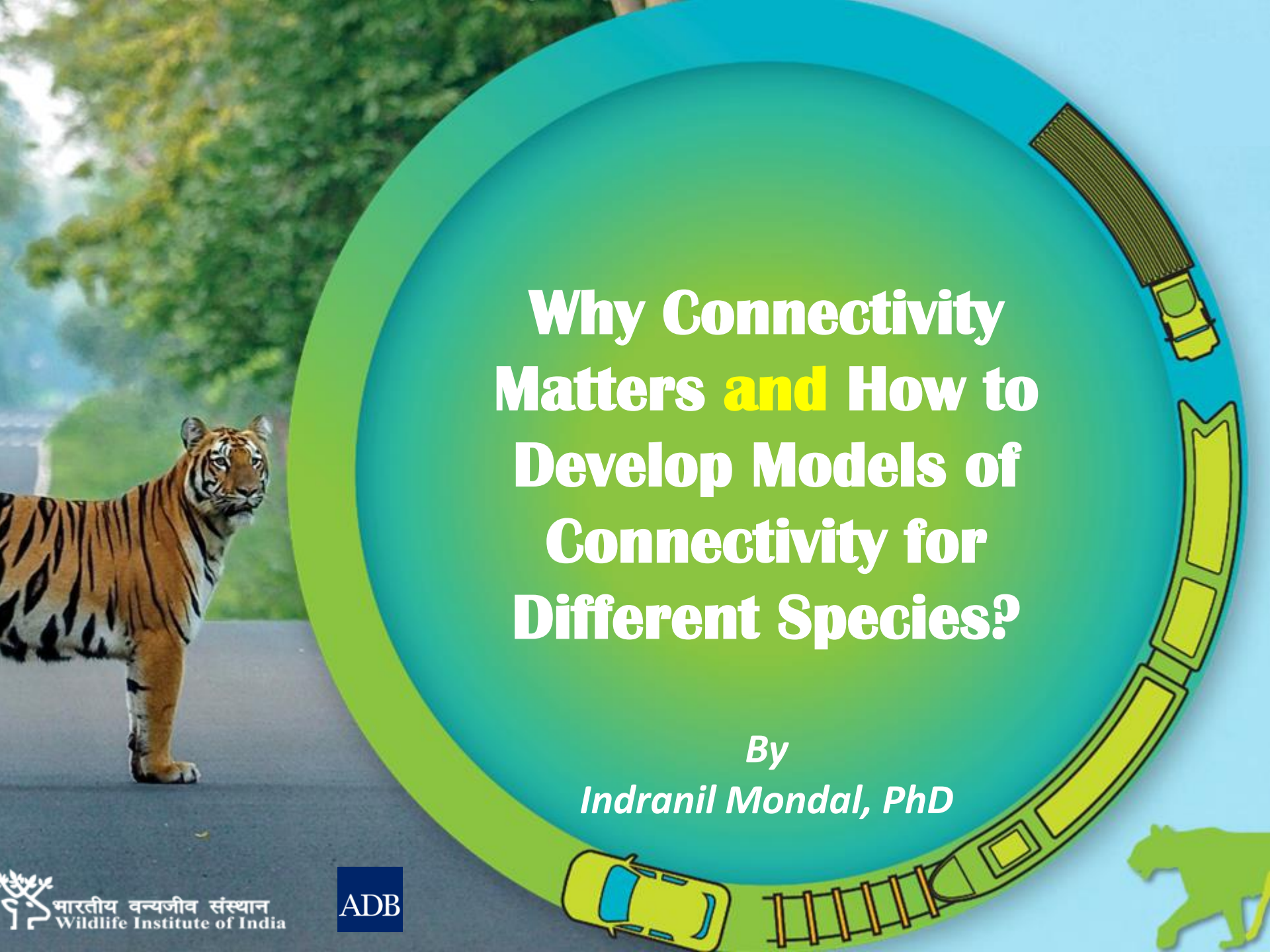


Why Connectivity Matters and How to Develop Models of Connectivity for Different Species?

By

Indranil Mondal, PhD

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

ADB

Fragmentation

- **Forest fragmentation is the process of dividing large tracts of forest into smaller isolated tracts surrounded by human-modified environments (Society of American Foresters 1998).**

- **Habitat fragmentation is defined as the process of dissecting large and contiguous areas of similar native vegetation types into smaller units separated by different vegetation types and/or areas of intensive human activity (Saunders *et al* 1991).**

Habitat Fragmentation

- Fragmenting landscapes → fragmented habitat
- Fragmentation affects habitat quality for over 80% of all mammal, reptile, bird, and amphibian species found in forest habitat (USDA Forest Service 1997).
- It has been cited as the primary cause of rapid species extinction, and the loss of native species (Wilcox and Murphy 1985).

Landscape Connectivity

The property of a landscape arising from the interaction between animal movements and landscape structure is known as *landscape connectivity* (*Merriam 1984*).

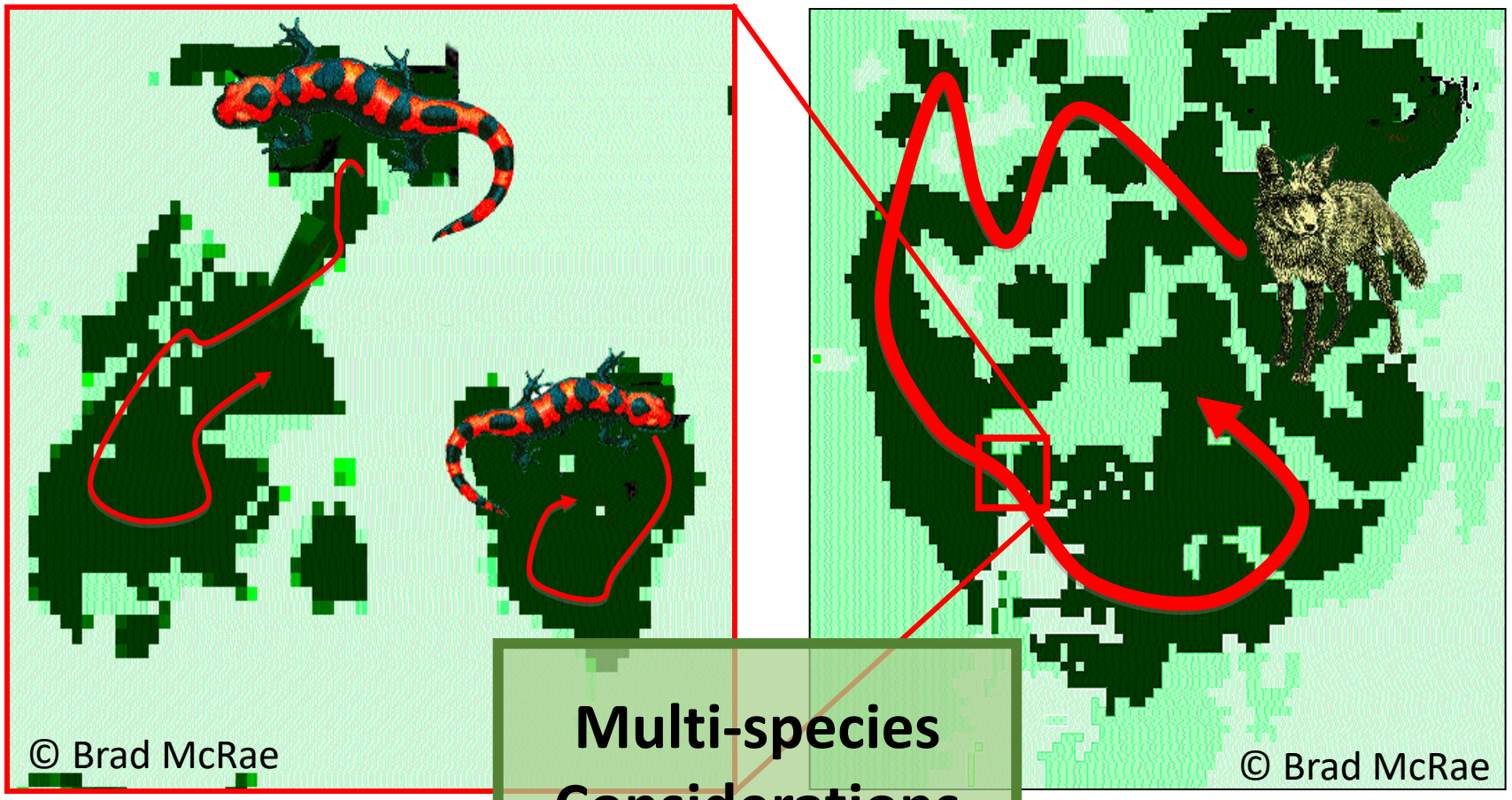
LANDSCAPE CONNECTIVITY

Structural connectivity:

Functional connectivity:

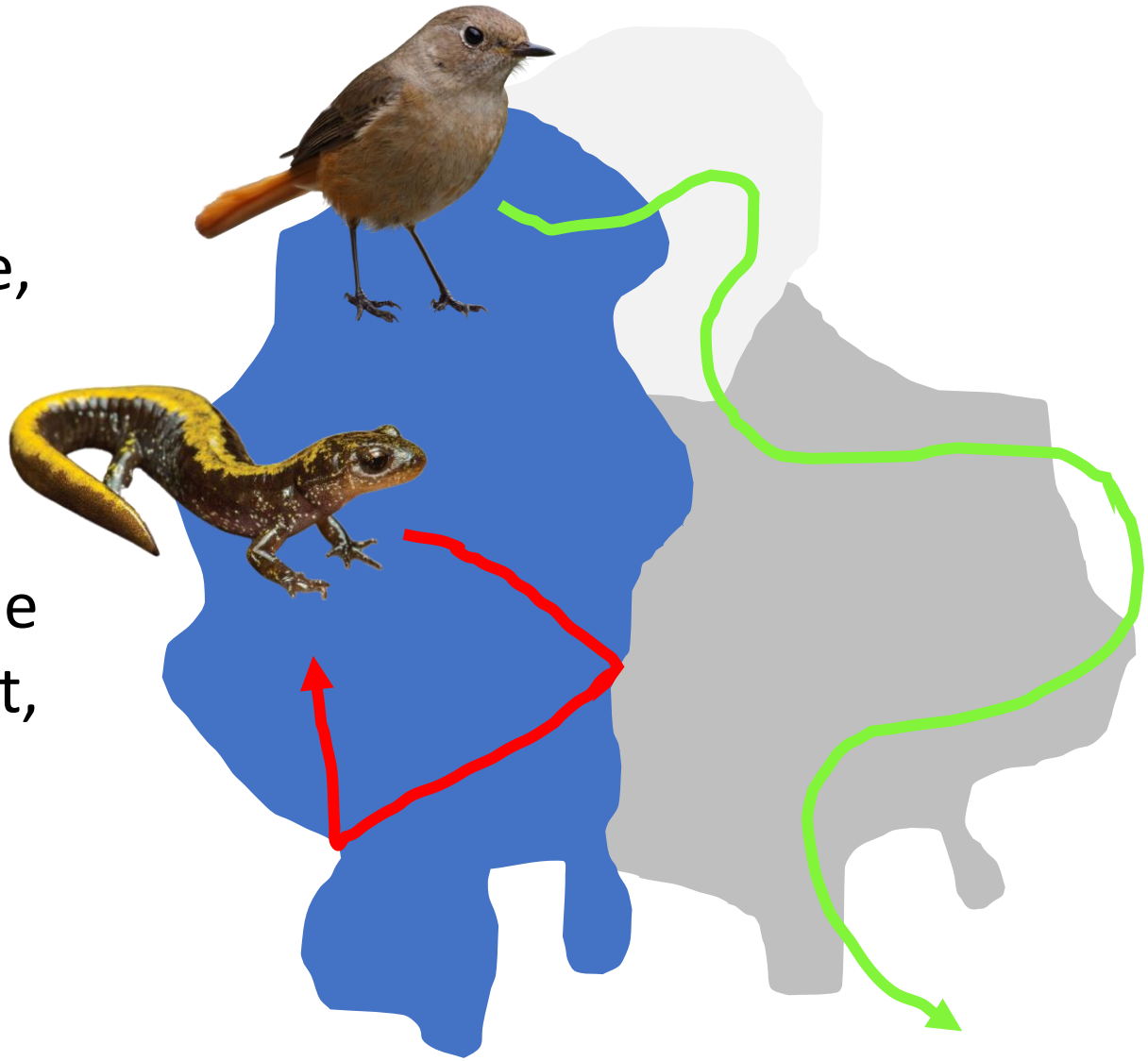
Landscape Connectivity: Process and scale dependence

Connectivity is dependent upon both the *scale* of observation and the ecological *process* under consideration.



