

Differences in space use by savannah elephants in and outside of Gonarezhou National Park, Zimbabwe



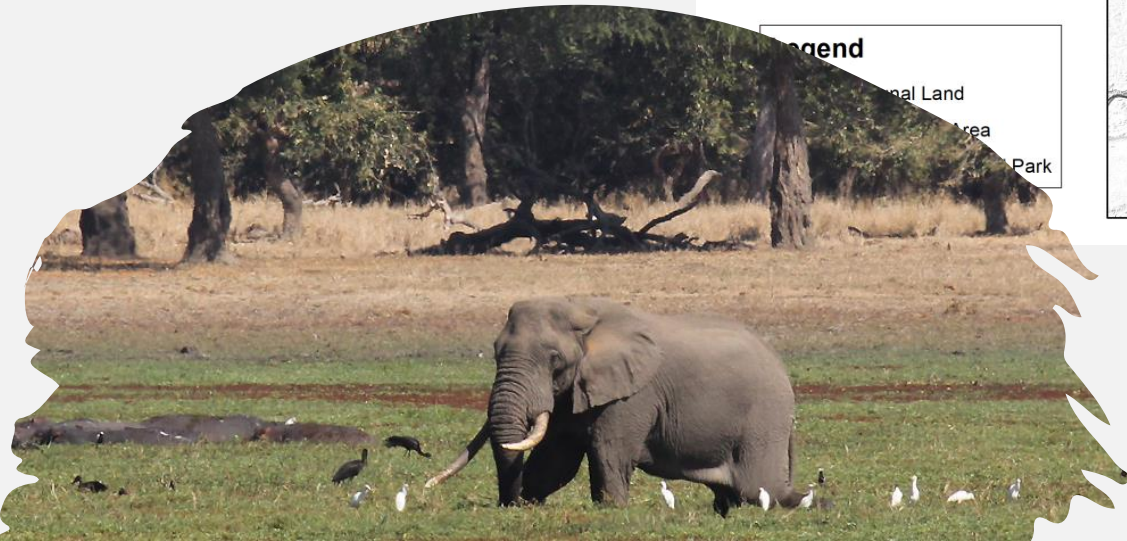
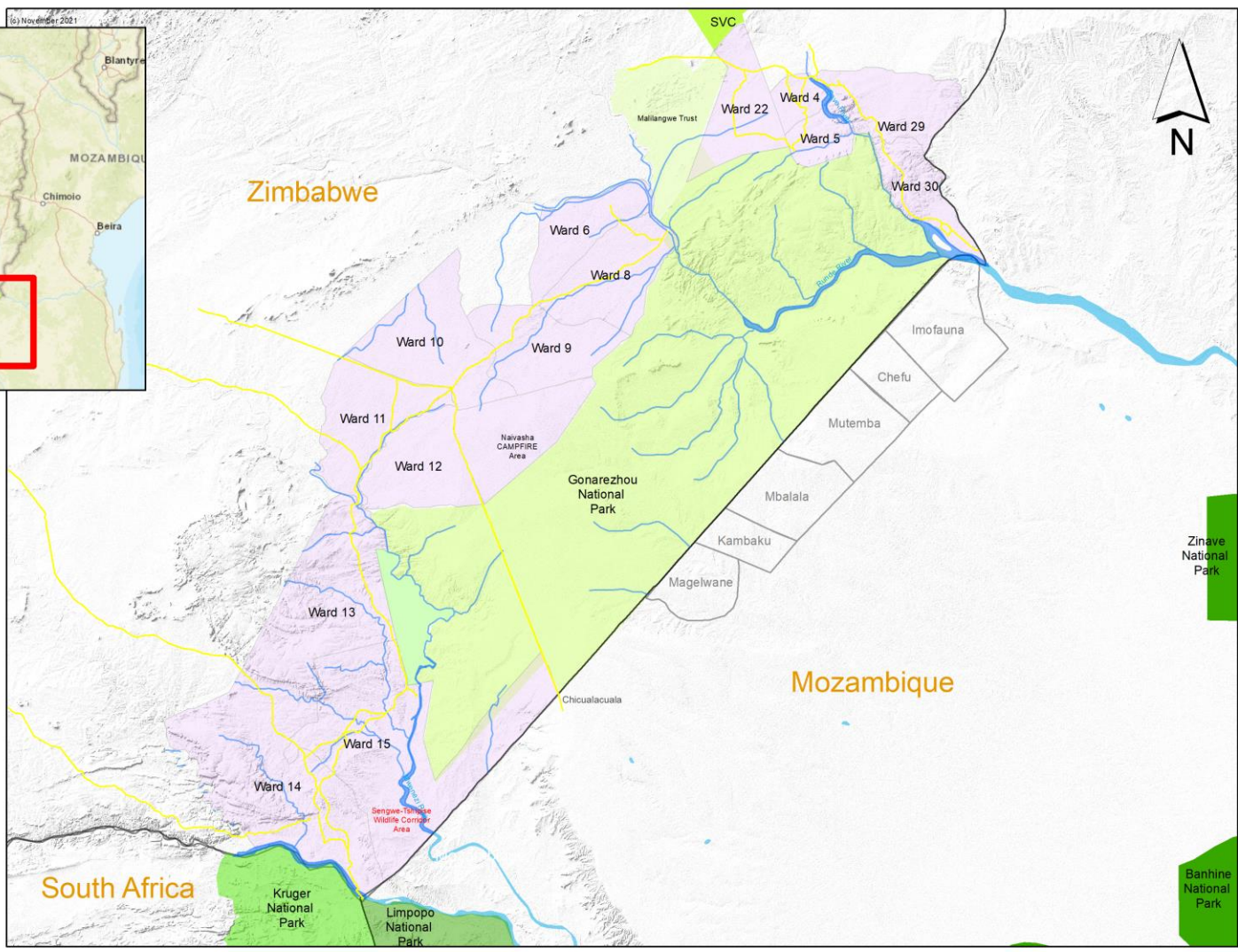
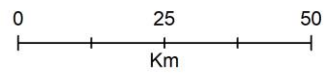
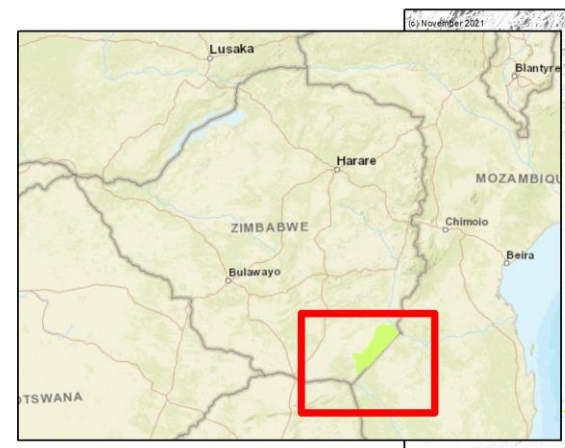
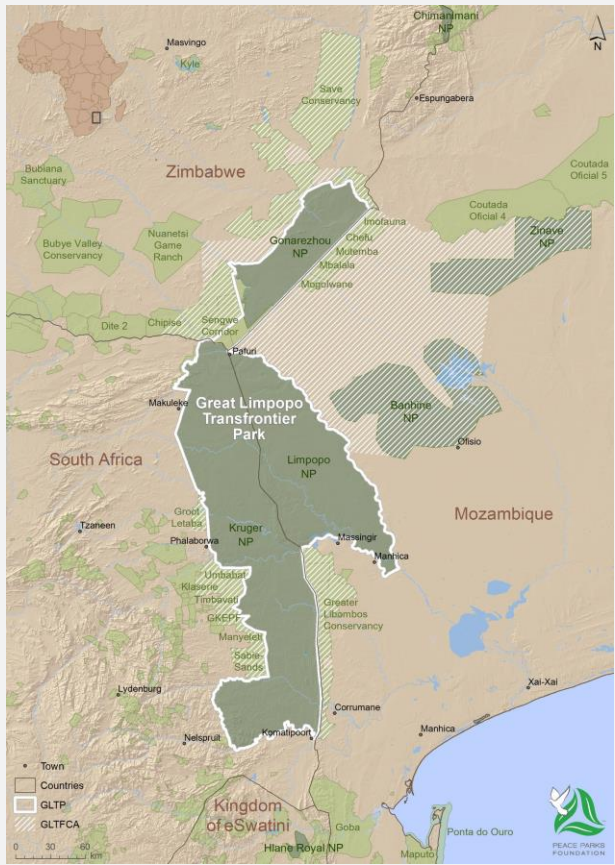
SAPIENZA
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Background

