Why is it so difficult to measure the economic value of changes in “biodiversity”?

Nick Hanley

University of Stirling

- Mostly talking about valuing **species** or **habitats** (changes in species and habitats)
- Main problem: biodiversity conservation produces a range of economic benefits, but many are not valued by markets
- This is changing very slightly, as markets emerge eg in the US for wetland offsets, habitat offsets, and species offsets
- But, 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 (utility)
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
- But in most cases, we need to use a range of "non-market valuation methods"
  - Production function
  - replacement costs and averting expenditure
  - Travel costs and hedonic pricing
  - Stated preference methods (contingent valuation and choice experiments)

Valuation method[a]	Types of value estimated[b]	Common types of applications	Ecosystem services valued
Travel cost	Direct use	Recreation	Maintenance of beneficial species, productive ecosystems and biodiversity
Averting behaviour	Direct use	Environmental impacts on human health	Pollution control and detoxification
Hedonic price	Direct and indirect use	Environmental impacts on residential property and human morbidity and mortality	Storm protection; flood mitigation; maintenance of air quality
Production function	Indirect use	Commercial and recreational fishing; agricultural systems; control of invasive species; watershed protection; damage costs avoided	Maintenance of beneficial species; maintenance of arable land and agricultural productivity; prevention of damage from erosion and siltation; groundwater recharge; drainage and natural irrigation; storm protection; flood mitigation
Replacement cost	Indirect use	Damage costs avoided; freshwater supply	Drainage and natural irrigation; storm protection; flood mitigation
Stated preference	Use and non-use	Recreation; environmental impacts on human health and residential property; damage costs avoided; existence and bequest values of preserving ecosystems	All of the above

Not a new problem!

- Techniques emerging since 1970s
- Much experience of applying these methods to (i) species conservation and (ii) habitat conservation , all over the world.
- Eg review in Richardson and Loomis, Ecol.Econ., 2009

Value estimate for changes in named species (Richardson and Loomis, 2009)

Table 2 – Summary of economic value of threatened, endangered and rare species ($2006)

	Low value	High value	Average of all studies
Studies reporting annual WTP			
Bald eagle	$21	$45	$39
Bighorn sheep			$17
Dolphin			$36
Gray whale	$24	$46	$35
Owl	$39	$130	$65
Salmon/Steelhead	$10	$139	$81
Sea lion			$71
Sea otter			$40
Sea turtle			$19
Seal			$35
Silvery Minnow			$38
Squawfish			$12
Striped Shiner			$8
Turkey	$11	$15	$13
Washington state anadromous fish populations	$147	$311	$241
Whooping crane	$44	$69	$56
Woodpecker	$13	$20	$16
Studies reporting lump sum WTP			
Arctic grayling	$20	$26	$23
Bald eagle	$245	$350	$297
Falcon			$32
Humpback whale			$240
Monk seal			$166
Wolf	$22	$162	$61

What determines this variation in WTP across species?

- Change in population size
- Type of species (marine, bird, mammal..)
- Use versus non-use

But also:

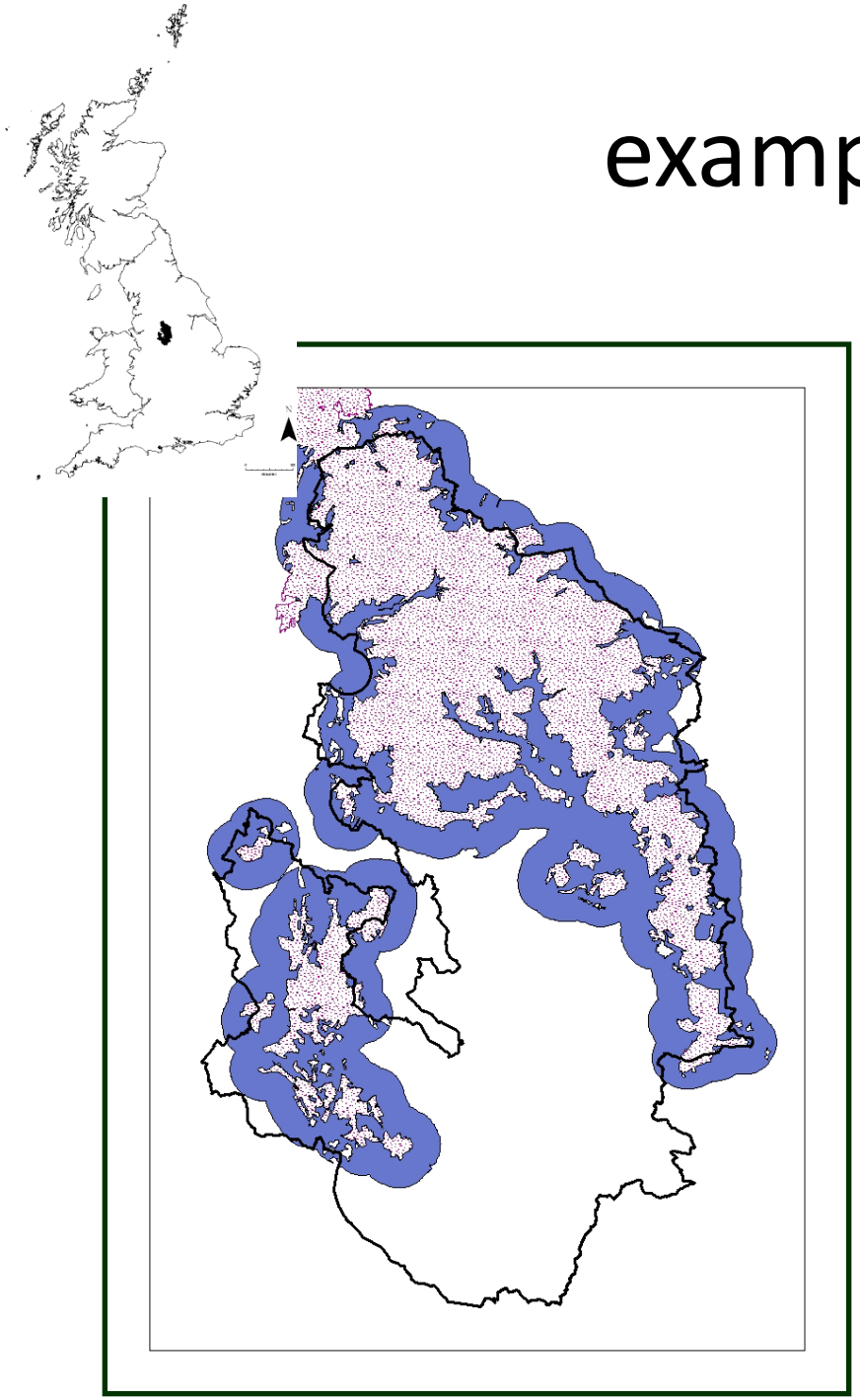
- Response rate, survey mode, valuation method

- This is a bit disappointing!

Valuing changes in habitat

- Eg changes in moorland

example: Peak District



- UK's first national park
- Biodiversity Action Plan priority species and habitats

Land uses:

- Livestock farming
- Grouse shooting
- Recreation
- Major catchments

CE design

- Moorland management intensity The intensity of management on the moorland areas currently varies across the national park. More intensive moorland management is represented by increased numbers of sheep and moorland burning.

- Moorland Fringe Management Intensity –More intensively managed moorland fringe with sufficient fertiliser input produces lush green fields, additionally increased sheep numbers would be present. Less intensive management leads to more scrubby appearance with occasional shrub like plants.

- Valley Bottom Farmland Management Intensity – three levels (More Intensive, No change in Intensity, Less Intensive). These are the "traditional" green fields of the English countryside, found in the Peak District at lower altitudes bordered by dry stone walls. More intensive management results in greener fields with more sheep, with less intensive management having the opposite impact.

- Tax – six levels selected based on average council tax in the areas, shown as additional tax burden to the household per year.

	A	B	Do Nothing
Moorland – intensity of management	Less Intensive – less sheep and burning. More bird species	No Change in Intensity	More Intensive – more sheep and burning
Moorland Fringe – intensity of management	Less Intensive– less sheep and burning. More bird species	Less Intensive– less sheep and burning. More bird species	More Intensive – more sheep, fertilizer and drainage
Valley Bottom Farmland – intensity of management	No Change in Intensity	Less Intensive – less sheep and fertiliser. More bird species	More Intensive – more sheep and fertilizer.
Footpath Network	Improved	Degraded	Degraded
Tax Cost	£5	£55	£0
Please tick the option you prefer.	☐	☐	☐

- Results show willingness to pay of local residents for more- **or** less-intensive management of the 3 habitats : strong preference for status quo.
- Show that people: (i) have values which vary across habitats (ii) prefer existing landscape to any change (iii) have values which depend on <u>when</u> they are measured (eg on-site versus remembered).

