Landscape Metrics
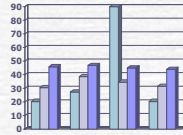
Quantitative Analysis of Landscape Structures

Motivation

biological ➡ DIVERSITY ⬅ landscape

✿ Bio-Diversity Convention 1992 Rio

"the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources."

Convention on
Biological Diversity

http://www.biodiv.org/

✿ Pan-European strategy for biological and landscape diversity

... innovative and proactive approach to stop and reverse the degradation of biological and landscape diversity values in Europe"

the Strategy Guide

http://www.strategyguide.org/

Development

- Quantitative description of ecological units
- Indices … since 70ies (PEET, PIELOU)
- Island Theory in Biogeography (MacARTHUR & WILSON)
- Dominance, Diversity, Area-Species Relationships
  ➡ *80ies*

Landscape Metrics

Explicit spatial views

- Composition vs. Configuration
- Patch context matters
  „ What happens within a patch is contingent on its location, relative to the structure of the surrounding mosaic ...." (WIENS)
- Patchiness – Patterns - Arrangement

Heterogeneous terminology …

- Landscape
- Heterogeneity
- Structure, Diversity
- Fragmentation

patch ecotope landscape element
land unit
patch size patchiness pattern
patch mosaic
landscape structure
landscape pattern
landscape context

diversity heterogeneity homogeneity
connectivity connectedness
ecotone
transition zone

## Patches & Patchiness

- **Patches**
  - area clearly separated from its environment
  - discrete, smallest homogeneous unit in a certain scale

- **Patchiness**
  - spatial heterogeneity aggregated from patches
  - hierachically organised mosaic
  - Within-patch-Heterogeneity ➜ Structure within patches, patchiness in finer scale
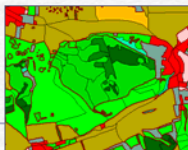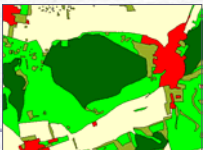
multiskalar multihierarchisch
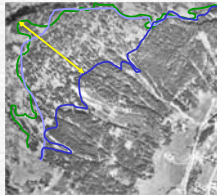
Multi-level analysis

- Patches
- Classes
- (Regions)
- Landscape

form metrics

configuration
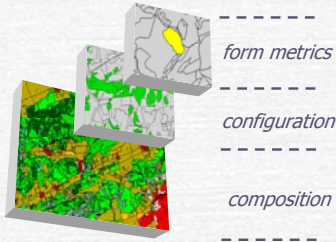
composition

‚Biases'

- Delineation and identification of Patches
- Study-Area Bias
- Thematic Resolution
- Geometric Resolution
- Formulas ☺

Landscape Composition
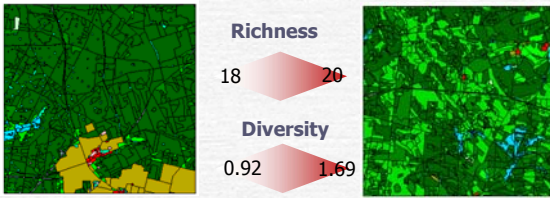
- Spatial diversity (HABER)
- Richness, Diversity, Dominance, Evenness
- Based on information theory

SHANNONs Diversity Index

$$= -\sum_{i=1}^{m} P_i \cdot \ln P_i$$

Dominance

$$= \ln m + \sum_{i=1}^{m} P_i \cdot \ln P_i$$

SHANNONs Evenness

$$= = \frac{-\sum_{i=1}^{m} P_i \cdot \ln P_i}{\ln m}$$

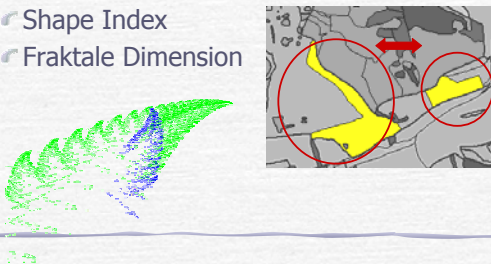## Landscape Composition

Depends on thematic resolution ...

Richness
18   20

Diversity
0.92   1.69

Landscape Composition

Depends on thematic resolution ...

