CONSERVATION GENETICS SPECIALIST GROUP

CONSERVATION PLANNING SPECIALIST GROUP

Mabula Ground Hornbill Project

Southern Ground-Hornbill

Population and Habitat Viability Assessment Workshop

21 – 24 August, Mabula, South Africa

FINAL REPORT

Workshop organised by: Mabula Ground Hornbill Project, IUCN Conservation Planning Specialist Group (CPSG), IUCN Conservation Genetics Specialist Group (CGSG)

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List of Acronyms

APNR	Associated Private Nature Reserves
APP	African Preservation Programme
AZA	Association of Zoos and Aquariums
BLSA	BirdLife South Africa
BMP	Biodiversity Management Plan
BMP-S	Biodiversity Management Plan for Species
BOPP	Birds of Prey Programme (associated with the Endangered Wildlife Trust)
BUFS	Bird Unfriendly Structures
CITES	Convention on International Trade in Endangered Species
CGSG	Conservation Genetics Specialist Group
CNCZ	Children and Nature Conservation Zimbabwe
CPSG	Conservation Planning Specialist Group
CVTF	Cape Vulture Task Force
DEA	Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
DEDEA	Department of Economic Development, Environmental Affairs
EAZA	European Association of Zoos and Aquaria
EKZNW	Ezemvelo KwaZulu-Natal Wildlife
EN	Endangered
EWT	Endangered Wildlife Trust
GDARD	Gauteng Department of Agriculture and Rural Development
IKS	Indigenous Knowledge Systems
IUCN	International Union for the Conservation of Nature
KNP	Kruger National Park
KZN	KwaZulu-Natal
LEDET	Limpopo Department of Economic Development, Environment and Tourism
MCDA	Multi Criteria Decision Analysis
MGHP	Mabula Ground Hornbill Project
MoU	Memorandum of Understanding
MSc	Master of Science
MTPA	Mpumalanga Tourism and Parks Agency
NEMA	National Environmental Management Act
NEMBA	National Environmental Management: Biodiversity Act
NGO	Non-Governmental Organisations
NPA	National Prosecuting Authority
NZG	National Zoological Gardens
PAAZA	Pan-African Association of Zoos and Aquariums
PhD	Doctorate of Philosophy
PHVA	Population and Habitat Viability Analysis
PT	Project Thunderbird
RSA	Republic of South Africa
SA	South Africa
SABAP	South African Bird Atlas Project
SANBI	South African National Biodiversity Institute

SAPS	South African Police Service
SSC	Species Survival Commission
SGH	Southern Ground-Hornbill
SOP	Standard Operating Procedures
ToPs	Threatened or Protected Species
UCT-FIAO	FitzPatrick Institute of African Ornithology, University of Cape Town
UKZN	University of Kwazulu-Natal
UP	University of Pretoria
VU	Vulnerable
Wits	University of Witwatersrand
WLTP	Women and Leadership Training Programme

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SECTION 1: EXECUTIVE SUMMARY

Executive summary

Only one of the nine African savanna hornbill species, the Southern Ground-Hornbill (*Bucorvus leadbeateri*: hereafter SGH) is listed as being of conservation concern (Taylor & Kemp, 2015), and is known across its range as the *rain bird* or *thunder bird* by indigenous people who share its habitat. The species is one of just two species in the genus *Bucorvus*.

The species is an apex predator and thus ecologically important, as well as holding immense cultural value to the majority of language groups across its range. It is a typical K-selected species, but is cooperatively breeding with massive spatial requirements. Consequently, the life-history traits, social structures and behaviours of the SGH interest both scientists (Kemp & Kemp, 1980, 2007; Kemp, 1988; Chiweshe, 2007) and followers of traditional lore (Bruyns, Williams, & Cunningham, 2013; H. C. Coetzee & Wilkinson, 2007; Msimanga, 2000; Muiruri & Maunda, 2010), coincidentally, are the same traits that make them ill-suited for survival under the growing ecological pressures of the Anthropocene (Crutzen, 2006).

The objective of the PHVA workshop was to review the knowledge-base for the species to ensure that conservation planning is sound and evidence-based, so as to maximise conservation resources in terms of strategic capacity, funding and effort.

This was the second Population and Habitat Viability Assessment (PHVA) workshop for the SGH, following an initial PHVA in 2005. It was hoped that sufficient representation could be present from other range-states, but only Zimbabwe was represented. Despite this, all efforts were made to ensure that this second PHVA is as relevant as possible across the full range of the species, supported by the considerable additional knowledge now available for the species.

Workshop process

An initial two-day intensive technical workshop was held to ensure that the VORTEX model was performing as optimally as current parameterisation would allow, prior to stakeholder engagement and ensuring that key data requirements and issues of conservation concern had been identified. This included an overview of both the outcomes of the 2005 workshop, and the subsequent Single Species Recovery Plan (Jordan *et al.*, 2011), and what new progress has been made, especially in data acquisition and generation of new knowledge. Participants worked in four groups, focusing on human-hornbill interactions, both positive and negative; 2) on land-use types and their impact on the species; 3) on captive breeding and reintroduction; and 4) on the ecology of the species. A small modelling group interacted with each of these groups and modified their modelling accordingly.

Thereafter, a two-day stakeholder engagement session was held, built around a number of presentations of recent research outcomes for SGH on conservation biology, molecular ecology, use of artificial nests as a conservation tool, the potential for population monitoring techniques and research into habitat requirements and demography. Workshop participants then, through discussion in plenary, formatted a collective vision for the future of this *Thunderbird*, which led to consensus on the following vision statement:

VISION: To stabilize and then reverse the decline of the Southern Ground-Hornbill (Bucorvus leadbeateri), with the aim to achieve its conservation down-listing within South Africa, and to support other range-state conservation efforts.

Finally, participants (as worked in three groups) addressed the following themes identified during plenary: 1) what should the conservation targets be and how can we meet them (*Conservation Status Working Group*); 2) what are the major issues beyond the borders of South Africa (*Range-state Working Group*) and how can range-states support each other's conservation efforts; and 3) how to address each of the threats identified for the South African population (*Risk Assessment Working Group*).

The participants began the process of expanding each topic into causal chains, considering additional factors and conditions that precipitate each threat and the impacts, real and potential of each threat on the SGH. The groups periodically reconvened in plenary to present their analyses and recommendations for discussion and consensus. The workshop concluded with a plenary discussion to identify priority actions for conservation.

This is the first conservation planning document that fully acknowledges the role that cultural protection has played for the species and that prioritises re-establishing this protection in areas where support has been lost as communities drift away from traditional belief structures, and supports it in areas where it is still extant.

Summary recommendations

The Conservation Status Working Group recommended a series of actions for **consistent data collection** to ensure that **evidence** would ultimately be available for **down-listing** of the species (via the IUCN Red Listing criteria), and to ensure that progress towards this goal could be tracked. With the proposed elevation of the species' conservation action to the national level via a Biodiversity Management Plan, several additional Standard Operating Procedures need to be developed for each of the existing conservation activities.

The Range-wide Working Group recognised the need for **increased research and conservation** intervention across the range. It was proposed that a network of **SGH champions** be established and supported. To this end a **Conservation Tool Kit** could help other range-states to reduce the lengthy learning period that the South African conservation efforts have required and would **implement tested actions** immediately. **Data** collection would also be **standardised** and centralised to allow for regional meta-analyses.

The Risk Assessment Working Group found that the species' **conservation profile needs to be elevated** nationally to enhance support from the South African government. At present, the coalition of SGH conservationists (the SGH Action Group) comprises mostly NGOs and academics, with few governmental stakeholders helping to drive the conservation agenda. It was also felt important to **increase the scope of the group** to incorporate an oversight body that will **streamline implementation**

of the PHVA's recommendations. The group also has weak representation in some areas, such as the Eastern Cape, and so local champions must be sought and supported.

Immediate conservation priorities for South Africa

1. Elevate the conservation profile of the SGH at the national level by ensuring that a **Biodiversity Management Plan** (BMP) for the species is compiled in conjunction with the Department of Environmental Affairs. This will combine valid actions from the previous Single Species Recovery Plan with the current PHVA, leading to a final state-of-the-art conservation plan for the species.
2. Establish Project Thunderbird as a more formal grouping of SGH stakeholders than the current Action Group to ensure swift action on PHVA recommendations.
3. Roll-out the **monitoring plan** already established for EKZNW across the country to all relevant provincial authorities.
4. Establish a **national poison forum** with other stakeholders to address wildlife poisoning beyond those focussed on ground-hornbills.
5. Establish a **national anti-lead ammunition forum** with other stakeholders to address lead toxicosis beyond those focussed on ground-hornbills.
6. Characterise and expand **cultural protection** as it is currently manifested in South Africa.

Priorities for other range-states

1. **Range-state champions/partners** should be identified for each range-state.
2. The participants of this PHVA should collate a **Conservation Tool Kit** for other range-states to use as a basis for ensuring the species can be monitored and protected by summarising all the currently available knowledge, including both positive and negative results.
3. A **meta-analysis** should assess where cultural protection holds and where it is not applicable across the range-wide population.

The stochastic population modelling showed clearly that the species' most important threats are anthropogenic in nature, and that if poisoning is not addressed (, both from agrochemicals and lead-based ammunition, the species will disappear from areas where poisoning occurs. Under this scenario, protected areas, including large national parks and reserves, and non-protected areas where cultural protection remains strong, are expected to be the only SGH refugia that will persist with minimal conservation intervention.

This PHVA report and the recommendations it contains are considered as advisory to provincial and national conservation-management authorities, and their collaborators, to help guide strategic actions thought to be beneficial to the long-term survival of the SGH, both within South Africa and beyond its borders.

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SECTION 2: SUMMARY ACTION PLAN

Summary Conservation Actions

This is a tabulated summary of the actions determined by each of the technical working groups. Major actions that were identified in the initial technical workshop, and still considered vital after the stakeholder workshop, are presented in the stakeholder outcomes (See Section 6 for full discussions and actions). The remaining actions suggested in the technical workshop (See Appendix 1 for full discussions and outcomes) are still presented after the stakeholder outcomes.

STAKEHOLDER WORKSHOP SUMMARY ACTIONS

WORKING GROUP 1: CONSERVATION STATUS AND THREAT AMELIORATION

Table 2.1. Actions presented by Working Group 1
(Action highlighted in green priorities for more than one group).

	Action	Implementing agencies	Timeframe
1.	Activate multi-province monitoring plan, including extended assessment of genetic diversity within and between populations.	Provincial nature conservation authorities, MGHP, all field workers, NZG.	EKZNW by end 2017, activated in other provinces during 2018, genetic analyses ongoing, sufficient data already collected for national 'heat' map.
2.	Ensure a Biodiversity Management Plan (BMP) is prepared with all necessary stakeholders.	DEA, NZG/SANBI (as host), MGHP, input from all stakeholders,	A date for the BMP workshop will be determined before the end of 2017.
3.	SOP and national plan for harvest, rearing, reintroduction and artificial nests, with targets and defined activities.	IUCN Reintroduction Specialist Group, MGHP.	By end 2018.
4.	Education focused at core-area custodianship, buffer zones and all demographic layers of the population (e.g. from community leaders down to school pupils).	All – a core function of Project Thunderbird.	Ongoing.
5.	Recognition of the power of cultural protection: Refine a locally specific cultural context, and expand coverage of indigenous traditional knowledge systems.	MGHP, Wits, CNZC, Zulu Royal Houses.	Begin immediately.

WORKING GROUP 2: BEYOND SOUTH AFRICA'S BORDERS

Table 2.2. Actions presented by Working Group 2.

	Action	Implementing agencies	Timeframe
1.	Create a range-wide network of SGH champions.	MGHP.	By mid-2018.
2.	Produce a Conservation Toolkit for supporting range-wide assessments.	PT.	By end-2018.

WORKING GROUP 3: RISK ASSESSMENT ACROSS LAND USE TYPES

Table 2.3. Actions presented by Working Group 3.

	Action	Implementing agencies	Timeframe
1.	Develop a Multi-Criteria Decision Analysis (MCDA) of threats with a threat map.	BirdLife South Africa, MGHP, Project Thunderbird, EWT, industry (game farming, cattle farming, timber, SAPS, NPA, PT.	By mid-2018.
2.	Establish "*Project Thunderbird*" as a more formal grouping of SGH stakeholders than the current Action Group.	MGHP, with support from any interested individuals and agencies.	Fully established by the end of 2017.
3.	Prepare a Biodiversity Management Plan (BMP) for SGH.	DEA, NZG/SANBI (as host), MGHP, input from all stakeholders.	A date for the BMP workshop will be determined before the end of 2017.
4.	Identify and support South African SGH champions.	All PT.	Ongoing.

ADDITIONAL OUTCOMES FROM THE TECHNICAL WORKSHOP

The following additional actions were determined by the Technical Working Group as important to be investigated further. For more details on objectives and actions see the relevant sections in Appendix 1.

WORKING GROUP 1: Human and Ground-Hornbill Interactions

Table 2.4. Actions presented by Working Group 1

	Action	Implementing agencies	Timeframe
1.	Research into Indigenous Knowledge Systems (IKS).	MGHP, Wits, WLTP, CNCZ.	Ongoing.
2.	Identify sustainable funding-mechanisms.	Project Thunderbird members.	By mid-2018.

WORKING GROUP 2: POPULATION VIABILITY ACROSS LAND-USE TYPES

Table 2.5. Actions presented by Working Group 2

1.	Spatial planning required for outputs from the Baobab hand-rearing facility.	MGHP, FIAO, UCT, MTPA.	By mid-2018.
2.	Research into limiting factors in varied land-use categories.	UKZN, MGHP, FIAO.	By mid-2021.
3.	Produce management and land-use guidelines for habitats where ground-hornbills still persist outside of protected areas.	MGHP, with input from all Project Thunderbird.	By mid-2018.

WORKING GROUP 3: CAPTIVE BREEDING, REARING AND REINTRODUCTION

Table 2.6. Actions presented by Working Group 3

1.	Self-sustaining captive population that retains 90% of South African genetic diversity with respect to the founder population, by adding two new breeding pairs to the global stock every two years from 2017.	All APP members (plus potentially involving EAZA, AZA and perhaps the Australian zoo community).	Ongoing.
2.	Reintroduction into RSA of three groups annually from the stock of 15 high quality chicks-reared at the Baobab.	MGHP.	Annually.

WORKING GROUP 4: ECOLOGY

Table 2.7. Actions presented by Working Group 4

1.	Increase long-term data collection in non-protected areas.	Provincial wildlife authorities, and DEA, circulating through to MGHP for data management and reporting.	Ongoing with 4-year cycle reporting. EKZNW-MGHP initiated 2018.
2.	Molecular studies to assess genetic diversity and fitness at different spatial scales, and to gain new insights into age at first breeding, diet.	NZG, UCT-FIAO, collection by all Project Thunderbird, University of Cardiff, Isotope laboratory – UP, UP-Onderstepoort.	2019.
3.	Safeguard and modify existing natural nesting sites.	UCT-FIAO, EWT-BBoPP, MGHP.	2019.
4.	Develop safe and successful methods to attach satellite or GPRS transmitters.	UCT-FIAO, EWT-BBoPP, MGHP.	By mid-2018.
5.	Investigate pathogens that may impact Ground-Hornbill health.	EWT-BBoPP, MGHP, NZG, UP-Onderstepoort.	By mid-2019.
6.	Collecting additional biological information.	UCT-FIAO, EWT-BBoPP, MGHP, PAAZA.	By mid-2020.

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SECTION 3: INTRODUCTION AND BACKGROUND

INTRODUCTION AND BACKGROUND

Since the first PHVA held in 2005, much research has been conducted on the SGH, including four PhD's and seven MSc studies completed on the species, and many insights gained through broader studies (2 PhDs) and the reintroduction and captive breeding programmes. This has contributed greatly to the knowledge base, and it was considered prudent to incorporate these data into a revised PHVA model to assess if current conservation planning is still relevant and evidence-based, so ensuring that strategic conservation resources are applied to ensure the persistence of the species.

The species is now formally listed by IUCN Red List criteria as Vulnerable continentally, Endangered in both South Africa and Namibia, and populations are in decline in most other range states. Locally, it is also listed as a Threatened or Protected Species, and thus accorded national protection; yet populations are still declining.

The SGH has several significant life history characteristics, each independently increasing its vulnerability to extinction: it is a diurnal, long-lived, large, conspicuous, apex avian predator, with large spatial needs that result in low densities and therefore small population size per unit area (Kemp, 1995). These features, together with cooperative breeding and other complex social structures, combine to produce naturally slow rates of reproduction and recruitment (Purvis *et al.*, 2000). Added to this, the species faces a number of anthropogenic threats (BirdLife International, 2014), each growing in scale as human development expands across sub-equatorial Africa.

As a consequence, population declines of SGH have already been reported for Kenya (BirdLife International, 2014), Malawi (Kalimira, 2007), Mozambique (Parker, 1999, 2005), Zambia (BirdLife International, 2014), Zimbabwe (Chiweshe, 2007; Maasdorp, 2007; Witteveen *et al.*, 2013), Botswana, and Swaziland (Parker, 1994), with declines best enumerated and most significant for South Africa (Kemp & Webster, 2008; Underhill, 2014; Taylor & Kemp, 2015) and Namibia (Simmons, Brown, & Kemper, 2015). The IUCN Red List status of SGH is Vulnerable (BirdLife International, 2014) but in the south of the range, the species is regionally listed as Endangered (Simmons, Brown & Kemper, 2015; Taylor & Kemp, 2015).

An analysis of the conservation status for all range-states (Kemp, 2017) found populations in Kenya to also be Endangered, and in smaller range-states where the species is only persisting in small conservation areas it is Critically Endangered (Rwanda, Burundi, Swaziland, Malawi), while populations are widely reported to be declining in Angola, southern Democratic Republic of Congo and northern Mozambique, areas which are largely data deficient other than for some aerial census data for national parks.

Considering the decline in many areas, it must be assumed that conservation efforts, such as currently underway in South Africa (Theron, Turner & de Waal, 2007) and Zimbabwe (Witteveen *et al.*, 2013), will be required on an increasing scale across the entire sub-equatorial range. In South Africa, conservation efforts started in earnest in the late 1990's, when it first became apparent that the species was in serious decline (Theron, Turner & de Waal, 2007). By this stage, basic population parameters and biology were known, except for a long-term study in a large protected area, the Kruger National Park (KNP; Kemp & Kemp, 1980; Kemp, 1988, 1995a; Kemp, Joubert & Kemp, 1989; Kemp & Begg, 1996, 2001). Based largely on these data, models of the population dynamics of the species for

South Africa showed that without conservation intervention the species was unlikely to recover (Morrison *et al.*, 2005; Spear, 2005; Morrison *et al.*, 2007).

