Biological Conservation 142 (2009) 1548–1555

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Short communication

Partnering with local communities to identify conservation priorities for endangered Grevy's zebra

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ARTICLE INFO

Article history:
Received 18 September 2008
Received in revised form 24 January 2009
Accepted 1 February 2009
Available online 5 March 2009

Keywords:
Pastoralism
Capacity building
Savannah ecosystems
Community monitoring
Grevy's zebra
Citizen science
Kenya
Samburu

ABSTRACT

Setting wildlife conservation priorities and determining how to meet them is challenging, particularly when policy decisions made at large scales need to be informed by a diversity of local conditions. The persistence of species that range widely demands that they coexist with people both within and outside formally protected areas. It is often politically and financially infeasible for one central body, such as a government wildlife agency, to monitor an entire population. Therefore, conservation planners are increasingly turning to local knowledge to inform conservation decisions. Here, we show the scientific and conservation benefits of recruiting and training local community members to collect data on an endangered species, the Grevy's zebra (*Equus grevyi*). We recruited 18 scouts from six community-held ranches in Samburu District, Kenya. The scouts record the location, group structure and habitat of all Grevy's zebra herds seen in walking surveys. Kernel analyses of scout herd observations indicate areas heavily used by Grevy's zebra, and the subset of these areas favored by females with young foals. The important areas identified by the scouts closely match those inferred from analyses of GPS radiocollar data. Further, scout data reveals extensive spatial and temporal overlap between livestock and Grevy's zebra. This overlap suggests the potential for competition between Grevy's zebra and domestic animals. We argue that scout programs such as ours can generate valuable insights for conservation planning. In addition, such programs have the potential to improve local attitudes toward wildlife conservation.

1. Introduction

Wildlife conservation requires identifying areas and issues most in need of attention and the opportunities available for managing them. Setting priorities and determining how to meet them is challenging, particularly when policy decisions made at large scales need to be informed by variable and fluctuating local conditions. The status of an endangered population, and the threats it faces, may vary greatly over its range. This is especially true for species that range widely, across boundaries of diverse ecological regimes. The persistence of such species demands that they coexist with people outside formally protected areas. It is often politically and financially infeasible for one central body, such as a government wildlife agency, to monitor an entire population. Are there key locations or habitats critical to the species? What specific human activities have the biggest positive or negative impact? Outside of protected areas, answering these questions and achieving conservation objectives depends on local knowledge and support. Here we show how we can gather and interpret data obtained from local communities to address conservation questions for Grevy's zebra (*Equus grevyi*) in Northern Kenya.

Grevy's zebra are a large, grazing equid adapted to arid savannahs in the Horn of Africa (Bauer et al. 1994; Ginsberg, 1988). The species has declined from 15,000 in the 1970s to under 3000 today, making them one of Africa's most endangered mammals (Moehlman, 2002; Williams, 2002). Their last stronghold is the savannahs of Kenya's Laikipia–Samburu ecosystem. Here, Grevy's zebra are a flagship species. Spreading over 40,000 square kilometers, this region is a mosaic of conservancies, commercial livestock ranches and community rangelands. Most Grevy's zebra are found on the community rangelands, properties occupied and managed by traditional pastoralists. Common domestic animals include sheep, goats, camels, donkeys and cattle.

One critical concern for Grevy's zebra is identifying locations that are most important to their survival and reproduction (KWS, 2008). A second question is how Grevy's zebra are impacted by

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0006-3207/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.biocon.2009.02.003

competition with people and their livestock. In a section of Samburu District, we have recruited Grevy's zebra "scouts". These community members collect data on Grevy's zebra habitat use and interactions with people. We initiated the scout program motivated by three factors. First, by engaging community members we hoped to encourage local support for Grevy's zebra conservation. Second, it is challenging to monitor Grevy's zebra with traditional survey methods alone, in a vast area with little infrastructure. Finally, we wanted to build local capacity so that future monitoring efforts can be led by community members.

In this paper, we present initial results from the Grevy's zebra community-based monitoring program. We test whether this information matches that achievable with a more expensive study of a subset of the zebra population, on whom GPS radiocollars were deployed. GPS collar data were gathered without direct community involvement. We show that scout data can inform conservation planning, by identifying areas of intensive Grevy's zebra use and critical breeding areas. We argue that engaging communities in formally monitoring an endangered species increases support for conservation action.

