TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

CEH
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

LUCI

LAND UTILISATION & CAPABILITY INDICATOR

A land management decision support tool and ecosystem process modelling framework

Bethanna Jackson, Bridget Emmett, David Cooper,
Lindsay Maskell, + more…

Services currently modelled by LUCI

Service	Method
Production	Based on slope, fertility, drainage, aspect, climate
C stock/emissions	IPCC Tier 1 – based on soil & vegetation
CH_4/N_2O emissions	IPCC Tier 1 – soils, vegetation, 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 Approach A	Cost-distance approach: dispersal, fragmentation, connectivity.
Habitat Approach B	Identification of priority habitat by biophysical requirements e.g. wet grassland
Coast 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

LUCI needs only three datasets; in theory available everywhere-

- Digital elevation data
- Land cover data
- Soil data

It infers values for other datasets where necessary, but the following and more are supported and improve its robustness:

- River network
- Management data to correct/adjust or overwrite land cover data as appropriate
- Geology, climate data, habitat/species data, etc

Provides pre-processing tools that reconcile inconsistencies in data/extents; also “batch scripts”

SEEA-EEA “Spatial Units”

- Basic spatial unit: finest available resolution of topographical “DEM” (at worst 50x50m at global scale, 5-15m usually)
- Land Cover/Ecosystem Functional Unit: Soil, land cover, land management, climate, altitude….
- Ecosystem Accounting Unit: Any – normally water basins, regional or other political boundaries, etc.

Negligible parameterization effort

1. LUCI is biophysical where possible, and respects fundamental physical thresholds at an appropriate scale
2. It otherwise follows established, parameterized empirical approaches (e.g. IPCC)
3. We provide default look up tables linked to input datasets for all applications, which can be modified by users if desired
4. Stakeholder process provides necessary check (else risk ease of application could lead to lack of appropriate interrogation)

Underlying principles:

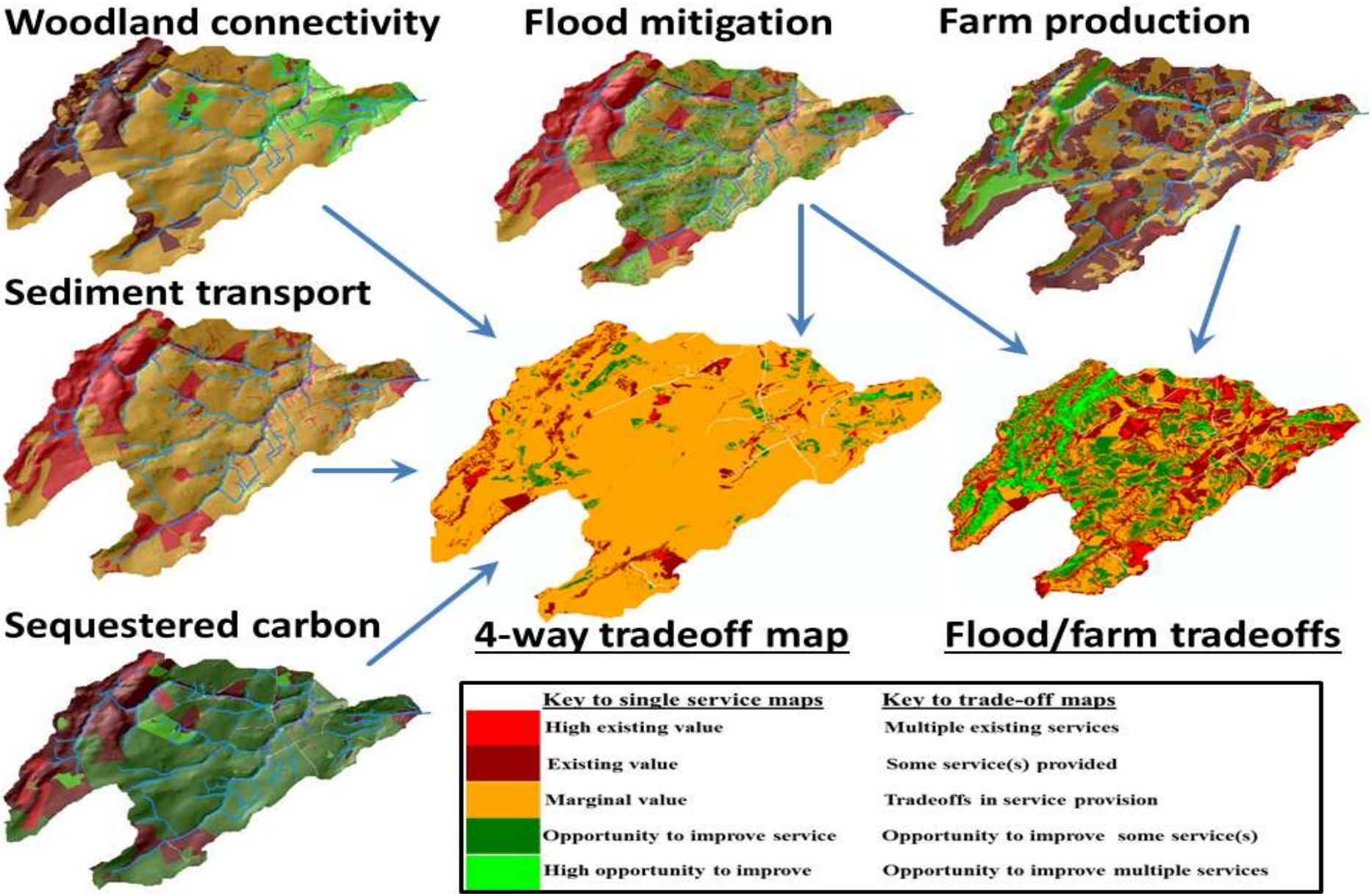
Practical

1) Can be run using nationally available data; i.e. available everywhere 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

