Financial and Economic Benefits of Integrated Crop-Livestock-Tree Systems in Europe

Paul J. Burgess[1], Anil R. Graves[1], João H.N. Palma[2], Josep Crous-Duran[2], and Matt Upson[1]

[1]Cranfield University, Cranfield, Bedfordshire, MK43 0AL, UK.
[2]Instituto Superior de Agronomia, Universidade de Lisboa, Portugal
p.burgess@cranfield.ac.uk

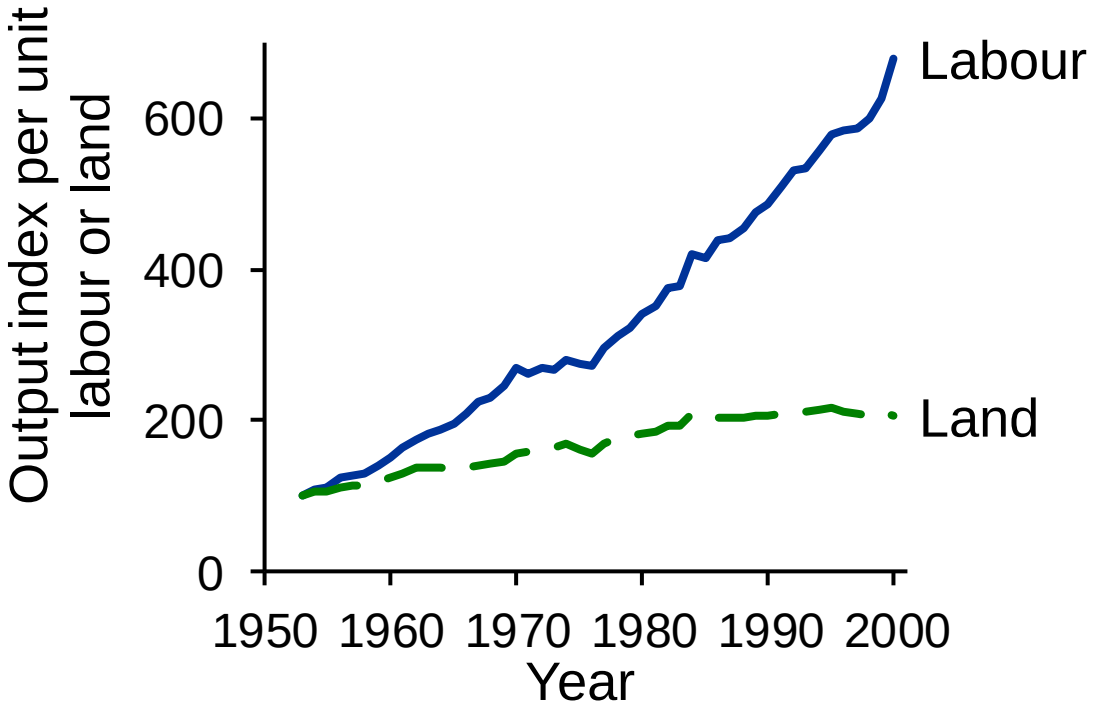
Presentation at World Congress on Integrated Crop-Livestock-Tree Systems, Brasilia, Brazil
14 July 2015

European Union's Seventh Framework Program for research, technological development and demonstration under grant agreement no 613520

Content

- Agricultural monocultures have societal costs
- Role for agroforestry
- Introducing AGFORWARD
- Two case studies on the financial and economic benefits of agroforestry in Europe

Simplification of systems



Separation of arable, livestock, and tree-crop enterprises in Europe has provided production benefits per unit land and per unit labour.

Levels of output per unit of land (dashed line) and unit of labour (solid line) in the UK between 1953 and 2000 (1953=100) (Thirtle and Holding, 2003).

