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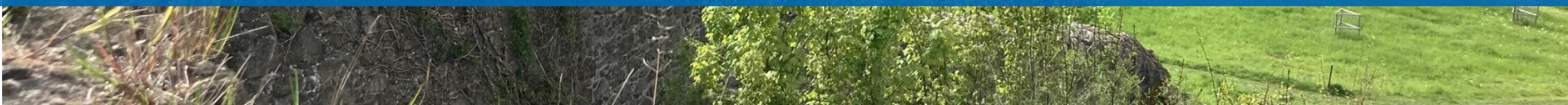
JUSTUS-LIEBIG-
UNIVERSITÄT
GIESSEN

Webinar: Farming with nature: support mitigating climate change and building resilience at farm and landscape level

Soil management and agroforestry: benefits for climate mitigation, yields, and resilience

Dr. Wiebke Niether

Chair of Organic Agriculture with Spezialisaton on Sustainable Soil Use / Justus-Liebig-University of Giessen, Germany



Soil health for sustainable soil functioning

Soil quality / soil health:

- Part of the environmental quality concept (beside water and air)
- Soil health → plant health → human health
- Chemical, physical and biological (soil biota) approach → dynamic

Indicators of a healthy soil:

Biological	Chemical	Physical
Earthworms	Labile C and N	Infiltration
N Mineralisation (microbiological processes)	Micronutrients	Aggregation
Microbial biomass	Sodicity, salinity	Porosity
Soil respîration	Other macronutrients (Mg, S, Ca)	Hydraulic conductivity
	Heavy metals	Penetration resistance
	Available N, K,P	Soil depth
	Available N, K,P	Structural stability
	Available N, K,P	Texture
	pH	Bulk density
	Total organic matter / Carbon	Water storage

Soil quality / soil health:

- Part of the environmental quality concept (beside water and air)
- Soil health → plant health → human health
- Chemical, physical and biological (soil biota) approach → dynamic
- Productivity of soils including the **interactions of humans and soil**

Management affects soil health:

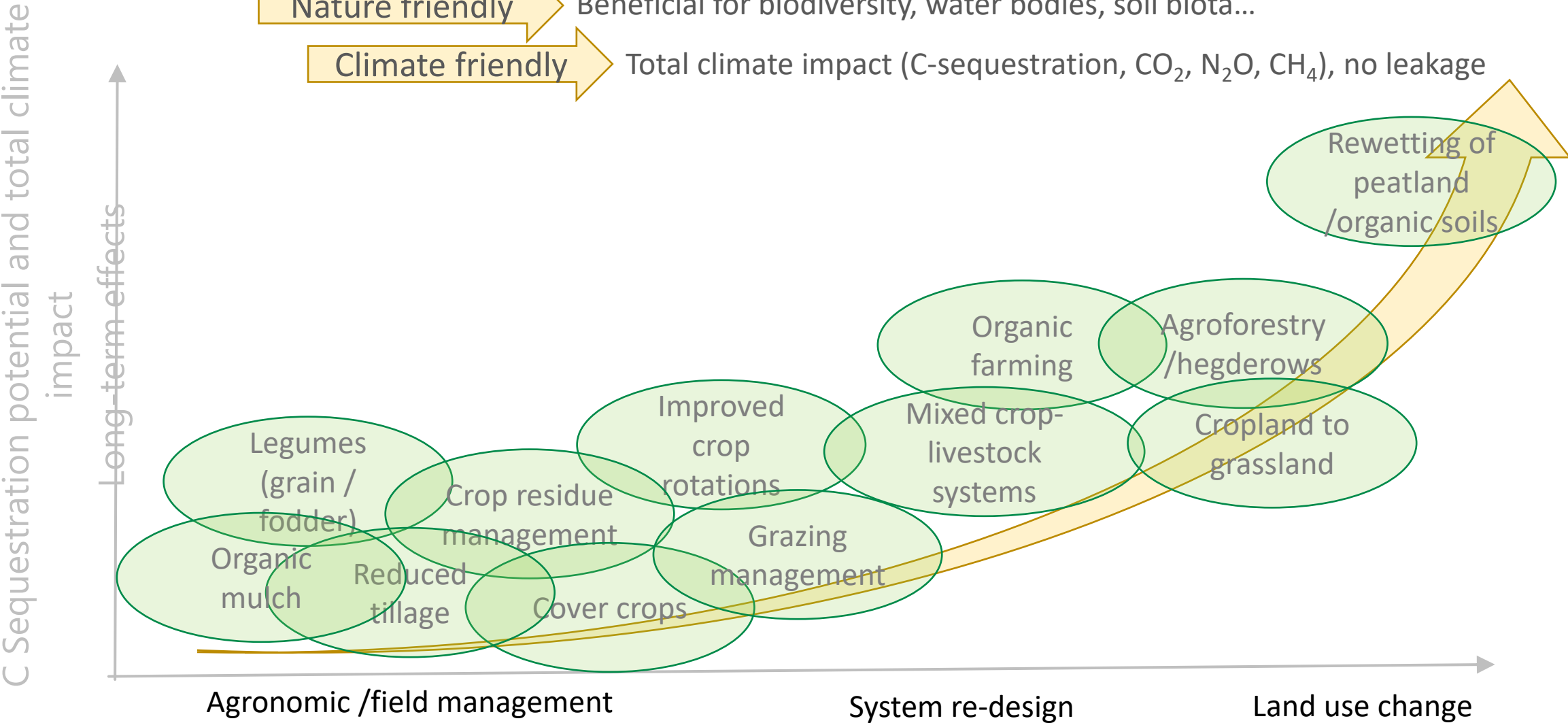
- Avoidance of pesticides
- Avoidance contamination: microplastics, antibiotics, polluted irrigation water
- Improving soil biodiversity and beneficial microbial abundance
- Avoidance of compaction, improvement of physical structure
- Enhancing input of carbon!

