Spatial pattern analyses across Africa for a better understanding of biodiversity patterns using remote sensing

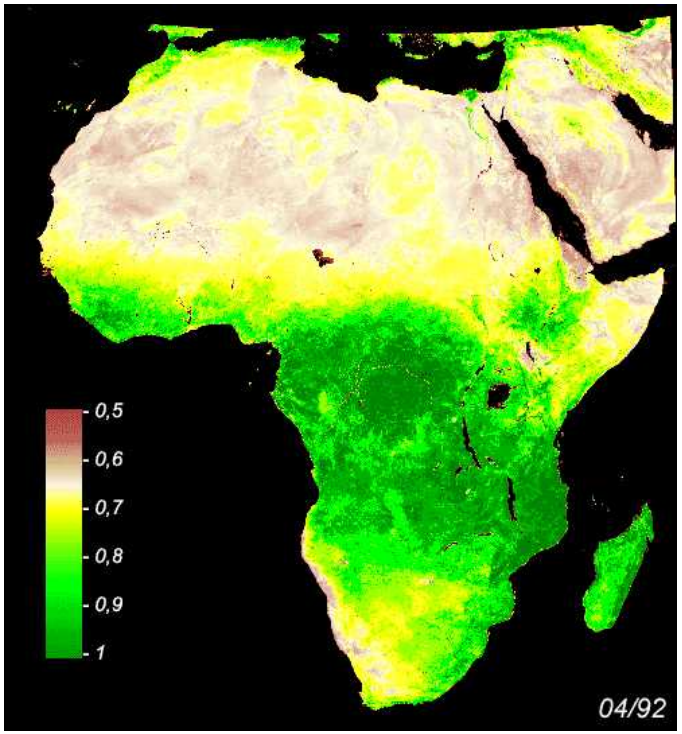
Wegmann, M., Magidi, J., Lung, T., Schaab, G., Krug, C., Knight R., Sommer, J. H., Sabellek, K., Fahr, J., Herkt, M., Barnikel, G., Penner, J., Rödel, M.-O., Keil, M., Landmann, T., Schmidt, M.

"Biodiversity of Africa - Observation and Sustainable Management for our Future!"
International Congress, 29 September – 3 October 2008, at Spier, RSA

Projektträger im DLR
Federal Ministry of Education and Research

Remote Sensing data

- temporal as well as spatial resolution improved, therefore:
  - improved discrimination of landcover through phenology (e.g. MODIS)
  - improved mapping of land cover change



NDVI time-series

Remote Sensing data

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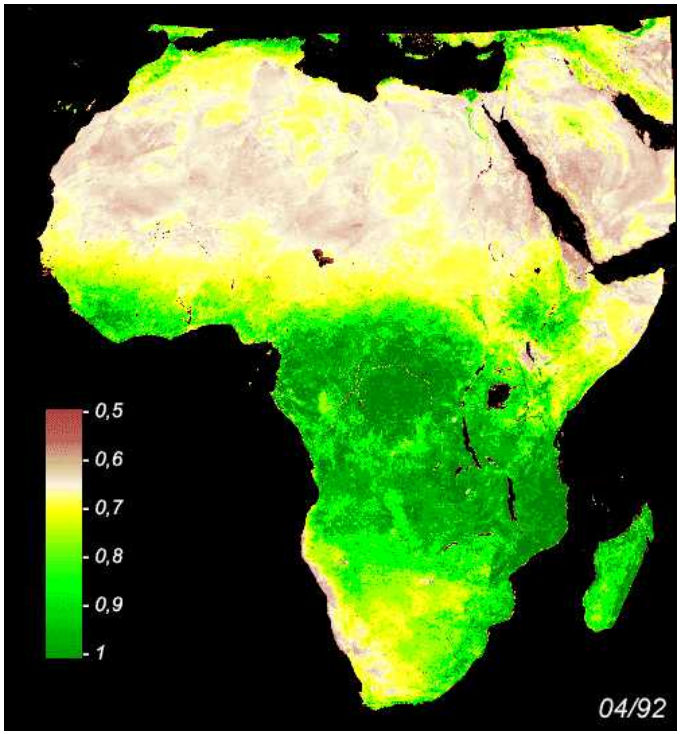
land cover maps → distribution of habitats

land cover change maps → dynamics of habitats for species

…but spatial attributes of the fragments provide further relevant ecological information on suitability of potential habitats

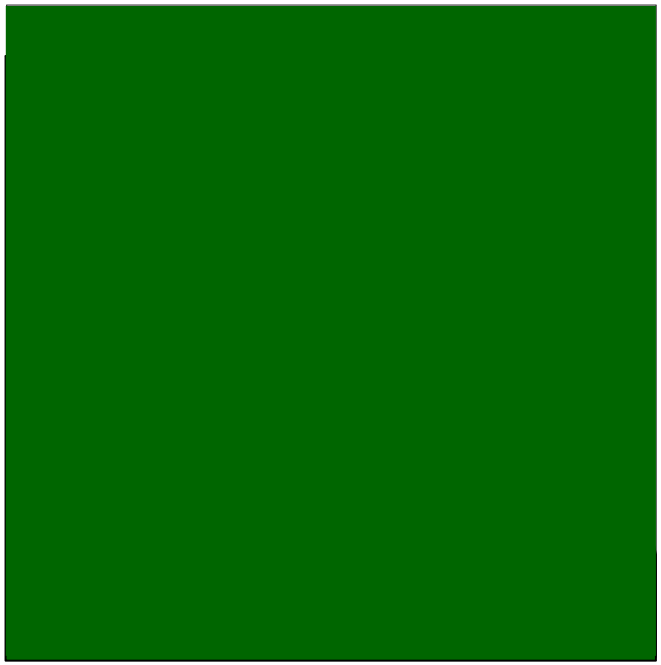
⇨ GMES, SEBI

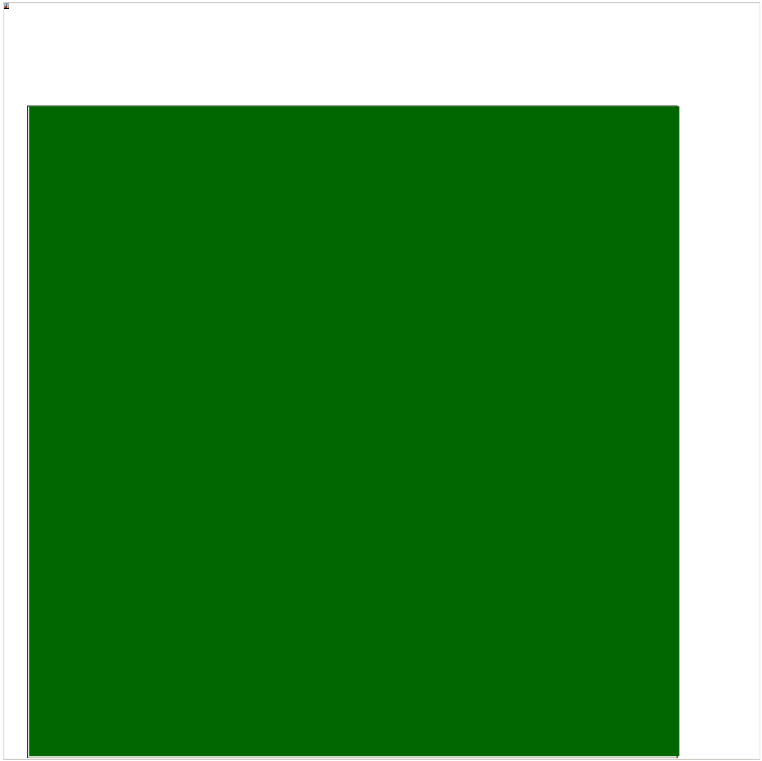


NDVI time-series

Spatial attributes

same **area** of landcover but different **spatial arrangement**





Spatial attributes

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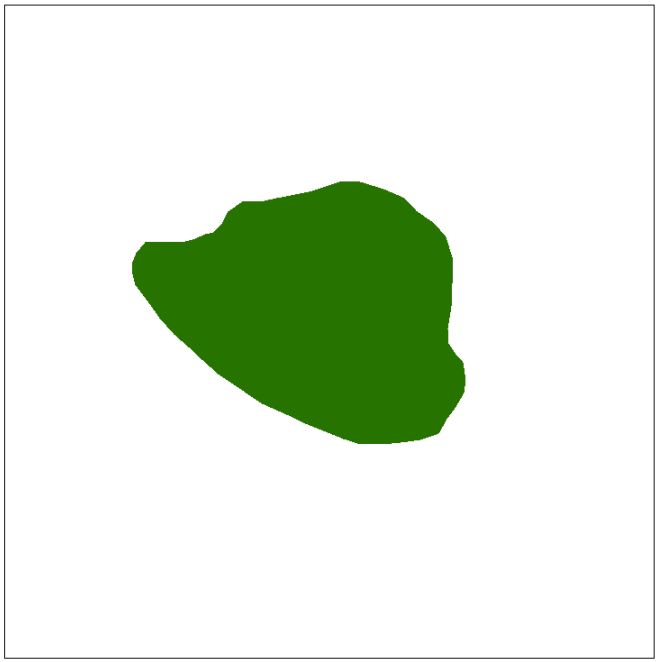
fragments might be inappropriate for a species:



