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

Presentation made by Paul Burgess, Cranfield University
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Trees in European crop fields: determining the trade-offs in profitability and ecosystem regulation

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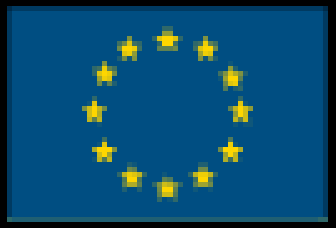


Outline

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

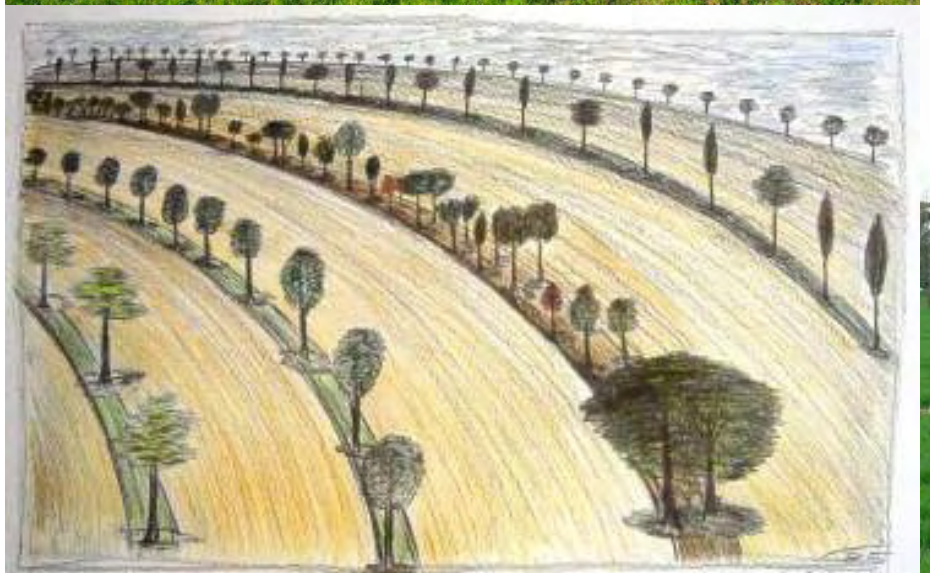
There has been a loss of wooded landscapes over much of Europe...

Tanner (1993)

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

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

.. and others have established trees in fields recently

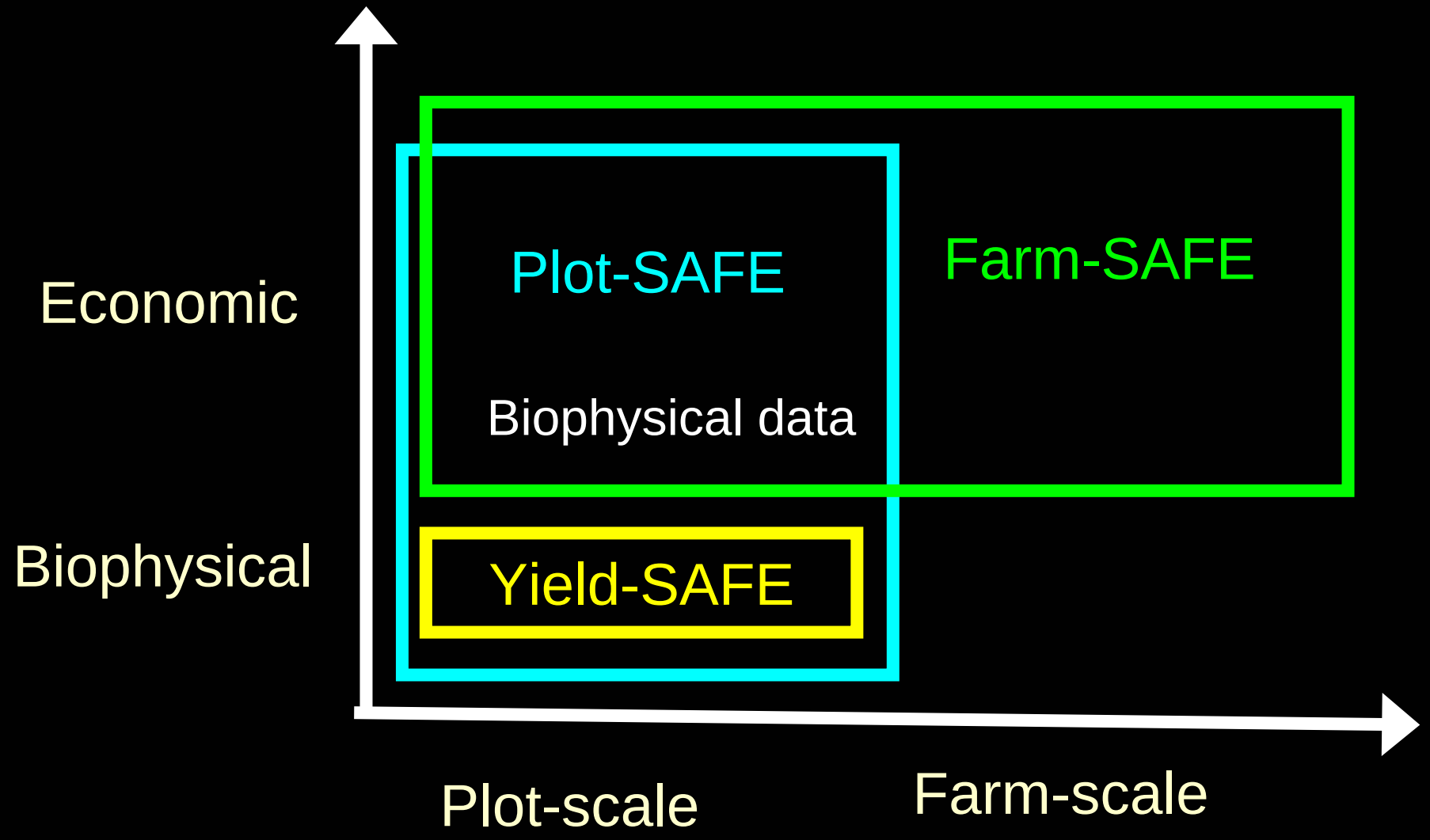


2. Method

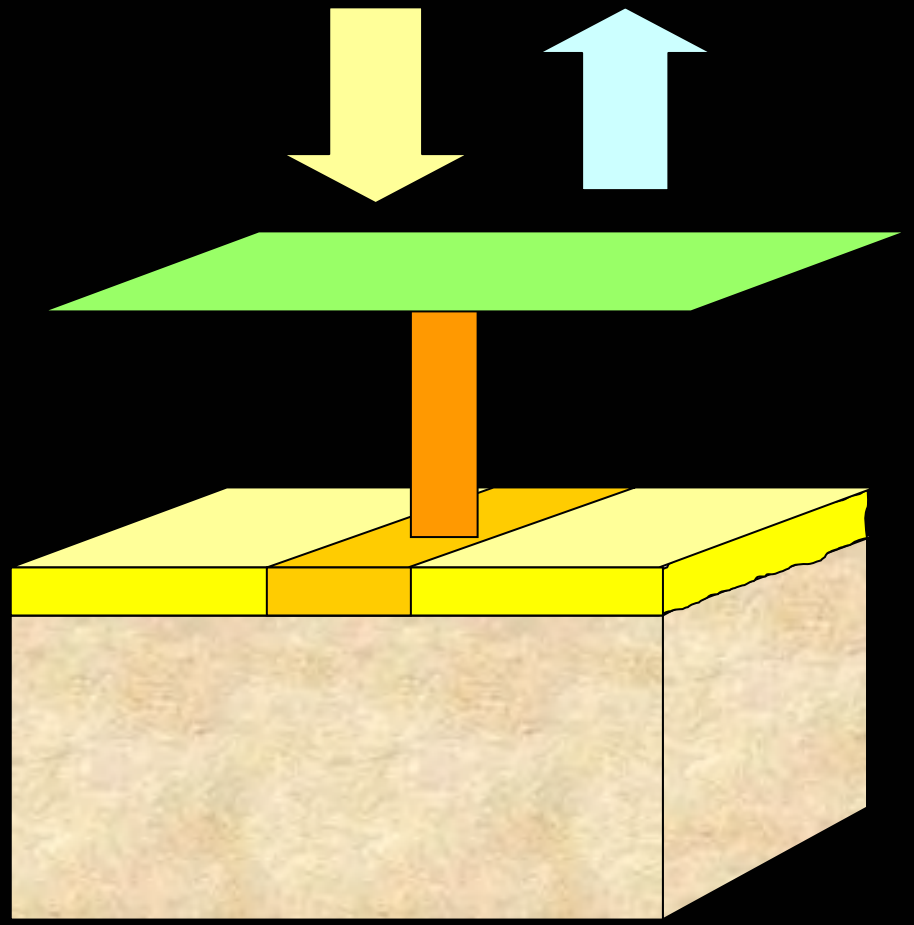
How to determine profitability and environmental effects?

