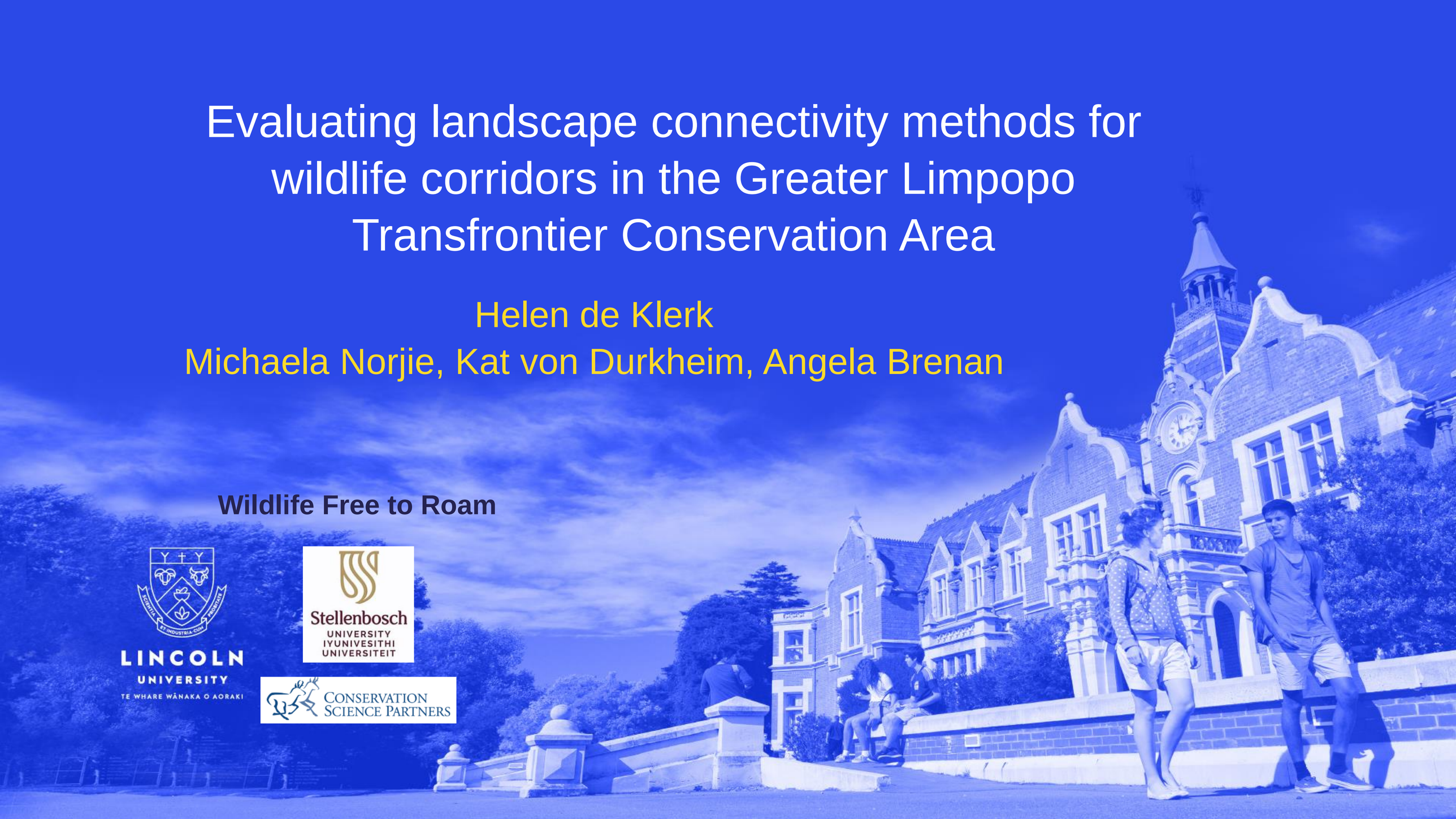
Evaluating landscape connectivity methods for wildlife corridors in the Greater Limpopo Transfrontier Conservation Area

