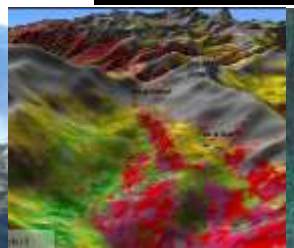
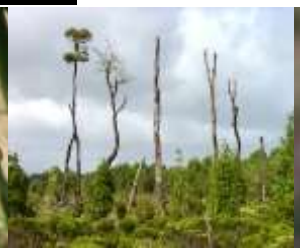
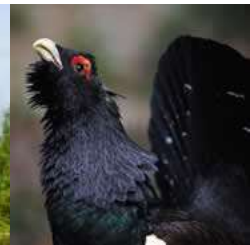
FRAGMENTATION AND CONNECTIVITY

TWO KEY CONCEPTS

Marine Le Louarn & Sandra Luque



The Challenge: A World in Crisis?

The Guardian

The decline of species ...

British study covering last 40 years points to worldwide mass extinction of wildlife and plants

A l'initiative de Jacques Chirac, une conférence internationale réunit à Paris, à partir du 24 janvier, responsables politiques et experts scientifiques

Alerte à la biodiversité menacée

A la différence du changement climatique, qui est un phénomène global, la crise de la biodiversité, générale, se traduit par une multitude d'événements locaux

DES EXTINCTIONS LOURDEMENT SOUS-ESTIMÉES

Ecology » Fish stocks and sea bird numbers plummet as soaring water temperatures kill off vital plankton

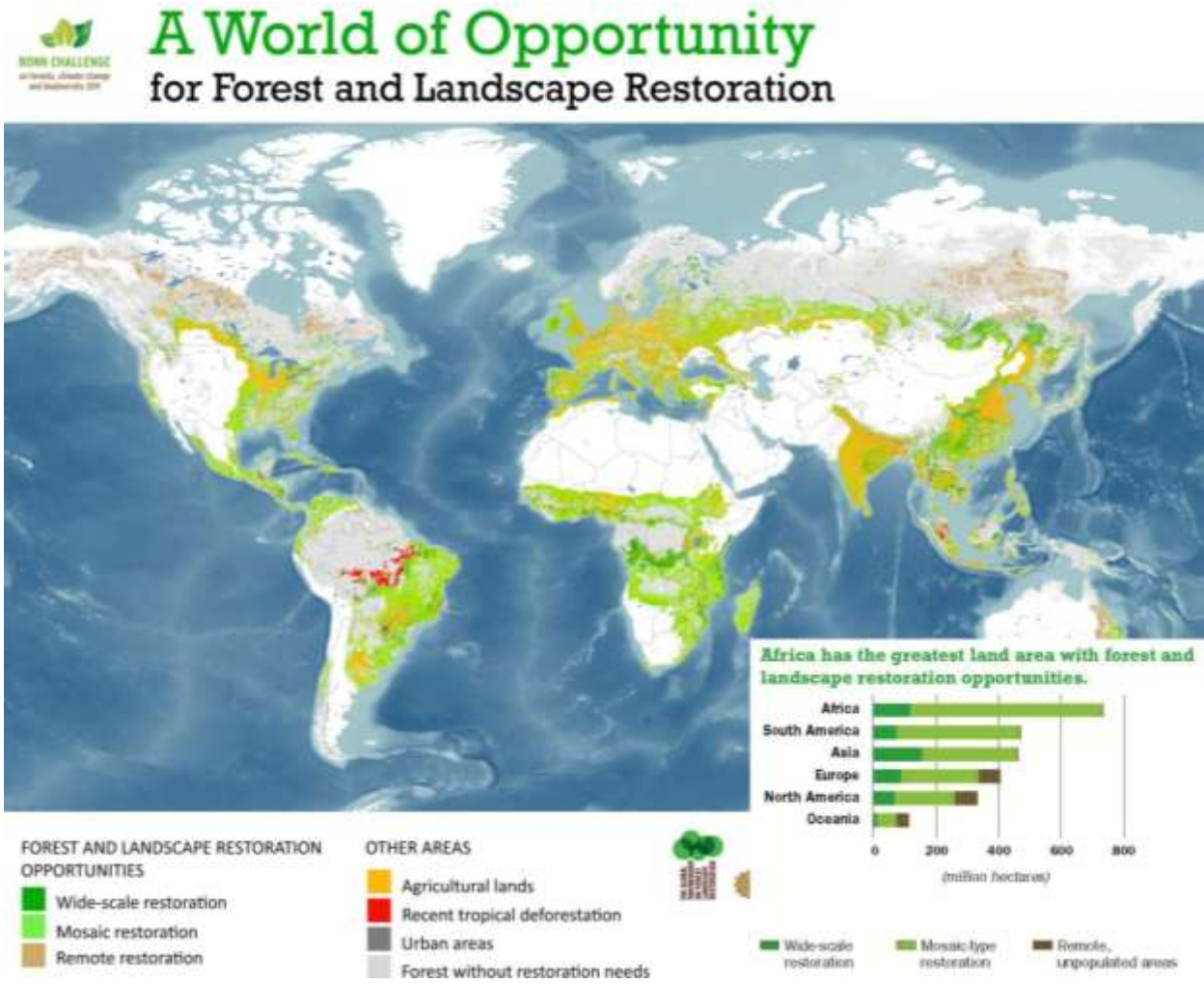
North Sea faces collapse of its ecosystem

Land degradation worldwide

Land Degradation Neutral World

LDN initiative: 15.3 Goal – United Nations

- **2 billion hectares of degraded land can be restored.**
- **500 million hectares are abandoned agriculture.**
- **LDN has the potential to cut up to 35% of global GHG emissions by sustainably storing carbon in soils and to enhance resilience to climate change.**
- **LDN is an efficient way to halt on-going biodiversity collapse through re-building sustainable landscapes.**



UNCCD 2016

Deforestation –
land degradation

Forest loss …

7.3 million hectares of forest, which is roughly the size of the country of Panama, are lost each year" (FAO, 2015).

Cattle

20.000 ha/day

14 ha/minute

Palm oil

about 36 football [soccer] fields worth of trees lost every minute (World Wildlife Fund (WWF, 2015)

http://www.globalforestwatch.org/#

Time is running out for the world's forests: total area is shrinking by the day

The State of the World's Forests 2018 warns that Latin America is one of three regions where deforestation continues

July 6, 2018, Santiago de Chile - Latin America is one of three regions where deforestation continues, according to The State of the World's Forests 2018, published today by the Food and Agriculture Organization of the United Nations, FAO.

The FAO report indicates that between 1990 and 2015, the world's forests decreased from 31.6% of the world's land areas to 30.6%, although the rate of loss has slowed down in recent years. This loss occurred mainly in developing countries, particularly in sub-Saharan Africa, Latin America and Southeast Asia.

According to the report, deforestation is the second leading cause of climate change - after the burning of fossil fuels - and accounts for almost 20% of all greenhouse gas emissions. This is more than the entire transport sector. Between 24% and 30% of the total mitigation potential can be obtained by stopping and reducing tropical deforestation.

Biodiversity Conservation more difficult that one may think…

Traditional Conservation Approaches	New Perspectives for Climate Change Adaptation
Assumptions of ecosystem stability	*Acceptance that ecosystems will change and species will move*
Managing for ecosystem resistance and resilience only	*Managing for transformation as well as resistance and resilience*
Addressing stressors one at a time	*Addressing multiple threats simultaneously*
Managing for species composition	*Managing for ecosystem functioning and services*
Managing at local scale, planning for short timeframes	*Broadening spatial and temporal scales of planning and management*
Managing for a single future outcome based on past history	*Managing based on scenario planning to evaluate outcomes under multiple plausible futures*






FRAGMENTATION & CONNECTIVITY LOSS

A major threat for biodiversity conservation and landscape ecological functions

MOVEMEMT ACROSS THE LANDSCAPE MATRIX: A KEY PROCESS FOR PLANT AND ANIMAL SURVIVAL

(Wiens et al. 1993)



