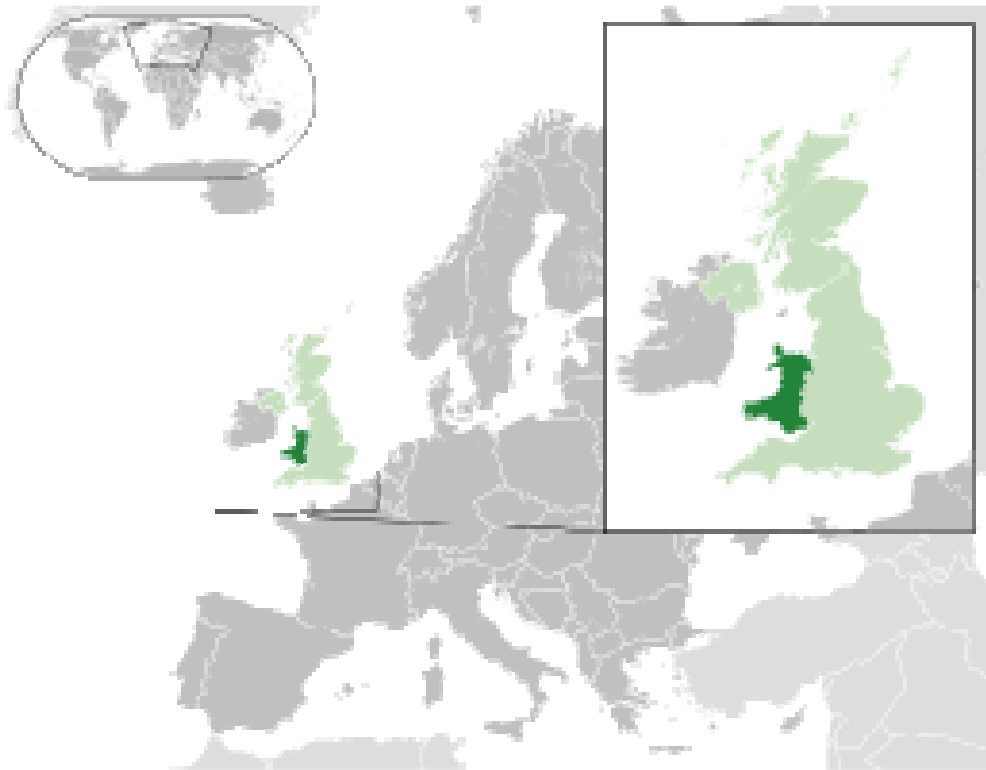# APPLYING LUCI AT THE NATIONAL SCALE IN WALES (and some model inter-comparisons)

Bridget Emmett[1], Bethanna Jackson[2] & The GMEP Team

[1]NERC's Centre For Ecology And Hydrology, [2]University of Wellington Victoria NZ,

Wales

Wales – some facts

3 million people
20,000km2
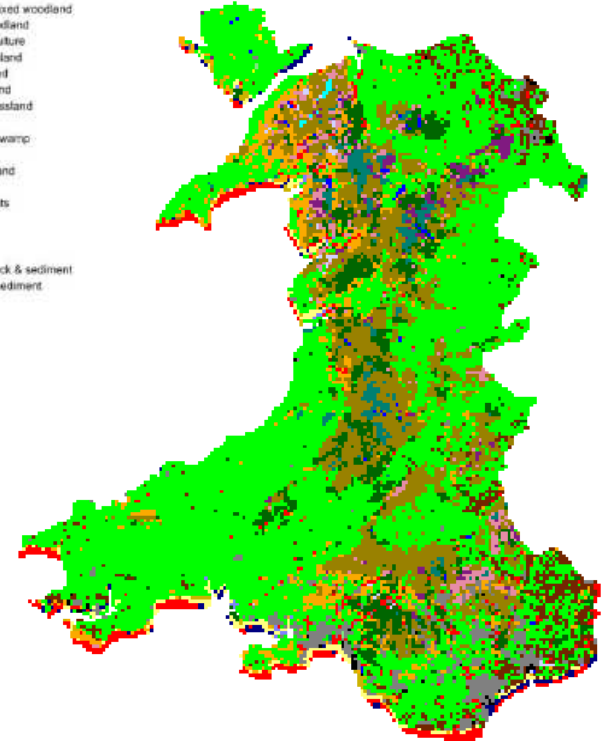1,200km coastline
One of wettest countries in Europe = grass!
95% rural land much of which is poor quality

GDP = £45blilion (of which tourism is £6B
(wildlife-based £2B); agriculture £1.4B;
forestry £0.5B

Devolved in 1998 from UK government

Issues:
Ongoing decline in biodiversity; failure to meet
Water Framework Directive targets; GHG
emissions actually increased last year; agri
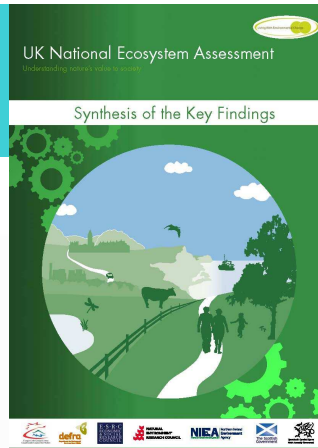sector heavily dependent on subsidies; poorly
performing economy/jobs

Broadleaved/mixed woodland
Coniferous woodland
Arable & horticulture
Improved grassland
Rough grassland
Neutral grassland
Calcareous grassland
Acid grassland
Fen, marsh & swamp
Heather
Heather grassland
Bog
Montane habitats
Inland rock
Saltwater
Freshwater
Supra-littoral rock & sediment
Littoral rock & sediment
Saltmarsh
Urban
Suburban