2. Methods

2.1. Study area

Our data come from the Samburu district of Kenya (longitude 37.07°E and latitude 1.25°N) (Thouless, 1995). This includes group ranches associated with the following community conservancies: West Gate Conservancy, Kalama Conservancy, Sessia and Ngaroni (Meibae Conservancy), Ngilai West (Namunyak Conservancy) and Serolevi (Sera Conservancy). Conservancies include one or more community-owned group ranches that agree to manage their land collectively for both livestock husbandry and wildlife conservation.

The main economic activity in the area is livestock husbandry. Human and livestock densities have risen in recent years. Over the last decade, wildlife conservation efforts have also grown, with over 12 pastoralist communities formally establishing conservancies on their land. These communities have diversified their economic base to include wildlife tourism.

The region is a typical arid savannah. The dominant tree species are of the genus Acacia. Ground cover is mixed forbs and grasses including *Indigofera* spp. and *Cynodon* spp. Average annual rainfall is 375 mm, with occasional droughts. Each group ranch has 4000–6000 inhabitants.

2.2. Scout data collection

During training, scouts learn about the biology of Grevy's zebra, and how to gather basic data on habitat characteristics, and the composition and activities of Grevy's zebra herds observed using the picture-based data sheet developed for the program. When scouts observe Grevy's zebra, they record whether livestock are present within 100 m of the zebra group. We choose 100 m as this represents the maximum distance at which we consider two individuals to be part of the same herd (Fischhoff et al., submitted for publication; Rubenstein and Hack, 2004). Scouts also record whether Grevy's zebra are within 100 m of open water. Zebras within 100 m of a water source are likely to drink there (Sundaresan and Fischhoff, unpublished). In addition, scouts record the location of all zebra herds using a Geographical Positioning System (GPS) device. Follow-up training is consistently carried out with scouts to maintain the quality of their data collection. To verify data quality during training, one of the authors (B.L.) shadowed scouts, simultaneously and independently filling out data sheets. Data recorded by B.L. closely matched those of scouts. Three scouts are employed from each of six conservancy areas. Each of the 18 scouts works 2 full days per week. The days are staggered among scouts, within a community, to broaden coverage. With three scouts in each community, Grevy's zebra are being monitored 6 days per week in each area. Data sheets are collected by the Grevy's Zebra Scout Program coordinator on a monthly basis. Upon collection the data are scrutinized for any inconsistencies and scout performance is closely monitored.

2.3. GPS radiocollar data

Fifteen Grevy's zebra females were fitted with GPS–GSM collars through the *Save The Elephants Tracking Animals for Conservation* project (STE, 2009). Females were chosen because their paths more closely track the distribution of resources in the landscapes, compared to males which are typically territorial (Rubenstein, 1986; Sundaresan et al., 2007a). Areas targeted for collaring were selected based on known populations of Grevy's zebra and were the same areas monitored by scouts. The aims of the collaring project were to gather fine-grained data on the resource and habitat use of Grevy's zebra and their response to conservancy management. Each collar records the individual's location once every hour. The data used for this analysis cover the period from June 2005 to September 2006.

2.4. Analyses

2.4.1. Identifying critical areas

We use the locations of Grevy's zebra sightings to determine the areas most intensively used. We perform a kernel density analysis on these locations (Seaman and Powell, 1996; Silverman, 1986; Worton, 1995). This analysis provides a nonparametric, smoothed density surface. We interpret areas of high usage as more important to Grevy's zebra. We perform one kernel density analysis based on all Grevy's zebra locations. To ask whether there are areas of intensive use by lactating mothers, we perform a second analysis on only the locations of groups containing foals less than three months old. Finally, we construct a third kernel density using locations from all the points recorded by the GPS radiocollars. We perform all these analyses using the software ArcGIS 9.2. For all analyses, we used a grid cell size of 1.6 km and search radius of 13.3 km.

Having estimated the kernel densities, we then ask whether scout and radiocollar data appear to indicate concordant areas as most intensively used by Grevy's zebra. For each dataset, we use the kernel density estimator to define contour polygons predicted to contain 95% of locations. We find the area of overlap between these 95% polygons for scout and radiocollar data.