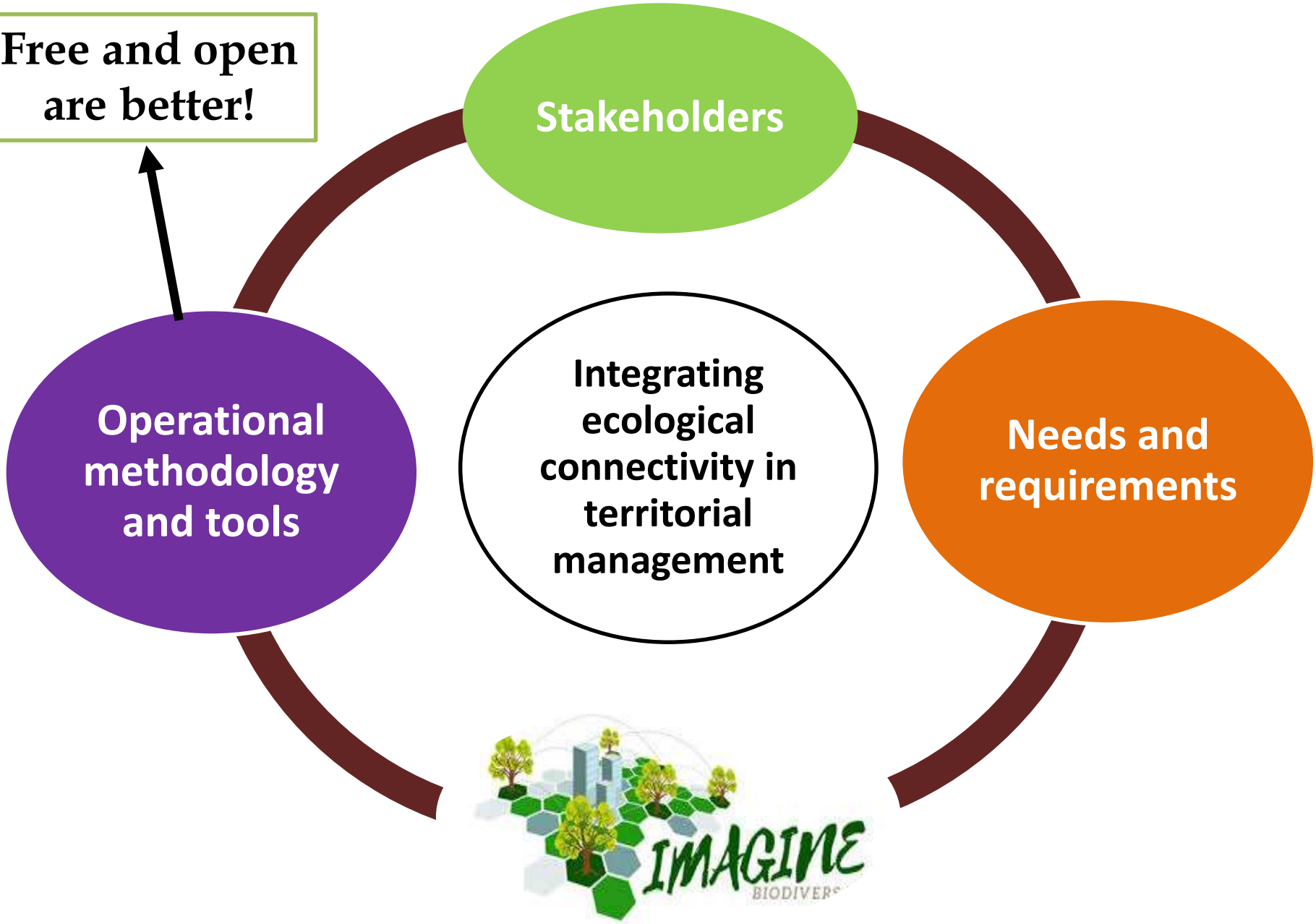

MAINTENANCE AND RESTORATION OF LANDSCAPE CONNECTIVITY

A major concern in conservation biology and land planning

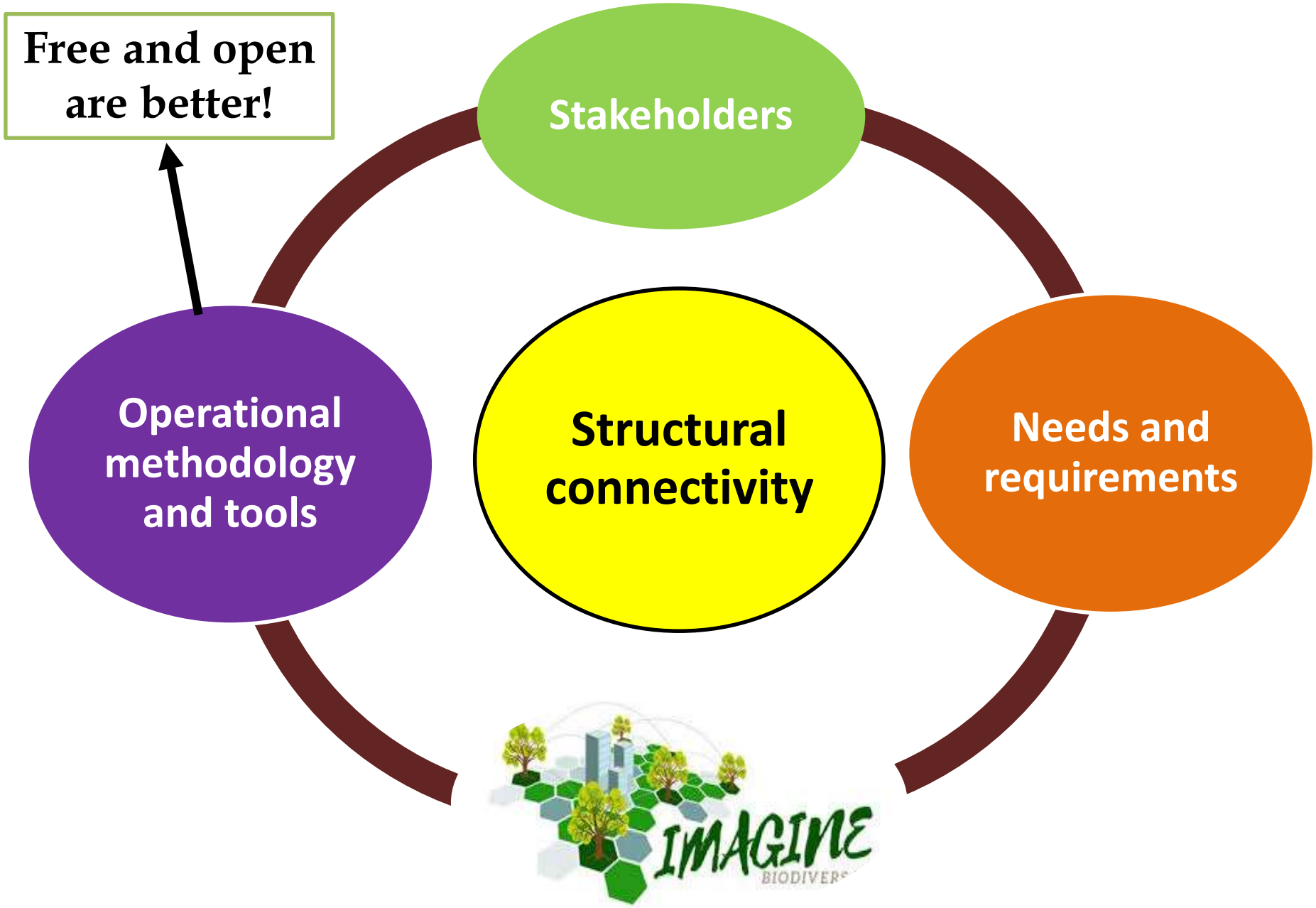
(Pascual-Hortal and Saura 2008, 2018)

Landscape connectivity

Free and open are better!



Landscape connectivity



Landscape connectivity: a dynamic process

(Taylor et al. 1993, Fahrig 2003,2017, Wiens 2003)

functional connectivity
refers to how the behavior of a dispersing organism is affected by landscape structure and elements

+

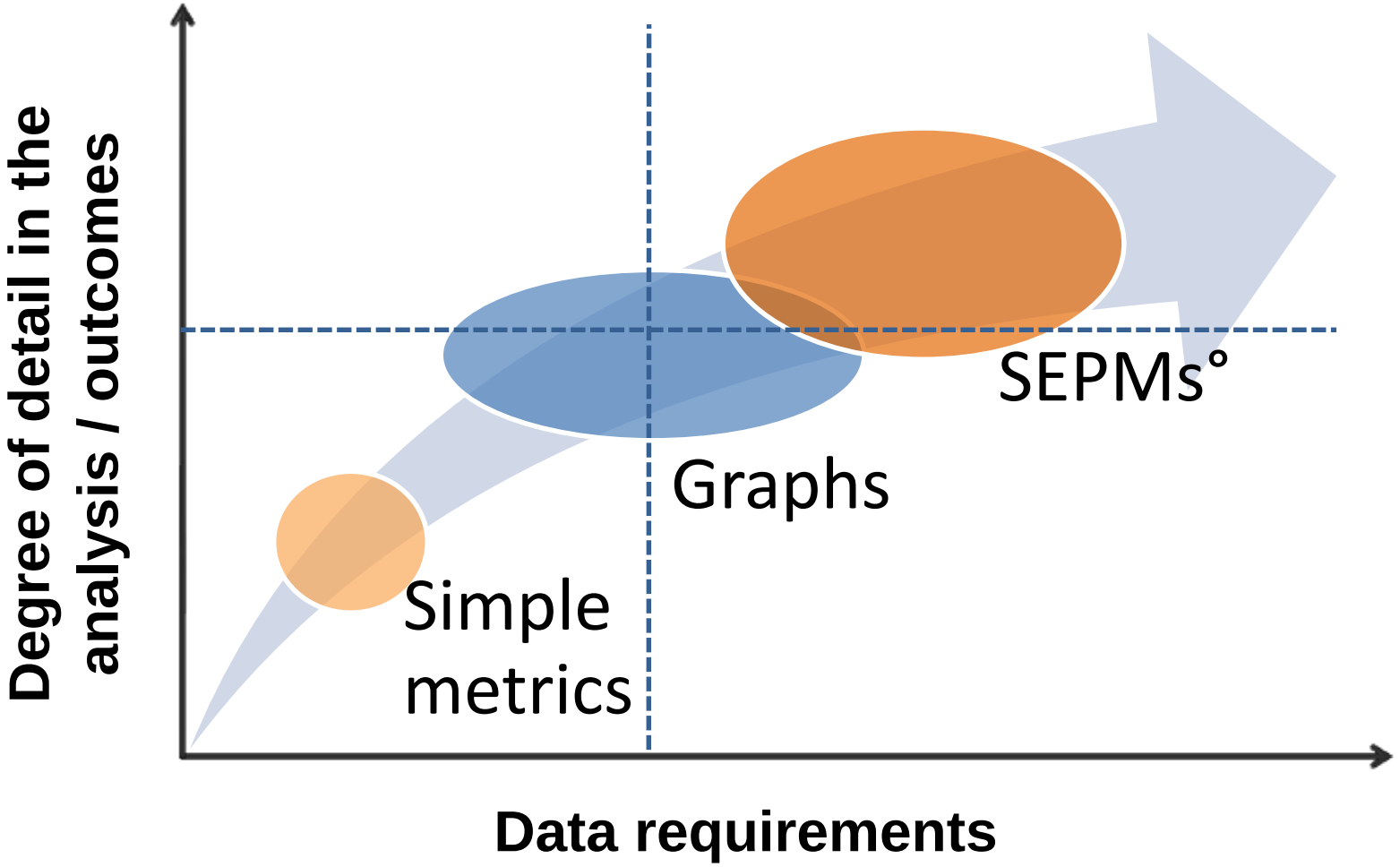
structural connectivity
depends on the spatial configuration of habitat patches in the landscape like physical contiguity, vicinity or presence of barriers

CONNECTIVITY DIAGNOSTIC

RETRIEVE information on:

- ❑ **spatial organisation at the habitat level of species**
- ❑ **contribution of each of the needed properties & elements within the network**

Balancing data requirements with detail in the outcomes



°Spatially explicit population models (SEPMs)

(After Saura pers. Com.)

Methodological framework:
Morphological Spatial Pattern Analysis (MSPA)

Structural Connectivity

GUIDOS Toolbox 2.7 (Vogt et al. 2007)

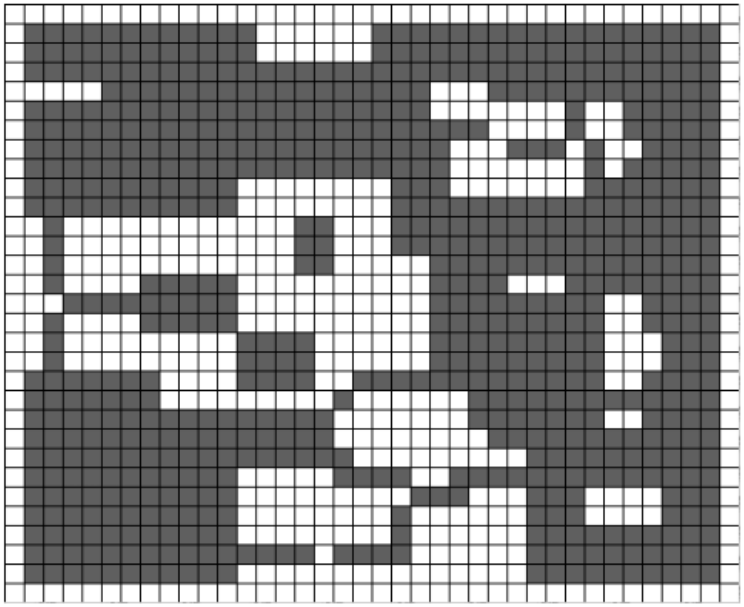
Methodological framework:
Morphological Spatial Pattern Analysis (MSPA)

GUIDOS Toolbox 2.7

How does it work?

