The potential role of Agroforestry in tackling Food Security and Bioenergy

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Outline

- What is Agroforestry
- Examples silvoarable agroforestry Europe
- Agroforestry and climate change
  - Soil erosion and water quality
  - Carbon Sequestration
  - Yield comparison
- CAP in Europe

Define Agroforestry

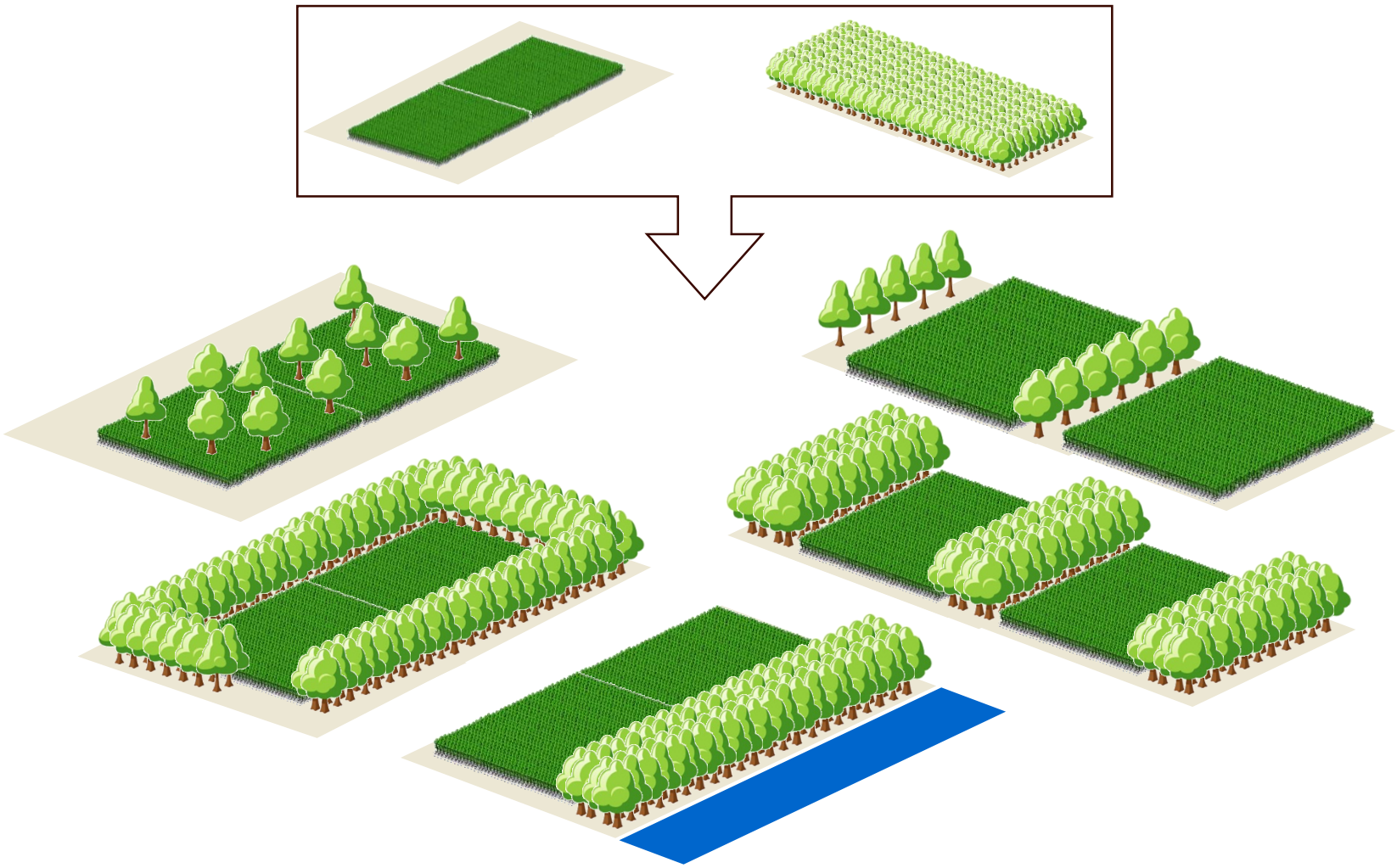
In the FP7 funded project AGFORWARD agroforestry is defined as the

deliberate **integration of woody vegetation, crops and/or livestock** on the same area of land to benefit from the resulting ecological and economic interactions. Trees can be inside parcels or on the boundaries (hedges).

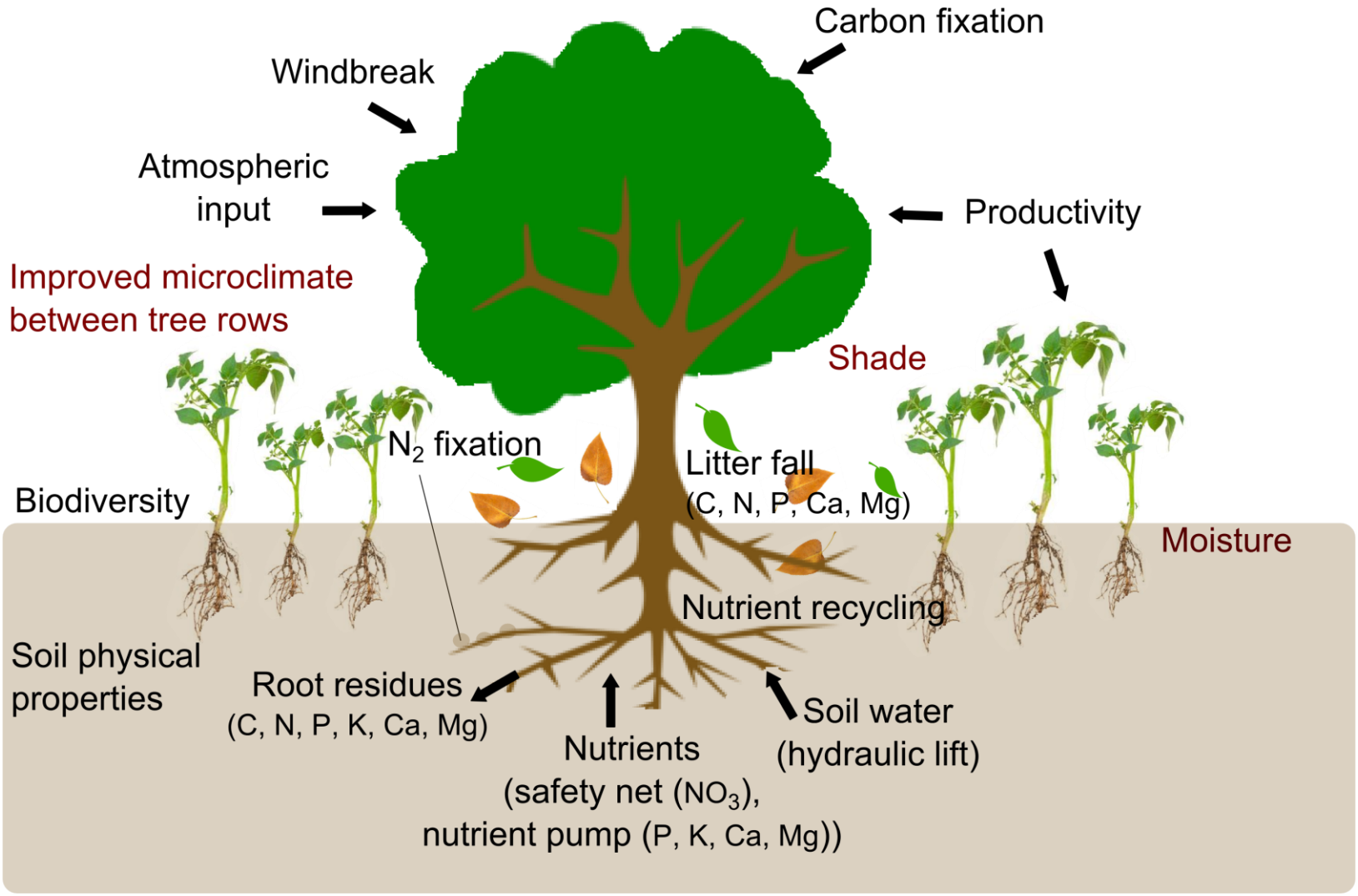
Holm oak Montado, South Portugal, by João Palma

