

Assessing the hydrogeomorphological effects of large woody debris in rivers: A study of both natural and restored wood in the River Blackwater, UK.



MSc Environmental Science: Integrated
Management of Freshwater Environments

Author: Rebecca Ing



Wood in Rivers

- Performed a vital function within forested river systems for over 400 million years
- Large Woody Debris dimensions; >1m in length and >0.1m in diameter
- LWD accumulations known as jams. Classified into active, complete and partial.
- Increases the diversity of channel hydraulics and morphology driven by:
 - Hydraulic roughness
 - Velocity variations
 - Spatial diversity of scour and deposition
 - Particulate organic matter retention
 - Hydraulic retention
- Subsequent ecological benefits
- Benefits of LWD not fully realised prior to 1980s
- Dramatic loss of in-channel and floodplain heterogeneity since the rise of the human population due to:
 - Historic forestry management
 - Active removal of LWD from rivers for navigation



Wood in River Restoration

- Value of reinstating wood for healthy functioning of fluvial systems is acknowledged.
- River restorations now attempt to re-establish natural functioning of wood in rivers.
- Under the objectives of the Water Framework Directive.
- Restorations often within modified water bodies and urbanised catchments – restoring natural functioning proves complex.
- Often less complex structures than natural LWD.
- Limited research – success yet to be fully understood.
- Extent to which emplaced wood can function as naturally accumulated LWD is largely unknown.



Research Locations

- River Blackwater, Hampshire.
- Loddon catchment.
- Only 16% urban and suburban land use but the area surrounding the River Blackwater is largely urbanised.
- Large section of channel modified and constrained within a narrow floodplain and limited riparian corridor over the past 200 years
- Two contrasting sites

Hawley Meadows – Restored LWD

- Hawley Meadows, Farnborough
- Department of Fisheries within the EA and Blackwater Valley Countryside Partnership – Restoration Scheme
- Channel subject to extensive historic channel modification
- Aim to improve habitat features to enhance fisheries
- Restorations in March 2007 (HM old restored) and March 2012 (HM newly restored)
- LWD secured in channel with posts and wiring
- Post restoration fish surveys proved successful



Research Locations

Moor Green – Natural LWD

- Moor Green Lakes, Sandhurst
- Unmodified forested channel
- High abundance of LWD jams
- Direct comparison to restored LWD within the same catchment



Methodology

Fieldwork

- Detailed spatial analysis at reach-scale (100m reaches) and microscale (surrounding LWD)
- Non-woody control reach at each site
- River Corridor Surveys and River Habitat Surveys
- Geomorphological mapping of LWD and a standardised wood jam survey
- In-channel measurements of velocity, water depth, substrate depth and calibre.
- High frequency 3D velocity currents using an ADV FlowTracker.
- Triplicate sediment sampling within dominant patch types
- Surveyed topographic data using a level
- A novel flow tracer experiment determined hydraulic retention (Milner & Gilvear, 2012).
- Travel times of aqua-spheres recorded
- Identifying major retention features



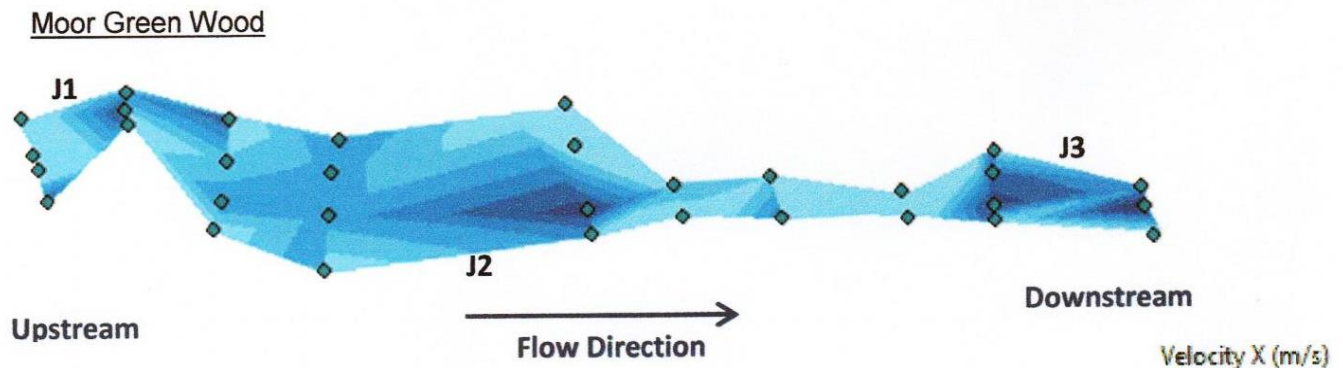
Methodology

Laboratory work

- Particle size distribution
- Moisture content
- Loss on Ignition (LOI) – Organic Matter Content

Data Analysis

- Topographic data mapped against hydraulic and substrate indices using ArcGIS to display spatial variations.
- Minitab Version 15 utilised for statistical analysis
- GRADISTAT Version 4.0 utilised for Particle Size analysis.



