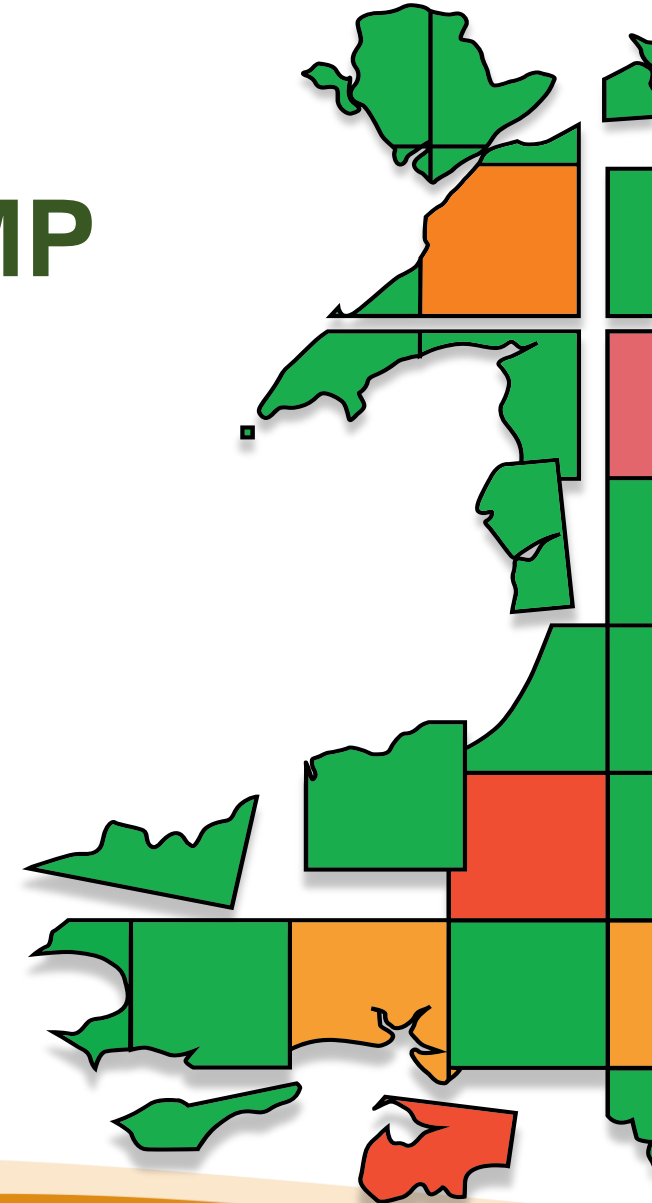


# Welcome & Introduction to ERAMMP Partner Consortium

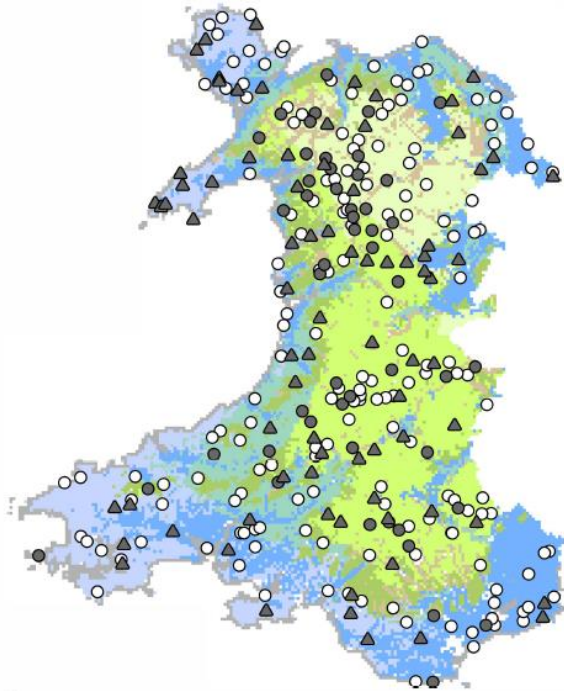
**Dr Alan Radbourne**

*UK Centre for Ecology & Hydrology*



# Monitoring

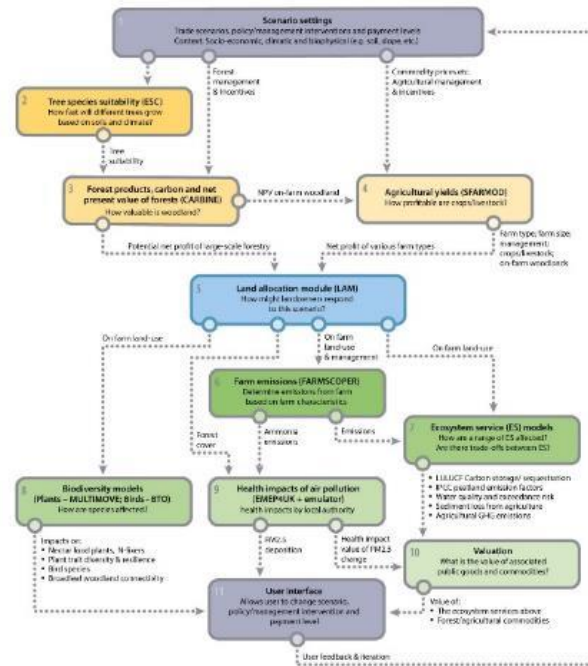
The longest running integrated national monitoring programme in the UK



# Three key elements

## Modelling

Exploring policy options and outcomes



# Evidence Provision

What we do know; what we don't know; trade-offs and co-benefits



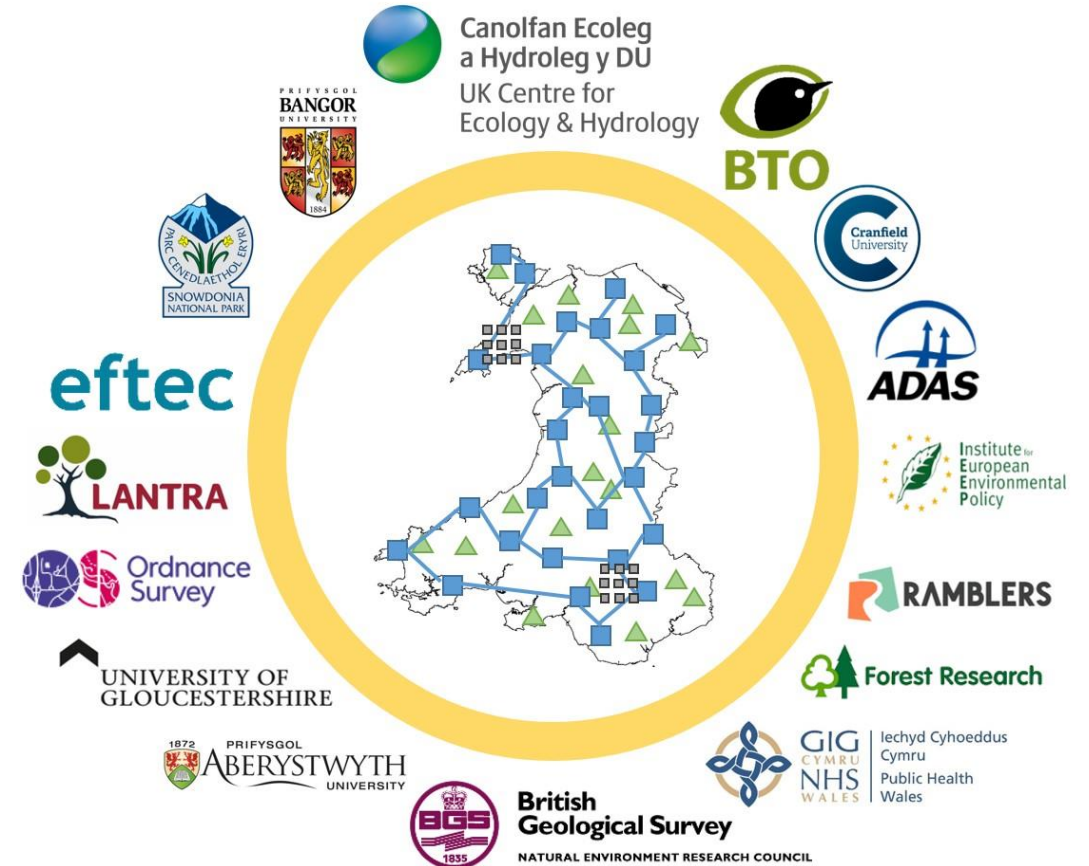
# Delivery through a 20 year community partnership

**Objectives:** To provide ongoing evidence and support for a wide range of evidence and modelling requirements

**Who:** 17 partners to ensure capability to cover agriculture, forestry, tourism, air, soil, water, climate, biodiversity, public health and well-being, economics and more....

**What:** A 10 year programme building on the last 10 years of collaboration (2012 – 2022 GMEP & ERAMMP'1')

**Funding:** Welsh Gov, with the programme led by UKCEH and past co-funding

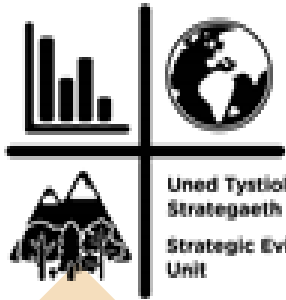


# Monitoring Sustainable Land Management in Wales – potential indicators

**Professor Bridget Emmett**

*UKCEH Head of Soils and Land Use*

*UK Centre for Ecology & Hydrology*

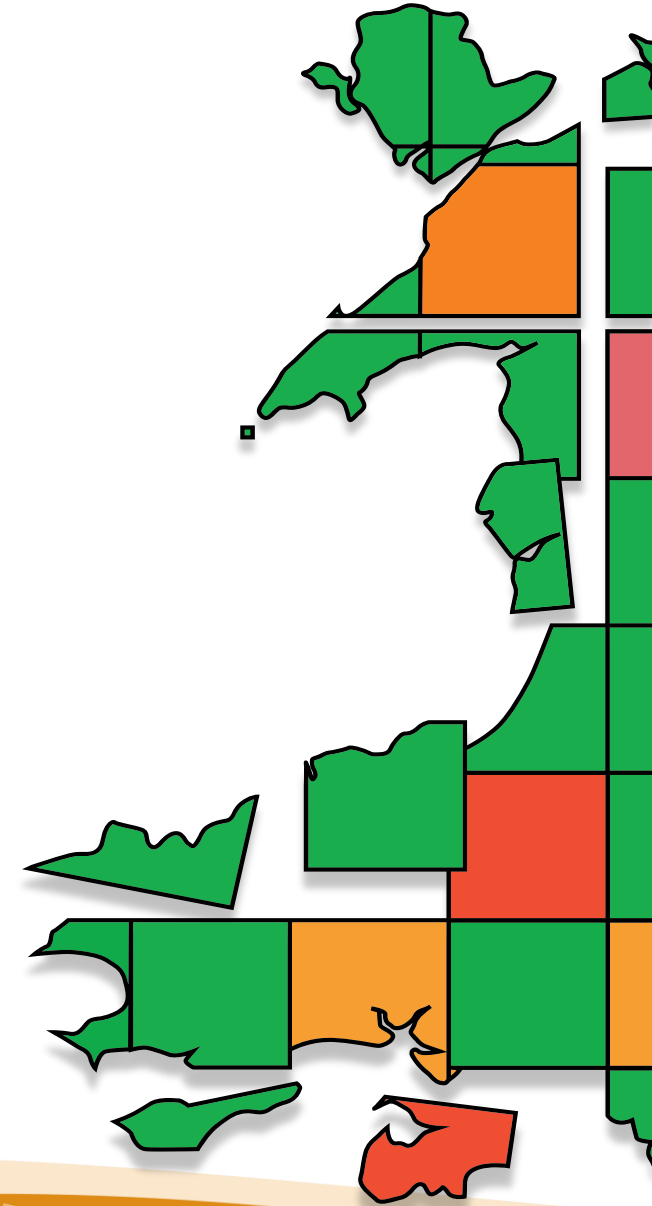


Uned Tystiolaeth  
Strategaeth  
Strategic Evidence  
Unit

Codi hyder ym sail  
tystiolaeth ni  
Building confidence in our  
evidence base



Canolfan Ecoleg  
a Hydroleg y DU  
UK Centre for  
Ecology & Hydrology



Llywodraeth Cymru  
Welsh Government



Canolfan Ecoleg  
a Hydroleg y DU  
UK Centre for  
Ecology & Hydrology

# Sustainable Land Management Objectives

- Sustainable production of food and other goods
- Mitigate and adapt to climate
- Maintain and enhance the resilience of ecosystems and the benefits they provide
  - (a) diversity between and within ecosystems;
  - (b) the connections between and within ecosystems;
  - (c) the scale of ecosystems;
  - (d) the condition of ecosystems (including their structure and functioning);
  - (e) the adaptability of ecosystems
- Conserve and enhance the countryside and cultural resources and promote public access to and engagement with them, and to sustain the Welsh language and promote and facilitate its use

**One distinct indicator and one distinct target is required for each objective  
(Dec 2025)**



Canolfan Ecoleg  
a Hydroleg y DU  
UK Centre for  
Ecology & Hydrology

Llywodraeth Cymru  
Welsh Government

# What makes a good indicator?

- Relevant
- Efficient
- Representative
- Can be linked to historic data (but also exploits new technology)
- Easily understood
- Reliable and reproducible.

Also can be:

- Individual indicator
- Aggregate indicator (if so – transparency needed how weighted)
- Proxy indicator

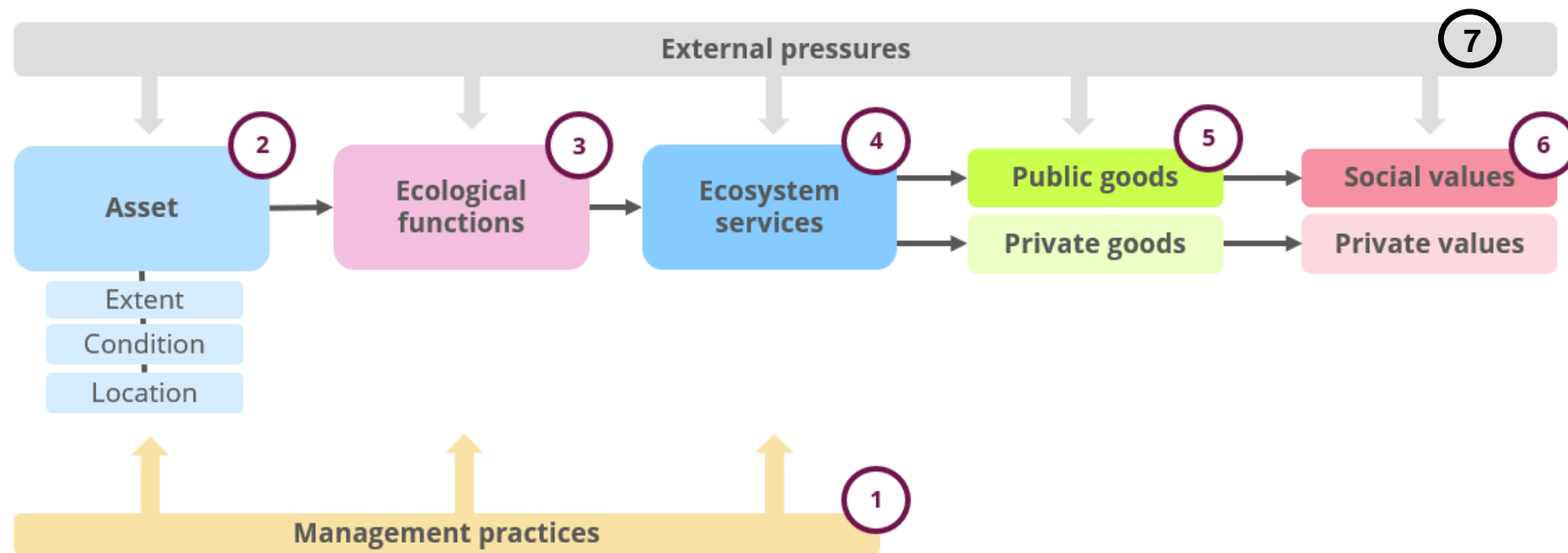


Llywodraeth Cymru  
Welsh Government



Canolfan Ecoleg  
a Hydroleg y DU  
UK Centre for  
Ecology & Hydrology

# An indicator can also be at any step in the Logic Chain Approach



1. **Management practices**
2. **Asset**
3. **Ecological functions**

4. **Ecosystem services**
5. **Public goods**
6. **Social values**

7. **External pressures**



# Past GMEP community work in this area agreed we need to .....

- Work collaboratively
- Service a wide customer base
- Collect once – re-use often
- Optimise and target
- Sharing of data
- Modelling and scenarios testing
- Rapid feedback to policy

