Challenges in valuing ecosystem services and biodiversity in wetlands

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Scotland

- Why should we spend money protecting endangered birds?
- What's the point of trying to conserve wetlands?
- In this talk, I suggest that one of the main reasons is that conserving biodiversity provides very real economic benefits.
- I also consider how we go about valuing ecosystem services
- And what the main problems are we face in both of these tasks.

outline

- Economic approaches to valuing biodiversity
- Some examples
- Problems
- Economic approaches to valuing ecosystem services
- Some examples
- Problems

1.The economics of valuing biodiversity

- Mostly talking about valuing **species** or **habitats** (changes in species and habitats), although a few studies have tried to value the "characteristics" of biodiversity itself
- Main problem: biodiversity conservation produces a range of economic benefits, but many are not valued by markets
- On the whole, we are faced with all the problems of non-market valuation

Economic values versus market values

- Economic values for biodiversity come through two routes:

1. Aspects of biodiversity contribute directly to peoples' well-being or utility (eg charismatic species like the golden eagle in Scotland).
2. Aspects of biodiversity contribute to the production of other goods or services which are then bought and sold (indirect values)

- In both cases, market prices do not reveal the full economic value of biodiversity due to the problem of "missing markets".

Measuring biodiversity values

- Market prices can be used in some cases eg contribution of biodiversity to development of new drugs or drought- or disease-resistant crops.
- But in most cases, we need to use a range of "non-market valuation methods"
  - Production function methods
  - Travel costs and hedonic pricing
  - Stated preference methods (contingent valuation and choice experiments)

But why would we want to put a $ value on the benefits of protecting biodiversity?

1. Showing the "value" or benefit of conservation in a way comparable with other types of benefit or cost ➔ cost-benefit analysis.
2. Design of policy
3. "Making the case for conservation"

Use in cost-benefit analysis

- Cost-Benefit Analysis: weighing up the social benefits and costs of public spending or decisions (see Hanley and Barbier, *Pricing Nature,* 2009)
- Classic problem that environmental impacts were excluded due to non-market nature.
- Original driving force for development of non-market valuation methods
- Some policy and project impacts on biodiversity can be included in a CBA.

Biodiversity values in cost-benefit analysis

- Include *changes* in biodiversity due to project or policy implementation
- Big problems in measuring / predicting these changes in physical terms,
- and in the choice of biodiversity metric
- and then in pricing these changes
- A growing use in environmental policy analysis generally, and some examples in biodiversity policy.

Examples of using monetary valuation of benefits of protecting biodiversity in CBA

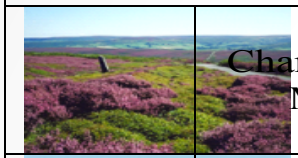
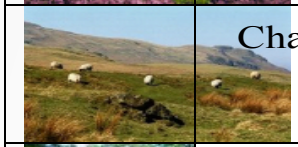
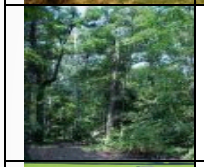
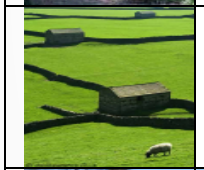
- Biodiversity action plans (for individual species) in the UK
- Designation of marine protected areas
- Making the case for the creation of new public forests
- Cost-benefit analysis of pollution reduction programmes in rivers and canals (eg Manchester Ship Canal)
- Design of climate change adaptation policies for biodiversity in Denmark.

Use of Valuation in the Design of Conservation Policy

- UK government pays farmers in "uplands" additional support compared to lowland farmers
- Historically, as an additional production-related subsidy
- But now, increasingly as a payment for "environmental goods" produced by upland farmers eg bird habitats, landscape quality
- But how should we determine such payments? Which species or habitat features should be prioritised for public spending?
- One idea is to base this on public Willingness To Pay.

An example

- landscape features associated with upland farming in England
- Choice experiment method
- 5 regions of the country with areas of upland farming
- Hanley et al, Jnl. Ag. Econ., 2007.

Policy Option	Current Policy	Policy Option A	Policy Option B
 Change in area of Heather Moorland and Bog	A loss of 2% (-2%)	A gain of 5% (+5%)	A loss of 2% (-2%)
 Change in area of Rough Grassland	A loss of 10% (-10%)	A gain of 10% (+10%)	A loss of 10% (-10%)
 Change in area of Mixed and Broadleaf Woodlands	A gain of 3% (+3%)	A gain of 20% (+20%)	A gain of 10% (+10%)
 Condition of field boundaries	For every 1km, 100 m is restored	For every 1km, 200 m is restored	For every 1km, 50 m is restored
 Change in farm building and traditional farm practices	Rapid decline	Much better conservation	No change
 Increase in tax payments by your household each year	£0	£40	£17
	Which do you like best?		