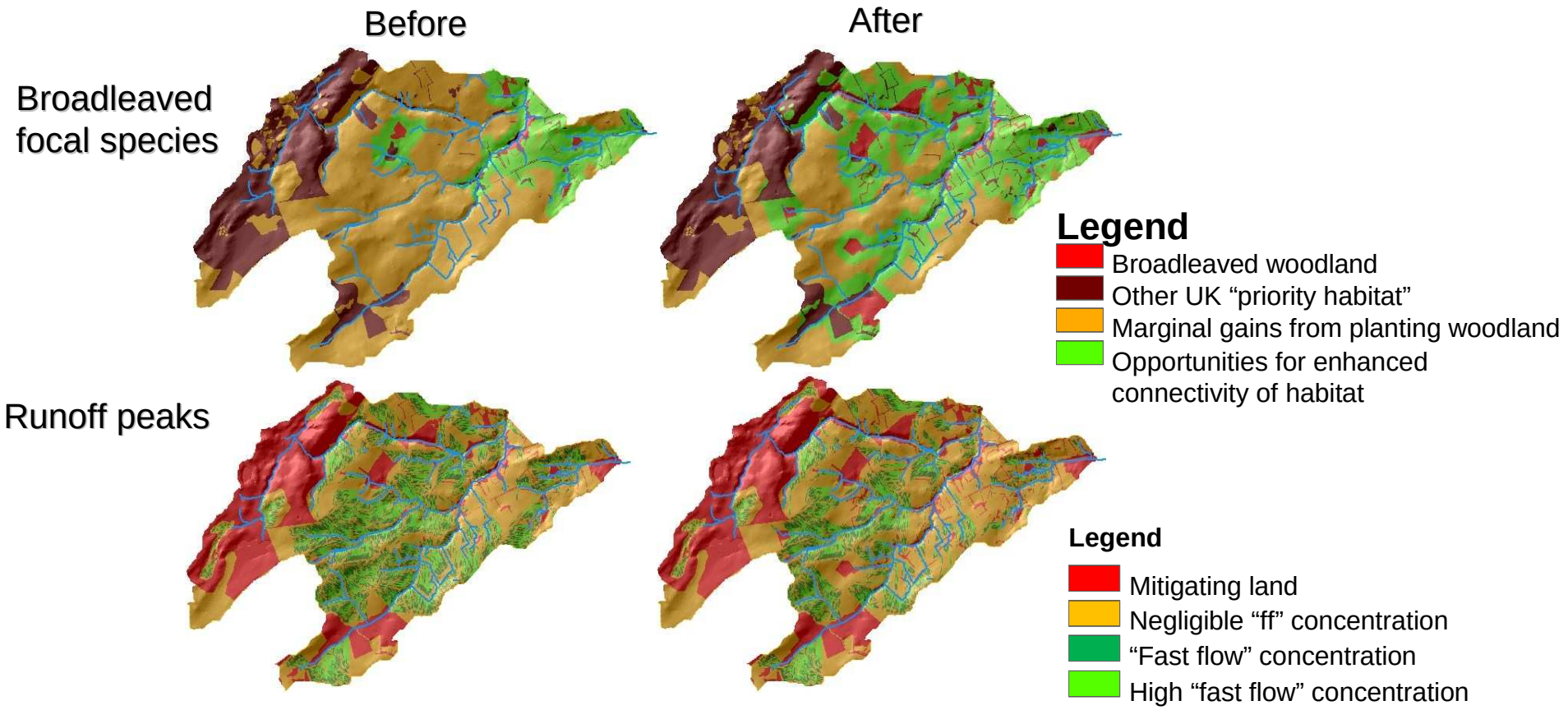
1) Operates at a spatial scale *relevant for field and sub-field level management decisions*
2) "Values" features and potential interventions by area affected, not just area directly modified
3) Addresses spatial tradeoffs & searches for "win-win" solutions

LUCI actively identifies tradeoffs and synergies



LUCI models the area impacted, not just area modified:

e.g. Impact of tree planting at Pontbren 1990



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

....and explores benefits of better spatial targeting: Environmental Stewardship (Env St) outcomes with and without LUCI

Metric	Units	Before Env St	After Env St	Optim Area with LUCI*	Optim Outcome with LUCI*
Total present carbon	kg/ha	199	207	221	212
Total future carbon	kg/ha	172	193	209	198

