., Johnston, D.S. and Kalcounis, M., 1997. Elephants, woodlands, and biodiversity in southern Africa. South African Journal of Science, 93(5), pp.231-236.
34 Guldemond, R.A., Purdon, A. and Van Aarde, R.J., 2017. A systematic review of elephant impact across Africa. PloS one, 12(6), p.e0178935.
35 Young, K.D., Ferreira, S.M. & van Aarde, R.J. 2009. Elephant spatial use in wet and dry savannas of southern Africa. Journal of Zoology, London doi:10.1111/j.1469-7998.2009.00568x
36 Carruthers, J., 1995. The Kruger National Park: a social and political history. University of Natal Press.
37 e.g., Trimble, M.J., Ferreira, S.M. & van Aarde, R.J. 2009. Drivers of megaherbivore demographic fluctuations: inference from elephants. Journal of Zoology, London doi:10.1111/j.1469-7998.2009.00560.x
38 e.g., Young, K.D., Ferreira, S.M. and van Aarde, R.J., 2009. The influence of increasing population size and vegetation productivity on elephant distribution in the Kruger National Park. Austral Ecology, 34(3), pp.329-342.
39 Shaffer, L.J., Khadka, K.K., Van Den Hoek, J. and Naithani, K.J., 2019. Human-elephant conflict: A review of current management strategies and future directions. Frontiers in Ecology and Evolution, 6, p.235.
40 Hart, C.R., 2014. The role of environmental justice in biodiversity conservation: Investigating experiences of communities near Kruger National Park, South Africa. Dalhousie Journal of Interdisciplinary Management, 10(1).
41 Grant, C.C., Bengis, R., Balfour, D., Peel, M., Davies-Mostert, W., Kilian, H., Little, R., Smit, I., Garaï, M., Henley, M., Anthony, B., Hartley, P. 2009. Controlling the distribution of elephants. In: Scholes, R.J. & Mennell, K.G. (eds). Elephant management: A scientific assessment for South Africa. Wits University Press, Johannesburg, South Africa. pp 329-369.

mouth disease outbreaks in cattle, not only has impacts on international trade economics[42], but impact local livelihoods and therefore relationships between the park and its neighbours. In addition, major concerns have been raised by owners of properties and reserves abutting Kruger that elephants are increasingly impacting on the aesthetics of these reserves through changing vegetation structure, particularly affecting large trees[43].

Though people all over the world are interested in Kruger's elephants, management has to trade-off responses to address local imminent risks to lives and livelihoods, against larger international reputational risks.

2.2.3 Elephant influence on responsible tourism objectives

Protected areas, wildlife and biodiversity are global assets – thus all humans, including future generations, have some stake in the outcome of the elephant management decisions. Additionally, elephants form part of the Big Five Tourism Marketing campaign and is a big drawcard for both local and international tourists. However, impacts are felt more closely by certain groups by virtue of their specific interests or values, and by others because of the proximity of their lives and livelihoods to protected areas and tourism or, most directly of all, to individual elephants posing a risk to life and property. Different groups are subject to different potential impacts, costs and benefits because of expanding range and use of habitats by elephants and the different management options. Protected Area managers are therefore faced with trading off potential economic and reputational benefits against local life and livelihood impacts.

2.2.4 Elephant influence on cultural objectives

Kruger's cultural objectives focus on providing a full spectrum of cultural experiences and access to culturally significant sites. Elephants may impact such sites, whether through damaging rock-packed walls or culturally significant trees such as baobabs, thereby negatively impacting the cultural heritage value of Kruger. Additionally, elephants may carry positive cultural value[44], including the use of elephant products such as dung as part of various medicinal practices by certain local people[45].

2.2.5 Elephant influence on effective park management

Kruger has a vast array of built infrastructure, including bulk water supply, wastewater treatment works, solid waste sites, plant nurseries and swimming pools, as well as extensive fences either fencing tourism infrastructure in or animals out. Elephants can cause damage to the infrastructure, which is usually associated with elephants

[42] e.g., Chepape, L. 2022. Ban to curb spread of foot-and-mouth disease in South Africa. Mail & Guardian. https://mg.co.za/environment/2022-08-25-ban-to-curb-spread-of-foot-and-mouth-disease-insouth-africa/

[43] Edge, A., Henley, M., Daday, J. and Schulte, B.A., 2017. Examining human perception of elephants and large trees for insights into conservation of an African savanna ecosystem. Human Dimensions of Wildlife, 22(3), pp.231-245.

[44] e.g., Moore, L., 2009. Beware the elephant in the bush: Myths, memory, and indigenous traditional knowledge in north-eastern Namibia. cultural geographies, 16(3), pp.329-349.

[45] e.g., Williams, V.L. and Whiting, M.J., 2016. A picture of health? Animal use and the Faraday traditional medicine market, South Africa. *Journal of Ethnopharmacology*, *179*, pp.265-273.

seasonally trying to access key fenced-off resources including vegetation, species, and water. Addressing these impacts to infrastructure requires a tailor-made approach for the situation.

2.3 History of elephant management

2.3.1 Interventions

From the early 1900s, when elephants were locally extirpated in Kruger, up until the 1960s, the management approach was largely that of restoring historic populations of elephants in the park. However, as early as the 1950s, concerns were expressed about the potential impacts of confined elephant populations on habitats. The first management interventions in South Africa to limit these impacts followed in 1967, when elephants were culled in Kruger for the first time[46].

When South Africa was accepted back into the international fold in the mid-1990s, SANParks' elephant management policies were questioned by international, and then local, animal rights groups. In response, SANParks agreed to suspend the practice of culling elephants and review both the purpose and methods of elephant management in its national parks. A thorough consultative policy review process sought the views, values, knowledge, and experiences of a wide range of local, national and international stakeholders. Contributors have ranged from members of communities neighbouring national parks to NGOs and international conservation organisations, animal rights and animal welfare groups, national conservation agencies from Namibia, Botswana, Zimbabwe and Mozambique, and a host of local and international scientists from a variety of disciplines and institutions[47].

In the 1990s SANParks adopted an adaptive management approach and redefined the Kruger management objectives[48]. The approach set Thresholds of Potential Concern[49] as triggers for decision-making and shifted management from using numbers to environmental indicators. The primary trigger in the revised elephant management approach of 1997 focused on numbers, allowing variation in elephant densities in six different zones across Kruger to learn about ecosystem responses[50]. The 1997 policy proposed to control fluctuations in certain areas through both culling and translocation, but encountered opposition in the form of ecological thinking, animal rights and societal values despite a broad consultative process in 2004 through the Elephant Indaba and the Luiperdskloof scientific meeting in 2005.

Political and public pressure prompted then Minister of Environment Affairs and Tourism (DEAT) to convene a Science Round Table in 2007 who advised that there is no need for the immediate and large-scale reduction of elephant numbers in Kruger. The advice affected all landowners with elephants in South Africa, which the Scientific

[46] Whyte, I.J., van Aarde, R.J. & Pimm, S.L. 1998. Managing the elephants of Kruger National Park. *Animal Conservation* 1: 77-83.
[47] Scholes, R.J. & Mennell, K.G. 2009. *Elephant management: A scientific assessment for South Africa.* Wits University Press, Johannesburg, South Africa
[48] Venter, F.J., Naiman, R.J., Biggs, H.C. & Pienaar, D.J. 2008. The evolution of conservation management philosophy: Science, environmental change and social adjustments in Kruger National Park. *Ecosystems* 11: 173-192.
[49] Biggs, H.C. & Rogers, K.H. 2003. An adaptive system to link science, monitoring and management in practice. In: du Toit, J.T., Rogers, K.H. & Biggs, H.C. (eds). *The Kruger experience: Ecology and management of savanna heterogeneity.* Island Press, Washington, USA. pp 59-80.
[50] Whyte, I.J., van Aarde, R.J. & Pimm, S.L. 1998. Managing the elephants of Kruger National Park. *Animal Conservation* 1: 77-83.

Round Table acknowledged by suggesting that in some instances elephant density, distribution and population structure may need to be managed to achieve biodiversity and other objectives[51]. An external peer-reviewed scientific assessment of elephant management[52] followed. At the same time the Minister embarked on an extensive consultation process and produced the Elephant Management Norms and Standards[53] in 2008. These explicitly recognised the management of elephant ecological impact, conflict, and effects on stakeholders rather than elephants, but needing to do so differently at different places and at different times. SANParks development of a process-based approach to elephant management focusing on dealing with causes and mechanisms of elephant effects, in line with evolving ecological thinking[54].

Issues of elephant management are complex and controversial, involving not only data and expert opinion, but also values, ethics, and emotions of stakeholders all over the world[55]. Both research and debate about elephants and their management will go on for a long time, but the process of managing national parks must continue if SANParks is to meet its mandate to conserve biodiversity and achieve its vision for a system of national parks that are the pride and joy of all South Africans. SANParks therefore developed new biodiversity management plans for all national parks in 2006 and 2007. The plans were based on full consultation with stakeholders and designed to meet the requirements of the National Protected Areas and Biodiversity Acts. Each plan sets out a desired state for the park's ecosystems and a strategy for achieving it. An important component of each plan is the large herbivore management policy. If a park supports elephants – as do Kruger, Addo Elephant, Mapungubwe, Marakele and Garden Route National Parks – then issues of elephant management were incorporated into a herbivore management plan. The current Kruger PMP was signed off by the Minister of the now DFFE in 2018 and followed a similar process of consultation and co-development.

2.3.2 Socio-ecological trends

Kruger was void of elephants in 1900 due to extensive hunting, most of which supported the ivory trade in the 1700s and 1800s[56]. The first elephant was noticed in 1905 close to the Olifants and Letaba Rivers' confluence[57]. The re-colonization and spread of elephants resulted in most of present-day Kruger occupied by elephants by 1958. Elephant numbers increased over several eras of management actions[58].

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[51] Owen-Smith, N., Kerley, G., Page, B., Slotow, R. & van Aarde, R. 2006. A scientific perspective on the management of elephants in the Kruger National Park and elsewhere. *South African Journal of Science* 102: 389–394.
[52] Scholes, R.J. & Mennell, K.G. 2009. *Elephant management: A scientific assessment for South Africa.* Wits University Press, Johannesburg, South Africa.
[53] DEAT. 2008. National Norms and Standards for the Management of Elephants in South Africa. National Biodiversity Management: Biodiversity Act, 2004 (Act No. 10 of 2004). http://extwprlegs1.fao.org/docs/pdf/saf85897.pdf
[54] Bulte, E, Damania, R., Gillson, L. & Lindsay, K. 2004. Space – the final frontier for economists and elephants. *Science* 306: 420-421.
[55] Dickson, P., and Adams, W.M., 2009. Science and uncertainty in South Africa's elephant culling debate. *Environment and Planning C: Government and Policy*, *27*(1), pp.110-123.
[56] Hall-Martin, A.J. 1992. Distribution and status of the African elephant *Loxodonta africana* in South African 1652-1992. *Koedoe* 35: 65-88
[57] Whyte, I.J. 2001. Conservation management of the Kruger National Park elephant population. PhD-dissertation, University of Pretoria, Pretoria, South Africa.
[58] Ferreira, S.M., Greaver, C. and Simms, C., 2017. Elephant population growth in Kruger National Park, South Africa, under a landscape management approach. *Koedoe: African Protected Area Conservation and Science*, *59*(1), pp.1-6.

Kruger was for a large part since its origin closed from surrounding areas through fences. Fences erected from 1958 to 1980[59] isolated Kruger from adjoining areas until the removal of some fences in the mid to late 1990s[60]. A few experiments evaluated birth control for elephants[61], but this was not conducted at a large scale.

The first concerns of elephant impact were in 1959 when stands of aloes disappeared in the Doispane area. In the late 1960s it was suggested that elephant utilisation was low to moderate and accentuated during the dry season[62]. Elephant damage to marula and knobthorn trees became apparent in the late 1970s[63]. By 1974, the number of mature trees declined to 6.4% of densities in 1944 in the Satara region[64]. Elephants use marula and knobthorn trees selectively based on assigned criteria of elephant damage[65].

Aerial photos showed that woody cover increased by 12% on granite soils, but declined by 64% on basalts, primarily because of a 38% decline in trees larger than 5m in height[66]. Woody cover declined in the south but increased in northern Kruger based on historical imagery compared in 2016[67]. These observations suggest that patterns of vegetation change were not consistent through different landscapes. Generally, it appears that increased mortality of large trees, assumed to be a result of elephant interactions, and declining recruitment assumed to be caused by fire may be the drivers of such change[68]. The suggestion is in line with results elsewhere on the interactions between fire and elephants as drivers of change in savanna systems[69].

Incidences of damage caused by elephants in areas abutting Kruger in South Africa varied between the northern and southern regions of the Park. For instance, elephants break the western boundary fence regularly, and have caused human deaths. Provincial Conservation authorities may cull some escaped DCAs, as per their mandate. For instance, the Limpopo Department of Economic Development, Environment and Tourism (LEDET) had to destroy 75 elephants associated with fence breakages and damage to property in the community areas abutting Kruger north of the Olifants River between 2000 and 2005. The Mpumalanga Province Tourism and Parks Agency (MTPA) also had to destroy an unknown number of elephants south of the Olifants River in recent years, in community areas bordering Kruger.

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[59] Mabunda, D., Pienaar, D.J., Verhoef, J., 2003. The Kruger National Park: a century of management and research. In: *The Kruger experience: Ecology and management of savanna heterogeneity*, du Toit, J.T., Rogers, K. & Biggs, H.C. Island Press, Washington. pp.3-21.

[60] Grant, C.C., Bengis, R., Balfour, D., Peel, M., Davies-Mostert, W., Kilian, H., Little, R., Smit, I., Garaï, M., Henley, M., Anthony, B., Hartley, P. 2009. Controlling the distribution of elephants. In: Scholes, R.J. & Mennell, K.G. (eds). *Elephant management: A scientific assessment for South Africa.* Wits University Press, Johannesburg, South Africa. pp 329-369.

[61] Fayer-Hosken, R.A., Grobler, D., van Altena, J.J., Bertschinger, H.J. & Kirkpatrick, J.F. 2000. Immunocontraception of African elephants. *Nature* 407: 149.

[62] van Wyk, P. & Fairall, N. 1969. The influence of the African elephant on the vegetation of the Kruger National Park. Koedoe 12: 66-75.

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[65] Shannon, G., Druce, D.J., Page, B.R., Eckhardt, H., Grant, R. & Slotow, R. 2008. The utilization of large savanna trees by elephant in southern Kruger National Park. *Journal of Tropical Ecology* 24: 281-289.

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[68] Asner, G.P., Vaughn, N., Smit, I.P. and Levick, S., 2016. Ecosystem-scale effects of megafauna in African savannas. *Ecography*, *39*(2), pp.240-252.

[69] 11 Sankaran, M., Hanan, N., Scholes, R., Ratnam, J., Augustine, D.J., Cade, B.S., Gignoux, J., Higgins, S., Le Roux, X., Ludwig, F., Ardo, J., Banyikwa, A.B., Bucini, G., Caylor, K.K., Coughenour, M.B., Diouf, A., Ekaya, W., Feral, C.J., February, E.C., Frost, P.G.H., Hiernaux, P., Hrabar, H., Metzger, K.L., Prins, H.H.T., Ringrose, S., Sea, W., Tews, J., Worden, J. & Zambatis, N. 2005. Determinants of woody cover in African savannas. *Nature* 438: 846–849.

2.3.3 Consequences of interventions

Elephant populations responded to various management interventions. During periods of culling, elephant numbers increased at 6.5%[70]. However, numbers of elephants in localised culling-targeted areas, decreased sharply, followed by excessively high population growth the following year[71]. Realised growth rates were much lower (*i.e.,* births minus natural deaths minus culling deaths) and varied between 0.65% to 1.51% (see Figure 1). Elephants remained at an average density of around 0.4 elephants per km^2 during this period. Starting in 1958, the park was increasingly fenced, and boreholes increased to more than 300 by the end of 1994, whereafter about half of the boreholes were closed in the next decade (see Appendix A for detail) and some fences were dropped.

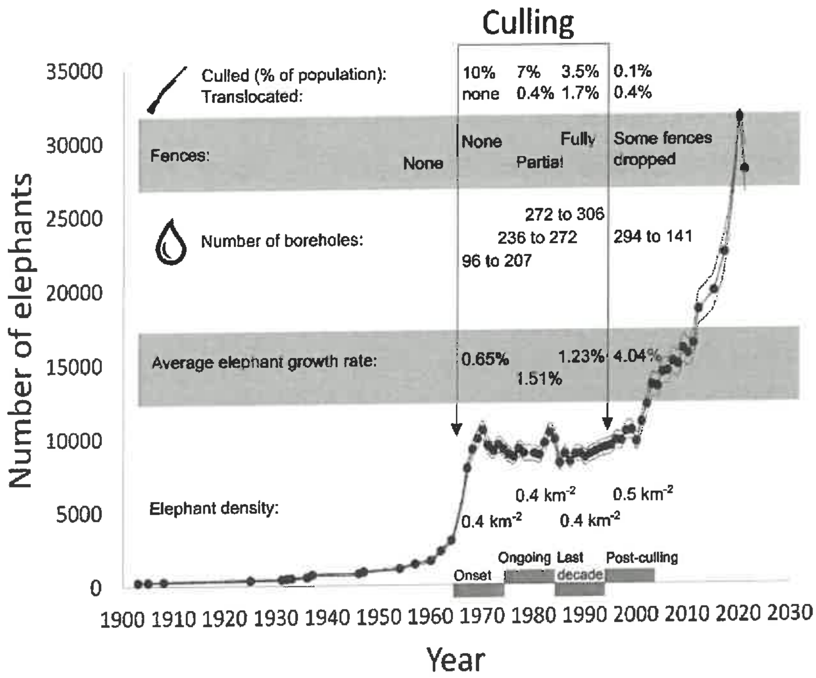

Figure 1. Corrected elephant estimates[72] in Kruger and summaries of interventions. The symbols represent the years when authorities conducted a survey. The dotted lines represent the estimated 95% confidence interval. By 2021, Kruger recorded 27,992 (95%CI: 26,401 – 29,584). Note that management through culling took place from 1967 to 1994.

These fence removals on the western and eastern boundary of Kruger provided opportunities for elephants to move after the first fence removal in 1994 between Kruger and some of the western private nature reserves[73]. For instance, population growth rates on eight adjacent protected areas to the west of Kruger ranged from -1% to 42% per annum since 1996[74].

[70] Ferreira, S.M., Greaver, C. and Simms, C., 2017. Elephant population growth in Kruger National Park, South Africa, under a landscape management approach. *Koedoe: African Protected Area Conservation and Science*, *59*(1), pp.1-6.
[71] van Aarde, R.J., Whyte, I.J. & Pimm, S.L. 1999. Culling and the dynamics of the Kruger National Park elephant population. *Animal Conservation* 2: 287-294.
[72] Ferreira, S.M., Greaver, C. & Simms, C. 2020. Sample-based estimates of elephants in Kruger National Park, South Africa. SANParks, Skukuza, South Africa. Unpublished.
[73] Whyte, I.J. 2001. Conservation management of the Kruger National Park elephant population. PhD-dissertation, University of Pretoria, Pretoria, South Africa.
[74] Data extracted from Whyte 2001 and the SANParks database – Database Manager Judith Kruger, SANParks, Skukuza, South Africa

In addition to allowing movements when fences were removed, managers also provided elephants with opportunities to make choices with regards to landscape features. The properties west of Kruger have much higher densities of boreholes and dams that provide additional water[75]. Movement from Kruger to conservation/reserve areas west of Kruger was most likely accentuated by more abundant water availability[76] on these properties when Kruger managers started closing boreholes[77]. However, the spatial responses of elephants to management are hard to define primarily because only distribution data during the dry season are available[78]. This data show that the distribution of elephants becomes less clumped as elephant numbers increase[79] especially while water distribution was more widespread. In other words, elephants' use was homogenised across the landscape. Elephants' use of the landscape also depends on rainfall (*e.g.*, net movement into the Park when below average rainfall in the region), greenness of vegetation, distance to perennial and artificial water, and fire regime (the latter three depend on sex of elephant) (see Appendix A for more context).

Although environmental conditions[80] and density[81] dictate demographic variability in elephant dynamics[82], the above movement patterns mask demographic responses in the Park. For instance, by 2015 the population in the Park was growing at 4.2% per annum[83], yet the Park experienced periods of intensive increase since then (*e.g.*, an increase of 9000 elephants between the 2017 and 2020 surveys, Fig.1) that far exceeds the maximum rate at which a population can increase from births and deaths alone[84]. These changes resulted from net movements into the Park in response to drought conditions[85] and likely to danger posed from people during a poaching surge in Mozambique[86]. Elephants may perceive Kruger as safe, both environmentally and from human persecution. This results in increased intensity of use by elephants of various Kruger landscapes. At a local scale, density dependence in habitat use is playing out[87]. For instance, areas close to rivers are experiencing a stabilization of dry season elephant densities[88].

