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Attaining sustainable use on private game ranching lands in South Africa

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ABSTRACT

Although the financial returns of game ranching in South Africa have been well documented, it is often implicitly assumed that the increased transition of lands to game ranching equates to net conservation gains in terms of habitat management and biodiversity conservation. As a first step towards testing this assumption, we conducted qualitative interviews with 28 game ranchers and 10 other key stakeholders in South Africa to investigate how ranchers manage habitat on their lands, and the degree to which they incorporate ecological advice into their land management activities. The purpose of this analysis was to elicit the range of views on how game ranching contributes to biodiversity conservation, rather than to measure the distribution of ranchers who engage in specific stewardship practices. We found that interviewed game ranchers engage in several stewardship practices that are consistent with sustainable use, namely: control of bush encroachment; removal of invasive, exotic plants; erosion control; the use of fire; and active management of game to maintain habitat quality. However, these land stewardship practices were not uniformly adopted by interviewed ranchers, and were not always based on ecological advice. Although our results cannot be expanded to the larger game ranching community in South Africa, they do suggest that game ranchers would benefit from active extension services that provide guidance on biologically sustainable land management practices, which would reinforce the long-term financial and ecological viability of game ranches.

1. Introduction

Wildlife policy in South Africa, which is in direct contrast to the North American Public Trust Doctrine, is founded on the concept of stewardship through individual ownership and sustainable use. In North America the government manages wildlife in trust (Smith, 2011) – wildlife is centrally owned and controlled. In South Africa, private landowners are given user rights to wildlife on their land by the provincial nature conservation authorities (Taylor et al., 2015; Bond and Cumming, 2006). Private landowners may then manage and earn income from the wildlife on their lands, which is intended to incentivize sustainable management of wildlife outside protected areas without implementing prescriptive, conservationist policies. Specifically, landowners with either exemption permits or certificates of adequate enclosure, whose lands are appropriately fenced, may hunt wildlife throughout the year, engage in game capture, and trade wildlife. Landowners without exemption permits or certificates of adequate enclosure (open farms) may also utilize wildlife on their land for commercial purposes. However, they must obtain individual hunting or capture permits each time they engage in commercial use of wildlife, and they may not hunt throughout the year (Taylor et al., 2015).

South Africa's model of user rights to wildlife has its origins in the 1960s, when Raymond Dasmann and Archie Mossman argued that multiple species game ranching could "be operated safely in ecologically fragile habitats", thereby bringing "marginal land into increased production" (Mossman, 1975: 993). It was recognized that game ranching provided a viable alternative use for private agricultural lands because native game species (which could be harvested for meat) are better adapted to the arid environment and habitats of South Africa (Bigalke, 1966; Castley et al., 2001; Carruthers, 2008; Lindsey et al., 2013). "At the time these ideas were introduced, they were radical, encompassing three major conceptual strands: (1) that the state should devolve proprietorship, including the responsibility for and benefits from managing wild resources, to the landholders … that live with them; (2) that natural resources should be exploited sustainably and as profitably as possible to achieve both conservation and development goals; and (3) that the neo-liberal concepts of markets, property, and exchange should play a greater role in shaping incentives for conserva-

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tion and allocating resources to their highest valued uses" (Child et al., 2013: 5).

Although the predictions that wildlife would replace livestock in terms of meat production were not realized (Carruthers, 2008; Lindsey et al., 2013), wildlife management still provided a comparative advantage over livestock production in terms of diversified income. Landowners were able to unlock multiple use values from wildlife management, including international trophy hunting, domestic meat hunting, game breeding, live animal sales, production of game by-products, and photographic tourism (van der Merwe and Saayman, 2003; van der Merwe et al., 2014; Lindsey et al., 2007a, 2013; Child et al., 2013; Bond and Cumming, 2006; van der Merwe et al., 2004). For those landowners who transitioned from livestock production to game ranching these income streams were apparently sufficient to offset the high levels of capital investment required to engage in game ranching (see also Cloete et al., 2007; Lindsey et al., 2007a,b).

The success of this system in generating a financial incentive to privately own and manage wildlife is evidenced by the dramatic increase in the amount of private land in game ranching (Reilly et al., 2003). Recent estimates suggest that there are between 9000 and 10,000 private commercial game ranches in South Africa that encompass 170,419 km^2 (over 17 million hectares) of land (Taylor et al., 2015), i.e. approximately 14% of South Africa's total land area.[1]

South Africa's property rights system has generated a clear financial incentive to invest in valuable game species. In this regard the system has been an economic success. However, little evidence exists on whether game ranching in South Africa aligns with 'sustainable use', as defined by the Convention on Biological Diversity (CBD), to which South Africa is a signatory (Castley et al., 2001). The White Paper on the Conservation and Sustainable Use of South Africa's Biological Diversity, the main policy document pertaining to the use and conservation of biodiversity in South Africa, is modeled on the CBD (Cousins et al., 2010). According to CBD Article 2, sustainable use encompasses 'the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations'. This definition of sustainable use centers on the management and use of wild species and *ecosystems* within *biologically sustainable limits* (Hutton and Leader-Williams, 2003, emphasis added by the authors). As such, sustainable use presents two challenges: 1) "to ensure that use increasingly becomes biologically sustainable"; and 2) "that wherever possible it serves as a conservation strategy to conserve specific resources and prevent the conversion of land to uses that are incompatible with biodiversity conservation" (Hutton and Leader-Williams, 2003: 223).

In determining whether game ranching is biologically sustainable, researchers have primarily focused on the number of game animals being managed on private lands, whether game species are being over utilized, translocation of wildlife outside their natural range, management of threatened and endangered species, predator management, anti-poaching enforcement, and the impacts of fencing on species movement (Cousins et al., 2008; Lindsey et al., 2007a,b, 2013, 2014; Castley et al., 2001) – i.e. the research has focused primarily on wildlife management. While this is an important component of sustainable use, the management of ecosystems within biologically sustainable limits is equally important. This latter issue has been largely overlooked in the peer-reviewed literature, even though estimates suggest that almost one third of South Africa's potential grazing land has been converted to game ranching (Bothma, 2005). There is some evidence in the grey literature that game ranches have contributed to conservation of vegetation and increased landscape connectivity (Langholz and Kerley, 2006; Lindberg et al., 2003; Goodman et al., 2002). However, oftentimes it is simply asserted that game ranching has generated strong incentives for landowners to invest in the conservation of habitat and ecosystem services on their lands (Bond and Cumming, 2006; Krug, 2001), without supporting data. Research on the ecological impacts of game ranching in terms of land management practices is largely missing. This is an important research gap.

