Sustainable agriculture is in our nature

Martin Wolfe and Joanne Smith

The Organic Research Centre and Wakelyns Agroforestry,Suffolk

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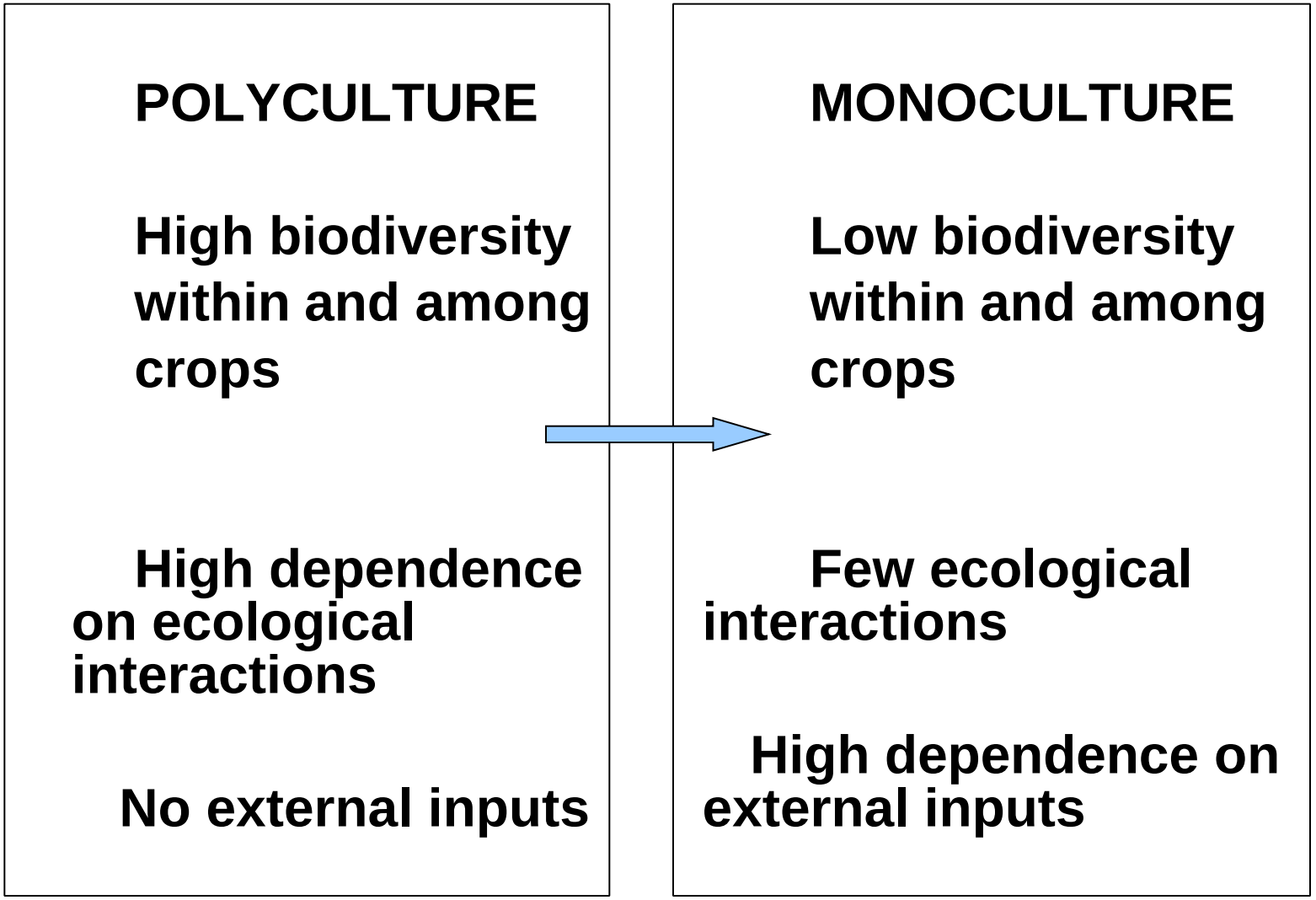
Agricultural Revolution



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Effects of Monoculture

1) High productivity of few commodities with low labour input

2) High financial, environmental and social costs

3) Major negative effect on biodiversity through replacement, toxicity etc.

Mitigating the effects of monoculture

a) 'Land-sparing', but with even greater intensification on the agricultural area

b) 'Land-sharing' with 'integrated' stewardship schemes

c) Both of the above using models based on some criteria to define the area of each

d) The fourth way: multicultural polyculture

Is organic farming the answer?