Negative externalities

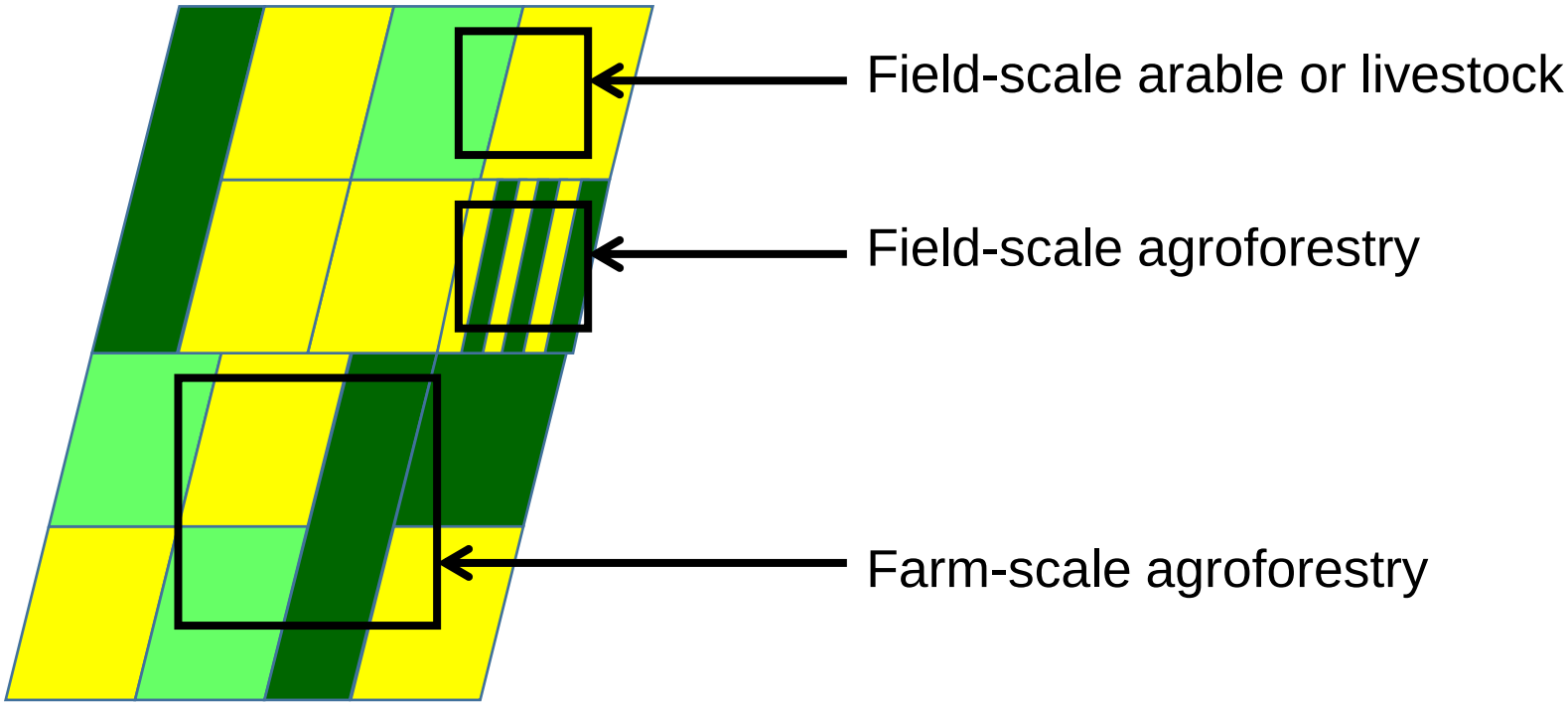
Value of provisioning and other ecosystem services of UK agricultural systems (after Chatterton et al 2014)

Agricultural system	Annual output (£ ha^{-1})	Annual ecosystem dis-services (£ ha^{-1})
Eggs	2114	-325
Pigs	1532	-375
Dairy and dairy beef	1479	-425
Chicken	1433	-277
Arable	634	-308
Suckler beef	422	-194
Sheep	247	25

