Additional text: The soil conservation challenge and win-wins for fragmented landscapes.
J. Tallowin.

Slide 3

The soil conservation challenge we face is to ensure food sustainability while at the same time making agriculture as clean as possible in relation to reducing gaseous emissions of greenhouse gases, minimizing nutrient leaching losses and sediment to our water courses and providing space for biodiversity in our countryside. Some challenge!

Slide 4

Conservation of soil is intimately linked to conservation of soil biodiversity and the connection between sustainable agri-ecosystems and conservation of soil biodiversity was recognized as a major global issue in 2002.

Slide 5

Soil biodiversity is important because of its role in all of the processes that we depend on or want to avoid exacerbating!

Slide 6

Soil structure is emerging as a major issue that is likely to compromise agri-ecosystem sustainability. The most obvious effect of structural damage to soils is impeded water penetration – the result being greater risk of surface run-off and consequent flooding. However, there appear to be less obvious consequences for example to farmland biodiversity.

Slide 7

Poor soil structure could be an important factor behind the long-term decline in farmland birds. However, the scientific literature is weak on this subject. It is contended that poor soil structure is linked to reduced abundance /availability of food for birds and thus wide-scale poor or damaged structure in agricultural soils could compromise our ability to achieve the Public Service Agreement target for farmland birds.

I have listed some key groups that are particularly important for insectivorous and omnivorous birds.

Slide 8

Our understanding of interactions between what we can see, higher plant diversity, and what we can't see, below ground biodiversity, is a scientific growth area, particularly in relation to interest in what soil carbon is doing. Type of plant has a major impact on the quality of organic matter and thus carbon entering the soil. Plants that produce lots of chemical protection against herbivory, such as polyphenols including complex compounds such as tannins, are contributing some relatively recalcitrant forms of carbon to the soil, which can have a long residence time in the litter fraction of the soil before being mineralized with the nutrient components being recycled. Slow mineralization processes and complex forms of nutrients will produce feed-back consequences for higher plants and above ground productivity.

Slide 9

For any soil biologists in the audience my apologies for this very simplified diagram summarises the soil processes and feed-backs that are affected by increased plant diversity. I hasten to add that the evidence for high carbon sequestration is still being established. What we do know is that increased plant diversity does confer greater nutrient use efficiency and non leaky soil systems.

Slide 10

So the soil conservation challenge for agriculture is how to achieve increased plant diversity. We know that plant diversity is highly constrained by elevated soil nutrient availability, which advantages a relatively few competitive species that outcompete and eliminate slower growing companions.

Slide 11

This figure comes from a farm survey that we carried out in 1999 and 2000. Plant diversity, in this case the number of plant species per meter square, fell dramatically with nitrogen inputs above 50 kg per hectare (0.4 cwt per acre). Above inputs of 100 kg of nitrogen per ha the grasslands were dominated by just one or two species of grass.

Forage yields with nitrogen inputs of less than 50 kg per ha are likely to be less than half of the yields from more intensive management systems.

Slide 12

More insidious and long lasting than nitrogen fertilization are the effects of phosphorus fertilizers on plant diversity. All high nature value grasslands in terms of plant interest are confined to soils with a phosphorus index of zero or at most one. Conventional i.e. non-organic and organic farming systems aim to maintain a P index of at least 2.

Slide 13

Fields with a soil phosphorus status of 1 will be sub-optimal for productivity and with food sustainability now high on the political agenda, quite rightly so, we clearly have a mis-match between our ability to achieve high plant diversity for all the environmental benefits that I have just outlined and our need to grow more food for human consumption.

Slide 14

This is where I get to the grist of my talk. The UK has an abundant resource of species-poor grassland. These grasslands are typical of Entry Level low input or zero input grassland categories EK2 and EK3.

Slide 15

I contend that species poverty devalues the Entry Level Scheme in that it constrains potential environmental benefits

Slide 16

I contend that we should be looking to large-scale improvement in the biodiversity and thus ecosystem services of our species-poor grassland resource in the UK.

In light of the constraints imposed by a legacy of high fertilizer inputs on creating species-rich grassland on former agriculturally improved land can moderate levels of plant diversity be established that will support sustainable agri-ecosystems?

I suggest that the way we do this is through the use of competitive species adapted to fertile growing conditions.

Slide 17

Reading University, ourselves at North Wyke and the British Trust for Ornithology reviewed the potential multifunctional value of a wide range of grassland plant species. Here is a selection of species that we evaluated. For each plant species invertebrate specialists at Reading examined their value to invertebrates as a pollen, nectar, or other food resource, the BTO assessed the PSA bird value, we at North Wyke assessed their forage feed value and their potential to affect soil structure. It becomes quickly apparent that some species such as red clover have the potential to be truly multifunctional in value. All the species listed here formed the basis for seed mixtures that we are now using to construct grasslands with modest levels of plant diversity.

Slide 18

We contend that modest increases in plant diversity can provide multiple benefits as this schematic figure indicates. Such grassland should provide win wins in terms of landscape, agronomic and biodiversity benefits as well as contributing to resource protection by reducing leaching losses and restructuring agriculturally damaged soils, which in turn should reduce erosion and flood risk. The overall value will be in human health and socio-economic value.