From efficiency & substitution to system re-design

Action principles:

Nature friendly → Beneficial for biodiversity, water bodies, soil biota...

Climate friendly → Total climate impact (C-sequestration, CO₂, N₂O, CH₄), no leakage



Improving soil functioning for sustainable production



«Conventional without C input»



«with C-input by compost»

Chemical properties: nutrient retention, soil fertility

(Mäder et al. 2002, Science)

25.10.2023

Dr. Wiebke Niether: Soil health and agroforestry

Improving soil functioning for system resilience and sustainable production

The same soils after heavy rain event



«Conventional without C input»



«with C-input by compost»

Physical properties: water infiltration, water retention

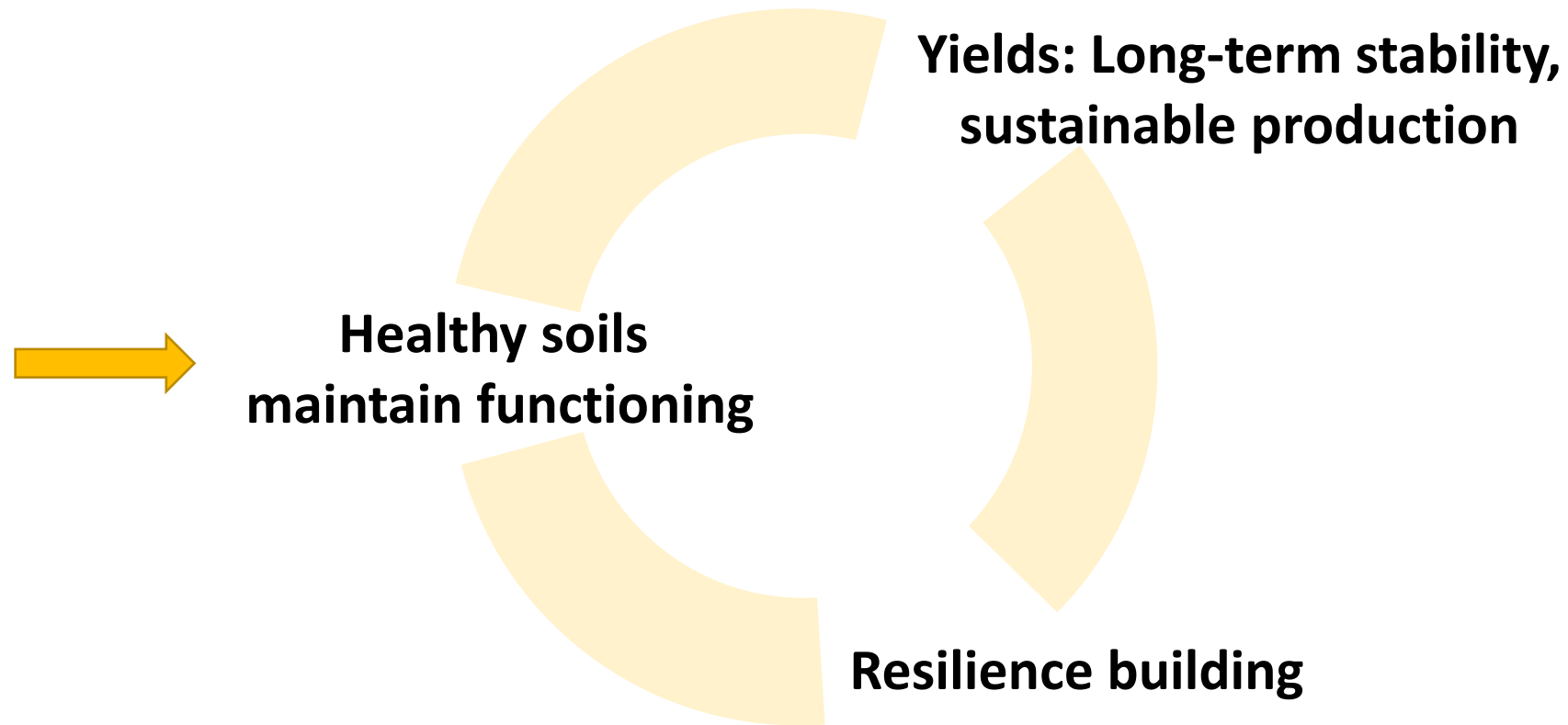
(Mäder et al. 2002, Science)