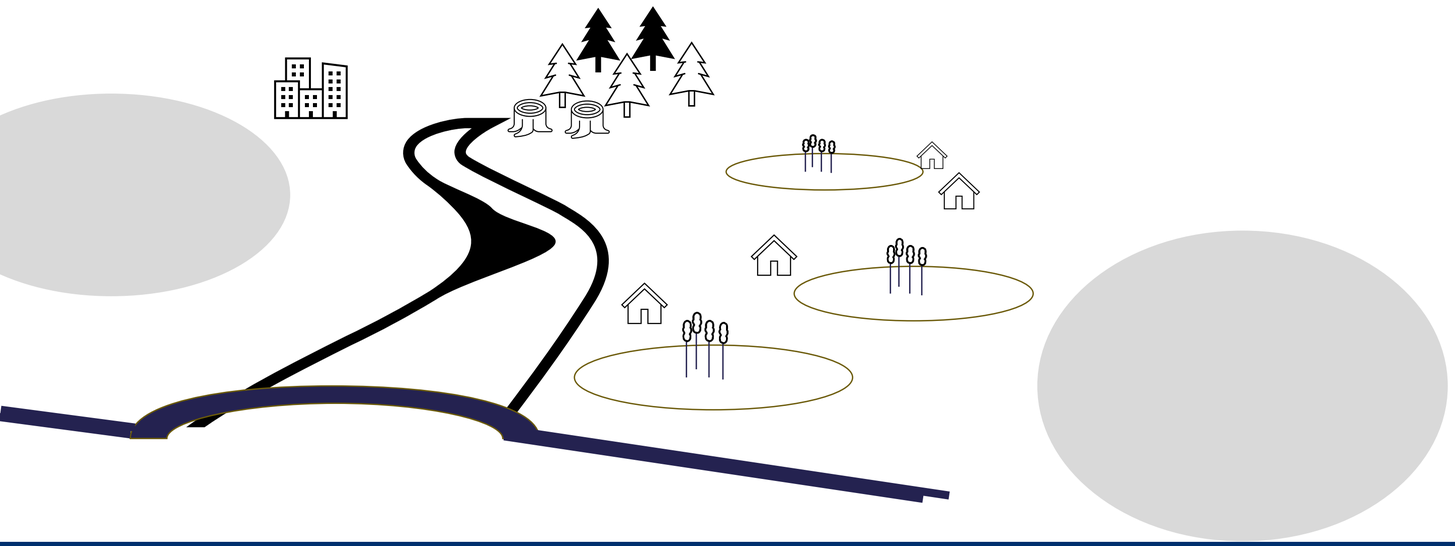
Helen de Klerk
Michaela Norjie, Kat von Durkheim, Angela Brenan

Wildlife Free to Roam



Wildlife / ecological corridors

- Human modification of landscapes
    - fragmentation of biotic populations
    - population level process



Ecological corridors

- Human modification of landscapes
    - fragmentation of biotic populations
    - population level process

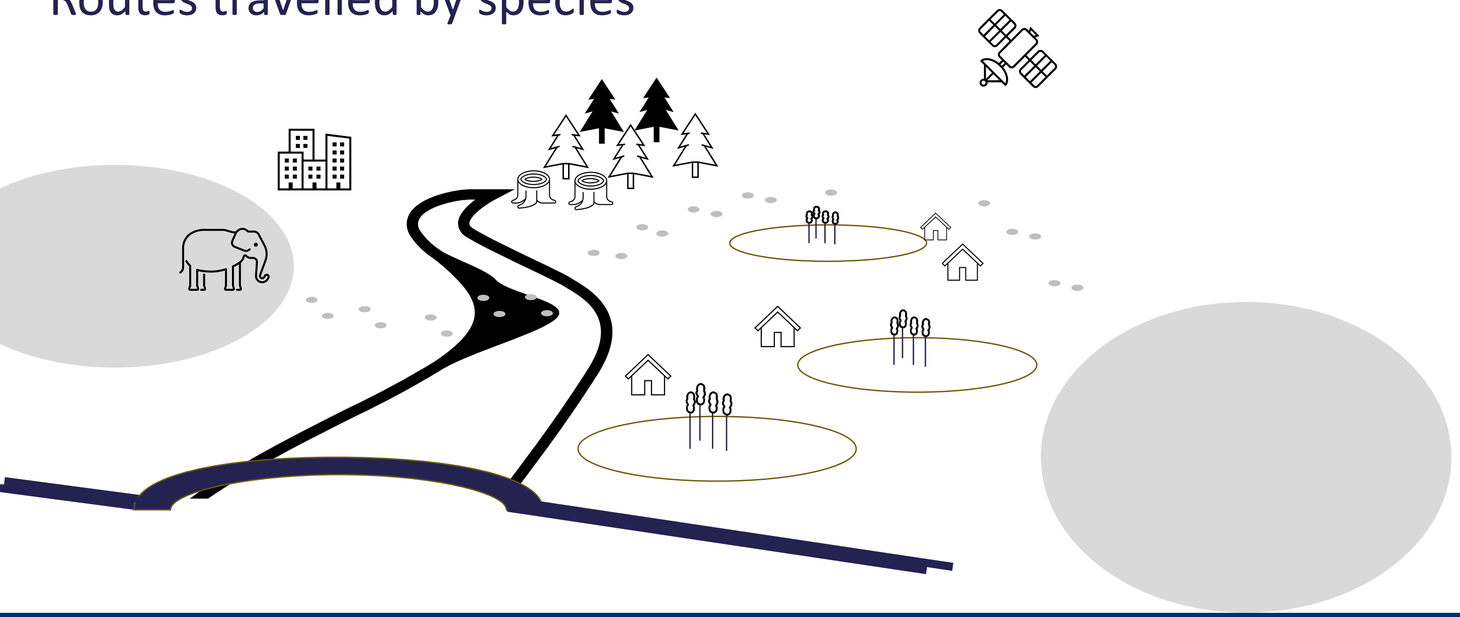
Spatial location of connecting corridors

Ecological corridors

- Human modification of landscapes
    - fragmentation of biotic populations
    - population level process