Given these kind of benefit estimates for different habitats..
*example for North-West England

Attributes	Implicit price in UK £/yr. per person	95% lower bound	95% upper bound
(shaded: significantly different from zero)			
Heather moorland and bog (1% increase)	0.78	0.45	1.11
Rough grassland (1% increase)	0.74	0.45	1.05
Mixed and broadleaf woodlands (1% increase)	0.61	0.30	0.91
Field boundaries (metre restored per km)	0.00	-0.03	0.04
Cultural heritage: from “rapid decline” to “no change”	1.03	-1.84	4.14
Cultural heritage: from “rapid decline” to “much better conservation”	4.89	1.52	8.43

Making the case for conservation

- Show how economies can benefit from protecting biodiversity
- And how this can enhance well-being

- TEEB reports

Valuing biodiversity as an input

- Value of wild insect pollinators to crop production and wild plants in UK
- Problems with data, but we think wild pollinator populations are falling, and species diversity is falling for sure in some areas
- Habitat change, pesticides,
- Yet many commercial crops rely on supply of pollination from wild pollinators – managed pollinators are imperfect substitutes

Biodiversity can also generate economic benefits through tourism

- Now the market does provide a reward
- Spending on whale and dolphin watching
- Protecting biodiversity in Eastern Africa as a way of boosting foreign exchange earnings, and reducing the conflicts between conservation and local economic livelihoods
- Examples from Ethiopia and Rwanda

Mountain nyala (Ethiopian highlands) and Mountain Gorilla (Virunga national Park)

Summing up so far..

- So, we can estimate monetary values for changes in species and changes in habitat
- And we can measure values people place on different "attributes" of biodiversity
- We can also measure economic value of different aspects of biodiversity by looking at its contribution to the production of marketed goods (eg role of wild pollinators in agricultural production)
- And links between biodiversity and "Subjective Well-Being" measures of happiness (Rehdanz, 2010).

What are the problems in doing this?

Problems (1) – what exactly do we mean by biodiversity anyway?

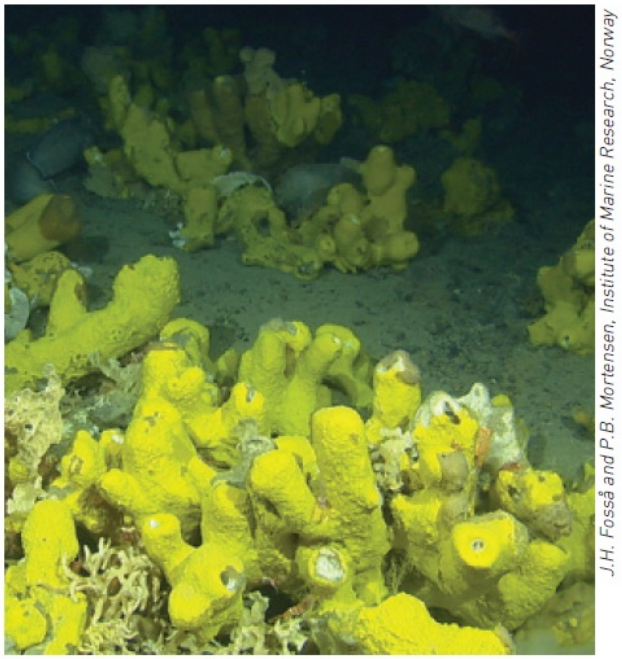
- Multiple interpretations in ecology
- Multiple degrees of understanding amongst people
- Multiple scales: local, regional, national etc.
- What makes most sense from an economics viewpoint?

Problems (2): understanding and information

- Economic analysis of policy using benefit-cost analysis means we assume people are the best judge of their own "well-being"
- Means we work with preferences as they exist
- But many people will have very incomplete understanding of the role or importance of different species/ecosystems
- The aspects of biodiversity most important for ecosystem functioning are likely to be the least familiar to voters/taxpayers?

