UNIVERSITY OF EXETER | LAND, ENVIRONMENT, ECONOMICS AND POLICY INSTITUTE

Bringing the Natural Environment into Economic Decision-Making

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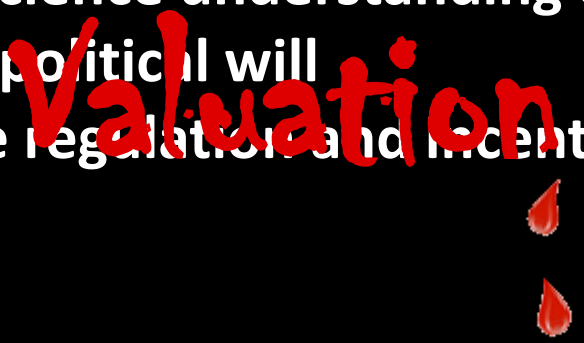
Wednesday 4th – Thursday 5th May 2016

Bringing the Natural Environment into Economic Decision-Making

- High quality data
- Excellent natural science understanding of the environment
- Popular support / political will
- Clear and effective regulations and incentives



Valuation: Two inescapable facts

1. Human wants (including those with the highest possible motivations such as improving society or even saving lives) exceed the resources available to satisfy them all;

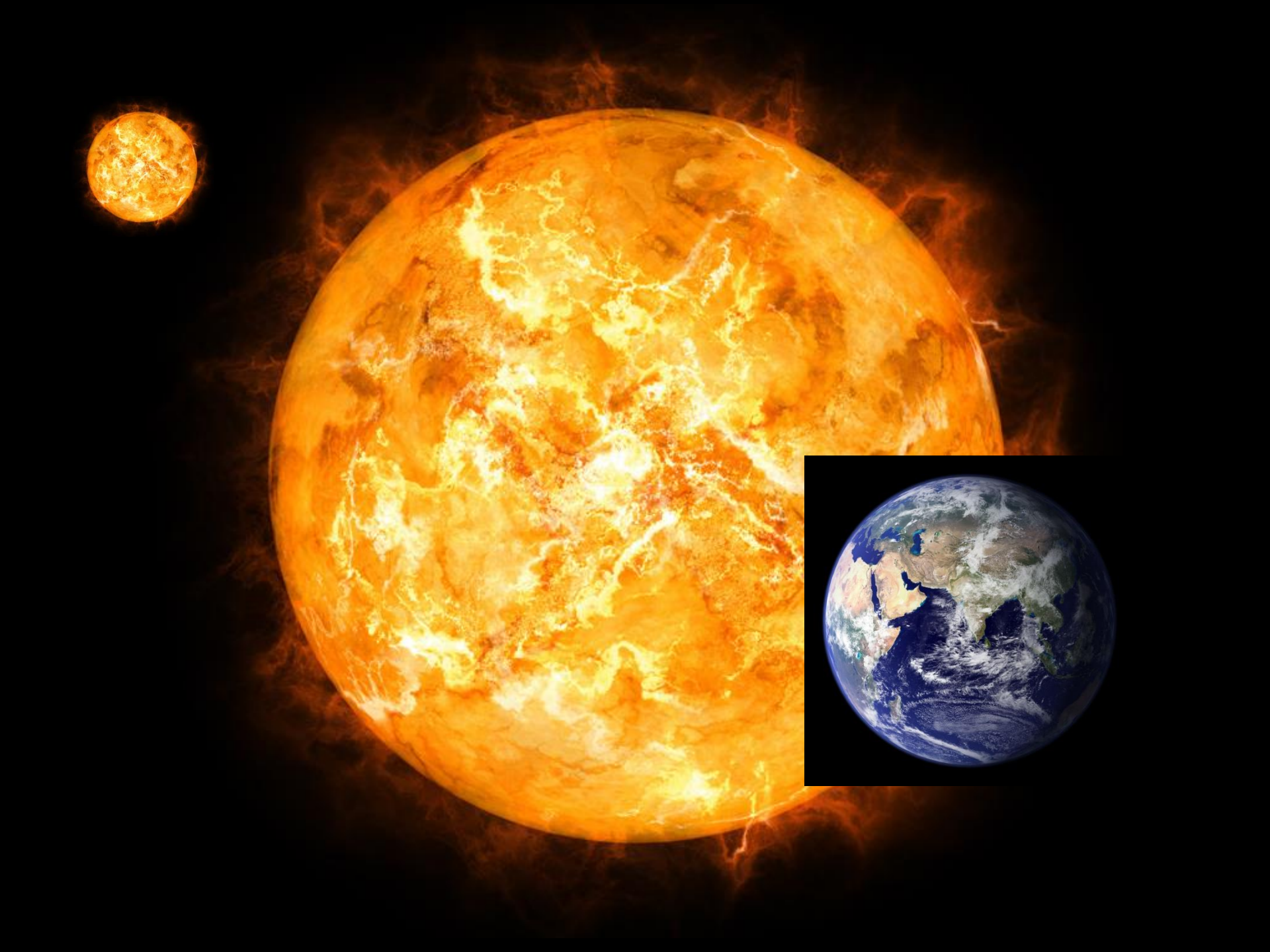
2. Because of these resource constraints, every time we decide to do one thing, we are in effect making a decision not to do another. We are implicitly placing values on each option.

Valuation is unavoidable; it is the essence of decision making.

To pretend otherwise is irresponsible

Be explicit about the valuations inherent in all decision making.

Recognise that all decisions imply trade-offs…..
…..especially those involving the natural environment




Steve Gould Photography

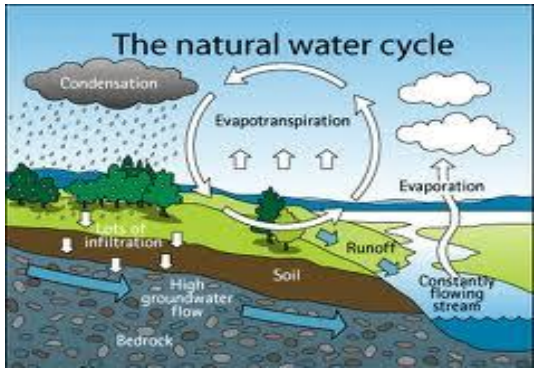

Steve Gould Photography

The environment, people and decision making

Solar & other physical inputs

Environmental processes

e.g. the water cycle, nutrient cycling, etc.



The environment, people and decision making

Natural capital

Solar & other physical inputs

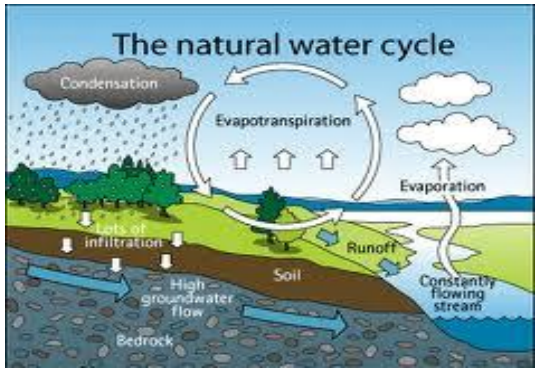
Solar & other physical inputs

Environmental processes

Ecosystem services

e.g. the water cycle, nutrient cycling, etc.

e.g. trees, clean water, etc.



The environment, people and decision making

Solar & other physical inputs

Natural capital inputs

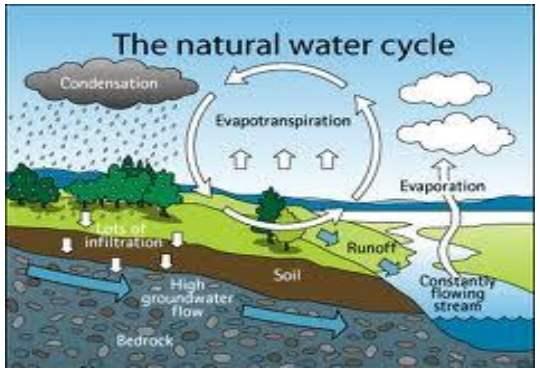
Other capital inputs

Environmental processes → **Ecosystem services** → **Goods**

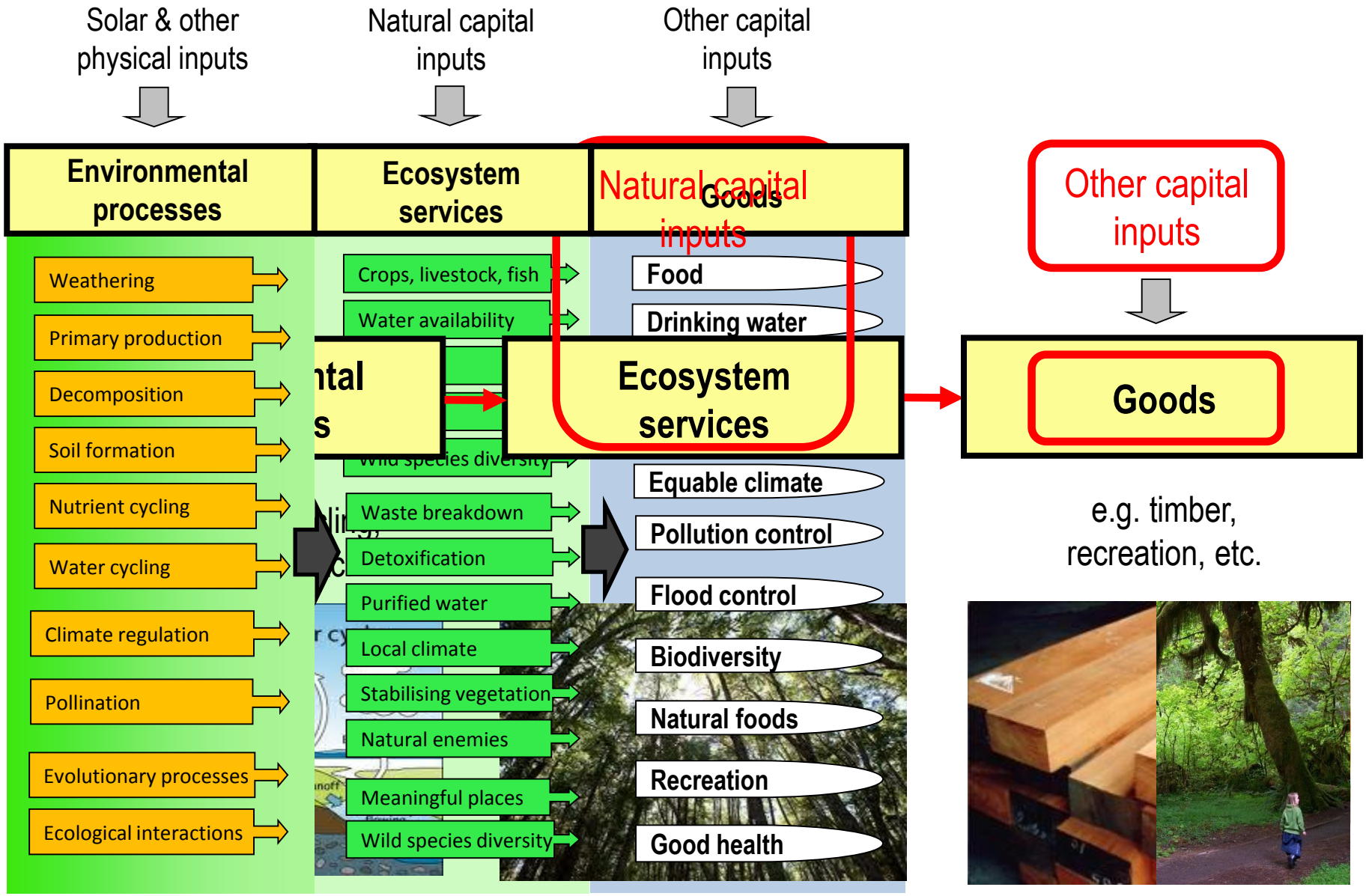
e.g. the water cycle, nutrient cycling, etc.

e.g. trees, clean water, etc.

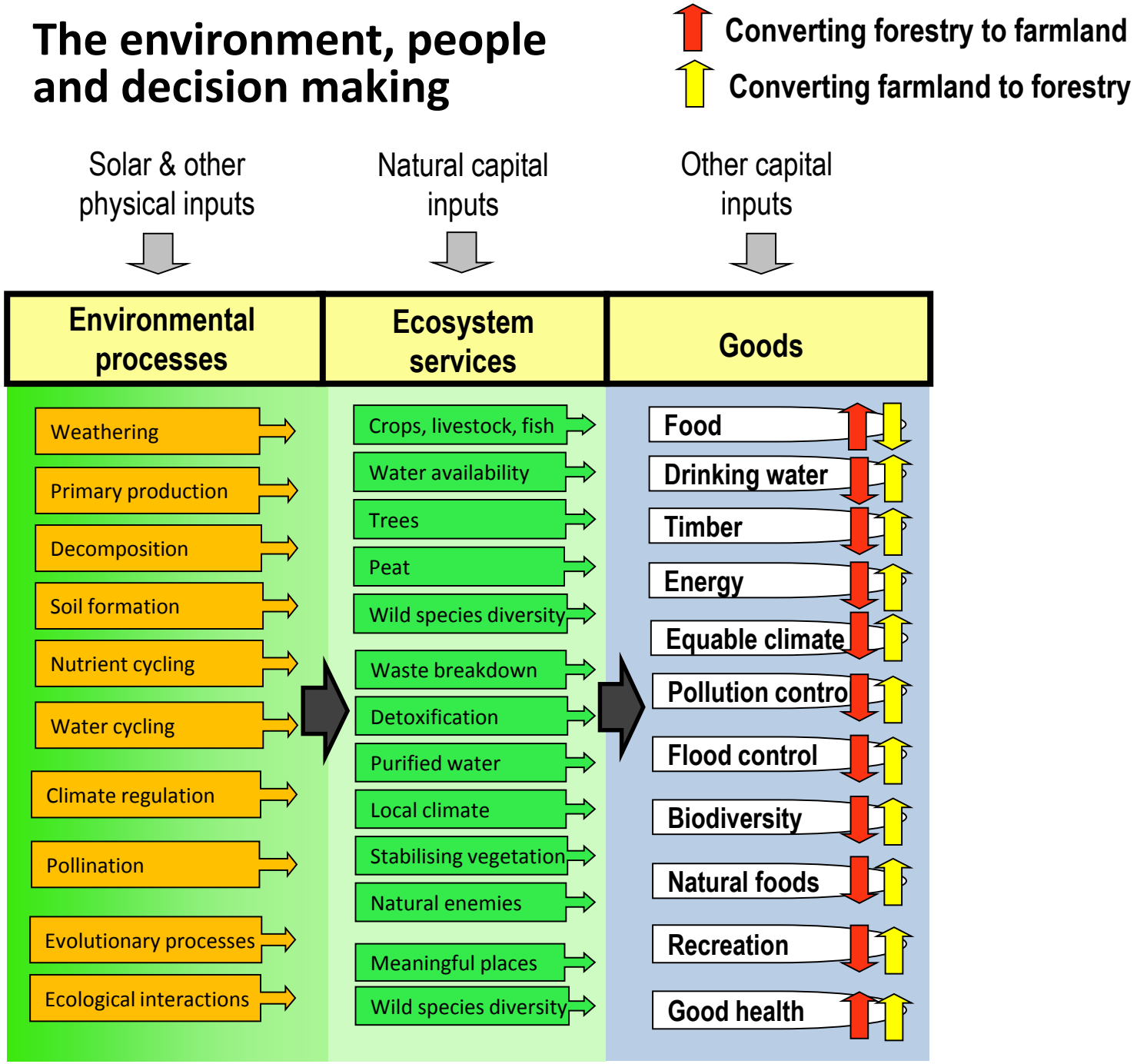
e.g. timber, recreation, etc.



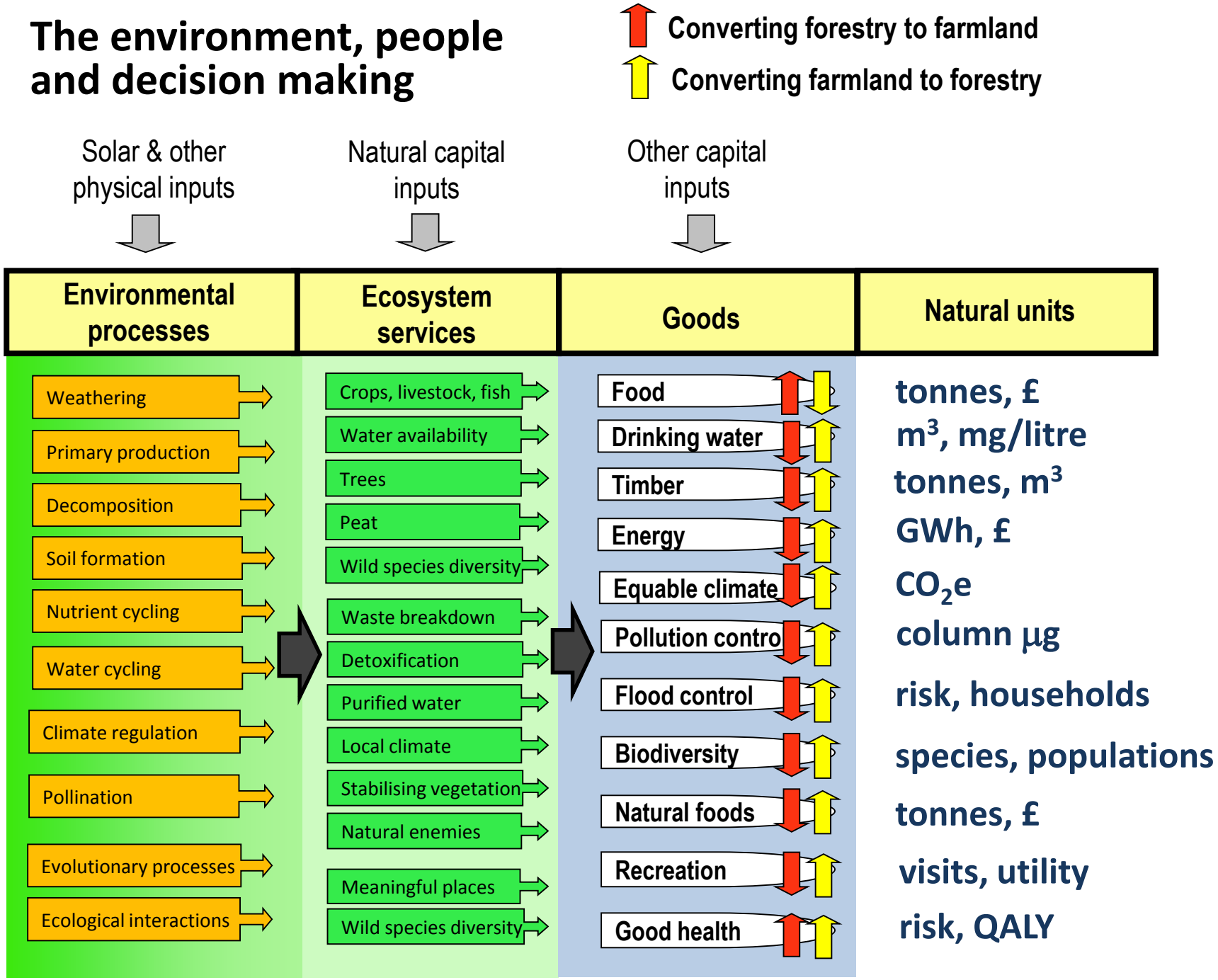
The environment, people and decision making