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

Use of models to determine environmental and economic effects

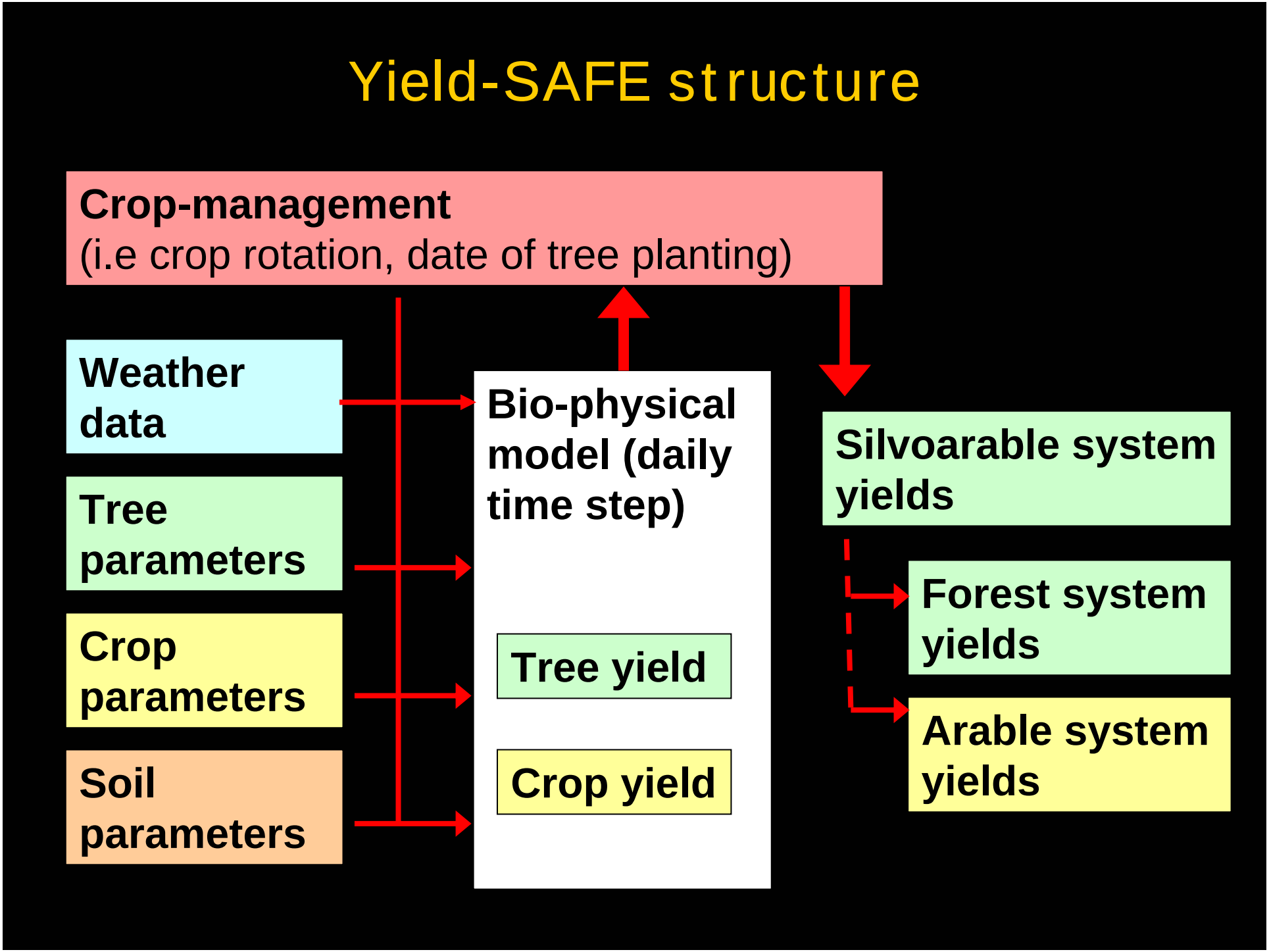


Yield-SAFE: state variables

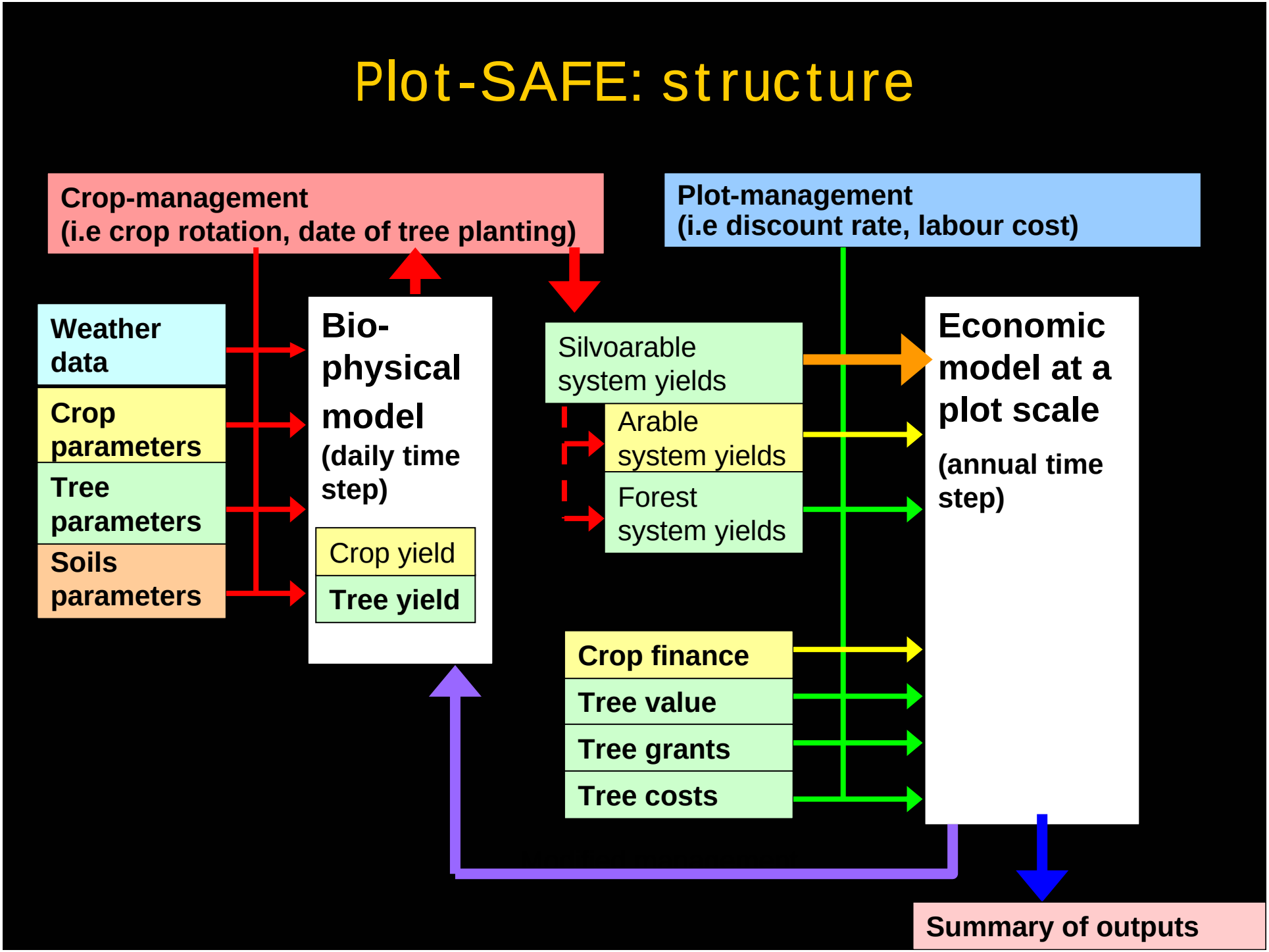


Tree	Biomass	B_t
	Leaf area	L_t
	Shoot number	N
Crop	Biomass	B_c
	Leaf area	L_c
	Thermal time	S
Soil	Water content	θ

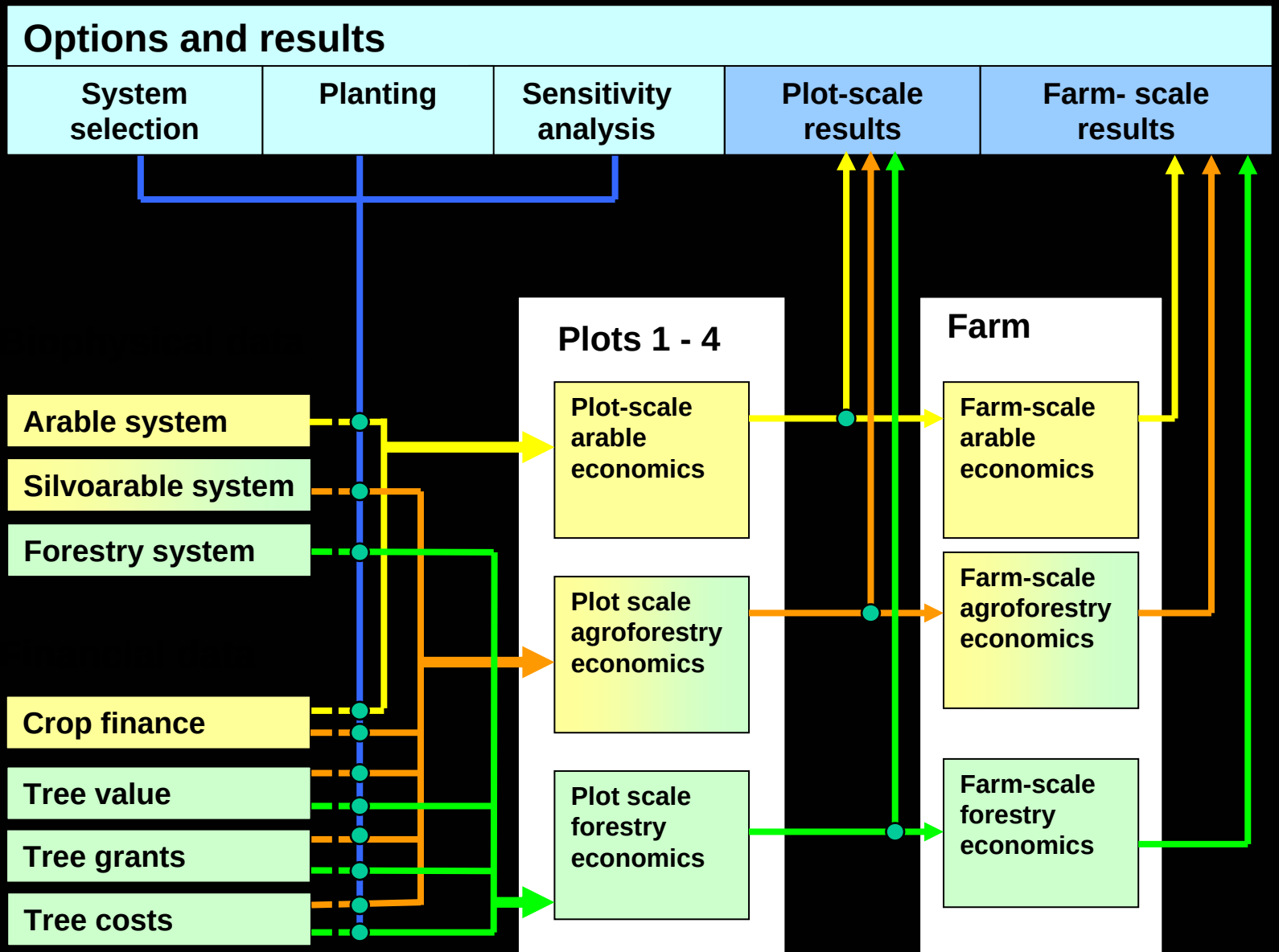
Yield-SAFE structure



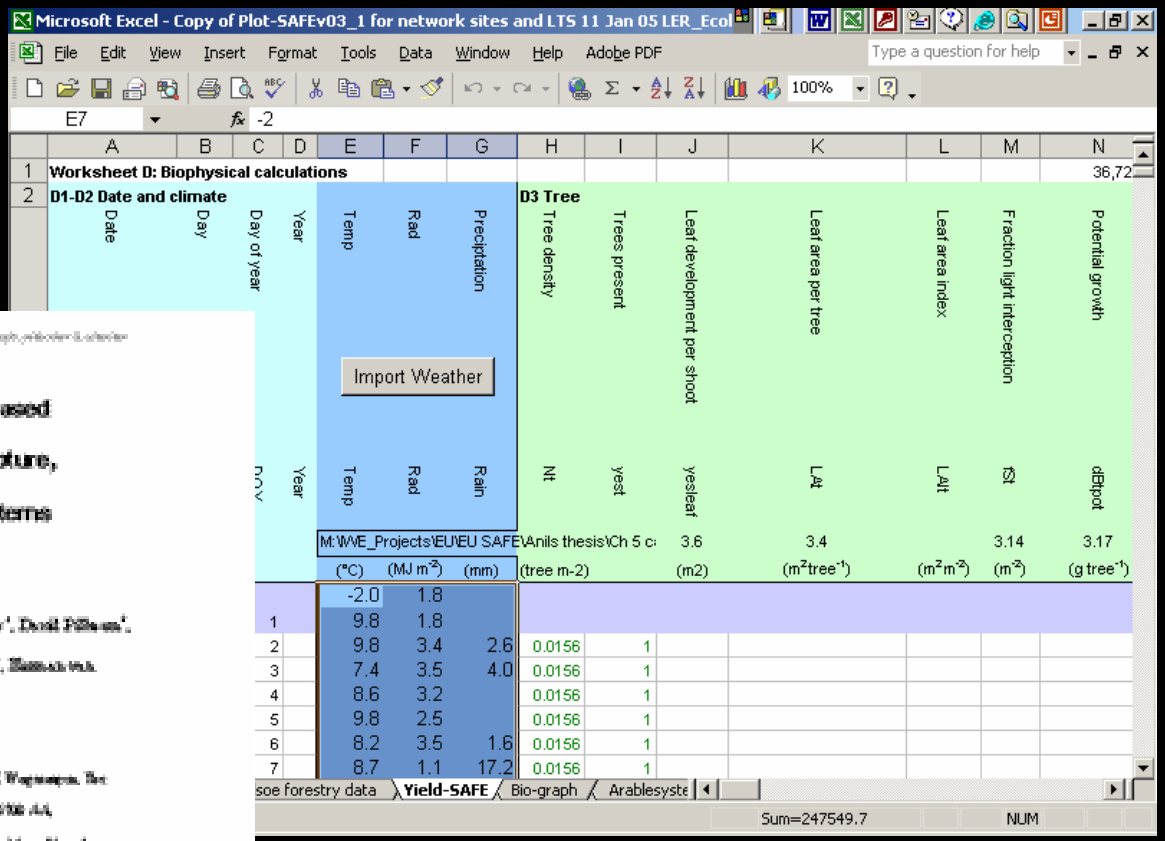
Plot-SAFE: structure

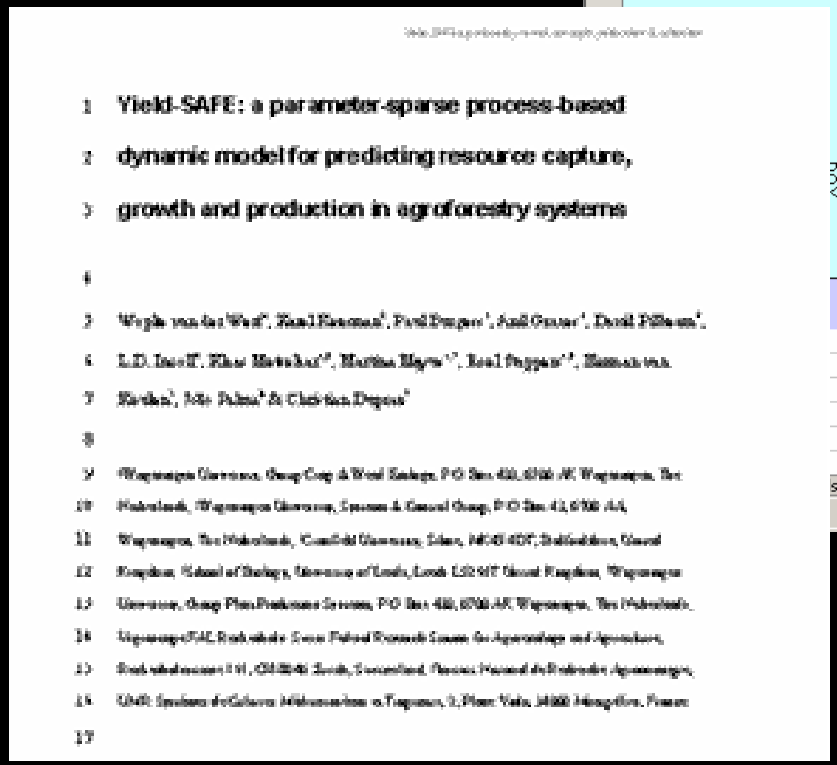


Farm-SAFE: structure



Description and software



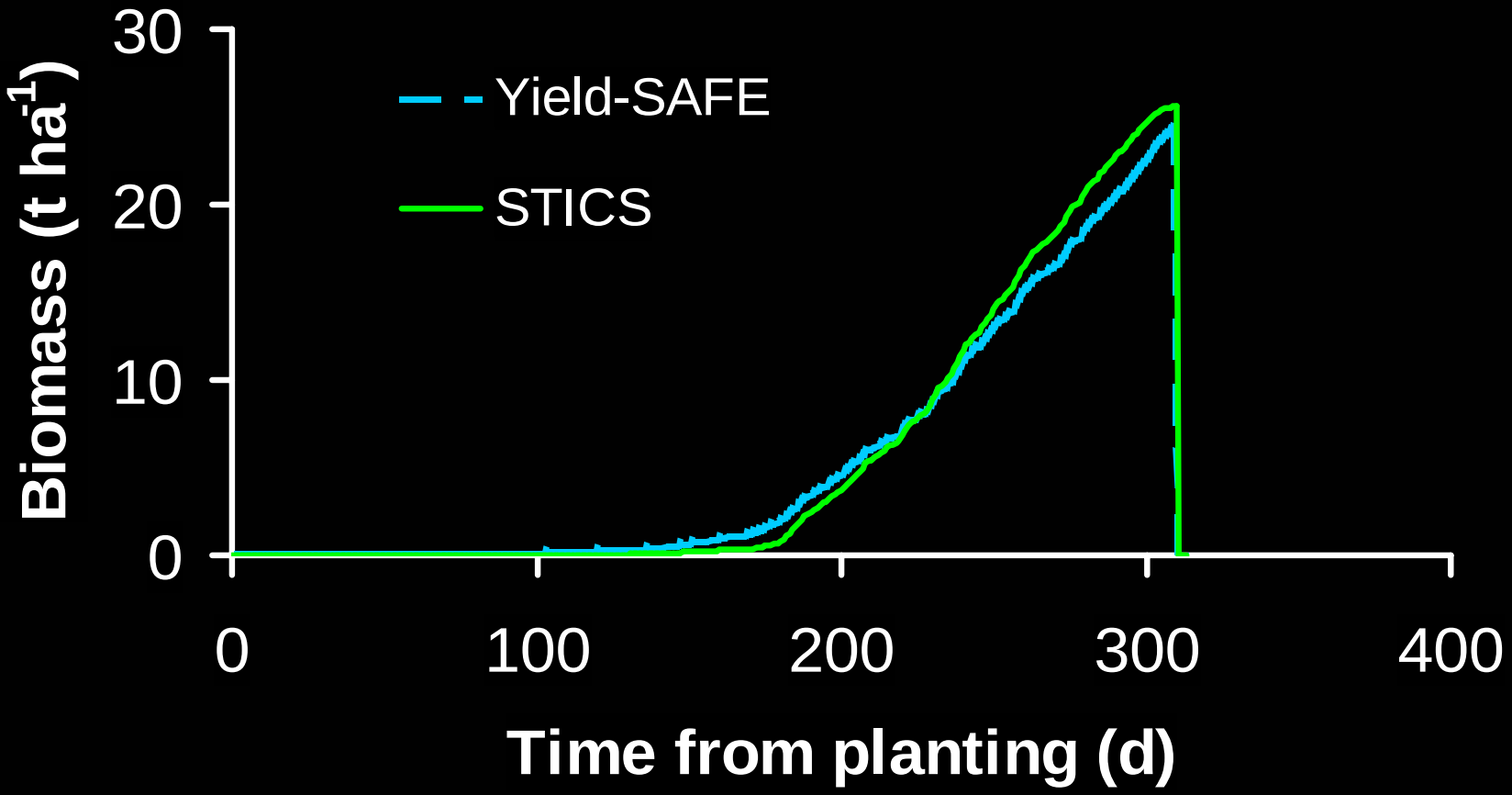


Yield-SAFE: a parameter-sparse process-based dynamic model for predicting resource capture, growth and production in agroforestry systems