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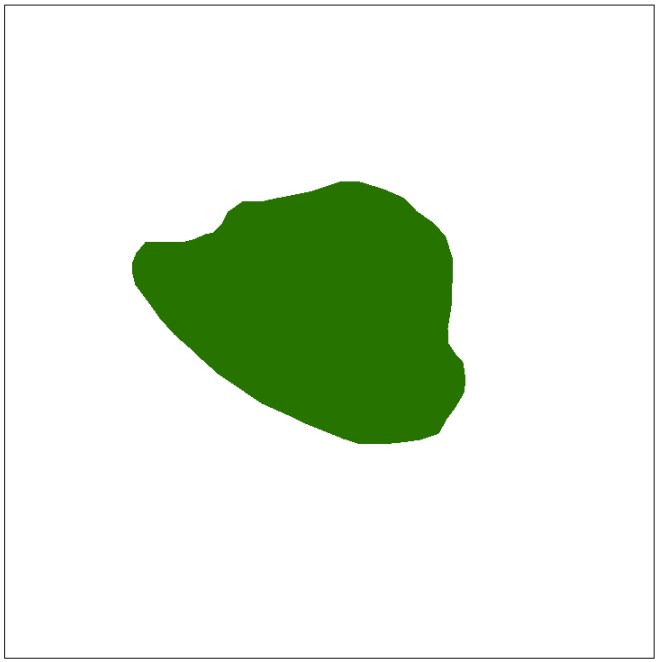

fragments might be inappropriate for a species:

- too small

Spatial attributes

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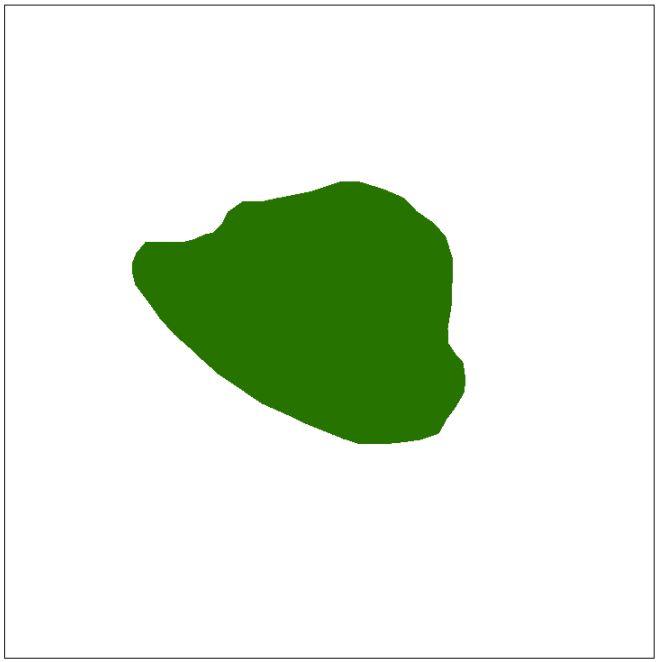
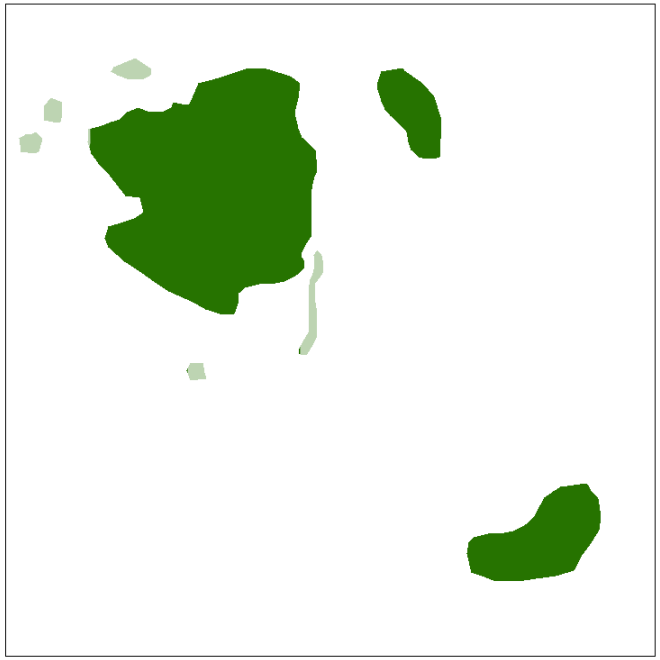


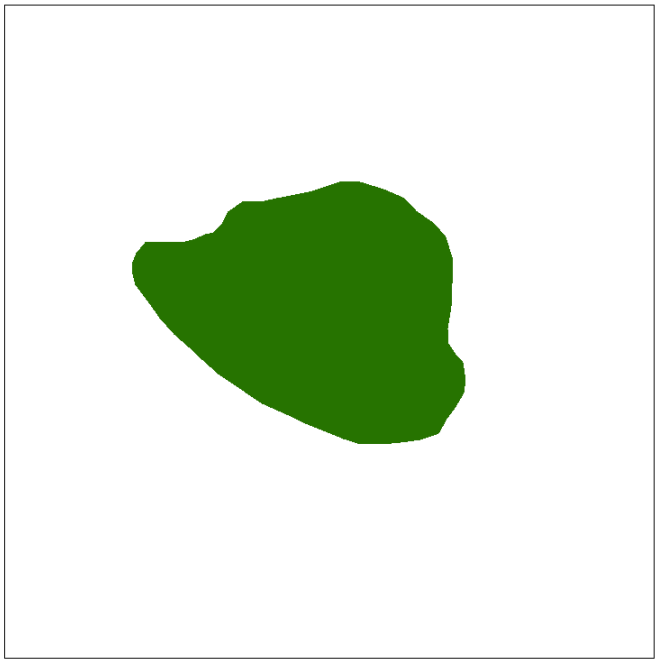
fragments might be inappropriate for a species:



- too small
- complex shape

Spatial attributes

same **area** of landcover but different **spatial arrangement**



fragments might be inappropriate for a species:

- too small
- complex shape
- too isolated

spatial attributes are important for land management and conservation planning

BIOLOG

Projektträger im DLR

Federal Ministry of Education and Research

Importance of spatial composition

Ecosystems need a minimum of spatial integrity to deliver their services:

- fragmentation results in e.g. smaller patch areas (e.g. edge effects) and decreased connectivity