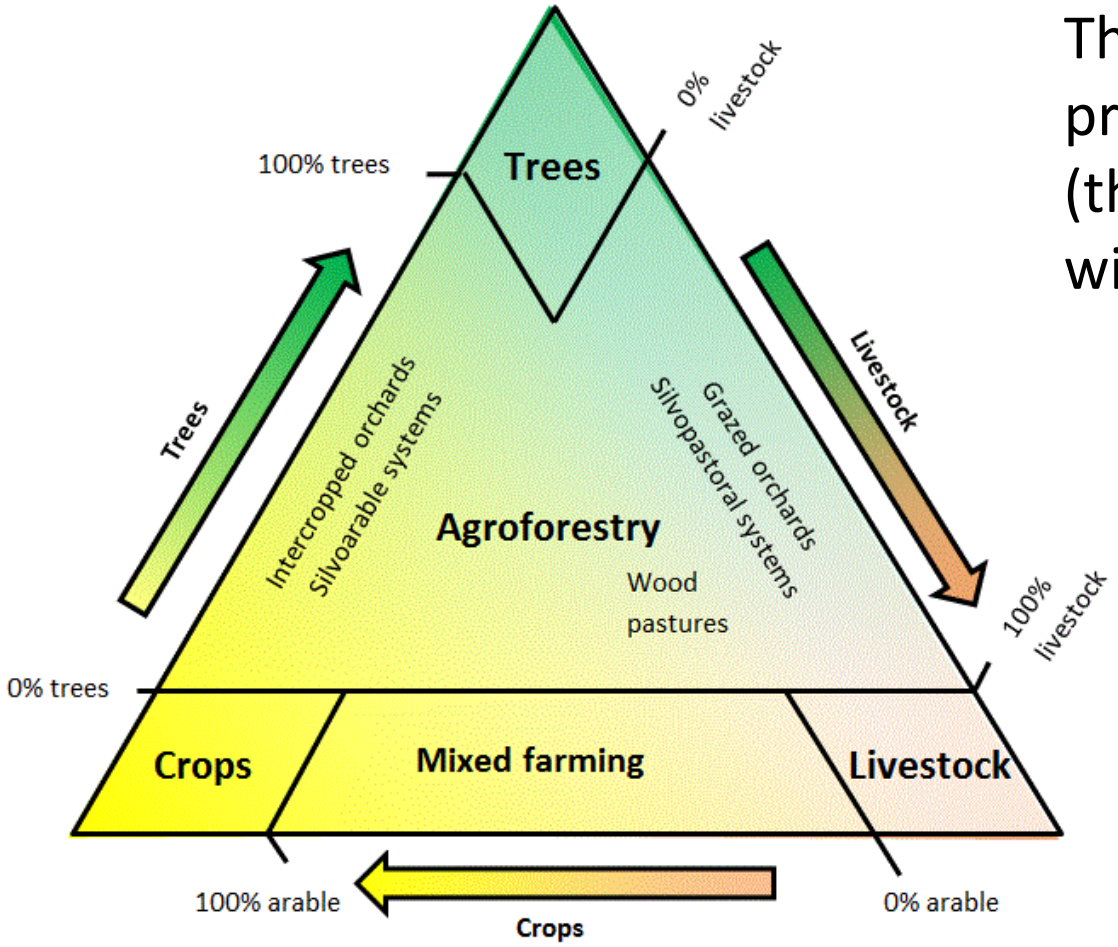
Although agriculture monocultures results in positive outputs of goods, most systems result in ecosystem dis-services (such as greenhouse gas emissions and reduced water quality) which can be valued.

Role for agroforestry

Policy makers in Europe are attracted by agroforestry (crop-livestock-tree systems) to reduce negative externalities.

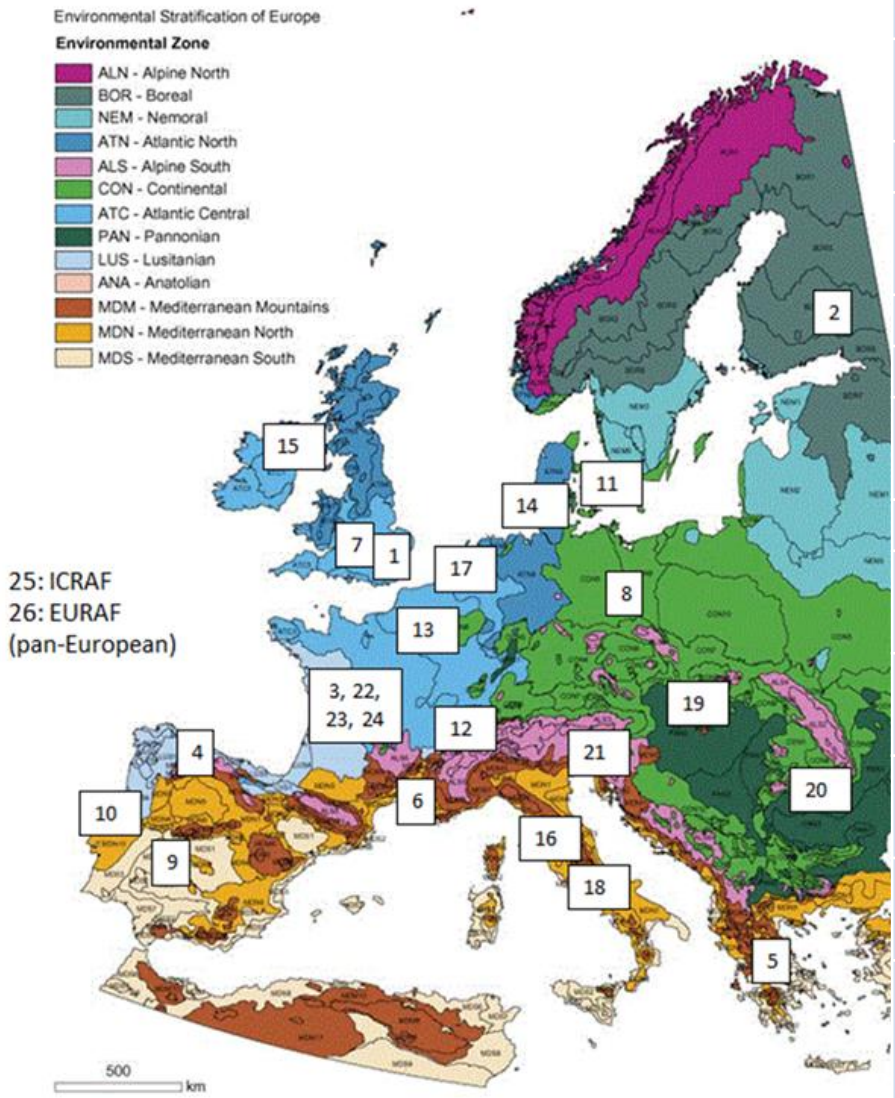


Introducing AGFORWARD



The AGFORWARD project is promoting agroforestry (the integration of trees with farming)

