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Water-use related ecosystem impacts: Comparing different indicators on global scale

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Aral Sea; Source: Wikipedia

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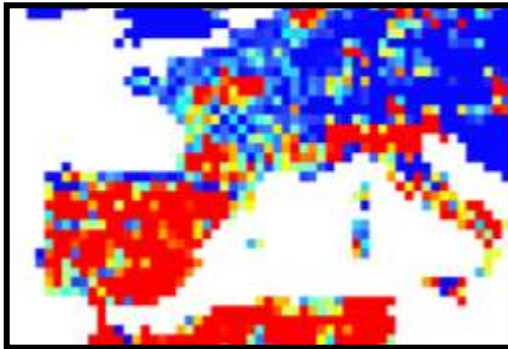Environmental Engineering

Content

- Level of regionalisation on global scale

- LCA and ecosystems

    - Land use, ecotoxicity, eutrophication, acidification

    - **Water use**

- Statistical analysis of different indicator on global scale

- Quantification of impact on ecosystems

- Discussion & Outlook

Modelling water use – level of regionalisation

- **Global GIS resolutions**

0.5° Grid	Watershed	Country

- **Methodology**
  - Combine data available for different resolutions
  - Derive important factors for assessment

→ Aggragate on watershed level

A glance at Land Use

- Biodiversity

  – Plant species

  – Reference state versus use phase

- NPP (net primary productivity)

  – Agricultural production often increases NPP

  – fNPP (NPP left in nature after extraction of products)

- Erosion

  – Potentially positive effect of water use (depends on situation)

Other impacts

- Ecotoxicity: Impact on set of indicator species

- Freshwater eutrophication: Impact on macrofauna as a whole

- Acidification: plant species in forest ecosystems

Water consumption

- Local impact on:
  - Wetlands
  - River / lakes including shores
  - Groundwater dependant vegetation

- Regional effect on
  - Vertebrates
    - Birds
    - Fish

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Measures for impact on ecosystem quality (EQ)

- Impact on NPP (g C / m^3)
- Impact on Biodiversity (PDF*m^2*yr / m^3)
  - Plants
  - Vertebrates
  - Birds
  - Fish
  - Molluscs
- Impact on ecosystems as whole ("collapse measure" / m^3)

New Zealand, North island

- High NPP
- High threatened bird BD
- Moderate plant BD,
- Low vertebrate BD

http://en.wikipedia.org/wiki/Image:New-zealand-tararuas-clem-creek-waiohine-river.jpg

Savanna, northern Tanzania

- High vertebrate BD
- High threatened bird BD,
- Moderate NPP,
- Low Plant BD

http://en.wikipedia.org/wiki/Image:Lions_Ngorongoro.jpg

East Tajikistan
(Pamir mountains, kuhistoni badakhshon)

- High plant BD
- Low NPP
- Low vertebrate BD
- Low threatened bird BD

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Comparability

- Which of the cases has higher EQ?

- What impact on EQ shall we assess in LCA ?
  - Water use
  - Other impact categories

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Applicability in regionalised LCA

- Global data availability

- Quality & uncertainty of data
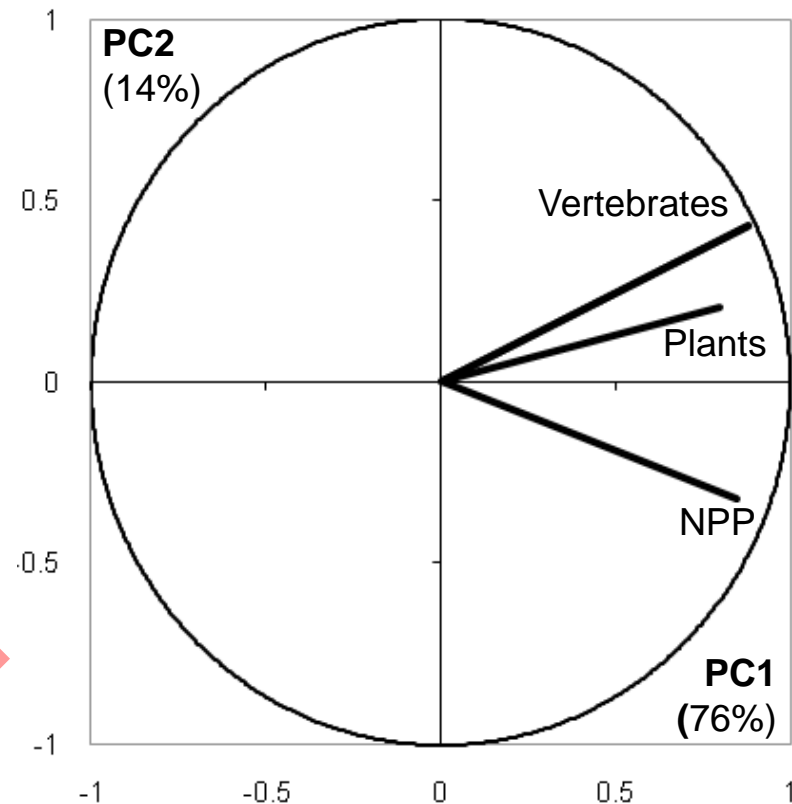
➡ Feasible for plant BD, NPP and vertebrate BD