The research presented in this paper builds on previous work by Cousins et al. (2008, 2010) and McGranahan (2008), which used in-depth stakeholder interviews to investigate the conservation role of game ranching. These are the few peer-reviewed studies that we are aware of that explicitly focused on land management by game ranchers in southern Africa (see also Smit, 2004). According to Cousins et al. (2008, 2010), game ranchers may not incorporate conservation ecology or ecological monitoring into their land management practices, owing to lack of knowledge of these concepts, the perception that these practices do not improve income, and/or beliefs that additional ecological management should be financed by the government through tax rebates. We expand upon this research by further investigating the degree to which game ranchers engage in *biologically sustainable* management of their lands. Specifically, we conducted in-depth semi-structured interviews to elicit information on:

- Which land and habitat management practices have been adopted by game ranchers; and
- The degree to which game ranchers incorporate ecological advice into their land management practices.

2. Methods

2.1. Semi-structured interviews

Given the exploratory nature of this research, we used semi-structured interviews to collect data (Creswell, 2003), which allowed us the flexibility to address new material that we did not anticipate, and to obtain more detailed information than would be possible through the use of quantitative research methods. During each interview, we asked a series of predetermined questions in a systematic order, namely:

- How do you manage habitat on your land?
- Approximately what percentage of your operational budget do you reinvest in habitat management?
- What are the key environmental issues that you deal with on your land?
- Do you measure ecosystem health on your property?
- Do you have a written management plan for your land? Who do you get land management advice from?

We also gave participants the freedom to digress and introduce new topics, allowing us to explore concepts beyond our prepared, standardized questions (see Whyte, 1984; Berg, 2001 Berg, 2001).

2.2. Sampling

In total, we interviewed 28 game ranchers (73.7% of interviews) and 10 other key stakeholders during July and August of 2015. Initially, we selected game ranchers to be interviewed from the membership list for Wildlife Ranching South Africa (WRSA),[2] a national wildlife ranching organization comprising game ranchers, professional hunters,

[1] This estimate was largely based on data provided by provincial governments for properties that have exemption permits. Data for open farms are limited. As such, Taylor et al. (2015) provided a minimum estimate of the amount of land that is allocated to game operations in South Africa.

[2] WRSA does not represent all game ranchers in South Africa. As such, we recruited study participants from a subset of the game ranching community. Nonetheless, WRSA is one of the major organizations that represent the game ranching community, and their membership list provided us with access to ranchers who utilized game for multiple different purposes (hunting, breeding, photographic tourism, and game meat production).

Table 1
Sampling of the WRSA membership list.

Province	Number of WRSA Members (Including Game Ranchers)[a]	Number of Ranchers Invited to Participate in Study	Number of Ranchers Interviewed
Limpopo	840	26	12
North West	261	3	1
Gauteng	188	3	1
Free State	180	3	2
Eastern Cape	143	3	0
Northern Cape	126	3	2
Western Cape	119	3	1
Kwa-Zulu Natal	75	3	2
Mpumalanga	68	3	1
Total	2000	50	22

[a] Note: The WRSA membership list includes multiple stakeholders in the game ranching industry. A subset of these individuals are game ranchers.

hunting outfitters, game reserves and commercial farmers. We used stratified random sampling to invite 50 WRSA members to participate in the interviews. For each of the provinces (except Limpopo province) three WRSA members were sent an e-mail inviting them to participate in the study. A total of 26 WRSA members from the Limpopo province were randomly sampled because this province contains 42% of WRSA members (see Table 1). In total, 22 of the individuals contacted agreed to participate in the study (44% response rate).[3]

We also used referral sampling (Berg, 2001) to recruit additional game ranchers to be interviewed. At the end of each interview, we asked if the respondent was willing to provide contact details for other game ranchers who might be interested in participating in an interview. This sampling approach provided us with an additional six interview participants. After conducting 28 interviews with game ranchers we were satisfied that we had achieved data saturation[4] for the research questions of interest.

Additional interviews were conducted with three ecologists who manage private game reserves that border the Kruger National Park (i.e. Associated Private Nature Reserve, APNR, managers), one geneticist who specializes in DNA testing for the game industry, three representatives for industry associations (the South African Hunters and Game Conservation Association, SAHGCA, the Professional Hunters' Association of South Africa, PHASA, and WRSA), and three individuals who specialize in game meat production (two of whom are also government employees). Additional insights and context were provided by informal discussions during visits to four game ranches and attendance at a game auction.

2.3. Qualitative analysis

All formal interviews were recorded. The interviews averaged 55 min in duration, translating into over 31 h of recorded interviews. All recorded interviews were fully transcribed using Dragon NaturallySpeaking software. Detailed notes were written upon completion of the informal, on-site interviews.

We completed content analysis of the transcripts and notes using an objective coding scheme (Berg, 2001). Specifically, we used an inductive approach to interpret and extract concepts and themes from the transcripts (Thomas, 2006). Our content analysis process followed the independent parallel coding procedure recommended by Thomas (2006) for improving the validity of analysis. The first two authors on this paper (Pienaar and Rubino) individually developed their own separate coding systems. These codes were used to develop more refined categories and patterns. Subsequent comparison of categories and patterns exhibited extensive overlap, indicating consistent findings. As such, we were able to develop a merged set of robust themes that emerged from our independent analyses (Thomas, 2006).

3. Game ranching operations

The game ranchers interviewed owned or managed a total of 96,031 ha of land (371 square miles). The mean landholding size was 3,430 ha (13.2 square miles). This exceeded the mean landholding size for game ranchers in South Africa (~1900 ha, Taylor et al., 2015). In general, interviewed ranchers derived multiple sources of income from game management. The largest share, 10 ranchers (35.7%), operated combined hunting and game breeding operations. A further four ranchers (14.3%) catered to both hunting and photographic tourism, while four ranchers (14.3%) engaged in all three activities (hunting, game breeding and photographic tourism). A total of six ranchers (20.7%) ran hunting operations only, while two ranchers (7.1%) ran breeding operations only, and the final two ranchers (7.1%) engaged only in photographic tourism.

The APNR reserve managers were responsible for habitat and game management on privately owned nature reserves bordering the Kruger National Park. These individuals managed properties that form part of the Balule Nature Reserve and Timbavati Game Reserve, which account for a total of 93,392 ha (360.6 square miles) of land. In contrast to standard game ranches, APNR lands are officially protected conservation lands that are governed by Mpumalanga provincial legislation, although they are privately owned, funded, and managed.