- Crop rotation
- Complex clover leys
- Builds-up own crop nutrition
- No herbicides, insecticides, fungicides, growth regulators
- More and larger hedges
- Smaller fields
- More mixed farms

- all help, but a LONG way to go

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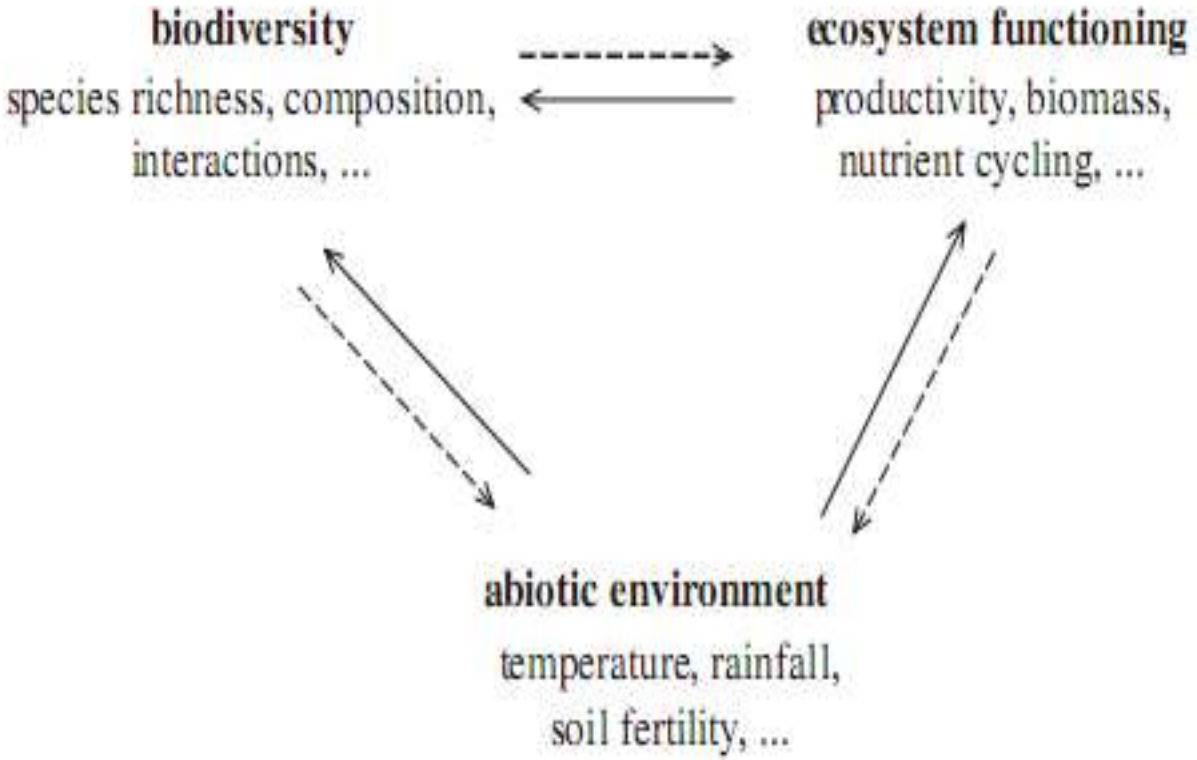
Effects of Polyculture

1. High productivity of many different outputs with higher labour input

2. Low financial and environmental costs with potentially high social gains

3. Large positive effects on biodiversity and ecosystem services

Feed-back systems



Loreau 2010

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- this is what we survive by - the natural world – or, as it is now frequently termed -

Ecosystem Services

Provisioning **(food and water, materials, energy);**

Regulating **(carbon sequestration, climate regulation, decomposition and detoxification, purification of water and air, pests and diseases, pollination);**

Supporting **(nutrient dispersal and cycling, seed dispersal, primary production);**

Cultural **(spiritual, health and recreational benefits)**

Unifying concepts in ecology (Loreau 2010)

There are positive correlations between:

A) DIVERSITY AND STABILITY

(e.g. wheat populations)

B) DIVERSITY AND PRODUCTIVITY

(e.g. large-scale natural grassland projects)

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Within-crop diversity: wheat populations

POSITIVE

Capacity: more phenotypic and genotypic variation

Complementation: different genotypes complement each other

Compensation: if some fail, others take their place

Change: evolutionary shifts in response to selection

NEGATIVE

Competition: may work against the four ‘Cs’ above.