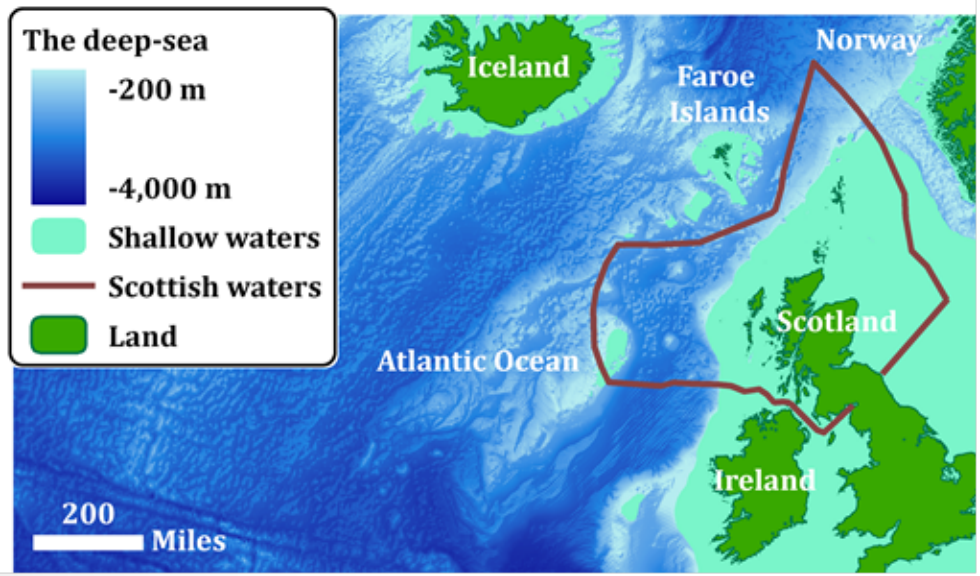
An illustration

- What are the values of protecting biodiversity and ecosystem services in the deep sea?
- Deep sea: areas below 200m. Corresponds to 64 per cent of the surface of the Earth and 90 per cent of our planet's ocean area
- Problem: most people have almost zero knowledge or experience of deep sea ecosystems (eg sea mounts, abyssal plains, vents..); and almost zero awareness of the creatures that inhabit these systems.
- Scientific knowledge is also lacking: only about 3% of sea floor is "properly mapped" in public domain, whilst guess as to number of species is 0.5 million – 100 million (Koslow, 2007)



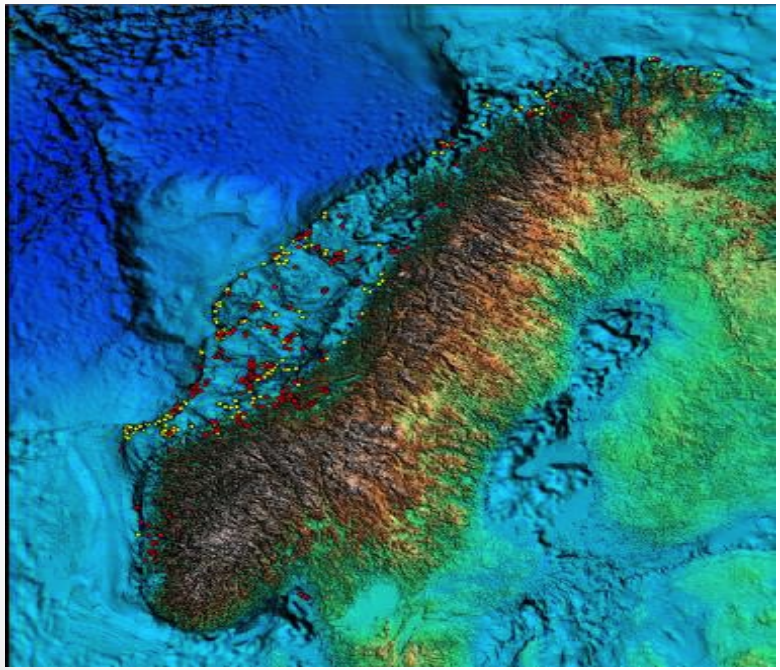
J.H. Fossa and P.B. Mortensen, Institute of Marine Research, Norway

But we can value changes in deep sea biodiversity!



- Jobstvogt et al, *Ecological Economics*, 2014
- Choice experiment of protection options for deep sea areas off coast of Scotland
- Showed that general public were willing to pay around £35 per household per year to increase protection to 1600 species from a baseline of 1000 species

Have also done this for protecting cold water corals off the coast of Norway



Figur 1 Gule prikker er korallrev som er rapportert av fiskere og andre, røde prikker er verifiserte forekomster av KK langs norskekysten per 2004 (Havforskningsinstituttet, hentet fra MD sin hjemmeside)

- A choice experiment
- People were expressing preferences for area of CWC protected, whether area was used for fisheries or oil/gas exploration, and how important it was as a habitat for fish
- Trade these off against the costs of establishing, monitoring and policing these protected areas

Effects of knowledge and experience on Willingness to pay

- If people know relatively little about ecosystems and biodiversity, does this matter when we use CBA for policy analysis?
- We tested for effects of knowledge on WTP to protect cold water corals in Norway – found that as your knowledge increases, your WTP also goes up
- We also tested how "experience" with environmental goods affects your values, although here there is an endogeneity problem
- For our coastal water quality sample, we show that, within a "random utility model", the scale parameter is increasing with experience, whilst the variance of scale is decreasing ➔ as people learn more about environmental goods, this changes their choices, making your choices and values less random.

