Soil conservation in the UK

IAgrE Lunchtime Seminar Series
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Cranfield Environment and Agrifood

IAgrE

The Queen's Anniversary Prizes
For Higher and Further Education
2017

International Decade of Soils 2015-2024

Soil conservation in the UK

Outline of the talk

1. Why do we need soil conservation in the UK?

2. Soil conservation practices to reverse and prevent soil degradation

3. The future of soil conservation….?

4. Q and As

International Decade of Soils 2015-2024

1. Why do we need soil conservation?

*"The thin layer of soil covering the earth's surface represents the difference between survival and extinction for most terrestrial life" **

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*From: Doran, J.W. and T.B. Parkin. 1994. Defining and assessing soil quality. Doran et al. (eds.), Defining Soil Quality for a Sustainable Environment. Soil Science Society of America.

1. Why do we need soil conservation?

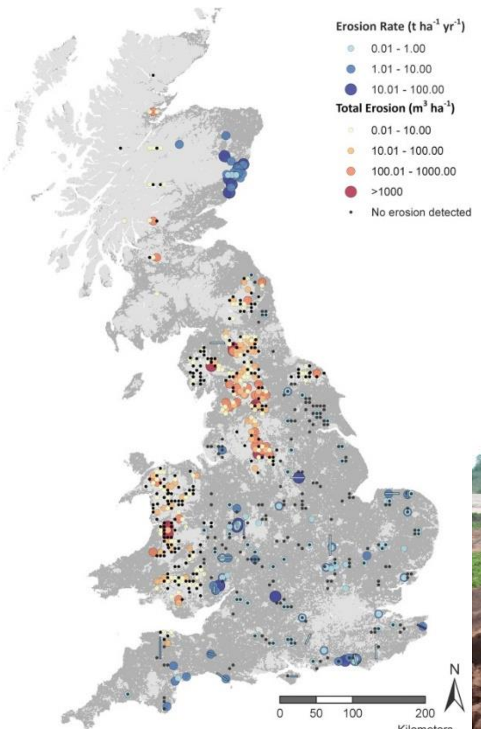
Increasing pressure on finite soil / land resources (food, fuel, infrastructure)

Estimated 12 million hectares of agricultural land worldwide are lost to **soil degradation** every year.

Soil degradation identified in Defra's 'Safeguarding Our Soils' and 25 Year Environment Plan, and in the EU's 'Thematic Strategy for Soil Protection' (2006)

Degradation threats: Soil erosion in the UK

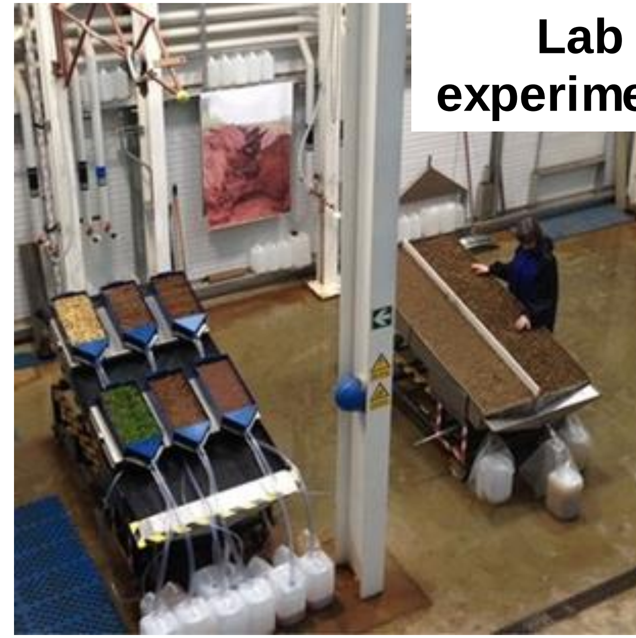
Threats to soils: soil erosion

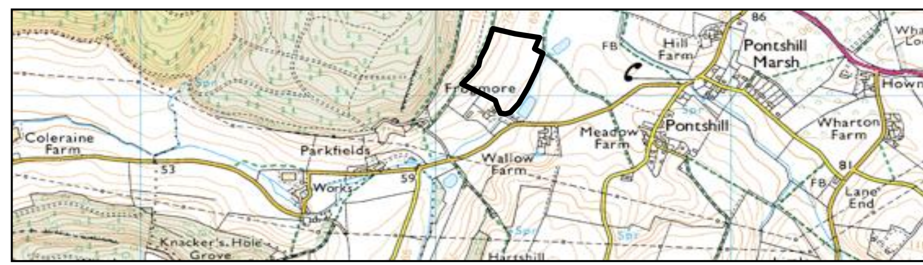


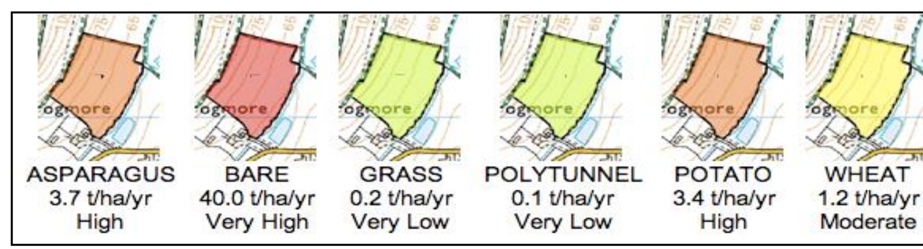
Spatial distribution and magnitude of soil erosion records (Benaud et al., 2020), Geoderma