2.4.2. Interactions with livestock

As a first step to determining how interactions with people may influence Grevy's zebras' choice of locations, we ask what fraction of Grevy's zebra scout observations coincide with domestic animals over the course of the day. We tally the number of zebra herd observations for which scouts recorded livestock as present within 100 m at the same time. For each hour of the day, we divide the count of livestock herds observed near zebra by the total number of zebra herds observed, to obtain the fraction of herds observed near livestock. Similarly, we determine how often Grevy's zebra are seen with different types of livestock.

Grevy's zebra resource needs vary by age and reproductive status (Ginsberg, 1988; Rowen, 1992; Rubenstein, 1986). Variation among zebras in the extent of their overlap with livestock may indicate higher potential for competition in specific reproductive classes. We use a chi-square test to examine if there is an association between Grevy's zebra reproductive class and proximity to domestic

animals. For each herd sighting that included zebras in a particular reproductive class, we count the number of sightings with and without livestock. We then compute a chi-square statistic to test for association between reproductive state and livestock presence.

Past research has hypothesized that water, a limited resource in the region, is a cause for competition between Grevy's zebra and people and their domestic animals (Nelson and Williams, 2000; Williams, 1998, 2002). We examine whether there is an association between observing Grevy's zebra close to water and observing them close to livestock. For all herd sightings, we tally the number of sightings with and without livestock present within 100 m. These tallies are made separately for sightings near water and away from water. We compute a chi-square test for association between livestock presence and proximity to water.

