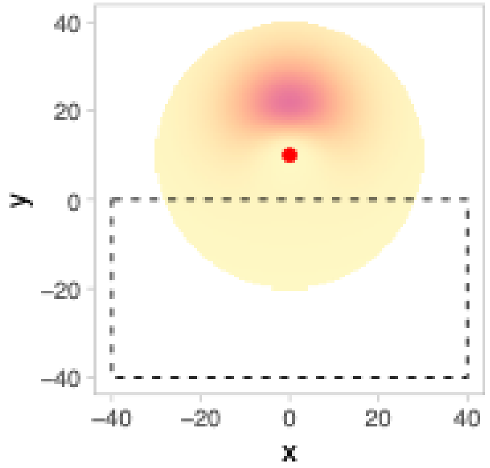
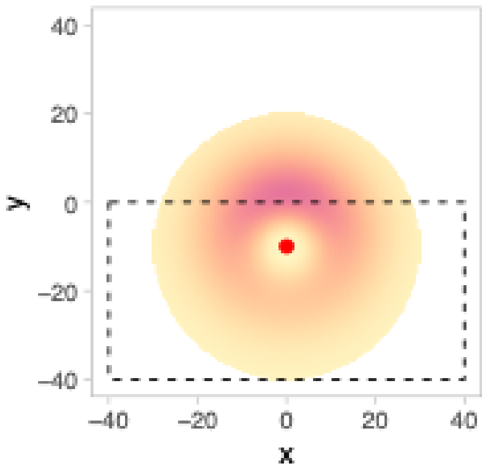
Simulate from fitted Integrated Step-Selection-Functions





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Animal Movement Course 2025

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Aims of this session

- Why to simulate?
- Simulate from fitted step selection functions
- Distinguish between redistribution kernel, selection-free movement kernel and movement-free habitat-selection function.

Some background reading

ECOSPHERE
AN ESA OPEN ACCESS JOURNAL

Article | Open Access

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: 88

BRITISH ECOLOGICAL SOCIETY Methods in Ecology and Evolution

APPLICATION | Open Access

Simulating animal space use from fitted integrated Step-Selection Functions (iSSF)

J. Signer, J. Fieberg, B. Reineking, U. Schlägel, B. Smith, N. Balkenhol, T. Avgar

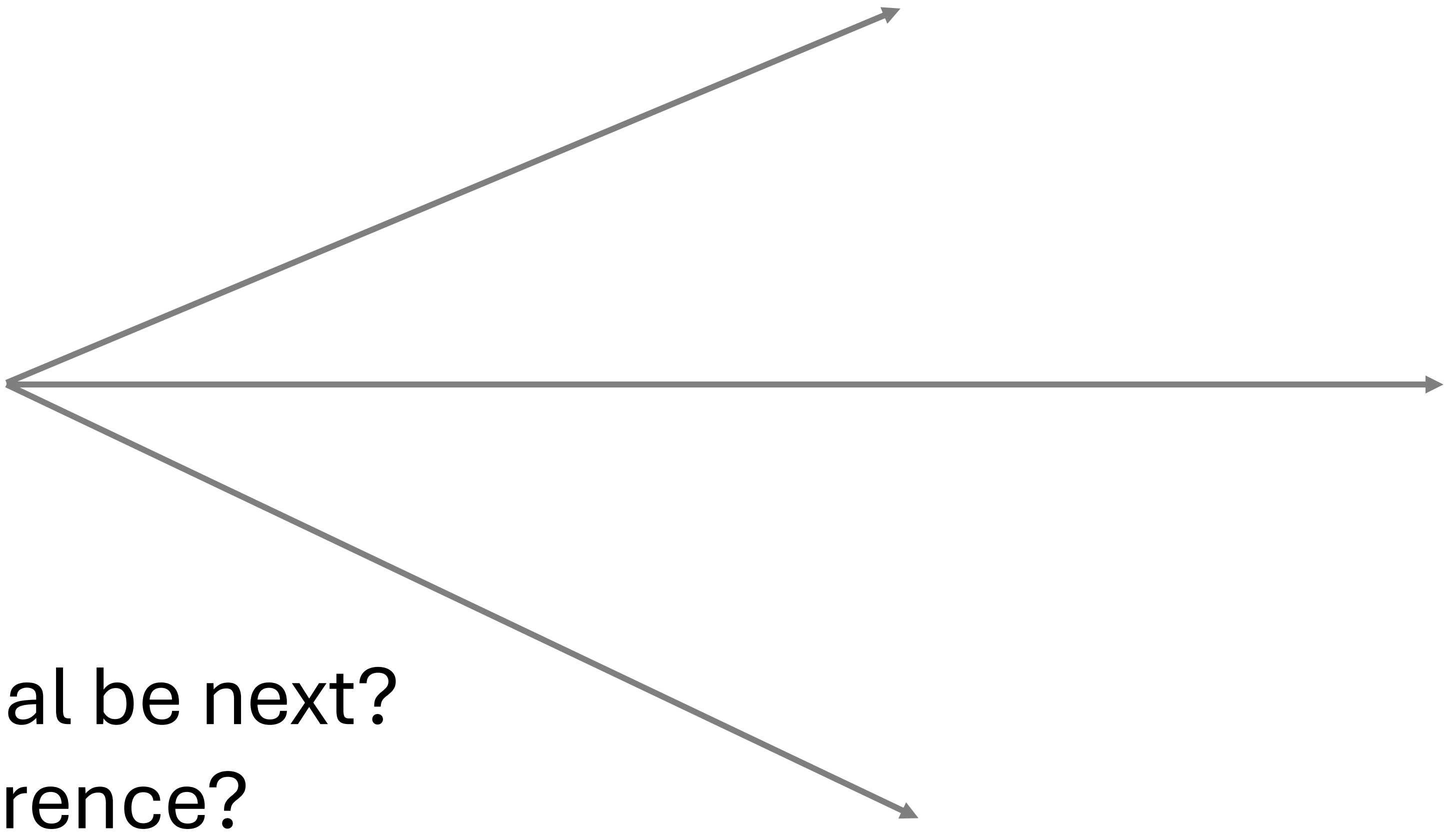
BRITISH ECOLOGICAL SOCIETY Journal of Animal Ecology