2. Measuring ecosystem service values: a framework

- According to the Millennium Ecosystem Assessment (2005), ecosystems such as wetlands provide society with a number of valuable *services*
- These are supporting, regulating, provisioning and cultural services
- Each of these benefit people, either directly or indirectly.

An example: Beaumont et al (*Marine Pollution Bulletin*, 2007), ecosystem services "delivered" by marine ecosystems.

- Supporting services
  - Resilience
  - Nutrient cycling

- Provisioning Services
  - Food products (eg fish)
  - Non-food products (eg seaweed for fertiliser)

- Regulation Services
  - Climatic regulation (eg role in C sequestration)
  - Storm protection (eg coastal mangroves)
  - Bio-remediation of wastes

- Cultural services
  - Cultural heritage
  - Recreation
  - Non-use benefits

- Biodiversity supports the "production" of all of these ecosystem services, but is also a feature of ecosystems that is important to people.
- Components of biodiversity also directly responsible for some ecosystem service supply
- Mace et al, *TREE*, 2012.

- Biodiversity sits "uneasily" in the ecosystem services framework
- Is it an aspect of ecosystem functioning; a final ecosystem service, or a benefit?

Ronnback et al, Ambio, 2007:

"Biodiversity has a fundamental role in providing the basis for all ecosystem goods and services, although detailed understanding of the underlying mechanisms is still limited."

But do these ecosystem services really have economic value?

- Yes, so long as they add to people's well-being ("utility"), for example because people enjoy walking in the forest
- Or because they provide inputs to production (eg wild pollinators)
- Or reduce the costs to people of climate change or extreme weather events (for example, by reducing soil erosion, providing defence against storms)
- Banzhaf and Boyd (2007) – need to distinguish between ecosystem services as inputs, and economic benefits which are produced with additional inputs, such as labour.

Economic values for ecosystem services (ES)

come through two routes:

- Service flows which contribute directly to peoples' well-being (utility)
- Service flows which contribute to the production of other goods or services which are then bought and sold (indirect values)

➔ In both cases, market prices do not reveal the full economic value of ES due to the problem of "missing markets".

➔ Means we often need to use "non-market valuation" methods to measure economic value of changes in ecosystem services

Economists mainly want to value *changes* in these service flows; for example, the effects of draining peatlands, or protecting a forest, or conserving a mangrove swamp, on the *flow* of ecosystem service values.

The exception is where we want to undertake an asset accounting exercise.

Recognising natural capital

- Growing moves within UN, EU, World Bank to include changes in a nation's natural capital in some kind of ecosystem accounting
- Means recognising value of service flows (benefits) and changes in the condition of natural assets eg soil reserves, forest stock
- Part of sustainability accounting
- Can show how a nation's *comprehensive wealth* is changing over time.

Ecosystems as assets

- **Barbier, E.B.** 2011. *Capitalizing on Nature: Ecosystems as Natural Assets*
- Since an ecosystem such as a forest produces a flow of ES over time, and thus a flow of benefits, we can think of it as a capital asset – as part of natural capital.
- Value of any asset is the Present Value of the (discounted) net benefits we get from that asset over some time period
- Changes in the value of these service flows changes the value of the asset
- For example, if wetlands are converted (loss in size of asset) or their service flows become degraded (eg capacity to act as nursery for fisheries, or as carbon sink), then their value as natural assets decline.

Key issues in measuring ecosystem asset values as part of natural capital.

- Do we have the physical data and the economic valuation data to track appreciation/depreciation over time?
- Are there thresholds beyond which the marginal value of benefits of protecting the asset jump suddenly? Do we know where these thresholds are?
- How much are we able to substitute for the services provided by the asset, and at what cost?
- What are the emerging threats to the condition of the asset?
- Who owns the asset? Who gets the benefits of its services?

- (UK Natural Capital Asset Check is investigating these issues for a number of case studies).