Since those first assessments, several conservation strategies were and continue to be tested and implemented, and ongoing research is currently being conducted by various stakeholders on populations in the KNP, Associated Private Nature Reserve (APNR), Sabi Sands Game Reserve, Limpopo River Valley and Zululand (South Africa), Gorongosa National Park (Mozambique), Matobo district (Zimbabwe) and northern Namibia. These efforts have yielded a greater knowledge base for the species, reaffirmed many earlier findings, and highlighted difficulties in rapid and meaningful data generation for such a low-density and long-lived species. Yet only two reviews of the species' biology were published (Sanft *et al.* 1960; Kemp, 1995), with species summaries drawn from these in subsequent unpublished local conservation plans (Morrison *et al.* 2005; Jordan, 2011). Recently, a full review of the conservation biology of the species was conducted (Kemp, 2017) and highlighted the need for increased implementation of proposed conservation actions.

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SECTION 4: BRIEFING DOCUMENTS

BRIEFING DOCUMENTS AND PRESENTATIONS

Since the first PHVA in 2005 a number of academic studies and research reports have been published. These were collated and made available to all participants prior to the workshop via a Dropbox link, and at the workshop each participant was given a flash drive with all the relevant documentation. Below is a list of the documents that were circulated. For those without a hyperlink please contact project@ground-hornbill.org.za for a file transfer.

Documents

Table 4.1. Table of all research and report documents produced since the 1st PHVA.

Literature Type	Citation
Hons & B-Tech	Dickens, J.,(2010). *How much is enough? Calibrating satellite telemetry for Southern Ground-Hornbills* (Unpublished honours thesis). University of Cape Town, Rondebosch, South Africa. Link
	Theron, N.T.,(2008). *The Foraging Ecology of Re-Introduced Southern Ground-Hornbill (Bucorvus leadbeateri) on Mabula Private Game Reserve, Limpopo Province* (Unpublished B-Tech research report). Tshwane University of Technology, Pretoria, South Africa. Link
	Jerling, F.,(2011).*The identification and verification of optimal reintroduction sites for the Southern Ground Hornbill Bucorvus leadbeateri in the Musina area of the Limpopo Province, South Africa* (Unpublished master's thesis). North-West University, Potchefstroom, South Africa. Link
MSc	Rode, S.C.,(2010). *Elephant Impact on the Large Tree Component and its Potential Effect on Selected Fauna* (Unpublished master's thesis). University of South Africa, Pretoria, South Africa. Link
	Spear, D.,(2005). *Dealing with Socially Complex Species in Population Viability Analysis: a Case Study of the Cooperatively-Breeding Southern Ground-Hornbill, Bucorvus leadbeateri* (Unpublished master's thesis). University of Cape Town, Rondebosch, South Africa. Link
	Theron, N.T.,(2011). *Genetic Connectivity, Population Dynamics and Habitat Selection of the Southern Ground Hornbill (Bucorvus leadbeateri) in the Limpopo Province* (Unpublished master's thesis). University of the Free State, Bloemfontein, South Africa. Link
	Wilson, G.,(2010). *What Causes Variation in the Reproductive Performance of Groups of Southern Ground-Hornbills Bucorvus leadbeateri?*(Unpublished master's thesis). University of Cape Town, Rondebosch, South Africa. Link
	Wyness, W.,(2011). *Home Range Use by Southern Ground-Hornbills (Bucorvus leadbeateri)-Quantifying Seasonal Habitat Selection and Vegetation Characteristics* (Unpublished master's thesis). University of Cape Town, Rondebosch, South Africa. Link
	Zogby, B.,(2015). *Fine-Scale Movements and Habitat Use of the Southern Ground-Hornbill Bucorvus leadbeateri* (Unpublished master's thesis). University of Cape Town, Rondebosch, South Africa. Link
PhD	Broms, K.M.,(2013). *Using Presence-Absence Data on Areal Units to Model the Ranges and Range Shifts of Select South African Bird Species* (Unpublished Doctoral Dissertation). University of Washington, Seattle, United States of America. Link
	Carstens, K.,(2017). *Nest boxes as a Conservation Tool for the Southern Ground Hornbill Bucorvus leadbeateri* (Unpublished Doctoral Dissertation). University of Cape Town, Rondebosch, South Africa.

	Coetzee, H.,(2013). *A Brief, Solution-Focused Approach to the Use of Southern Ground-Hornbills in Cultural Practices* (Unpublished Doctoral Dissertation). North-West University, Potchefstroom, South Africa. Link
	Combrink, L.,(2017). *The Habitat, Foraging and Nesting Requirements of Southern Ground-Hornbills in the Kruger National Park, South Africa* (Unpublished Doctoral Dissertation). University of Kwazulu-Natal, Pietermaritzburg, South Africa. Link
	Kemp, L.V.,(2017). *Conservation Biology and Molecular Ecology of the Southern Ground-Hornbill Bucorvus leadbeateri (Vigors, 1825)* (Unpublished Doctoral Dissertation). University of the Free State, Bloemfontein, South Africa. Link
	Loftie-Eaton, M.,(2017). *The Impacts of Bush Encroachment on Bird Distributions in the Savanna Biome of South Africa* (Unpublished Doctoral Dissertation). University of Cape Town, Rondebosch, South Africa. Link
Publications	Broms, K. M., Johnson, D. S., Altwegg, R., & Conquest, L. L.,(2014). Spatial Occupancy Models Applied to Atlas Data Show Southern Ground Hornbills Strongly Depend on Protected Areas. *Ecological Applications*, **24**(2), 363-374. Link
	Carstens, K. F.,(2014). Egg-capping in the Southern Ground-Hornbill *Bucorvus leadbeateri*. *Ostrich*, **85**(1), 89-91. Link
	Chiweshe, N.,(2007). The Current Conservation Status of the Southern Ground Hornbill *Bucorvus leadbeateri* in Zimbabwe. *The Active Management of Hornbills and their Habitats for Conservation*: 4–9 November 2005, Bela Bela, 252-266. Link
	Coetzee, H., & van Rensburg, L.,(2011). Identifying Optimal Reintroduction Sites for *Bucorvus Leadbeateri* in South Africa (*Powerpoint Slides*). Link
	Coetzee, H. C.,(2007). 'Oxpecker' Ground Hornbills: a New Symbiotic Interaction Between the Southern Ground Hornbill and African Warthog. In: Kemp, A. C. & Kemp, M. I. (eds). The Active Management of Hornbills and their Habitats for Conservation, pp. 396. *Proceedings of the 4th International Hornbill Conference*, Mabula Game Lodge, Bela-Bela, South Africa. Link
	Coetzee, H., Nell, W., & Van Rensburg, L.,(2014). An Exploration of Cultural Beliefs and Practices Across the Southern Ground-Hornbill's Range in Africa. *Journal of ethnobiology and ethnomedicine*, **10**(1), 28. Link
	Coetzee, H., Nell, W., & van Rensburg, L.,(2014). An Intervention Program Based on Plant Surrogates as Alternatives to the Use of Southern Ground-Hornbills in Cultural Practices. *Ethnobotany Research and Applications*, **12**, 155-164. Link
	Combrink, L., Combrink, H. J., Botha, A. J., & Downs, C. T.,(2017). Nest Temperature Fluctuations in a Cavity Nester, the Southern Ground-Hornbill. *Journal of Thermal Biology*, **66**, 21-26. Link
	Cooper, M., & Jordan, L.,(2013). Random Time-Activity Budgets in Captive Southern Ground Hornbill *Bucorvus leadbeateri*. *South African Journal of Science*, **109**(7-8), 01-02. Link
	Aggarwal, R. K., Allainguillaume, J., Bajay, M. M., Barthwal, S., Bertolino, P., Chauhan, P., & Díaz Ferguson, E.,(2011). Permanent Genetic Resources Added to Molecular Ecology Resources Database 1 August 2010–30 September 2010. *Molecular ecology resources*, **11**(1), 219-222. Link
	Daso, A. P., Okonkwo, J. O., Jansen, R., Brandao, J. D., & Kotzé, A.,(2015). Mercury concentrations in eggshells of the southern ground-hornbill (*Bucorvus leadbeateri*) and wattled crane (*Bugeranus carunculatus*) in South Africa. *Ecotoxicology and environmental safety*, **114**, 61-66. Link
	Daso, A. P., Okonkwo, J. O., Jansen, R., Forbes, P. B., Kotzé, A., & Rohwer, E. R.,(2015). Polybrominated Diphenyl Ethers (PBDEs) in Eggshells of the Southern Ground-hornbill (*Bucorvus leadbeateri*) and Wattled Crane (*Bugeranus carunculatus*) in South Africa. *Chemosphere*, **118**, 284-292. Link

	Jordan, M.,(2011). Southern ground hornbill (*Bucorvus leadbeateri*) species recovery plan for South Africa. *Johannesburg: Conservation Breeding Specialist Group (SSC/IUCN)/CBSG South Africa/Johannesburg Zoo/Endangered Wildlife Trust*. Link
	Koeppel, K. N., & Kemp, L. V.,(2015). Lead toxicosis in a southern ground hornbill *Bucorvus leadbeateri* in South Africa. *Journal of avian medicine and surgery*, **29**(4), 340-344. Link
	Martin, G. R., & Coetzee, H. C.,(2004). Visual fields in hornbills: precision-grasping and sunshades. *Ibis*, **146**(1), 18-26. Link
	Morrison, K., Daly, B., Burden, D., Engelbrecht, D., Jordan, M., Kemp, A., & Friedmann, Y.,(2005). Southern ground hornbill (*Bucorvus leadbeateri*) population and habitat viability assessment (PHVA) workshop report. *Conservation Breeding Specialist Group (SSC/IUCN) South Africa, Endangered Wildlife Trust, Lanseria, South Africa.* Link
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Presentations of the latest research

Presentations were then made on a range of topics. For links to the full presentations please click the author name.

1. **Rob Little**: Reversing the decline of Southern Ground-Hornbills. Link

2. **Kate Carstens**: Breeding and dispersal implications for the conservation of the Southern Ground-Hornbill. Link

3. **Evans Mabiza**: CNCZ: Matobo Ground-Hornbill Project 2012 – 2017. Link

4. **Lucy Kemp and Brent Coverdale**: Monitoring ground-hornbills at a provincial scale. Link

5. **Lucy Kemp**: Distribution and conservation at a range-state scale, molecular analysis and analysis of past reintroductions. Link

6. **Katja Koeppel**: Veterinary Management of the Southern Ground-Hornbill (Bucorvus leadbeateri) as a Tool to Enhancing Reintroduction Success Link

Poster: Veterinary management of the Southern Ground-Hornbill (Bucorvus leadbeateri) as a tool to enhancing reintroduction success. Link

7. **Zwalake Zondi**: Southern Ground-Hornbill Internet Trade. Link

Southern Ground-Hornbill

Population and Habitat Viability Assessment Workshop

FINAL REPORT

SECTION 5: OUTPUTS FROM WORKING GROUPS

WORKING GROUP 1: CONSERVATION STATUS & AMELIORATION WITH FOCUS ON SOUTH AFRICA

Antoinette Kotze, Rob Little, Alan Kemp, Ray Jansen, Gareth Tate, Megan Murison

Introduction

This working group was tasked with answering the following overriding question:

What needs to be done to stabilise and reverse the decline of the SGH, with the aim of down-listing its IUCN threat status within South Africa, and supporting range state conservation efforts?

This is required to know what steps need to be taken to achieve the overall vision statement of this PHVA document.

Problem statements, goals & actions

1. **It is unknown what requirements must be met to support the criteria for species recovery - one measure of which would be the down-listing of the species' IUCN threat category in South Africa (EN) and elsewhere in Africa (VU).**

Based on previous IUCN red-listing exercises for South African birds, the formal and informal criteria applicable for down-listing (in no particular order) are:

- Quantified evidence that the population is *increasing* in numbers nationally and regionally throughout its range.
- Quantified evidence that the population is *expanding* nationally and regionally throughout its range.
- Evidence that appropriate measures have been put in place to support increased protection nationally.
- Country-based empirical evidence to support national down-listing throughout the species' range states (may not apply to regional down-listing, will apply to outside RSA).
- National signatories (DEA) to support the down-listing throughout the region – potentially as an outcome of a biodiversity management plan (BMP).
- Evidence of healthy levels of genetic diversity within and among populations within and among range states. This will be conducted by ongoing sub-sampling site evaluation of heterozygosity and allelic diversity based on sites chosen from a genetic diversity heat map produced for the species.

Goals

1. Increase population nationally and regionally throughout its range-states.
2. Expand population nationally and regionally throughout its range-states.
3. Measures put in place to reduce threats and support increased protection nationally.
4. Country-based evidence to support national down-listing throughout the species' range-states (may not apply to regional down-listing, will apply to out of RSA).
5. National signatories (DEA) to support the down-listing throughout the region.
6. Assess and maintain genetic fitness within and between populations.

Actions (numbers in brackets relate to goals above)

a) Whenever a group is found without juveniles, attempt to find a nest site and, if no nest found, supplement artificial nest (1 & 2). (All field workers, MGHP to provide nests)
b) Monitoring of nest activity and breeding success (1 & 2). (All fieldworkers)
c) Implement actions from the risk assessment and threat reduction group (Group 3) (1 & 2). (Project Thunderbird)
d) Encourage and implement custodianship of groups and monitoring of populations (3).
e) Implement monitoring for detection of population change, positive and negative, to inform adjustments to management plans (3).
f) Education, awareness and educational reinforcement (3).
g) Community and cultural support (3).
h) Incorporate information and outputs from range-states group (Group 2) (4) (MGHP).
i) Collate existing evidence into a BMP (Biodiversity Management Plan) to be implemented by government (5). (All PT)
j) Molecular evidence that shows that there is population fitness e.g. genetic diversity is assessed and monitored to indicate genetic viability and fitness within and between populations (6).
k) Conservation genetics map of fine-scale population structure for South Africa (NZG, MGHP, FIAO).
l) Additional occurrence data is required (preferably as point data but pentad scale data will suffice as this is consistent with SABAP 2). It is imperative that groups are reported as groups and individuals as individuals (1 & 2). (MGHP to collaborate with EKZNW for finalisation of their monitoring plan and the implementation of this approach in then taking other provinces)
m) SOPs and a national plan for harvest, rearing and reintroduction is required (2), with targets and defined activities. This will be derived from the MCDA to be held after the BMP has been established or to be done concurrently. Most of the protocols are already completed and MGHP will prepare a reintroduction plan according to the IUCN Reintroduction Guidelines.

2. ***What data are needed to feed into the evidence underpinning the above? What are the gaps? Who will provide the data and who will fill the gaps?*** New data have been processed/analysed, primarily in the form of six PhD theses.

Actions

a) Key data on community protection and the role of cultural relevance for the SGH should be extracted from the literature collated and expanded, and incorporated within the MGHP education awareness and cultural programmes. (MGHP, WLTP, CNCZ to undertake).
b) Protocol and guideline documents have been developed for many of the activities above. E.g. EKZNW monitoring programmes, re-introductions, harvesting and rearing, nest boxes, nest finding and checking, custodianships. (MGHP to undertake and disseminate for comment).

Final recommendations

1. **Roll out multi-province monitoring plans as these will lead to:**
    a) Quantification of the national population at the level of pentads, groups and numbers (1 & 2).
    b) The rate of acquirement of new pentads should be decreasing as a measure of success, leading eventually to no new records. (1 & 2).
    c) Further interrogations within the pentads whether there are groups, and, within their territories whether there are active nests. Collate information on group age and structure (1 & 2).
    d) Identify core areas on the pentad map to develop clusters of custodianship agreements (3).

2. **Education and awareness**
    a) Education focused at, buffer zones of core area custodianships and at all demographic layers of the population (e.g. from community leaders down to labourers and schools) (3).
    b) Approach the Department of Education for application as a learning outcome in preparatory schools (3).

3. **Recognition of power of cultural protection**
    a) Roll out lessons learnt from KZN community activities and the Zimbabwe case study (3).
    b) Refine a locally specific cultural context and expand on integration of SGH conservation and biology into indigenous traditional knowledge systems (3).

4. **Research**
    a) Baseline information exists, but need finer scale population genetic structure assessment as a management tool (6).
    b) Use genetics as a monitoring tool for reintroductions to ensure genetic variability in reintroduced individuals (6).
    c) Attract more interest into research on the SGH at the tertiary level (3).

5. **Range-wide**
    a) Explore the immigration of the pentad concept into the buffer zones of our neighbouring countries, Botswana, Mozambique and Zimbabwe. Standardise data collection methods (4) and link these to the operation at pentad scale.

6. **Raise the species' conservation profile**
    a) Develop a BMP for the species. Enthuse government agencies from provincial to national levels (5).
    b) Adopt inherent stakeholder collaboration that works within the needs of the BMP, including the insurance of relevant capacity (5).
    c) Conscientize local authorities, empowering them to participate in and transform the SGH sector decolonise the knowledge base (5).

WORKING GROUP 2: BEYOND SOUTH AFRICA'S BORDERS

Background

The SGH has several significant life history characteristics, each independently increasing its vulnerability to extinction: it is a diurnal, long-lived, large, conspicuous, top-order avian predator, with large spatial needs that result in low densities and small population size per unit area (Kemp, 1995). These features, together with cooperative breeding and other complex social structures, combine to produce naturally slow rates of breeding and recruitment (Purvis *et al.*, 2000). Added to this, the species face a number of anthropogenic threats (BirdLife International, 2017), each growing in scale as human development expands across sub-equatorial Africa.

As a consequence, population declines of SGH have already been reported for Kenya (BirdLife International, 2014), Malawi (Kalimira, 2007), Mozambique (Parker, 1999, 2005), Zambia (BirdLife International, 2014), Zimbabwe (Chiweshe, 2007; Maasdorp, 2007; Witteveen *et al.*, 2013), Botswana, and Swaziland (Parker, 1994), with declines best enumerated and most dire for South Africa (Kemp & Webster, 2008; Underhill, 2014; Taylor & Kemp, 2015) and Namibia (Simmons et al., 2015). The IUCN Red List status of SGH is Vulnerable (BirdLife International, 2014) but in the south of the range, the species is regionally listed as Endangered (Simmons, Brown & Kemper, 2015; Taylor & Kemp, 2015). Considering the decline in many areas, it must be assumed that conservation efforts, such as those currently underway in South Africa (Theron, Turner & de Waal, 2007) and Zimbabwe (Witteveen *et al.*, 2013), will be required on an increasing scale across the sub-equatorial range.

