Potential Hydrological Implications of Widespread Afforestation in Great Britain

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Potential Hydrological Implications of Widespread Afforestation in Great Britain

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Background

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- Climate models suggest limiting CO_2 can **reduce** the number of **negative effects** on communities across the world (CCC, 2019a, IPCC, 2018)
- Afforestation being treated as a **'silver bullet'** (Seddon et al. 2021)
- One of the ways that the UK government proposes to reach **Net Zero** by **2050** is to **increase** the amount of **afforestation** (CCC, 2019b)

Press release

Tree planting rates to treble by end of this Parliament

Plans to treble tree planting rates by the end of this Parliament to be set out by the Environment Secretary in a speech this week

From: Department for Environment, Food & Rural Affairs, Forestry Commission, Natural England, and The Rt Hon George Eustice MP

Published 17 May 2021

Plans to treble tree planting rates over the course of this Parliament will be set out by the Environment Secretary this week.

Motivation

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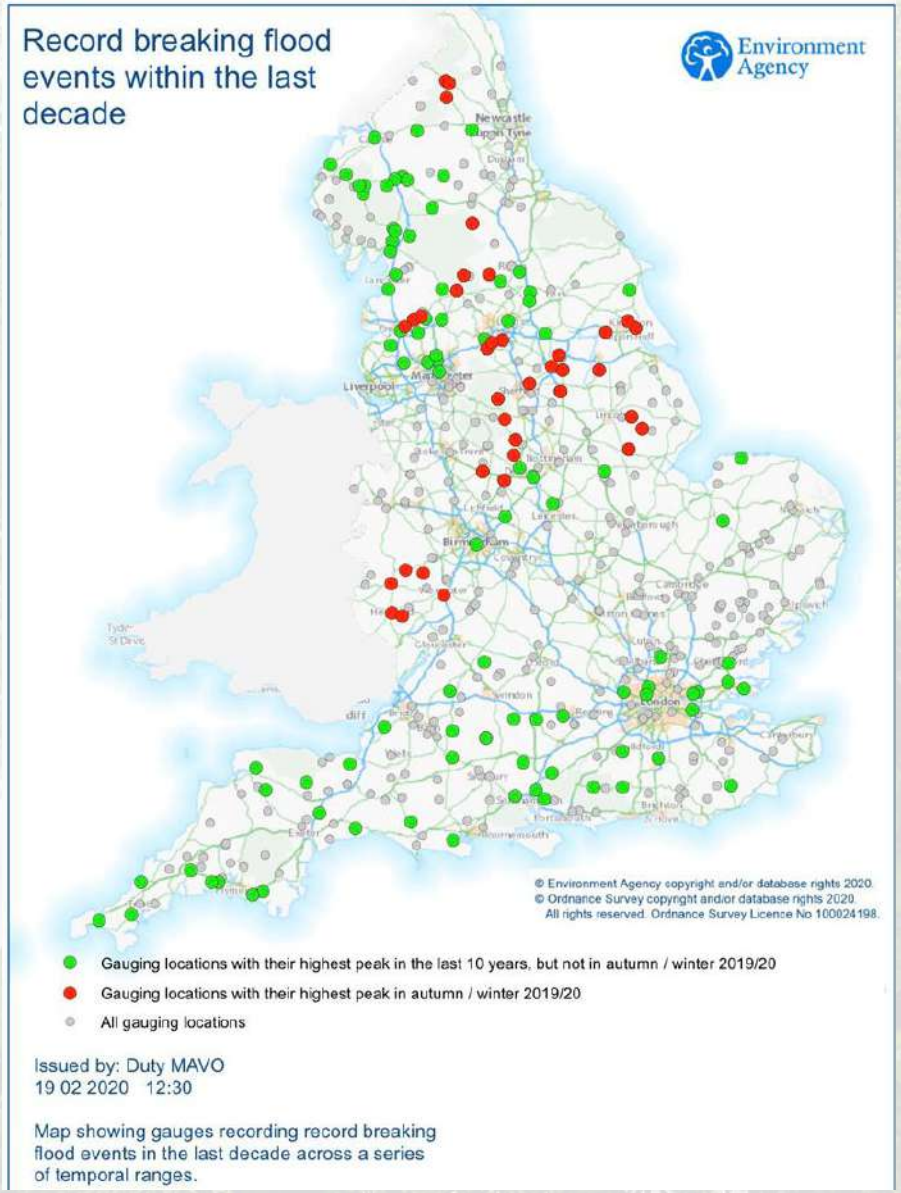
- Widespread land cover changes likely to have largescale impacts on the hydrological cycle
- Planting trees in the right place for the right reason
  - Natural Flood Management
- Understanding the **spatial** and **temporal** scales of afforestation impact



