Achieving Net Zero: Understanding the Potential Hydrological Impacts of Changing Climate and Land Cover in the UK

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1. Introduction

- Catchment hydrology is **evolving** as **climate** and **land cover** changes.
- UK government plans **widespread afforestation** to reduce carbon emissions to **net zero by 2050** (CCC, 2019). Research has investigated its potential as **natural flood management** (Dadson et al., 2017).
- Understanding afforestation influence on catchment hydrology is important for efficient implementation of land cover change.
- The **Joint UK Land Environment Simulator (JULES)** is good to comprehend changing land cover and climate on catchment hydrology across the UK (Best et al.; Clark et al., 2011).

2. Aims

1. **To what extent does afforestation influence UK streamflow?**
2. **How does afforestation location influence catchment streamflow dynamics?**
3. **Where can afforestation locations reduce high flows?**

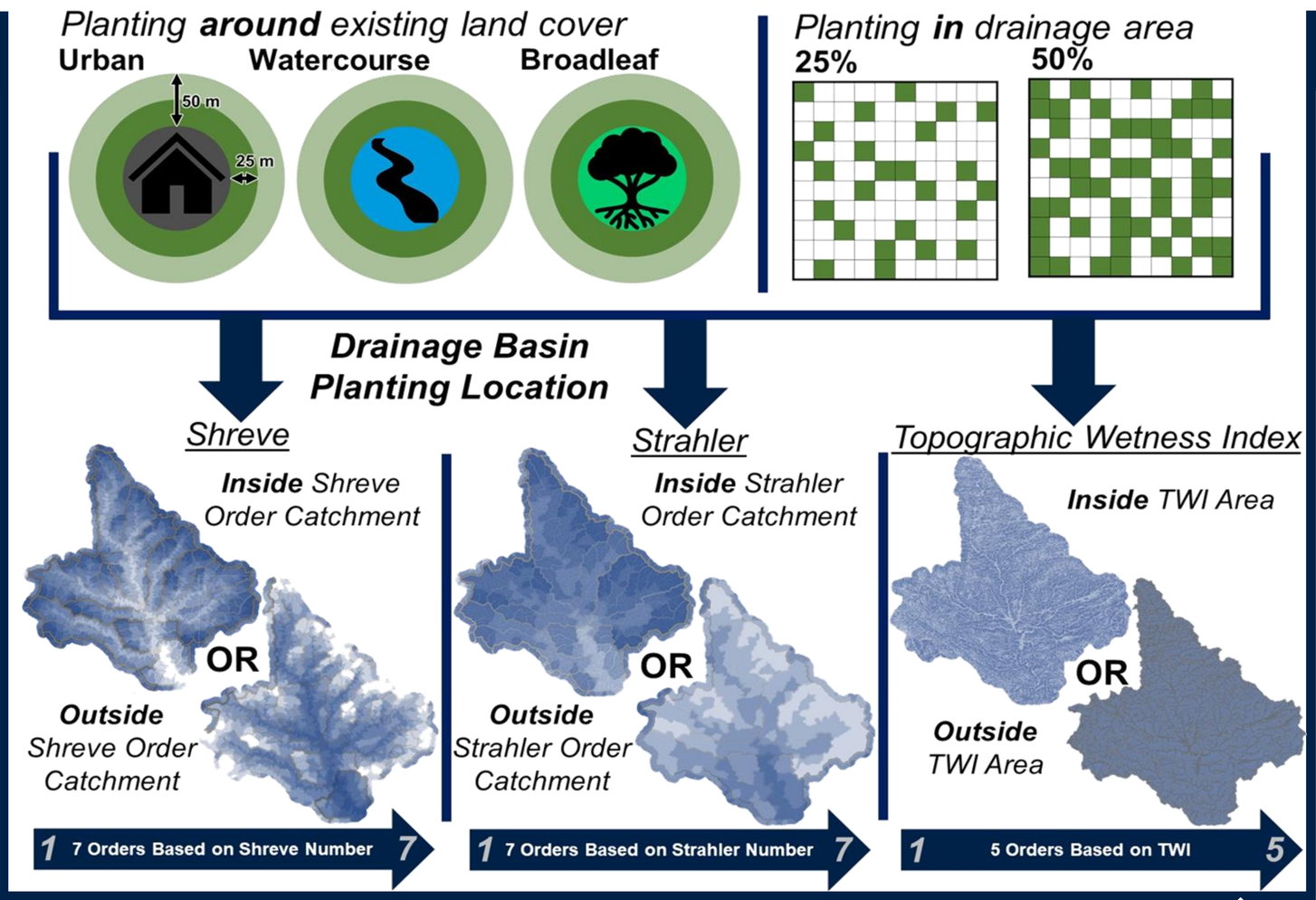


Figure 1: *Decisions for creating afforestation scenarios for each catchment.*

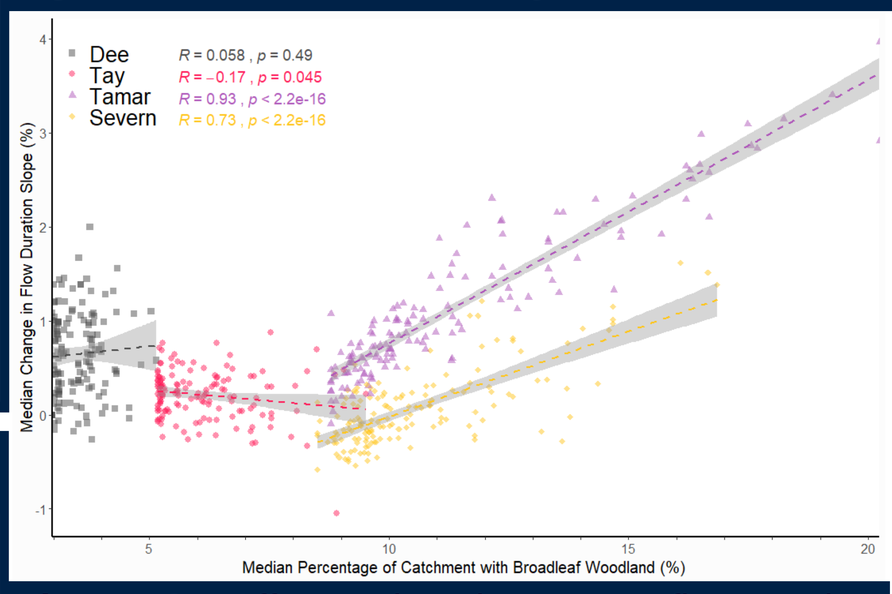


Figure 3: *Afforestation increases flow regime variability more significantly in some catchments.*