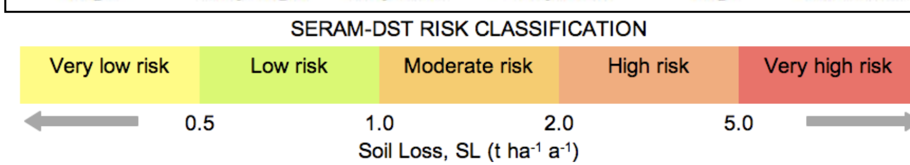
Field erosion surveys

Lab experiments



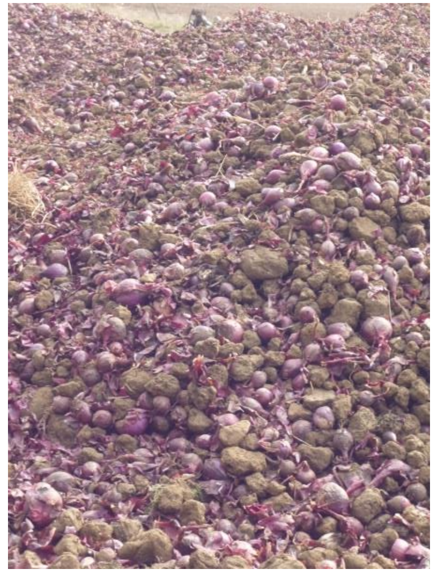






Modelling: soil erosion risk classes

1. Why do we need soil conservation?

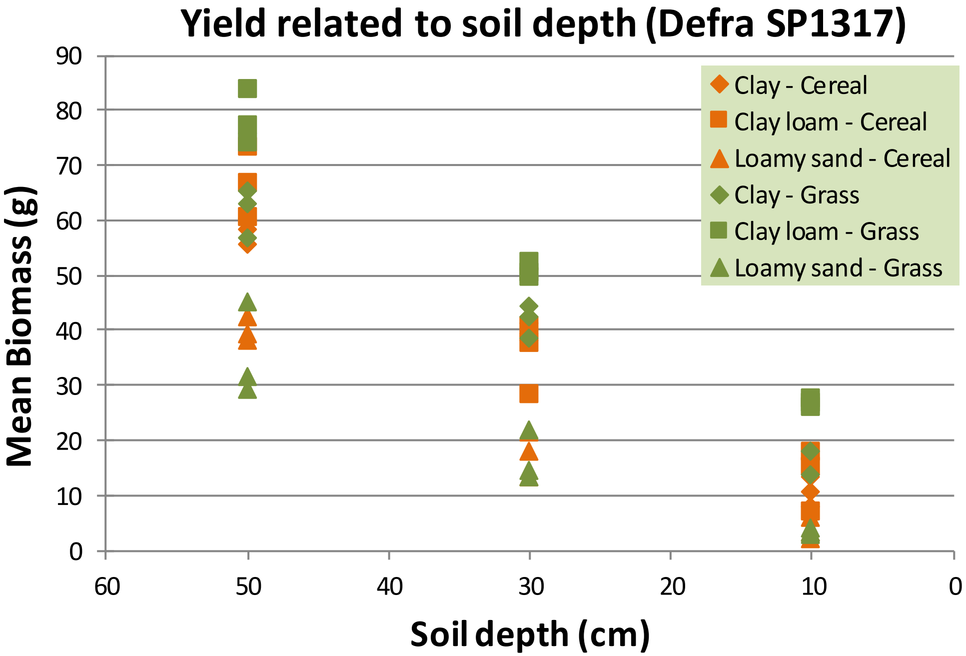


	Wind erosion	Tillage erosion	Co-extraction with root crops and farm machinery	Water
Typical erosion rate range (t ha^{-1} $year^{-1}$)	0.1 – 2.0	0.1 – 10.0	0.1 – 5.0	0.1 – 15.0
Land use affected	Arable, upland, some pasture	Arable	Arable	Arable, pasture, upland
Exported off field	Yes	No	Yes	Yes

Comparison of the magnitude of soil loss for different erosion processes in the UK (Owens et al., 2006). *N.B.* Rate of soil formation ≈ 1 t ha^{-1} $year^{-1}$ (Verheijen et al., 2009)

1. Why do we need soil conservation?

- Irreversible loss of a natural resource / asset?
  - e.g. loss of soil depth due to erosion
- Yield decline (quantity, quality and reliability; e.g. 20 million tonnes of grain per annum; UNCCD, 2011)
- Costs (e.g. reseeding, nutrient replacement)
- True impacts on food production currently masked by unsustainable inputs?
  - Irrigation
  - Chemical fertilisers



1. Why do we need soil conservation?

Soil erosion and runoff from agricultural land is thought to deliver up to

- 70% of sediments (eroded topsoil)
- 60% of nitrates (NO_{3-}) (mostly soluble, in runoff)
- 25% of phosphates ($(PO_4)^{3-}$) (mostly adsorbed to sediment)

to receiving waters (National Audit Office, 2010).

Specifically, 487 rivers in England are failing their water quality targets for sediments:

- 2,480 due to excessive agricultural phosphate inputs
- another 2,346 due to the water industry not being able to meet phosphate discharge targets

(Source: Environment Agency, 2015)

Total costs of soil degradation £ million per year
(From Graves et al. (2011). Prices adjusted for inflation, 2020)

£ million per year	Ecosystem service						Total	
	Provisioning	Regulating services				Cultural		
	Agricultural production	Flooding	Water quality	GHG emissions	Other		Central estimate	
Soil erosion	**49**	**79**	**73**	**11**	**?**	**?**	**212**	14%
Compaction	**244**	**195**	**85**	**61**	**?**	**?**	**586**	39%
Loss of organic matter	**2**	**?**	**?**	**671**	**?**	**?**	**673**	45%
Contamination	**?**	**?**	**?**	**?**	**31***		**31***	2%
Loss of soil biota	**?**	**?**	**?**	**?**	**?**	**?**	**0**	0%
Soil sealing	**?**	**?**	**?**	**?**	**?**	**?**	**0**	0%
TOTAL	**£295.24 m**	**£274.5 m**	**£158.6 m**	**£742.98 m**	**£30.5 m**	**0**	**£1,502 m**	**100%**
%	20%	18%	11%	49%	2%	0%	100%	

*cost of regulation to protect soils from contamination ? Estimates not available at national scale

From Graves, A., Morris, J., Deeks, L.K., Rickson, J., Kibblewhite, M.G., Harris, J.A. and Farewell, T.S. (2011) The Total Costs of Soils Degradation in England and Wales. Final project (SP1606) report to Defra.