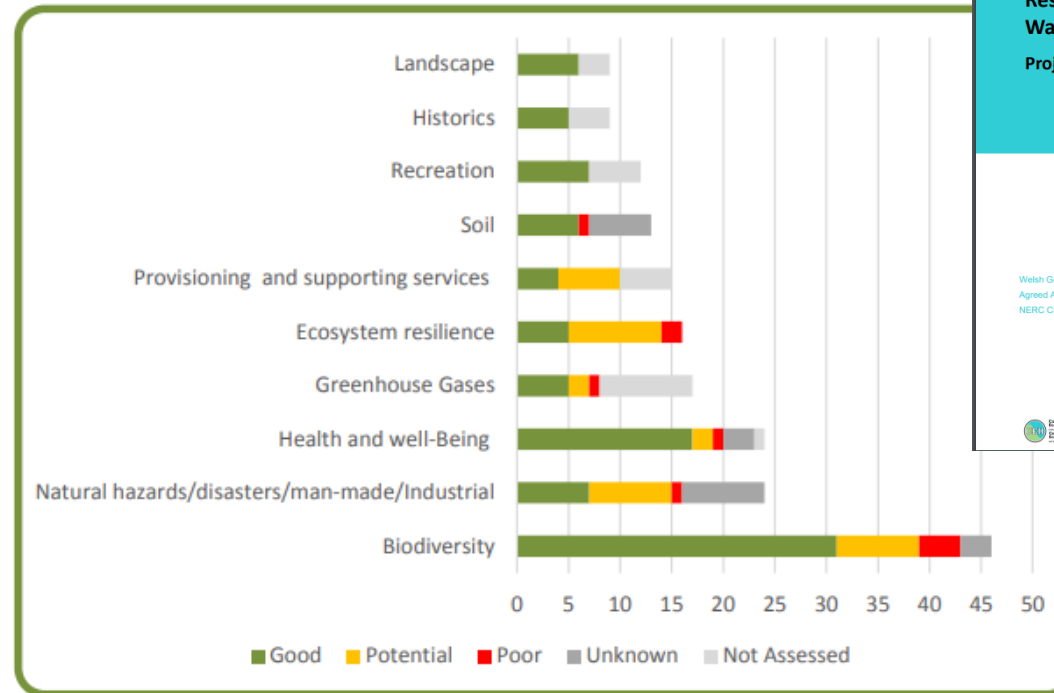


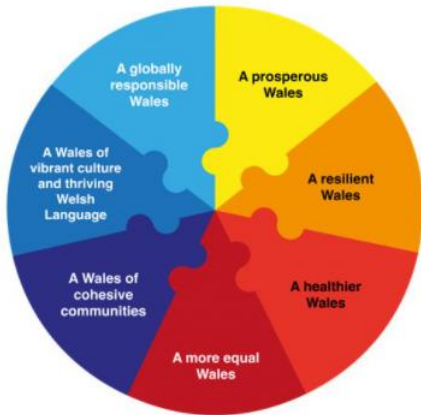
Figure 3: Number of monitoring schemes in the land-based sector and an assessment of their likely relevance/utility for a NRMF – View 1



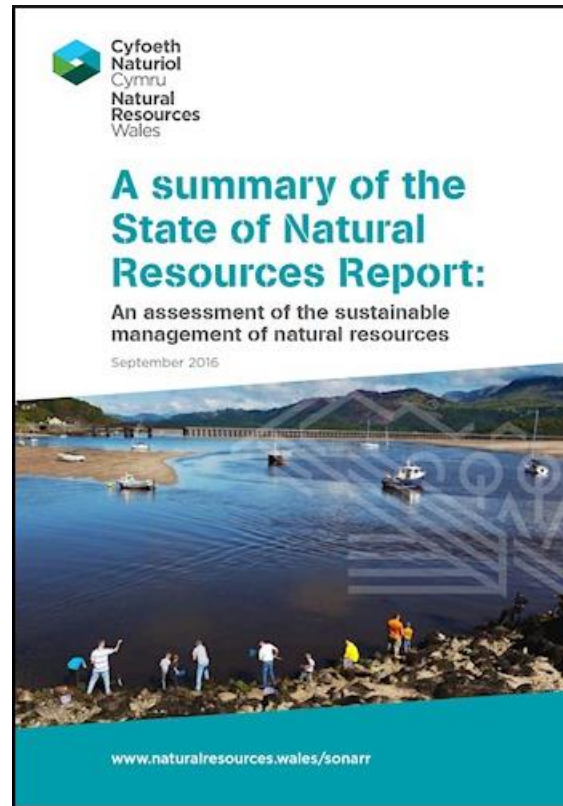


# Current reporting lines

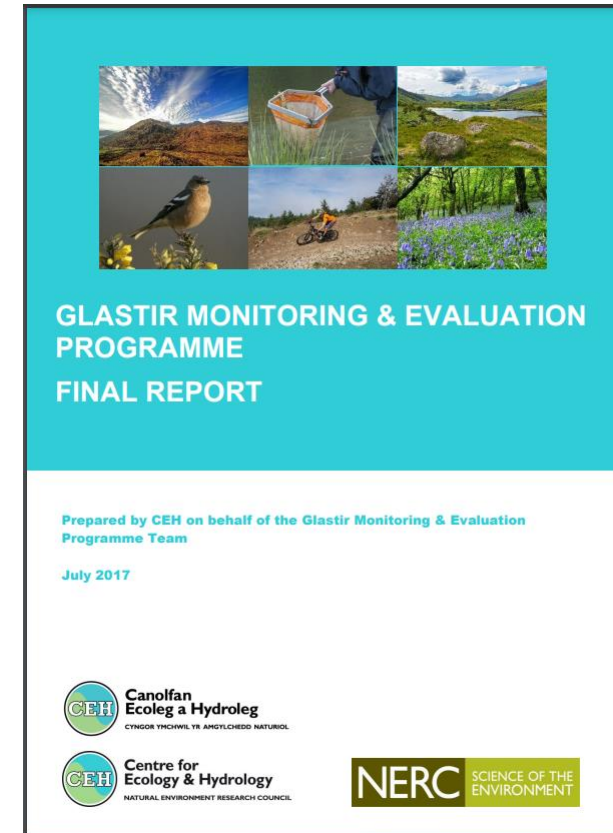
## WFG National Indicators



## SoNaRR



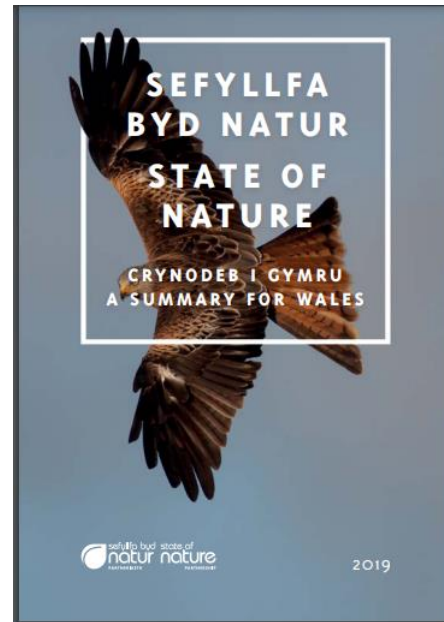
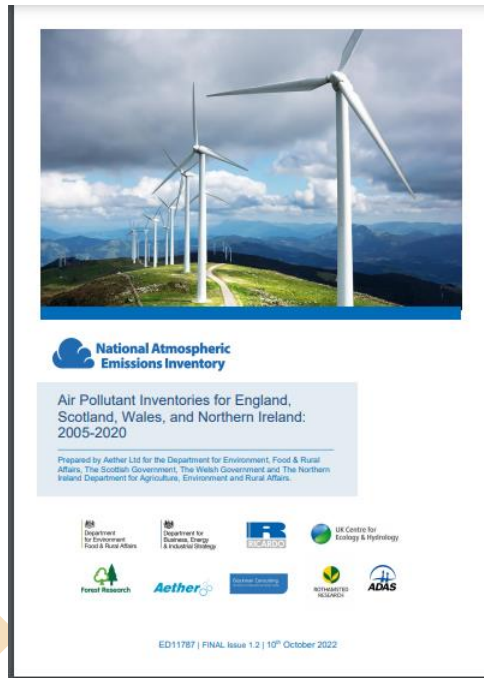
## GMEP/ERAMMP



# And.....

## National Atmospheric Emissions Inventory

Title: Devolved Administration GHG Inventory 1990-2020



Office for National Statistics

Statistical bulletin

## UK natural capital: ecosystem accounts for freshwater, farmland and woodland

Natural capital accounts for freshwater, farmland and woodland have been developed with categories not previously included. Methodology is experimental and some services are not currently measured.



Llywodraeth Cymru  
Welsh Government

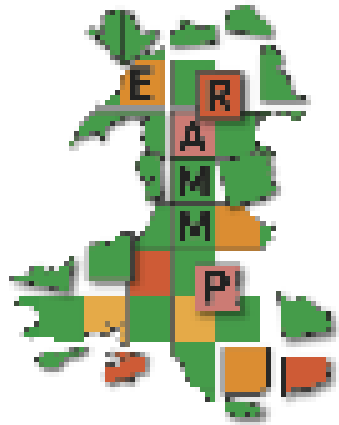


Canolfan Ecoleg a Hydroleg y DU  
UK Centre for Ecology & Hydrology

# National robust data sources (field, EO, citizen, social, modelling....)



Cyfoeth Naturiol Cymru  
Natural Resources Wales



etc..



Biological  
Records Centre

etc...



Forest Research



UK Centre for  
Ecology & Hydrology



LIVING  
WALES



Llywodraeth Cymru  
Welsh Government

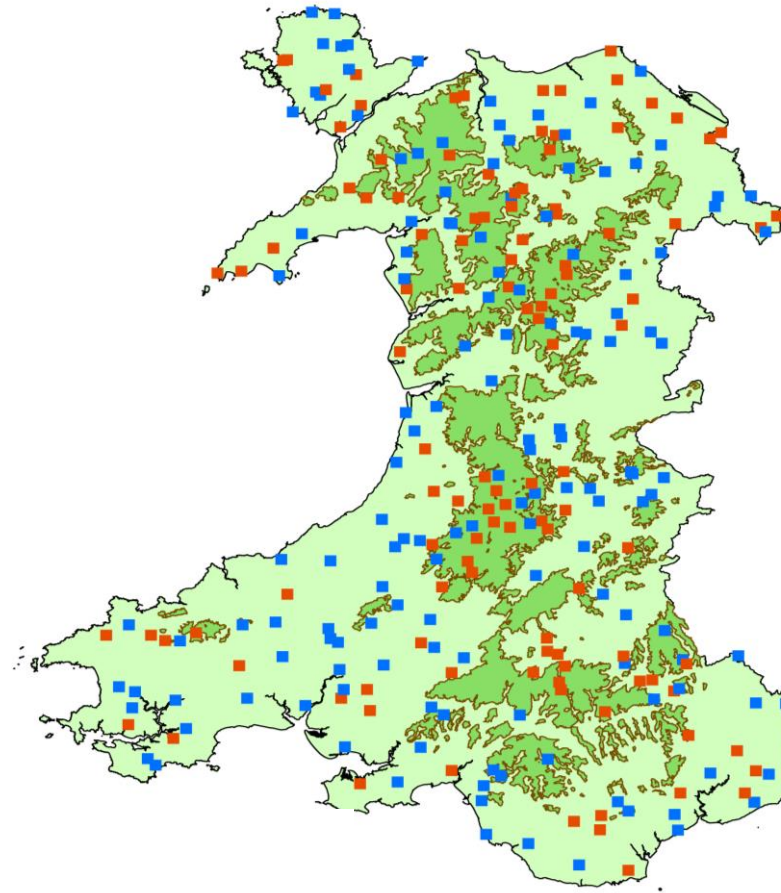


Canolfan Ecoleg  
a Hydroleg y DU  
UK Centre for  
Ecology & Hydrology

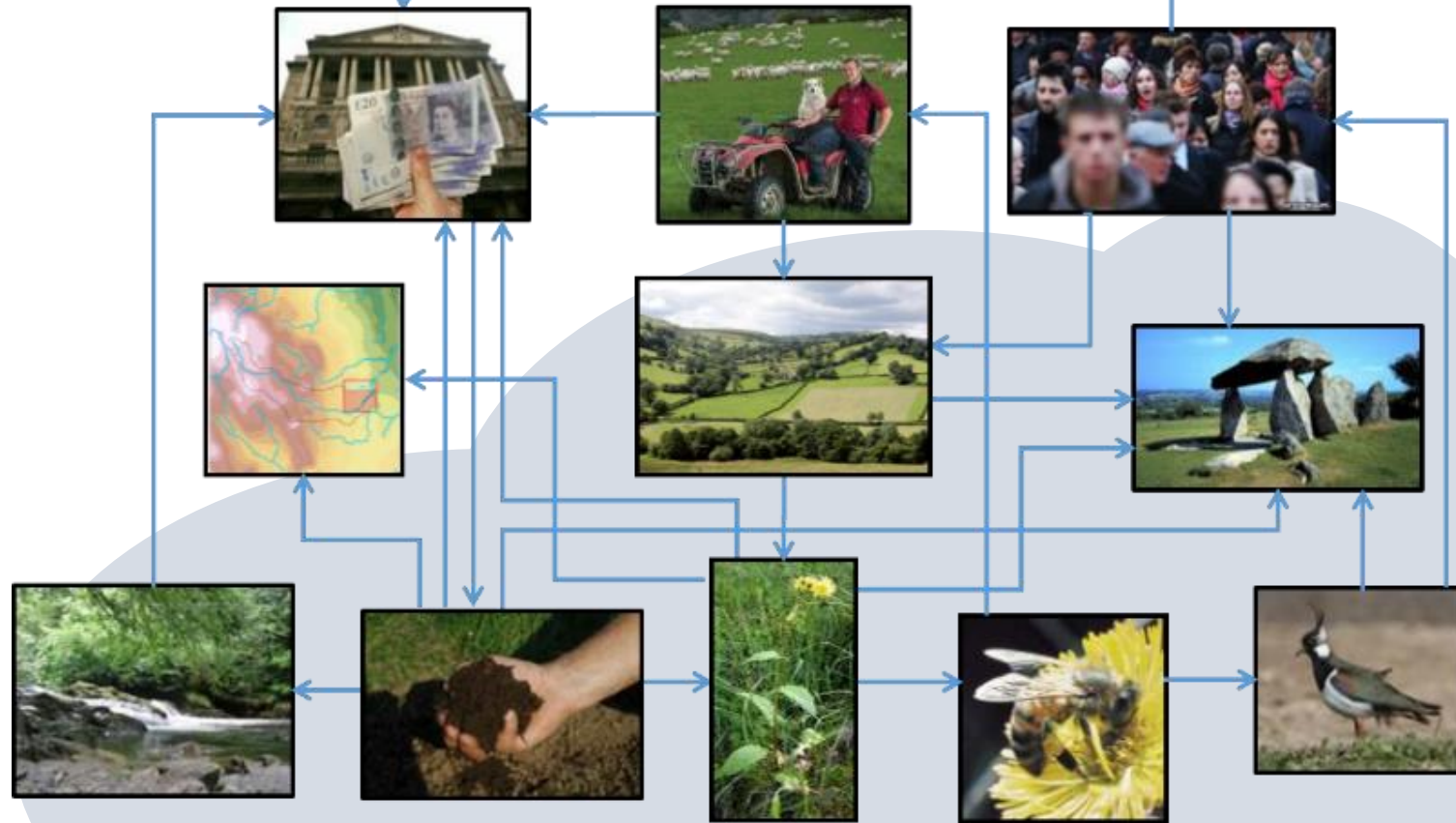
# One data source is the GMEP / ERAMMP National Field survey

- Vegetation composition
- Pollinator surveys
- Bird surveys
- Woodland and woody linear feature mapping
- Soil sampling and peat depth
- Soil erosion
- Ponds
- Headwater streams
- Landscape photography
- Historic environment features
- Public footpaths

All co-located in a carefully selected set of 300  
1km squares to provide nationally representative  
statistics of the state of the wider countryside