  → altered species distribution & species communities

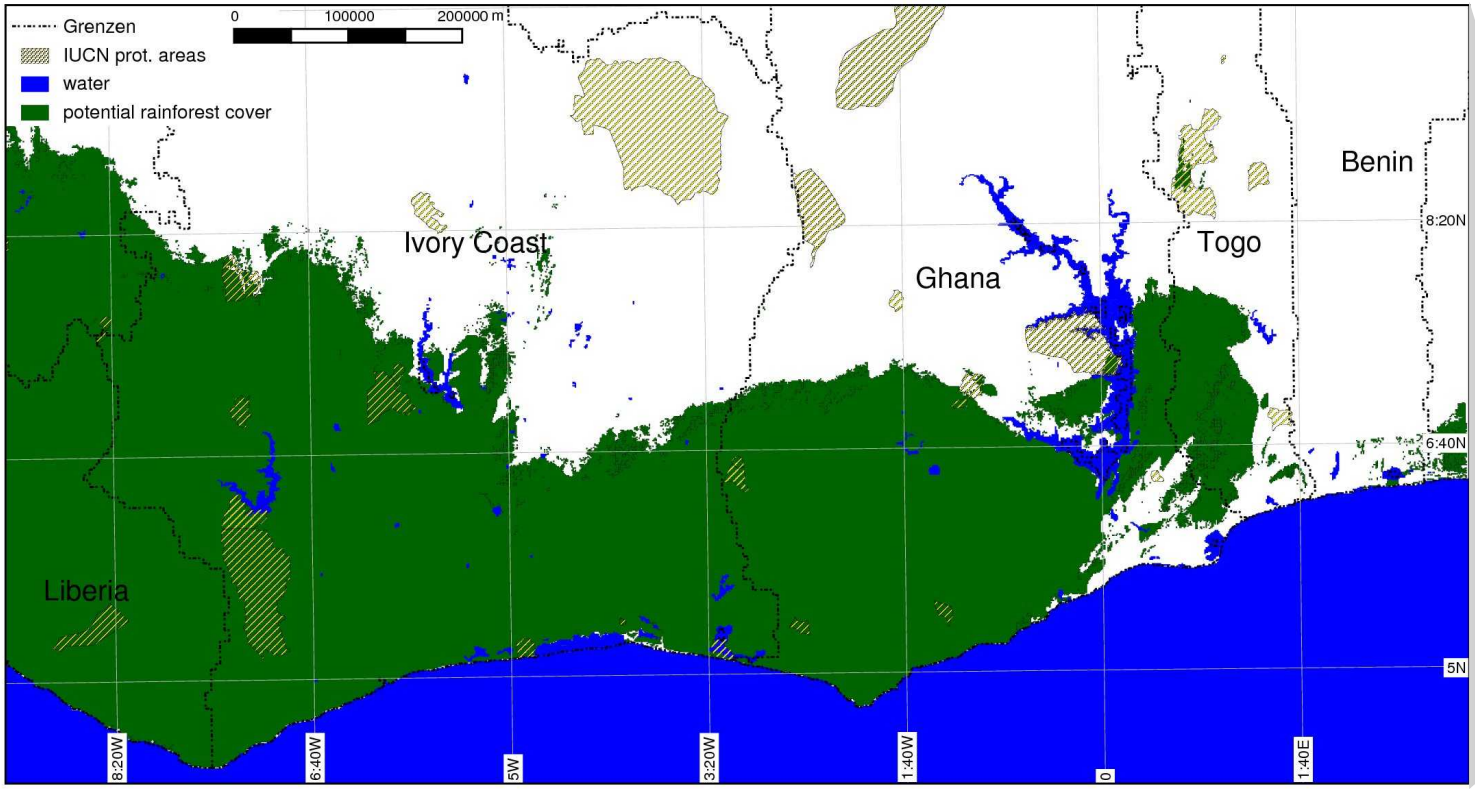
talk 1.4

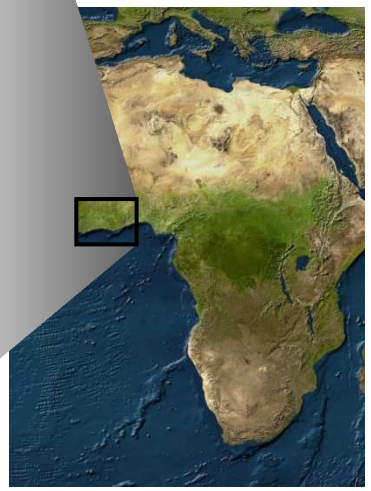
- spatial pattern analysis is essential for **species distribution models** and resulting suggestions for **protected area networks**

talk 3.3

Fragmentation of pristine areas

Potential forest distribution using a spatial prediction modelling approach with e.g. precipitation, temperature, soil and elevation data

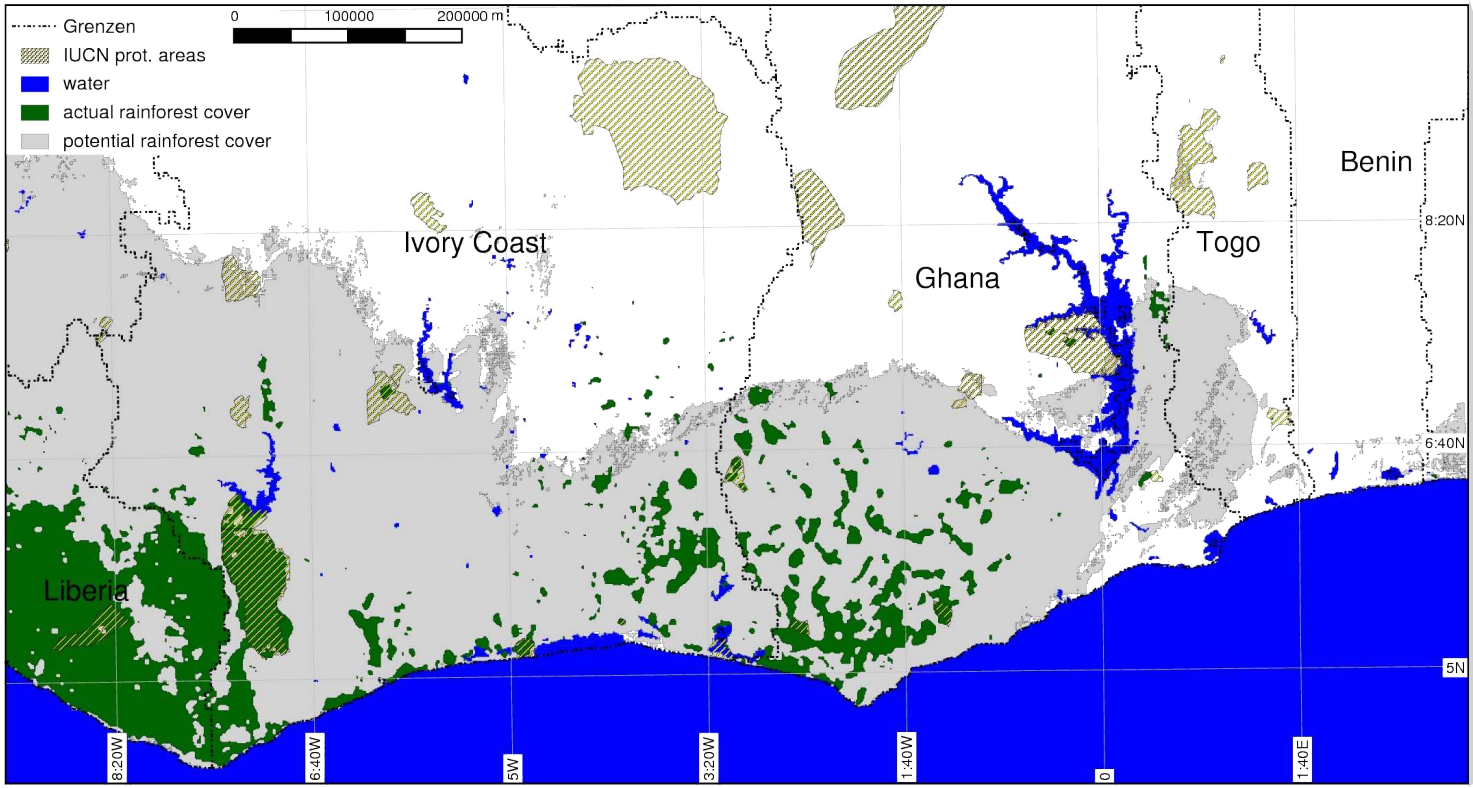


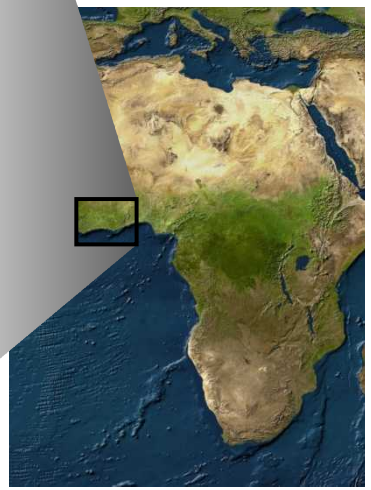


Maxent 3.0.1, 18 variables, n=1000

Fragmentation of pristine areas

Actual rainforest cover (MODIS, 2001-2006)
> 80% loss in rainforest cover; highly fragmented





