Profits from productive trees in your farming system

Stephen Briggs

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FARMERS WEEKLY

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Philip Clarke

Friday 5 August 2016 9:30

INDEPENDENT

Soil erosion a major threat to Britain's food supply, says Government advisory group

The Committee on Climate Change (CCC) report says the UK will be in danger of producing less food in the coming decades

Tom Bawden | @BawdenTom | Monday 29 June 2015 | 16 comments

HM Government

A Green Future: Our 25 Year Plan to Improve the Environment

FARMERS WEEKLY

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Tuesday 21 October 2014 8:51

Philip Case

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By Roger Harrabin
BBC environment analyst

2 June 2016 | Science & Environment

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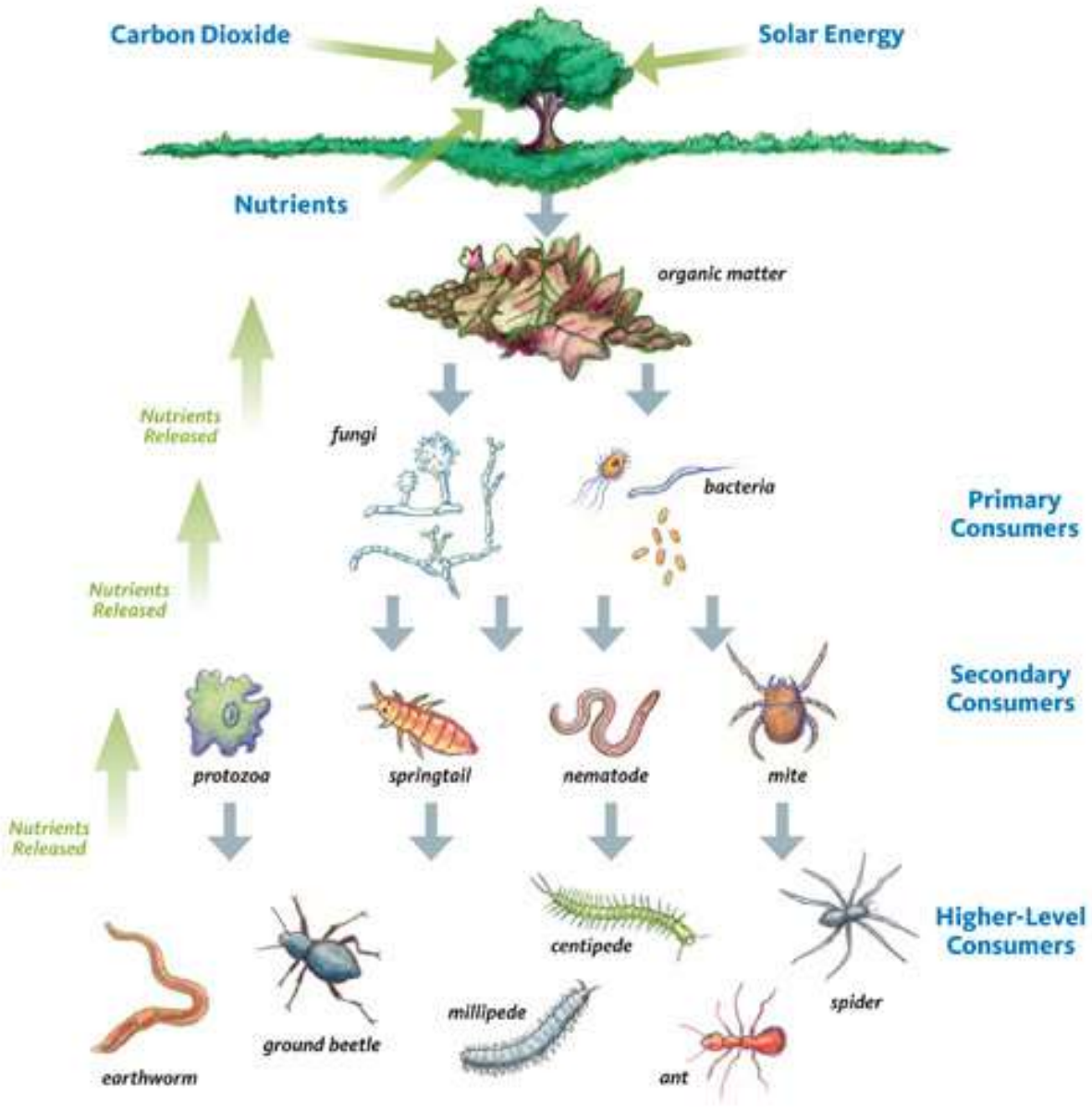
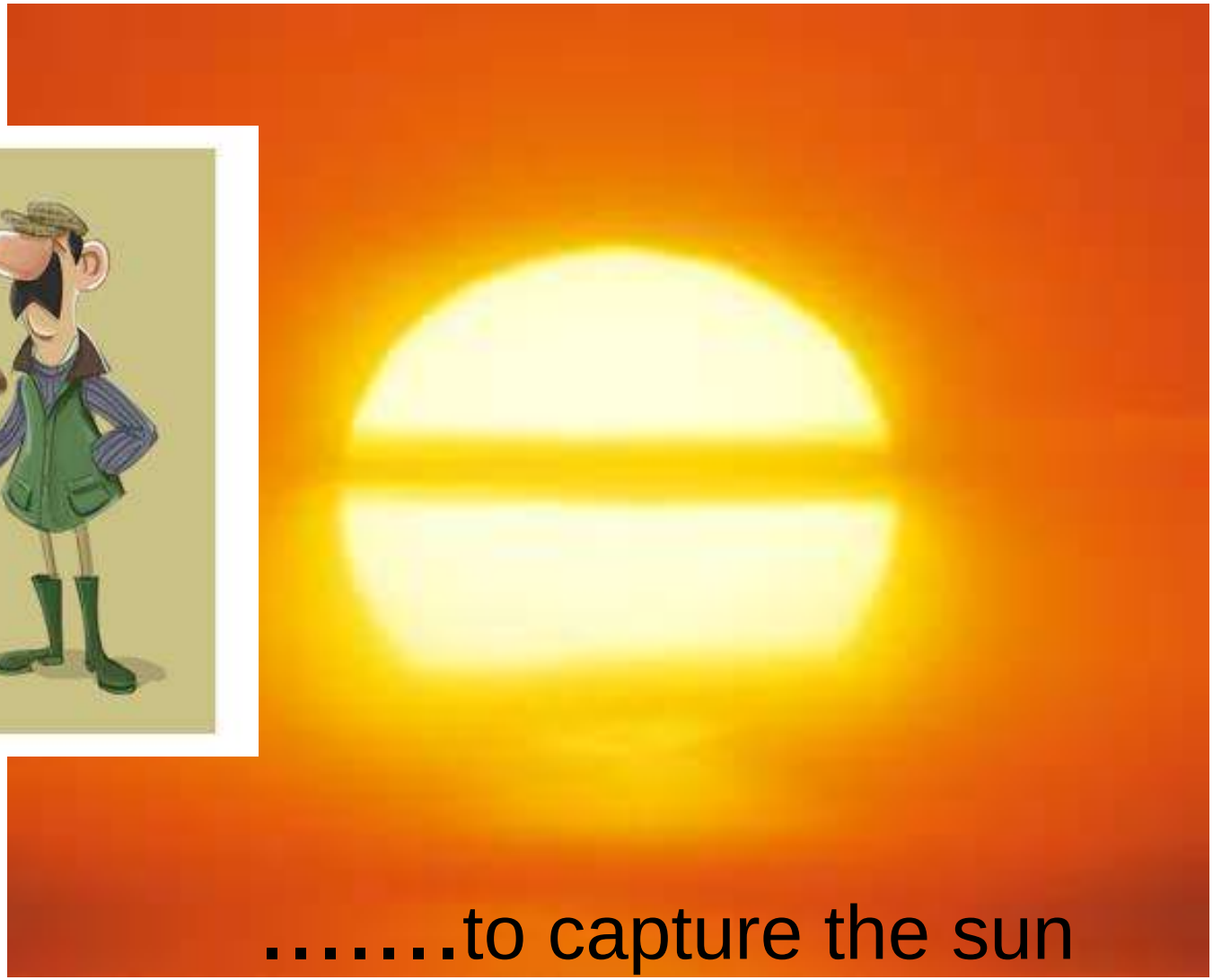
Soil food web



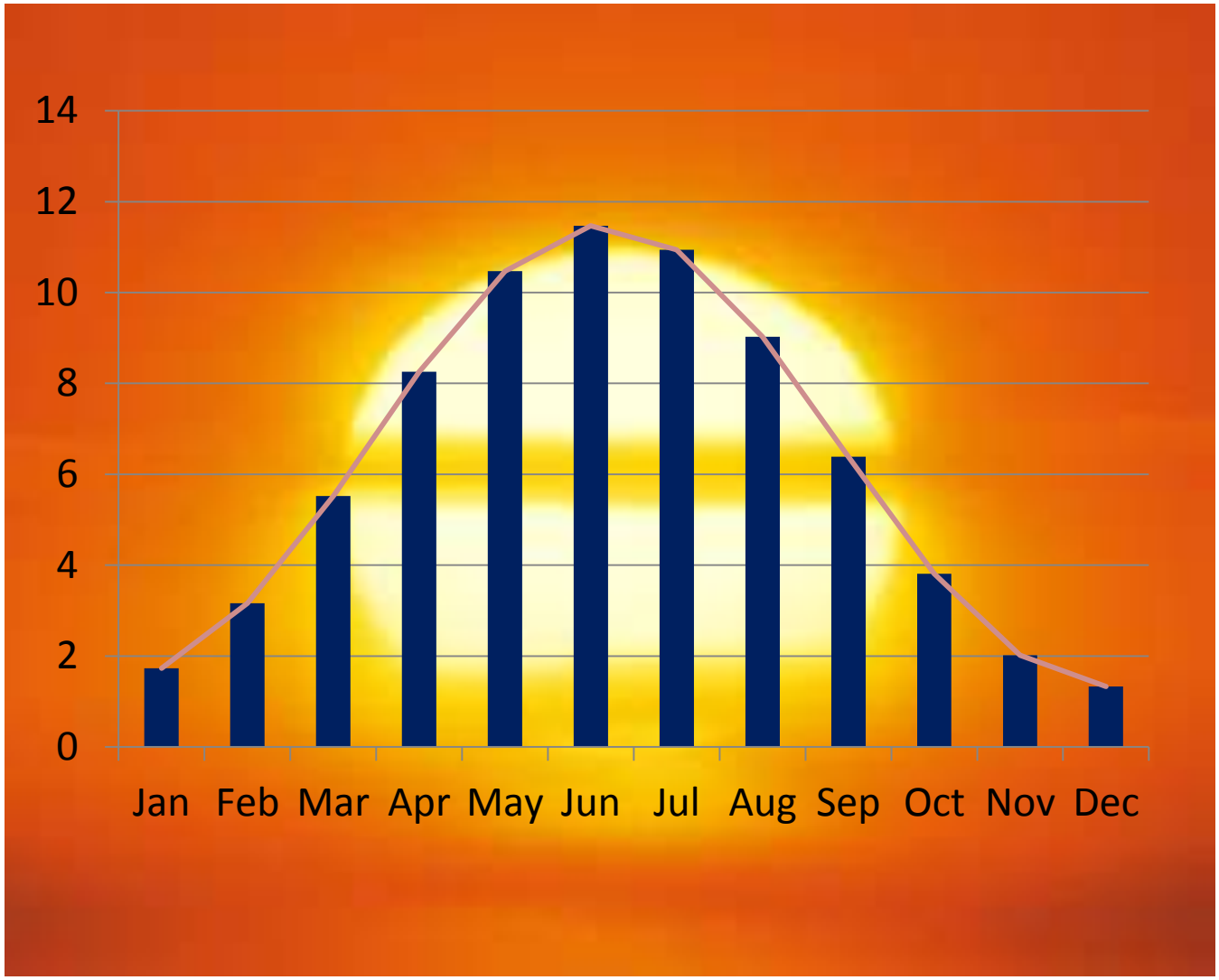
What is a farmers job.....