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Entry point to Ministers

John Griffiths, Environment Minister, UN Climate Change Conference, DOHA 2012)

"Wales will become the first country in the world to make it legally binding for all public bodies, from health trusts to libraries and schools, to take account of the environment and social issues when they make a decision"
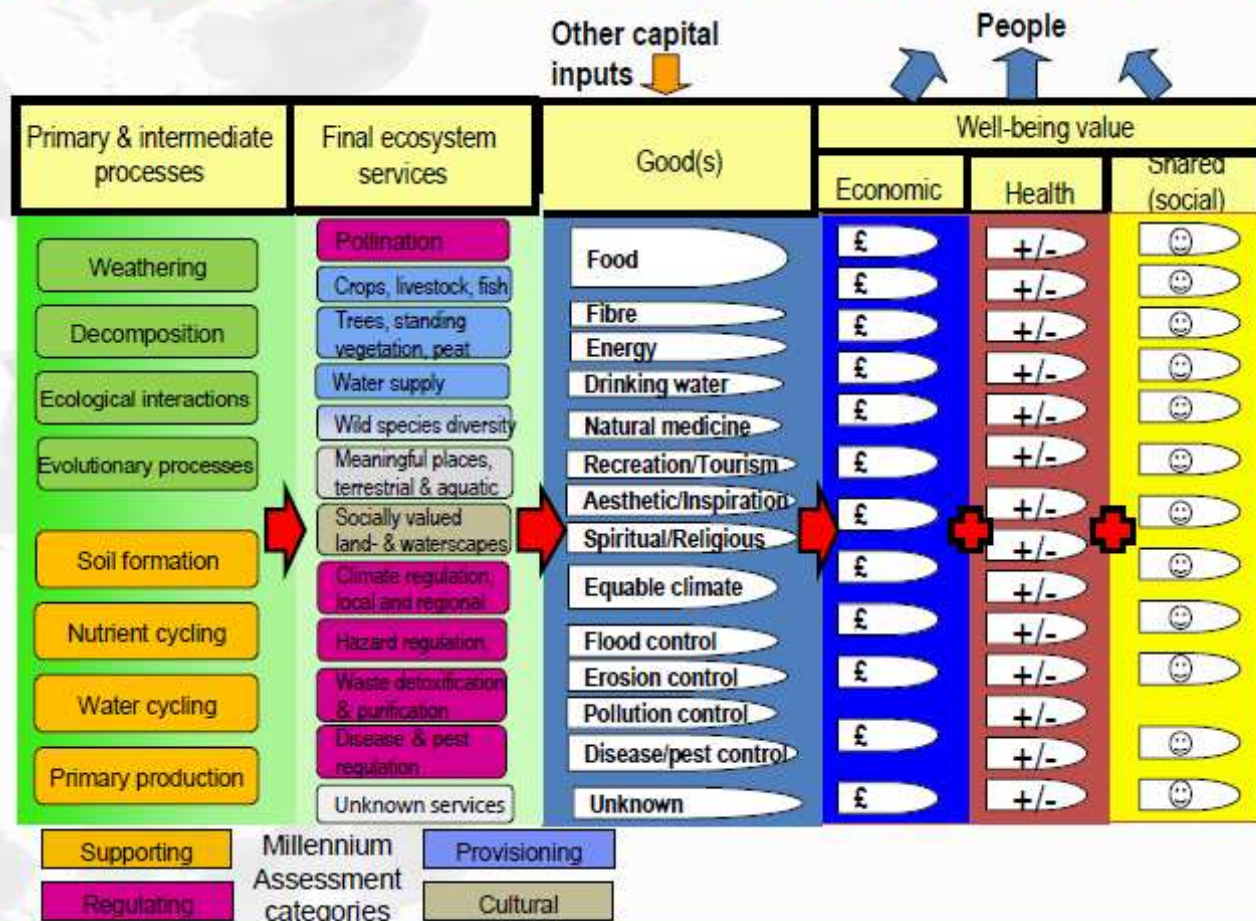
Wales needs the models such as LUCI to undertake the spatial planning and scenario analysis for <u>integrated management</u> of 95% non-urban area of the country to deliver SD. An end to silo management!

Number: WG15440

Welsh Government
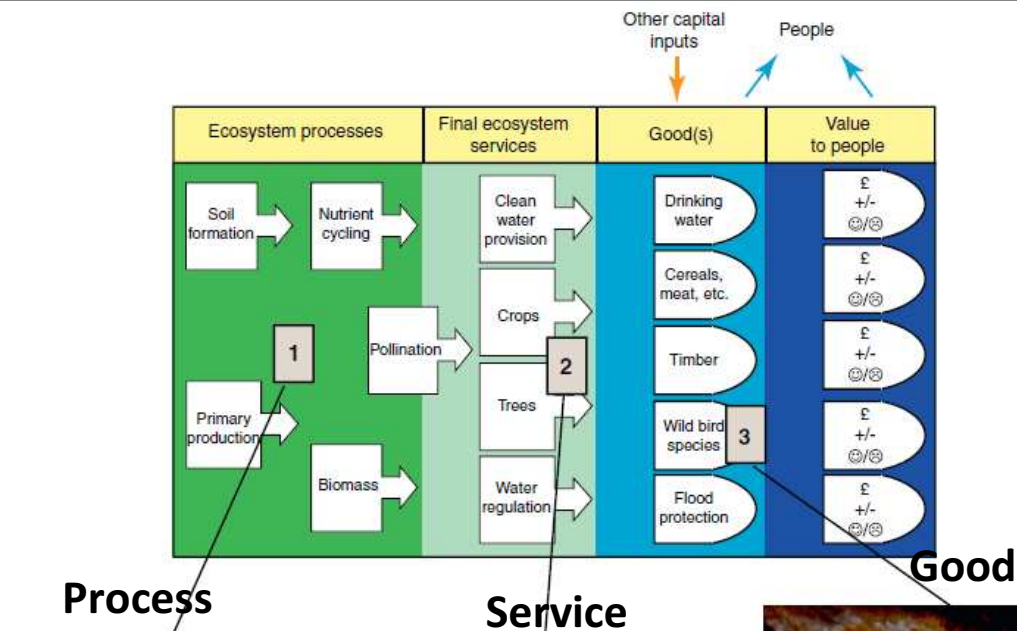**Consultation Document**