Ambitious, but not cloud cuckoo land, as DEFRA have sponsored a new research project to test whether we can achieve these objectives.

Slide 19

The new DEFRA funded research project, titled Widescale Enhancement of Biodiversity: effects on other resources or WEB for short, is a collaborative project between ourselves at North Wyke and the Centre for Ecology and Hydrology.

Slide 20

The WEB objectives:

Establish legume- or legume + forb-rich mixtures in grass only swards to:

- achieve modest plant diversity enhancement
- increase pollen and nectar resources

- improve soil structure
- reduce nutrient loss via leaching
- improve agronomic value

Establish benefits for bees and other nectar feeders of a disturbance-free period during mid-summer under either grazing or cutting regimes.

Slide 21

There are two field sites for the WEB project one at North Wyke, which is the chequer board looking field in the middle distance and the other site, is at Jealotts Hill in Berkshire.

Slide 22

We have used a minimal cultivation approach to introducing the new species, largely to avoid the enormous release of nutrients and consequent losses involved with ploughing. We do have a ploughed and an undisturbed grass controls. At North Wyke we used a Hunter strip seeder to create about 40-50percent bare ground we then broadcast the species onto the paddocks and rolled. We had to use slug pellets during the early stages of establishment. We sowed either a mixture of grass species including a high sugar variety ryegrass, or the mix of grass species plus a mixture of legume species or a mixture of grasses legumes and forb species. This was so that we could examine whether there are incremental benefits of including some deep rooted forbs.

Slide 23

The management involves either cutting or grazing with beef cattle. Within each of these typical main treatments a part of the paddock is separated off and does not receive any disturbance during 8 weeks in the mid summer (July and August) to provide nectar and pollen resources for bees etc.

Slide 24

This is what the grass only swards look like.

Slide 25

And this is what the grass, legume and forb mixture looked like this summer. Apart from the abundance of red clover, you can see the blue flowers of chicory, the yellow of birds foot trefoil, there is also forage burnet, yarrow and black knapweed as well as ryegrass, timothy, cocksfoot and meadow foxtail.

Slide 26

We survey nectar and pollen feeding insect numbers and diversity as indicators of biodiversity benefit.

Slide 27

We examine forage quality and live weight gain to evaluate the agronomic benefits of the different mixtures. Unfortunately we did not have the resources to use long horns as grazers, as some other

research that we did with Jeff Wood at Bristol University established that they produce the best beef of all beef breeds!

Slide 28

We are measuring leaching losses and changes to soil structure. Here we are inserting porous tubes to collect samples of soil water which we then analyse for dissolved nitrogen and phosphorus content. We are also measuring soil penetrability and changes in soil bulk density.

Slide 29

Tools are becoming available to simultaneously consider how choices affect delivery of a range of services.

1. We need to understand effect of management for biodiversity on these other services

2. Is this another way to deliver (some) farmland biodiversity?

3. Should we focus on only multifunctional options?

4. How do we defend options for biodiversity which don't deliver for other services, or worse, deliver disservices?

Slide 30

WEB is a test bed of a holistic approach to integrating soil conservation with all of the other requirements that we need our agricultural land to deliver.

Slide 31

To date most of the research on resource protection has concentrated on intensively-managed ryegrass or ryegrass-clover systems. Considering the proportion of semi-improved species-poor grassland in the UK it is timely that some research attention has recently focussed on quantifying product to pollutant ratio from grazing low input more extensively managed pastures. However, the grassland that was used for this research was certainly not species-rich or of high biodiversity value. The research was designed to complement other DEFRA funded research on gaseous emissions and water quality impacts.

Slide 32

Water framework targets for N and P losses, faecal pathogen transmission from livestock systems and atmospheric emissions, particularly NH_3 and methane are the key issues of resource protection. Biodiversity does not feature among the priorities; the challenge is to quantify the extent to which semi-natural species-rich grasslands can contribute towards resource protection by acting as a non leaky buffer to sensitive resources.

Slide 33

The challenge is to link modelling effort on optimising resource protection at catchment and higher scales to predict effects on other grassland landscape functions including specific biodiversity functions such as pollination or pest and disease control services, i.e. ecosystem services models.

Validation will require experimental sites in which different components of the landscape such as land-use intensity can be manipulated spatially.

I will use North Wyke as an example of what I mean.

Slide 38

Unfortunately we do not have the resources to take the agronomic benefit analysis the whole way to the end product, which would have been really good. However, not IGER's work with Prof Jeff Woods team at Bristol has also shown that meat from grass fed animals has enhanced beneficial omega-3 fatty acids compared with animals on "conventional high concentrate" feedings systems. The meat from grass fed animals has enhanced antioxidant content compared with meat from animals on "conventional high concentrate" diets. This enhanced antioxidant or vitamin E content gives meat prolonged retention of red colour and shelf life (so product appears more "red" and more "stable" when presented on a supermarket shelf).

The Bristol team have also found that meat from animals that were predominantly grass fed had enhanced flavour compared with meat from animals on "conventional high concentrate" diets.

Slide 40

There is an urgent need to deliver the evidence to underpin sustainable agri-ecosystems!