Questions

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1. **To what extent does afforestation influence streamflow?**

   What is the magnitude of change?

2. **How does afforestation location influence streamflow dynamics?**

   Can we plant trees in the right place?

3. **Which catchment properties alter streamflow sensitivity to afforestation?**

   Can we extrapolate the response of catchments to afforestation?

Methodology

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- **Twelve catchments** in Great Britain
- CHESS-met (Robinson et al. 2017) for the period 2000-2010
- Large ensemble of afforestation scenarios- c. **300** per catchment
  - Based on:
    - Existing Land Cover
      - **Urban**
      - **Broadleaf**
      - **Watercourses**
    - Stream Order and Propensity for Saturation
      - **Shreve** and **Strahler** Orders
      - **Topographic Wetness Index**

Methodology: Scenarios

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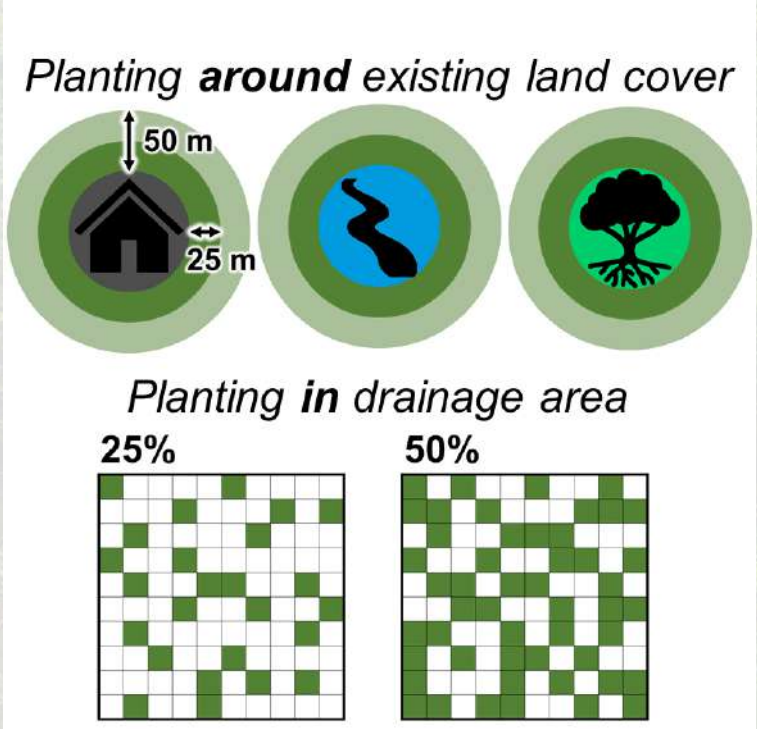
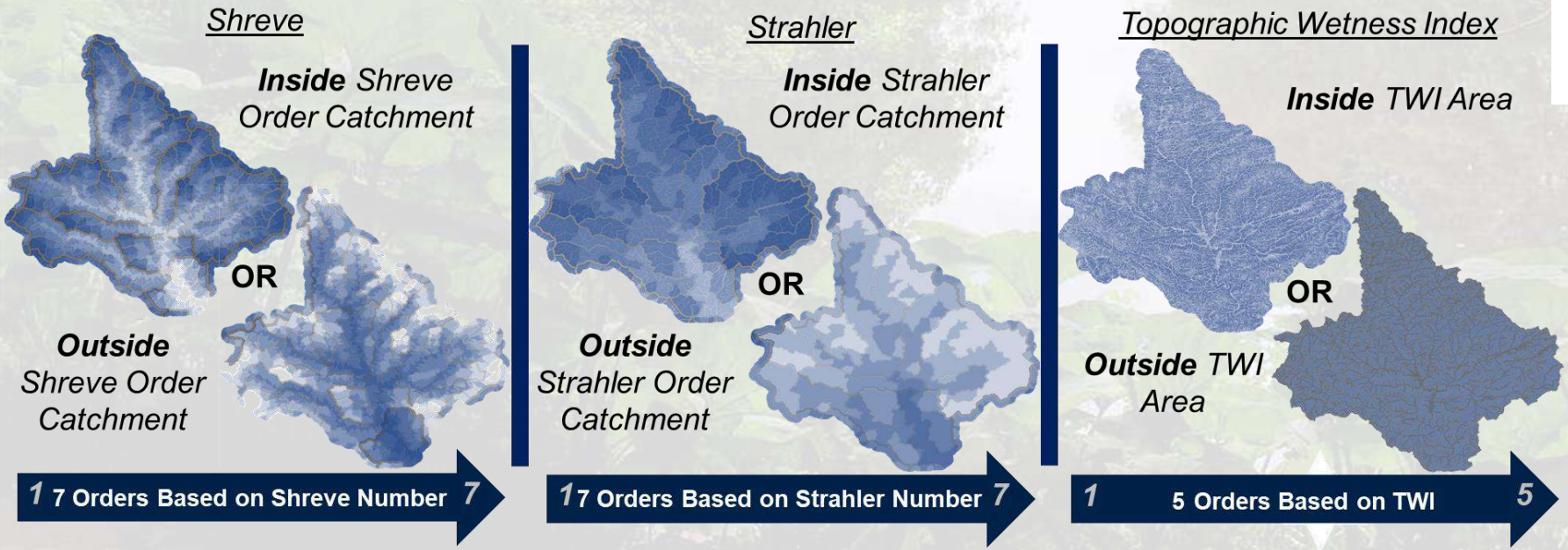
- **Around existing land cover** at 25 – 50 m
- **Inside** and **outside drainage areas** at 25 and 50 %
- Use of hydrologic eight metrics to quantify difference between afforestation and no change