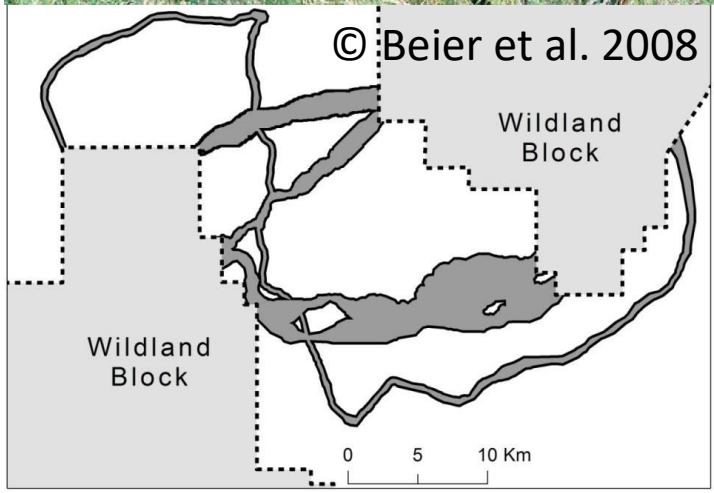
Multi-species Considerations

For a given landscape, its connectivity may vary radically with respect to different processes (e.g., beetle movement, bird flight, seed dispersal, fire spread).



Need for Landscape Connectivity

- Individual movement to access resources in home range
- Immigration: can prevent local extinction (demographic rescue) or recolonize after local extinction
- Seasonal migration
- Gene flow (the ability to evolve)
- Ecological processes and flows (e.g., disturbance, predator-prey interactions, seed dispersal)
- Population movement in response to disasters or changing climate



Connectivity "Conceptual Model"

Wildlife Movement Requirements:

- **Daily movements**
- **Seasonal movements**
- **Dispersal and colonization of vacant habitat**

Fragmentation:

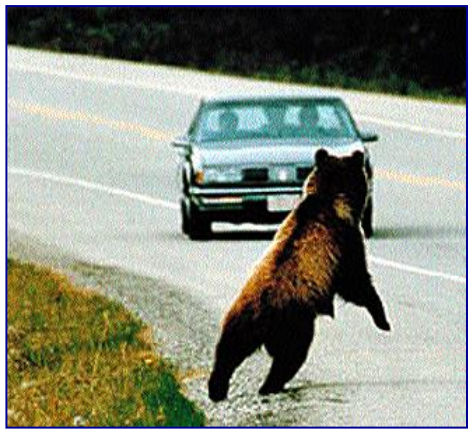
- Land clearing
- Development
- Roads / Traffic
- People

STRESSORS

Habitat Effects

Alienation

Direct Mortality



Slides adapted from: Brad McRae (2009) Landscape connectivity, The Nature Conservancy

Connectivity "Conceptual Model"

Wildlife Movement Requirements:

- **Daily movements**
- **Seasonal movements**
- **Dispersal and colonization of vacant habitat**

Habitat Alterations:

- Fragmentation
- Land clearing
- Development
- Roads / Traffic
- People

STRESSORS

Habitat Effects

Alienation

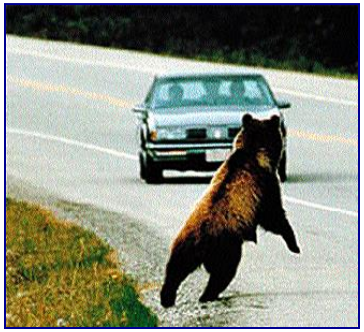
Direct Mortality

Impacts to Individual Animals

Wildlife Population Impacts

Biodiversity & Ecosystem Effects

e.g., reduced native species diversity



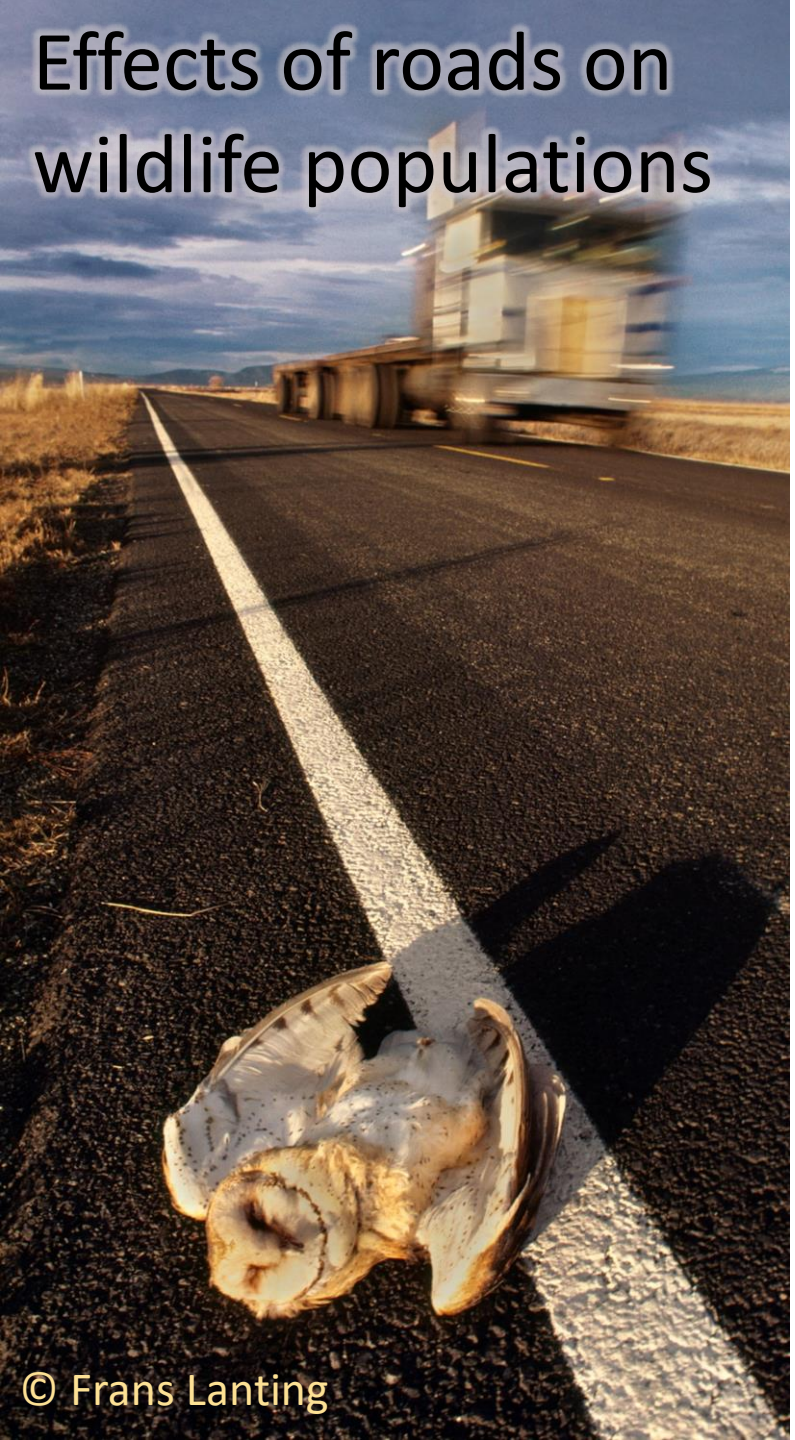
Slides adapted from: Brad McRae (2009) Landscape connectivity, The Nature Conservancy

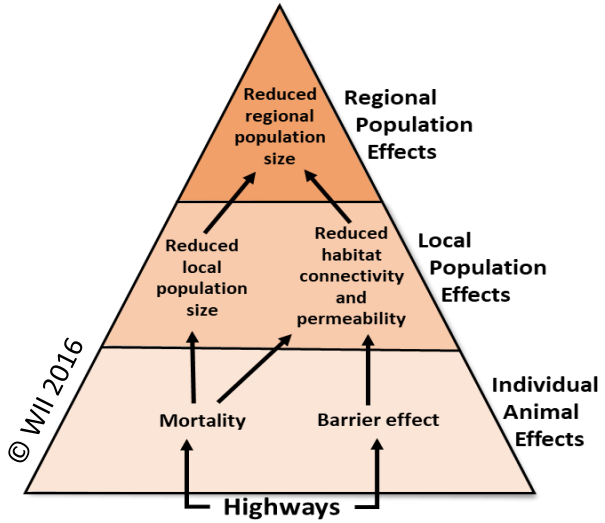
The **IUCN WCPA Connectivity Conservation Specialist Group** defines an ecological corridor as "a clearly defined geographical space, not recognized as a protected area or other effective area-based conservation measure, that is governed and managed over the long-term to conserve or restore effective ecological connectivity, with associated ecosystem services and cultural and spiritual values."

Why should we care ??

- Keeping habitats connected is a key conservation strategy to protect biodiversity
- Connected habitats ensure undisrupted ecological flows: energy, nutrient, water cycle….
- Intact ecological flows ensures a stable climate, water in our river, more fertile soil, better air quality…..

