Restore, Rewild, Recover: Enabling riverscape resilience through process-based restoration.

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Engineering and Physical Sciences Research Council

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University of Glasgow

What am I?

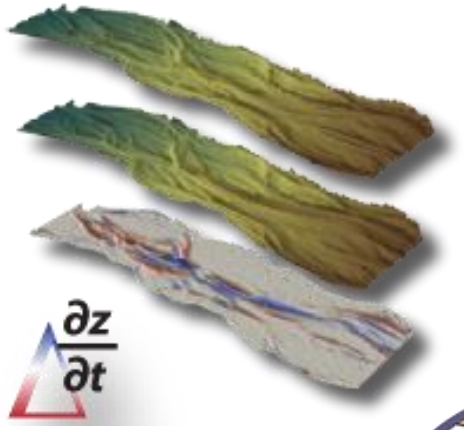
2nd year PhD student - fluvial geomorphologist

Where am I?

In a river then at my desk

What am I doing?

Looking at how riverscapes change over time post-restoration

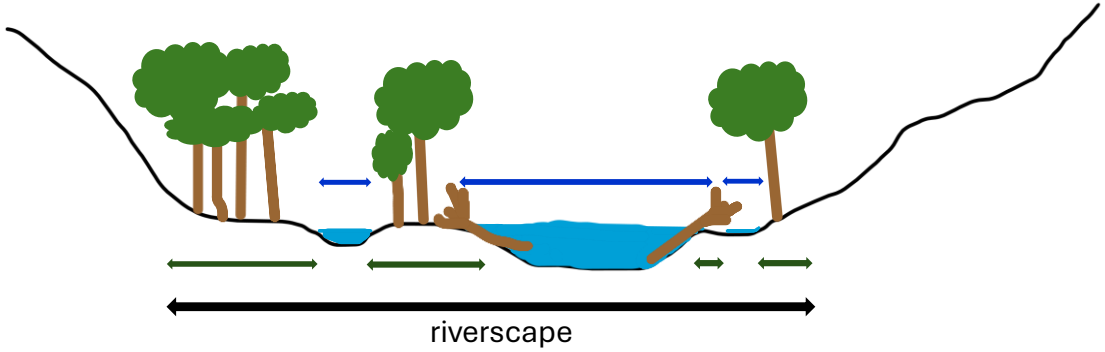


Key terms:

REWILD

"*Rewilding means enabling nature's recovery, whilst reflecting and respecting Scotland's society and heritage, to achieve more resilient and autonomous ecosystems*" (Waylen and Marshall, 2023).

RIVERSCAPE



RIVERSCAPE RESILIENCE

A riverscape's ability to self-sustain and dynamically adjust to recover from environmental perturbations, accounting for uncertainties in climate, flow and wood regimes.

PROCESS-BASED RESTORATION

River restoration which focuses on restoring flow and sediment regimes that create and maintain geomorphic units e.g, pools, riffles, bars

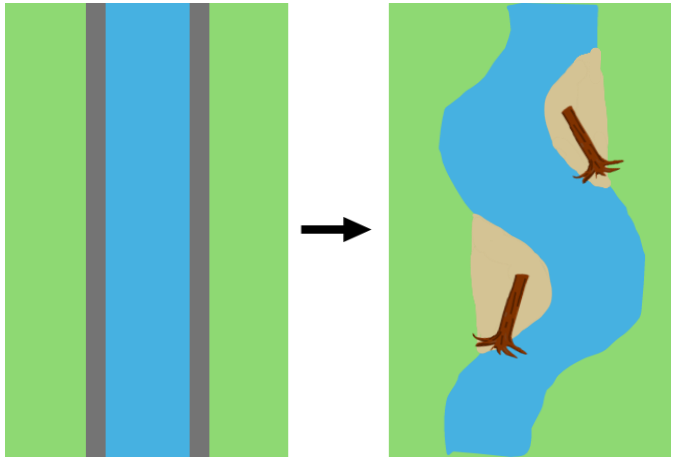
Process-based restoration

- River restoration which focuses on restoring flow, wood and sediment regimes that create and maintain geomorphic units e.g, pools, riffles, bars