Proposals for a
Sustainable Development Bill

Date of issue: May 2012

www.cymru.gov.uk

Llywodraeth Cymru
Welsh Government

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Ecosystem services – monetary and non-monetary value

Process

Service
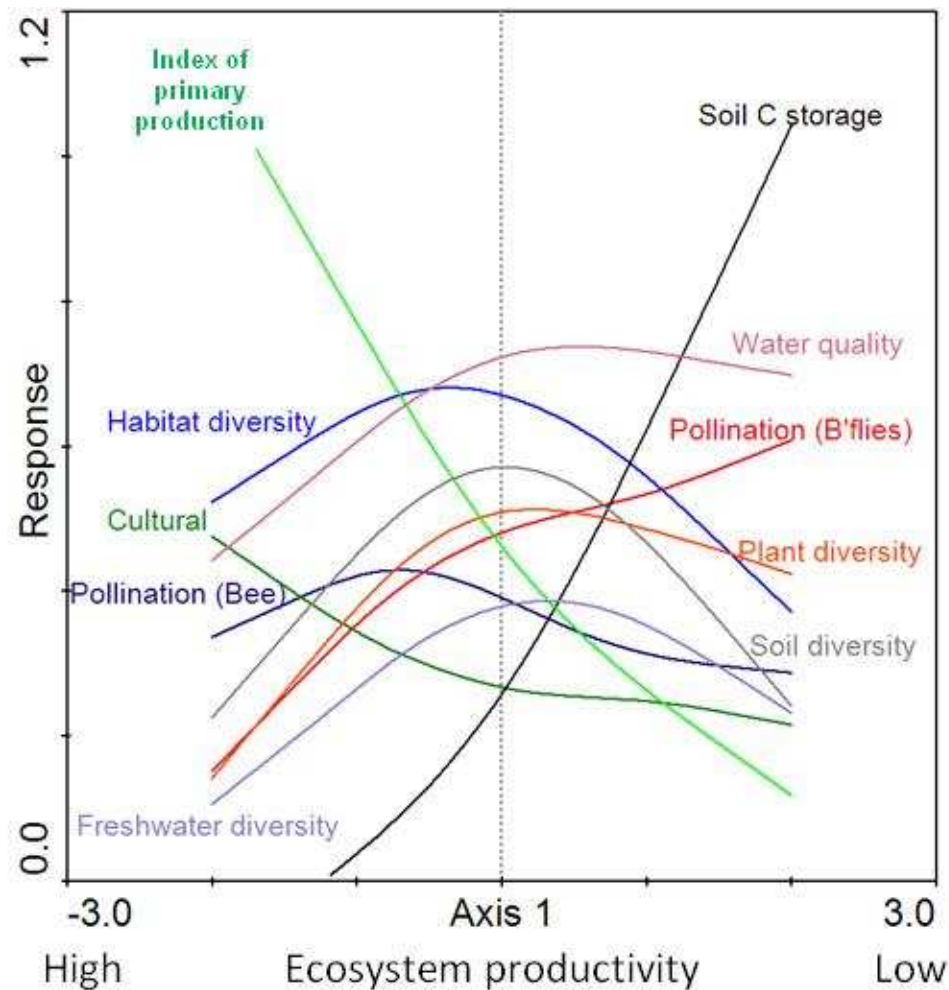
Good

Functional diversity

Species and genes for:
- *Medicinal value*
- *Wild reservoir for farmed crop and animals*

Wildlife has value in itself:
- *cultural*
- *aesthetic*
- *spiritual*

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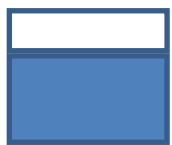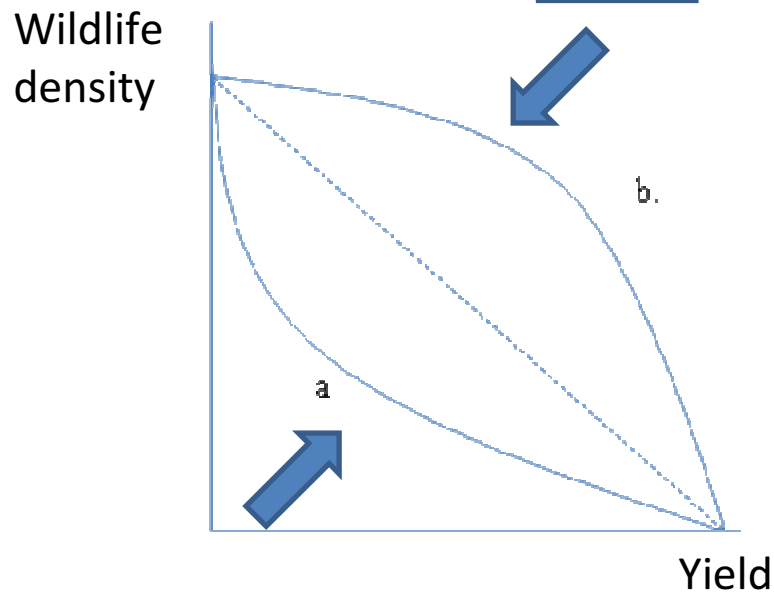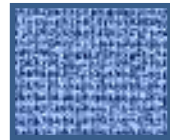NATURAL ENVIRONMENT RESEARCH COUNCIL