.....to capture the sun

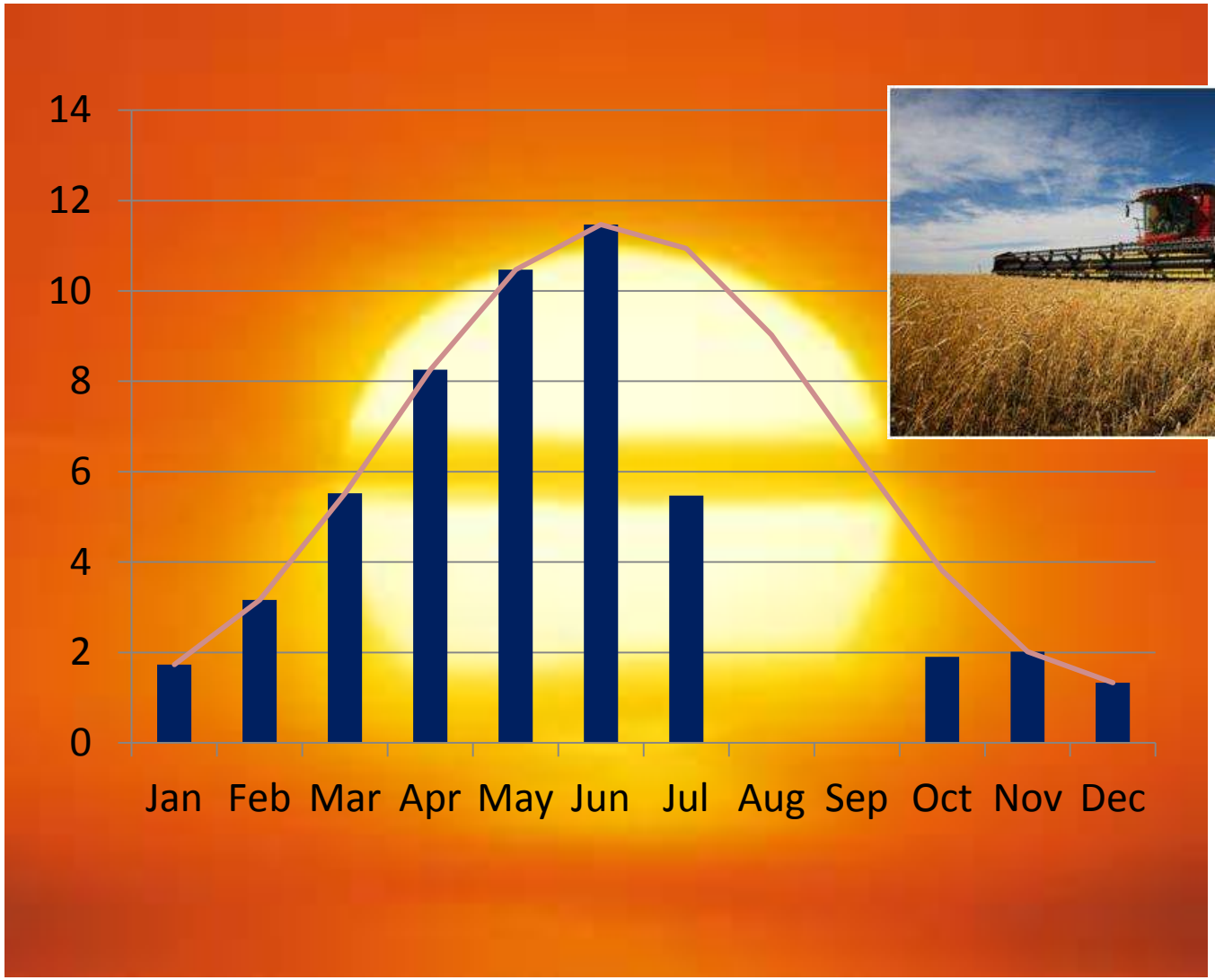
& turn it into carbon (*crops, animal feed etc*)

Capturing the sun



Potential daily sun hours

Capturing the sun



Potential daily sun utilisation by combinable crops


Trees important for climate change adaptation ✓
Could trees have an important role in agriculture ?
Agroforestry– an alternative approach ?


High Weald

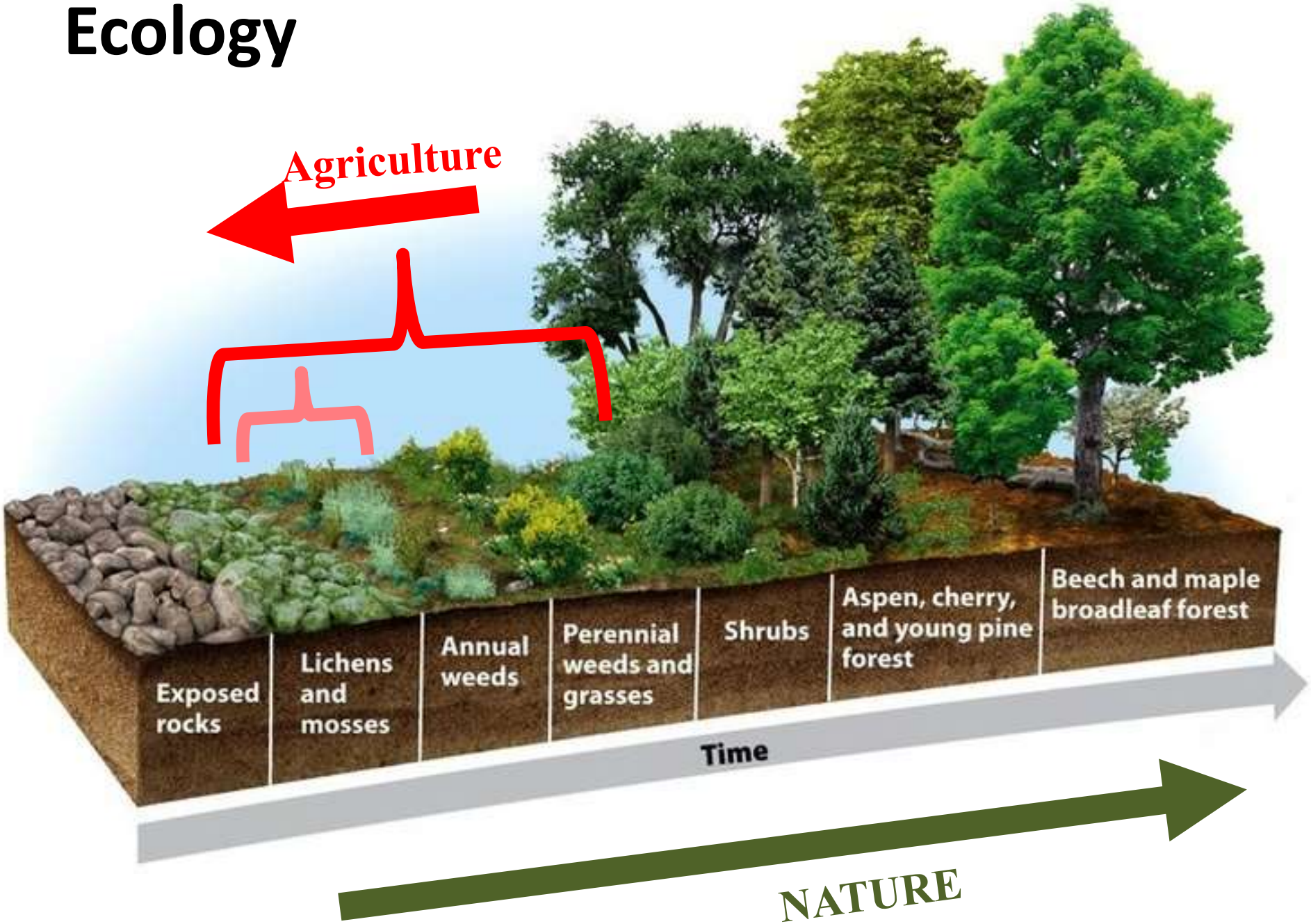
What is agroforestry

- Land use where trees are combined with crops and/or livestock on the same unit of land and where there is significant ecological or economic interaction between the tree and the agricultural components

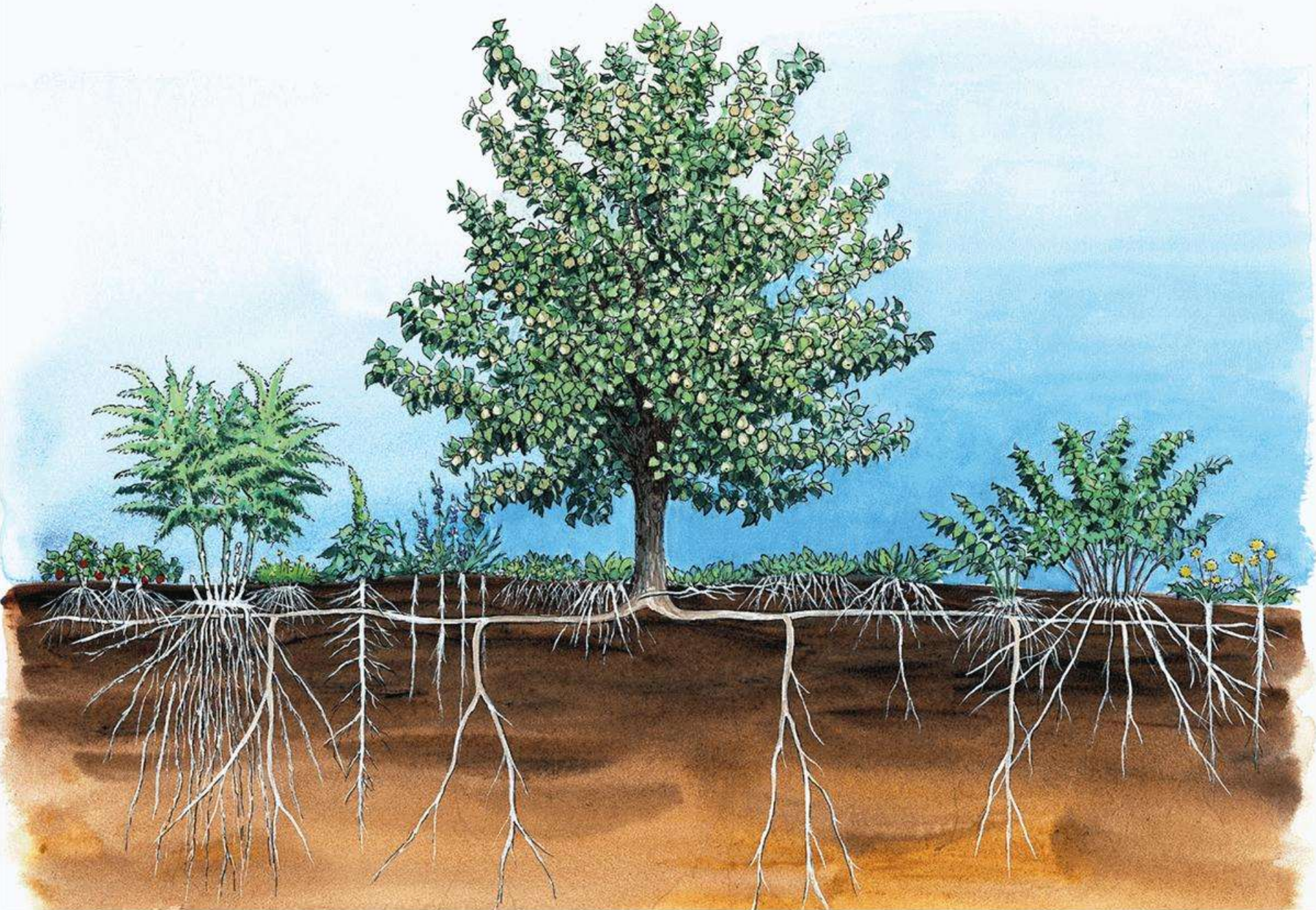
- ***Silvopasture*** - Trees in grazed pasture in regular of varied pattern

- ***Silvoarable*** – tree and crop combinations

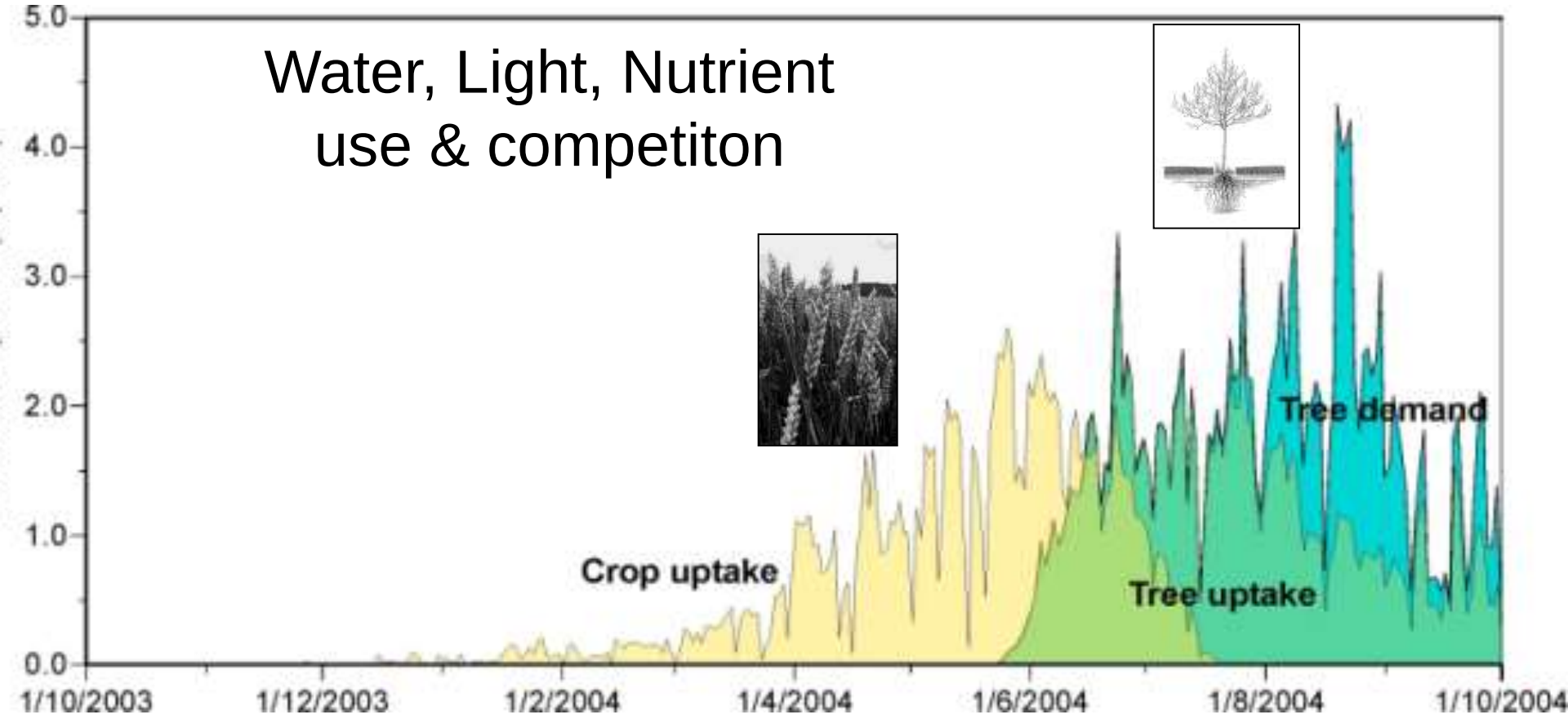
Ecology


Agriculture
Exposed rocks
Lichens and mosses
Annual weeds
Perennial weeds and grasses
Shrubs
Aspen, cherry, and young pine forest
Beech and maple broadleaf forest
Time
NATURE

