LUCI- a spatially and temporally explicit framework exploring opportunities for enhancing multiple ecosystem services through targeted land management

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TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI

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LUCI-Land Utilisation and Capability Indicator GIS toolbox

Holistic and spatially explicit consideration of impacts of land use on the following services:

- **Food provisioning**
  - **agricultural productivity**
- **Water regulation**
  - **flood risk**
  - **erosion and sediment transfer**
  - **water quality (N & P, but more to come...)**
- **Climate regulation**
  - **carbon stock versus sequestration/emissions**
- **Biodiversity**
- **Cultural/historical features**

Allows stakeholders to simply and actively explore tradeoffs

LUCI-Land Utilisation and Capability Indicator GIS toolbox

- **Values existing features and potential for change by "service".**

- **Explores where multiple benefits and financial incentives exist.**

- **"Tier 1" designed to rapidly explore spatial trade offs and synergies with other ecosystem services – explores impacts of small-scale (sub-field level) changes at landscape scale.**

- **"Tier 2" algorithms allow quantification of performance of these scenarios of land use under different climatic events.**

- **Designed to work with widely available (national) data and update with local knowledge where possible -applications to date in UK (Wales and England), NZ (Hawkes Bay and East Coast), Ghana, Greece.**

LUCI allows interventions to be spatially targeted according to end-user priorities

Mitigated land

Non-mitigated land

Mitigating feature
(e.g. wetland, forest)
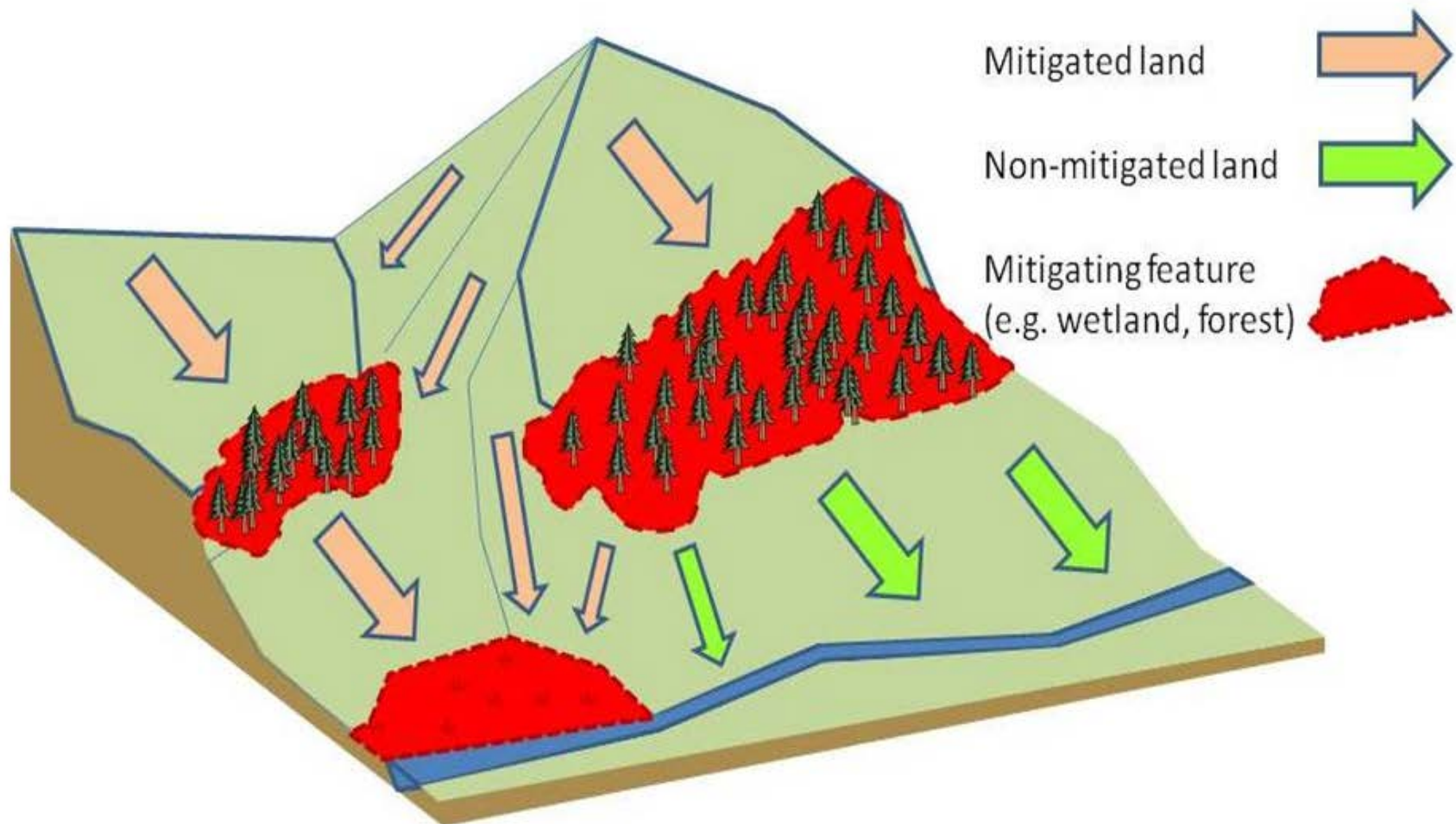
e.g. small but strategic features can have large effects