RESEARCH METHODS GUIDE | Open Access

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

Jonathan R. Potts, Luca Börger

What is it all about?



Animal at time t

Where will the animal be next?
Does it have a preference?
Can it reach its preferred position in space?

Animal at time $t + 1$

So, we have a fitted model

- Remember

What is the model, that we fitted:

What is the probability that the animal will be at position **s** at the next time step (t + Δt), given the animal is currently (t) at position **s’**.

Movement free habitat selection function: where the animal would like to go.

Selection free movement kernel: where the animal is able to go (given constraints in movement).

$$\boxed{(\mathbf{s}, t+\Delta t) | u(\mathbf{s}', t)} = \frac{\boxed{w(\mathbf{X}(\mathbf{s}); \beta(\Delta t))}\boxed{\phi(\theta(\mathbf{s}, \mathbf{s}'), \gamma(\Delta t))}}{\underbrace{\int_{\tilde{\mathbf{s}} \in G} w(\mathbf{X}(\tilde{\mathbf{s}}); \beta(\Delta t)) \phi(\theta(\tilde{\mathbf{s}}, \mathbf{s}'); \gamma(\Delta t)) d\tilde{\mathbf{s}}}_{\text{Normalizing constant}}}$$

Let’s reuse `m5` from before

- We model habitat selection for distance to forest and movement as a function of time of day.

$$(\mathbf{s}, t + \Delta t) | u(\mathbf{s}', t) = \frac{w(\mathbf{X}(\mathbf{s}); \beta(\Delta t))\phi(\theta(\mathbf{s}, \mathbf{s}'), \gamma(\Delta t))}{\underbrace{\int_{\tilde{\mathbf{s}} \in G} w(\mathbf{X}(\tilde{\mathbf{s}}); \beta(\Delta t))\phi(\theta(\tilde{\mathbf{s}}, \mathbf{s}'); \gamma(\Delta t)) d\tilde{\mathbf{s}}}_{\text{Normalizing constant}}}$$

Results of model 5

$$(\mathbf{s}, t+\Delta t) | u(\mathbf{s}', t) = \underbrace{\frac{w(\mathbf{X}(\mathbf{s}); \beta(\Delta t))\phi(\theta(\mathbf{s}, \mathbf{s}'), \gamma(\Delta t))}{\int_{\tilde{\mathbf{s}} \in G} w(\mathbf{X}(\tilde{\mathbf{s}}); \beta(\Delta t))\phi(\theta(\tilde{\mathbf{s}}, \mathbf{s}'); \gamma(\Delta t)) d\tilde{\mathbf{s}}}}_{\text{Normalizing constant}}$$

What next?