No active interventions such as re-meandering

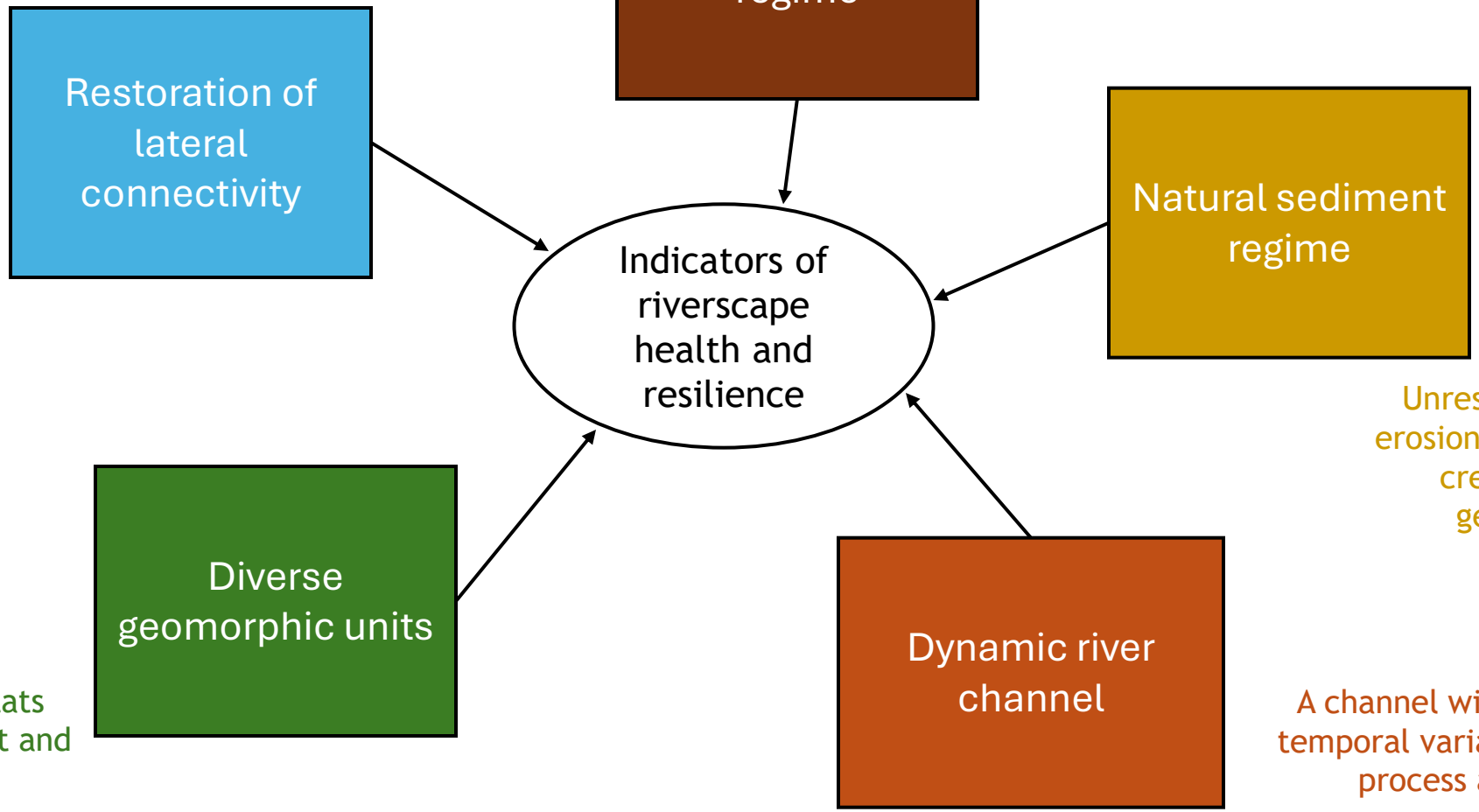
Removing pressures *i.e embankments, bank protection*

Reinstating natural processes *e.g by placing large wood*



Well suited to rivers with high recovery potential:
- high energy
- bed material of boulders, cobbles, gravels
- wandering, plane-riffle, step-pool morphology

How do we know when a river has recovered?



Exchanges of water, sediment and organic material between channel and landscape.

Exchanges of wood between the floodplain and river channel. Storage of in-channel large wood. Riverscape wood available for recruitment to channel.

Unrestricted processes of erosion and deposition which create and maintain geomorphic units.

A mixture of river habitats defined by their sediment and flow conditions.

A channel with spatial and temporal variations in fluvial process and form.

Degraded Scottish Riverscapes

- 56 % of Scotland's rivers have poor morphological and riparian woodland conditions (The Riverwoods Science Group, 2022).