4. Interview results

Four major themes emerged during interviews with game ranchers and APNR reserve managers: (1) the control of bush encroachment, invasive plant species and erosion as indicators of good habitat management; (2) game management as an integral component of habitat management; (3) the relative environmental impact of game ranching compared to other agricultural land uses; and (4) the relative importance placed on written management plans and ecological monitoring, depending on ranchers' background and objectives. We explore each of these themes in turn.

4.1. Theme 1: habitat management on private game ranches and reserves

When asked how they manage habitat, the game ranchers (hereafter referred to as 'ranchers') and APNR reserve managers typically spoke about their efforts to control bush encroachment, invasive plant species, and erosion. In total, 16 ranchers (57.1%) described efforts to control bush encroachment. A total of 23 ranchers (82.1%) either engaged in efforts to remove alien invasive plant species from their land (20 ranchers, 71.4%) or stated that their property does not contain these species (3 ranchers, 10.7%). Another two individuals who are involved with the game ranching industry (hereafter referred to as 'stakeholders') also discussed how landowners manage alien invasive plant species, based on their personal observations. Thirteen ranchers (46.4%) and two APNR reserve managers mentioned efforts to control soil erosion when discussing their land management practices. It should

[3] It should be noted that interviews were conducted during the hunting season in South Africa. This presented some issues, since game ranchers who were involved in hunting operations were unable to participate in the study at the agreed date and time because they had clients, or the call could not be connected because of lack of cell phone access (5 failed interviews). The international controversy over Cecil the Lion also occurred during our research, which adversely impacted response rates during the second half of the study because ranchers became concerned that we were misleading them about who we are and the purpose of the study. In each case, we would try to contact an individual three times.

[4] Data saturation occurs when no new qualitative data or information is generated during semi-structured interviews, i.e. this data is reflected in previous interviews (Francis et al., 2010; Guest et al., 2006). Saturation is a measure used to determine the adequacy of sample size in qualitative research (Green and Thorogood, 2004). Although there is debate within the literature about the rigor and appropriateness of saturation for determining sample size in qualitative research (Francis et al., 2010; Guest et al., 2006; O'Reilly and Parker, 2012), we ceased interviews because no new opinions or information about habitat and game management were forthcoming during interviews.

be noted that although we present some information in this manuscript about the number and percentage of respondents who expressed certain opinions, our results should not be interpreted as quantitative results, and should not be used to make inferences for the larger population of game ranchers in South Africa.

4.1.1. Efforts to control bush encroachment

Bush encroachment refers to woody plant (tree and shrub) proliferation at the expense of grasses in savannas and grasslands (Hudak and Wessman, 2001). Respondents (12 ranchers; 2 other respondents) explicitly stated that overgrazing (which was primarily ascribed to excess stocking of cattle in the past, although these individuals also recognized that overgrazing occurs when game stocking rates are too high) has resulted in colonization of these overgrazed areas by indigenous and pioneer plant species, oftentimes the sicklebush (*Dichrostachys cinerea*), as demonstrated by the following exemplar quotes:

> "Cattle do an extreme amount of overgrazing. There is bush encroachment."

> "Overgrazing was an issue in the past, before we started game [ranching]. Back in the 1940s when my great grandfather farmed with cattle, overgrazing did happen. Definitely. And as a result [bush grew] up. There is an overpopulation of the sickle bush. But now that we are farming with game, [we] farm with a lot less animals and they eat less than cattle. Our income is much higher with game than with cattle. Management of the grass is much easier when you have less animals, and they eat less."

> "I have had parts of my property completely overtaken by indigenous trees that completely invade the land at the expense of grasses. And if you look at the old pictures of this area, from 100 years ago, you would see that yes, the trees are there, but there were about 200–400 trees per hectare. Nowadays in the bad parts of my property you will find 4000 trees per hectare."

> "We had to do an ecological assessment. If I look back on that and see how the different types of grazing have changed, it's quite dramatic. I think cattle have a very negative impact on the diversity of grasses. They're very selective grazers. That's changed now [with the switch to game farming]. I've had a lot of different types of grasses come up."

Respondents' perceptions were consistent with ecological research, which has shown that chronic cattle grazing and fire suppression are primary causes of bush encroachment (Lindsey et al., 2013; Chown, 2010; McGranahan, 2008; Smit, 2004). Hudak and Wessman (2001) estimated that grazing and fire suppression doubled bush densities in South Africa over the past century.

In order to control bush encroachment, ranchers and APNR reserve managers used both mechanical and chemical treatments. One respondent stated that combined chopping and herbicide use is highly effective, allowing approximately 60% of bush encroachment to be reversed in a single year. However, respondents stated that ongoing annual treatment is required to effectively control bush encroachment, and at least two respondents had engaged in bush encroachment efforts for over eight years.

Finally, ranchers sought to address bush encroachment by conducting burns, sowing grass seed, and stocking a higher proportion of browsers than grazers on their land to control the bush and allow grasses to recover (see Theme 2). Ranchers considered efforts to control bush encroachment as a sign of good habitat management, in large part because the grazing capacity of rangelands and biodiversity are thereby improved. Bush encroachment is a serious concern for conservation managers because it reduces the grazing capacity of savanna rangelands and results in changes in ecosystem structure – which may result in long-term changes in ecosystem function, carbon storage, and biodiversity (Hudak and Wessman, 2001; O'Connor 2005; Wigley et al., 2009; Chown, 2010; see also Alkemade et al., 2013). Accordingly, appropriate efforts by ranchers to reverse bush encroachment provide a larger conservation benefit.

However, it is possible that ranchers may have engaged in indiscriminate, non-selective bush control measures, which would then undermine savanna stability and resilience, resulting in the re-establishment of new woody seedlings and more severe bush encroachment. The information we collected did not allow us to determine whether ranchers were engaging in best practices for controlling bush encroachment, only that they were aware of the need for controlling bush encroachment.

4.1.2. Invasive plant removal

When asked which alien invasive plants they control, ranchers identified a wide variety of species that are consistent with the prominent invasive alien plant taxa in South Africa, e.g. *Acacia*, *Eucalyptus* and *Lantana* species, prickly pear (*Opuntia* species), cocklebur (*Xanthium* species), guava (*Psidium* species), and the castor-oil plant (*Ricinus communis*). Research suggests that invasive alien plants occupy approximately 1.813 million condensed hectares[5] in South Africa, and invasions have not decreased over time (van Wilgen et al., 2012), which means that ranchers' efforts to control these species are of importance to biodiversity conservation.