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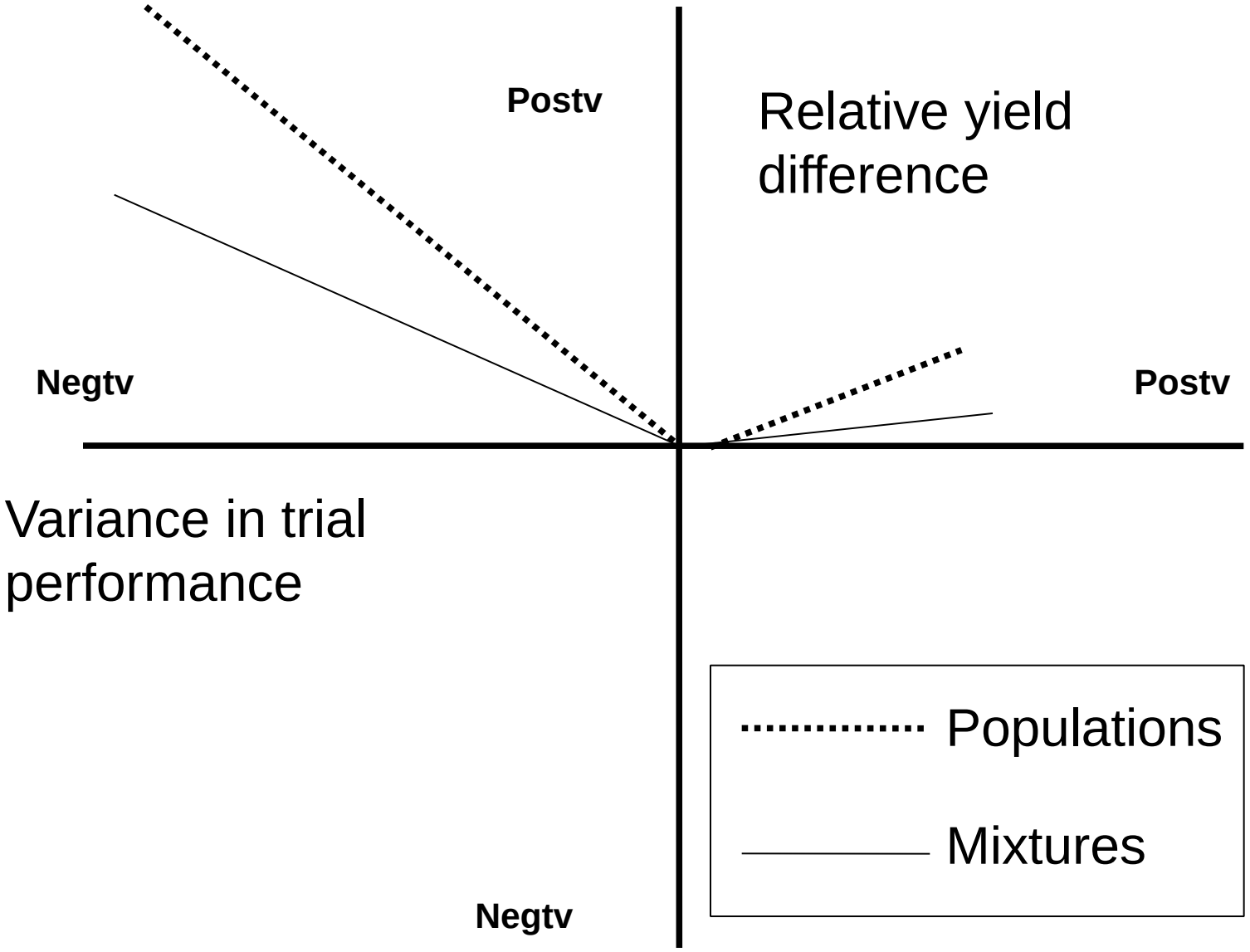
	Bezostaya	Cadenza	Hereward	Maris Widgeon	Mercia	Monopol	Pastiche	Renan	Renesansa	Soissons	Spark	Thatcher	Buchan	Claire	Deben	HTL	Norman	Option	Tanker	Wembely
Bezostaya		*yq*	*yq*	*yq*	*yq*	*yq*	*yq*	*yq*	*yq*	*yq*	*yq*	*yq*	Y	Y	Y	Y	Y	Y	Y	Y
Wembley	*yq*	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	Y	Y	Y	Y	Y	Y	Y	
Tanker	*yq*	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	Y	Y	Y	Y	Y	Y		
Option	*yq*	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	Y	Y	Y	Y	Y			
Norman	*yq*	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	Y	Y	Y	Y				
HTL	*yq*	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	Y	Y	Y					
Deben	*yq*	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	Y	Y						
Claire	*yq*	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	Y							
Buchan	*yq*	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ								
Thatcher	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q									
Spark	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q										
Soissons	Q	Q	Q	Q	Q	Q	Q	Q	Q											
Renesansa	Q	Q	Q	Q	Q	Q	Q	Q												
Renan	Q	Q	Q	Q	Q	Q	Q													
Pastiche	Q	Q	Q	Q	Q	Q														
Monopol	Q	Q	Q	Q	Q															
Mercia	Q	Q	Q	Q																
Maris Widgeon	Q	Q	Q																	
Hereward	Q	Q																		
Cadenza	Q																			

Y - 36 crosses; Q – 66 crosses; YQ – 107 crosses
(Total crosses – 190 rather than 210 because of Bezostaya)
(NB Mixtures have only 9 (Y), 12 (Q) or 20 (YQ) fixed components)