Integrated monitoring demonstrated fundamental ecological constraints on ecosystem services

Countryside Survey Integrated Monitoring

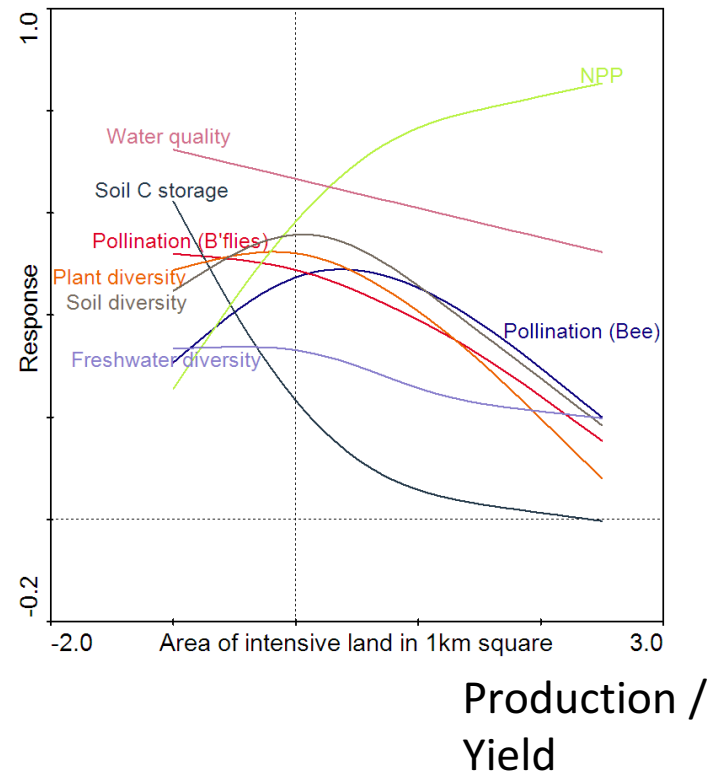Maskell et al. (2013) Journal of Applied Ecology

Land sharing is optimal for food and wildlife

Wildlife density

Land sparing is optimal for food and wildlife

Ecosystem service

Yield

Production / Yield

Green et al. (2005) Sicence 307: 550-555

In addition, Wales now has the GMEP project

Aims

- To quantify extent, condition and change of Natural Capital assets in Wales

- Attribute change and determine implications for ecosystem services

- Determine impact of land management interventions through Glastir RDP programme as it is going along!

- Scenario analysis, trade-offs and optimisation

Objective, independent, scientific approach

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Land management scheme **Glastir**

- *A whole farm sustainable land management scheme.*

- *5 priorities:*

  - *Combating climate change (regulating)*

  - *Improving water management (regulating/provisioning)*

  - *Maintaining and enhancing biodiversity (supporting/cultural)*

  - *Landscape and historic landscape (cultural)*

  - *Increasing area and improving management of woodland (provisioning)*

GMEP = Glastir Monitoring and Evaluation Programme

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ca.£80M to Welsh farmers every year to benefit the environment and compensate for reduction in income

The question is: does it?

Landscape, historic environment, access and recreation

N₂O
CO₂

Economics

Farmer practice

Soils and water flow/quality
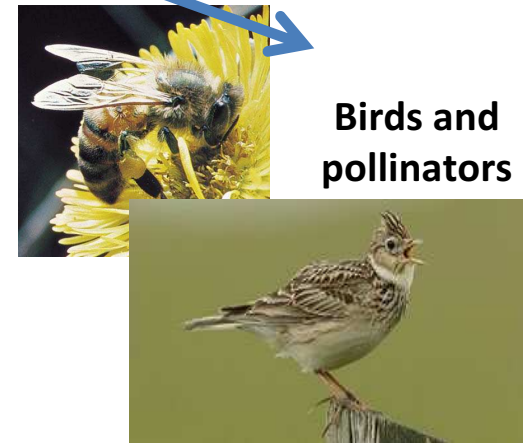
Birds and pollinators

The GMEP approach

- Combined monitoring and modelling approach

- Monitoring for:
  - Evidence-base outcomes
  - Deliver reporting requirements
  - Drive models (farmer practice survey)

- Models for:
  - Early results for bidiversity, carbon and water etc!
  - Evaluate difficult to measure outcomes (GHG)
  - Upscale
  - Explore scenarios
  - Identify trade-offs
  - Models as hypotheses
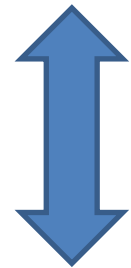
So we need models: Why LUCI?