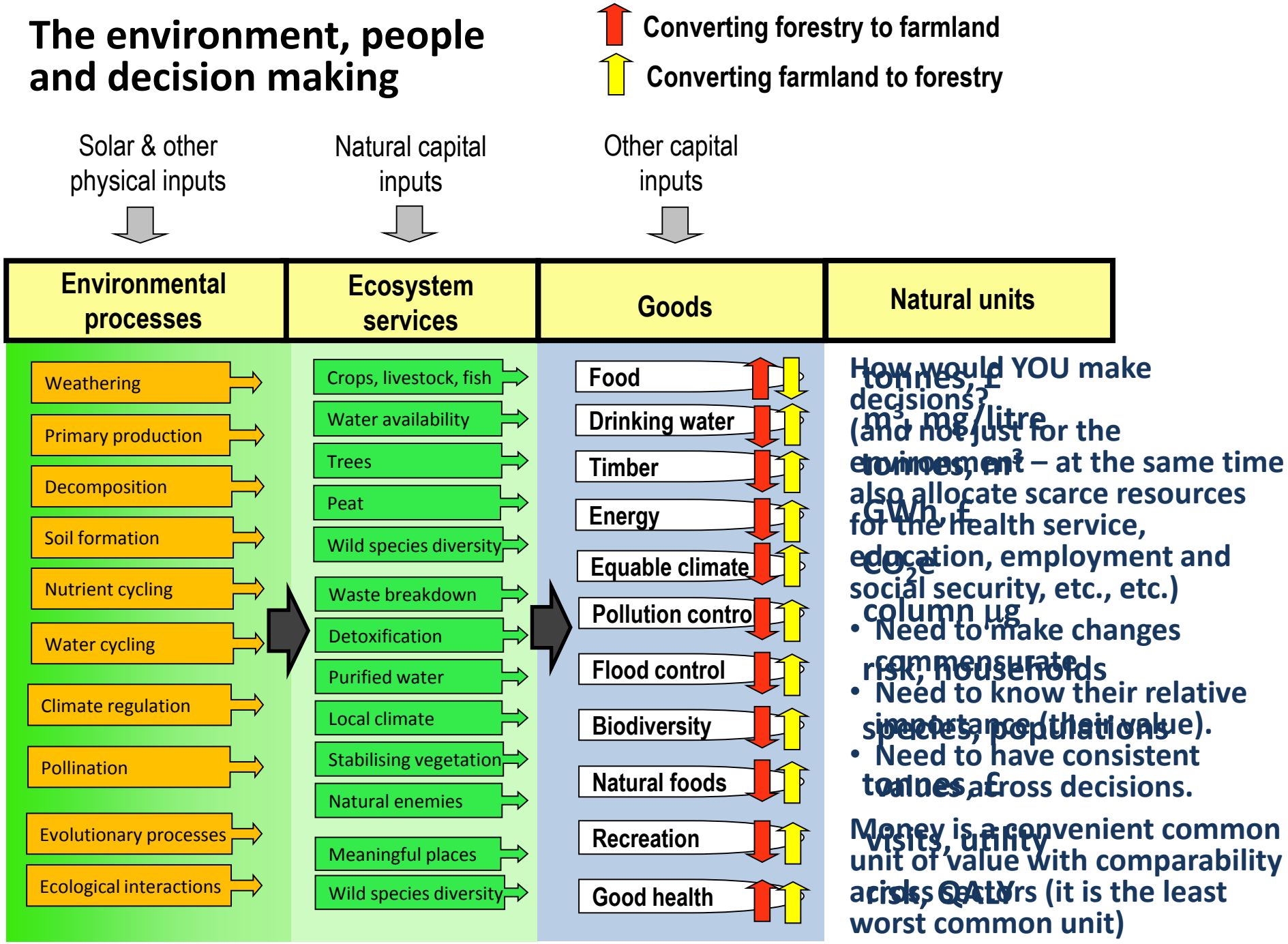
The environment, people and decision making



The environment, people and decision making



The environment, people and decision making



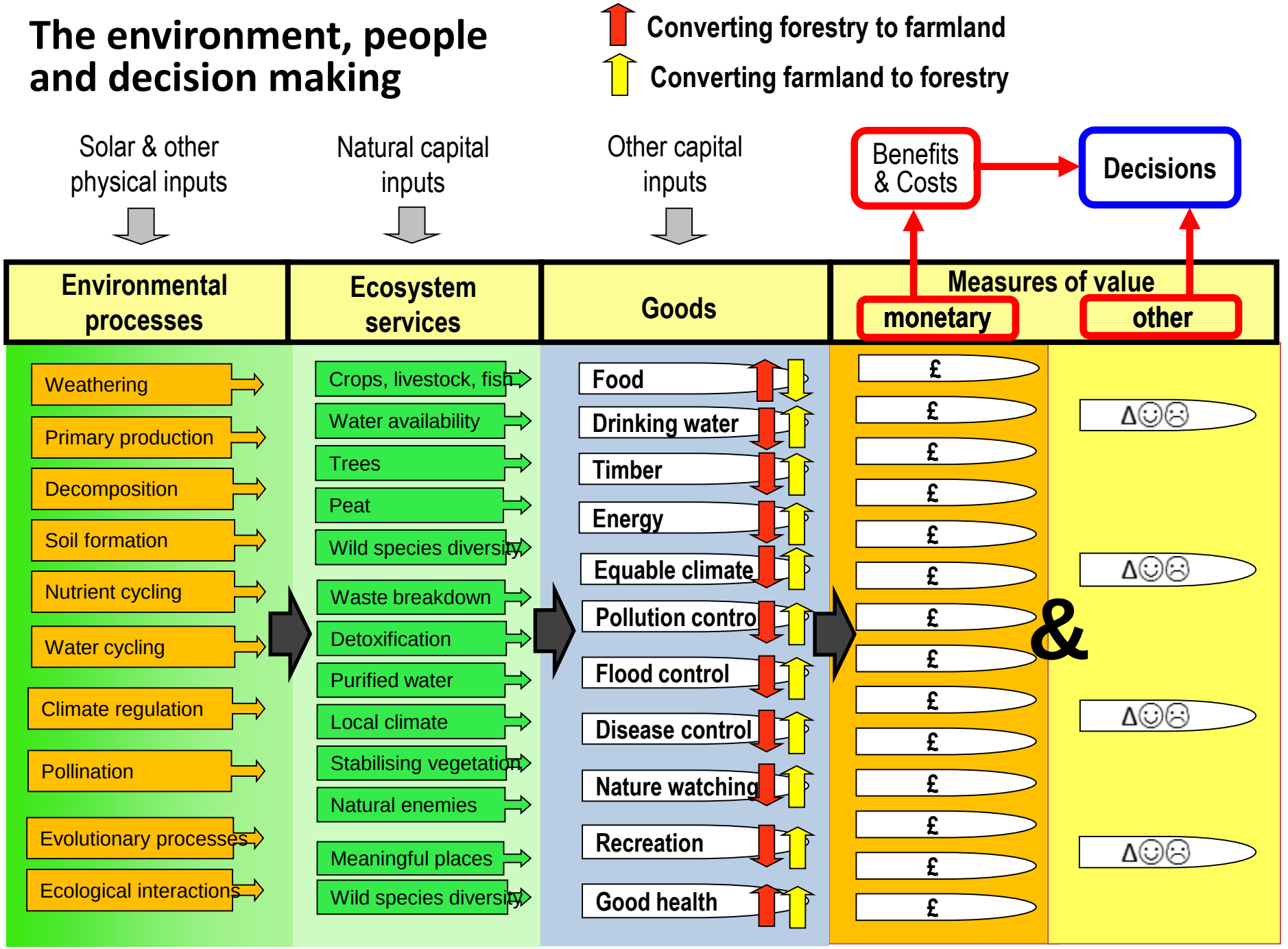
How would YOU make decisions?

(and not just for the environment – at the same time also allocate scarce resources for the health service, education, employment and social security, etc., etc.)

- Need to make changes commensurate.
- Need to know their relative importance (their value).
- Need to have consistent values across decisions.

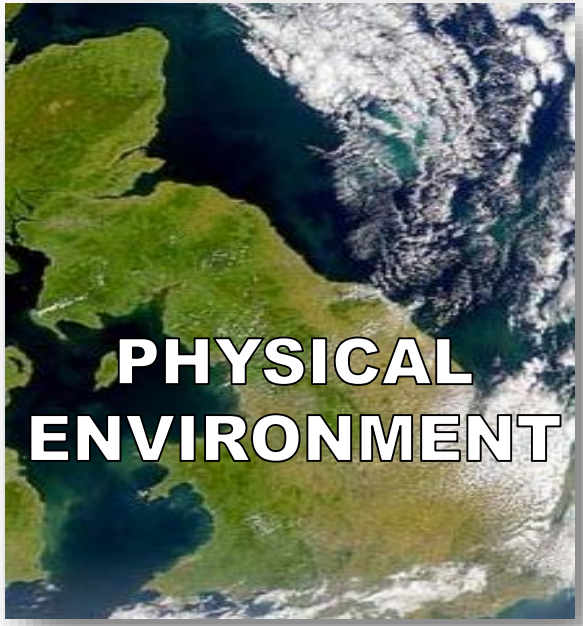
Money is a convenient common unit of value with comparability across sectors (it is the least worst common unit)

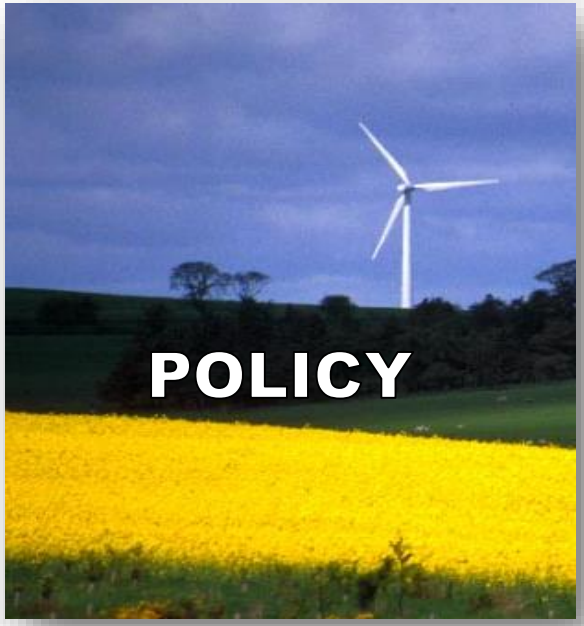
The environment, people and decision making



Decision support: Rather than inventing future worlds - understand the drivers of change

e.g. Understanding changes in agricultural land use





Soils	Output prices	Common Agricultural Policy
Temperature	Input costs	Environmental Policy
Rainfall	Technology	Intervention

Spatially referenced data for all of GB; High resolution; 55,000 cells; Approx. 50 records per cell p.a.; data from 1972 to 2010; Nearly 40 million observations

Validate analyses – but not like this!

Constrained optimization problem:

$$\pi^L(\mathbf{p},\mathbf{w},\mathbf{z},L) = \max_{s_1,\ldots,s_h}\{\pi(\mathbf{p},\mathbf{w},\mathbf{z},L,s_1,\ldots,s_h) : \sum_{i=1}^{h} s_h = 1\}$$

Farmers determine land use subject to a variety of contraints

Estimation profit function:

$$\bar{\pi}^L = \alpha_0 + \sum_{i=1}^{m+n-1}\alpha_i x_i + \frac{1}{2}\sum_{i=1}^{m+n-1}\sum_{j=1}^{m+n-1}\alpha_{ij}x_i x_j + \sum_{i=1}^{h-1}\beta_i s_i + \frac{1}{2}\sum_{i=1}^{h-1}\sum_{j=1}^{h-1}\beta_{ij}s_i s_j + \sum_{i=1}^{k+1}\gamma_i z_i^* +$$
$$+\frac{1}{2}\sum_{i=1}^{k+1}\sum_{j=1}^{k+1}\gamma_{ij}z_i^* z_j^* + \sum_{i=1}^{m+n-1}\sum_{j=1}^{h-1}\delta_{ij}x_i s_j + \sum_{i=1}^{m+n-1}\sum_{j=1}^{k+1}\phi_{ij}x_i z_j^* + \sum_{i=1}^{h-1}\sum_{j=1}^{k+1}\varphi_{ij}s_i z_j^*$$

e.g.: physical environment of farms, prices; costs; policy; etc.

Example derived yield function:

$$\frac{\partial\bar{\pi}^L}{\partial x_i} = y_i^L = \alpha_i + \sum_{j=1}^{m+n-1}\alpha_{ij}x_j + \sum_{j=1}^{h-1}\delta_{ij}s_j + \sum_{j=1}^{k+1}\phi_{ij}z_j^*$$

These dictate potential yields

Optimal land allocation:

$$s_i = \theta_i + \sum_{j=1}^{m+n-1}\theta_{ji}x_j + \sum_{j=1}^{k+1}\eta_{ji}z_j^*$$

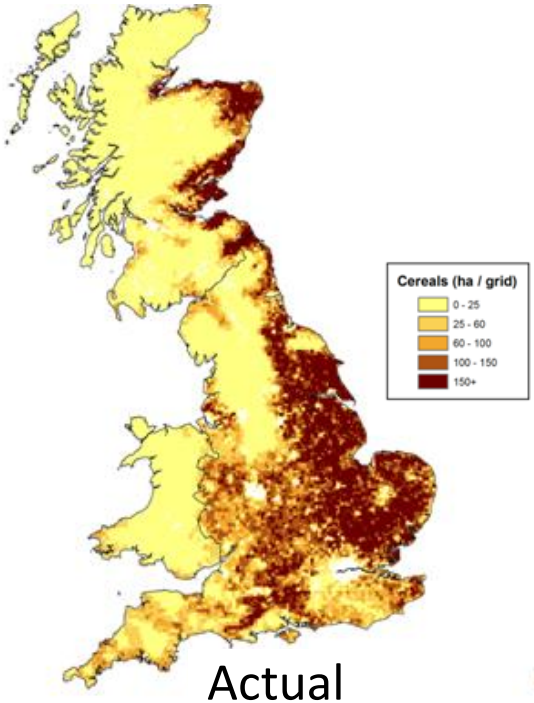
for *i* = 1,..,*h-1*

The model estimates land use – which can be compared against actual observations to test model validity

Like this!

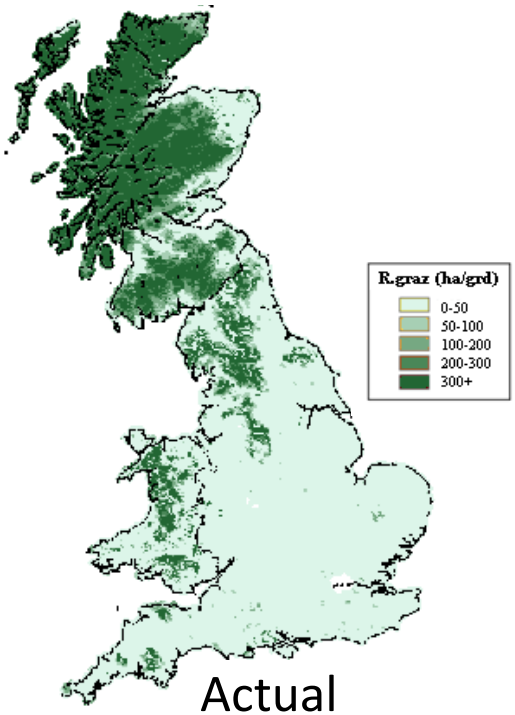
Out-of-sample, actual versus predicted validation tests