Resilience



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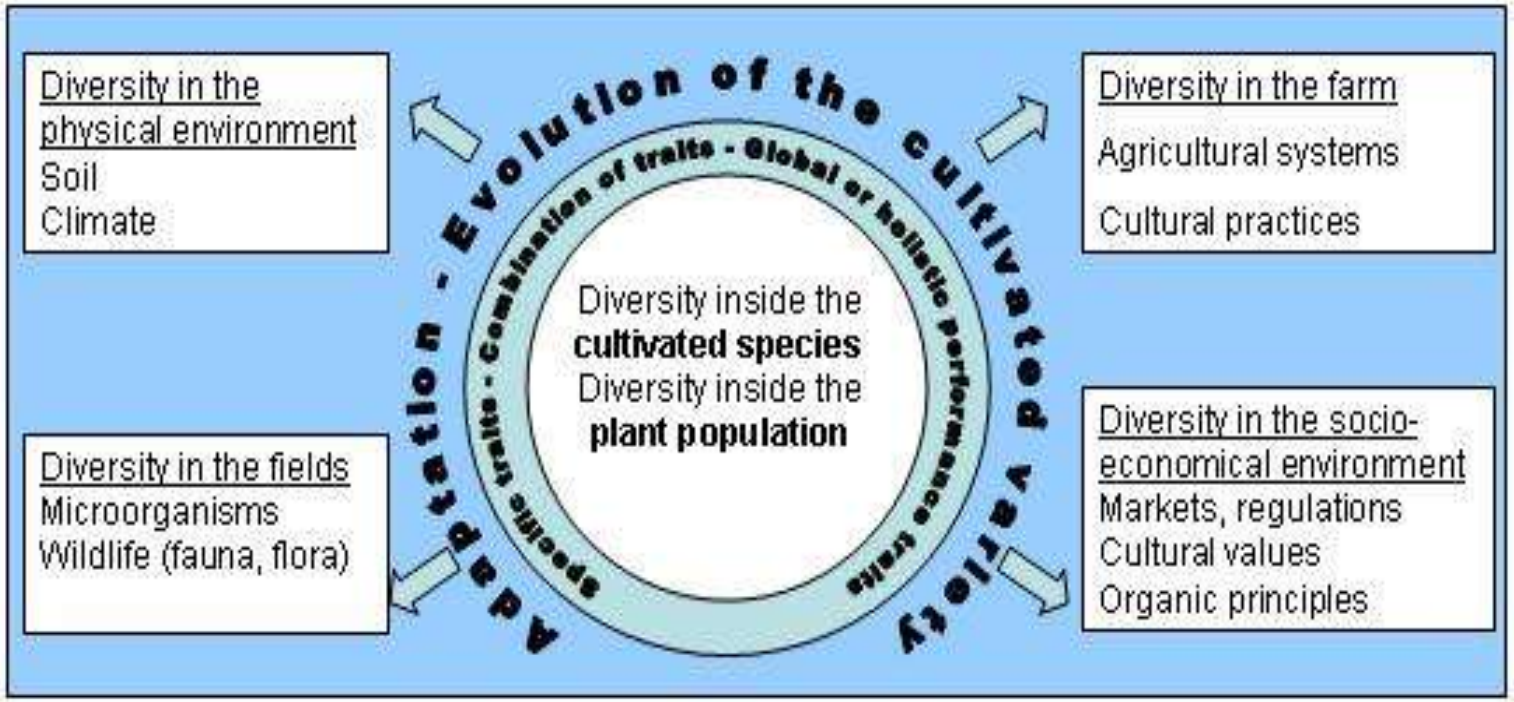
Project 3: SOLIBAM

The SOLIBAM diagram (Strategies for Organic and Low-input Integrated Breeding and Management) – an EU project started in March 2010:



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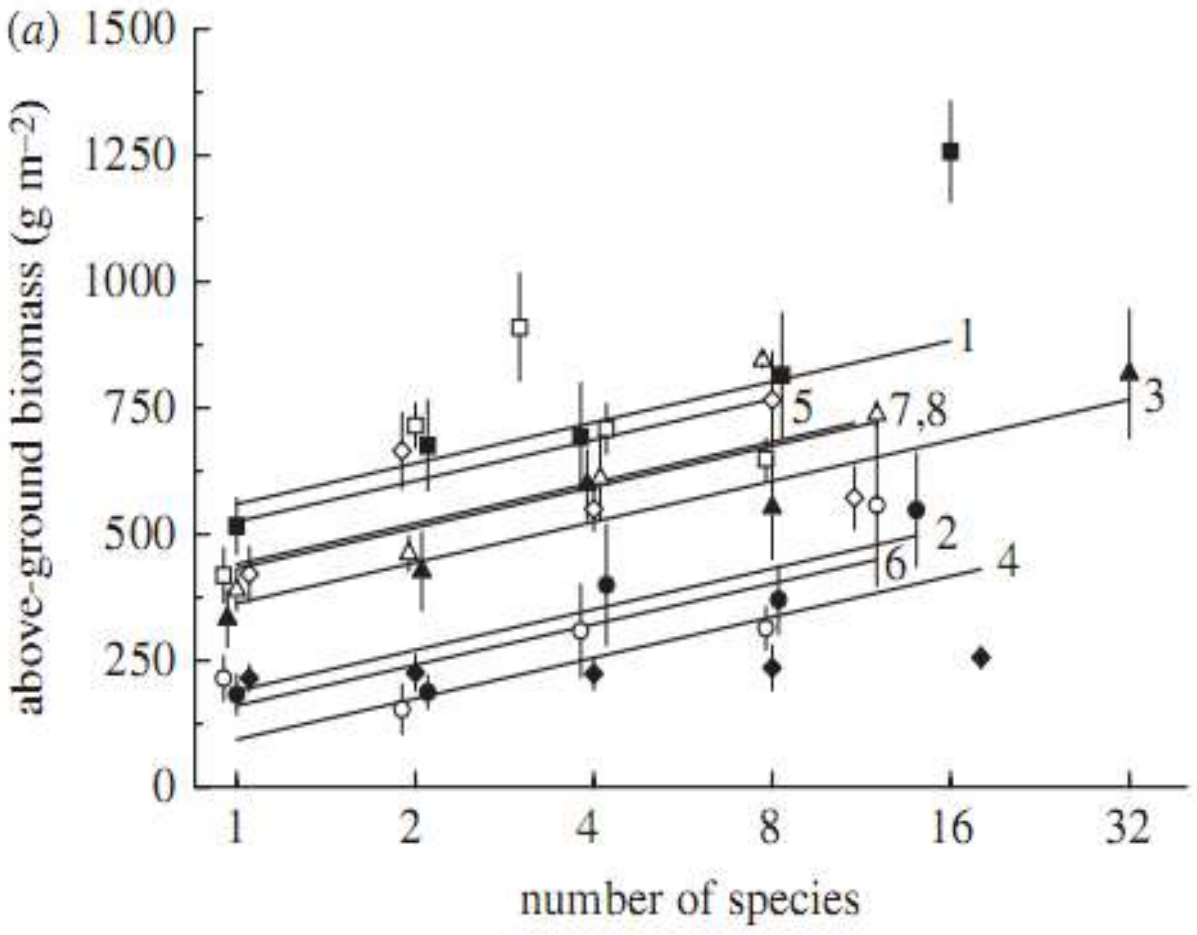
Diversity and Productivity

Natural grassland experiments

BIODEPTH project: biomass and diversity at eight European sites



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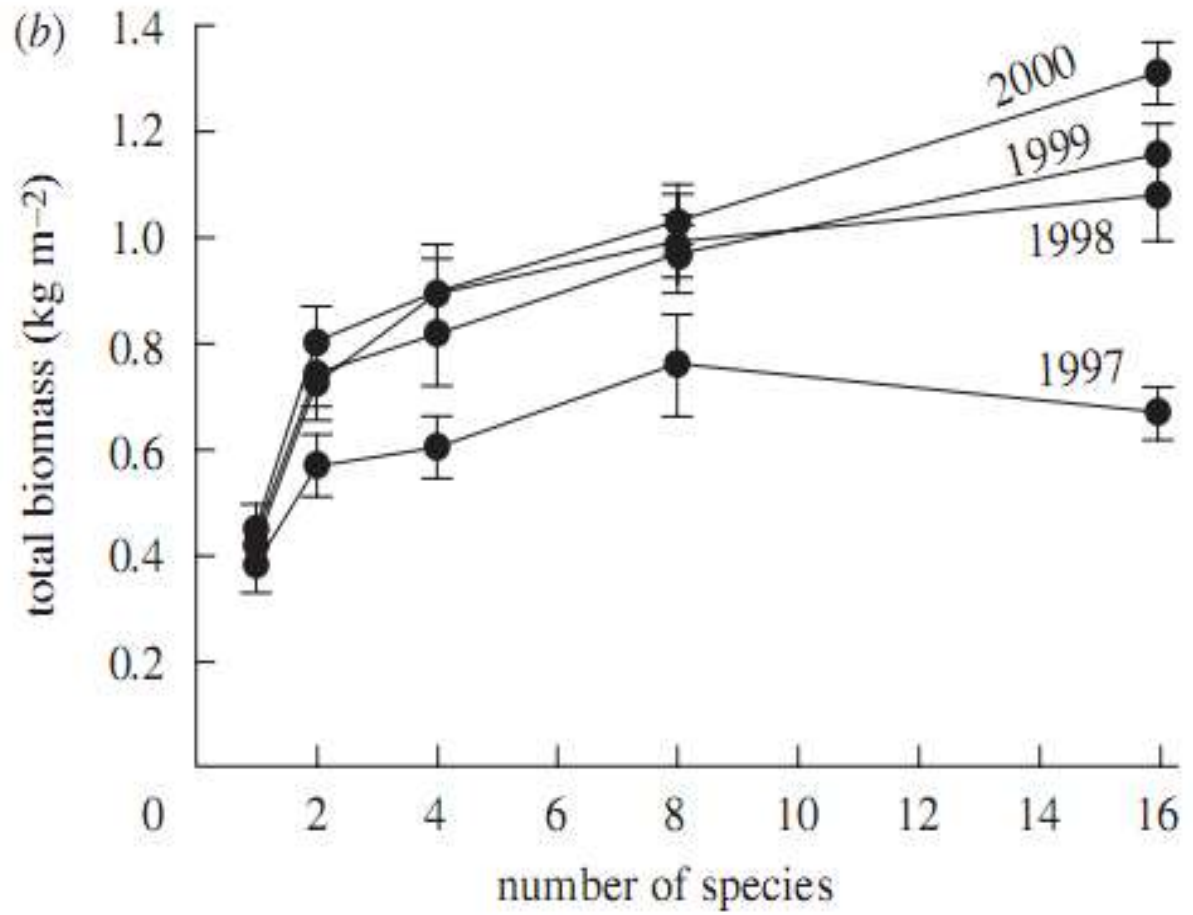
Cedar Creek: Biomass and biodiversity improves with time



