dNmark
research alliance

# Effects of land management, climate, and human development on ecosystem services for sustainable natural resource management (RC4)

Katrine Grace Turner
PhD student

- A Critical Overview
  a) The Ecosystem Services Concept and Definition
  b) Distribution in general
  c) The Need for Research

- Quantify Ecosystem Services
  a) Ecosystem services selection
  b) Measurements and data selection
  c) Modeling ecosystem services
  d) Modeling caveats

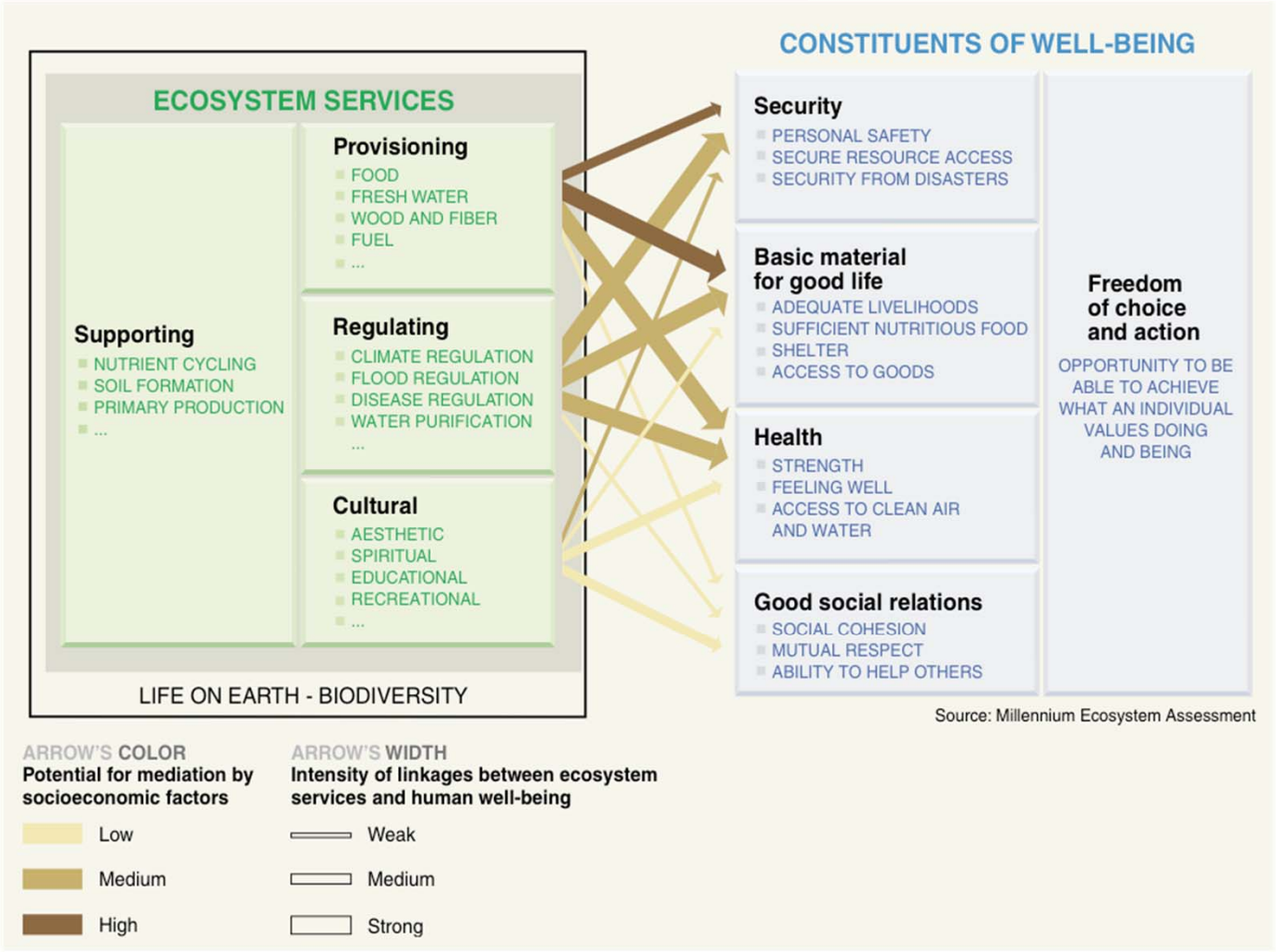
- Geography of ecosystem services
  a) Results

- Content
  a) Overview: The Ecosystem Services Concept and Definition
  b) Quantification of ecosystem services
  c) Geography of Danish ecosystem services

# The Ecosystem Service Concept and Definition

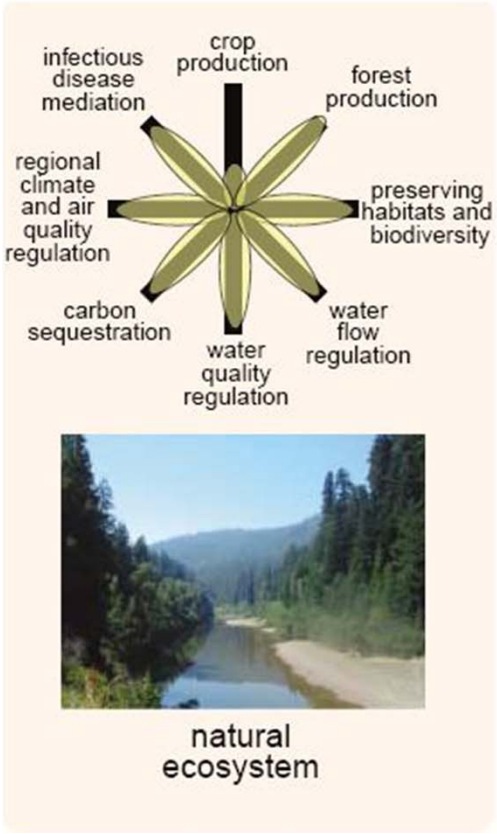
- **The benefits people obtain from ecosystems** (MA 2005)

- Provisioning services: **physical goods** (utilitarian)
- Cultural services: **non-material goods and services** (socio-cultural)
- Regulating services: **ecosystem processes** (ecological)
- Supporting services: uphold **ecosystem functions** (Intrinsic)




Critical overview → Quantification → Geography

# The Need for Research?




Critical overview → Quantification → Geography

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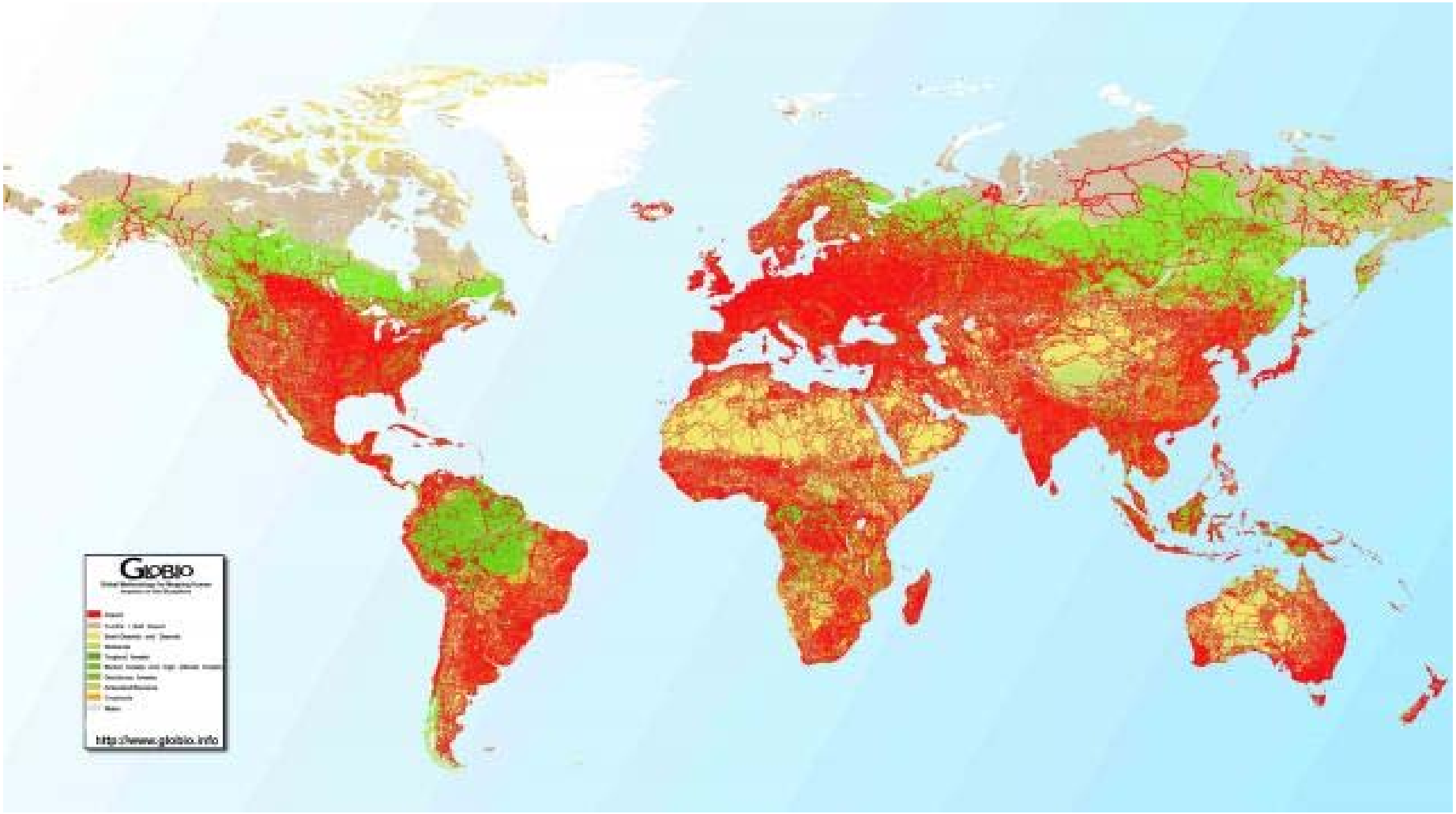
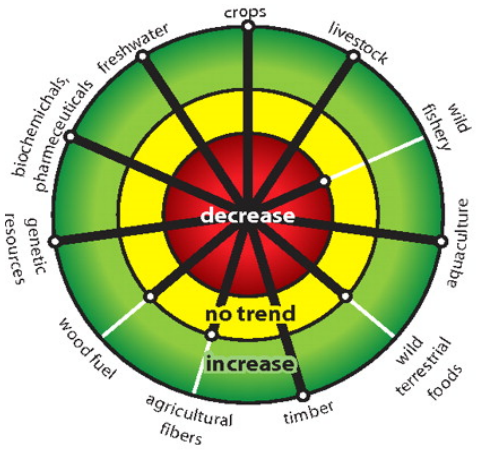
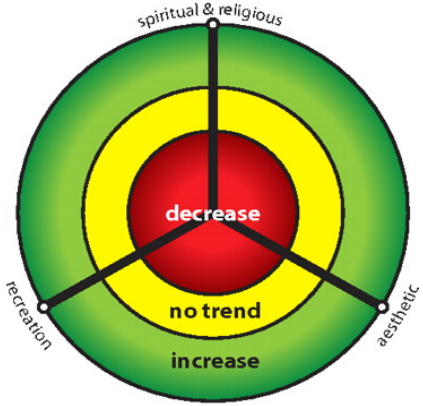