The SGH has been reported in sixteen range-states: South Africa, Namibia, Botswana, Zimbabwe, Swaziland, Mozambique, Malawi, Angola, Zambia, Democratic Republic of Congo (DRC), Rwanda, Burundi, Kenya, Uganda and Tanzania, with one record for Zanzibar (Kemp, 1995) and one for Lesotho (D. Maphisa*,* pers. comm.). Coarse range-distribution maps are needed, based on historical, mostly museum-specimen localities, including that for the other *Bucorvus* species that occurs north of the equator. The SGH and the Northern (Abyssinian) Ground-Hornbill *B. abyssinicus* have been shown to be parapatric (Sanft, Wermuth, Mertens, Hennig, 1849; Snow, 1978; Kemp, 1995) (Figure 2.1). The area of range overlap in southern Kenya and Uganda is small (Musila, 2007; Odull & Byaruhanga, 2009), with each species essentially found on either side of the equator and overlap attributed to dispersal rather than breeding individuals (Kemp, 1995), with *B. abyssinicus* restricted to dry grasslands in northwest Kenya and *B. leadbeateri* found in moister rangelands in the southwest (Musila, 2007). No reports of hybridization has been found.

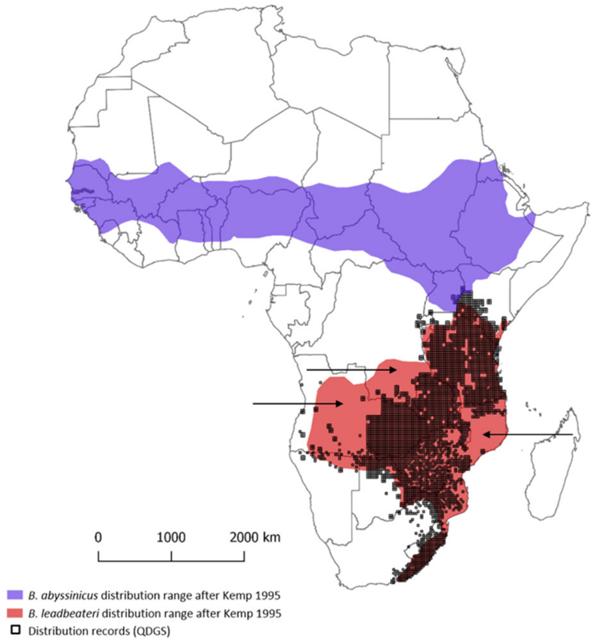

Figure 5.1. Map of the range distribution for both *Bucorvus* species after Kemp (1995), overlain with all known records for SGH (*B. leadbeateri)* and arrows indicating three major data-deficient regions (scant records published and no atlas data) for Angola, Democratic Republic of Congo and northern Mozambique (Kemp, 2017).

Problem statement

There are declines reported across the range but there is a lack of distribution and ecological data to allow for accurate conservation status assessments that would guide the need for conservation intervention.

The main focal area for both research and conservation has been South Africa and Zimbabwe, with only South Africa and Namibia able to produce a regional conservation assessment for the species. The main source of distribution data has been from a one-off atlas initiative, with only the Southern African Bird Atlas Project (SABAP) able to provide replicate atlas data to allow for analysis of range change, and thus the ability to assess population trends.

Threat analysis has, to date, consisted of expert opinion, with no known data collection to support this. For some range-states expert opinion however has led to conflicting views on population trends.

Goals, cost benefits & actions

1. Find the right people in each range state to implement monitoring and conservation initiatives.

Short-term objectives

- Reach out to government and non-governmental agencies (e.g. Birdlife Partners) to gather recommended contacts per country.
- Initiating a network of support (e.g. IUCN Hornbill Specialist Group).

Long-term objectives

- A functioning network of people across range-states who will champion the species, and has the relevant backing of authorities.
- Provide ongoing support in terms of grants and research methodologies.

Cost-benefit analysis

Creating a network of partners will be a good way of sharing information. In many of the range states resources are limited, and effectiveness of partners may be restricted due to work load and resource availability. This can be ameliorated by supporting the access of international funds for additional staff and resources. The only initial cost will be the outreach to each range state.

Actions: Identify and establish contacts in each range state that can oversee and implement nationwide monitoring.

2. Providing the people with the tools to implement these monitoring plans.

Short-term objective

- The initiation and standardization of data collection with support and guidance from the South African national action group.

Long-term objective

- Comparable data sets across the range of the species, to allow for a proper understanding of density demographics and threats across the entire range.

Cost-benefit analysis

This approach will be positive in that it will encourage research, allow for standardized research that can allow for regional meta-analyses, enhance interest in the species and this approach will be a low-cost product that can be distributed to all other parties involved. There may however be high initial interest with a subsequent drop, and there may be potential data-sharing conflicts. The costs will be country specific and dependent on needs. PT may be able to provide advice on how to acquire funds.

Actions

Creation and distribution of toolkits.

WORKING GROUP 3: RISK ASSESSMENTS ACROSS LAND USE TYPES

Introduction

The aim of this group was to highlight, discuss, critically analyse and propose solutions to potential risks and threats for SGHs across the major land use types in South Africa. The four major land use types highlighted by the Land Use Working Group (Technical Workshop) were: commercial agriculture, community owned rangelands, private conservation properties and government owned reserves including formally protected sites, such as World Heritage Sites. The broad threats and their perceived risk levels for each of the land use types has been summarised below (Table 1).

Table 5.1: The potential threats to SGHs in South Africa across the major land use types, with their associated threat levels (H=high, M=medium, L=low).

Potential threats		Land use types			
		Commercial	Communal	Private Con.	Formal Con.
1	Electrical infrastructure	H	H	H	H
2	Agrochemicals	H	M	M	L
3	Lead	M	L	H	H
4	Burning/veld management	M	M	H	H
5	Human-wildlife conflict and lack of awareness	H	M	M	M
6	Disease	M	M	M	M
7	Lack of law enforcement	M	M	M	M

Problem statements, goals and actions

1. The use of bird unfriendly electrical infrastructure in SGH range states across all land-use types.

Goals

a) Identify all bird unfriendly structures (BUFS) in SGH range states.

Action: ESKOM/EWT has started assessing the current infrastructure to determine where BUFS are and is developing a risk map for South Africa since the end of 2016 (proactive mitigation campaign). Megan Murison to update PT. Identify SGH unfriendly structures to add to tool kit and separate locations as a separate action.

b) Development of mitigation review and feedback loop for SGH electrocution incidents through MGHP, WLTP, EWT, Leeupoort Raptor Conservancy.

Action: Create an online platform where positions of problem transformers can be shared by land owners or community members by using the *MapMarker* App *to pin point their positions as currently done for the SGHs. Trial roll-out of transformer identification through the MGHP, WLTP, EWT and Leeupoort Raptor Conservancy (LRC) (private conservation). (Deadline: roll out of action in 6 months February 2018)*.

Data available: ESKOM/EWT strategic partnership through the Wildlife and Energy Programme (Megan Murison).

2. A) The inappropriate and/or negligent use of agrochemicals in commercial and community land use types.

Goals

a) Resurrect the Poison Working Group as soon as possible (conservation benefits for multiple species i.e. vultures, cranes etc.).

Meeting with Business Industry Manager of EWT (Constant Hoogstad) and Arnaud le Roux, as well as with industry representatives. Get a declaration of intent from industry leaders to reduce and better-manage the "cradle-to-grave" process for the use of agrochemicals. (*Deadline: before end of 2017*).*Action*: Within two months (October 2017) send out a call for members to join the new Poison Working Group.

b) Start an awareness campaign around the dangers and health issues of using agrochemicals.
Action:
Project Thunderbird to champion this.

B) The targeted use of agrochemicals to exterminate wildlife and/or pests

Goals

c) Law enforcement capacity building to ensure that SGH are flagged in poaching/wildlife poisoning incidents.

Action: Brent Coverdale to engage with Gareth Tate to ensure that SGH are incorporated into existing poison intervention training. *Data available:* Arnaud le Roux to follow up on Groblersdal data indicating negative effects of using agrochemicals on humans. Olifants River Crocodile study data (Stephan Woodborne).

3. The presence of lead in the SGH range-states is causing damage to the birds through both short- and long-term exposure.

The current problem is multi-faceted: 1) lead bullets are cheaper than alternative lead-free ammunition, 2) hunters have negative perceptions about non-lead ammunition, 3) wing-shooters do not see alternatives, and 4) hunters commonly do not believe the science behind the negative health impacts of lead, to humans or wildlife.

Goals

d) Initiate buy-in from hunting industry (private conservation industries) to buy lead-free ammunition. This *will be an on-going action.*

Action: Arnaud le Roux to raise issues of lead in the environment at rangeland management forum and other community group meetings. MGHP to engage with Peter Oberem re non-lead ammunition. Get a Vet (Katja Koeppel) or Doctor to present about the effects of lead accumulation in humans to organisations such as *WRSA, PHSA, SAWingShooter, CHASA, SAHunters* (12-month time frame). Will need both a bottom-up approach: consumers going to ammunition manufacturers to demand that lead-free ammunition is manufactured at cheaper rates (M. Murison suggested creating bullets from recycled plastic as a possible option). Carte Blanche exposé with a ballistics expert to add to expertise behind the argument. Link lead poisoning to the Poison Working Group (point 2).

Lead accumulation in HUMANS must be the KEY driving approach to change the culture of gun-users in South Africa.

Data available: Internationally there are a wealth of papers with regards to lead toxicosis in both humans and wildlife. Locally few papers exist for avian cases of lead toxicosis – e.g. Koeppel and Kemp (2015) for SGH. Katja Koeppel to provide details on the study of lead accumulation in hunters (and the venison they harvest). Support Linda van den Heever's lead and vulture research with data for any species.

4. **Unfriendly veld management practices that detract from SGH population growth and survival.**

Goals

a) Project Thunderbird awareness campaign to educate various stakeholders and land owners.

Action: MGHP to create guideline document (*deadline for toolkit will need to be in the next 12 months*) that can be circulated to the broader Project Thunderbird communities. *This action will be ongoing*.

b) Create feedback loop/monitoring system for management of landscapes where SGHs occur.

Action: Contact organisations such as the ARC, Dept. of Agriculture, Working on Fire, Grassland Society of South Africa (GSSA) to promote better veld management nationally to the benefit of biodiversity and subsequently the SGHs.

Data available: *APNR research on habitat use and spatial movement of SGHs, Loftie-Eaton and Combrink thesis.*

5. **The interaction between SGHs and humans can lead to untimely death of perceived "problem" birds.**

Goals

Develop and launch an online platform for Project Thunderbird.

To establish a national coordinating group responsible for ensuring implementation and review of ongoing SGH conservation initiatives. The group will comprise of different stakeholders with the aim to conserve SGH. This group will effectively morph the existing Action Group into a nationally relevant coordinating group, termed "Project Thunderbird".

Action: Register a domain name for Project Thunderbird with a contact number, email, FB page, national reporting WhatsApp number and YouTube channel with SGH footage. Have a nominated social media manager to run the platform as a reporting mechanism. Affected persons can make contact via various channels and nominated representative can delegate local ground-based representative to respond to issues. *Deadline 3 months to launch - reporting forum create a database of window breaking incidents, livestock (chicken) predation and other SGH-human conflicts.* MGHP to initiate.

Action: Window-breaking mitigation strategy in combination with PG Glass or Glassfit to provide support through window replacement. (I.e. example in Zimbabwe – put ash on school windows during the holidays and clean it off of the top windows during the term). Target rural schools not individual homesteads i.e. commercial concerns should be able to support themselves to allow the various NGOs to support schools etc. that do not have the budget to mitigate.

Action: Ensure that the MGHP Guidelines/Manual document gets widely circulated to address issues of human-SGH conflict (deadline: MGHP TBC as distributing these guidelines).

Data available: MGHP, PT.

6. Mitigation of pandemics and the lack of outbreak response.

Goals

a) Identify potential diseases that pose a risk to SGHs.

Action: If an outbreak is detected, an alert must be sent to the stakeholders (via the online platform and by the PT social media person) in areas potentially at risk, followed by heightened monitoring of wild SGHs and carcass collection if needed. *Deadline: 12 months*. Ensure that pathology samples are sent to the NZG Biobank (Kim Labuschagne).

b) Create response strategies for currently known diseases that impact on SGHs.

Action: Feed vaccines to released birds, canon-net to capture birds or chick laced with sedative to improve capture of birds for delivery of vaccines. (Katja Koeppel and Wildlife and Energy Programme EWT). Use of any drone protocol will need to be cleared with CAA.

Data available: Katja Koeppel can provide data on this and use of the monthly DAFF disease outbreak reports to drive alerts.

7. Lack of appropriate enforcement of current biodiversity legislation and implementation of prosecution and suitable penalties for crimes involving SGHs.

Goals

a) Improve the capacity of law enforcement agencies through improved awareness about SGHs. i.e. a SGH is as important as a rhinoceros.

Actions:

a) Better identification of species involved in wildlife crimes,
b) Improved understanding of the importance of ALL wildlife species,

c) Improve understanding of the current conservation and biodiversity legislation.
d) Join forces with other species stakeholder and perhaps make the toolkit for all EN and CR avian species.

Engagement with NPA (magistrate, prosecutors, traditional leadership) to ensure appropriate prosecution of wildlife crimes involving SGH. ***Action:*** For Project Thunderbird: develop a toolkit to cover national and provincial legislation, with input from Croplife South Africa/AFCHASA on agricultural legislation and legal use of pesticides and agrochemicals. Call meetings with traditional leadership to run workshops and engage with local and regional leaders about incorporating protection. Chain of command from local villages to higher leadership: Headman → Councillor → Chief.

Suggested need to provide magistrates with financial evidence of the value of the SGHs to direct penalty charges. ***Data available:*** Sale prices from private sales.

b) Identify champions for SGH conservation in areas that currently have no conservation support.

Action: Identify stakeholders in areas where no work is currently being conducted i.e. the Eastern Cape. Find and support the development of champions for the SGHs in those areas. Target conservancies/farmer's associations to get potential leads on contact people (i.e. Jenny and Walter Curry).

Additional notes: Climate change and how it will affect future distribution is important as is understanding how more than one habitat/geography-specific threats are co-related to land use. Given the SGH N/E/SE range, would these threats affect all SGH land use types equally?

Cost-benefit analyses

1. A) Identify BUFS: low cost with large benefit to incorporate the reporting of BUFS by the WLTP using the MapMarker App.

   B) Low cost with high benefit to generate feedback on mitigating BUFS.
2. A) "Project Poison" and "Project Lead" to keep meetings virtual and at a low cost.

   B) Higher cost associated with going on road show to educate necessary stakeholders but given greater stakeholder engagement may share costs.
3. End-user costs are potentially high (changing to more expensive lead-free ammunition).

   Costs to attend AGMs of the highlighted organisations and to present human safety and lead poisoning to a broader membership. Treatment of lead-poisoned birds is expensive. COST of lead poisoning in humans is greater than the cost of educating them about it.
4. Small cost to generate information pack/guidelines document. Use current capacity of existing extension officers to lower cost of distributing information.

Monitoring system for veld condition will be costly and development of the monitoring plan will require costs too.

5. Registering and maintenance of the domain name is about R700 per year but this will be an important platform, also cost of a social media manager to run domain and social media profiles (MGHP to initiate).
6. Catching wild birds will have associated costs but if canon-netting from a drone or "sleepy-mice" can be developed this cost could be reduced and the ongoing supplementary food conditioning of reintroduced birds negates this requirement for vaccine administration.
7. Law enforcement: Road show to law enforcement agencies and cost to develop a standard toolkit, costs to travel and hold meetings with necessary authorities, a buy in from stakeholders.

Final recommendations (s**ee Appendix 1: Technical Working Group 1 for synergistic recommendations)**

1. Development of a risk map with layers created for each of the abovementioned threats/risks. Working Group (MCDA a good tool for this). Spatial data for each threat layer will need to be provided by nominated representatives (perhaps as part of the proceedings of the BMP).

2. Formation and launch of 'Project Thunderbird' to drive broader SGH threat mitigation and to serve as an oversight body for SGH.

3. Prepare a Biodiversity Management Plan (BMP) for SGH. (This national plan, signed by the Minister, institutionalizes SGH conservation and thus create a succession plan in the event that current members of PT move on to other career paths).

Identify and support SGH champions within the different areas of the range where work is currently not being conducted (I.e. BirdLife South Africa community guides, bird clubs, local community members/ leaders etc.). This can be driven in conjunction with the MGHP Custodianship Programme and the BirdLife Species Guardian Programme.

WORKING GROUP 4: STOCHASTIC POPULATION MODELLING

Mike Bruford, Isa-Rita Russo, Rhys Bruford

Introduction

Following on from the development of a working baseline model during the Technical workshop (Appendix 1, Working Group 5), more realistic and management orientated models were developed. These models focused mainly on understanding the consequences of current land-use practices on hornbill demography, resource availability and likely growth within those constraints. Five land-use classes were defined: 1) protected areas (predominantly based on data from Kruger National Park), 2) Populations found associated with local communities where the birds receive active protection (based largely on data from Matopo, Zimbabwe but clearly applies to certain communities and ethnic groups in South Africa and elsewhere), 3) Populations located along local communities where the birds receive no protection (i.e. have no special cultural status), 4) Populations living in commercial game land, including that which has recently been converted from cattle and other livestock farming, 5) Populations living in commercial agricultural land including that under cattle and other livestock rearing but also arable, forestry and related land-use. The different impacts of these land-use classes on the SGH were implemented in the model via changes in mortality, reproductive output and alterations in carrying capacity. As with previous models, catastrophes were not modelled at this stage, but could be done in the future.

First, a baseline model was constructed for the current South Africa population based on the current available habitat of 288,000 hectares, an average territory size of 100 hectares and an overall average of 2.75 birds per 100km^2 (Kate Carstens, *pers comm*). This sums to a carrying capacity of 7,920. The first model, run without reference to land-use class, is based solely on habitat suitability as per vegetation types and with assumed homogeneity across the country in terms of mortality, reproductive output and carrying capacity (Figure 5.2).