Flood peak reduction with small strategically targeted tree planting and wetland creation
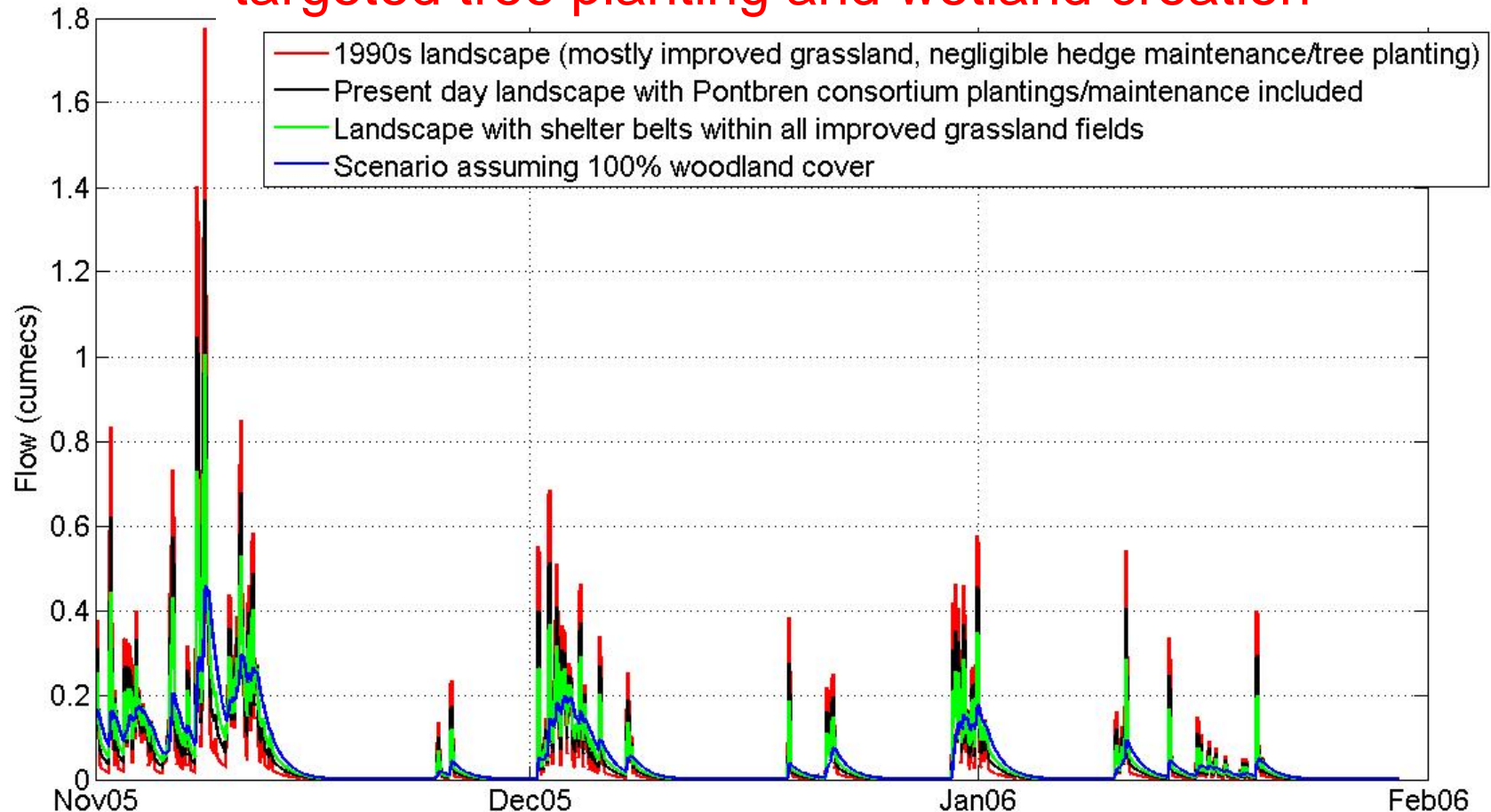
Bassenthwaite catchment, Lake District, Northwest England

Latest application - Bassenthwaite

- Scheme in place paying farmers to reduce impact of production on environment.

- Concerns current interventions are not delivering "best value for money"

