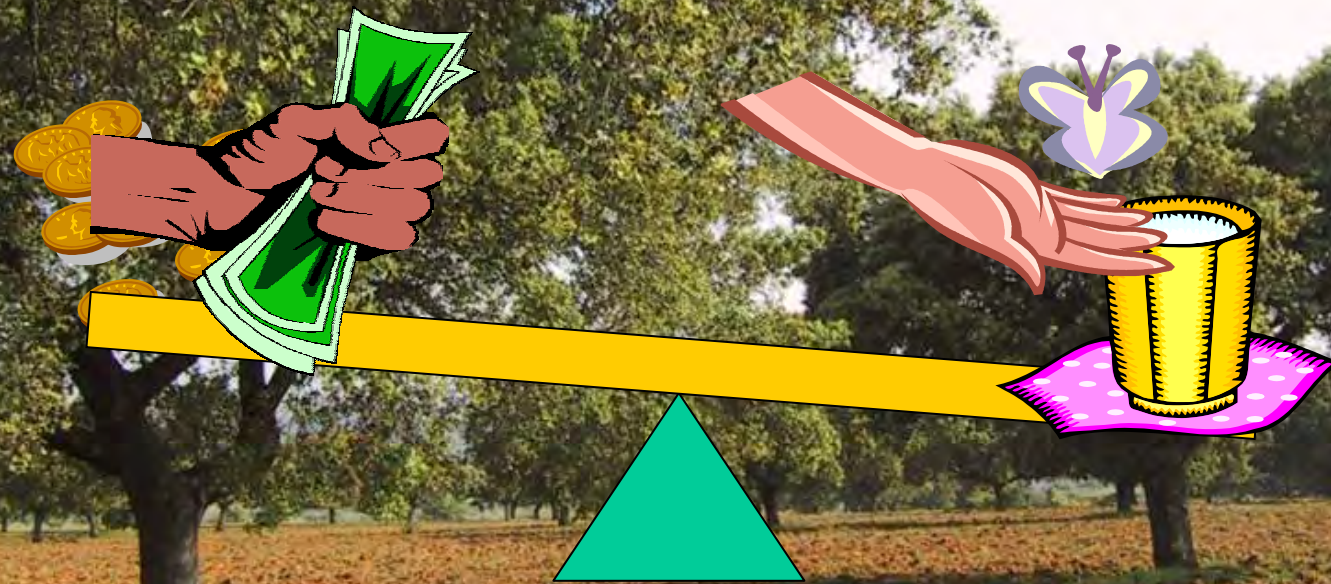


Trees in European crop fields: determining the trade-offs in profitability and ecosystem regulation



Presentation made by Paul Burgess, Cranfield University
at Farm Woodland Forum meeting,
Gregynog Conference Centre, 29 June 2005

The background of the slide is a photograph of a rural landscape. In the foreground, there is a field of dry, brownish vegetation, possibly a field of wildflowers or a recently harvested crop. In the middle ground, there is a line of trees with green foliage. The sky is visible in the background, showing a mix of blue and white clouds. The overall scene is a typical European agricultural landscape.

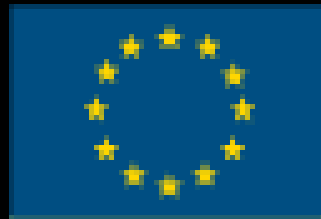
Trees in European crop fields: determining the trade-offs in profitability and ecosystem regulation

Paul Burgess¹, Anil Graves¹, João Palma²,
Felix Herzog², Yvonne Reisner², Gerardo Moreno³,
Mercedes Bertomeu³, Christian Dupraz⁴, Fabien Liagre⁵,
Herman van Keulen⁶, L.D. Incoll⁷, David Pilbeam⁷,
and Terry Thomas⁸

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³Extremadura University, Spain, ⁴INRA, Montpellier, France;
⁵APCA, Paris, France; ⁶Wageningen University, the Netherlands,
⁷ University of Leeds, UK; ⁸BEAM (Wales) Ltd, Anglesey, Wales

Acknowledgements

This research was funded through the European Union 5th Framework through the contract QLK5-2001-00560 and the Swiss Federal Ministry of Science and Technology contract 00.0158.



Outline

1. Trees in fields
2. Method
3. Production
4. Profitability
5. Ecosystem regulation
6. Conclusions

There has been a loss of wooded landscapes over much of Europe...



Tanner (1993)

...trees have become segregated from
agriculture...

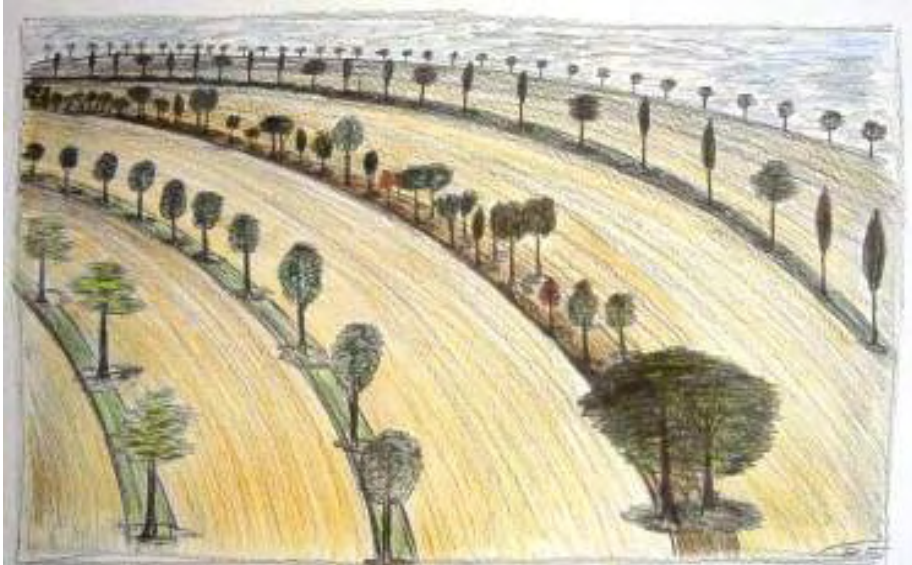


~60% decline of field trees
in England 1980-1998

.. but some farmers have maintained agroforestry systems ...



.. and others have established trees in fields recently



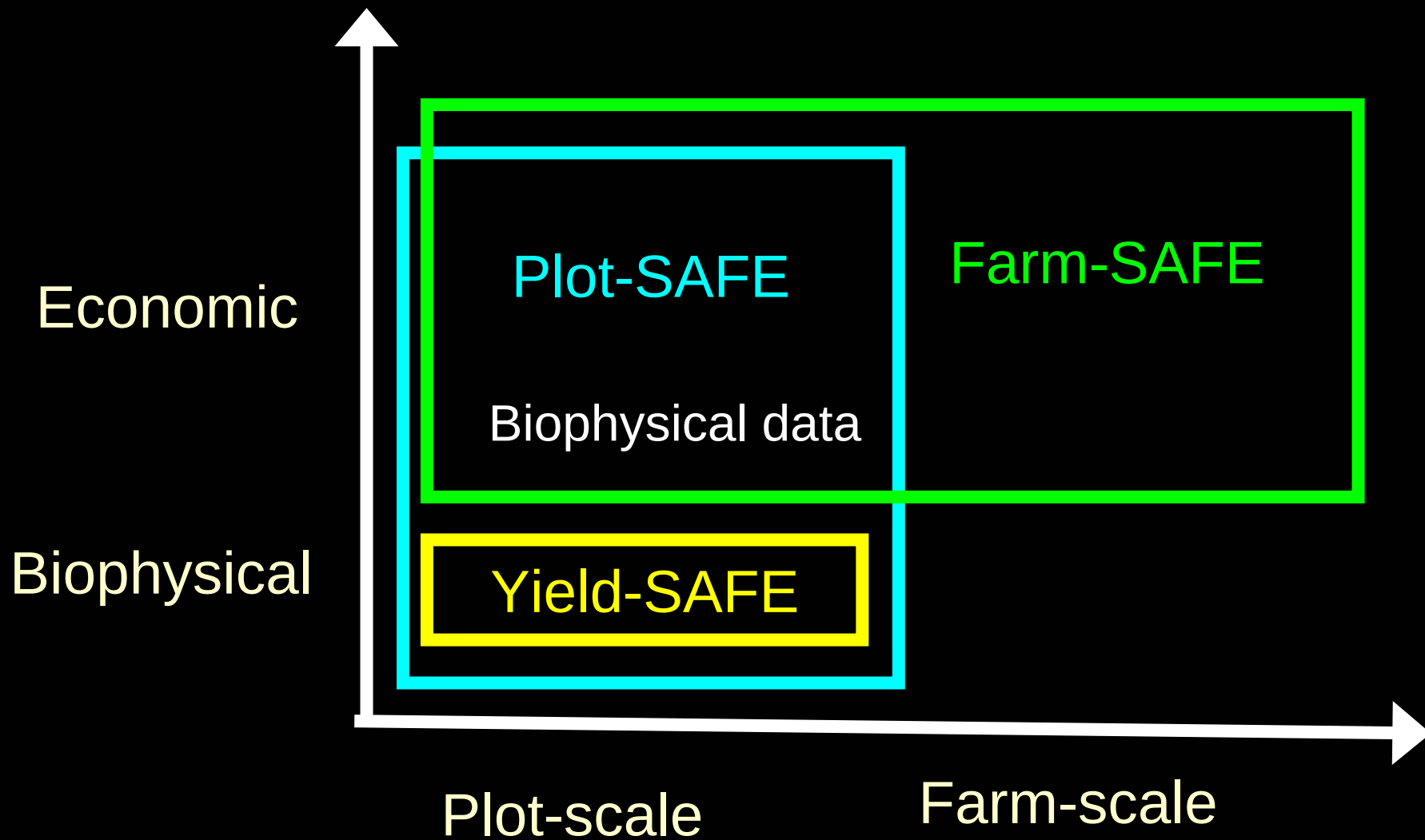
2. Method

A photograph of a vibrant green field, possibly a pasture or a young forest, with several trees of varying sizes scattered throughout. The sky is bright and slightly hazy. The text is overlaid on the left side of the image.

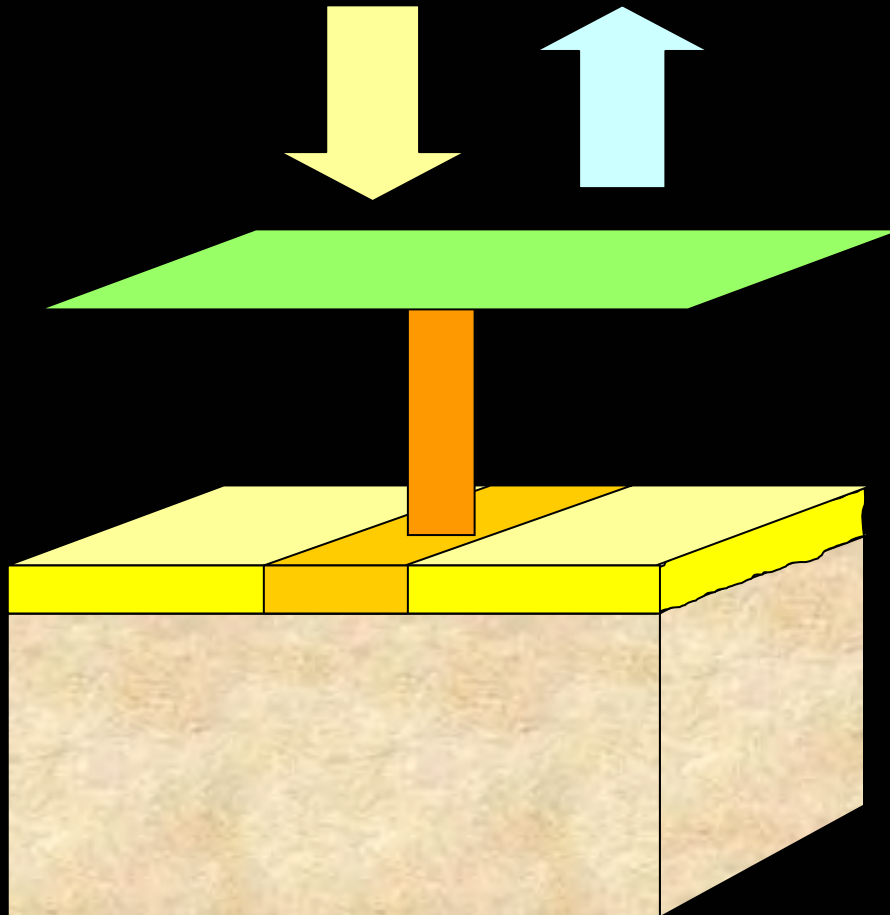
How to determine profitability and environmental effects?

