Ökosystemdienstleistungen von Wäldern

Kategorien, Indikatoren und Datenlage - Einige Beiträge aus landschaftsökologischer Sicht

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Struktur des Beitrags

- Wie verstehen wir die konzeptionelle Stellung des Ecosystem Service-Ansatzes?
- Wie können wir Ecosystem Services in der Landschaft differenzieren?
- Wie können Ecosystem Services in der Landschaft quantifiziert werden?
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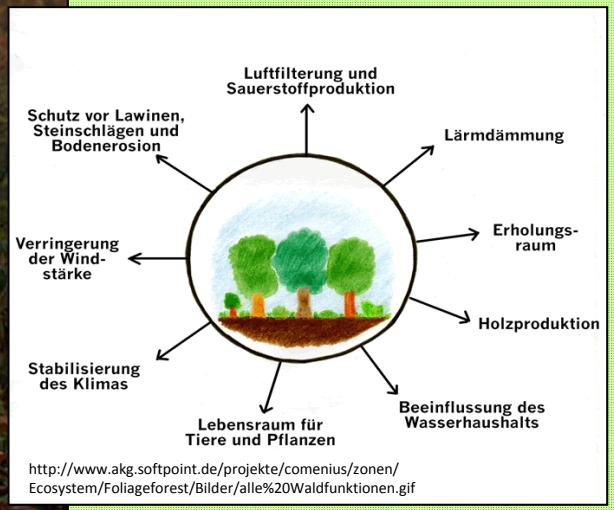
Waldfunktionen

Nutzfunktion

- Holzproduktion



http://www.akg.softpoint.de/projekte/comenius/zonen/Ecosystem/Foliageforest/Bilder/alle%20Waldfunktionen.gif

Schutzfunktion

- Wasser
- Boden
- Luft
- Klima
- Lärm
- Lebensraum
- Biodiversität
- Erosion, Hochwasser
- Lawinen, Steinschlag

Erholungsfunktion

- Erholung
- Naturerfahrung
- Ästhetik
- Inspiration
- Information
- Erziehung

Provisioning Services

Regulating Services

Cultural Services

Waldfunktionen = Ökosystem-Typ-spezifische „Services“

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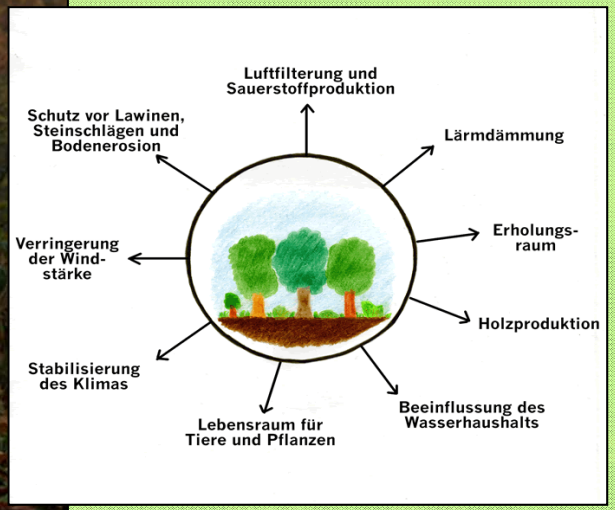
- Holzproduktion



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Wichtige konzeptionelle Unterschiede:

- Herkunft und Konzeptentwicklung
- Grundlegendes Naturverständnis
- Anwendbarkeit auf Ökosystem-Typen
- Einbindung des Mensch-Umwelt-Systems
- Bedeutung ökonomischer Argumente
- Verbreitung und Anwendung
- Konzeptionelle Einbindung

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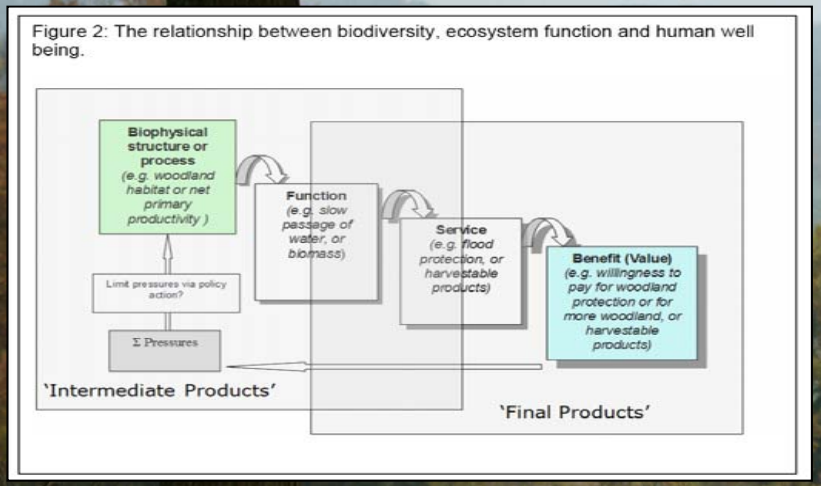
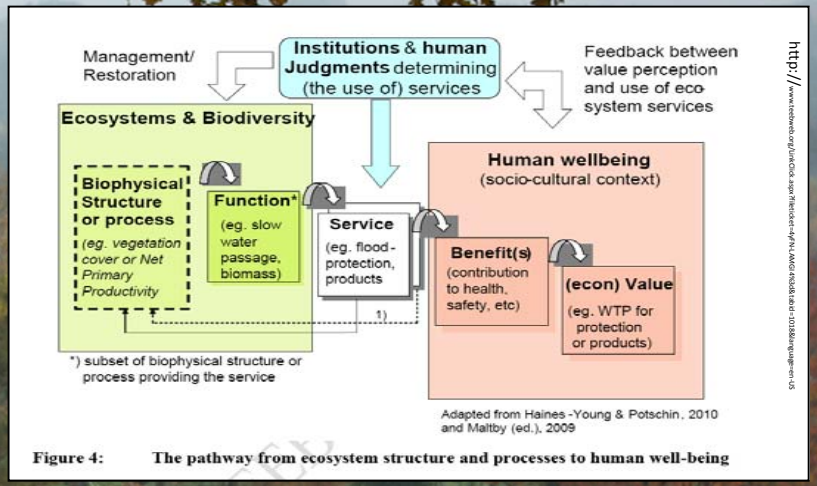
- **Konzeptionelle Einbindung**

Provisioning Services | **Regulating Services** | **Cultural Services**

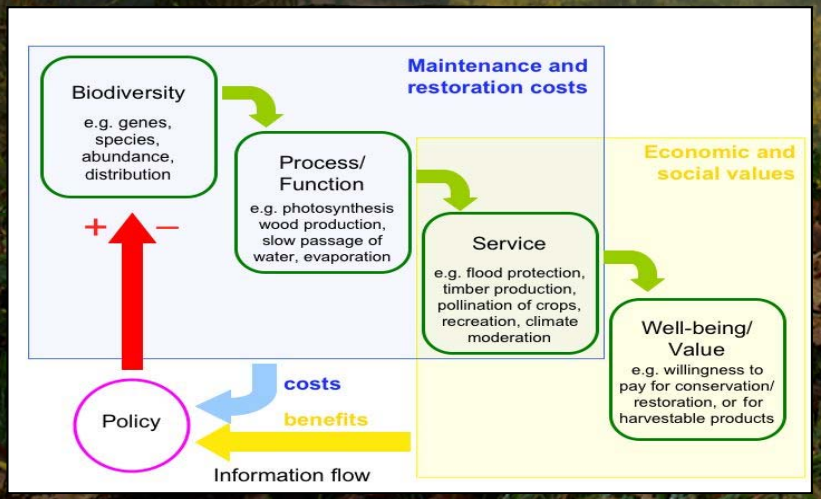
The „ecosystem service cascade“



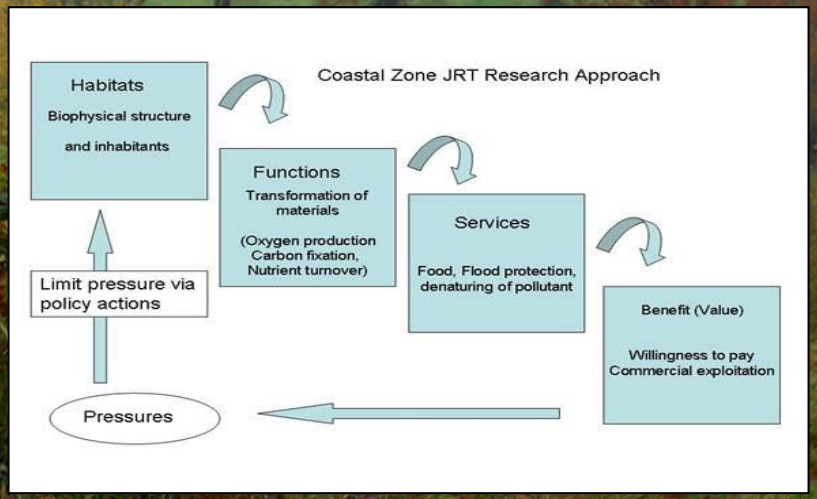
Haines-Young and Potschin (2010)



TEEB Report (2010)



De Groot et al. (2010)



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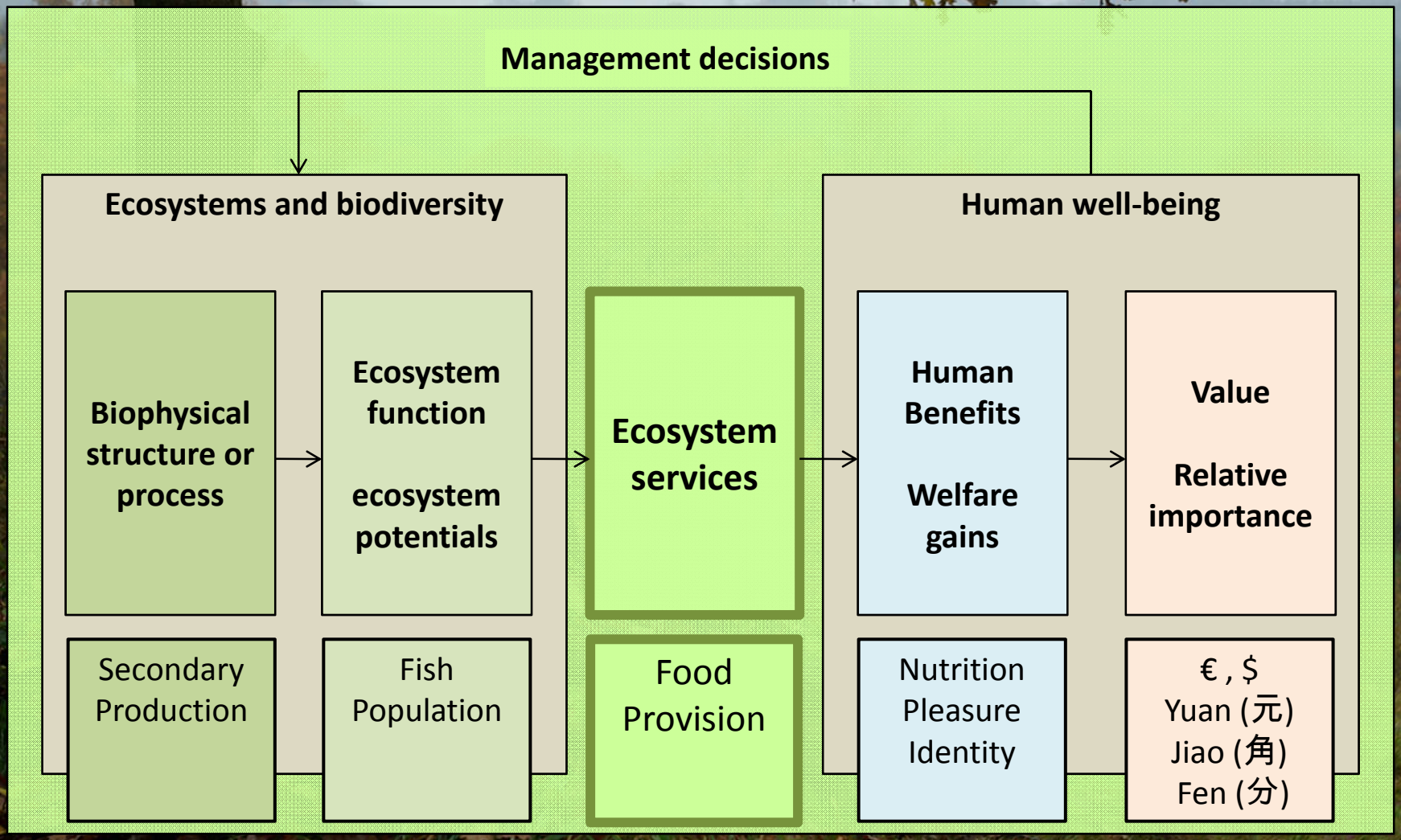


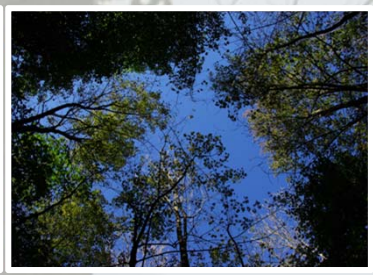
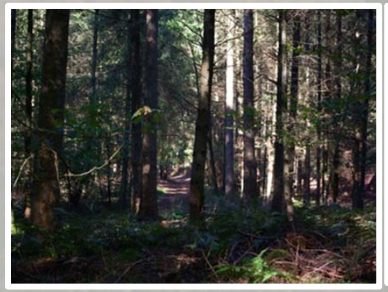


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Provisioning services:

Goods produced or provided by ecosystems

- **Food**
  - Crops
  - Livestock
  - Capture Fisheries
  - Aquaculture
  - Wild Foods
- **Fiber**
  - Timber
  - Cotton, Hemp, Silk
  - Wood Fuel
- **Energy**
- **Genetic Resources**
- **Biochemicals**
- **Freshwater**

Millenium Assessment (2005)

Regulating services:

Benefits obtained from regulation of ecosystem processes

- **Air Quality Regulation**
- **Climate Regulation**
  - Global (CO_2 sequestration)
  - Regional and local
- **Erosion Regulation**
- **Nutrient Regulation**
- **Water Purification**
- **Disease Regulation**
- **Pest Regulation**
- **Pollination**
- **Natural Hazard Regulation**

Millenium Assessment (2005)

Cultural services:

Non-material benefits obtained from ecosystems

- **Spiritual and Religious Values**
- **Knowledge Systems**
- **Educational values**
- **Inspiration**
- **Aesthetic Values**
- **Social Relations**
- **Sense of Place**
- **Recreation and Ecotourism**

Millenium Assessment (2005)

Services used in landscape assessments

(following Burkhard et al. 2009)

Provisioning services

- Crops
- Livestock
- Fodder
- Captured fisheries
- Aquaculture
- Wild foods
- Timber
- Wood fuel
- Energy
- Biochemicals/Medicine
- Frehwater

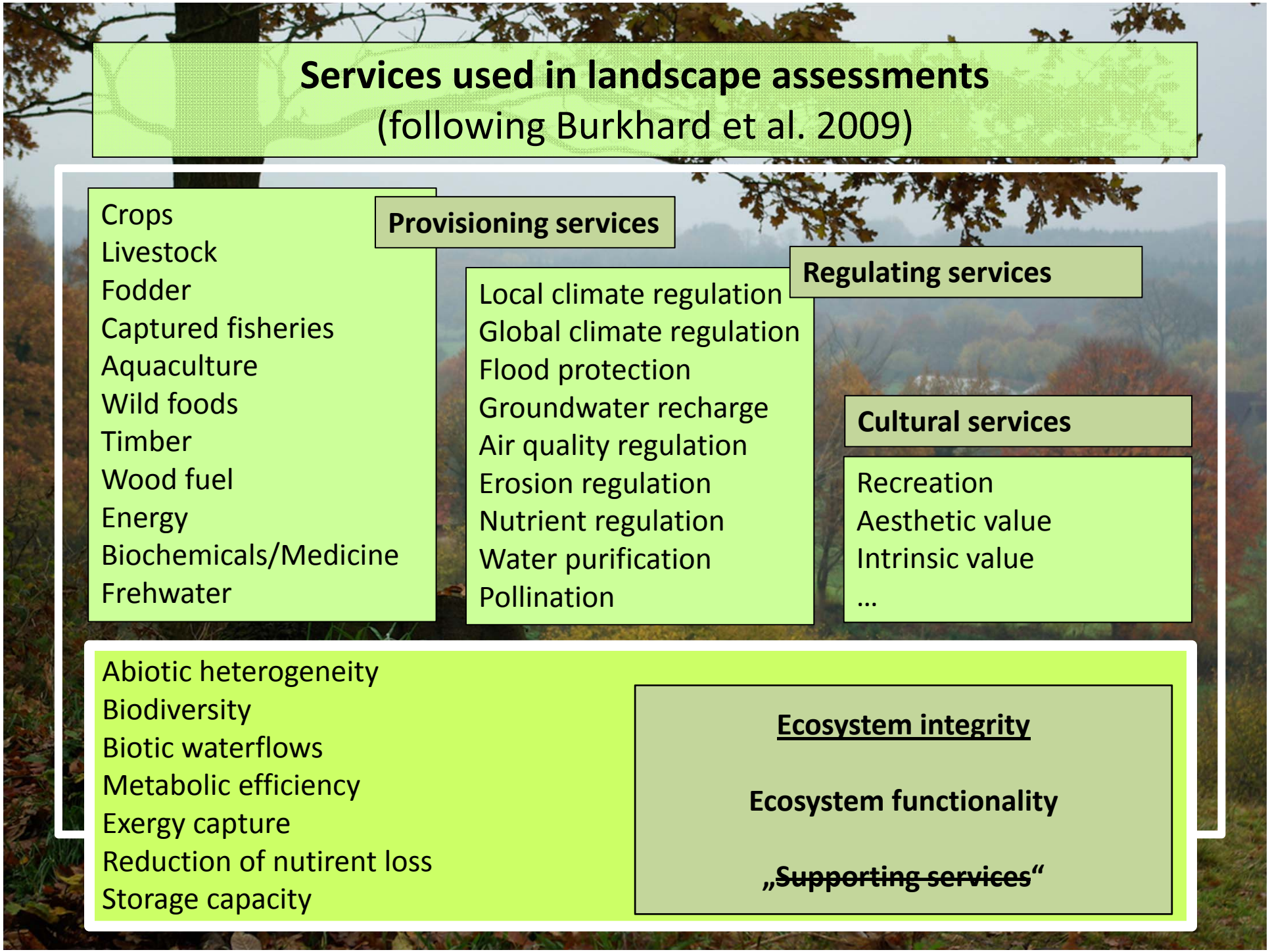
Regulating services

- Local climate regulation
- Global climate regulation
- Flood protection
- Groundwater recharge
- Air quality regulation
- Erosion regulation
- Nutrient regulation
- Water purification
- Pollination

Cultural services

- Recreation
- Aesthetic value
- Intrinsic value
- …

All services and _all_ service potentials should be taken into account to support trade-offs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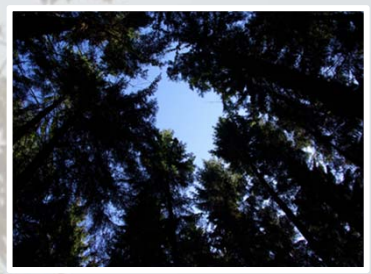
Recreation
Aesthetic value
Intrinsic value
…
Abiotic heterogeneity
Biodiversity
Biotic waterflows
Metabolic efficiency
Exergy capture
Reduction of nutirent loss
Storage capacity
Ecosystem integrity
Ecosystem functionality
„~~Supporting services~~“

Struktur des Beitrags



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Physische Ableitung von Services

- Messung
- Kartierung
- Ableitung / Herleitung
- Abschätzung
- Statistische Auswertung
- Tabellarische Wertzuweisungen
- Modellanwendung
- Transfer - Funktionen

http://www2.fz-juelich.de/icg/icg-3/datapool/page/1422/Measuring-and-Modelling.jpg, http://www.schreiadlerschutz.de/wp/wp-content/uploads/2008/03/kartierung_maerz1.jpg, http://www.cio.bund.de/SharedDocs/Bilder/DE/Bilder/110727_bkg_bild.html

