

Factors influencing ecological sustainability in the ostrich industry in the Little Karoo, South Africa.

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Thesis

Presented to the Faculty of Science in fulfillment of the requirements for the Degree of Masters of Science, Department of Botany at Rhodes University, Grahamstown.

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February 2014

ABSTRACT

The Little Karoo, situated in the Succulent Karoo biome of South Africa, has been heavily transformed by land use, and only 8.6 % of the remaining natural vegetation is considered to be intact. There is ample evidence that the main cause of degradation is the overstocking of ostriches, an industry that has been the major economic driver of the area for more than 150 years. The ostrich stocking rate currently recommended is 22 ha.ostrich⁻¹. A literature review was used to examine the evidence, assumptions and rationale on which recommended and actually implemented stocking rates for ostriches are based. No experimental evidence using ostriches was found that supported the recommended stocking rate as either ecologically or economically sustainable. From the literature, there appears to be a wide gap between what are considered to be economically and ecologically sustainable stocking rates, with the implication that these two aims may be impossible to reconcile when practicing ostrich farming on natural veld. A comparison of recommended with actual stocking rates among land managers in the Little Karoo showed that all land managers far exceeded the recommended agricultural stocking rate of 22.8 ha.ostrich⁻¹. However, the stocking rates reported by land managers to the South African Ostrich Business Chamber were found to accurately reflect actual numbers determined when whole flocks had to be slaughtered after an outbreak of avian influenza. The recommended stocking rate appeared to be irrelevant to ostrich flock breeders and there appeared to be a trade-off between profitable ostrich farming and sustainable land-use practices. This study also investigated the attitudes and behaviour of ostrich farmers. It was found that environmental attitude is most likely the most important characteristic of a land manager to ensure positive conservation behaviour. This characteristic was most prominent in younger land managers with larger farms. The last component of the study integrated the context

and complexity of the long term social, economic and ecological sustainability of this industry through the development of a logic model. The results showed a general lack of linkages between industry elements which impact on achieving sustainability targets. Greater collaboration between industry role-players, organized agriculture and conservation organizations is required to find a balance between utilization and conservation in the ostrich industry.

Factors influencing ecological sustainability in the Little Karoo, South Africa.

APPROVED BY:

Supervisor:

Susanne Vetter

DECLARATION

I, the undersigned, hereby declare that the work contained in the thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

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ACKNOWLEDGEMENTS

I would like to extend gratitude to my two supervisors, Drs. Susi Vetter and Andrew Knight. Thank you for sharing your knowledge, giving me guidance and support throughout the course of my research. I would like to thank Mark Difford for doing the statistical analyses of my research questionnaire, helping me to understand the results.

To the South African Ostrich Business Chamber, allowing me to conduct the research as part of the biodiversity management project, also for giving me the financial support. To CapeNature: especially my Area Manager, Ivan Donian - for your support and allowing me the time to finish the end product.

To my two project partners, Yvette Lötter and Stefan Pieterse, for accompanying me to every farm.

To the land managers of the Little Karoo: for giving me their time and showing true Karoo hospitality.

To my friends and my family and to Alan, Reece and Christian: Thank you for your support, prayers and belief in me. May all honor and praise go to God, the Spirit that has lead me through every step of the way and blessed me with the wisdom and insight to complete this task to the best of my ability. Philippians 4:13.

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CHAPTER 1: INTRODUCTION

ABSTRACT

Degradation of arid and semi-arid rangelands is an important global issue responsible for the gradual changes in the global carbon cycle and possibly the global climate. Unsustainable agricultural rangeland practices such as the overstocking of domestic livestock are today still the main cause of degradation in the semi-arid and arid rangelands of southern Africa. The Little Karoo is a semi-arid region located in the Succulent Karoo biome of South Africa and the area's lower lying vegetation has undergone severe degradation due to a long history of overstocking with livestock and especially unsustainable ostrich farming practices over the past 150 years. The Little Karoo is today still the most important ostrich-producing region in South Africa and is the economic driver of the area. The concerns about the impacts of ostrich farming on biodiversity conservation, land degradation and veld rehabilitation, remain a challenge for both agricultural and conservation organizations.

This study's overall objective is to identify factors influencing the ecological sustainability of the ostrich industry by focusing particularly on the human and social dynamics of land managers and the inter-institutional dynamics of this industry in the Little Karoo.

Keywords: land degradation, Little Karoo, ostrich farming.

1

Background to the study

¹The term **veld**, a generic term referring to the open grazing areas of southern Africa as opposed to **vegetation** was used in most chapters of this thesis. The term **land manager** also refers to **farmers** in general.

Degradation in the world's arid and semi-arid rangelands is a widespread phenomenon (Walker et al., 1981; Sundquist, 2003) and will remain an important global issue for the 21st century because of its adverse impact on agronomic productivity, the environment, and its effect on food security and the quality of life (Eswaran, 2001). Land degradation is the gradual process in which the value of the biophysical environment is affected by a combination of human-induced processes acting upon the land and can be considered in terms of the loss of actual or potential productivity or utility as a result of natural or anthropic factors (Conacher and Conacher, 1995; Eswaran, 2001). It is estimated that up to 40 % of the world's agricultural land is seriously degraded (Sample, 2007). The impacts of degradation range from changes in the global carbon cycle and possibly the global climate (Houghton and Hackler, 2001) to affecting regional climate (Pielke et al., 2002; Kalnay and Cai, 2003). The expansion of land use in recent decades has also caused declines in biodiversity through the loss, modification, and fragmentation of habitats, degradation of soil and water, and overexploitation of local species (Pimm and Raven, 2000).

Unsustainable agricultural rangeland practices such as the overstocking of domestic livestock and overgrazing are currently the main anthropogenic forces of dry land degradation in the semi-arid and arid rangelands of southern Africa and land-use change is expected to remain the dominant driver of biodiversity loss in southern Africa over the next century (Downing, 1978; Scholes and Biggs, 2005; Biggs et al., 2008). Degradation and desertification in South Africa are among the most critical environmental issues, intricately linked to food security, poverty, urbanization, climate change, and biodiversity (Hoffman et al., 1999). Hoffmann et al. (1999) reported that the land in 25 % of the 367 magisterial districts in South Africa is already severely degraded.

South African's history of research into land degradation has been going on for many years (Hoffman and Todd, 2010). Numerous publications (Kokot, 1948; Acocks, 1953; Jarman and Bosch, 1973; Hoffman and Cowling, 1990), official investigations (Anonymous, 1923; Anonymous, 1951) and government and public intervention schemes (Anonymous, 1991; Du Toit et al., 1991) have demonstrated the concern shown by South Africans towards the issue of land degradation (Hoffman and Todd, 2010). The 1946 Soil Conservation Act (No. 45 of 1946) focused on soil conservation and the provision of extension services to land managers (Donaldson, 2002; Beinart, 2003). Extension officers were tasked to promote behavioural change amongst land managers by establishing soil conservation committees that regulated community behaviour and increased community ownership and responsibility for land management. These committees were found to work most effectively where there was an enthusiastic uptake by local land managers (Beinart, 2003). The Act was revised in 1969 establishing the voluntary Stock Reduction Scheme, which remained in effect until 1978. Whilst these various government schemes and interventions over the years resulted in improved rangeland condition, they generally failed to halt unsustainable land-use practices (Hoffman and Ashwell, 2001).

Biodiversity importance and prominent land-uses of the Little Karoo

The Succulent Karoo biome, which extends from the southwest of South Africa through the north-western areas of South Africa and into southern Namibia (Anonymous, 2003), has extraordinarily high plant endemism. More than 6350 vascular plant species have been recorded in this hotspot, with approximately 2440 (38 %) species endemic and 936 (15 %) International Union for Conservation of Nature (IUCN) Red Data listed species (Driver et al., 2003). The Succulent Karoo has the richest succulent plant diversity in the world (Desmet and Cowling, 2005). Only 3.5 % of the biome's land area is formally conserved (South Africa Environment Outlook Report, 2006). Brooks et al. (2002) predicted that, based on the current rate of habitat loss, 544 endemic plant species and 12 endemic vertebrate species face extinction. The Critical Ecosystem Partnership Fund

(CEPF) considers the Central Little Karoo a conservation priority (Anonymous, 2003) and the South African National Spatial Biodiversity Assessment (Rouget et al., 2004) similarly identified the Succulent Karoo Biome as a priority terrestrial conservation area.

Located in the Succulent Karoo biome, the Little Karoo is an east - west oriented semi desert valley lying between two parallel mountain ranges of the Western Cape of South Africa (Le Maitre et al., 2007) (Figure 1). The Little Karoo has been identified through a number of processes as an area of critically important biodiversity. It contains three of 34 global biodiversity hotspots, the Succulent Karoo, Maputaland - Pondoland - Albany and the Cape Floristic Region Biodiversity hotspots (Figure 2). Biodiversity hotspots are the biologically richest and the most endangered terrestrial eco-regions on earth. Hotspots contain at least 1500 species of vascular plants as endemic species and have lost 70% or more original habitat (Mittermeier et al., 2005).

Much of the Little Karoo biodiversity has been degraded. A study of the transformation of Little Karoo vegetation (Thompson et al., 2005) shows a large proportion of the vegetation of the lower lying areas of the Little Karoo having undergone severe degradation (Table 1). The low lying areas of the Little Karoo, in which most ostrich farming takes place (Cupido, 2005), consist mainly of the Gannaveld and Apronveld habitats of the succulent karoo vegetation types (Vlok et al., 2005). Both these habitat types are accessible to livestock and are especially suitable for ostrich farming (Cupido, 2005; Thompson et al., 2008).

The Little Karoo is primarily an agricultural region where the very limited surface and ground water is used to irrigate agricultural land and range-fed livestock. A variety of vegetables (produced both for seed and food), fruit trees, cereal crops such as wheat, oats, barley and rye, are grown, but lucerne remains the dominant cultivated crop. The history of the region's land use has been dominated by extensive grazing and browsing

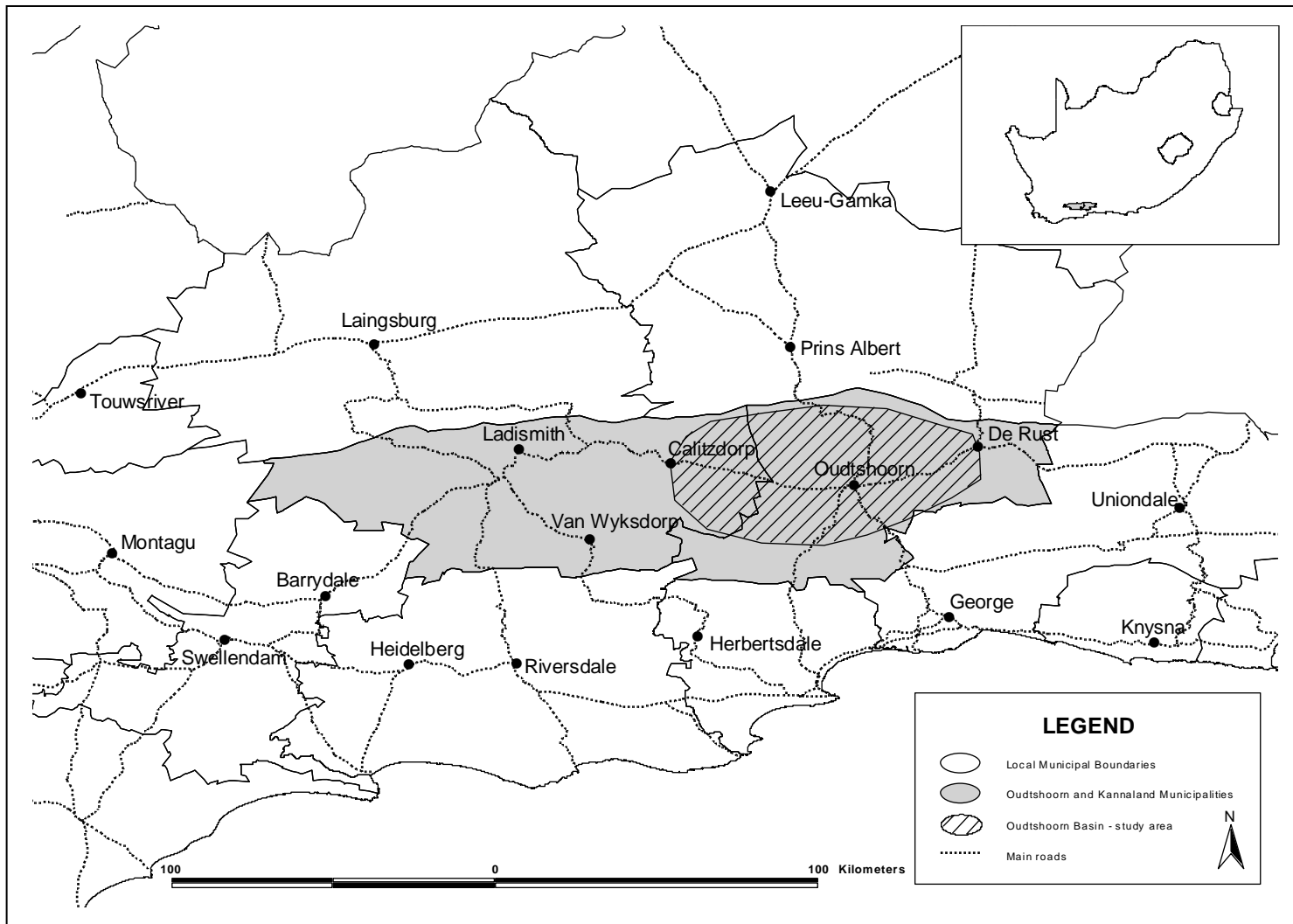


Figure 1. The Little Karoo, showing major towns and the Oudtshoorn basin, the study area.

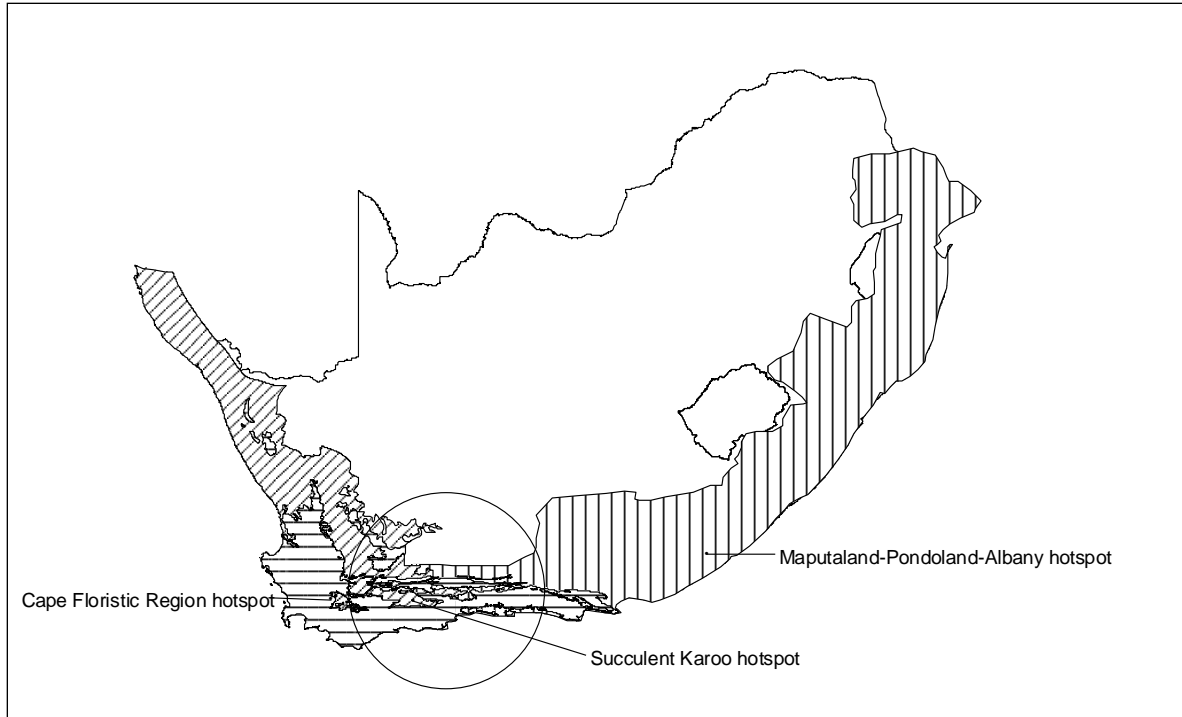


Figure 2. Map of South Africa showing the Maputaland-Pondoland-Albany, Cape Floristic Region and Succulent Karoo biodiversity hotspots (Mittermeier et al., 2005). The circle shows the intersection of the three hotspots in the Little Karoo.

by livestock since the 1730s (O’Farrell et al., 2008). Historical records indicate that certain districts in this region have been heavily overstocked by cattle, horses, donkeys, sheep, goats and ostriches. The cultivation of lands has only transformed about 10 % of the natural habitat (Dean and Milton, 2003; Thompson et al., 2008).

Historic overview of ostrich farming in the Little Karoo

Wild ostriches were already present in the Western Cape when the Western Cape was first settled by Europeans from the mid-17th century (Holtzhausen and Kotze, 1990). The first South African exports of wild ostrich feathers to Europe took place in 1838 (Holtzhausen and Kotze, 1990).

Table 1. Extent of degradation, expressed as a percentage of the natural area of each habitat type (i.e., excluding habitat transformed by urban development and agriculture), in four semi-arid habitats in the Oudtshoorn Basin of the Little Karoo (Thompson et al., 2008). Also shown are data derived from the National Land Cover (NLC) assessment (Fairbanks et al., 2000).

Habitat	Area (ha) (%)	Thompson et al., 2008			NLC	
		Intact	Moderately degraded	Severely degraded	Natural	Degraded
Gannaveld	87,587 (9.3)	1.4	59.6	39.0	91.8	8.2
Apronveld	52,203 (5.6)	1.5	44.2	54.3	72.4	27.6
Succulent Karoo-Thicket Mosaic	410,510 (43.8)	9.1	63.2	27.7	99.2	0.8
Spekboom Thicket	386,931 (41.3)	10.7	77.9	11.4	96.8	3.2
Total	937,232 (100)	8.6	67.9	23.5	97.9	2.1

Due to the decrease in the number of wild ostriches, efforts to tame and breed ostriches began in around 1850. Ostrich-feather farming as an organized agricultural practice only began in the Little Karoo in about 1863 (Oudtshoorn, 1952; Talbot 1961; Smith 1964; Holtzhausen and Kotze, 1990). Many land managers claimed that they were the first to breed, raise and pluck the feathers of ostriches (Nel, 1995), but the land managers of Oudtshoorn were the pioneers of this industry. Ostrich-farming became an extremely profitable industry in 1870, after the invention of the first ostrich egg incubator (Holtzhausen and Kotze, 1990).

Early in the industry's development, Wallace (1896) predicted that *'the profit per bird will be greatest when ostriches do not exceed a certain, and not an excessive, proportion of the stock upon a farm'*. Between 1900 and 1913 the industry reached a zenith in what is today known as the second ostrich-feather boom period and ostrich feathers ranked fourth on the list of South African exports, after gold, diamonds and wool. At

this stage there were close to a million ostriches on farms in South Africa (Holtzhausen and Kotze, 1990; Nel, 1995).

In 1914 the industry collapsed virtually overnight. The worldwide socio-economic effects of World War I, the overproduction of plumes and the disorganized marketing in South Africa were seen as the main causes for the feather market slump, which continued until after World War II (Holtzhausen and Kotze, 1990). In 1925 the South African Ostrich Farmers' Co-operative was founded with the purpose to fix prices, to regulate the market and to promote the industry (Nel, 1995), but only 11 years after the feather market slump, the industry was still very vulnerable and the Co-operative failed. However, with the founding of the Klein Karoo Agricultural Co-operative in 1945 the ostrich industry recovered again. Ostrich leather and biltong (dried meat) replaced feathers as the most important marketable products. Ostrich farming was no longer limited to the Little Karoo, and land managers across South Africa wanted to share in the industry. Producer unions were established in other areas, outside the Little Karoo, and in 1993 the ostrich industry was deregulated. Although Oudtshoorn remains the core of the commercial ostrich farming industry, ostrich land managers all over South Africa may participate in a free market principle industry (Nel, 1995).

Ostrich farming in its current context

Today, it is nearly impossible to estimate how many ostriches are in South Africa, the number of ostriches that are slaughtered annually, average around 250 000 which excludes breeding ostriches and chicks (Durr, 2011). More than 85 % of ostrich farms are now situated in the Little Karoo, which is the most important ostrich-producing region in the country. Approximately 70 % of all South African ostrich products originate there (Anonymous, 1999). The South African ostrich industry is mainly export-driven, with 95 % of produce being exported to markets in Europe, America and the Far East (Brand and Jordaan, 2001). The South African Ostrich Business Chamber (SAOBC)

serves as the coordinating body for the ostrich industry to benefit both the producers and the processors of ostriches and ostrich products. The R1.2 billion rand a year ostrich industry provides employment for approximately 20 000 workers in the Greater Oudtshoorn area. This number significantly increases when secondary jobs such as tourism, production of ostrich leather goods and decorative ostrich eggs are added (Brand and Jordaan, 2001).

However, the effects of heavy stocking rates applied by early settlers are still evident in the condition, composition and structure of the present vegetation of the region (Dean and Roche, 2007). In an attempt to holistically improve the sustainability of the ostrich industry in the Little Karoo, the South African Ostrich Business Chamber (SAOBC), which serves as a coordinating body for the ostrich industry, initiated the Ostrich Industry Biodiversity Management Project, (OIBMP) in 2007. This initiative, coordinated by the researcher, is a biodiversity and business project, which aims to address biodiversity conservation and implement anti-degradation and rehabilitation actions across the Little Karoo, including provision of an extension service to the ostrich farming community. The project is affiliated with the Green Choice Alliance, a World Wide Fund for Nature (WWF) South Africa and Conservation International (CI) led partnership, “to share in a platform that engages with business, raises awareness about conservation farming practices and develops common standards and monitoring frameworks for best practices in biodiversity and business initiatives in South Africa” (Botha et al., 2008).

In 2007 the SAOBC considered various key strategic initiatives to conserve the Little Karoo. One sustainability initiative was the transitioning of the industry from farming with ostriches on open natural veld to an intensive pen-breeding system. In 2008 the SAOBC’s OIBMP commissioned an agricultural economist to conduct a study of the economic importance of the ostrich industry in the Little Karoo (Murray, 2008a). This was followed by a study that assessed pen-breeding and its likely economic effects on

ostrich production (Murray, 2008b). These reports guided the Long-term Biodiversity Management Strategy (Botha et al., 2008) of the OIBMP. In 2009 the SAOBC made a specific move towards the pen breeding system and developed land manager-friendly guidebooks such as the Bakkie-boekie and Pen-breeding Guidelines (see <http://www.ostrichsa.co.za/biodiversity.php>) to assist land managers in the change-over. This was the industry's first steps towards sustainable ostrich production and guided the industry towards ensuring ostrich land managers safeguard the unique biodiversity of the Little Karoo (Botha et al., 2008). Thus far, this initiative has found it very challenging to find solutions to the sometime contradictory objectives of ostrich farming and biodiversity conservation (Botha et al., 2008). O'Farrell et al. (2008) also highlight how difficult in general it is to manage semi-arid rangeland systems for long-term sustainability. Sustainable solutions that reconcile ecological and economic imperatives require research and management interventions to focus on dynamic interactions of nature and society and to address these challenges with the broader community (Clark and Dickson, 2003).

This thesis represents an interdisciplinary investigation into whether, and how, ostrich farming and biodiversity conservation in the Little Karoo South Africa can be reconciled. The overall objective is to identify factors influencing the ecological sustainability of the ostrich industry by focusing particularly on the human and social dynamics of land managers and the inter-institutional dynamics of the ostrich industry.

Overview of chapters

This chapter gave an overview of the context and background to this study and outlined the objectives and structure of the thesis. More specific background information on different aspects of the study is covered in the different data chapters (see below).

Chapter 2 is a literature review to search systematically for the scientific basis for ecologically and/or economically sustainable ostrich stocking rates on natural veld in the Little Karoo.

Chapter 3 examines current stocking rates on ostrich farms in the study area compared to the actual ostrich figures reported to the South African Ostrich Business Chamber. The chapter looks at a) whether land managers underreport and b) whether and to what extent they overstock with breeding ostriches on natural veld and whether this relates to factors such as farm size.

Chapter 4 draw on the human and social attributes of a survey conducted amongst land managers in the study area. The survey data was used to obtain a better understanding of land managers' level of conservation knowledge, their behaviour and attitude towards the environment and their willingness to collaborate and to identify possible characteristics that may positively influence their decision to look after their natural environment.

Chapter 5 develops a logic model for the ostrich industry to process and understand the context of the data from focus group sessions held with the main role-players of the ostrich industry. The model was used to evaluate the effectiveness of the relationships between role-players, such as government, non-government and agricultural organizations towards a sustainable ostrich industry.

Chapter 6 synthesizes the main findings of the study and contains concluding remarks and future research recommendations.

Chapters 2 to 5 of the thesis are presented as stand-alone manuscripts with separate supplementary material presented in appendices.

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CHAPTER 2: EVIDENCE FOR ECOLOGICALLY SUSTAINABLE OSTRICH BREEDING PRACTICES ON NATURAL VELD IN THE LITTLE KAROO, SOUTH AFRICA

ABSTRACT

Land degradation in the Little Karoo is extensive. Unsustainable land-use practices, such as overstocking with breeding ostriches on natural veld, has been one of the main agricultural farming activities responsible for this degradation. The National Department of Agriculture, Fisheries and Forestry has set a general livestock stocking rate of 60 ha.LSU⁻¹ as a guideline for the Little Karoo on natural veld, which equates to 22.8 ha.ostrich⁻¹. The aim of this review is to examine the scientific principles, data and assumptions the current recommended stocking rate of 22.8 ha.ostrich⁻¹ for breeding ostriches on natural veld in the Little Karoo is based on and to investigate if there is a stocking rate (or range of stocking rates) that has been demonstrated to be ecologically and/or economically sustainable. The results of the review delivered no evidence that the recommended agricultural stocking rate of 22.8 ha.ostrich⁻¹ is economically or ecologically sustainable in the Little Karoo. Most studies only address a single dimension of sustainability and it appears that an industry switch from extensive to intensive breeding practices may be a solution for the shorter term. Further research is required that takes on a holistic approach to include the socio-economic and ecological aspects of ostrich farming in the Little Karoo.

Key words: overstocking, stocking rate, economic sustainability, ostrich farming, flock breeding

INTRODUCTION

The overstocking of domestic livestock and overgrazing are believed to be the main anthropogenic forces of dry land degradation in the semi-arid and arid rangelands of southern Africa (Downing, 1978). These unsustainable land-use practices have resulted in the degradation of extensive semi-arid environments and this is an issue that South Africans have been grappling with for well over a century (Hoffman and Ashwell, 2001; Beinart, 2003). These processes are expected to remain the dominant driver of biodiversity loss in southern Africa, especially in arid regions (Scholes and Biggs, 2005; Biggs et al., 2008). This is of great concern as the reported levels of degradation may have been seriously underestimated (Rouget et al., 2006).

The National Grazing Strategy, developed in 1985 by the South African Department of Agriculture was founded upon the concept that rangelands, especially of the semi-arid Karoo, have been significantly degraded by irreversible vegetation change and soil erosion (Du Toit et al., 1991). The Little Karoo, situated in the arid Succulent Karoo biome in western Southern Africa (Mucina et al., 2006), has been the centre of the ostrich farming industry in South Africa for more than 150 years, beginning in the early 1860s. Ostrich farming which is still the economic driver of the area, is recognized as the major agent of veld degradation in the region (Beinart, 2003; Cupido, 2005; Le Maitre et al., 2007; Thompson et al., 2005; Murray, 2008a; O'Farrell et al., 2008; Thompson et al., 2008) and have serious implications on the natural veld. Sixty-five percent of ostrich breeders in South Africa are situated in the Little Karoo (Van Zyl, 2001).

Ostriches at high densities in arid environments are very destructive on natural veld and therefore breeding flocks which are kept at such high densities are the main cause of trampling (Smit, 1963; Milton et al., 1994). The trampling effect leads to soil compaction, the removal of the biological soil crust (Cupido, 2005), which increases the

risk of soil erosion by wind, destruction of sensitive plants and loss of biodiversity (Lombard and Wolf, 2004; Cupido, 2005). The trampling of natural veld is considerably worsened by the territorial behaviour of ostriches during the breeding season (Cupido, 2005; Esler et al., 2006). Differently to livestock, ostriches pull entire seedlings and small plants from the ground, rather than just eating the aboveground material (Esler et al., 2006). The conventional rotation practice to move livestock when the veld shows signs of degradation is also incompatible with ostrich flock breeding due to their territorial behaviour (Cupido, 2005). The effects of overstocking and trampling have also resulted in hydrological changes over large areas of the Little Karoo (Dean and Macdonald, 1994). The disturbance of the balance between overland flow and infiltration resulted in increased erosion of fragile soils (Snyman and Van Rensburg, 1986; Friedel et al., 1990; Keay-Bright and Boardman, 2006). The flow patterns in rivers were altered by sediments, salts, organic matter, and nutrients eroded from slopes and accumulating in river systems, reducing the water-holding capacity of rivers and dams (Costelloe et al., 2005). Water is the basis of life and the primary constraint on further development in the Little Karoo (Le Maitre et al., 2007). Ultimately the effects of land degradation on the hydrological processes of the Little Karoo will have a direct impact on the ostrich industry because of its absolute reliance on lucerne for the production of fodder, which requires large quantities of water (Dean and Macdonald, 1994; Cupido, 2005).

The history of stocking rates in South Africa

Determination of appropriate stocking rates for grazing animals is one of the most important tasks of rangeland managers (Holoček et al., 1999). In the late 1800s, estimation of livestock stocking rates tended to be based on periods of high rainfall, therefore the inclination was to maintain high populations of livestock on the land in the hope of rain (Beinart, 2003). Forage use and animal performance would have varied yearly in response to growing conditions (Smit, 2000). Because of the development of farming techniques that allowed more intensive forms of production, the need for

establishing criteria and sustainable ways for determining the carrying capacity of African rangelands became more important (Cupido, 2005).

Over the years the government department of agriculture developed various agricultural research projects, grazing strategies and grazing trials to calculate carrying capacities and produce grazing capacity maps. Grazing strategies were debated by land managers, government, researchers and practitioners. By the early 1960s the government agricultural research farms proposed grazing practices such as the few-camp rotational grazing system as opposed to the traditional continuous grazing system in all semi-arid management systems. This was developed through grazing trials where animal performance versus stocking density was recorded on the government research farms (Hoffman et al., 1999). The “three camp” rotational system remained the most widely implemented system for livestock farming in the semi-arid regions such as the Karoo (Archer, 2004). Other multi-camp rotational grazing systems such as Acocks’ (1966) non-selective grazing and short-duration grazing were also proposed and advocated (Hoffman, 1988; Savory, 1988; Hoffman et al., 1999). New management systems for veld and rangeland farming such as Holistic Resource Management were introduced (Archer, 2004) in the 1970s and are fairly common in the Karoo today (Esler et al., 2006).

The National Department of Agriculture, Forestry and Fisheries (NDAFF) has a long history of overseeing wide-ranging legislation, to maintain and improve rangeland conditions (Talbot, 1961; O’Farrell, et al., 2008). This included interventions from the government such as the lands right system (1878), the Drought Investigation Commission, the Soil Conservation Act of 1946 and the National Grazing Strategy (1985). Today, the utilization of these resources to ensure protection and sustainability is an obligation that comes through the implementation of the Conservation of Agricultural Resources Act, 1983 (Act 43 of 1983) (CARA). This legislation included aspects that

specifically seek to address veld management practices and to reduce the detrimental impacts of unsustainable livestock numbers on natural veld (Van Eeden, 1996; Hoffman, 1996). A provision under regulations 10 and 11 of the said Act allowed the NDAFF, as custodians of these resources, to set up norms and standards of grazing in South Africa to ensure compliance with the Act. In 1993 national grazing capacity norms were established by experts and a grazing capacity map was developed (Figure 1). This map was based on the imagery of Advanced Very High Resolution Radiometer of the National Oceanic and Atmospheric Administration (AVHRR/NOAA) (Anonymous, 2009) and climatic variables, particularly rainfall, but apparently there was no published methodology for this map. The map divided South Africa into various agricultural regions, each with its own unique forage production capability. These regions were each allocated a specific grazing capacity, based on agricultural activities and the forage needs of growing animals (Cupido, 2005; Du Toit, 2010).

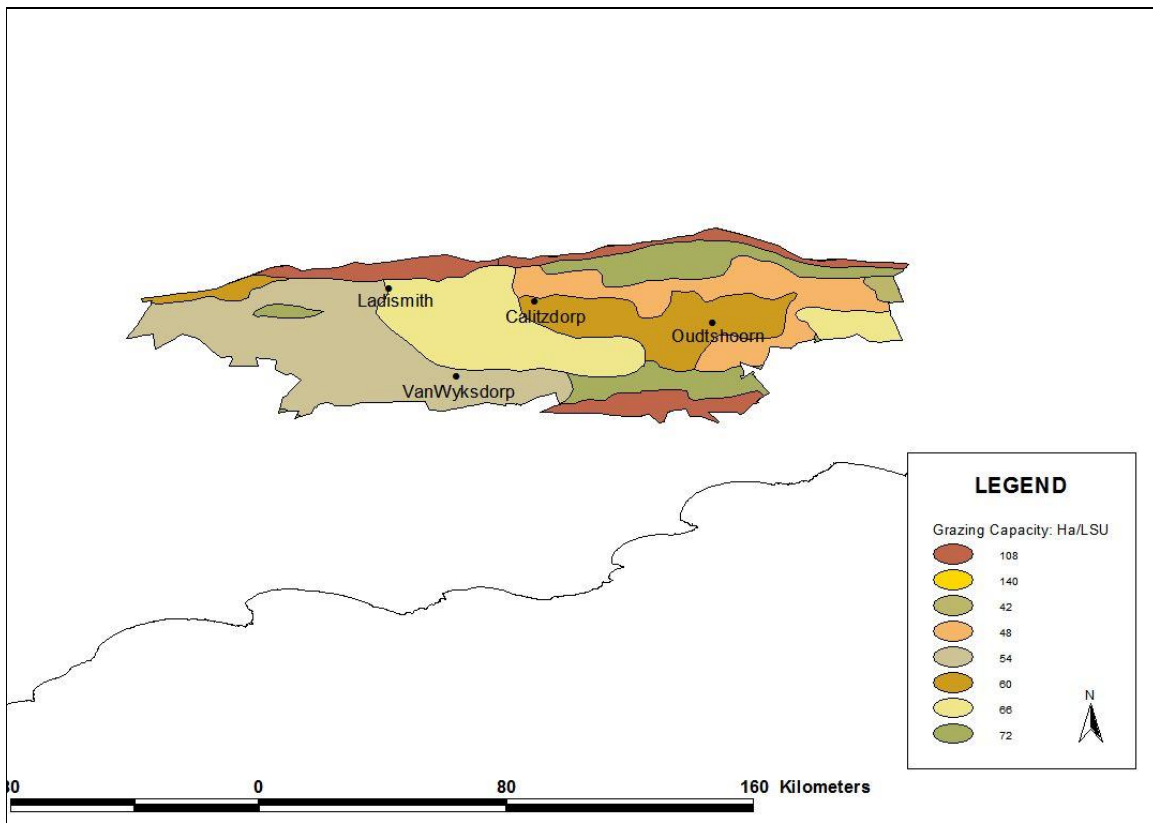


Figure 1. The 1993 government-recommended grazing capacity map for the Little Karoo.

Large Stock Unit (LSU) is regarded as an animal with a mass of 450 kg and is considered to be the average number of animals that a particular rangeland will sustain over time (Meissner, 1982; Galt et al., 2000). Meissner et al. (1983) developed conversion tables that classified animal species according to their estimated fodder requirements. These tables have a sound theoretical base that considered the species of animal, maturity type and physiological and reproductive state of each animal and grazing preference (Danckwerts and Tainton, 1996). The tables were published in the Government Gazette (1985). CARA (1983) expressed the stocking rate of natural veld as a specified number of hectares per LSU (ha.LSU^{-1}) and was indicated on a topo-cadastral map (1993 map) for the various agricultural regions of South Africa. Every land user is restricted to the number of animals kept on natural veld on the farm to not more than the number that is indicated on the map. Applied stocking rates are always calculated on the basis of animal weight (Meissner, 1982; Venter 1982; Meissner et al., 1983), i.e. determined by reference to the LSU into which the animals to be used are classed. Stocking rate is usually expressed as x ha.animal^{-1} and is defined by the Society for Range Management as the amount of land allocated to each animal unit for the grazable period of the year (Galt et al., 2000). However, on account of the fact that most farming systems deal with growing animals, i.e., producing meat and/or fibre and not with mature animals only, the applied stocking rate per farm, varies over a season and therefore, due recognition should be given to the weight of the animals when they are introduced onto the veld at the start of the grazing season (Du Toit, 2010).

In recent years government started questioning the validity of the 1993 map and the practicability of upgrading this map using remotely sensed data became a reality (Anonymous, 2009). Estimated stocking rates as laid down by CARA were very broad-scale and did not necessarily show the estimated grazing capacity at farm scale, or take into consideration local climatic conditions, such as precipitation, and soil nutrients, as practiced in some countries such as Australia, making it very difficult to recommend stocking rates at all (Cupido, 2005). The condition of

rangelands today is taken up in the new grazing capacity map that was developed in 2009 by using the Normalized Difference Vegetation Index (NDVI) satellite data. The NDVI used a combination of satellite bands to reflect aboveground green vegetation cover (net primary production). The new map still predicts the grazing capacity according to the standards LSU definition (Meissner et al., 1983) dry matter intake, but uses the vegetation annual net primary production and satellite imagery to produce a grazing capacity of presumed available vegetation types for herbivore consumption. Meissner et al. (2013) proposed that the predictions of the new map must be considered base line and that it should be revisited at regular intervals to observe future deviations as a result of variables such as stocking rate, precipitation and climate change. The 1993 map though, remains the official document on grazing capacity norms until the new map is published (Anonymous, 2009).

There have also been debates in recent years that suggest that semi-arid systems are non-equilibrium rangelands (Behnke and Scoones, 1993), where grazing has very little impact on veld, but that degradation is rather determined by abiotic factors such as rainfall and drought (Ellis and Swift, 1988). They believed that degradation of veld in semi-arid rangelands as a result of overgrazing is unlikely (Ellis and Swift, 1988; Behnke and Scoones, 1993; Sullivan and Rohde, 2002). Although there has been recognition that there are probably elements of both equilibrium and non-equilibrium dynamics in semi-arid rangelands (Vetter, 2005; Gillson and Hoffman, 2007; Todd and Hoffman, 2009) Todd and Hoffman (2009) reported that the non-equilibrium dynamics associated with other semi-arid areas such as the grasslands of East Africa and the Sahel (Ellis and Swift, 1988), do not fit well with the dynamics of the Karoo shrublands of southern Africa because of the fundamental differences in the dynamics of the vegetation as well as the more intensive type of livestock farming practiced. Archer (2004) and Campbell et al. (2006) have suggested a move beyond this debate and rather towards a more synergistic and flexible approach to rangeland management in semi-arid areas. Archer

(2004) has made recommendations for more sustainable grazing practices under conditions of variable rainfall.

