

Farming under the Challenge of Climate Instability

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MONOCULTURE

High COMPETITION: identical individuals occupy same niche in space and time

- has to be minimised by high INPUTS of
Nutrients
Pest, disease and weed control
Water
- which are DEPENDENT on
Stable environment
Availability of resources
Cheap energy

Yellow stripe rust of wheat



Boosting evolution of the pathogen

- a. *P. striiformis* had to evolve as a spore-producing 'factory' – just to survive
- b. Thus, monoculture encouraged massive population increase in the pathogen (which overcame R vars, fungicides)
- c. Now globalisation of resistance monoculture has selected

**GREATER AGGRESSION AND WIDER
CLIMATE TOLERANCE**

Milus, E.A., Kristensen, K., and Hovmoller, M.S. 2009. *Phytopathology* 99:89-94.

Climate change and climate instability

There is a pressing need, simultaneously, both to:

a) Adapt, and

b) Mitigate

- *but how? Where is the model?*

The best model ?

Charles Darwin already had the answer in 1859:

the NATURAL WORLD

- with all of its **DIVERSITY**,
INTERACTIONS and evolution of
COMPLEXITY

Unifying concepts in ecology (Loreau 2010)

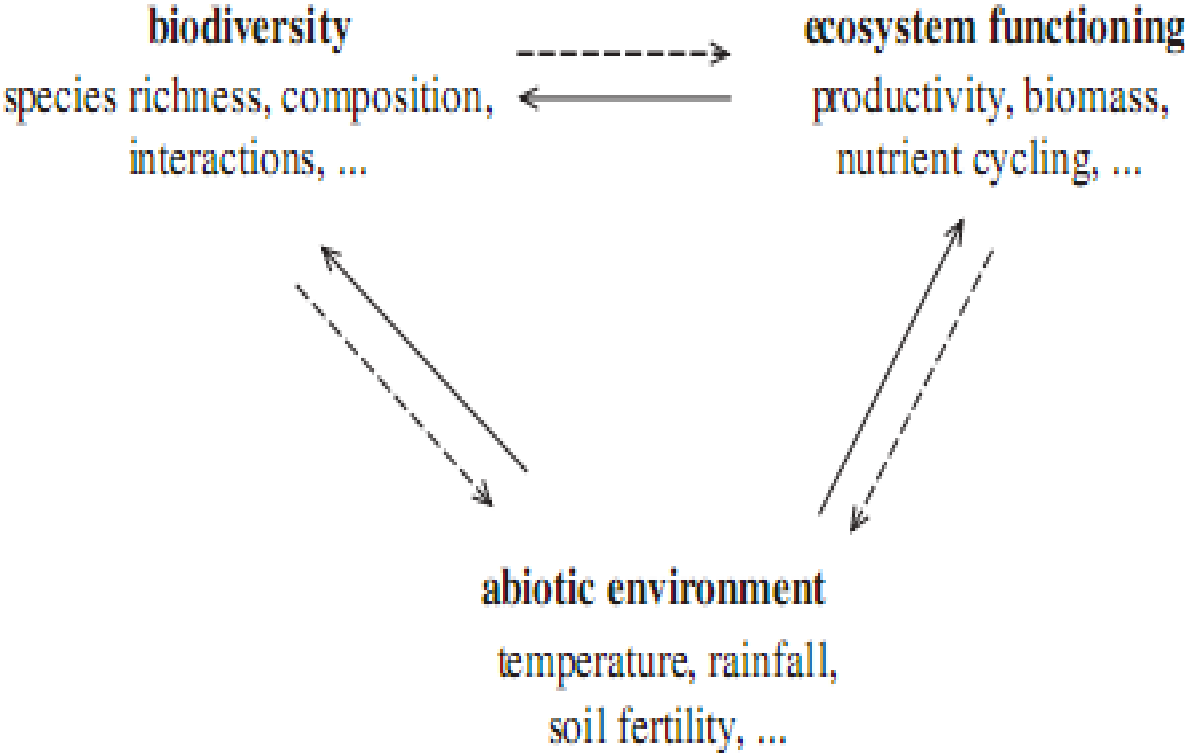
There are positive correlations between:

a) DIVERSITY and STABILITY

b) DIVERSITY and PRODUCTIVITY

- *recently proven for large-scale natural and agricultural systems*

Feed-back systems



Loreau 2010

Yield gain from natural grassland species mixture

(Yields in t/ha)