- Land has become **a limited resource**, and most animals are geographically isolated.
- Unfortunately, the elephants` range is declining due to **habitat fragmentation** associated with land use systems.
- Within the GLTFCA, GNP represents a **formally protected** (core) area that is surrounded by land use systems (buffers) of varying degrees of protection.
- These `buffers` present various threats to **wildlife dispersal** opportunities and this isolates the GNP elephant population, likely contributing to the consistently high growth rate.
- The **influence of elephants** on the decline of tree species and the degradation of vegetation types in GNP has been recorded (*Tafangenyasha 2001, Gandiwa et al. 2012, Kupika et al. 2014, O`Connor et al. 2024*).
- The **dispersal of elephants** from GNP to neighbouring PAs such as Zinave and Banhine in Mozambique is important to avoid further habitat degradation.



- Dry savanna - (552mm mean annual rainfall 2016 to 2022)
- 2.22 Elephants per sq.km - (2022 survey)

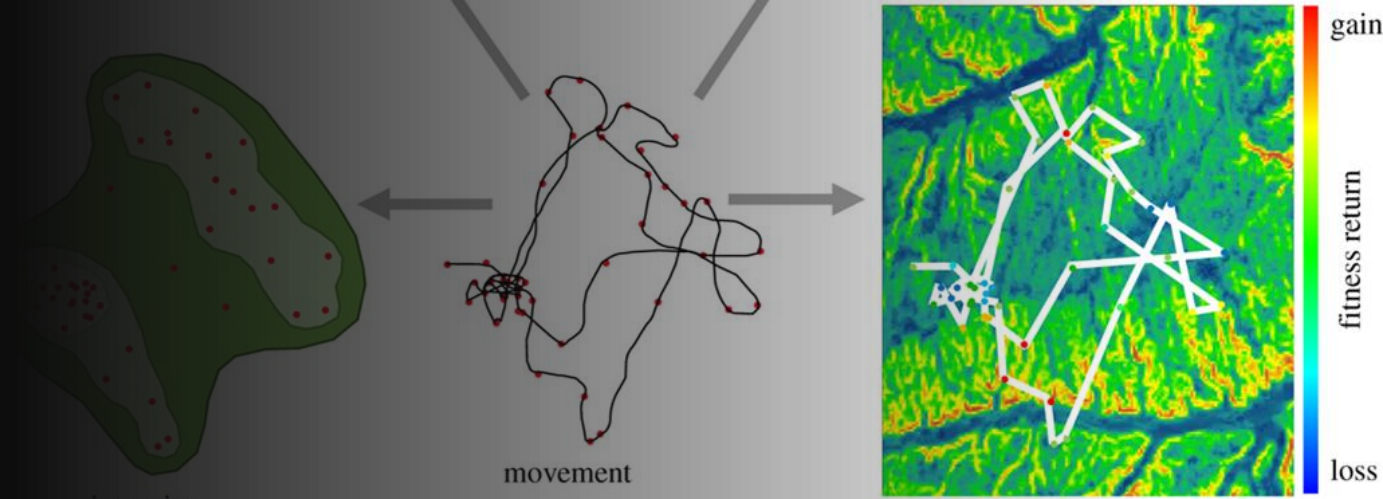
The background of the slide is a photograph of a savanna landscape. In the foreground, there is a large, weathered rock formation with a prominent vertical crack. The ground is dry and sandy with sparse, low-lying vegetation. In the middle ground, a wide, sandy riverbed or dry river channel winds through the landscape. The background shows a vast, open plain under a sky with scattered, light-colored clouds. The overall lighting is soft, suggesting either early morning or late afternoon.

The overall objectives of this study were to:

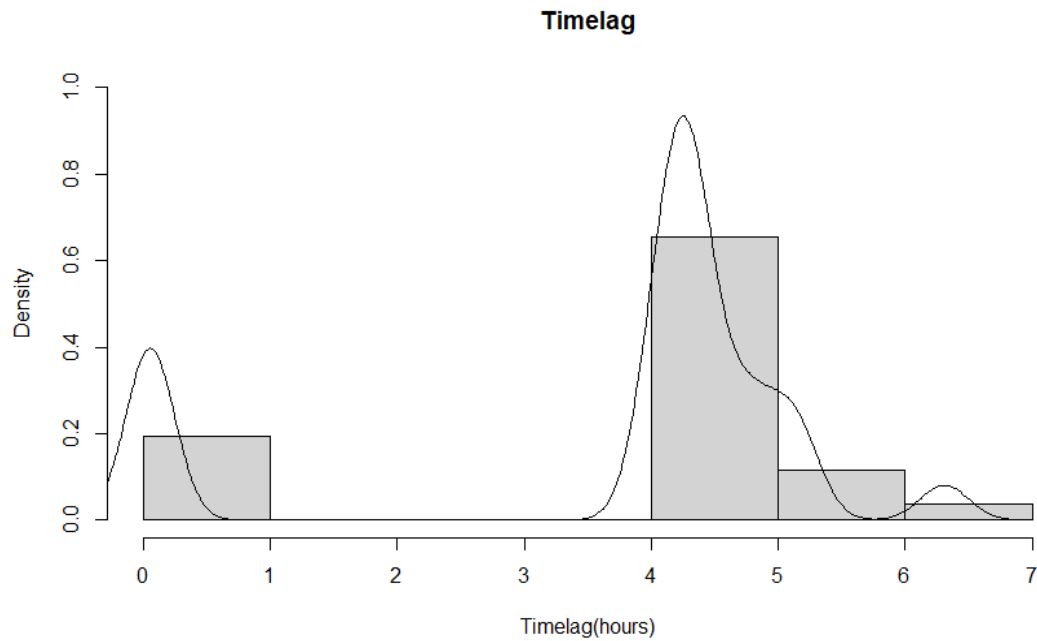
- i) establish how environmental variables (distance from water, and vegetation productivity) influence space use of elephants across seasons.
- ii) investigate the extent to which male and female elephants used landscapes outside GNP, focusing on the effects of season and landcover types on the likelihood of elephants dispersing outside the protected area.

Scope

- Collared elephants
- Choices of home range
- Movement patterns *vis-a-vis* Socio-environmental factors