Results: Afforestation Extent

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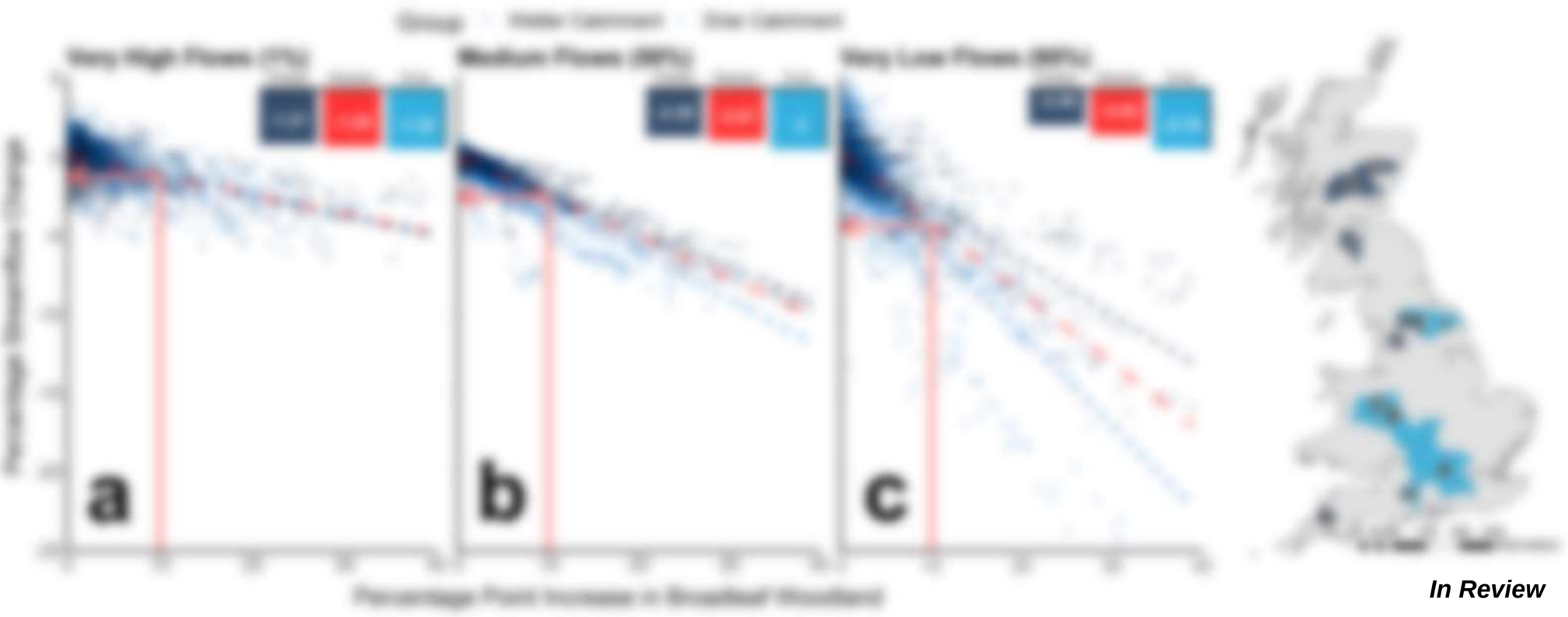

In Review

- On average, reduction in streamflow with afforestation at all flow quantiles
- **Greater response in drier** catchments