- LUCI being applied to identify where to better target agri-environment measures to improve carbon, water flow and quality, biodiversity while maintaining productivity
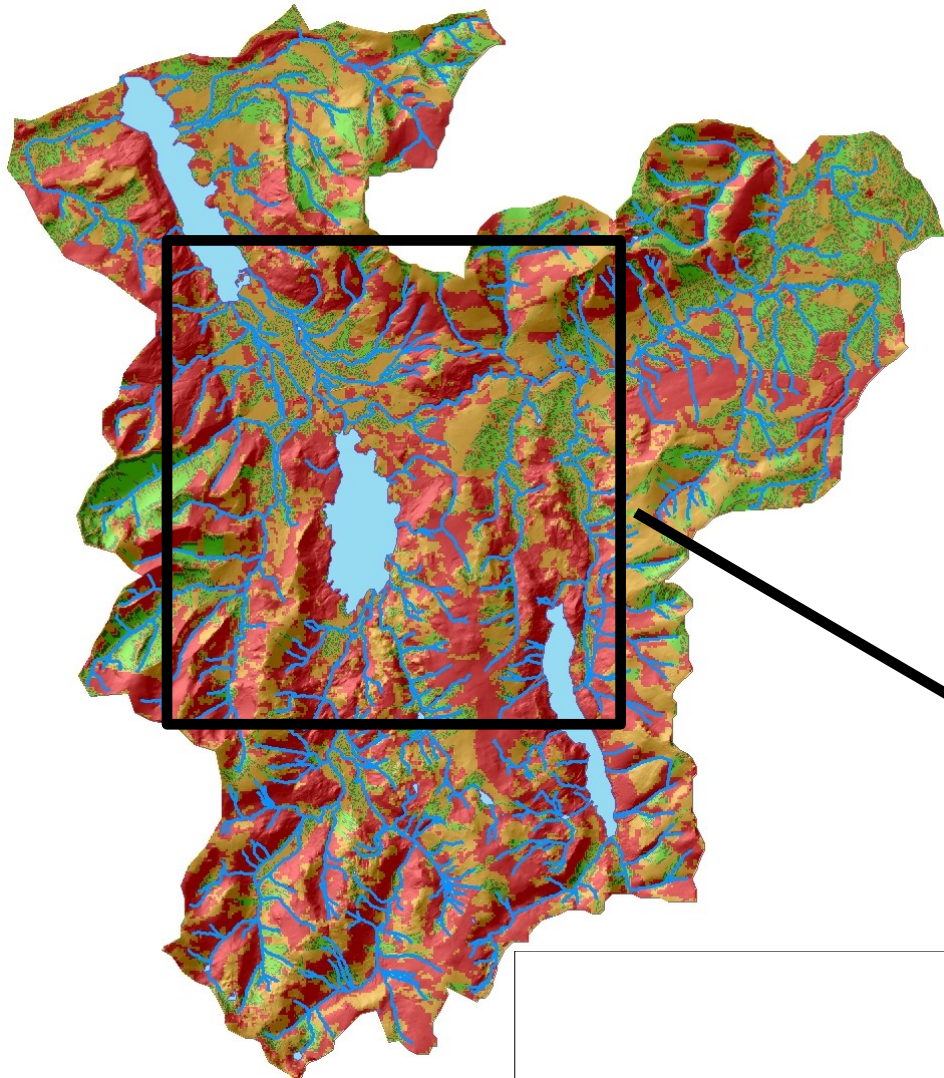
Agricultural productivity- predicted versus current
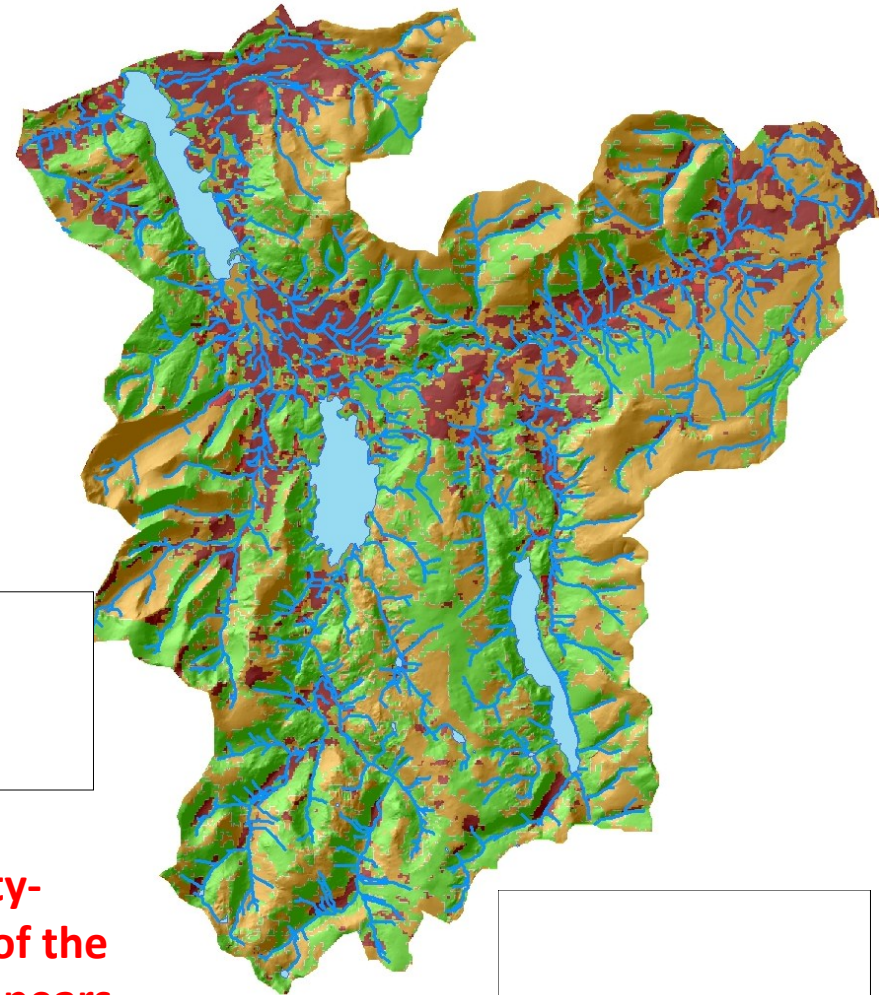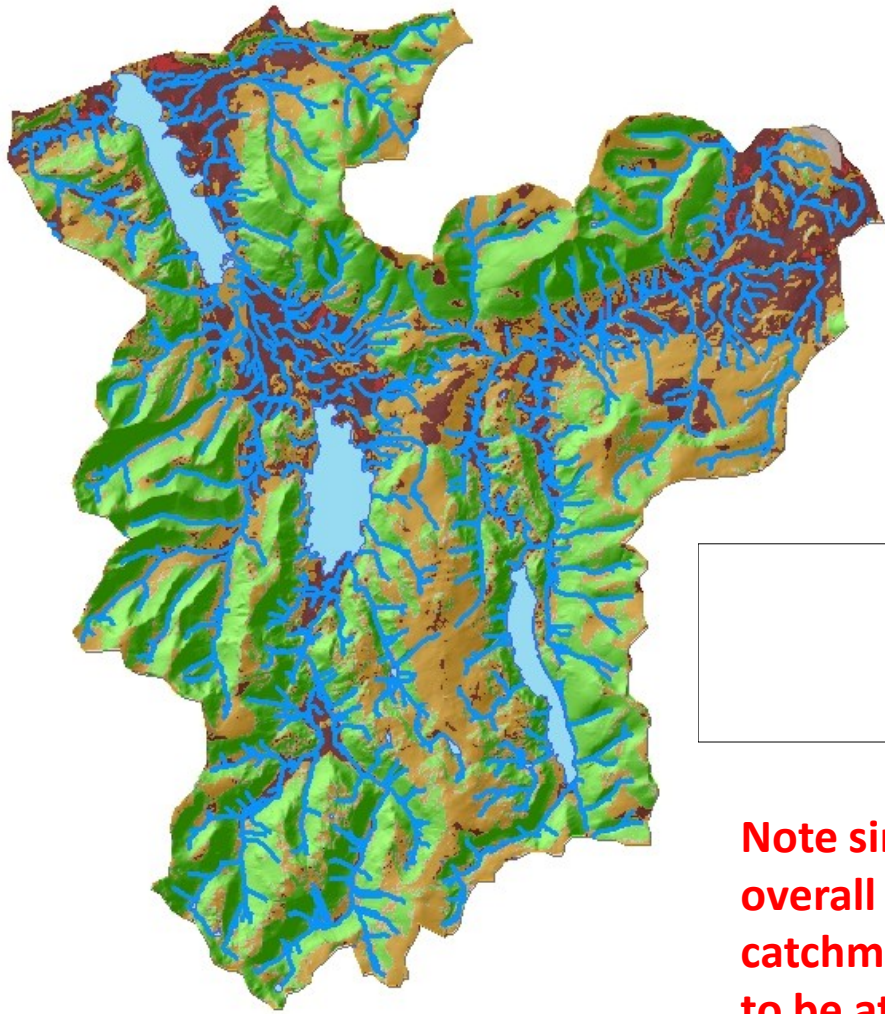
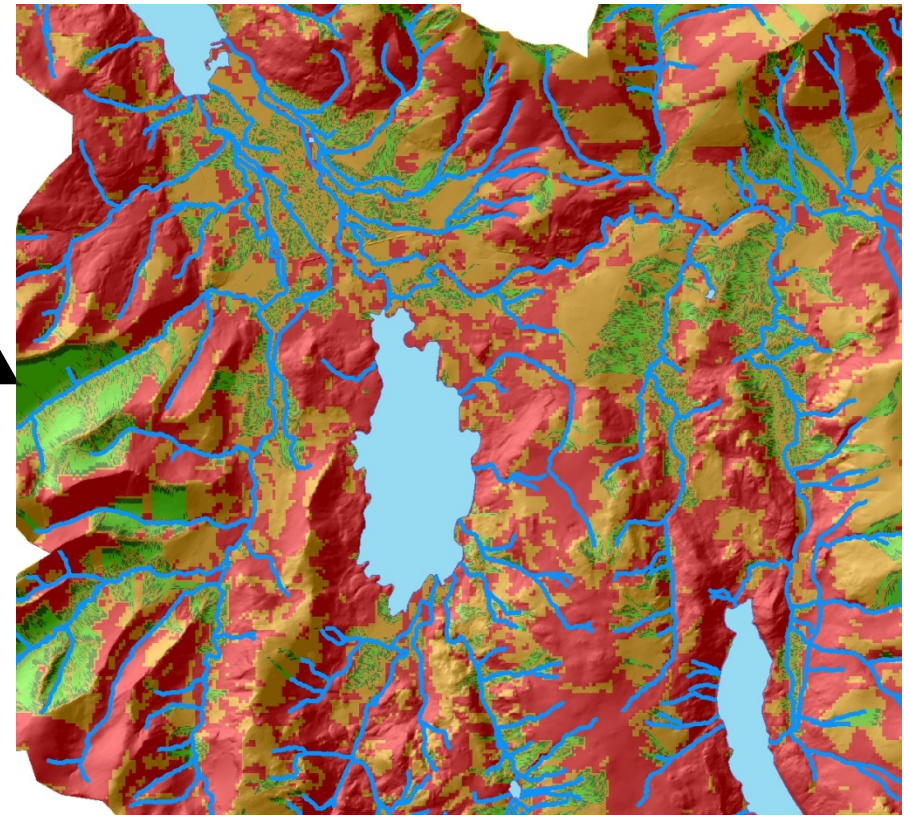**Note similarity- overall most of the catchment appears to be at close to optimum utilisation**

