Simulating Space Use

Johannes Signer & Brian Smith

November 2022

Why to simulate?

Different end products are available:

1. The individual path
2. Where is the animal next?

Some times we are aiming to **Utilization Distribution** (UD).
The UD is defined as:

> *The two-dimensional relative frequency distribution of space use of an animal (Van Winkle 1975)*

We can distinguish between two different UDs:

1. Transient UD (TUD) is the expected space-use distribution over a short time period and is thus sensitive to the initial conditions (e.g., the starting point).

2. Steady state UD (SSUD) is the long-term (asymptotically infinite) expectation of the space-use distribution across the landscape.

Think-pair-share: Can we use a HSF/RSF to predict a possible path of the animal.

Predicting space use from HSF

From HSF we can only estimate a SSUD. This is done by using the following formula

$$UD(s_j) = \frac{w(s_j)}{\sum_{j=1}^{G} w(s_j)} = \frac{\exp(\sum_{i=1}^{n} \beta_i x_i(s_j))}{\sum_{j=1}^{G} \exp(\sum_{i=1}^{n} \beta_i x_i(s_j))}$$

The intercept (β_0) is **not** included.

For iSSF this a bit more complicated

If we take the same approach for iSSFs, we introduce a **bias** because we are neglecting conditional formulation of iSSFs when creating maps.

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Estimating utilization distributions from fitted step-selection functions

Johannes Signer, John Fieberg, Tal Avgar

First published: 11 April 2017 | https://doi.org/10.1002/ecs2.1771 | Citations: 24

Corresponding Editor: Lucas N. Joppa.

- Simulations were used to compare two approaches:
  - naive
  - simulation-based

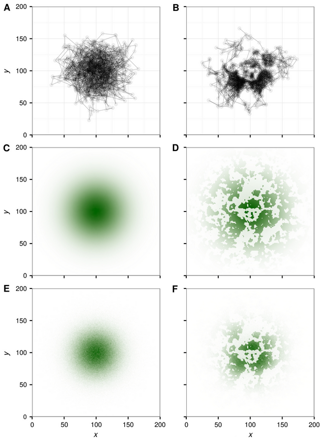

Figure 1: Source Signer et al. 2017

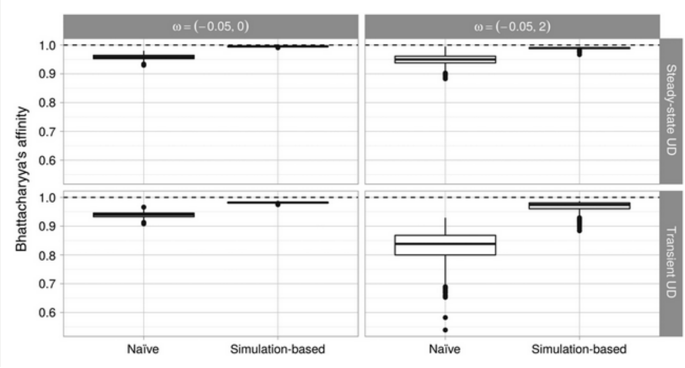

Figure 2: Source Signer et al. 2017

The bias becomes even worse if selection is stronger:

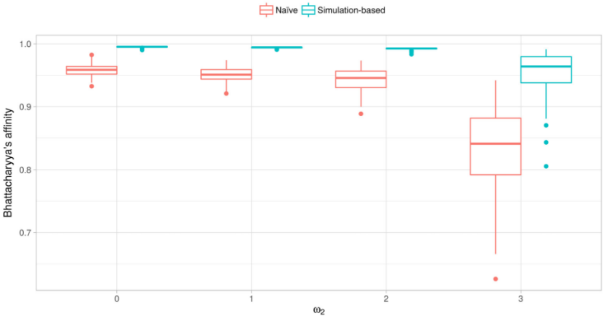

Figure 3: Source Signer et al. 2017

This bias propagates through derived quantities (e.g., home-range size)

