Biomass Crops and Diversification – Demonstration Event

Multifunctional Landscapes

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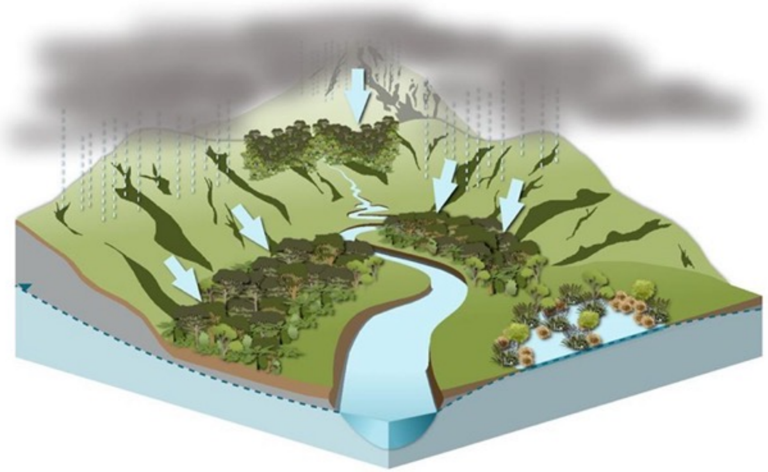
From Newcastle. For the world.

UK landscapes to produce food, natural resources and deliver ecosystem services

Natural Flood Mitigation



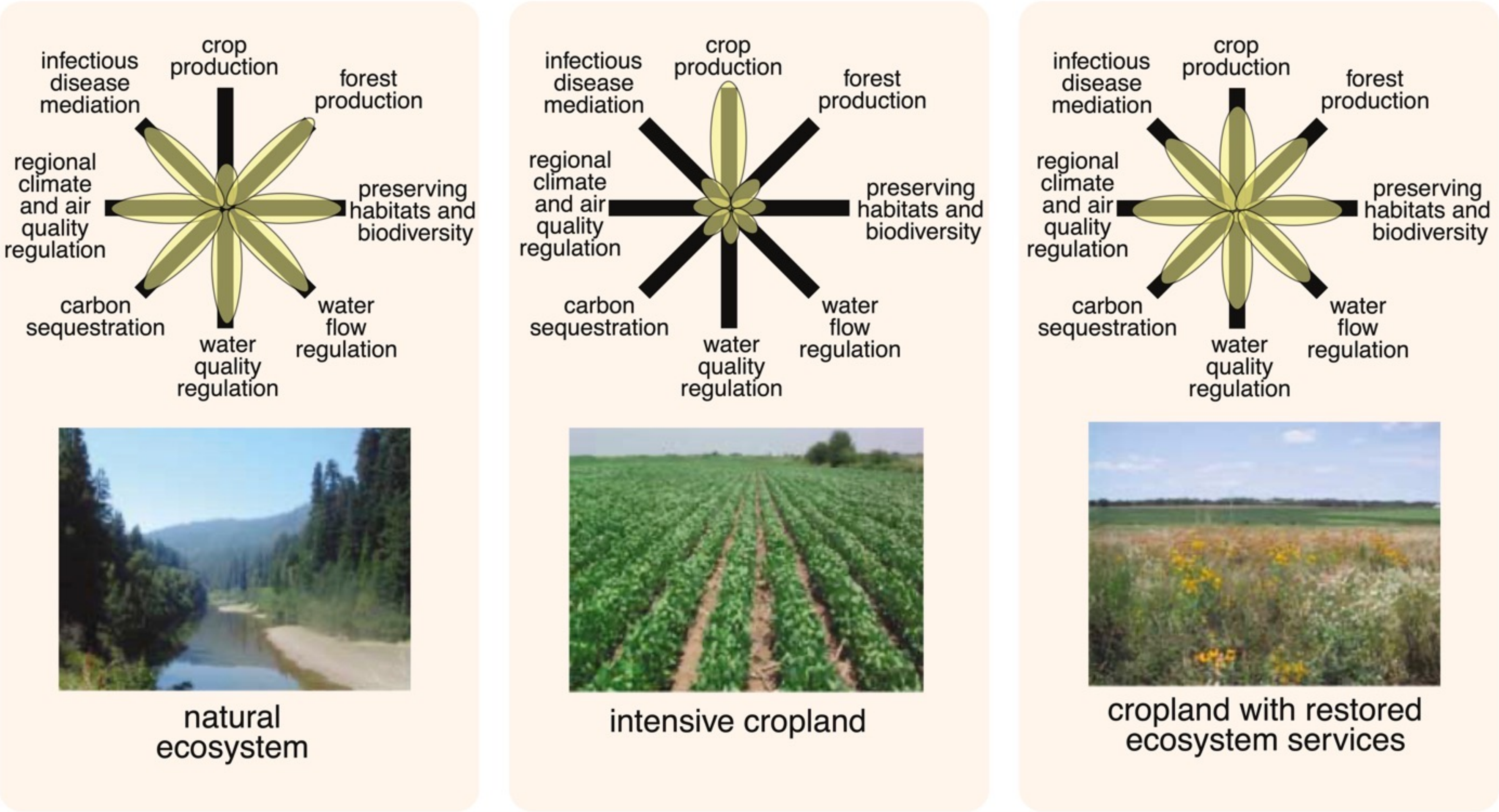
Water & Environment J, Volume 35: 514-529

