

# Simulating Space Use

Johannes Signer & Brian Smith

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# 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 UD:

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 an 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 ( $\beta_0$ ) 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

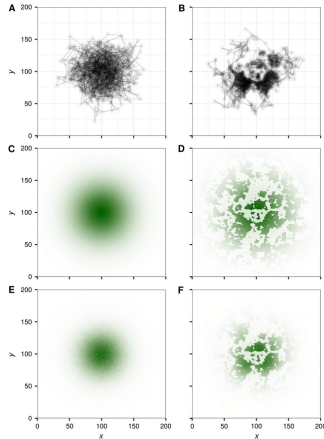


Figure 1: Source Signer et al. 2017

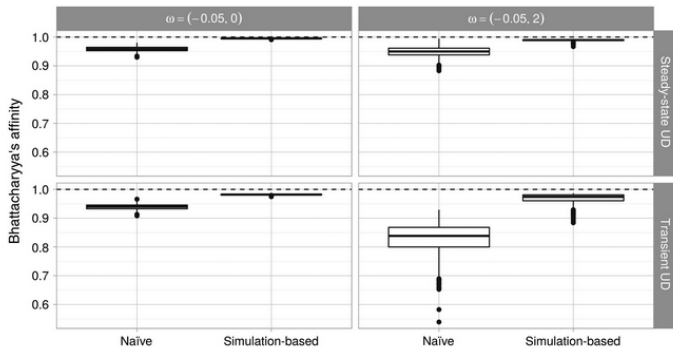


Figure 2: Source Signer et al. 2017

The bias becomes even worse if selection is stronger:

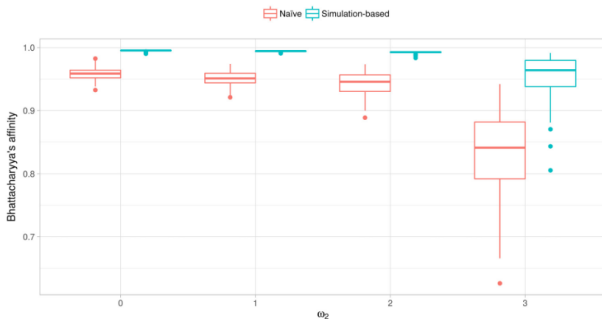


Figure 3: Source Signer et al. 2017



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

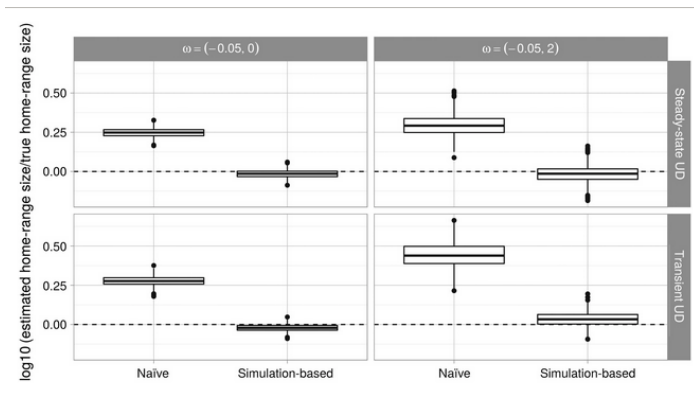


Figure 4: Source Signer et al. 2017




# 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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## Estimating utilization distributions from fitted step-selection functions

Johannes Signer  John Fieberg, Tal Avgar

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## Methods in Ecology and Evolution



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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Research Article

## Evaluation of Connectivity Among American Black Bear Populations in Georgia


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](#)

## Towns and trails drive carnivore movement behaviour, resource selection, and connectivity

[Jesse Whittington](#) , [Mark Hebblewhite](#), [Robin W. Baron](#), [Adam T. Ford](#) & [John Paczkowski](#)

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

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- Some studies applied this already,
- and methods being developed.

## Methods in Ecology and Evolution



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>

- Simulating space use from fitted iSSFs received a lot of interest.
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Received: 19 July 2022 | Accepted: 16 October 2022

DOI: 10.1111/1365-2656.13832

RESEARCH METHODS GUIDE

Journal of Animal Ecology



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

Jonathan R. Potts<sup>1</sup> | Luca Börger<sup>2,3</sup>



# The iSSF (again)

$$(\mathbf{s}, t + \Delta t)$$

We want to model the probability that the animals moves to position  $\mathbf{s}$  at time  $t + \Delta t$

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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<sup>1,2</sup>.