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[75] Smit, I.P., Peel, M.J., Ferreira, S.M., Greaver, C. and Pienaar, D.J., 2020. Megaherbivore response to droughts under different management regimes: lessons from a large African savanna. *African Journal of Range & Forage Science*, *37*(1), pp.65-80.
[76] *e.g.*, Smit, I.P.J., C.C. Grant & B.J. Devereux. 2007a. Do artificial waterholes influence the way herbivores use the landscape? Herbivore distribution patterns around rivers and artificial surface water sources in a large African savanna park. *Biological Conservation* 136: 85-99.
[77] Smit, I.P.J., C.C. Grant & I.J. Whyte. 2007b. Elephants and water provision: what are the management links? *Diversity and Distributions* 13: 666-669.
[78] Ferreira, S.M., Greaver, C. and Simms, C., 2017. Elephant population growth in Kruger National Park, South Africa, under a landscape management approach. *Koedoe: African Protected Area Conservation and Science*, *59*(1), pp.1-6.
[79] Young, K.D., Ferreira, S.M. and van AARDE, R.J., 2009. The influence of increasing population size and vegetation productivity on elephant distribution in the Kruger National Park. *Austral Ecology*, *34(3), pp.329-342.*
[80] e.g., Wittemyer, G., Ganswindt, A. & Hodges, K. 2007a. The impact of ecological variability on the reproductive endocrinology of wild female African elephants. Hormonal Behaviour 51: 346-354.
[81] Chamaille-Jammes, S., M. Valeix, & H. Fritz. 2007. Managing heterogeneity in elephant distribution: between elephant popultion density and surface-water availability. *Journal of Applied Ecology* 44: 625-633.
[82] Trimble, M.J., Ferreira, S.M. & van Aarde, R.J. 2009. Drivers of megaherbivore demographic fluctuations: inference from elephants. *Journal of Zoology, London* doi:10.1111/j.1469-7998.2009.00560.x
[83] Ferreira, S.M., Greaver, C. and Simms, C., 2017. Elephant population growth in Kruger National Park, South Africa, under a landscape management approach. *Koedoe: African Protected Area Conservation and Science*, *59*(1), pp.1-6.
[84] Calef, G.W. 1988 Maximum rate of increase in the African elephant. *African Journal of Ecology* 26: 323–327.
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[86] Herbig, F. and Minnaar, A., 2019. Pachyderm poaching in Africa: Interpreting emerging trends and transitions. *Crime, Law, and Social Change*, *71*(1), pp.67-82.
[87] Robson, A.S. and Van Aarde, R.J., 2018. Changes in elephant conservation management promote density-dependent habitat selection in the Kruger National Park. *Animal Conservation*, *21*(4), pp.302-312.
[88] Louw, A.S., MacFadyen, S., Ferreira, S. and Hui, C., 2021. Elephant population responses to increased density in Kruger National Park. *koedoe*, *63*(1), pp.1-13.

In addition, the distribution of elephant impacts on trees, while highly heterogeneous, was largely unrelated to the dry season distribution of elephants themselves – damages concentrated in densely treed areas and particularly on basaltic soils. Bull elephants and mixed herds differed markedly in their distributions, with bulls concentrating at basaltic sites close to artificial waterholes and mixed herds aggregating around permanent rivers[89]. In addition, elephants rarely eliminate any species of woody savanna plants. Such plants resprout after damage by fire or herbivory. Effects can be subtle on specific species, *e.g.*, entire populations of the African palm, *Hyphaene petersiana*, do not reach sexual maturity when chronically browsed by elephants[90]. Consequences of homogenization by uniform use of landscapes by elephants carry important concerns. For instance, animal diversity declines with homogenization of canopy cover[91].

2.4 Operational reflection and lessons learned

The above reflections on the history, past and recent trends highlight key lessons. Elephant numbers are declining on a continental scale[92], and are generally only a quarter of what they can potentially be[93]. In this context, global concerns focus largely on the persistence of elephants. Kruger has more elephants than what was present in the last two or three centuries[94], but are not isolated from the landscape with considerable movements of elephants across the GLTFCA as a whole[95]. As a result, the Park is seen as making some contribution to buffering the losses of elephants elsewhere in Africa.

The Park experienced treefalls since the 1940s which continued during the elephant culling period[96]. Although archaeological evidence suggests a vibrant ivory trade, by 1725, records of elephant hunting in Kruger disappeared with elephants thought to be shot to local extinction between 1880 to 1896[97]. This suggests low intensity of use by elephant for an extended time which likely resulted in broadscale tree establishment. Continued tree falls that vary over space and time with elephants accentuating the effect of a variety of factors including fire, elevation, and soil[98], could reflect a system recovering from extended periods of mega-herbivore absence.

Although large tree fall is ongoing, the region also noted a general increase in woody cover since 1940, except when there are elephants and rainfall is below 650 mm[99]. At

[89] Abraham, J.O., Goldberg, E.R., Botha, J. and Staver, A.C., 2021. Heterogeneity in African savanna elephant distributions and their impacts on trees in Kruger National Park, South Africa. *Ecology and evolution*, *11*(10), pp.5624-5634.
[90] Midgley, J.J., Coetzee, B.W., Tye, D., and Kruger, L.M., 2020. Mass sterilization of a common palm species by elephants in Kruger National Park, South Africa. *Scientific reports*, *10*(1), pp.1-5.
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[94] Ferreira, S.M., Greaver, C. & Simms, C. 2020. Sample-based estimates of elephants in Kruger National Park, South Africa. SANParks, Skukuza, South Africa. Unpublished.
[95] Huang, R.M., van Aarde, R.J., Pimm, S.L., Chase, M.J. and Leggett, K., 2022. Mapping potential connections between Southern Africa's elephant populations. *PloS one*, *17*(10), p.e0275791
[96] Trollope, W.S.W., Trollope, L.A., Biggs, H.C., Pienaar, D. and Potgieter, A.L.F., 1998. Long-term changes in the woody vegetation of the Kruger National Park, with special reference to the effects of elephants and fire. *Koedoe*, *41*(2), pp.103-112.
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[98] Asner, G.P., Vaughn, N., Smit, I.P. and Levick, S., 2016. Ecosystem-scale effects of megafauna in African savannas. *Ecography*, *39*(2), pp.240-252.
[99] Stevens, N., Erasmus, B.F.N., Archibald, S. and Bond, W.J., 2016. Woody encroachment over 70 years in South African savannahs: overgrazing, global change or extinction aftershock?. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *371*(1703), p.20150437

the same time, high intensity fires reduce woody cover[100], but also cause more large trees to eventually fall over, especially when damaged by elephants[101]. The interaction between fire and elephants, thus, influence ecological heterogeneity across the Park's landscapes[102].

Several perspectives advocate addressing ecological changes by controlling elephant population sizes. These values can range widely. For instance, some tourists and landowners value elephants, but many do not enjoy seeing elephant impact resulting in damaged trees. At the same time, some stakeholders prefer ecosystem management with low preference for elephant population control through culling[103]. Some stakeholders advocate contraception as an alternative for controlling populations[104].

The control of populations assumes direct links between elephant impacts and elephant population sizes. The interaction between elephants and a range of factors creates ecological heterogeneity[105] with outcomes resulting in ecologically impacts not associating simply with elephant population sizes[106]. In addition, ecological influences of elephants are not uniform across landscapes. Elephant impacts are typically more prominent at a local scale, which is a mismatch with how elephants use landscapes at a regional scale[107].

These reflections highlight that ecological resilience depends on variation in elephant landscape use over time and place as well as how often these places experience fires. How elephants use specific localities rest on resources that they depend on – water, food, places of comfort and places of safety. For instance, provision of additional water made elephants use localities within landscapes intensely regardless of season[108], while clumped distribution of boreholes increased intensity of use by elephants of the specific area[109]. In this context, managing the influences that elephants have requires focusing on the local scale and targeting the resource that determines why elephants spend time at a locality. Interventions should thus influence how elephants use a locality. Controlling populations may not alter elephant use substantially. For instance, controlling elephant numbers through contraception did not influence landscape use by elephants[110], and would not address managing ecological influences[111] in the absence of complimentary creation of resource

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[100] Scholtz, R., Donovan, V.M., Strydom, T., Wonkka, C., Kreuter, U.P., Rogers, W.E., Taylor, C., Smit, I.P., Govender, N., Trollope, W. and Fogarty, D.T., 2022. High-intensity fire experiments to manage shrub encroachment: lessons learned in South Africa and the United States. *African Journal of Range & Forage Science, 39*(1), pp.148-159.
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[102] MacFadyen, S., Hui, C., Verburg, P.H. and Van Teeffelen, A.J., 2019. Spatiotemporal distribution dynamics of elephants in response to density, rainfall, rivers and fire in Kruger National Park, South Africa. *Diversity and Distributions, 25*(6), pp.880-894.
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[105] MacFadyen, S., Hui, C., Verburg, P.H. and Van Teeffelen, A.J., 2019. Spatiotemporal distribution dynamics of elephants in response to density, rainfall, rivers and fire in Kruger National Park, South Africa. *Diversity and Distributions, 25*(6), pp.880-894.
[106] Guldemond, R.A., Purdon, A. and Van Aarde, R.J., 2017. A systematic review of elephant impact across Africa. *PloS one, 12*(6), p.e0178935.
[107] Delsink, A., Vanak, A.T., Ferreira, S. and Slotow, R., 2013. Biologically relevant scales in large mammal management policies. *Biological Conservation, 167*, pp.116-126.
[108] Purdon, A. and Van Aarde, R.J., 2017. Water provisioning in Kruger National Park alters elephant spatial utilisation patterns. *Journal of Arid Environments, 141*, pp.45-51.
[109] Gaylard, A., 2015. *Adopting a heterogeneity paradigm for understanding and managing elephants for biodiversity: A case study in riparian woodlands in Kruger National Park* (Doctoral dissertation, University of the Witwatersrand, Faculty of Science, School of Animal, Plant and Environmental Sciences).
[110] Delsink, A.K., Kirkpatrick, J., Van Altena, J.J., Bertschinger, H.J., Ferreira, S.M. and Slotow, R., 2013. Lack of spatial and behavioral responses to immunocontraception application in African elephants (Loxodonta africana). *Journal of Zoo and Wildlife Medicine, 44*(4s).
[111] Kerley, G.I. and Shrader, A.M., 2007. Elephant contraception: silver bullet or a potentially bitter pill?. *South African Journal of Science, 103*(5-6), pp.181-182.

variability. Maintaining, restoring, or mimicking the effect of resource availability does influence landscape use by elephants[112].

These lessons suggest that managing the influence that elephants have is about where they are, what type of elephant is at a specific locality, how often they return, and whether the receiving environment is resilient to their presence and activities.

2.5 Method of Revision

2.5.1 Stakeholder participation

SANParks interpret the Norms and Standards for Elephant Management as an outcome of extensive public participation embedded within the process for establishing a PMP. This took place in 2018[113]. As such consultation with regards to the Kruger EMP focused on immediately affected stakeholders, mostly local people, co-operative agreement partners and tourism service providers.

In addition, the Park engaged extensively with local people through meetings as part of establishing a National Elephant Strategy for South Africa (2021), and the GLTFCA Elephant Management Framework (2021). This provided specific opportunities for principally affected stakeholders to provide input into the management of elephants in the Kruger, and the Greater Kruger area (see Appendix B).

2.5.2 Mechanisms of local scale elephant impacts

The Kruger Conservation Management Committee (CMC) identified potential areas of local concern (elephant impact areas) though multiple meetings with rangers, scientists, and conservation staff[114]. A focus was on considering an area of concern that could arise from any mechanism that give rise to managers perceiving that management interventions regarding elephants are needed in the specific area. This focused on the location and extent of an area, the mechanism(s) that give rise to the concern, as well as the feasibility and potential of different elephant management interventions to address damages caused and ecological impacts. The proposed management interventions at a local scale considered the Elephant Norms and Standards and these were used as framework to guide possible management interventions including some small-scale disturbance experiments, some of which are already implemented by landowners in the broader GLTFCA landscape. The purpose of these will be to see if repeated temporally unreliable but spatially predictable disturbance could motivate elephants to visit an area less frequently. SANParks also considered which types of monitoring will be appropriate for the planned experimentation including measuring the responses of elephants as well as biological diversity.

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[112] e.g., Smit, I.P. and Ferreira, S.M., 2010. Management intervention affects river-bound spatial dynamics of elephants. *Biological Conservation*, *143*(9), pp.2172-2181.
[113] SANParks. 2018. Kruger National Park: Stakeholder participation report. https://www.sanparks.org/assets/docs/conservation/park_man/knp/knp-stakeholder-report.pdf
[114] Wigley-Coetsee, C., Greaver, C., Simms, C., MacFadyen, S. & Ferreira, S. 2022. Elephant Management in Kruger National Park. Internal Report 15/2022. Scientific Services, SANParks, Skukuza

2.5.3 Adaptive management

A key challenge is identifying issues and concerns that are likely to impact on the achievement of managing the contribution and influences of elephants to the Park's objectives. This is a key aspect contributing to the adaptive planning process and helps set management actions, which emerge at the operational end of the objectives-hierarchy of SANParks management plans[115]. Review of 10 years of elephant management in Kruger (2013-2022) has shown that Park management achieved a great deal of what it set out to do 10 years ago (86% achievement of implementation actions)[116]. More importantly, the review consolidated various lessons which has influenced how SANParks think about elephants and impact on various ecological values, this informed the revision of the EMP.

3. Elephant Management Objectives for Kruger National Park

The revision and reflections highlight that managing the ecological influence on people, culture and biodiversity is a key element across a large landscape, traded-off against ensuring the persistence of elephants and mitigate impacts of illegal activities on elephants. Even so, elephants provide numerous opportunities and benefits to people. This spectrum requires cross cutting fostering of trusting stakeholder relations. In this context, four strategic objectives seek to enhance the contributions that elephants can make to achieving the objectives of Kruger (Table 1).

Table 1. Elephant management objectives for Kruger National Park.

Objective 1
Foster meaningful stakeholder relationships: growing local and regional understanding of the role of elephants, through improving livelihoods and reducing conflict with people.
Objective 2
Maintain resilient elephant populations by reducing impacts from poaching, poisoning, and snaring.
Objective 3
Manage the ecological and cultural role of elephants by allowing their dynamic functioning in the ecosystem, while reducing ecological risks and promoting their cultural value.

[115] Gaylard, A. and Ferreira, S., 2011. Advances and challenges in the implementation of strategic adaptive management beyond the Kruger National Park-making linkages between science and biodiversity management. *Koedoe: African Protected Area Conservation and Science*, 53(2), pp.1-8.
[116] SANParks. 2022. Review report: Elephant Management Plan, Kruger National Park, 2013-2022. Scientific Services, SANParks, Skukuza

Objective 4
Facilitate opportunities and benefits associated with elephants by promoting all their values[117] as well as the ecosystem services they provide.

4. Management of wild elephants

A. General information and inventory

4.1. General

4.1.1 Names of owner and manager	**4.1.2 Postal Address**
Owner: South African National Parks Park Manager: Oscar Mthimkhulu	Kruger National Park Private Bag X402 Skukuza 1350
4.1.3 Telephone and fax numbers +27 (0)13 735 4000	

4.2 Farm name[118]

The name of the area is the Kruger National Park. The park was proclaimed on 2 September 1926 (Government Gazette No 1576 dated 2 September 1926). A full list of the declarations appears in Appendix A.

4.3 Extent of the property and areas with elephants[119]

The park is currently 1,919,430 ha in size, of this, 1,913,327 ha is declared and managed. The Park forms the core of the GLTFCA measuring almost 100,000 km². The Great Limpopo Transfrontier Park (GLTP), straddling the borders of Mozambique, South Africa and Zimbabwe constitutes a conservation area of 37,572 km², and include Kruger in South Africa, the Limpopo in Mozambique and Gonarezhou in Zimbabwe. The larger conservation area will also include Banhine and Zinave National Parks in Mozambique as well as various privately, community and state-owned conservation areas in Mozambique, South Africa and Zimbabwe bordering then GLTP. Currently parts of the fence with the Limpopo have been dropped, and a corridor area linking Kruger to Gonarezhou has been identified.

117 Values include consumptive, non-consumptive, tangible and non-tangible aspects. These include tourism benefits as well as benefits from a range of elephant products
118 Farm Name (including all registered farm names, numbers, and portion numbers in the fenced area).
119 Precise extent of the property and the specific enclosure where the elephants will be kept.

The park is also part of the United Nations Educational, Scientific and Cultural Organisation (UNESCO) Vhembe and Kruger to Canyons (K2C) Biosphere Reserves (BR). The K2C BR straddles the Mpumalanga and Limpopo Provinces, and contains widely diverse landscapes, ranging in altitude from 300 m above mean sea level (AMSL) in the east to more than 2,000 m AMSL in the Drakensburg Escarpment where the plateau basin begins. It is of ecological importance. It contains three major biomes (distinctive biogeographic regions), namely dry savanna woodlands, Afromontane Forest, and Afromontane grassland. These climatic variations further add to the increase in ranges of habitats which favour species diversity. As the altitude (and consequently rainfall) increases from east to west, vegetation progressing from scrub and savannah upwards into South Africa's unique fynbos floral system, rainforests, and climax grasslands on the top of the Escarpment, where water is more abundant.

The Vhembe BR holds a unique and extraordinary biological and cultural diversity represented in the Soutpansberg and Blouberg Mountains and the Mapungubwe World Heritage Site. The BR includes the high biodiverse northern part of Kruger, the Mapungubwe National Park and World Heritage Site, several Provincial Nature Reserves, two recognised centres of biodiversity and endemism (the Soutpansberg and Blouberg) and the Makgabeng Plateau with more than 1,000 rock art sites.

4.4 Land uses and activities on all neighbouring properties[120]

Private and provincial nature reserves, informal conservation areas, and community subsistence farming compatible with conservation land use practices are found along the western boundary of the central- and northern sections of the park. Mines such as the largest open pit mine in the southern hemisphere at Phalaborwa. Further north the landscape becomes more rural with former homelands, meaning that the land is mostly occupied by rural villages with limited economic opportunities, large subsistence agricultural areas and high unemployment rates. The park has peri-urban to urban development on its western and southern boundaries with the densest development occurring along the southwestern section of the park. This includes sugarcane plantations to the south of the Crocodile River, the rural areas of Bushbuckridge, forestry along the escarpment and the cityscape of the Nelspruit area.

[120] Description of the land uses and activities on all neighbouring properties.

4.5 Compilers[121]

Table 2. List of names, contact details, qualifications, and experience of the various compilers who contributes towards elephant management in Kruger.

Name	Designation	Contact Details	Qualification
Sam Ferreira	Large Mammal Ecologist	sam.ferreira@sanparks.org	Phd +25 years
Danny Govender	General Manager: Savanna Research Unit	danny.govender@sanparks.org	MSc (Disease Ecology) +15 years
Cathy Greaver	Regional Ecologist	cathy.greaver@sanparks.org	MSc +15 years
Corli Wigley-Coetsee	Scientist: Vegetation Dynamics	corli.wigley-coetsee@sanparks.org	Phd +10 years

4.6 Proximity to settlements, rural communities, and tribal land.

The park is situated within the following district and local authority boundaries:

- Ehlanzeni District Municipality:
  - Bushbuckridge Local Municipality
  - Mbombela Local Municipality and
  - Nkomazi Local Municipality
- Mopani District Municipality:
  - Ba-Phalaborwa Local Municipality
  - Greater Giyani Local Municipality and
  - Mopani Local Municipality
- Vhembe District Municipality:
  - Musina Local Municipality
  - Collins Chabane Local Municipality and
  - Thulamela Local Municipality.

The park has peri-urban to urban development on its western and southern boundaries with the densest development occurring along the southwestern section of the park. This includes sugarcane plantations to the south of Crocodile Bridge, the rural areas of Bushbuckridge, forestry along the escarpment and the cityscape of the Nelspruit area, with further prospecting and mining threats in this region. This potentially brings further challenges such as urban sprawl impacting on the borders of the park through more development applications. Along the western boundary of the central section of the park, mostly private and provincial nature reserves and other informal conservation areas are found. This creates a good ecological buffer to environmental or developmental issues. However, mining poses challenges to the ecological integrity of especially downstream water, with Phalaborwa having one of the largest open pit mines in the southern hemisphere.

[121] Name, contact details and qualifications of an ecologist or compiler of the plan or person who did the survey

Further north the landscape gets more rural with former homelands, meaning that the land is mostly occupied by rural villages with limited economic opportunities and large subsistence agricultural areas. The highest general poverty index and dependency on natural resource use is within the Mutale and Greater Giyani Local Municipalities. The historic imbalances in South African society resulted in most people living without land and housing, access to potable water and sanitation for all, affordable and sustainable energy sources, illiteracy, poor quality of education and training and poor and inaccessible health services. The latest population estimates by Statistics South Africa states that Limpopo's population increased to 5.77 million in 2017, whilst the share of the national total remained constant at 10.2%[122].

According to Statistics South Africa's Quarterly Labour Force Statistics[123], the unemployment rate in Limpopo was 38.2% at the beginning of 2017. Limpopo recorded the fourth highest unemployment rate amongst the nine Provinces. In July 2017, the number of grant payments in Limpopo stood at 2,448,580 or 14.1% of the total number of grant payments. Limpopo registered the fourth highest number of social grant pay-outs in the country[124]. The latest population estimates by Statistics South Africa states that Mpumalanga's population increased to 4.44 million in 2017, whilst the share of the national total remained constant at 7.9%[125].

The unemployment rate in Mpumalanga was 39.4%[126] at the end of 2015. Mpumalanga recorded the third highest unemployment rate. Mpumalanga's human development index stands at 0.694 as measured in 2014. Mpumalanga recorded the fourth highest human development index level among the nine provinces in 2014. In July 2017, the number of grant payments in Mpumalanga stood at 1,451,304 or 8.4 % of the total number of grant payments. Mpumalanga registered the sixth highest number of social grant pay-outs in the country[127]. High levels of unemployment and poverty occur in many of the communities located along the park boundary. Kruger is one of the most important sources of economic injection and with tourism numbers rising continually (over 1.81 million visitors in 2016 / 17) this trend is set to continue. In the 2016 / 17 financial year the park recorded a total income of close to R 825 million. Most of the employees from the park originate from the surrounding communities, and a large component of the Human Resource expenditure is channelled to these areas and households through the payment of salaries. The numerous hotels, lodges, guesthouses, and Bed & Breakfasts in the Lowveld area are indicative of the attraction force of the park for tourists to the Lowveld. The total economic multiplier value of the park is in the region of R 2 billion per annum[128].

