

Can pastoral communities offer solutions for conserving the Endangered Grevy's zebra *Equus grevyi* at the periphery of its range?

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Abstract Little is known about the Endangered Grevy's zebra *Equus grevyi* in far northern Kenya, where the species exists in small, isolated populations at the periphery of its range. Understanding the threats facing this species is a prerequisite for effective conservation planning but its rarity makes obtaining accurate information challenging. We set out to establish the current status of, and attitudes towards, Grevy's zebra in northern Kenya using local knowledge as the primary source of information. Pastoralists perceived Grevy's zebra to be in decline as a result of drought, lack of pasture and water, and hunting for consumptive use. There was also evidence of competition with livestock. Attitudes towards Grevy's zebra were predominantly positive, influenced by a range of perceived benefits of living alongside the species, and an absence of severe costs. Coupled with evidence of local conservation efforts in several locations, this is a positive starting point for community-based conservation.

Keywords Community-based conservation, Grevy's zebra, hunting, Kenya, livestock, local knowledge, pastoralist

Introduction

Changes in wildlife densities, both increases and losses, can have wide-ranging perturbative consequences for both biodiversity and human communities (Tuytens et al., 2000). This applies particularly to communities living in vulnerable environments with low species richness and abundance and limited resources (Chivian & Bernstein, 2008). The persistence of wildlife in such environments is made more precarious by their already advanced state of adaptation to environmentally extreme, niche habitats, such as in arid lands (Becker & Ginsberg, 1990). As environmental conditions become more variable, species at low

density are susceptible to population crashes, which can have dramatic consequences for wider ecosystem functioning (Soulé et al., 2003).

In semi-arid rangelands globally, pastoralists and their livestock can coexist with wildlife more readily (typically at low stocking levels) than can extractive or intensive land uses such as agrobusinesses (Du Toit & Cumming, 1999; Georgiadis et al., 2003; Niamir-Fuller et al., 2012). The relationship between pastoralists and wildlife, as with other human–wildlife relations, is influenced by the balance of perceived costs and benefits derived from particular species (Murombedzi, 1999; Alexander & McGregor, 2000). Where the perceived costs are high, negative and retaliatory reactions can be extreme; for example, it is common for pastoralists to kill carnivores in response to livestock predation (Woodroffe, 2000; Kissui, 2008).

Conversely, wildlife-derived benefits have the potential to generate support for conservation locally (Infield, 1988; Lewis et al., 1990; Archabald & Naughton-Treves, 2001) by improving livelihoods, offsetting the costs of conservation, and encouraging the protection of wildlife (Gillingham & Lee, 1999; Gadd, 2005). Increasingly, pastoral communities are seeking opportunities to benefit from wildlife.

Grevy's zebra *Equus grevyi*, categorized as Endangered on the IUCN Red List (Moehlman et al., 2013), is an arid-adapted equid that lives alongside pastoral communities across much of its range. For historical population information on the approximately 80% decline and redistribution of the species see Williams (2002). More recent aerial and ground censuses estimated a global population of 1,800–2,800 (KWS, 2012). The species now occurs only in northern Kenya, where 90% of the population persists within five recently designated management zones (Low et al., 2009a; Fig. 1), and in isolated areas of north-eastern and southern Ethiopia (KWS, 2008).

The North zone is the largest of the Grevy's zebra management zones, comprising 60% of remaining Grevy's zebra range by area, but it has been excluded from national surveys because of its size and the low zebra density there (Low et al., 2009a). Subpopulations are believed to be small, fragmented and vulnerable to localized extinction (Woodfine et al., 2009). Grevy's zebras have been recorded in and around Sibiloi National Park (the only protected area within the North management zone) and the eastern Chalbi Desert for decades (Rowen & Ginsberg, 1992; Nelson &

