

Land Use Change Analysis, Evaluating LUC scenarios and landscape multifunctionality



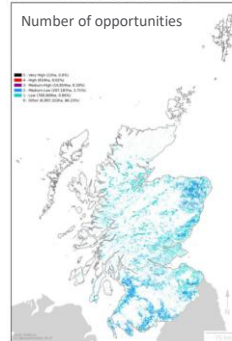
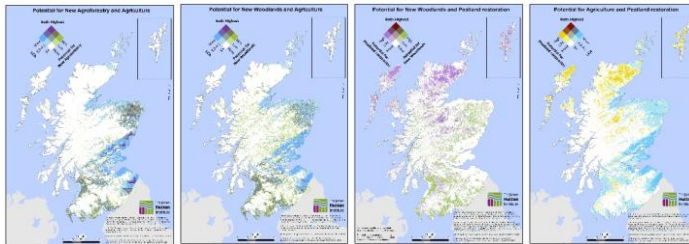
The James
Hutton
Institute

Alessandro Gimona, Marie Castellazzi

C3 - End of Year 4 meeting with Scottish Government, 21 April 2026

Outline

1. Transformative land use change towards net zero publication ([Gimona et al, 2026](#))
2. Joint environmental and economic feasibility of tree planting publication ([Ovando et al, 2025](#))
3. Landscape multifunctionality – potential ([Land Use Strategy Evidence pack](#), and beyond)



Science of The Total Environment
Volume 1012, 15 January 2026, 181132

Transformative land use change towards net zero: balancing emissions through woodland expansion and livestock reduction in Scotland

Alessandro Gimona ^a, Marie Castellazzi ^a, Doug Wardell-Johnson ^a, Dave Miller ^a, Keith Matthews ^a

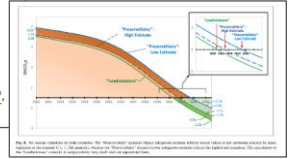


Fig. 8. The carbon footprint of different land use scenarios in Scotland. The 'Woodland expansion + Livestock reduction' scenario shows the lowest carbon footprint across the range of opportunities. The 'Baseline' scenario shows the highest carbon footprint across the range of opportunities. The 'Woodland expansion' scenario shows a moderate carbon footprint across the range of opportunities. The 'Livestock reduction' scenario shows a moderate carbon footprint across the range of opportunities.

Forest Policy and Economics
Volume 174, May 2025, 103481

Feasibility of woodland expansion for carbon offsetting in Scotland revisited

Paola Ovando ^{a, b}, Marie Castellazzi ^b, Andrea Baggio-Compagnucci ^{b, c}, Richard J. Hewitt ^{b, d}, Alessandro Gimona ^b

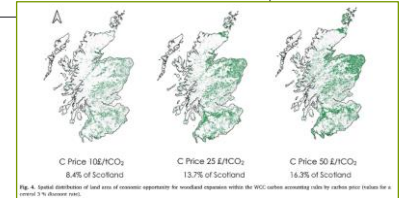
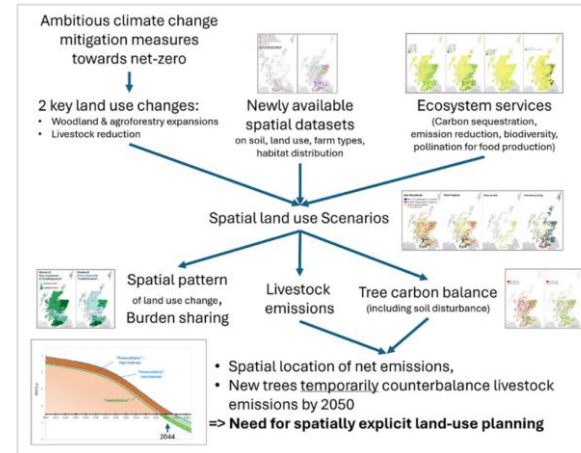
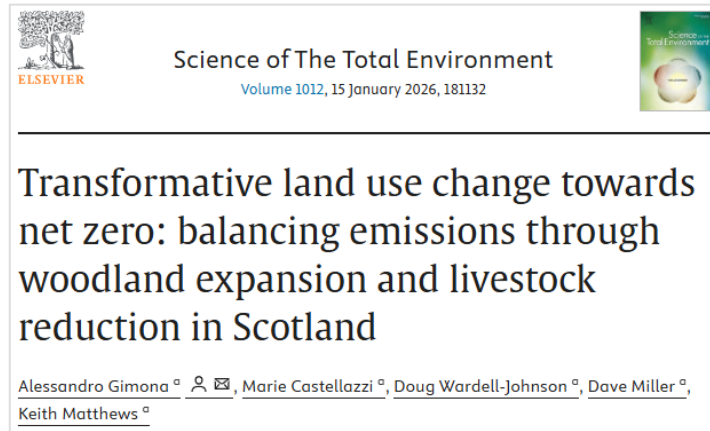