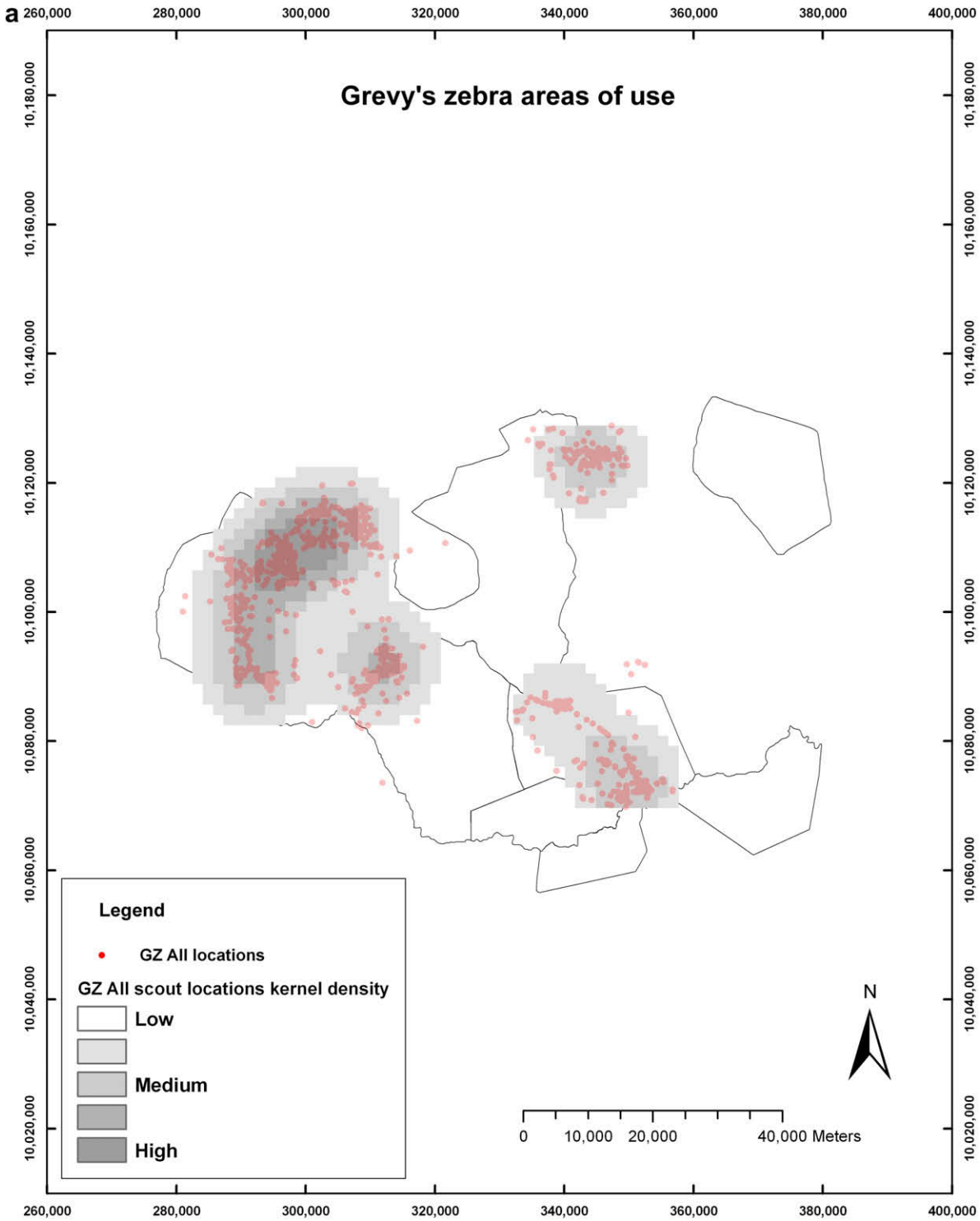
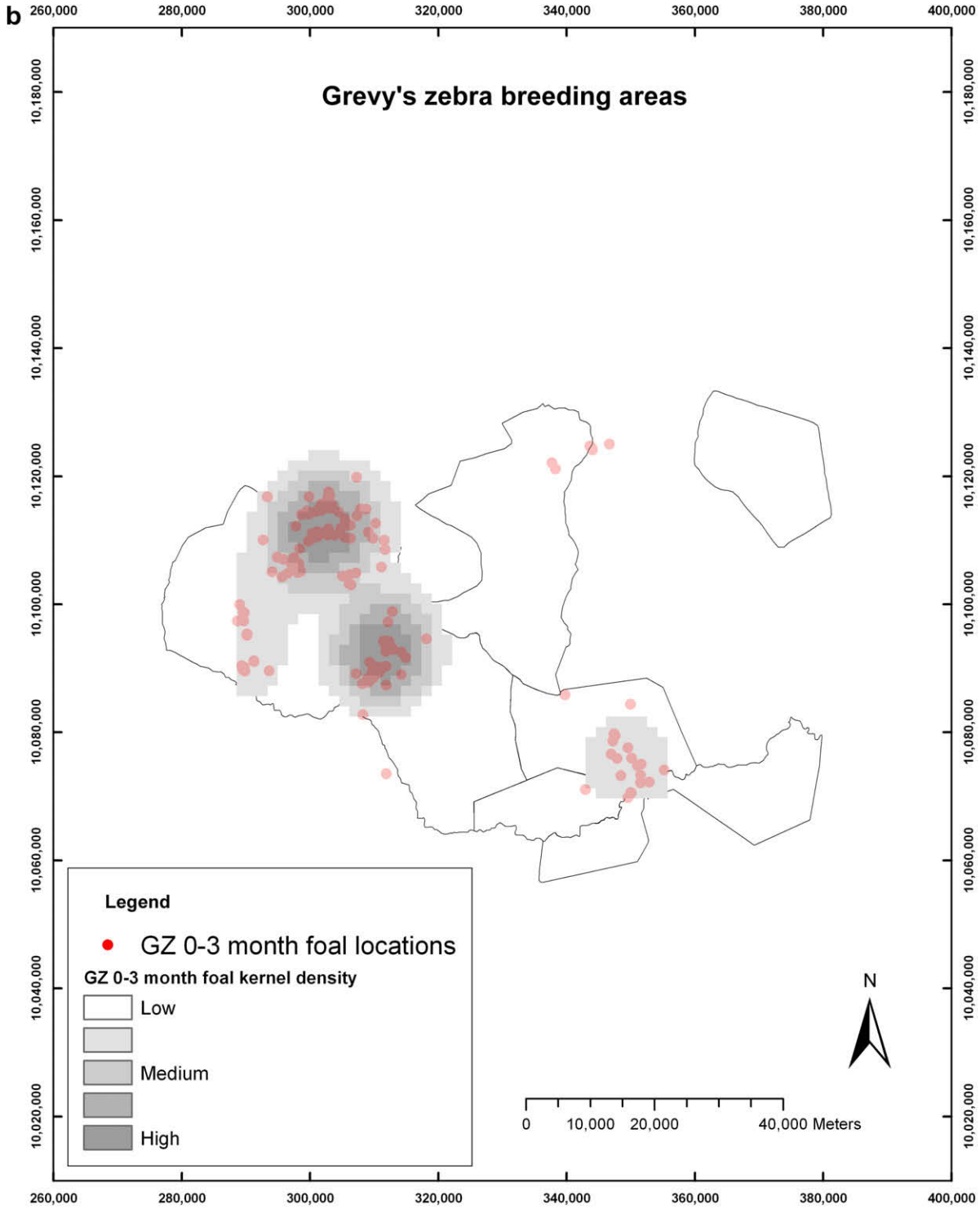