Limited land and natural resources

Policy and societal pressure to meet Net Zero, conservation and environmental targets

Food system influenced by external markets and food imports

Flower diagram conceptualising benefits and trade-offs of Multifunctional Landscapes



Foley et al. (2005). *Science*

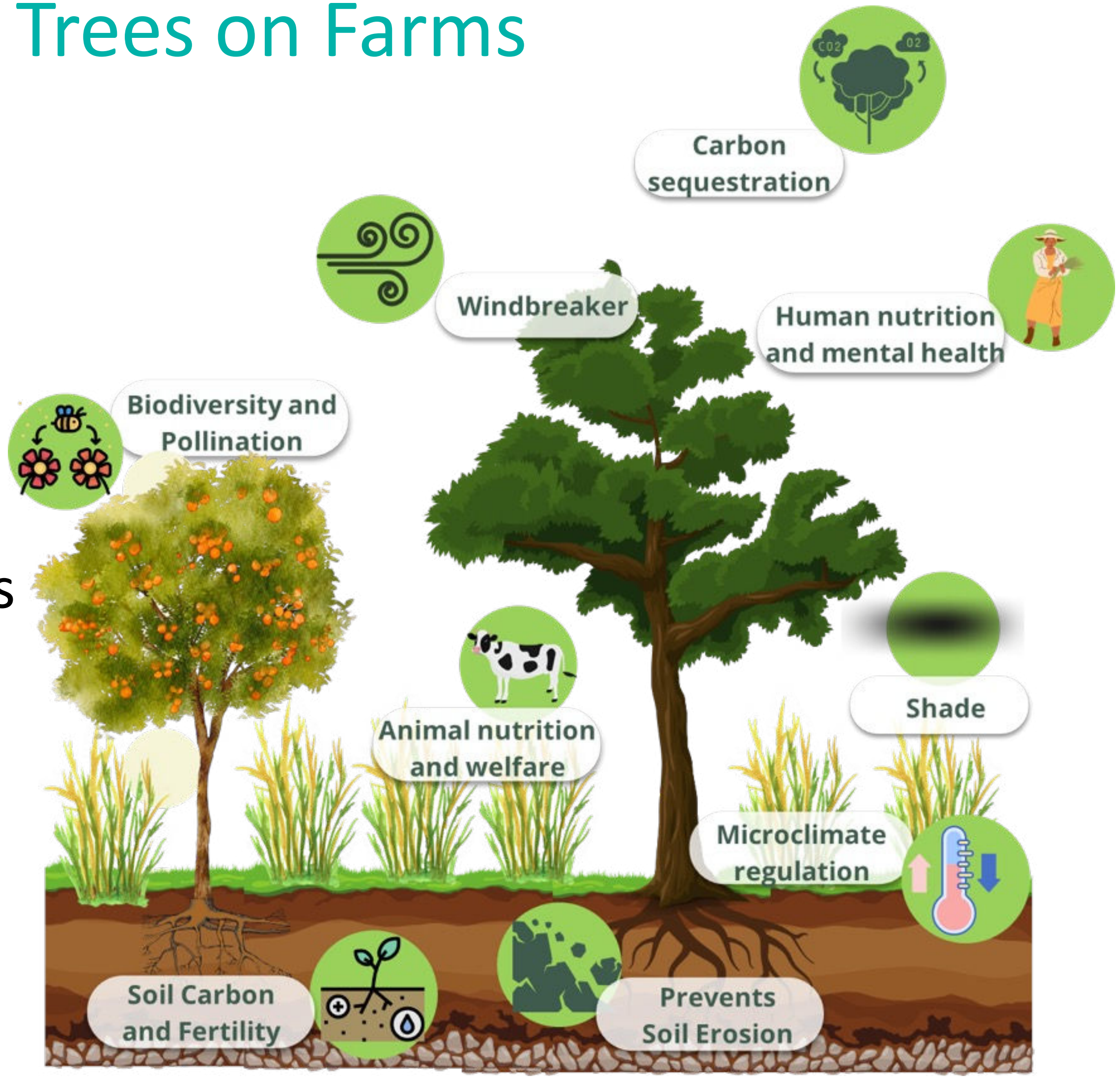
Example: Benefits and Trade-offs of Trees on Farms