Partners



1.	Cranfield University	14	Aarhus University
2.	European Forest Institute	15	AFBI
3	ACTA	16	CRA
4	University of Santiago de Compostela	17	Louis Bolk Institute
5	TEI Stereas Elladas	18	CNR
6	INRA	19	NYME
7	Organic Research Centre	20	Universitatea Babes-Bolyai
8	BTU Cottbus	21	Veneto Agricoltura
9	Universidad de Extremadura	22	Agroof
10	Instituto Superior de Agronomia, Lisbon	23	APCA
11	University of Copenhagen	24	Association Française d'AgroForesterie
12	Research Station FDEA-ART Zurich	25	World Agroforestry Centre
13	Wervel vzw	26	European Agroforestry Federation

www.agforward.eu

www.facebook.com/AgforwardProject

Establishment on 40 agroforestry stakeholder groups across Europe

800 + farmers and other stakeholders

Legend

- AGFORWARD stakeholder group
- AGFORWARD replicated experiment
- AGFORWARD demonstration or trial site
- Other agroforestry replicated experiment
- Other demonstration and trial site

Agroforestry of high nature and cultural value

Dehesa, Spain and Montado, Portugal

Bocage agroforestry, France

Agroforestry with reindeer, Sweden

Other systems

- Silvopastoral systems with oak, Greece
- Bocage agroforestier, Bretagne, France
- Oak wood pasture in Sardinia, Italy
- Wood pasture, UK
- Agroforestry in the Spreewald floodplain, Germany
- Wood pasture, Hungary
- Wood pasture, Transylvania in Romania

Agroforestry with high value trees

Intercropping and grazing of olive systems in Italy

Intercropping oranges in Greece

Grazed orchards in England, Northern Ireland, and France

Other systems

- Chestnut agroforestry, Galicia, Spain
- Intercropping and grazing of walnut plantations in Spain
- Intercropping of olives in Greece
- “Bordure” trees in France

Integrating trees into arable systems

Switzerland

Mediterranean regions of France

Italy

Other systems

- Alley cropping, Hungary
- Trees in arable systems in Greece
- Silvoarable agroforestry in S.W. France
- Silvoarable agroforestry in Western France
- Silvoarable agroforestry in Northern France
- Silvoarable agroforestry in UK
- Alley cropping in Germany

Integrating trees into livestock systems

Agroforestry with Celta pigs in Spain

Poultry agroforestry in the UK

Agroforestry with ruminants, France

Other systems

- Agroforestry for poultry in the Netherlands
- Agroforestry with organic poultry in Denmark
- Agroforestry with free-range pigs, Italy
- Agroforestry with free-range pigs, Denmark
- Fodder trees for goats and sheep in the Netherlands

Developed research protocols

Each group has developed a protocol, available on the AGFORWARD website.

About 20-30% of the interventions are being addressed by a clearer assessment of the inputs and outputs of the systems using biophysical and economic models

Case study 1: Woodland eggs in the UK
(Burgess et al., 2014)

Price (£ per six eggs) of free range and woodland eggs (source: retailers' websites, April 2014)

Supermarket	Free-range	Woodland
Aldi	1.00	1.19
Morrisons	1.39	1.59

UK consumers are willing to pay a premium of £0.20 for six woodland eggs in two supermarkets

UK egg packers are willing to give a price premium of £0.01 for six woodland eggs compared to "free-range" (IGD, 2008)

Financial analysis of woodland eggs
(Burgess et al. 2014)

Benefits	(£ ha^{-1} a^{-1})
Price premium (1 p per 6 eggs)	933
Improved egg quality (less seconds)	327
Sub-total	1260

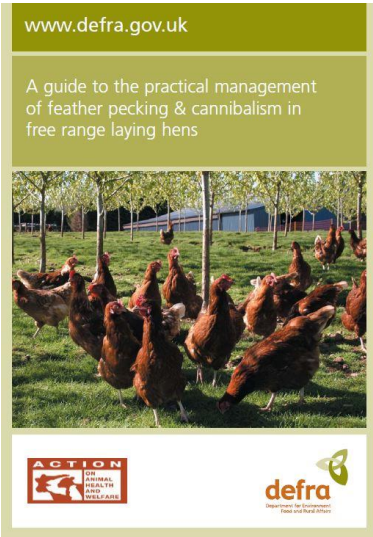
Assumed one-off costs	(£ ha^{-1})
Cost of tree planting	380
Reduction in land value	1700

Assumed annual costs	(£ ha^{-1} a^{-1})
Loss of more eggs in the field	174
Maintenance cost of trees	60
Sub-total	234

Financial analysis: benefits and costs to the farmer

Assuming a premium of 1 pence per six woodland eggs and an 8% discount rate, a farmer could gain an additional £700 ha^{-1} (3500 R$ ha^{-1}) per year over the first 15 years.