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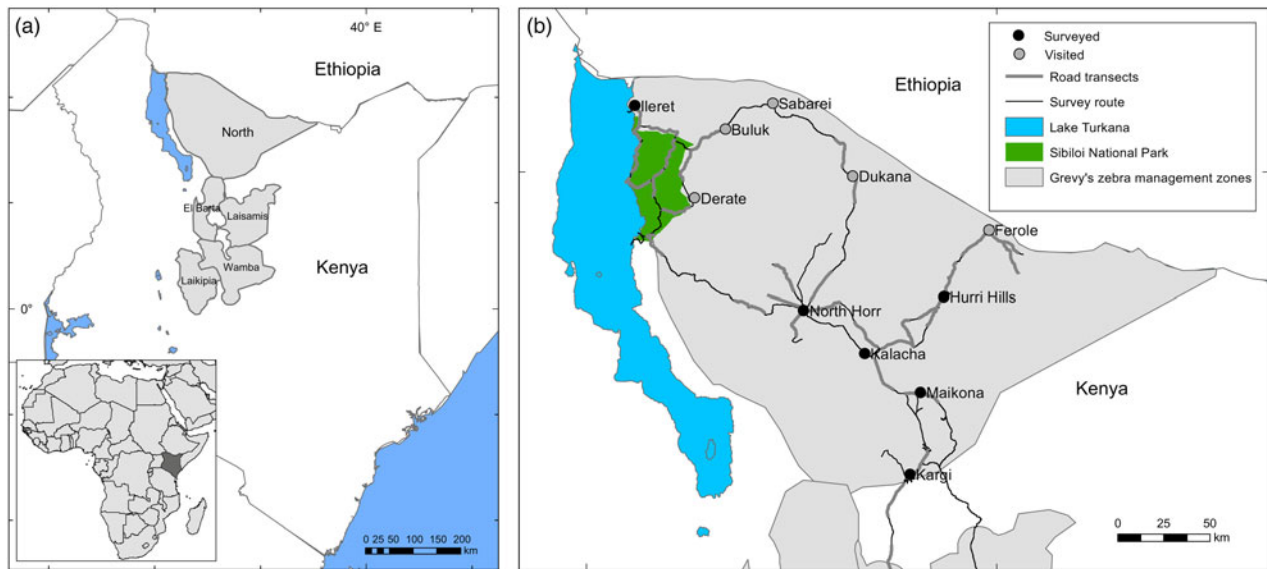


FIG. 1 (a) The Grevy's zebra *Equus grevyi* management zones in northern Kenya. (b) Survey transects and interview locations in Marsabit District, in the North management zone.

Williams, 2003), and as recently as 2005 (Woodfine et al., 2009), but little is known about the species' current status or population trend in this zone.

Despite their small size, the importance of remote subpopulations should not be under-estimated, as they may play a role in metapopulation processes such as dispersal, which occur at the landscape scale (Smith et al., 1993; Balmford et al., 1998). It is possible that a linkage still exists between the Kenyan and Ethiopian Grevy's zebra populations (Woodfine et al., 2009).

The decline of the Grevy's zebra has been primarily attributed to commercial hunting for skins, poaching and competition with domestic livestock for scarce water and grazing resources (Williams, 2002; Williams & Low, 2004). Although there has been no commercial hunting of the species in Kenya since a total wildlife hunting ban was implemented in 1977, several pastoral communities are still believed to hunt the Grevy's zebra for subsistence food and medicines (KWS, 2008). Recent declines in northern Kenya are attributed to disease and drought (Manyibe et al., 2006; Muoria et al., 2007; KWS, 2012).

Reports from the North management zone suggest surviving herds of the Grevy's zebra may live in close proximity to livestock in some areas (Nelson & Williams, 2003; Woodfine et al., 2009). Thus, where the Grevy's zebra exists outside protected areas, tolerance for the species on the part of the pastoralist community will be important to its persistence.

We utilized local pastoral knowledge to assess perceptions of the status of the Grevy's zebra in the North management zone, with the objectives of (1) determining the presence of the Grevy's zebra, (2) identifying perceived

population trends, (3) identifying threats to the species, and, primarily, (4) understanding the attitudes of pastoralists towards the species, and the variables driving these attitudes. We are concerned with the species' potential for persistence in an increasingly anthropogenic environment and hence present our findings using socially contextualized information alongside documented species decline (Williams, 2002). As such, rather than presenting population data we present the views of pastoralists regarding range and population trends. This information will aid understanding of the level of resistance or support for the inclusion of the Grevy's zebra in landscapes occupied by pastoral communities, and facilitate the formulation of strategies for the conservation of outlying subpopulations of the species.

