THE GREAT GREVY'S RALLY
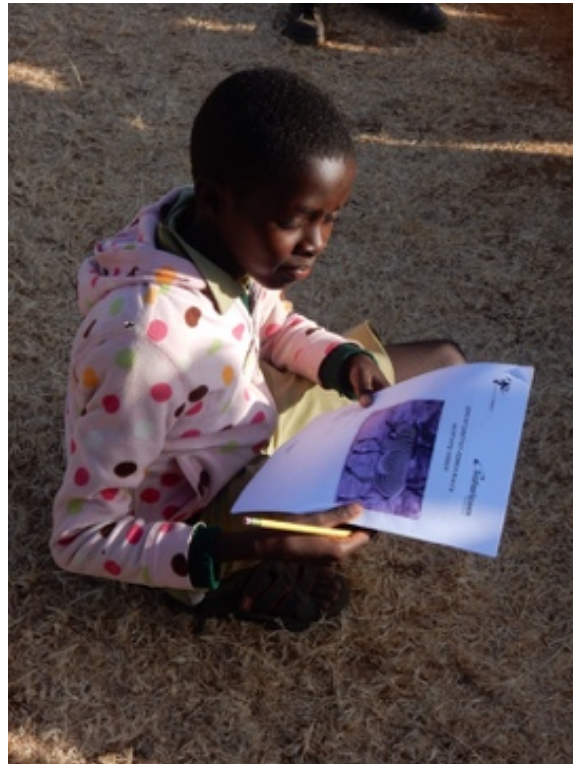
The State of Kenya's Grevy's Zebras and Reticulated Giraffes: Results of the Great Grevy's Rally 2018

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The Challenge

Grevy's zebras are one of seven remaining species of equids left on the planet. In the 1970s they roamed widely in the semiarid habitats throughout the horn of Africa[1] (Fig. 1). In Kenya alone, there were over 15,000. They were typically seen in Samburu, Isiolo and Marsabit counties and herds sometimes numbered into the thousands! By the late 1980s, the range had shrunk and numbers had dropped to around 4,000 because of over- hunting for their beautiful skins. Despite a ban on the skin trade, they continued to decline due to hunting for subsistence meat, loss of habitat and competition with livestock for forage and water. By the early 2000s, only about 2,000 Grevy's zebras were estimated to remain[2-4].
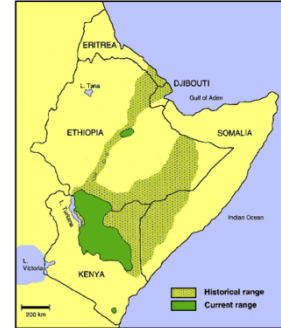

Fig.1. Grevy's zebra range. Adapted from Moehlman (2012)

Counting Grevy's zebra has always posed a challenge. Traditionally, they have been counted from the air, but detecting them can be problematic as they like to shade under trees in the heat of the day. In addition, they are
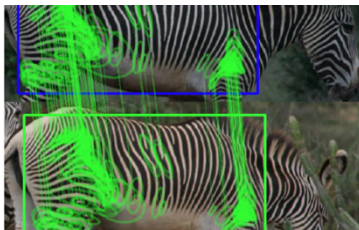

Fig. 2. Wildbook 'Hotspot' matching algorithm identifying areas of body regions showing matches.

sometimes confused with plains zebras. In 2016 the Grevy's Zebra Technical Committee proposed a radical change of tactic by enlisting the public to search for them by driving throughout the Grevy's zebras range, often repeatedly covering the same routes, and photographing every Grevy's zebra seen over two consecutive days. This first every Great Grevy's Rally took place in January 2016 and produced over 25,000 useable photographs! By using WILDBOOK computer algorithms individuals were identified by comparing computer generated 'hot spots' on the body (Figure 2).

By using 'Sight-Resight' statistics (see methodology section for details), scientists were then able to estimate population sizes nationally and by county. In total, Kenya's population of Grevy's zebras was estimated at 2350 in 2016. Each individual was subsequently aged and sexed, and given that the population contained about 70% adults and 30% infants and juveniles ('recruits'), the population was considered stable based on demographic modeling simulations[5].

Fig. 3. Citizen scientists from all walks of life photographing and gathering data on Grevy's zebras during the GGR.

To determine if the population was indeed sustaining itself, another massive citizen science effort (Fig. 3) was planned for two years later in January 2018. Such a re-census was important because in the intervening years since

2016, Kenya has been plagued by severe droughts in its central and northern counties where Grevy's zebras reside. Not only would the droughts severely reduce forage, competition with livestock would be intensified, especially since 150,000 additional cows were added to the Grevy's zebra's rangeland. Moreover, diseases such as anthrax, and poaching also increased. Thus, knowing how Grevy's zebras fared during this 'perfect storm' of environmental stressors became a critical concern.

