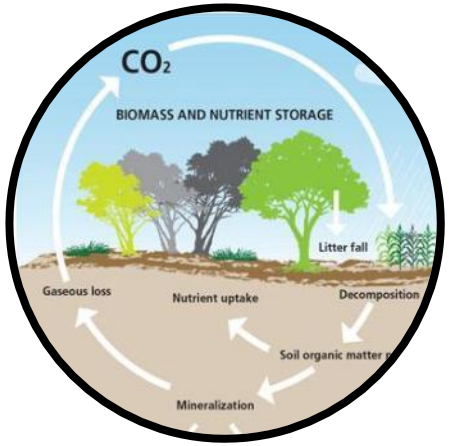
Ecosystem services in grasslands: evidence, trade-offs and restoration



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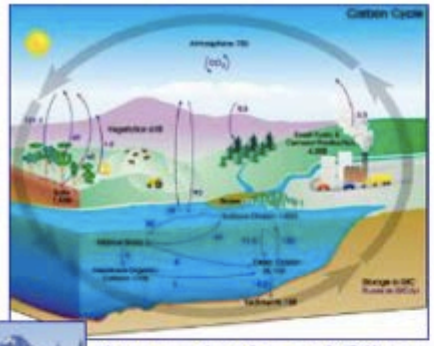
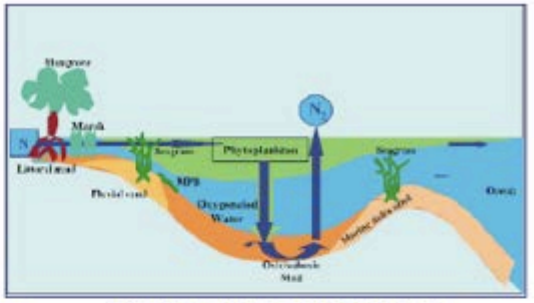
Ecosystem services – definitions and types



Atmospheric and Climate Regulation

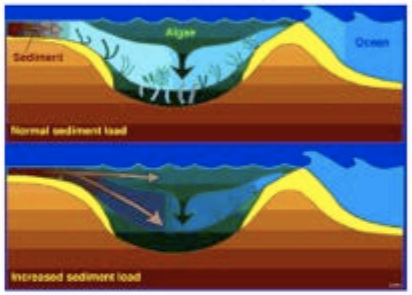
Flood Attenuation/ Storm Surge Protection



Biogeochemical Cycling

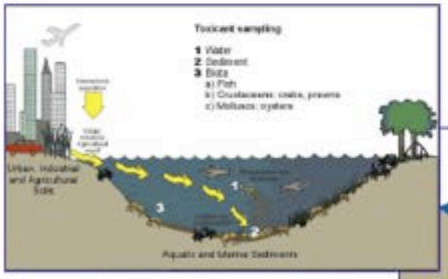
Recreation / Aesthetic

Food and Fiber

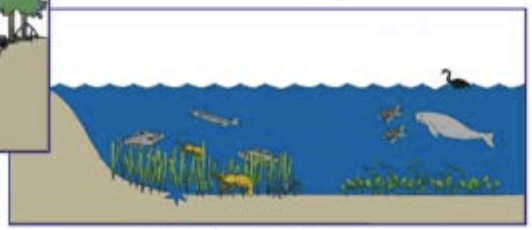


Soil and Sediment Regulation

Water Quality and Supply



Waste Regulation



Habitat/Fisheries

Pest and Disease Regulation

Grasslands – 13% of Earth's surface

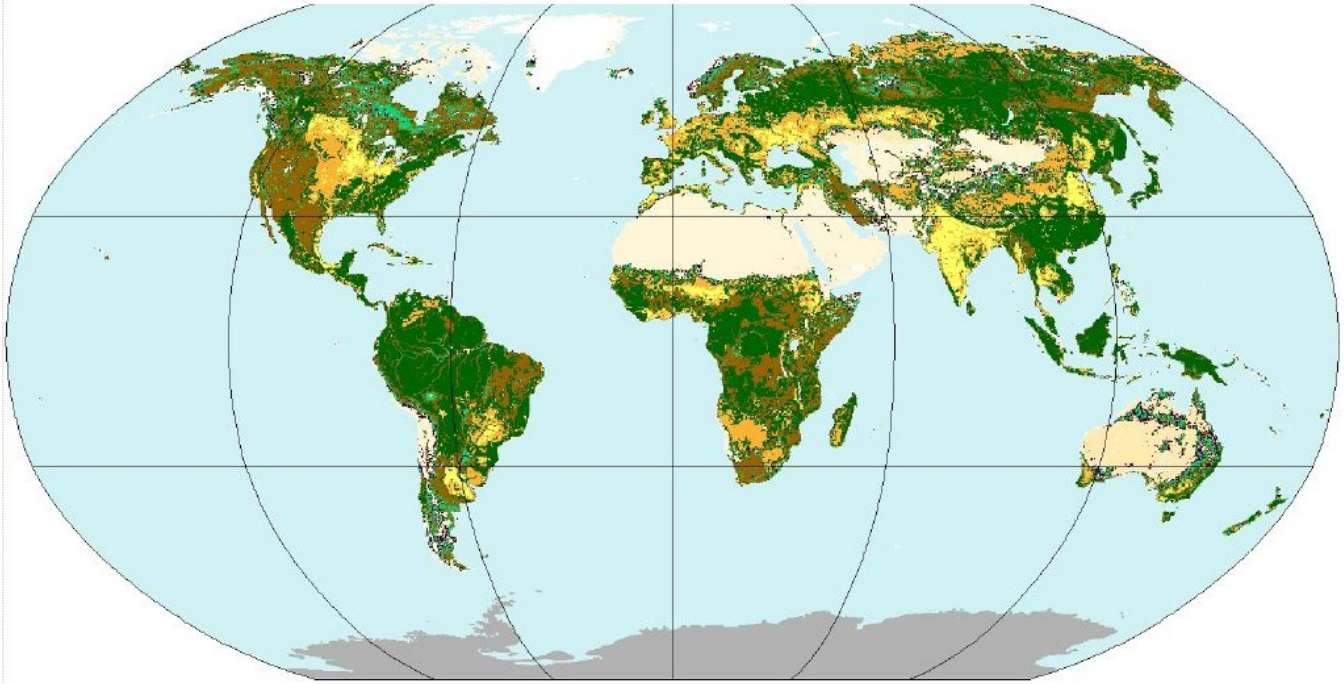


Figure 3 – Distribution of dominant GLC-SHARE Land Cover Database.

