

DISPERSAL & CONNECTIVITY

IN PHYSICAL, SEASONAL, AND EXTREME LANDSCAPES



BOTSWANA
PREDATOR
CONSERVATION

PhD Defense, 3rd July 2024



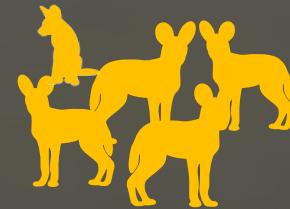
David D. Hofmann
(david.hofmann2@uzh.ch)



University of
Zurich ^{UZH}







INTRODUCTION



CHAPTER I

CHAPTER II

CHAPTER III

CHAPTER IV

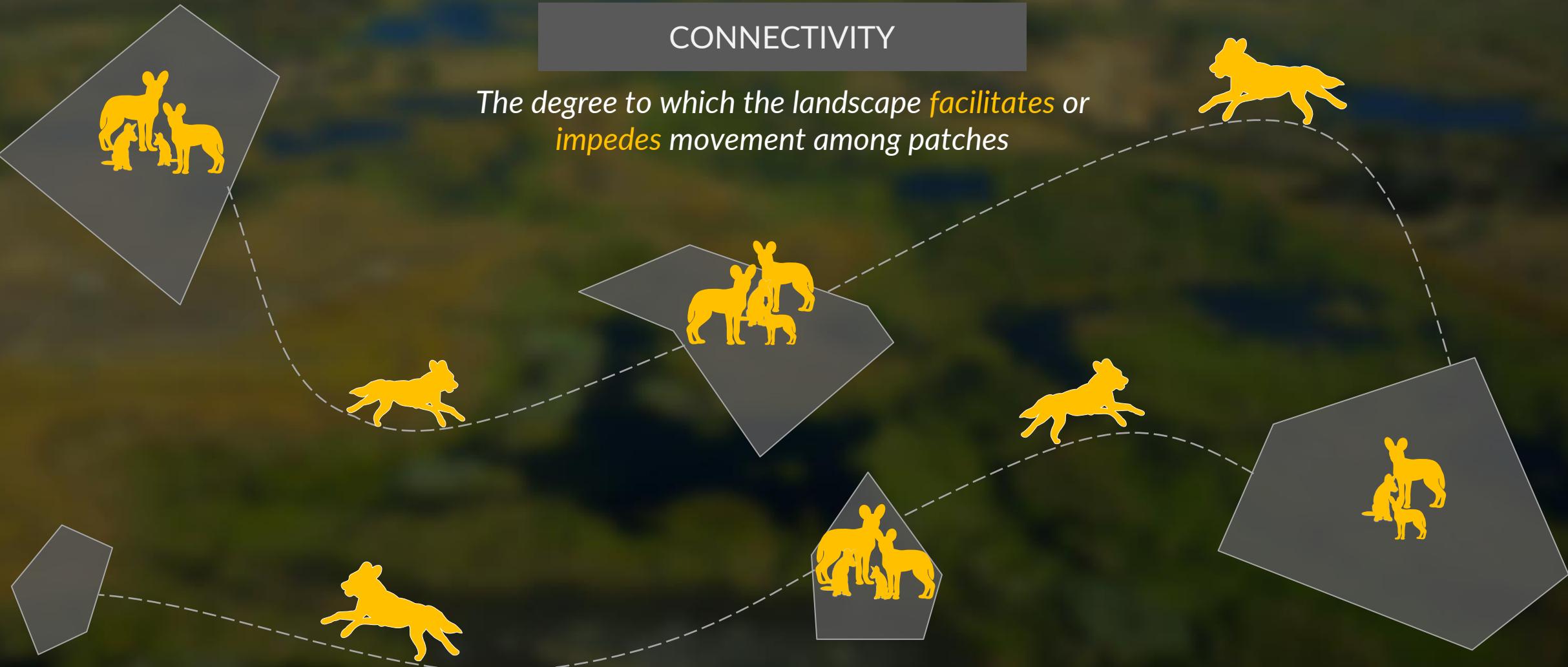
DISCUSSION

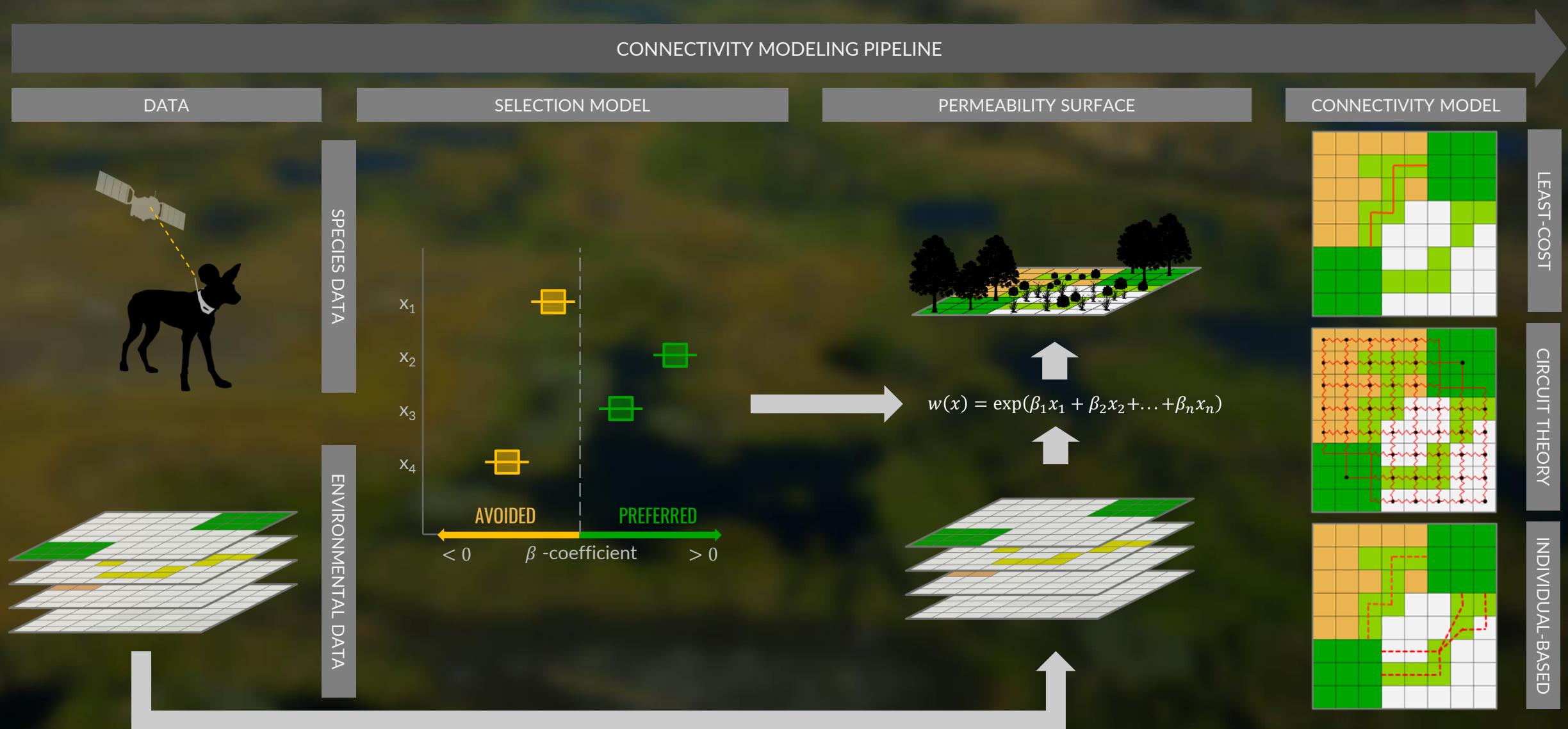




CONNECTIVITY

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







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



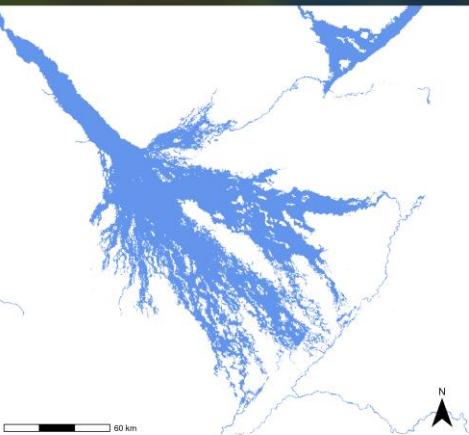
University of
Zurich^{UZH}



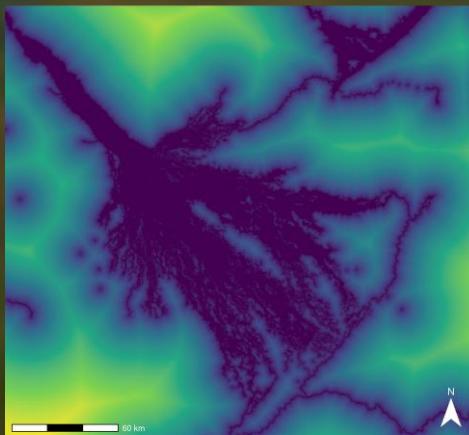
Google Earth
Data SIO, NOAA, U.S. Navy



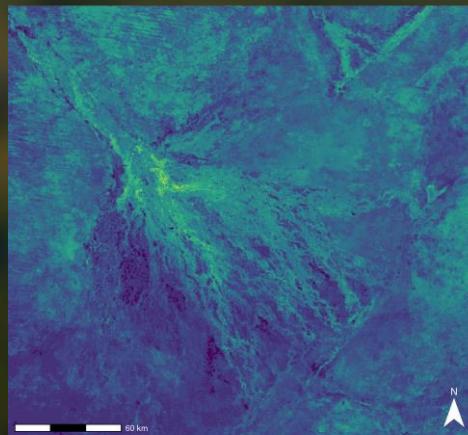
WATER COVER



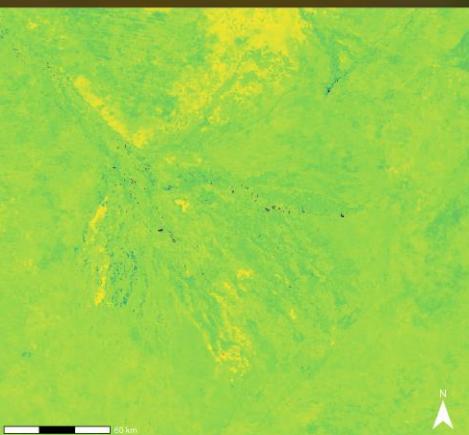
DISTANCE TO WATER



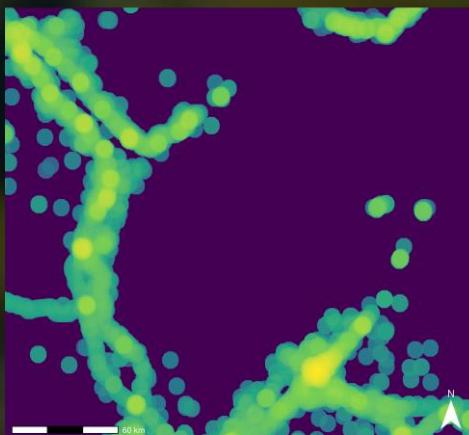
TREE COVER



SHRUB COVER



HUMAN INFLUENCE

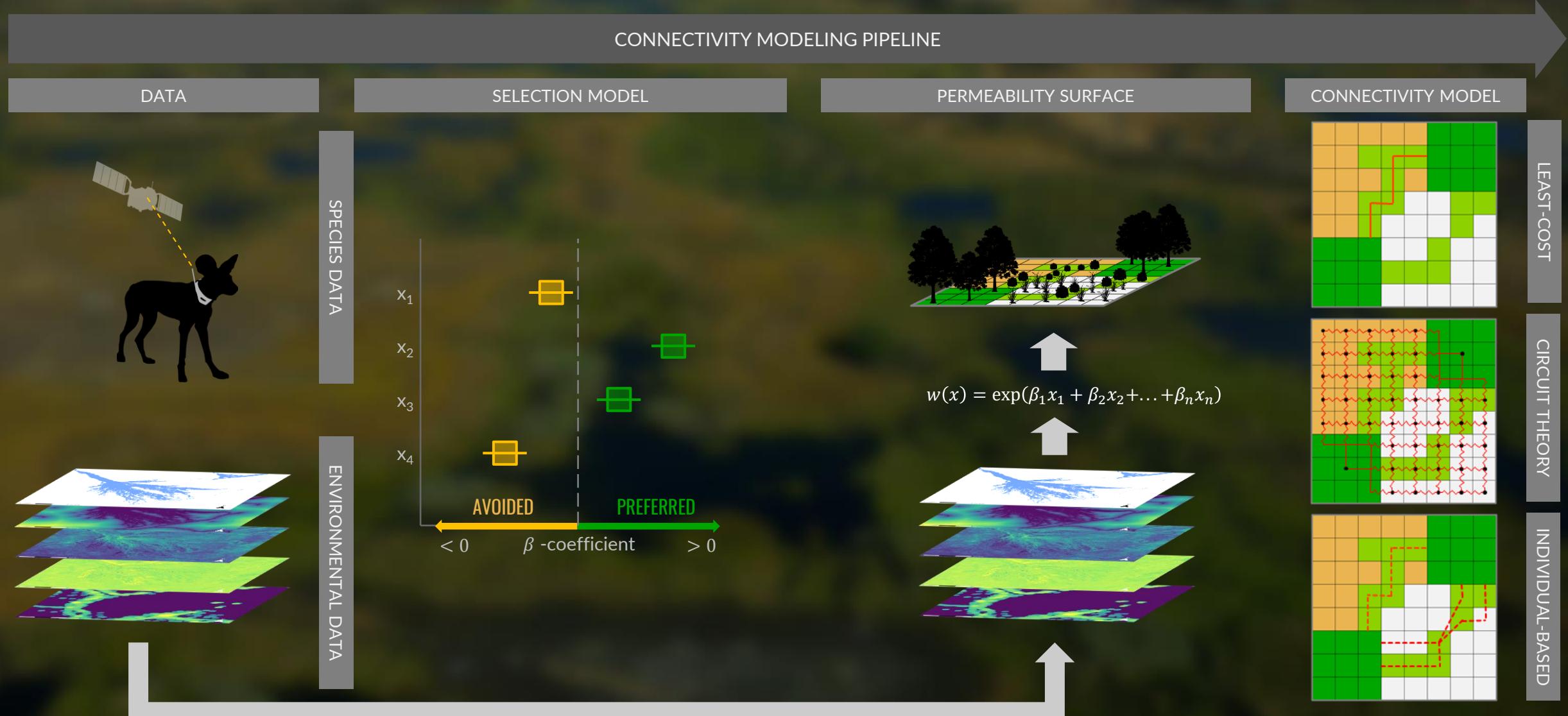


CLIMATE



LIGHT







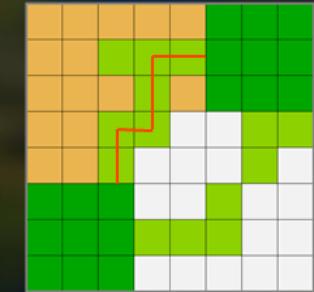
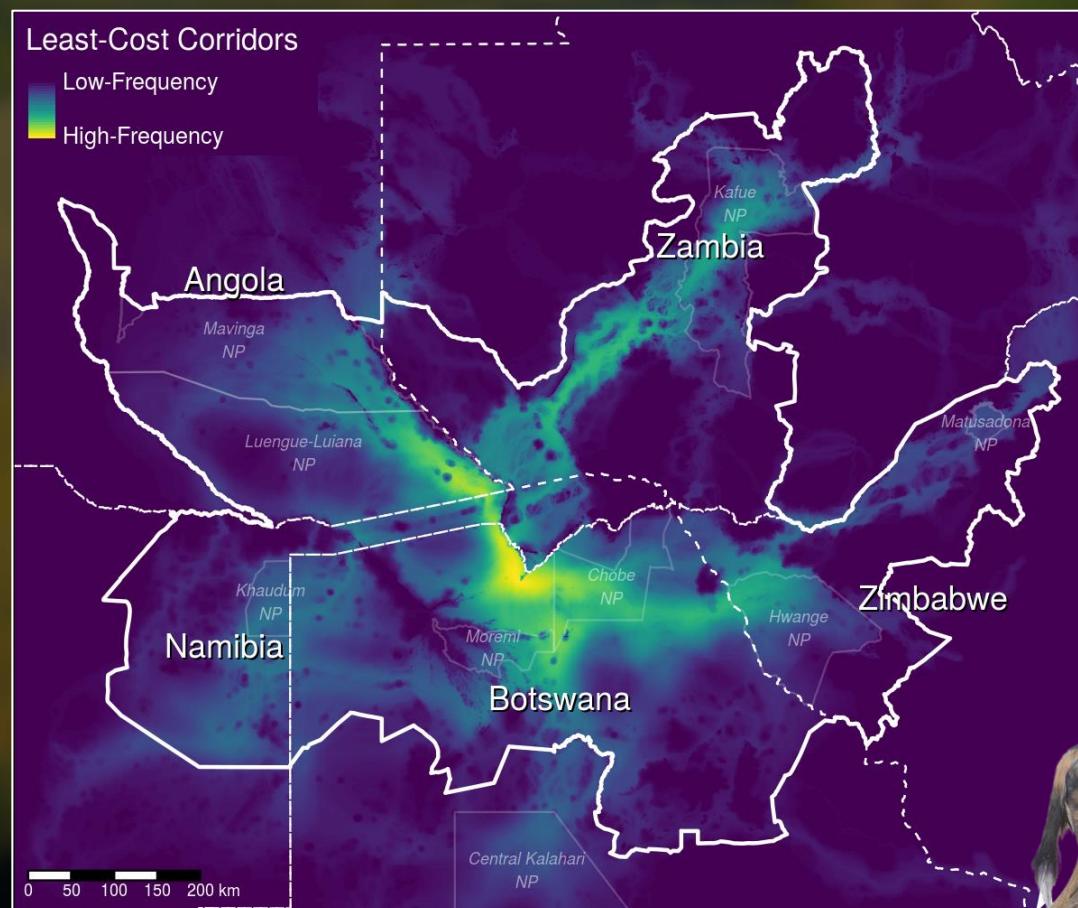
CONNECTIVITY MODELING PIPELINE

DATA

SELECTION MODEL

PERMEABILITY SURFACE

CONNECTIVITY MODEL



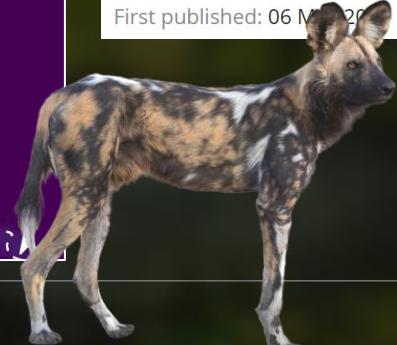
Journal of Applied Ecology

RESEARCH ARTICLE | [Full Access](#)

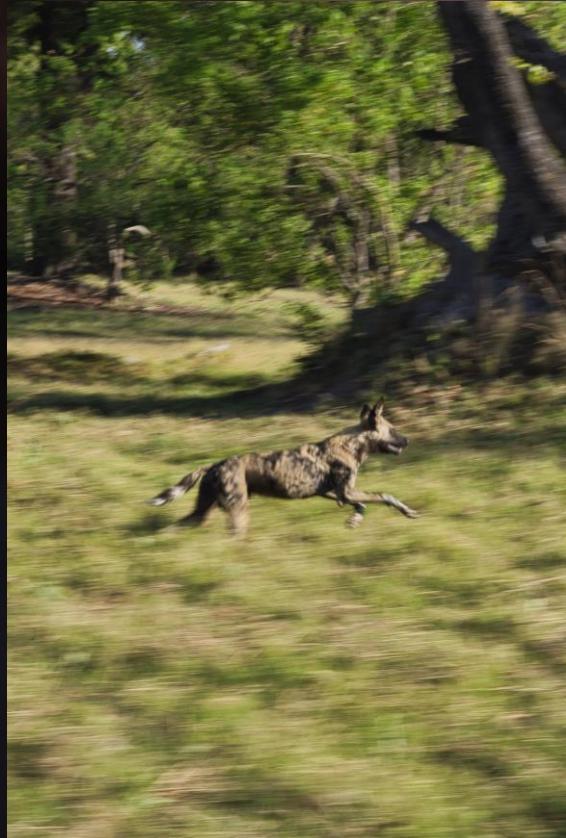
Bound within boundaries: Do protected areas cover movement corridors of their most mobile, protected species?