Study area

The North zone covers c. 23,000 km² of north-western Marsabit District, bordering Lake Turkana to the west and the border with Ethiopia to the north (Fig. 1), at an altitude of 360–900 m. The topography is characterized by open plains interspersed with inselbergs and volcanic cones. Marsabit District is one of the driest areas of Kenya, classed as a semi-desert or desert ecoclimate zone. With low agricultural potential, the principal livelihood for 80% of the population is pastoral livestock keeping. The single functional protected area within the study area is Sibiloi National Park, on the eastern shore of Lake Turkana (Fig. 1).

We focused on four pastoralist groups: the Rendille, Dassanech, Borana and Gabbra, each occupying different

but overlapping areas of Marsabit District. Pastoral culture does not vary greatly between these groups (Eangelou, 1984; Layne-Cappock, 1994; Fratkin, 2001; Oba et al., 2001). Generally a hierarchical economic and social significance is ascribed to classes of livestock along a continuum ranging from small stock (goats and sheep), used as an easily liquidated resource when cash or protein are required, and larger stock (cattle and camels), which denote status and wealth. Wildlife hunting practices, however, vary between these cultural groups; for example, the Borana are believed to have taboos regarding which animals they may eat, and strong conservation ethics (Kassam & Megerssa, 1990), whereas the Rendille are reported to hunt the Grevy's zebra illegally for their fat, believing it to have medicinal properties (Williams, 2002).

Methods

The traditional culture of northern Kenya supports a heritage of caste-based social geometry (Klüver, 2003). Generally, tribal culture conforms to a gerontocratic structure with several distinct classes: women and children, who are focused on the homestead; young men transitioning into adulthood through a circumcision or warrior class and living independently; and adult men classed as elders, who are perceived as community decision makers (Spencer, 1965). This structure provides a rich diversity of roles, yielding a cross-section of information from day-to-day encounters with wildlife by people gathering wood and water resources locally, herders moving livestock across grazing areas, warriors travelling greater distances between communities, and elders (both men and women) providing historical context from which spatial and temporal insights may be drawn. Local knowledge is increasingly employed as a reliable means of wildlife research (e.g. Low et al., 2009b) and is well suited to studies constrained by time and logistics, where gathering empirical census and observational data is often impractical.

There are six permanent settlements in the North zone and these were selected as focal sites for the study (Fig. 1). Structured interviews were used to gather information on people's perceptions of the distribution of the Grevy's zebra, the threats to the species, and attitudes towards its conservation.

Interviews were developed and reviewed independently by sociological research experts (see Acknowledgements) before being piloted among pastoral communities in the Laikipia management zone at the southern extreme of the range of the Grevy's zebra (Sundaresan et al., 2012). Interviews complied with the ethical standards of the participating organizations. The interview team was led by an experienced interviewer, who consulted community elders to explain the purpose of the study and sought permission

to undertake interviews. Once permission was granted, elders were asked to select people in their area who had knowledge of wildlife, representing age and gender equally. The survey was undertaken during 1–23 February 2010 and comprised 159 interviews in total across the six locations (mean = $27 \pm$ SD 2 interviews per location). The respondents comprised 64 young adults (40 females, 24 males), 81 elders (34 females, 47 males) and 14 of unknown age class (3 females, 11 males).

The interviewer asked a series of binary questions requiring a 'yes' or 'no' response, as well as questions where the respondent was asked to select an answer from contingent valuation indices ranking a set of issues. Further, open-ended questions elicited discursive responses. Questionnaires were checked for consistency in translation and meaning by team members who spoke the various languages used across the study area. Respondents were asked to provide the following socio-economic information: age, gender, level of formal education (none, primary, secondary, tertiary, other) and cultural grouping. Respondents were also asked if they had any previous experience of conservation activities, including campaigns, meetings, workshops, wildlife tourism or other activities.