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Comparison on global scale

- Pearson correlations between plant BD, NPP and vertebrate BD on global grid:
  - R-factors of ~0.6 for each couple (N = 62'696)

- Can a single indicator be used?

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Principal Component Analysis (PCA)

- Transformation from original indicator to Principal Components (PC) and explained variance

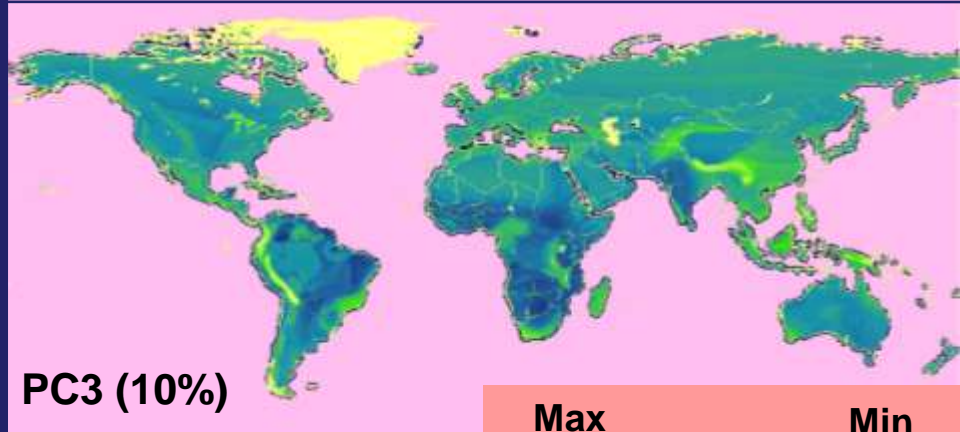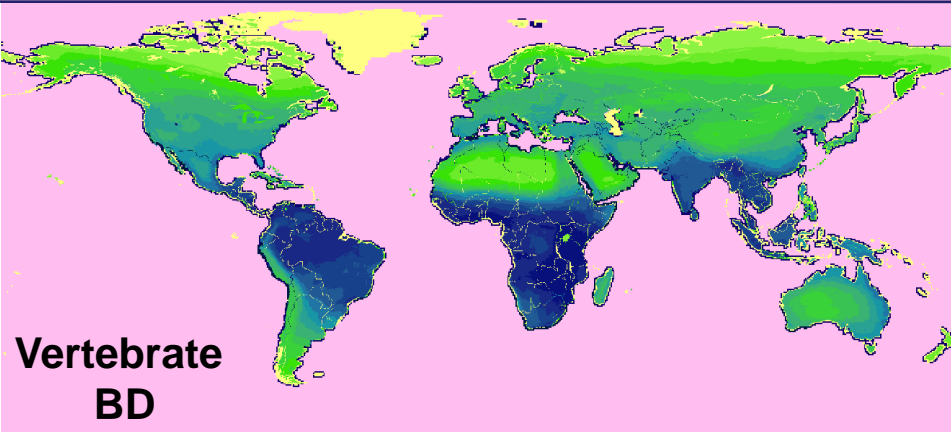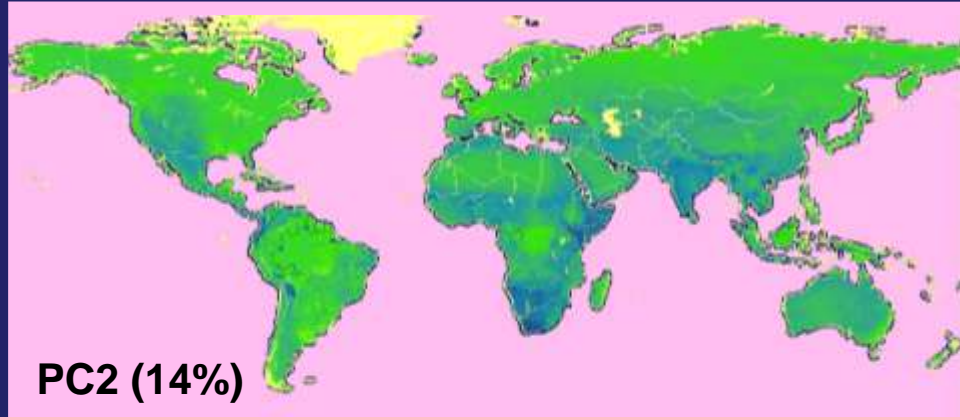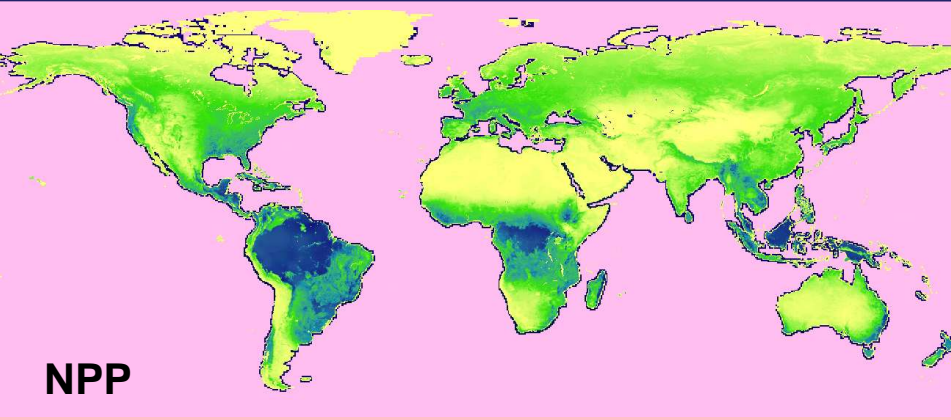|	PC1 (76%)	PC2 (14%)	PC3 (10%)
Plant BD	0.437	0.227	-0.870
NPP	0.663	-0.736	0.141
Vertebrate BD	0.608	0.638	0.472