Benefits

- Water regulation
- Microclimate buffering
- Carbon storage in plants and soil
- Reduced soil erosion and pollutant run-off
- Pollinators, natural pest control
- Income from biomass or non-timber products

Trade-offs

- Less land for crops and forage
- Reduced yield due to competition
- Pests and crop raiders
- Disease spill-over
- Skills development needed



Planting Bioenergy Crops and Woody Plants Increases Aboveground Carbon Density

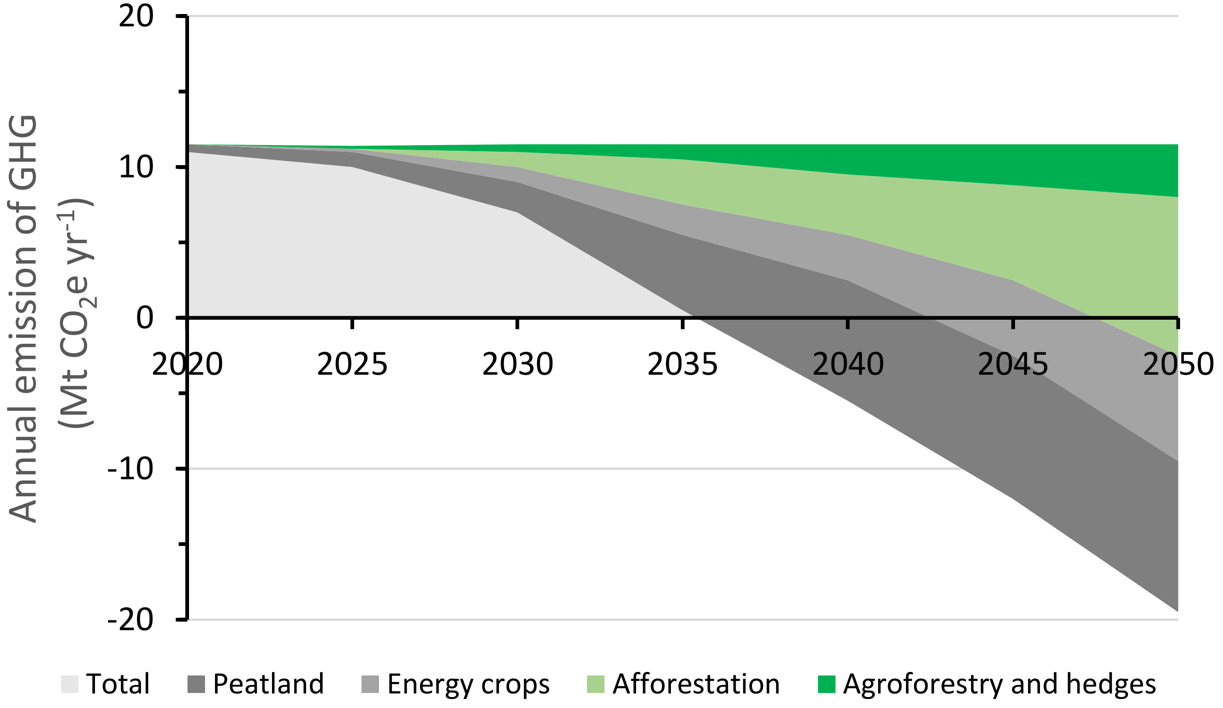


Figure 22. Schematic demonstration of abatement in the land use and land use change and forestry sector in the Balanced Net Zero Pathway (after CCC 2020b, page 171)