- Converting ten percent of a catchment from grasslands to broadleaf woodland reduces median streamflow by **2.6% ± 1 (10 mm yr^{-1}± 2.1).**

Results: Afforestation Extent

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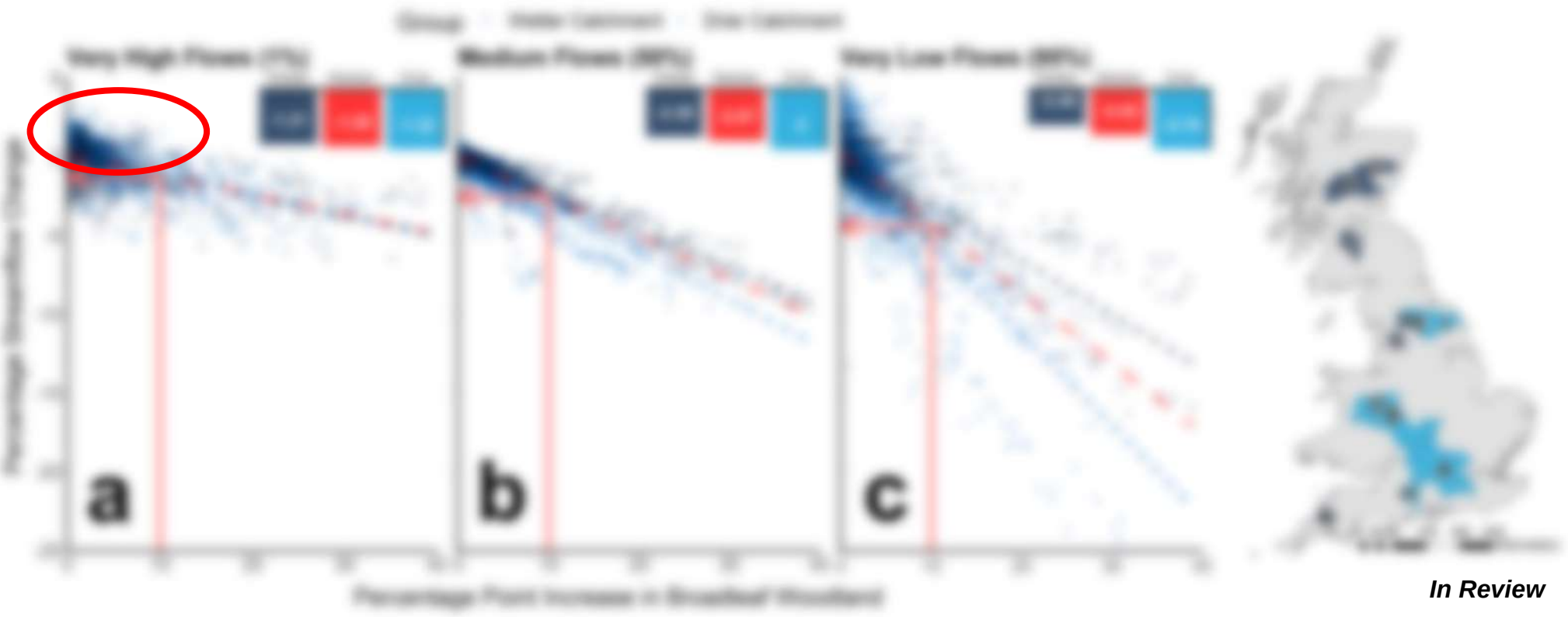