- Difficulty in waiting 60 years
- Relative to arable cropping and forestry

Use of models to determine environmental and economic effects



Yield-SAFE: state variables



Tree	Biomass	B_t
	Leaf area	L_t
	Shoot number	N
Crop	Biomass	B_c
	Leaf area	L_c
	Thermal time	S
Soil	Water content	θ

Yield-SAFE structure

Crop-management
(i.e crop rotation, date of tree planting)

**Weather
data**

**Tree
parameters**

**Crop
parameters**

**Soil
parameters**

**Bio-physical
model (daily
time step)**

Tree yield

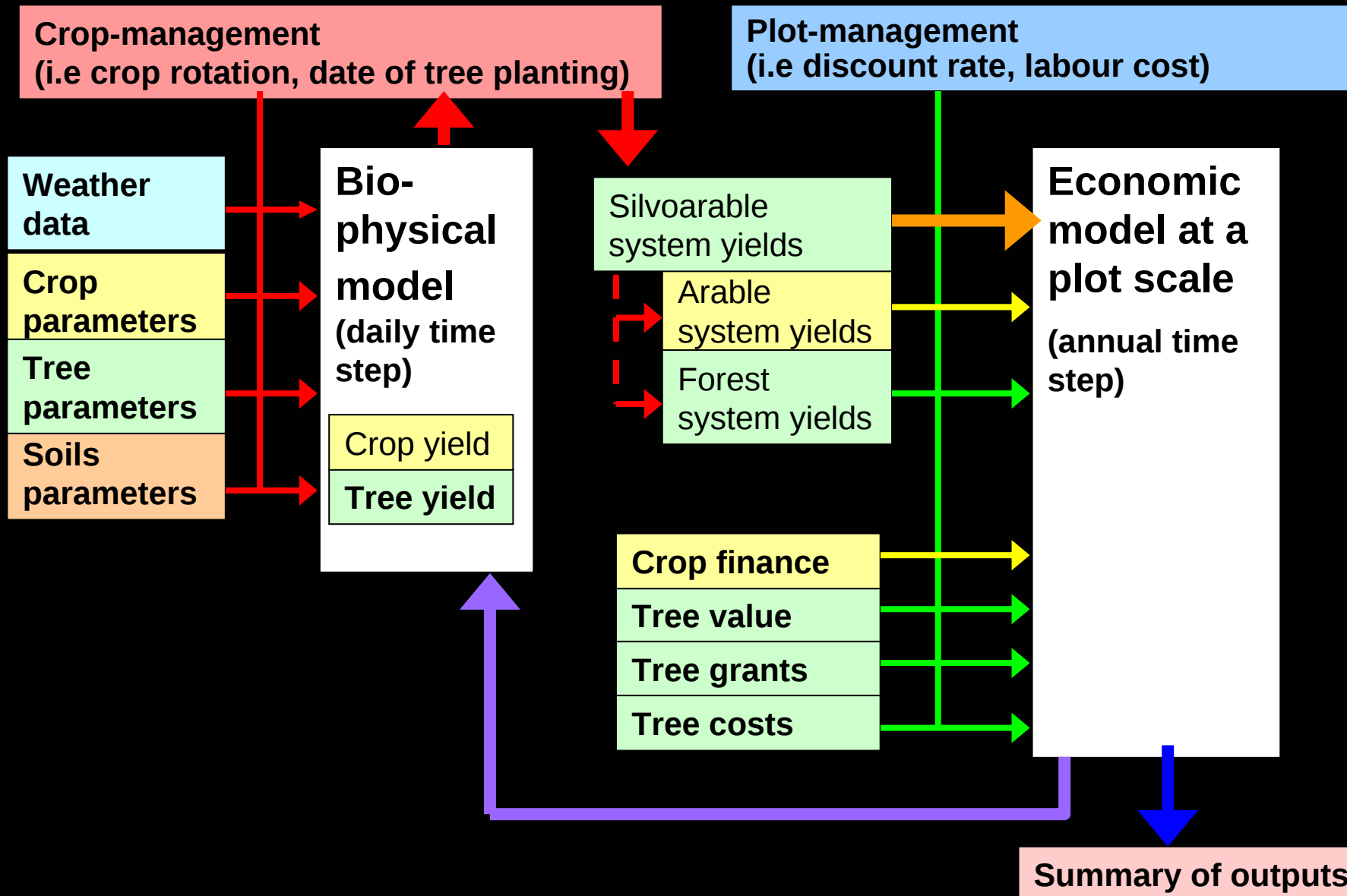
Crop yield

**Silvoarable system
yields**

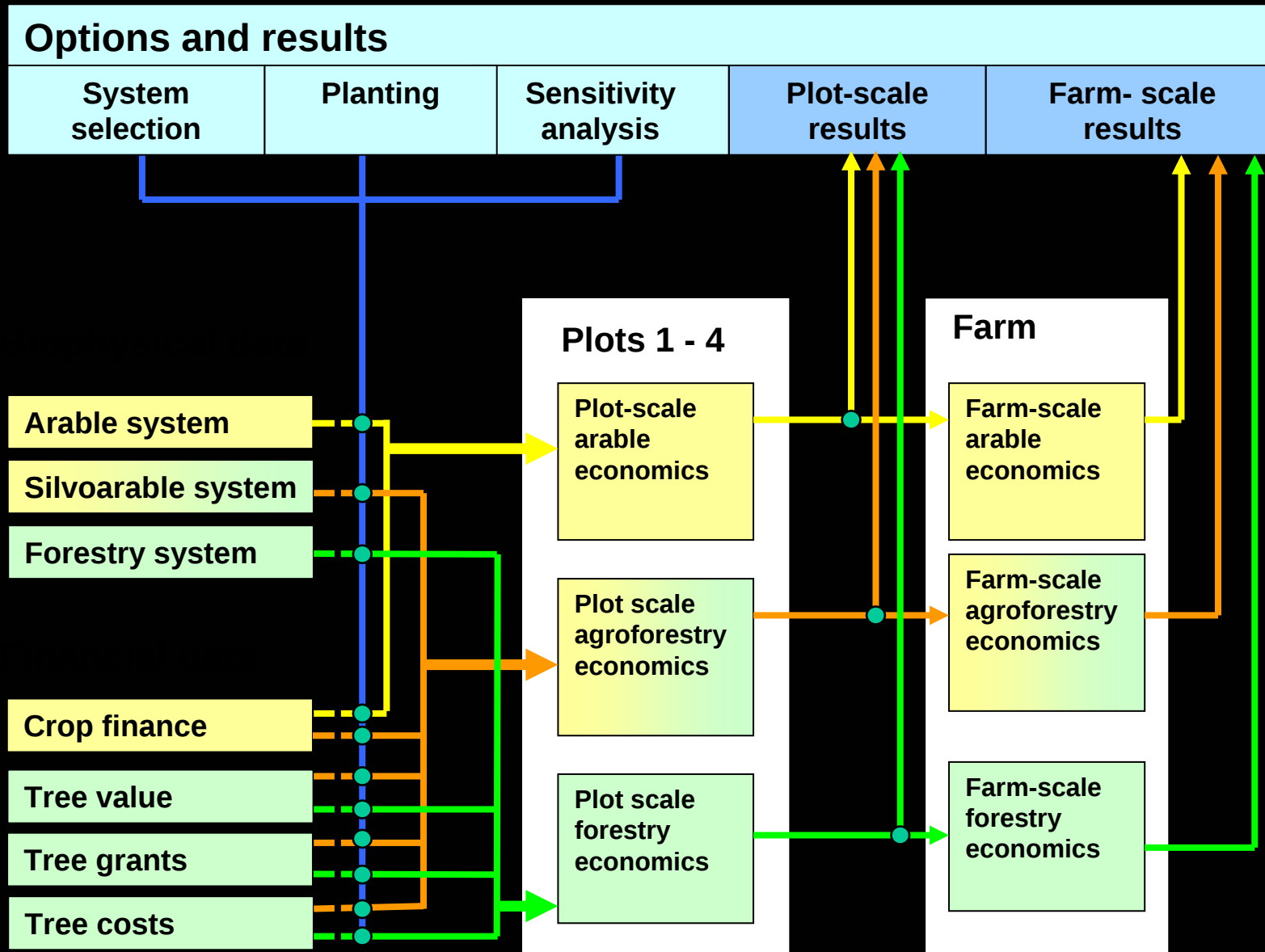
**Forest system
yields**

**Arable system
yields**

Plot-SAFE: structure



Farm-SAFE: structure



Description and software

[illegible]

Microsoft Excel - Copy of Plot-SAFEv03_1 for network sites and LTS 11 Jan 05 LER_Ecol

File Edit View Insert Format Tools Data Window Help Adobe PDF

Type a question for help

E7 -2

Worksheet D: Biophysical calculations

D1-D2 Date and climate

D3 Tree

Import Weather

M:\WE_Projects\EU\EU SAFE\Anils thesis\Ch 5 c

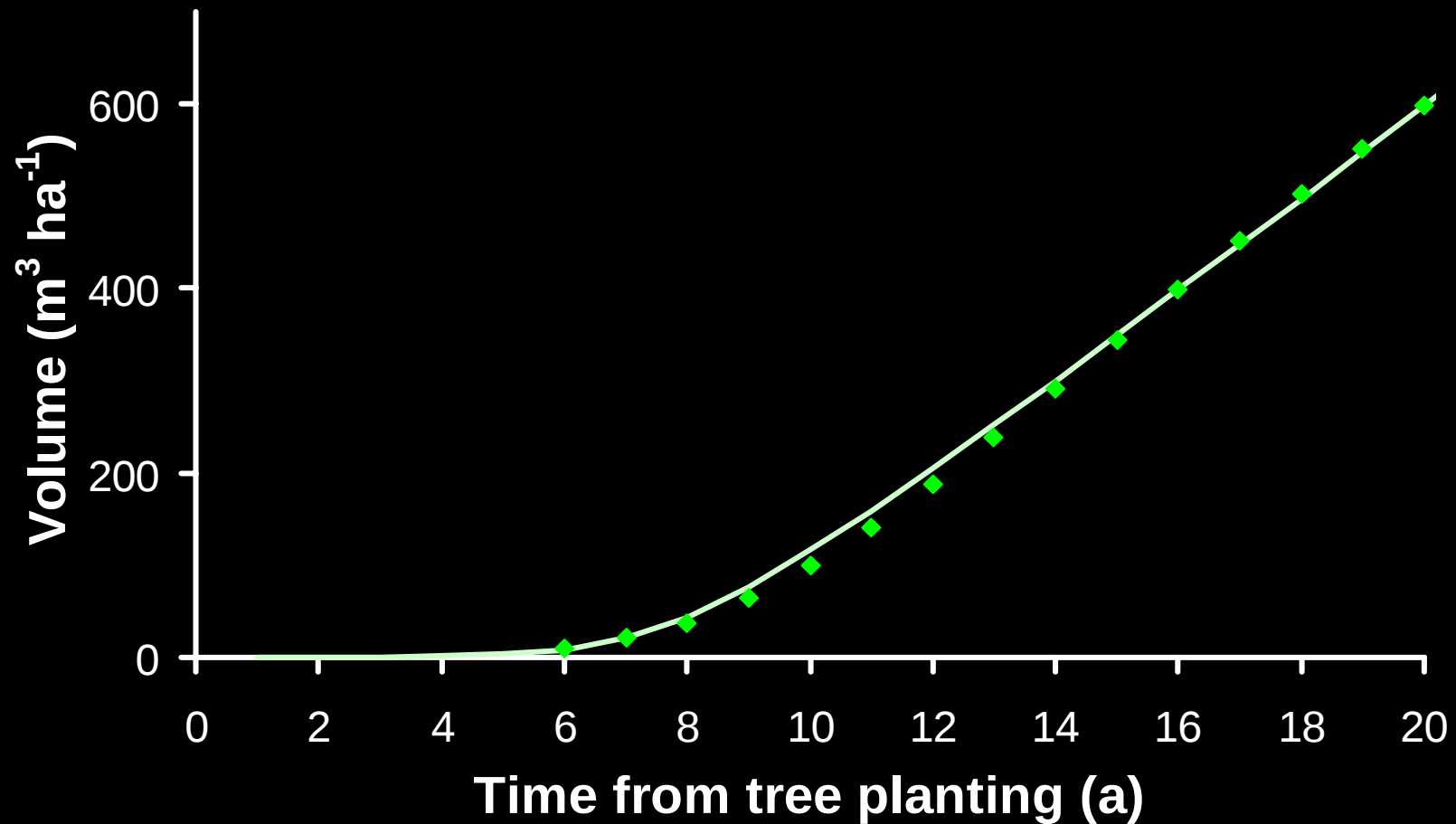
(°C) (MJ m⁻²) (mm)

(tree m⁻²) (m²) (m²tree⁻¹) (m²m⁻²) (m²) (g tree⁻¹)

	Temp	Rad	Precipitation	Tree density	Trees present	Leaf development per shoot	Leaf area per tree	Leaf area index	Fraction light interception	Potential growth
1	-2.0	1.8								
2	9.8	1.8								
3	9.8	3.4	2.6	0.0156	1					
4	7.4	3.5	4.0	0.0156	1					
5	8.6	3.2		0.0156	1					
6	9.8	2.5		0.0156	1					
7	8.2	3.5	1.6	0.0156	1					
8	8.7	1.1	17.2	0.0156	1					