Predicted"Optimum" agricultural utilisation

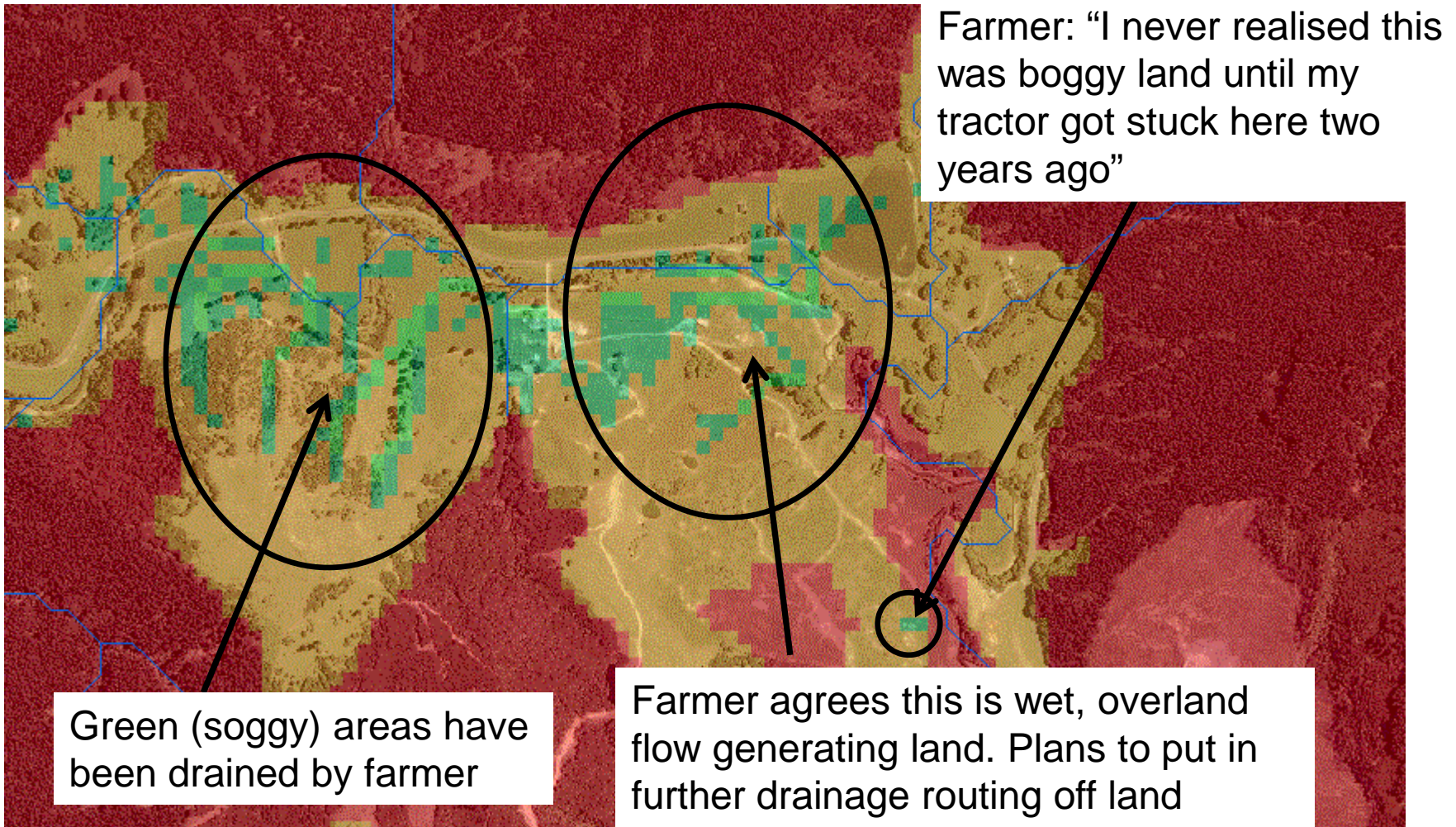Current agricultural utilisation
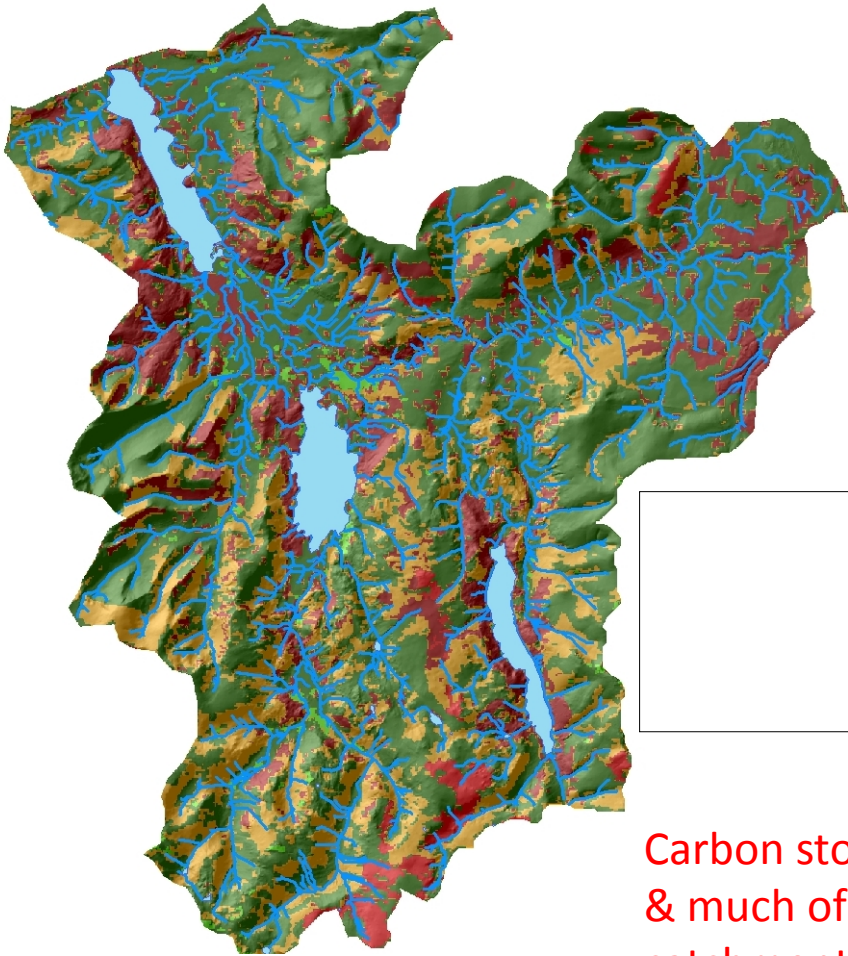
Bassenthwaite flood mitigation layer

Much of the land is already providing flood mitigation (red) or being mitigated (orange); but some areas remain where additional protection through targeted land use could be added