Fig. 4. Spatial distribution of land area of potential opportunities for woodland expansion under the WCC carbon economy rules for carbon price values for a range of 5% discount rates.

1. Transformative Land use change towards net zero

- Publication :

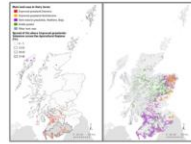


Ambitious climate change mitigation measures towards net-zero

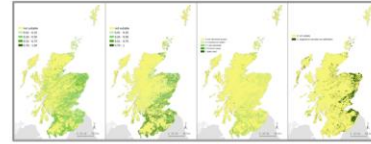


2 key land use changes:

- Woodland & agroforestry expansions
- Livestock reduction

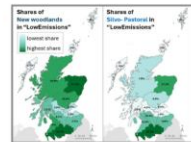
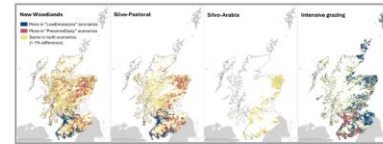


Newly available spatial datasets on soil, land use, farm types, habitat distribution



Ecosystem services (Carbon sequestration, emission reduction, biodiversity, pollination for food production)

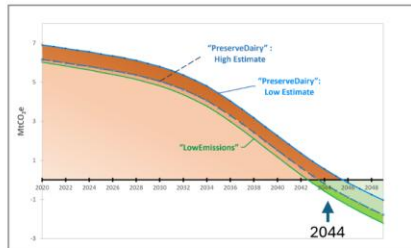
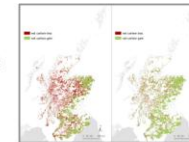
Spatial land use Scenarios



Spatial pattern of land use change, Burden sharing

Livestock emissions

Tree carbon balance (including soil disturbance)

