# Appendix

## Step by Step: Using Integrated Step Selection Analysis to Simulate Wild Dog Dispersal and Assess Landscape Connectivity

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**Running Title:** Release the Dogs! Simulating Wild Dog Dispersal to Assess Landscape Connectivity

**Keywords:** dispersal, simulation, movement, integrated step selection function, Kavango-Zambezi Transfrontier Conservation Area, landscape connectivity, Lycaon pictus

## A.1 Source Areas & Points

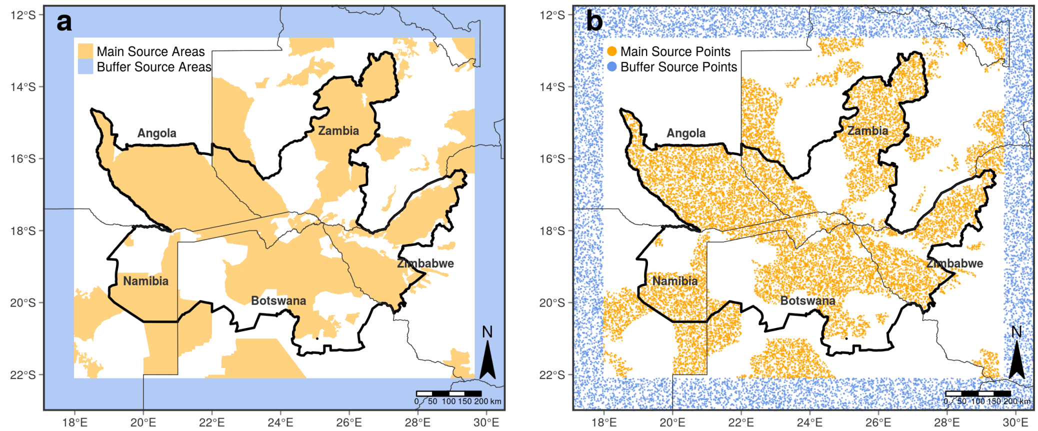


**Figure S1:** (a) Different source areas from which we released virtual dispersers. We only considered contiguous protected areas (national parks, game reserves, and forest reserves) that were larger than 700 km$^2$. This size corresponds to the average home range requirement for viable wild dog populations (Pomilia et al., 2015). To render potential immigrants into the study system, we also initiated dispersers within a buffer zone (blue) surrounding the main study area. (b) Source points from which dipsersers were released. 50'000 dispersers were released within the main study area (green dots) and another 30'000 dispersers within the virtual buffer (blue dots).

## A.2 Model Selection Results

**Table S1:** Results from the forward model selection procedure based on Akaike's Information Criterion (AIC; Burnham and Anderson, 2002). The model in the top row was the model that we used to simulate movement of dispersers. The base model upon which we based our movement model is depicted in the last row. We omitted all models with an AIC weight of zero from the table.