Cereals



Actual

Grasslands

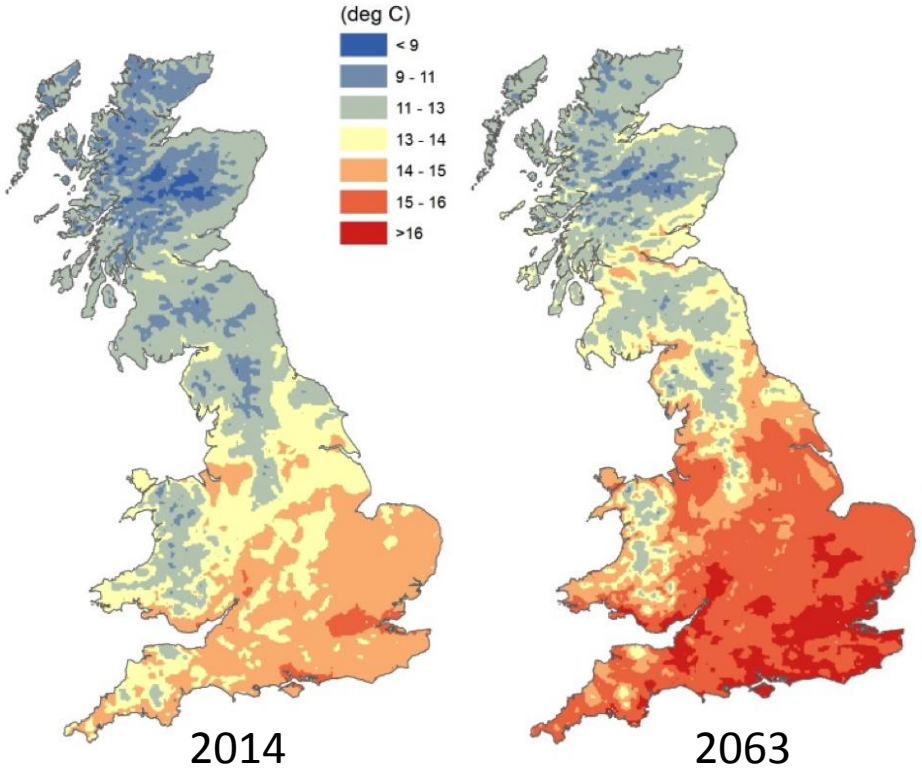


Actual

Show how drivers lead to change

e.g. Climate change

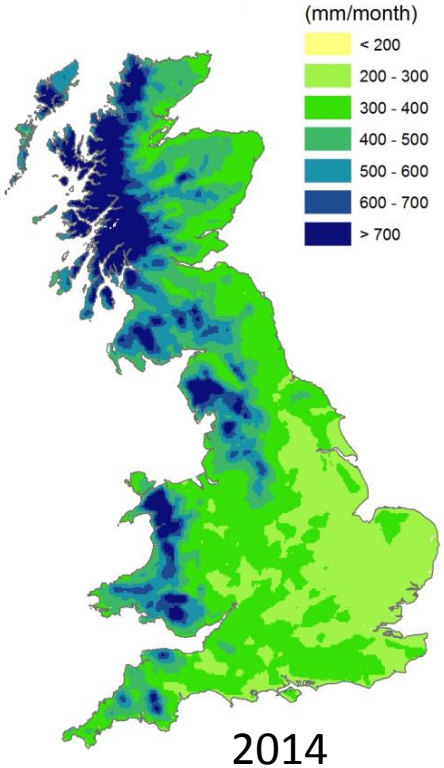
Temperature



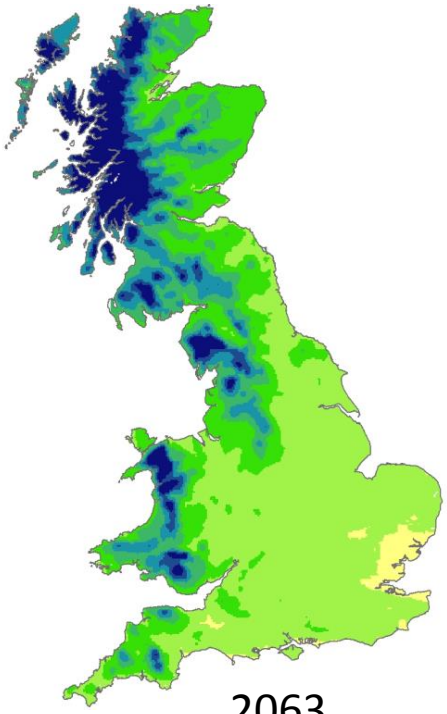
2014

2063

Rainfall



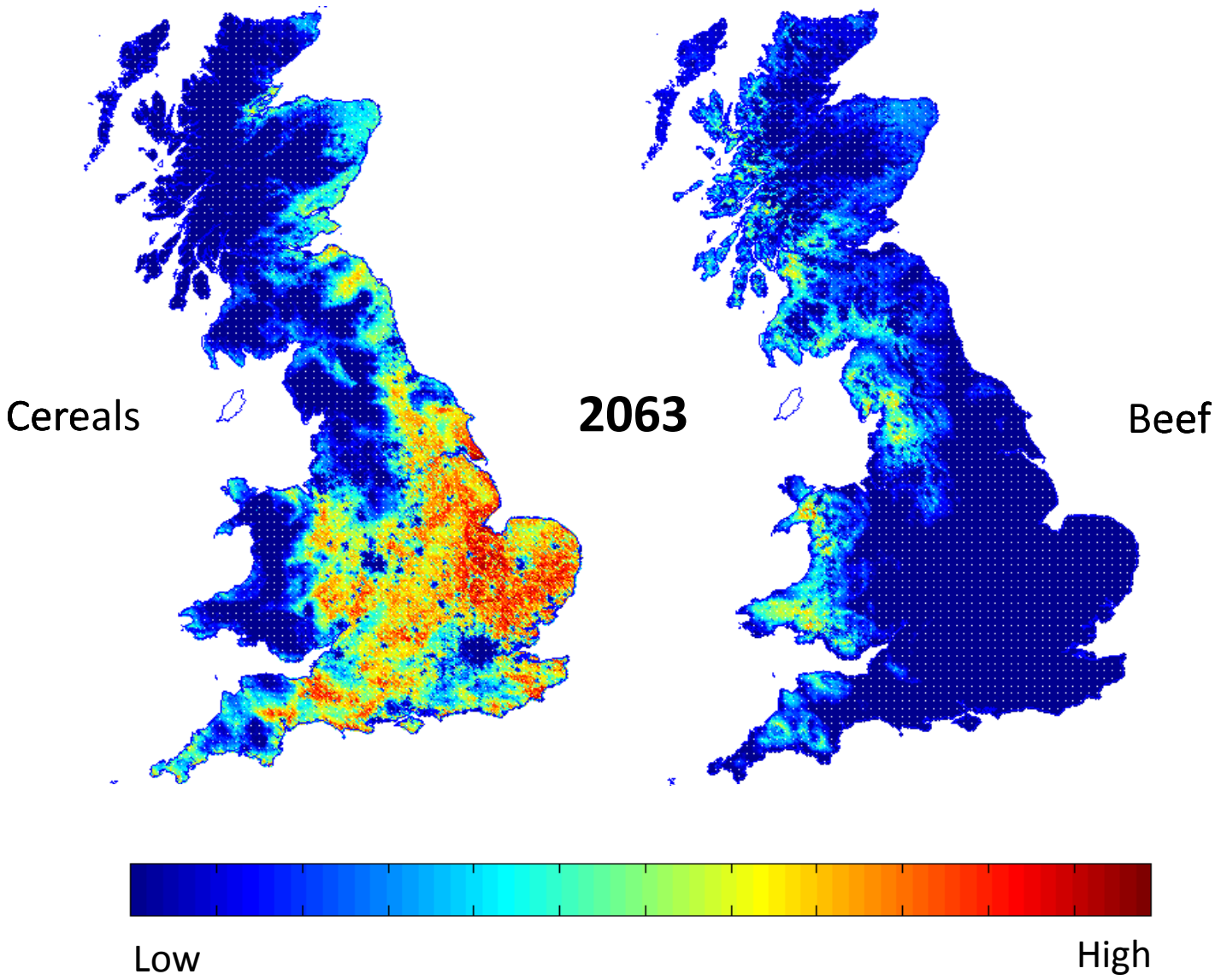
2014



2063

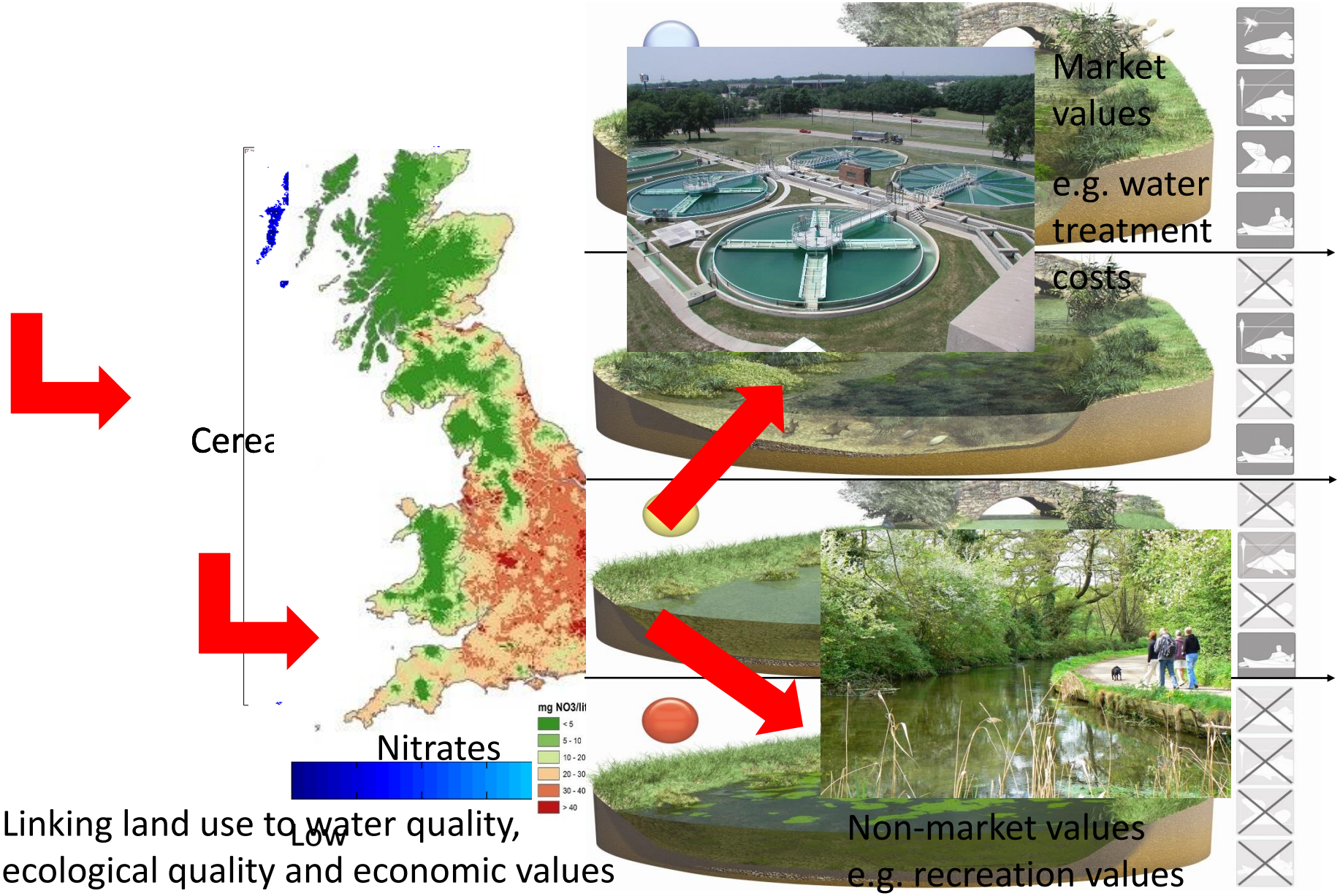
Show the consequences of change

e.g. Changing climate → Changing land use



Show the consequences of change

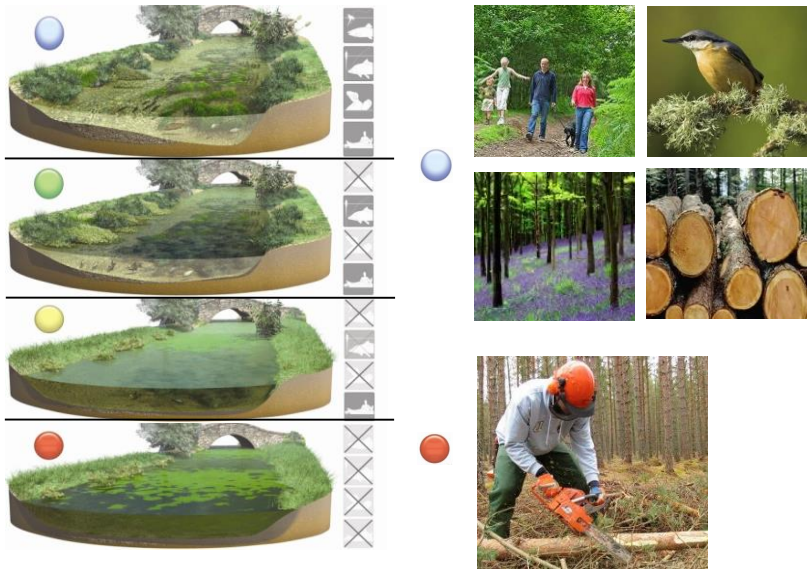
e.g. Climate → Land use → Water quality → Ecology → Values

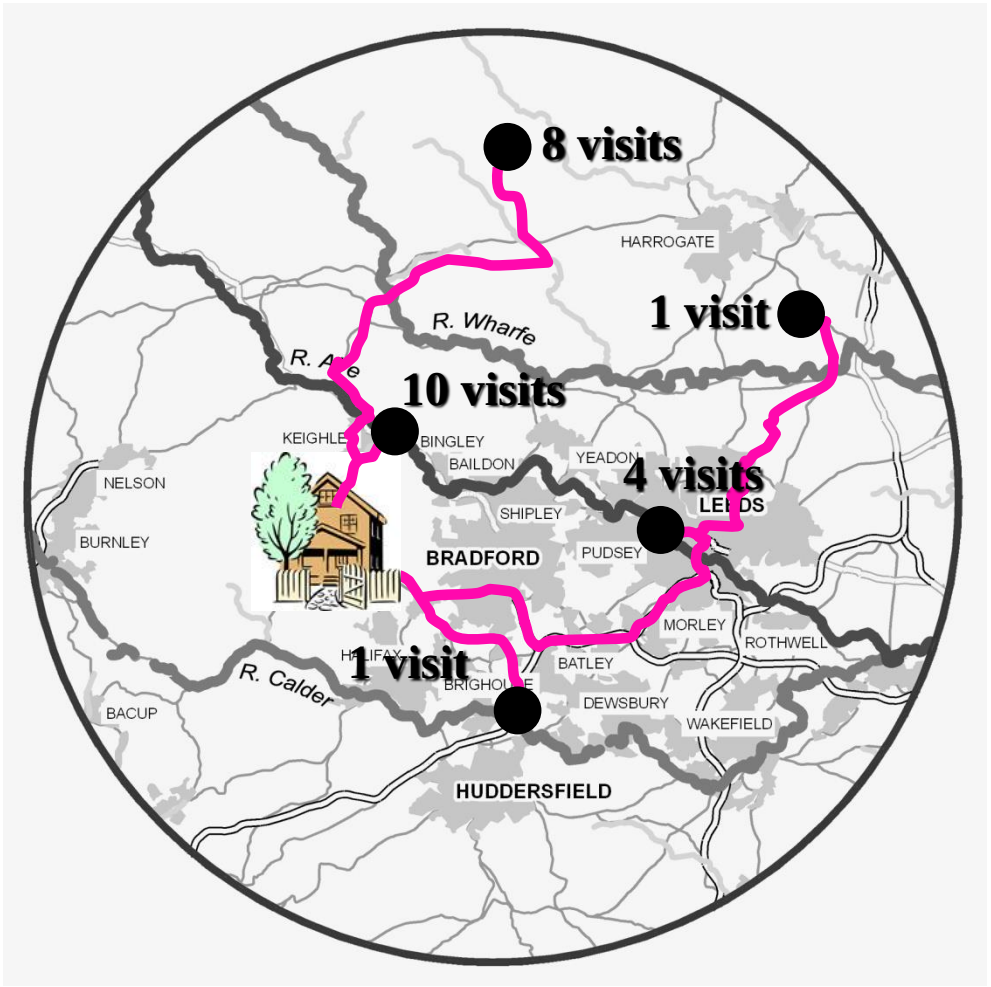


Linking land use to water quality, ecological quality and economic values

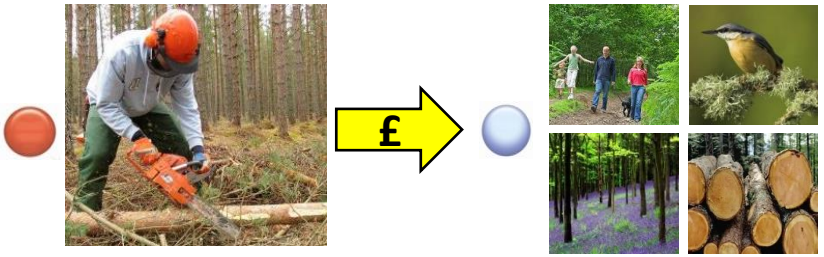
Explain the derivation of economic values

- Household survey data (e.g. MENE):
  - Home location
  - Location of visited sites
  - Visit frequency
  - Calculate visit travel time & costs
  - Data on site quality





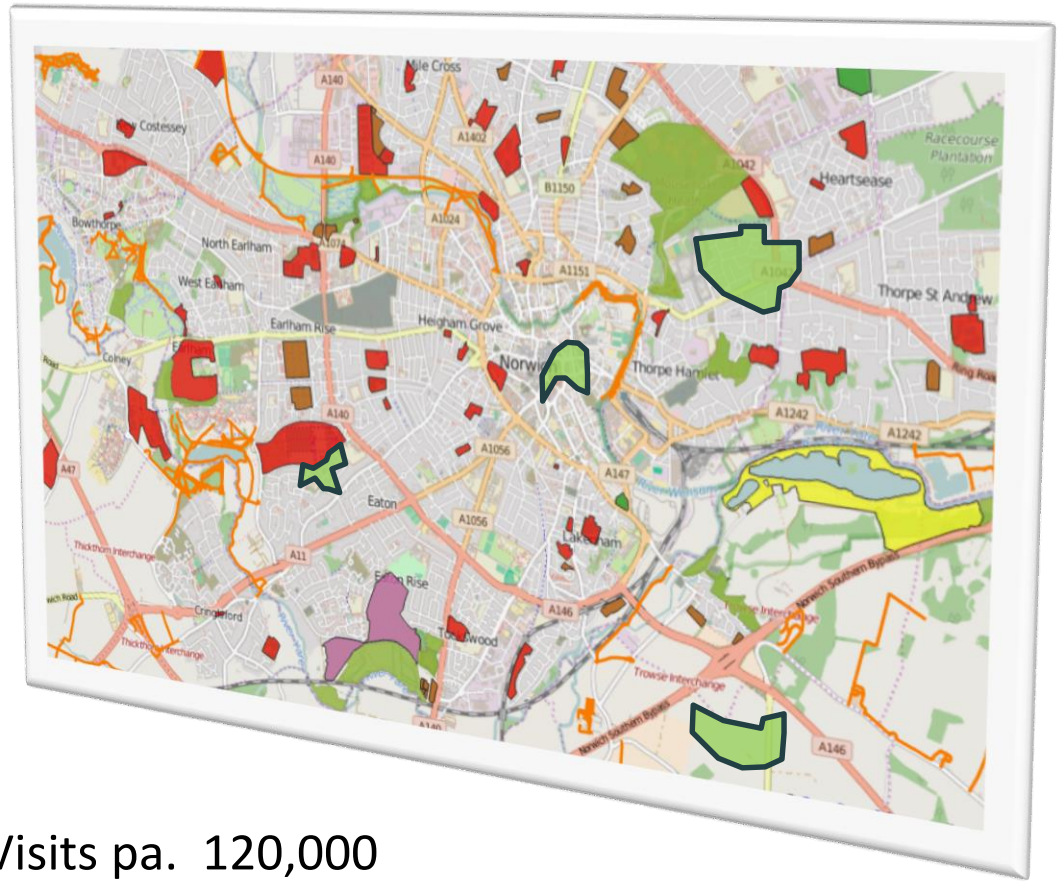
- Analysis



From research to decisions: Decision support tools

Co-design tools with decision makers
e.g. 1: Recreation planning

ORVal:
Outdoor
Recreation
Valuation Tool

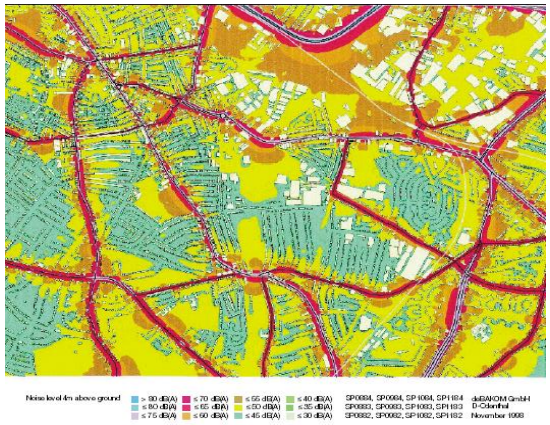


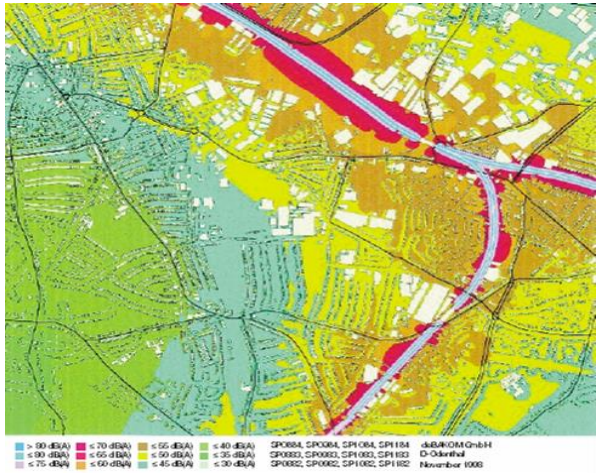
Department
for Environment
Food & Rural Affairs