2. Soil conservation practices to reverse and prevent soil degradation

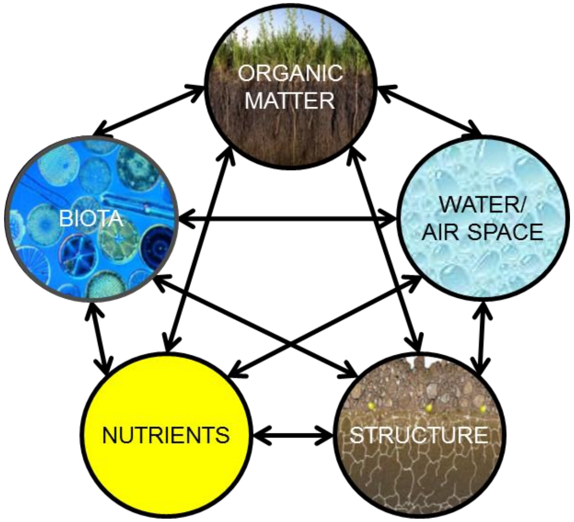
Aim: "To maintain a fertile seedbed and root zone, whilst retaining maximum resistance to soil degradation"

1. Enhance productivity (quantity, quality and reliability of marketable yield)
   - Improve uptake of water and nutrients by roots
   - Reduce pests / diseases / weeds

2. Control soil degradation
   - Erosion; diffuse pollution; compaction; losses of C, organic matter and habitats; salinisation; acidification

3. Concept of "sustainable intensification"
   - Producing more (quantity/ quality/ reliability of marketable yield) with less environmental impact / damage

1 + 2 = 3 ☺



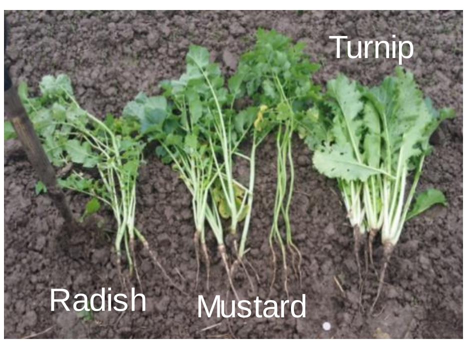
Soil health: the pivotal 5
(after K Ritz, pers. comm)

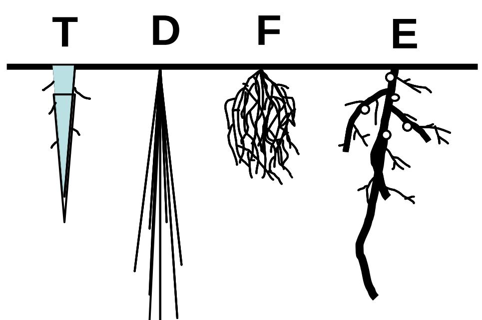
Soil erosion, Bedfordshire

Cranfield Environment and Agrifood

2. Soil conservation practices to reverse and prevent soil degradation

- Cultivations and tillage practices
- Cover cropping
- Field engineering structures
- Erosion control products (e.g. geotextiles)
- Soil (organic) amendments





Soil conservation practices: The SOWAP Project: Soil and Water Protection in Northern Europe

Who? Project Team

- Academia
- Non-governmental organisations
- Commercial enterprises
- And most importantly farmers

What?

- Conservation agriculture in annual crops: maize, potat[illegible]r beet
- Funding € 4m (EU-Life Environment Programme)
- 4 year project

Where?

- UK (Holnicote Estate, Selworthy, Somerset (NT estate) and Loddington, Leicestershire (Allerton Trust estate)
- Belgium, Hungary, Czech Republic, France
- Links with ProTerra project (France, Spain, Portugal, Italy) on perennial crops: vineyards and olive orchards

The Allerton Trust

Objectives of SOWAP

SOWAP aims to demonstrate:

- the viability, effectiveness and benefits of “conservation oriented” land management systems in:
    - improving catchment water quality
    - protecting soil resources
    - promoting biodiversity

- the environmental impacts associated with “conventional” arable land use practices, in terms of
    - pollution of water resources
    - reduced biodiversity
    - degradation of soil resources
    - less carbon sequestration

SOWAP methodology

Field scale soil erosion plots are used to:

- compare different soil management practices
  - Conventional (ploughed, inverted soil)
  - SOWAP (minimum tillage (e.g. direct drill) + cover crop)
  - Farmer Preference (subsoiling, non inversion tillage)

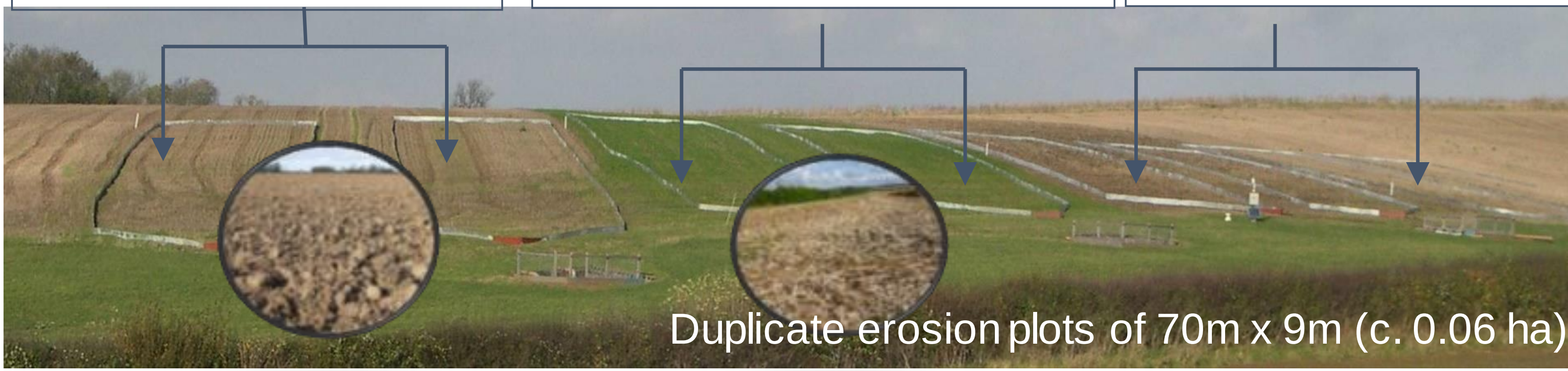
- measure runoff volume, sediment mass, and pesticides, N, P, K and C in runoff and sediment (sources and pathways)

