Modelling the potential benefits of woodland expansion in Wales

S Smart[1], S Anthony[2], B Jackson[3], B Emmett[1], R Swetnam[4] and the GMEP team

[1]Centre for Ecology and Hydrology, [2]ADAS, [3]Bangor University, [3]Victoria University of Wellington, [4]Staffordshire University

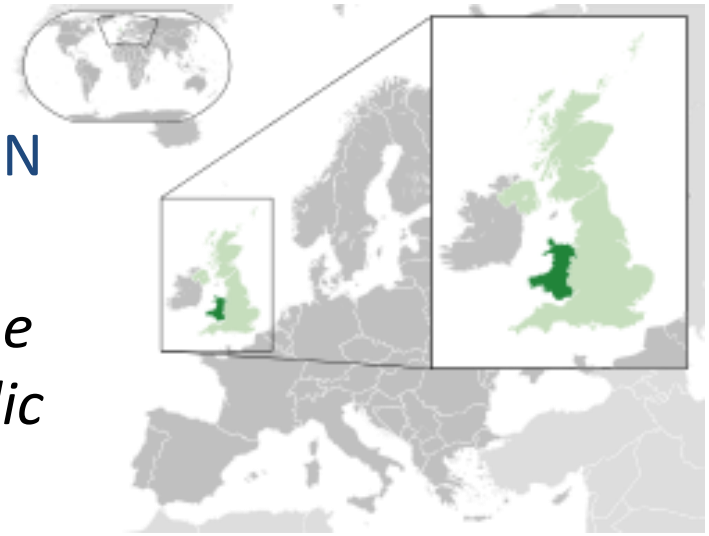
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Glastir Monitoring and Evaluation Programme

A small country with a big ambition

DOHA 2012 UN CLIMATE CHANGE CONFERENCE COP18 CMP8

Wales is one of only 3 nations with sustainable development enshrined within its constitution



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"

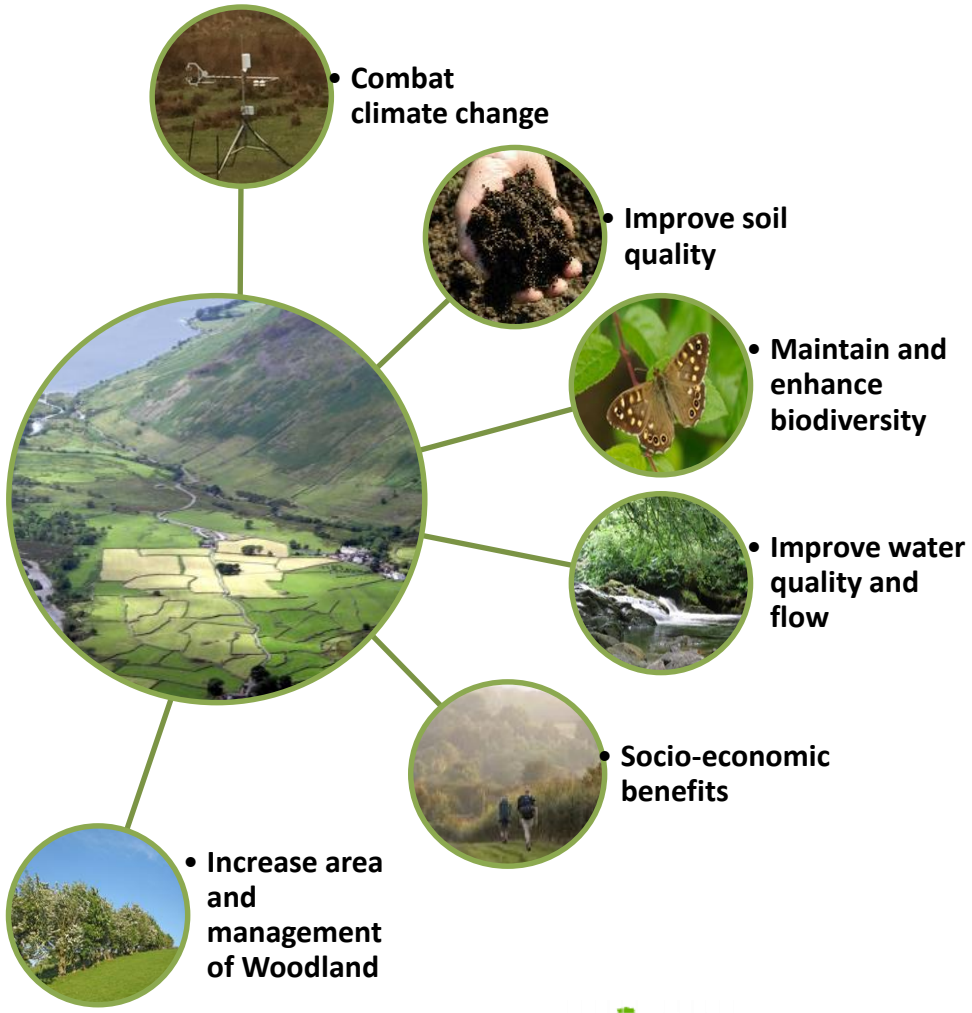
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Glastir Monitoring and Evaluation Programme

Glastir: A single payment agri-environment scheme with 6 high level aims

> 150 management interventions eligible for payment

- 16 of these directly support woodland expansion which can also contribute to the other aims but by how much?

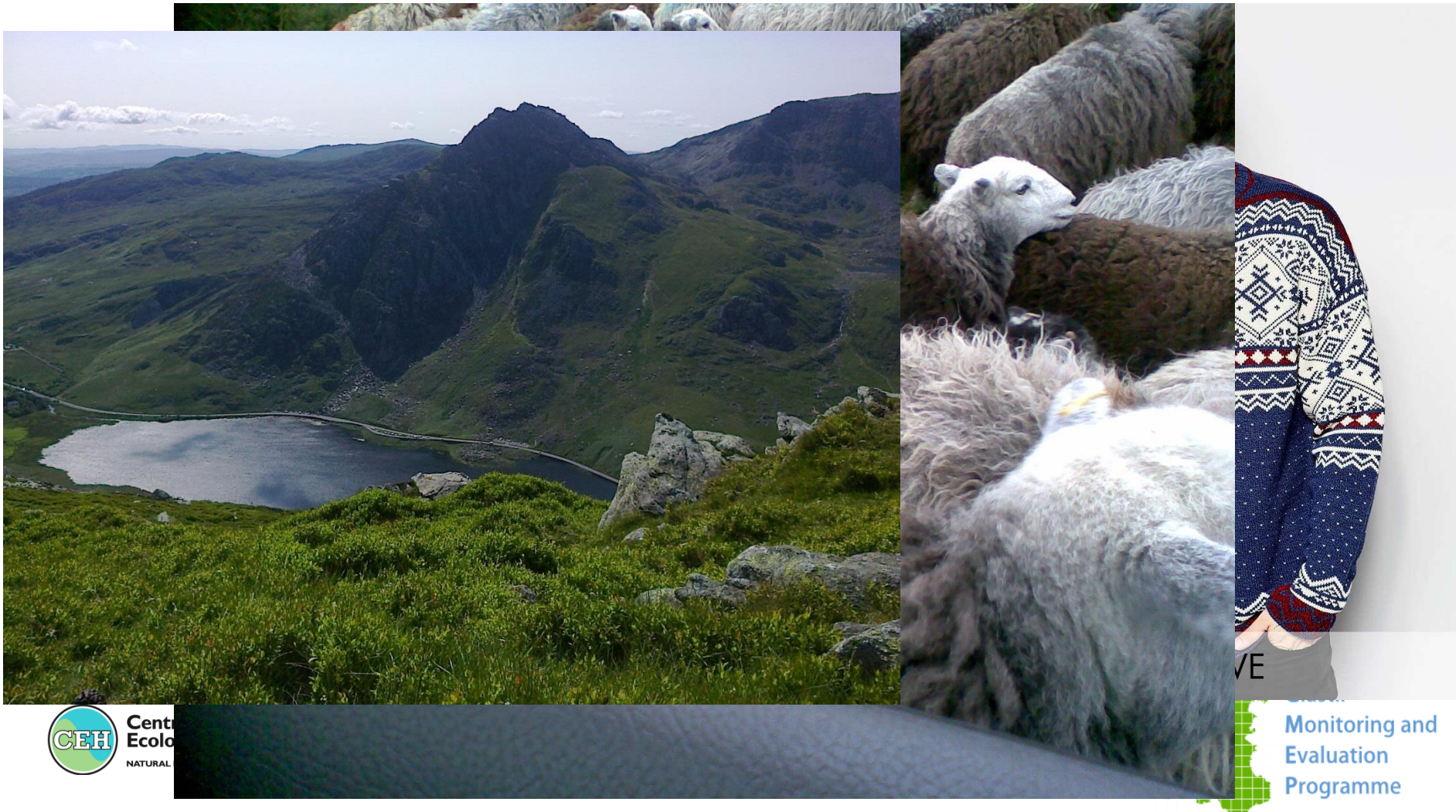


Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Glastir Monitoring and Evaluation Programme