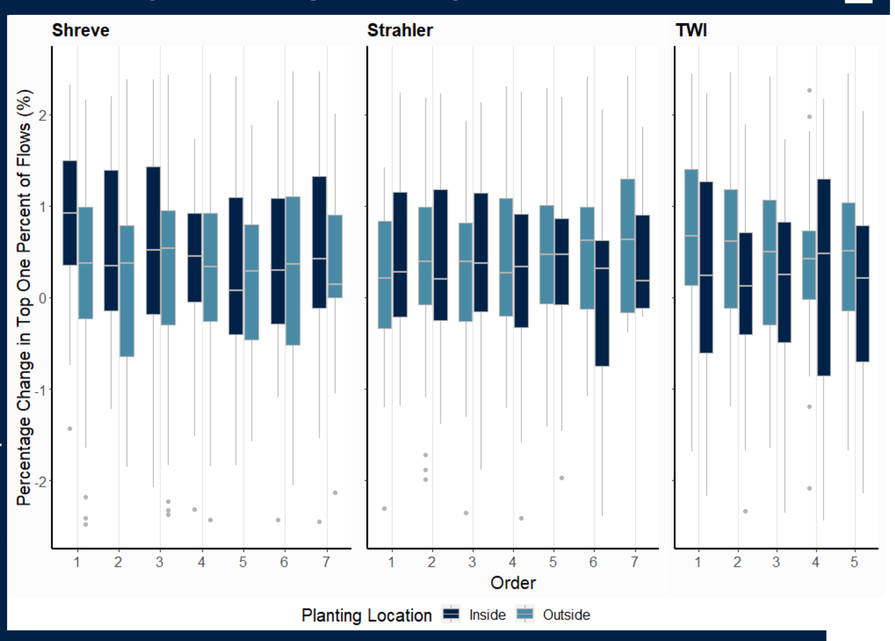
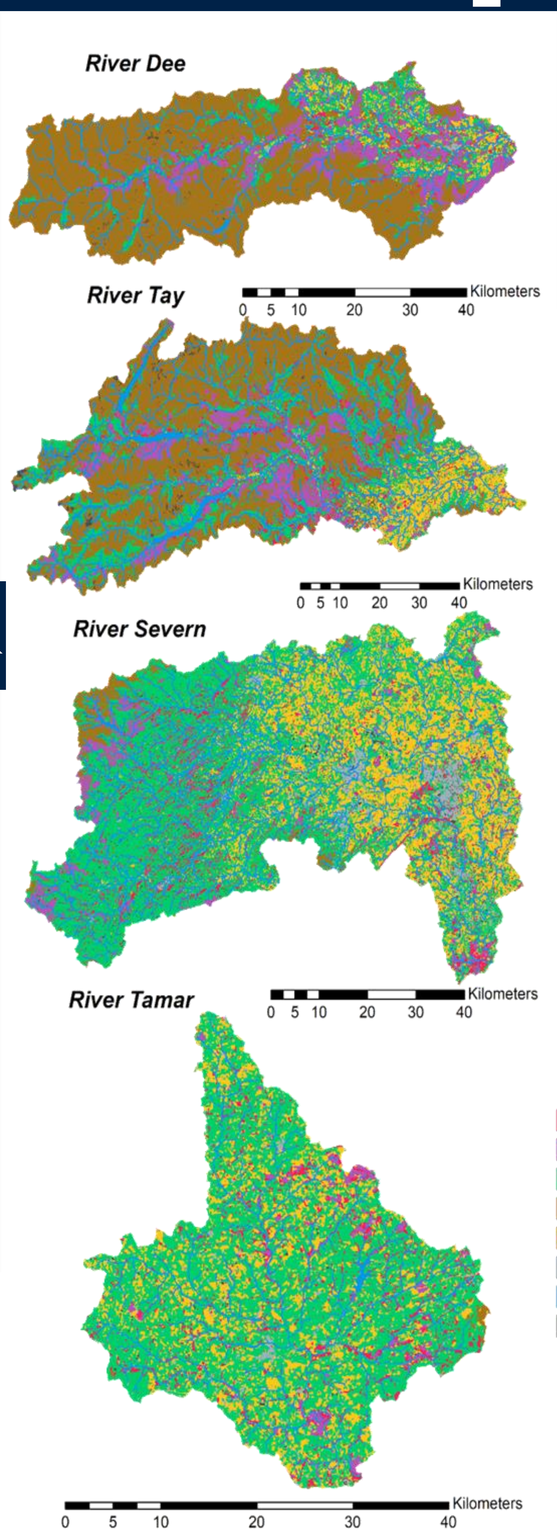


Figure 4: *Drainage basin afforestation area does not significantly alter high streamflow across catchments.*

3. Methodology

- Selected catchments investigated to find land cover change influence on streamflow [Figure 2].
- Up to **304 afforestation scenarios** created for each catchment using the land cover map 2000 (Fuller et al., 2002).
- Scenarios based on **existing land cover** and **drainage area location** [Figure 1].
- Afforestation of 25 and 50 m **around** land cover and 25% and 50% afforestation both **inside** and **outside** drainage basin areas**.**
- JULES run with CHESS-met between 2000-2010 (Robinson et al. 2017).
- Standard metrics used to determine land cover impact on streamflow.