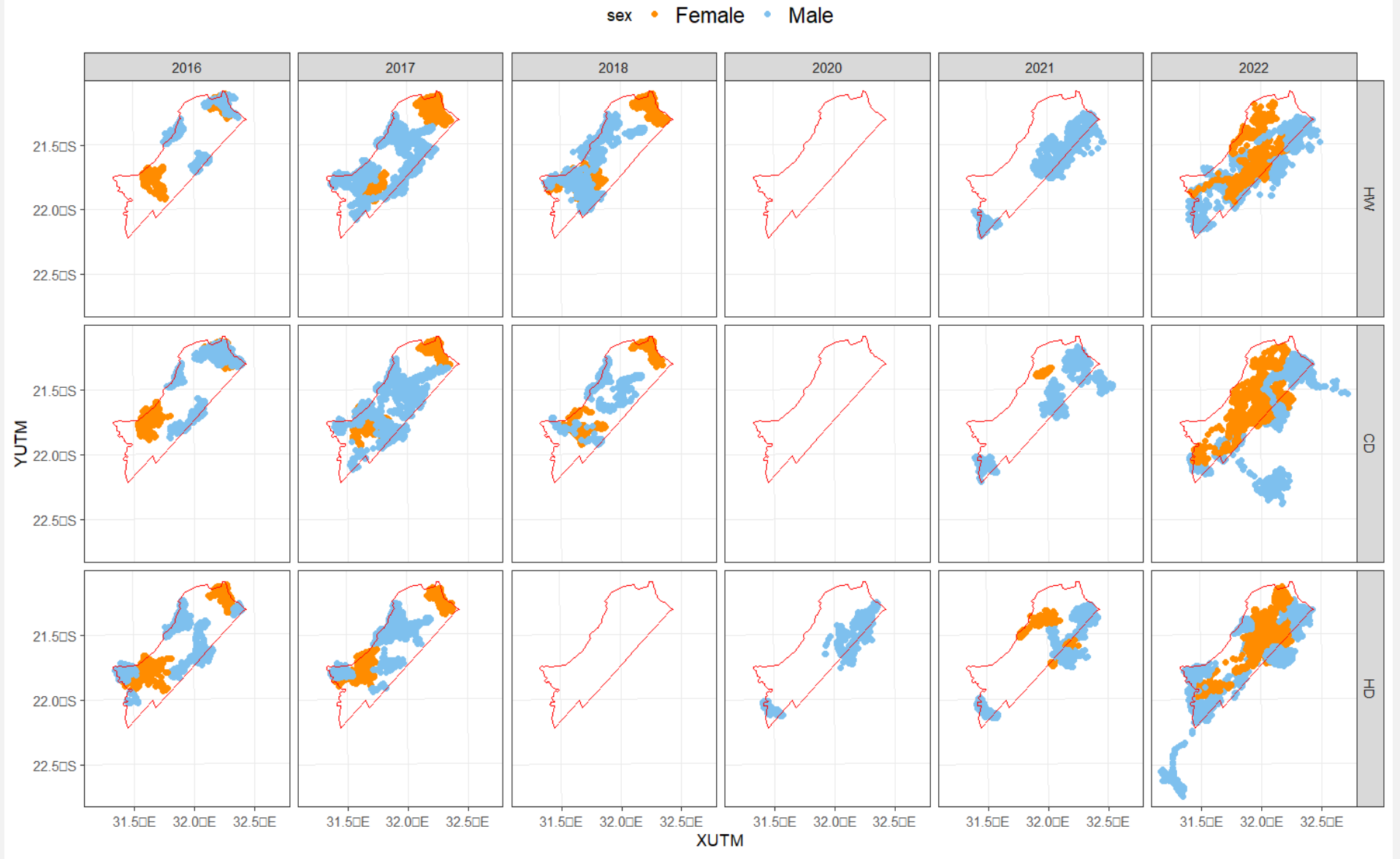
Elephant movement



Density distribution of time lags between data points (mean = 3.67, sd = 1.86)

- Elephants (n = 26) were collared between February 2016 and November 2022.
- 7 Female & 19 males
- 4 hour download intervals
- Average tracking period was 503 days (SD = 277)
- Telemetry locations were divided into three seasons and combined across years.
- Hot and wet (HW) season was defined as December - March
- Cool and dry (CD) as April - July inclusive,
- Hot and dry (HD) as August - November inclusive,

Extent of space use



A photograph of two elephants, an adult and a calf, silhouetted against a bright, hazy background of a forest at sunrise or sunset. The elephants are standing on a grassy bank, and the air is filled with mist or dust, creating a soft, golden glow. The trees are dense and their leaves are backlit by the sun, creating a dappled light effect.

Space use

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Inside the PA

Wanted to know...

- i) the variation in home range sizes between male and female elephants across seasons;
- ii) the overlap of the home ranges between consecutive seasons as a measure of spatial use intensity; and
- iii) how environmental variables (distance from water, and vegetation type and productivity) influence space use by elephants.



Data collection

Elephant collar data

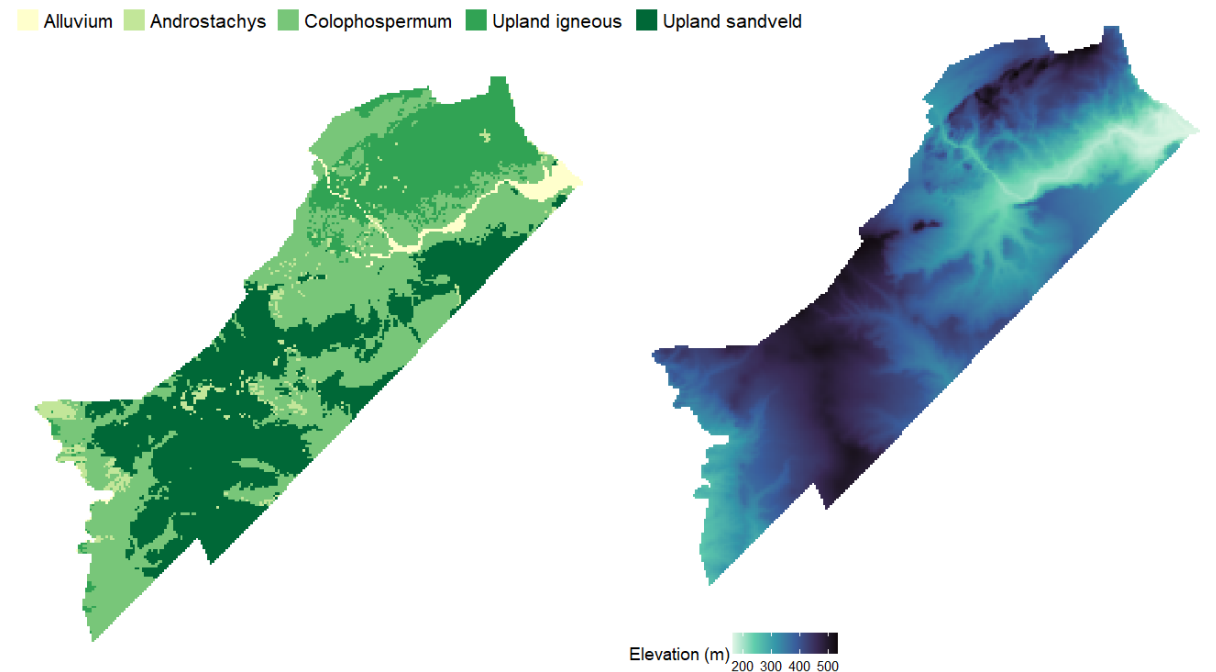
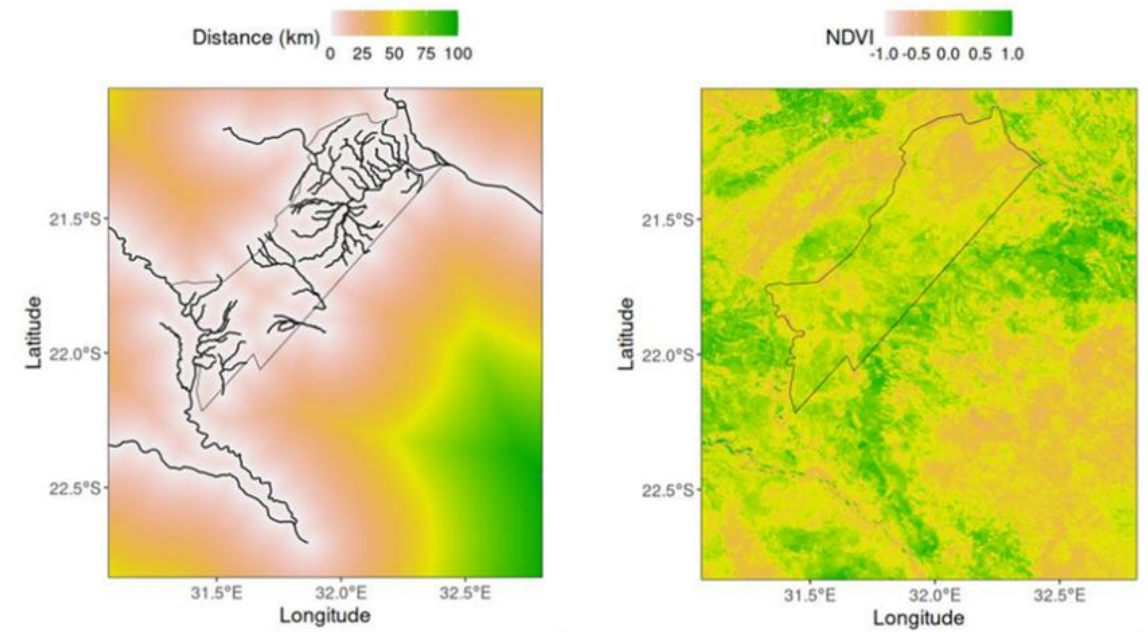
- Classified by season