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- and the importance of perenniality

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Advantages of long-term perennial grassland versus annual wheat

A. Above Ground

- Higher N yield, no inputs
- Perennials dominant, high diversity
- Pollinators, herbivores, detrivores more, more diverse

B. Below Ground

- Roots longer, deeper
- Food webs more diverse and structured
- Soil: more C and N, better structure, less leaching
- Better water quality (reduced NO3-N load)

(Glover et al., 2010)

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Root biomass below native perennial prairie versus crop land in Kansas (Culman et al. 2010)

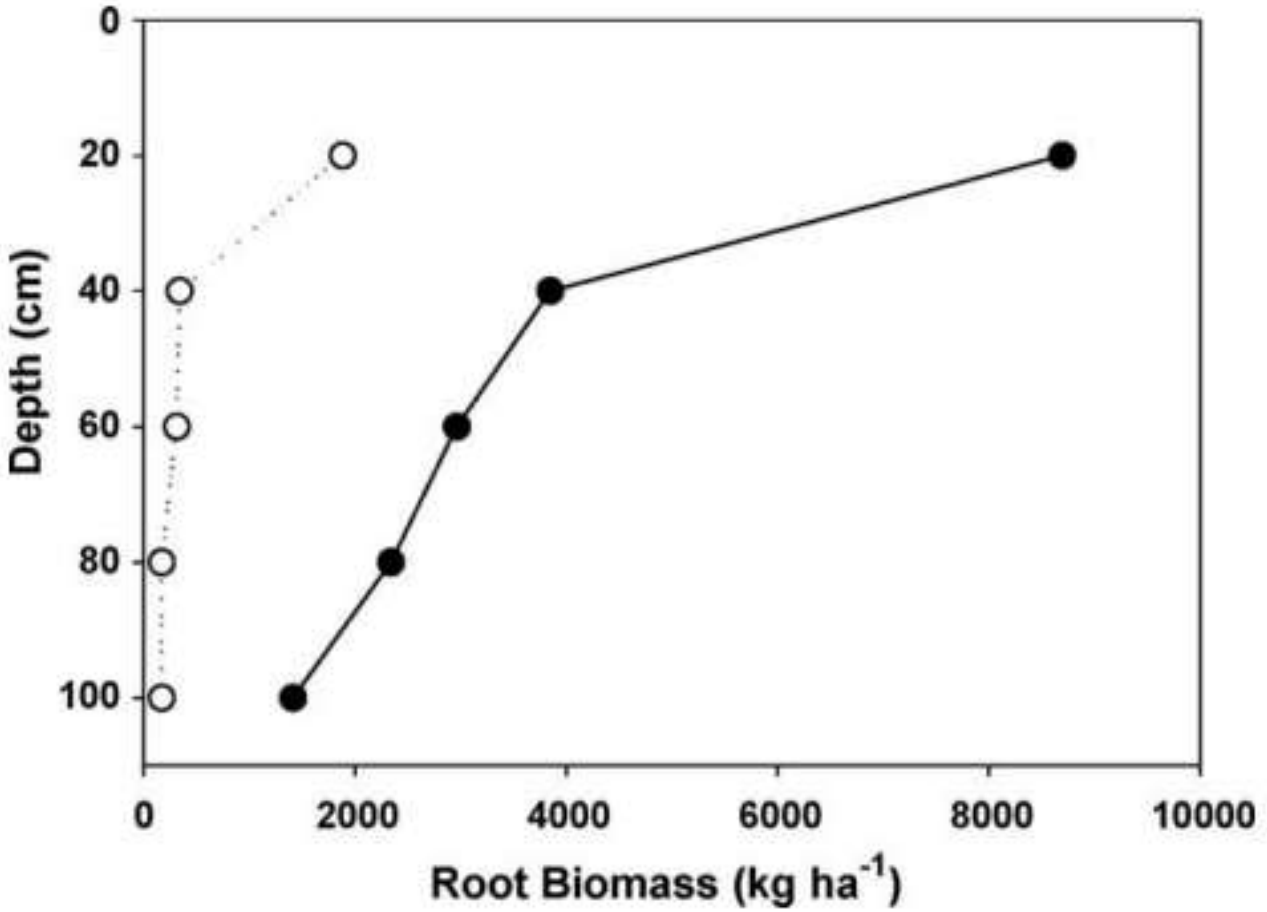

Fig. 1. Root biomass in the Niles grassland (closed circles) and cropland (open circles) site at 0–20 cm, 20–40 cm, 4–60 cm, 60–80 cm, and 80–100 cm.