Alien plant invasions reduce ecosystem integrity by altering the structure and functioning of ecosystems, with negative consequences for biodiversity and the provision of ecosystem services (van Wilgen et al., 2008, 2012). Natural vegetation in South Africa provides multiple important ecosystem services (e.g., surface water runoff, groundwater recharge), which "are under considerable threat from invasive alien plants" (van Wilgen et al., 2012). The spread of invasive alien plants has resulted in native species loss, increased fire intensity and resultant erosion, increased evaporation rates, reduced stream flow and dilution capacity, and increased nutrient concentrations in groundwater (Chamier et al., 2012).

Although the total economic costs of alien plant invasions are unknown, the costs that have been documented include reductions in water supply (by an estimated 30%) and annual government expenditures of US$ 15–50 million through the Working for Water program to control invasive plants – a total of US$ 388 million spent between 1995 and 2008 (Pimentel et al., 2001; see also Perrings et al., 2010; Pimental 2011; van Wilgen et al., 2012). If the value of reduced biodiversity, ecosystem services and aesthetics were added to the documented costs of invasive plant control, then the total economic cost of alien plant invasions in South Africa would be several times higher than these cost estimates suggest.

Interviewed ranchers were engaging in invasive plant control, either through enrolling in the Working for Water program or by funding these efforts from their own incomes. In common with bush encroachment, ranchers controlled alien invasive plant species through mechanical and chemical treatment. In some cases, landowners also used bacterial control and fire to remove alien invasive plants. As noted by one respondent, it is important during the treatment process to contain plant seeds, thereby making the treatment process additionally intensive. Other respondents stated that they must continually engage in invasive plant management because neighboring landowners do not control invasive plants, seeds are dispersed by birds, and/or invasive plants are reintroduced through waterways.

Although invasive plant control is central to good land and habitat

[5] Condensed hectares were calculated by van Wilgen et al. (2012) by collecting "data on the extent and location of areas invaded by all important invasive alien plant taxa … The species data were captured, together with estimates of their density for each of the mapped areas, in a GIS database… these density estimates [were converted] to 100% equivalent cover ("condensed ha"), using the formula $C = d/100 \times A$, where C is the area expressed as condensed ha, d is the density (% cover), and A is the area in ha within which the density was assessed" (pg. 29).

management, stakeholders noted that many game ranchers may not engage in effective invasive plant control because it is an intensive process that requires considerable labor effort. When asked how much labor is allocated to invasive plant removal, four ranchers estimated that they allocate between three and 10 staff, either permanently (as part of their job duties) or part time (up to two months per year), to invasive plant removal (on properties ranging in size from 1400 to 5200 ha). Other ranchers allocated their staff, as needed, to invasive plant control, but could not provide an estimate of labor effort invested in invasive plant removal. One rancher estimated that he spends ZAR 50,000 per year ($4015 in 2015 USD), which equated to approximately 10 percent of his operating budget, on the control of invasive plant species.

The investment that is required to manage habitat was captured in the following exemplar statements:

> "[The expenses] are mostly in the form of labor in terms of sending people in with chainsaws to clear out invasives."

> "We have a full-time alien invasive species project where we clear out stuff like lantana … all the invasive species from South America. We have a full-time team of people that are just clearing those plants."

4.1.3. Erosion control

Oftentimes, interviewed ranchers attributed erosion to past use of the property for row crops or livestock grazing (and associated issues with overgrazing). Erosion was also attributed to water run-off from mountainous areas, or erosion along waterways. Erosion control efforts ranged from maintenance of infrastructure (in particular, roads and water diversion channels adjacent to roads) to excluding game animals from certain areas of the property for two to three years to allow natural revegetation. Ranchers described a process of placing thorn brush on overgrazed areas to deter animals, placing rocks or trees where water runs off mountains, and using rocks, tires, and building rubble to fill eroded areas. In most cases, ranchers stated they had either controlled erosion or were in the process of reversing issues with erosion. There was some recognition that erosion control efforts must be implemented over the medium- to long-term to be effective. One rancher stated that it would take 50–100 years to fully control erosion on the property, a task that would be passed on to his children and grandchildren when they inherit the land.

On APNR properties, managers stated that off road use of vehicles is permitted but landowners are required to rehabilitate land if there are associated negative impacts such as erosion. The number of vehicles that may be used on properties is also restricted. These properties hire ecologists to devise land rehabilitation plans, and the costs of implementing the plans are then incurred by the landowners.

4.1.4. Use of fire and other stewardship practices

Five additional land management practices were mentioned by ranchers, namely: 1) the use of controlled fire (N = 7, 25%); 2) measures to improve soil quality through the application of manure (N = 2; 7.1%); 3) mowing (N = 2; 7.1%); 4) limited use of chemicals (N = 1, 3.6%); and 5) refusal to allow rubbish to be buried on the farm, i.e. all rubbish is taken into town to the dump (N = 1, 3.6%). Ranchers who incorporated fire into their land stewardship stated that they either engage in controlled burns or allow natural fires on their property. The frequency of fire use ranged from annual burns to one controlled burn every four years.

These individuals considered fire to be an important component of land management that helps to increase grass production, control bush encroachment, and improve grass ecology (see also McGranahan, 2008) – an argument that is consistent with ecological research showing that the interaction between grazing and fire "promotes heterogeneity and provides the foundation for biological diversity and ecosystem function of … African grasslands… For ecosystems across the globe with a long history of fire and grazing, pyric herbivory with any grazing herbivore is likely more effective at restoring evolutionary disturbance patterns than a focus on restoring any large vertebrate while ignoring the interaction with fire and other disturbances" (Fuhlendorf et al., 2009: 588; see also Chown, 2010).

However, not all ranchers incorporated controlled burns as part of their land management. A total of four ranchers (14.3%) took actions to prevent fire because they consider fire to be a threat to the wildlife and vegetation on their land. Only two (out of seven) ranchers who used fire as part of their land management practices had been advised by an ecologist or consultant. As noted by one respondent, in order to appropriately apply fire, landowners should work with ecologists to generate burn schedules. He argued that because contracting an ecologist is expensive many landowners do not engage in controlled burns, or do not understand how to burn properly (see also McGranahan, 2008). This is a cause for concern because fire suppression or inappropriate application of fire by game ranchers may adversely impact biodiversity (Yarnell et al., 2007; Little et al., 2013).