16 species grown as
separate monocultures 7.35

Same 16 species grown
as an intimate mixture 11.43

(after Reich et al., 2001)

***“Species redundancy enhances
ecosystem resilience”***

The effects of deforestation on humans and on the planet

Negative climate change, rainfall decline, salinisation, desertification, loss of biodiversity above and below ground, soil erosion -

Strife, war and loss of civilisations.....

The value of trees to humans and to the planet

- *to humans:*

shade, shelter, heating (domestic, smelting), cooking, building (houses, boats), utensils, tools, other artefacts, fruit, nuts, medicines, animal fodder and bedding – and more....

- *to the planet:*

local climate, habitat for plant and animal biodiversity above and below ground, soil development, air and water production, filtration and cycling, carbon sequestration, nutrient cycling – and more....

Diversification

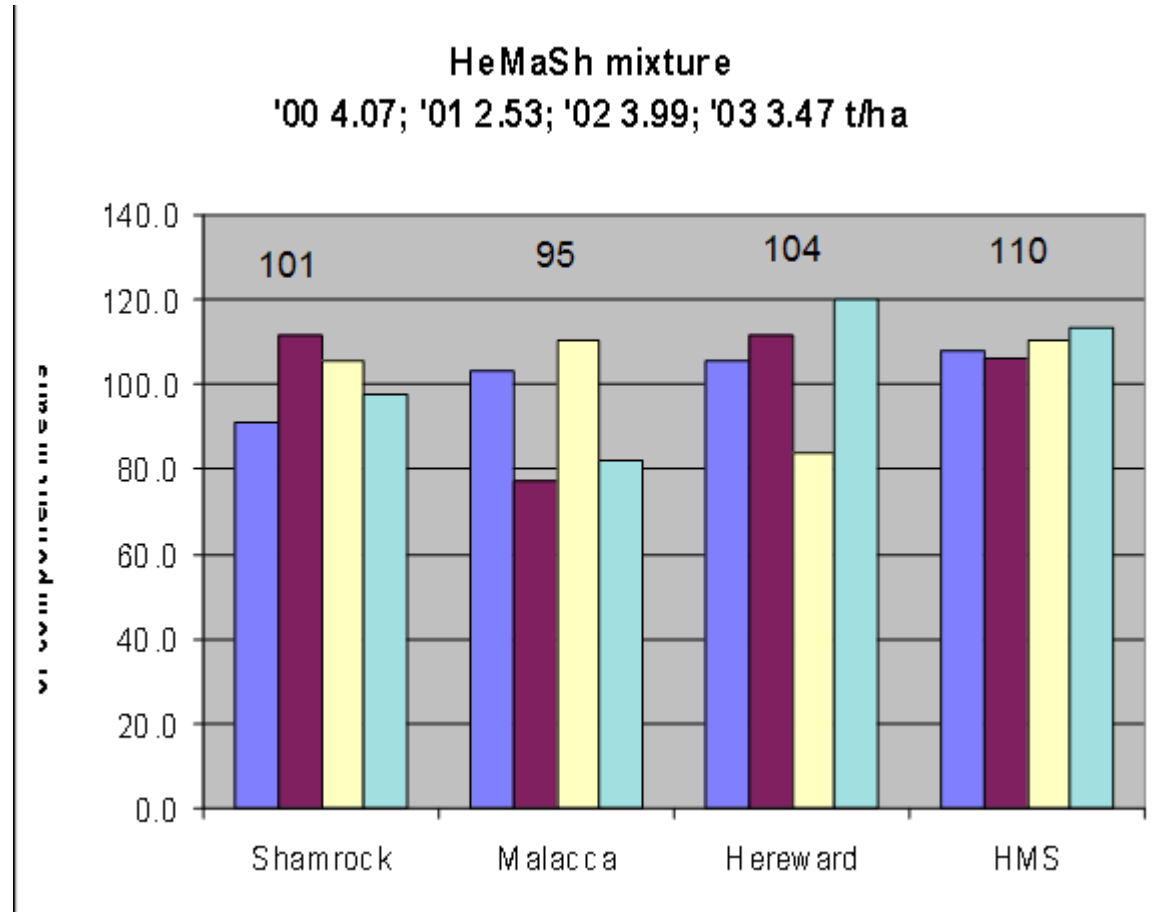
Diversity is needed, simultaneously:

a) within crops (mixtures, populations)

