Increasing carbon sequestration and mitigating carbon emissions

Opportunities provided by agroforestry

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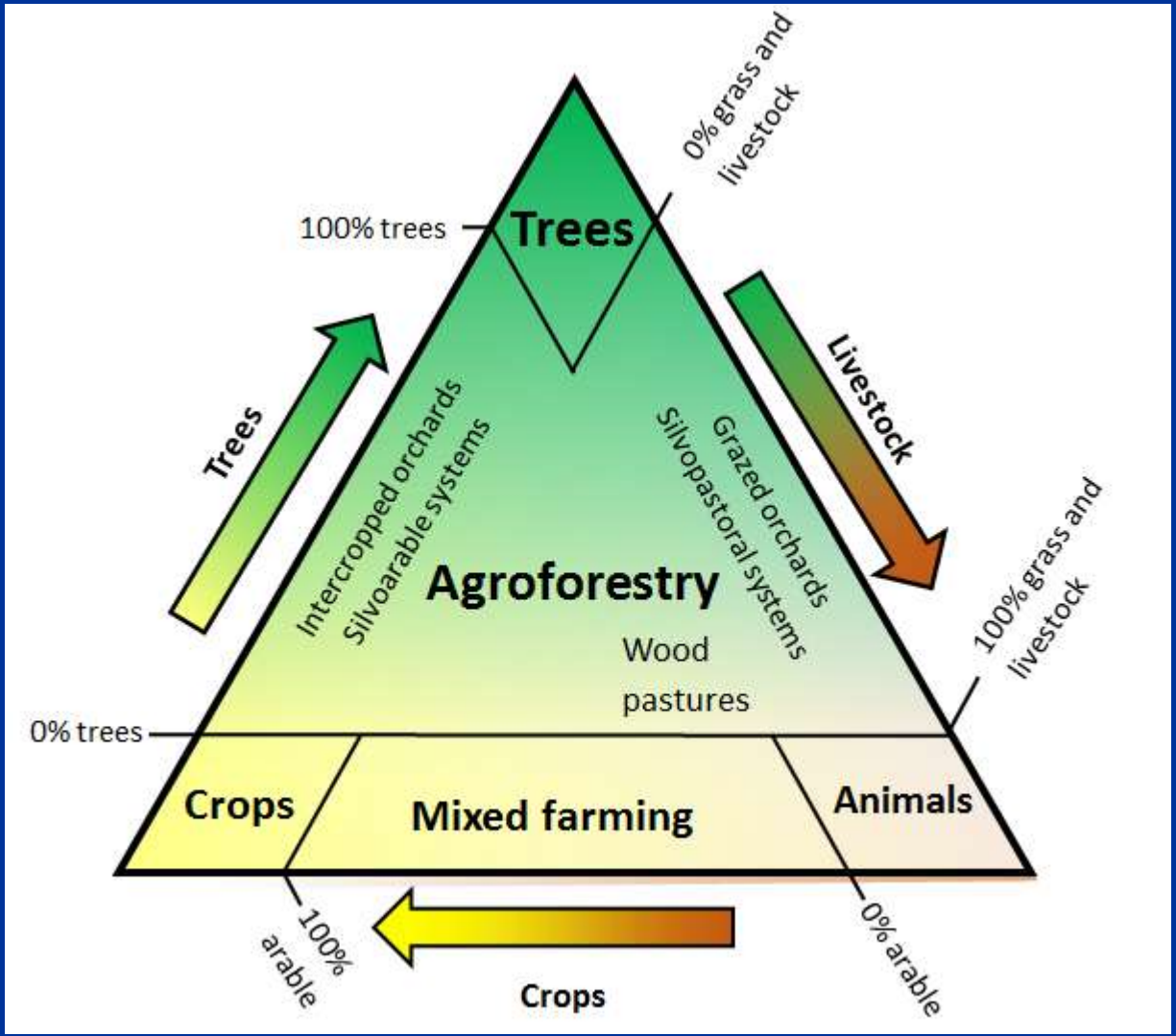
Agroforestry: the practice of deliberately integrating woody vegetation with crops and/or animals