Beispiele: Standortvergleiche

Vergleich
Acker – Wald

Bornhöveder
Seenkette


DEC 1999
Kiel
Jungmoräne
Holsteinische Schweiz
Plöner See
Geest
Neumünster
Scharbeutz
Bornhöveder Seenkette
© 2008 Tele Atlas
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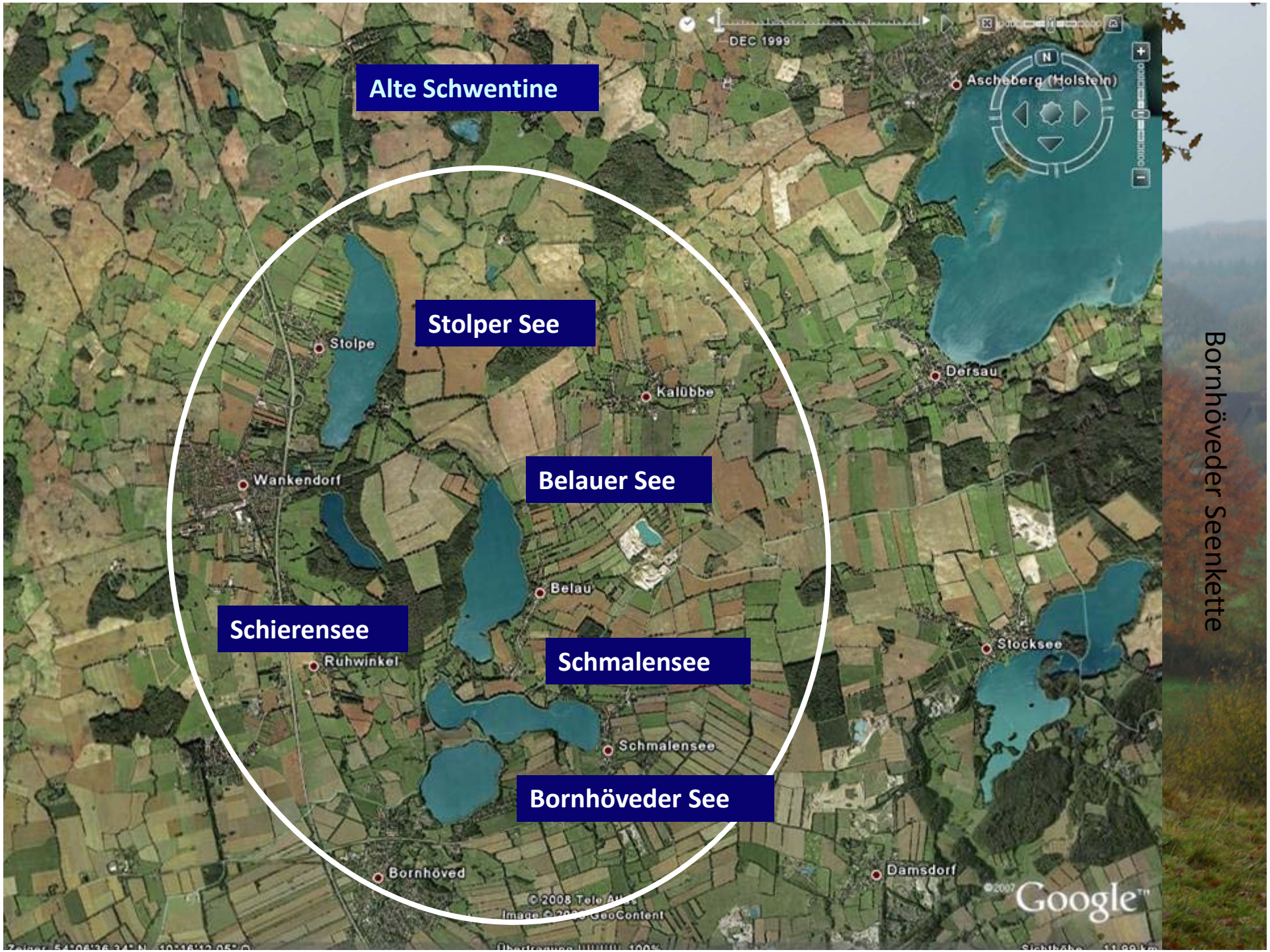
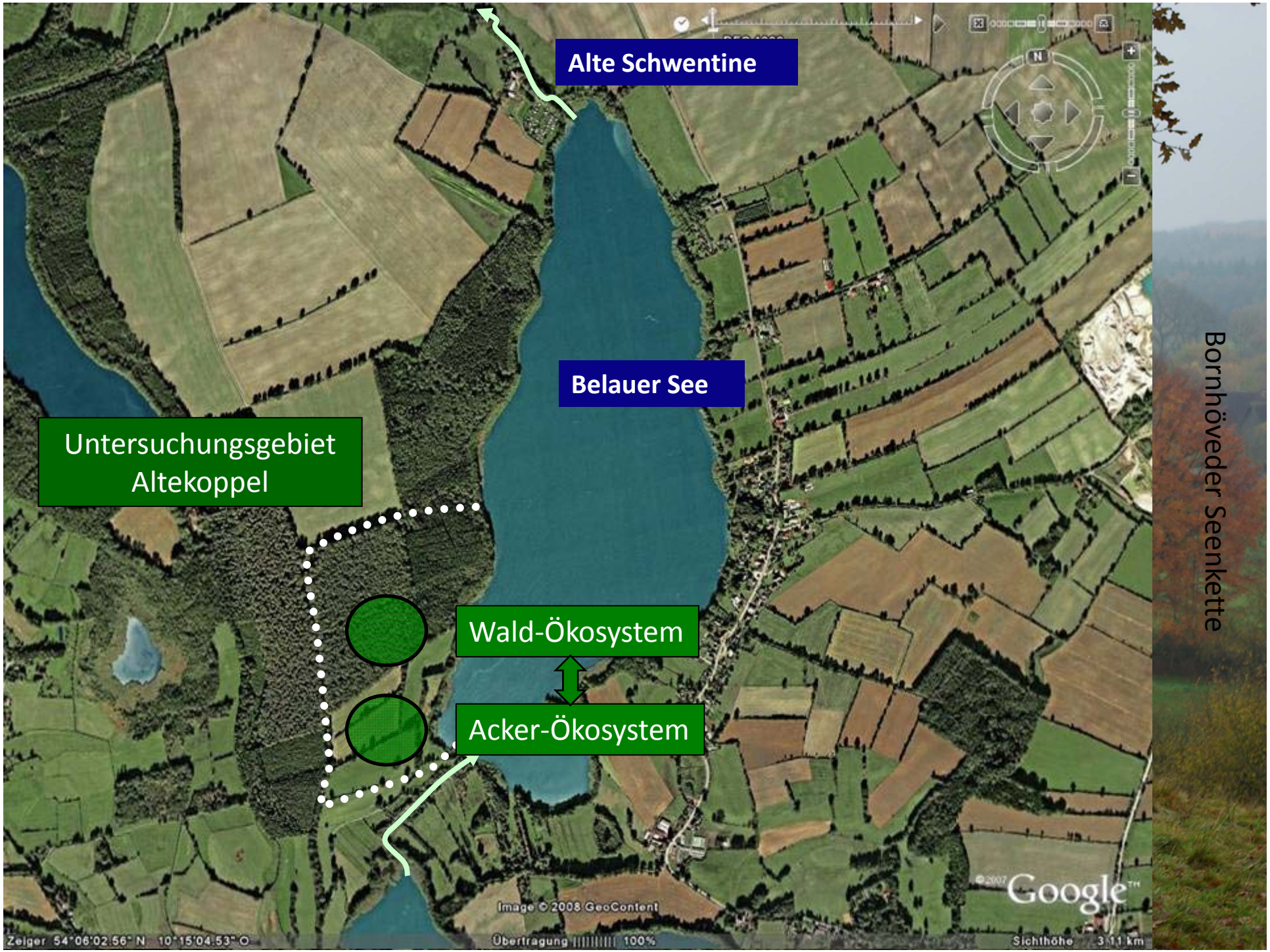
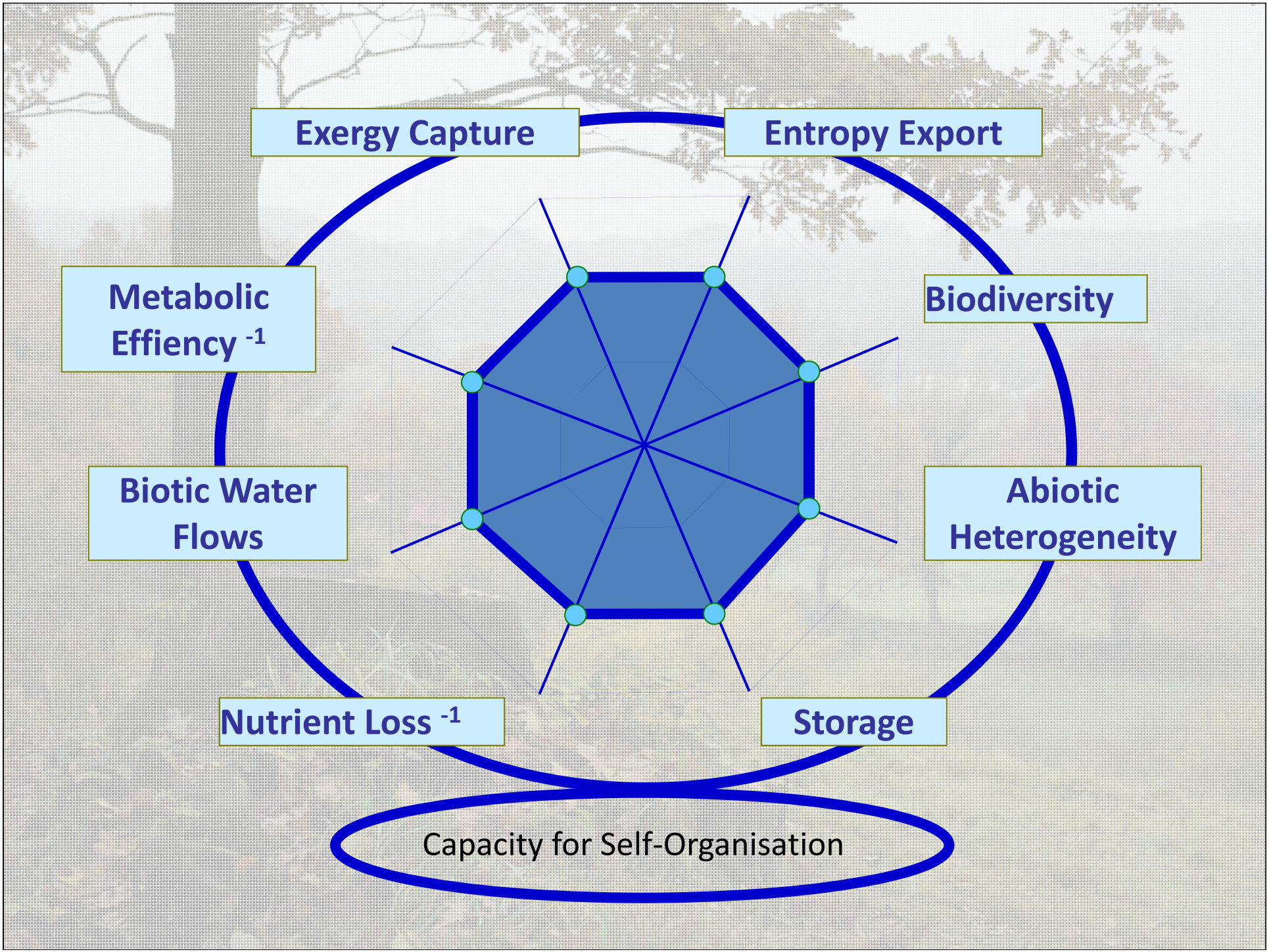
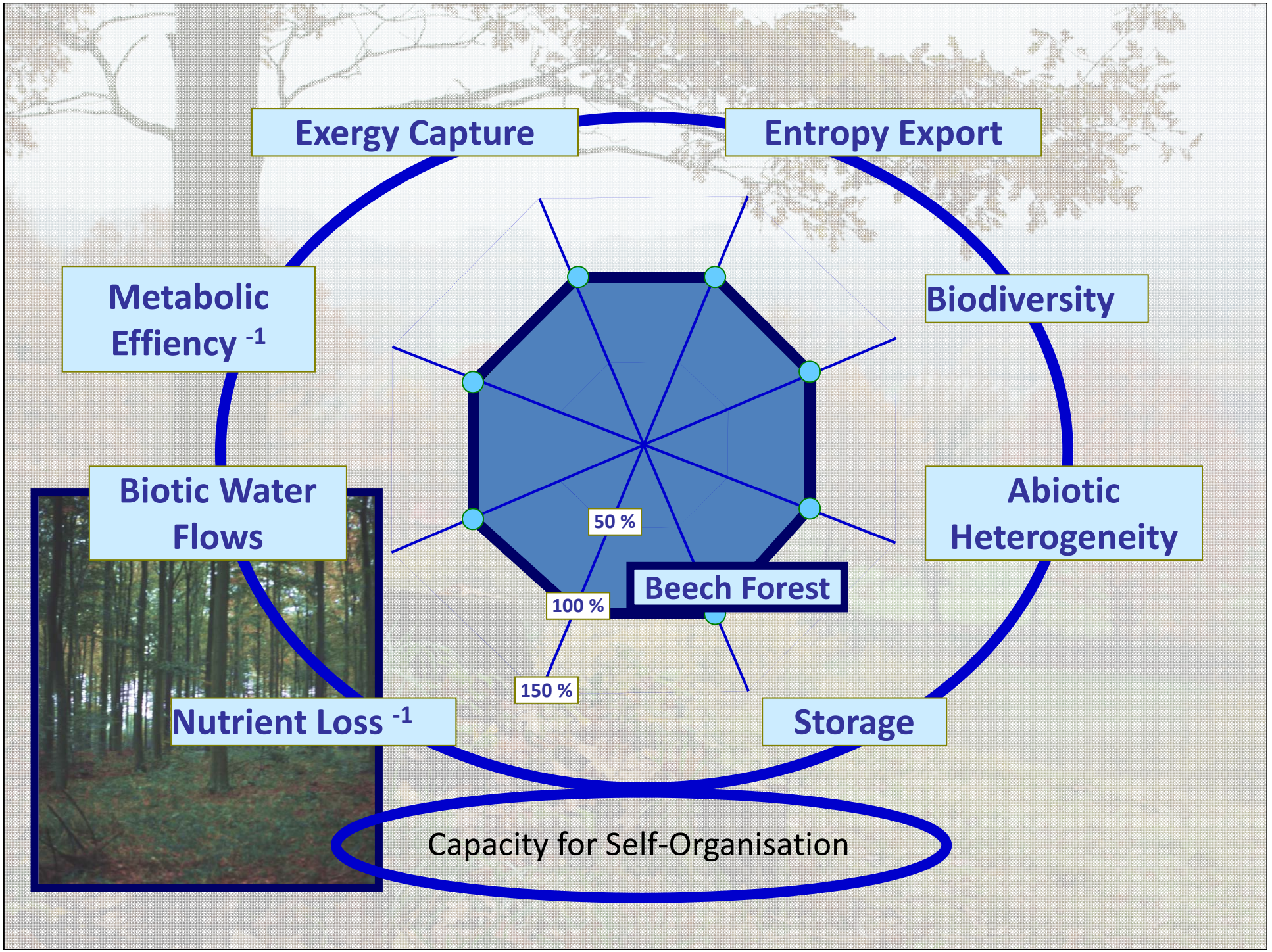
Image NASA
Google


Alte Schwentine
Stolper See
Belauer See
Schierensee
Schmalensee
Bornhöveder See
Stolpe
Wankendorf
Kalübbe
Dersau
Belau
Ruhwinkel
Schmalensee
Bornhöved
Damsdorf
Ascheberg (Holstein)
Plocksee
DEC 1999
Google
Bornhöveder Seenkette


Alte Schwentine
Belauer See
Untersuchungsgebiet
Altekoppel
Wald-Ökosystem
Acker-Ökosystem
Bornhöveder Seenkette
Image © 2008 GeoContent
Google


Exergy Capture
Entropy Export
Metabolic Effiency -1
Biodiversity
Biotic Water Flows
Abiotic Heterogeneity
Nutrient Loss -1
Storage
Capacity for Self-Organisation


Exergy Capture
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Biodiversity
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Abiotic Heterogeneity
50 %
Beech Forest
100 %
150 %
Nutrient Loss -1
Storage
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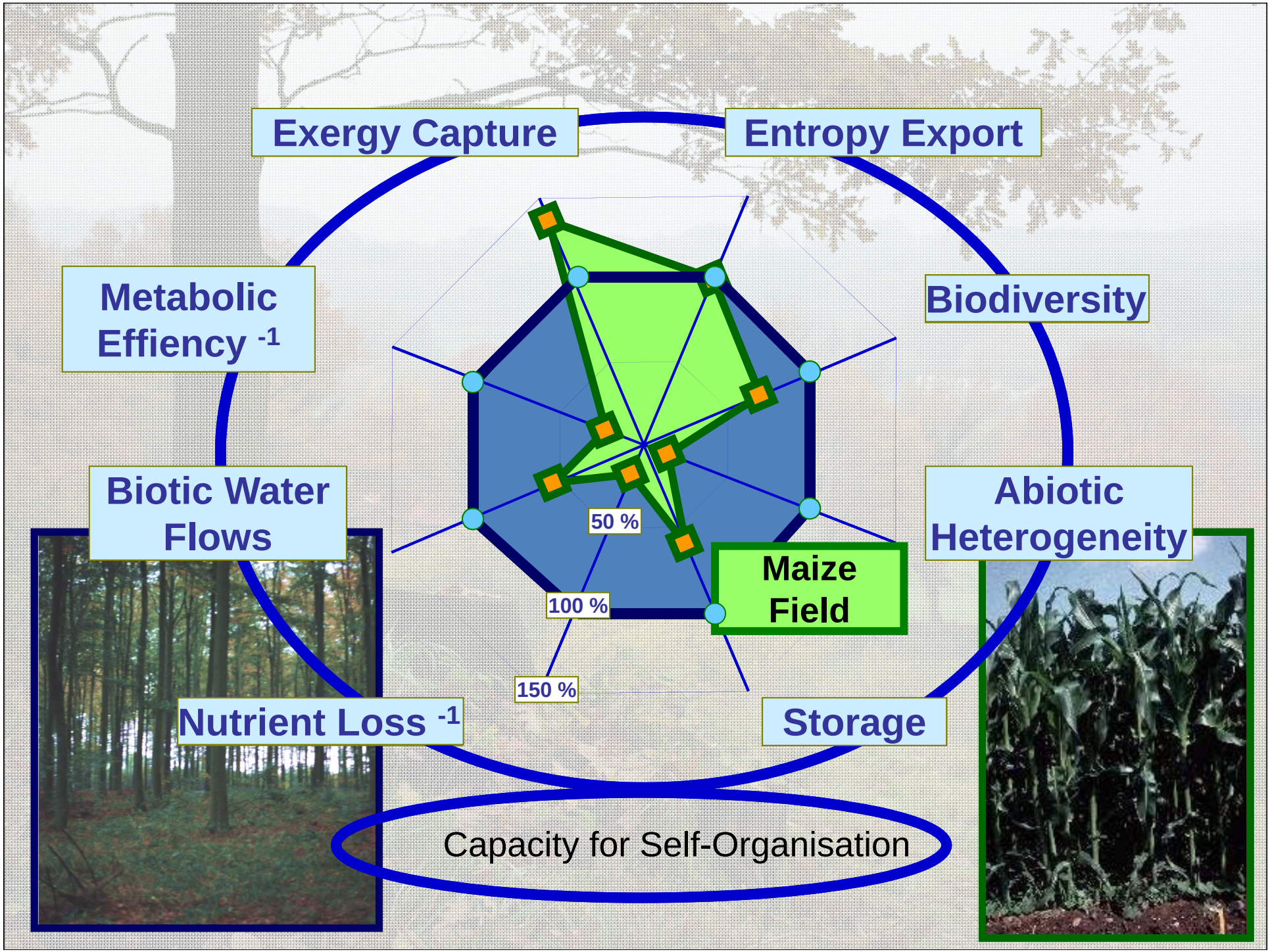
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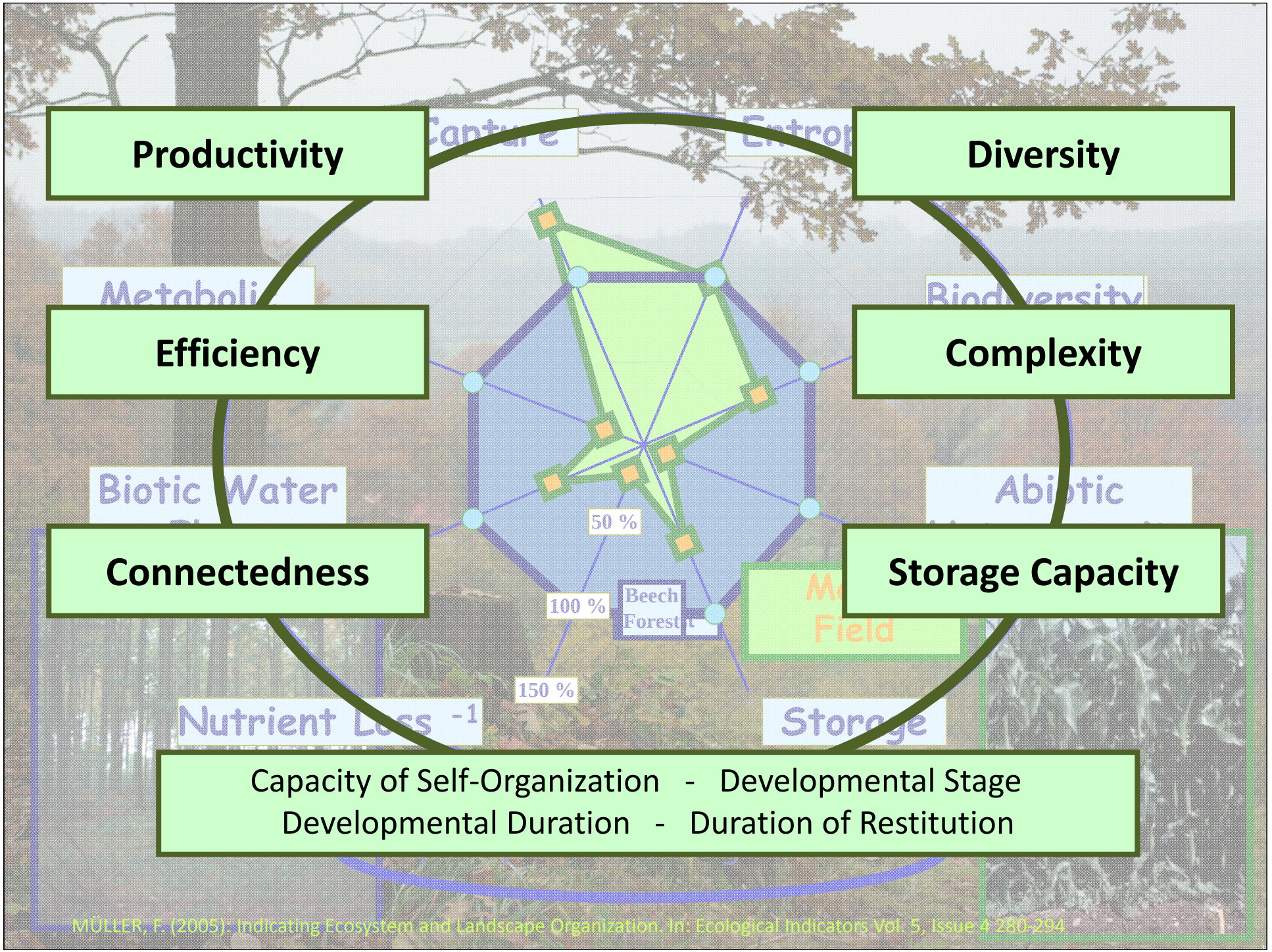
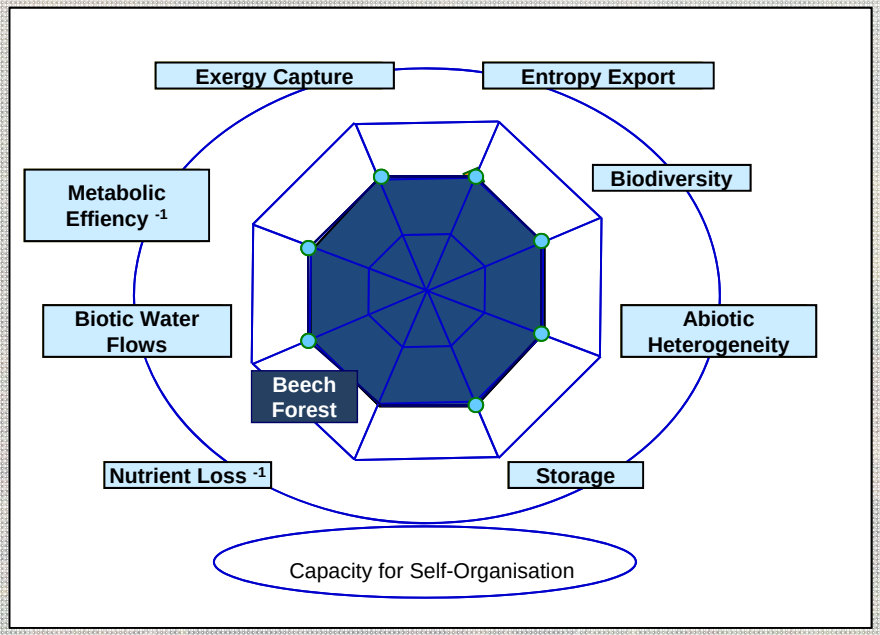
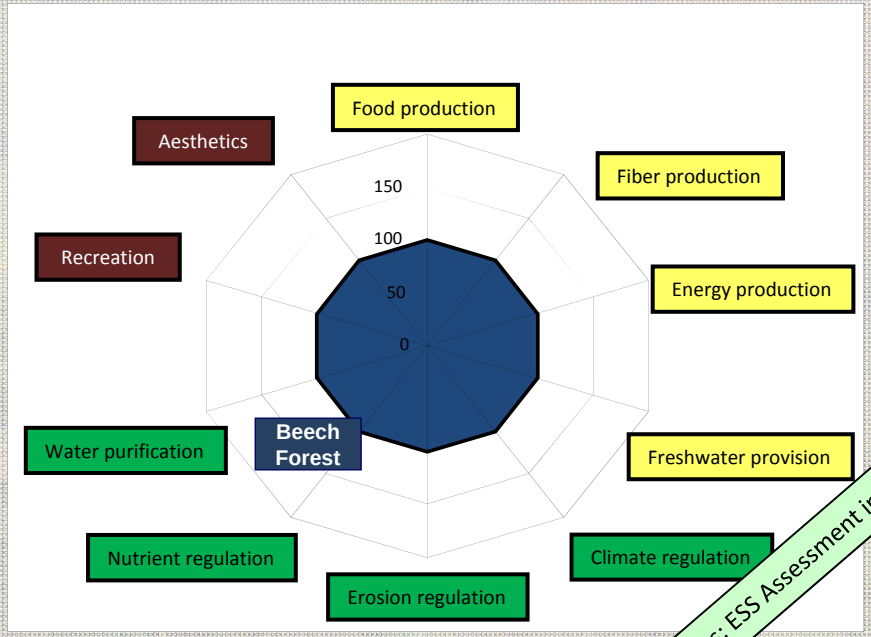