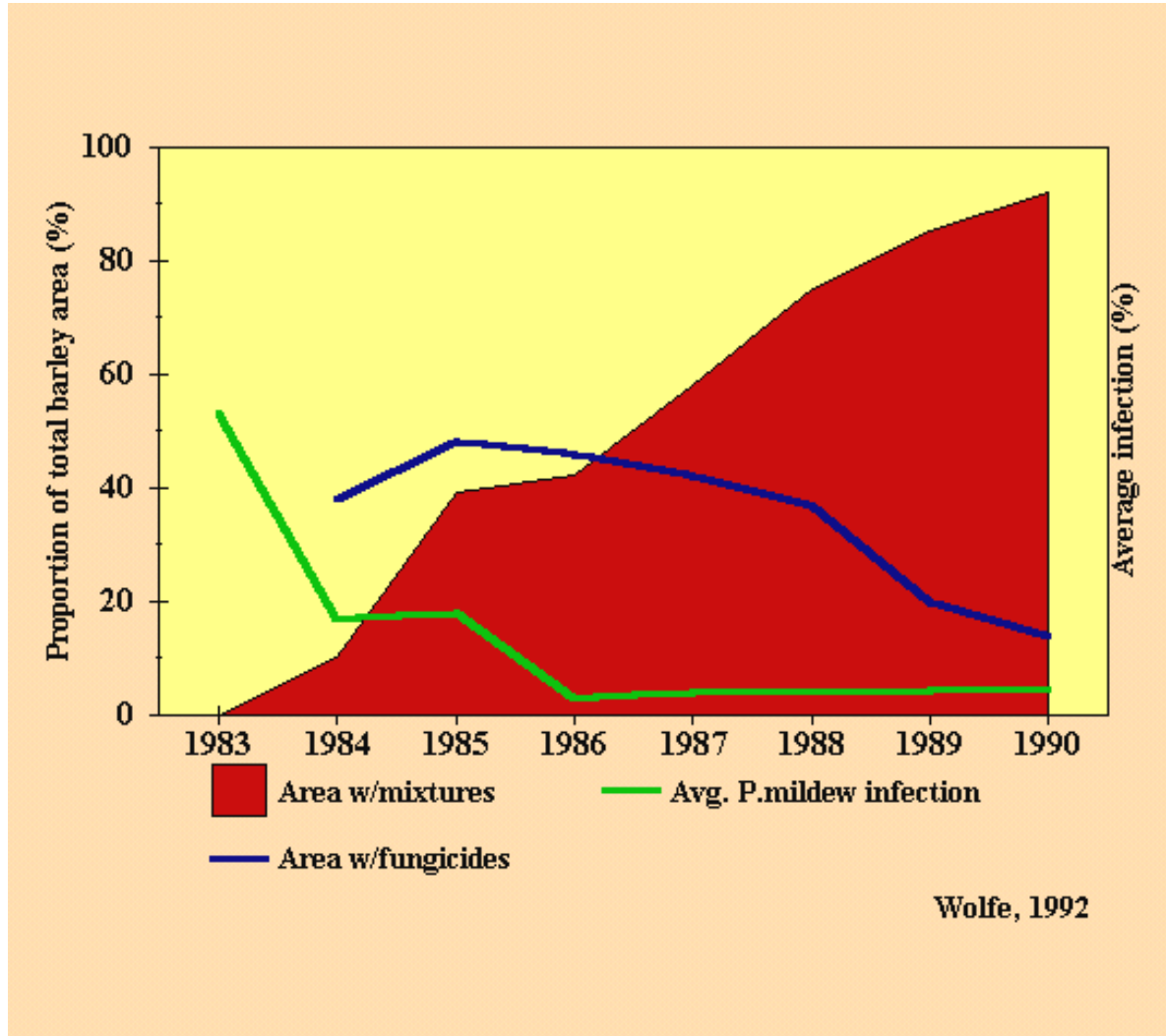
b) among crops, animals (rotations, species mixtures, inter-cropping)

c) among the main elements (agroforestry)