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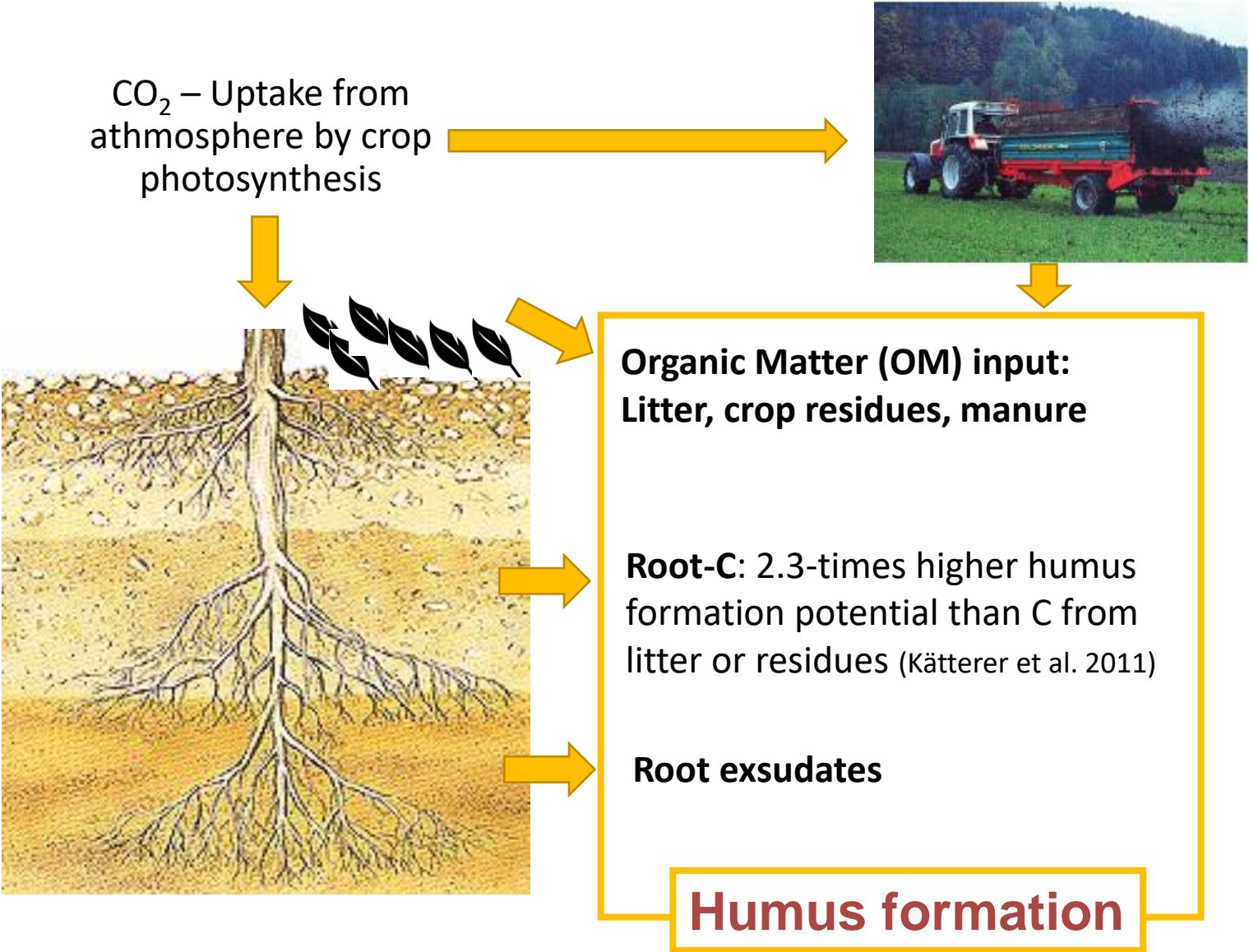
Dr. Wiebke Niether: Soil health and agroforestry

„The soil is the base“ (Schreefel et al. 2020)

→ Building resilience and maintaining yields



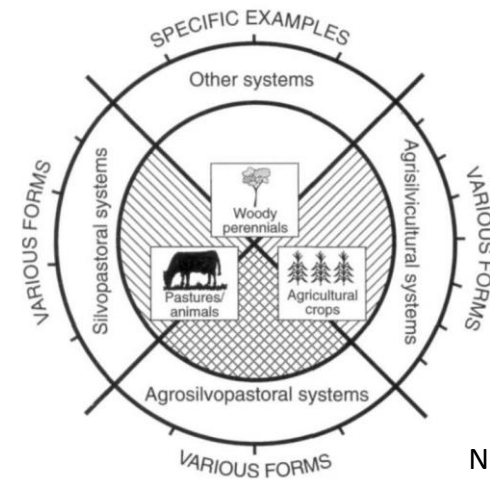
Soil organic matter is a key indicator for soil health



Agroforestry: agricultural system re-design

Use of the same area:

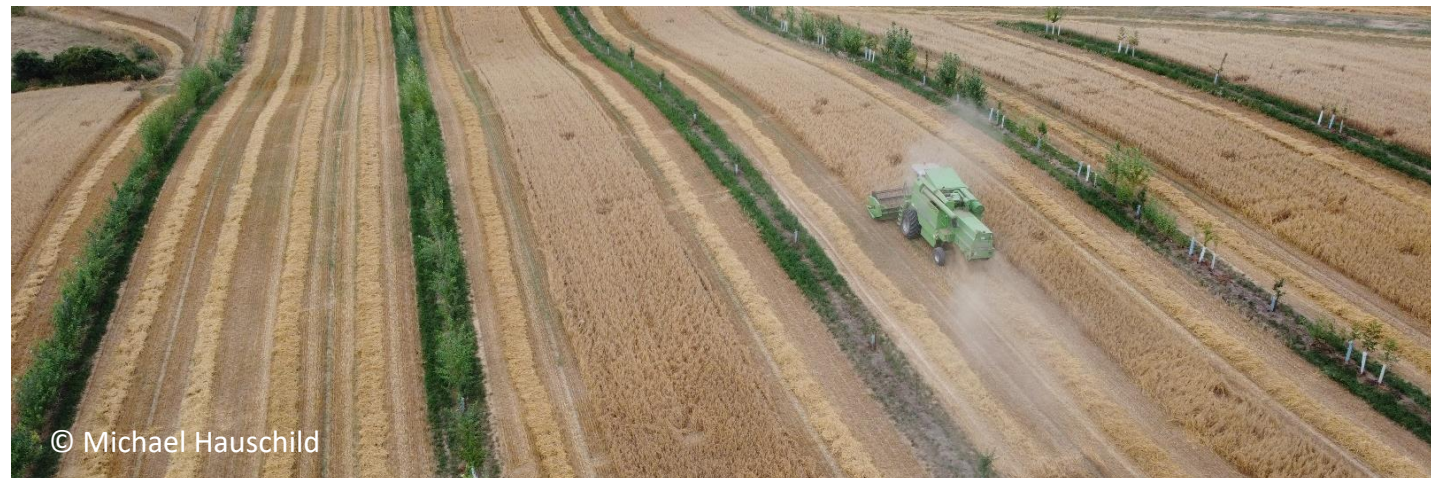
- Spatial /temporal synergies between components
- Fostering ecosystem services and functioning



Pasture with trees or shrubs:
silvopastoral agroforestry system



Cropland with trees or shrubs:
silvoarable agroforestry system



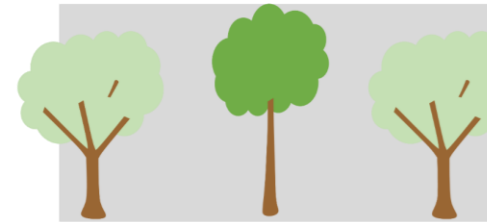
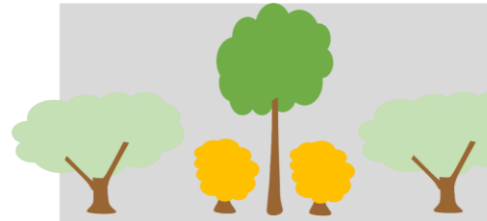
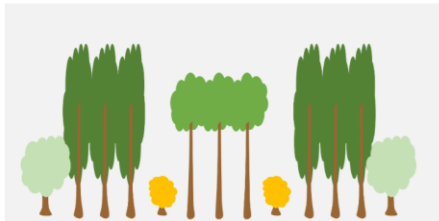
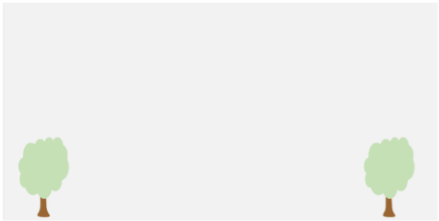
Agroforestry: agricultural system redesign from field to landscape level