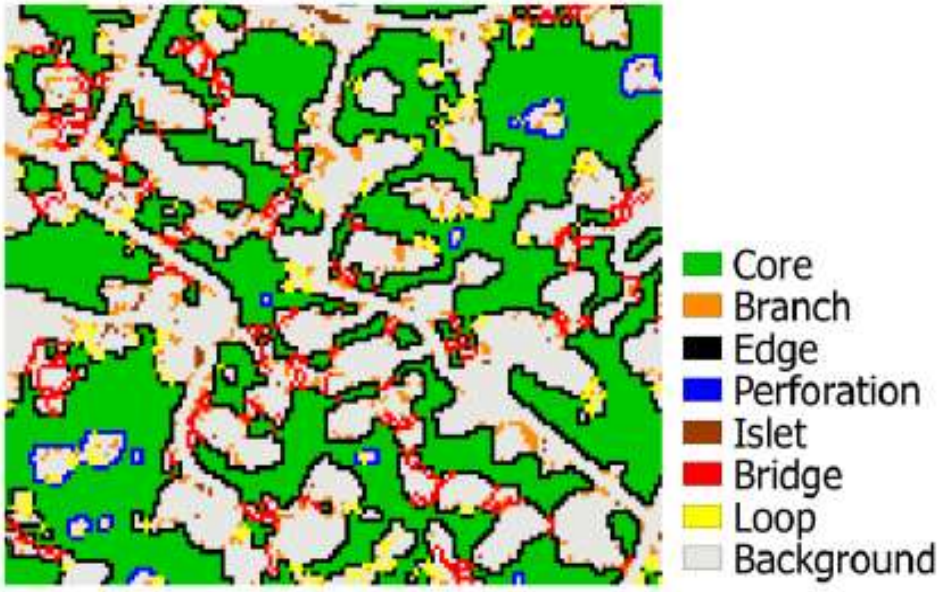
A binary map is analysed with a customised sequence of mathematical operators

MSPA: →



Segmentation of a binary mask

The results are **mutually exclusive** feature classes describing the **geometry** and the **connectivity** of the spatial arrangement of the image object



Methodological framework:
Input data from Remote Sensing

Selection of Land Cover map

EUROPEAN COMMISSION
Global Human Settlement

Joint Research Centre
JRC

GHS BUILT-UP

Global Human Settlement Layer
38m ; 250m and 1km resolution
Decimals values from 0 to 1

Sentinel 1

opernicus
Land Monitoring Service

European Settlement Map
2.5m resolution
12 thematic classes

SPOT 5 & SPOT 6

Large diversity of choice – Depend on the objectives
Free and open

Methodological framework:
Morphological Spatial Pattern Analysis (MSPA)

GUIDOS Toolbox 2.7

MSPA Applications

Analysis of forest map of the Val Grande National Park in North Italy
Indicators of forest fragmentation

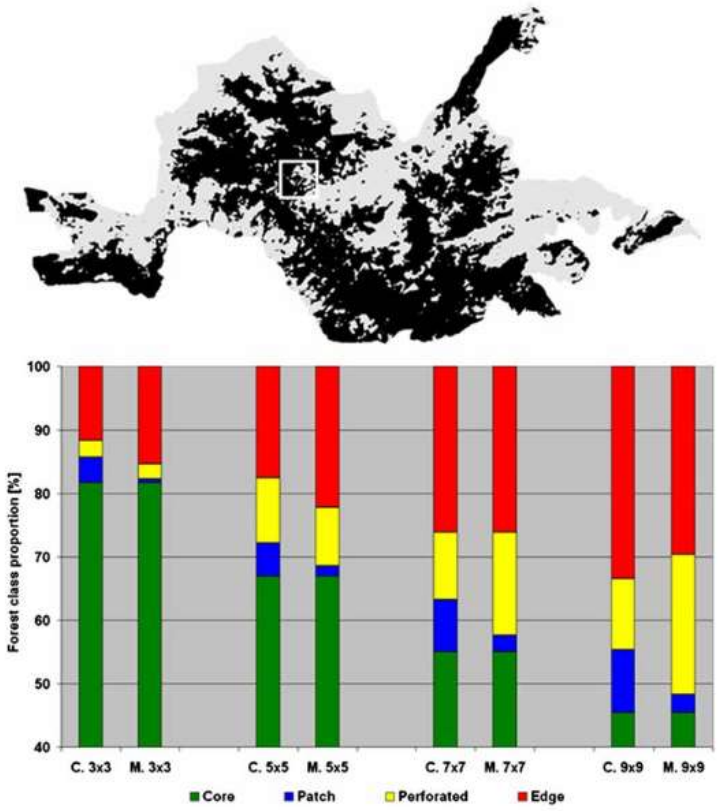
Landscape Ecol (2007) 22:171–177
DOI 10.1007/s10980-006-9013-2

REPORT

Mapping spatial patterns with morphological image processing

Peter Vogt · Kurt H. Riitters · Christine Estreguil · Jacek Kozak · Timothy G. Wade · James D. Wickham

Fig. 5 Top: The forest mask of the Val Grande National Park with a rectangular sub-region for a magnified view of the classification (Fig. 6). Bottom: Comparison of the forest class proportion derived for the convolution (C.) and the morphological approach (M.). The window dimension (convolution) or SE-size (morphological) is shown under each column



Methodological framework:
Morphological Spatial Pattern Analysis (MSPA)

GUIDOS Toolbox 2.7

MSPA Applications

ELSEVIER

Ecological Indicators 7 (2007) 481–488

ECOLOGICAL INDICATORS

This article is also available online at: www.elsevier.com/locate/ecolind

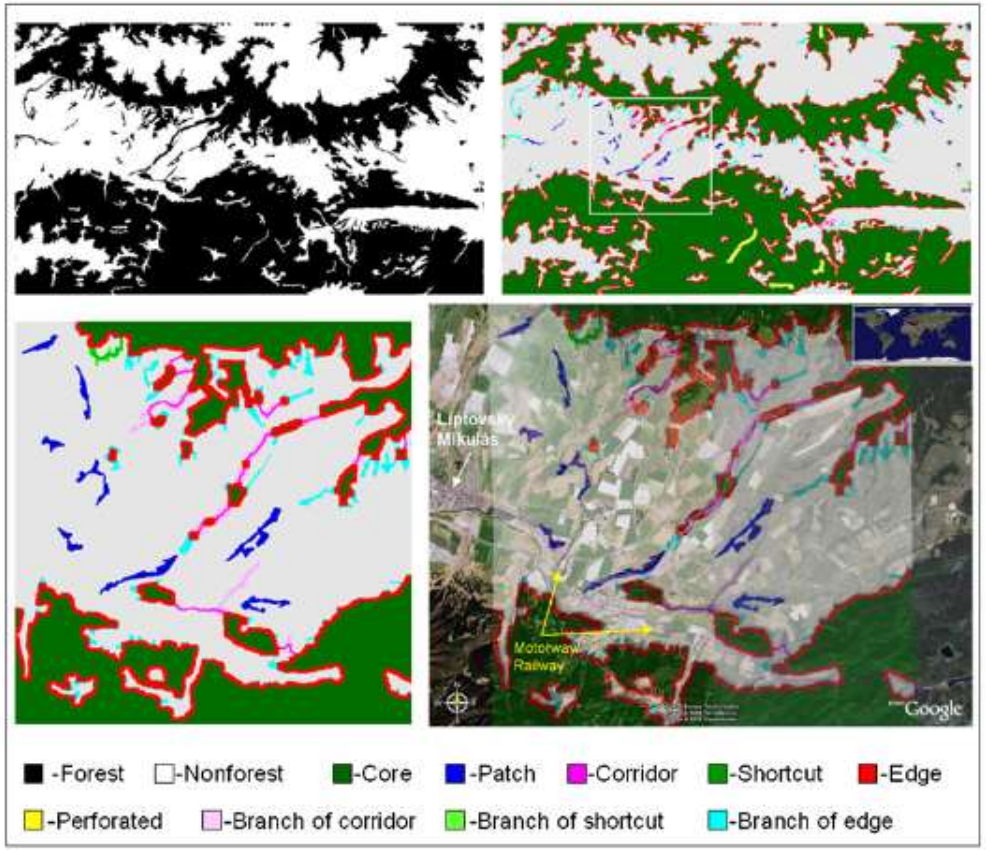
Mapping landscape corridors

Peter Vogt [a,*], Kurt H. Riitters [b], Marcin Iwanowski [c], Christine Estreguil [a], Jacek Kozak [d], Pierre Soille [e]

[a] European Commission-DG Joint Research Centre, Institute for Environment and Sustainability, Land Management and Natural Hazards Unit, T.P. 261, Via E. Fermi 1, 21020 Ispra (VA), Italy
[b] US Forest Service, Southern Research Station, 3041 Cornwallis Road, Research Triangle Park, NC 27709, USA
[c] Institute of Control and Industrial Electronics, Warsaw University of Technology, ul.Koszykowa 75, 00-662 Warszawa, Poland
[d] Institute of Geography and Spatial Management, Jagiellonian University, Gronostajowa 7, 30-387 Kraków, Poland
[e] European Commission-DG Joint Research Centre, Institute for Environment and Sustainability, Spatial Data Infrastructures Unit, T.P. 262, Via E. Fermi 1, 21020 Ispra (VA), Italy

Received 11 October 2006; received in revised form 3 November 2006; accepted 6 November 2006

Corridor mapping in northern Slovakia



Methodological framework:
Morphological Spatial Pattern Analysis (MSPA)

GUIDOS Toolbox 2.7

MSPA Applications

Evaluate the effect of land-cover changes in the US on the Green Infrastructures network

Landscape and Urban Planning 94 (2010) 186–195

Contents lists available at ScienceDirect

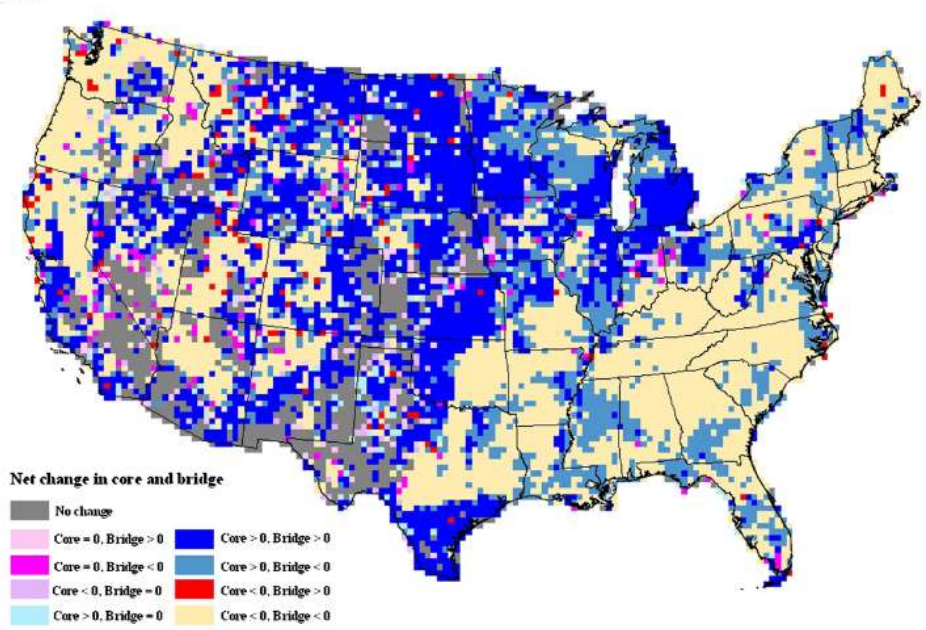
Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