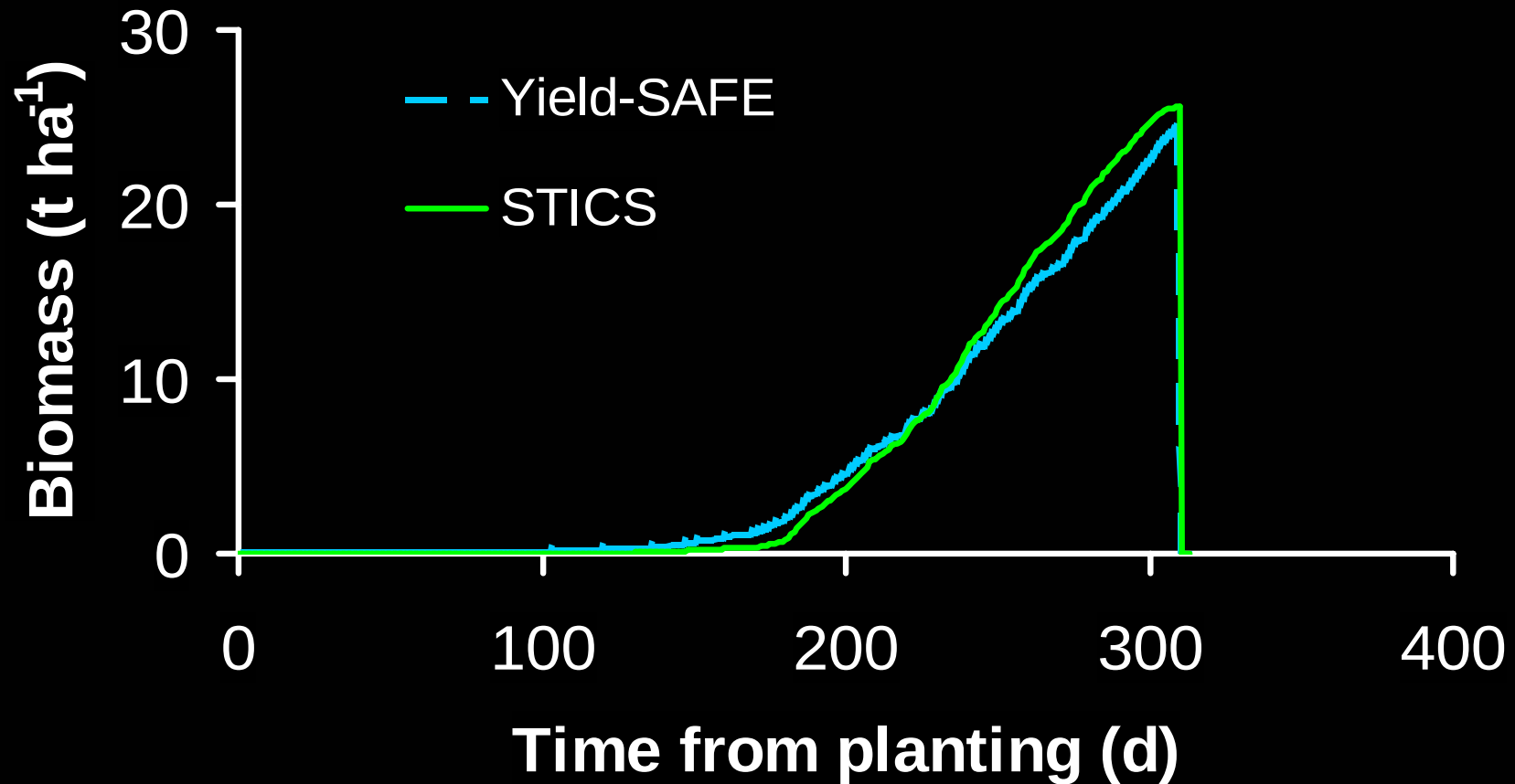
Sum=247549.7 NUM

Calibrated output: forestry growth



Potential poplar growth in the Atlantic region simulated with Yield-SAFE compared to data from yield tables

Calibrated output: wheat yield



Total wheat biomass predictions from Yield-SAFE calibrated to output from the comprehensive crop growth model STICS

Validation: UK Silvoarable Network

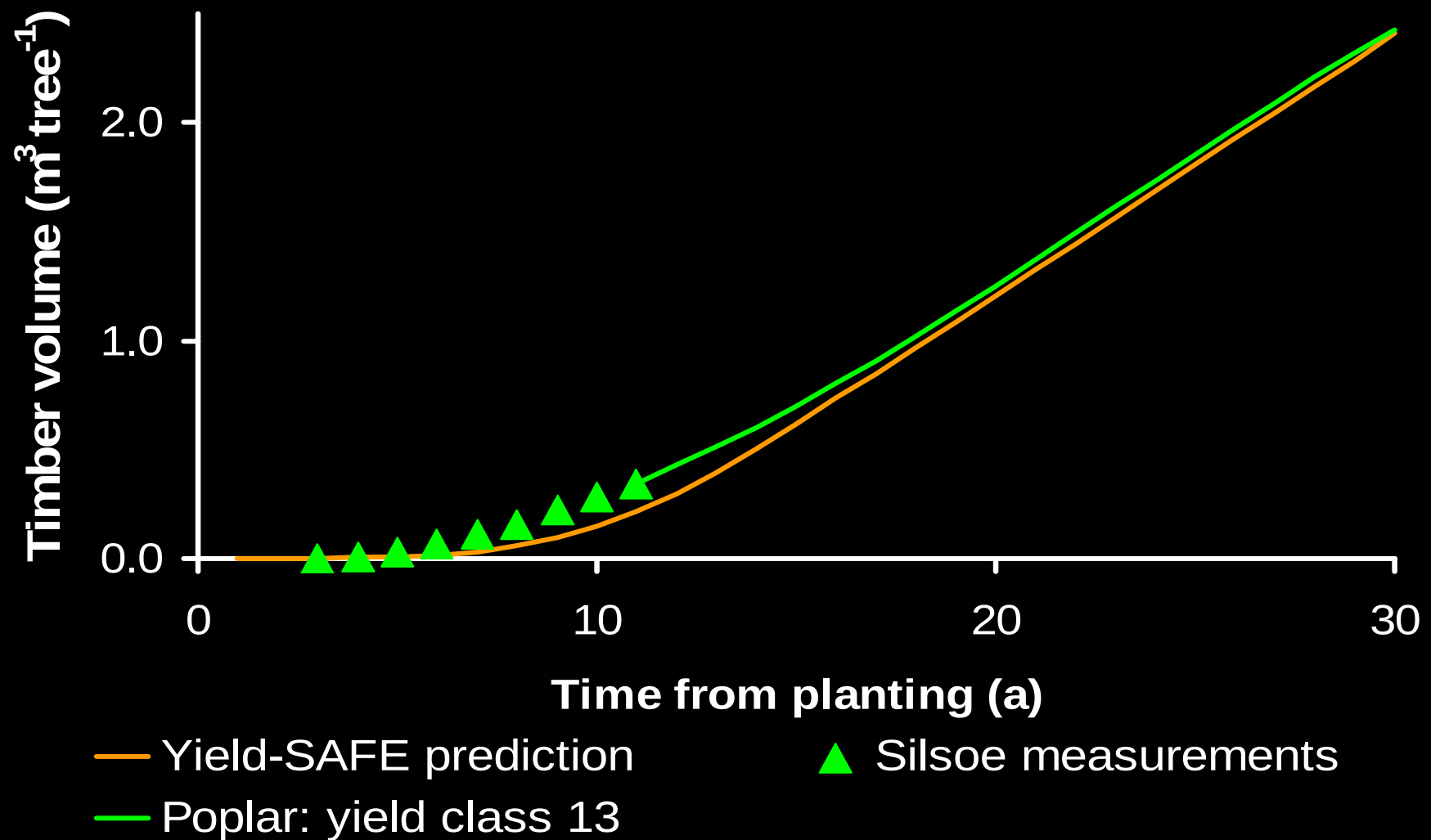


Site calibration for Silsoe

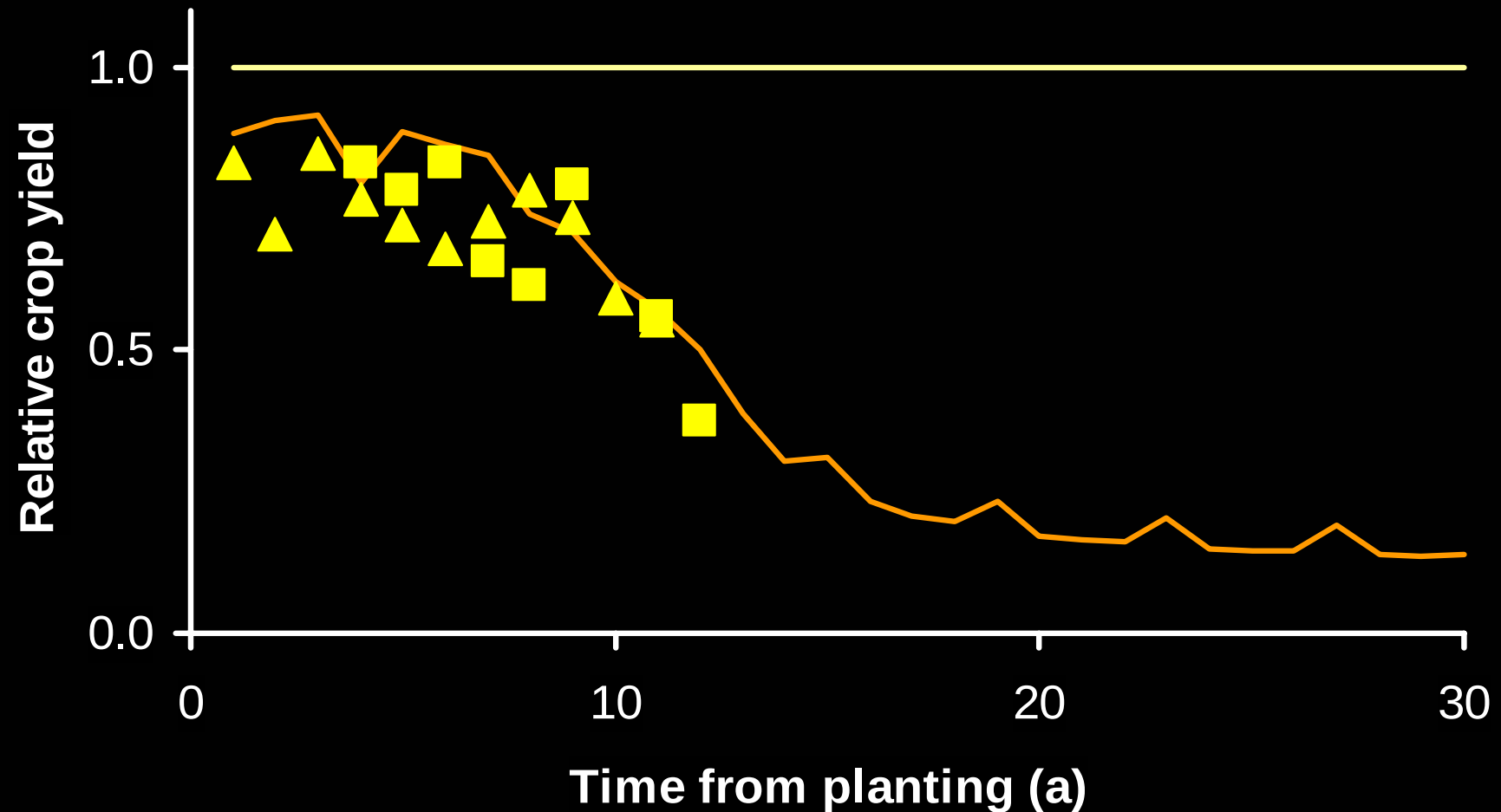
The model was calibrated for tree-only and crop-only reference yields by modifying the transpiration coefficient and the harvest index

	Poplar	Wheat
Timber yield ($\text{m}^3 \text{ tree}^{-1}$) (30 years)	2.4	-
Crop yield ($\text{t ha}^{-1} \text{ a}^{-1}$)	-	8.2
Transpiration coefficient ($\text{m}^3 \text{ kg}^{-1}$)	0.42	0.32
Harvest index (%)	49	51

Validation: timber volume per poplar tree at Silsoe



Validation: relative crop yield with poplar agroforestry in the UK



— Relative arable yield
■ Silsoe measurements

— Yield-SAFE prediction
▲ Leeds measurements

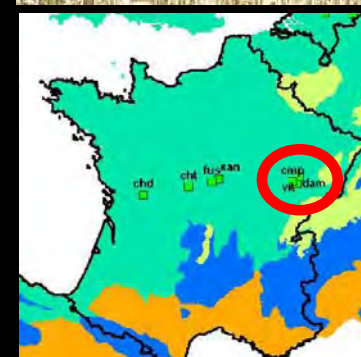
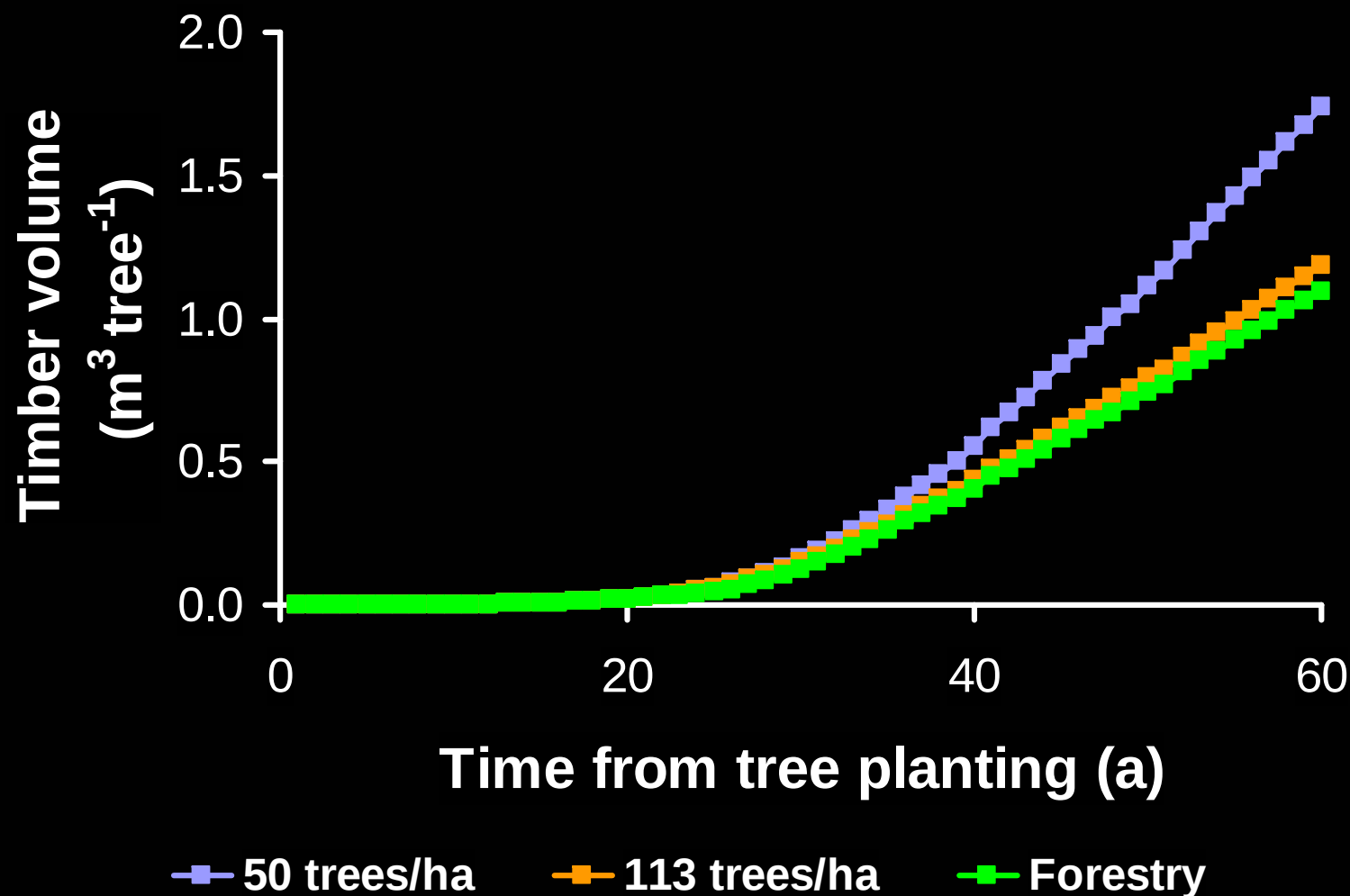
Conclusions: models