Some examples of applying the ES valuation approach

- Uplands in the UK
- Coastal waters in the UK and Ireland

Uplands in the UK

- Taken from UK National Ecosystem Assessment (2011)

The NEA looked at 8 UK Broad Habitats

Freshwaters - Openwaters, Wetlands and Floodplains

Urban

Marine

Coastal Margins

Mountains, moors and heathlands

Semi-natural grasslands

Enclosed farmland

Woodlands

Distribution of UK Habitats

Although lacking in extremes – there are no high mountains, no true deserts and no major rivers – the UK is in fact remarkably variable biophysically, ecologically and socially, with complex underlying geology, a wide climatic range, (from very wet to semi-arid), and large variations in the distribution of the human population, from extensive areas of near-wilderness (in Scotland) to one of the world's largest metropolitan areas (Greater London). In the UK NEA this diversity has been captured in eight Broad Habitat types (**Figure 12**):

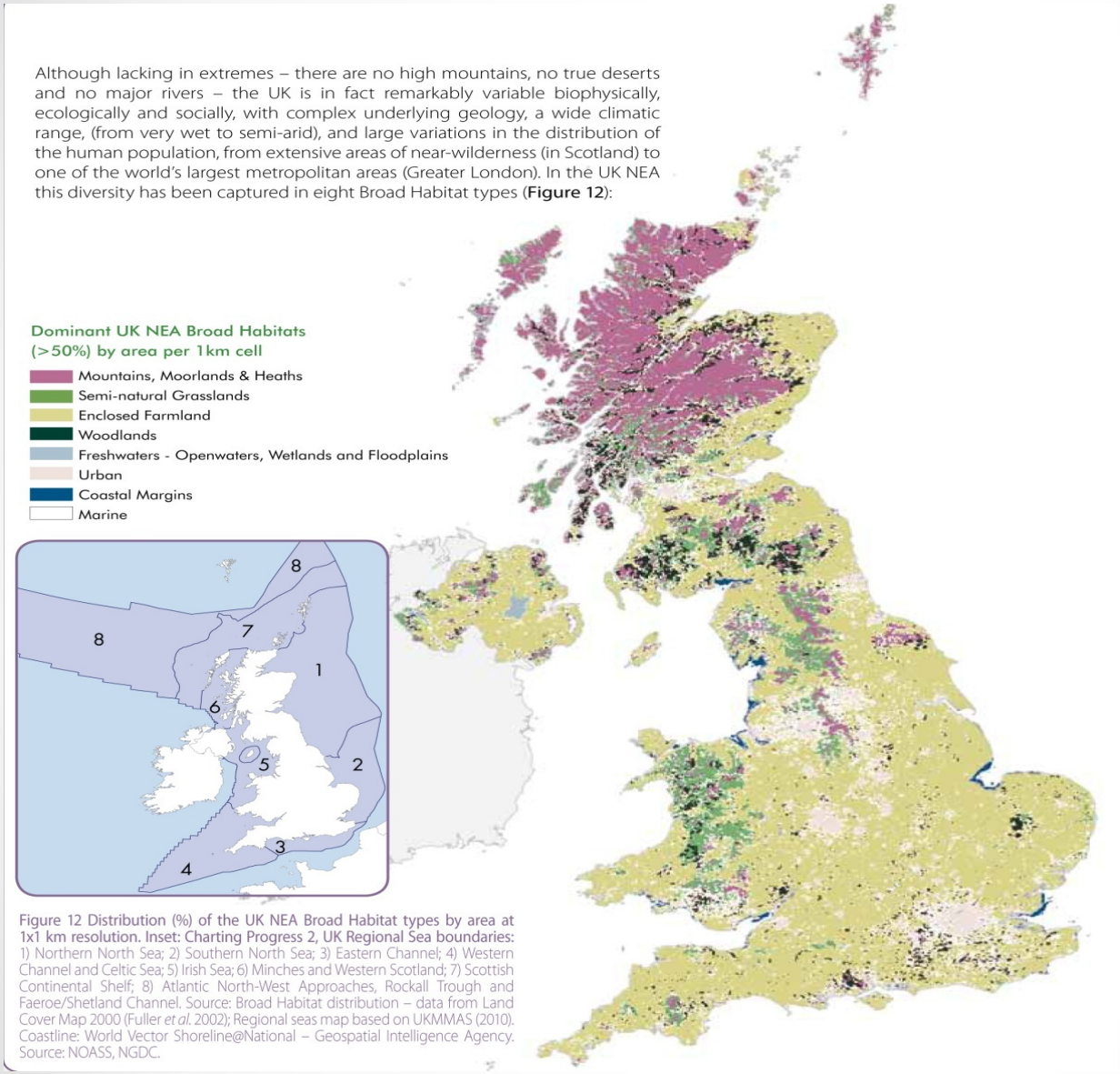
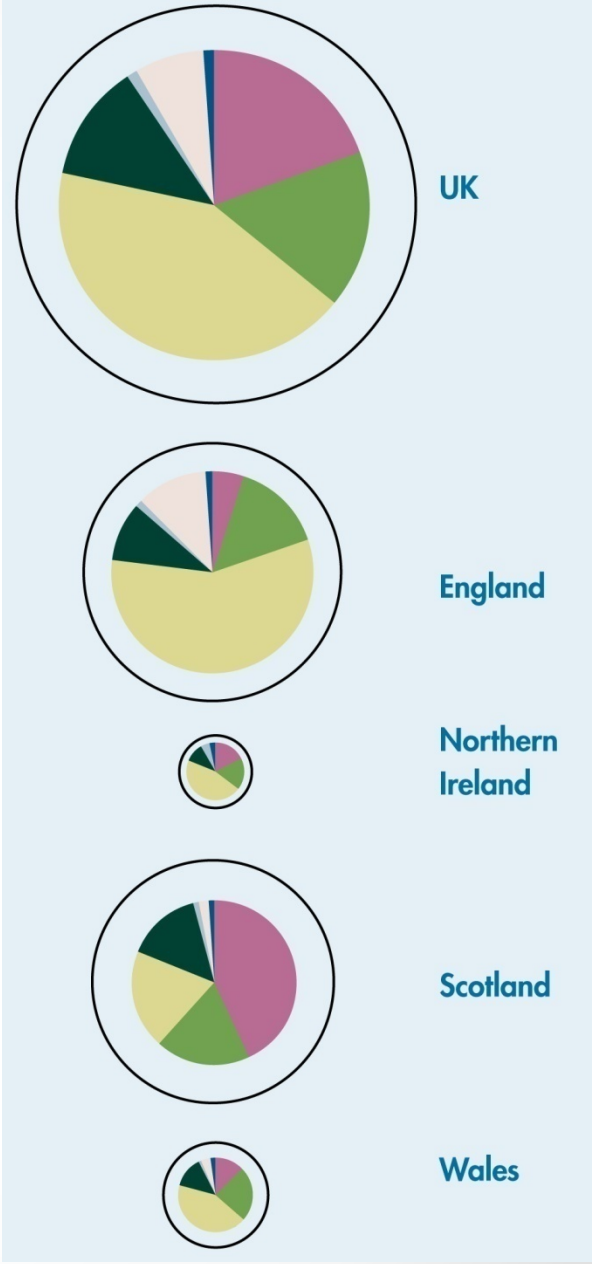