Classification tree, MOD09 1000m, 2001-2006

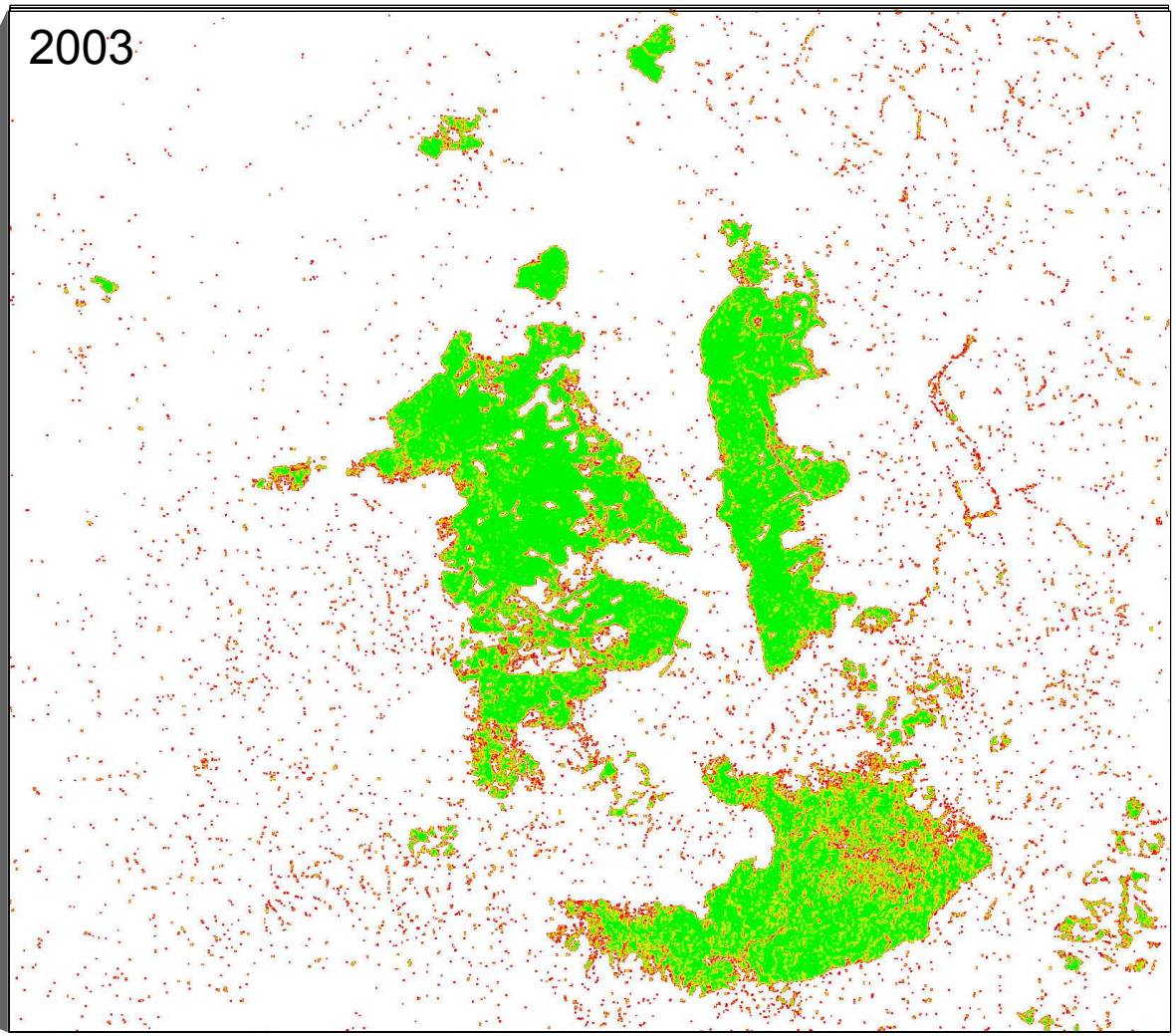
Fragmentation of pristine areas

Kakamega-Nandi Forests

→ 60% loss in natural forest cover since 1913

→ forest fragmentation

talk 2.3



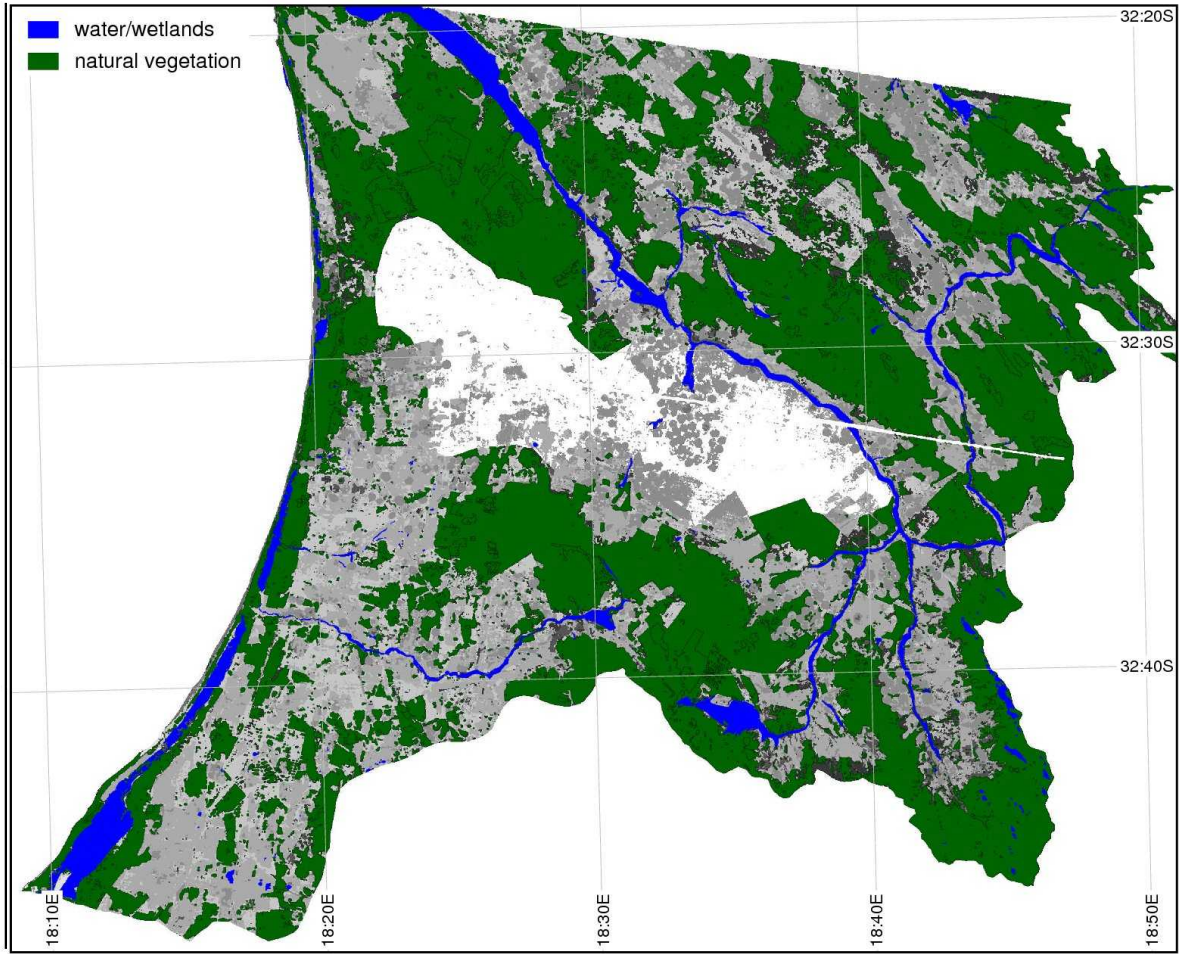
Aerial photography, Landsat MSS, (E)TM

Fragmentation of pristine areas

Sandveld (1990-2007)
→ Sand Fynbos and Strandveld

→ fragmentation

poster

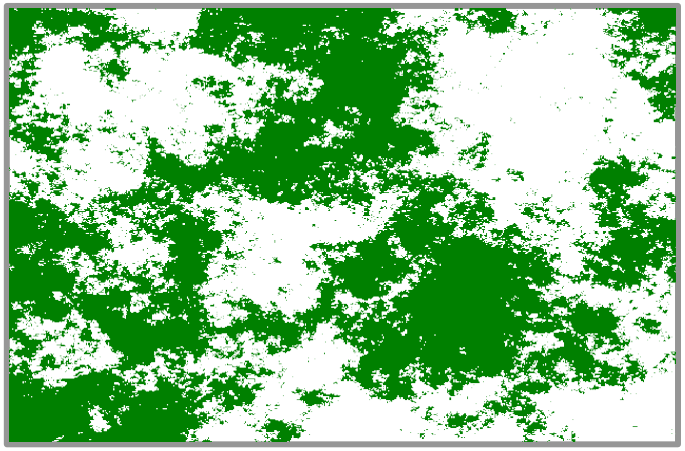


2007

Landsat MSS, (E)TM

Analysis of spatial patterns

Fragmentation of pristine areas



Patches: smaller, complex shapes, reduced connectivity

Analysis of spatial patterns

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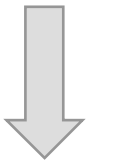