Scenarios assume business as usual for inputs and livestock densities

Table 3 Prediction of the GHG balances from planting different proportions of UK grassland (11.18 million ha) to silvopasture

Scenario	Baseline grassland (ha)	Area of UK grassland converted to silvopasture (ha)	Annual conversion required for steady state harvesting (ha)	Steady state GHG balance after year 40 ($t\ CO_2e$ yr-1)	Steady state relative livestock production (%)	Year in which net zero grassland production is achieved	Year in which net zero with 2022 is achieved	2022–2080 balance ($t\ CO_2e$)
Baseline	11,180,000			-44,049,200*	100*	–	–	-2,598,902,800
10% silvopasture		1,118,000	27,268	-22,344,024**	95**	Not achievable	Not achievable	-1,847,139,545
20% silvopasture		2,236,000	54,537	-638,849**	90**	Not achievable	Not achievable	-1,095,376,290
30% silvopasture		3,354,000	81,805	21,066,327**	86**	2051	Not achieved	-343,613,035
50% silvopasture		5,590,000	136,341	64,476,678**	76**	2044	2063	1,159,913,475

Table 3 *shows that establishing agroforestry on 10% of grassland would absorb only half the GHG emissions associated with UK grassland and associated livestock from 2022 by 2060. Under the 30%, net zero was achieved in 2051 and thereafter, sequestration exceeded emission for the UK grassland area as a whole. Meanwhile, under a scenario where 50% of UK grassland is converted to agroforestry net zero was achieved by 2044 and the rate of sequestration was sufficiently high for all emissions from UK grassland to be negated by 2063.*

Under the 10% silvoarable scenario, while sequestration by the trees and soil would not create the conditions for net zero agriculture, it did result in significant carbon absorption against a relatively limited impact on productivity.

Table 4 Prediction of the GHG balances from planting different proportions of UK cropland (4.84 million ha) to silvoarable systems

Scenario	Baseline arable land (ha)	Area of UK arable land converted to silvoarable (ha)	Annual conversion required for steady state harvesting (ha)	Steady state GHG balance after year 30 ($kt\ CO_2e$ yr-1)	Steady state relative agricultural production (%)	Year in which net zero arable agriculture is achieved	Year in which net zero with 2022 is achieved	2022–2080 balance ($t\ CO_2e$)
Baseline	4,840,000			-9,051*	100*	-	-	-533,997,200
10% silvoarable		484,000	16,133	-3,812**	92**	Not achieved	Not achieved	-317,144,283
20% silvoarable		968,000	32,267	1,426**	84**	2048	Not achieved	-100,291,365
30% silvoarable		1,452,000	48,400	6,665**	76**	2042	2063	116,561,552
50% silvoarable		2,420,000	80,667	17,141**	61**	2037	2048	550,267,387

*Notes: * The steady state for the baseline is constant between 2022 and 2080.*

*** The steady state for the scenarios is achieved from 2051 – 2080 when the total area of land to be converted under each scenario is achieved. Prior to that, the silvoarable land is still being increased. This modelling is based on 150 stems/ha.*

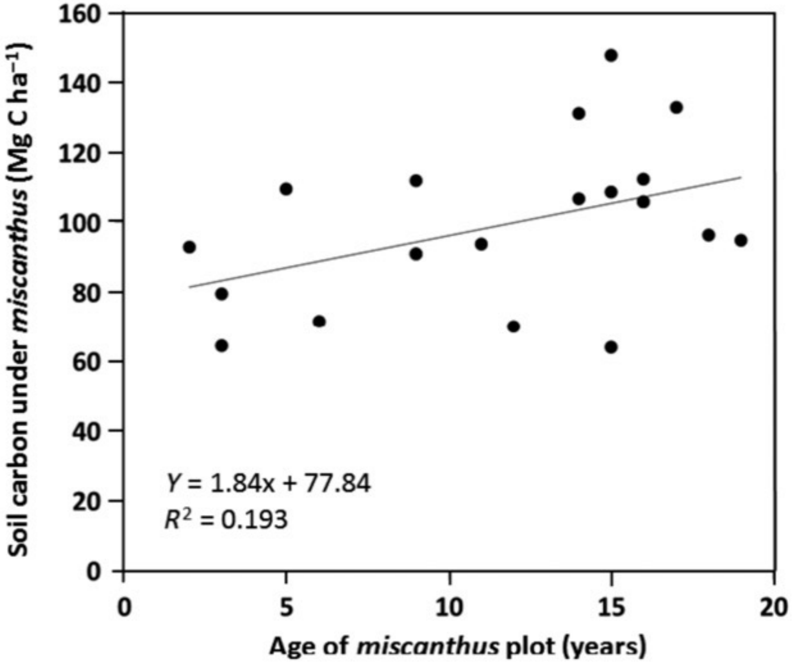
Mitigation contingent on high farmer adoption