***Optim area= same area/payment,more outcome;**

***Optim outcome = less area/payment, similar outcome**

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Metric	Units	Before Env St	After Env St	Optim Area with LUCI*	Optim Outcome with LUCI*
Total present carbon	kg/ha	199	207	221	212
Total future carbon	kg/ha	172	193	209	198
Broadleaf woodland	km^2	18	34	32	26
Area accessible to BLW species	%	45	70	74	69
Potential wet grassland	%	0.9	0.7	0.1	0.3
Land in production	%	47	39	43	44
Non-“mitigated” land	%	37.7	25.5	24.3	32.7
Connected sediment generating land	%	11.3	6.7	3.6	5.9
P export to rivers/lake	kg/ha/yr	0.178	0.173	0.164	0.171
Peak flow change in max. Summer flood	%	baseline	-2.3	-9.3	-3.1

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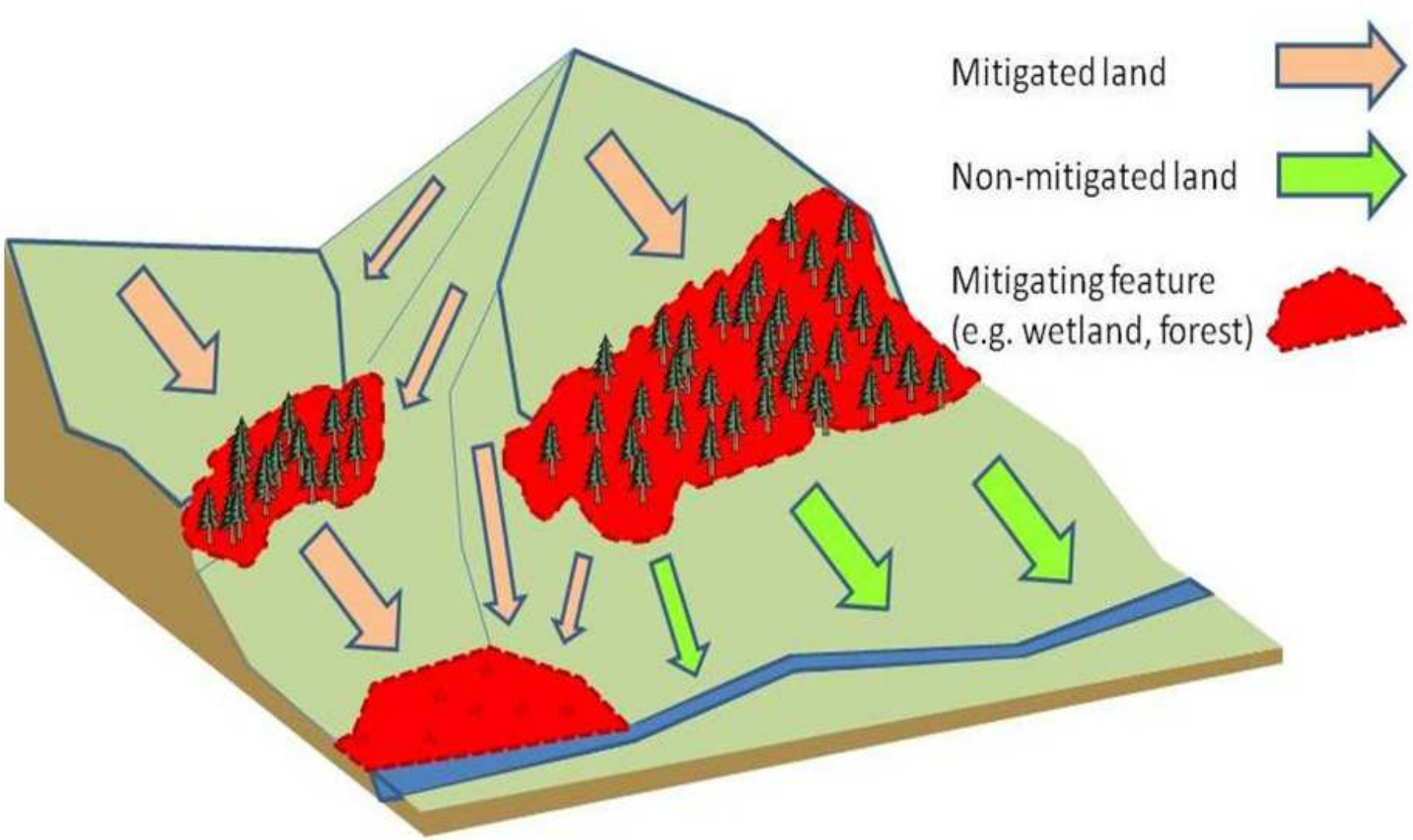
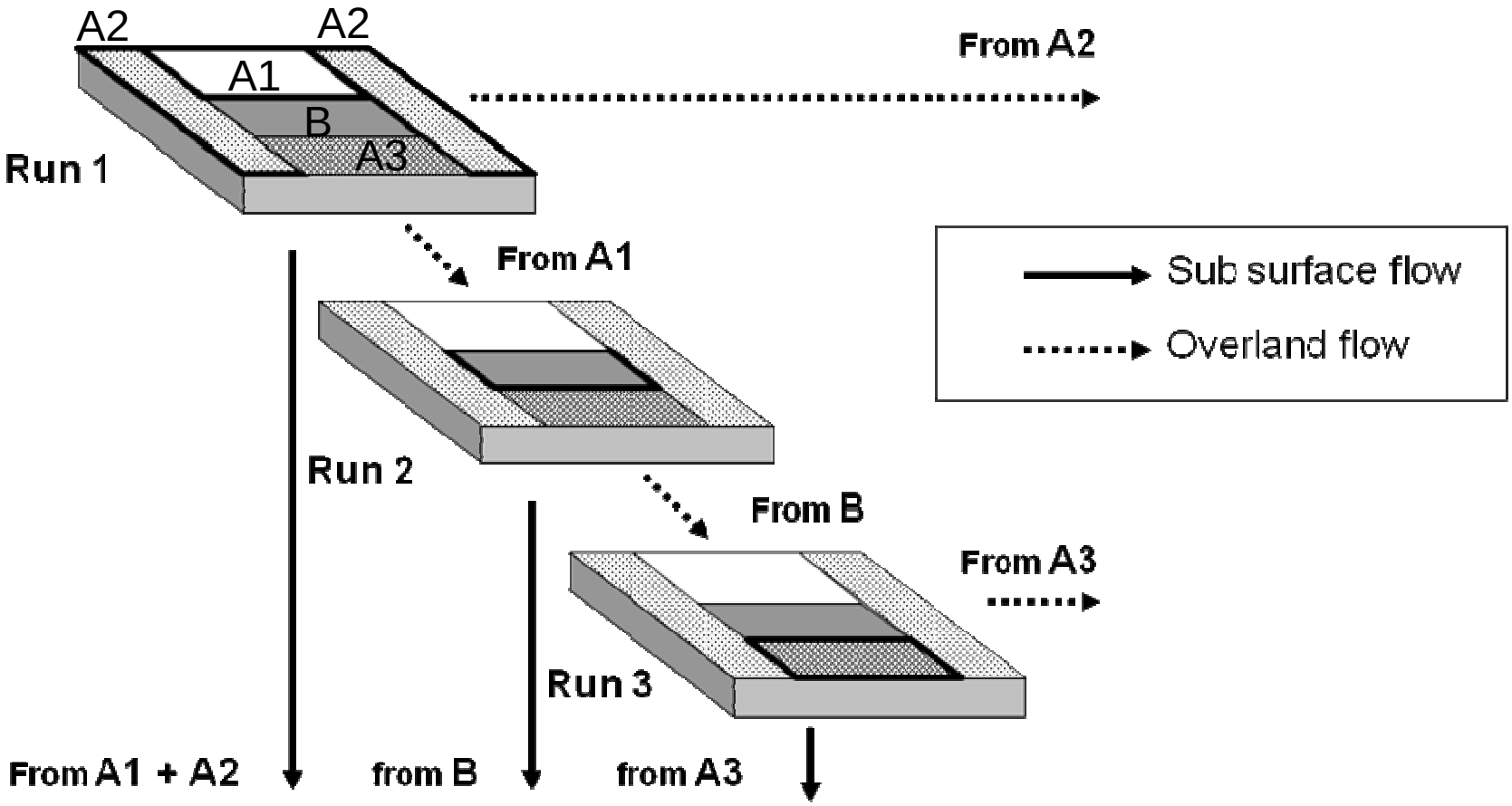
Water quantity, quality and sediment delivery services