Distribution Respondents were asked how often they saw the Grevy's zebra and when they had last seen them (1 day, 1 week, 1 month, 1 year, > 1 year, never). We realize that pastoralists' perceptions of time may vary from our own; nevertheless, this scale provided a relative measure of time (see below). Respondents were also asked how many Grevy's zebra herds they had seen, how large they were, and where they were located. Information on the Grevy's zebra distribution collected during interviews was verified by conducting surveys in parallel to the interviews on 20 km road transects radiating away from each survey settlement, with findings represented as number of observations per km driven. The surveys were conducted from 4 × 4 vehicles travelling at 20–30 km per hour, and observations of livestock, the Grevy's zebra and other large mammalian wildlife were recorded. A total of 660 km of road transect surveys were undertaken to verify responses to the sociological survey. Transects were not repeated and were thus considered to be indicative of wildlife and livestock encounter patterns at the time of survey, and used to verify claims relating to recent sightings, as a means of generally validating the accuracy of responses. At each survey location water sources identified by respondents as being used by wildlife were surveyed in the early morning for evidence of wildlife tracks and signs.

Current status Respondents were asked if they perceived increasing, decreasing or constant trends in the abundance

of the Grevy's zebra within their area during the previous 10 years, and what might be the reason for the observed trend. Threats identified in this way were ranked according to the number of times they were mentioned. Hunting has been considered to be a major factor in the decline of the Grevy's zebra (Williams, 2002; Williams & Low, 2004). In each settlement respondents were asked whether any wild species were hunted, before being asked to name them. If the Grevy's zebra was not mentioned, we asked the direct question 'Is the Grevy's zebra hunted in this area?', being careful to phrase the question in the third person, as hunting is a sensitive issue. Finally, respondents were asked why the Grevy's zebra was hunted. Binary logistic regression was used to investigate variables that influenced hunting patterns, with yes or no responses to the question 'Does hunting of the Grevy's zebra occur in your area?' used as the binary dependent variable. Independent variables included location (study settlement), cultural group and presence of the Grevy's zebra (frequency of sighting).

Costs and benefits of living with the Grevy's zebra

Respondents were asked if they experienced any benefits or costs from living alongside the Grevy's zebra, and the total number of costs and benefits cited by each respondent was recorded. All costs and benefits identified were ranked according to the number of times they were mentioned.

Attitudes towards the Grevy's zebra Two fixed-response questions were asked at different times to determine respondents' attitudes towards the Grevy's zebra. Firstly, we asked whether having the Grevy's zebra in their area was good or bad. Secondly, we asked how important it was to have the Grevy's zebra within the area, as an internal check for the earlier response. Respondents selected one of five responses to each question, which translated to the following attitude scores: 1 = very positive, 2 = positive, 3 = neutral/not sure, 4 = negative, and 5 = very negative. Both answers were combined to form a single additive score whose internal consistency was tested using Cronbach's alpha (Cronbach, 1951), which returns a value of 0–1, with higher values indicating greater consistency. Multiple linear regression was used to investigate various factors influencing people's attitudes towards the Grevy's zebra (Mascie-Taylor, 1994), including perceived costs and benefits associated with the zebra, the location of respondents, their direct experience of the Grevy's zebra, their contact with conservation activities, and socio-economic variables of gender, age, education level and cultural group. A power analysis was undertaken post hoc using *G*Power 3.1.9.2* (Faul et al., 2009) to ensure the statistical robustness of the test.

TABLE 1 Perceptions of pastoral communities of the distribution of the Grevy's zebra *Equus grevyi* in northern Kenya (Fig. 1) compared to field observations of the species, with the percentage of respondents who reported seeing the Grevy's zebra locally, the timing of the observations, and the number of Grevy's zebras recorded during field surveys.

Location	% of respondents who reported seeing the species locally	Timing of observation	No. recorded during field survey
Ileret	95	< 1 week previously	16 sighted; 2 spoor
Kargi	96	< 1 week previously	6 sighted; 14 spoor
Maikona	72	1 week previously	2 spoor
Kalacha	97	> 1 year previously	
North Horr	40	> 1 year previously	
Hurri Hills	8	> 5 years previously	

Results

Males and females were equally represented (52% and 48%, respectively) among interview respondents. The greatest number of respondents were in the 20–30 age category (27%), with the least number in the < 20 group (7%). The majority of respondents (80%) had no formal education. Those interviewed were Gabbra (58%; 42 males, 51 females), Rendille (17%; 18 males, 11 females), Dassanech (13%; 13 males, 8 females) and Borana (6%; 8 males, 5 females), with other groups (6%; 2 males, 1 female) comprising the remainder. Contact with a conservation activity was rare. Most respondents (56%) had no contact; 14% had attended meetings, workshops, campaigns or other fora.