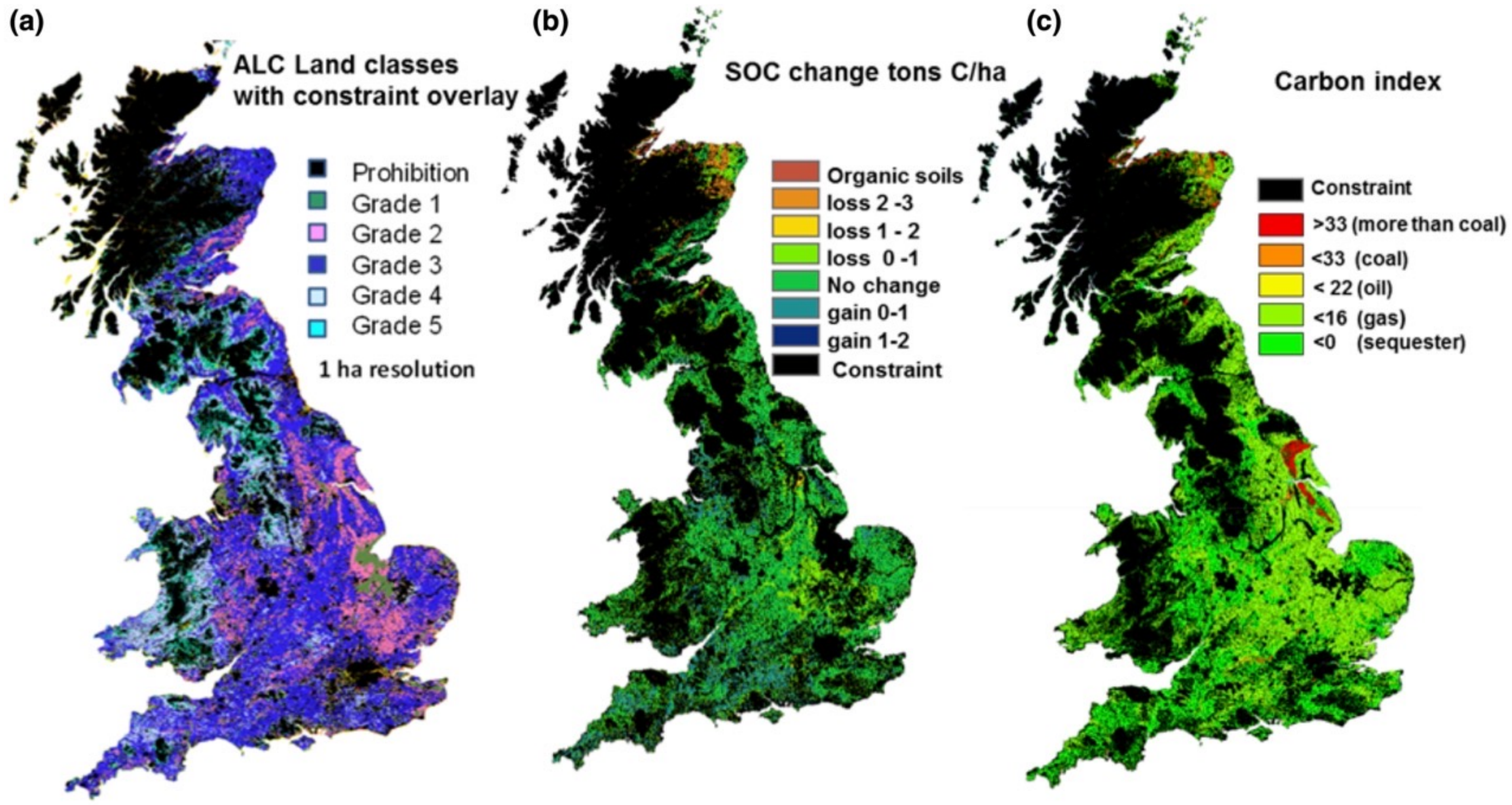
>30% conversion of current agriculture to agroforestry required