01 Artificial Surfaces
02 Cropland
03 Grassland
04 Tree Covered Area
05 Shrubs Covered Area
06 Herbaceous Vegetation
07 Mangroves
08 Sparse Vegetation
09 Baresoil
10 Snow and Glaciers + Antarctica
11 Water bobies
Antartica

FAO 2014

Artificial Surfaces	01	
Cropland	02	
Grassland	03	
Tree Covered Areas	04	
Shrubs Covered Areas	05	
Herbaceous vegetation, aquatic or regularly flooded	06	
Mangroves	07	
Sparse vegetation	08	
Baresoil	09	
Snow and glaciers	10	
Water bodies	11	

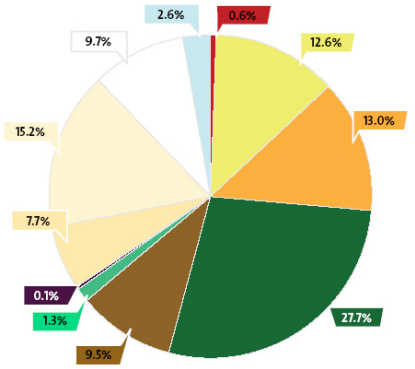


Figure 5 – GLC-SHARE distribution of land cover types

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Semi-natural grassland in UK ~ 1.69M ha ~ 7% of land surface

Improved grassland = 21%

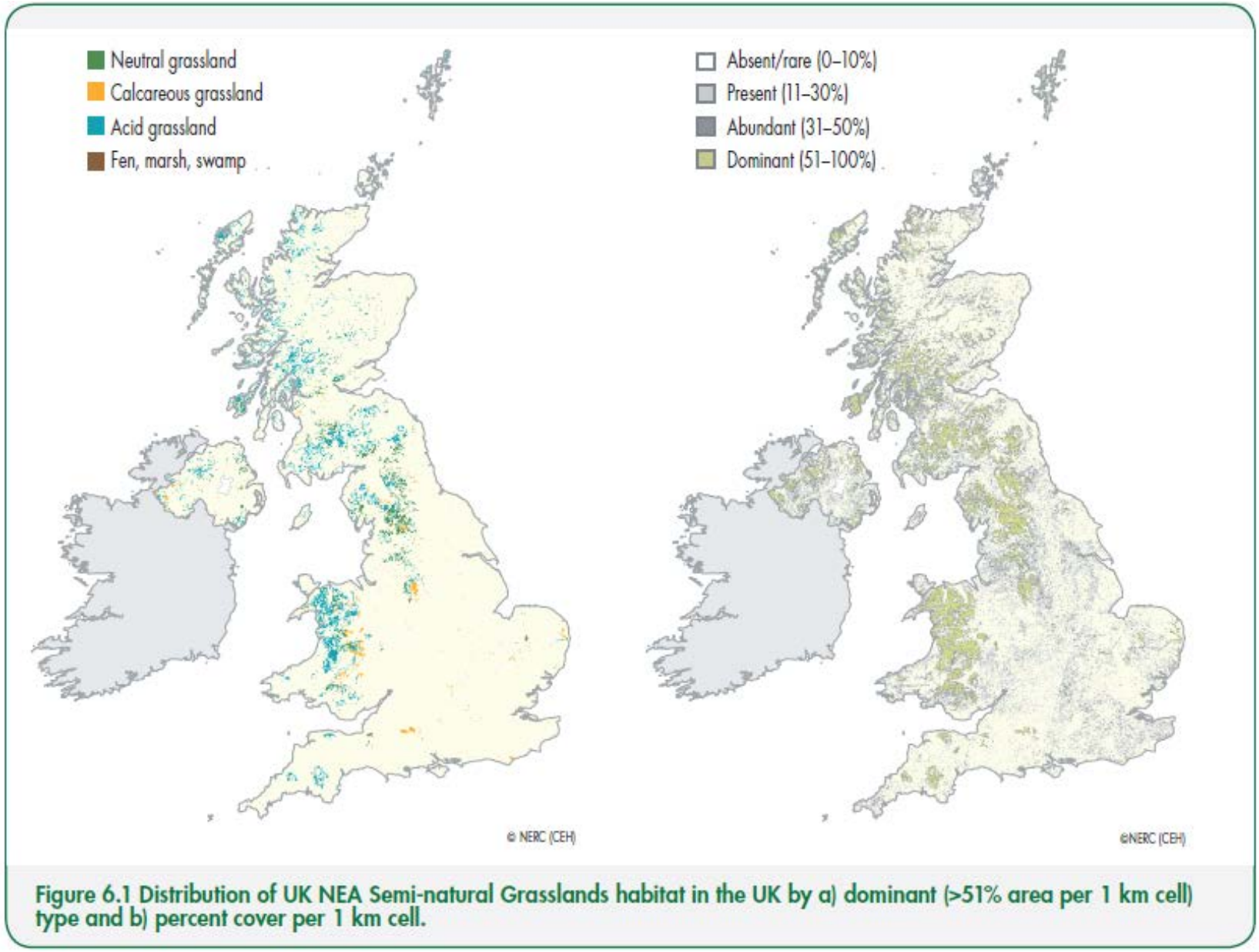
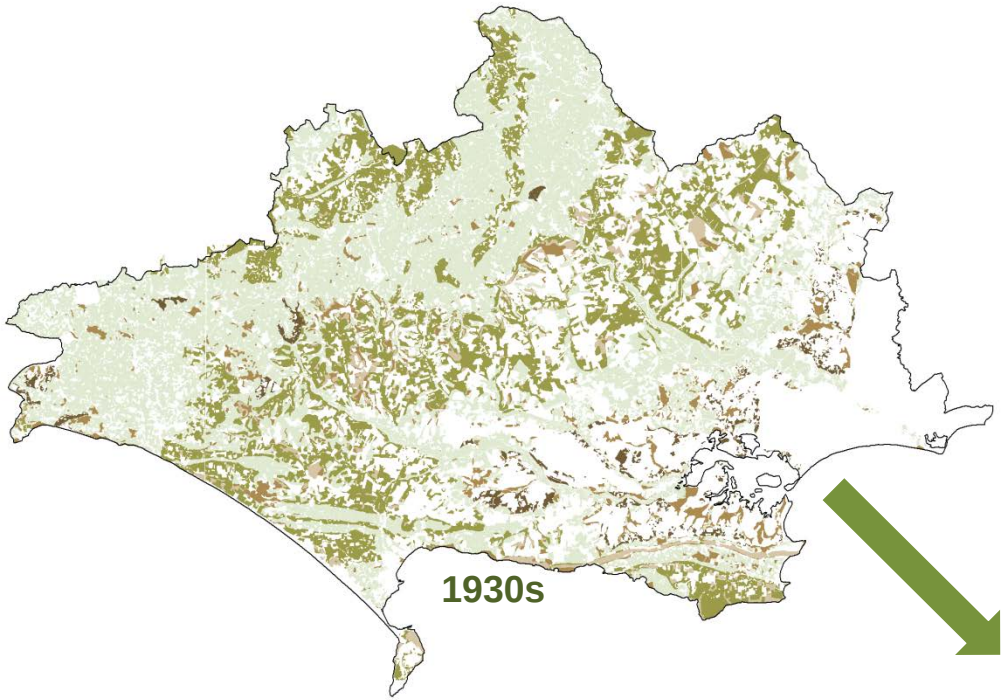


Figure 6.1 Distribution of UK NEA Semi-natural Grasslands habitat in the UK by a) dominant (>51% area per 1 km cell) type and b) percent cover per 1 km cell.