Figure 12 Distribution (%) of the UK NEA Broad Habitat types by area at 1x1 km resolution. Inset: Charting Progress 2, UK Regional Sea boundaries: 1) Northern North Sea; 2) Southern North Sea; 3) Eastern Channel; 4) Western Channel and Celtic Sea; 5) Irish Sea; 6) Minches and Western Scotland; 7) Scottish Continental Shelf; 8) Atlantic North-West Approaches, Rockall Trough and Faeroe/Shetland Channel. Source: Broad Habitat distribution – data from Land Cover Map 2000 (Fuller *et al.* 2002); Regional seas map based on UKMMAS (2010). Coastline: World Vector Shoreline@National – Geospatial Intelligence Agency. Source: NOASS, NGDC.



- During the last 20 years, MMH is estimated consistently to cover about 18% of the UK.
- Scotland 43% of land surface area, 12% in both Wales and Northern Ireland and 5% in England
- six broad habitats: *Bracken, Dwarf shrub heath, Bog, Fens, Montane, Inland rock*
- ***Many MMH ecosystem services are produced jointly by other habitats (eg woodland, semi-natural grasslands)***
-

Figure 1 Montane: *Racomitrium heath* on Creag Meagaidh, Cairngorms, Scotland. *Photo courtesy of René Van der Wal.*

Component priority habitats: Blanket bog

Figure 7 Bog: Blanket bog, Flow Country, Caithness, Scotland. *Photo © Steve Moore/SNH.*

Main drivers of trends (fall in quality and quantity):