Spatial location of connecting corridors

Routes travelled by species



Ecological corridors

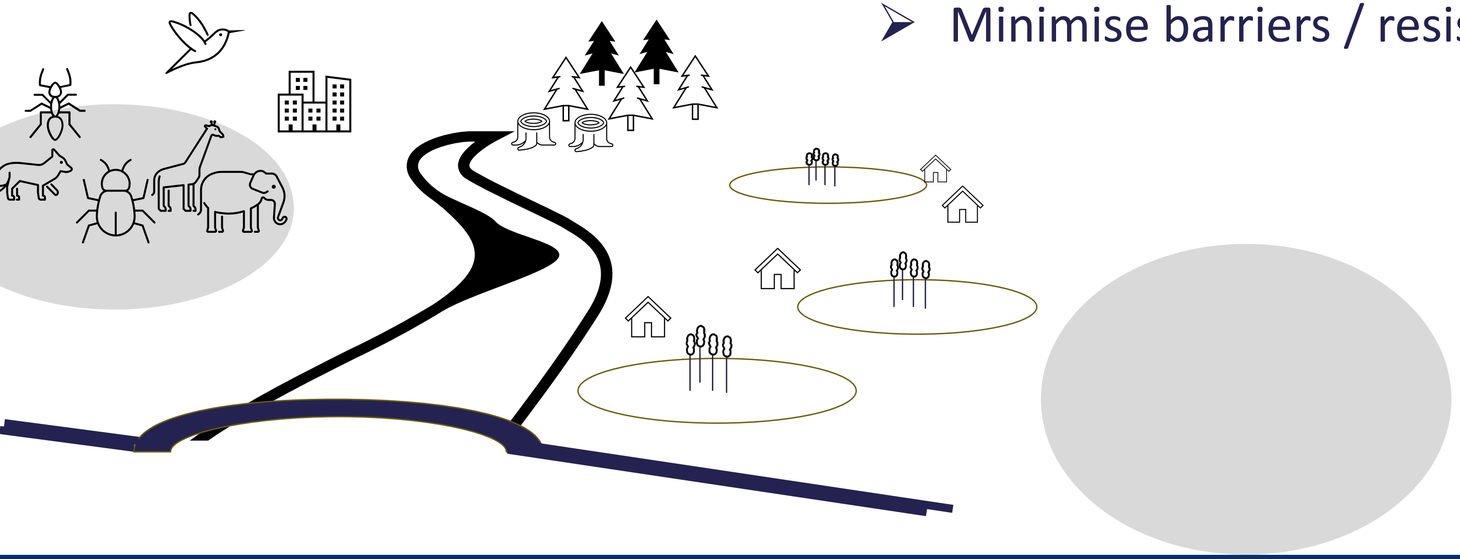
- Human modification of landscapes
    - fragmentation of biotic populations
    - population level process

Spatial location of connecting corridors

Routes travelled by species

Landscape connectivity & species agnostic / structural corridors

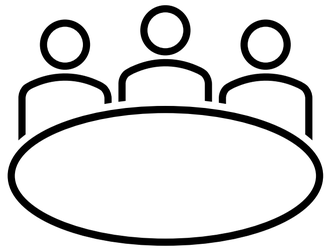
- Minimise barriers / resistance to movement



Barriers to movement and data choices

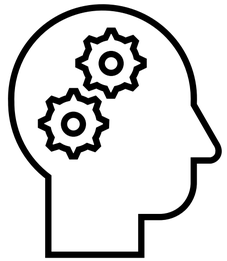
Identify barriers to biotic movement

- areas of low resources
- areas of conflict
- situation dependent
- include stakeholders



Gathering data to represent barriers and conducting analyses lead to choices

- weight given to barriers during development of resistance surfaces
- data layer chosen to represent barriers (landuse)
- spatial resolution (pixel size)
- which model /algorithm to use



impact of choices

Cushman and Landguth 2010; Dutta et al. 2022;Zeller et al. 2017

Study Area

- Great Limpopo Transfrontier Conservation Area
- 100,000km2
- Joins protected areas:

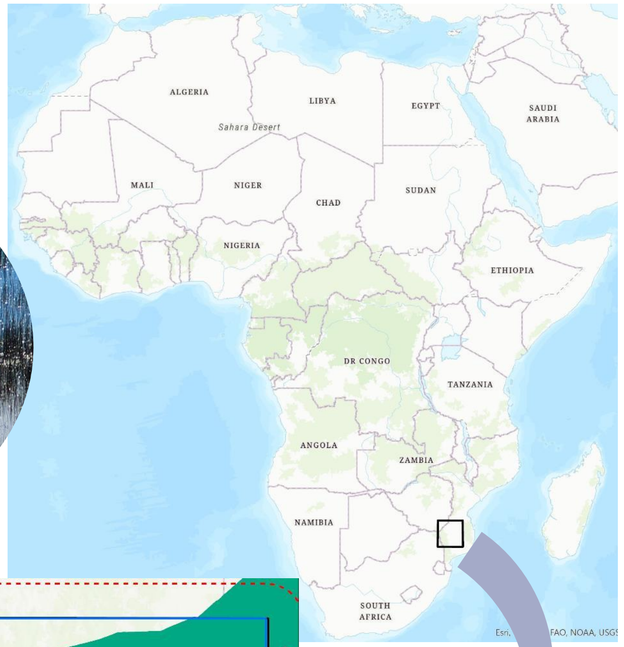
  Kruger National Park (South Africa),

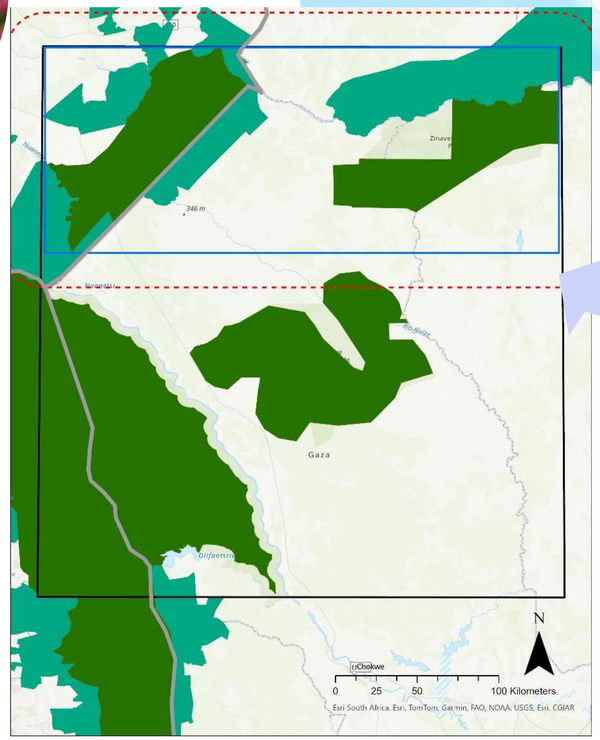
  Limpopo, Banhine and Zinave National Parks (Mozambique)

  Gonarezhou National Park (Zimbabwe)
- Biodiverse > 850 animal species

  > 2000 plant species

  varied ecosystems





Peace Parks Foundation, 2021; Roque et al., 2022 South African National Parks, 2023

(Peace Parks Foundation, 2021; South African National Parks, 2023)