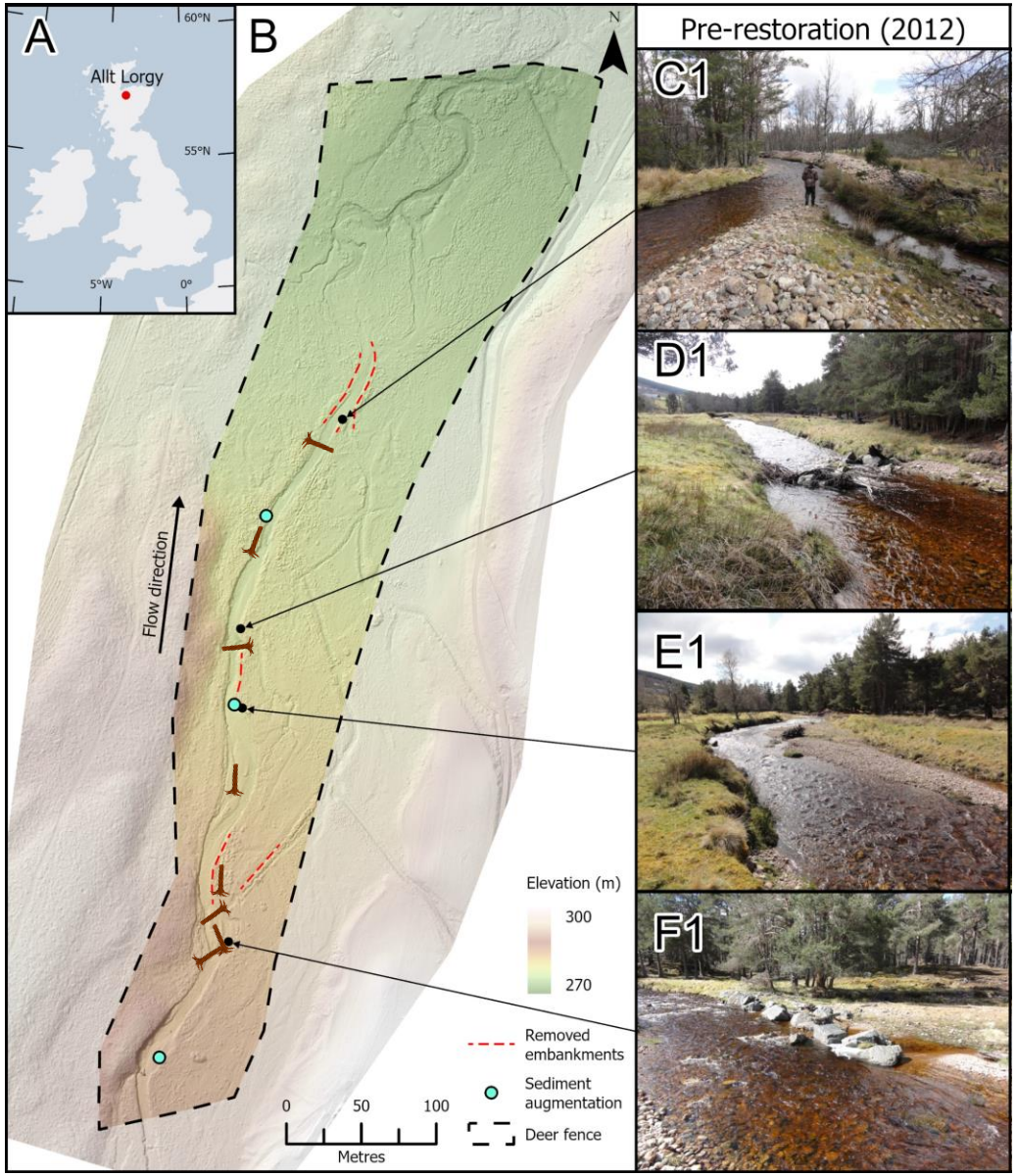
- River channels are exhibiting a simplified morphology for their energy regime.
  - Disconnected from floodplains.
  - Limitation of natural fluvial processes.
  - Homogenous habitats.

Limited ability of Scottish riverscapes to respond to environmental fluctuations.


Photo: Hamish Moir


Photo: Hamish Moir

Process-based restoration – Allt Lorgy, Carrbridge



Large wood placement

Embankment removal

Sediment augmentation

Deer fencing

Post-restoration assessment methods

High-resolution topographic survey (UAV LiDAR and in-channel RTK-GNSS)

