Week 5: Introduction to Animal Movement Analyses in R

Lecture: Tuesday, 13 April 2021 and Thursday, 15 April 2021
8:30 am – 10:20 pm EDT

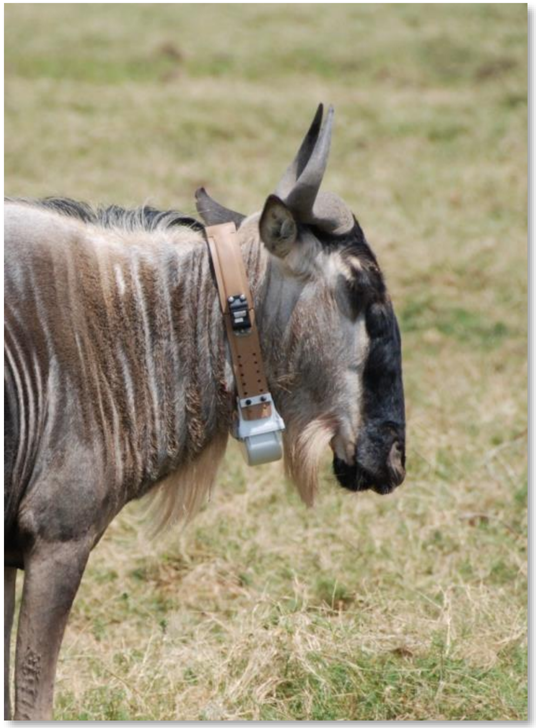
Instructor:
Jared Stabach (StabachJ@si.edu)

Week 5: Introduction to Movement Analyses

Lecture: Tuesday, 06 April 2021 and Thursday, 08 April 2021
8:30 am – 10:20 pm EDT

Tuesday

- Data Import & Cleaning
    - Time Stamp Formatting
    - Duplicate Removal
    - Assessing Model Assumptions
    - Filtering Start Dates
    - Assessing Data Quality
    - Calculating Fix Success
- Data Visualization
    - Animating Animal Movements (Super Fun!)



We will use GPS collar data, collected on white-bearded wildebeest (*Connochaetes taurinus*) during my doctoral work from 2010-2013 for all exercises. Methods, however, should be broadly applicable to other taxa.

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Week 5: Introduction to Movement Analyses

Lecture: Tuesday, 06 April 2021 and Thursday, 08 April 2021
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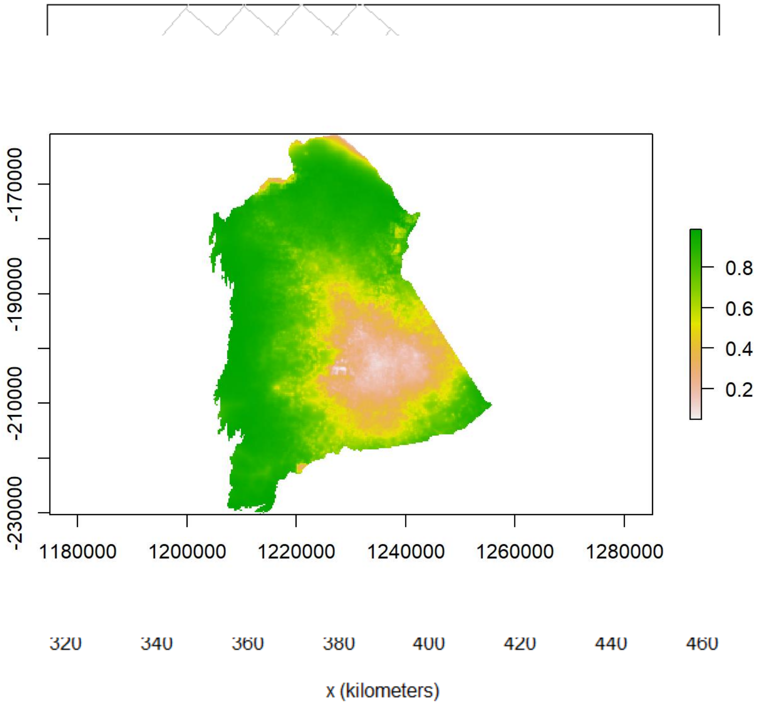
Thursday

- Calculate Home Range
    - Minimum Convex Polygon (MCP)
    - Autocorrelated Kernel Density Estimation (AKDE)

- Resource Selection Function (RSF) Analysis
    - 'Use' vs 'Availability' design
    - Define 'Availability;
    - Create spatial database
    - Perform logistic regression
    - Assess response curves
    - Generate a prediction map



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At least 58 packages in R to analyze animal tracking data

How to know which to use?