Ostrich flock breeding practices in the Little Karoo

Esler et al. (2006) estimated that the natural density of wild ostriches in the Karoo is approximately 100.ha.ostrich⁻¹. In South Africa on commercial ostrich farms stocking densities are considerably different depending on the type of ostrich production enterprise, such as slaughter ostriches, breeding ostriches, hatcheries and chick rearing. Ostriches that are reared for slaughter purposes are kept on lucerne pastures at a wide range of stocking rates (Dean et al., 1993). Stocking rates range from 0.0016 – 0.08.ha.ostrich⁻¹ depending on rainfall or irrigation (Smit, 1963; Verwoerd et al., 1999; Strydom, 2010). Traditionally and currently, ostrich land managers who keep ostriches for breeding purposes use the flock breeding system where ostriches are kept in large flocks on natural veld for the duration of the breeding season to produce eggs (Nel, 1995). This differentiates ostrich farming from other livestock farming systems. The natural veld serves as the main food source for livestock, but for ostriches it is most often is only used as a holding area for breeding flocks (Lambrechts et al., 2004). Ostriches are also fed specific commercial feed rations to ensure optimal breeding and production success (Lambrechts et al., 2004). This has two main implications 1) the need to have enough naturally growing forage to feed ostriches is not necessarily a consideration when calculating stocking rates and 2) it has little effect on land managers' production if the natural veld degrades, since ostriches are not reliant on primary production. There is therefore no need to have enough natural forage available. The breeding season usually lasts eight months, which is from May/June to the end of January [Department of Agriculture: Western Cape and South African Ostrich Business Chamber (SAOBC), 2006]. To ensure optimal egg production, land managers have to ensure that ostriches are not to be disturbed or removed from their breeding camps even if the natural veld shows signs of degradation (Department of Agriculture: Western Cape and SAOBC, 2006). The guidelines of the ostrich industry stipulate that

ostriches in a three camp flock breeding system should be rotated every year. However, the limited availability of natural veld for ostrich farming and the recovery of natural veld, especially after a dry season, does not allow enough time for the vegetation to rest during a three year rotational period (Cupido, 2005).

Current recommended stocking rates for ostrich on natural veld

The NDAFF has set a general livestock stocking rate of 60 ha.LSU⁻¹ as a guideline for the Little Karoo on natural veld. An adult ostrich is considered to be equivalent to 0.38 LSU, indicating a recommended commercial ostrich stocking rate of 2.63 ostriches per 60 ha, or 22.8 ha.ostrich⁻¹ on natural veld. However, further official interpretation equates this to 7.6 ha.ostrich⁻¹ if a three camp system is used, where natural veld is used every three years for the full year. This is further reduced to 5.ha.ostrich⁻¹ if a three camp system is used and the camps are used only for the 8 month breeding season (Murray, 2008a). Therefore the recommended stocking rate of 22.8 ha.ostrich⁻¹.year⁻¹ can be applied at different densities (ha.ostrich⁻¹) depending on the rotation and resting system used.

The SAOBC (2003) recommends a minimum stocking density of 10 ha.ostrich⁻¹ in the case of larger breeding flocks, for an eight month breeding season. This guideline, however, was updated in 2009 with the only reference to a stocking rate as the following: The numbers of birds must be in accordance with the carrying capacity of the natural veld for a specific production area. This carrying capacity will only be valid for the breeding period, which normally ranges from May/June to the end of January, after which camps and birds should have a rest period (SAOBC, 2009).

The aim of this review is to examine the scientific principles, data and assumptions that the current recommended stocking rate of 22.8 ha.ostrich⁻¹ for breeding ostriches on natural veld in the Little Karoo, are based on. The study also aims to examine the

literature for other suggested stocking rates, and the evidence, assumptions and arguments these are based on. Finally the review investigates whether there is a stocking rate (or range of stocking rates) that has been demonstrated to be ecologically and/or economically sustainable, and if so, whether both ecological and economic goals can be satisfied at a similar stocking rate.

METHODS

A systematic review methodology was initially adopted per Pullin and Stewart (2006). A systematic review begins with a specific question and clearly defined subject, intervention and outcome elements that are answerable in scientific terms (Jackson 1980). The question is very important to the process, because it generates literature search terms and determines relevance criteria (National Health Service Centre for Reviews and Dissemination, 2001) that assist to find all available evidence to answer the research questions. Two specific review questions were formulated:

1. Is the recommended agricultural stocking rate of 22.8 hectare per ostrich ecologically sustainable for ostrich land managers in the Little Karoo?
2. Is the recommended agricultural stocking rate of 22.8 hectare per ostrich economically sustainable for ostrich land managers in the Little Karoo?

The following broad search strings were developed from the review question so that all studies eligible for inclusion were identified: ostrich AND farming OR ostrich AND agriculture OR ostrich AND agriculture AND stocking rate OR ostrich AND agriculture AND grazing OR *Struthio camelus* AND farming OR *Struthio camelus* AND stocking rate AND economic AND stocking rate OR economic AND ostrich AND farming OR economic AND *Struthio camelus* AND farming OR ostrich AND Little Karoo OR *Struthio camelus* AND Little Karoo OR 22.8 AND ostrich OR 22.8 AND *Struthio camelus*.

The term 'economic' was interchanged with 'ecological' in the search string, to cover both research questions. To ensure that all publications related to the review question

were identified, the term carrying capacity* was also interchanged with stocking rate*. The process was repeated for each search string in every major electronic research database (Table 1). The following electronic databases were searched: Web of Knowledge, African Journals Online, JSTOR, Scopus, Science Direct, Google Scholar, Primo Cross Search, and the “grey literature” search engine, Google (Pullin and Stewart, 2006). Grey literature included publications such as books and articles in magazines. References opportunistically provided by colleagues and unpublished data was also screened and included in the results. No date limit was set for the searches. Some of the electronic databases would only accept short search strings. Therefore in each database where this was the case the same systematic approach was used to do multiple searches with shorter search strings (Table 1).

Following testing, it was found that after the first 50 articles or first 2 pages, the articles became irrelevant to the review question, especially where search results totaled more than 100. Reviewed publications were limited to the first 100 publications in each database, to ensure consistent method replication. Publication details were captured in a data extraction table and the results from the ‘economic’ and ‘ecological’ searches were captured separately. The headings ‘database’, ‘search term’, ‘number of records’, ‘publication title’ and ‘category (yes/no)’ were used to capture the data.

The publications were reviewed in four stages. In the first stage, the titles of the publications were screened and the criterion that was applied to include articles in the results was to determine if the title related in any way to the questions of the review, or did it have any relevance to ostriches or animal stocking rates/carrying capacities. All duplicate publications were removed.

Table 1. The total number of publications that were found for each search string in every electronic database, including duplicate publications. For the purpose of the results in this table, economic* are interchangeable with ecological* in the search string column.

Resource database	Search string	No of articles with economic*	No of articles with ecologic*	Total no of articles
Web of Knowledge	ostrich* AND farming OR ostrich* AND agriculture* OR ostrich* AND agriculture* AND stocking rate OR ostrich* AND agriculture* AND grazing OR Struthio camelus AND farming OR Struthio camelus AND stocking rate AND economic AND stocking rate OR economic AND ostrich* AND farming OR economic AND Struthio camelus AND farming OR ostrich* AND Little Karoo OR Struthio camelus AND Little Karoo OR 22.8 AND ostrich* OR 22.8 AND Struthio camelus	233	258	491
AJOL ¹	ostrich* AND Little Karoo	-	-	15
AJOL	ostrich* AND farming*	-	-	5
AJOL	ostrich* AND agriculture*	-	-	2
AJOL	ostrich* AND stocking rate	-	-	2
AJOL	agriculture* AND stocking rate*	-	-	1
Jstor	ostrich* AND economic AND stocking rate OR economic AND ostrich* AND farming OR economic AND Struthio camelus AND farming OR ostrich AND Little Karoo OR Struthio camelus AND Little Karoo	982	652	1634
Jstor	ostrich* AND farming AND agriculture	-	-	736

Resource database	Search string	No of articles with economic*	No of articles with ecologic*	Total no of articles
Jstor	ostrich* AND agriculture AND grazing	-	-	541
Jstor	ostrich* AND Little Karoo	-	-	250
Jstor	Struthio camelus AND farming OR Struthio camelus AND stocking rate	-	-	99
Jstor	ostrich* AND agriculture AND stocking rate	-	-	70
Jstor	ostrich* AND agriculture AND economic* AND Little Karoo	55	58	113
Jstor	ostrich* AND agriculture AND grazing* AND Little Karoo	-	-	52
Jstor	ostrich* AND stocking rate AND economic* AND Little Karoo	12	14	26
Jstor	ostrich* AND stocking rate AND Struthio camelus AND economic* AND Little Karoo	1	2	3
Primo	ostrich* AND farming* OR ostrich* AND agriculture* OR ostrich* AND agriculture* AND stocking rate* OR ostrich* AND agriculture* AND grazing* OR Struthio camelus* AND farming* OR Struthio camelus* AND stocking rate* AND economic* AND stocking rate* OR economic* AND ostrich* AND farming* OR economic* AND Struthio camelus* AND farming* OR ostrich* AND Little Karoo* OR Struthio camelus* AND Little Karoo* OR 22.8 AND ostrich* OR 22.8 AND Struthio camelus*	15	24	39

Resource database	Search string	No of articles with economic*	No of articles with ecologic*	Total no of articles
Primo	ostrich* AND Little Karoo	-	-	41
Science direct	Struthio camelus AND farming OR Struthio camelus AND stocking rate	-	-	34
Science direct	ostrich* AND agriculture AND economic* AND Little Karoo	30	18	48
Science direct	ostrich* AND stocking rate AND economic* AND Little Karoo	12	46	58
Science direct	ostrich* AND Little Karoo	-	-	164
Science direct	ostrich* AND agriculture AND stocking rate	-	-	67
Science direct	ostrich* AND agriculture AND grazing* AND Little Karoo	-	-	41
Scopus	ostrich* AND Little Karoo	-	-	1
Scopus	ostrich* AND farming AND agriculture	-	-	5
Scopus	ostrich* AND agriculture AND grazing	-	-	2
Scopus	ostrich* AND agriculture*	-	-	20

Resource database	Search string	No of articles with economic*	No of articles with ecologic*	Total no of articles
Scopus	ostrich* AND economic*	63	21	84
Scopus	struthio camelus AND economic*	22	9	31
Google Scholar	ostrich* AND economic AND stocking rate OR economic AND ostrich* AND farming OR economic AND Struthio camelus AND farming OR ostrich AND Little Karoo OR Struthio camelus AND Little Karoo	53	48	101
Google	ostrich* AND farming* OR ostrich* AND agriculture* OR ostrich* AND agriculture* AND stocking rate* OR ostrich* AND agriculture* AND grazing* OR Struthio camelus* AND farming* OR Struthio camelus* AND stocking rate* AND economic* AND stocking rate* OR economic* AND ostrich* AND farming* OR economic* AND Struthio camelus* AND farming* OR ostrich* AND Little Karoo* OR Struthio camelus* AND Little Karoo* OR 22.8 AND ostrich* OR 22.8 AND Struthio camelus*	2960	2590	5550

AJOL¹ – African Journal Online

The second stage screened the abstract and full text of each publication and included publications based on the research subjects 'ostrich', 'Little Karoo' and 'stocking rate/carrying capacity'.

The third stage was to produce a publication summary where the results of the second stage were categorized (Appendix A, Table S1).

The fourth and last stage allowed for additional reviewing. All the publications in the publication summary were further examined to synthesize the final results. As a final filter, it was noted in the publication summary if the text of the publications made any reference to the stocking rates of ostriches on natural veld in the Little Karoo. For quality assessment, a second reviewer independently applied the same process to examine the publication summary and to ensure that publications were consistently categorized. The final results were tabulated to form a summary of the publications that recommended, cited, or reported stocking rates of ostriches on natural veld in the Little Karoo (Table 2).

RESULTS

Overall search results

A total of 10326 articles from all the electronic databases were found, using the collective search strings. More than half of the articles were identified using Google. Where the terms economic* and ecological* were interchanged in the search string, the totals amounted to 4438 and 3740 respectively. These results also included duplicate articles from the various electronic resource databases. Interchanging carrying capacity* with stocking rate* did not produce any additional articles. A total of 62 publications were found where the full text was assessed for reference to ostriches, the Little Karoo and/or stocking rate/carrying capacity. Seven additional publications

Table 2. A summary of the publications that refer to stocking rates of ostriches on natural veld in the Little Karoo. The stocking rates indicated in **bold** was recommended and others were either reported, cited, or an actual farming practice. The type of study is categorized as ‘review’ – a study of synthesized literature, or ‘research’ which is based on data, e.g. observational or experimental. The table also indicates from which type - economic, ecological or *ad hoc* search, the publication derived from.

Publication Title	Journal Title	Date	Lead Author	Lead author's affiliation	Collaborating organization	Type of study	Location of study	Scale of study	Theme of study	Stocking rate: ha.ostrich ⁻¹	Economic, ecologic or <i>ad hoc</i> search
The influence of stocking rate and male : female ratio on the production of breeding ostriches (<i>Struthio camelus</i> spp.) under commercial farming conditions.	South African Journal of Animal Science	2004	Lambrechts, H. Swart, D.; Cloete, S.W.P.; Greyling, J.P.C.; van Schalkwyk, S.J.	Govt. dept. Agric.	Dept. Agric., University, Consultants and Ostrich Processors	research	private land	local	stocking rate	Economic sustainable: recommendation large flocks (114 birds) on 1ha camps: 0,009 Small flocks (13 birds)on 0.30ha camps: 0.02 Cited Deeming and Burbier, 1999, Cited SAOBC, 2003: 10	Economic & ecologic

Publication Title	Journal Title	Date	Lead Author	Lead author's affiliation	Collaborating organization	Type of study	Location of study	Scale of study	Theme of study	Stocking rate: ha.ostrich ⁻¹	Economic, ecologic or <i>ad hoc</i> search
Ostrich farming in the Little Karoo.	Bull. agric. Serv. RSA.	Dep. tech. 1963	Smit, D. J. v. Z.	Govt. dept. Agric.	n/a	review	n/a	Regional	ostrich farming	Economically sustainable: recommendation of own experience: 4.28 good condition veld or average 10-12 poor condition veld	Economic
Effect of supplementary feed and stocking rate on the production of ostriches grazing irrigated lucerne pasture.	South African Journal of Animal Science	2009	Strydom, M. Brand, T.S.; Aucamp, B.B.; van Heerden, J.M.	Govt. dept. Agric.	University, Agric. research organization and, Dept. Agric.	research	Govt. research farm	local	ostrich production	Cited from Smit, 1963: 5 good condition veld and 10-12 poor condition veld	Economic
Economic Case for Pen-breeding	Unpublished	2008	Murray, M.	Private Consultant	Private Gvt. Conservation Agency, Agri Organisation	research	Private land	Local	Ostrich Economics	Economically sustainable: recommended pen-breeding system Reported recommended government stocking	<i>Ad hoc</i>

Publication Title	Journal Title	Date	Lead Author	Lead author's affiliation	Collaborating organization	Type of study	Location of study	Scale of study	Theme of study	Stocking rate: ha.ostrich ⁻¹	Economic, ecologic or <i>ad hoc</i> search
										rate: 22.8	
Food Selection by Ostrich in Southern Africa.	The Journal of Wildlife Management	1994	Milton, S.J. Dean, W.R.J; Siegfried, W.R.	University	n/a	research	Private and governm ent	Sub-continental	Ostrich foraging	Actual farming practice stocking rate: 0.1-0.3	Economic & ecologic
The Financial Costs of Ecologically Non-sustainable Farming Practices in a Semiarid System.	Restoration Ecology	2009	Herling, Margot C. Cupido, C; O'Farrell, P. J.; Du Plessis, L.	research organiza-tion	Dept. Agric. and Research organization	research	private land	local	financial feasibility of rehabili-tation	Actual farming practice stocking rate: 2.34	Economic & ecologic
Assessment of veld utilisation practices and veld condition in the Little Karoo.	MSc thesis, University of Stellenbosch	2005	Cupido, C.	University	n/a	research	Private land	Local	veld condition	Average of actual farming practice stocking rates: 13.6	Economic & ecologic

Publication Title	Journal Title	Date	Lead Author	Lead author's affiliation	Collaborating organization	Type of study	Location of study	Scale of study	Theme of study	Stocking rate: ha.ostrich ⁻¹	Economic, ecologic or <i>ad hoc</i> search
Biodiversity restoration: Ostrich sector takes giant strides to preserve the Little Karoo.	The Waterwheel	2010	Van Vuuren, L.	Unknown	n/a	review	n/a	Local	Biodiversity restoration	Reported recommended government stocking rate: 23	Economic & ecologic
Retention and Restoration of the Biodiversity of the Little Karoo.	CSIR unpublished report	2008	Forsyth, G. Vlok, J.H.J., Reyers, B.	Research organization	Research organization and Private consultant	review	n/a	Local	carrying capacity	Ecologically sustainable: recommended: 30-90	<i>Ad hoc</i>

obtained from *ad hoc* searches and colleagues were included in the publication summary, bringing the total to 69 publications. Twenty-seven of the 69 publications appeared in both the economic and ecological search results. A final nine publications (13 %) out of 69 were included in the publication summary (Table 2).

All nine publications recommended, cited or reported, stocking rates for breeding ostriches on natural veld, which ranged from 0.009 ha.ostrich⁻¹ to 90 ha.ostrich⁻¹. Three publications recommended stocking rates based on economic sustainability, and another study cited the stocking rates recommended by one of these publications. Three publications reported the stocking rates of actual farming practices. Two publications (Murray, 2008 and Van Vuuren, 2010) referred to the recommended government stocking rate, and finally, one publication recommended ecologically sustainable stocking rates. Seven of the nine studies were conducted in the Little Karoo, South Africa. The other two publications were southern Africa and the Karoo region.

Summary of publications: stocking rates for breeding ostriches on natural veld in the Little Karoo

A strict systematic review method could not be followed since the findings necessary for a systematic review were not sufficient (too few publications) and therefore not scientifically robust as per the systematic review criteria.

Recommendation of economically sustainable stocking rates

Lambrechts et al.'s (2004) research study aimed to provide information on the reproductive performance of ostriches maintained at different stocking rates and different male:female ratios under intensive commercial conditions in the Little Karoo, South Africa. Lambrechts et al. (2004) studied actual farmed stocking rates of large flocks (over 100 ostriches) on 1 ha camps and small flocks (9-13 birds) on small camps

(0.3 ha) and recommended an optimal stocking rate of 0.009 ha.ostrich⁻¹ for large flocks and 0.02 ha.ostrich⁻¹ for small flocks, based on different reproductive aspects. This study was purely an economic study with no consideration of ecological sustainability, in fact the authors seemed to consider any ostrich camp used for breeding purposes to be a write-off, due to trampling. The other stocking rates cited in the research study was Deeming and Burbier's (1999) study that reviewed the behaviour of ostriches in natural and captive conditions. Deeming and Burbier's (1999) observed that ostrich breeding flocks in South Africa typically range from 150-200 birds, which are maintained in camps of hundreds of hectares in size. Lambrechts et al. (2004) also cited the guidelines of the SAOBC (2003), which recommends a stocking rate of 10 ha.ostrich⁻¹ for breeding birds during an eight month breeding season. This stocking rate is a guideline and has no scientific background.

Smit (1963) described the farming practices generally employed in the Little Karoo and made no reference to any scientific study. Smit (1963) discussed the issue of veld carrying capacities amongst land managers and suggested not to fix a definite number due to the diverse nature of ostrich farming practices and the differences in veld condition on each farm. In the case of the flock breeding system on natural veld, Smit (1963) reported that 5 ha.ostrich⁻¹ could probably be maintained on Karoo veld in good condition and 10 – 12ha ostrich⁻¹ could probably be maintained on Karoo veld in poor condition. Smit (1963) recommended that the size of the veld should not be considered as a limiting factor when calculating stocking rate, and where ostriches receive supplementary feeding, the concentration of birds can even be increased. The recommendation is based on economic sustainability and it appears that it does not consider ecological sustainability. Strydom et al. (2009) cited Smit (1963) as background to the study that investigated the effects of supplementary feed and stocking rate on the production of ostriches grazing irrigated lucerne pastures. This study is based on breeding ostriches on lucerne pastures and not natural veld.

Murray's (2008b) study mentioned the recommended agricultural stocking rate of 22.8 ha.ostrich⁻¹. However, the aim of the study was to capture the economics of ostrich pen-breeding, and its likely economic effect on ostrich production in the Little Karoo. Murray (2008b) studied the economic viability of a pen-breeding system as opposed to that of a flock breeding system and recommended that the pen-breeding system would be the better option, financially, over the longer term (Murray, 2008b). Pen-breeding is where breeding duos (1 male : 1 female), or preferably trios (1 male : 2 female), are kept in a camp of approximately 0.25 ha.

Actual farming practice stocking rates reported

Milton et al. (1994) studied ostriches on natural veld in southern African savanna, desert grassland, arid shrubland and fynbos to determine the physical and chemical factors that influenced food selection. The study site in the arid shrubland was on seven different ranches in the Karoo. The stocking rates for ostriches on these ranches ranged between 0.1 and 0.3 ha.ostrich⁻¹ which seems to be implemented by land managers on an economic basis. Milton et al. (1994) concluded that ostriches are selective herbivores that feed on new growth, short-lived forbs, and grasses and for this reason, from an economic point of view cannot be maintained on natural veld, but should rather be kept on irrigated lucerne camps. Milton et al. (1994) also recommended that if ostriches are confined to natural vegetation on ranches, stocking rates must be compatible with the maintenance of healthy populations of their preferred forage plant species.

The Herling et al.'s (2009) publication is a financial feasibility study carried out in the Little Karoo that explored the restoration costs associated with shifting a production focus from ostrich farming to sheep production. The study was carried out in the Oudtshoorn magisterial district, in Gannaveld, one of the eight major vegetation types of the Little Karoo. The aim of their study was to create awareness around the actual

costs or opportunity costs of keeping ostriches and how long it takes to recover financial costs associated with veld rehabilitation as a result of ostrich farming. The stocking rate for ostriches on natural veld that is mentioned in the study is based on the actual figures of an ostrich enterprise, i.e. 6.16 ha/LSU, which equates to 2.34 ha.ostrich⁻¹. The study concluded that the stocking rate which is maintained at 2.34 ha.ostrich⁻¹ makes this a financially viable enterprise, although non-sustainable in terms of the environment (Herling et al., 2009). Their findings indicated that rehabilitation was excessively expensive for an individual over the medium term of 20 years and only becomes feasible over a longer time period. This study also revealed the true costs associated with the unsustainable practice of ostrich farming, which sends an alarming message.

The MSc thesis by Cupido (2005), titled 'Assessment of veld utilization practices and veld condition in the Little Karoo' explores the current veld management practices implemented by livestock land managers in the Little Karoo. The study has found that the perception of land managers on veld condition and stocking rates are very optimistic and as a result, grazing capacities are overestimated and overstocking occurs within the area. The study found that land managers on average overstock by 67 % (13.6 ha.ostrich⁻¹) over the recommended government stocking rate of 22.8 ha.ostrich⁻¹. However, if there appears to be little scientific evidence that the recommended stocking rate is ecologically or economically sustainable, any figure of x % overstocking, is rather meaningless. Cupido stated that it is not economically viable for ostrich land managers to keep flock breeding ostrich numbers at the recommended stocking rate and suggested that alternative measures for breeding practices such as small breeding camps should be considered and further investigated. The placement of these camps is critical and should preferably be placed in rocky areas where no threatened plants are present (Cupido, 2005).

Recommendation of ecologically sustainable stocking rates

Van Vuuren (2010) placed an article in the Water Wheel, a magazine aimed at improving general public understanding of science and technology. In this article Van Vuuren (2010) reports on the impacts of ostrich farming on the biodiversity in the Little Karoo, and the development of various restoration methods for Karoo veld. Van Vuuren (2010) mentions that the government recommended stocking rate is 23 (22.8) ha.ostrich⁻¹, but that the actual stocking rates can be 30 times as dense to ensure profitability. This assumption is not scientifically based and is the opinion of the people that were interviewed by the author.

As a result of the intense focus the Succulent Karoo and the Little Karoo in particular has received because of its status as an internationally recognized biodiversity hotspot, a detailed Little Karoo Vegetation Map was compiled by Vlok et al. in 2005 (Forsyth et al., 2008). The purpose of the map was to provide baseline information for informed decision-making on conservation, sustainable commercial farming and land-use planning in the region and especially to enable landowners, land managers, environmental conservation agencies and regional planners to take informed decisions on sustainable land-use practices and determining priorities for conservation projects in the Little Karoo region (Vlok et al., 2005). Vlok et al. (2005) used a gradient analyses approach to do the mapping, which forms the basis of landscape ecology. The terrestrial vegetation of the Little Karoo was divided into the different biomes, i.e. Succulent Karoo biome, Sub-tropical Thicket biome and the Fynbos biome. The biomes were divided between the different major habitats types they represent (habitat names are the local names used in the Little Karoo area, i.e. ranteveld, apronveld, gannaveld, quartzveld, sandveld, kalkveld and succulent karoo mosaic arid renoster veld). The biomes and habitats combined were divided into sectors which were based on the name of the main farm or area as known by the local people. A six-tier vegetation classification system was developed, tested and improved in the field and the vegetation was mapped. A total of 56 habitat types, comprising of 369 vegetation units,

were identified and mapped in the Little Karoo region. All of these units constitute critical components of the Little Karoo (Anonymous, 2008).

Another mapping project was undertaken to spatially quantify the grazing impacts and land-use in the Little Karoo and to produce a transformation map, based on the delineation of the current degradation status for the vegetation units as defined in the detailed vegetation map (Thompson et al., 2005) (Figure 2). Thompson et al.'s (2005) map indicated that almost two thirds of the surface area of the Little Karoo has been transformed to some extent by the actions of man, with 29 % severely transformed, 36.5 % moderately transformed, and only 36.7 % still in a pristine condition.

Forsyth et al. (2008) prepared a report for the Critical Ecosystem Partnership Fund (CEPF) to develop fine-scale spatial data to capacitate land-use decision-makers within the Little Karoo to take sound decisions on vital factors that affect the ecology, biodiversity and economy of the Little Karoo. The report produced a grazing capacity map for ostriches on natural veld in the Little Karoo, based on the underlying spatial data of the detailed vegetation and degradation maps for the Little Karoo (Vlok et al., 2005; Thompson et al., 2005) (Figure 3). The spatial data were used to first map the distribution of threatened ecosystems in the Little Karoo which were based on the classification scheme developed by International Union for Conservation of Nature (IUCN) to categorize species into, among other categories, critically endangered, endangered and vulnerable. The vegetation types were also classified into ecosystem status categories, of critically endangered, endangered and vulnerable, according to the approach and guidelines of the South African National Biodiversity Institute (SANBI). The categories were based on the difference between the conservation target and the extant habitat of each vegetation type (Forsyth et al., 2008). Both, the layer of threatened ecosystems and the guidelines for threatened ecosystems were used to develop the ostrich grazing capacity map (Forsyth et al., 2008).

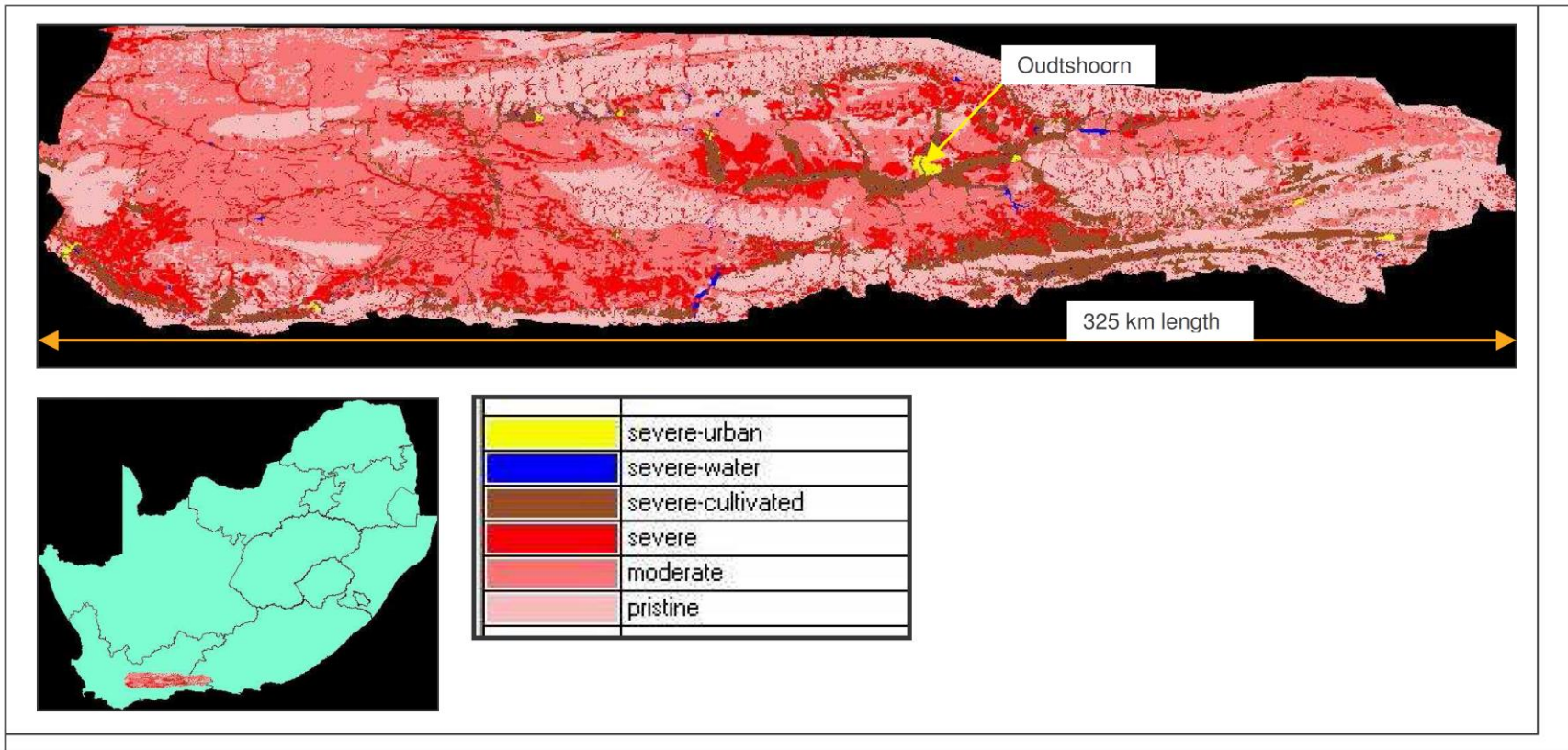


Figure 2. Transformation map of the Little Karoo (Thompson et al., 2005).

Little Karoo: Ostrich capacity

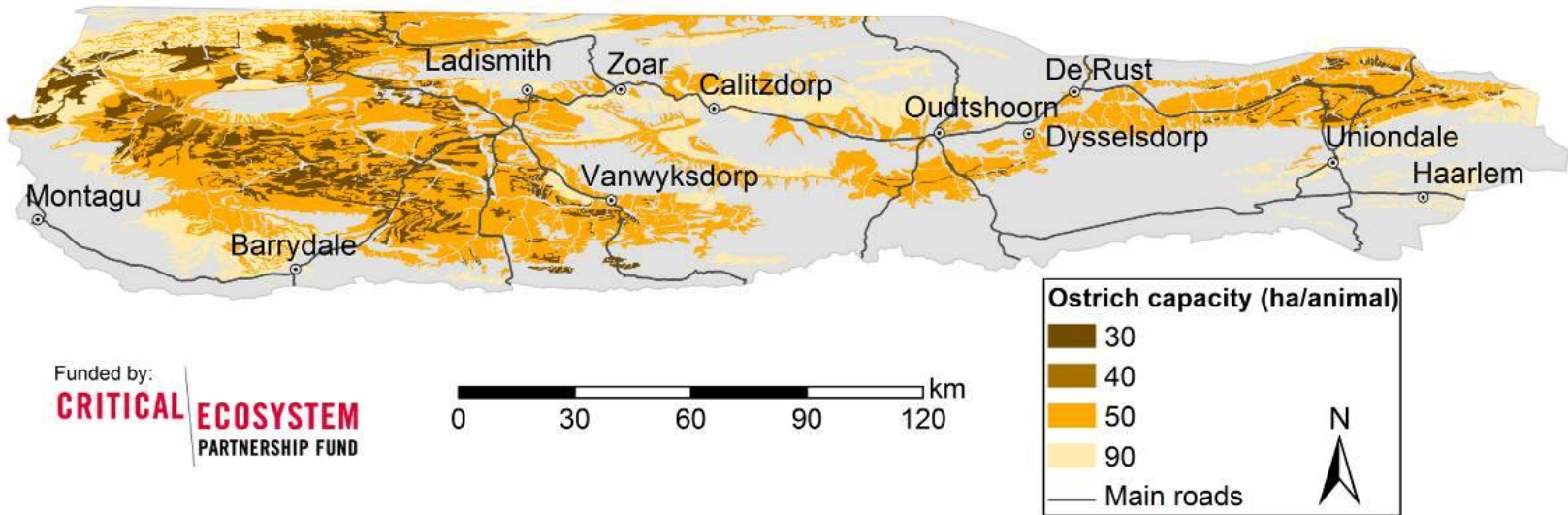


Figure 3. The map shows the estimate area (hectares) required per ostrich if the natural vegetation is to be maintained in a good ecological condition (Forsyth et. al, 2008).

The ostrich grazing capacity map by Forsyth et al. (2008) shown in Figure 3 represented 56 habitat types of the Little Karoo and was amalgamated into 10 habitat classes. Each class was scored according to the number of hectares required per ostrich if the vegetation were to be maintained in an ecologically healthy state. The map recommended ostrich stocking rates of 30-90ha.ostrich⁻¹, depending on the vegetation type.

DISCUSSION

The results from the review delivered no evidence that the recommended agricultural stocking rate of 22.8 ha.ostrich⁻¹ is economically or ecologically sustainable in the Little Karoo. None of the studies assessed sustainability in a holistic way, but rather focused on a single dimension of sustainability. The topics of the publications ranged across a wide spectrum of topics, from socio-economic to ecological studies.

Various publications recommended stocking rates of which one (Lambrechts et al., 2004) was based on scientifically rigorous research experiments. These publications recommended a range of stocking rates considered suitable for production but these high stocking rates result in total destruction of the natural veld. Three publications reported actual stocking rates implemented on farms which were considered to be economically sustainable for that particular land manager. The implemented stocking rates were based on land managers' perceptions and experience in ostrich farming and therefore the reported stocking rates could not be considered scientifically rigorous.

The map of Forsyth et al. (2008) is the only publication that recommended stocking rates specifically for ecological sustainability. The more conservative stocking rates (30-90 ha.ostrich⁻¹) are aimed at encouraging ostrich land managers to use their natural veld in a sustainable way, but are too low to meet the lifestyle expectations of the land manager. The biggest concern about this product is that once again it only considers

one dimension of sustainability and inevitably runs the risk of being rejected by ostrich land managers.

I considered Murray's (2008b) publication, although an economic study, as the only study that provided a solution for both economic and ecologic sustainability. Although the study did not specifically recommend a stocking rate, it suggested that a progressive change-over from a flock breeding to a pen-breeding system is financially more sustainable (gross margins over a 20 year period increased by 20.2 %). Intensive ostrich farming on small breeding pens can potentially be constructed on old or marginal cultivated lands or badly degraded areas to minimize the impact on the natural environment. In some cases where there is no option, a trade-off can be considered where a small portion of natural veld is sacrificed to retain the ecological integrity and biodiversity of the rest of the natural area. Murray (2008b) has found that land managers can even increase their flock size on this smaller area, without compromising production or animal health and ethical regulations. There is however some reluctance of land managers to take up this system due to their perceptions and construction costs associated with pen-breeding (see chapter 4).

This review is limited by the number of publications found to be relevant to the research questions, because I specifically restricted the study to the Little Karoo. Comparison of the results presented here with studies from other similar landscape could yield greater insights.

Global trends in breeding ostrich practices

It seems that South Africa and Israel are very similar when it comes to the implementation of flock breeding practices. Farming with large flocks, ranging from 150-200 birds, is a well-known practice in both these countries (Deeming and Bubier,

1999). The breeding practice similar to what Murray (2008b) recommended is being used in Australia. Pairs, trios and duos are, with the breeding quads consisting of two males and two females are being used (More, 1997). Similarly in Poland ostriches are bred as pairs (duos), trios or as small flocks and most land managers pay special attention to the space requirements of breeders to create optimum exercise conditions (Horbańczuk, 2002). In Europe the minimum space requirement for the maintenance of ratite breeding birds is 0.12 ha, with larger areas recommended to ensure well-being and proper exercise conditions (Horbańczuk, 2002). However, no stocking density was recommended by Horbańczuk (2002). In New Zealand the stocking rate for breeding pairs in open conditions should not exceed $0.05 \text{ ha.ostrich}^{-1}$ for breeding flocks and the minimum camp sizes required for breeding pairs and trios are 0.06 ha and 0.20 ha respectively (Animal Welfare Advisory Committee, 1998). Martin (2009) from the University of Western Australia, said in a report titled “The Future of the Ostrich Industry in a Changing world” that, to increase efficiency, productivity and profitability, ostrich farms need to reduce two major inputs – land used and feed costs per bird slaughtered. It appears that ostrich farming in other parts of the world are practicing intensive ostrich breeding practices, but in South Africa, flock breeding remains the most prominent breeding practice (Cupido, 2005).

Economic versus Ecological considerations – the need for a sustainable stocking rate.

Literature clearly encourages ecological considerations for livestock and rangeland management. Smith (2000) suggested that there is a need for more scientifically based determinations of stocking rates, based on concerns for the need to improve animal performance, more efficient grazing use, or improving resource conditions for livestock in general. But there is also the need to consider economic aspects, which are currently lacking. According to Adams and Revell (2003), scientific research on the production of ostriches in commercial breeding systems in particular is scarce, which has thus far hindered the development of best practice techniques to enable producers to farm as cost-effectively as possible. Ostrich land managers claim that the recommended

government stocking rate is unprofitable (see Chapter 4) and that mostly economic aspects are considered when farming with breeding ostriches (Cupido, 2005). To add to this, the SAOBC recommended a stocking rate of 10 ha.ostrich⁻¹ for the eight month breeding season, which is contrary to the recommended government stocking rate (SAOBC, 2003). Lambrechts et al. (2004) has suggested that ostrich breeding flocks can be maintained at even higher stocking rates than those presently recommended or used on commercial farms. This potential intensification of ostrich farming on natural veld has serious implications for the conservation of Succulent Karoo vegetation and ecosystem functioning and services in the Little Karoo (Lambrechts et al., 2004; Desmet and Cowling, 2005; Le Maitre et al., 2007; Le Maitre and O'Farrell, 2008; Reyers et al., 2009). It presents a challenge to both the ostrich industry and conservation agencies to ensure the conservation of natural resources, while allowing for economically viable commercial ostrich production (Lambrechts et al., 2004).