# Co-located measurements to identify inter-dependencies

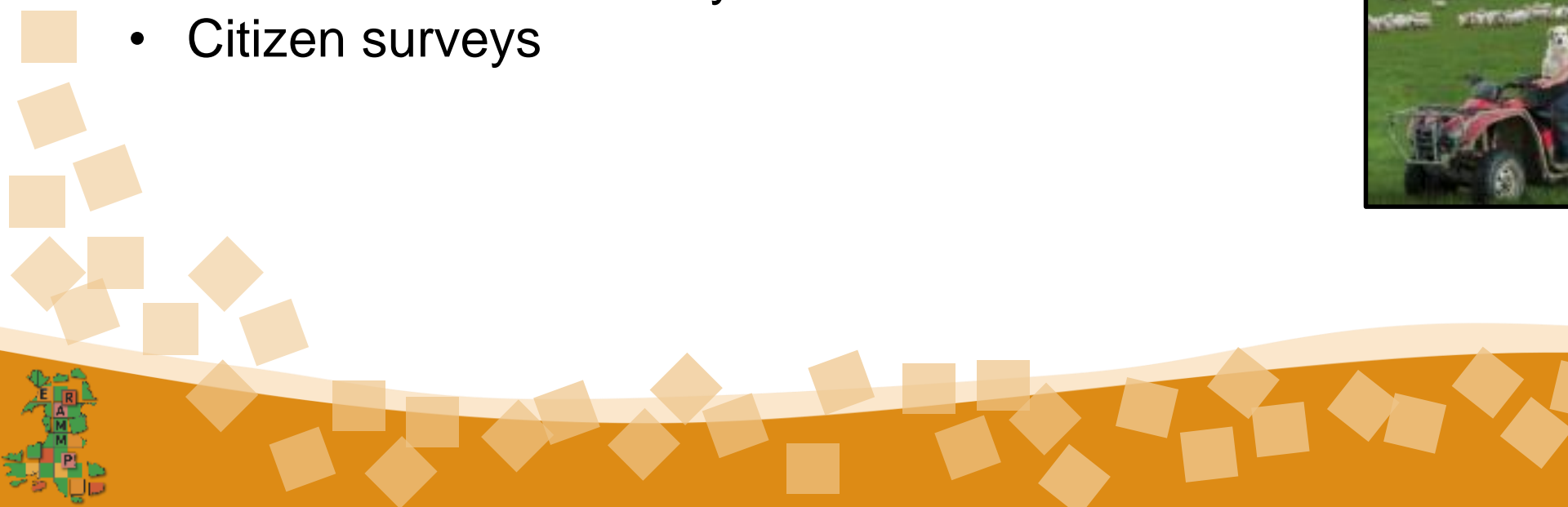
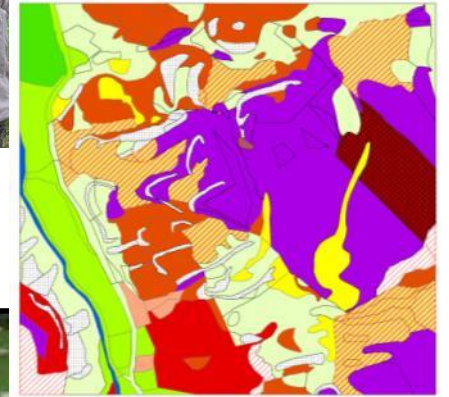


Blue indicates - captured in field survey. Other outcomes through farmer surveys, modelling and economic analysis use different approaches



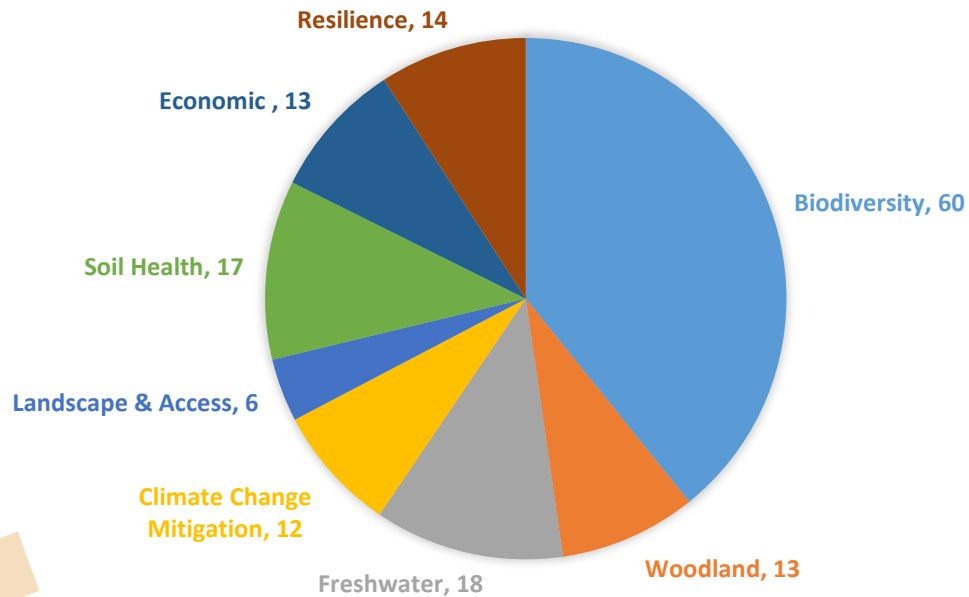
# GMEP/ERAMMP also captures additional evidence through..

- Citizen science
- Earth Observation, aerial photography, LiDAR
- Modelling
- Carbon footprinting
- Farmer Practice Surveys
- Citizen surveys

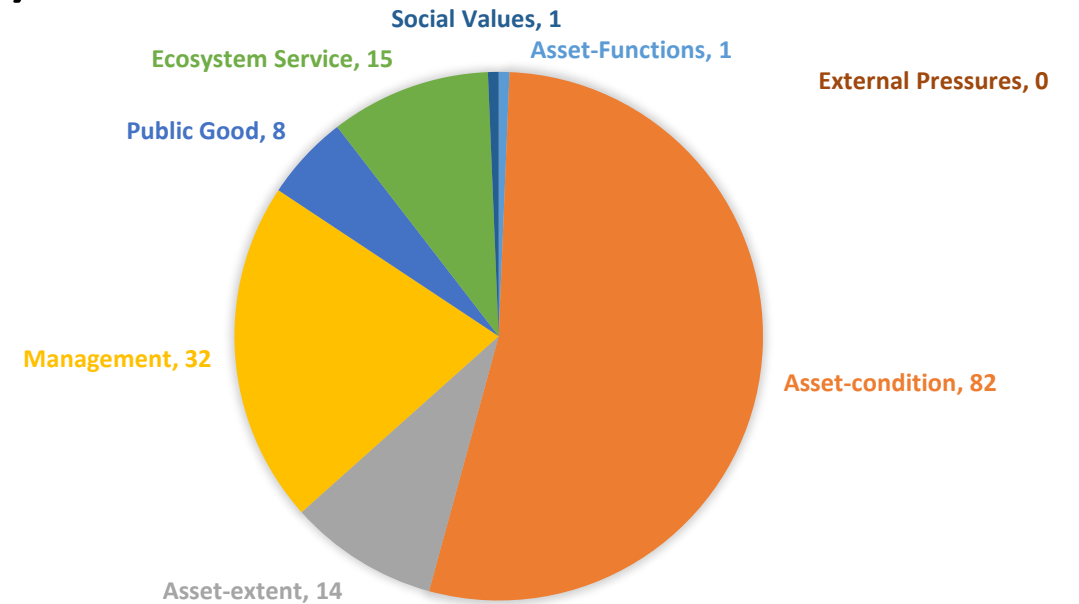


# Categories (and number) of indicators GMEP/ERAMMP indicators reported in the past by: a) Glastir objectives and b) logic chain stages

a)

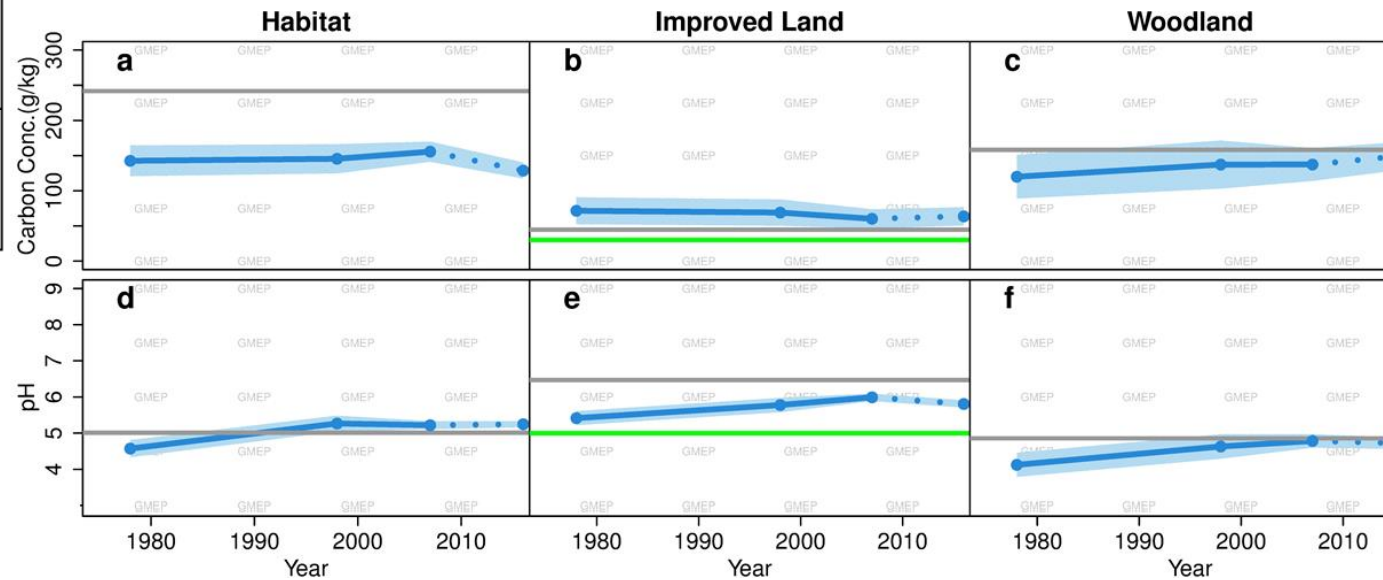


b)



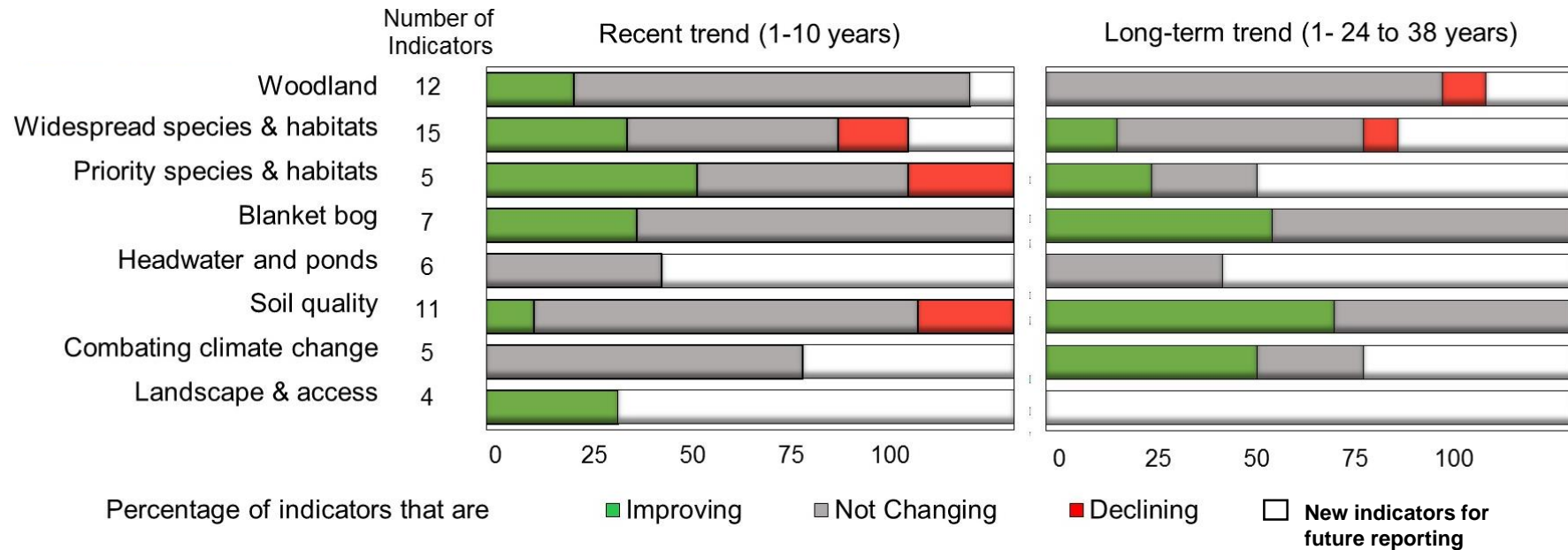
# National data tables and trends (e.g. soil carbon)

Indicator	Countryside Survey <sup>3</sup>				GMEP 2013-16	Significant differences		In scheme compared to national average
	1978	1990	1998	2007		Overall	Latest period	
Improved land	71.6		69.0	60.2	63.7	=	=	=
Habitat land	142.6		145.5	155.6	128.8	=	-	=
Woodland	120.0		137.3	137.3	150.0	+	=	=





# But then we need easily accessible summaries of what is improving, declining and stable in short and long term



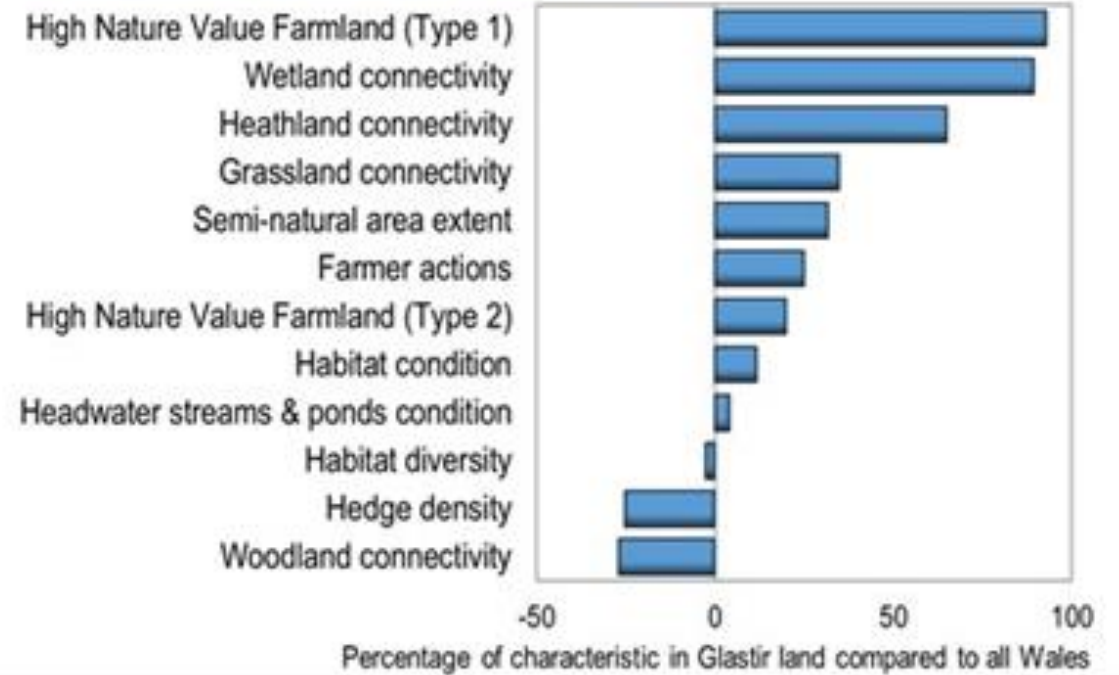
# And then we can convert the field survey data into elements linked to resilience

## The DECCA concept of resilience:

- **D**iversity
- **E**xtent
- **C**ondition
- **C**onnectivity
- **(A**daptive capacity)

Land coming into the Glastir scheme is already more 'resilient' than rest of Wales  
GMEP report (2017)

### Characteristics of land related to resilience:



# And Natural Capital Accounts....

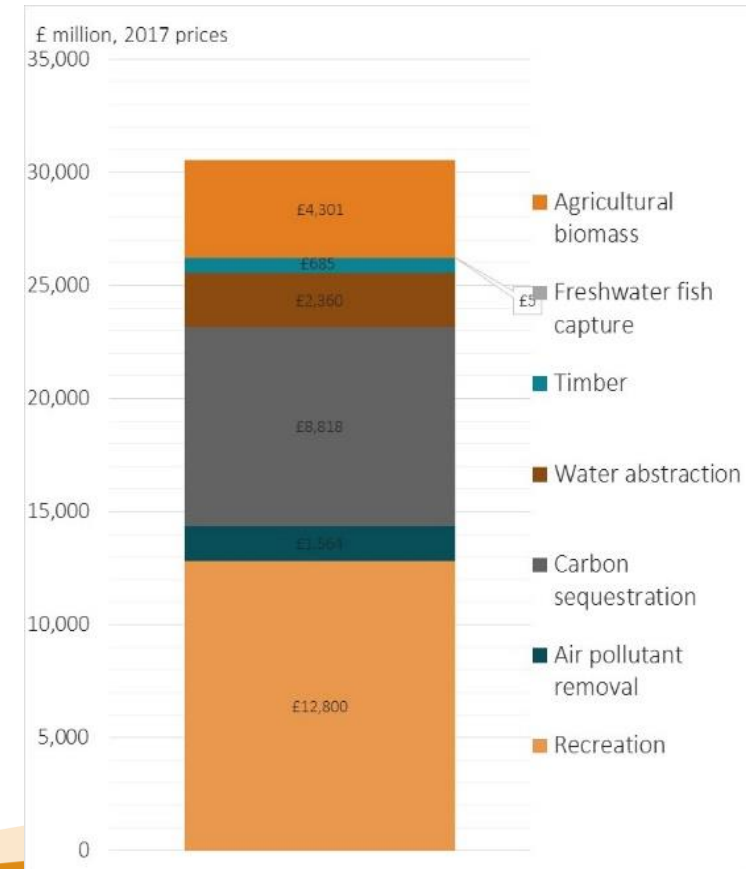
Accounts and valuation (where that's possible) of the benefits we derive from our Natural Resources working with the Office of National Statistics

**Farmland, Forestry and Freshwater = £30.5 billion pa**

**76%** is not captured in standard GDP assessment

Recognition the accounts are incomplete as standardised methods are unavailable for all services  
Other sources of evidence need to be included in any policy decision.