Journal of Animal Ecology

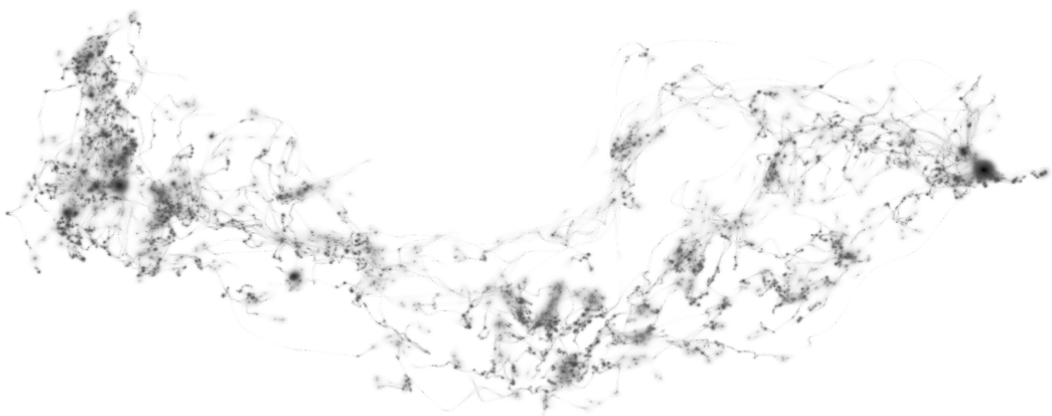
BRITISH ECOLOGICAL SOCIETY

BIOLOGGING: REVIEW

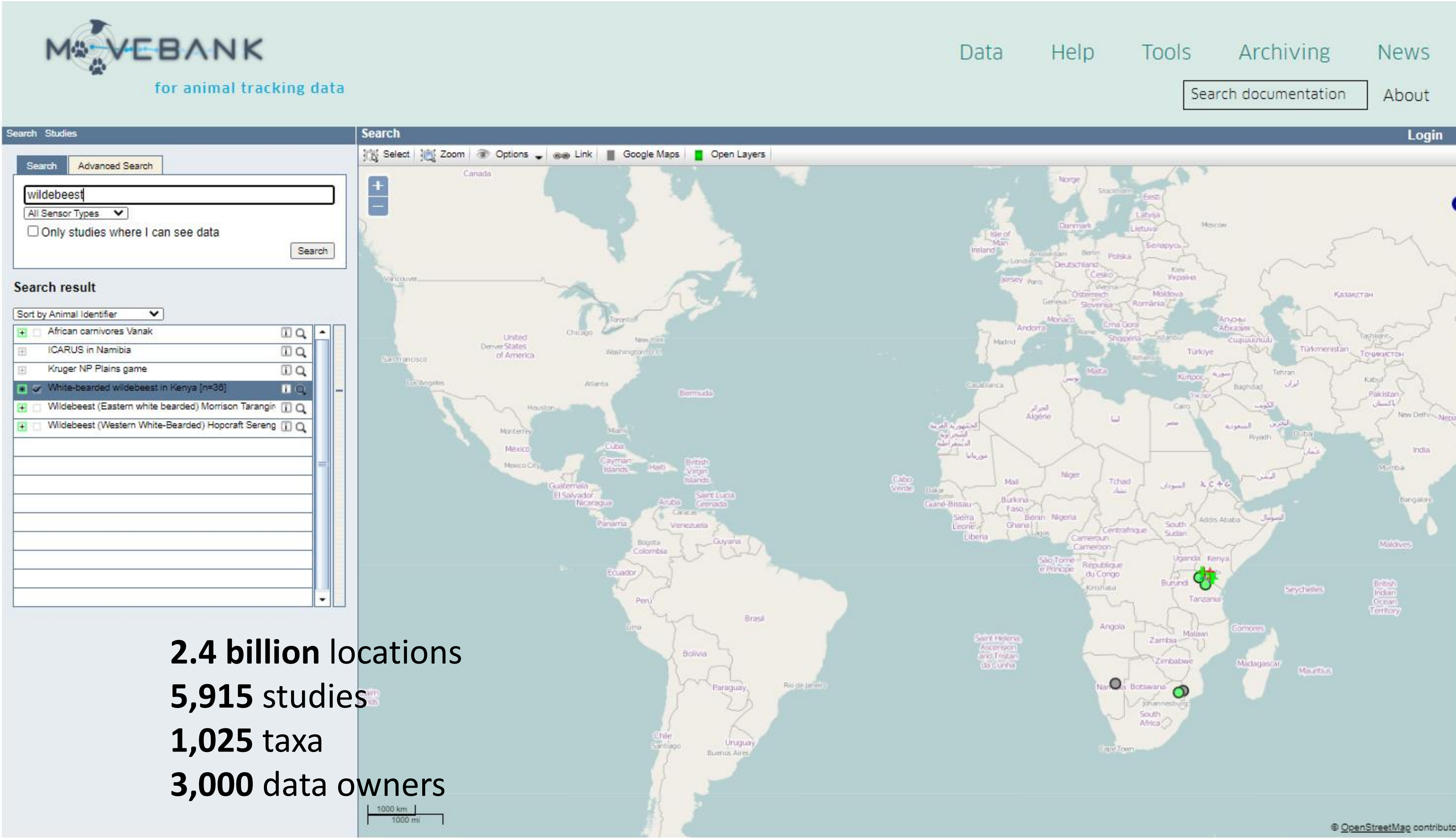
Navigating through the R packages for movement

Rocío Joo, Matthew E. Boone, Thomas A. Clay, Samantha C. Patrick, Susana Clusella-Trullas, Mathieu Basille

First published: 06 October 2019 | https://doi.org/10.1111/1365-2656.13116 | Citations: 3