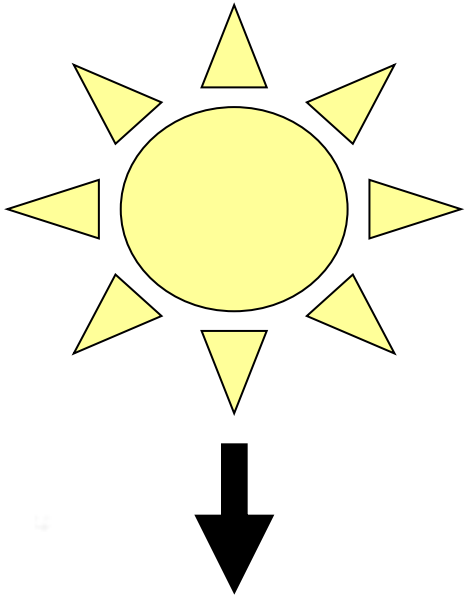
In nature, plants do not grow in a monoculture

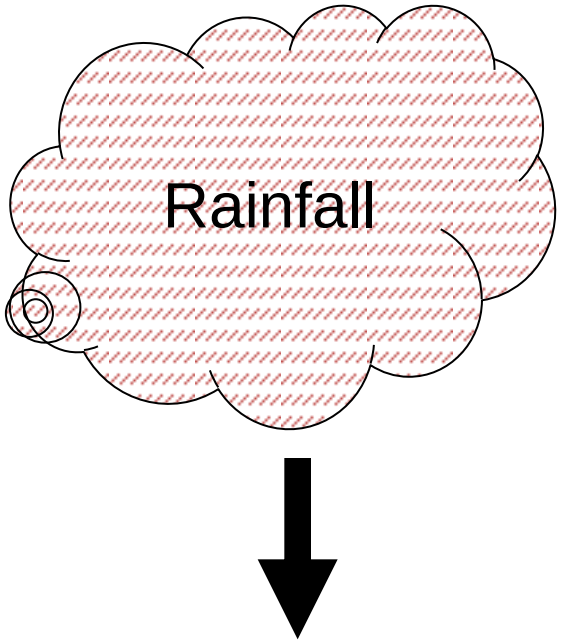


Water, Light, Nutrient use & competiton



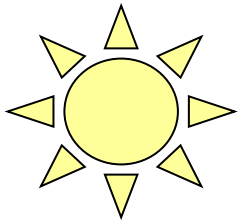
Crops & trees use water, light, nutrients from different '*spaces*' and at '*different periods***' during the season**





Monoculture Crops grow 0 -1 m above ground only

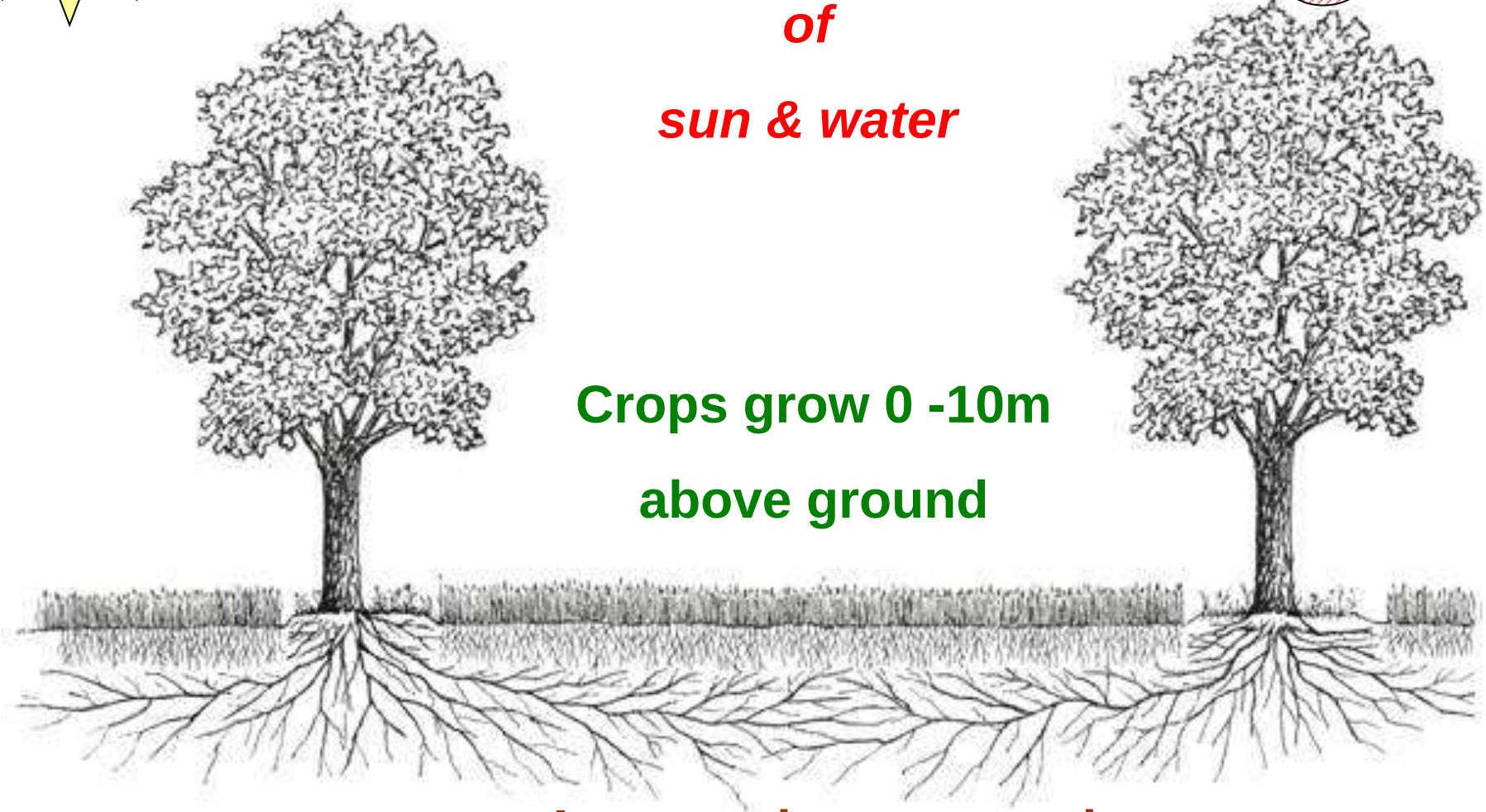
Monoculture roots grow 0 -1 m below ground only



Improved use

of

sun & water



Crops grow 0 -10m

above ground

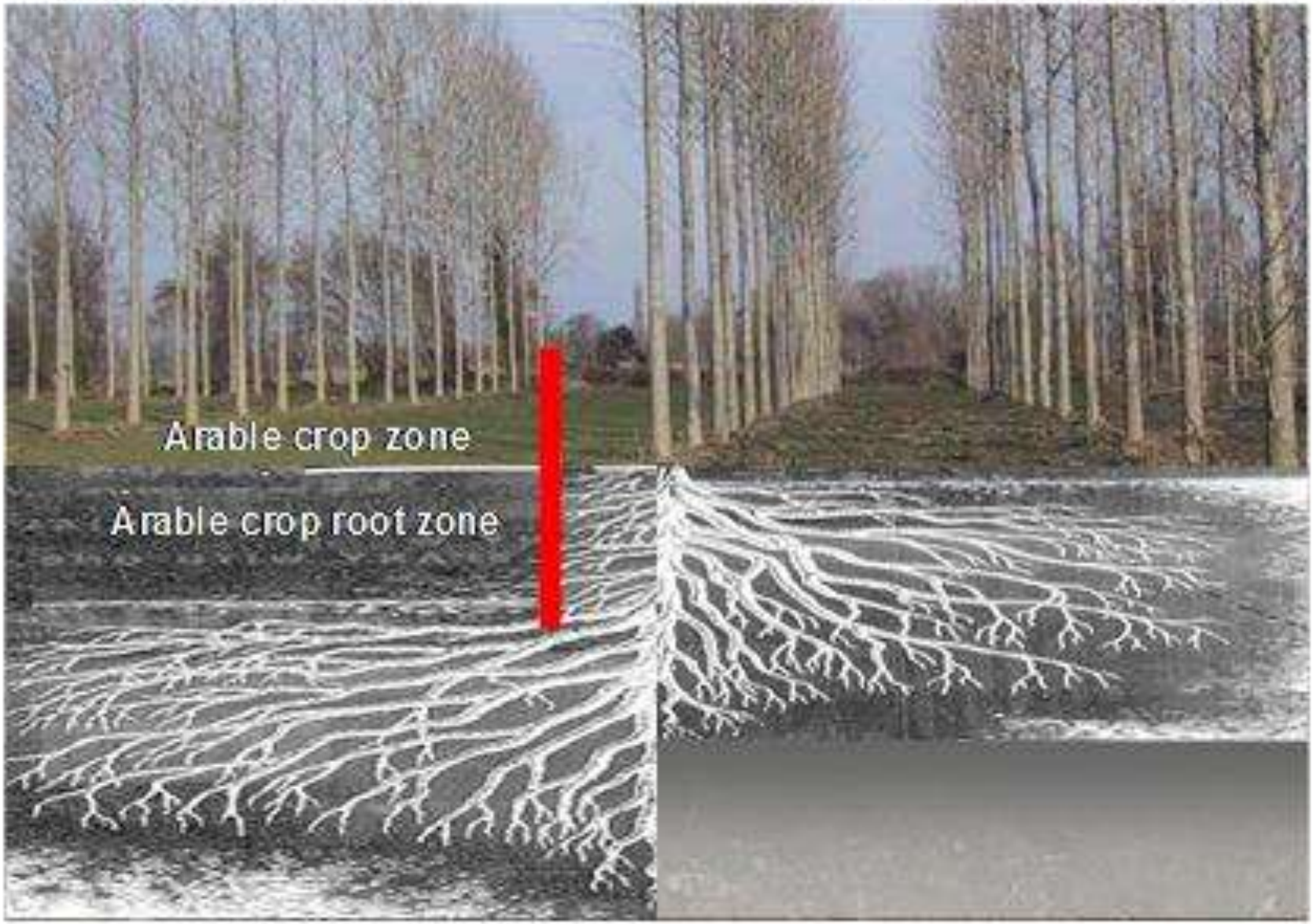
Improved root spread,

nutrient use & reduced leaching

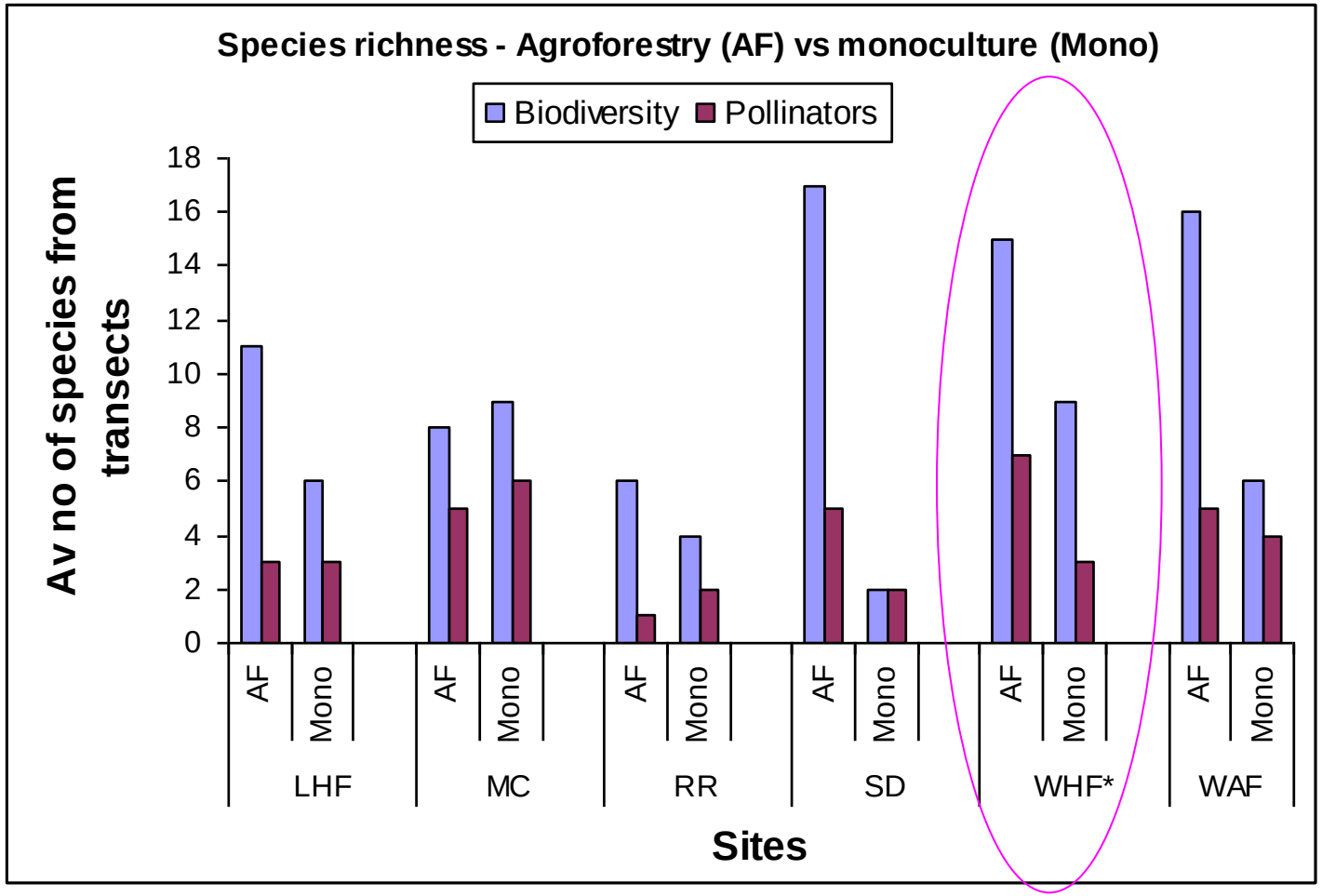
Forest tree roots

Agroforestry tree roots

Agroforestry **Forest plantation**



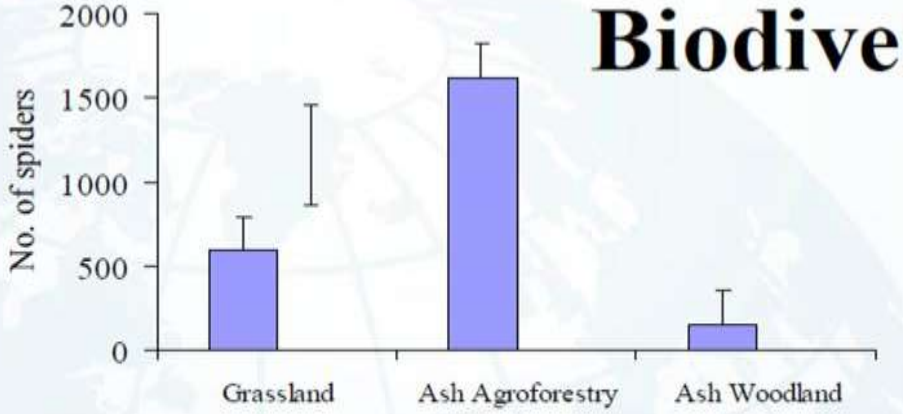
Biodiversity & Ecosystems services research