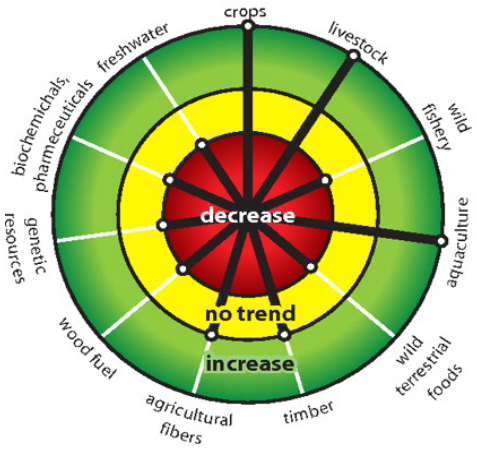
Human use



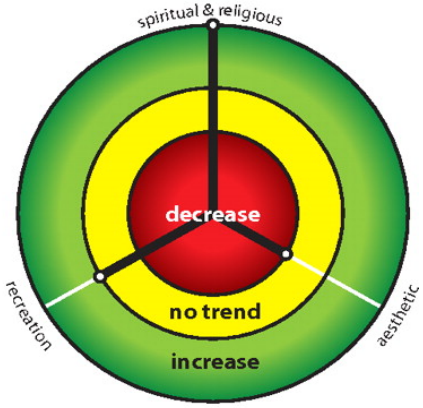





Condition








Provisioning services | Regulating services | Cultural services

Critical overview → Quantification → Geography

Carpenter et al. 2009

# Distribution in general

- **Vegetation cover** (Dick et al. 2010, Zhang et al. 2011)
- **Slope** (Zhang et al. 2011. Dick et al. 2010, Raudsepp-Hearne et al. 2010)
- **Rainfall/climate** (Zhang et al. 2011)
- **Biodiversity** (Bai et al. 2011)

Critical overview → Quantification → Geography

# Distribution in general

- **Land use:**
  - **Agriculture**
  - **Urbanization**

  (Zhang et al. 2011, Bai et al. 2011, Dick et al. 2010, Raudsepp-Hearne et al. 2010, MA 2005)

- **Development status**
  - Segregation of wild areas and production landscapes

  (MA 2005, Raudsepp-Hearne et al. 2010, Tscharntke et al. 2005)

- **Aesthetics**

Critical overview → Quantification → Geography

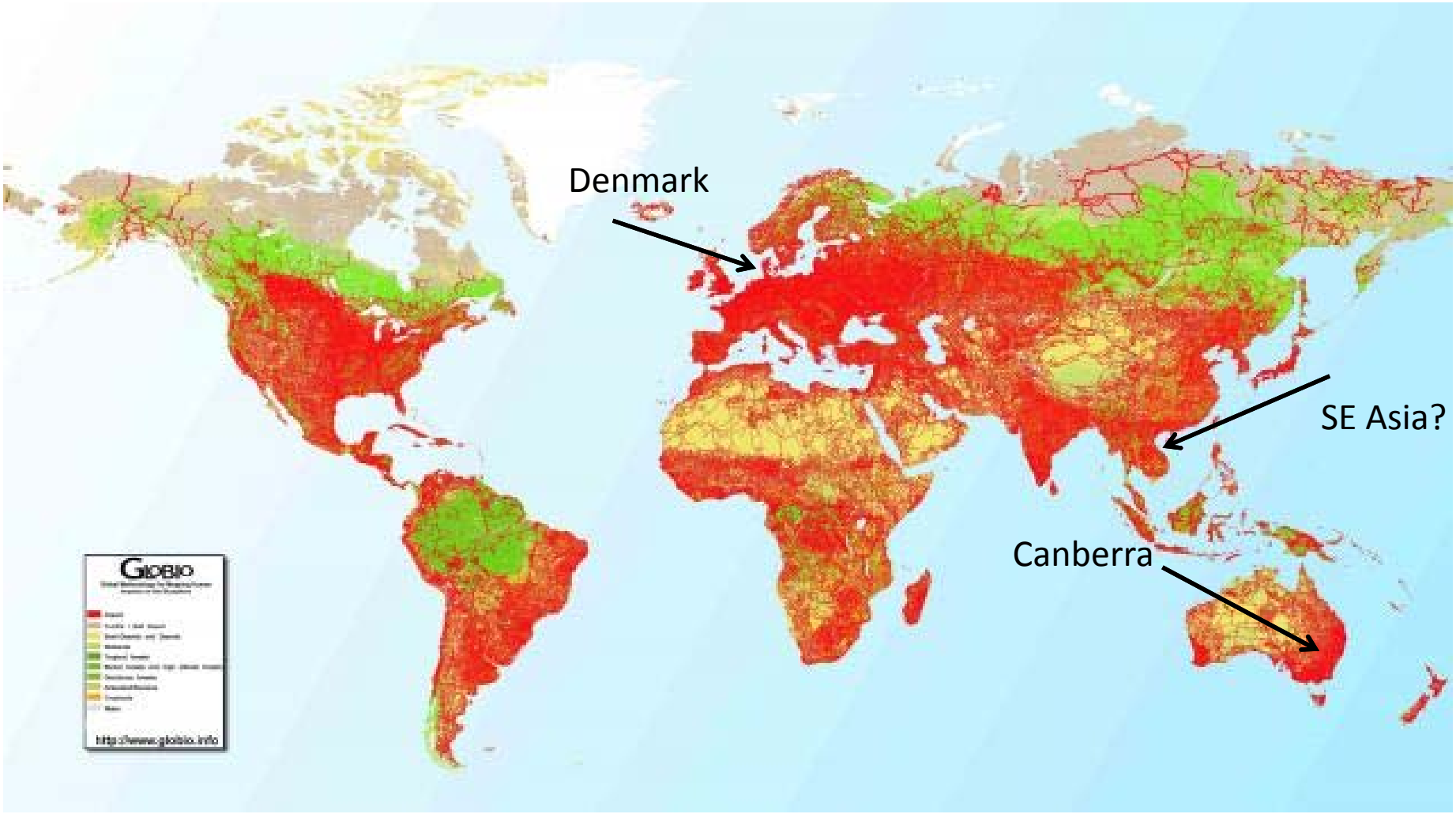
- **What are the consequences of land management type, climate, and human development on ecosystem service distribution and interactions?**

I. How does the ESbundles **trade-offs and synergies** differ with management scale units?

II. Does certain **land use patterns** increase the production of multiple synergistic ecosystem services?

III. How does the provision and demand for ecosystem services change with demography, development, and climate, and **how do we compare** between different societies and regions?

# Locations



- Site specific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# Distribution in general

- Vegetation cover (Dick et al. 2010, Zhang et al. 2011)
- Slope (Zhang et al. 2011. Dick et al. 2010, Raudsepp-Hearne et al. 2010)
- Rainfall/climate (Zhang et al. 2011)
- Biodiversity (Bai et al. 2011)

- Community specific



Critical overview → Quantification → Geography

# Distribution in general

- Land use: (Zhang et al. 2011, Bai et al. 2011, Dick et al. 2010, Raudsepp-Hearne et al. 2010, MA 2005)
  - Agriculture
  - Urbanization
- Aesthetics
- Development status
  - Segregation of wild areas and production landscapes

(MA 2005, Raudsepp-Hearne et al. 2010, Tscharntke et al. 2005)