MÜLLER, F. (2005): Indicating Ecosystem and Landscape Organization. In: Ecological Indicators Vol. 5, Issue 4 280-294

Ecosystem integrity
(Supporting services)

Ecosystem services

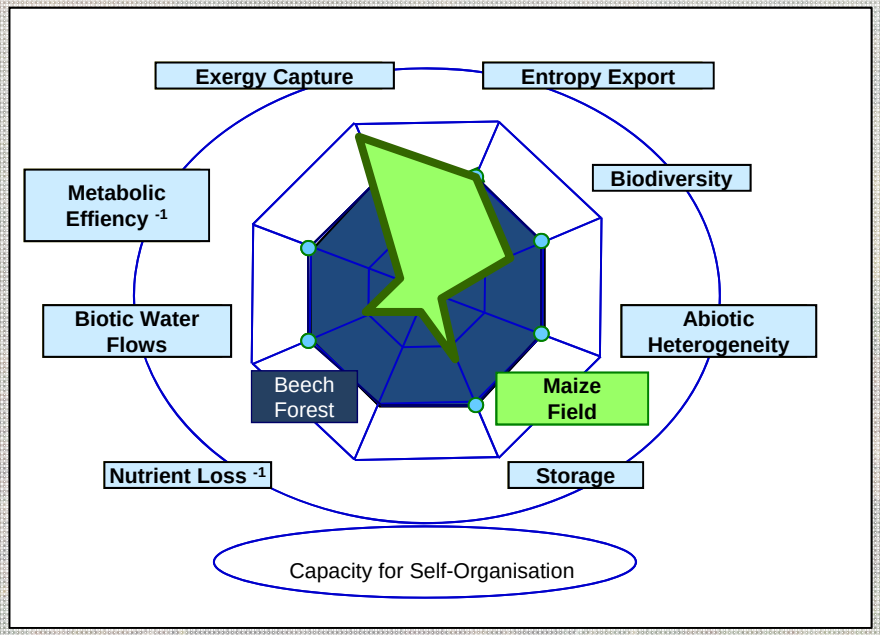


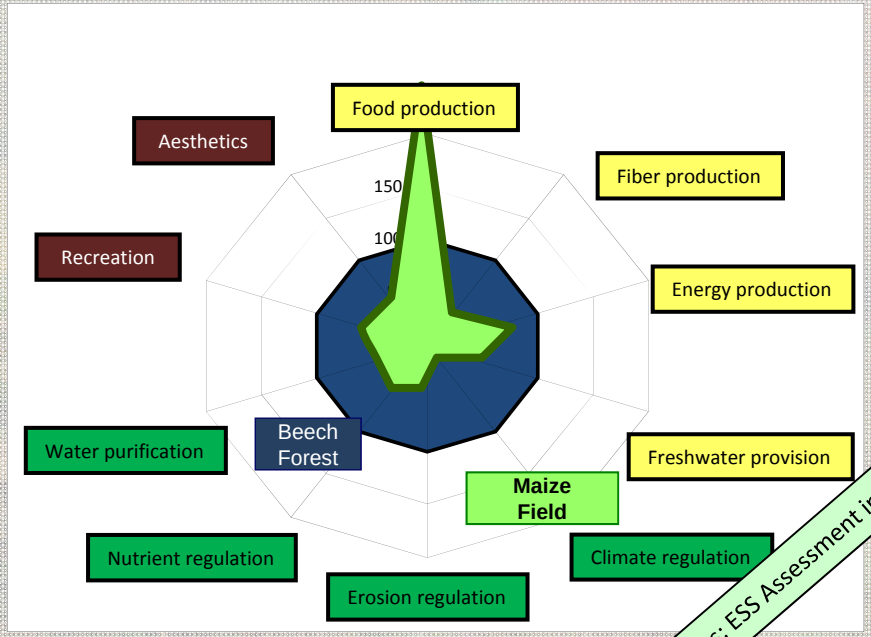


Hypotheses: ESS Assessment in work

Ecosystem integrity
(Supporting services)

Ecosystem services

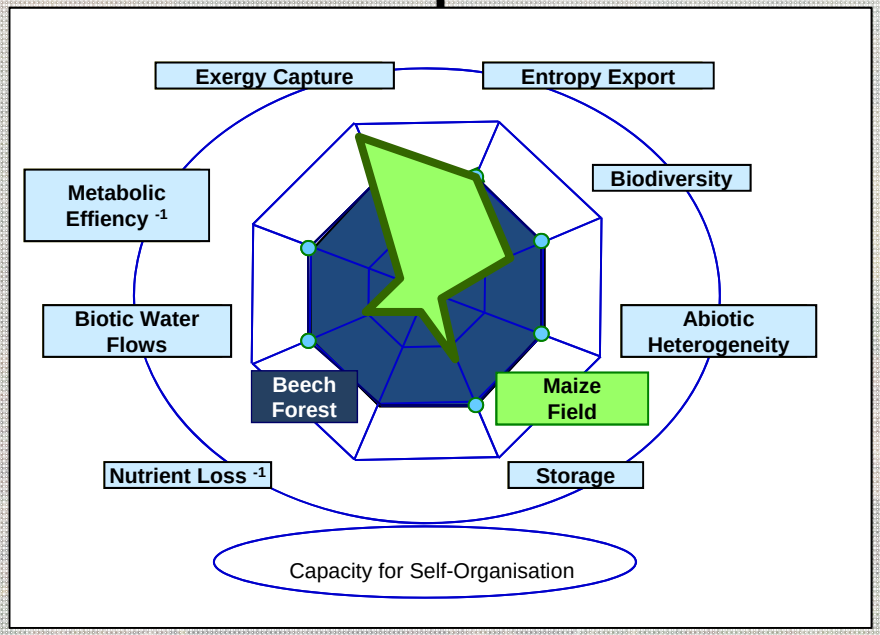




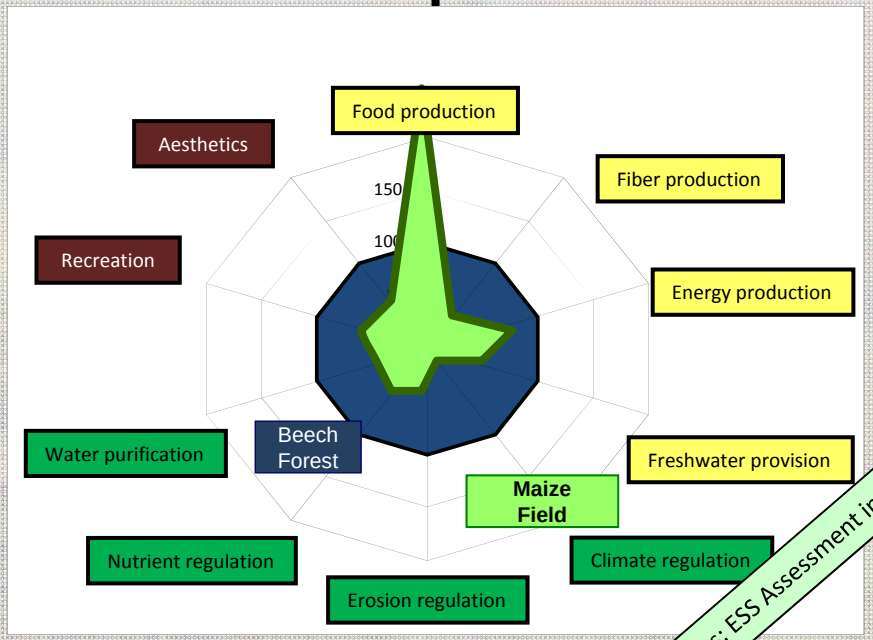
Hypotheses: ESS Assessment in work

Distinct information

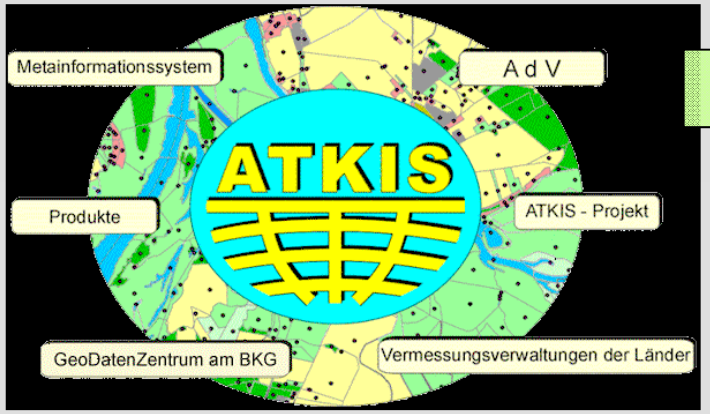
Ecosystem integrity
(Supporting services)



Ecosystem services



Physische Ableitung von Services auf der Landschaftsebene: Matrix-Ansatz



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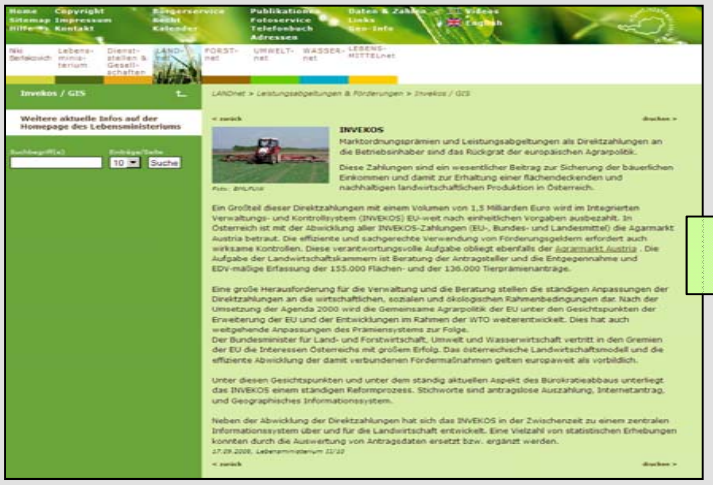
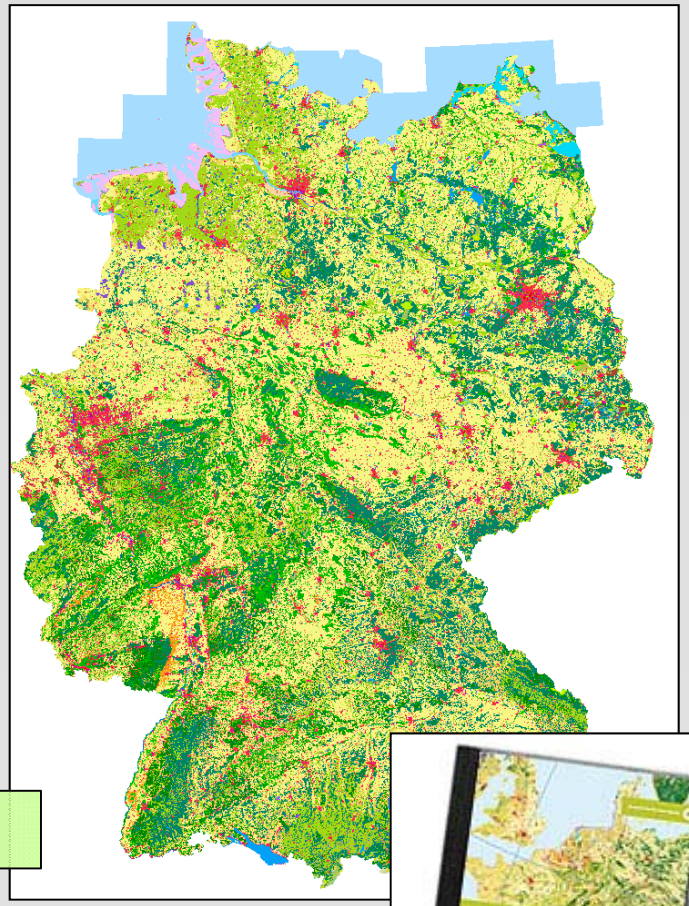


INVEKOS



CORINE

	Ecological Integrity Σ	Abiotic heterogeneity	Biodiversity	Biotic waterflows	Metabolic efficiency	Exergy Capture (Radiation)	Reduction of Nutrient loss	Storage capacity (SOM)	Regulating services Σ	Local climate regulation	Global climate regulation	Flood protection	Groundwater recharge	Air Quality Regulation	Erosion Regulation	Nutrient regulation	Water purification	Pollination	Provisioning services Σ	Crops	Livestock	Fodder	Capture Fisheries	Acquaculture	Wild Foods	Timber	Wood Fuel	Energy	Biochemicals / Medicine	Freshwater	Cultural services Σ	Recreation& Aesthetic Values	Intrinsic Value of Biodiversity
Continuous urban fabric	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Discontinuous urban fabric	7	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	3	1	0	1	0	0	1	0	0	1	0	0	0	0
Industrial or commercial units	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Road and rail networks	4	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Port areas	2	1	1	0	0	0	0	0	3	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Airports	7	1	1	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Mineral extraction sites	4	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Dump sites	8	2	1	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Construction sites	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Green urban areas	18	3	3	2	1	4	3	2	11	2	1	0	2	1	2	1	1	1	2	0	0	0	0	0	1	0	1	0	0	0	3	3	0
Sport and leasure facilities	16	2	2	2	1	4	3	2	9	1	1	0	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0
Non-irrigated arable land	22	3	2	3	4	5	1	4	5	2	1	1	1	0	0	0	0	0	21	5	5	5	0	0	0	0	0	2	1	0	1	1	0
Permanently irrigated land	21	3	2	5	2	5	1	3	5	3	1	1	0	0	0	0	0	0	18	5	5	2	0	0	0	0	0	1	1	0	1	1	0
Ricefields	20	3	2	5	1	5	1	3	4	2	0	0	2	0	0	0	0	0	7	5	0	2	0	0	0	0	0	0	0	0	1	1	0
Vineyards	14	3	2	3	1	3	0	2	3	1	1	0	1	0	0	0	0	0	5	4	0	0	0	0	0	0	1	1	0	0	5	5	0
Fruit trees and berries	21	4	3	4	2	3	2	3	19	2	2	2	2	2	2	1	1	5	13	5	0	0	0	0	0	4	4	1	0	0	5	5	0
Olive groves	17	3	2	3	2	3	1	3	7	1	1	0	1	1	1	1	1	0	12	4	0	0	0	0	0	4	4	1	0	0	5	5	0
Pastures	24	2	2	4	5	5	2	4	8	1	1	1	1	0	4	0	0	0	10	0	5	5	0	0	0	0	0	1	0	0	3	3	0
Annual and permanent crops	18	2	2	3	2	4	2	3	7	2	1	1	1	1	1	0	0	0	20	5	5	5	0	0	0	0	0	1	1	0	1	1	0
Complex cultivation patterns	20	4	3	3	2	4	1	3	5	2	1	1	1	0	0	0	0	0	9	4	0	3	0	0	0	0	0	1	2	0	2	2	0
Agriculture& natural vegetation	19	3	3	3	2	3	2	3	13	3	2	1	2	1	3	0	1	0	21	3	3	2	0	0	3	3	3	2	1	0	5	2	3
Agro-forestry areas	27	4	4	4	3	4	4	4	13	2	1	1	1	1	2	1	1	3	14	3	3	2	0	0	0	3	3	2	0	0	3	3	0
Broad-leaved forest	31	3	4	5	4	5	5	5	39	5	4	3	2	5	5	5	5	5	21	0	0	1	0	0	5	5	5	1	5	0	10	5	5
Coniferous forest	30	3	4	4	4	5	5	5	39	5	4	3	2	5	5	5	5	5	21	0	0	1	0	0	5	5	5	1	5	0	10	5	5
Mixed forest	32	3	5	5	4	5	5	5	39	5	4	3	2	5	5	5	5	5	21	0	0	1	0	0	5	5	5	1	5	0	10	5	5
Natural grassland	30	3	5	4	4	4	5	5	22	2	3	1	1	0	5	5	5	0	5	0	3	0	0	0	2	0	0	0	0	0	6	3	3
Moors and heathland	30	3	4	4	5	4	5	5	20	4	3	2	2	0	0	3	4	2	10	0	2	0	0	0	1	0	2	2	0	0	10	5	5
Sclerophyllous vegetation	21	3	4	2	3	3	4	2	7	2	1	1	1	0	0	0	0	2	8	0	2	0	0	0	1	0	2	0	3	0	6	2	4
Transitional woodland shrub	21	3	4	2	3	3	4	2	3	1	0	0	0	0	0	0	0	2	5	0	2	0	0	0	1	0	2	1	0	0	4	2	2
Beaches, dunes and sand plains	10	3	3	1	1	1	0	1	6	0	0	5	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	7	5	2
Bare rock	6	3	3	0	0	0	0	0	3	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	0
Sparsely vegetated areas	9	2	3	1	0	1	1	1	3	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Burnt areas	6	2	1	0	0	0	0	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glaciers and perpetual snow	3	2	1	0	0	0	0	0	10	3	3	0	4	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5	5	5	5	0
Inland marshes	25	3	2	4	4	4	3	5	14	2	2	4	2	0	0	4	0	0	7	0	2	5	0	0	0	0	0	0	0	0	0	0	0
Peatbogs	29	3	4	4	4	4	5	5	24	4	5	3	3	0	0	3	4	2	5	0	0	0	0	0	0	0	0	2	0	0	8	4	4
Salt marshes	23	2	3	4	3	3	3	5	8	1	0	5	0	0	0	2	0	0	2	0	2	0	0	0	0	0	0	0	0	0	3	3	0
Salines	2	1	1	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0
Intertidal flats	13	2	3	0	2	1	4	1	7	1	0	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4	4	0
Water courses	18	4	4	0	3	3	3	1	10	1	0	2	1	0	0	3	3	0	12	0	0	0	3	0	4	0	0	3	0	5	10	5	5
Water bodies	23	4	4	0	4	4	3	4	7	2	1	1	2	0	0	1	0	0	12	0	0	0	3	0	4	0	0	0	0	5	9	5	4
Coastal lagoons	25	4	4	0	5	5	3	4	5	1	0	4	0	0	0	0	0	0	16	0	0	0	4	5	4	0	0	1	0	0	9	5	4
Estuaries	21	3	3	0	5	5	3	2	9	0	0	3	0	0	0	3	3	0	17	0	0	0	5	5	4	0	0	2	0	0	7	4	3
Sea and ocean	15	2	2	0	3	3	4	1	13	3	5	0	0	0	0	5	0	0	11	0	0	1	5	5	0	0	0	3	0	0	6	4	2