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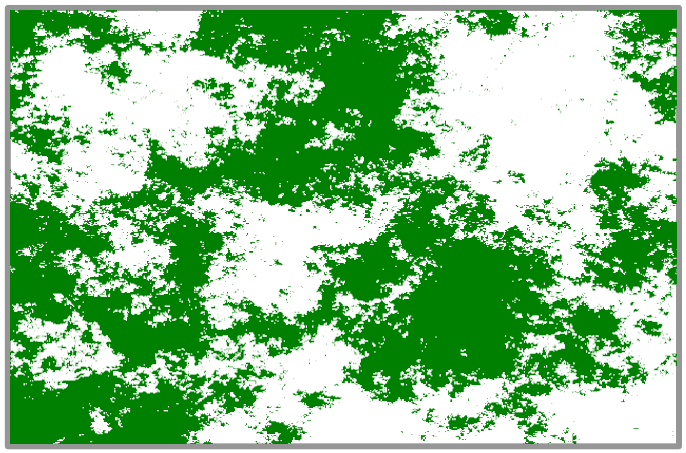
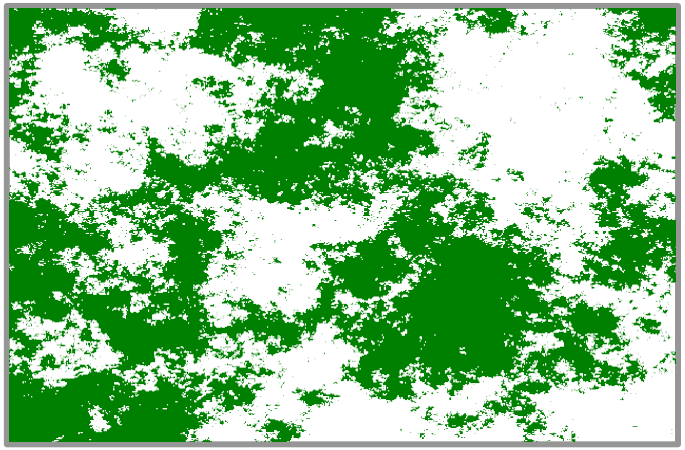


How to analyse spatial patterns with respect to ecological relevance?

Analysis of spatial patterns

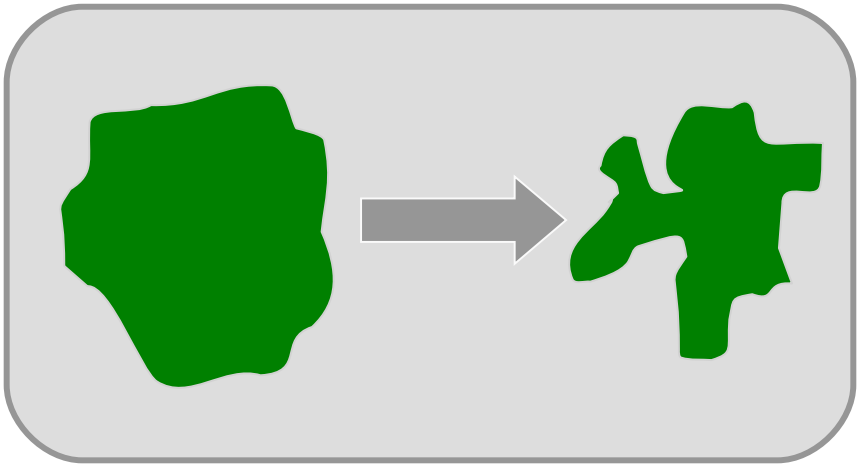
Fragmentation of pristine areas



Patches: smaller, complex shapes, reduced connectivity

indices

single patch: e.g. area, SHAPE



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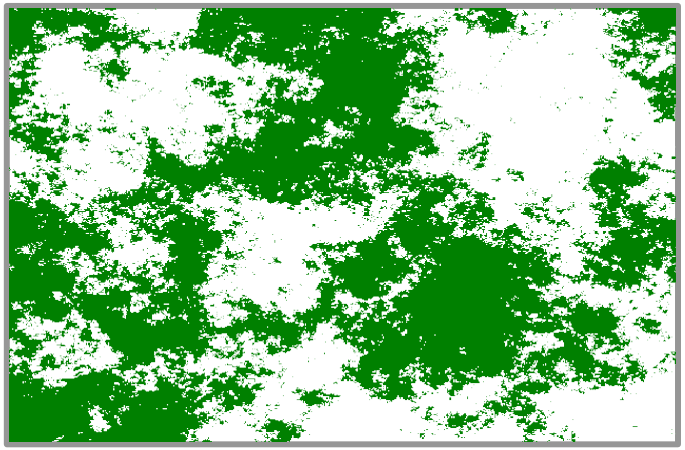

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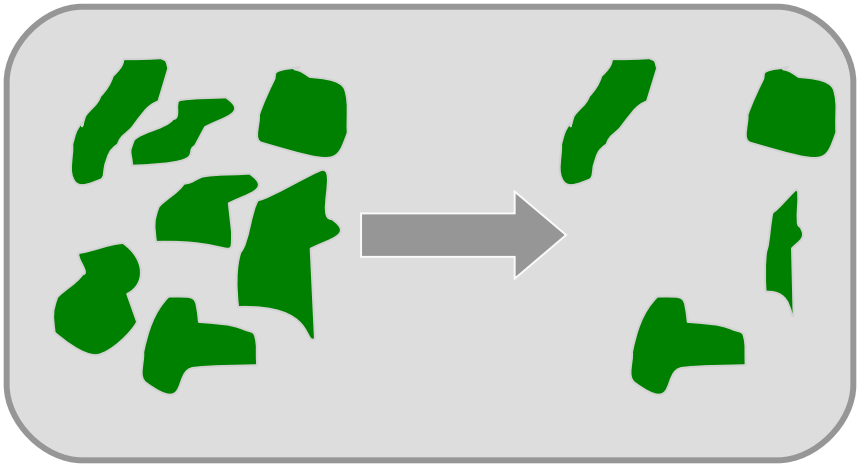

patch connectivity: e.g. distance between patches

In-house software development for spatial analysis

Various software packages serve the purpose to analyse spatial patterns (e.g. Fragstats)

- semi-automatic processing
- implemented in a GIS
- potential to modify/implement algorithms

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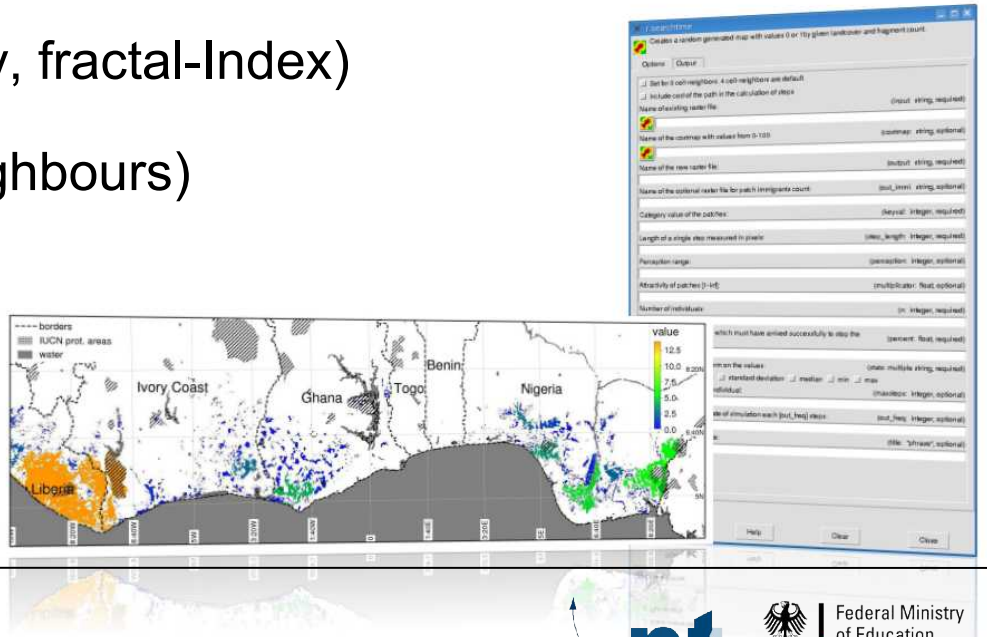
- basic analysis (SHAPE, asymmetry, fractal-Index)
- Connectivity analysis
    - k-ENN (Euklidean Nearest Neighbours)
    - Omnidirectional Connectivity