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!

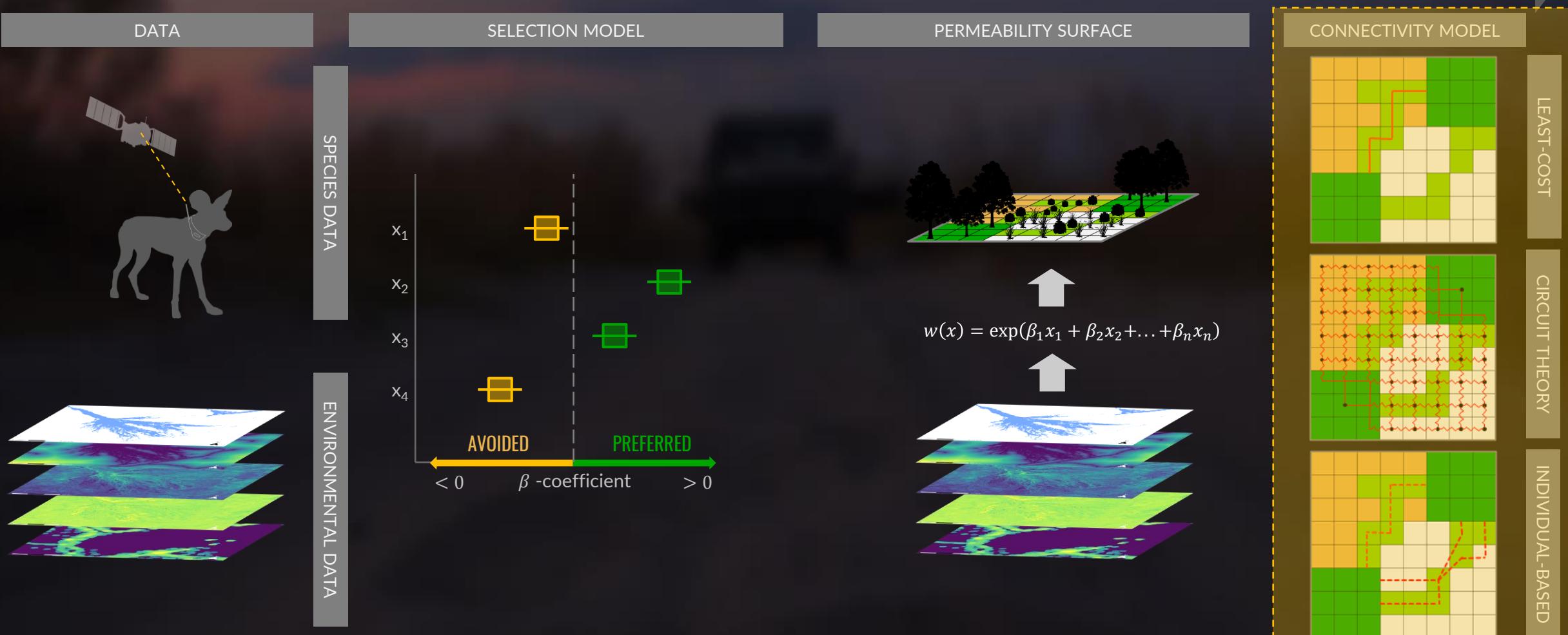


A Three-Step Approach for Assessing Landscape Connectivity via Simulated Dispersal: African Wild Dog Case Study

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

Landscape Ecology, 2023

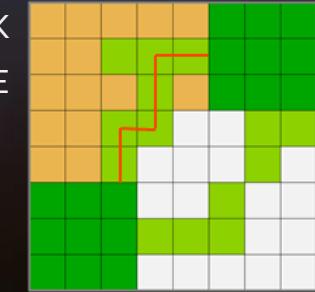
CONNECTIVITY MODELING PIPELINE





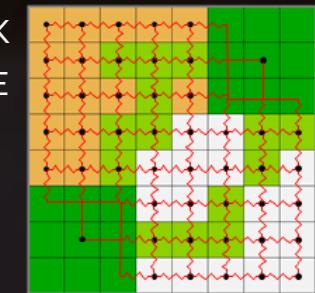
CONNECTIVITY MODEL

OPTIMIZED WALK

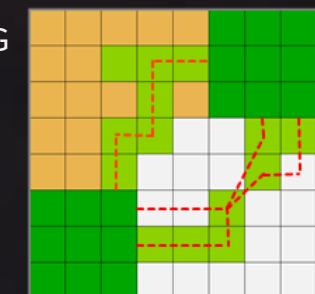
 ∞ PERCEPTIONAL RANGE

RANDOM WALK

1 PX PERCEPTIONAL RANGE



STANDARDIZED PROTOCOLS LACKING

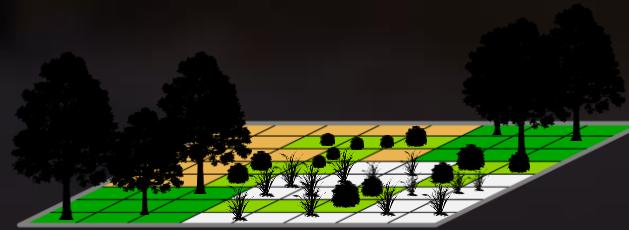


LEAST-COST

CIRCUIT THEORY

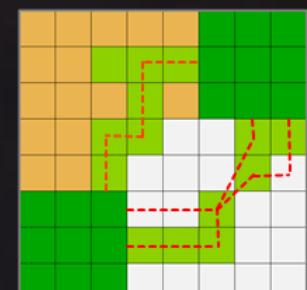
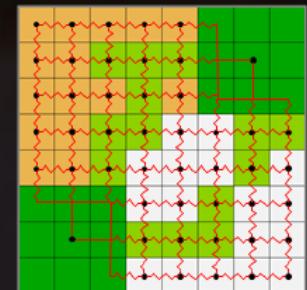
INDIVIDUAL-BASED

PERMEABILITY SURFACE



UNCONDITIONAL PREDICTION

CONNECTIVITY MODEL



LEAST-COST

CIRCUIT THEORY

INDIVIDUAL-BASED

CONNECTIVITY MODELING PIPELINE



CONNECTIVITY MODELING PIPELINE

DATA

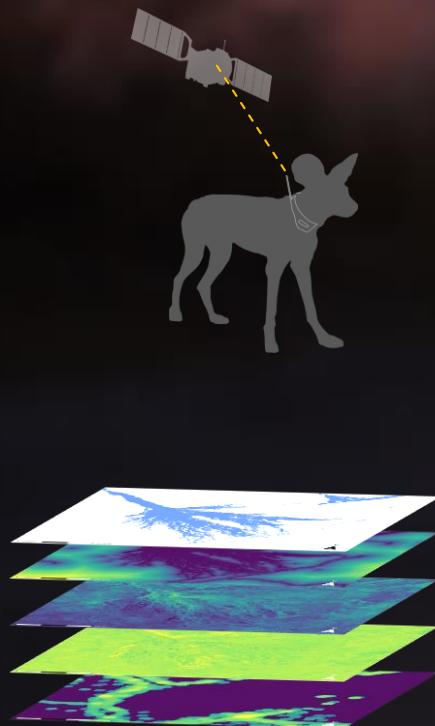
SELECTION MODEL

DISPERSAL SIMULATION

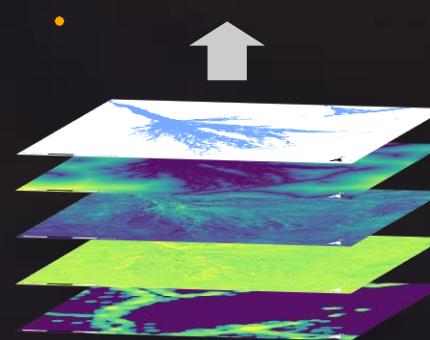
SPECIES DATA



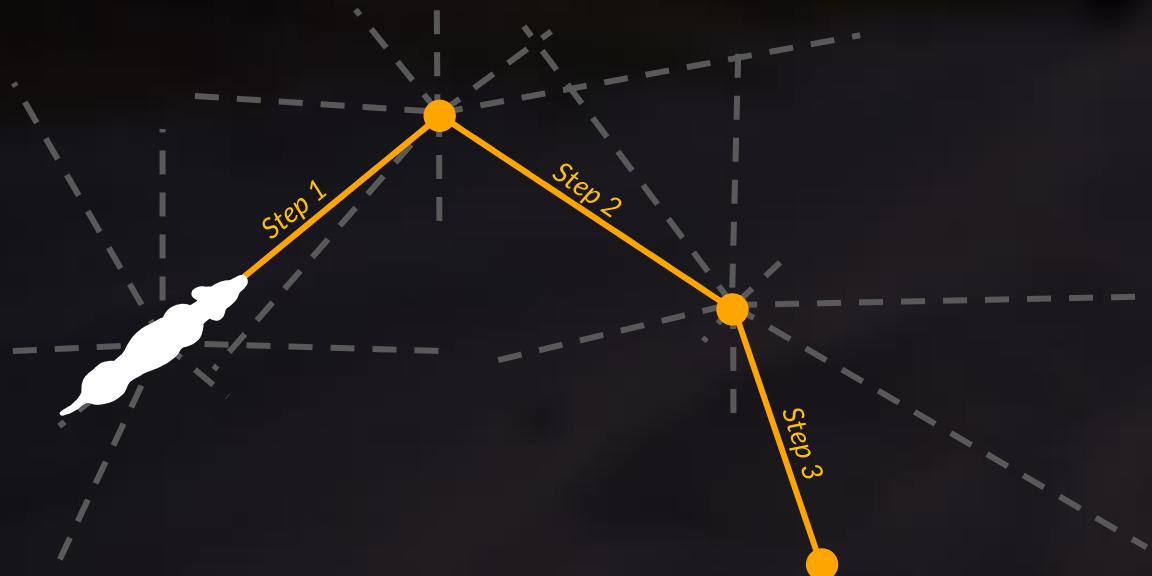
INTEGRATED STEP-SELECTION FUNCTIONS



ENVIRONMENTAL DATA



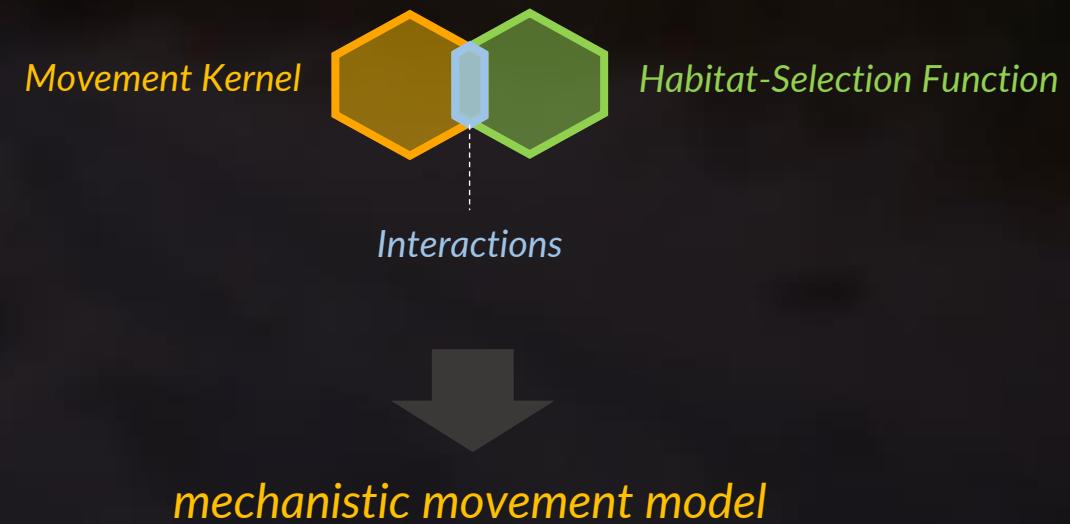
INTEGRATED STEP-SELECTION FUNCTIONS

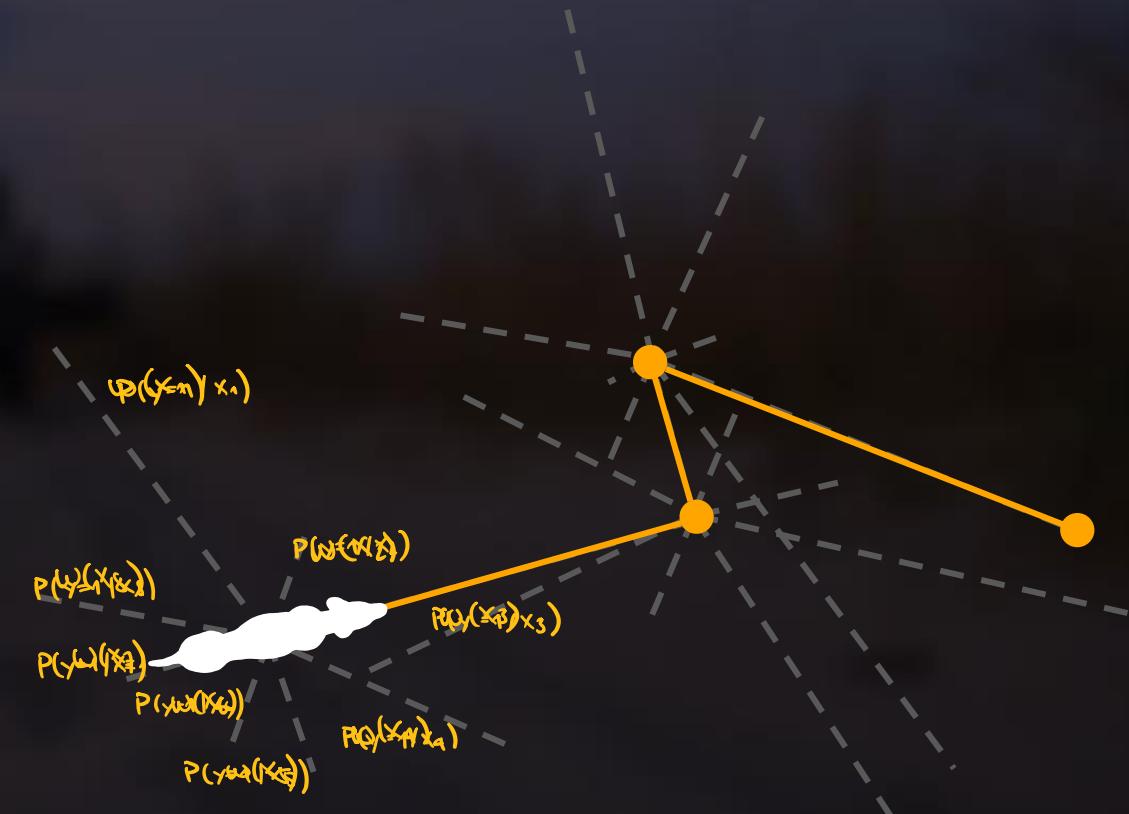
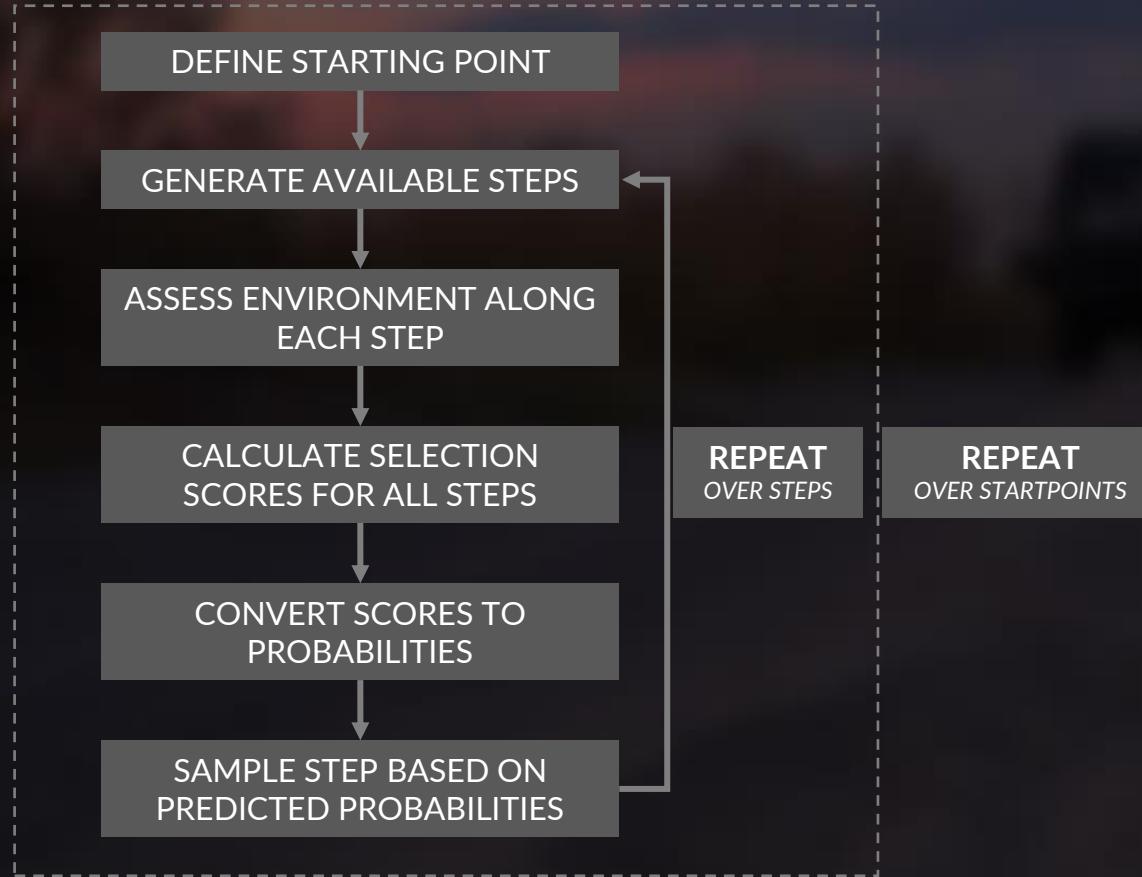