Wakelyns Agroforestry, Suffolk, UK, by Permaculture Association

Define Agroforestry



Interactions in Agroforestry Systems



Silvoarable Agroforestry in Europe

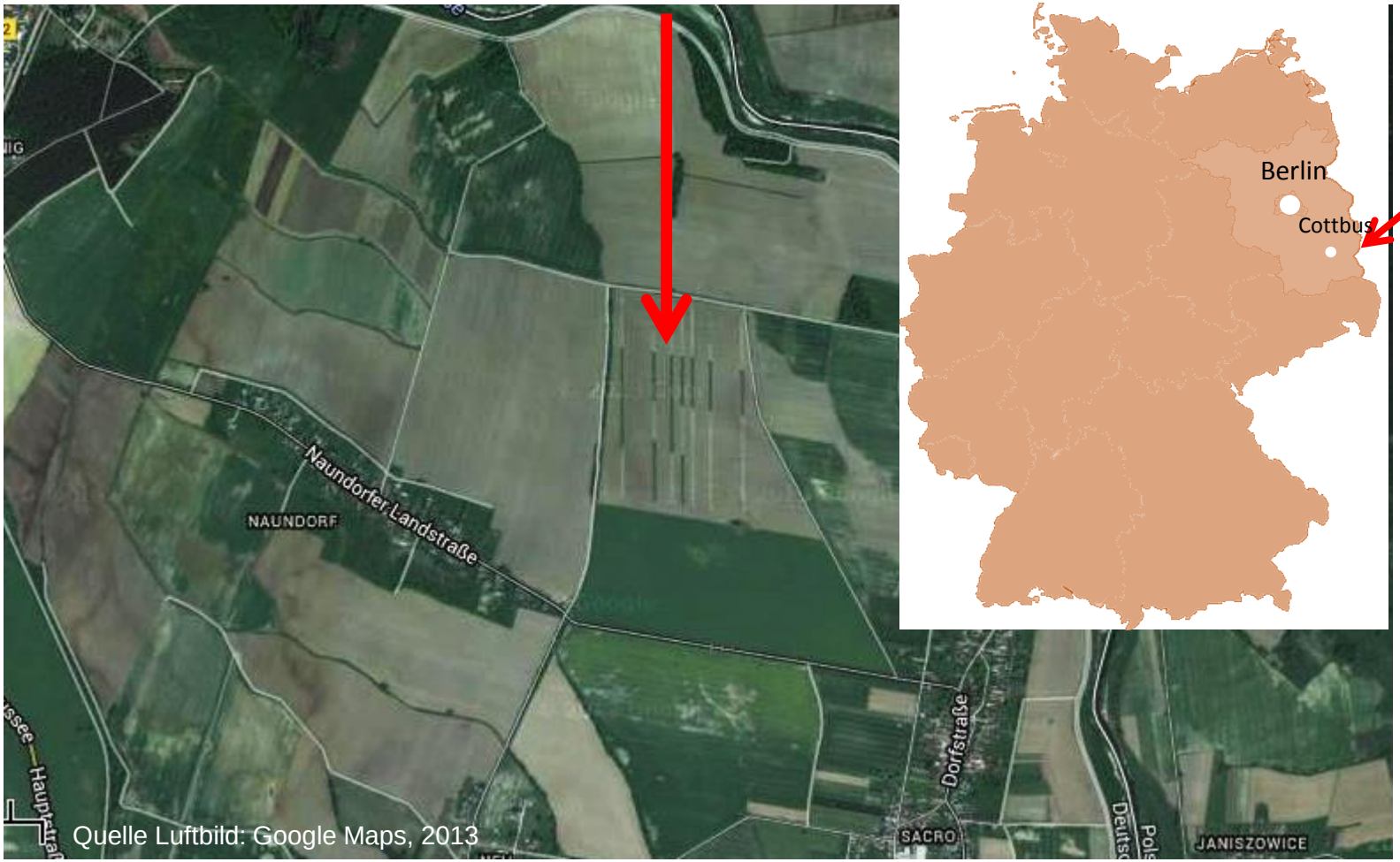
- Unique heritage of traditional agroforestry systems with high nature and cultural value
- High potential for innovative modern agroforestry systems

Silvoarable system: Cork oak (*Quercus subur*) and cereals in Portugal by João Palma.

Silvoarable Agroforestry in Europe

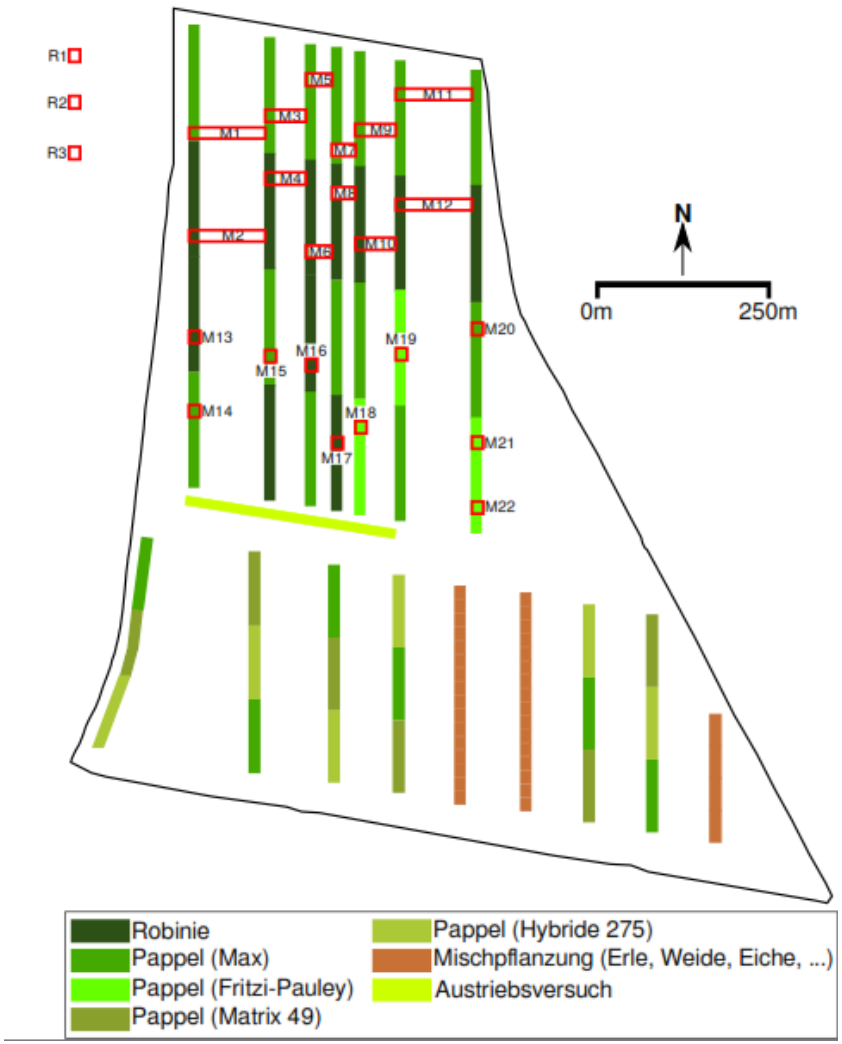
Silvoarable system: Alley cropping system consisting of hedgerows with poplar (*Populus nigra* x *P. maximowiczii)* and black locust (*Robinia pseudoacacia*) and winter weed (*Triticum aestivum*) within the alleys close to Forst, Germany (source Freese, 2014).