Effects of roads on wildlife populations





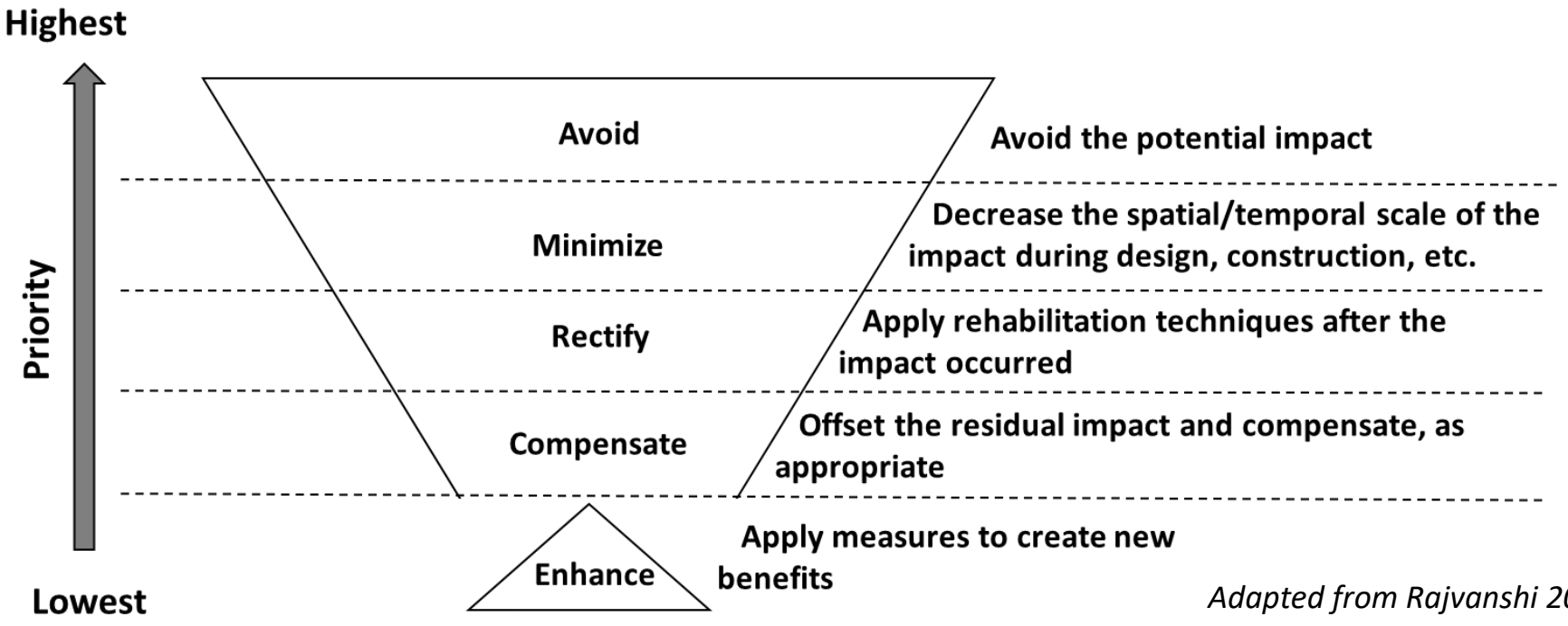
UNEP/CMS/COP11/Doc.23.3.2: Guidelines

Potential Impact	Roads	Rail Lines	Fencing[1]
Wildlife strikes	high	medium	not applicable
Entanglement/trap mortality	not applicable	not applicable	high
Habitat fragmentation	high	high	high
Altering behaviour	high	high	high
Barrier to movement	high	high	high
Altering use of habitat	high	high	high
Increased human presence	high	medium	not applicable
Increased hunting	high	low	not applicable
Conduits for invasive alien species	high	high	not applicable
Effects on population genetics	high	high	high
Air pollution	high	low	not applicable
Altering natural processes	low	low	high
Changed discharges in water bodies	high	high	not applicable

Relationship rating: high - medium - low - not applicable -



Strategic measures to mitigate impacts of Highways on wildlife



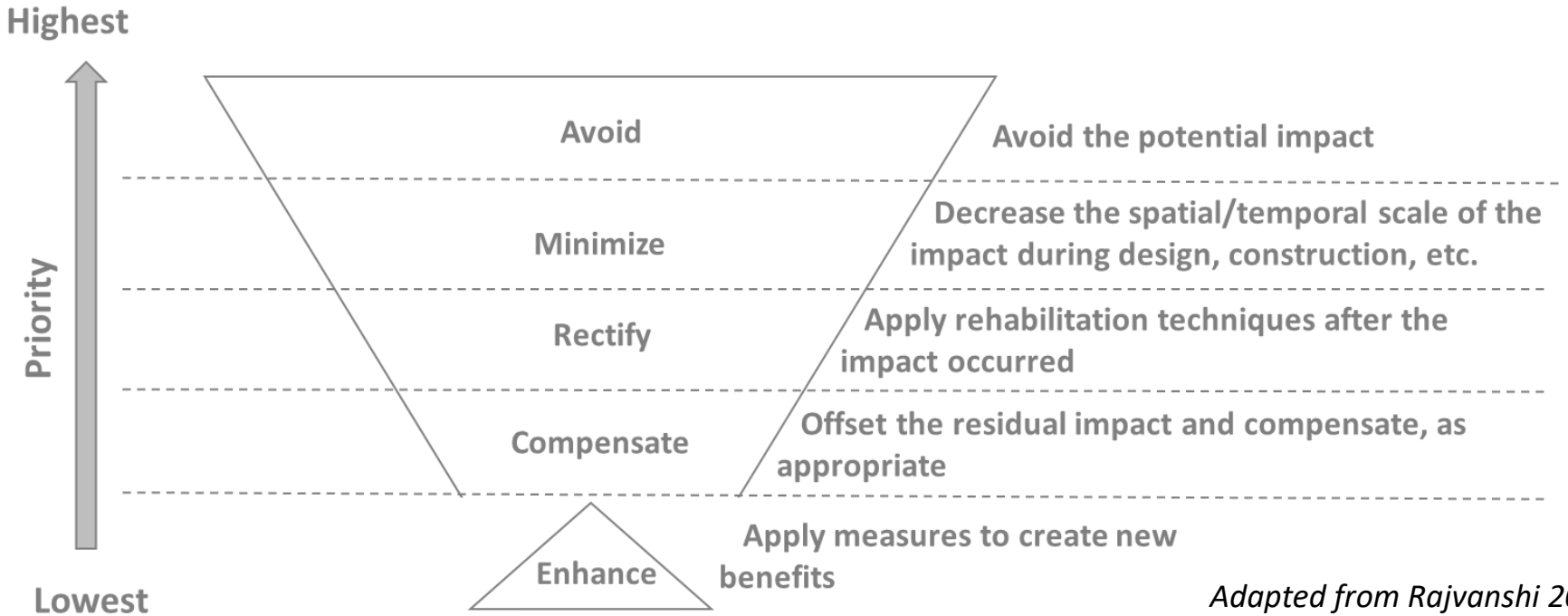
Adapted from Rajvanshi 2008



Strategic measures to mitigate impacts of Highways on wildlife

Structural: Alter animal behavior e.g., Viaducts, Ropeway, Culvert, Passes, Fence, Canopy bridge

Nonstructural: Alter human behavior e.g., Ecological triage, Legal and policy instruments, Habitat Management, Plantation, Traffic management, Signage, Warning System



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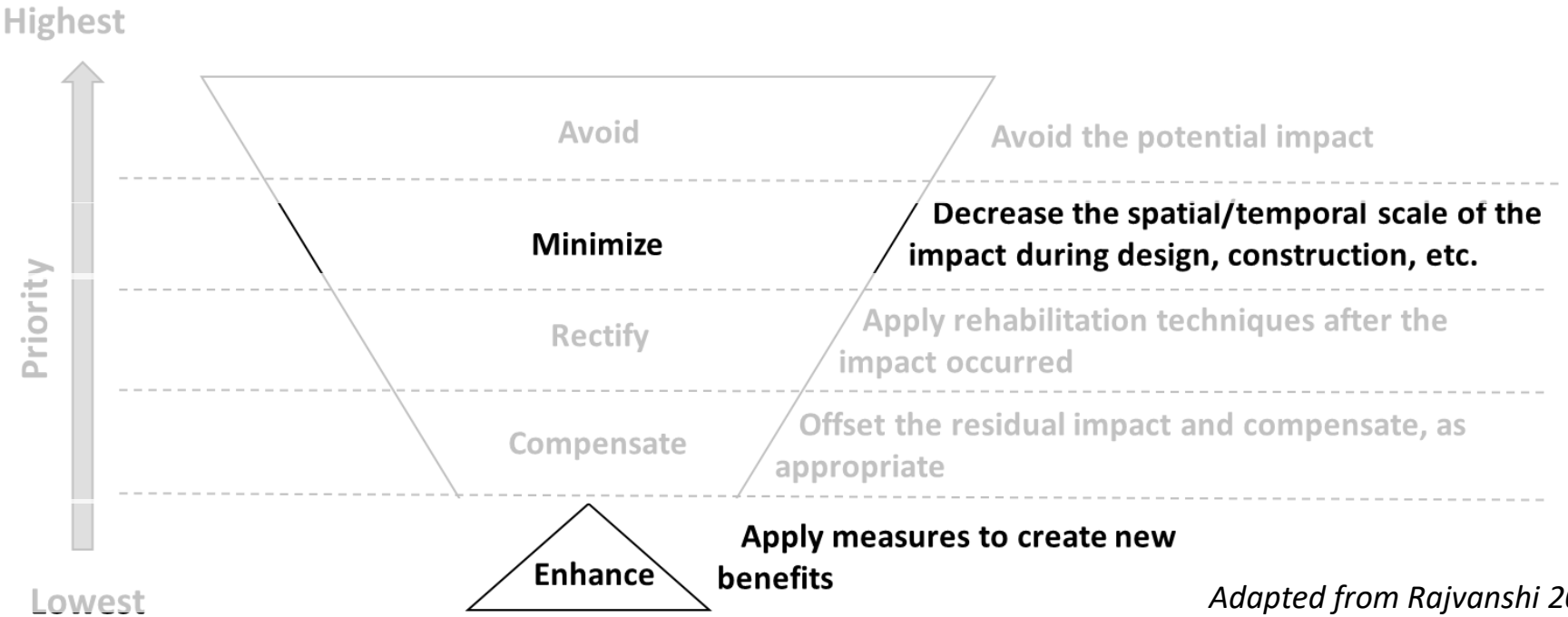
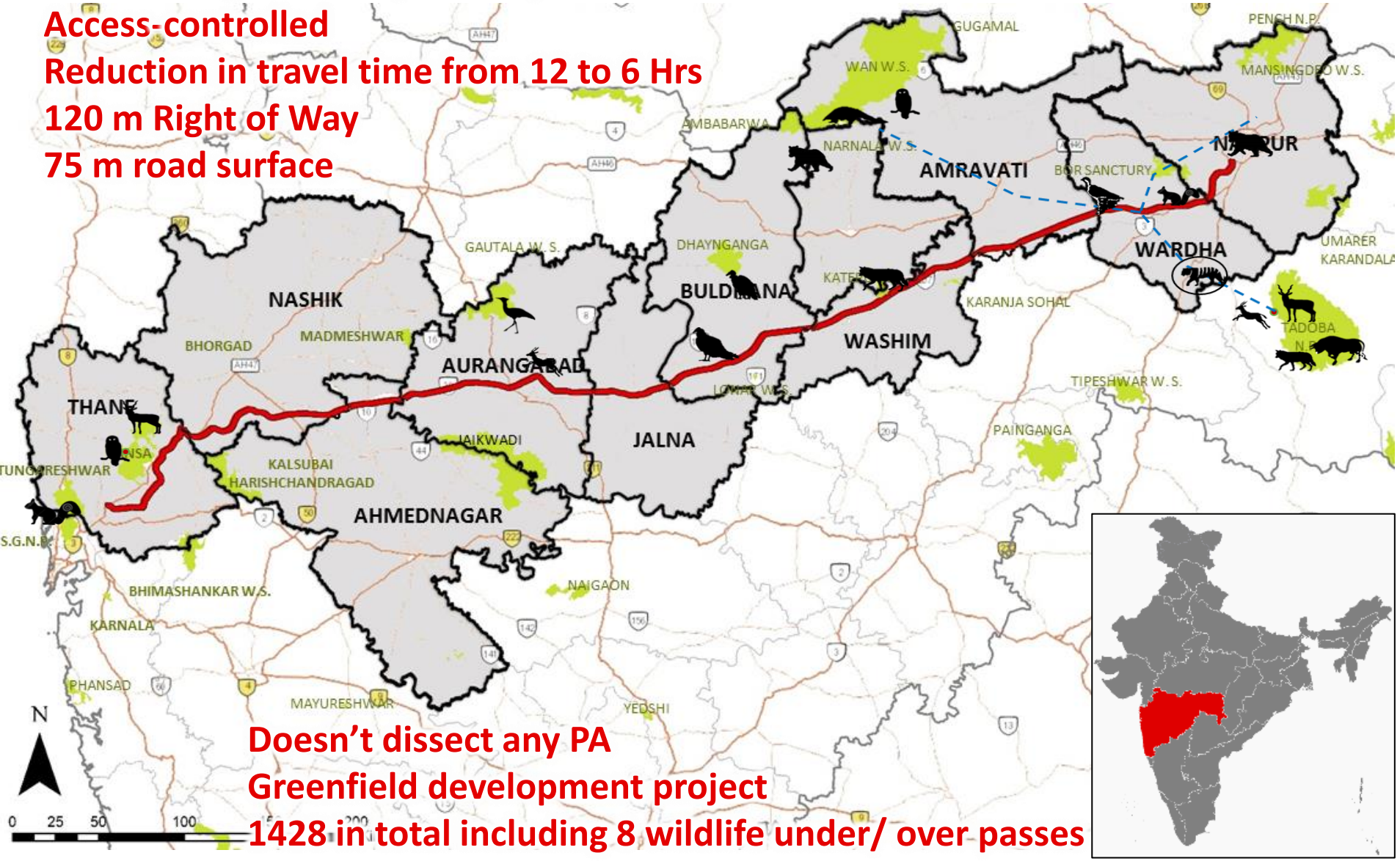


