

# DISPERSAL & CONNECTIVITY

IN PHYSICAL, SEASONAL, AND EXTREME LANDSCAPES



BOTSWANA  
PREDATOR  
CONSERVATION

PhD Defense, 3<sup>rd</sup> July 2024



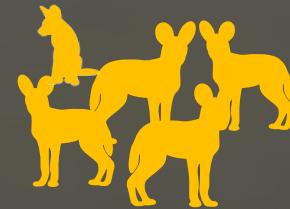
David D. Hofmann  
(david.hofmann2@uzh.ch)



University of  
Zurich <sup>UZH</sup>







# INTRODUCTION



# CHAPTER I

# CHAPTER II

# CHAPTER III

# CHAPTER IV

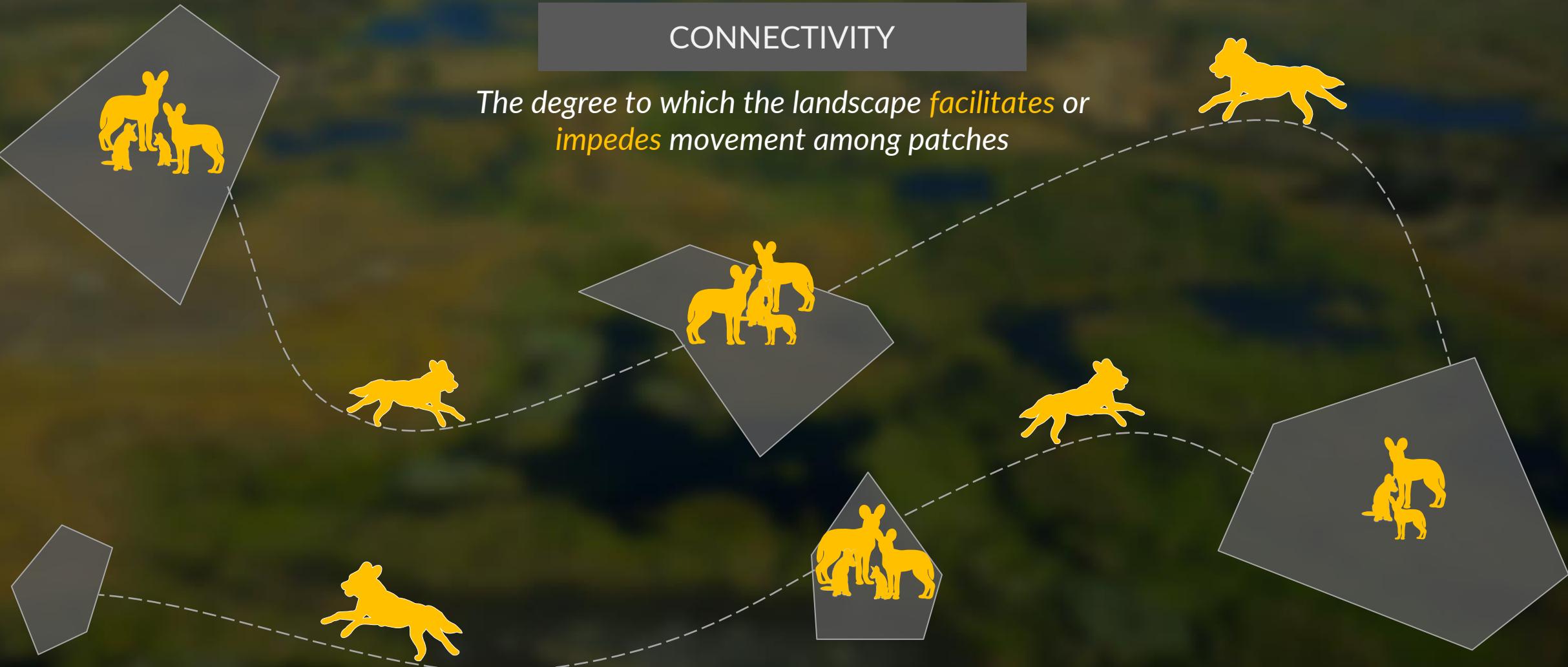
# DISCUSSION



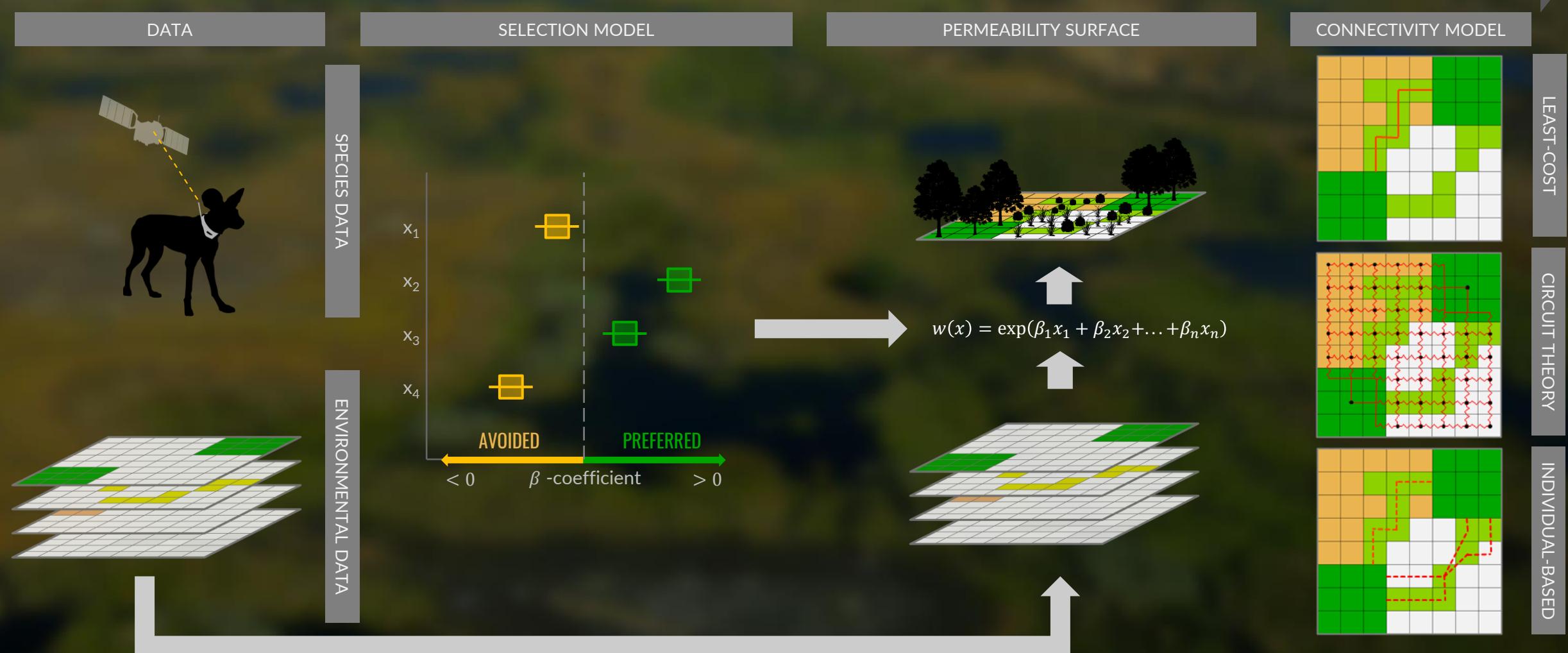


## CONNECTIVITY

*The degree to which the landscape **facilitates** or **impedes** movement among patches*



## CONNECTIVITY MODELING PIPELINE





# AFRICAN WILD DOG

*Lycaon pictus*

- ❖ Highly social, pack-living species
- ❖ Extremely wide-ranging
- ❖ < 6,000 individuals remaining
- ❖ Africa's most endangered large carnivore
- ❖ Strongly dependent on dispersal





# THE DISPERSAL PROJECT

- ❖ Since 2015
- ❖ 70 individuals collared
- ❖ 30 dispersed



BOTSWANA  
PREDATOR  
CONSERVATION



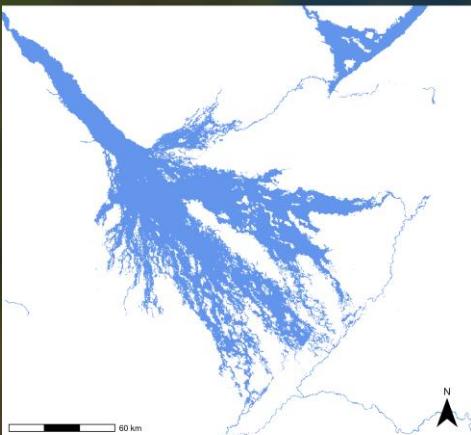
University of  
Zurich<sup>UZH</sup>



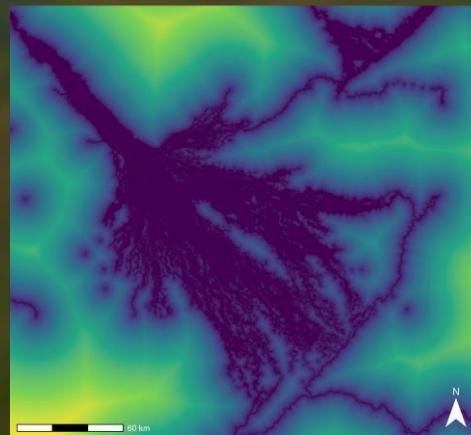
Google Earth  
Data SIO, NOAA, U.S. Navy



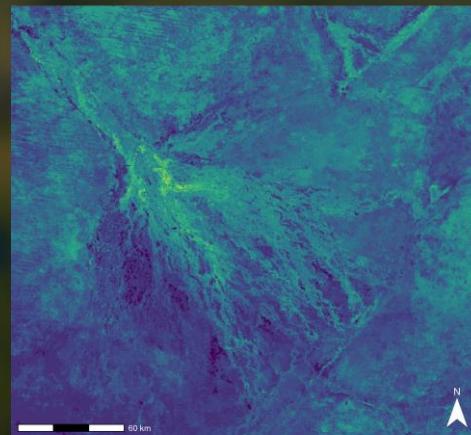
WATER COVER



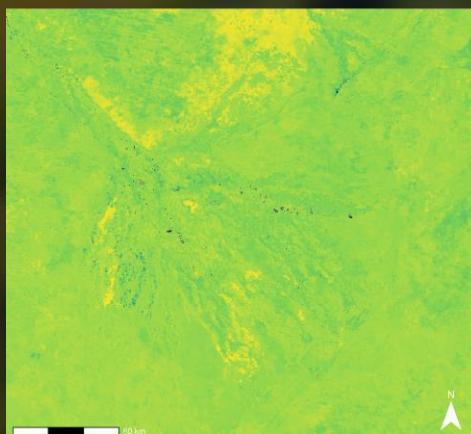
DISTANCE TO WATER



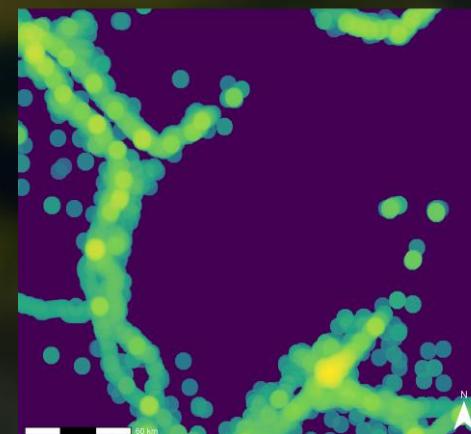
TREE COVER



SHRUB COVER

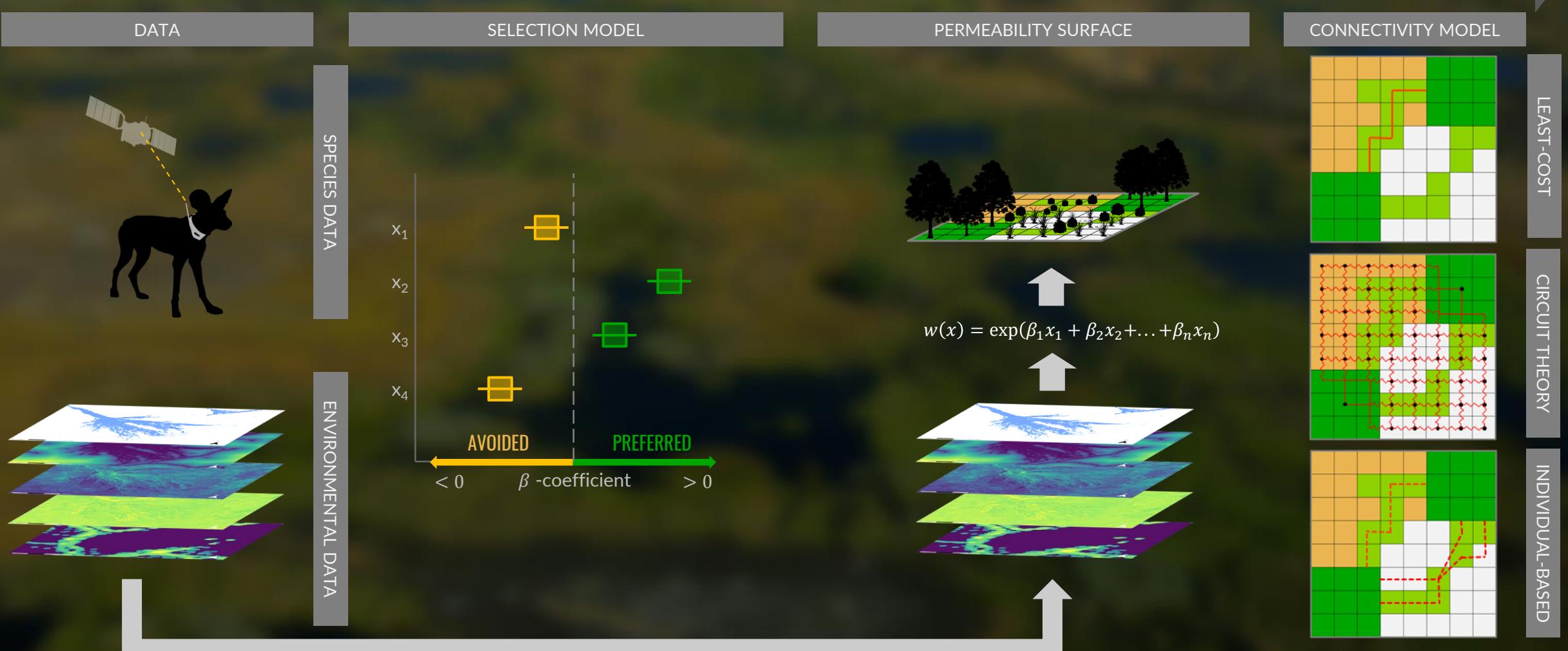


HUMAN INFLUENCE





## CONNECTIVITY MODELING PIPELINE





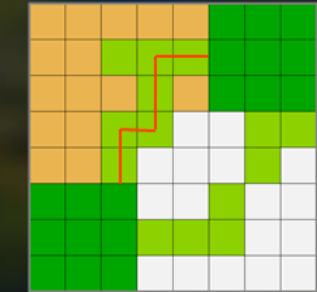
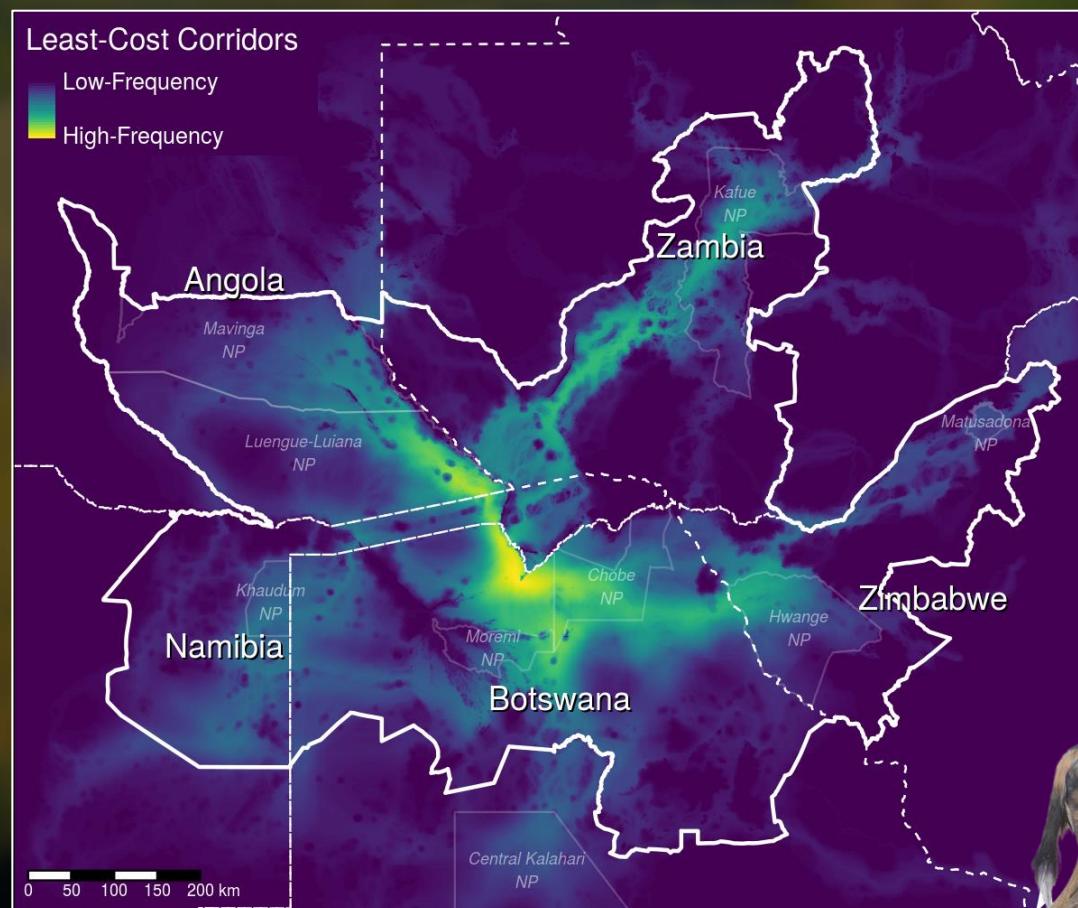
## CONNECTIVITY MODELING PIPELINE

DATA

SELECTION MODEL

PERMEABILITY SURFACE

CONNECTIVITY MODEL



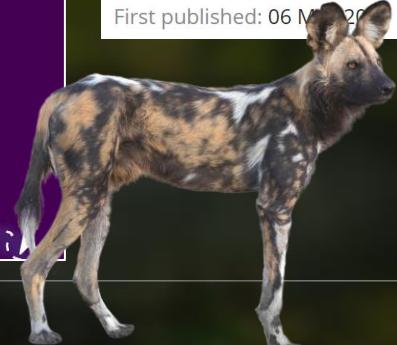
**Journal of Applied Ecology**

RESEARCH ARTICLE | [Full Access](#)

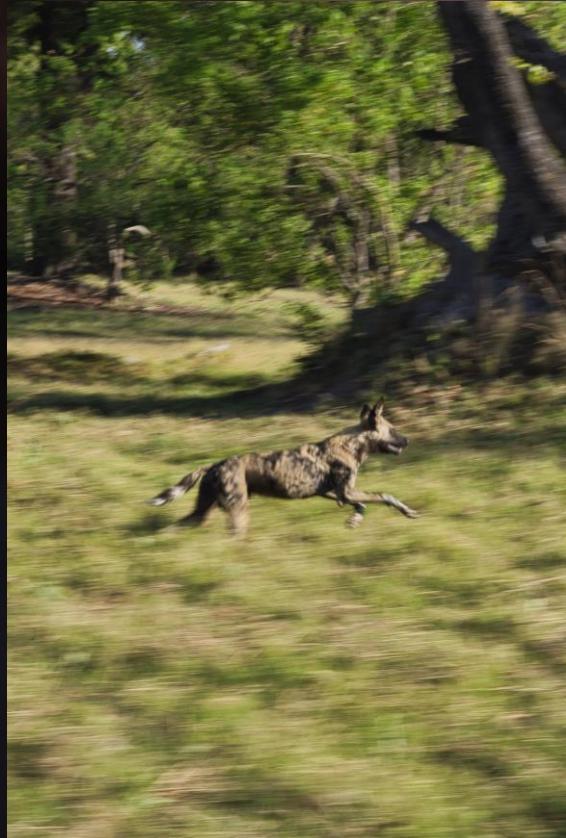
**Bound within boundaries: Do protected areas cover movement corridors of their most mobile, protected species?**

David D. Hofmann ✉, Dominik M. Behr, John W. McNutt, Arpat Ozgul, Gabriele Cozzi

First published: 06 May 2021 | <https://doi.org/10.1111/1365-2664.13868>



We can probably do better!