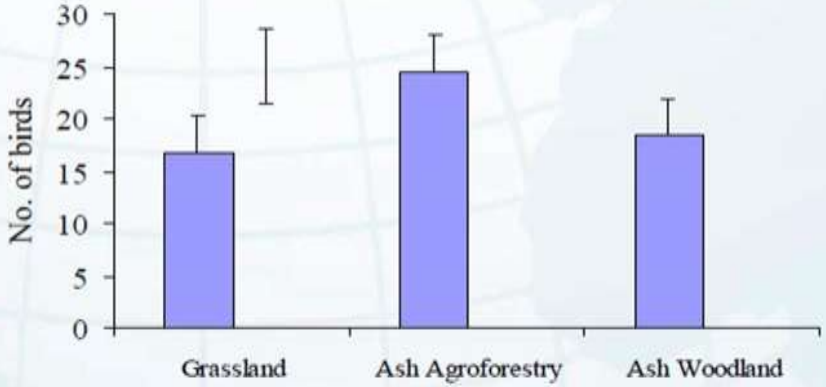
Comparison of species richness between agroforestry (AF) and monoculture (mono) at 6 farms in England 2009-2011.

Source : A Varah Reading University

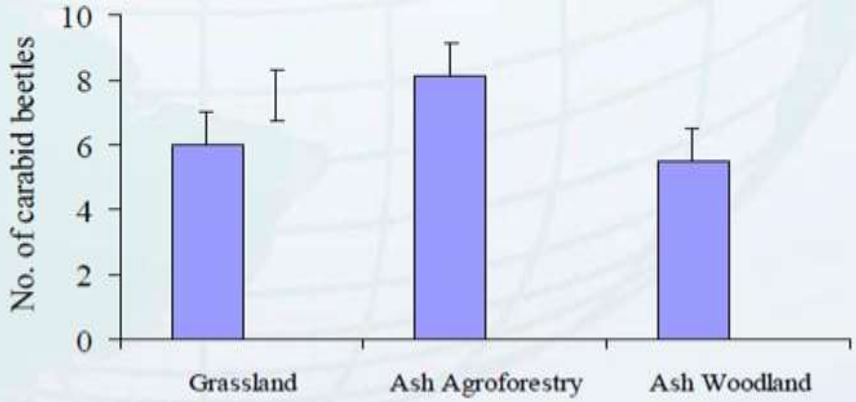
Biodiversity Benefits



Spiders



Birds



Beetles

afbi Agri-Food and Biosciences Institute

Source : J McAdam AFBI


What about resource utilisation
&
Competition for resources ?

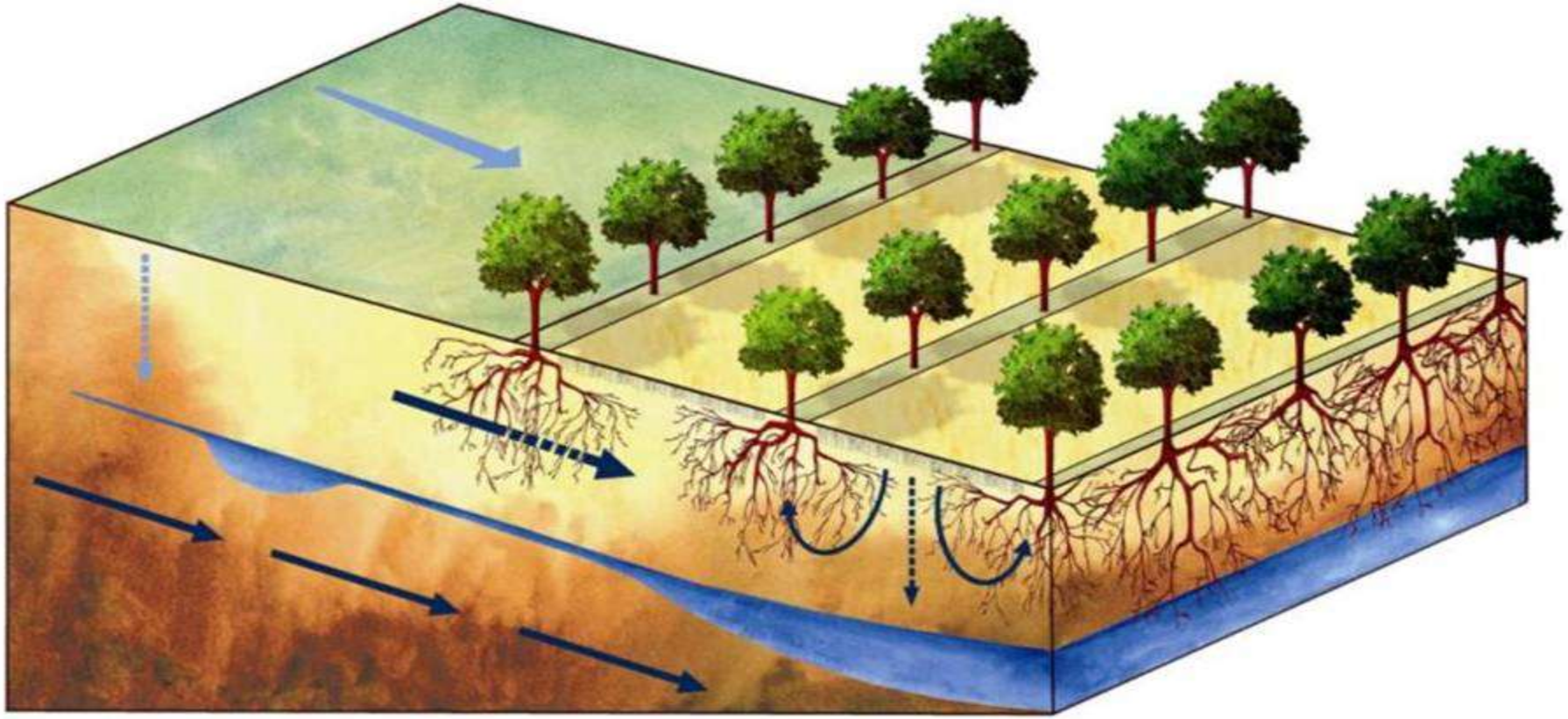
•Improved soil & water quality protection