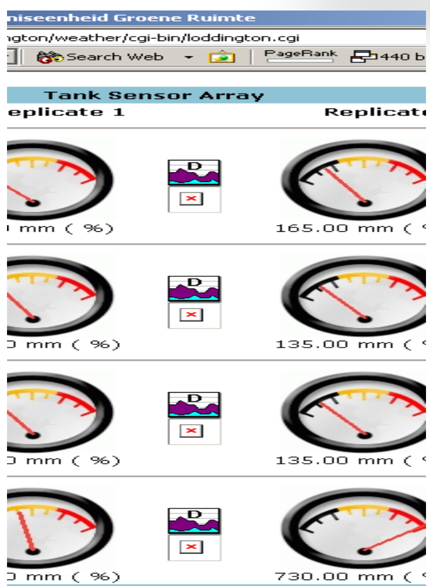
- SOWAP also evaluated biodiversity and levels of nutrients and pesticides in catchment waters (receptors)

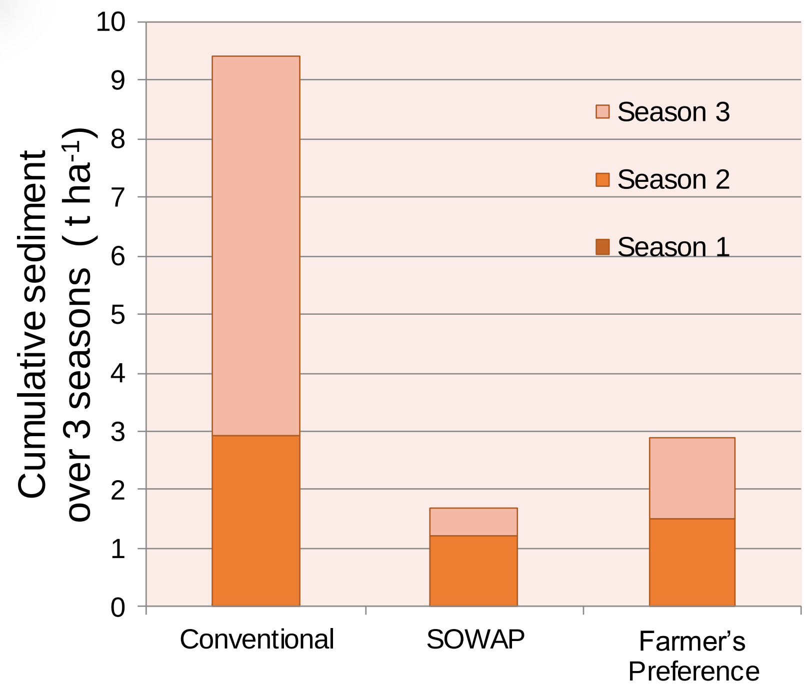
+ Biodiversity, agronomy, economics at field, farm and catchment scale

2. Soil conservation practices to reduce soil and water losses: Soil and Water Protection in Northern Europe (SOWAP)

Conventional practice | SOWAP (Minimum tillage) | Farmer's Preference





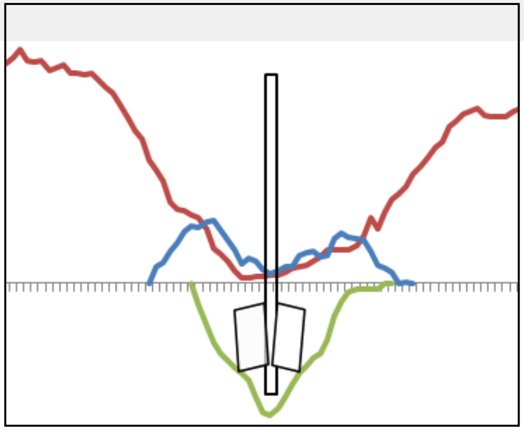
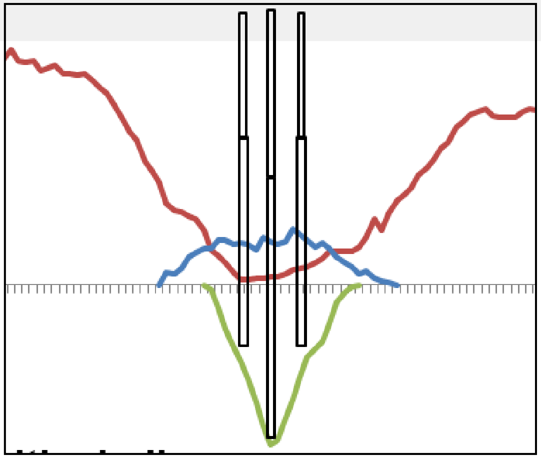
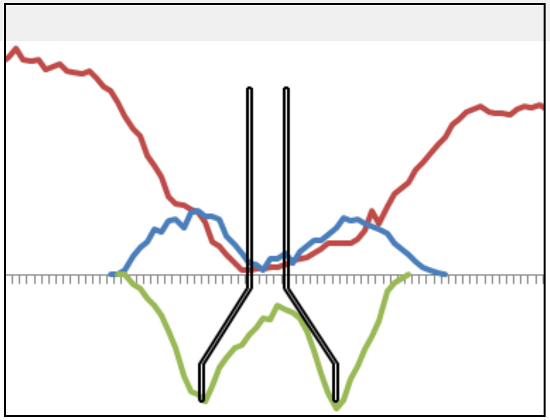


2. Soil conservation practices: Optimising soil disturbance and use of mulches for soil erosion and runoff control (Dr. Joanne Niziolomski)