SELECTION SCORE

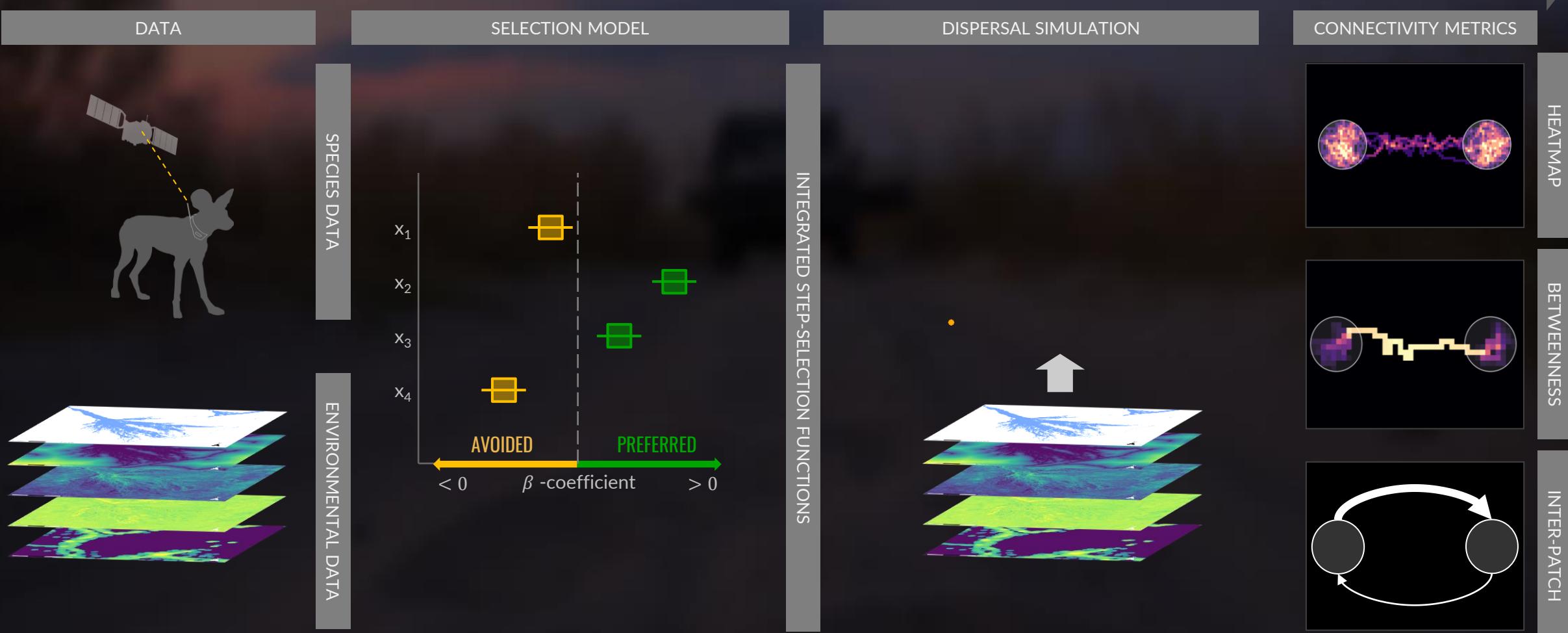
$$w(x) = \exp(\beta_1 x_1 + \beta_2 x_2 + \dots + \beta_i x_i)$$

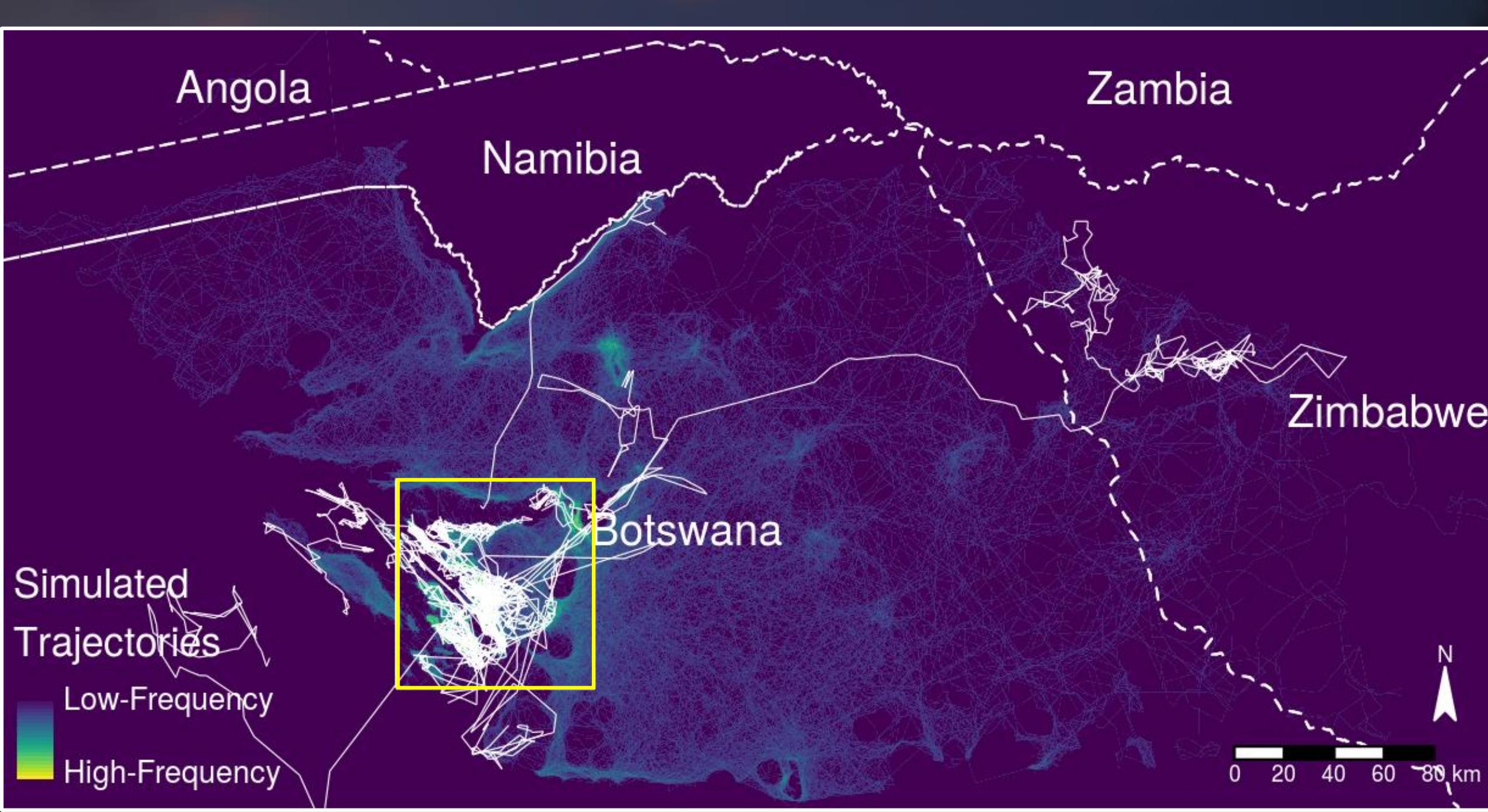
MIXED EFFECTS CONDITIONAL LOGISTIC REGRESSION