Fig. 1. Map of Grevy's zebra observations and kernel density. The kernel indicates density of herd observations, with each observation weighted by the herd size. Darker areas indicate greater density of observed foals in the vicinity of the location. The kernel density at a location represents the density of individuals observed nearby, as defined by a grid cell and search radius. For this analysis, each grid cell is 1.6 km and search radius is 13.3 km. (a) Kernel density map of areas used by all Grevy's zebra herds as observed by scouts. (b) Kernel density map of Grevy's zebra breeding areas, as defined by scout observations of herds containing foals aged less than 3 months. (c) Kernel density map of location data collected from 15 GPS collared Grevy's zebra.

3. Results

3.1. Critical areas

In Fig. 1a, we show the 95% kernel density contour for all Grevy's zebra observations made by scouts (N = 1746 herd locations). Based on the location of the contour, scouts observe Grevy's zebra most frequently in the following areas: Naibelibeli and Namanyarabo in West Gate Conservancy; Lkisin, Ngaroni, Ndonyo Werikon and Barsalinga in Meibae Conservancy; the Kalama Conservancy headquarters; the border with Samburu National Reserve and Serolevi on the boundary of Namunyak Conservancy. If we examine only the subset of Grevy's zebra sightings with young foals (Fig. 1b), the location of the kernel density contour overlaps that of all locations. But the scout data reveal some additional areas that may be important for raising foals. Based on the scout data, we conclude that key areas for Grevy's zebra foaling in these community lands also include: Lkisin and Ngaroni in Meibae Conservancy,



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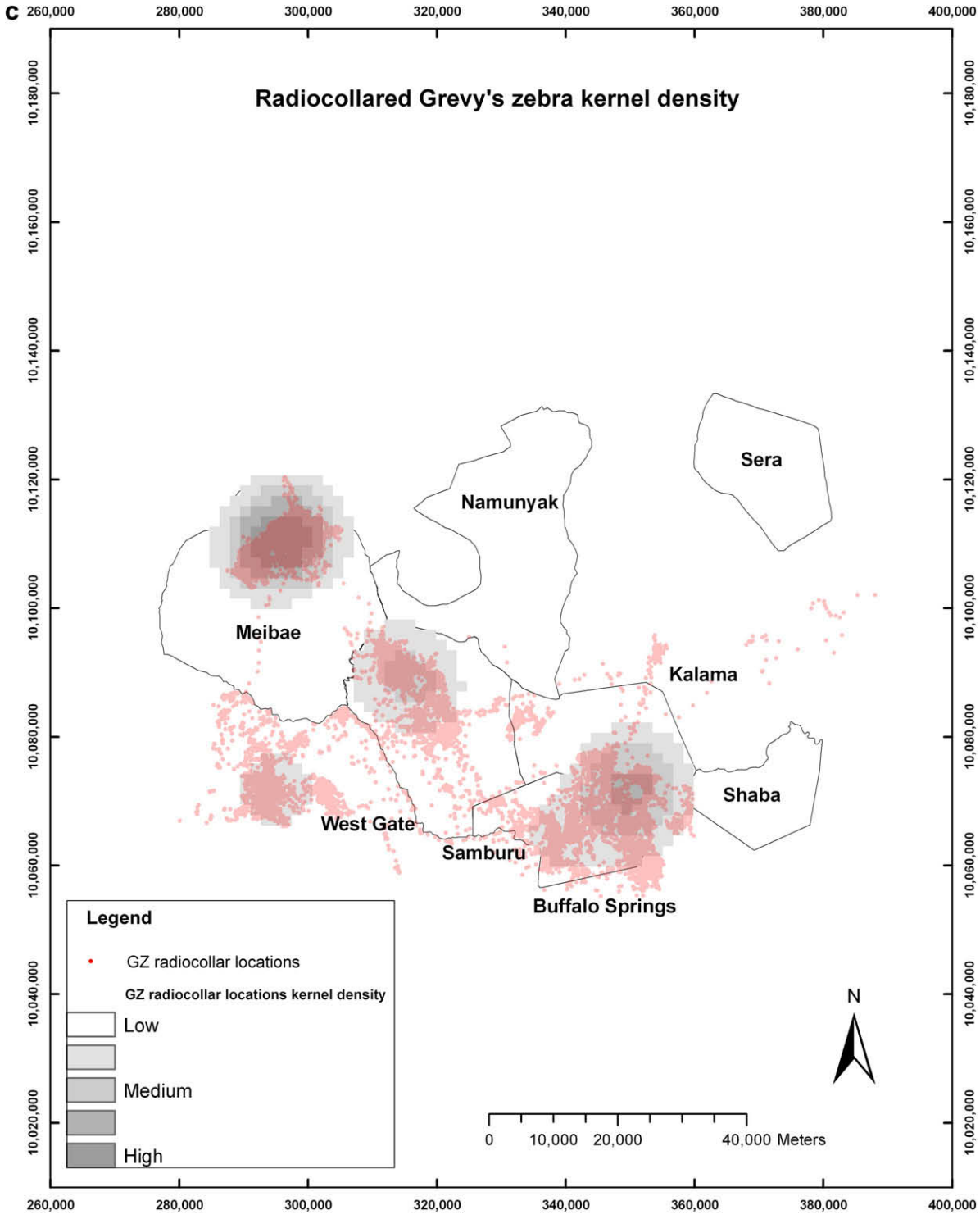