Experimental Field in Forst/ Lusatia



Quelle Luftbild: Google Maps, 2013

Experimental Field in Forst/ Lusatia

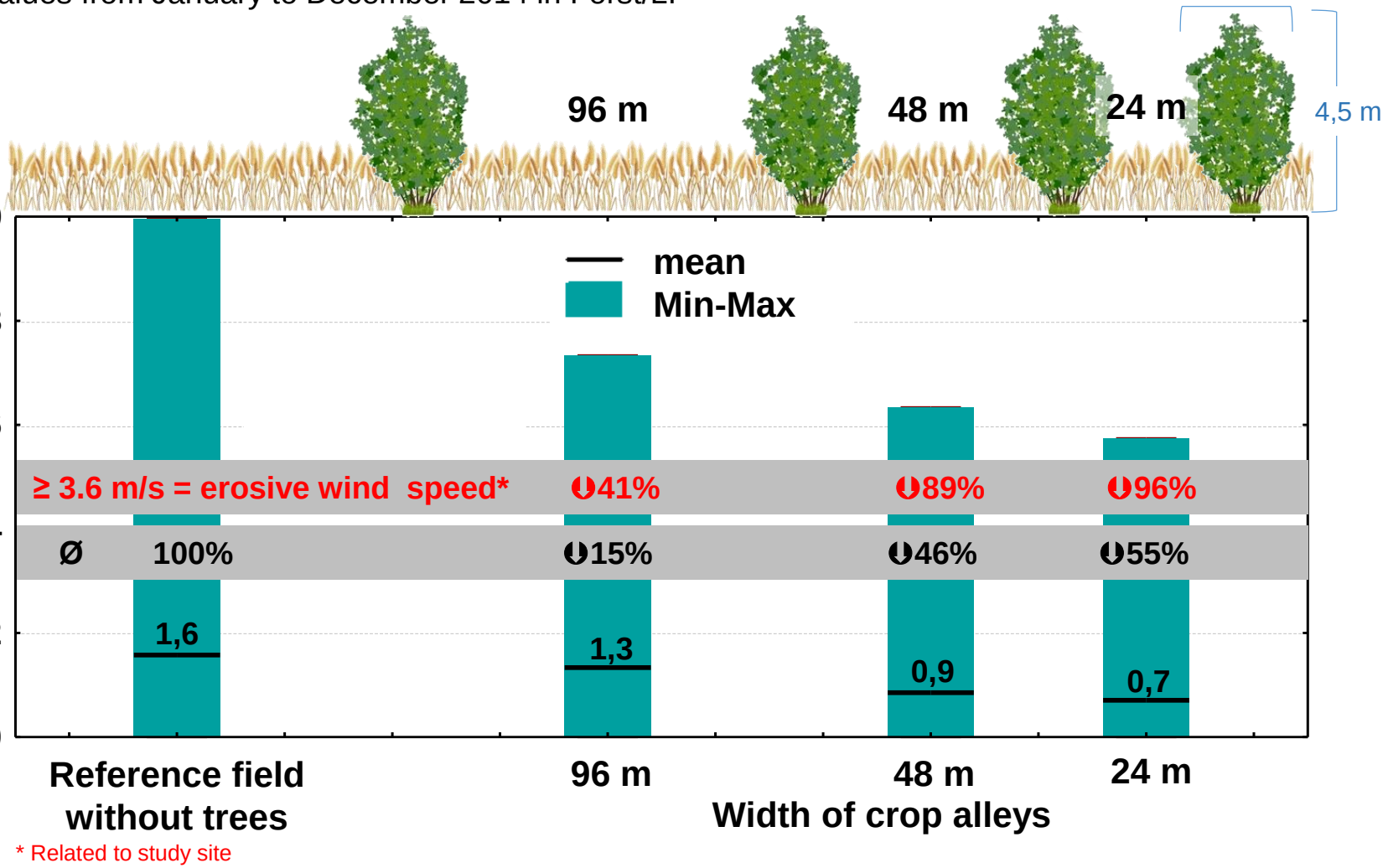


- 40 ha, planted 2010, (2011) (North)
- 30 ha planted in 2014 (South)
- Trees: Black locust and Poplar
- North-South-Direction
- Crop alleys: 24, 48, 96 (North) or 72 144m (South)
- Crops: maize, potato, sugar beet, wheat
- Soil: Gley-Vega and Pseudo Gley-Vega
- Humus content 1.9%
- Groundwater 0.8-2.3 m below surface

Experimental Field in Forst/ Lusatia

Agroforestry and Wind (Erosion)

Mean values from January to December 2014 in Forst/L.