A national assessment of green infrastructure and change for the contern
United States using morphological image processing

James D. Wickham[a,*], Kurt H. Riitters[b], Timothy G. Wade[a], Peter Vogt[c]

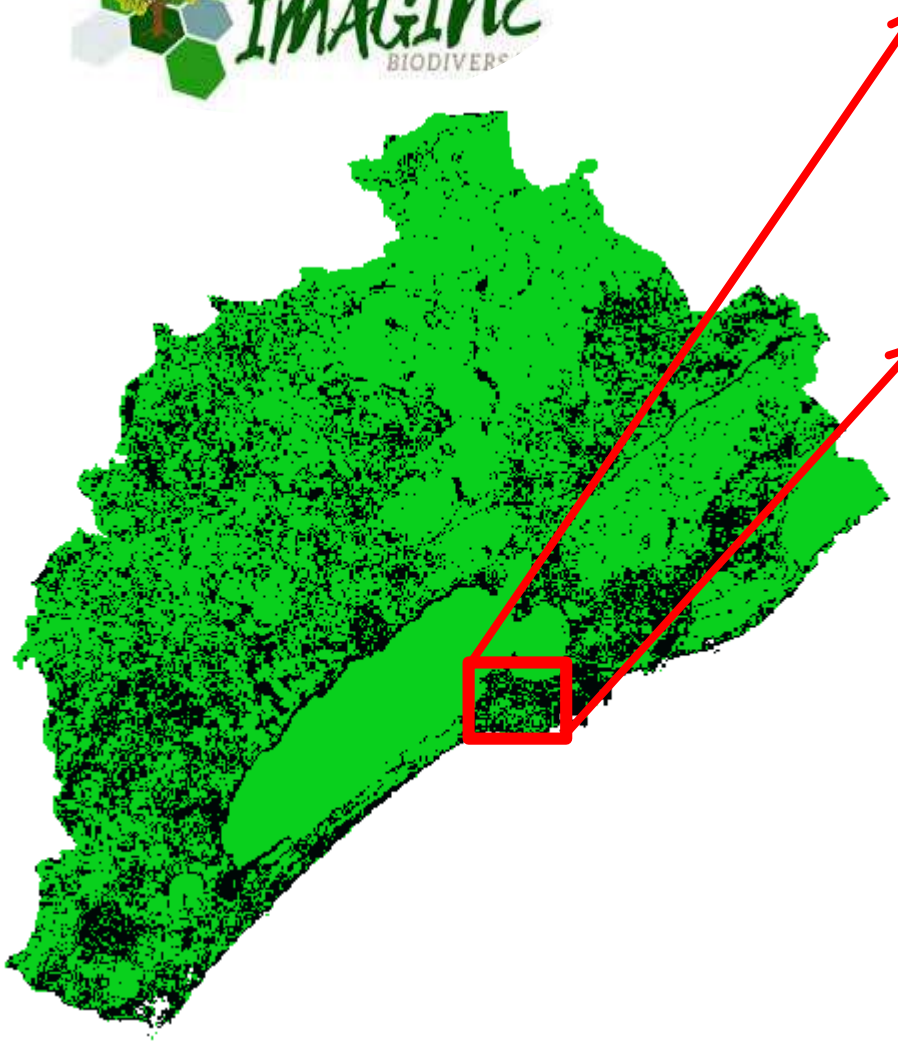
[a] U.S. EPA, Office of Research and Development, National Exposure Research Laboratory (MD: E243-05), 109 TW Alexander Dr., Research Triangle Park, NC 27711,
[b] US Forest Service, Southern Research Station, 3041 Cornwallis Road, Research Triangle Park, NC 27709, USA
[c] European Commission, Joint Research Center, Institute for Environment and Sustainability, Land Management, T.P. 261, Via E. Fermi 1, 21020 Ispra (VA), Italy

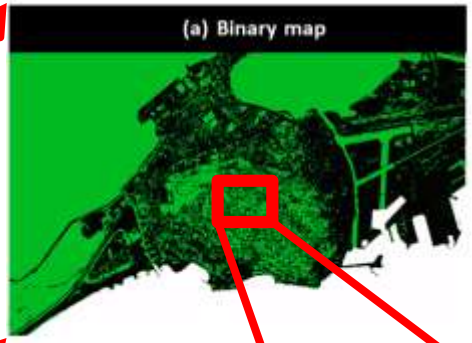


Methodological framework:
Input data from Remote Sensing

Grey Infrastructures
Green Infratructures

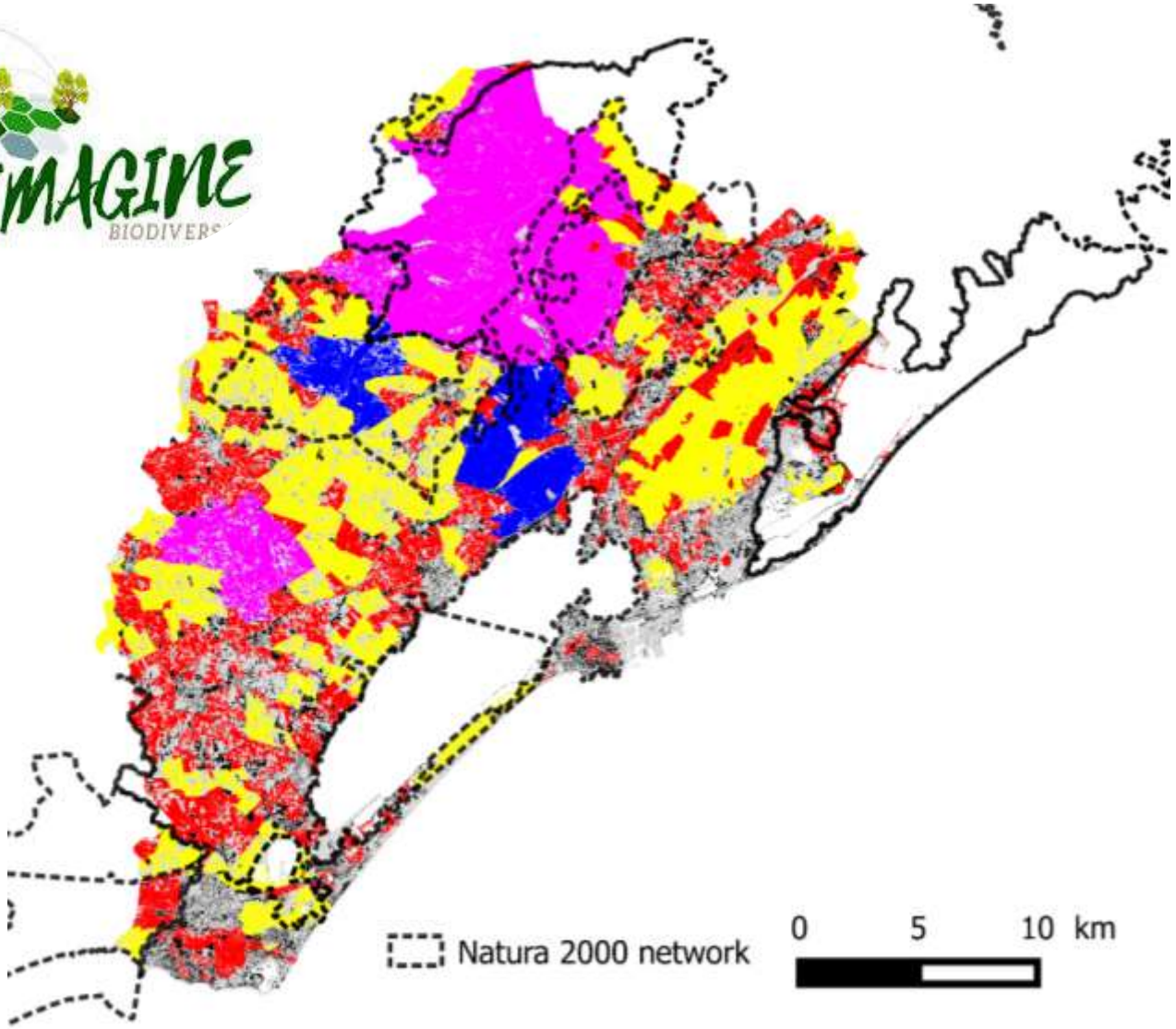
Based on European Settlement Map
2.5m resolution
12 thematic classes