- We can use the output of model 5 to create a redistribution kernel.
- A redistribution kernel is the product of a selection-free movement kernel and a movement-free habitat-selection function.

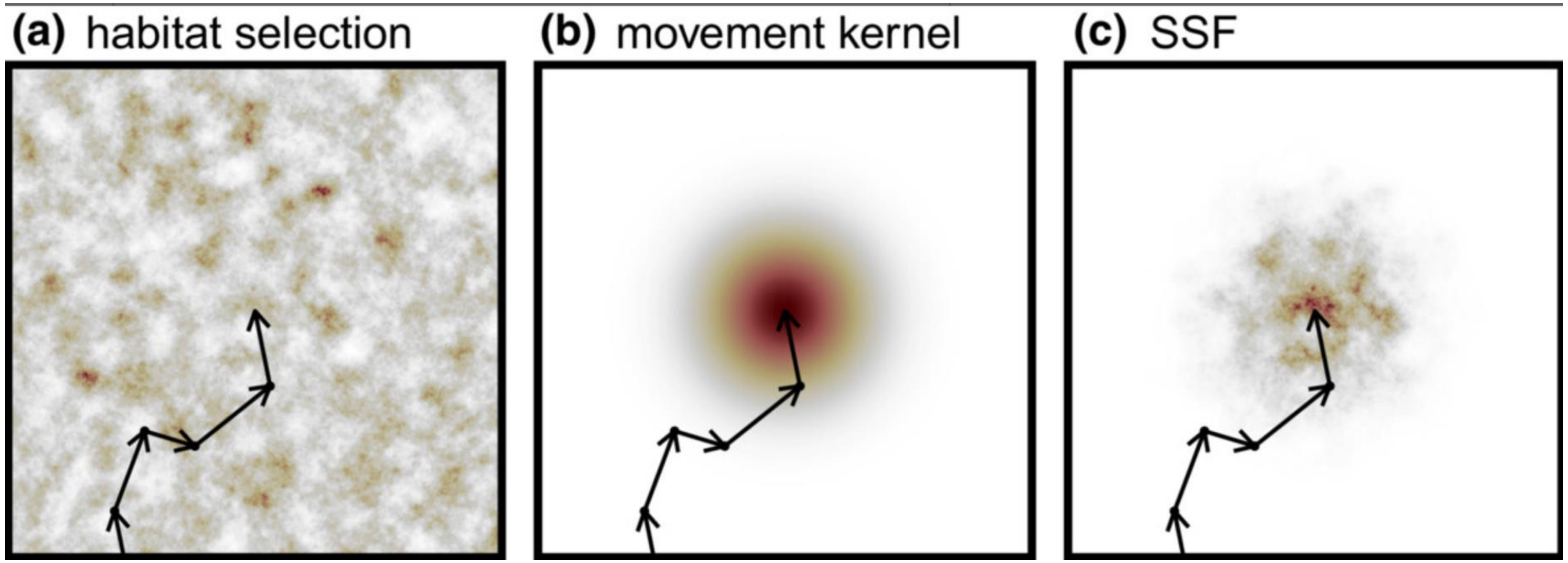
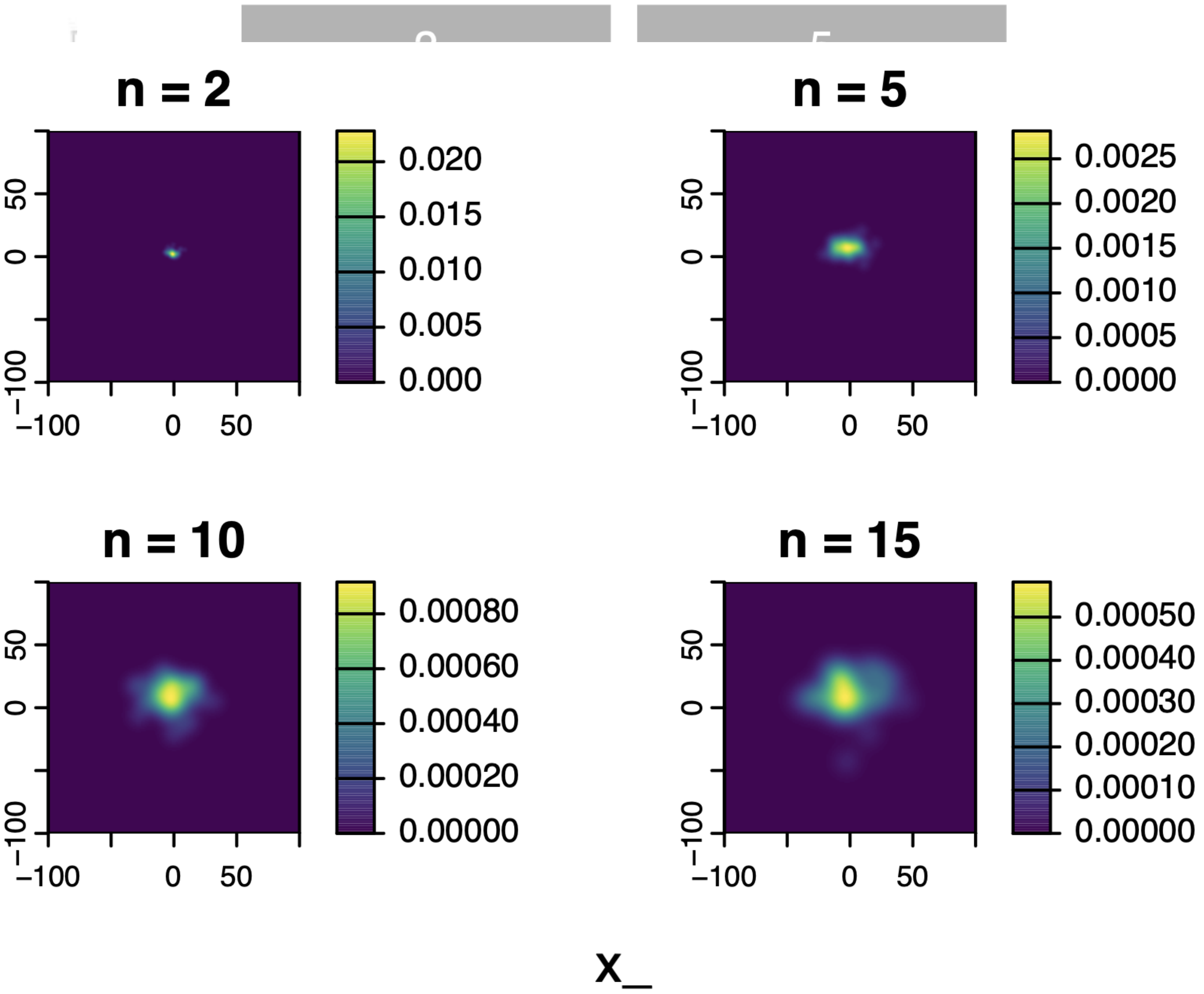