Where to get data…………



2.4 billion locations
5,915 studies
1,025 taxa
3,000 data owners

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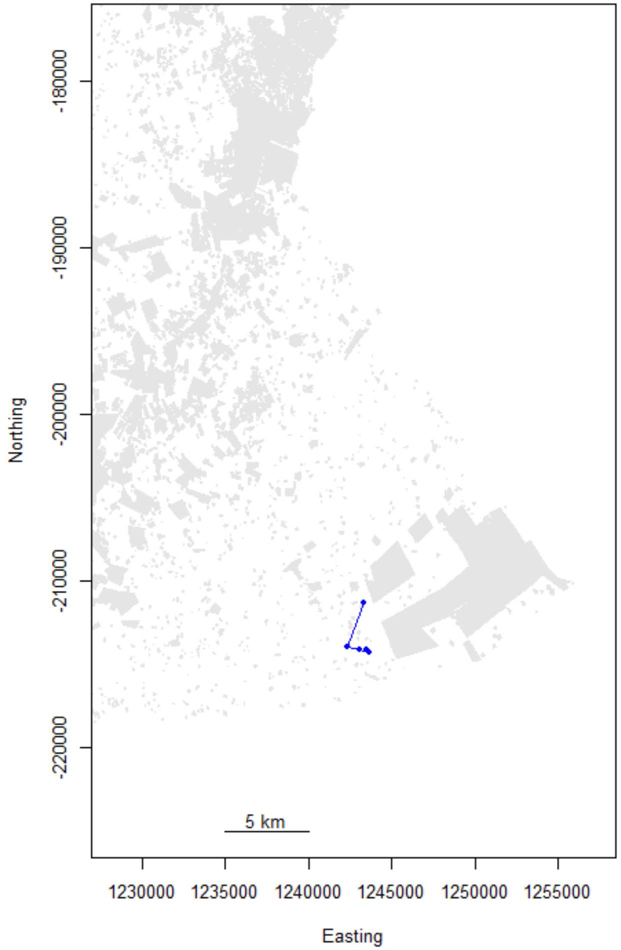
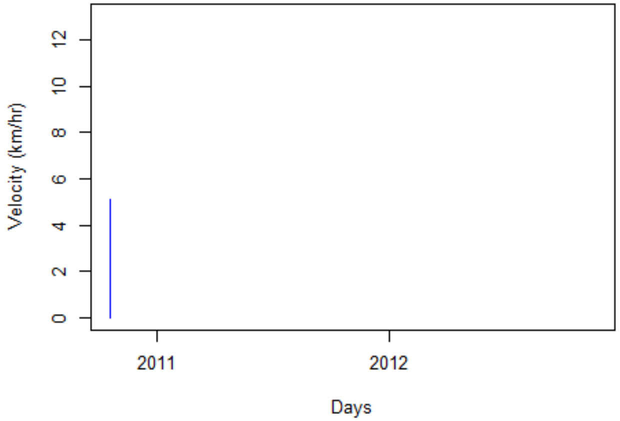
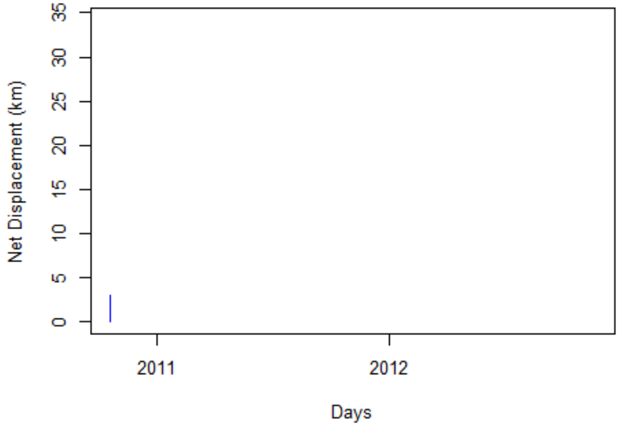
Visualize Movement Data

White-bearded wildebeest (*Connochaetes taurinus*)







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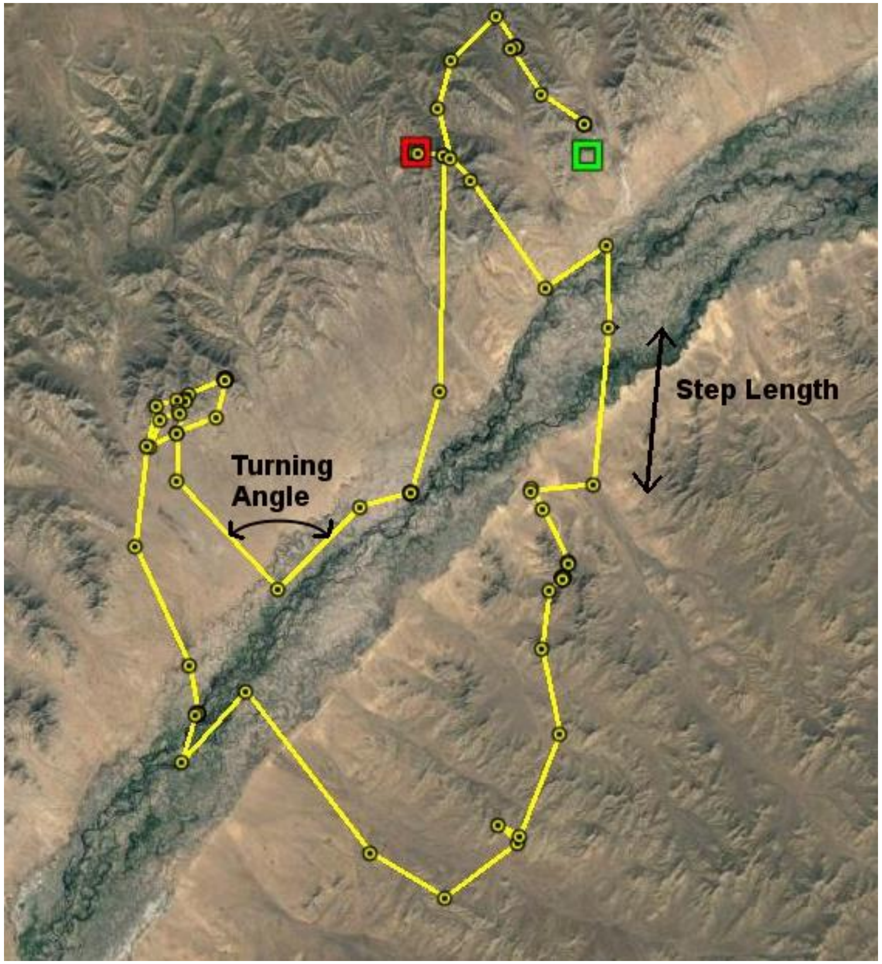
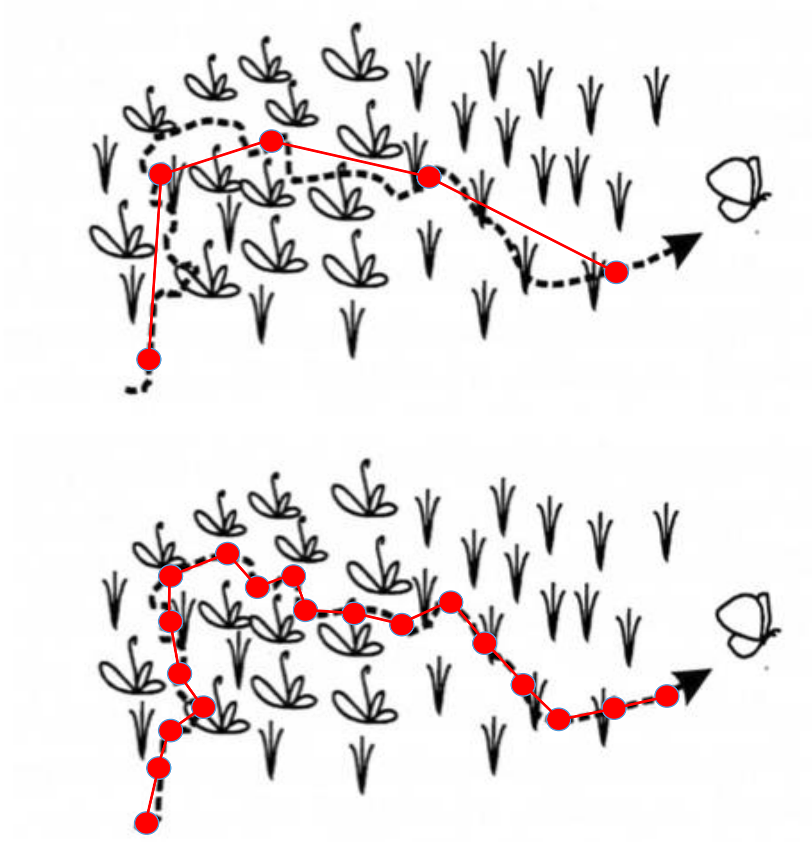
Properties of a Movement Path