In Review

- Potential to increase river flow – why?

Results: Afforestation Extent

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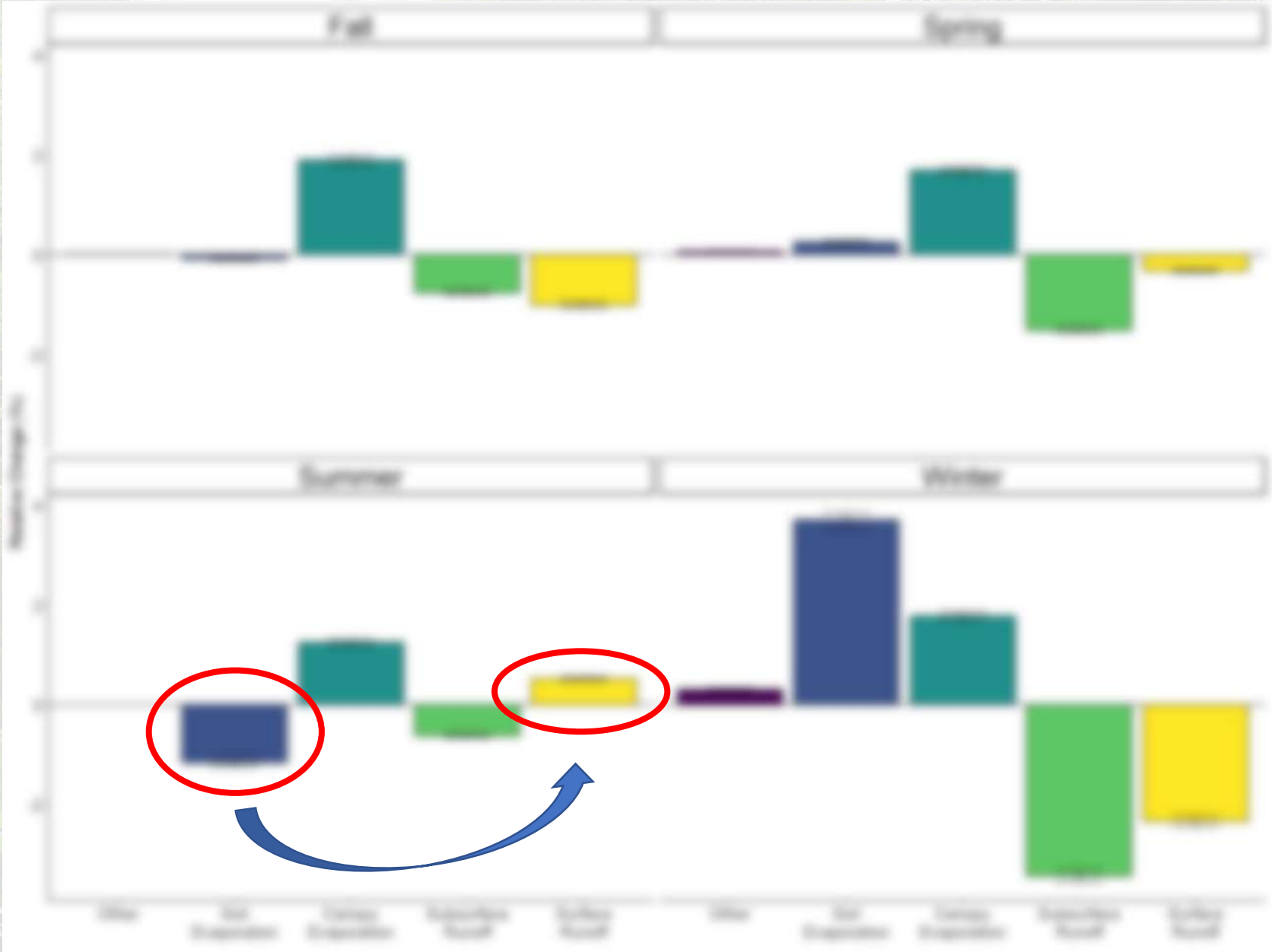
Reduction in soil evaporation