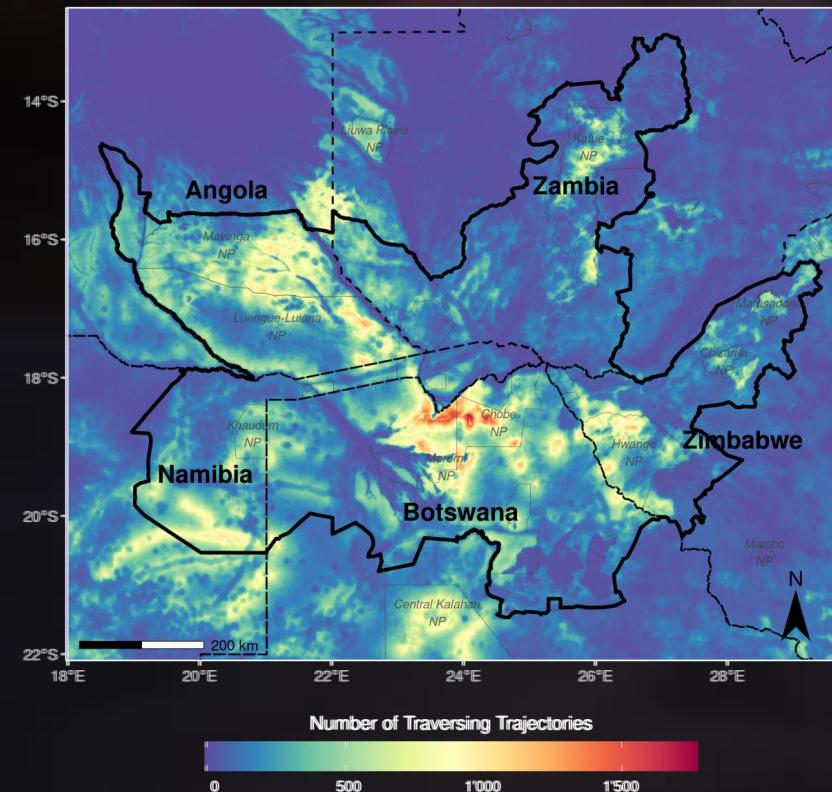
CONNECTIVITY MODELING PIPELINE





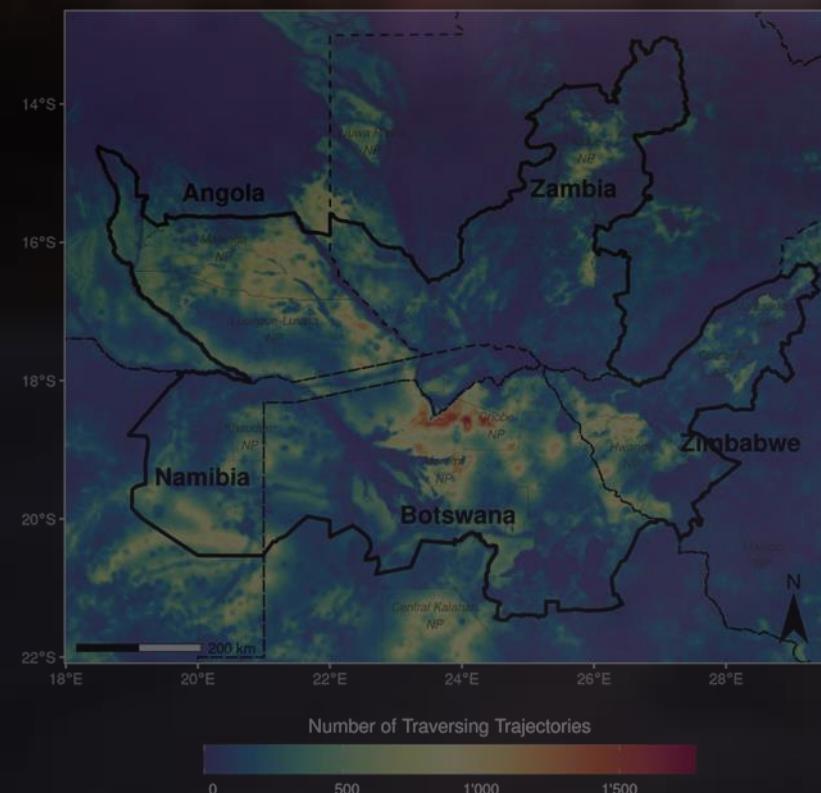
intensity of use

HEATMAP

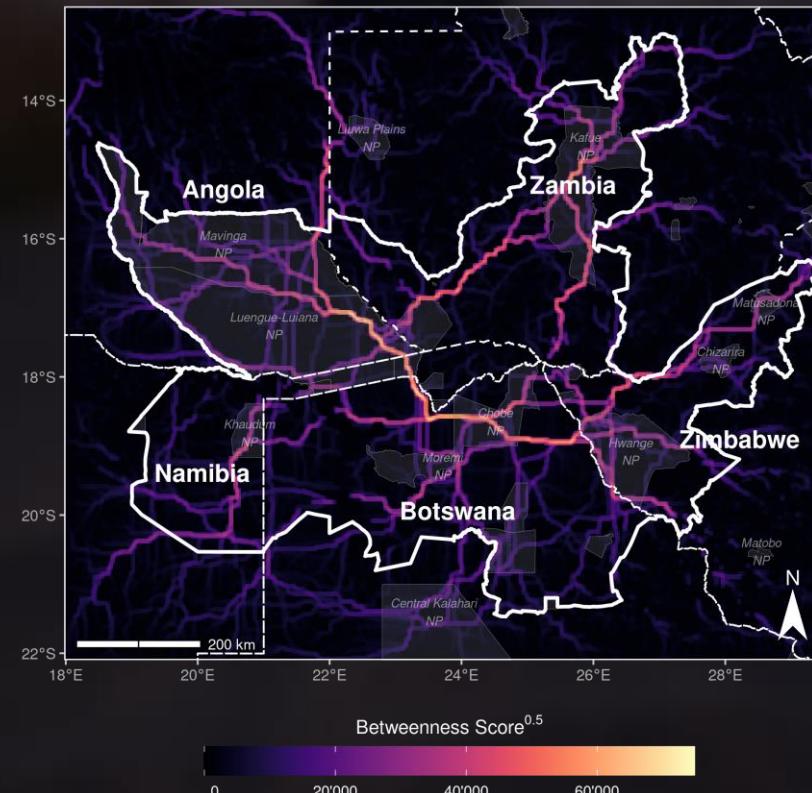


corridors/bottlenecks

HEATMAP

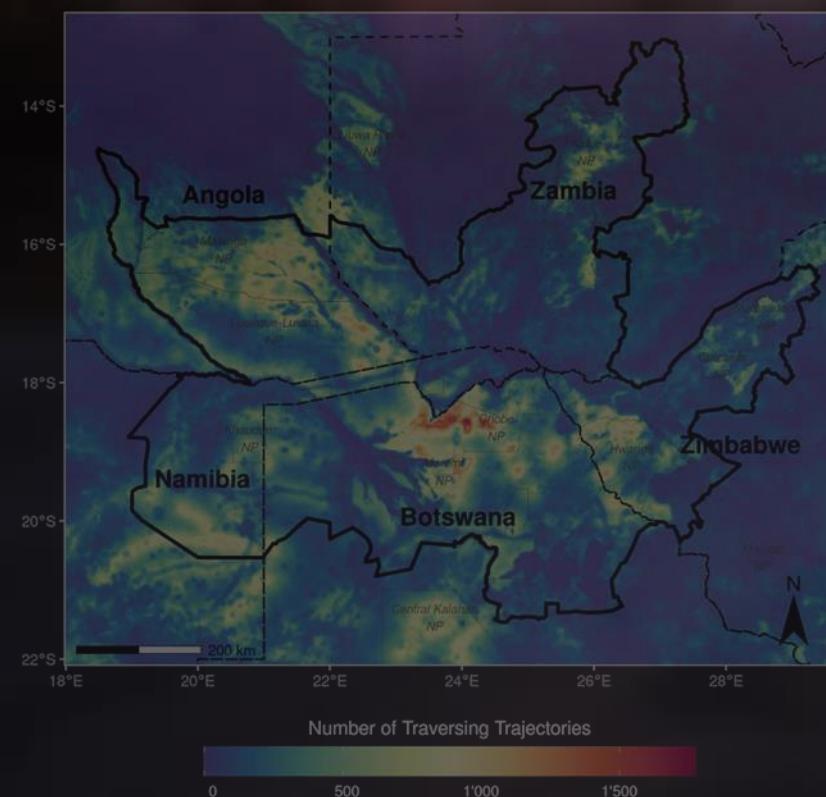


BETWEENNESS

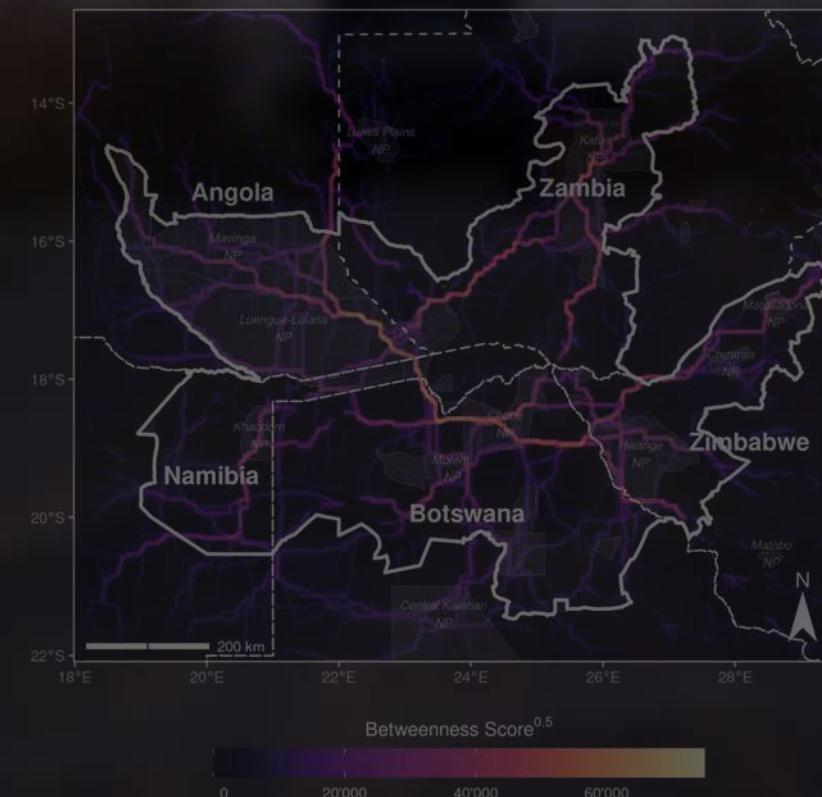


connections / dispersal durations

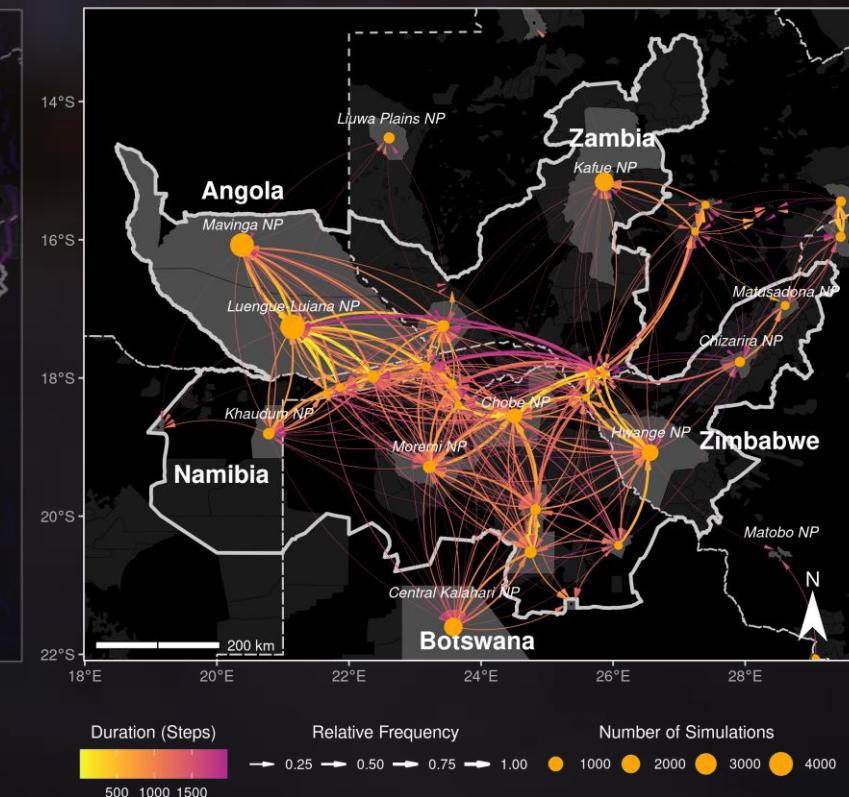
HEATMAP



BETWEENNESS

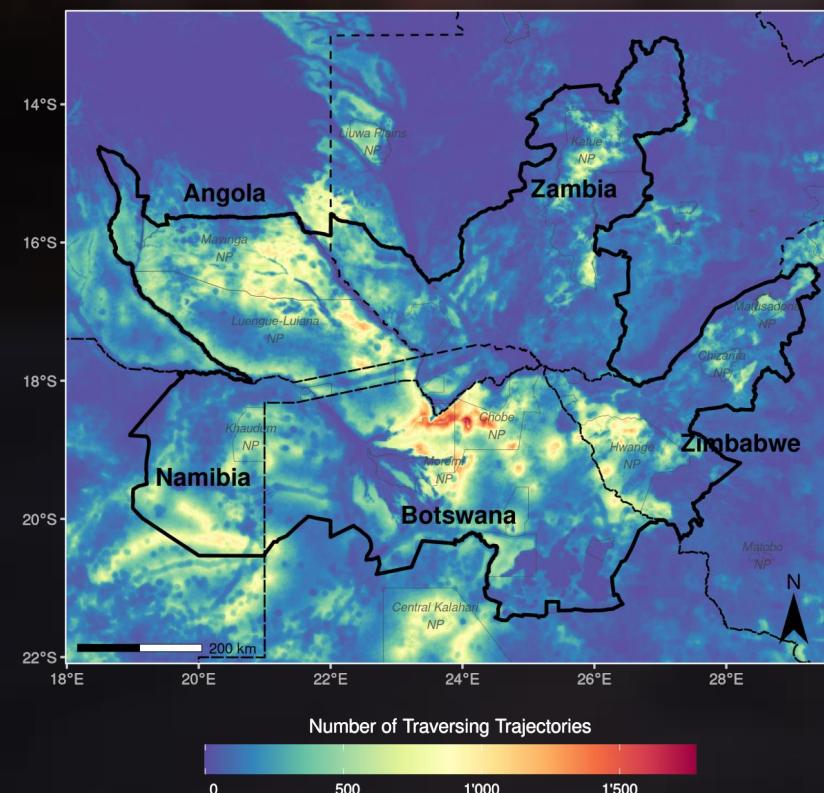


INTER-PATCH CONNECTIVITY

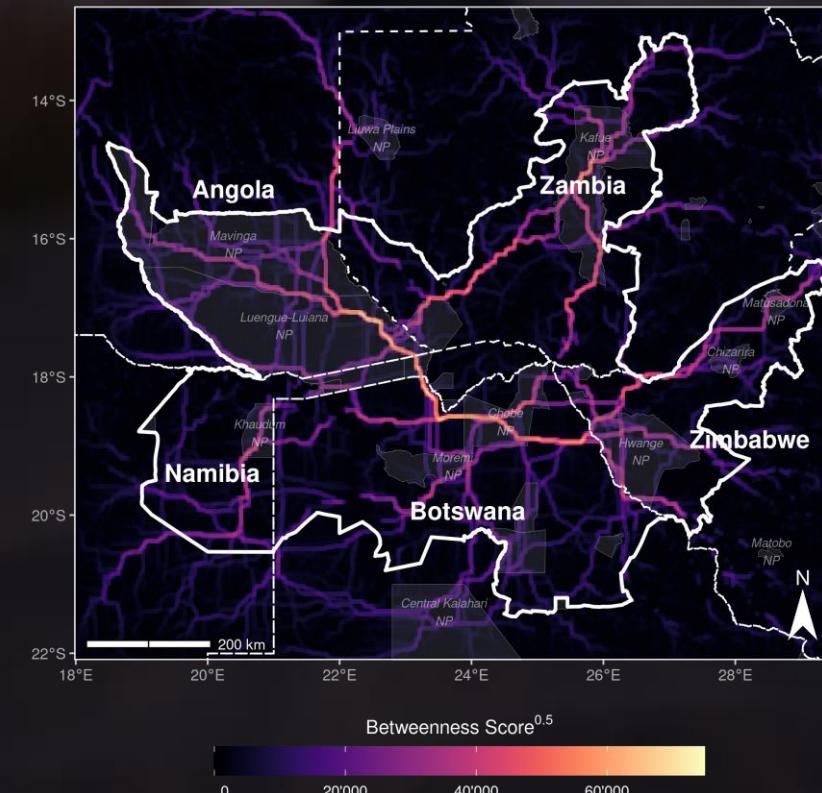


intensity of use

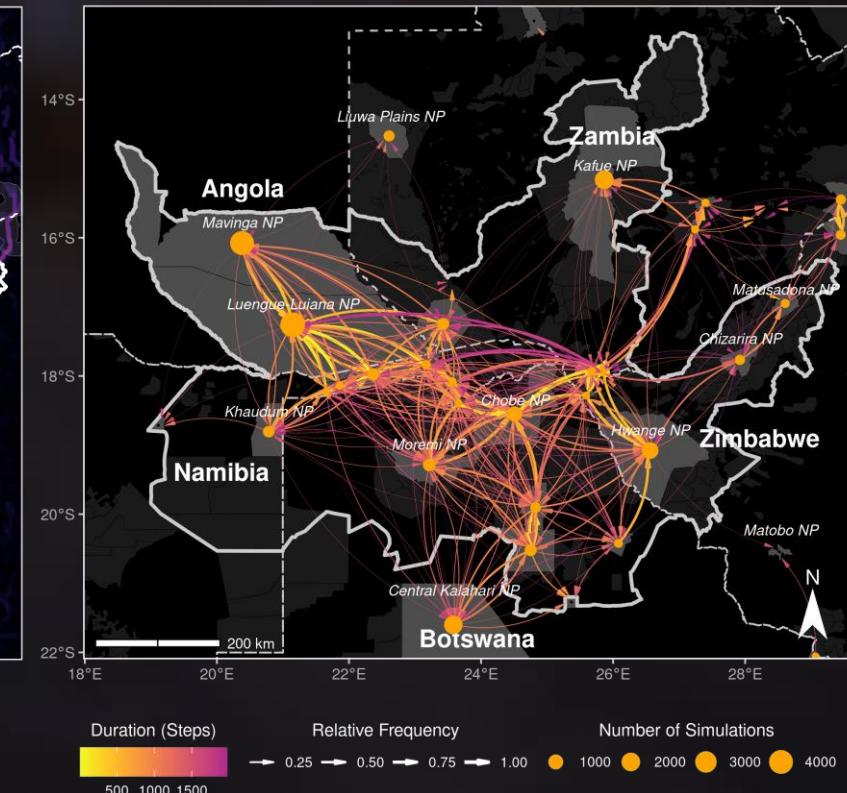
HEATMAP

*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

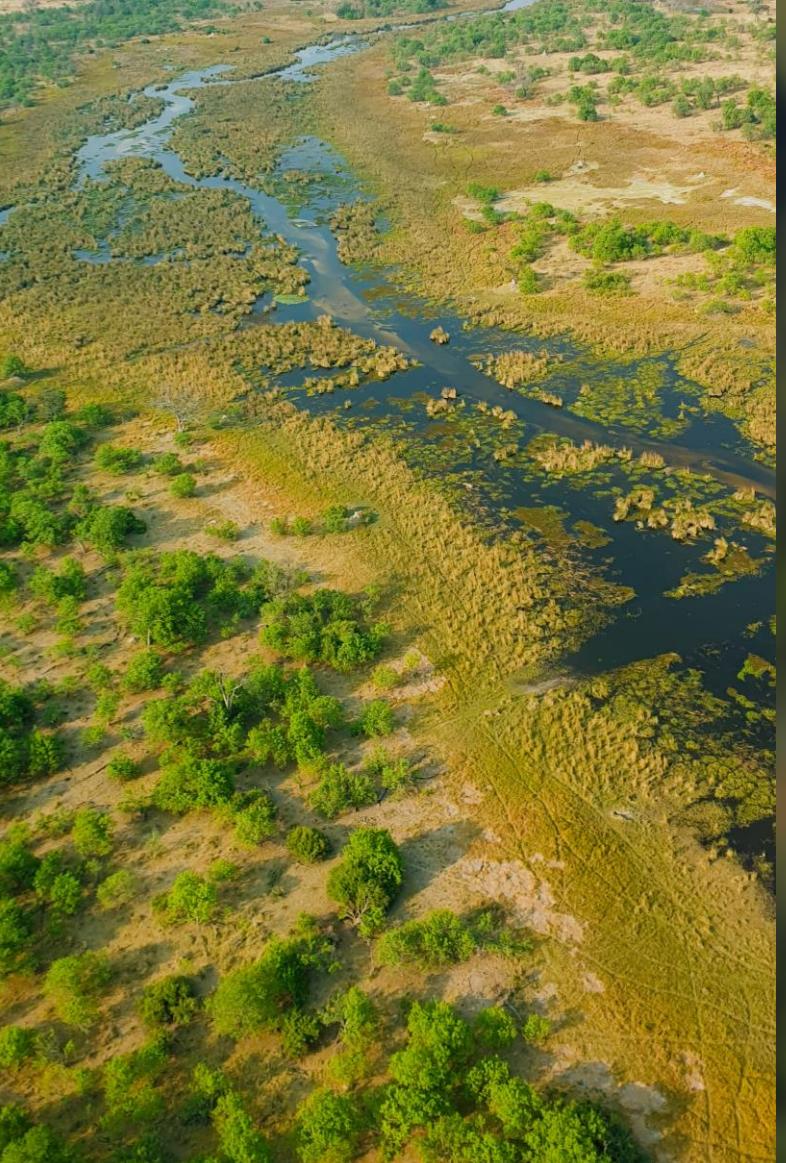
- ✓ New simulation-based connectivity model
- ✓ Complementary connectivity metrics
- ✓ African wild dog case study
 - Non-trivial modeling decisions
 - Assumed unchanged landscape

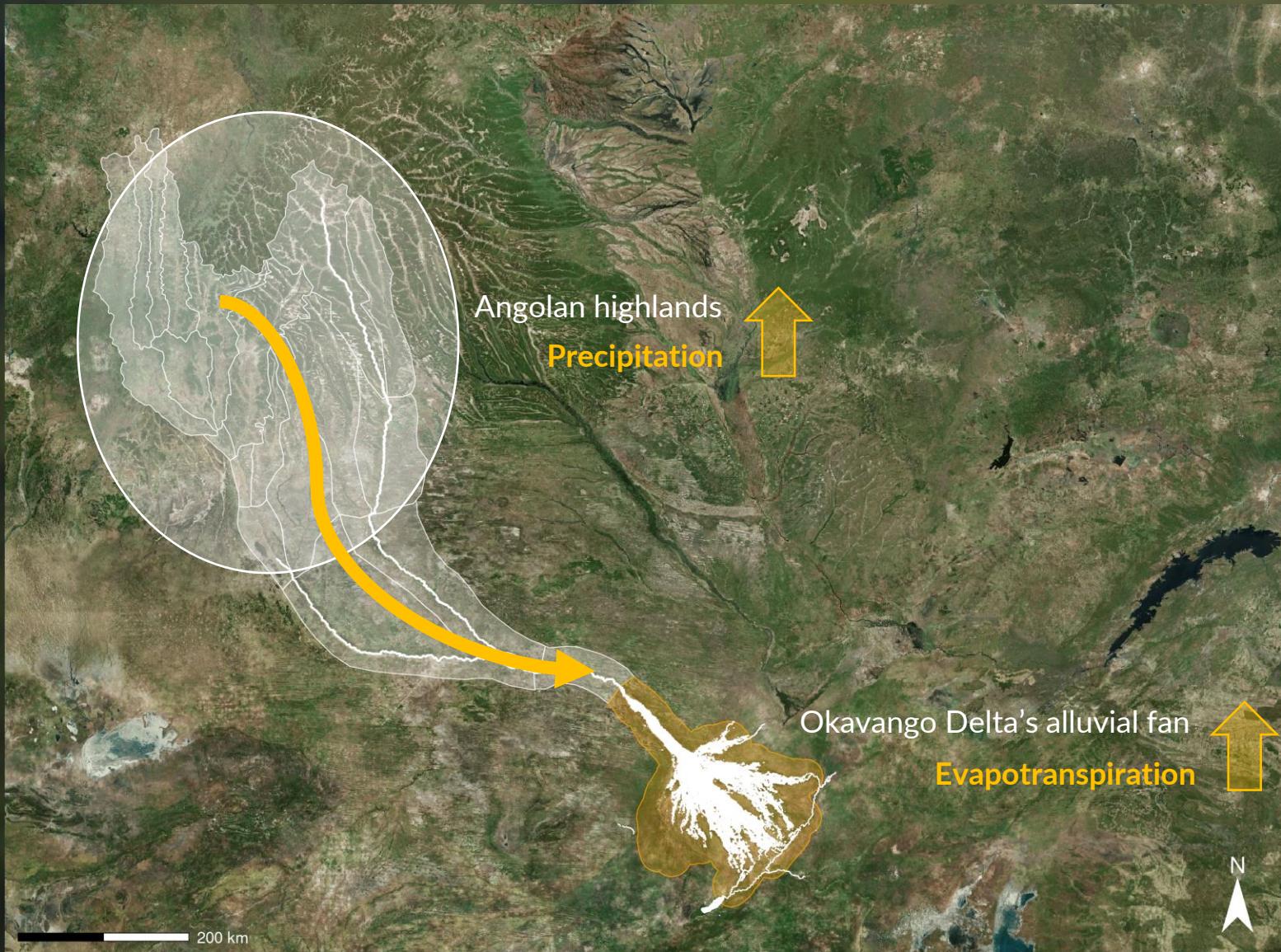


Dispersal and Connectivity in Increasingly Extreme Climatic Conditions

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

Global Change Biology, 2024



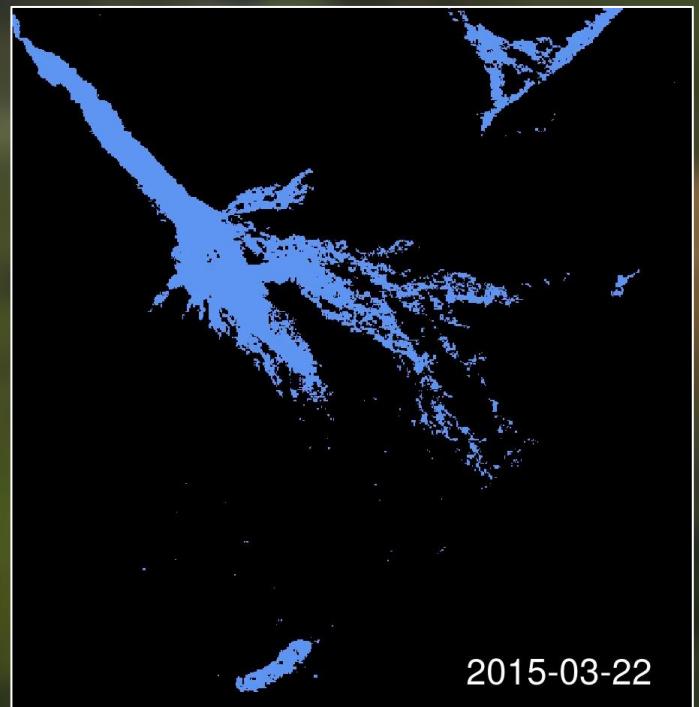


floodmaprwww.github.com/DavidDHofmann/floodmapr

`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](#)).