| Covariates | AIC | ΔAIC | Weight | LogLik |
|---|---|---|---|---|
| **Base Model** + sl:LA + WA:sl + log(sl):cos(ta) + DTW:cos(ta) + WO:sl + HI:cos(ta) + SH:sl + DTW:sl + sl:cos(ta) | 89392.88 | 0.00 | 0.15 | -44670.44 |
| **Base Model** + sl:LA + WA:sl + log(sl):cos(ta) + DTW:cos(ta) + WO:sl + HI:cos(ta) + SH:sl + DTW:sl + sl:cos(ta) + SH:log(sl) | 89393.92 | 1.04 | 0.09 | -44669.96 |
| **Base Model** + sl:LA + WA:sl + log(sl):cos(ta) + DTW:cos(ta) + WO:sl + HI:cos(ta) + SH:sl + DTW:sl + sl:cos(ta) + DTW:log(sl) | 89394.13 | 1.25 | 0.08 | -44670.06 |
| **Base Model** + sl:LA + WA:sl + log(sl):cos(ta) + DTW:cos(ta) + WO:sl + HI:cos(ta) + SH:sl + DTW:sl + sl:cos(ta) + WO:log(sl) | 89394.25 | 1.37 | 0.08 | -44670.13 |
| **Base Model** + sl:LA + WA:sl + log(sl):cos(ta) + DTW:cos(ta) + WO:sl + HI:cos(ta) + SH:sl + DTW:sl | 89394.36 | 1.48 | 0.07 | -44672.18 |
| **Base Model** + sl:LA + WA:sl + log(sl):cos(ta) + DTW:cos(ta) + WO:sl + HI:cos(ta) + SH:sl + DTW:sl + sl:cos(ta) + log(sl):LA | 89394.44 | 1.56 | 0.07 | -44670.22 |
| **Base Model** + sl:LA + WA:sl + log(sl):cos(ta) + DTW:cos(ta) + WO:sl + HI:cos(ta) + SH:sl + DTW:sl + sl:cos(ta) + HI:sl | 89394.56 | 1.68 | 0.07 | -44670.28 |
| **Base Model** + sl:LA + WA:sl + log(sl):cos(ta) + DTW:cos(ta) + WO:sl + HI:cos(ta) + SH:sl + DTW:sl + sl:cos(ta) + WA:log(sl) | 89394.57 | 1.69 | 0.07 | -44670.29 |
| **Base Model** + sl:LA + WA:sl + log(sl):cos(ta) + DTW:cos(ta) + WO:sl + HI:cos(ta) + SH:sl + DTW:sl + sl:cos(ta) + WO:cos(ta) | 89394.59 | 1.71 | 0.07 | -44670.30 |
| **Base Model** + sl:LA + WA:sl + log(sl):cos(ta) + DTW:cos(ta) + WO:sl + HI:cos(ta) + SH:sl + DTW:sl + sl:cos(ta) + WA:cos(ta) | 89394.63 | 1.75 | 0.06 | -44670.31 |
| **Base Model** + sl:LA + WA:sl + log(sl):cos(ta) + DTW:cos(ta) + WO:sl + HI:cos(ta) + SH:sl + sl:cos(ta) | 89394.68 | 1.80 | 0.06 | -44672.34 |
| **Base Model** + sl:LA + WA:sl + log(sl):cos(ta) + DTW:cos(ta) + WO:sl + HI:cos(ta) + SH:sl + DTW:sl + sl:cos(ta) + HI:log(sl) | 89394.69 | 1.81 | 0.06 | -44670.35 |
| **Base Model** + sl:LA + WA:sl + log(sl):cos(ta) + DTW:cos(ta) + WO:sl + HI:cos(ta) + SH:sl + DTW:sl + sl:cos(ta) + SH:cos(ta) | 89394.84 | 1.96 | 0.06 | -44670.42 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| **Base Model**: cos(ta) + sl + log(sl) + WA + WO + DTW + HI + SH | 90091.40 | 787.67 | 0.00 | -45030.70 |

*Note:* ta = Turning Angle, sl = Step Length, LA = Low Activity, WA = Water, DTW = Distance To Water, SH = Shrubs/Grassland, WO = Woodland, HI = Human Influence.

## A.3 Movement Model Interpretation

To ease with the interpretation of the most parsimonious movement model, we followed recommendations published in Fieberg et al. (2020) and produced a series of plots highlighting how the habitat and movement kernel depended on covariate values (Figure S2). To visualize the movement kernel and its interactions with other covariates, we used model estimates and updated our tentative distribution parameters for turning angles (von Mises distribution with concentration $\kappa = 0$) and step lengths (gamma distribution with scale $\theta =$ 6'308 and shape $k = 0.37$) by applying the function `update_vonmises()` from the R-package `amt` (Signer et al., 2019). This allowed us to compute probability densities of turning angles and step lengths under varying values of the associated covariates, while holding all other covariates constant (Figure S2, a1-a8). Moreover, we investigated the habitat kernel by computing relative selection strengths (RSS) between a set of steps where values of the covariate of interest was varied to a reference step where the covariate value was fixed to its centered value. To illustrate model uncertainty, we also generated large-sample confidence intervals using standard errors associated with each model estimate (Figure S2, b1-b5).