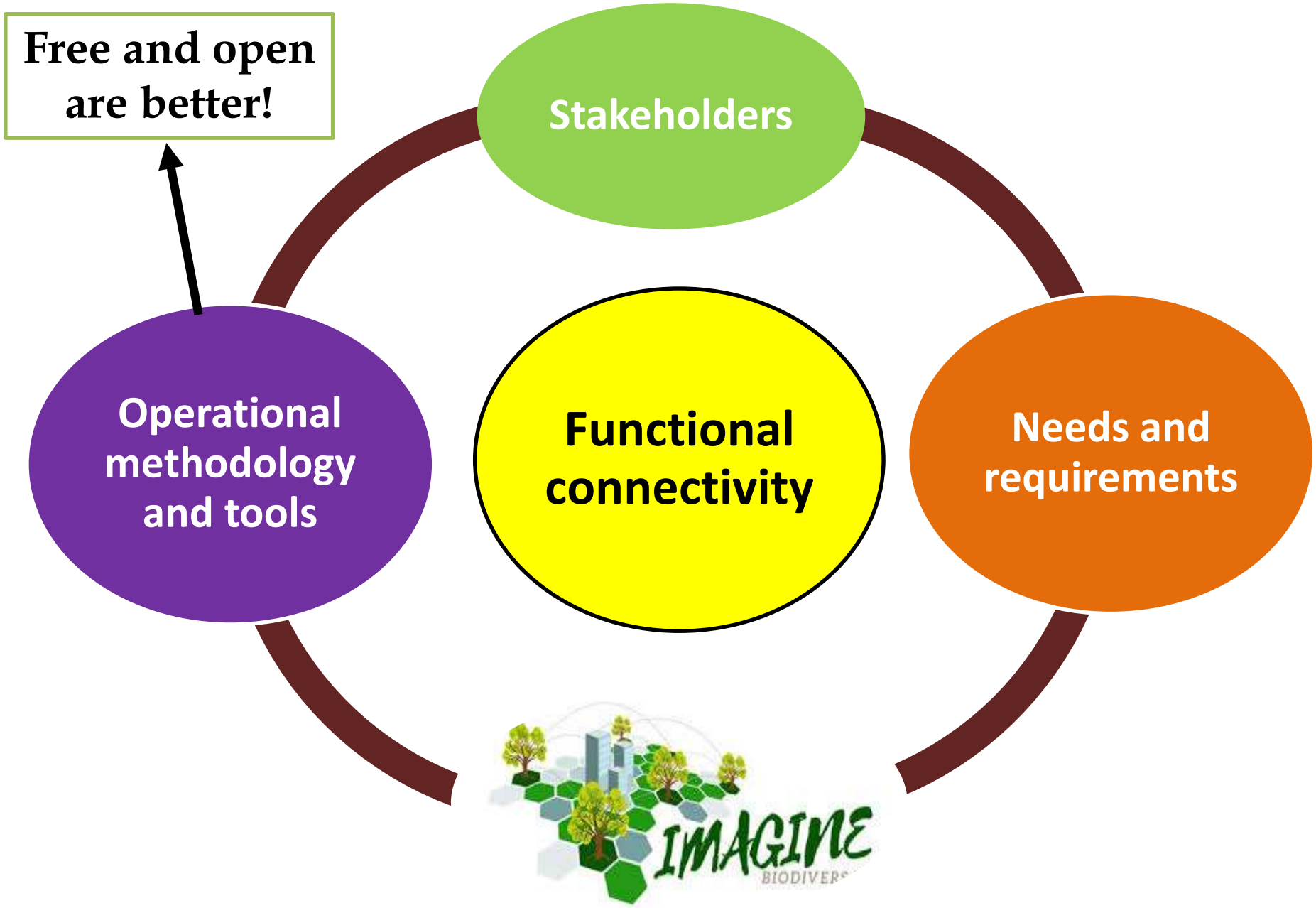


Core
Branch
Edge
Perforation
Islet
Bridge
Loop
Background

RESULTS:
Where and how large are the GI patches? *Accounting* feature

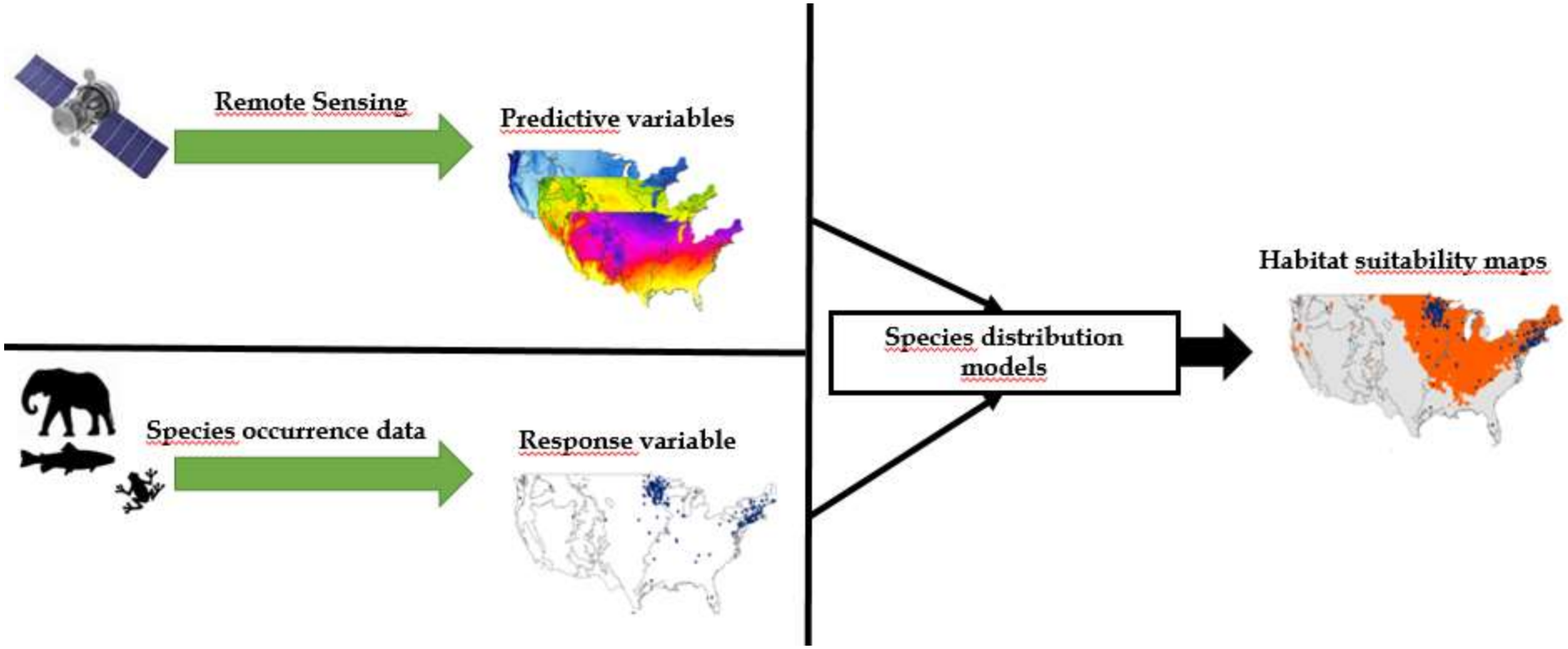


Landscape connectivity



Species Distribution Models

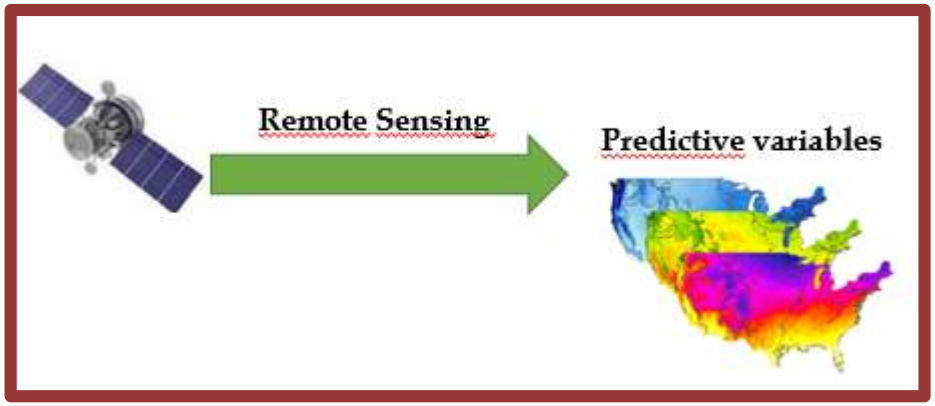
Required to study the relationship between species and their environment



Adapted from Briscoe Runquist et al. 2019

Species Distribution Models

Required to study the relationship between species and their environment



Remote Sensing in Ecology and Conservation
Open Access
ZSL
LIVING CONSERVATION

INTERDISCIPLINARY PERSPECTIVES

Will remote sensing shape the next generation of species distribution models?

Kate S. He[1], Bethany A. Bradley[2], Anna F. Cord[3], Duccio Rocchini[4], Mao-Ning Tuanmu[5], Sebastian Schmidtlein[6], Woody Turner[7], Martin Wegmann[8,9] & Nathalie Pettorelli[10]

Species Distribution Models

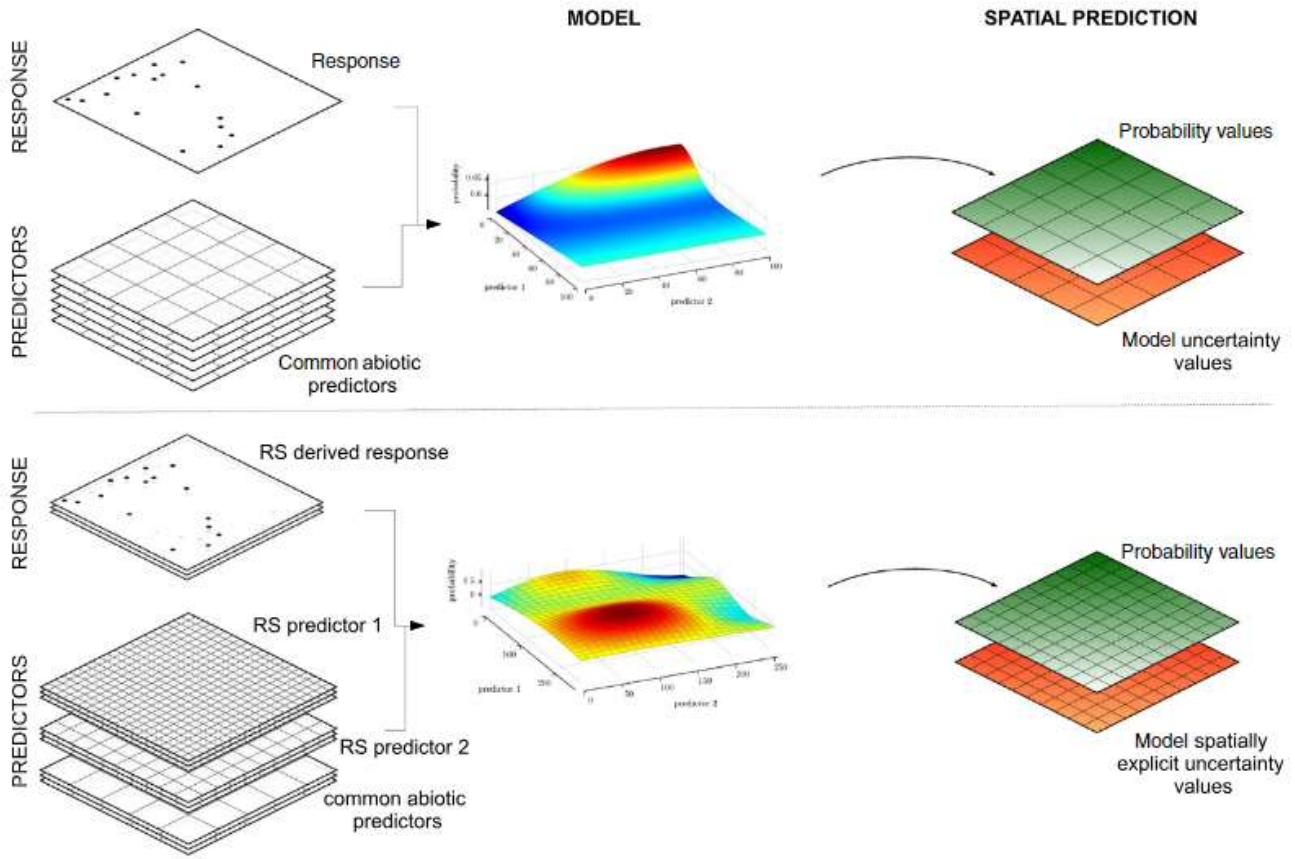
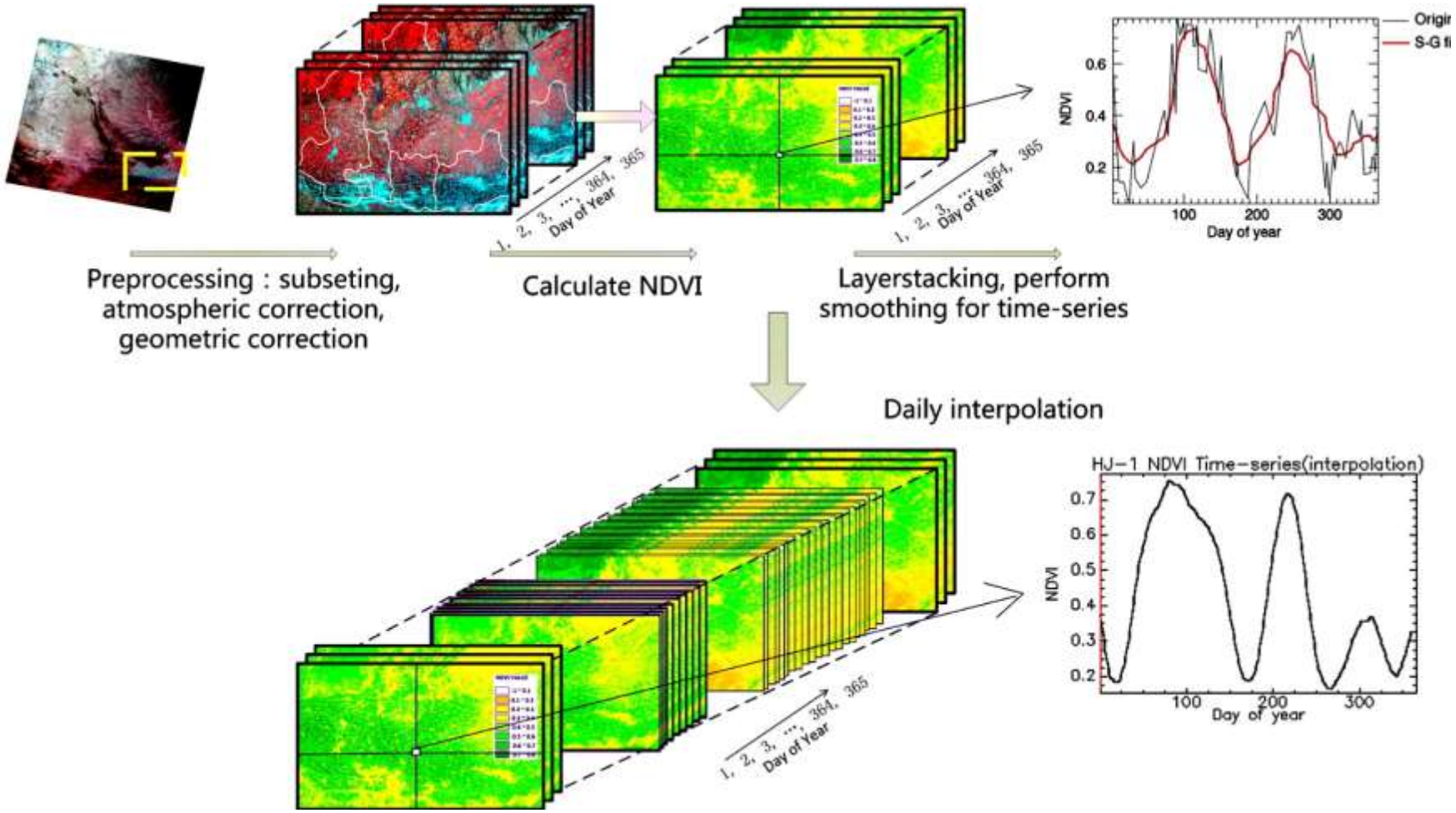