- Step length
- Turning angle
- Velocity
- Autocorrelation



Things to be wary of



Different sampling rates give different answers

Home Range

Burt (1943): the area occupied by an individual during normal everyday activities (i.e., mating, feeding, carrying for young)

A home range must contains all the necessary resources to insure survival and reproduction

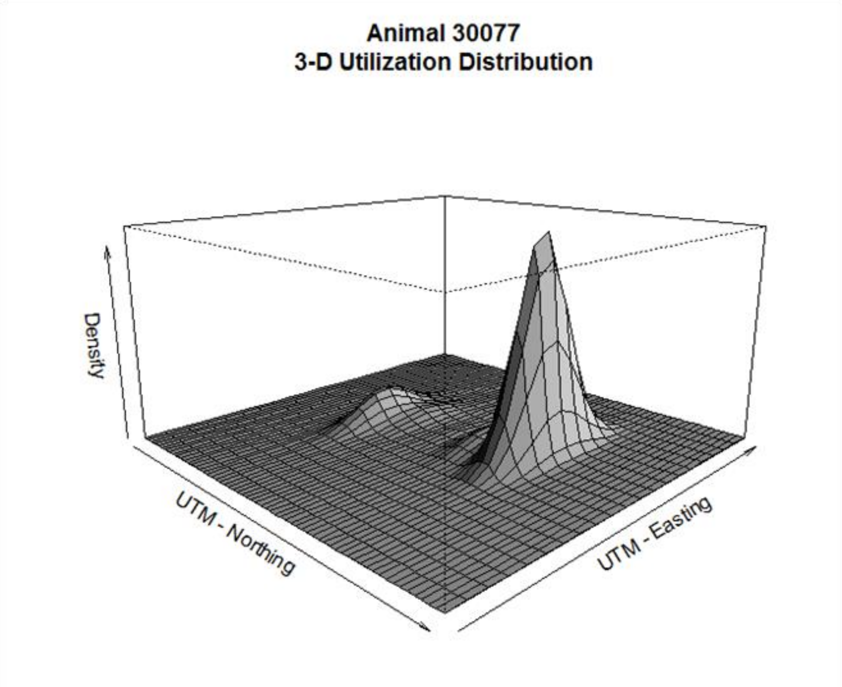
Spatial expression of behaviors animals perform to survive and reproduce (Borger et al. 2008)

Home Range Characteristics

- Individual spends majority of time here
- Vary in size
  - Gender
  - Seasonally
  - By region/habitat
- Irregular shape
- Increase in size over time, but should asymptote (resident assumption)
- Successful individual will have a high quality home range