Adapted from Rajvanshi 2008

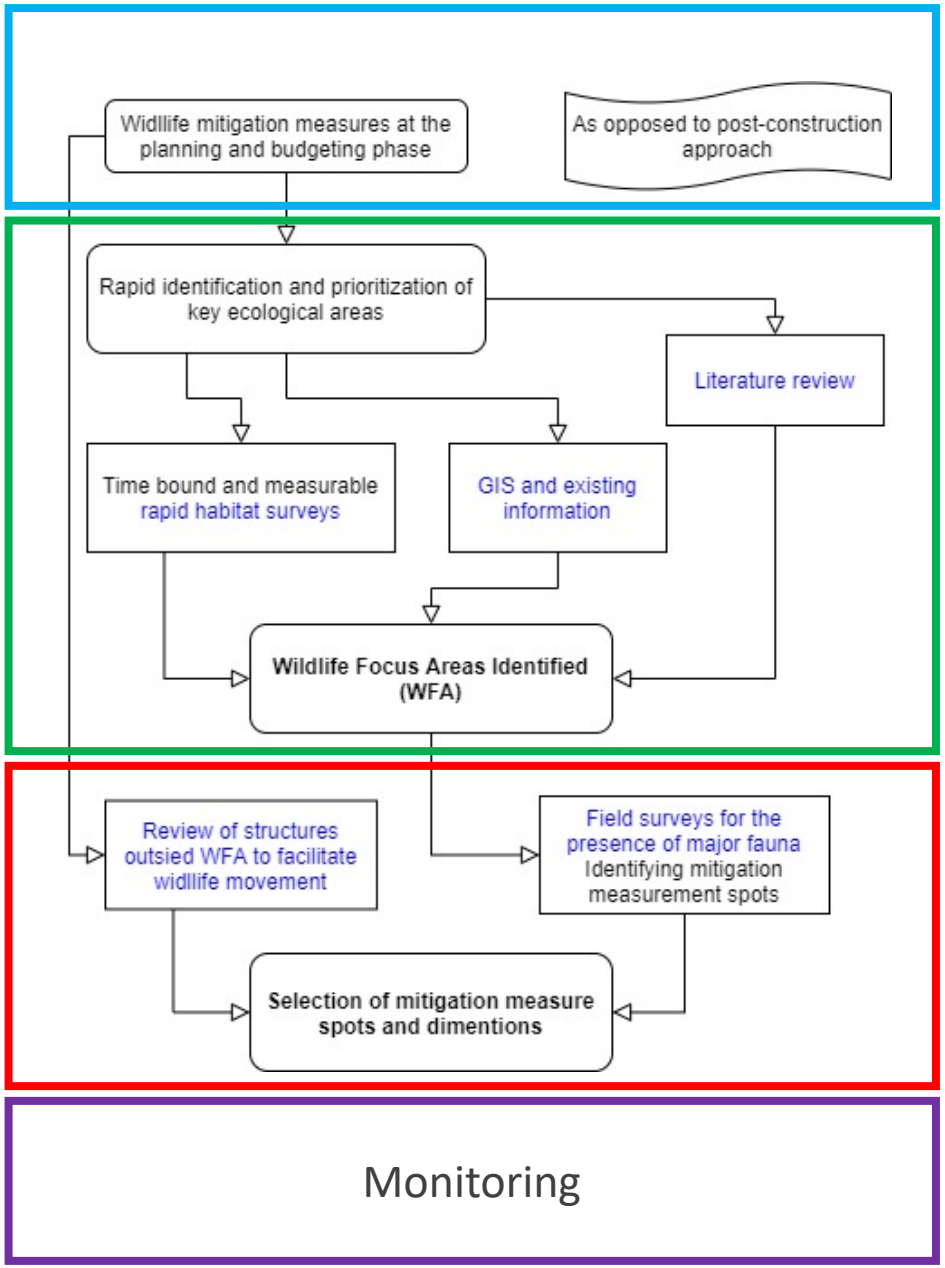
MAHARASHTRA
SAMRUDDHI
MAHAMARG

701 km long 8 lane expressway
Access-controlled
Reduction in travel time from 12 to 6 Hrs
120 m Right of Way
75 m road surface



Doesn't dissect any PA
Greenfield development project
1428 in total including 8 wildlife under/ over passes

Process formulation



1

Consideration in planning phase

2

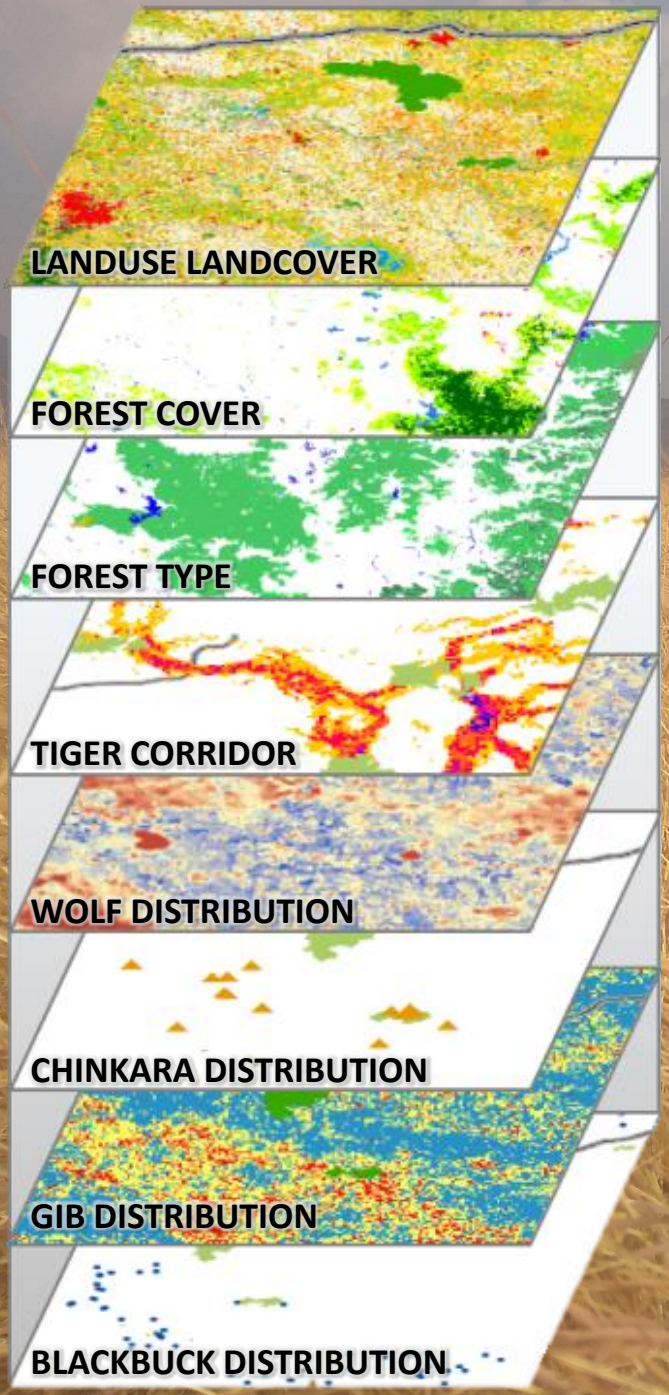
Identification of "**Go"/** "**No-go"** areas to avoid delays in project implementation

3

Field surveys, data analysis and prescription of mitigation measures

4

Simultaneous and post-construction monitoring



Remotely sensed Indicators for prioritizing segments for assessment and mitigation

- Adjacency to **PAs** or **Eco-sensitive zones**
- Habitat of **Tiger** and key **prey** species
- Presence or **probable habitat** of **conservation priority species**
- **Priority habitats** with **high endemism in plants and lower taxa**

Reconnaissance survey

Data on **habitat**, **animal sightings** (direct or indirect), **road kills** and **public questionnaire surveys** through ***ad-libitum*** sampling

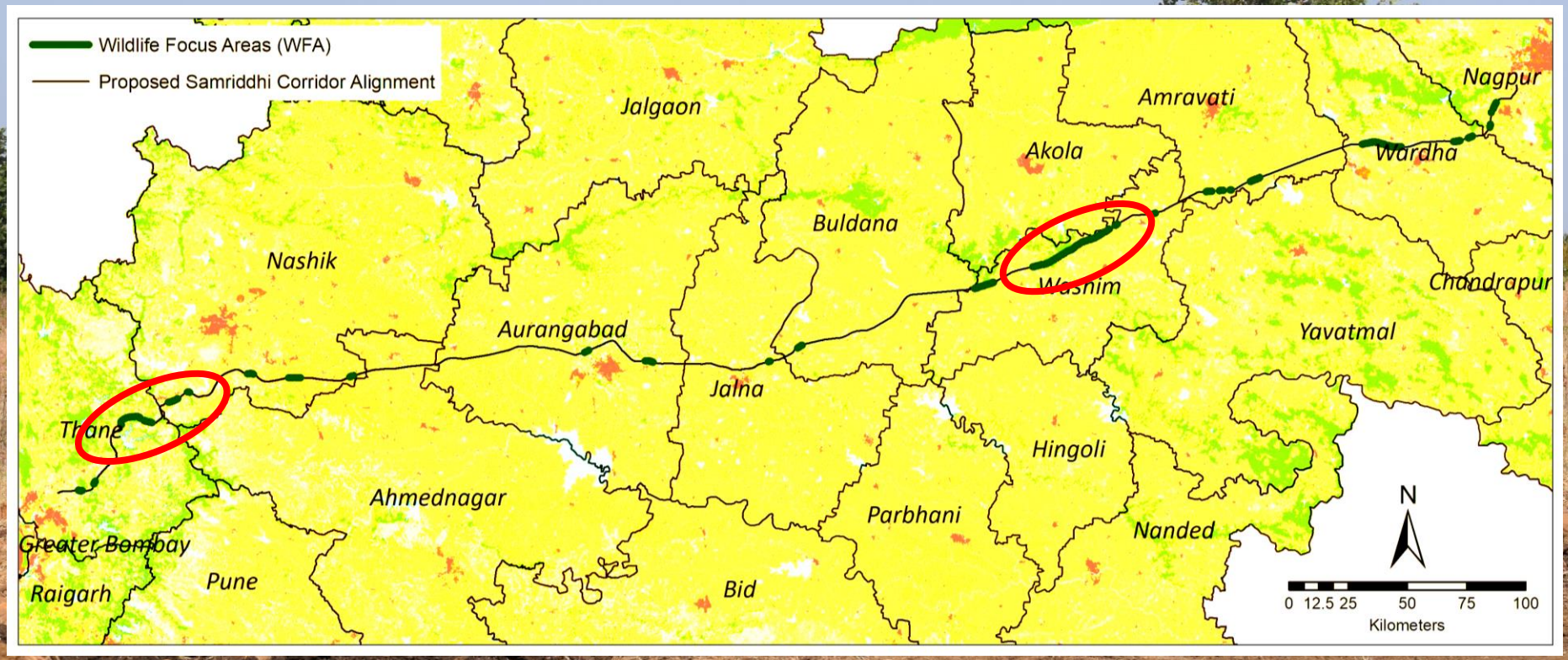
Joint visits to the sites along with **forest officials** and **road agency engineers** from the construction contractor

Plans and drawings were consulted to visualize the proposed road in three dimensions

Identification of Wildlife Focus Area

A **hierarchical approach** was adopted to arrive at the WFAs

A total of **117.73 km** long stretch was identified as **the wildlife focus areas (WFA).** They occur in **35** discrete segments.