Image source: Michelot et al. 2024; MEE

What can we do with a redistribution kernel?

- Simulate an individual path by consecutively sampling from the redistribution kernel.
- Simulate space use on the long term (steady state utilization distribution [UD]) or short term space use (transient UD).

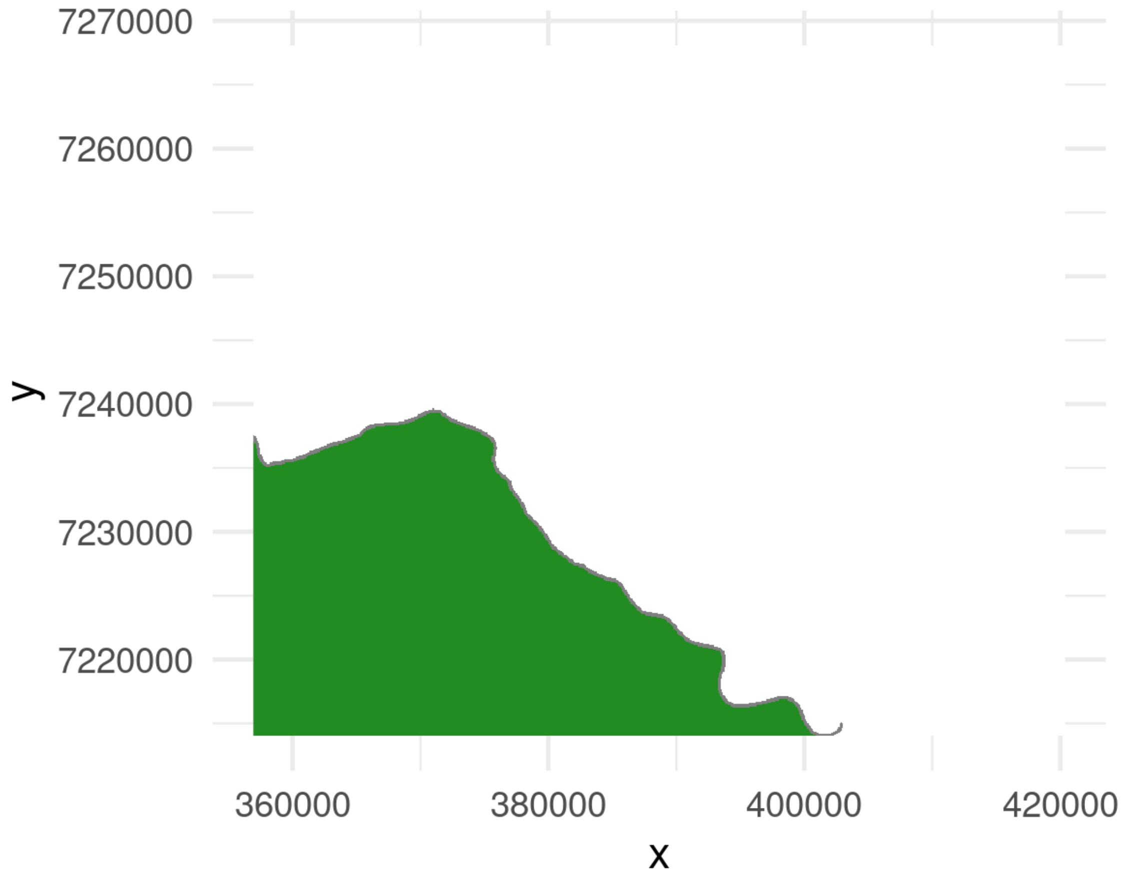


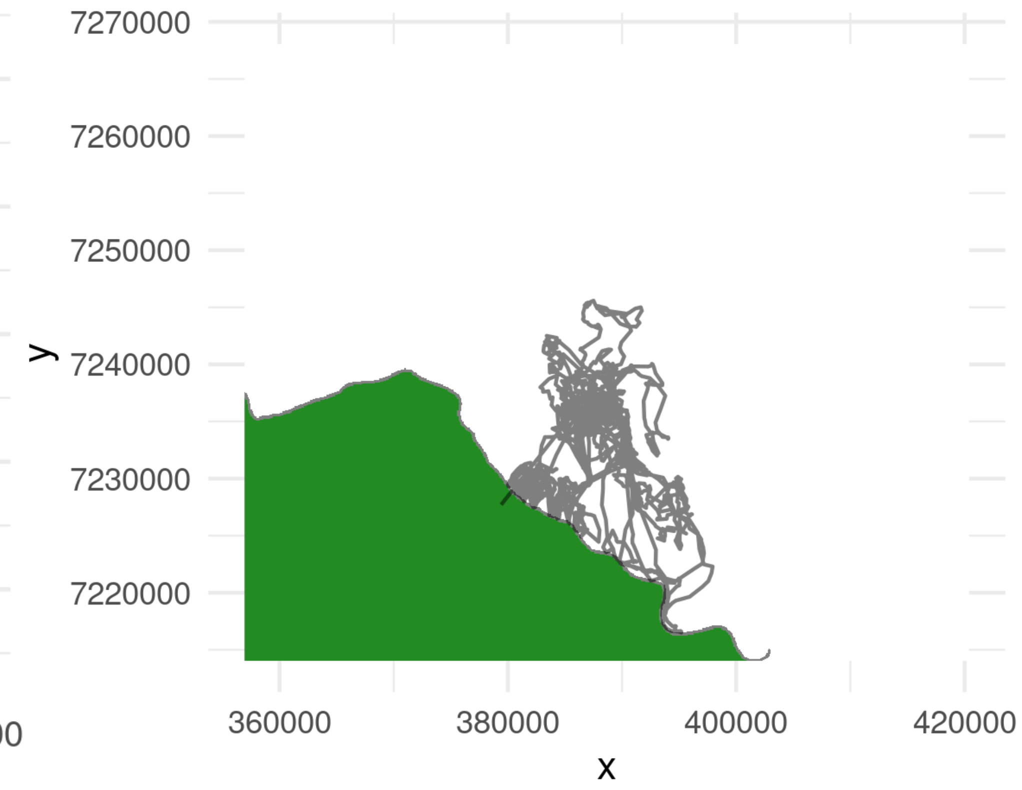
An example

- Model movement of African buffalo. We fitted three models:

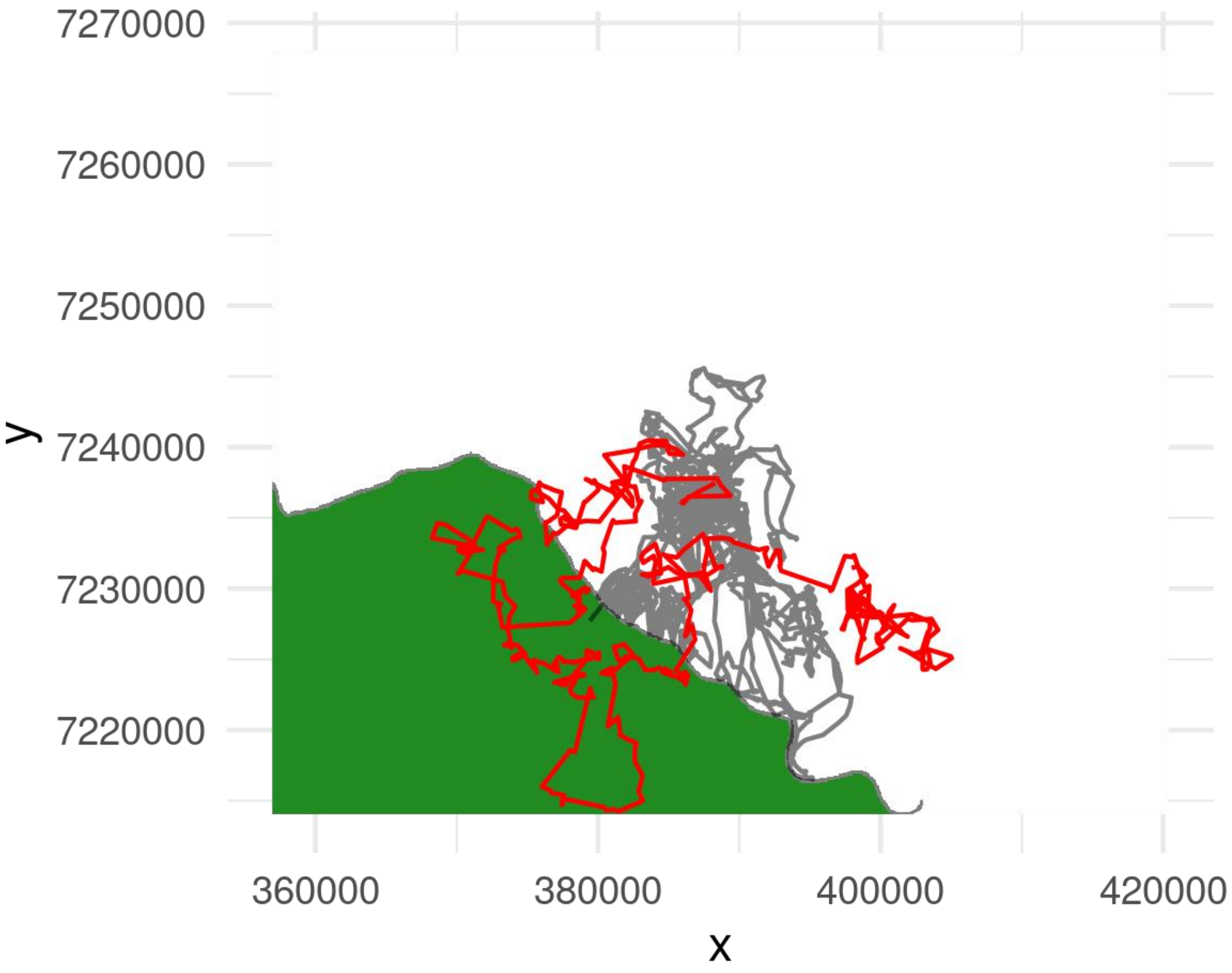
1. **Base model**: `case_ ~ cos(ta_) + sl_ + log(sl_) + water_dist_end`
2. **Home-range model**: `case_ ~ cos(ta_) + sl_ + log(sl_) + water_dist_end + x2_ + y2_ + I(x2_^2 + y2_^2)`
3. **River model**: `case_ ~ cos(ta_) + sl_ + log(sl_) + water_dist_end + x2_ + y2_ + I(x2_^2 + y2_^2) + I(water_crossed_end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