Environmental variables

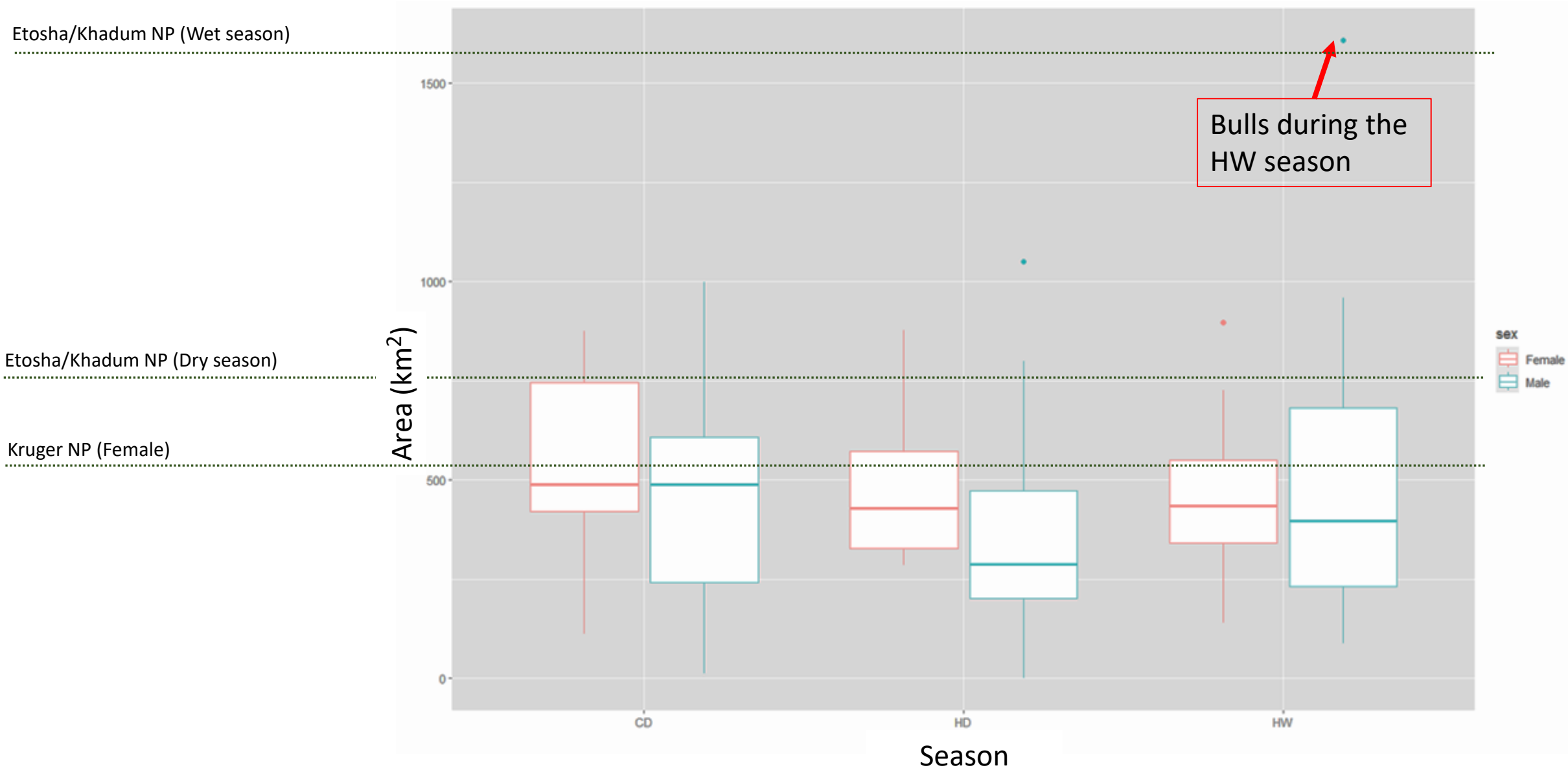
- NDVI
- Distance from water

Vegetation types

- GNP vegetation by Cunliffe et al. (2012)
- Reclassified into five categories



Home range analysis (KDE 95%)



Home range overlap (Bhattacharyya Affinity - BA, index)

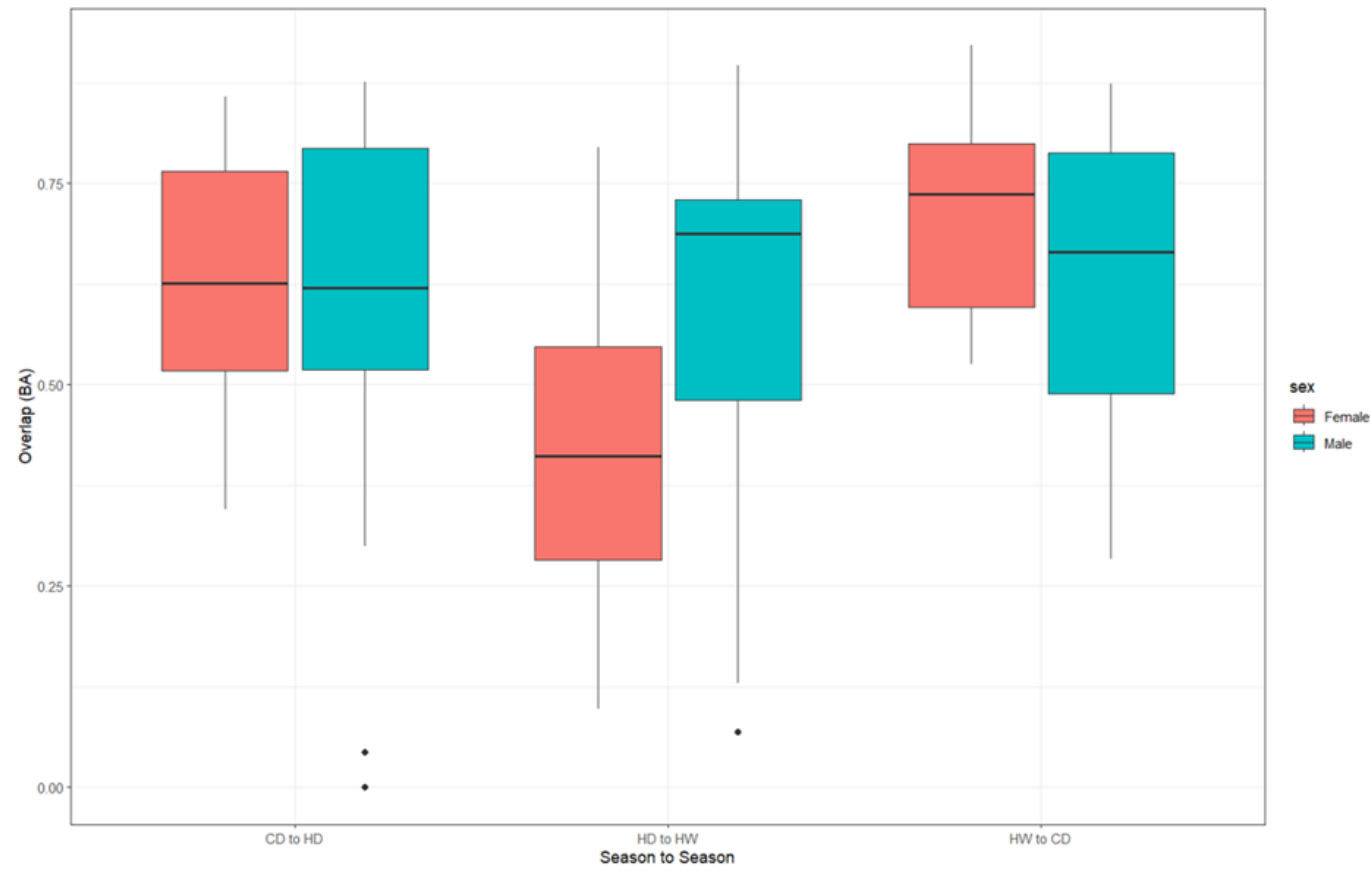


Table 2. Seasonal overlap of elephant home ranges by sex and based on the Bhattacharyya Affinity (BA) index. Seasons are: CD = cool dry, HD = hot dry, HW = hot wet. N = Number of combinations within the data for when there is a transition from one season to another, SD = Standard Deviation from the mean BA index, SE = Standard Error, CI = Confidence Interval.