More on habitat values

- 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?	☐	☐	☐

Table 5. Implicit prices and 95% confidence intervals
All values, £/household/year

Region Attribute	North West	Yorks and Humber	West Midlands	South West	South East
HMB	0.23 (0.09 0.41)	0.31 (-0.49 1.05)	0.81 (0.40 1.37)	1.64 (-5.42 11.10)	0.53 (0.26 0.88)
RG	0.09 (-0.44 0.20)	0.67 (-0.76. 2.40)	0.76 (-0.15 1.83)	0.23 (-4.94 11.50)	0.12 (-0.46 0.72)
BMW	0.24 (0.10 0.45)	-0.13 (-1.22 0.47)	0.54 (0.07 1.03)	0.73 (-2.79 6.13)	0.54 (0.27 0.86)
FB	0.02 (0.00 0.03)	0.04 (-0.03 0.13)	0.01 (-0.04 0.06)	-0.01 (-0.32 0.50)	0.03 (0.00 0.06)
CH1	1.69 (0.18 3.24)	5.96 (0.36 18.64)	3.23 (-1.11 9.71)	16.04 (-0.91 21.35)	-0.85 (-3.60 2.16)
CH2	0.49 (-3.14 4.11)	16.73 (0.07 48.57)	23.78 (13.44 41.67)	26.75 (-79.5 134.0)	6.60 (0.18 15.01)

Key: HMB = heather moorland and bog - % increase; RG = rough grassland - % change; BMW – broadleaved and mixed woodland, % change; FB = field boundaries, length conserved; CH1 = cultural heritage no change rather than rapid decline; CH2 – cultural heritage much better conserved rather than rapid decline.

Some studies have also attempted to measure “characteristics” of biodiversity

- Eg Christie et al, Ecol Econ, 2006
- Changes in local biodiversity in two areas of England
- Again, use of choice experiment method

Study Design

- selection of levels and attributes is key.
- Started from ecologists' listing of key attributes of biodiversity, tried these out in focus groups, and thought about what policy needs were (not just values for the cute and familiar)
- Many "ecological" attributes not understandable to general public eg keystone species
- Final set was a compromise between these considerations

Aspects of biodiversity included in choice experiment design

- Familiar species of wildlife
- Rare (unfamiliar) species of wildlife
- Habitat quality
- Ecosystem services

- Plus a price term (increase in taxes)

	POLICY LEVEL 1		**POLICY LEVEL 2**		**DO NOTHING (Biodiversity degradation will continue)**
Familiar species of wildlife	Protect *rare* familiar species from further decline		Protect *both rare and common* familiar species from further decline..		Continued decline in the populations of familiar species
Rare, unfamiliar species of wildlife	Slow down the rate of decline of rare, unfamiliar species.		Stop the decline and ensure the recovery of rare unfamiliar species		Continued decline in the populations of rare, unfamiliar species
Habitat quality	Habitat restoration, e.g. by better management of existing habitats		Habitat re-creation, e.g. by creating new habitat areas		Wildlife habitats will continue to be degraded and lost
Ecosystem process	Only ecosystem services that have a direct impact on humans, e.g. flood defence are restored.		*All* ecosystem services are restored		Continued decline in the functioning of ecosystem processes
Annual tax increase	10	25	100	260	520	No increase in your tax bill

Information provision

- Pre-testing showed variable but low information levels about biodiversity
- We used a powerpoint show to get across information about the choice experiment attributes and levels, relating them to the local situation re. biodiversity and its loss
- De-briefing showed people understood what they were being asked to do in the choice tasks

A: Familiar Species of wildlife

... any bird, mammal, reptile or plant that is likely to be recognised by members of the general public.

C*ommon* familiar species :

- Squirrel
- Kestrel
- Blue tit
- Poppies

R*are* familiar species :

- Otter
- Brown Hare
- Skylark
- Song thrush

B: Rare (unfamiliar) species of wildlife

… any species of wildlife that:

- has officially been designated as being rare or endangered,
- but which members of the general public are unlikely to know about.
- Can be just as important as familiar species
- Examples include:
  - Pasque flower
  - Bearded stonewort
  - Long horn beetle
  - Black hairstreak butterfly

Implicit prices (WTP /hld/yr) for Cambridgeshire sample

Attribute	*Implicit Price*	*SE*	*95%lower*	*95%upper*
Familiar-RARE	35.65	17.19	1.95	69.34
Familiar- RARE +COMMON	93.49	18.03	58.15	128.82
RARE slow down loss	-46.68	15.88	-77.80	-15.55
RARE recovery	115.13	21.22	73.53	156.72
Habitat - RESTORE	34.4	15.32	4.37	64.42
Habitat – CREATE NEW	61.36	17.52	27.02	95.69
Ecosystems-HUMAN	53.62	16.97	20.35	86.88
Ecosystems-ALL	42.21	19.23	4.51	79.90

So..