Barriers

Resistance

- towns and settlements
- crops
- roads, railways
- rivers

Landcover

30m PeaceParks LC

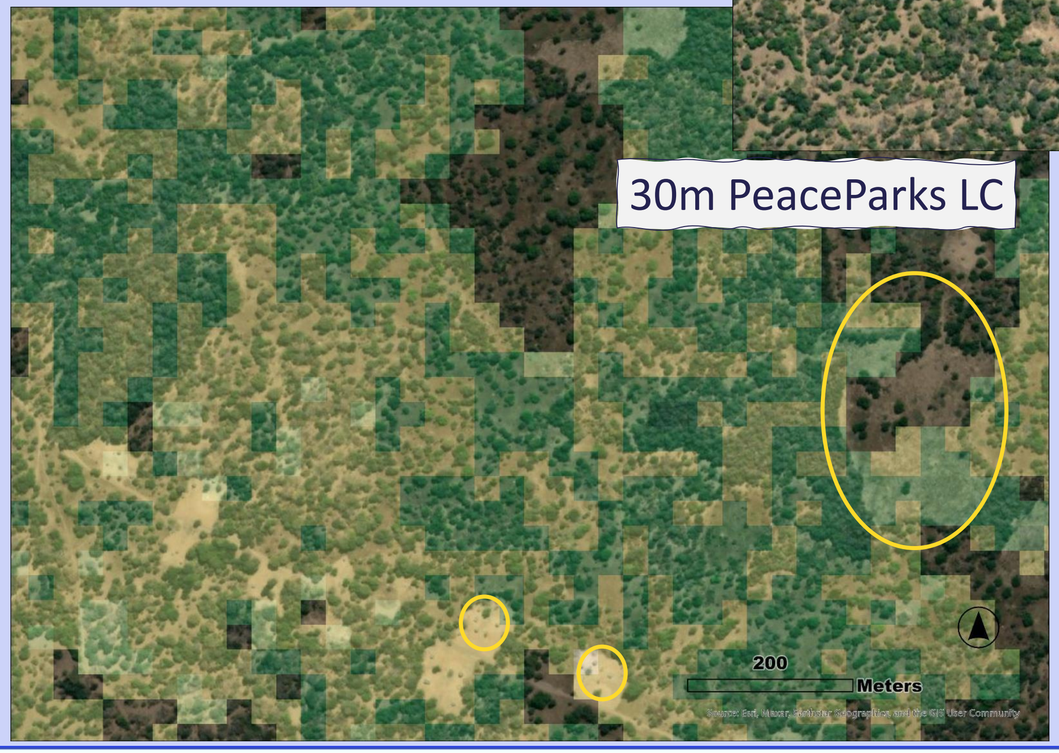
100m Copernicus LC

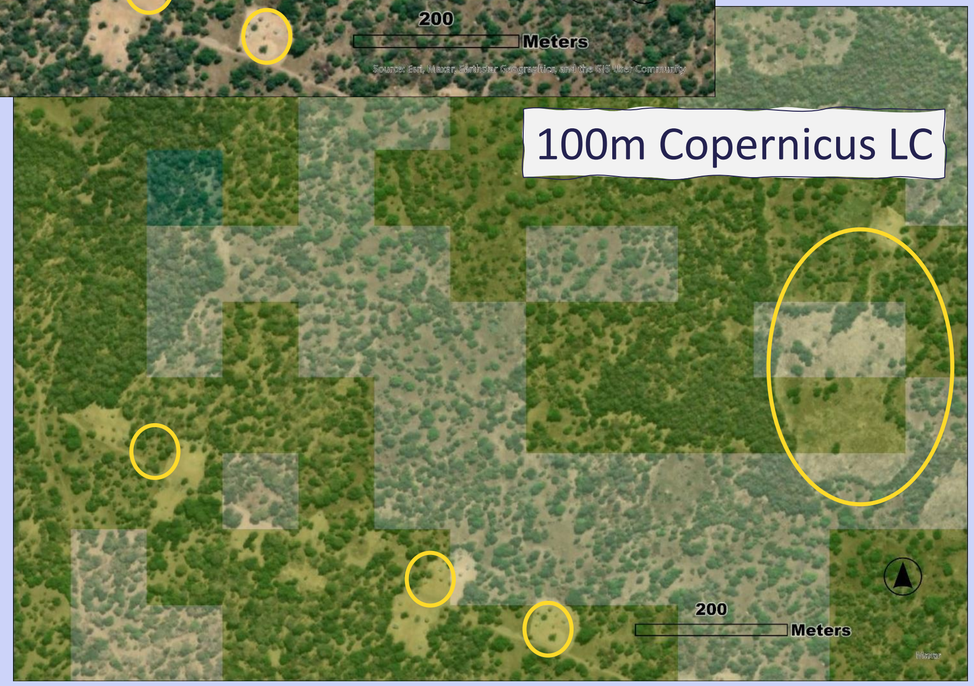
Human modified (settlements, crops)