Field trial tillage / implement treatments

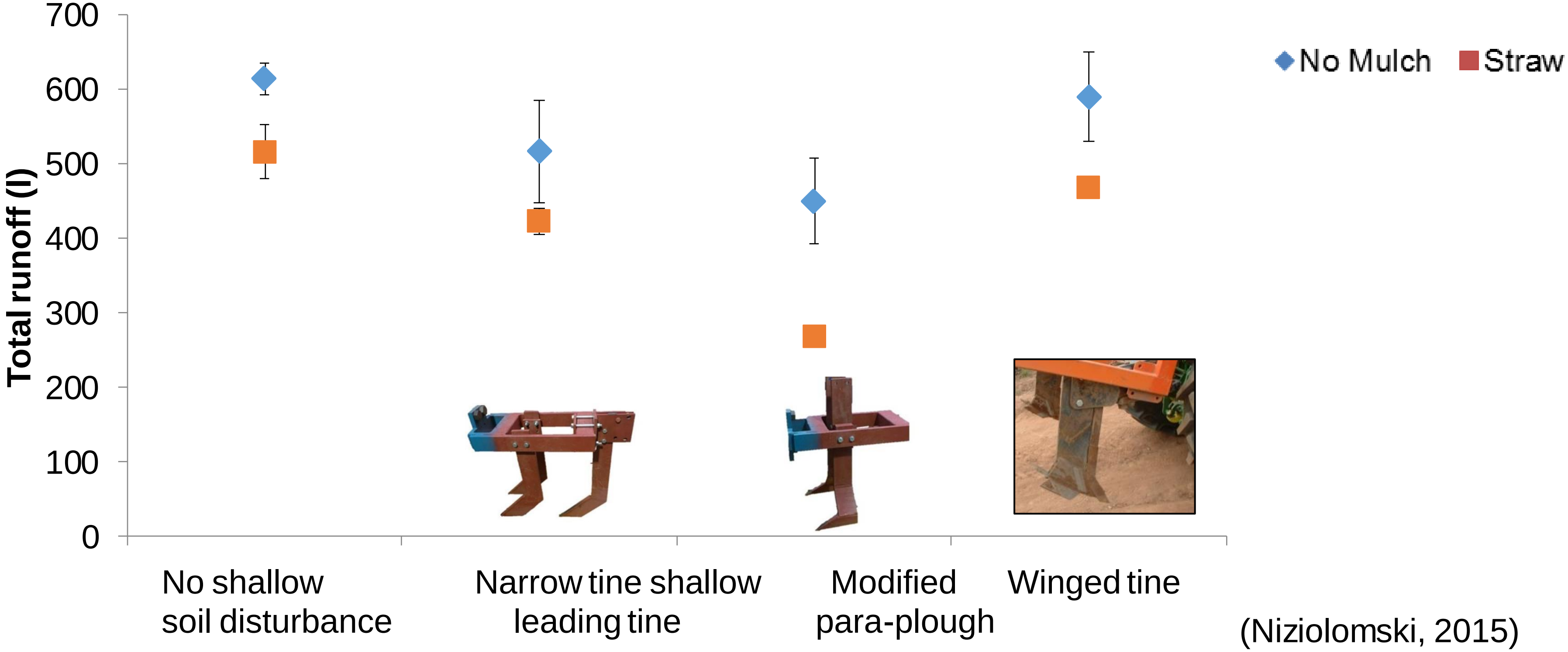
Winged_soil_bin.mp4

Shallow soil disturbance (175 mm), both with and without straw mulch (6 t ha^{-1}).

Winged tine	Narrow with two shallow leading tines	Modified para-plough
		
		

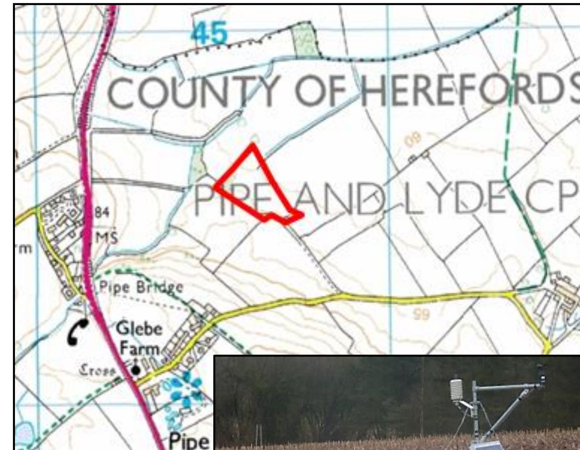
Soil disturbance field trial results: Total runoff volume (l)

- Straw mulch always reduced runoff
- MPP with straw reduced total runoff significantly (p<0.05) compared with all other treatments.

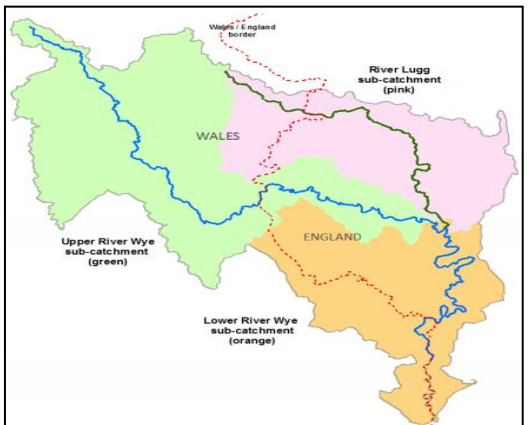


(Niziolomski, 2015)

2. Soil conservation practices: Using filter sox and P sorbing materials



The use of filter socks to mitigate runoff, soil and nutrient losses from arable lands. PhD research project, Alexandra Cooke.