Table 1. Categories of GGR 2018 participants

Conservation Orgs	15%
Community	7%
Conservancy	13%
County Government	7%
KWS	6%
Private Ranches	7%
Scientist	6%
Internationals	13%
Kenya Participants	27%
Corporate	2%

On January 28th and 29th 2018, 212 photographers in 143 vehicles participated in the second Great Grevy's Rally covering 25,000 KM^2 and snapping over 49,000 photographs of which 23,000 were of Grevy's zebras. Table 1 shows a breakdown in the nature of the participants and Figure 4 shows a heat map of the distribution and intensity of sightings of Grevy's zebras. Since IUCN listed giraffes worldwide in 2017 as 'threatened ', Rally photographers also took 18,000 pictures of reticulated giraffes since they occupy the same habitats as Grevy's zebras and they often co-occur. Nature's natural 'barcodes of tens of thousands of Grevy's zebra stripes and reticulated giraffe tiles were analyzed by WILDBOOK computer algorithms to identify unique individuals sighted and resighted over the two consecutive days[6-8].
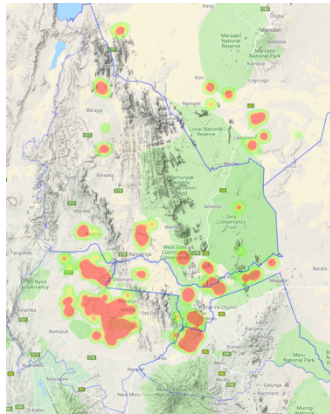

Fig. 4. Heat map showing the distribution and intensity of Grevy's zebra sightings.

Results

<u>Grevy's zebras.</u> The results that emerged from GGR 2018 are heartening. Overall, Grevy's zebras have weathered the perfect storm of drought, increased competition with livestock and increased poaching and disease. Nationally, the numbers have actually increased from 2350 ± 93 to 2812 ± 163 (Fig. 5). Examination of the numbers by county reveal how this increase came about. Overall, the counties with the largest populations (Laikipia, Samburu and Meru) showed no statistically significant change. Although numbers seem to be slightly higher in those counties in 2018 than in 2016, the 95% confidence intervals on the estimates are larger as well. This is because more unique individuals were seen on days 1 and 2 with fewer being resighted on day 2. As a result, estimates of population sizes become larger. But with fewer resightings, confidence in those estimates become lower. Since the confidence intervals between the 2016 and 2018 estimates overlap for these three populations, the increases are not statistically significant. For the northern counties, however, showing small populations in 2016— Isiolo and Marsibit—the increases are so large that the confidence limits between years do not overlap. Thus, the increases are significant and real. These increases are the result of enhanced effort: more teams were assigned to these areas where zebras are more sparsely distributed and they drove routes repeatedly. Consequently, many individuals that were missed in the last Rally were seen this time around. In effect, almost 300 new individuals were 'found' in GGR 2018!
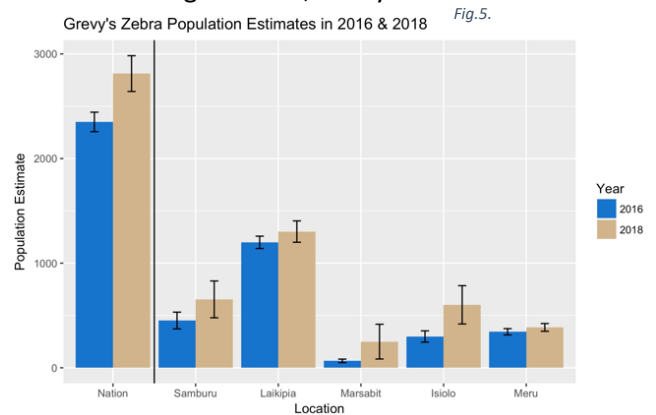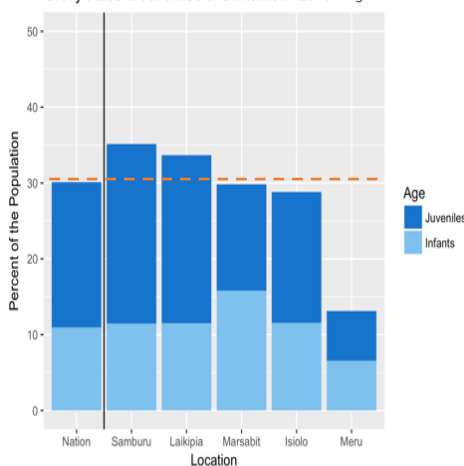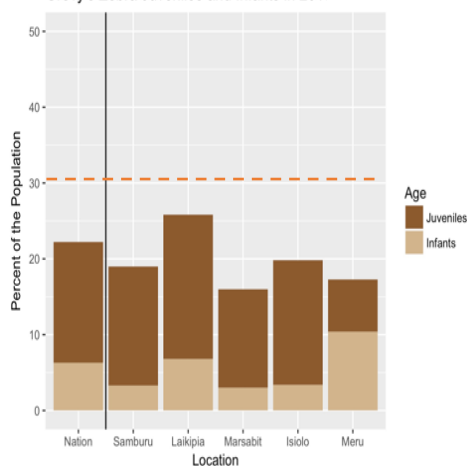