Figure 1. A comparative modeling framework of the current SDMs (above) and the NG-SDMs (below), showing remotely derived response variable and multi-scale predictor variables, including spatially explicit uncertainty of predictor variables. In classical SDMs, uncertainty is often not reported in a spatially explicit manner and one layer per predictor is used. In contrast, NG-SDMs can have a stack of images organized systematically by scales in time to capture each predictor, thus resulting predictions with high accuracy. NG-SDMs, next generation species distribution models.

Species Distribution Models



From Pan et al. 2015

Species Distribution Models

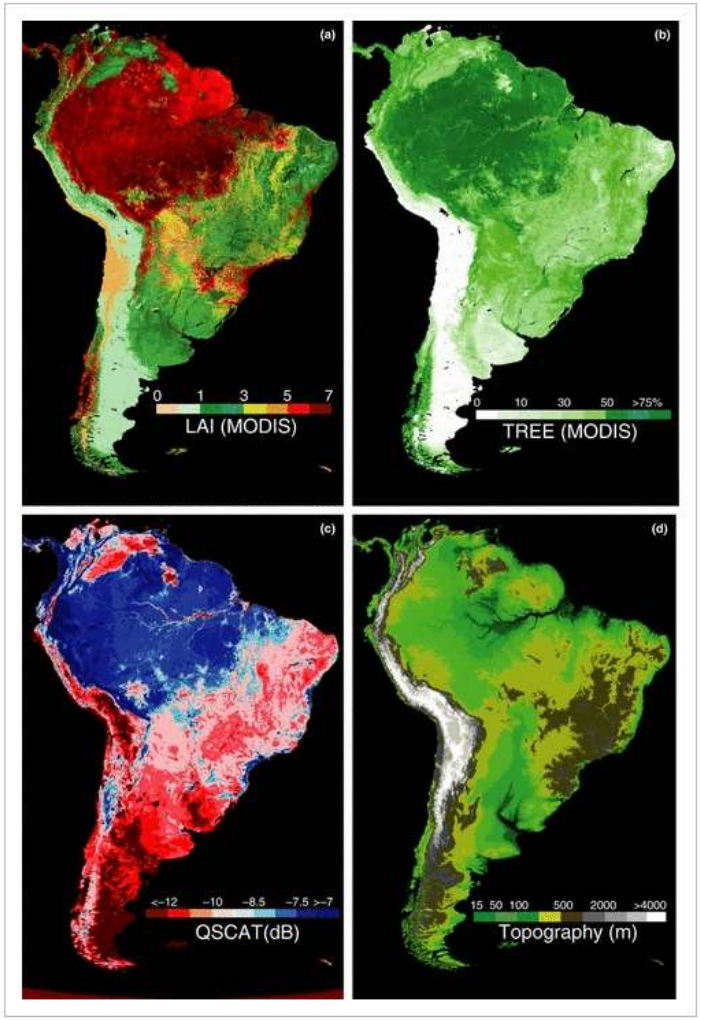
Journal of Biogeography

Full Access

Predicting species distributions across the Amazonian and Andean regions using remote sensing data

Wolfgang Buermann, Sassan Saatchi, Thomas B. Smith, Brian R. Zutta, Jaime A. Chaves, Borja Milá, Catherine H. Graham

MODIS 8-day Leaf Area Index product derived from atmospherically corrected MODIS surface reflectances.



To assess habitat suitability for birds, a combination of remote sensing and climatic layers resulted in the best model performance

Species Distribution Models

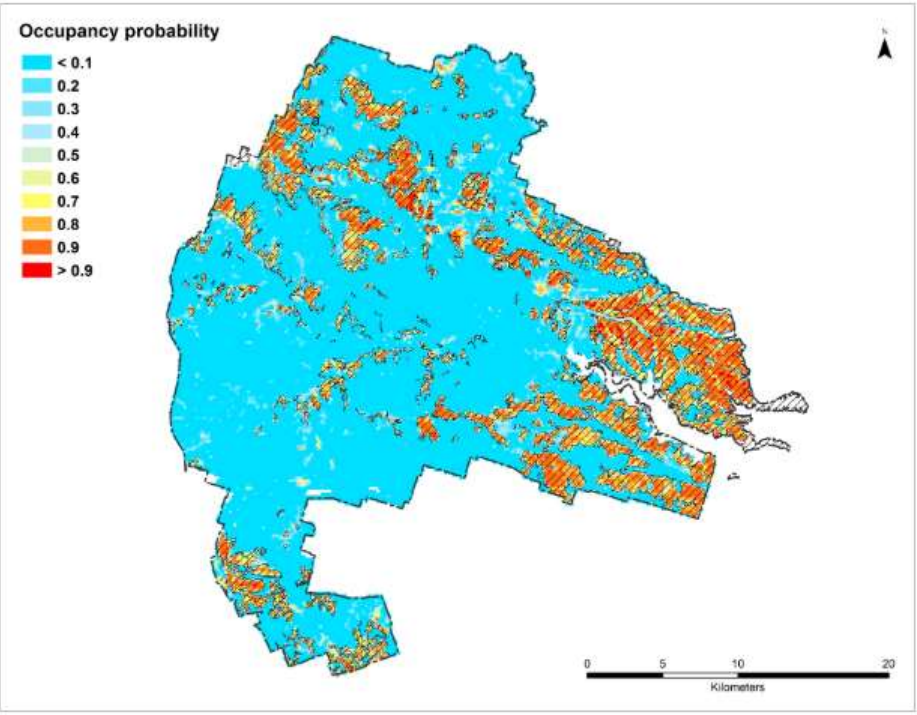
ECOSPHERE
AN ESA OPEN ACCESS JOURNAL

Article | Open Access

Using LiDAR-derived vegetation metrics for high-resolution, species distribution models for conservation planning

S. L. Farrell, B. A. Collier, K. L. Skow, A. M. Long, A. J. Campomizzi, M. L. Morrison, K. B. Hays, R. N. Wilkins

High-resolution LiDAR-derived metrics for vegetation height and canopy cover



Models without LiDAR-derived vegetation height and canopy cover estimates = lower model weight (ΔAICc > 50) than those models with LiDAR-derived metrics for canopy cover and height

Species Distribution Models

Response variable can also be acquired with remote sensing

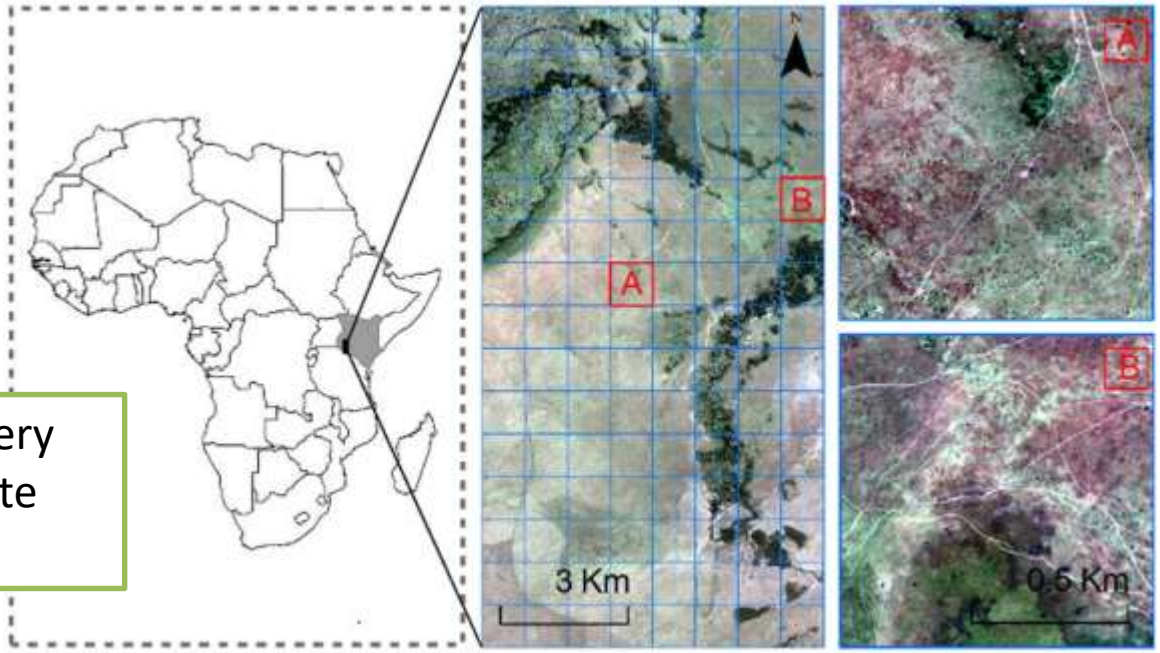
OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