•Wind speeds reduced

•Reduced evaporation and water loss from crops

• Improved drainage

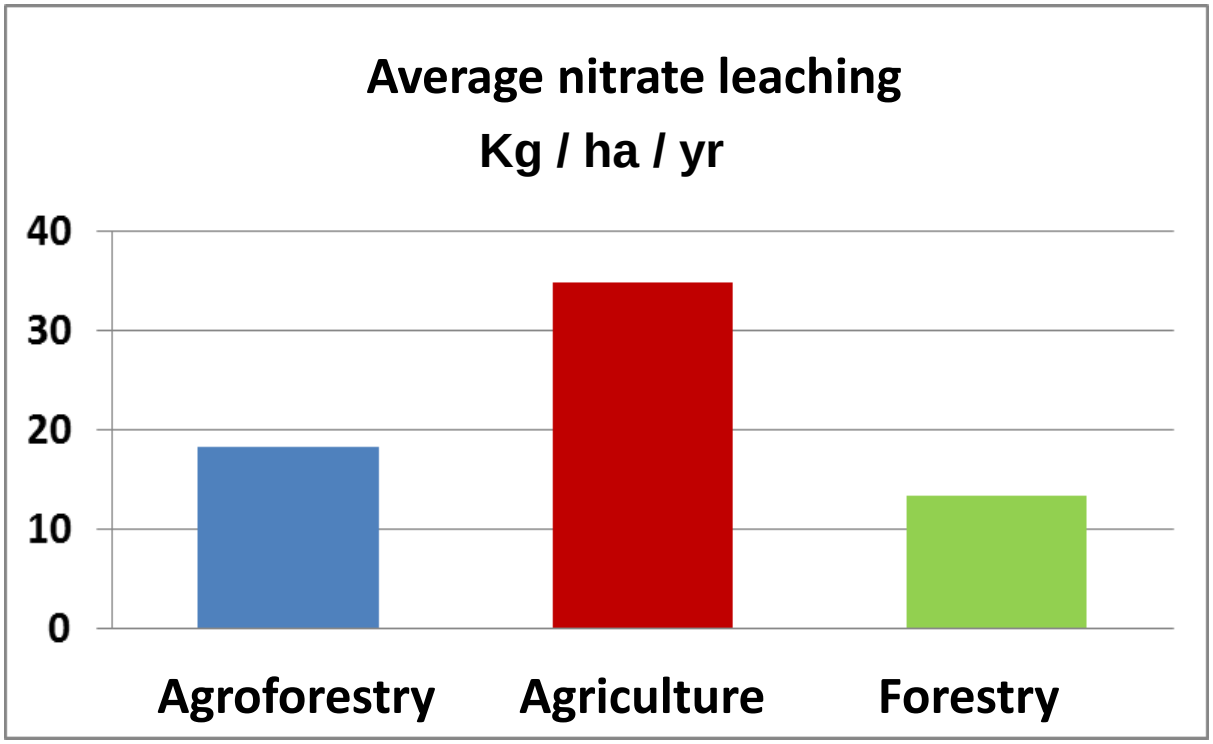
•Microclimate modified

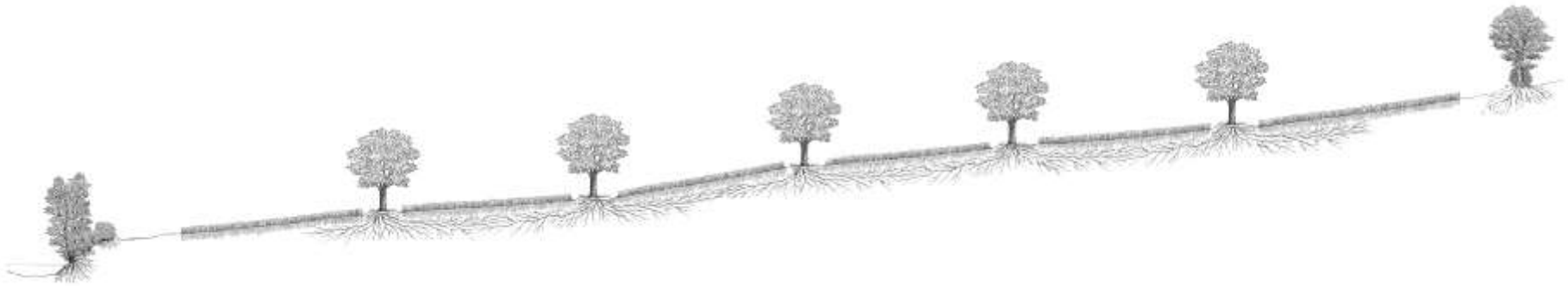


Reduced Nitrogen leaching

Up to 50% less N lost under Agroforestry than arable

Trees capture N not used by crops





Source : Research by INRA Restinclières, France

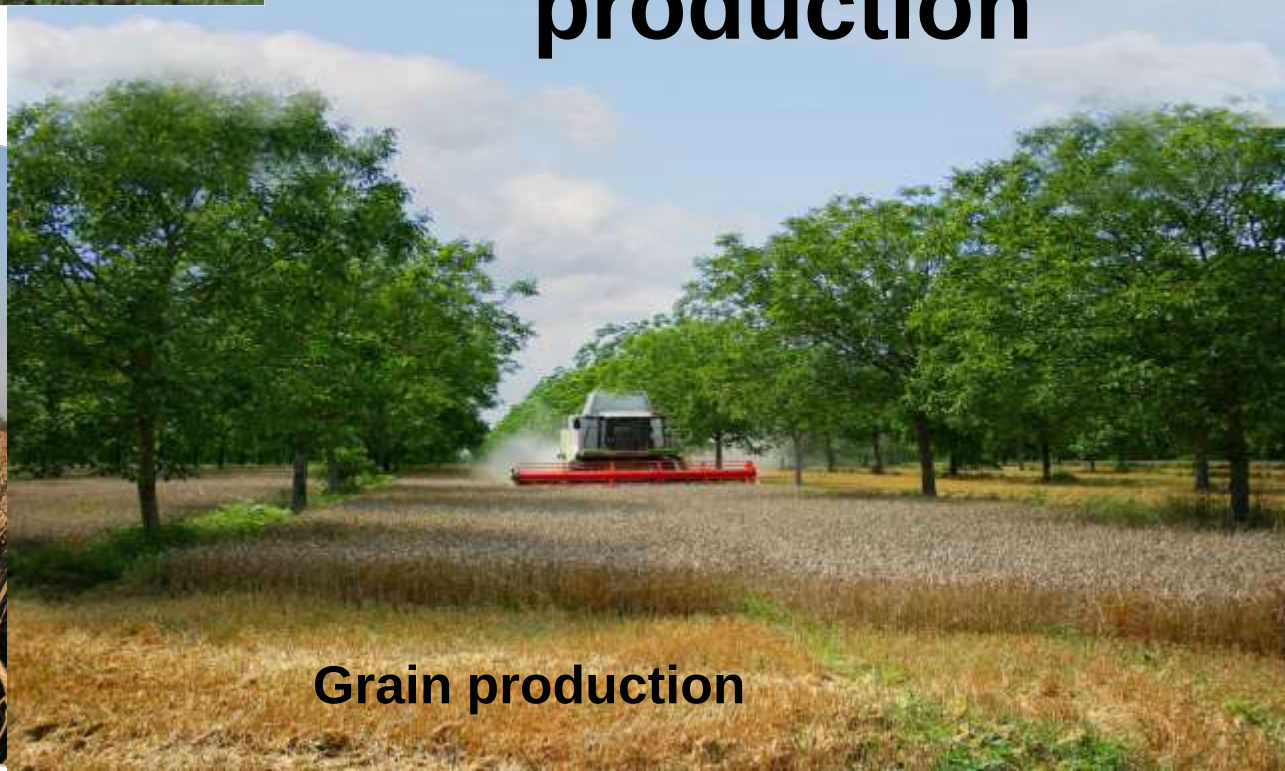
Examples of agroforestry

Silvo-arable : crops & trees

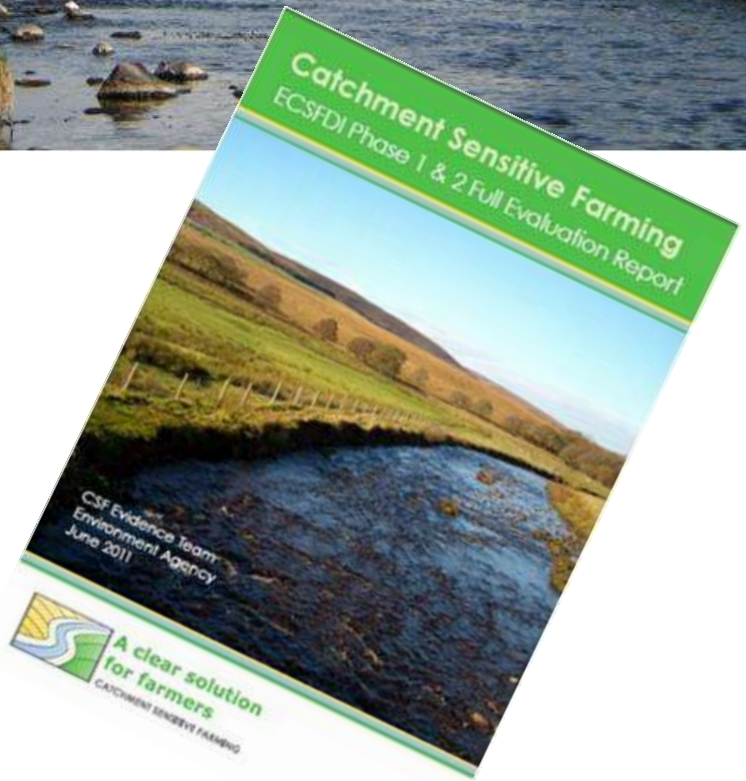
Using field scale machinery

Crop rotation & timescales longer

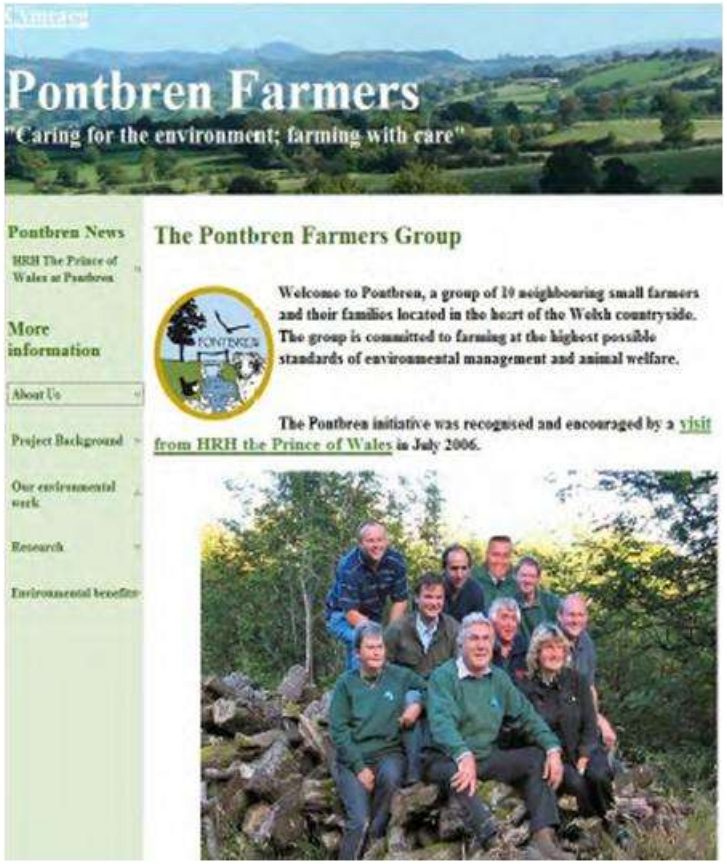
Agroforestry & crop production



Catchment scale

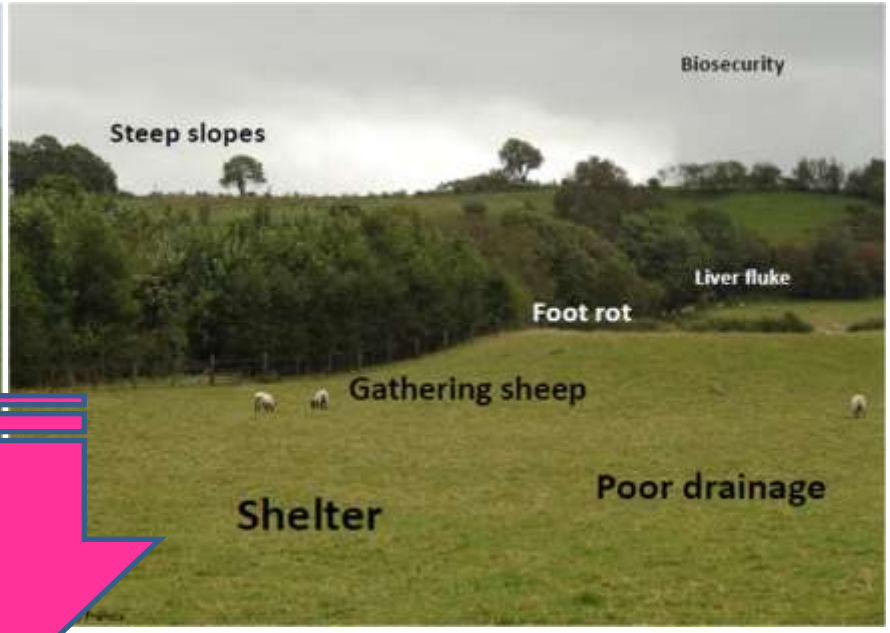


Pontbren



During the 19th and 20th centuries landscapes had become simplified


Overland flow was a significant runoff path


Biosecurity
Steep slopes
Liver fluke
Foot rot
Gathering sheep
Poor drainage
Shelter


'Woodland' increased from 1.5% to 5%


Water infiltration in shelter belts was 60 times that of neighbouring grassland

Business benefits

- Increase in farm net income
- Improved efficiency of livestock enterprises
- Future proofing
- Reducing the risk of water pollution and biosecurity

Poultry


Sainsbury's
Woodland
Woodland
Class A
6 Medium
Free Range Eggs
WOODLAND

Silvo-pastoral: trees and livestock

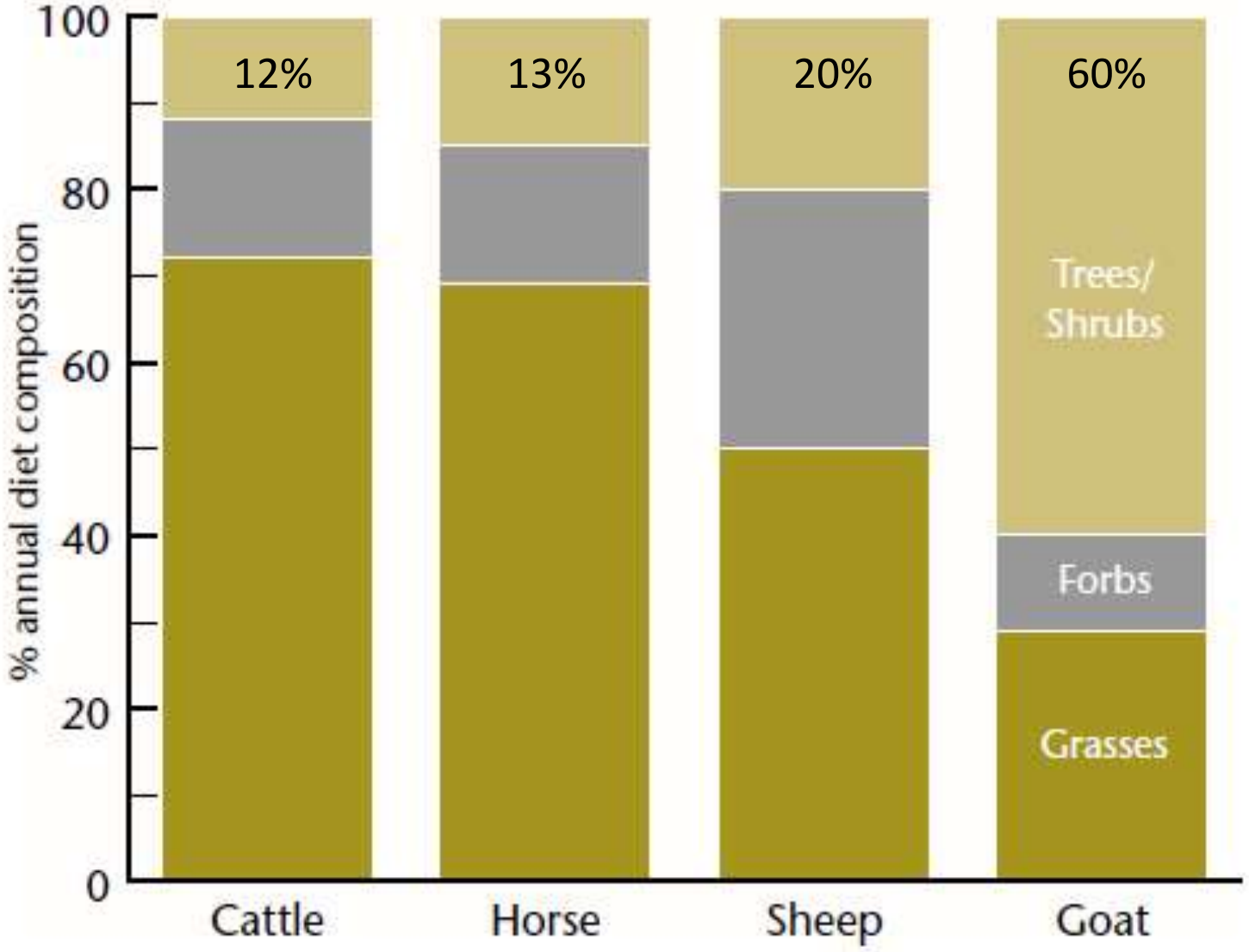
Feed & Browse

Tree forage – increasing interest

- Trace minerals
- Protein rich leaves
- Medicinal benefits
- Diet supplementation
- Willow & poplar browse?