McGranahan (2008) argued that "rangeland patches that are progressively burned … increases species diversity, heterogeneity, and ecosystem function… In the patch-burning scheme, a dynamic mosaic develops around the burn cycle, as grazers focus their attention on the most recently burned patches. This constitutes a natural pattern of veld utilization by wildlife, and the availability of recently-burned veld has been shown to be important to the reproductive success of some game species" (pp. 1973–1974). Our results suggest that game ranchers would benefit from sound ecological advice and outreach that demonstrate how appropriate veld management practices may further improve economic returns, while also improving ecosystem functions and biodiversity. Specifically, game ranchers would benefit from "explicit information on the influence of timing, season and frequency of burns on diversity in landscapes of different productivity" (Chown, 2010: 3732), as epitomized by the following quote:

> "We tried burning once. It's something that we don't know enough about. We're really skeptical about trying things that we're not sure if they work or they don't. And we have a lot of natural fires anyway coming through the farm from time to time. We did try burning areas that weren't usually affected by natural fires but it's very difficult to tell whether it's been beneficial or not. So the burn that we did about two years ago, I'm not really sure if it was beneficial. I think the natural burns work better. They burn cooler because you generally have rain that comes after it and puts them out."

4.1.5. Costs of land management

Although game ranchers may not engage in optimal habitat management, our results suggest that responsible ranchers engage in habitat and land management to the extent of their expertise and financial capabilities. Ranchers stated that they are willing to incur the financial, time and labor costs of habitat management, in order to support wildlife on their lands. Their ability to finance these efforts was ascribed to the higher incomes generated by game ranching, as opposed to cattle ranching (see also Wigley et al., 2009). According to respondents, the level of habitat management game ranchers engage in is directly linked to the income generated by the ranch. Although this means that lower-income ranches cannot engage in rigorous habitat management, respondents argued that "the average rancher is not reckless", i.e. that the average rancher understands that his/her income depends on habitat quality, and will invest in good land management practices, subject to budget constraints and level of ecological knowledge.

When we asked ranchers to indicate what share of their operating budget is allocated to land management practices, estimates provided by 17 ranchers ranged from 2% to 40% of their operating budgets (mean of 15%). One rancher stated that he had spent ZAR 350,000 ($28,103) on habitat management in 2015, which equated to approximately 3% of his total operating budget for the year. Another rancher stated that although the property could be maintained with between 20 and 22 employees, she hires between 30 and 35 people each year to ensure that the property is kept in prime condition. In total, nine ranchers who engaged in active habitat management were unable to estimate what percentage of their budget is allocated to these practices. The remaining two ranchers did not actively manage habitat but rather let the land regenerate by converting the land to wildlife management, ensuring that they did not overstock the property, and allowing recolonization of native plant species.

4.2. Theme 2: game management as part of habitat management

When discussing habitat management practices, we found that the majority of ranchers linked habitat and game management. Thirty-three individuals (86.8% of all respondents), of which 27 were ranchers, raised the issue of controlling overgrazing through appropriate game stocking rates when discussing habitat management.

4.2.1. Determining appropriate stocking rates

Two key issues raised were: (1) the importance of managing land for both grazers and browsers; and (2) stocking the appropriate numbers of these species based on the available habitat and rainfall levels, which is consistent with ecological recommendations (Smit, 2004; see also McGranahan 2008). For example, some ranchers noted that the areas of their property with the lowest rainfall are generally the most palatable,[6] and must be managed to limit overgrazing in dry years. These ranchers kept track of which areas of the property are most heavily utilized by different game species, in order to manage or prevent overgrazing.

In total, nine ranchers (32.1%) hired a manager with an ecological background, received advice from the provincial department of environment or nature conservation, or used ecological assessments to determine the mix of vegetation on their land, and the corresponding mix and quantity of game species that can be supported by this vegetation. For example, one rancher described the ecological assessment that was drafted with the assistance of researchers at the University of Pretoria in the following manner:

> "They look at different grass types, trees, and so on. For your grazers, they look at what types of grass you have – what's edible – and the same with the trees and shrubs for browsers. And for the larger animals like giraffe, they assess the types of high trees. And they give you a full overview of what you have as far as habitat is concerned. Then from that you work it out – I can have so many browsers, so many grazers, and so forth. And then you can decide on the numbers, because you know that the different grazers eat different parts of the grass. You don't want to destroy the habitat. That's very important. This is really one of the most important management tools you need to have."

Although this particular rancher worked with university ecologists to draft his game management plan, various consultants and companies also provide this service for game ranchers who do not have formal ecological training. Two of the ranchers who had invested in a formal ecological survey did, however, point out that this survey provides a baseline that is then adapted according to the knowledge, experience, and management objectives of the landowner. As such, ranchers may not fully comply with ecological recommendations. Ranchers who did not invest in ecological monitoring either used their own knowledge of land management (based on their previous experience as farmers and hunters), advice from other game ranchers, farmers, professional hunters and culling operations, books, wildlife ranching magazines, or trial and error to determine appropriate stocking rates to prevent overgrazing.

Ranchers also stated that they use Meissner tables (Meissner, 1982, 1996) to determine the total game population they can stock on their land. These tables provide guidelines for stocking rates, based on the foraging guild for each species (bulk grazer, concentrate grazer, browser, and mixed grazer/browser), Large Stock Unit (LSU)[7] equivalent measures for different game species, and the corresponding number of hectares required to support each animal (e.g. Boshoff et al., 2001). One rancher stated that he allocates 54 ha per grazing animal to prevent overgrazing, per advice that was provided by government ecologists. Another rancher explained that his property is located in an area in which the LSU is 21 ha. However, he stocks the land below this rate, regarding the Meissner tables as a method to determine the maximum carrying capacity for the property. Two other ranchers argued that they have no issues with overgrazing because they stock their properties at 70–80% of the rate suggested by LSU calculations. These ranchers implemented conservative stocking rates to allow animals to be carried through drought periods without adversely affecting the condition of the game or the property.

Ranchers ascribed their ability to stock properties below carrying capacity to the fact that the economic returns from game ranching exceed livestock production, i.e. ranchers can generate higher incomes with fewer animals. Moreover, ranchers argued that they can generate a higher return on their land because they can stock both grazers and browsers on the same property. As noted by a representative of SAHGCA, proper veld management allows for the implementation of a high production system (better quality veld, fewer animals). This provides a clear financial incentive to stock the property appropriately if the owner plans to manage the land in the medium- to long-run. As opined by one game rancher, if they "were to overgraze the property then it would take up to 15 years for the veld to recover". Although the motivation to stock land conservatively is driven by financial considerations, efforts by responsible game ranchers to prevent overgrazing are consistent with biodiversity conservation and improved ecosystem services provision (e.g. Scott-Shaw and Morris, 2015).