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[122] Statistics South Africa (Stats SA). 2017a. *Mid-year population estimates 2017*. Available at http://www.statssa.gov.za/publications/P0302/P03022017.pdf
[123] Statistics South Africa (Stats SA). 2017b. *Quarterly labour force survey Q1:2017*. Available at http://www.statssa.gov.za/publications/P0211/P02111stQuarter2017.pdf
[124] South African Social Security Agency. Annual Report 2016/2017 https://nationalgovernment.co.za/entity_annual/1361/2017-south-african-social-security-agency-(sassa)-annual-report.pdf
[125] Statistics South Africa (Stats SA). 2017a. *Mid-year population estimates 2017*. Available at http://www.statssa.gov.za/publications/P0302/P03022017.pdf
[126] Statistics South Africa's Quarterly Labour Force Statistics (2017b),
[127] South African Social Security Agency. Annual Report 2016/2017 https://nationalgovernment.co.za/entity_annual/1361/2017-south-african-social-security-agency-(sassa)-annual-report.pdf
[128] Saayman, M., Kruger, M. & Fouché, M., 2010, Travel motives to Kruger and Tsitsikamma National Parks: A comprehensive study, *South African Journal of Wildlife Research* 40(1), 93–102. http://dx.doi.org/10.3957/056.040.0106

By partnering with neighbouring district and local municipalities, various external donors and neighbouring local communities, the park has made good strides towards enabling previously disadvantaged individuals and small micro-medium enterprises (SMMEs) better access to park-related opportunities. These range from biodiversity conservation, (alien eradication through the Working for Water programme) and selling arts and crafts to the concessions programme (outsourcing catering and transport services to neighbouring communities of the park).

4.7 Potential for enlarging the Park[129]

The consolidation of the park remains a national priority for SANParks given its recognised biodiversity, its landscape interface, and its regional social-economic importance. The consolidation also addresses national objective SO1.1 of the National Biodiversity Strategy and Action Plan (NBSAP). The expansion programme is informed by SANParks policy regarding land inclusion the National Protected Areas Expansion Strategy (NPAES), the National Biodiversity Assessment[130] and the Kruger Land Inclusion and Co-operative and Contractual Agreement Protocol.

The consolidation programme aims to contribute to NPAES that recommends expansion towards 12 % of the terrestrial area and 25 % of the marine inshore areas for South Africa. The primary focus for expansion will firstly be on the protection of, and the unlocking of associated sustainable socio-economic benefits of integrated biodiversity areas such as the Madimbo corridor, Makuya Nature Reserve, Mutale towards Soutpansberg corridor (these areas securing the Mutale and Luvuvhu River systems), Madimbo corridor (Limpopo River system), Letaba Ranch / Mthimkulu complex (Letaba River system), Olifants -, Selati -, Blyde River corridors and the Croc-River gorge (linking to Barberton Mountain lands region) corridor (the Inkomati: Crocodile River system).

The further inclusion of community and other conservation areas adjacent to the park will be strictly guided by the SANParks Land acquisition Policy, and the Kruger Land Inclusion Protocol, providing clear biodiversity, land use, socio-economic, management, governance, and risk criteria. SANParks may consider land inclusion on a contractual basis and / or co-operative arrangement as per the NEMPAA framework.

The primary focus for land consolidation will be on conservation areas open to the park but not managed by the park, and on unlocking mutual biodiversity and socio-economic local and regional benefits through the expanded and diversified conservation estate (Appendix A). These will be pursued through the GLTFCA arrangements and GLTP Treaty. Central to this will be the regularisation and management of these conservation areas within an overarching GLTFCA "Norms and standards", "best practice" guidelines and incentive frameworks. The park is bordered by private, community and state owned / managed conservation areas on the western boundary, such as several different reserves structures within the open Associated

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129 Information as to whether there is potential for enlarging the property.

130 Driver, A., Sink, K.J., Nel, J.L., Holness, S., van Niekerk, L., Daniels, F., Jonas, Z., Majiedt, P.A., Harris, L., Maze, K. 2012. National Biodiversity Assessment 2011: An assessment of South Africa's biodiversity and ecosystems. Synthesis Report. South African National Biodiversity Institute and Department of Environmental Affairs, Pretoria

Private Nature Reserves and/or adjacent conservation area complex (Timbavati Nature Reserve, Klaserie Game Reserve, Umbabat, Thornybush, Balule, Kapama), Mhethomusha, Sabie Sand Wildtuin, Mala Mala, Letaba Ranch-complex, Makuya Nature Reserve, and a range of other informal conservation areas.

4.8 Specifications of the perimeter fence

The park was fenced between 1959 and 1980 to curb the spread of diseases, to keep dangerous game from leaving the park and to facilitate patrolling the boundary to control poaching. Good quality and well-maintained electric fences remain the fencing standard for carnivore proofing in private game reserves, however they require an effective monitoring and maintenance system, which has proven difficult along the park's expansive western boundary. As a result, the fencing standard has shifted to the "I" Beam fence since 2010, which has been rolled out to various sections of the park. The fence is currently managed by the State Veterinary Services, under the Department of Agriculture, Land Reform and Rural Development (DALRRD).

More recently, the employment of Environmental Monitors dedicated to Human Wildlife Conflict (HWC) management provides the park with much needed additional human resources for effective fence line patrols, which shorten both the detection and reaction time to DCA and other fence insurgences in the north of the park. Furthermore, the Environmental Monitors living in the villages adjacent to the park, provide an important information gathering function regarding illegal activities. The eastern boundary fence with Mozambique is managed as a National Border by the Department of Public works.

4.9. Financial plan and ability to manage elephants[1]

SANParks follow an annual budget planning process and allocates funding for the management of national parks. Elephant management embeds within the implementation of the Mapungubwe Park Management Plan[2]. Financing the implementation of this elephant management plan are thus provided through the SANParks annual budgeting process.

4.10. Ecological characteristics[131]

4.10.1 Climate and hydrology[132]

The park's climate ranges from tropical to subtropical with high mean summer temperatures and mild, generally frost-free winters. Rainfall, delivered mostly through convective thunderstorms, is concentrated between October and April. A rainfall gradient stretches from an annual mean of about 750 mm in the south-west, to 350 mm in the north-east, although strong inter-annual and roughly decadal cyclic variations exist, with droughts considered endemic. In the 50 years between 1960 and

[1] Financial plan indicating the ability of the owner of the elephants to continuously manage the elephants.
[2] SANParks. 2019. Mapungubwe Nation Park and World Heritage Site: Integrated Management Plan. SANParks, Groenkloof, South Africa. https://www.sanparks.org/assets/docs/conservation/park_man/mapungubwe_approved_plans.pdf
131 Ecological information should be collected and analysed by an ecologist. Methods used should be scientific and described in detail. The scale of the maps should be at least 1-50 000.
132 General climatic and hydrological data (e.g., rainfall, temperatures).

2009, average minimum and maximum temperatures have both increased by about 0.85 °C at Skukuza[133]. In 2016 the hottest day recorded was 45.1 °C and the lowest temperature 2.6 °C. The dominant winds are from the southeast and northwest directions with the average wind speeds around 2.5 m/second. The mean humidity at midday in summer ranges from 50 to 53 % and in winter from 37 to 42 %[134].

4.10.2 Geology[135]

The park is underlain by a variety of igneous, sedimentary, and metamorphic geological formations as well as unconsolidated sediments deposited over a time span of more than 3.5 billion years[136]. The most important litho- stratigraphic units that are present in the park include, the Basement Complex which consists of ancient granitoid rocks of Swazian age (>3,090 million years), sedimentary and volcanic rock of the Soutpansberg Group and the volcanic rock of the Karoo Supergroup[137]. Geologically, the park is divided roughly into granites (coarse-grained igneous rock) on the west and basalts (fine-grained igneous rock) on the east. The regions of the park located above granitoid rocks are distinctly gentle to moderately undulating areas with noticeable inselbergs. These inselbergs are dome-like structures in the granitoid rocks with higher weathering resistance[138]. Roughly 60 % of the park's surface is underlain by various types of Precambrian granitoid rocks[139]. These rocks provide the basement on which the 1,800 million years old Soutpansberg Group and the 300 million years - 170 million years old Karoo sedimentary and Lebombo volcanic rocks, located north of the Soutpansberg and along the eastern boundary of the park, could be deposited[140]. In some areas where gabbro and dolerite intrusions strike through these granitic areas, the landscape features are flatter areas of relief[141].

The Malelane Mountains in the southwestern region of the park comprises of granite, gneiss and migmatite[142]. Due to the lithological strike in a north-south orientation, the geological succession changes from west to east. A narrow north-south stretch of sedimentary rocks separates the granitic and basaltic regions while a rhyolite band runs parallel on the eastern boundary of the park[143]. There is an assortment of geological material in the park which is evident from the Lebombo Mountains on the eastern boundary with Mozambique, the sandstone hills northeast of Punda Maria and the granitic rocky terrain in the southwest of the park between Pretoriuskop and Malelane[144]. The topography in the park is also influenced by differences in the underlying geology's resistance to weathering and the intensity of dissection in

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133 van Wilgen, N. J., Goodall, V., Holness, S., Chown, S. L. and McGeoch, M. A. 2016. *Rising temperatures and changing rainfall patterns in South Africa's National Parks.* International Journal of Climatology 36:706–721.
134 Du Toit, J.T., Rogers, K.H. and Biggs, H.C. (Eds.). 2003. *The Kruger Experience: Ecology and management of savanna heterogeneity.* Island Press, Washington.
135 General description of the geology
136 Venter, F.J., Scholes, R.J. and Eckhardt, H.C. 2003. *The abiotic template and its associated vegetation pattern.* In: eds. Du Toit, JT, Rogers, KH and Biggs, HC, The Kruger experience: Ecology and management of savanna heterogeneity, Ch. 5, 83-129. Island Press, Washington, D.C., USA.
137 Venter, F.J. 1990. *A classification of land for management planning in the Kruger National Park.* PhD Thesis, University of South Africa.
138 Venter, F.J. and Bristow, J.W. 1986. *An account of the geomorphology and drainage of the Kruger National Park.* Koedoe 29: 117-124.
139 Barton, J.M. (Jr.), Bristow, J.W. and Venter, F.J. 1986. *A summary of the Precambrian Granitoid Rocks of the Kruger National Park.* Koedoe 29: 39-44.
140 Barton, J.M. (Jr.), Bristow, J.W. and Venter, F.J. 1986. *A summary of the Precambrian Granitoid Rocks of the Kruger National Park.* Koedoe 29: 39-44.
141 Venter, F.J. and Bristow, J.W. 1986. *An account of the geomorphology and drainage of the Kruger National Park.* Koedoe 29: 117-124.
142 Schutte, I.C. 1986. *The general geology of the Kruger National Park.* Koedoe 29: 13-37.
143 Venter, F.J., Scholes, R.J. and Eckhardt, H.C. 2003. *The abiotic template and its associated vegetation pattern.* In: eds. Du Toit, JT, Rogers, KH and Biggs, HC, The Kruger experience: Ecology and management of savanna heterogeneity, Ch. 5, 83-129. Island Press, Washington, D.C., USA.
144 Mabunda, D, Pienaar, D.J. and Verhoef, J. 2003. The Kruger National Park: A century of management and research. In: eds. Du Toit, J.T., Rogers, K.H. and Biggs, H.C., *The Kruger experience: Ecology and management of savanna heterogeneity*, Ch. 1, 3-21. Island Press, Washington, D.C., USA.)

locations that border the major rivers in the park[145]. Within the park, the Lebombo Mountains peaks at a maximum height of 497 AMSL while the Malelane Mountains in the southwestern region of the park averages about 800 AMSL. The remainder of the park is a gently undulating landscape between 200 m and 400 m AMSL with a gentle gradient to the east[146]. The Nwambiya Sandveld is a flat landscape situated south-east of Pafuri consisting of old coastal deposits, including cobble stone layers and flattened sand dunes of the Cenozoic[147].

4.10.3 Soils[148]

There is strong correlation between geology and soils of the park[149]. Soil profiles generally become shallower as rainfall decreases towards the north. This is particularly noted for the coarse-grained soils (sands and loamy sand) derived from the granitic materials, where soil depths decrease from approximately 150 cm in the Pretoriuskop area (rainfall 750 mm/yr) to 30 cm north of Phalaborwa (rainfall 350 mm/yr). In the southern granitic parts of the park, which are underlain by the granite / gneiss of the basement complex, there are numerous catenas throughout the landscape with the distinctive crest to valley bottom catenal sequence. From crest to valley bottom the soils usually occur in the following pattern: along the crest and midslopes sandy-hydromorphic (coarse grained) soils, duplex soils along the foot slopes and complex alluvial soils are found along the valley bottoms. The Karoo sequence (basalt) which is a predominantly flat landscape (low undulation) produces fine-grained soils that have high clay content with olivine-rich clay soils in the northern plains and olivine-poor soils in the southern plains. Alluvial soils occur along most of the drainage lines in the park, the extent of which increases as the size of drainage lines increase. Older river terraces and gravels also occur along the major rivers. The most extensive alluvial deposits are found along the Limpopo and Luvuvhu Rivers in the north of the park[150]. Soil can be defined as a naturally occurring body of unconsolidated material which supports functional ecosystems. This vital resource delivers very specific services to the ecosystem which varies between soil types. Soil properties such as depth, texture and structure control the movement and storage of water underground. These physical soil properties along with soil nutrients are evidently reflected in the biotic components of the ecosystem[151].

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145 Schutte, I.C. 1986. *The general geology of the Kruger National Park*. Koedoe 29: 13-37; Venter, F.J. 1990. *A classification of land for management planning in the Kruger National Park*. PhD Thesis, University of South Africa.

146 Schutte, I.C. 1986. *The general geology of the Kruger National Park*. Koedoe 29: 13-37; Venter, F.J. 1990. *A classification of land for management planning in the Kruger National Park*. PhD Thesis, University of South Africa.

147 Venter, F.J. 1990. *A classification of land for management planning in the Kruger National Park*. PhD Thesis, University of South Africa.

148 General description of the soils

149 Venter, F.J. 1990. *A classification of land for management planning in the Kruger National Park*. PhD Thesis, University of South Africa; Venter, F.J., Scholes, R.J. and Eckhardt, H.C. 2003. *The abiotic template and its associated vegetation pattern*. In: eds. Du Toit, JT, Rogers, KH and Biggs, HC, The Kruger experience: Ecology and management of savanna heterogeneity, Ch. 5, 83-129. Island Press, Washington, D.C., USA.

150 Venter, F.J. and Bristow, J.W. 1986. *An account of the geomorphology and drainage of the Kruger National Park*. Koedoe 29: 117-124; Venter, F.J. 1990. *A classification of land for management planning in the Kruger National Park*. PhD Thesis, University of South Africa; Venter, F.J., Scholes, R.J. and Eckhardt, H.C. 2003. *The abiotic template and its associated vegetation pattern*. In: eds. Du Toit, JT, Rogers, KH and Biggs, HC, The Kruger experience: Ecology and management of savanna heterogeneity, Ch. 5, 83-129. Island Press, Washington, D.C., USA.

151 Venter, F.J. and Bristow, J.W. 1986. *An account of the geomorphology and drainage of the Kruger National Park*. Koedoe 29: 117-124

4.10.4 Vegetation[152]

Approximately 2,000 plant species occur in the park, including 400 trees and shrubs, and 220 grasses. Numerous classification systems have been used to divide the park into various vegetation, physiographic and natural history zones, and composites of these.

At a very coarse level, the vegetation can fall into three regions. A lower nutrient, higher rainfall well-wooded area occurs in the southeast and important trees are bushwillows, *Combretum* spp., especially *C. apiculatum*, knob thorn *Acacia (Vachellia) nigrescens*, tamboti *Spirostachys africana* and marula *Sclerocarya birrea* (e.g., SVl3, SVl10). The southeast lies on basalts with palatable productive grasslands and some trees such as knob thorn, marula and leadwood *C. imberbe* (e.g., SVl5). The northern half of the park is, broadly speaking, dominated by mopane *Colophospermum mopane* with more fertile open grasslands on the eastern basaltic half, and more undulating landscapes with woodlands including bush willow trees *Combretum* spp. in the northwestern quadrant (e.g., SVmp3, SVmp5, SVmp6, SVmp8). Despite a dominance of mopane in the north, some very interesting vegetation can be found in the north. Lowveld Riverine Forest occurs along the major rivers in the north of the park (FOa1) with large specimens of fig trees, *Ficus* spp., fever trees *Acacia (Vachellia) xanthophloea*, Ana trees *Faidherbia albida* and Nyala trees *Xanthocercis zambesiaca* forming part of this endangered vegetation type. Although broadly driven by flooding regimes, this vegetation type is heavily impacted by elephants, and elephants and smaller species such as impala limit recruitment of new riparian trees.

Moving away from this riverine vegetation in the north, a more arid area is found with the baobabs *Adansonia digitata* and, common star-chestnuts *Sterculia rogersii* being just a few of the impressive species to be seen (SVmp2). Although much of the areas don't have water available seasonally, and thus offer some protection from elephants, areas closer to permanent water may have high impacts. In terms of biodiversity rich areas, Punda Maria is a wonderfully rich botanical area, and it is home to one of the important endangered species in the park, the pepper bark *Warburgia salutaris,* sought after for its medicinal qualities. The relatively rare sandveld vegetation type, Nwambiya-Pumbe Sandy bushveld, can be found to the east of Punda Maria (FOz8). This vegetation type has very high botanical biodiversity, but most species are unpalatable, and the area is also far from water, which results in little elephant impacts.

At a finer scale, two important pieces of work have contributed to the understanding of vegetation patterns within the park. Although vegetation classification was not the main aim of these, the vegetation classifications obtained have been used to delineate the park into management units:

[152] Detailed description of the vegetation.

The park was delineated[153] into 35 landscapes[154] The vegetation component of the land types[155] was mapped using descriptions by various SANParks staff[156,157,158], as well as 1,500 Braun-Blanquet plots.

Fifty-six land types were proposed (and these were amalgamated into 11 land systems) as a basis from which to plan management and ecological studies of the park. To delineate the land types, Venter thus classified vegetation, which was done at about 2,000 sites. The vegetation was described using an adapted Braun-Blanquet method[159] cover was estimated according to scale[160] and the structural classification method[161].

The most recent vegetation classification[162] of was done during the revision of vegetation nationwide. The 21 vegetation types that fall within the park are summed up regarding cover within the park, geology and soils, landscape features, and vegetation in Appendix A below. In addition, the relationship between the Gertenbach and Venter classifications are also shown.

4.10.5 Preferred management density of elephants

Due to the size and diversity of habitats, as well as distance to water, the density of elephants in KNP is variable. The published literature says that on the average elephant density will fluctuate between 1-2 elephants per 100Km^2, however we acknowledge that in some habitats, elephant density will be much higher than 2, and in other areas they will be much lower than 1 elephant 100km^2.

4.10.6 Game species and numbers[163]

The diversity of landscapes in the park provides many different habitats and resources across a large scale. Several mammal species live in these habitats in Kruger (Table 3) and use the variety of resources.

Body mass distribution of species present has no discontinuity, a feature of relatively intact ecosystems, with body mass ranging from 3,500 kg to 6,000 kg for cow and bull African elephants respectively to 6.2 g for the pygmy mouse[164]. Although much focus is on the charismatic species that tourists favour, the park abounds with rodent (25), shrew (5) and bat (44) species[165]. In addition, rarely seen species such as aardvark *Orycteropus afer* and pangolins *Smutsia temmenicki* also live in the park, while rangers and visitors recording occasional sightings of species such as brown hyaena *Hyaena brunnea* in recent years.

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153 Gertenbach, W. D. 1983. Landscapes of the Kruger National Park. Koedoe 26:9–121.
154 a landscape is defined as "an area with a specific geomorphology, macroclimate, soil and vegetation pattern and associated fauna
155 an area or group of areas throughout which a recurring pattern of topography, soils and vegetation can be recognized
156 Coetzee, B. J. 1982. Phytosociology, vegetation structure and landscapes of the Central District, Kruger National Park. PhD Thesis, University of Pretoria.
157 Gertenbach, W. D. 1983. Landscapes of the Kruger National Park. Koedoe 26:9–121.
158 Fraser, S. W., Van Rooyen, T. H., and Verster E. 1987. Soil-plant relationships in the central Kruger National Park. Koedoe 30:19–34.
159 Coetzee, B. J., and P. J. Nel. 1978. A phytosociological reconnaissance of Mlilwane Wildlife Sanctuary, Swaziland. Koedoe 21:1–36.
160 Coetzee, B. J. 1982. Phytosociology, vegetation structure and landscapes of the Central District, Kruger National Park. PhD Thesis, University of Pretoria.
161 Gertenbach, W. D. 1983. Landscapes of the Kruger National Park. Koedoe 26:9–121.
162 Mucina, L., & Rutherford, M.C. 2006. The vegetation of South Africa, Lesotho, and Swaziland. South African National Biodiversity Institute.
163 Game species and numbers present on property
164 (Skinner & Smithers, 1990)
165 (Bronner et al., 2003)

The compliment of mammal species living in the park includes 8 endangered species, 7 vulnerable, 16 near threatened and 112 species of least concern. Even so, species abundances differ substantially between species. Overall, mammal biomass is dominated by the mega-herbivores such as African elephant, white rhinoceros, giraffe, buffalo, hippopotamus, and black rhinoceros. These species are key role players in ecosystem dynamics within the park. Most of the large and mega herbivores have been stable or are increasing since 2008 except for black and white rhinoceros (due to poaching) and rare antelope species such as roan antelope *Hippotragus equinus*.