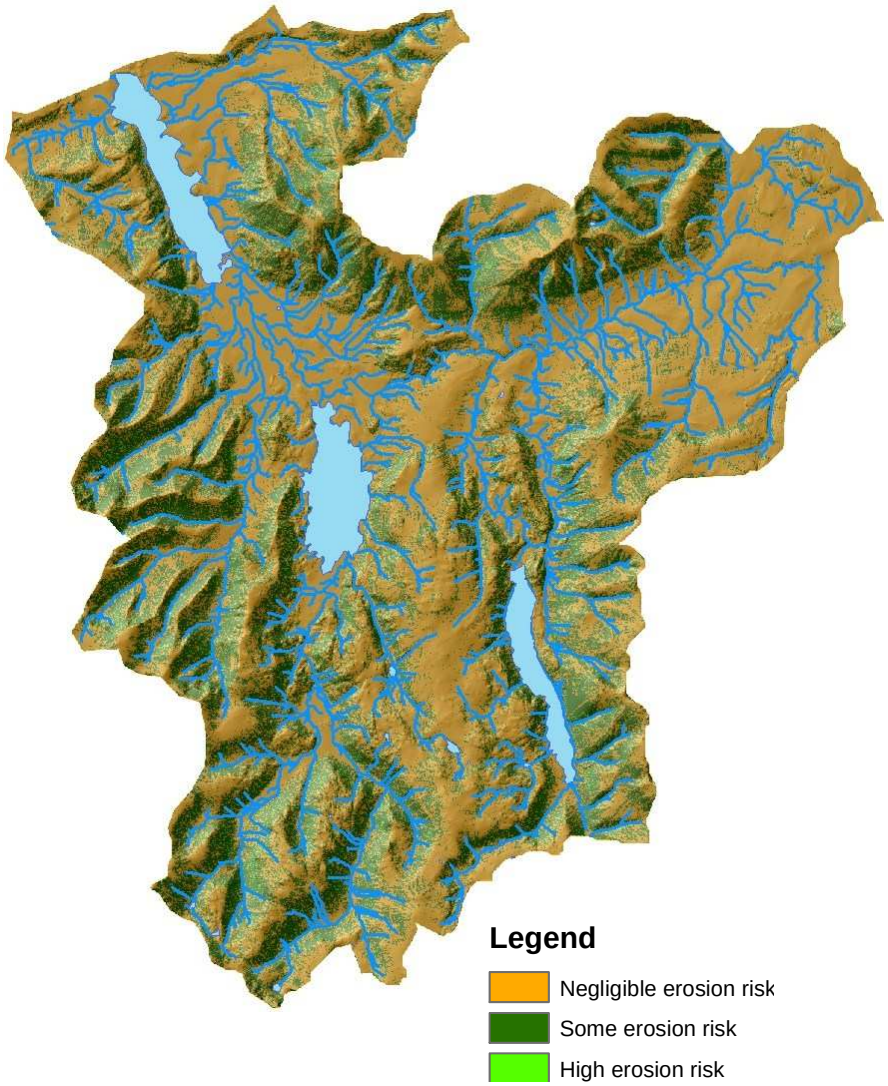


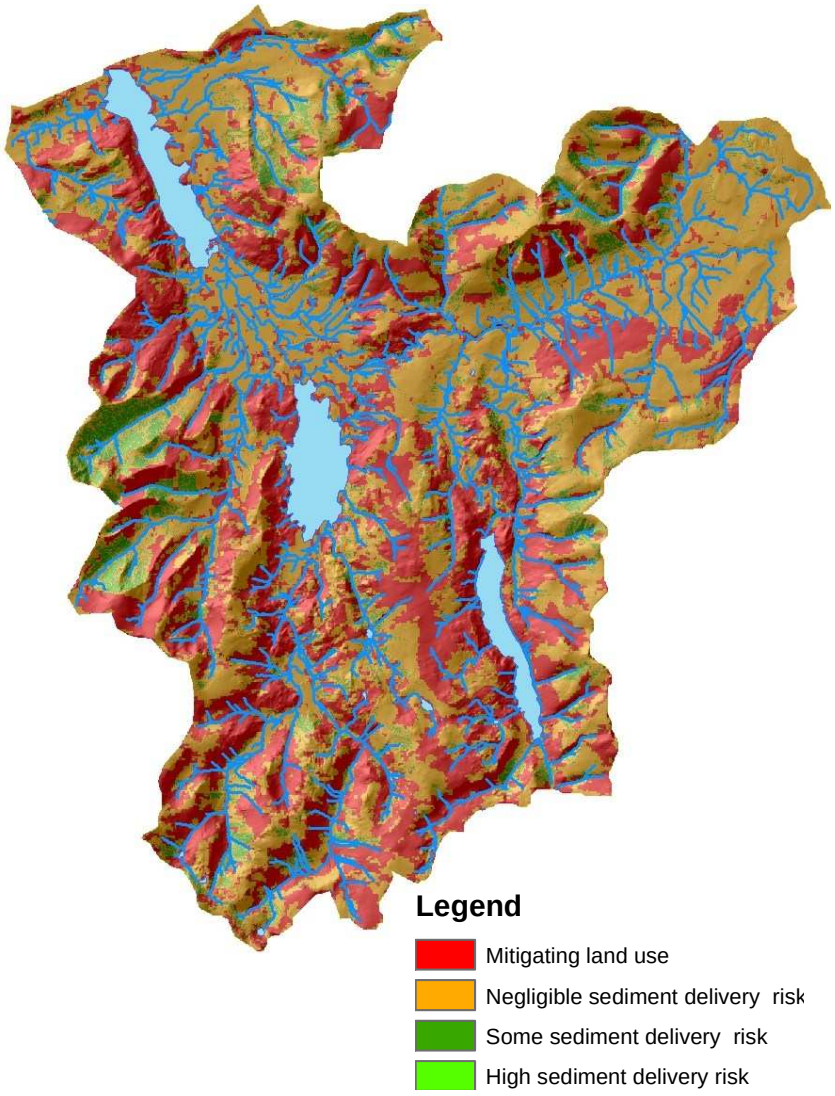
Cascade routing approach



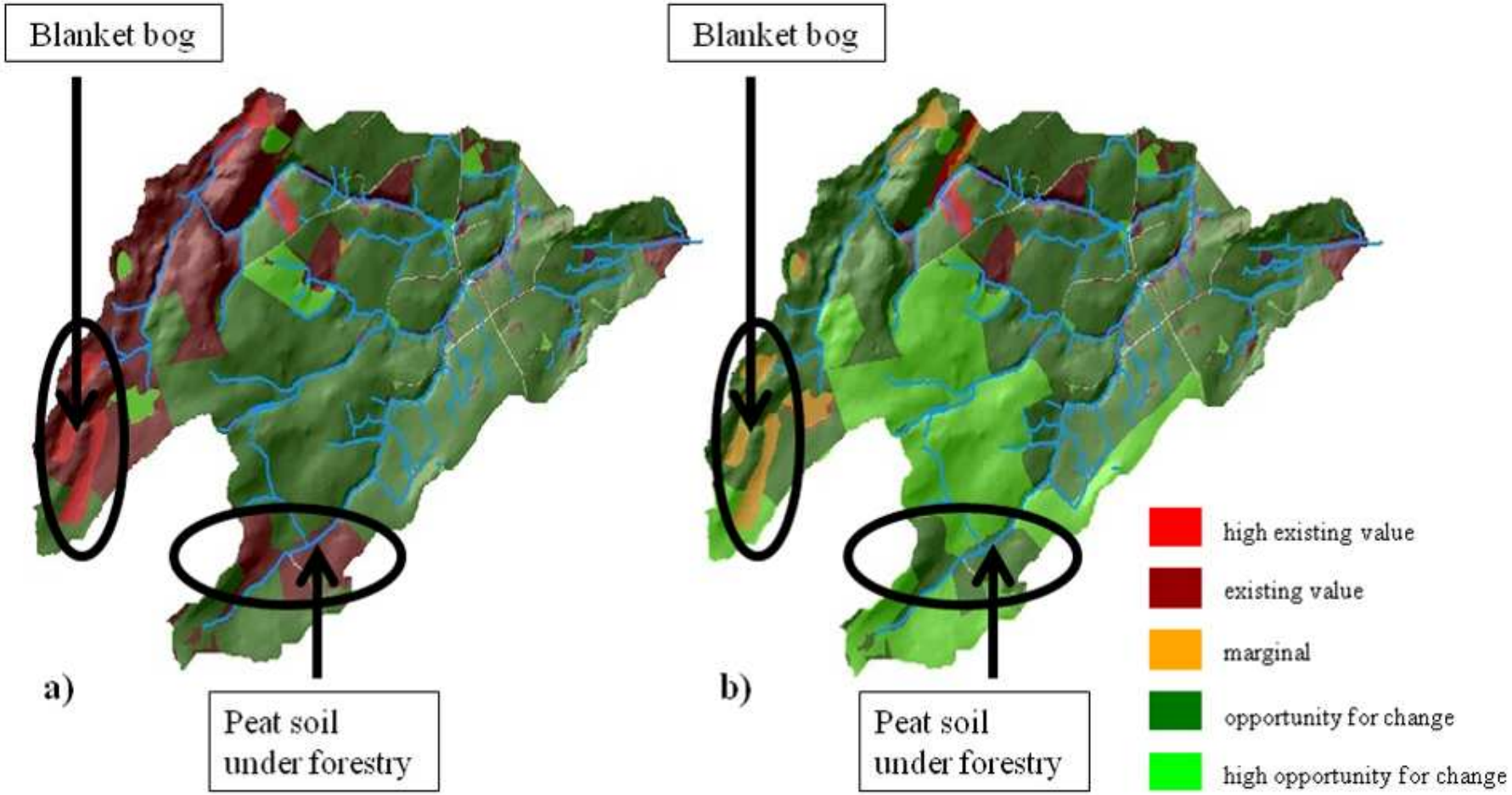
Run	Parameterisation	Water flux at surface (m)
1	A	Rainfall – evapotranspiration
2	B	Rainfall - evapotranspiration + overland & throughflow contribution from run 1 * $area_{A2}/area_{B}$
3	A	Rainfall - evapotranspiration +overland & throughflow contribution from run 2 * $area_{B}$ /$area_{A3}$

Example water service layers: erosion and sediment delivery (Bassenthwaite catchment, England)