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

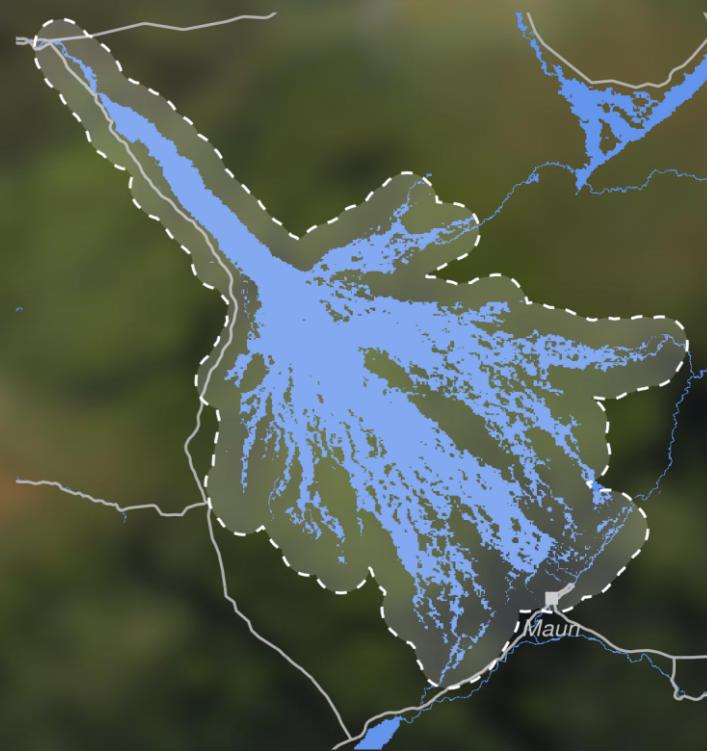


MINIMUM FLOOD SCENARIO



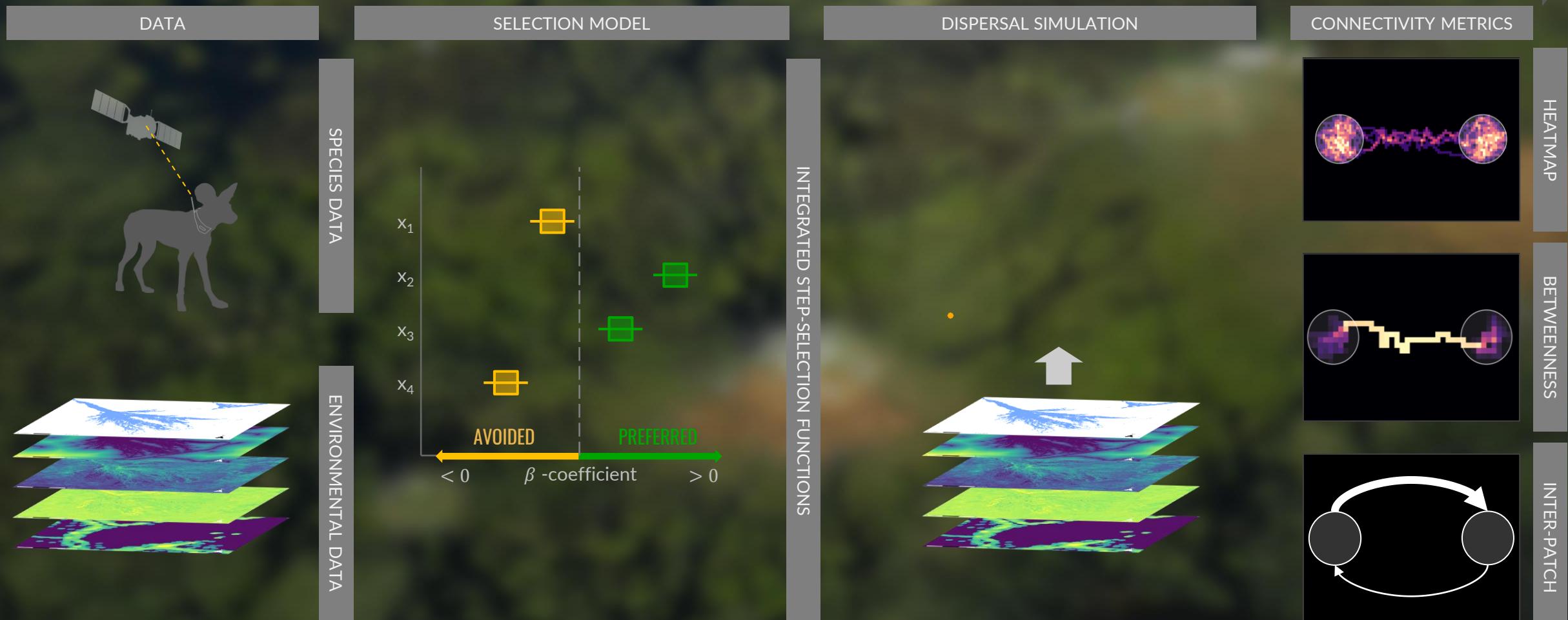
~ 3'500 km²

MAXIMUM FLOOD SCENARIO



~ 9'500 km²

CONNECTIVITY MODELING PIPELINE



CONNECTIVITY MODELING PIPELINE

DATA



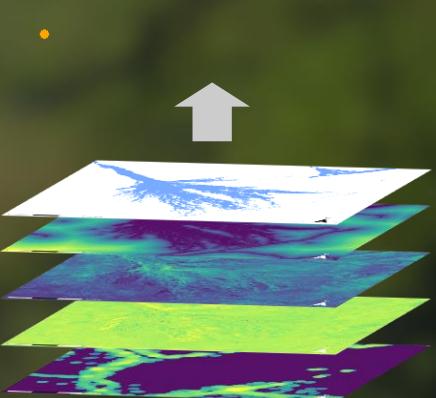
SPECIES DATA



ENVIRONMENTAL DATA

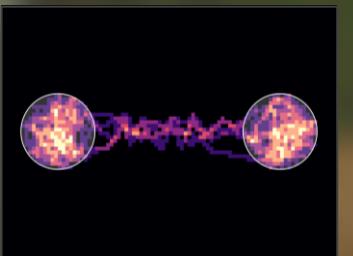
SELECTION MODEL

DISPERSAL SIMULATION

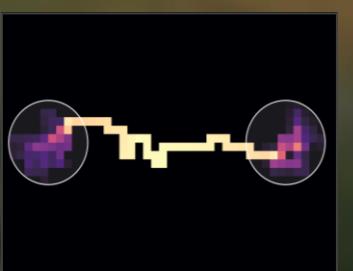


INTEGRATED STEP-SELECTION FUNCTIONS

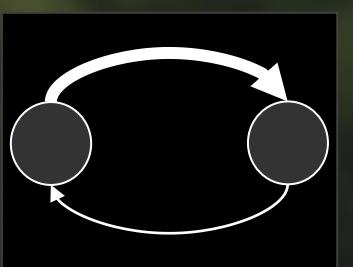
CONNECTIVITY METRICS



HEATMAP



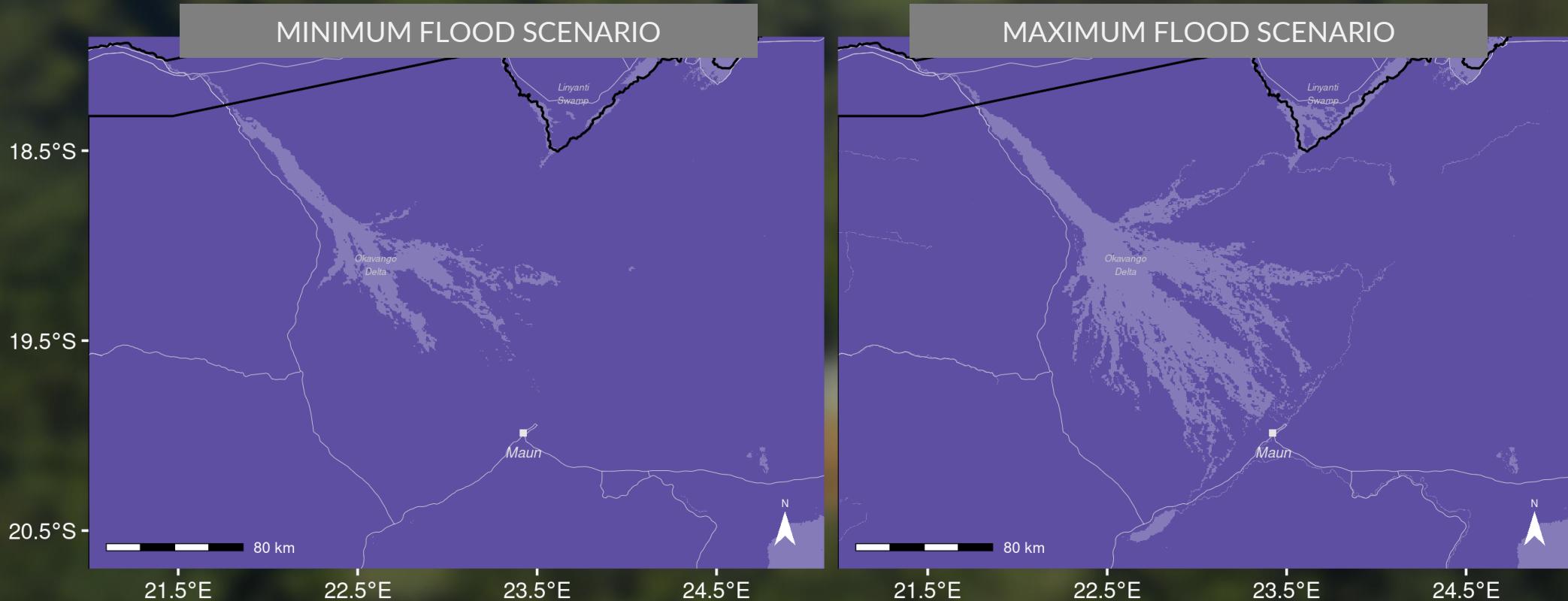
BETWEENNESS

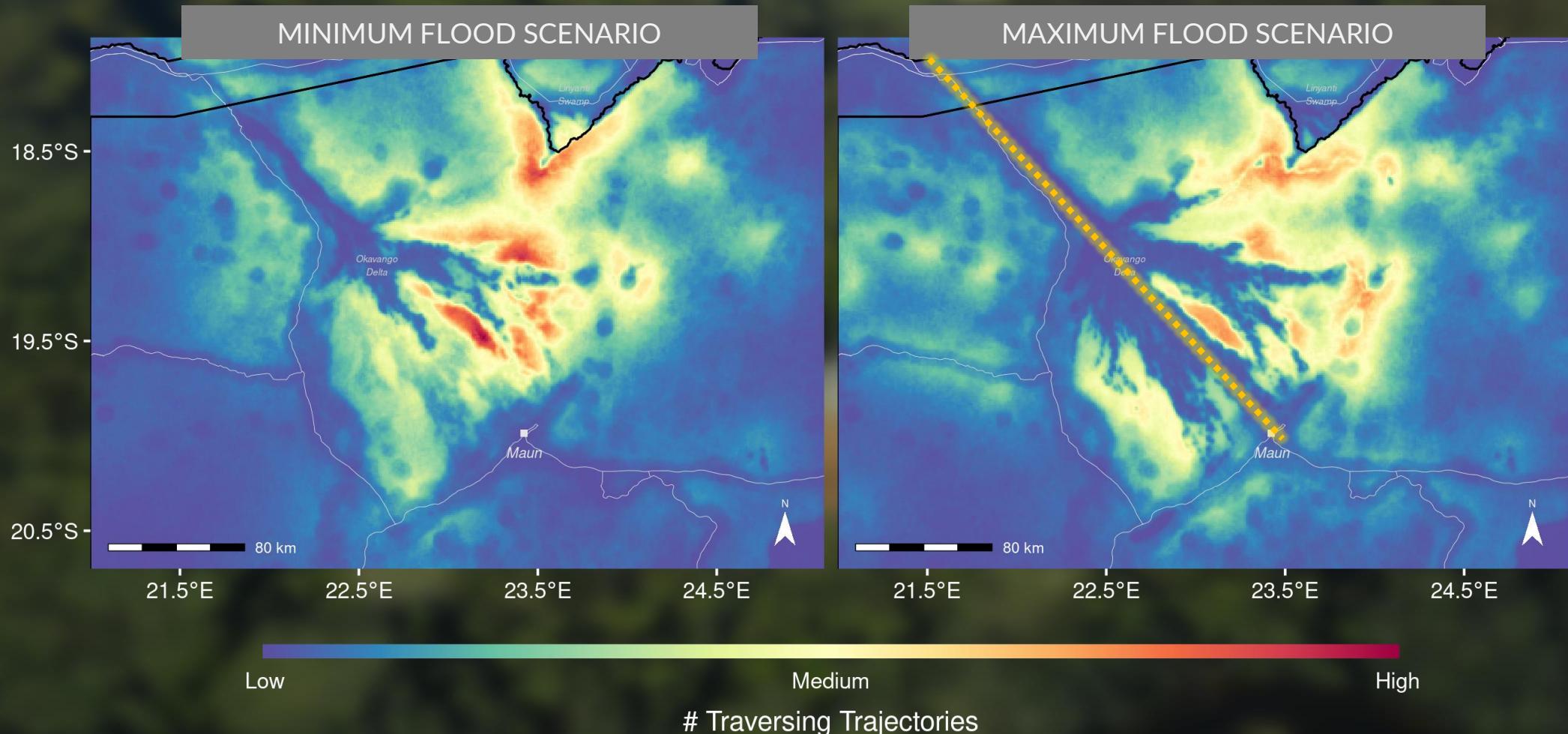


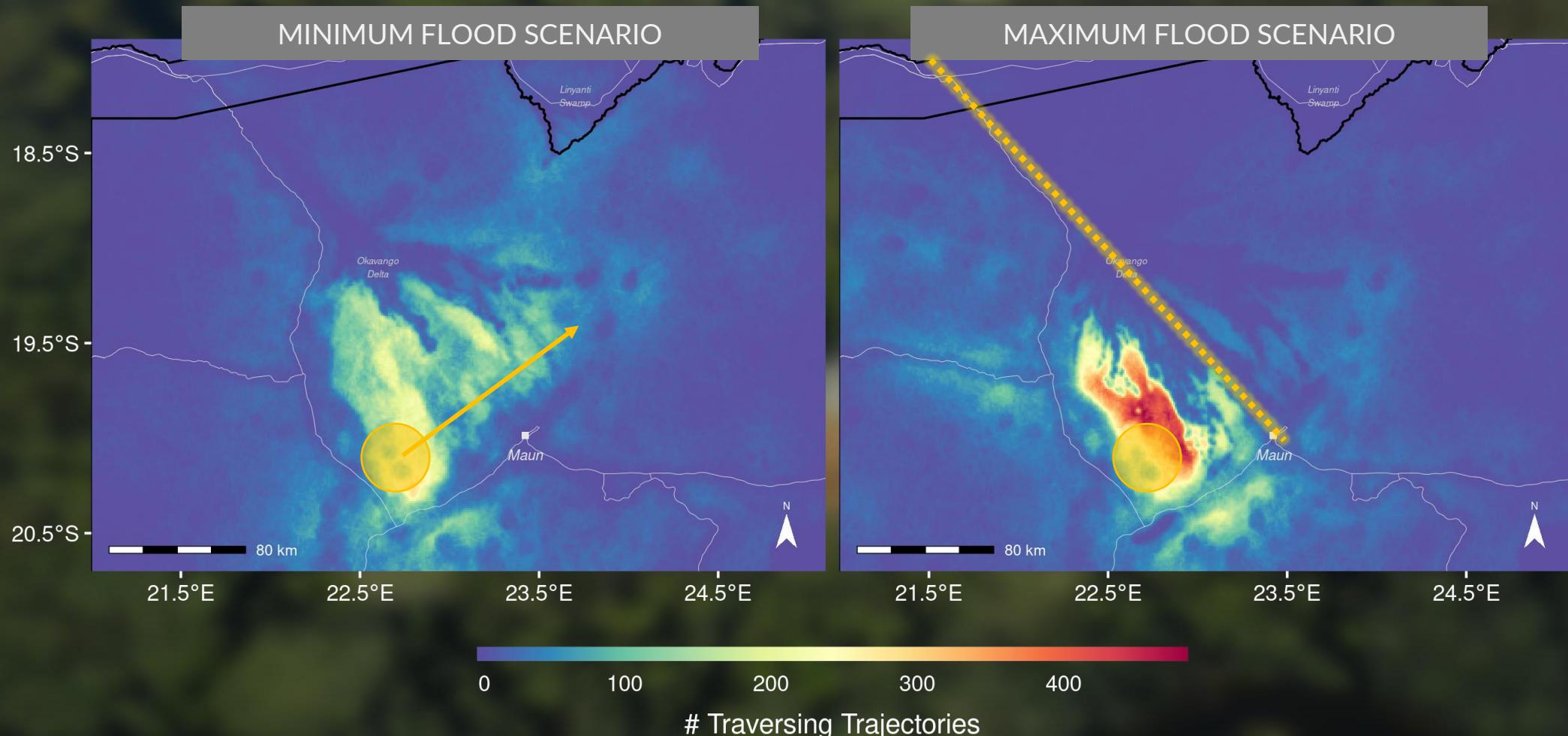
INTER-PATCH

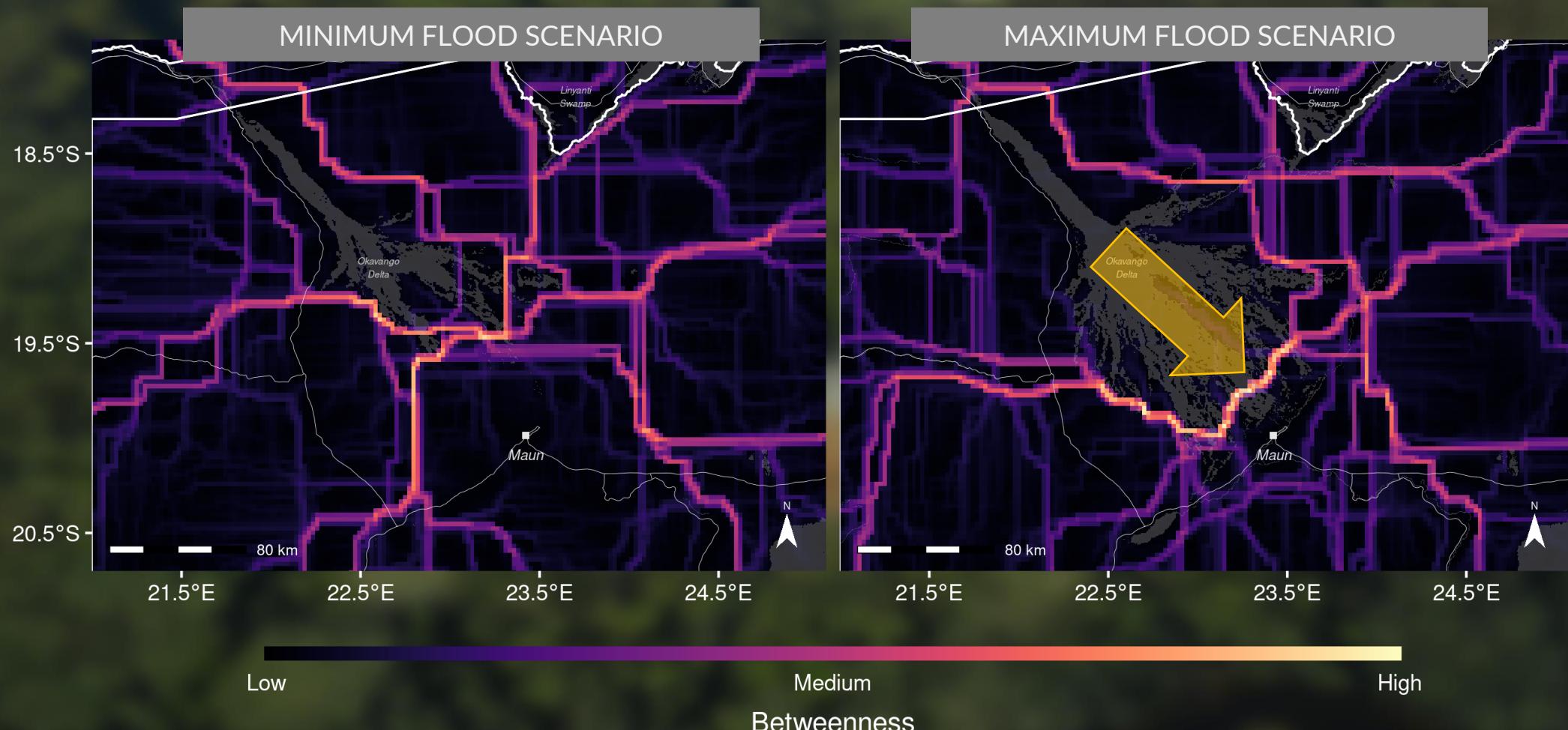
CONNECTIVITY MODELING PIPELINE