Cupido (2005) reported in his study that none of the current ostrich management systems, even the three-camp-system that has been recommended for more than two decades, can prevent or reverse the degradation of natural vegetation. According to Cupido (2005), to simply reduce the number of ostriches on the veld is also not a solution. Nel (personal communication, 2010) stated unambiguously that there is actually no way of determining a conventional stocking rate for ostriches, since ostriches do not feed mainly off the natural vegetation but are fed and that the main impact ostriches have in natural areas is trampling, not grazing. Therefore the recommended agricultural stocking rate, which is primarily based on other herbivorous livestock needs, does not appropriately consider the unique ostrich farming practices and unusual ostrich behaviour. One can assume that if the recommended stocking rate was based on a balanced environmental and economic outlook, the severe degradation and high density of ostriches in the Little Karoo may have been substantially less.

RECOMMENDATIONS

From the literature, there appears to be a wide gap between what are considered to be economically and ecologically sustainable stocking rates, with the implication that these two aims may be impossible to reconcile when practicing ostrich farming on natural veld. A shift by the ostrich industry from a veld-based flock breeding system to a pen-based system could possibly be the only mutually beneficial option open to both conservationists and land managers. Murray (2008b) has shown that the progressive change over to pen breeding has a definite economic benefit to the land manager. The extent of economic benefit will depend on the individual land manager's management ability. The pen breeding system shows productivity levels significantly higher than veld-based flock breeding as it allows for better selective breeding with ostriches, which would improve production (Murray, 2008b). At the same time it would result in the reduction of ostrich numbers in the open veld that would allow for the opportunity to implement rehabilitation programmes of degraded areas. Land managers and agricultural practitioners must bear in mind that the process of selecting pen breeding sites need to consider marginal lands or severely degraded areas and that natural veld should not be considered.

A revitalized research programme is urgently needed in the Little Karoo that takes the ostrich industry into a new direction. To date, research has been too narrowly focused on vegetation studies and the state of degradation in the Little Karoo, which describe the current state and decline of biodiversity but offer little reliable information for improving the sustainability of ostrich production. Research needs to holistically consider the social, economic and ecological aspects of ostrich farming and must attempt to find a balance between them. Research projects that include holistic sustainability should be identified and prioritized in collaboration with the industry and the conservation and agricultural agencies represented in the Little Karoo. Environmentally orientated non-government organizations (NGOs) should also form an integral part of this collaboration. This study (chapters 4 and 5) has subsequently

established that NGOs are currently not utilized efficiently in this regard and may be an important resource for funding and expertise (Anonymous, 2001).

Despite all the evidence of degradation and alternative breeding practices, it still seems that land managers in the Little Karoo are not willing to change their well-established ostrich breeding practices. The ostrich carrying capacity map produced for the Little Karoo is unlikely to be adopted by land managers if it will negatively impact on their livelihoods. Research that focusses on land managers' attitudes and how their decision-making processes could be influenced needs to take priority. Chapter 4 has indicated that environmental attitude is most probably the most important characteristic that determines behaviour of ostrich land managers in the Little Karoo. This research also need to explore ways of improving environmental attitude, possibly through agricultural and conservation extension work.

ACKNOWLEDGEMENTS

I would like to thank Dr. A.D. Wheeler for taking the time to review the results of the publication summary for quality and consistency.

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CHAPTER 3: ACTUAL VS. REPORTED OSTRICH NUMBERS ON FARMS IN THE LITTLE KAROO

ABSTRACT

The Little Karoo is an arid region within the Succulent Karoo Biome, South Africa. Ostrich farming has been the main economic driver of the region, but decades of unsustainable land-use practices including overstocking with ostriches have put this region's lowland biodiversity under severe threat. I undertook a survey and collated data from the South African Ostrich Business Chamber (SAOBC) to determine ostrich stocking densities in the study area, to establish how actual stocking rates compare to the recommended carrying capacity and whether ostrich numbers are reported accurately by ostrich land managers. I hypothesized that land managers overstock but under-report ostrich numbers to the business chamber to conceal the high concentration of ostriches on farms. All land managers far exceeded the recommended agricultural stocking rate of 22.8 ha.ostrich⁻¹. Despite this, reported numbers closely reflected actual numbers and there was no evidence of consistent underreporting. The recommended stocking rate appears to be irrelevant to ostrich flock breeders and there appears to be a trade-off between profitable ostrich farming and sustainable land-use practices. It also appears that land managers are confident that the SAOBC is supportive of these high densities of ostriches. Cooperation and collaboration between conservation, agriculture, research and the SAOBC may be the way to find a balance for utilization and conservation in the ostrich industry.

Keywords

Little Karoo, ostrich farming, stocking rate, overstocking, biodiversity.

INTRODUCTION

Land degradation is a wide-spread phenomenon in the arid and semi-arid rangelands of the world (Walker et al., 1981; Sundquist, 2003). Land-use and land-cover changes are so pervasive that, when aggregated globally, they significantly affect key aspects of

Earth System functioning and have a direct impact on biotic diversity worldwide (Sala et al., 2000), it contribute to local and regional climate change (Chase et al., 1999) as well as to global climate warming (Houghton et al., 1999). Land-use change is the primary source of soil degradation (Tolba et al., 1992) and the altering of ecosystem services affect the ability of biological systems to support human needs (Vitousek et al., 1997). Ninety percent of Africa's surface is considered arid, semi-arid or dry-humid (UNCCD, 1995.), therefore the natural capital and ecological services rangelands have to offer to developing countries, should not be underestimated. More than 80 % of South Africa's land surface is considered grazing land or natural veld and is used for agricultural purposes (Hoffmann and Ashwell, 2001). Overgrazing is considered the most important cause of rangeland degradation in South Africa (Van der Westhuizen et al., 1999; Snyman, 2004). According to rangeland scientists an estimated 66 % of the rangelands of South Africa are in a moderate to serious phase of degradation (Scheepers and Kellner, 1995). A lack of an up-to-date national data set of degradation and desertification exists and so it is difficult to quantitatively determine whether the state of degradation has worsened since 1999 (South Africa Environment Outlook Report, 2006). Hoffmann et al. (1999) reported that the land in 25 % of the 367 magisterial districts in South Africa is already severely degraded.

Overstocking remains the most important type of veld degradation in South Africa and is recognized as a priority, at some level, in more than half of the magisterial districts of South Africa (Hoffmann et al., 1999). Widespread significant vegetation change, primarily caused by overgrazing, resulted in the decline of long-term productivity in virtually the entire Karoo region (Roux and Vorster, 1983; Roux and Theron, 1987; Deon and Macdonald, 1994; Dean et al., 1995; Pelsler and Kherehloa, 2000; Hoffmann and Ashwell, 2001). Hoffmann and Ashwell (2001) considered the magisterial commercial farming districts of Oudtshoorn and Calitzdorp in the Little Karoo as the most degraded areas in the Western Cape (South Africa Environment Outlook Report, 2006). Cupido (2005) has found that the veld condition in the Little Karoo can be related to altitude,

vegetation types and land use. The major form of land use in these semi-arid ecosystems has, since the 1730's, been extensive grazing and browsing by livestock such as sheep and goats, but mainly ostriches (Hoffmann et al., 1999; Cupido, 2005).

Lambin et al. (2001) have found that responses to economic opportunities, as mediated by institutional factors, drives land-cover change worldwide and that neither population nor poverty alone constitute the sole and major underlying causes.

The semi-arid Karoo comes with a history of overstocking, by 1865 this area had become stocked to capacity (Dean and MacDonald, 1994) and rangelands were already showing signs of progressive degradation (Shaw, 1875). The Fencing Act in 1912 required land managers to fence their properties and made possible the division of farms into 'camps'. This marked the beginning of rotational grazing in the Karoo. Fencing also made possible the over-utilization of patches, since livestock could then be confined to small areas (Talbot, 1961). Despite severe droughts in the 1920s, stocking rates had again increased throughout the semi-arid and arid areas of the southern region of South Africa (Dean and Macdonald, 1994). Trends in stocking rates, which have fallen by about 50 % over 100 years (Downing, 1978; Dean and Macdonald, 1994), imply progressive loss of usable primary productivity and the degradation loss of rangelands.

Carrying capacities in the Little Karoo tended to be based on periods of high rainfall (Beinart, 2003) and land managers perceived drought as unusual and did not stockpile fodder to sustain production during periods of drought. The inclination was thus to maintain high populations of livestock on the land in the hope of rain – this, in spite of an emerging view, particularly held by land managers, that droughts were increasing in frequency and that the timing of rainfall was changing, causing rangeland degradation (Brown, 1875 cited in Beinart, 2003). The widespread introduction of wind pumps in the

late 1800s (Alexander, 2000; Vegter, 2000) meant that land managers could expand the number of livestock watering points, thereby further increasing their stocking rates.

In many ways the history of the ostrich industry reflects that of the whole of the Little Karoo (O'Farrell et al., 2008). The industry began in the early 1800s when international demand for ostrich feathers manifested. The industry expanded rapidly, and became the dominant farming activity throughout the Little Karoo (O'Farrell et al., 2008). Ostriches did not require a large area, which was important because farms had been subdivided within families – in effect, shrinking the size of individual farming areas (O'Farrell et al., 2008). Small farming units are one of the major factors that contribute to poor implementation of healthy veld management practices (Anonymous, 1999), and Cupido (2005) found that economic considerations are the primary reason why ostrich land managers overstock breeding ostriches on natural veld. He also found that the perceptions of land managers in the Little Karoo on veld condition and stocking density are fairly optimistic, which results in grazing capacities that are overestimated and therefore overstocking in the region. He measured that more than 19 % of land managers perceive that their stocking rate is excellent, compared to the estimated grazing capacity of the Department and only 7.79 % perceived that they heavily overstock their veld. His analysis indicated that ostrich land managers are likely to overestimate the grazing capacity on their farms from 34 % up to >66 % when compared to the estimated grazing capacity of the Department of Agriculture. Murray (2008a) found in his study of the economic aspects of ostrich breeding practices in the Little Karoo that the land managers in his sample size overstocked by 182 %. He found that all of the land managers overstocked, ranging from 'best' land manager 22 %, to 'worst' land manager 1835 %.

The South African Ostrich Business Chamber (SAOBC) serves as a coordinating body for the ostrich industry to benefit both the producers and the processors of ostriches and

ostrich products. All operating ostrich farms are registered with the business chamber and ostrich numbers are reported to the business chamber on a monthly basis (personal communication Kruger, 2011). The perception amongst conservation and agriculture extension agencies are that generally, ostrich land managers under-report their monthly ostrich numbers to the SAOBC (personal communication Anton Kruger, 2010, Kobus Nel, 2010 and Alan Wheeler, 2011) to conceal the high concentration of ostriches on their farms. Cupido's (2005) and Murray's (2008a) studies did not include officially reported ostrich numbers that extended over a period of time. In Cupido's (2005) study land managers reported a stocking rate by completing a questionnaire and Murray (2008a) obtained a stocking rate through interviews with land managers; both methods were a once-off reporting. Reported data which extended over a period of time is expected to give more reliable information to estimate the true extent of ostrich stocking rates in the Oudtshoorn basin.

The first aim of this study was to determine whether, and to what extent, ostrich land managers overstock their farms and under-report their ostrich numbers and to test whether land managers with smaller pieces of land used for ostriches were more likely to overstock. The second aim was to compare reported (reported data from the SAOBC) to actual ostrich numbers (slaughter data from the Department of Agriculture) to determine whether, and to what degree, land managers under-reported ostrich numbers.

METHODS

Study Area and Sample Selection

The study is located in the Oudtshoorn basin, a 10,163 km² area in the north east of the Little Karoo Region of South Africa and includes Oudtshoorn, the largest town. The Little Karoo is a semi-arid, intermontane basin, where three biodiversity hotspots (the

Succulent Karoo, Maputaland - Pondoland - Albany and the Cape Floristic Region) intersect (Vlok et al., 2005). The low-lying parts of the basin are dominated by dwarf, succulent shrublands associated with the Succulent Karoo biome (Thompson et al., 2008a). Although the area is mainly classified as part of the Succulent Karoo Biome, it also has clear links with the Sub-tropical Thicket Biome and the Fynbos Biome (Schutte-Vlok, 2003).

A biodiversity assessment was carried out in the Little Karoo by Skowno et al. (2010). The aim of this assessment was to produce a Critical Biodiversity Area (CBA) map that would identify biodiversity features and areas where conservation compatible land-use practices are required in order to meet nationally accepted targets for pattern and process. The CBA map was used as a guide to focus on the ostrich farms in the Little Karoo that fall in remaining areas of critically endangered vegetation types.

During April 2011 Avian Influenza (AI) / H5N2-virus was identified on a farm in the Little Karoo. This outbreak of AI triggered the ban on all ostrich exports to the European Union (Durr, 2011). More than 50 000 ostriches have been slaughtered since the outbreak in April 2011 which affected 41 farms (34 land managers). On 19 farms only slaughter birds were slaughtered and on 22 farms all ostriches (slaughter and breeder) were slaughtered. Of these 41 farms, those that met the following criteria were selected: they were situated in the Oudtshoorn Basin, they were part of a CBA, and the landowners had at least one years' ostrich numbers reported to the SAOBC. The resulting sample comprised of 27 (10.5 %) farms belonging to 23 owners of the 256 registered ostrich farms in the Oudtshoorn Basin.

Since the outbreak of AI is thought to have been caused by contact of ostriches with certain wild bird species (Thompson et al., 2008b), it can be assumed that the land

managers that were affected by AI represents a random sample of ostrich land managers in the Oudtshoorn Basin.

DATA COLLECTION AND ANALYSIS

A questionnaire was used to conduct structured personal interviews with 23 land managers, representing 27 farms. Questionnaires developed by Cupido (2005), Geurrero et al. (2010) and Winter et al. (2007) were used to inform the questionnaire used for this study. Information on farming practices such as use of natural veld for breeding ostriches and the size of the breeding camps were used for this study. These questions formed part of a bigger questionnaire on behaviour and attitudes which will be reported on in Chapter 4.

Ostrich numbers reported monthly on each farm were obtained from the SAOBC's Database. Following the outbreak of AI, the Department of Agriculture's Animal Health Directorate culled all ostriches on affected farms. The data of the total number of ostriches slaughtered for each farm were obtained from the Veterinary Technicians. Soon after the cull, the Veterinary Technicians carried out eight rounds of ostrich censuses on all ostrich farms. The census data were obtained for this study, but the slaughter data proved to be more useful as they were collected closer to the date ostrich numbers were last reported to the SAOBC than the date of the first census. The window period for possible variance caused by mortalities and trading of ostriches was thus the smallest when using the slaughter data set to compare actual to reported ostrich numbers.

The ostrich numbers reported for at least 12 months from each land manager and slaughtered numbers from the veterinary technicians were compiled. The ostrich

numbers reported closest to the date of slaughter (hereafter “slaughter numbers”) were extracted for comparison of actual vs. reported numbers.

For assessing the extent to which land managers overstock, only land managers (N=12) who used natural veld for their breeding birds were selected. The size of the natural veld breeding camp was divided by the mean number of veld breeding ostriches reported over the 12 month period to first calculate the actual stocking rate of ostriches on each farm. The recommended stocking rate (22.8 ha.ostrich⁻¹ on farms of different sizes) was compared to the actual stocking rate using Excel scatter plots. From this a ‘percentage value overstocking’ more than the recommended stocking rate was calculated for each farm. Spearman’s rank correlation was used to test whether there was a relationship between the size of the land used to keep ostriches and the extent of overstocking, as the data were not normally distributed.

In order to test whether there is a significant under or -over reporting of ostrich numbers to the SAOBC, the data were square-root transformed to meet assumptions of normality. A spearman rank order correlation was done to examine the relationship between the numbers of ostriches slaughtered and the numbers reported by land managers. This correlation was compared visually to the 1-1 relationship which would exist if reporting was completely accurate. A paired t-test was performed to compare the number of ostriches reported to the number of ostriches slaughtered on each farm.

RESULTS

Stocking density on ostrich farms: actual vs. recommended

It is clear from the results that none of the land managers in the study adhere to the recommended stocking rate of 22.8 ha.ostrich⁻¹. Figure 1 shows that all land managers overstock, in most cases by several times the recommended number of ostriches. The

land manager closest to the recommended stocking rate used only 268 ha of natural vegetation and overstocked by 51 %. There was a significant relationship between the farm size (natural veld used for ostriches) and the percentage of overstocking (Spearman $R = -0.496$, d.f. = 20, $p = 0.0155$; see Figure 2).

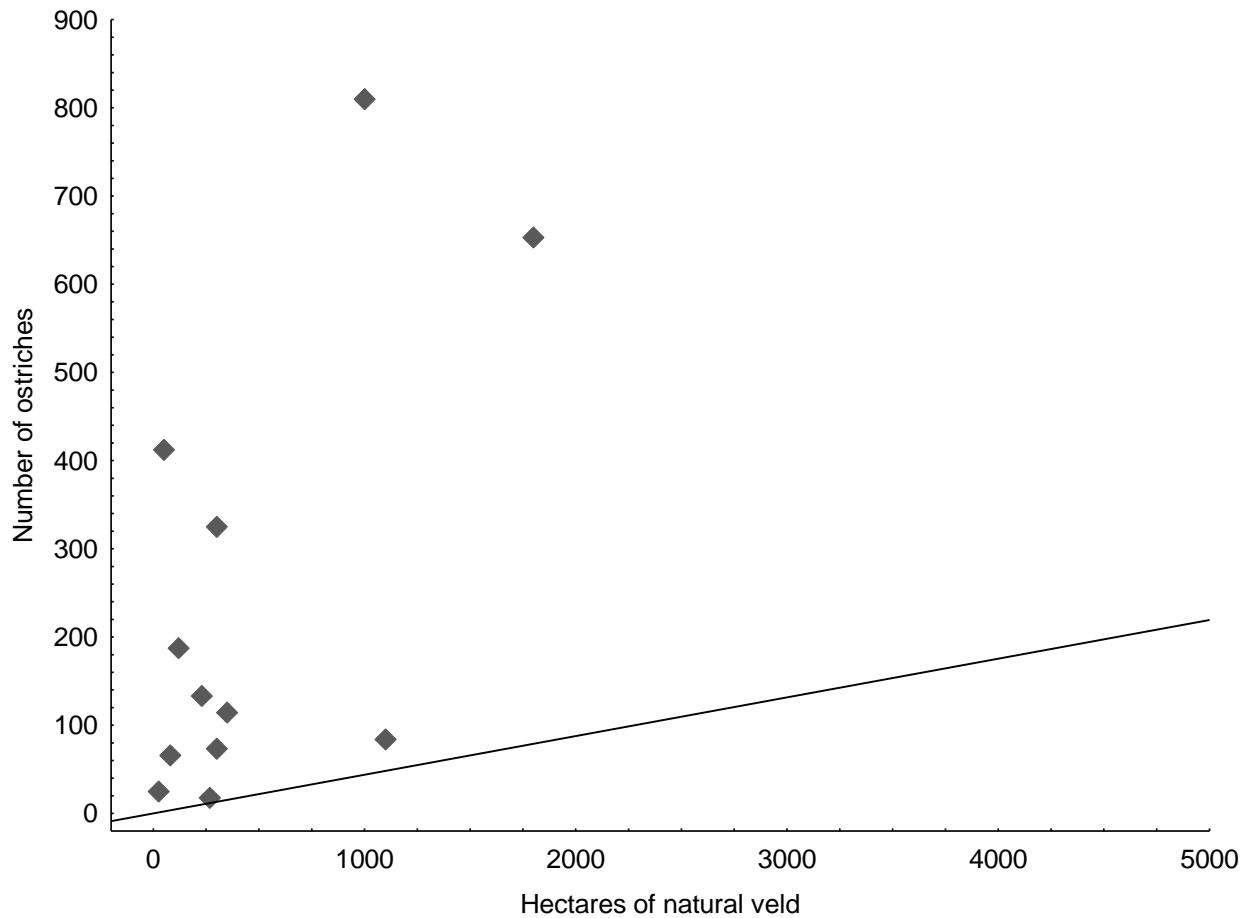


Figure 1. All land managers overstock their natural veld with breeding ostriches. The black line represents recommended number of ostriches per farm (using 22.8 ha.ostrich-1 as the recommended stocking rate).

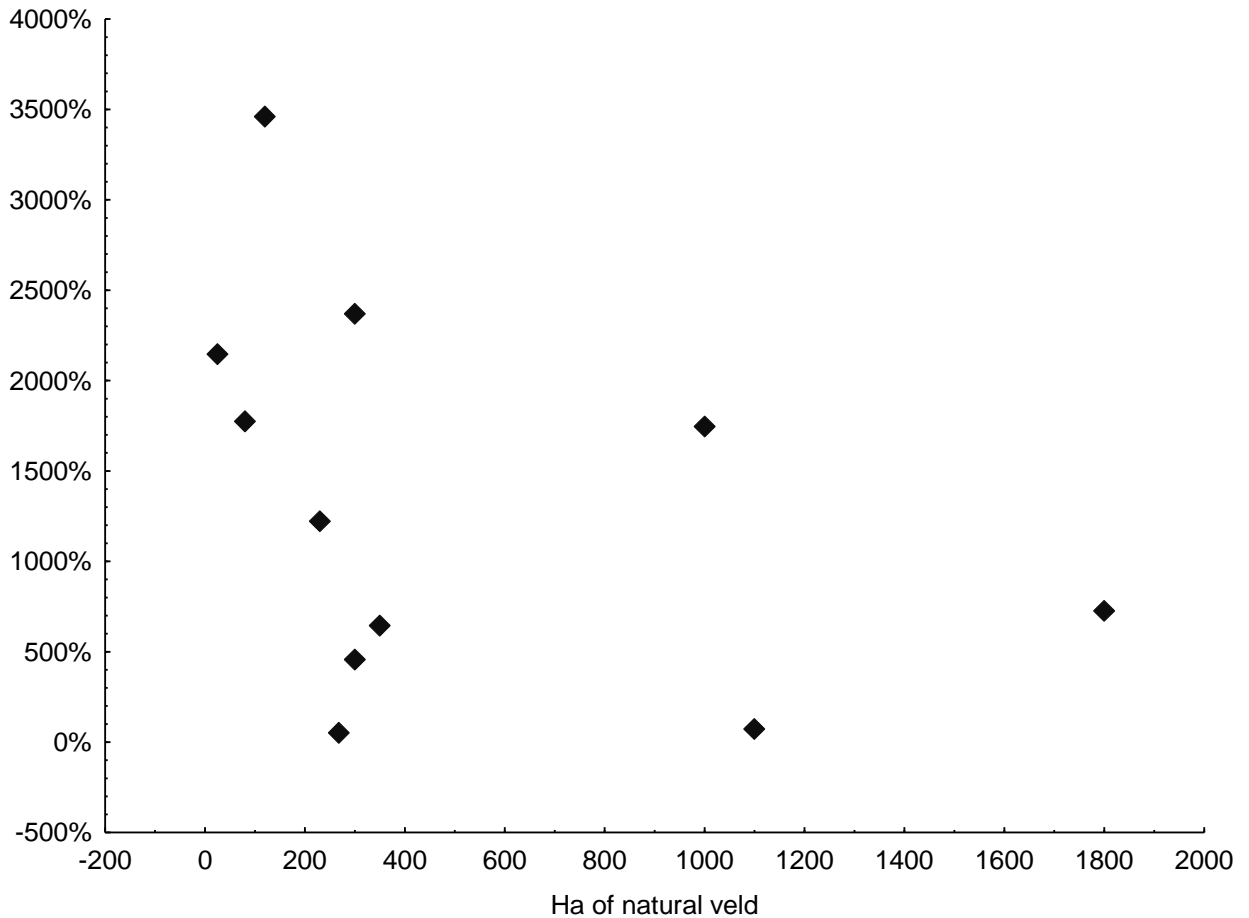


Figure 2. Overstocking (%) of breeding ostriches against farm size (ha of natural veld). One land manager who overstocked 18 000 % (farm size 50 ha) was considered to be an outlier and omitted from the graph in order to reveal the spread of the other data points.

Extent of over or –underreporting of ostrich numbers: Actual vs. Reported

The numbers of ostriches land managers reported agreed closely with the number of ostriches that were slaughtered (Figure 3). There was a strong correlation between actual and reported numbers ($r^2 = 0.95$, d.f. = 44, $p > 0.5$), and the regression line for this relationship was very close to the $y = x$ line which represents completely accurate reporting. The results of the paired t-test showed no significant difference between what a land manager reports and the number that were slaughtered ($t = 0.07$).

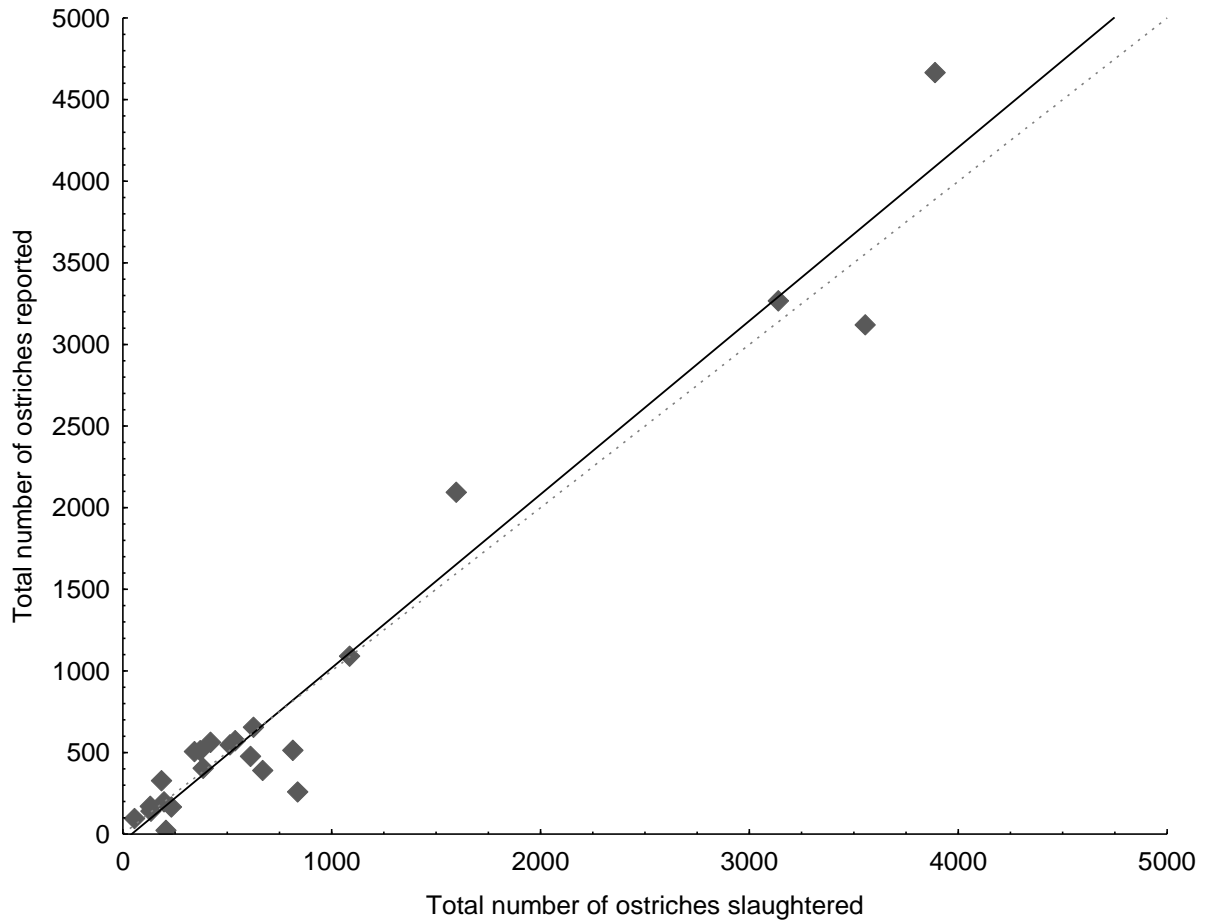


Figure 3. Represented here is the reported ostrich numbers vs. the number actually slaughtered on each of the 12 farms where breeding flocks are kept on natural veld. The solid line represents reported vs. slaughtered and the dotted line a trend-line from reported vs. slaughtered. Data points \blacklozenge falling above and below the line shows over- and -under reporting, respectively.

DISCUSSION

All the land managers in the study sample are overstocking with breeding ostriches on their natural veld. It seems that the recommended stocking rate for ostriches is considered to be completely irrelevant by land managers using ostrich flock breeding practices in the Oudtshoorn Basin CBA's. Literature now widely acknowledges that sustained excessive stocking rates in arid and semi-arid rangelands cause degradation (Cupido, 2005; Dean and Roche, 2007; Thompson et al., 2005). Le Maitre et al. (2007) presented evidence that human activities such as overgrazing of drylands and cultivation of alluvial areas have degraded the ecosystems of the floodplains over large

areas of the Little Karoo over the past 120 years. They also conclude that the current land-use practices are not sustainable, putting the livelihoods of many people at risk. This raises serious concern, since this study has highlighted that the agricultural recommended stocking rate of 22.8 ha.ostrich⁻¹ is not applied by any of the ostrich land managers in CBA's falling within the Oudtshoorn Basin whose records were detailed enough. There is no obvious reason to expect land managers outside the CBA's and/or who have not kept detailed records will stock at lower levels, and it is thus likely that overstocking, in some cases by several times the recommended stocking rate, is typical of ostrich farms in the area. Cupido (2005) has reported that the land managers' perceptions of stocking rates are optimistic and they feel they do not overstock. He concluded that this perception gives an indication of the land managers' inability to 'read the land', since they consider vegetation cover as the most important indicator of veld condition.

Cupido (2005) concluded that the perceived overestimation of stocking rates by ostrich land managers may be related to the provision of food supplements to breeding ostriches on natural veld. This practice differs from those employed by other livestock farming systems, e.g. sheep and beef cattle, where the natural veld areas serve as the main food source (Lambrechts et al., 2004). The fact that ostrich land managers use the natural veld only as holding areas for breeding flocks and which are then fed commercial breeder diets, contributes to the insignificant grazing effect ostriches have on natural veld, compared to the devastating effect of trampling. It is therefore clear that the recommended agricultural stocking rate needs to be revised and that the trampling effect of ostriches on natural veld should rather be taken into consideration.

In the literature review of this thesis (Chapter 2) no evidence of a sustainable economic or ecologically stocking rate for breeding ostriches on natural veld in the Little Karoo could be found. There is very little solid evidence underlying the recommended

22.8 ha.ostrich⁻¹ stocking rate and it may therefore not be the best benchmark to assess overstocking on natural veld. Determination of stocking rates are therefore left to each individual land manager's social value or perception, which drives their decision making, rather than ecological science or considerations (Heitschmidt et al., 2004).

The results show there is a negative relationship between farm size and stocking rates. This means that land managers with larger farms or breeding camps are less likely to overstock with ostriches on their natural veld. The size of natural veld that is being used for ostrich breeding practices, ranges from 25 ha to 1800 ha, of which 72.7 % is less than 400 ha's. Cupido (2005) have found in his study that 60 % of farms in the Little Karoo region are less than 2000 ha in size and relatively smaller compared to those throughout the country.

Opportunity for conservation may lie with land managers with larger farms since they present larger areas that are both lightly stocked and less severely impacted by ostriches than on smaller farms. Conversely, land managers with small farms may have a more limited opportunity for reducing stocking rates as this affects the overall scale of their production. They are unable to compete without the economies of scale available to larger farms. The recommended stocking rate would simply leave them with too few ostriches to make a profit. This has been verified by Cupido (2005), since he has concluded that economic considerations are the primary reason why ostrich land managers overstock breeding ostriches on natural veld. Several researchers (King and Bembridge, 1988; Murray, 2008b) have pointed out that effective economic messages should be developed together with awareness programmes to inform land managers of the importance of conserving biodiversity and also to present cost-effective and sustainable alternative ostrich farming practices. The importance of collaboration across different sectors (researchers of different fields, land managers and managers) and using the different types of available data to support this are evident.

The expectation that land managers were not honest in their reporting was shown to be unjustified. Land managers voluntarily report their ostrich numbers accurately to the SAOBC, even when they grossly exceed the recommended numbers based on the estimated stocking rate for ostriches in the Little Karoo. This suggests that there is a degree of trust between ostrich land managers and the SAOBC. It would also appear that land managers expect the SAOBC to side with them and to have the same attitude regarding economic vs. environmental priorities, and that they are confident that their overstocking is acceptable to the SAOBC. This is potentially significant when it comes to conservation and agricultural sectors collaborating with the SAOBC. Best management practices are promoted by academics, non-profit organizations, conservation agencies, such as CapeNature and extension educators who are concerned with the environmental impacts of farming. Conservation practices are however not always readily adopted by the farming community (Quinn and Burbach, 2010). The values people place on ecosystem services are considered to be highly dependent on social and environmental factors (Carpenter and Folke, 2006).

The question that remains is what makes land managers reluctant to change their practices, even when alternative options prove to be more economically viable, and what it will take to effect changes in farming practices. The attitude and behaviour of the ostrich land managers towards biodiversity conservation and the factors that may influence their choices in farming practices will be examined in chapter 4.

Vetter (2005) reviewed the debates around equilibrium and non-equilibrium systems and their implications in the management of arid and semi-arid rangelands. Her review found that rangeland management in drylands is complex and that factors such as spatial, bio-physical, social, cultural and economics influences should also be taken into consideration. She identified the growing need to integrate the ecological, economic,

social and institutional dimensions of rangeland research. Re-evaluating the recommended stocking rate that takes these elements into consideration would encourage further cooperation and collaboration between all the relevant sectors.

Therefore to conclude, it is critical that the recommended agricultural stocking rate for ostriches on natural veld in the Little Karoo need to be revised and that the fundamental factors discussed above need to be considered. Serious attention need to be given to farm extension services and land manager education programmes, which includes veld assessment methods (Cupido, 2005), veld knowledge and farm conservation practices. The historical impact ostriches have had on the Little Karoo and the fact that Cupido (2005) have found that no grazing system can prevent or reverse the degradation of natural veld caused by breeding ostriches on natural veld, stocking at low densities would not be considered as an option. It is therefore inevitable that land managers need to switch to intensive ostrich breeding practices, as recommended by Murray (2008b) if we want to safeguard the biodiversity of the Little Karoo.

ACKNOWLEDGEMENTS

I thank the landowners of the Little Karoo for participating in the interviews, giving me their full support. The South African Ostrich Business Chamber for providing assistance and permission to use information and the veterinary technicians of the Oudtshoorn Research Farm, for providing crucial data that supported the research.

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CHAPTER 4: ENVIRONMENTAL ATTITUDES AND BEHAVIOUR OF OSTRICH LAND MANAGERS IN THE LITTLE KAROO, SOUTH AFRICA.

ABSTRACT²

Issues of environmental sustainability are mainly about human choices and actions. Understanding these may assist us in determining the factors that predict or influence an individual's behaviour towards the environment. In South Africa approximately 80 % of the most scarce and threatened vegetation types are in the hands of the private agricultural community. In the Little Karoo, which is situated in the internationally recognized Succulent Karoo hotspot, decades of unsustainable land-use practices including ostrich flock breeding practices have put this region's lowland biodiversity under severe threat. We conducted interviews with 23 ostrich land managers in the Oudtshoorn basin to get an understanding of the type of ostrich breeding practices being implemented, land managers' attitude and behaviour towards the environment and their willingness to collaborate with conservation orientated organizations. Demographic information of land managers was used to identify possible characteristics that may influence land manager attitudes or behaviour. Flock breeding was the prevailing ostrich breeding practice and land managers in general were more willing to collaborate with agricultural than conservation organizations. Environmental attitude had a significant relationship with conservation behaviour, whereas land managers' level or education, years of farming experience and farm size did not show any relationship with conservation behaviour. Three groups of land managers were identified based on their scores for environmental attitude, of which one group of land managers were younger and had a more positive conservation attitude and behaviour. Land managers in general indicated a particular preference for collaborating with agricultural organizations and this provides an opportunity for organizations to engage

² The statistical analyses of this paper were carried out by Mark Difford.

with the land managers, particularly the one group, which appears to present the best opportunity for conservation.

Keywords

Environmental sustainability, ostrich farming practices, land managers, conservation knowledge, willingness to collaborate.

INTRODUCTION

Environmental sustainability is becoming the major social issue of the present century (Wilson, 2001). Many human activities, including agriculture, reduce the capacity of ecosystems to benefit people by degrading them (Webb, 1996; Matson et al., 1997). Over the past 50 years, human activities have altered ecosystems faster and more extensively than ever before. Human activities cause habitat loss and fragmentation, resulting in the loss of species and ultimately in the decline of ecosystem functions (Driver et al., 2012). The agricultural sector globally is moving towards sustainability in farming practices to ensure that they can meet world food demands, enhance rural livelihoods and stimulate economic growth (Scotcher, 2009).

In South Africa approximately 80 % (by area) of the most scarce and threatened vegetation types are privately owned by the agricultural community (Botha, 2001). Many regions of high conservation value are also dominated by production landscapes in complex social-ecological systems (Briggs, 2001) and have been subdivided into small management units with numerous owners who have different land-management goals and practices. Land transformation has left 34 % of South Africa's ecosystems threatened. Of these, 21 ecosystems (5 %) are critically endangered (Goldblatt, 2010). The variety of factors such as shrinking budgets, lack of capacity and competing socio-economic priorities (Botha, 2001) have made the acquisition of land for strict reservation no longer a feasible conservation strategy (Miller and Hobbs, 2002; Rosenzweig, 2003). Therefore, the future conservation of threatened ecosystems lies

predominantly in the hands of land managers and private landowners (Winter et al., 2007).

Issues of environmental sustainability are mainly about human choices and actions and psychologists have therefore much to contribute to the understanding and formulating of how such change might occur (Mayer and Frantz, 2004). Because psychologists refer to individual behaviour rather than to behaviour of whole societies, they ask questions such as what determines an individual's ecological behaviour, i.e. 'actions which contribute towards environmental preservation and/or conservation' (Axelrod and Lehman, 1993) or how behaviour can be changed in a more ecological direction. To answer the questions around what determines an individual's ecological behaviour (Axelrod and Lehman, 1993), environmental attitude is considered one of the most promising concepts and almost two-thirds of all environmental psychological publications include environmental attitude in one way or another (Newhouse, 1990).

An environmental attitude is an individual's enduring disposition toward the environment (Quinn and Burbach, 2010) and according to Ajzen (1985, 1991) is also a direct predictor of behaviour intention. Milfont (2007) defines it as a psychological tendency expressed by evaluating the natural environment with some degree of favour or disfavour. Attitude towards the environment commonly refers to environmental concern (Vining and Ebreo, 1992), which is used either as a multiple or a single component approach (Furher, 1995) covering either environment in general or some particular aspects of the environment e.g. air quality (Kaiser et al., 1999). There are many environmental attitude measures available based on different conceptual and theoretical frameworks, but there seems to be a consensus that environmental attitude is multidimensional and organized in a hierarchical fashion (Milfont and Duckitt, 2010). Dimensions often used to measure attitude or behaviour are human and social capital factors such as conservation knowledge, conservation behaviour, willingness to

participate and willingness to collaborate (Knight et al., 2010). Kaiser et al. (1999) established that environmental attitude is a powerful predictor of ecological behaviour.