## Natural Capital Accounts for Wales for Farmland, Forestry and Freshwater



# Challenges and opportunities going forward

- A focus on Sustainable Land Management and SMNR
- How to aggregate individual indicators to provide a single indicator for each SLM objective
- Recognise the benefits of better alignment of programmes and indicators across the UK whilst recognising devolved needs
- Monitoring of designated land is a gap
- Land to sea transfer and interface is poorly captured
- Citizen science versus citizen engagement – being clear which and when its appropriate
- Better exploitation of new technologies e.g. remote sensing but recognising it can't do everything
- Integration of monitoring and modelling / environmental and social data
- Data access and sharing whilst protecting personal data



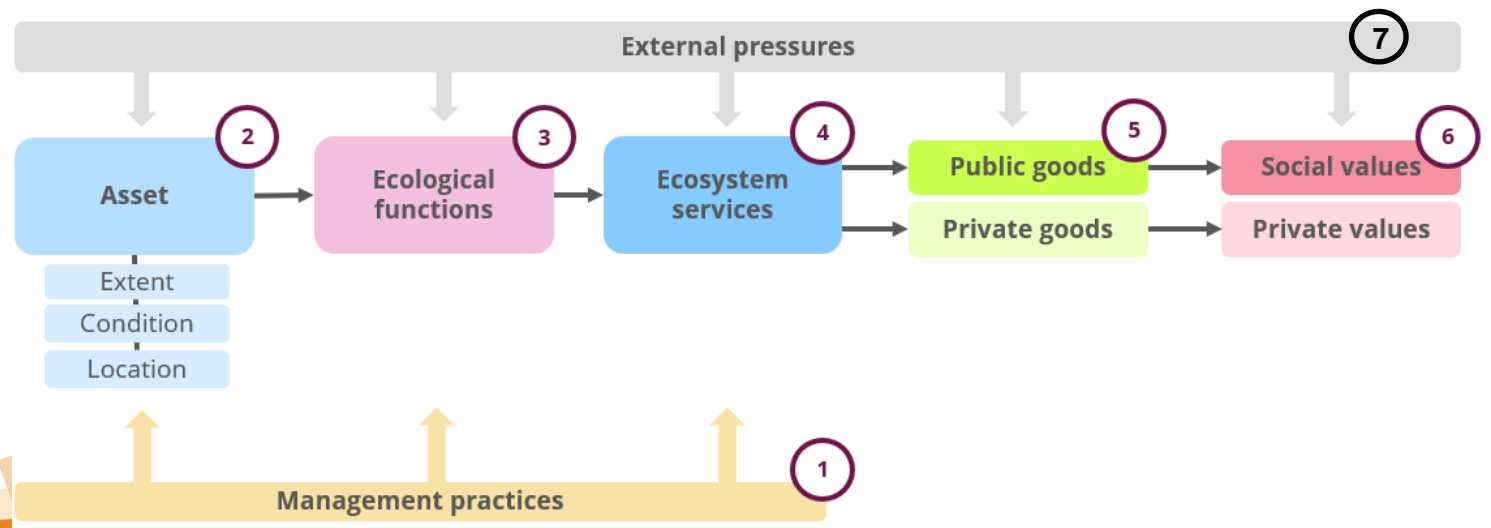
Llywodraeth Cymru  
Welsh Government



Canolfan Ecoleg  
a Hydroleg y DU  
UK Centre for  
Ecology & Hydrology

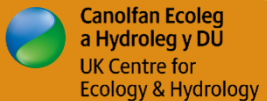
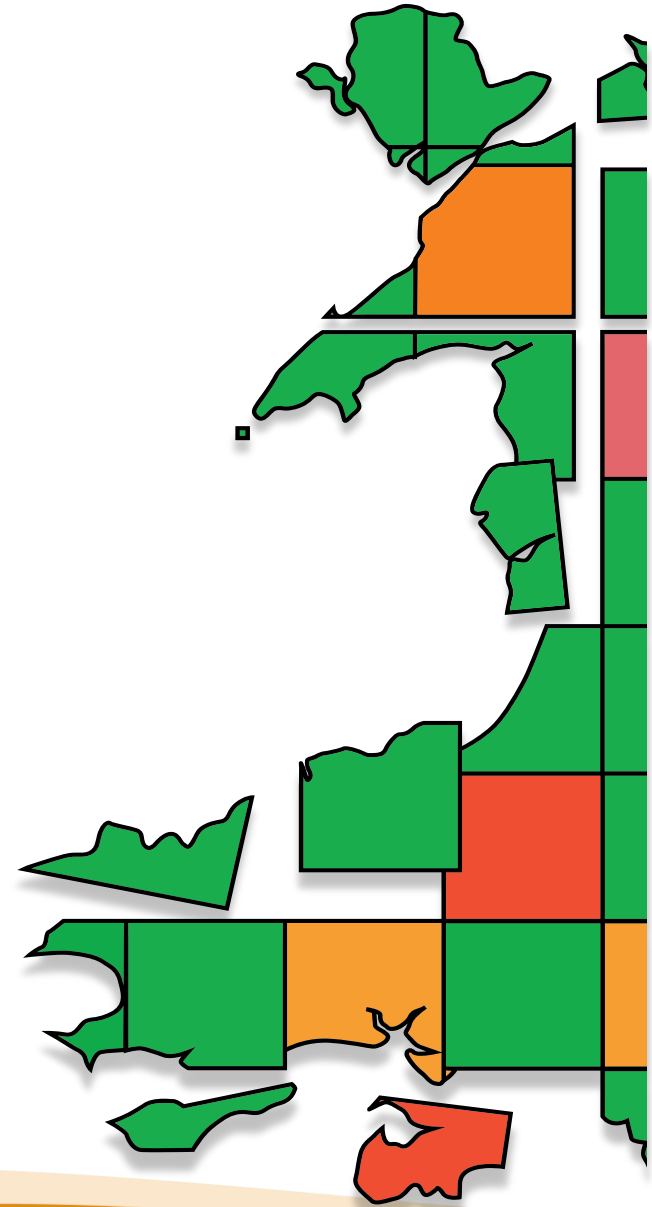
# Questions for you.....

1. What should be the balance across the logic chain?
2. What indicators will resonate with government, stakeholders including the wider public
3. How to aggregate to provide a single indicator for each SLM objective – “one out / all out”?
4. What have we missed?
  - End points for sustainable land management?
  - Data sources?
  - Other?



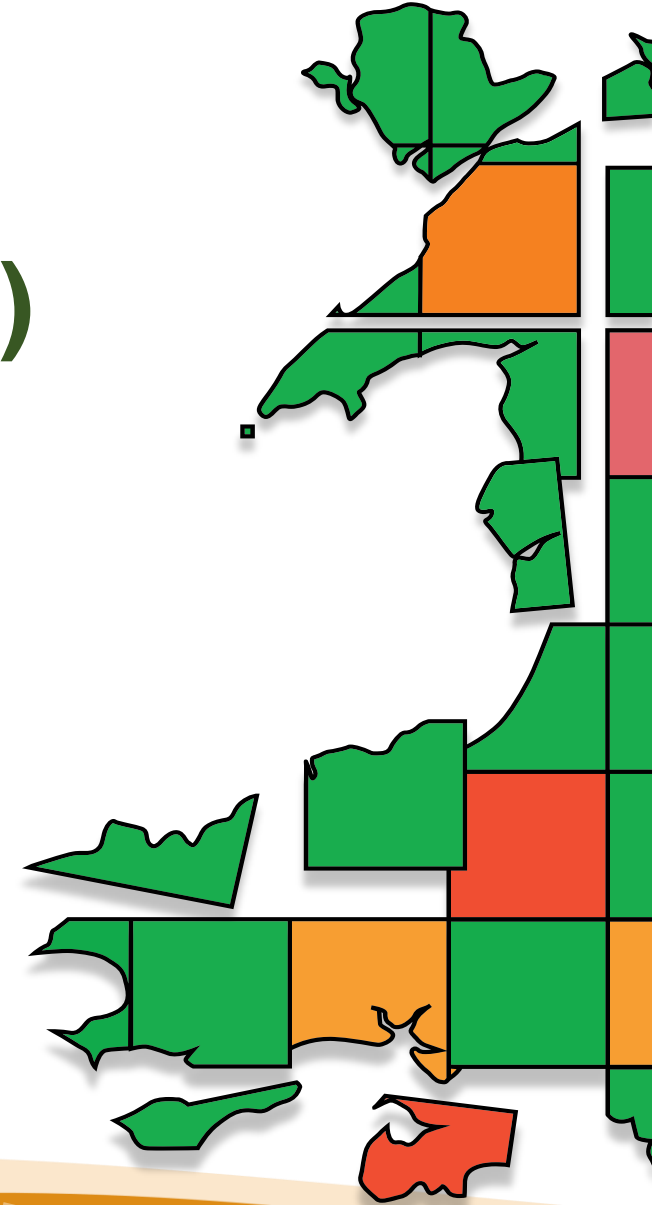
**Thank you  
Diolch!**

**[www.erammp.cymru](http://www.erammp.cymru)  
[www.erammp.wales](http://www.erammp.wales)**



# The ERAMMP Integrated Modelling Platform (IMP)

**Professor Paula Harrison**  
*UK Centre for Ecology & Hydrology*



# The complexity of modelling land use and environment

**MULTIPLE DRIVERS**

**COMPLEX INTERACTIONS**

Between Drivers

Between Sectors

Across Space

**COMPLEX CHALLENGES  
... AND OPPORTUNITIES**

How to incentivise change?

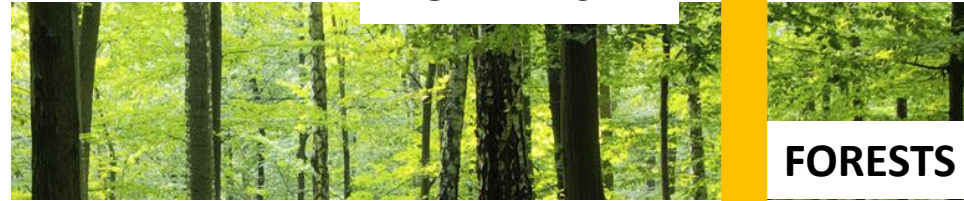
How to maximise synergies ...

... and avoid unexpected trade offs!

**AGRICULTURE**

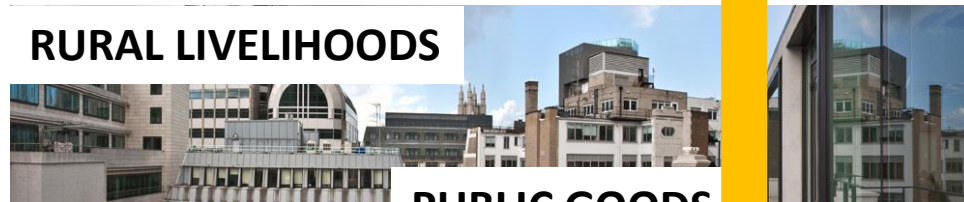


**BIODIVERSITY**



**FORESTS**

**RURAL LIVELIHOODS**



**PUBLIC GOODS**



**ENVIRONMENT**





# Scenario and modelling platforms

**Scenarios:** Combine consistent changes in multiple drivers to portray a range of plausible futures for a region.

**Models:** Simulate consequences of scenarios and enable exploration of the effectiveness of policy options and management strategies.

## Integrated Modelling Approaches:

- Integrated models **build understanding of the complex interdependencies** within human-environment systems and allow exploration of responses that are robust to multiple uncertain futures and avoid unintended trade-offs.
- Single sector models may misrepresent the **direction, magnitude and spatial pattern** of impacts because they omit these complex interdependencies.



Llywodraeth Cymru  
Welsh Government



Canolfan Ecoleg  
a Hydroleg y DU  
UK Centre for  
Ecology & Hydrology

# Benefits of integrated cross-sectoral modelling

Differences between single sector and integrated models by regions within the EU:

	European Union	Alpine (EU)	Atlantic (EU)	Continental (EU)	Northern (EU)	Southern (EU)
Biodiversity (arable)		↕		↕	↕	
Unmanaged land						
Biodiversity (forest)						↕
Arable land	↕		↕	↕		↕
Intensive agriculture	↕		↕	↕		↕
Extensive grassland	↕		↕	↕		↕
Irrigation						
Carbon storage				↕		↕
Water exploitation index		↕		↕		
Food provision						
Flooded people		↕		↕		↕
Unmanaged forest						
Managed forest						
Urban area						

Change > 100%	
Change > 50%	
Change > 25%	
Change > 5%	
Change < 5%	

↕ Direction of change differs between single sector and integrated models

Harrison et al. (2016). Climate change impact modelling needs to include cross-sectoral interactions. *Nature Climate Change*, 6(9): 885-890.



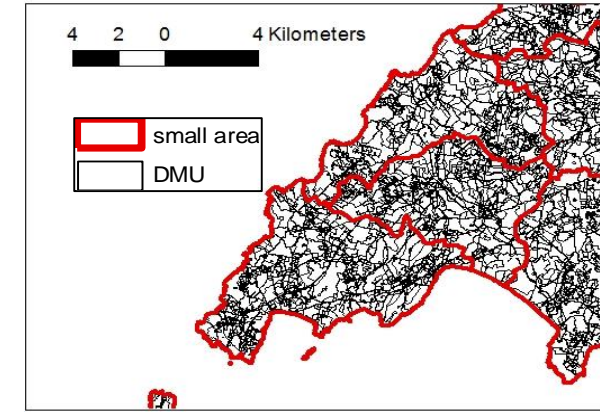
# What is the ERAMMP IMP?