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

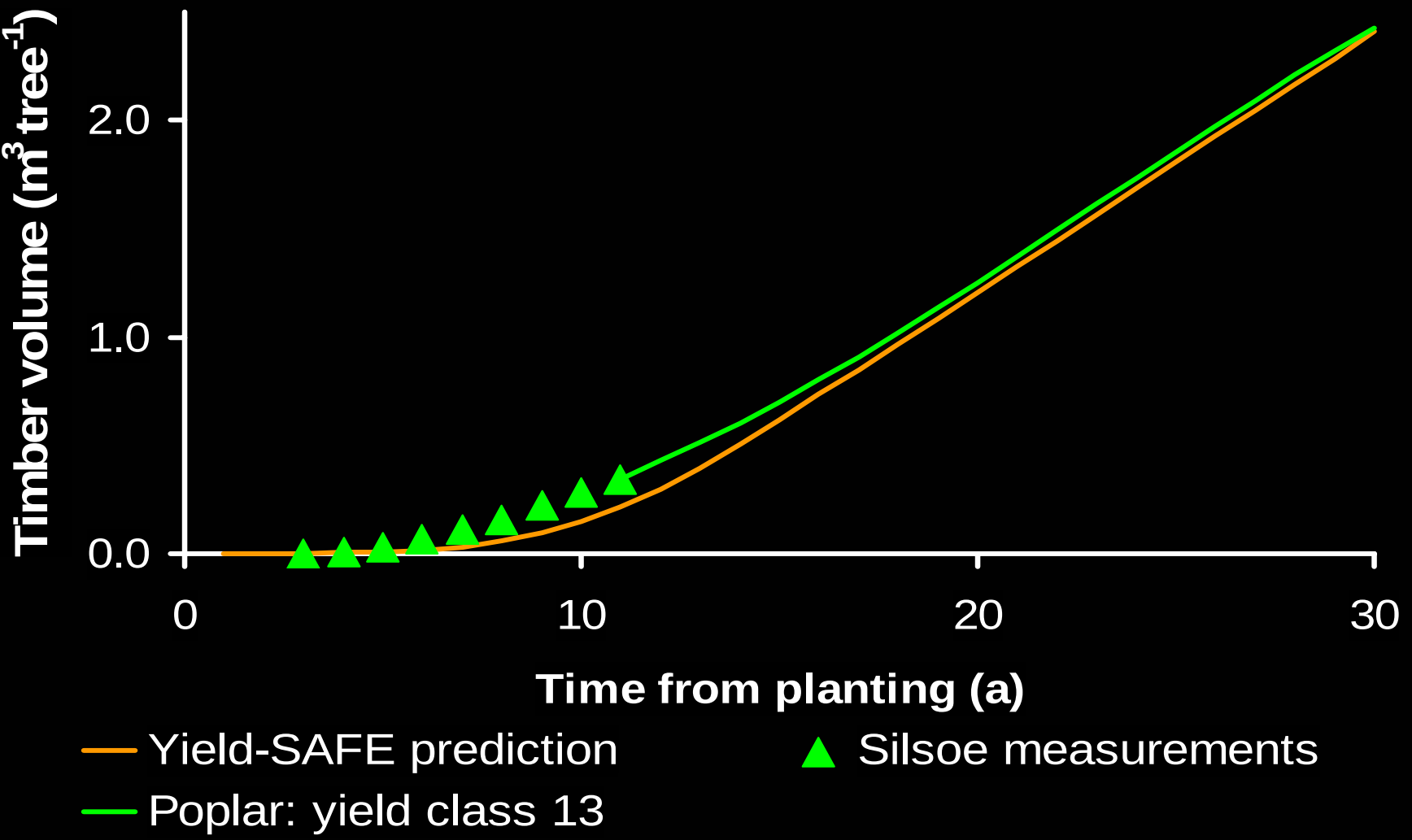
Validation: UK Silvoarable Network

Site calibration for Silsoe

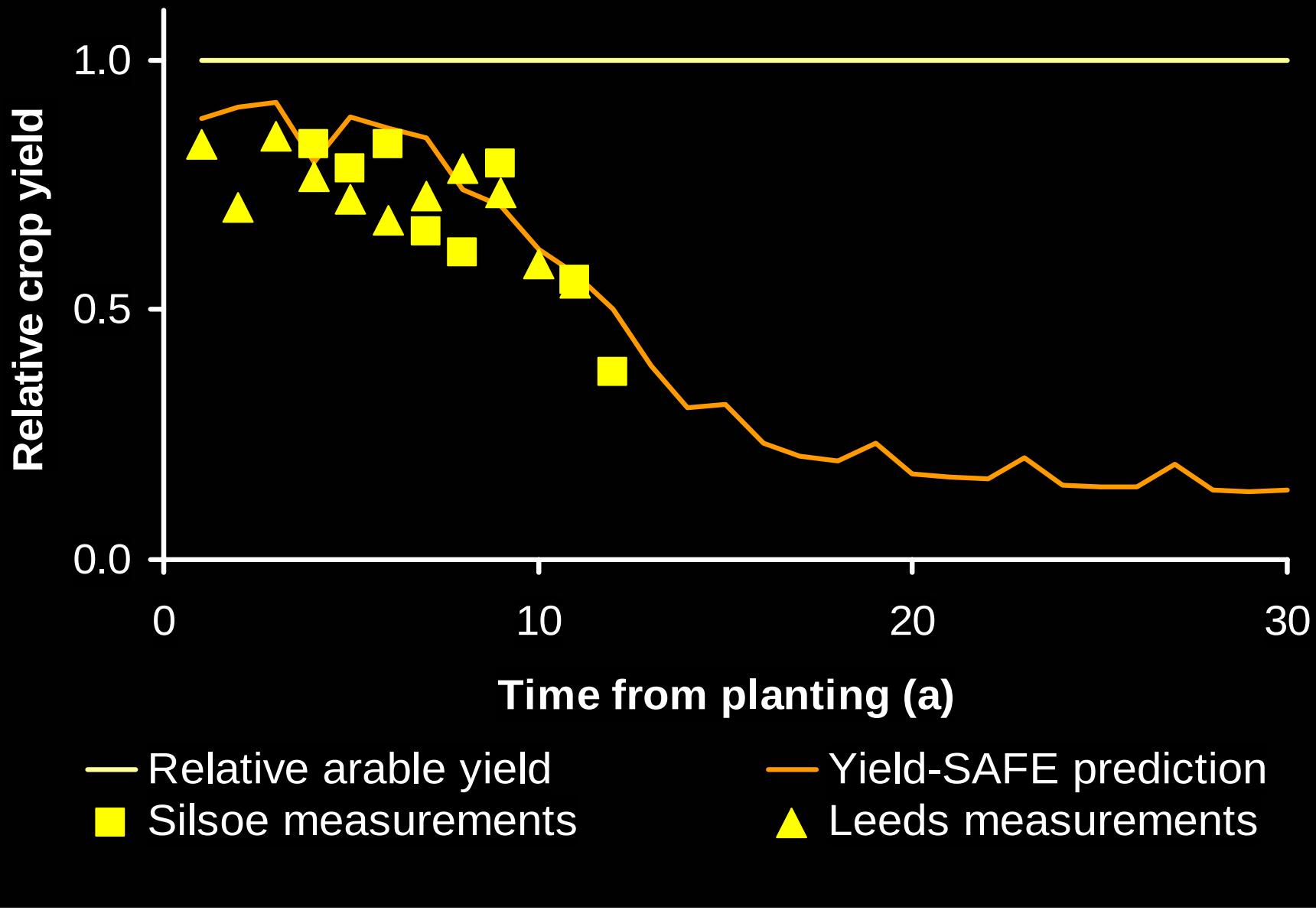
The model was calibrated for tree-only and crop-only reference yields by modifying the transpiration coefficient and the harvest index

	Poplar	Wheat
Timber yield (m^3 $tree^{-1}$) (30 years)	*2.4*	-
Crop yield (t ha^{-1} a^{-1})	-	*8.2*
Transpiration coefficient (m^3 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

