Potential impacts of climate projections on wildlife in savanna ecosystem of East Africa

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Climate change background
Introduction: Background

- Climate change is a growing threat to wildlife in the East African savannas (Ogutu et al., 2016).
- Increase in frequency and severity of droughts and floods is expected to increase (Field et al., 2012)
- On average, global temperature has increased by 0.72°C since 1950 (Hartmann et al., 2013)
By 2030 the temperature is projected to increase between 0.9°C and 1.22 °C in the Kenya rangelands for RCP 4.5 by 2030 and by 2050 between 1.39 and 1.84°C. The worst scenario RCP 8.5 by 2070 the temperature is projected to increase between 1.75 and 2.28°C.

CAMCO Report 2016, Said et., 2017
Historical changes in temperatures in Kenya Arid and semi-arid lands

a) Maximum temperature
b) Minimum temperature

Said et al., 2017 PRISE Report
Wildlife in Kenya

The wildlife is found in Arid and semiarid (80% of Kenya land area)

Contributes about 10% to GDP through tourism
Kajiado County is species rich in wildlife and also has some of highest densities of wildlife in the country.

It the third important tourist destination in the country and famous for its large elephant and migratory wildebeest populations.

**Figure 1:** Study area map showing Kajiado county and the 4 unique ecosystems consisting of 1 – Athi Kaputei, 2 – Amboseli, 3 – Central plains and 4 – West Kajiado.
Concerns of climate and biodiversity

Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines

Gerardo Ceballos, Paul R. Ehrlich, and Rodolfo Dirzo

In our sample, comprising 32 species (985/597,600) are described in population size and range we have detailed data, all have lost 3 ranges and more than 40% of the population declines (≥50% range beyond global significance). The rate of population declines and extinction cascades consequences on the vital to sustaining civilization. We propose to highlight the current and future extinction event.

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Equal contribution

Impacts of climate change on the future of biodiversity

Abstract

Many studies in recent years have investigated the effects of climate change on biodiversity. In this review, we examine the different phenomena that are associated with climate change, including habitat loss, altered species distributions, and changes in phenology. We discuss the role of climate change in shaping the future of biodiversity, including the potential for species extinction and the need for adaptation and mitigation strategies.

Keywords: Biodiversity, climate change, species extinctions.

Introducing the future of biodiversity

Biodiversity and climate change

Predicting the response of biodiversity to climate change has become an extremely active field of research (e.g. Dillon et al. 2010; Gilman et al. 2012).

Extreme Wildlife Declines and Concurrent Increase in Livestock Numbers in Kenya: What Are the Causes?


University of Nairobi, Institute for Crop Science, 34057, Nairobi, Kenya, and Department of Resource Surveys and Remote Sensing, P.O. Box 474-00100, Nairobi, Kenya, and Kenya National Trust, 14 Riverside, Cavenagh Block 3rd Floor, Suite B, Riverside Drive P.O. Box 48187-00100, Nairobi, Kenya, and Center for Sustainable Drylands Ecoversity and Biodiversity, University of Nairobi, P.O. Box 130147, 00100, Nairobi, Kenya, and Northern Rangelands Trust, Private Bag, Isiolo, 05200, Kenya

Research Article

There is growing evidence of escalating wildlife losses worldwide. Extreme wildlife losses have recently been documented for large parts of Africa, including western, Central, and Eastern Africa. Here, we report extreme declines in wildlife and contemporaneous increase in livestock numbers in Kenya rangelands between 1977 and 2016. Our analysis uses systematic aerial monitoring survey data collected in rangelands that collectively cover 88% of Kenya’s land surface. Our results show that wildlife numbers declined on average by 58% between 1977 and 2016. The magnitude of decline varied among species but was most extreme in large mammals (≥88%) and now severely threatens the population viability and persistence of large mammals. In addition, livestock biomass and numbers of sheep and goats (76.3%) and camels (13.1%) have increased significantly in the same period. As a result, livestock biomass was 8.1 times greater than that of wildlife in 2011–2013 compared to 3.5 times in 1977–1980. Most of Kenya’s wildlife (ca. 30%) occurred in ranch County alone. The proportion of the total national wildlife population found in each county increased between 1977 and 2016 substantially only in Tana River and Laikipia but marginally in Garissa and Wajir counties, largely reflecting greater wildlife losses elsewhere. The declines raise very grave concerns about the future of biodiversity in Kenya and elsewhere.
Objectives

• Map herbivore distribution in Kajiado county

• Analyses both spatial and temporal changes in temperature changes temperature for the three RCPs 2.6, 4.5 and 8.5.

