Science to Policy: Impacts of trees on farm ecosystem services

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Sêr Cymru National Research Network
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Multi-Land was a Research Cluster that ran between 2013 and 2018 from the Sêr Cymru National Research Network for Low Carbon, Energy & Environment (see: www.nrn-lcee.ac.uk).

Multi-Land's aim was to investigate whether and how the incorporation of trees and hedgerows in pastoral landscapes could contribute to on-farm productivity/efficiency, flood risk mitigation, and national carbon targets.

This is a summary of the policy implications of both scientific review and original research undertaken by Multi-Land that fall within the remit of current and evolving Welsh policy.

Key recommendations

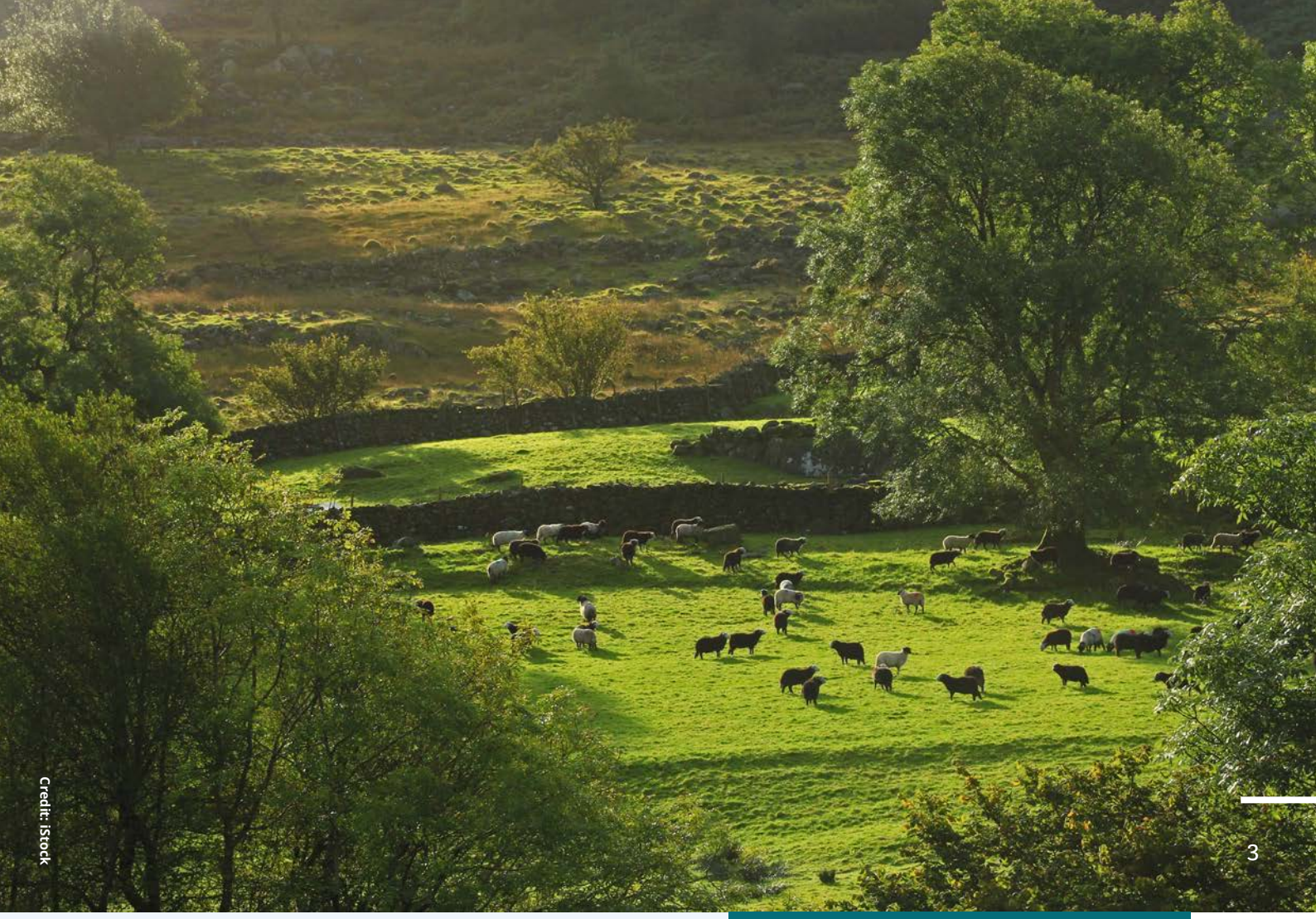
From its evidence of positive effects of tree and hedgerow planting on flood defence, livestock shelter and landscape resilience, Multi-Land recommends that:

- **New policy clearly highlights the full suite of benefits trees can bring to farms.** Current segregation between woodlands and agriculture in farm support schemes leads to disjointed management. Trees are seen by farmers as a diversification strategy with a set of new products, rather than a support mechanism, e.g. for livestock shelter and forage.