UAV aerial imagery

Vertical Aerial Imagery

Geomorphic Change Detection software

Geomorphic Unit Tool

R LidR package

Elevation change mapping

Geomorphic unit mapping

Riverscape tree regeneration mapping

Active channel area

In-channel large wood mapping

Primary Data

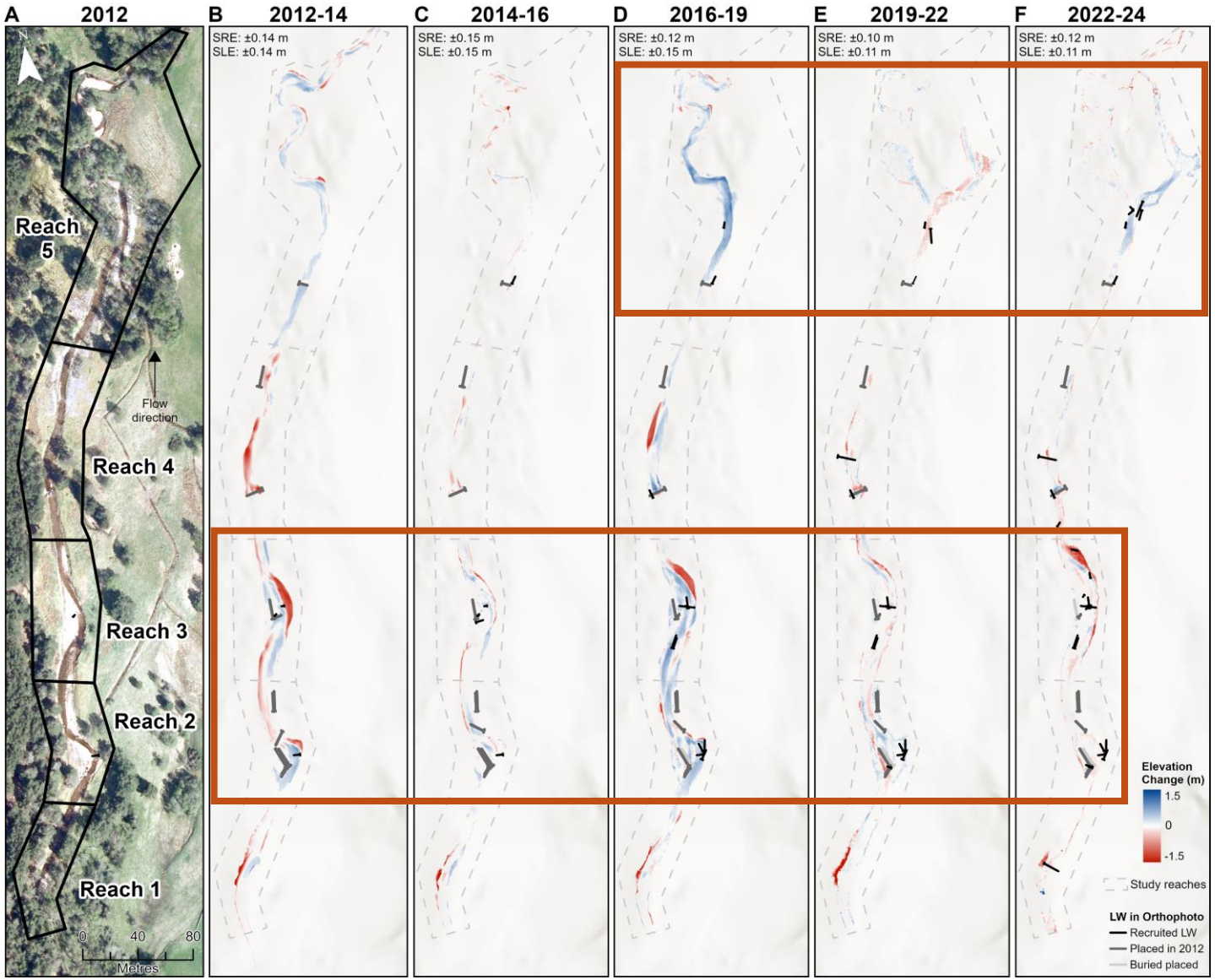
Secondary Data

Processing Tools

Results

How has the Allt Lorgy riverscape evolved post-restoration?

Allt Lorgy has self-healed to a dynamic planform.