- Biophysical process model basis

- Spatially explicit

- Can run on just 3 national datasets (but can use more if available)

- Scale (5m x 5m so can explore subfield scale and integrate to any scale)

- Modular

- Stakeholder friendly interface

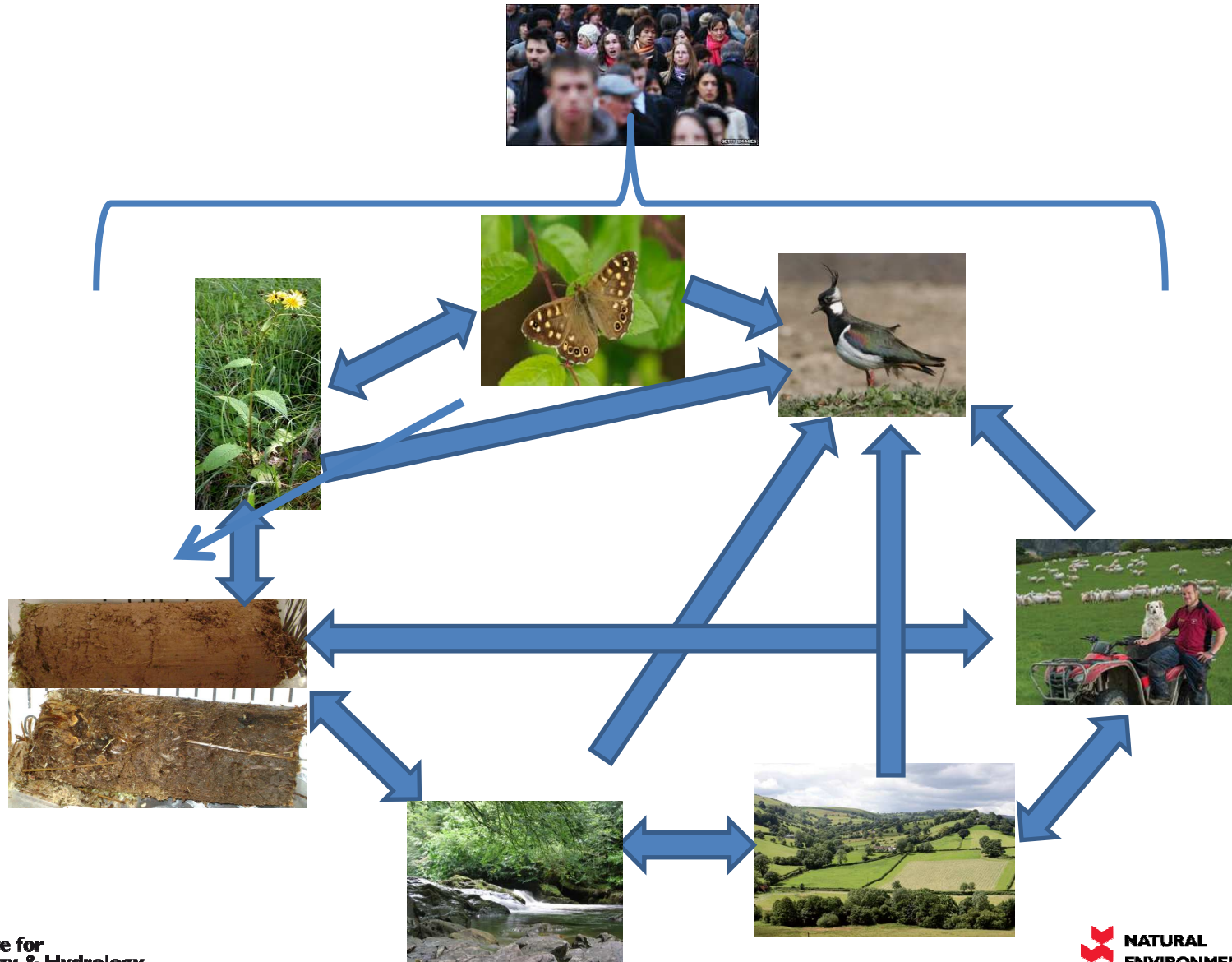- Scenarios, optimisation, trade-offs

Services currently modelled by LUCI

Service	Method
Production	Based on slope, fertility, drainage, aspect
Carbon	IPCC Tier 1 – based on soil & vegetation
Flooding	Detailed topographical routing of water (5m by 5m) accounting for storage and infiltration capacity as function of soil and land use.
Erosion	Slope, curvature, contributing area, land use, soil type
Sediment delivery	Erosion combined with detailed topographical routing
Water quality	Export coefficients combined with water flow and sediment delivery models
Habitat (Approach A)	BEETLE – Forest Research's cost-distance approach to dispersal, examines connectivity of habitats
Habitat (Approach B)	Identification of priority habitat by biophysical requirements e.g. wet grassland
Tradeoffs/synergy identification	Various layering options with categorised service maps; e.g. Boolean, conservative, weighted arithmetic

GMEP uses an ensemble approach for modelling

Model name	Glastir Outcome				
	Biodiversity	Climate Change mitigation	Soil and water flow/quality	Landscape and historic features	Woodland expansion and management
ADAS GHG and diffuse pollution model		Ruminants and manures; energy; fertiliser emissions (direct and indirect)	Diffuse pollution, and sediments		
LUCI	Connectivity between semi-natural habitats only included for now	Impact of land use on biomass and soil C stocks	Runoff/flooding; sediment delivery, N and P export	Erosion damage possible	Impacts of woodland loss or expansion on C sequestration
LULUCF		Impact of land use on biomass and soil C stocks only.			Impacts of woodland loss or expansion on C sequestration
Multimove	Change in habitat suitability for > 1000 higher plants based on 6 environmental variables	Interaction between interventions and climate change on plant biodiversity	Impact of change in soil moisture resulting from interventions on plant biodiversity		Impacts of woodland management on groundflora diversity
Ecosse		Soil based GHG emissions			
LUCI	Trade-offs and spatial analysis				