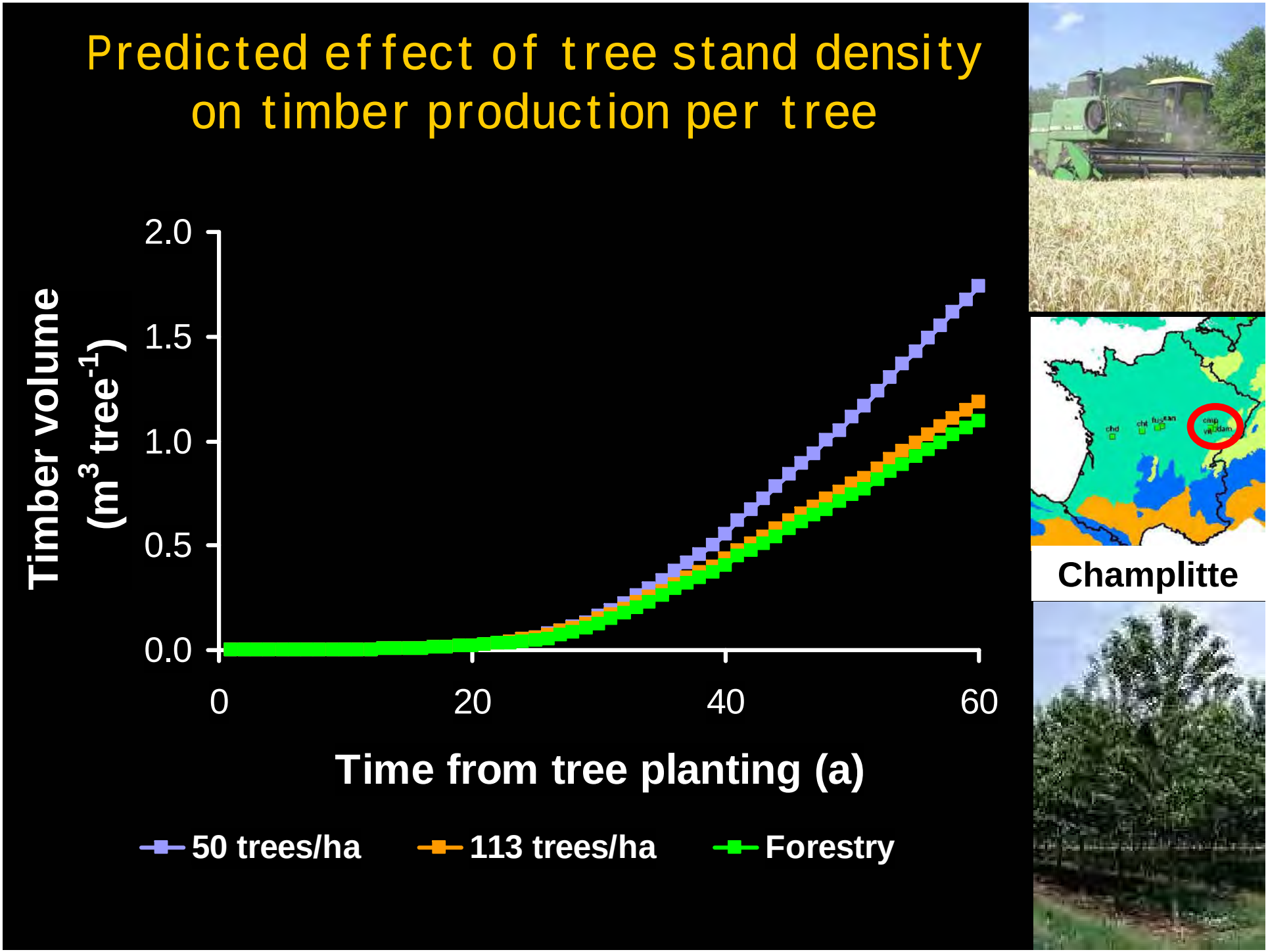


Conclusions: models

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

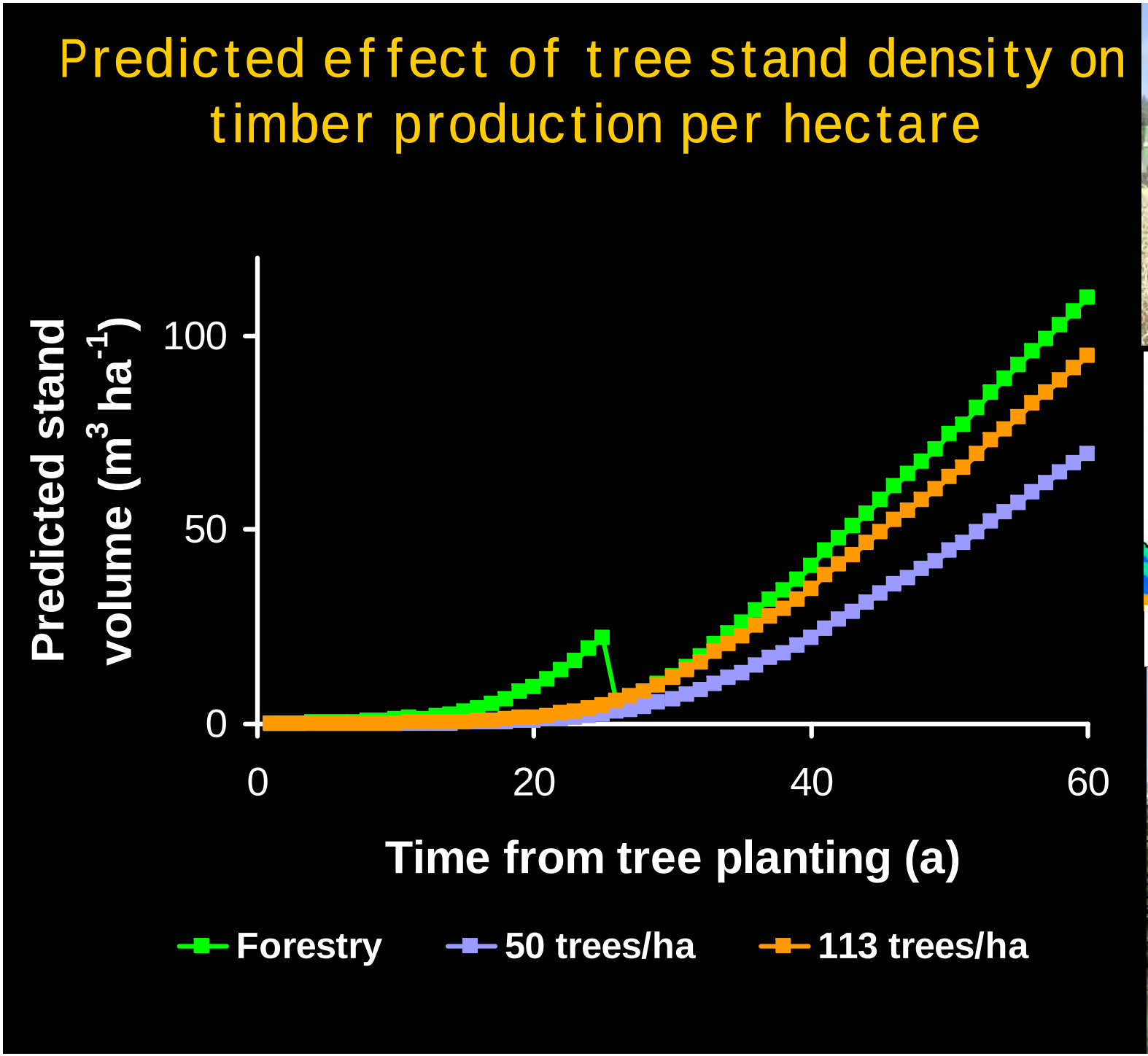
3. Production

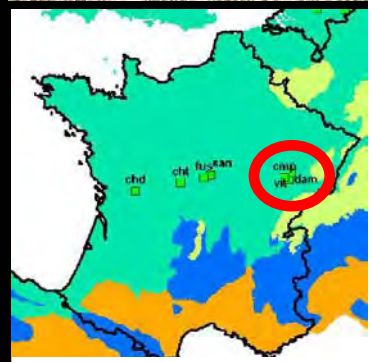
Predicted effect of tree stand density on timber production per tree



Champlitte

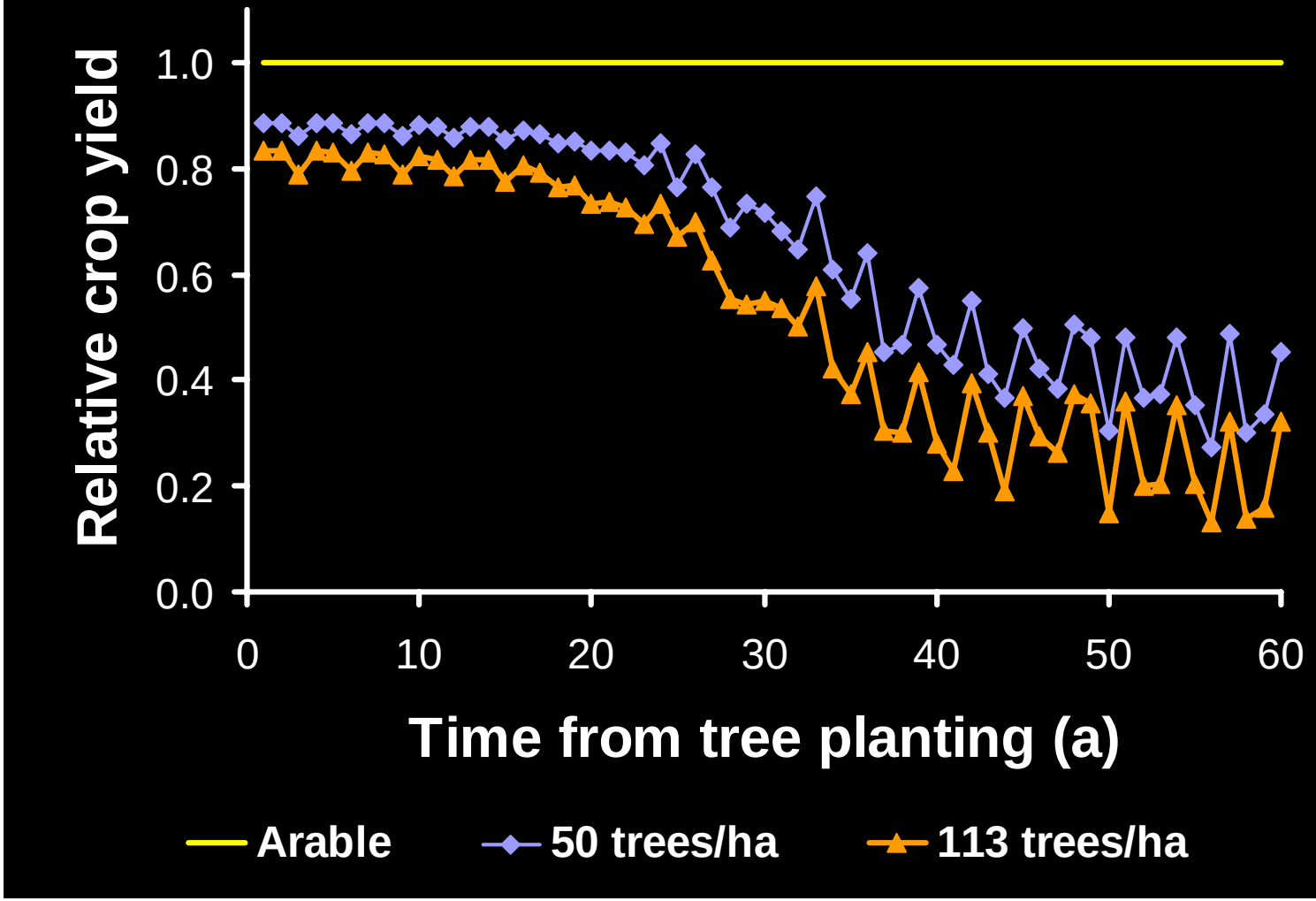
Predicted effect of tree stand density on timber production per hectare

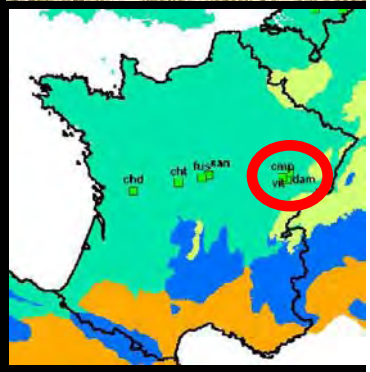




Champlitte

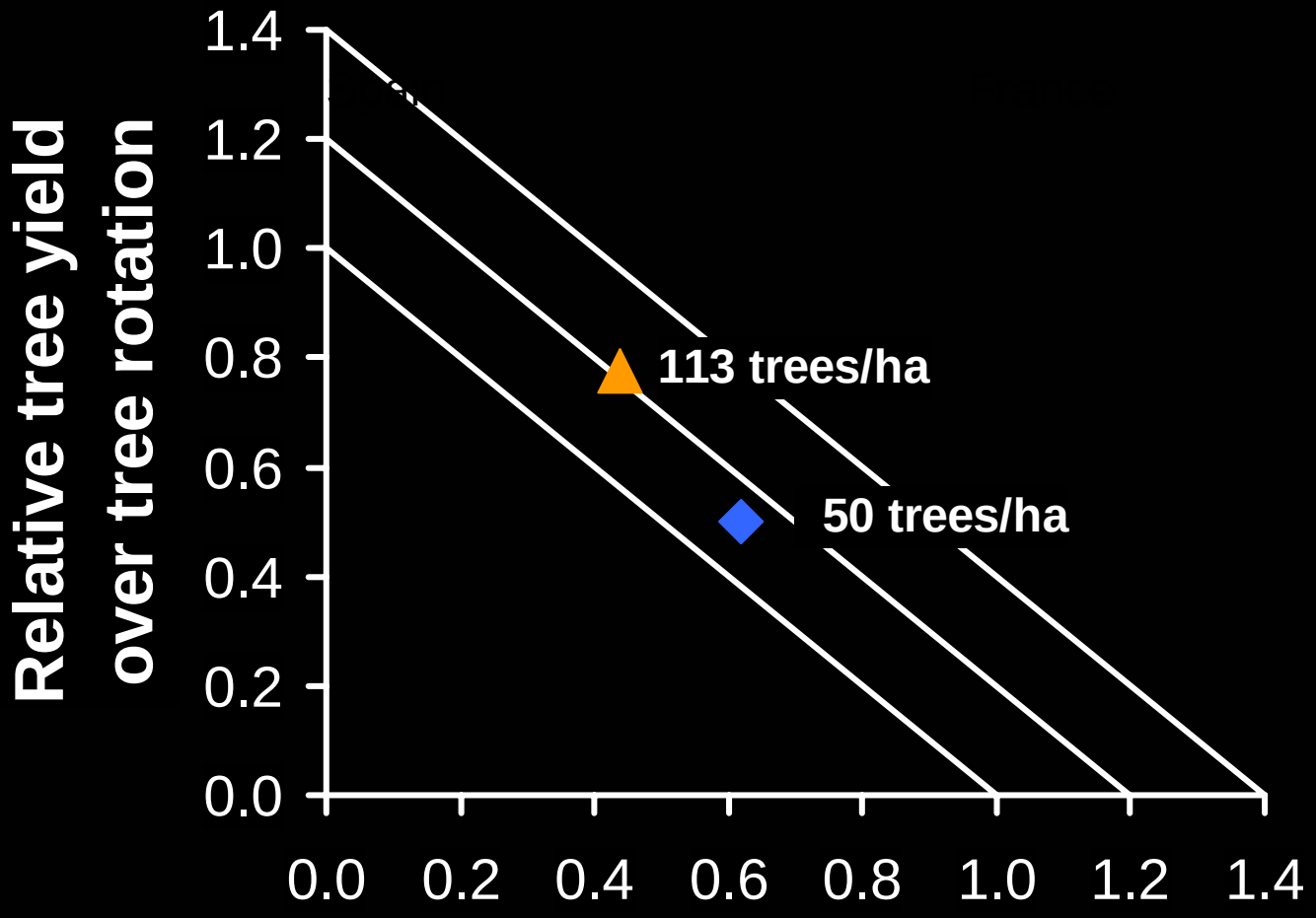
Predicted effect of tree stand density on relative yields of a wheat/wheat/oilseed rotation

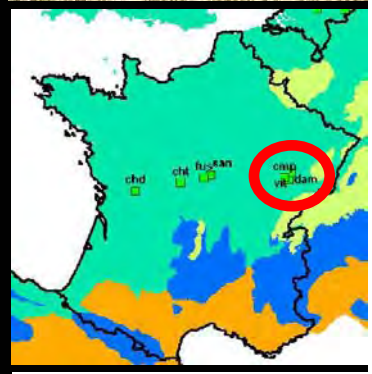




Champlitte

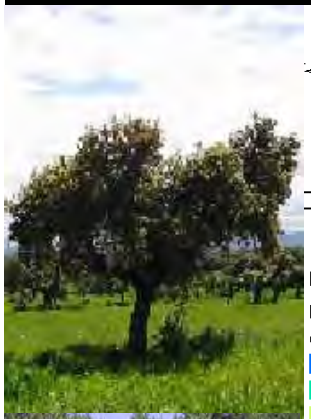
Effect of tree density on relative productivity