Tree (re-) integration in Landscapes

Different tree line designs

Young system

Mature system



12 m

12 m

Minarsch et al. (under revision)
25.10.2023



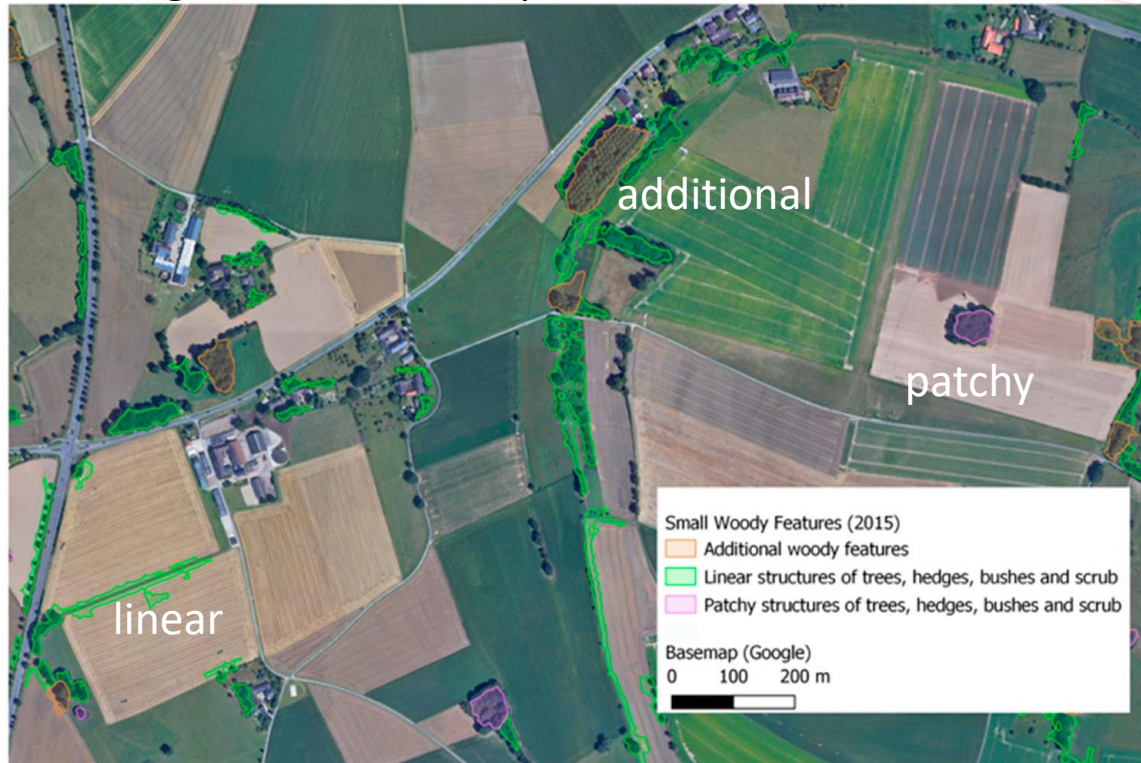
Source: agriculture.co.uk/resources/wakelyns-agroforestry-resilience-through-diversity



Source: kaiser-photo.com/knicks-in-schleswig-holstein-2/

Agroforestry: mitigation and other benefits JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Classes of small woody landscape features embedded within agricultural landscapes

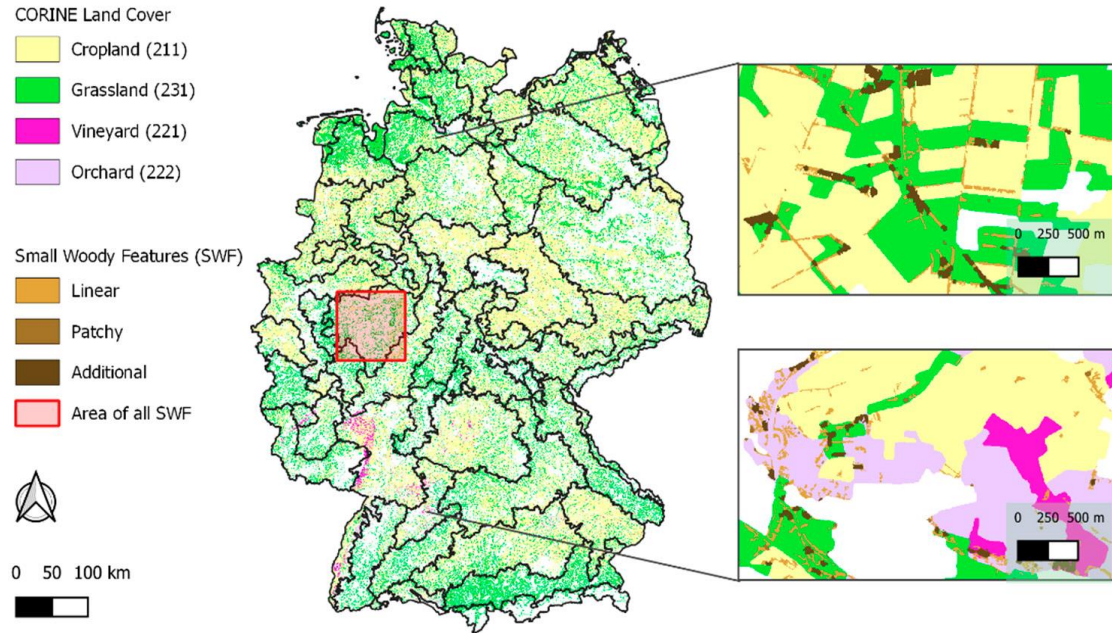


Benefits for agricultural landscapes:

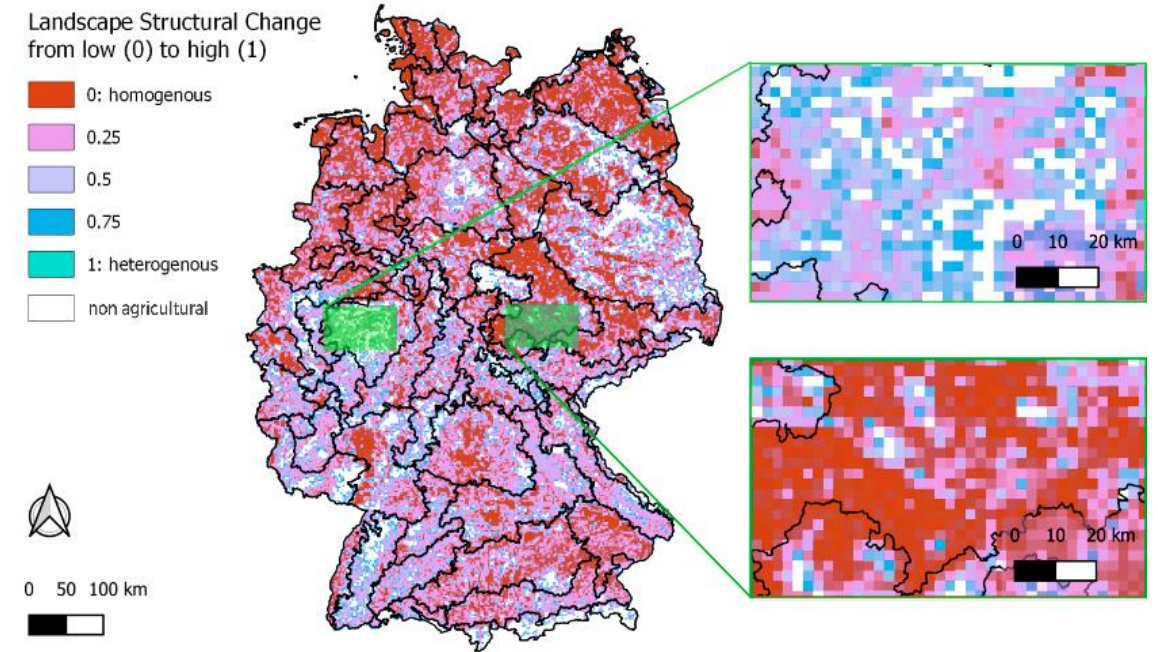
- Above- and belowground carbon stocks (soil organic carbon and total biomass carbon)
- Increasing biodiversity through habitat building, shelter
- Landscape connectivity

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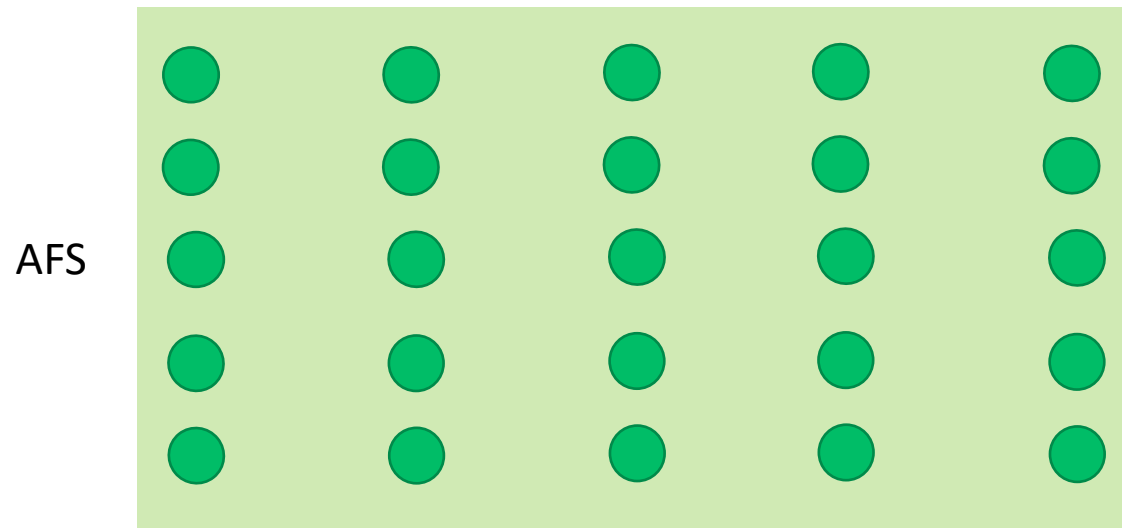
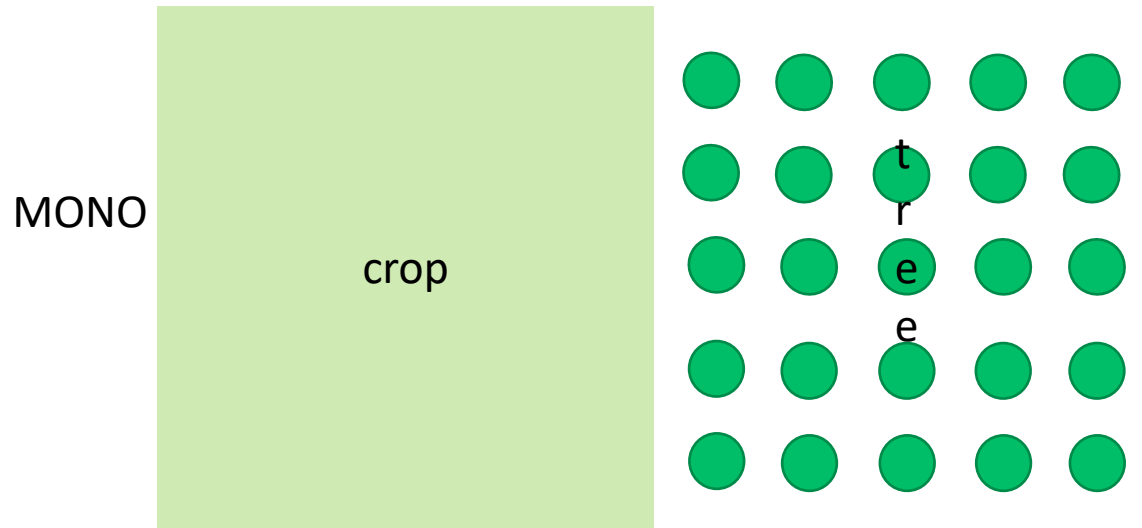
Distribution of small woody features across Germany