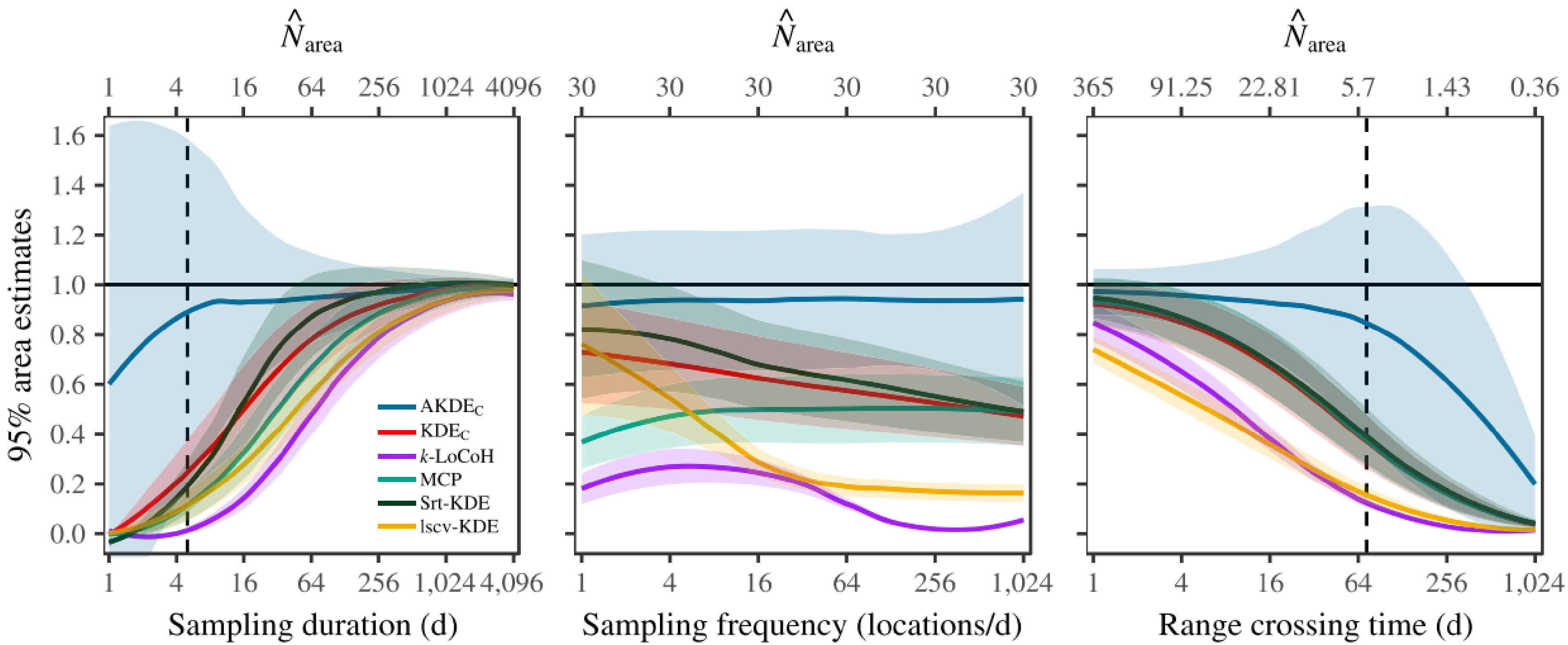
Multiple Home Range Estimators Exist

- Minimum Convex Polygons
- Harmonic Means
- Jennrich Turner
- Kernel Density
    - Brownian Bridge Kernel
    - Random Bridge Kernel
- Local Convex Hull (LoCoH)
- Characteristic Hull
- ....



All of these methods assume that data are IID (Independent and Identically Distributed)

Quantitative Assessment of Home Range Estimators



ECOLOGICAL MONOGRAPHS
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A comprehensive analysis of autocorrelation and bias in home range estimation

MICHAEL J. NOONAN; MARLEE A. TUCKER; CHRISTEN H. FLEMING; THOMAS S. AKRE; SUSAN C. ALBERTS; ABDULLAHI H. ALI; JEANNE ALTMANN; PAMELA CASTRO ANTUNES; JERROLD L. BELANT; DEAN BEYER; NIELS BLAUM KATRIN B€OHNING-GAESE; LAURYCULLEN JR.; ROGERIO CUNHA DE PAULA; JASJA DEKKER; JONATHAN DRESCHER-LEHMAN; NINA FARWIG; CLAUDIA FICHTEL; CHRISTINA FISCHER; ADAM T. FORD; JACOB R. GOHEEN; RENE JANSSEN; FLORIAN JELTSCH; MATTHEW KAUFFMAN; PETER M. KAPPELER; FLAVIA KOCH; SCOTT LAPOINT; A. CATHERINE MARKHAM; EMILIA PATRICIA MEDICI; RONALDO G. MORATO; RAN NATHAN; LUIZ GUSTAVO R. OLIVEIRA-SANTOS; KIRK A. OLSON; BRUCE D. PATTERSON; AGUSTIN PAVIOLO; EMILIANO ESTERCI RAMALHO; SASCHA R€OSNER; DANA G. SCHABO; NURIA SELVA; AGNIESZKA SERGIEL; MARINA XAVIER DA SILVA; ORR SPIEGEL; PETER THOMPSON; WIEBKE ULLMANN; FILIP ZIEz BA; TOMASZ ZWIJACZ-KOZICA WILLIAM F. FAGAN; THOMAS MUELLER; AND JUSTIN M. CALABRESE

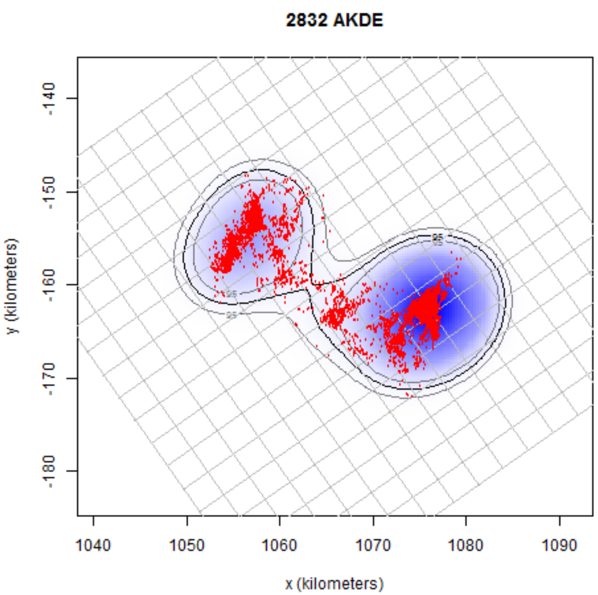
Home Range
Continuous-Time Movement Modeling (CTMM) Framework

Methods in Ecology and Evolution
British Ecological Society
Methods in Ecology and Evolution 2016
doi: 10.1111/2041-210X.12559