Critical overview → Quantification → Geography

# Critical Overview

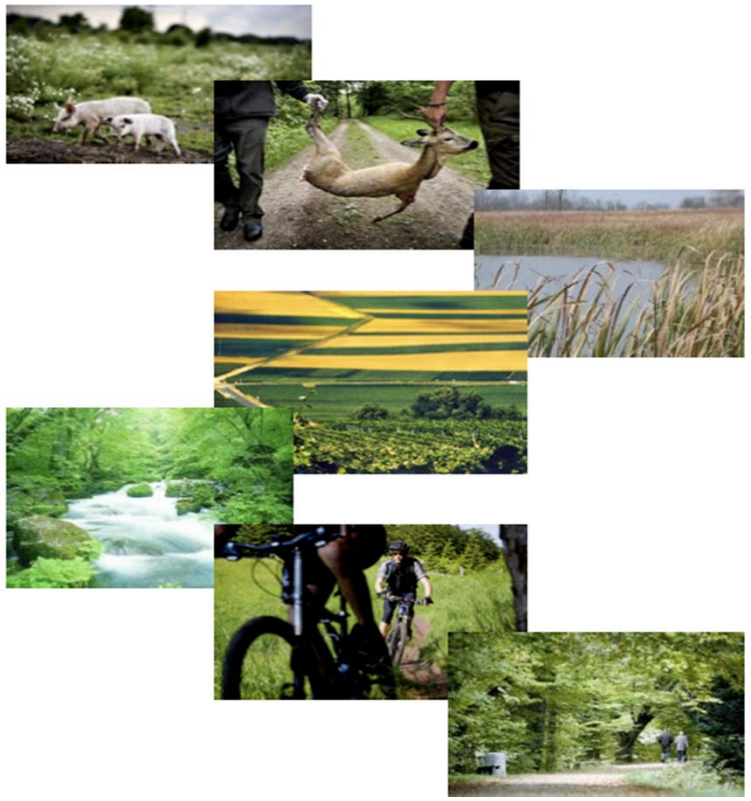
- Benefits from nature which sustains health and well-being
- Site and community specific
- Need for further research to deal with increased human pressure and resource use in a deteriorating natural world

# Quantifying ecosystem services

a) Ecosystem services selection
b) Measurements and data selection
c) Modeling ecosystem services
d) Modeling caveats

# Ecosystem services selection

Identify important services for the area:



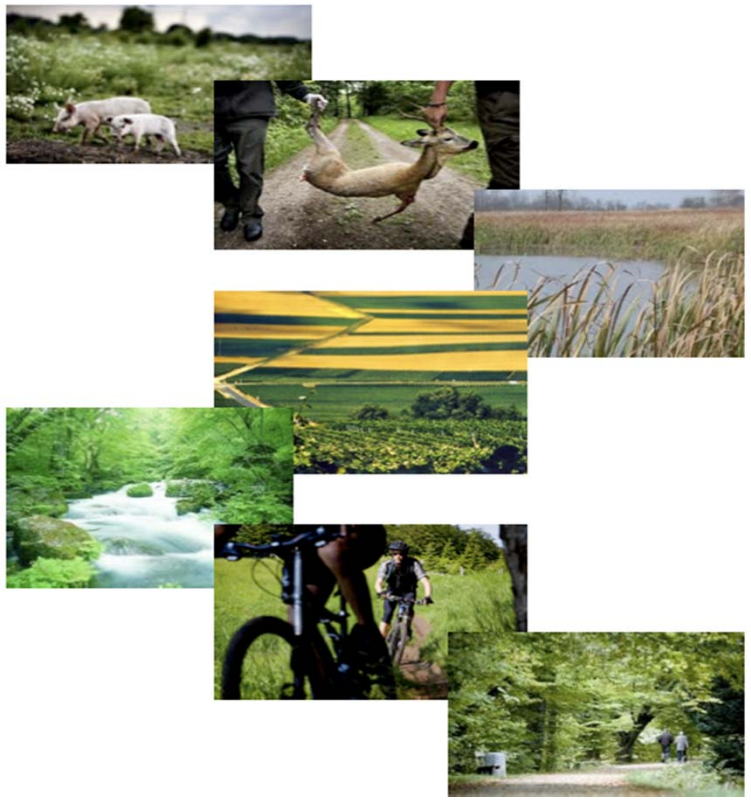
- **Provisioning**
- **Regulating**
- **Cultural**
- **Supporting**

Critical overview → Quantification → Geography

# Ecosystem services selection

Identify important services for the area:

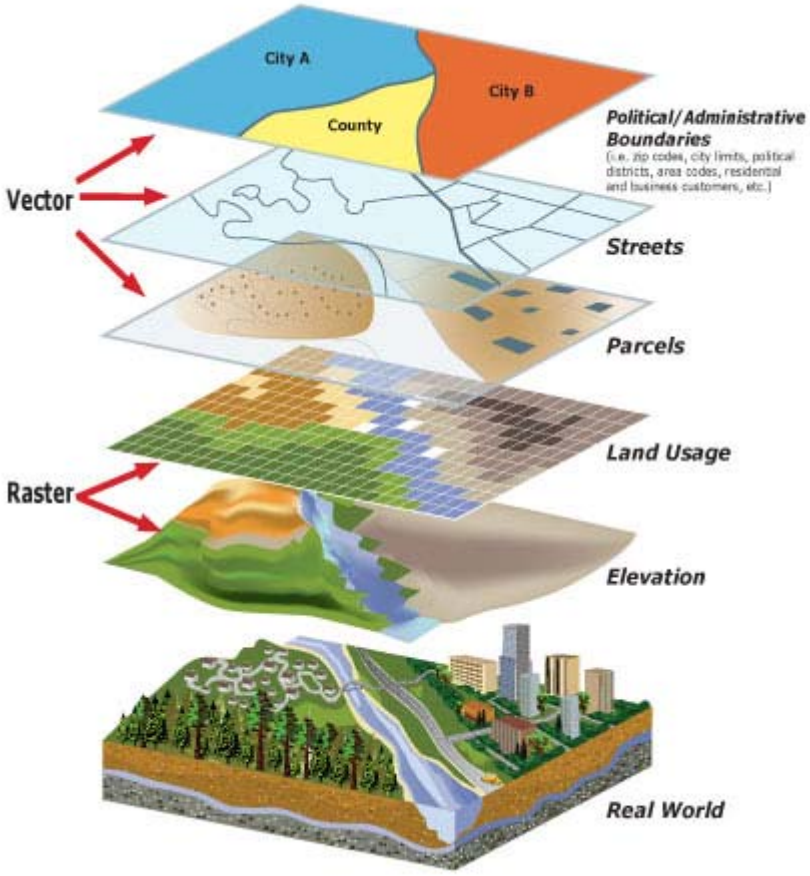
- **Provisioning**
  - Crops
  - Animals
  - Drinking water
- **Regulating**
  - Carbon storage
  - Wetland
  - Humus content
- **Cultural**
  - Tourism
  - Nature appreciation
  - Conservation
  - Cottages
  - Hunting



Critical overview → Quantification → Geography

# Modeling Ecosystem Services

- Land use/land cover data
  - readily available
  - by proxy
- Empirical mapping of services




Critical overview → Quantification → Geography

| | | |
|---|---|---|
| **Provisioning** | | |
| Crops | Field area per grid cell | Fields registered for any crop production in 2008 (TOP10DK) |
| Animals | Livestock units per grid cell | One livestock unit is measured as an output of 100 kg N in waste products. Used as a planning and legislative measurement for livestock. Of both cows and pigs (2008) |
| Drinking water | Scale value of area per grid cell | Drinking water zoning, 0 no interest and 1 high interest, is based on water demand (current and future), properties of the soil and land-use in the area above the aquifers . |
| **Regulating** | | |
| Carbon storage | Forested area per grid cell | Above ground carbon sequestration measured as total forested area (TOP10DK) |
| Wetland | Wetland area per grid cell | Waste water treatment facilitation and flood regulation, measured as total wetland area (TOP10DK) |
| Humus content | Percentage pr grid cell | Humus percentage of soil A-horizon |
| **Cultural** | | |
| Recreation | Facilities per grid cell | Aggregated list of natural and cultural facilities and heritage sites, all entries from the Danish Nature Agency (www.naturstyrelsen.dk) |
| Nature appreciation | Entries per grid cell | The number of species registrations on the website fugleognatur.dk in 2009. Entries give a measure of nature appreciation at the specific location. |
| Conservation | Protected area per grid cell | Conservation areas are protected through established legal processes, based on their inherent value to the environment and the public. |
| Cottages | Cottage-zone area of per grid cell | Cottages are found in cottage zones as planned by the local Municipality at suitable sites. |
| Hunting | Hunting ratio per grid cell | Hunting ratio is consolidated from a municipality scale database of hunting statistics and a point record of roe deer traffic kill to interpolate to scale. |