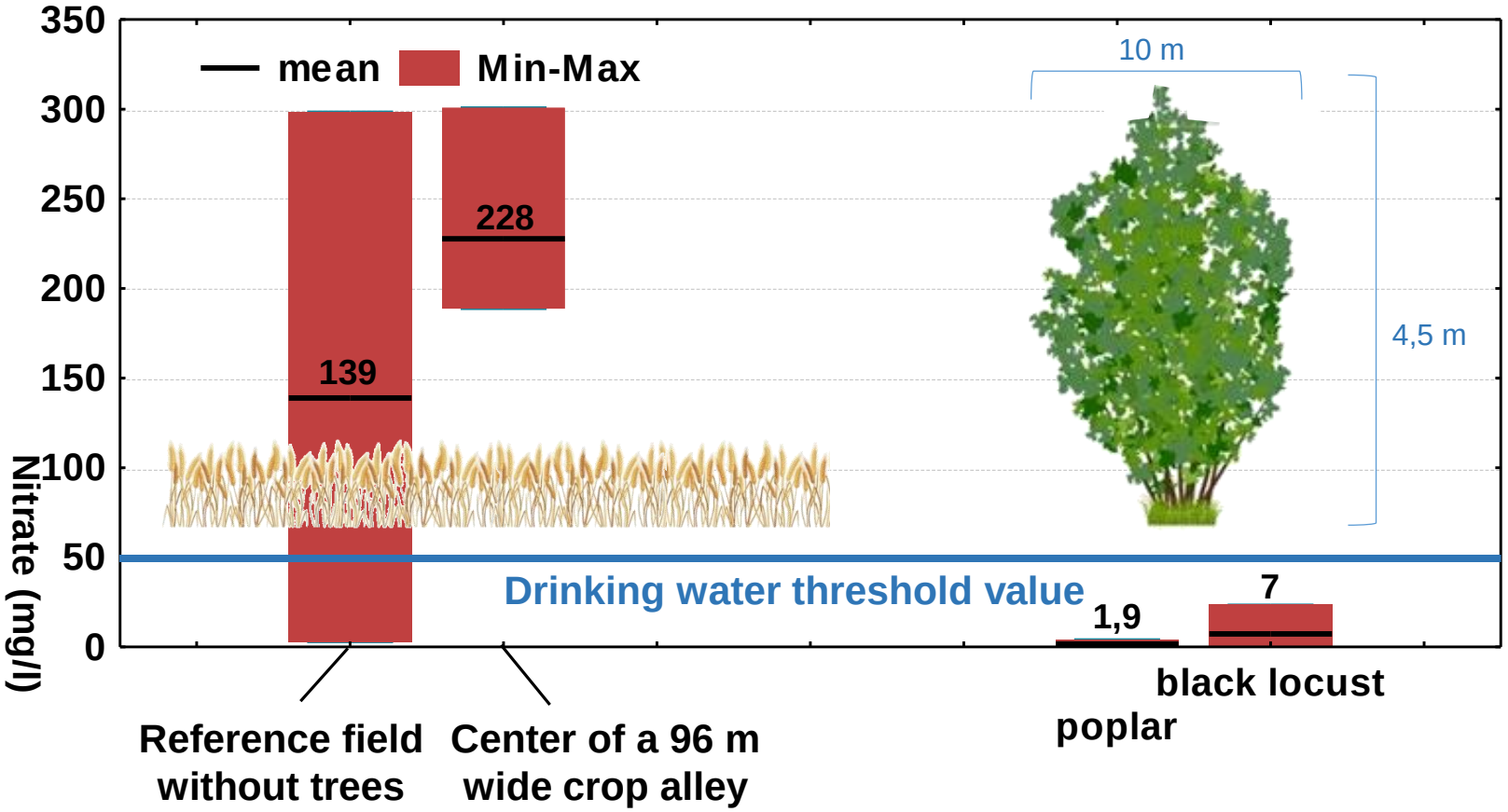
* Related to study site

Seapage and ground water monitoring

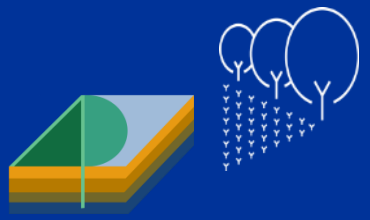
- Groundwaterl evel measurment
- Suction cup for seapage water

Agroforestry and Ground Water Quality

Mean values of **NO_3- concentration** in groundwater in Forst/L. from January to September 2014



Conclusions Wind and Ground- and Surface Water Quality



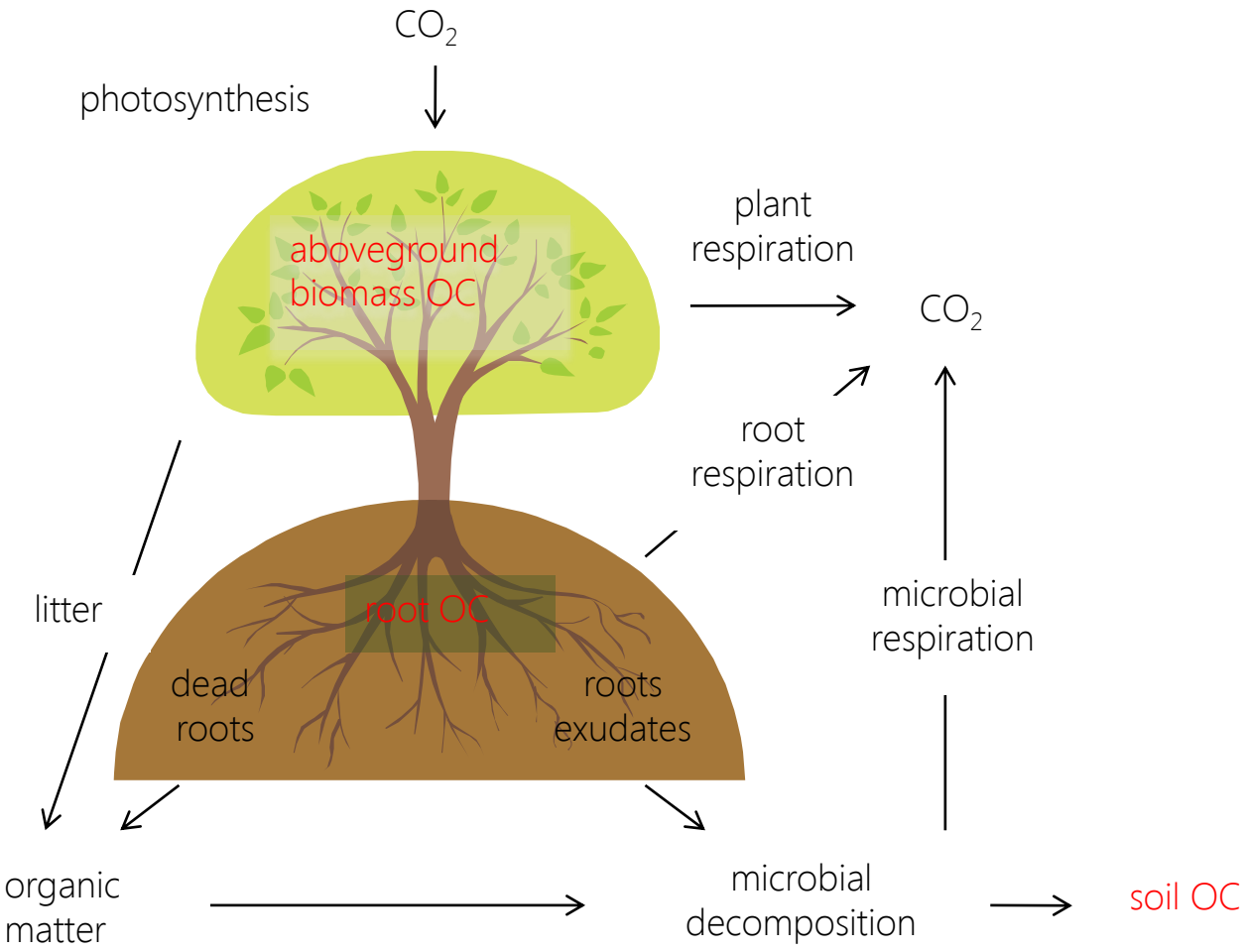
Wind
- Significant decrease of wind speed
- Optimum width of crop alleys under actual tree management = 70 m
- Decrease of evapotranspiration leading to higher available water
- Positive impact on crop yield expected

Water
- NO_3^- concentration in groundwater (0.8 – 2m level) is much lower under tree strips compared to crop alleys.
- P is not affected (not shown)