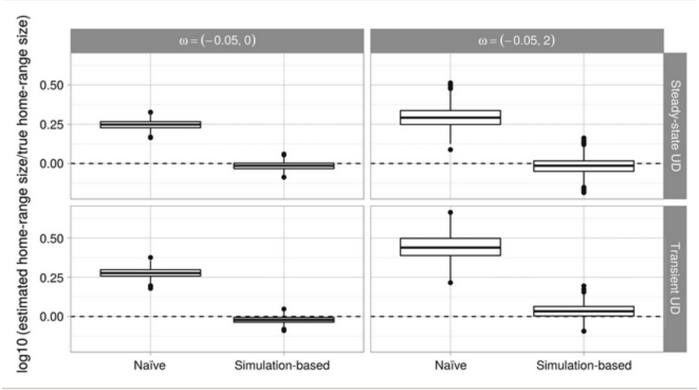

Figure 4: Source Signer et al. 2017

Take-home messages

- Simulation allow us to predict space-use in the long term, novel environment or other individuals.
- For iSSA it is important to acknowledge the conditional formulation.
- We can acknowledge the conditional formulation by using simulations.

- Simulating space use from fitted iSSFs received a lot of interest.

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Methods in Ecology and Evolution BRITISH ECOLOGICAL SOCIETY

RESEARCH ARTICLE

Parametrizing diffusion-taxis equations from animal movement trajectories using step selection analysis

Jonathan R. Potts, Ulrike E. Schlägel

First published: 17 May 2020 | **https://doi.org/10.1111/2041-210X.13406** | Citations: 8

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MICHAEL J. HOOKER, JOSEPH D. CLARK, BOBBY T. BOND, MICHAEL J. CHAMBERLAIN

First published: 08 April 2021 | https://doi.org/10.1002/jwmg.22041

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Research | Open Access | Published: 08 April 2022

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Jesse Whittington, Mark Hebblewhite, Robin W. Baron, Adam T. Ford & John Paczkowski

Movement Ecology **10**, Article number: 17 (2022) | Cite this article

1652 Accesses | **264** Altmetric | Metrics

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Methods in Ecology and Evolution | BRITISH ECOLOGICAL SOCIETY

RESEARCH ARTICLE | Open Access

Assessing the predictive power of step selection functions: How social and environmental interactions affect animal space use

Jonathan R. Potts, Luca Börger, Bronson K. Strickland, Garrett M. Street

First published: 24 May 2022 | https://doi.org/10.1111/2041-210X.13904

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Received: 19 July 2022 | Accepted: 16 October 2022
DOI: 10.1111/1365-2656.13832

Journal of Animal Ecology BRITISH ECOLOGICAL SOCIETY

RESEARCH METHODS GUIDE

How to scale up from animal movement decisions to spatiotemporal patterns: An approach via step selection

Jonathan R. Potts[1] | Luca Börger[2,3]

The iSSF (again)

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The **redistribution kernel** consists of two components:

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The **redistribution kernel** consists of two components:

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2. Habitat covariates are weighted with the selection coefficients to obtain the movement-free habitat-selection function.
3. The selection-free movement kernel and the movement-free selection-function are then multiplied and normalized.

What is next?

- We can either work with the redistribution kernels for each relocation, or
- sample one location as the next point to move to. This could be repeated many times and we can simulate a new track from the model that we fitted.

Case study

To illustrate the use of simulation, we fitted an iSSF to tracking data of a single African buffalo[1,2].

[1] For details of the data see: Getz et al. 2007 LoCoH: Nonparameteric kernel methods for constructing home ranges and utilization distributions. PLoS ONE

[2] Cross et al. 2016. Data from: Nonparameteric kernel methods for constructing home ranges and utilization distributions. Movebank Data Repository. DOI:10.5441/001/1.j900f88t.