Until now, social psychologists interested in environmental sustainability have applied knowledge from the research literatures on attitudes (Kellert, 1993; Rauwald and Moore, 2002), persuasion (Gonzales et al., 1988; Davis, 1995), commitment (Pallak et al., 1980; Werner et al., 1995), normative influence (Aronson and O' Leary, 1982; Cialdini et al., 1990) and incentives (Levitt and Leventhal, 1986; Stern et al., 1992). Studies of personal characteristics including environmental attitudes affecting land managers' adoption of conservation practices remain limited (Quinn and Burbach, 2008) and to date are highly skewed toward the North American Region (Amsalu and De Graaff, 2007; Knowler and Bradshaw, 2007). Quinn and Burbach's (2010) work in the United States that examined the relationship between land managers' use of conservation practices that impact surface water quality and the personality characteristics of environmental attitude and moral reasoning about the environment, suggested that the general farming population is not sufficiently concerned about conservation practices and there was a significant negative relationship between anthropocentric reasoning and pro-environmental behaviours. According to Buttel (1975), Kronus and Van Es (1976), Tremblay and Dunlap (1978) and Lowe and Pinhey (1982), studies have shown that as a group, land managers tend to be less concerned about the environment than other groups, because of the nature-exploitative character of farm work (Williams and Moore, 1991). Quinn and Burbach (2010) suggest that efforts to encourage the adoption of conservation practices therefore need to target the entire farming community.

A few South African studies have focused on aspects pertaining to conservation on private land. Savy (2003) focused specifically on private land-conservation and land managers' attitude towards conservation in the grasslands of Kwazulu-Natal. Savy

(2003) found that an interaction between attitudes towards the relative importance of conservation and levels on interest in Wattled Crane conservation was the best predictor of behaviour. Opportunity costs also played a role in determining current conservation effort of land managers. Winter et al. (2007) specifically studied the attitudes and behaviour of landholders toward the conservation of Renosterveld and found that land managers who are younger were more willing to conserve, did not necessarily have a better education, and owned larger farms (>500 ha) with greater amount of remnant Renosterveld (>300 ha) than those less willing to conserve. Winter et al. (2007) also found that attitudes toward Renosterveld were largely negative because it is not economically advantageous to retain it. Knight et al. (2010) assessed human and social factors to define opportunities for implementing effective conservation action on private land. Their work provided conservation and land management professionals direction on where and how implementation of local-scale conservation should be undertaken to ensure it is feasible. Pasquini et al. (2009) interviewed owners of private conservation areas in the Little Karoo, South Africa. They examined landowner opinions of existing conservation policies and their relationships with the local conservation authority and assessed landowner preferences regarding conservation incentive measures. They concluded that conservation policies for private lands could benefit from the provision of extension services to landowners and public acknowledgement of the contributions private conservation areas make.

The Little Karoo, a semi-arid region located in the Succulent Karoo biome of South Africa, is primarily an agricultural region which is very dependent on the limited supply of surface and ground water to irrigate agricultural land and range-fed livestock. The Succulent Karoo biome is internationally recognized as being one of only two biodiversity hotspots found in arid regions (Mittermeier et al., 2005) due to its high levels of plant endemism and its extensive transformation, which is estimated to be at least 70 % (Myers et al., 2000). Farming practices such as extensive grazing and browsing by domestic small stock and especially ostriches have resulted in severe

degradation of more than 50 % of the region (Thompson et al., 2008; Herling et al., 2009). This has resulted in ecosystem changes over large areas of the Little Karoo, which has caused a loss in productivity and biodiversity (Dean and Macdonald, 1994; Thompson et al., 2005; Vlok et al., 2005). Le Maitre et al. (2007) presented evidence that the effects of human activities on the Little Karoo over the past 120 years have been severe. Cupido (2005) found that free-range ostrich farming is the major cause of veld degradation in the Little Karoo and that the current grazing systems and veld management practices are unsustainable. A recent study showed that ecosystem services in the Little Karoo are in decline, which raises concerns about the region's long-term productivity and its resilience to floods, drought or market shifts (Reyers et al., 2009). The history of land-use decisions and their impacts in the Little Karoo point to the need to create future economies and livelihoods that are sustainable (Le Maitre et al., 2007). To achieve this, it is important to understand the human and social factors that drive the decision-making processes of land managers and to translate that in effective conservation action (Cowling et al., 2003). Understanding the constraints experienced by land managers in their farming operations is important, because management practices are influenced by land managers' perceptions of the compatibility of such practices with their needs and production goals (Botha, 1991).

This study aims to obtain a better understanding of the land managers' level of conservation knowledge, their behaviour and attitude towards the environment and their willingness to collaborate and to identify possible characteristics that may positively influence a land manager's decision to look after their natural environment. A deeper insight into land managers' attitudes and behaviours will contribute towards identifying conservation opportunities in the landscape (Knight and Cowling, 2007).

This study aimed to investigate several aspects in relation to the attitudes and behaviour of ostrich land managers' in the Little Karoo. Ostrich farming consist of

several different systems, of which all or a subset may be found on any particular farm. There are various breeding practices being implemented by ostriches land managers, such as free range flock breeding on natural veld, intensive group breeding and intensive pen-breeding. Free range flock breeding on natural veld is considered to be the most destructive ostrich farming practice (Cupido, 2005), whereas intensive pen-breeding is considered to be a more ecologically and economically sustainable alternative (Murray, 2008a; Murray, 2008b; Mugido, 2011), since it affects much smaller areas of land. One aim of this study was to determine which systems are practiced, as well as the reasons for the choice of farming practices and for not practicing alternative methods. It was predicted that most land managers practice the traditional flock breeding system, the practice causing the most damage to the environment, because it is the way generations before them have been farming with ostriches. The second aim was to explore land managers' attitudes towards the use of natural veld and towards its conservation. It was expected that land managers may have positive attitudes to the environment generally, but that these may not necessarily be reflected in their actions on their farm. We also set out to measure land managers' knowledge and awareness of conservation issues in the Little Karoo. It was expected that many land managers would be relatively unfamiliar with the conservation issues of the area, especially the biodiversity status of the Little Karoo. We aimed to establish whether land managers were willing to collaborate with a variety of conservation-orientated institutions, what types of initiatives they would consider becoming involved in and what types of incentives would make conservation actions more attractive. We predicted that land managers' willingness to collaborate would be more likely to be directed towards agricultural, rather than conservation, organizations. We expected to find that most land managers are not currently participating in conservation activities, but that many would be interested in becoming involved if a range of suitable incentives were offered. We predicted that land managers would be more pro-conservation in their attitudes and behaviour the higher their level of education (Rahm and Huffman, 1984; Amsalu and De Graaff 2007; Knowler and Bradshaw, 2007; Quin and Burbach, 2010), whereas they

would potentially be more conservative in their practices the older they are or the more years of farming experience they have. Finally, we expected owners of smaller farms to be more constrained in their behaviour, but not necessarily in their attitude or knowledge (Rahm and Huffman, 1984; Winter et al., 2007; Quin and Burbach, 2008).

METHODS

Study Area and Sample Selection

The study was located in the Oudtshoorn basin, a 10,163 km² area in the north east of the Little Karoo Region which includes Oudtshoorn, the largest town. The Little Karoo is a semi-arid, inter-montane basin, where three biomes (Fynbos, Succulent Karoo and Thicket biomes) and biodiversity hotspots (the Succulent Karoo, Maputaland - Pondoland - Albany and the Cape Floristic Region) intersect (Vlok et al., 2005). The low-lying parts of the basin are dominated by dwarf, succulent shrublands associated with the Succulent Karoo biome (Thompson et al., 2008). Thomson et al. (2005) mapped the degradation of the Little Karoo at a scale of 1:50 000 in 2005 and have found that the remaining natural area of semi-arid habitats in the Oudtshoorn basin covers an area of approximately 937,232 ha (92 % of original extent) (Thompson et al., 2008). This remaining natural area excludes areas that have been completely transformed by urban development and agriculture and is made up of four primary semi-arid habitats; Gannaveld, Apronveld, Succulent Karoo Mosaic Thicket and Spekboom Thicket. Of the total remaining natural area only 8.6 % remains intact, while 67.9 % is moderately degraded and 23.5 % severely degraded (Thompson et al., 2008).

Gannaveld and Apronveld habitats, described as dwarf succulent shrublands dominated by *Salsola* and *Pteronia* spp. respectively, make up approximately 15 % of the total semi-arid habitats in the Oudtshoorn basin. Only 1.4 % of Gannaveld remains intact while 59.6 % is moderately degraded and 39 % severely degraded (Thompson et al. 2008). In

Apronveld, only 1.5 % remains intact. Forty-four percent is moderately degraded and 54.3 % severely degraded. Both these habitat types are accessible to livestock and are especially suitable for ostrich farming (Cupido, 2005; Vlok et al., 2005; Thompson et al., 2008). As a result of these maps a fine scale or Critical Biodiversity Area (CBA) map was produced by Skowno et al. (2010). The CBA map was used as a guide to define the study area and to focus on the ostrich farms in the Little Karoo that fall in remaining areas of critically endangered vegetation types.

More than 80 % of all South African ostrich farms are situated in the Little Karoo, making it the largest contributor to the economy of the region (Talbot, 1961; Cupido, 2005; Le Maitre et al., 2007). All operating ostrich farms are registered with the South African Ostrich Business Chamber (SAOBC), the coordinating body for the ostrich industry that aims to benefit both the producers and the processors of ostriches and ostrich products (SAOBC, 2011). Several biodiversity initiatives have been launched since the availability of fine-scale CBA maps in 2005. The Gouritz Biodiversity Corridor was launched in 2005 under the auspices of CapeNature, the provincial conservation agency, and has since then changed its governing structure to that of a Biosphere Reserve and non-profit organization. It is now known as the Gouritz Cluster Biosphere Reserve (Pasquini, 2008). A biodiversity and business initiative was also launched in 2007, known as the Ostrich Industry Biodiversity Management Project. This project is being implemented by the SAOBC and its aim is to investigate and promote alternative ostrich farming practices in the Little Karoo (Botha et al., 2008). To achieve this, one of the strategies for the biodiversity project team is to collaborate with the Provincial Department of Agriculture's LandCare division and to approach farm extension services with an integration of ostrich farming best practices (conservation) and farm management advice (LandCare). Area Wide Planning is the tool used to implement this approach and integration. LandCare area-wide projects involve pro-active ways of preventing the extensive degradation of the natural resources; it is a process that enables communities to craft their future desired condition and then implement projects to reach this

sustainable objective. Area Wide Planning requires the gathering and mapping of demographic farm information to get an overview of, *inter alia*, current farming enterprises, planned new farming developments and infrastructure of a region (Anonymous, 2002).

DATA COLLECTION AND ANALYSIS

To investigate the attitudes and behaviour of ostrich land managers in the Little Karoo towards conservation, a questionnaire was used to conduct a structured personal interview with 23 land managers, representing 27 farms. Twenty-two of the 23 land managers were the owners of the properties. The sample was selected from 41 farms that were affected by an avian influenza outbreak in 2011, as a result of which all their ostriches were slaughtered. The farms also met the following criteria: i) the farm is situated in the Oudtshoorn Basin; ii) the farm falls within a CBA; and iii) the farm is registered with the SAOBC.

This generated accurate data on ostrich numbers which were used for a related study (Chapter 3). By applying this set of criteria, the resulting sample consisted of 27 farms belonging to 23 land managers. The outbreak of AI was found to be associated with any concentration of ostriches in a camp. It was also found to be associated with an increased frequency of contact with certain wild bird species on farms (Thompson et al., 2008). Viruses exist and flow through complex agri-food systems, and it has proved impossible to predict the direction or speed of their movement through livestock farming regions (Hinchliffe, 2001; Bickerstaff and Simmons, 2004; Law, 2006). It was therefore assumed that the farms that were affected by AI were a random sample of ostrich farms in the Oudtshoorn Basin.

All the interviews were conducted between May and November 2012. Questionnaires developed by Cupido (2005), Geurrero et al. (2010), Winter et al. (2007) and Knight et al.

(2010) were used to inform the questionnaire used for this study. The questionnaire (Appendix B) was subjected to a review by two researchers and was also tested in two pilot interviews conducted with landowners not included in the sample. The pilot interviewees felt comfortable answering all the questions and did not feel that any aspects were too probing or sensitive. The questions were a combination of quantitative, qualitative, closed and open-ended questions. The closed-ended questions provided greater uniformity of responses and included Likert-statements and a variety of demographic questions. The open-ended questions allowed the interviewer to probe certain issues in more depth (Winter et al., 2007).

The questionnaire was grouped into eight sections and totaled 131 questions. We identified four main sections or scales (Table 1) of social and human dimensions that hypothetically influence or reflect the character of land managers in their behaviour towards the environment (Winter et al., 2007; Knight et al., 2010). These four sections comprised of 66 of the total 131 questions and covered environmental attitude (EA), conservation knowledge (CK), conservation behaviour (CB) and general land manager willingness to collaborate (WC) with organizations, willingness to participate in conservation and interest in incentives (Appendix C, Table S1). The first section of the questionnaire consisted of a range of demographic and farm-related questions to provide background information on the land managers and their farms, which were expected to influence the attitudes and behaviour of ostrich land managers towards the environment. These included the number of years the land manager has been on the farm, how many generations the farm had been in the family, the size of the farm, the size of cultivated lands and natural veld, various measures of affluence and the number of staff employed. Another section pertaining to ostrich farming practices consisted of a range of closed and open-ended questions, on what kind of ostrich farming practices were being implemented on the farm, at what scale and why land managers chose specific practices and avoided others. Another section consisted of a range of closed and open-ended questions pertaining to ostrich stocking rates, including the thinking of

land managers on flock breeding practices, how they decide how many ostriches to stock on natural veld and what they think their natural veld stocking capacity is.

Table 1: The four main sections and two sub-sections of social and human dimensions included in the questionnaire that hypothetically influence the character of land managers in their behaviour towards the environment, adopted from Winter et al. (2007) and Knight et al. (2010). The questions that were asked under each section are presented in the supplementary material, Tables S4-S8 (Appendix C).

Section	Measure	Rationale
Environmental attitude (EA)	General environmental concern	Environmental attitude is a powerful predictor of ecological behaviour (Kaiser et al., 1999).
Conservation Knowledge (CK)	Knowledge and awareness levels of conservation importance of the Little Karoo.	Environmental knowledge is one of three concepts making up the theory of planned behaviour (Kaizer et al., 1999) and is a significant prediction of ecological behaviour intent.
Conservation Behaviour (CB)	Implementation of conservation-friendly activities, such as soil erosion measures and monitoring.	Behaviour comprises a component of the tripartite model for describing attitudes (Bohner and Wanke, 2002). Behaviour is observable actions (Gray, 2002)
Willingness to collaborate (WC)	Identifies the agencies or organizations a land manager will or will not engage with and indicating their willingness to engage or work with them.	Conservation of biological diversity usually demands explicit recognition of cross-boundary cooperation (Rickenbach et al., 2004). It is important to know which land managers are most willing to collaborate, since the effectiveness of conservation interventions are reliant on mutual cooperation and collaboration.
Sub-section: participate	Willingness to Identify conservation activities land managers are most likely to participate.	Private land conservation requires a better understanding of the social and economic factors that underpin land managers' willingness to participate in conservation activities (Curtis et al., 2001).
Sub-section: incentives	Interest in Identify the incentives land managers are most interested in.	Private-land conservation initiatives are often voluntary and so rely on incentives and encouragement (Young et al., 1996; Byron and Curtis, 2002).

Land managers were asked what they perceived the condition of their natural veld to be and whether they believed the recommended agricultural stocking rate of 22.8 ha.ostrich⁻¹ to be economically profitable. The questionnaire was concluded with a section on personal information, such as age, family information and education, believing that the respondent at this stage would feel comfortable in providing information of a personal nature.

The questionnaire was developed in English and translated into Afrikaans, since the majority of the land managers in the Little Karoo are Afrikaans speaking. The interviews were carried out in the presence of the local LandCare officer and the SAOBC biodiversity project team, of which the researcher was the project coordinator. The farming community was familiar with this integrated unit, since collaboration had taken place since 2007. Area Wide Planning was carried out at the same time, since the information that was required for the Area Wide Planning complemented the interview questionnaire. We did not expect that this arrangement would influence the way the land managers answered the questions, in fact we believed that this arrangement and the fact that the land managers knew the unit well, assisted in the extent to which the land manager opened up in the interview. Prior to the starting, land managers were told the interview would be confidential and that their identities would remain anonymous. Interviews lasted between 45 minutes and 1.5 hours. All interviews were transcribed and transcribed texts were coded by labeling related data with numerical category codes.

Cronbach's alpha (α) (Cronbach, 1951), Revelle's beta (β) (Revelle, 1979) and McDonald's total omega (ω_t) (McDonald, 1999) were used to assess internal consistency and dimensionality of the four scales (CB, CK, EA and WC) and to sharpen the scales by retaining the question set that is most unidimensional and internally consistent. Mokken scale analysis (Mokken, 1971), a non-parametric form of item response theory,

was carried out to cluster and sharpen the scale for WC. Relationships between the latent variables (LVs) were explored by using a pairs plot and variations of a correlation biplot that derived from a correspondence analysis of the raw data matrix, i.e. of the scores of the LVs. Multivariate CART (classification and regression tree) and multivariate analysis of variance (MANOVA) were used to explore the relationships between LVs and predictor variables (ancillary data) and to cluster groups of land managers with different scores for the four scales considered together. The ancillary data that were included in the analysis are presented in Table S2. Causal models, Shipley's (2000) test and partial least square path model (PLS-PM) were also applied to the four scales to determine how the LVs influence each other.

RESULTS

Land managers – demography, general responses, behaviour, attitudes and willingness to collaborate

All of the land managers were very willing to answer the questions and did not show any concern about confidentiality. The fact that we were a well-known unit in the farming community, representing agriculture and the SAOBC, appeared to put the land managers at ease, made them willing to participate, and respondents showed no hesitation in answering all of the questions.

All of the land managers were white males (Table S3. a,b). The largest portion of land managers (35 %) were between the age of 41-50 and 83 % were Afrikaans-speaking (Table S3. b,c). Twenty-six percent of land managers had between 11-20 years of farming experience and 48 % had between 21-30 years of farming experience (Table S3. d). Farms ranged from >50 ha to 12 000 ha with most farms (48 %) falling between 100-500 ha. Ninety-one percent of land managers indicated that ostrich farming is their primary land-use (Table S3. d-f), 17 % indicated sheep and the production of lucerne products (hay, seed or pellets) as their second priority land-use and 39 % indicated that cattle was their third priority land-use (Table S3. g,h). Sixty five percent of land

managers learnt how to farm ostriches from their fathers; 22 % were the first generation on the farm, the rest were between 2nd and 7th generation. Only 17 % did not have any tertiary qualifications and 35 % had a formal qualification in Agriculture (Table S3. i-l).

Interestingly, only one land manager (4 %) had no breeding ostriches and four of the 22 remaining land managers implemented a combination of flock-breeding, pen-breeding and group-breeding practices. Flock breeding was by far the most popular breeding practice and was implemented by 68 % of respondents (Table S3. m,n). The two main reasons land managers gave for this type of breeding practice were that it was less intensive and easier to manage than pen-breeding, and that it was the most profitable practice. Only two respondents reported that they implemented flock breeding primarily because it is the way it has always been and they are not interested in other methods. Other reasons included that they did not have much success with pen-breeding, there is enough natural veld for the birds to roam and the birds are familiar with the veld. When land managers were asked how they decided at what density to stock ostriches in a veld camp, a large portion (27 %) considered the camp size and another large portion (27 %) considered the carrying capacity of the veld. Aspects such as the number of ostriches owned and past practices were also mentioned.

Eighteen land managers had an opinion on the stocking rate of ostriches on their natural veld. Two of the 18 thought that ostriches should not be kept on natural veld at all because ostriches cause too much damage, but most (72 %) suggested a stocking rate of less than 10 ha.ostrich⁻¹ on natural veld. The majority (87 %) were of the opinion that the recommended agricultural stocking rate of 22.8 ha.ostrich⁻¹, is 'very unprofitable' (Table S3. o,p) Twenty one of the 23 land managers have flat areas or valleys on their farm where the majority of ostrich farming activities take place; all of them perceived the vegetation of these areas to be in a good condition.

Attitudes toward the environment were generally positive (Table S4). The majority of land managers 'agreed' or 'strongly agreed' (hereafter, both categories are reported together as 'agreed') with a variety of statements indicating pro-environmental attitudes and behaviour. Most (96 %) agreed that the owners of the land are responsible for the protection of biodiversity on their property.

Nine questions around conservation issues in the Little Karoo were asked to measure the conservation knowledge of land managers (Table S5). The majority of respondents were aware that the Little Karoo's vegetation is endangered (74 %) and that it is important in terms of its biodiversity (70 %). Most land managers (74 %) also indicated that they knew the reasons why the lower lying areas of the Little Karoo should be conserved. All except two indicated that they were aware of the Ostrich Biodiversity Management project and that they were aware of the prescribed government stocking rates, but more than half of the land managers did not know about the existence of the CapeNature Stewardship Programme. Seventy-eight percent thought that the people of the area were becoming more aware of the conservation importance of the vegetation of the Little Karoo.

The behaviour of land managers towards conservation was similarly mostly positive (Table S6). Eighty-seven percent have undertaken soil conservation measures for reducing soil erosion in the last 5 years and 70 % indicated that they had undertaken nature conservation activities such as surveys, restoration and monitoring on their farms in the last five years. Sixty-five percent thought it was necessary to have an environmental management plan for their farm and 91 % and 92 % respectively implemented healthy waste management practices and alien vegetation clearing on their farms. On the other hand, most did not monitor their veld condition on a formal basis (43 %), operate eco-tourism activities on their farm (83 %) or liked to attend conservation related workshops or meetings (48 %).

When asked whether offering incentives to landowners is a good idea to motivate them to promote conservation on their land, 95 % agreed with the statement (Table S7). The majority of land managers indicated an interest in incentives on a 5-point scale, although a large proportion (48 %) was not interested in ‘public or community recognition for their conservation efforts’ (Table S8). The incentives respondents were mostly interested in were assistance with fencing and land management (87 %) and subsidy for conservation work (92 %).

Of the 24 organizations, the four land managers were most willing to collaborate with were the National Department of Agriculture, Fisheries and Forestry (NDAFF), the South African Police Service (SAPS), a Farmers’ Association (AgriKK) and a Neighbouring Farmer (Table S1). Organizations respondents were least inclined to collaborate with were the Wildlife Environmental Society of South Africa (WESSA), Rhodes University and local and district municipalities. Many land managers have never heard of WESSA (43 %), Gouritz Biosphere Reserve (22 %) and the Cape Leopard Trust (22 %).

Question reduction

The scales summarized below (Table 2) were derived from the original scales by eliminating items that did not meet the criteria for forming a unidimensional scale (Tables S1, S4, S5 and S6). As a result of the sharpening, items were reduced by 48 % from the original 66 questions.

Relationships between Latent Variables and the Ancillary Variables

Relationships between the four latent variables (CB, CK, EA and WC) and four key ancillary variables [(Years Farming (YrF), Farm Size (FSz), Farmer Age (FAge), Level of Education (LoE)] were explored using a pairs plot of key variables (Figure S1).

Table 2. Statistics on Reliability and Dimensionality for the four sharpened scales. Four out of nine items in CB, five out of nine from CK, eight out of 13 items from EA, and 15 out of 24 items from WC were eliminated.

Scale	RV^{A*}	Reliability ^(†)					Dimensionality ^(‡)			
		α	λ_6	ω_t	MS	LC_R	H	β	ECV	ω_h
Conservation Behaviour (CB)	0.913	0.881	1.000	0.990	0.841	0.777	0.593	0.814	0.502	0.704
Conservation Knowledge (CK)	0.806	0.849	1.000	0.999	0.655	0.763	0.553	0.631	0.563	0.710
Environmental Attitude (EA)	0.838	0.905	0.979	0.991	0.904	0.835	0.653	0.785	0.655	0.839
Willingness to Collaborate (WC) [C19]	0.846	0.945	1.000	0.984	0.926	0.900	0.671	0.841	0.632	0.783

^(*)RV indexes the extent to which the matrix of scores of the sharpened scale matches or approximates that of the unsharpened scale.

^(†)Reliability if the item is dropped. The first three indices derive from classical test theory, the last two from Mokken scale analysis (non-parametric IRT): α is Cronbach's alpha; λ_6 is the sixth of Guttman's coefficients; ω_t is McDonald's total omega; MS is Molenaar and Sitjma's coefficient of reliability; LC_R is coefficient of latent class reliability.

^(‡)Dimensionality if the item is dropped. H is Loevinger's coefficient of scale scalability (from Mokken scale analysis); β is Revelle's beta (from item-cluster analysis); ECV is Reise's explained common variance; ω_h is McDonald's hierarchical omega.

There were significant, positive ($P \leq 0.05$) correlations between YrF and FAge ($p < 0.001$), between EA and CB ($p < 0.001$), between CB and CK ($p < 0.01$) and between CK and FAge ($p \leq 0.05$). There was a close to significant, positive correlation between CB and FAge ($p \leq 0.1$) which was interesting, especially given the negative relationship between WC and FAge ($p < 0.1$). There was a notable lack of correlation between WC and CK, FSz, FAge and LoE, CB and YrF, FSz and LoE. Level of Education was not significantly correlated with any the other variables.

A hierarchical agglomerative cluster analysis indicated three distinct clusters of land managers (Figure 1).

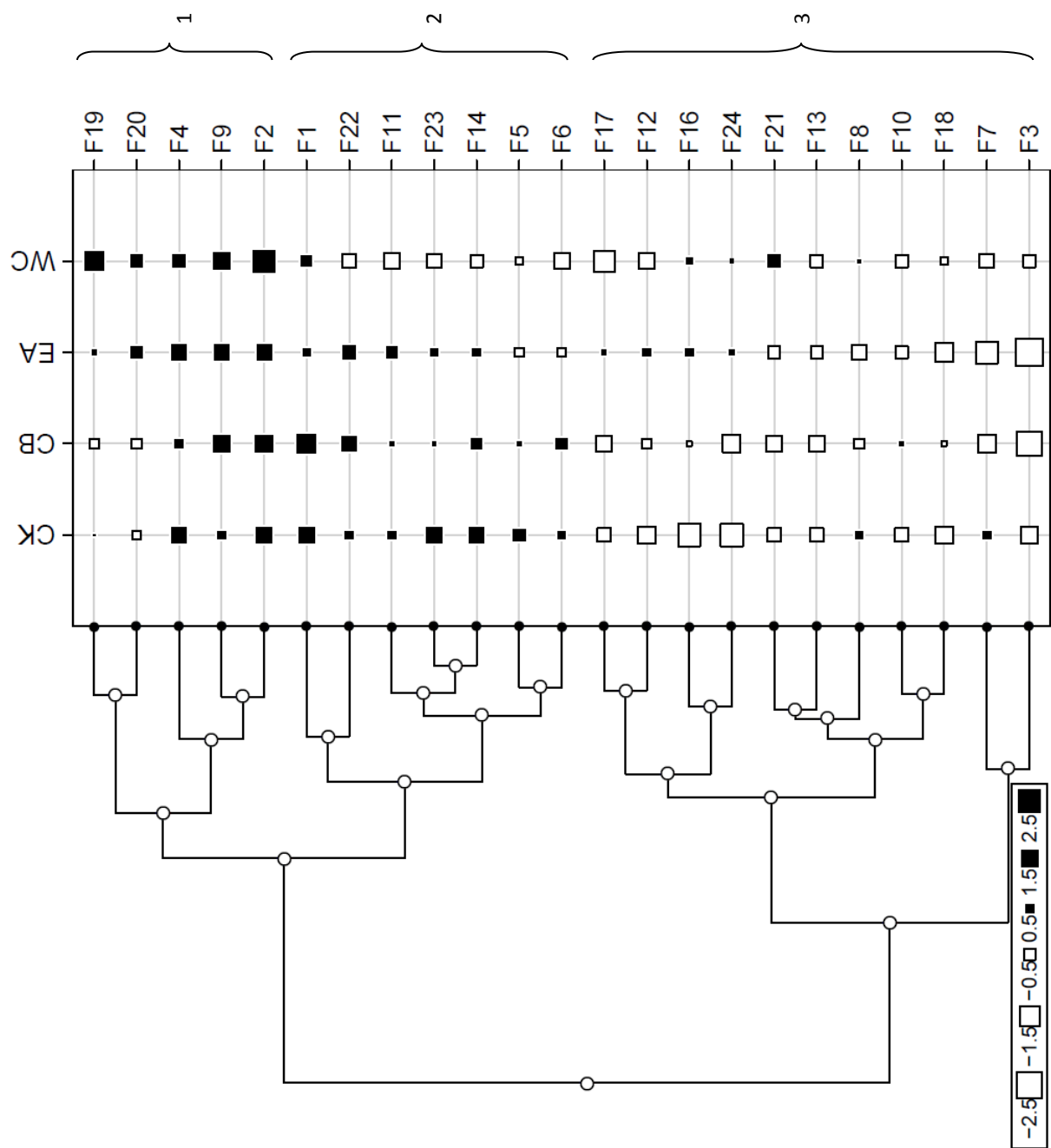


Figure 1. The hierarchical agglomerative cluster analysis with associated table of standardized values using complete linkage and Euclidean distance. Columns in the associated table of values arranged based on column scores from the first dimension of a correspondence analysis of the raw data table.

Land managers in cluster 1 had the highest EA and CB, land managers in cluster 2 scored moderately on CK, CB and EA but low on WC, and land managers in cluster 3 scored lower than average on all items. The three clusters and their ancillary variables were compared (Table S9), and this showed that land managers in cluster 1 had the fewest years of farming experience, but scored the highest (60 %) in implementing the pen-breeding system and only 40 % of land managers in this cluster used the natural veld for breeding ostriches.

A multivariate CART showed that there were three groups of land managers with different scores for the four LVs considered together (Figure 2). The three groups were defined by differences in the number of years they have been farming (YrF) and by farm size (FSz). Parametric and non-parametric omnibus tests of the null hypothesis that there were no differences between the grand means of the three groups were highly significant (parametric test: $p = 0.0061$; non-parametric test: $p = 0.0045$), though the effect-size was relatively small (26.98 % variance explained). The analysis showed that CB and CK were the highest in land managers who have farmed for ≥ 31 years. Their EA scored markedly lower than that of the land managers with less farming experience and the larger the farm size (≥ 2050 ha), being similar to (somewhat greater) than that of the land managers with less farming experience and smaller farms. CK was by far the lowest in land managers with < 31 years of farming experience and smaller farms (< 2050 ha). Land managers with < 31 years of farming experience were, however, more willing to collaborate than land managers with more farming experience, the degree of willingness being greatest in the less experienced land managers with the larger farms (≥ 2050 ha).

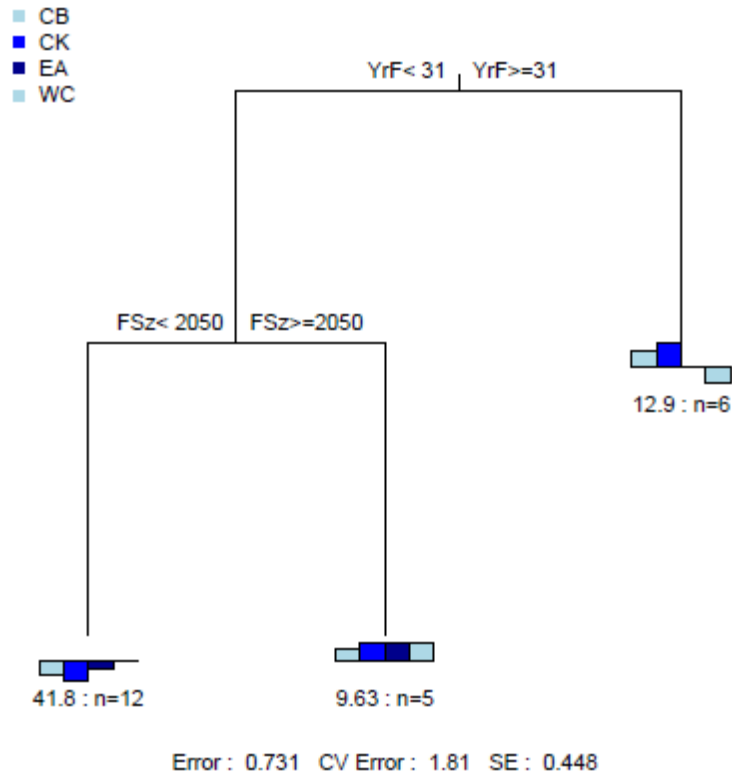


Figure 2. Multivariate CART of the predictors of the latent variables. The model has an approximate R^2 of 0.269, meaning it explains approximately 26.98 % of the variance of the latent variables. Bars show deviations from the grand mean of each scale.

A principal component analysis (Figure 3) indicated that land managers with < 31 years farming experience and the smallest category farm (YrF < 31 and FSz < 2050 ha) formed a distinct group. All but one of the land managers in this group scored less than the mean (given by the origin), or not much more than it, on three of the four scales, viz. CB, CK and EA. Yet nearly half of the land managers in this group had high WC scores, which were only surpassed by those of two other land managers, both members of the “inexperienced” group with larger farms (YrF < 31 and FSz ≥ 2050). The three groups (YrF < 31 and FSz ≥ 2050, YrF ≥ 31, YrF < 31 and FSz < 2050 ha) corresponded more or less with clusters 1, 2 and 3 respectively, identified in the cluster analysis.

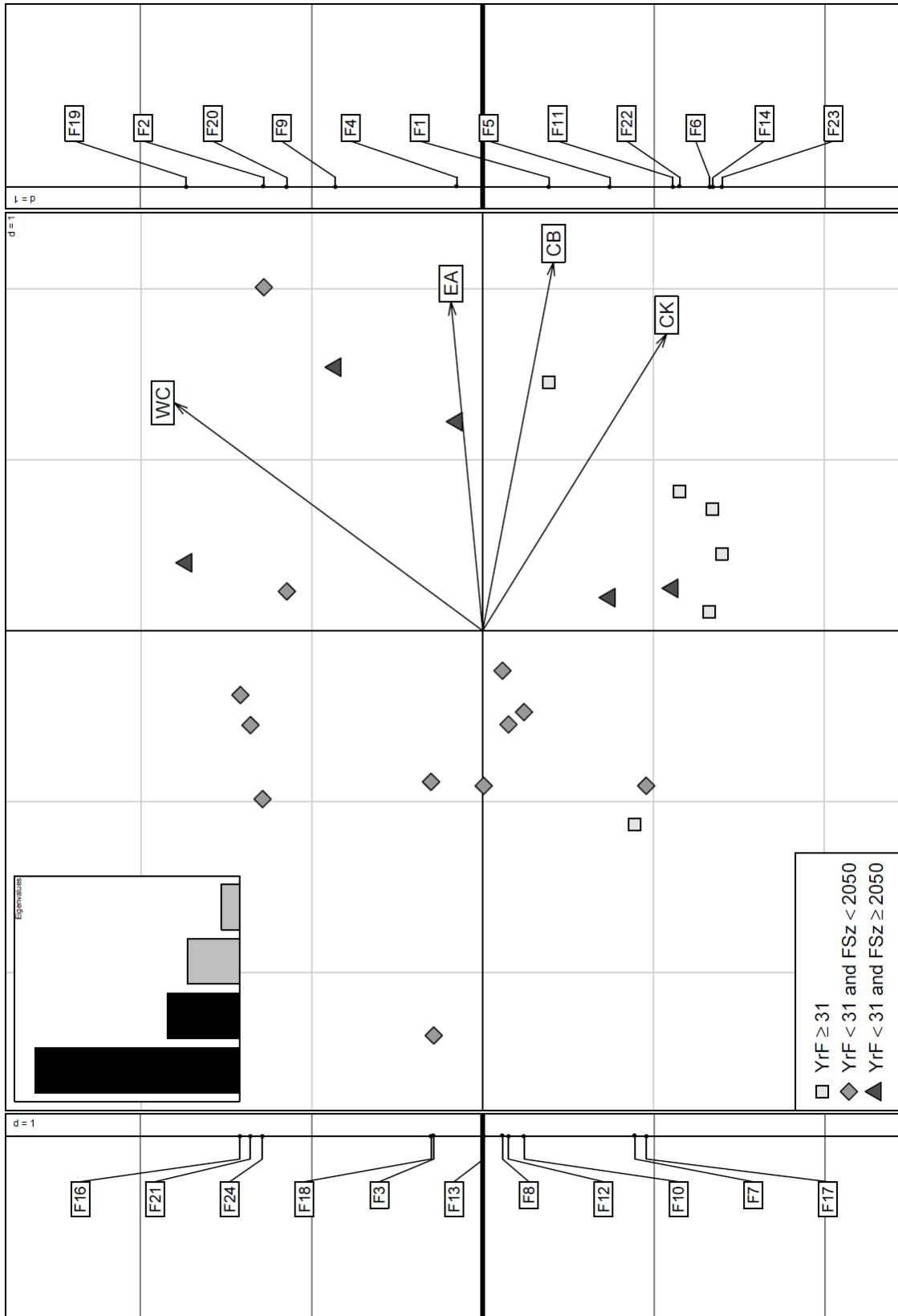


Figure 3. Shows the principle component analysis biplot of the latent variables. Side panels label the background scatter (land managers) to left and right of the origin. As shown in the legend, the symbols index the three clusters determined by the multivariate CART illustrated in Figure 2 (symbols show CART groups from Figure 2).

Two causal networks were extracted from the data using a set of causal-miners (Figure 4). Both models were plausible descriptions of the data, based on Shipley's *C* test. The best-fitting of the two networks was used as the structural model for Pearson- and Spearman-based partial least squares path models (Figure S2).

The results in one model (Figure 4a) suggest that conservation behaviour can affect or influence conservation knowledge and environmental attitude, which indirectly cause willingness to collaborate. The other model (Figure 4b) suggests that environmental attitude can influence or affect conservation behaviour, which in turn influences or affects conservation knowledge. Therefore investing time and effort on increasing land managers' willingness to collaborate or their conservation knowledge is unlikely to be effective in influencing their conservation-related behaviour. Willingness to collaborate is independent of CB, CK, and poorly influenced by EA, possibly being more dependent on unpredictable human elements such as individual personality.