Groundtruthing (Uawa Farm, New Zealand)

Farmer: "I never realised this was boggy land until my tractor got stuck here two years ago"

Green (soggy) areas have been drained by farmer

Farmer agrees this is wet, overland flow generating land. Plans to put in further drainage routing off land

Bassenthwaite carbon layers – stock vs sequestration
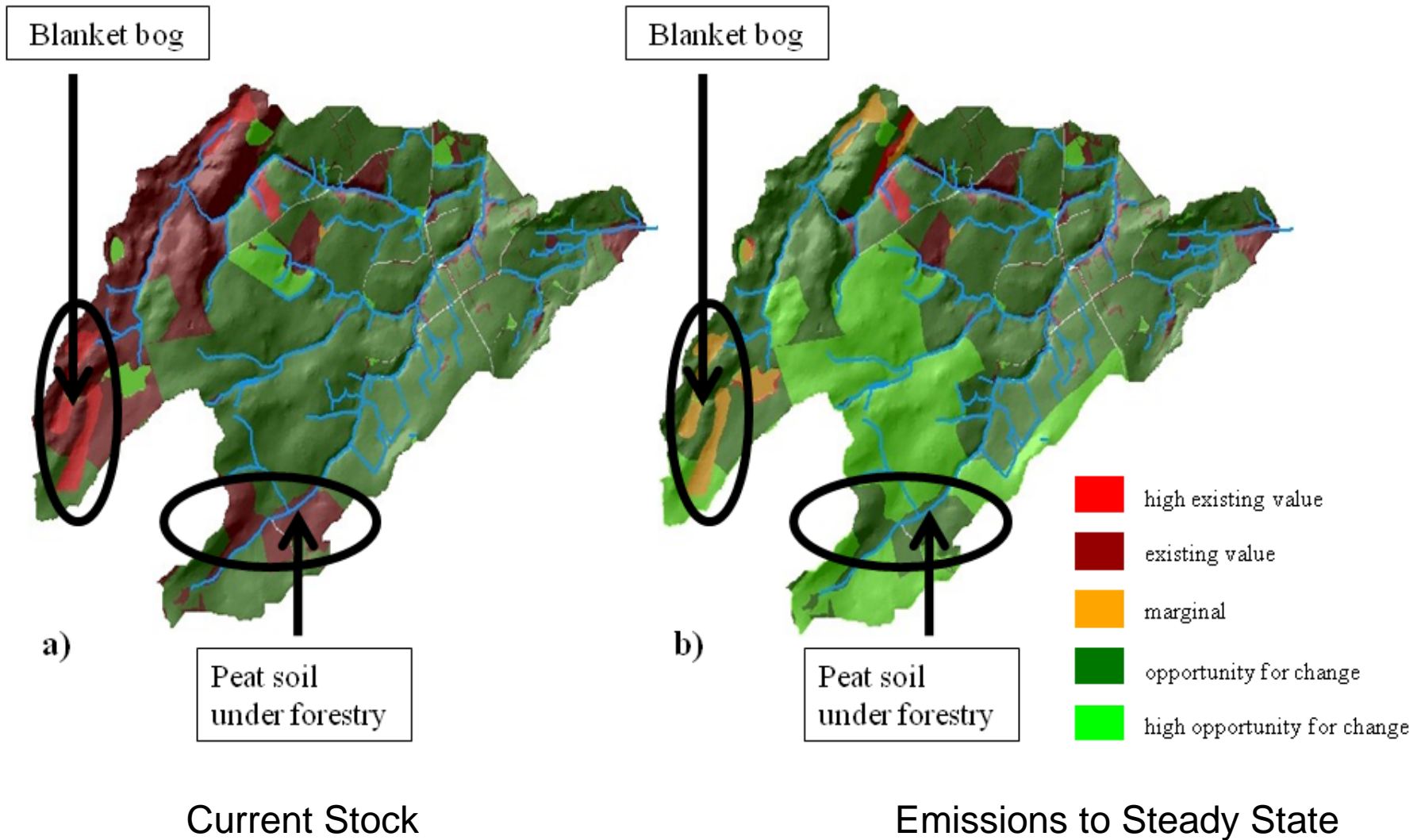