1. Validated daily-time-step biophysical model of the yields of arable, silvoarable and forestry systems over a tree rotation (up to 60 years)
2. Lack of data describing tree growth at low stand densities constrained model validation
3. Start simple

3. Production



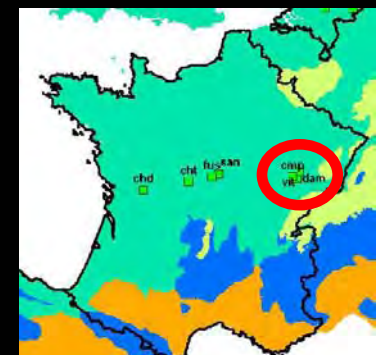
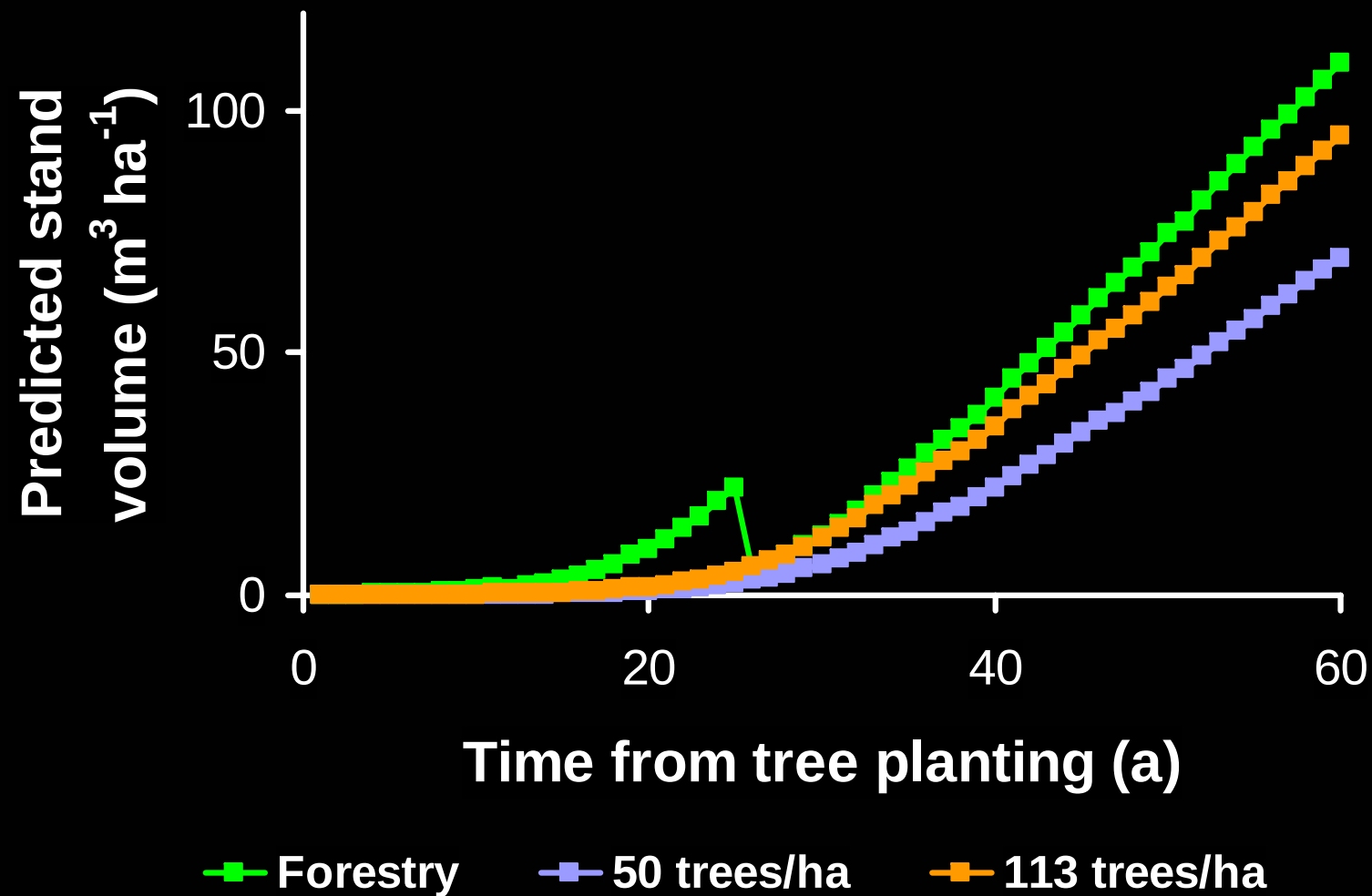
Predicted effect of tree stand density on timber production per tree



Champlitte



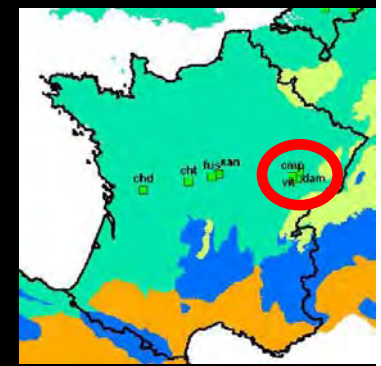
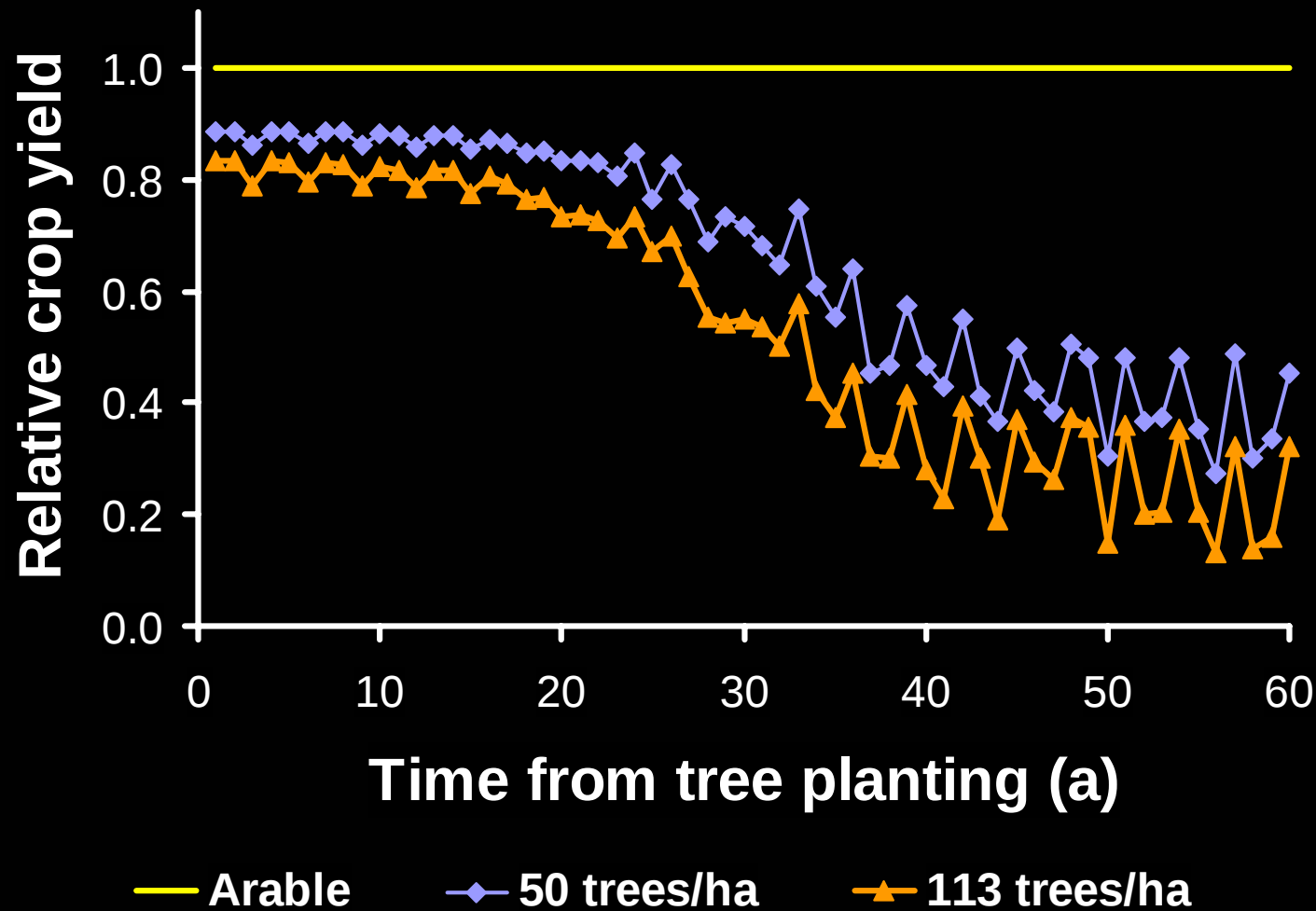
Predicted effect of tree stand density on timber production per hectare



Champlitte



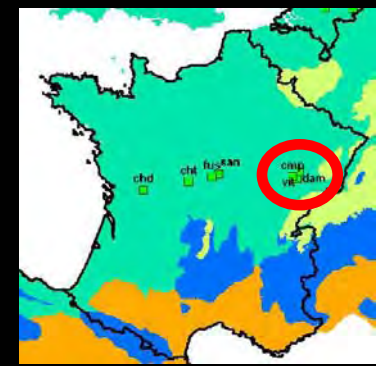
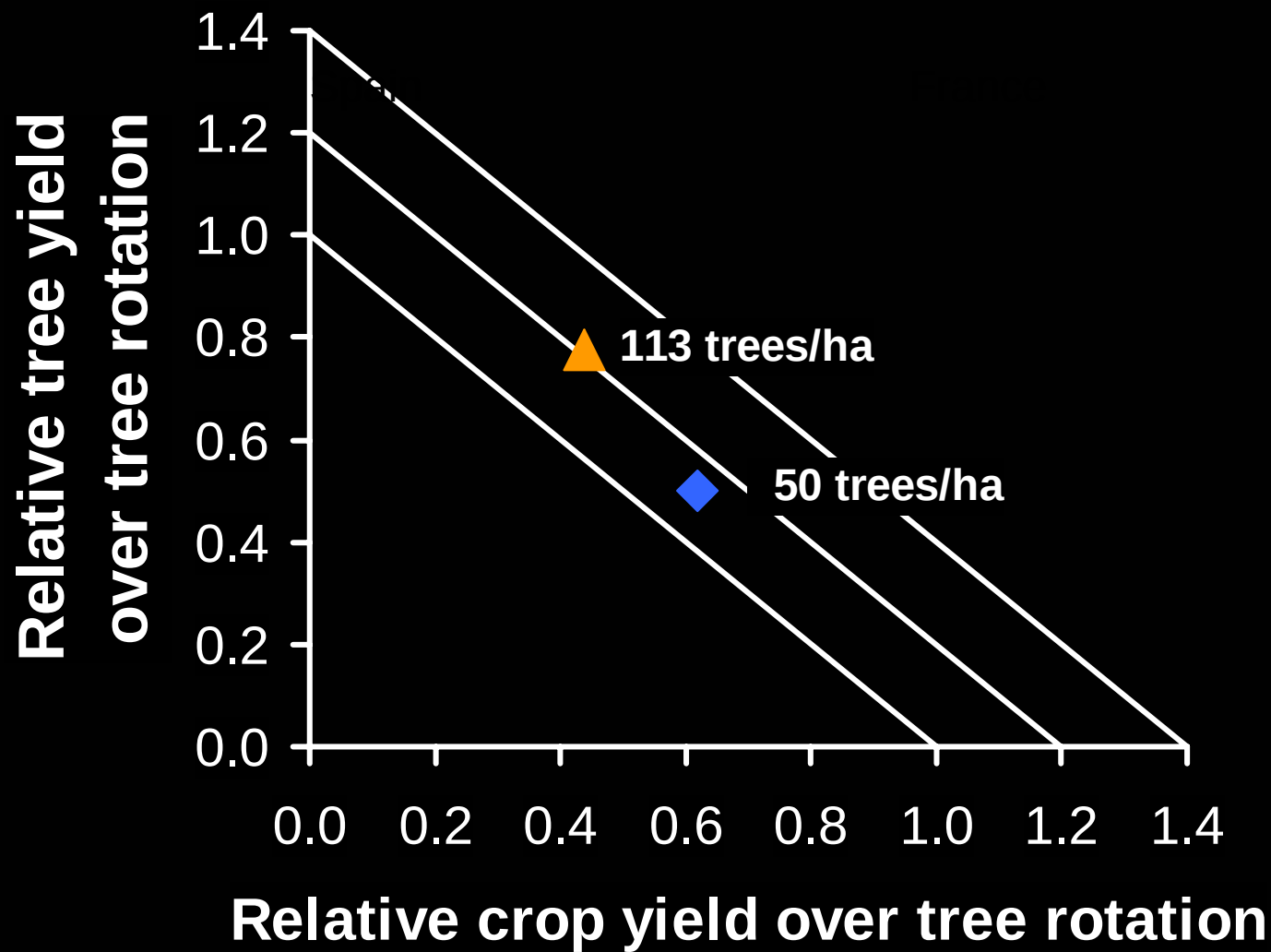
Predicted effect of tree stand density on relative yields of a wheat/wheat/oilseed rotation