Landscape structural change arising from inclusion of small woody features



Agroforestry: mitigation - yield

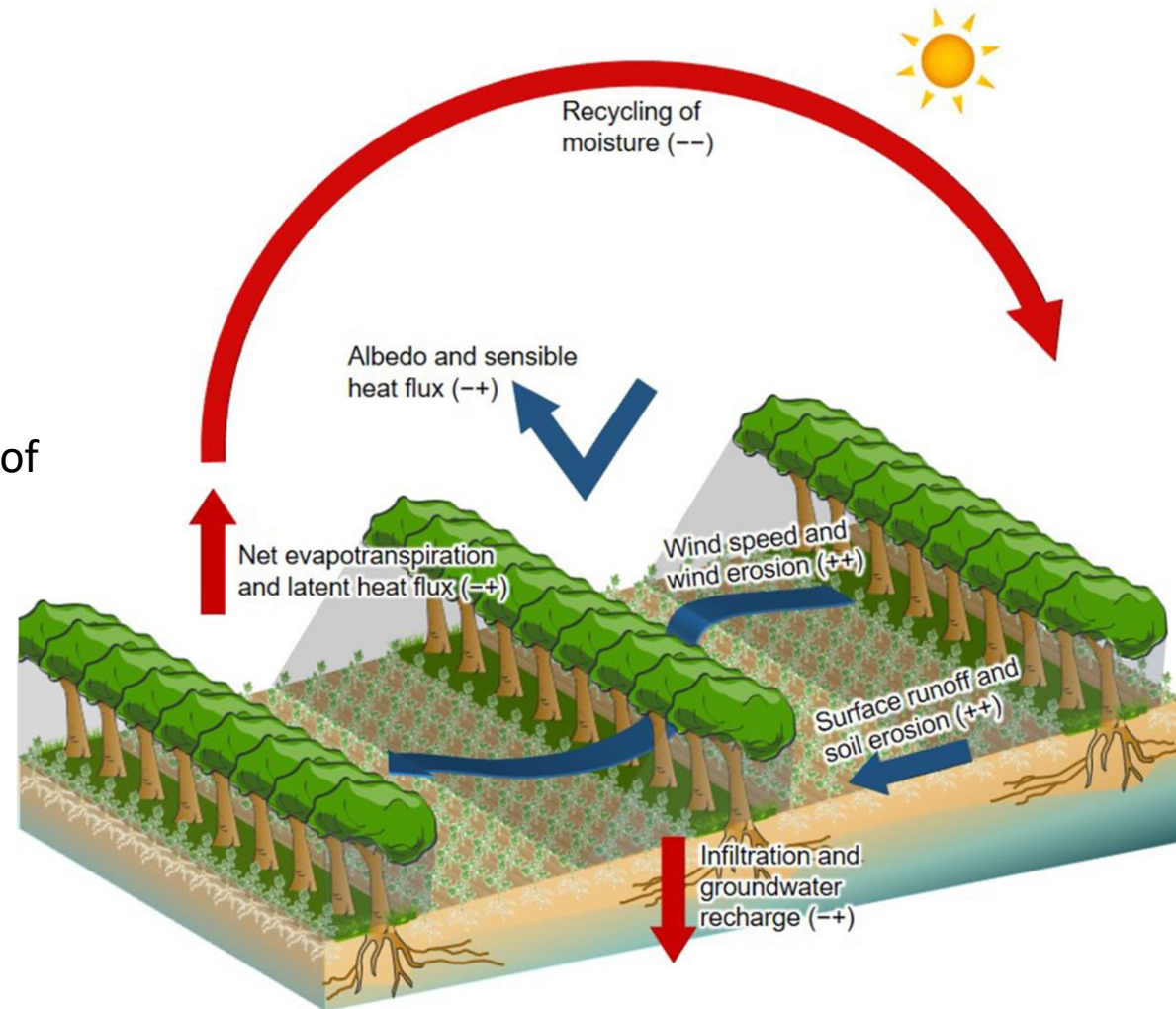


$$\text{„Land Equivalent Ratio“} = \frac{AFS_{tree\ yield}}{MONO_{tree\ yield}} + \frac{AFS_{crop\ yield}}{MONO_{crop\ yield}}$$