Distribution Encounters with the Grevy's zebra were most frequent around the settlements of Ileret, Kalacha, Kargi and Maikona (Fig. 1), where > 70% of respondents claimed they had seen the Grevy's zebra. In North Horr and Hurri Hills, 40 and 8% of respondents, respectively, claimed to have seen the Grevy's zebra (Table 1). Respondents in Ileret, Kargi and Maikona had seen the Grevy's zebra within the previous week (recent past), whereas in Kalacha and North Horr it had not been seen for 1 year (representing a noticeable absence), and in Hurri Hills it had not been seen for 5 years (representing a significant period of time; Table 1). These results correspond with direct and indirect observations of the Grevy's zebra during the survey (Table 1). Spoor of two individuals were found in Derate, 55 km south-east of Ileret, and 16 individuals were sighted by staff of the Kenya Wildlife Service at Alia Bay, within Sibiloi National

TABLE 2 Results of binary logistic regression investigating variables affecting hunting of the Grevy's zebra (variable(s) entered on step 1: Location; variables excluded: Cultural group, Presence of Grevy's zebra).

	B	SE	Wald	df	Sig.	Exp(B)
Location			20.32	5	0.001	
Location(1)	-20.153	12118.697	0.000	1	0.999	0.000
Location(2)	-20.327	12118.697	0.000	1	0.999	0.000
Location(3)	-20.915	12118.697	0.000	1	0.999	0.000
Location(4)	-17.907	12118.697	0.000	1	0.999	0.000
Location(5)	-22.525	12118.697	0.000	1	0.999	0.000
Constant	21.203	12118.697	0.000	1	0.999	1.62

Park, c. 30 km south of Ileret (Fig. 1). At Kargi six individuals were observed at natural springs, and spoor of a further 14 were observed at man-made dams. At Maikona spoor and dung of two individuals were observed at a water point to the east of the town (Fig. 1). No Grevy's zebras or their signs were observed at Kalacha, North Horr or Hurri Hills. Local knowledge indicated that the Grevy's zebra moves between Sibilo National Park and Chew Bahir in Ethiopia via Buluk (Fig. 1), which was evidenced by a post-survey aerial sighting of a herd of 28 individuals on the Ethiopian border south of Chew Bahir in March 2010 (J. Roberts, pers. comm.).

Current status Across the study area 91 respondents (57%) believed the Grevy's zebra had declined, whereas 45 (28%) believed numbers had increased. Two respondents (1%) believed the numbers had stayed the same, and 22 (14%) did not know. Declines were most widely recognized in Kalacha (93%), Maikona (84%) and Ileret (58%). Among those who believed the Grevy's zebra had declined, the following reasons were given: drought (n = 61; 67%), lack of pasture (n = 39; 43%), illegal hunting (n = 29; 32%), lack of water (n = 24; 26%), disease (n = 17; 19%), human interference (n = 20; 22%), predators (n = 12; 12%), and overstocking of livestock (n = 2; 2%). Drought was most frequently cited as an agent of decline in Kalacha and Maikona. Lack of pasture in Kalacha and lack of water in Kalacha and Hurri Hills were also believed to have driven decline. Illegal hunting was cited as a cause of decline in all six study settlements over the previous 10 years. Thirty-eight respondents (24%) stated that the Grevy's zebra was hunted locally, whereas 109 (69%) claimed there was no hunting. Two people (1%) were not sure, and 10 others (6%) made no comment. Comparing survey settlements, hunting was indicated in Maikona (n = 15; 58%), a settlement of predominantly Gabbra people, and Ileret (n = 10; 42%), predominantly Dassanech. At the remaining sites < 25% of respondents believed the Grevy's zebra was hunted, falling to 3% in Kalacha, and zero in the Hurri Hills. Location was a significant factor in explaining reported patterns of