Current carbon stocks

Carbon stocks are low, & much of the catchment appears to be continuing to lose carbon.
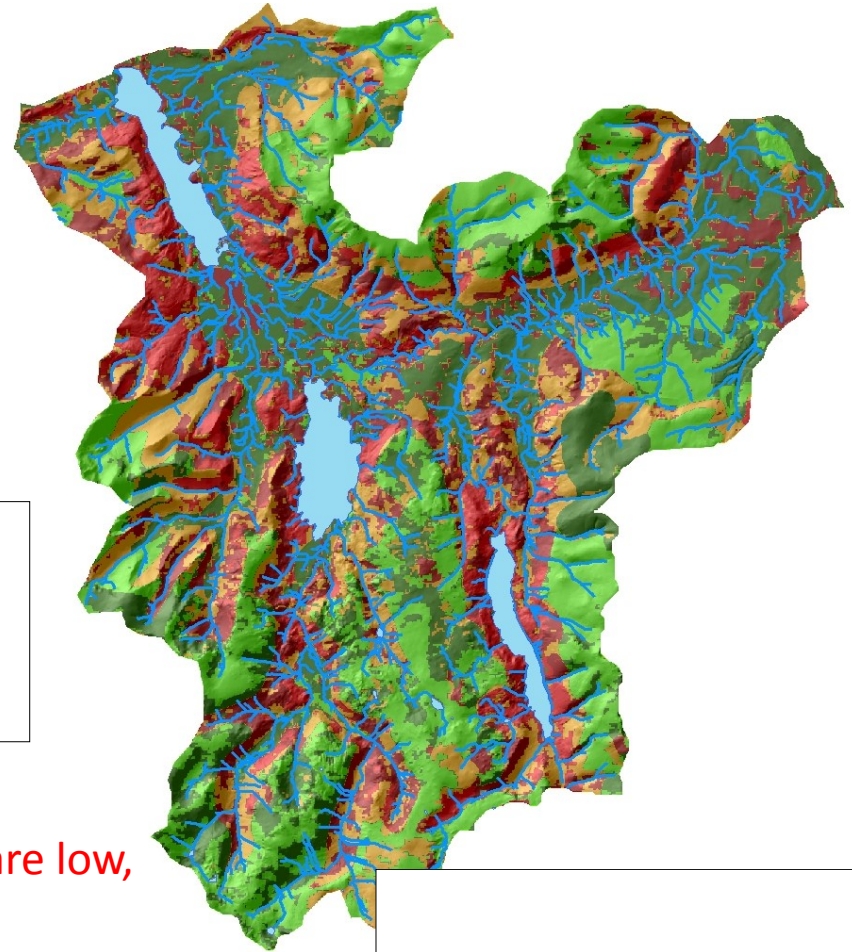
Gains or losses of carbon
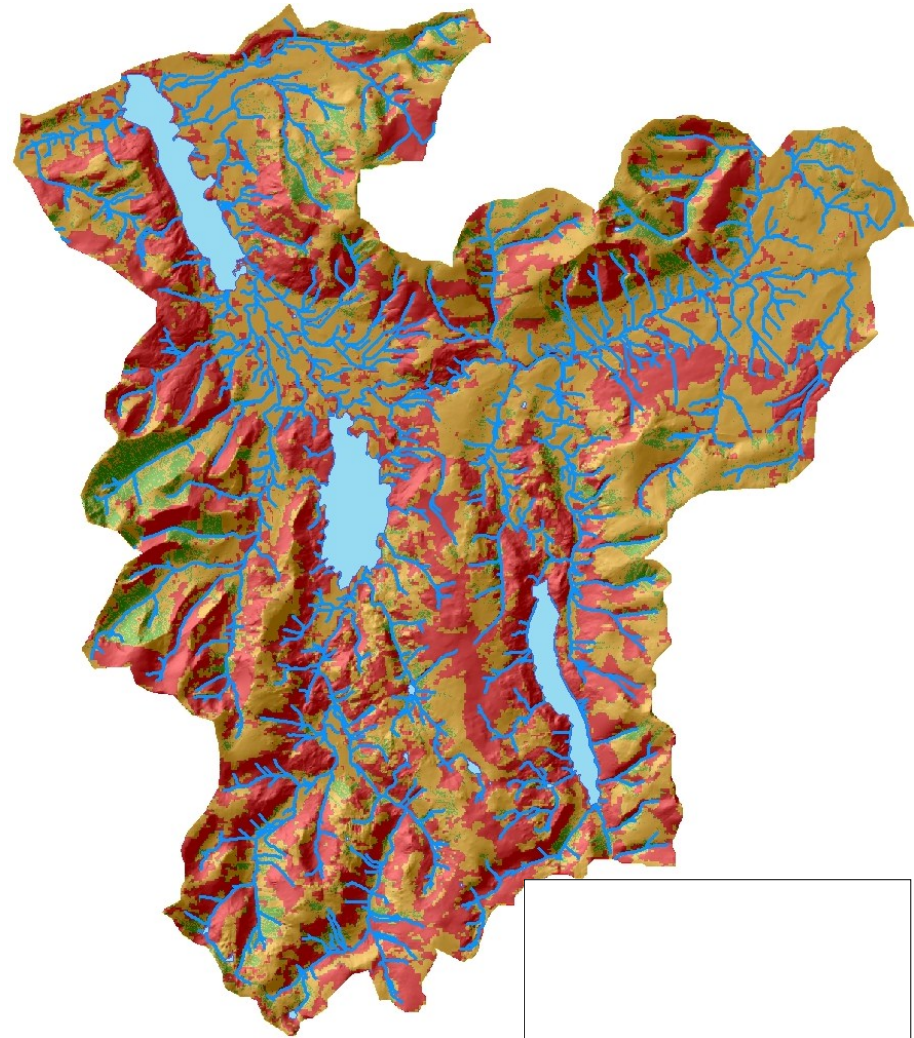
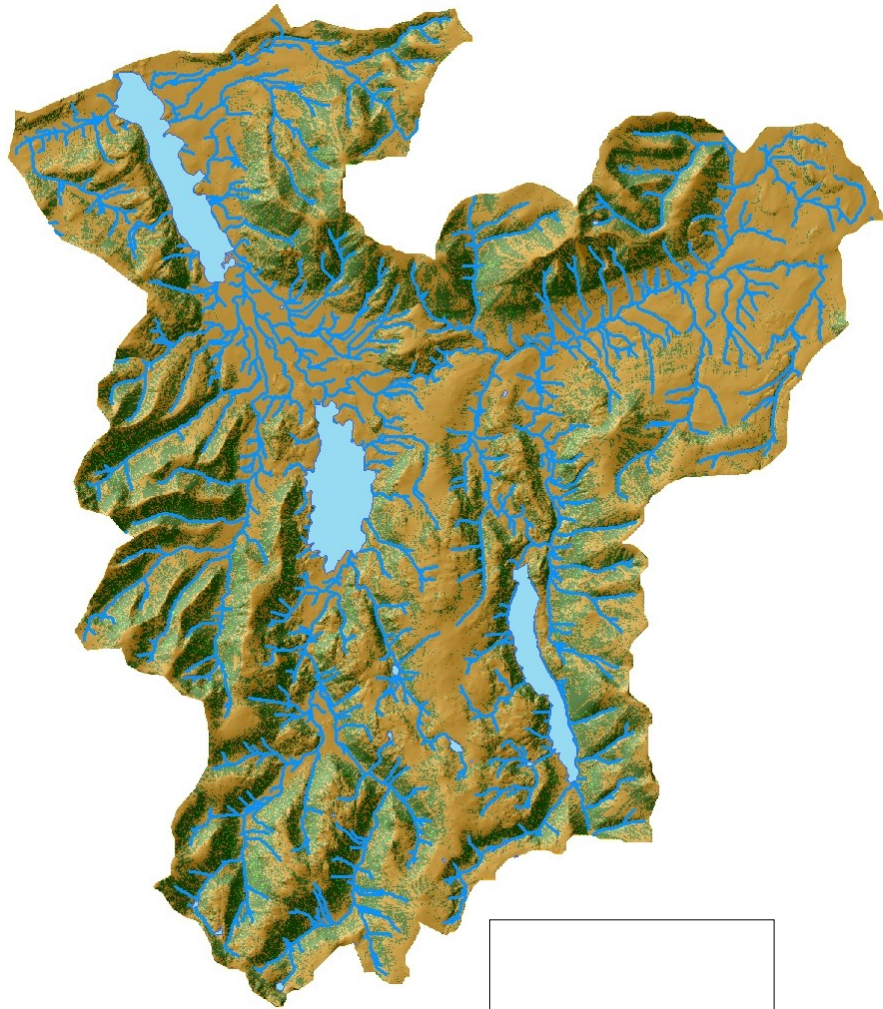# Carbon layers -stock vs sequestration