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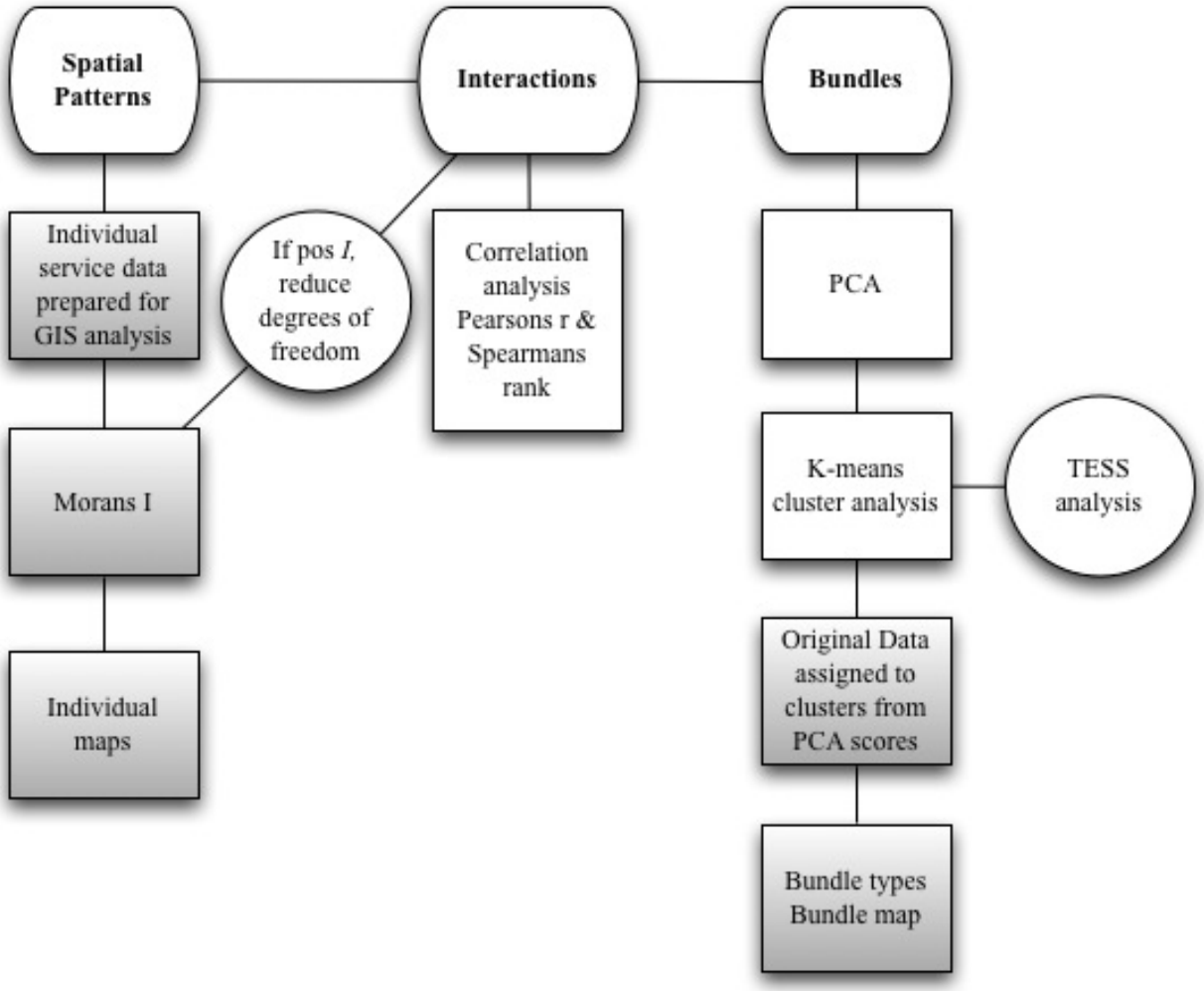
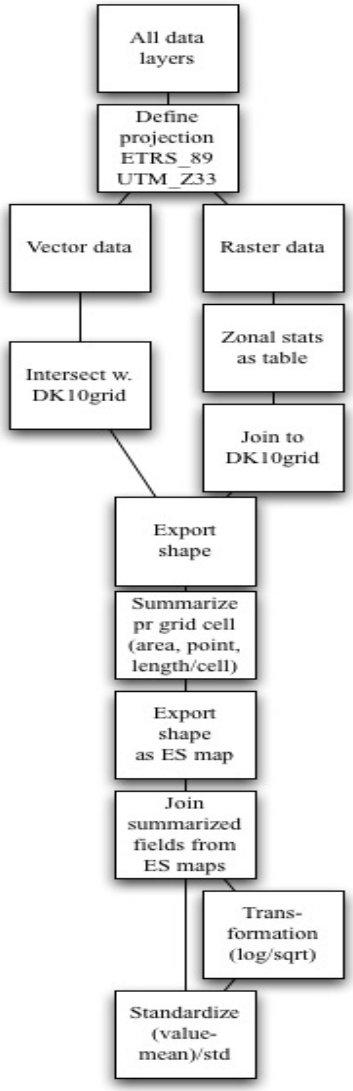
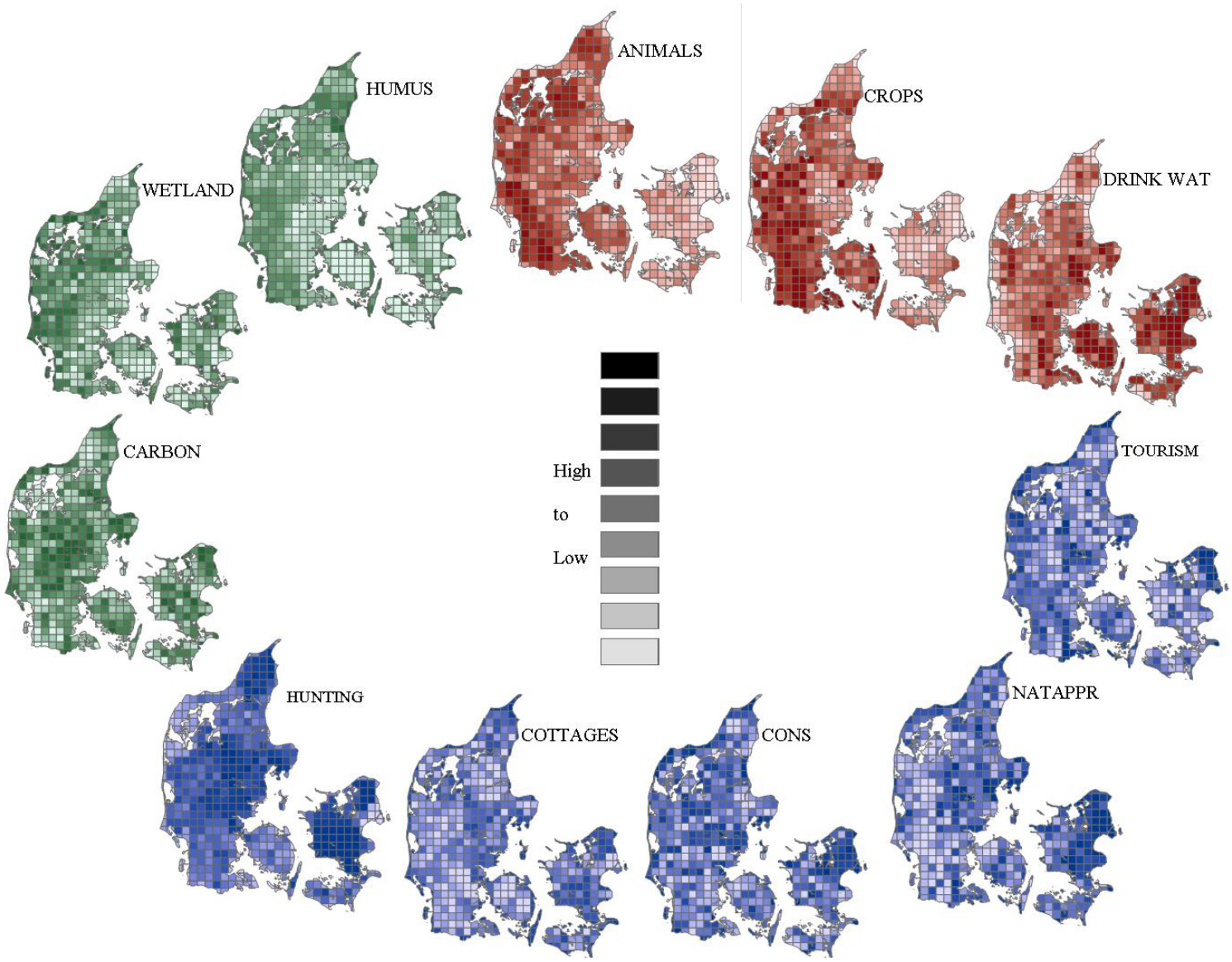



Critical overview → Quantification → Geography




Critical overview → Quantification → Geography



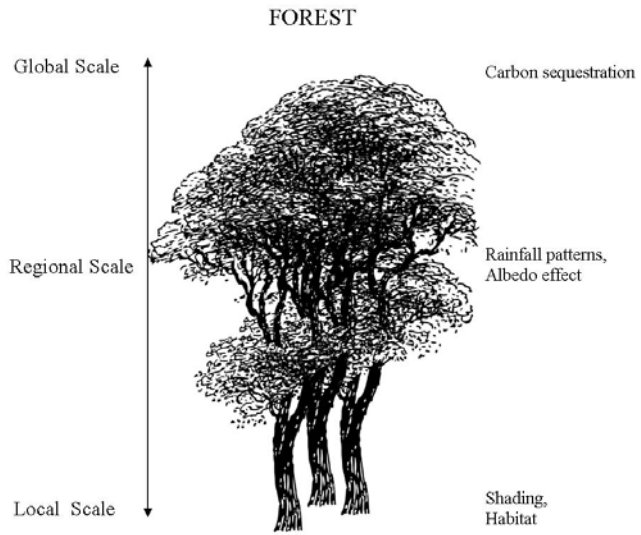

Critical overview → Quantification → Geography

# Modeling Caveats

# Problems to be aware of…

# Modeling Caveats

- Scale
  - Does the scale capture the essential processes?