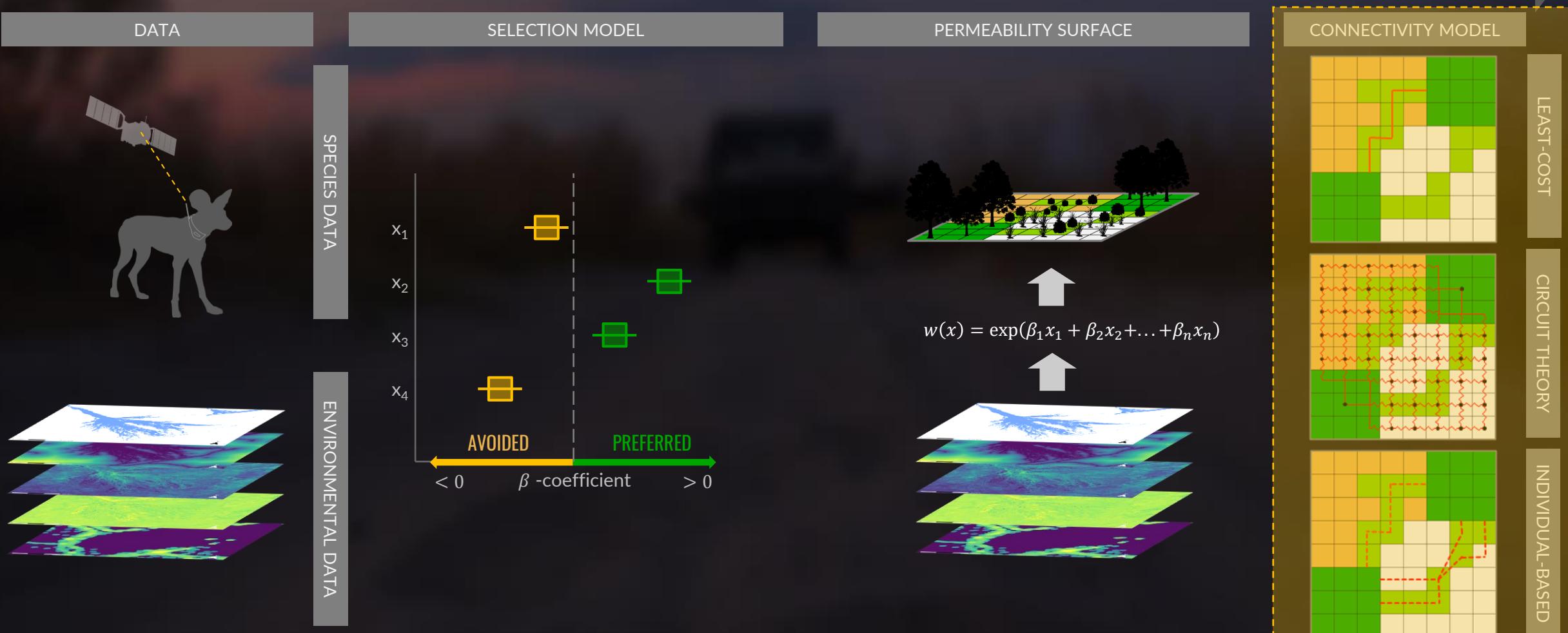


## A Three-Step Approach for Assessing Landscape Connectivity via Simulated Dispersal: African Wild Dog Case Study

David Hofmann, Gabriele Cozzi, John W. McNutt, Arpat Ozgul, Dominik Behr

*Landscape Ecology*, 2023

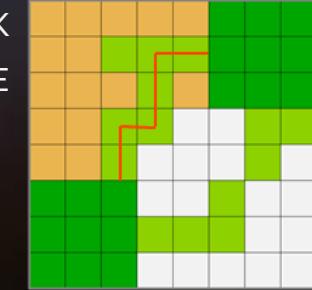
## CONNECTIVITY MODELING PIPELINE





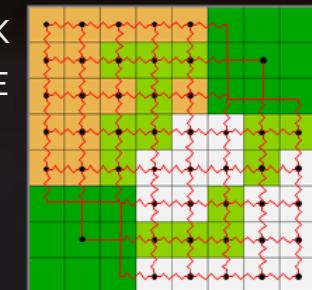
## CONNECTIVITY MODEL

OPTIMIZED WALK

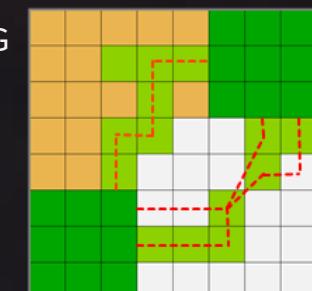
 $\infty$  PERCEPTIONAL RANGE

RANDOM WALK

1 PX PERCEPTIONAL RANGE



STANDARDIZED PROTOCOLS LACKING

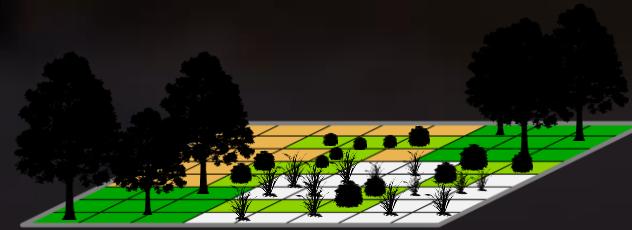


LEAST-COST

CIRCUIT THEORY

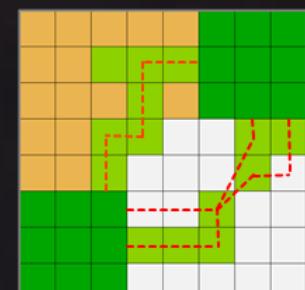
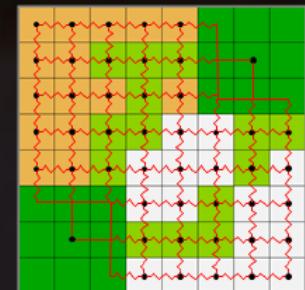
INDIVIDUAL-BASED

PERMEABILITY SURFACE



UNCONDITIONAL PREDICTION

CONNECTIVITY MODEL

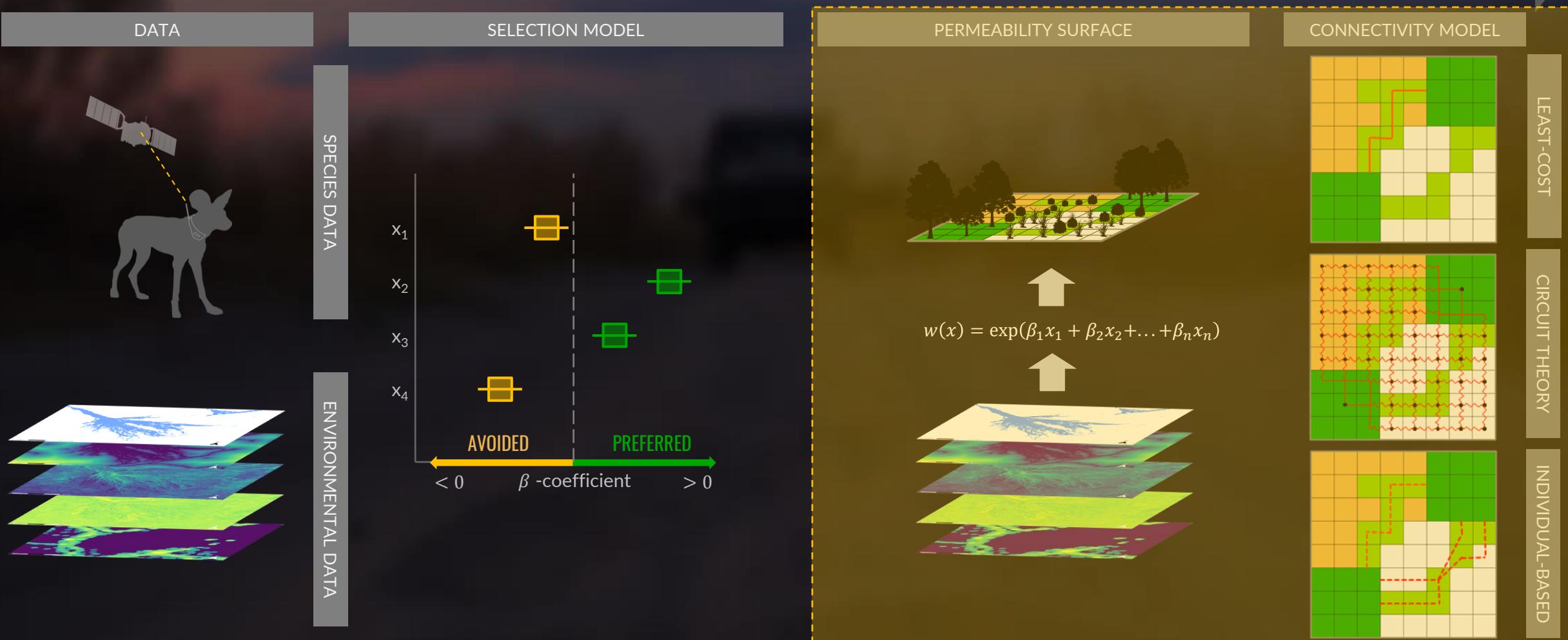


LEAST-COST

CIRCUIT THEORY

INDIVIDUAL-BASED

## CONNECTIVITY MODELING PIPELINE



## CONNECTIVITY MODELING PIPELINE

DATA

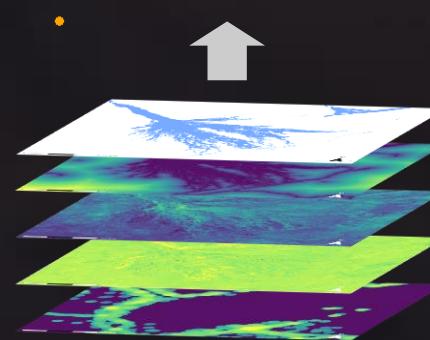
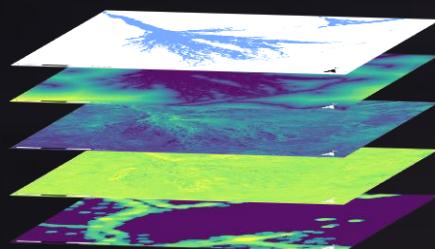
SELECTION MODEL

DISPERSAL SIMULATION

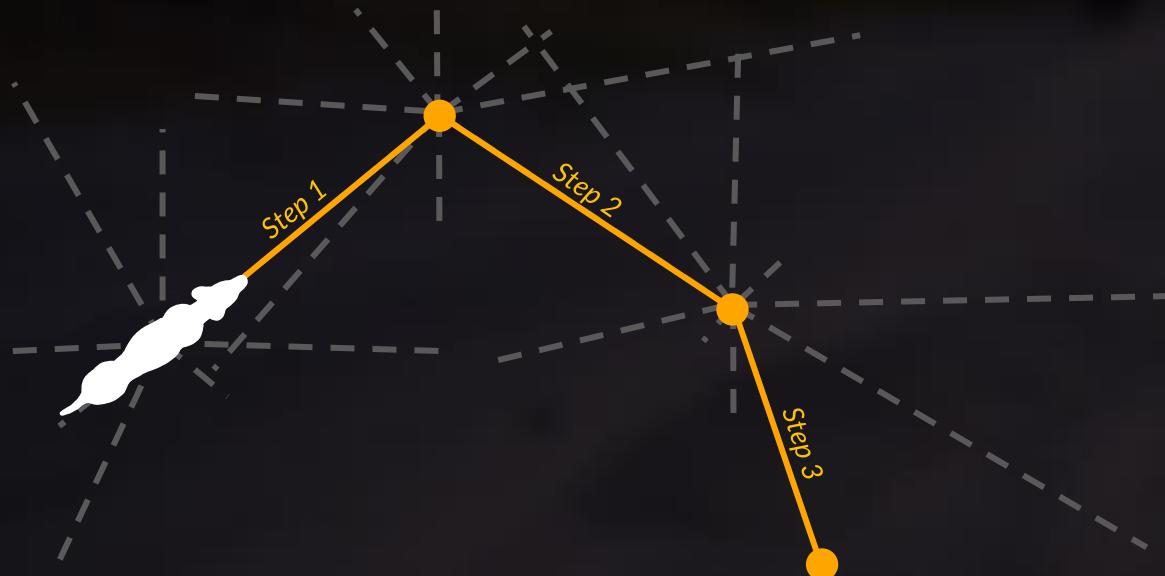
SPECIES DATA



INTEGRATED STEP-SELECTION FUNCTIONS



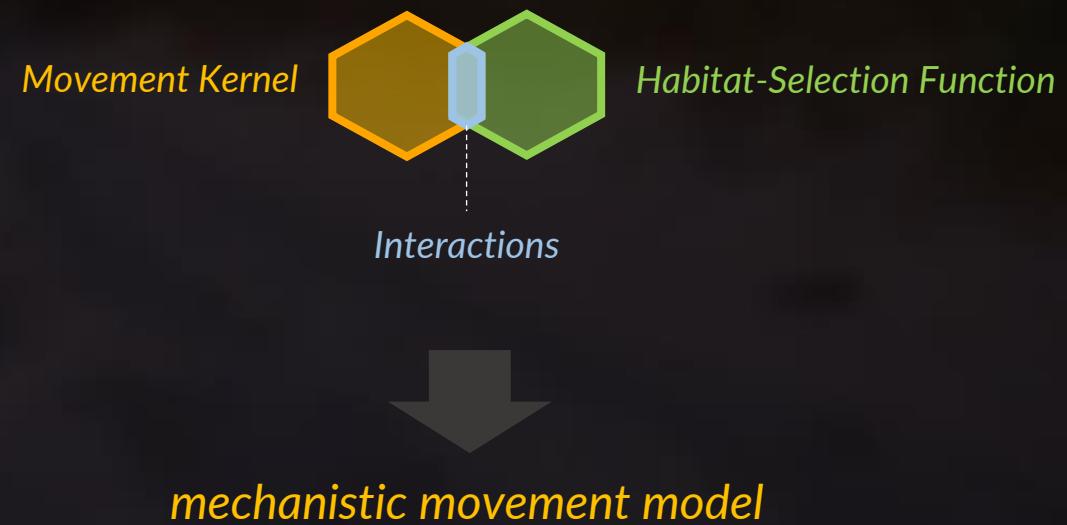
## INTEGRATED STEP-SELECTION FUNCTIONS

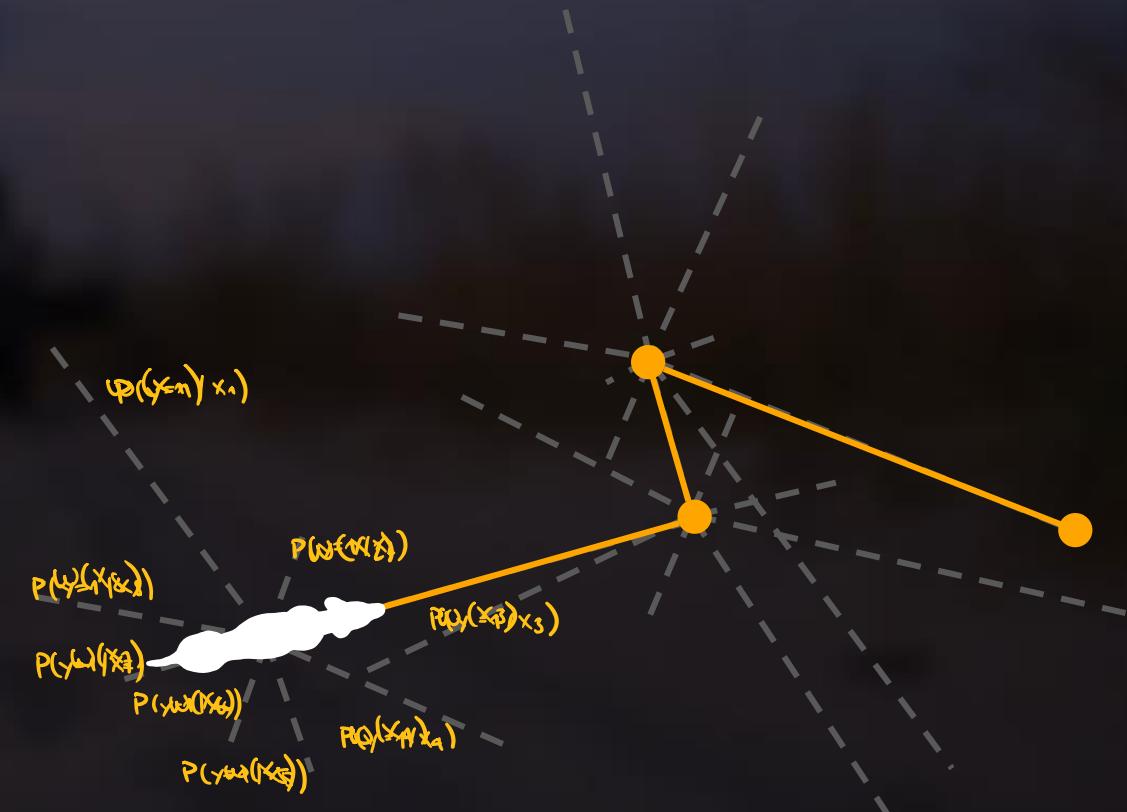
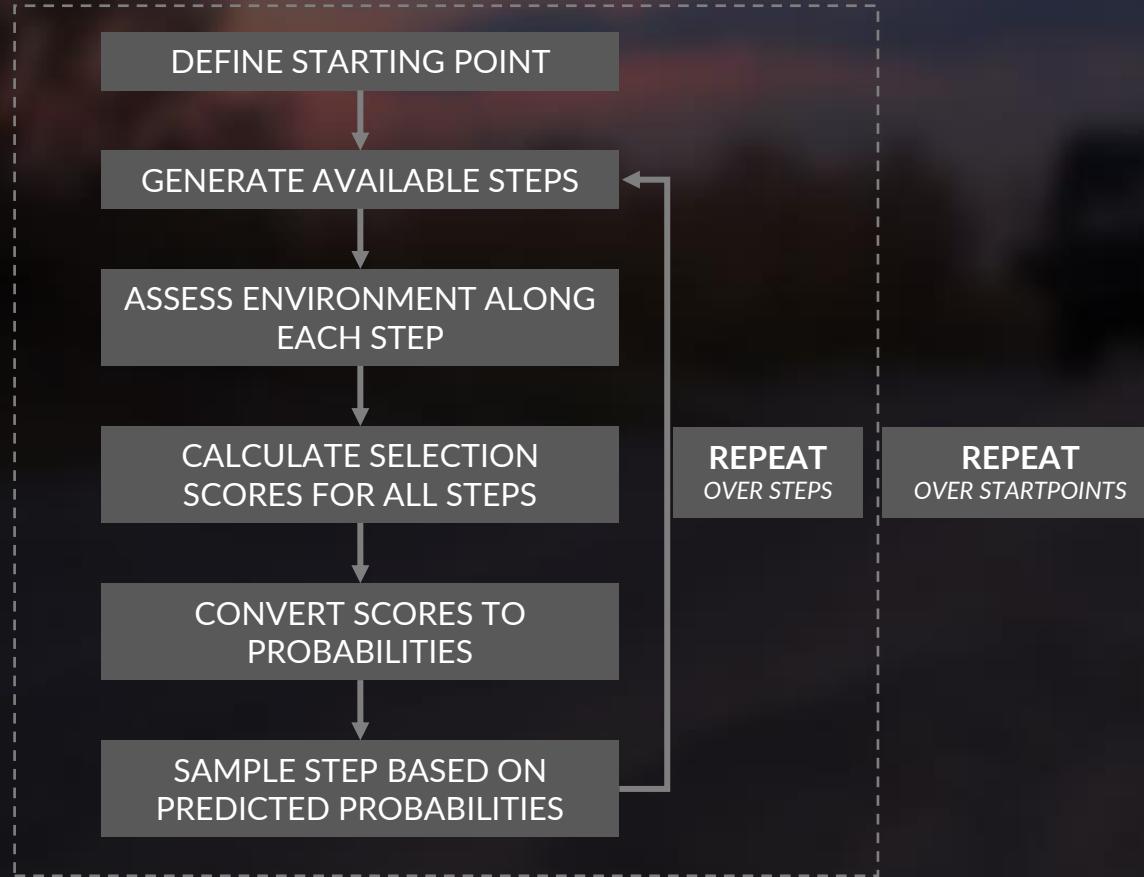