Champlitte



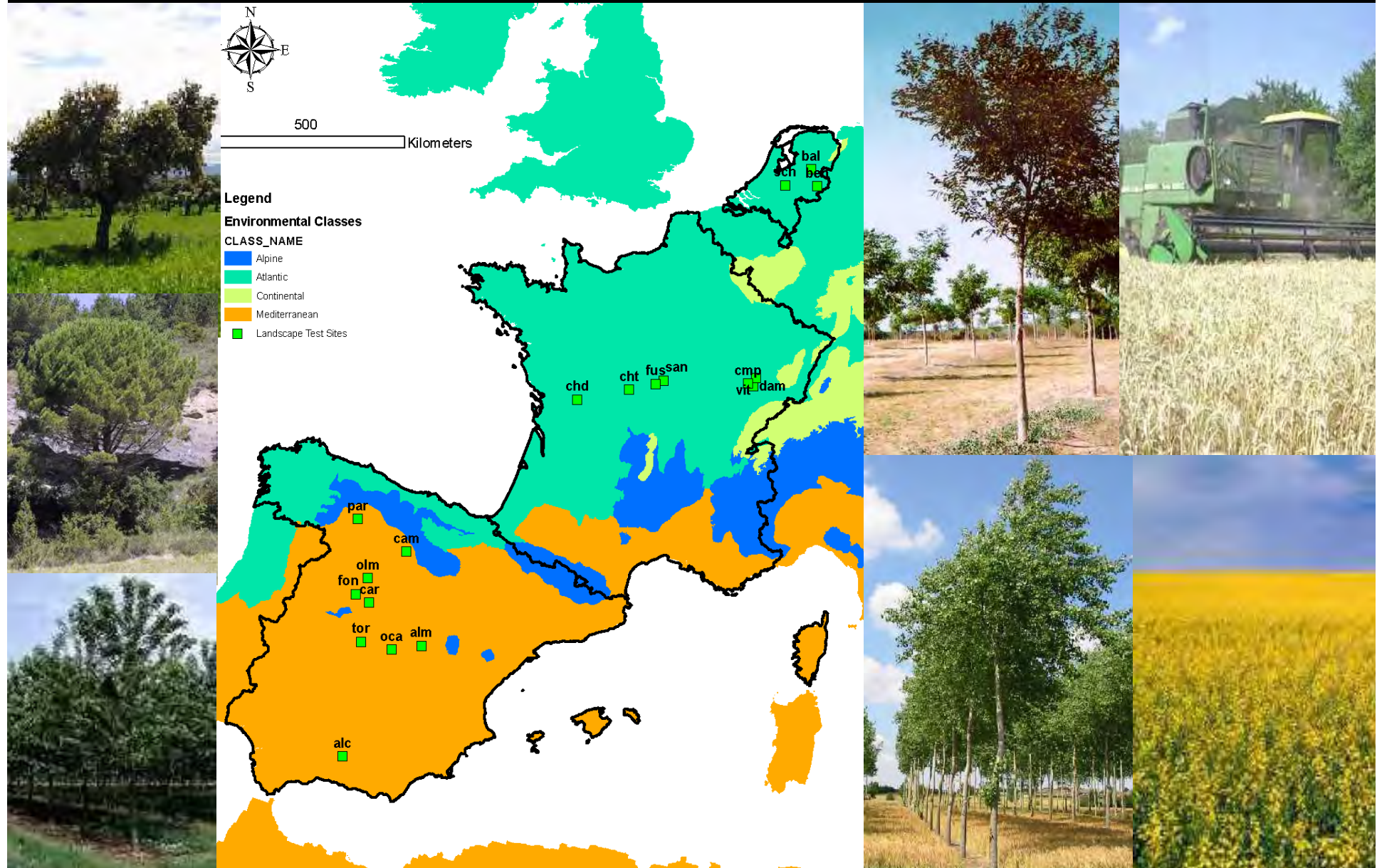
Effect of tree density on relative productivity



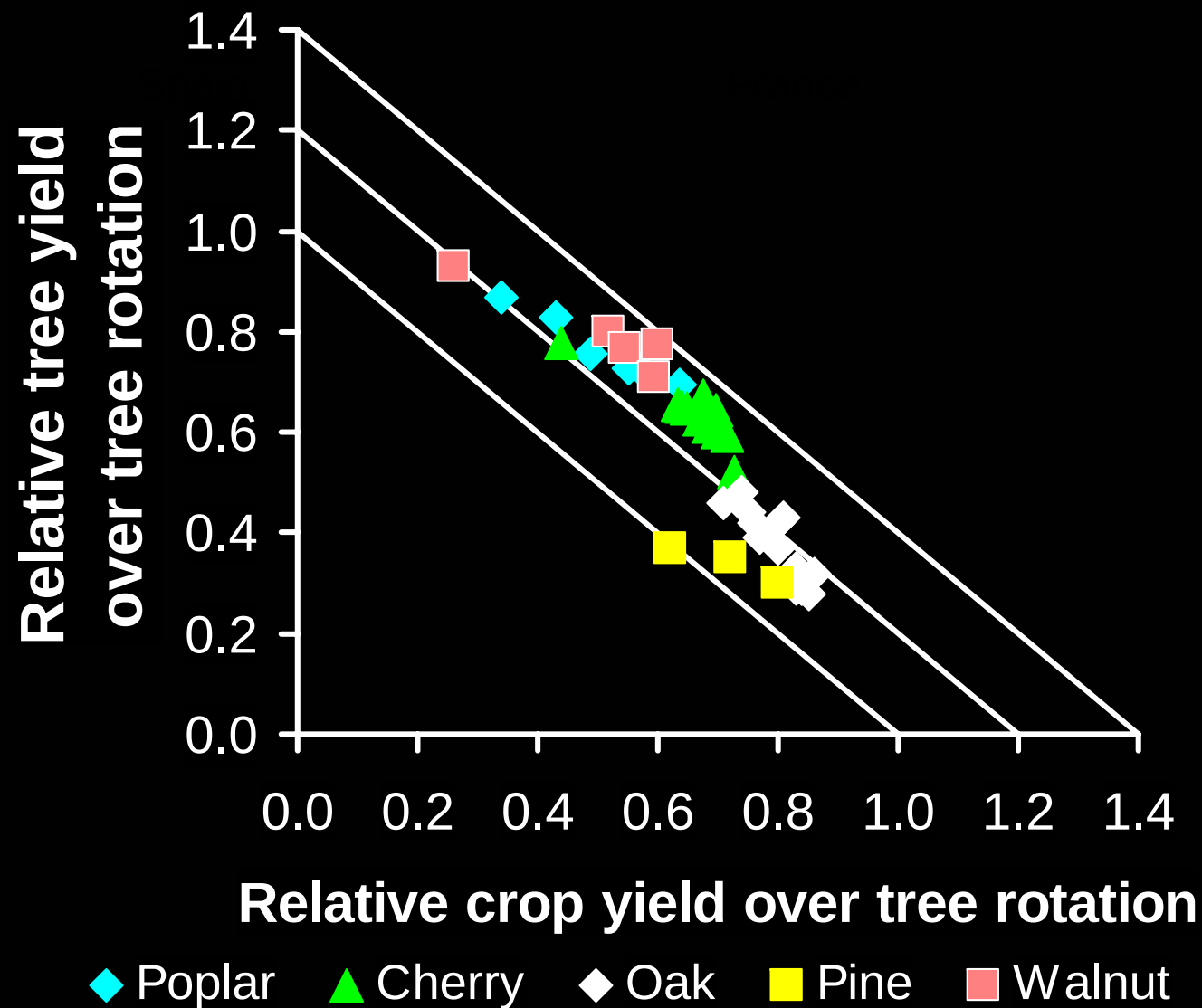
Champlitte



Production determined for selected locations, tree and crop species in Europe



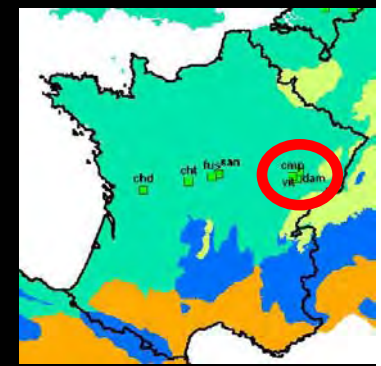
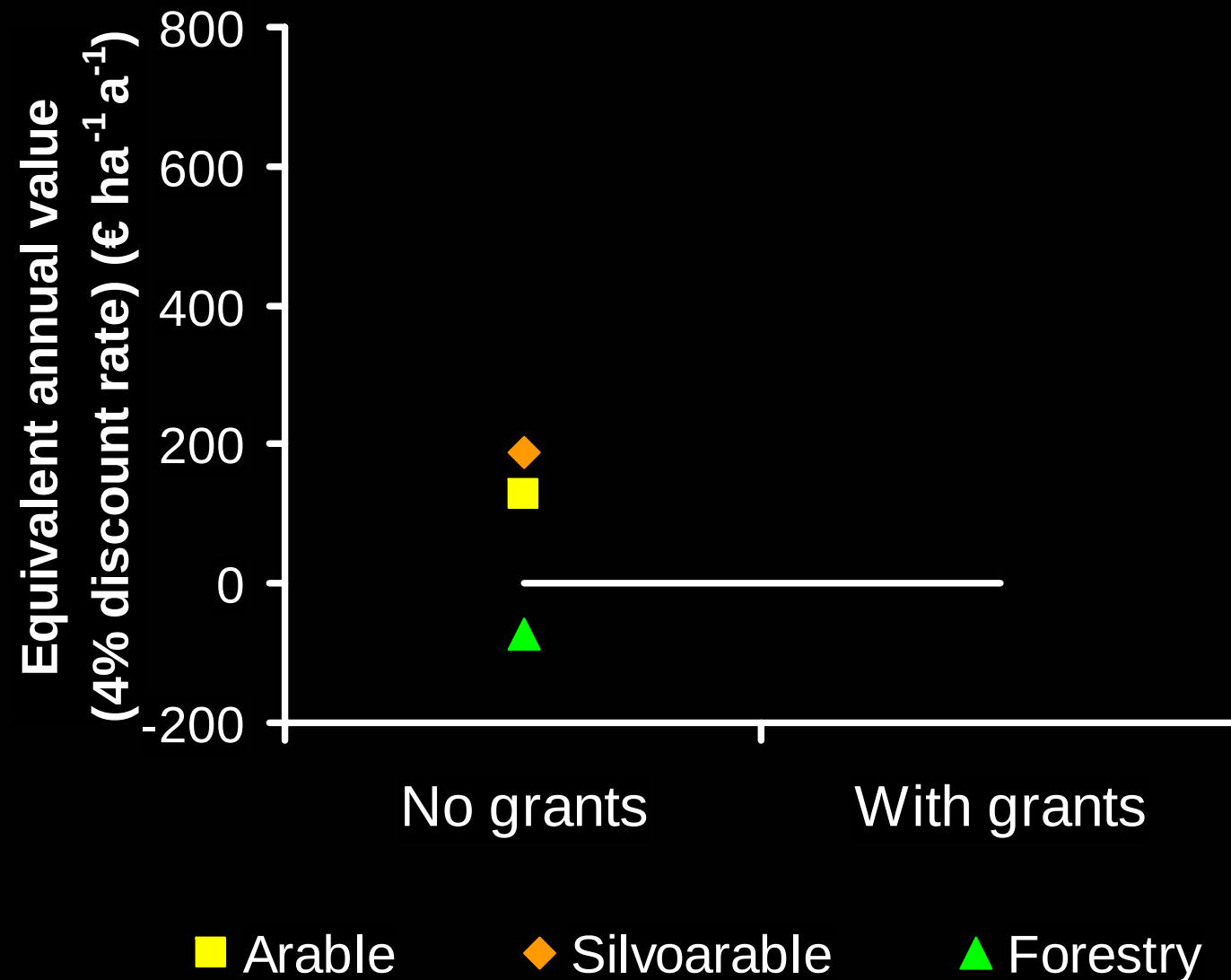
Integrating trees and crops can result in improved site productivity