Spotting East African Mammals in Open Savannah from Space

Zheng Yang, Tiejun Wang, Andrew K. Skidmore, Jan de Leeuw, Mohammed Y. Said, Jim Freer

Published: December 31, 2014 • https://doi.org/10.1371/journal.pone.0115989



Large mammals detected from very high-resolution GeoEye-1 satellite images

Species Distribution Models

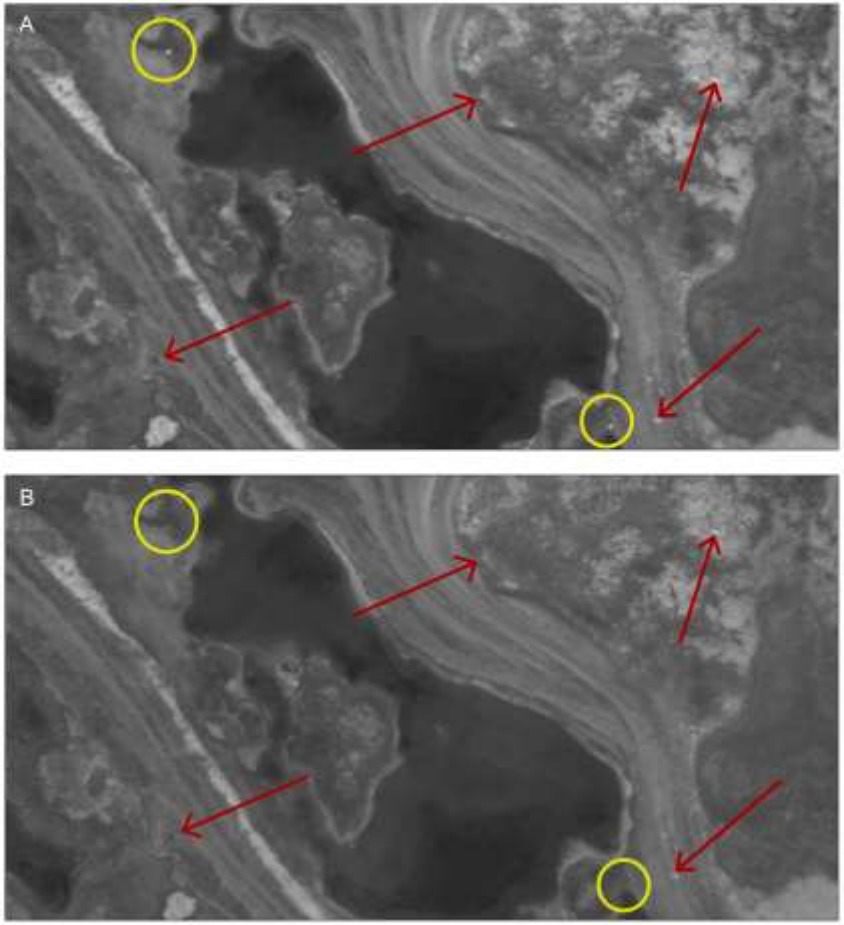
Response variable can also be acquired with remote sensing

OPEN ACCESS PEER-REVIEWED
RESEARCH ARTICLE

Polar Bears from Space: Assessing Satellite Imagery as a Tool to Track Arctic Wildlife

Seth Stapleton, Michelle LaRue, Nicolas Lecomte, Stephen Atkinson, David Garshelis, Claire Porter, Todd Atwood

Published: July 9, 2014 • https://doi.org/10.1371/journal.pone.0101513



WorldView-2 satellite, ~0.5 m resolution at nadir; Quickbird, 0.65 m resolution

Biodiversity conservation
&
Species habitat management

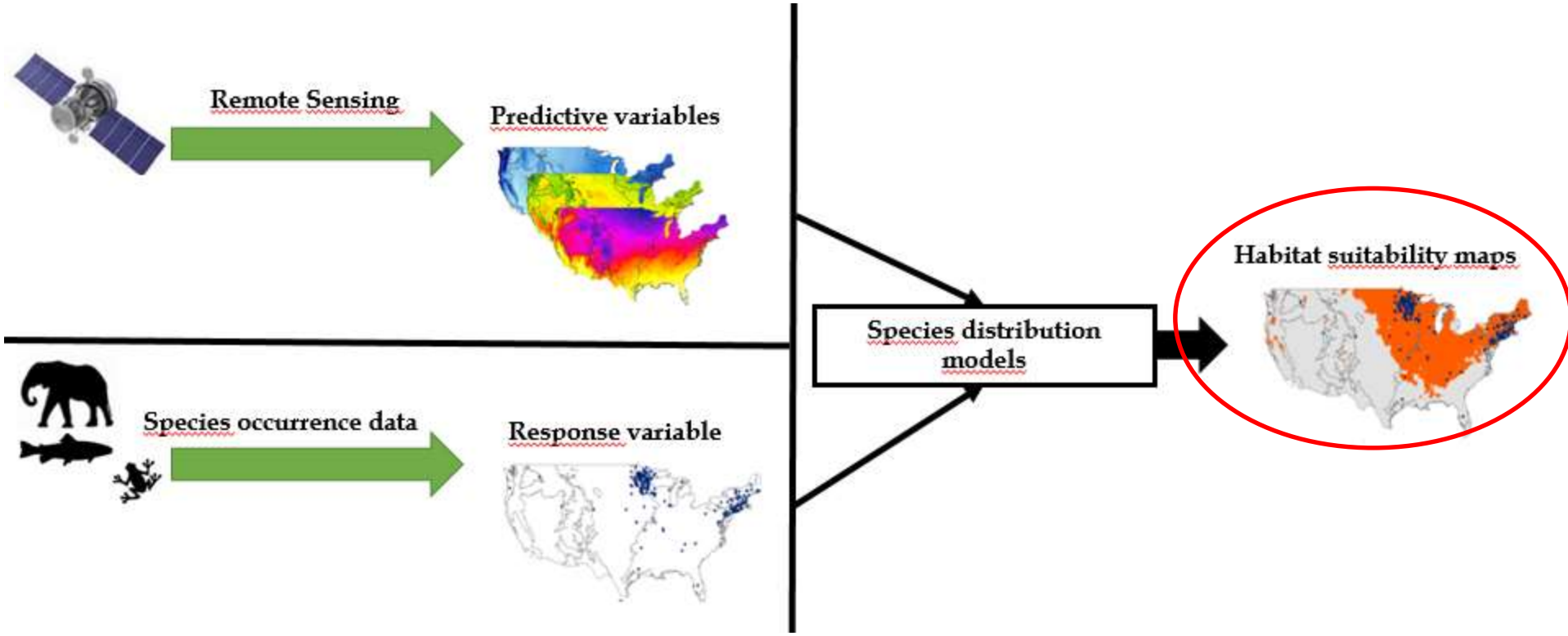
Le Roux et al. 2017

Species habitat suitability models combined with connectivity analyses for forest bats dwelling species

- ❑ Locate species,
- ❑ know their ecology,
- ❑ manage their habitats

Species Distribution Models

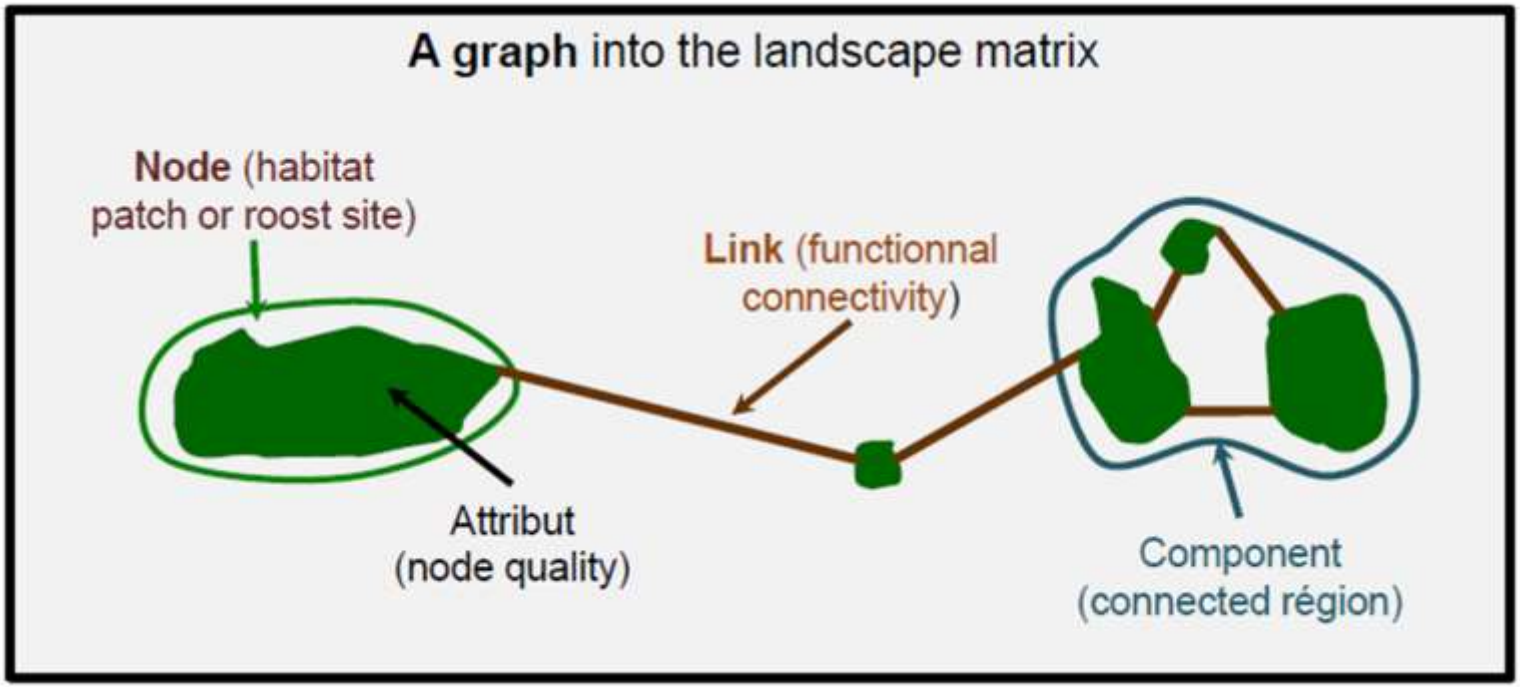
Required to study the relationship between species and their environment



