Biodiversity and ecosystem services: How are they linked in the real world?

James Bullock
“Nature and its vital contributions to people, which together embody biodiversity and ecosystem functions and services, are deteriorating worldwide”
Biodiversity, ecosystem functions & ecosystem services

**Biodiversity measure** ➔ **Intermediate functions** ➔ **Final services**

- **Plant & soil biodiversity** ➔ C sequestration, GHG emissions ➔ *Climate regulation, forage production*
- **Freshwater biodiversity** ➔ Nutrient cycling, trophic webs ➔ *Fish production, water quality*
- **Insect & landscape diversity** ➔ Pollination, pest control ➔ *Crop production*
- **Species & landscape diversity** ➔ Recreation, aesthetics ➔ *Cultural services*

Adapted from UK National Ecosystem Assessment
Evidence for (positive) BD-ES relationships

- from pot or plot scale species richness – ecosystem function (BD-EF) experiments
- often EF = production or related measure

Concepts in linking biodiversity and ecosystem services

Does BD affect ES directly?

At what scales should we study BD-ES relationships?

How do BD-ES relationships change across landscapes?

What are the processes behind BD-ES relationships?

What is the role of BD in the resilience of ES delivery?
1400km$^2$ of downland comprising grassland, arable, woodland, rivers & urban
A varied lowland landscape
Research along a biodiversity gradient

- Semi-natural
- Restoring
- Intensive agriculture
A variety of ecosystem services

GHG & soil processes

Clean water & fisheries

Pollination & pest control

Cultural services
Greenhouse Gases & Soil Processes

Landscape gradient study.
No clear relationship between plant diversity & soil processes
Experiment – functional diversity in restored grassland

FG1: Variable longevity, deep roots, large leaves
FG2: Long lived, small rosettes, shallow
FG3: Long lived, shallow roots, thick leaves
Restoration experiment – functional diversity

Trait values & diversity drive soil functions & resilience

Multifunctionality = respiration, soil nutrients, N emissions, Carbon

Functional diversity & the soil food web

No drought: strong relationships between soil food web & ecosystem processes – respiration & decomposition

Drought: decoupling of relationships. But plant root traits become important

Fry et al. (in prep)
Pollinators, crop pollination and landscape diversity
Oilseed rape fields with different amount of semi-natural grassland

Landscape structure & crop pollination

- Pollinator quadrat
- Pitfall trap and water trap
- Natural enemy count
- Suction sampling point
- Plants marked for yield
- Margin plant survey (if margin)
Pollinators not driven by semi-natural land cover

Main landscape driver = oilseed rape crops

Amount OSR: taxonomic group, $F_{3,96} = 12.74^{***}$

Shaw et al. (in review)
Oilseed rape yield increased by pollinator abundance and trait diversity

Meta-analysis

<table>
<thead>
<tr>
<th>Natural pollinator communities (field studies)</th>
<th>Pearson's correlation with oilseed rape yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abundance ($n = 16$)</td>
<td>0.37 (0.24, 0.49)</td>
</tr>
<tr>
<td>Species richness ($n = 14$)</td>
<td>0.05 (−0.18, 0.28)</td>
</tr>
<tr>
<td>Effect group richness ($n = 13$)</td>
<td>0.13 (−0.14, 0.39)</td>
</tr>
<tr>
<td>Functional divergence ($n = 12$)</td>
<td>0.47 (0.34, 0.58)</td>
</tr>
<tr>
<td>Body length CWM ($n = 13$)</td>
<td>0.08 (−0.16, 0.32)</td>
</tr>
<tr>
<td>Stigmal contact CWM ($n = 12$)</td>
<td>0.09 (−0.15, 0.31)</td>
</tr>
<tr>
<td>Hairiness index CWM ($n = 13$)</td>
<td>0.07 (−0.17, 0.30)</td>
</tr>
<tr>
<td>Phylogenetic MPD ($n = 15$)</td>
<td>0.09 (−0.14, 0.31)</td>
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</tbody>
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Cultural services, species and landscape diversity

- Cultural diversity
- Spiritual and religious values
- Knowledge systems
- Educational values
- Inspiration
- Aesthetic values
- Social relations
- Sense of place
- Cultural heritage values
- Recreation and ecotourism
Cultural services & biodiversity

Mechanisms by which people benefit from biodiversity

Biodiversity in the environmental setting

Direct Interaction: (outdoor activities) horse riding, walking, researching etc.

Indirect interaction (communications) art film, literature, discussion

Benefit pathways
- Cognitive
- Intuitive
- Creative
- Regenerative
- Communicative
- Retrospective

Benefits from biodiversity
- learning, mental development, aesthetic sense and pleasure, mental and physical restoration, sense of identify and place, social cohesion, spiritual and religious belief

Wellbeing
- Security
- Basic material for good life
- Health
- Good social relations

Public Participation GIS (PPGIS)

“Mark on the map 3 outdoor places of personal importance to you”

Welcome to the Wessex-BESS survey on the benefits of Wiltshire green places

466 selected points
Important spaces relate to landscape variables

- Protected areas, accessibility, land cover and land form influence the delivery of cultural services
- Some variation over different visual scales
- Also depending on form of engagement; e.g. + rivers for recreation, + historic monuments for cognitive benefits
- Need for landscapes of high ecological quality, diverse and near to towns

Self-reported satisfaction with species types

- 549 face-to-face interviews across study area
- Aims:
  1. Quantify the satisfaction that members of public get from particular species groups
  2. Relate variation in benefits to the charisma of species groups

<table>
<thead>
<tr>
<th>Effect on enjoyment or satisfaction from the countryside</th>
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</thead>
<tbody>
<tr>
<td>Very negative</td>
</tr>
<tr>
<td>Present as they are now</td>
</tr>
<tr>
<td>No longer present at all</td>
</tr>
<tr>
<td>Decreased presence*</td>
</tr>
<tr>
<td>Increased presence**</td>
</tr>
</tbody>
</table>

* a halving (50% less) ** half as many again (50% more)

People report benefits from biodiversity

- More benefits from more “charismatic” species
- Greater benefits reported by people engaged in ‘nature activities
- Less charismatic species liked by people engaged in nature activities
- Biodiversity in the local landscape gives benefits to the public

Conclusions: Biodiversity-EF-ES relationships

• Ecosystem services ≠ ecosystem functions
• Ecosystem services require large-scale research and variety of methods
• Land use is a primary driver of ecosystem services
• Biodiversity sometimes adds to ecosystem services
Project team & funding
Are biodiversity and ecosystem services linked?

“Biodiversity might have a role as:
(1) a regulator of ecosystem processes
(2) a final ecosystem service
(3) a good that has value of its own”

Mace et al. TREE 2012