4. Profitability



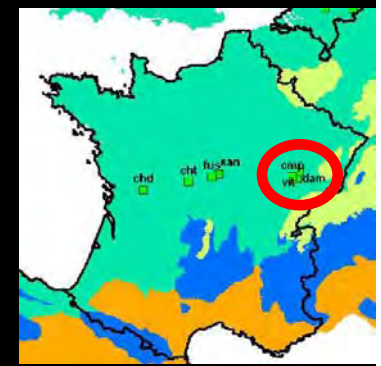
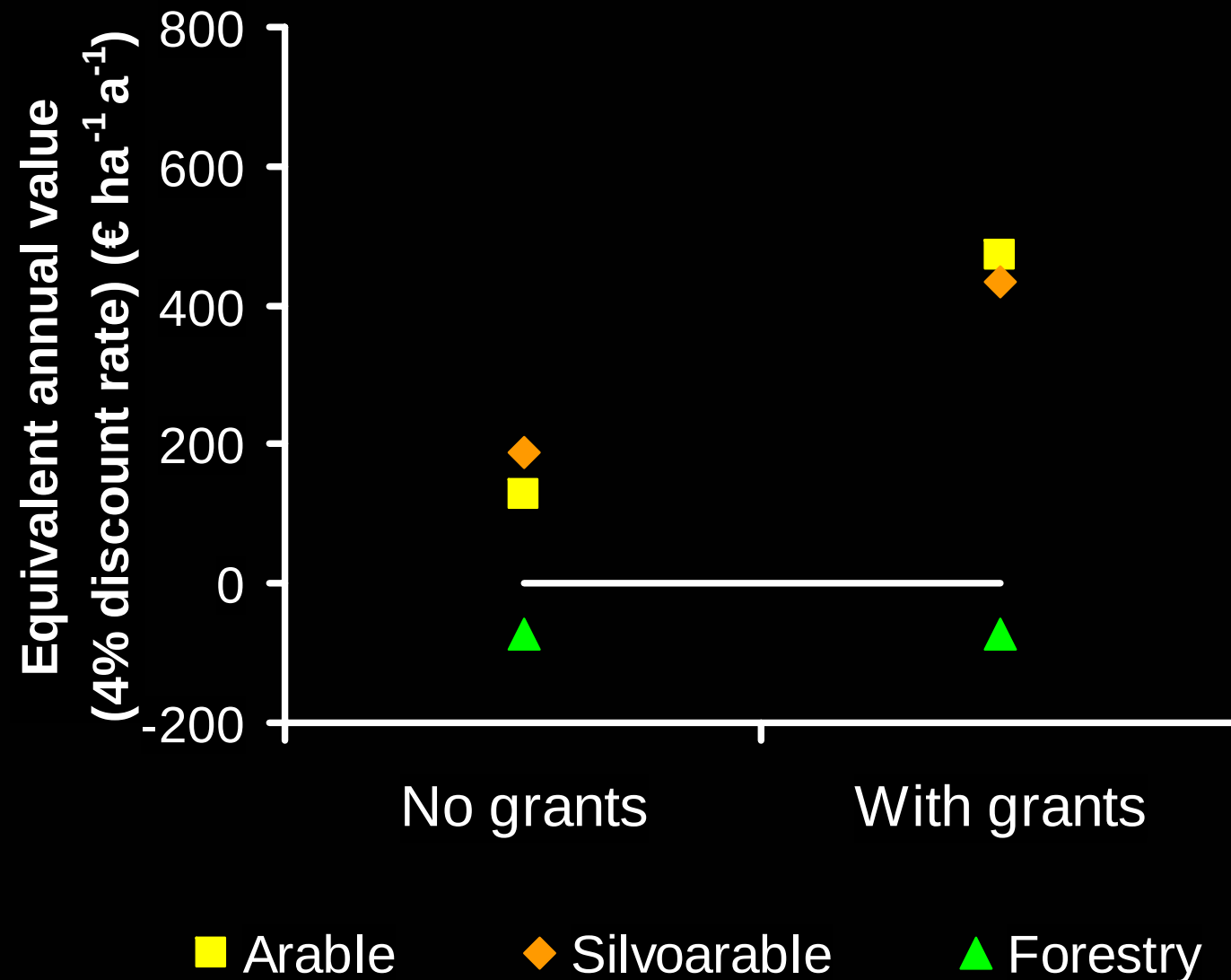
Effect of system on profitability



Champagne



Effect of system on profitability



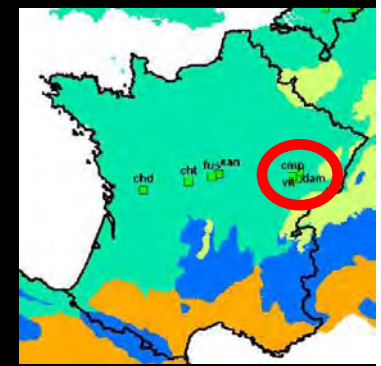
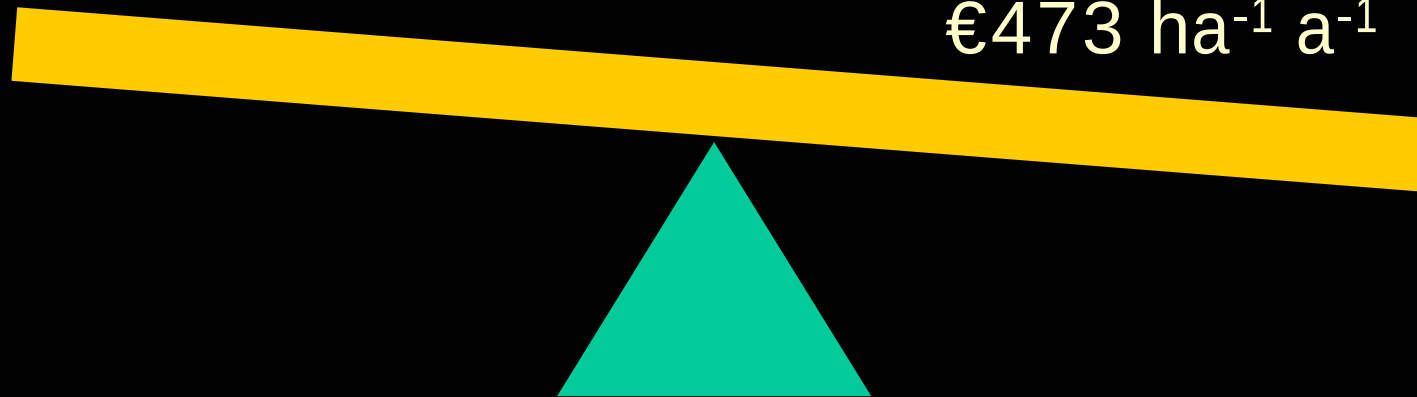
Champlitte



Profitability, with grants, of arable and an agroforestry system (113 trees/ha) at Champlitte

Agroforestry
€434 ha⁻¹ a⁻¹

Arable
€473 ha⁻¹ a⁻¹

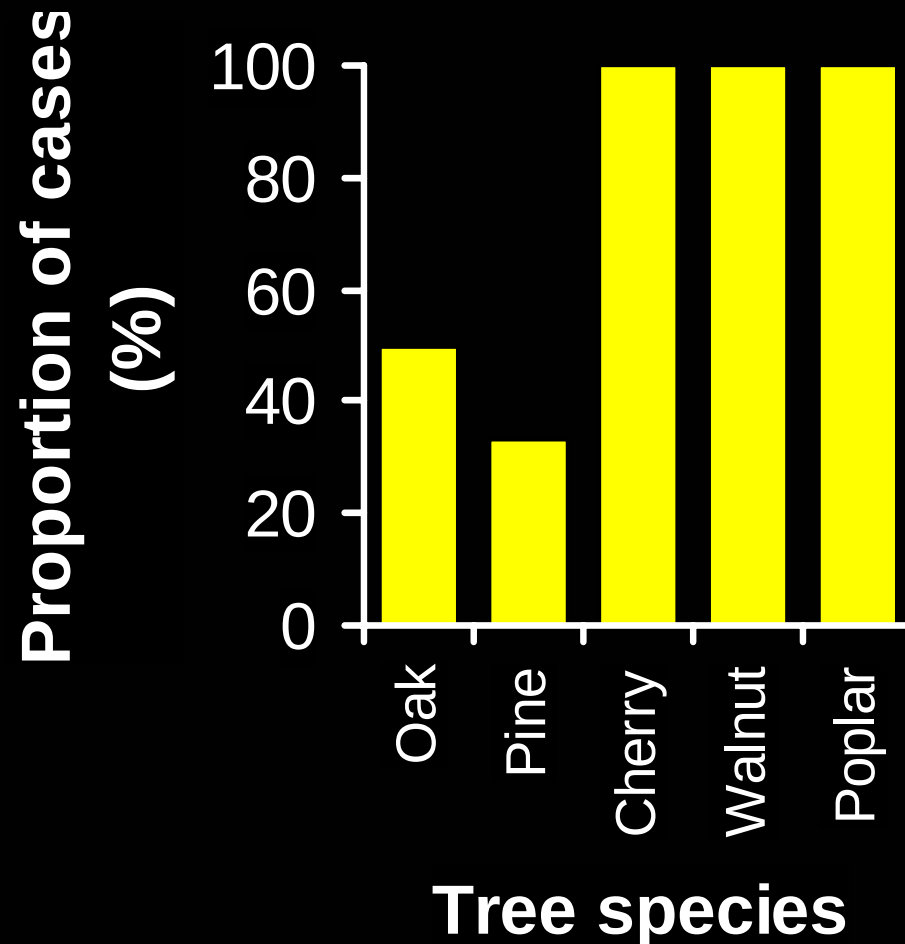


Champlitte

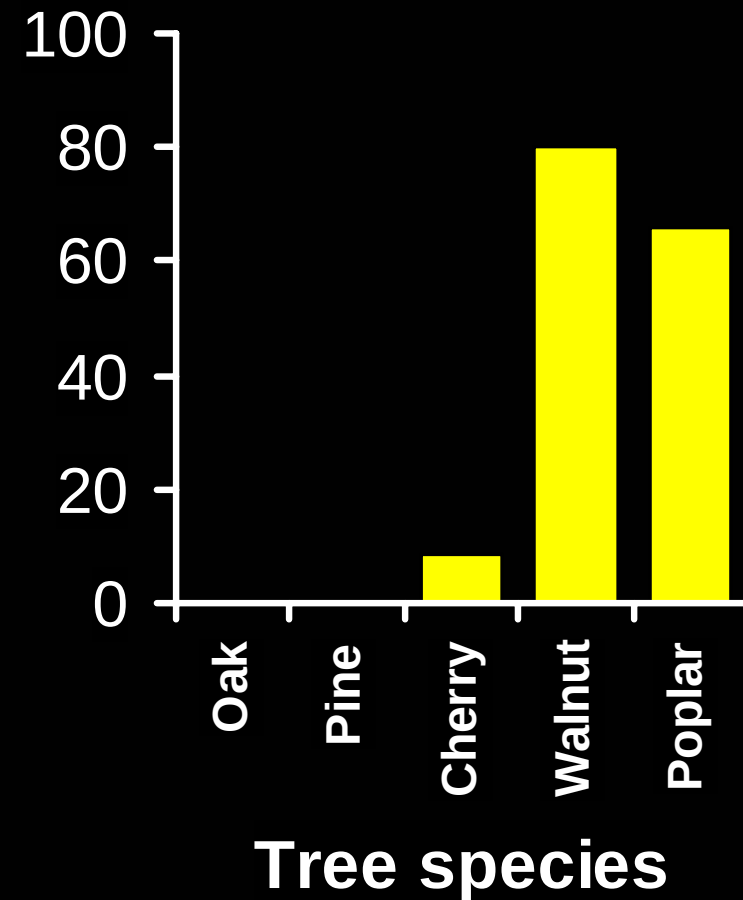


Farm-scale analysis (2005 grants; 4% discount rate)

Agroforestry more
profitable than forestry



Agroforestry more
profitable than agriculture



Conclusions: production and economics

Agroforestry results in greater site productivity than growing trees and crops separately

