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

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Ecosystem services – definitions and types

- Flood Attenuation/Storm Surge Protection
- Biogeochemical Cycling
- Soil and Sediment Regulation
- Water Quality and Supply
- Pest and Disease Regulation
- Food and Fiber
- Waste Regulation
- Habitat/Fisheries
- Recreation/Aesthetic
- Atmospheric and Climate Regulation
Grasslands – 13% of Earth’s surface

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

Figure 5 – GLC-SHARE distribution of land cover types

FAO 2014
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
(Semi-natural) grassland – a ‘fluid’ habitat

Ecological succession

Agricultural conversion

Bullock et al (2011) UKNEA
Fluidity seen within landscapes; e.g. ...
## Table 6.12 The final services and goods provided by Semi-natural Grasslands.

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

<table>
<thead>
<tr>
<th>Cause</th>
<th>Rare breeds</th>
<th>Plant wild relatives</th>
<th>Pollination</th>
<th>Pest control</th>
<th>Livestock production quantity</th>
<th>Livestock production quality</th>
<th>Greenhouse gas storage</th>
<th>Water quality</th>
<th>Water flow</th>
<th>Soil structure</th>
<th>Biodiversity</th>
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<td>Greenhouse gas storage, etc.</td>
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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 m³
- Climate – less CO₂ but more methane production from wetter soils
- Disease – historical & future malaria risk

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)

SNG undervalued in terms of single ecosystem 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
- Red: Existing wading bird & other wetland habitat
- Brown: Other identified “priority habitat”
- Orange: No existing identified habitat or suitability for wading bird habitat
- Green: Opportunities to establish additional wading bird habitat

Existing wet grassland, and opportunities to establish further grassland
Designing landscapes for multiple services (& biodiversity)

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

Legend
- Red: Existing provision in both services
- Brown: Provision in one service and no degradation in either
- Orange: Negligible provision or trade-offs between provision
- Green: Opportunity to improve single provision with no degradation
- Light Green: Opportunity to improve provision in both services

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

1400km² of downland comprising grassland, arable, woodland, rivers & urban
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....
Restoring semi-natural grassland for biodiversity & services

Well-researched restoration methods for semi-natural grassland

Scientifically-based restoration methodologies

Understanding rates & limitations on restoration

- Butterflies
  - Similarity to target vs. Years of restoration

- Plants
  - Similarity to target vs. Distance to ancient grassland

Rey Benayas & Bullock 2012 *Ecosystems*
Woodcock et al 2012 *Biol Cons*
Bullock et al 2011 *TREE*
Fagan et al 2008
Pywell et al 2002

Implemented in policy
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

Rey Benayas, et al 2009 Science
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
(Wet) grassland ecosystem services into the future

- 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

From UKNEA chapter on freshwaters