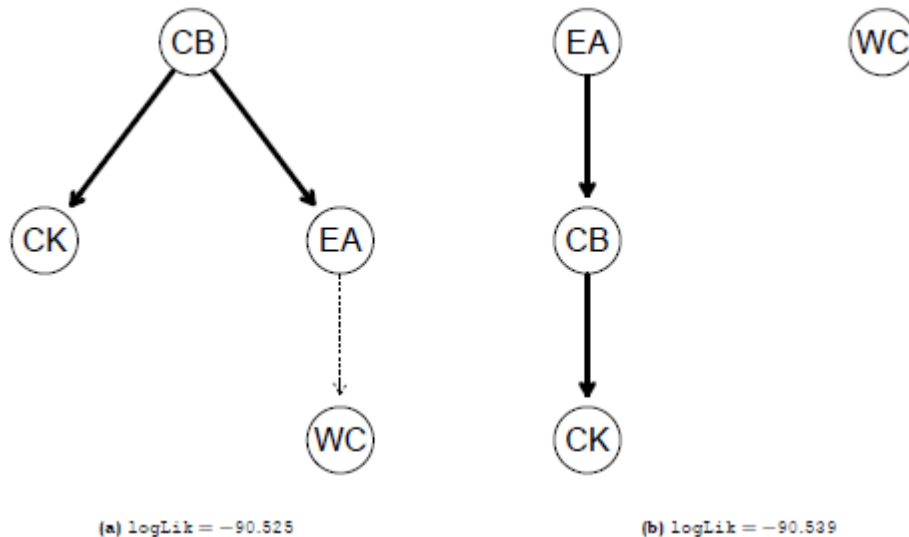


Figure 4. Causal networks of the latent variables. For sub-figure (a), Shipley's test of the adequacy of the model is $C_{df=6} = 2.947$, $\rho = 0.815$. For sub-figure (b) it is $C_{df=8} = 7.756$, $\rho = 0.458$. Based on the log-likelihood, the model shown in (a) fits marginally better than that shown in (b). In (a) CB has an indirect influence on WC; in (b) EA has an indirect influence on CK, WC being isolated, being influenced by nothing and influencing nothing.

DISCUSSION

In most countries in the world where ostriches are farmed commercially, i.e. Australia, Germany, Britain, Brazil and Poland, intensive ostrich breeding practices are being implemented. Breeding ostriches are either kept in pens, open stables or paddocks (COE, 1997; McKeegan and Deeming, 1997; More, 1997; Black, 2001; Horbańczuk, 2002). Israel and Zimbabwe are two of the very few countries, similar to South Africa, where the maintenance of breeding ostriches in large flocks, is a well-known practice (Dzama et al., 1995; Deeming and Burbier, 1999). Our results showed that most land managers in the Little Karoo practiced the traditional flock breeding system. Cupido (2005) also found in his study that 84 % of ostrich land managers in the Little Karoo implemented this breeding practice. While more economically and ecologically sound alternatives have been recommended (Murray, 2008b), the question remains why land managers still implement flock breeding.

The land managers in general indicated that they knew and were aware of the conservation issues concerning the Little Karoo and indicated a willingness to collaborate more with agricultural organizations, than conservation. The general attitude land managers showed towards the natural environment was also positive. Most land managers were aware of the conservation issues and biodiversity importance of the Little Karoo and also believed that their natural veld areas suitable for ostrich farming were in a good condition. What is very worrying though is the management of their flock breeding system. Ten hectares per ostrich seemed to be the preferred stocking rate for most land managers as opposed to the recommended agricultural stocking rate of 22.8 ha.ostrich⁻¹, which they considered to be economically unprofitable. Economic considerations are the primary reason why land managers in the Little Karoo are implementing flock breeding practices (Cupido, 2005). The fact that there is an absence of ecological and economic evidence in the literature regarding clear

scientific guidelines for sustainable ostrich stocking rates in the Little Karoo (Chapter 2) may have an important influence on how land managers may implement alternative farming practices.

Ostrich farming has been practiced in the region for more than 150 years (Herling et al., 2009), which is considered to be the oldest commercial ostrich industry in the world (Holtzhausen and Kotze, 1990). Most landowners have learnt how to farm with ostriches from their fathers and are the second to seventh generation on the farm. Considering these facts, it is not unrealistic to believe that the many generations of farming with ostriches has entrenched a tradition that appears to be sustained until today. The implication of this is that should this tradition continue and few opportunities for new landowners with new ideas are made available, the biodiversity of the Little Karoo and possibly the sustainability of the industry will remain at great risk.

Considering the situation that the results have illustrated above and using the results of the cluster analysis, opportunity may lie with the land managers of cluster one, i.e. land managers F2, F4, F9, F19, and F20. This cluster represents land managers with the highest environmental attitude and if the casual model proves to be correct, by investing time and effort into their environmental attitude, their conservation behaviour and knowledge may improve. This cluster also showed the greatest degree of willingness to collaborate with organizations, in which case all four scales of social and human dimensions are either already high or stand a chance to be improved. The majority of landowners (60 %) in this cluster, do not have any breeding ostriches on their natural veld (refer to Chapter 3). It appears that the two agricultural organizations, the NDAFF and AgriKK, who are also the most preferred organization by land managers with larger farms (>340 ha), may be a very important catalyst to advocate alternative ostrich farming methods in this cluster. Conservation agencies should target these organizations for partnerships to promote sustainable ostrich farming practices. The

reasons the SAPD is also one of the most preferred organizations to collaborate with, may be due to the need for the protection and prevention of crime such as stock and tool theft, on farms.

Cluster two with more than ≥ 31 years farming experience, on the other hand, showed a general unwillingness to collaborate and low environmental attitude. Conservation behaviour and conservation knowledge in this cluster were, however, the highest in this group. Therefore to further invest time and effort in their conservation behaviour may indirectly influence their willingness to collaborate. It therefore appears that this cluster would be the second choice for opportunity investment. Cluster three with 'inexperienced' land managers and smaller farms appears to be a group of landowners where time and effort to change attitude or behaviour should not be a priority. Although their lack of experience could mean that with more input they could become more aware and involved, land managers with small farms may have a more limited opportunity for change as they are unable to compete without the economies of scale available to larger farms (Chapter 3). There is also potentially less natural veld to conserve on smaller farms, but the potential return for investment in building relations to initiate change in attitude and behaviour will be far greater on larger farms.

Conservation behaviour

It was expected that land managers would have stronger pro-conservation attitudes and behaviours the higher their level of education, but the results showed that LoE had no significant relationship with conservation behaviour. Although land managers' education has been shown to be one of the strongest variables determining conservation behaviour (McDowell and Sparks 1989; Wilson, 1992), this appeared not to be the case in the Little Karoo.

It was predicted that land owners with more years of farming experience would potentially be less likely to change their traditional farming practices and therefore would be less willing to implement alternative best practices. The relationship between of CB and years of farming (YrF) was, however, not significant, which indicated that more years of farming experience does not necessarily influence conservation behaviour.

Finally, it was also predicted that the smaller the farm, the more constrained land managers would be in adopting pro-conservation behaviour, though not necessarily in their attitudes or knowledge. The relationship of CB with farm size (Fsz) was, however, also not significant.

Conservation attitude

We found that there was a significant positive correlation between environmental attitude and conservation behaviour. This is in contrast to the findings by Quinn and Burbach (2010), who found no significant relationship between environmental attitudes and pro-environmental behaviours and concluded that while land managers may feel some concern towards the environment, they do not readily adopt conservation practices. The causal networks from our data suggest that conservation attitude and behaviour can influence or affect one another. The importance of causal models is that they suggest where one should invest resources and effort if one wants to change circumstances. In this case, the findings suggest that effort towards changing land managers' environmental attitude may bring about a change in conservation behaviour. This causal relationship warrants more in-depth research, as does establishing what kind of investments can be made into improving the attitude of land managers to bring about behaviour change.

Willingness to collaborate

Although Knight et al. (2010) successfully used cluster analysis to identify land managers who were willing to collaborate, the data from ostrich land managers in the Little Karoo suggest that willingness to collaborate is an index that indicates organizational preference, but not a factor likely to directly influence conservation-related behaviour. As predicted, agricultural organizations were the most preferred, which would suggest that they play an important role with land managers, and that they would be the obvious choice to suggest or implement change towards conservation farming practices. McDowell (1988) emphasized that personal interaction has a far greater potential than any other method for persuading land managers of endangered vegetation types to adopt alternative land management practices. Agricultural extension services are one of the most common forms of public-sector support of knowledge diffusion. Effective agricultural extension can bridge the gap between new technology and changes in the individual land manager's land management. In addition to information, extension agents can inform land managers about improved farm management practices and managerial skills, thus facilitating a shift to more efficient methods of production (Birkhaeuser et al., 1991). A clear example of improved farm management practices would be the adoption of the pen breeding system, which brings an economic benefit to the land manager and ecological benefit to conservation (conserving large tracks of natural veld once flock breeding ostriches are removed and placed in smaller pens). This is where LandCare's Area Wide Planning integrative process could play an important role in facilitating collaboration between not just agriculture and land managers, but also conservation organizations. The fact that land managers in this study site received this integrated approach well, suggest that this process can be implemented across the landscape between agricultural organizations, industry and other conservation orientated organizations.

In contrast to agricultural organizations, conservation-orientated organizations like the Cape Leopard Trust, WESSA or the Gouritz Biosphere Reserve were not very well-known, liked or trusted amongst land managers. It would be valuable to establish if the low

willingness to collaborate with these conservation organizations is due to a lack of familiarity with the organizations, or whether land managers actively avoid them. If there is active avoidance of certain organization, it would also be of interest what the reasons are, and whether these can be changed. A logic model of the ostrich industry (presented in chapter 5) illustrated no relationship between conservation NGOs and the ostrich industry; the NGOs are entirely isolated from the activities the industry engages in. The reasons for this situation warrant further in-depth research to address them. Based on the findings of this research, I would suggest that conservation-orientated organizations need to collaborate with agriculture in general to mainstream conservation practices on farms. NGOs have been playing a powerful role in sustainable development, particularly in their partnerships with key stakeholders, in serving the needs of individuals and communities. Many of these environmentally orientated NGOs are developing a more sophisticated understanding of environmental problems, based on sound scientific research and are developing effective strategies to solve environmental problems through strategic partnerships (Kong et al., 2002).

It is clear that a variety of historical factors and human and social dimensions are responsible for much of the degradation of biodiversity in the Little Karoo. Now would be a critical time for conservation agencies, NGOs and agriculture to devise innovative strategies to influence the behavioral pattern of land managers in the Little Karoo. The solutions will require adjusting current farming practices, a re-evaluation of the interpersonal relationships between conservation organizations, agriculture and land managers, and the manner in which they interact with one another (Winter et al., 2007). Previous studies have suggested that most land managers consider protection of the environment as important, although economic pressure often prevents the implementation of these objectives (Plieninger et al., 2004; Winter et al., 2007). The provision of economic incentives is thus a major determinant of conservation attitude (Plieninger et al., 2004) and increased extension support was pointed out as a practical positive inducement for conservation (Winter et al., 2007).

The findings in this study confirm that the traditional flock breeding system is still the prevailing breeding ostrich farming practice in the Little Karoo. Environmental attitude is most likely the most important characteristic of a land manager to ensure positive conservation behaviour. Characteristics such as knowledge, number of years farming or the size of the farm do not necessarily determine positive conservation behaviour. Land managers indicated a particular preference for collaborating with agricultural organizations and this provides an opportunity for organizations to engage with the land managers in cluster one, who were younger and had more positive conservation attitudes and behaviour. It is also necessary to investigate what factors can improve environmental attitudes and conservation knowledge of ostrich land managers. Partnerships should be established to create opportunities for conservation projects that can assist the ostrich industry to move towards the global agricultural trend of sustainability in farming practices while maintaining their economic viability.

ACKNOWLEDGEMENTS

I thank the landowners of the Little Karoo for participating in the interviews, giving me their full support. The South African Ostrich Business Chamber for providing assistance and permission to use information, the veterinary technicians of the Oudtshoorn Research Farm for providing crucial data that supported the research. I would also like to thank Mark Difford who carried out the statistical analyses of this paper, and Susi Vetter and Andrew Knight who reviewed the questionnaire survey.

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CHAPTER 5: TOWARDS UNDERSTANDING THE COMPLEXITY OF THE OSTRICH INDUSTRY IN THE LITTLE KAROO, SOUTH AFRICA.

ABSTRACT

The intensification of agriculture to meet the increase of food demands in especially developing countries are responsible for placing our natural resources under severe pressure. The increasing pressures of unsustainable agricultural practices lead to further ecosystem degradation and species extinction. In recent years there has been a trend towards sustainable agriculture, which claimed that the health of the agricultural sector is dependent on sustainable farming methods that must ensure the long term protection and production of the land. Sustainable agricultural initiatives have developed guidelines that aim to support land managers with principles and techniques for achieving sustainability that can be applied across different agricultural sectors. The aim of this study was to evaluate the overall effectiveness of the ostrich industry, using the process of developing a logic model to understand and illustrate the functioning of the industry in relation to all its available resources. The logic model of the ostrich industry has shown that it is performing poorly regarding achieving the goals of social, economic and environmental sustainability and it suggests that the role-players in the industry need to be involved and committed to the development and implementation of a strategy to achieve the long term goals. Resolving incompatibilities amongst the approaches of the various role-players in the industry and the long term sustainable goals in general, would be a good approach to start in achieving a sustainable industry.

Keywords: sustainability, logic model, focus group.

INTRODUCTION

Land managers across the world are under increasing pressure to further intensify their agricultural outputs to meet rising food demands. Developing countries in Sub-Saharan Africa will become more dependent on agricultural imports; therefore food security in

many poor areas will not improve without substantial increases in local production (FOA, 2002). Some land managers have responded by increasing their use of pesticides, herbicides, fertilizers and water, and by expanding their area under cultivation (Scotcher, 2009). Genetically Modified crops are also a response to improve the reliability and quality of the world food supply (Connor et al., 2003). Uncontrolled, these increasing pressures will lead to further ecosystem degradation and species extinction (Scotcher, 2009). Quinn and Burbach (2010) have reported that conservation practices are not always readily adopted by farming communities, especially land managers who consider human well-being over ecosystem health. Agricultural trends in South Africa have recently been investigated by non-profit organizations such as the World Wide Fund for Nature - South Africa (WWF-SA) and Conservation International (CI) (Scotcher, 2009; Goldblatt, 2010), and have revealed the emergence of increasing numbers of farms striving for sustainability. WWF-SA's report stated that the health of the agricultural sector depends on the sustainability of farming methods; practices must protect the long term productivity of the land and must ensure profitable yields and the well-being of land managers and farm workers (Goldblatt, 2010).

Various sustainable farming initiatives and guidelines have emerged both internationally and in South Africa. Best management practices are promoted by academics, non-profit organizations and extension educators who are concerned with the impacts of farming on the environment (Quinn and Burbach, 2010). These guidelines aim to support land managers with principles and techniques for achieving sustainability that can be applied across different agricultural sectors and includes descriptions of the methodologies and practices currently associated with sustainable agriculture (Scotcher, 2009). This can provide a starting point for greater collaboration between governments, land managers, consumers and industry (Scotcher, 2009).

The Little Karoo is situated in the Succulent Karoo, one of South Africa's three biodiversity hotspots (Mittermeier et al., 2005). The ostrich farming industry in South Africa has existed for more than 150 years, and has been centered in the Little Karoo (Talbot, 1961; Cupido, 2005). The industry has been associated with severe vegetation degradation across the region (Beinart, 2003; Cupido, 2005; Le Maitre et al., 2007; Thompson et al., 2005; Thompson et al., 2009). A study of the transformation of Little Karoo vegetation (Thompson et al., 2005) shows a large proportion of the vegetation of the lower lying areas of the Little Karoo having undergone severe degradation. Of the total remaining natural area, only 8.6 % was considered intact, 67.9 % moderately degraded and 23.5 % severely degraded (Thompson et al., 2008). Cupido (2005) found that ostrich land managers are overly optimistic regarding the condition of their natural veld, and that their primary goals when ostrich farming are economic benefits. The ostrich industry may struggle to adopt alternative natural veld best practices that include a strong environmental dimension.

To address concerns about biodiversity conservation, land degradation and veld rehabilitation in especially in the Oudtshoorn area, the South African Ostrich Business Chamber initiated the Ostrich Industry Biodiversity Management Project (Botha et al., 2008). This project is being implemented by the SAOBC and aims to investigate and promote alternative ostrich farming practices in the Little Karoo (Botha et al., 2008). The measuring and reporting of the effectiveness of the implementation of this conservation initiative, however, has been challenging. The need to establish the effectiveness of relationships between industry role-players and the clarity of responsibilities of each role-player was necessary. A tool to assist the industry to describe and evaluate the achievement of the sustainability goals stated within the strategy of the OIBMP was necessary.

To evaluate the overall effectiveness of the ostrich industry, a framework is required that depicts the Little Karoo ostrich farming system, inclusive of the assumptions being made regarding the resources expected to be required to support the activities, and expected outputs of the industry along with the activities and outputs needed, to realize the intended sustainable long term outcomes of the industry (Wholey, 1994). These assumptions are often referred to as programme theory (Bickman, 1987, 1990; Weiss, 1997).

Logic Models and Theories of Change

A logic model expresses a “theory of action” or “theory of change” for a programme, such as the ostrich industry. It is an essential ingredient for guiding an evaluation of the effectiveness of the industry in achieving its goals under the OIBMP by identifying key programme elements and articulating how these elements are expected to relate to one another (Anderson, 2000; Cooksy et al., 2001). It describes logical linkages among programme resources, activities, outputs, audiences, and short, intermediate and long term outcomes (McLaughlin and Jordan, 1999). Logic models further help to identify partnerships critical to enhancing performance, since they demonstrate links from situations (problems) to the interventions (inputs and outputs), and the impact (outcome) (McLaughlin and Jordan, 1999; Millar et al., 2001). The Logic Model development process has been used for at least thirty years and presents a plausible and sensible process for understanding how a programme will work under certain conditions to solve identified problems (Bickman, 1987). Currently, logic models are the most universal form of theory of change representation used for planning and evaluation (Margoluis et al., 2009). The Second Southern African Bird Atlas Project is a recent example of a logic model that has been developed for a conservation project in South Africa (Wright, 2011). The process has highlighted the central role stakeholders play in their programme, through their contributions to scientific data and activities required for generating and maintaining the programme. The usefulness of a logic model for the ostrich industry lies in the process of identifying the key elements of the industry and

how they relate to each other (Cooksy et al., 2001), assisting the industry to visually represent the complexity of the ostrich industry. Margoluis (2009) has stated that it is impractical to believe that we can completely eliminate all the details in a project, but a logic model can help reduce the effects of a complex industry by helping people to understand it better.

Programme theory should be both prescriptive and descriptive, meaning that a programme manager has to both explain the elements of the programme and present the logic of how the programme works (Chen, 1990). The elements of a logic model are programme resources, activities, outputs, short-, medium- and long-term outcomes and external influences (Wholey, 1987). A Logic Model captures the logic flow and linkages that exist in the ostrich industry. Using all the elements, the model organizes the information for role-players to understand and evaluate the hypothesized linkages and the researcher in turn can assess all the linkages and determine whether it is complete (McLaughlin and Jordan, 1999).

The objective of this study is to use the process of developing a logic model to understand and illustrate the functioning of the ostrich industry in relation to all available resources, demonstrating relationships between industry role-players and the intended short to long term outcomes. To identify key areas/linkages that are missing which if addressed could improve the success of achieving those outcomes and to also identify missing linkages/elements that could explain the lack of biodiversity-friendly practices at this stage.

METHODS

The process for developing a Logic Model for the ostrich industry comprised five stages (McLaughlin and Jordan, 1999): 1) collecting relevant information; 2) defining the

ostrich industry and its context; 3) defining the elements of the logic model; 4) constructing the logic model; and 5) verifying the logic model.

The final product of the Logic Model development process was a diagram, or conceptual model, that described the overall functioning of the ostrich industry (McLaughlin and Jordan, 1999).

Stage 1: collecting relevant information

Information relevant for describing the elements and logic of the ostrich industry was gathered from multiple sources. These included industry documentation such as strategic plans, codes of conduct, policy documents and focus group sessions with key role-players in the industry. This information was essential to gain insight into the industry and what key contextual factors to consider when designing the logic model.

Stage 2: defining the ostrich industry and its context

Small focus groups were conducted with role players representing the main groups of stakeholders in the ostrich industry. The focus group method is an effective research tool for deriving individual and collective opinions, values and beliefs from an identified group to evaluate services or programmes (Kitzinger, 1995; Cote-Arsenault and Morrison-Beedy, 1999; Krueger and Casey, 2000). This process also encouraged the development of a shared vision among each group of stakeholders for how the industry functions which is the product of persistent discovery and negotiation between and amongst stakeholders. Three separate focus groups were conducted representing the main role-players in different sectors of the ostrich industry, namely Government (i.e., departments with statutory responsibility for managing natural resources), Ostrich Producers (i.e., farmers) and the Ostrich Processors (SOABC, veterinarians and OIBMP members). Each group consisted of four participants who were selected on the basis of

their anticipated ability to provide insight into, and information on, the ostrich industry, as well as to provide sufficient diversity to encourage discussion (Bloor et al., 2001). Each focus group interview was led by the same neutral, qualified facilitator, who was selected based on her in depth knowledge and understanding of the ostrich industry and conservation. The facilitator was briefed before the focus group session and was familiar with the questions that had to be asked during the discussions. The principal investigator documented through note-keeping and audio recording the interactions as they occurred within the group. A fourth and final focus group, consisting of a subset of members of the three focus groups, was conducted by the same facilitator to construct the logic model and verify the logic model (stages 4 and 5).

In order to determine the structure to guide the focus group enquiry, a question route was developed to guide the focus groups and to enhance the consistency of data that was obtained between the groups (Halcomb et al., 2006). A 'funnel' approach was used to frame the development of the questioning route (Morgan, 1997; Beyea and Nicoll, 2000). This approach allowed for a wider perspective of individual experiences in the initial stages, followed by specific questioning in the subsequent stages of the discussion (Krueger, 1998).

The discussion was first introduced with an introductory question to stimulate group discussion and was followed by transition questions that gradually narrowed the focus of the discussion (Table 1). The key questions were presented as the core of the research topic, which was to determine the perceptions of role-players in the ostrich industry and the impact this has on environmentally sustainable farming practices. The focus group discussions were closed with an ending question and a final question (Morgan, 1993; Krueger, 1998).

Table 1. The questions comprising the question route (per Halcomb, 2007) followed during three focus groups representing three different sectors of the ostrich industry, namely Government, Ostrich Producers and the Ostrich Processors.

Topic: Determining whether perceptions of role-players in the ostrich farming industry impact on environmentally sustainable practices at a landscape-level in the Little Karoo, South Africa.	
Introductory Question	Please tell us your first name and describe in a few words what you think sustainable ostrich farming is.
Transition Question	<p>a. What is your general perception of the Ostrich Industry at the moment?</p> <p>b. What is your perception of CapeNature (the conservation agency)?</p> <p>c. What is your perception of the Department of Agriculture?</p>
Transition Question	<p>Sustainability has many definitions and often means something different to different people. For the purpose of this research sustainability is defined as having three components (economic, social and environmental) – how do you understand the term sustainability?</p> <p>a. With the difficulty the industry is facing at present it may be that current practices are not sustainable. What do you regard as economic sustainability in the Ostrich Industry?</p> <p>b. What do you regard as social sustainability in the Ostrich Industry?</p> <p>c. The industry has in the past been blamed for its negative impact on the natural environment. What do you regard as environmental sustainability in the Ostrich Industry?</p>
Key Question	<p>Much of the Little Karoo is degraded as a result of ostrich farming practices more generally.</p> <p>a. Do you think that, at the actual stocking rates that we have in the Little Karoo at present, ostrich farming is sustainable?</p> <p>b. Is the recommended agricultural stocking rate of 22.8ha per ostrich an economically and environmentally sustainable practice?</p>
Key Question	<p>a. What economic, environmental or social initiatives are there currently in or for the industry that you regard as sustainable?</p> <p>b. What opportunities are there currently in or for the industry that you regard as sustainable?</p> <p>c. What obstacles are there in the ostrich industry that prevents sustainability?</p>
Key Question	Comparing current vs. historical ostrich farming practice. What aspects have remained the same and why?
Ending Question	<p>Role-players in the industry need to work together to achieve and maintain sustainability.</p> <p>a. Who are these role-players and what do you understand to be the role of each one to achieve and maintain sustainability?</p> <p>b. What is working and what is not working?</p>
Final Question	Is there anything else that anyone feels that we should have talked about, but didn't?

The facilitator used the facilitation package Participlan® to present the questions to the focus group and to capture their responses (Botha and Gardener, 2003). Nine A0 self-adhesive sheets were placed against a wall labeled with all the questions. The group proceeded through all the questions whilst the facilitator stuck all the responses from the participants on the A0 sheet, beneath the relevant questions. Where applicable, responses were clustered. All the information generated during the discussions was also captured in writing by the researcher. The process was repeated with each focus group.

Stage 3: Defining the elements of the logic model

All the responses from the Participlan® sheets and field notes were collated in a document. Responses were then qualitatively classified, coded and used to produce a list of all items or elements relevant to each category of the logic model, using the categories suggested by McLaughlin and Jordan (1999). In producing a logic table, the elements were classified as resources; activities; outputs; short term-, intermediate- and long term outcomes and external influences.

Stage 4: Constructing the logic model

A fourth and final focus group, consisting of a subset of members of the three focus groups, was conducted by the same facilitator to verify the accuracy of the information. The logic table with classified elements (resources, activities, outputs and short-term, intermediate and long-term outcomes) was presented to the fourth focus group. The group assessed the accuracy and completeness of the information contained in the logic table. The elements in each category were combined with similar/duplicated functions to reduce and simplify the lists. The focus group then manually constructed the logic model by using the industry elements in the resource category, linking it to the respective activities, which in turn were linked to the outputs, giving rise to the desired short, intermediate and long-term outcomes. In addition to the existing linkages, the

linkages that should be in place between specific elements were also illustrated to indicate which elements had become excluded due to missing linkages and therefore which may have an influence on the overall effectiveness of the ostrich industry in achieving its goals. Indirect linkages were also identified between the various elements. Indirect linkages were considered by the final focus group as linkages that are, by default, part of the industry, but do not function as a critical part in the operations of the industry and are therefore linkages that are not directly responsible for the achievement of a sustainable industry.

Stage 5: Verifying the logic model with key role-players

The logic model was verified by the final focus group, assessing all of the linkages present in the industry, and whether these were complete (Wright, 2011). Further investigation of the logic model was used to generate recommendations for the industry.

RESULTS

The elements of the logic table that were assessed by the final focus group session resulted in changes to the logic table (Appendix D, Table S1).

Structure of the Ostrich Industry System

The 37 resources identified during the three focus group sessions were grouped and summarized to 13 resources. The 24 activities identified were grouped and summarized to 17 activities. The 11 outputs were grouped and summarized to nine outputs. The desired short-term outcomes were expanded and refined from four to five outcomes and the intermediate outcomes were expanded and refined from six to seven outcomes. The desired long-term outcomes and external influences remained unchanged, three and nine respectively. For the purpose of simplicity, the External Influences are

presented in the supplementary information (Figure S1), but should be taken into account when interpreting the logic model.

In the diagrammatic representation of the logic model (Figures 1 and 2), the boxes represent the steps that can be counted or monitored relatively easily and the lines connecting the boxes are the perceived linkages or causal relationships that require in-depth study to determine and explain what features of the programme contribute, or not, to the achievement of the intended outcomes (McLaughlin and Jordan, 1999).

The logic model for this study is presented in two halves, to maintain some simplicity in a very complex model. The first half (Figure 1), illustrates the resources, activities and outputs of the programme and the linkages between them. The second half (Figure 2), continues from the programme's outputs to the desired outcomes. Simple linear paths could not be used to link the various elements, since many of these were linked to more than one other element, as is often the case in complex logic models (Wright, 2011).

The logic model for the ostrich industry presented a total of 63 elements and 465 links, of which 250 are in place and 215 that are required but that are missing. Three of the 250 are indirect linkages and only 14 of the 215 missing linkages are indirect. An example of an indirect linkage can be seen between the ostrich Producers and Marketing (Figure 1). Marketing is not a primary function of the producer, although the quality of the product presented by the producer will have an effect or indirect impact on the way it is being marketed.

It is clear from the logic model that the relationships between the various elements in the ostrich industry are highly complex and that the industry is dependent on a complex suite of interacting resources, ranging from institutions, such as government agencies,

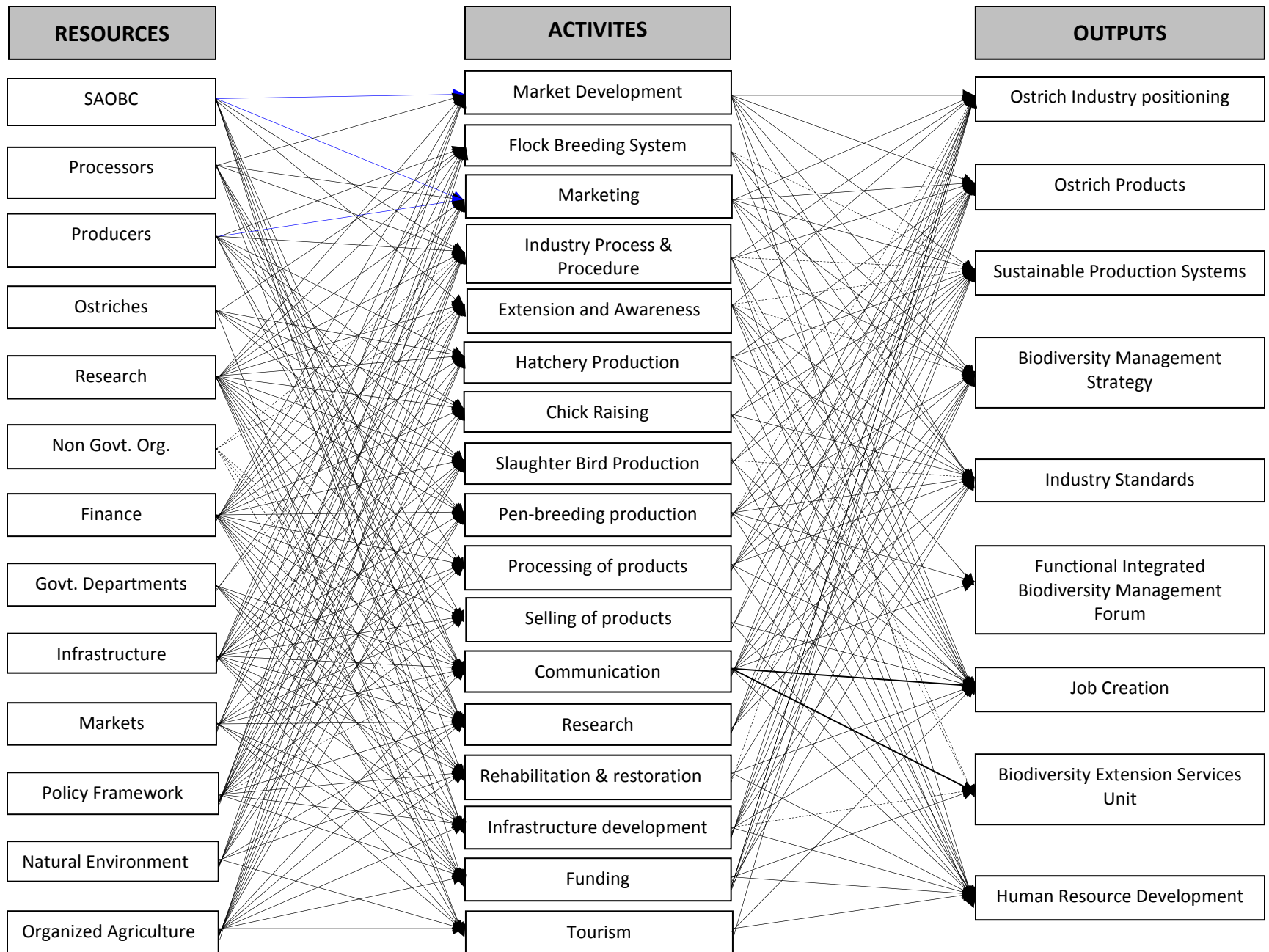


Figure 1. First half of the Logic Model illustrating the complex relationships of the Ostrich Industry. The black solid lines represent the linkages between elements that are in place and the black hatched lines linkages that should be in place. The blue solid or hatched lines represent indirect linkages between elements that are or should be in place.

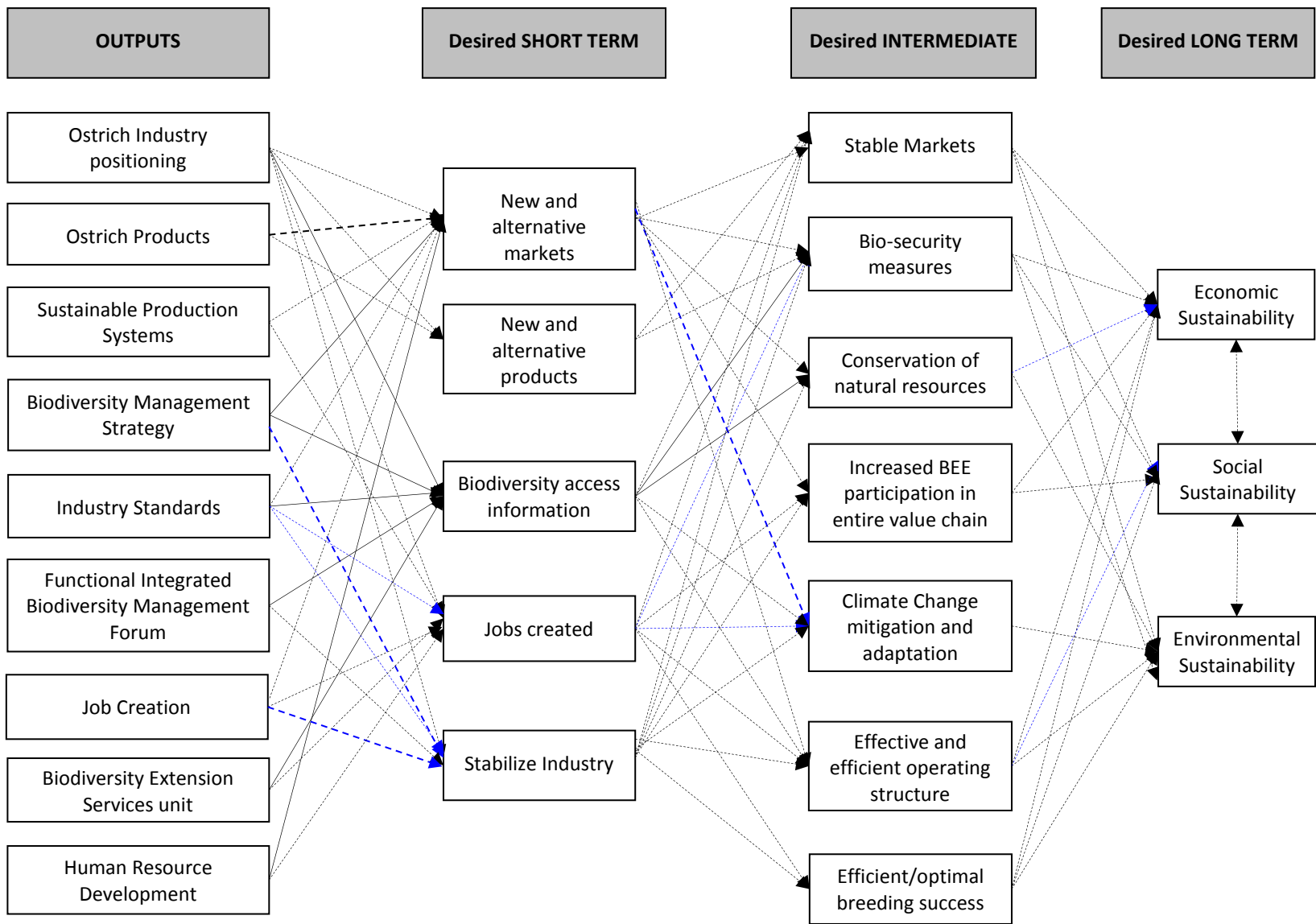


Figure 2. Second half of the Logic Model illustrating the complex relationships in the Ostrich Industry between the outputs, short-, intermediate-, and long-term outcomes. Solid lines represent the linkages between elements that are in place and the hatched lines linkages that should be in place. The blue hatched lines represent indirect linkages between elements that should be in place.

to physical elements, such as infrastructure and the natural environment. The activities documented in the logic model are mostly reliant on resources such as Research (17), Finance (17), Infrastructure (16) and the Policy Framework (15), which have the highest number of linkages.

Functioning of the Ostrich Industry System

At a glance, looking only at the resources, activities and outputs categories, the industry appears to be operating effectively. All the available resources are contributing to the activities that need to take place in the industry. However, should one take the flow of relationships a level further, looking at the linkages between outputs and desired short, intermediate and long term outputs, 84 % of the linkages are missing. The logic model illustrates quite clearly that there is a serious deficiency in the achievement of the industry's desired short to long term goals, considering the number of logic model elements that are not interconnected.

The main role-players in the industry's presentation of relationships as they were represented by the focus groups have been extracted from the logic model to individually illustrate their contribution to the longer term outcomes of the industry. Figures S1, S3, S5 and S7 in the supplementary information are simplified logic models that illustrate the existing relationships of the SAOBC, Government Departments, Producers and Processors in the industry respectively. The decision was made by the final focus group to combine the various national, provincial and local government departments which include institutions such as CapeNature, Department of Agriculture, veterinary services and Local and District Municipalities as a single resource, because overall they represent regulatory functions. Figures S2, S4, S6 and S8 in the supplementary information depict the linkages in the simplified logic models that should be in place, (i.e. the black hatched lines).

There appeared to be no significant differences in the number of missing linkages between the four main role-players of the ostrich industry (Table 2). The comparison of the four main role-players' individual logic models in terms of their functioning, i.e. the percentage

of linkages that are missing in terms of the overall number of linkages, indicated that the ostrich Processors seemed to be slightly more effective in contributing to the sustainability of the industry (42 % missing linkages) compared to the Government Departments who have more than half of their linkages (52 %) missing. This shows that the Government Departments are the weakest role-player of the four, but this is hardly noticeable in the complex logic model. Overall, all the role-players seem to be performing poorly regarding the achievement of the sustainability goals presented by the ostrich industry, showing no complete linkages towards the desired long term outcomes.

Table 2. The linkages of the four main role-players show that all role-players have more than 40 % of their desired linkages missing, therefore contributing to failure in achieving the long term outcomes of the industry (see also Figures S1 – S8).

Resource	Total existing linkages	Total missing linkages	Total number of linkages	% Linkages missing
SAOBC	69	56	125	45
Govt. Departments.	51	56	107	52
Ostrich Processors	62	45	107	42
Ostrich Producers	63	58	121	48

The elements from the connected logic models (Figures S1, 3, 5, and 7) compared to the same elements of the hatched logic models (Figures S2, 4, 6 and 8) show that certain elements in each category of the logic models are being excluded as a result of the missing linkages. The missing linkages of the SAOBC (the black hatched lines in Figure S2) resulted in the complete exclusion of three short term outcomes (New and Alternative Products, Jobs Created and Stabilize Industry), five intermediate outcomes (Stable Markets, Increased BEE Participation in entire value chain, Climate Change Mitigation and Adaptation, Effective and Efficient Operating Structure and Efficient/Optimal Breeding Success) and three long term outcomes (Economic Sustainability, Social Sustainability and Environmental Sustainability).