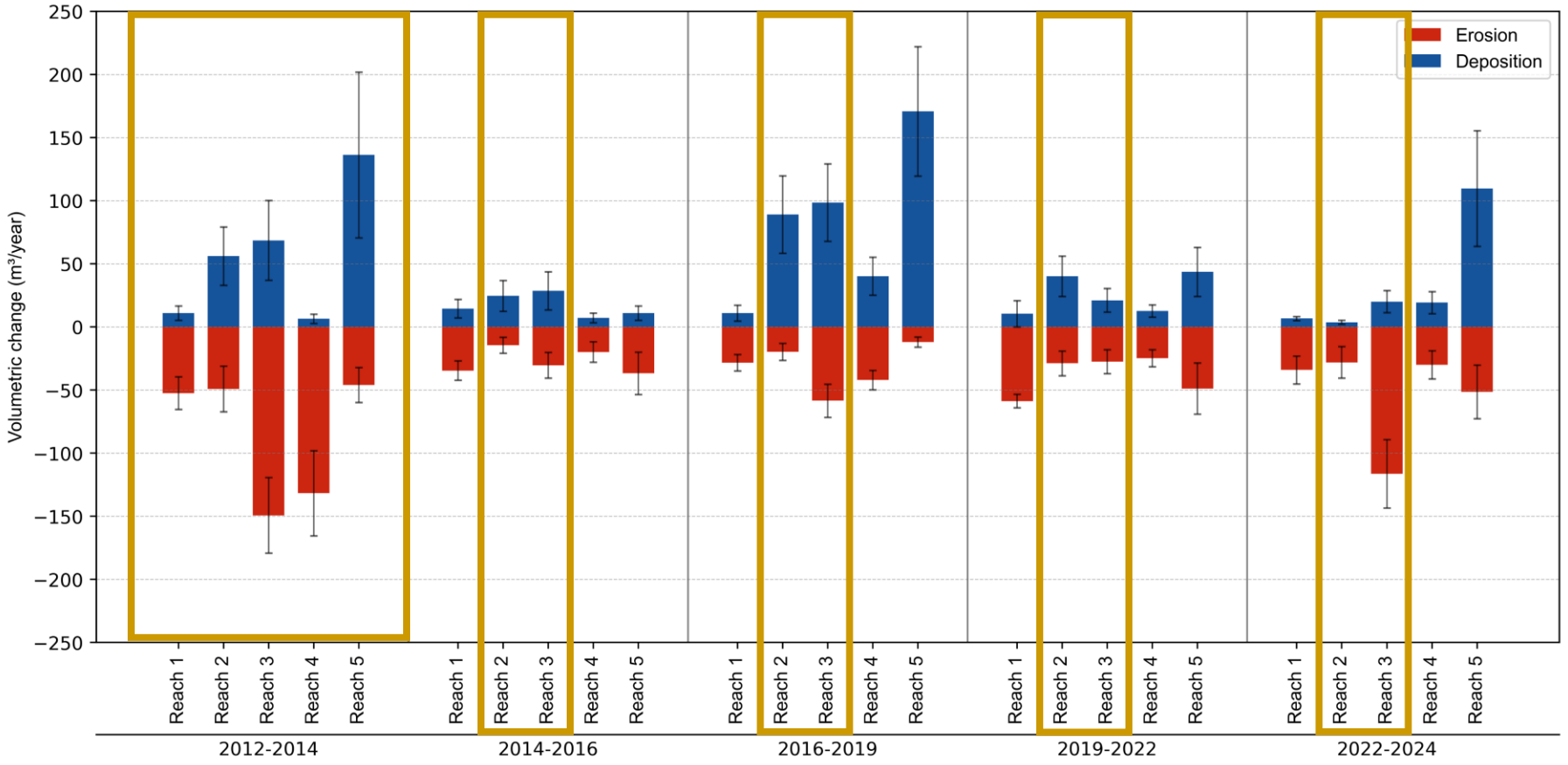


Changes in elevation between each topographic survey, red = erosion and blue = deposition.

Indicators of geomorphic dynamism:

- Lateral erosion, concentrated in reaches with large wood placement and embankment removal.
- Avulsion where embankments were removed.
- Post-restoration fluctuations in geomorphic change = ongoing channel adjustment to reinstated fluvial processes and high flow events.

A natural sediment regime has been reinstated.

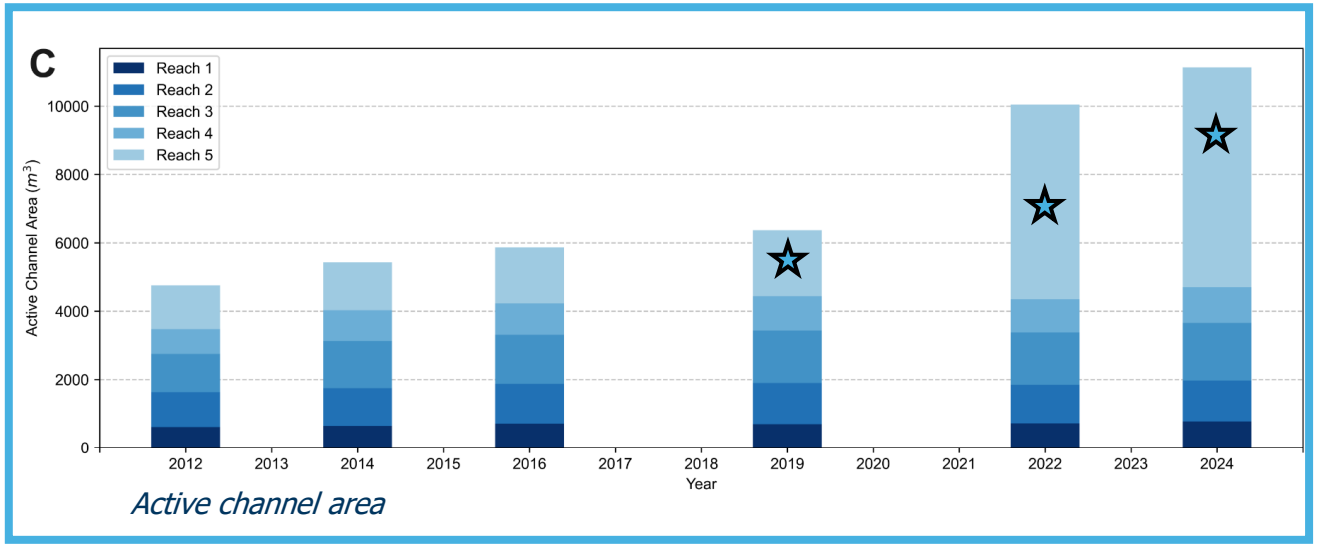


Changes in elevation between each topographic survey, red = erosion and blue = deposition.