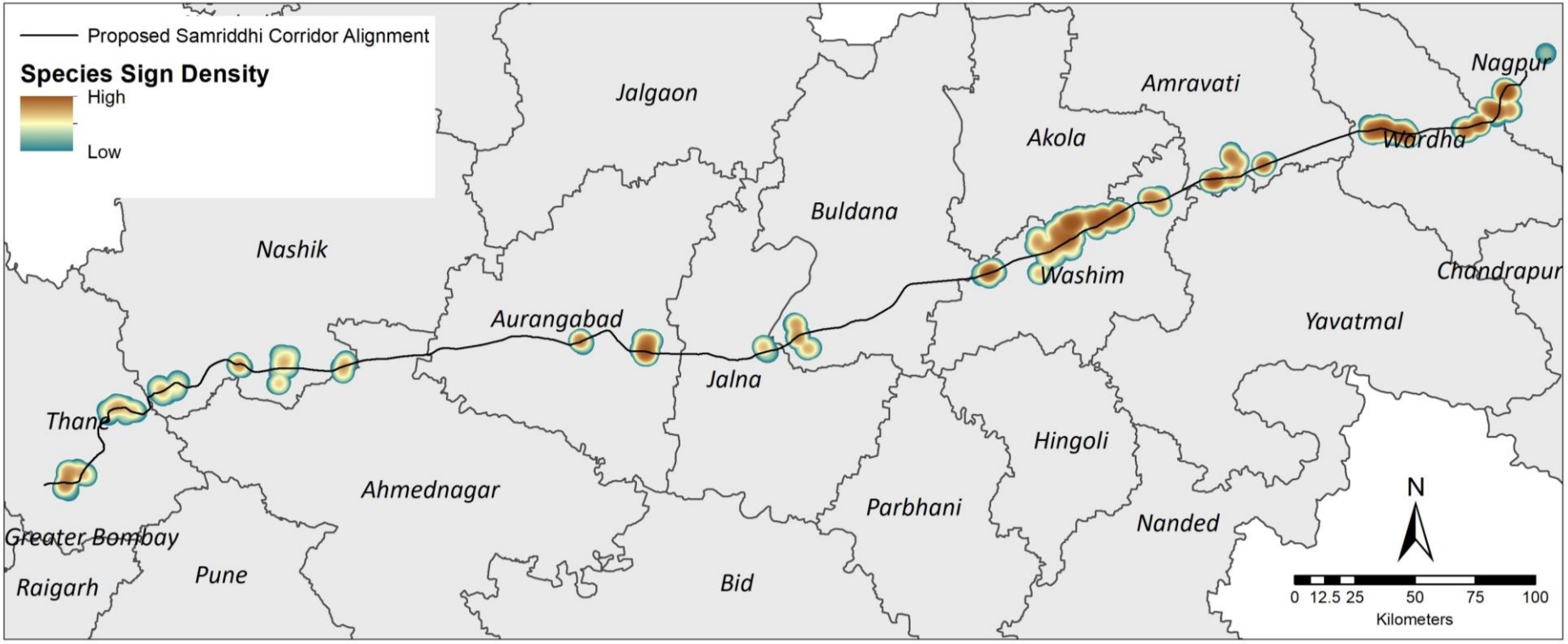


Detailed sign survey in WFAs

Results

We generated ***intensity maps of animal signs*** to identify the critical locations on the alignment where mitigation measures are required.

Species sign density hotspots



Mitigation measures

The suggestions were made in consideration of ***species sign density***, ***surrounding habitat***, ***topography*** and ***land use land cover*** to avoid ***anthropogenic interference*** and ensure ***habitat connectivity*** across the landscape

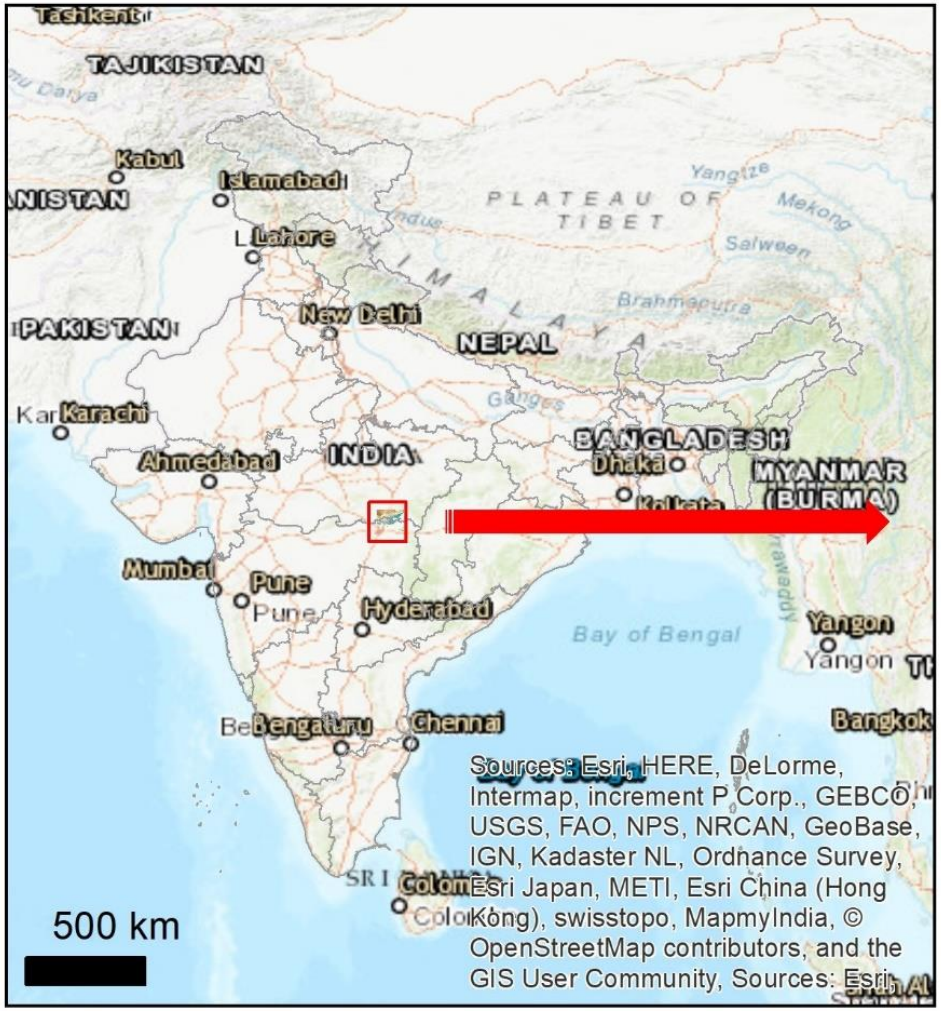
Structure Type	Within WFA	Outside WFA
Box Culvert	109	518
Canal Bridge	1	18
LVUP/Cart Track	26	235
CUP/PUP/POP	44	180
Major Bridge	5	26
Minor Bridge	19	232
Viaduct/Flyover	19	45
VUP/VOP/ROB	46	216
Wildlife Overpass	7	2
Wildlife Underpass	17	25
Tunnel	2	5
Total	295	1502
	1797	

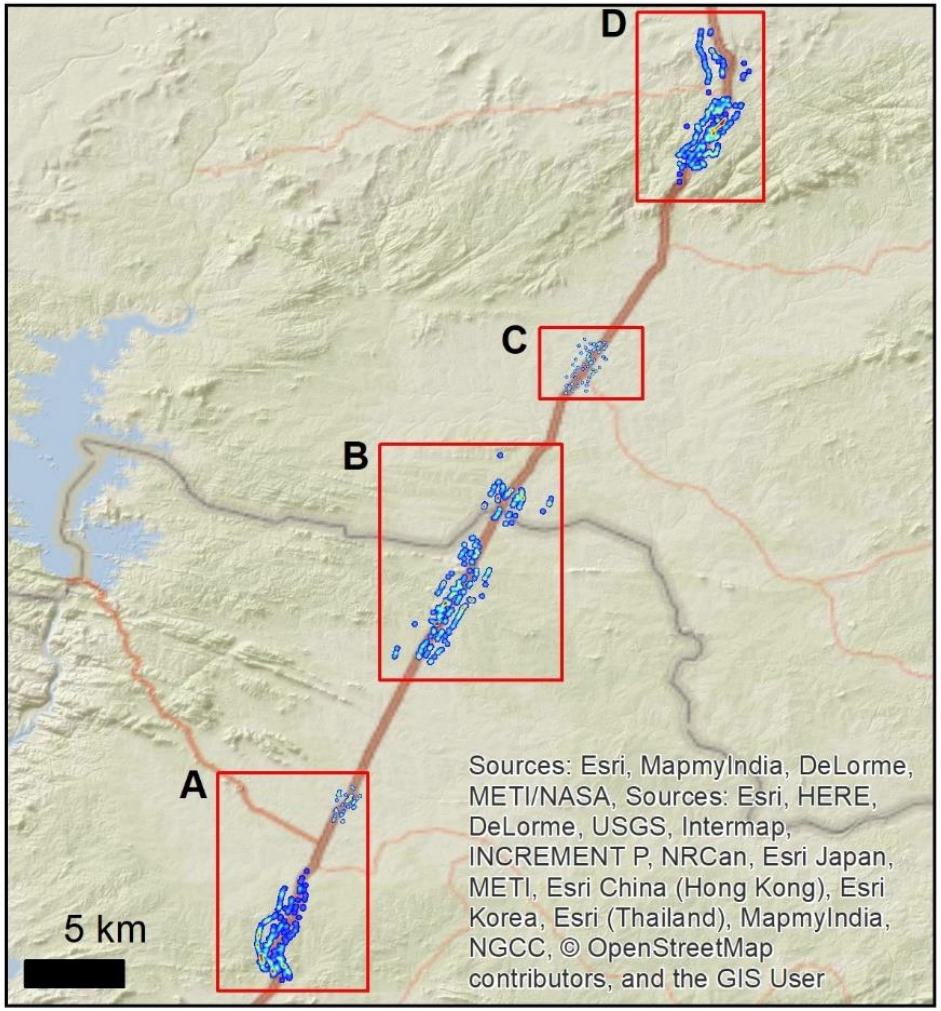
Technical Report No. 2015/006

PROPOSED MITIGATION MEASURES FOR MAINTAINING HABITAT CONTIGUITY AND REDUCING WILD ANIMAL MORTALITY ON NH 6 & 7 IN THE CENTRAL INDIAN LANDSCAPE

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

May, 2015


Tashkent
TAJIKISTAN
Kabul
Islamabad
PLATEAU OF TIBET
Yangtze
Mekong
Salween
Brahmaputra
Lahore
New Delhi
PAKISTAN
NEPAL
Karachi
Ganges
BANGLADESH
Dhaka
INDIA
Ahmedabad
MYANMAR (BURMA)
Kolkata
Mumbai
Pune
Hyderabad
Bay of Bengal
Yangon
Bangkok
Bengaluru
Chennai
Colombo
500 km
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community, Sources: Esri,