Increase topsoil moisture

Increase summer runoff



Results: Afforestation Location

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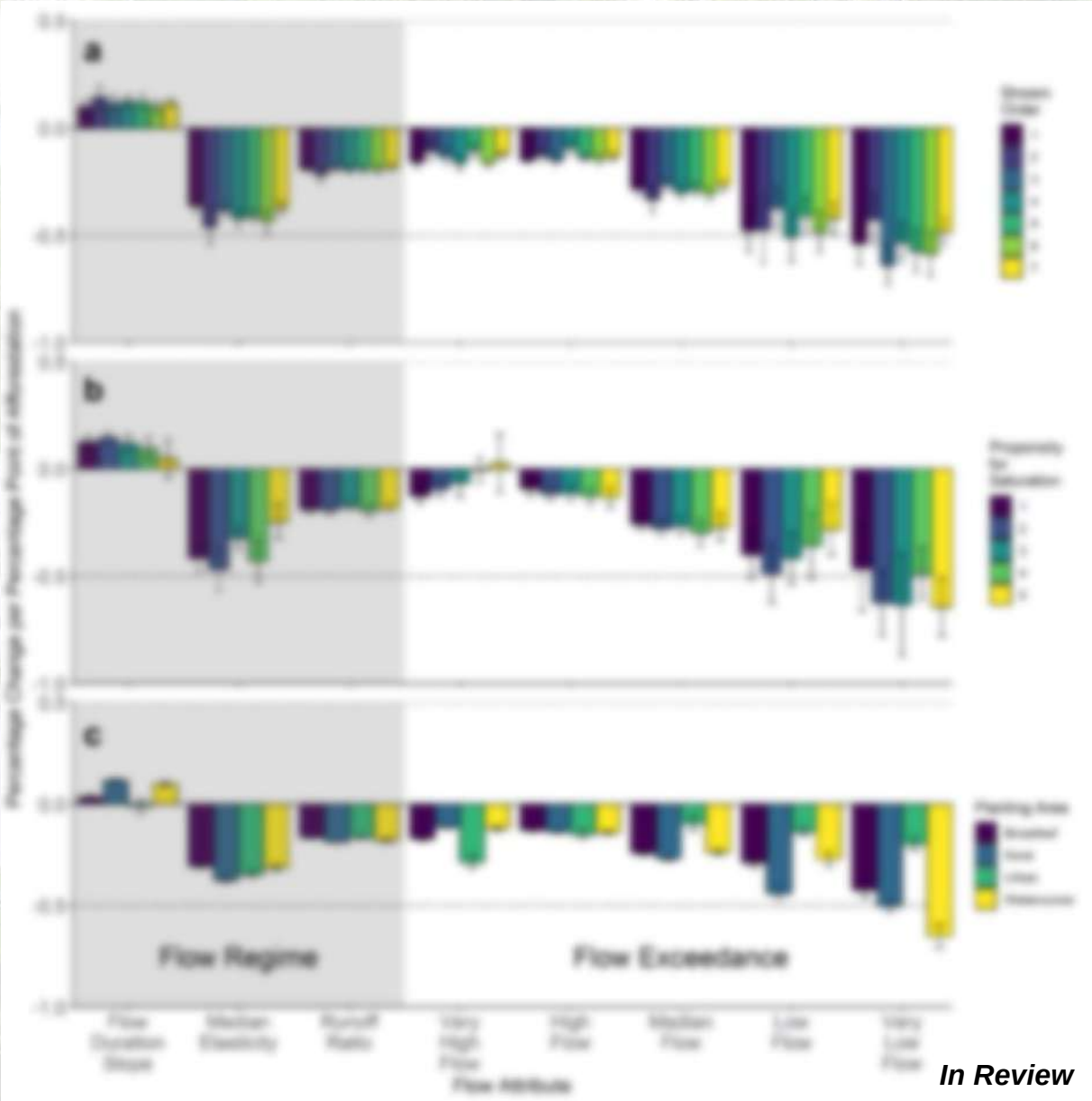
- **No clear location** for optimal afforestation planting
- **Location has the strongest** influence in the smallest catchments
- **No difference** in planting in uplands against lowlands or inside and outside drainage areas