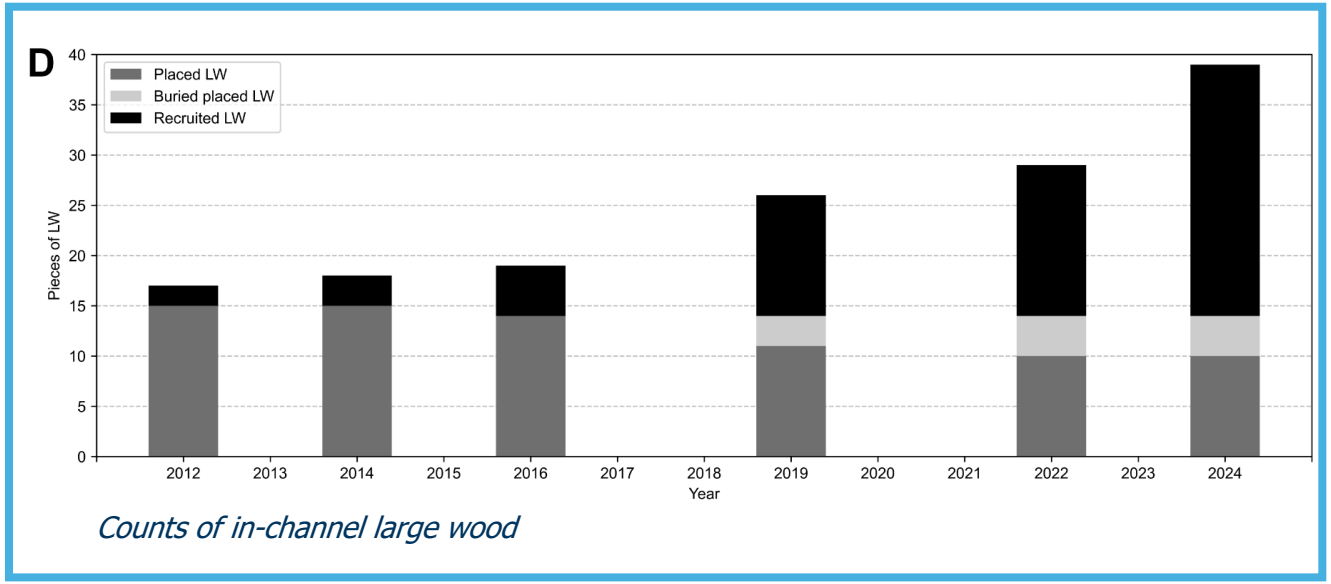
Indicators of natural sediment regime:

- Erosion and deposition kick-started 2 years post-restoration.
- Local sediment transport processes in reaches with placed large wood.
- Post-restoration fluctuations in geomorphic change = ongoing channel adjustment to reinstated fluvial processes and high flow events.

Lateral connectivity has been restored.



Active channel area



Counts of in-channel large wood

Indicators of restored lateral connectivity:

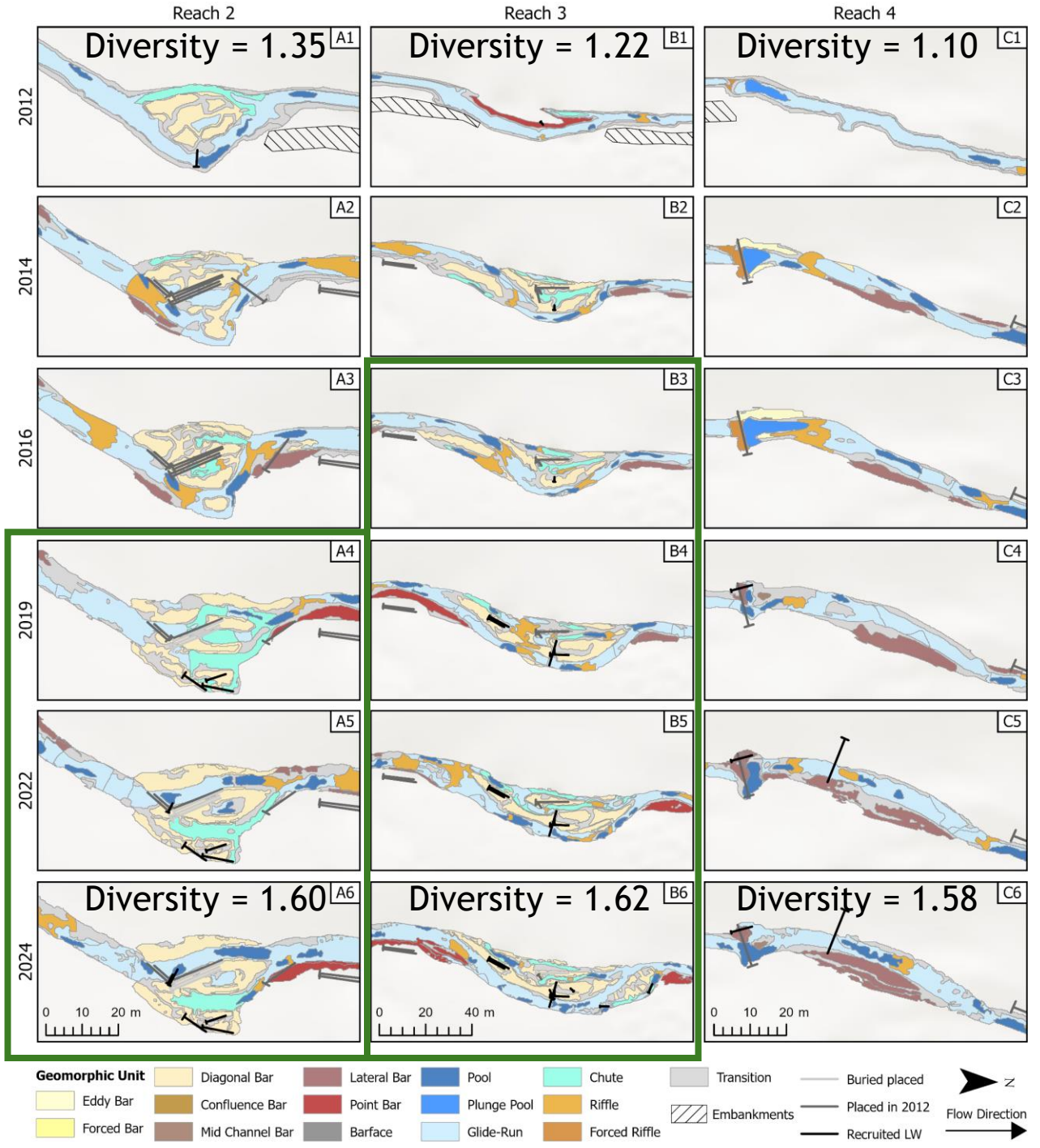
- Increase in active channel area, indicating lateral erosion.
- Avulsion at downstream end of reach.
- Increase in naturally recruited in-channel large wood.