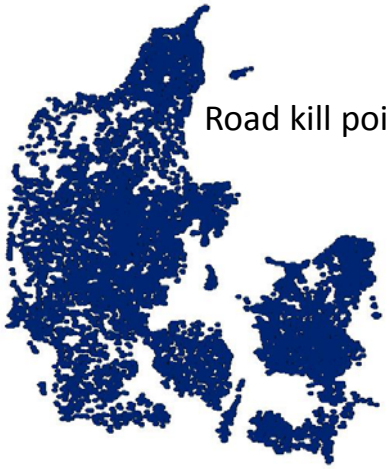



Critical overview → Quantification → Geography

# Modeling Caveats

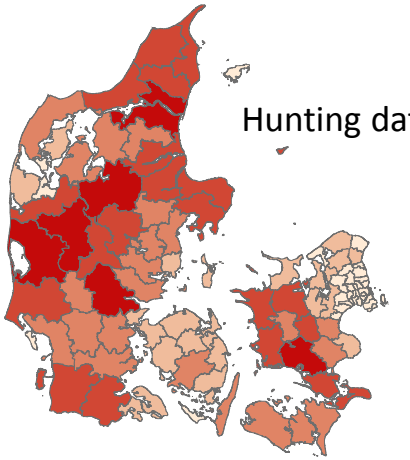
- Spatial Scale
  - Scale of data the same as scale of analysis?
    - Hunting Data at municipality scale
      - Added traffic kills GPS point-record to the layer for better accuracy

# Hunting Data

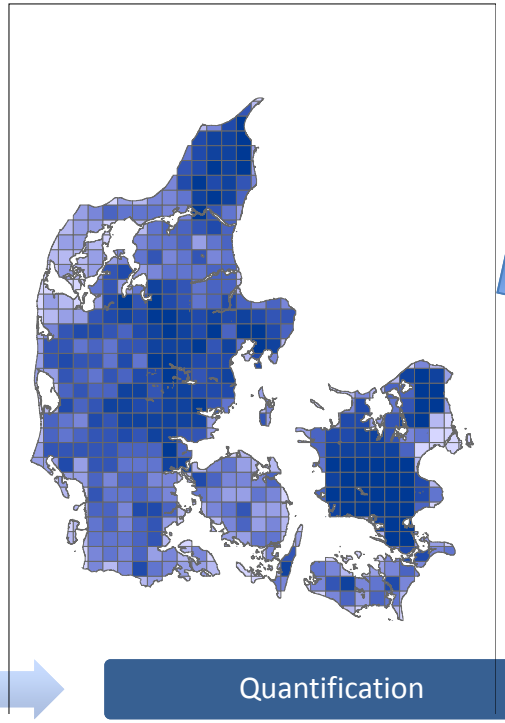


Road kill points

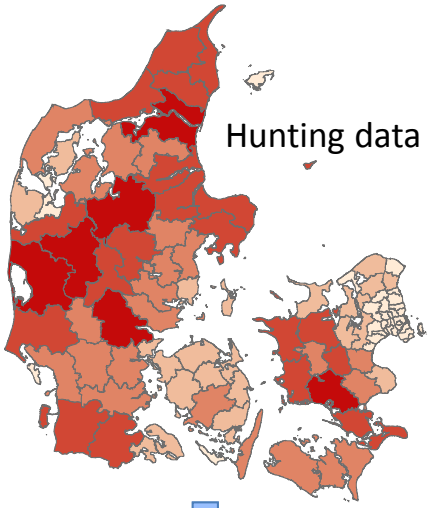
Adjusted for population, roadnet, and area



Hunting data



Critical overview → Quantification → Geography



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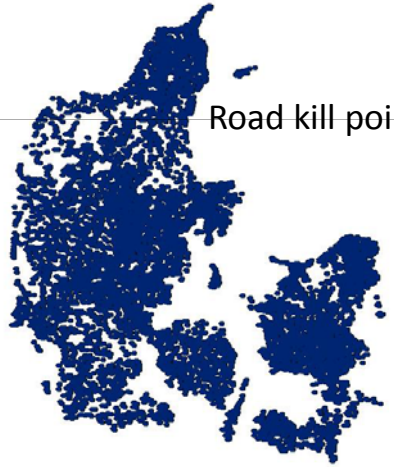
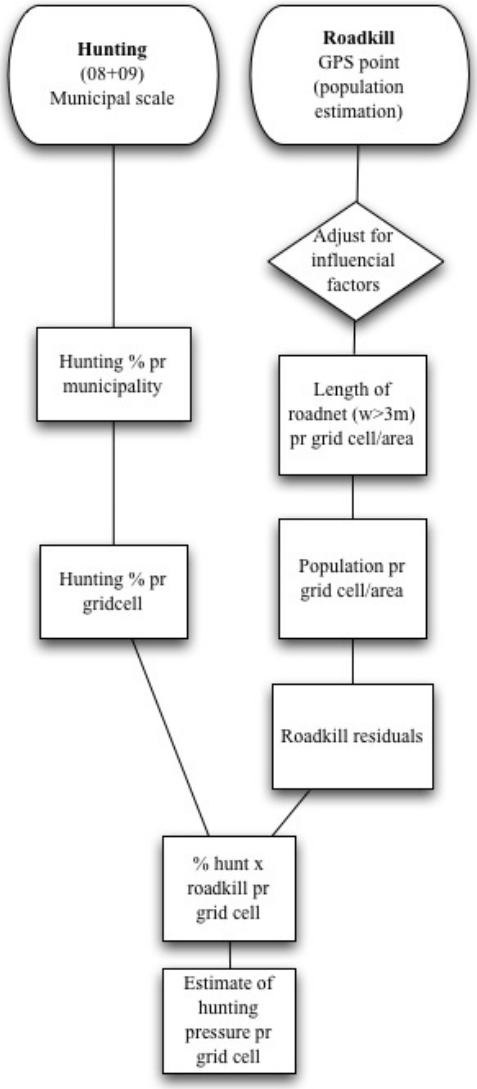
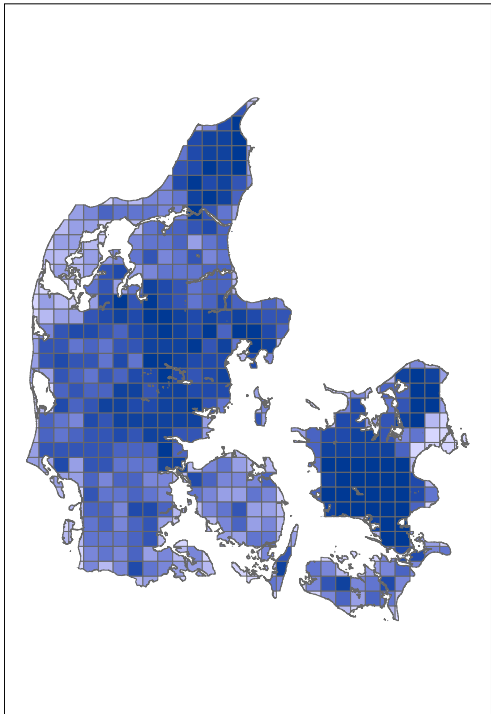


Road kill points

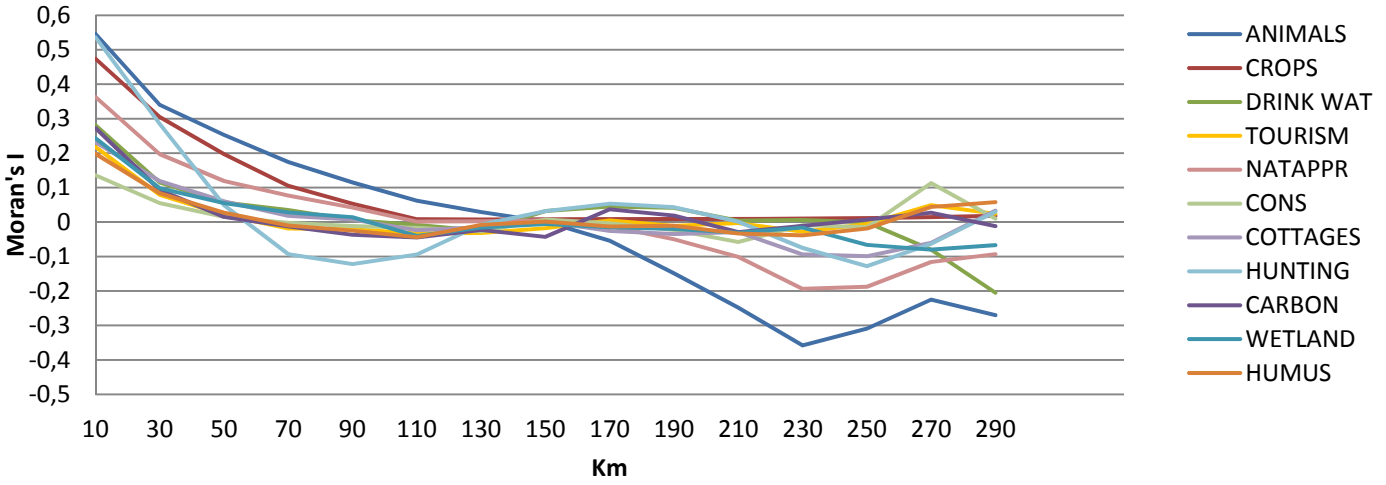


Critical overview → Quantification → Geography

# Modeling Caveats

- Spatial autocorrelation
  - Close things tend to be more alike than things farther away
    - Have the same climate, topography, soil structure, random events, etc, within the area?
  - Affects degrees of freedom in statistical analysis