2. Soil conservation practices:

Use of grassed waterways for runoff and soil erosion control

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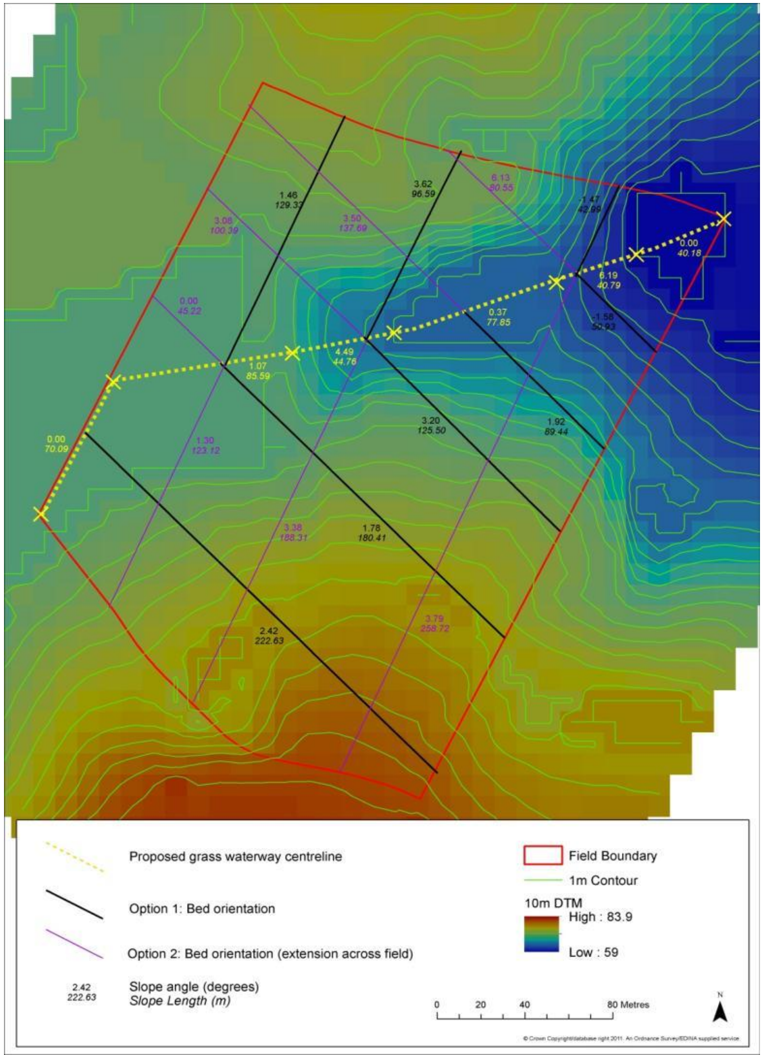
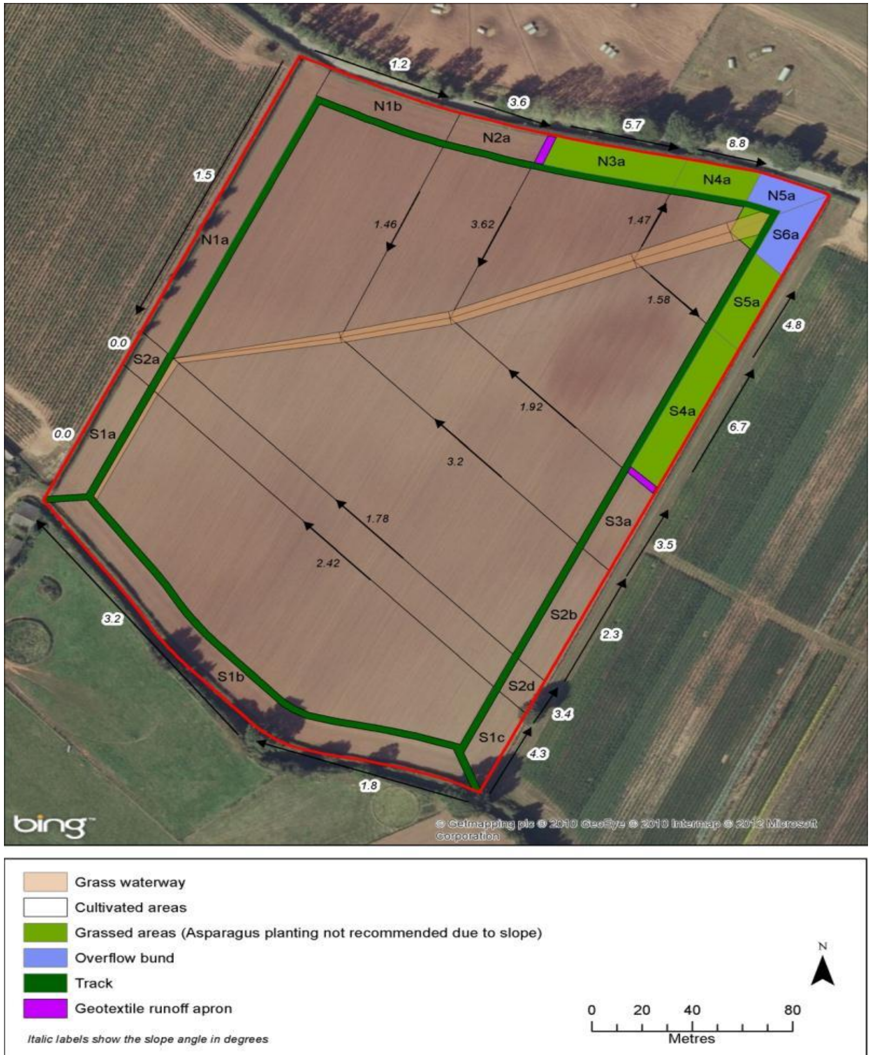
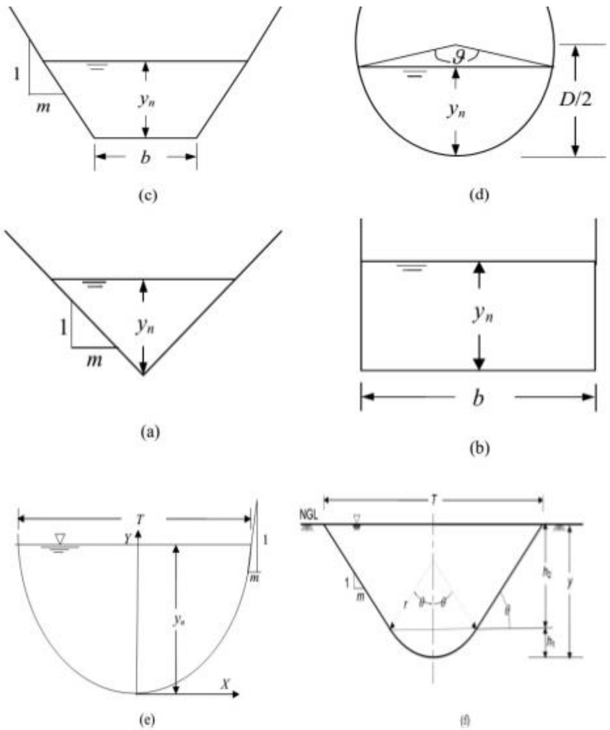
Use of grassed waterways for runoff and soil erosion control

Field survey and erosion risk assessment





Soil conservation practices:
Use of grass waterways for runoff and erosion control



Waterway designs based on open channel hydraulics (flow discharge (based on catchment area and character), channel roughness, hydraulic radius, channel depth and channel width)

2. Soil conservation practices: use of geotextiles for soil erosion control

- Definition:

"permeable textile materials, used with foundation, soil, rock, earth or any geotechnical engineering related material".

John, 1987.