| Seasonal transitions | Sex | N | BA index value | SD | SE | CI |
|----------------------|--------|----|----------------|-------|-------|-------|
| CD to HD | Female | 10 | 0.630 | 0.165 | 0.052 | 0.118 |
| CD to HD | Male | 20 | 0.589 | 0.248 | 0.055 | 0.116 |
| HD to HW | Female | 11 | 0.421 | 0.219 | 0.066 | 0.147 |
| HD to HW | Male | 32 | 0.583 | 0.219 | 0.039 | 0.079 |
| HW to CD | Female | 11 | 0.712 | 0.128 | 0.039 | 0.086 |
| HW to CD | Male | 25 | 0.623 | 0.179 | 0.036 | 0.074 |

Distance from water

- Results show that both male and female elephants remained relatively close to rivers (Table 3), with females remaining closer (mean = 1.82 km, SE = 0.023) during the HD season.
- Highest deviation by males during the CD season possibly using ephemeral pans and water courses

Table 3. Mean distance (km) of male and female elephants from major river systems in different seasons, based on composite data for 2016–2018 and 2020–2022. N = Number of elephant data points, SD = Standard Deviation, SE = Standard Error, CI = Confidence Interval.

| Season | Sex | N | Mean (km) | SD | SE | CI |
|--------|--------|--------|-----------|-------|-------|-------|
| HW | Female | 5,253 | 2.558 | 2.274 | 0.031 | 0.062 |
| | Male | 14,127 | 2.003 | 2.146 | 0.018 | 0.035 |
| CD | Female | 7,401 | 2.272 | 2.158 | 0.025 | 0.049 |
| | Male | 14,602 | 2.832 | 6.454 | 0.053 | 0.105 |
| HD | Female | 6,992 | 1.824 | 1.890 | 0.023 | 0.044 |
| | Male | 18,627 | 3.730 | 3.729 | 0.027 | 0.054 |

Vegetation types

- There was a significant difference ($\chi^2 = 6344$, $df = 4$, $p < 0.001$) in use of vegetation types by male and female elephants during different seasons.
- Males mostly used the *Colophospermum mopane* (62.9%) vegetation type, while
- The females used mainly Mopane (33%), Upland igneous (32.5%), and Upland sandveld (27.9%) vegetation types
- Both sexes used the Upland sandveld less during the dry seasons than during the wet season.