- We can estimate values (in euro) 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 in agricultural production)
- And links between biodiversity and “Subjective Well-Being” measures of happiness (Rehdanz, 2010).

- However, there are a number of interesting problems which we face in applying economic valuation methods to changes in biodiversity, whatever index we use to measure biodiversity.

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.

Problems (2)

- Economic analysis of policy using CBA 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
- Aspects of BD most important for ecosystem functioning are likely to be the least familiar?

- Can address some problems of understanding using **valuation workshop** technique (MacMillan et al, Ecol.Econ., 2006)
- Opportunities for people to discuss BD, and become more informed about it
- Can trace process of preference construction, and effects of more information
- But means we are changing preferences/values as we measure them?
- Problems of aggregation.

Problems (3)

- Standard economic theory of value assumes preferences exist for every good
- Alternative view is that preferences and values are *constructed* in a context-specific manner, based on underlying attitudes and beliefs
- *Example for biodiversity: values depend on naming of different species*
- Valuation methods need to able to trace the process of preference construction?
- But also implies economic values respond to how they are measured

Problems (4)

- Also some evidence that biodiversity values depend on *how* conservation is undertaken
- Czajkowski and Hanley, 2009, *Env. and Res. Econ*.
- Focus on one of the most ecologically valuable forests in Poland: Bialowieza.
- Famous for its natural dynamics and species richness (contains 40% of known species in Poland)

Our choice experiment

- Attributes selected: natural ecosystem processes, rare species of flora and fauna, ecosystem components, plus a price (national tax increase)
- labelling of alternatives to test if the respondents are indifferent to how a given level of biodiversity protection was achieved:

National park versus "other means"

	Option A:	Option B:	Option C:
	Status Quo	Extension of the National Park	Other Form of Protection
Natural Ecological Proceses	**no change –** protection of natural ecological proceses at 16% of the forest area	**no change –** protection of natural ecological proceses at 16% of the forest area	**no change –** protection of natural ecological proceses at 16% of the forest area
Rare Species of Fauna and Flora	**no change –** decline threatening extinction	**substantial improvement –** better condition of current standings and their expansion	**partial improvement –** maintaining and better condition of current standings
Ecosystem Components	**no change –** lack of some components and decrease in quality of the existing ones	**minor improvement –** regeneration of deteriorated components on 10% of the forest area	**partial improvement –** regeneration of deteriorated components on 30% of the forest area
Cost – your tax increase (yearly)	0 zł	50 zł	10 zł
CHOICE	☐	☐	☐

Table 2. Implicit price estimates (EUR)

Variable	Implicit price	Standard Error	p-value
Natural Ecological Processes (1-level improvement)	4.32	0.825952	0.0000
Natural Ecological Processes (2-level improvement)	5.52	1.024932	0.0000
Rare Species (improvement)	3.12	0.824432	0.0002
Ecosystem Components (1-level improvement)	3.98	1.054462	0.0002
Ecosystem Components (2-level improvement)	4.21	0.960714	0.0000
Ecosystem Components (3-level improvement)	5.60	1.076968	0.0000
Park (alternative specific constant)	4.77	0.781302	0.0000

Wald Statistic	287.14050
$\Pr\left(\chi^2 > \text{critical value}\right) =$	0.0000000

- Results show WTP is higher when protection is via extension of national park status.
- But why?

(5) Biodiversity and resilience

- Strong argument in ecology that more diverse systems can have higher (measurable) resilience
- Does this have an economic value, independent of other aspects of biodiversity?
- Walker et al (ERE, 2009): yes, although hard to measure empirically
- Distance-to-threshold measures in context of future shocks to the system.

(6) Fit within Ecosystems Service Valuation concept?

- Eg TEEB, UK National Ecosystems Assessment
- Biodiversity as one aspect of ecosystem functioning → value of changes in biodiversity gets picked up by changes in "final" ecosystem service flows, and thus no additional value of biodiversity itself
- Yet biodiversity may also be important determinant of various "cultural services" eg recreation, landscape non-use values
- Biodiversity does not fit well in this methodology?

- Questions?
- Email n.d.hanley@stir.ac.uk