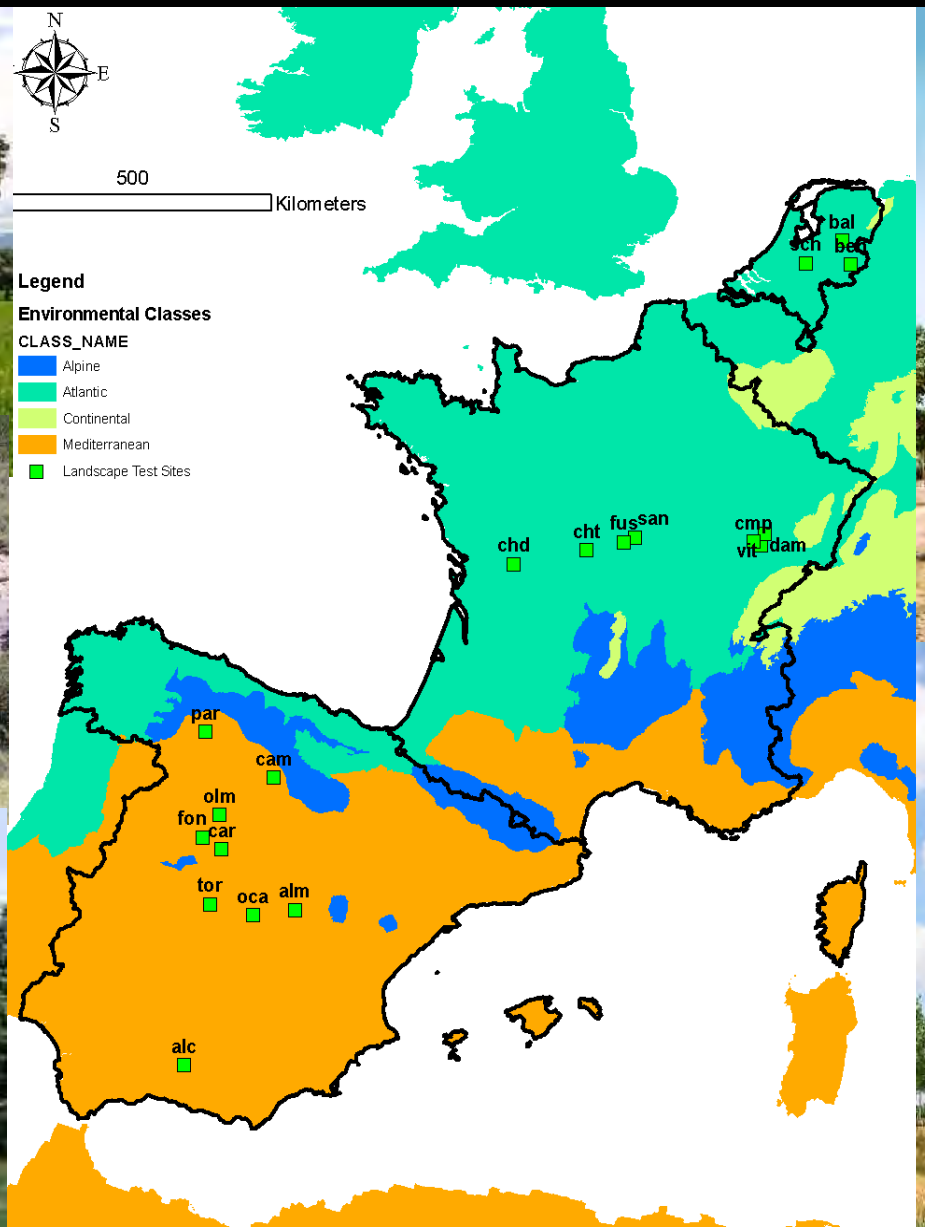




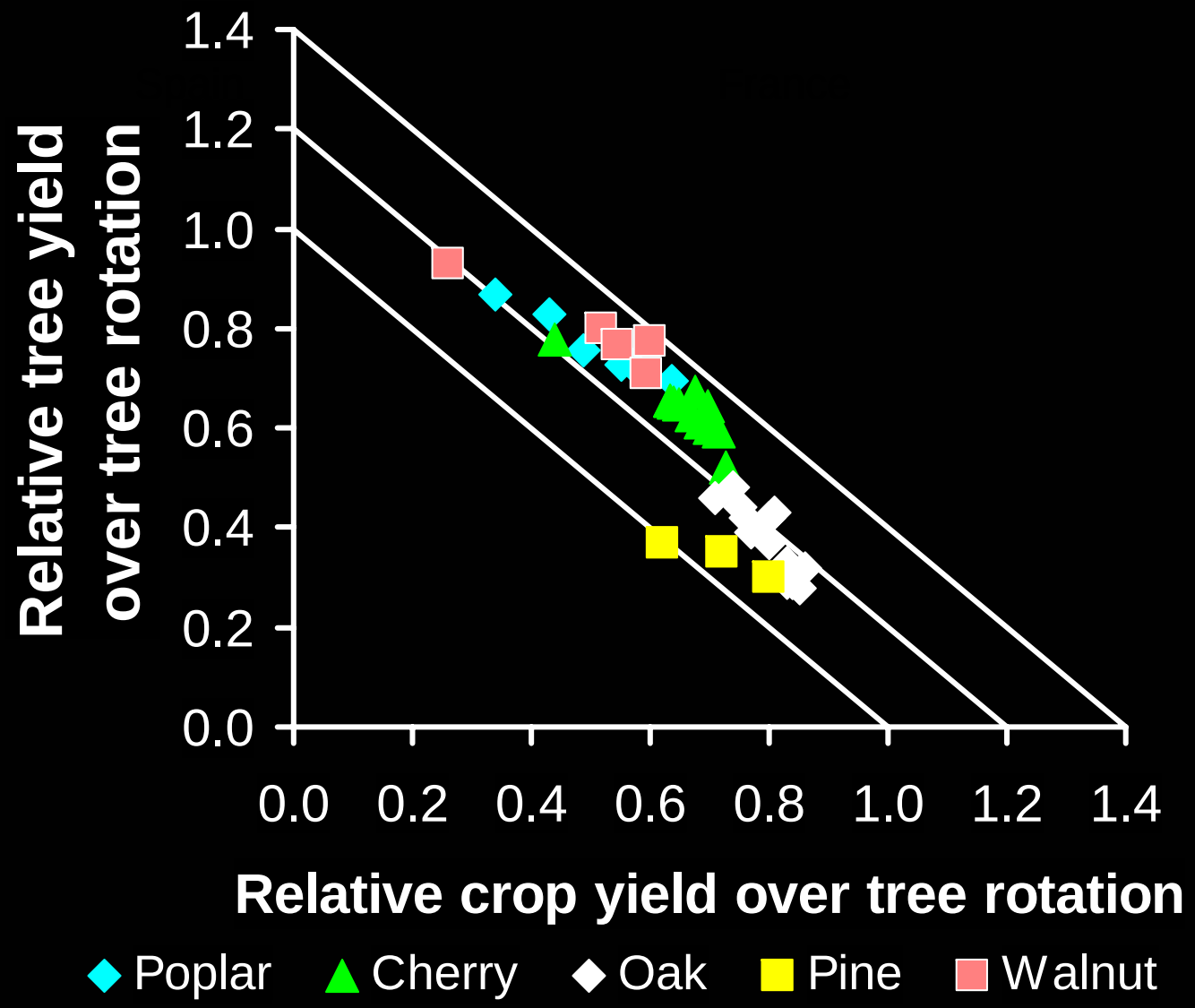
Champlitte

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



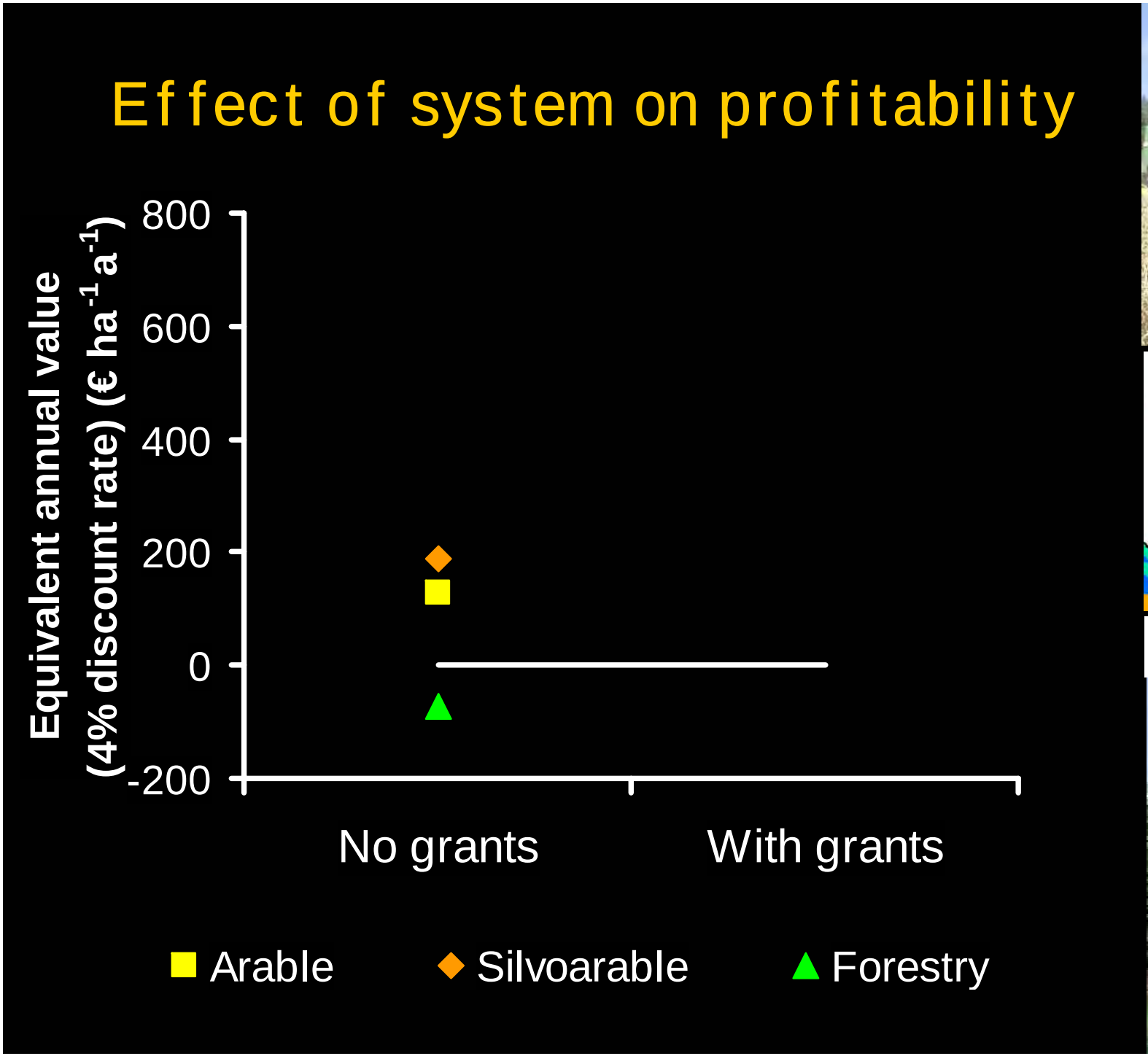


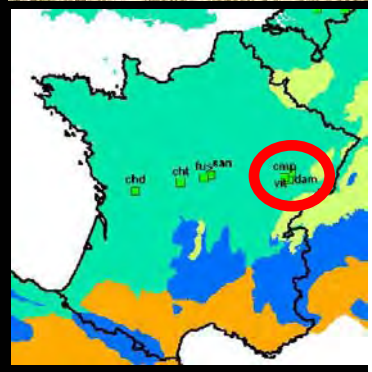
Integrating trees and crops can result in improved site productivity