Woodland

Grassland

Sparse grassland





Data processing

30m PeaceParks LC

100m Copernicus LC

River

Road

Railway

Human settlements

Resample

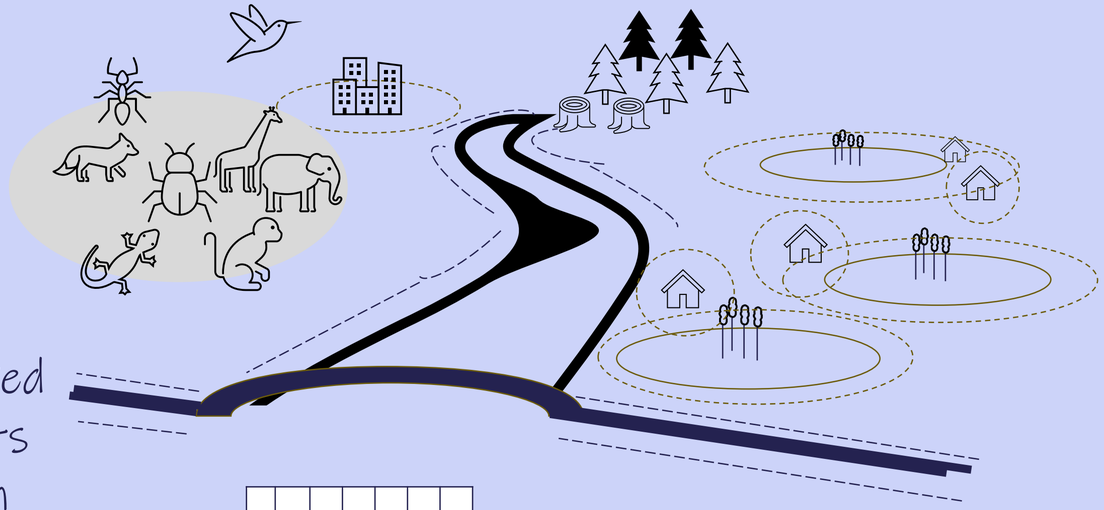
mode

100m PeaceParks LC

1 pixel
Round 1: 30m,
Round 2: 100m

Buffer

Observed effects 200m



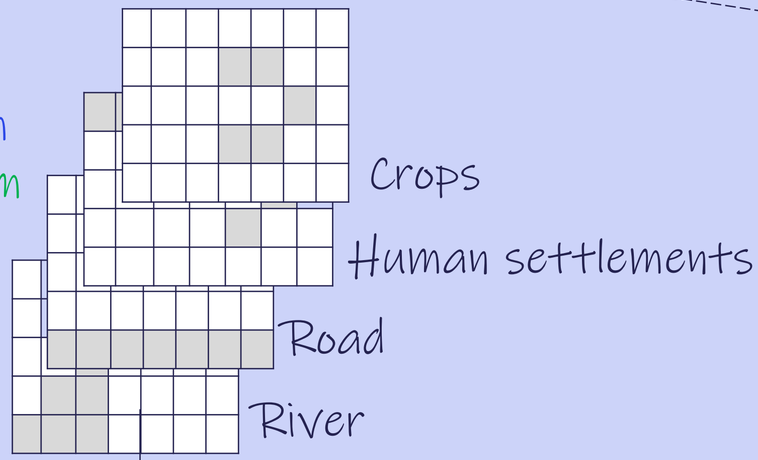
Rasterise

Round 1: 30m
Round 2: 100m

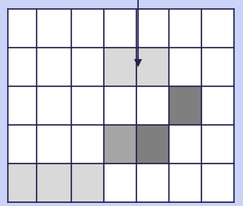
Reclassify

Natural = 0
Human modified = 10
100
1000

Reclassify



Combine
Maximum layer weighting

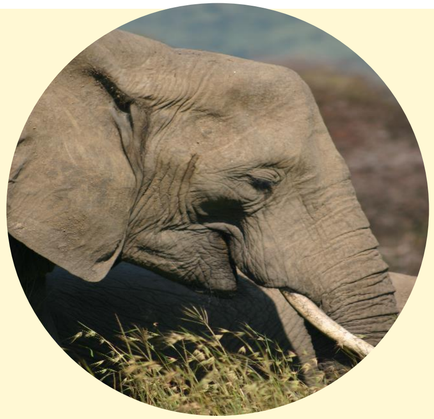


Max weight resistance surface

Resistance surface

Analyses

Resistance surfaces



Least cost
(Linkage Mapper)

Circuit Theory
(Circuitscape)

Least cost

- Assign weights to barrier to movement layers
- Calculate cumulative cost surface
- Continuous path along lowest cost

- Assumes species have full knowledge of all landscape routes and always choose the optimal path to reach their destination
  - regular movements
  - seasonal migrations

Adriaensen et al., 2003

Circuit theory

- Models species movement between habitat patches using electrical circuit principles
  - Calculate resistance (Current, voltage)
  - Paths to minimise resistance

- Can model random walk
- or ‘prior’ landscape knowledge’ animal movements

McRae et al., 2008

Compare weightings of resistance layer

Top 10%

Overlay comparison

Least cost
(Linkage Mapper)

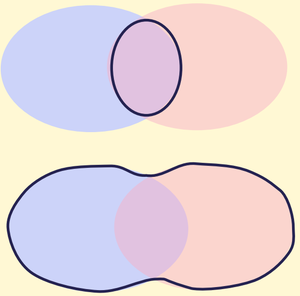
Circuit Theory
(Circuitscape)

PeaceParks (30m)	PeaceParks (100m)	Copernicus (100m)
Weight 10	Weight 10	Weight 10
Weight 100	Weight 100	Weight 100
Weight 1000	Weight 1000	Weight 1000

PeaceParks (30m)	PeaceParks (100m)	Copernicus (100m)
Weight 10	Weight 10	Weight 10
Weight 100	Weight 100	Weight 100
Weight 1000	Weight 1000	Weight 1000

Jaccard's similarity index (Arponen et al., 2012)

$$= \frac{\text{shared area}}{\text{sum total}}$$



Compare spatial resolution

Top 10%

Overlay comparison

Least cost
(Linkage Mapper)

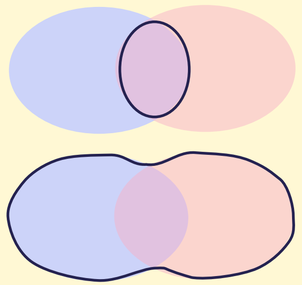
PeaceParks (30m)	PeaceParks (100m)	Copernicus (100m)
Weight 10 ⟷	Weight 10	Weight 10
Weight 100 ⟷	Weight 100	Weight 100
Weight 1000 ⟷	Weight 1000	Weight 1000

Circuit Theory
(Circuitscape)

PeaceParks (30m)	PeaceParks (100m)	Copernicus (100m)
Weight 10 ⟷	Weight 10	Weight 10
Weight 100 ⟷	Weight 100	Weight 100
Weight 1000 ⟷	Weight 1000	Weight 1000

Jaccard's similarity index (Arponen et al., 2012)

$$= \frac{\text{shared area}}{\text{sum total}}$$



Compare source of landuse data layer

Top 10%

Overlay comparison

Least cost
(Linkage Mapper)

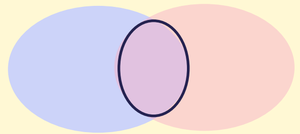
PeaceParks (30m)	PeaceParks (100m)	Copernicus (100m)
Weight 10	Weight 10 ⟷	Weight 10
Weight 100	Weight 100 ⟷	Weight 100
Weight 1000	Weight 1000 ⟷	Weight 1000

Circuit Theory
(Circuitscape)

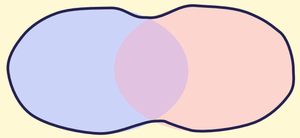
PeaceParks (30m)	PeaceParks (100m)	Copernicus (100m)
Weight 10	Weight 10 ⟷	Weight 10
Weight 100	Weight 100 ⟷	Weight 100
Weight 1000	Weight 1000 ⟷	Weight 1000

Jaccard's similarity index (Arponen et al., 2012)

$$= \frac{\text{shared area}}{\text{sum total}}$$



intersect



union

Results: weights

Least cost
(Linkage Mapper)

PeaceParks (30m)		PeaceParks (100m)		Copernicus (100m)	
Weight 10	88	Weight 10	82	Weight 10	83
Weight 100	86	Weight 100	52	Weight 100	25
Weight 1000		Weight 1000		Weight 1000	