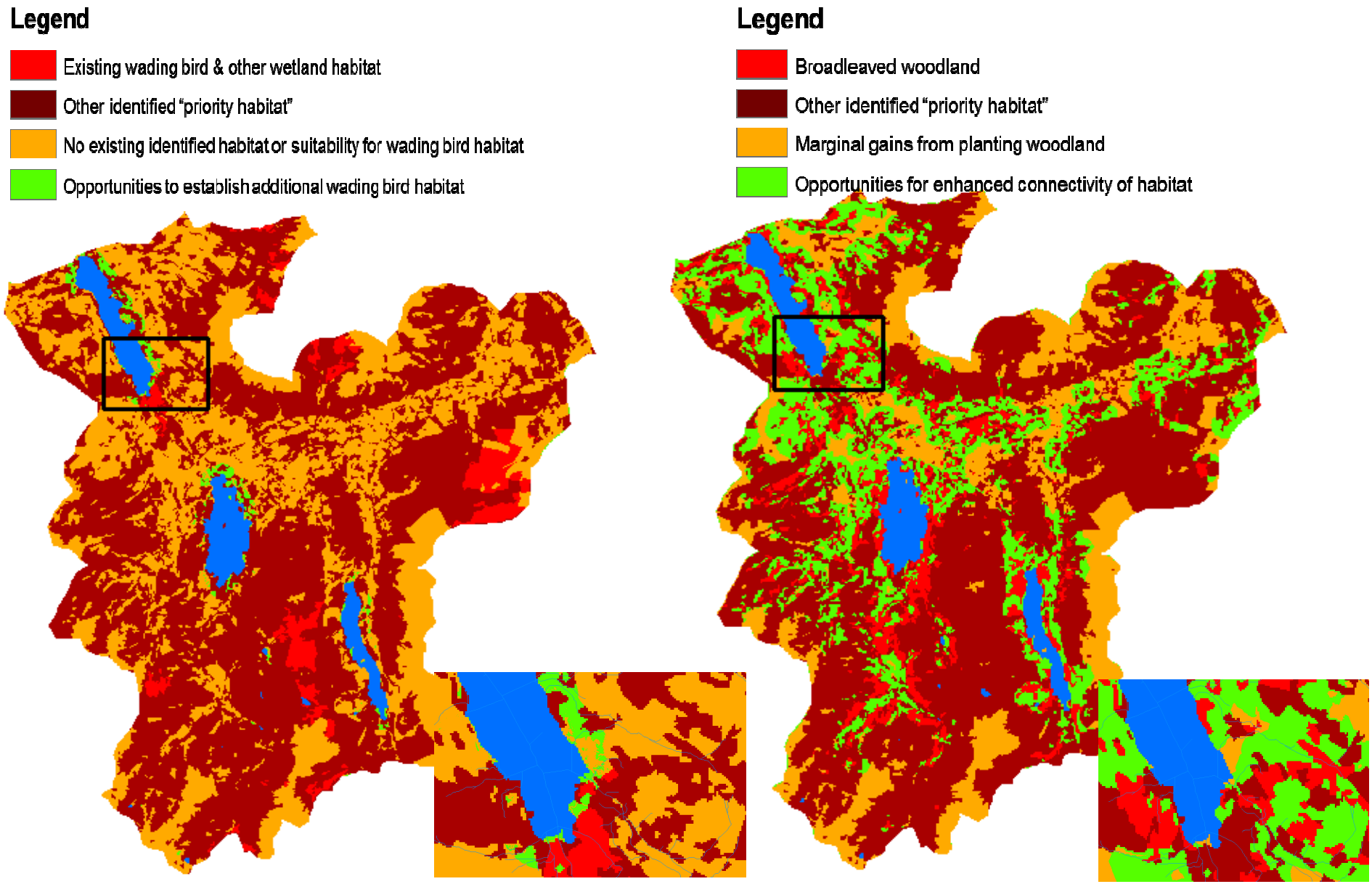




Example carbon – stock & sequestration; IPCC Tier 1 compatible; depends on land cover & soil (Pontbren catchment, Wales)



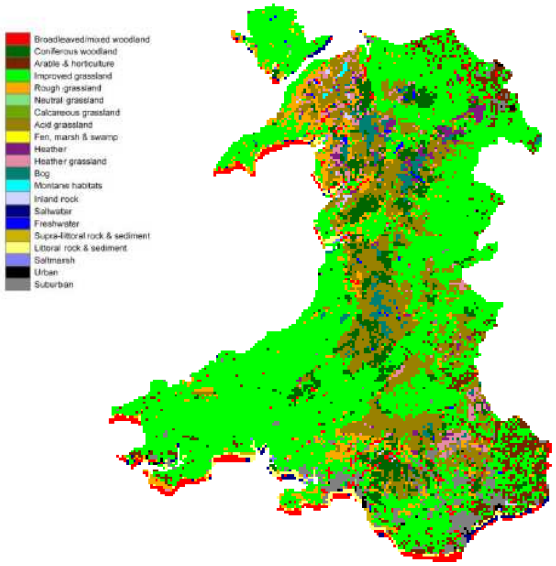
Biodiversity – Habitat indicators

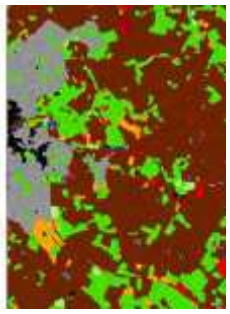


Biodiversity: inclusions coming (1)

Metrics (calculated for 1km square)

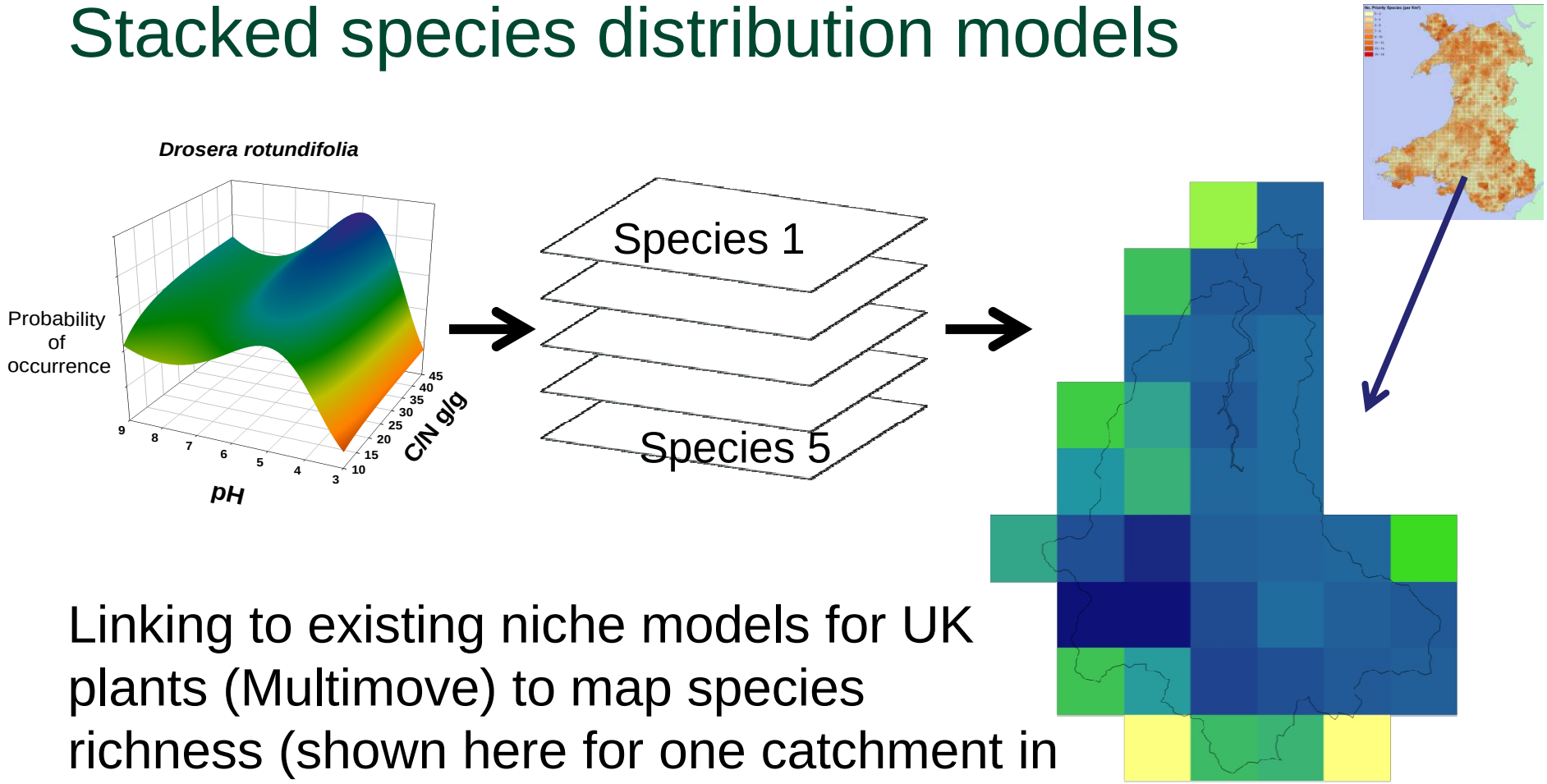
- Habitat richness: total number of habitats
- Diversity (e.g. Simpsons, Shannon index)
- Evenness
- Similarity (e.g. Bray-Curtis)
- Mean patch size
- Vegetation structure
- Total length of linear features (e.g. hedgerows, walls) where resolution of product permits