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<sup>1</sup>For details of the data see: Getz et al. 2007 LoCoH: Nonparametric kernel methods for constructing home ranges and utilization distributions. PLoS ONE

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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)`

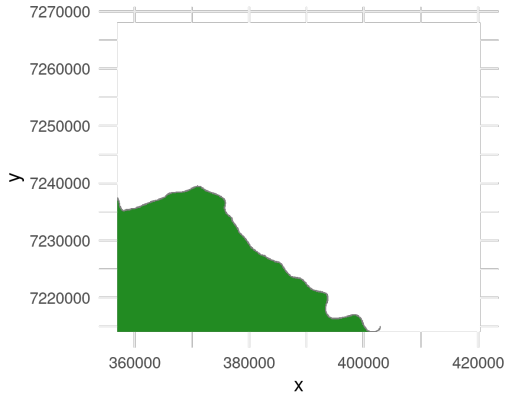
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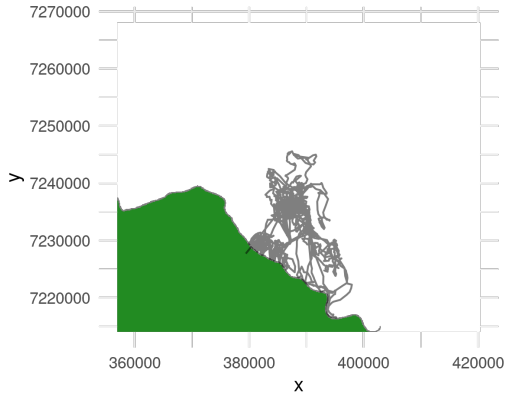
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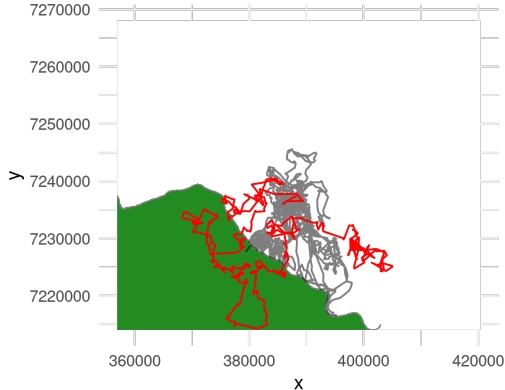
## The setting



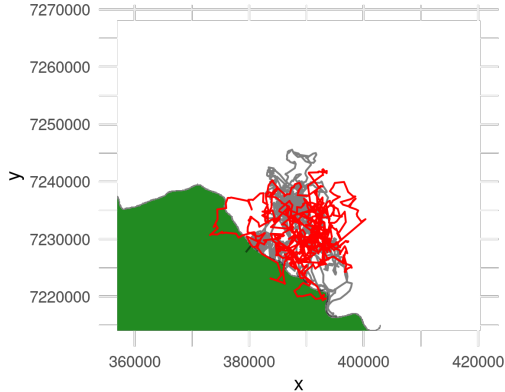
## The observed track



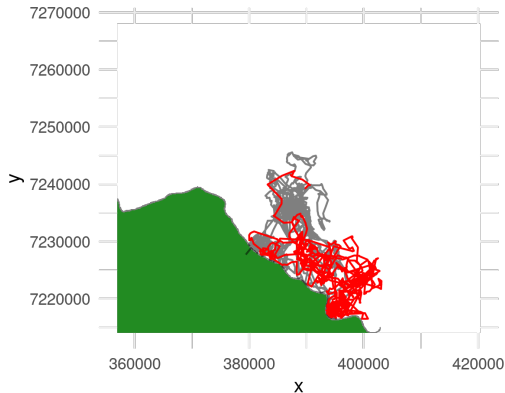
**Base model:**  $\text{case\_} \sim \cos(\text{ta\_}) + \text{sl\_} + \log(\text{sl\_}) + \text{water\_dist\_end}$



**Home-range model:**  $\text{case}_i \sim \cos(\text{ta}_i) + \text{sl}_i + \log(\text{sl}_i) + \text{water\_dist\_end}_i + x2_i + y2_i + I(x2_i^2 + y2_i^2)$



**River model:**  $\text{case\_} \sim \cos(\text{ta\_}) + \text{sl\_} + \log(\text{sl\_}) +$   
 $\text{water\_dist\_end} + \text{x2\_} + \text{y2\_} + \text{I}(\text{x2\_}^2 + \text{y2\_}^2) +$   
 $\text{I}(\text{water\_crossed\_end} \neq \text{water\_crossed\_start})$



# 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.