- A tool for rapid exploration of the effects of policy and management interventions on farm viability, land use and public goods in Wales.
- It takes an integrated approach, recognising that policy effects in one sector have indirect effects in other sectors.
- It comprises a chain of specialised, state-of-the-art models covering agriculture, forestry, land use allocation decisions, biodiversity, ecosystem services (water quality, air quality and carbon/greenhouse gases) and their valuation.
- User specified interventions and model outputs are aligned where possible to support and inform policy development:
  - Post EU Exit trade deals
  - Sustainable Farming Scheme (Ongoing)

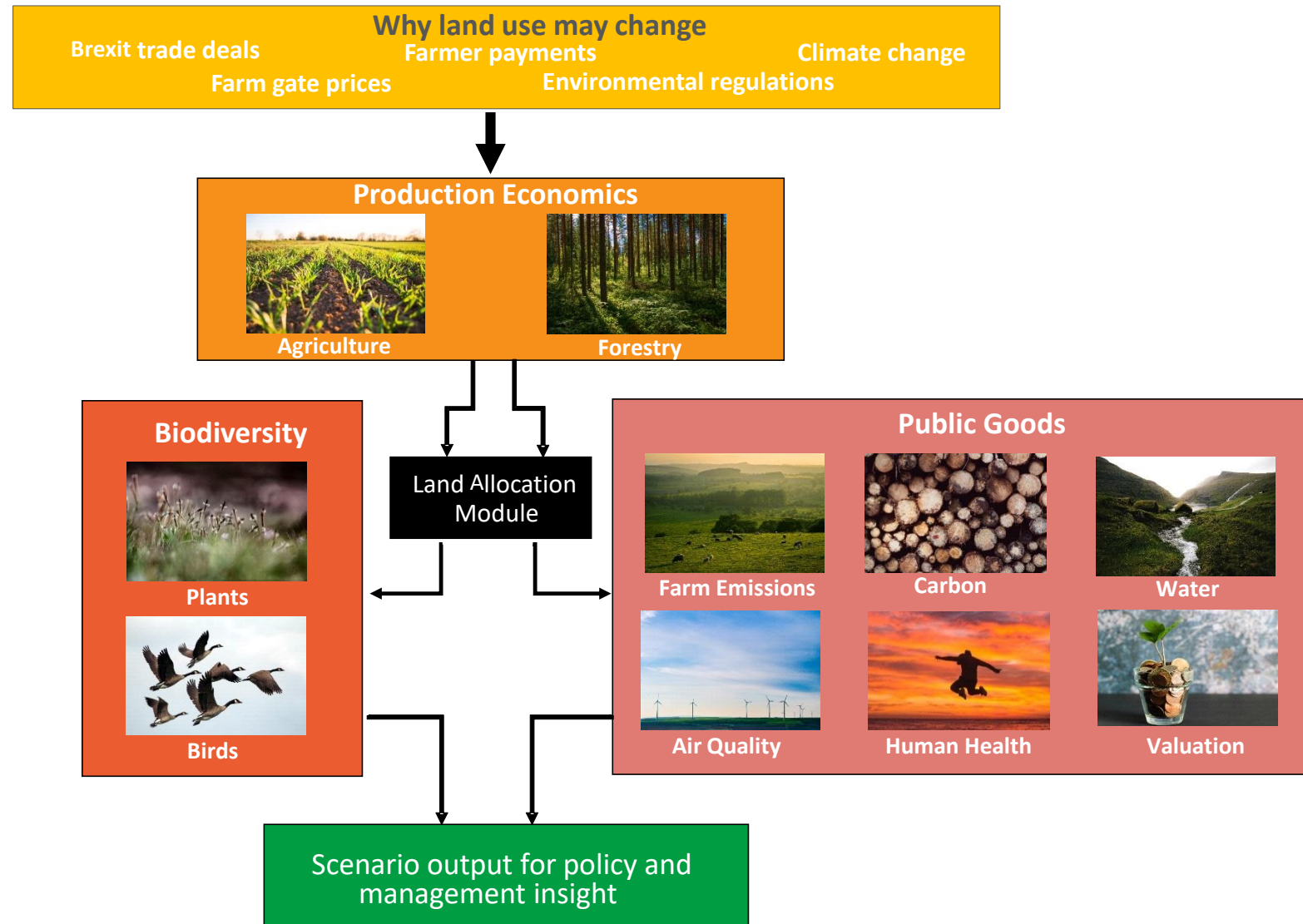


# What is the ERAMMP IMP?

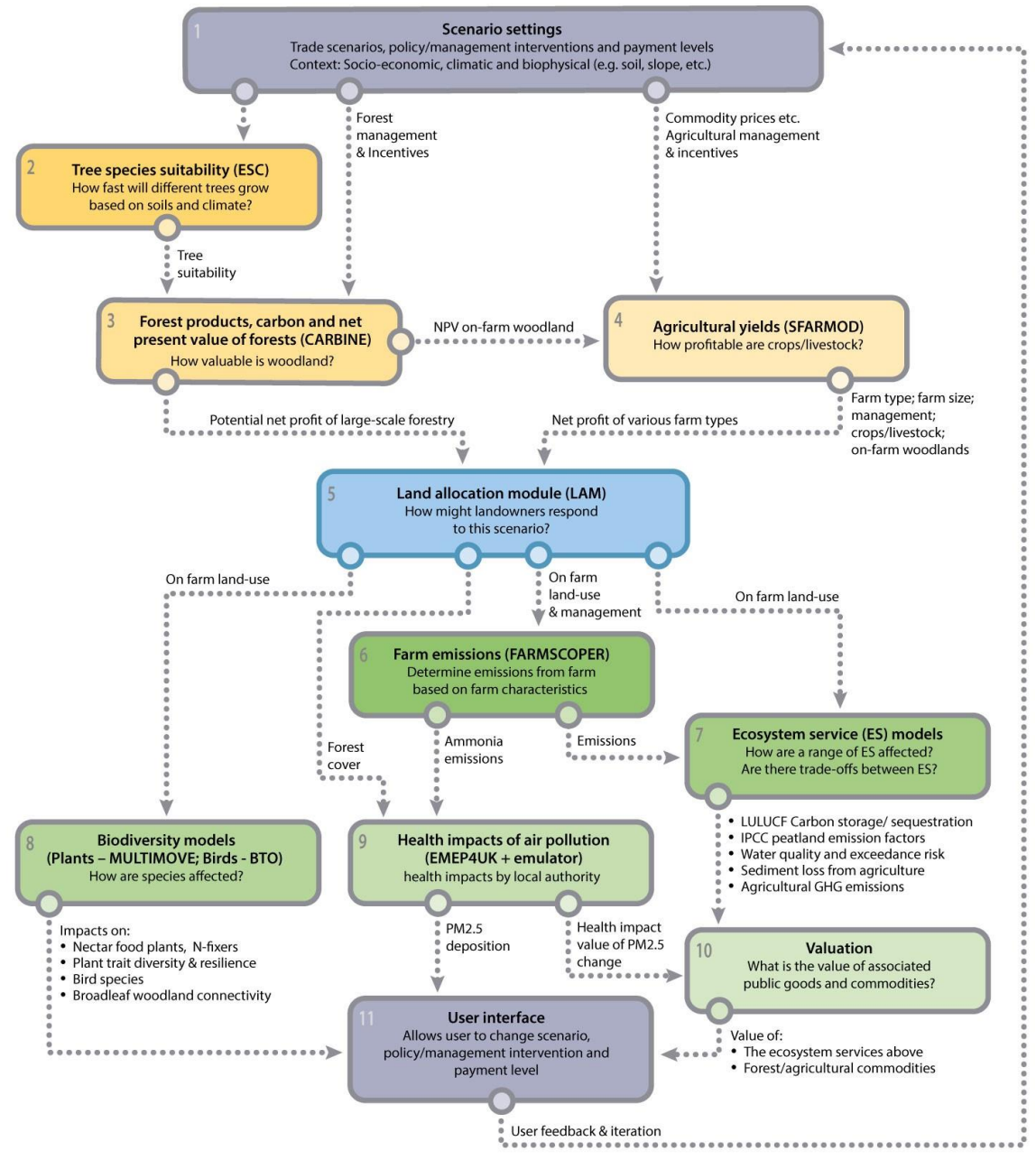
- **It is highly spatially resolved:**
  - The IMP operates at various spatial resolutions depending on what scale is most appropriate for the indicator being simulated.
  - The finest spatial resolution is used for simulating farm type and land use transitions is the Decision-Making Unit (DMU).
  - A DMU is sub-farm (often field-scale) defined as a managerially homogenous cluster of soil type, rainfall and land cover.



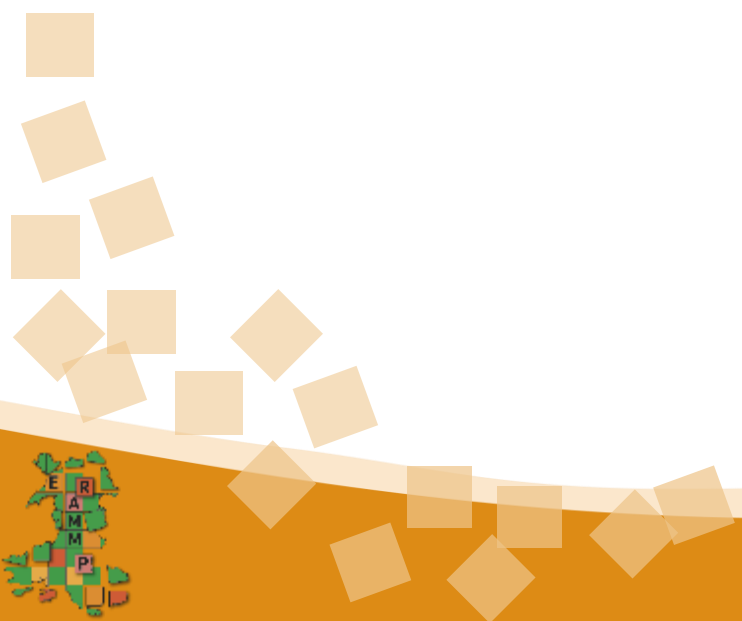
# A simplified overview of the IMP



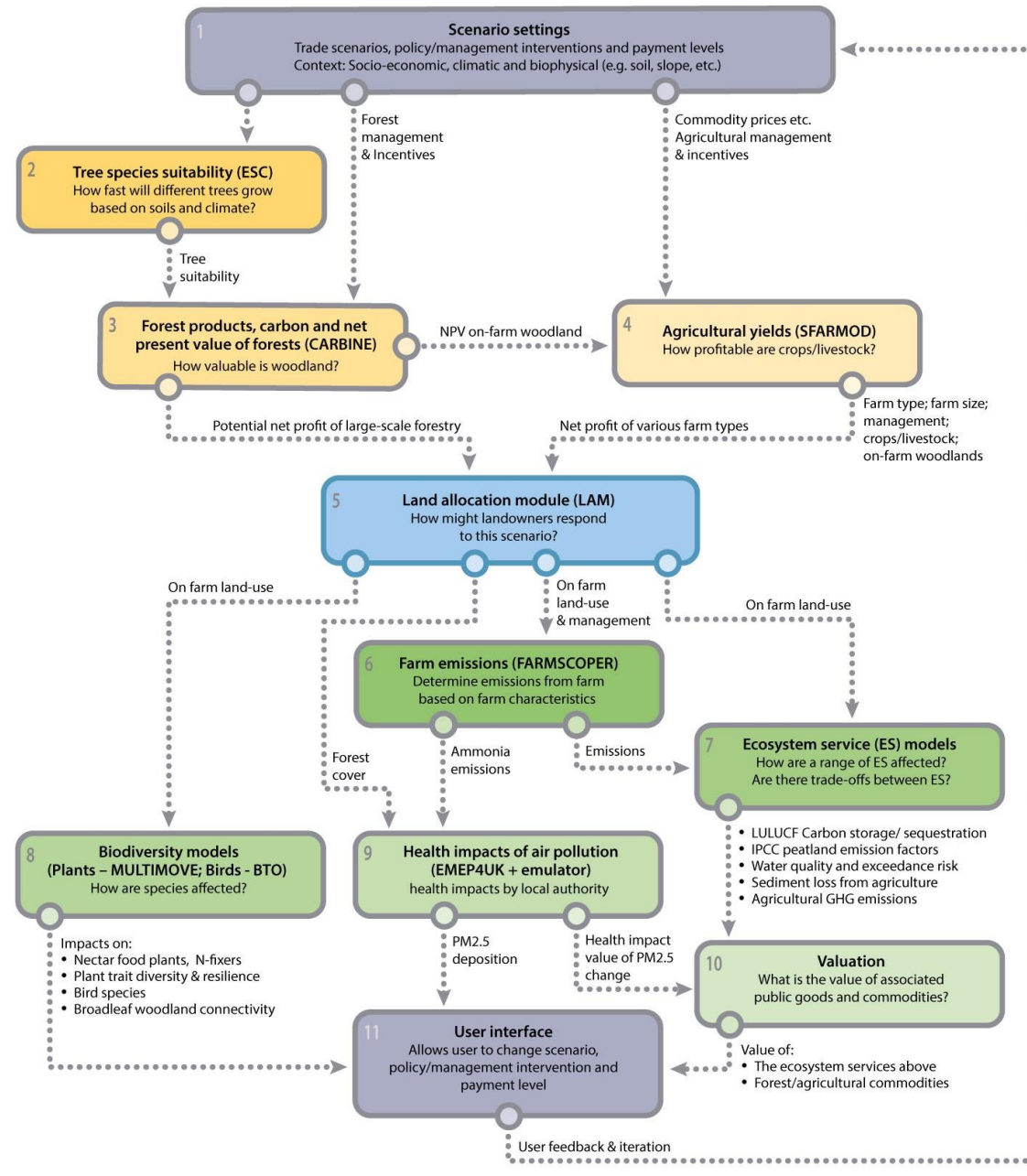
# IMP schematic



- Scenario settings co-created with Welsh Government
- 11 linked models
- Each model is run for multiple scenario settings to build up a data cube
- Data is passed between models to represent interdependencies between sectors
- Interface to present/access data



# IMP schematic



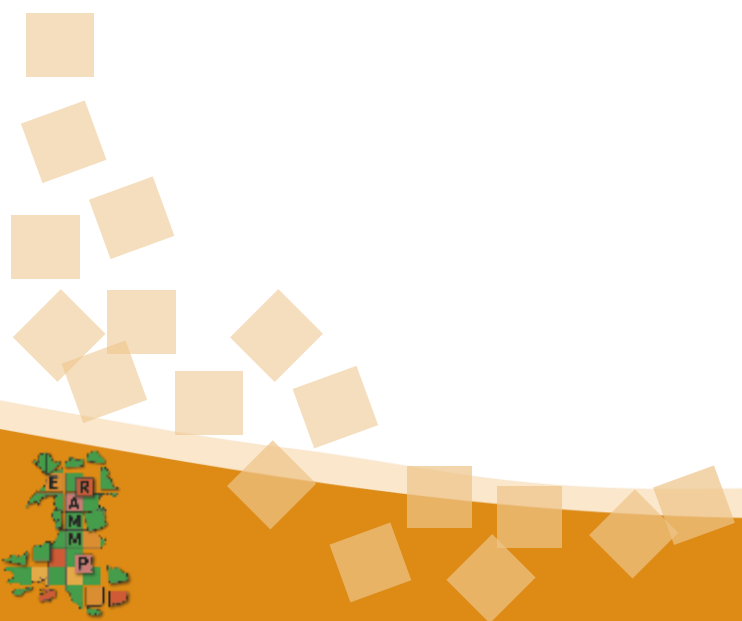
Scenario settings co-created with Welsh Government

## Top of modelling chain:

- Simulates land use and land management change

## Bottom of modelling chain:

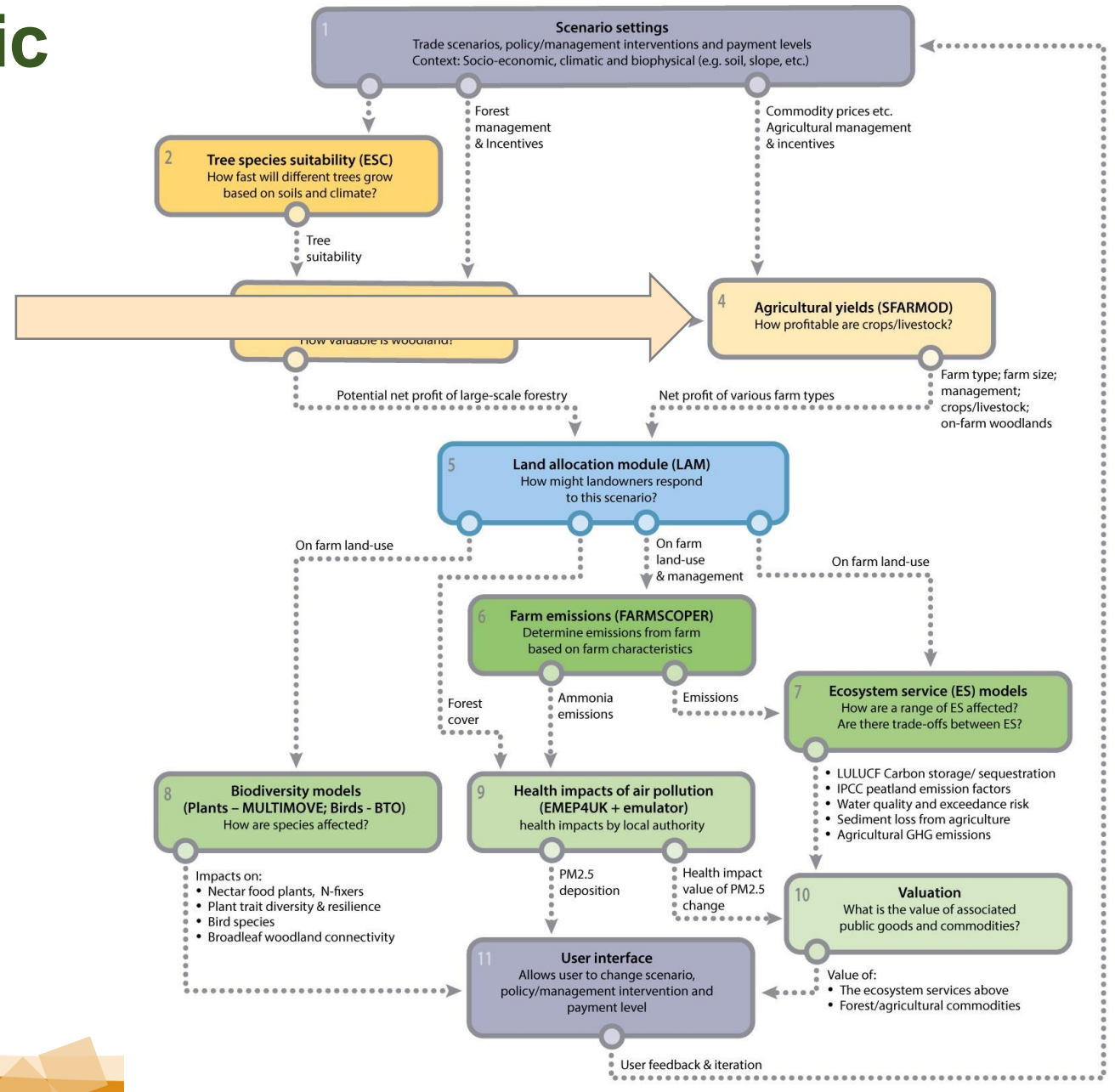
- Simulates consequences of land use and land management change on biodiversity and ecosystem services