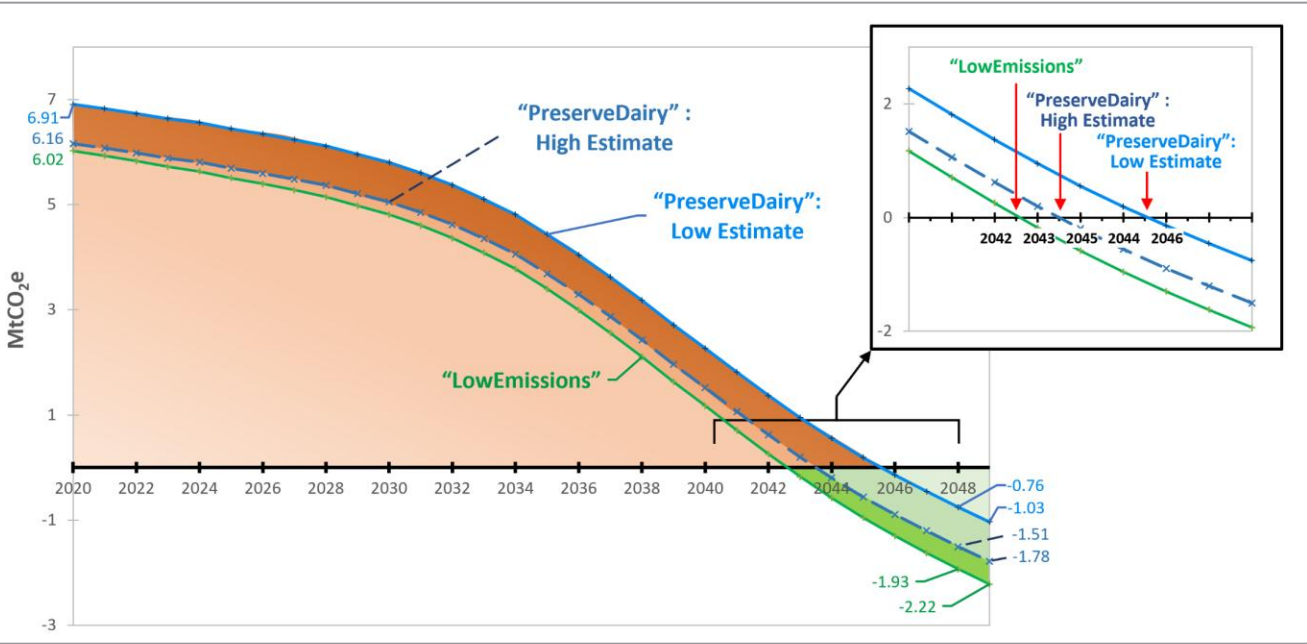


- Spatial location of net emissions,
- New trees temporarily counterbalance livestock emissions by 2050

=> **Need for spatially explicit land-use planning**

1. Can trees offset ruminants' emissions?

Net CO₂e 2020-2050



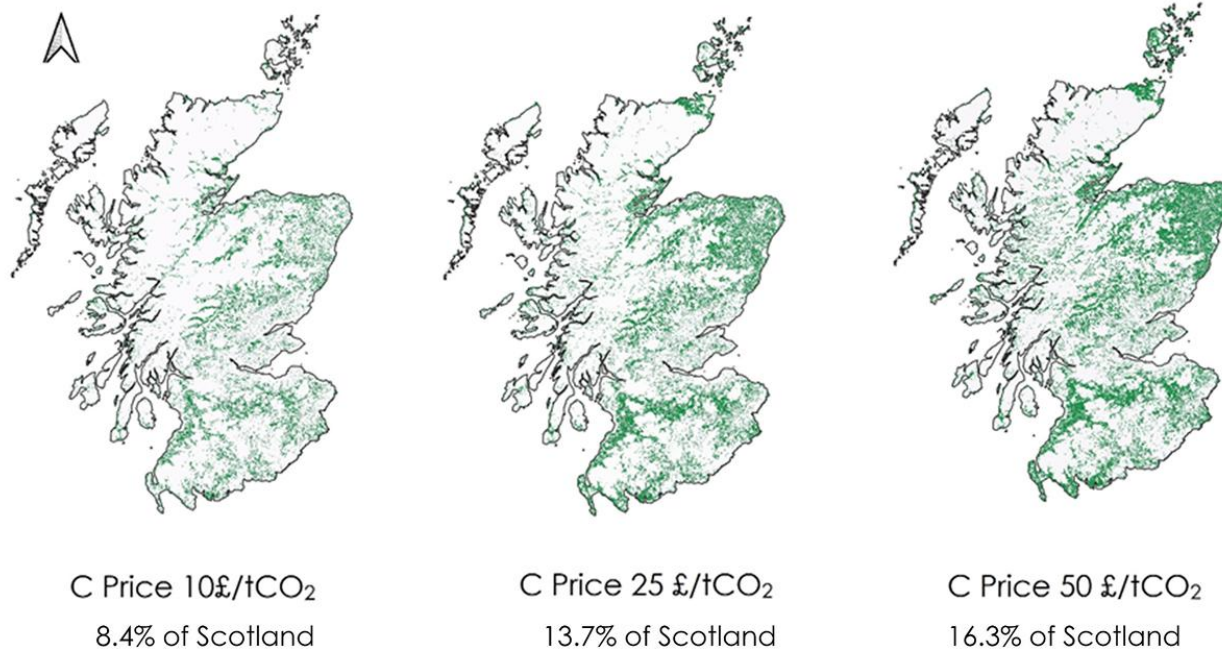
Scenario:

~30 k ha per year of woodland + agroforestry (65% -35%)

Linear decrease in Ruminants to 50% of baseline

Fig. 8. Net annual emissions for both scenarios. The "PreserveDairy" scenario Higher mitigation estimate reflects lowest values of net emissions reached by some replicates of the scenario (Fig. 6, 5th quantile), whereas the "PreserveDairy" scenario Lower mitigation estimate reflects the highest net emissions. The uncertainty of the "LowEmissions" scenario is comparatively very small and not represented here.