Visits pa. 120,000

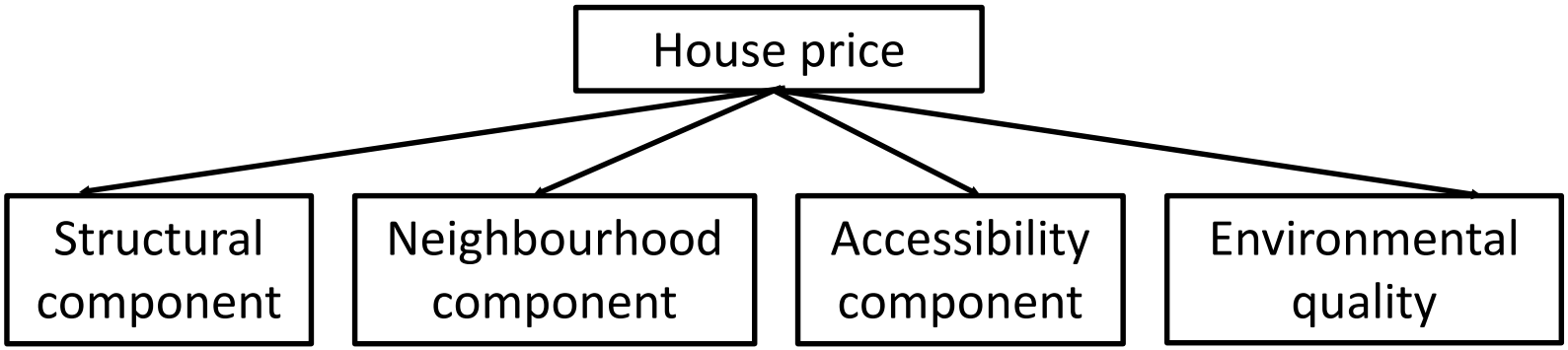
Value: £450,000

Co-design tools with decision makers
e.g. 2: Valuing transport noise



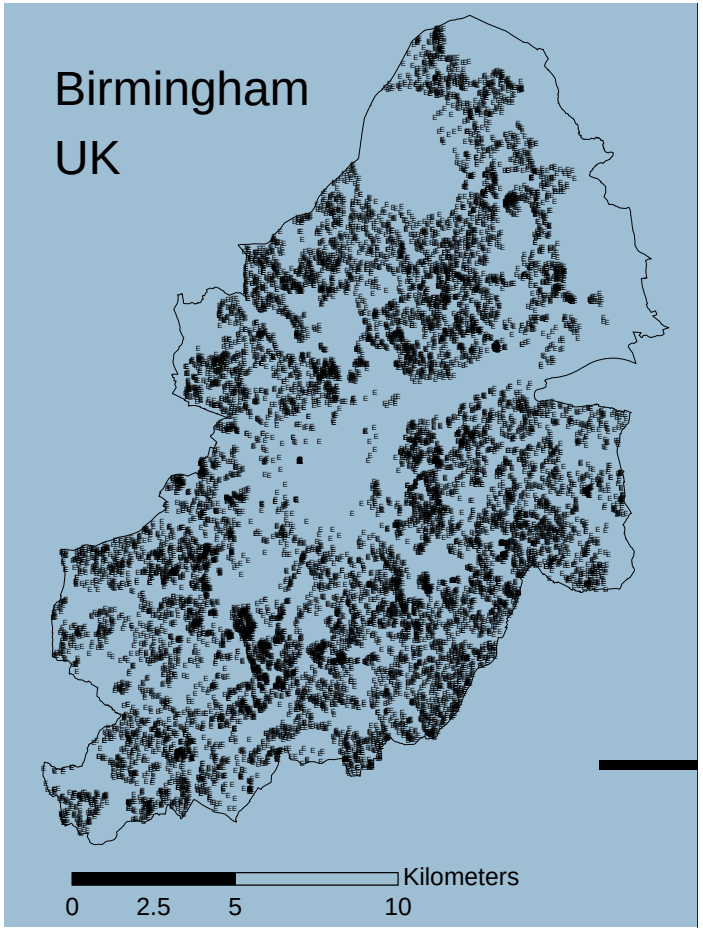


Valuing transport noise



Valuing transport noise: Data

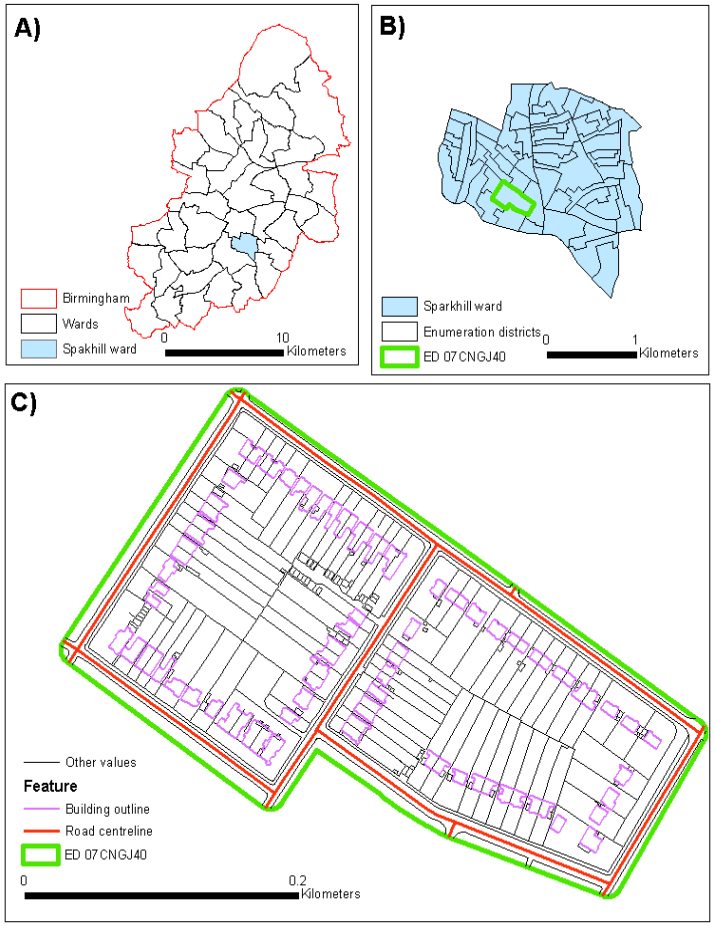
- Hedonic property price study for the DfT, feeding directly into their cost-benefit rules for road decision making
- Case study of UK's second largest city
- 10,848 residential property sales



Valuing transport noise: Data

Structural Attributes:

floor area, garden area, bedrooms, WCs, storeys, garage, central heating, age, property type, Beacon group



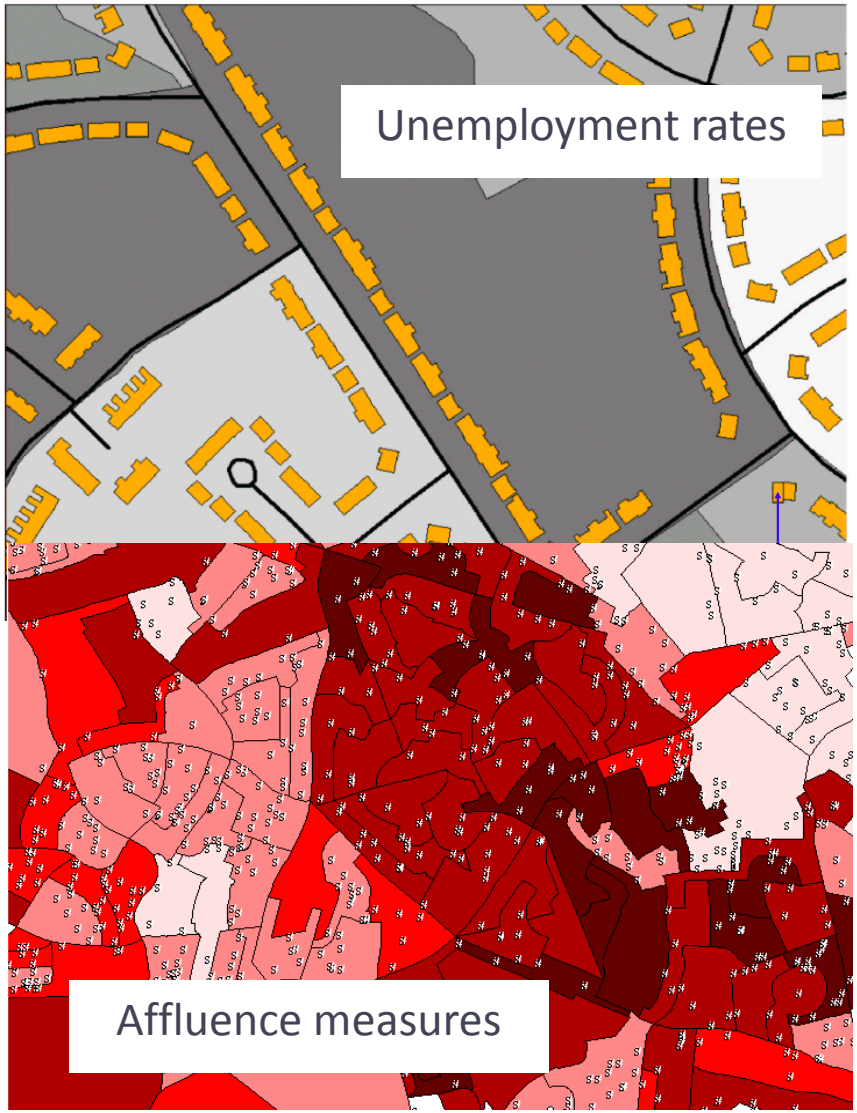
Valuing transport noise: Data

Structural Attributes:

floor area, garden area, bedrooms, WCs, storeys, garage, central heating, age, property type, Beacon group

Neighbourhood Attributes:

Wealth, ethnicity, adult age composition, family composition



Valuing transport noise: Data

Structural Attributes:

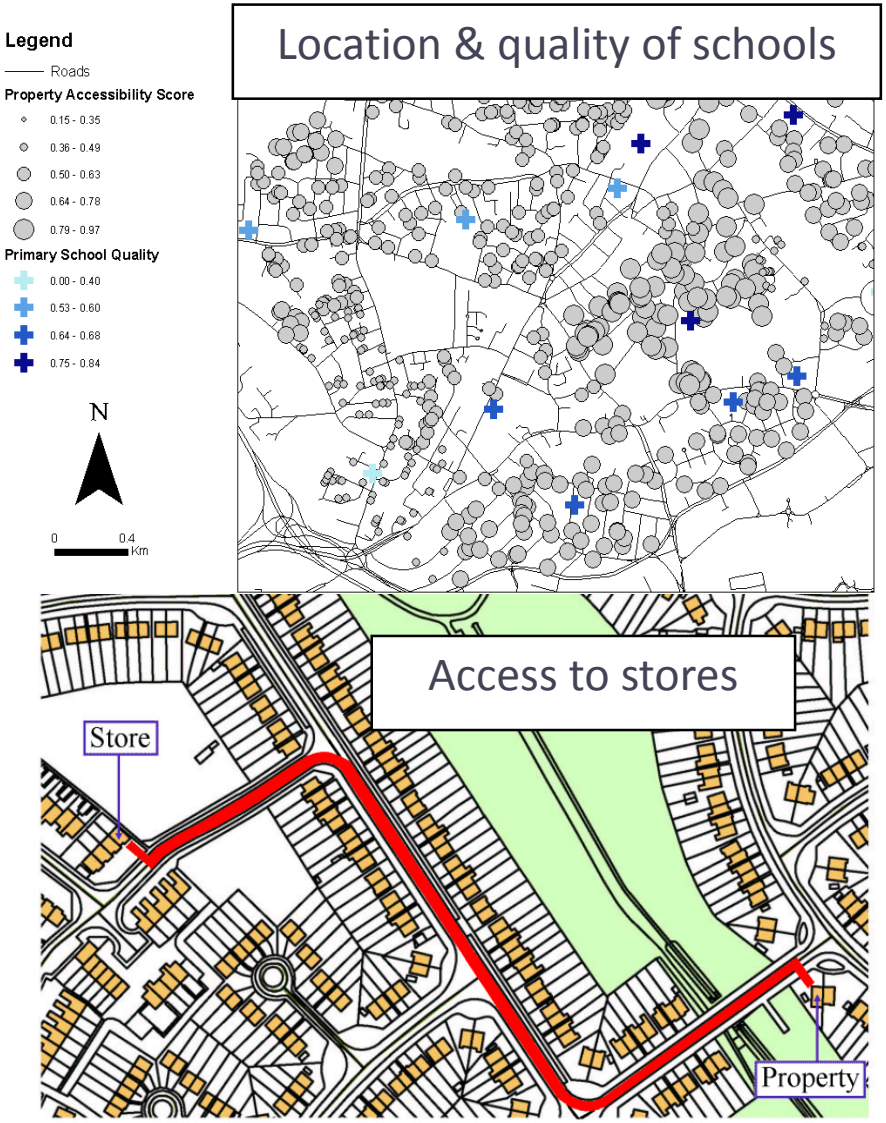
floor area, garden area, bedrooms, WCs, storeys, garage, central heating, age, property type, Beacon group

Neighbourhood Attributes:

Wealth, ethnicity, adult age composition, family composition

Locational Attributes:

CBD, local commercial centres, railway stations, recreational parks, industrial areas (various types), land fill sites, primary schools, wards



Valuing transport noise: Data

Structural Attributes:

floor area, garden area, bedrooms, WCs, storeys, garage, central heating, age, property type, Beacon group

Neighbourhood Attributes:

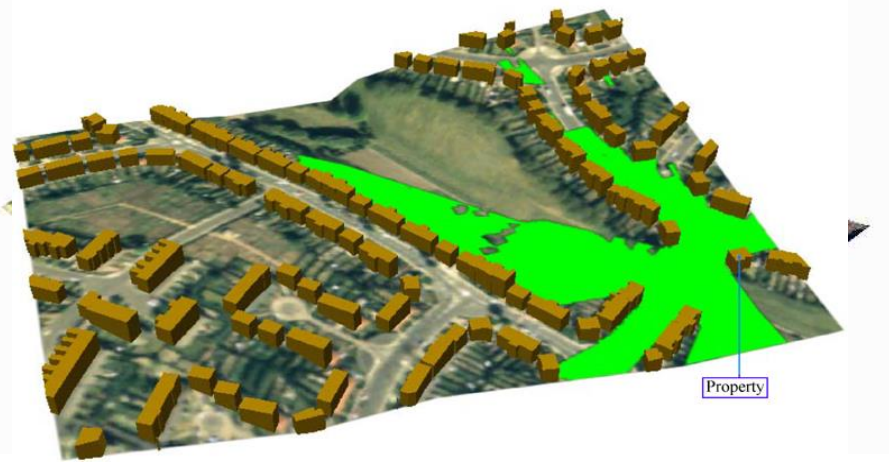
Wealth, ethnicity, adult age composition, family composition

Locational Attributes:

CBD, local commercial centres, railway stations, recreational parks, industrial areas (various types), land fill sites, primary schools, wards

Environmental Attributes:

views of parks, views of water, road noise, rail noise, aircraft noise



Valuing transport noise: Data

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Wealth, ethnicity, adult age composition, family composition

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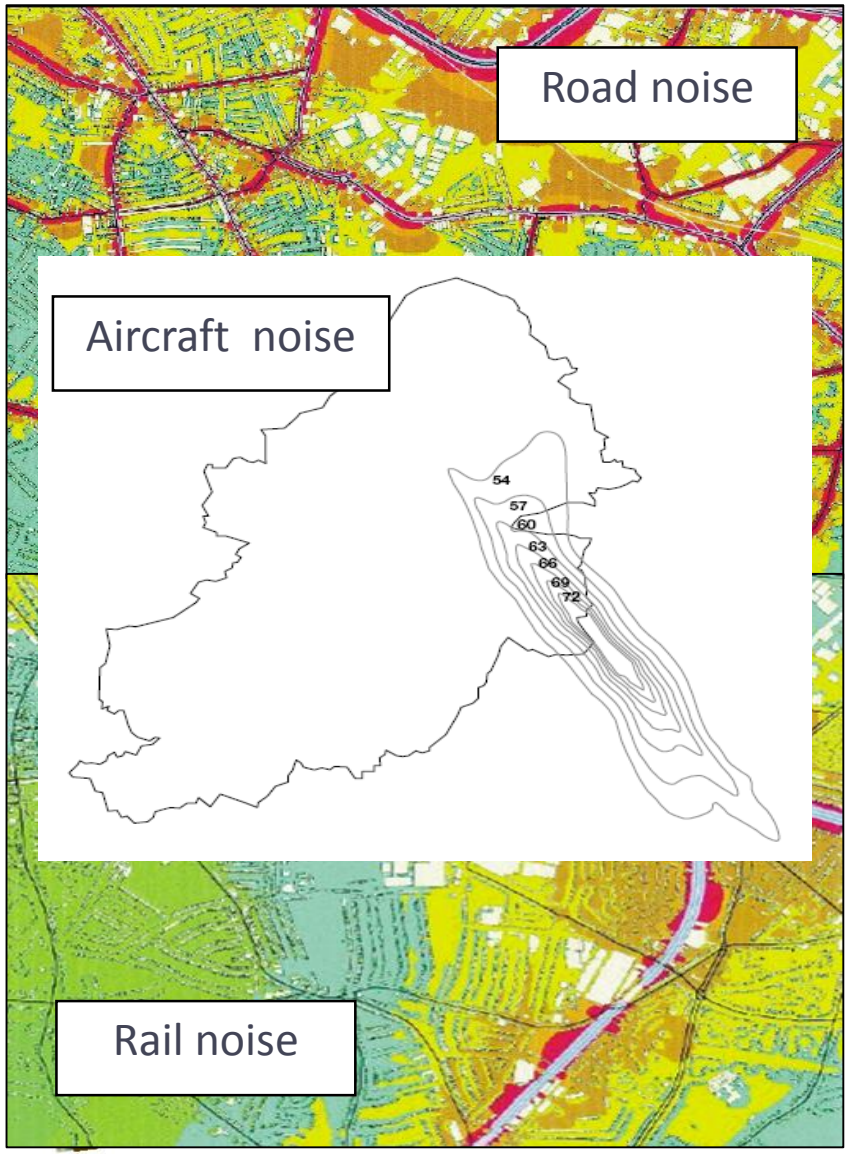


Valuing transport noise: Analysis

A selection of property price determinants

Variable	Submarket							
	1	2	3	4	5	6	7	8
Bedrooms	0.026*	-0.002	0.032**	0.036***	0.024**	0.005	-0.024	0.002
Garage	0.033	0.020	0.036*	0.034***	0.047***	0.069***	0.033***	0.135**
House Floors	-0.147***	-0.083**	-0.129*	-0.093***	-0.133***	-0.159***	-0.068**	-0.097
Detached House	0.119*	0.163***	0.112***	0.103***	0.110***	0.062**	0.178***	0.073
Primary School	0.0087	0.120***	0.161***	0.203***	0.042*	0.146***	0.105***	0.148
Wealth	0.170***	0.142***	0.225***	0.142***	0.195***	0.160***	0.145***	0.207***
Road Noise	-.0043*	-.0158***	-.0035*	-.0034**	-.0067***	-.0050**	-.0042**	-.0115**
n	1,395	1,091	1,268	1,861	1,536	1,338	2,097	303

Dependent variable = Natural Log of Property Price.