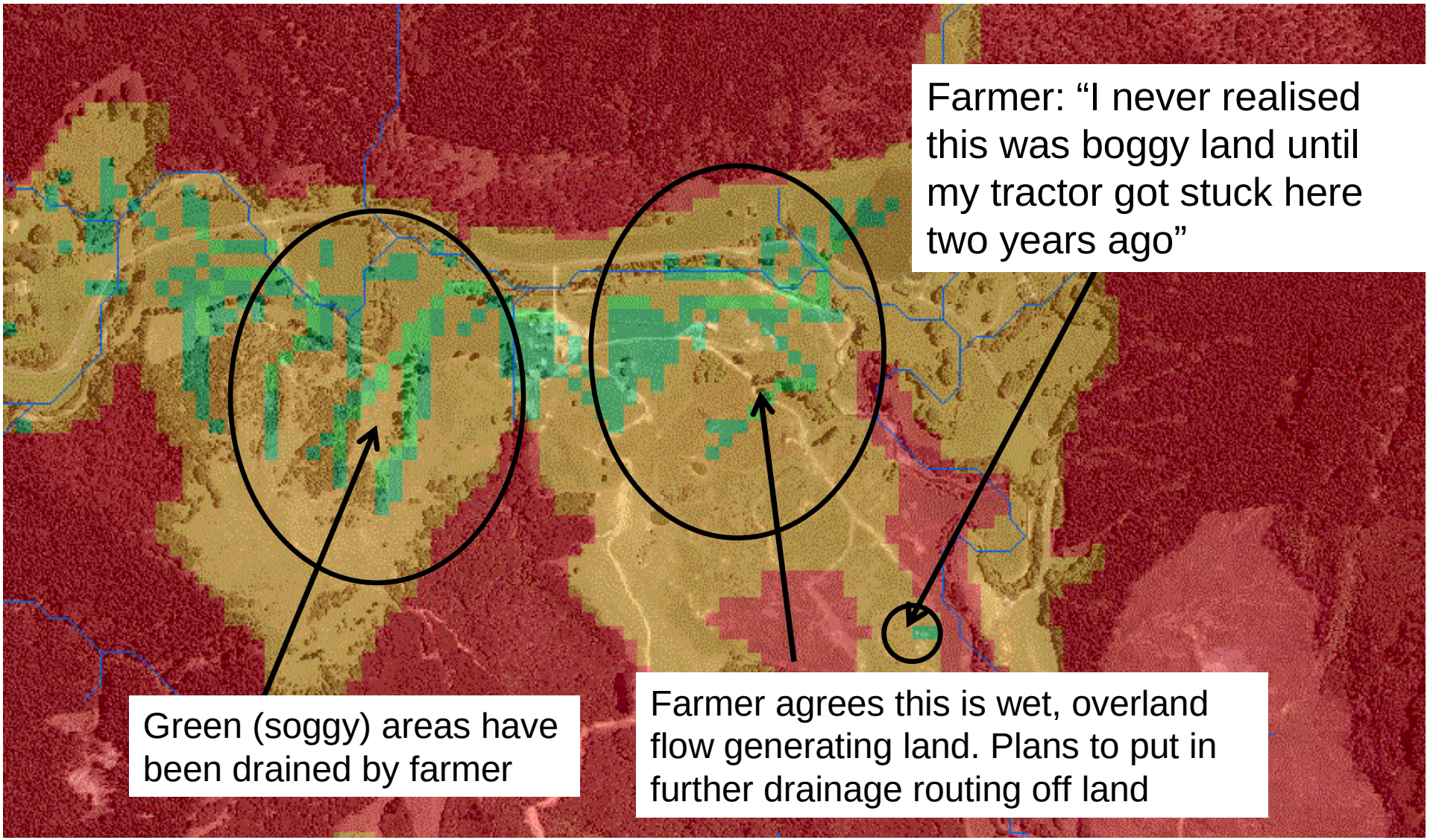
Biodiversity: inclusions coming (2)

Stacked species distribution models

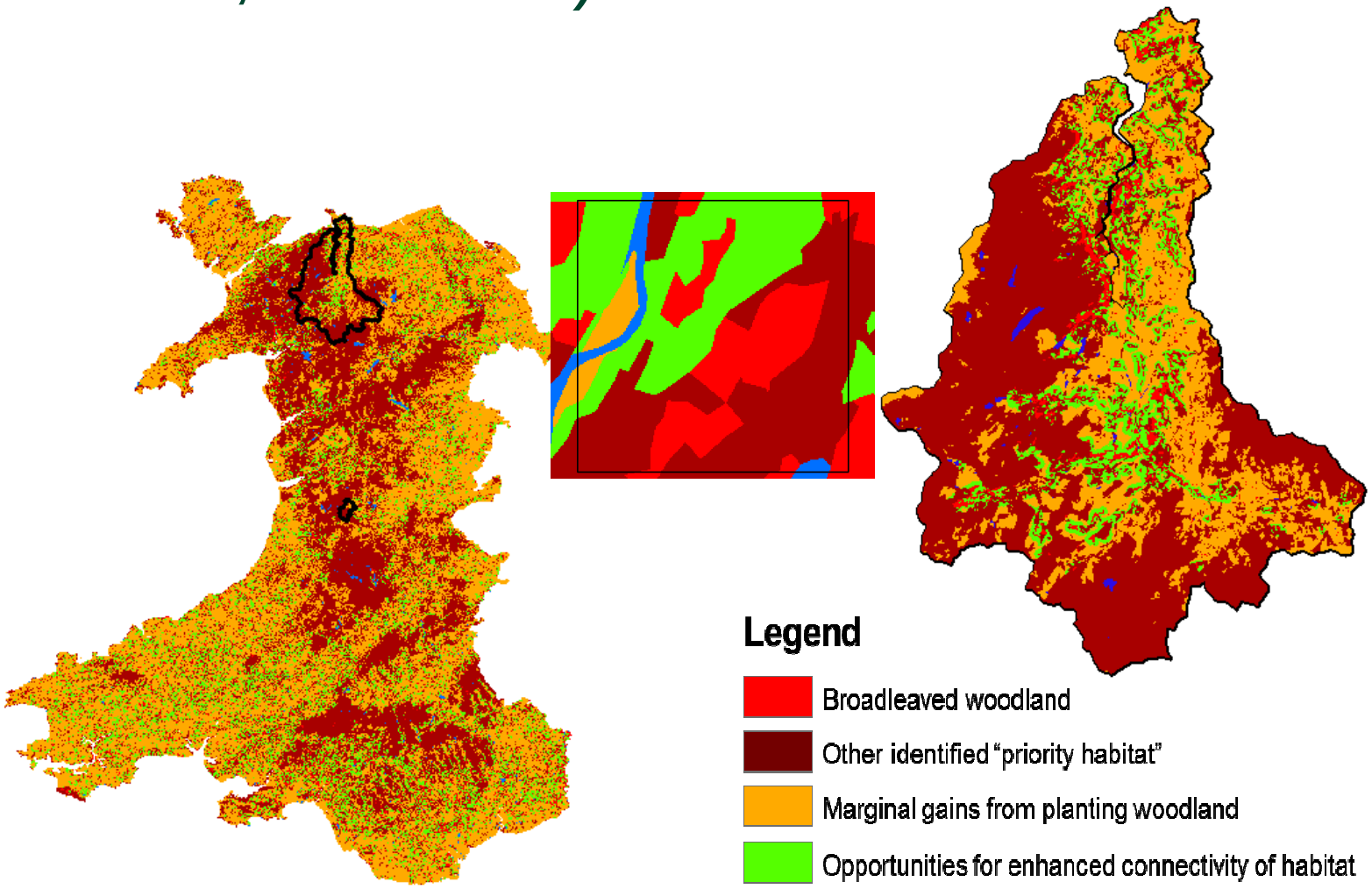


Linking to existing niche models for UK plants (Multimove) to map species richness (shown here for one catchment in Wales). Predictions of the distributions of individual species can be combined to predict total biodiversity.