In France, agroforestry

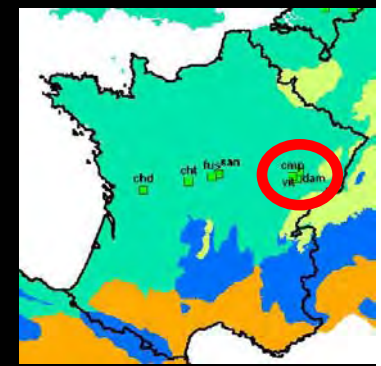
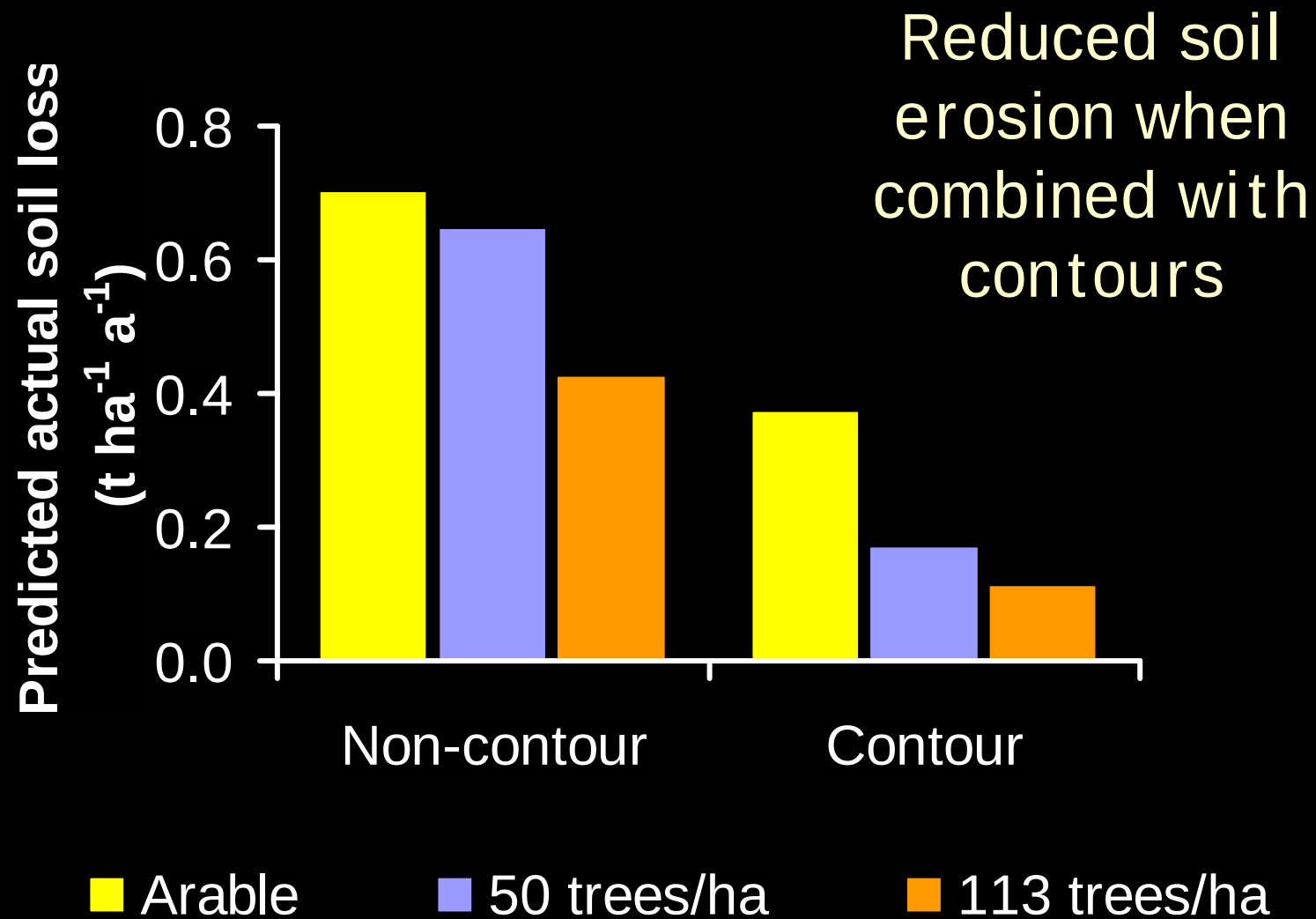
- is often the most profitable way of establishing walnut, cherry and poplar in arable areas
- with walnut and poplar is competitive with arable monocultures
- with current grants, cherry is less profitable than arable systems

5. Environmental regulation

- Soil erosion
- Groundwater recharge
- Nitrogen leaching
- Carbon sequestration



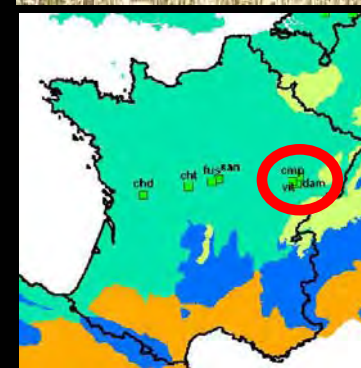
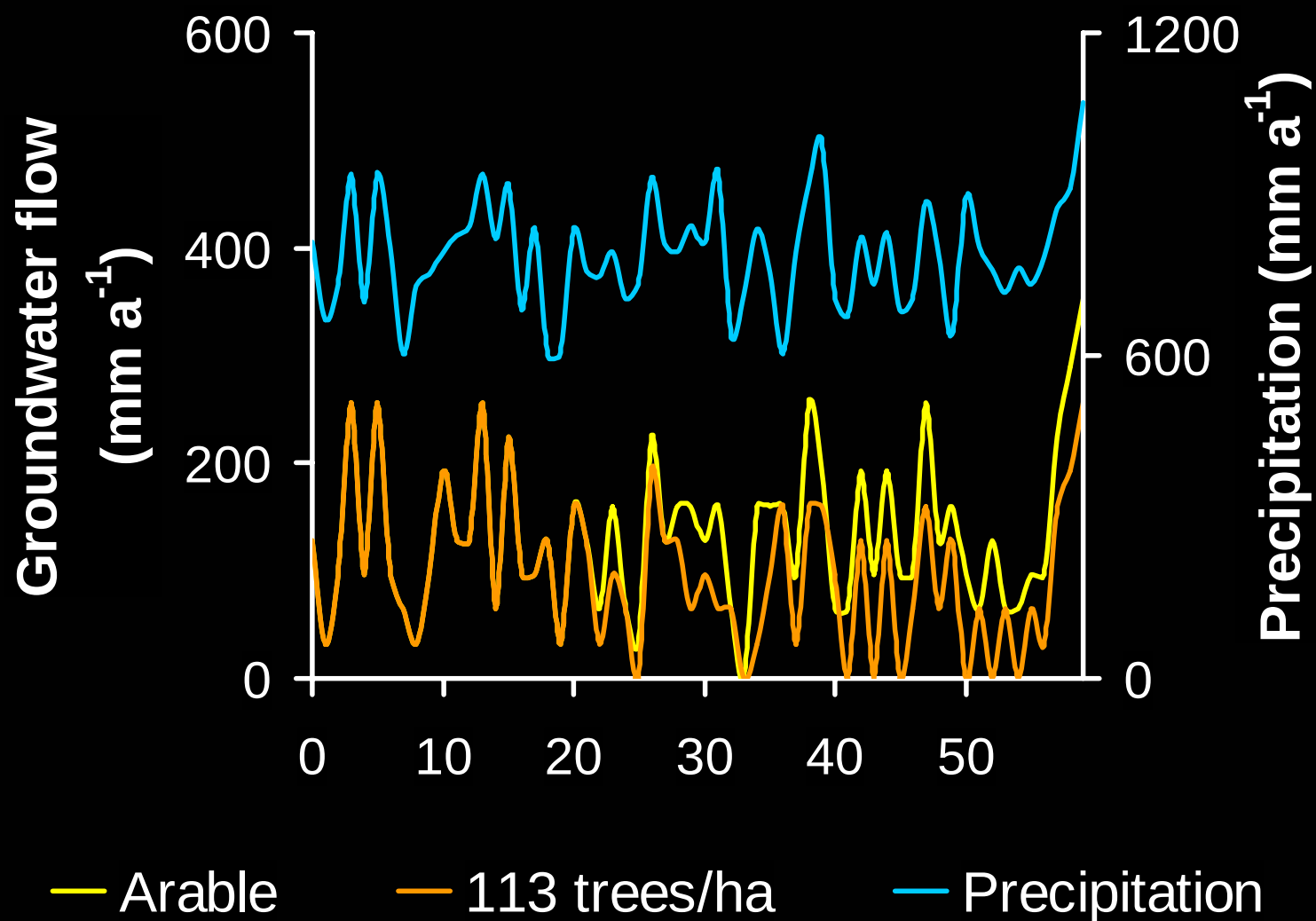
Predicted effect of agroforestry and contours on soil erosion at Champlitte



Champlitte



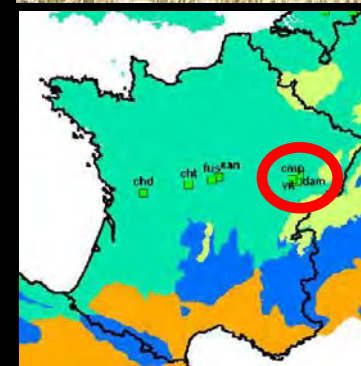
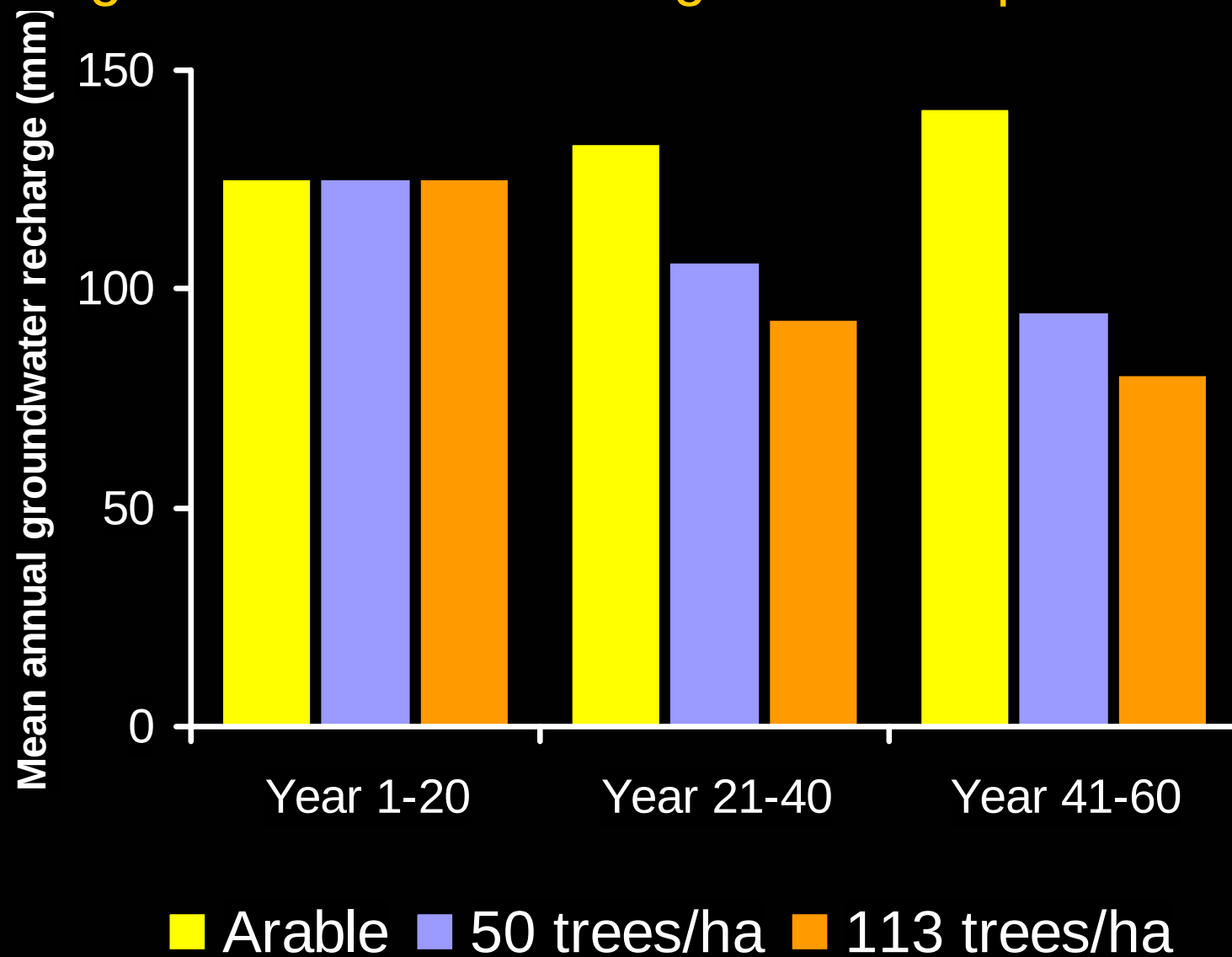
Predicted effect of agroforestry on groundwater recharge at Champlitte



Champlitte



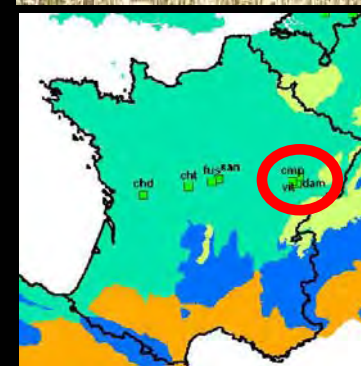
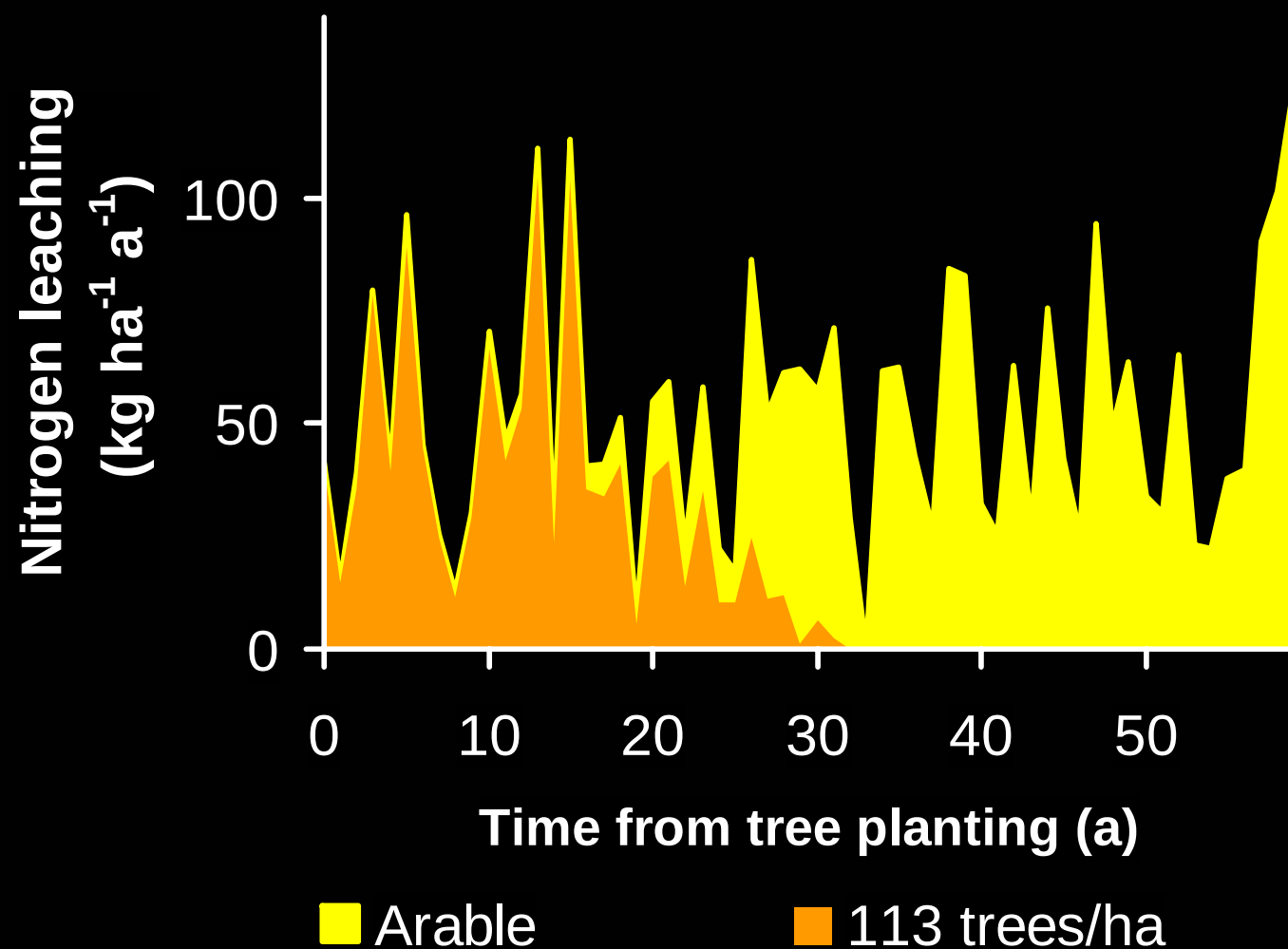
Predicted effect of agroforestry on groundwater recharge at Champlitte