- **Agri-environment schemes need to address lags between implementation and result in order to be attractive to farmers who may be appreciably risk-averse.** Tree-based farm stewardship is a long-term investment as it takes time for saplings to grow into hedges, shelter belts or a source of tree fodder. Time is also required for land managers to develop new skills in tree management.

- **Inclusion of trees in farming systems should be encouraged to provide livestock with access to tree fodder and shelter.** Tree fodder offers the potential to improve livestock mineral nutrition, reduce animal parasite load and suppress greenhouse gas production in the rumen. Tree shelter can increase farm resilience to extreme events by reducing mortality and increasing the conversion of feed to weight gain, thereby reducing livestock maintenance costs.

- **Decision support tools should be offered at the planning stage of farm woodland schemes to aid farmers in tree species selection and assessment of benefits and trade-offs.** Hedgerows have the potential to enhance carbon storage, improve water infiltration, and mitigate soil compaction from grazing livestock, but these benefits depend on landscape location, soil type and tree species.



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Background

If the UK leaves the EU this is likely to change the nature and magnitude of agricultural subsidies. The Welsh Government has outlined proposed structures in their recent consultation on a new Land Management Programme to replace the Common Agricultural Policy (CAP)[1] should the UK no longer be in the EU. This programme focuses on economic resilience and public goods; the latter are non-market benefits such as clean water, biodiversity, and recreational value. This reflects a longer-term environmental focus of the Government on the Welsh landscape. For example, Wales was the only EU country under the Common Agricultural Policy to allocate the maximum allowed proportion of subsidies to Pillar II, the funding strand that encompasses agri-environment schemes. In addition to agricultural policy, Wales has drafted several Acts (Box 1) that promote a healthy society based on a healthy environment that needs protection. To achieve this, key concepts such as ecological resilience, sustainability, 'climate-smart' actions, and nature-based solutions have become increasingly prominent in Welsh Government policy. Multi-Land has addressed these concepts by researching trade-offs between agricultural intensification and landscape resilience, which may change how we optimise land use.

Box 1. Relevant Welsh Government policy strands

Well-being of Future Generations Act 2015
Outlines seven well-being goals including: Resilience (enhancing biodiversity and functioning, resilient ecosystems), Global responsibility (effect of improving economic and environmental conditions in Wales on the rest of the world)[2]

Environment Wales Act 2016
Including I: Sustainable management of natural resources, and II: Climate change (carbon budgeting, emissions targets)[3]

Woodlands for Wales Strategy 2018
Sets out the outcomes that we require from woodlands and trees, to benefit the economy, environment and people of Wales and provide prosperity for all[5]

Brexit and Our Land 2018
Planned changes to agricultural subsidies in Wales if the UK leaves the EU (consultation closed 30.10.2018)[1]

Figure 1 (Left)
Trees can be placed in pastures to optimise carbon storage, silage production, shelter and hydrology, without compromising vehicle access. This farm lost whole fields-worth of EU subsidies due to exceeding tree density limits in a silvopastoral livestock farming system (Henfaes, Bangor University).

(Right)
Shelter for sheep can improve animal welfare and the conversion efficiency of feed to animal live weight gain particularly during extreme weather events, which is especially important in the context of climate change predictions.

Can sustainability, resilience and productivity occur together?

Ecological resilience is central to the Well-being of Future Generations[2] and Environment Wales Acts[3]. In their State of Natural Resources Report[4], Natural Resources Wales defined resilience as "how well ecosystems can deal with disturbances - either by resisting them, recovering from them, or adapting to them". In Wales, disturbances may include repeated incidence of one or more extreme weather events such as heavy rain, drought, and wind, all of which are predicted to increase with climate change. The last few years have seen combinations of winter floods, springtime cold snaps and prolonged summer heat waves.

Extreme weather events do not only affect landscape resilience, but also farm productivity in the form of reduced silage harvests and animal live weight gain, as well as production losses due to soil degradation resulting from erosion and flooding. To improve both ecological resilience and the long-term sustainability of farm productivity, there have been recent calls to bring back the woody landscape features that largely disappeared from the UK during agricultural intensification over the last 70-80 years[6]. Pollarding, for example, where tree canopies were managed for alternative forage production when grass was unavailable to livestock, has largely vanished from Welsh pastoral culture, which has led to the loss of in-house back-up fodder as well as natural shelter.

Multi-Land quantified the effects that a lack of shelter can have on livestock production, especially on upland farms. The findings show that wind-break provision by tree shelter-belts can have significant benefits for livestock welfare and reduce livestock maintenance costs by increasing the conversion efficiency of feed to animal live weight gain[7]. This offers significant potential to increase the resilience of upland farming to extreme weather events (Fig. 1).

Non-market benefits (such as flood control, clean water and biodiversity) will need to be considered more fully in stewardship, so incorporating these concepts into the productivity mind-set will be key to successfully managing land for multiple benefits. For example, increasing the availability of shelter thoughtfully, especially in upland areas where shelter is most lacking, would not only improve animal welfare and live weight gain, but also enhance flood control, carbon storage and biodiversity. Together, these benefits improve multiple ecosystem functions and resilience.