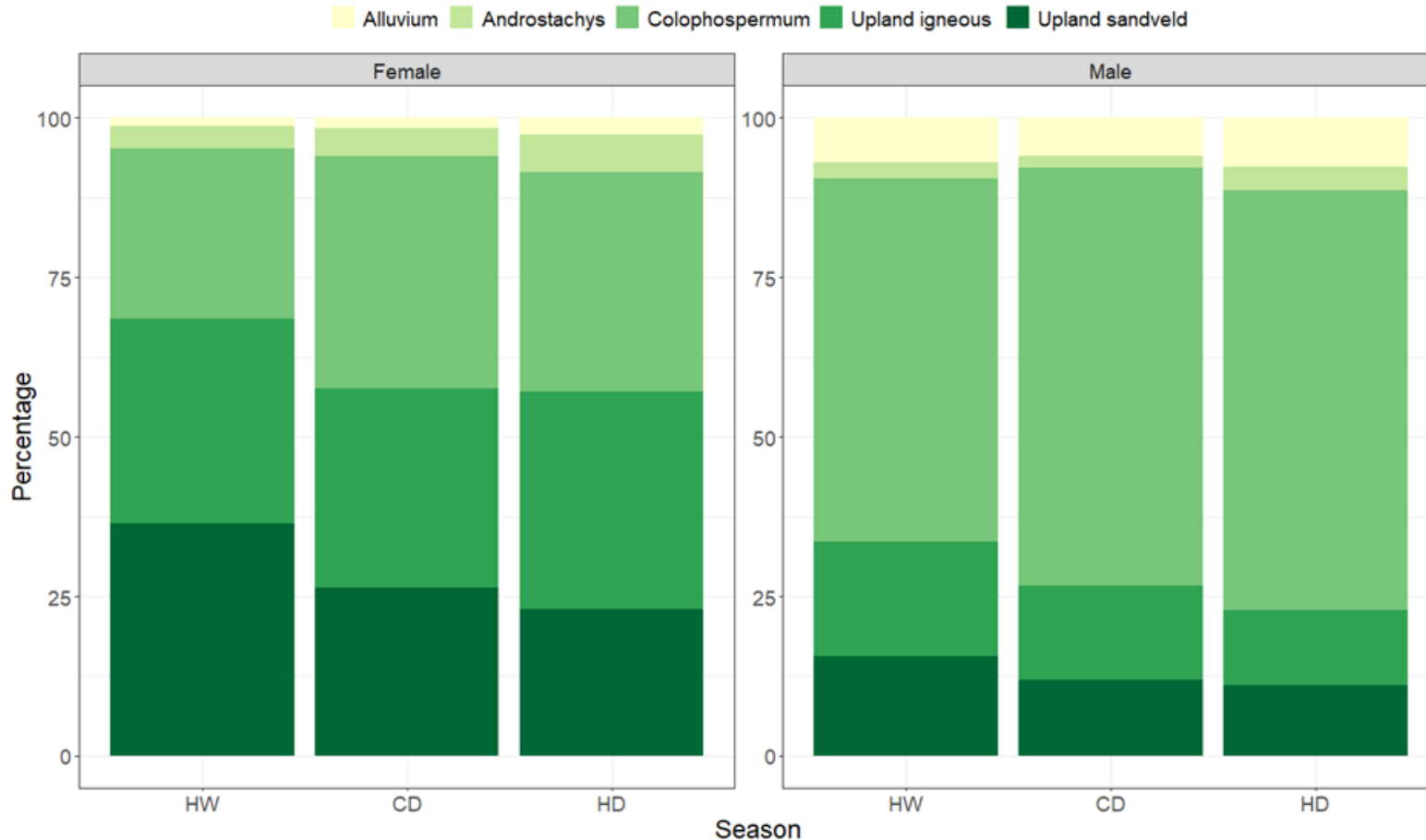


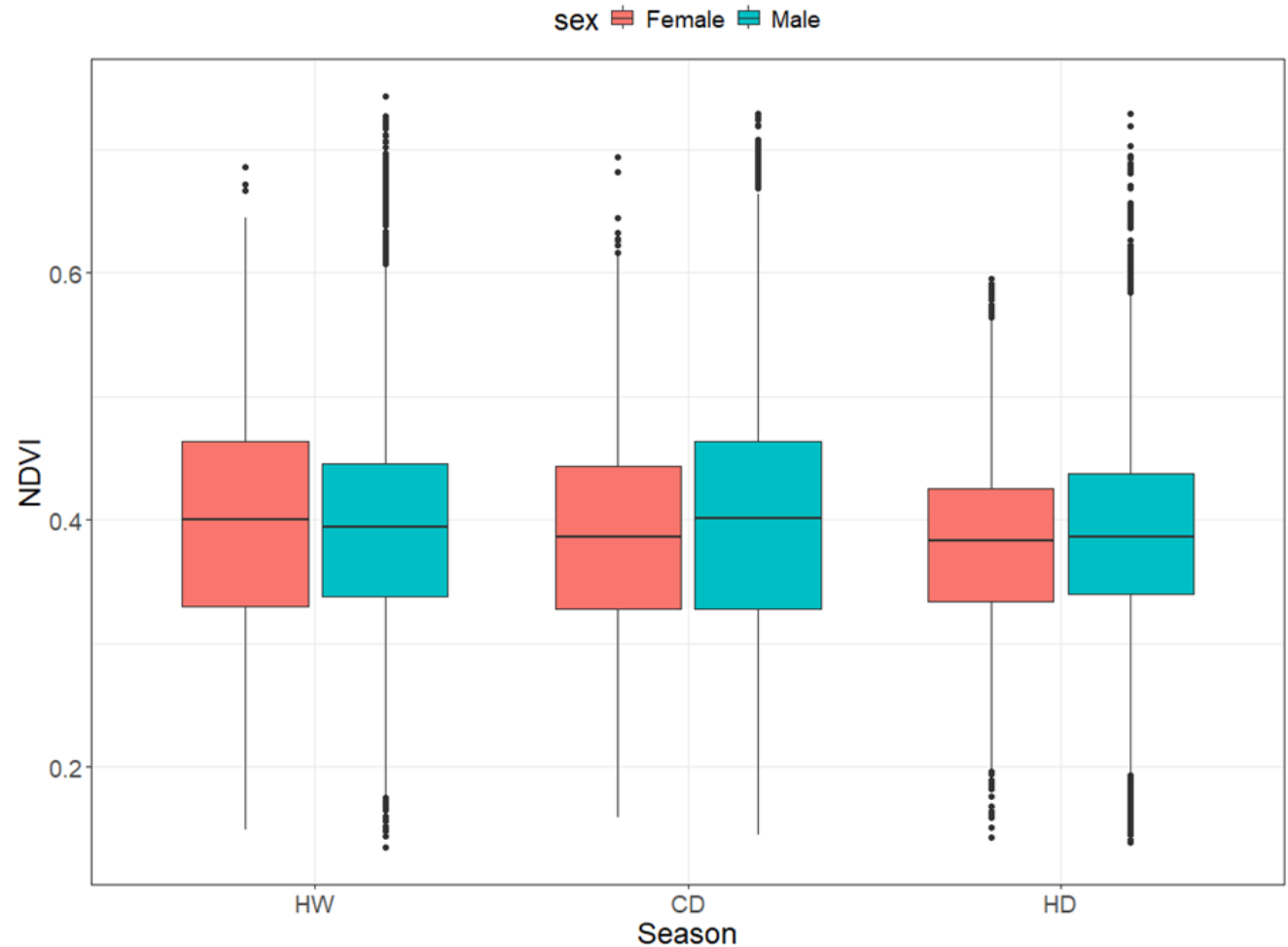
Table 4. Total utilization (%) of different vegetation types by female and male elephants over the entire study period.

| | Vegetation Type | | | | |
|--------|-----------------|---------------------|-----------------------|----------------|-----------------|
| | Alluvium | <i>Androstachys</i> | <i>Colophospermum</i> | Upland igneous | Upland sandveld |
| Female | 1.97 | 4.61 | 33.1 | 32.5 | 27.9 |
| Male | 6.99 | 2.8 | 62.9 | 14.6 | 12.7 |

Vegetation productivity

- Both males and females utilized areas with moderately green vegetation across all seasons
- Complex link between NDVI and vegetation quality

*They can find these areas without having to change the location of their home ranges largely!





Space use

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Outside the PA

Wanted to know...

- i. the extent to which male and female elephants utilise the landscapes outside GNP,
- ii. if season, and landcover types influence the likelihood of elephants dispersing outside the protected area,
- iii. if time of day had an impact on how elephants used landscapes in Mozambique and Sengwe communal lands as a way of assessing differences in behaviour of elephants when ranging within non-protected areas of varying human densities.



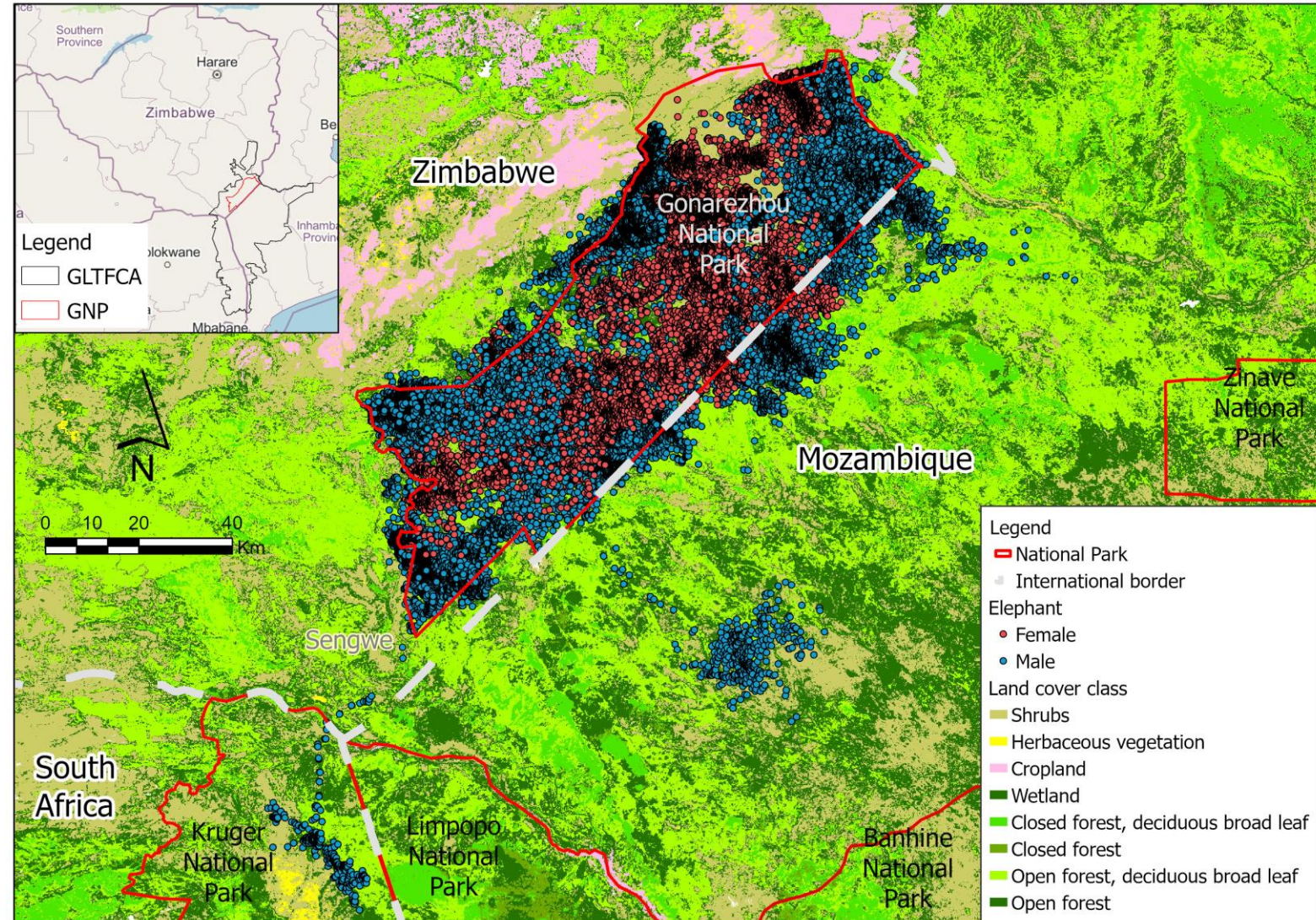
Data collection

Elephant collar data

- Classified by season
- Classified by time of day
- Classified by location

Land cover data

- ESA, 2019 Collection 2 Copernicus Global Land Service (CGLS)