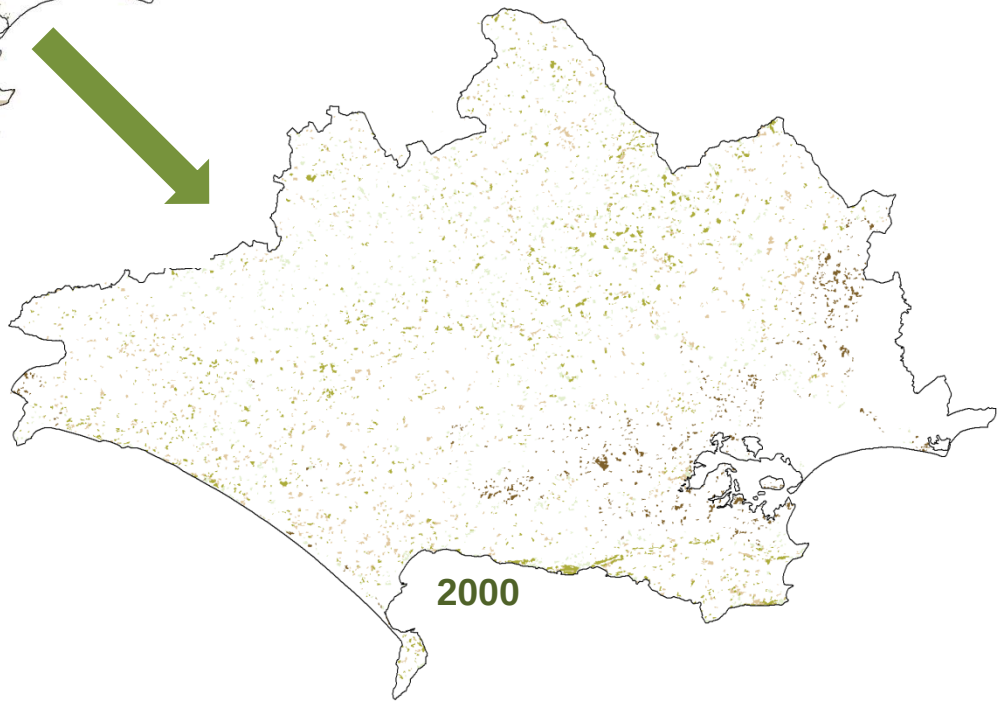
Bullock et al (2011) UKNEA Semi-natural grasslands chapter

Semi-natural grassland – huge losses over the 20th C



Dorset

- 97% of semi-natural grasslands lost 1930s-2000
- Mostly to arable & intensive grassland
- Similar numbers elsewhere in the UK



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Hooftman & Bullock 2012. Biol Cons

(Semi-natural) grassland – a ‘fluid’ habitat

Ecological succession

Agricultural conversion

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Bullock et al (2011) UKNEA

Fluidity seen within landscapes; e.g.....

Ecosystem services from semi-natural grasslands

Table 6.12 The final services and goods provided by Semi-natural Grasslands.

Service Group	Final ecosystem service	Goods and benefits
Provisioning	Livestock: forage for cattle, sheep, etc.	Food (meat, milk), fibre (wool), possibly enhanced quality of meat and milk
	Standing vegetation: biomass crops	Possibly fuel
	Crops: pollination and pest control spillover	Food (crops)
Cultural	Environmental settings: valued species and habitats, agricultural heritage, archaeological heritage, grazing for rare livestock breeds, ecological knowledge, training areas	Physical and psychological health, social cohesion, recreation and tourism, UK research base, UK military training
Regulating	Climate regulation: sequestration and storage of carbon and other greenhouse gases	Avoidance of climate stress
Provisioning	Water quantity: storage of water and recharging of aquifers	Potable water, water for food production, flood protection
	Purification: reduced pollution and storage of pollutants	Clean air, clean water, clean soils
Regulating	Wild species diversity: plant genetic diversity, seed for restoration projects	Genetic resources, bioprospecting, recreation and tourism, ecological knowledge

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Bullock et al (2011) UKNEA

Forage for livestock – evidence in the UKNEA

- Much lower production than improved grasslands (<30% dry matter)
- Lower digestibility than improved grasslands (60-80%)
- Higher plant diversity increases production in the absence of fertilisers
- Little evidence that 2ndary metabolites in SNG are beneficial (e.g. against parasites)
- Inconsistent evidence that forage from SNG produces better meat
- Good evidence that cheese flavour, etc better from animals on SNG (France)
- Association with traditional breeds (cultural services)

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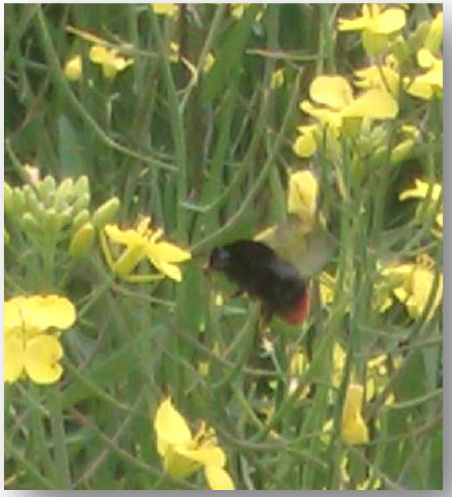
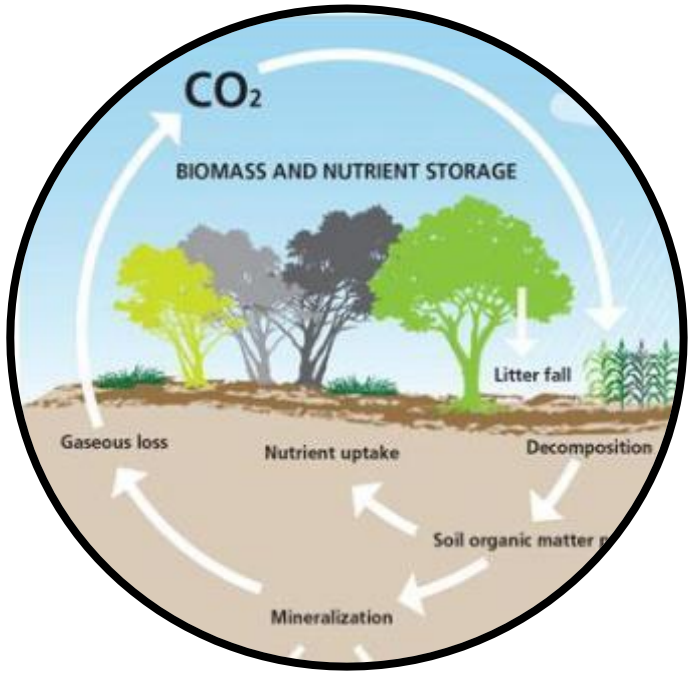
Crop pollination & pest control – evidence in the UKNEA



- **SNG certainly support pollinators & pest natural enemies**
- **Some evidence that pollinators 'spill-over' from SNG onto crops**
- **Little evidence that pest natural enemies show such spill-over (less mobile)**

Greenhouse gases & carbon – evidence in the UKNEA



- According to the Countryside Survey (15cm depth) SNG soils store high levels of carbon (acid = 82 t/ha, neutral 62 t/ha)
  - compared to arable (43 t/ha)
  - and improved (61 t/ha)
  - and even woodland (66 t/ha)
- But data could be better
- GHG probably lower than in improved – lower stocking rates (methane) & fertilisation (nitrous oxide)
- Little evidence that plant richness increases carbon storage