Current Stock

Emissions to Steady State

Habitat connectivity – broadleaved woodland

Legend

🟥	Broadleaved woodland
🟫	Other UK "priority habitat"
🟧	Marginal gains from planting woodland
🟩	Opportunities for enhanced connectivity of habitat
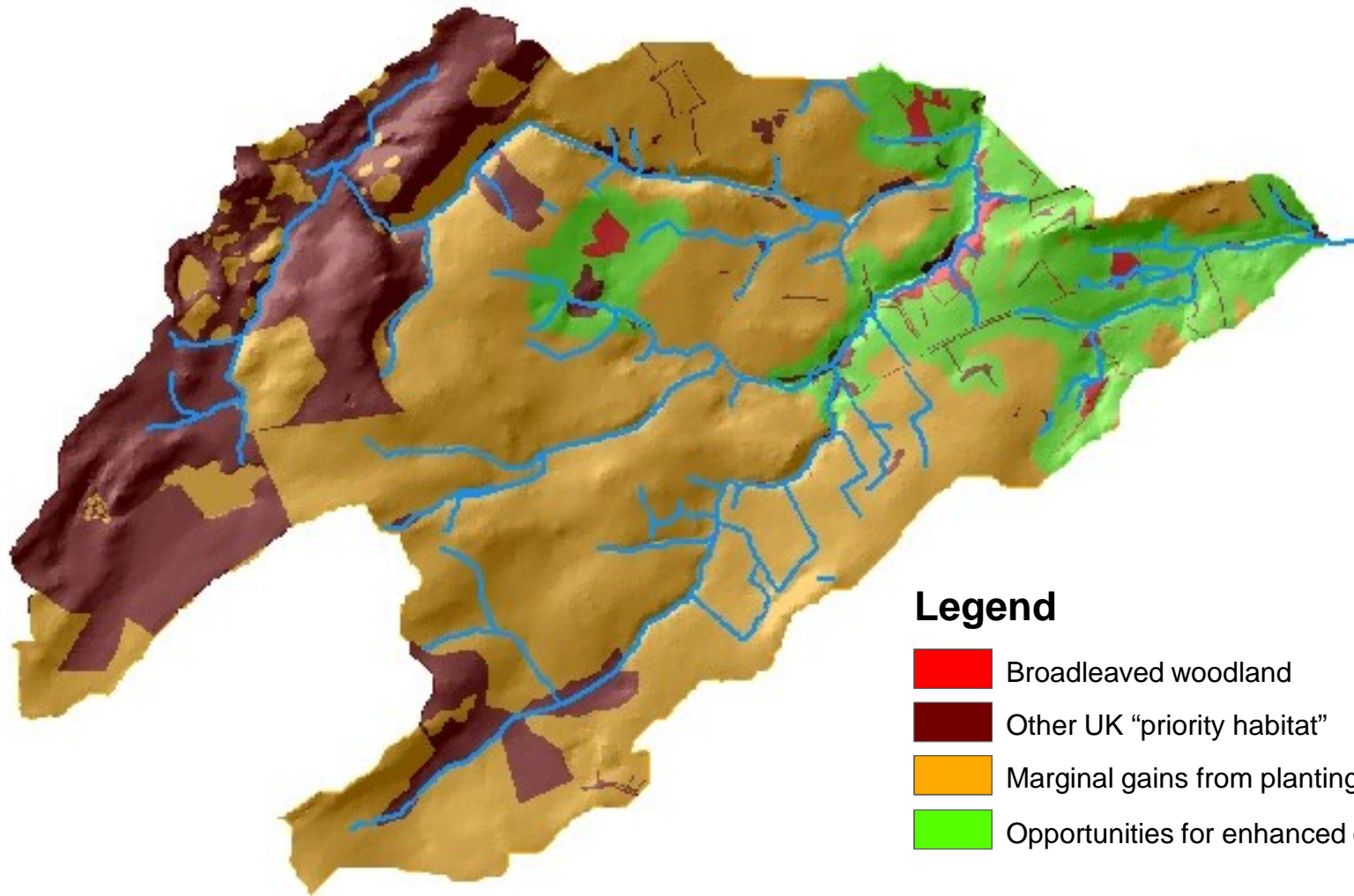
Bassenthwaite erosion and sediment delivery layers

Flood mitigation / carbon additive tradeoff layer
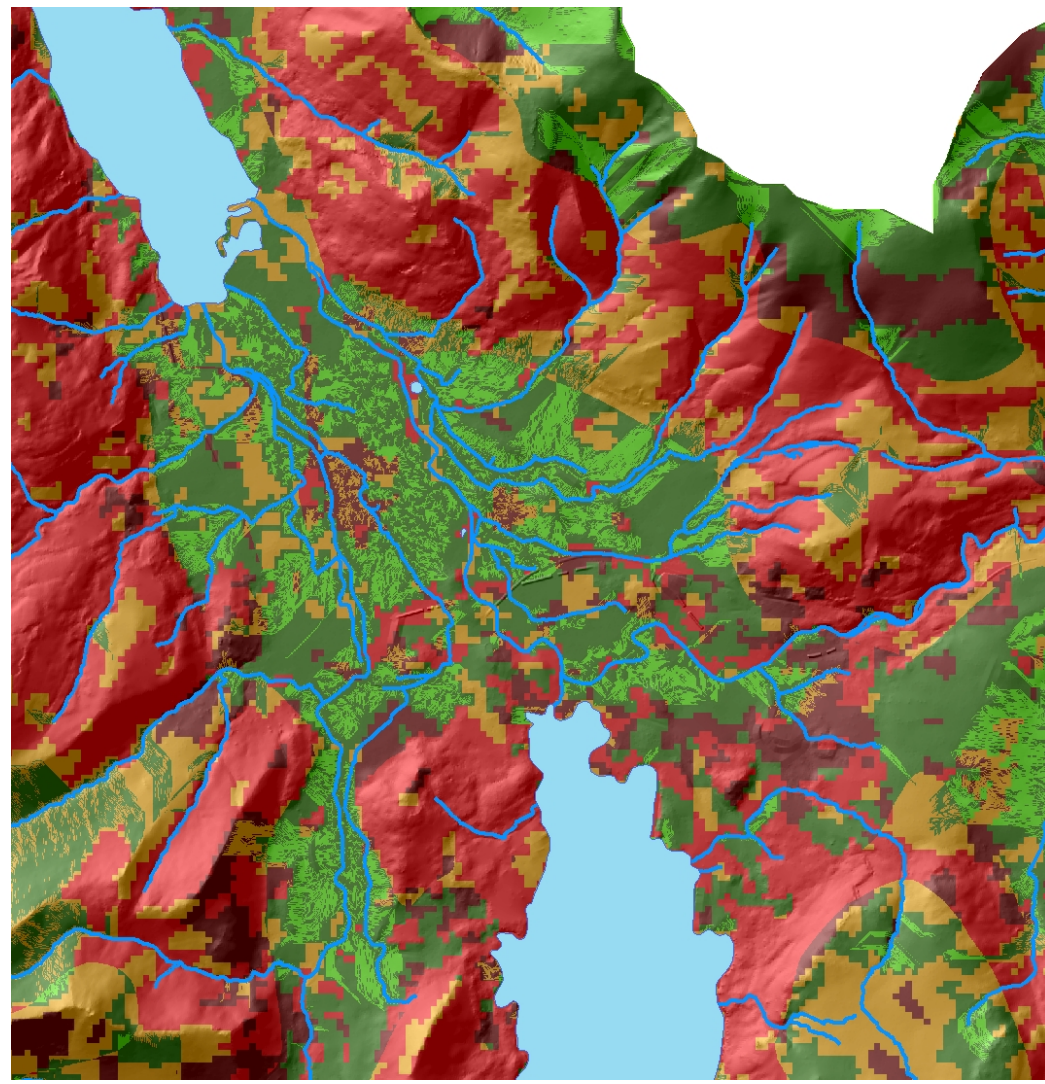
Legend