• Calculate the percentage loss in wildlife range for various species
Data and analysis

• **Climate data** - temperatures projections based on three RCPs 2.6, 4.5 and 8.5 that were estimated for the time intervals 2030s, 2050s and 2070s. The analysis was based on Regional Climate Model as under Coordinated Regional Downscaling Experiment (CORDEX) program sponsored by World Climate Research Program (WCRP).

• **Wildlife data** – 17 aerial census conducted by Directorate of Resource Surveys and Remote Sensing (from 1977 to 2014).

• **Analysis** - Each of 15 species were overlaid with projected maximum temperature for the three RCPs 2.6, 4.5 and 8.5 for the time periods 2030s, 2050s and 2070s. For each species we derived a temperature threshold at which the densities of animals were approaching their minimal densities. For each scenario we reported the percentage changes in the range for each of the 15 species.
Predicted aspects of climate change and some examples of their likely effects on different levels of biodiversity

Source: Bellard et al. 2012
<table>
<thead>
<tr>
<th>Thomson's gazelle</th>
<th>Impala</th>
<th>Warthog</th>
<th>Gerenuk</th>
<th>Grant's gazelle</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Thomson's gazelle" /></td>
<td><img src="image2" alt="Impala" /></td>
<td><img src="image3" alt="Warthog" /></td>
<td><img src="image4" alt="Gerenuk" /></td>
<td><img src="image5" alt="Grant's gazelle" /></td>
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<tr>
<td>Coke hartebeest</td>
<td>Lesser kudu</td>
<td>Eland</td>
<td>Buffalo</td>
<td>Wildebeest</td>
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<td><img src="image6" alt="Coke hartebeest" /></td>
<td><img src="image7" alt="Lesser kudu" /></td>
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<td><img src="image9" alt="Buffalo" /></td>
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<tr>
<td>Waterbuck</td>
<td>Burchell's zebra</td>
<td>Oryx</td>
<td>Giraffe</td>
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<tr>
<td><img src="image11" alt="Waterbuck" /></td>
<td><img src="image12" alt="Burchell's zebra" /></td>
<td><img src="image13" alt="Oryx" /></td>
<td><img src="image14" alt="Giraffe" /></td>
<td><img src="image15" alt="Elephant" /></td>
</tr>
</tbody>
</table>
Projected temperature (minimum & maximum) changes in Kajiado 2006 to 2100 for RCP 2.6, 4.5 and 8.5.
Table 3: Temperature projections for the 3 RCPs for the periods of 2030s, 2050s, 2070s

<table>
<thead>
<tr>
<th>RCP</th>
<th>2030s</th>
<th>2050s</th>
<th>2070s</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP 2.6</td>
<td>1.16</td>
<td>1.26</td>
<td>1.10</td>
</tr>
<tr>
<td>RCP 4.5</td>
<td>1.00</td>
<td>1.55</td>
<td>1.83</td>
</tr>
<tr>
<td>RCP 8.5</td>
<td>1.36</td>
<td>1.99</td>
<td>3.09</td>
</tr>
</tbody>
</table>

Figure 4: Spatial projections of maximum temperatures changes in Kajiado counties based on RCPs 2.6, 4.5 and 8.5 for the period 2030, 2050 and 2070.
Wildlife distribution in relation to temperature

Ogutu et al., 2016
Results
Projected percentage change in species range for RCP 2.6 for 2030s, 2050s and 2070s

a) RCP 2.6 2030
-90  Waterbuck
 -89  Burchell's zebra
 -86  Thomson's gazelle
 -84  Eland
 -82  Elephant
 -78  Buffalo
 -72  Gerenuk
 -65  Giraffe
 -50  Grant's gazelle
 -41  Oryx
 -35  Lesser kudu
 -26  Impala
 -13  Kongoni
 -12  Oryx

b) RCP 2.6 2050
-90  Waterbuck
 -89  Burchell's zebra
 -86  Thomson's gazelle
 -84  Eland
 -82  Elephant
 -78  Buffalo
 -72  Gerenuk
 -65  Giraffe
 -50  Grant's gazelle
 -41  Oryx
 -35  Lesser kudu
 -26  Impala
 -13  Kongoni
 -12  Oryx

c) RCP 2.6 2070
-89  Waterbuck
 -88  Burchell's zebra
 -85  Thomson's gazelle
 -83  Eland
 -80  Elephant
 -76  Buffalo
 -70  Gerenuk
 -63  Giraffe
 -50  Grant's gazelle
 -41  Oryx
 -34  Lesser kudu
 -25  Impala
 -12  Kongoni
 -11  Oryx
Projected percentage change in species range for RCP 4.5 for RCP 2.6 for 2030s, 2050s and 2070s