These results suggest that this arid-adapted species was able to withstand the triple threats of the last few years. For the most part adult survival remained high and for those that did perish, the
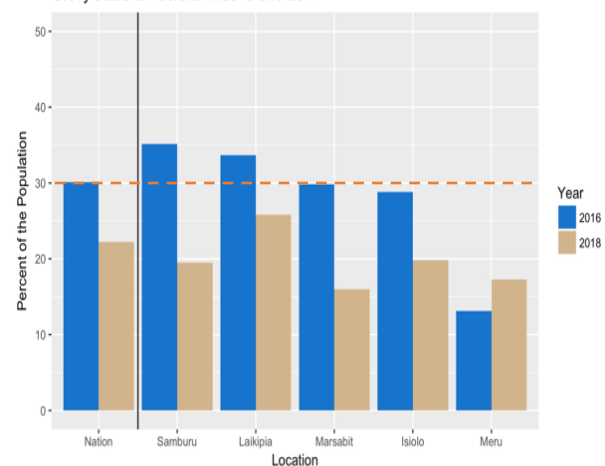
large number of juveniles identified in the 2016 census (Fig. 6) survived well enough to replace them. However, when the overall demographics—age and sex structure—of the population was examined, it is clear that the triple stressors impacting the population reduced overall fecundity. The percentage of foals identified declined nationally from approximately 11% in 2016 to approximately 5 % in 2018 (Figs 6 and 7). Only Meru county—essentially Lewa Conservancy—showed an increase in foal survival. Whereas infants and juveniles—'recruits' when combined—accounted for approximately 30% of the population nationally and for most counties in 2016, by 2018 this percentage had declined to 22% nationally (Fig. 8). Only in Laikipia county did the proportion of 'recruits' approach levels that could maintain population sustainability.
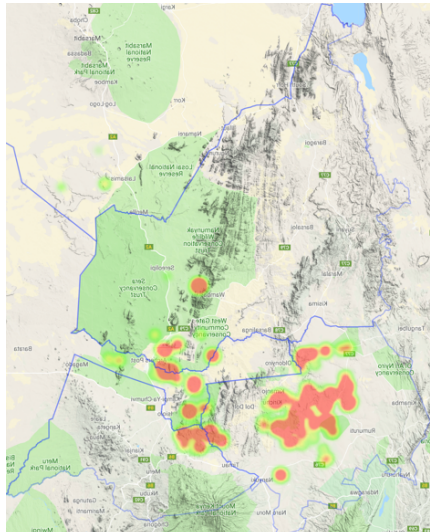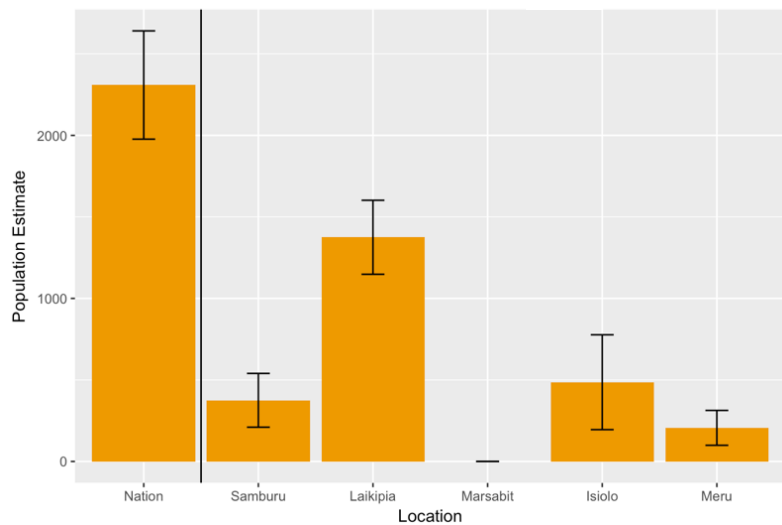

Fig. 9. Location of reticulated giraffe sightings.