Woodlands in Wales have suffered from land-use

- **11 million sheep lead to less trees but lots of warm clothing**



Monitoring and Evaluation Programme

Clear-felling in 1940/50's removed woodland and trees

(for example Smart et al 2014. *J.Ecol.* 103, 1273-1287)

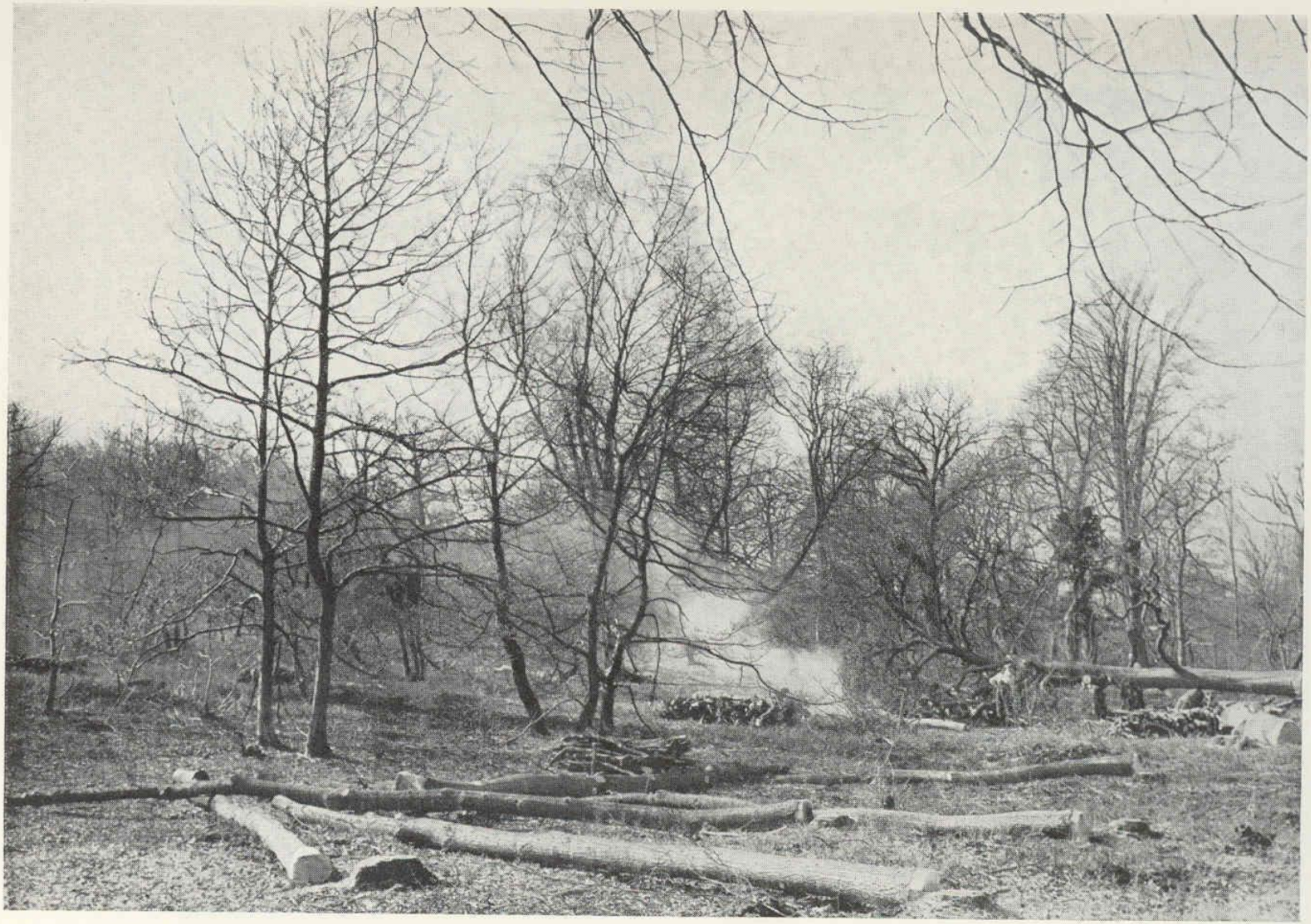


PLATE IX. Devastated woodland. The best stems of oak and sweet chestnut have been felled, leaving only small and crooked trees, too sparse to form a crop.

Using models to project impact of Glastir options

Glastir "woodland expansion" options evaluated for impact at national scale (for low, medium and high uptake scenarios):

1. Allow Woodland Edge to Develop Out into Adjoining Field
2. Create Streamside Corridor with Tree Planting

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Programme

The LUCI model for testing land-use scenarios

- LUCI implements & extends the Polyscape framework described in Jackson et al (2013)*.
- First developed in one catchment. Farmers & scientists worked together to design intervention measures to improve economics and reduce environmental impact.
- Further work up-scaling impacts of detailed farm interventions to catchment scale & conversations with farmers and interdisciplinary scientists inspired design criteria.

*Jackson, B, Pagella, T, Sinclair, F, Orellana, B, Henshaw, A, McIntyre, N, Reynolds, B, Wheater, H, Eycott, A (2013). Polyscape: a GIS mapping toolbox providing efficient and spatially explicit landscape-scale valuation of multiple ecosystem services, Urban and Landscape Planning 112, 74-88.

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

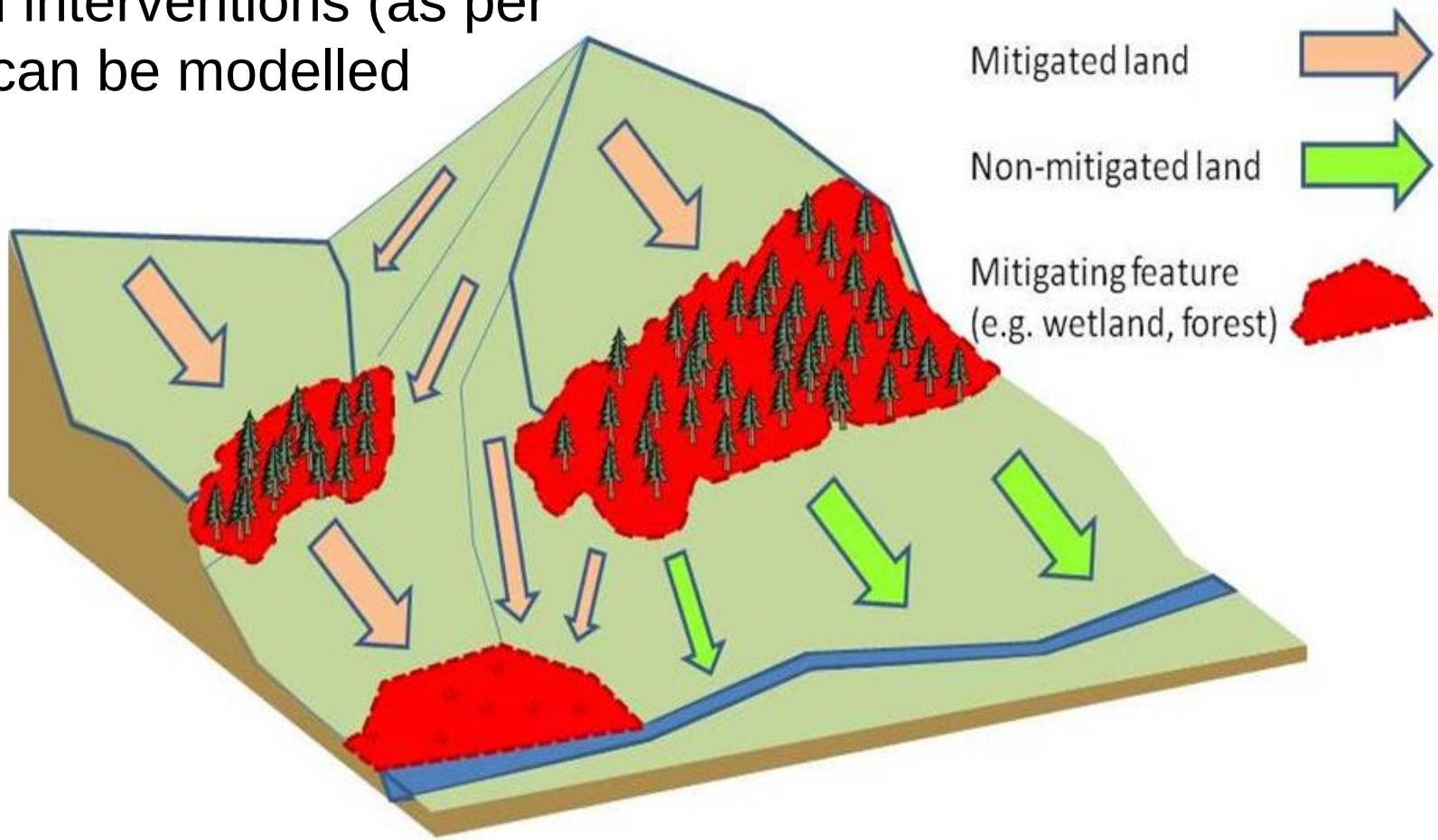
Glastir Monitoring and Evaluation Programme