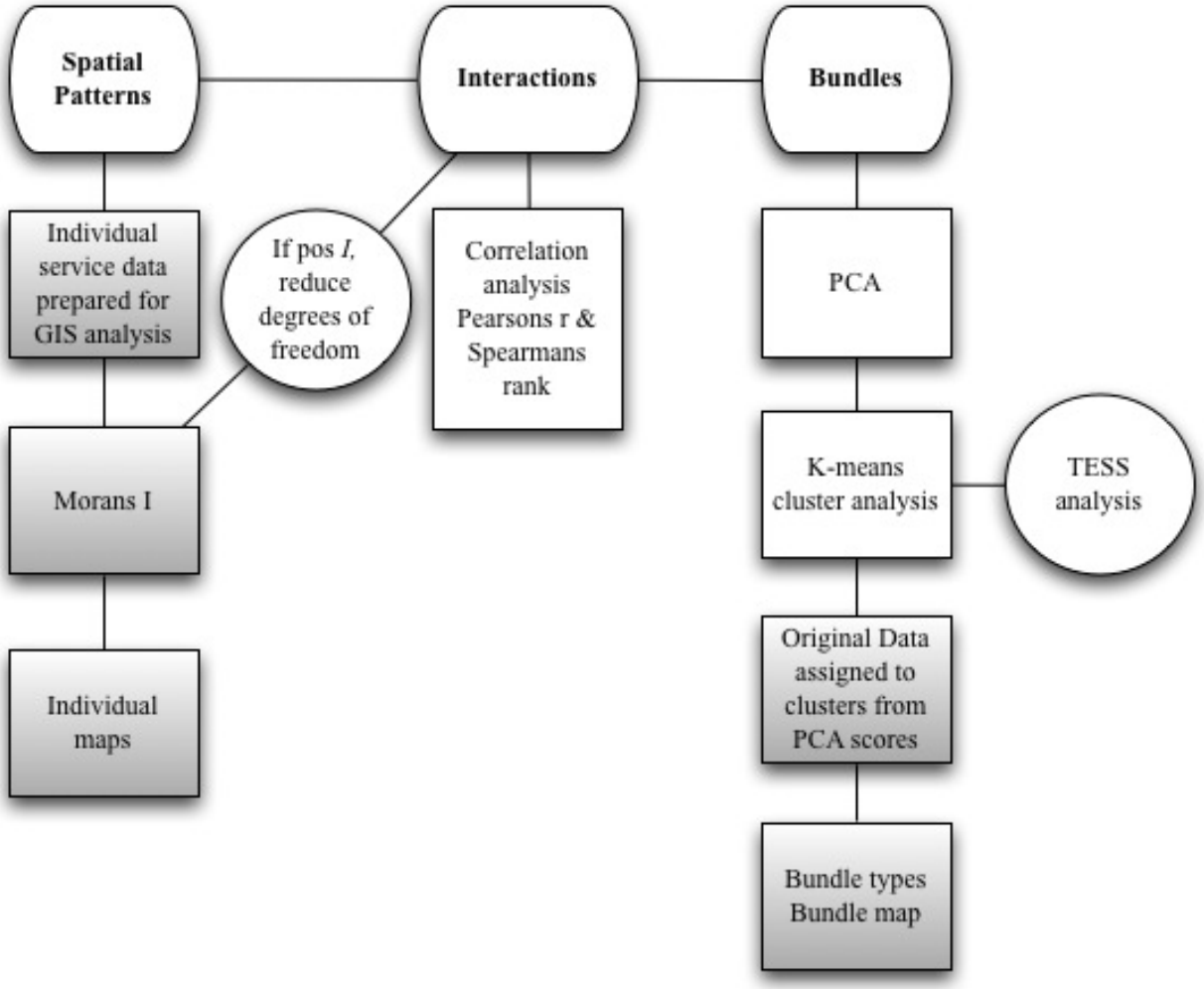

Critical overview → Quantification → Geography

# Quantification

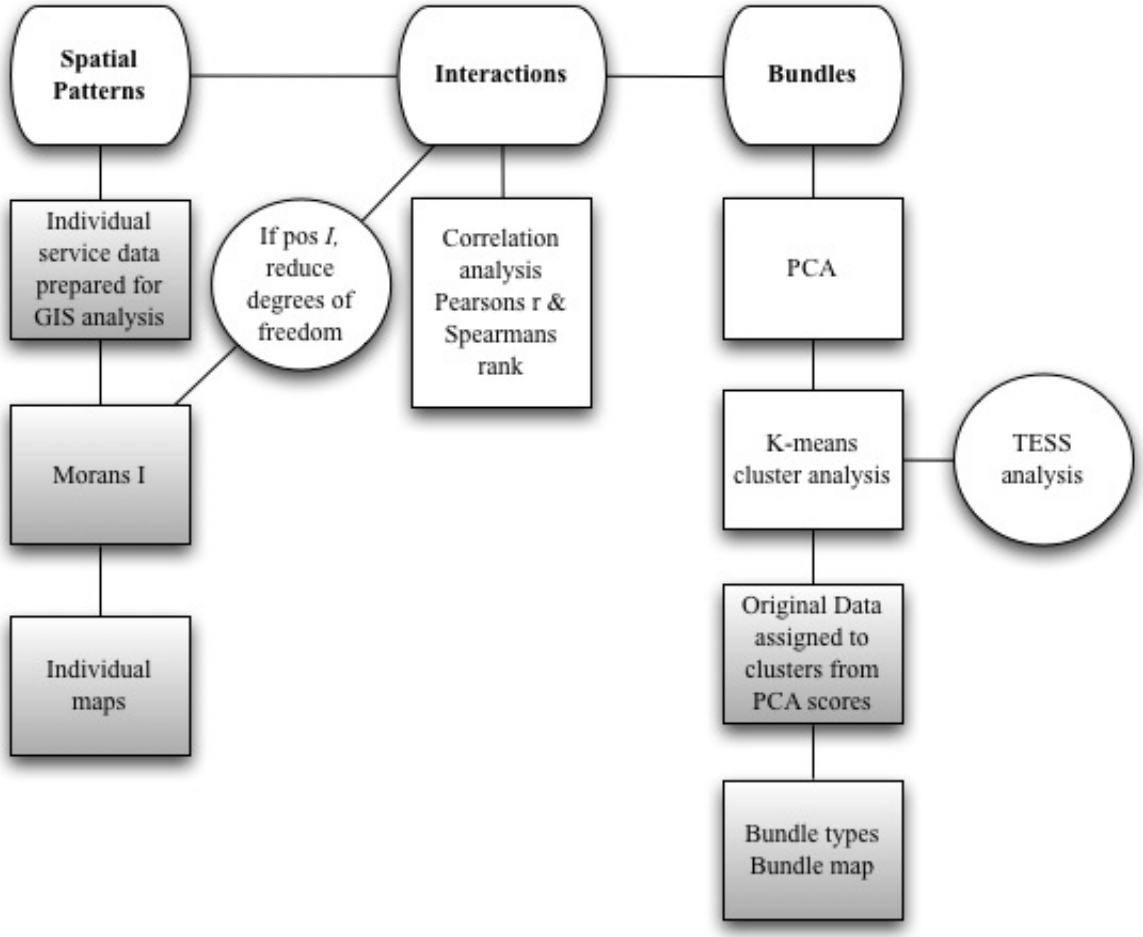
- Selected area specific services
- Service selection and measurements should have a sound hold in theory, but should be able to adapt for practicality
- Spatial modeling offers a strong tool for quantifying services when caveats are considered beforehand and adjusted for