Water quality & quantity – evidence in the UKNEA

- Little data
- Storage of water less than under woodland or scrub
- But more than under arable or improved grass
- Less soil compaction than under intensive grazing - decreased flood risk
- Low intensity management results in lower pollution – lower fertiliser & pesticide, but also better ability to store, e.g, N.
- Little evidence that plant richness enhances water quality or storage (although legume content may be important)

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Cultural services – evidence in the UKNEA

- Many aspects: heritage, recreation, tourism, education, aesthetics, religion, etc
- SNG can be linked with many aspects of cultural services
- But hard to study & quantify
- People differ in their likes & dislikes based on experience, knowledge, geography, etc
- Evidence that many people respond more to landscapes rather than local biodiversity (‘cultural landscapes’)

Trade-offs – production *vs* other services

Table 6.14 Suggested direct relationships between major ecosystem services of Semi-natural Grassland. + positive, – negative, 0 no relationship. Biodiversity (plant species richness) is included to illustrate its important role in many services. In each case, the relationship is one of cause and effect (hence the focus on a direct relationship); the cause is the column title and the affected service is in the row. Unfilled cells indicate that no direct relationship is expected.

Cause	Rare breeds	Plant wild relatives	Pollination	Pest control	Livestock production quantity	Livestock production quality	Greenhouse gas storage	Water quality	Water flow	Soil structure	Biodiversity
Effect											
Cultural services	+	+	+		—	+					+
Rare breeds					—						0
Plant wild relatives					—						+
Pollination					—						+
Pest control					—						0
Livestock production quantity	0					—				+	+
Livestock production quality	0				—						+
Greenhouse gas storage, etc.					—/0					+	+
Water quality					—					+	+
Water flow					—					+	
Soil structure					—						
Biodiversity	0		+		—					+	

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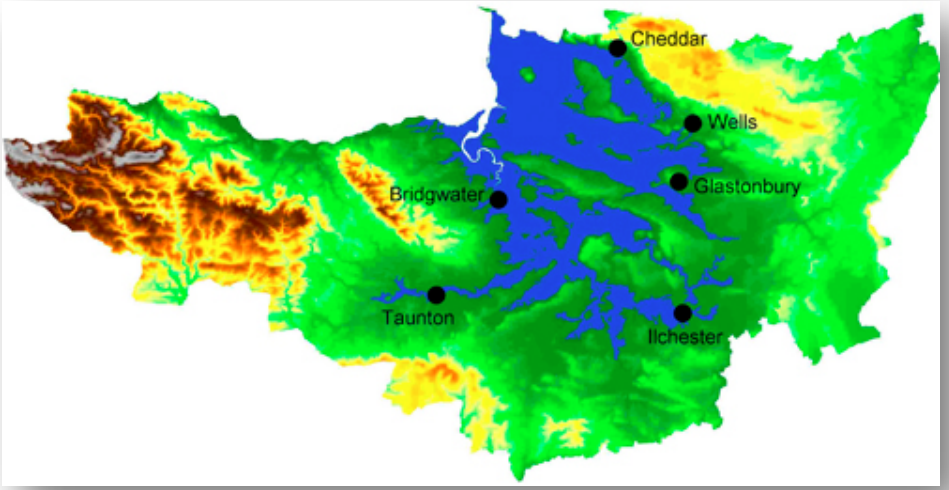
What about floodplain meadows?!

Somerset Levels – positives and negatives

- with thanks to Mike Acreman



- **Peat extraction – 9% of UK supply**
- **Local products – Cheddar cheese**
- **Recreation – 7,000 visits *pa* to RSPB reserves**
- **Heritage – wet soils preserve archaeology & paleoecology**
- **Social cohesion – wetlanders, farming communities**
- **Flood alleviation – River Parrett floodplain 6.8M m^3**
- **Climate – less CO_2 *but* more methane production from wetter soils**
- **Disease – historical & future malaria risk**

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Acreman et al (2011) Hydrol. Sci. Journal

Trade-offs in managing the Somerset Levels

Raised water levels

Benefits

- Wetland birds, etc
- Recreation
- Archaeology
- CO_2 reduction

but

- Reduced flood protection
- Methane production (when water table <10 cm)
- Reduced grazing quality (10% less hay, 40% less liveweight gain on aftermath under Tier 3)

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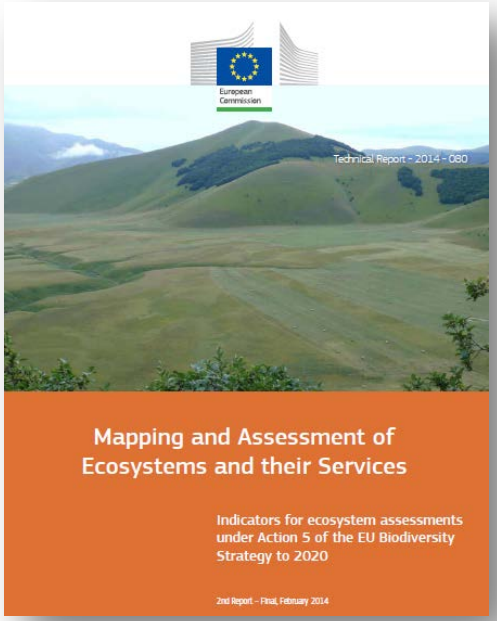
Acreman et al (2011) Hydrol. Sci. Journal

SNG undervalued in terms of single ecosystem services?



Service Group	Final Ecosystem Service	Mountains, Moorlands & Heaths	Semi-natural Grasslands	Enclosed Farmland	Woodlands	Freshwaters – Openwaters, Wetlands & Floodplains	Urban	Coastal Margins	Marine
Provisioning	Crops		↔	↗		↓	↗	↘	
	Livestock/Aquaculture	↓	↗	↔	↔	↘	↔	↘	↗
	Fish					↘	↔	↘	±
	Trees, standing vegetation, peat	↘	↔	↗	↗	↘	↔	↘	
	Water supply	↔	↘	↘	↔	↘	↔	~	
	Wild species diversity	↔	↓	↓	↗	↘	↔	↘	↘
Cultural	Environmental settings: Local places	↔	↔	~	↑	↗	↔	↔	~
	Environmental settings: Landscapes/seascapes	↔	↔	↔	↗	↔	↔	↗	~
Regulating	Climate	↔	↔	↗	↗	↔	↘	↗	↘
	Hazard	↘	↔	↘	↗	↘	↘	↔	↓
	Disease and pests	↔	↔	±	↘	↘	~	±	↘
	Pollination	↘	↘	↘	↔		↔	↔	
	Noise	↔	↔	~	↗	↔	↓	↔	
	Detoxification & purification: Water quality	↔	↗	±	↔	±	±	~	↔
	Detoxification & purification: Soil quality	↔	↘	↘	↔	↘	↓	↘	
	Detoxification & purification: Air quality	↔	↔	↗	↗	↔	↔	↔	~

Figure 5 Relative importance of Broad Habitats in delivering ecosystem services and overall direction of change in service flow since 1990. This figure is based on information synthesized from the habitat and ecosystem service chapters of the UK NEA Technical Report (Chapters 5–16), as well as expert opinion. This figure represents a UK-wide overview and will vary nationally, regionally and locally. It will therefore also inevitably include a level of uncertainty; full details can be found in the Technical Report. Arrows in circles ● represent where there is high evidence for or confidence in the direction of service flow amongst experts; arrows in squares ■ represent where there is less evidence for or confidence in the direction of service flow. Blank cells represent services that are not applicable to a particular Broad Habitat.