Geomorphic unit diversity has increased.

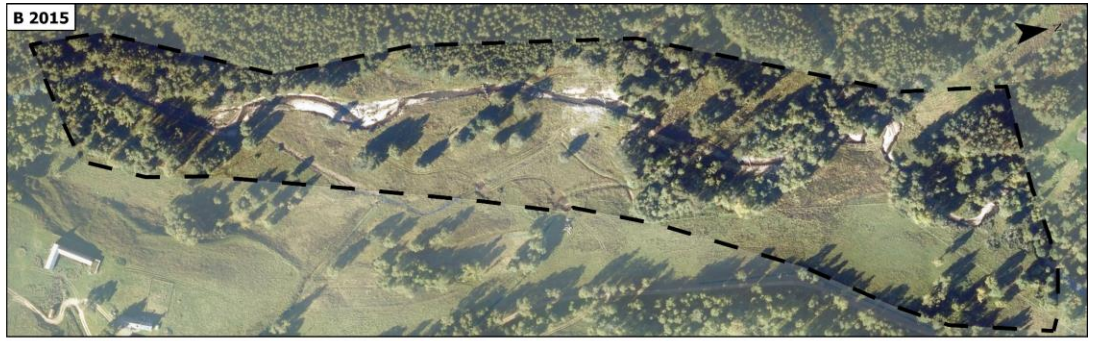
Each different colour shape = different geomorphic unit.
Lines = large wood.

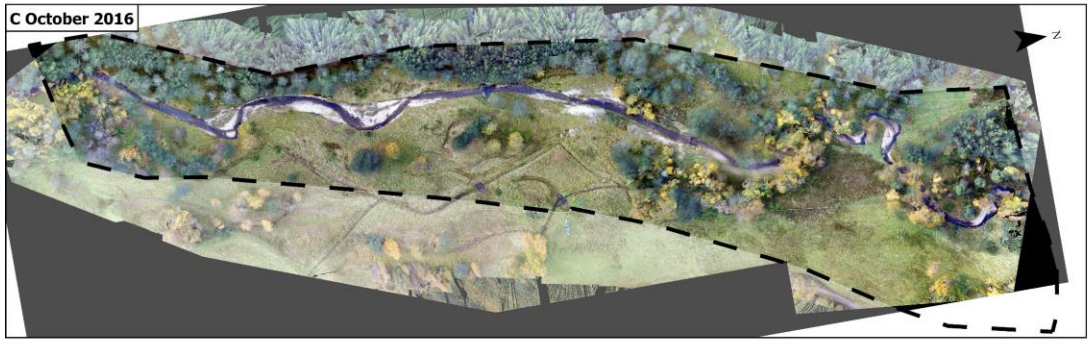
Indicators of diverse geomorphic units:

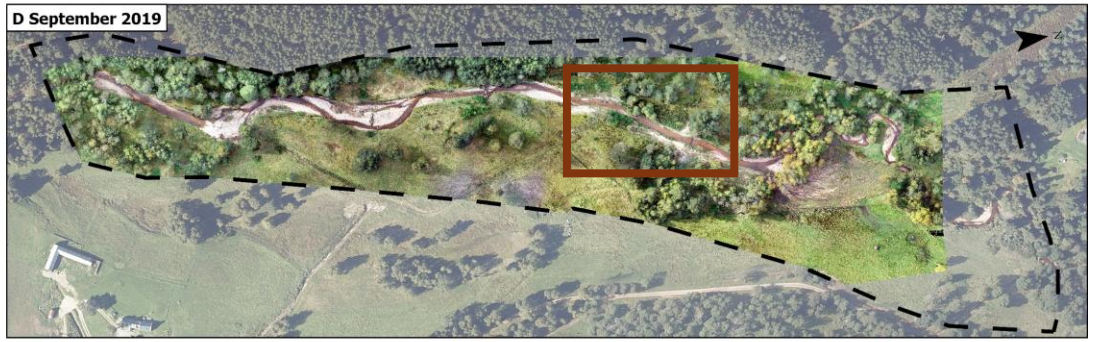
- Increased geomorphic unit diversity post-restoration.
- Development of depositional geomorphic units (e.g diagonal bars) driven by large wood placement.
- Dynamic change in geomorphic units in response to natural recruitment of large wood.