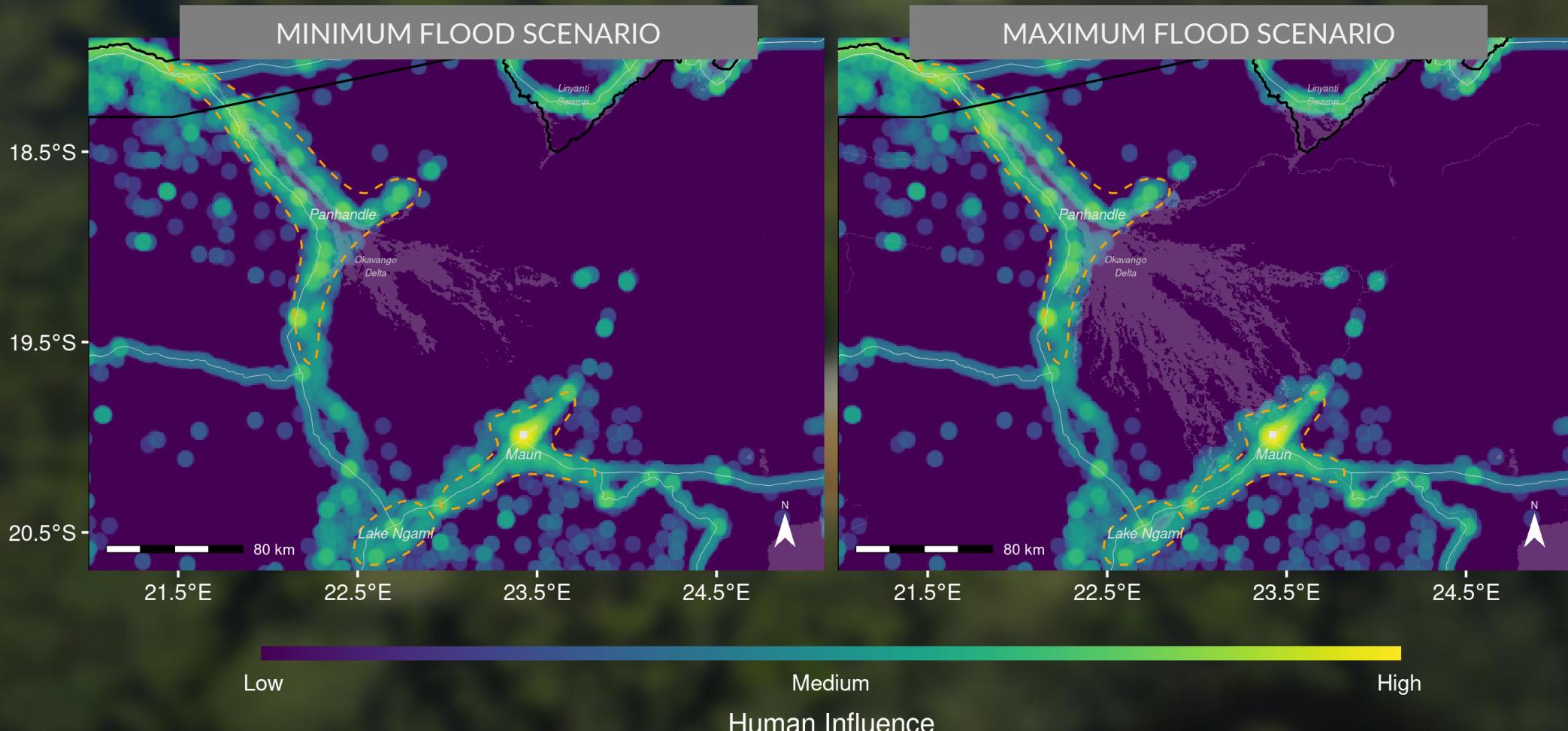


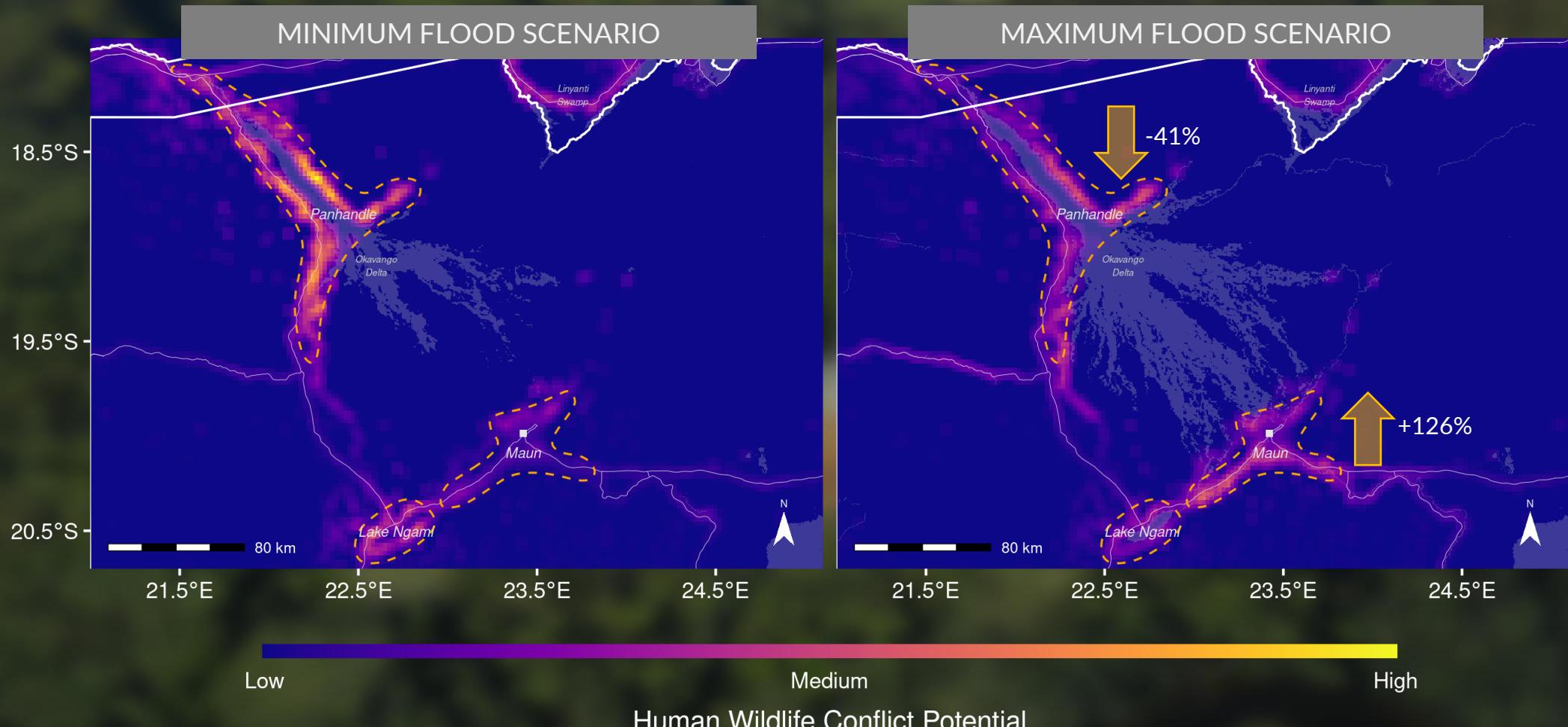




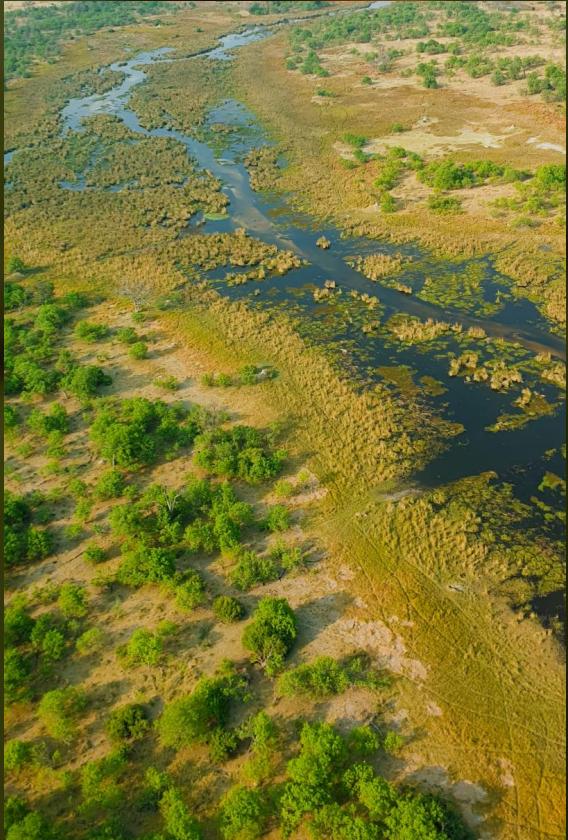












Dispersal and Connectivity in Increasingly Extreme Climatic Conditions

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

Global Change Biology, 2024

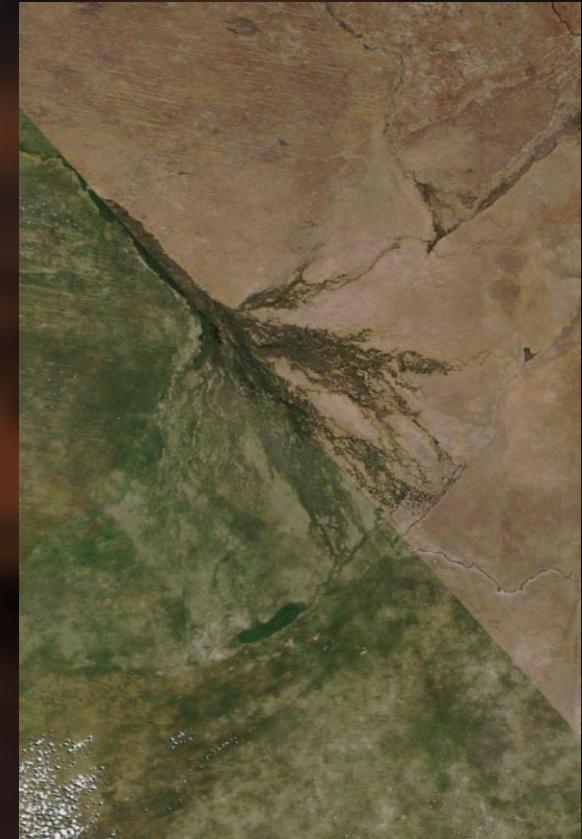
- ✓ Different connectivity patterns depending on future conditions
- ✓ Re-arrangement of movement corridors
- ✓ New potential HWC hotspots
 - Vegetation change
 - Seasonal changes



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

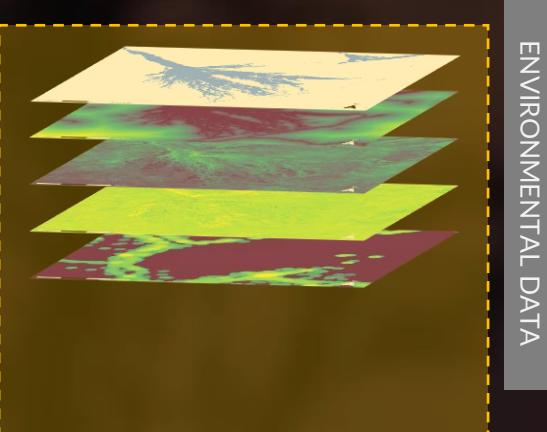


SELECTION MODEL

SPECIES DATA

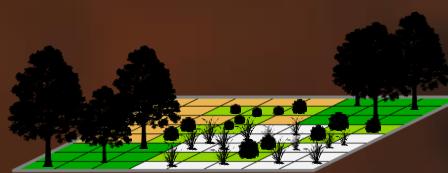


PERMEABILITY SURFACE

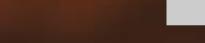
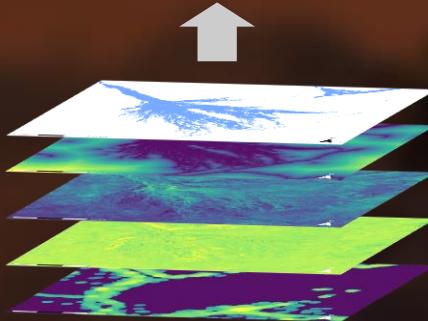