# IMP schematic

## Farm-scale model:

- Decisions based on profitability (considering climate, soils, management and incentives)



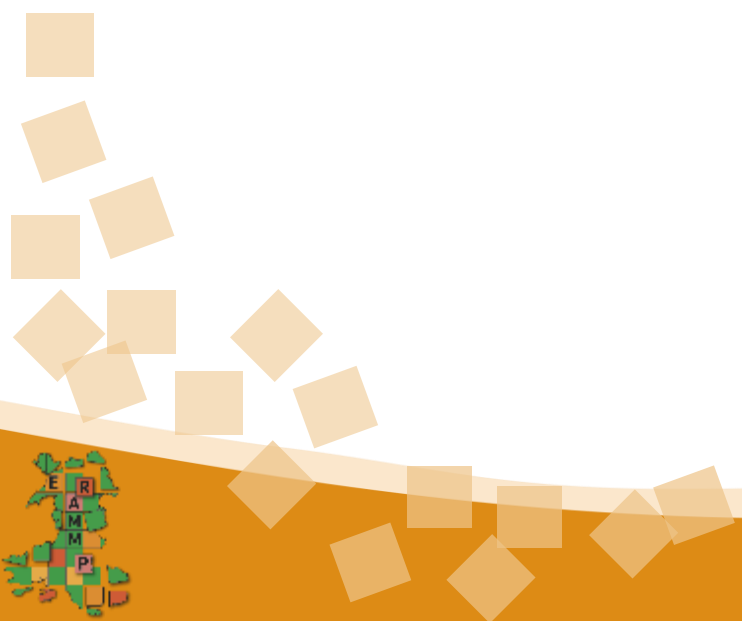
Scenario settings co-created with Welsh Government

## Top of modelling chain:

- Simulates land use and land management change

## Bottom of modelling chain:

- Simulates consequences of land use and land management change on biodiversity and ecosystem services

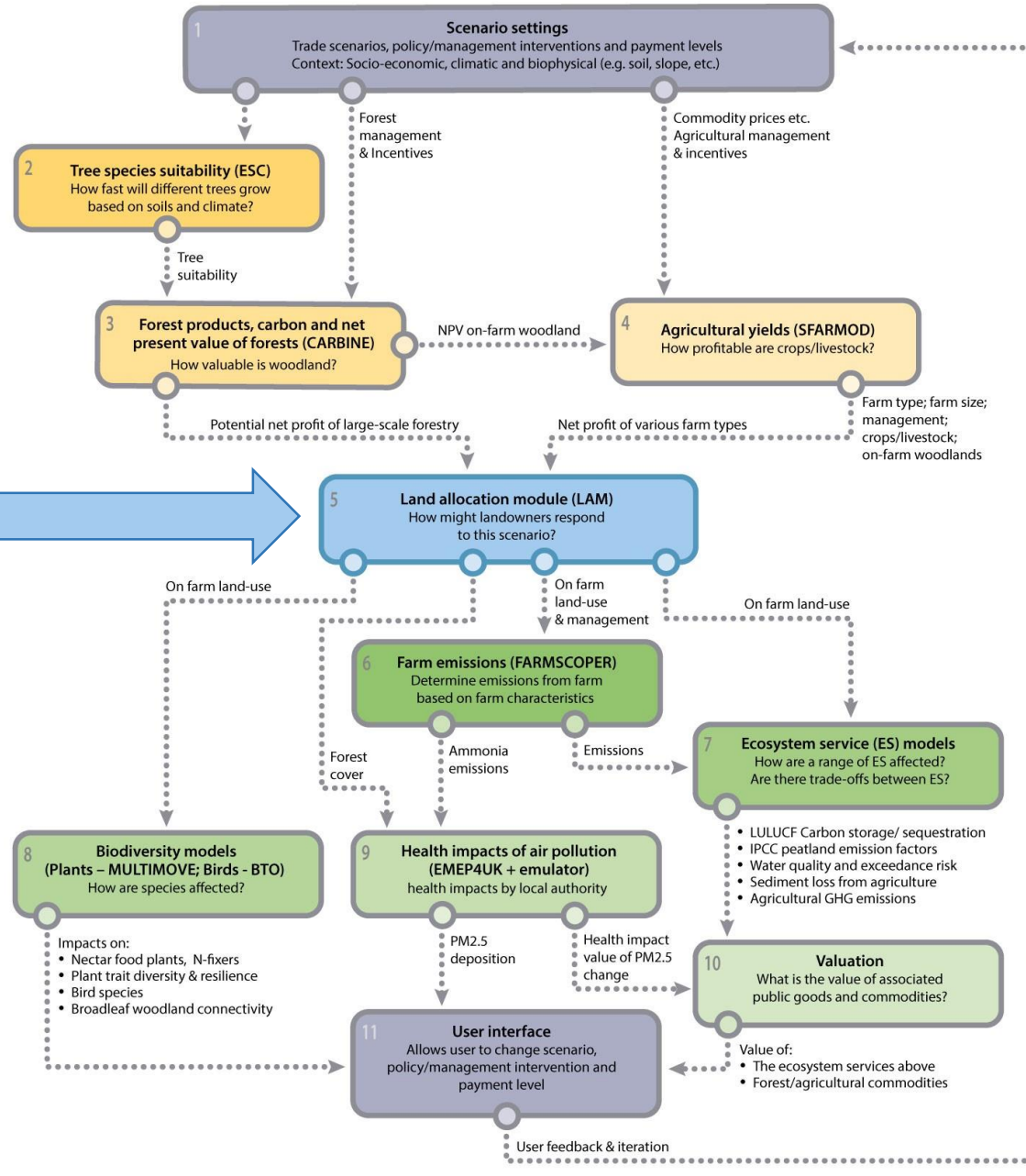
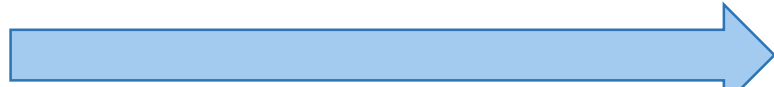




# IMP schematic

## Land Allocation Model:

- Developed specifically with WG to respond to changes in on-farm income



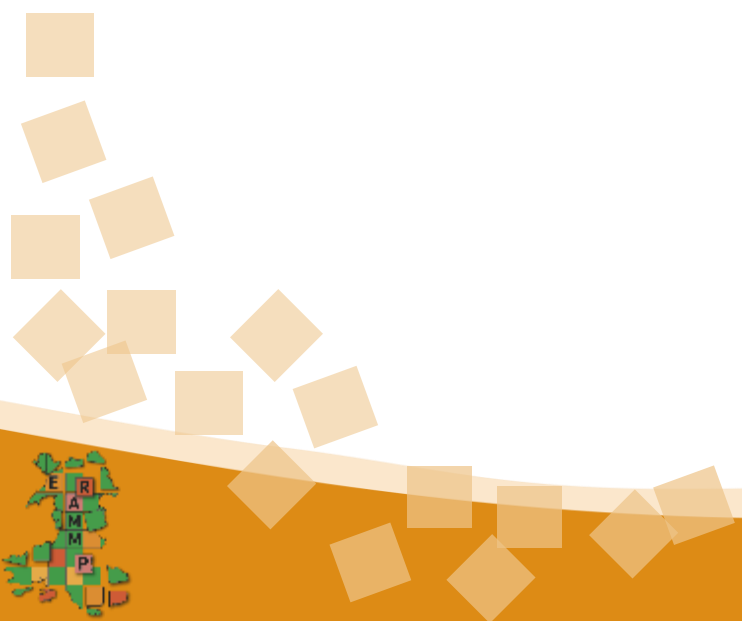
Scenario settings co-created with Welsh Government

## Top of modelling chain:

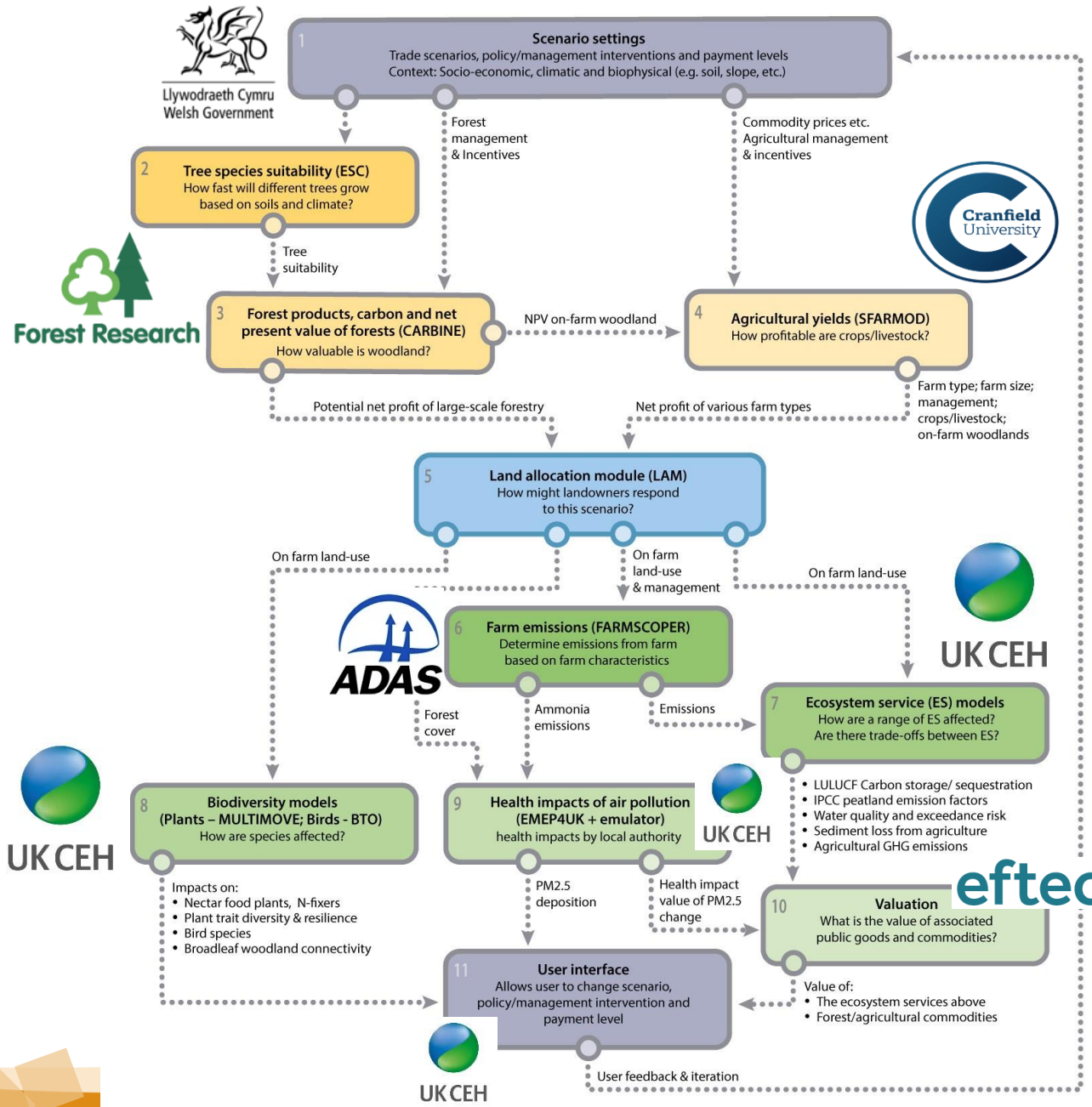
- Simulates land use and land management change

## Bottom of modelling chain:

- Simulates consequences of land use and land management change on biodiversity and ecosystem services



# A partnership approach



# Aqua Book Compliance

## RIGOUR:

- **Repeatable:** Same inputs/ constraints → same outputs.
- **Independent:** Free of prejudice or bias.
- **Grounded in reality:** Connections made between the analysis and its real-world consequences.
- **Objective:** Effective engagement and suitable challenge reduces potential bias.
- **Uncertainty-managed:** Uncertainties identified, managed and communicated.
- **Robust:** Result provided in the context of residual uncertainty and limitations in order to ensure it is used appropriately.



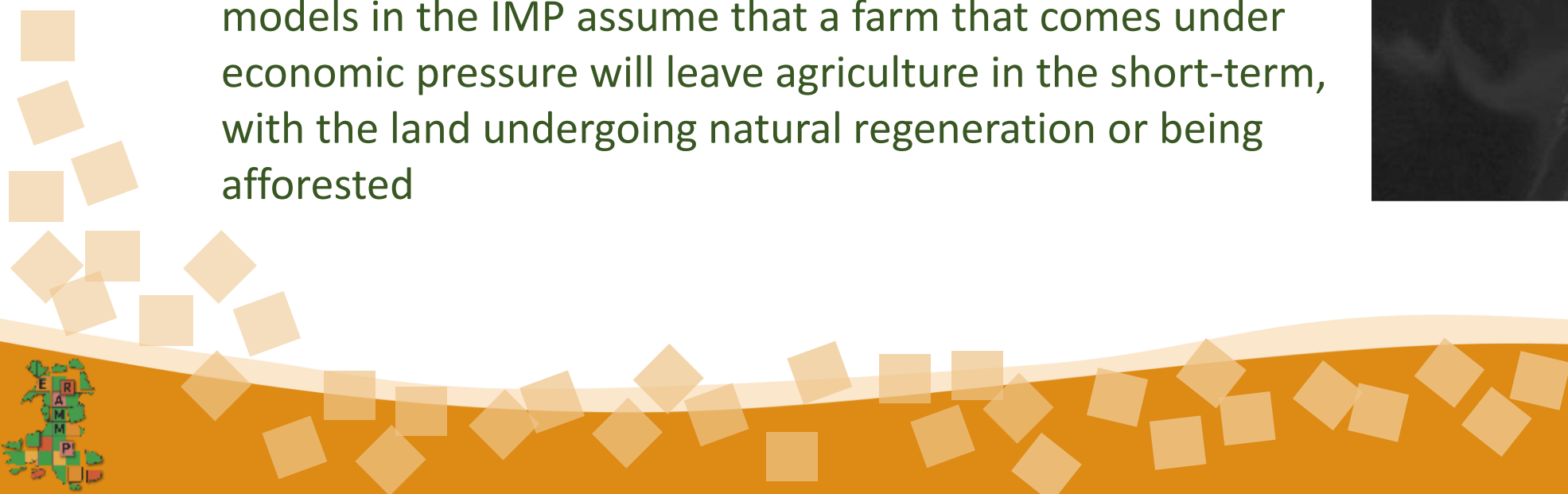
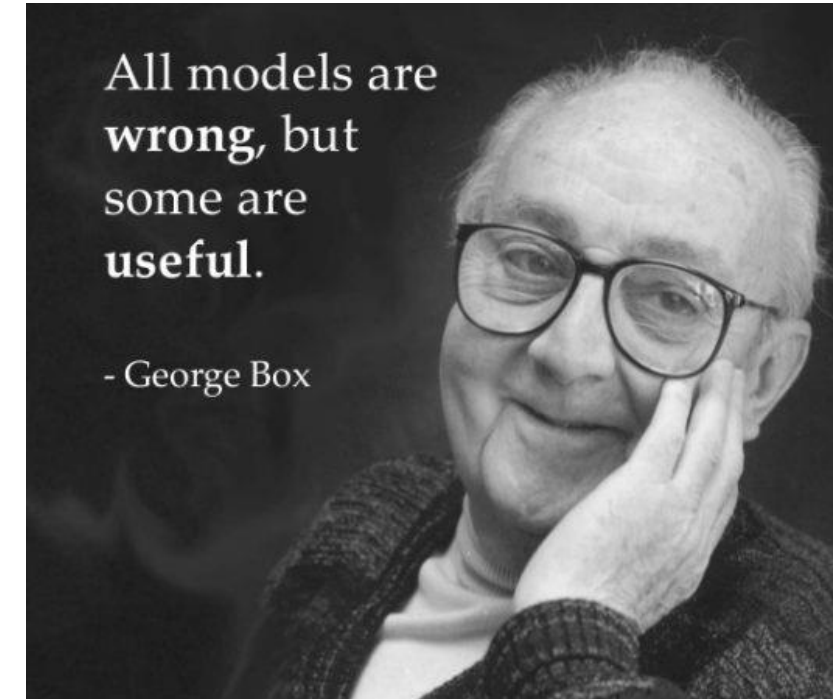
- **Assumptions detailed and agreed**
- **QA performed and documented**
- **Uncertainties explored**



# IMP limitations and assumptions (examples)

Models are a simplification of reality, but they can provide useful insight when used for a particular purpose ... all models have limitations and make simplifying assumptions, e.g.