Table 3. Estimates for animal abundances in Kruger National Park. We provide 95% CI ranges where available and indicate the method, 5-year trend and year of the last estimate. (-) species does not occur in the park, nc – not counted. Methods: r – registration studies, b – block counts, d – transects using distance sampling, t – total counts, g – guestimate usually from ranger experience, p – photographic mark-recapture, c – call-up surveys, s – sample surveys using fixed width transects, ct – camera traps mark-recapture, as – adaptive sampling. Trends: u – unknown, i – increase, d – decrease, 0 – non-directional. We round values larger than 10 to the nearest 5, and larger than 50 to the nearest 10.

Kruger National Park	
Species	**Number**
Black rhinoceros	149-261 (b,d,2022)
Blue wildebeest	9342-17936 (d,d,2017)
Buffalo	31071-34426 (b,0,2021)
Cheetah	330-500 (p,u,2009)
Common reedbuck	300 (g,u,2009)
Eland	226-294 (b,0,2021)
Elephant	26401-29584 (b,i,2021)
Giraffe	7598-11972 (d,i, 2017)
Greater kudu	4520-8697 (d,0,2017)
Hippopotamus	3986 (t,d,2017)
Impala	114202-173207 (d,0, 2017)
Leopard	1630-2860 (ct,u,2011)
Lichtenstein hartebeest	30 (g,u,2009)
Lion	1715-1891 (c,i,2015
Mountain reedbuck	150 (g,u,2009)
Nile crocodile	3326 (t,i,2017)
Nyala	300 (g,u,2009)
Ostrich	nc
Plains zebra	28868-38931 (d,i,2017)
Roan antelope	40-75 (b,0,2021)

Kruger National Park	
Species	**Number**
Sable antelope	384-470 (b,0,2021)
Spotted hyena	7000-7680 (c,i,2015)
Tsessebe	208-287 (b,0,2021)
Warthog	1410-3573 (d,0,2017)
Waterbuck	2995-7810 (d,0,2017)
White rhinoceros	1711-1988 (b,d,2022)
Wild dog	280-300 (p,u,2021)
Incidental observations of other species during aerial surveys for which methods are not appropriate	
Chacma baboon	nc
Bushbuck	500 (g,u,2009)
Bushpig	nc
Common duiker	nc
Black-backed jackal	nc
Klipspringer	nc
Kori bustard	nc
Porcupine	nc
Steenbok	nc
Vervet monkey	nc
Vultures	nc

4.10.7 Sensitive habitats and species

Table 4 summarises the percentage area of the park covered by each use zone, as well as the percentage of the highly environmentally sensitive and valuable areas (defined as areas with values in the top quartile of the sensitivity-value analysis) that are within each zone. This indicates that nearly 81.5 % of the park is covered by zones that are strongly conservation orientated in terms of their objectives. The table demonstrates some correlation between the spatial distribution of environmentally sensitive areas and conservation-orientated zones, with 71.8 % of highly sensitive areas in the conservation orientated zones. Conversely, the tourist orientated zones covers 18.6 % of the park yet contains approximately 28.6 % of sensitive areas.

Table 4 Summary of the percentage area of the park covered by each use zone

Zone emphasis	Use zone	Zone as a % of park area	% of highly sensitive areas that are in a zone
Conservation orientated	Wilderness	42.46	28.54
	Remote	16.27	20.95
	Primitive	22.68	22.29
Tourism orientated	Low intensity leisure	8.75	11.76
	High intensity leisure	9.84	16.46

4.10.8 Disturbed or degraded areas[166]

Environmental disturbances that hinder ecosystem stability and function, threaten the various benefits derived from national parks as they result in decreased species diversity and subsequent decline in ecological function and resilience. Such anthropogenic disturbances should be mitigated, and ecological processes restored to reduce undesirable impact on the biological integrity of ecosystems. In some cases, the disturbed or damaged ecosystem cannot re-establish on their own without human facilitation, often because the environment has been exposed to frequent or intense disturbances that hinder or delay ecosystem repair.

Most degradation types in the park are human-induced such as past agricultural practices, artificial water provision, invasive alien species (although relatively small scale), past and present herbivory, old infrastructure, erosion and soil degradation. Apart from human-induced activities, degradation can also be caused by natural disturbances (*i.e.*, floods, droughts) that are too frequent or severe to allow natural ecosystem recovery in a reasonable period. Degradation resulting from various factors, including climate perturbations and extreme events, inappropriate fire or

[166] Disturbed or degraded areas such as bush encroachment and soil erosion

herbivory regimes, alien species invasion, as well as human activities, generally reduces flows of ecosystem goods and services.

Responding to these various sources of degradation includes the closure, removal and rehabilitation of certain artificial water sources such as dams, reservoirs and drinking troughs, the closure and rehabilitation of disused management roads, the removal and rehabilitation of redundant structures, the rehabilitation of all man induced erosion and other disturbed sites such as disused gravel pits, addressing bush encroachment and to prevent (where possible) and respond appropriately to poison and pollution incidences in the park.

This program depends on two external funders, namely the Expanded public works programme (EPWP) Biodiversity Social Projects (BSP) program and South African National Defence Force (SANDF), for implementation. Kruger Management must also ensure that sufficient funds are budgeted for internal operations aimed at erosion control and maintenance of existing management roads.

4.10.9 Water bodies and distribution thereof[167]

The park lies within the central region of two transboundary river basins, the Inkomati and the Limpopo systems. The Inkomati system is shared by South Africa, Swaziland, and Mozambique, while the Limpopo system is shared by South Africa, Mozambique, Zimbabwe, and Botswana. At the broadest scale surface water is available throughout the year in the five perennial rivers that flow into the park and drain its seasonal and ephemeral streams with the exception during extreme droughts. These rivers are the Luvuvhu, Letaba, Olifants, Sabie-Sand and the Crocodile. The diametrically opposed geologies of the Granites and the Basalts in the park have a strong influence on seasonal and ephemeral stream density with a significantly greater density on the former. Whilst surface water availability in these channels is seasonal to intermittent, on the basalts in particular surface water is often present in local pools along the drainage network where these streams intersect the local groundwater table.

[167] Description of all available water bodies and distribution thereof described.

4.10.10 Maps

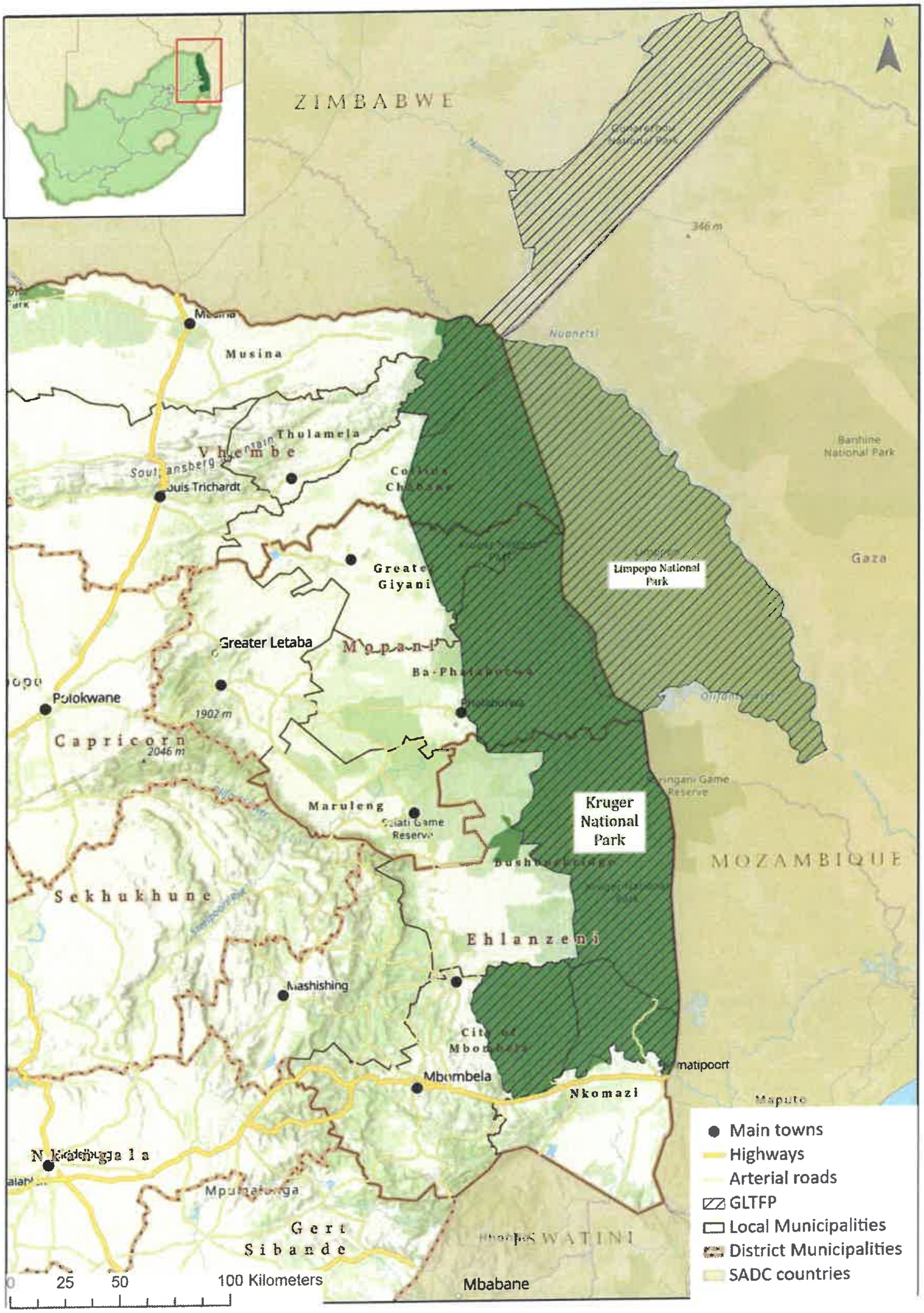

Figure 1. Location map of Kruger National Park within a regional context

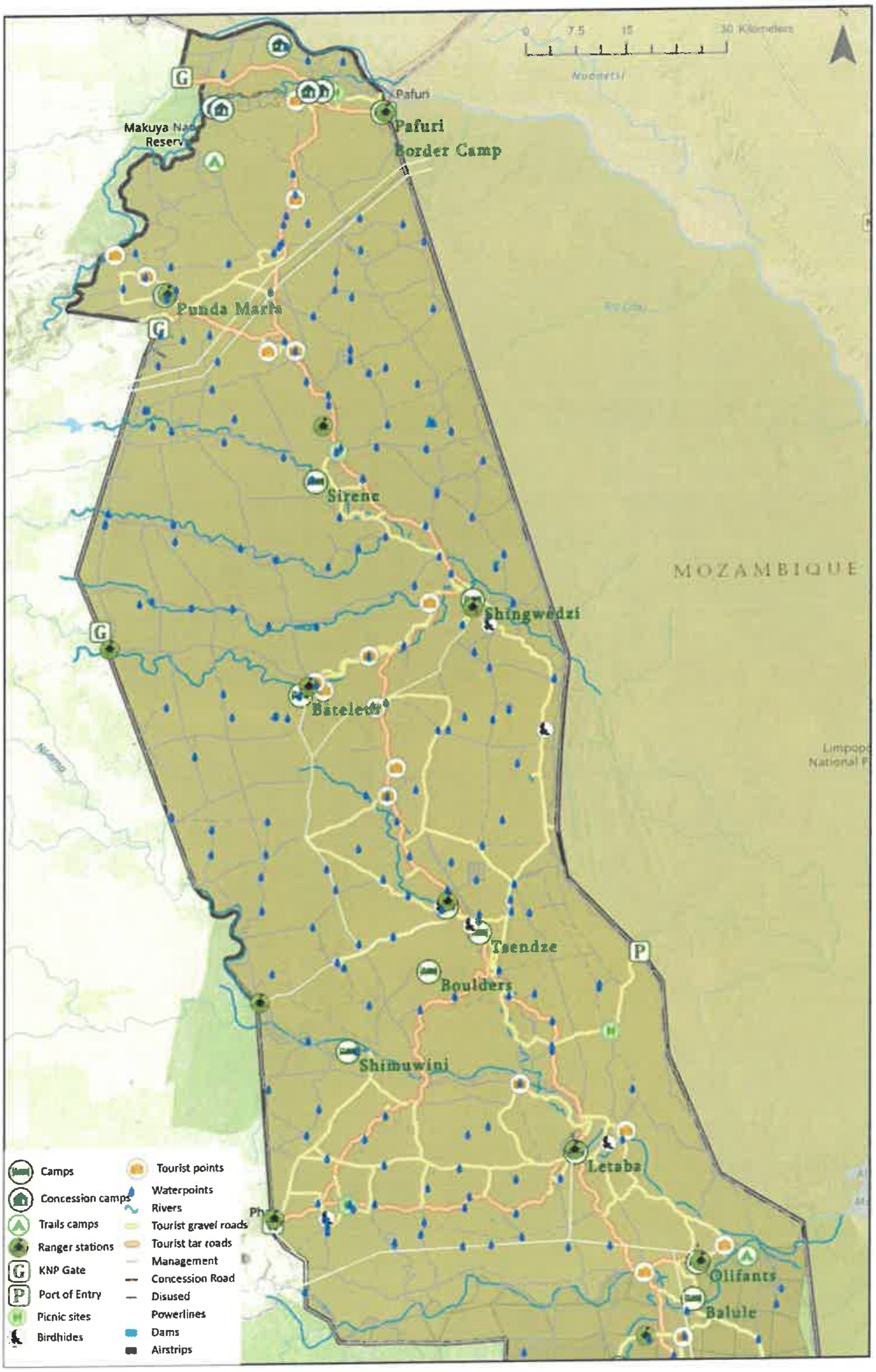

Figure 2a. Topographic map of Kruger National Park, north of Olifants River, illustrating farm boundaries, camp(s), roads, water points, infrastructure, etc.)

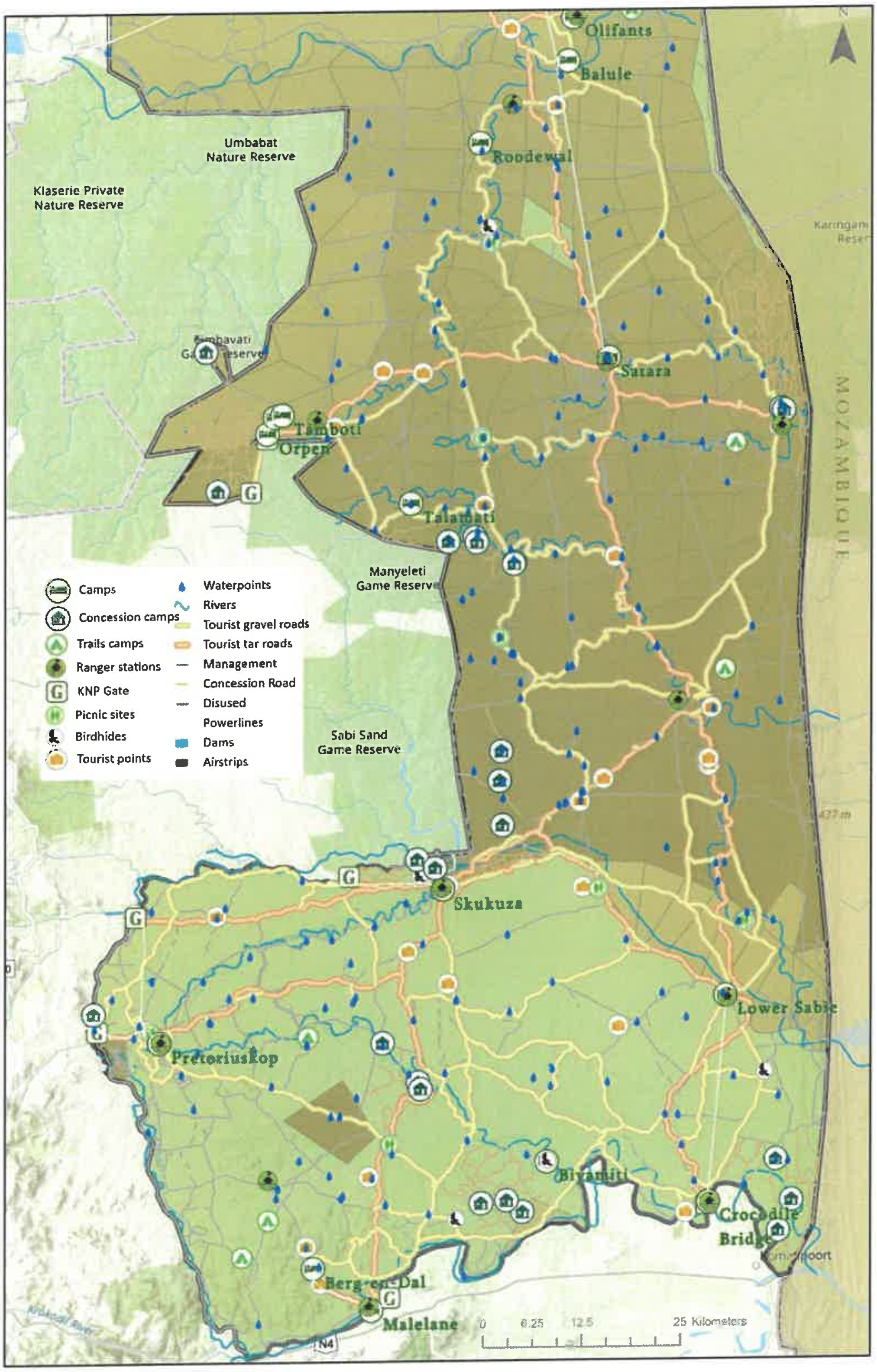

Figure 2b. Topographic map of Kruger National Park, south of Olifants River, illustrating farm boundaries, camp(s), roads, water points, infrastructure, etc.)

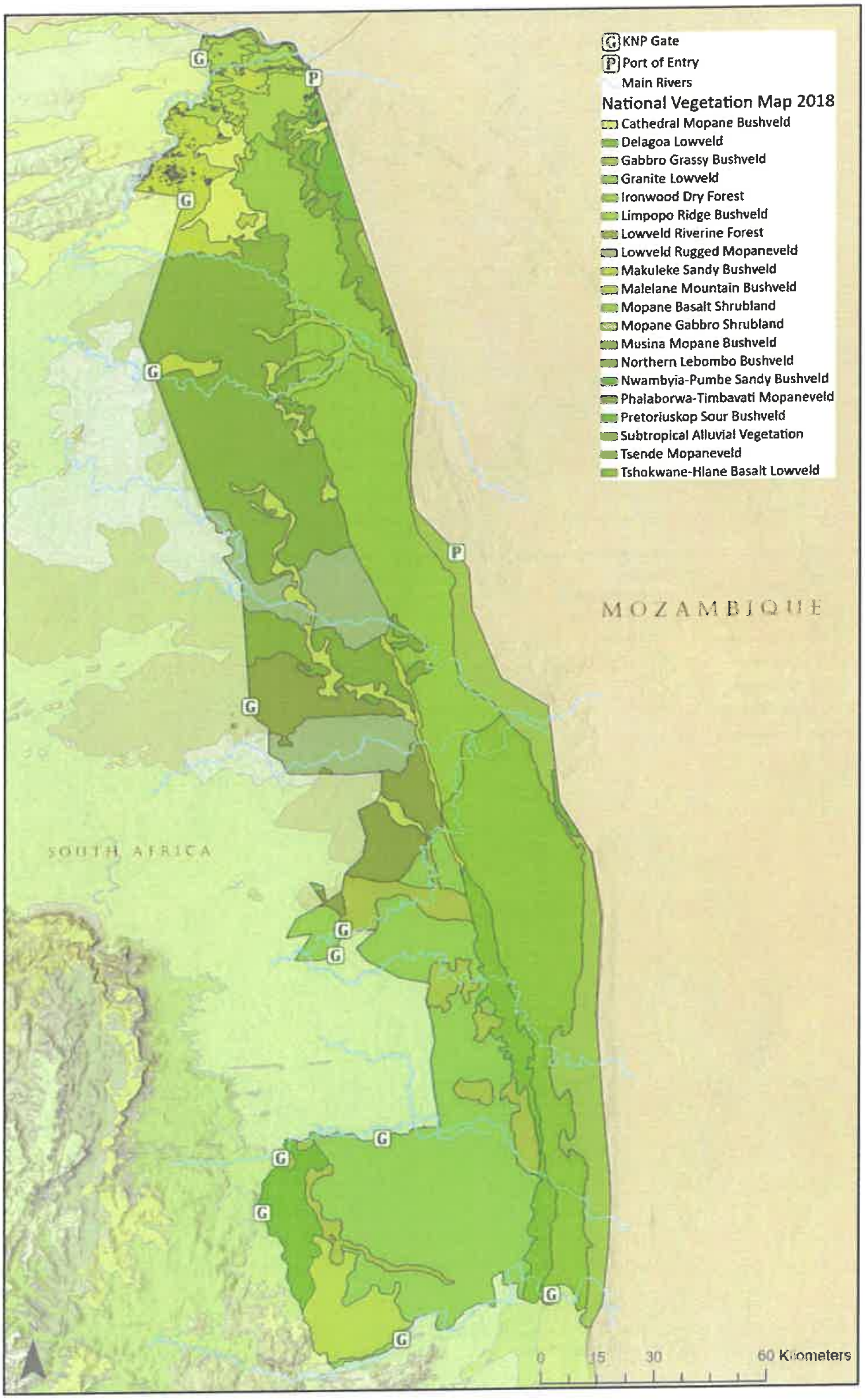

Figure 3. Vegetation map of Kruger National Park

B. Management goals and objectives

SANParks envisage *a resilient*[168] *Kruger elephant population over extensively linked landscapes*[169]*, enhancing biodiversity, improving equitable*[170] *socio-economic benefits, whilst inspiring and connecting diverse cultures.* Kruger has a complexity, richness and diversity of socio-ecological systems and the promotion of conservation in all its complexities is fundamental to SANParks' core biodiversity conservation values[171]. These complexities are addressed through a strategic adaptive management approach[172] within which the management of elephants in Kruger embeds.