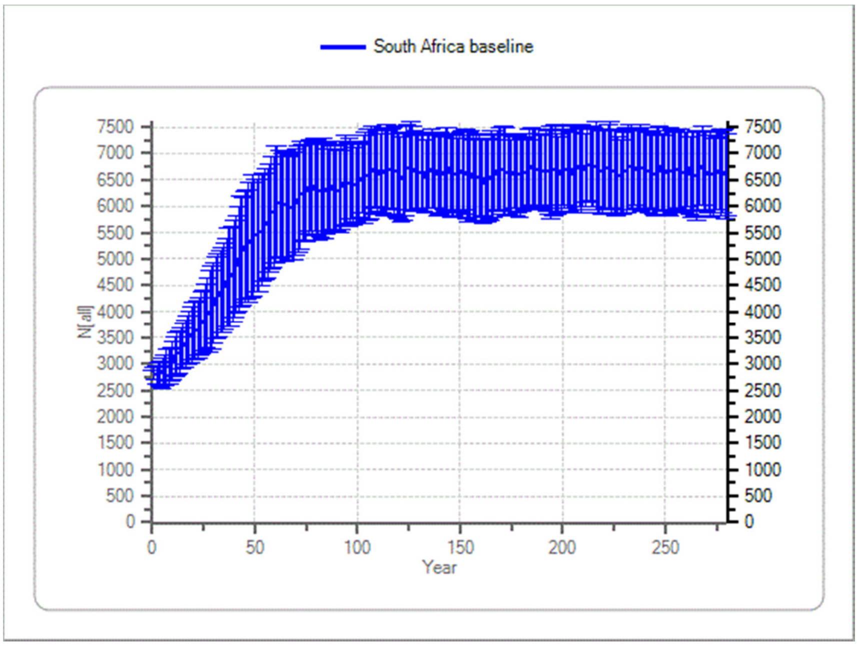

Figure 5.2 Growth curve for an idealised South African SGH population with no land-use specific constraints on demographic rates.

The assumptions of the model in Figure 2 are unrealistic but were used for comparative purposes. The model produced a mean stochastic growth rate of 0.0144, with a mean final population size of 788, achieving carrying capacity around year 100 of the 270-year (ten generation) model.

A more realistic model was then implemented that took account of land-use induced demographic variance. In the absence of full land-use data, an assumption was made that all land-use classes comprise an equal proportion of the SGH's current and future distribution range. Table 5.2 shows the underlying assumptions and how mortality schedules and carrying capacity were altered. Mortality sources were agreed with land-use participants (including Arnaud Leroux), a veterinarian (Katja Koeppel) and Lucy Kemp and were based on data collected on known mortality events and an assessment of current practices.

Table 5.2. Land-use model assumptions for increased mortality and carrying capacity.

	Roads and electrical transformers	Ingestion of harmful chemicals	Accidents involving farming infrastructure	Harvesting for traditional medicine	Carrying capacity multiplier from baseline model
Protected Area	2%	--	--	--	1.0
Communities protecting birds	2%	--	--	1%	5.0
Communities not protecting birds	2%	5%	--	1%	0.5
Commercial game farming	2%	10%	2%	--	0.75
Commercial agriculture	2%	10%	2%	--	1.0

The results for population growth are summarised in Figure 5.3, which shows a very different outcome from the South Africa baseline model. Only populations living in protected areas and communities providing protection to the SGH showed evidence for positive growth or stability (mean stochastic r-values 0.006 and -0.0002, respectively). Extinction was predicted with a probability of 1.0 for populations on commercial land (mean time to extinction 125 years) and of 0.68 for populations living in communities where no protection is provided (P = 0.68, mean time to extinction 235 years). These results emphasise the need for special measures to be implemented to protect populations outside of protected areas if the species is to have a viable future in South Africa.

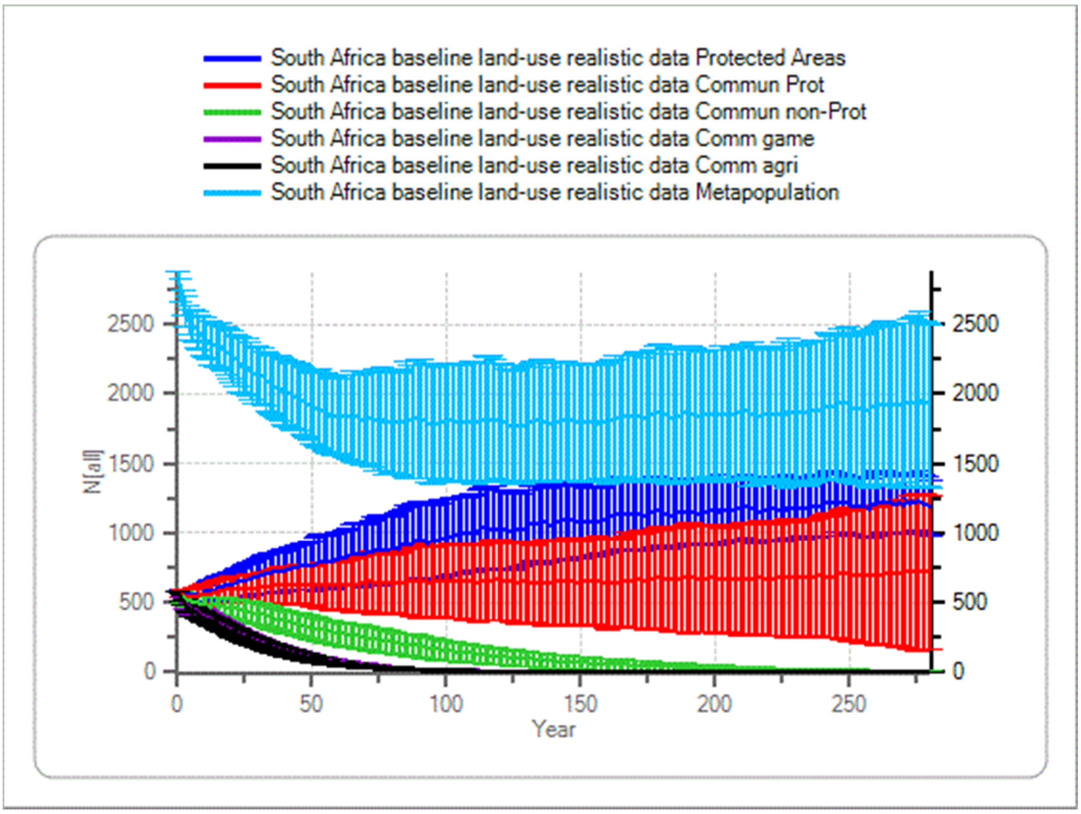

Figure 5.3. Growth curve for SGH populations living in different land-use classes**.**

The key outcome is that the use of bio-pesticides and other poisons on commercial land has a very strong impact on the species, which is otherwise able to withstand low level mortality due to human infrastructure such as by collision on roads or with transformer boxes. Table 5.3 shows the summary output from these models in terms of population demography.

Table 5.3. Model outcomes for land-use analysis (mean of 500 simulations).

Population	det-r	stoch-r	SD(r)	PE	N-extant	N-all	Gene Div	Allele N	Mean TE
Protected Areas	0.025	0.006	0.069	0	1185	1185	0.988	155	0.0
Community Protected	0.022	0	0.05	0	719	719	0.979	101	0.0
Community non-protected	0.005	-0.019	0.086	0.68	11	3.80	0.747	7.50	235.2
Commercial game farming	-0.018	-0.041	0.1	1.00	0	0	0	0	126.9
Comm agriculture	-0.018	-0.041	0.098	1.00	0	0	0	0	127.6
Meta	0.013	0.001	0.048	0	1907	1907	0.993	259	0.0
Community protected Matobo Zimbabwe	0.085	0.083	0.015	0	1538	1538	0.986	130	0.0

Det-r = deterministic growth rate, Stoch-r = stochastic growth rate, PE = Probability of extinction, N-extant = mean population size for surviving models, N-all = mean population size for all models, GeneDiv = mean heterozygosity, AlleleN = mean number of alleles per locus, MeanTE = mean time to extinction

The final row in **Table 5.3** refers to a specific model implemented for the Matobo Hills population in Zimbabwe, which receives very strong community protection and has high cultural significance for the community. Here mortality has been very rarely observed for the last five years, female productivity is approximately 80% breeding per year and the population shows strong evidence of growth to mean group sizes of 7-9 individuals. Under these unusual but highly beneficial circumstances, the population is predicted to grow at 8.3% per annum. This perhaps provides an ideal target by which other non-protected area population might be compared.

In summary, only **protected populations are predicted to grow** under the current model, and under extreme levels of culturally mediated protection, they can grow rapidly. However, the use of harmful chemical substances is predicted to have a **strongly negative impact** on the population and lead to extinction on commercial land where they are being applied, even if in adjacent areas. It is worth noting that our mortality multiplier (10% across age classes) for poisoning was regarded by most participants as being highly conservative. In addition, no poisoning related catastrophes were modelled, despite the fact that pesticide and other chemical uses are known to have had catastrophic effects on vulture populations worldwide and the northern bald ibis in Morocco. Under this land-use scenario the South African population will grow slowly over the coming decades but will remain susceptible to chance events and will need strong conservation measures outside of protected areas if it is to survive.

Southern Ground-Hornbill

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SECTION 6: LITERATURE CITED

LITERATURE CITED

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SECTION 7: APPENDICES

APPENDIX 1: REPORT OF THE INTENSIVE TECHNICAL WORKING GROUP ON POPULATION MODELLING FOR THE SOUTHERN GROUND-HORNBILL (*BUCORVUS LEADBEATERI*)

WORKSHOP HELD AT MABULA PRIVATE GAME RESERVE, LIMPOPO

21-22 August 2017

The Technical Workshop was convened to provide a state-of-the-art overview of the status of Southern Ground-Hornbills, their habitat and threats, and to agree on a set of parameters for stochastic population modelling of the South African population using the modelling program Vortex v10, with the intention that it can be used for use across the entire range. The meeting divided into four working groups, focusing on 1) human-hornbill interactions, both positive and negative; 2) land-use types; 3) captive breeding and reintroduction and 4) ecology. The reports tendered by these groups were reviewed in Plenary, modified and approved by all participants (see list of attendees in Appendix 2). The formatting of each report was quite different and this report is a synthesised formatted version of the originals. A working group on population viability analysis used the parameters and outputs to initiate the stochastic modelling, a full version of which will be appended to this report when modelling is completed after the Stakeholder Workshop.

WORKING GROUP 1: ANTHROPOGENIC INTERACTIONS

Background

Ground-hornbills have a dual relationship with humans; a negative association due to losses to habitat and populations to various anthropogenic land uses, persecution, use for trade or medicine; and a positive association with cultural belief systems and appreciation as an icon of the savanna and grassland biomes.

Threats

Ground-hornbills in RSA hold down larger territories than would be expected for their body size (Kemp, 1995). Energetically, these are beyond their ability to patrol and so less time- and energy-intensive use of vocalisations is used to proclaim and maintain boundaries. Only when an incursion is detected, and visually confirmed, will they actively engage in defence. This territorial drive is high year-round, with a peak before and at the start of breeding. The birds will also attack their own reflections in windows (Forsberg, 1994; Oatley, 1967; C. J. Vernon, 1982) or shiny surfaces (such as metallic coloured vehicles), which results in broken window panes, often in large quantities as they move from pane to pane. This puts the whole group at risk of injury from broken glass but also leads to intense conflict with humans. Persecution by irate landowners leads to direct mortality or reduced productivity, with confirmed reports of a community burning down the resident ground-hornbill group's nest (Blouberg, Limpopo Province) or stoning a nest and causing abandonment (Melmoth, KwaZulu-Natal Province). Ground-hornbills are actively persecuted for breaking windows (Vernon, 1986; Forsberg, 1994; Kemp, 1995; Maasdorp, 2007). This behaviour is universal and reported from throughout their range. Mitigation to prevent them from seeing their own reflections is the only way to reduce this human-wildlife conflict, with a temporary and cheap solution being use of a solution of wood ash or paint on the panes (Chiweshe, 2007) and a more permanent one using perforated one-way-vision vinyl film (pers. obs.). Experiments in the use of commercial acoustic bird scarers failed (L. Kemp; pers.obs.).

The species favours short-grass areas and is commonly found on mown grass airstrips and road verges, with reports of group members being shot to ensure runways are kept clear (Mundy, 2000; Chiweshe 2007) or as road-kill (Kemp & Kemp, 1980). In rural areas, ground-hornbills are reported to prey on poultry and small pets (Maasdorp, 2007; Witteveen *et al.*, 2013), or on commercial concerns such as bee hives (El-niweiri & Satti, 2008), making them targets for retaliatory disturbance or killings.

Non-targeted anthropogenic effects are also having a negative impact on the species. Even within the largest protected areas, effects of rising carbon dioxide levels and temperatures, coupled with erratic rainfall are leading to bush encroachment as conditions favour woody plant growth (ref?). The increasing use of chemicals in the environment leads to toxic compounds that cause both immediate mortalities (e.g. poisons, pesticides) and chronic physiological effects that reduce population growth (e.g. mercury and other persistent pollutants; Daso *et al.,* 2015a,b, Koeppel & Kemp, 2015).

Ground-hornbills forage together as a group (Farlow, 1976), primarily hunting independently of each other for small food items but they also act as a team when hunting larger prey items (Bennun, 1992; Driver & Humphries, 2014). This group-foraging behaviour, however, means that if a carcass or bait is laced with poison then it is likely that all group members will scavenge on the bait and this will increase mortalities. Use of chemical pesticides to target wildlife is increasing across Africa (Ogada, 2014), although reported poisoning cases for ground-hornbills have been assumed incidental or secondary through poison-laced bait intended for other species (Engelbrecht *et al.*, 2007, Jordan, 2011). Government-led rabies-vector and Red-billed Quelea (*Quelea quelea*) control campaigns contributed to widespread declines with associated die-offs of non-target scavenging species (Bothma, 2012; Chiweshe, 2007; Talbot, 1976). What is of particular concern for end-users of traditional medicines is that methods of harvest increasingly include persistent poisons, such as aldicarb, which remain in the parts consumed by patients (Bruyns et al., 2013; Ogada, 2014) and risk human or wildlife morbidity or fatalities, as for vultures (Mander *et al.* 2007). Ingestion of lead shot or bullet fragments incorporated into muscle tissues, usually from discarded offal after hunting, leads to both acute and chronic lead toxicosis (Koeppel & Kemp, 2015). Ground-hornbills dig for food, particularly during the dry season, a behaviour that has led to mortalities being reported from antipersonnel mines (Maasdorp, 2007; Masterson, 1957). Ground-hornbills are also caught unintentionally in snares (Chiweshe, 2007), both within (Stalmans, Peel, & Massad, 2014) and outside protected areas (E. Mabiza pers. comm., 2015; L. Kemp, pers. obs.).

Trade exists in the species, both at a local level for traditional medicine and ritual practise (Anon, 1998; Msimanga, 2000; Kalimira, 2007; Maasdorp, 2007; Bruyns, Williams & Cunningham, 2013; Witteveen *et al.*, 2013; Coetzee, Nell & van Rensburg, 2014), and across international borders for the zoo and aviculture trade (Trail, 2007). It has been reported across the range that where cultural practices are respected there is an inherent protection for the species (Trail, 2007). However, in areas where cultural taboos are less rigid, the species becomes prey to traders and their suppliers, either opportunistically, or as directed trade (Thiollay, 2006). It is difficult to quantify the scale of trade as the species is not listed by the Convention on International Trade in Endangered Species (CITES). Use of body parts is reported on a local scale but trade is reported only for formal traditional medicine markets, not for domestic use (Ngwenya, 2001; Maasdorp, 2007; Whiting, Williams & Hibbitts, 2011; Bruyns, Williams & Cunningham, 2013; Williams, Cunningham, *et al.*, 2013).

The scale of development in rural areas appears to have a marked influence on the persistence of the species. Ground-hornbills are susceptible to electrocution on transformer boxes (Jordan, 2011). With development, degradation, fragmentation and transformation of natural habitats also expand. Some less affluent and less developed areas now appear to sustain ground-hornbill populations at higher densities than areas where development increased the number of potential threats within a territory. It would be essential to tease out how much of this protection is because of strong cultural protection for the species in communal lands and how much of it is simply an increase in losses to newly arrived threats within a region.

Cultural dynamics

Hornbills, as an order, are revered and recognised as strong cultural icons in both Africa and Asia. The snake-killing ground-hornbill with its striking aposematic (red, black, white) colouration and deep rhythmic drum-like calling duet is embedded in human cultures across the range, featured in art and customary dress (Bastin, 1984; Chanda & Daniel, 2014; Kalimira, 2007), musical instruments, and riddles and songs (Godfrey, 1941; Estermann, 1964; Khumalo, 1974; Vernon, 1986; Anon, 1998; Maasdorp, 2007). It is sighted at homesteads or moving through villages, and accepted and tolerated as part of the rural landscape (Norton, 1982; Penzhorn, 1983). Ground-hornbills are reported to be powerful as both ritual and palliative medicine across their range for both *Bucorvus* species. This has accorded them wide-spread protection (Penzhorn, 1983), which has created *de facto* protected areas where these traditions remain strong (e.g. Matopos Tribal Trust Land, Zimbabwe; Witteveen *et al.*, 2013, Mabiza, E, pers. comm.). This powerful status also creates a conservation challenge, since although mostly accorded cultural protection, ground-hornbills are also occasionally utilised for specific purposes.

The most widespread and prevalent value ascribed to the species is the belief in their ability to predict, signal or bring the summer rains, vital to subsistence farmers' survival (Koopman, 2011; Chiweshe, 1998; Godfrey, 1941; Coetzee *et al.,* 2014b; Vernon, 1986; Orlove *et al.* 2010; Brunton & Badenhorst 2013; Chisadza *et al.,* 2013; Rusinga *et al.,* 2014; Msimanga, 2000; Muiruri & Maunda, 2010; Simelane, 2011; Nevill, 1984; Maasdorp 2007b; Kuckertz 1983; Okonya & Kroschel 2013; Hockley & Archer, 1966; Vernon 1974; Jiri *et al.,* 2015). Accordingly, whole birds, alive or dead, or just some part, such as a feather, are reported to be placed in a river bed to avert drought, and crops are planted 'when the birds call'. This power is believed to be so strong that the bird, carcass or feather(s) must be removed later from the site, lest floods prevail. Their rain-related powers extend to being able to avert lighting strikes (H. Coetzee, Nell, & Rensburg, 2014; Derwent & Mander, 1997; Koopman, 2011). Already concern has been expressed by the people who rely on them for climate prediction (Rusinga *et al.*, 2014), as the species enabled them to know when it is worth preparing fields. This link to the rain is likely due to the species requirement for sufficient summer rain to initiate breeding.