Carbon storage and greenhouse gas emissions

The UK is required by law to reduce its carbon emissions by at least 80% of 1990 levels by 2050, and this is incorporated into the Welsh Government decarbonisation programme. The UK Climate Change Committee (CCC) accepts that these targets may be challenging to achieve in Wales due to a disproportionate share of 'hard-to-reduce' emissions, for example in agriculture and industry, and fewer suitable sites to store carbon dioxide. It follows that any advances in mechanisms to reduce greenhouse gas emissions and increase carbon storage in agricultural systems would be much welcomed. Indeed, the CCC recommend that DEFRA and the Devolved Administrations "put in place farming policies to reduce emissions that move beyond the current voluntary approach and replace the Common Agricultural Policy (CAP) with a framework that links support to measures aimed at emissions reduction and removals"[8].

Multi-Land evaluated the potential contribution of hedges to emissions reductions via carbon storage and changes to carbon dioxide emission pathways (Fig. 2). This followed a long-standing absence of woody features from national carbon stock calculations, in part due to their small size, which were impossible to capture with available mapping tools. Based on Multi-Land's calculation of Welsh carbon stocks, the establishment of woody plants, particularly along water courses which have a long history of deforestation would offer a particularly cost-effective opportunity to improve carbon management at a landscape scale.

Multi-Land research into the influence of hedges on soil greenhouse gas fluxes has found that carbon dioxide emissions from soil in the un-grazed zone directly under hedges is lower than in livestock-grazed pasture due to temperature and moisture influences on soil microbial activity. (The only exception to this benefit of hedges is during extreme events such as drought, when there is a pulse in carbon dioxide emissions). Open pastures, in contrast, may act as carbon sources rather than sinks, although this is influenced by factors such as soil type and grazing intensity.

In laboratory studies with different types of tree fodder, Multi-Land found that tree fodder reduced ruminant production of methane compared with hay. This highlights the potential to use trees as browse material to reduce greenhouse gas emissions from livestock-grazed pasture systems. Further work is now needed to determine the potential for tree fodder to support livestock productivity during periods of forage shortage (e.g. drought) and its effects on methane production in the field.

Figure 2
Left: when New Zealand ceased subsidising farms in 1985, increased productivity was portrayed as a success story despite potential negative environmental impacts due to intensification, such as nitrogen pollution and biodiversity loss[9]. Right: retaining more 'extensive' features such as hedges in Wales contributes positively to animal welfare and efficiency of feed conversion to live weight gain, reduced erosion, increased carbon storage and biodiversity.

Flooding

The role of trees in flood prevention is very topical and increasingly used as an argument for increased tree planting. However, this effect is complex and requires detailed investigation, particularly to determine where trees, and of what species, should be planted to provide maximum benefit[10]. In general, a naturally drained, wooded landscape reduces localised flood peaks compared with a grass-covered counterpart based on research from multiple countries and forest types[11]. However, the role of hedgerows in natural flood management is poorly understood. Most evidence from the UK is primarily derived from just one study (at Pontbren in mid-Wales[12]). More information is needed about the effect of different tree species, on different soils, in all seasons and across multiple years to reduce uncertainties about best practice.

Multi-Land studied the effects that different tree species have on soil pore size and density, both of which affect the rate at which water moves through soil (hydraulic conductivity). The soil structure that develops under ash (*Fraxinus excelsior)* was found to provide a two- to four-fold increase in hydraulic conductivity compared with other trees, leading to faster rates of water infiltration. Landscape planning for natural flood management, therefore, would benefit from detailed considerations of tree species selection and placement. This finding also suggests that the loss of ashes to ash dieback disease (*Hymenoscyphus fraxineus*) is likely to affect landscape hydrology, potentially increasing flood risk.

More research is needed on:

- Local-scale changes in flooding following deforestation and different forms of afforestation to produce accurate flood forecasts.
- The potential for tree fodder to support livestock productivity during periods of forage shortage (e.g. drought) and its effects on methane production.
- The impacts of an increase in tree cover in the landscape on overall farm income.

Credit: Multi-Land

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The over-arching mission of the Network was to promote excellent research within Wales into the sustainable use of natural resources for the provision of energy, water, food, and other ecosystem services. The Network was the catalyst to bring a diverse set of talented researchers and partners into new collaborations, in order to conduct innovative research that was highly pertinent on an international research agenda.

Four themes tie together all research funded by the Network:
1. Sustainable Intensification
2. Low Carbon Energy Pathways
3. Developing the Bio-Economy
4. Impacts & Mitigation of Climate Change and Human Activities

The core of the Network research was centred around 8 Research Clusters (supporting 18 Research Fellows and 12 PhD students) and 10 Returning Fellowships. The latter were individuals returning from extended career breaks. It also supported STEM outreach opportunities, public lectures and a diverse range of workshops and events on topical science issues. **www.nrn-lcee.ac.uk**

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