Four strategic elephant management objectives (Table 5) have been developed for Kruger National Park, with 13 associated management actions to address these. See Section 10 for details.

Objective 1 **Foster meaningful stakeholder relationships**: growing local and regional understanding of the role of elephants, through improving livelihoods and reducing conflict with people. *Objective 2* **Maintain resilient elephant populations** by reducing impacts from poaching, poisoning, and snaring. *Objective 3* **Manage the ecological and cultural role of elephants** by allowing their dynamic functioning in the ecosystem, while reducing ecological risks and promoting their cultural value. *Objective 4* **Facilitate opportunities and benefits associated with elephants** by promoting all their values[173] as well as the ecosystem services they provide.

[168] Resilient refers to ability to resist or recover from disturbance
[169] Lived-in regional landscape- large mixed land-uses that are compatible with elephant presence over 3 countries that make up the GLTFCA.
[170] Equitable acknowledges that not all stakeholders are equal, and that stakeholders directly impacted and affected by elephants should have access to more benefits
[171] Kruger National Park Management Plan 2018-2028. https://www.sanparks.org/assets/docs/conservation/park_man/knp/knp-approved-plan.pdf
[172] 2 Roux, D.J. and Foxcroft, L.C., 2011. The development and application of strategic adaptive management within South African National Parks. Koedoe: African Protected Area Conservation and Science, 53(2), pp.1-5.
[173] Values include consumptive, non-consumptive, tangible & non-tangible aspects. These include tourism benefits as well as benefits from a range of elephant products

4.11. Habitat

4.11.1 Veld condition[174]

The original technique for assessing veld condition as well as the key grasses, are well described[175,176]. The initial calibration of the disc pasture meter was undertaken in 1986[177] and subsequently revised in 2006[178], although for consistency, SANParks used the initial calibration throughout. The methods used in the more recent surveys that have taken place since 2016 is also well described[179,180]. Veld condition assessments take place annually during March-May, weather, funding, and capacity depending.

4.11.2 Rehabilitation programme for degraded areas.

Since the park's proclamation, evolving management practices resulted in certain changes and ecosystem impacts over the years. Management interventions such as the erection of fences, fire management, water provision and animal population controls, as well as the development of infrastructure for management and tourism purposes, progressively reshaped the natural environment within the park. Although localised to a certain extent, these actions and developments did have certain negative impacts on ecological processes, "sense of place" and wilderness qualities within the park and these must be mitigated or rehabilitated to an acceptable level. This includes the closure, removal and rehabilitation of certain artificial water sources such as dams, reservoirs and drinking troughs, the closure and rehabilitation of disused management roads, the removal and rehabilitation of redundant structures, the rehabilitation of all human induced erosion and other disturbed sites such as disused gravel pits, addressing bush encroachment and to prevent (where possible) and respond appropriately to poison and pollution incidences in the park. The immediate challenge is the removal and rehabilitation of redundant and manmade structures from the park, specifically prioritising structures in wilderness areas of the park to secure their statutory protection as wilderness under the NEMPAA.

Current erosion problems in the park are mainly associated with (i) incorrect road alignment through sensitive soils and seep lines, (ii) erosion around artificial water sources such as dams and windmills where excessive trampling and the unnatural channelling of water resulted in ongoing erosion problems, (iii) erosion linked to the closure of approximately 1,146 km of management roads (of which 600 km are bordering wilderness areas and must receive priority attention) and (iv) disused gravel pits.

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174 Veld condition monitoring methods and time schedules
175 Trollope, W. S. W., Potgieter, A. L. F., & Zambatis, N. (1989). Assessing veld condition in the Kruger National Park using key grass species. Koedoe, 32(1), 67-93.
176 Trollope, W. S. W. (1990). Development of a technique for assessing veld condition in the Kruger National Park using key grass species. Journal of the Grassland Society of southern Africa, 7(1), 46-51.
177 Trollope, W. S. W., & Potgieter, A. L. F. (1986). Estimating grass fuel loads with a disc pasture meter in the Kruger National Park. Journal of the Grassland Society of Southern Africa, 3(4), 148-152.
178 Zambatis, N., Zacharias, P. J. K., Morris, C. D., & Derry, J. F. (2006). Re-evaluation of the disc pasture meter calibration for the Kruger National Park, South Africa. African Journal of Range and Forage Science, 23(2), 85-97.
179 Staver, A. C., J. Botha, and L. Hedin. 2017. Soils and fire jointly determine vegetation structure in an African savanna. New Phytologist 216:1151–1160.
180 Staver, A. C., J. Botha, and C. Wigley-Coetsee. 2019. Grazer movements exacerbate grass declines during drought in an African savanna. Journal of Ecology.

4.11.3 Fire management plan

Since 1926, the Fire Management Strategy in the park has continuously evolved. For nearly a century, various fire policies have been implemented – these ranged from total fire suppression, to prescribed burning in fixed seasons and frequency, to only allowing lightning fires to burn and suppression of all other fires. The current Strategy may be described as an integrated fire management protocol that allows for burning of the veld by rangers to achieve specific ecological objectives. This fire protocol has been in place since 2012 when it was modified to implement the fire plan within ecological fire management zones which are defined by rainfall, geology, and historical fire return intervals.

4.11.4 Water provision

After the establishment of the park, long periods of drought and the subsequent migration of wildlife and fencing in of wildlife, resulted in the widescale artificial water provisioning for wildlife. This led to the construction of dams and the drilling of boreholes across the park landscape, an estimated 1,500 boreholes have been drilled.

The changes in water provision had several unforeseen consequences, which included the decrease in numbers of rare antelope which were indirectly affected by higher competition from water dependent species as well as increases in predators. The confinement, protection and historic high-water provision within park has been beneficial to elephant. The population grew to about 7,000 towards the end of the 1960s and was kept at this figure through culling (about 16,000 elephants were removed between 1966 and 1994). A moratorium on culling was instituted in 1994 and elephant numbers have increased to around 19,000 by 2017.Individuals choose where to go in a landscape based on where resources are located. Essential resources, like water for many large vertebrates, are the first determinant.

4.11.5 Population management of other wildlife species

The park had relative low mammalian herbivore numbers in historic times and the Lowveld during the mid to late-19th century had especially low numbers due to uncontrolled hunting and a rinderpest epidemic[181]. The park was fenced between 1959 and 1980 to curb the spread of diseases, to keep dangerous game from leaving the park and to facilitate patrolling the boundary to control poaching. As game had less access to water due to the disruption in their movements, artificial water was provided. The changes in water provision had several unforeseen consequences, which included the decrease in numbers of rare antelope which were indirectly affected by higher competition from water dependent species as well as increases in predators. The confinement, protection and historic high-water provision within park has been beneficial to elephant. The population grew to about 7,000 towards the end of the 1960s and was kept at this figure through culling (about 16,000 elephants were

[181] Mabunda, D., Pienaar, D.J., Verhoef, J., 2003. The Kruger National Park: a century of management and research. In: *The Kruger experience: Ecology and management of savanna heterogeneity*, du Toit, J.T., Rogers, K. & Biggs, H.C. Island Press, Washington. pp.3-21.

removed between 1966 and 1994). A moratorium on culling was instituted in 1994 and elephant numbers have increased to around 19,000 by 2017.

Individuals choose where to go in a landscape based on where resources are located. Essential resources, like water for many large vertebrates, are the first determinant. The second is where individuals perceive safety from predators including man. Individuals then choose places based on where replaceable resources are (*e.g.*, one grass type versus another grass type). The intensity of herbivory will thus be a consequence of the spatial distribution and variability of resources. The spatial gradient of herbivory disturbances reduces or homogenize if factors in the landscape make the distribution of resources more even through the landscape (*e.g.*, widespread water provisioning, broad-scale fires, fences excluding access to some resources *etc.*). In addition, using herbivores for socio-economic development purposes may result in reduced herbivore effects if management implements excessive removals (mopane worms *Gonimbrasia belina*, buffalo, hippopotamus etc.).

4.11.6 Preferred management density

Due to the size and diversity of habitats, as well as distance to water, the density of elephants in Kruger is variable. The published literature says that on the average elephant density will fluctuate between 1-2 elephants per 100 km^2, however we acknowledge that in some habitats, elephant density will be much higher than 2, and in other areas they will be much lower than 1 elephant.100 km^{-2}.

4.12 Information pertaining to elephants

4.12.1 Purpose of introduced elephant

The Kruger elephant population was re-established after it had been hunted out of the areas, through naturally colonisation from neighbouring areas in the early 1900s. African elephants play key roles in ecosystems. While global concerns focus on poaching, elephants can cause habitat change across landscapes of multiple uses. Elephants also harm the well-being of people. Habitat change and conflict with people associate with how intense elephants use landscapes. Elephants are thus ecosystem engineers that carry benefits and costs for people dictated by where and how elephants use landscapes.

In this context, envisage *a resilient*[182] *Kruger elephant population over extensively linked landscapes*[183]*, enhancing biodiversity, improving equitable*[184] *socio-economic benefits, whilst inspiring and connecting diverse cultures.* Kruger has a complexity, richness and diversity of socio-ecological systems and the promotion of conservation in all its complexities is fundamental to SANParks' core biodiversity conservation values[185]. These complexities are addressed through a strategic adaptive

[182] Resilient refers to ability to resist or recover from disturbance
[183] Lived-in regional landscape- large mixed land-uses that are compatible with elephant presence over 3 countries that make up the GLTFCA.
[184] Equitable acknowledges that not all stakeholders are equal, and that stakeholders directly impacted and affected by elephants should have access to more benefits
[185] Kruger National Park Management Plan 2018-2028. https://www.sanparks.org/assets/docs/conservation/park_man/knp/knp-approved-plan.pdf

management approach[186] within which the management of elephants in Kruger embeds.

4.12.2 Preferred population size[187]

The Kruger elephant population forms part of the regional elephant population roaming freely between South Africa, Mozambique, and Zimbabwe. Therefore, SANParks anticipate variable elephant density over time and between the three countries.

4.12.3 Public consultation[188]

SANParks interpret the Norms and Standards for Elephant Management as an outcome of extensive public participation embedded within the process for establishing a PMP. This took place in 2018[103]. As such consultation with regards to the Kruger EMP focused on immediately affected stakeholders, mostly local people, co-operative agreement partners and tourism service providers.

In addition, the Park engaged extensively with local people through meetings as part of establishing a National Elephant Strategy for South Africa, and the GLTFCA Elephant Management Framework. This provided specific opportunities for principally affected stakeholders to provide input into the management of elephants in the Kruger, and the Greater Kruger area.

4.12.4 Specifications for the release camp

The Kruger elephant population forms part of the regional elephant population roaming freely between South Africa, Mozambique, and Zimbabwe. Therefore, release camps are not required.

4.12.5 Control of elephant population size[189]

Due to the free roaming nature of the regional Kruger elephant population, SANParks focus on manipulating the spatial use of elephants rather than their numbers. Manipulation of spatial use of elephants focus on key areas of concern where elephants may influence conservation outcomes. A key aspect is identifying and defining the mechanisms of how elephants influence these areas. Interventions then focus on targeting the specific mechanism which involve disturbing and interrupting the mechanism e.g., closure of a bore hole. These activities do need to integrate with the GLTFCA Elephant Management Framework.

Removal of individual elephants within the park will be based on damage causing and problem animal principles.

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[186] Roux, D.J. and Foxcroft, L.C., 2011. The development and application of strategic adaptive management within South African National Parks. Koedoe: African Protected Area Conservation and Science, 53(2), pp.1-5.
[187] Number of elephants kept or to be introduced, and preferred population size to be maintained.
[188] participation reports, where there is contractual agreements between the management authority of a protected area and a private land owner(s).
[189] Interventions to manage elephant population size and elephant impact, and a culling plan if the management intervention involves culling.

4.12.6 Sex and age ratios[190]

SANParks does not explicitly manipulate age and sex ratios. These indicators are outcomes of vital rates such as births, natural deaths, and movements in and out of the Park.

4.12.7 Measures to prevent poaching.

4.12.7.1 Anti-poaching

Protecting elephants align strongly with the activities protecting rhinos in the Park[191]. This focuses on maintaining ecological integrity as well as the safety and security of sections within the Park through access control, particularly at entrance gates, and regular patrolling of boundary fences and section edges. A key element is staff integrity supported by integrity management system aimed at establishing a proud and responsible compliment of staff. Key elements include processes that enhance a feeling of co-decision making and ownership of elephants, while also dealing swiftly and independently with breaches of integrity by staff.

A second element focuses on situational awareness making use of various sources of information obtained through regular monitoring of sections and technology enablers such as ground-based radar, camera traps, vehicle number plate recognition systems, optimized ranger patrols, etc. Addressing potential poaching threats focuses on detecting and disrupting threats to elephants through detecting incursions using ranger patrols, specialized technology, and dedicated response procedures.

4.12.7.2 Investigations

Investigations focuses on syndicates and perpetrators involved in snaring, poisoning, and poaching. The key focus is to provide information that can help disrupt supply chains of illegal products that criminals focus on.

4.12.7.3 Poisoning and snaring

Rangers patrol sections on a regular basis. Upon encountering poisoning incidences, SANParks will implement the protocols for managing poisoning incidences.

When Rangers encounter snares, they will remove these and hand in to the relevant Section Ranger. In addition, SANParks will conduct regular de-snaring operations in hotspot snaring areas. Responses to reports of snared and injured elephants first and foremost inform the Operations Manager of Veterinary Wildlife Services. At the same time the relevant Section Ranger will assess the case and use the guidance from lethal management of wildlife standard operating procedures[192]. In the case of an opportunity to remove snares from an individual, the Operation Manager of Veterinary

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190 If and how sex and age ratios will be manipulated.
191 SANParks. 2022. Rhinoceros Conservation Strategy. 17/Pr-CSD/strat/Rhino Conservation (02-22) v1. Groenkloof, SANParks, South Africa.
192 SANParks. 2021. Standard Operating Procedure for the Lethal Management of Wildlife in South African National Parks Refer Reference Number: 17/PR-VWS/sop/lethal management (10/05) v1 (11/16) v2 (03/21) v3. Groenkloof, SANParks, South Africa.

Wildlife Services will deploy veterinary and aerial support in collaboration with the relevant Section Ranger.

4.12.7.4 Handling of ivory procedures

Elephant tusks and ivory pieces found and collected during patrols and management activities taking place throughout the Park needs to be transported to and handed in at the Wildlife Products Section for transfer to the High Value Store located in Skukuza for proper recordkeeping[193]. It is imperative to manage this ivory properly as per legislation in terms of marking the ivory with Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) numbers and reporting annually to the DFFE. Management also refers to the legal sale of ivory to South African citizens. SANParks ivory handling procedure makes provision for the safeguarding of ivory from the time of the animal mortality or discovery thereof until the sale of the products.

4.12.8 Provision for adequate insurance

Currently the Park infrastructure is adequately insured against animal damage. There is currently no liability insurance that covers when an animal leaves the park and causes damage outside, and the provincial nature conservation authorities are responsible for responding to DCAs. The park currently pays compensation for stock loss associated with large predators and is exploring the possibility of compensation for damages associated with elephants.

4.12.9 Contingency plans[194]

Response to damage causing (individuals causing damage outside the Park) and problem (individuals causing damage inside the Park) elephants abides by the Norms and Standards for the Management of Damage-Causing Animals in South Africa[195]. The SANParks Integrated Wildlife Management Policy guides the decision procedures applied to managing damage causing and problem elephants[196].

The procedure requires reporting of incidents of elephants that left the Park or cause damages within the Park. The relevant Section ranger will investigate and assess the case and conditions. If human life is immediately in danger, the individual elephants will be euthanized following the legal standards as specified in the National Norms and Standards for the Management of Elephants in South Africa[197]. If no human life is in danger, the response in collaboration with MTPA and LEDET focuses on potential options of moving elephants away from the area of damage or potential damage (often physical chasing through various means). If barriers impose on encouraging elephants to move themselves, an assessment in discussion with Kruger Conservation

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193 SANParks. 2017. Standard operation procedures for the management and safeguarding of ivory and rhino horn in SANParks. 16/Pr-Parks & KNP/pro/Ivory and rhino horn (08-17) Vs1. Groenkloof, SANParks, South Africa.
194 Contingency plans to deal with elephant problems
195 DFFE. 2016. Norms and Standards for the Management of Damage Causing Animals in South Africa. National Biodiversity Management: Biodiversity Act, 2004 (Act No. 10 of 2004). https://www.dffe.gov.za/sites/default/files/gazetted_notices/nemba10of2004_managementofdamagecausinganimalsinsa_gn40412_0.pdf
196 SANParks. 2020. Integrated Wildlife Management Policy. 17/P-CSD/pol/Wildlife Management v2 (09-20). Groenkloof, SANParks, South Africa. Section 5.8.
197 DEAT. 2008. National Norms and Standards for the Management of Elephants in South Africa. National Biodiversity Management: Biodiversity Act, 2004 (Act No. 10 of 2004). http://extwprlegs1.fao.org/docs/pdf/saf85897.pdf

Management, LEDET and MTPA advises on capture and translocation. Translocation should focus on taking elephants to areas in the Park that minimize subsequent transgressions by those elephants. habitual elephants, *i.e.*, those that transgressed more than three times, and who poses increasing threat to human life will be euthanized following the legal standards. If translocation is not feasible, then those elephants will be euthanized following the legal standards.

Treatment of carcasses is case specific and follow three guidelines. When outside the Park use of carcasses by local people fall under the jurisdiction of MTPA, LEDET and relevant Departments in Mozambique and Zimbabwe guided by national health and veterinary regulations. SANParks will support these departments on request for oversight and the safe use of elephant carcasses. Within the Park, SANParks will recover carcasses that are within reasonable distance from the Meat Processing Plant in Skukuza. Upon clearance by State Veterinarians, the carcasses will be processed for contribution to Sustainable Resource Use[198], and contribute to building constituency with local stakeholders[199]. When carcasses are beyond reasonable distance from the Meat Processing Plant, they will be left to natural decomposition in the field. In all cases, ivory will be collected following the ivory procedures.

Note that an incident is formally recorded in the DCA register of LEDET, MTPA or SANParks and an incident report is completed and forwarded to the other parties.

Contact Details: Veterinary Wildlife Services, Skukuza, 1350, Tel. 013 735 4110

4.12.10 Feeding[200]

SANParks adopted a systems-based approach and does not feed elephants. The food gradients in Kruger are sufficient for the needs of elephants.

4.12.11 Threat analysis and security plan

The purpose of this programme is to provide a safe and secure environment for both staff and visitors to the park while at the same time will ensure that the integrity of the natural and cultural resources of the area is maintained in a sustainable manner. The park is globally recognised as an iconic national park. Any compromise with regards to safety would receive negative international coverage. The risks to visitors to the area remains low but at the same time the risk to natural resources is real, due to the ever-growing pressures of society and organised crime syndicates on our natural heritage.

The rural, but rapidly urbanising communities near the park are increasing exponentially and pose an increasing threat to Park resources. All staff must be familiar with standard operating procedures related to safety and security. Formal training of staff who deals with all forms of illegal activity in the park has been elevated and receives high priority. The Safety and Security Plan comprehensively addresses

[198] SANParks. 2020. Integrated Wildlife Management Policy. 17/P-CSD/pol/Wildlife Management v2 (09-20). Groenkloof, SANParks, South Africa. Section 5.9.
[199] Section 10.7, Kruger National Park Management Plan 2018-2028. https://www.sanparks.org/assets/docs/conservation/park_man/knp/knp-approved-plan.pdf
[200] Feeding scheme in case of a natural food supply shortfall.

both the strategic and operational aspects of visitor safety and security. A detailed Strengths, weaknesses, opportunities, and threats (SWOT) analysis of issues affecting safety and security in the park has been developed and the resulting strengths, weaknesses, opportunities, and threats have been converted into achievable objectives and are reviewed regularly. Proactive consideration including those listed are discussed in some detail: working hours, law and order, high risk areas, personnel, infrastructure, resources, equipment, staff training, reporting, data capture, record keeping, monitoring, information, and intelligence. In addition to this several reactive considerations including immediate action drills, emergency procedures and evacuation plans have been developed.

4.12.12 The long-term population structure[201]

Elephants in Kruger have a close to natural age structure, as there is no selective removal and animals are not contracepted.

Section C: Information after approval for introductions of elephants[202]

4.13 Details of the elephants

4.13.1 The complete translocation history of each individual

(a) Origin of the elephants[203]

The elephant population of Kruger grew from natural colonization after going extinct locally. Re-colonization started in the early 1900s.

(b) The age of elephants and selection of elephants to be translocated[204]

Not applicable to Kruger.

4.13.2 Serial numbers of transponders (microchips) to be inserted where appropriate

Not applicable to Kruger.

4.13.3 The management of the capture, transport and keeping in boma[205]

Not applicable to Kruger.