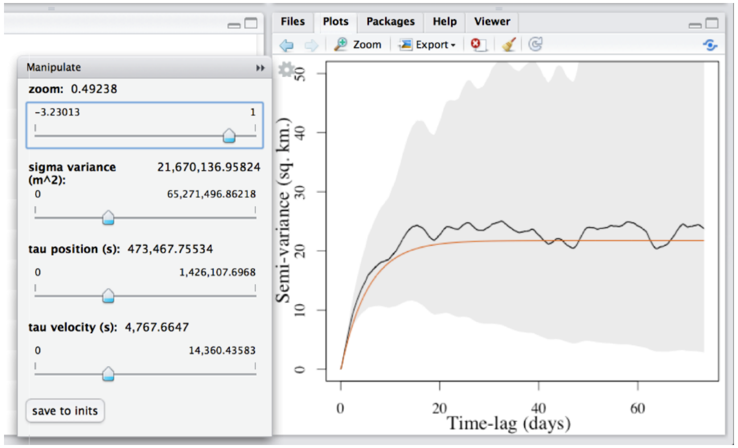
APPLICATION

ctmm: an R package for analyzing animal relocation data as a continuous-time stochastic process

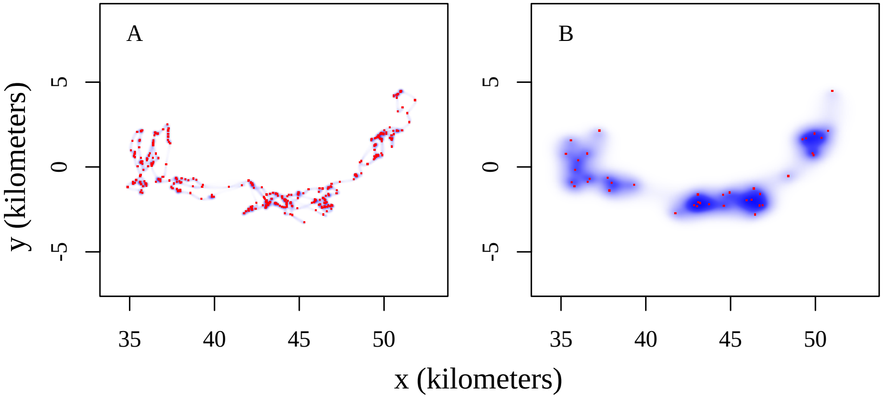
Justin M. Calabrese[1,2*], Chris H. Fleming[1,2] and Eliezer Gurarie[2]



Visual diagnostics
Model selection (AIC)



Home range estimation



Path reconstruction
Occurrence distribution

Home Range
Continuous-Time Movement Modeling (CTMM) Framework

Methods in Ecology and Evolution

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APPLICATION

ctmm: an R package for analyzing animal relocation data as a continuous-time stochastic process

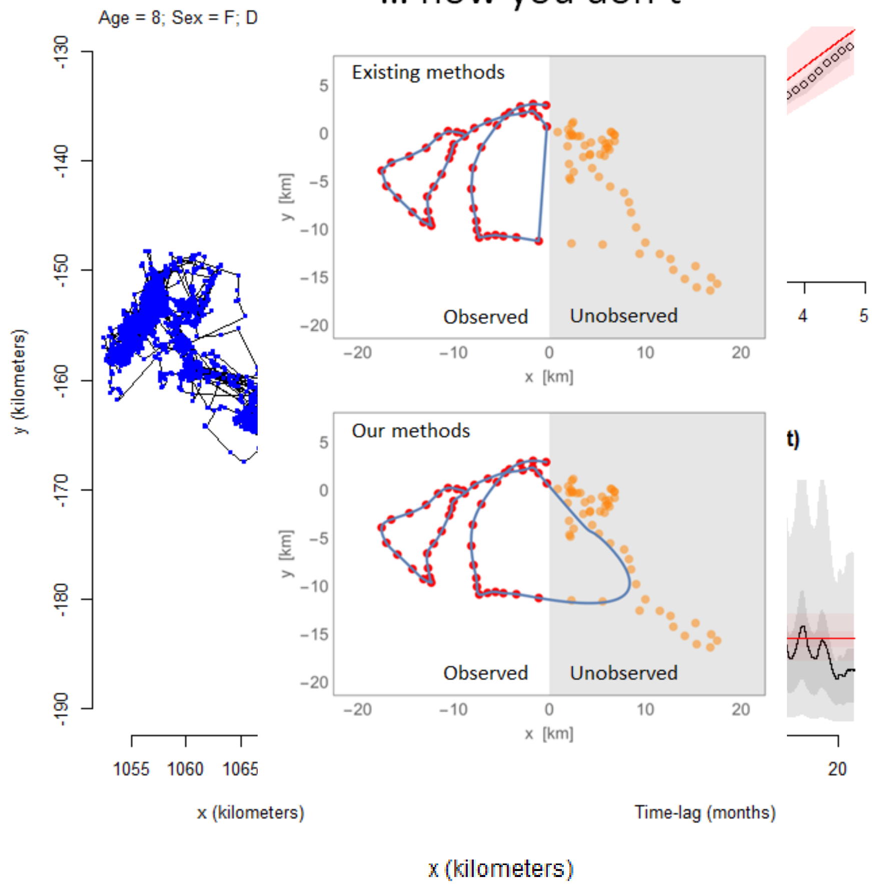
Justin M. Calabrese[1,2*], Chris H. Fleming[1,2] and Eliezer Gurarie[2]

Now you see me…

… now you don't

- Incorporate autocorrelation structure
- Insensitive to irregular sampling/data gaps
- Candidate model evaluation (AIC)
- Quantitatively evaluate range residency

- Observed to outperform previous methods
  (MCP, KDE, LoCoH)
- Confidence interval estimation
- Conservation implications