4. Profitability

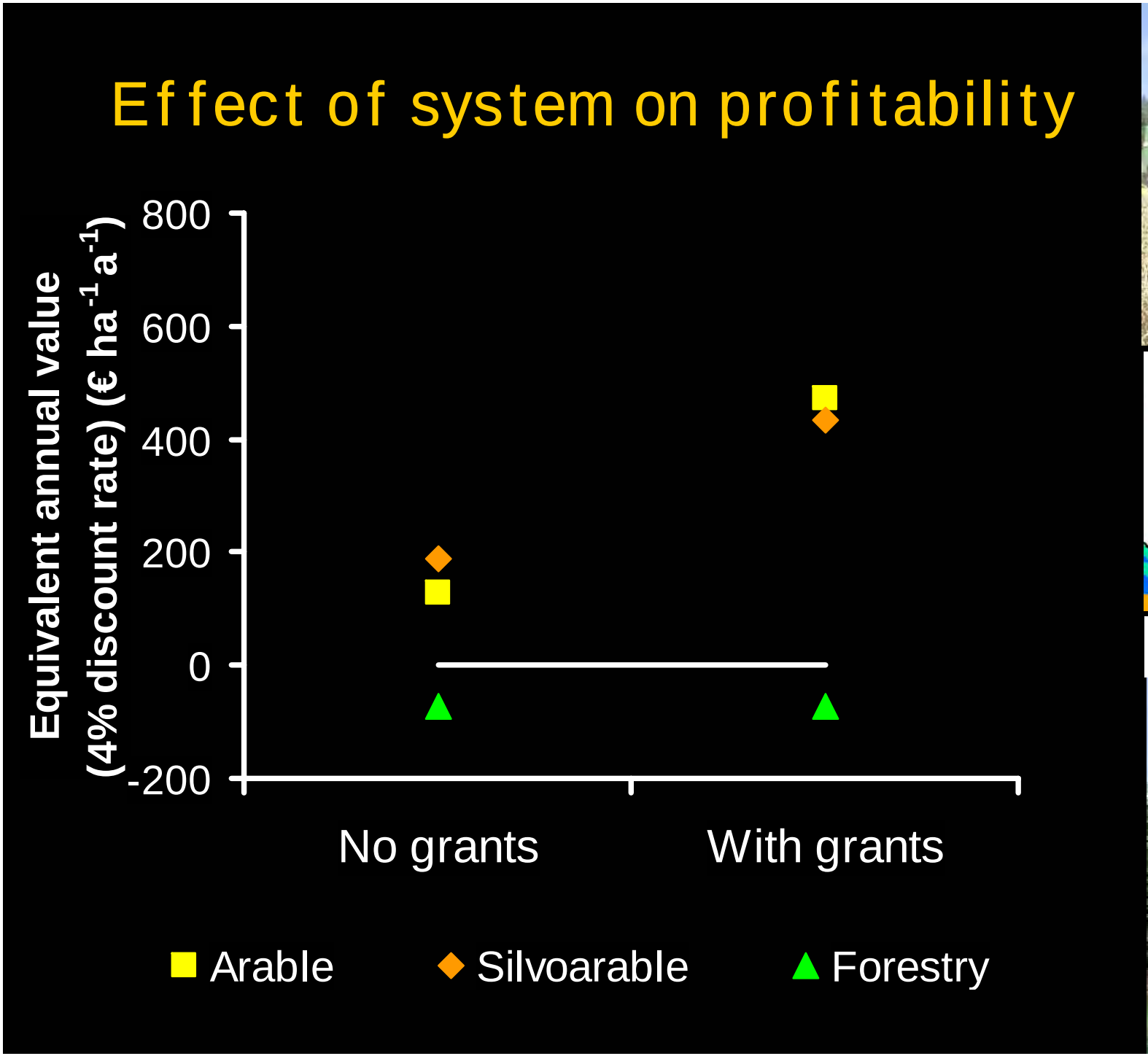
Effect of system on profitability

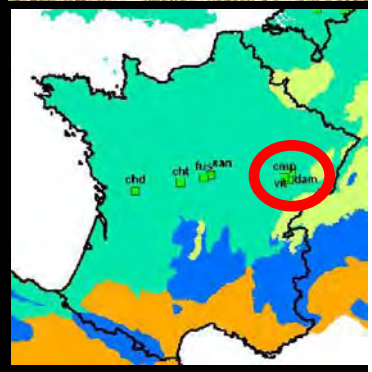




Champlitte

Effect of system on profitability



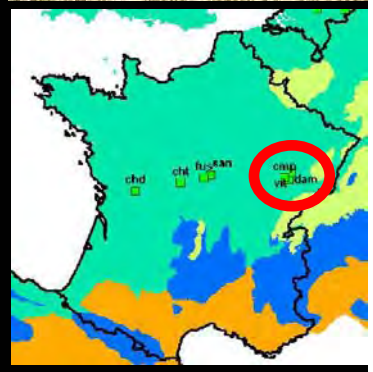


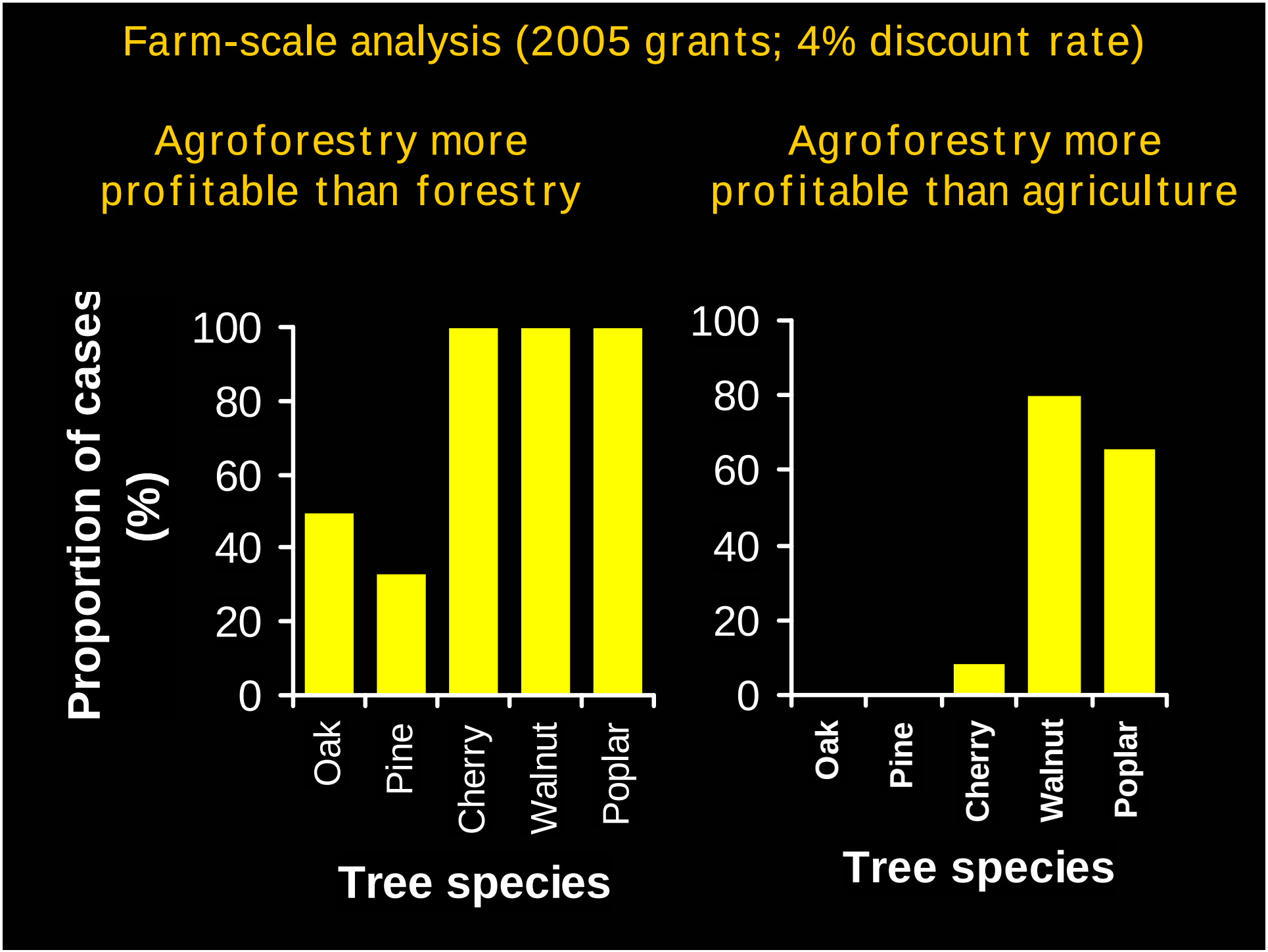
Champlitte

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}




Farm-scale analysis (2005 grants; 4% discount rate)
Agroforestry more profitable than forestry
Agroforestry more profitable than agriculture
Proportion of cases (%)
100
80
60
40
20
0
Oak
Pine
Cherry
Walnut
Poplar
Tree species
100
80
60
40
20
0
Oak
Pine
Cherry
Walnut
Poplar
Tree species

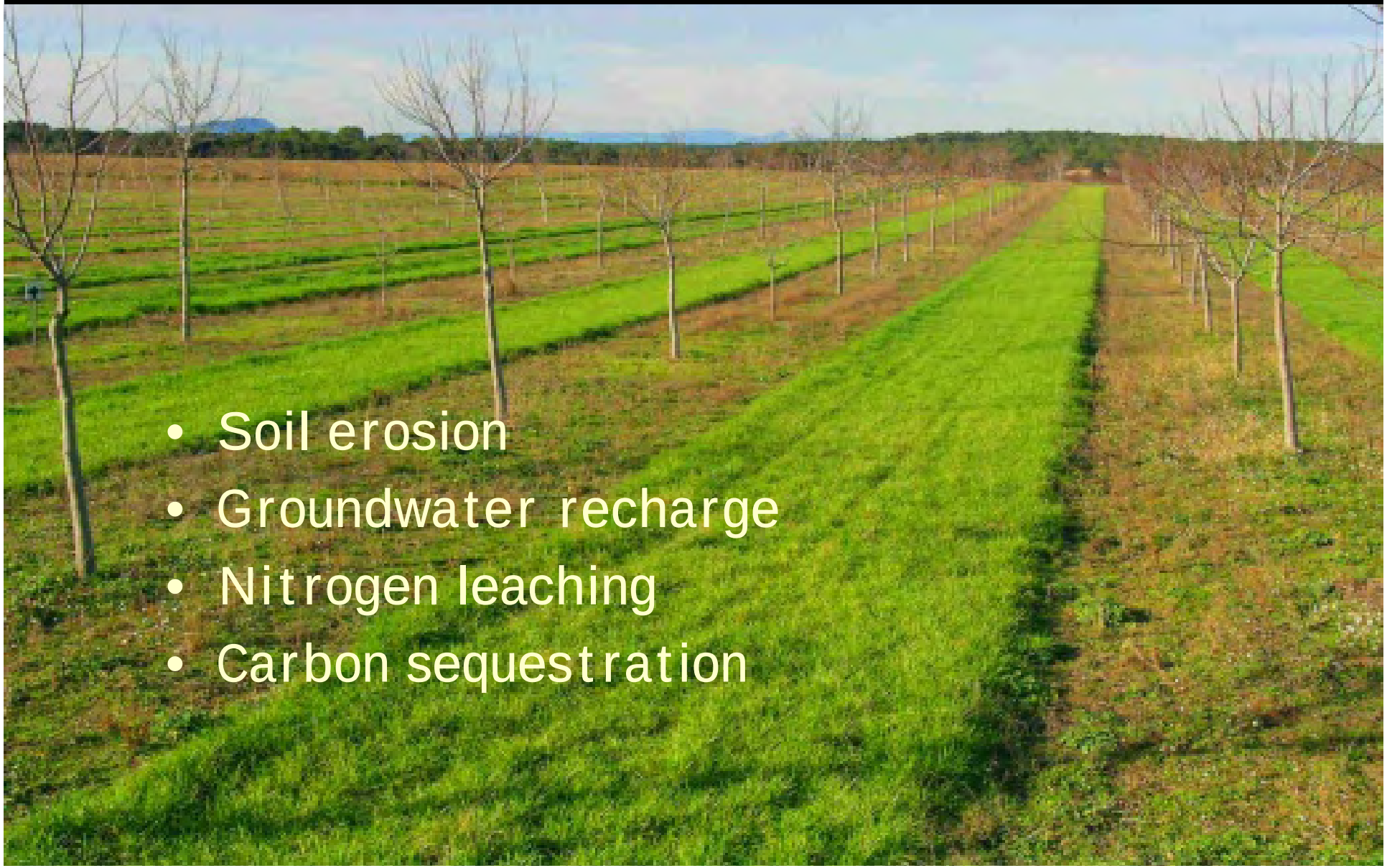
Conclusions: production and economics

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

In France, agroforestry

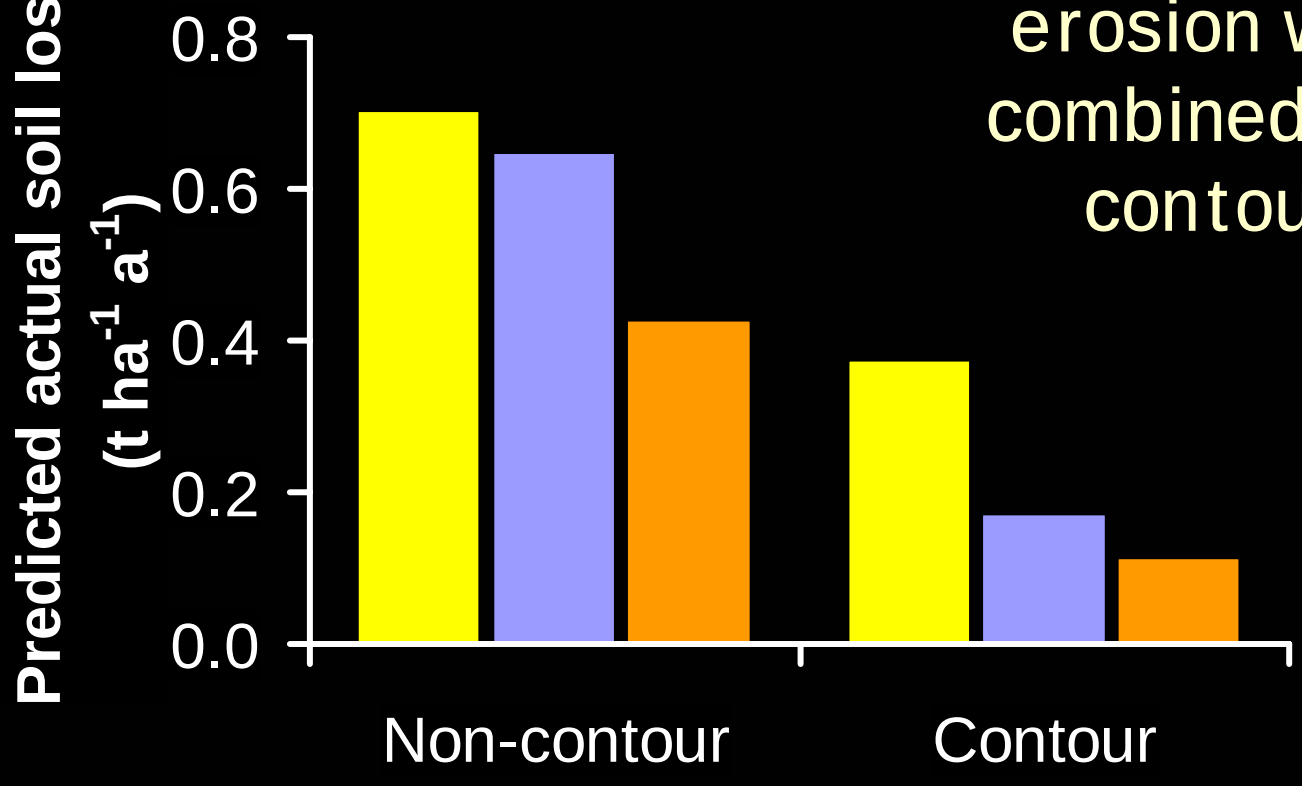
- is often the most profitable way of establishing walnut, cherry and poplar in arable areas
- with walnut and poplar is competitive with arable monocultures
- with current grants, cherry is less profitable than arable systems