Importance of Broad Habitat for delivering the ecosystem service
- High
- Medium – High
- Medium – Low
- Low

Direction of change in the flow of the service
- ↑ Improving
- ↗ Some improvement
- ↔ No net change
- ± Improvement and/or deterioration in different locations
- ↘ Some deterioration
- ↓ Deterioration
- ~ Unknown

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Semi-natural grasslands to deliver multiple services

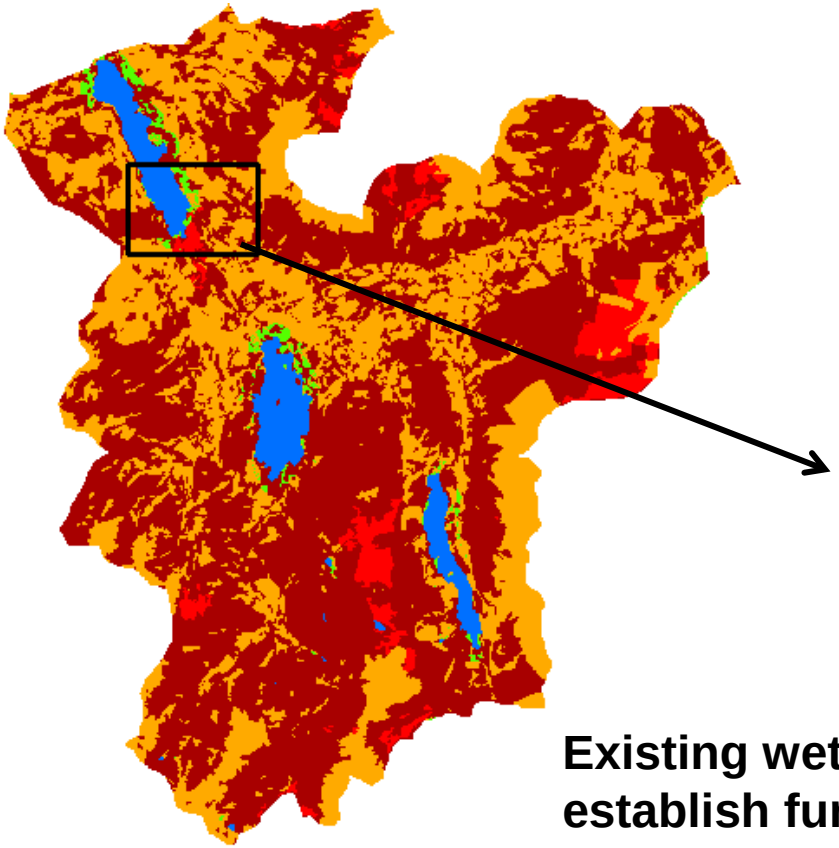
Semi-natural Grasslands present opportunities for delivering multiple services while requiring relatively low energy inputs

In contrast to improved grassland, SNG:

- store more carbon and produce less nitrous oxide & methane
- allow greater water infiltration rates and enhanced storage
- produce less pollution
- provide recreation, aesthetic & spiritual resources, etc
- might be manipulated floristically to increase production, carbon storage
- albeit with lower overall animal production

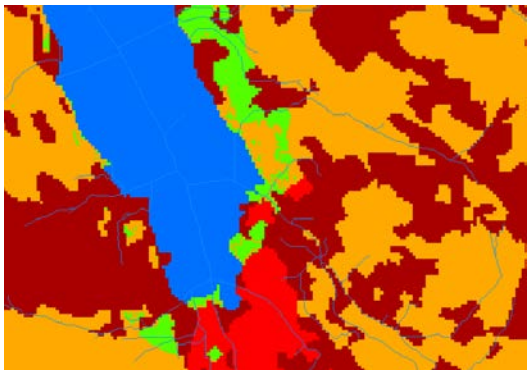
Designing landscapes for multiple services (& biodiversity)

Bassenthwaite Catchment – modelling possible futures, synergies & trade-offs with the LUCI model



Legend

- Existing wading bird & other wetland habitat
- Other identified "priority habitat"
- No existing identified habitat or suitability for wading bird habitat
- Opportunities to establish additional wading bird habitat



Existing wet grassland, and opportunities to establish further grassland

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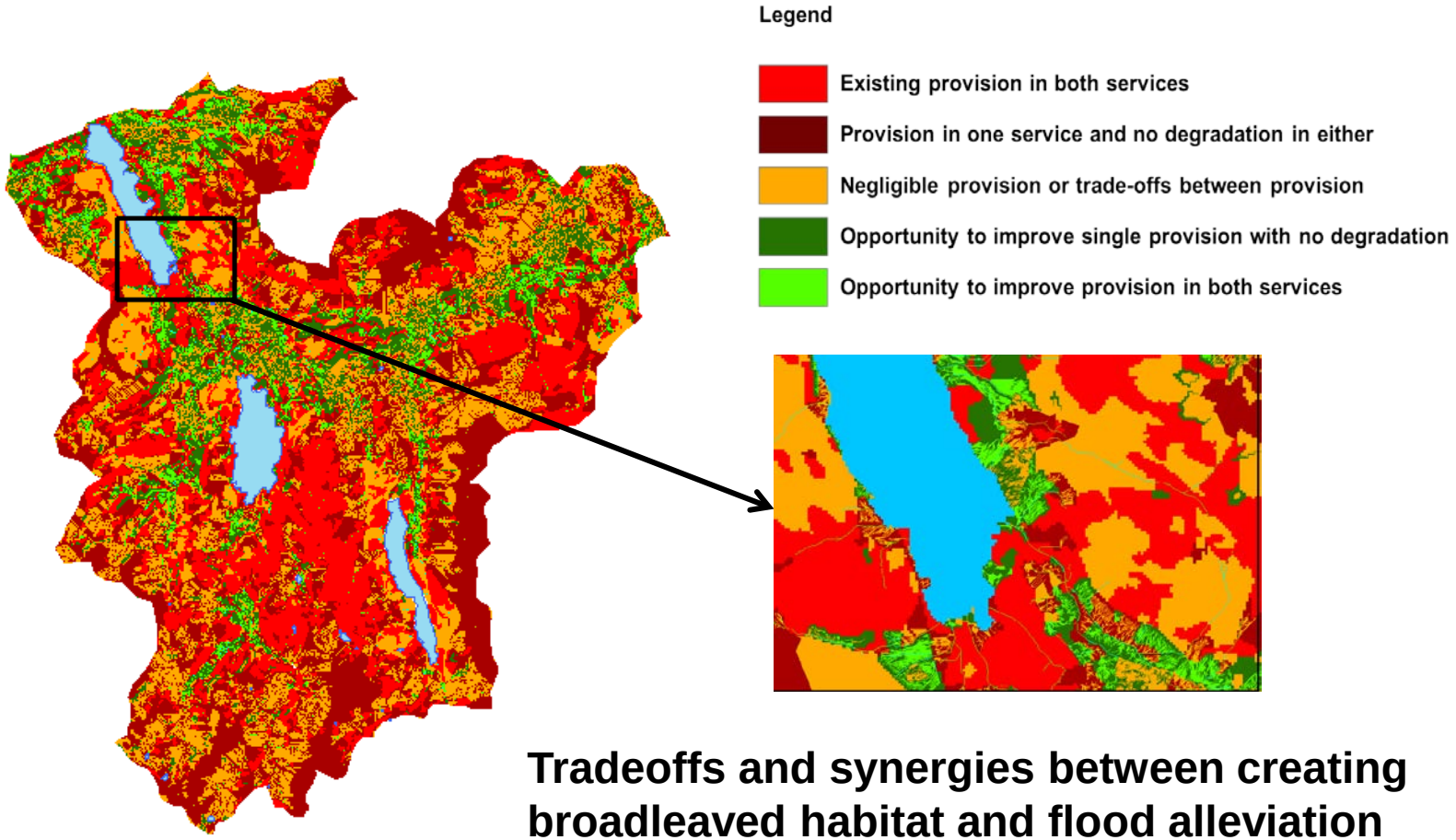
Designing landscapes for multiple services (& biodiversity)