The continental reference to the species as a *rain bird* or *thunder bird* is likely due to the species occurring overwhelmingly in Bantu-speaking regions, where cultural associations were transferred by mutually intelligible sub-languages as the Bantu spread South and East about 3000 years ago[ref?]. This analysis of cultural reverence also highlighted how varied it is across and within various language groups. This would make broad national policies very difficult to implement. For example, within Zimbabwe, the bird is reported to be widely protected by isiNdebele speakers (Chiweshe, 1998; Maasdorp, 2007; Bruyns, Williams & Cunningham, 2013; Witteveen *et al.*, 2013), but less so by chiShona speakers (Bruyns et al., 2013). This difference may have contributed to the patterns of its current distribution and range contractions. Uses are also often contradictory within the same culture: bringing both good luck (Howell & Nkomo, 2000) or bad luck (Chiweshe, 1998; Gonzalez, 2011; Wilfred, 2007), or death (Bruyns et al., 2013; H. Coetzee, Nell, & van Rensburg, 2014; Godfrey, 1941; Msimanga, 2000; Muiruri & Maunda, 2010; Whittall, 1969), or strength (H. Coetzee, Nell, & Rensburg, 2014), or fertility (Chanda & Daniel, 2014), depending on the context. To hurt, disturb or kill a bird is often treated as tantamount to killing a member of one's own family, and the species is accorded full burial customs if killed, or even found dead (Mabiza pers. com.), to prevent a retaliatory killing incurred through witchcraft (Kideghesho 2009a; Bruyns *et al.* 2013; Vernon 1986; Msimanga 2000; Adanson 1757; Godfrey 1941; Maasdorp 2007b). Use of alternate surrogate species (plant or more common avian species) has been proposed as a conservation technique, but Coetzee *et al.* (2014) found that for certain medicinal and ritual uses there were no surrogates as powerful as the ground-hornbill, such as for strength, courage and leadership (H. Coetzee, Nell, & Rensburg, 2014). An alternative approach suggested by Williams and Whiting (2016), to counter the anxiety of healers and diviners in disclosing actual uses, is rather to understand the symptoms being treated, often symptomatic of issues in the society at large.

Conservation interventions

BirdLife International (2014) suggested priority actions that have already been initiated in South Africa, and to some extent in Zimbabwe; (i) to conduct population surveys and establish monitoring, (ii) begin awareness campaigns to prevent persecution, (iii) identify key stronghold habitat and prevent degradation, and (iv) continue to research the effectiveness of artificial nest-sites. In South Africa, these actions are in line with priorities drawn from initial stakeholder engagement to ensure that sufficient research and action were invested for the species, with a total of 71 research and conservation interventions proposed (Morrison *et al.*, 2005). Several have been reiterated as priorities in the Single Species Action Group (Jordan, 2011), with additional actions bringing the total list to 74 interventions. Only 13 have been completed, with 52 still in progress and a further nine still to be initiated (see Appendix 2.3? for a summary table of details of what is being conducted, where and to what stage). Knowledge retention, however, is weak and emphasis must be placed on documentation of decision-making processes, actions and outcomes. In South Africa, of the group that formed the initial stakeholder engagement a decade ago, only 6 of the original 35 participants are still involved, and insights have been with lost due to having insufficient data collection, analysis and storage mechanisms in place. The conservation of this species will require long-term commitment and sustainable programmes supported by both finances and human resources. It will require the development of a 'community of practice' (Cundill, Roux, & Parker, 2015) to ensure that the programme is truly able to benefit from the trans-disciplinary community of stakeholders and to be transparently cooperative. It is vital that data, even anecdotal, be accumulated and stored efficiently, and shared widely and transparently.

Goals, objectives and actions

Goal 1

A Biodiversity Management Plan (BMP) for the SGH may be the appropriate national vehicle to support and ensure implementation of the PHVA. A BMP would ensure implementation and accountability with annual reporting requirements.

Goal 2

To establish a national coordinating group responsible for ensuring implementation and review of ongoing SGH conservation initiatives. The group will comprise different stakeholders with the aim to conserve SGH. This group will effectively morph the existing Action Group into a nationally relevant coordinating group, termed "Project Thunderbird"(Figure 4).

Figure 7.1. Draft logo (by Gareth Tate)

Objectives:

- Establish a central repository for data and relevant information;
    - Facilitate and implement data sharing between different parties;
- Perform a coordinating function to reduce the duplication and overlap of work/research;
- Perform a conflict management function between different stakeholders;
- Review and monitor the outcomes of the PHVA (and defined within the BMP);
- Create a platform for prioritising research;
- Facilitate partnerships between stakeholders, and find relevant new stakeholders;
- Support, coordinate and review funding initiatives; and
- Enlist adaptive management (monitoring and evaluation) to ensure a positive feedback loop

Actions:

- Develop terms of reference for this group (e.g. a guiding document);
- Determining membership and responsibility;
- Develop a succession plan to capacitate others with the institutional knowledge;
- Investigate relationship between BMP and IUCN Hornbill Specialist Group; and

Initiate launch of Project Thunderbird via social media platforms.

Possible partners/collaborators:

The current Southern Ground-Hornbill Action Group members, together with SANBI, DEA, Provincial conservation agencies, tertiary institutions, conservation NGOs, IUCN Specialist Group, private land-owners, parastatal organizations, industry (agrochemicals/other), community-based initiatives (e.g. WLTP)

Goal 3

To develop a Multi Criteria Decision Analysis (MCDA) to prioritise threat mitigation, implement appropriate interventions and manage actions taken, allowing for sustainable resource allocation.

Objectives:

- To model threats across the distribution ranges;
- Ensure appropriate allocation of resources and work load in addressing those threats;
- Ensure stakeholders are held accountable, involved and capacitated accordingly, e,g, harsher punishments for misuse of agrochemicals;
- Develop and implement appropriate relevant mitigation strategies for industry and government partners; and
    - Ensure incidents are investigated thoroughly, and appropriate action taken;

- Investigate lead poisoning initiatives and options to reduce lead use throughout South Africa; and
    - Supporting current initiatives (BirdLife South Africa).

Actions:

- Identify the person/body to develop this tool;
- Ensure all stakeholders contribute appropriate data to make the model robust; and
- Ensure responsible pesticide use is encouraged (ranges from direct application to storage).

Possible partners:

University of Cape Town, BirdLife South Africa, MGHP, Project Thunderbird, EWT, industry, SAPS, NPA

Goal 4

To enhance and support the cultural protection and indigenous knowledge of SGH across its range states.

Objectives:

- Utilize indigenous knowledge systems (encapsulating all facets of such) to enhance SGH conservation; and
    - Utilizing traditional leadership structures;
    - Ensure appropriate implementation and adequate feedback loops into the community (especially with student projects);
    - Prioritize support; and
- Develop appropriate communication and awareness tools across generations and cultures;

Actions:

- Initiate and support existing awareness and custodianship programmes; and
- Investigate social science tools for communicating across generations/culture
    - Establish a research bursary fund.

Possible partners:

Project Thunderbird, Department of Education.

Goal 5

To develop a sustainable funding mechanism for SGH conservation in South Africa. Ensuring that the PHVA/BMP actions drive funding objectives.

Objectives

- Ensure consistent funding for SGH projects for the next 5-10 years whilst protecting individual organisations funder relationships and integrity;
- Avoiding redundancy in funding applications and projects; and
- Investigate alternative funding mechanisms

Actions:

- Identify key individuals that act as a ‘middle man’ between funders and organisations (technical writers); and
    - Act as the conduit to support funding for work accepted as a priority within the PHVA, and ensuing BMP; and
- Initiate a social media funding campaign.

Possible partners:

Project Thunderbird

WORKING GROUP 2: POPULATION VIABILITY ACROSS LAND USE TYPES

Background

Land use identification

Southern Ground Hornbills (SGHs) are found across a diverse range of savanna-type ecoregions throughout the eastern half of South Africa (Kemp, 2017). A range of land use types are found within each of these broader ecoregions and have been subdivided into general categories below (Figure 1). Key land use types have been highlighted where conservation strategies may benefit the SGHs and further research can be rolled out. The three key land use types are privately owned conservation land (and wildlife rangelands), agricultural land (crop and livestock) that is suitable for the SGHs, and communal rangelands for domestic livestock (Figure 2.1 grey shading).

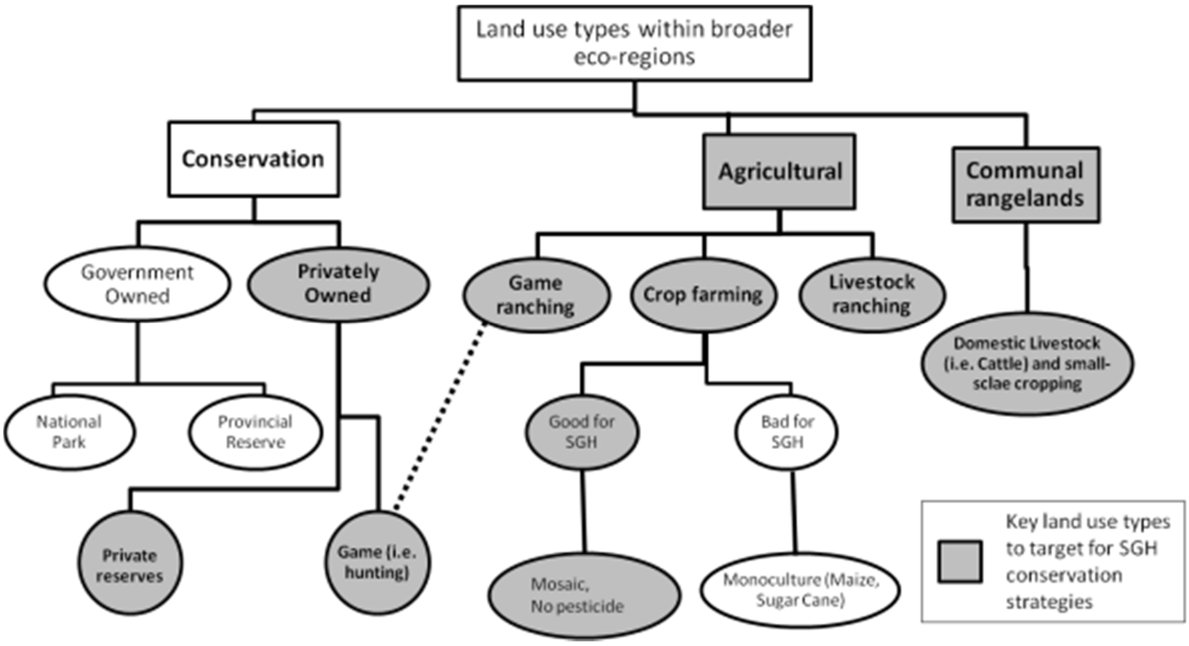

Figure 7.2. Identification of key land use types found in the known broad eco-regions within the natural distribution of the Southern Ground Hornbill.

Goals, objectives and actions

Identify large SGH-friendly core and buffers areas for custodianship work, future research and management interventions that will benefit the species and promote population growth and range expansion.

Goal 1

Interrogate productivity of the BAOBAB (captive rearing programme at Loskop Dam Nature Reserve – MGHP/MTPA Alliance)

i. How many individuals/groups are able to be reintroduced per year into selected suitable sites (Table 1). *See captive breeding Working Group 3 section for further info.*
ii. Potential group configuration will be modelled as an alpha male, alpha female with two helper males per introduced group of four birds

Table 7.1: Some test examples for land use model variables for reintroducing SGHs to identified core areas

BAOBAB hand-rearing programme	
Time to raise a chick to releasable age (months) could be longer for males	6
Maximum chicks that can be raised simultaneously	15
Rate of production (birds/year)	15
Bird variables	
Average Home Range (km^2)	100
Average Group Size (no. birds)	4
Core Area Variables (still to be ascertained)	
Number of groups reintroduced	5
Total area available, km^2	500
Total number of birds hosted	20
Number of SA core areas	3
Timeline for reintroductions	
Time to populate one core area (years)	3
Time to reintroduce into all core areas (years)	9

- Map current potential available habitat throughout historical range of SGHs (L. Kemp) to assist in suitable site selection/identification in different core areas of historical range (i.e. Eastern Cape, Kwa-Zulu Natal, Limpopo)
- What proportion of the SGH population is found in other key land use types?
    - Spatial ecology research into the fine-scale available habitat using remote sensing (and LiDAR?) to identify potential movement corridors, core available habitat and currently less desirable areas that could be managed into desirable habitats using Megan Loftie-Eaton (PhD) woody cover parameters and current SGH ecology knowledge

- Identify core areas and suitable buffer zones for potential dispersal of introduced population offspring

Goal 2

Test limiting factors for SGH success in the identified key land use types, especially those outside of the protected area network (i.e. communal rangelands and agricultural land): collaboration with the ecology section Working Group 4 needed.

- APNR research has covered how the population behaves in the private conservation sphere; new research needs to target communal rangelands and agricultural land use types in other parts of the natural SGH range
- We conclude from the APNR data that nests are not a limiting factor in any land use type as artificial nests can be provided that the birds will use successfully (Carstens pers. comm., 2017)
- At least three MSc students could be attracted to assess how the SGHs are using the habitats in different land use types within selected areas, as determined through spatial analysis as per Goal 1)

2. Proposed future research will need to focus on habitat use in the key land use types, while also measuring population ecology in each of the abovementioned areas (Table 3)

Table 7.2: Research needs identified for the Southern Ground Hornbills (SGH) in different areas of the South African distribution. Each category will need to be investigated in the areas specified in Table 2.

• **Habitat use** - Direct observations - Vegetation Analysis (how does vegetation structure influence access to food items – diet). - Satellite tracking.	• **SGH Ecology** - Breeding. - Population dynamics.

Goal 3

Recognition of the species in provincial and national land use management plans and policies (refer to Working Group 1 for further information)

- Use connection with Prince Buthelezi to push for national recognition through DEA and national scientific authority
- Ensure trickle-down effect from national bodies to provincial authorities i.e. MTPA, EKZNW, LPTA, etc.
- Also use a bottom-up approach by directly contacting the provincial conservation authorities to recognise SGH in their management plans. Example of the oribi is

suggested as a successful example of this approach. Provincial authorities that need to be approached are the Eastern Cape, KwaZulu Natal, Mpumalanga and Limpopo

Goal 4

Develop guideline document which can be distributed to land owners/managers/communities/custodians to promote SGH conservation through management and mitigation.

- Use the APNR data, which provides the support data to guide development of management guidelines and educate land owners about managing their veld for the benefit of the hornbills
- Must be tailor-made to the different land use types i.e. do not provide a sweetveld land owner with sourveld strategies
- Megan Loftie-Eaton (PhD) woody cover parameters combined with current habitat-use data in private conservation land use types (APNR) to generate data-based management guidelines

Modelling Implications

- PHVA models will need to be populated based on the ecological data collected across the different land use types. The PHVA model developed in 2017 represents the private conservation land-use type. Future PVHA models can be developed for the other key land-use types once the baseline data has been collected through the research projects mentioned under goal (ii)
- Reintroduction rates developed under goal (i) can be included in the current PVHA model to represent the supplementation of individuals into historically occupied areas

WORKING GROUP 3: CAPTIVE BREEDING, REARING AND REINTRODUCTION

Captive Population

Goals

Direct conservation goals

The following direct conservation goals have been identified for the *ex situ* population using the "IUCN Species Survival Commission guidelines on the use of *ex situ* management for species conservation" (IUCN/SSC, 2014)

1) **Demographic manipulation** i.e. 2nd chick collections (head started programme)
2) **Source of population restoration** i.e. to re-establish the species in parts of its former range or to reinforce an existing population
3) **Research and training** – direct conservation benefit
4) **Education and awareness programmes** – to address specific threats or constraints to the conservation of the species or its habitat. (Need to target communities directly linked to SGH)

Indirect conservation goals

As well as contributing directly to the Conservation of the species, several indirect conservation goals have also been identified:

5) Small scale fund raising to contribute to high priority *in situ* projects
6) Carry out education and awareness about the status of and threats to the species and its habitat / ecosystem.

Objectives:

Goal 1: Demographic Manipulation

- Maintain annual harvest sufficient to meet population restoration targets
- Ensure harvest is genetically representative
- Manage for natural sex bias

Goal 2: Source of population restoration

- Maintain current breeding pairs in PAAZA accredited facilities for output to be used as reintroduction stock.

Goal 3: Research and training

- Maximise potential of captive birds for research (Genetic, medical trials, physiological, vocalisations, behavioural, transmitter attachments etc)

Goal 4: Education and awareness programme (including indirect conservation goals)

- Maximise awareness potential

    - Communities that have a direct influence over conservation goals
    - Communities that have an indirect influence over conservation goals and for general awareness

Fund raising

Actions:

Goal 1: Demographic Manipulation

- Categorise captive capacity and enclosures;
- Differentiate between true captive and transitioning birds;
- Increase carrying capacity for transitioning birds.

Goal 2: Source of population restoration

- Master egg sexing technique on captive bird's eggs;
- Refine minimum husbandry standards;
- Develop training materials on husbandry standards;
- Identify pairs that are genetically over represented to ensure genetic diversity;
- Maintain current number of breeding pairs;
- Maintain South African birds and Tanzanian birds separately

Goal 3: Research and training

- Initiate research:
    - To assess if telomere length can be utilised for age determination, which will require controls of known-age individuals inhabiting similar habitats to ensure calibration; and
    - Colouration and age – photo survey.
- Initiate two pilot projects:
    - Send SA pair overseas – expand holding / breeding facilities; and
    - *Attempt transport of an egg from an overseas facility to test the feasibility of large-scale import of eggs for rearing at the Baobab facility (from genetically suitable pairs)

Goal 4: Education and awareness programme (including indirect conservation goals)

- Educational messaging guidelines to be developed for use by *Ex situ* facilities
- Facilities to identify fund raising opportunities where possible

To find solutions for the following limiting factors:

- Too many females – as a result of harvesting as well as for captive breeding;
- Unsuitable males for release remaining in captivity (fondly termed '*cabbage patch kids*');
- The MoU with SANParks does not permit selling of harvested birds overseas – what to do with non-releasable birds?
- Captive facilities not always sustainable;

- Not enough facilities (unless overseas zoos are co-opted);
- Husbandry standards – not all facilities currently holding SGH follow the protocols for husbandry standards;
- and not enough research in captivity regarding group dynamics.

Actions

Notes:

- Potential new breeding enclosures:
  - 5 at the Baobab Rearing Centre;
  - 2 at National Zoological Gardens (NZG);
  - 1 at Mokopane (NZG satellite facility);
  - 1 at Johannesburg Zoo; and
  - 1 at Ubhetyan-o-Africa'
- Establish whole breeding groups for release from Baobab;
- Breeding enclosures - potential for multiple breeding enclosures at a single facility. It is fine to hear each other but better not to let them see each other; and

Reintroduction

Reintroduction of three groups annually off production of 15 high-quality reintroduction stock reared at the Baobab.

Problem statements

a) Do not have enough sites for bush schools (appropriately in areas where needed – site selection);
    a. Habitat; and
    b. Monitors.
b) Staff capacity for oversight.
c) Bush schools will be time restricted – once breeding themselves will no longer be able to augment group.