D
C
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5 km
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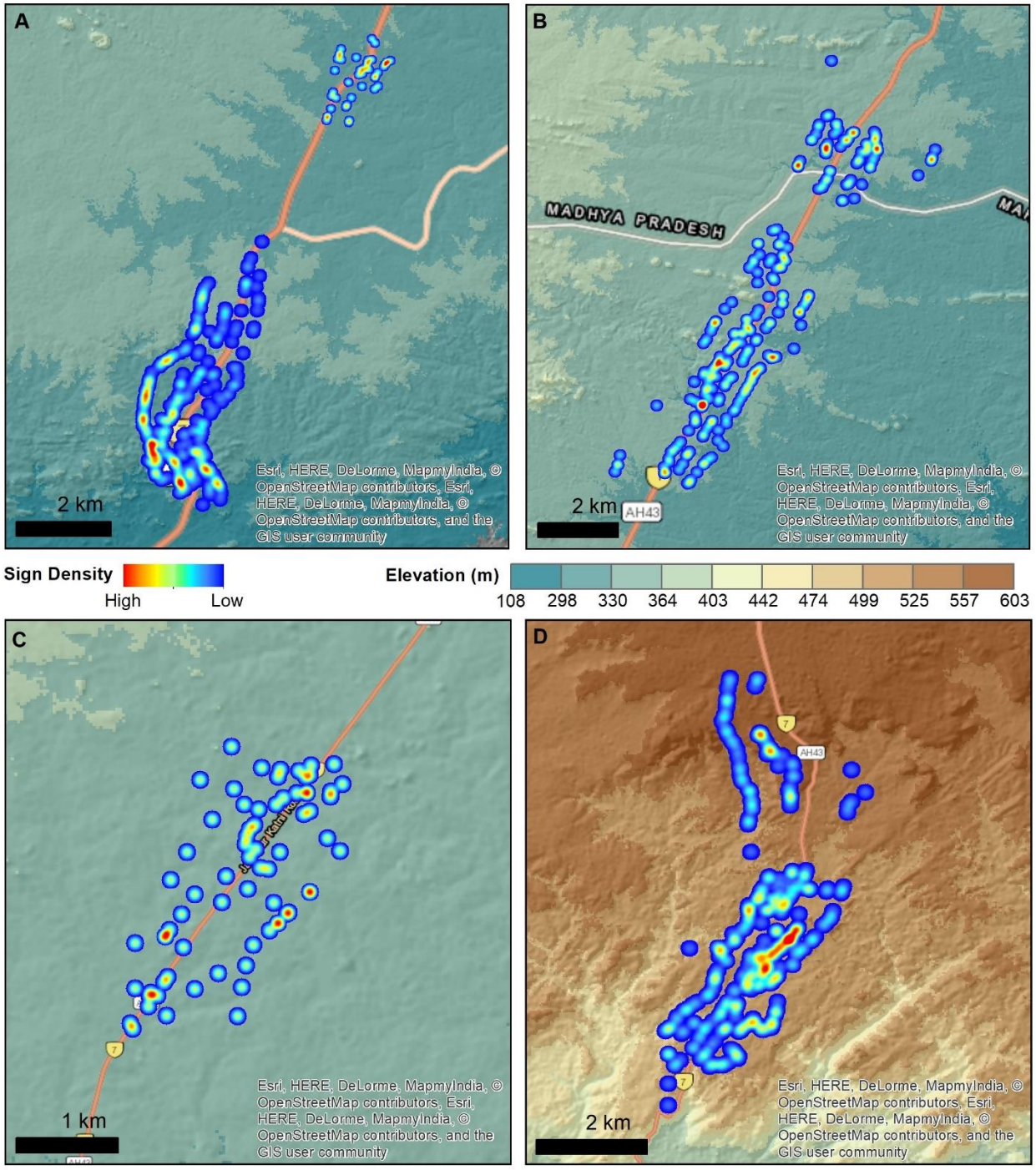
A
2 km
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community
B
MADHYA PRADESH
2 km
AH43
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Sign Density
High
Low
Elevation (m)
108 298 330 364 403 442 474 499 525 557 603
C
1 km
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D
AH43
2 km
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Smart integration of wildlife conservation concerns
Intelligent formulation of policies

Wildlife Habitat Connectivity Modelling

Steps to approach a connectivity analysis

1. Data Selection

- Species selection (consideration of scale)
- Habitat covariate selection
- Data selection (remotely sensed data, primary field data, open access data)
- Data preparation

2. Model parameterization

- Model parameterization (empirical approach, expert opinion)
- Final cost surface

3. Connectivity modelling

- Corridor mapping
- Barrier mapping
- Corridor prioritization

Tiger corridors of Vidarbha, Central India

Data used….

- Species data:
  - *Tiger presence data (sign survey, camera trap)*
  - *Tiger tracking data*
- Habitat covariate data:
  - *Normalized difference vegetation index (NDVI)*
  - *Distance from roads*
  - *Land use*
  - *Livestock population*
  - *Terrain ruggedness*
  - *Annual precipitation*
  - *Distance from forest*
  - *Distance from Protected Areas*
  - *Annual mean temperature*

Model parameterization and combination

Habitat Suitability Index

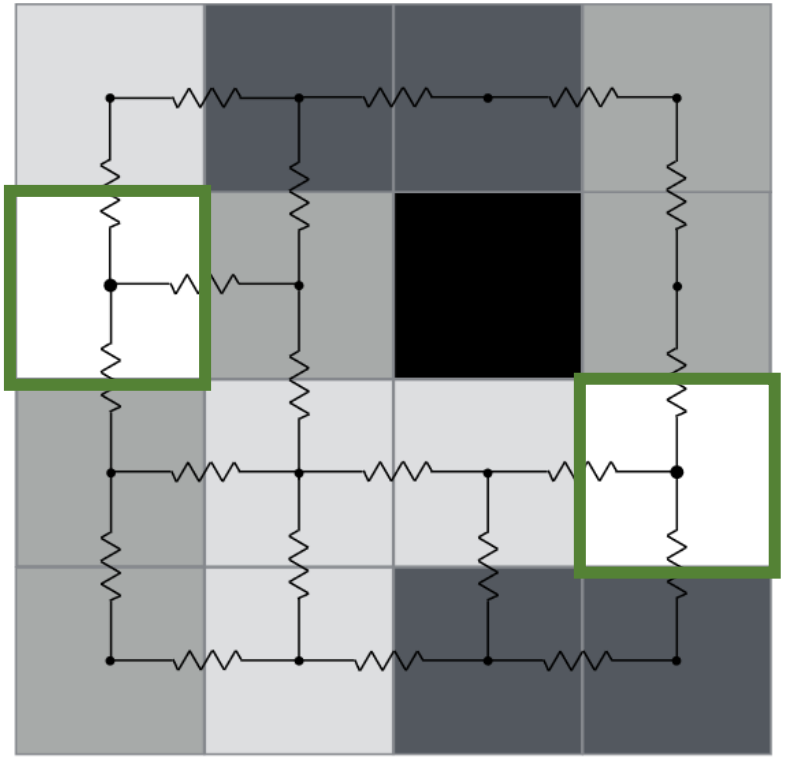
MAXENT Model

Proxy for habitat permeability (cost)

Circuit Theory

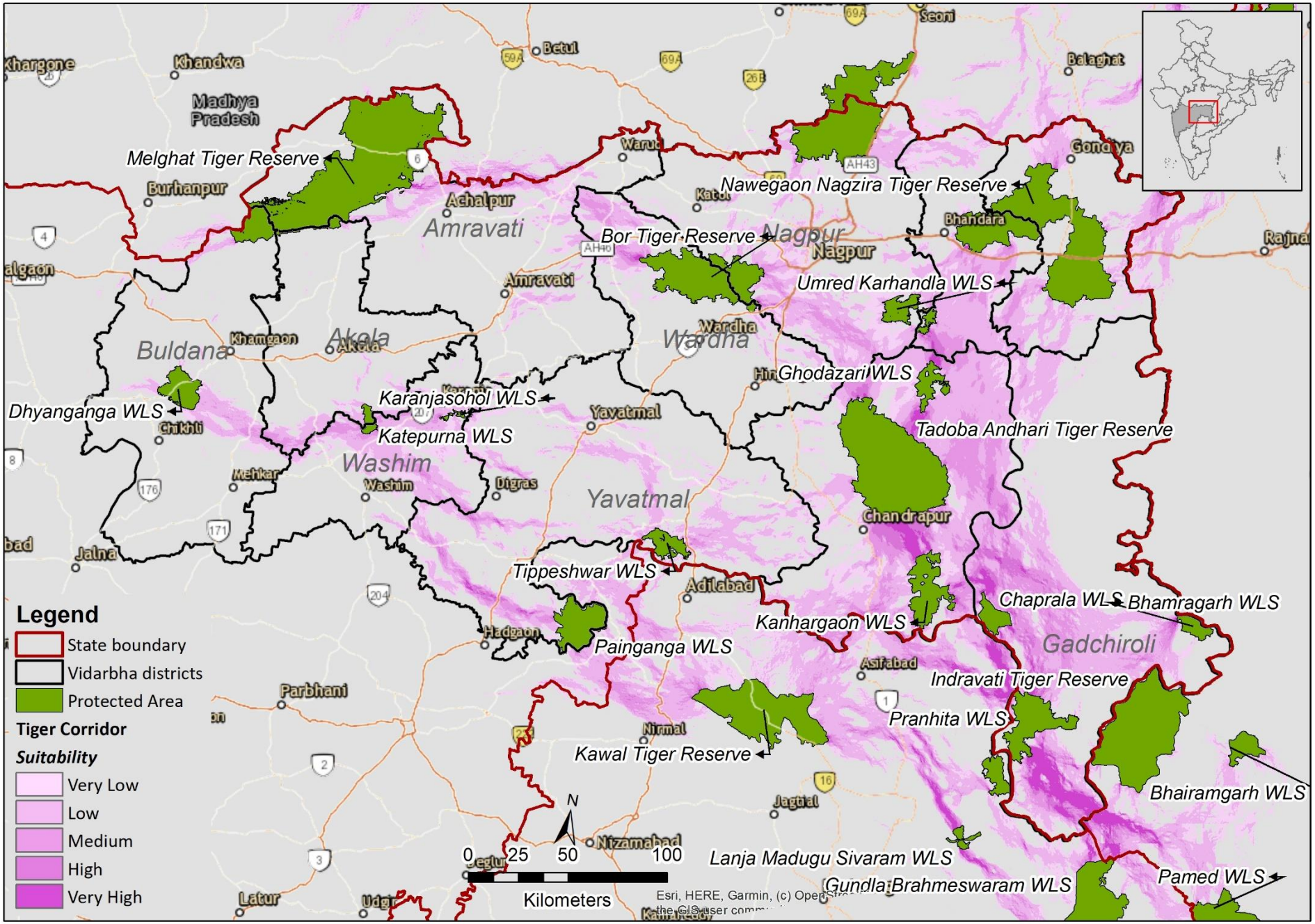
Circuit Theory

- Habitats patches (Protected areas) = nodes
- Connectivity (corridors) = linear edges (resistors as in electronic circuit).
- RESISTANCE (Ω) = amount of resistance offered by the landscape to the movement of an animal from one node to the other.
- Current values → To identify landscape corridors, features through which dispersers have a high likelihood of passing.