- The IMP is applied to only full-time farms (> 1 FTE labour)
- Changes in land use are driven by on-farm economics and land suitability. They do not take into account skills or cultural and behaviour responses
- As a simplification, the biodiversity and ecosystem service models in the IMP assume that a farm that comes under economic pressure will leave agriculture in the short-term, with the land undergoing natural regeneration or being afforested



# Demonstrating the analytical capability of the IMP

Six land use scenarios were provided by WG based on a series of internal and external workshops as changes in farm gate (output) prices and input costs to explore different post-Brexit trade agreements:

1. Trading on world prices – based on FAPRI MFTA
2. **FTA with the EU only (from FAPRI data)**
3. **FTA with All (EU, USA, Australia and NZ)**
4. FTAs with USA, Australia and NZ; No FTA with EU
5. FTAs with EU, Australia and NZ; No FTA with USA
6. FTAs with EU, USA and Australia; No FTA with NZ.

Environment and Rural Affairs  
Monitoring & Modelling Programme  
(ERAMMP)

ERAMMP Report-60:  
ERAMMP Integrated Modelling Platform (IMP)  
Land Use Scenarios

Harrison, P.A.<sup>1</sup>, Dunford, R.<sup>1</sup>, Beauchamp, K.<sup>2</sup>, Cooper, J.<sup>3</sup>, Cooper, J.M.<sup>1</sup>, Dickie, I.<sup>4</sup>, Fitch, A.<sup>1</sup>, Gooday, R.<sup>5</sup>, Hollaway, M.<sup>1</sup>, Holman, I.P.<sup>5</sup>, Jones, L.<sup>1</sup>, Matthews, R.<sup>2</sup>, Mondain-Monval, T.<sup>1</sup>, Norris, D.A.<sup>1</sup>, Sandars, D.<sup>5</sup>, Seaton, F.<sup>1</sup>, Siriwardena, G.M.<sup>3</sup>, Smart, S.M.<sup>1</sup>, Thomas, A.R.C.<sup>1</sup>, Trembath, P.<sup>1</sup>, Vieno, M.<sup>1</sup>, West, B.<sup>1</sup>, Williams, A.G.<sup>5</sup>, Whittaker, F.<sup>1</sup>, Bell, C.<sup>1</sup>

<sup>1</sup> UK Centre for Ecology & Hydrology, <sup>2</sup> Forest Research, <sup>3</sup> British Trust for Ornithology, <sup>4</sup> eftec, <sup>5</sup> ADAS, <sup>6</sup> Cranfield University

Client Ref: Welsh Government / Contract C210/2016/2017  
Version 1.0.1  
Date: 05-August-2022

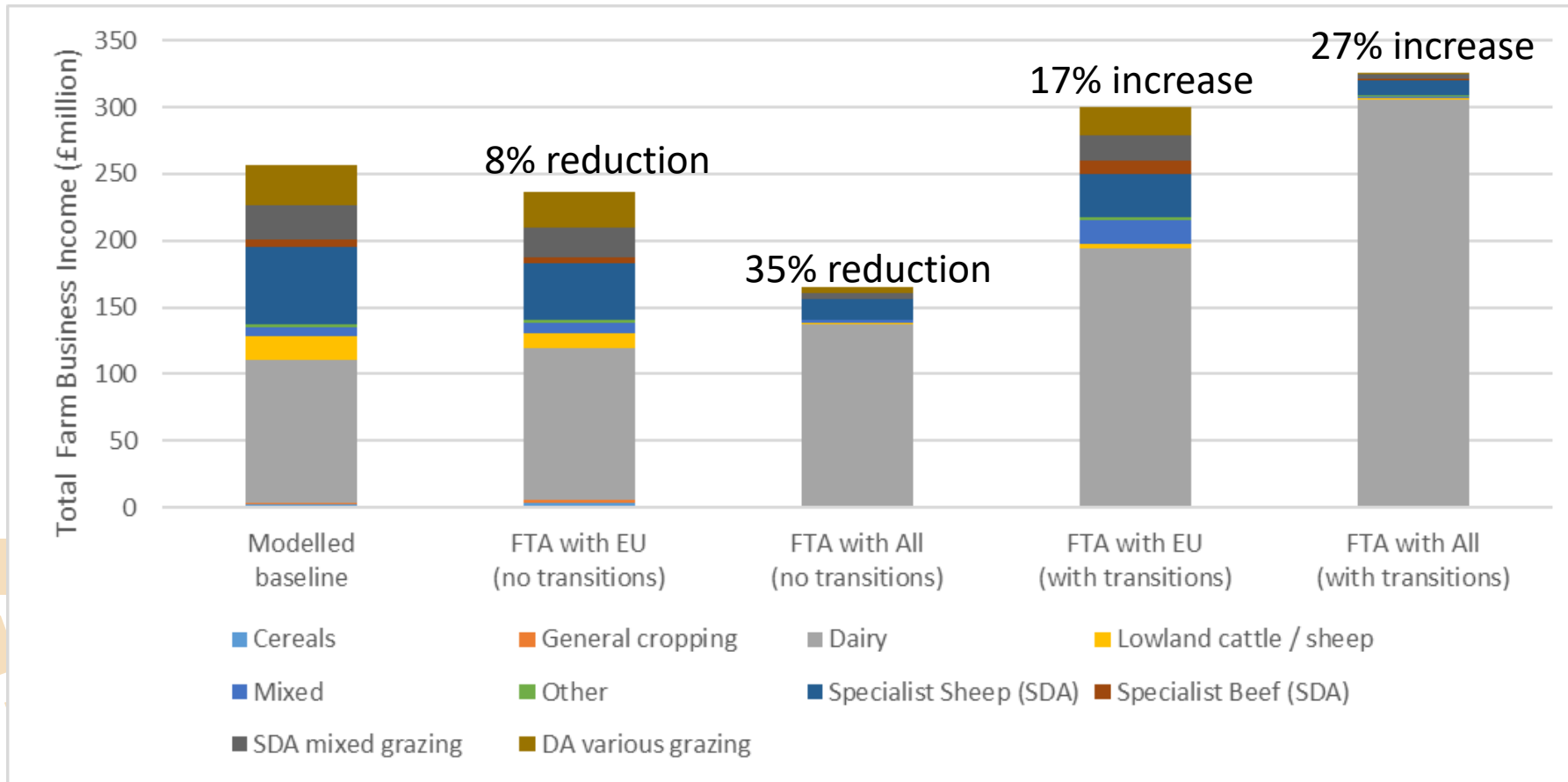


<https://erammp.cymru/en/integrated-monitoring-platform>



Canolfan Ecoleg  
a Hydroleg y DU  
UK Centre for  
Ecology & Hydrology

# Total Farm Business Income from full-time farms

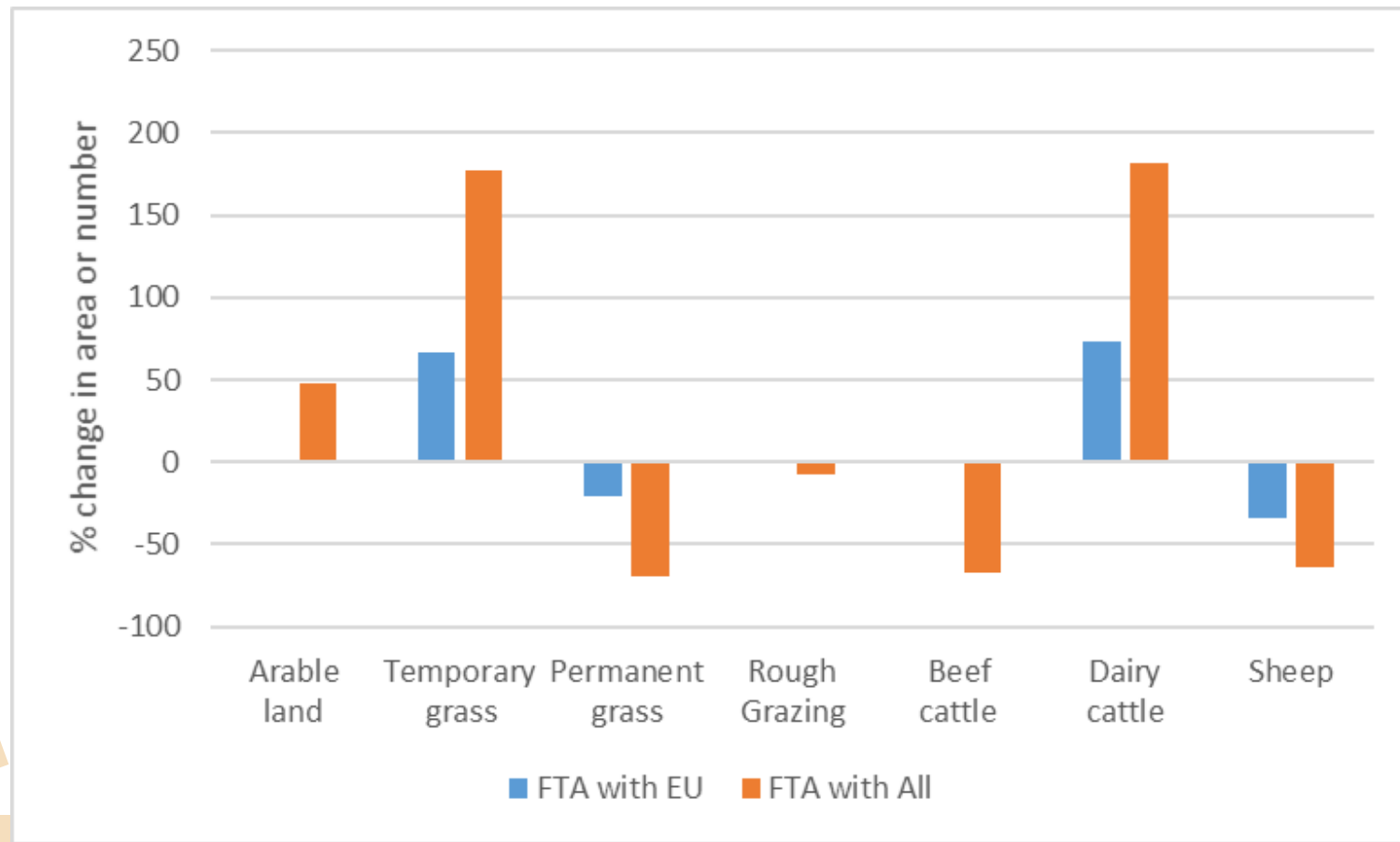


Total number of full-time farms:

- 7726 in Baseline
- 7117 in FTA with EU
- 6052 in FTA with All



# Change in managed land use and livestock



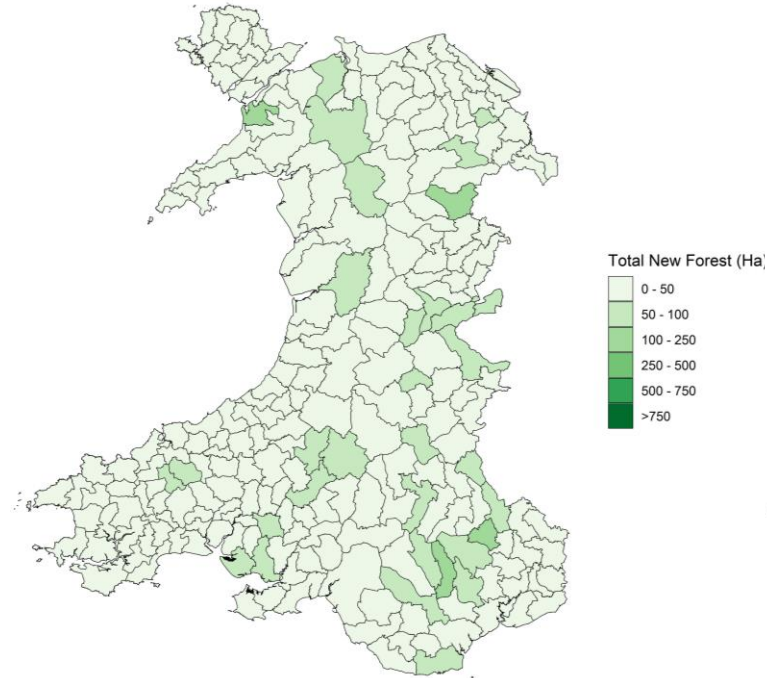
Percentage change (relative to simulated baseline)

Simulated farms remaining in full-time agriculture:  
FTA with EU: 7117  
FTA with All: 6052



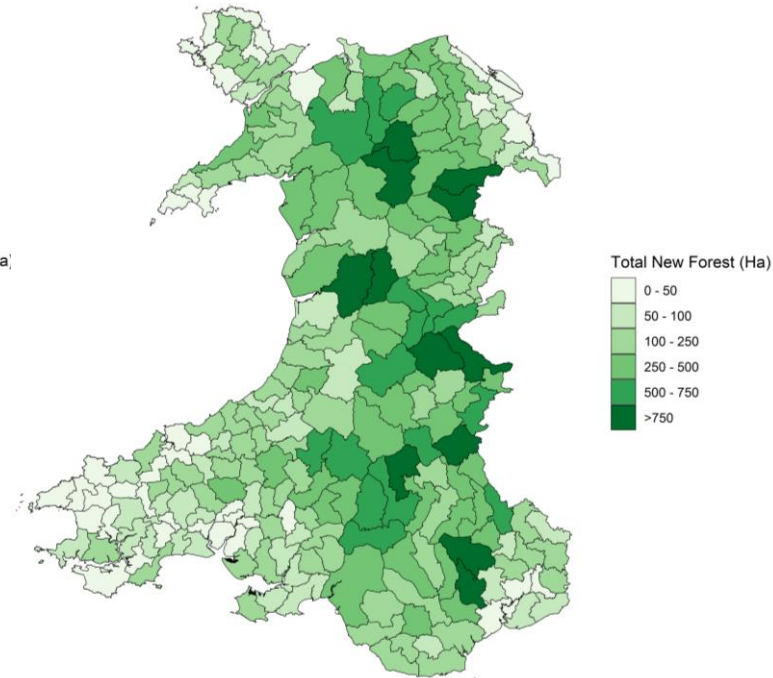
# New woodland on farms leaving full-time agriculture

FTA with EU



Total area of new woodland:  
6,060 ha (+5%)

FTA with All



Total area of new forest:  
53,995 ha (+32%)

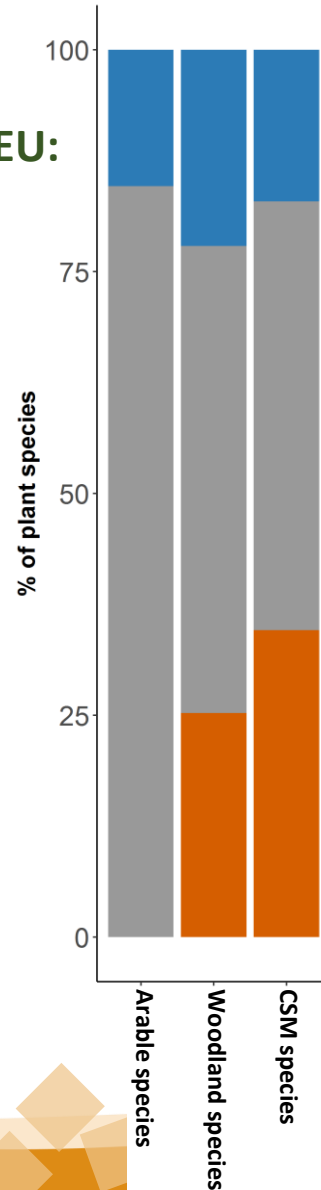
- Total new woodland area (ha) from afforestation and natural regeneration.
- Totals largely driven by afforestation.
- Afforestation will only occur on appropriate former agricultural land that will generate a positive net present value (NPV) from forestry.