hunting (Wald = 20.32, $P < 0.01$); cultural group and presence of zebra were not (Table 2). The primary reason cited for hunting the Grevy's zebra was the medical properties of its fats (n = 27; 23%), which are used to treat a range of ailments, including tuberculosis, sexually transmitted diseases, stomach problems and malaria. Meat for consumption (n = 21; 18%) or sale (n = 11; 9%), and the use of skins in ceremonies, bedding, and for carrying goods (n = 10; 8%) were also cited as reasons for hunting. A number of respondents stated they did not hunt (n = 16; 13%), were unsure (n = 27; 23%) or were unwilling to discuss the issue (n = 4; 3%). Two people (2%) stated that overstocking of livestock contributed to the decline of the Grevy's zebra. Livestock accounted for 94.5% of all observations on road transects, with wildlife accounting for only 5%, and the Grevy's zebra 0.1%. Observations of livestock were highest for North Horr (118.5 per km), followed by Hurri Hills (85.4), with other areas having < 55 livestock per km. The distribution of the Grevy's zebra and other wildlife along road transects displayed a strong negative correlation with livestock (Spearman's $\rho = -0.62$, $P < 0.001$). Fifty-three percent of respondents believed the Grevy's zebra drank at night in their area; a further 16% believed they drank in the morning or evening, and 14% believed they drank during the day.

Costs and benefits of living with the Grevy's zebra

According to 43% (n = 68) of respondents there were no costs associated with living with the Grevy's zebra, whereas 57% (n = 91) believed there were costs, citing the depletion of grass and water supplies (n = 58; 36% and n = 18; 11%, respectively), pollution of water sources with dung (n = 18; 11%), damage to feet by toxic urine (n = 9; 6%), desertification (n = 8; 5%), destruction of fences (n = 6; 4%), and incarceration as punishment for poaching (n = 2; 1%). Twelve people (8%) believed there were costs but did not specify what they were. According to 113 respondents (71%) there were benefits from the Grevy's zebra, whereas 47 (29%) perceived none. Benefits included tourism (n = 40; 25%), aesthetic beauty (n = 27; 17%), income from commercial activity (n = 26; 16%), medicinal

TABLE 3 Summary of multiple linear regression investigating variables affecting pastoralists' attitudes towards Grevy's zebra.

Model	Predictors	R ²	Change	Significance
1	No. benefits	0.26	0.26	0.000
2	No. benefits + no. costs	0.28	0.02	0.046
3	No. benefits + location + no. costs	0.34	0.06	0.001

products (n = 22; 14%), meat (n = 13; 8%) and employment opportunities (n = 12; 8%). Other perceived benefits included alerting people to danger from predators and people (n = 9; 6%), indicating locations of water and pasture in times of drought (n = 6; 4%), a source of leather (n = 6; 4%), being generally good for development (n = 4; 3%) and producing dung useful for lighting fires (n = 1; 1%). Ten people (6%) indicated that the Grevy's zebra provided benefits, but did not specify what they were.

Attitudes towards the Grevy's zebra There was close agreement in the answers to fixed-response questions relating to attitude, with Cronbach's alpha (0.71) exceeding accepted scores (e.g. 0.61 in Walpole & Goodwin, 2001). The additive attitude score was adopted as the measure of attitude towards the Grevy's zebra. Attitudes towards the species were predominantly positive: 65% of respondents held positive views, 39% being very positive (35 males, 27 females) and 26% positive (20 males, 22 females); 18% held neutral views (17 males, 11 females); 13% (8 males, 13 females) and 2% (2 males, 1 female) held negative and very negative views, respectively. There was no discernible effect of gender on attitude.

Three of the eight factors tested were significant in predicting the attitudes of 159 respondents towards the Grevy's zebra. These factors in combination explained one-third of the variation in attitude scores ($r^2 = 0.331$, $df = 158$, $P < 0.001$). The residuals were normally distributed and did not display any relationship with the predicted variables. Power analysis returned a T-value of 1.65 and power of 1.00, indicating a statistically robust test with a reliably low probability of statistical error (Cohen, 1988). The number of perceived benefits was the strongest predictor of attitudes towards the Grevy's zebra ($R^2 = 0.26$). Location exerted a weak positive influence on attitude ($R^2 = 0.06$). The number of costs exerted a weak negative influence on attitude ($R^2 = -0.02$). Neither an individual's experience of the Grevy's zebra nor their contact with conservation activities was significantly influential on attitudes towards the Grevy's zebra, nor were any socio-economic variables (Table 3).