Services currently modelled by LUCI

Service	Method
Production	Based on slope, fertility, drainage, aspect, climate
C stock/emissions	IPCC Tier 1 compatible – based on soil & vegetation
CH_4/N_2O emissions	IPCC Tier 1 compatible– soils, veg, stocking rate, fertiliser
Flooding	Topographical routing of water accounting for storage and infiltration capacity as function of soil & land use.
Erosion	Slope, curvature, contributing area, land use, soil type
Sediment delivery	Erosion combined with detailed topographical routing
Water quality	Export coefficients (land cover, farm type, fertiliser, stocking rate info) combined with water and sediment delivery models
Habitat Approaches	1) Cost-distance approach: dispersal, fragmentation, connectivity. 2) Identification of priority habitat by biophysical requirements e.g. wet grassland 3) Measures of habitat richness, evenness, patch size etc
Coast/ floodplain inundation risk	Based on topography and input height of storm surge/long term rise etc: surface and groundwater impacts estimated
Tradeoffs/synergy identification	Various layering options with categorised service maps; e.g. Boolean, conservative, weighted arithmetic, distribution plots

LUCI allows interventions to be spatially targeted according to end-user priorities (5m x 5m scale)

So small interventions (as per Glastir) can be modelled



LUCI models the area impacted, not just the area modified

- Modelled benefits of tree planting in a test catchment in 1990 for broadleaved woodland focal species. Runoff mitigation was 4 times the actual area modified

Service	Actual area modified (%)	Area receiving benefit (%)
Broadleaved focal species	6.8	28.5
Runoff peak	3.2	12.0

- In other catchments we observe a range from x1 to 10 depending on site and placement

Conclusion: Spatially explicit modelling with biophysical processes is critical if benefits are not to be under-estimated

Underlying principles:

Practical

1) Can be run using nationally available data; so *relevant to national spatial planning*
2) Modular – can embed external models & export aspects to other models
3) Fast running, enabling interactive scenario exploration

Conceptual

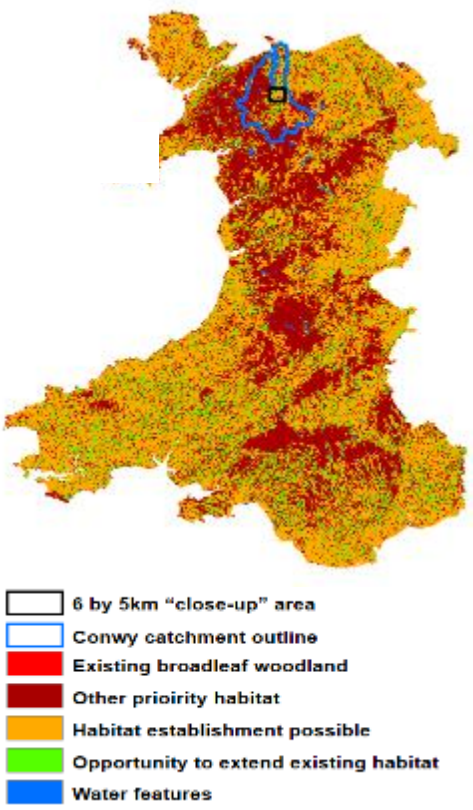
1) Operates at a spatial scale *relevant for field and sub-field level management decisions*
2) "Values" features and potential interventions by area affected, not just area directly modified
3) Addresses spatial tradeoffs & searches for "win-win" solutions

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

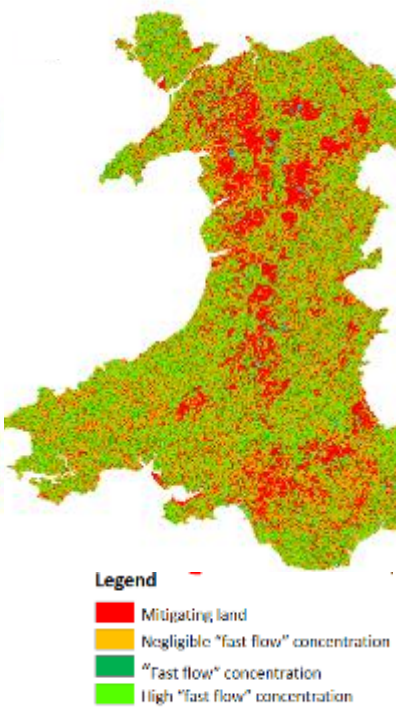
Glastir Monitoring and Evaluation Programme

Mapping of Ecosystem services was done at 5m x 5m scale (resolution of the DEM) for each catchment then aggregated to country level