Nonetheless, it should not be inferred that all ranchers stock their properties at the optimal rate, or that they use the appropriate information and metrics to determine stocking rates. One respondent argued that:

> "My belief is that if game is utilized properly, and [ranches are] not overgrazed … we will see improvement of the natural habitat and better utilization of that habitat. We would be [stocking] animals that use the habitat differently; they eat different strata of plant life. But what [ranchers] need is a lot of education. I can tell you that … there's a lot of overgrazing. [Ranchers] think that they can just throw game on the game farm. Nobody is really looking at reproduction rates of these animals, and that's how overgrazing becomes an issue. The whole reason why [records of game populations and habitat quality are] important is because we won't be able to [determine optimal use] until we record it."

4.2.2. Game offtakes

Controlling the number, mix and composition of game populations

[6] In general, areas with sweetveld are more heavily utilized by game. "Sweetveld occurs in areas with low water supply and where parent material gives rise to soils with a high base status" (Ellery et al., 1995: 38), and is characterized by better forage quality.

[7] "An LSU is the equivalent of a steer with a mass of 450kg (992 lb) and a mass gain of 500g (1.1 lb) per day on grass pasture with a mean digestible energy concentration of 55%; to maintain this, 75 megajoules of metabolizable energy per day is required. The concept of the LSU, or AU (Animal Unit), was developed for the livestock industry to determine grazing capacity and has been defined as the area of natural vegetation (ha) required to carry a single LSU for the normal grazeable period without deterioration of the grazing or the soil" (Boshoff et al., 2001:33).

is central to how game ranches are managed to prevent overgrazing – especially during drought periods. As noted by one rancher, properties on which the reproductive rates for different species are not taken into account are characterized by overgrazing even if the property is stocked with the appropriate mix of browsers and grazers. According to the ranchers interviewed, a mix of hunting, culling and live sales are used to manage game populations, depending on the type of income generated by the property, personal preferences, and the relative economic returns to be earned. According to respondents, on a well-managed property, these offtake calculations are based primarily on available resources and vegetation. The monetary value of game species is a secondary consideration, although low-value species such as the common warthog (*Phacochoerus africanus*) and impala (*Aepyceros melampus*) are more likely to be culled or removed in higher numbers (see also McGranahan, 2008).

4.2.3. Grazing management

According to ranchers, some of the other approaches they use to ensure that properties do not become overgrazed include: relocation of game to other areas of the property; rotation of different game species across fenced sections of the property (referred to as camps) because these species graze and browse differently; resting vegetation within camps by removing game; and keeping water troughs dry in areas that are overgrazed. In general, ranchers stated that larger properties are less likely to be overgrazed, especially if these lands are managed as extensive systems with no internal fences. (However, it should be noted that even in well managed extensive systems overgrazing may occur at water points or in areas with more palatable vegetation.) According to ranchers, semi-intensive and intensive systems with breeding camps require careful management to ensure that the camps are not damaged.

4.2.4. Game counts

In order to assess what offtakes are required to maintain game and veld quality, ranchers monitor game populations on their properties. The majority of ranchers interviewed (23 ranchers, 82.1%) stated that they conduct annual (21 ranchers, 75%) or semi-annual (2 ranchers, 7.1%) game counts. Only two ranchers (7.1%) stated that they do not conduct game counts. It should be noted that game counts are not only used to determine what offtake rates are required for extensive properties, but also to determine population trends, which indicate whether a species is being overharvested, which could reduce the financial returns of a hunting operation.

Game counts are typically conducted in the dry season (August and September) when vegetation is less dense. In total, 14 ranchers (50%) stated that they conduct aerial game counts using their own helicopter or by hiring a contractor or veterinarian to conduct the aerial count. The remaining ranchers who conducted game counts stated that they prefer to conduct field counts for two reasons: (1) the vegetation and topography of their land prevents effective aerial counts; and/or (2) aerial counts are too expensive. These ranchers used a variety of methods to count game. For example, the property owner or manager and a team of employees conducted the count using: ground monitoring; monthly or annual counts from vehicles; a 24 h survey of game at a specific location (e.g. a waterhole); and walking the property.

4.3. Theme 3: environmental impacts of game ranching

One of the arguments made by ranchers was that they could not increase game stocking rates without acquiring additional land. This is consistent with the fact that game ranching typically occurs on marginal lands with low rainfall. South Africa is largely arid or semi-arid, and is vulnerable to land degradation from poor stewardship practices, which will be further compounded by climate change (Gbetibouo and Ringler, 2009; Goldblatt, 2010). Owing to climate-soil combinations, the majority of South Africa's land surface (69%) is primarily suitable for grazing (Goldblatt, 2010), and may be used for either livestock or game ranching.

It is within this context that the game ranching industry argues that the transition from livestock to game has generated net ecological benefits. The argument, which was articulated by our respondents, is that game species are adapted to the habitat and climate of South Africa, and hence have less impact on resources (vegetation, soil, water) if ranches are well managed. Moreover, they argued that by transitioning to game ranching, biodiversity on private lands has increased because habitat is provided for non-game species (birds, insects and small predators).

4.3.1. Non-game species as an indicator of improvements in environmental quality

To obtain information from respondents about how biodiversity on their properties has changed since they commenced game ranching, we asked them to discuss any changes that they have observed in non-game species. The responses to these questions were highly informative about how game ranchers view environmental and habitat quality.

Although they do not engage in large-scale management of non-game species, ranchers discussed various efforts to support and promote bird populations on their lands. These included: placing nesting boxes on their properties for the use of owls and the red-billed oxpecker (*Buphagus erythrorhynchus*) (one rancher had placed 100 oxpecker nesting boxes on his 4000 ha property); eliminating dips or using dips that will not harm oxpeckers; reintroducing oxpeckers on the property; working with NGOs to recover the vulnerable southern ground hornbill (*Bucorvus leadbeateri*); monitoring fish-eating bird species on an annual basis; providing additional feed (corn, offal, animal carcasses) for birds; the removal of telephone wires from the property to prevent injury to Verreaux's (black) eagles (*Aquila verreauxii*); the introduction of 14 breeding pairs of the critically endangered white-backed vulture (*Gyps africanus*) on the property; and prohibiting the hunting of game birds (e.g. the helmeted guineafowl, *Numida meleagris*). Although some of these efforts (e.g. feeding of birds) may run counter to best conservation practices, in general game ranchers valued the presence of bird species on their properties. Game ranchers indicated that they have observed an increase in and the re-establishment of bird populations (in particular oxpeckers, birds of prey, and game birds) with the reintroduction of game. They also discussed an increase in dung beetle species and populations on their properties.