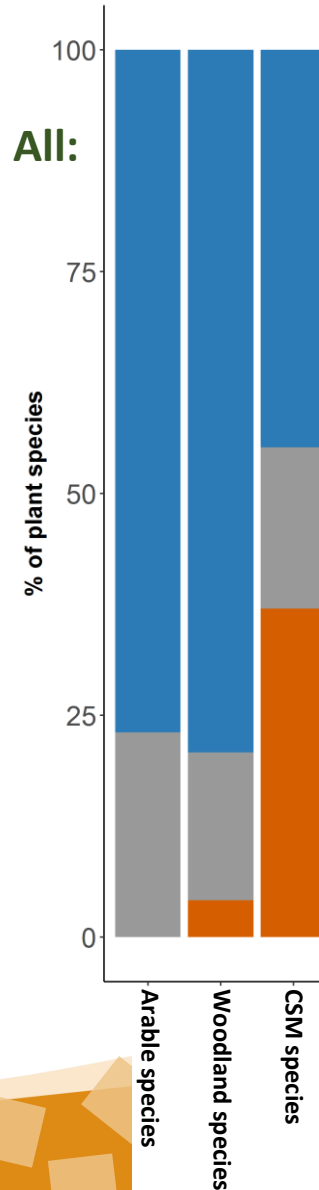


# Change in habitat suitability for plants

FTA with EU:



FTA with All:



Projected change in suitable niche space

- Significant increase
- No change
- Significant decrease

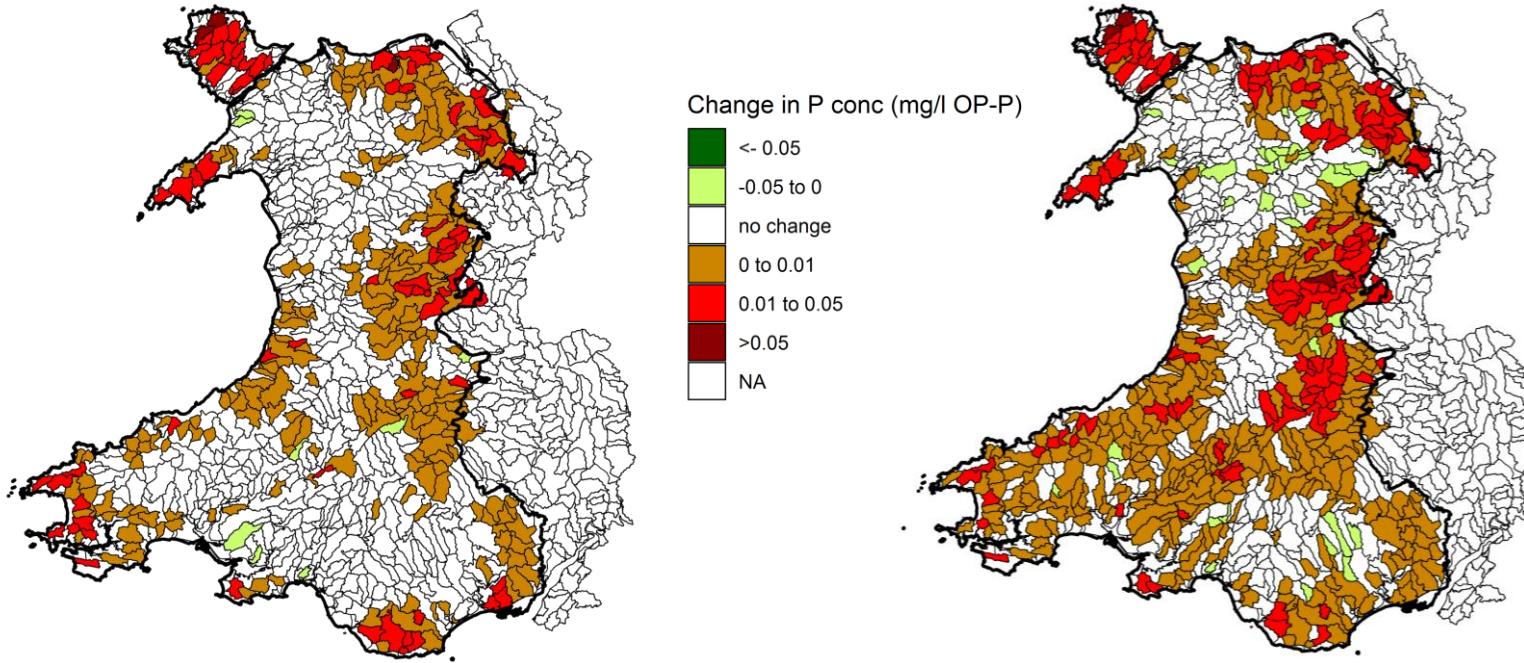
CSM = Common Standards Monitoring species (specialist plants of other semi-natural habitats)



# Water quality: Change in P concentration in WFD catchments

FTA with EU

FTA with All



- P concentration is projected to deteriorate in several catchments, reflecting increased agricultural intensity (dairy).
- P concentration is projected to improve in some catchments where land transitions to non-agricultural uses, including woodland.

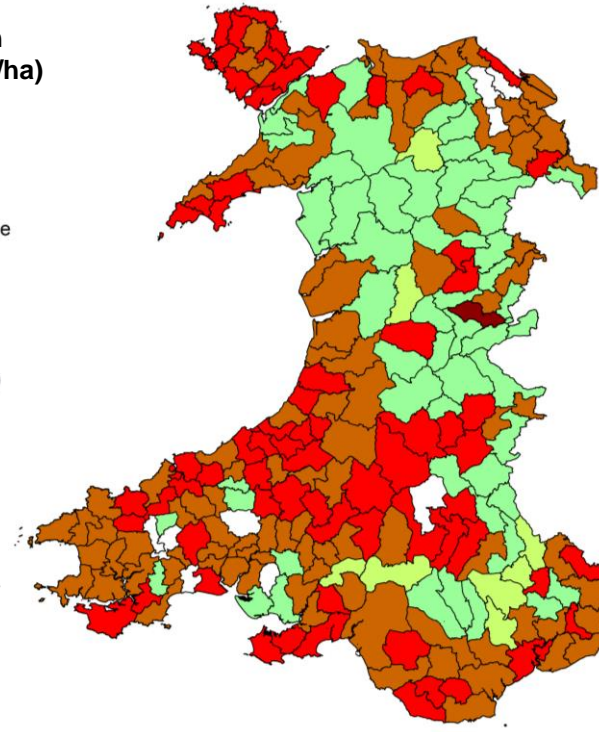
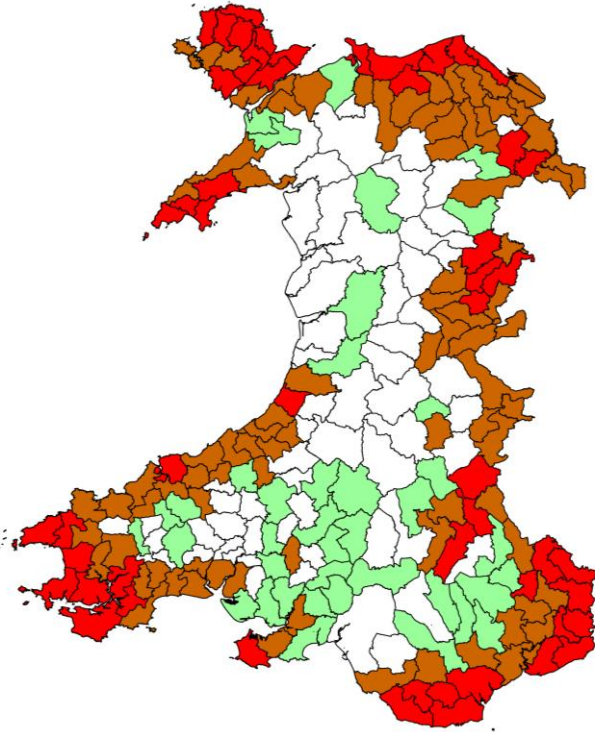
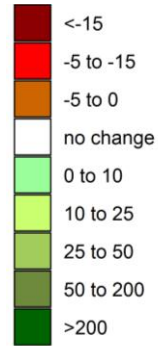


# Changes in LULUCF carbon stock

FTA with EU

FTA with All

Change in  
C stock (t/ha)



- Decreases reflect reductions in areas of permanent and rough grass, and increases in arable-grass rotation.
- Increase reflect new woodland, largely due to the significant C storage potential of biomass and harvested wood products.



# Summary of public goods values

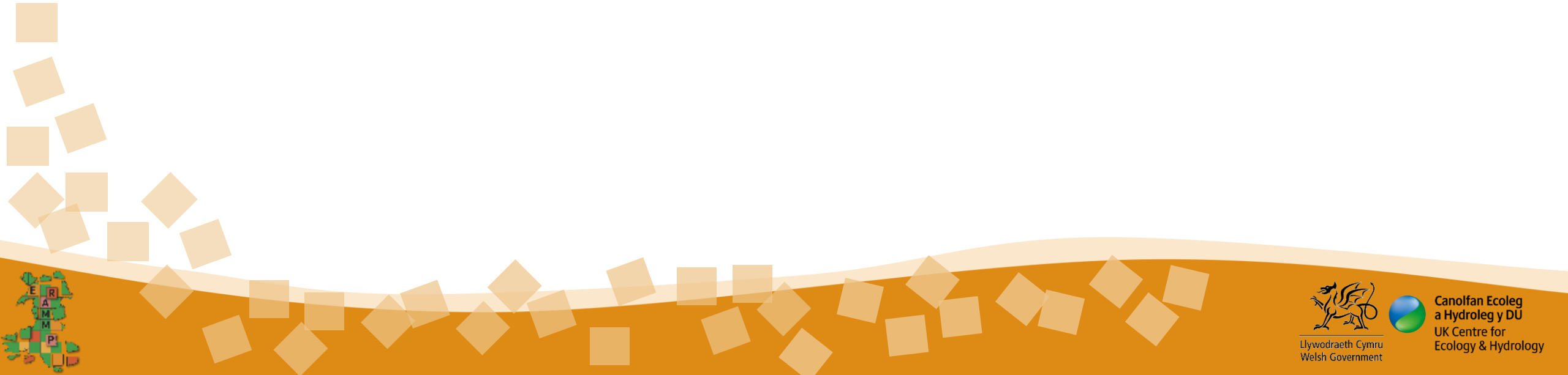
Benefits	FTA with EU	FTA with All	Units	FTA with EU	FTA with All	Type of value
	Physical measure			Present value, 75 yrs, £		
Air Quality	Increase of 60 years	Increase of 59 years	Avoided Life Years Lost each year	- £ 85m	- £ 85m	Reduction in costs of health impacts from air pollution
Water Quality	65 Deteriorate, 3 Improve	108 Deteriorate, 5 Improve	Expected changes in WFD status due to changes in P	- £ 33m	- £ 47m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
Carbon & GHGs	Increase of 116m tCO <sub>2</sub> e	Increase of 218m tCO <sub>2</sub> e	Total tonnes of net CO <sub>2</sub> eq sequestration and avoided emissions over 75 years	- £ 8,037m	- £ 14,990m	Benefit of reducing carbon emissions from non-traded sources

**NB:** Negative values are good – they are a reduction in costs!



# Iterative exploration of SFS bundles of actions

- The IMP has been/is being used to model some potential elements of the SFS.
- Highly exploratory and iterative process:
  - working together over the longer term to iteratively test policy assumptions
  - learning from previous iterations informs runs for next phase
  - responsive to both emerging evidence and policy



# IMP Paper in Press!

- Harrison et al. (2023)
- Submitted March 2023
- Journal: Environmental Modelling and Software
- Describes:
  - The IMP approach
  - The models involved
  - The QA of the models and IMP
  - Example applications to illustrate capability
  - It's world-leading co-design approach to supporting policy exploration and testing

[https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=4408349](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4408349)

## An adaptable integrated modelling platform to support rapidly evolving agricultural and environmental policy

### *Environmental Modelling & Software*

Paula A. Harrison<sup>a,\*</sup>, Kate Beauchamp<sup>b</sup>, Joe Cooper<sup>c</sup>, Ian Dickie<sup>d</sup>, Alice Fitch<sup>e</sup>, Richard Gooday<sup>f</sup>, Michael Hollaway<sup>g</sup>, Ian P. Holman<sup>h</sup>, Merryn Hunt<sup>a</sup>, Laurence Jones<sup>e</sup>, Thomas Mondain-Monval<sup>a</sup>, Daniel Sandars<sup>g</sup>, Gavin Siriwardena<sup>c</sup>, Fiona Seaton<sup>a</sup>, Simon Smart<sup>a</sup>, Amy Thomas<sup>g</sup>, Bede West<sup>g</sup>, Freya Whittaker<sup>a</sup>, Ed Carnell<sup>h</sup>, Robert W. Matthews<sup>b</sup>, Sophie Neupauer<sup>d</sup>, Vadim Saraev<sup>i</sup>, Janice Scheffler<sup>h</sup>, Philip Trembath<sup>a</sup>, Massimo Vieno<sup>h</sup>, Adrian C. Williams<sup>g</sup>, Robert W. Dunford

<sup>a</sup> UK Centre for Ecology & Hydrology, Library Avenue, Bailrigg, Lancaster LA1 4AP, UK

<sup>b</sup> Forest Research, Alice Holt Lodge, Farnham, Surrey GU10 4LH

<sup>c</sup> British Trust for Ornithology, The Nunnery, Thetford, IP24 2PU, UK

<sup>d</sup> eftec, Economics For The Environment Consultancy Ltd, 10F Printing House Yard, Hackney Road, London, E2 7PR, UK

<sup>e</sup> UK Centre for Ecology & Hydrology, Environment Centre Wales, Deiniol Road, Bangor, LL57 2UW, UK

<sup>f</sup> ADAS, Unit 14 Newton Court, Pendeford Business Park, Wolverhampton, WV9 5HB, UK

<sup>g</sup> Cranfield University, Cranfield, Bedfordshire MK43 0AL, UK

<sup>h</sup> UK Centre for Ecology & Hydrology, Bush Estate, Penicuik, EH26 0QB, UK

<sup>i</sup> Forest Research, Northern Research Station, Bush Estate, Roslin, EH25 9SY

<sup>j</sup> UK Centre for Ecology & Hydrology, Maclean Building, Benson Lane, Crowmarsh Gifford, Wallingford, OX10 8BB, UK

\*Corresponding author; email: [PaulaHarrison@ceh.ac.uk](mailto:PaulaHarrison@ceh.ac.uk); Tel: +44 1524 595858; UK Centre for Ecology & Hydrology, Library Avenue, Bailrigg, Lancaster LA1 4AP, UK



# Summary

- The IMP provides a **policy-relevant, integrated modelling tool** that can provide scientific evidence to inform rapidly evolving policies across sectors.
- Particularly important to its development and its application to the SFS are:
  - **Co-design** through a long-term partnership between WG and the IMP team;
  - **Transparency** of the model and its assumptions (following Aqua book);
  - **Iterative approach**: builds trust and understanding in the results;
  - **Flexible**: can be adapted quickly to changing WG needs;
  - **Timely**: model runs delivered at a pace that is able to inform quickly evolving policy needs.



# Diolch / Thank you

For further information on the IMP, contact:

- [PaulaHarrison@ceh.ac.uk](mailto:PaulaHarrison@ceh.ac.uk)
- [RDunford@ceh.ac.uk](mailto:RDunford@ceh.ac.uk)