Variation in the diet of domestic stock

http://www.forestry.gov.uk



Leaf nutrition in tree species compared to hay and red clover (%)						
Tree species	moisture	Ash	Fat	Sugar	Protein	Fibre
Wych elm	12.6	9.9	2.9	49.2	13.2	12.3
Rowan	11.9	5.9	6.5	50.4	9.9	15.4
Goat willow	11.5	6.1	3.8	50.3	11.6	16.7
Aspen	10.8	8.5	6	43.5	13.3	20.9
Ash	11.6	6.3	3	50.4	12	16.7
Grey alder	11.9	3.9	5.9	43.6	17.6	17.4
Birch	11.7	3.9	7	49.2	12	16.2
meadow hay	*14.96*	*5.42*	*2.2*	*44.43*	*8.51*	*24.56*
red clover	*15.65*	*5.17*	*1.88*	*36.76*	*10.98*	*28.56*
Birks et al 1989						

Palatability classes

1. Aspen, Willow
2. Ash, Rowan
3. Hazel, Oak
4. Scots pine, Juniper, Holly
5. Birch, Hawthorn
6. Beech
7. Alder

- *Lowland woodland - aspen may be class 3*
- *Scots pine, juniper, holly good as winter food as evergreen*
- *Ongoing debate as to holly/hawthorn further up list – often browsed but prob only when other species are removed first or not present*

Heifers (May – September)	Time spent browsing (%)	Species preferred
Spring	**19.3**	**Hazel Hawthorn Hornbeam**
Early summer	**5.9**	
Late summer	**5.4**	

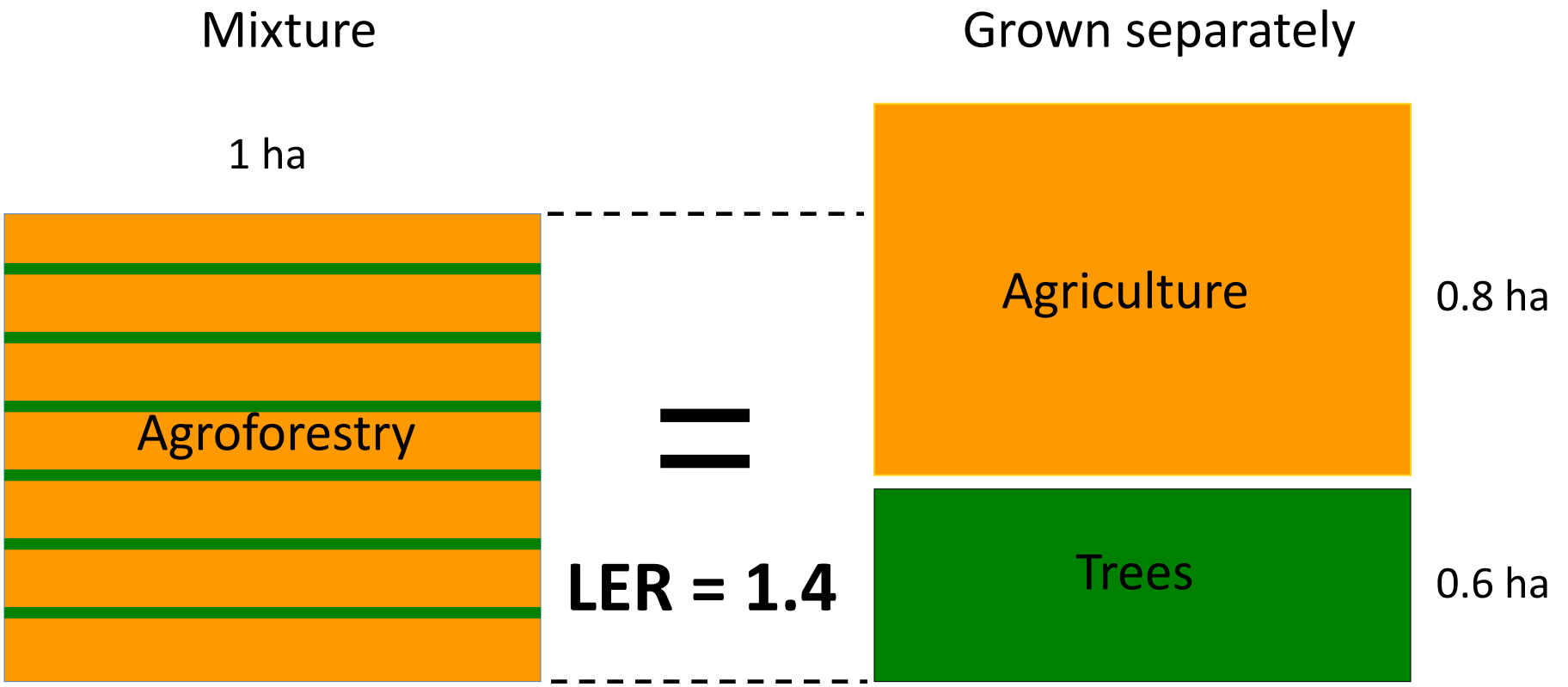
Shelter

(Ralph, 1981)	LAMB MORTALITY (%)	
	SHELTER	NO SHELTER
Single births	8.9	17.5
Multiple births	38.8	51.3

Lindsay Whistance


Monoculture
Agroforestry
How can we compare productivity?

Land equivalent ratio of productivity

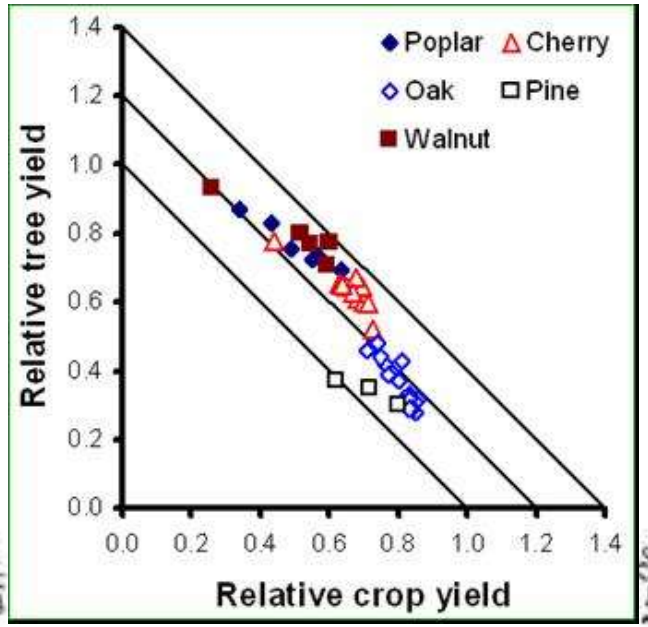


An LER of 1.4 means 100 ha of agroforestry produces as much crop & tree products as 140 ha farmland where trees and crops are separated

Land Equivalent Ratio (LER) (Mead and Willey, 1980)

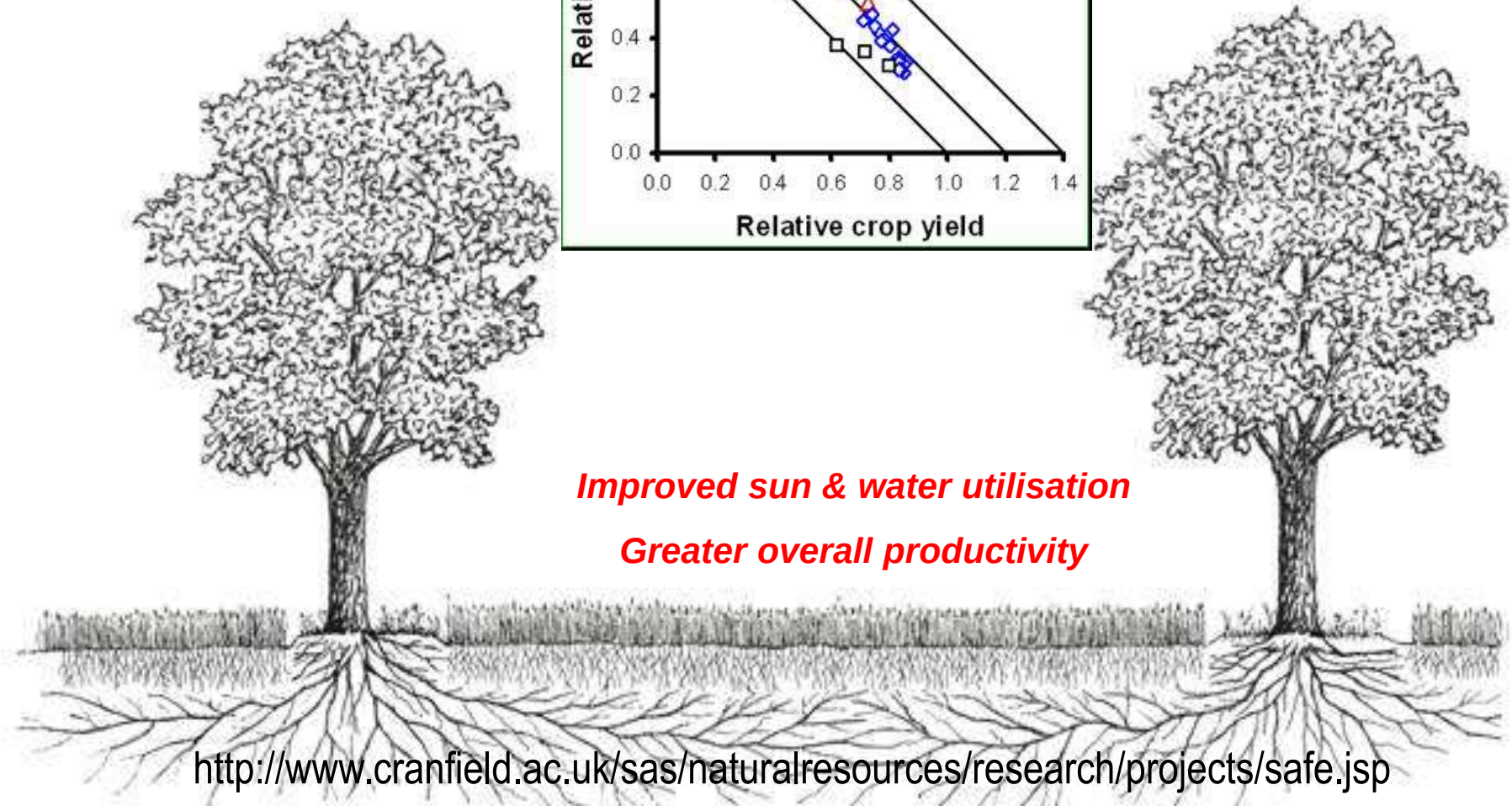
Balancing productivity with environment management

Tree and crop yields for 42 tree-crop combinations



LER's

1.1 to 1.4

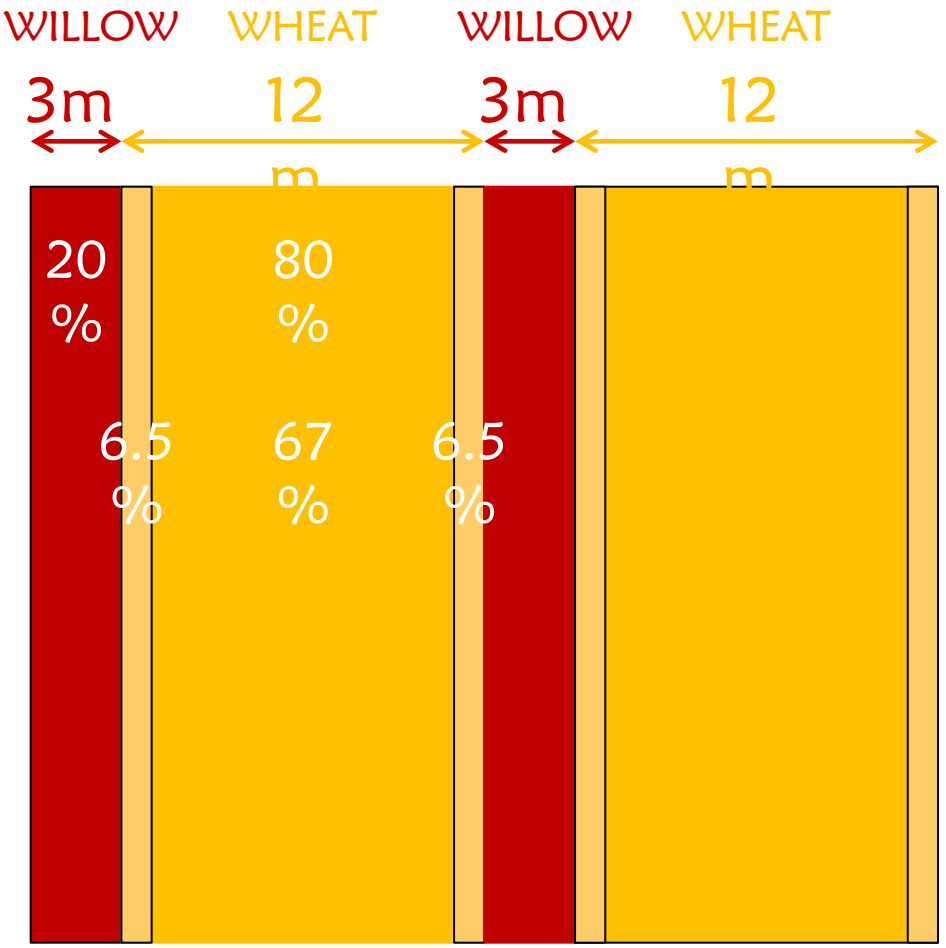


Improved sun & water utilisation

Greater overall productivity

http://www.cranfield.ac.uk/sas/naturalresources/research/projects/safe.jsp

Willow alley cropping at Wakelyns



1ha agroforestry =

0.2 willow +

0.67 wheat (@100% yield) + 0.13 wheat (@50% yield)

Land Equivalent Ratio

Willow

SRC Plantation: 25 odt/ha **every 3 years** = 8.33 odt/ha/year

Agroforestry: 6.7 odt/ha **every 2 years** = 3.35 odt /ha/year

Winter wheat (organic)

Monoculture: 5 t/ha

Agroforestry: 2007-2011 average for Wheat 6.98 t/ha

Shaded area @ 50% yield = 0.13 ha (0.45 t/ha)

+

Non shaded area @ 100% yield = 0.67 ha (4.68 t/ha)

Wheat output = 5.13 t/ha

Land Equivalent Ratio

$$LER = \frac{Tree\ agroforestry\ yield}{Tree\ monoculture\ yield} + \frac{Crop\ or\ livestock\ agroforestry\ yield}{Crop\ or\ livestock\ monoculture\ yield}$$

$$LER = \frac{3.35}{8.33} + \frac{5.13}{5}$$

LER = 0.40 + 1.03

LER = 1.43

i.e. 43% more land needed under monocultures to produce same yields.