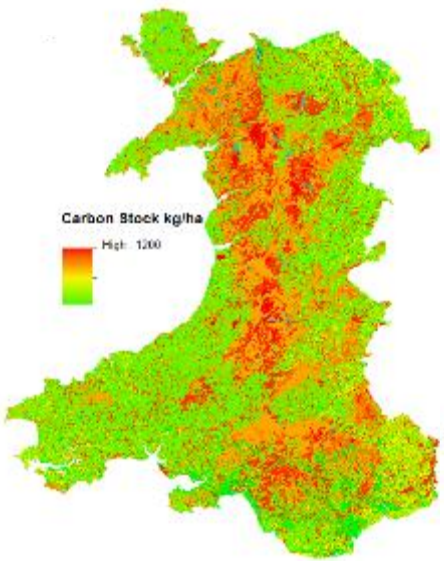
Habitat Priority areas



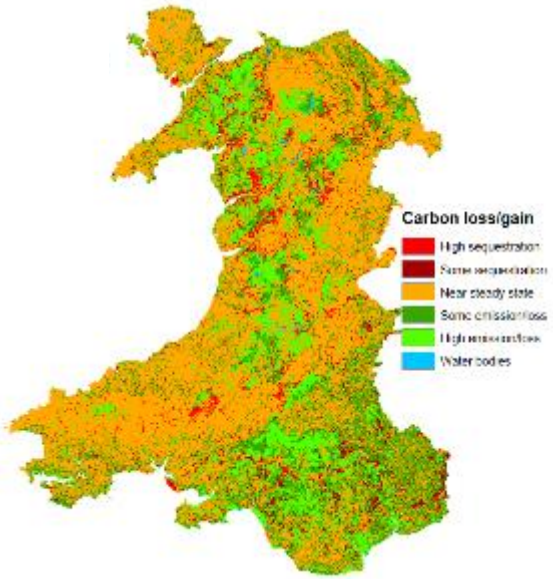
Flood generating and mitigating land



Carbon storage



Carbon emission



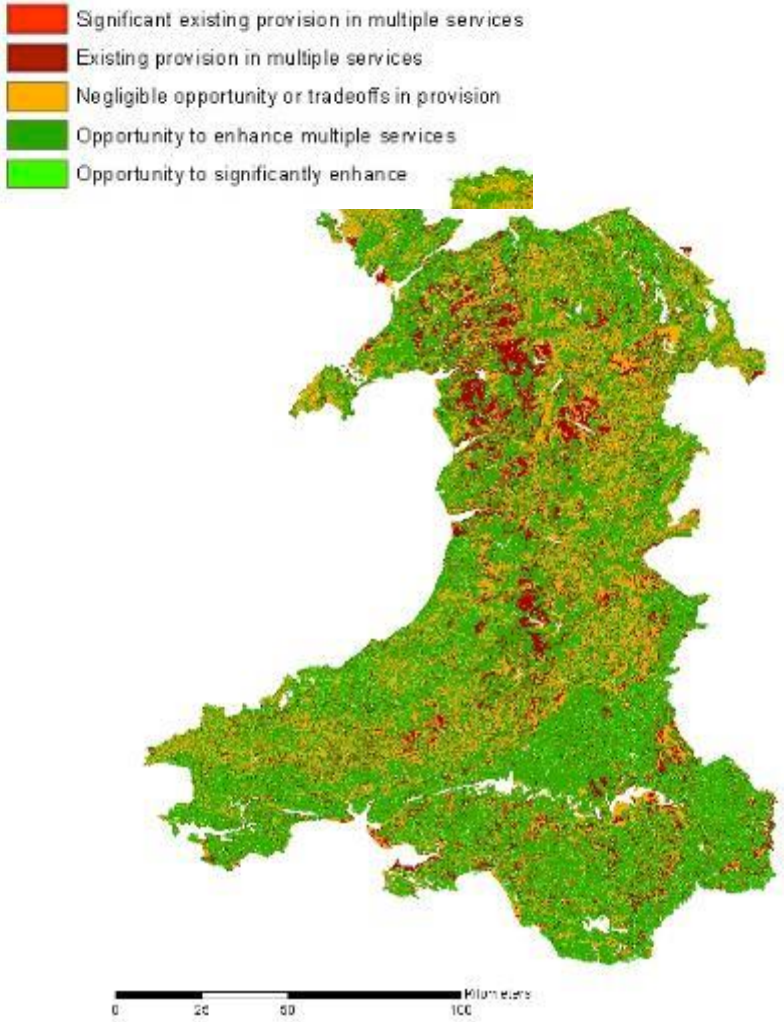
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

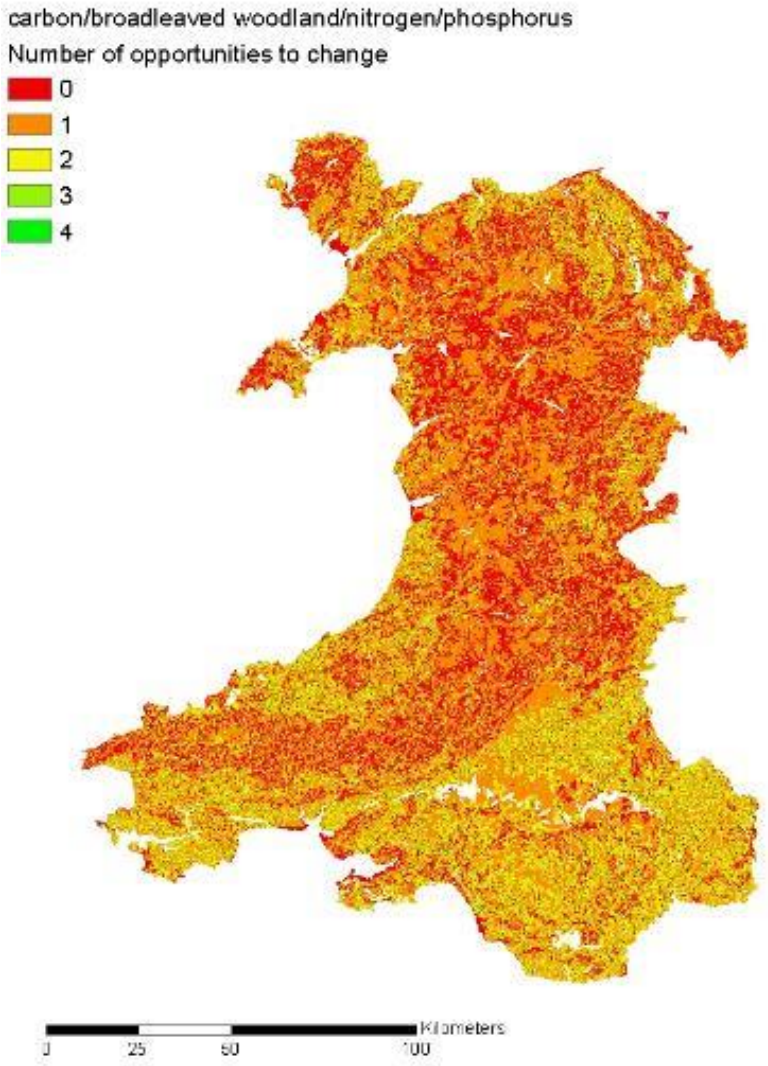
Emmett et al. 2014 GMEP first year Report.
Jackson et al,. 2013. Urban and Landscape Planning 112, 74-88.

What happens when we look at trade-offs spatially for 4 services (N & P to waters, carbon and woodland connectivity)

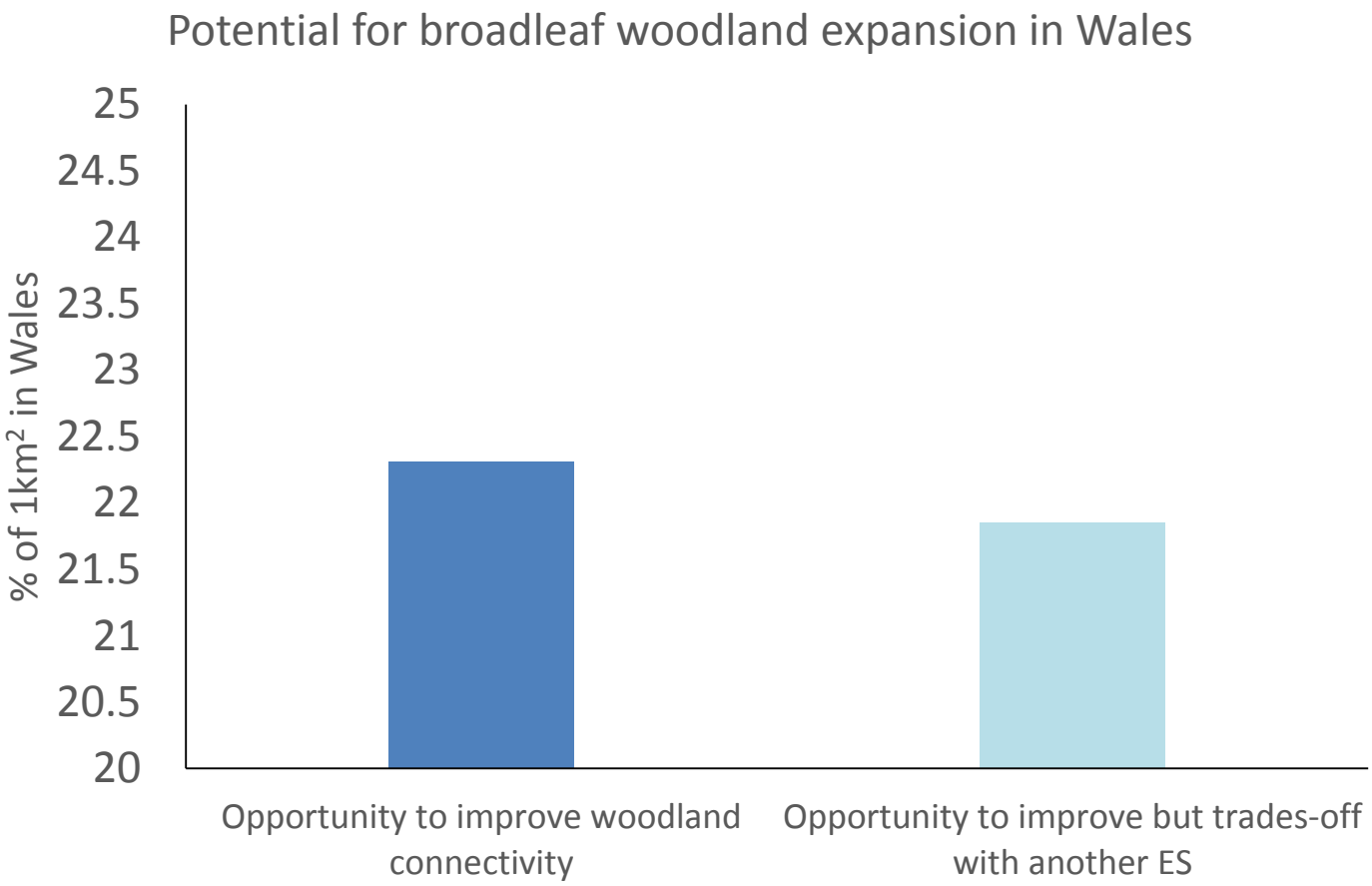
67% of Wales have opportunities to improve services. This is greater than the total area with existing good services.