## SELECTION SCORE

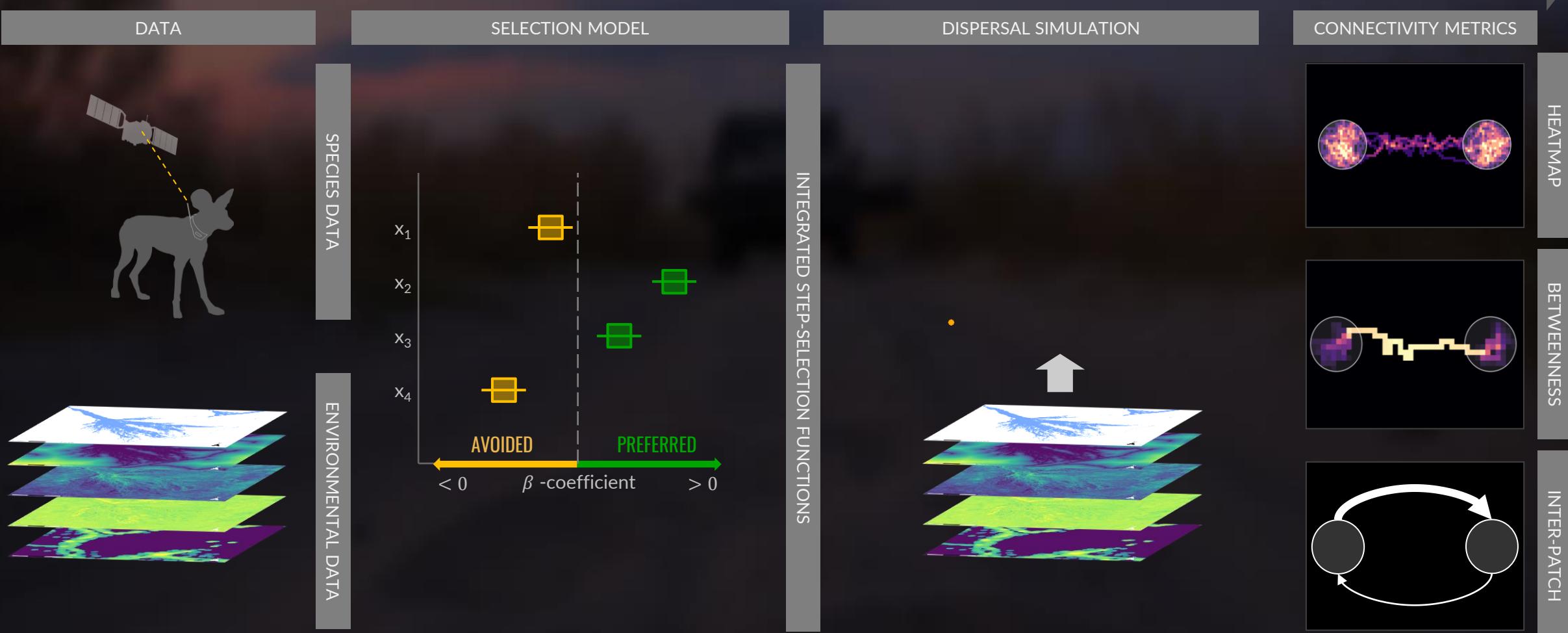
$$w(x) = \exp(\beta_1 x_1 + \beta_2 x_2 + \dots + \beta_i x_i)$$