Short term goal / actions

a) Increase the staff compliment for the Mabula ground hornbill project;
b) Refine and implement mechanism to only harvest male chicks;
c) Identify release sites for all female group(s); and
d) Investigate programme to alternate harvesting between captive bred and wild bred sources

Variables to consider for augmentation of existing groups:

- Age of released birds;
- Time of year/season;
- Parent reared vs hand reared;
- Sex of chick;
- Group composition of group to be augmented;
- Time of chick in boma before release;
- Chick personality;
- Nest position in relation to release boma;
- Supplementary feeding;
- Rainfall ;
- Average temperature;
- Acceptance behaviour shown;

- ‘Gut feeling‘/previous experience;
- Release from boma methodology;
- Only male released; and
- Only effective if group does not breed – cannot release if group has own chick.

Variables to consider for group releases (See Working Group 2: Goal 1)

- Distance between groups;
- Suitable human neighbours (land uses);
- Habitat suitability;
- Food availability;
- Group bonding prior to release; and
- Surplus females (all female release?).

Implications for Modelling

Assumptions

- Simple monogamous system
- Single pair model

Baseline Model

- Starting from scratch from 4 pairs: 1st year mortality down to 10%;
- Females 1st breeding at 6 and males at 8;
- Proportion breeding per annum = 75%;
- 2 chicks 50% of the time;
- 20 year model; and
- Result - grows to carrying capacity in20 years. Inbreeding co-efficient = 3.5 %.

Model 1: Adding new pairs

- Adding new breeding pair every 2 years;
- Achieves carrying capacity much faster (after 12 years). Inbreeding down to 1%;

Model 2: Harvesting

- Adding new breeding pair every 2 years;
- Can sustain removal of 1 x 1 year old males for next 20 years.

Model 3: (Wild harvesting)

- Removal of groups from wild population
- Source group reintroductions from wild

Still to Model: How many birds need to be released (and survive to breeding age) per annum to make a significant difference to the survival of the population *in situ?*

IUCN/SSC (2014). Guidelines on the Use of Ex Situ Management for Species Conservation. Version 2.0. Gland, Switzerland: IUCN Species Survival Commission.

WORKING GROUP 4: ECOLOGY

Kate Carstens, Antoinette Kotze, Kyle Middleton, Alan Kemp

Background

A wealth of recent theses and publications have greatly enhanced our understanding of the ecology of the species since the last PHVA. Within the last decade, these have described the threat of bush-encroachment (Loftie-Eaton 2017), assessed the status and genetic connectivity of the species across its entire distribution (Kemp 2017), investigated habitat preferences and habitat use by social groups (Wyness 2011, Zoghby 2015), investigated factors associated with reproductivity (Wilson et al. 2011), and assessed the role of nest boxes as a conservation tool (Carstens 2017). Importantly, much-needed data on the ecology of the species was generated from studies outside of South Africa (Msimanga 2004, Witteveen et al. 2013). These are just a few of the research outputs generated on this species recently, and each one has contributed to the information required to make evidence-based conservation plans.

There are important gaps in our knowledge which require addressing in the near future to build on the current and existing foundation of knowledge. Some have more of a conservation focus, others to simply deepen our understanding of the species. These goals, each described in the section below, focus on a wide range of outstanding issues, such as: increasing our understanding of the population size outside of protected areas, using molecular markers to address questions regarding relatedness and health, and understanding basic biological aspects such as moult. It is acknowledged that there will always be gaps in the knowledge, and that in the future more biological questions will arise. However, by tackling these goals listed below, we will be making significant progress toward resolving some long-standing, unanswered questions about this fascinating species.

Goals, objectives & actions

Goal 1: Increase long-term data in non-protected areas

Objectives

- Estimate reliable estimate of population size in KZN
- Estimate reliable estimate of population size nationally

Actions

- Citizen science and provincial monitoring plan, at p entad level, reliability indicated by colour (green to red) over 4-year cycle, from presence/absence to productivity, nest sites and possibly including group composition in reports by .2018).
- Mimic KZN monitoring plan and implement nationally, coordinated at a national level. Eastern Cape: Xhosa hierarchy. Limpopo: Venda (e.g. Ramaphosa, Duncan MacFadyen). Each province to have a coordinator to make phone calls to areas to get sightings, with help through e.g. EPWP, foot soldiers on the ground by 2019).

Possible partners

EKZNW, MGHP, provincial wildlife authorities and DEA, EWT, directed through MGHP.

Expected Outcome

- A province-wide coverage of ground-hornbill population size, productivity
- A nation-wide coverage of ground-hornbill, population size, productivity

Goal 2: Various molecular studies to assess the genetic fitness across different spatial scales, and to gain new insights into age at first breeding, diet

Objectives

- Assess relatedness at the group level;
- Assess genetic fitness, distribution-wide (immunity);
- Determine whether investigating telomere length can be used to age ground-hornbills; and
- Can faecal samples and feathers be used for diet analysis and or isotope analyses?

Actions (all by end 2019)

- ;Initiate a study investigating relatedness of group members using blood samples collected nationwide);
- Initiate a study investigating genetic fitness via immunity using toll-like receptors;
- Initiate a study testing the feasibility of utilising telomere lengths as a means of aging ground hornbills.; and
- Initiate a study investigating the composition (species) of ground hornbill diets using DNA barcoding.
- Generate a standardised sampling protocol to collect all samples necessary for all studies involving SGH biological samples and/or isotopes.

Possible partners

- NZG, MGHP, UCT to liaise and plan the way forward on outputs, Project Thunderbird
- Potential collaborators: Isotope lab at UP, University of Cardiff

Expected Outcome

- Understand the relatedness of individuals in a group, prevalence of EPCs, and whether or not the ground hornbill group organisation suggests a dynasty;
- Create an immune assessment map, to understand variation in the immune system;
- Given that age is hard to predict, determine age with telomere lengths; and
- Determine a sampling strategy per site.

Goal 3: Safeguard and modify existing natural nesting sites and/or supply artificial nests

Objectives

Ensure the long-term persistence of existing natural tree cavities for nesting.

Actions (by end 2018)

- Place stones around tree bases to block access by elephants
- Metal sheets around tree bases to protect against nest predators

Erect artificial nests where ecologically applicable, and logistically, ecologically and socially feasible.

Possible partners
All field workers.

Expected Outcome
Safe-guard existing natural tree nesting sites and/or supply new/additional ones

Goal 4: Find a way to attach transmitter

Objectives
To develop a safe way of attaching transmitters that can ultimately be used in future studies involving movement of individuals. E.g. to understand dispersal propensity of females and males, as well as how floater individuals move in time and space.

Actions (by 2019)

- A safe design to hold a transmitter for at least a year, transmitting every 5-10 minutes, not more than an hour
- Trial designs in captivity (MGHP, Dr Katja Koeppel) and in a managed situation (Mabula),

MGHP),EWT to recapture remaining harnessed birds in KNP to assess any chafing or damage

Possible partners
EWT, MGHP, UCT-FIAO

Expected Outcome
A publication on the history of transmitter-use: type, attachment and a SOP

Goal 5: Gain a better understanding on predation levels at nests

Objectives
Identify nest predators and nest predation frequency

Actions (by end 2018)
Install camera traps inside and outside nests.

- Where deemed necessary, install metal sheets around the bases of nest trees to protect incubating females and growing chicks against nest predators.

Possible partners
UCT-PFIAO, EWT, MGHP

Expected outcome

- Identification of nest predator species,;
- Accurate predation frequencies; and
- Increase fledging success

Goal 6: Investigate parasites and pathogens that may impact Ground-Hornbill health

Objectives

Identify pathogens, such as ticks and mites that may impact individual health.

Actions (end 2017)

- Initiate the collection of ecto-parasites (ticks and feather mites, lice) during handling of birds.

Collect blood smears to identify endo-parasites and blood samples to detect pathogens

***Possible** partners*

UCT-FIAO, EWT, NZG, MGHP, UP. Koeppel + students).

Expected outcome

Epidemiological survey of ground-hornbill diseases and the creation of an SOP produced for consistent sampling

Goal 7: Collecting additional biological information

Objectives

- Identify the moult pattern of the species;
- Investigate group and sex recognition through vocalisation recordings;
- Understand helper roles in territory defence and chick provisioning.
- Investigating ground hornbill 'side-burns' as a means of individual identification.; and
- Investigate into bill and throat pouch colouration and how it changes with age and social status

Actions (all 2017-2019)

- Using captive individuals where possible, photograph spread wing and tail feathers and record feather moult. In addition, collect moulted feathers to re-create moult pattern;
- Record calls of groups and individuals, no further than 300 m away, during dawn chorus and opportunistically. Record vocalisations at captive facilities;
- Install camera traps at nests to record chick-provisioning rates. Use call-ups to assess individual roles in territory defence; and
- Photograph individuals in the field in the cases where groups are hard to catch, to provide a means of individual identification failing ringing or tattooing - if it is it consistent, can you

use it to age? Is there any effect on ageing, or effects dominance or individual suppression behaviour

Possible partners

PAAZA facilities, UCT-FIAO, Additional data by EWT, PAAZA, MGHP

Expected outcome

- A moult library for the species;
- An understanding of inter- and intra-group communication.; and
- Determining whether Contribution of unrelated individuals to territory maintenance/defence and chick provisioning, as compared to related individuals
- The development of a reliable technique for identifying individuals based on phenologies.

WORKING GROUP 5: STOCHASTIC POPULATION MODELLING

Michael W Bruford, Isa-Rita Russo, Rhys WN Bruford

Methods

The software VORTEX 10 (Lacy et al. 2015) was used to conduct stochastic population modelling of the Southern Ground-Hornbill (SGH), focusing in the first instance on South African populations. This analysis builds upon work that was carried out in 2005 during the first SGH PHVA workshop, where stochastic modelling was also included, using Vortex 9.4, by Kerryn Morrison and colleagues.

Briefly, the 2005 PHVA model was first re-analysed using Vortex 10 under Malthusian conditions (in the absence of inbreeding depression, catastrophes and carrying capacity limitation, for input data see Table 7.4). This model predicted the population to decline rapidly, indicating that the 2005 life history data did not permit the population to grow under ideal conditions. Therefore, a new model was constructed and sensitivity tested to better reflect the species' capacity for intrinsic growth (up to 2% per annum) that the SGH is now known to possess (Kemp, A. *pers. comm*.).

Using a combination of 2005 values with new data from SGH studies at the Associated Private Nature Reserves (APNR), Mpumalanga Province (Kate Carstens *et al.* unpublished), and collected by L Kemp from workshop participants, and others prior to the meeting, parameters were identified and modified accordingly (see description of the APNR study site below). Altered parameters included inbreeding, Environmental Variation (EV) correlation between reproduction and survival, maximum age of reproduction (females/males), maximum life span (females/males), age and sex specific mortality, and fecundity (maximum number of progeny, sex ratio at birth, distribution of broods per year, number of offspring per brood). Five hundred iterations were initially used with the population size being arbitrarily set at 200 individuals to analyse the performance of the model. Sensitivity testing was carried out to optimise the Malthusian growth rate in accordance with expectation for constrained and unconstrained populations (r~0.01 and ~0.02 respectively).

Once the Malthusian model was optimised, density dependent reproduction (DDR) was included, using demographic data from Carstens *et al.* (unpublished) for APNR (Table 7.5). A growth curve was developed by comparing change in mean group size and total offspring productivity between 2000 and 2015 (Figure 7.3). The results indicate a substantial Allee effect for offspring productivity (35% of maximum), a maximum productivity at 63.5% of carrying capacity K (K defined at the point at which group size did not increase over time) and a substantial decline in productivity as group size asymptotes (to 45% of maximum). The shape of the curve was also used to quantify the Allee (=1) and steepness parameters (=1). It should be emphasised that this curve was generated for a population at artificially high density due to the use of nest boxes to encourage breeding at APNR.

Table 7.3: Summary model outputs for final Malthusian model and (modified) density dependence. (det-r = deterministic intrinsic rate of growth, stoch-r = stochastic intrinsic rate of growth, PE = probability of extinction, N-all = mean final population size for all simulations, AlleleN = Final number of alleles, MeanTE = average time to first extinction.

Scenario	#Runs	det-r	stoch-r	PE	N-all	GeneDiv	AlleleN	MeanTE
Malthusian with density dependence and age first breeding 17	500	-0.018	-0.023	0.712	2.30	0.697	5.01	162.2
Malthusian with density dependence and age first breeding 19	500	-0.020	-0.025	0.824	1.39	0.680	4.84	153.3
Malthusian with density dependence and age first breeding 12	500	-0.013	-0.017	0.332	11.82	0.802	9.41	170.3
Malthusian with density dependence and age first breeding 13	500	-0.014	-0.018	0.404	9.25	0.775	8.36	168.7
Malthusian with density dependence and age first breeding 14	500	-0.015	-0.019	0.508	6.16	0.764	7.57	166.0
Malthusian with DD +20%, age first breeding 15	500	0.022	0.012	0	1899	0.984	113.59	0.0
Malthusian with DD +15%, no dispersal mortality, age 15	500	0.020	0.009	0	1235	0.980	95.20	0.0
Malthusian with DD +19%, no dispersal mortality, age 15	500	0.022	0.012	0	1850	0.984	112.43	0.0
Malthusian with DD +18%, no dispersal mortality, age 15	500	0.021	0.011	0	1747	0.983	110.01	0.0
Malthusian with DD +18%, no dispersal mortality, age 15	10000	0.021	0.011	0	1706	0.983	108.45	0.0
Malthusian no DD and age first breeding 15	500	0.009	0.008	0	1134	0.980	93.68	0.0

The first implementation of density dependent reproduction on the optimised Malthusian model caused the population to decline substantially. As a result of this, and in discussion with the Ecology working group and other members of the workshop, and accounting for the fact that the APNR population was established using a high density of nest boxes, further sensitivity testing was conducted. The two parameters that were varied were age of first reproduction for both sexes (n=15, Table 7.4) and density dependence, where the negative effects on productivity were reduced by 15-20% (Table 7.5). Further sensitivity testing using data and discussion with the group resulted in a final baseline model with a reduction in density dependent effects for P(0) and P(K) of 18%, which produced a deterministic growth rate of 0.021 and a stochastic growth rate of 0.011 (Table 7.3, Figure 7.3). Using the final parameter values (Table 7.4), a simulation of 10 000 iterations was conducted to verify this baseline model (Table 7.4 & 7.5). This final baseline model was used in subsequent management scenario testing.

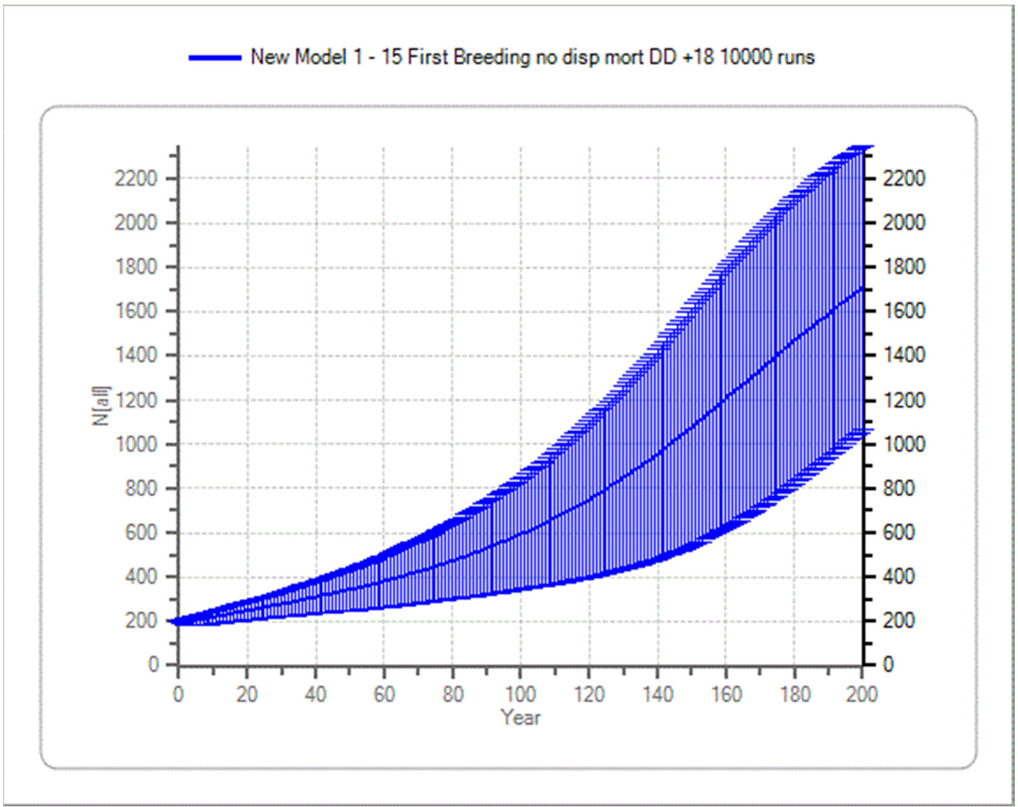

Figure 7.3. Growth curve (including standard deviation) for final baseline model (mean of 10,000 iterations presented).

Management Models

Captive breeding/reintroduction

In collaboration with the Captive Breeding working group a series of models were developed to test the sustainability of the captive population in its current situation, how it may be improved using regular supplementation from wild-caught birds and how it might provide a source for augmentation of social groups in the wild. The current captive population only comprises four breeding pairs of South African origin and we tested how this population would be expected to develop with (one pair every two years for 10 years) and without supplementation over the coming 20 years. We further assessed whether a supplemented population could provide a male chick for reintroduction into the wild once the captive population had achieved carrying capacity (90 birds).

Specifics of the captive model included: 20 and 40 year time-scale, implementation of inbreeding depression (due to small population size - we used 6.29 Lethal Equivalents, and 50% of inbreeding depression due to recessive lethals, the default values in Vortex in the absence of other data), EV correlation of reproduction and survival = 0, age of first offspring 6 for females and 8 for males, 75% of females breeding per year, 50% producing one offspring and 50% produce 2, low mortality rates (10% for 0-1, 5% for subadults and 2% for adults), 100% of males in breeding pool, initial population size of 8 (four pairs), carrying capacity of 90 (currently there are 60 South African birds being held and ~30 of Tanzanian origin). Figure 7.4 shows the results for all three scenarios in terms of population size and Figure 7.5 for inbreeding coefficient.