(McRae 2006; McRae and Beier 2007; McRae et al. 2008; Shah and McRae 2008)

Tiger Corridor Map of Vidarbha, Central India

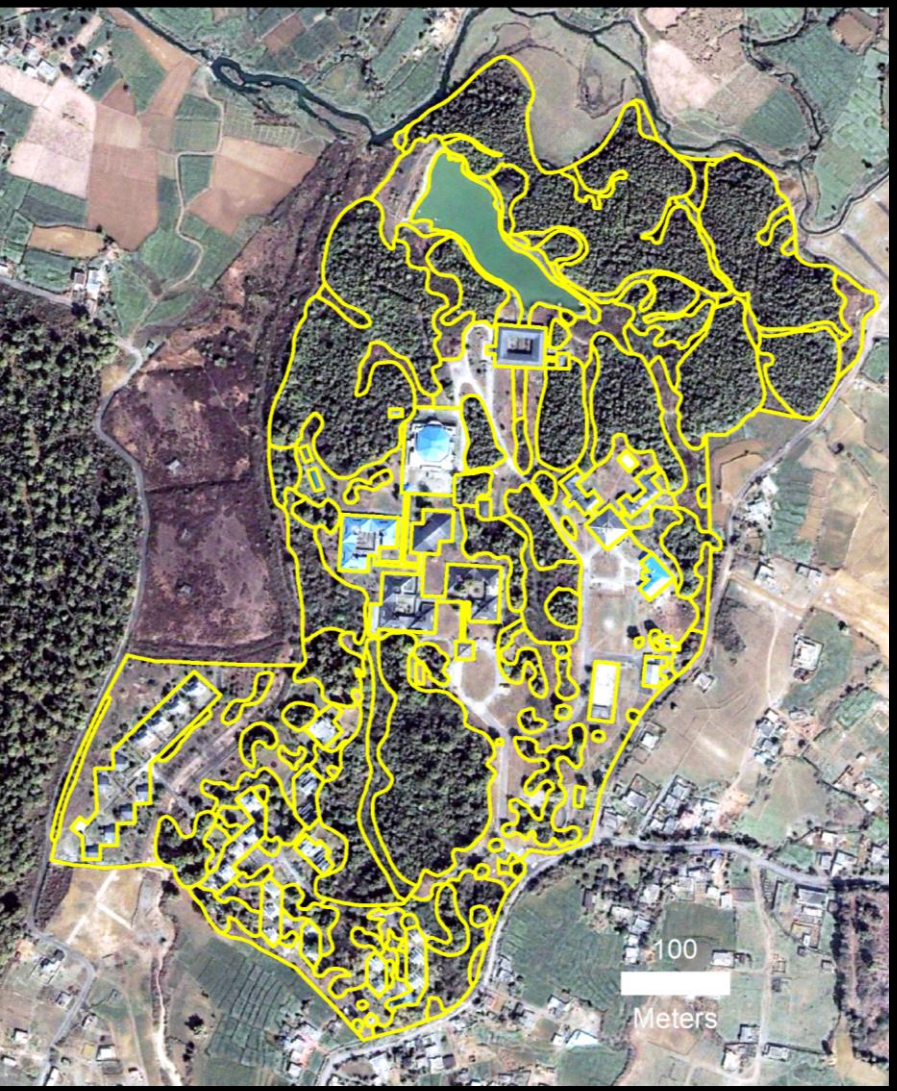


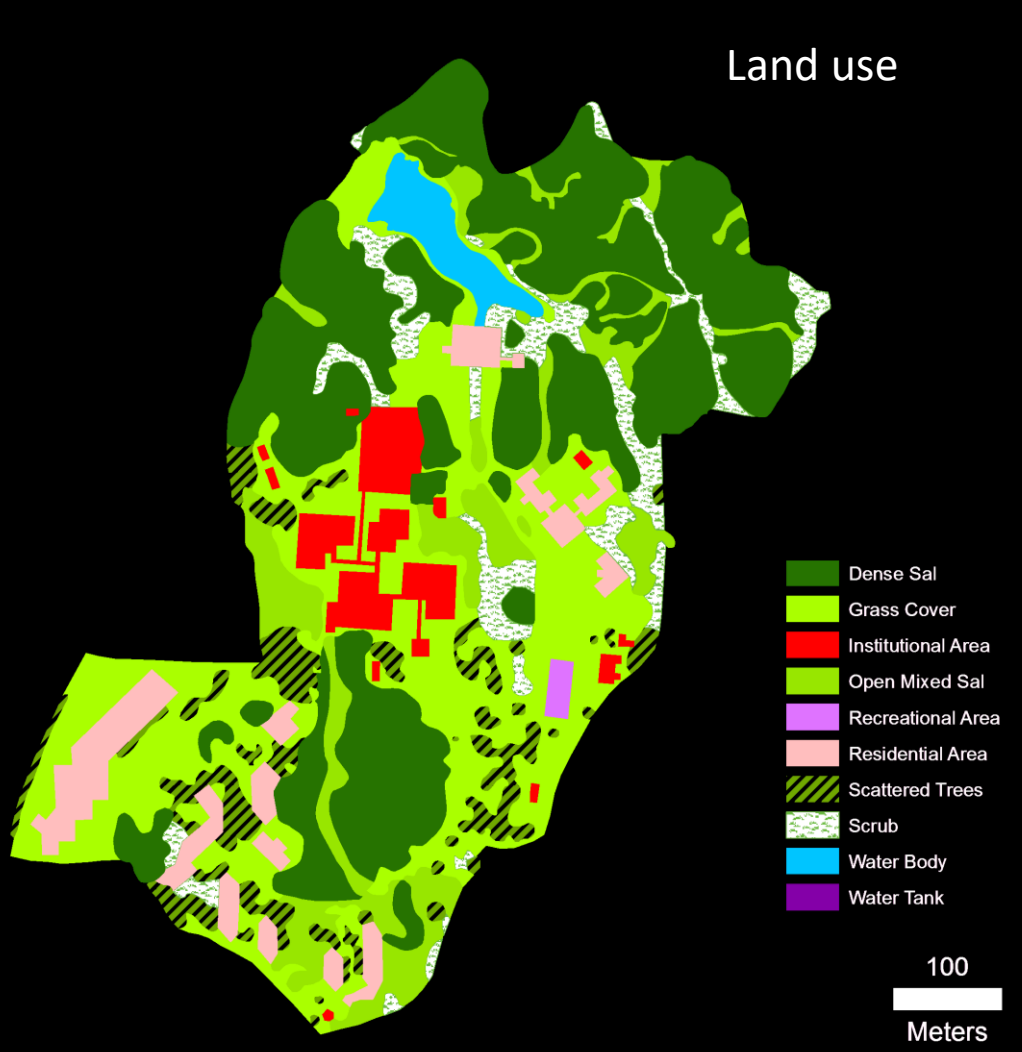
Fine scale movement corridors for the Tricarinate Hill-turtle

Data used….

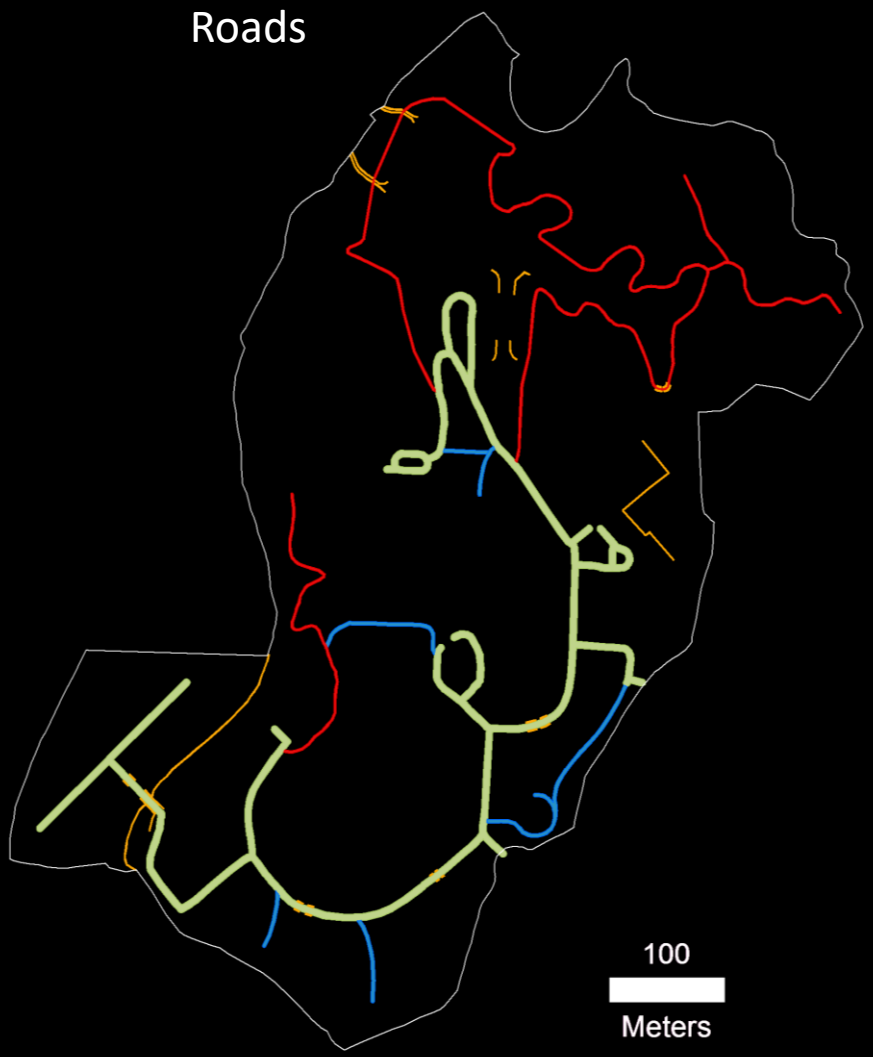
- Habitat (mapped from 0.5m satellite imagery)
- Roads (mapped using handheld GPS unit)
- Resource (food)
- Slope (mapped from contours generated from ground surveys)