However, this is generally only for 1-2 services (red / orange/yellow)





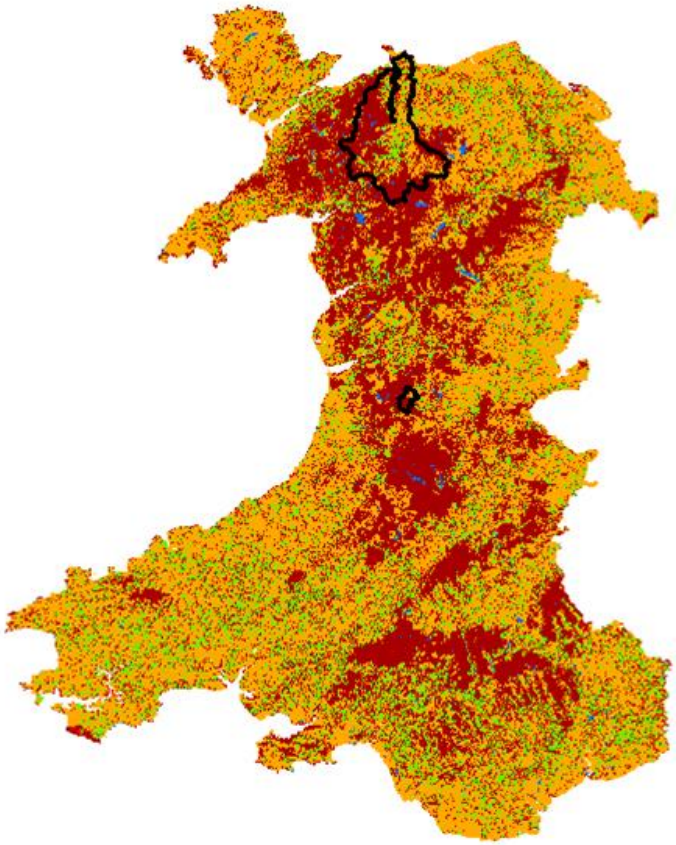
Summary for Wales; woodland expansion only taking into account trade-offs with other ecosystem services

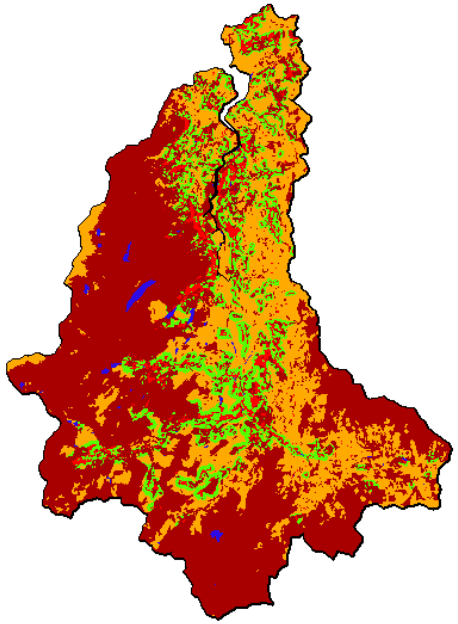


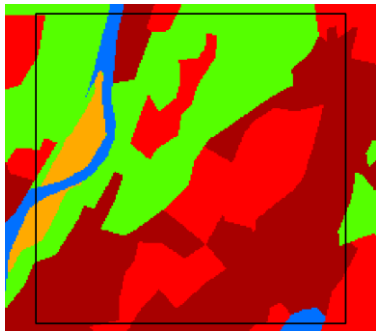
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Glastir Monitoring and Evaluation Programme

Multi-scale analysis: country, catchments, sq km







Legend

- Broadleaved woodland
- Other UK “priority habitat”
- Marginal gains from planting woodland
- Opportunities for enhanced connectivity of habitat

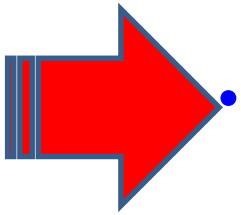
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Glastir Monitoring and Evaluation Programme

Results from all-of-Wales application of LUCI to project impact of Glastir options

Glastir "woodland expansion" options evaluated for impact at national scale (for low, medium and high uptake scenarios):

1. Allow Woodland Edge to Develop Out into Adjoining Field
2. Create Streamside Corridor with Tree Planting



LUCI predictions ranged from:

- increased accessible land for broadleaf focal species by 3 to 12%,
- reduced potential flood generating land by 1 to 9%,
- increased national carbon storage by ca. 0.4%,
- reduced eroded soil and phosphorus delivery by up to 15%

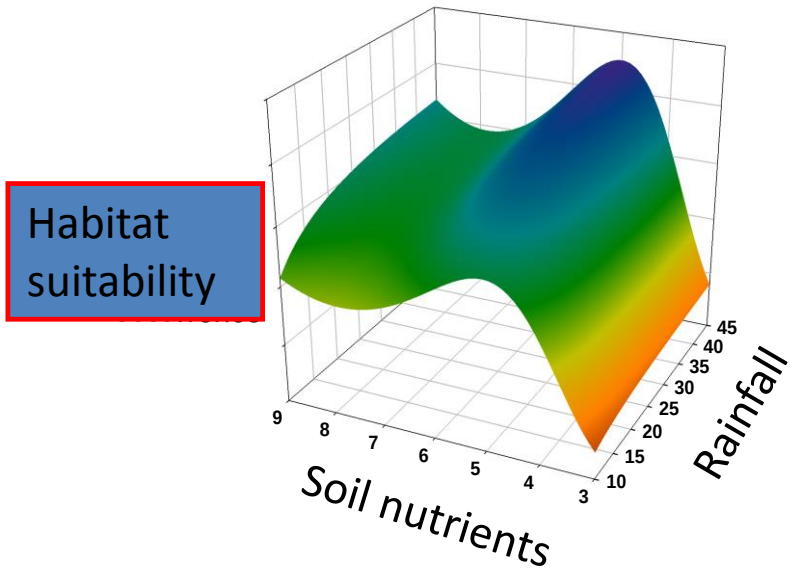
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Glastir Monitoring and Evaluation Programme

Modelling impacts on woodland biodiversity – plant species

- We used an ensemble of plant species niche models called MultiMOVE. Each model quantifies the environmental preferences of a species across Britain.
- The models are built from national scale, fine resolution presence / absence datasets.
- They cover 97% of high conservation value indicators, all major nectar plants, all ecosystem dominants and many less common species.
- All models have been compiled into a user friendly R package with functions to easily extract, map and plot model output. An example species….