Burgess & Graves 2022

Increases in Perennial Crops on Farms Can Reverse Soil Carbon Loss

Modelling of *Miscanthus* suggests that soil carbon losses can be halted or reversed over two decades





McCalmont et al. (2017). *GCB Bioenergy*

Nitrous Oxide Emissions Lower in Agroforestry

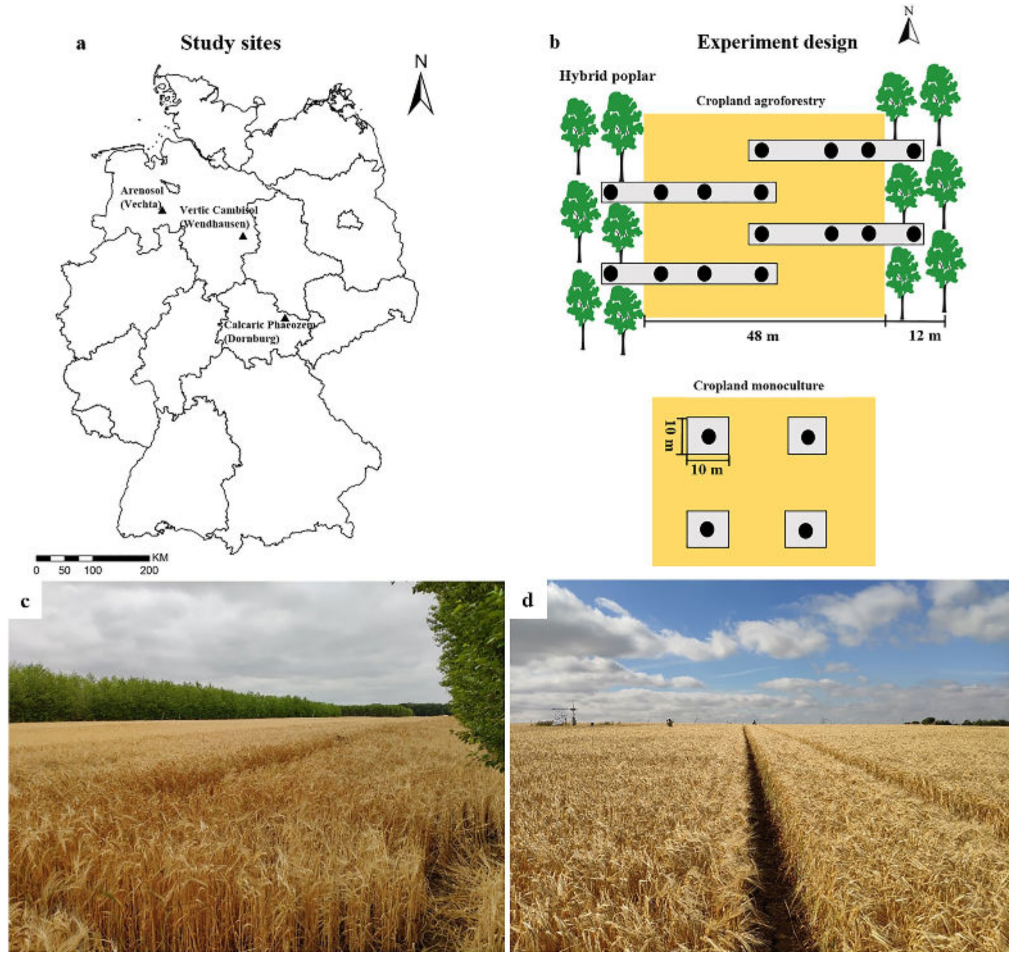


Figure 1. (a) Locations of the three study sites in Germany. (b) The layout of the experimental design: ● indicate sampling locations (in the cropland agroforestry, each replicate plot (▭) was sampled at the tree row, 1-m, 7-m, and 24-m distances from the tree row; in the cropland monoculture, measurements were taken in the center of each replicate plot). (c) Cropland agroforestry and (d) monoculture at Dornburg in the Phaeozem soil (picture credit: G. Shao).