Reticulated Giraffe Population Estimates in 2018 *Fig. 10.*

Reticulated giraffes. For the very first time, Citizen Science and WILBOOK have generated an estimate of 2309 ± 332 reticulated giraffes inhabiting the semi-arid areas of central and northern Kenya as shown in the heat map illustrated in figure 9. The overall numbers are low and even lower then those of Grevy's zebras. In addition, variation among counties is large (Fig. 10). As is the case with Grevy's zebras, Laikipia county is home to 60% of Kenya's reticulated giraffes.

Conclusions

Despite a perfect storm of environmental stressors, the state of the Grevy's zebra in Kenya is strong. Numbers remained stable over the last two years based on the estimate derived from the first Great Grevy's Rally. Moreover, with increased effort, individuals missed in 2016 were found and identified in 2018. Thus, the estimated numbers for central and northern Kenya have actually increased.

Given that the drought ended with a deluge of exceedingly heavy rains, rangelands in central and northern Kenya are now replete with grass. Both livestock and Grevy's zebras are in excellent bodily condition which augurs well for the future. Ordinarily, females that give birth and successfully rear their young to one year of age—the age of independence—skip one year, or even two, before conceiving again. When females terminate their pregnancies early or lose their young, however, they are likely to conceive during the next breeding season, especially if forage is plentiful and body condition is high. Given that this is currently the situation, the likelihood is great that a large pulse of infants will appear in 2019, thus offsetting whatever decline in numbers might occur given the shortage of infants and yearlings found in 2018.

The fact that over 70% of Kenya's Grevy's zebras are now identified individually, a national data base is emerging. Going forward, pictures taken by scientists, scouts, camera traps and tourists during the intervening years between Great Grevy's Rallies will provide fine-grained data on locations, associations, movements and habitat use as impacted by climate change and human impacts.

The population size estimates of reticulated giraffes nationally and by county are concerning. The largest populations are in Laikipia county which has become the hottest spot for both reticulated giraffe and Grevy's zebras. If Laikipia's rangelands and their use continue to be managed sustainably, then giraffe numbers should increase. If they do, then Laikipia has the potential become the source of individuals which should disperse, thus increasing population sizes elsewhere in Kenya's arid and semi-arid areas. Although there are many regions where both species co-exist, reticulated giraffe are absent in areas where Grevy's zebras are themselves sparsely distributed. Given that extra effort was needed in 'finding' the 'missing' zebras in these areas during the second Rally, focusing more effort on sighting giraffes will be needed in the next Rally to assess whether the low numbers estimated in this Rally are real. At least by creating a baseline of photographs of the identities and locations of reticulated giraffes, scientists and conservationists are now positioned to begin understanding the movements, associations and habitat uses of reticulated giraffes which have now been listed as 'threatened'.

Methodologies

Sampling. Teams were assigned to blocks and were encouraged to repeatedly cover as much ground as possible on two consecutive days. By holding the Rally on two consecutive days each sampled population can be considered 'closed' which simplifies the statistical analyses used to estimate population sizes because no births, deaths, immigrations or emigrations will have occurred. Moreover, by having multiple drivers covering the same routes at different times of day the assumption of 'equal catachability' is also approached. While some individuals were only sighted once, some Grevy's were photographically captured 79. On average each zebra was photographed approximately 5 times.

Identification. Once the images are gathered they are filtered to eliminate those that did not contain Grevy's zebras or giraffes. Of a total of almost 50,000 images, using WILDBOOK's detection algorithmic pipeline reduced the number of photographs to be analyzed to 22,918 and 18,008 for Grevy's zebras and reticulated giraffes respectively. Once the software put 'bounding boxes' around individuals (54,810 for zebras and 30,262 for giraffes), the images were analyzed by the 'Hotspotter' algorithm to determine if individuals were new or previously seen. Once the number of unique individuals were determined, then then the number of sightings and resightings could be scored.

Statistical Analyses. Armed with the number of sightings on days 1 and 2 and the number of resightings on day 2, population size estimates for the nation, each county and even each property or land holding, could be computed using the Lincoln-Peterson Index and its associated confidence interval equations[9].

$$N \text{ estimate} = S1*S2/R;$$
$$CI = N \text{ estimate} \pm 1.96 \sqrt{((S12 * S2[S2 - R])/R2)},$$

Where N is the number of individuals, S1 is the number of unique individuals sighted on day 1, S2 is the number of unique individuals sighted on day 2, R is the number of individuals re-sighted on day 2 that were also seen on day 1 and CI is the 95% confidence interval bounding the population size (N) estimate.

Acknowledgments

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