Resource Selection Function Analysis

Describe the relationship between an animal and its environment

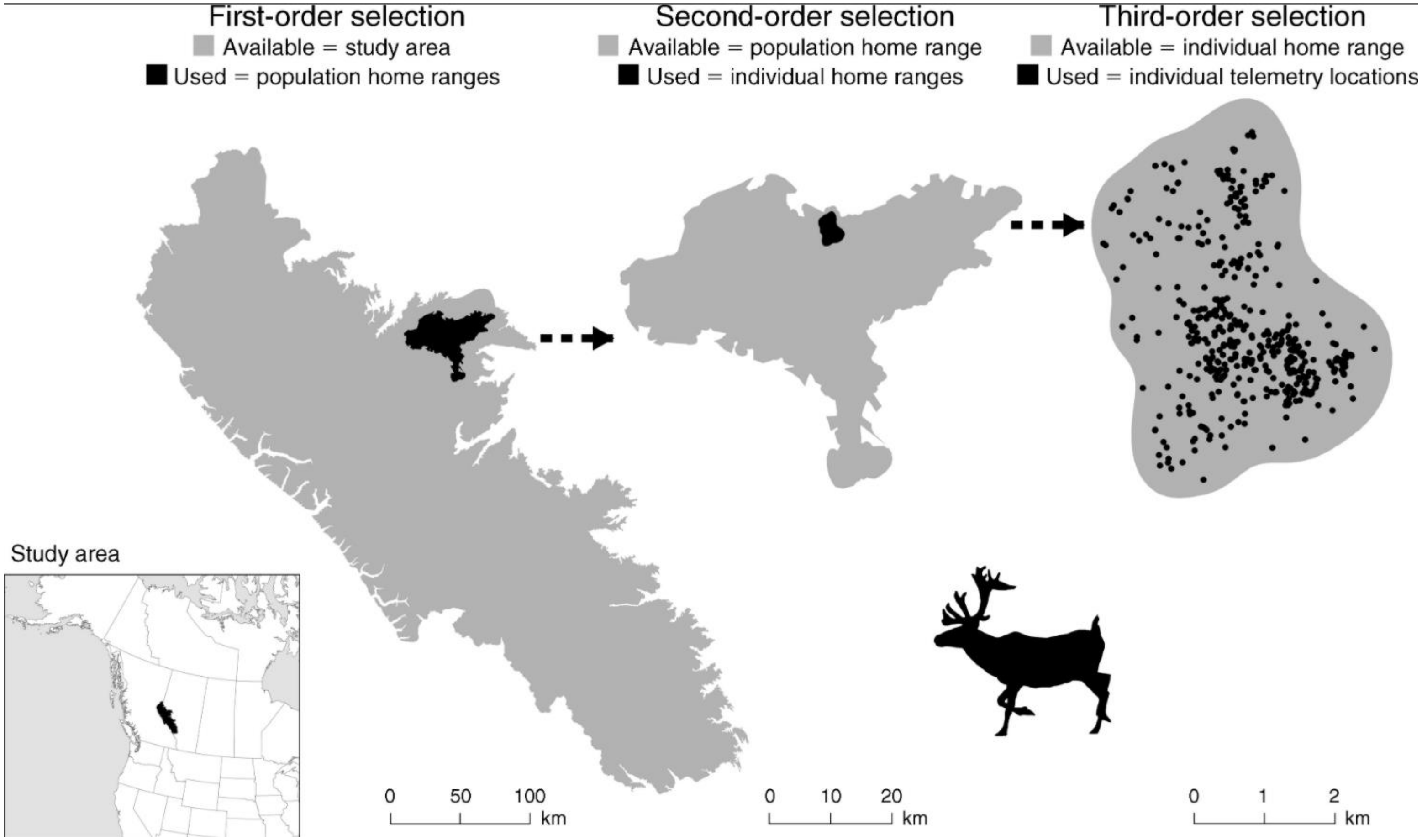
Point Process Model: Points Instead of Paths – A first step

Does the animal use a habitat type more than expected by random

Positive response – Animal prefers habitat type
Negative response – Animal avoids habitat type

Orders of Selection – Different scales of inference

Johnson, D. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61:65-71.



Fourth-order selection: Local habitat selection (individual steps)

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Transcending scale dependence in identifying habitat with resource selection functions

Nicholas J. DeCesare, Mark Hebblewhite, Fiona Schmiegelow, David Hervieux, Gregory J. McDermid, Lalenia Neufeld, Mark Bradley, Jesse Whittington, Kirby G. Smith, Luigi E. Morgantini, Matthew Wheatley, Marco Musiani ... See fewer authors

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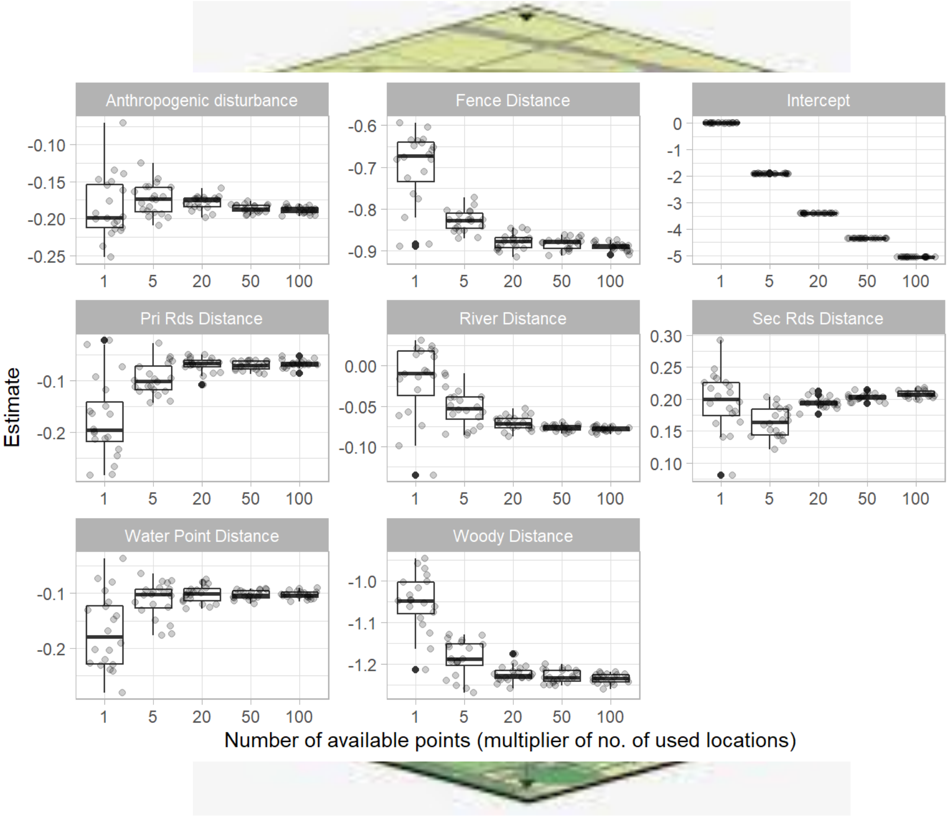
Use v. Availability Study Design