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3. **River model**: `case_ ~ cos(ta_) + sl_ + log(sl_) + water_dist_end + x2_ + y2_ + I(x2_^2 + y2_^2) + I(water_crossed_end != water_crossed_start)`

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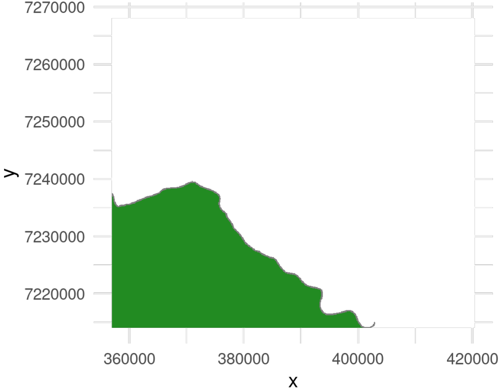
The setting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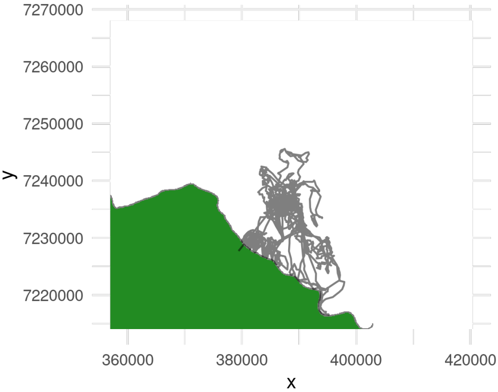
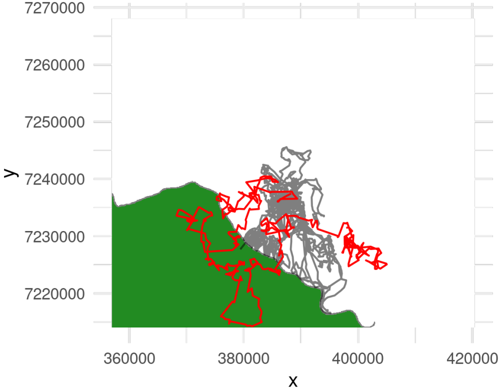
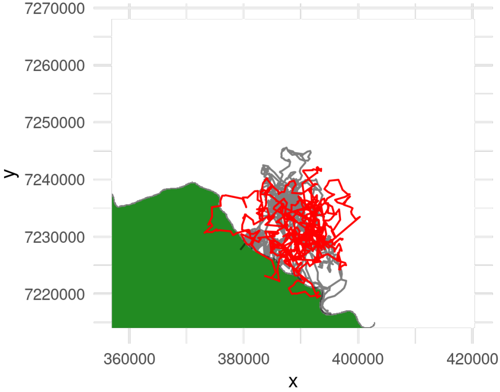
The observed track



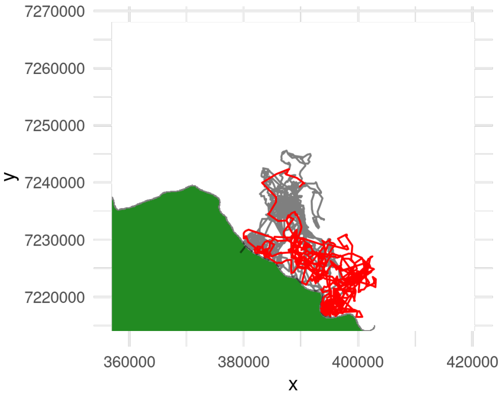
Base model: `case_ ~ cos(ta_) + sl_ + log(sl_) + water_dist_end`



Home-range model: `case_ ~ cos(ta_) + sl_ + log(sl_) + water_dist_end + x2_ + y2_ + I(x2_^2 + y2_^2)`



River model: `case_ ~ cos(ta_) + sl_ + log(sl_) + water_dist_end + x2_ + y2_ + I(x2_^2 + y2_^2) + I(water_crossed_end != water_crossed_start)`



Key resources/publications

- Avgar, T., Potts, J. R., Lewis, M. A., & Boyce, M. S. (2016). Integrated step selection analysis: bridging the gap between resource selection and animal movement. Methods in Ecology and Evolution, 7(5), 619-630.
- Potts, J. R., & Schlägel, U. E. (2020). Parametrizing diffusion-taxis equations from animal movement trajectories using step selection analysis. Methods in Ecology and Evolution, 11(9), 1092-1105.
- Signer, J., Fieberg, J., & Avgar, T. (2017). Estimating utilization distributions from fitted step-selection functions. Ecosphere, 8(4), e01771.