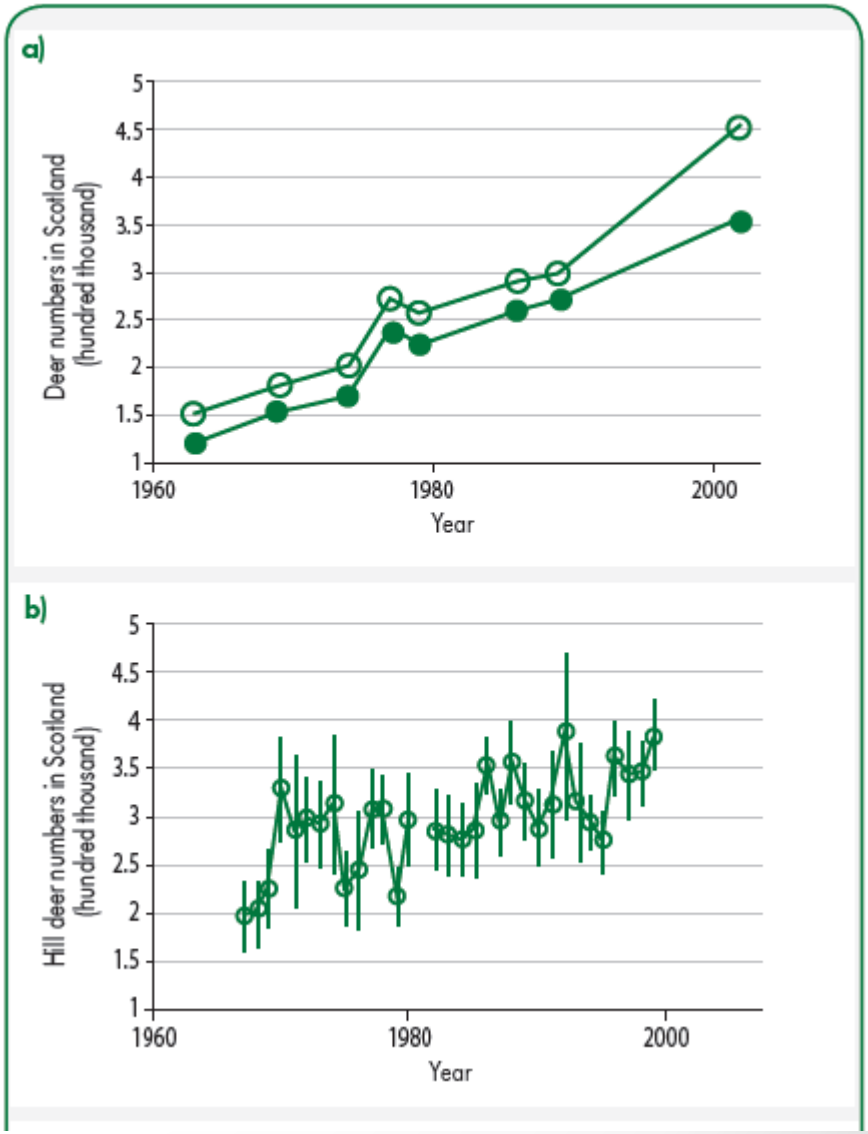
forest planting, air pollution (S and N), agriculture (direct conversion; over-grazing), grouse moor management.

Figure 5.9a Eroding blanket bog in the southern Pennines, England. *Photo courtesy of North Pennines AONB Partnership.*

Figure 5.9b Houses encroaching on lowland heath in Dorset, England. *Photo courtesy of Peter Wakely/ Natural England.*

Changes in pressures

- Example: grazing pressures from deer



What are the ecosystem service flows to be valued?

- Livestock products (lambs, cattle)
- Game (grouse, red deer..)
- Peat extraction
- Water supply
- Air pollution removal
- Mitigation of flood and wild fire risks
- Carbon store/sink
- Outdoor recreation
- Cultural/non-use values of landscape