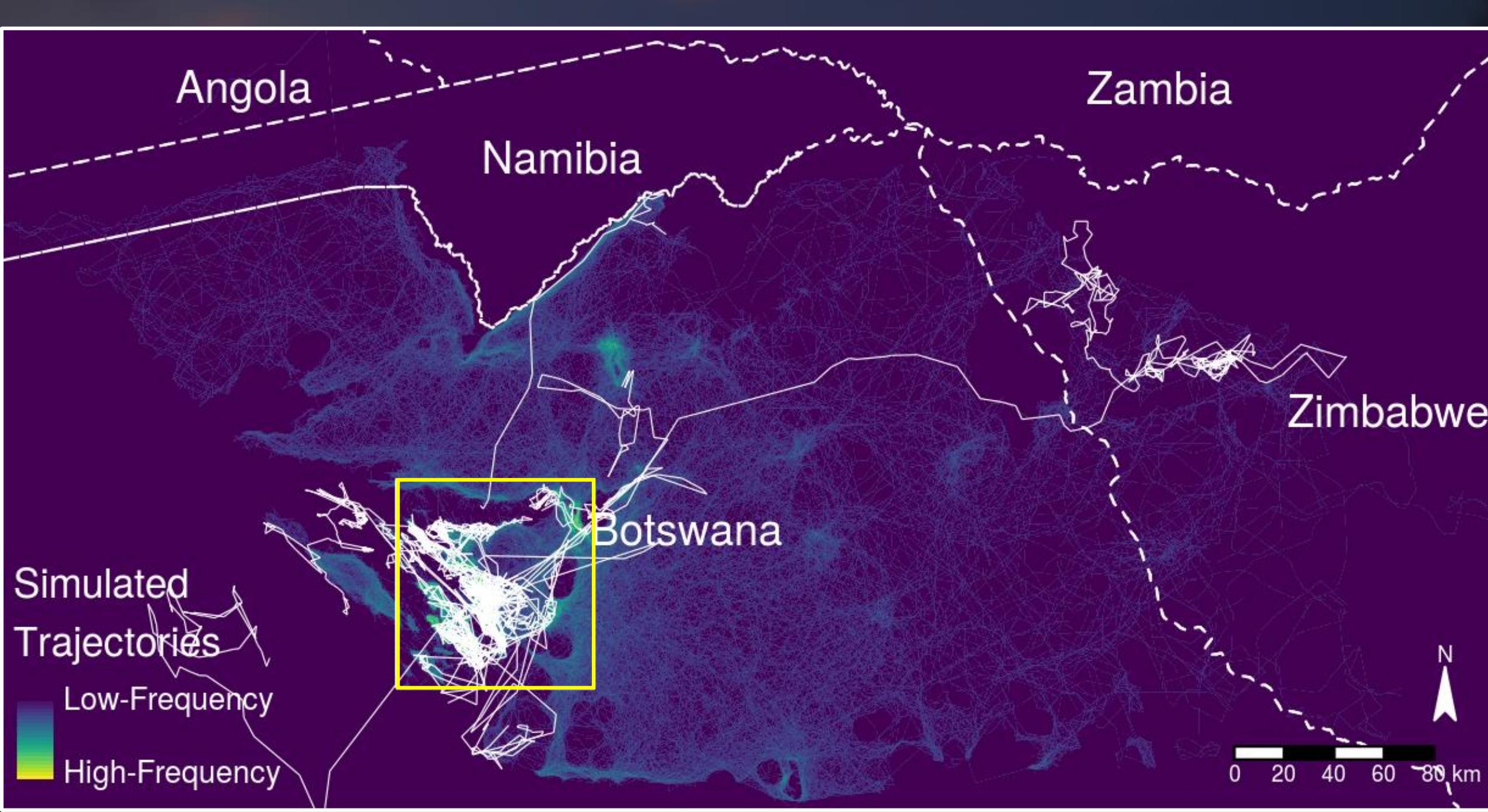
## MIXED EFFECTS CONDITIONAL LOGISTIC REGRESSION





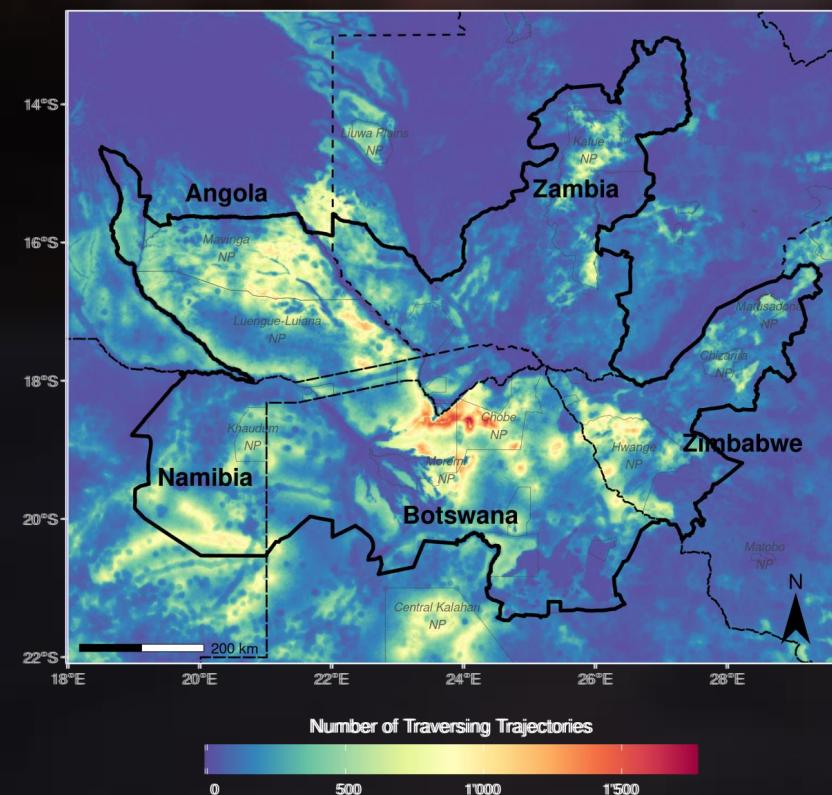
## CONNECTIVITY MODELING PIPELINE





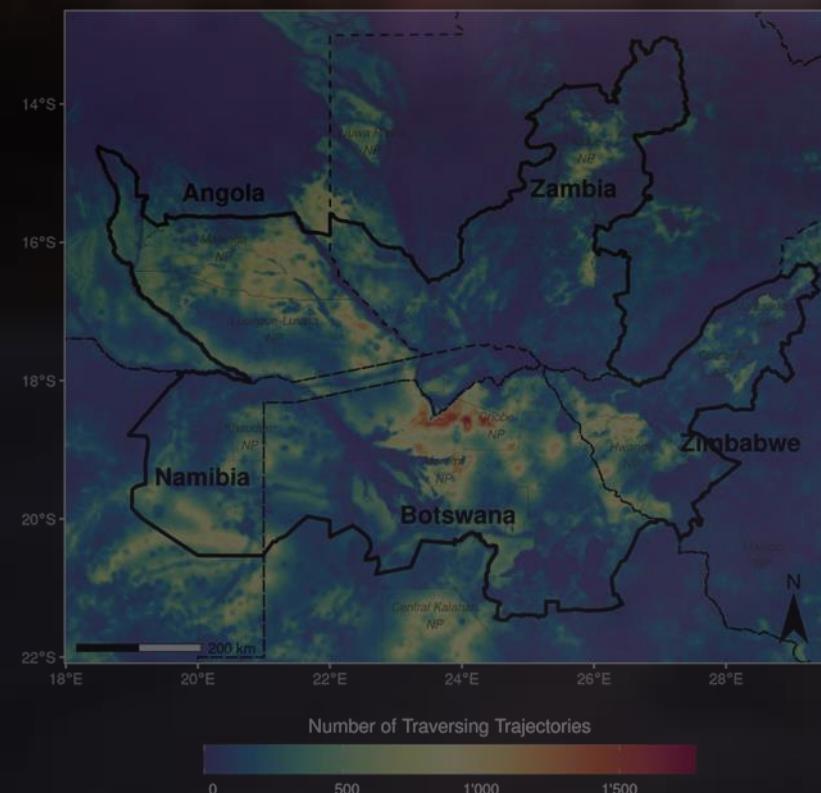
*intensity of use*

HEATMAP

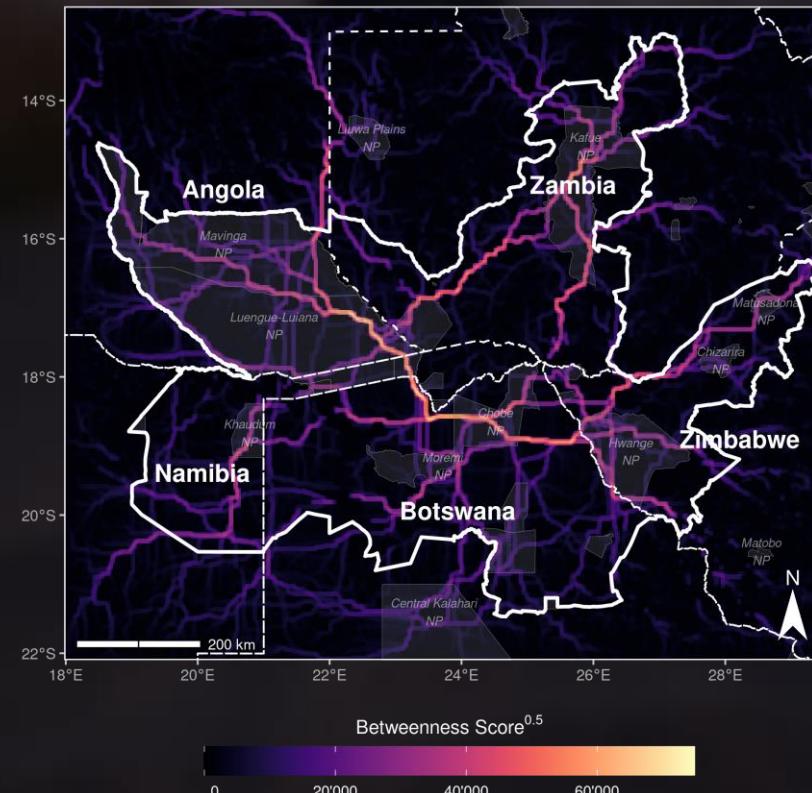


*corridors/bottlenecks*

HEATMAP

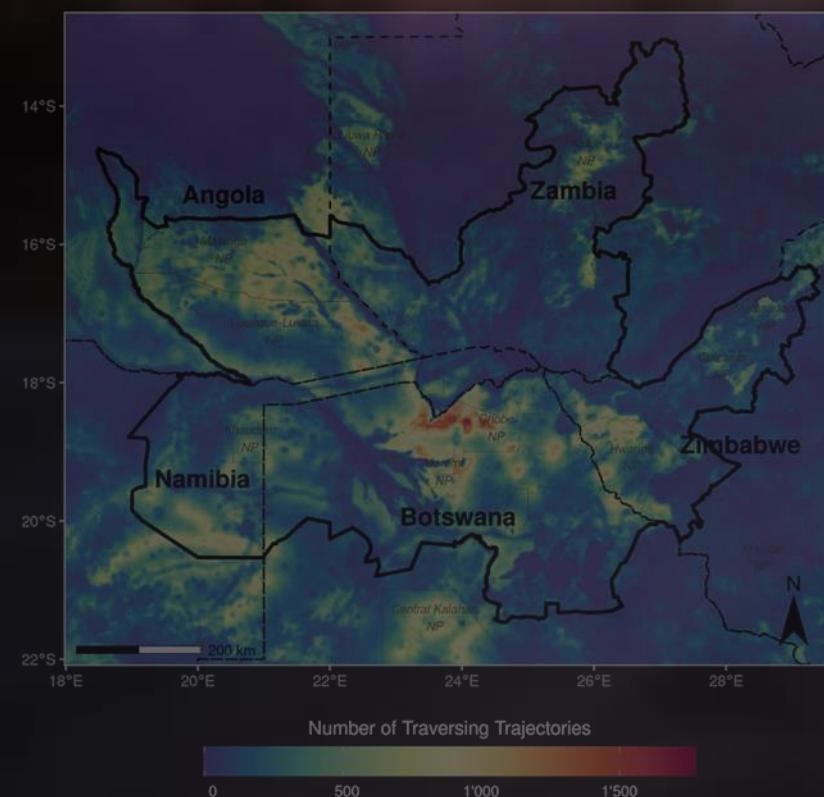


BETWEENNESS

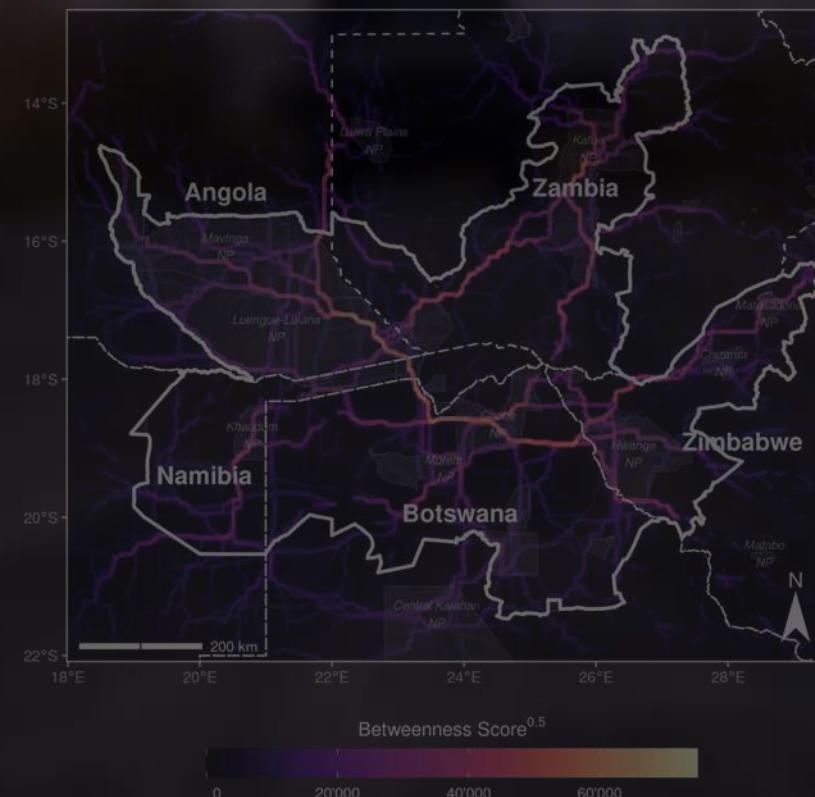


*connections / dispersal durations*

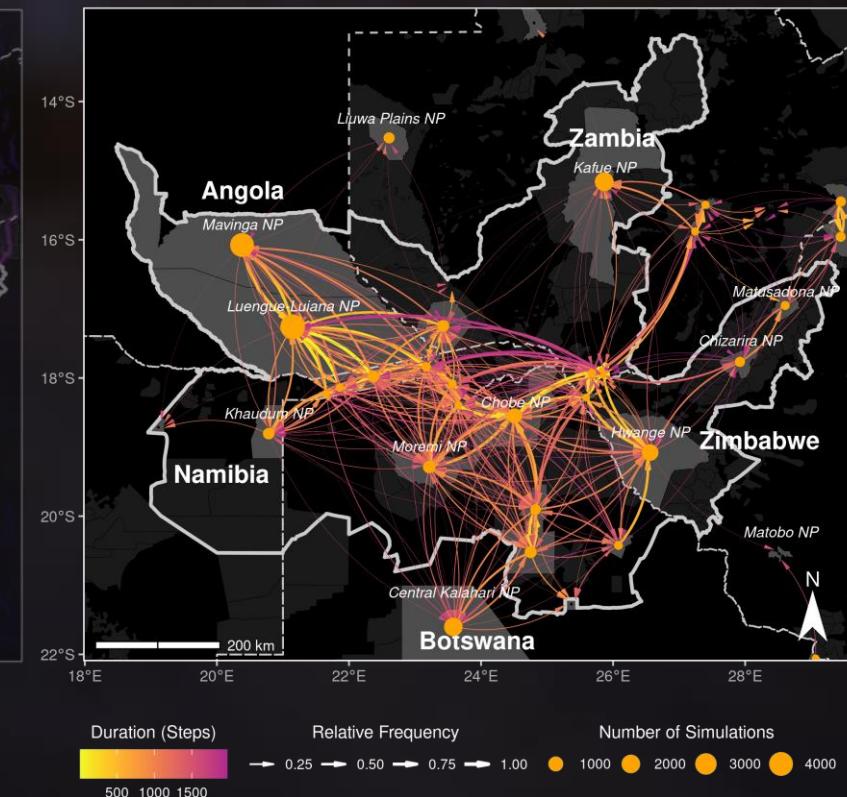
HEATMAP



BETWEENNESS

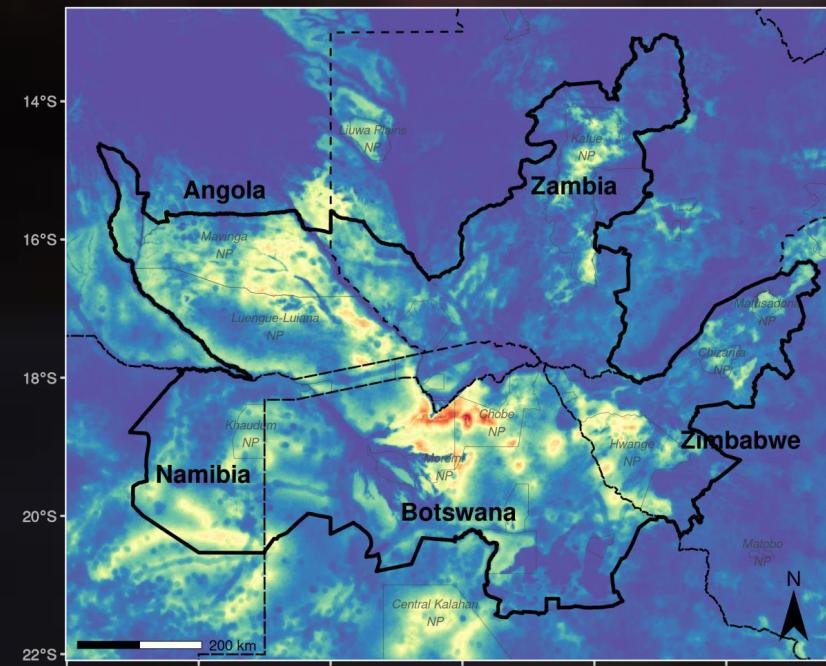


INTER-PATCH CONNECTIVITY

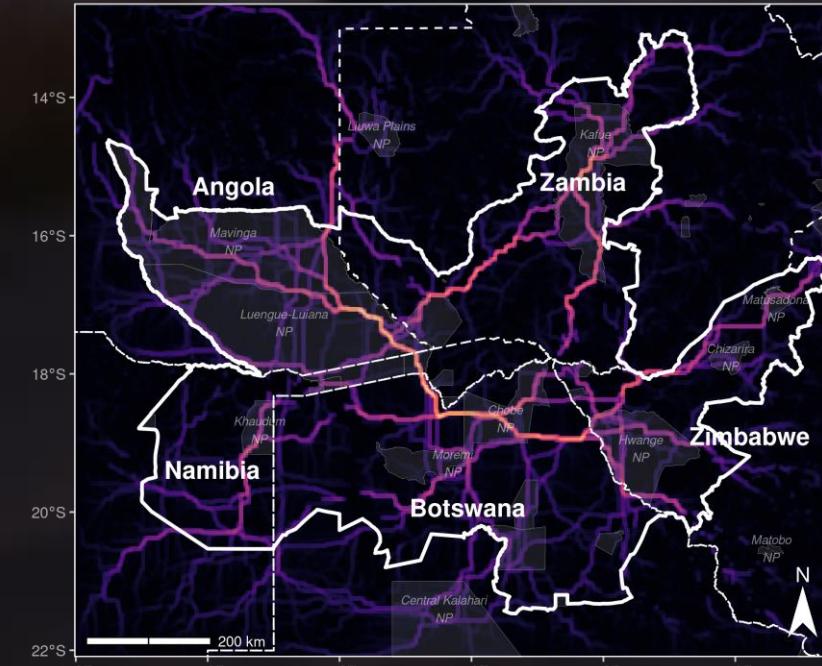


*intensity of use*

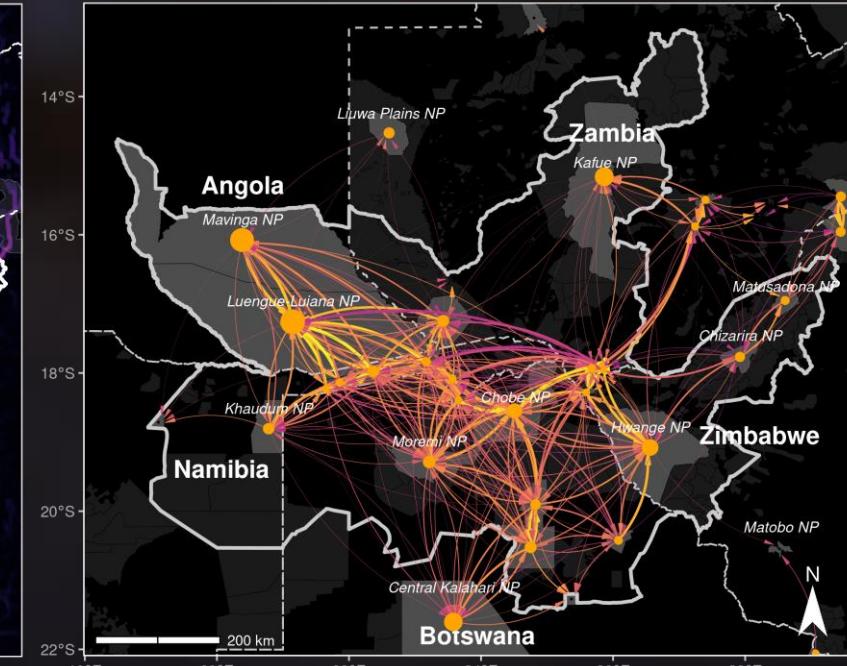
HEATMAP

*corridors/bottlenecks*

BETWEENNESS

*connections / dispersal durations*

INTER-PATCH CONNECTIVITY







CHAPTER I

SIMULATE DISPERSAL

## A Three-Step Approach for Assessing Landscape Connectivity via Simulated Dispersal: African Wild Dog Case Study

David Hofmann, Gabriele Cozzi, John W. McNutt, Arpat Ozgul, Dominik Behr

*Landscape Ecology*, 2023

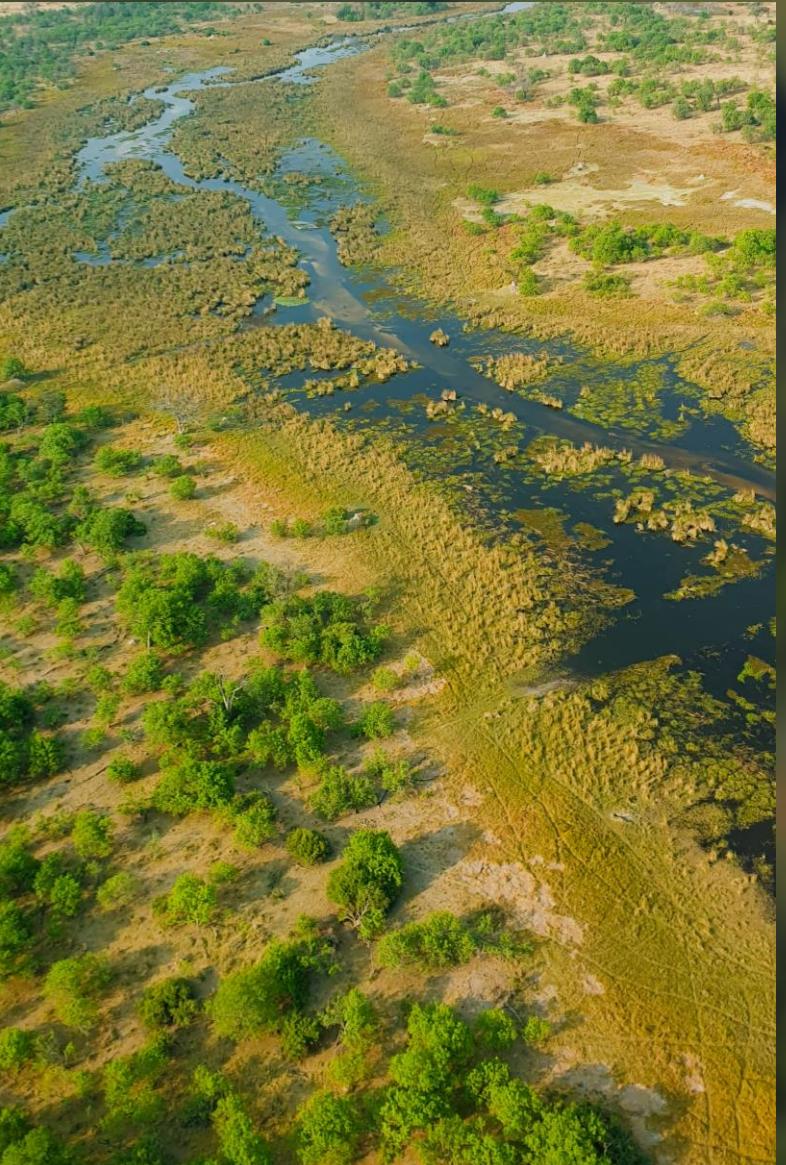
- ✓ New simulation-based connectivity model
- ✓ Complementary connectivity metrics
- ✓ African wild dog case study
  - Non-trivial modeling decisions
  - Assumed unchanged landscape

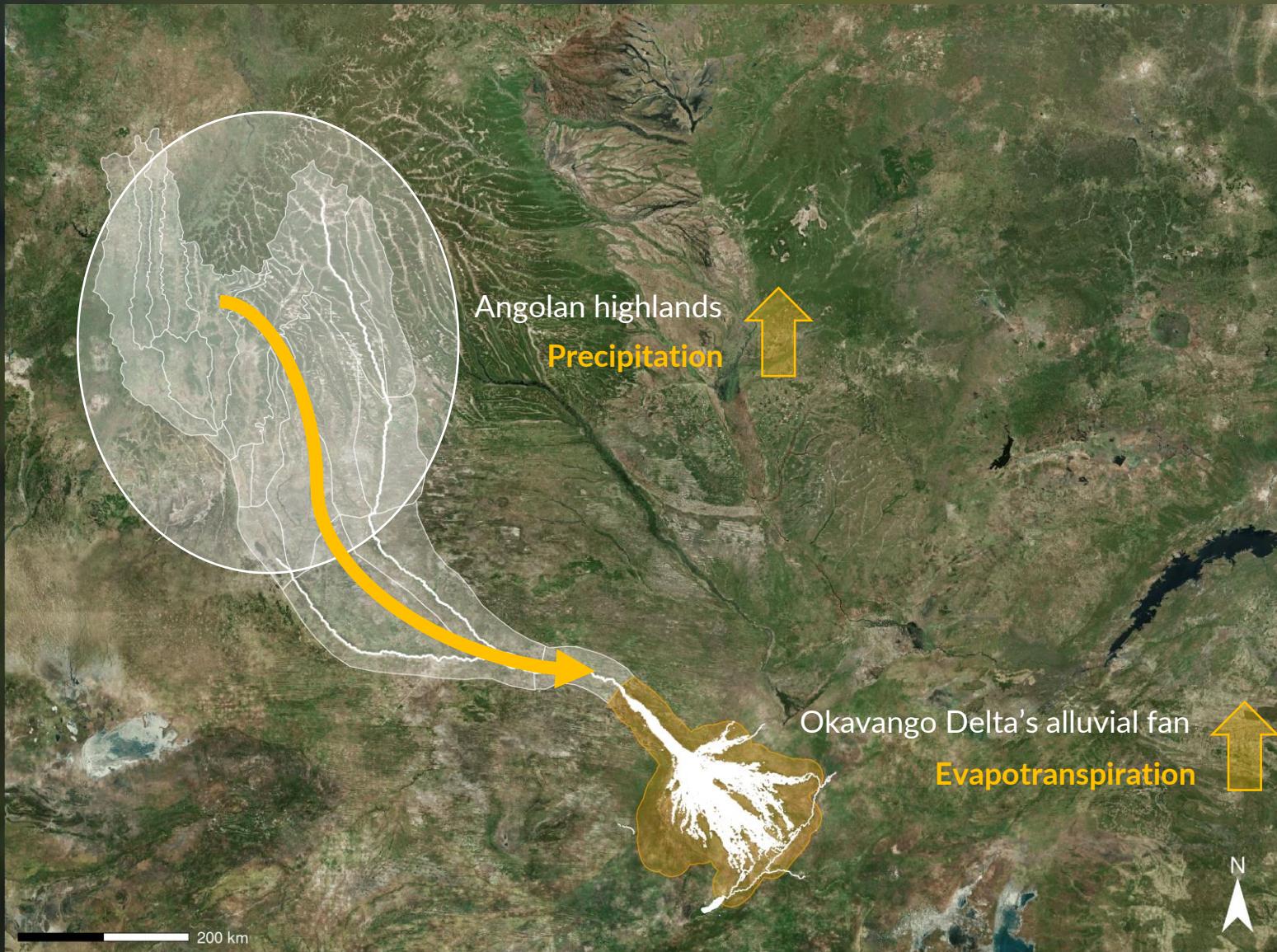


## Dispersal and Connectivity in Increasingly Extreme Climatic Conditions

David D. Hofmann, Dominik M. Behr, John W. McNutt, Arpat Ozgul, Gabriele Cozzi

*Global Change Biology*, 2024



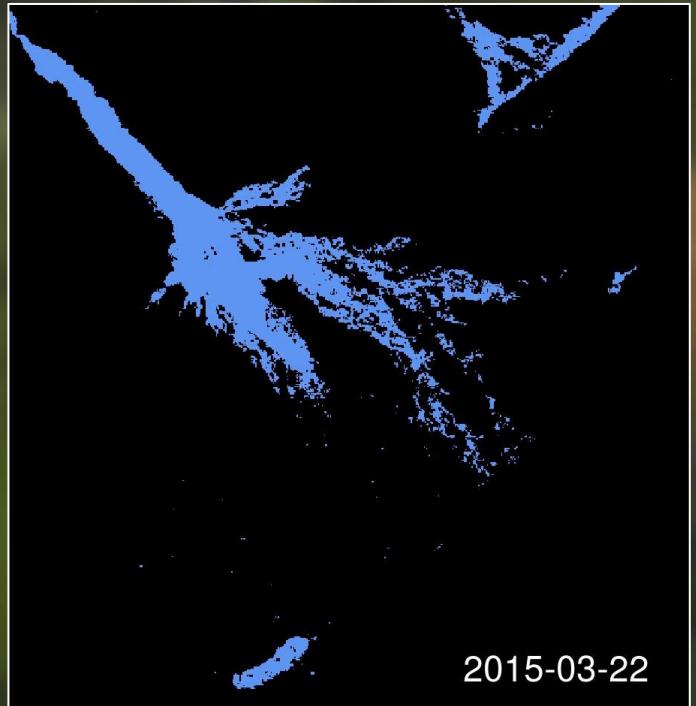


**floodmapr**[www.github.com/DavidDHofmann/floodmapr](https://www.github.com/DavidDHofmann/floodmapr)

`floodmapr` is an R-package that allows you to download and classify MODIS MCD43A4 satellite imagery into binary maps of dryland and water cover. To be able to download data, you need to have an EarthData account (free). The classification algorithm is based on the publication of Wolski et al., 2017 and currently only applicable for the extent of the Okavango Delta (see [Okavango Research Institute](#)).