SRT coppice willow / wheat monocultures
vs
Willow – Wheat Agroforestry

	land area	yield	Value	Component	Total
	%	ha/yr	£/t	Output	Output
				£/ha/yr	£/ha/yr
Monoculture					
SRT Plantation Willow	100	8.33 odt	60	499.8	
					499.8
Organic wheat	100	5 t	270	1350	
					1350
Agroforestry					
Willow	20	3.35 odt	60	201	
					201
Wheat 100%	67	4.68 t	270	1263.6	
Shaded wheat 50%	13	0.45 t	270	121.5	
		5.13 t	270		1385.1
					1586.1
LER = 1.43	3.35	$\frac{\text{Tree agroforestry yield}}{\text{Tree monoculture yield}} + \frac{\text{Crop or livestock agroforestry yield}}{\text{Crop or livestock monoculture yield}}$			5.13
	8.33				5

Maximising the arable benefits

As already discussed, planting trees on arable land can offer benefits to the understorey crops in terms of helping to conserve the soil and reducing wind speeds. However, the value of the arable crop in a silvoarable system can also be increased by choosing the correct type of crop, maximising light interception by the crop, and minimising weed competition.

Choice of arable crop

A wide range of arable crops have been used in silvoarable systems. The crops tested in the UK Silvoarable Network included winter wheat, barley and beans, and spring wheat, barley and peas. It probably makes sense to avoid crops with a C4 photosynthetic pathway like maize which benefit from high light levels. Previous advice suggested avoiding potatoes, but they have been grown in an organic system at Wakelyns Agroforestry in Suffolk. Sugar beet had also been warned against due to the large machinery, but it has been successfully grown in Germany in 24 m alleys[2].

Figure 23: Willow and barley silvoarable system

Wakelyns Agroforestry, Suffolk UK

What is the long-term plan for the system?

Is the aim to retain arable cropping over the length of a tree rotation (typically 25–60 years), or is the silvoarable system a way to ensure continued cropping and income during the establishment stages of the trees? Although many farms will have less structured forms of Agroforestry systems Figure 18 shows one way of thinking about long term planning.

Figure 18: Agroforestry systems

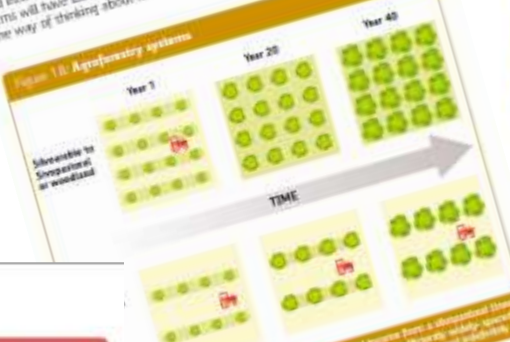


Table 8: Sample year 6–15 gross margin from silvoarable agroforestry system

Apple agroforestry

Silvoarable orchard cereal system: 85 trees per hectare with a combine harvester or sprayer boom width of 24–36 metres in between the rows, with tree spacing every 3 m in the row.

Apples – Orchard system

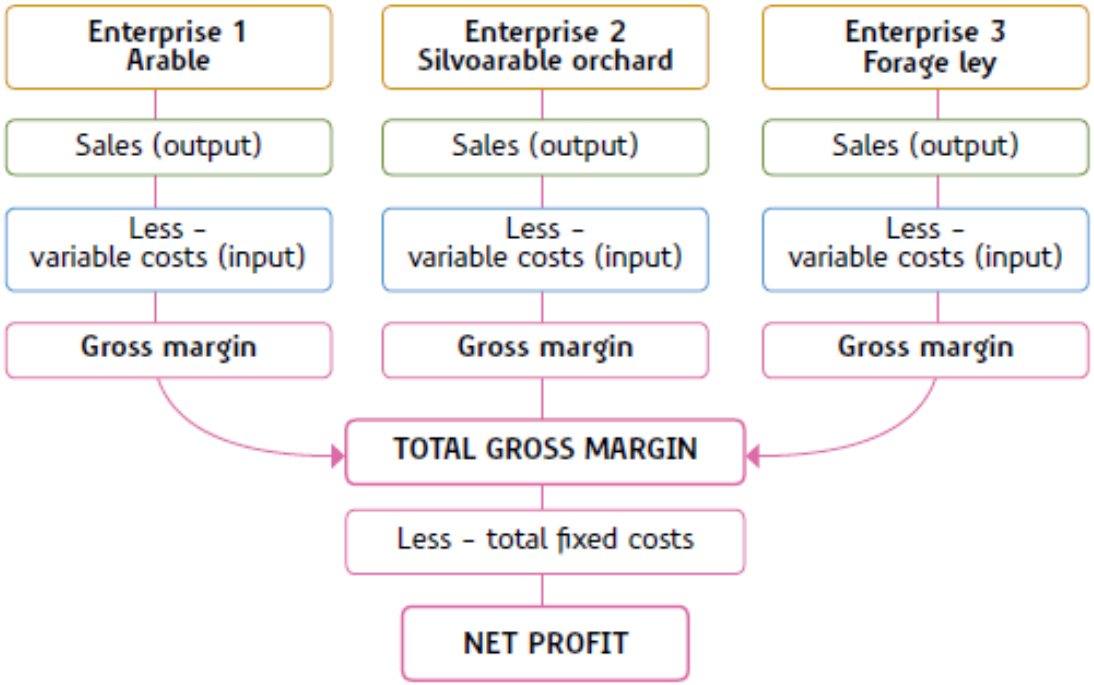
Production level	Average		
	Ha	Ac	
Yield tonne/hectare (acre)	1.7	0.7	
	£		£/tonne
Output at £900/t	1530	619	900
Variable Costs £/ha (ac):			
Orchard Depreciation	60	24	35
Pruning / Clearing	50	20	29
Fertiliser / Sprays	81	33	48
Crop Sundries	20	8	12
Harvesting	117	47	69
Grading / Packing	248	100	146
Storage / Bin hire	142	57	83
Packaging	111	45	65
Transport	90	36	53
Commission / Levies	115	47	68
Total Variable Costs	**1034**	**418**	**608**
Gross Margin £/ha (ac)	**496**	**201**	**292**
Silvoarable - Top Fruit Gross Margin £/ha (ac)	**1242**	**503**	**731**

Tree age	Year 1–3	Year 4–5	Year 6–15	Year 16–25
Tree yield	zero	50%	100%	75%

THE AGROFORESTRY HANDBOOK

Agroforestry for the UK

Figure 34: **The agroforestry gross margin system** © Ian Knight



This system of enterprise budgeting has the advantage of not allocating fixed costs between individual enterprises. The gross margin system brings simplicity when implementing changes to a farming system such as the establishment of agroforestry. You can evaluate relatively simply the financial effects of planting trees within a field by replacing one gross margin (for instance an annual crop/livestock) with another gross margin for the trees.

Table 10: **Sample net revenue increase after replacing 20 ha of cereal crop with 20 ha of agroforestry**

		£
Gross margin gain:	20 ha silvoarable agroforestry at £496/ha	9,920
Gross margin lost:	20 ha winter oats at £404/ha	8,080
	Net revenue gain	**1,840**

Table 9: **Sample year 6–15 gross margin from silvoarable agroforestry system**

Apple agroforestry			
Silvoarable orchard cereal system: 85 trees per hectare with a combine harvester or sprayer boom width of 24–36 metres in between the rows, with tree spacing every 3 m in the row.			
Apples – orchard system			
Production level	**Average**		
	per ha	*per ac*	
Yield: tonne/hectare (acre)	1.7	*0.7*	
	£		**£/tonne**
Output at £900/t	1,530	*619*	900
Variable Costs £/ha (ac):			
Orchard depreciation	60	*24*	35
Pruning/clearing	50	*20*	29
Fertiliser/sprays	81	*33*	48
Crop sundries	20	*8*	12
Harvesting	117	*47*	69
Grading/packing	248	*100*	146
Storage/bin hire	142	*57*	83
Packaging	111	*45*	65
Transport	90	*36*	53
Commission/levies	115	*47*	68
Total variable costs	**1,034**	***418***	**608**
Gross margin £/ha (ac)	**496**	***201***	**292**
Silvoarable – top fruit gross margin £/ha (ac)	**1,242**	***503***	**731**

Tree age	**Year 1–3**	**Year 4–5**	**Year 6–15**	**Year 16–25**
Tree yield	zero	50%	100%	75%

Figure 37: **Silvoarable fruit cereal system in Cambridgeshire**

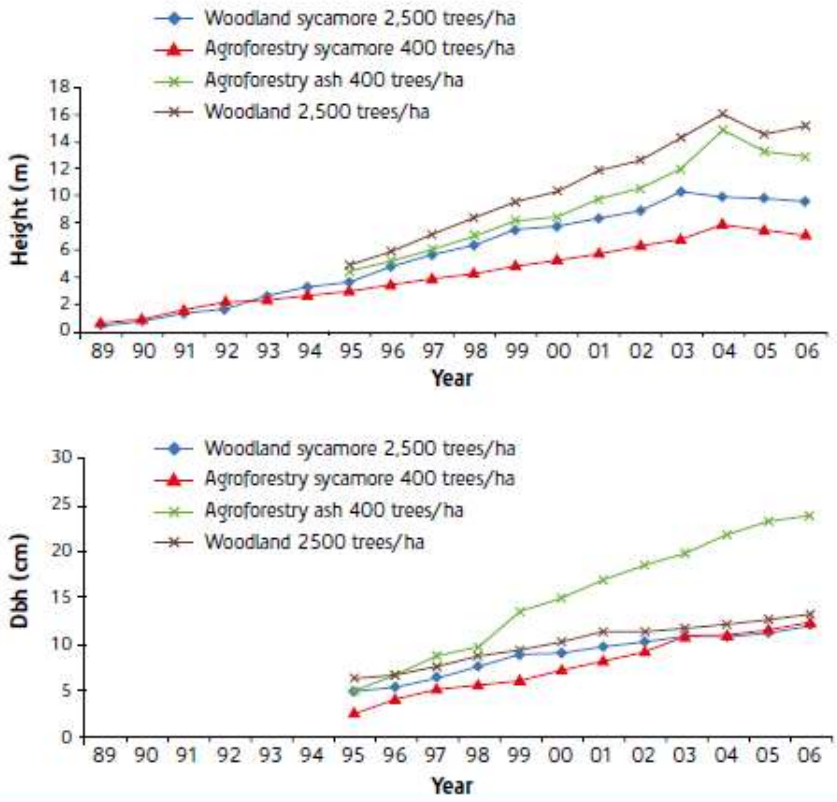
Lowland silvopasture gross margins

Below is a sample of physical assumptions, capital investment and gross margins for a lowland silvopasture agroforestry system.

Table 14: **Sample gross margin lowland silvopasture – walnut and clover ley silage**

Silvopasture – walnuts			
This gross margin example outlines a five-year cutting ley with walnut trees planted at 28 m between the rows and 3 m tree spacings within the row, which equates to 27 trees per hectare. Typically, this field would be an arable field or temporary grass field on a livestock farm which forms part of a wider rotation, with the five-year cutting ley providing a cash crop of big bale silage for selling off farm. This silvopasture system can be described as a walnut orchard. This system could use early and late-pollinating varieties such as Broadview, Buccaneer, Frankette, Rita, Northdown Clawnut.			
Clover ley – silage			
Five-year grass and white clover cutting ley			
Production level	**Average**		
	per ha	*per ac*	
Yield: tonne/hectare (acre)	28	*11*	
	£		**£/tonne**
Output at £50/t at 30% dry matter big bales	1,400	*567*	50
Variable Costs £/ha (ac):			
Establishment and seed	198	*80*	7
Fertiliser	41	*17*	1
Sprays	19	*8*	0.7
Silage conservation costs £/ha:			
Silage additive and wrap	73	*30*	3
Contractor charges	261	*106*	9
Net variable costs five-year white clover ley	91	*37*	3
Total variable costs	**683**	***276***	**24**
Gross margin £/ha (ac)	**717**	***290***	**26**

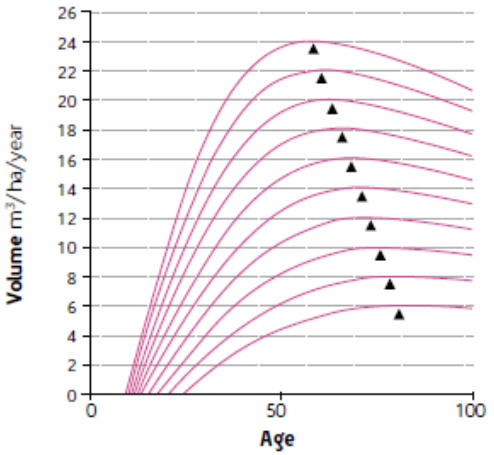
Figure 41: **Comparison of tree heights and trunk diameters of different trees grown as woodland and as agroforestry**



Work carried out at AFBI Loughgall site, Northern Ireland. Copyright McAdam J., Olave R., Agri Food and Biosciences Institute (AFBI)