- Synthetic and natural fibres

- Not a new technique
  - ancient Egypt - World War II - 1960s
  - present day use - more environmentally sensitive products
  - implications for world trade and economic development

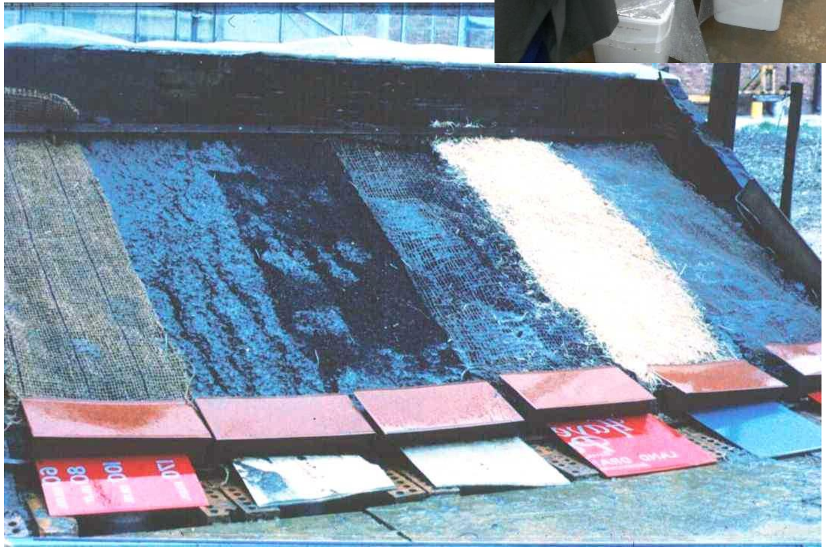
- Used in civil engineering projects
  - Separation, filtration, ground stabilisation, erosion control, vegetation management

- Sales = 250 - 400 million metre^2 per annum

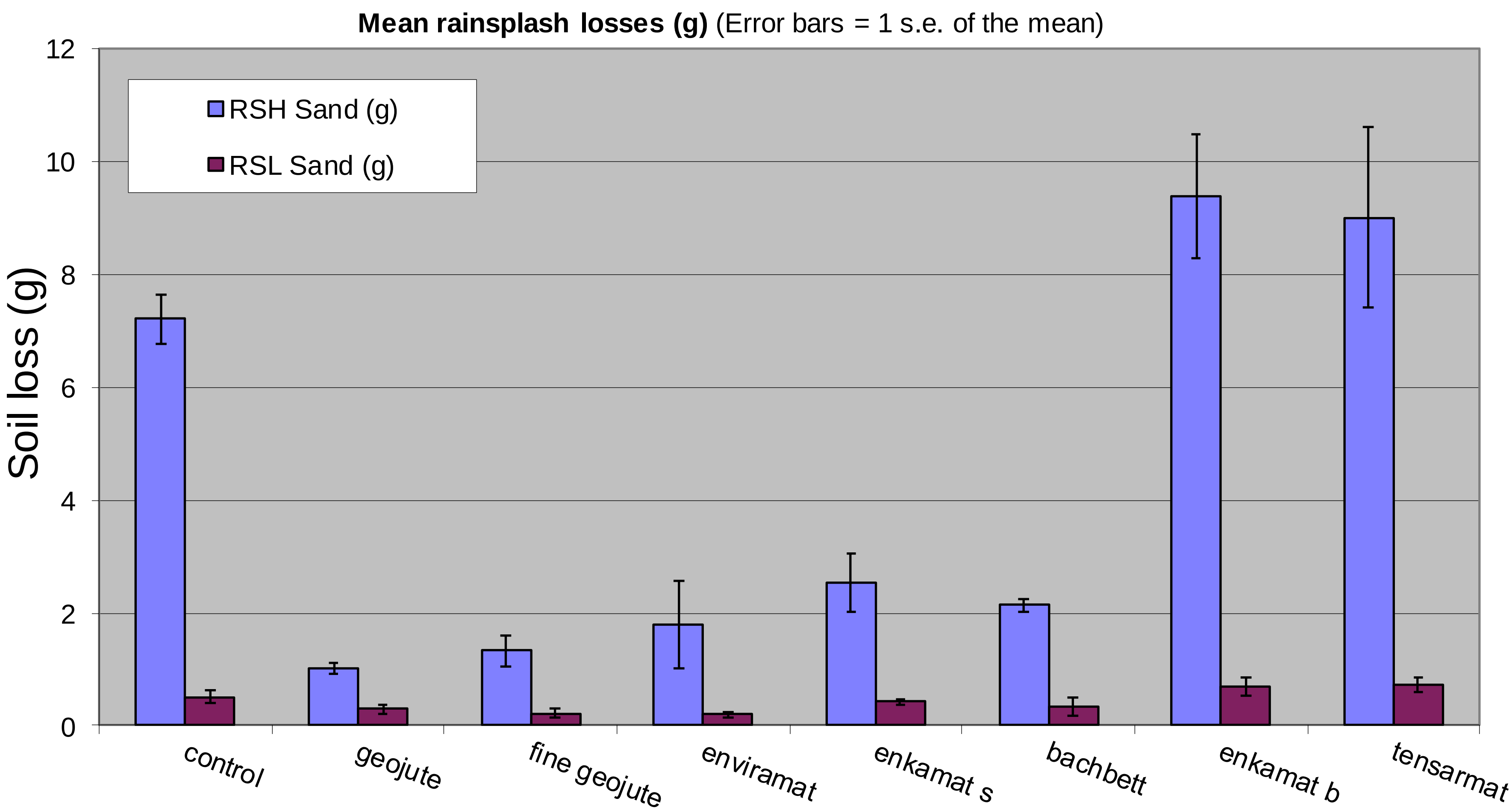
Geotextiles for soil erosion control

Evaluating geotextiles for erosion control

- How do these products work?
  - rainsplash erosion
  - runoff erosion
  - combined rainsplash and runoff



Geotextiles – control of rainsplash erosion



Correlation coefficients between geotextile properties and erosion control effectiveness (soil loss; as measured when rainfall and runoff processes are combined)