$$SWIR_{thresh} = SWIR_{wet} + 0.3 * (SWIR_{dry} - SWIR_{wet})$$

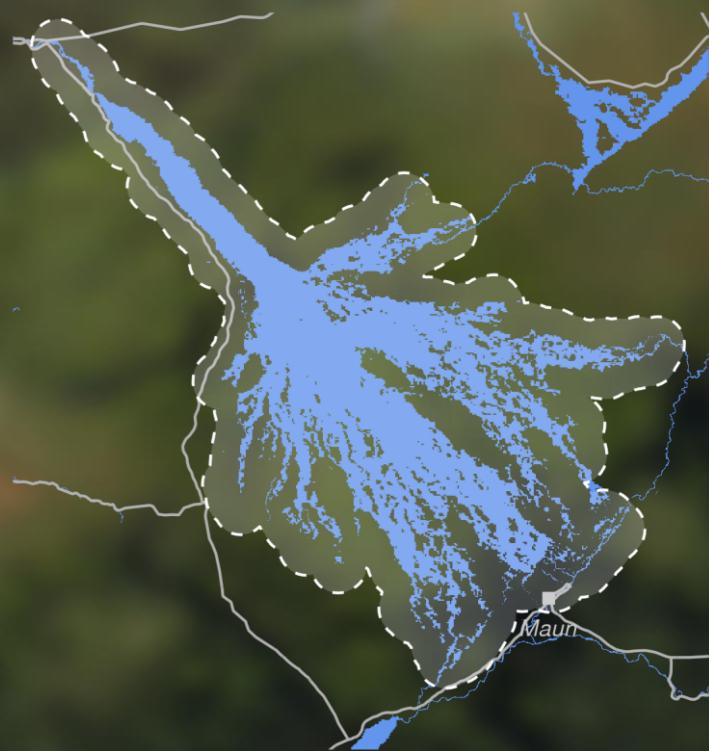


MINIMUM FLOOD SCENARIO



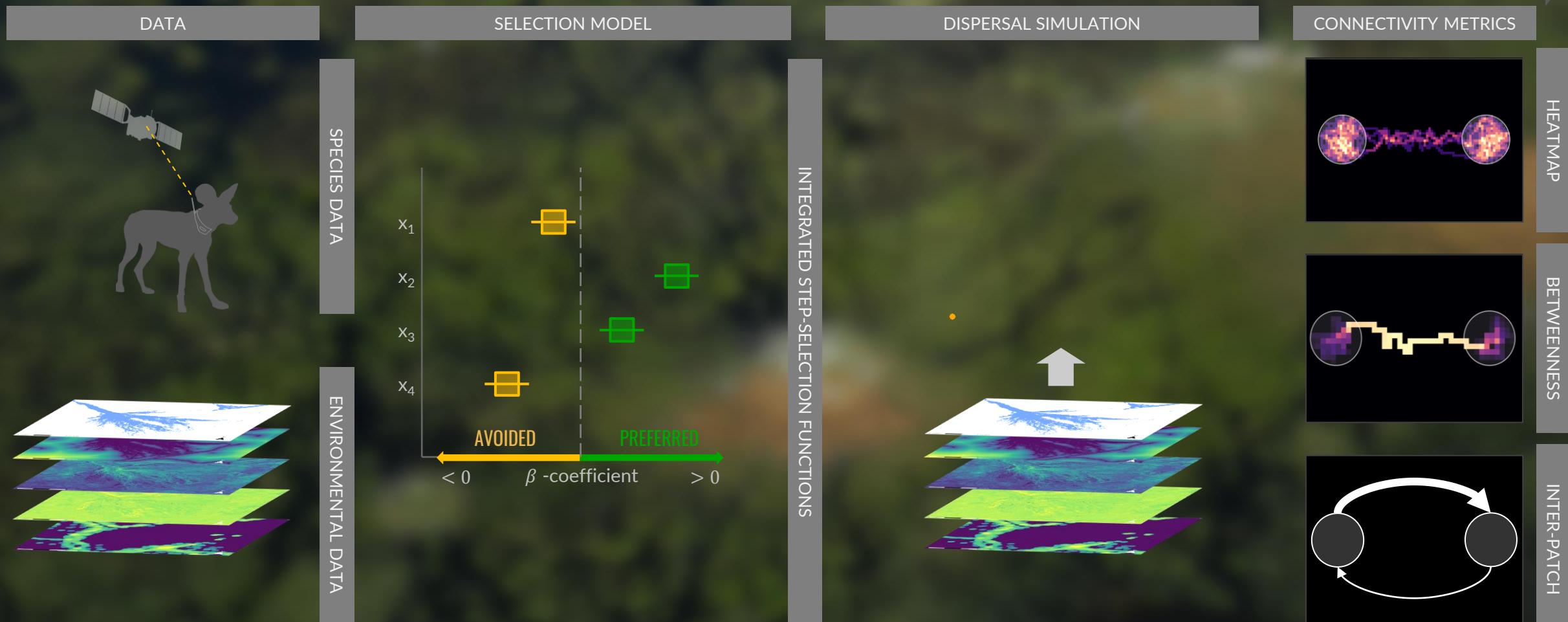
~ 3'500 km<sup>2</sup>

MAXIMUM FLOOD SCENARIO



~ 9'500 km<sup>2</sup>

## CONNECTIVITY MODELING PIPELINE



## CONNECTIVITY MODELING PIPELINE

## DATA

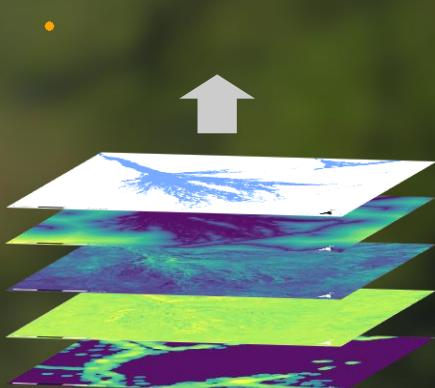


SPECIES DATA  
ENVIRONMENTAL DATA

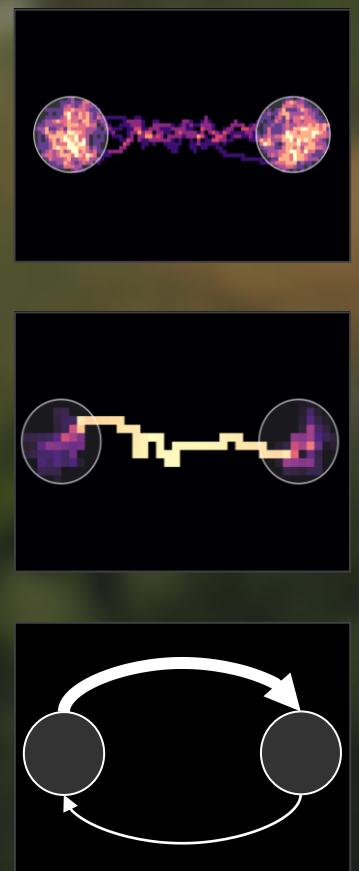
## SELECTION MODEL



## DISPERSAL SIMULATION

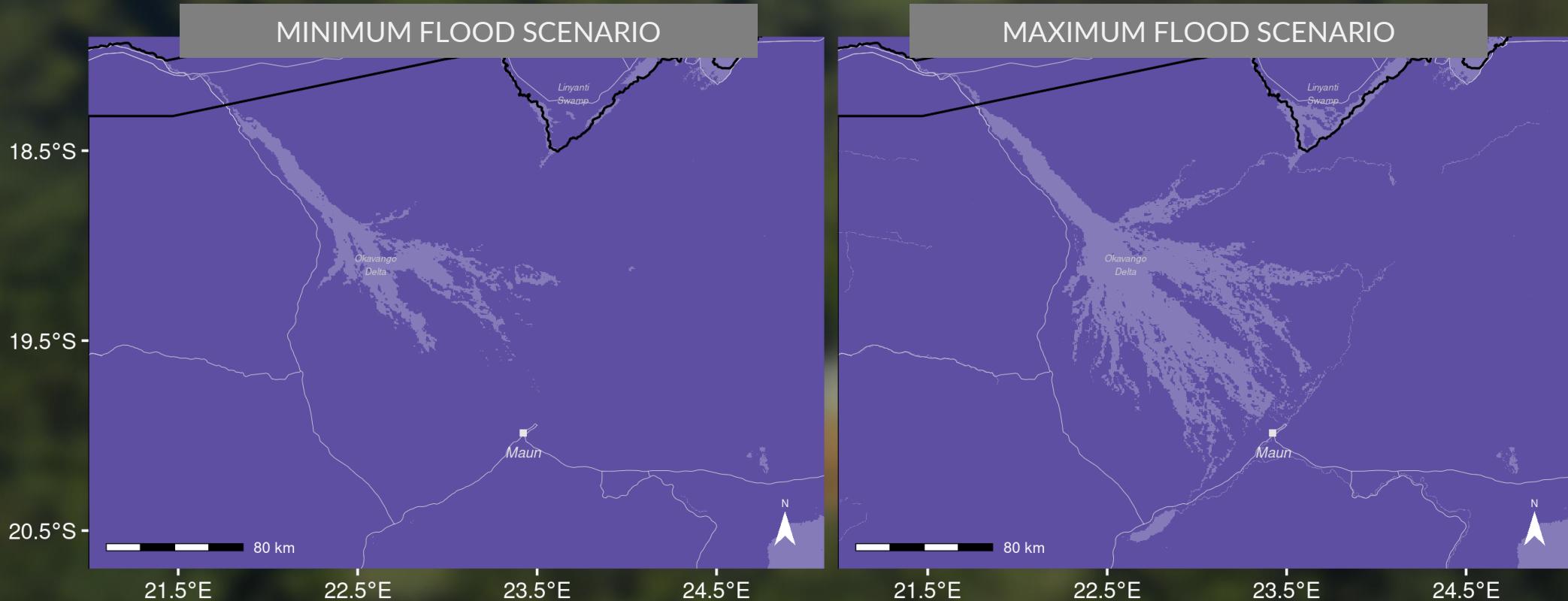


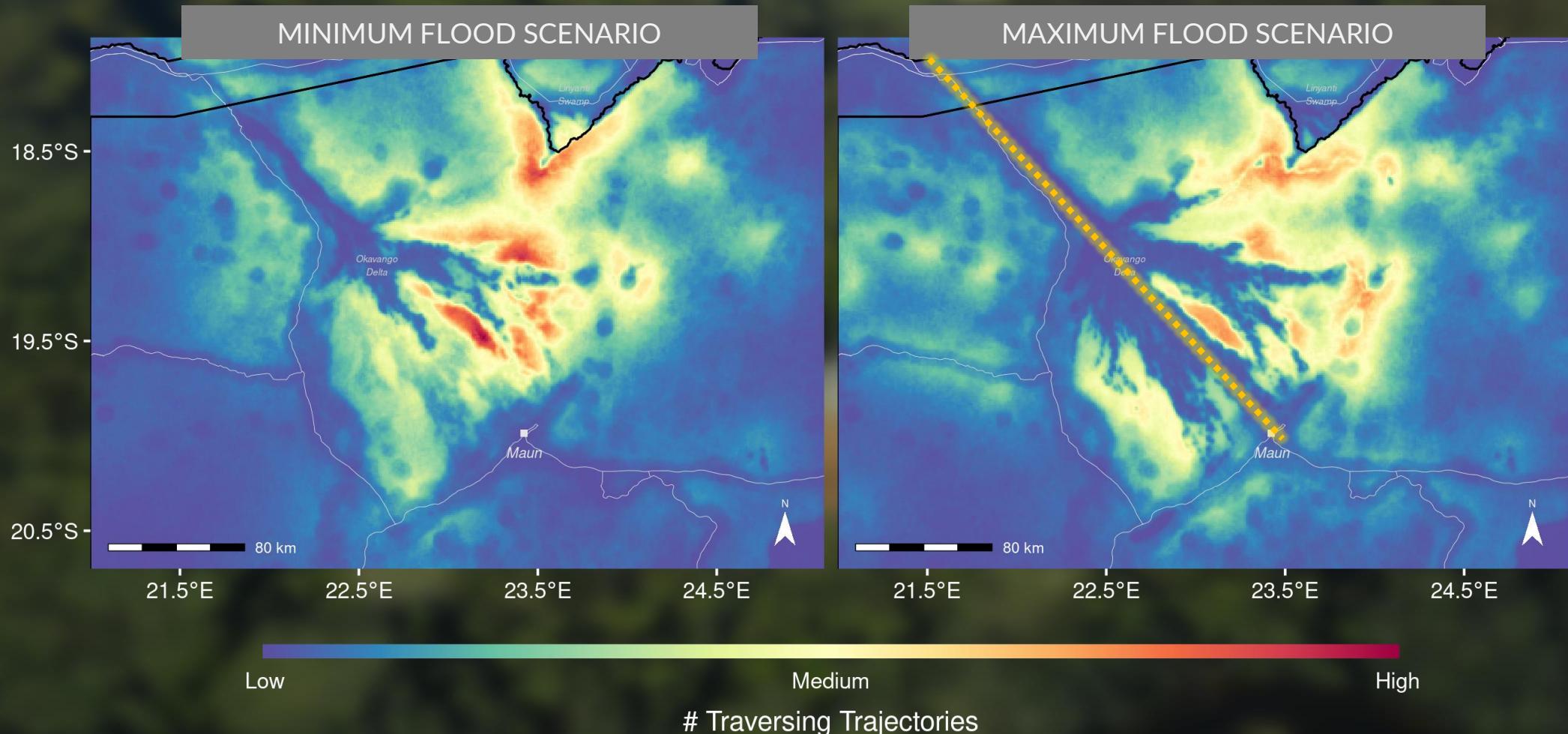
## CONNECTIVITY METRICS

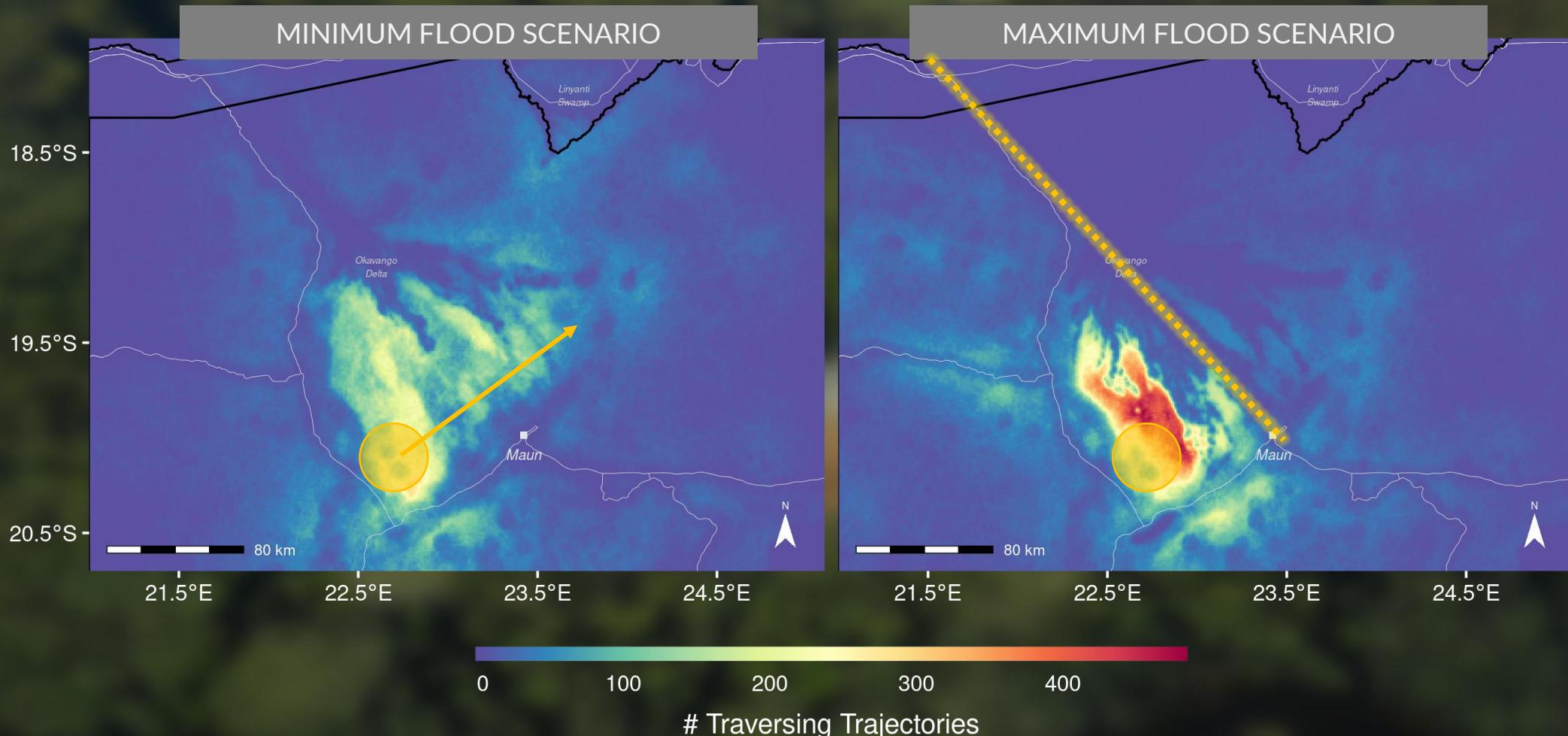


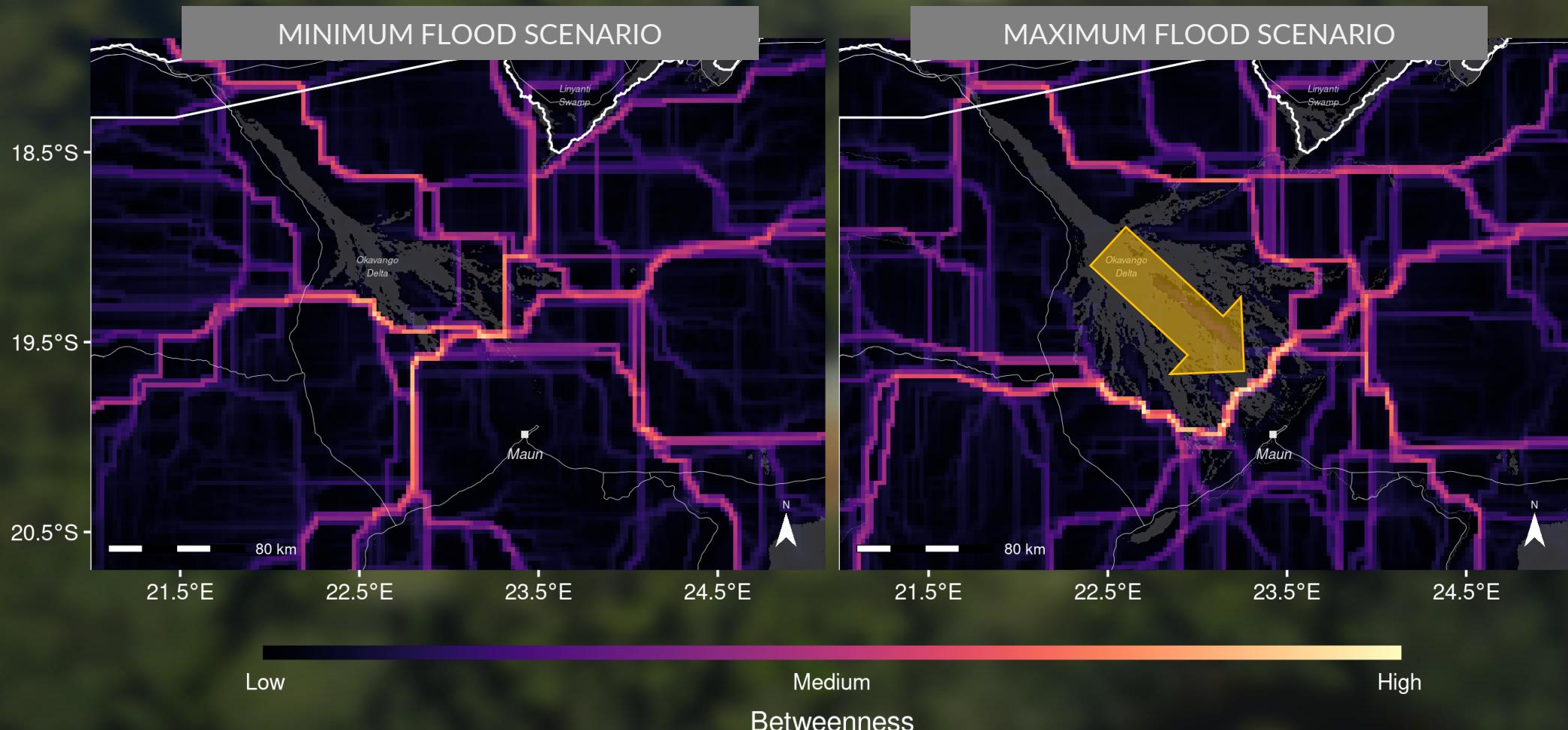
## CONNECTIVITY MODELING PIPELINE

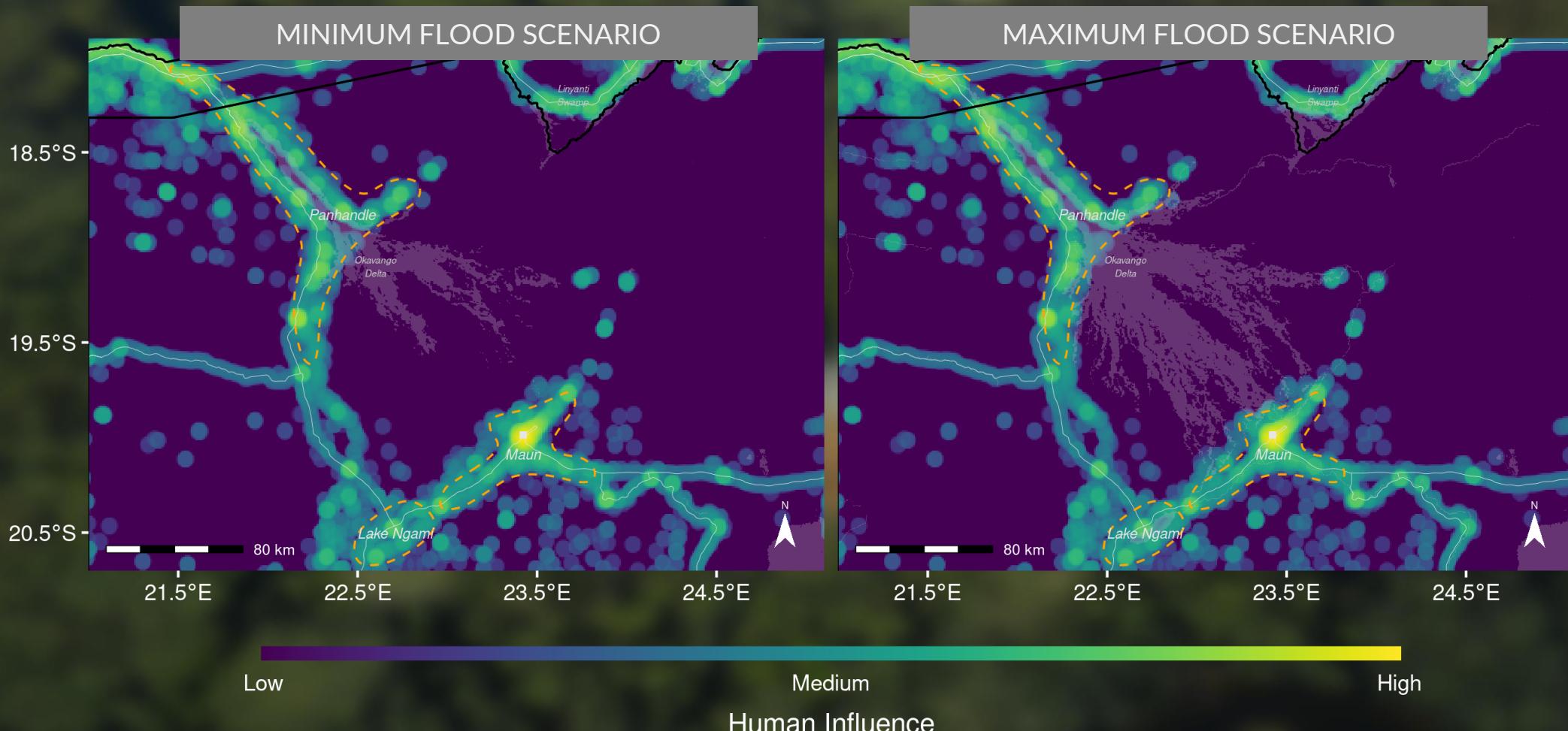


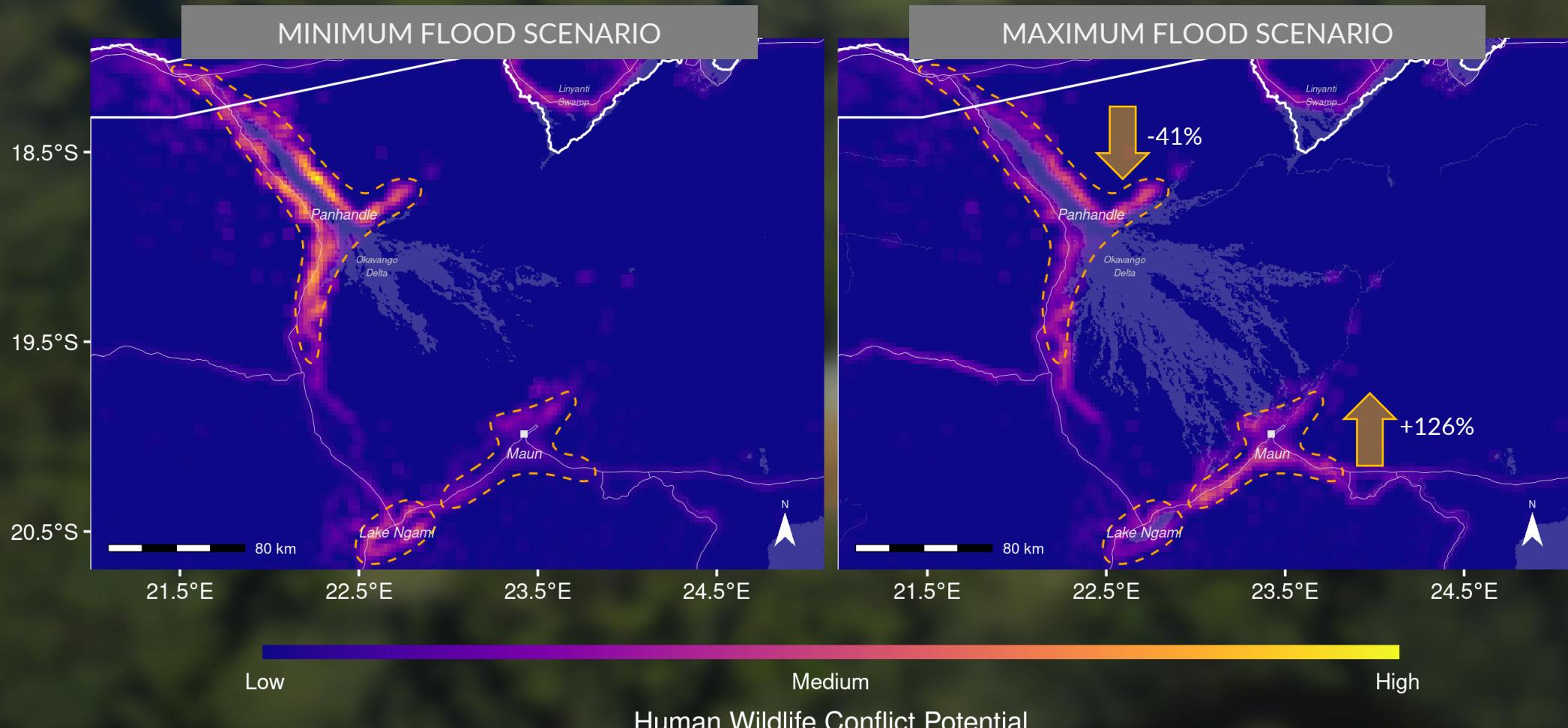
