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- Habitats and linear features
- Species (birds, invertebrates and plants)
- Streams and ponds (habitat, macro-invertebrates, diatoms, aquatic, plants, chemistry)
- Landscape including historic environment features, access and recreation
- Soil (physical structure, erosion, pesticides, nutrients and biodiversity)
- Diffuse Pollution and Climate Change Mitigation
- Economics for farmers & social surveys to identify wider benefits within Wales
- Integration across elements
  - Spatial context of measures
  - trade-offs and co-benefits
  - implications for Natural Capital and Ecosystem Services

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So many metrics appropriate for SEEA EEA Ecosystem condition and services (LUCI outputs in red)

- Ecosystem condition and extent table

- Biodiversity
  - Plant, soil, bird, pollinators & aquatic; Invasives; appropriate diversity; presence of common standards species; linear features; **connectivity; habitat extent;** habitat diversity

- Soil 'quality' (physical, chemical & biology)

- **Water flow and quality**

- Primary production (specific leaf area)

- Historic features condition assessment

- etc

- Services table

- **C storage and emissions**

- **Flood regulation**

- **Water quality**

- **Production (actual and potential)**

- **Priority habitat and diversity (actual and potential)**

- **GHG emissions (just added)**

- Landscape perception / aesthetic

- Access/recreation
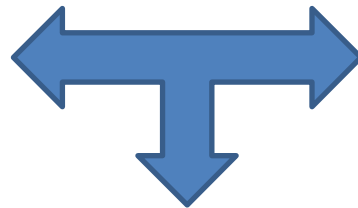
- Direct and indirect employment

- etc

Actual versus potential (e.g. Production)

➤ **Potential**
- Land typology based (LUCI)
- Climate based (JULES model)
- Forestr models (CARBINE)

➤ **Actual**
- Harvested timber
- Livestock units
- AICS data
- Specific leaf area (proxy for primary production in semi-natural systems)

Comparison gives you:
- Human modification metric
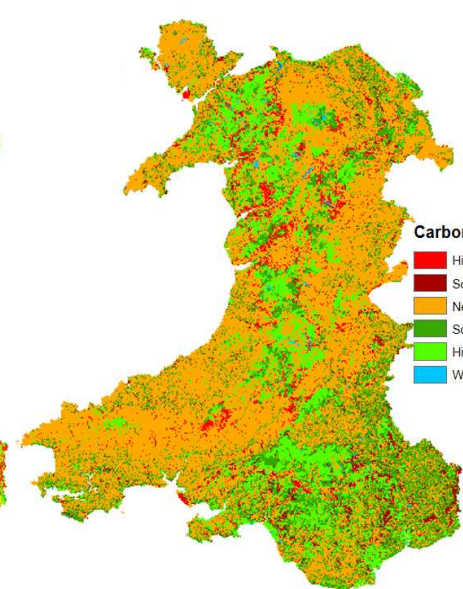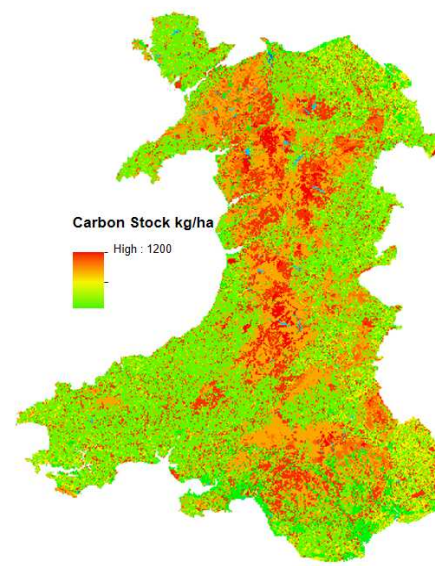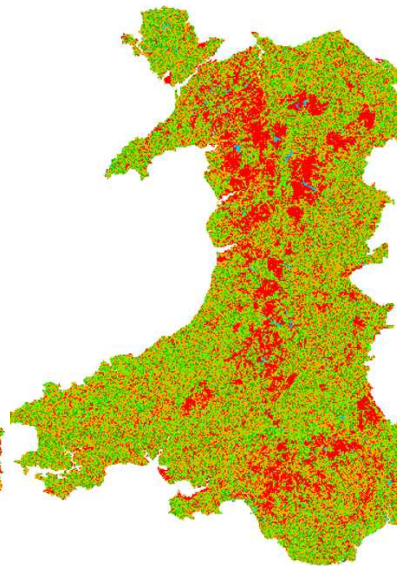- Potential for restoration
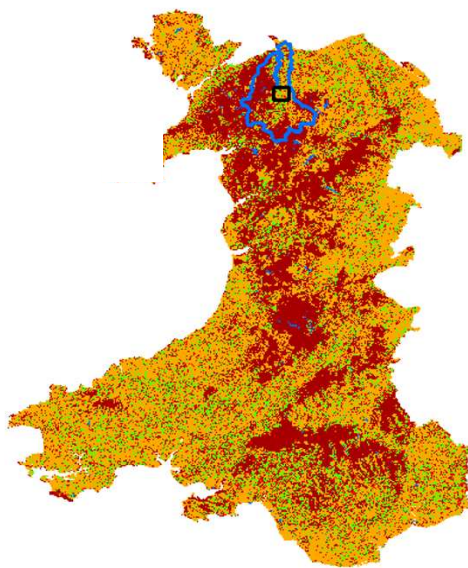- Areas of over or under - exploitation