- Factor loading (contribution of original indicator to PC)

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What does this result mean?

- PC1 should be the single indicator based on PCA-results
  - Is that credible?
  - What is the unit of the PC?

➡ comparison of plant BD, NPP and vertebrate BD on global map

➡ Calculation of principal components (PC#) for each grid cell (0.5°)

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Plant BD

PC1 (76%)

NPP

PC2 (14%)

Vertebrate BD

PC3 (10%)

Max   Min
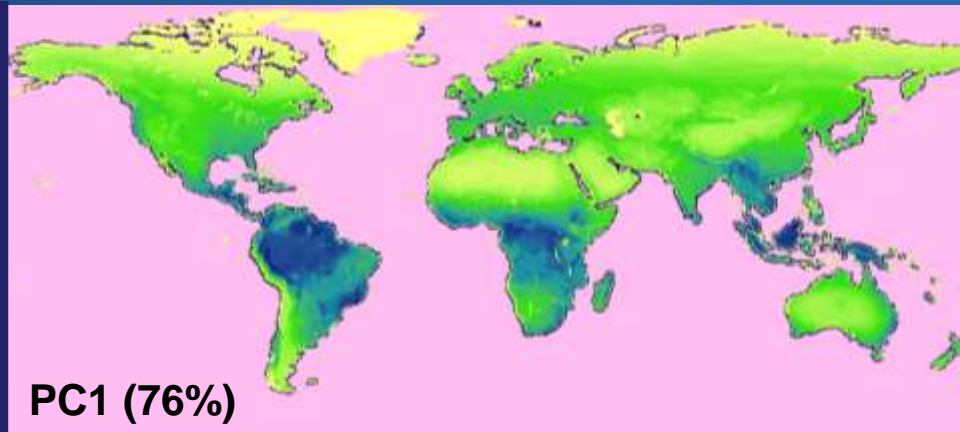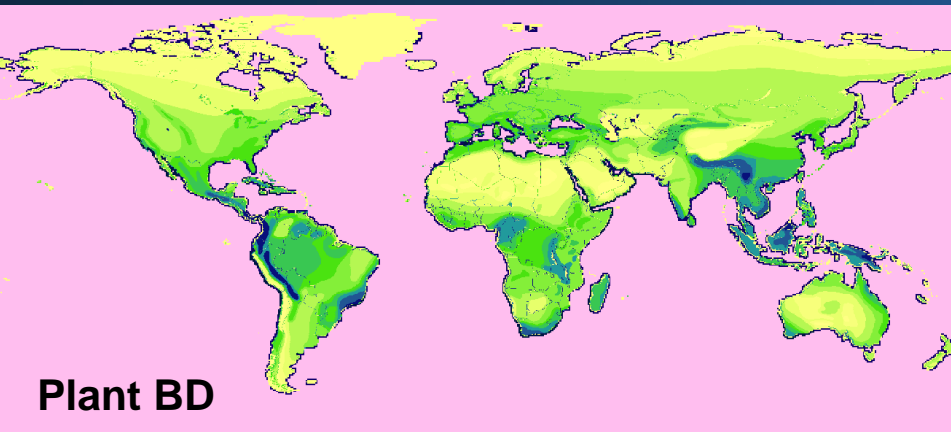
Insights PCA