But: leaching rate and groundwater movement has to be quantified

Agroforestry and Carbon Sequestration

Organic carbon cycle

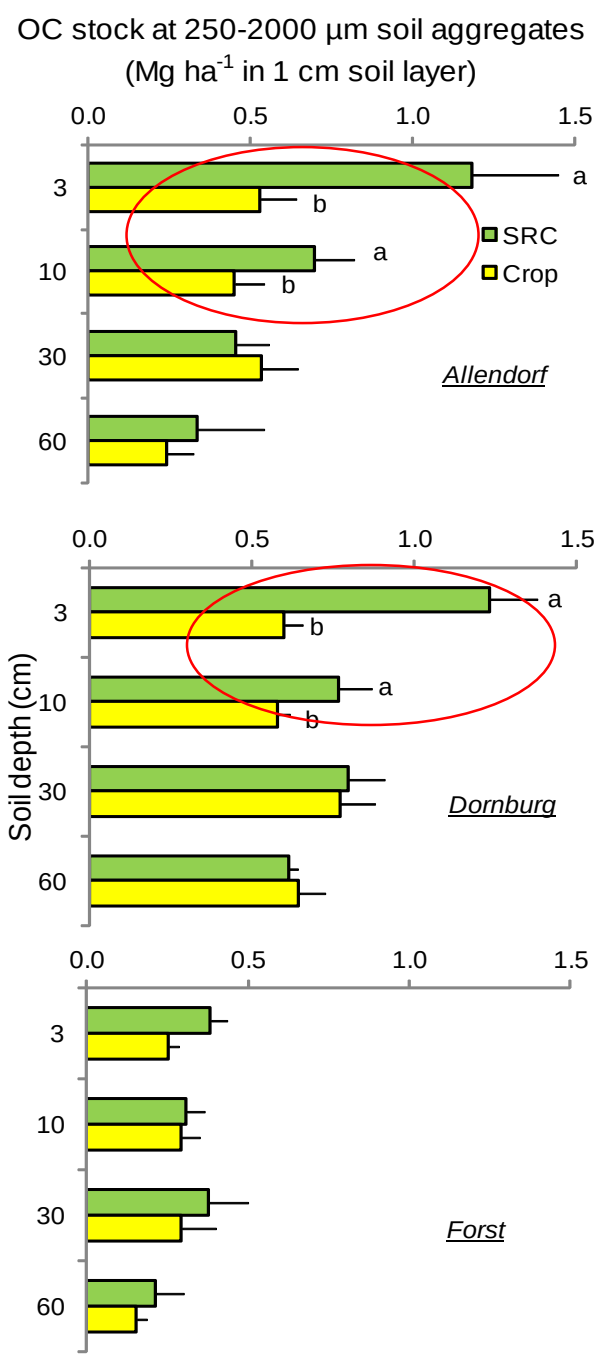


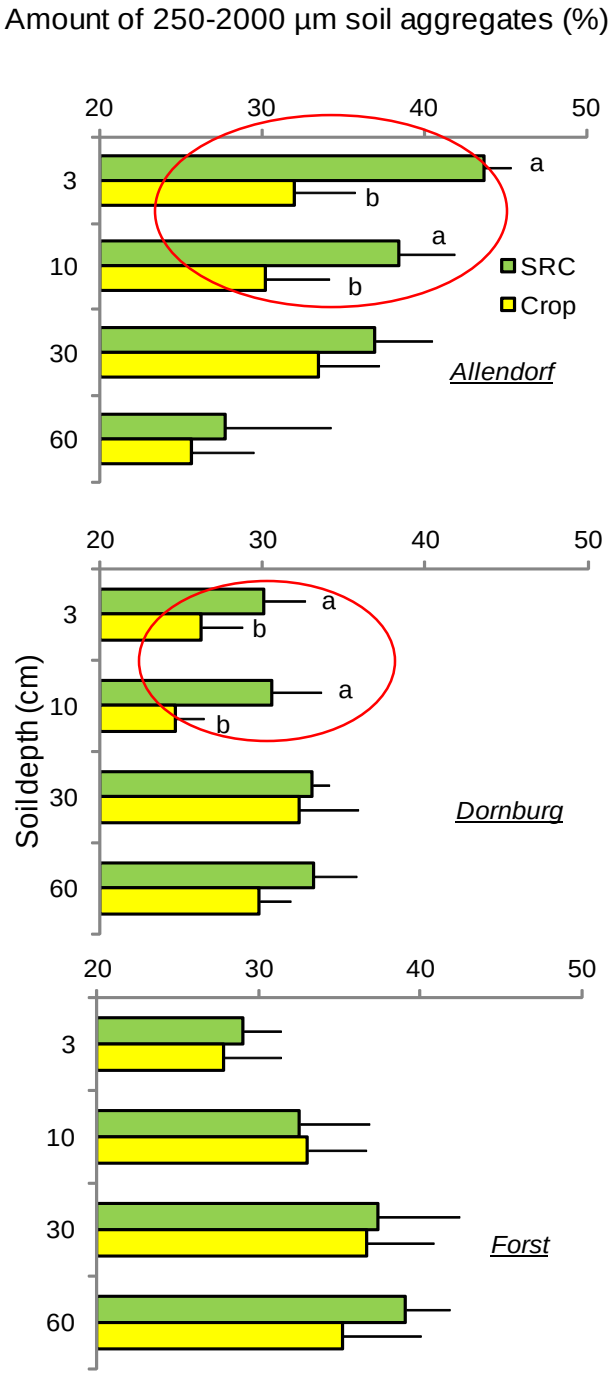
Carbon stocks and soil aggregates

Accumulation of labile C fractions in the topsoil

Macro-aggregate formation

OC inclusion within soil aggregates, which may preserve it from decomposition and enhance C sequestration