Logistic regression analysis

$$w(x, \beta)=\exp(\beta_1 x_1+ \beta_2 x_2+ \cdots+\beta_n x_n)$$

Extr
Valu



Habitat covariates:

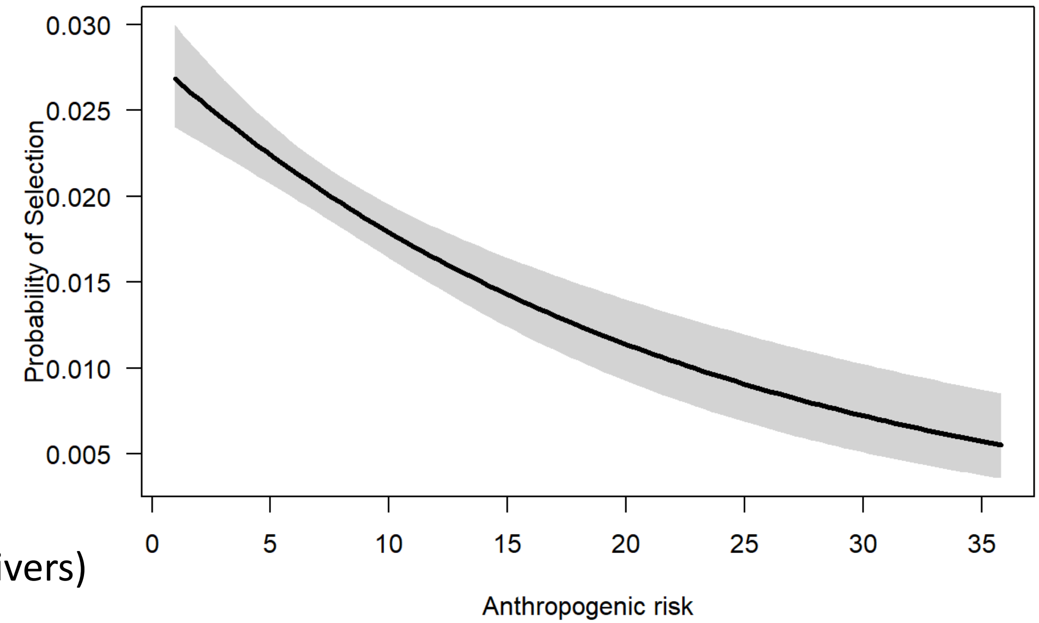
- Anthropogenic Footprint
- Distance to landscape features (Roads, Rivers)
- ……

Simulation analysis required to estimate required availability sample

Use v. Availability Study Design

Logistic regression analysis

$$w(x, \beta)=\exp(\beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n)$$

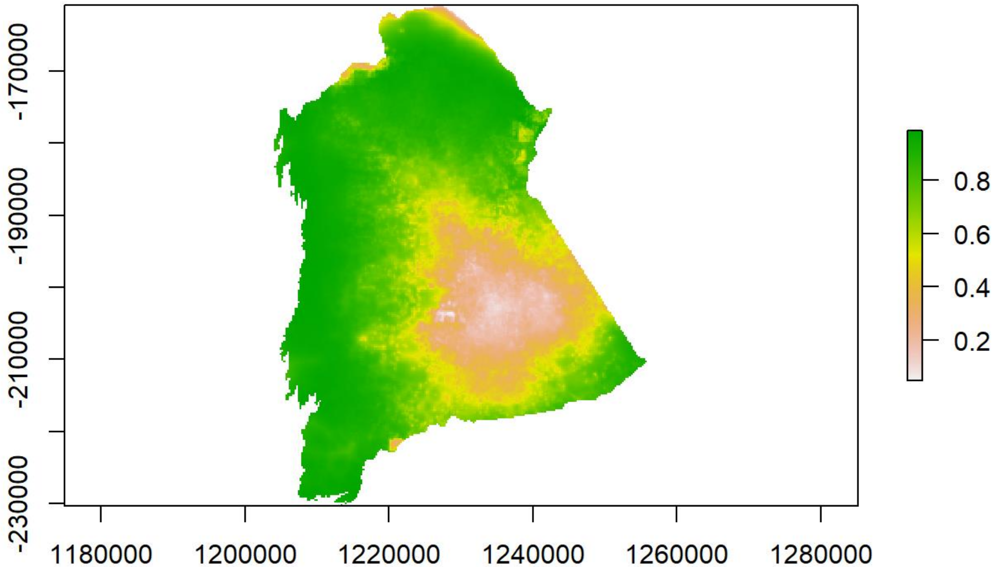


Habitat covariates:

- Anthropogenic Footprint
- Distance to landscape features (Roads, Rivers)
- ……

Resource Selection Function Analysis

Final Prediction



For more information:

A 'How-to' Guide for Interpreting Parameters in Habitat-Selection Analyses

John Fieberg, Johannes Signer, Brian Smith, Tal Avgar

doi: https://doi.org/10.1101/2020.11.12.379834