Mapping ESS supply

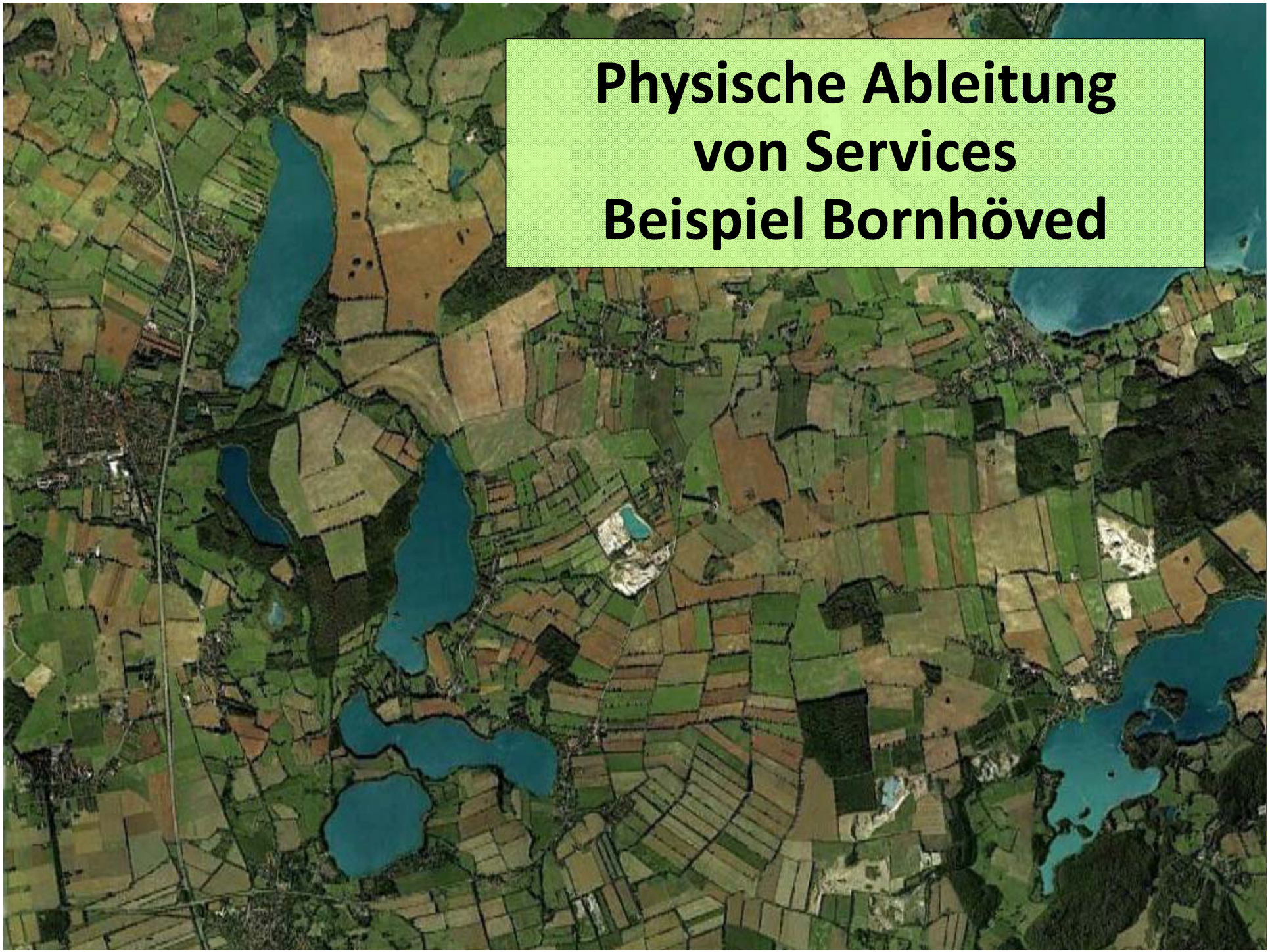
Assessment matrix
land cover types *vs*
ecosystem services

- basic assumptions -

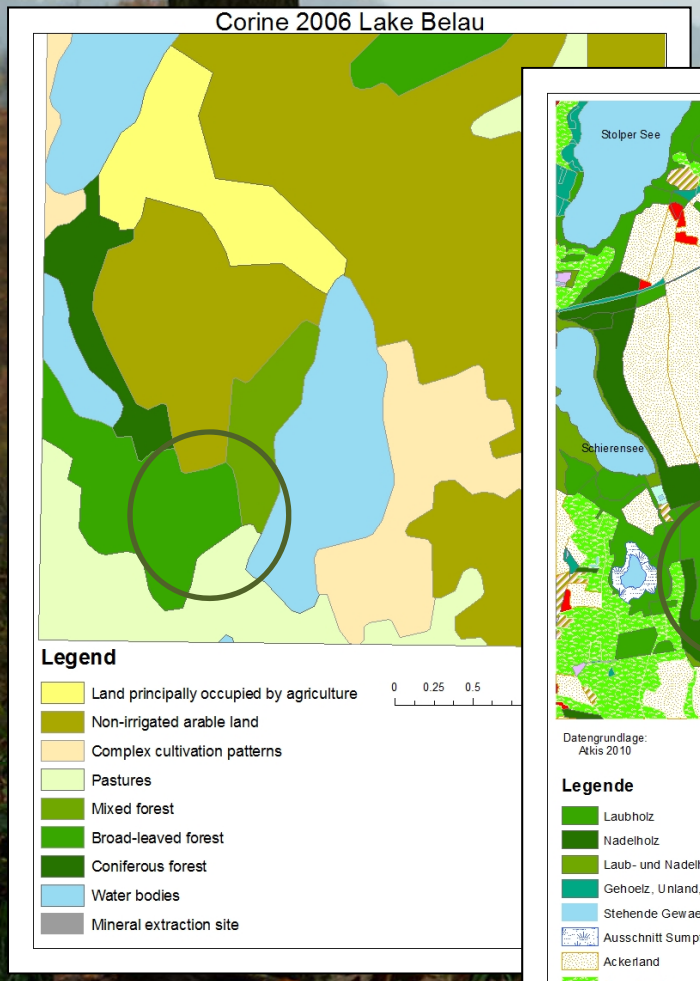
Scale for assessing capacities:

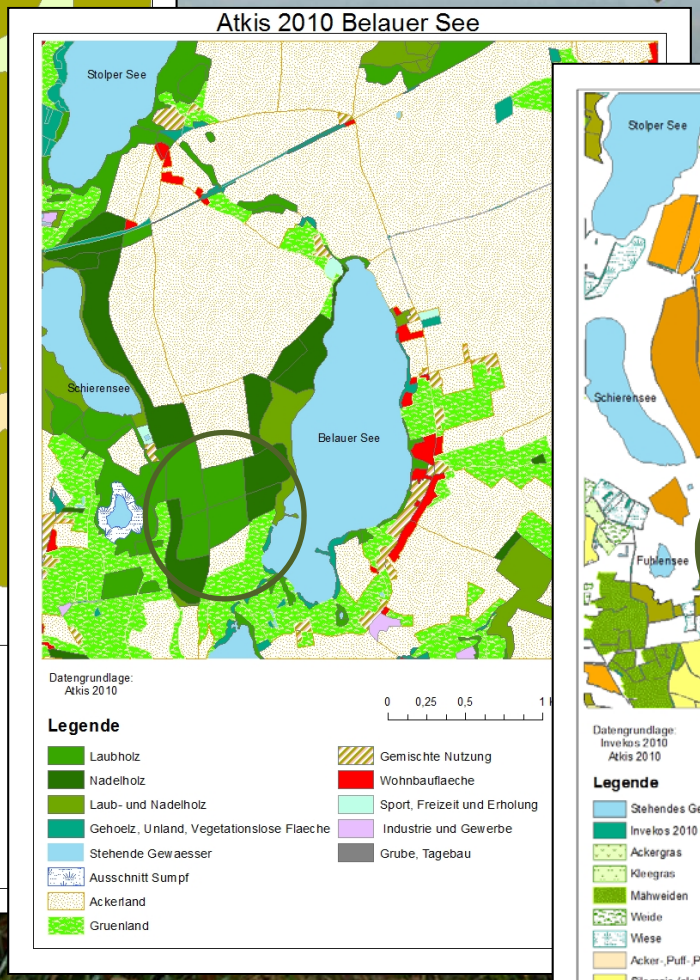
0 = no relevant capacity
1 = low relevant capacity
2 = relevant capacity
3 = medium relevant capacity
4 = high relevant capacity
5 = very high relevant capacity

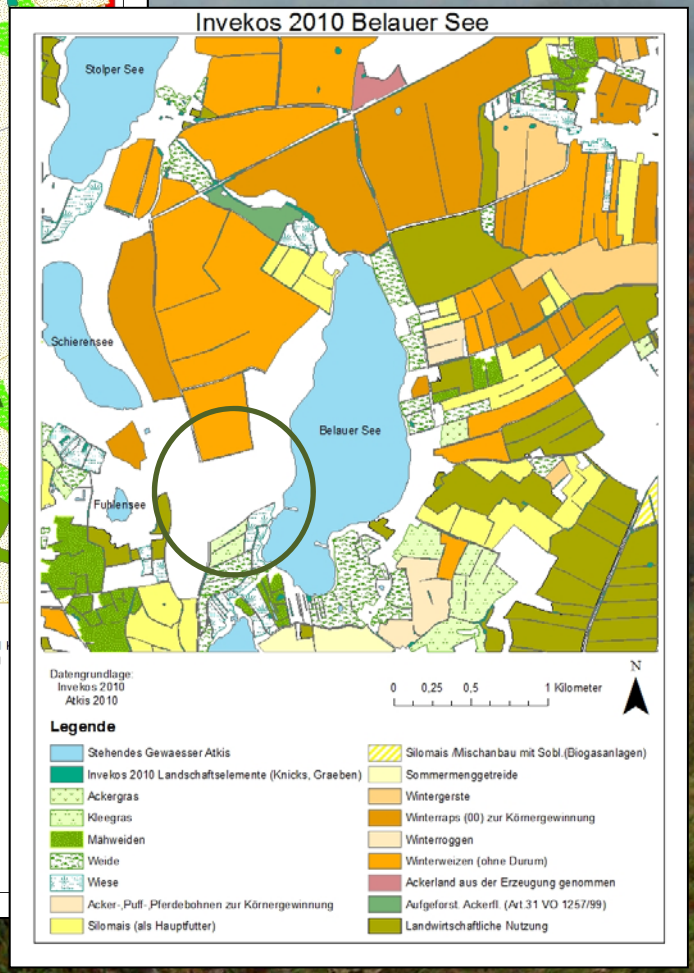
Burkhard et al. in *Landscape online* (2009)


Physische Ableitung
von Services
Beispiel Bornhöved

Hypothesenkarten - Landnutzung







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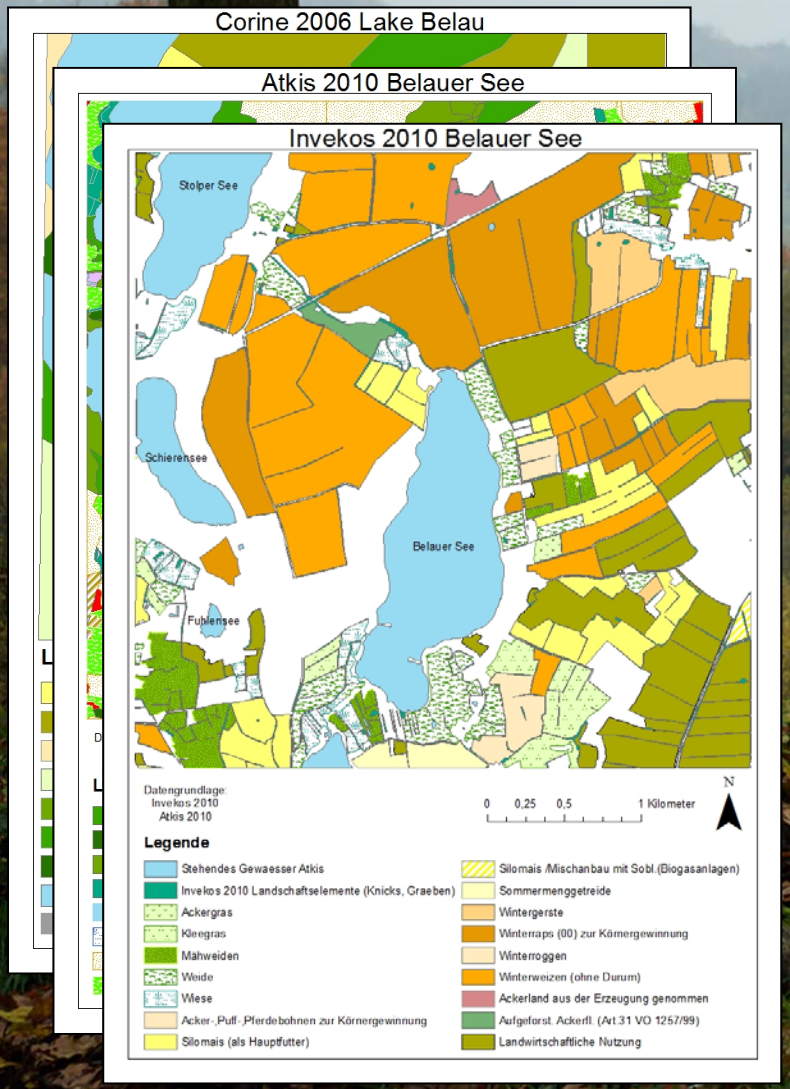
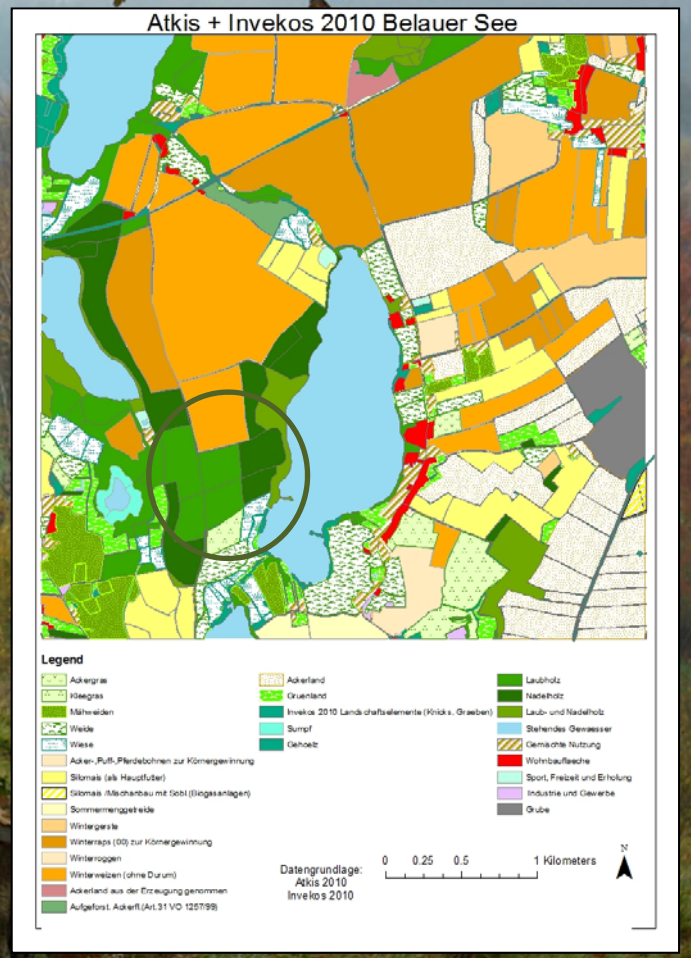
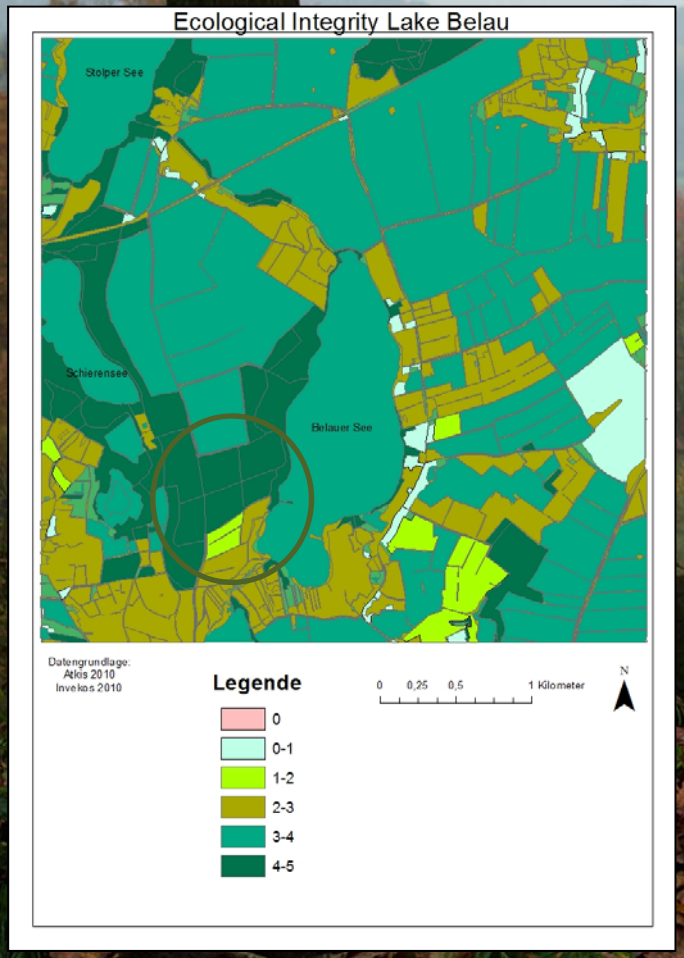
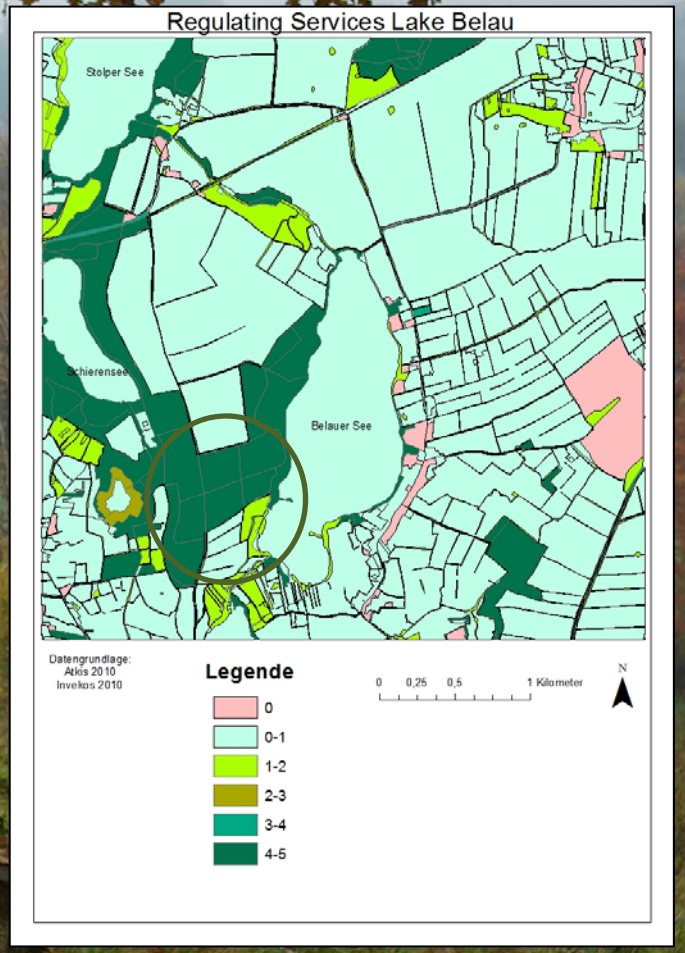
Hypothesenkarten - Landnutzung