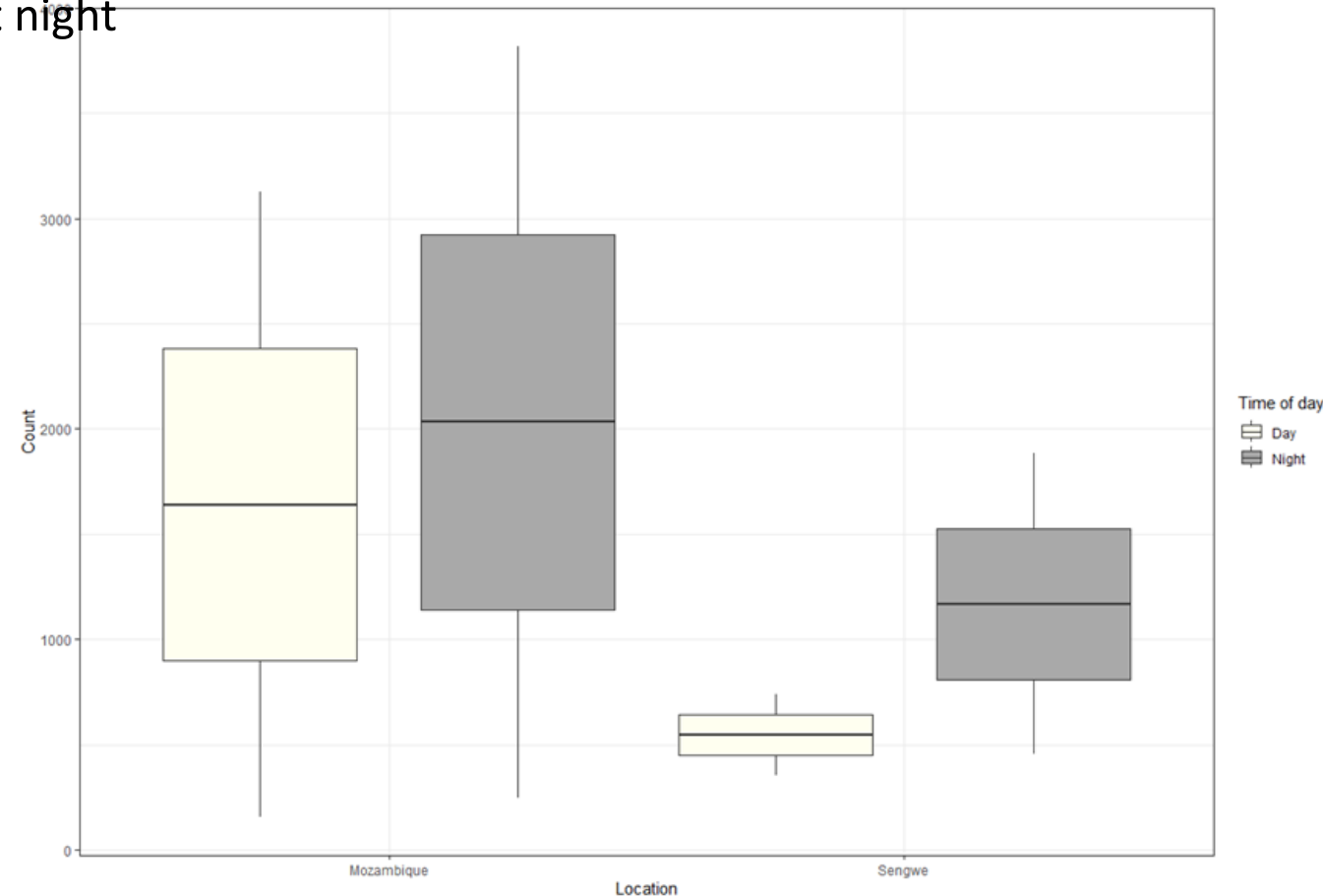


Landscape use — Sengwe vs Mozambique

- High fidelity to GNP - 84.5% of the time tracked was spent inside the park
- Time of day & location significantly influenced the study individuals' utilization of the Mozambique or Sengwe landscape.
- The Sengwe landscape accounted for 31.83% of the total elephant activity outside GNP with 68.17% of elephant location data being within Mozambique.
- Elephant activity in Sengwe, significantly occurred at night

Table 2: P-values from the ANOVA (poisson regression with log link) showing significant differences (p-value < 0.05) in the expected number of observations of elephants by daytime (Day or Night) and location (Sengwe or Mozambique).

| Source of variation | Estimate | SE | Z value | P value |
|---------------------------------|----------|---------|---------|------------|
| (Intercept) | 7.40276 | 0.01746 | 424.03 | <2e-16 *** |
| Daytime-Night | 0.21427 | 0.02347 | 9.13 | <2e-16 *** |
| Location-Sengwe | -1.09922 | 0.03492 | -31.48 | <2e-16 *** |
| Daytime-Night : Location-Sengwe | 0.54568 | 0.04352 | 12.54 | <2e-16 *** |



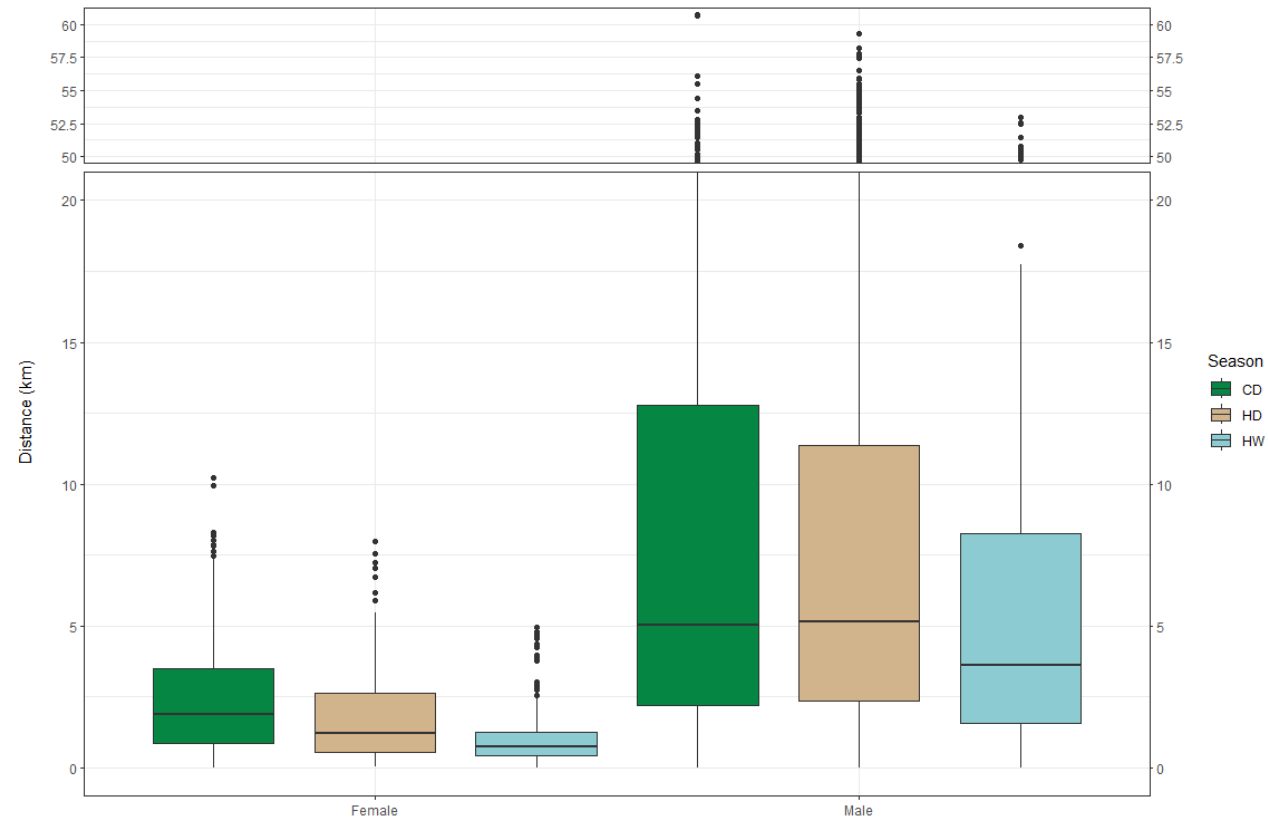
Distanced travelled outside the PA

- Distances travelled by the elephants were significantly different between all seasons for both males and females, and
- Males travelled significantly longer distances than females during all three seasons (Table 4),
- Though during the HW season, both sexes travelled the least away from the Park
- Females remained within a 15km radius from the park boundary whilst males travelled up to 60km.