5. Elephants in the legal context

The natural resources in South Africa are conserved and managed within the context of a comprehensive legal framework which is guided at a high level in accordance with the country's constitution. Within the overall framework of the Constitution, there are various sections of legislation which govern elephant management. Specific

201 Identification of the long-term population structure in view of the management objectives of the population.
202 Section C: Information to be provided after approval for the introduction of elephants, but before a permit may be issued
203 (e.g., location, habitat, fencing and size of reserve/farm)
204 (e.g., exposure to tourists, fences and boma).
205 (Including sedation) of elephants, as well as the name of the acting veterinary practitioner

management plans are compiled for individual elephant populations in line with the PMP. The purpose, strategic goals and actions of the elephant management plan is guided by the overarching legislation embedded in the National Environmental Management Act (NEMA) 107 of 1998 that provide for co-operative, environmental governance by establishing principles for decision-making on matters affecting the environment, institutions that will promote co-operative governance and procedures for co-ordinating environmental functions exercised by organs of state.

5.1 National Norms and Standards for the Management of Elephants in South Africa (GN 251/GG 30833/ 29 February 2008)

Of direct relevance are the National Norms and Standards for the Management of Elephants in South Africa which were developed in terms of section 9 of the National Environmental Management: Biodiversity Act, 2004 (Act No 10 of 2004) and came into effect on 1 May 2008. The Norms and Standards for the Management of Elephants in South Africa has been in review since 2018.

5.2 The National Environmental Management: Protected Areas Act, 2003 (Act No. 57 of 2003)

Of relevance is Section 39 of NEMPAA which deals with the preparation of management plans for protected areas. It specifically provides that a management plan for a protected area should at least contain a coordinated policy framework, planning measures, controls and performance criteria, a program for its implementation and its costing, procedures for public participation, and the implementation of community-based natural resource management as well as a zoning of the area indicating what activities may take place in different sections of the protected area as set out in Section 41(2) of NEMPAA.

5.3 The National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)

NEMBA came into operation on 01 September 2004 and provides for the management and conservation of South Africa's biodiversity within the framework of the National Environmental Management Act, 1998 (Act No.107 of 1998; NEMA). In 2013, amendments to the NEMBA were gazetted (Section 57 of Act No. 10 of 2004 and Section 35 of 2009; NEMBA). Section 43 of NEMBA provides that any person, organisation, or organ of state desiring to contribute to biodiversity management may submit to the Minister for his or her approval, a draft management plan for an indigenous species listed in section 56 of the NEMBA or an indigenous species not listed, but that warrant special conservation attention. The biodiversity management plan must be aimed at ensuring the long-term survival in nature of the species or ecosystem to which the plan relates, must indicate who will be responsible to implement this, and must be consistent with the NEMBA, all national environmental management principles, the national biodiversity framework, any applicable bioregional framework, any environmental implementation plans and management plans referred to in Chapter 3 of NEMA, any municipal integrated development plan, any other plans prepared in terms of national or provincial legislation that is affected and any relevant international agreement binding on the Republic of South Africa.

5.4 Threatened and Protected Species Regulations (GN 152/ GG 29657/ 23 February 2007)

The African elephant is listed as a Protected species in the list of Threatened or Protected Species (GN No R151/GG 29657/ 23 February 2007). In terms of section 56(1)(d) of NEMBA this means a species which is of such high conservation value or national importance that it requires national protection. The Threatened or Protected Species regulations (GN No R152/GG 29657/ 23 February 2007) restricts activities involving the African elephant and permits are required to carry out these activities.

5.5 Critically Endangered, Endangered, Vulnerable or Protected Species

Notwithstanding the provisions as indicated in section 45 of NEMBA, these requirements are also highly relevant to matters connected therewith in the publication of lists of critically endangered, endangered, vulnerable, and protected species (GN 151/GG 29657/ 23 February 2007) to avoid the management of elephants in isolation of South Africa's biodiversity that warrants national protection.

6. Implementation in support of elephant management objectives

6.1 Management Actions

The Park requires to implement various management activities, some of which support more than one strategic action and elephant management objectives (Fig. 4). Often, however, a key activity to support a specific strategic action carry risks and opportunities. Additional key activities are then required to mitigate those risks.

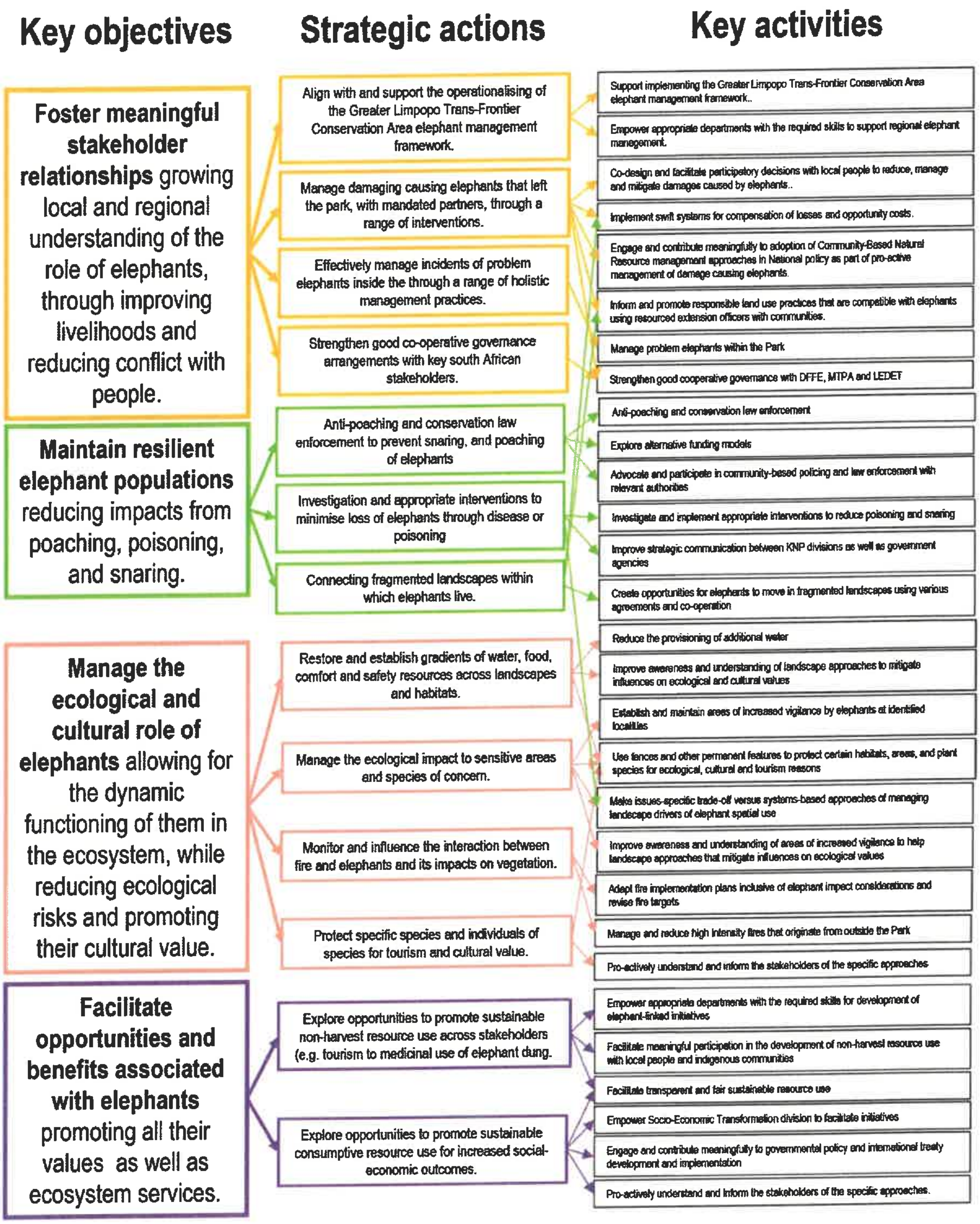

Figure 4. Elephant management objectives for Kruger National Park linked to strategic actions. Note that several key activities support achieving these objectives through supporting the achievement of strategic actions.

6.1.1 Achieving Objective 1

Foster meaningful stakeholder relationships: growing local and regional understanding of the role of elephants, through improving livelihoods and reducing conflict with people.

Recognises that elephants in Kruger roam far beyond the boundaries of the Park. It thus focuses firstly on aligning with and supporting the operationalising of the GLTFCA Elephant Management Framework. This should provide better relationships between the Park and regional stakeholders. The Park, however, have limited capacity to contribute to management issues in the broader region.

A key strategic action is to manage damaging causing elephants that leave the Park, with mandated partners, through a range of interventions. This should also result in better relationships between the Park and local communities, especially if there are potential for benefits to local communities from damage causing elephants by adopting a community-based natural resource management approach. Inefficient responses, however, will degrade relationships between the Park and local communities.

Elephants also cause damage inside the Park. A strategic focus is on effectively managing incidents of problem elephants inside the Park through a range of holistic management practices that reduces losses to infrastructure and mitigate threats to SANParks staff and visitors.

The final focus is on strengthening good co-operative governance arrangements with key south African stakeholders. This will provide substantive opportunities to influence responsive and transparent policies that can help build trust across a range of stakeholders.

No.	Strategic Actions	Responsible Division/Unit*	Reporting / Evaluation	Kruger Park Management Plan Reference
1.1	Align with and support the operationalising of the Greater Limpopo Trans-Frontier Conservation Area Elephant management framework.	CM	Quarterly Reports	Regional Integration
1.2	Manage damaging causing elephants that left the park, with mandated partners, through a range of interventions.	CM / C	Quarterly Reports	-
1.3	Effectively manage incidents of problem elephants inside the through a range of holistic management practices.	CM	Quarterly Reports	-
1.4	Strengthen good co-operative governance arrangements with key south African stakeholders.	CM	Annual Reports	-

CM – Conservation Management; C – Communications; RS Ranger Services; ECI – Environmental Crime Investigations

6.1.2 Achieving Objective 2

Maintain resilient elephant populations by reducing impacts from poaching, poisoning, and snaring.

Focus on a strategic action of anti-poaching and conservation law enforcement to prevent snaring and poaching of elephants. This will carry safety and security spin-offs for people and other species linked to regional safety and security. Financial constraints may limit efficiency, while interventions could break down relationships with local people.

A second strategic action focuses on investigations and appropriate interventions to minimise loss of elephants through disease or poisoning. A key spin-off is a general safer environment for people, their livestock, and other wild species. Diseases have not presented any population level impact in elephants; however continued surveillance of suspicious deaths is required to proactively detect any new cases of disease emergence or re-emergence.

A final strategic action focuses on connecting fragmented landscapes within which elephants live. Negative impact on species that are used by elephants may be minimised, but the landscape around the Park may experience increased incidences of human-elephant conflict.

No.	Strategic Actions	Responsible Division/Unit*	Reporting / Evaluation	Kruger Park Management Plan Reference
2.1	Anti-poaching and conservation law enforcement to prevent snaring, and poaching of elephants	RS	Quarterly Reports	-
2.2	Investigation and appropriate interventions to minimise loss of elephants through disease or poisoning	ECI / CM	Quarterly Reports	-
2.3	Connecting fragmented landscapes within which elephants live.	CM	Annual Reports	-

CM – Conservation Management; C – Communications; RS Ranger Services; ECI – Environmental Crime Investigations

6.1.3 Achieving Objective 3

Manage the ecological and cultural role of elephants by allowing their dynamic functioning in the ecosystem, while reducing ecological risks and promoting their cultural value.

Strategically focuses on restoring and establishing gradients of water, food, comfort and safety resources across landscapes and habitats. This will result in heterogenous distribution of and variable use of landscapes by elephants. In some instances, however, responses by elephants may amplify impacts in specific areas. Some public members may see interventions like the closure of water in a negative light.

A second strategic action focuses on managing the ecological impact to sensitive areas and species of concern. This should also lead to increased and maintained biodiversity and, in specific cases, the persistence of sensitive species. A challenge is that species focussed versus systems-based focussed approaches may generate unrealistic expectations from certain stakeholder groups. Particularly focal interventions may be seen in negative light by some members of the public.

The third strategic action recognizes that other factors influence the ecological role of elephants. It specifically focuses on monitoring and influencing the interaction between fire and elephants and its impacts on vegetation. This is intended to reduce the impact of fire on trees damaged by elephants. In addition, managing and reducing high intensity burns originating from outside the Park may also benefit other species (*e.g.*, poachers setting fires to attract animals to the boundary). A particular risk is that an intervention won't have the desired outcome, or have unintended consequences (*e.g.*, increased encroachment) due to other drivers, such as climate change, that are not in the control of the Park.

The final strategic action seeks to protect specific species and individuals of species for tourism and cultural value, that could lead to better outcomes for sensitive and culturally important species or individuals of species. Again, species focus versus systems-based focus may generate unrealistic expectations, as well as not all stakeholders finding certain interventions acceptable.

No.	Strategic Actions	Responsible Division/Unit*	Reporting / Evaluation	Kruger Park Management Plan Reference
3.1	Restore and establish gradients of water, food, comfort and safety resources across landscapes and habitats.	RS	Quarterly Reports	-
3.2	Manage the ecological impact to sensitive areas and species of concern.	RS	Research Progress Report	-
3.3	Monitor and influence the interaction between fire and elephants and its impacts on vegetation.	RS / CM	Research Progress Report	-
3.4	Protect specific species and individuals of species for tourism and cultural value.	RS / CM	Research Progress Report	-

CM – Conservation Management; C – Communications; RS Ranger Services; ECI – Environmental Crime Investigations

6.1.4 Achieving Objective 4

Facilitate opportunities and benefits associated with elephants by promoting all their values as well as the ecosystem services they provide. 5.1.4 Facilitate opportunities and benefits associated with elephants.

Focus on exploring opportunities to promote sustainable non-harvest resource use across stakeholders (*e.g.*, tourism to medicinal use of elephant dung). This could promote constituency of elephants across a broad suite of stakeholders, with interventions finding acceptability across wider suite of stakeholders. The Park, however, has limited capacity, while some activities (e.g., dung collection) may create unrealistic expectations.

The last action focuses on exploring opportunities to promote sustainable consumptive resource use for increased social-economic outcomes. This could increase the appreciation of all values of elephants to local communities with associated increased tolerance to the presence of elephants in the broader landscape. Critical risks include conflicting policies and international treaties, apart from poor organisational capacity and lack of resources. Interventions may not be acceptable to every stakeholder.

No.	Strategic Actions	Responsible Division/Unit*	Reporting / Evaluation	Kruger Park Management Plan Reference
4.1	Explore opportunities to promote sustainable non-harvest resource use across stakeholders (e.g., tourism to medicinal use of elephant dung.	CM	Quarterly Reports	-
4.2	Explore opportunities to promote sustainable consumptive resource use for increased social-economic outcomes.	CM / C	Quarterly Reports	-

CM – Conservation Management; C – Communications; RS Ranger Services; ECI – Environmental Crime Investigations

6.2 Regional integrated elephant management

Regional integration of elephant management is embedded in the GLTFCA, Contractual and Co-operative conservation arrangements programme of the Kruger PMP[206]. Specific focus is on supporting the implementation of the GLTFCA Elephant Management Framework[207]. This includes: support to identify and formally establish wildlife corridors that enable the movement of elephants between protected and conservation areas; empowering communities to make decisions about access to and the use of natural resources, including elephants; develop and implement consistent measures and approaches to offset and mitigate the impacts of human-elephant conflict; improve communication and cooperation to effectively combat illegal wildlife trade and undertake law enforcement; and contribute to coordinated monitoring and research related to elephant conservation and management. SANParks is a member of the GLTFCA Elephant Management Task team coordinating and facilitating implementation.

At a local scale within South Africa, elephant management embeds in the integrated land use and regional planning and management programme[208]. This focuses on various aspects including conservation management support; HWC management; fire management; research; eco-tourism promotion; and support to the wildlife economy.

6.3 Damage causing and problem elephants

Response to damage causing (individuals causing damage outside the Park) and problem (individuals causing damage inside the Park) elephants abides by the Norms

[206] Section 10.2.2, Kruger National Park Management Plan 2018-2028. https://www.sanparks.org/assets/docs/conservation/park_man/knp/knp-approved-plan.pdf
[207] GLTFCA, 2022. Greater Limpopo Transfrontier Conservation Area Elephant Management Framework. USAID, WWF, GIZ. Available from marisa.coetzee@sanparks.org
[208] Section 10.2.1, Kruger National Park Management Plan 2018-2028. https://www.sanparks.org/assets/docs/conservation/park_man/knp/knp-approved-plan.pdf

and Standards for the Management of Damage-Causing Animals in South Africa[209]. The SANParks Integrated Wildlife Management Policy guides the decision procedures applied to managing damage causing and problem elephants[210].

The procedure requires reporting of incidents of elephants that left the Park or cause damages within the Park. The relevant Section ranger will investigate and assess the case and conditions. If human life is immediately in danger, the individual elephants will be euthanized following the legal standards as specified in the National Norms and Standards for the Management of Elephants in South Africa[211]. If no human life is in danger, the response in collaboration with MTPA and LEDET focuses on potential options of moving elephants away from the area of damage or potential damage (often physical chasing through various means). If barriers impose on encouraging elephants to move themselves, an assessment in discussion with Kruger Conservation Management, LEDET and MTPA advises on capture and translocation. Translocation should focus on taking elephants to areas in the Park that minimize subsequent transgressions by those elephants. habitual elephants, *i.e.*, those that transgressed more than three times, and who poses increasing threat to human life will be euthanized following the legal standards. If translocation is not feasible, then those elephants will be euthanized following the legal standards.

Treatment of carcasses is case specific and follow three guidelines. When outside the Park use of carcasses by local people fall under the jurisdiction of MTPA, LEDET and relevant Departments in Mozambique and Zimbabwe guided by national health and veterinary regulations. SANParks will support these departments on request for oversight and the safe use of elephant carcasses. Within the Park, SANParks will recover carcasses that are within reasonable distance from the Meat Processing Plant in Skukuza. Upon clearance by State Veterinarians, the carcasses will be processed for contribution to Sustainable Resource Use[212], and contribute to building constituency with local stakeholders[213]. When carcasses are beyond reasonable distance from the Meat Processing Plant, they will be left to natural decomposition in the field. In all cases, ivory will be collected following the ivory procedures (10.5.4 Handling of Ivory Procedures).

Note that an incident is formally recorded in the DCA register of LEDET, MTPA or SANParks and an incident report is completed and forwarded to the other parties.

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209 DFFE. 2016. Norms and Standards for the Management of Damage Causing Animals in South Africa. National Biodiversity Management: Biodiversity Act, 2004 (Act No. 10 of 2004). https://www.dffe.gov.za/sites/default/files/gazetted_notices/nemba10of2004_managementofdamagecausinganimalsinsa_gn40412_0.pdf

210 SANParks. 2020. Integrated Wildlife Management Policy. 17/P-CSD/pol/Wildlife Management v2 (09-20). Groenkloof, SANParks, South Africa. Section 5.8.

211 DEAT. 2008. National Norms and Standards for the Management of Elephants in South Africa. National Biodiversity Management: Biodiversity Act, 2004 (Act No. 10 of 2004). http://extwprlegs1.fao.org/docs/pdf/saf85897.pdf

212 SANParks. 2020. Integrated Wildlife Management Policy. 17/P-CSD/pol/Wildlife Management v2 (09-20). Groenkloof, SANParks, South Africa. Section 5.9.

213 Section 10.7, Kruger National Park Management Plan 2018-2028. https://www.sanparks.org/assets/docs/conservation/park_man/knp/knp-approved-plan.pdf

6.4 Engaging with People

Engaging with people seek to enhance the way local communities can cope with challenges as well as benefit from opportunities linked to elephants. This embeds within the Stakeholder Engagement Programme of the Park[214].

6.4.1 Mitigating elephant conflict

Mitigating human-elephant conflict focuses on two aspects – the first is building trusting relationships though having focal discussions on how to respond to elephants. This focuses on co-decisions on activities and approaches in how to deal with elephants that do leave the Park and potentially could cause damage.

A second key element is sharing best practices in responsible land-use to help reduce potential for human elephant conflict. Information will focus on a range of tools[215] including night guarding, noise deterrents, fire deterrents, buffer zones, bio-fences, chilly-smoke, chilly-fences, trenches, trip-alarms, beehive fences, solar electric fences, and intelligent farms. An additional focus is also on guiding people on elephant behaviour and the best ways to respond when encountering an elephant, whether on foot or in a vehicle.

6.4.2 Mitigating elephant damage

Mitigating elephant damage once it has taken place focuses on acknowledging the loss of property. SANParks do not yet have a monetary compensation scheme for damages caused by elephants to property but will participate in the development of a National Policy as part of pro-active management of wildlife conflict including elephants. Even so, a key element is to regularly engage with local people acknowledging the losses caused by elephants. A key aspect is to use such incidences to collectively discuss improvements and responses that can prevent future losses.

When elephants caused the loss of a human life, SANParks in collaboration with LEDET and MTPA, will engage with the relevant family and find agreed ways to support the family's grief process. In addition, a specific case will be referred to SANParks Legal Services.

6.4.3 Community safety and security

A key element integrating with the Stakeholder Engagement Programme of the Park is collective discussions with local communities on safety and security. Although this is a broader context, SANParks will facilitate discussions inclusive of criminal activities regarding elephants between law enforcement agencies, SANParks and local

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[214] Section 10.8.2, Kruger National Park Management Plan 2018-2028. https://www.sanparks.org/assets/docs/conservation/park_man/knp/knp-approved-plan.pdf
[215] King, L., Oldenburg, C. & Cookson, L. 2018. Twelve tools to live in harmony with elephants. https://elephantsandbees.com/wp-content/uploads/2019/07/King-2018-HEC-Toolbox.pdf

communities. This seeks to develop a common understanding of factors threatening community safety and security that could impact on elephants. Importantly it seeks to co-develop responses and programmes through participatory approaches with local people that can enhance trust as well as community safety and security.