- PC1 weakens extreme values of individual indicators
  - Mainly due to lower variance in vertebrate BD
  - Result seems quite reasonable

- Practicability: Combination of NPP and Plant BD might be used
  - To describe EQ in understandable units
  - To weight relative impacts on EQ (PDF)

  ➡ It does still not cover everything
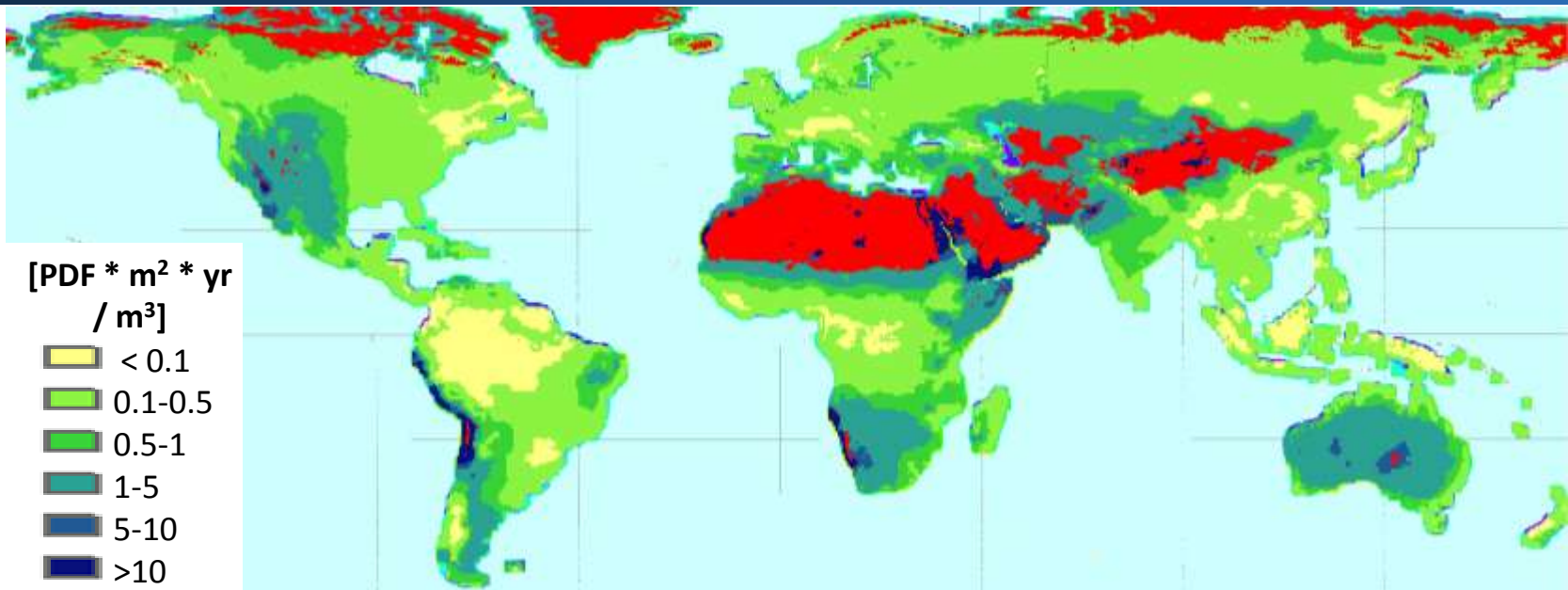
Further steps in impact assessment

- Degradation from reference state should be integrated in weighting
  - Avoid double-counting!