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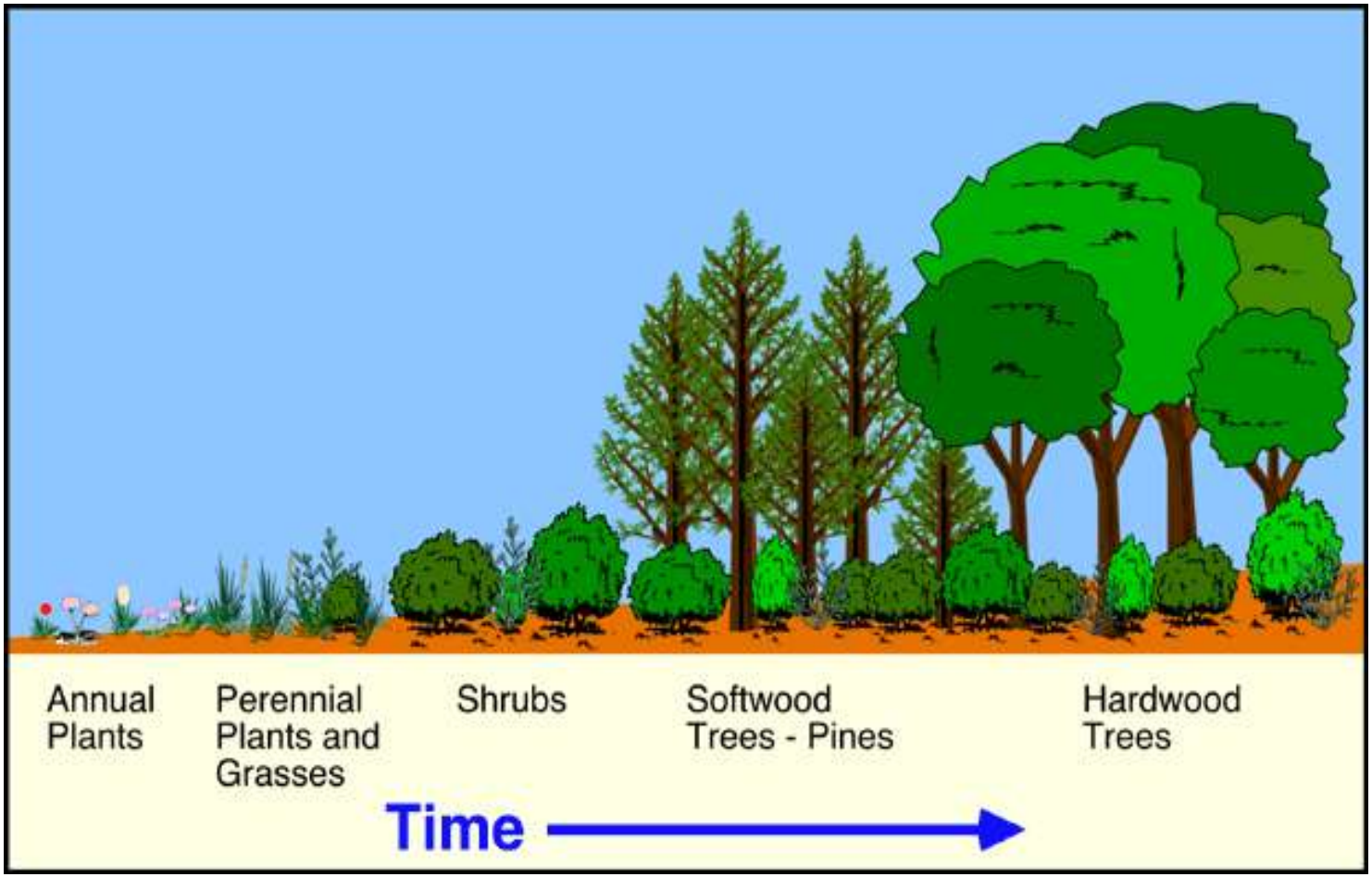
- leading to the ultimate step

AGROFORESTRY

- the integration of tree management into agriculture

- and the cultivation of woodland edge

Plant succession to climax vegetation



Models of Plant Succession

a) FACILITATION MODEL – early stage species change the abiotic environment which facilitates later stage species

b) TOLERANCE MODEL – later species have higher tolerance of diminishing resources

c) INHIBITION MODEL – later species accumulate by replacing earlier ones when they die