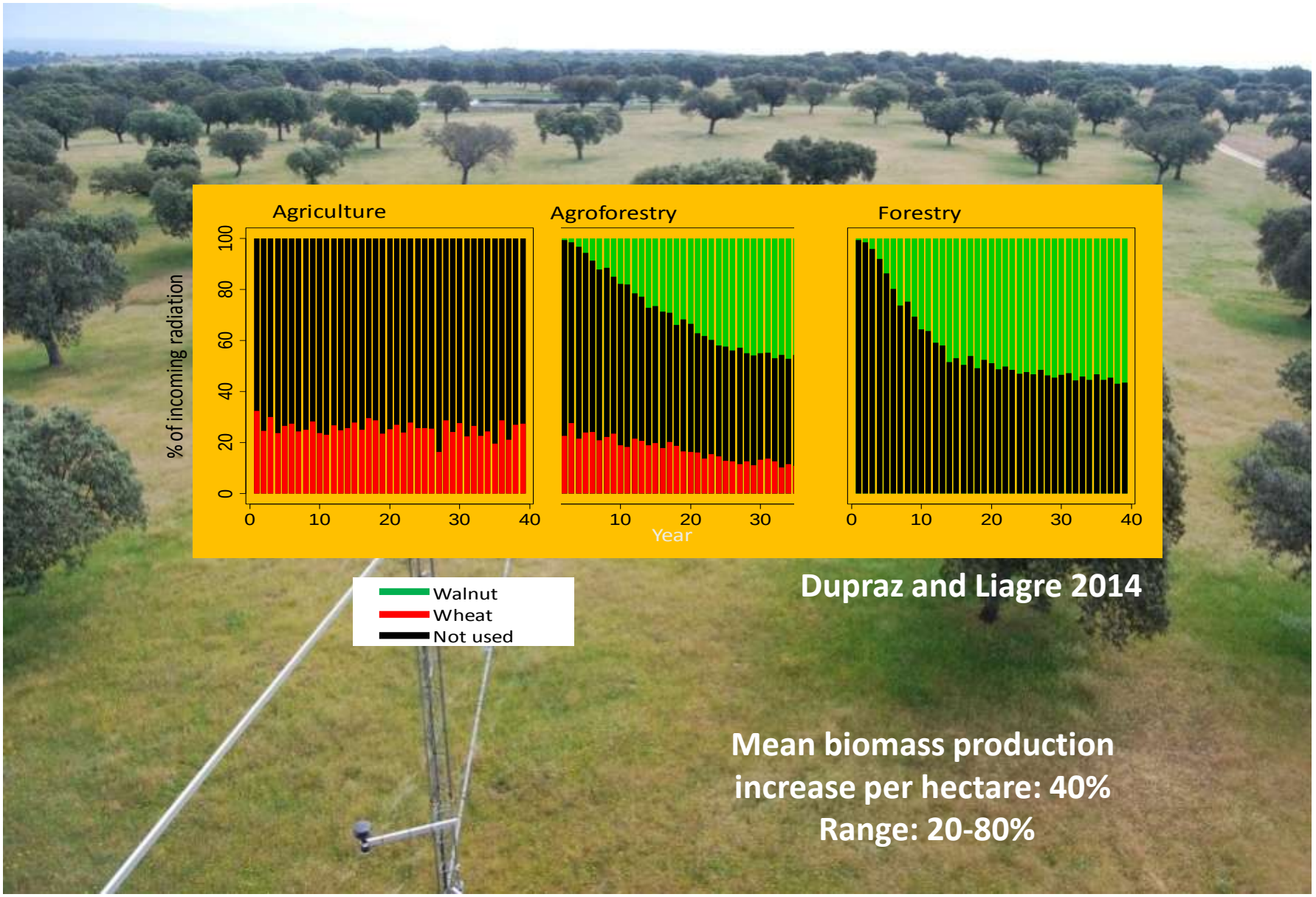


Agroforestry practices

Silvopastoral	Silvoarable	Hedgerows, windbreaks and riparian buffer strips	Forest farming	Homegardens
				
Combining trees and shrubs with forage and animal production	Widely spaced trees and shrubs inter-cropped with annual or perennial crops	Lines of natural or planted trees/shrubs bordering croplands/pastures to protect livestock, crops, and/or soil and water quality	Forested areas used for production or harvest of natural standing speciality crops	Combining trees/shrubs with vegetable production in urban areas

USDA, ICRAF, FAO

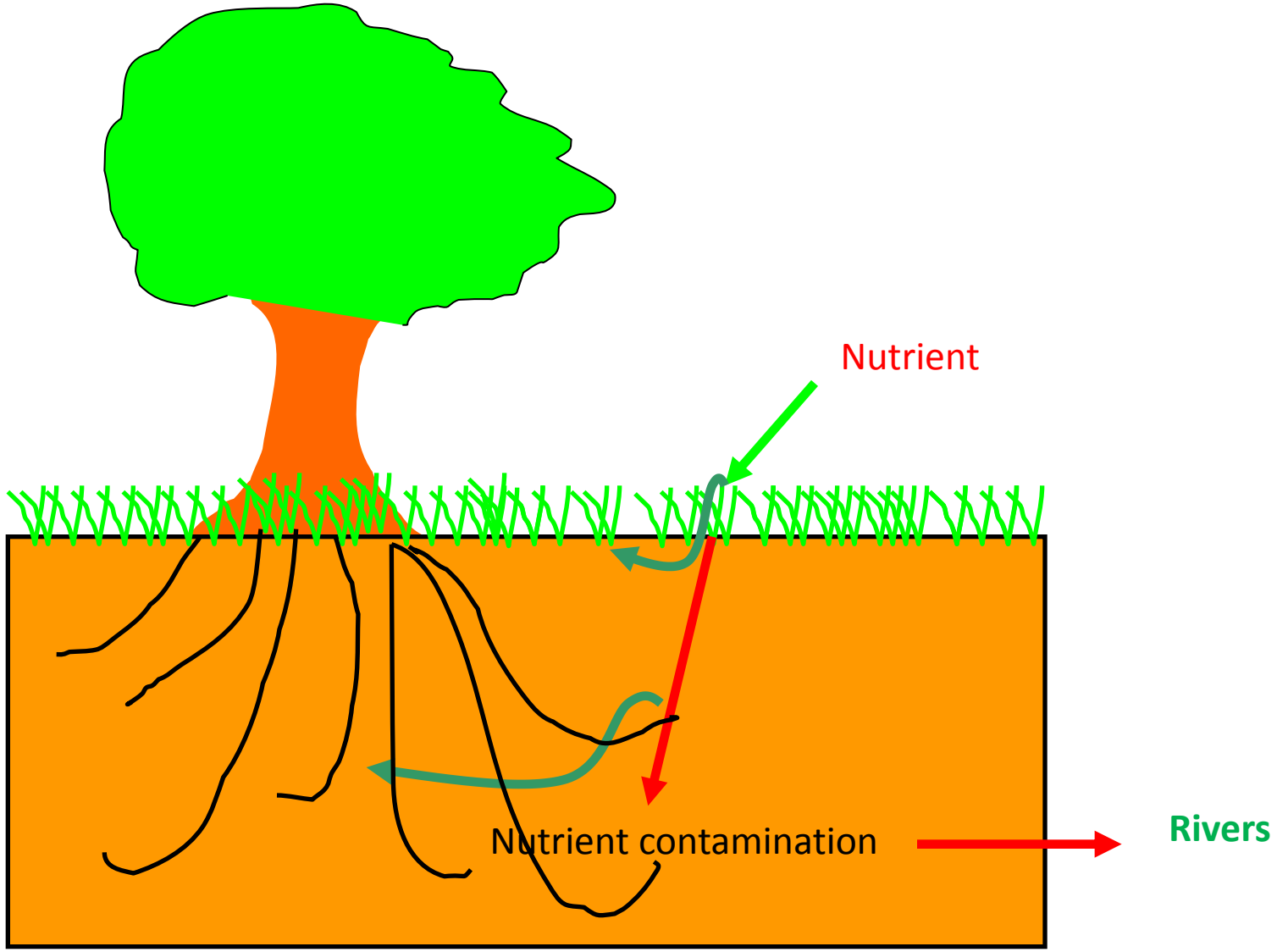
Agroforestry – a tool for eco-intensification?