One rancher actively manages his land for the vulnerable black-footed cat (*Felis nigripes*), and ensures that the South African springhare (*Pedetes capensis*) is not killed on his property because this is prey for the cat. This rancher said that he was 21 years old before he saw his first black-footed cat, and that this was a profound experience for him. As he explained, "We try to protect because we love nature."

4.3.2. The water footprint of game ranching

When we asked respondents about the environmental impact of game ranching, another key issue raised was the water footprint of game ranching. South Africa is one of the most water scarce countries in southern Africa, and is characterized by extremely variable rainfall (Goldblatt, 2010). This was reflected in the comments of respondents, who addressed the issues of low rainfall and the scarcity of surface water (17 respondents), and how this determines both water management on their properties and the viability of other agricultural production practices.

Only 12 percent of South Africa is suitable for the production of rain-fed crops, and climate change predictions suggest that rainfall will become increasingly infrequent but intense, which will further increase production risk (Goldblatt, 2010; Schlenker and Lobell, 2010; Blignaut et al., 2009). "Rain-fed food production systems will … come under intense pressure due to shifts in weather patterns and changes in rainfall events and hydrological regimes and greater dependency on land and water resources, causing further resources degradation and eroding productivity" (Khan and Hanjra, 2009: 130).

The South African Department of Water Affairs and Forestry (DWAF) showed that in 2000, South Africa used 98.6% of its total reliable surface water supply (of which the largest share, 60%, was allocated to irrigation agriculture), and 12 of the country's 19 water catchments reported water deficits (DWAF, 2004). Within this context, researchers have argued that "game ranching … is a potential sustainable method of protein production that requires lower inputs, has a low carbon footprint and offers greater economic returns than traditional livestock operations" (Cooper and van der Merwe, 2014: 249), while also maintaining biodiversity.

Although the virtual water content[8] of game has not been measured, in South Africa the virtual water content of beef cattle (the key alternative use of game ranching lands) is 16,095 m^3/ton, which exceeds the water content of swine (8799 m^3/ton), sheep (7476 m^3/ton), goats (5440 m^3/ton) and poultry (5035 m^3/ton) (Chapagain and Hoekstra, 2003; but see also Scholtz et al., 2013, who argue that the virtual water content of livestock – especially livestock produced on extensive operations – has been overstated). The game ranching industry argues that the virtual water content of game is lower than livestock (e.g. Dry, 2011). According to respondents, game animals produced within an extensive system require minimal supplemental feeding (typically only during drought periods), which means that the total amount of water required to produce game on extensive operations is lower than that required to produce feedlot-based livestock, which is predominant in South Africa (Blignaut et al., 2009). However, game animals produced in an intensive system likely have a higher virtual water content because they are routinely provided with supplemental feed.

According to respondents who are involved in game meat production, livestock are also more costly in terms of water to slaughter because they are processed in an abattoir where large quantities of water are used to clean carcasses (approximately 900 liters per livestock unit). These individuals argued that far less water is used to process a game carcass in the field, although they had no research reports that could be used to quantify the amount of water used. Based on these arguments, both game production and harvesting are less water intensive than alternative agricultural uses of game ranching lands, although further research is required to test these claims.

4.4. Theme 4: formal management plans and ecological monitoring

Conservation NGOs and provincial government officials have criticized game ranchers for managing their lands for profit at the expense of biodiversity and ecosystem function, not employing staff with ecological training, and not implementing ecological management plans, in favor of using trial and error approaches to management (Cousins et al., 2008). The argument made by these groups is that increased ecological monitoring by game ranchers will result in more informed, improved management decisions (Cousins et al., 2008).

To some degree our findings support these assertions. The majority of ranchers did not have a formal written management plan. Rather, these individuals (18 ranchers, 64.3%) relied on their own prior experience in land management and game ranching (see also Cousins et al., 2008), or the ecological knowledge of their managers, to determine how best to manage the property and game. According to one rancher, there is a distinction between farmers who have transitioned to game ranching, and entrepreneurs who have invested in game ranching:

> "I don't really have a plan in pages. It's all in my head. But you must not compare me with a businessman who has become a game farmer. Remember, I have many years of experience. You cannot compare me with someone with no knowledge of ecology. Those owners should have management plans."

These sentiments were echoed by a rancher who had a Bachelor's degree in game management:

> "I don't write it down, but I know in my mind [what I want to accomplish on the property]. I studied for three years. And I've been on the property since I was born – managing it by myself 100 percent for the past 10 or 15 years. So when you're on a property you know, you have a plan. You know in your mind where you want to go and what you want to do with it."

Ranchers who did have a written management plan stated that this plan was required to obtain government permits. According to interviewees, these management plans included a property description, rainfall records, a description of the game ranching business, information about game species populations, which game are being bred, other non-game species that appear on property, vegetation species on the property, adequacy of the vegetation to support game species, the type of fences the property contains, and medium-term guidelines for the operation (including game, vegetation and fire management). Ranchers either wrote the plan themselves based on guidelines provided by the provincial government (N = 5; 17.9%), or hired ecological consultants to write these plans or to provide them with the ecological assessments needed to write the plans (N = 4; 14.3%) (note: 1 respondent did not state who had written the management plan). Two ranchers who had contracted an ecological consultant to produce a management plan expressed some concern that these plans may be confusing to landowners. Accordingly, they treated the management plan as a guideline, which they then used to develop their own management goals:

> "The first [management plan] was [written] by a consultant, but we eventually started doing it ourselves [because it's more] practical. The consultants always sound very good, a very good management plan. But we couldn't always understand everything, so now we have a more basic and more understandable and applicable [plan that focuses on] day to day things. It explains why and how and when, how frequently, things like that…"

> "You need to do a very good ecological study, and from that you set up a management plan… [The ecological consultants] give you a plan as a guideline. But you must further it, because every person knows best what he is doing and what he wants to do. Then you just must make sure that your plan fits into their overview – that blueprint. Different people will have a different view of what they want to do. Maybe they want to have more browsers or more grazers. It's different from farm to farm, and region to region."