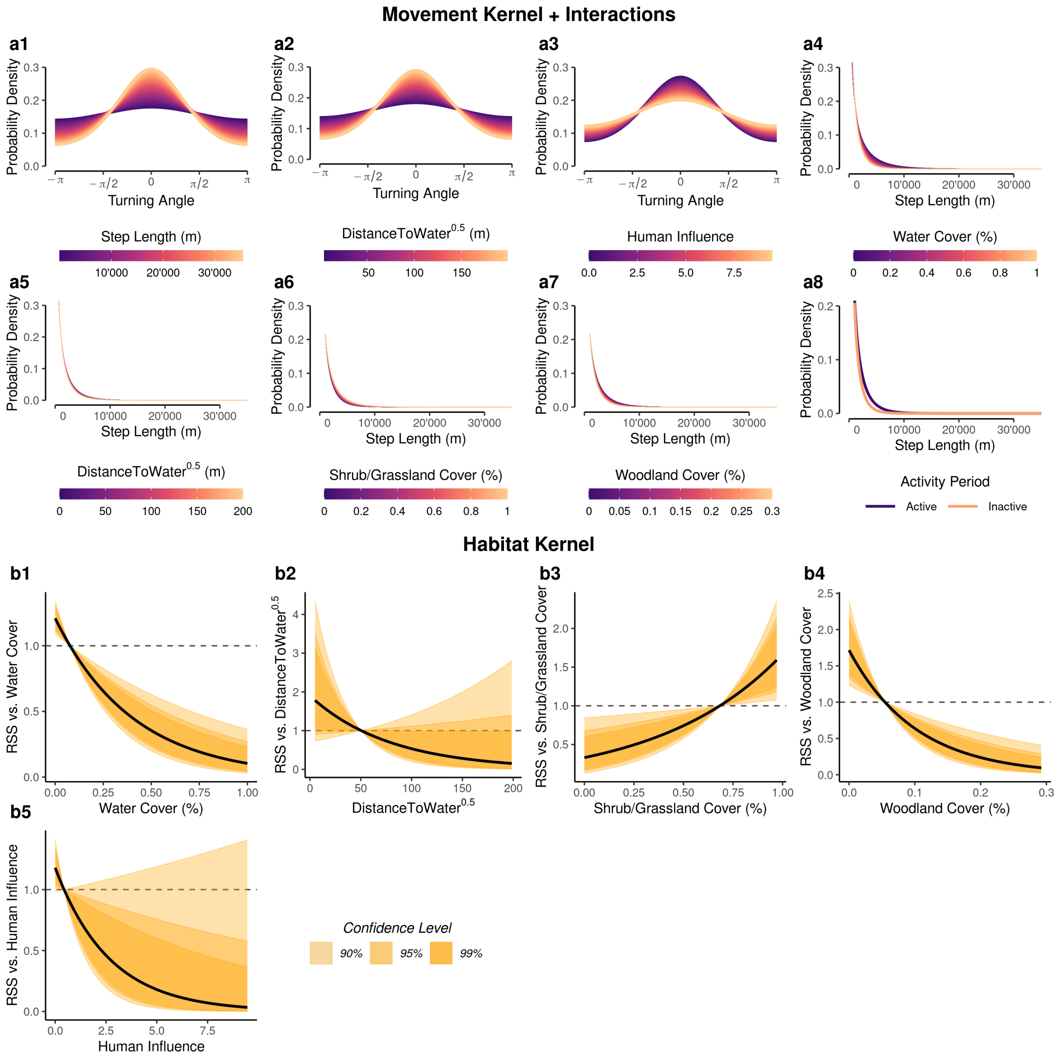


**Figure S2:** Auxiliary plots that help with the interpretation of the most parsimonious movement model from Table S1. The plots were generated following recommendations reported in Fieberg et al. (2020). Subplots **a1** to **a8** highlight dispersing wild dogs' movement kernel and indicate how the kernel is influenced by interactions with other covariates. Subplots **b1** to **b5** depict results from dispersing wild dogs' habitat kernel and highlight differences in predicted relative selection scores (RSS) when varying values of the covariate of interest. For each covariate, predictions were made on the range of values that was observed in the real data, assuming that all other covariates were centered and that steps were realized during periods of "high" wild dog activity. Plot a1, for example, can be interpreted as follows: the probability of realizing a step with a low turning angle is much higher when the corresponding step is large. Moreover, b1 can be interpreted as follows: relative probability of using a step decreases as the amount of water cover along the step increases.