6.4.4 Awareness

Engaging with people on ecological management is a key function of the Park. Information on elephants will integrate in the existing engagement programmes.

6.5 Elephant protection

6.5.1 Anti-poaching

Protecting elephants align strongly with the activities protecting rhinos in the Park[216]. This focuses on maintaining ecological integrity as well as the safety and security of sections within the Park through access control, particularly at entrance gates, and regular patrolling of boundary fences and section edges. A key element is staff integrity supported by integrity management system aimed at establishing a proud and responsible compliment of staff. Key elements include processes that enhance a feeling of co-decision making and ownership of elephants, while also dealing swiftly and independently with breaches of integrity by staff.

A second element focuses on situational awareness making use of various sources of information obtained through regular monitoring of sections and technology enablers such as ground-based radar, camera traps, vehicle number plate recognition systems, optimized ranger patrols, etc. Addressing potential poaching threats focuses on detecting and disrupting threats to elephants through detecting incursions using ranger patrols, specialized technology, and dedicated response procedures.

6.5.2 Investigations

Investigations focuses on syndicates and perpetrators involved in snaring, poisoning, and poaching. The key focus is to provide information that can help disrupt supply chains of illegal products that criminals focus on.

6.5.3 Poisoning and snaring

Rangers patrol sections on a regular basis. Upon encountering poisoning incidences, SANParks will implement the protocols for managing poisoning incidences.

When Rangers encounter snares, they will remove these and hand in to the relevant Section Ranger. In addition, SANParks will conduct regular de-snaring operations in hotspot snaring areas. Responses to reports of snared and injured elephants first and foremost inform the Operations Manager of Veterinary Wildlife Services. At the same

[216] SANParks. 2022. Rhinoceros Conservation Strategy. 17/Pr-CSD/strat/Rhino Conservation (02-22) v1. Groenkloof, SANParks, South Africa.

time the relevant Section Ranger will assess the case and use the guidance from lethal management of wildlife standard operating procedures[217]. In the case of an opportunity to remove snares from an individual, the Operation Manager of Veterinary Wildlife Services will deploy veterinary and aerial support in collaboration with the relevant Section Ranger.

6.5.4 Handling of ivory procedures

Elephant tusks and ivory pieces found and collected during patrols and management activities taking place throughout the Park needs to be transported to and handed in at the Wildlife Products Section for transfer to the High Value Store located in Skukuza for proper recordkeeping[218]. It is imperative to manage this ivory properly as per legislation in terms of marking the ivory with CITES numbers and reporting annually to the DFFE. Management also refers to the legal sale of ivory to South African citizens. SANParks ivory handling procedure makes provision for the safeguarding of ivory from the time of the animal mortality or discovery thereof until the sale of the products.

6.6 Ecological management

Ecological management embeds within the Integrated Wildlife Management Policy of SANParks[219].

6.6.1 Manipulating spatial use of elephants

Influencing spatial use of elephants will focus on continuing with the management of additional artificial water-points in the landscape, and in particular the continued removal and rehabilitation of earthen dams. An additional element is focusing on integration with regional initiatives and the maintenance of elephant movement corridors, especially removal of fences if these provide constraints to free movement of elephants.

6.6.2 Elephant impact areas

A key aspect is focusing on elephant impacts at local scales across numerous localities in the Park (Figures 5-7). These focus on several reasons of concern including ecological aspects (poaching hotspots, vegetation associated with perennial rivers, vegetation associated with seasonal rivers, vegetation associated with fire impacts, and other vegetation concerns that are site specific).

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[217] SANParks. 2021. Standard Operating Procedure for the Lethal Management of Wildlife in South African National Parks Refer Reference Number: 17/PR-VWS/sop/lethal management (10/05) v1 (11/16) v2 (03/21) v3. Groenkloof, SANParks, South Africa.
[218] SANParks. 2017. Standard operation procedures for the management and safeguarding of ivory and rhino horn in SANParks. 16/Pr-Parks & KNP/pro/Ivory and rhino horn (08-17) Vs1. Groenkloof, SANParks, South Africa.
[219] SANParks. 2020. Integrated Wildlife Management Policy. 17/P-CSD/pol/Wildlife Management v2 (09-20). Groenkloof, SANParks, South Africa.

Elephant Impact Areas - 2019 Update

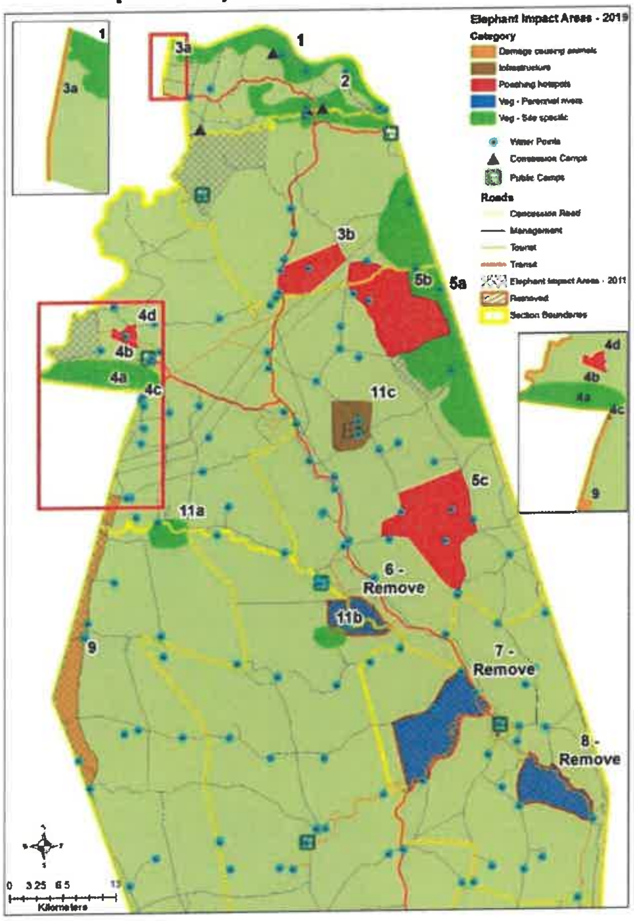

Figure 5. Key Elephant Impact Areas in the northern parts of Kruger National Park.

Elephant Impact Areas - 2019 November Update

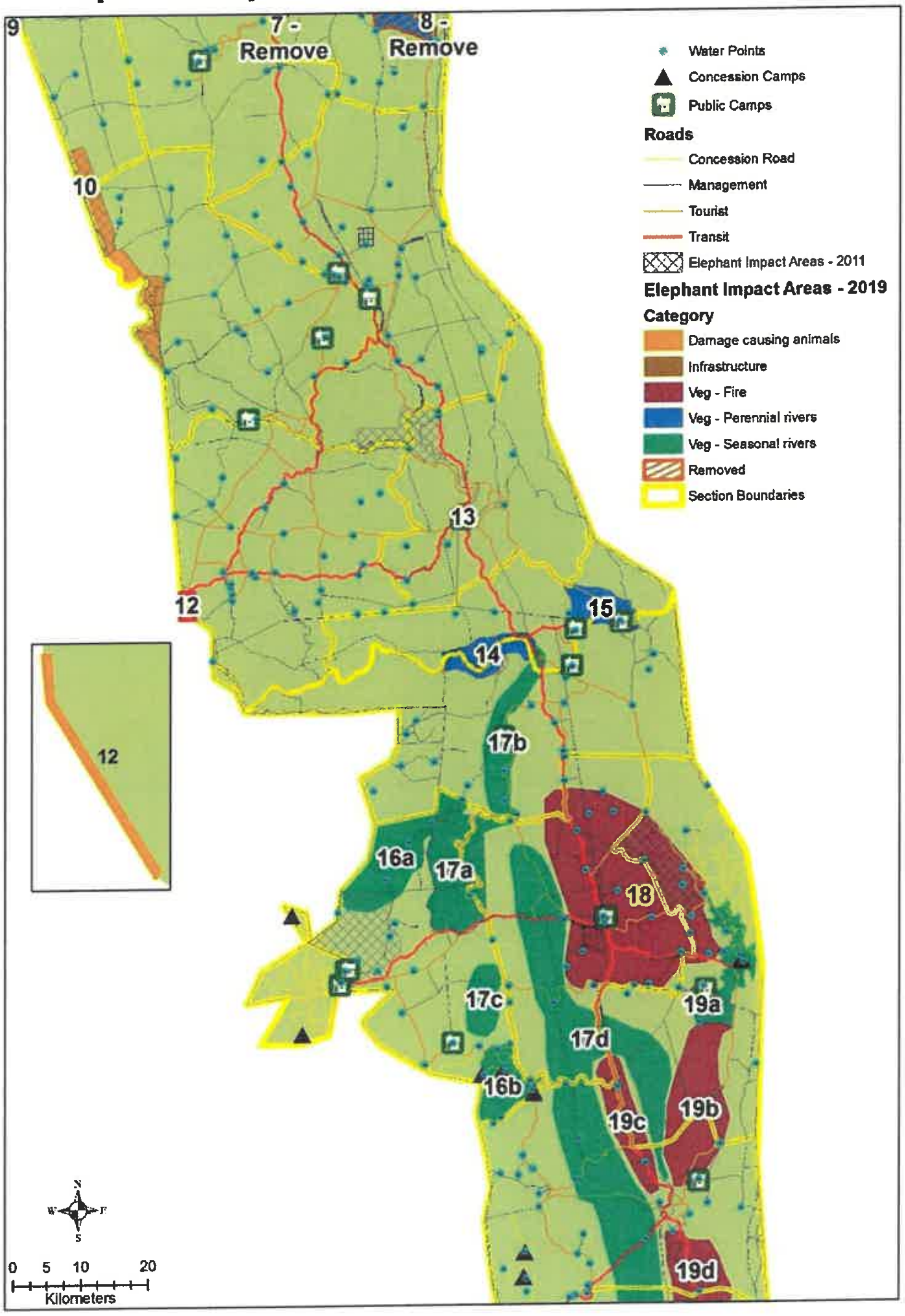

Figure 6. Key Elephant Impact Areas in the central parts of Kruger National Park.

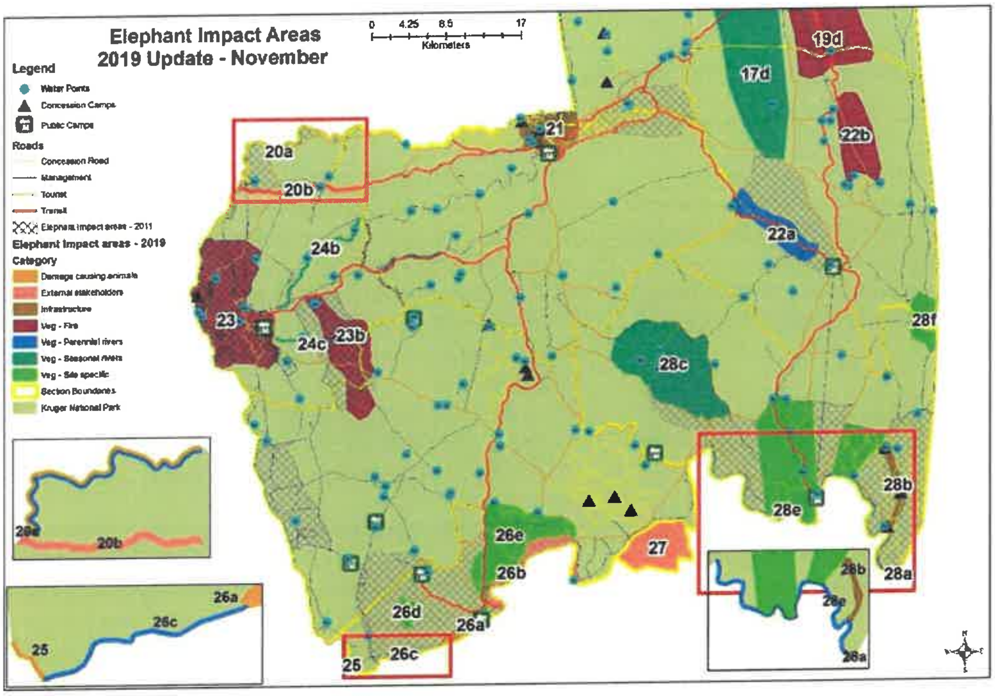

Figure 7. Key Elephant Impact Areas in the southern parts of Kruger National Park.

The mechanisms that lead to a specific concern linked to an elephant impact area provides key insight for the consideration of the type of intervention needed (Table 5). This helps to inform interventions that could take place over the short- to medium-term, experimental disturbance of elephant at very localised scales, and where no intervention is envisioned. No intervention for an area is mostly the result of it being a low priority in terms of elephants as often vegetation dynamics in an area are driven by factors other than elephants, such as flooding and/or low logistical feasibility (4d, 5a, 6, 7, 8, 14, 15, 20a, 22b, 23, 24, 26c, 26d, 26e, 28 c, 28d, 28e, 28f). Management interventions vary from opening of alternative water to the lethal removal of small bull herds that leave the park repeatedly and cause damage to crops and stakeholder relationships (4a, 4b, 4c, 28a, 28f). Several small-scale experiments of disturbance to create less intense use by elephants are also proposed (1, 7, 11a, 13, 17d, 18, 19c, 19b, 22b and 26b). Although areas are often of large extent, interventions can only happen at localised scales due to logistics.

Interventions associate with measuring the intensity of use of these areas using seasonal elephant dung surveys, together with annual aerial surveys. In addition, the state and change in ecological features measures indicators of producers (herbaceous vegetation and trees), consumers (use by large herbivores, small mammal, and bird communities) and decomposers (dung beetles) to help link elephant intensity of use to changes in biodiversity features. This can help to inform and revise approaches targeting the management of elephant influences within EIAs. EIAs and proposed interventions will change as more knowledge is gained from managing the elephant impact at local scales.

Table 5. Concerns linked to elephants and summaries of the underlying mechanisms giving rise to the concern.

Type of concern	Mechanism giving rise to concern
1. Changes in vegetation in areas of specific concern (e.g., Ramsar sites, listed vegetation types, threatened vegetation)	Flooding regimes have changed. Anthropogenic influence missing (landscape of high vigilance no longer present). Water closure and hunting elsewhere may affect elephant distribution.
2. Changes in vegetation, generally along perennial rivers and flooding important	Flooding regime driven. Anthropogenic influence missing (landscape of high vigilance no longer present). Floods may remove trees and low recruitment as a result of elephants and other herbivores.
3. Changes in vegetation, generally away from large rivers but close to seasonal rivers	These are areas that have plenty of natural water and is mostly situated on good soils. People may have been present historically and illegal and legal hunting in region may drive also drive distribution patterns.
4. Changes in vegetation, interaction between elephants and fire important	High intensity fires and other fire effects exacerbate effects of elephants
5. Damage causing animals	Elephants either break through fences or moving through badly maintained fences to utilise resources outside of the park, in some instances elephants are lured by purposeful placement of fruit, etc.
6. Infrastructure concerns	Elephants repeatedly break infrastructure, e.g., break fences to gain access to tourist camps or break decks at concessions.
7. Pressure from external stakeholders	Stakeholders feel that their nature experience is being compromised by elephants
8. Poaching hotspots	Usually, villages where poachers reside not too far away, in some cases, poachers may be trying to find rhino and if not successful, poach elephants opportunistically.

6.6.3 Removal of elephants

In cases where interventions require the removal of elephants through translocation SANParks take guidance from the existing SANParks Standard Operating Procedures (SOP) for the Capture, Transportation and Maintenance in Holding Facilities of Wildlife[220]. For cases that require culling, SANParks apply the guidance within the Elephant Management Norms and Standards and will submit a separate culling plan when required.

6.6.4 Fire interactions with elephants

Consideration of elephant effects link strongly with the Fire Management Lower-Level Plan of Kruger[221].

[220] SANParks 2017. SANParks Standard Operating Procedures (SOP) for the Capture, Transportation and Maintenance in Holding Facilities of Wildlife.
[221] Kruger National Park Management Plan 2018-2028. https://www.sanparks.org/assets/docs/conservation/park_man/knp/knp-approved-plan.pdf

6.6.5 Veterinary considerations

Veterinary considerations (including the planning, drug administration, handling of the immobilized animals, management of disease effects) are carried out according to the SANParks SOP for the Capture, Transportation and Maintenance in Holding Facilities of Wildlife[222]. These guide the operations policy of Veterinary Wildlife Services and is approved by the SANParks Animal Use and Care Committee (AUCC).

6.7 Socio-economic development

Elephant contributions to various aspects in the region will integrate with the Socio-Economic Development Programme of the Park[223].

7. Monitoring and Reporting

SANParks will report within the reporting requirements on implementation of Kruger PMP. The focus is on 16 performance indicators (see Section 6.1). In addition, for integrated evaluation of implementation and learning, an annual reflective report will be compiled that serves to guide the subsequent year's implementation planning. This will reflect on relevant elephant management actions undertaken and/or reasons for not undertaking certain actions. The report is anticipated to be compiled through a reflective science-management forum / engagement.

Monitoring focuses on population surveys at optimized intervals. A key element is evaluating the intensity with which elephants used key areas of concern making used of dung counts. SANParks will link measures of biodiversity to these measures of intensity of use by elephants and use this to inform adaptive responses.

8. Management plan review

The Norms and Standards for Elephant Management in South Africa are currently under review (October 2022). Once gazetted, SANParks will ensure alignment of this elephant management plan with any changed prescripts. The Norms and Standards Regulations released by the Minister of Fisheries, Forest and the Environment require an EMP for each Park to be prepared by an elephant ecologist. This EMP has been developed as a collaborative effort inclusive of reflections on the lessons learnt from the previous plan. Furthermore, the EMP will be appropriately reviewed in conjunction with the revision of the Kruger PMP.

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222 SANParks 2017. SANParks Standard Operating Procedures (SOP) for the Capture, Transportation and Maintenance in Holding Facilities of Wildlife.
223 Kruger National Park Management Plan 2018-2028. https://www.sanparks.org/assets/docs/conservation/park_man/knp/knp-approved-plan.pdf

Appendix A – Additional information

Land Declarations

Government Notice 210 in Government Gazette 9532 of 21 December 1984 declared the following portions of land to be part of Kruger in terms of the National Parks Act (Act No. 57 of 1976):

1. Portion 2 (a portion of Portion 1) of the farm Toulon 383 KU, Province of Transvaal, 9.9993 ha in extent, described in SG A4827/82.

Government Notice 482 in Government Gazette 15540 of 11 March 1994 declared the following portions of land to be part of Kruger in terms of the National Parks Act (Act No. 57 of 1976):

1. Remaining Extent of the farm Kempiana 90, in extent 3 960,5422 hectares;

2. the farm Lillydale 89, in extent 3 919,6874 hectares;

3. the Remaining Extent of the farm Morgenzon 199, in extent 2 114,3169 hectares;

4. the farm Springvalley 200, in extent 3 838,1499 hectares; and

5. Remaining Extent of Portion 1 of the farm Valkgezicht 75, in extent 863,8188 hectares,

Government Notice 458 in Government Gazette 19927 of 16 April 1999 declared the following portions of land from Kruger in terms of the National Parks Act (Act No. 57 of 1976):

1. The land described by the figure "aBCDEFGHJKLm middle of the Limpopo River n middle of the Luvuvhu River p middle of the Mutale River a" and referred to as "the farm Makuleke No. 6-MU" in Diagram SG No. 10710/1998 in extent 22 733,6360 hectares, situated in the Pafuri area Soutpansberg District, Northern Province. [Definition of Kruger National Park substituted by s. 2 of Act 60/79 and amended by Proc. 210/84, GN 703/89 and GN 458/99]

Land excluded

Government Notice 12 in Government Gazette 7988 of 15 January 1982 excluded the following portions of land from Kruger in terms of the National Parks Act (Act No. 57 of 1976):

1. A portion of the farm Kingfishers Spruit 93 KU, Province of Transvaal, 0.0450 ha in extent,

described in diagram 430/1898 (DB237/13). Government Notice 703 in Government Gazette 11822 of 14 April 1989 excluded the following portions of land from the KNP in terms of the National Parks Act (Act No. 57 of 1976):

2. "Remainder of the farm Sigambule 216, Registration Division JU, in extent 547,0131 ha;

3. Portion 1 of the farm Sigambule 216, Registration Division JU, in extent 468,6482 ha;

4. farm Matsulu 543, Registration Division JU, in extent 1 155,6013 ha;

5. farm Makawusi 215, Registration Division JU, in extent 1 067,1731 ha."

Government Notice 458 in Government Gazette 19927 of 16 April 1999 excluded the following portions of land from Kruger in terms of the National Parks Act (Act No. 57 of 1976):

1. The land described by the figure *"aABCQq* middle of the Limpopo River *n* middle of the Luvuvbu River *p* middle of the Mutale River *a"* in extent about 19 176 hectares, situated in the Pafuri area, Soutpansberg District, Northern Province.

Consequences of interventions

In Kruger as a whole, during the years of culling managers had observed growth rate during the onset of culling era (from 1967 to 1974) of 0.65% (0.59% to 0.70%). At that time elephant density was 0.41±0.03 n.km^{-2}, managers culled 10.2±5.1% of the population each year, there were no fences, 96 to 207 boreholes provided additional water, a prescribed burning approach and the Park experienced 534±11 mm (510 mm to 605 mm) annual rainfall.