- generally, diversity and thus stability and productivity, increase with time, until the mature phase

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Advantages of tree integration

- Achieves ecosystem intimacy
- Carbon capture and storage
- Ammonia abatement
- Nutrient cycling
- Produces food, fuel and fibre
- Biodiversity
- Crop and animal protection and nutrition
- Also protects soil, water and air
- Employment opportunities; pension scheme

Inputs needed:

- Soil, sun, air, water – and some labour

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Winter wheat and hazel in 2006

Clover ley in 2008

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Potato crop in 2009

Hazel coppice recovery on single row (4 months)

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Wheat populations and diverse hardwood trees

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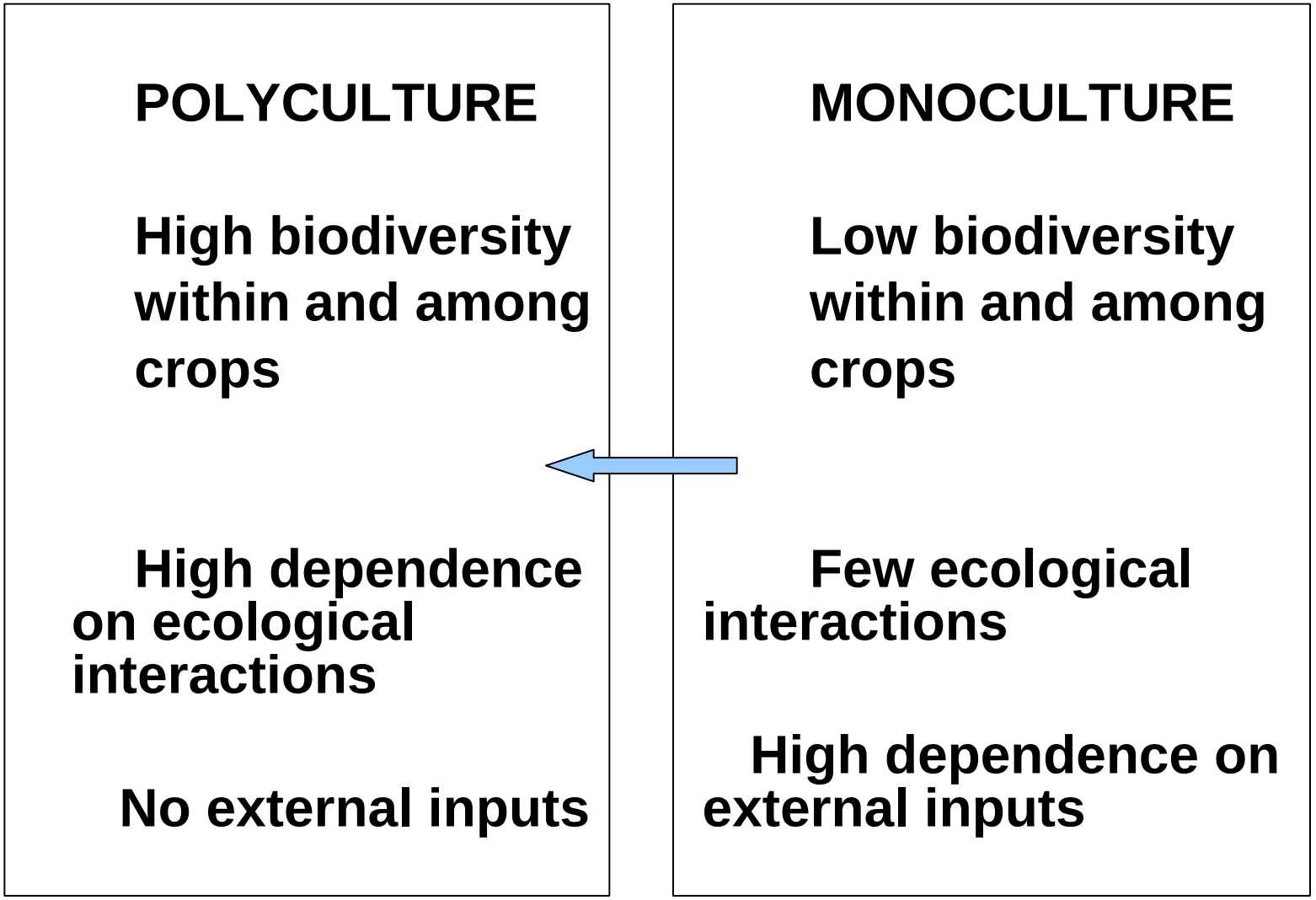
Agricultural Revolution



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The Answer - Diversity:

DARWIN, C. (1859) On The Origin Of Species By Means Of Natural Selection

"So in the general economy of any land, the more widely and perfectly the animals and plants are diversified for different habits of life, so will a greater number of individuals be capable of there supporting themselves."