ENVIRONMENTAL DATA

INTEGRATED STEP-SELECTION FUNCTIONS

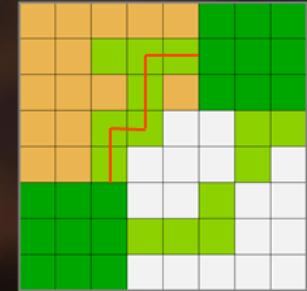


$$w(x) = \exp(\beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n)$$

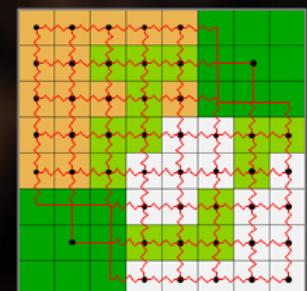


CONNECTIVITY MODEL

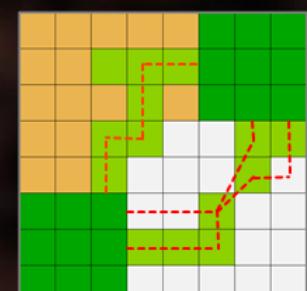
LEAST-COST



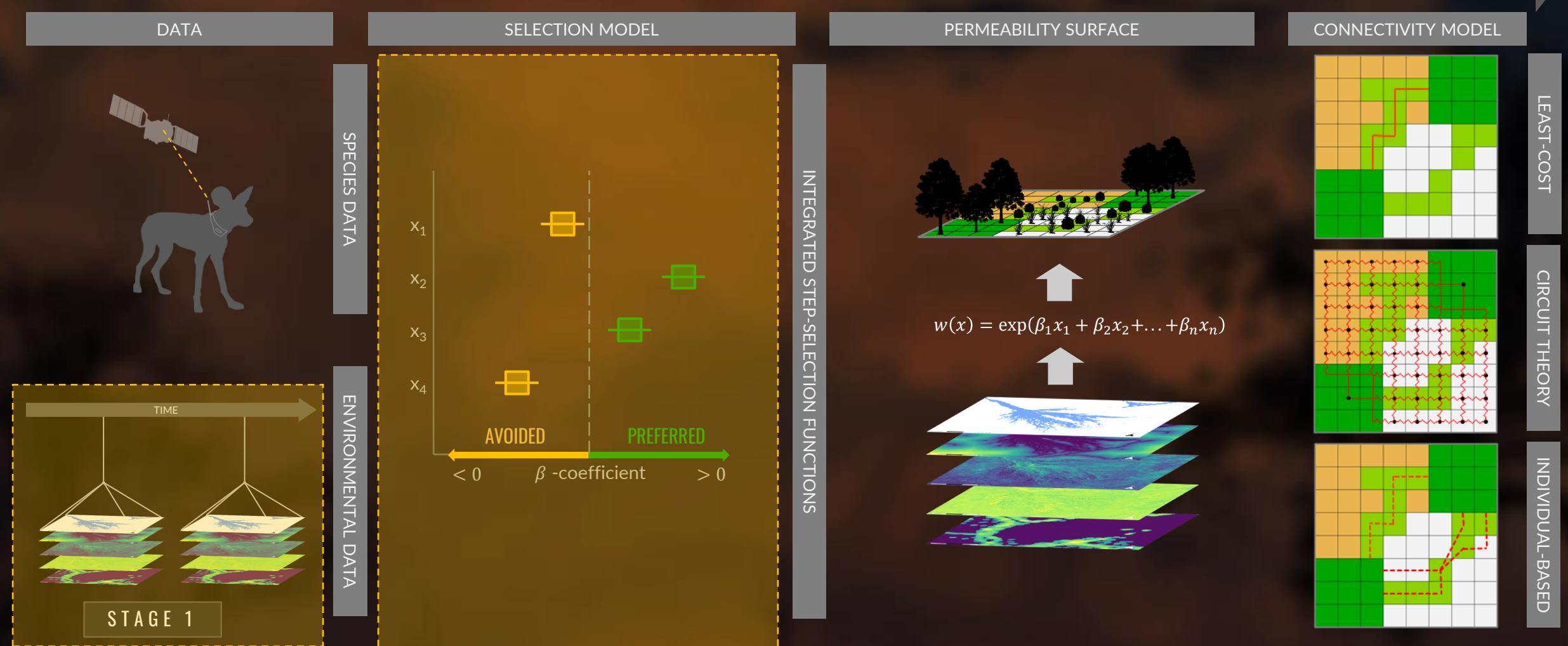
CIRCUIT THEORY



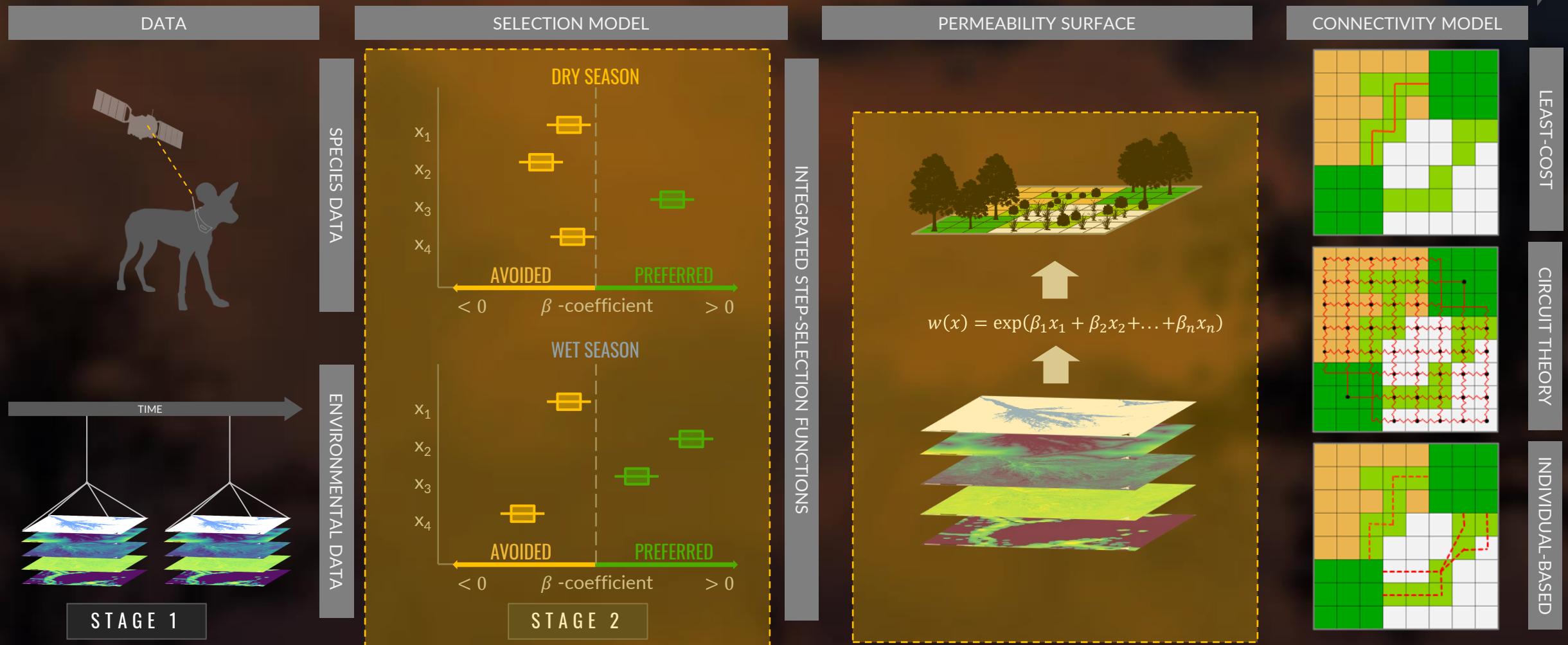
INDIVIDUAL-BASED



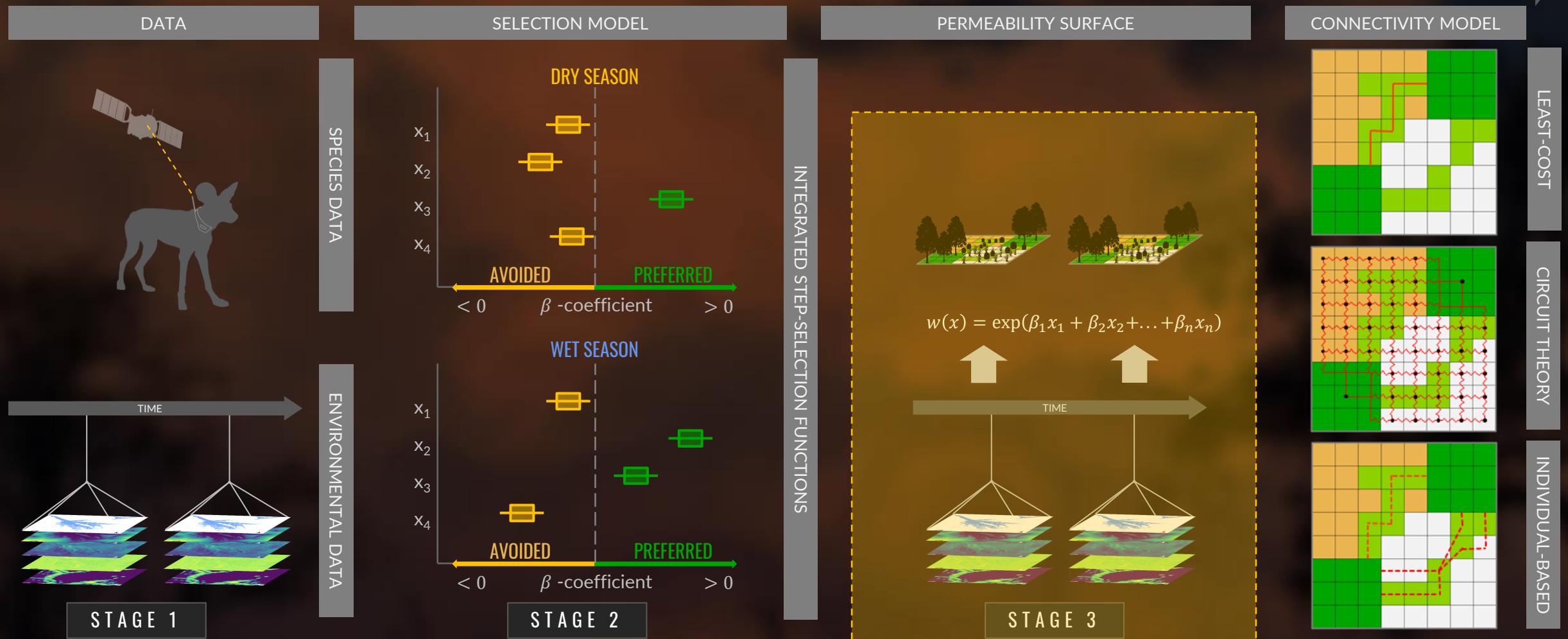
CONNECTIVITY MODELING PIPELINE



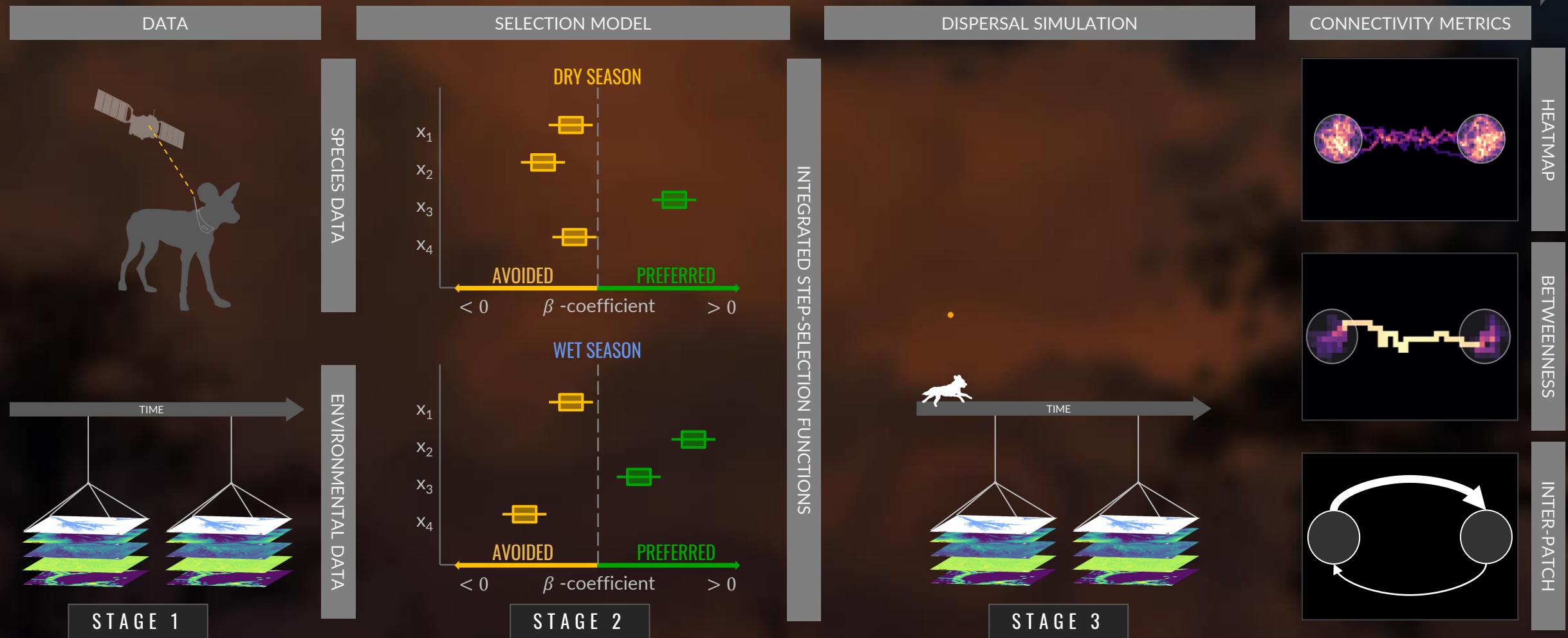
CONNECTIVITY MODELING PIPELINE

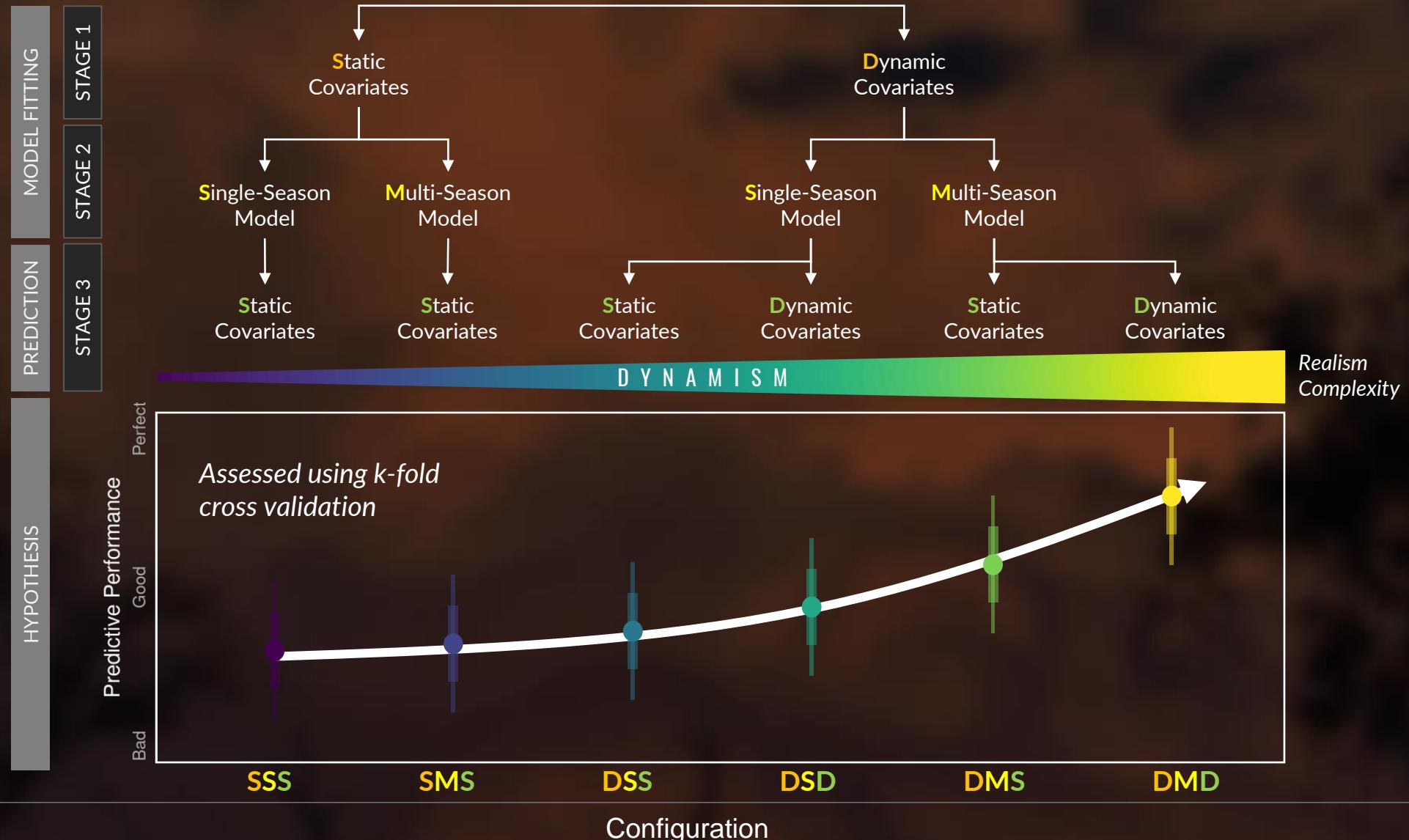


CONNECTIVITY MODELING PIPELINE

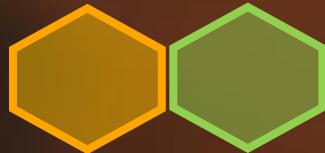


CONNECTIVITY MODELING PIPELINE



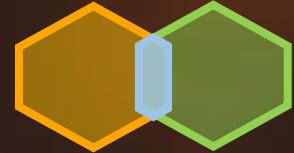


SIMPLISTIC MODEL

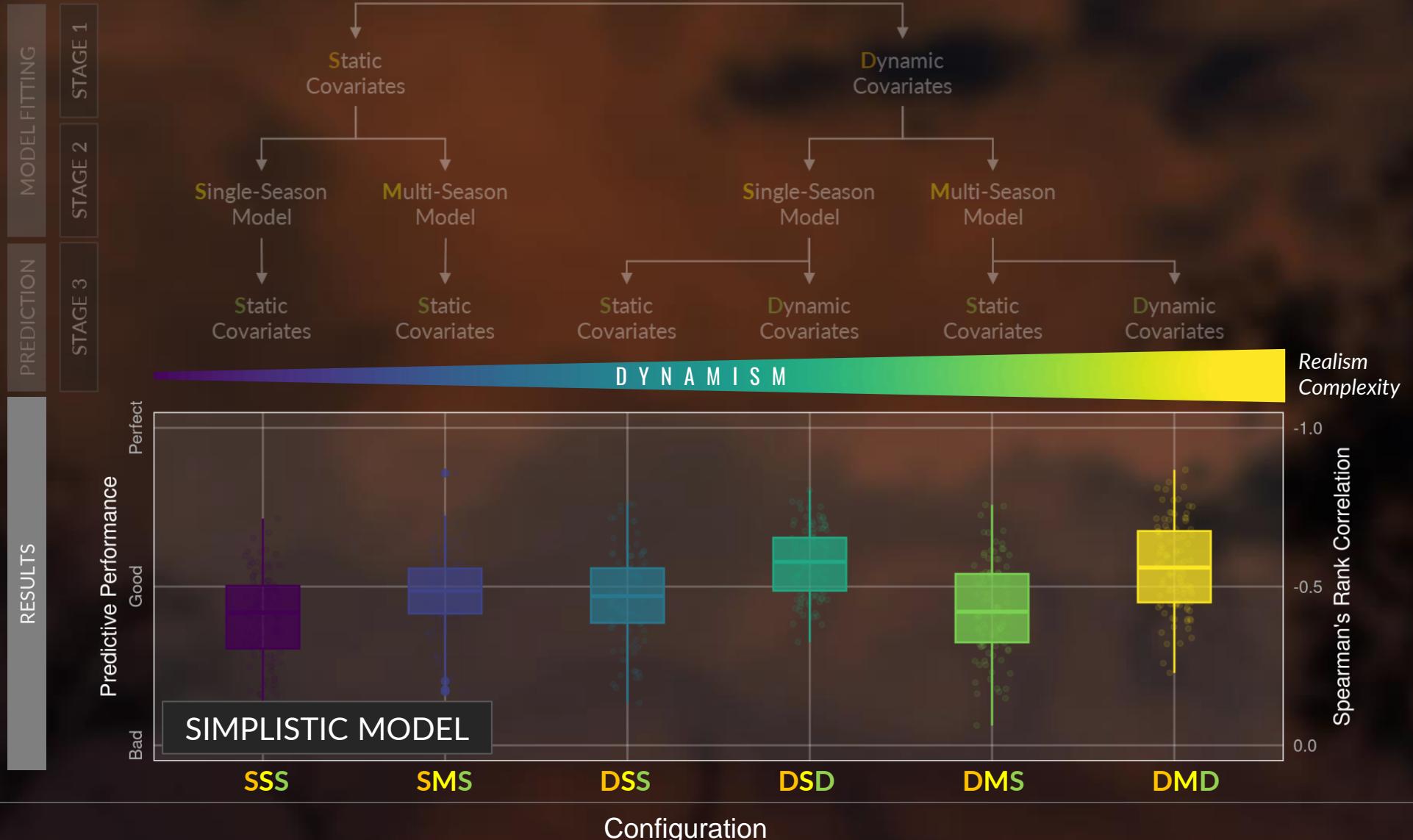


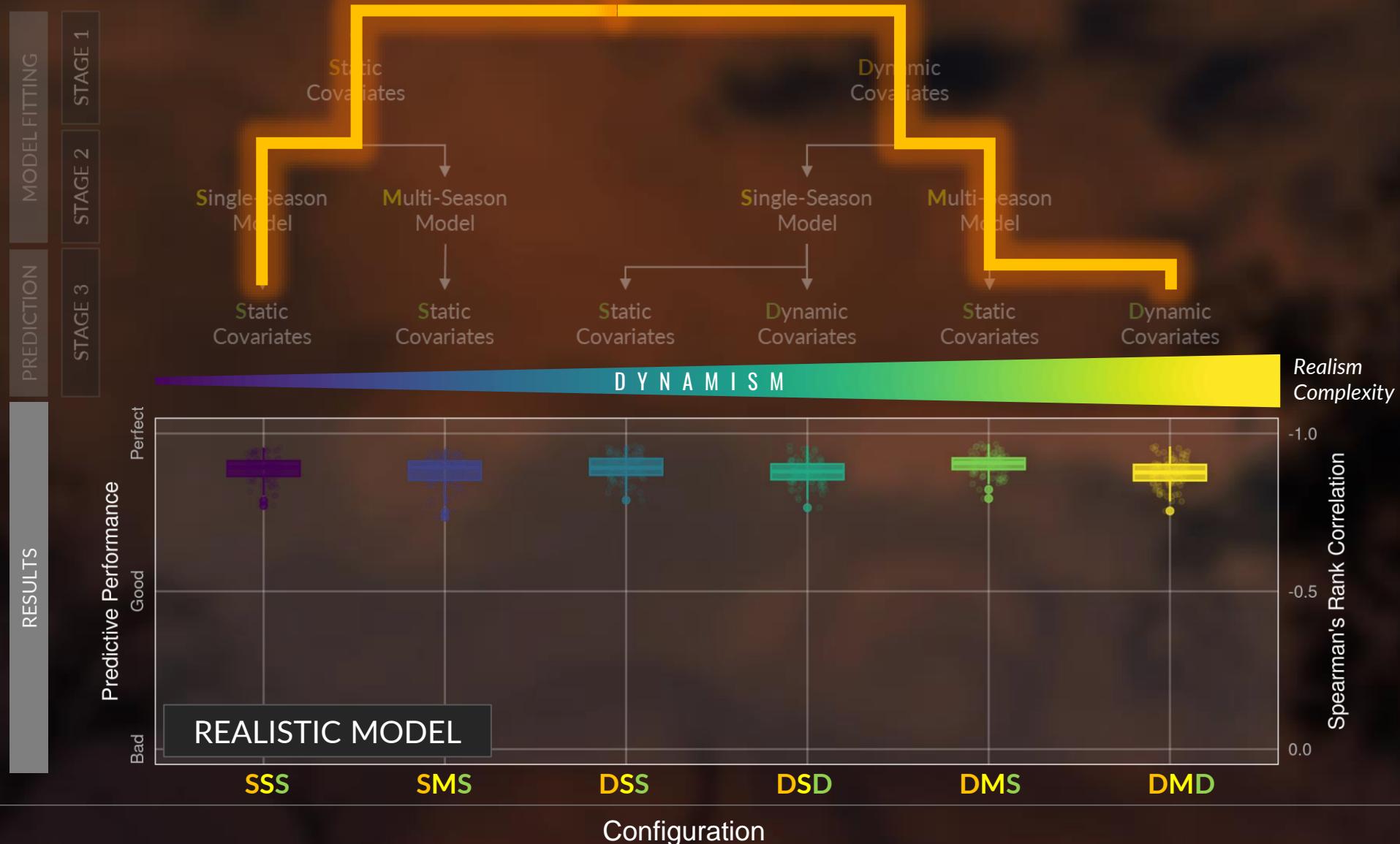
$$w(x) = \text{Movement Kernel} + \text{Habitat Selection Function}$$