# Geography of ecosystem services

a) Results…

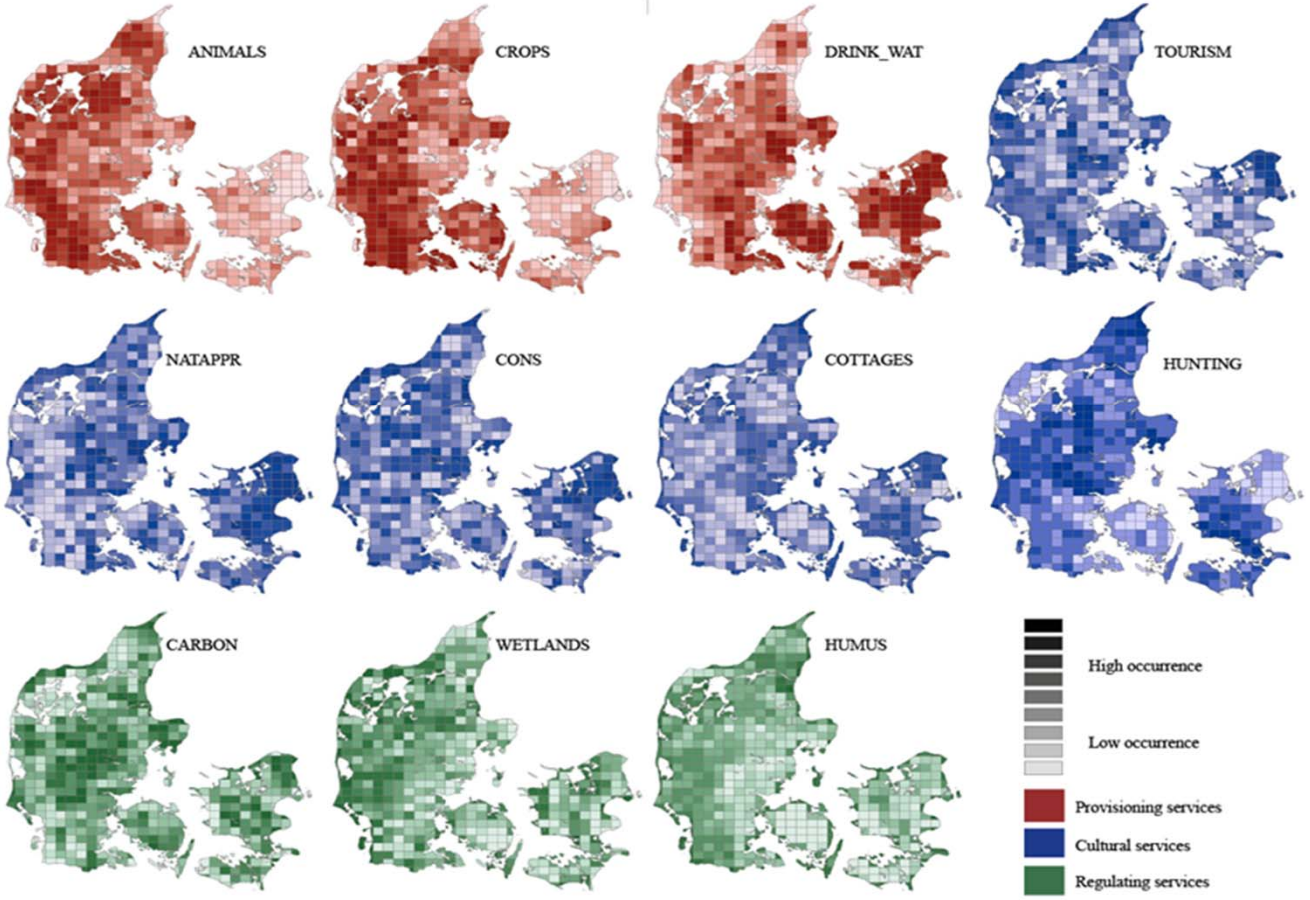



Critical overview → Quantification → Geography




Critical overview → Quantification → Geography

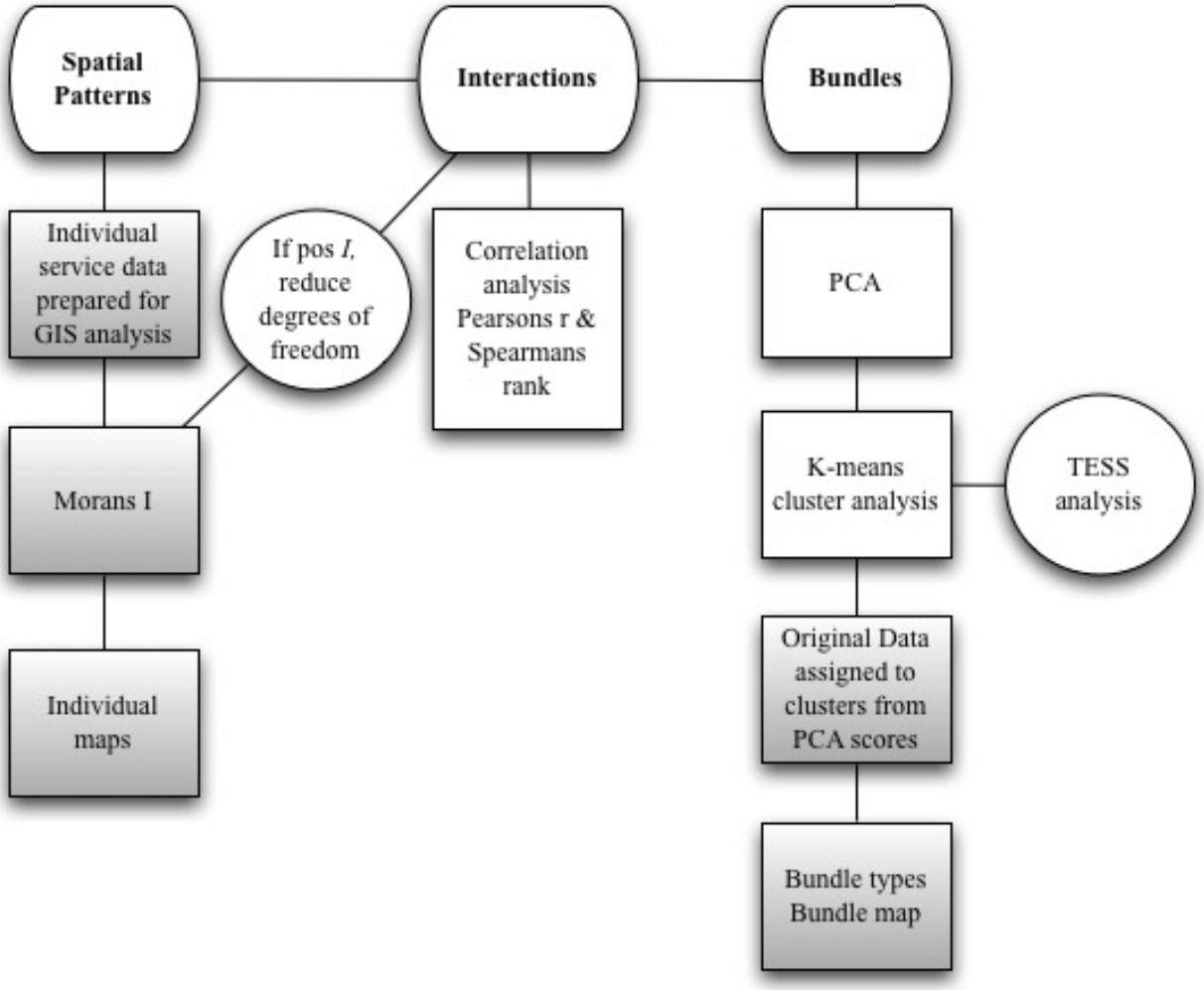
# Distribution in Denmark




Provisioning services, Cultural services, Regulating services

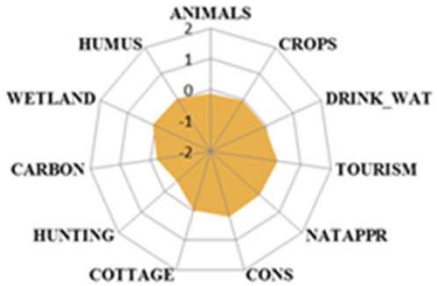
Critical overview → Quantification → Geography

| Positive | | Negative | | Uncorrelated | |
|---|---|---|---|---|---|
| COTTAGES vs. HUMUS | 0.605 | HUMUS vs. HUNT | -0.606 | HUMUS vs ANIMALS | -0.059 |
| CROPS vs. ANIMALS | 0.580 | HUMUS vs. DRINK WAT | -0.531 | HUNT vs. CROPS | -0.052 |
| COTTAGES vs. TOURISM | 0.406 | NATAPPR vs. ANIMALS | -0.489 | WETLAND vs. CARBON | -0.049 |
| CONS vs. NATAPPR | 0.387 | COTTAGES vs. ANIMALS | -0.435 | COTTAGES vs. CARBON | -0.025 |
| TOURISM vs. HUMUS | 0.363 | NATAPPR vs. CROPS | -0.430 | WETLAND vs. ANIMALS | -0.024 |
| HUMUS vs. WETLAND | 0.347 | TOURISM vs. HUNT | -0.380 | HUNT vs. NATAPPR | -0.021 |
| HUNT vs. DRINK WAT | 0.336 | COTTAGES vs. DRINK WAT | -0.369 | NATAPPR vs. WETLAND | 0.004 |
| NATAPPR vs. TOURISM | 0.305 | WETLAND vs. DRINK WAT | -0.357 | NATAPPR vs. DRINK WAT | 0.014 |
| COTTAGES vs. NATAPPR | 0.304 | COTTAGES vs. CROPS | -0.343 | NATAPPR vs. HUMUS | 0.022 |
| CONS vs. WETLAND | 0.274 | CONS vs. CROPS | -0.341 | HUMUS vs. CROPS | 0.024 |
| HUNT vs. CARBON | 0.273 | CONS vs. ANIMALS | -0.300 | WETLAND vs. CROPS | 0.036 |
| NATAPPR vs. CARBON | 0.252 | CARBON vs. ANIMALS | -0.278 | DRINK WAT vs. ANIMALS | 0.044 |
| CONS vs. TOURISM | 0.242 | TOURISM vs. DRINK WAT | -0.255 | HUNT vs. ANIMALS | 0.055 |
| COTTAGES vs. WETLAND | 0.228 | COTTAGES vs. HUNT | -0.251 | DRINK WAT vs. CROPS | 0.081 |
| CONS vs. CARBON | 0.224 | CARBON vs. CROPS | -0.231 | | |
| HUMUS vs. CARBON | 0.221 | TOURISM vs. ANIMALS | -0.228 | | |
| COTTAGES vs. CONS | 0.177 | TOURISM vs. CROPS | -0.186 | | |
| TOURISM vs. CARBON | 0.162 | WETLAND vs. HUNT | -0.182 | | |
| CONS vs. HUMUS | 0.111 | CARBON vs. DRINK WAT | -0.166 | | |
| TOURISM vs. WETLAND | 0.102 | CONS vs. DRINK WAT | -0.105 | | |
| | | CONS vs. HUNT | -0.103 | | |