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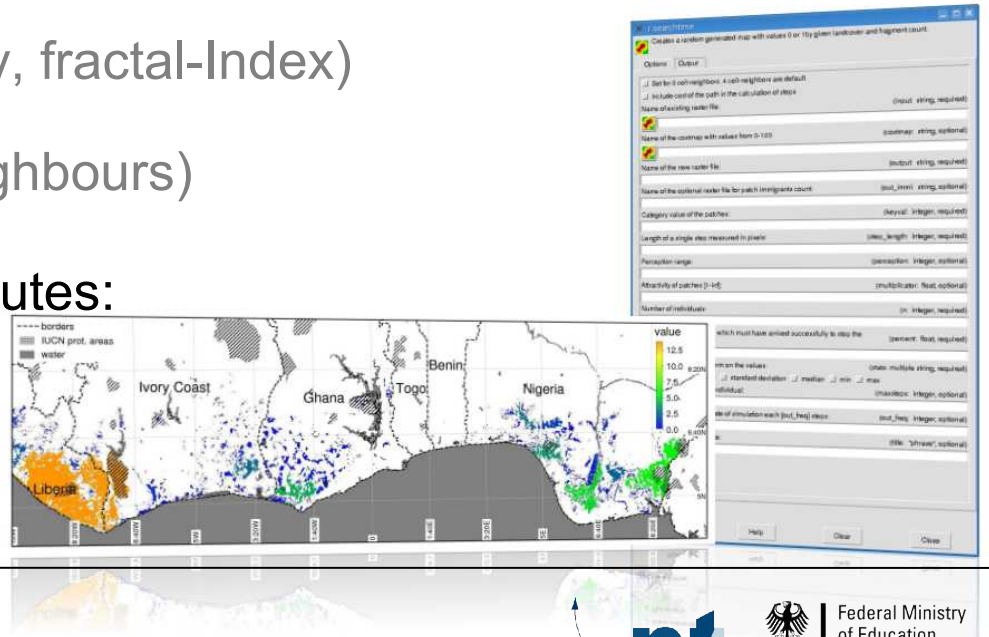
Considering the environmental attributes:

- k-FNN (Functional/ecological NN)
- individual-based metrics
    - (Im-)Migration
    - Searchtime



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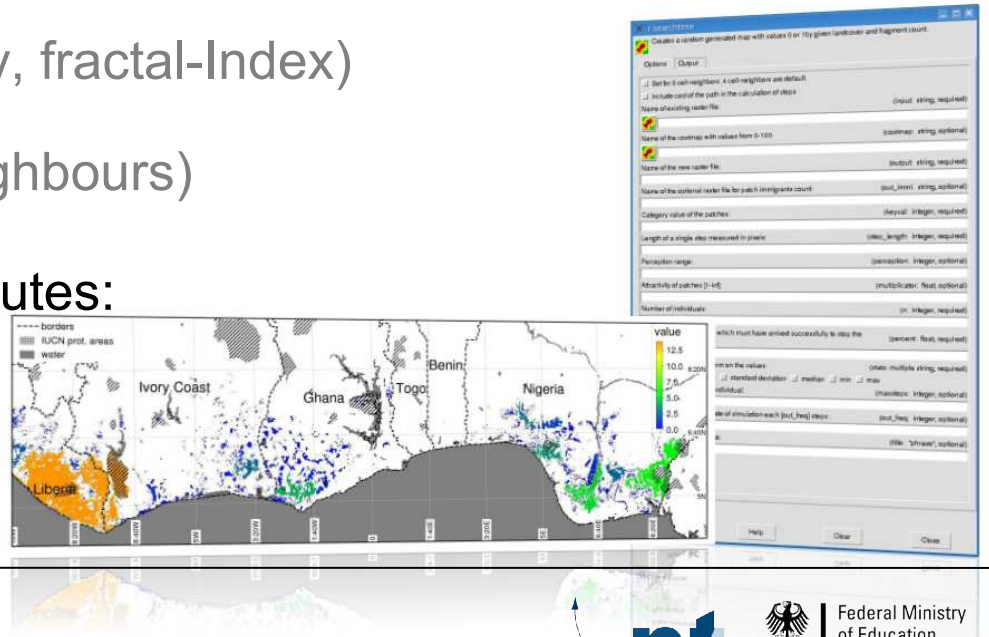
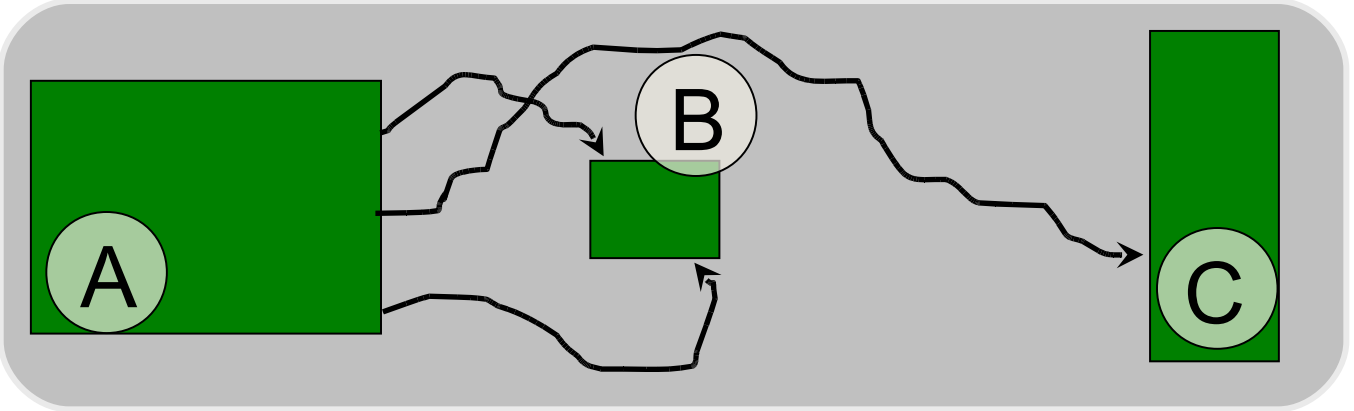
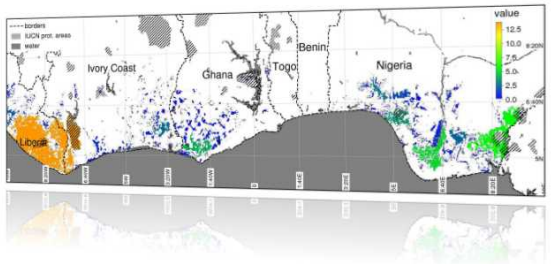


Connectivity: Searchtime

Influenced by:

- perception range
- attractiveness of patches





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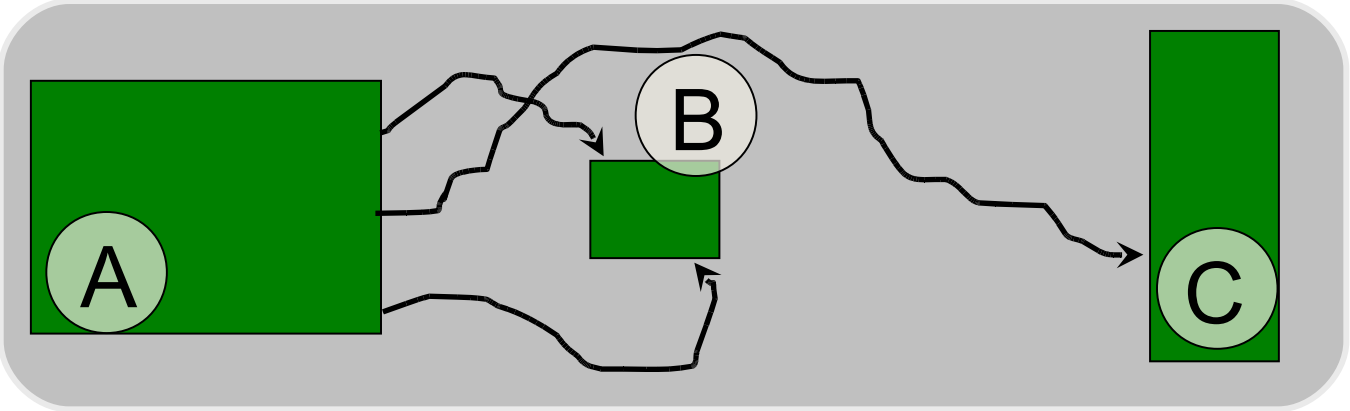
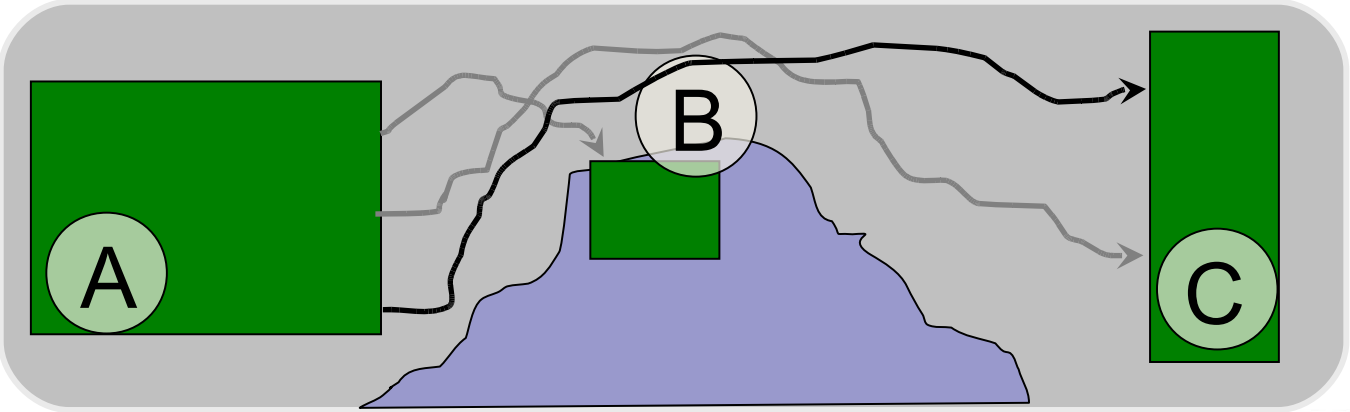
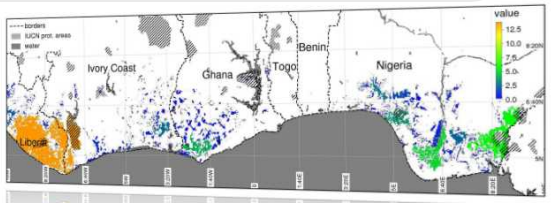


additionally:

- …
- env. suitability
- env. costs





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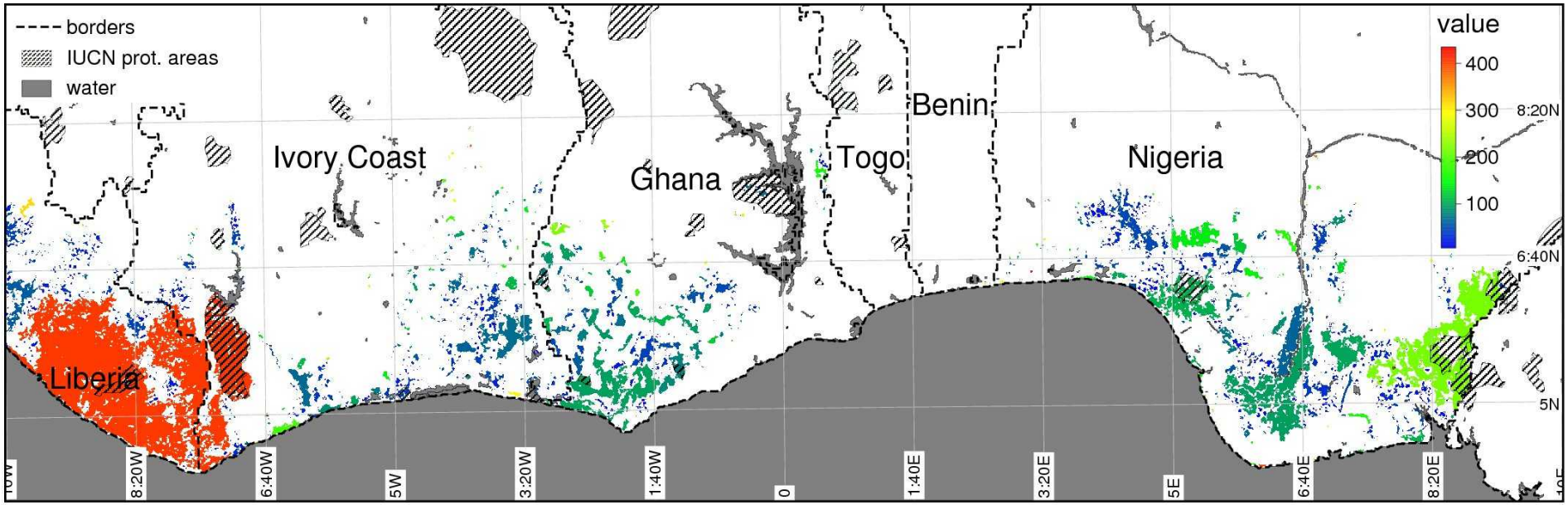
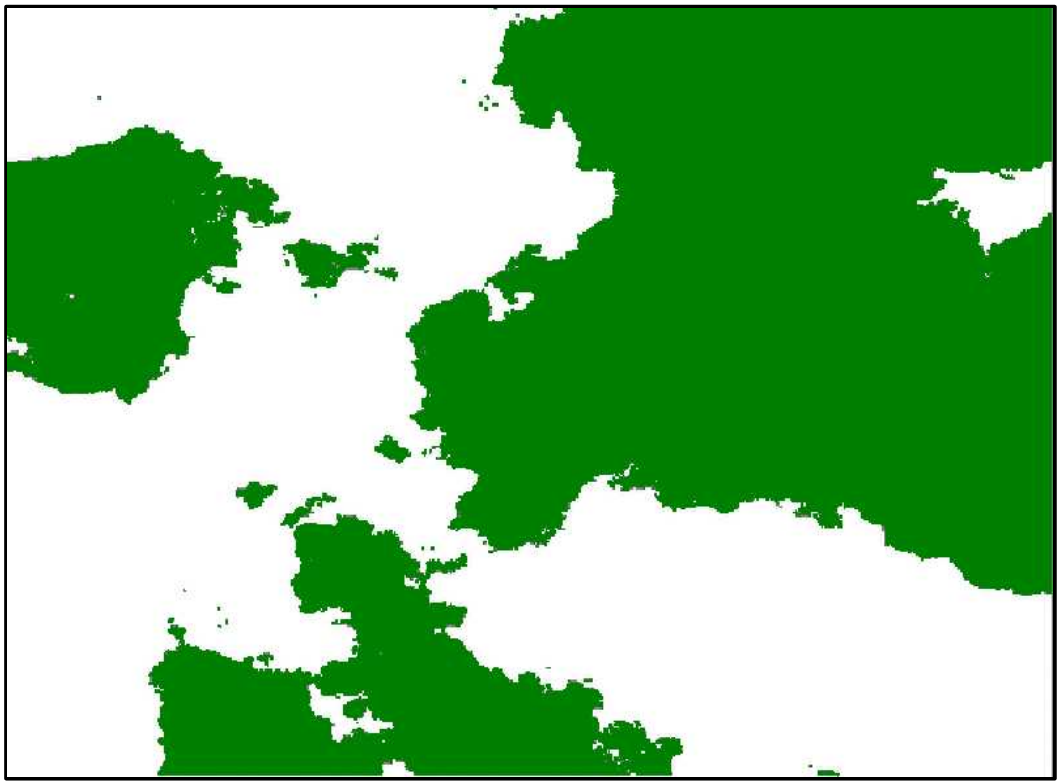


average Searchtime, individuals/patch=10000

Patch contribution to connectivity

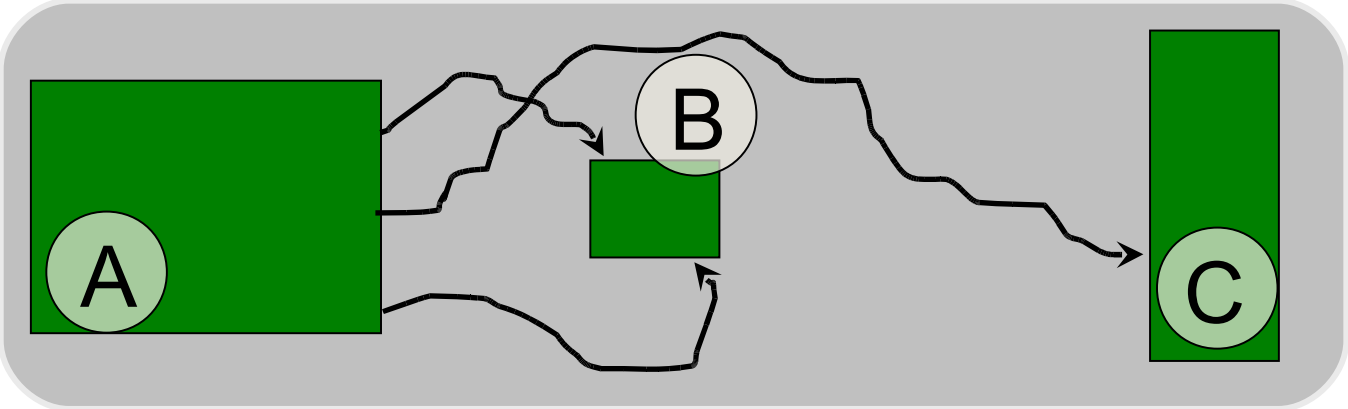
Iterative removal of patch *x* and assign differences of *searchtime* of all other patches.