Adapted from Briscoe Runquist et al. 2019

Species Distribution Models Feat. Connectivity analysis

Combining species distribution models and Connectivity analysis

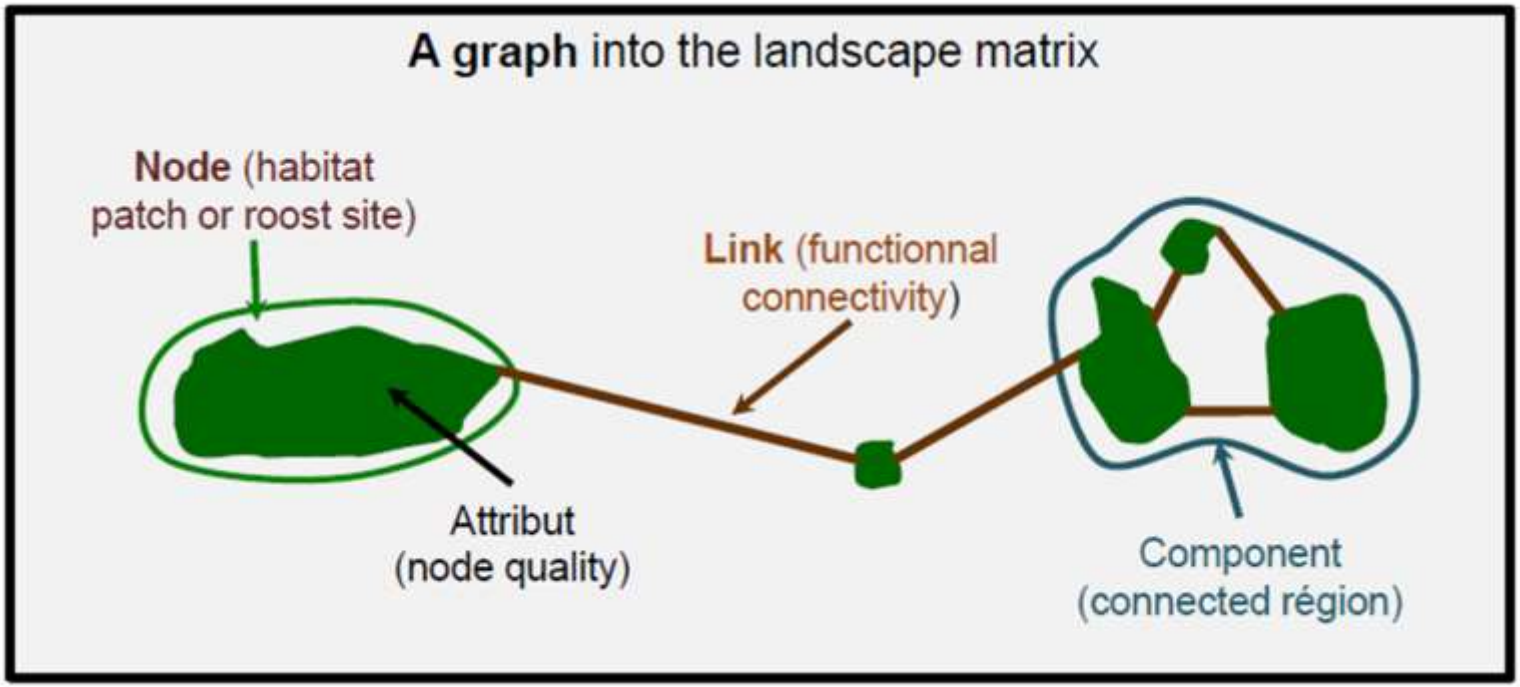


Nodes = suitable areas (from SDM) + occupied sites

From Le Roux et al. 2017

Species Distribution Models Feat. Connectivity analysis

Combining species distribution models and Connectivity analysis

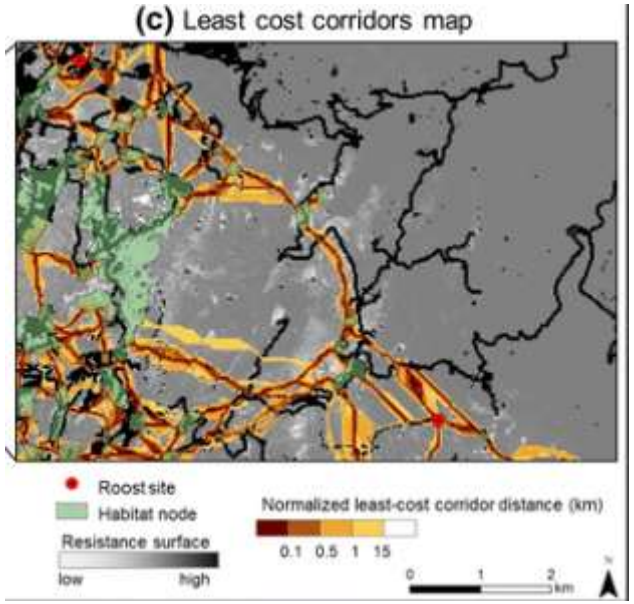


The **links** between nodes are evaluated by least-cost corridor analysis (CircuitScape, McRae et al. 2008)

From Le Roux et al. 2017

Species Distribution Models Feat. Connectivity analysis

Combining species distribution models and Connectivity analysis



Least-cost corridor analysis

Habitat suitability values → Resistance map

Resistance map → Weighted Distance map (real distance multiplied by resistance score) from each pixel on the map to the nearest node.

= Least-cost corridor identified between any pair of nodes

From Le Roux et al. 2017

Species Distribution Models Feat. Connectivity analysis

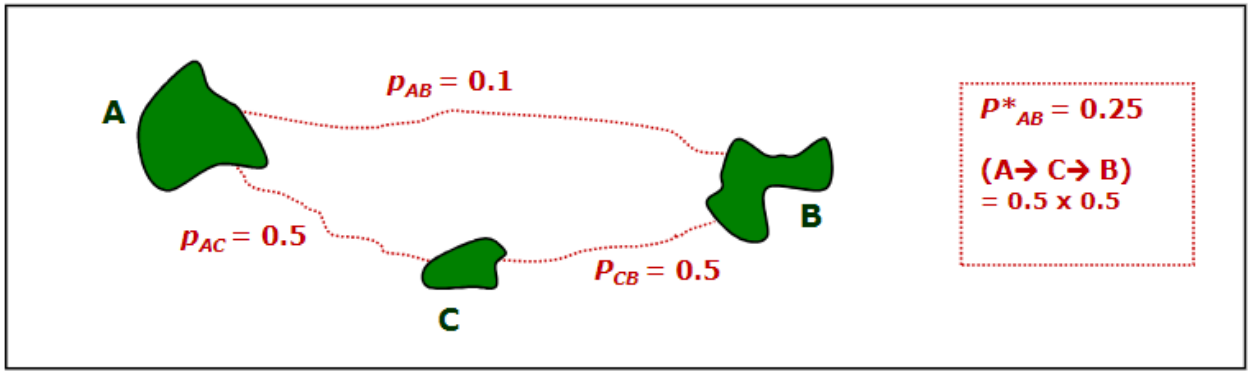
Combining species distribution models and Connectivity analysis

Node importance analysis (Conefor Sensinode)

WEIGHTED GRAPHS (Saura & Pascual-Hortal 2007)

Probability of Connectivity (PC)

$$PC = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} a_i \cdot a_j \cdot p^*_{ij}}{A_L^{\,2}}$$



a_i, a_j: patch attribute (area, habitat quality, etc.)

p^*_{ij}: maximum product probability

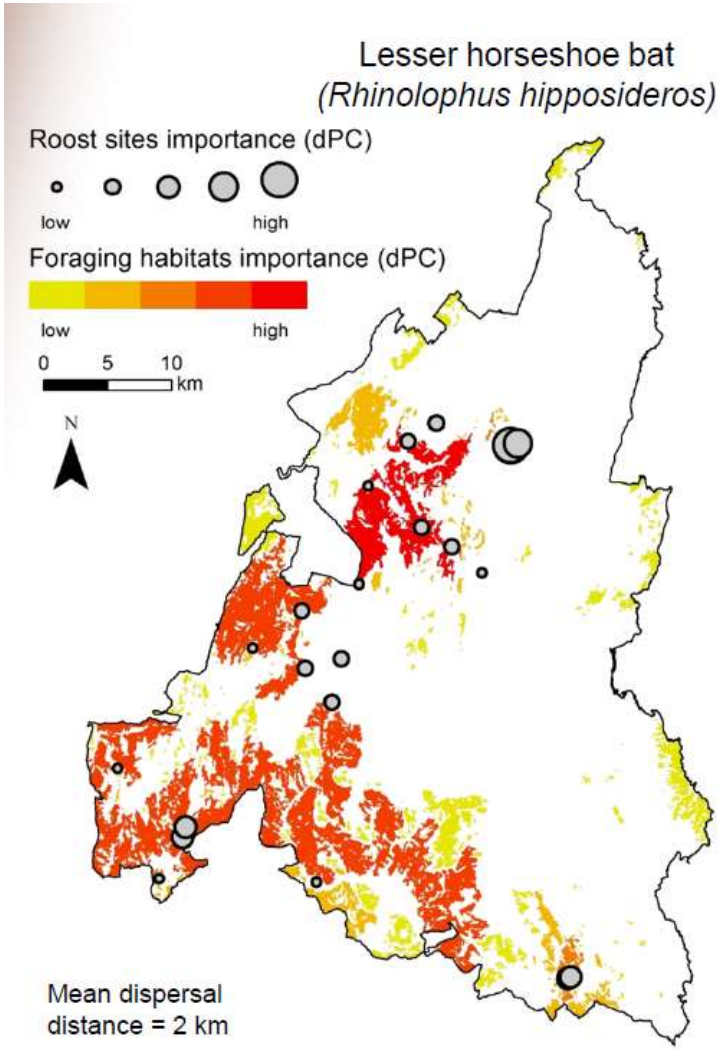
$p^*_{ij}=1$ when $i=j$, $p^*_{ij} \geq p_{ij}$

A_L: maximum landscape attribute

Species Distribution Models Feat. Connectivity analysis

Combining species distribution models and Connectivity analysis

Node importance analysis (Conefor Sensinode)



From Le Roux et al. 2017

Take Home Message

From a remote sensing point of view

From a sociological point of view

In Ecology, why promoting a single species with the rank of ambassodor for the entire biodiversity of a geographical area?....

Take Home Message

From a remote sensing point of view

From a sociological point of view

HYBRID MULTI-SPECIES DISTRIBUTION MODELS

In Ecology, why promoting a single species with the rank of ambassodor for the entire biodiversity of a geographical area?....


…Learning
to think *ecologically*
the relations, the landscape, the planning
R. Steiner