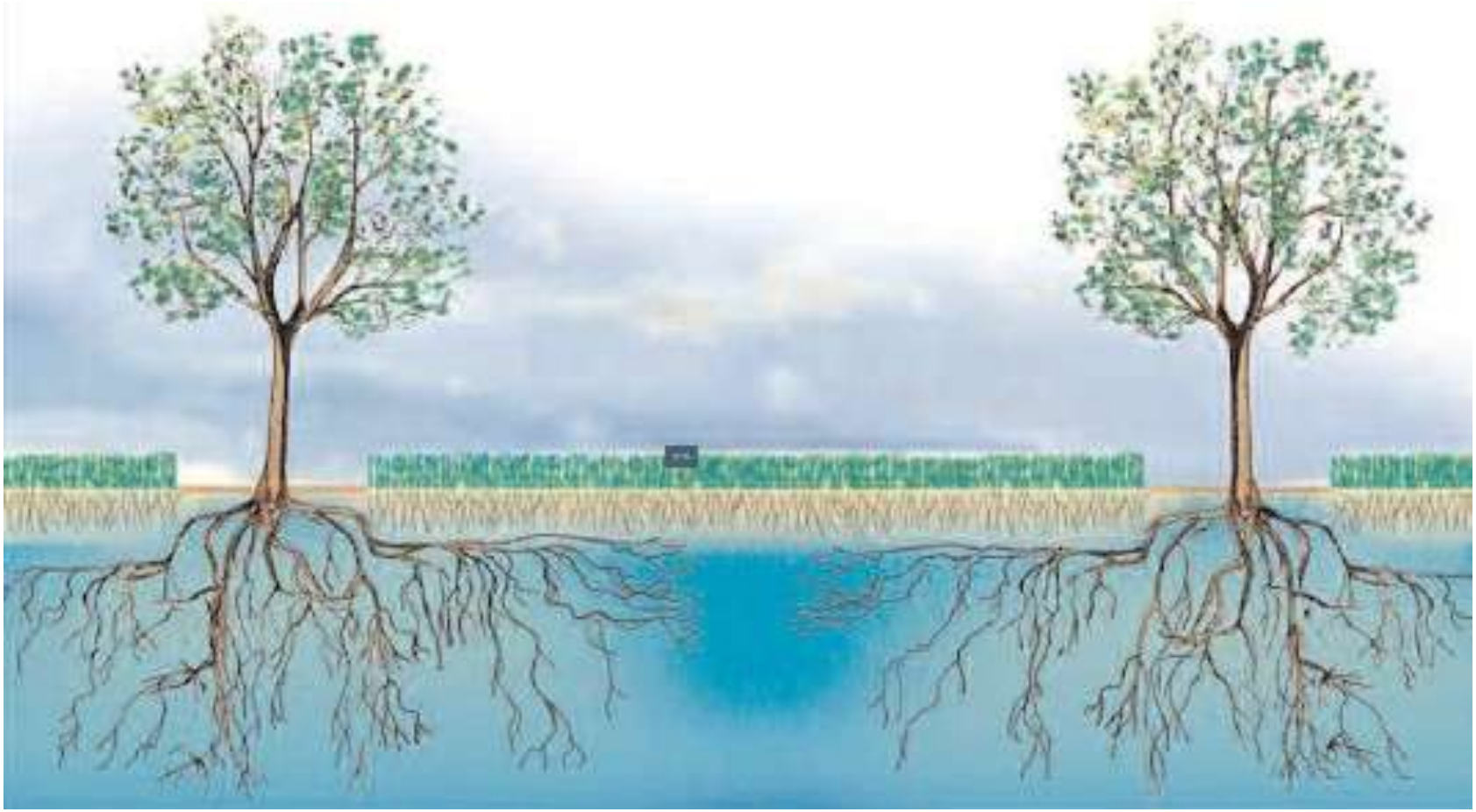
Dupraz and Liagre 2014

Mean biomass production increase per hectare: 40%
Range: 20-80%

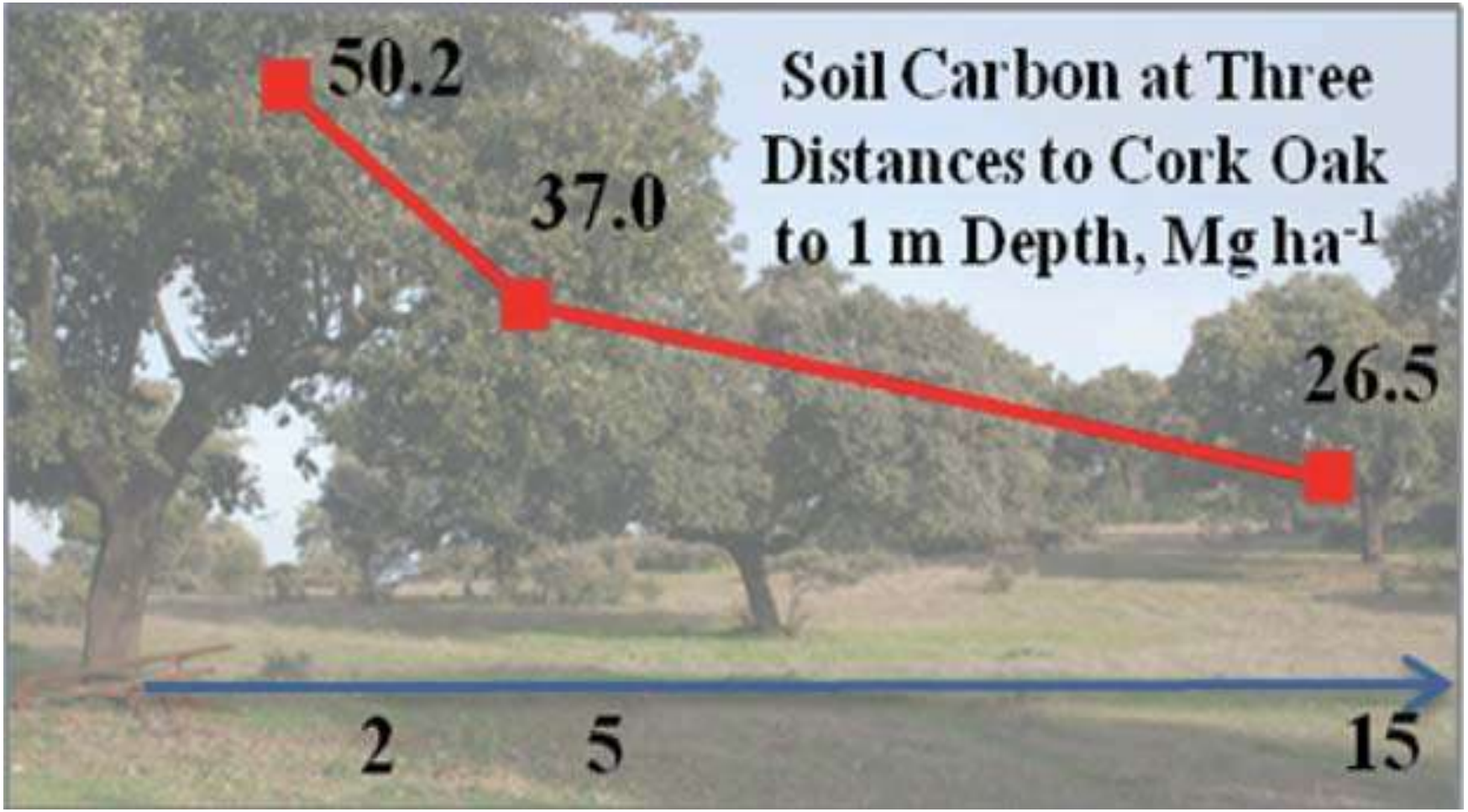
Belowground level



Carbon



Dupraz and Liagre



Howlett et al., Spain

Carbon stock in hedges

GoogleEarth image of a Hawthorn hedge, trimmed on three-year cycle, at Harnhill Manor Farm, Gloucestershire