5. Environmental regulation

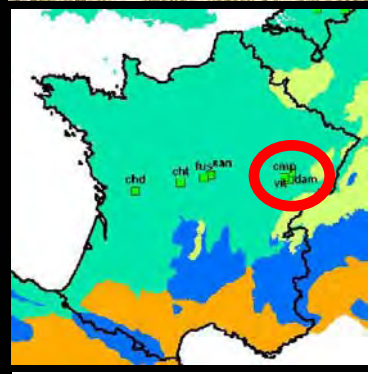


- Soil erosion
- Groundwater recharge
- Nitrogen leaching
- Carbon sequestration

Predicted effect of agroforestry and contours on soil erosion at Champlitte

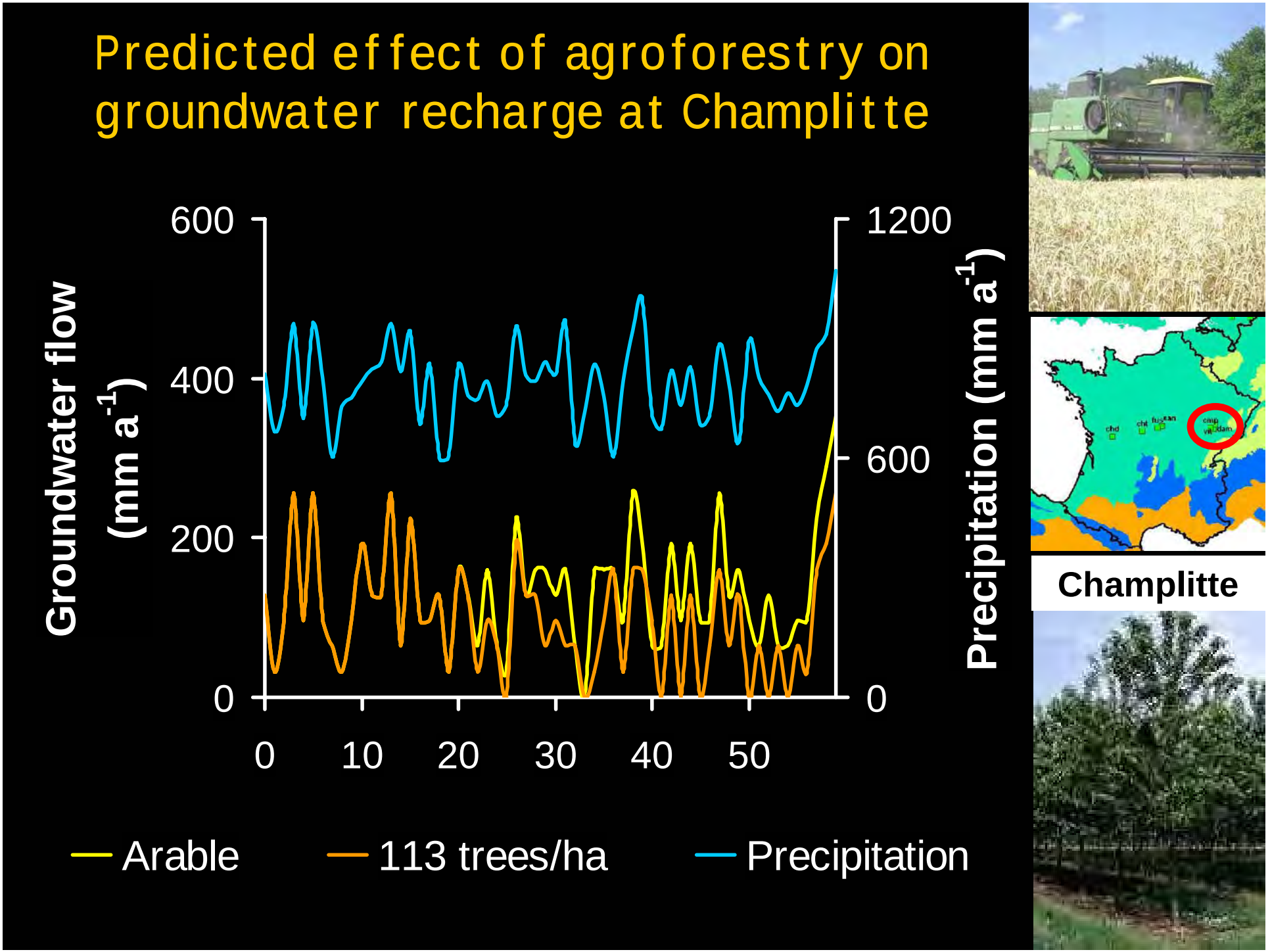


Reduced soil erosion when combined with contours



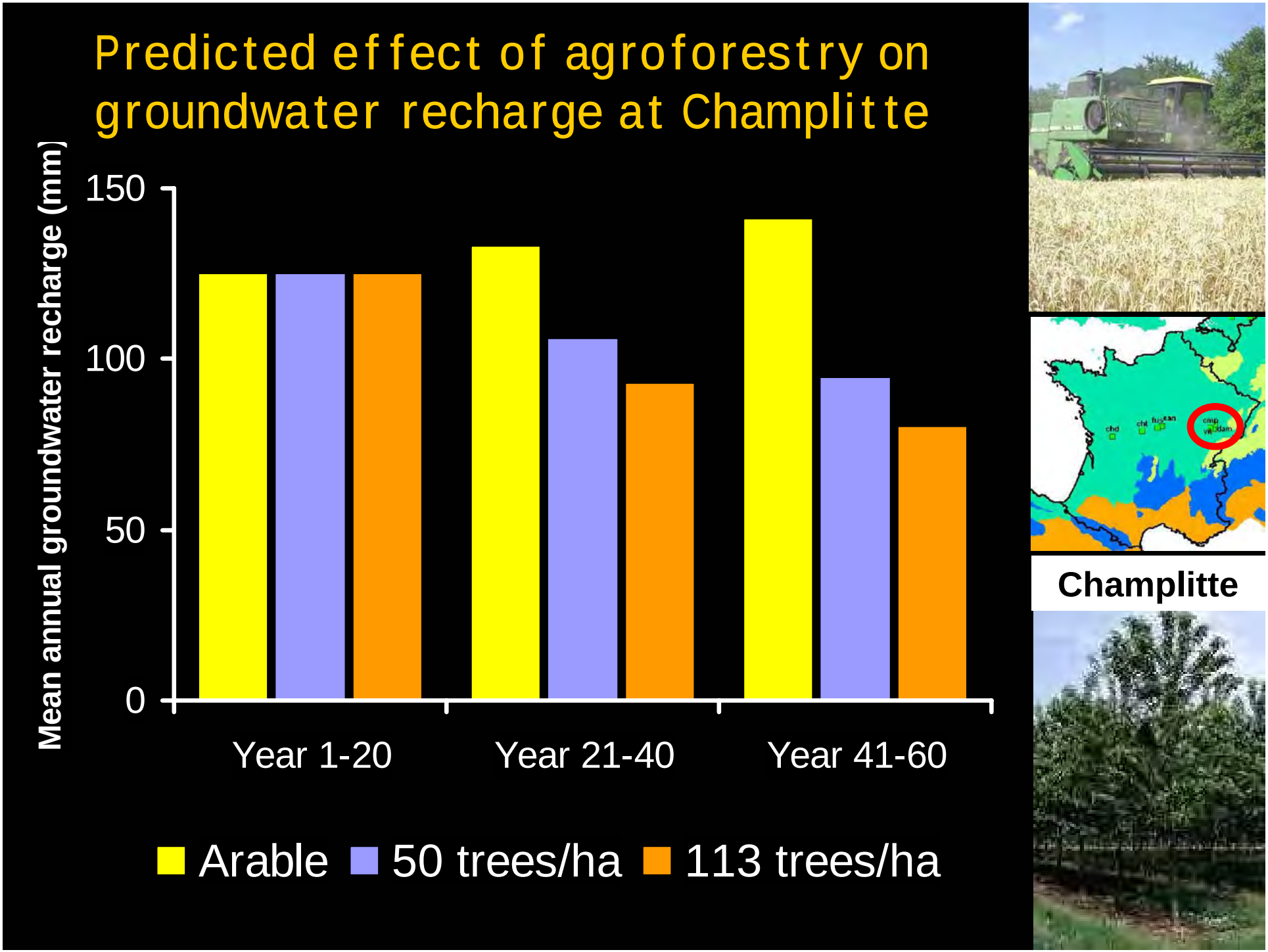
Champlitte

Predicted effect of agroforestry on groundwater recharge at Champlitte



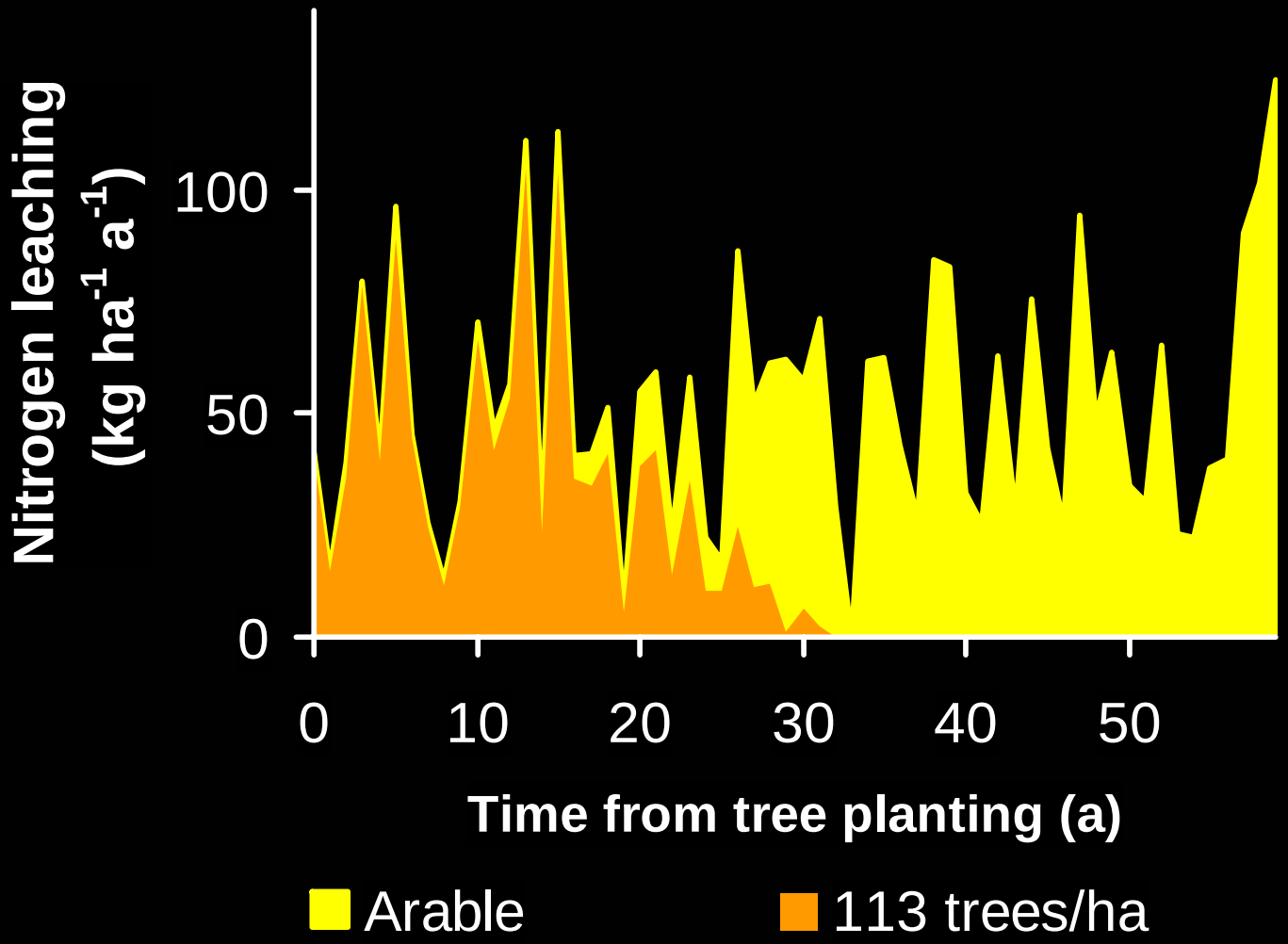
Champlitte

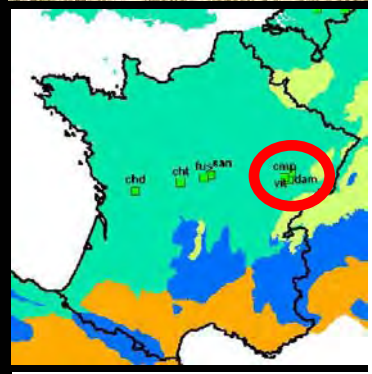
Predicted effect of agroforestry on groundwater recharge at Champlitte



Champlitte

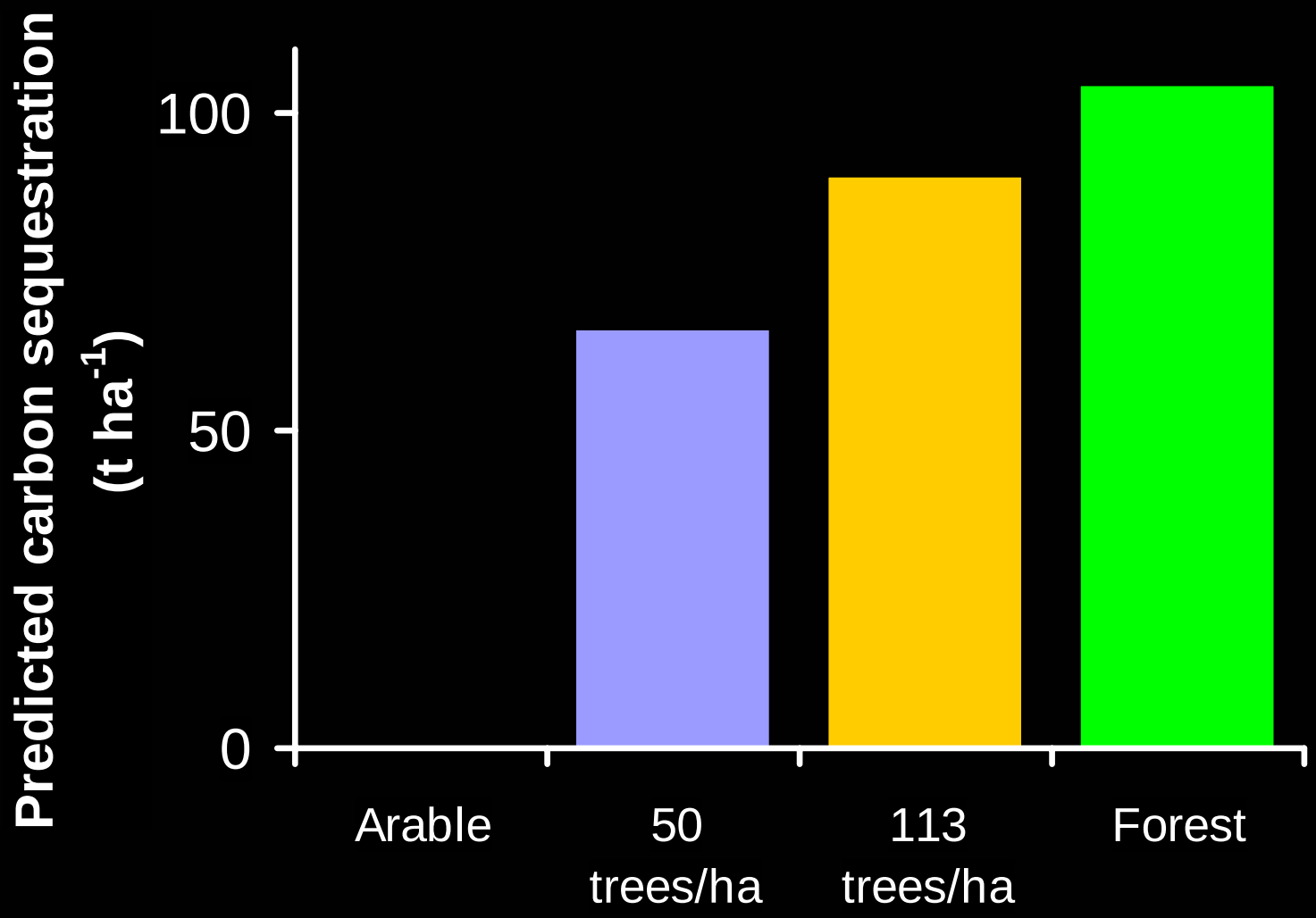
Predicted effect of agroforestry on nitrogen leaching at Champlitte