Patch contribution to connectivity

Searchtime

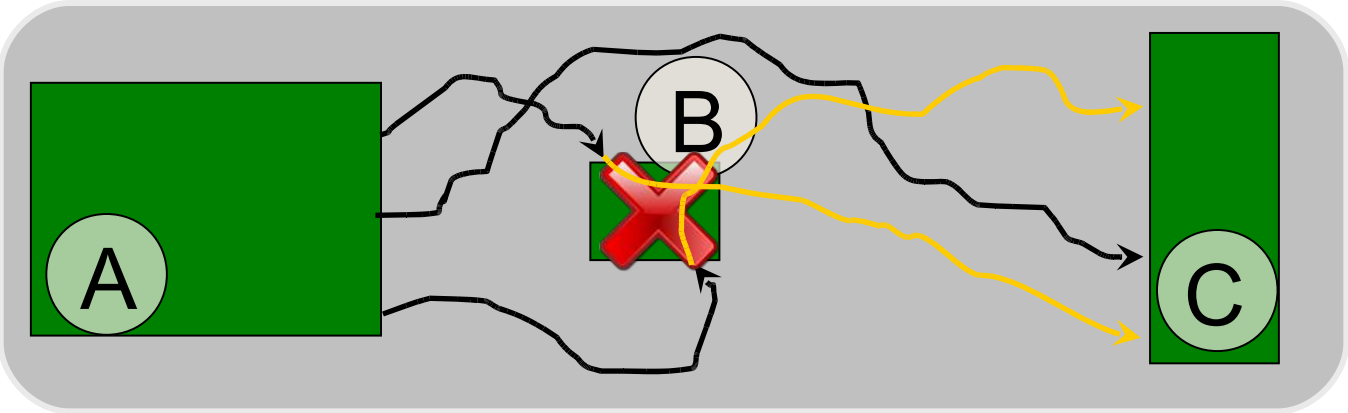
- with all patches in the landscape



Differences in searchtime after removal of patch B

Diff. in searchtime

- each patch iteratively removed from the landscape



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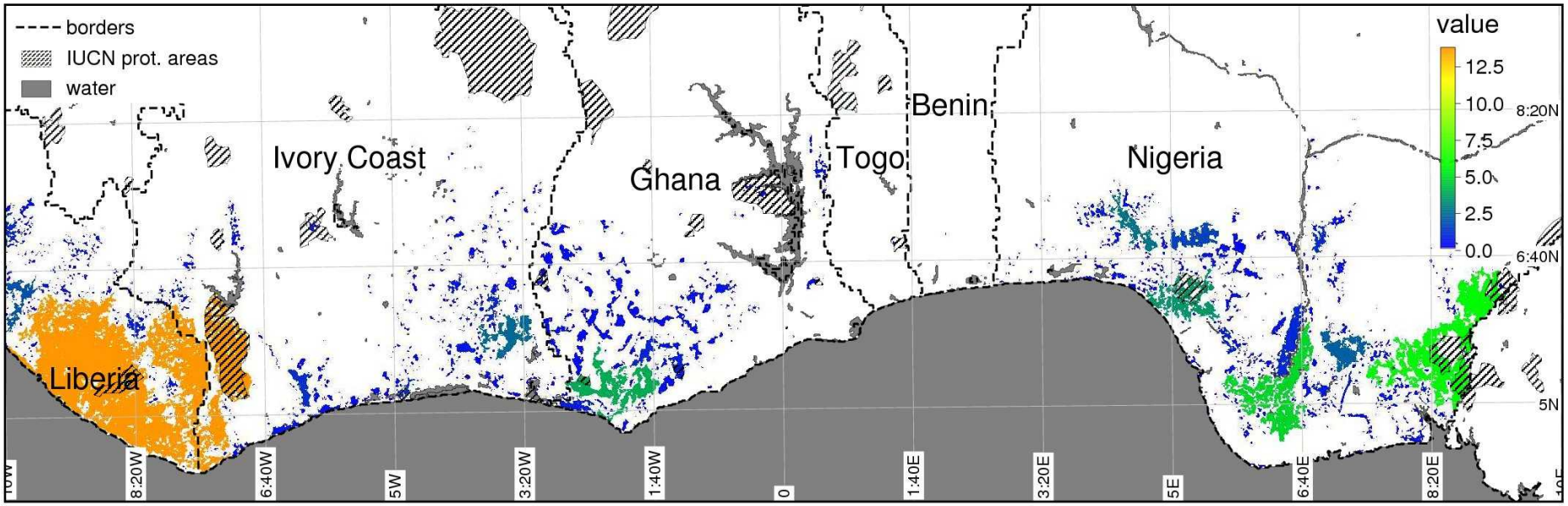

- small agglomerated rainforest remnants in West Africa contribute less to sustaining connectivity than larger patches but are nevertheless important

Differences in average Searchtime, individuals/patch=10000

Application & Outlook

- development of new spatial algorithms software (OpenSource)
- spatial pattern analysis created value for BIOTA
  - assessment of patch relevance for conservation planning
  - improvement in species distribution models (e.g. overestimation)…
  - usefulness of this analysis in South Africa and Mexico for conservation planning & resource management (SANBI, CONABIO)

... and beyond?

- the spatial analysis can be extended to a global biodiversity monitoring scheme using remote sensing in order to:
  - track near real-times spatial ecosystem changes
  - identify biodiversity threats through
    - increased edge effects
    - isolation of remnants etc.

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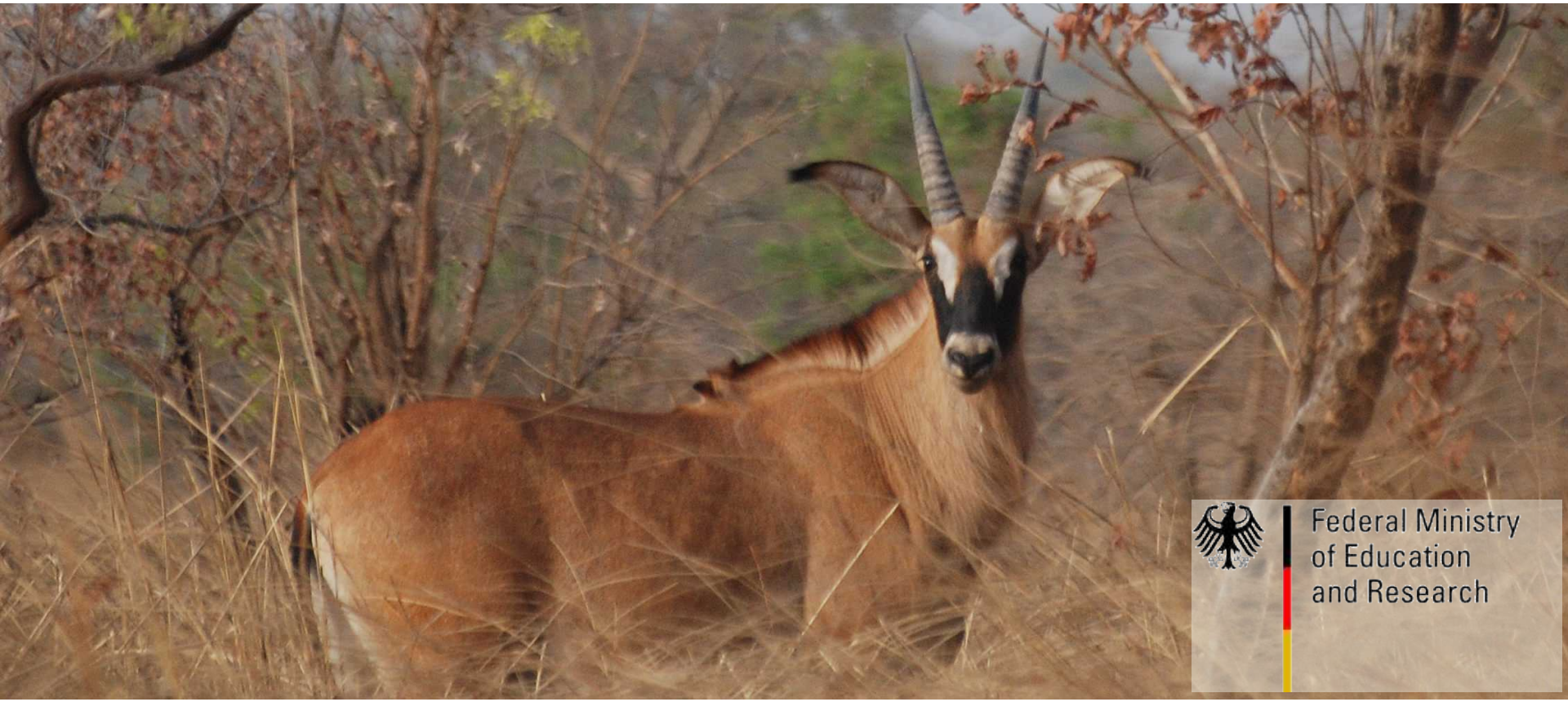
– the spatial analysis can be improved from being based on categorical landcover to continuous information about landcover like
  – fractional cover
  – quality of cover (e.g. degradation) 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