*Implications on connectivity?

Table 4: P-values from the ANOVA (log-linear regression model), showing that the likelihood of going far from the Park (given that the elephant went outside) significantly (p -value < 0.05) varied by sex (Male or Female) and season (HD, HW, CD). With Sex = 'Female' and Season = 'CD' as reference category.

| Source of variation | Estimate | SE | T value | P value |
|----------------------|----------|---------|---------|----------------|
| (Intercept) | 7.16989 | 0.06173 | 116.142 | $< 2e-16$ *** |
| Sex-Male | 0.76579 | 0.06697 | 11.435 | $< 2e-16$ *** |
| Season-HD | -0.49609 | 0.10652 | -4.657 | $3.25e-06$ *** |
| Season-HW | -0.95084 | 0.10931 | -8.698 | $< 2e-16$ *** |
| Sex-Male : Season-HD | 0.46777 | 0.11266 | 4.152 | $3.32e-05$ *** |
| Sex-Male : Season-HW | 0.53495 | 0.11631 | 4.599 | $4.29e-06$ *** |



Landcover types (In and Outside the park)

- There was a significant difference in the landcover types that were utilised by elephants when they were inside vs outside the park ($\chi^2 = 5712$, $df = 7$, $p\text{-value} < 0.05$).
- When outside the Park, males utilised more of the forested land cover types and less of shrublands,
- Whereas when outside females remained in shrublands similar to areas they utilised when inside the park.

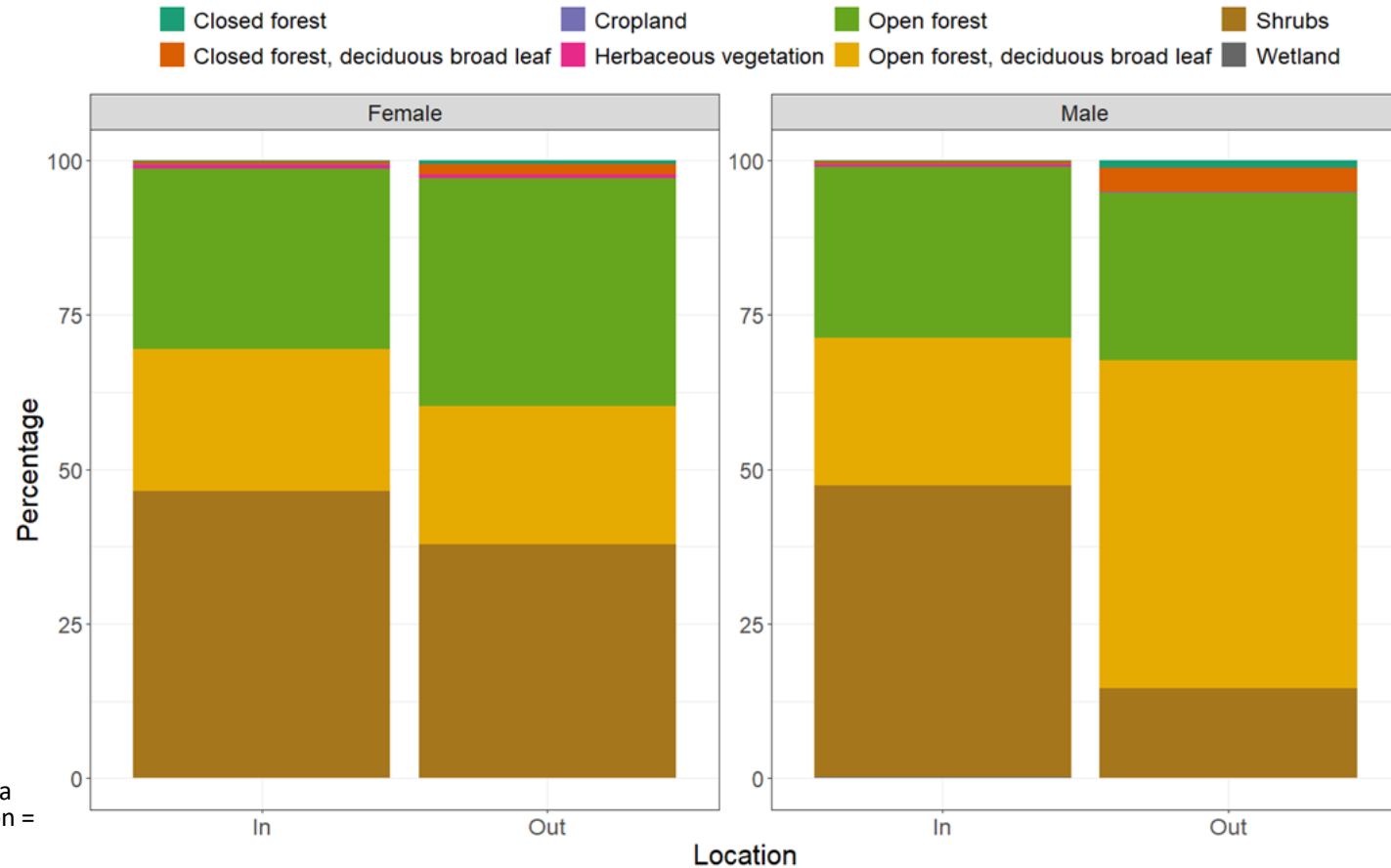


Table 3: P-values for differences between sex, location, and their joint effect resulting from a multinomial logistic regression having Sex='Female', Landcover = 'Closed forest' and Location = 'In' as the reference category. *P-value > 0.05

| | (Intercept) | sexMale | locationOut | sexMale:locationOut |
|-------------------------------------|-------------|---------|-------------|---------------------|
| Closed forest, deciduous broad leaf | 0.000 | 0.027 | 0.589* | 0.140* |
| Cropland | 0.568* | 0.005 | 0.702* | 0.757* |
| Herbaceous vegetation | 0.000 | 0.000 | 0.015 | 0.001 |
| Open forest | 0.000 | 0.033 | 0.004 | 0.200* |
| Open forest, deciduous broad leaf | 0.000 | 0.091* | 0.000 | 0.193* |
| Shrubs | 0.000 | 0.069* | 0.000 | 0.003 |
| Wetland | 0.001 | 0.001 | 0.453* | 0.009 |

Key takeaways

- This study examined how collared elephants in the GNP used their space.
- The results showed that most of the space used was within the boundaries of the PA (84%)
- Mozambique is utilized more than the Sengwe corridor to Kruger NP.
- Elephants retained at least 60% of their home range between consecutive seasons. Likely increasing their impact on certain vegetation communities.
- The high fidelity to GNP in this study might indicate to the success of this park in meeting elephant needs (possibly security and ecological).

Conclusion

- To achieve a **stable elephant population** growth rate in Gonarezhou NP, there is a need to consider immediate interventions for addressing barriers to the movement, to avoid the risk of escalating fragmentation of the landscape.
 - **Prioritise conservation** efforts and pilot projects to test the functionality of the Sengwe corridor.
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Thank you