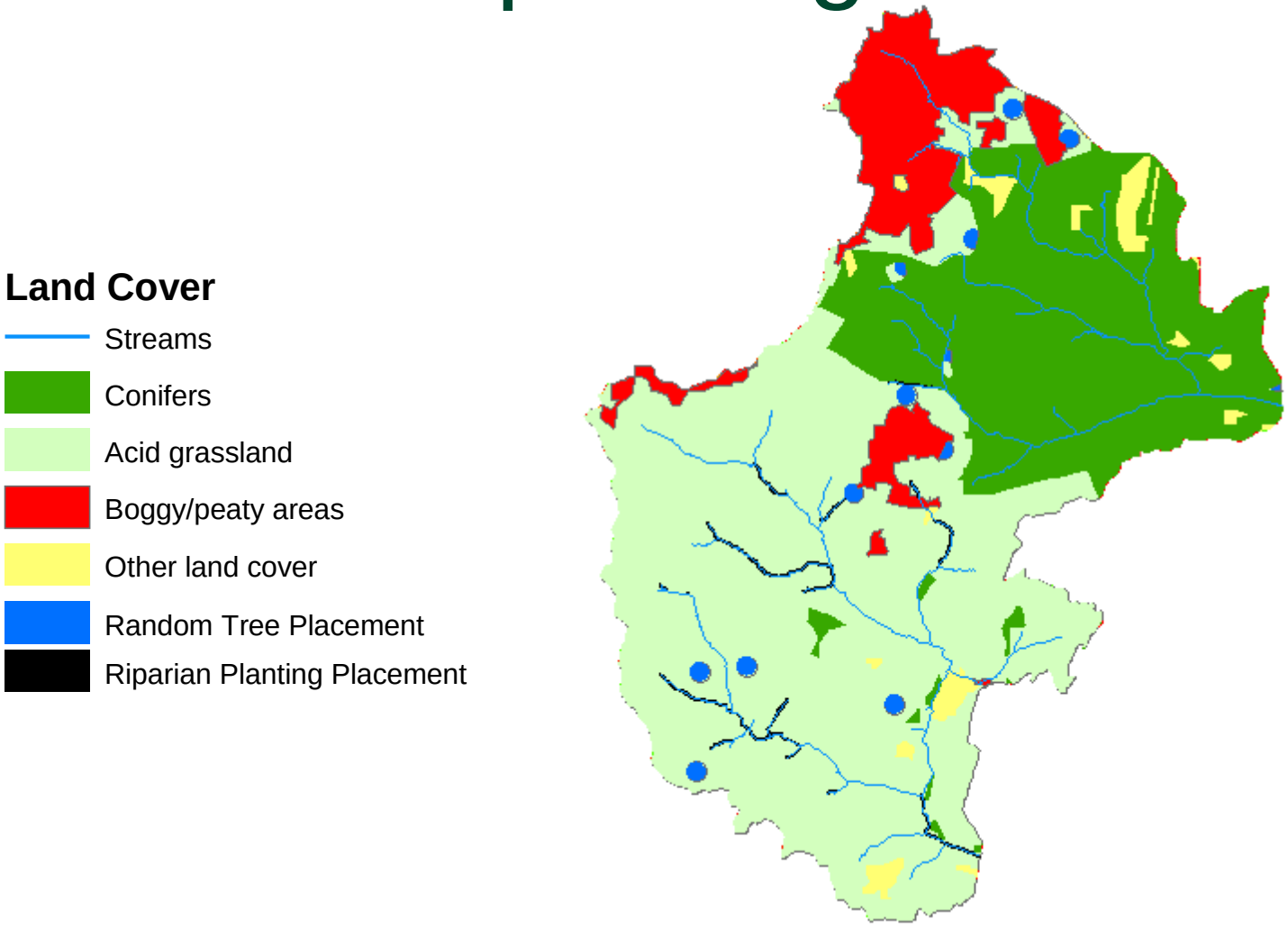
Groundtruthing flood generation output (Uawa Farm, New Zealand)



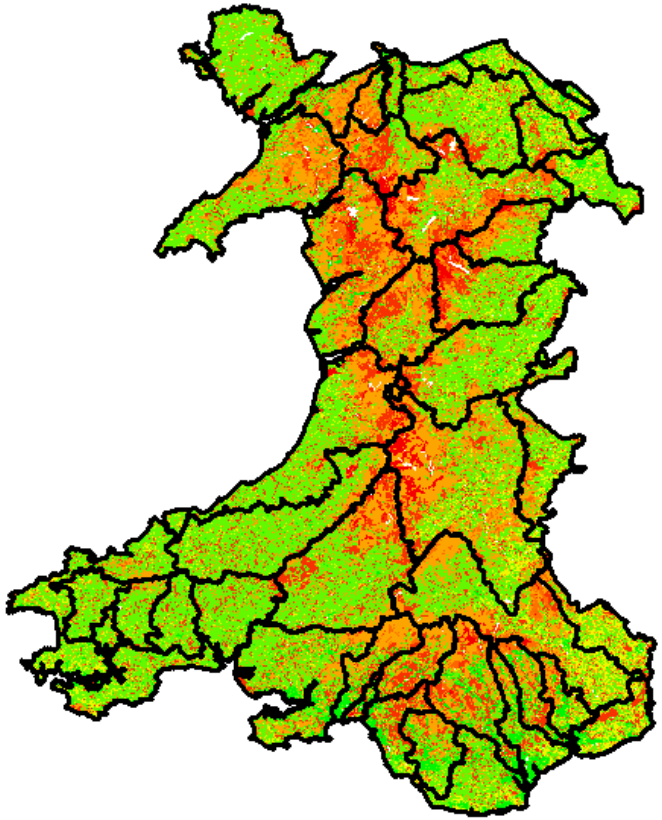
Aggregation: 5x5m (e.g.) to country, 1km square, water bodies catchments, also by “ecosystem functional units” (e.g. land cover, elevation)



Example disaggregation: placement of tree planting



LUCI parallelised & running over all of Wales



42 catchments / catchment bundles
5x5m resolution
~800 million points for each output layer
Approx 1 day *computer effort* to reconcile data
Approx 1 day *computer effort* to generate land management scenario, generate all ecosystem service outputs, and stitch outputs together for mapping/analysis
2-3 man-hours total
(output to left is carbon stock, red high, green low)