Economic (societal) benefits



Animal welfare: Injurious feather pecking
Bright and Joret (2012) also report reduced injurious feather pecking by laying hens in a woodland environment

Ammonia capture and carbon sequestration benefits of the trees is small: less than 0.01 pence per six eggs

Amenity value of the trees (calculated using the Arboriculture Asssociation method) may be worth up to 0.18 pence per six eggs

Woodland eggs make sense from financial and economic perspectives

Case study 2: Financial analysis of trees in arable systems

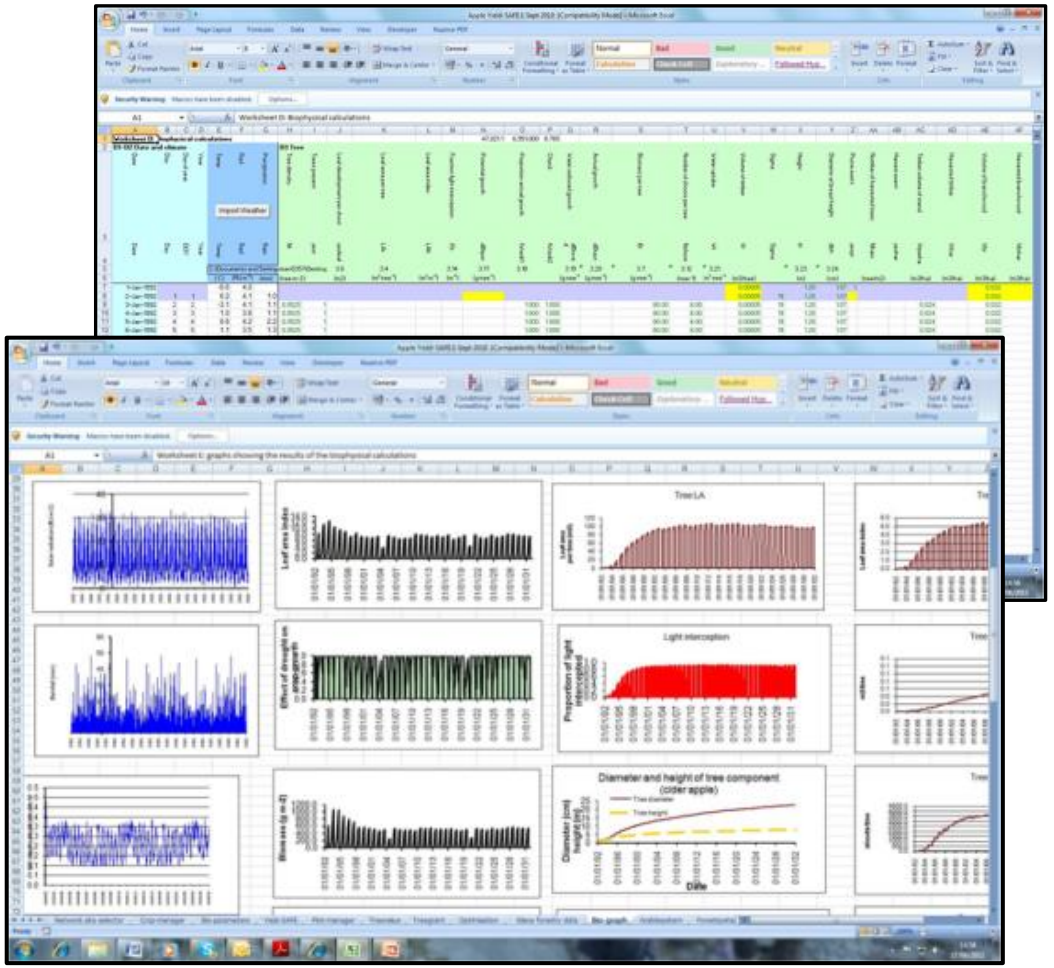
Unfortunately trees in Europe do not grow as fast as in Brazil

There is increasing interest in tree planting in arable systems, particularly in France where it is possible to grow high value trees within rotations of 40-60 years.