2. Environmentally and financially additional areas (trees vs livestock)

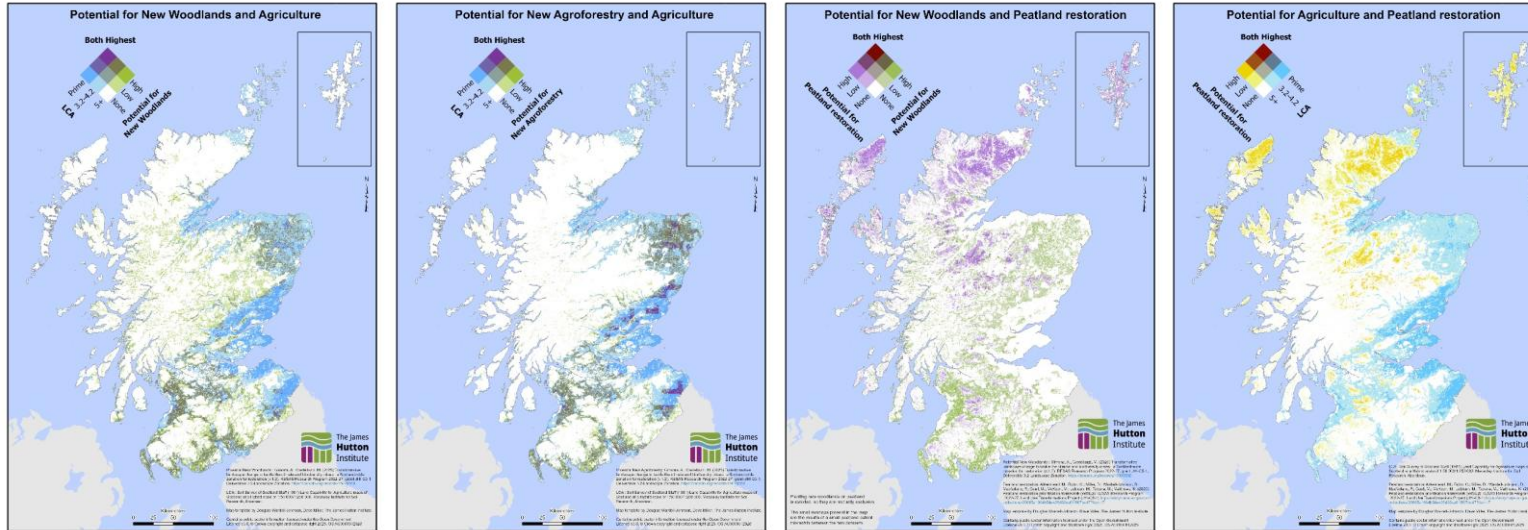


Current average
Carbon price :
~ £ 26 per ton of
CO₂e

Fig. 4. Spatial distribution of land area of economic opportunity for woodland expansion within the WCC carbon accounting rules by carbon price (values for a central 3 % discount rate).

3. Landscape multifunctionality - potential

- Bivariate maps included in “[Land Use Strategy Evidence pack](#)” and its [storymap](#).



RESAS Staff, Matthews, K., Miller, D., Wardell-Johnson, D., Whitaker, J., Gimona, A. & Castellazzi, M. (2026) Land Use Strategy - Supporting Evidence and Analysis: Evidence Pack published with the Land Use Strategy. <https://www.gov.scot/publications/scotlands-fourth-land-use-strategy-supporting-evidence-pack/>

New Woodlands and new Agroforestry: Gimona, A., Castellazzi, M. (2025) Transformative landscape change to tackle the climate and biodiversity crises: a Scotland-wide zonation for restoration (v.1.2). RESAS Research Program 2022-27, grant JHI-C5-1, Deliverable 3.2-Landscape Zonation. <https://doi.org/10.5281/zenodo.15078550>