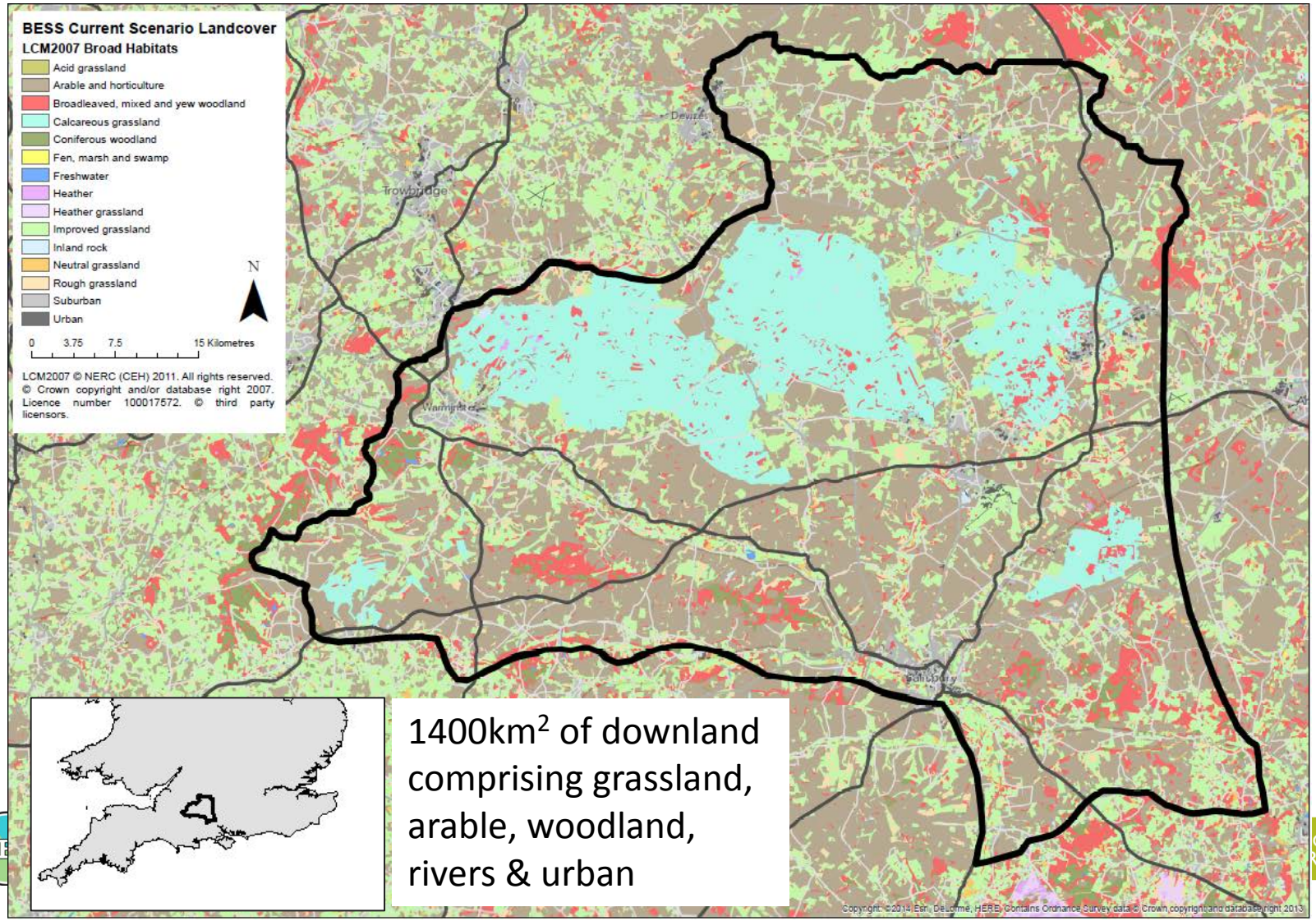
Bassenthwaite Catchment – modelling synergies & trade-offs with the LUCI model



Tradeoffs and synergies between creating broadleaved habitat and flood alleviation

Impacts of land use change scenarios

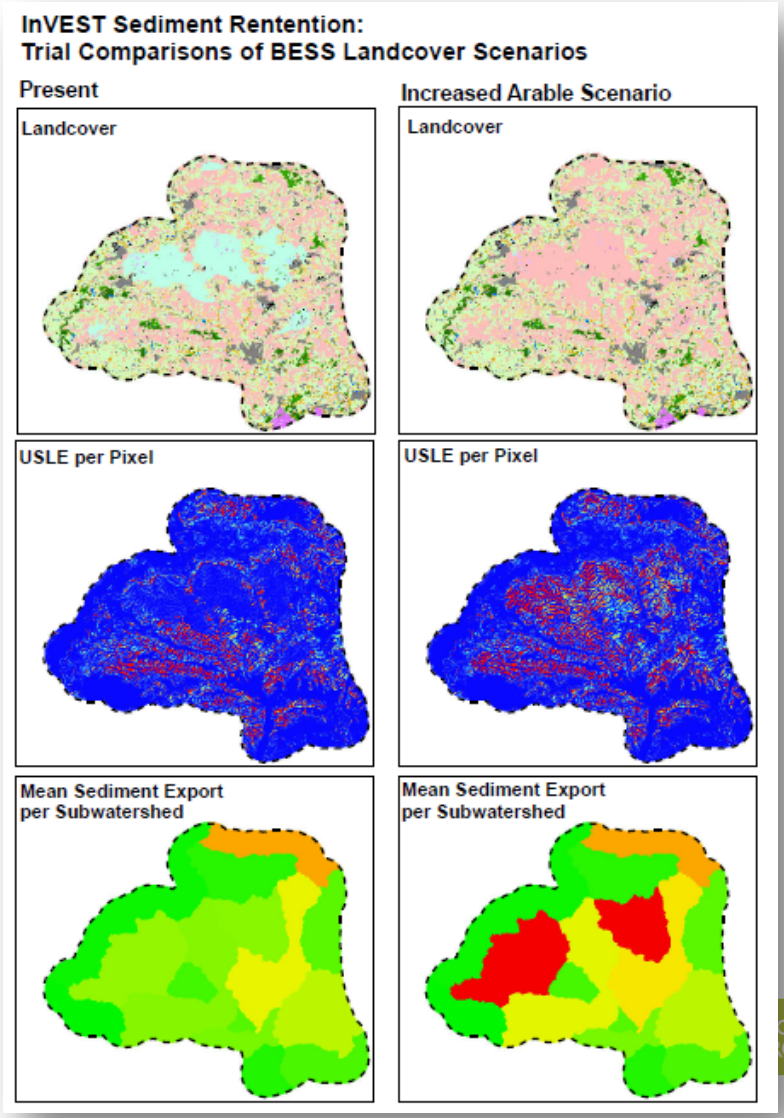
Wessex BESS (Wiltshire chalk landscape) – stakeholder input on possible futures & modelling of impacts, using InVEST