Biophysical models

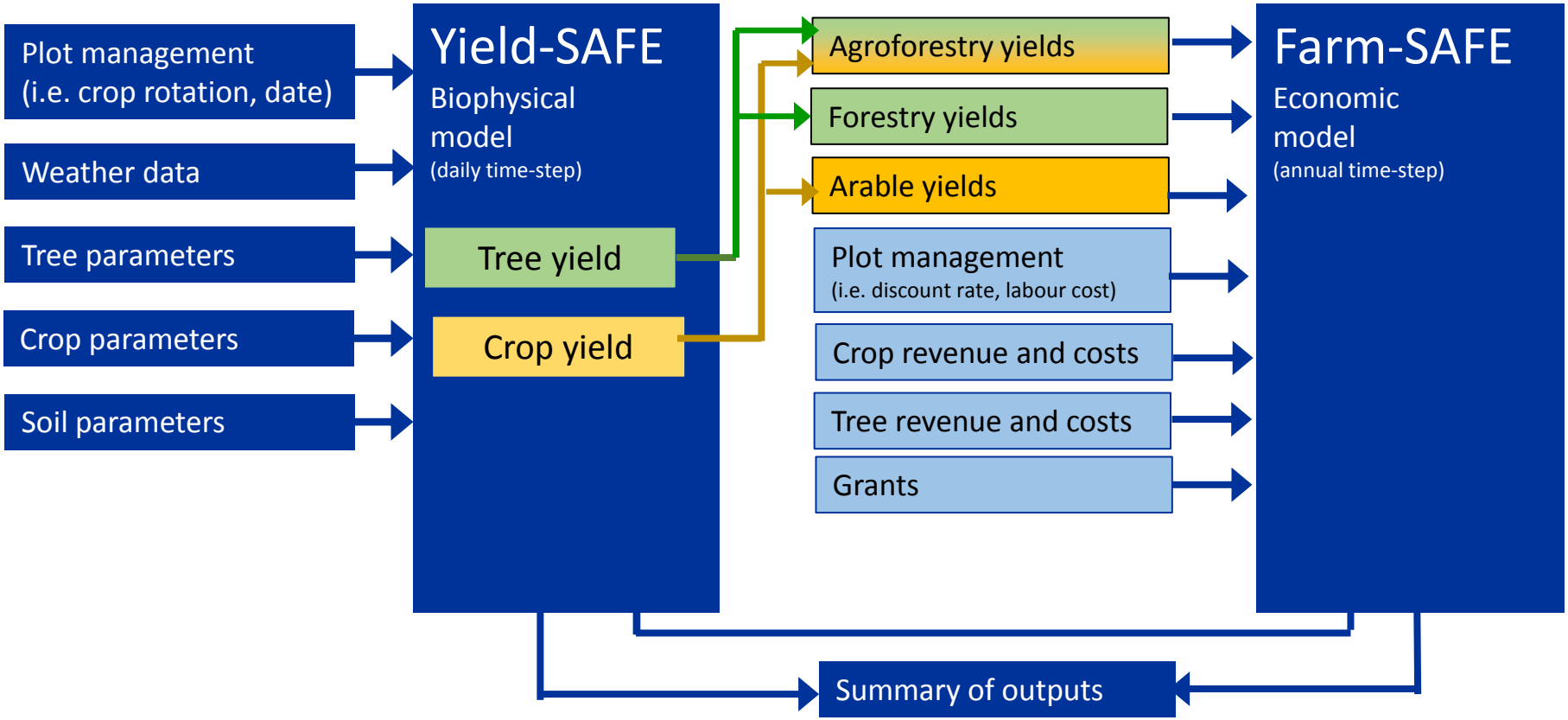
We cannot wait 60 years, so we use a parameter-sparse biophysical model called **Yield-SAFE** to describe tree, grass and arable yields on a daily time-step in different combinations
(van der Werf et al, 2007)

A more detailed 3-D model called **Hi-sAFe** has also been developed by INRA



Financial analysis using Farm-SAFE

A spreadsheet model to integrate the results of the biophysical model with data on costs, values, and grants, and discount rates



Case study 2: Financial analysis for silvoarable systems

Equivalent annual value (EAV) (2005) of silvoarable systems compared with arable and forestry monocultures in W. France (Graves et al., 2007)

Wild cherry	Without grants (€ ha^{-1} a^{-1})	With EU grants (€ ha^{-1} a^{-1})
Arable	14	381
Forestry	-111	63
Silvoarable	68	336

Walnut	Without grants (€ ha^{-1} a^{-1})	With EU grants (€ ha^{-1} a^{-1})
Arable	91	459
Forestry	227	394
Silvoarable	296	504

Case study 2: Financial analysis for silvoarable systems

Equivalent annual value (EAV) (2005) of silvoarable systems compared with arable and forestry monocultures in W. France (Graves et al., 2007)