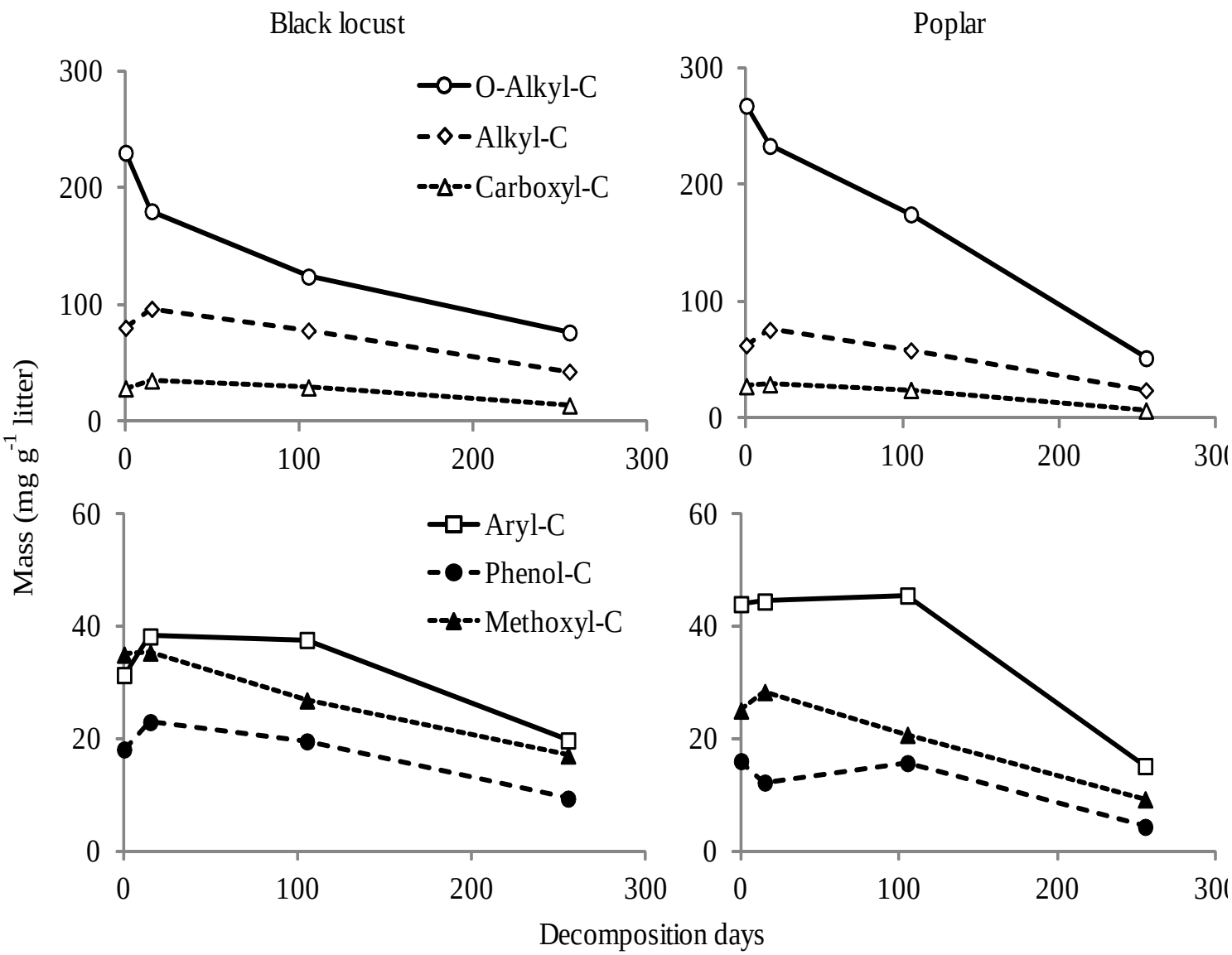




Changes in carbon functional groups during litter decomposition

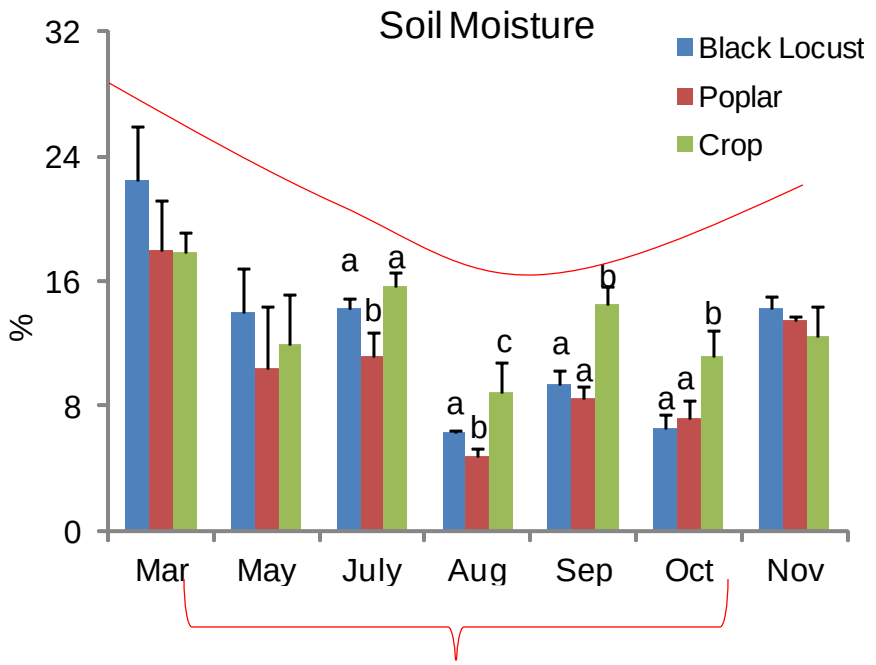
Poplar and black locust litter showed some differences in chemical composition and decomposition rates

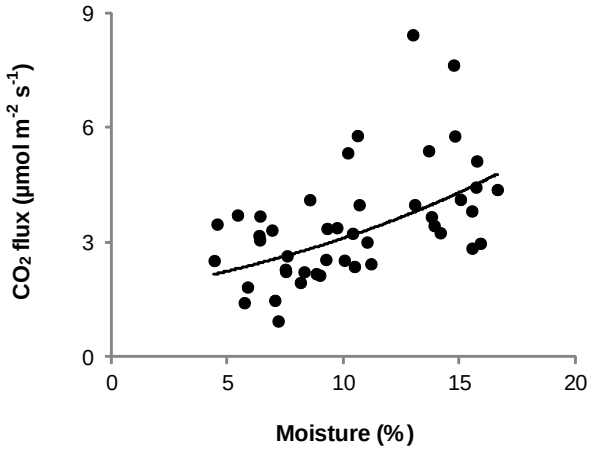
More of easily decomposable carbohydrates (O-Alkyl-C) in poplar litter: but decomposition restricted by low N content and high C:N ratio



Relationships between soil moisture and CO_2 flux

When the conditions are not restricted by low temperature or low photosynthetic activity, moisture may enhance soil respiration





$y = 1.61e^{0.0653x}$

$r = 0.55$ ($p < 0.01$)

Conclusions C-Sequestration

- Fast litter production and rapid decomposition in poplar and black locust hedgerows result in accumulation of labile OC fractions in the topsoil layer

- Greater macro-aggregates formation in tree hedgerows related to "zero tillage" may promote long-term OC storage, as C occluded within aggregates has lower exposure to microbial decomposition and longer residence time

- A greater C loss with soil respiration from trees hedgerows in summer may be compensated by a greater C assimilation and storage in woody biomass, and lower respiration in autumn compared to the tilled crop strips

Outlook

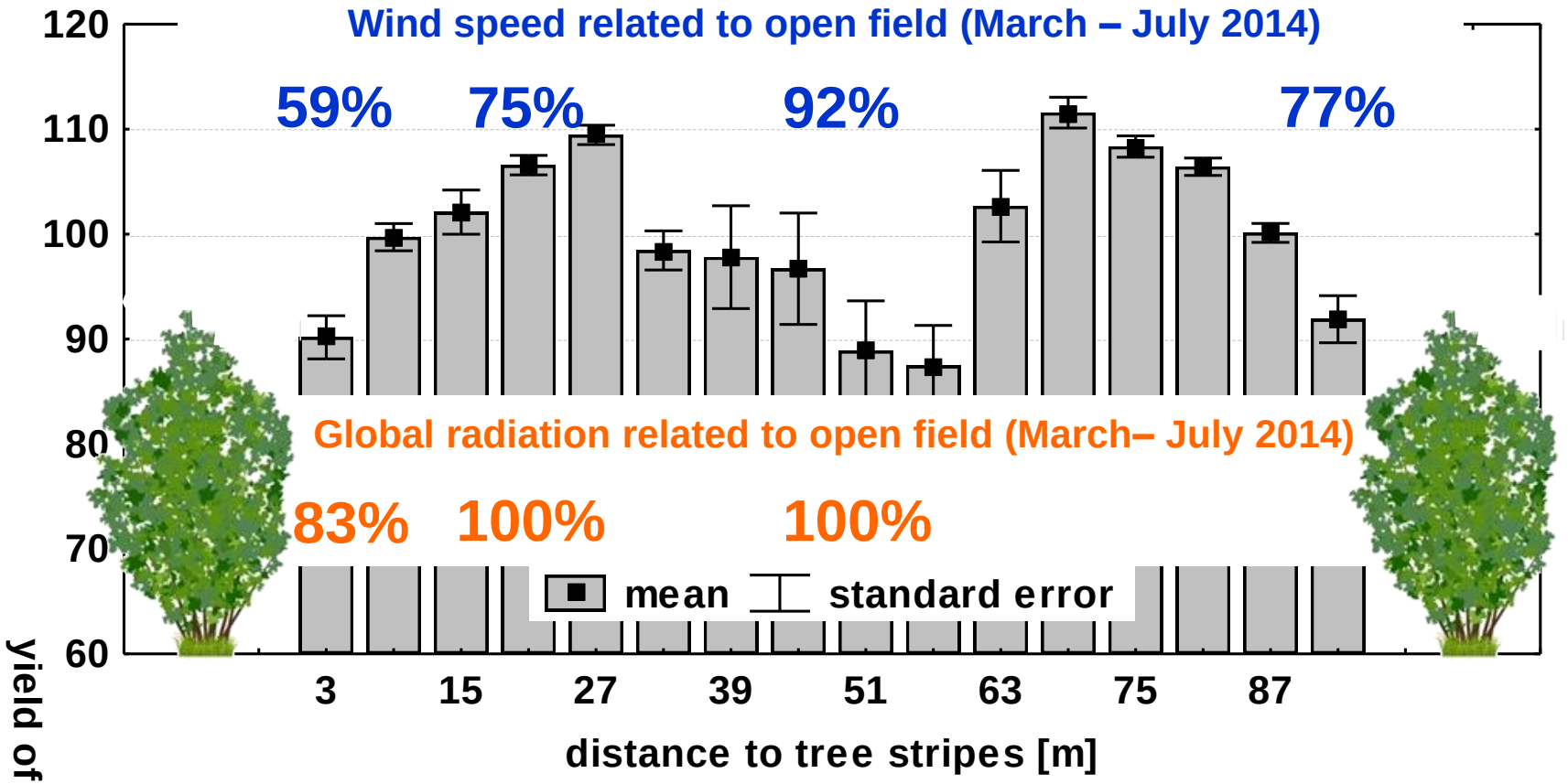
Pathway and accumulation of litter-originated C compounds in soils (experiment under controlled conditions, evaluation of long-term changes in labile C fractions, microbial respiration, leaching, accumulation of stable C fractions)