Av

80

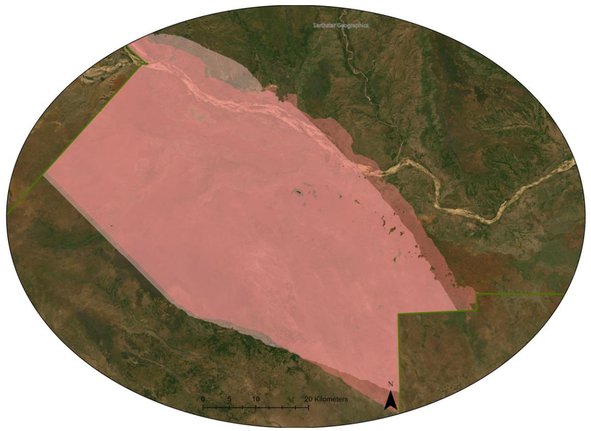
43

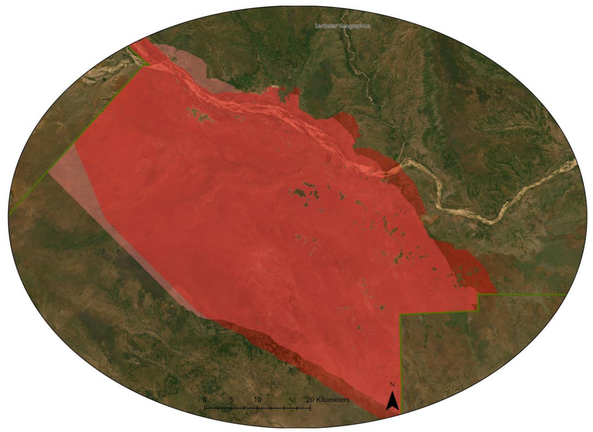
62

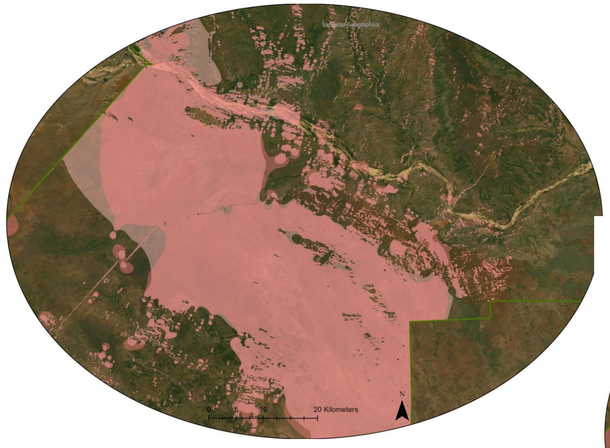
Circuit Theory
(Circuitscape)

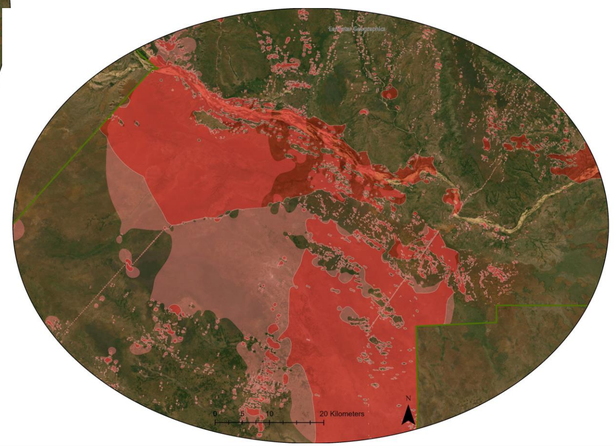
PeaceParks (30m)		PeaceParks (100m)		Copernicus (100m)	
Weight 10	82	Weight 10	69	Weight 10	25
Weight 100	52	Weight 100	37	Weight 100	33
Weight 1000		Weight 1000		Weight 1000	

30m PeaceParks









Weight 10
Weight 100
Weight 1000

Results: pixel size

Least cost
(Linkage Mapper)

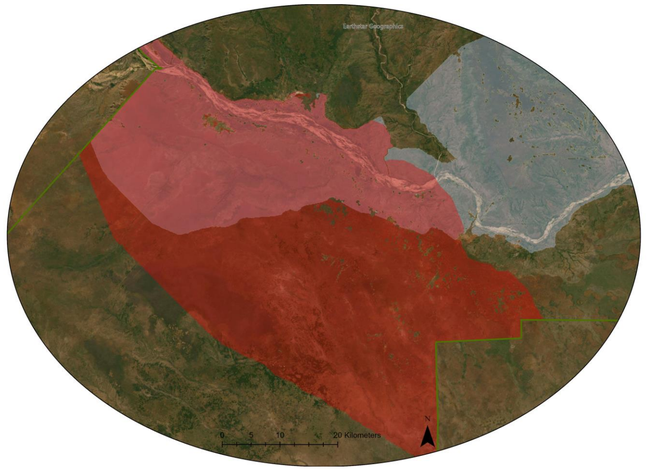
PeaceParks (30m)		PeaceParks (100m)	Copernicus (100m)
Weight 10	97	Weight 10	Weight 10
Weight 100	91	Weight 100	Weight 100
Weight 1000	**25**	Weight 1000	Weight 1000

Av 71

Circuit Theory
(Circuitscape)