Feasibility of UK/global applications

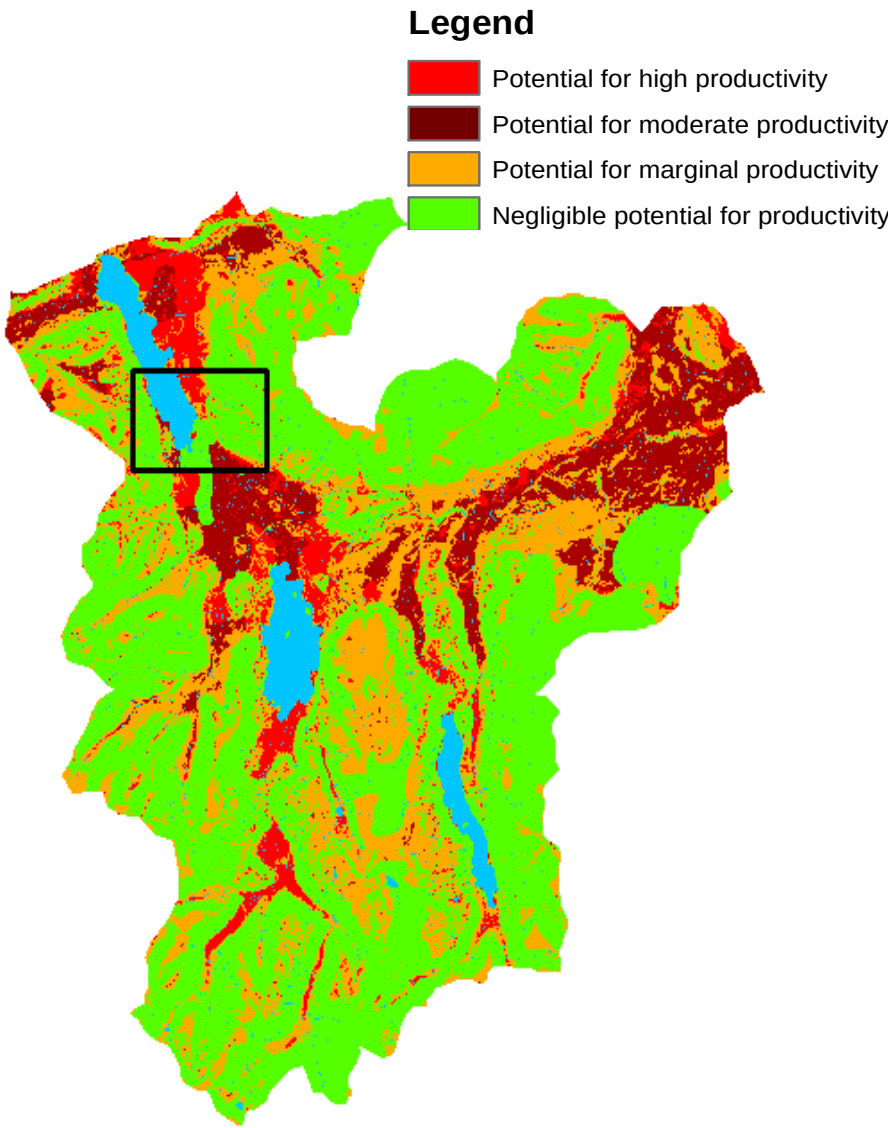
- Very!
- 2 days on 1 desktop computer to run 800 million element Wales application
- But LUCI now parallelized & server-supported- HPC or Beowulf cluster

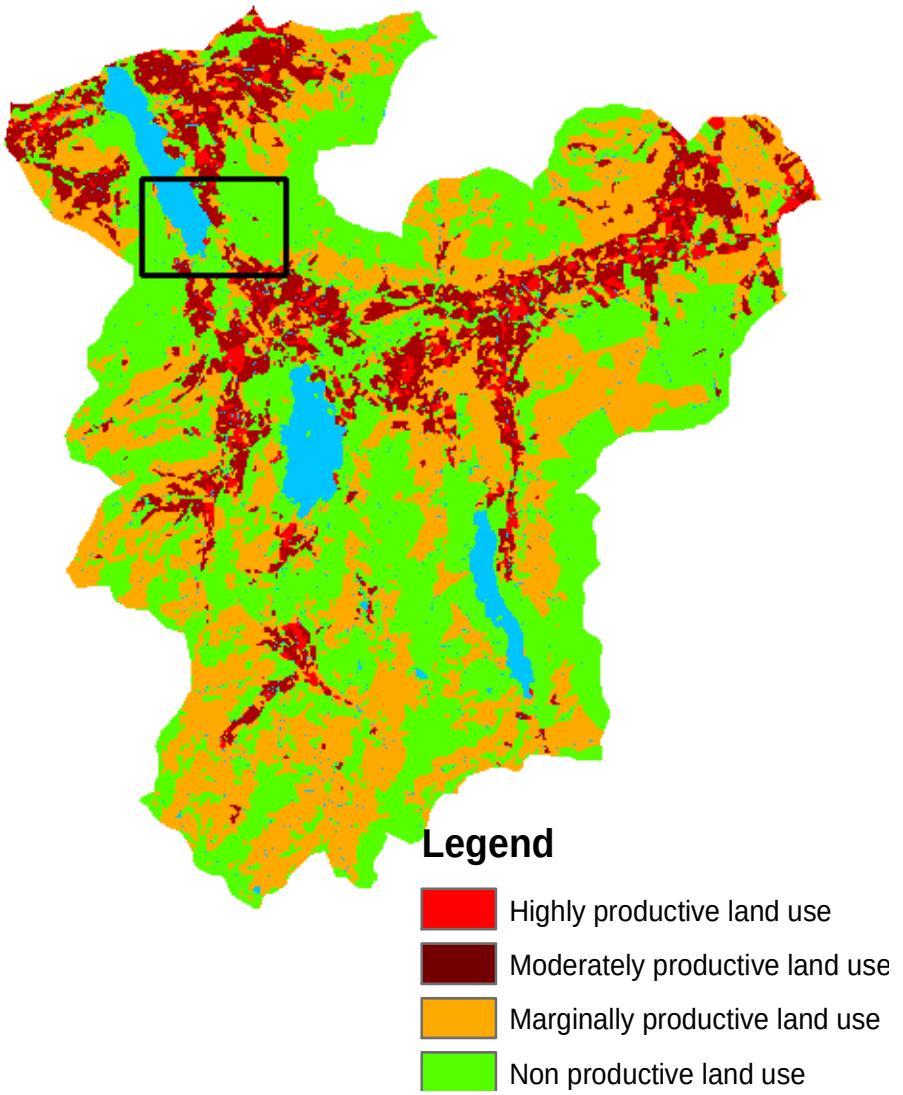
Application scale	DEM	Area (km2)	No. elements	Region time/ Wales time
Wales	5x5m	2.1×10^4	0.8×10^9	1
UK	5x5m	2.4×10^5	9.7×10^9	12
World	50x50m	1.5×10^8	60.0×10^9	75

Environment-economy linkage

- Not explicitly linked
- Implicitly linked through agricultural productivity. Economic valuation of primary production will be included later
- LUCI output being translated into economic terms in current project (TEEB Phase II compatible)
- Cultural-environment-economy linkage coming through focus of current funded projects on European subsidies & cultural mapping work.

Potential versus current production





Final points, then final questions:

Stakeholder engagement;

Cultural service work;

Protection of historical features, viewsheds etc.

Remaining questions:

- Treatment of uncertainty – standard MC approach, plus new spatial uncertainty routines
- Time elements – full temporal support for mass routing; more coming; other services generally estimate change from “current” to steady-state conditions under different scenarios
- Flows / beneficiaries
- Reliance: Currently use ArcGIS, otherwise no reliance on additional/proprietary software (+LUCI is being web enabled)

We see data reliance as bigger issue