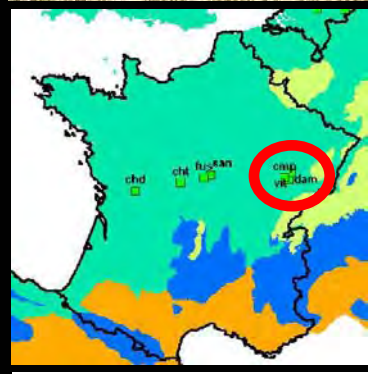




Champlitte

Predicted carbon sequestration over 60 years using wild cherry at Champlitte





Champlitte

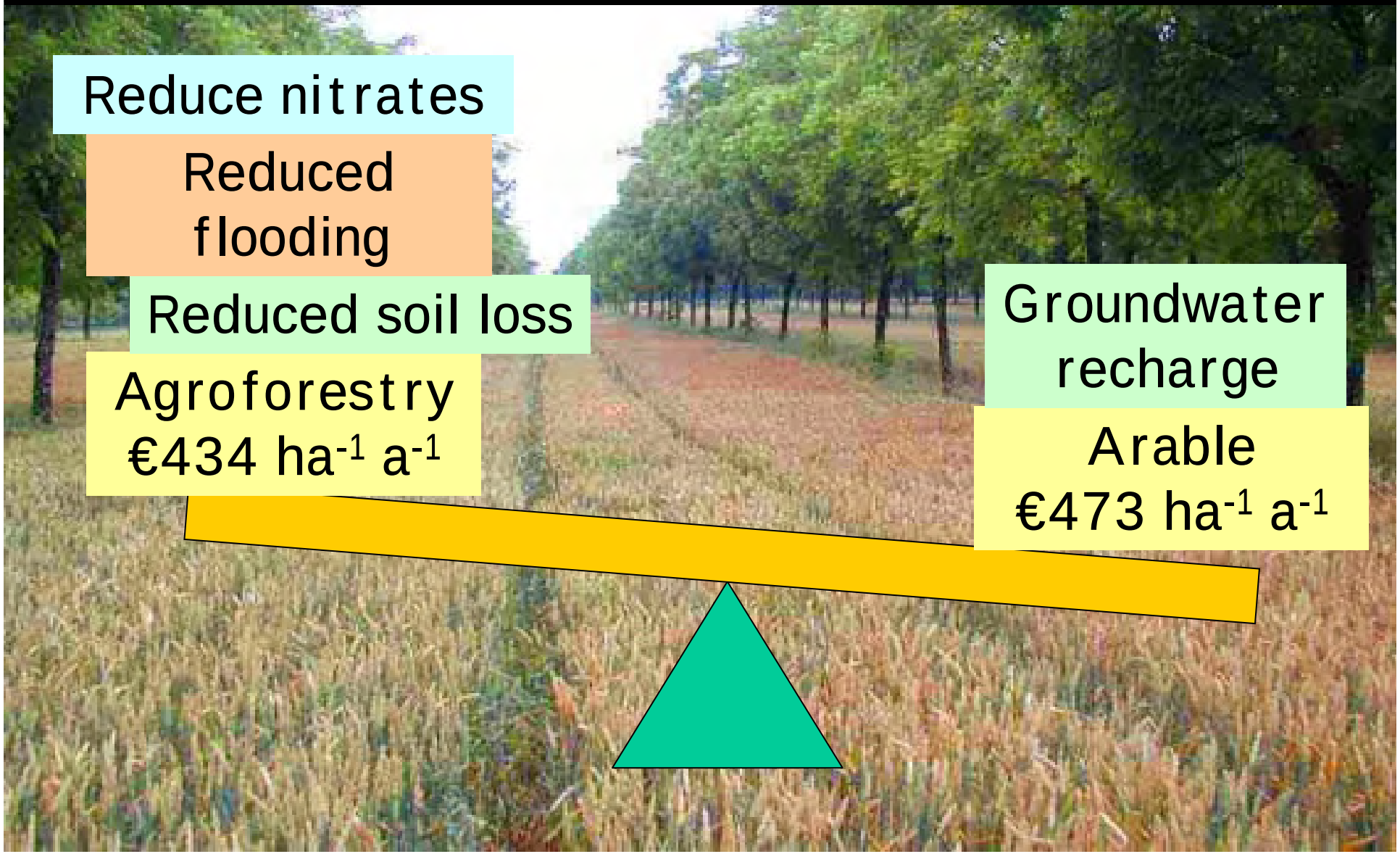
Conclusions: Environment

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

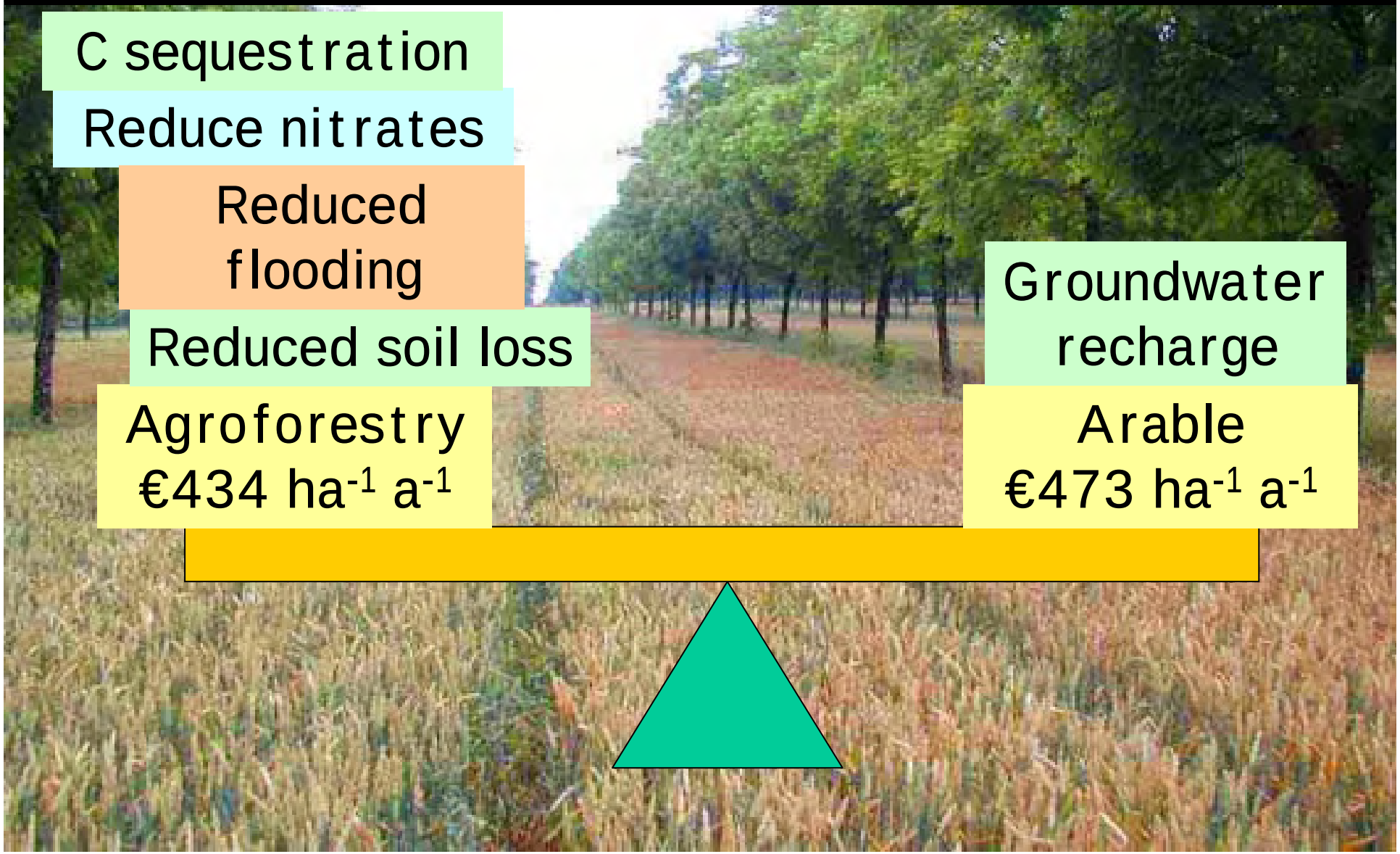
As tree density increased, predicted:

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

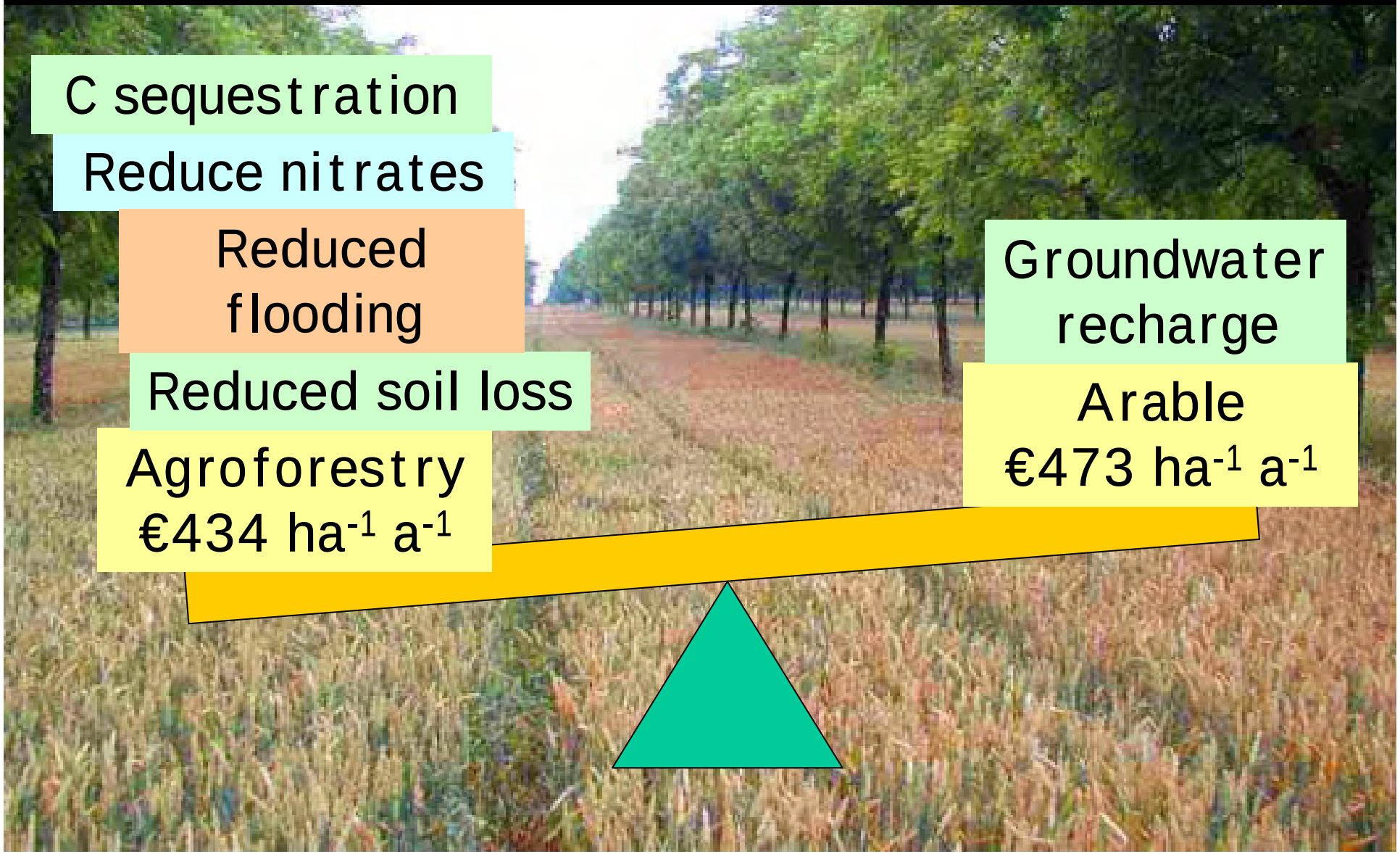
Trade-offs in profitability and environmental regulations



Trade-offs in profitability and environmental regulations



Trade-offs in profitability and environmental regulations



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