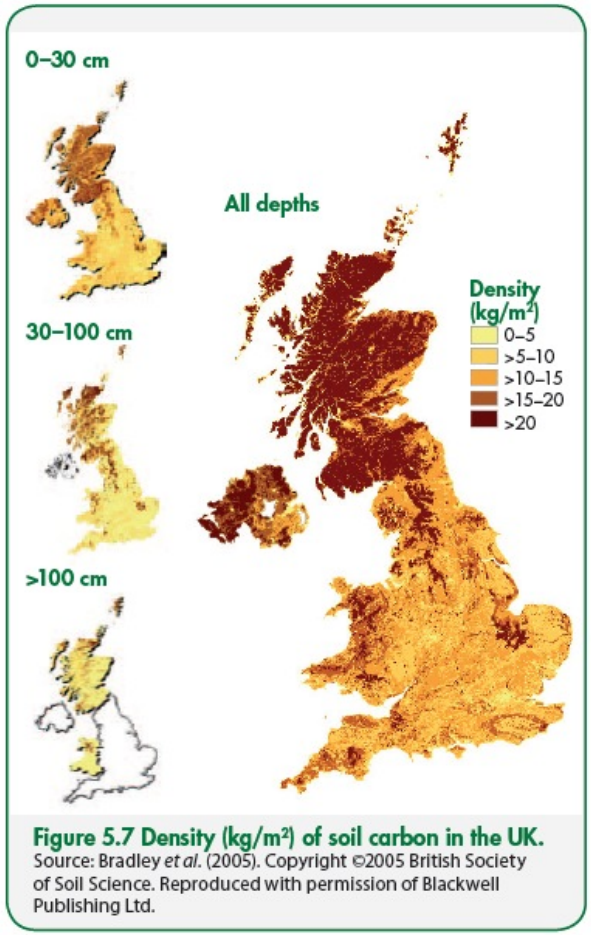


Figure 5.7 Density (kg/m²) of soil carbon in the UK.
Source: Bradley *et al.* (2005). Copyright ©2005 British Society of Soil Science. Reproduced with permission of Blackwell Publishing Ltd.

- Carbon storage provided by the MMH habitat

Valuing changes to cultural ecosystem services again!

- landscape features associated with upland farming in England
- Choice experiment method
- 5 regions of the country with areas of upland farming
- Hanley et al, Jnl. Ag. Econ., 2007.

Example (2): coastal ecosystems

- Water quality at the coast likely to change in response to new legislation eg revised Bathing Waters Directive; creation of new Marine Protected Areas; implementation of Marine Strategy Framework directive.
- We use choice experiments to estimate some of the economic impacts of these changes in ecosystem quality

Choice Experiment design.

- *Human Health risk*.
- *Beach Debris management*
- Nutrient cycle will be affected, and therefore the ecological condition of sea bed (*benthic health*) will also change. ➔ Impacts upon other species – mammals, birds etc. so these are used as indicators.
- *Costs;* specified for recreational users as additional travel cost per trip to beach with higher standards. Levels range from $1 to $18. For off-site surveys in UK, we used council taxes as the bid vehicle instead.
- ***Sampling:*** *beach users and general public in UK (Scotland, Northern Ireland) and Ireland.*

Sample Card

	Beach A	Beach B	Beach C
Benthic Health and population.	**Small increase** More fish, mammals and birds. Limited potential to notice the change in species numbers.	**Large increase** More fish, mammals and birds and an increased potential of seeing these species.	**No Improvement**
Health Risk (of stomach upsets and ear infections)	**Very Little Risk** Excellent water quality	**5% Risk** Good water quality	**10% Risk** No improvement
Debris Management	**Prevention** More filtration of storm water, more regular cleaning of filters and better policing of fly tipping.	**Collection and Prevention** Debris collected from beaches more regularly in addition to filtration and policing.	**No Improvement**
Additional yearly water and sewerage rates	£18	£67	£0
Please tick the **ONE** option you prefer.	☑	☐	☐

Note that beach visitor version has extra travel costs per trip instead of annual water/sewerage rates

N.Ireland – beach users

Table 13: Willingness to Pay estimates for different specifications and groupings										
	All respondents – conditional logit		All respondents – error component		Active Users – error component		Illness Sufferers – Error Component		Regular Visitors – error component	
	WTP	SE	WTP	SE	WTP	SE	WTP	SE	WTP	SE
Benthic Health – small increase	£3.83***	0.448	£4.67***	0.527	£5.40***	1.72	£5.54***	1.74	£5.27***	0.795
Benthic Health – large increase	£5.02***	0.502	£5.97***	0.525	£9.34***	1.95	£6.70***	1.93	£6.66***	0.839
Health Risk 5%	£4.13***	0.512	£5.36***	0.722	£9.49***	2.81	£9.48***	2.32	£5.93***	1.184
Health Risk – very little	£5.44***	0.526	£7.22***	0.666	£13.56***	2.80	£12.86***	2.28	£8.84***	1.067
Debris - Prevention	£6.30***	0.483	£7.37***	0.513	£10.77***	1.98	£8.54***	1.53	£8.10***	0.808
Debris – Collection & Prevention	£7.23***	0.513	£8.72***	0.605	£12.54***	2.55	£10.24***	2.03	£9.34***	0.993

Ecosystem service valuation is not easy to do well

- US National Research Council, 2005: "the fundamental challenge in valuing ecosystem services lies in providing an explicit description and adequate assessment of the links between the structure and function of ecosystems, the benefits derived by humanity, and their ..values".

- Polasky and Segerson, 2009: problem is due to ..

..''the lack of multi-product ecological production functions to quantitatively map ecosystem structure and function to a flow of services that can be valued''

- Thanks for listening

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