Champlitte



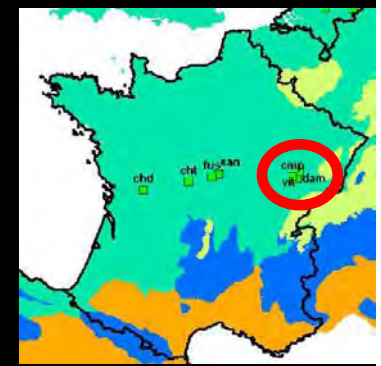
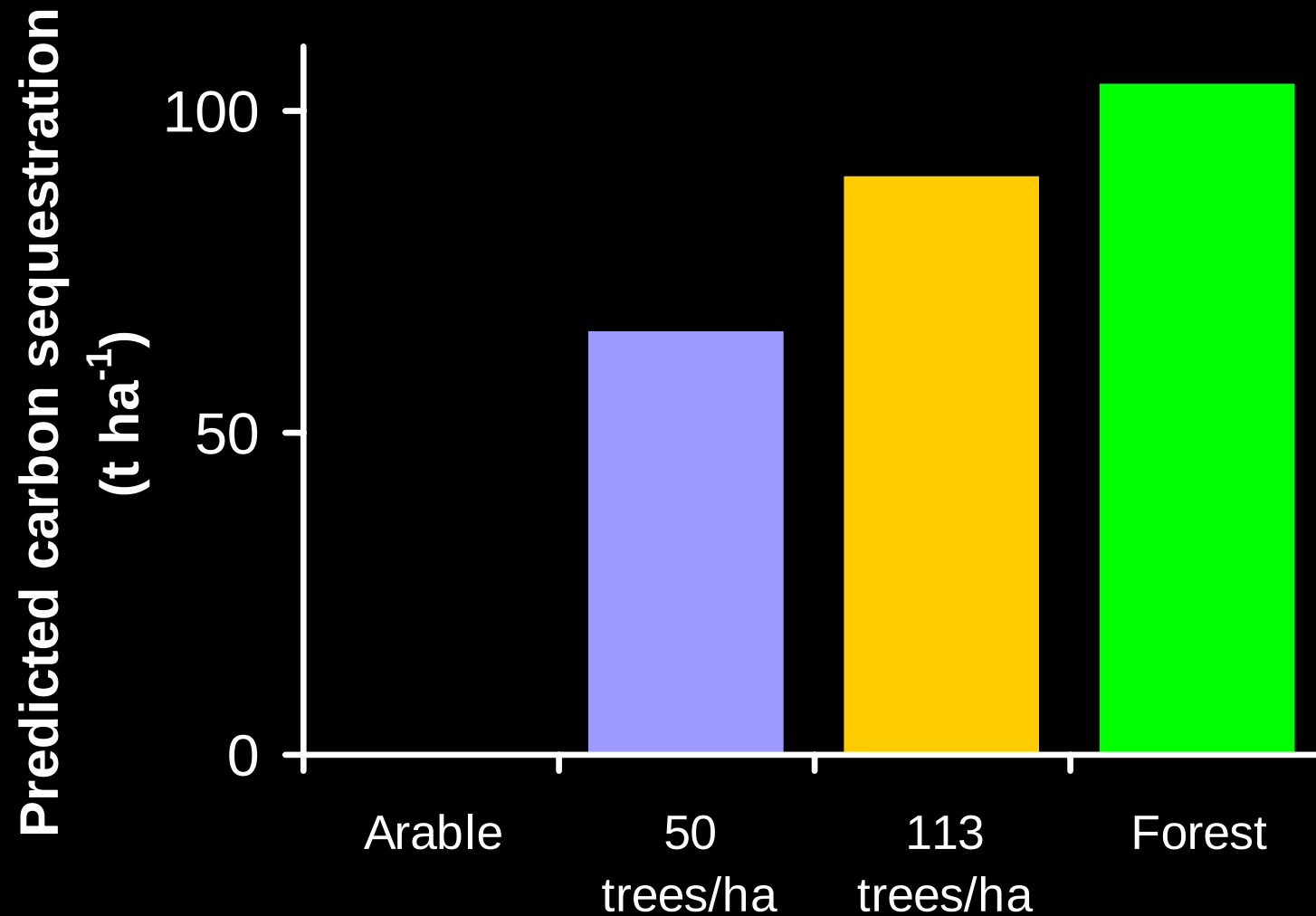
Predicted effect of agroforestry on nitrogen leaching at Champlitte



Champlitte



Predicted carbon sequestration over 60 years using wild cherry at Champlitte



Champlitte



Conclusions: Environment

A biophysical model was used to predict key environmental effects of an arable monoculture and agroforestry at different tree densities, however validation is required

As tree density increased, predicted:

- soil erosion decreased
- groundwater recharge decreased
- nitrogen leaching decreased
- carbon sequestration increased

Trade-offs in profitability and environmental regulations

Reduce nitrates

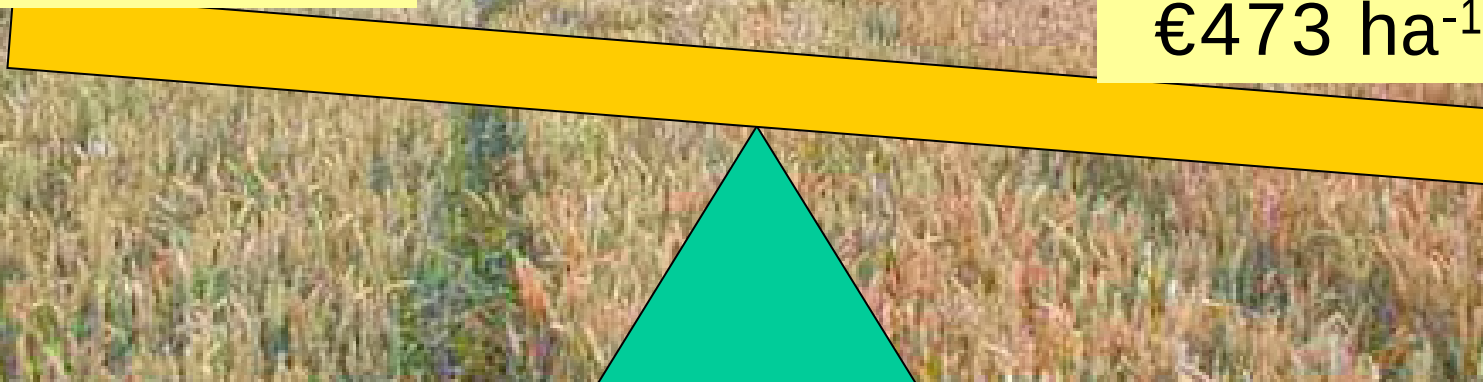
Reduced
flooding

Reduced soil loss

Agroforestry
€434 ha⁻¹ a⁻¹

Groundwater
recharge

Arable
€473 ha⁻¹ a⁻¹



Trade-offs in profitability and environmental regulations

C sequestration

Reduce nitrates

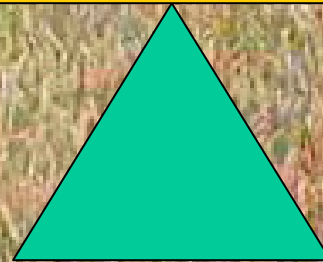
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Trade-offs in profitability and environmental regulations

C sequestration

Reduce nitrates

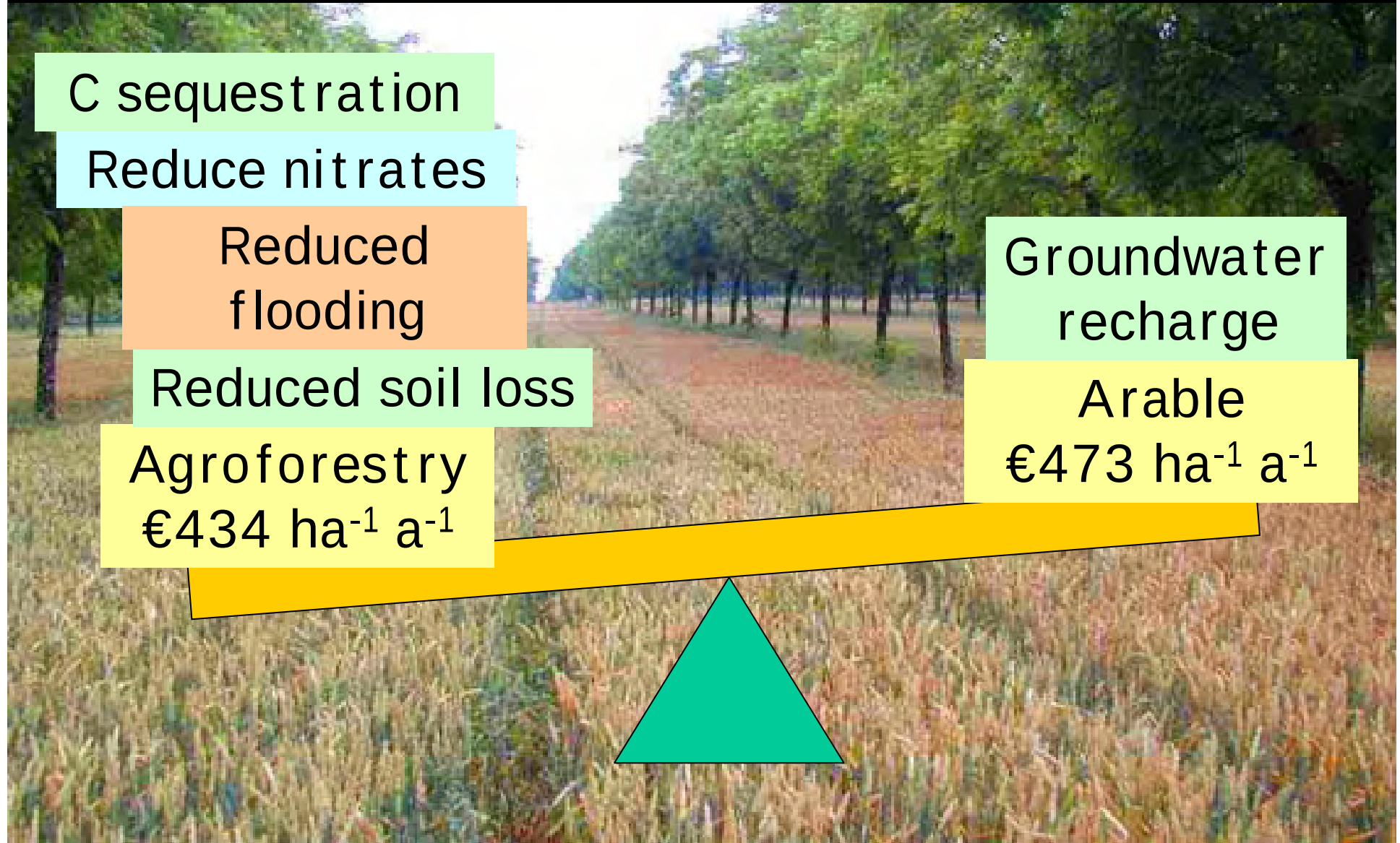
Reduced
flooding

Reduced soil loss

Agroforestry
€434 ha⁻¹ a⁻¹

Groundwater
recharge

Arable
€473 ha⁻¹ a⁻¹



Conclusions: determining trade-offs

Although agroforestry may not be the most profitable option to an individual farmer, it may still be the best option for society.

A bio-economic model, linked to some environmental models, can be used to compare key economic and environmental effects of arable, forestry and agroforestry systems