* = sig. @ 10% level; ** = sig. @ 5% level; *** = sig. @ 1% level

Valuing transport noise: Analysis

First stage analysis of implicit prices: Not all noise is equal

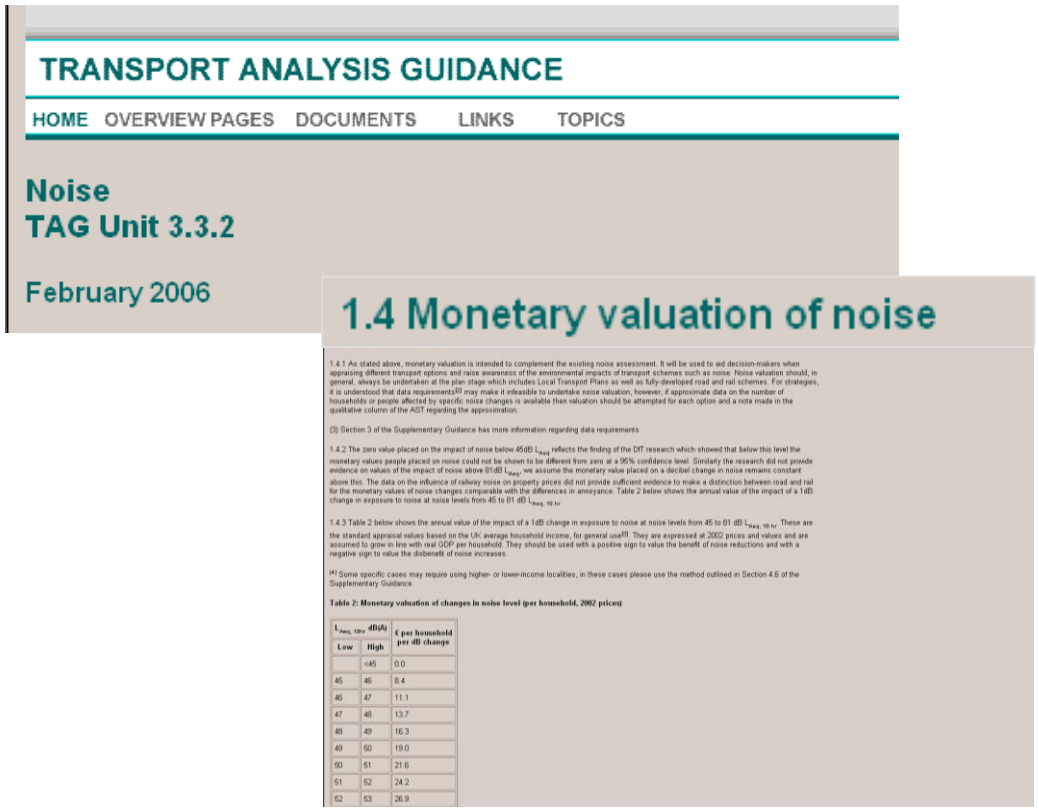
% change in house prices per dB_{LEQ}	Road noise	Rail noise	Airplane noise
	-.28%	-.84%	-.98%

Second stage analysis: Welfare changes (values) in £/year

Noise Change (dB)	Road noise	Rail noise	Airplane noise
80 to 79	87.91	135.29	147.97
79 to 78	85.52	133.05	145.73
.	.	.	.
57 to 56	33.03	83.73	96.41
56 to 55	30.64	81.49	94.20

Welfare changes calculated at median house price expenditure (1997 values)

Valuing transport noise: Decision support tool



TRANSPORT ANALYSIS GUIDANCE

HOME OVERVIEW PAGES DOCUMENTS LINKS TOPICS

Noise
TAG Unit 3.3.2

February 2006

1.4 Monetary valuation of noise

1.4.1 As stated above, monetary valuation is intended to complement the existing noise assessment. It will be used to aid decision-makers when appraising different transport options and raise awareness of the environmental impacts of transport schemes such as noise. Noise valuation should, in general, always be undertaken at the plan stage which includes Local Transport Plans as well as fully-developed road and rail schemes. For strategies, it is understood that data requirements[3] may make it infeasible to undertake noise valuation, however, if approximate data on the number of households or people affected by specific noise changes is available then valuation should be attempted for each option and a note made in the qualitative column of the AST regarding the approximation.

(3) Section 3 of the Supplementary Guidance has more information regarding data requirements.

1.4.2 The zero value placed on the impact of noise below 45dB L_{Aeq} reflects the finding of the DfT research which showed that below this level the monetary values people placed on noise could not be shown to be different from zero at a 95% confidence level. Similarly the research did not provide evidence on values of the impact of noise above 81dB L_{Aeq}, we assume the monetary value placed on a decibel change in noise remains constant above this. The data on the influence of railway noise on property prices did not provide sufficient evidence to make a distinction between road and rail for the monetary values of noise changes comparable with the differences in annoyance. Table 2 below shows the annual value of the impact of a 1dB change in exposure to noise at noise levels from 45 to 81 dB $L_{Aeq, 18 hr}$

1.4.3 Table 2 below shows the annual value of the impact of a 1dB change in exposure to noise at noise levels from 45 to 81 dB $L_{Aeq, 18 hr}$. These are the standard appraisal values based on the UK average household income, for general use[4]. They are expressed at 2002 prices and values and are assumed to grow in line with real GDP per household. They should be used with a positive sign to value the benefit of noise reductions and with a negative sign to value the disbenefit of noise increases.

[4] Some specific cases may require using higher- or lower-income localities, in these cases please use the method outlined in Section 4.6 of the Supplementary Guidance.

Table 2: Monetary valuation of changes in noise level (per household, 2002 prices)

$L_{Aeq, 18hr}$ dB(A)		£ per household per dB change
Low	High	
	<45	0.0
45	46	8.4
46	47	11.1
47	48	13.7
48	49	16.3
49	50	19.0
50	51	21.6
51	52	24.2
52	53	26.9

Department for Transport

Table 2: Monetary valuation of changes

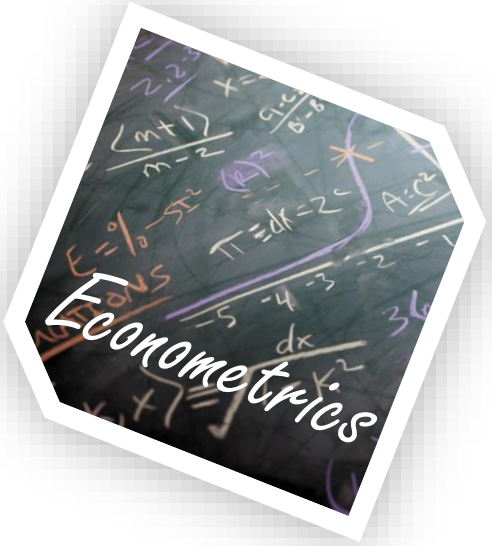
$L_{Aeq, 18hr}$ dB(A)		£ per household per dB change
Low	High	
	<45	0.0
45	46	8.4
46	47	11.1
47	48	13.7
48	49	16.3
49	50	19.0
50	51	21.6
51	52	24.2
52	53	26.9

However complex the analysis needs to be, the tool should be as simple as possible

Co-design tools with decision makers
e.g. 3: Green Taxes

Department for Transport

HM Treasury



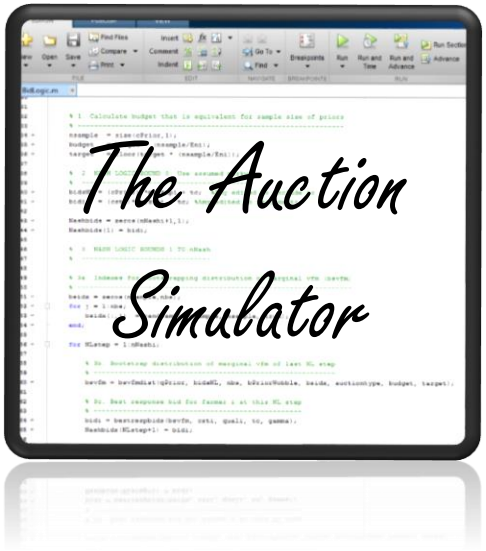
Co-design tools with decision makers
e.g. 3: Green Taxes

Department for Transport

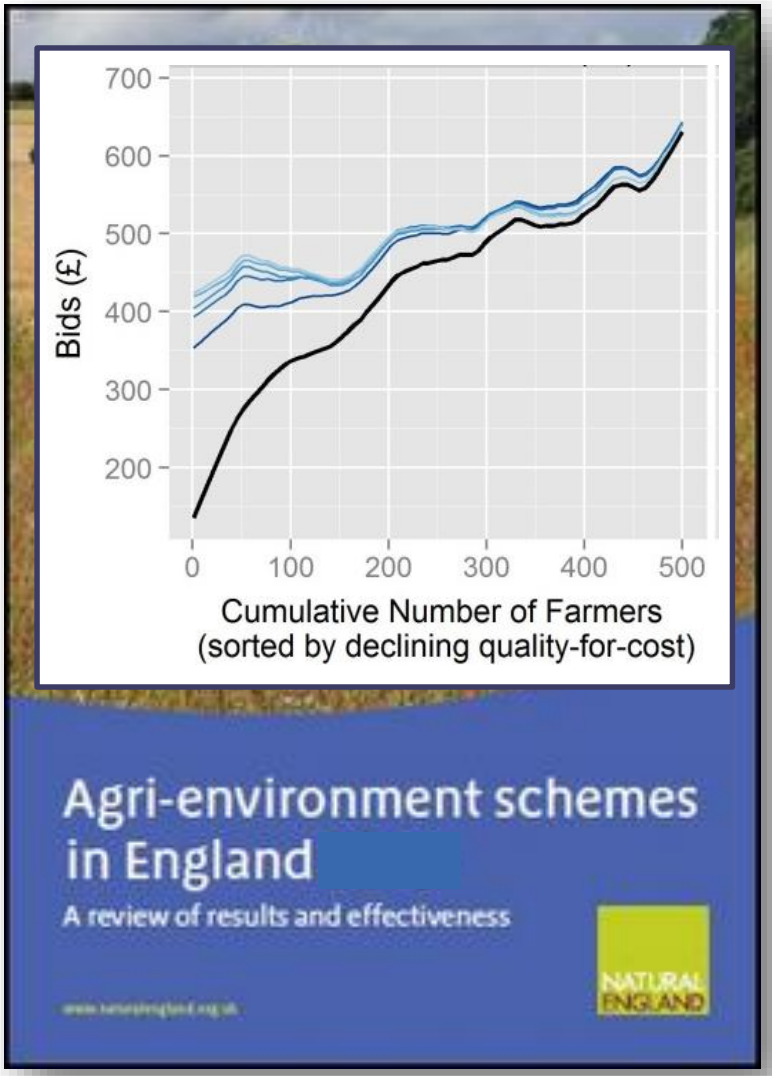
HM Treasury

Co-design tools for policy implementation: Incentive Mechanisms for Natural Capital Management