Discussion

We sought to determine the attitudes of local communities towards the Grevy's zebra, and their perceptions of the status

of the species at the periphery of its range in northern Kenya. Through a combination of direct field observations and assessing local knowledge we confirmed the distribution of the Grevy's zebra in three locations and documented a perceived decline in numbers, in concurrence with published assessments for the species across the North management zone. This decline was linked to several key threats. We identified largely positive attitudes towards the Grevy's zebra in response to a number of perceived benefits and an absence of severe threats to livelihood. These results provide important information for the development of strategies to conserve the remaining northern subpopulation.

Distribution and status

The Grevy's zebra persists in and around Sibiloi National Park close to Ileret, and around the settlements of Kargi and Maikona in the eastern Chalbi desert. Local knowledge and recent sightings indicate that Grevy's zebra may still move between Sibiloi (Kenya) and Chew Bahir (Ethiopia) through areas surrounding the border outpost of Buluk, and this finding requires further research.

The Grevy's zebra was most abundant around Kalacha, Maikona and Ileret but was perceived to be in decline in all survey locations. The decline was attributed to a combination of anthropogenic and environmental threats. Weather patterns in northern Kenya have become increasingly unpredictable (DFID, 2009; MET, 2012), and a temporally localized drought during 2008–2009 led to a lack of pasture and low availability of water. Drought was considered to be an especially strong agent of decline for the Grevy's zebra in both Kalacha and Maikona, where mean annual rainfall is only c. 200 mm.

Poor availability of water was identified as the greatest threat and was perceived to affect both livestock and wildlife. Excluding Lake Turkana, water sources were described as being limited to widely dispersed and infrequent permanent springs, boreholes and occasional surface water pools across the North zone. This threat was perceived to be most prevalent in Kalacha and the Hurri Hills, with the latter having no wildlife-accessible surface water in the dry season.

Poor availability of pasture, the second highest threat, was mentioned in all study settlements but most prominently at Kalacha, where pasture is limited by low and unpredictable rainfall (Government of Kenya, 2008). Fears expressed

about limited pasture may reflect concerns that the arid lands of northern Kenya are deteriorating (Lusigi et al., 1986), with livestock overgrazing leading to degradation of the grazing resource (Parker & King, 2008). Perceptions of poor availability of pasture may also point to ecological competition between wildlife and livestock for limited grazing resources (Gadd, 2005). Competition with livestock was identified as a cost of living with the Grevy's zebra; however, defining the magnitude and nature of competition between wildlife and livestock is difficult (Prins, 2000; Young et al., 2005). Furthermore, these effects may potentially be mitigated by synergies between grazers and livestock, as has been suggested in Laikipia (Kinnaird & O'Brien, 2012).

Few respondents considered overstocking of livestock to be a problem for the Grevy's zebra, which reflects the importance of livestock to people's livelihoods. However, direct observations made during this survey suggest that livestock may displace wildlife. More than half of the respondents believed the Grevy's zebra drank at night. This pattern has been observed previously where livestock dominated water sources during the day, displacing the Grevy's zebra (Williams, 2002; Woodfine et al., 2009).

Spatial separation of wildlife and livestock has been observed around water sources in northern Kenya, with livestock concentrated in areas close to permanent water, and wildlife further away (de Leeuw et al., 2001). Results from road transects suggest this separation may occur more widely across the landscape, with the implication that livestock may displace grazing wildlife from grassland resources. However, the extent to which the Grevy's zebra may be displaced from pasture must be established by further research, as reports from other areas suggest that they can coexist (GZT, 2015). Such displacement, viewed in the context of ongoing rangeland degradation, could represent a significant reduction in the temporal and spatial availability of grazing and water resources to the Grevy's zebra (Williams & Low, 2004).

A number of respondents identified disease as an agent of population decline. This is consistent with previous research (Manyibe et al., 2006; Muoria et al., 2007). Research is also underway to establish the degree to which livestock-borne diseases affect the Grevy's zebra (KWS, 2008; Hawkins et al., 2015).

Illegal hunting of the Grevy's zebra appears to be widespread, being mentioned in every settlement and by nearly one-quarter of all respondents despite being a controversial topic. Hunting was considered to be most prevalent in Ileret, in agreement with previous findings, where uncontrolled illegal hunting was noted around Sibiloi National Park close to Ileret (Woodfine et al., 2009), and at Maikona, which was not surveyed previously.