Impacts of land use change scenarios

Wessex BESS (Wiltshire chalk landscape) – stakeholder input on possible futures & modelling of impacts, using InVEST

1) Agricultural intensification/expansion
2) Urban expansion
3) Floodplain management
4) Mineral gas exploitation
5) Increased land use by military
6) Biofuel expansion....



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Restoring semi-natural grassland for biodiversity & services

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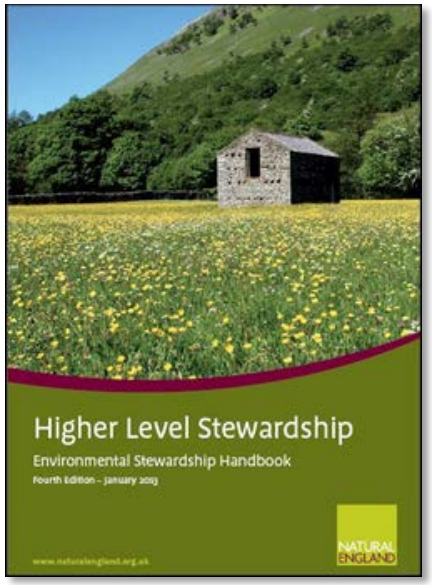
Bullock et al (2012) Trends in Ecology and Evolution

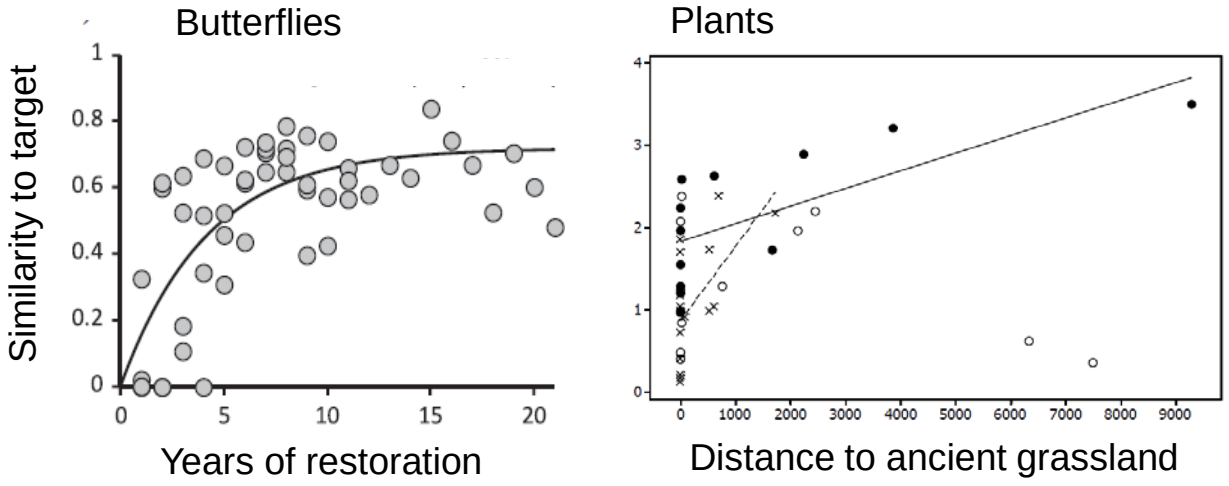
Well-researched restoration methods for semi-natural grassland

Scientifically-based restoration methodologies

Implemented in policy



Understanding rates & limitations on restoration



Rey Benayas & Bullock 2012 *Ecosystems*

Woodcock et al 2012 *Biol Cons*

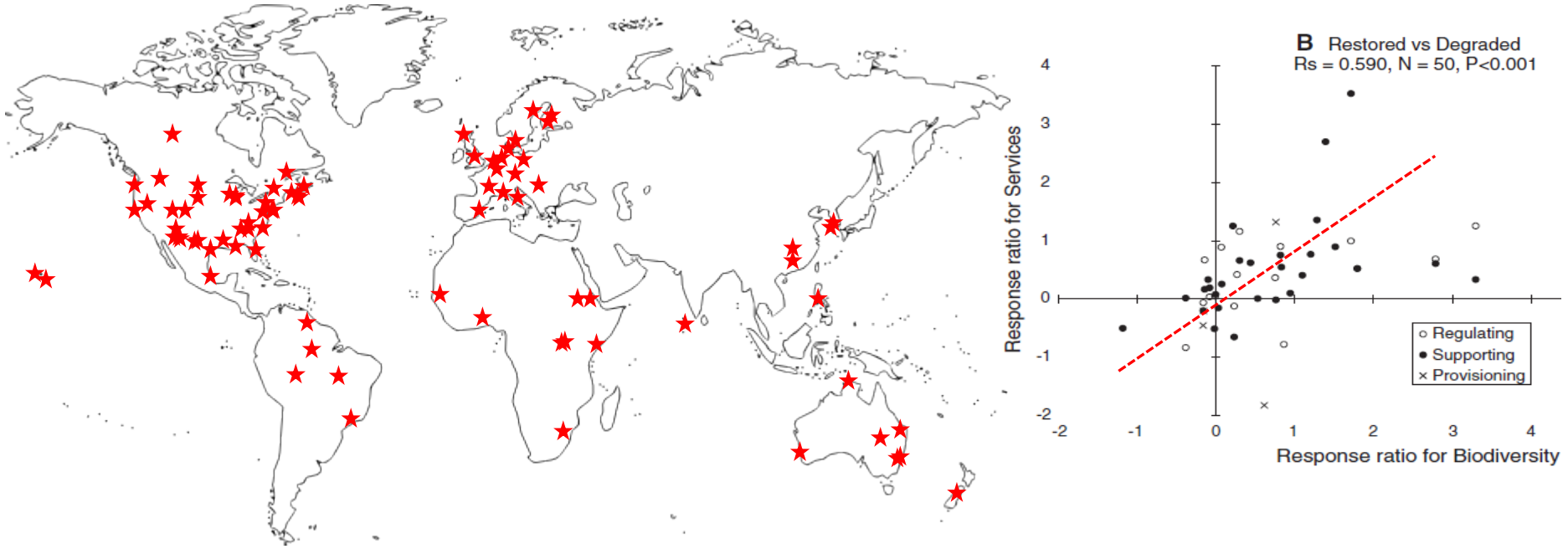
Bullock et al 2011 *TREE*

Fagan et al 2008

Pywell et al 2002

Globally – restoration of biodiversity benefits services

Analysis of 89 real-world restorations – tropical/temperate, aquatic/terrestrial



- Restored systems have 25% more services & 44% more biodiversity than degraded
- *But* pristine systems have 25% more services & 16% more biodiversity than restored