Hypothesenkarten
Integrity und Regulating Services





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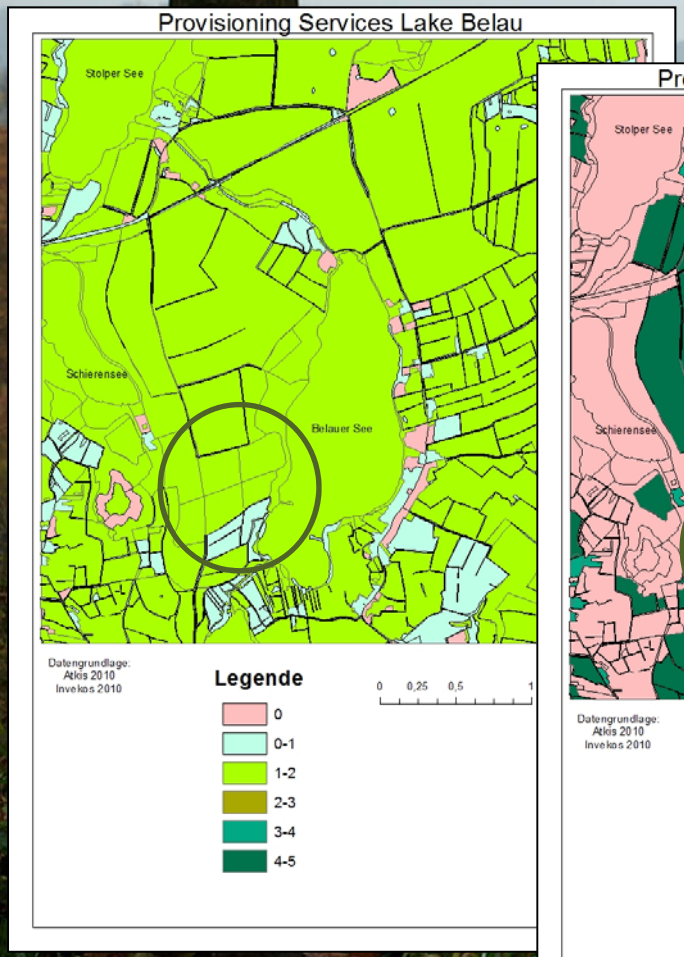
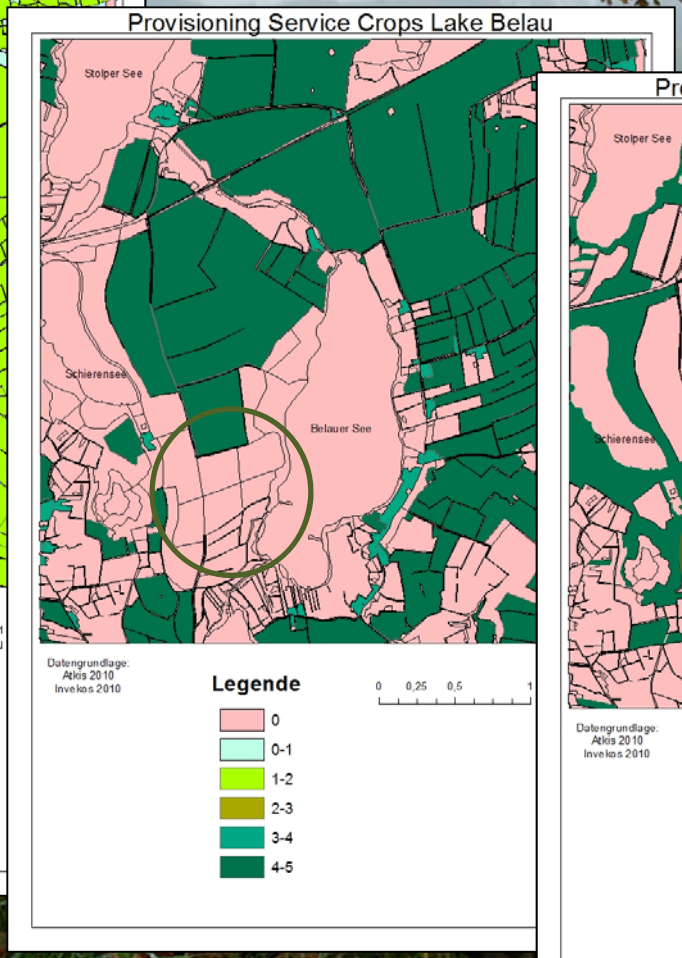
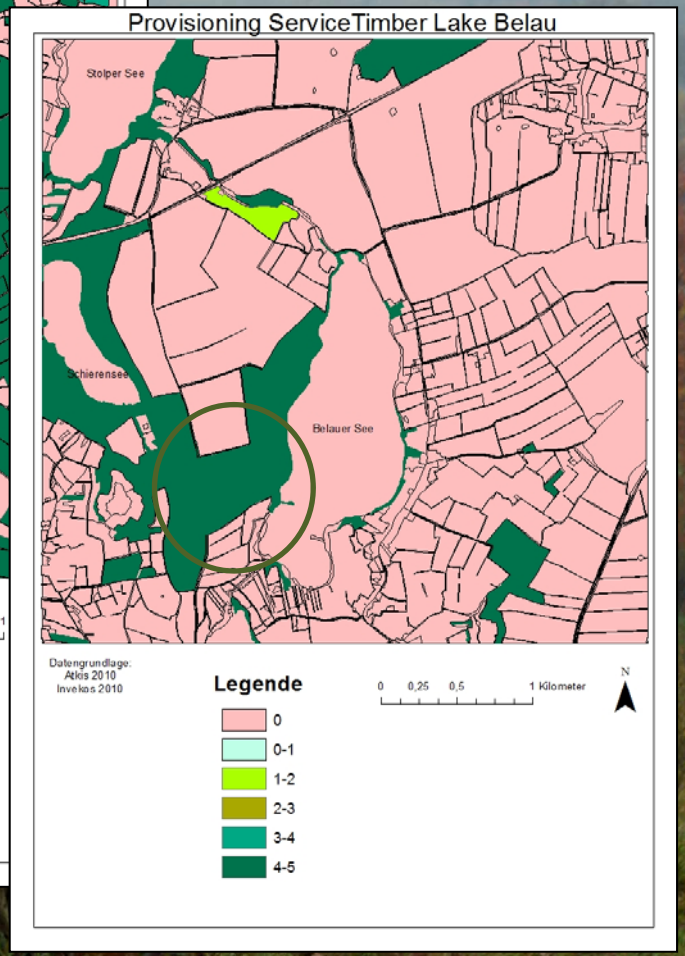
Hypothesenkarten
Provisioning Services







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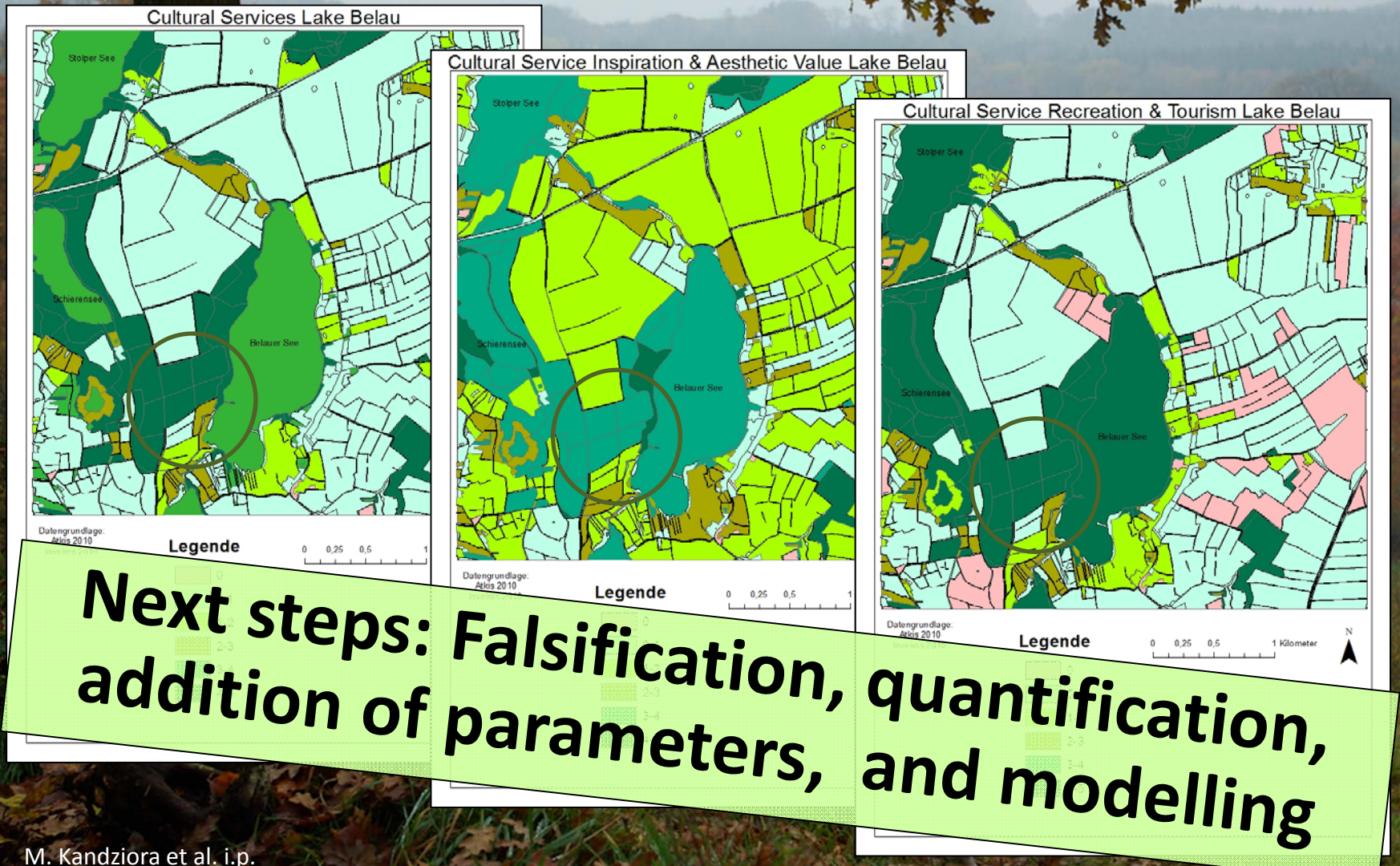
Hypothesenkarten
Cultural Services

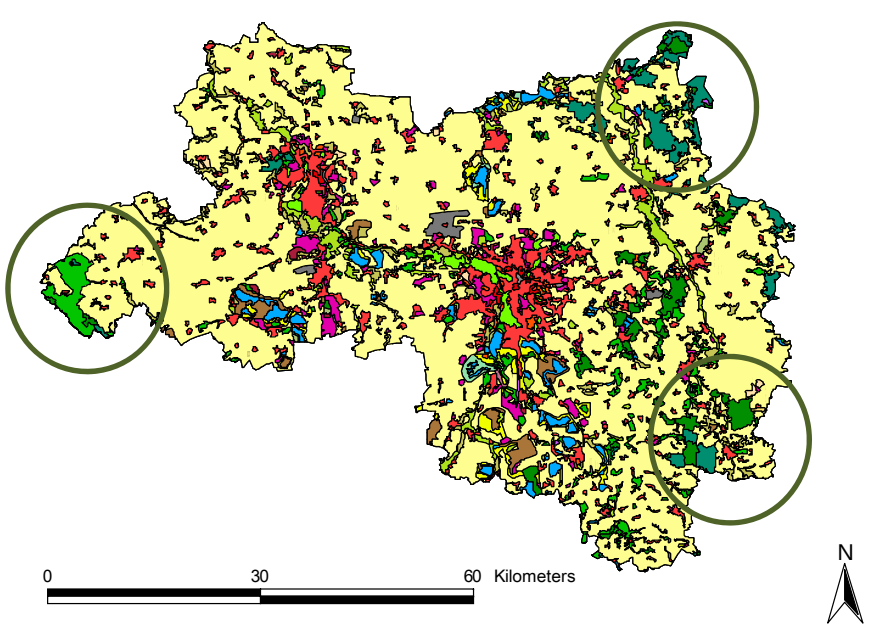


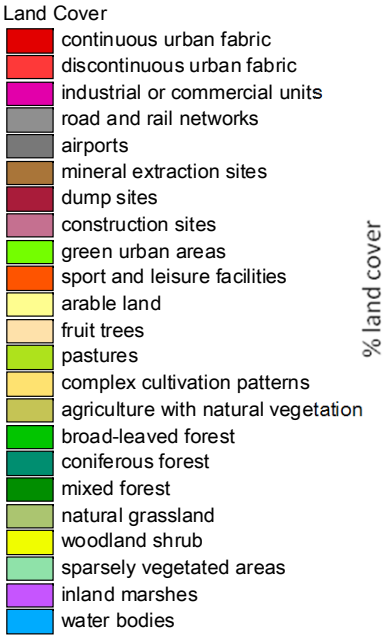
Next steps: Falsification, quantification, addition of parameters, and modelling

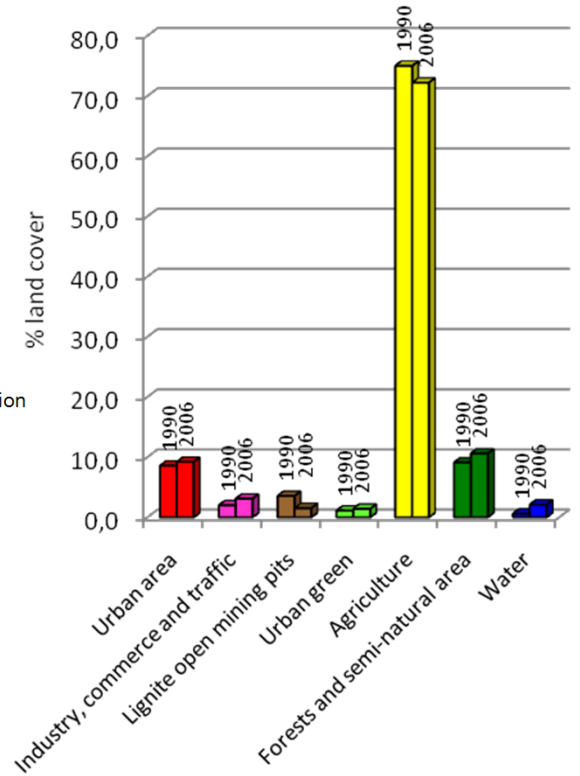
M. Kandziora et al. i.p.

Physische Ableitung von Services
Beispiel Halle-Leipzig

Land cover pattern in the case study region







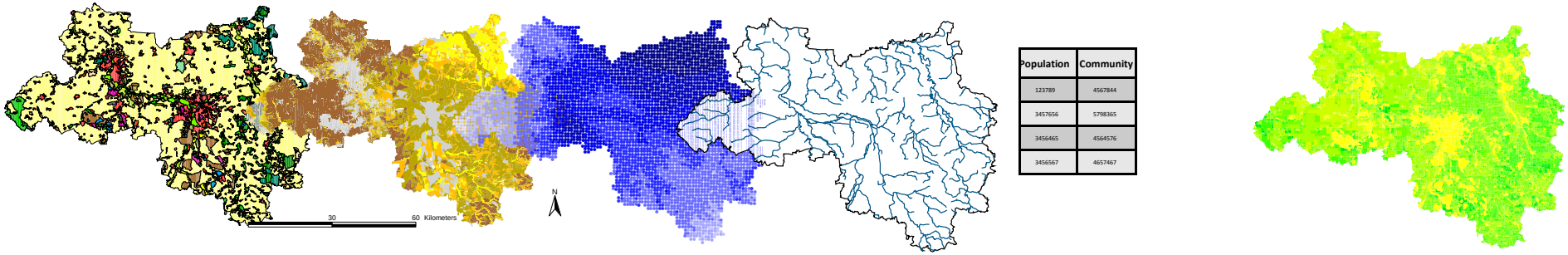
Mapping methods of ecosystem services supply and demand

F. Kroll, B. Burkhard, F. Müller (i.p.)

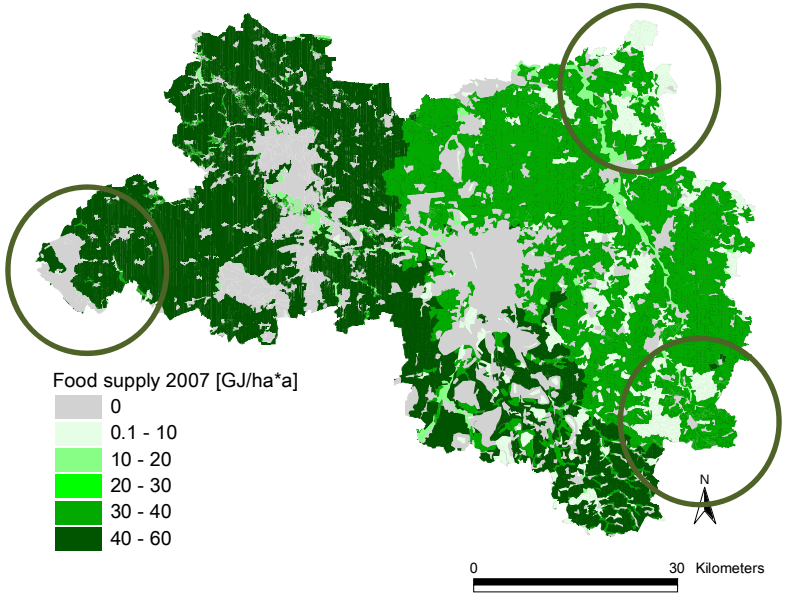
Ecosystem Service Methods

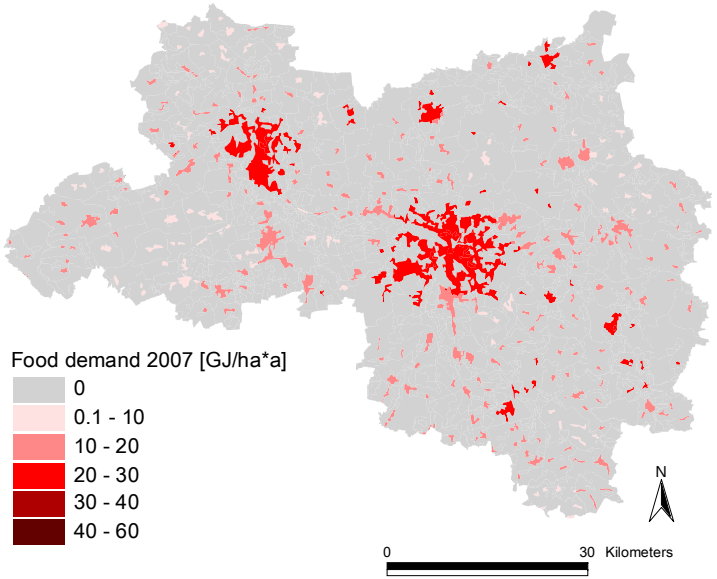
- **Quantification** of **energy** (GJ/ha), **water** (m^3/ha), **food** (GJ/ha), **CO_2 sequestration** (t CO2/ha) supply and demand at the landscape scale for 2007
- Quantification of ES **supply and demand** using readily available spatial and statistical data:
- **Spatial data**: Corine land cover, climate data on a 1x1km solution (precipitation, evapotranspiration), soil map (soil fertility, actual field capacity, root depth, groundwater level, humus content), ATKIS river map, Traffic network map, Landsat satellite images
- **Statistical data**: population numbers, resource consumption of different sectors, CO2 emissions of different sectors, traffic volumes, location of wind-, water- and solar power plants, cultivation of bio energy crops, crop yield, crop composition, yield of other agricultural products, lignite extraction, national forest inventory

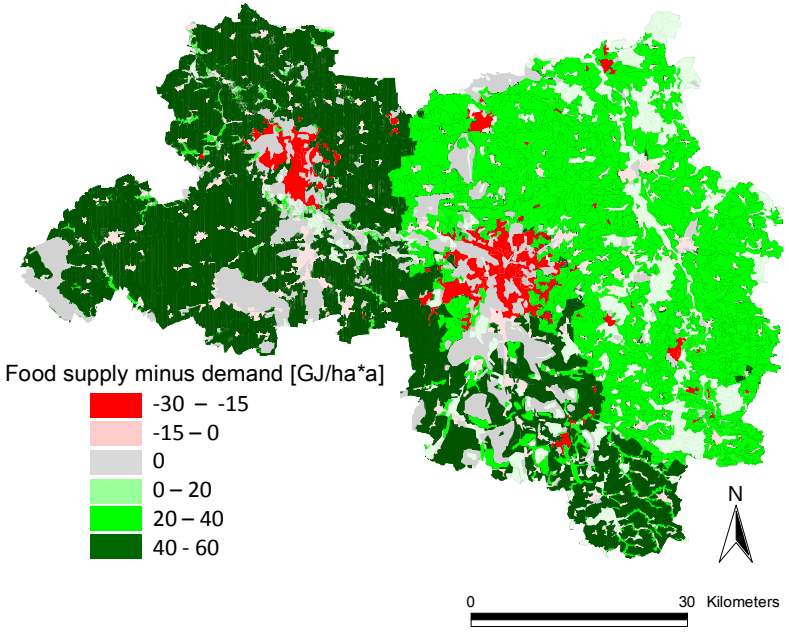
Land cover data + Soil data + Climate data + Hydrology data + Statistical data → Ecosystem service map