Wheat variety mixture: stability



A 350,000 hectare field trial: spring barley mixtures in the GDR

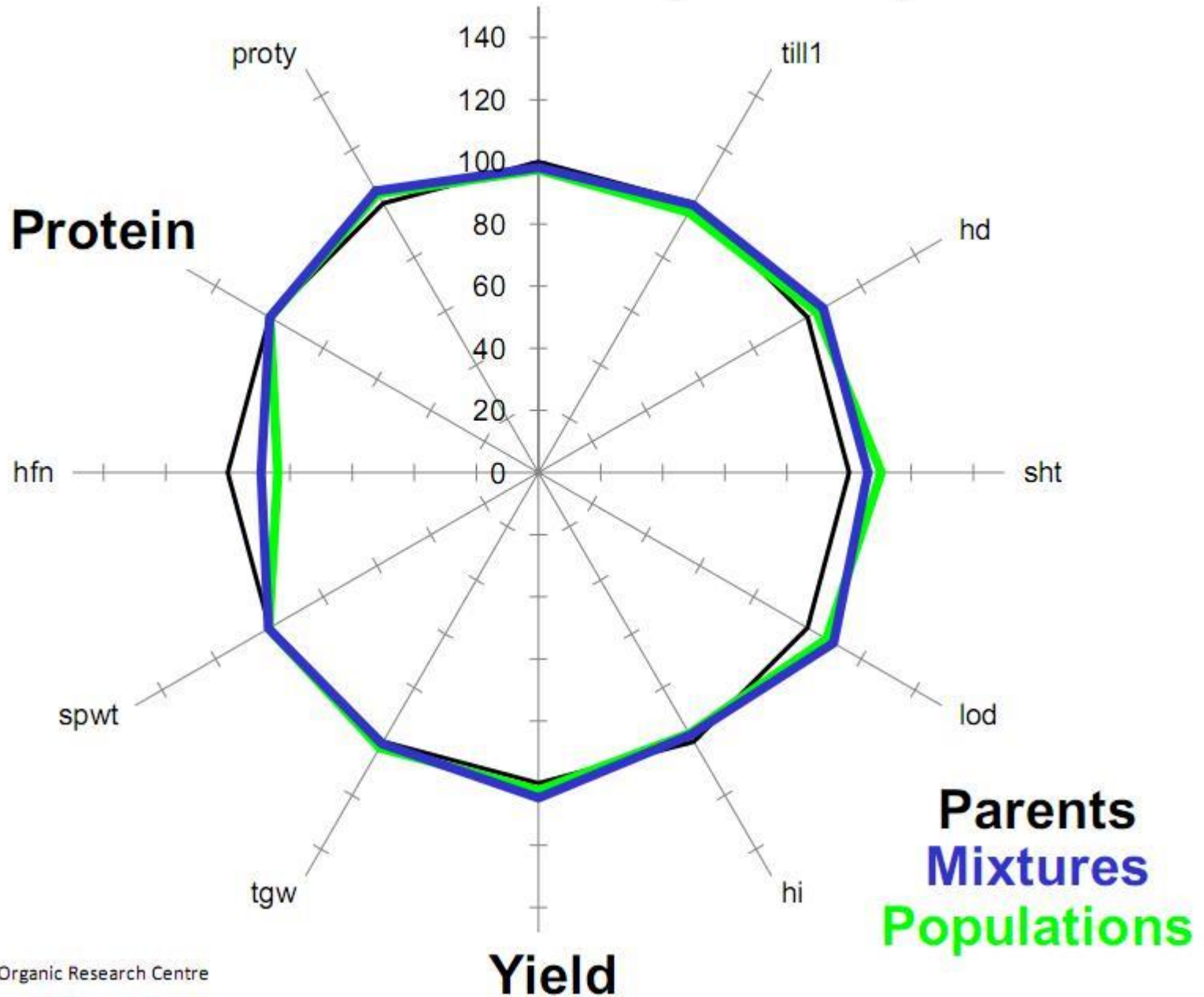


Half-diallel crossing scheme for wheat populations

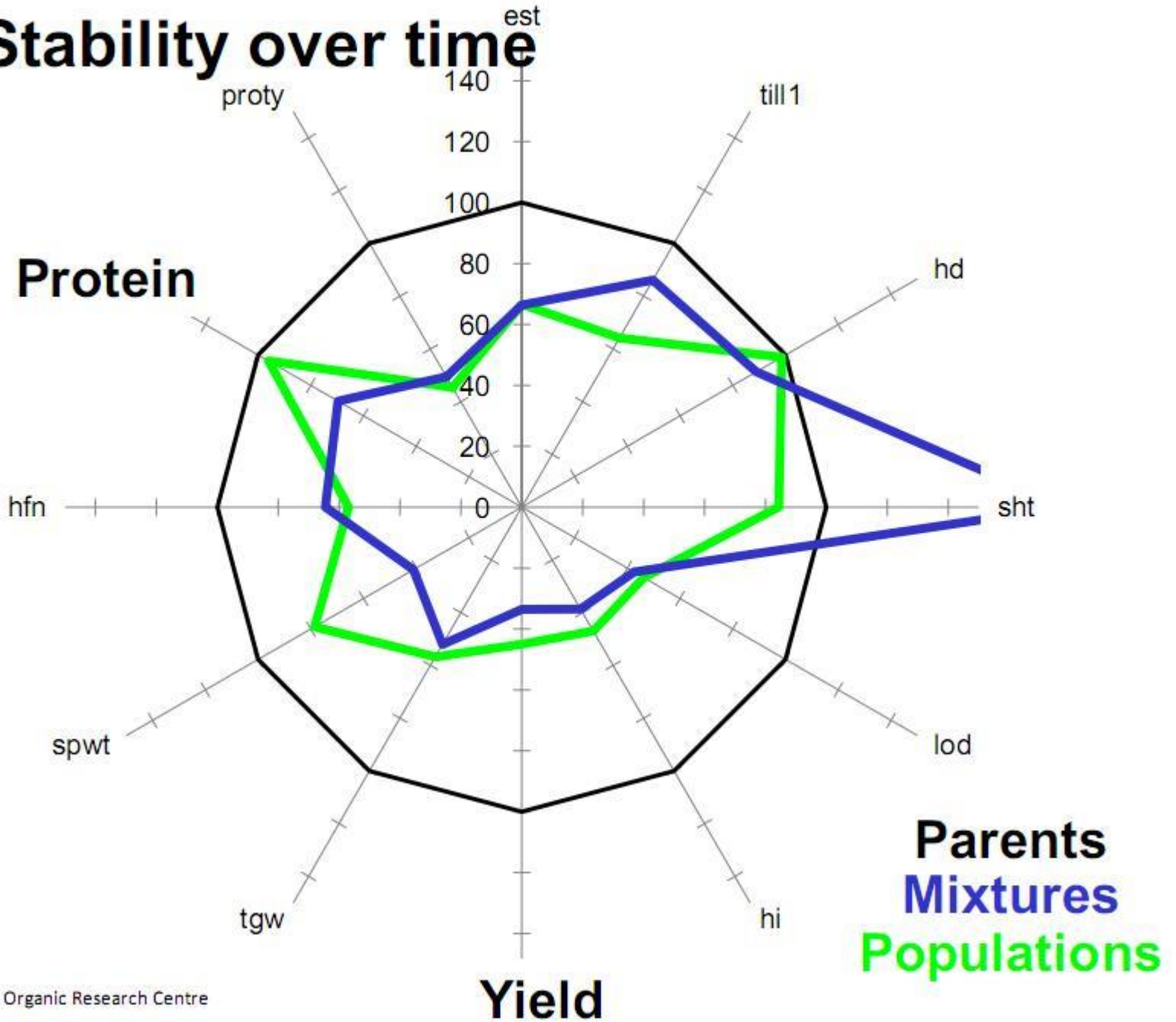
	Bezostaya	Cadenza	Hereward	Maris Widgeon	Mercia	Monopol	Pastiche	Renan	Renesansa	Soissons	Spark	Thatcher	Buchan	Claire	Deben	HTL	Norman	Option	Tanker	Wembely	
Bezostaya		yq	yq	yq	yq	yq	yq	yq	yq	yq	yq	yq	Y	Y	Y	Y	Y	Y	Y	Y	Y
Wembely	yq	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	YQ	Y	Y	Y	Y	Y	Y	Y	Y	
Tanker	yq	YQ	YQ	YQ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