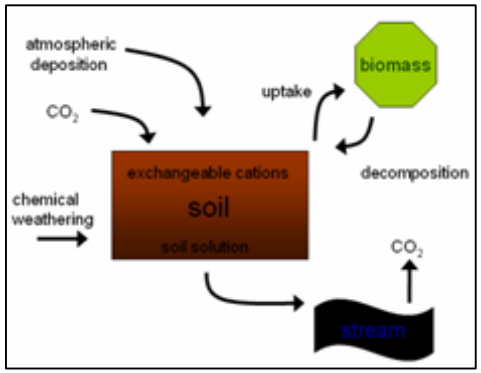
Trollius europaeus



Model application: Use available knowledge and dynamic modelling to simulate change in soil conditions and canopy height.

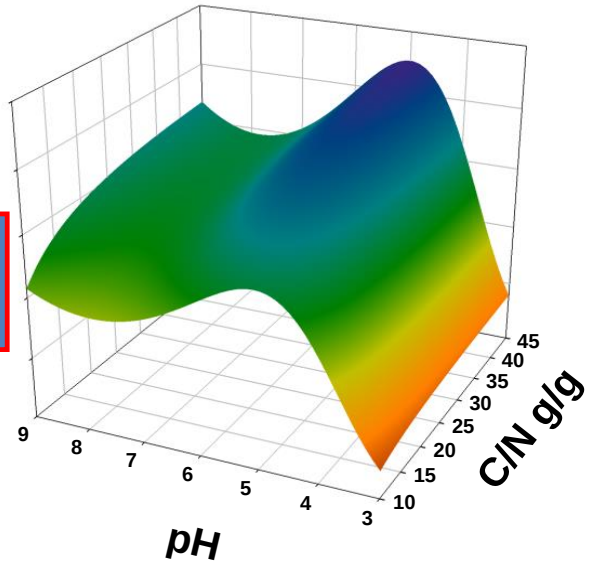
(see De Vries et al 2010. *Ecol. Applications* 20, 60-79; Smart et al 2010. *J.Veg.Sci* 21,643-656; Henrys et al (in press). *New Journal of Botany*)

Dynamic models e.g.
LUCI,MAGIC,VSD



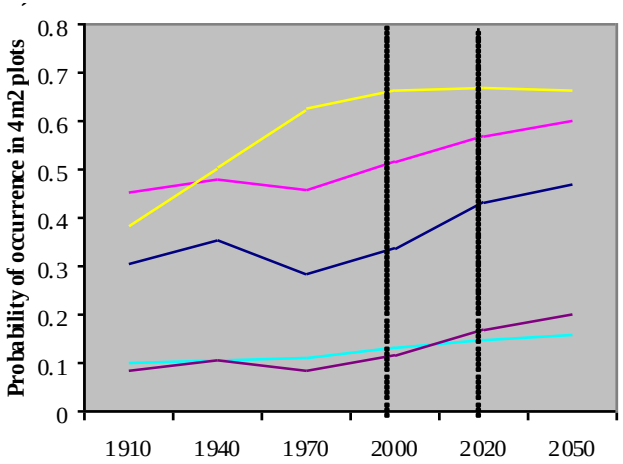
pH, C/N dynamics, vegetation height

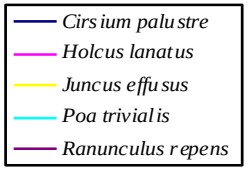
Niche model; MultiMOVE



Habitat suitability

Projected species change

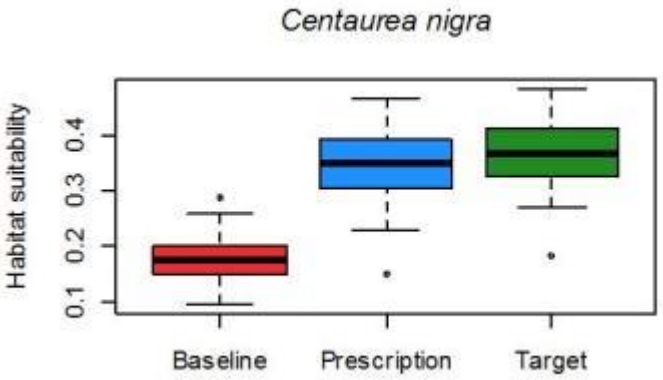




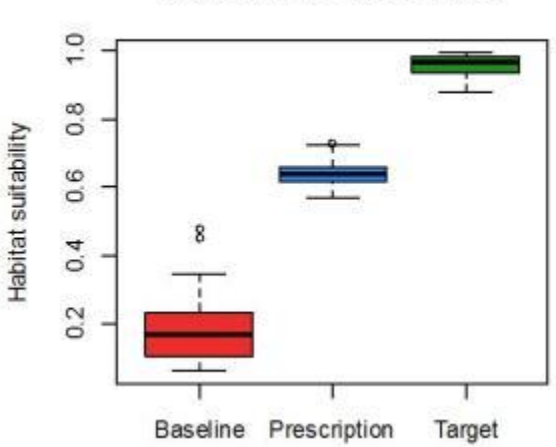
Implications for biodiversity and ecosystem services

Model application: Simulation of the impacts of Glastir interventions using MultiMOVE

Low input woodland rides (AWE/Advanced 15). No fertiliser for 12 years on **Improved Grassland** (baseline habitat). Target habitat is considered to be **Neutral Grassland and Scrub**.



Woodland expansion (AWE 24). Scenario covers 23 years of natural succession. Baseline habitat is **Improved Grassland** and target habitat is **Broadleaved Woodland**.



Summary of woodland expansion simulation:

- **Ecological impacts take time: >25 years for habitat suitability to approximate target conditions for woodland specialist plants.**
- **Conditions already favourable for generalist weeds!**
- **Species pool depletion may restrict community assembly.**
- **Model simulations help manage expectations for stakeholders.**

Who derives landscape benefits from Glastir?

- What aspects of the Welsh landscape do the public value?
- Do different groups value the landscape in similar ways? *Or are there important differences?*
- How do we measure this?
- What are the implications for woodland expansion in Wales?

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Glastir Monitoring and Evaluation Programme