The use of ecologists to write management plans was also adopted by private reserves in the APNR. According to reserve managers, these plans incorporate multiple sections that pertain to: annual game counts and censuses, hunting and culling of game, habitat management, erosion control, annual veld monitoring, alien plant control, and waterhole management. The plans are used to guide the actions of landowners within the reserves, in particular their environmental management actions, in order to attain sustainable utilization and conservation.

In keeping with the above findings, 12 ranchers (42.9%) stated that they do not engage in formal monitoring of ecosystem health on their properties, relying on informal, personal observation to assess changes in ecosystem quality. Monitoring consisted of actions such as taking photographs of the property over time to assess changes in environmental quality, although six ranchers (21.4%) had worked with ecologists (from universities or their provincial environmental departments) to conduct ecological assessments. These formal ecological

[8] "The virtual water content of a commodity is the volume of water used to produce this commodity… the virtual water content (m^3/ton) of live animals is calculated, based on the virtual water content of their feed and the volumes of drinking and service water consumed during their lifetime" (Chapagain and Hoekstra, 2003: 7).

assessments focused on vegetation analysis, monitoring of predators, and game assessments. As stated by one rancher who engages in ecological monitoring:

> "It's very important to me. It's probably one of the most important things. You must remember that I live for my property. Anything that can harm the property I don't do. I am not just a farmer who is here to make money. I know we all have to make money, but the land has been passed down for generations and we take care of the property as best we can. I try all the different techniques to keep it as healthy and stable as I can."

5. Discussion and concluding comments

Loss of natural habitat is the greatest single cause of biodiversity loss in terrestrial ecosystems in South Africa (Driver et al., 2005). The primary causes of species and habitat loss are land conversion to cultivated land, urban sprawl, alien plant invasion, and plantation forestry (Chown, 2010; Scholes and Biggs, 2004). Moreover, protected lands in South Africa constitute only ~6.5% of the country's total land area, and are too small to ensure long-term biodiversity conservation (Cousins et al., 2008; Lindsey et al., 2007a,b). Within this context, sustainable management of species and habitat on game ranches is critical to attaining long-term conservation. Although game ranching tends to disproportionately favor savannah biomes over grassland biomes, management practices that conserve or restore natural habitat are nonetheless important for the conservation of biodiversity and ecosystem services in South Africa (Cousins et al., 2008). "The land making up the 'matrix' between conserved habitats [i.e. private lands] will be crucial in both the future conservation of many species and in the context of broader ecosystem functioning. Changes in habitat structure outside of pristine habitats play a critical role in determining species composition, which is influenced both by losses of indigenous species and gains of species not naturally representative of the original system" (Little et al., 2013).

Although our study is exploratory in nature, our findings suggest that ranchers engage in land stewardship practices that are consistent with sustainable use and biodiversity conservation – to the extent of their budget constraints and ecological knowledge. In particular, ranchers engage in efforts to control bush encroachment, invasive plant species, and overgrazing of their land – all of which support ecosystem services provision, even though that does not explicitly factor into ranchers' decision-making paradigm. Ranchers also value the existence of non-game species, even though these species do not generate direct income. What remains unclear is whether ranchers are applying appropriate fire management practices on their lands, whether ranchers are making optimal decisions on how to stock their land with game (and which animals are culled or removed), how camp size (i.e. the creation of smaller camps to keep high-value species for intensive breeding purposes) impacts habitat integrity, and the water-related impacts of their operations. The fact that many interviewed game ranchers did not engage in ecological monitoring is another potential cause for concern. Ranchers may make sub-optimal habitat and land management decisions, based on inaccurate information from colleagues, or lack of understanding of the trade-offs between short-term profits and long-term costs of reversing or controlling unintended, negative habitat impacts.

Our results suggest that the conservation effectiveness of game ranching could be augmented through the implementation of outreach and extension programs that educate ranchers on improved management practices and practical implementation of these practices. Specifically, ranchers require extension services to assist them in integrating ecological knowledge into their habitat management. For example, ranchers may be engaging in suboptimal control of bush encroachment. According to Smit (2004), rather than removing all woody vegetation, game ranchers should use thinning to reduce the density of woody vegetation and retain or encourage the growth of large trees, and post-thinning management to keep areas open (Smit, 2004). Effective control of bush encroachment may be complex and costly, and ranchers would benefit from understanding the tradeoffs between rapid (and apparently less expensive) control of bush encroachment and long-run (potentially costly) impacts on habitat, ecosystem function, and wildlife production (Smit, 2004; see also McGranahan, 2008). Game ranchers may also benefit from knowledge that bush encroachment may be detrimental to some browsers, which is contrary to common belief (Smit, 2004). Further, although game ranchers are using LSUs to prevent overstocking of their properties, they would likely benefits from better information on how localized impacts of herbivores on vegetation impact vegetation structure and composition, thereby impacting habitat suitability for other species and biodiversity (Gordon et al., 2004). Better understanding of which species, and which sections of a population are adversely impacting habitat, may assist game ranchers by allowing more targeted culling or off-takes, thereby reducing both short- and longer-run costs of game population and habitat management.

Because land management by ranchers is generally not subsidized by the government or conservation groups, extension materials should demonstrate how improved environmental management practices would translate into direct or indirect income generation, or reinforce the stewardship values of ranchers. Ranchers must understand how improved management benefits the long-term financial and ecological viability of their operations. Unfortunately, it is currently uncertain that the government would invest in these extension services, even though they are likely necessary to attain sustainable use on ranchlands. All respondents argued that provincial environmental and agricultural departments are understaffed, under-resourced, and no longer recruit staff with the appropriate training and expertise to advise landowners, which has led to a breakdown in landowner trust in government. Failure to adequately document the conservation impacts of game ranching, which support ecosystem health and thereby improve economic and social welfare, likely reinforces lack of government support for game ranching (Lindsey et al., 2013).

Given the exploratory nature of our research, our findings should be augmented by quantitative research, specifically surveys of South African game ranchers, to determine how ranchers are managing their lands, and what implications this has for biodiversity and ecosystem services provision (see also Taylor et al., 2015; Lindsey et al., 2007a,b). Specifically, these surveys should address what number of ranchers engage in each of the stewardship practices identified in this paper, why ranchers engage in stewardship practices, whether ranchers' stewardship practices are based on sound ecological advice, and how ranchers would prefer to receive information about stewardship activities. Research is also required into what level of income ranchers require to finance different stewardship activities, and whether wildlife-based incomes are sufficient to finance best stewardship practices. Simultaneous on-site ecological and biological studies are required to assess the conservation effectiveness of game ranchers' land management practices, and how these practices may be improved.

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