Performance: Parents, mixes, CCP's

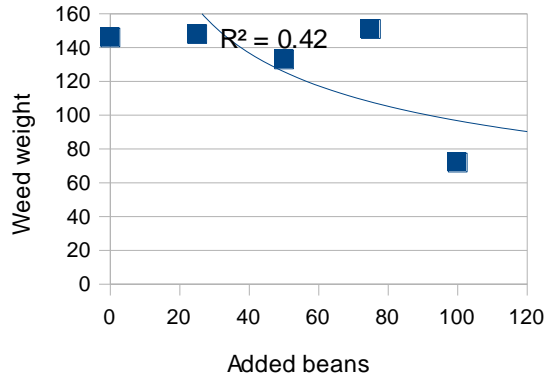


Stability over time

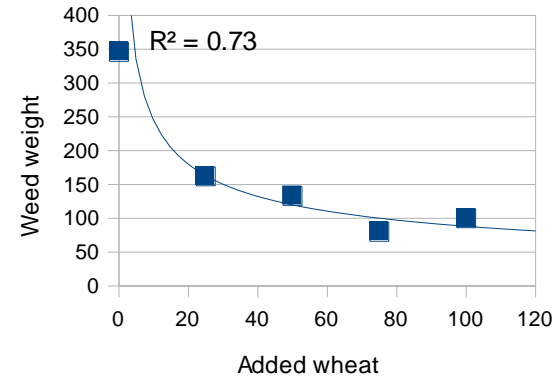


One effect of mixing wheat and beans

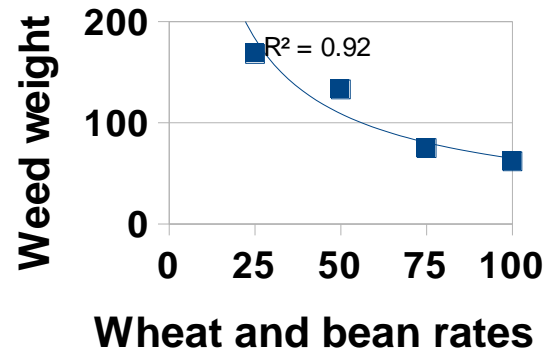
50% wheat - beans added



50% beans - wheat added



Equal rates - 25% to 100%



Clover (mix)/vegetable inter-cropping



Tools for veg/clover inter-cropping



Agroforestry

the integration of trees, arable crops and livestock (including fish) into farming systems

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

Wakelyns Agroforestry

Established from 1994 – 22.5ha

Willow
coppice

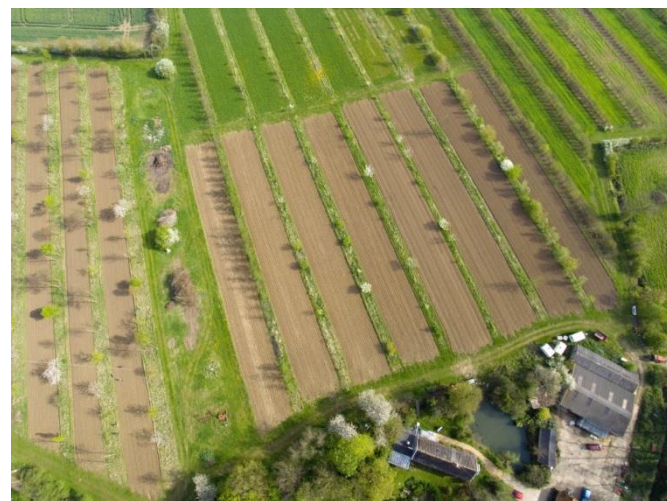
Hazel
coppice

Mixed
hardwood and
fruit trees



Agroforestry at Wakelyns

- Organic arable rotation and trials
- Products include timber, energy, fruit, nuts, craft materials, cereals, vegetables, soil fertility, pest & disease control, biodiversity.....