For Government…



Department
for Environment
Food & Rural Affairs



For Business…

SOUTH WEST WATER

UPSTREAM THINKING
A South West Water Initiative

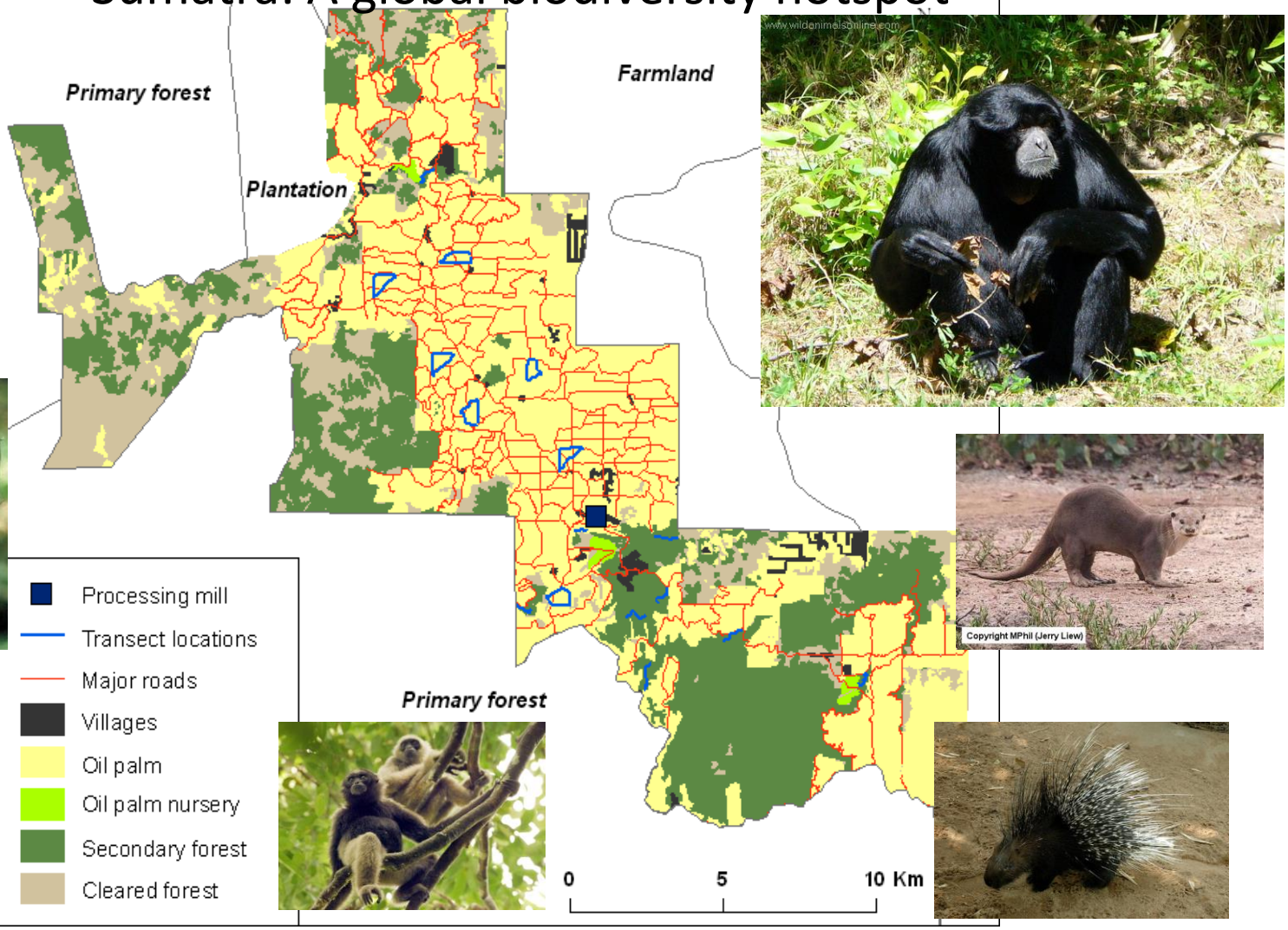
anglianwater

Slug itOut
healthy crops, healthy water

For Business & NGOs…

Study site

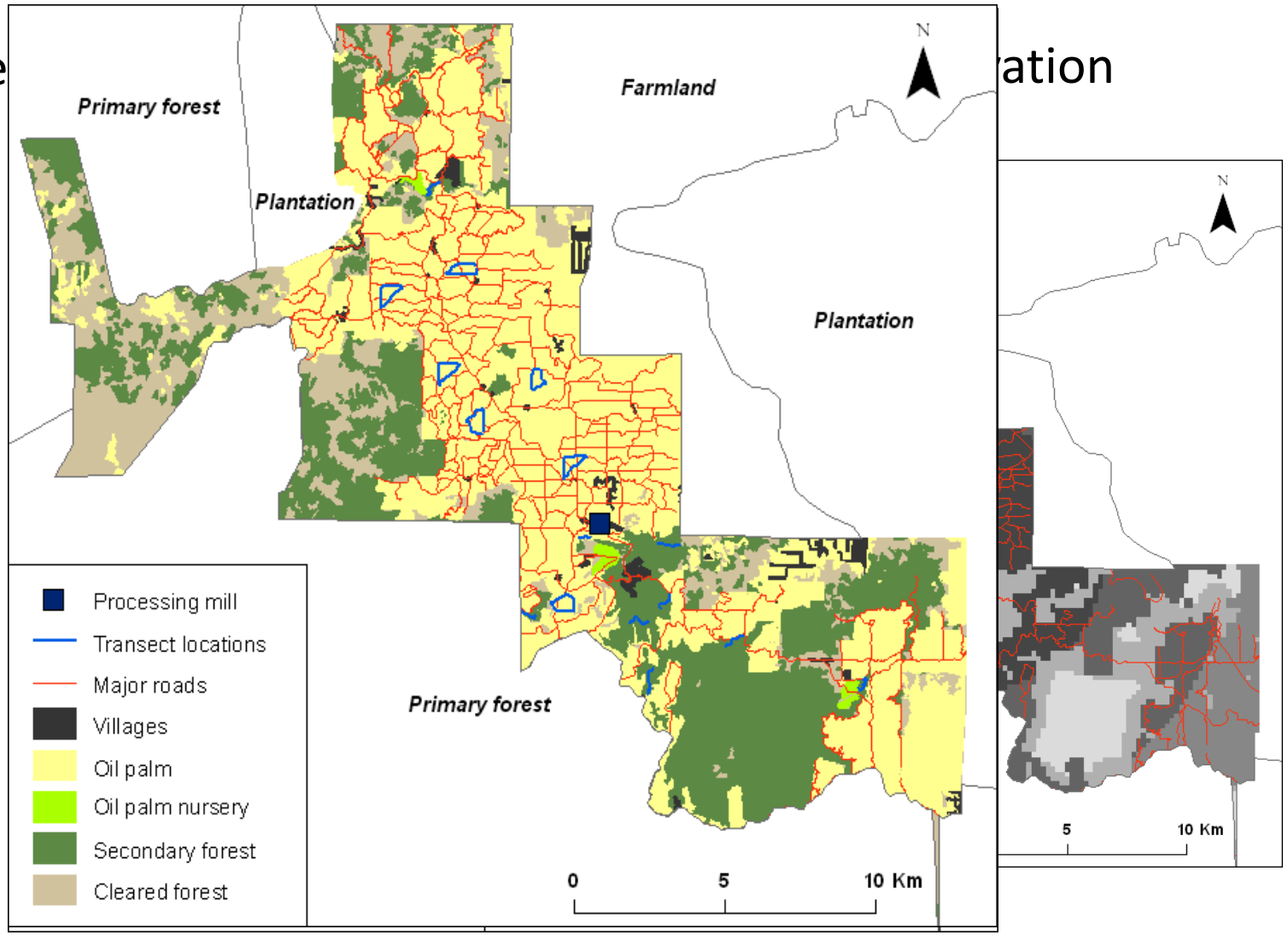
Sumatra: A global biodiversity hotspot



For Business & NGOs…

Effectiveness of conservation

Effectivene ation

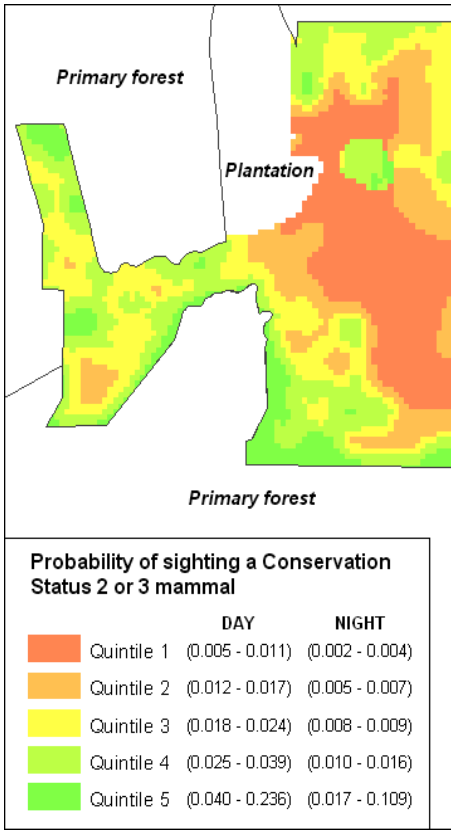


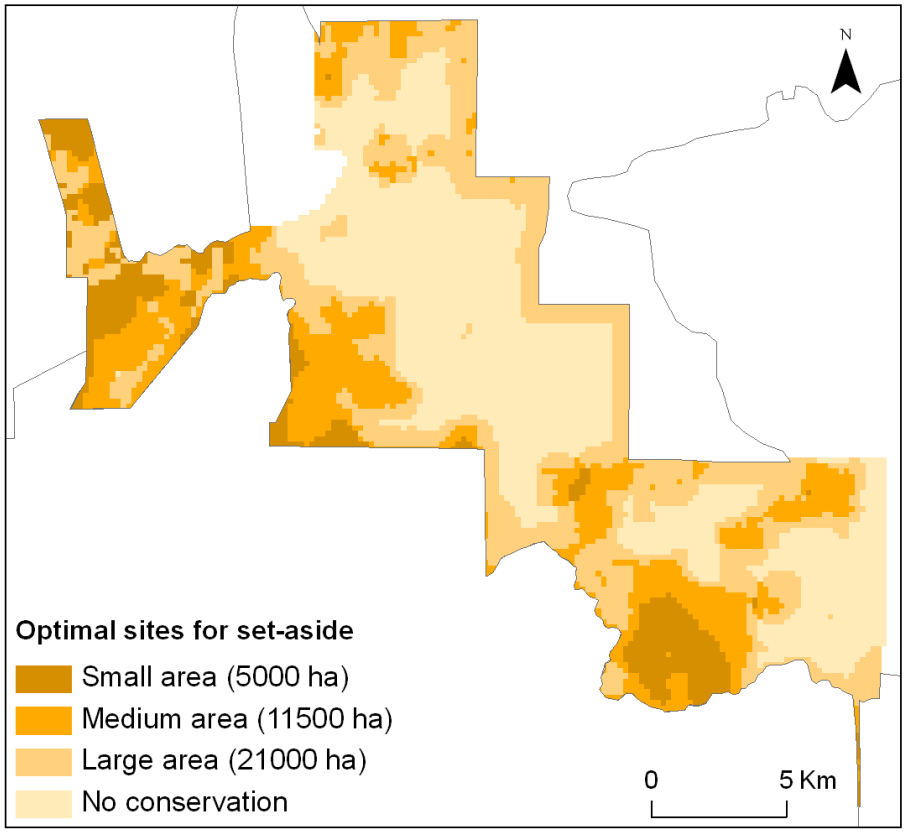
For Business & NGOs…

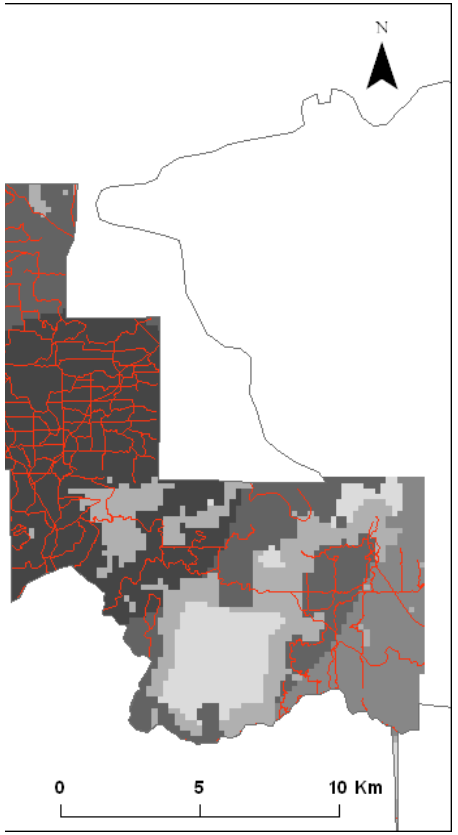
Effectiveness of conservation

Cost-effectiveness of conservation

Cost of conservation



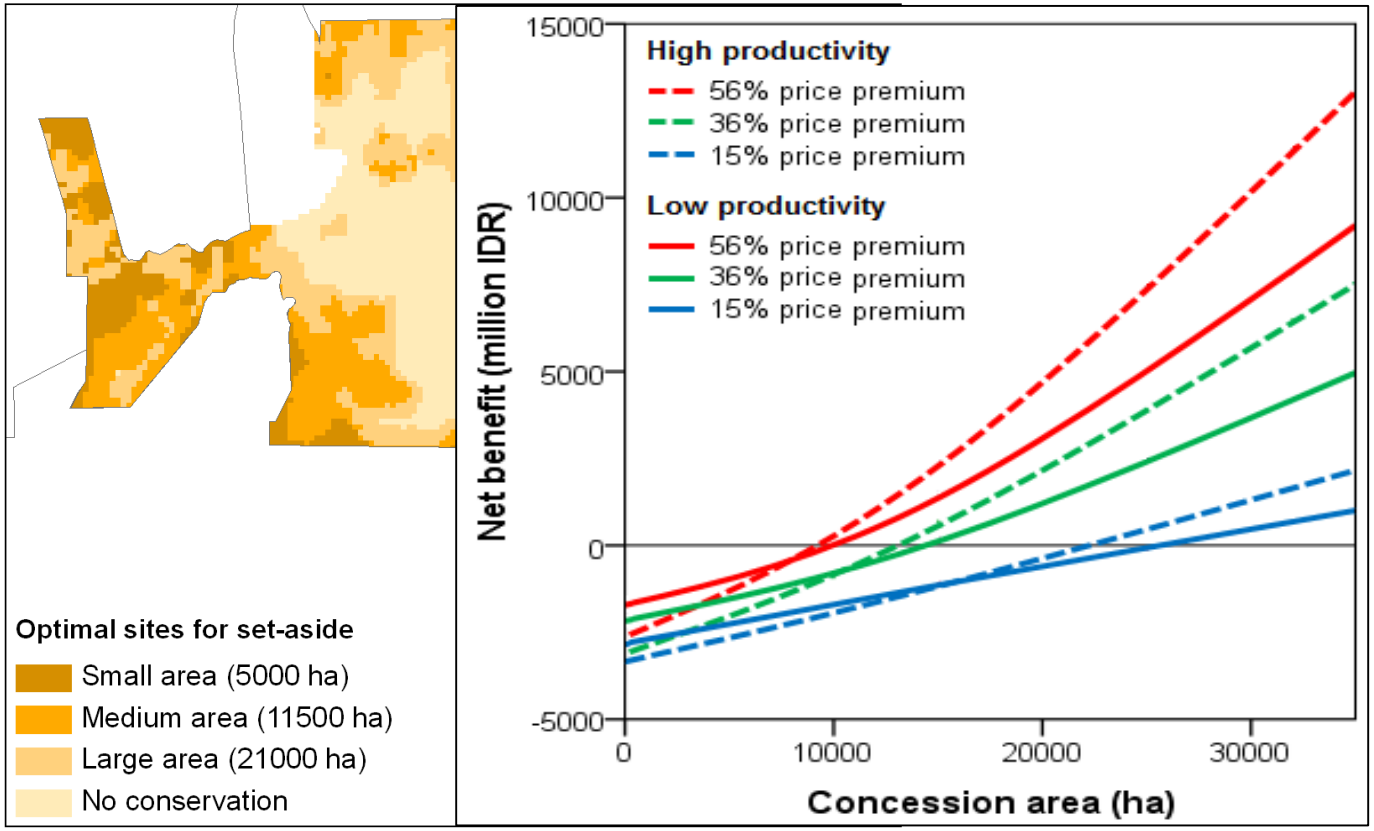




For Business & NGOs…

Cost-effective conservation

Profitability of conservation



Bringing multiple tools together: The Integrated Model

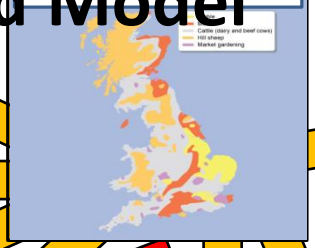
TIM

TIM

Bringing multiple tools together: The Integrated Model

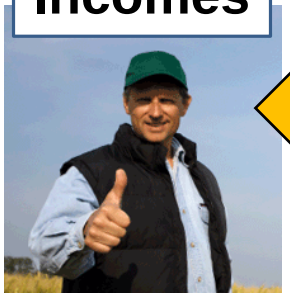
Food

Land use



Timber

Incomes



TIM

Market values

Social Value

Non-market values

Biodiversity

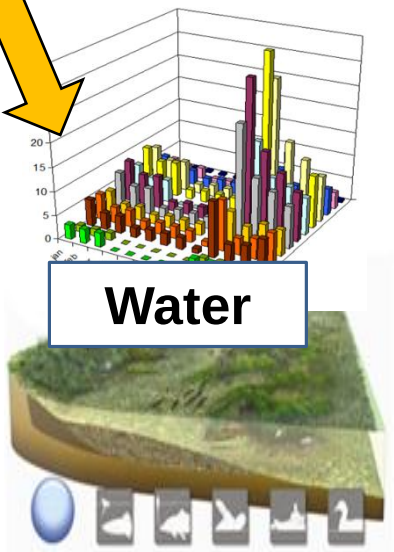
Drivers of change: Policy, Market & Environment

Values

Greenhouse gases

Recreation

Water



TIM

Food

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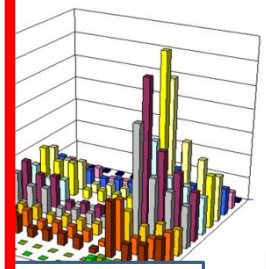
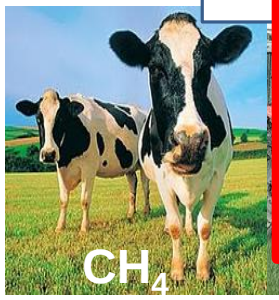
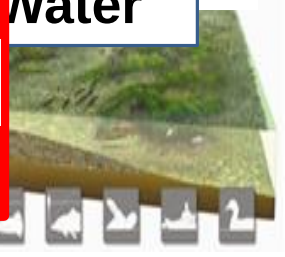
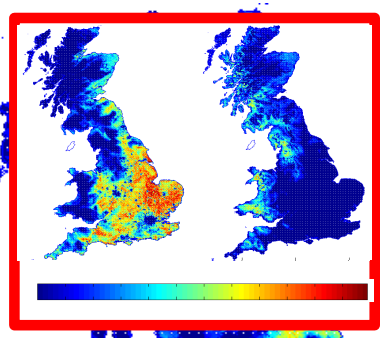
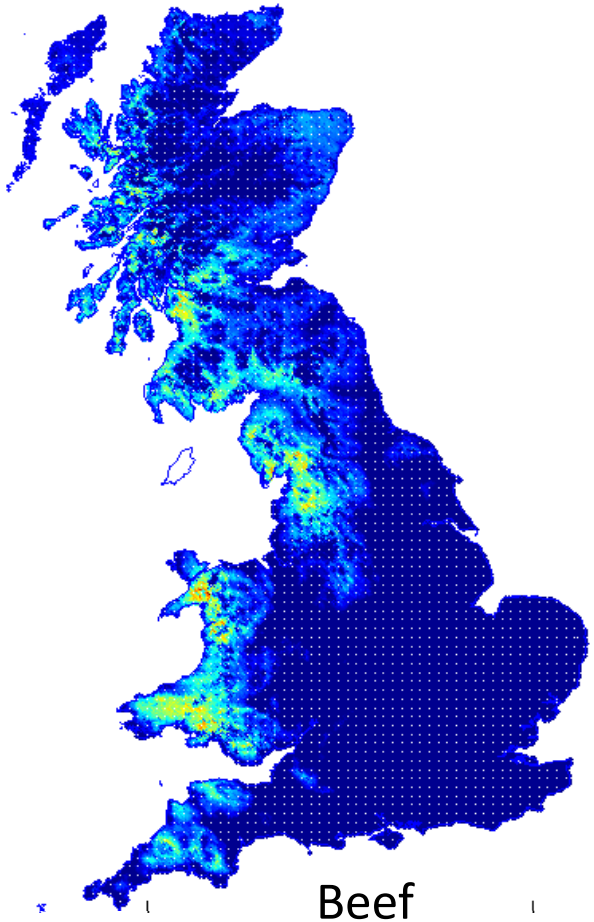


Water









Cereals

Beef

Low

High

N_2O

CO_2

Soil

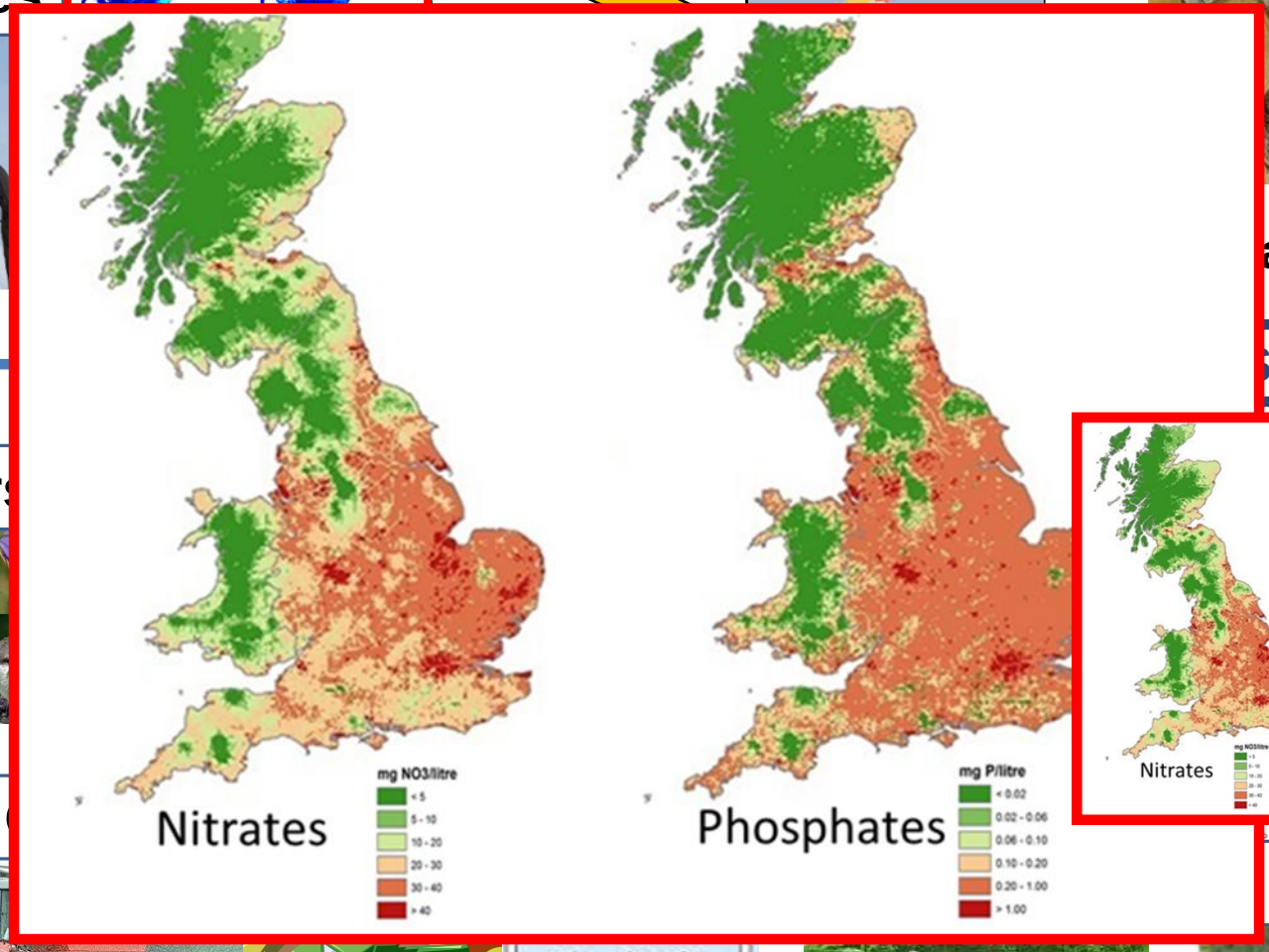
TIM

Food

Land use

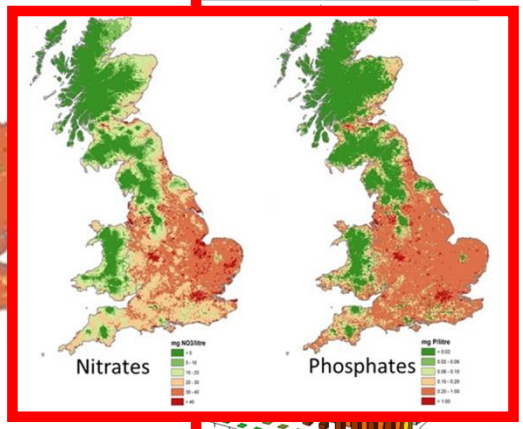
Timber

Incomes

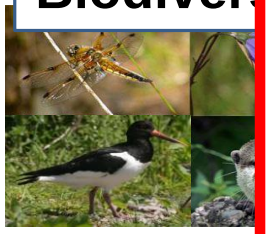


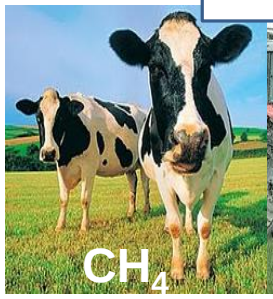
arket values

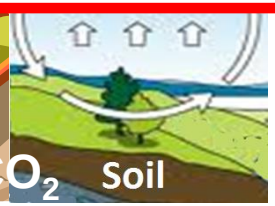
Social Value



Biodiversity





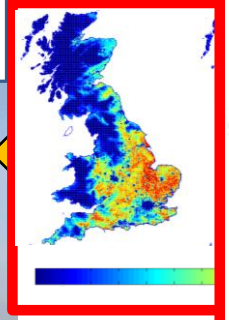


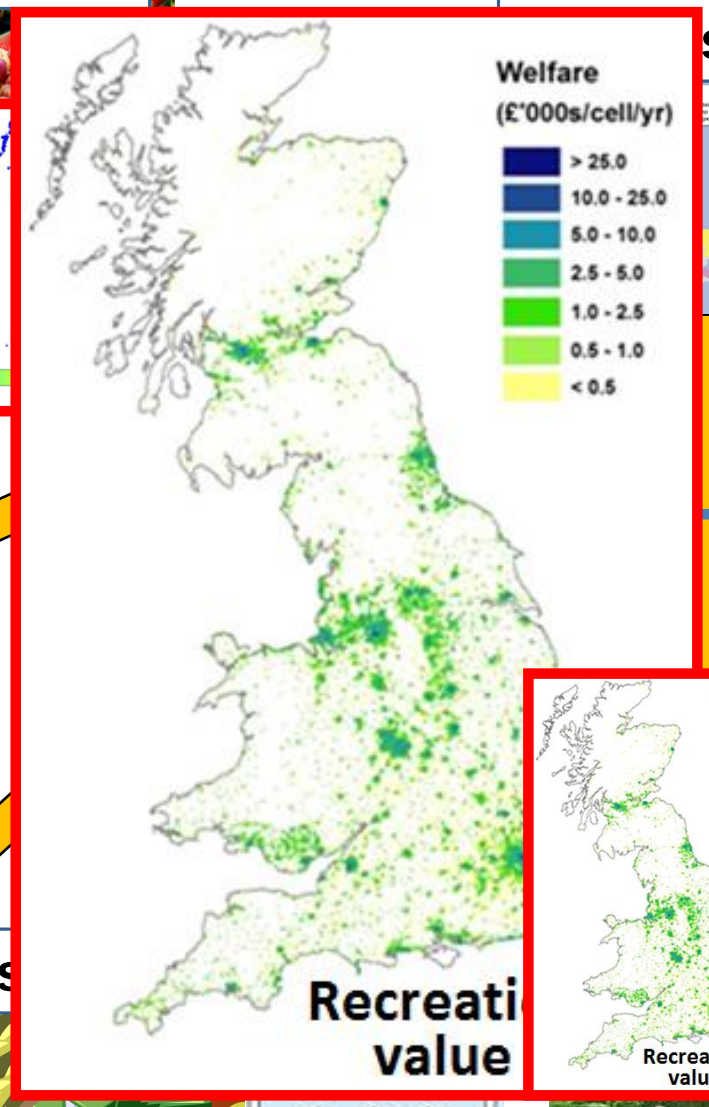
Water

TIM

Food

Incomes





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Market values

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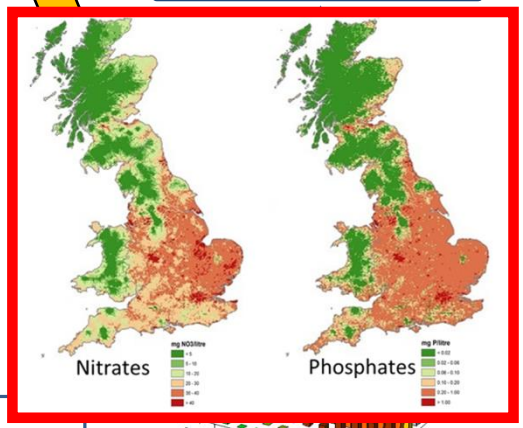