Fig. 1 (*continued*)

Nagoruworu in West Gate Conservancy, and the Kalama Conservancy headquarters.

Finally, we determined a third kernel density contour, based only on the locations of 15 GPS radiocollared Grevy's zebra ($N = 33059$ GPS fixes). The 95% kernel contour indicates that the areas most used by the radiocollared individuals include Lkisin and Ngaroni in Meibae Conservancy; Namanyarobo and Naibelibeli in West Gate Conservancy; Samburu and Buffalo Springs National Reserves to the south of Kalama Conservancy; the Kalama Conservancy headquarters; and Longopito in Kipsing (Fig. 1c).

If we compare the contours for the scout data to those describing the radiocollar data, we find overlap in the following places: Lkisin in Meibae Conservancy; Namanyarabo in West Gate Conservancy; and the border of Samburu National Reserve and Kalama Conservancy. Of the 3396 km^2 encompassed by the GPS radiocollar 95% contour, 57% is also found in the 95% contour determined from the scout observations.

3.2. Interactions with livestock

Fig. 2 shows the fraction of Grevy's zebra sightings close to livestock over the course of the day. We see that Grevy's zebra are observed in proximity to livestock in approximately 40–50% of all zebra observations, over all hours of the day except for before 8 am and after 6 pm. In Fig. 3, we plot the fraction of Grevy's zebra herds found close to four types of livestock – camels, cattle, donkeys and small stock (sheep and goats). We find that Grevy's zebra are most often seen with small stock and camels, and to a lesser extent with cattle. Only one observation, out of 2347, was with donkeys.

Livestock are a more frequent presence for zebras of particular reproductive states. A chi-square test indicates that a group's likelihood of being in close proximity to livestock significantly depends on reproductive class ($\chi^2 = 25.6$, $df = 3$, $p < 0.001$; Fig. 4). Territorial males and nonlactating females are relatively unlikely to be found in proximity to livestock. By contrast, bachelors and lactating females are more often seen with livestock.

Livestock are found more often with Grevy's zebra in locations close to water. We find a significant association between livestock presence and proximity to water ($\chi^2 = 13.3$, $df = 1$, $p < 0.001$). Livestock are seen with zebras in 49% of the 315 sightings near water, compared to 38% of the 2032 zebra sightings away from water.