National maps from LUCI showing areas of current high delivery and opportunities to enhance (driven from 3 datasets)

Habitat Priority areas

Flood generating and mitigating land

Carbon storage

Carbon emission

Carbon Stock kg/ha

High : 1200

Carbon loss/gain
- High sequestration
- Some sequestration
- Near steady state
- Some emission/loss
- High emission/loss
- Water bodies

- ☐ 6 by 5km "close-up" area
- ☐ Conwy catchment outline
- 🟥 Existing broadleaf woodland
- 🟫 Other prioirity habitat
- 🟧 Habitat establishment possible
- 🟩 Opportunity to extend existing habitat
- 🟦 Water features

Legend
- 🟥 Mitigating land
- 🟧 Negligible "fast flow" concentration
- 🟩 "Fast flow" concentration
- 🟩 High "fast flow" concentration

Sediment, N and P loading also available

N_2O and CH_4 now available (Tier 1)

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Land management interventions tested

- Retain Winter Stubbles
- Allow Woodland Edge to Develop Out into Adjoining Field
- Grazing Management of Open Country
- Grazed Permanent Pasture with No Inputs
- Create Streamside Corridor with Tree Planting
- Mechanical Bracken Control

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Future for LUCI in Wales

- National reporting
- Identify spatial targeting of payments
- How to build in greater resilience
- Identifying alternative interventions they be paying for
- In field assessment and self-reporting by farmers using a LUCI app (linked to 'Mysoil' app – 12million web hits, 12000 users)
- Information for cost-benefit analysis
- National accounts!?

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GMEP data also will help deliver to many other national and international requirements:

EC Rural Development Plan +

– Water Framework Directive

– Habitats and Bird Directive

– Convention on Biological Diversity

– Kyoto/UN Framework Convention on Climate Change

– etc

- Metrics (e.g. LUC) used <u>must</u> be consistent across these e.g. landcover change also drives LULUCF GHG reporting

3 model comparisons in progress
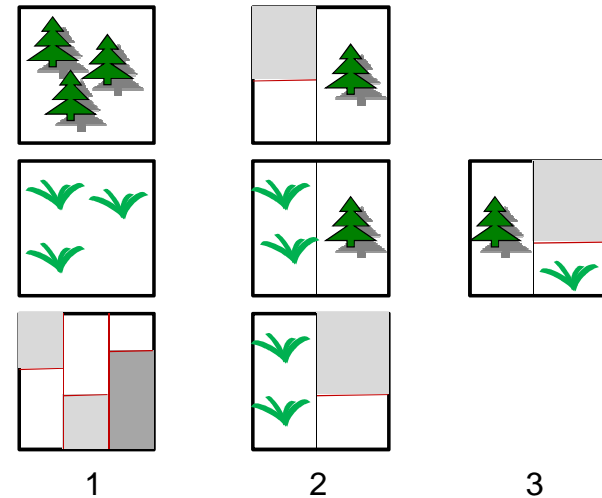
Model inter-comparison 1 (River basin scale)

Models: LUCI; InVEST; ARIES

Spatial context to ecosystem service provision

The role of pattern, configuration, composition, size of landscape units for a test river basin (Conwy, North Wales)

4 services:

- Carbon sequestration
- Water supply
- Water quality regulation
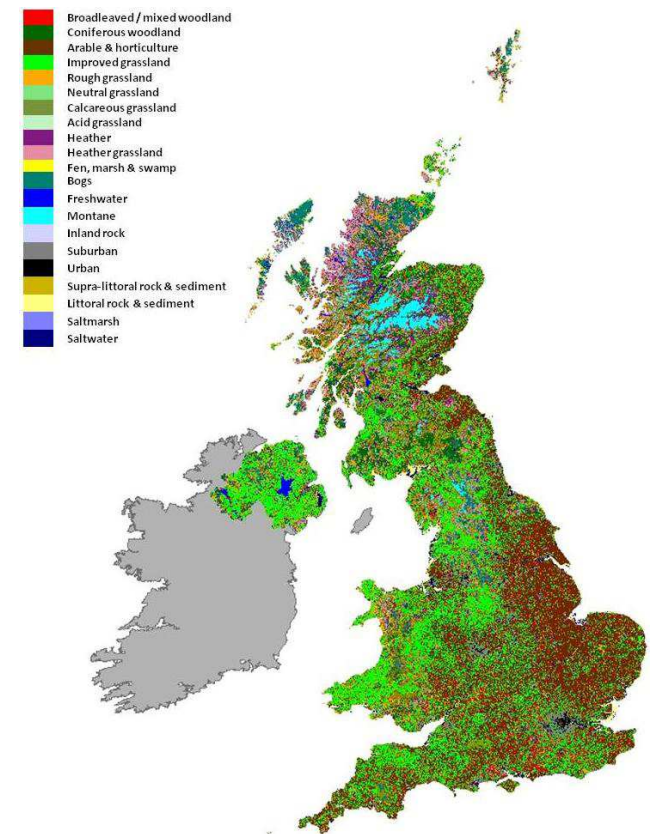- Agricultural production
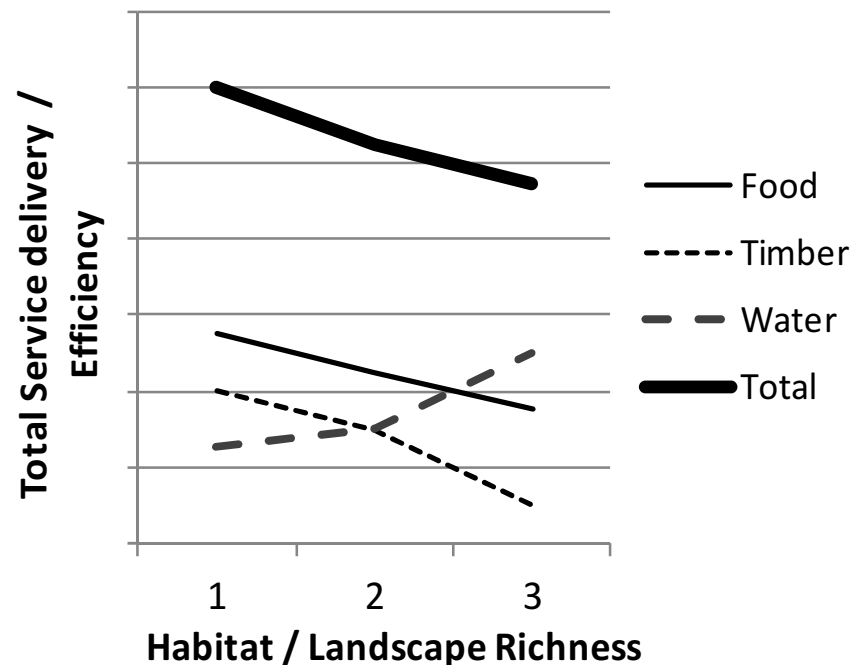
Model inter-comparison 2 (National scale)