The Government Departments were the only role-player of the main four that had a missing linkage between a resource (Government Departments) and an Activity (Figure S4). It

resulted in the exclusion of one activity (Extension and Awareness). The Processors' missing linkages (Figure S6) resulted in the complete exclusion of two short term outcomes (Jobs Created and Stabilize Industry). The Producers' missing linkages (Figure S8) resulted in the exclusion of the same short term outcomes as the SAOBC. All four main role-players have excluded the same intermediate to long term outcomes as a result of the missing linkages.

Two other resources stood out with missing linkages between the resource and its associated activities. Policy Framework had a missing linkage with Communications (activity) and Non-government Organizations (NGOs) had all its linkages towards its activities missing (Industry Process and Procedure, Extension and Awareness, Communication, Research, Rehabilitation and Restoration and Funding). NGOs account for a total of 52 missing linkages, which excluded six activities, five outputs, four short term, seven intermediate and three long term outcomes.

Final comparisons between the number of existing versus missing linkages for elements related to the three long term outcomes, i.e. Environmental, Economic and Social, show that, in the first half of the logic model between the resources and outputs (Table 3), the existing linkages in the industry are far more focused on the Social desired long term outcome. Twenty-nine linkages (100 %) related to the Social long term outcome were in place, whereas 70 (91 %) and 43 (84 %) for Economic and Environment long term outcomes, respectively, were in place. Interestingly, the environmental focus in the second half of the logic model (outputs to long term outputs), appears to be the strongest with 30 % of linkages in place (Table 4). Comparing the overall total number of linkages of the logic model the Economic (n=111) far outweighs the Social (n=40), although there is no substantial difference between the three when quantified as a percentage (Table 5).

Table 3. A comparison of the number of linkages between elements in the first half of the logic model (Figure 1) related to economic, environmental and social outcomes.

Long-term outcome related elements	Number existing linkages	Number missing linkages	Total linkages	% linkages in place	% missing linkages
Economic	70	7	77	91	9
Environmental	43	8	51	84	16
Social	29	0	29	100	0

Table 4. A comparison of the number of linkages between elements in the second half of the logic model (Figure 2), related to economic, environmental and social outcomes.

Long-term outcome related elements	Number existing linkages	Number missing linkages	Total linkages	% linkages in place	% missing linkages
Economic	2	32	34	6	94
Environmental	7	16	23	30	70
Social	0	11	11	0	100

Table 5. An overall comparison of the number of linkages between elements in the logic model, related to economic, environmental and social outcomes.

Long-term outcome related elements	Number existing linkages	Number missing linkages	Total linkages	% linkages in place	% missing linkages
Economic	72	39	111	65	35
Environmental	50	24	74	68	32
Social	29	11	40	72	28

DISCUSSION

The purpose of the development of a logic model for the ostrich industry was to graphically present the flow of existing relationships between all the elements related to one another and to evaluate their effectiveness in ultimately achieving the desired long term goals of the

industry. The model also aimed to identify missing linkages between elements that may cause the exclusion of key elements in the industry, especially the key elements responsible for environmental sustainability.

A measure of the effectiveness of a programme is represented by the number of complete linkages within the logic model (Margoluis et al., 2009). Programmes which are ineffective at achieving their goals have numerous excluded elements, including outputs and outcomes. The quantity of information gathered in the logic tables and the graphic display of the logic model clearly indicates the complexity of the ostrich industry, including the many facets, enterprises and resources, and many missing linkages especially between outputs and short, intermediate and (especially) long term outcomes. It appears that the ostrich industry is not effective in achieving any of its long term outcomes, because of numerous excluded elements.

When comparing the four main role-players, all appeared to be equally ineffective in achieving the desired short to long term outcomes of the industry. The reason why the Processors perform slightly better may be due to the fact that it is entirely focused on economic welfare, which was strongly represented in the first half of the logic model. The results suggested that the main role-players operate in separate 'silos', which perhaps explains why so many linkages are missing towards the long term outcomes.

The short term desired outcome Stabilize Industry, stands out as the element that may potentially be the biggest hindrance to the industry in achieving its sustainability goals as it is the element with the most missing linkages to the Intermediate Outcomes. This element draws especially on various external influences, such as Disease, Extreme Environmental Events, Climate Change and External Markets. For example, the Newcastle disease outbreak of 1993 that continued sporadically through the 1990s (Alexander, 2000) and the Avian Influenza epidemic in 2004/5 and 2011/12 caused astronomical ostrich losses (Klein Karoo, 2006; Durr, 2011) that clearly demonstrated the lack of capacity to stabilise the industry. Fortunately the SAOBC has recently developed a new set of biosecurity measures that reduce the risk of ostrich related diseases by at least 80 % (SAOBC, 2011). The impact of

extreme environmental events, such as periodic drought or flooding (O'Farrell et al., 2008), can substantially reduce ostrich production or cause large-scale damage to farm infrastructure. Poor production results in unsatisfied market interest and product prices shift in response to market demand, which makes the ostrich industry exceptionally vulnerable to external markets. Most of these elements form part of the ostrich financial cycle and are direct causes of instability (World Ostrich Association, 2013).

A resource that appears to be important and which could play a powerful role in the sustainability of the industry, particularly in partnership with key role-players, is the NGO resource (Kong, 2002). It is interesting to note that NGOs such as the Gouritz Cluster Biosphere Reserve (GCBR) and the Wildlife Environmental Society of South Africa (WESSA) have been identified as resources, but are the only resources that are completely excluded (all linkages missing) from the industry and therefore not being utilised. Results of a survey conducted to determine the attitudes and behaviours towards the environment of ostrich land managers in the Little Karoo (Chapter 4) indicated that land managers were least willing to collaborate with NGOs compared to other institutions such as agriculture, conservation, national or provincial departments and have never heard of NGOs such as WESSA, the GCBR and the Cape Leopard Trust. This may explain why there are no linkages in place. Another possibility for the absence of NGOs is that the ostrich industry is a very old, well-established industry. Many NGOs target the rural poor, whose livelihoods are generally focused on primary agriculture or trade, processing and services linked to the agricultural sector (Anonymous, 2001). NGOs can play a fundamental role in promoting sustainable consumption and can have a significant role in shaping or influencing consumer behaviour (Anonymous, 2001). Involving NGOs as a strategic partner in the industry could establish new linkages between Sustainable production systems and New and Alternative markets (Peattie and Charter, 2003).

Besides the NGO resource, two other resources in the logic model have missing linkages to an activity. Policy Framework has a missing linkage to Communication, and Government Departments have a missing linkage to Extension and Awareness. The link between the industry's Policy Framework and Communication is an essential connection.

Communication is a function that supports and accompanies the processes of decision-making and action, and is therefore an essential element that is necessary to contribute to the achievement of sustainability in the industry (Godemann, 2011). The lack of permanent staff and funding in government departments, especially organizations such as CapeNature and the Department of Agriculture, are potential obstacles in achieving their connection to Extension and Awareness. Agricultural extension is critical for agricultural growth and food security and a greater emphasis needs to be given to the government's capacity to fund public sector institutions (Purcell, 1997).

The output Biodiversity Extension Services Unit is currently a vulnerable element in the ostrich industry system. This externally funded unit is responsible for the OIBMP, delivering all environmental outputs. Should this unit cease to function, the environmental focus in the entire logic model will be at risk and therefore reduce any chance of achieving environmental sustainability.

The evaluation of all the existing linkages between the elements in the various categories, i.e. from the resources to the outputs, presents an industry that is effectively producing all its required outputs, i.e. achieving outputs with a very strong social and economic focus. The existing linkages between the outputs and long term outcomes however, have a stronger environmental focus, although overall the evaluation of the model presents a bleak picture, with less of 50 % of the short term outcomes, 28 % intermediate and none of the long term outcomes being achieved.

The industry continues to function and remains a major economic role-player, and there is an almost equal mix of economic, social and environmental responsibilities in the first half of the model. Is it really that critical to work towards the desired long term goals of a sustainable industry, or more importantly, how achievable are the three outcomes in practice?

Sustainable agriculture is defined as the capability of maintaining its productivity and usefulness to society of the long run. It must be environmentally sound, resource-

conservation, economically viable and socially supportive and commercially competitive (Ikerd, 1993). The global pursuit of “sustainable agriculture” has become a popular code word for an environmentally sound, productive, economically viable and socially desirable agricultural industry (Schaller, 1993). There is a strong belief amongst environmentalist that resource conservation, protection of the environment, and farming in partnership with nature, all requirements of sustainability will enhance, not reduce, global food production (Schaller, 1993). The implementation of the sustainability paradigm has reached a status of highest international socio-political concern following the United Nations Conference on Environment and Development in Rio de Janeiro (UNCED, 1992) in 1992. The question has been raised as to whether it is realistic for the agricultural sector, as in the case of the ostrich industry, to achieve the transfer of this complex theory into practice with the available methods and scientific knowledge (Von Wirén-Lehr, 2001). Agricultural production also represents a highly complex system composed of various interacting parameters of both environmental conditions as well as human activities (Giampietro and Bukkens, 1992), which was also clearly evident in the logic model of the ostrich industry. Despite the agricultural complexity, Von Wirén-Lehr (2001) identified three main obstacles that restrict the transfer of theoretical sustainability paradigm into agricultural practice: 1) the lack of systemic and transferable indicators which characterize agricultural and other ecosystems regarding all dimensions of sustainability, 2) the deficit of an adequate evaluation of agro-ecosystems and 3) the lack of principal guidelines for the formulation of management advice for practical application. Von Wirén-Lehr (2001) suggested that goal-oriented concepts based on models for agronomy and management show a high potential to overcome obstacles of implementation and therefore represent a promising tool to bridge the gap between theory and practice of sustainability in agriculture. The logic model has highlighted specific gaps, i.e. attention to awareness and extension, and collaboration between agriculture, conservation and NGOs, that may provide some direction for the industry to overcome the challenge of sustainable agriculture.

There is substantial evidence in South Africa that agriculture as a whole needs to implement improved environmentally sound farming practices if they are to ensure ongoing productive agricultural systems and food security and that the health of the agricultural sector depends

on the sustainability of farming methods (Goldblatt, 2010). Therefore the industry's desire to achieve a sustainable industry is certainly in line with the global and South African trend and there are many ways of overcoming the identified obstacles and establishing linkages between role-players. For example, Australia is currently experiencing a dramatic change in attitude towards land management. The increasing acceptance of this paradigm by all levels of the community bodes well for the participation of people in working towards a more sustainable agriculture in Australia. Their challenge however is to continue to question the concepts of what constitutes 'improvement' and what they want to 'sustain' in their agriculture, and at the same time maintain the momentum of change in the face of the harsh economic realities of today (Sriskandarajah, 1992).

CONCLUSION

This evaluation of the ostrich industry has shown that it is performing poorly regarding achieving the goals of social, economic and environmental sustainability. This research presented a clear visual representation of the ostrich industry's theory of operation, which makes transparent the story of how the ostrich industry functions together with all the role-players, its complexity and serious challenges in establishing and maintaining all linkages in the logic model. The logic model suggests that these role-players all need to be involved and committed to the development and implementation of a strategy to achieve the long term goal of economic, social and environmental sustainability. Forming cross-sector collaborations and partnerships that more effectively use the knowledge and capabilities of organizations such as the SAOBC, Government Departments, Processors, Producers and NGOs, can create new opportunities to achieve both greater industry profitability and ultimately stronger environmental protection (Rondinelli and London, 2003).

Stabilizing the industry has subsequently proven to be a critical element that could potentially secure many other linkages in the model. The identification of possible mitigating activities against certain external factors may assist the industry to stabilize to a certain degree. For example, Fisher et al. (2005) suggested that the adaptation of agricultural techniques will be central to limit potential damages under climate change. Disaster management suggested multilevel governance systems that can enhance the

capacity to cope with uncertainty and surprise by mobilizing diverse sources of resilience (Adger et al., 2005). In South Africa though, agricultural development is unlikely to improve land managers' resilience to drought and other situations that may cause hardship. Factors such as the lack of access to resources and institutional support are reducing their capacity to absorb or adapt to changes (Berkes, 2007; Vetter, 2009). Long-term flexible and opportunistic research to investigate resilience and thresholds for droughts is a solution, but poses its own challenges (Vetter, 2009).

The identification of NGOs within the Little Karoo with similar long term outcomes would be a positive first step in the establishment of strategic partnerships within the industry. Funding and expertise are resources often shared by NGOs (Anonymous 2001). Involving NGOs and establishing relationships with them will certainly support the industry in maintaining relationships to elements in the logic model and potentially build new ones to achieve industry sustainability.

Goldblatt (2010) emphasized the importance of using biodiversity initiatives to ensure environmental sustainability within the agricultural sector, with many retailers and manufacturers in South Africa, and globally, having implemented sustainability standards for 'greening' their product ranges through certification. Securing funding for the Biodiversity Extension Services Unit is therefore critical, since they play a major role in this process. Perhaps a more detailed logic model that specifically focuses on the reasons why certain recommendations such as best practices are not being adopted by the industry could be considered.

Sustainable agriculture is not new and across the world agricultural sectors are finding it very challenging to understand and implement sustainability (Schaller, 1993). The ostrich industry is not unique in their representation of missing linkages to achieve sustainability, but it is not an excuse to conduct 'business-as-usual' and to not critically pursue their long-term goals. Sustainable agriculture can be viewed from all three, economic, ecological and social perspectives, and should be assessed relative to all three. The key is that conceptual

diversity exists in thinking about, and practicing, sustainable agriculture. Each focus implies a different emphasis and a distinct set of analytical questions. Resolving incompatibilities amongst these approaches of the various role-players in the industry and the long term sustainable goals in general, would be a good approach to start linking all the elements in the logic model.

ACKNOWLEDGEMENTS

I would like to thank the focus group facilitator, Susan Botha for conducting all four focus groups which was exceptionally well executed.

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CHAPTER 6: SYNTHESIS AND RECOMMENDATIONS

Although the Little Karoo is one of the least economically developed and populated regions in South Africa it is under severe pressure due to agricultural activities such as irrigated cultivation and the overstocking of livestock, causing serious concern about the current and future states of biodiversity in the area (Hoffman and Ashwell, 2001; Hewitson and Crane, 2006; Keay-Bright and Boardman, 2006; Rouget et al., 2006; MacKellar et al., 2007; Thompson et al., 2008).

While it is well known that ostrich farming has generally had a significant detrimental impact on the natural environment of the Little Karoo (Cupido, 2005; Thompson et al., 2005; Dean and Roche, 2007; Le Maitre et al., 2007), it became clear during this study that specific aspects within the ostrich industry play a significant role in causing this degradation. In this chapter I summarize the important overall findings of this study and suggest ways forward towards achieving an ecologically sustainable ostrich industry in the Little Karoo for the future.

KEY FINDINGS AND RECOMMENDATIONS

There are currently no evidence-based, scientifically defensible carrying capacity estimates for ostrich farming on natural veld in the Little Karoo. The currently recommended stocking rate of 22.8 ha.ostrich⁻¹ is based on herbivorous livestock estimated fodder requirements and fails to take into account peculiarities of ostrich grazing and their territorial behaviour. The absence of scientific data regarding economically and ecologically sustainable ostrich farming in the Little Karoo in particular and the lack of clear guidelines on appropriate ostrich stocking rates, is of great concern.

Ostrich farming practices differ in many ways from other livestock farming methods (Cupido, 2005) and ostrich farming cannot be compared to other livestock farming methods when considering the carrying capacity of natural veld and the appropriate ostrich stocking rates. Should the ostrich industry choose to remain predominantly an

industry that uses the traditional veld-based flock breeding system, there needs to be focused research on developing ostrich stocking rates that take into account the unique impacts of ostriches on the veld such as trampling, compaction of soil and the removal of whole plants, and grazing systems more generally, that include not just the stocking rate, but also rotation, rest and sensitive areas to avoid, and must include especially the social and economic requirements of the ostrich industry.

It is clear that currently the recommended ostrich stocking rates are not being adhered to or enforced in the Little Karoo and that land managers do not believe that these are suitable for an economically viable farming operation. This holds serious implications for biodiversity conservation. The traditional flock ostrich breeding system is still the prevailing breeding ostrich farming practice in the Little Karoo despite much evidence that this system is the main cause of veld degradation and despite the fact that alternative breeding practices are available. This points clearly to land manager perceptions and attitudes regarding the benefits of the traditional farming practices as opposed to alternative methods that may have greater economic benefits and less impact on the environment. The understanding of these reasons and how to make alternative methods more viable for land managers should be a research priority. The majority of land managers considered the currently recommended stocking rate of 22.8 ha.ostrich⁻¹ for breeding ostriches on natural veld to be much too low to be economically viable. There appears to be a very large gap between what currently is estimated to be ecologically sustainable (60 – 90 ha.ostrich⁻¹; Forsyth et al., 2008) and economically viable (10 ha.ostrich⁻¹; SAOBC, 2003) and this suggests that even if estimates of ecologically sustainable stocking rates are refined they are unlikely to meet land managers' economic needs under the current farming and market system.

One of the most significant changes that could take place is a shift by the ostrich industry from a veld-based flock breeding system to a pen-based breeding system. This would allow for better selective breeding with ostriches that would improve production (Murray, 2008), reduce the existing rate of degradation of natural veld and may allow for the slow rehabilitation of already degraded areas through the implementation of veld rehabilitation projects. The biggest obstacles to achieving this are probably land

manager attitudes and perceptions and pen-breeding infrastructure cost. There has been since 2007 a move towards the development of best practices for the industry (Botha, 2008), and more recently (2012) the development of draft standards for the industry in terms of the provisions of the National Environmental Management Act (NEMA, Act 107 of 1998). These standards are taking into consideration the mitigating factors for the potential destruction of natural veld in the case of pen breeding facilities, bio-security measures and ethical standards as it is provided in terms of the Veterinary Procedures Notices No. 04 (Animal Diseases Act 35 of 1984). The consideration and publication of the industry standards have unfortunately been held up due to the lack of funding and lengthy legislative processes (Anonymous, 2012). There would however still be the need for further experimental studies on the long term economic benefits of the pen-breeding system and at the same time examine the reservations land managers have towards pen-breeding. These studies should look into the detail of what their arguments and evidence is based on, and inform experimental studies so that land managers' perceptions can be tested.

Not surprisingly then, all land managers interviewed in the study area were overstocking on their natural veld. The percentage of overstocking was far greater on smaller farms, perhaps indicating that the risk of degradation is reduced as the farms get bigger. Although characteristics such as knowledge, number of years farming or the size of the farm do not necessarily determine positive conservation behaviour of land managers in the Little Karoo, attitude towards the environment is the most important characteristic of a land manager that influences positive conservation behaviour. It was found that the group that displayed the most positive attitude and behavior towards the environment was the younger land manager group with larger farms. This group also indicated the greatest willingness to collaborate with other conservation organizations and is least pressurized to overstock. All this suggests that land managers of larger farms, for a variety of reasons, i.e. less pressure to overstock, more natural veld under management which can simultaneously contribute to biodiversity conservation, and apparent conservation opportunity based on the findings of this study (Chapter 4), are the ones most likely to engage in biodiversity conservation. It

was found that ostrich land managers in general indicated a particular preference to collaborate with agricultural organizations but it appeared that conservation orientated organizations' especially non-government organizations (NGOs) like the Cape Leopard Trust, the Wildlife and Environment Society of South Africa (WESSA) or the Gouritz Cluster Biosphere Reserve (GCBR), were not very well-known, liked or trusted amongst land managers.

A logic model developed for the ostrich industry similarly showed that relationships between non-governmental organizations and the industry were lacking. Forming cross-sector collaborations and partnerships that more effectively use the knowledge and capabilities of all the main industry role-players, i.e. the South African Ostrich Business Chamber (SAOBC), Government Departments, Processors, Producers and NGOs, can create new opportunities to achieve both greater industry profitability and ultimately stronger environmental protection (Rondinelli and London, 2003). The overall lack of success of the ostrich industry's long term sustainability goals, as indicated by the logic model, highlighted the importance of the identification and involvement of NGOs with similar long term outcomes to that of the industry. Funding and expertise are resources often shared by NGOs (Anonymous, 2001) and this certainly will support the industry in maintaining critical relationships and to potentially build new ones to achieve industry sustainability. Stabilizing the industry has subsequently proven to be a critical element in the industry that needs attention. Further research to identify possible mitigating activities against certain external factors such as the adaptation of agricultural techniques to limit potential damages under climate change, and multilevel governance systems that can enhance the industry's capacity to cope with uncertainty and surprise by mobilizing diverse sources of resilience (Adger et al., 2005; Fisher et al., 2005) is critical.

All land managers sampled voluntarily reported their ostrich numbers accurately to the SAOBC, even when they grossly exceeded the recommended stocking rate for ostriches in the Little Karoo. This suggests that there is a high level of trust between ostrich land managers and the SAOBC and that land managers feel that the high stocking rates they apply do not need to be hidden, indicating clearly that the current recommended stocking rates are not perceived by the land managers to be economically viable. This

also indicates (confirmed from the data in Chapter 4) that the land managers do not perceive their stocking rates to be ecologically unsustainable, since most land managers seemed to feel their natural veld was in good condition. It also suggests that many land managers either are not fully aware of the significant impact overstocking of ostriches has on the environment, or that the attitude of land managers is that the economic considerations far outweigh the environmental considerations (Cupido, 2005). The full time integration of the biodiversity project within the SAOBC as the trusted partner for land managers will have significant positive implications for collaboration between ostrich farming practices and biodiversity conservation. The structure within the SAOBC needs to be critically examined and revised to accommodate the permanent appointment of the Biodiversity Project unit.

The SAOBC's Biodiversity Project has gone a long way in terms of creating awareness amongst all the role players around the importance of the Little Karoo biodiversity and adapting farming practices to avoid degrading the area further. This kind of inclusive initiative should continue to bridge the gaps as highlighted in the logic model and needs to be strongly supported by government conservation organizations such as CapeNature and the Department of Agriculture. This project should become the facilitator in ensuring agriculture, conservation, researchers and other role players develop effective economic and environmental awareness programmes to inform the ostrich industry of possible alternative and sustainable ostrich farming methods that are cost effective and do not detrimentally impact on the biodiversity of the Little Karoo. The establishment of a mutual platform to accommodate these discussions needs to be implemented by the Biodiversity Project.

The current momentum of the SAOBC Biodiversity Project indicates that now would be a critical time for conservation agencies, NGOs and agriculture to develop innovative strategies that include increased extension support and provision of economic incentives to influence the behavioral pattern of land managers in the Little Karoo. Because these aspects are so important in determining how the environment is managed, further research is required to investigate what factors can improve environmental attitudes and conservation knowledge of ostrich land managers, especially towards younger land managers with larger farms.

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APPENDIX A

SUPPLEMENTARY MATERIAL FOR CHAPTER 2:

Evidence for Ecologically Sustainable Ostrich Breeding Practices on Natural Veld in the Little Karoo, South Africa

Introduction

This document contains the publication summary which was referred to in the results of this paper.

Table S1: Summary of publications

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
Title	In which Journal did it appear?	2001		Uni/research organisation/ agri gov dept	review vs research	Where did the study take place? Pvt land/communal land/gov land/protected area?	local / regional / national / sub-continent al / continent al / global	i.e. ecosystem service provision	What stocking density do they recommend/stock?	From what search did the paper come from? Economic/Ecological/Both	yes/no
Arid and semiarid rangeland production systems of Southern Africa: Wildlife	Secheresse	2006	Palmer, Riordan Anthony Peel, Michael Kerley, Graham	research organisation	research	n/a	sub-continent al	rangeland production	n/a	Economic	No

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
Living with disease? Biosecurity and avian influenza in ostriches	Agricultural Human Values	2011	Mather, Charles. Marshall, Amy	University	review	private land	national	animal disease	n/a	Both	No
Time-activity budget of greater rheas (<i>Rhea americana</i> , Aves) on a human-disturbed area: the role of habitat, time of the day, season and group size	Acta Ethol	2010	de Azevedo, Cristiano Schetini. Ferraz, João Bosco; Tinoco, Herlandes Penha; Young, Robert John; Rodrigues, Marcos.	University	research	private land	regional	animal behaviour	n/a	Economic	no
The Financial Costs of Ecologically Nonsustainable Farming Practices in a Semi-arid System	Restoration Ecology	2009	Herling, Margot C. Cupido, Clement F.; O'Farrell, Patrick J.; Du Plessis, Lozelle	research organisation	research	private land	local	financial feasibility of rehabilitation	Actual farmed ostriches 2.3ha.ostrich ⁻¹	Both	yes
Ecosystem Services, Land-Cover Change, and Stakeholders: Finding a Sustainable Foothold for a Semi-arid Biodiversity Hotspot	Ecology and Society 14(1): 38	2009	Reyers, Belinda. O'Farrell, Patrick J. ; Cowling, Richard M.; Egoh, Benis N.; Le Maitre, David C.; Vlok, Jan H. J.	University	review	n/a	local	ecosystem services	n/a	Both	no

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
Risk factors for seropositivity to H5 avian influenza virus in ostrich farms in the Western Cape Province, South Africa	Preventive Veterinary Medicine 86 (2008) 139–152	2008	Thompson, Peter N. Sinclair, Marna; Ganzevoort, Boto	University	review	private land	regional	ostrich disease	n/a	Both	No
Ostrich farming and environmental management tools: an overview	Australian Journal of Experimental Agriculture, 2008, 48, 1308–1313	2008	Rodrigues, G.S. Buschinelli, de A. C.C.; Muniz, L.R.	research organisation	review	private land	regional	Ostrich farming environmental management	n/a	Both	no
A collaborative research initiative for the environmental management of ostrich production	Brazilian Journal of Poultry Science	2007	Rodrigues, G.S. Buschinelli. C.C. de A. Rodrigues, I.A. Medeiros, C.B.	research organisation	review	private land	local	Ostrich farming environmental management	n/a	Economic	no
Year-round behavioural sequences in captive ostrich (<i>Struthio camelus domesticus</i>) pairs	Applied Animal Behaviour Science 103 (2007) 156–166	2007	Csermely, Davide. Gaibani, Giorgia; Dardani, Enrica.	University	research	private land	local	ostrich behaviour	n/a	Economic	no
Vegetation changes (1995-2004) in semi-arid Karoo shrubland, South Africa: Effects of rainfall, wild herbivores and change in land use	Journal of Arid Environments 64 (2006) 174–192	2006	T. Kraaija, , S.J. Milton	gov conservation organisation	research	Protected Area, government land - Karoo National Park	local	vegetation dynamics	n/a	Both	no

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
The influence of stocking rate and male : female ratio on the production of breeding ostriches (Struthio camelus spp.) under commercial farming conditions	South African Journal of Animal Science 2004, 34 (2)	2004	Lambrechts, H. Swart, D.; Cloete, S.W.P.; Greyling, J.P.C.; van Schalkwyk, S.J.	Gov agri organisation	research	private land	local	stocking rate	actual farmed ostriches: 0.009ha.ostrich h ⁻¹ for large flocks (114) 0.02ha.ostrich ⁻¹ for small flocks (13)	Both	Yes
Newcastle disease and avian influenza A virus in wild waterfowl in South Africa	AVIAN DISEASES 44:655-660, 2000	2000	S. Pfitzer,A D. J. Verwoerd,B G. H. Gerdes,B A. E. Labuschagne,B A. Erasmus,c R. J. Manvell,D and Ch. GrundA	University	research	Private land	local	animal disease	n/a	Economic	no
The nutrition requirements and foraging behaviour of ostriches	ASIAN-AUSTRALASIAN JOURNAL OF ANIMAL SCIENCES	2003	Miao, Z.H. Glatz, PC; Ru, Y.J.	University	research	unknown	unknown	ostrich nutrition & behaviour	n/a	Both	no
A review of Ostrich farming	Tijdschrift voor Diergeneeskunde Volume 125, Issue 9, 1 May 2000	2000	Lambooij, E. Pieterse, C.	research organisation	review	unknown	unknown	Ostrich production	n/a	Economic	no

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
Commercial ostrich farming in Botswana	South African Journal of Animal Science	1999	Mushi, E.Z.	College	review	private land	national	Ostrich production	n/a	Economic	No
Effects of gender and group size on the time-activity budgets of adult breeding ostriches (<i>Struthio camelus</i>) in a farming environment	Applied Animal Behaviour Science 51 (1997) 159-177	1997	McKeegan, D.E.F.; Isa, J.F.W.; Chabo, R.G.; Modisa, L.; Kono, P.	Agri company	research	private land	local	ostrich behaviour	n/a	Both	no
RECUMBENCY IN OSTRICHES	The-Compendium-on-continuing-education-for-the-practicing-veterinarian (USA) DEUTSCHE TIERARZTLICHE WOCHENSCHRIFT	1995	University of Pretoria	University, research institute and agri college	review	unknown	unknown	Ostrich health	n/a	Economic	no
OSTRICH - FARM-ANIMALS	Volume: 101 Issue: 3 Pages: 88-91	1994	Gobbel, T.	unknown	review	unknown	unknown	ostrich products	n/a	Economic	no

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
The development of ratite production through continued research	World's Poultry Science Journal / Volume 68 / Issue 02 / June 2012, pp 323-334	2012	Cloete, S.W.P. Brand, T.S.; Hoffman, L.; Brand, Z.; Engelbrecht, A.; Bonato, M.; Glatz, P.C.; Malecki, I.A.	university	review	n/a	global	ratite production	n/a	Economic	No
Wild ostrich (<i>Struthio camelus</i>) ecology and physiology	Journal Tropical Animal Health and Production	2010	Cooper, R.G. Horbańczuk, J.O.; Villegas-Vizcaíno, R.; Sebei, S.K.; Faki Mohammed, A.E.; Mahrose, K. M. A	university	review	n/a	global	ostrich behaviour & ecology	n/a	Economic	no
Deriving a preliminary breeding objective for commercial ostriches: an overview	Australian Journal of Experimental Agriculture	2008	Cloete, S.W.P. Engelbrecht, A.; Olivier, J.J.; Bunter, K.L.	university	research	Government research farm	local	ostrich genetic traits and economic assessment	n/a	Both	no
Ostrich production in the arid environment of Kuwait	Journal of Arid Environments (2003) 54: 219–224	2003	Al-Nasser, A. Al-Khalaifa, H.; Holleman, K.; Al-Ghalaf, W.	research organisation	review	n/a	national	ostrich farming	n/a	Both	no

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
Ostrich flock health	Seminars in Avian and Exotic Pet Medicine	2001	Black, D.	consultants	review	n/a	global	ostrich health	n/a	Both	No
Critical factors in ostrich (<i>Struthio camelus australis</i>) production: a focus on southern Africa	World's Poultry Science Journal	2000	Cooper, R.G.	university	review	n/a	sub-continent al	ostrich management	n/a	Economic	no
Ostrich farming (<i>Struthio camelus</i>) under the climatic conditions of Hestia - analysis of meteorological data for the application of the BML(2 's expert recommendation concerning ostriches (1996).	Deutsche Tierärztliche Wochenschrift	2000	Schmitz, J.	research organisation	research	unkown	regional	climate influence on ostrich farming	n/a	Economic	no
A note on effects of gender and time of day on the winter time-activity budget of adult ostriches (<i>Struthio camelus</i>) in a farming environment	Applied Animal Behaviour Science 59 1998. 363–371	1998	Deeming, D.C.	university	research	private land	local	ostrich behaviour	n/a	Both	no
Monitoring the health and productivity of farmed ostrich flocks	Austrian Veterinary Journal	1997	More, S.J.	university	review	private land	regional	ostrich health and production	n/a	Economic	no
DOWN ON THE OSTRICH FARM	International wildlife	1984	Younghusband, P.	unknown	review	unknown	unknown	ostrich farming	n/a	Both	no

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
Effect of supplementary feed and stocking rate on the production of ostriches grazing irrigated lucerne pasture	South African Journal of Animal Science 2009, 39	2009	Strydom, M. Brand, T.S.; Aucamp, B.B.; van Heerden, J.M.	gov dept. Agriculture	research	Government research farm	local	ostrich production	cited: 5ha.ostrich ⁻¹ on good veld 10-12ha.ostrich ⁻¹ on poor veld	Economic	yes
Ostrich Farming in South Africa	Journal of the Royal African Society	1920	Deurden, J.E.	unknown	review	n/a	national	ostrich farming	n/a	Economic	no
Agriculture in the natural world: progressivism, conservation and the state. The case of the Cape Colony in the late 19th and early 20th centuries	Kronos No. 29, ENVIRONMENTAL HISTORY (NOVEMBER 2003) (pp. 109-138	2003	Brown, Karen	university	review	n/a	regional	Agricultural history	n/a	Economic	no
Economic Incentives for Restoring Natural Capital in Southern African Rangelands	Frontiers in Ecology and the Environment, Vol. 1, No. 5 (Jun., 2003), pp. 247-254	2003	Milton, S.J. Dean, W. R.J.; Richardson, D.M.	university	review	n/a	national	restoration ecology and economy	n/a	Economic	no

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
Linking Ecosystem Services and Water Resources: Landscape-Scale Hydrology of the Little Karoo	Frontier Ecology Environ	2007	Le Maitre, D.C. Milton, S.J.; Jarman, C.; Colvin, C.A.; Saayman, I.; Vlok, J.H.J.	research organisation	review	n/a	local	ecosystem services	n/a	Both	no
Devising Appropriate Policies and Instruments in Support of Private Conservation Areas: Lessons Learned from the Klein Karoo, South Africa	Conservation Biology	2010	Pasquini, L. Cowling, R.M.; Twyman, C.; Wainwright, J.	university	review	Private land	local	Private land conservation	n/a	Economic	no
Growth, Flowering and Recruitment of Shrubs in Grazed and in Protected Rangeland in the Arid Karoo, South Africa	Vegetatio, Vol. 111, No. 1 (Mar., 1994), pp. 17-27	1994	Milton, S.J.	university	research	private land	local	vegetation dynamics	n/a	Economic	no
Safeguarding Biodiversity and Ecosystem Services in the Little Karoo, South Africa	Conservation Biology	2010	Reyers, Belinda. Carwardine, J.; Bode M.; O'Farrell, P.J.; Wilson, K.A.; Possingham, H.P.; Rouget, M.; De Lange, W.; Richardson, D.M.; Cowling, R.M.	university	review	n/a	local	ecosystem services	n/a	Both	no

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
Using Diet and Plant Resources to Set Wildlife Stocking Densities in African Savannas	Journal of Arid Environments	2004	Archer, E.R.M	university	research	private land	regional	grazing systems	n/a	Economic	No
A Conceptual Model of Arid Rangeland Degradation	BioScience	1994	Milton, S.J. Dean, W.R.J.; Du Plessis, M.A.; Siegfried, W.R.	university	research	n/a	global	rangeland degradation	n/a	Economic	no
Latitudes and longitudes: comparative perspectives on Cape environmental history	Kronos, No. 29, ENVIRONMENTAL HISTORY	2003	Jacobs, N.J.	university	review	n/a	regional	Environmental History	n/a	Economic	no
Food Selection by Ostrich in Southern Africa	The Journal of Wildlife Management	1994	Milton, S.J. Dean, W.R.J.; Siegfried, W.R.	university	research	Private and government	sub-continent al	Ostrich foraging	Actual wild flocks: 01.-0.3ha.ostrich ⁻¹	Economic	yes
Field Metabolism, Water Requirements, and Foraging Behavior of Wild Ostriches in the Namib	Ecology, Vol. 74, No. 2 (Mar., 1993), pp. 390-404	1993	Williams, J.B. Siegfried, W.R.; Milton, S.J.; Adams, N.J.; Dean, W.R.J.; du Plessis, M.A.; Jackson, S.	Percy FitzPatrick Institute of African Ornithology, University of Cape Town	research	private land	local	Ostrich behaviour and physiology	n/a	Economic	no
Energy, Water, and Solute Balance of the Ostrich <i>Struthio camelus</i>	Physiological Zoology, Vol. 56, No. 4 (Oct., 1983), pp. 568-579	1983	Withers, P.C.	Percy FitzPatrick Institute of African Ornithology, University of Cape Town	research	Government research farm	local	Ostrich physiology	n/a	Economic	no

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
Twenty years of rest returns grazing potential, but not palatable plant diversity, to Karoo rangeland, South Africa	Journal of Applied Ecology	2010	Seymour, C.L.; Milton, S.J.; Joseph, G.S.; Dean, W.R.J.; Dithobolo, T.; Cumming, G.S.	Applied Biodiversity Research Division, South African National Biodiversity Institute, Kirstenbosch Research Centre	research	private land	local	grazing potential	n/a	Economic	no
The Feather Palace	Transition, No. 77 (1998), pp. 70-85	1998	Nixon, R.	unknown	review	n/a	local	Ostrich history	n/a	Economic	no
Biodiversity restoration: Ostrich sector takes giant strides to preserve the Little Karoo	The Waterwheel	2010	Van Vuuren, L.	unknown	review	n/a	local	biodiversity restoration	recommended government stocking rate: 23ha.ostrich ⁻¹	Both	yes
The role of private conservation areas in biodiversity representation and target achievement within the Little Karoo region, South Africa	Biological Conservation	2009	Gallo, J.A.; Pasquini, L.; Reyers, B.; Cowling, R.M.	Plant Conservation Unit, Department of Botany, University of Cape Town	research	n/a	regional	Private land conservation	n/a	Both	no

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
Desertification in the semi-arid Karoo, South Africa: review and reassessment	Journal of Arid Environments	1995	Dean, W.R.J. Hoffman, M.T.; Meadows, M.E.; Milton, S.J.	Percy Fitzpatrick Institute of African Ornithology, University of Cape Town, Applied Biodiversity Research Division, Kirstenbosch Research Centre, South African National Biodiversity Institute; Department of Botany and Zoology, Stellenbosch University,	review	n/a	regional	desertification	n/a	Both	No
Severely degraded rangeland: Implications for plant diversity from a case study in Succulent Karoo, South Africa	Journal of Arid Environments	2010	Rutherford, M.C. Powrie, L.W.	Department of Botany and Zoology, Stellenbosch University,	research	private land	local	Plant diversity in degraded rangeland	n/a	Both	no
Biodiversity of The Succulent Karoo and Cape Flora	Encyclopedia of Biodiversity, 2007, Pages 1-8	2007	Rundel, P.W. Cowling, R.M.	University of California, Los Angeles USA	review	n/a	regional	Succulent Karoo Biodiversity	n/a	Economic	no

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
The possibilities and pitfalls presented by a pragmatic approach to ecosystem service valuation in an arid biodiversity hotspot	Journal of Arid Environments	2011	O'Farrell, P.J.; De Lange, W.J.; Le Maitre, D.C.; Reyers, B.; Blignaut, J.N.; Milton, D.J.; Atkinson, D.; Egoh, B.; Maherry, A.; Colvin, C.; Cowling, R.M	Natural Resources and the Environment, CSIR	review	n/a	regional	ecosystem services	n/a	Both	no
Time-activity budget of ostriches (<i>Struthio camelus</i>) offered concentrate feed and maintained in outdoor pens	Applied Animal Behaviour Science, 22 (1989) 347-358	1989	Degen, A.A. Kam, M.; Rosenstrauch, A.	Isan Centre for Comparative Medicine and Desert Animal Research, Jacob Blaustein Institute for Desert Research, Ben-Gurion University of the Negev, Israel.	research	research station	local	ostrich behaviour	n/a	Both	no
Vigilance and group size in ostriches	Animal Behaviour	1980	Bertram, B.C.R.	The Research Centre, King's College, Cambridge	review	Protected Area, government land - Tsavo National Park	regional	ostrich behaviour	n/a	Economic	no