Luo et al. (2022). *JGR Biogeosciences*

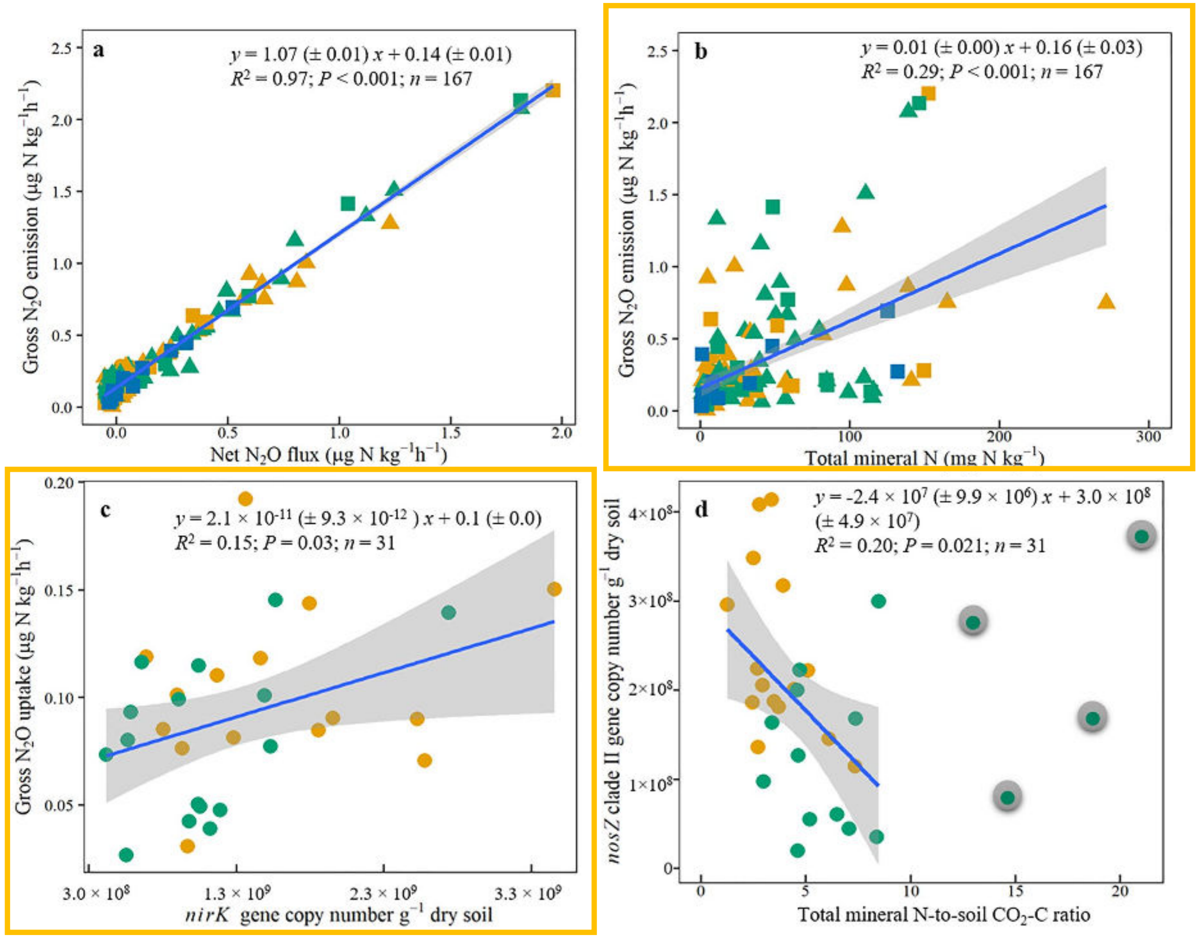
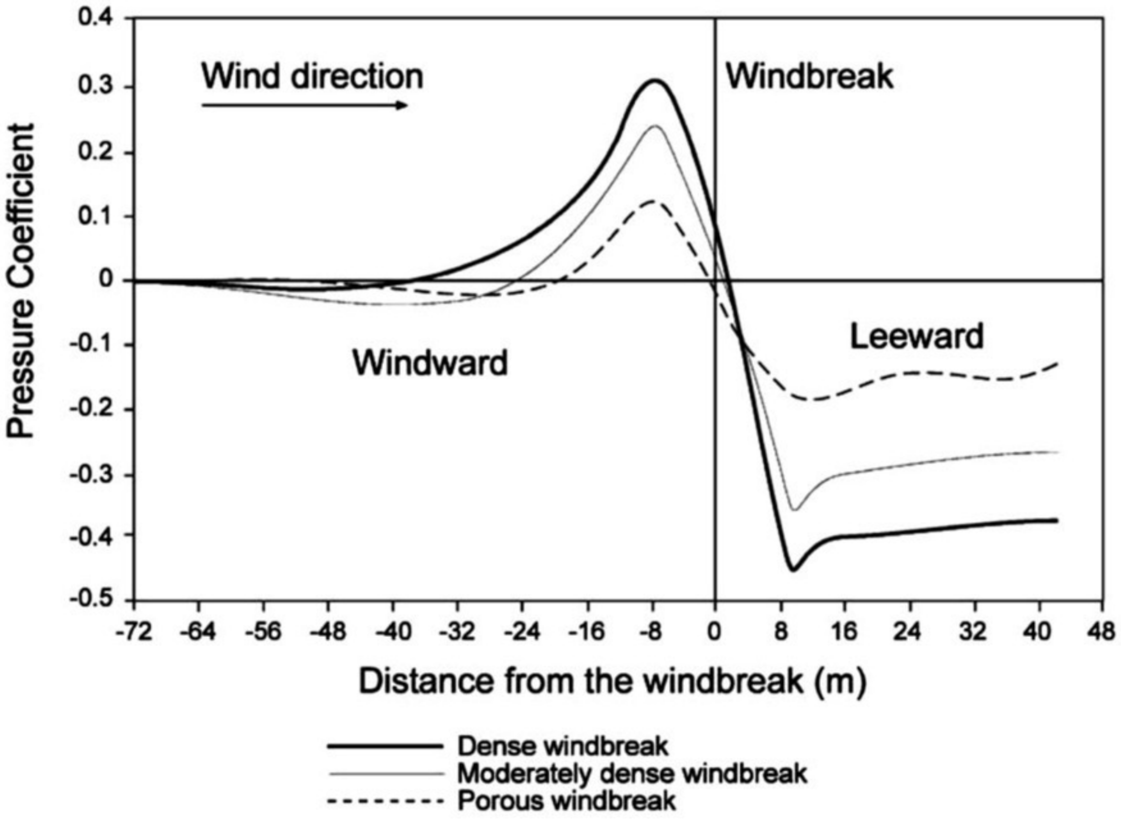