## Dispersal and Connectivity in Increasingly Extreme Climatic Conditions

David D. Hofmann, Dominik M. Behr, John W. McNutt, Arpat Ozgul, Gabriele Cozzi

*Global Change Biology*, 2024

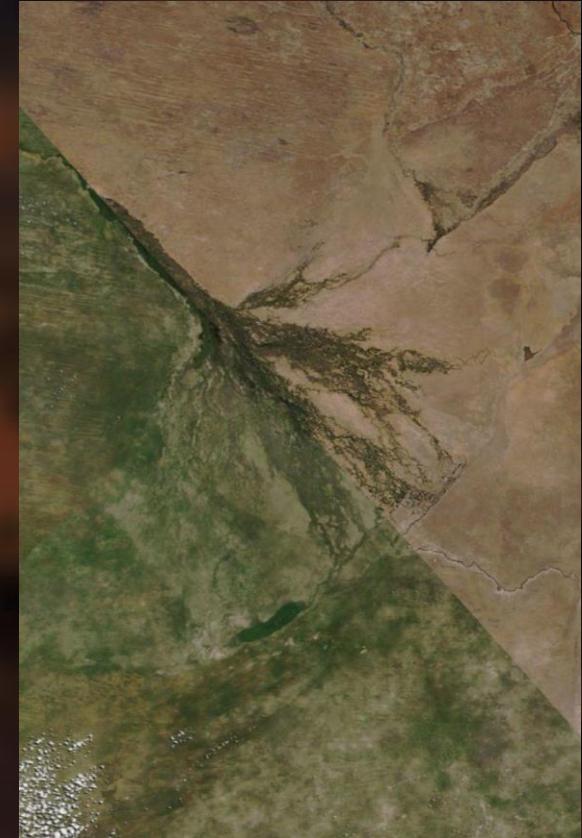
- ✓ Different connectivity patterns depending on future conditions
- ✓ Re-arrangement of movement corridors
- ✓ New potential HWC hotspots
  - Vegetation change
  - Seasonal changes



## The Effects of Increasing Seasonal Dynamism when Predicting Connectivity: Advantages or Unnecessary Complications?

David D. Hofmann, Dominik M. Behr, John W. McNutt, Arpat Ozgul, Gabriele Cozzi

*To be submitted*



## CONNECTIVITY MODELING PIPELINE

DATA



SPECIES DATA

ENVIRONMENTAL DATA

SELECTION MODEL

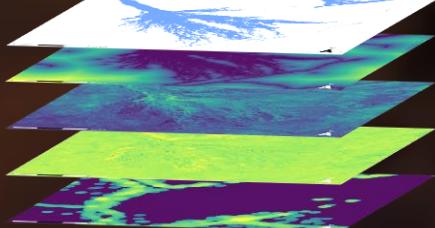


PERMEABILITY SURFACE

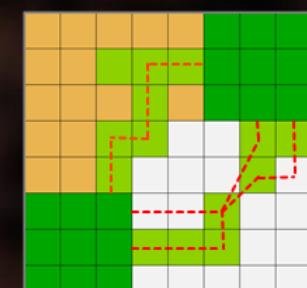
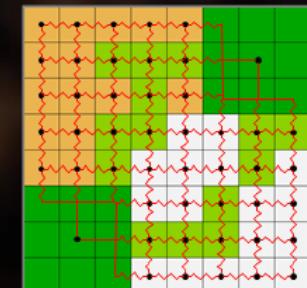
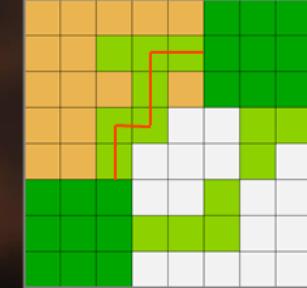