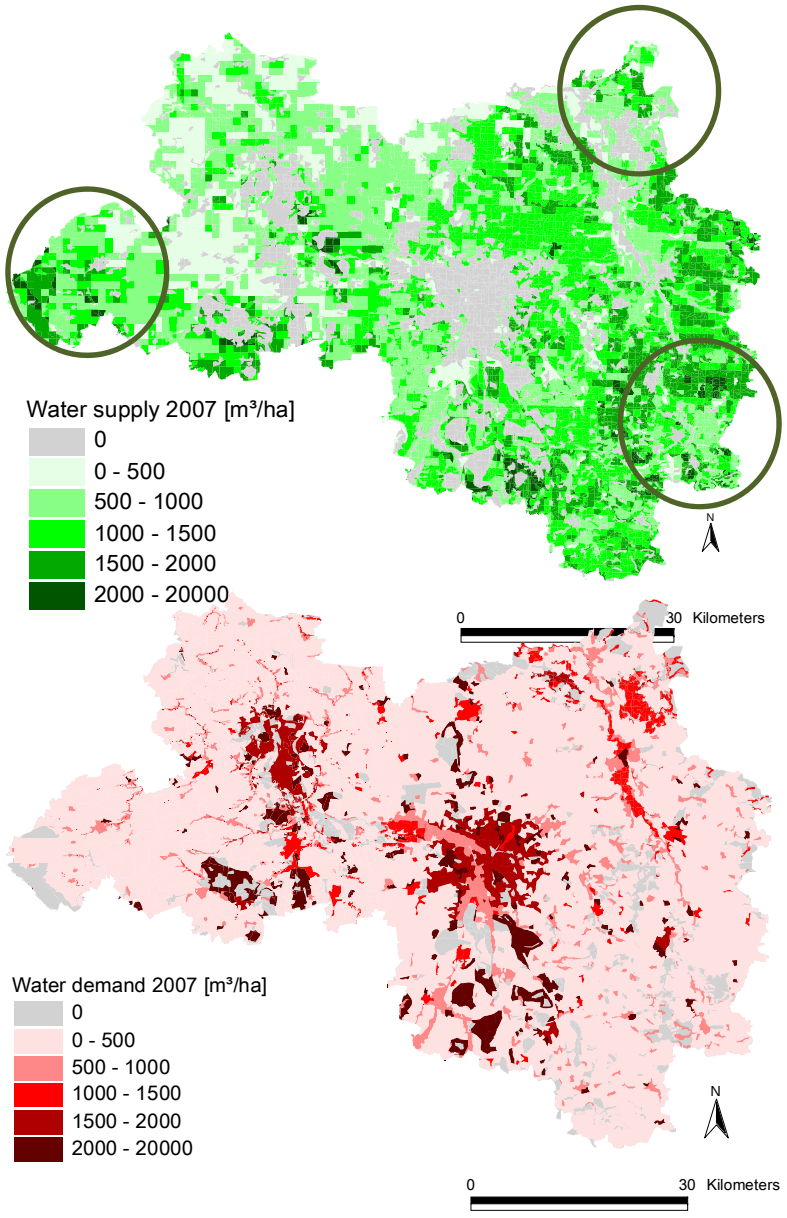
Food supply and demand

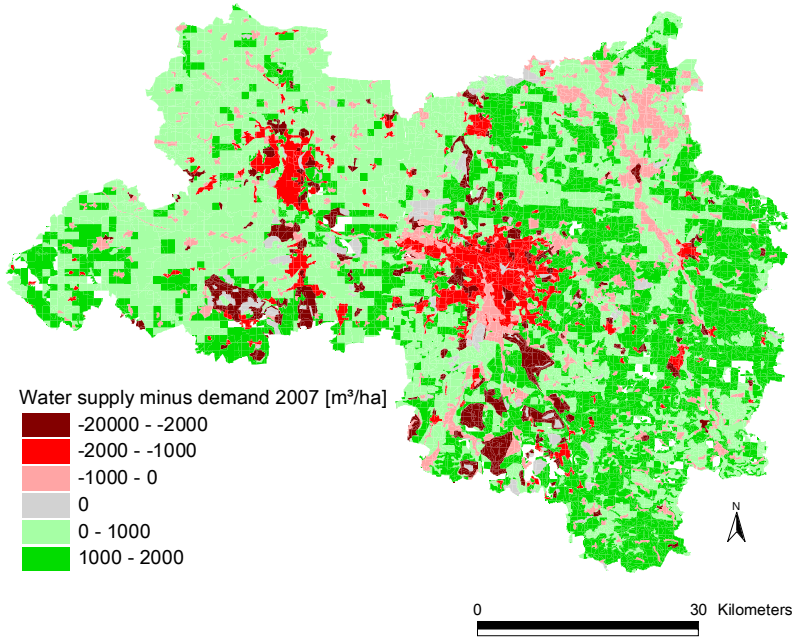






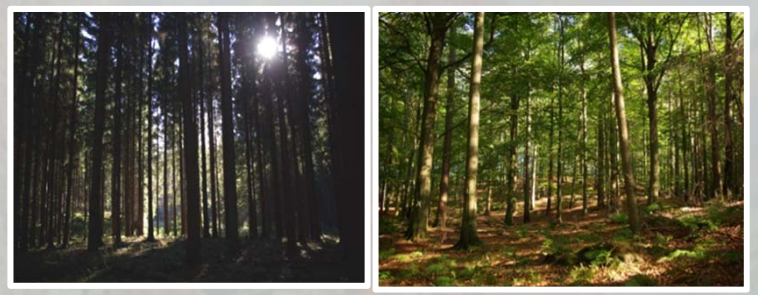
Water supply and demand





Struktur des Beitrags

- Wie verstehen wir die konzeptionelle Stellung des Ecosystem Service-Ansatzes?
- Wie können wir Ecosystem Services in der Landschaft differenzieren?
- Wie können Ecosystem Services in der Landschaft quantifiziert werden?
- **Welche Variablen können als <u>geeignete Indikatoren</u> genutzt werden?**
- **Welche <u>Daten</u> können zur Service-Abschätzung verwendet werden?**
- Wie stehen Ecosystem Services im Verhältnis zu Naturschutz-Zielen?
- Was sollten wir bei der Nutzung des Ecosystem-Service-Konzepts beachten?


LTER ENVEUROPE Indicator set

clau-- DRAFT VERSION v2.0 – Nov 2010 --

ENVEurope

Environmental quality and pressures assessment across Europe:

The LTER network as an integrated and shared system for ecosystem monitoring

Action 2 Parameters and methods elaboration

Subaction 2.2 List of parameters and harmonized methods

Activity code A2.2.2a: From processes to parameters: development of the conceptual background and a set of guiding questions making decisions how to come from processes and functions to parameters traceable
Activity period: 03-12/2010

Activity code A2.2.2b: From processes to parameters: proposal about focal qualities of monitored systems
Activity period: 10/2010-02/2011

Activity code A2.2.3a: Review and selection of abiotic/biotic indicators: review of indicator-focused action at EU and national level
Activity period: 10/2010-06/2011

Authors: Benjamin Burkhard, Felix Müller, Kiel
Contributions by: Mark Frenzel, Halle; Hendrik Schubert, Rostock

Indicandum				LTER ecosystem types and exemplary indicators		
				terrestrial ecosystems	freshwater ecosystems	marine ecosystems
Ecosystem structures	Biotic diversity		flora diversity	No. species plants	No. species plants	No. species plants
			fauna diversity	No. species animals	No. species animals	No. species animals
			additional variables	Biodiversity index	Biodiversity index	Biodiversity index
	Abiotic heterogeneity		soil heterogeneity	Soil types/area	Sediment types/area	Sediment types/area
			water heterogeneity	Soil moisture/area	Morphology type	Morphology type
			air heterogeneity	Stratification	-	-
			habitat heterogeneity	Habitat types/area	Habitat types/area	Habitat types/area
			additional variables	Landscape metrics	Landscape metrics appl	Landscape metrics appl
Ecosystem process	Energy budget	*input*	exergy capture	Primary production	Primary production	Primary production
		storage	exergy storage	Soil org. carbon	Carbon cont. sediment	Carbon cont. Sediment
		output	entropy production	Respiration	Respiration	Respiration
		additional state variables	meteorology	Radiation balance	Radiation balance	Radiation balance
		efficiency measures	metabolic efficiency	P/B quotient	P/B quotient	P/B quotient
	Matter budget	*input*	matter input	Deposition	Nutrient inflow	Nutrient inflow
		storage	matter storage	Nutrient contents soil	N. contents sediments	N. Contents sediments
		output	matter loss	Nutrient Leaching	Nutrient discharge	Nutrient discharge
		additional state variables	element concentrations	Element balances, pH	Element balances, LF	Element balances, LF
		efficiency measures	nutrient cycling	Input/Output ratio	Input/Output ratio	Input/Output ratio
	Water budget	*input*	water input	Precipitation	Precipitation, inflow	Precipitation, inflow
		storage	water storage	Field capacity	Water volume	Water volume
		output	water output	Seepage	Discharge	Discharge
		additional state variables	Water flows	Evapotranspiration	Evapotranspiration	Evapotranspiration
		efficiency measures	biotic water flow	Transp. / Evaprotransp.	Input/Output ratio	Input/Output ratio

Hierarchical overview of **ecological integrity indicators** for the different LTER ecosystem s

List of ecological integrity and ecosystem service components with definitions and potential indicators

(based on de Groot et al. 2010, Burkhard et al. 2009, Müller & Burkhard 2007, MA 2005).

Indicandum	Definition	Potential indicators
Ecological integrity (instead of supporting services)		
Abiotic heterogeneity	The provision of suitable habitats for different species, for functional groups of species and for processes is essential for the functioning of ecosystems.	Habitat diversity indices Heterogeneity indices, e.g. humus contents in the soil Number/area of habitats
Biodiversity	The presence or absence of selected species, (functional) groups of species or species composition.	Indicator species representative for a certain phenomenon or sensitive to distinct changes.
Biotic water flows	Referring to the water cycling affected by plant processes in the system.	Transpiration / total evapotranspiration
Metabolic efficiency	Referring to the amount of energy necessary to maintain a specific biomass, also serving as a stress indicator for the system.	Respiration / biomass (metabolic quotient)
Exergy capture	The capability of ecosystems to enhance the input of usable energy. Exergy is derived from thermodynamics and measures the energy fraction that can be transformed into mechanical work. In ecosystems, the captured exergy is used to build up biomass (e.g. by primary production) and structures.	Net primary production Leaf area index LAI
Reduction of nutrient loss	Referring to the irreversible output of elements from the system, the nutrient budget and matter flows.	Leaching of nutrients e.g. N, P
Storage capacity	Is referring to the nutrient, energy and water budgets of the system and the capacity of the system to store them when available and to release them when needed.	Solved organic matter N, C_{org} in the soil N, C in biomass

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Provisioning ecosystem services

Crops	Cultivation of edible plants.	Plants / ha kJ / ha
Livestock	Keeping of edible animals.	Animals / ha kJ / ha
Fodder	Cultivation and harvest of animal fodder.	Fodder plants / ha kJ / ha
Capture fisheries	Catch of commercially interesting fish species, which are accessible for fishermen.	Fishes available for catch / ha kJ / ha
Aquaculture	Animals kept in terrestrial or marine aquaculture.	Number of animals / ha kJ / ha
Wild foods	Harvest of e.g. berries, mushrooms, wild animal hunting or fishing.	Plant biomass / ha Animals available / ha kJ / ha
Timber	Presence of trees or plants with potential use for timber.	Wood / ha kJ / ha
Wood fuel	Presence of trees or plants with potential use as fuel.	Wood or plant biomass / ha kJ / ha
Energy (biomass)	Presence of trees or plants with potential use as energy source.	Wood or plant biomass / ha kJ / ha
Biochemicals / medicine	Production of biochemicals, medicines.	Amount or number of products kg / ha
Freshwater	Presence of freshwater.	l or m^3 / ha

List of ecological integrity and ecosystem service components with definitions and potential indicators

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Regulating ecosystem services

Local climate regulation	Changes in land cover can locally affect temperature, wind, radiation and precipitation.	Temperature, albedo, precipitation, wind Temperature amplitudes Evapotranspiration
Global climate regulation	Ecosystems play an important role in climate by either sequestering or emitting greenhouse gases.	Source-sink of water vapour, methane, CO_2 Carbon sequestration rate
Flood protection	Natural elements dampening extreme flood events	Number of floods causing damages
Groundwater recharge	The timing and magnitude of runoff, flooding, and aquifer recharge can be strongly influenced by changes in land cover, including, in particular, alterations that change the water storage potential of the system, such as the conversion of wetlands or the replacement of forests with croplands or croplands with urban areas.	Groundwater recharge rates
Air quality regulation	The capacity of ecosystems to remove toxic and other elements from the atmosphere.	Leaf area index, Stemflow chemistry, Air quality amplitudes
Erosion regulation	Vegetative cover plays an important role in soil retention and the prevention of landslides.	Loss of soil particles by wind or water Vegetation cover, USLE components
Nutrient regulation	The capacity of ecosystems to carry out (re)cycling of e.g. N, P or others.	N, P or other nutrient turnover rates, Plant uptake, leaching
Water purification	Ecosystems have the capacity to purify water but can also be a source of impurities in fresh water.	Water quality and quantity Water chemistry parameter
Pollination	Ecosystem changes affect the distribution, abundance, and effectiveness of pollinators. Wind and bees are in charge of the reproduction of a lot of culture plants.	Amount of plant products distribution of plants availability of pollinators

List of ecological integrity and ecosystem service components with definitions and potential indicators

(based on de Groot et al. 2010, Burkhard et al. 2009, Müller & Burkhard 2007, MA 2005).

Cultural ecosystem services

Recreation & aesthetic values	Refers specifically to landscape and visual qualities of the resp. case study area (scenery, scenic beauty). The benefit is the sense of beauty people get from looking at the landscape and related recreational benefits.	Number of visitors or facilities Questionnaires on personal preferences
Intrinsic value of biodiversity	The value of nature and species themselves, beyond economic or human benefits.	Number of endangered, protected or rare species or habitats
+ further case study specific indicators, e.g. **Spiritual and Religious Values** **Educational values** **Inspiration** **Aesthetic Values** **Social Relations** **Sense of Place**		Number of visitors Eduction concepts, participants Interviews Landscape heterogeneity, interviews Interviews Interviews

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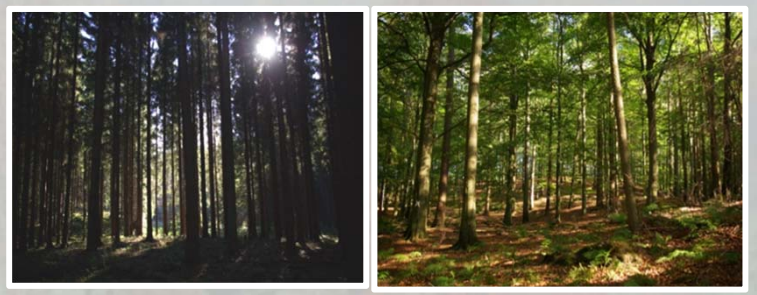
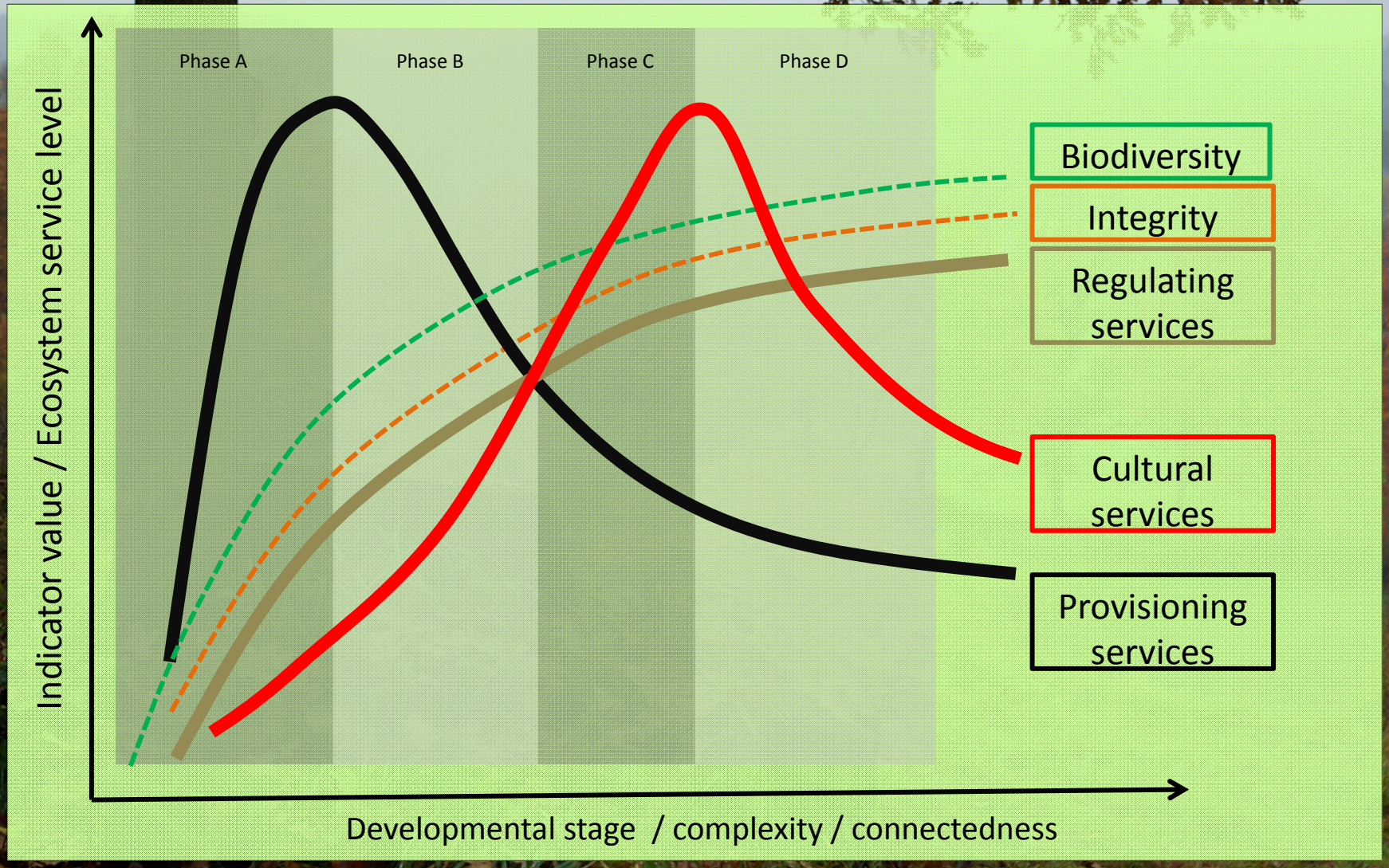


Interrelations biodiversity - biogeochemistry – ecosystem services

How are these relations treated in literature?

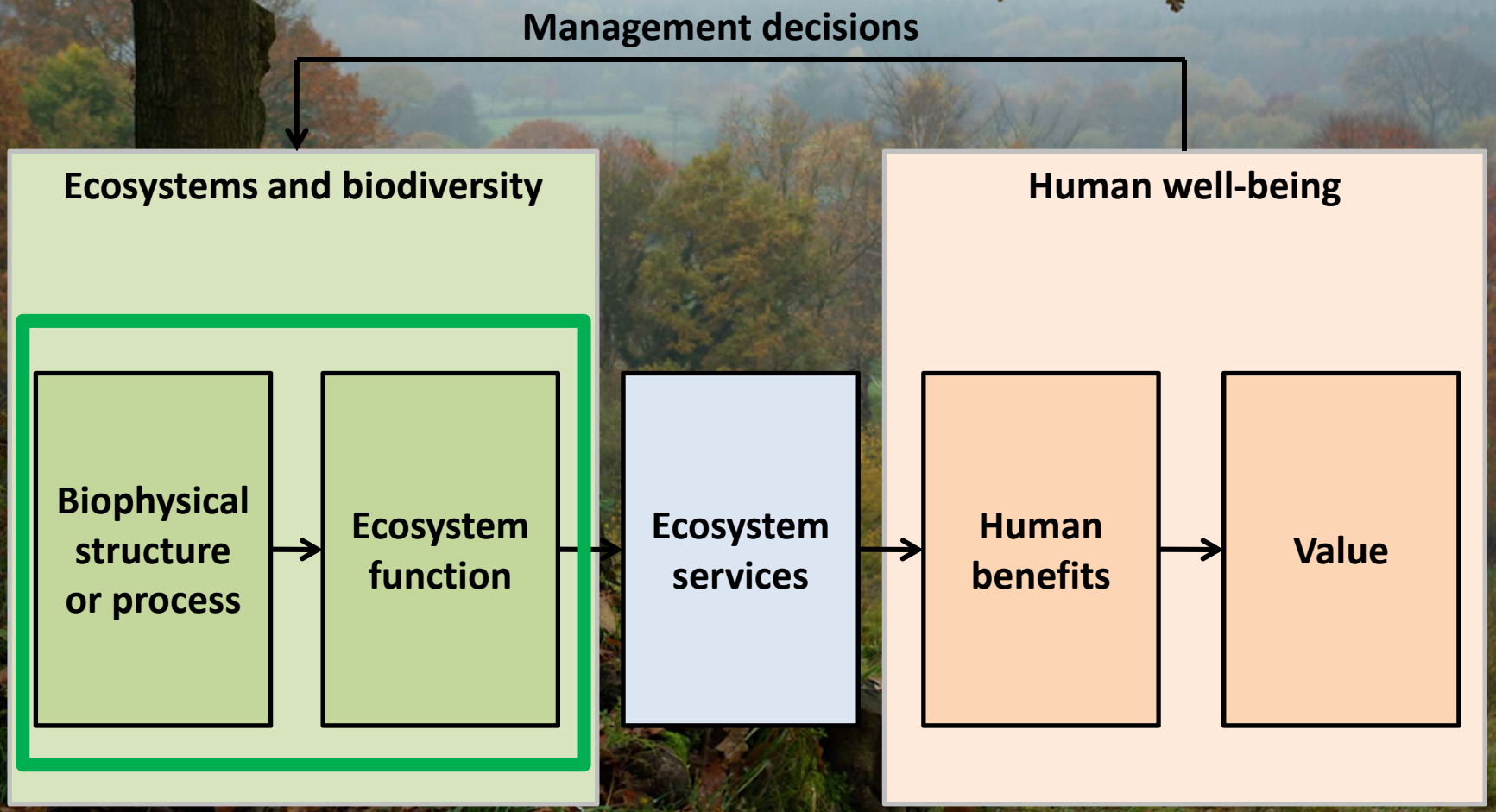
- **Neglecting** the linkages → e.g. benefit transfer
- Treating services, biodiversity and functionality as **generally positively linked** phenomena
- Preferring **composition** to diversity
- Focusing on **functional traits, functional groups or functional significance** to link the concepts
- Distinguishing different **scales** to link the concepts
- Investigating different **developmental stages** to link the concepts
- Modelling partial ecosystem relations: **interaction analysis**