In Review

Results: Afforestation Location

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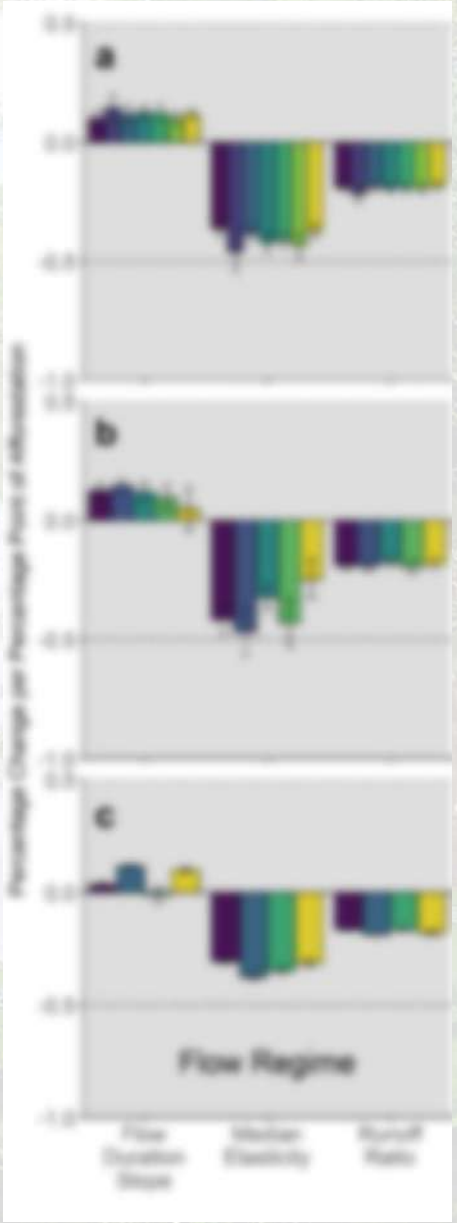
- **Other points to note:**
  - *Slight increase in flow variability*
    - *Predominantly driven by reduction in low flows with little or slight change in high flows*
  - *Decreased responsiveness to rainfall*