Figure 3. Cropland agroforestry and monocultures over 1.5 years of measurements: regression (parameter estimates ± 95% confidence interval) of gross N_2O emission with net N_2O flux (a) and total mineral N (b) across three sites. Agroforestry tree rows over 1.5 years of measurements: regressions between gross N_2O uptake and *nirK* gene abundance (c), and between *nosZ* clade II gene abundance and mineral N-to-soil CO_2-C ratio (d, including only ratios <10). Each data point is a monthly mean of four (in Phaeozem and Cambisol soils) or eight replicate plots (in Arenosol soil). Tree row (●), crop row (1-m, 7-m, 24-m sampling locations, (▲), monoculture (■), Phaeozem soil (●), Cambisol soil (●), Arenosol soil (●).

Microclimate Buffering: Windbreaks and Shelterbelts Enhance Yield



Brandle et al. (2004). *Agroforestry Systems*

Table 1. Relative responsiveness of various crops to shelter.

Crop	No. of field years	Weighted mean yield increase %
Spring wheat	190	8
Winter wheat	131	23
Barley	30	23
Oats	48	6
Rye	39	19
Millet	18	44
Corn	209	12
Alfalfa	3	99
Hay (mixed grasses and legumes)	14	20

Source: Kort (1988).

Nuberg (1998). *Agroforestry Systems*

Biodiversity and Pest Trade-offs

Example: Farmer-identified Adoption Barriers for Agroforestry

Costs and protection → Implementation costs and protection from damage

Tree suitability & disease → Climate change, species choice, knowledge of tree-crop interactions

Knowledge/capacity → Skills and training

Grants & subsidies → Too rigid and difficult to interpret in the context of business

https://blogs.ncl.ac.uk/marionpfeifer/agroforestry-in-the-uk/