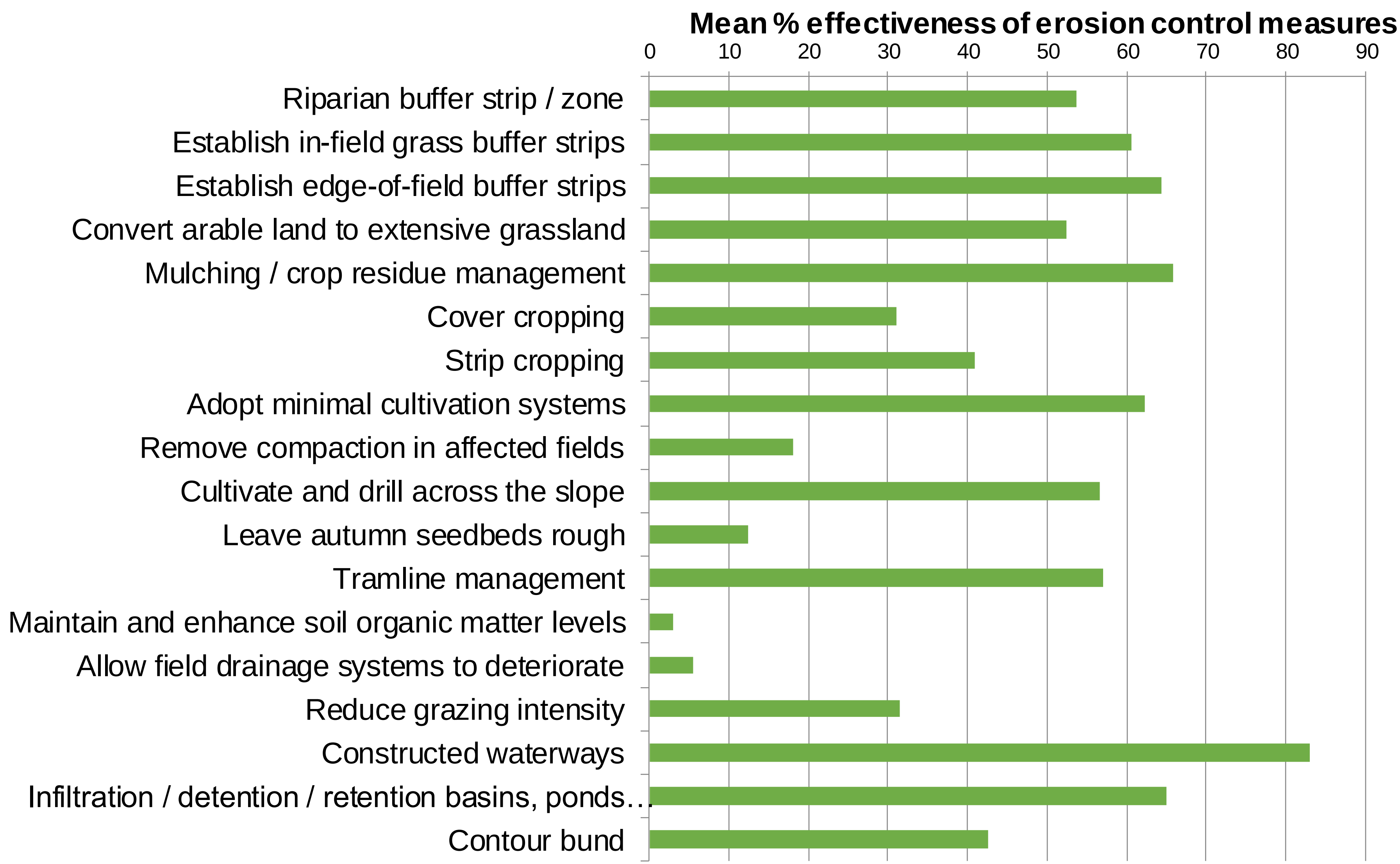
Geotextile property	Correlation with erosion control effectiveness	Significance of correlation
Area of geotextile (%)	-0.872	$p<0.05$
Depth of flow (mm)	-0.830	$p<0.05$
Manning's roughness coefficient (n) / Geotextile Induced Roughness	-0.710	$p<0.05$
Water holding capacity (%)	-0.837	$p<0.05$
Weight ($g\ m^{-2}$)	-0.719	$p<0.05$
Wet weight as % after 24 hours	-0.842	$p<0.05$
Wet weight as % after 48 hours	-0.599	$p<0.10$
Cost ($\$\ m^{-2}$)	0.297	NS
Flow velocity ($m\ s^{-1}$)	-0.068	NS
Mean yarn diameter (mm)	-0.467	NS
Tensile strength ($kN\ m^{-1}$)	0.294	NS
Thickness (mm)	0.373	NS

3. The future of soil conservation: climate change

Climatic trend (UKCP18)	Soil erosion processes
Increasing summer temperatures	Drier soils more prone to wind erosion More hydrophobicity ⇨ increased runoff and associated erosion.
Increasing winter temp	Later harvests increase the risk of loss of soil co-extracted on root vegetables and farm equipment if the soil moisture is high.
More extreme high temperature	Greater risk of unstable atmospheric conditions and high intensity thunderstorms, leading to runoff and erosion. Drier soils – wind erosion
Higher winter rainfall	Wetter soils more prone to aggregate breakdown, compaction, smearing and generation of surface flow and erosion.
Higher wind speeds	Greater wind speeds, combined with drier, more friable, soils in summer months will increase the potential for wind erosion.
Less summer rainfall	Drier soils (see above). Poorer crop canopy development, leading to more exposure of bare soil when rain falls and higher erosion risk (water and wind)
More intense downpours	Rainfall intensity is strongly and positively correlated with soil erosion rates Short duration, high intensity rainfall events may become the dominant mechanism of soil erosion in the future.
More winter storms	Wetter soils, leading to shorter time to generation of runoff and greater volume of runoff, leading to increased soil erosion risk

Contour planting on terraces in Montgomery County, Iowa. USDA Photo by Tim McCabe.

3. The future of soil conservation practices… but do they work?



4. Soil conservation in the UK: Take home messages

- Soil is essential for the successful delivery of several goods and services to society
- However, soil can be (irreversibly?) damaged by degradation processes such as soil erosion
- Soil conservation practices can be used to reverse and prevent soil degradation
- However, no matter how effective your solution, it will fail without the right economic and social conditions

Thank you for your attention.

Any Questions?

With thanks to all funding bodies and colleagues, especially Rob Simmons, Jo Niziolomski, Alex Cooke, John Chinn, the SOWAP team, Roy Morgan and many others….