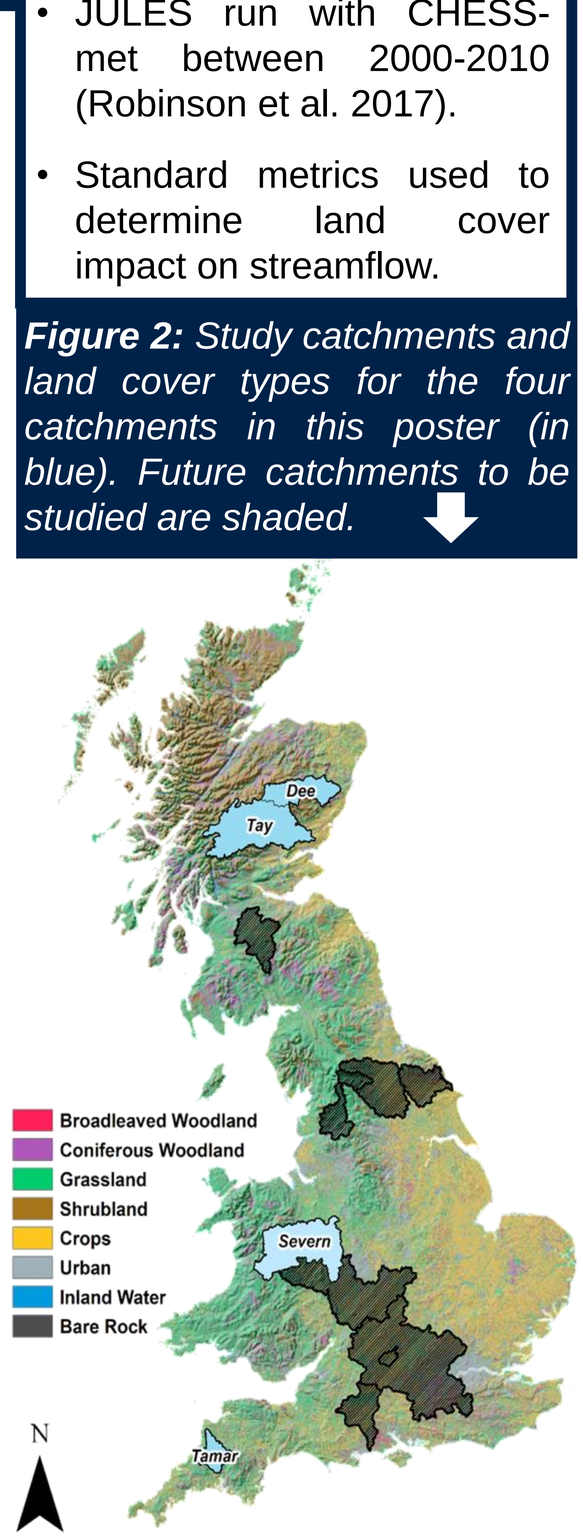


Figure 2: *Study catchments and land cover types for the four catchments in this poster (in blue). Future catchments to be studied are shaded.*

4.Results

1. Increasing afforestation **decreases low flows,** whilst not significantly decreasing high flows, leading to **increased flow regime variability** [Figure 3]. Catchment **responsiveness to rainfall and runoff-rainfall ratio decreases** with increased afforestation.
2. Planting in increasing Shreve and Strahler order generally leads to **increased flow regime variability** but this **reduces** with increasing **TWI order** [Figure not on poster]. Runoff-rainfall ratio decreases weakly on average with increasing Shreve and Strahler order but decreases with TWI order.
3. **No significant reductions or differences** in high flow distributions exist when **planting around existing land cover**. **No clear drainage basin area** to target for all catchments **to reduce high flows** [Figure 4]. Some drainage basin areas create greater variability in high flows.

5. Outcomes and Future

- **Afforestation location has a significant impact** on catchment hydrology- increasing flow regime variability and dampening catchment response to rainfall.
- Care must be taken on afforestation location as it can lead to **unintended changes in streamflow** e.g. increase extremes.
- Plan to study more catchments [Figure 2] and use ensemble weather forecasts to test future climate impacts on streamflow.

References: Best, M.J., et al. (2011). *The Joint UK Land Environment Simulator (JULES), model description–Part 1: energy and water fluxes*. Geoscientific Model Development, 4(1), pp.677-699; CCC, (2019). *Net Zero: The UK's contribution to stopping global warming*. Available at: https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf [Accessed 17 December 2019]; Clark, D.B., et al. (2011). *The Joint UK Land Environment Simulator (JULES), model description—Part 2: carbon fluxes and vegetation dynamics.* Geoscientific Model Development, 4(3), pp.701-722; Dadson, S. J., et al. (2017). *A restatement of the natural science evidence concerning catchment-based "natural" flood management in the UK.* In Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences (Vol. 473, Issue 2199); Fuller, R.M. et al. (2002). *The UK Land Cover Map 2000: construction of a parcel-based vector map from satellite images.* The Cartographic Journal, 39(1), pp.15-25; Robinson, E. L., et al. (2017). *Climate hydrology and ecology research support system meteorology dataset for Great Britain (1961-2015) [CHESS-met] v1.2.* NERC Environmental Information Data Centre. https://doi.org/https://doi.org/10.5285/b745e7b1-626c-4ccc-ac27-56582e77b900