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Rey Benayas, et al 2009 *Science*

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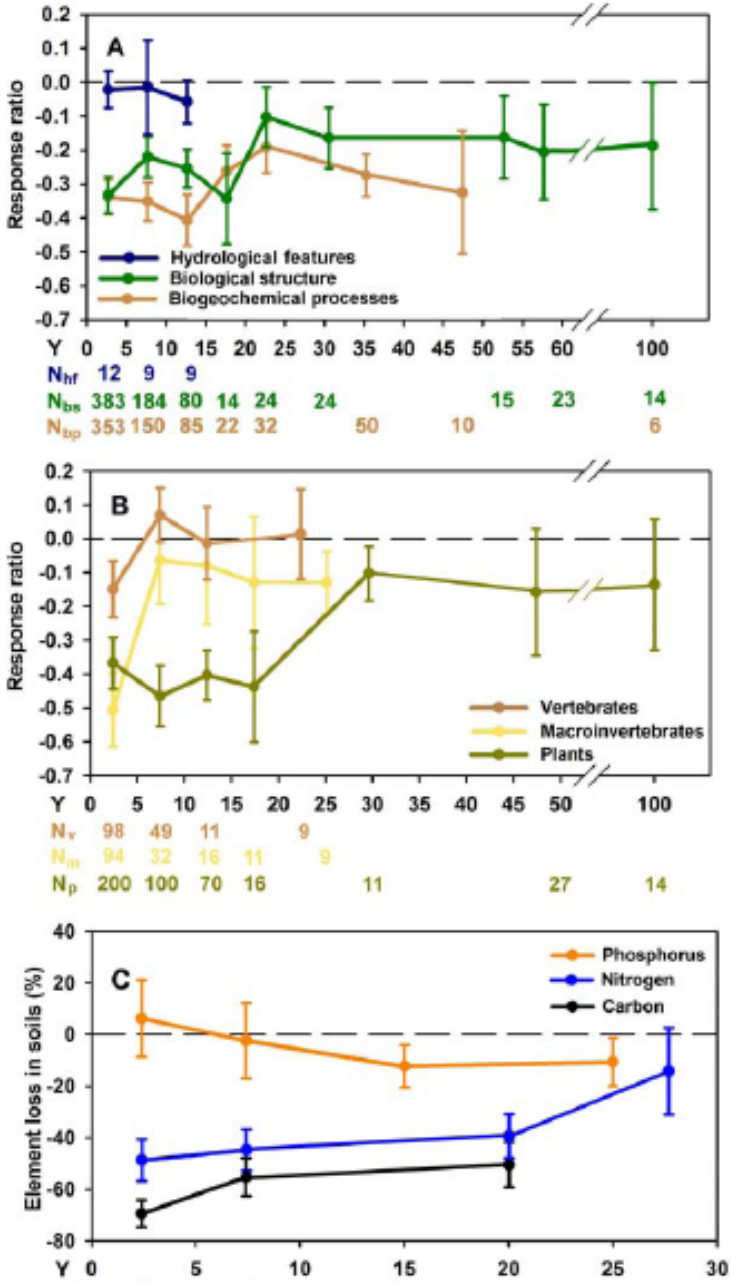
Wetland restoration trajectories – incl. floodplains



Meta-analysis by Moreno-Mateos et al 2012

- **621 wetlands across the world**
- **Conclude recovery is slow**
- **Hydrology (water storage, flooding, ...) recovers rapidly**
- **Biodiversity components = 77% of target, even after 100 yr**
- **But animals recover more rapidly than plants**
- **Storage & cycling of biogeochemicals varies (overall 74% after 100 yr) – C & N take a long time to recover**
- **Larger wetlands recover more rapidly**
- **Recovery more rapid in warmer climates**

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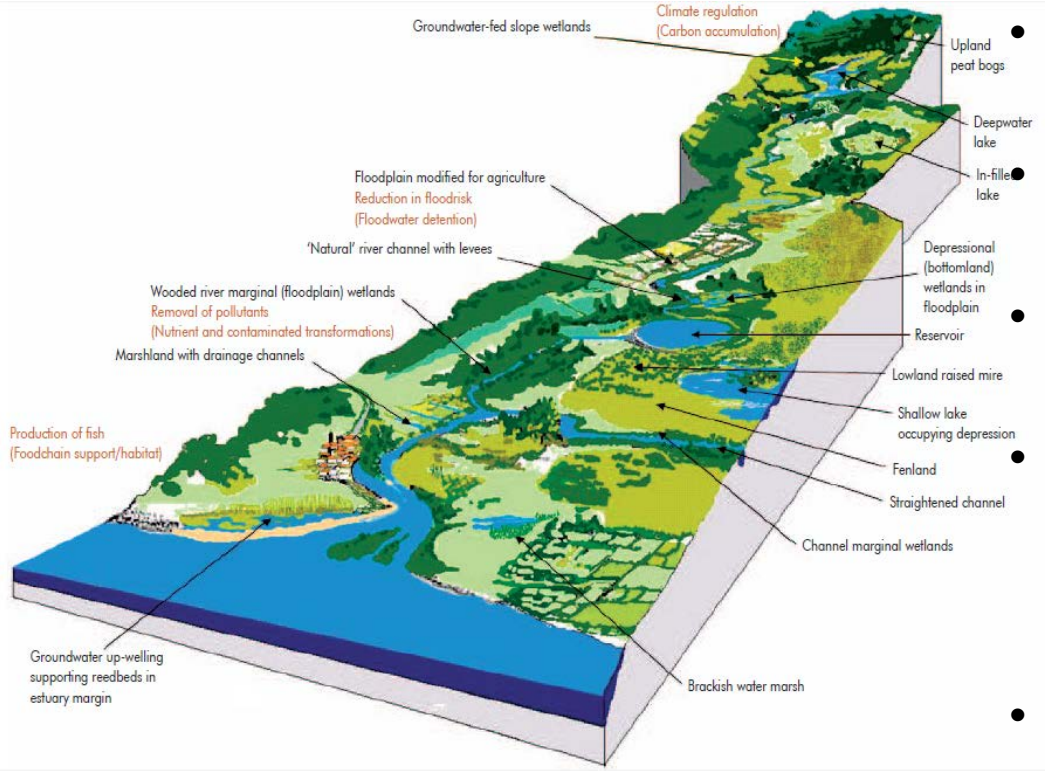
(Wet) grassland ecosystem services into the future



From UKNEA chapter on freshwaters

- **Semi-natural grasslands can provide multiple services**
- **Along with moderate animal production**
- **Probably suffered the most losses of any semi-natural system**
- **Restoration can work, but complete recovery is a long process**
- **Landscape planning should consider multiple ecosystems and their interactions in supporting biodiversity and services**
- **All this requires research & synthesis**
- **Rather than assumptions (‘expert opinion’) about service provisioning, links to biodiversity & restoration success**