Carbon storage from a PhD by Matthew Axe (2015)

	Field margin	2 m high Hedgerow
Above ground biomass (kg/m^2)	0.26	2.78
Below ground biomass (kg/m^2)	0.40	3.87
Soil organic carbon (0-30 cm) (kg/m^2)	8.51	9.87
Total carbon (kg/m^2)	9.17	16.52
Increase in carbon (kg/m^2)		**7.35**
Assume 100 ha farm with 1.5 m wide hedges and 8000 m of hedges (t C)		88.2
Value[a] of carbon stored in hedges (£)		**1470**

[a]Assumed values of C is £16.72 per tonne (Bateman et al. 2014), which is within the range (£11-37) quoted by Forestry Commission, 2016)

[b]: Mean field size of 12.5 ha

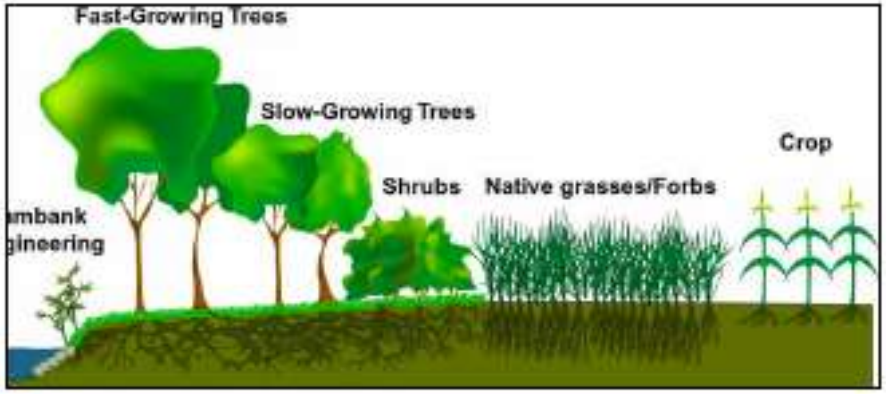
Carbon sequestration of hedges managed for woodfuel

Estimate of carbon sequestration from a blackthorn hedge managed on 15 year rotation for woodfuel (Crossland 2015)

	Below-ground C	Harvestable carbon in woodfuel
Carbon sequestration ($kg/m^2/year$)	0.053	0.470
C sequestration (100 ha farm with 8000 m (1.5 m wide) hedges (t C/year)	0.63	5.64
Value of carbon[a] (£/year)	**11**	**94**

[a]Assuming a carbon value of £16.72/t C (Bateman et al. 2014)

Riperian buffer: Another practice suitable for biomass production



Carbon sequestration by parkland

Carbon sequestration by parkland (4% tree cover) over 14 years from tree planting (Upson et al. 2016)

	Pasture	Parkland	Wood
Tree biomass (t C/ha)	0.0	4.0	35.9
Soil organic carbon (t C/ha)	59.6	59.4	46.2
Total (t C/ha)	59.6	63.4	82.1
Change (t C/ha)		3.8	22.5
Value of change[a] (£/ha)		**63.5**	**376**
Net change (t C/ha/year)		**0.29**	**1.60**
Annual value of C sequestration[a] (£/ha/year)		**4.5**	**26.8**

[a]Assuming a value of £16.72/t C (Bateman et al. 2014)

How can agroforestry enhance provision of ecosystem services?

Reducing **Physical degradation**:

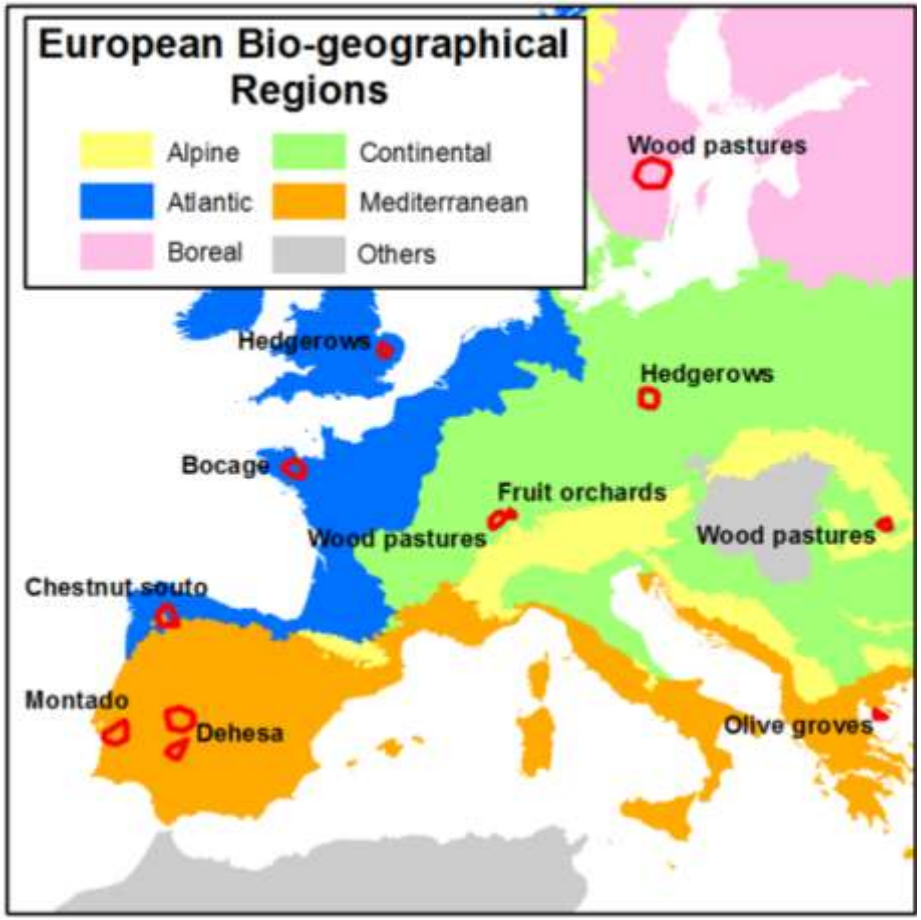
Flooding

Erosion

Forest fires

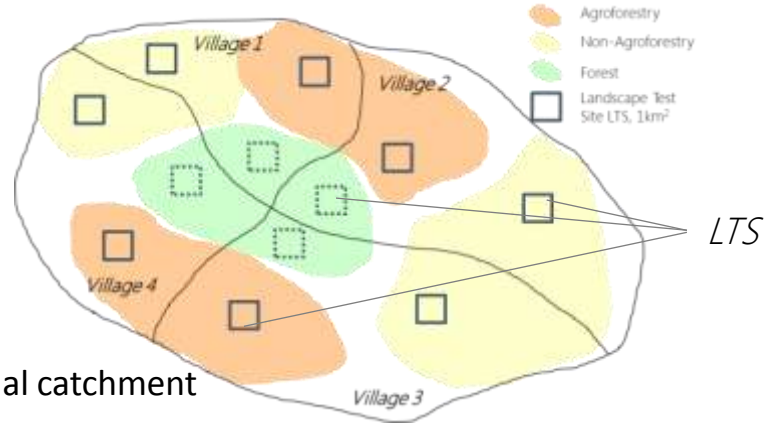
Reducing **Chemical degradation**: i.e. organic or inorganic fertilizers

Impact: landscape agroforestry studied in twelve European regions



Twelve case study regions in Europe

- Atlantic (3)
- Mediterranean (4)
- Continental (4)
- Boreal (19



Social catchment

- **Landscape Test Sites** (LTS), 8-12 x 1 km^2
  - Habitat mapping
  - Modelling biophysical benefits
- **Social catchment**, 50–200 km^2, 5–6 municipalities
  - Public Participation Geographic Information System (PPGIS)
  - Deriving socio-cultural benefits

Kay et al. (2017) Agroforestry Systems

Does European agroforestry provide **biodiversity and biophysical** benefits?

Fruit Orchards, Central Europe

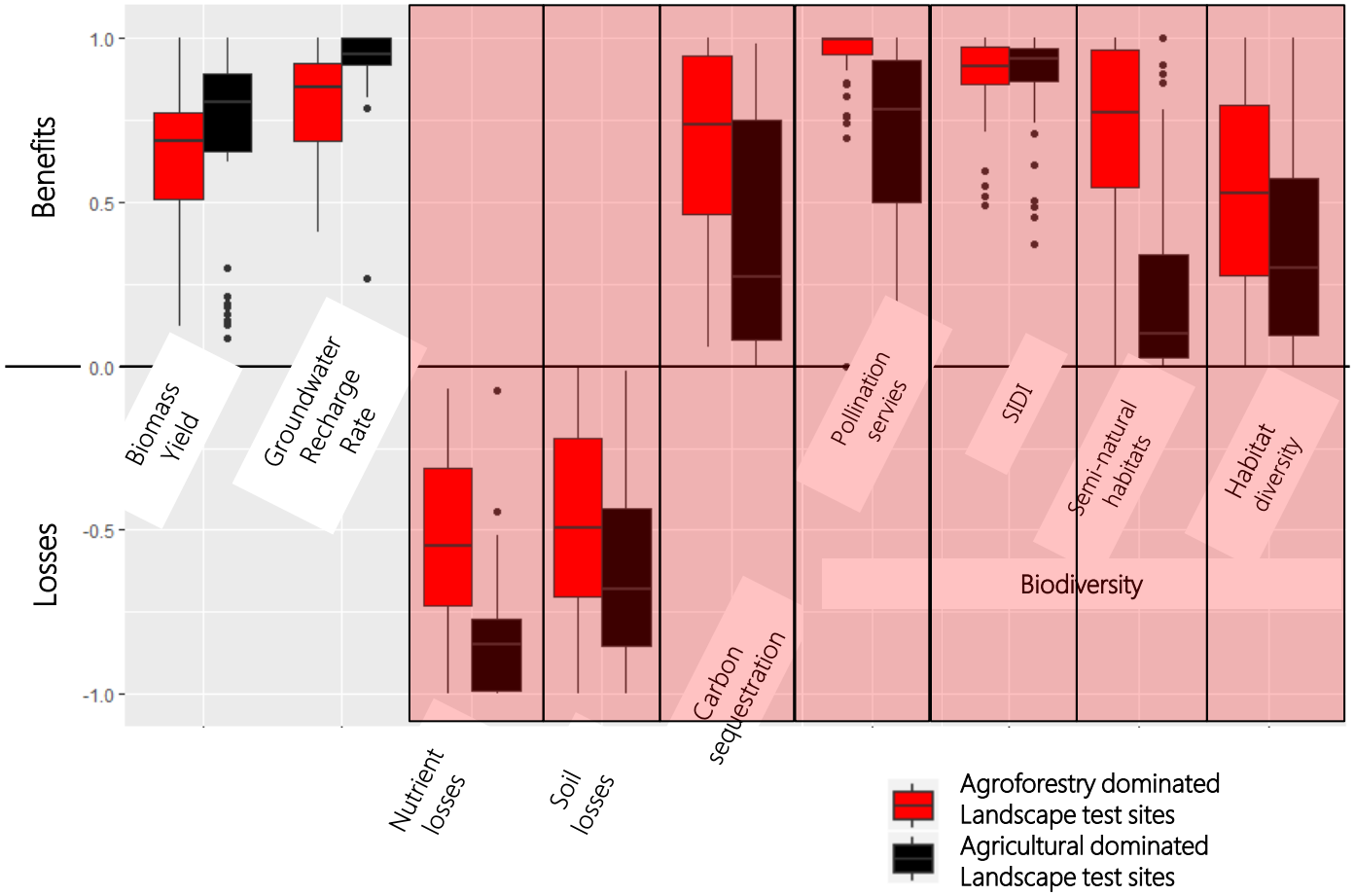
AF - LTS

NAF - LTS

Modelled Ecosystem Services

- Biomass yield
- Groundwater recharge rate
- Nutrient retention
- Soil preservation
- Carbon sequestration
- Biodiversity
  - Functional biodiversity (Pollination)
  - Habitat diversity