## A.4 Heatmaps in Relation to Number of Simulated Steps

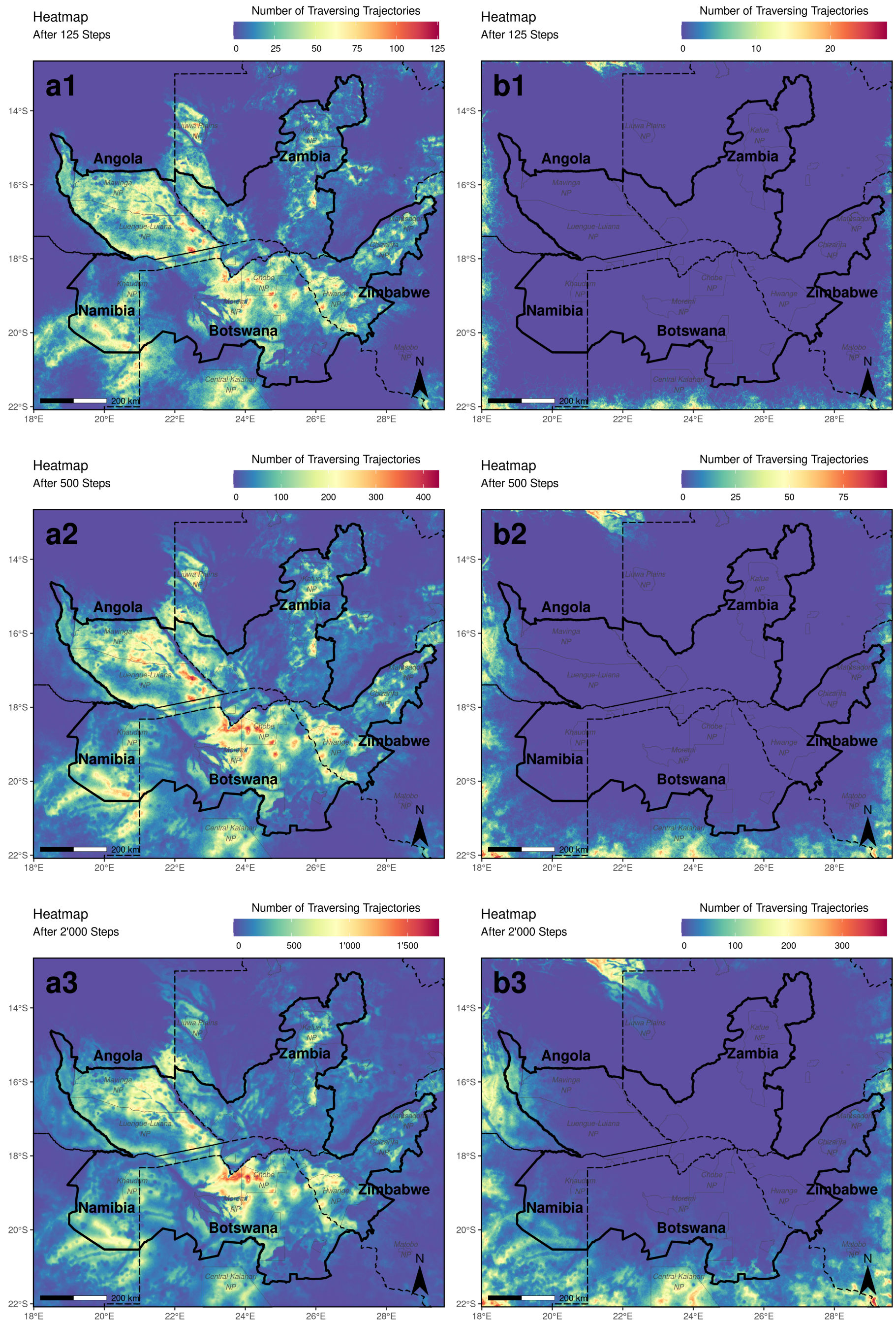


**Figure S3:** Heatmaps produced when considering 125, 500, and 2000 simulated steps, respectively. The left panel (a1, a2, a3) was generated based on simulations initiated within the main study area, the right panel (b1, b2, b3) was generated based on simulations initiated within the buffer area. To produce the heatmap presented in the main manuscript (Figure 5), we tallied the values from maps a3 and b3.

## A.5 Betweenness Maps in Relation to Number of Simulated Steps

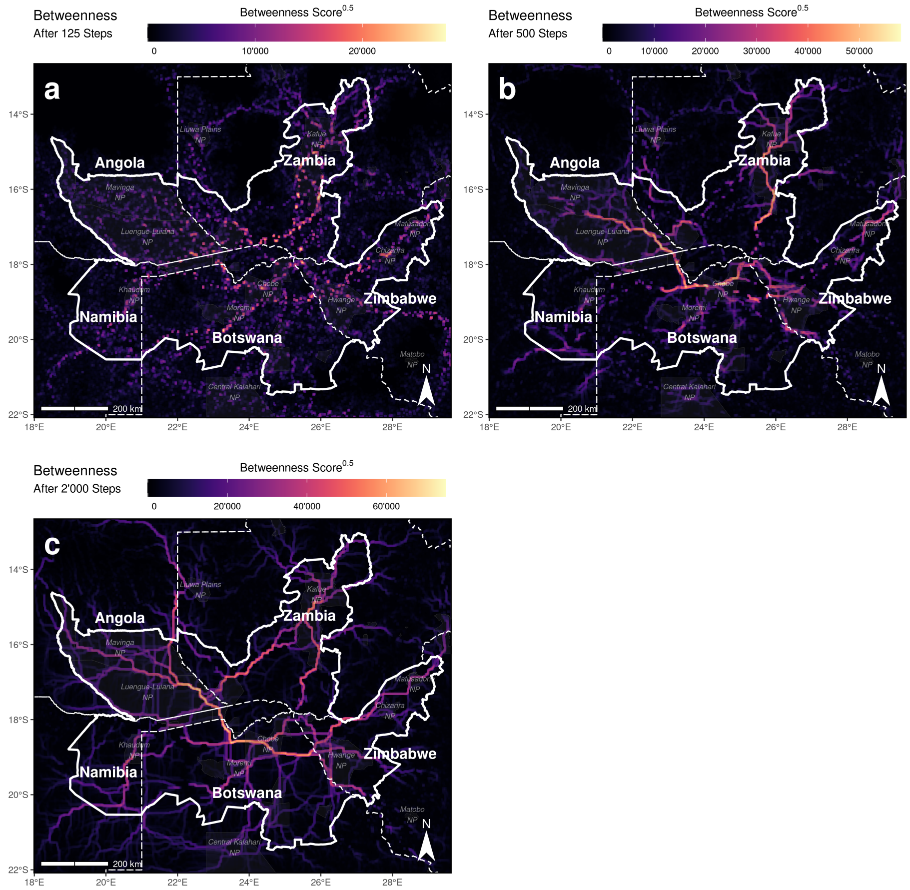


**Figure S4:** Maps of betweenness scores produced when considering (a) 125, (b) 500, (c) and 2000 simulated steps, respectively. A high betweenness score indicates that the respective area has a high importance for linking other regions in the study area.

# References

Burnham, K. P. and Anderson, D. R. (2002). *Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach*. Springer Science & Business Media, Ney York, NY, USA.

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