a) RCP4.5 2030

-88
-31
-32
-11
-46
-30
-29
-54
-15
-20
-4

Waterbuck
Warthog
Oryx
Lesser kudu
Impala
Kongoni
Grant's gazelle
Giraffe
Gerenuk
Buffalo
Elephant
Eland
Thomson's gazelle
Burchell's zebra
Wildebeest

a) RCP4.5 2050

-96
-40
-55
-37
-20
-4
-36
-55
-45
-10
-15
-16
-60
-4

Waterbuck
Warthog
Oryx
Lesser kudu
Impala
Kongoni
Grant's gazelle
Giraffe
Gerenuk
Buffalo
Elephant
Eland
Thomson's gazelle
Burchell's zebra
Wildebeest

a) RCP4.5 2070

-97
-46
-62
-23
-65
-39
-39
-62
-70
-49
-9
-11
-48
-16

Waterbuck
Warthog
Oryx
Lesser kudu
Impala
Kongoni
Grant's gazelle
Giraffe
Gerenuk
Buffalo
Elephant
Eland
Thomson's gazelle
Burchell's zebra
Wildebeest
Projected percentage change in species range for RCP 8.5 for RCP 2.6 for 2030s, 2050s and 2070s

-100 -80 -60 -40 -20 0

<table>
<thead>
<tr>
<th>Species</th>
<th>RCP 8.5 2030</th>
<th>RCP 8.5 2050</th>
<th>RCP 8.5 2070</th>
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<tbody>
<tr>
<td>Waterbuck</td>
<td>-94</td>
<td>-70</td>
<td>-90</td>
</tr>
<tr>
<td>Warthog</td>
<td>-83</td>
<td>-52</td>
<td>-74</td>
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<tr>
<td>Oryx</td>
<td>-13</td>
<td>-8</td>
<td>-2</td>
</tr>
<tr>
<td>Lesser kudu</td>
<td>-39</td>
<td>-11</td>
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<td>Kongoni</td>
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<td>Grant's gazelle</td>
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<tr>
<td>Giraffe</td>
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<td>Gerenuk</td>
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<tr>
<td>Buffalo</td>
<td>-2</td>
<td>-65</td>
<td>-65</td>
</tr>
<tr>
<td>Elephant</td>
<td>-4</td>
<td>-42</td>
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<tr>
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<td>Thomson's gazelle</td>
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<tr>
<td>Burchell's zebra</td>
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<td>-71</td>
</tr>
<tr>
<td>Wildebeest</td>
<td>-94</td>
<td>-97</td>
<td>-98</td>
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### Summary of Projected Impacts

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Period</th>
<th>&gt;50% loss (extreme)</th>
<th>30-50% loss (severe)</th>
<th>&lt; 30% loss (moderate)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RCP 2.6</strong></td>
<td>2030s</td>
<td>3 out of 15</td>
<td>7 out of 15</td>
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</tr>
<tr>
<td></td>
<td>2050s</td>
<td>5 out of 15</td>
<td>5 out of 15</td>
<td>5 out of 15</td>
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<tr>
<td></td>
<td>2070s</td>
<td>3 out of 15</td>
<td>8 out of 15</td>
<td>4 out of 15</td>
</tr>
<tr>
<td><strong>RCP 4.5</strong></td>
<td>2030s</td>
<td>3 out of 15</td>
<td>7 out of 15</td>
<td>5 out of 15</td>
</tr>
<tr>
<td></td>
<td>2050s</td>
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<td>5 out of 15</td>
</tr>
<tr>
<td><strong>RCP 8.5</strong></td>
<td>2030s</td>
<td>5 out of 15</td>
<td>5 out of 15</td>
<td>5 out of 15</td>
</tr>
<tr>
<td></td>
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<td>5 out of 15</td>
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<td>2070s</td>
<td>10 out of 15</td>
<td>2 out of 15</td>
<td>3 out of 15</td>
</tr>
</tbody>
</table>
Conclusion and what needs to be done?

1) This study has indicated projected temperatures increase will have a devastating impacts on large herbivore and the RCP 8.5 will be extremely deleterious.

2) The government should focus conservation on species that are highly threatened (buffalo, Thomson’s gazelle, warthog, waterbuck, and wildebeest) that might become extinct as a result of global climate change – some of these species are migratory and attracts large numbers of Tourist to the country.

3) Incorporate predicted climate change impacts into wildlife and conservation managements plans.

4) Reduce pressure on species from non-climate stressors to give the animals maximum flexibility to evolve responses to climate change.

5) Initiate breeding and conservation programs and encourage wildlife farming
Acknowledgments

1. The Directorate of Resource Surveys and Remote Sensing for provision of the 17 census data for the Kajiado county.

2. PRISE and ICPACC projects for providing data on climate projections

3. Dr Gilbert Ouma, Gordon Wayumba, Patrick Omondi, and Mohammed Yahya Said for the supervision