INTEGRATED STEP-SELECTION FUNCTIONS

$$w(x) = \exp(\beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n)$$



CONNECTIVITY MODEL

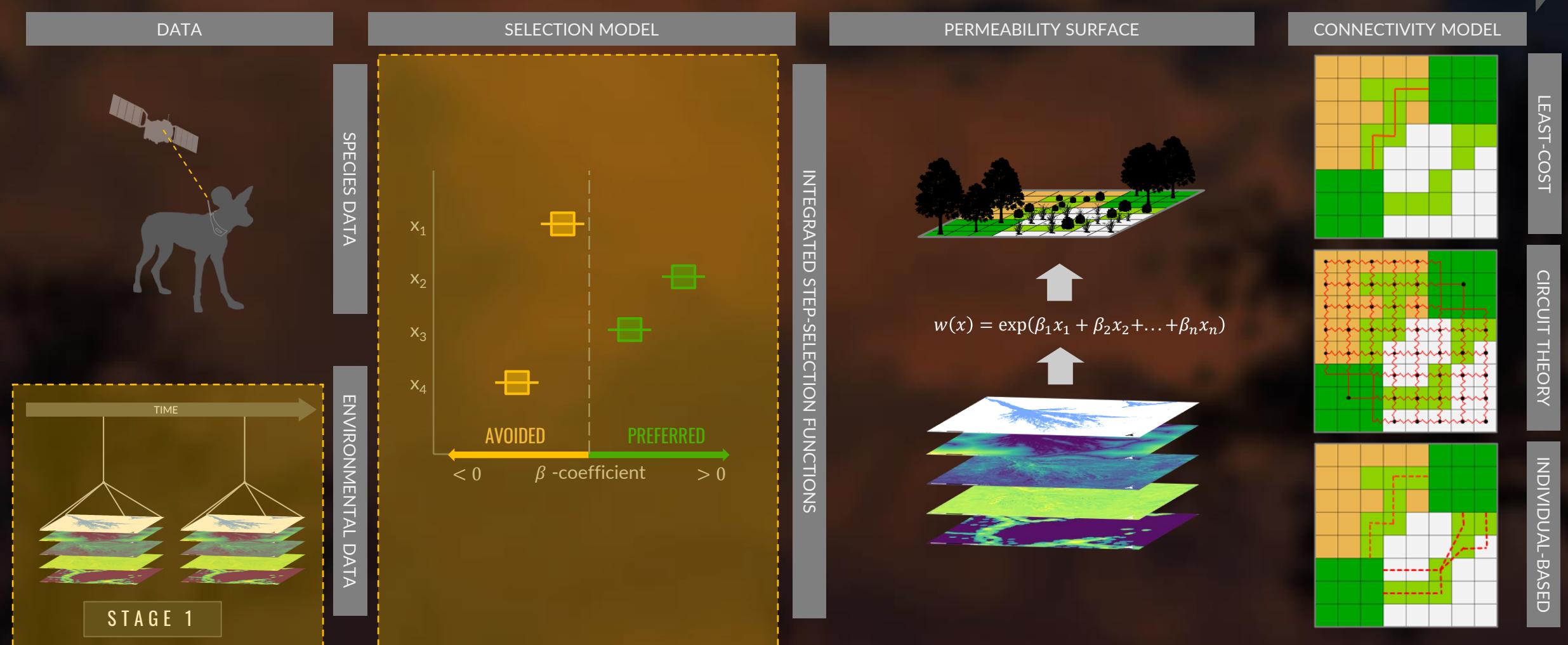


LEAST-COST

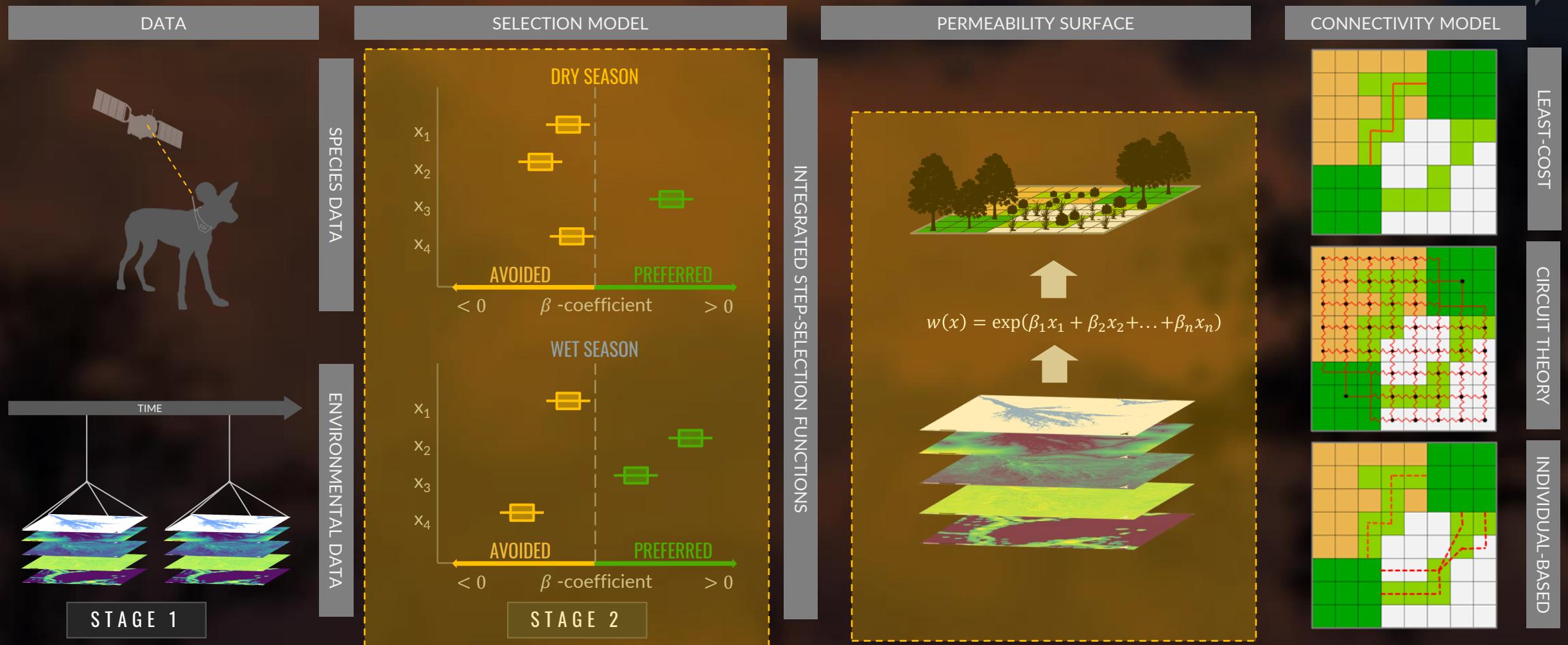
CIRCUIT THEORY

INDIVIDUAL-BASED

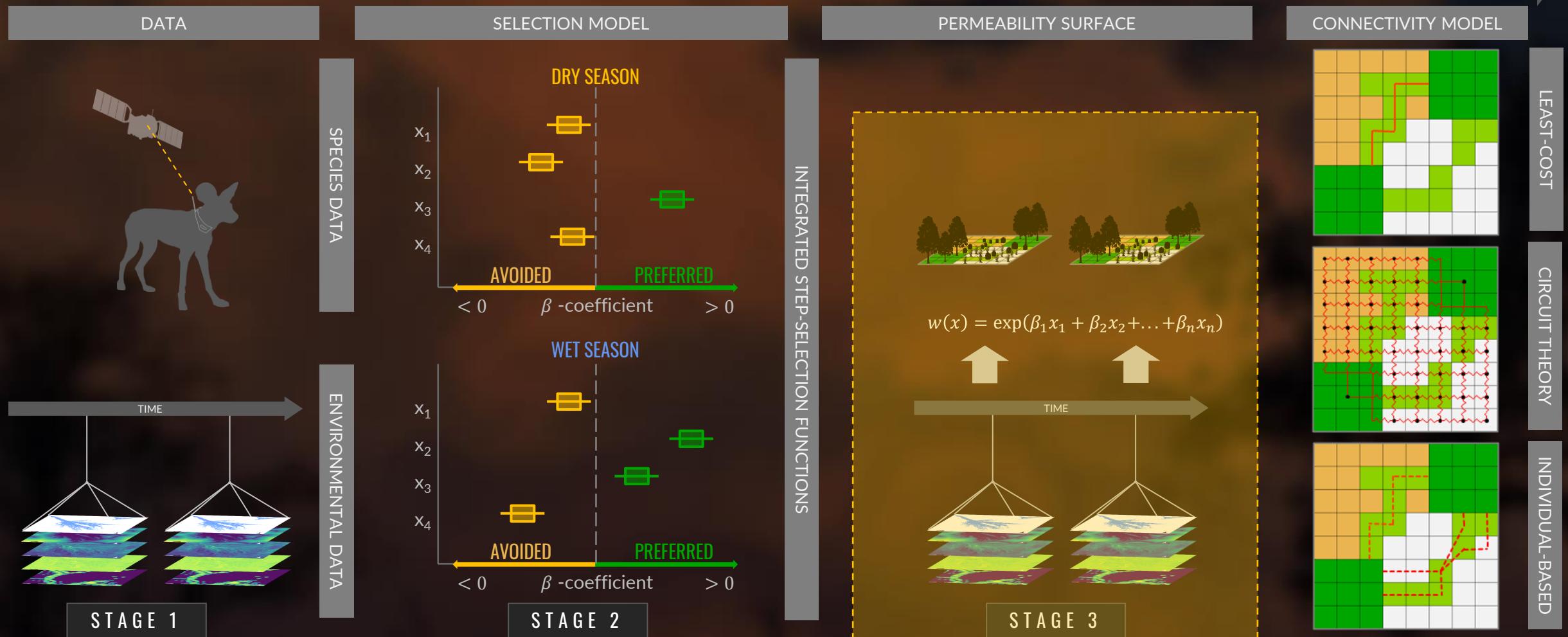
## CONNECTIVITY MODELING PIPELINE



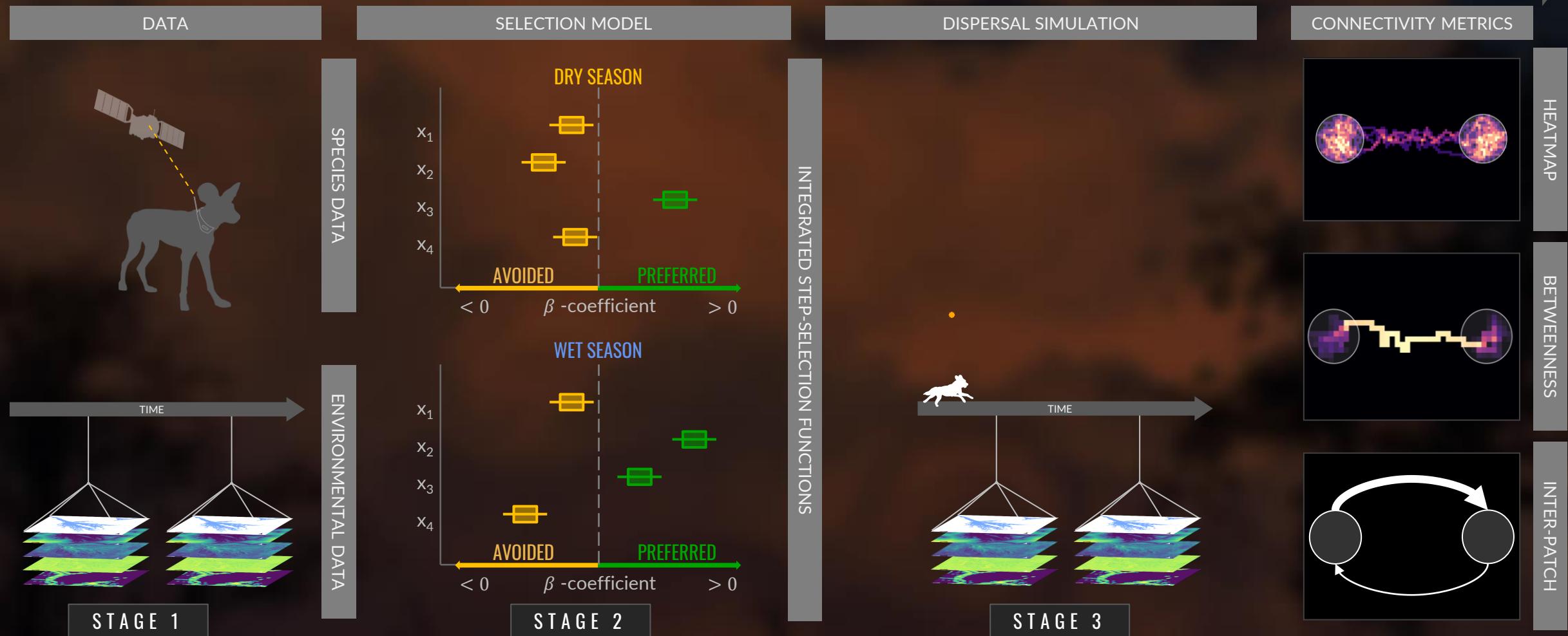
## CONNECTIVITY MODELING PIPELINE

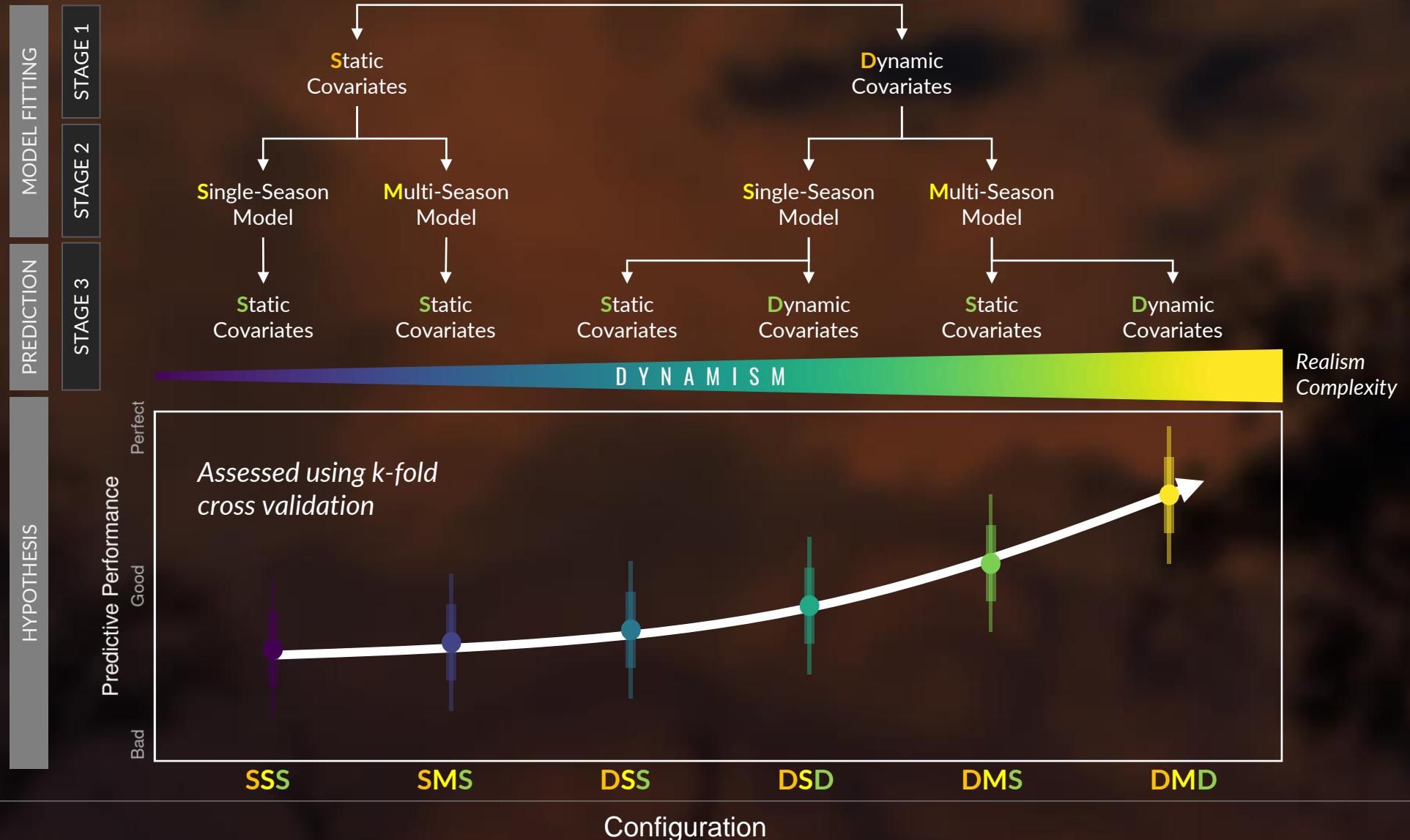


## CONNECTIVITY MODELING PIPELINE

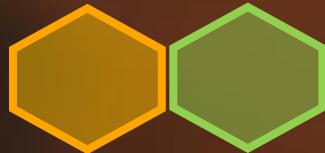


## CONNECTIVITY MODELING PIPELINE



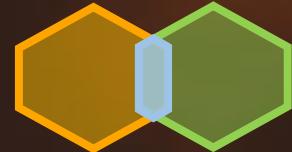


## SIMPLISTIC MODEL

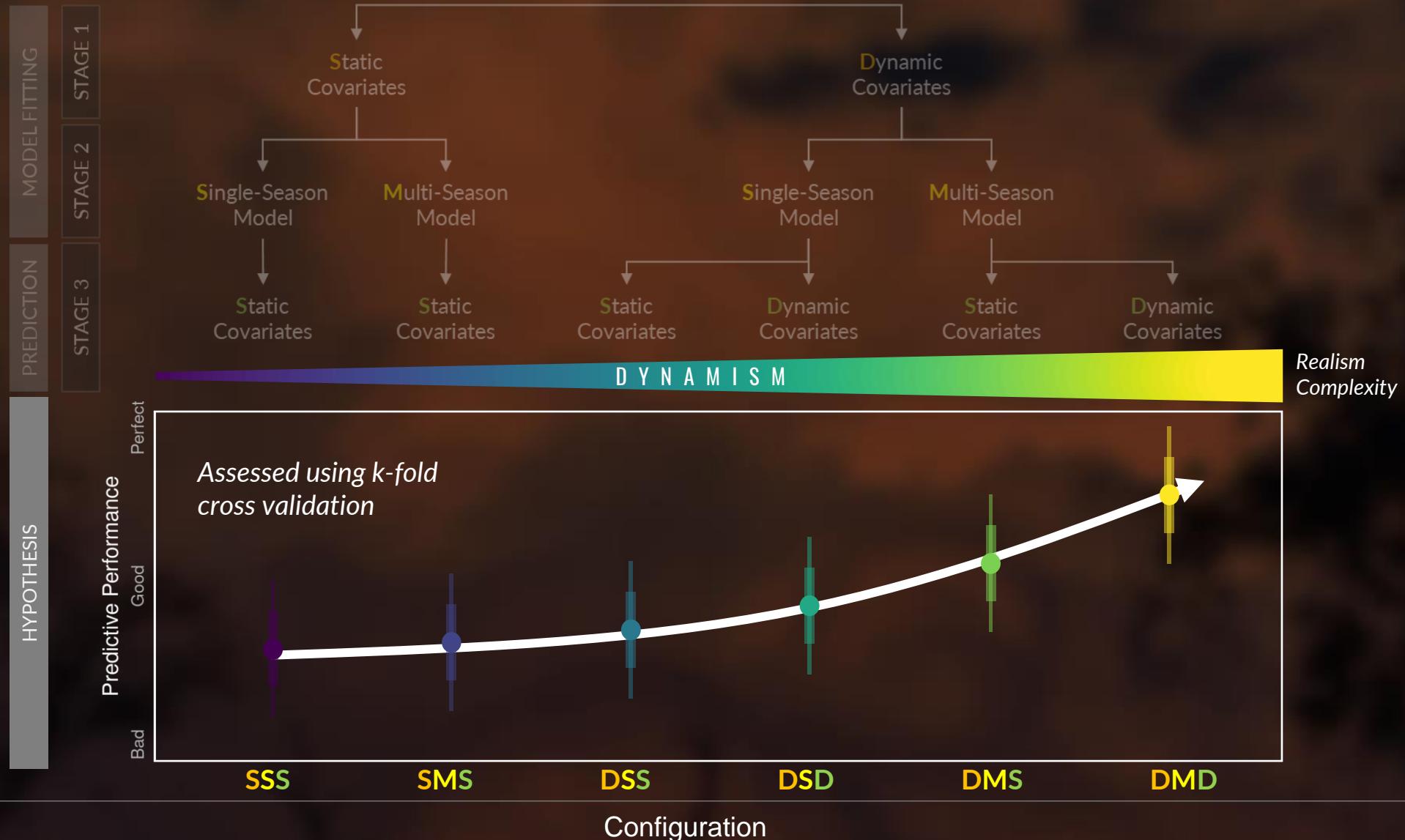


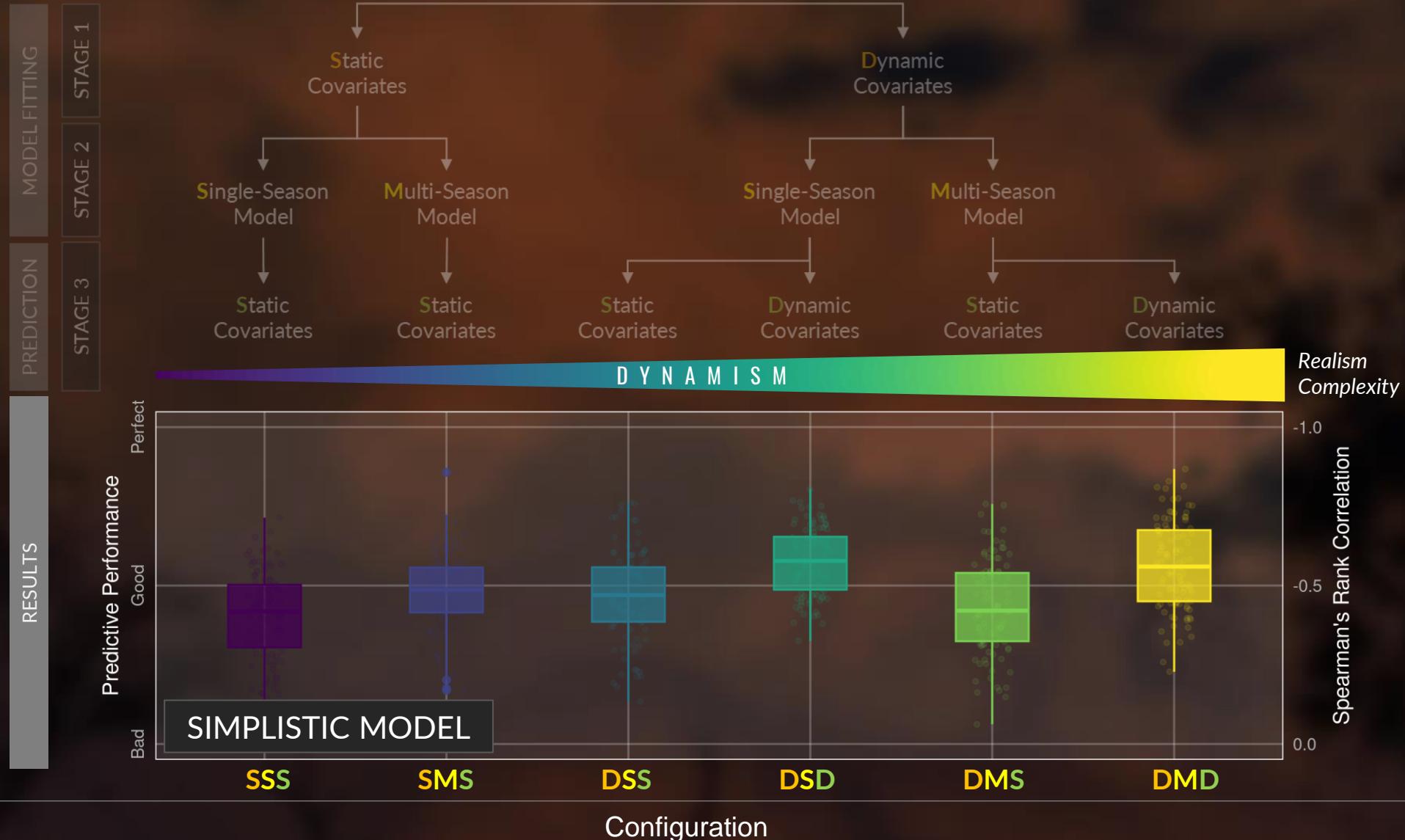
$$w(x) = \text{Movement Kernel} + \text{Habitat Selection Function}$$