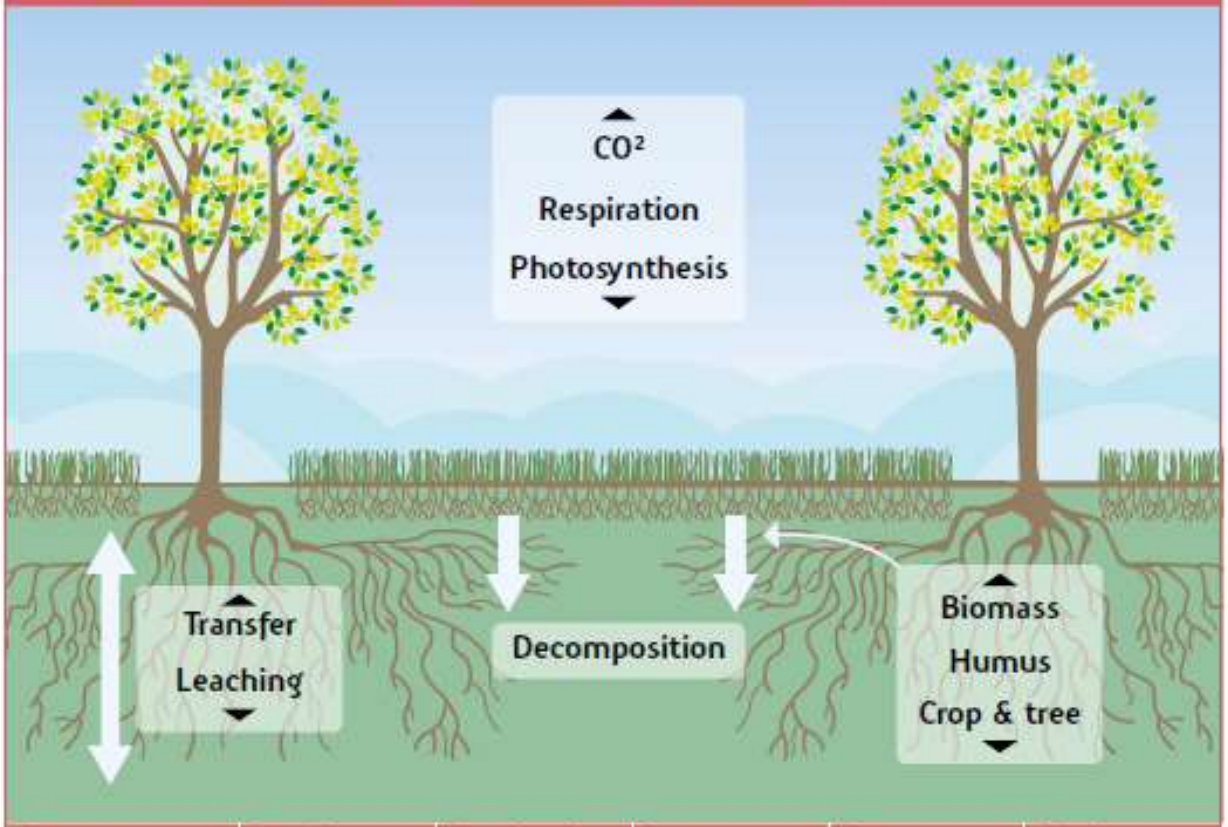
Tree grow rates & management

Figure 47: **General illustration of yield class curves in forest conditions showing that yield class is defined as the point of maximum mean annual increment, which will vary by age, species and site**



Carbon

Figure 44: **Carbon-storage potential of agroforestry**



Tree type	Rotation years	Tree density (trees/ha)	Storage potential (tC/ha)	Average storage during the rotation (tC/ha)	Total storage (tC/ha)
Slow-growing	50	50	1.5	37.5	75
Slow-growing	50	100	3	75	150
Quick-growing	15	50	2	15	30
Quick-growing	15	100	4	30	60

Agroforestry can contribute to climate change mitigation, with more potential than most other options for carbon sequestration in European agriculture.

Carbon sequestration income

Agroforestry & Climate change

- Committee on Climate Change (CCC) recommends Government commits to an **increase in tree canopy** cover from **13% to 17%** to **meet UK's ambition** of net **zero emissions by 2050**

- =30,000 ha new woodland **/yr** (=***2 Billion trees*** *@ 2,000 stems /ha*)

- FC stats report 13,000 ha of new woodland in 2018
  - *85% in Scotland with only 1,400 ha in England!!*

- 72% of the UK's land area is Farmland >>>>>>>>> **Agroforestry**

- A further **5.8%** of farm land to be converted **into tree canopy** to meet **17%** canopy cover to be met **= net zero emissions target**

Markets

Sporting products

Farming & recreation

Fruit & Nut products

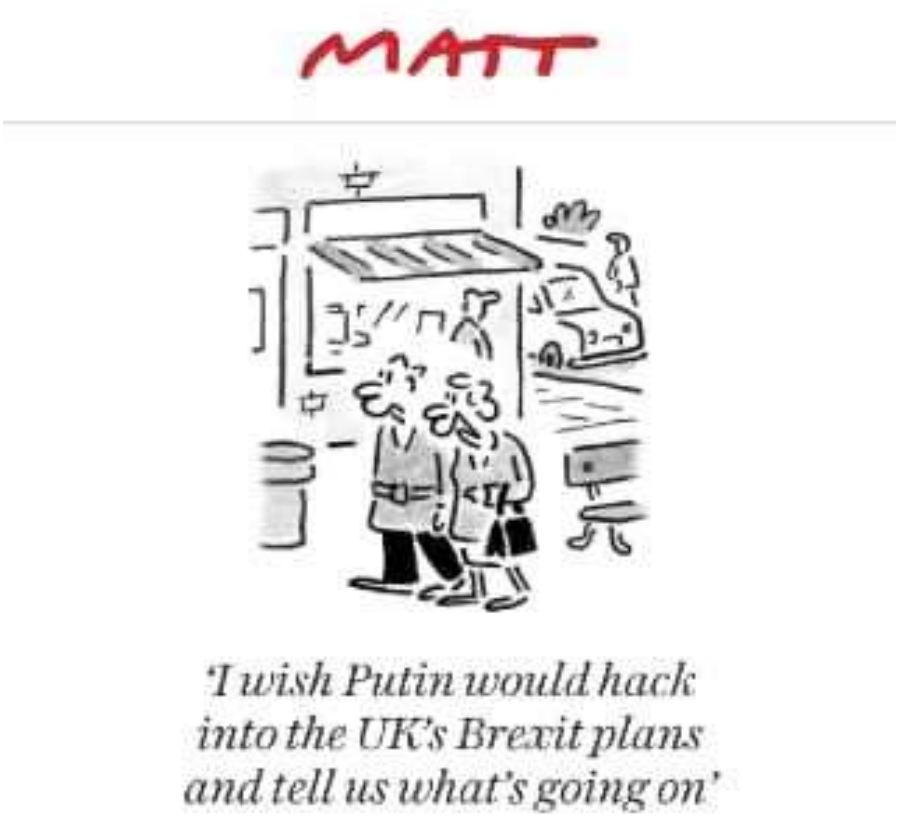
Timber products

Energy products

EU policy

- Agroforestry eligible under CAP
  - Greening measures
  - Ecological Focus Area (EFA) option

- Article 23 Pillar II funding (*5yr plant & Maintenance*)



UK structural & policy challenges

- Land tenure – in England
  - Ownership (68%) vs Tenancy (32%)
  - New shared ownership models may be needed

- Separate Forest & Agriculture policies

Forestry Commission

defra
Department for Environment
Food and Rural Affairs

Bluebell Farms Ltd

Agroforestry into practise

- 280 acre organic farm
- Owned, tenanted, contract
- 125 acre agroforestry

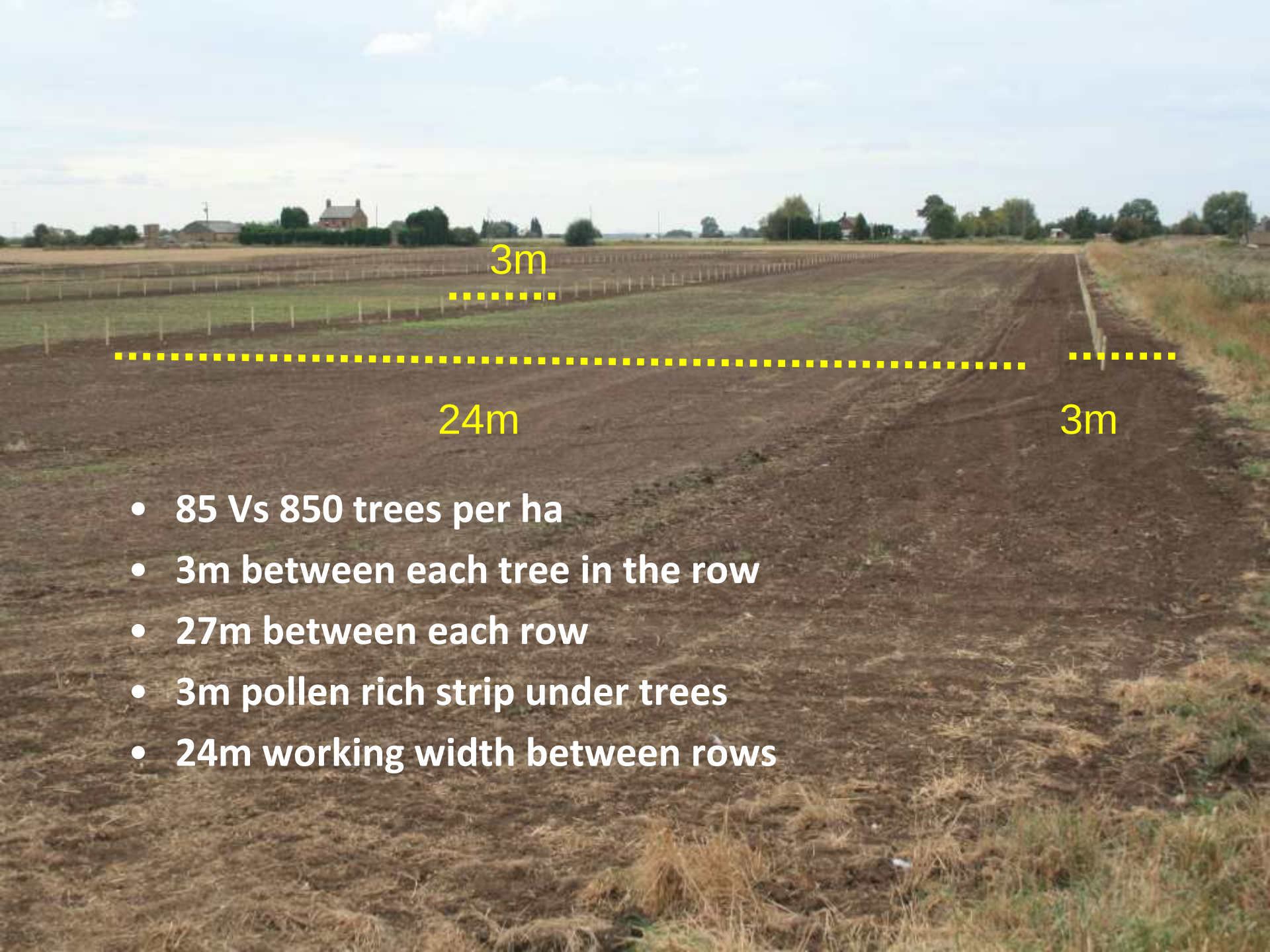
Drivers

- Multifunctional land use
- Cropping & enterprise diversity
- Soil protection
- Conservation & Habitat creation
- Market opportunities

Limitations

- 15yr tenancy
- Retain CAP eligibility
- Capital
- Profitability
- No livestock facilities

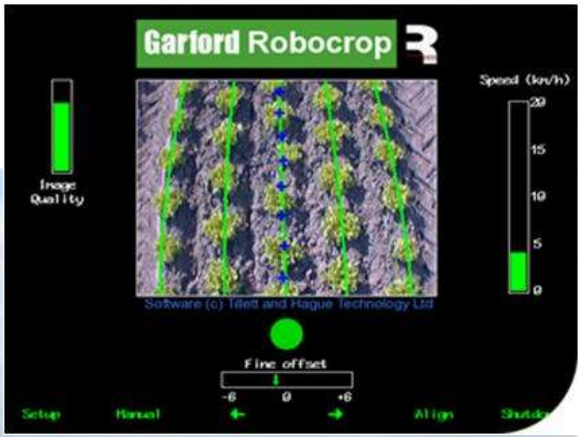
Agroforestry system - 85 trees per ha



- 85 Vs 850 trees per ha
- 3m between each tree in the row
- 27m between each row
- 3m pollen rich strip under trees
- 24m working width between rows


27m
24m

Drilling 6m



Robocrop 6m


3m wide Nectar & Wild flower
strip Under tree rows

52ha of Agroforestry at my own farm in Cambridgeshire


NEW HOLLAND


AK02
HJC

Companion planting, Relay cropping & precision Ag

£

Organic Oats W	£/ha	£/ac
OUTPUT		
6.4t/ha @ £330/t	2112	855
COSTS		
cults	167	68
seed	105	42
fert	50	20
sprays	0	0
weed	56	23
Rouge	15	6
harvest	110	45
	503	204
Gross Margin	1609	651

Organic Wheat S	£/ha	£/ac
OUTPUT		
5.25t/ha @ £325/t	1706	691
COSTS		
cults	167	68
seed	100	40
fert	50	20
sprays	0	0
weed	56	23
Rouge	15	6
harvest	110	45
	498	202
Gross Margin	1208	489

Organic Apples	£/ha	£/ac
OUTPUT		
6t/ha @ £280/t (28p/kg)	1680	680
HLS	550	223
	2230	902
COSTS		
cults	0	0
seed	0	0
fert	5	2
sprays	0	0
mow	5	2
harvest	313	126
storage	20	8
	343	139
Gross Margin	1888	764

HARVEST BARN

FARMSHOP

Concluding thoughts

Agroforestry = 'Ecological' intensification

Summary ;

- Use what is already there better…….
- Improved resource capture and use
- Profitability equal to or greater than monoculture
- Soil and environment protection
- Enhanced biodiversity
- Crops/animals maintain annual income -Trees provide long term income & capital asset Improved resource use
- Policy developments required

For construction….

There was a ‘*breakthrough*’ moment

Farmers & Foresters

‘*Agri*’phobia & ‘*Arba*’phobia

I believe that agroforestry is a ‘*climate smart*’ *breakthrough* for agriculture

Farmers could adopt agroforestry on at least 20% of their land

5.8% of land to meet net zero emissions target for Climate change

Agroforestry is one of the few options with the potential to help reduce greenhouse gas emissions, help protect natural resources whilst at the same time producing more food and biomass

Go home

Walk outside…….

Look up…. Look down …

Consider the extra dimensions
that can be cropped
to produce more !

3 Dimensional Land Use

Sometimes the thing that is holding you back...

...is all in your head.