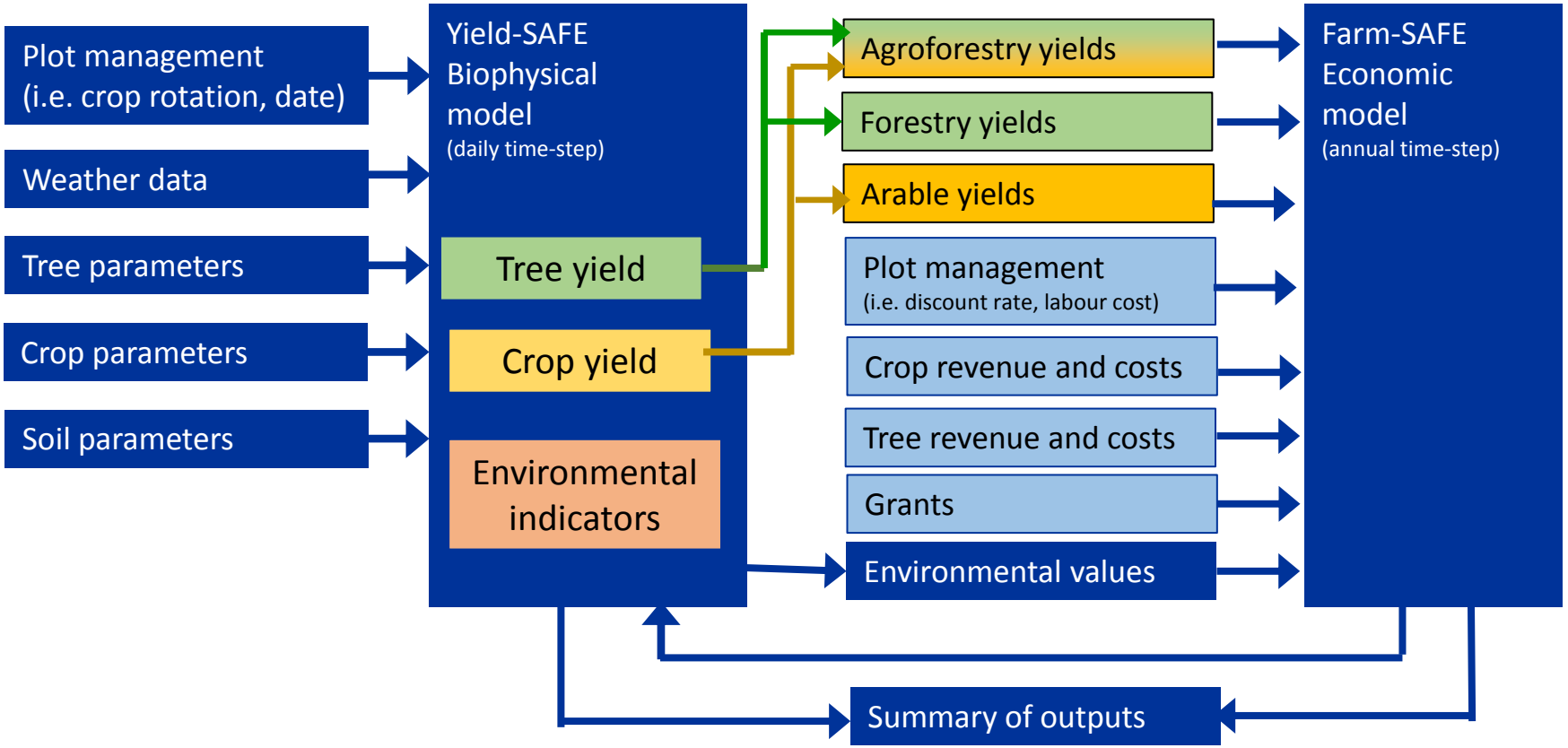
Wild cherry	Without grants (€ ha^{-1} a^{-1})	With EU grants (€ ha^{-1} a^{-1})

Note: these values from 2005 do not include the management and administrative costs associated with complexity

	(€ ha^{-1} a^{-1})	(€ ha^{-1} a^{-1})
Arable	91	584
Forestry	227	417
Silvoarable	296	598

Economic analysis using Farm-SAFE

A spreadsheet model to integrate the results of the biophysical model with data on costs, values, and grants, and discount rates



Environmental services provided by agroforestry

Equivalent annual value (EAV) of silvoarable systems relative to arable monoculture, assuming discount rate of 4% (after Andreola, 2014).

Cherry	Wild cherry (€ ha^{-1} a^{-1})	Walnut (€ ha^{-1} a^{-1})
Carbon sequestration[1]	36	99
Improved water quality[2]	42	42
Improved air quality[3]	3	3
Sub-total	81	144

[1] Assuming Carbon price increasing from 0 in 2020 to £30 per t C from 2050.