Agroforestry and Yield Comparison

Accurate harvest (220 plots) of wheat in 2014, Forst/L.

Agroforestry and Yield Comparison Wheat

Mean values of wheat yield on 96 m- crop alley [n = 8] in 2014, Forst/L.



Agroforestry and Yield Comparison Model YieldSafe and Parameter

Daily Climate:

– Radiation [W/m^2];
– Temperature [°C];
– Precipitation [mm].

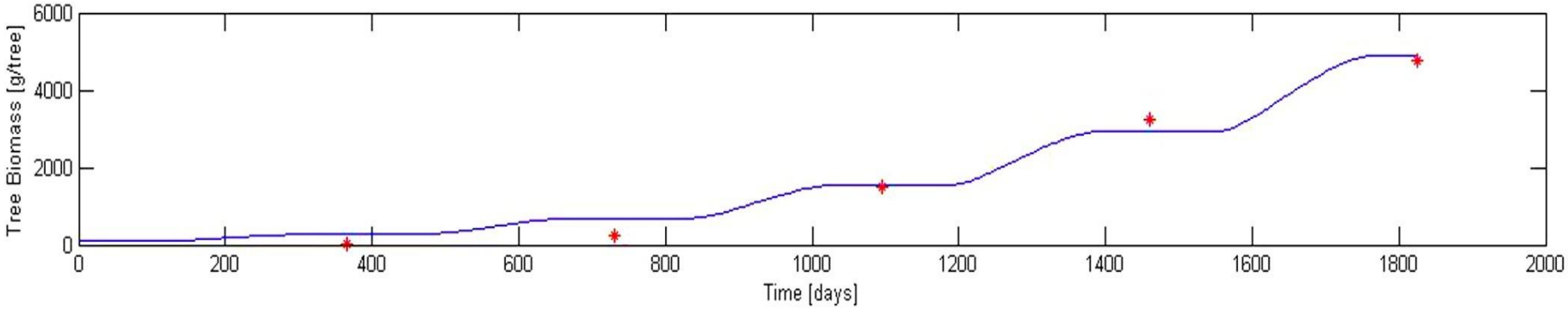
Biophysical Initialization:

– Initial Biomass;
– Initial Leaf Area;
– Initial Soil Water Content;
– Soil Texture

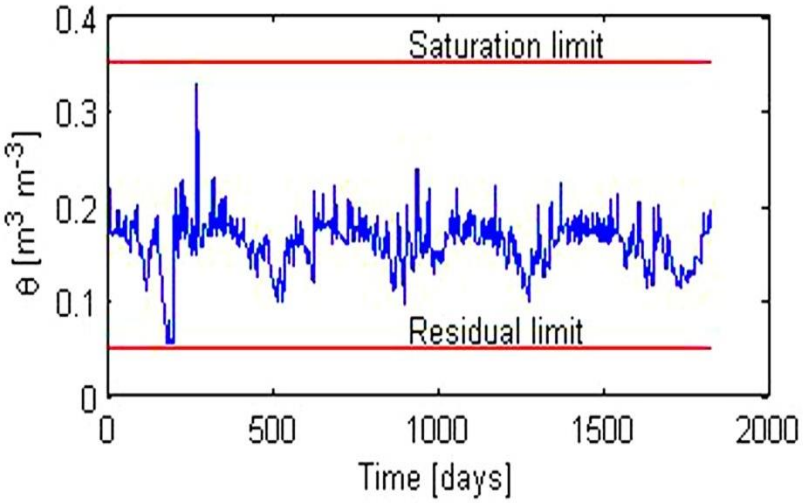
Agricultural Management

Agroforestry and Yield Comparison
Tree biomass

Tree biomass modeling by YIELDSAFE – Harvest in 2014/15 in Forst/L.



Soil water availability

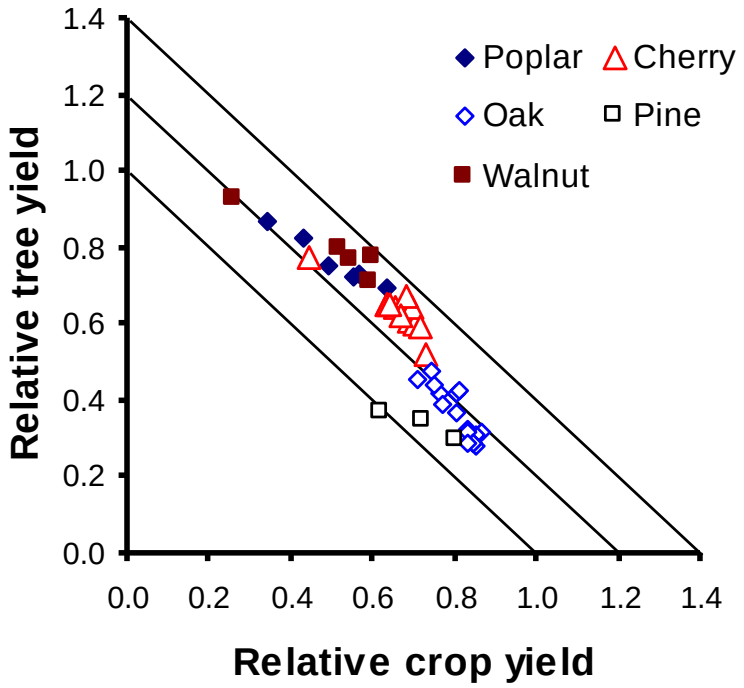


- Yield of trees (woody biomass) with 10 t DM/ ha*year
- Yield of trees does not compete economically with wheat

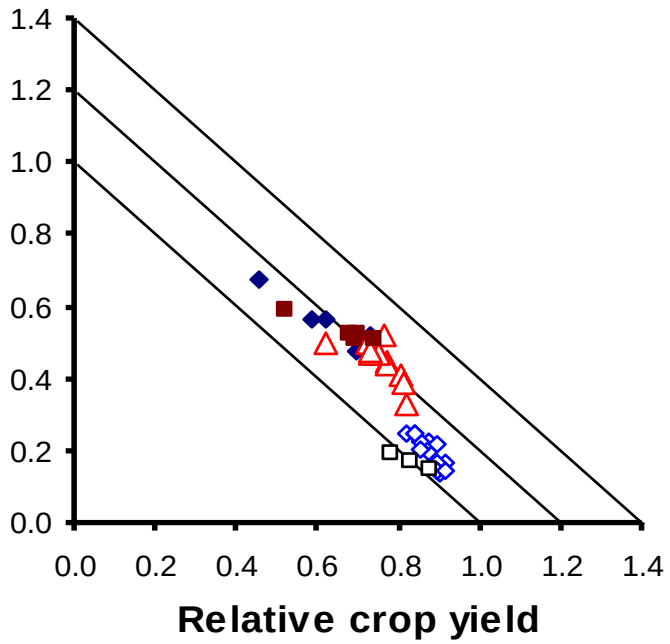
Yield comparison and Land Equivalent Ratio (LER)