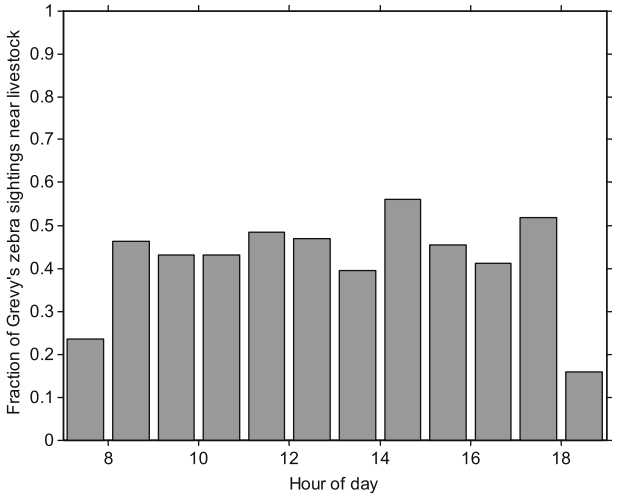

Fig. 2. The plot shows the proportion of Grevy's zebra scout observations that were made within 100 m of livestock, by time of day.

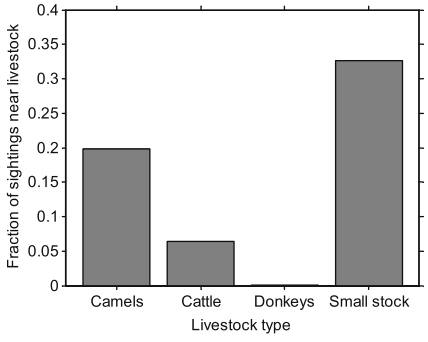

Fig. 3. The plot shows the fraction of Grevy's zebra observations near particular livestock types, out of all observations made near livestock. Livestock types include camels, cattle, donkeys, and small stock (sheep and goats).

Fig. 4. The plot shows the fraction of observations near livestock for Grevy's zebra in different reproductive classes.

4. Discussion

As land use intensifies in northern Kenya, habitat area and quality decline for Grevy's zebra (KWS, 2008; Williams, 2002). From a Grevy's zebra's perspective, not all places are equally useful. Certain locations better satisfy Grevy's zebra needs, which vary depending on sex, age and reproductive status. Locations attractive to wild grazers like Grevy's zebra may also appeal to pastoralists and their livestock herds. Within this increasingly crowded sphere of Grevy's zebra existence, we want to identify locations of particular importance, where we should focus our efforts on facilitating coexistence between people and zebras. One way to achieve lower-intensity land use is for people to supplement their income through wildlife tourism. In many community-held properties, this requires restoring and setting aside areas where wildlife conservation is the primary goal and livestock are seasonally limited or excluded. Communities often want to determine which areas of their property have the best potential as wildlife habitat. In this area, Grevy's zebra are considered a key tourism draw. Determining critical areas for Grevy's zebra thus becomes both an economic and conservation goal.

Using data collected by local community scouts we have identified areas of intensive use by Grevy's zebra in a region of Kenya's Samburu district. These areas generally match those indicated by the locations of radiocollared Grevy's zebra. Based on these two sources of evidence, we can be more confident that these areas represent critical habitat. The radiocollar data validate additional conclusions we can draw from scout data. The scout data allow us to identify places commonly used by females with young foals. For an endangered species, successful reproduction is imperative. These locations should be targeted for protection. We can go on to ask what ecological conditions, for example vegetation characteristics or water sources, make these areas particularly attractive to Grevy's zebra mothers. We argue that scout data is a useful tool for finding key locations in other parts of the Grevy's zebra range.

We find extensive overlap between Grevy's zebra and livestock, which are typically accompanied by herders. It is an open question whether this overlap translates into competition that harms Grevy's zebra reproduction or survival. Past work on Grevy's zebra has suggested that zebra competition with livestock for water negatively affects Grevy's zebra foal survival (Williams, 1998). On a commercial ranch in neighboring Laikipia district, we found that Grevy's zebra avoid active cattle corrals (Sundaresan et al., 2007b). With our data, we find that co-occurrence of Grevy's zebra with domestic animals is especially common around water holes.

We cannot yet say whether Grevy's zebra avoid livestock or human settlements in this region.