[2] Assuming reduction in nitrogen leaching

[3] Assuming reduction of pollution due to NO_2, SO_2, PM_{10} and $PM_{2.5}$

Conclusions

- Through AGFORWARD (www.agforward.eu) the EU is seeking to promote trees in agriculture in Europe
- We are working with over 800 farmers and other stakeholders
- We are developing existing financial and economic analysis tools (Yield-SAFE and Farm-SAFE) to predict the financial and economic effects of integrated crop-livestock-tree systems, relative to existing practice
- There are systems that work
- Tools to address complexity?
- Join us at https://www.facebook.com/AgforwardProject

References

AGFORWARD (2015). AGFORWARD website. www.agforward.eu

Andreola S (2014). Assessing the economic externalities of silvoarable agroforestry: an ecosystem services approach. Unpublished MSc thesis September 2014. Cranfield University

Bright A and Joret A (2012) Laying hens go undercover to improve production. Veterinary Record 170: 228

Burgess, P.J. and Morris, J. (2009). Agricultural technology and land use futures: the UK case. *Land Use Policy* 26S: S222-S229.

Burgess PJ, Belot V, Buachie E, Cuartero de Frias F, Nedved K, Rodriguez Arquero E (2014). The economics of woodland eggs in the UK. In: 2nd European Agroforestry Conference 4-6 June 2014, Cottbus, Germany Book of Abstracts. 67-70.

Burgess, P.J., Sanchez Martinez, P.J., Williams, A.G. (2015). At what scale should livestock-forest systems be considered? Poster at World Congress of Integrated Crop-Livestock-Forest Systems. 12-17 July 2015, Brasilia, Brazil

Burgess PJ, Crous-Duran J, den Herder M, Fagerholm N, Freese D, Garnett K, Graves AR, Hermansen JE, Liagre F, Mirck J, Moreno G, Mosquera-Losada MR, Palma JHN, Pantera A, Plieninger T, Upson M (2015). AGFORWARD Project Periodic Report: January to December 2014. Cranfield University: AGFORWARD.

Chatterton, J., Graves, A., Audsley, E., Morris, J., & Williams ,A.(2014). Using systems-based LCA to investigate the environmental and economic impacts and benefits of the livestock sector in the UK. Journal of Cleaner Production In Press, Accepted Manuscript, Available online 15 July 2014

References

Graves, A.R., Burgess, P.J., Palma, J.H.N., Herzog, F., Moreno, G., Bertomeu, M., Dupraz, C., Liagre, F., Keesman, K., van der Werf, W. Koeffeman de Nooy, A. & van den Briel, J.P. (2007). Development and application of bio-economic modelling to compare silvoarable, arable and forestry systems in three European countries. *Ecological Engineering* 29: 434-449.

Graves, A.R., Burgess, P.J., Liagre, F., Terreaux, J-P., Borrel, T, Dupraz, C., Palma, J. & Herzog, F. (2011). Farm-SAFE: the process of developing a plot- and farm-scale model of arable, forestry and silvoarable economics. *Agroforestry Systems* 81: 93-108.

Palma, J.H.N., Graves, A.R., Bunce, R.G.H., Burgess, P.J., de Filippi, F., Keesman, K.J., van Keulen, H., Liagre, F., Mayus, M., Moreno, G., Reisner, Y. & Herzog, H. (2007). Modeling environmental benefits of silvoarable agroforestry in Europe. *Agriculture, Ecosystems and Environment* 119: 320-334.

Palma, J.H.N., Graves, A.R., Burgess, P.J. & Herzog, F. (2007) Integrating environmental and economic performance to assess modern silvoarable agroforestry in Europe. *Ecological Economics* 63: 759-767.

Palma, J.H.N., Graves, A.R., Burgess, P.J., Keesman, K.J., van Keulen, H., Mayus, M., Reisner, Y. & Herzog, F. (2007). Methodological approach for the assessment of environment effects of agroforestry at the landscape scale. *Ecological Engineering* 29: 450-462.

Thirtle, C., and Holding, J. (2003) Productivity in UK Agriculture: Causes and Constraints. Report to Department for Environment, Food and Rural Affairs. Wye, Kent: Imperial College

van der Werf, W., Keesman, K., Burgess, P.J., Graves, A.R., Pilbeam, D, Incoll, L.D, Metselaar, K., Mayus, M., Stappers, R., van Keulen, H., Palma, J & Dupraz, C. (2007). Yield-SAFE: a parameter-sparse process-based dynamic model for predicting resource capture, growth and production in agroforestry systems. *Ecological Engineering* 29: 419-433.

www.agforward.eu

Thank you

AGFORWARD (Grant Agreement N° 613520) is co-funded by the European Commission, Directorate General for Research & Innovation, within the 7th Framework Programme of RTD. The views and opinions expressed in this presentation are purely those of the writers and may not in any circumstances be regarded as stating an official position of the European Commission.