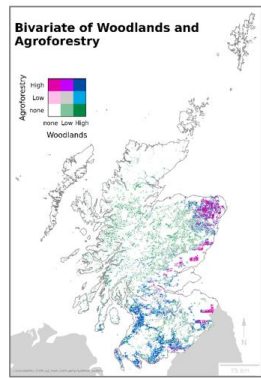
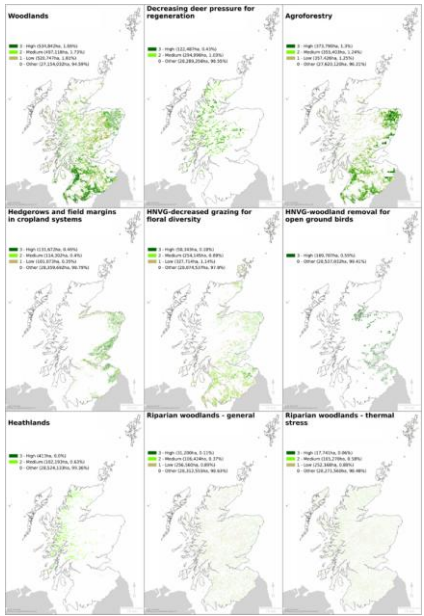
Peatland restoration: Aitkenhead, M.; Robb, C.; Miller, D.; Wardell-Johnson, D.; Macfarlane, F.; Coull, M.; McKeen, M.; Jabloun, M.; Tavana, M.; Matthews, K. (2025) [Peatland restoration prioritisation framework \(WISE2\)](https://storymaps.arcgis.com/collections/20665a1964b54e429d32ca61f897bd47?item=7). RESAS Research Program 2022-27, Land Use Transformations Project (JHI-C3-1) <https://storymaps.arcgis.com/collections/20665a1964b54e429d32ca61f897bd47?item=7>

LCA : Soil Survey of Scotland Staff (1981) [Land Capability for Agriculture maps of Scotland](#) at a Hybrid scale of 1:50 000/1:250 000. Macaulay Institute for Soil Research, Aberdeen.

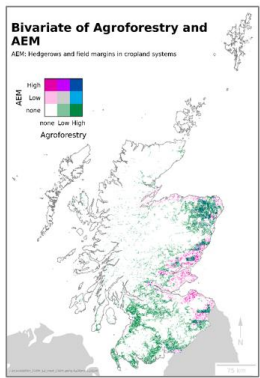
3. Landscape multifunctionality - potential

- Bivariate maps from Landscape zonation.

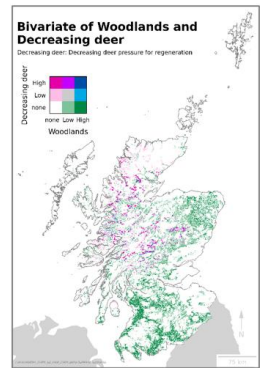
Landscape zonation



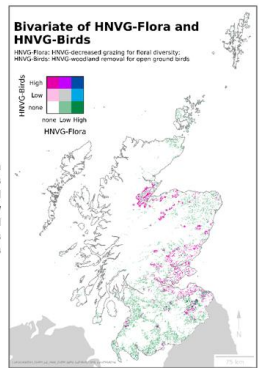
left) New woodlands and Agroforestry: the latter is restricted to agricultural and pastoral areas, whereas woodland potential is more widespread, but both present highest ecosystem services potential in the south-west.



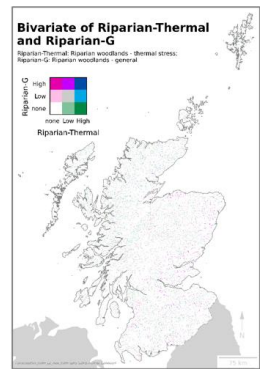
right) Agroforestry and hedgerows and field margins (AEM): the latter is even more restricted to agricultural areas than Agroforestry.



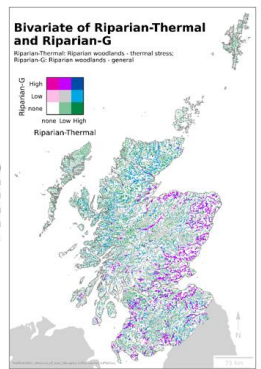
left) New woodlands and decreasing deer pressure for regeneration. Regeneration was identified as being within 1km of existing woodlands and in high deer density areas: mostly in the north west.



right) Restoration of High Nature Value Grasslands (HNMG) for i) decreased grazing for floral diversity and ii) for woodland removal for open grounds birds



Riparian woodlands for general purposes or specifically for thermal regulation.