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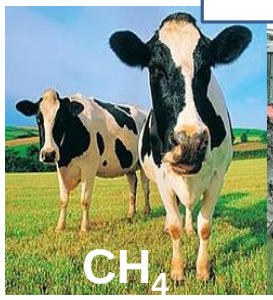
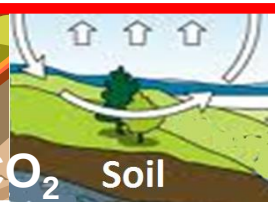
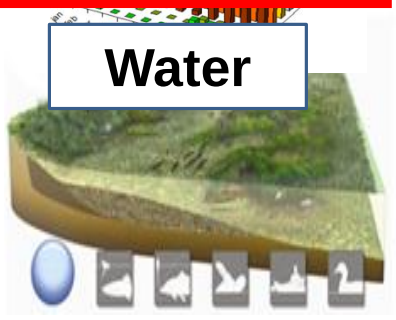




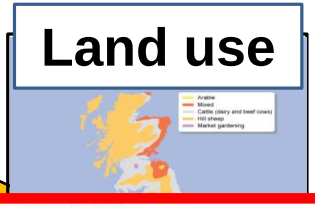
Water



TIM

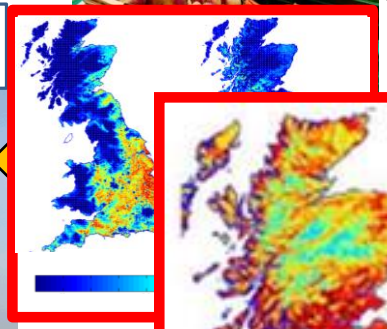
Food

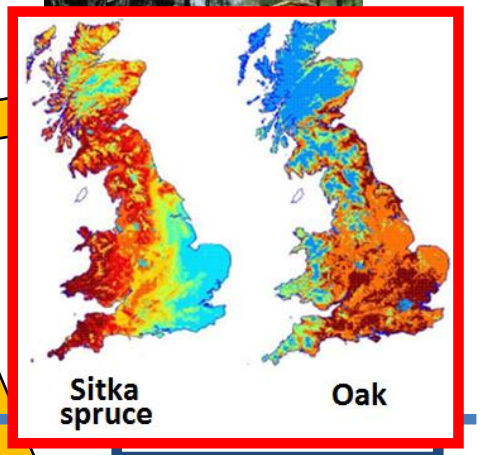
Land use

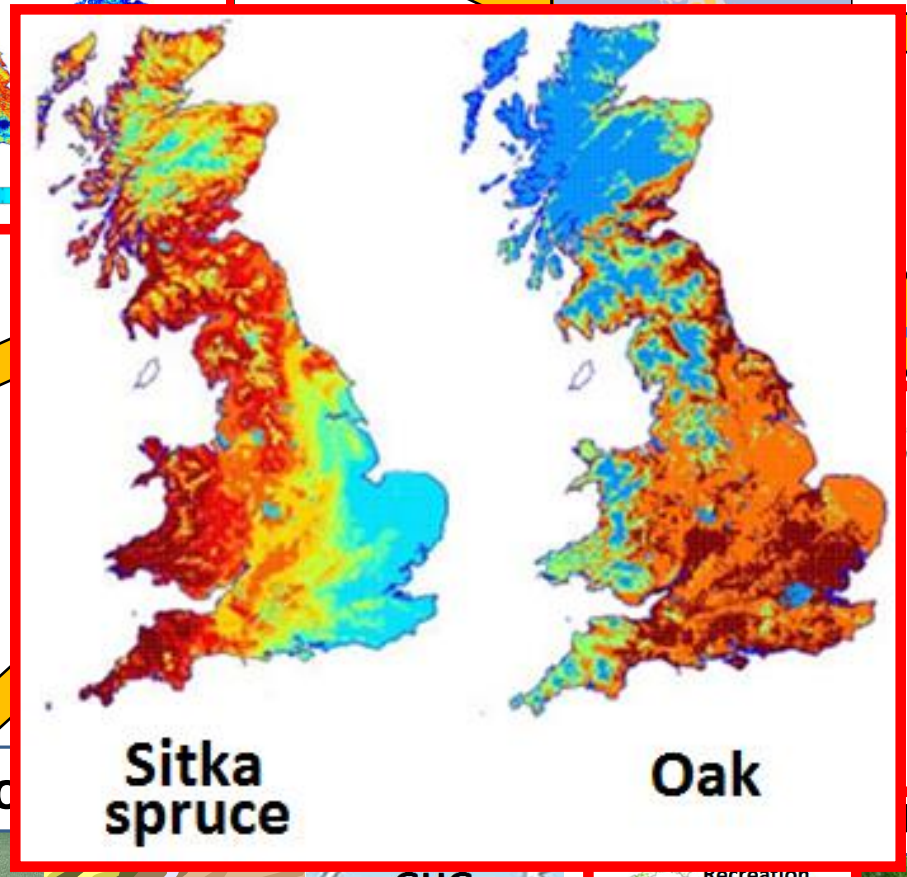


Timber

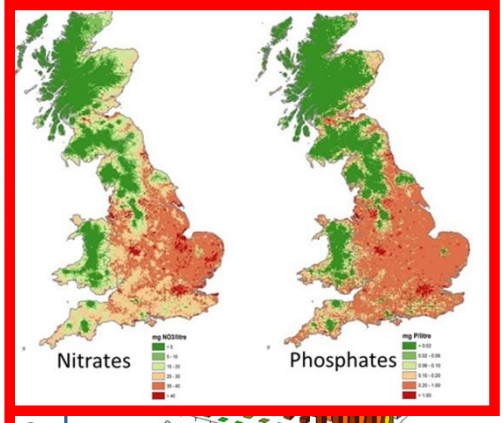
Incomes







Biodiversity



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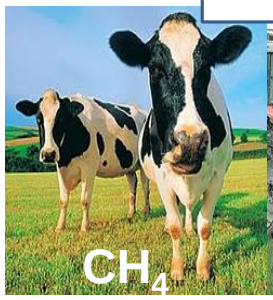
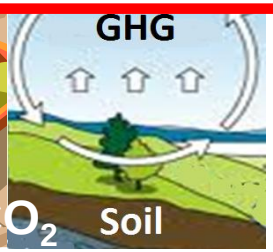
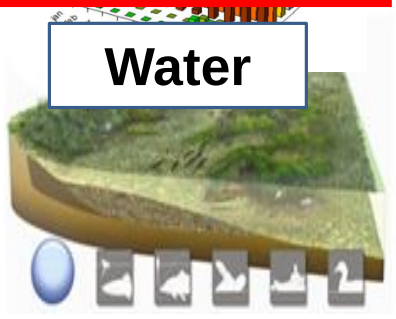




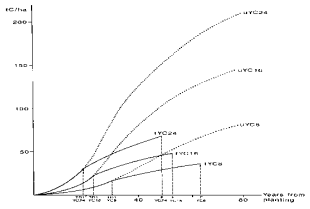
Recreation value

Water

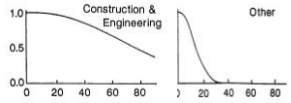


TIM Land use change: GHG values (CO_2, N_2O, CH_4)

Carbon storage in crops & trees



Carbon release from harvest & felling



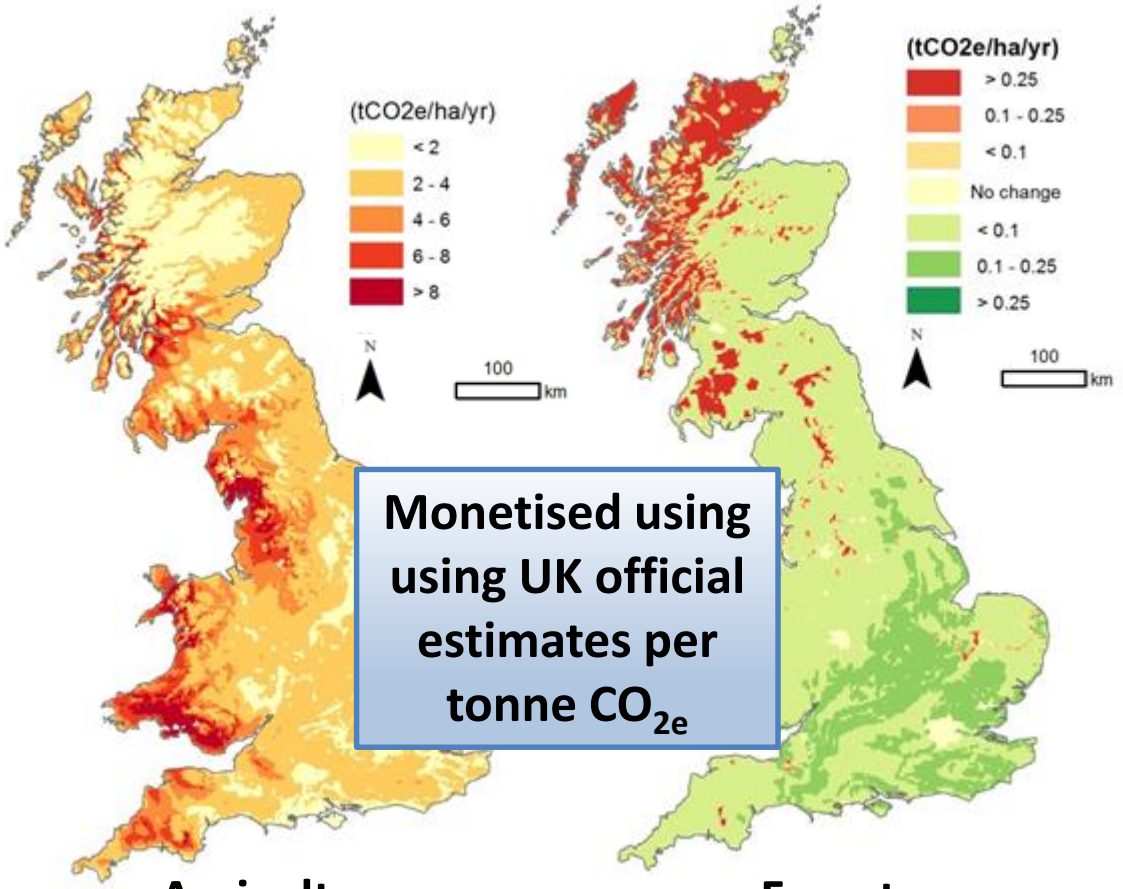
Soil carbon changes

Soil type	Upland sites		
	Under grass	Under trees	Change
Peat	1200	450	(750)
Humic gley	180-400	250-450	50-70
Podzol	200-400	250-450	50
Brown earths	n/a	n/a	n/a
Humic stagno podzol	180-400	250-450	50-70
Stagnogley	170-400	250-450	0-50

Machinery & fertiliser emissions

Livestock emissions

Average annual GHG emissions 2014-63



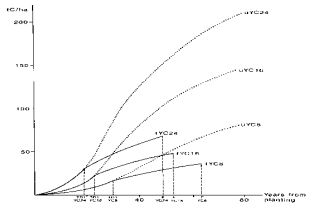
Monetised using using UK official estimates per tonne CO_{2e}

Agriculture

Forestry

TIM Land use change: GHG values (CO_2, N_2O, CH_4)

Carbon storage in crops & trees



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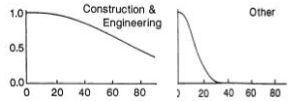

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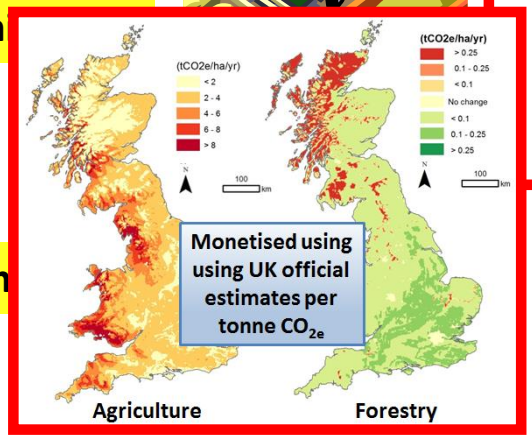
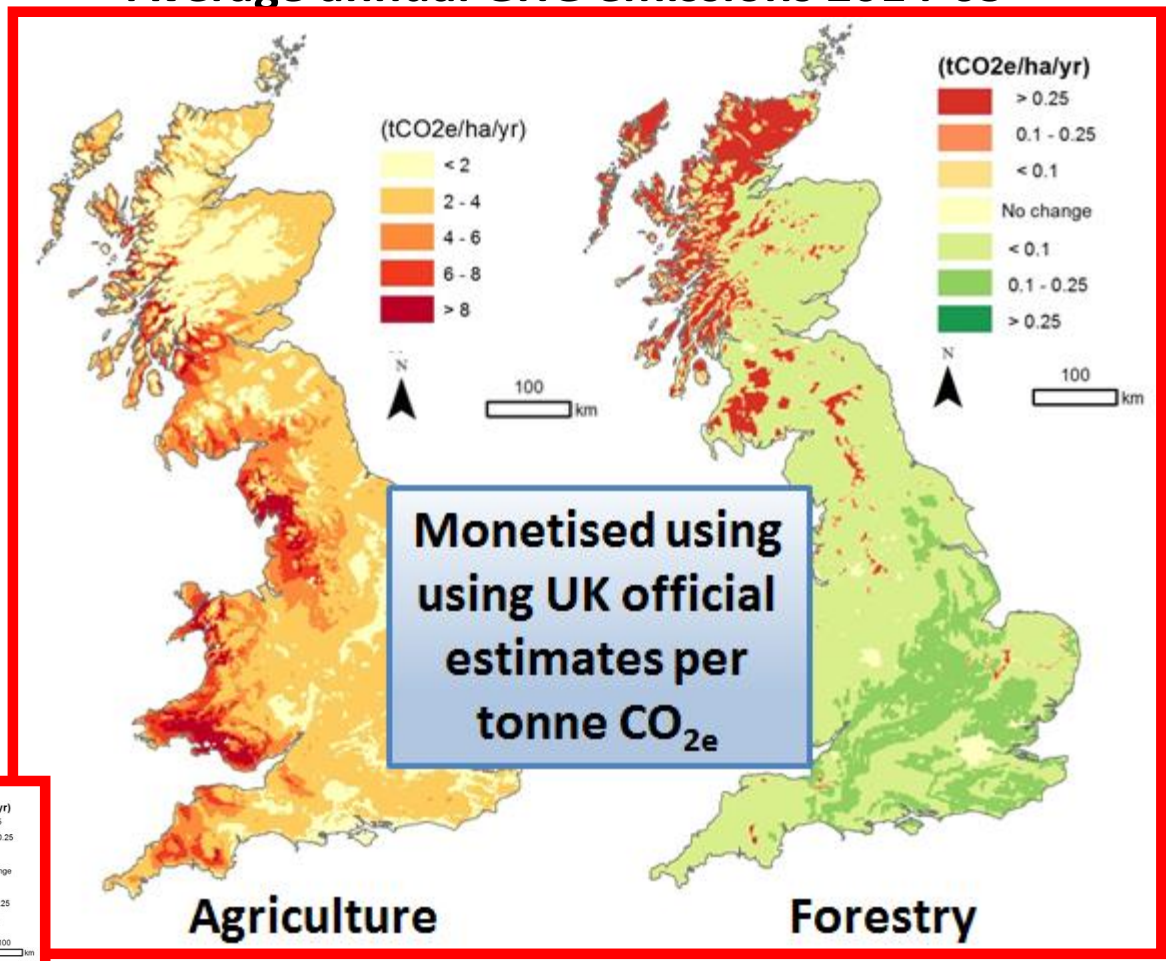


Average annual GHG emissions 2014-63



TIM

Land use impacts on Biodiversity

BTO
Looking out for birds

Data:
- Grid referenced
- GB coverage
- Time series

BBS

Breeding Birds Survey:
Bird diversity indices

TIM

Land use impacts on Biodiversity

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Modell ... es:

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Land use

Breeding Birds Survey:
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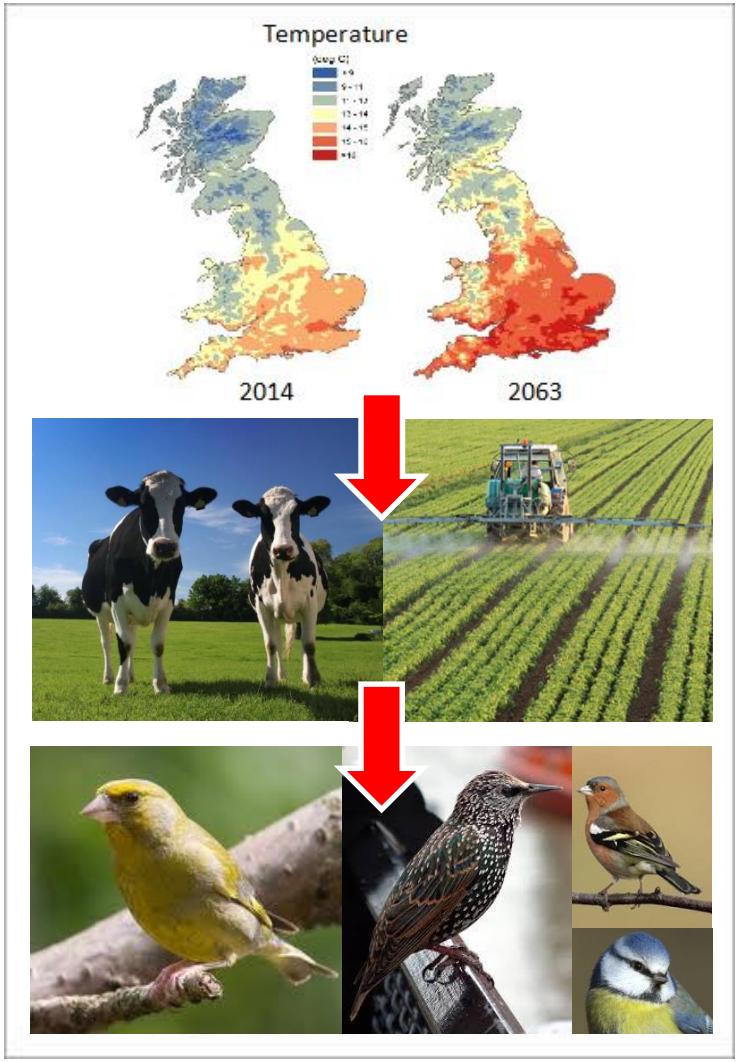
Biodiversity