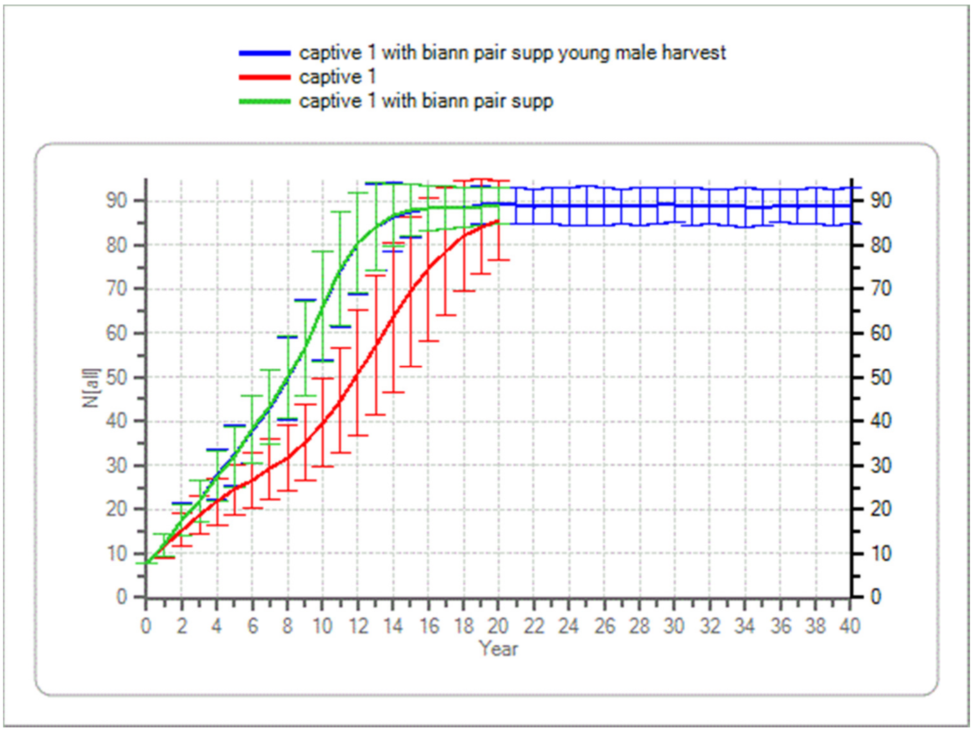

Figure 7.4: Population growth over 20 and 40 years in captive population models.

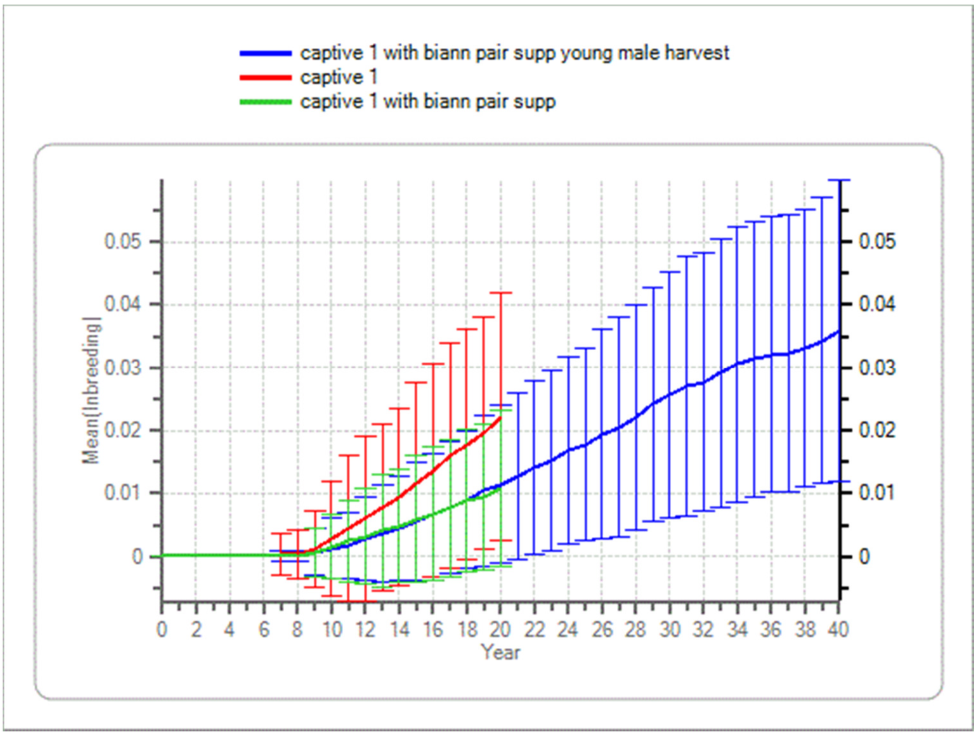

Figure 7.5. Inbreeding coefficient over 20 and 40 years in captive population models

It can be seen that the pair supplementation model provides a benefit not only in assisting the captive population in achieving carrying capacity, which it does after just 14 years, but also constrains the inbreeding coefficient below 1%. However, it should be noted that in the absence of further supplementation into the captive population, the inbreeding coefficient achieves 3.5% at the end of 40 years, implying that further, periodic supplementation is needed to maintain genetic health. Most importantly however, this analysis shows that the captive population, provided it receives periodic supplementation of wild pairs, can produce one male chick every 2 years, for wild the augmentation purposes, without any negative effect on the demographic stability of the captive population.

Reintroduction using only wild birds

Next, we simulated the effects of an ongoing plan to harvest redundant chicks from approximately 100 wild nests to supply birds for the establishment of new SGH groups in areas between current populations to provide population connectivity between currently disconnected sites. Two group demographies were employed, first establishing a group with four subadult individuals aged 3 years, and second with an adult pair and a three-year old helper male. Here the modelling largely followed the baseline scenario described above with the exception that: simulations ran for 40 years, density dependence was not used, an initial population size equal to that currently estimated for South Africa was used as the 'source' population (n~2,880, although it is clear that not all birds and nests can provide chicks for this program, we decided to examine the effects of harvesting on the population as a whole), a carrying capacity of 7,920 (currently estimated for the whole of South Africa, Carstens *pers comm*), harvesting of whole groups (2 and 3 groups, tested for both group configurations) every year for 20 years of the 40 year simulation. However, this will require further modelling as the current reintroduction programme is based on harvest of redundant second-hatched chicks that would naturally die and so has no impact on the remaining wild population. The occasional harvest of sub-adult males to take the role of mentors in 'bush-schools' will thus have negligible effect on the remaining population, but perhaps if the group size of origin is low, there might be with Allee effects on the group. This has only been undertaken once and no impact was measured in breeding success (Carstens K., pers. comm.).

A very clear outcome was achieved using all scenarios (**Figure 7.6**). All scenarios showed that the harvesting program would not impact on population growth, genetic diversity or probability of extinction. A stochastic growth rate of 0.0121 - 0.0125 was generated in all cases, very similar to the baseline growth model. Indeed, the deterministic growth rate (0.0331) is significantly higher than the baseline, possibly reflecting the increased growth expected for a large population (although it should be borne in mind that density dependence was not implemented here, due to the fact that harvesting acts in the same way as density dependence would in natural populations).

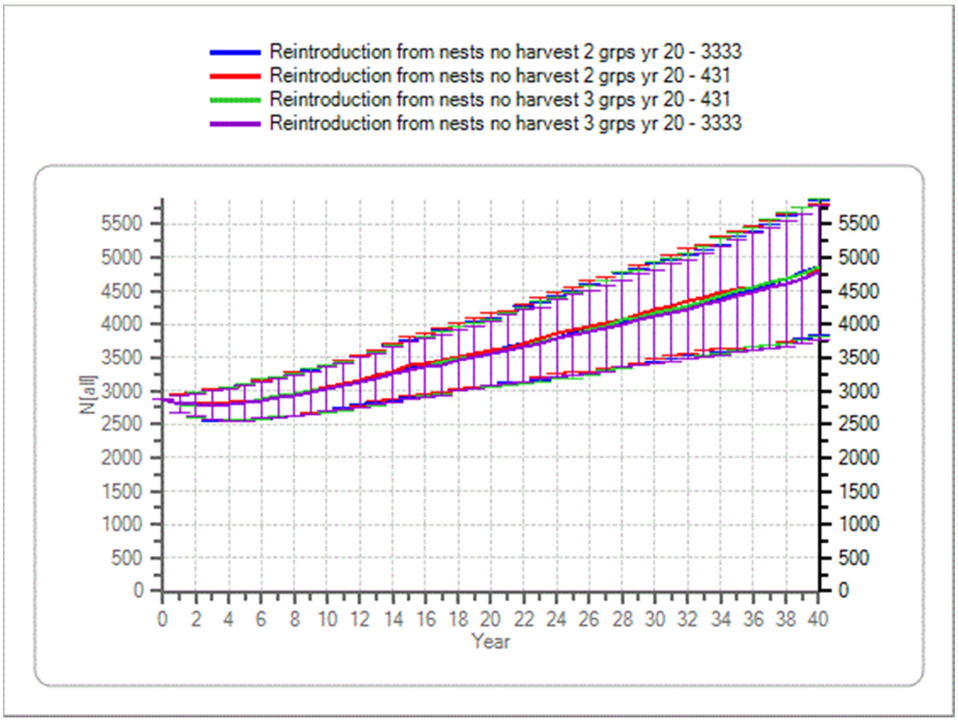

Figure 7.6. Population growth over 40 years in wild reintroduction models

Group-level reintroduction

Finally, group level reintroduction plans were tested in collaboration with the land-use group to assess whether current plans for reintroduction of groups into conservancies could be carried out in a sustainable fashion. Here, models were developed for the establishment of five social groups at a hypothetical site with 10 available territories to establish whether such group-based reintroductions could result in a viable population becoming established. Once again, model parameters largely followed those for the baseline wild scenario with the exception of: simulations ran for 40 years, 10 subpopulations were used (to represent groups and empty territories), inbreeding depression was used in some scenarios using the same values as for the captive population, female dispersal was modelled for individuals aged 1-2 with 10% between each subpopulation (summing to a 100% probability for each bird), a dispersal modifier function (=D*[(S='F') OR (RAND>0.9)] was used to simulate male dispersal occurring at 10% of the probability of female dispersal, 75% survivorship during dispersal, an initial population size of four or five birds (one female aged 16, one male aged 2, one male aged 3, one male aged 16 for four birds with an additional male aged 2 for five-bird models), carrying capacity per territory of 6 birds and finally population supplementation was modelled for some scenarios with birds (males aged 4 and 10) at year 5 and 10.

This complex model proved very difficult to stabilise and it was found that the populations would not survive unless mortality was substantially altered to reflect the interventional management needed to assist the establishment of these groups (see Kemp 2017). Altering the model to reflect this, and using mortality values of 9% for individuals aged 1-3 years with 5% thereafter resulted in a population that stabilised (but which did not show signs of growth) over 40 years in terms of numbers but where individual subpopulations had a probability of extinction of ~0.3 (**Figures 7.7** and **7.8**). These models will require further evaluation during the workshop.

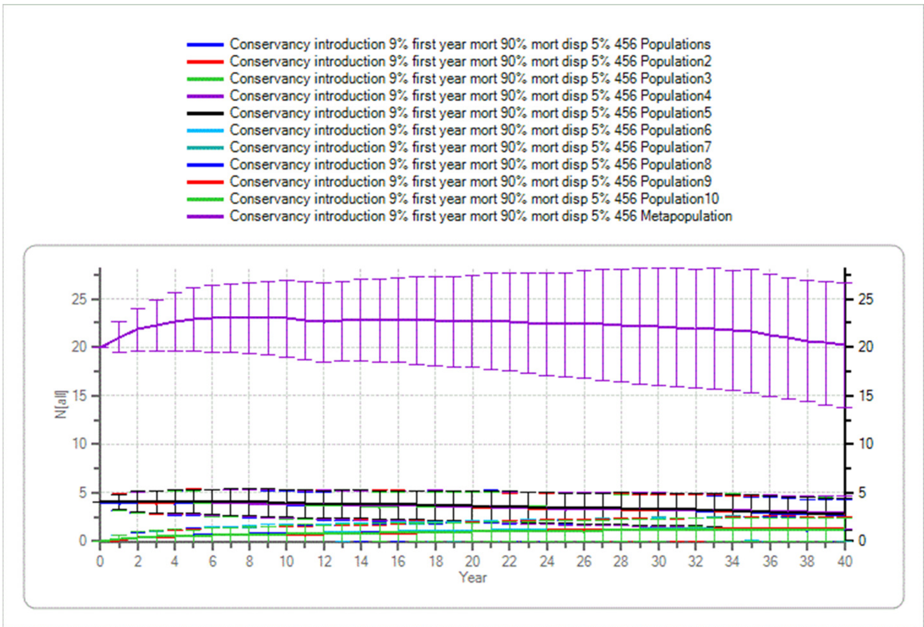

Figure 7.7 Population growth in group level conservancy model for five introduced groups over 40 years, with managed mortality.

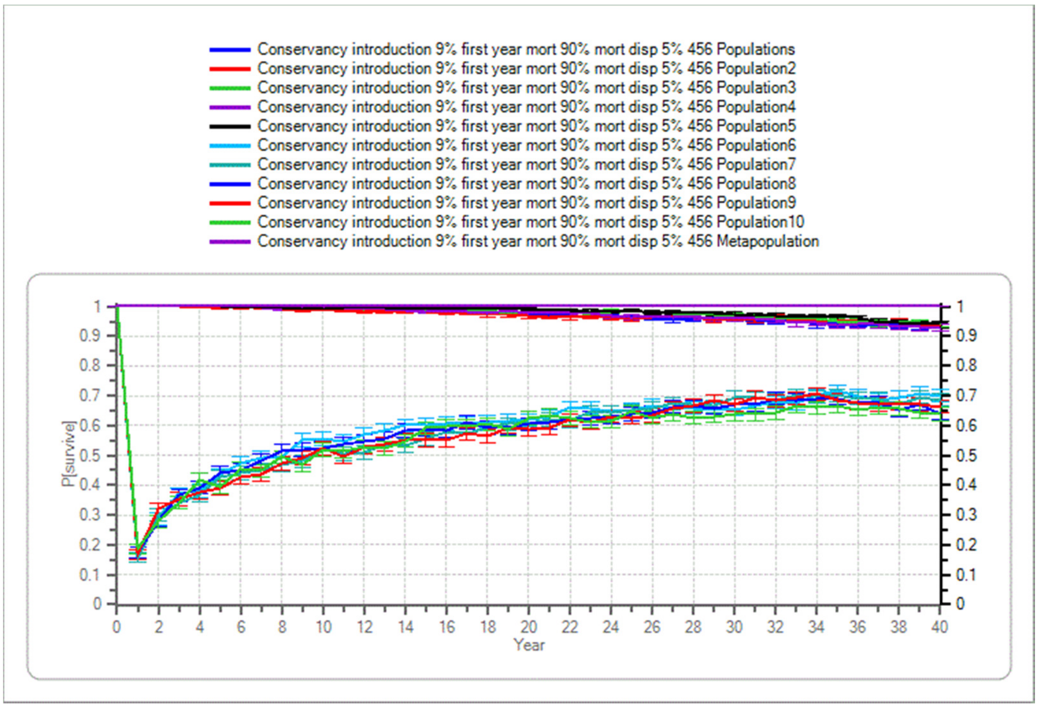

Figure 7.8. Probability of survival in group level conservancy model for five introduced groups over 40 years, with managed mortality.

Table 7.4. Malthusian parameter values

Parameter	Tested parameter values	Final value	Justification
Number of years	200 (approx. 10 generations)	200	Approximately 10 generations
Inbreeding depression	None	None	Very little inbreeding recorded, population sizes in 1 000s
EV correlation	0.2	0.2	While good years for reproduction are good years for survival, bad years for reproduction have very little effect on survival
Reproductive system	Long term monogamy	Long term monogamy	Almost universally observed
Age of first reproduction for females	9-15, 17, 19-21, 23, 25	15	Based on field observations a value lower than 15 seemed unlikely. Sensitivity testing showed that a value above 15 was not viable
Age of first reproduction for males	9-15, 17, 19-21, 23, 25	15	As above
Maximum age of female reproduction	50	50	Field/captive observations
Maximum age of female reproduction	50	50	Field/captive observations
Maximum life span of females/males	60	60	Field/captive observations
Maximum number of broods per year	1	1	Field/captive observations
Maximum number of progeny	1	1	Although three eggs can be produced, which may hatch, only one chick survives to fledge in natural conditions. Due to difficulties in observing nests and limited availability of data on

Parameter	Tested parameter values	Final value	Justification
			first year mortality, data gathering focused on measuring mortality for the one surviving chick
Sex ratio at birth	50%	50%	Field/captive observations
% Females breeding	57%	51.3%	Carstens' APNR data for 31 adult females and 22 female chicks were analysed using standard mortality schedules, inferring that expectation of three non-breeding chicks surviving to adulthood: 10% of female adult population size generating 51.3% (SD = 40%, Kemp, personal communication)
% One brood	100%	100%	Field observations
% Broods with one offspring	100%	100%	Field observations
Mortality rates: Female	Y 0-1: 40.5, 36.5, 32.5, 28.35	Y 0-1: 28.35	Sensitivity testing was carried out, with mortality rates used that contributed to the model generating r-values as described above (Kemp, personal communication). Initial mortality % values were based on discussion with the different working groups but the model showed no population growth. Mortality values had to be adjusted by an incremental decrease of 10% (up to 30%) in order to generate r-values as described by Kemp
	Y 1-2: 45, 40.5, 36, 31.5, 28.35	Y 1-2: 28.35	*, ¶
	Y 2-3: 20.25, 18.25, 15.25, 14.175	Y 2-3: 14.175	*
	Y 3-4: 20.25, 18.25, 15.25, 14.175	Y 3-4: 14.175	*
	Y 4-5: 20.25, 18.25, 15.25, 14.175	Y 4-5: 14.175	*
	Y 5-6: 20.25, 18.25, 15.25, 14.175	Y 5-6: 14.175	*

Parameter	Tested parameter values	Final value	Justification
	Y 6-7 onwards: 2.7	Y 6-7 onwards: 2.7	*
Mortality rates: Males	Y 0-1: 40.5, 36.5, 32.5, 28.35	Y 0-1: 28.35	*
	Y 1-2: 20.25, 18.25, 16.25, 14.175	Y 1-2: 14.175	*
	Y 2-3: 20.25, 18.25, 16.25, 14.175	Y 2-3: 14.175	*
	Y 3-4: 20.25, 18.25, 16.25, 14.175	Y 3-4: 14.175	*
	Y 4-5: 25, 22.5, 20, 17.5, 14.175	Y 4-5: 14.175	*, ß
	Y 5-6: 20.25, 18.25, 16.25, 14.175	Y 5-6: 14.175	*
	Y 6-7 onwards: 2.7	Y 6-7 onwards: 2.7	*
% Males in breeding pool	69%	69%	Field observations (Carstens *et al.* unpublished)
Initial population size	200	200	Arbitrary value for baseline model
Carrying capacity	2500	2500	Arbitrary value for baseline model

[#]Generation time of 20 years.