In the period of ongoing culling (1975 to 1984), elephant numbers increased on average by 1.51% per annum (-2.54% to 5.55%), but the park still maintained an average density of 0.41±0.03 n.km^{-2}. Managers culled 7.1±5.0% and translocated 0.4±0.4% of the population annually. The Park was partially fenced, had 236 to 272 active boreholes and applied prescribed burning. The annual rainfall was 516±12 mm (358 mm to 591 mm).

The last decade of culling (1985 to 1994) had elephant numbers changing each year on average at 1.23% (-2.16% to 4.62%). During this period elephant density was 0.39±0.03 n.km^{-2}. Managers culled a smaller fraction of the population (3.5%±0.9%) but live removed more (1.7±0.9%) of the population each year. The Park was completely fenced, had 272 to 306 boreholes, and used a prescribed burning programme changed to one that mimicked natural fires. It was, however, a dry period with an average of 398±13 mm (144 mm to 478 mm) annual rainfall.

The decade after culling stopped (1995 to 2004) recorded elephant numbers increasing at 4.04% (-0.39 to 8.47) with average annual density of 0.50±0.07 n.km^{-2}. A very small fraction of the population was culled as damage causing and problem elephants (0.1±0.2%) and few were translocated out of the Park (0.4±0.4%). Authorities dropped some fences and closed several boreholes (141 to 294 boreholes were active) while mimicking natural fire regimes. The park had average annual rainfall of 538±10 mm (430 mm to 597 mm).

The historic distribution data does not allow evaluation of how variable distribution was at a specific locality. If there was no variability, elephants were consistently at the same place from year to year when managers kept elephant numbers low. Variability in density at different scales shows significant declines at the 1 km^2, 5 km^2 and 25 km^2 scale with increase in elephant numbers, but not so at the 100 km^2 and 400 km^2 scale between 1998 and 2004. This means that elephants respond to landscape features differently at different scales. Part of these spatial patterns noted from the distribution recorded in the dry season relate to food availability, but vegetation productivity, a measure of food availability explained on average only 14% of the dry season distribution of elephants between 1998 and 2004[224]. The unexplained variation may be associated with other factors such a water distribution or selection for riparian areas for reasons other than food resources such as seeking shade.

Patterns in elephant densities along different rivers provide some insight into spatial responses by elephants to management[225]. Rivers in Kruger can be perennial, seasonal, intermediate seasonal and small streams. Several places are relatively far from rivers. Change in densities within 2 km of these types of rivers from an era of intensive management (*i.e.,* culling and water provision prior to 1994) to an era of reduced management (*i.e.* no culling and reduced water provision after 1998) varied between the eight major catchments in Kruger. Densities increased dramatically along the Crocodile River but declined along the Olifants River. More importantly, variance in densities from year to year increased when management intensity reduced. This suggests that spatial responses to management may alter spatial and temporal variation in the intensity with which elephants use landscapes in Kruger.

Comparison of Kruger with other places in Africa provides further insight to spatial responses of elephants. Seasonal home ranges for individual elephants extracted from radio collared animals during the intensive management eras overlapped significantly more than anywhere else once the effect of rainfall and density has been accounted for. Intensive management (*i.e.*, culling and water provisioning) may thus have increased the intensity with which an individual elephant uses a specific patch in a landscape. Such changes in the intensity of use may drive how elephants affect other conservation values.

The movements of elephants realized strongly during the most recent drought of 2015 and 2016[226]. In normal years, seasonal movements result in elephants often spending time on different properties (*e.g.*, Sabi Sand Game Reserve and the Park[227]) with behavioural shifts typically switched on by key environmental cues such as local and regional rainfall patterns[228]. During the drought of 2015 to 2016, elephants made net movements from the private reserves west of the Park with high levels of additional

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224 Young, K.D., Ferreira, S.M. and van Aarde, R.J., 2009. The influence of increasing population size and vegetation productivity on elephant distribution in the Kruger National Park. *Austral Ecology*, *34*(3), pp.329-342.

225 Smit, I.P. and Ferreira, S.M., 2010. Management intervention affects river-bound spatial dynamics of elephants. *Biological Conservation*, *143*(9), pp.2172-2181.

226 Swemmer, A.M., Bond, W.J., Donaldson, J., Hempson, G.P., Malherbe, J. and Smit, I.P., 2018. The ecology of drought-a workshop report. *South African Journal of Science*, *114*(9-10), pp.1-3.

227 Thomas, B., Holland, J.D. and Minot, E.O., 2012. Seasonal home ranges of elephants (Loxodonta africana) and their movements between Sabi Sand Reserve and Kruger National Park. *African Journal of Ecology*, *50*(2), pp.131-139.

228 Birkett, P.J., Vanak, A.T., Muggeo, V.M., Ferreira, S.M. and Slotow, R., 2012. Animal perception of seasonal thresholds: changes in elephant movement in relation to rainfall patterns. *PloS one*, *7*(6), p.e38363.

water availability into Kruger with far less additional water. This was in response to better food availability[229]. The elephants thus respond to their environment resulting in habitat use being scale dependent. Forage characteristics drive habitat selection at coarse spatial scales, and surface water at fine spatial scales[230]. This has important implications because of mismatches between the scale at which elephants influence conservation values (*e.g.*, a patch of trees favoured by elephants), the landscape that an elephant use (*e.g.*, a region dominated by mopani trees) and management interventions (*e.g.*, reducing total population size)[231].

In addition, bulls and cows respond differently to resources in the landscape. For instance, wet season home ranges for both sexes linked to intermediate greenness overall. During the dry season, males tended to be in areas of intermediate greenness, and females in areas of intermediate and high greenness[232]. Elephants interact strongly with fires even as bull and cow groups segregated less when densities increased recently. Bulls concentrate in areas receiving lower rainfall but more frequent fires – cows preferred areas with higher rainfall experiencing less frequent fires. Both concentrate closer to major rivers in the dry season[233].

Landscapes thus play a key role in dictating elephant responses. It will also play a role in dictating the influences of elephants on various conservation values. For instance, treefall rates were higher in areas accessible to elephants, but proportionally more treefall occurred on high-nutrient basalts and in lowland catena areas[234]. Elephants and fire, however, interact although elephant density was up to two times more influential than fire frequency in determining treefall rates[235]. At the same time, elephants suppress woody encroachment in areas that experiences low rainfall[236].

Elephant social factors also contribute to sex differences in land use[237], while the presence of people in the landscape influenced movements stronger in the wet season when elephants avoided people. In the dry season elephants use scarce resources closer to people but do so mostly at night with bulls doing it more often[238]. It is likely that expanded movements of elephants across the GLTFCA[239] could lead to increases in human-elephant interactions. Even so, the Park has a history of colonization by elephants[240], and this continues.

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229 Smit, I.P., Peel, M.J., Ferreira, S.M., Greaver, C. and Pienaar, D.J., 2020. Megaherbivore response to droughts under different management regimes: lessons from a large African savanna. *African Journal of Range & Forage Science*, *37*(1), pp.65-80.
230 De Knegt, H.J., Van Langevelde, F., Skidmore, A.K., Delsink, A., Slotow, R., Henley, S., Bucini, G., De Boer, W.F., Coughenour, M.B., Grant, C.C. and Heitkönig, I.M., 2011. The spatial scaling of habitat selection by African elephants. *Journal of Animal Ecology*, *80*(1), pp.270-281.
231 See Delsink, A., Vanak, A.T., Ferreira, S. and Slotow, R., 2013. Biologically relevant scales in large mammal management policies. Biological Conservation, 167, pp.116-126.
232 Marshal, J.P., Rajah, A., Parrini, F., Henley, M., Henley, S.R. and Erasmus, B.F., 2011. Scale-dependent selection of greenness by African elephants in the Kruger-private reserve transboundary region, South Africa. *European Journal of Wildlife Research*, *57*(3), pp.537-548.
233 MacFadyen, S., Hui, C., Verburg, P.H. and Van Teeffelen, A.J., 2019. Spatiotemporal distribution dynamics of elephants in response to density, rainfall, rivers and fire in Kruger National Park, South Africa. *Diversity and Distributions*, *25*(6), pp.880-894.
234 Asner, G.P. and Levick, S.R., 2012. Landscape-scale effects of herbivores on treefall in African savannas. *Ecology letters*, *15*(11), pp.1211-1217.
235 Asner, G.P., Vaughn, N., Smit, I.P. and Levick, S., 2016. Ecosystem-scale effects of megafauna in African savannas. *Ecography*, *39*(2), pp.240-252.
236 Stevens, N., Erasmus, B.F.N., Archibald, S. and Bond, W.J., 2016. Woody encroachment over 70 years in South African savannahs: overgrazing, global change or extinction aftershock?. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *371*(1703), p.20150437.
237 Du Plessis, K., Ganswindt, S.B., Bertschinger, H., Crossey, B., Henley, M.D., Ramahlo, M. and Ganswindt, A., 2021. Social and Seasonal Factors Contribute to Shifts in Male African Elephant (Loxodonta africana) Foraging and Activity Patterns in Kruger National Park, South Africa. Animals, 11(11), p.3070.
238 Cook, R.M., Parrini, F. and Henley, M.D., 2015. Elephant movement patterns in relation to human inhabitants in and around the Great Limpopo Transfrontier Park. *Koedoe: African Protected Area Conservation and Science*, *57*(1), pp.1-7.
239 Huang, R.M., van Aarde, R.J., Pimm, S.L., Chase, M.J. and Leggett, K., 2022. Mapping potential connections between Southern Africa's elephant populations. PloS one, 17(10), p.e0275791.
240 De Flamingh, A., Roca, A.L. and Van Aarde, R.J., 2018. Origin and phylogeography of African savannah elephants (Loxodonta africana) in Kruger and nearby parks in southern Africa. *Conservation genetics*, *19*(1), pp.155-167.

Table Appendix 1.1. Vegetation types as found in Mucina and Rutherford (2006) with descriptions and correlation with Gertenbach landscapes.

Vegetation types	Cover within KNP	Geology and soils	Landscape	Vegetation	Gertenbach landscapes
SVmp 2 Limpopo Ridge Bushveld	2.2	Steep basalt slopes and shallow calcareous soils, rich in lime concretions	Irregular plains with ridges and hills	*Kirkia acuminata* on some ridges and *Adansonia digitata* on shallow calcareous gravel	25, 26
SVmp3 Cathedral mopane bushveld	1.5	Sandstone and shale of the Karoo Supergroup, soils often deep with high Na	Flat to concave landscape	High moderately closed tree savanna dominated by *Colophospermum mopane* 10-15 m tall	15
SVmp4 Mopane Basalt Shrubland	14.8	Basalts of the Letaba Formation, soils deep with high clay content	Plains and slightly undulating plains	Medium to low shrubs dominated by 1-2 m *Colophospermum mopane*	22, 23
SVmp5 Tsende Mopaneveld	17.4	Letaba Basalts of the Karoo Supergroup, quartz-feldspar rocks of the Goudplaats Gneiss Basement	Slightly undulating plains	Medium to high shrubby savanna dominated by *Colophospermum mopane* but *Combretum apiculatum* increasing on less clayey soils	9, 11, 12, 27
SVmp6 Lowveld Rugged Mopaneveld	5.6	Gneiss with some ultramafic metavolcanic rocks (e.g. amphibole, serpentine, etc)	Slightly to extremely irregular plains with sometimes steep slopes and prominent hills	Dense shrubs, occasional trees and sparse ground cover	10, 7
SVmp7 Phalaborwa-Timbavati Mopaneveld	4.5	Quartz-veldspar of the Makhutwsi Gneiss with some granite; sandy soils on the uplands and clayey soils in the bottom lands	Undulating plains	Open tree savanna on the uplands dominated by *Combretum apiculatum, Terminalia sericea* and *Colophospermum mopane*, *Combretum apiculatum* decreasing on more clayey soils and *Acacia nigrescens* becoming more common	6,8
SVmp8 Mopane Gabbro Shrubland	1.6	Gneiss intruded by dykes of gabbro; soils dark with relatively high clay content	Slightly irregular to slightly undulating landscape with numerous outcrops of gabbro	Mainly a low shrub layer with two structural variations; shrubveld with very little trees and shrubveld with few larger trees	24
SVl1 Makuleke Sandy Bushveld	3.5	Sandstone of the Waterberg system with diabase sills and dykes intruded, Cave sandstone forms prominent hills (koppies); deep sands to shallow sandy lithosols	Variable landscapes from low mountains, slightly to extremely irregular plains to hills (koppies)	Tree savanna on deep sand and moderately to dense ground cover; different on stony ground where *Kirkia acuminata, Croton gratissimus*, *Combretum apiculatum* and *Diplorhyncus condylocarpon* can be found	34, 16, 33
SVl2 Nwambiya-Pumbe Sandy bushveld	0.1	Cretaceous Malvernia Formation conglomerate with overlying sandstone and quaternary sands; soils deep sands and some shallow lithosols	Flats with several pans	Moderately open tall scrubland with few trees; *Xeroderris stuhlmannii, Xylia torreana and Hugonia orientalis* important taxa	32, 30
SVl3 Granite Lowveld	16.8	Archain gneiss and granite; sandy soils in uplands and clayey soils with high Na in lowlands	Unique catenal pattern	Tall shrubland with few trees to moderately dense low woodland on deep sandy soils (uplands), dense thicket to open savanna on lowlands with dense herbaceous layer, *Terminalia sericea* and	5,4,3

				Eragrostis gummiflua on seeplines (midslope)	
SVl4 Delagoa Lowveld	2.6	Karoo Supergroup shale and sandstone with sheets and dykes of dolerite; soils rich in Na and prone to erosion	Terrain concave, low lying and quite flat with slight slopes	Dense tree or tall shrub layer dominated by *Acacia welwitschia*	13
SVl5 Tshokwane-Hlane Basalt Lowveld	11.8	Letaba Formation basalts; black, brown or red clayey soils, vertisols in low-lying areas	Usually flat plains	Open tree savanna, often dominated by *Sclerocarya birrea* and *Acacia nigrescens*, moderately dense shrub layer and dense herbaceous layer	17,18,21,20,14
SVl6 Gabbro Grassy Bushveld	3.8	Intrusions of gabbro; dark vertic clay soils that swell and shrink	Flats and hills	Open savanna with dense grass cover with few trees	19
SVl10 Pretoriuskop Sour Bushveld	2.0	Granite and gneiss; shallow, leached red to yellow-brown sandy to sandy-loam soils	Mainly uplands	Open tree savanna dominated by *Terminalia sericea* and *Dichrostachys cinerea* with few shrubs and dense tall grass layer dominated by sour thatch grasses	1
SVl11 Malelane Mountain Bushveld	2.4	Granite and gneiss; shallow, coarse, sandy lithosols	Hills with large boulders	Open savanna on mountains and higher-lying slopes, with open to dense short mountain bushveld on rocky outcrops and lower lying areas	2
SVl15 Northern Lebombo Bushveld	7.0	Rhyolite and basalt of the Lebombo Group as well as dykes of granophyre; stony shallow lithosols with some deeper soils	Ridges and frequent rocky outcrops	Open bushveld dominated by Combretaceae and many tree succulents	29,31
AZi11 Subtropical Salt Pans	0.02	Pans on Cenozoic alluvium, sand and calcrete, water recedes during drier periods and salt precipitates on banks	Shallow depressions, often on old alluvial terraces of rivers	Bank reeds, low herb-lands or macrophytic floating vegetation in perennial pans	
AZa7 Subtropical Alluvial Vegetation	1.3	Recent alluvial deposits with deep fine-structured sandy to loamy soils and often waterlogged	Flat alluvial riverine terraces	Macrophytic vegetation, marginal reedbeds, flooded grasslands, ephemeral herb-lands and riverine thickets	
FOa1 Lowveld Riverine Forest	0.2	Recent alluvial deposits with deep, fine-textured soils	Riverine vegetation subjected to flooding	Tall forests fringing larger rivers and water pans, trees include *Acacia robusta* subsp. *clavigera*, *Breonadia salicina*, *Diospyros mespiliformis*, *Faidherbia albida*, *Ficus sycomorus*, etc.	
FOz8 Sand forest	0.1	Dull brown/red-brown, deep arenosols, and dystric regosols (soils contain very little clay and are acidic)	Flats	Dense thickets (5-6 m) and poorly developed ground layer; *Baphia massaiensis*, *Cleistanthus schlecteri* and *Guibourtia conjugata* most conspicuous trees in Nwambiya, well developed shrub layer with *Eragrostis moggii* in ground layer	
FOz9 Ironwood dry forest	0.2	Soutpansberg Group sandstone and quartzite, Lebombo Group Rhyolites and Cretaceous Malvernia Formation sandstones; red-brown to brown-red sand to sandy-loam soil	Moderate to steep mountain slopes	Dense forest (thicket) dominated by *Androstachys johnsonii*, *Croton pseudopulchellus* in understorey	

Appendix B. Records of stakeholder engagements at various scales

1. Stakeholder engagement process for the revisions of the Kruger National Park Management Plan.

Executive summary[241]

In compliance with National Environmental Management: Protected Areas Act (Act No. 57 of 2003) (NEMPAA), SANParks has initiated a process to revise the Kruger PMP. The management plan was formulated over a period of 12 months following extensive consultation through 54 public and focus group meetings with the public and with interested groups. The management plan will guide the Park's strategic direction and operations in relation to broader regional land use for the next ten years. The management plan has been aligned with national and international legislation and agreements. The plan furthermore seeks alignment with the National Development Plan and the Ministerial Delivery Outcomes.

A total of 3,465 stakeholders participated in the desired state meeting (2017), which provided the strategic direction for Kruger for the next 10 years. A total of 2,297 stakeholders attended the second round of public meetings (2018), during which the draft management plan was presented. 483 inputs were received during the meetings and in written format. Issues raised by the public during development of the plan include, but are not limited to, job creation, business partnerships, opportunities to participate in the wildlife economy and tourism, better communication and feedback, the state of basic services, crime and its impact, damage-causing animals, increased community access to the Park, increased environmental education and awareness programmes, opportunities for inclusion, partnerships with Mozambique and Zimbabwe, concerns about the impact of commercial developments on wilderness areas, and clarification on resource use.

The Kruger PMP will be guided by eight high-level objectives and operationalised through 30 implementation plans. The plan will focus on various programmes such as regional integration with other sectors and land uses, socio-economic development such as the Land Claimant and Wildlife Economy Programmes, Tourism, Cultural Heritage, Stakeholder Engagement, Wilderness, and Effective Park Management. The latter will focus on financial sustainability, safety and security, HWC management, human capital management and research programmes. The Park recognises that a holistic approach is required to ensure strategic alignment, sustainability and transformation of the conservation sector, in line with the SANParks Vision: "A sustainable National Park System connecting society". Implementation will therefore require a multi-institutional and sectoral approach that engenders co-operation and collaboration with a range of sectors, communities and strategic partners within the

241 Full report available at www.sanparks.org/assets/docs/conservation/park_man/knp/knp-stakeholder-report.pdf

fields of environmental management, rural development and livelihoods, food security and land reform, local government and human settlements, safety and security, education and health, spatial planning and infrastructure development.

2. Stakeholder engagement for the Greater Limpopo Transfrontier Conservation Area elephant management framework

Approach[242]

The GLTFCA Elephant Management Framework has been developed through a collaborative approach that has engaged the expertise that exists within the GLTFCA landscape. This commenced with the development of a GLTFCA Wildlife Translocation Policy and a situational analysis in which various aspects of elephant biology and their conservation and management were considered. The intention of this was to provide a comprehensive overview of elephants within the GLTFCA considering issues related to legislation and policy, ecology, social and economic dynamics and the philosophies and approaches to elephant management within the GLTFCA. This included a stakeholder mapping exercise that informed a stakeholder engagement strategy which was developed prior to stakeholder engagement being undertaken. Stakeholder engagement covered a range of topics that included:

National elephant management approaches.

Values linked to elephant conservation and management.

Landscape and biodiversity issues.

Elephant management tools.

Socio-economic benefits.

Human-wildlife conflict.

Illegal wildlife trade and law enforcement capacity.

Monitoring and research.

These topics and the discussions and issues that emerged from the stakeholder engagement process have informed the elephant management framework that has been developed.

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242 Details are available in the Great Limpopo Transfrontier Conservation Area Elephant Management Framework - Stakeholder Engagement Report. Available from Conservation Outcomes

3. Stakeholder engagement for the national elephant heritage strategy relevant to Kruger

Executive Summary[243]

This engagement session was held after the GEF 6 feedback session that was held in the morning. The purpose of this engagement session was to discuss elephant management in South Africa, with community representatives from areas adjacent to the Kruger. The need for this engagement was precipitated by three elephant-management related projects that required community inputs for their processes. The national elephant management strategy aims to develop a strategy that includes community voices in driving decisions about how elephants are managed in South Africa. The GLTFCA elephant management framework aims to have engaged with community representatives as part of their stakeholder engagement process. And the GEF 7 funded HWC project aims to get inputs from people living with DCAs in the landscape with regards to HWC mitigation measures. Broad outcomes from the engagement included the need to recognise community voices throughout various stages in the development of these various management plans and enable opportunities for input at various levels throughout their development. It was highlighted that people need to benefit in diverse ways from the existence of elephants and that the strategies being proposed to enable those processes through devolving decision making. Further engagement for the national elephant management strategy will include both national and regional People and parks forums as well as lower-level engagement through community forums and representing various additional interest groups, with the P and P forum being consulted and involved throughout.

[243] Detailed report available from Louise Swemmer, louise.swemmer@sanparks.org