Ecosystem succession and service provision



after de Groot et al. (2010), Joergensen et al. (2007), Burkhard et al. (2010), and Braat and ten Brink (2008)

The „ecosystem service cascade“



After Haines-Young and Potschin (2010), Maltby (2009), de Groot et al. (2010)

Effects of ecosystem properties and processes on ecosystem integrity variables

↗ Increase in (Y) has a supporting effect on (X)

↗↘ Interactions can have supporting or reducing effects

↘ Increase in (Y) has a reducing effect on (X)

Indirect effects are governing all relationships

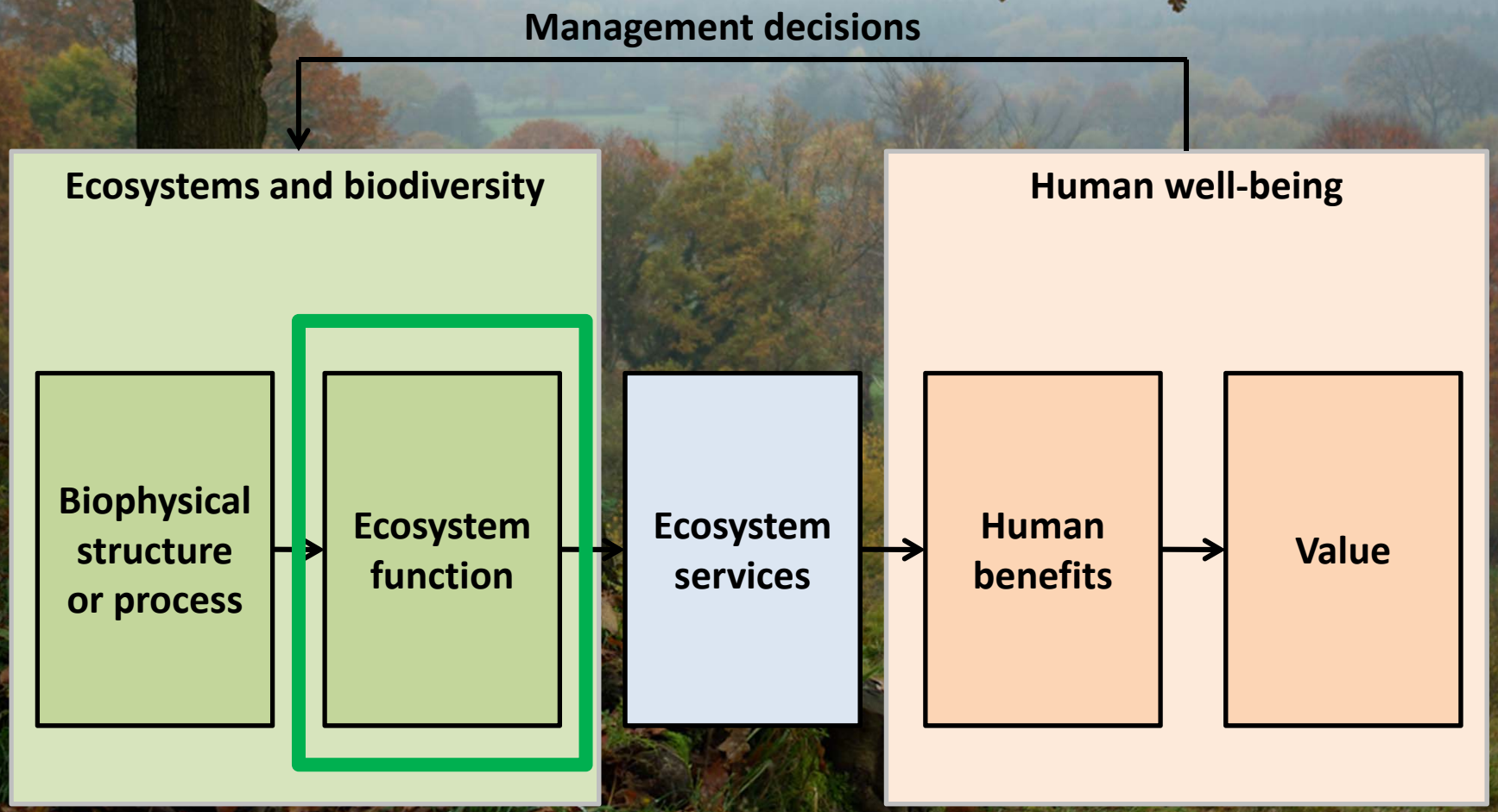
Integrity indicators (X) ⇩ Ecosystem properties (Y)	Exergy capture	Entropy production	Storage capacity	Cycling & nutrient loss reduction	Biotic water flows	Metabolic efficiencies	Hetero-geneity	Bio-diversity
No. plant species	↗	↗	↗	↗	↗	↗	↗	↗
No. animal species		↗	↗	↗		↗	↗	↗
Primary production	↗	↗	↗	↗↘	↗	↗↘	↗↘	↗↘
Respiration		↗	↘	↘		↘		
Solar radiation	↗	↗	↗↘	↗	↗↘	↗↘		↗↘
Reflection	↘	↗	↘		↗↘			
Long-wave radiation	↘	↗	↘		↗↘			
Pre								
Wa								
Eva								
Dep								
Fer								
Per								
Adsorption			↗					

1. **Direct effects: biodiversity → integrity**
2. **Direct effects : other variables → integrity**
3. **Indirect effects: all variables → integrity**

~~Effect chain~~
Effect network

4. **Effect strength (and impact) is strongly variable**
5. **Scale effects: biodiversity and heterogeneity setting constraints?**

The „ecosystem service cascade“



After Haines-Young and Potschin (2010), Maltby (2009), de Groot et al. (2010)

Relationships among ecosystem and integrity variables

⌑ : internal feed back loops

Integrity indicators (X) ⇩ Integrity indicators (Y)	Exergy capture	Entropy production	Storage capacity	Cycling & nut-rient loss reduction	Biotic water flows	Metabolic efficiencies	Heterogeneity	Biodiversity
Exergy capture	⌑	↗	↗	↗	↗		↗↘	↗↘
Entropy production		⌑	↘	↘		↘	↗↘	↗↘
Storage capacity		↘	⌑	↗	↗	↗	↗↘	↗↘
							↗↘	↗↘
							↗↘	↗↘
							⌑	↗
							↗	⌑

1. Direct effects: biodiversity → integrity
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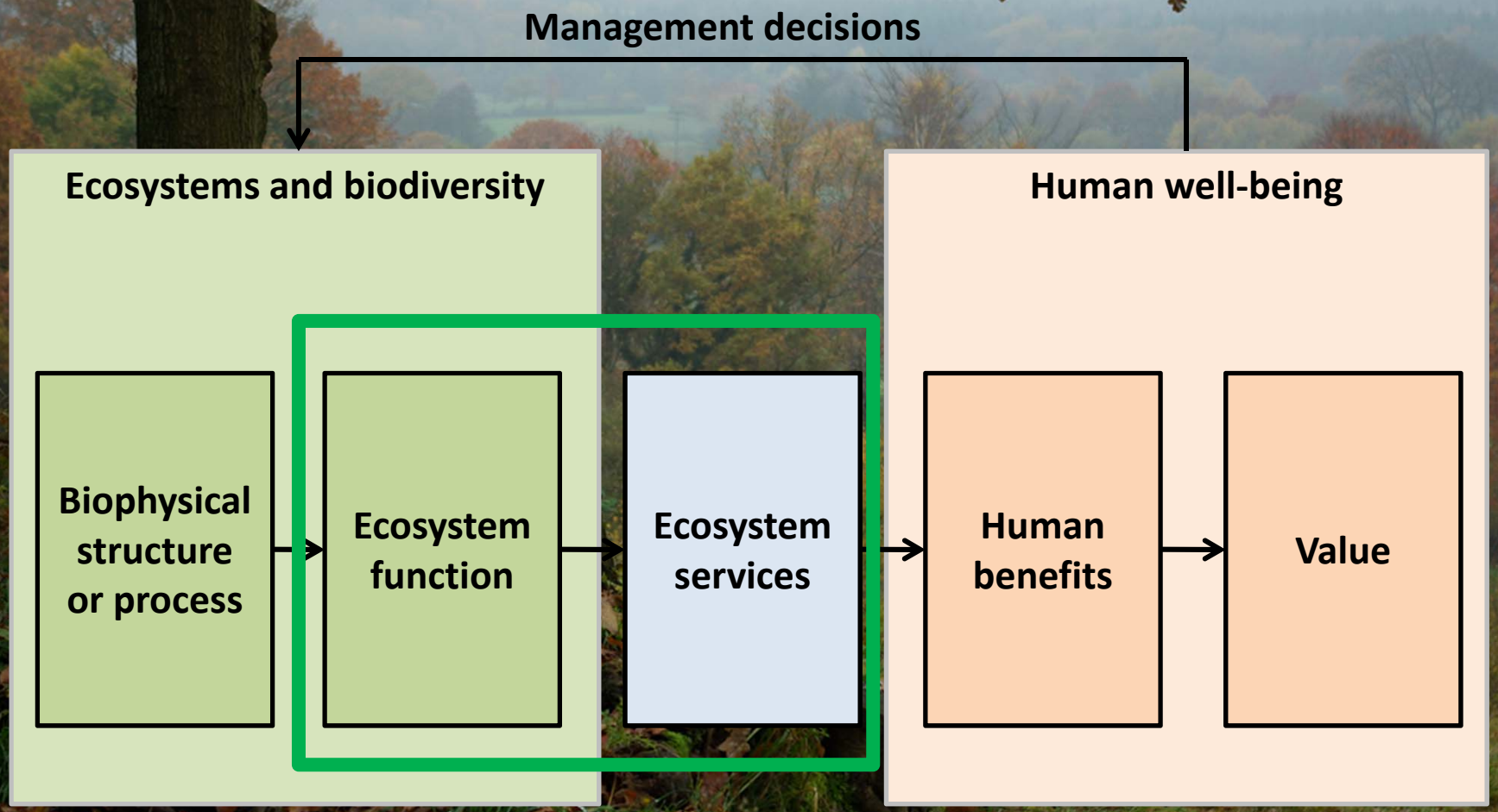
3. Indirect effects: all variables → integrity
4. Effects strength (and impact) is strongly variable
5. Scale effects: biodiversity and heterogeneity setting constraints?
6. **Functional variables put influence on biodiversity in a non-linear manner**
7. **Predictions of positive or neative feed backs are hardly possible**

The „ecosystem service cascade“



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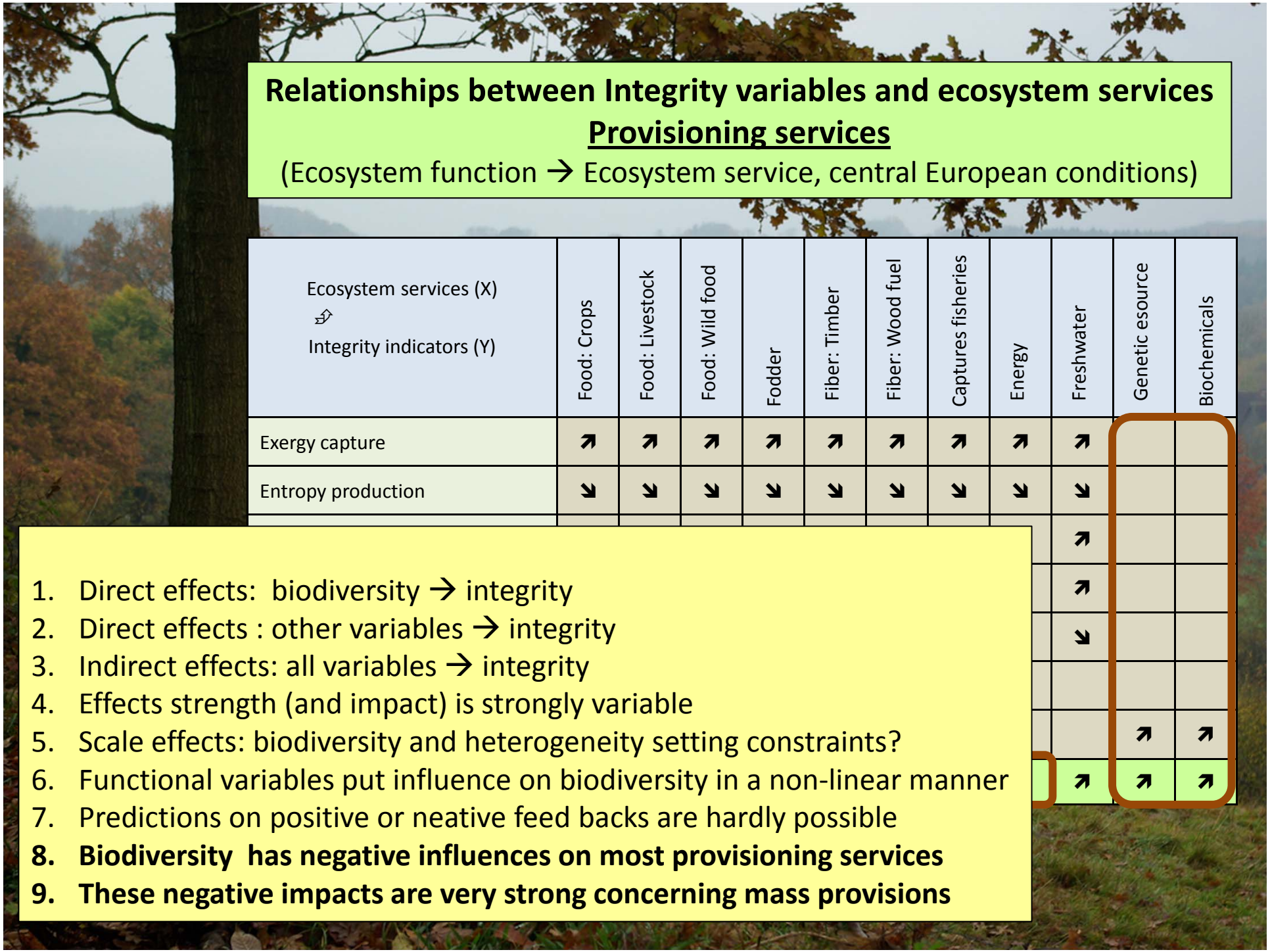

Relationships between Integrity variables and ecosystem services

Provisioning services

(Ecosystem function → Ecosystem service, central European conditions)

Ecosystem services (X) → Integrity indicators (Y)	Food: Crops	Food: Livestock	Food: Wild food	Fodder	Fiber: Timber	Fiber: Wood fuel	Captures fisheries	Energy	Freshwater	Genetic esource	Biochemicals
Exergy capture	↗	↗	↗	↗	↗	↗	↗	↗	↗		
Entropy production	↘	↘	↘	↘	↘	↘	↘	↘	↘		
									↗		
									↗		
									↘		
										↗	↗
									↗	↗	↗

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8. **Biodiversity has negative influences on most provisioning services**
9. **These negative impacts are very strong concerning mass provisions**

Relations between integrity variables and ecosystem services: <u>Regulating and cultural services</u>

Ecosystem services (X) ⇗ Integrity indicators (Y)	Air quality reg.	Global climate	Local climate reg.	Reg. of water flows	Erosion reg.	Nutrient reg.	Water purification	Disease reg.	Pest regulation	Pollination	Nutural hazard reg	Spiritual values	Educational values	Aesthetic values	Recreational values
Exergy capture	↗	↗	↗	↗	↗	↗	↗		↗		↗				
												↗	↗	↗	↗
												↗	↗	↗↘	↗↘

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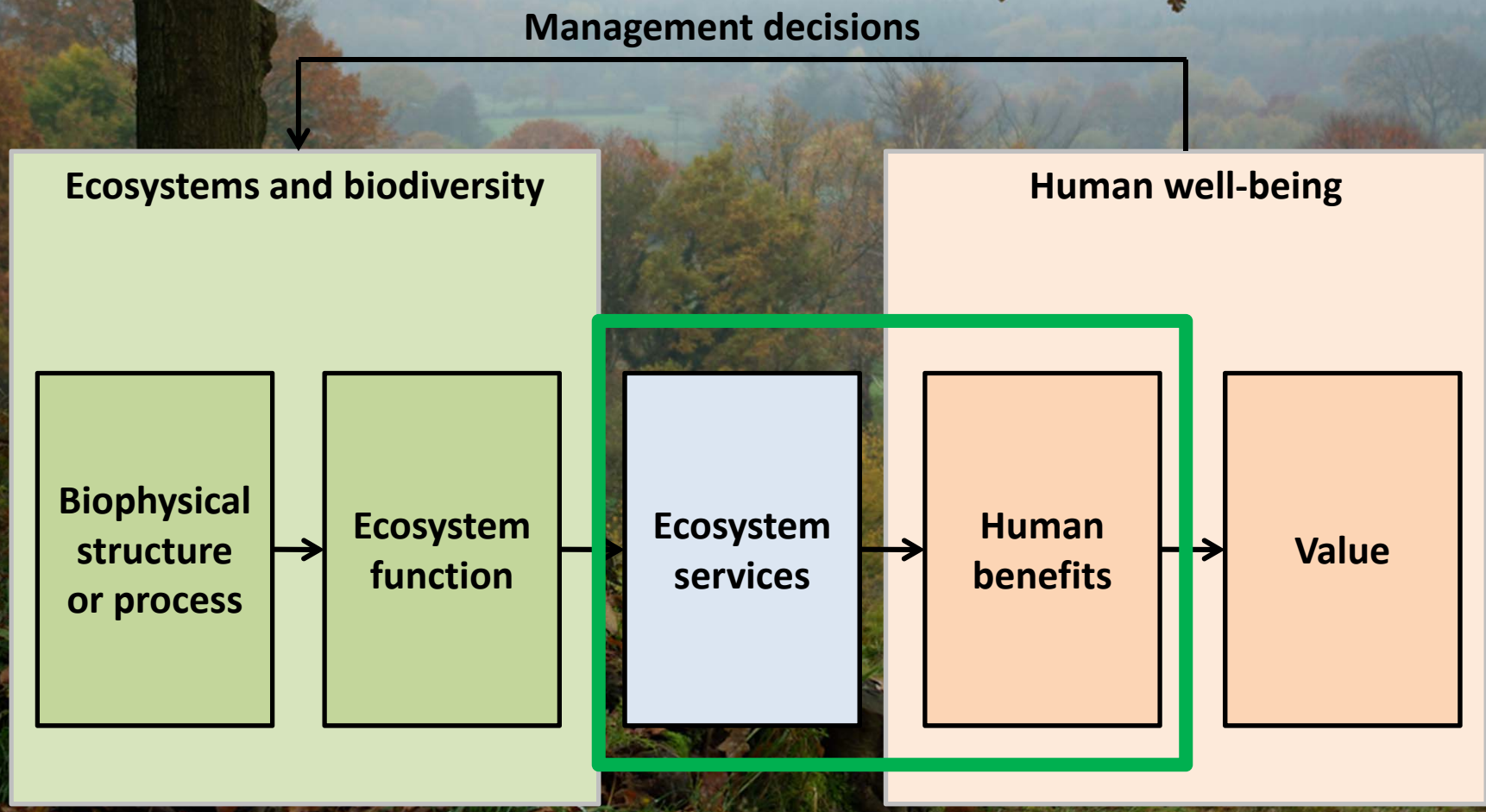
The „ecosystem service cascade“