- Existing value in both services
- Existing value in 1 service
- Marginal values or tradeoffs between services
- Opportunity to improve 1 service
- Opportunity to improve both services

Opportunity for improvement here

Carbon, productivity and flood mitigation opportunities

Legend

- ■ (red) Existing value in both services
- ■ (dark red) Existing value in 1 service
- ■ (orange) Marginal value or tradeoffs between services
- ■ (dark green) Opportunity to improve 1 service
- ■ (light green) Opportunity to improve both services

Once we move to consider three independent services change in most areas requires trading off services against each other (orange areas)

However, quite a few opportunities remain to improve at least two services (dark green) with no negative effect on the third, a few opportunities exist to improve all three (light green)

Changing valuation of landscape from two scenarios (2)

Table 1: Area of catchment accessible to broadleaf focal species (%)

	Broadleaf habitat	Other priority habitat	Other areas accessible to habitat species	Area non-accessible to habitat species
Pre- tree planting	3.0	21.8	15.0	60.2
Post tree planting	9.8	21.5	36.7	32.0
Change	**+6.8**	**-0.3**	**+21.7**	**-28.2**

Table 2: Changing proportions of mitigated land using two vegetation scenarios (%)

	Mitigating land	**Mitigated** land	**Non-mitigated** land
Pre- tree planting	27.2	31.4	41.4
Post tree planting	30.4	40.2	29.4
Change	**+3.2**	**+8.8**	**12**

Tier 2: problem of prohibitive cost of spatially explicit routing between landscape elements solved by new algorithm

From **A2**

Run 1

From **A1**

Run 2

From **B**

From **A3**

Run 3
from **A3**

From **A1 + A2**   from **B**   from **A3**

Sub surface flow

Overland flow
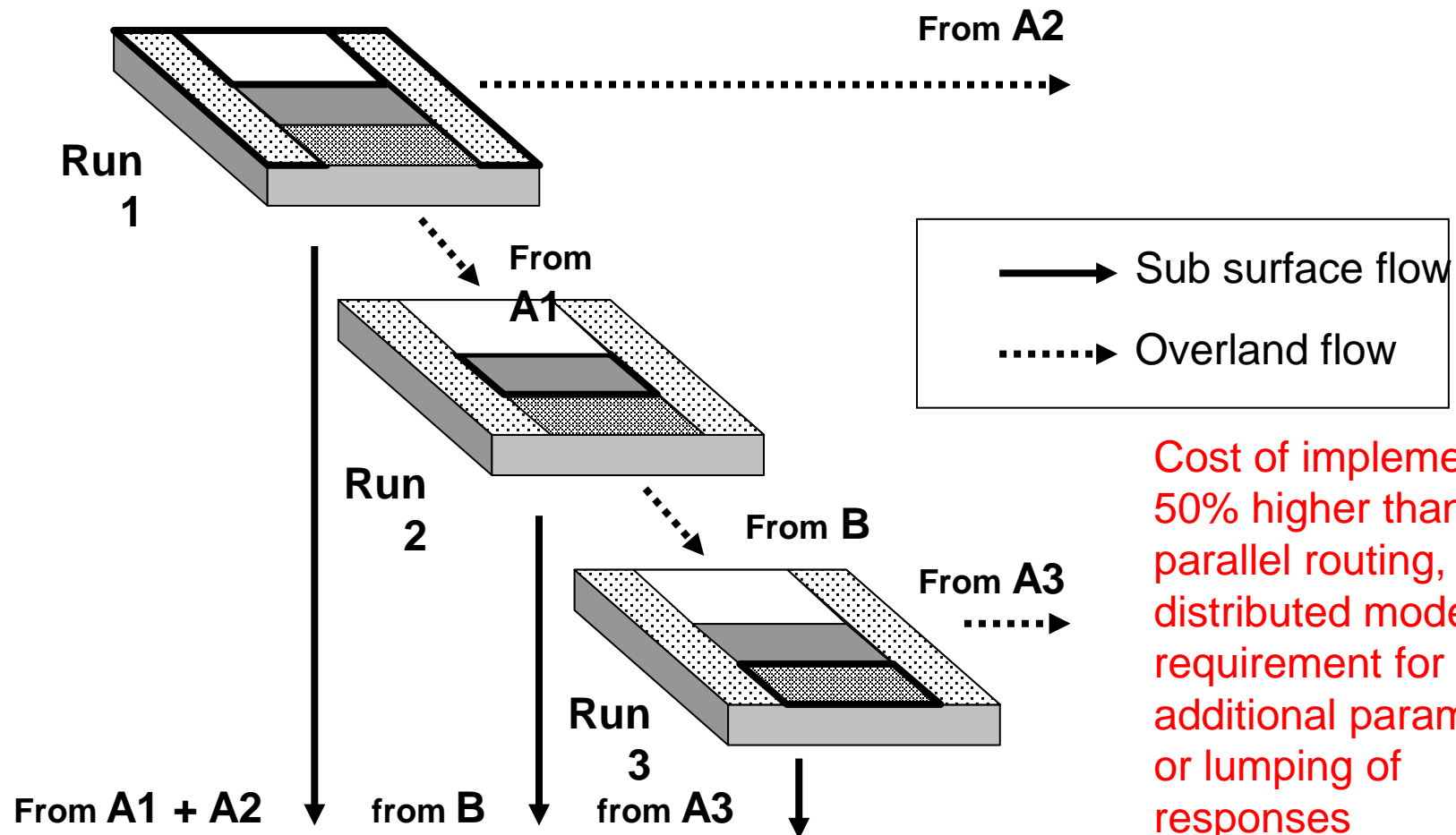
Cost of implementation 50% higher than parallel routing, << distributed model. No requirement for additional parameters or lumping of responses

'WET' Largest rainfall event

Quickflow (mm)

21/07/1992 15:00   22/07/1992 01:00   22/07/1992 07:00   22/07/1992 13:00   22/07/1992 18:00

- - - original rain (mm)   Scenario 1 (current land use)

Sceario 2 (buffers removed)   Scenario 3 (buffers added)

'DRY' largest rainfall

Quickflow (mm)

7/03/09 13:26   7/03/09 14:24   7/03/09 15:21

- - - normal rainfall (mm)   Scenario 1 (current land use)

Scenario 2 (buffers removed)   Scenario 3 (buffers added)

Ongoing development

- Further testing, development, groundtruthing, & augmentation of algorithms in contrasting locations

- Adding temporal functionality to allow impact of varying climate events to be considered: e.g. to track nutrients sediment/erosion, and crop growth/fitness in time

- Addition of economic valuations, improved biodiversity representation, greenhouse gas emissions, protection of infrastructure, etc…

Conclusions

LUCI is an ecosystem service tool covering
1) climate regulation,
2) food provisioning,
3) water flow and quality regulation
4) biodiversity
It uses nationally available data (but incorporates local data where available)

LUCI's uniqueness is:
1) It simply and actively address tradeoffs between ecosystem services;
2) It has the ability to represent sub-field management interventions at catchment scale.

Thank you!

Questions?

For further information:

Paper in press:

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

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