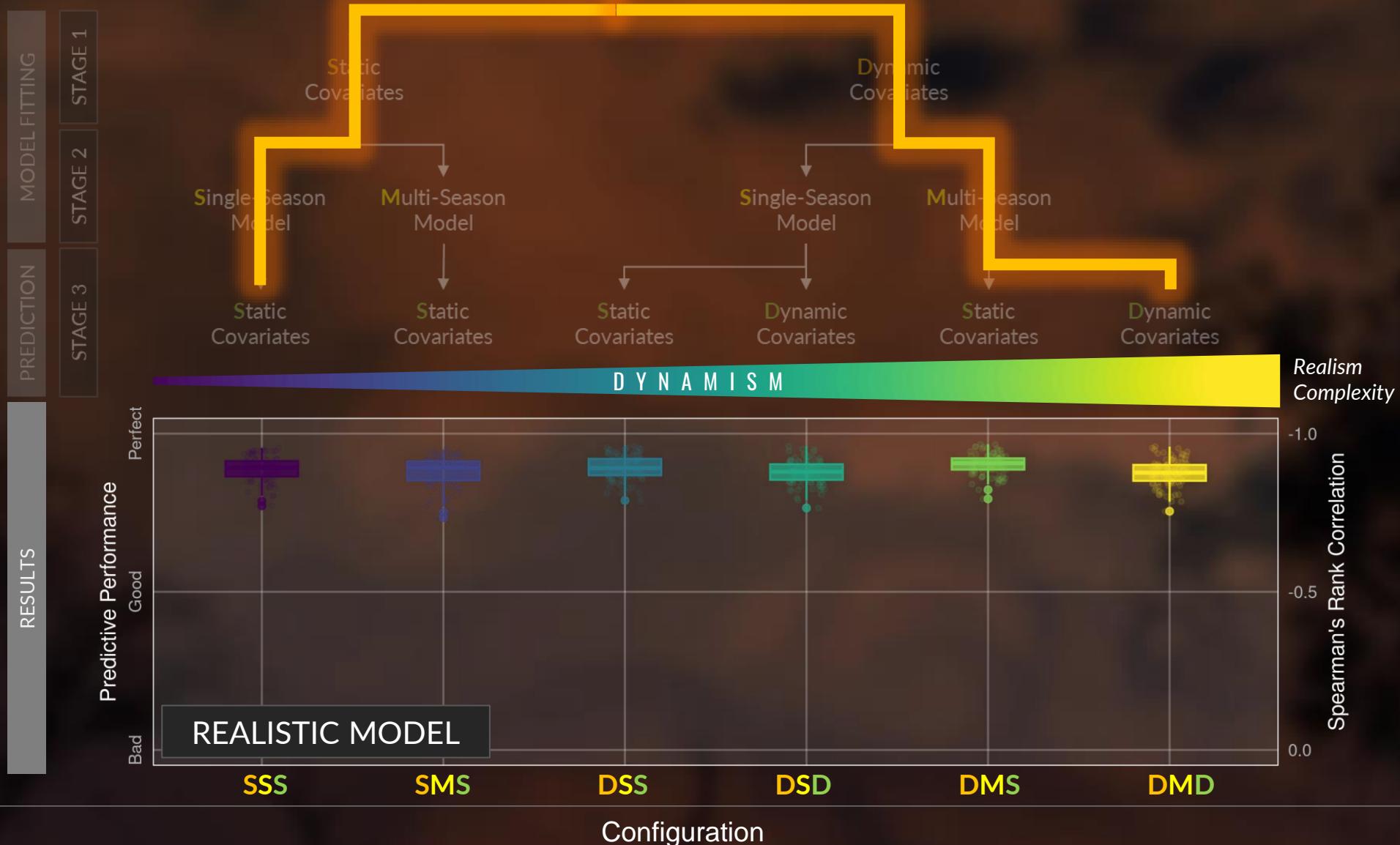
## REALISTIC MODEL

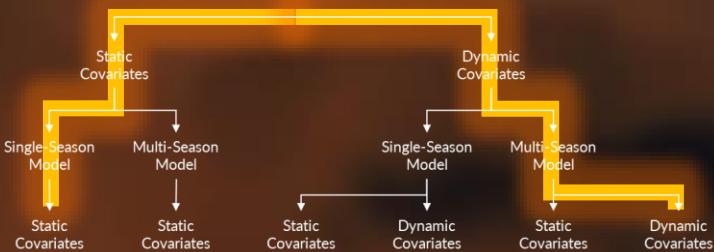


$$w(x) = \text{Movement Kernel} + \text{Habitat Selection Function} + \text{Movement Kernel: Habitat Selection Function}$$



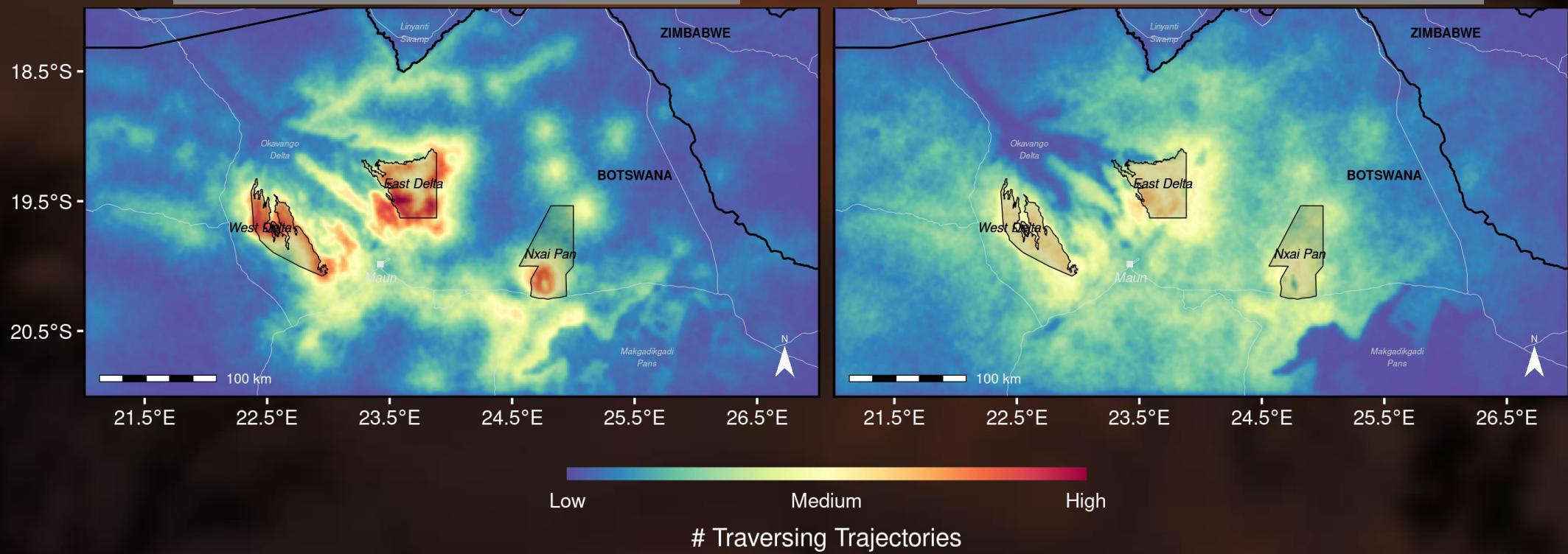






NO DYNAMISM (SSS)

MAXIMUM DYNAMISM (DMD)



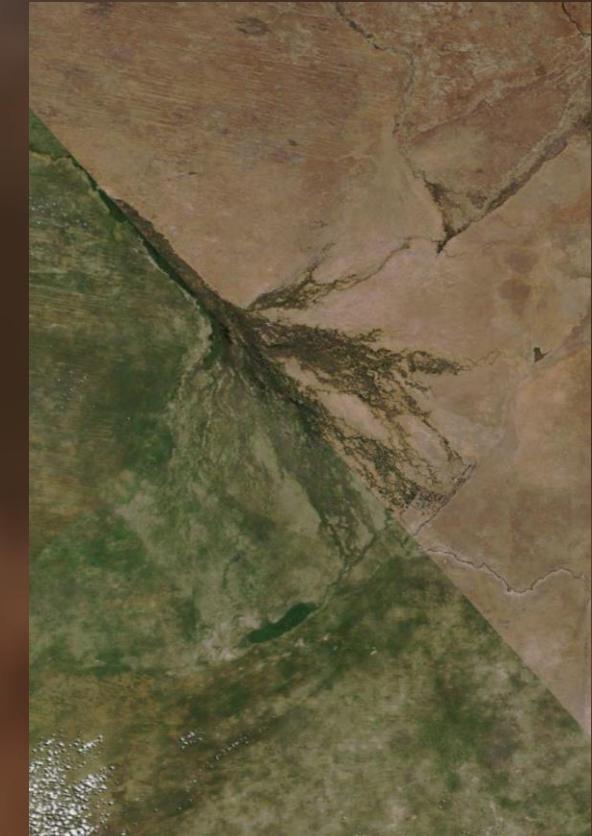


# The Effects of Increasing Seasonal Dynamism when Predicting Connectivity: Advantages or Unnecessary Complications?

David D. Hofmann, Dominik M. Behr, John W. McNutt, Arpat Ozgul, Gabriele Cozzi

*To be submitted*

- ✓ Provide conceptual framework for seasonal connectivity
- ✓ Marginal improvements upon incorporating seasonality
- ✓ Seasonal corridors
- Focus on landscape characteristics





# Methods for Implementing Integrated Step-Selection Functions with Incomplete Data

David D. Hofmann, Gabriele Cozzi, John Fieberg

*Movement Ecology*, 2024





## Methods for Implementing Integrated Step-Selection Functions with Incomplete Data

David D. Hofmann, Gabriele Cozzi, John Fieberg

*Movement Ecology*, 2024

- ✓ Including irregular data improves estimator precision
- ✓ Provide methods for dealing with irregularity
- ✓ Dynamic + model approach is flexible and powerful
  - Slight biases in the movement kernel remain





CHAPTER I



SIMULATE DISPERSAL

CHAPTER II



EXTREME CONDITIONS

CHAPTER III



SEASONALITY

CHAPTER IV



DATA IRREGULARITY



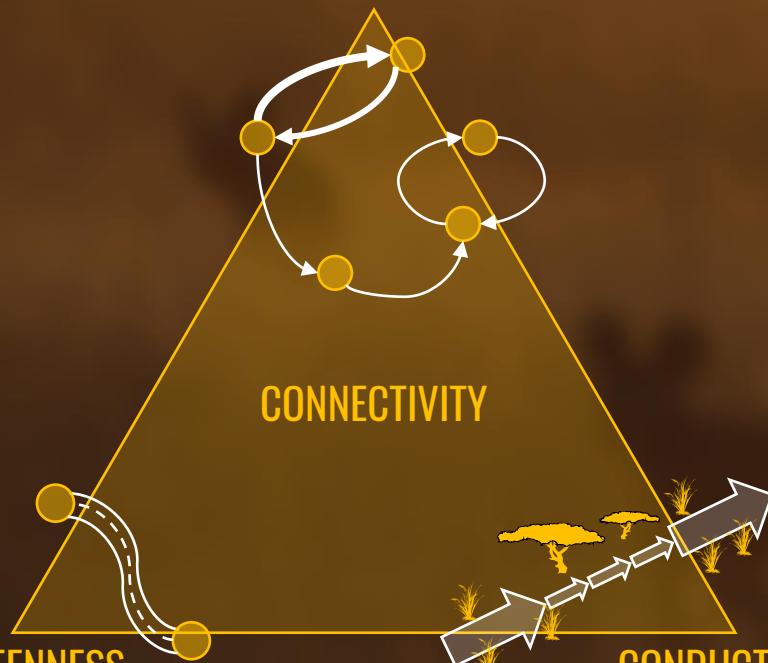
## CONNECTIVITY





the degree to which different patches or habitats within a landscape are functionally connected

### CONNECTEDNESS



### CONNECTIVITY

### BETWEENNESS

the importance of different elements of the matrix in facilitating movement between other patches or habitats

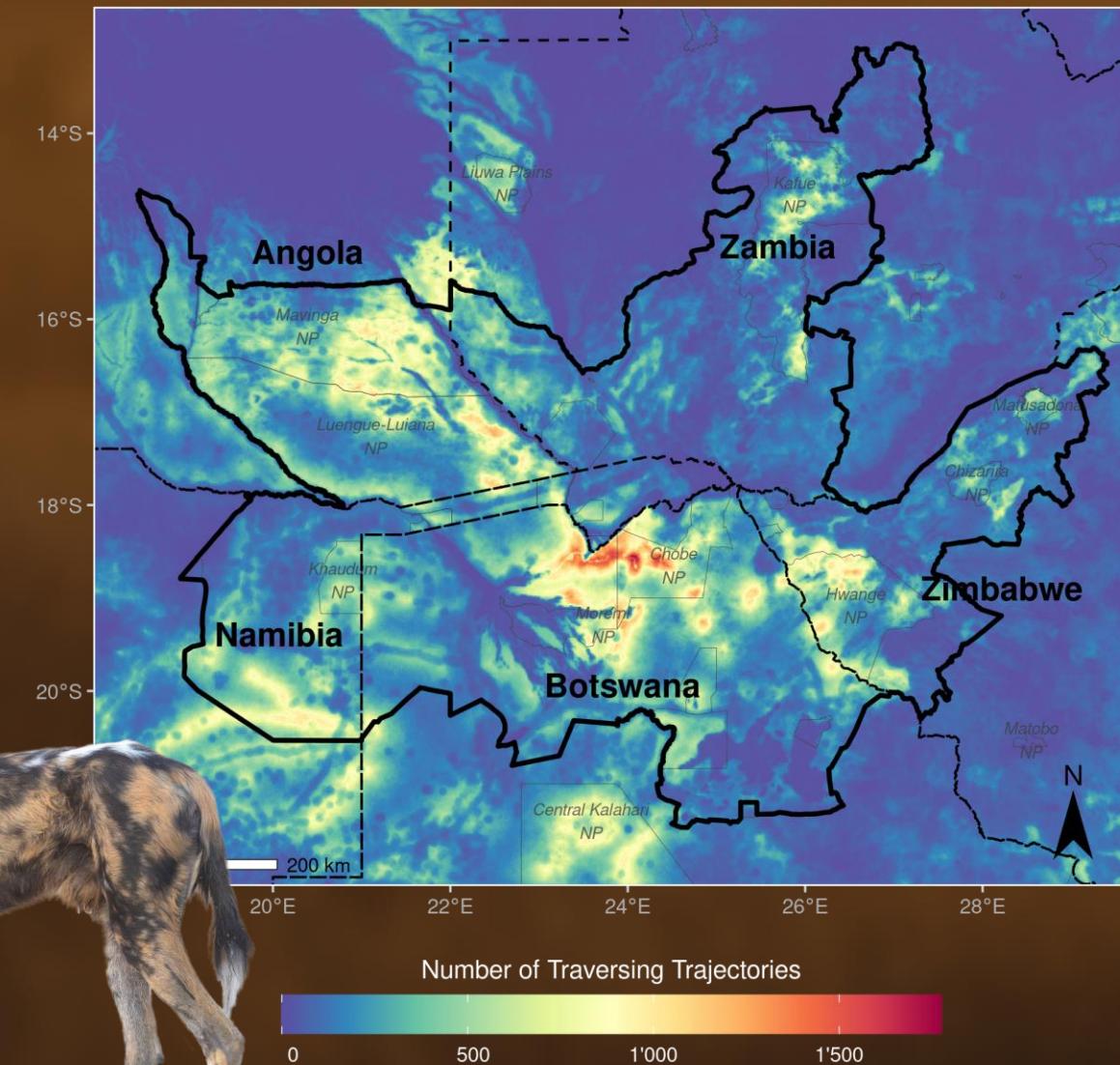


### CONDUCTANCE

the degree to which the landscape allows movement or flow of organisms across it.



- ✓ KAZA-TFCA is a promising conservation initiative
- ✓ Northern Botswana is a key area within KAZA-TFCA
  - Recolonization of surrounding areas
  - Dispersal hub
- ✓ Biological understanding > model complexity

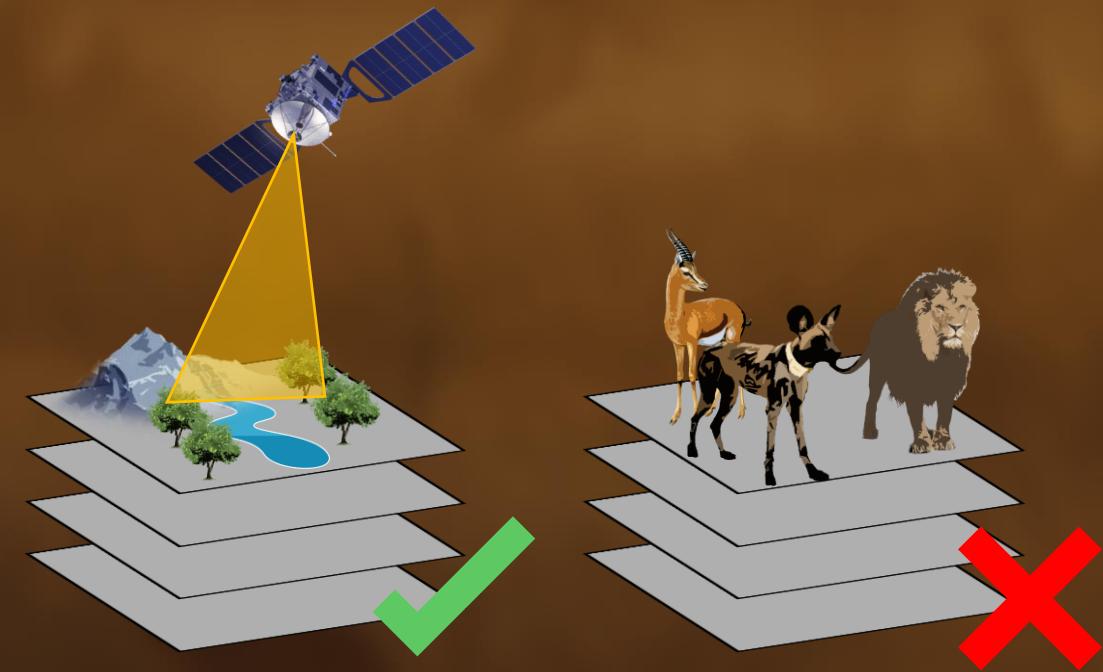




Species are embedded in an intra- and inter-specific landscape



→ Often neglected in studies of landscape connectivity



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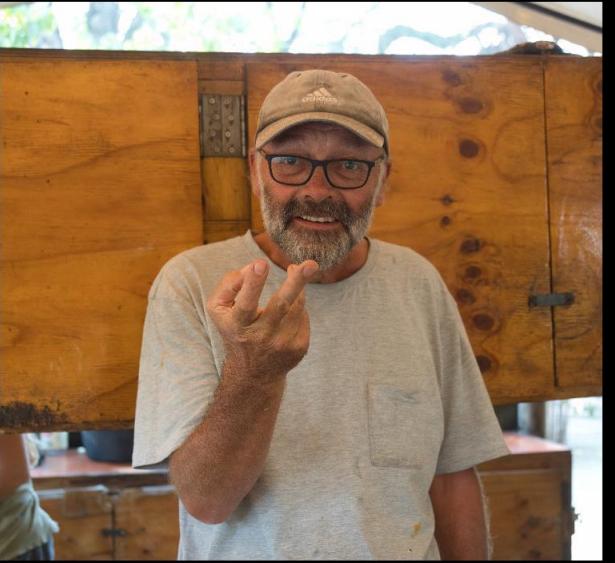


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# THANK YOU!

CHAPTER I



SIMULATE DISPERSAL



EXTREME CONDITIONS

All R-scripts and LaTeX files are available via  
<https://github.com/DavidDHofmann/PhD>

CHAPTER II

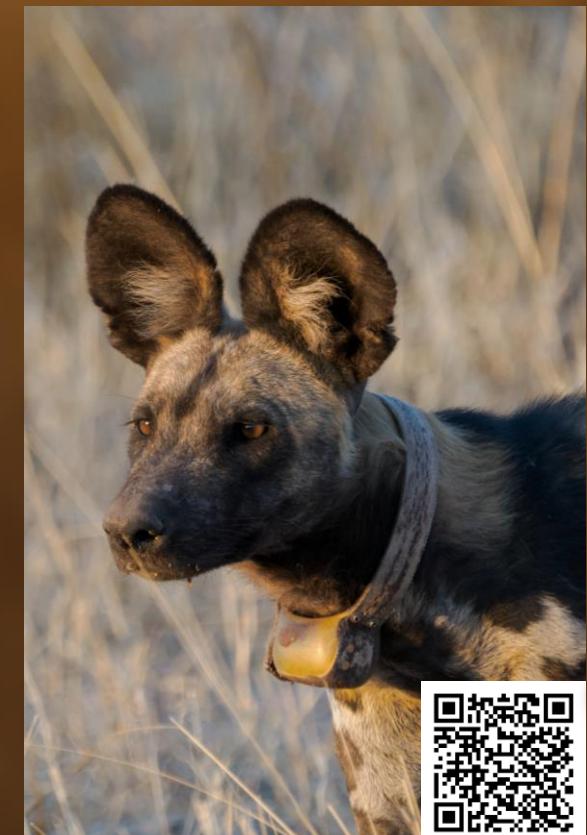


CHAPTER III



SEASONALITY

CHAPTER IV



DATA IRREGULARITY