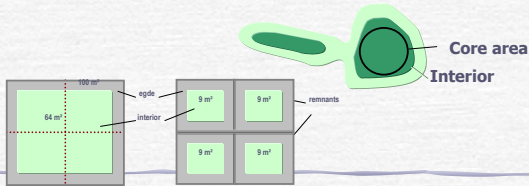**Richness**
7   7
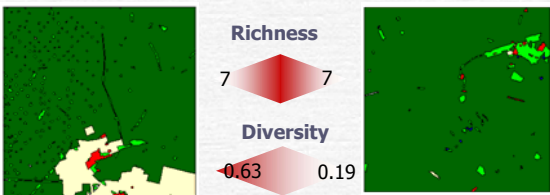
Diversity
-0.63   0.19

Patch Metrics
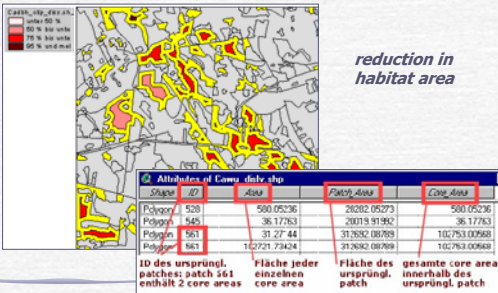
- Area metrics, Perimeter
- Shape Index
- Fraktale Dimension

Core Area Metrics

- edge-effect, transition zone, Ecotone
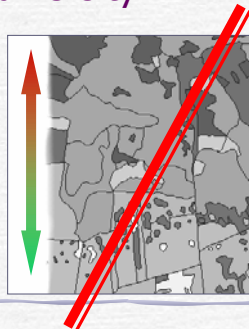- effective area for edge-sensitive species

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Core Area Metrics
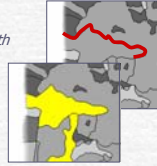

reduction in habitat area

Structural diversity

- Borderline density ➜ degree of linkage and connectedness
  .
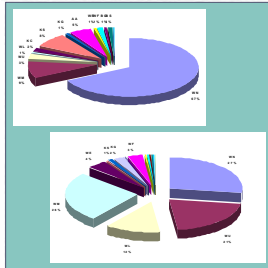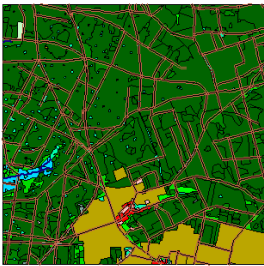- Fragmentation ➜ artificially increased

Edge Metrics

- Total Edge *(Total lenght of patch perimeter within classes)*
- Edge Density *(Total lenght of patch perimeter within study area, normalized by acre)*
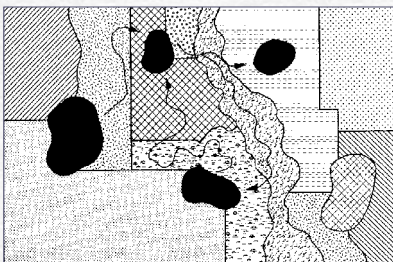- Mean Patch Edge *(mean perimeter length per patch)*

Edge Metrics

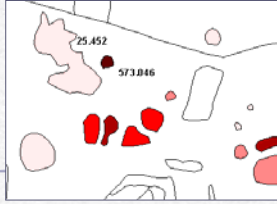Alternative: look at fractal dimensions

Meta population theory

Distance based indices - Proximity

- Proximity Index: area weighted distance ➔ several variants
  - ...measures both the degree of patch isolation and the degree of fragmentation" (MacGARIAGAL & MARKS)
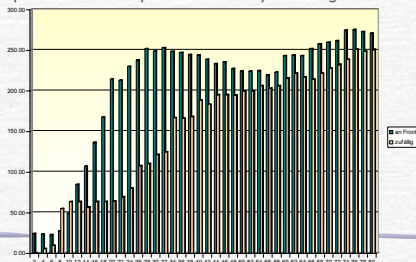- Based on Index by WHITCOMB (1981) *Interaction Among Patches*

$$\Sigma\ S\ /\ z^2$$

Proximity Index – Proximity Buffer

PB

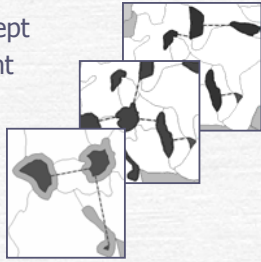## Proximity Index – Modelling

- Stability of habitat distribution
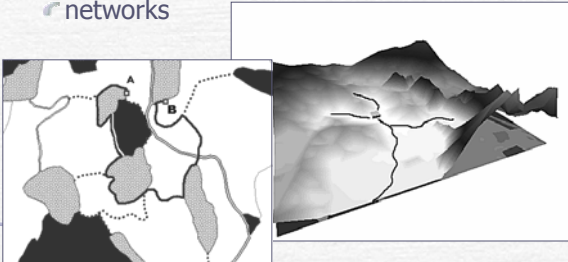 - ➔ stepwise removal of patches randomly vs. along one front

Euclidean distance metrics

- stepping-stone concept
- perception dependent

Non-euclidean distance metrics

- cost surfaces ('landscape resistance')
- networks

Software

- FRAGSTATS (MacGARIGAL & MARKS)
- Fragstats Arc*
- Patch Analyst (REMPEL)
- Habitat Analyst (REMPLE)
- RULE (GARDNER)
- Animal Movement (USGS)
- ClaraT (MILNE)
- LEAP II