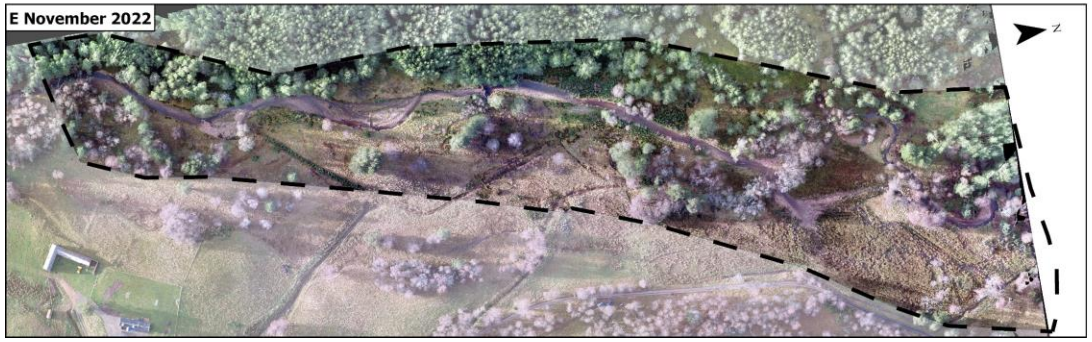


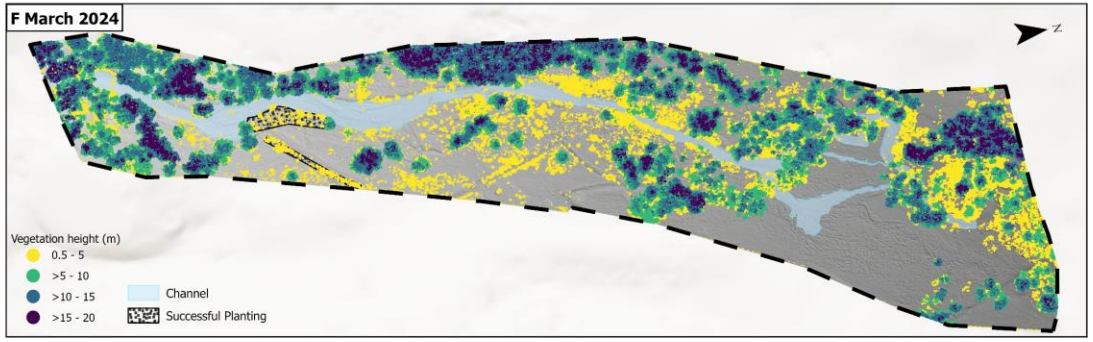
A natural wood regime is being restored.







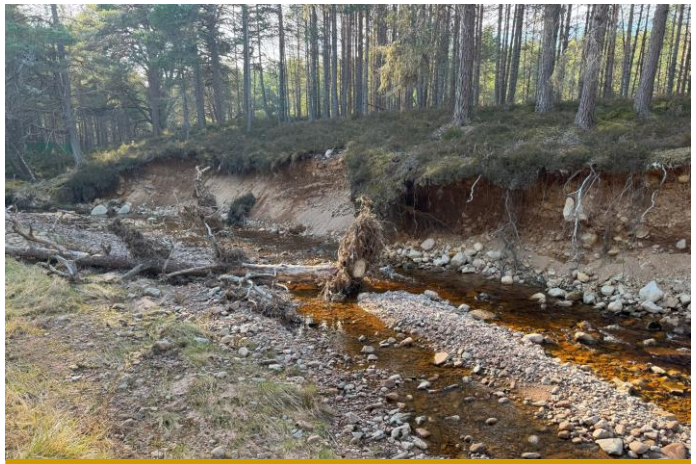




Restoration of lateral connectivity

Natural wood regime

Indicators of riverscape health and resilience



Natural sediment regime

Diverse geomorphic units

Dynamic river channel

Natural wood regime

Restoration of lateral connectivity

Natural sediment regime

Indicators of riverscape health and resilience

Diverse geomorphic units

Dynamic river channel

Conclusions

- Application of riverscape rewilding principles helped Allt Lorgy to self-heal to a self-sustaining dynamic planform.
- Large wood placement reinvigorates local sediment transport processes, encourages morphological diversity and lateral connectivity.
- In-channel storage capacity of large wood increases post-restoration.
- Deer fencing facilitates the natural regeneration of native tree species across the riverscape.
- A natural wood regime forms an integral part of supporting natural riverscape functioning, hence increasing riverscape resilience.

Thank you!

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Daniels, L.J., Williams, R.D., Creed, M.J., Quick, L., MacDonell, C.J., Moir, H., Roberts, K. (In review). Let the riverscape grow! Riverscape rewilding restores lateral connectivity and promotes geomorphic recovery in a Scottish gravel-bed river. Science of the Total Environment.