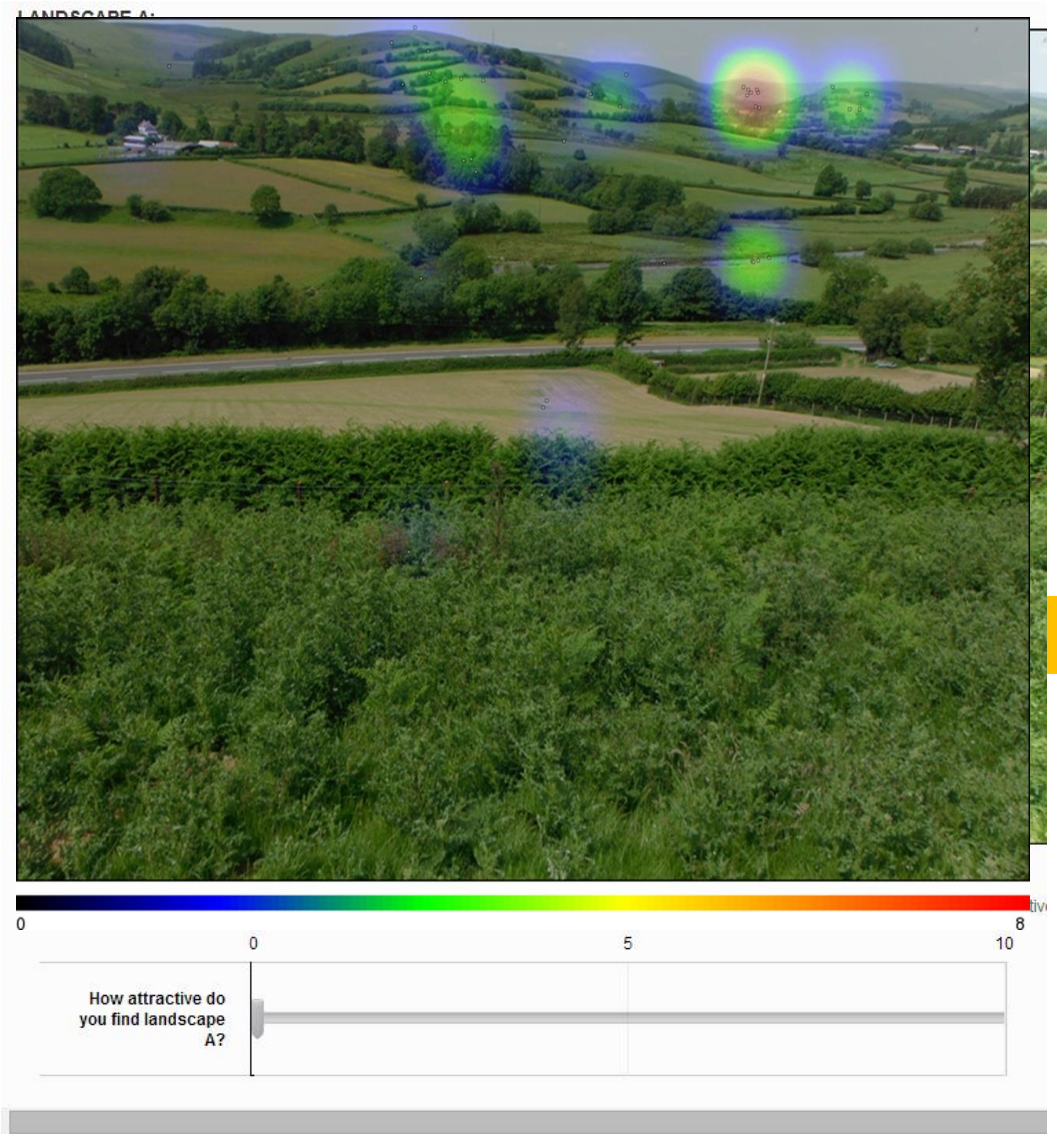
Aims of the landscape work

- To assess landscape quality*: complexity, topography, heterogeneity, built components, seasonal diversity and 3D visual setting.*
- To quantify the visual accessibility of these landscapes to the general public.
- To quantify the historic assets and sites provided, their condition and the socio-economic benefits derived from them.
- To quantify the impact of change to these landscapes as implemented under the targeted elements of the Glastir scheme.

Spectacular?

Dull?

Public preference survey



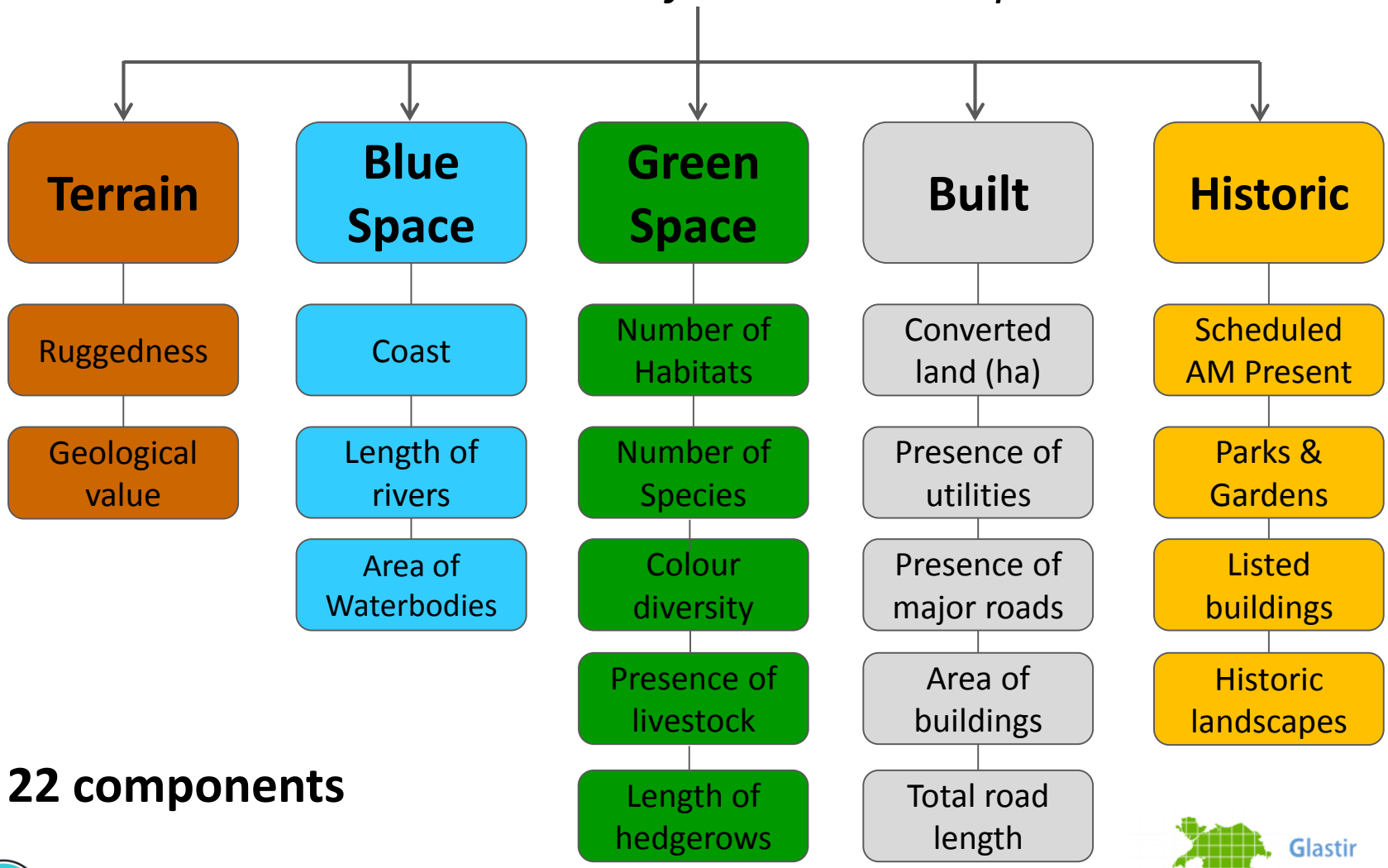
Heatmap results

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Glastir Monitoring and Evaluation Programme

Visual Quality Index

Values calculated for each 1km square

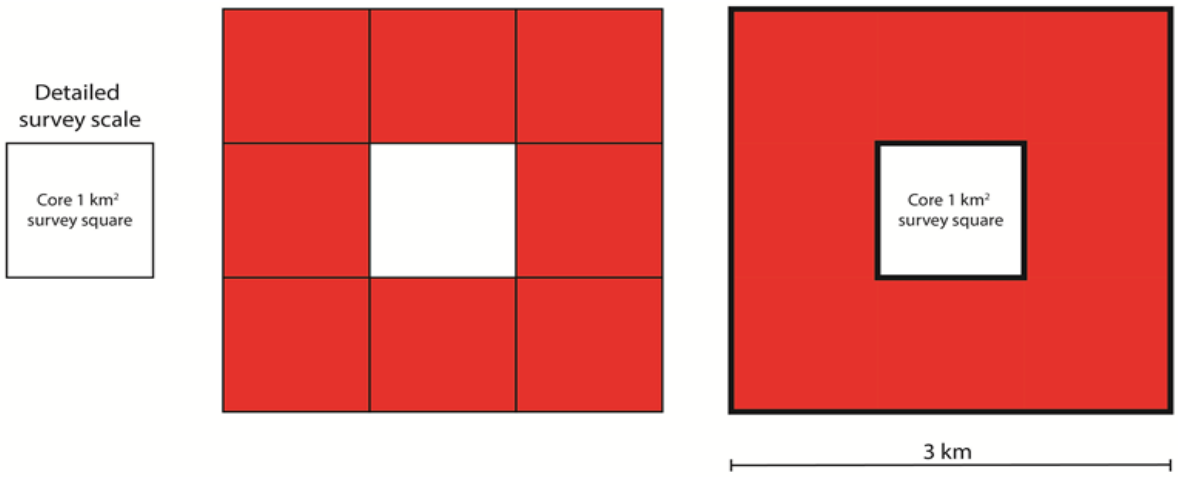


22 components

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Glastir Monitoring and Evaluation Programme

How does the landscape model work?