Agroforestry: mitigation - yield - resilience

Microclimate and water balance effects at the field to landscape scale of the implementation of alley cropping systems

→ Improving growing conditions under a changing climate



Change relative to sole cropping

- █ Increase
- █ Decrease

Strength of scientific evidence

- ++ Strong evidence
- + Moderate evidence
- + Based on process understanding, limited evidence
- Difficult to prove, no evidence

System re-design: mixed crop-livestock systems

Redirecting the trend of farm specialisation

- On farm system level (internal cycles)
- Or on territorial level (fodder – manure cooperatives)

Ecological-functional **intensification** and **circularity**
in the soil-plant-animal system

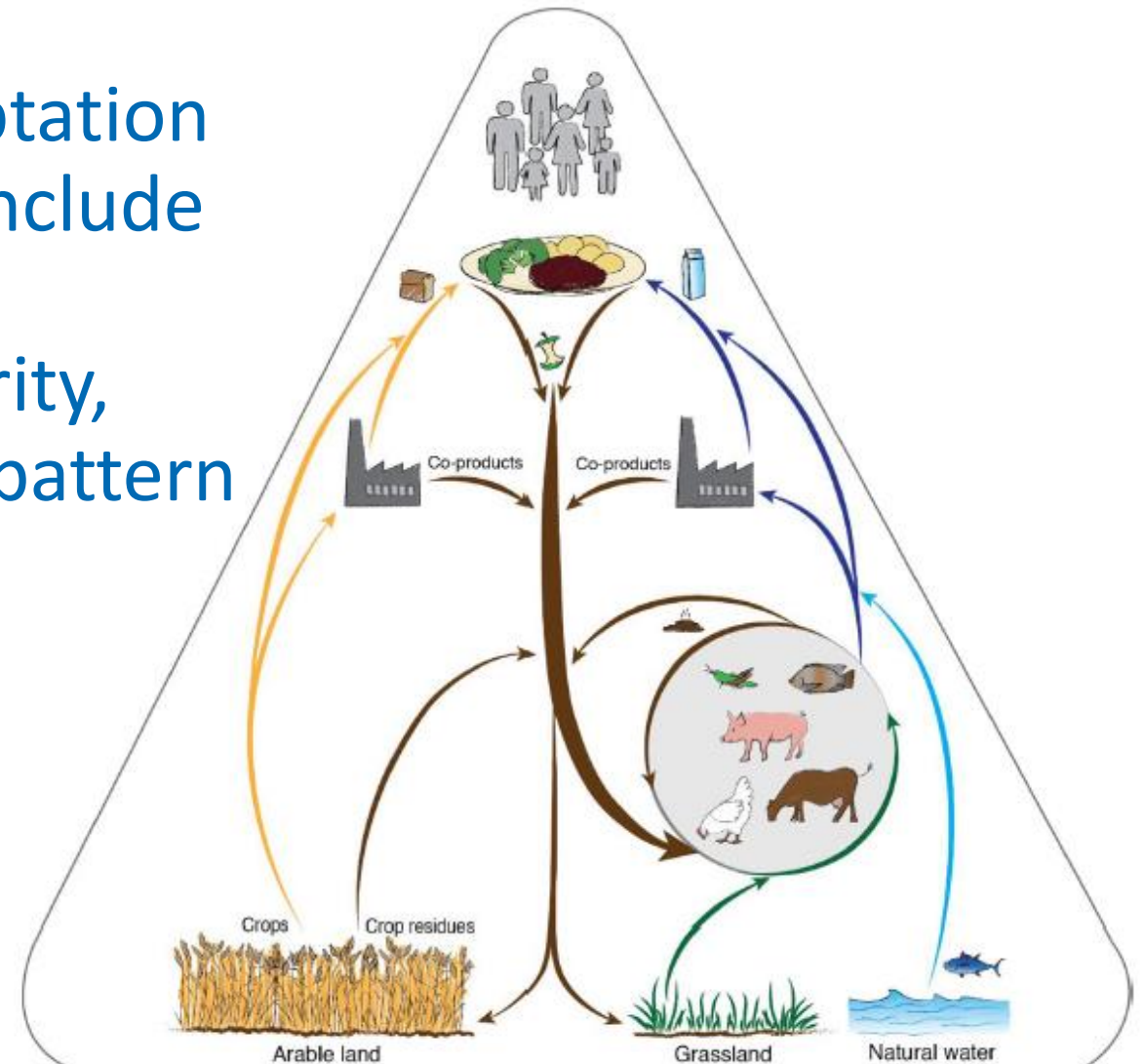
- Increasing efficiency and reducing yield gaps (e.g. in organic agriculture)
- Using natural processes and ecosystem services or functioning
- Close interaction of crop production and livestock keeping
- Symbioses, Synergies, multi-dimensionality (including bioeconomy)



Agroecology

Climate change mitigation and adaptation and sustainable production has to include farm (soil) management but also the value chain and circularity, consumer action and consumption pattern

- Food System approach
- Agroecology





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Thank you for your attention and joining the webinar

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