Yes!- Agroforestry enhances biodiversity and biophysical ecosystem services



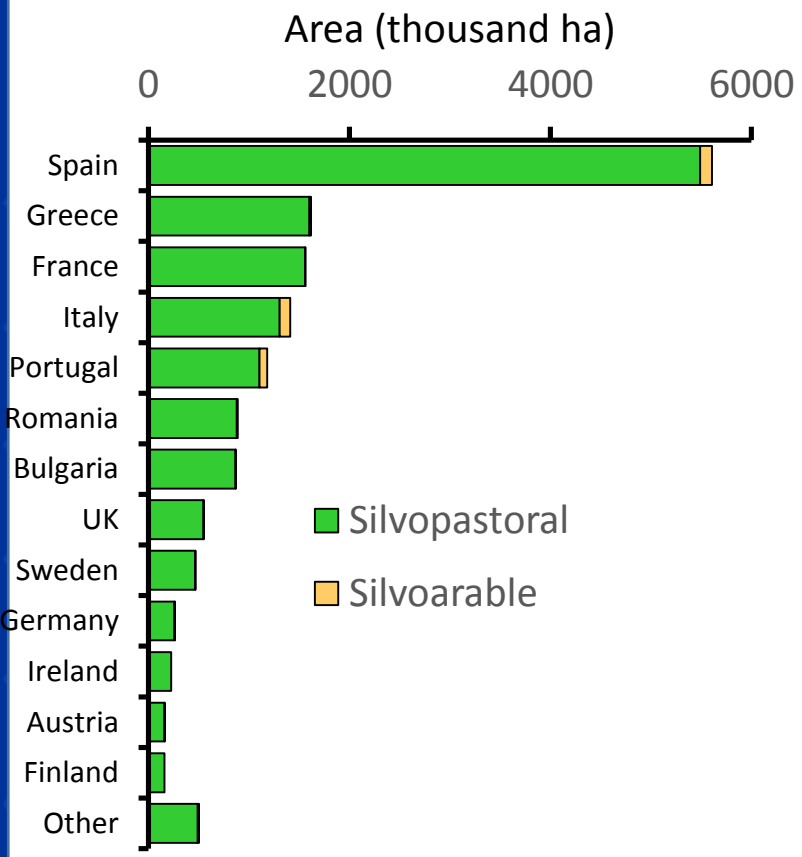
Agroforestry dominated landscapes

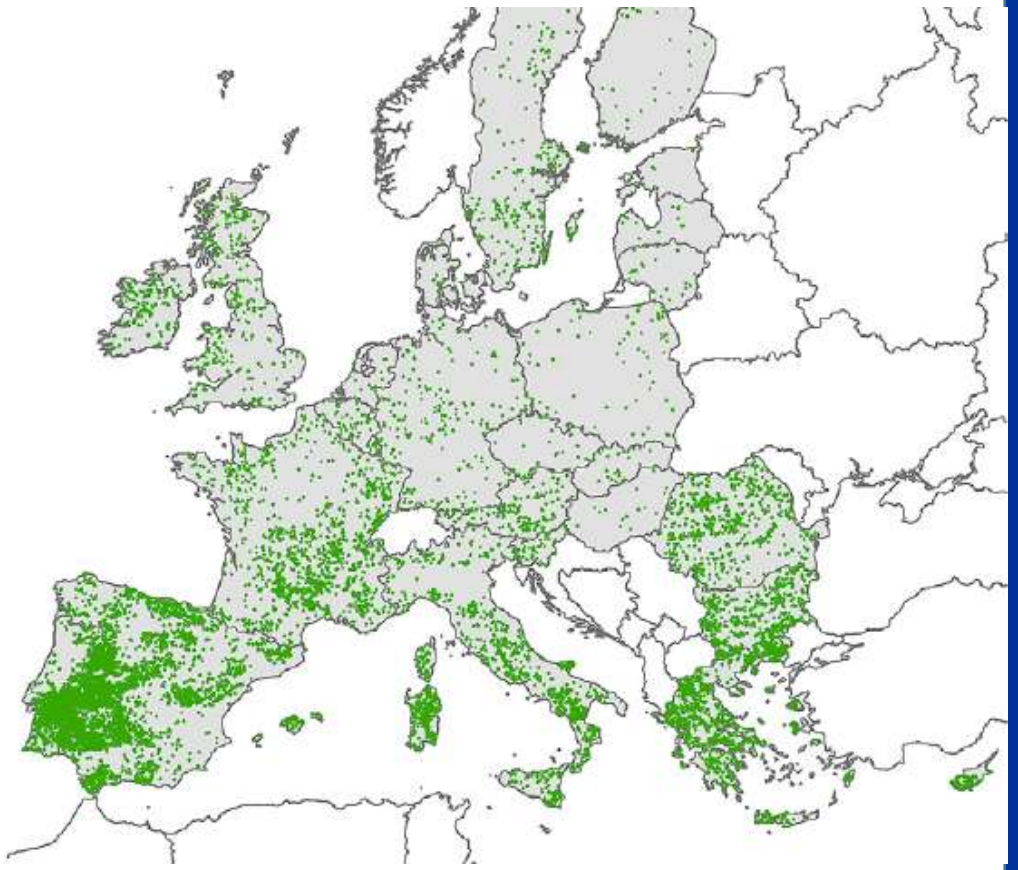
- better nutrient retention
- higher carbon sequestration
- higher soil preservation
- higher pollination services
- higher proportions of semi-natural habitats