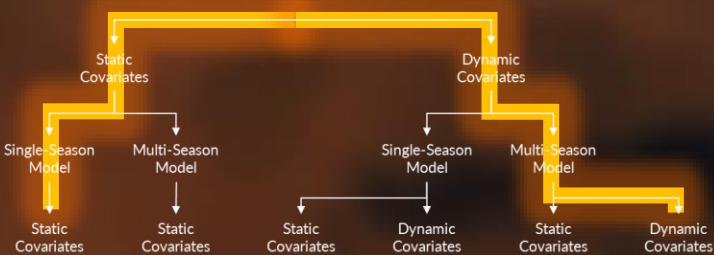
REALISTIC MODEL



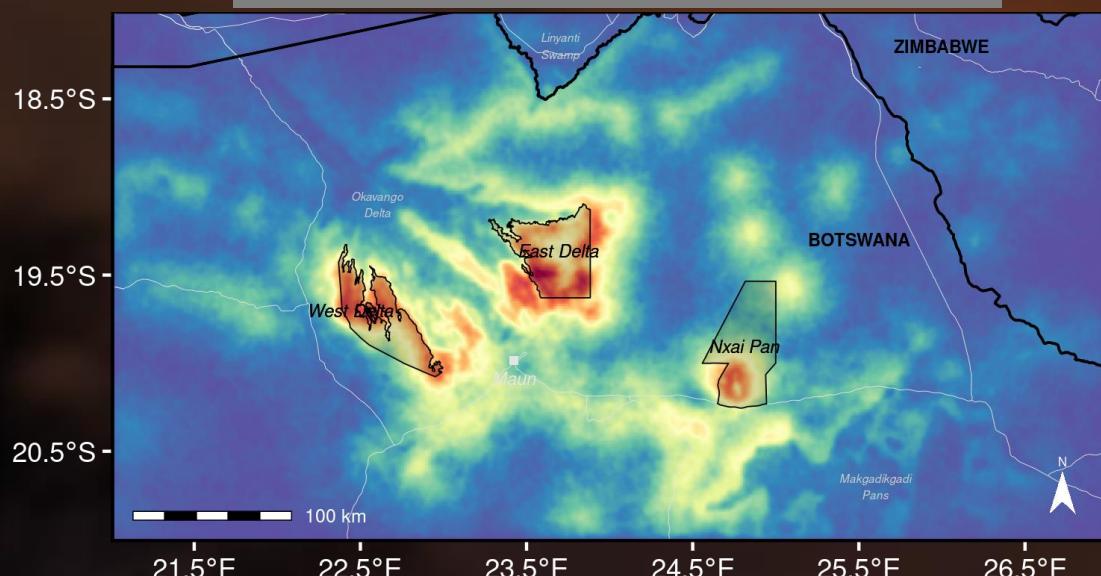
$$w(x) = \text{Movement Kernel} + \text{Habitat Selection Function} + \text{Movement Kernel: Habitat Selection Function}$$



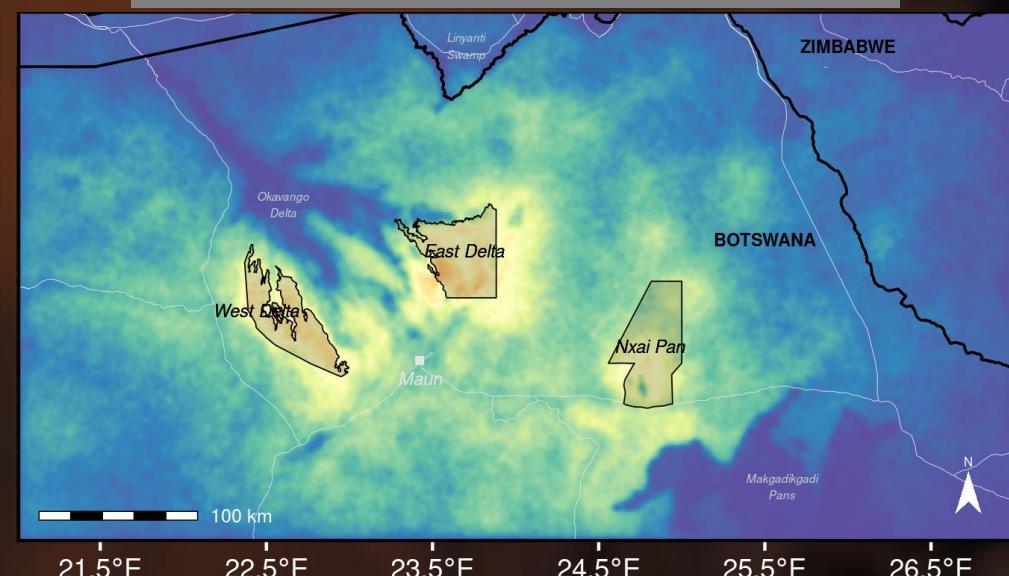




MOST STATIC (SSS)



MOST DYNAMIC (DMD)



Low Medium High
Traversing Trajectories

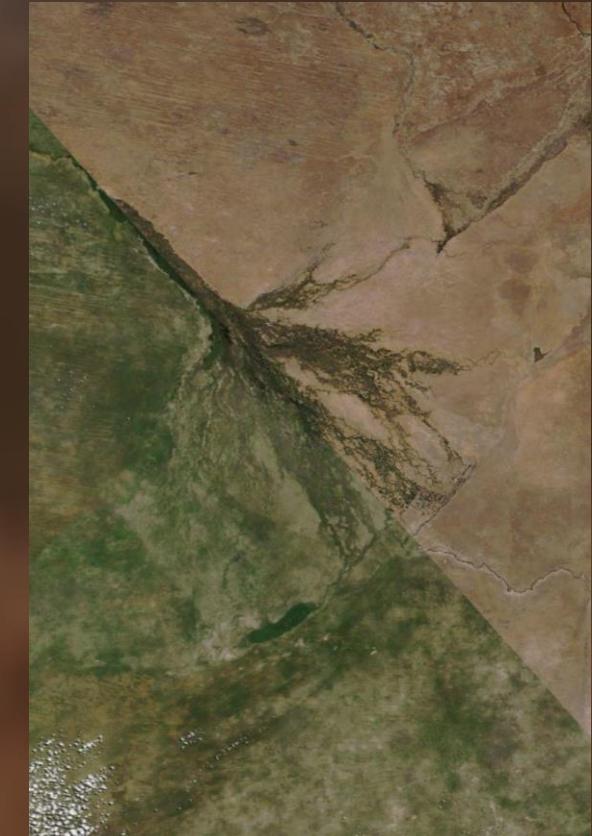


The Effects of Increasing Seasonal Dynamism when Predicting Connectivity: Advantages or Unnecessary Complications?

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

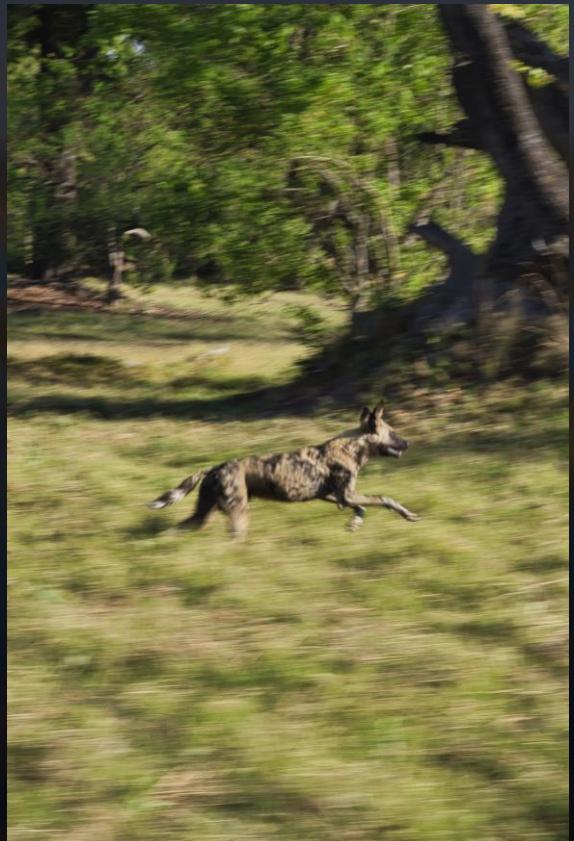
David D. Hofmann, Gabriele Cozzi, John Fieberg

Movement Ecology, 2024





CHAPTER I



SIMULATE DISPERSAL

CHAPTER II



EXTREME CONDITIONS

CHAPTER III



SEASONALITY

CHAPTER IV



DATA IRREGULARITY



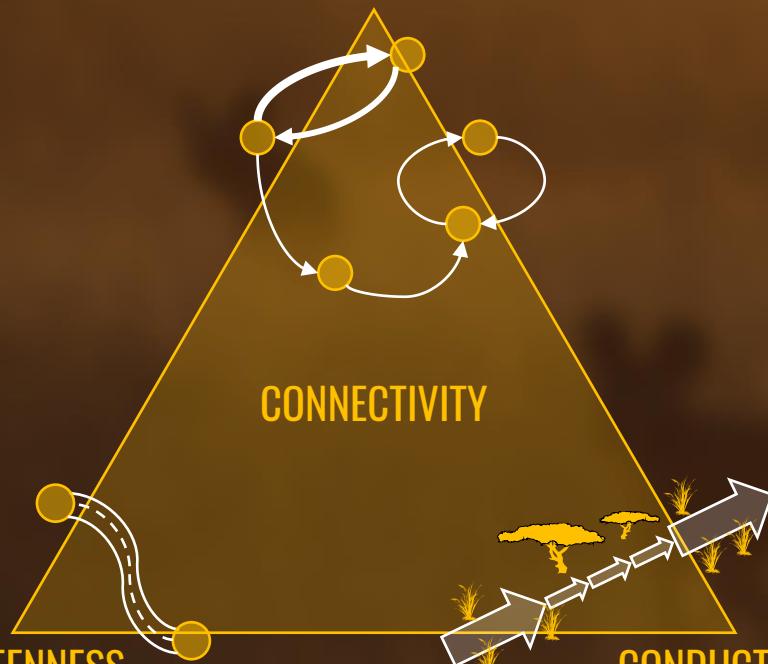
CONNECTIVITY





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

CONNECTEDNESS



BETWEENNESS

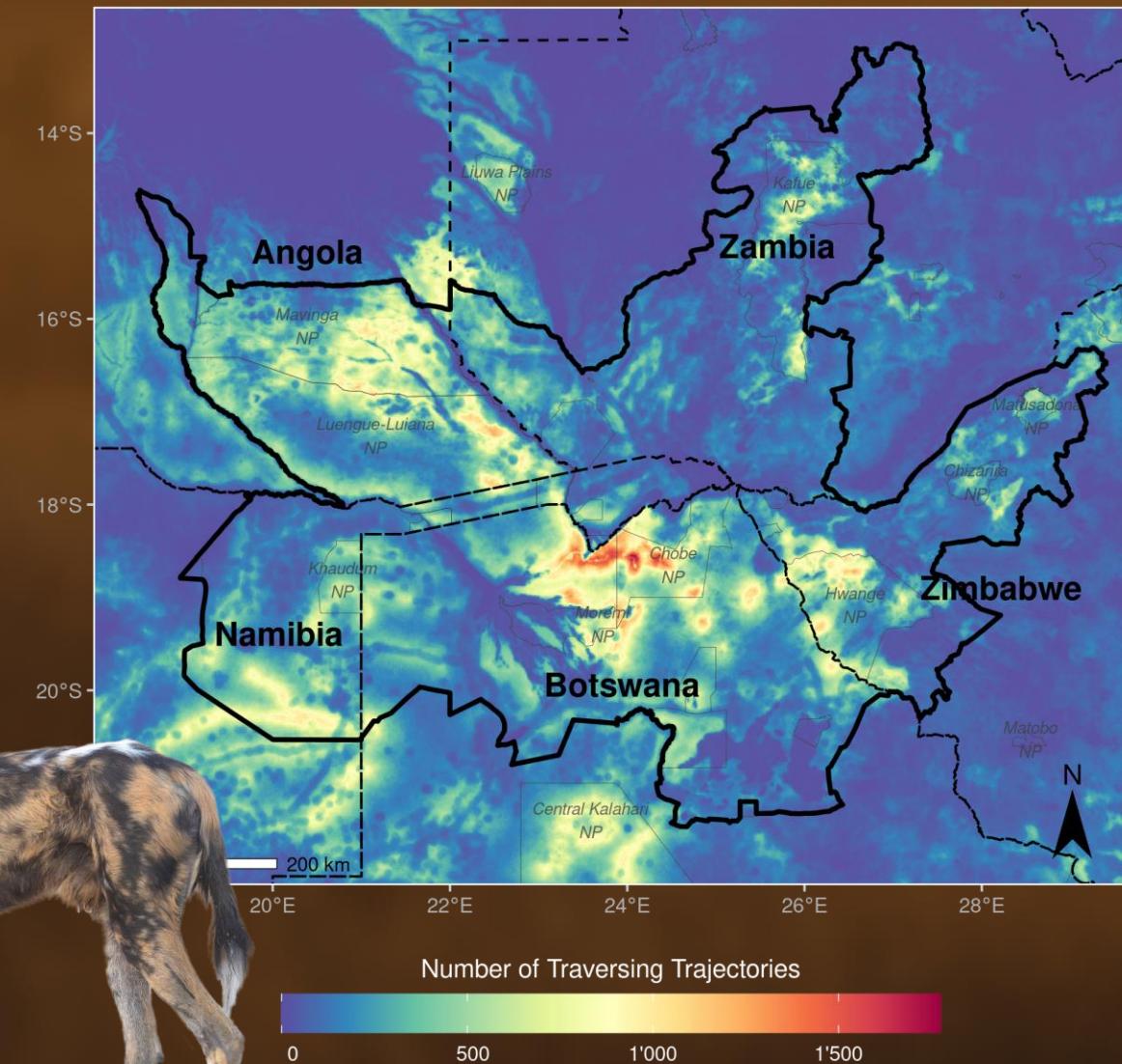
the importance of different elements of the matrix in facilitating movement between other patches or habitats

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

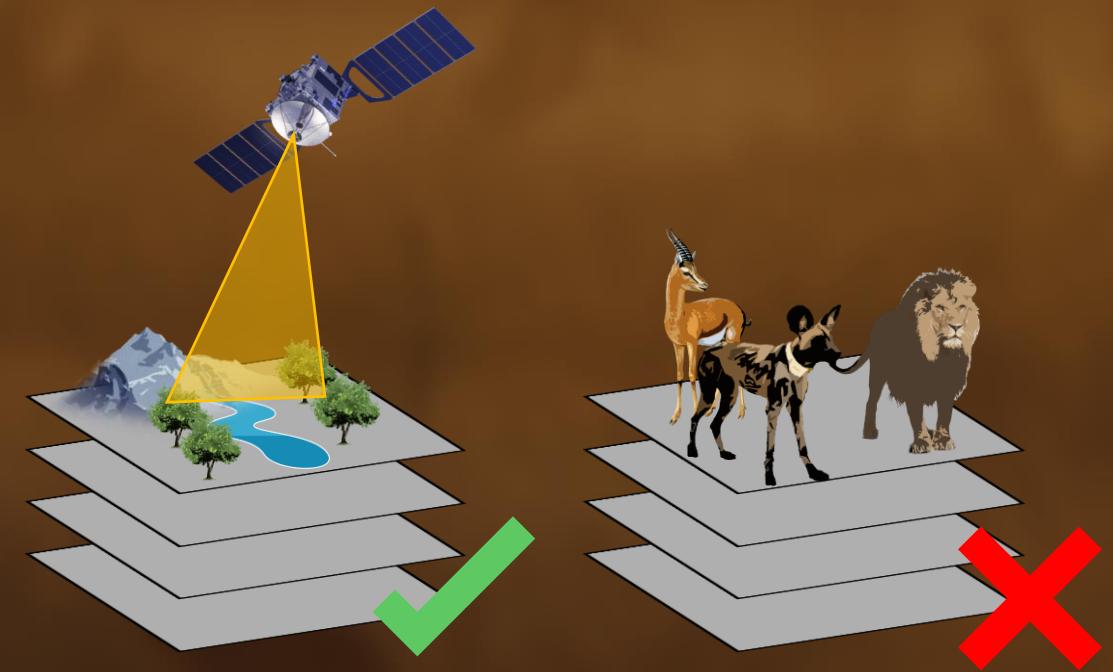




Species are embedded in an intra- and inter-specific landscape



→ Often neglected in studies of landscape connectivity



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Parrotia Stiftung

Stiftung Temperatio

Wilderness Wildlife Trust

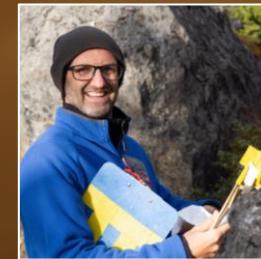
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Photo credit: Arpat Ozgul, David Hofmann

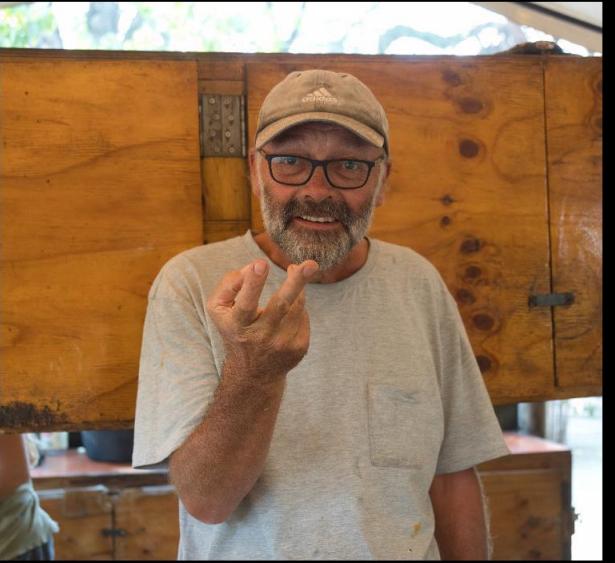


Photo credit: Cole Franklin, Jeroen van Rooijen, Hannah Gormley, David Bessenhofer, David Hofmann



THANK YOU!

CHAPTER I



SIMULATE DISPERSAL



EXTREME CONDITIONS

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

CHAPTER II



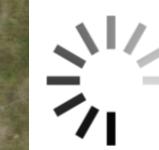
EXTREME CONDITIONS



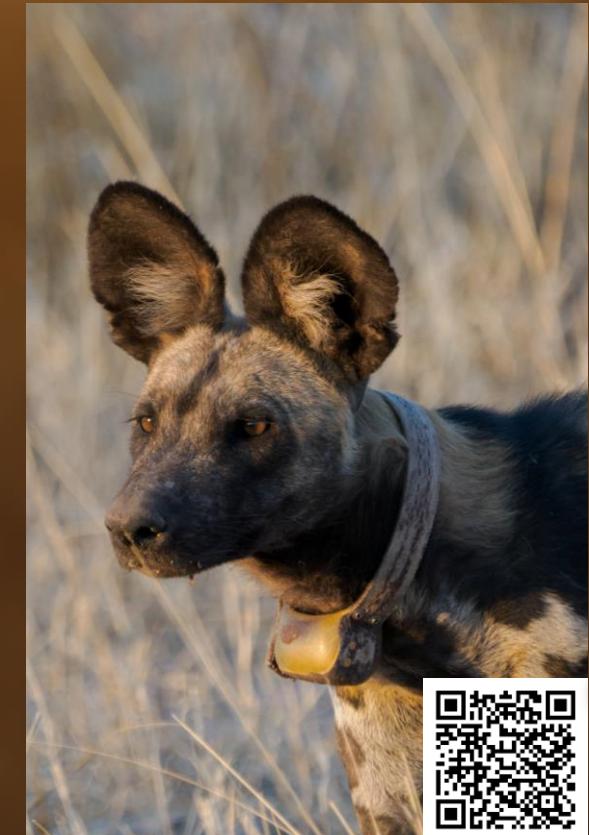
CHAPTER III



SEASONALITY



CHAPTER IV



DATA IRREGULARITY