- Vulnerability of ecosystem regarding water lack crucial point

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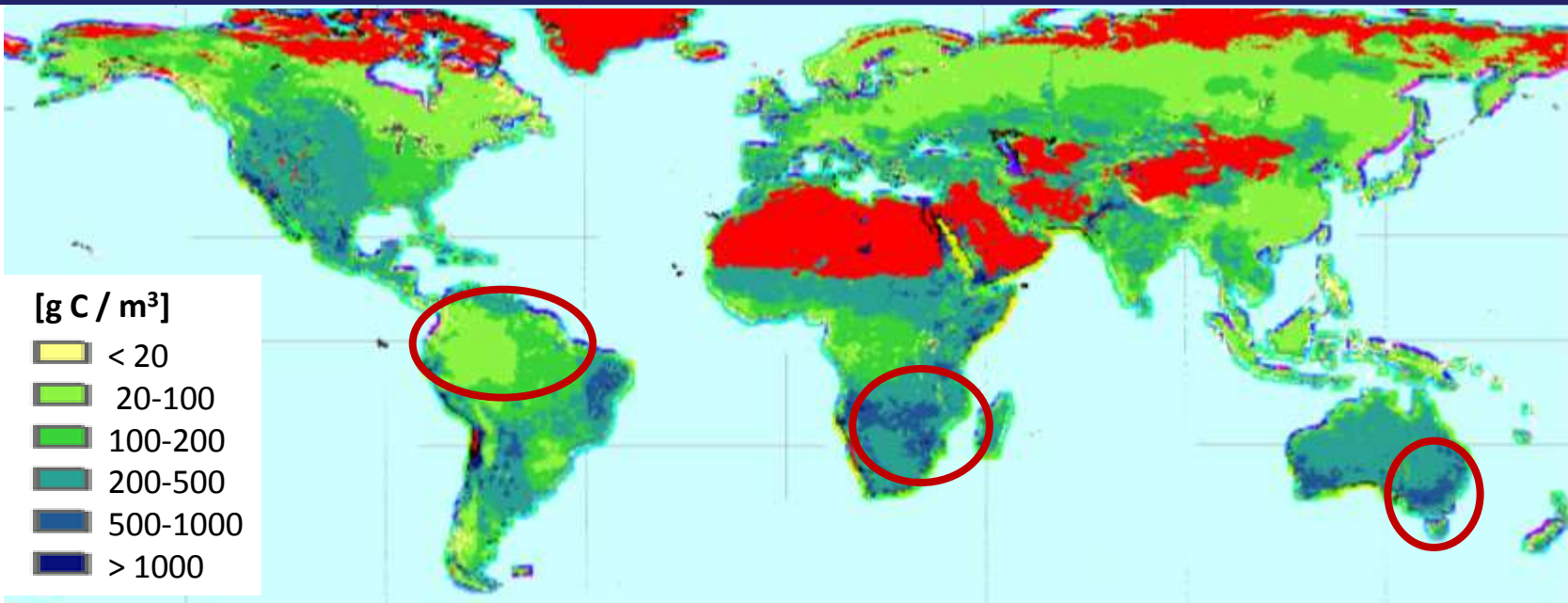Environmental Engineering

Vulnerability of ecosystems

- Mainly based on climatic factors
  - Temperature
  - Precipitation
  - Radiation
  - Evapotranspiration

- Inclusion of basic land cover classes

- Application for impact quantification
  - Relative impact: PDF $*$ m^2 $*$ yr / m^3
  - Weighted impact: NPP (g C / m^3)

Impact on plant BD
(unweighted)

[PDF * m² * yr / m³]
- [ ] < 0.1
- [ ] 0.1-0.5
- [ ] 0.5-1
- [ ] 1-5
- [ ] 5-10
- [ ] >10

Impact on NPP
(weighted)

[g C / m³]
- [ ] < 20
- [ ] 20-100
- [ ] 100-200
- [ ] 200-500
- [ ] 500-1000
- [ ] > 1000

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Discussion

- Relative impact (as PDF)
  - Neglecting increased impact in area with high ecosystem quality
  - Is comparable to impacts from land use in current LCIA methods

- Absolute impact (as NPP)
  - Neglecting relevance of impact for total ecosystem
  - Is a general damage unit for ecosystem productivity

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Conclusion

- Impacts should be quantified in a way allowing direct comparison to land use in LCA

- Water use impacts vary regionally and hence require regionalised impact assessment methods

- Current approaches to assess water use require further research and development

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Thanks for your attention!

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