Models: LUCI; InVEST;

InVEST application at UK scale in progress

Wales included so comparison of outputs with LUCI outputs possible

4 services:

- Carbon sequestration
- Water supply
- Water quality regulation
- Agricultural production

Legend:
- Broadleaved / mixed woodland
- Coniferous woodland
- Arable & horticulture
- Improved grassland
- Rough grassland
- Neutral grassland
- Calcareous grassland
- Acid grassland
- Heather
- Heather grassland
- Fen, marsh & swamp
- Bogs
- Freshwater
- Montane
- Inland rock
- Suburban
- Urban
- Supra-littoral rock & sediment
- Littoral rock & sediment
- Saltmarsh
- Saltwater

Model Intercomparison 3 (Multiple national scale)

Models: Co$ting Nature; InVEST; ARIES

Overarching Aim: : Which Ecosystem Service Models Best Capture the Needs of the Rural Poor in sub-Saharan Africa?"

Obj 1: To explore the appropriate level of model complexity required to map, in sufficient detail to inform policy, ES of importance to poverty alleviation in sub-Saharan Africa.

Ob. 2: To explore the potential and synergies of existing models of ES to make explicit the links between services, their benefit flows and human wellbeing changes of the poor.

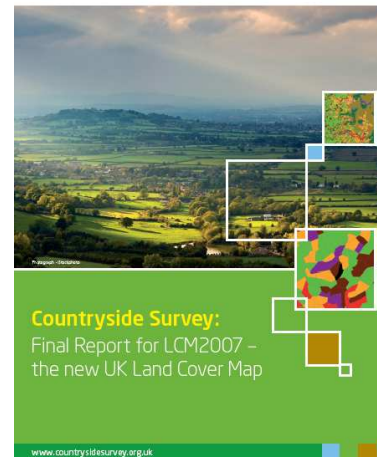| Country	Biophysical data						Beneficiary data				
	P	Cro	Stor	NTF	Gra	Polli	Cro	NTF	Gra	Polli	
Benin				✓				✓			
Burkina Faso			✓					✓			
Cameroon				✓				✓			
Equatorial Guinea				✓				✓			
Ethiopia	✓						✓				
Ghana			✓	✓				✓	✓		
Kenya	✓			✓	✓		✓		✓	✓	
Malawi	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Namibia				✓				✓			
Nigeria				✓				✓			
Sierra Leone					✓					✓	
South Africa	✓	✓	✓	✓	✓	✓		✓			
Tanzania	✓	✓	✓	✓			✓	✓	✓		
Uganda				✓				✓			
Zambia	✓				✓	✓		✓			

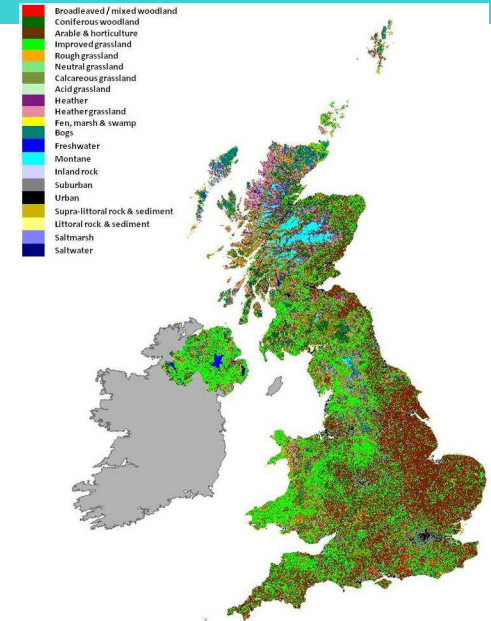# Questions?

bae@ceh.ac.uk

The UK is rich in data to enable integrated assessments such as that required by SEEA

- Landcover maps at 25m resolution , soils, DEM etc

- Integrated Monitoring Programmes e.g. Countryside Survey

- EU Inspire directive and UK data.gov.uk

www.countryside.org.uk