The Wakelyns Systems

HARDWOODS

- a) ash, hornbeam, Italian alder, oak, small-leaved lime, sycamore, wild cherry
- b) as above with dispersed apple

FRUIT AND NUT

- a) range of topfruit, some under-storey fruit bushes
- b) walnut and plum varieties

COPPICE SYSTEMS

- a) mixture of willow varieties
- b) outcrossing hazel population

Willow alleys: 1yr and 2yr



Some willow data.....

Five component mixture – planted as pairs of rows – produces

44 t fresh wt/ha/2years

Equals: 11 t dry wt/ha/year

- which gives a *Land Equivalent Ratio* of about 1.4

(- but an FER of about 2.2 using heating oil prices)

The Organic Research Centre



Pest and diseases – an example



Wakelyns Agroforestry

- ~ 2ha system
- 21 varieties of apple; 38 trees
- 7 timber species
- 12m crop alleys
- Planted 1994
- Unsprayed

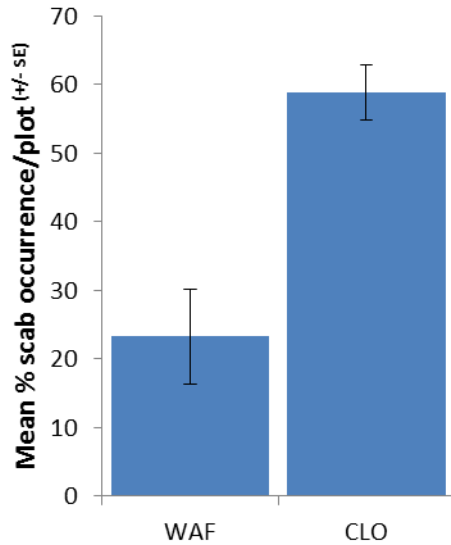
Clarkes Lane Orchard

- 0.2 ha new orchard
- Planted 2004
- 19 varieties of apples
- M9 rootstock (dwarfing)
- 3m between rows, 1.5m between trees within row
- Unsprayed

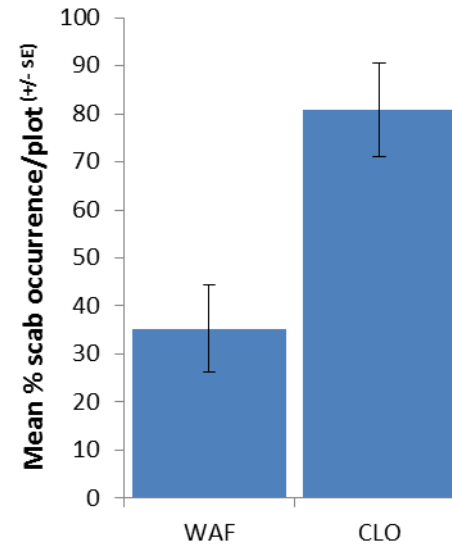


Scab occurrence 2012

Small fruits (early July)



Large fruits (end August)



The birds and the bees.....



BIRDS: on 22ha, 45-50 species

BEES: 40,000/ha on legume leys



.....and the BUTTERFLIES

NB natural selection of farm AND woodland types

Summary benefits of agroforestry

Provisioning: fruit, nuts, browse, timber, energy

Regulating: carbon sequestration, organic matter, shade/shelter and local climate regulation, pest and disease control, pollination, purification of soil, water and air

Supporting: nutrient dispersal and cycling, seed dispersal, soil microbial development, habitats

Cultural: employment and pensions, spiritual, health and recreational benefits

Inputs? - soil, air, water, sun – and some labour

To make this work, there is a need for

a) a better appreciation of **TOTAL productivity** from, and **environmental benefits** of, agroforestry systems

b) appropriate **regulatory changes** to allow farmers to take advantage of agroforestry systems – as in EU policy

- explored by Jo Smith, ORC, in

http://orgprints.org/18248/1/Agroforestry_policy_v1.1.pdf