1. Calculate a **Visual Quality Index** for each 1 km² survey square
2. From the PROW, model a range of **Viewsheds**:
   - *Calculate what can be seen within the surveyed 1 km²*
   - *Calculate what can be seen of the surrounding 3 x 3 km²*
   - *Calculate what part of the 1 km² can be seen from the 3 x 3 km²*
3. **Combine**

VQI

✚

Viewshed

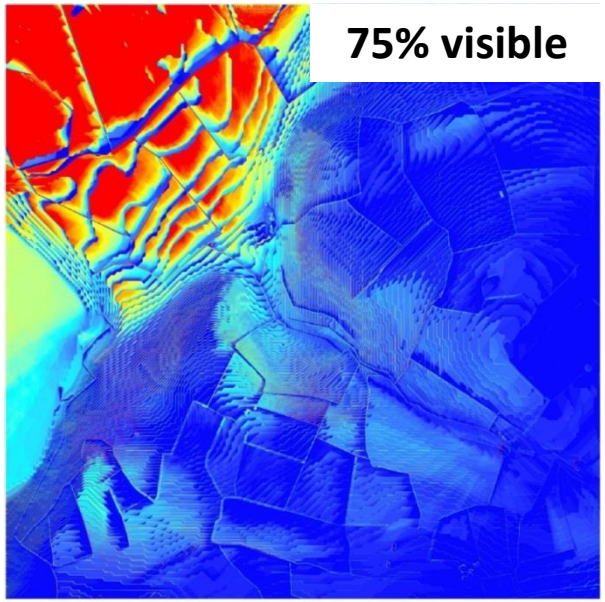
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Glastir Monitoring and Evaluation Programme

The Viewshed Model: Results

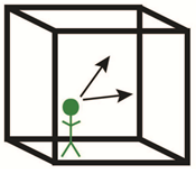
The detailed view

(*what can be seen from within the 1km*)



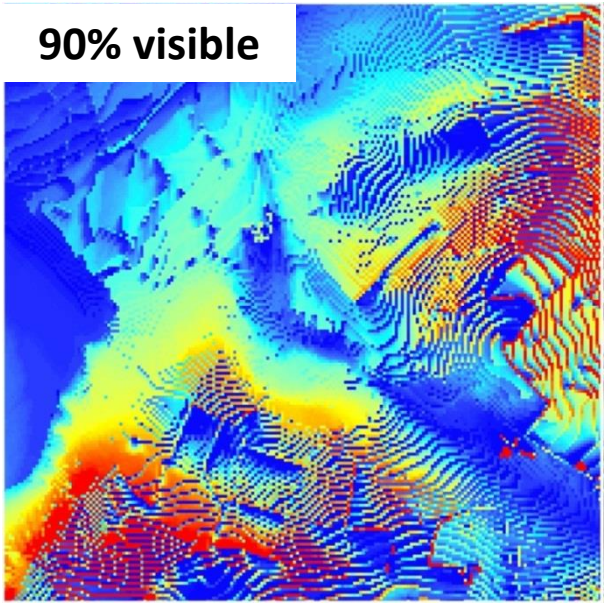
Visible from most points

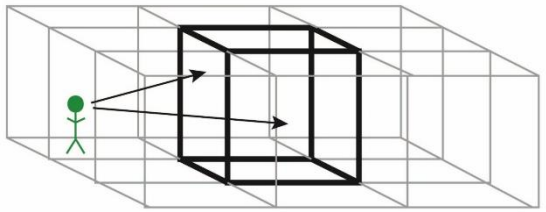
Not visible from any point



The surrounding view

(*what can be seen from the surroundings*)

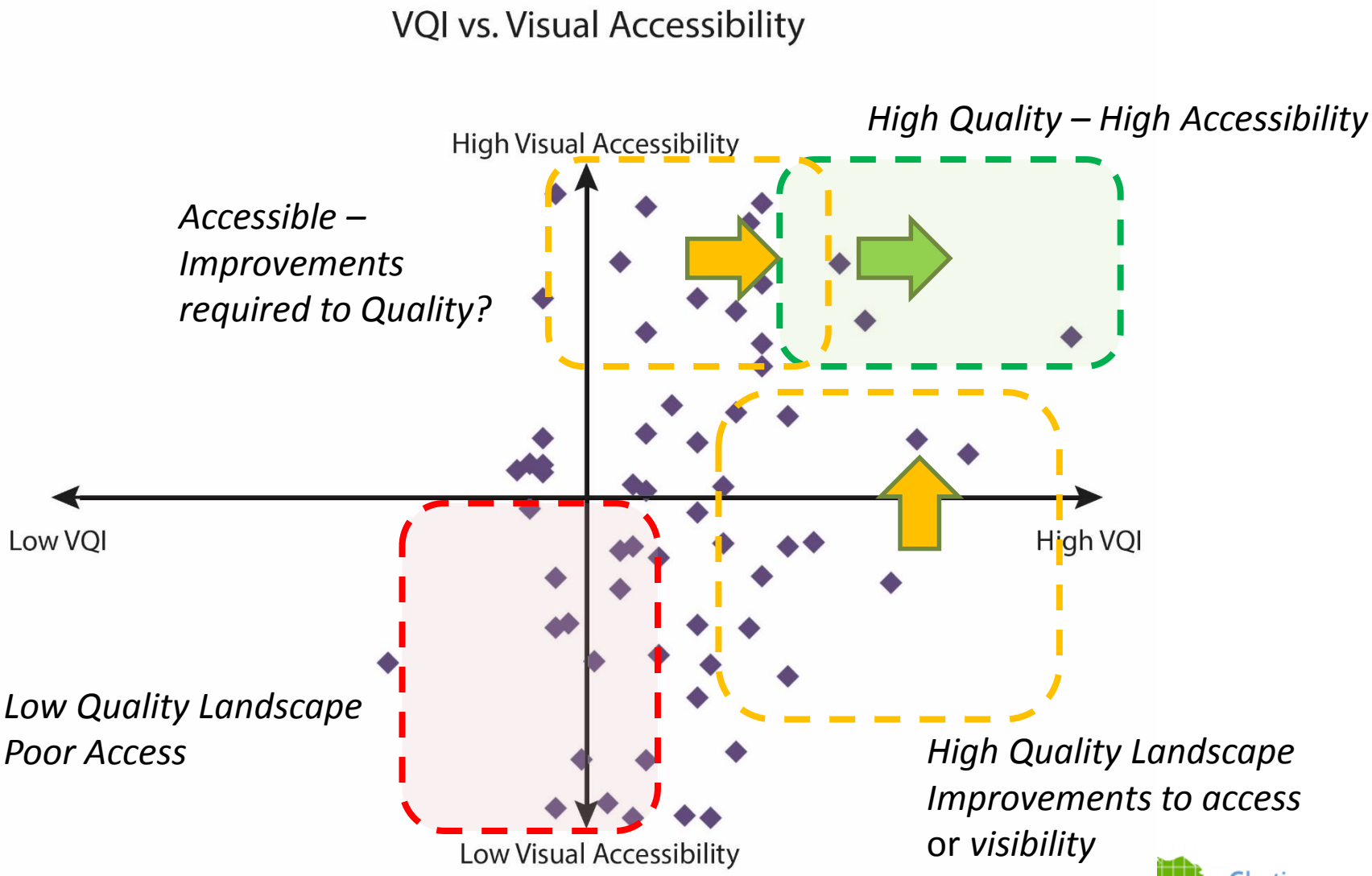




Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Monitoring and Evaluation Programme

Woodland is often valued highly but can reduce accessibility.



Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Glastir Monitoring and Evaluation Programme

Conclusions: benefits of woodland expansion in Wales

- Farm level reductions in **diffuse pollution and GHG** can be as high as 80% for some interventions. National level generally delivered 1-10 %
- The two Glastir woodland options (woodland edge expansion and streamside corridor planting):
  - increased accessible land for **broadleaf focal species** by 3 to 12%,
  - reduced the potential reduction in **flood generating land** by 1 to 9%,
  - increased national **carbon storage** by ca. 0.4%,
  - reduced eroded **soil and phosphorus delivery** by up to 15%
- Changes in habitat suitability varied. Significant progress towards target habitat suitability scores within 10-23 years of uptake of options but no guarantee they will appear if scarce in species pool
- 94% of people in Wales say that woodlands 'benefit' their local community. 65% regularly visit woodlands.