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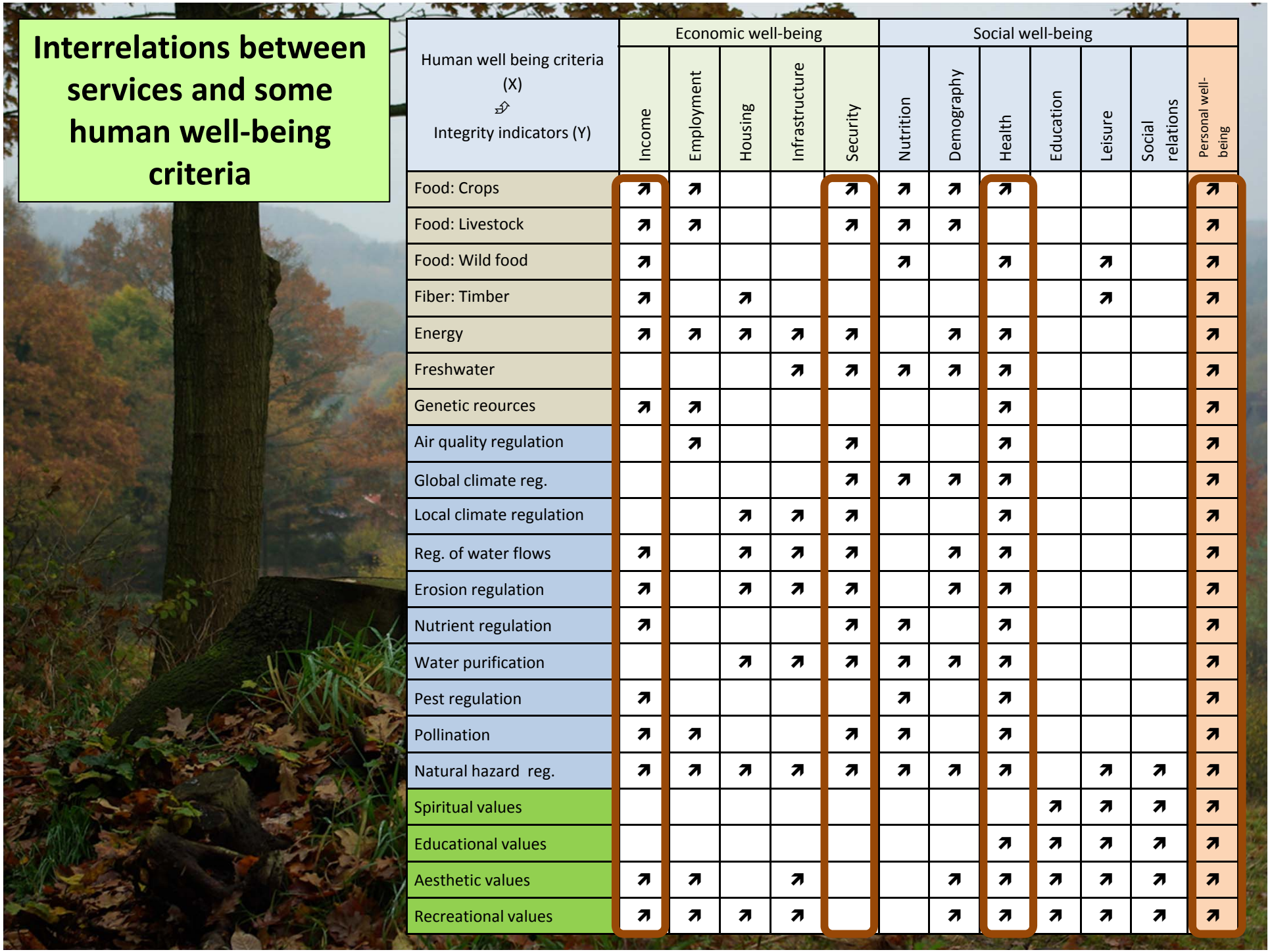
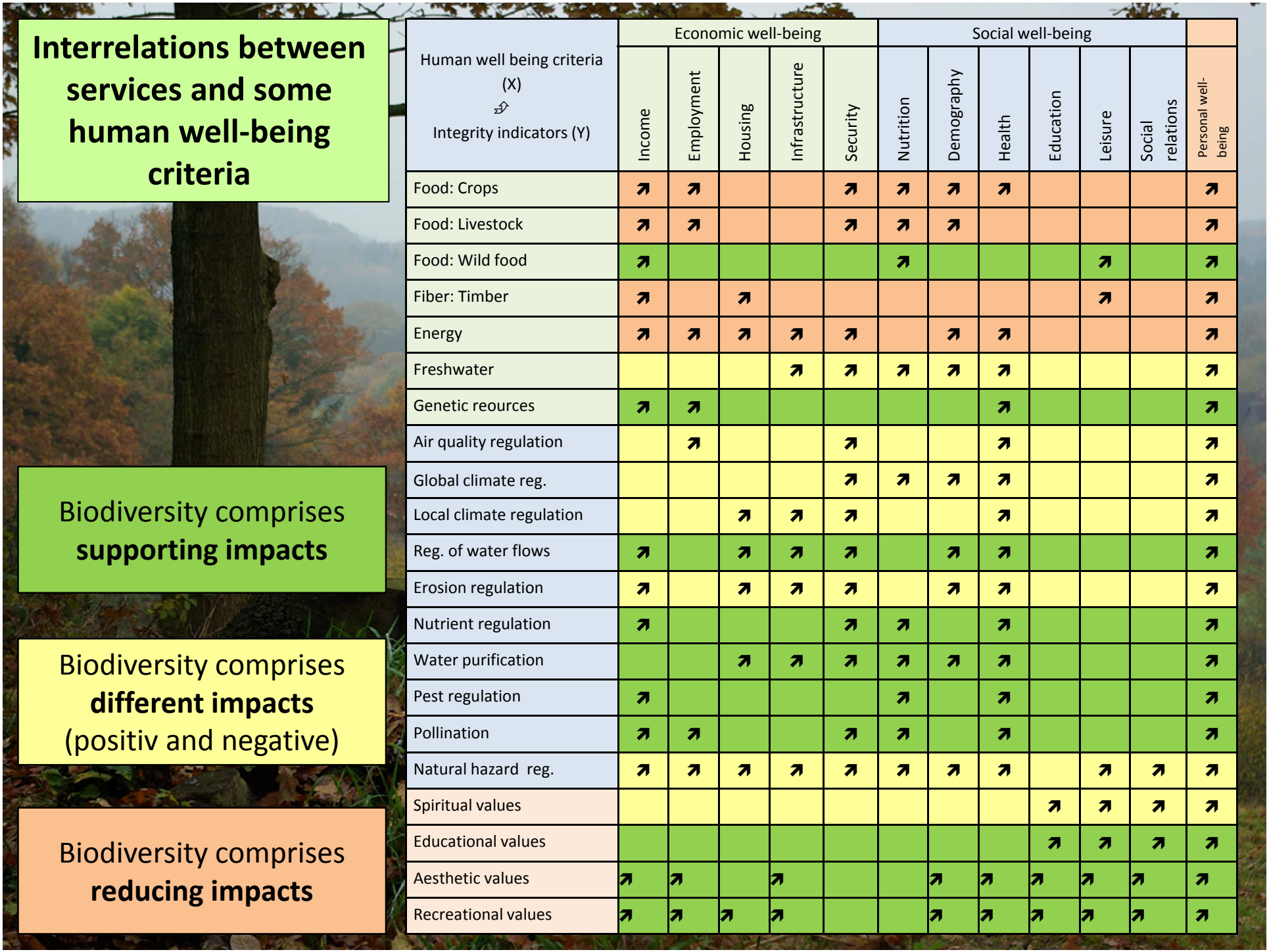


Interrelations between services and some human well-being criteria

Human well being criteria (X) ⇨ Integrity indicators (Y)	Economic well-being					Social well-being						
	Income	Employment	Housing	Infrastructure	Security	Nutrition	Demography	Health	Education	Leisure	Social relations	Personal well-being
Food: Crops	↗	↗			↗	↗	↗	↗				↗
Food: Livestock	↗	↗			↗	↗	↗					↗
Food: Wild food	↗					↗		↗		↗		↗
Fiber: Timber	↗		↗							↗		↗
Energy	↗	↗	↗	↗	↗		↗	↗				↗
Freshwater				↗	↗	↗	↗	↗				↗
Genetic reources	↗	↗						↗				↗
Air quality regulation		↗			↗			↗				↗
Global climate reg.					↗	↗	↗	↗				↗
Local climate regulation			↗	↗	↗			↗				↗
Reg. of water flows	↗		↗	↗	↗		↗	↗				↗
Erosion regulation	↗		↗	↗	↗		↗	↗				↗
Nutrient regulation	↗				↗	↗		↗				↗
Water purification			↗	↗	↗	↗	↗	↗				↗
Pest regulation	↗					↗		↗				↗
Pollination	↗	↗			↗	↗		↗				↗
Natural hazard reg.	↗	↗	↗	↗	↗	↗	↗	↗		↗	↗	↗
Spiritual values									↗	↗	↗	↗
Educational values								↗	↗	↗	↗	↗
Aesthetic values	↗	↗		↗			↗	↗	↗	↗	↗	↗
Recreational values	↗	↗	↗	↗			↗	↗	↗	↗	↗	↗



Interrelations between services and some human well-being criteria

Biodiversity comprises **supporting impacts**

Biodiversity comprises **different impacts** (positiv and negative)

Biodiversity comprises **reducing impacts**

Human well being criteria (X) ⇨ Integrity indicators (Y)	Economic well-being					Social well-being						
	Income	Employment	Housing	Infrastructure	Security	Nutrition	Demography	Health	Education	Leisure	Social relations	Personal well-being
Food: Crops	↗	↗			↗	↗	↗	↗				↗
Food: Livestock	↗	↗			↗	↗	↗					↗
Food: Wild food	↗					↗				↗		↗
Fiber: Timber	↗		↗							↗		↗
Energy	↗	↗	↗	↗	↗		↗	↗				↗
Freshwater				↗	↗	↗	↗	↗				↗
Genetic reources	↗	↗						↗				↗
Air quality regulation		↗			↗			↗				↗
Global climate reg.					↗	↗	↗	↗				↗
Local climate regulation			↗	↗	↗			↗				↗
Reg. of water flows	↗		↗	↗	↗		↗	↗				↗
Erosion regulation	↗		↗	↗	↗		↗	↗				↗
Nutrient regulation	↗				↗	↗		↗				↗
Water purification			↗	↗	↗	↗	↗	↗				↗
Pest regulation	↗					↗		↗				↗
Pollination	↗	↗			↗	↗		↗				↗
Natural hazard reg.	↗	↗	↗	↗	↗	↗	↗	↗		↗	↗	↗
Spiritual values									↗	↗	↗	↗
Educational values									↗	↗	↗	↗
Aesthetic values	↗	↗		↗			↗	↗	↗	↗	↗	↗
Recreational values	↗	↗	↗	↗			↗	↗	↗	↗	↗	↗

Interrelations between services and some human well-being criteria

Human well being criteria (X) ⇩ Integrity indicators (Y)	Economic well-being					Social well-being						
	Income	Employment	Housing	Infrastructure	Security	Nutrition	Demography	Health	Education	Leisure	Social relations	Personal well-being
Food: Crops	↗	↗			↗	↗	↗	↗				↗
Food: Livestock	↗	↗			↗	↗	↗					↗
Food: Wild food	↗					↗				↗		↗
Fiber: Timber	↗		↗							↗		↗
Energy	↗	↗	↗	↗	↗		↗	↗				↗
Freshwater				↗	↗	↗	↗	↗				↗

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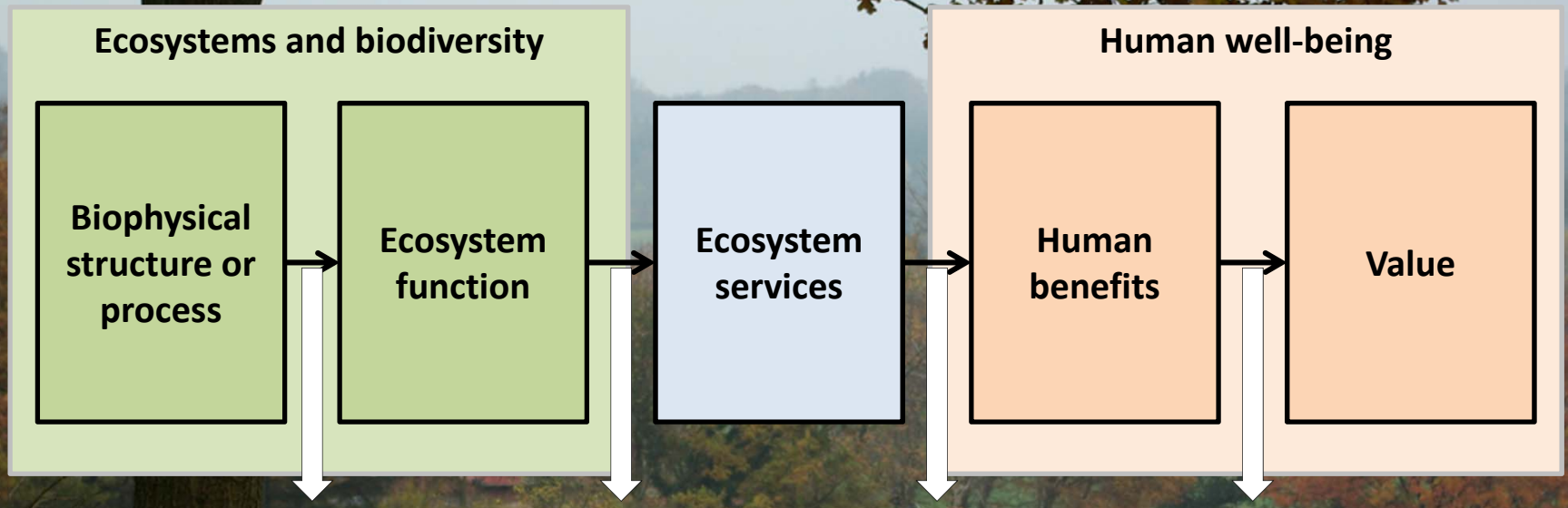
11. Biodiversity especially supports the community based regulations
12. Biodiversity plays a major role for cultural services
13. **The final effects in several cases do not show direct corelations with biodiversity**

Resulting hypotheses



Biodiversity strongly depends on functional relations

i.e. long-term processes

Biodiversity supports most (not all) functional features with distinct relations and strengths

Biodiversity supports distinct services different:

Provisioning ↘

Regulating ↗

Cultural ↗↘

Biodiversity effects are lost in complexity due to the high indirectness of community effects

Valuation can not be related to **biodiversity** alone, and service provision is no good reason to support biodiversity

Ecosystem performance related to the whole functional ensemble plays a major role

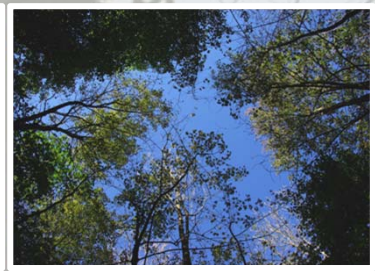
Struktur des Beitrags

- Wie verstehen wir die konzeptionelle Stellung des Ecosystem Service-Ansatzes?
- Wie können wir Ecosystem Services in der Landschaft differenzieren?
- Wie können Ecosystem Services in der Landschaft quantifiziert werden?
- Welche Variablen können als geeignete Indikatoren genutzt werden?
- Welche Daten können zur Service-Abschätzung verwendet werden?
- Wie stehen Ecosystem Services im Verhältnis zu Naturschutz-Zielen?
- **Was sollten wir bei der Nutzung des Ecosystem-Service-Konzepts <u>beachten</u>?**

Problems and conclusions

Ecosystem services provide excellent potentials for

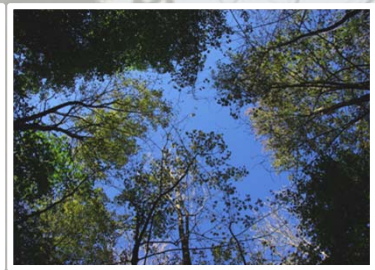
- the characterization of **human-environmental interactions**
- for **environmental evaluation**
- to clarify man‘s **dependence** from nature
- for the **classification** of human-environmental interactions
- for **decision-based trade-offs**
- for better environmental **planning strategies**
- to derive the **interactions between biodiversity and human actions**
- to characterize **sustainable development** strategies
- to link **structures and functions**



Several conceptual questions remain:

- Is the basic concept of ecosystem service types really structurized **consistently**?
- Can we really find **clear interrelations** between service provision and human well-being?
- Can we really **compare (and add) the different monetary service values** if they have been quantified on the base of different methodologies?
- Are we in danger of loosing the **intrinsic values** of nature?
- How can we cope with the large **regional differences** of ecosystem service valuation?
- How can we best represent the **supporting services?**

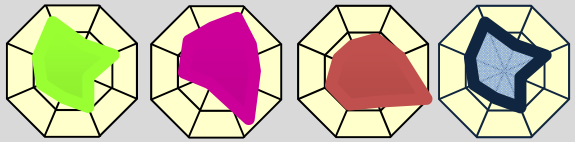



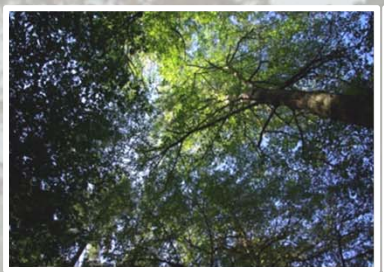
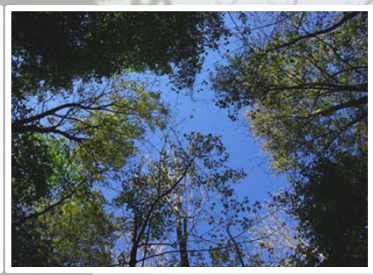
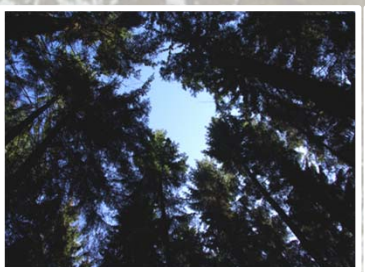




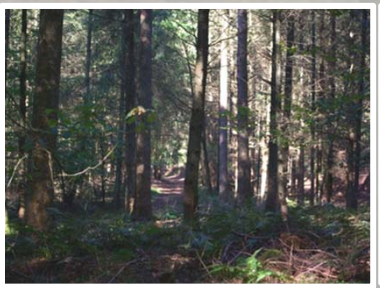

Ecosystem services in assessment and management:

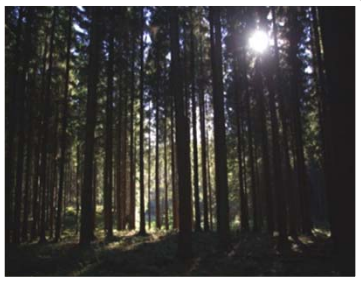
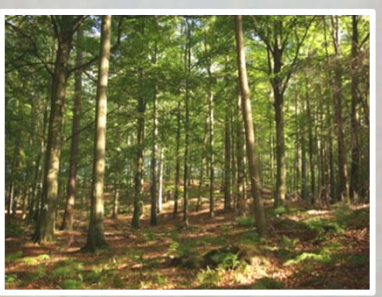
- **Services alone** do not provide sufficient information
- Services analyses should be accompanied by **structural and functional attributes**




Forest functions provide an excellent basis for services.
The general service **classification** can also be applied in forests.



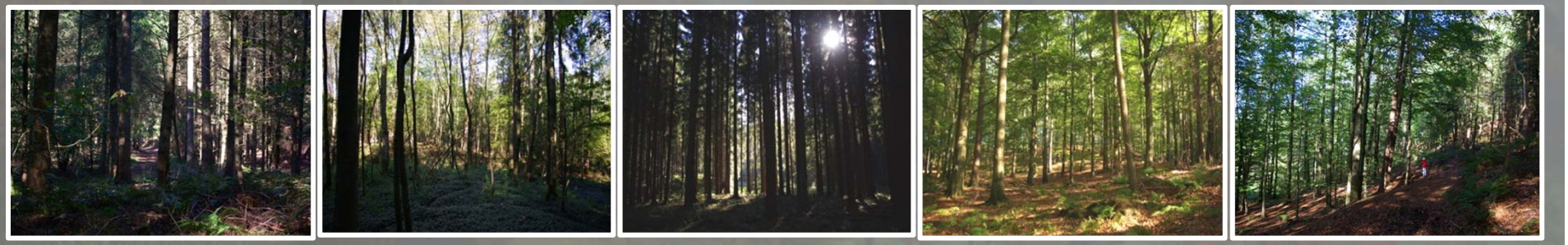



Landscape services can easily be derived, but rigorous quantification and modelling are effortful and need further work.

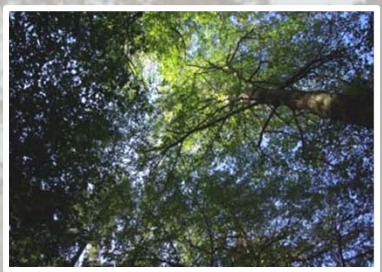
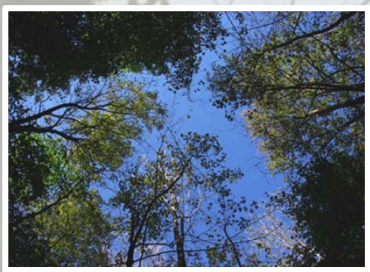
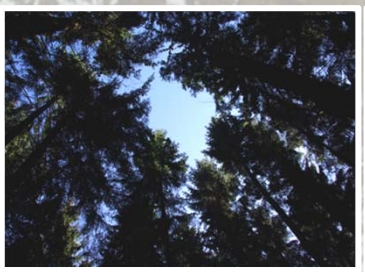
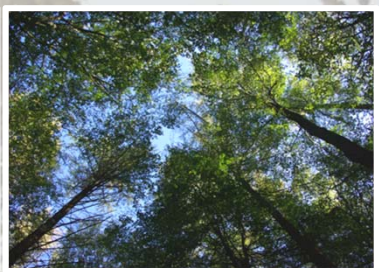
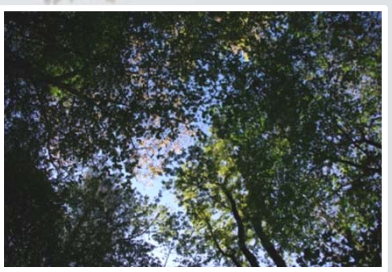



Summarizing .....

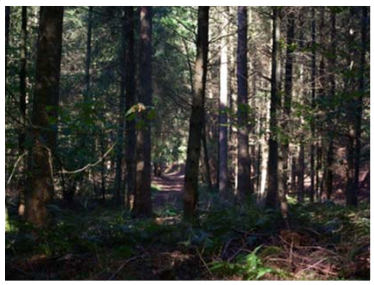
Several indicators for forest ecosystem services are available and many of them are already used; selection must follow study targets and regional **data availability.**



As the **relations between biodiversity and ecosystem services** are complex and sometimes diffuse, the suitability in nature protections is not always clear.

Thanks for your attention (and sorry for the English slides)





Thanks to co-workers B. Burkhard, F. Delong, S. Jantz, F. Kroll, M. Kandziora, Y. Hou