TIM

Land use impacts on Biodiversity

Lack of robust values means that biodiversity impacts were not monetised but rather are used as a constraint

BTO
Looking out for birds

Data:
- Grid referenced
- GB coverage
- Time series

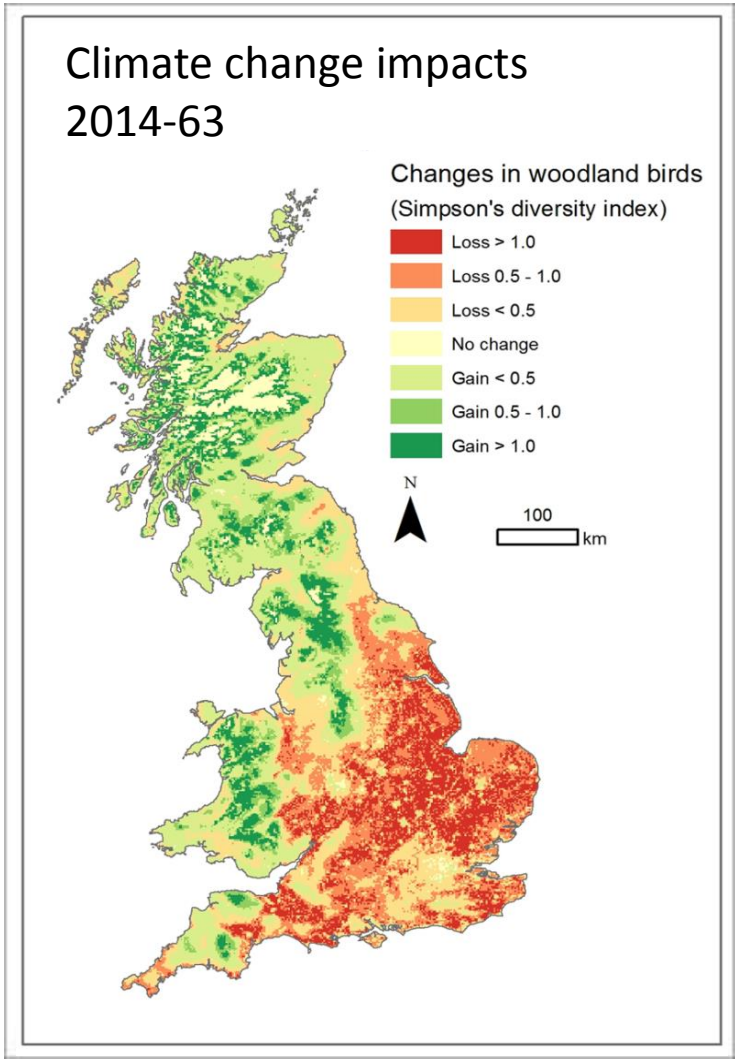
Modelled linkages:

Impact of climate change induced changes in land use 2014-63:

- Some increases in upland biodiversity
- Offset by losses in lowland areas due to greater extent and intensity of arable production.

Climate change
↓
Land use
↓
Biodiversity

Measure of biodiversity change	Mean*	S.E. Mean
All Birds	-0.248	0.006
Woodland Birds	-0.034	0.004
Farm Birds	-0.032	0.004
Red/Amber Birds	-0.092	0.002



TIM

Land use impacts on Biodiversity

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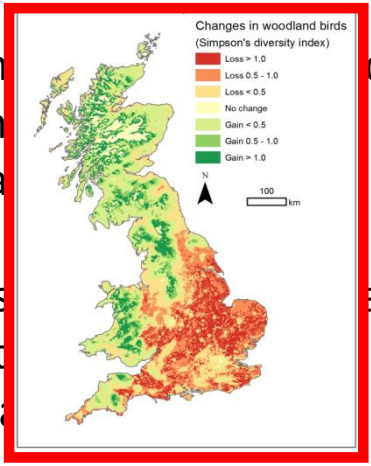
Data:
- Grid referenced
- GB coverage
- Time series

Impact of clim d changes in lan
- Some increa biodiversity
- Offset by los as due to great intensity of



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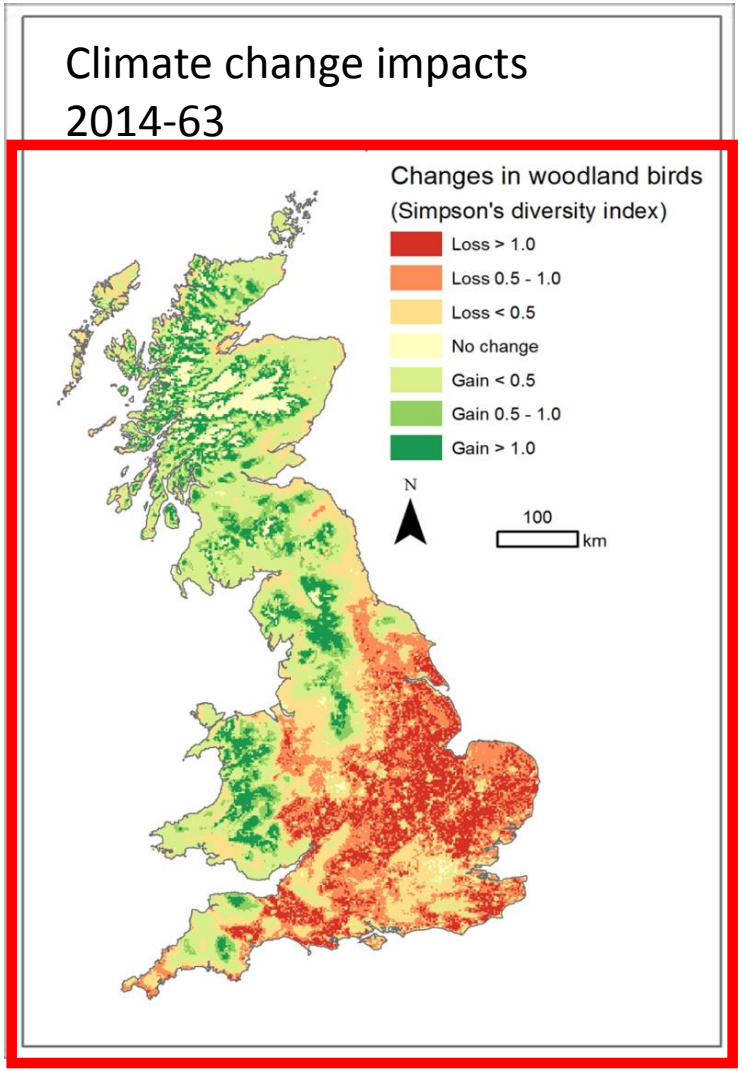
Climate change impacts 2014-63

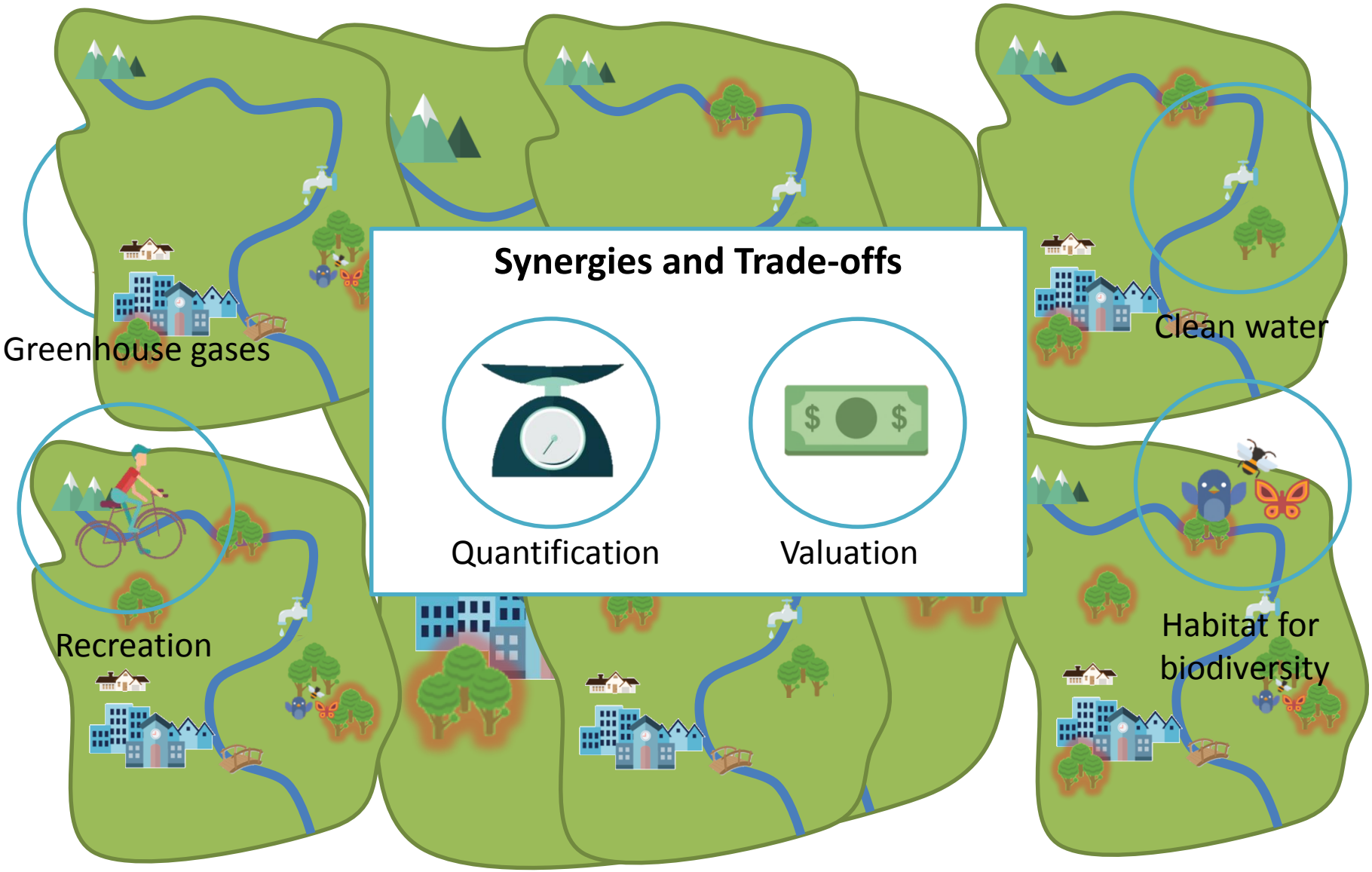


Managing Natural Capital: Integrated Optimisation

Greenhouse gases

Habitat for biodiversity

Managing Natural Capital: Integrated Optimisation



TIM

The Integrated Model

Where to plant Britain's new woodlands

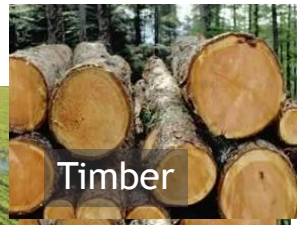
TIM

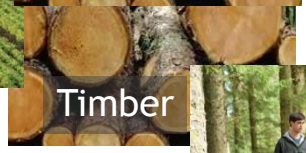
The Integrated Model

Where to plant Britain's new woodlands

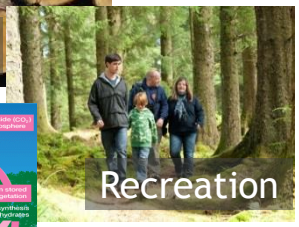
Targeted using:
market value (food & timber) only

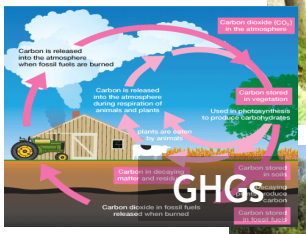
Cost benefit value including externalities:
- £66million p.a.

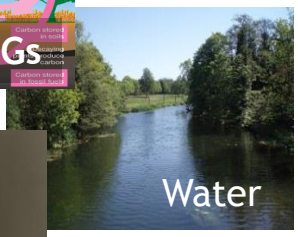




Targeted using:
market value (food & timber)
+ greenhouse gases
+ recreation
+ water quality improvement
+ biodiversity improvement





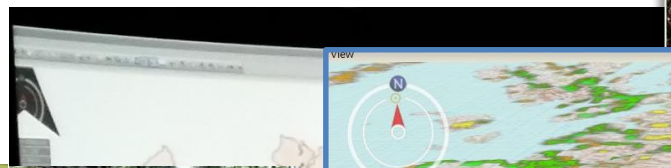


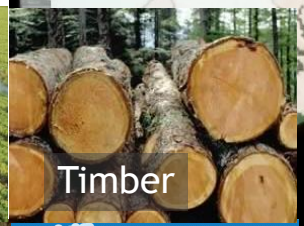
Cost benefit value including externalities:
+ £546million p.a.

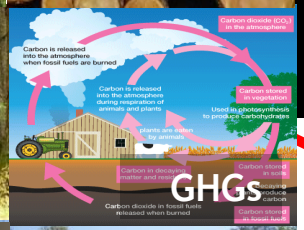
TIM

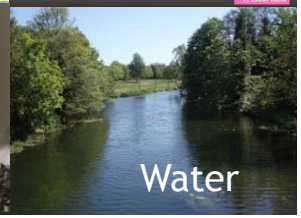
The Integrated Model

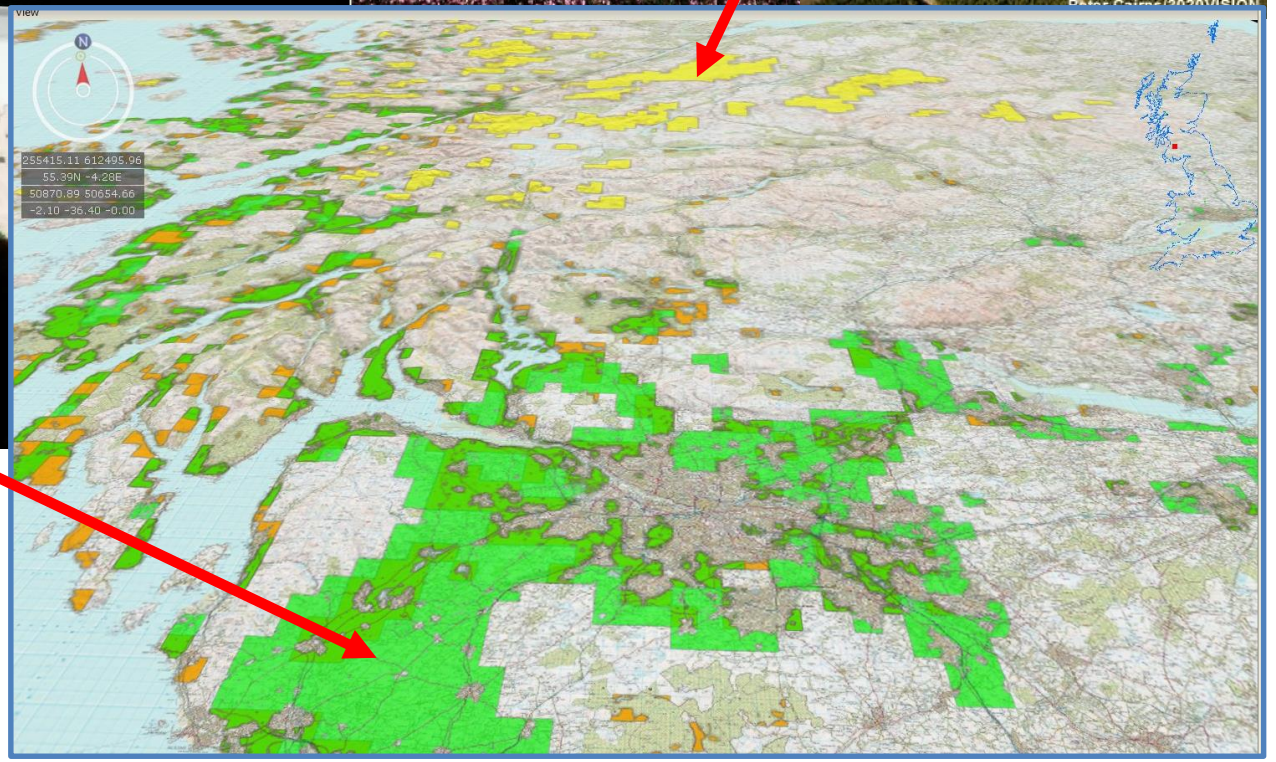
Input to participatory decision making: Virtual reality representation











Bringing the Natural Environment into Economic Decision-Making

Some principles

- There are always trade-offs so there are always values
- Use the framework, language and units of decision making
- Rather than inventing future worlds, understand the drivers of change so that analyses are restricted to only considering what is possible using feasible policy instruments
- Analyses need to be validated clearly
- Analyses should capture necessary complexity but decision support tools should be as simple as needed to get the job done
- Co-design decision support tools with their intended users

Policy impact

UK-NEA & Follow-On

"Applying ecosystem service valuation across the UK"

Natural Environment White Paper

"mainstream the value of nature across our society"

Water White Paper

"A vision for future water management in which water is valued as the precious and finite resource it is"

Engaging the Business Sector

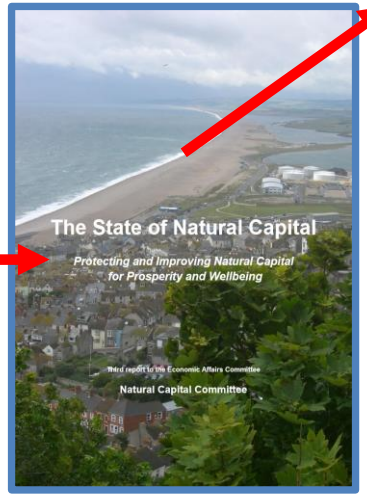
ecosystemmarkets TASK FORCE

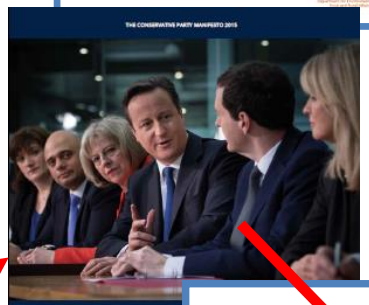
Research for ES decision making

NERC SCIENCE OF THE ENVIRONMENT
VALUING NATURE NETWORK
Bridging disciplines and building relevance
OPERAS
VALUING NATURE PROGRAMME
BBSRC bioscience for the future
E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL
THE NEXUS NETWORK
Living With Environmental Change

The Natural Capital Committee

HM TREASURY





The 25 year plan for the Environment (NCC Recommendation 1)

The Government agrees with the Committee's recommendation to develop a 25 year plan for the natural environment

The Plan will:

- Place the UK a world leader in **using data, tools and techniques to understand, map and monitor the environment, the benefits it provides** and how they are changing;
- **Improve decision making** at all scales so we can make better informed decisions about **where strategic investments in natural capital are needed to deliver the greatest benefits;**
- **Deliver on a range of natural capital related commitments**; protect habitats; spend £3 billion from the Common Agricultural Policy to enhance England's countryside over the next five years; plant an additional 11 million trees; launch an ambitious programme of pocket parks; tackling air and water pollution; and ensuring the value of Green Belts and AONB's, National Parks, SSSI's and other environmental designations are appropriately protected.

This plan will be an opportunity to:

- **Improve how we manage** and access our natural environment;
- Aid the **delivery of multiple benefits**;
- **Build resilience** in the face of growing pressure and change;
- Unleashing **new and innovative opportunities for investment** in our natural assets.

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