Results: Afforestation Sensitivity

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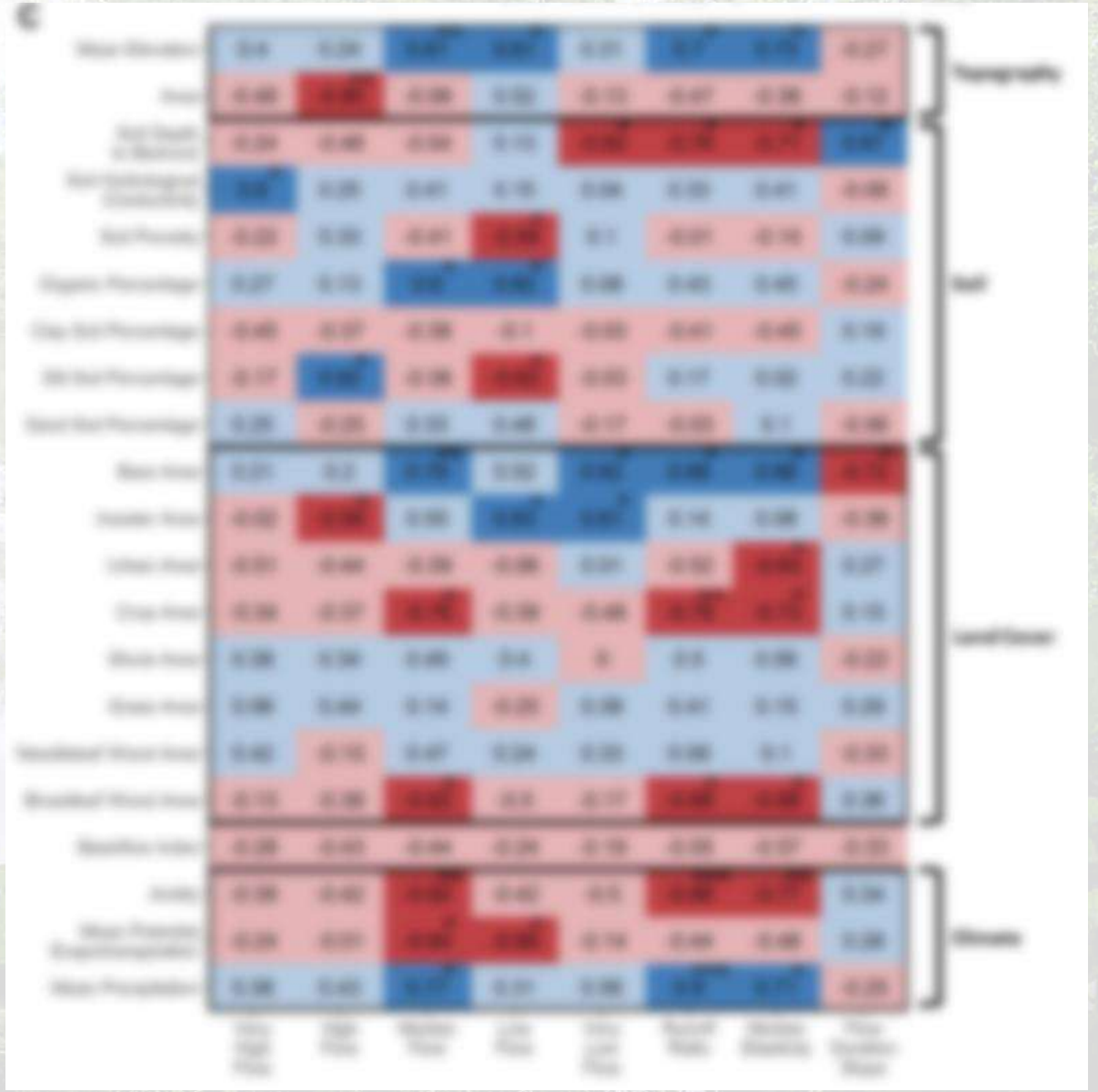
- **Tree-planting influence** on streamflow is smaller in areas with **higher rainfall and shallower soils**
- **Climate** has a strong influence on catchment response



Results: Conclusion

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- Converting ten percent of a catchment from grasslands to broadleaf woodland reduces median streamflow by **2.6% ± 1 (10 mm yr^{-1}± 2.1)**.
- There is **no single afforestation location that has a consistently higher impact** on high streamflow than others; planting location matters most in small catchments.
- Afforestation of catchments with **less rainfall and deeper soils causes a greater reduction in median and low streamflow**.
- Potential increase in summer flows?

Thank you for listening!

Any questions?

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