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
Beyond the “climate versus grazing” impasse: using remote sensing to investigate the effects of grazing system choice on vegetation cover in the eastern Karoo	Journal of Arid Environment	2004	Archer, E.R.M	Department of Environmental and Geographical Science, University of Cape Town	research	unknown	regional	vegetation cover	n/a	Both	no
Ostrich management practices in three states of Northern Nigeria	Veterinary World, 2011, Vol.4(2):64-67	2011	Mshelia, W.P. Abdu,P.A.; Abdussamad A.M.; Wakawa A.M.; Malumfashi A.	Department of Veterinary Surgery and Medicine, Ahmadu Bello University, Zaria, Nigeria	review	private land	regional	ostrich management	n/a	Both	no
The impact of indigenous ungulate herbivory over five years (2004–2008) on the vegetation of the Little Karoo, South Africa	African Journal of Range & Forage Science 2009	2009	Hoffman, M.T. Madden, C.F.; Erasmus, K.; Saayman, N.; Botha, J.C.	CSIR	research	private land	Local	vegetation dynamics	n/a	Economic	no
Applying a resilience framework in the pursuit of sustainable land-use development in the Little Karoo, South Africa.	African Sun Media	2008	O'Farrell, P.J. Le Maitre, D.; Gelderblom, C.; Bonora, D.; Hoffman, M.T.; Reyers, R.	CSIR	review	n/a	regional	sustainable landuse	n/a	Economic	no

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
Assessment of veld utilisation practices and veld condition in the Little Karoo	MSc thesis	2005	Cupido, C.	University of Stellenbosch	research	private land	local	Veld utilisation and practices	Average of actual farmed ostriches: 13.6ha.ostrich ⁻¹	Both	yes
Ostrich farming in the Little Karoo	Bull. Dep. agric. tech. Serv. Republ. S. Air. 1963 pp. iv + 103 pp.	1963	SMIT, D. J. v. Z	Department of Agriculture, Oudtshoorn	review	n/a	regional	ostrich farming	recommendation of own experience 4.28ha or 10-12ha.ostrich ⁻¹	Economic	yes
Calls to improve water management in Klein Karoo	Water Wheel 8 (5) , pp. 20-23	2009	Van Vuuren, L.	unknown	review	n/a	local	water management	n/a	Both	no
The wild ostrich (Struthio camelus): A review	Tropical Animal Health and Production 41 (8) , pp. 1669-1678	2009	Cooper, R.G. Mahrose, K.M.A., Horbanczuk, J.O., Villegas-Vizcaíno, R., Sebei, S.K., Mohammed, A.E.F.	university	review	n/a	global	ostrich behaviour and ecology	n/a	Both	no
Ostrich (Struthio camelus) production in Egypt	Tropical Animal Health and Production 40 (5) , pp. 349-355	2008	Cooper, R.G. Mahrose, Kh.M.A., El-Shafei, M., Marai, I.F.M.	university	review	n/a	national	ostrich farming history	n/a	Ecological	no

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
Changing predictors of spatial and temporal variability in stocking rates in a severely degraded communal rangeland	Land Degradation and Development 23 (2) , pp. 190-199	2012	Vetter, S. Bond, W.J.	university	research	communal	local	stocking rate	n/a	Ecological	no
Mapping Grazing-Induced Degradation in a Semi-Arid Environment: A Rapid and Cost Effective Approach for Assessment and Monitoring	Environmental Management	2008	Thompson, M. Vlok, J., Rouget, M., Hoffman, M.T., Balmford, A. Cowling, R. M.	Private	research	n/a	local	Mapping and monitoring land degradation	n/a	add hoc search	no
The Concept of Rangeland Carrying Capacity in Sub-Saharan Africa - Myth or Reality	Land Degradation and Rehabilitation	1990	De Leeuw, P.N., Tothill, J.C.	unknown	review	n/a	sub-continent al	Carrying capacity	n/a	add hoc search	no
Retention and Restoration of the Biodiversity of the Little Karoo.	CSIR unpublished report	2008	Forsyth, G. Vlok, J.H.J., Reyers, B.	research organisation	review	n/a	local	Carrying capacity	Recommendation: 30-90ha.ostrich ⁻¹	add hoc search	yes
Historical changes in stocking rates of domestic livestock as a measure of semi-arid and arid rangeland degradation in the Cape Province, South Africa.	Journal of Arid Environments	1994	Dean, W.R.J. Macdonald, I.A.W.	University	research	n/a	regional	stocking rate			
Rangelands at equilibrium and non-equilibrium: recent developments in the debate	Journal of Arid Environments	2005	Vetter, S.	University	review	n/a	global	stocking regimes	n/a	add hoc search	no

Paper	Journal	Year	Lead Author	Lead author's affiliation	Type of study	Location	Scale of study	Theme of study	Stocking rate	Economic, Ecological or Ad hoc search	Final inclusion
In search of optimal stocking regimes in semi-arid grazing lands: One size does not fit all			Campbell, B.M. Gordon, I.J., Luckert, M.K., Petheram, L., Vetter, S.	University	review	n/a	global	stocking regimes	n/a	add hoc search	No
Exploring some socio-economic dynamics within the South African ostrich industry	Elsenburg Journal	2010	Qamarana, Lukhanyo and Nowers, Riaan	gov dept. Agriculture	review	n/a	national	socio-economic dynamics	n/a	add hoc search	no
Economic Case for Pen-breeding	Un-published	2008	Murray, M.	Private Consultant, Gvt. Conservation Agency, Agri Organisation	research	Private land	Local	Ostrich Economics	Recommendation of government stocking rate: 22.8ha.ostrich ⁻¹	add hoc search	yes

APPENDIX B

QUESTIONNAIRE

Section A: Farm information

- A1 How many years have you been farming?
- A2 Have you been farming continually? Yes=2; no=1
- A3 How many years on this specific farm?
How many generations has this farm been in your family?
- A4
- A5 How many years has your family been on the farm?
- A6 What is the size of the total area (ha) of your farm?
- A7 How many ha's do you own?
- A8 How many years have you owned the farm?
- A9 How many ha do you hire? n/r=0
- A10 How many years have you been hiring? n/r=0
- A11 How many ha's do you have in partnership? n/r=0
How many ha's do you have in undivided shares?
n/r=0
- A12
- A13 How many ha of natural veld do you have? n/r=0
- A14 How many ha's of perennial crops? n/r=0
- A15 How many ha of other cultivated lands? n/r=0
- A16 How many ha's of other landuse? n/r=0
How many veld types can you name on your farm?
n/r=0
- A17

A18. How important are the following topographic features for ostriches farming? (select which are applicable): n/r=0; not important=1; occasionally important=2; very important=3

- A18a river floodplain
- A18b flats
- A18c foothills
- A18d mountainous areas
- A18e cultivated areas
- A19 What is the average annual rainfall on your farm (mm)?
- A20 Is this your own observation? Yes=2, no=1, n/r=0
- A21 Over what period did you observe this? n/r=0

A22. What type of livestock do you keep on the natural veld? yes=2, no=1, n/r=0

- A22a none
- A22b sheep
- A22c cattle
- A22d goats
- A22e ostriches

A22f game

A23. Over the last 5 years, from which farming activity does your largest income derive from? (in order of priority 1-15; n/r=0)

A23a sheep
A23b cattle
A23c goats
A23d ostriches
A23e game
A23f lucern hay
A23g lucern seed
A23h lucern pellets
A23i vinyard
A23j vegetable seed
A23k cash crops
A23l egg incubation
A23m dairy
A23n tourism
A23o grain

A24. Which factors do you think may contribute to receiving a higher income from ostrich farming and which factors are not important? (please score according to importance); makes no difference=0, helps but not crucial=1, would contribute significantly=2, crucial=3

A24a larger property
A24b Better breeding and selection practices
A24c Better fodder supplement
A24d Better mineral supplement
A24e Pen-breeding system
A24f Better veld condition
A24g More water
A24h Better farmer knowledge and skill
A24i More ostriches
A24j Less ostriches
A24k better prices for ostriches
A24l bio-security measures
A24m more research
A24n stable market
A24o better prices for fuel, mielies and electricity
A25 Are you diversifying your income? Yes=2, no=1, n/r=0

A26. What factors prohibit you from diversifying any further? Yes=2, n/r=0

A26a limited water supply
A26b theft
A26c limited funds
A26d too small property
A26e other

- A27 Do you have new plans for the management or use of your natural veld in the next 5 years? Yes=2; no=1, uncertain=0
- A28 What do you use your natural veld for? Nothing=5, improve veld with management practice=4, utilise veld for cattle=3, utilise veld for small stock=2, utilise veld for ostriches=1, n/r=0
- A29. What is the structure of the farm business? Yes=2; no=1
- A29a trust
- A29b cc
- A29c partnership
- A29d company
- A29e privately owned by the owner
- A 30. How many vehicles, related to the business do you own? What is the latest model (age) for each category? n/r=0
- A30a Bakkies
- A30b Newest model
- A30b 1 Age
- A30c Tractors
- A30d Newest model
- A30d 1 Age
- A30e Trucks
- A30f Newest model
- A30f 1 Age
- A30g Harvesters
- A30h Newest model
- A30h 1 Age
- A30i Platsnyers
- A30j Newest model
- A30j 1 Age
- A30k Quad bikes
- A30l Newest model
- A30l 1 Age
- A30m Motorcycles
- A30n Newest model
- A30n 1 Age
- A30o Digger loader
- A30p Newest model
- A30p 1 Age
- A31 What is the total number of staff (all permanent labourers, domestic and managers) members on the farm?
- A32 Total number of farmwork labourers?

A33. What are the farmwork labourers' skill-level? yes=2, no=1, n/r=0

- A33a unskilled
- A33b semi-skilled
- A33c skilled
- A33d fully skilled
- A34 Total number of domestic workers?

A35. What are the domestic workers' skill-level? Yes=2, no=1, n/r=0

- A35a unskilled
- A35b semi-skilled
- A35c skilled
- A35d fully skilled
- A36 Total number of Managers?

A37. What are the managers' skill-level? Yes=2, no=1, n/r=0

- A37a unskilled
- A37b semi-skilled
- A37c skilled
- A37d fully skilled
- A37e fully skilled - tertiary

**Section B:
Environmental
Attitude**

Strongly disagree=1; Disagree=2; Neutral=3;
Agree=4; Strongly agree=5

- B1 I think that any conservation efforts are futile; it is too late to make a difference.
- B2 I don't think climate change is a reality and intend to do business as usual.
- B3 I believe that we are only stewards of the land and are responsible for leaving it in a healthy condition for generations to come
- B4 I believe there is no balance between conservation and utilisation – economic sustainability is the most important consideration
- B5 It is possible to improve my farming methods to have less impact on the environment.
- B6 I need more interaction with Nature Conservation to assist me with better veld management decisions
- B7 I believe that my farming venture would benefit if I became involved with the ostrich biodiversity project.
- B8 I would be interested in possibly becoming a partner with the ostrich biodiversity project to look at alternative practices that benefit both the environment and my business.

**Section C:
Conservation
Knowledge**

Yes=2; Unsure=1; No=0

- C1 Were you aware, prior to this interview, that the Little Karoo forms part of 3 globally important hotspots for plants and animals?
- C2 Were you aware that 25 vegetation types in the Little Karoo are endangered?
- C3 The reasons why the Little Karoo's lower laying vegetation types should be conserved are clear to me.
- C4 Do you read books on the ecology or the natural environment of the Little Karoo?

- C5 Do you know what the responsibility of CapeNature is?
Prior to this interview, have you heard about the
C6 Ostrich Biodiversity Management Project?
Do you know that there are government prescribed
C7 stocking rates?
Do you think that people in this area are becoming
more aware of the conservation importance of the
C8 vegetation of the Little Karoo?

**Section D:
Conservation
Behaviour**

Strongly disagree=1; Disagree=2; Neutral=3;
Agree=4; Strongly agree=5

- D1 I have undertaken soil conservation measures for
reducing soil erosion in the last 5 years.
I have undertaken nature conservation activities for
any plants or animals in the last 5 years (e.g. surveys,
D2 re-introductions, restoration, monitoring).
I formally monitor my veld condition, using a
D3 recognised method
D4 I operate ecotourism activities on my farm.
I like to regularly attended conservation workshops
D5 and or meetings.
It is necessary to have an environmental management
D6 plan for my farm.
I regularly report interesting plants/animals to Nature
D7 Conservation.
I implement healthy waste management on my farm
D8 and encourage my workers to do the same.
D9 I implement alien clearing activities on my farm.

**Section E:
Willingness**

Collaboration willingness index: Very high=5;
high=4, Moderate=3; Low=2; very low=1;
never heard of them=0

- E1a Nat. Dept. Environmental Affairs
E1b Dept. Land Affairs
E1c Dept. Water Affairs
E1d SAPD
E1e CapeNature
E1f Dept. Agriculture, Forestry & Fisheries
E1g LandCare
E1h Dept Environ. Affairs & Dev. Plan
E1i Oudtshoorn municipality
E1j Eden District municipality
E1k Gouritz Biosphere Reserve
E1l Cape Leopard Trust
E1m WESSA
E1n Agri Klein Karoo
E1o Agricultural Research Council
E1p Oudtshoorn Research Farm
E1q Rhodes University
E1r University of Stellenbosch
E1s Farmers' Association

Willingness to participate in conservation:
Strongly disagree=1; Disagree=2; Neutral=3;
Agree=4; Strongly agree=5

Incentives: Very interested=5; interested=4;
neutral=3; possibly interested=2; Not at all
interested=1

- E1t A neighbouring Conservancy
- E1u SAOBC
- E1v Ostrich Biodiversity Project
- E1w A neighbouring farmer
- E1x Private consultant
- E2a Offering landowners various types of incentives (e.g. financial, motivational, property or rights-based) is a good idea for promoting conservation on private land.
- E2b Protection of plants and animals that occur outside of protected reserves should be the responsibility of private landowners.
- E2c CapeNature or another government organisation should bear the costs for the conservation and management of endangered veld types on my farm
- E2d I have heard about CapeNature's stewardship programme
- E2e I would be interested to know more about the stewardship programme
- E2f I would like to participate in a stewardship programme, regardless of any incentives
- E2g I am only interested in stewardship if substantial incentives are offered
- E3a Tax deduction or rate rebates for conservation land and activities
- E3b Assistance with fencing and land management
- E3c Subsidy for conservation work, i.e. erosion control or alien clearing
- E3d Access to scientific information and support
- E3e Public / community recognition (e.g. certificates, photos and magazine article)
- E3f Free access to all CapeNature Reserves
- E3g Eco-tourism support and incentives
- E3h Law enforcement support
- E3i Assistance with farm environmental management plans and maps

**Section F:
Ostrich Farming**

F1. Where did you learn to farm with ostriches?
Yes=2, no=1, n/r=0

- F1a father
- F1b family
- F1c own experience
- F1d research farm
- F1e tertiary education

F2. What type of ostrich farming practice did you implement? Yes=2, no=1, n/r=0

- F2a breeding birds
- F2b slaughter birds
- F2c hatchery
- F2d chicks
- F2e feathers
- F3 What are the reason/s for this type of farming practice?

F4. What type/s of ostrich farming do you intend to carry on with in the next 5 years? Yes=2; no=1, unsure=0	F4a breeding birds F4b slaughter birds F4c hatchery F4d chicks F4e feathers
F5. What type of ostrich product(s) do you produce or focus on? Indicate their importance according to income; 1=most, 4=least; 0=n/r	F5a skin F5b meat F5c feathers F5d chicks
F6. How many birds do you farm with (before the Avian Flu' struck) – before February 2011?	F6a breeding birds F6b slaughter birds
F7. What type of breeding bird practice do you implement? Yes=2, no=1, no breeding birds=0	F7a pen-breeding F7b flock breeding F7c group breeding F7d Reasons for this type of breeding practice?
F8. Where do you keep your breeding ostriches? Yes=2, no=1, no breeding birds=0	F8a veld F8b croplands/drylands F8c pens/camps F8d Reasons for keeping ostriches there?
F9. Where do you keep your slaughter birds? yes=2, no=1, n/r=0;	F9a croplands F9b drylands F9c feedlots
F10. What factors do you consider when putting ostriches into a natural veld camp? Yes=2, no=1, n/r=0	F10a consider nothing F10b veld must be in good condition F10c veld must be flat F10d water availability F10e amount of birds/size of camp and period F10f No ostriches must be on the veld
F11. During which months of the year are the ostriches in the veld? Yes=2; no=1	F11a January F11b February F11c March F11d April F11e May F11f June F11g July F11h August

- F11i September
- F11j October
- F11k November
- F11l December

Section G: Veld Stocking Densities

- G1 How do you decide how many ostriches to stock on the veld?
In your opinion, what do you think is the correct stocking density for ostriches on your natural veld (how many HA per ostrich)? n/r=NR; no idea=N; there should be no ostriches on the veld, because they cause too much damage=0
- G2 The average recommended stocking density of ostriches on natural veld determined by the Department of Agriculture is 22.8h/ostrich. How economically profitable do you think this figure is? n/r=0; very unprofitable=1; satisfactory=2; very profitable=3
- G3

G4. In your opinion, what do you estimate the overall condition of your natural veld to be?
Pristine=3; good=2; poor=1; n/r=0

- G4a Hill tops
- G4b Slopes
- G4c Valley/flats

G5. What is the average condition of natural veld in ostrich camps on hill tops, slopes and valleys in percentage: n/r=not applicable

G5a. Hill tops

- G5a1 pristine
- G5a2 good
- G5a3 poor

G5b. Slopes

- G5b1 pristine
- G5b2 good
- G5b3 poor

G5c. Valley/flats

- G5c1 pristine
- G5c2 good
- G5c3 poor

Section H: Personal information

- H1 Gender: Male=2, female=1
- H2 How old are you?
- H3 Cultural group: White Afrikaans=1; White English=2
What language do you primarily use at home?
- H4 Afrikaans=1; English=2
- H5 Marital Status: single=1, Married=2, Divorced=3
- H6a Number of children?

- H6b Number of children in Preschool; n/r=0
- H6c Number of children in Public Primary school;n/r=0
- H6d Number of children in public High School; n/r=0
- H6e number of children in University; n/r=0
- H6f number of children Independent; n/r=0
- Landowner highest level of education completed?
 Highschool=1; N6 Certificate= 2; Diploma=3; Partially
 University Degree=4; Unversity Degree=5; Honours
 Degree=6; Masters Diploma=7
- H7 Have you got a formal qualification in Agriculture?
 yes=2; no=1;
- H8 Where does your spouse come from? Locally=1; out of
 town=2; n/r=0
- H9
- H10 How long has she been on this farm?
 Does she live on the farm on a full-time basis? Yes=2;
 n/r=0
- H11 What is her involvement with farming? Fulltime=3;
 part-time=2; own business/career=1; n/r=0
- H12 What is her highest level of education completed?
 n/r=0; Highschool=1; diploma=2; degree=3
-

APPENDIX C

SUPPLEMENTARY MATERIAL FOR CHAPTER 4:

Attitudes and Behaviour of Ostrich Land Managers in the Little Karoo, South Africa.

Introduction

This document contains the detailed Tables and Figures which were referred to in the methods and results of this paper. The questions (items) are presented as they were originally worded.

Table S1. The 24 organizations and type of institution they represent* and the degree to which respondents were willing to collaborate (WC). Organizations are listed in order of land manager preference (sum of 'high' and 'very high'). Indicated are the response % of item (score indicated in parenthesis), mean and median scores from the final scales. Items that are shaded were dropped from the scale once it was tested for internal consistency and reliability and the sharpened scale was produced.

Items from questionnaire (E1a-E1x)	% Never heard of (0)	% Very low (1)	% Low (2)	% Moderate (3)	% High (4)	% Very high (5)	Mean score	Median score
Dept. Agriculture, Forestry & Fisheries (NPLGo)*	0	0	0	13	48	39	4	4
SAPD (NPLGo)	0	0	0	17	43	39	4	4
Farmers' Association (AOo)	0	0	0	17	52	30	4	4
A neighbouring farmer (P)	0	0	0	17	43	39	4	4
Oudtshoorn Research Farm (AOo)	0	0	0	22	48	30	4	4
LandCare (NPLGo)	0	0	0	26	43	30	4	4
Agri Klein Karoo (AOo)	0	0	9	17	35	39	4	4
SAOBC (AOo)	0	4	9	17	43	26	4	4
Ostrich Biodiversity Project (COo)	0	0	4	26	39	30	4	4
CapeNature (COo)	0	0	0	35	30	35	4	4

Items from questionnaire (E1a-E1x)	% Never heard of (0)	% Very low (1)	% Low (2)	% Moderate (3)	% High (4)	% Very high (5)	Mean score	Median score
Dept. Water Affairs (NPLGo)	0	4	0	39	39	17	4	4
Agricultural Research Council (AOo)	13	4	0	26	39	17	3	4
A neighbouring Conservancy (COo)	0	0	0	48	43	9	4	4
Private consultant (P)	0	0	4	43	39	13	4	4
University of Stellenbosch (AI)	0	4	4	43	39	9	3	3
Cape Leopard Trust (COo)	22	9	4	26	22	17	3	3
Dept. Land Affairs (NPLGo)	0	0	4	61	26	9	3	3
Gouritz Biosphere Reserve (COo)	22	0	13	30	13	22	3	3
Nat. Dept. Environmental Affairs (NPLGo)	0	4	0	65	13	17	3	3
Dept. Environ. Affairs & Development Planning (NPLGo)	0	0	9	61	26	4	3	3
Oudtshoorn municipality (NPLGo)	0	13	17	39	17	13	3	3
Eden District municipality (NPLGo)	0	9	13	48	17	13	3	3
Rhodes University (AI)	4	9	13	43	22	9	3	3
WESSA (COo)	43	4	4	22	17	9	2	2

The 24 organizations are categorized and indicated in parenthesis as follow: Conservation orientated organization (COo), Agricultural orientated organization (AOo), Academic Institution (AI), National, Provincial or local government organization (NPLGo) and Private (P).

Table S2. The original ancillary variables that were selected from scales containing demographic and personal data that may have an influence on the attitudes and behaviour of land managers towards the environment. Scale codes are indicated in parenthesis. Items marked with ^(**) were selected as key variables in the final analysis.

Question	Demographic variable measured	% respondents	Max/min	Mean score	Median score
For how long have you been farming? (A4) ^(**)	Years of farming experience	n/a	52/4	26	24
What is the size of your farm (total area)? (A9) ^(**)	Average size of the farms in hectares	n/a	10100/40	1806	450
How many vehicles (incl. tractors, trucks, motorbike, boats, caravans etc.) do you own? (A23)	Measure of affluence, number of vehicles/motorised implements	n/a	23/2	10	10
How many permanent workers do you have on the farm (in total)? (A24)	Measure of affluence, number of employees	n/a	31/2	11	8
Where did you learn to farm with ostriches? (F1)	% respondents learnt from their fathers	65	n/a	n/a	n/a
Where do you keep your breeding ostriches? (F8)	% respondents using natural veld	52	n/a	n/a	n/a
In your opinion, what do you think is the carrying capacity for ostriches on <u>your</u> natural veld? (G2)	% respondents having an opinion and recommended ostrich.ha ⁻¹	78	50/0	7	2
The average recommended stocking density of ostriches on natural veld determined by the Department of Agriculture is 22.8ha.ostrich ⁻¹ . How economically profitable do you think this figure is, and why? (G3)	% respondents commenting 22.8ha.ostrich ⁻¹ is "very unprofitable"	87	n/a	n/a	n/a
In your opinion, how do you estimate the condition of your natural veld to be? (G4)	% respondents commenting "good"	91	n/a	n/a	n/a
In which year were you born? (H6)	Age of land manager	n/a	77/33	50	49
What language do you primarily use at home? (H8)	% respondents speaking Afrikaans	83	n/a	n/a	n/a
Level of education completed? (H11)	% respondents who have a tertiary qualification	83	n/a	n/a	n/a
What course(s)/degree(s) did you complete? (H12)	% respondents having a qualification in Agriculture	34	n/a	n/a	n/a

Table S3: Summary tables of demographic information relating to the 23 ostrich farmers (a-l).

a) Gender

Question (H1)	% respondents male	% respondents female
Gender	100	0

b) Cultural group and language

Question (H3)	% respondents white Afrikaans	% respondents white English
Cultural group & language	83	17

c) Age

Question (H2)	% respondents >30 years	% respondents 31-40 years	% respondents 41-50 years	% respondents >51-60 years	% respondents >60 years
How old are you?	0	26	35	22	17

d) Years farming experience

Question (A1)	% respondents >10 years	% respondents 11-20 years	% respondents 21-30 years	% respondents 31-40 years	% respondents 41-50 years	% respondents >51 years
How many years have you been farming?	4	26	48	9	9	4

e) Farm size

Question (A6)	% respondents >50 ha	% respondents 100-500 ha	% respondents 600-1000 ha	% respondents 1500-2500 ha	% respondents 5000-12 000 ha
What is the size of the total area (ha) of your farm?	4	48	13	22	13

f) Primary farming activity (priority 1)

Question (A23)	% respondents sheep	% respondents cattle	% respondents goats	% respondents ostriches	% respondents lucern	% respondents tourism
Over the last 5 years, from which farming activity does your largest income derive from?	0	4	0	91	17	4

g) Second priority arming activity

Question (A23)	% respondents sheep	% respondents cattle	% respondents goats	% respondents ostriches	% respondents lucern	% respondents vegetable seed
Over the last 5 years, from which farming activity does your 2nd largest income derives from?	17	9	4	4	17	9

h) Third priority arming activity

Question (A23)	% respondents sheep	% respondents cattle	% respondents goats	% respondents ostriches	% respondents lucern	% respondents vegetable seed
Over the last 5 years, from which farming activity does your 3 rd largest income derives from?	17	39	0	4	13	4

i) Generations on farm

Question (A4)	% respondents 1 st	% respondents 2 nd	% respondents 3 rd	% respondents 4 th	% respondents 5 th	% respondents 6 th	% respondents 7 th
How many generations has this farm been in your family?	22	7	26	13	13	13	4

j) Ostrich farming education

Question (F1)	% respondents father	% respondents other (family, research farm, etc.)
Where did you learn to farm with ostriches?	65	34

k) Tertiary education

Question (H7)	% respondents High School	% respondents N6 Certificate	National Diploma	Partially University degree	University degree	Honours degree	Masters Diploma
Landowner highest level of education completed?	17	4	48	4	17	4	4

l) Formal qualification in Agriculture

Question (H8)	% respondents yes	% respondents no
Have you got a formal qualification in Agriculture?	35	65

m) Ostrich farming practice

Question (F2)	% respondents breeding birds	% respondents slaughter birds	% respondents hatchery	% respondents chicks
What type of ostrich farming practice did you implement?	96	100	78	100

n) Ostrich breeding practice

Question (F7)	% respondents pen-breeding	% respondents flock breeding	% respondents group breeding
What type of breeding bird practice do you implement?	41	68	14

o) Ostrich stocking rate: ha.ostrich⁻¹

Question (G2)	% respondents no ostriches	% respondents <10 ha.ostrich ⁻¹	% respondents 11-20 ha.ostrich ⁻¹	% respondents 21-50 ha.ostrich ⁻¹
In your opinion, what do you think is the correct stocking density for ostriches on your natural veld (how many HA per ostrich)?	11	72	6	11

p) Recommended agricultural stocking rate (22.8 ha.ostrich⁻¹)

Question (G2)	% respondents very unprofitable	% respondents satisfactory	% respondents profitable
The average recommended stocking density of ostriches on natural veld determined by the Department of Agriculture is 22.8h/ostrich. How economically profitable do you think this figure is?	87	13	0

Table S4. Order and content of Likert statements (B1-B12) to measure the attitude of the land managers (n = 23) towards the environment (EA), indicating response % of land managers, mean and median scores from the final scales. The 5-point Likert scale used indicated that for questions that consisted of a positive statement were scored 1 = strongly disagree and 5 = strongly agree, whereas questions that were stated as a negative statement, indicated with (*), the scoring was reversed. Items indicated with a hash (#) were added to the scale, so that all items that are best related to this scale are grouped together. Items that are shaded were dropped from the scale once it was tested for internal consistency and reliability and the sharpened scale was produced.

Item	1	2	3	4	5	Mean Score	Median Score
I think that any conservation efforts are futile; it is too late to make a difference ^(*)	0	4	0	39	57	4	5
I don't think climate change is a reality and intend to do business as usual ^(*)	0	9	17	43	30	4	4
I believe that we are only stewards of the land and are responsible for leaving it in a healthy condition for generations to come	4	0	4	30	61	4	5
I believe there is no balance between conservation and utilisation – economic sustainability is the most important consideration ^(*)	0	22	4	48	26	4	4
It is possible to improve my farming methods to have less impact on the environment	4	17	9	52	17	4	4
I need more interaction with Nature Conservation to assist me with better veld management decisions	4	13	22	57	4	3	4
I believe that my farming venture would benefit if I became involved with the ostrich biodiversity project	0	22	22	48	9	3	4
I would be interested in possibly becoming a partner with the ostrich biodiversity project to look at alternative practices that benefit both the environment and my business	4	9	22	52	13	4	4
Protection of plants and animals that occur outside of protected reserves should be the responsibility of private landowners ^(#)	0	0	4	74	22	4	4
CapeNature or another government organisation should not bear the costs for the conservation and management of endangered veld types on my farm ^(#)	4	35	30	22	9	3	3
I would be interested to know more about the stewardship programme ^(#)	4	9	13	65	9	4	4
I would like to participate in a stewardship programme, regardless of any incentives ^(#)	4	9	26	52	9	4	4
I am only interested in stewardship if substantial incentives are offered ^(#)	9	26	22	30	13	3	3

Table S5. Order and content of Likert statements (C1-C9) to measure the land managers' (n = 23) knowledge on conservation (CK), indicating response % of land managers (score indicated in parentheses), mean and median scores from the final scales. Items indicated with a hash [#] were added to the scale, so that all items that are best related to this scale are grouped together. Items that are shaded were dropped from the scale once it was tested for internal consistency and reliability and the sharpened scale was produced.

Item	% no (0)	% unsure (1)	% yes (2)	Mean Score	Median Score
Were you aware, prior to this interview, that the Little Karoo forms part of 3 globally important hotspots for plants and animals?	30	0	70	1	2
Were you aware that 25 vegetation types in the Little Karoo are endangered?	26	0	74	1	2
The reasons why the Little Karoo's lower lying vegetation types should be conserved are clear to me	13	13	74	2	2
Do you read books on the ecology or the natural environment of the Little Karoo?	57	4	39	1	0
Do you know what the responsibility of CapeNature is?	22	9	70	1	2
Prior to this interview, have you heard about the Ostrich Biodiversity Management Project?	9	0	91	2	2
Do you know that there are government prescribed stocking rates?	9	0	91	2	2
Do you think that people in this area are becoming more aware of the conservation importance of the vegetation of the Little Karoo?	9	13	78	2	2
I have heard about CapeNature's stewardship programme [#]	57	0	43	1	0

Table S6. Order and content of Likert statements (D1-D9) to measure the land managers' (n = 23) conservation behaviour (CB), indicating response % of land managers (score indicated in parenthesis), mean and median scores from the final scales. The 5-point Likert scale used indicated that for questions that consisted of a positive statement were scored 1 = strongly disagree and 5 = strongly agree. Items that are shaded were dropped from the scale once it was tested for internal consistency and reliability and the sharpened scale was produced.

Item	1	2	3	4	5	Mean Score	Median Score
I have undertaken soil conservation measures for reducing soil erosion in the last 5 years	0	4	9	65	22	4	4
I have undertaken nature conservation activities for any plants or animals in the last 5 years (e.g. surveys, re-introductions, restoration, monitoring)	0	13	17	57	13	4	4
I formally monitor my veld condition, using a recognised method	4	39	22	30	4	3	3
I operate ecotourism activities on my farm	22	61	0	17	0	2	2
I like to regularly attended conservation workshops and or meetings	9	39	13	26	13	3	2
It is necessary to have an environmental management plan for my farm	0	9	26	52	13	4	4
I regularly report interesting plants/animals to Nature Conservation	13	57	22	9	0	2	2
I implement healthy waste management on my farm and encourage my workers to do the same	0	4	4	65	26	4	4
I implement alien clearing activities on my farm	0	4	4	57	35	4	4

Table S7. Order and content of Likert statement (E2a) to measure the land managers' (n = 23) interest in incentives, indicating response % of land managers (score indicated in parenthesis), mean and median scores from the final scales. The 5-point Likert scale used indicated that for questions that consisted of a positive statement were scored 1 = strongly disagree and 5 = strongly agree.

Item	1	2	3	4	5	Mean Score	Median Score
Offering landowners various types of incentives (e.g. financial, motivational, property or rights-based) is a good idea for promoting conservation on private land	0	0	4	65	30	4	4

Table S8. Order and content of Likert statements (E3a-E3i) to indicate the land managers' (n = 23) interest in different types of incentives, indicating response % of land managers (score indicated in parentheses), mean and median scores from the final scales. The 5-point Likert scale used indicated that for questions that consisted of a positive statement were scored 1 = Not at all interested and 5 = Very interested.

Item	1	2	3	4	5	Mean Score	Median Score
Tax deduction or rate rebates for conservation land and activities	4	9	9	48	30	4	4
Assistance with fencing and land management	4	4	4	48	39	4	4
Subsidy for conservation work, i.e. erosion control or alien clearing	0	4	4	57	35	4	4
Access to scientific information and support	4	4	9	57	26	4	4
Public / community recognition (e.g. certificates, photos and magazine article)	48	0	22	30	0	2	3
Free access to all CapeNature Reserves	4	4	17	57	17	4	4
Eco-tourism support and incentives	13	4	4	65	13	4	4
Law enforcement support	0	9	9	57	26	4	4
Assistance with farm environmental management plans and maps	9	4	4	61	22	4	4

Table S9. A summary of the comparisons between the three clusters and their ancillary variables.

	Ave. number of years farming	Ave. farm size	% pen-breeding system	% flock breeding system	Ostriches breeding on natural veld
cluster 1	19	3524	60	60	40
cluster 2	32	2149	42	71	57
cluster 3	23	799	30	70	55

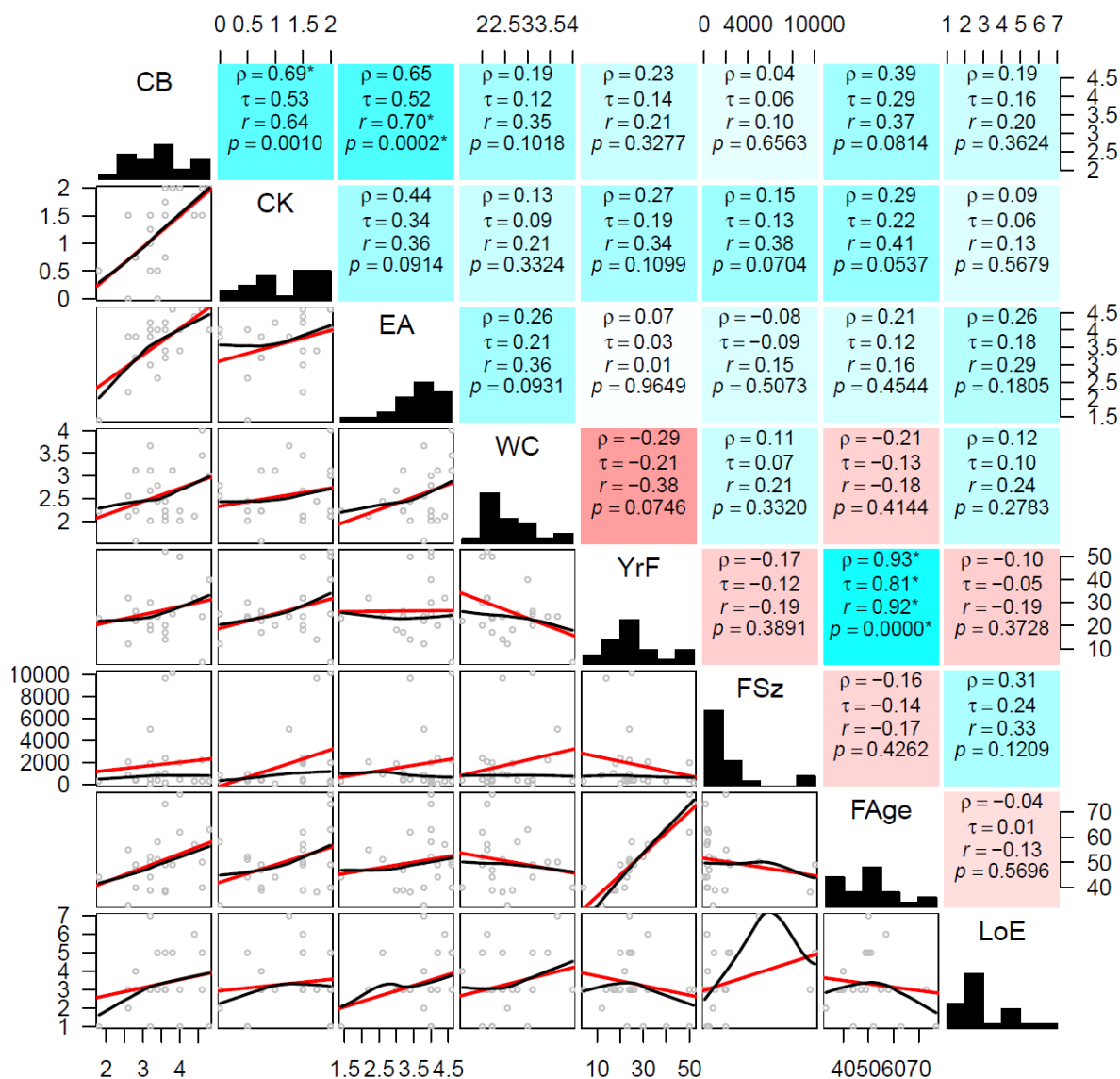
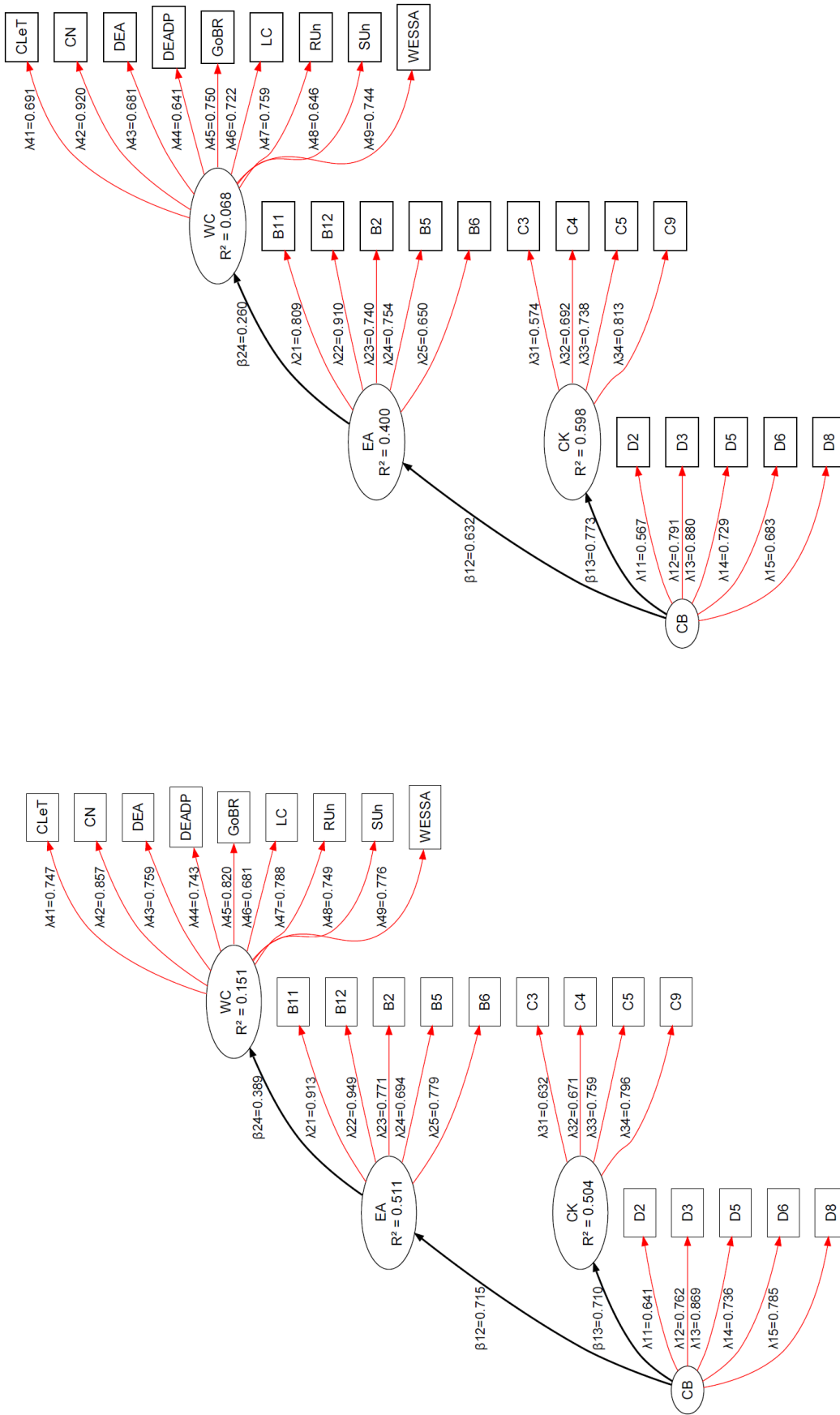


Figure S1. Pairs plot of key variables in the dataset. The red trace is a least-squares regression line, the black trace is loess (or scatterplot) smoother, i.e. a locally-weighted, data-driven, smoother. ρ and τ are Spearman's and Kendall's rank-based correlation coefficients, respectively; r is Pearson's product-moment correlation coefficient; p is the p-value from an (exact) test of the statistical significance of Pearson's correlation coefficient. The acronyms are CB (conservation behaviour), CK (conservation knowledge), EA (environmental attitudes), WC (willingness to conserve), YrF (years farming), FSz (farm size), FAge (farmer's age) and LoE (farmer's level of education).