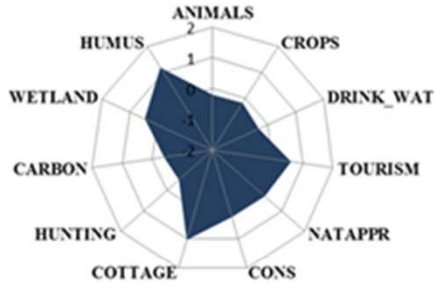



Critical overview → Quantification → Geography

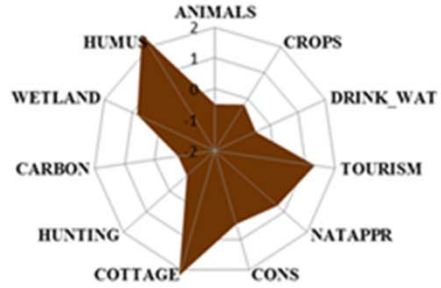
***Multifunctional***

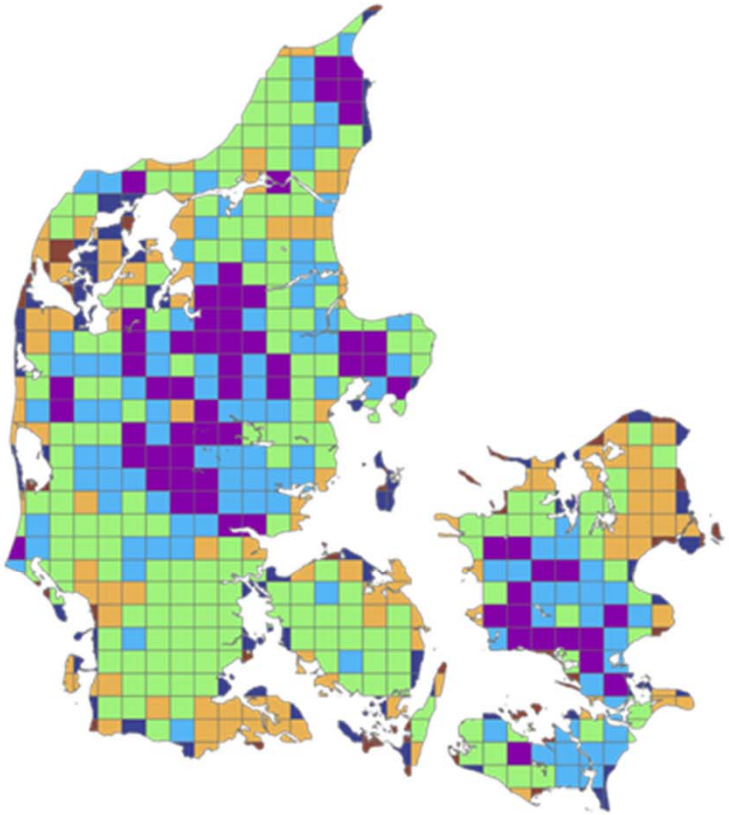



***Coastal Recreation***

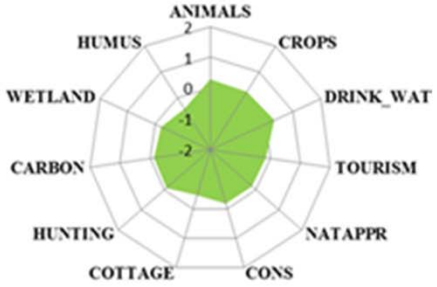



***Coastal Tourism***

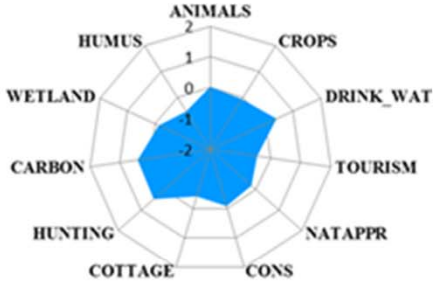


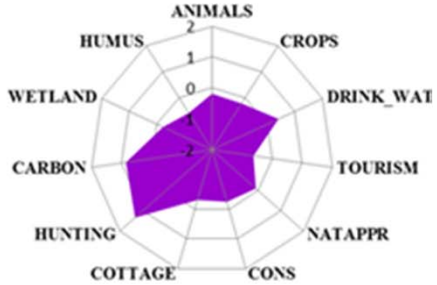
***Agriculture***




***Mixed Provisions***




***Forest Recreation***




Critical overview → Quantification → Geography

# Geography

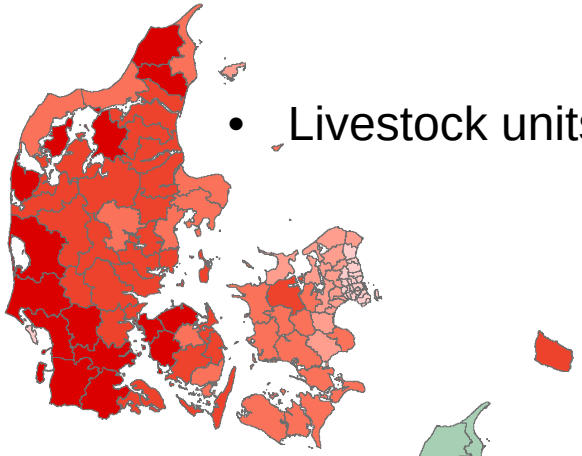
- Cultural-regulating service synergies
- Provisioning service trade-offs
- Coastal areas have the highest amount of potential regulating-cultural service synergies.
- Agricultural intensification in western parts.
- Carbon(forest)-cultural service synergies increases towards eastern Denmark.

Critical overview → Quantification → Geography

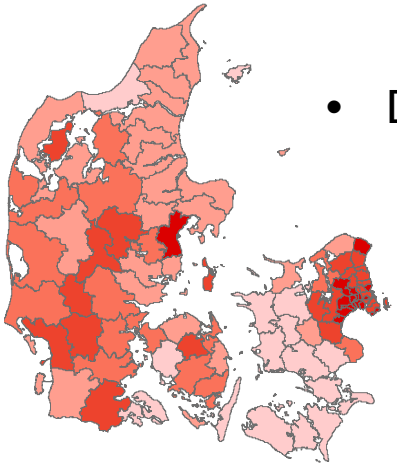
# Conclusion

- ES are benefits from nature which sustains health and well-being.
- ES are site and community specific.
- Need for further research to deal with increased human pressure and resource use in a deteriorating natural world.
- Service selection and measurements should have a sound hold in theory, but should be able to adapt for practicality.
- Distribution in DK is determined by socio-ecological conditions, such as coastal-inland dynamics and societies demand for recreational services

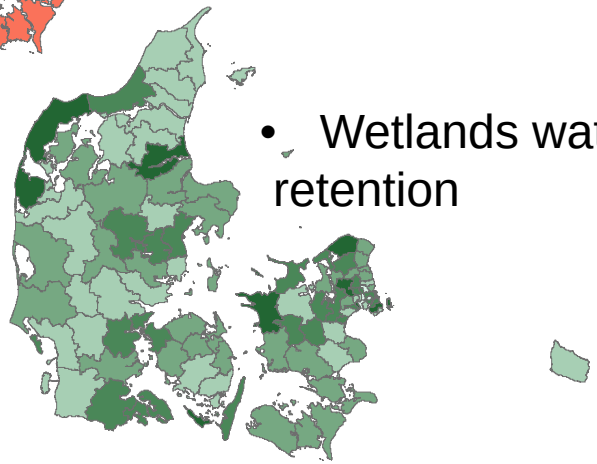
# • Prelim results from municipality scale



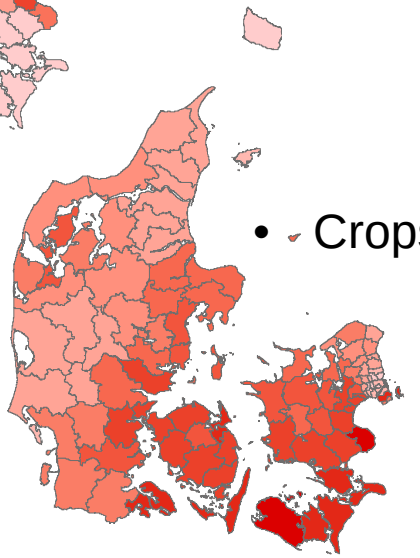
• Livestock units



• Drinking water



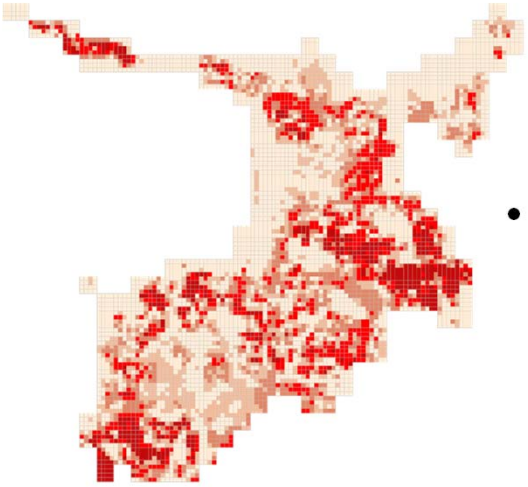
• Wetlands water retention



• Crops

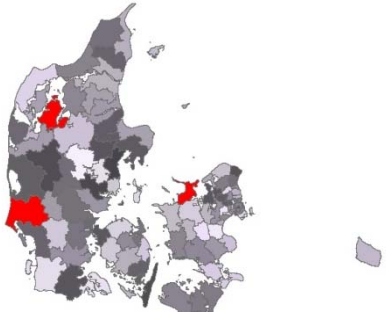
Critical overview → Quantification → Geography

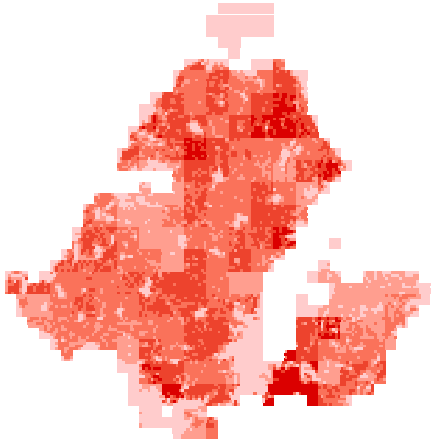
# • Prelim results from 250x250m



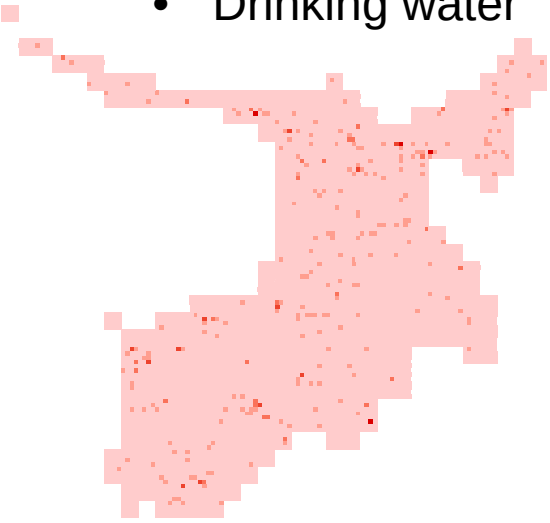
• Crops

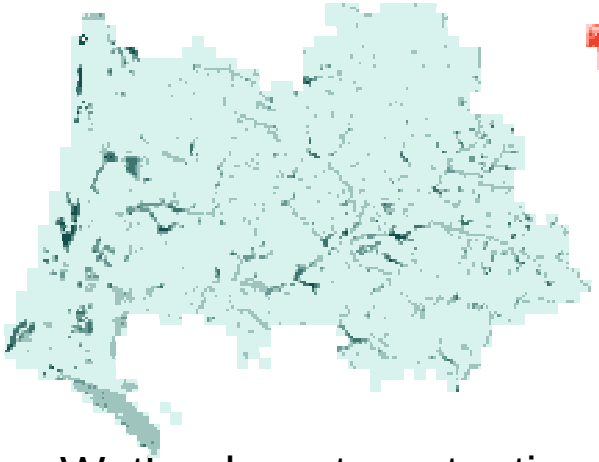
• Livestock units





• Drinking water





• Wetlands water retention

Critical overview → Quantification → Geography

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Critical overview → Quantification → Geography