Agricultural dominated landscapes

- higher annual biomass yields
- higher groundwater recharge rates

Current extent of agroforestry in Europe

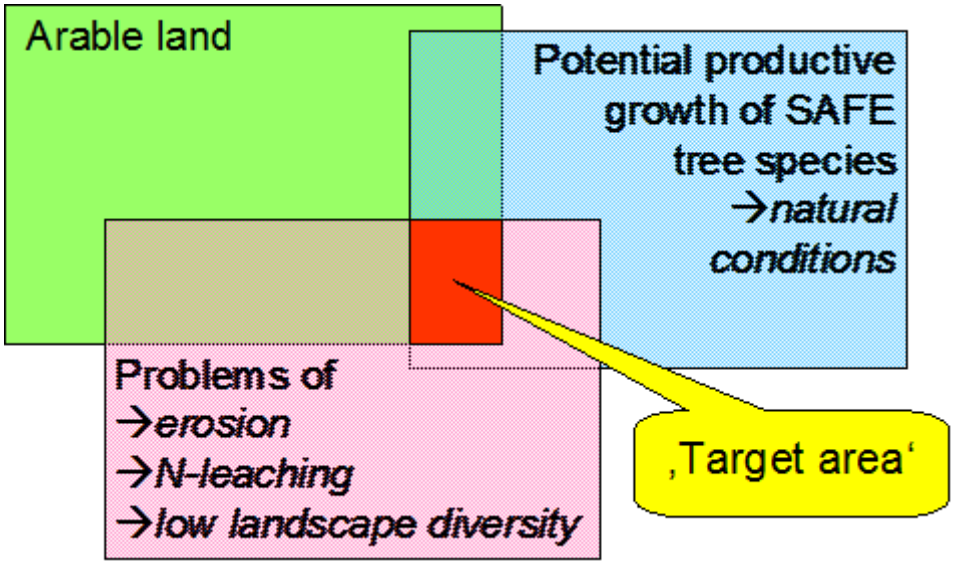


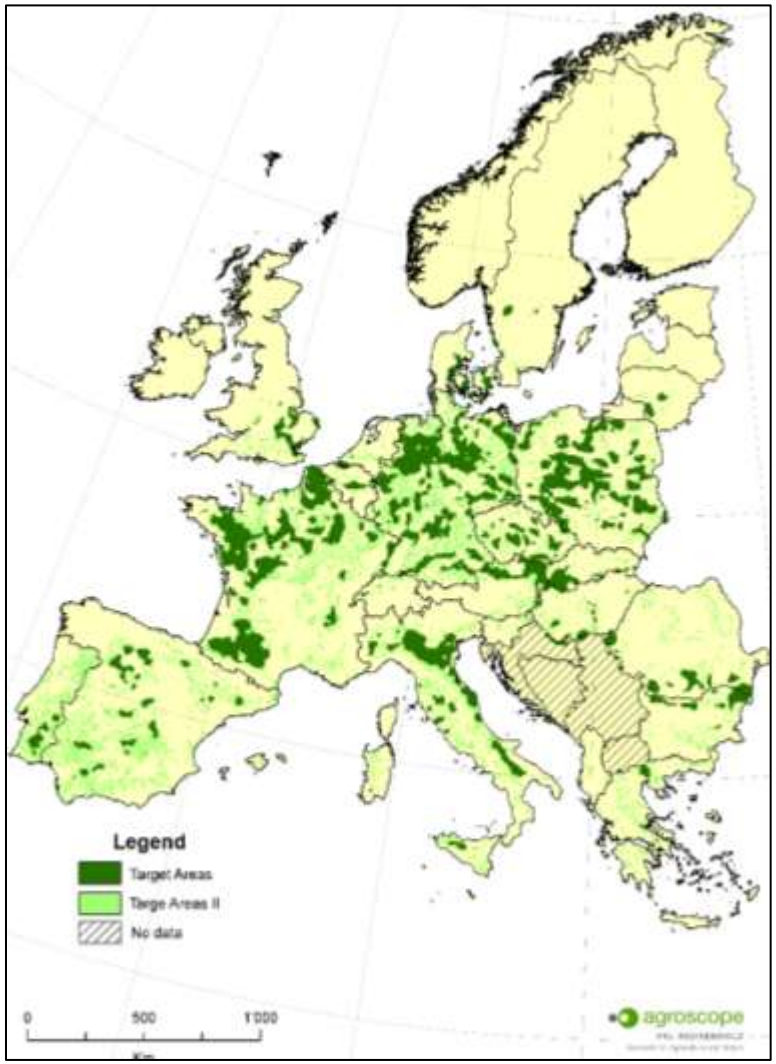


Area of agroforestry: Using LUCAS data:15.4 Mha (3.6% of total area and 8.8% of agricultural area) (den Herder et al. 2017).

Impact: where can agroforestry yield environmental benefits?

Results from SAFE project (Reisner et al. 2007)





→ 650’000 km^2
40% of European arable land

Reisner, et al. (2007) Ecol. Engin 29, 401 – 418 ; Palma et al. (2007) Agric., Ecosyst. Environ. 119, 320 – 334.

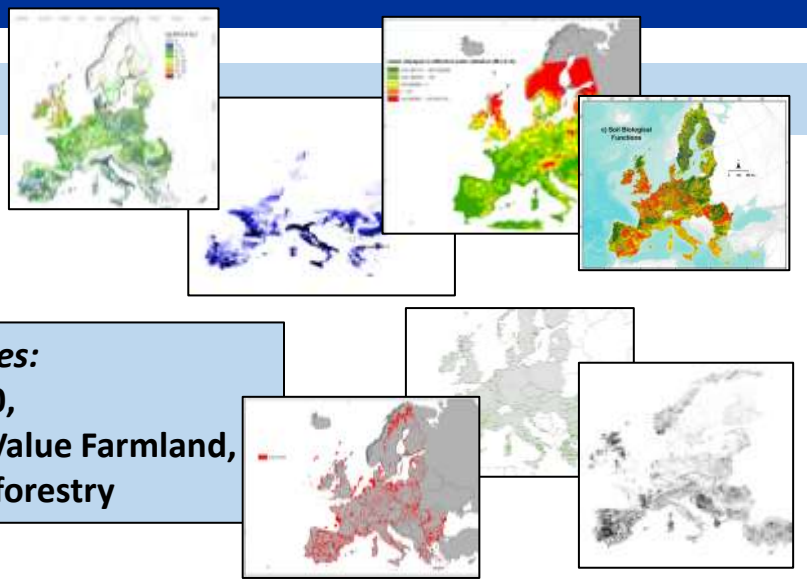
What can agroforestry do to help reaching future goals of European CAP? – ongoing

A. Agroforestry - Priority Region:

Deficit areas:
focussing on soil, water, biodiversity and climate change

without

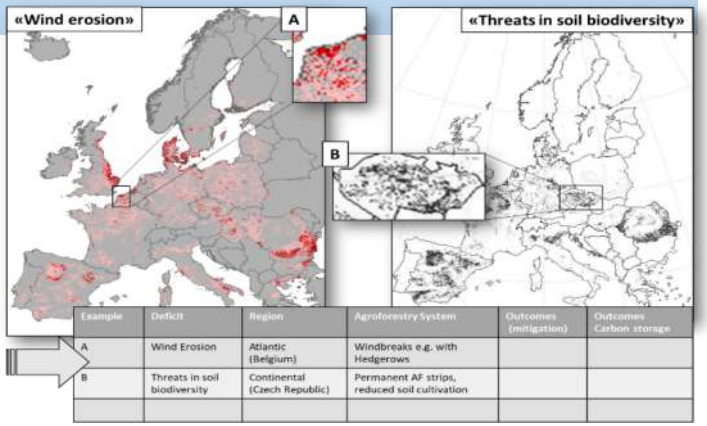
Exclusion zones:
NATURA 2000,
High Nature Value Farmland,
Existing Agroforestry



B. Matrix of agroforestry that can regionally mitigate the above-mentioned deficits: Key findings from AgForward participatory R&D process

C. Contribution to CAP goals

- Estimation of the potential of the proposed agroforestry systems to mitigate multiple environmental problems based on results from 12 European case study regions
- Estimation of their overall contribution to climate change mitigation via carbon storage in Europe.