- Biophysical results from YieldSAFE suggested that AF systems could be more productive then growing trees and crops separately (LER>1)
- Systems at 113 trees per ha provided greater LERs than for the 50 trees per hectare system

a) 113 trees per hectare



b) 50 trees per hectare



Graves et al. 2007 Ecological Engineering 434-449

Conclusions Yield Comparison

- YieldSAFE model predict the tree woody biomass on field scale
- Climate, soil and tree parameters easy to handle
- But, nutrient availability (N,P) has to be involved for crop modelling
- Biophysical results from YieldSAFE suggested that AF systems could be more productive then growing trees and crops separately (LER>1)

Agroforestry in CAP in EU

- **EURAF (European Agroforestry Federation)** accomplished introduction of incentives for agroforestry establishment in CAP.

- 1st Pillar:
- Restrictive definition agroforestry; only tree alignments considered
- Groves, hedges, riparian vegetation, silvopastoral systems and grazed orchards left out.
- Max 50 trees/ha set by Member States

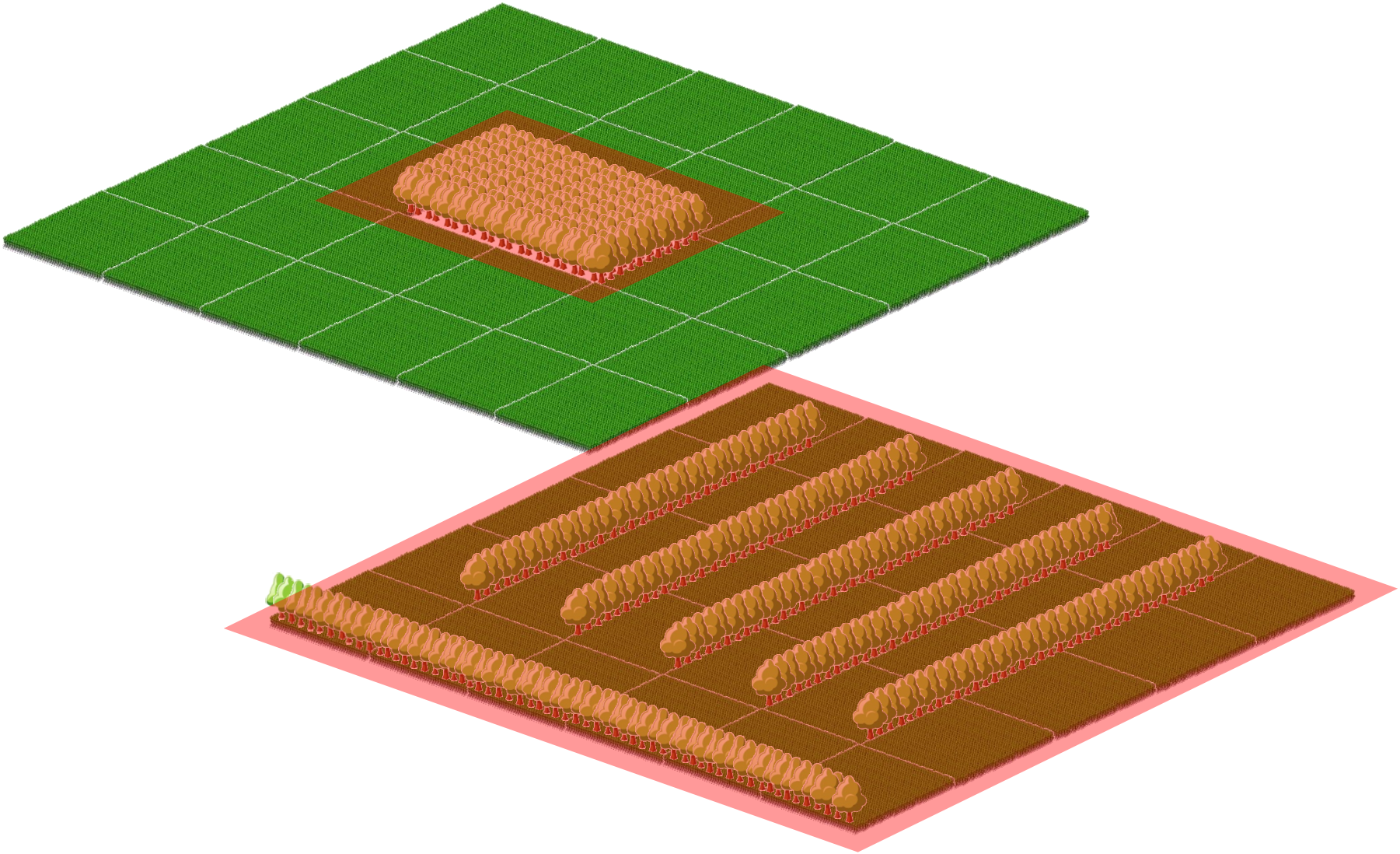
- 2nd Pillar:
- Measure 222 doesn't recognize the diversity of agroforestry, only for establishment new systems

EURAF – Lobby in Brussel

	EURAF Request	New CAP 2014-2020
Pillar 1	• Inclusion AF in Ecological Focus Area • Increase trees per ha (up to 250)	• AF listed in Ecological Focus Area • Other measures such as landscape features (hedges, lines of trees, isolated trees etc.), buffer strips and short rotation coppice. • Increase trees per ha up to 100
Pillar 2	• Inclusion definition of agroforestry • Extension public support up to 5 years for establishment • Deletion link between agroforestry and extensive agriculture	• Inclusion definition of agroforestry (Regulation (EU) 1305/2013, Article 23) • Maintenance cost up to 5 years for establishment • All agricultural systems: organic, extensive, conventional

- Steps forward may remain unnoted if Member States do not seize these opportunities offered by the EU legislator!
- Lobbying at European and *national* level required!

Agroforestry in CAP – Cause low uptake



Agroforestry in CAP – Cause low uptake

Improve Greening measurements in Germany

Presumption: total area of arable land = 100ha

- Short rotation coppice plantation
- 15 ha X 0.3 (Weighting factor) = 4.5 ha
- 4.5 ha of 100ha = 4.5 %

Resulting in:

4.5 % of 100ha

approved Greening

- Agroforestry system
- 5 % tree density on 100ha = 5 ha
- Weighting factor 1 (in CAP)
- but complex approach by Agroforestry

Resulting in:

100% wanted Greening

Conclusion

- From a biophysical perspective, silvoarable systems provided a means of increasing crop and tree output in comparison with growing trees and crops on separate land.
- From a purely financial perspective, silvoarable systems can be more profitable than the status quo arable systems in many cases. Best results appear to be achieved with high value trees or short rotation trees.
- However, trees provide a range of ecosystem services and can reduce the externalities of production.
- These "non-market benefits" can be of great value to society. The value of these is being investigated on the AGFORWARD project.

Thank you for your attention!

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