(a) Uses Pearson's r for the measurement model.

(b) Uses Spearman's ρ for the measurement model.

Figure S2. Partial least squares path model fitted to the causal network shown in Figure 3 of the paper. The measurement model is drawn in red, the structural model in black. The items of the scale are drawn using rectangles, the latent variables using ellipses. The lambdas (λ , loadings) correspond to Pearson (subfigure a) or Spearman (sub-figure b) correlations with the LV's, the betas (β) correspond to standardized regression coefficients. The R^2 values associated with the endogenous latent variables are coefficients of determination and show the proportion of a latent variable's variation that the path (or paths) projecting onto it explain, i.e. the paths drawn in black.

APPENDIX D

SUPPLEMENTARY INFORMATION FOR CHAPTER 5:

Towards Understanding the Complexity of the Ostrich Industry in the Little Karoo, South Africa.

This document contains the detailed Tables and Figures which were referred to in the methods and results of this paper.

Table S1 - The logic table lists the responses or elements from all three focus groups. The rows and cells do not relate to one another.

Resources	Activities	Outputs	Short Term Outcomes	Intermediate Outcomes	Long Term Outcomes	External influences
Processors	Market development	Industry product reputation and branding	New markets	Secure markets	Economic sustainability	Markets
Human Resources (Ostrich Producers)	Flock breeding	Ostrich Products	Biodiversity information access.	Bio-security measures	Social sustainability	Bureaucracy and local government
Ostriches	Hatchery production	Pen breeding systems	Increased breeding success	Conservation of natural resources (stewardship agreements)	Environmental sustainability	Diseases
Natural Environment	Ostrich Industry Structure	Green marketing strategy	Jobs created	Black Economic Empowerment		Climate Change
Gouritz Cluster Biosphere Reserve (GCBR)	Stewardship	Biodiversity management Strategy		Climate Change mitigation and adaption		Politics
Laboratory	Chick raising production	Veld rehabilitation strategy		Optimal resource utilization		Damage Causing animals
Risk management mechanisms	Marketing	Selective breeding programme				Exchange rate
Financial: donor/Govt. funding	Slaughter birds production	Industry Standards				Theft
Infrastructure	Pen breeding production	Functional Integrated Biodiversity				Extreme environmental events (drought,

Resources	Activities	Outputs	Short Term Outcomes	Intermediate Outcomes	Long Term Outcomes	External influences
		Management forum.				flood, heat, cold)
IT resources: Software and website	Workshops (Training and information sharing for producers)	Job creation strategy.				
Legislation	Administration	Biodiversity extension services unit				
Economy	Environmental Regulation/legislation					
Markets	Industry regulation					
Academic Institutions	Processing and production of ostrich products					
Capital goods	Packaging of products					
South African Ostrich Business Chamber (SAOBC)	Selling of products					
Workforce	Formal Public Relations (website, media)					
Ostrich Biodiversity Project & Project Management Team	Environmental Awareness					
National Ostrich Processors of South	Producer cooperation					

Resources	Activities	Outputs	Short Term Outcomes	Intermediate Outcomes	Long Term Outcomes	External influences
Africa (NOPSA)						
South African Ostrich Producers' Association (SAOPA)	Networking with Govt. dept.'s: Dept. of Agriculture, Dept. of Environmental Affairs and Development Planning and CapeNature.					
CapeNature	Research					
Veterinary services and animal health, food security	Rehabilitation and restoration of eroded natural veld					
Provincial Department of Agriculture (PAGri)	Infrastructure development					
National Department of Agriculture (NAGri)	Fundraising					
Dept. of Water Affairs (DWA)						
Dept. of Trade and Industry (DTI)						
Dept. of Social Development (DSD)						
Oudtshoorn Municipality						
Eden District						

Resources	Activities	Outputs	Short Term Outcomes	Intermediate Outcomes	Long Term Outcomes	External influences
Municipality						
South African Police Services (SAPD)						
Dept. of Land Affairs (LA)						
Organized Agriculture (Agri Klein Karoo)						
National Council of Societies for the prevention of Cruelty to Animals (NSPCA)						
Tourism						
Ostrich feed companies						
Dept. of Transport (DoT)						
Transport contractors						

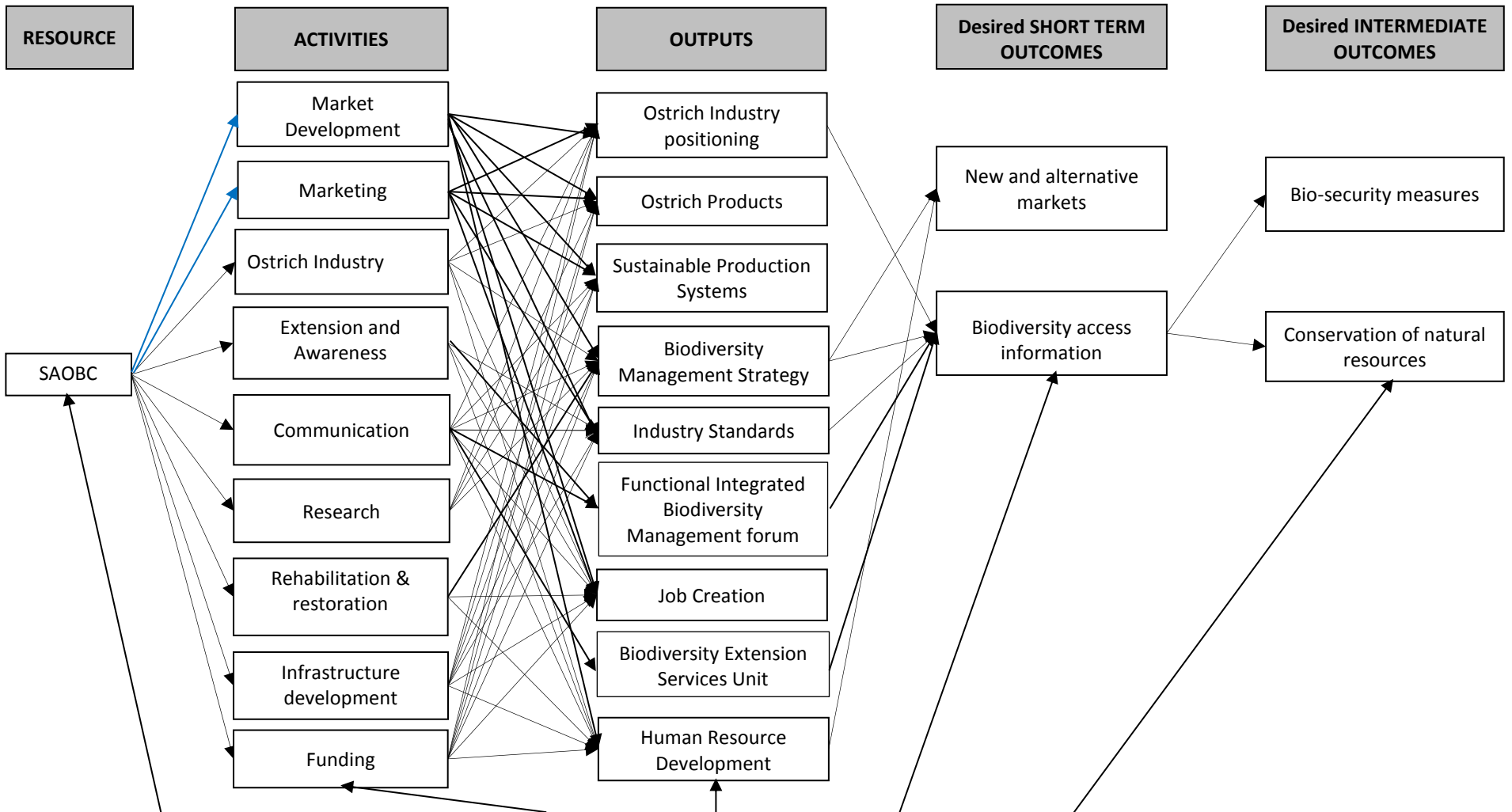


Figure S1 - A simplified logic model, depicting only the complete linkages of the SAOBC and the rest of the elements of the ostrich industry, reaching as far as two intermediate outcomes. The black lines represent direct links with the elements, which means that it has a direct influence on the operations of the industry and the blue lines represents an indirect link to the elements, not influencing the day to day operations of the industry. The external influences effects all the categories in the logic model.

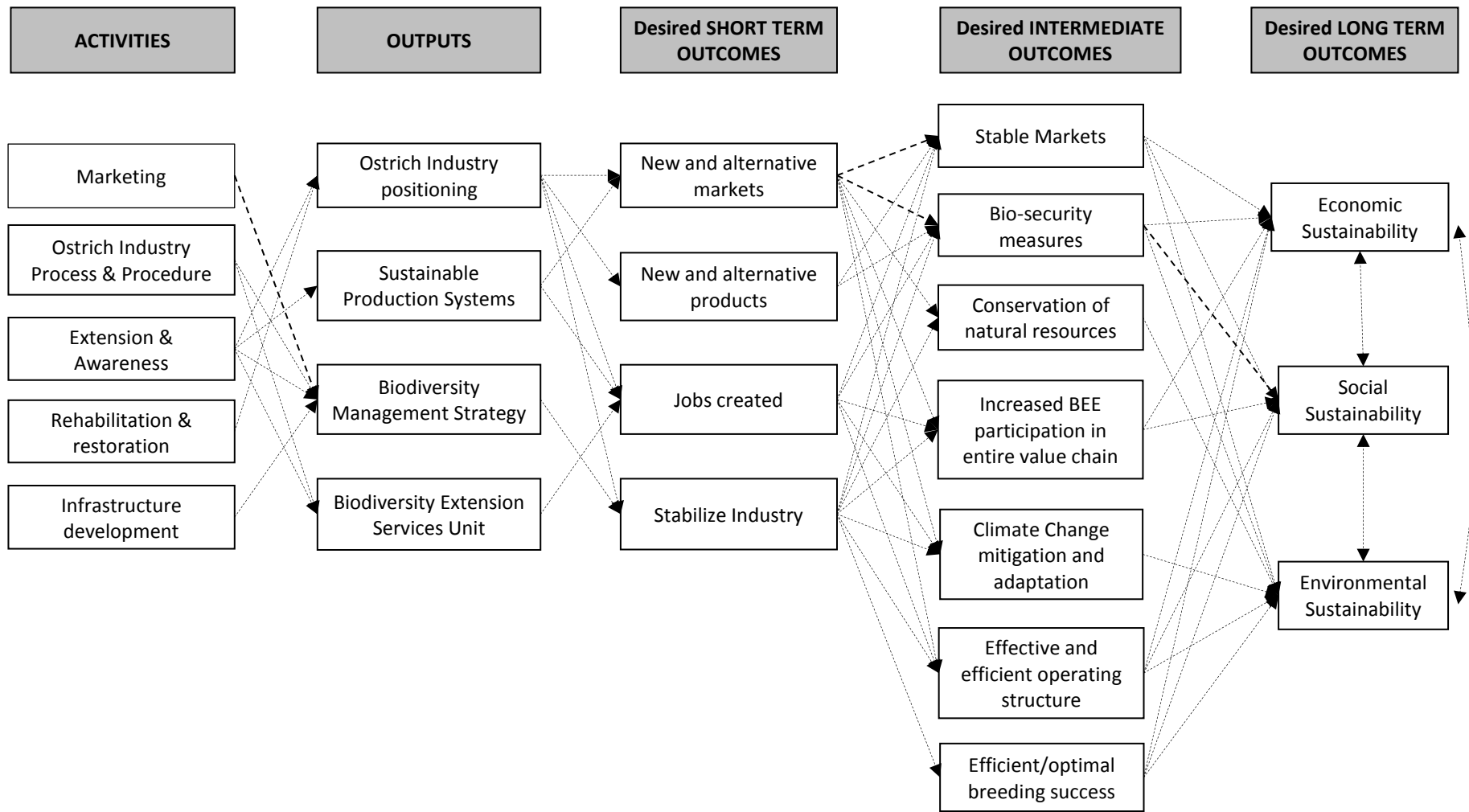


Figure S2 - A simplified logic model depicting the relationships or linkages between elements that should be in place for the SAOBC (the resource), from activities to the short to long-term outcomes, to be able to achieve a sustainable ostrich industry.

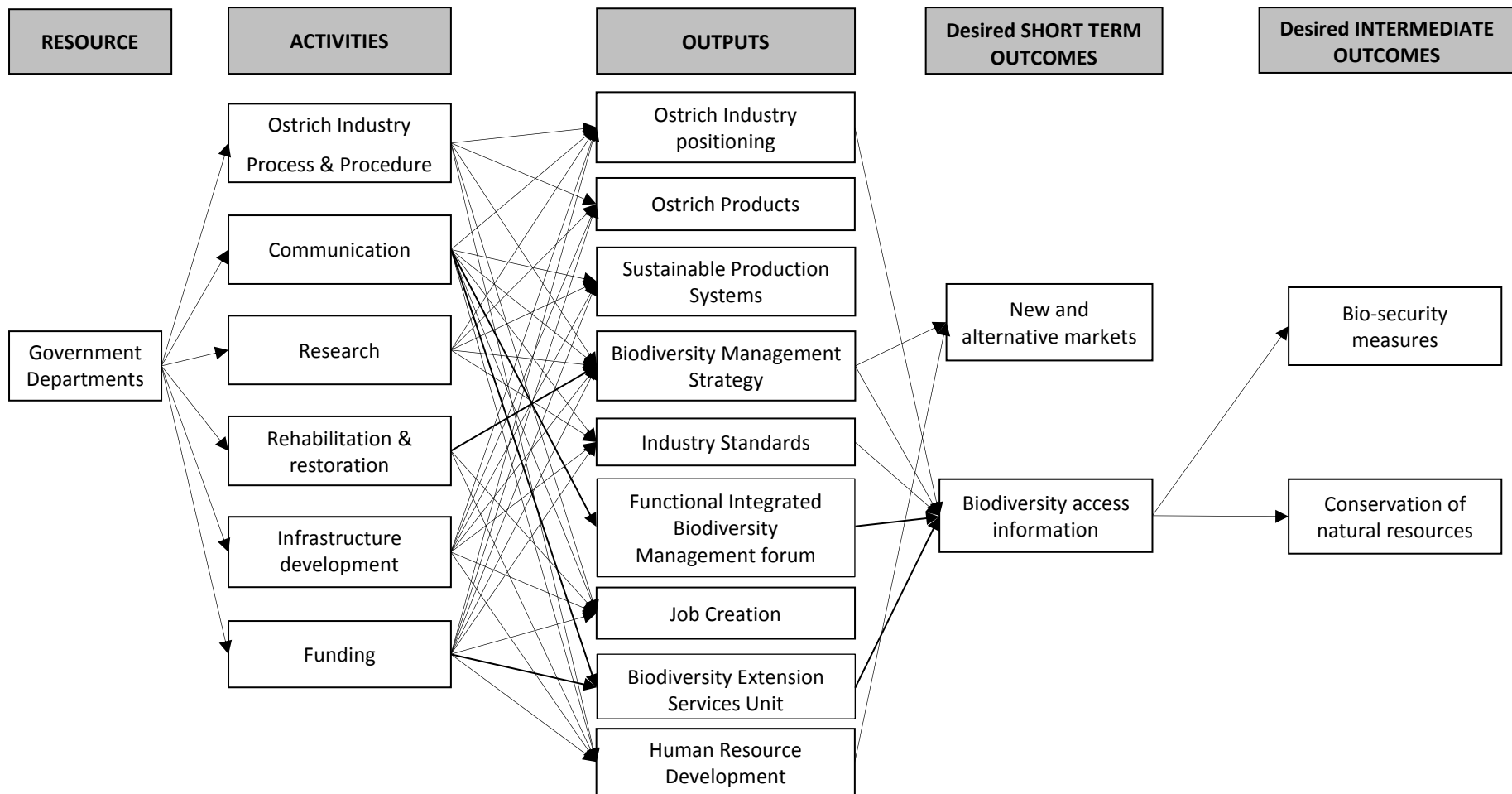


Figure S3 - A simplified logic model, depicting how the national, provincial and local departments as listed in Table S1 links directly to the elements of the ostrich industry, reaching as far as two intermediate outcomes.

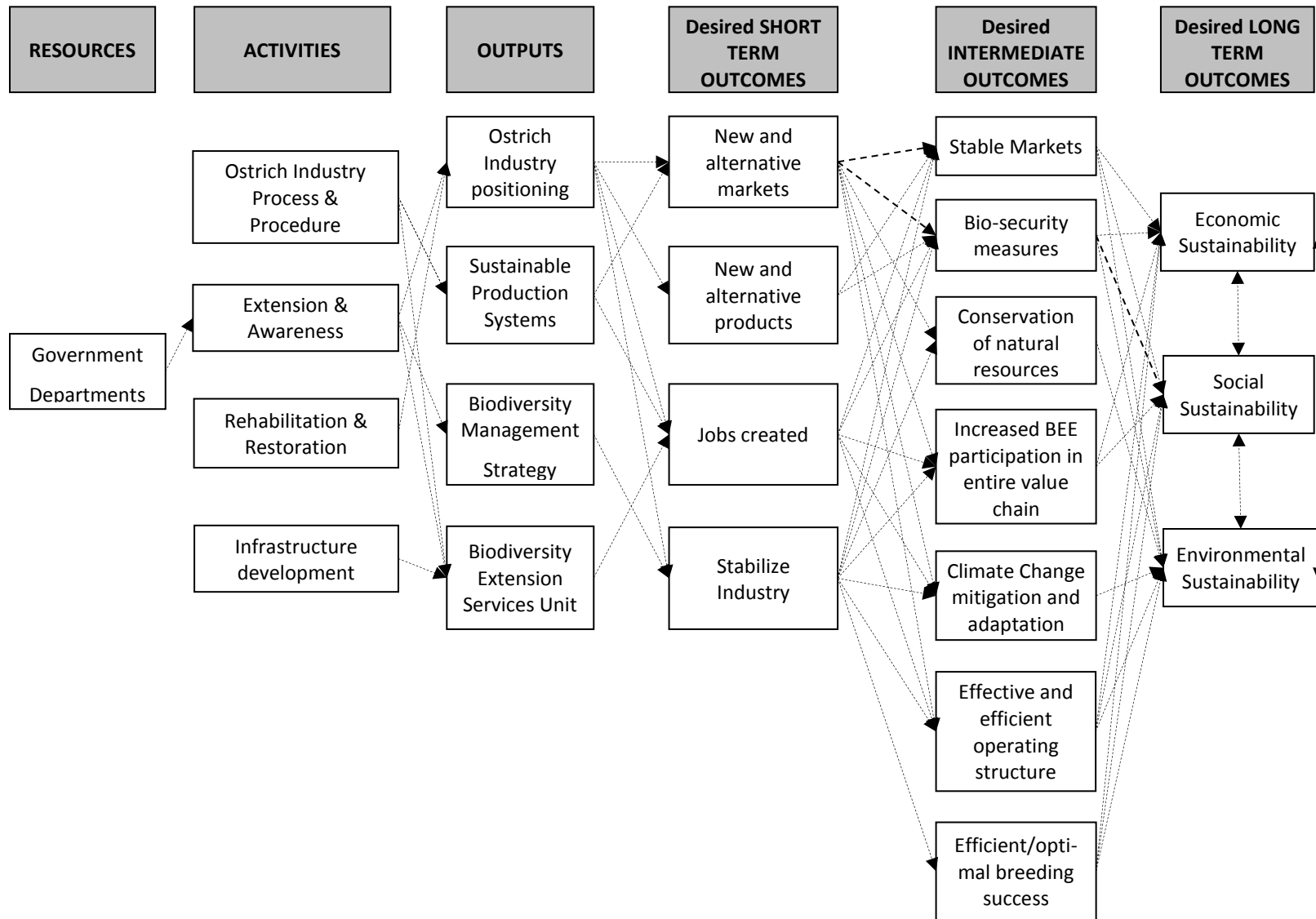


Figure S4 - A simplified logic model, depicting the relationships or linkages between elements that should be in place for the national, provincial and local government listed in Table S1, to be able to achieve a sustainable ostrich industry.

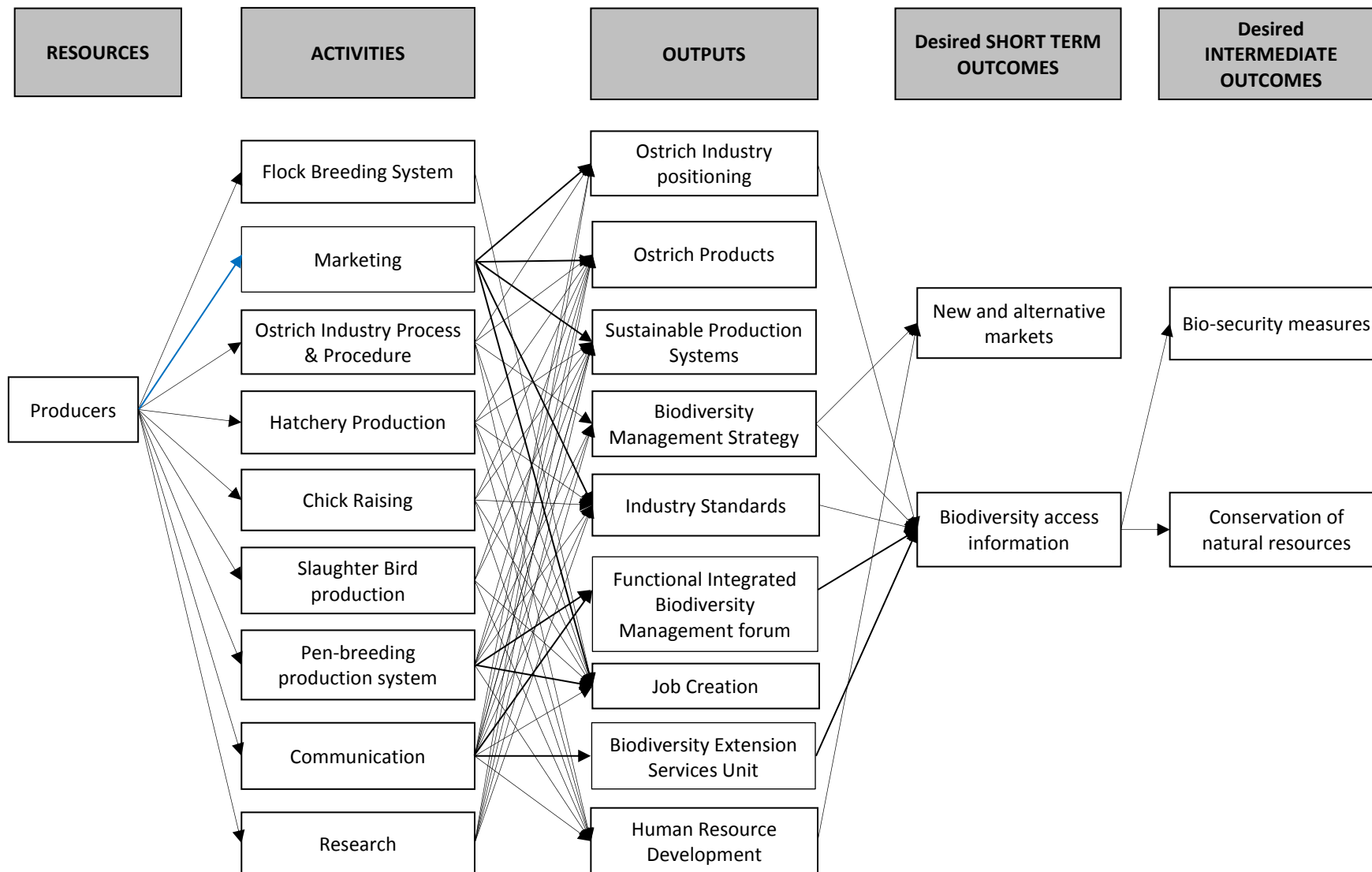


Figure S5 - A simplified logic model, depicting how the ostrich Producers link directly to the elements of the ostrich industry, reaching as far as two intermediate outcomes. The blue line represents the indirect link to the element, which does not have a direct influence on the day to day operations of the industry.

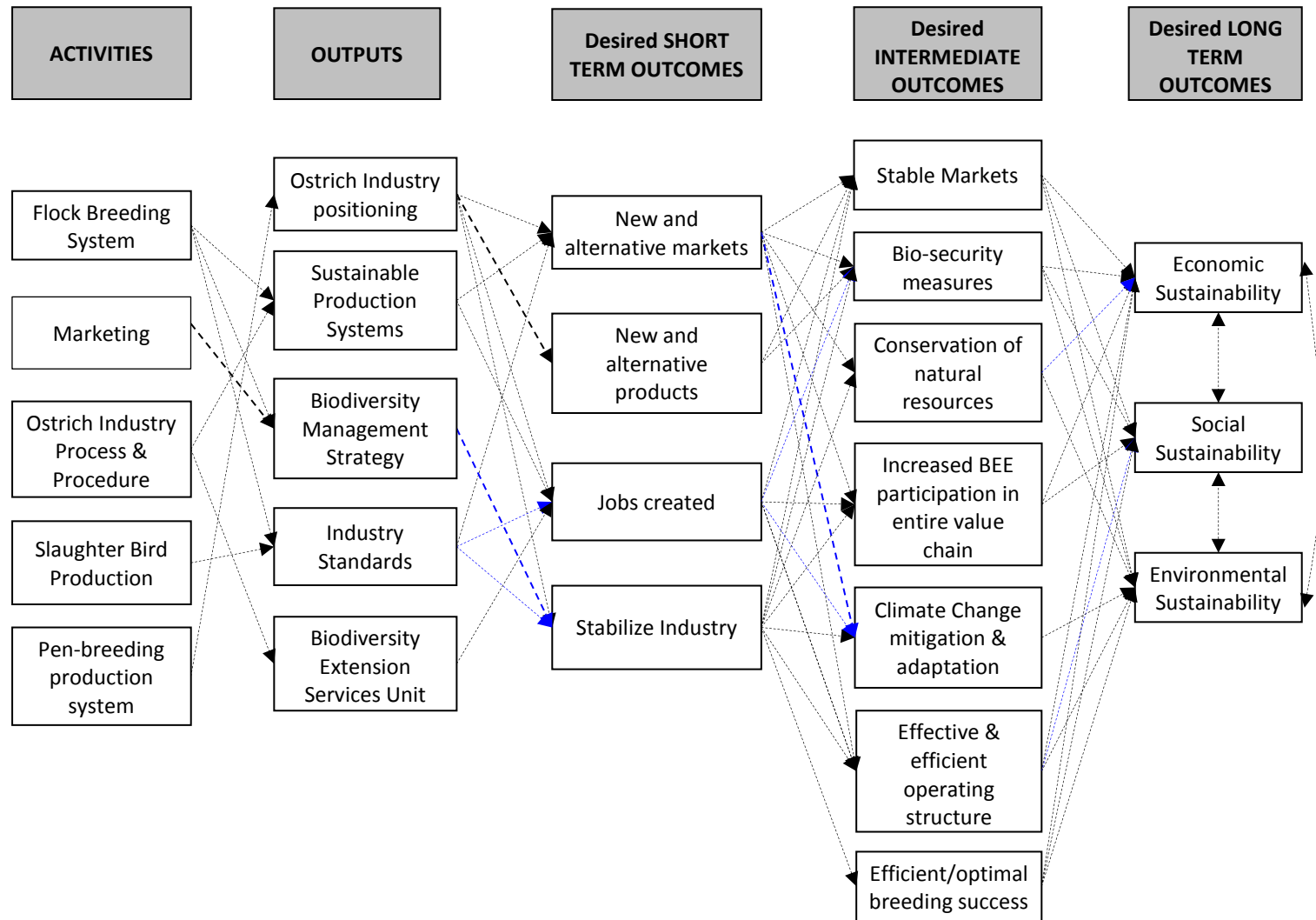


Figure S6 - A simplified logic model depicting the relationships or linkages between elements that should be in place for the Producers, to be able to achieve a sustainable ostrich industry. The blue hatched lines represent indirect links that should be in place, meaning that the links do not have a direct impact on the day to day operations of the ostrich industry.

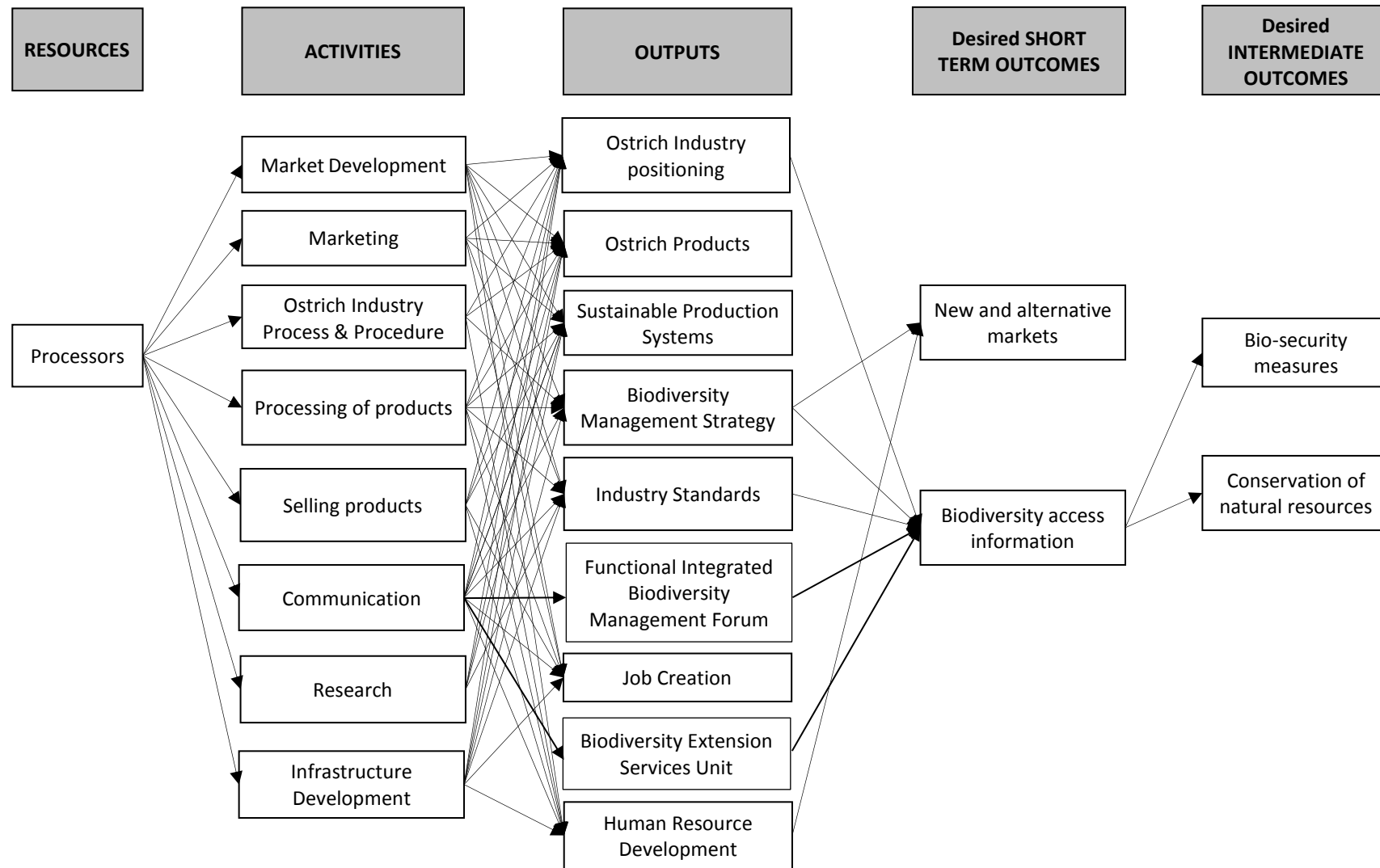


Figure S7 - A simplified logic model, showing how the Processors directly link to the elements of the ostrich industry, reaching as far as two intermediate outcomes.

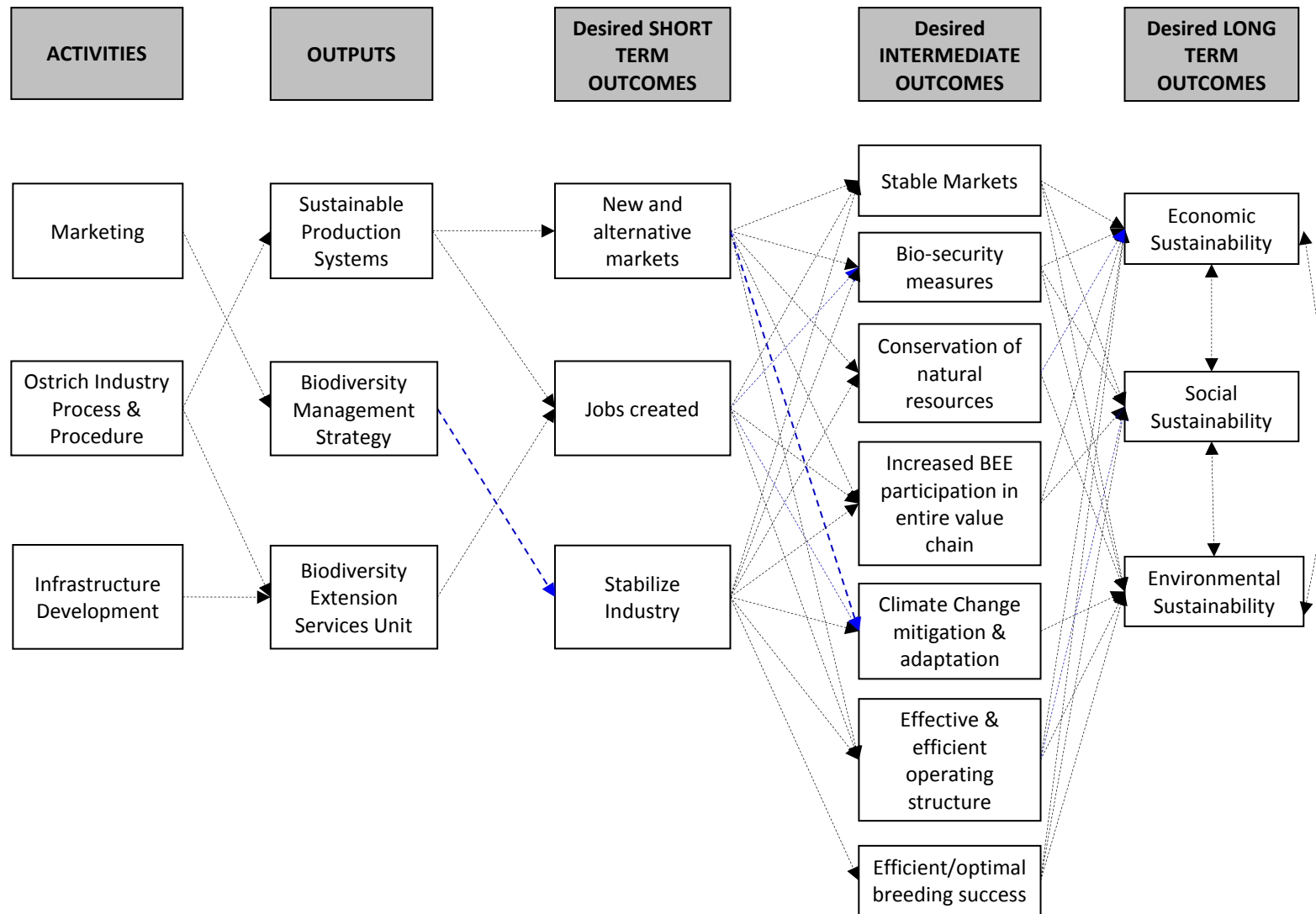


Figure S8 - A simplified logic model depicting the relationships or linkages that should be in place for the industry Processors to achieve a sustainable ostrich industry. The blue hatched lines indicate indirect links which do not affect the day to day operations of the industry, but should be in place.