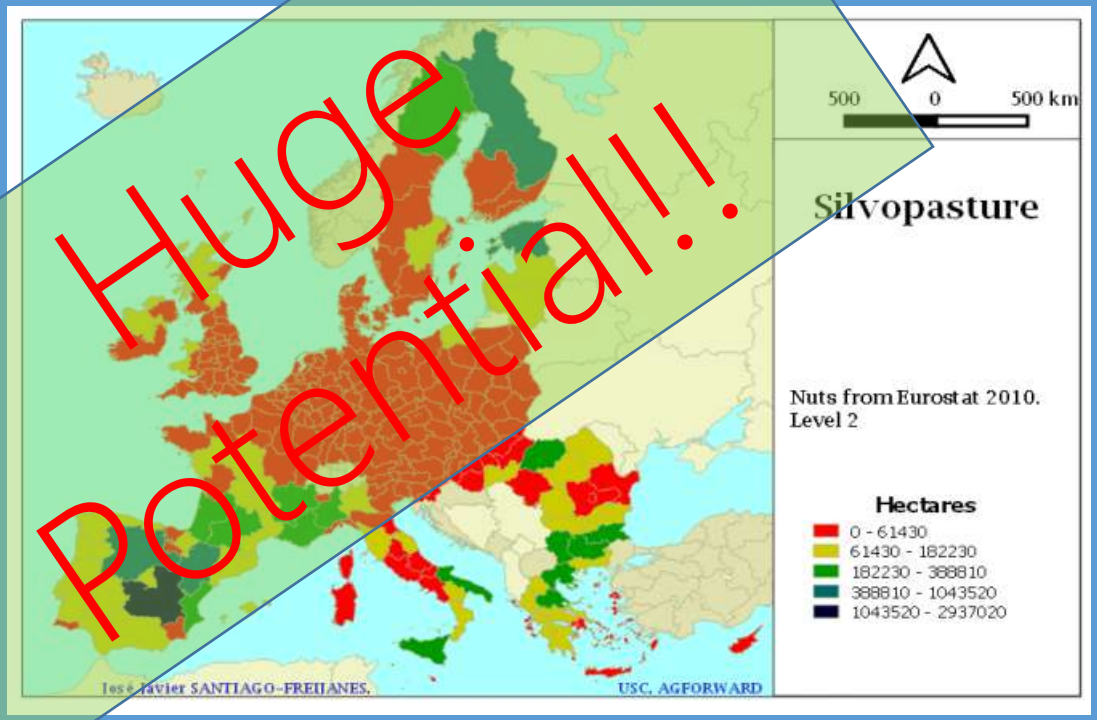


Example	Deficit	Region	Agroforestry System	Outcomes (mitigation)	Outcomes Carbon storage
A	Wind Erosion	Atlantic (Belgium)	Windbreaks e.g. with Hedgerows		
B	Threats in soil biodiversity	Continental (Czech Republic)	Permanent AF strips, reduced soil cultivation		

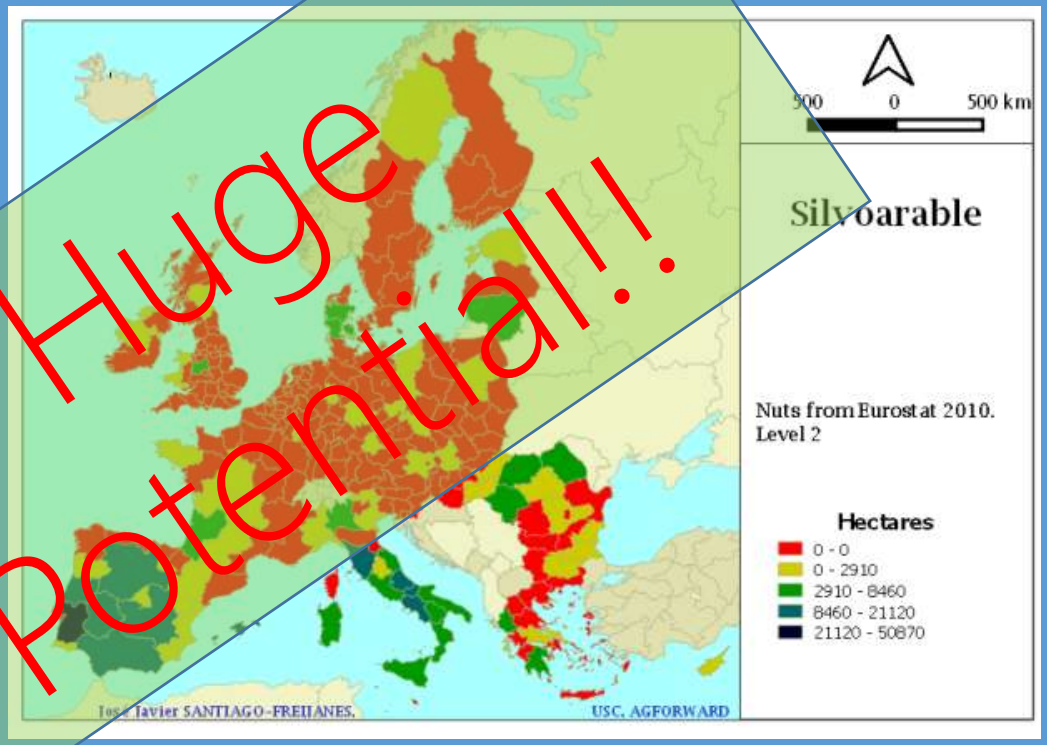
Silvopasture	Brief description
	Woody + forage and animal production

19.5 Million ha

10% EU potential area



Huge Potential!!

Silvoarable	Brief description
 422,250 hectares **0,4 % EU Arable land** **USA: <1%**	Woody + annual or perennial crops 

Huge Potential!!

Conclusions

- Agroforestry is an excellent tool to increase productivity and provide ecosystem services if adquate species are mixed for a specific context
- Agroforestry increases resilience in plots and farms while mitigating and adaptating to climate change
- Woody components providing multiple ES benefits in agricultural systems and should be promoted

Thank you for your attention!

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