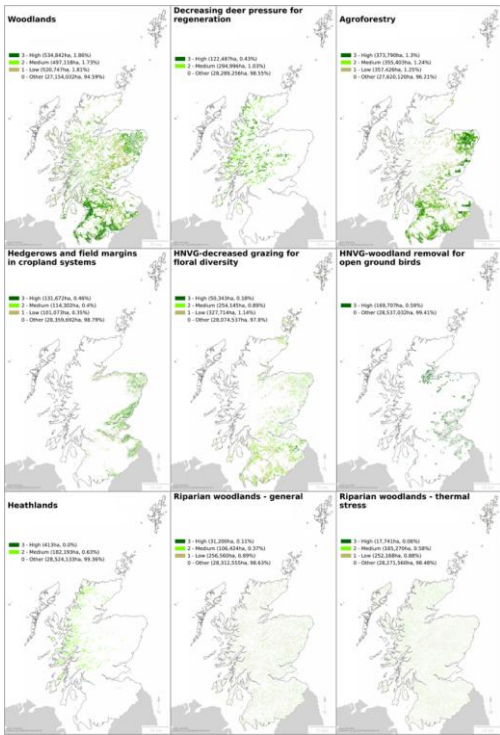


left) right) To ease reading, the map on the left (100m resolution) was summarised at 1km with the maximum value for each pixel.

ES Figure 1. "High Medium Low" priority levels for Landscape Zonation for each topic, in the brackets: hectares and % of Scotland extent. HNMG = high nature value grasslands

3. Landscape multifunctionality - potential

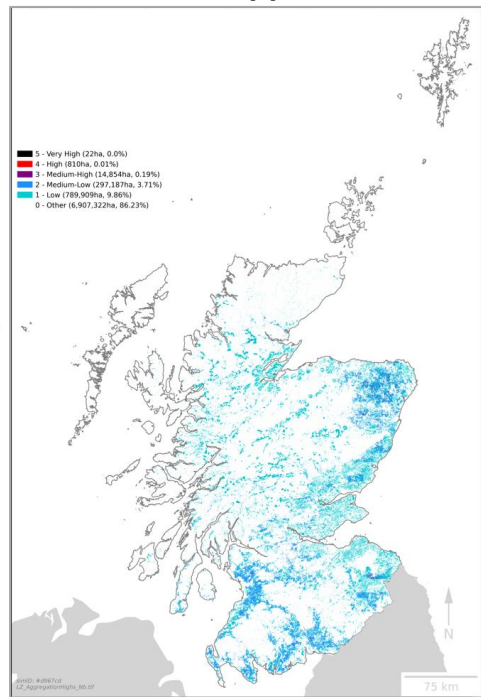
Landscape zonation



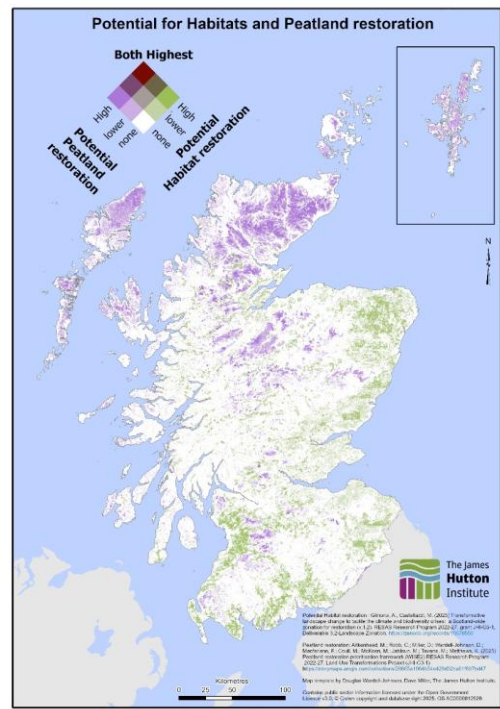
Combination of all top zones



Number of opportunities



Overlay with peatland restoration

ES Figure 1. "High Medium Low" priority levels for Landscape Zonation for each topic, in the brackets: hectares and % of Scotland extent. HNVG = high nature value grasslands

Figure 3. Number of all "High" Landscape Zonation maps (currently without Peatland), in the brackets: hectare and % of Scotland extent. 6.26% of Scotland extent is within only 1 "High" Landscape Zone, 4.13% in two zones, and only 0.13% with three zones.

n.b. the above map is not published