[¶]Females disperse at age 1-2 and not at age 5-6. Mortality for dispersing females is higher than the 0-1 year mortality (due to no group protection). Mortality was changed so that females age 1-2 had a mortality of 45%.

[ß]Males leave their natal groups at age 4-5 and therefore a mortality rate of 25% was given because they are more easily incorporated into a social group than females.

Table 7.5. Baseline parameter values including the Density Dependent Reproduction (DDR) rates.

Parameter	Values (range)	Final value	Justification
% Breeding at low density, P(0)	35, 50, 51, 52, 53, 54, 55	53	The initial value was based on Carstens' APNR data. DDR rates were sensitivity tested by using different threshold % values (frm the original value a 15, 16, 17, 18, 19 and 20% increase). The interaction between age of first reproduction for both females and males and DDR rates caused a population decline. First reproduction age (both sexes) lower than 15 seemed unlikely and sensitivity testing showed that a value above 15 was not viable. Therefore, first age of reproduction was kept at 15 and a range of values were tested for DDR rates (as described above)
% Breeding at carrying capacity, P(K)	45, 60,61, 62, 63, 64, 65	63	The initial value was based on Carstens' APNR experiment.
Allee parameter, A	1	1	Followed most closely the shape of the curve (Figure 12)
Steepness parameter, B	1	1	Followed most closely the shape of the curve (Figure 12)

Description of the APNR study site

Study area

This Associated Private Nature Reserves (APNR) study site is situated on the western boundary of the Kruger National Park in north-eastern South Africa and encompasses four private nature reserves: Klaserie, Timbavati, Umbabat and Balule. The APNR was formed in 1976 when fences between these reserves were removed, and with the removal of fences between the Kruger National Park and the study area during the 1990s. Before their establishment as private nature reserves, land-use was mainly gamehunting, cattle grazing and the growing of fruit (Bornman 1995) - hornbills were present but not under study. The vegetation within the study area falls within the Savanna Biome of South Africa, varying from open savanna to closed woodland (van der Waal 2010).

Group structure

Due to the study area virtually lacking natural tree cavity nesting sites, artificial nest boxes were provided at a density higher than natural nest sites found in undisturbed areas. The study site contains 31 groups in 180,000 ha, of which 18 are known to breed. Average group size during 2000-2015 was 4.0 ± 1.4 individuals per group, but varied between 3 (2000) and 4.9 (2015). Thirty-one nest boxes were installed, 14 in the winters of 2002, 11 in 2003, three in 2005, one in 2009 and two in 2013, which are assumed to have increased the density of ground hornbills in the region. Nest boxes were placed in three of the four reserves, excluding the Balule reserve. Thirteen natural nesting sites were known, of which four are still present.

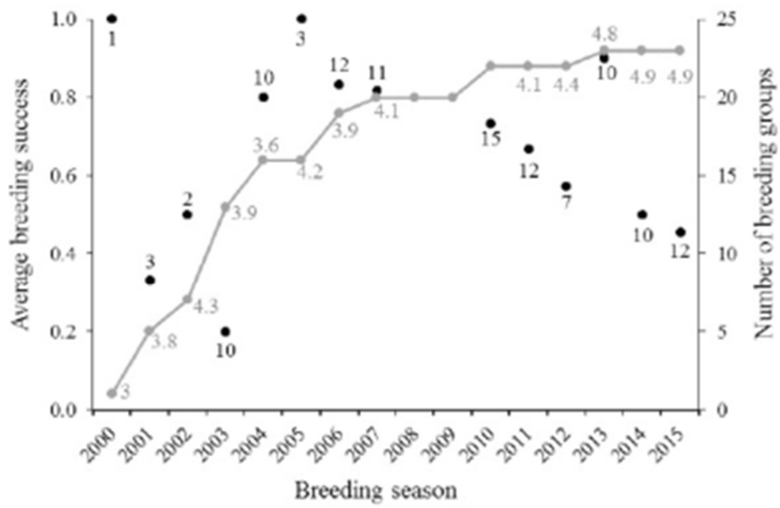

Figure 2.7. Variation in average seasonal breeding success (black dots) relative to the number of breeding groups (grey line). Data for group sizes were not available during 2008–2010. Number of breeding attempts made and average group size are provided next to black and grey data points, respectively.

Figure 7.9. Relationship between productivity (average breeding success) and number of breeding groups over time. The number of breeding groups asymptotes at 4.8/4.9 by which time (2013) the breeding success declines from its maximum (4.2 breeding groups) by 55% (Kate Carstens PhD research, unpublished).

APPENDIX 2: LIST AND CONTACT DETAILS OF ALL WORKSHOP PARTICIPANTS

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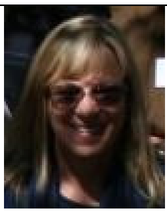
Antoinette Kotze	National Zoological Gardens: Research & Scientific Services	antoinette@nzg.ac.za	0123392795	
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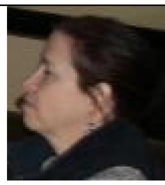
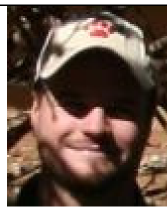
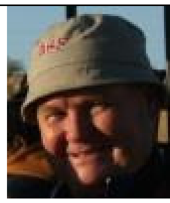
Fiona Zerbst	Wildlife Ranching SA	fionazerbst@gmail.com		
Gareth Tate	Endangered Wildlife Trust	garetht@ewt.org.za	0824473619	
Gavon Calverley	Cattle Farming	mbutu@lantic.net	0824091825	
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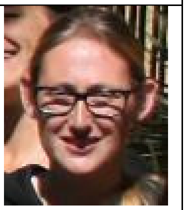
Kara Heynis	Lory Park Zoo	kara@lorypark.co.za	0723425984	
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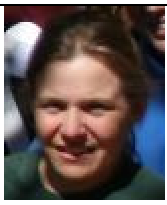
Katja Koeppel	Univsersity of Pretoria	katja_koeppel@gmx.net	0721732282	

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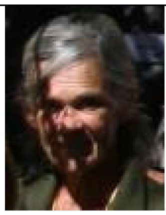
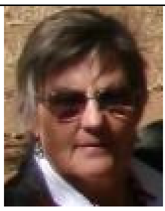
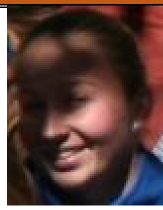
Lucy Kemp	Mabula Ground Hornbill Project	project@ground-hornbill.org.za	0832898610	
Lucy Young	University of Witwatersrand	lucyyoung861@gmail.com	0798760155	NO PHOTO
Meg Kemp	Naturalists & Nomads	bubo.owl@gmail.com		
Megan Murison	Endangered Wildlife Trust	meganm@ewt.org.za	0824885465	
Melissa Whitecross	BirdLife South Africa	melissa.whitecross@birdlife.org.za	0824526021	
Mike Bruford	Cardiff University	BrufordMW@cardiff.ac.uk	+44 2920 874312	

Name	Affiliation	Email Address	Phone Number	Photo
Mike Harman	Private	mikehornbill@gmail.com	0833954997	
Natasha Nel	Mabula Ground Hornbill Project	natasha@ground-hornbill.org.za	0832898611	
Nomusa Mkhungo-Mtungwa	Women's Leadership and Training Programme	gnomusam@gmail.com	0785997063	
Ray Jansen	Tshwane University of Technology	JansenR@tut.ac.za	0825551016	
Rhys Bruford	University of Exeter	rwnbruford@gmail.com	+44 2920 874312	
Rob Little	FitzPatrick Institute of African Ornithology, UCT	rob.little@uct.ac.za	0216504026	
Sandi Calverley	Cattle Farming	mbutu@lantic.net	0827238223	

Name	Affiliation	Email Address	Phone Number	Photo
Savannah Mollett	Lory Park Zoo	sav123.bodine@gmail.com		
Sharon Thompson	Endangered Wildlife Trust	sharon.thompson@sanparks.org	0137353545	NO PHOTO
Sophie Neller	Mabula Ground Hornbill Project / University of Pretoria	sophie@ground-hornbill.org.za	0745041342	
Tracy Rehse	Pan African Association of Zoos and Aquaria	tracy@nzg.ac.za	0833347839	NO PHOTO
Zwelakhe Zondi	South African National Biodiversity Institute	z.zondi@sanbi.org.za	0810476669	

APPENDIX 3: WORKSHOP AGENDAS

4.1 AGENDA FOR THE INTENSIVE TECHNICAL WORKSHOP

DAY 1 – Monday, 21st August, 2017

08.30 – 12.30

- General welcome and introductions
- Goals of the modelling workshop (Lucy Kemp, Mike Bruford)
- SGH population biology: what do we know and what have we learned since 2005? (presentations from participants)
- BREAK
- Vortex and stochastic population modelling – application to ground hornbills (Mike Bruford)
- Format for the coming 1.5 days: establish working groups (All)

12.30 – 14.00 LUNCH BREAK

14.00 – 17.30

- Working groups meet (1. modelling; 2. ecology, behaviour and population biology; 3. Landscape management including protected areas; 4. Direct threats, including persecution, poisoning, livestock etc).
- Plenary report from each group on progress including modelling implications.
- Identification of group priorities for Day 2.

DAY 2 – Tuesday, 22nd August, 2017

08.30 – 12.30

- Working groups meet for second session.
- Plenary report from each group on progress including modelling implications.

12.30 – 14.00 LUNCH BREAK

14.00 – 17.30

- Working groups draft their reports
- BREAK
- Plenary report from each group on final outcomes including modelling.
- Establishing messages for full stakeholder workshop on Days 3 and 4.

4.2 AGENDA FOR THE FULL STAKEHOLDER WORKSHOP

DAY 1 – Wednesday, 22nd August, 2017

08.00 – 08.30

- Arrival and registration of participants, participants to be seated in the conference venue.

08.30 – 10.30

- Welcome, opening address (Prince Mangosuthu Buthelezi, traditional prime minister to the Zulu monarch and nation); participant introductions, introduction to workshop process and ground rules.
    - Presentations on status, new data and conservation activities.

Presentations:

Rob Little Summary FitzPatrick MSc Summary
Kate Carstens PhD
Dr Katja Koeppel - Veterinary
Lucy Kemp Provincial Monitoring Plan and PhD
Any other presentations welcome
Q & A – 40 minutes

- Plenary development of a vision statement for the species.
- Discussion of the definition of viability or other recovery criteria.
- Threat analysis (plenary activity by all participants) and impacts on the species.
- Identify small working groups based on topics identified by threat analysis and other presentations.

10.30 – 11.00 TEA BREAK

- Presentation of Technical Workshop and initial PHVA results by Prof. Bruford
- Briefing on working groups.
- Registration for working groups.
- Structured plenary discussion analyzing the issue(s), documenting available evidence, and developing goals around a vision and/or threats analysis (we encourage active discussions in addition to presentations to spur creative thinking and additional perspectives and information).

12.30 - 13.30 LUNCH BREAK

13.30 – 15.00

- Discussing and evaluating management strategies and making tentative recommendations
- Working group sessions followed by plenary presentations throughout each day.
- Group tasks include:

  -Detailed problem statement and analysis, including data assembly (facts vs assumptions) and development of causal chains (what is causing the issue, and what are the impacts on species viability in terms of survival, reproduction, K, fragmentation, etc.)
  -Identification of goals to address threats
  -Identification of short- and/or long-term objectives to meet goals

-Identification of potential actions under the objectives
-Evaluation of benefits, costs, risks, and feasibility of potential actions at either the action or the objective level; modeling may be helpful in some cases
-Final recommended objectives and actions, as detailed as possible

15.00-15.30 TEA BREAK
15.30-16.30 Report back by working groups for discussion and comment

Further discussions by working groups into the evening as required.

DAY 2 – Thursday, 23rd August, 2017

08.00 – 12.30 Working groups continue (refreshments provided to each group).

12.30 – 13.30 LUNCH BREAK
14.00 – 16.00 Final summary presentations and recommendations; identification of major priority recommendations across all groups and by all participants; identification of next steps.

16.00 – 17.30 Presentation of summary (Bruford)
Closing remarks (Dr Alan Kemp)

APPENDIX 4: IMAGES OF THE PARTICIPANTS AT WORK


WORKING GROUP ONE


WORKING GROUP TWO


WORKING GROUP THREE

A 'sundowner' break for the participants to get outdoors after all the day's hard work and a chance for more informal discussions.

APPENDIX 5: OPENING AND CLOSING ADDRESSES

Appendix 5a: Opening Address by Prince Mangosuthu Buthelezi

Message of support

Prince Mangosuthu Buthelezi MP
President of the Inkatha Freedom Party
Inkosi of the Buthelezi clan
Traditional Prime Minister to the Zulu Monarch and Nation

"Growing up as a young child in Mahashini, at the palace of my Uncle King Solomon ka Dinuzulu, I shared the responsibility of all young boys; of herding cattle. As we walked through the fields and communal grazing areas, we often saw iNsingizi, the Southern Ground Hornbill. Wherever there were cattle, there were iNsingizi.

The booming call of these large birds was familiar to us. It reminded us of the seasonal blessing of rain. In our culture, these birds were never hunted, for fear of unleashing torrential downpours. But seeing iNsingizi in a grazing area meant that the area was being cleared of snakes and scorpions. So we welcomed their presence.

Today, however, when I walk among my cattle in Mahlabathini, it is very rare to see a Southern Ground Hornbill. Tragically, in the whole of northern Zululand, there may be fewer than 25 breeding groups left. They may soon become Critically Endangered.

I long to see this symbolic bird reinstated in the collective memory. I want my grandchildren and great grandchildren to see iNsingizi and to hold them in high regard, as our ancestors did. It would be an unspeakable loss to our cultural and natural heritage to allow these birds to slip into extinction.

I am therefore enormously grateful for the work being done to preserve the species, through research, habitat augmentation, awareness campaigns, the rescuing, hand-rearing and rewilding of chicks, and their reintroduction into our wildlife areas. I must thank the Kemp family and the team at the Mabula Ground Hornbill Project for their invaluable service to conservation.

As a lifelong conservationist, I know that conservation initiatives must be supported and driven by traditional leaders and traditional communities. As Prime Minister to the Zulu Monarch and Nation, and Inkosi of the Buthelezi Clan, I have championed an intensive conservation dialogue. I intend to see that dialogue encompass the protection of the Southern Ground Hornbill, as part of our future conservation plan, and I make myself available to open the way.

The work being done over the next four days will be invaluable to the survival of iNsingizi. Thank you for your participation in this important workshop. "

To see the documentary that was set to this opening address please contact project@ground-hornbill.org.za for a link.

Appendix 5b: Closing Address by Dr Alan Kemp

Message of gratitude

Dr Alan (and Meg) Kemp

Retired Curator of Birds and Director of the Ditsong Museum of Natural History; Currently Scientific Advisor to the Mabula Ground Hornbill Project

We found the first nest that triggered this study in the Kruger National Park in 1967, 50 years ago this spring. Five years later in the summer of 1972-73, we spent four months finding and following as many SGH groups as could be located within an area centred on Satara Rest Camp. The end result was an estimated density of 100 km^2 per group ($n = 14$), with a mean group size of 3.6, led by an alpha pair and including variable numbers of helper adults (predominantly males) and immatures (of varying ages). A number of nest sites were found and, over as many subsequent years as possible, additional groups and nest sites were located, the contents checked and all group sizes and age/sex compositions recorded. These data formed the basis for most early SGH perceptions and conservation considerations.

Wherever possible, effort and information was expanded. The low density, projected small total population size and limited breeding potential for the species (and for other large avian species) convinced KNP authorities to include SGHs in their annual aerial counts during 1978-86, which expanded the distribution and group-size data to cover 90% of the KNP. Throughout 1990-92, the Big-Six bird project, in collaboration with the Percy Fitzpatrick Institute, maintained a KNP-wide record of SGH sightings and the sample of nest sites known rose to 50, representing an estimated quarter of the KNP groups.

In the original Satara study, when the second-hatched chick was found to succumb early in the nestling period, its conservation potential was realised and these redundant chicks were removed opportunistically for hand rearing, with low success initially until the National Zoological Gardens added their support and skills. Two attempted hard releases followed, of three and two captive-reared birds into Malolotja, Swaziland in 1995: both failed, but the best lasting three months. In 1998, two MSc students then harvested and reared chicks, testing a community-based protocol for rearing in collaboration with the Makuleke living adjacent to the northern KNP. By 1999, this developed into the soft release of three juveniles, with community assistance, and was the start of the Mabula-based reintroduction efforts into vacant but historically occupied habitats.

From 1999-2005, establishment of a free-ranging Mabula group, and improvement of harvest from the wild and rearing of redundant chicks met with some scepticism and some success. Enthused and conducted by Ann Turner, the funds she raised, and the students and volunteers she attracted, various experiments were tried with different release techniques and alternative interventions for group augmentation in the wild. As ideas, projects and participant's increased, conflicting opinions and organisations precipitated the need for national discussion and culminated in the 2005 PHVA1. Other organisations took control of sections of the interests pioneered at and by the MGHP, the Fitztitute adopting the artificial nest programme, and the EWT formed its own Ground Hornbill Working Group. Sensing the fragmentation of effort, the National Zoological Gardens then facilitated formation of an informal national Action Group, which elected its own chairperson, to coordinate these disparate groups and individuals. This Action Group later built on the results and recommendations from PHVA1 to initiate a more detailed Species Recovery Plan published in 2011.

In the 12 years from the 2005 PHVA1 to the present 2017 PHVA2, much more research and publication has been completed - six PhDs, seven MScs, 2 Honours projects and 25 formal research papers, besides numerous and various technical protocols for many practical aspects of, for example, nest location/examination, ageing/sexing, harvesting, rearing, handling, morphometric and veterinary sampling, and marking techniques! All this new information, together with all the new unpublished national, extra-limital, range-wide and captive insights that have become available, plus the expert facilitation and modelling provided by Dr Mike Bruford and his team, have produced results that are a quantum increase in accuracy and credibility than those from PHVA1.

As two of only three participants from PHVA1, and the oldest, it was exciting to be part of the collation of all this new information and, as a swansong, to be able still to make some contributions to the discussions. Most of the participants who contributed to the tsunami of new information now available are mostly in their middle years and will be able to provide the expert guidance necessary for the years ahead until PHVA3. Best of all, was also meeting the healthy population of new and enthusiastic young participants, who are well placed to rejuvenate some of the organisations involved, and to drive the plans now being developed for the immediate future.

Both SGH and human populations have passed through approximately two generations in the 50 years that this interest in SGH study and conservation has persisted. Our best wishes to future generations of both species.