The Grevy's zebra scout program is an example of citizen science, in which community members, typically lacking formal scientific background, engage in the collection and interpretation of scientific data. The citizen science model has been applied across diverse ecosystems and human societies, to the study of species distributions and phenology (Evans et al., 2005; Pattengill-Semmens and Semmens, 2003), disease (Dhondt et al., 1998), effects of introduced species (Nelson et al., 2005), and human hunting (Noss et al., 2005).

We have shown the biological insights possible from data gathered by a relatively inexpensive citizen science program. The cost of employing and managing a scout is approximately US$760 per year. By contrast, each GPS radiocollar costs $3700. In addition, there are deployment, data downloading and collar recovery costs that reach $1000 a year or more, depending upon the number of collars and their spatial distribution. We argue that the scout program is a more cost-effective method to gather data on broad scale zebra distribution patterns and spatiotemporal interactions with livestock and humans.

Aside from our need to answer biological questions, and do so in a cost-effective manner, we have chosen to work with community scouts as data gathering partners for three reasons. First, for the results of conservation science to be applied in these communities, it is essential for them to participate in the process throughout. The data resulting from citizen science projects studies have been effectively used in other community-based natural resource management programs (Danielsen et al., 2005; Measham, 2007; Stuart-Hill et al., 2005). In our program, we organize annual workshops for scouts, community managers and other stakeholders, at which we present analyses of scout data and discuss their implications. Scouts' information about the locations of Grevy's zebra get discussed in further community meetings and are subsequently used to determine which sections of community-owned land should be managed for conservation. In turn, community leaders use these results in their negotiations with the Kenya Wildlife Service and other partners to develop conservation and management plans. Community conservancies have used information collected by scouts in planning new human settlements away from key Grevy's zebra areas, to avoid displacing Grevy's zebra. Further, new water sources have been located away from Grevy's zebra preferred areas, as identified by scouts' data. Funding to establish two community conservancies, West Gate and Meibae, was secured as a direct result of data gathered by Grevy's zebra scouts, even prior to the analyses in this paper.

The second reason to involve local scouts is to raise community awareness of Grevy's zebra biology. Studies of other citizen science projects indicate improvement in participant understanding of focal species biology (Brossard et al., 2005). Through observations of Grevy's zebra herds scouts become local experts on the species. We believe they then take on a role as ambassadors for Grevy's zebra within their society. Finally, programs such as this enhance local capacity to monitor and understand wildlife. This is important in the long term, because sustainable conservation requires that local people have the know-how to make biologically sound management decisions. Addressing the needs of Grevy's zebra leads to improvements in rangeland management and resource use more generally. With more controlled management of domestic species, potential opportunities for developing tourism operations in community rangeland are greatly increased.

Acknowledgments

We wish to thank the Saint Louis Zoo for funding this project since its inception in 2003. In particular, Martha Fischer was instrumental in mobilizing resources for this program. We thank Rikapo Lentiyoo for his assistance in the field in coordinating scout training and data collection. We thank the communities of Kalama, Sessia, Ngaroni, West Gate, Serolevi and Ngilai West for giving their support to the project and passing on valuable information to the Grevy's zebra scouts. We remember with warmth the late James Munyugi for his expert facilitation of the first community meetings in which we introduced the Grevy's zebra scout program. We thank Save The Elephants for allowing us to use GSM collar data from the *STE Tracking Animals for Conservation Project*. We thank the Kenya Wildlife Service for endorsing the project. We appreciate the assistance of Preetika Hirani in initial organization of data and questions. Finally, we thank the women and men on the Grevy's Zebra Scout team who have not only collected valuable data on the species but have also been instrumental in changing the behavior of their fellow community members towards Grevy's zebra. For supporting the authors' work, we recognize Grevy's Zebra Trust (B.L.), Northern Rangelands Trust (B.L.), Lewa Wildlife Conservancy (B.L.), Denver Zoological Foundation (S.R.S), Princeton University (S.R.S, I.R.F, D.I.R), McMaster University (I.R.F), Smithsonian Institution Postdoctoral Fellowship (I.R.F) and US National Science Foundation (grants IOB-9874523, IBN-0309233 and III CXT - 0705311) (S.R.S, I.R.F, D.I.R). For hosting us while we analyzed data and wrote the manuscript, we thank Ol Pejeta Conservancy and Mpala Research Center.

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