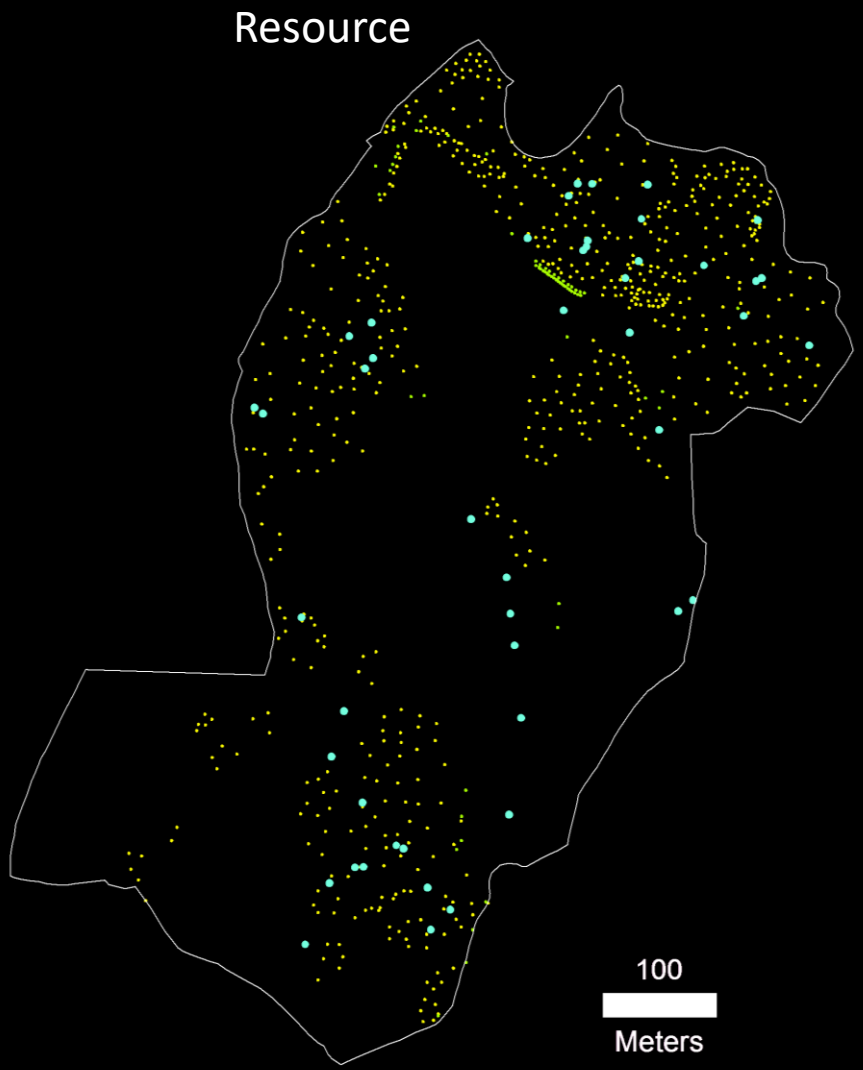
Fine-scale habitat covariate generation



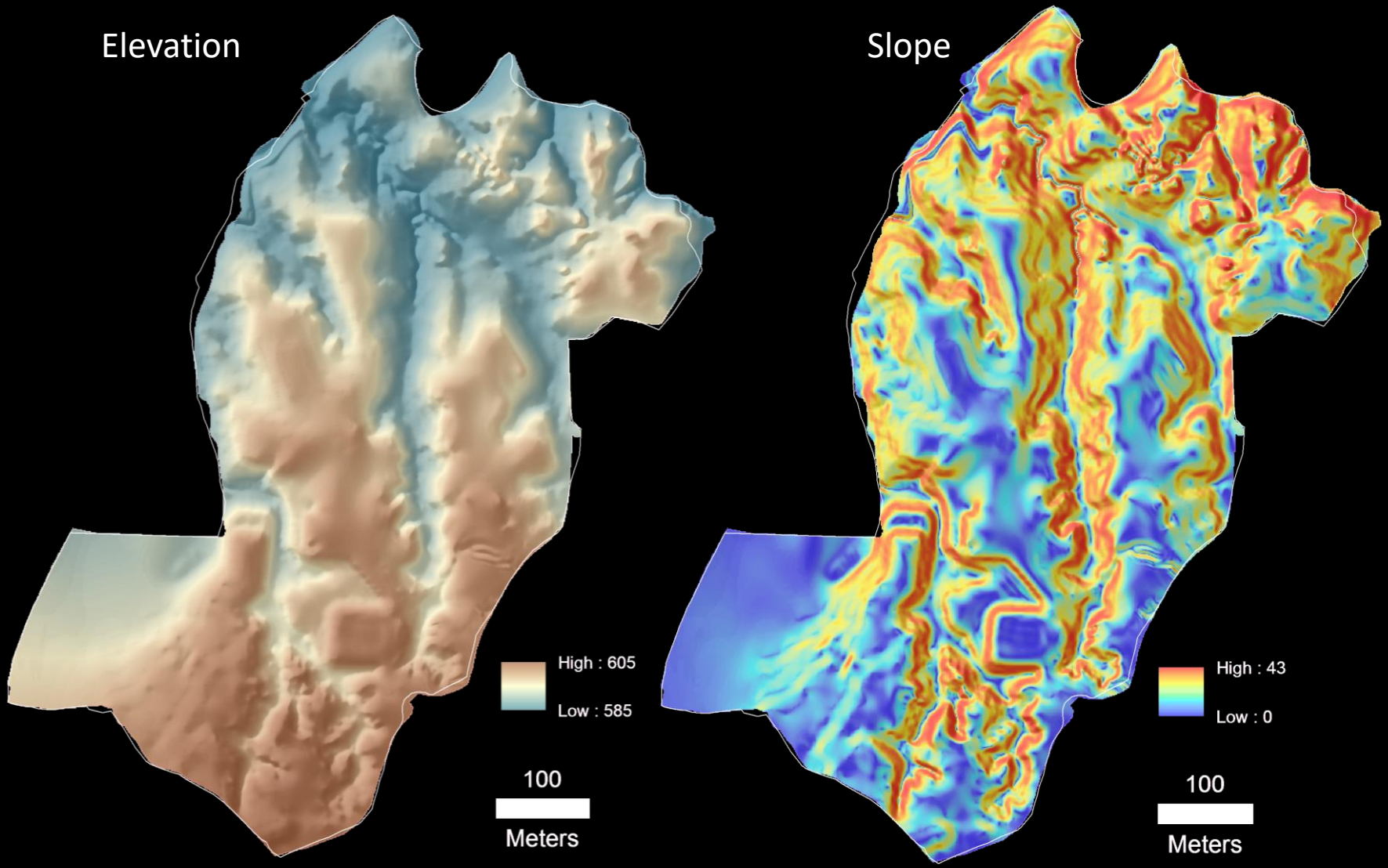


Fine-scale habitat covariate generation





Fine-scale habitat covariate generation



Parameterization of conductance values

(Expert opinion)

Cover type	Conductance	Cover type	Conductance	Cover type	conductance
Dense sal	10	Open Mixed sal	8	Scrub	7
Scattered trees	3	Grass cover	1	Waterbodies	2
Buildings	0	Road(6m)	0	Road(3m)	2
Nature trail	8				

Resource	Conductance
Lantana	0
Carrisa and Jasmnium	5
Earthworms	8

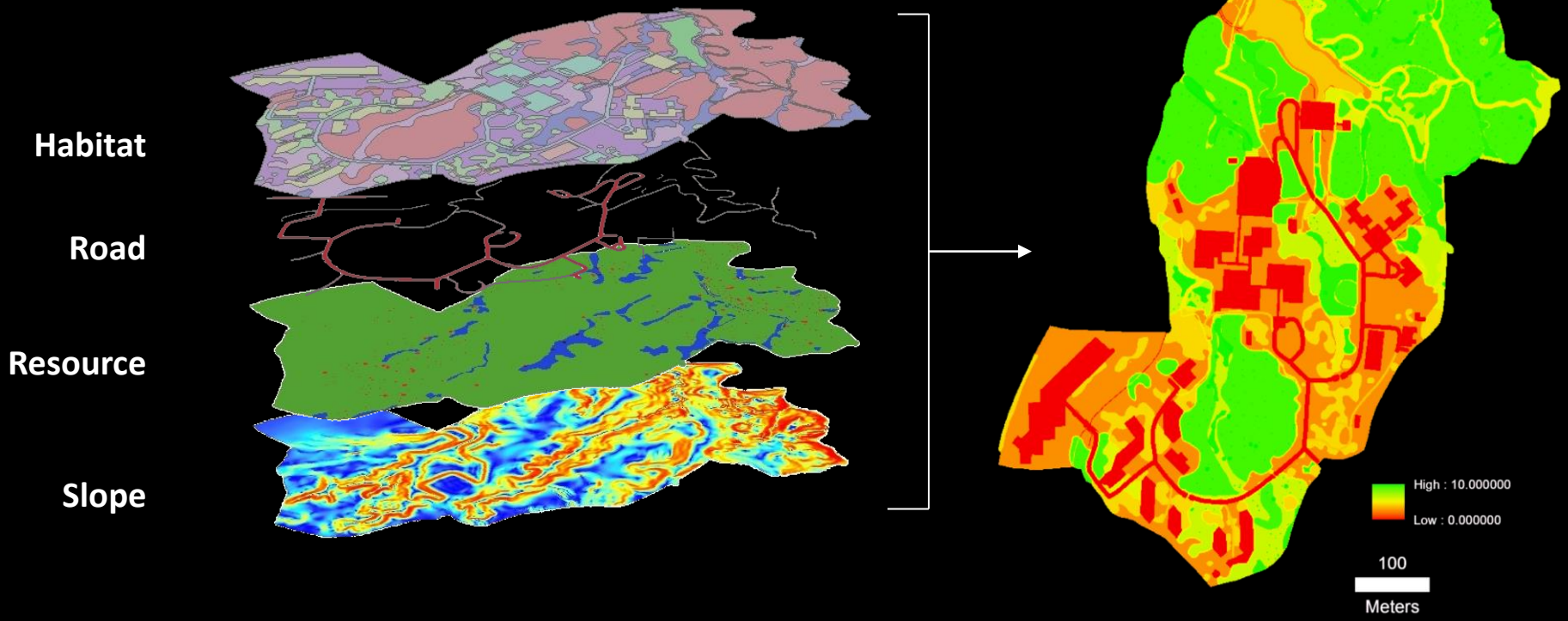
Slope (degrees)	Conductance
0 to 30	7
> 30	4

(Spear et al. 2010; Store 2001)

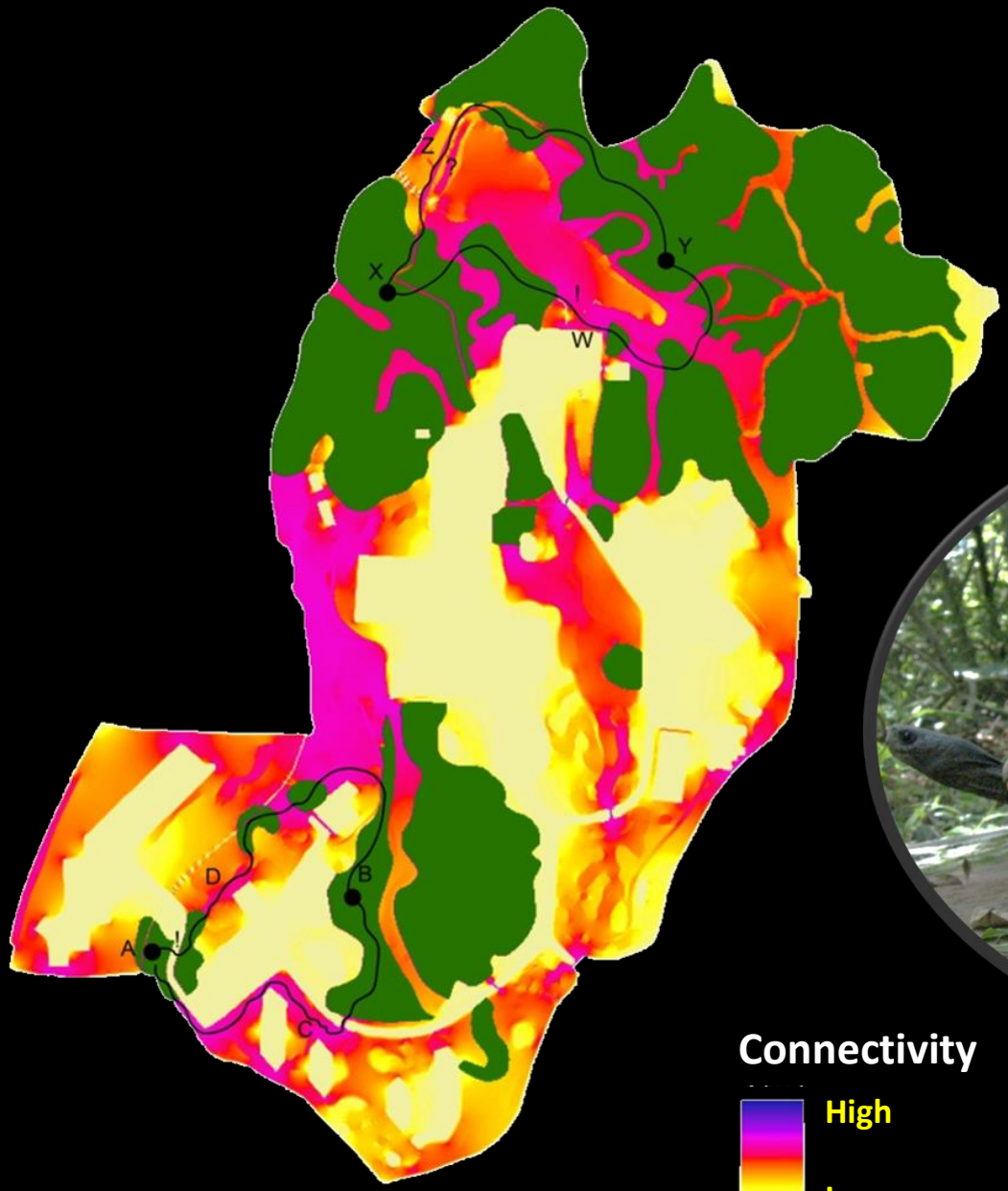
Generation of final cost surface

AHP - Analytic Hierarchy Process (Saaty 1970)

Cost surface



Fine scale connectivity map



Connectivity

High

Low

ACKNOWLEDGEMENTS

Director & Dean, WII

National Tiger Conservation Authority

Maharashtra State Road Development Corporation (MSRDC)

Maharashtra State Forest Department

Asian Development Bank

Thank you