The perception that hunting was prevalent was significantly influenced by location. However, there was little evidence for the previously suspected cultural influence on hunting

patterns, possibly because of the uneven sampling of cultural groups, which was difficult to control for in the field.

One-quarter of all respondents believed hunting was carried out to provide fats for medicinal purposes. This perception was strongest in Maikona, Kargi, North Horr and Ileret, indicating that it spanned the Gabbra, Rendille and Dassanech cultural groups. Hunting of the Grevy's zebra for meat was widely acknowledged at Ileret and North Horr, primarily for subsistence use but also for sale, indicating the existence of a local market for bushmeat. However, in North Horr no Grevy's zebras had been seen for more than 1 year and few people believed that hunting occurred locally, suggesting that any zebra products were sourced from other areas.

Attitudes towards the Grevy's zebra

Pastoral attitudes towards the Grevy's zebra were predominantly positive. Where a greater number of benefits were perceived, attitudes were also more positive. Direct and potentially hazardous interactions can engender negative attitudes towards species (e.g. elephants *Loxodonta africana*, Naughton-Treves, 1997; lions *Panthera leo*, Woodroffe, 2000); however, respondents appeared not to face such interactions with the Grevy's zebra. Many respondents perceived few or no costs associated with living alongside the species. The most serious livelihood costs were considered to be competition with wildlife for grazing and water resources.

Tourism, meat, medicine and money were among the most recognized benefits across the study area. Such tangible benefits have also been determined to be prominent in other studies (Gillingham & Lee, 1999; Murphree, 2001). Respondents recognized the potential for the Grevy's zebra to attract tourism revenue, although there is currently minimal passing trade in tourists through the North zone. Consumptive uses of the Grevy's zebra, although prominent, were not the most commonly recognized benefits.

Additional benefits included zebra behaviour alerting herders to the presence of predators, and indicating the location of good grazing and water in times of drought. Such benefits are reflective of the close proximity in which pastoral herders and the Grevy's zebra can exist within the landscape.

The beauty of the Grevy's zebra was the second most cited benefit, although in previous studies acknowledgement of the intrinsic value of wildlife has been secondary to the direct goods and services it provides (Emerton, 2001). This sentiment may indicate that the Grevy's zebra has a cultural or spiritual significance, which could be an important motivation for conserving the species, and requires further attention.

Further evidence of the cultural value of wildlife was found in the border settlement of Ferole (Fig. 1), where traditional beliefs had led to the creation of a wildlife sanctuary around a sacred hill, where strict rules about resource use and hunting were in force. Although there was no evidence of the Grevy's zebra at this location, various other wildlife species were observed, indicating that cultural values can provide a powerful incentive for wildlife conservation. Such traditional values have been under-utilized in conservation in developing countries to date (Infield, 2001) and could play a key role in the conservation of wildlife in northern Kenya, as they have further south in the core of the Grevy's zebra's range (GZT, 2015).

The global population of the Grevy's zebra is estimated to be < 3,000 (KWS, 2012) and the species remains threatened with extinction. In the North zone small, fragmented populations are vulnerable to extirpation, and the loss of the species from this area could affect the wider population through loss of landscape-level functions such as dispersal and gene flow. Pastoral communities appear to recognize many benefits of having this and other species present in the environment, and the loss of the Grevy's zebra could result in a tangible reduction in human well-being and cultural wealth.

To persist, the Grevy's zebra and other wild species require continued access to shared resources such as water and pasture through planned development (Letoiye, 2014). Efforts must be focused on understanding the interaction between livestock and wildlife and the scale of ecological competition between them, to mitigate or dispel these perceived threats. In the meantime, innovative rangeland management approaches that have been implemented successfully elsewhere in Africa, including controlled grazing areas identified and managed by communities (Roba & Oba, 2008), should be evaluated for their capacity to improve grazing quality and access for livestock and wildlife.

Practical action, including awareness campaigns, should target locations where hunting and consumptive use of the Grevy's zebra and other wildlife is indicated. Alternatives to consumptive uses should be explored, including improvement of access to conventional medicines, improvement of livelihoods through sound livestock husbandry practices, and access to veterinary services and cattle markets. These factors, in combination with careful development planning, would constitute a conservation strategy inclusive of human development needs. We believe this is achievable, given the pastoral community's positive attitudes towards wildlife in general and the Grevy's zebra in particular.

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