The observed data

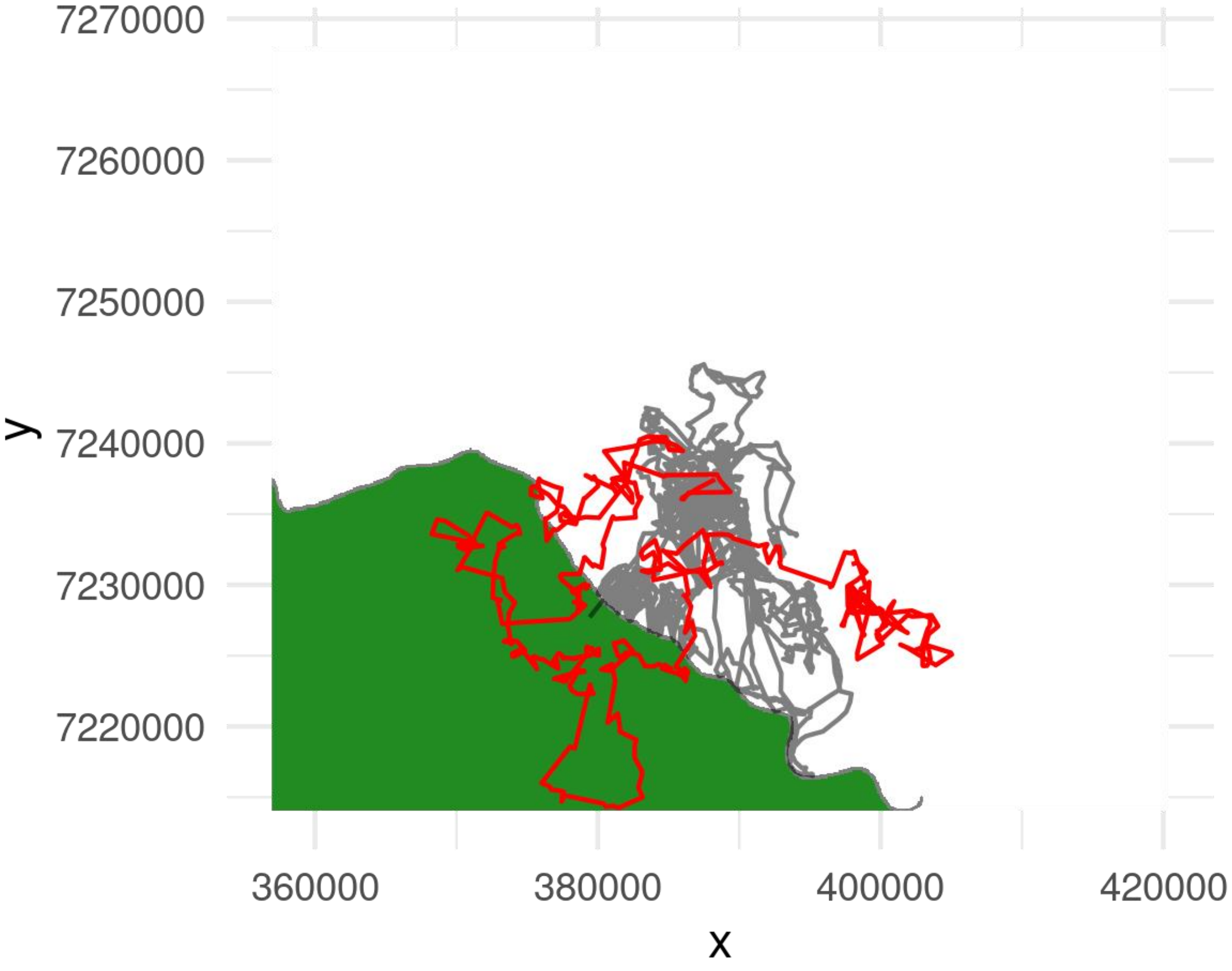




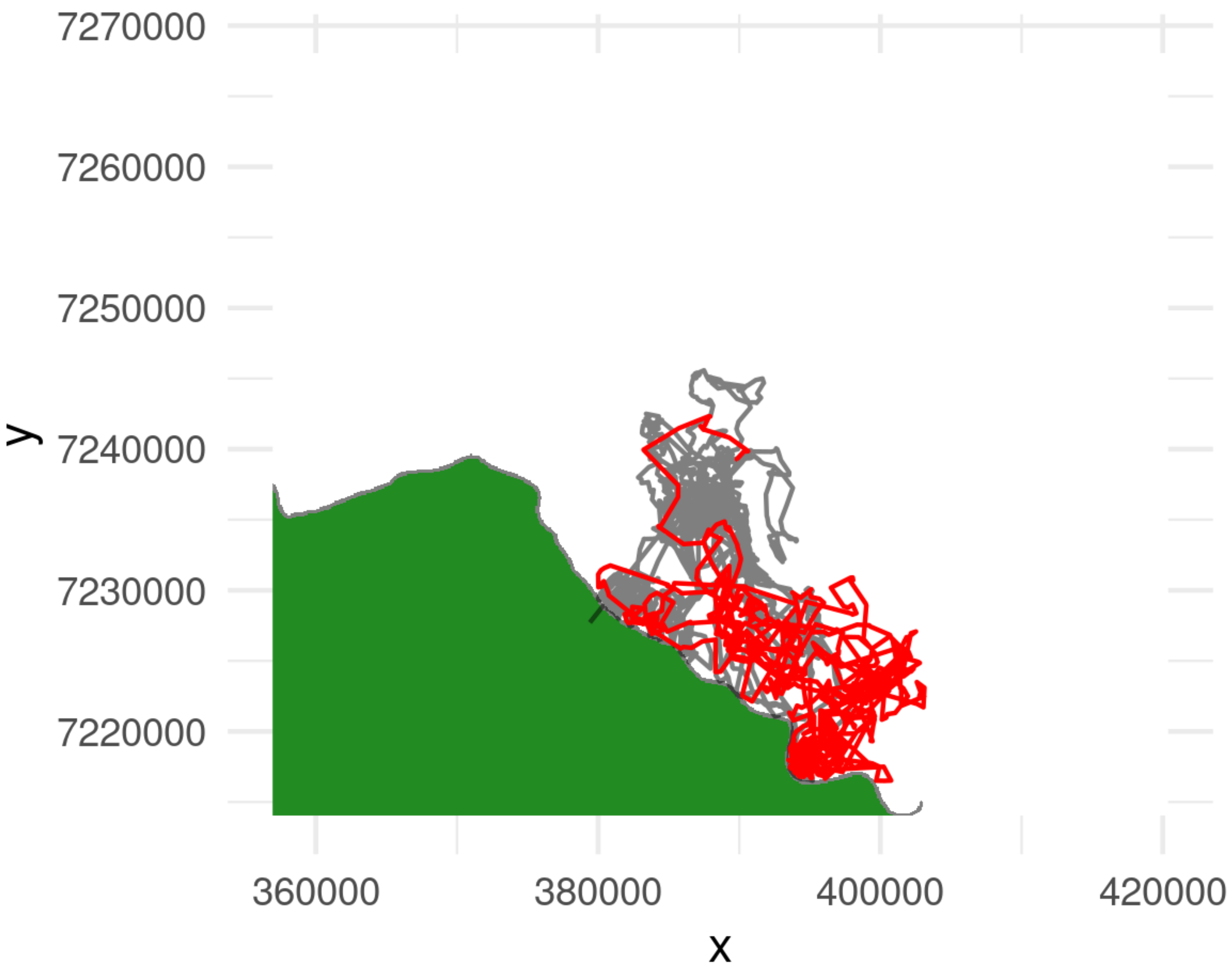
Model 1: Naïve model



Model 2: With home ranging



Model 3: With river crossing



Practical