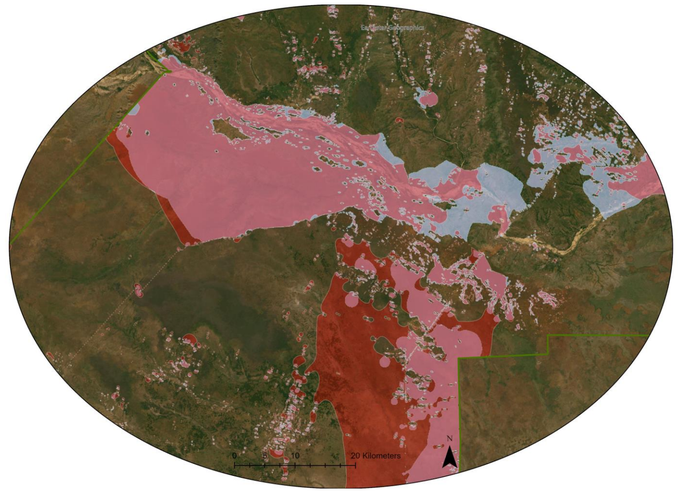
PeaceParks (30m)		PeaceParks (100m)	Copernicus (100m)
Weight 10	89	Weight 10	Weight 10
Weight 100	74	Weight 100	Weight 100
Weight 1000	**54**	Weight 1000	Weight 1000

Av 72



30m

100m



Results: Effect of landcover data

PeaceParks vs Copernicus

Least cost
(Linkage Mapper)

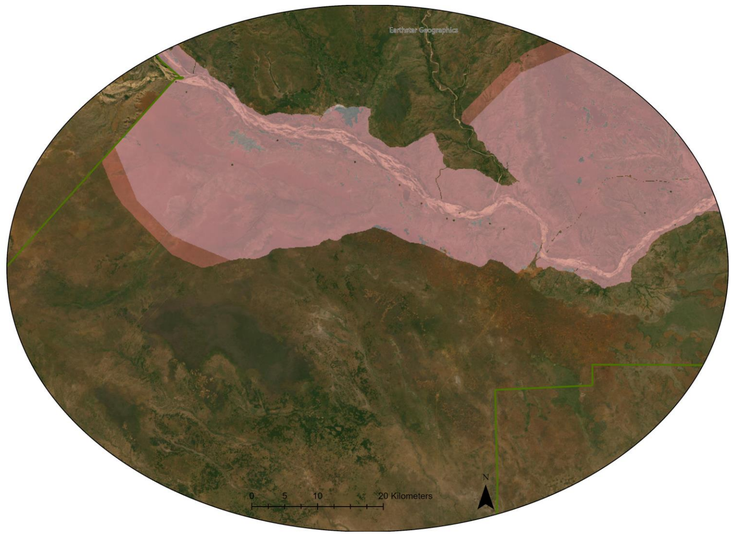
PeaceParks (30m)	PeaceParks (100m)		Copernicus (100m)
Weight 10	Weight 10	97	Weight 10
Weight 100	Weight 100	93	Weight 100
Weight 1000	Weight 1000	90	Weight 1000

Av 93

Circuit Theory
(Circuitscape)

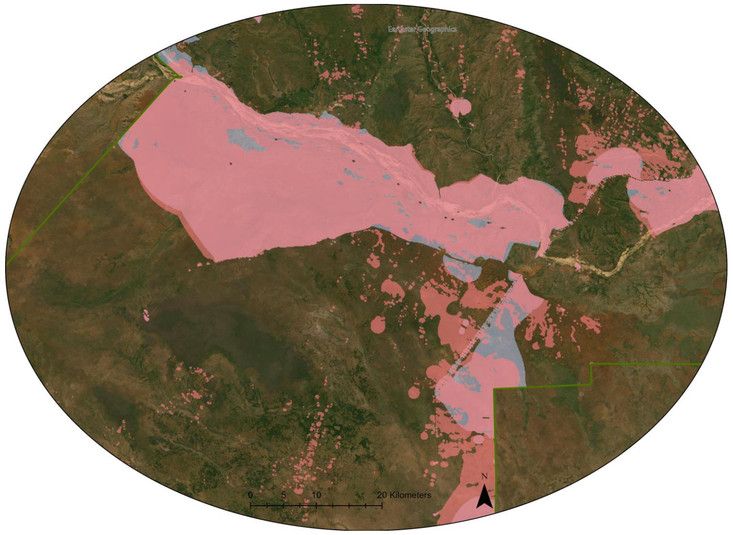
PeaceParks (30m)	PeaceParks (100m)		Copernicus (100m)
Weight 10	Weight 10	72	Weight 10
Weight 100	Weight 100	67	Weight 100
Weight 1000	Weight 1000	71	Weight 1000

Av 70



PeaceParks 100m

Copernicus 100m



Recommendations

- Check impact of parameters
  for each new study
  impacts could different across areas
- Sense check range of outputs with stakeholders
  - Include stakeholders from start with selection of parameters
  - Be prepared to run multiple analyses across scenarios
  - Present outputs back to stakeholders to understand impact of decisions on parameters

The algorithms and datasets do help objectively recognise areas where the costs of corridor establishment will probably be lowest in terms of human conflict and natural barriers to movement.

This refinement does help a lot across large areas where on the ground knowledge might not be perfectly consistent over the whole area.