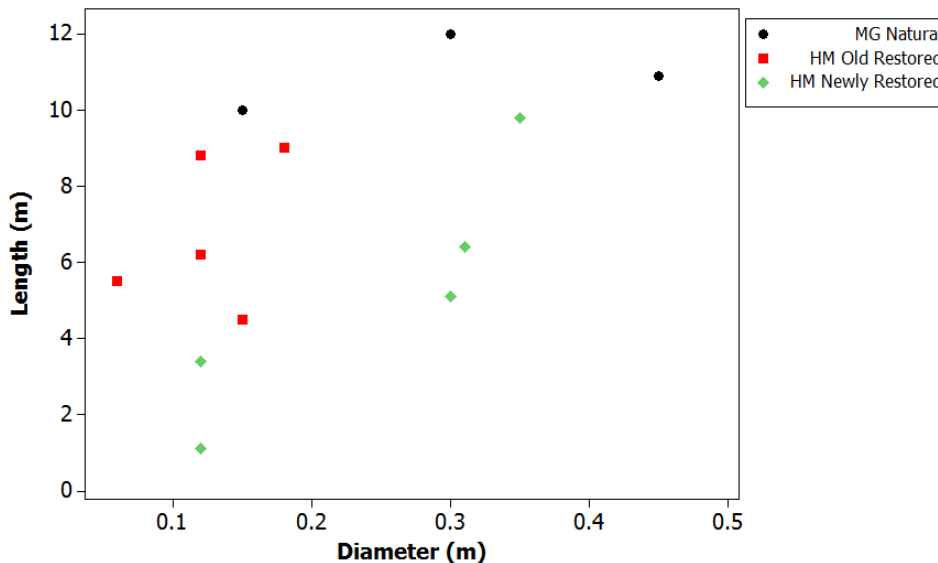
Results

Jam Characteristics

- All restored LWD of partial class – smaller dimensions and lower blockage ratios
- Active, complete and partial jams at Moor Green
- Mean blockage ratios of LWD - highest at Moor Green and lowest at HM Old Restored
- Key LWD at HMOR shows the lowest range of orientations (0-45°), with greater variability identified at HMNR (15-135°) and MG (0-150°) (Figure 4.213).



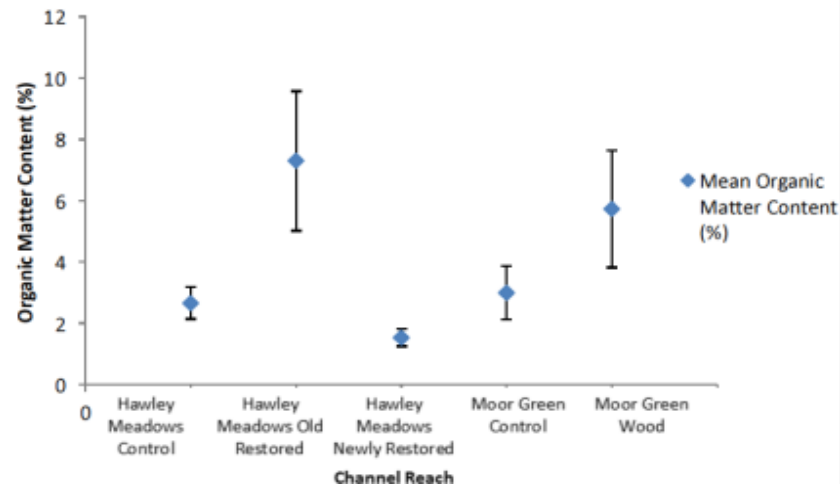
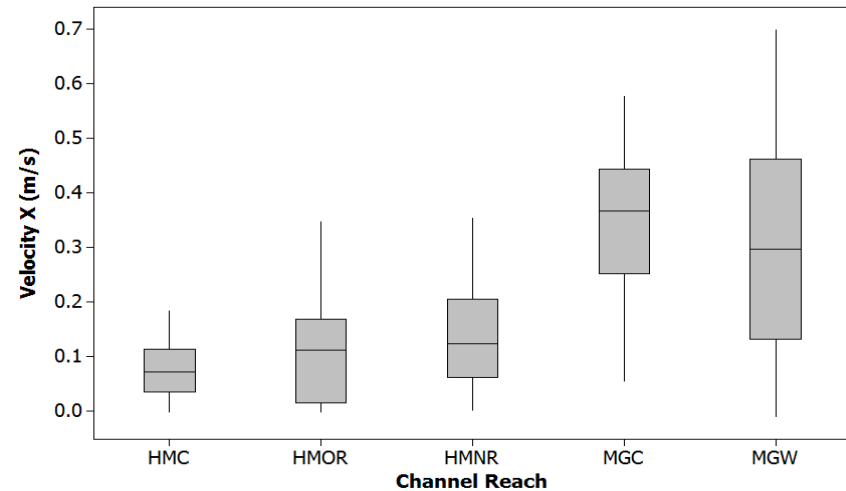
Length Vs Diameter



Results

Hydromorphology

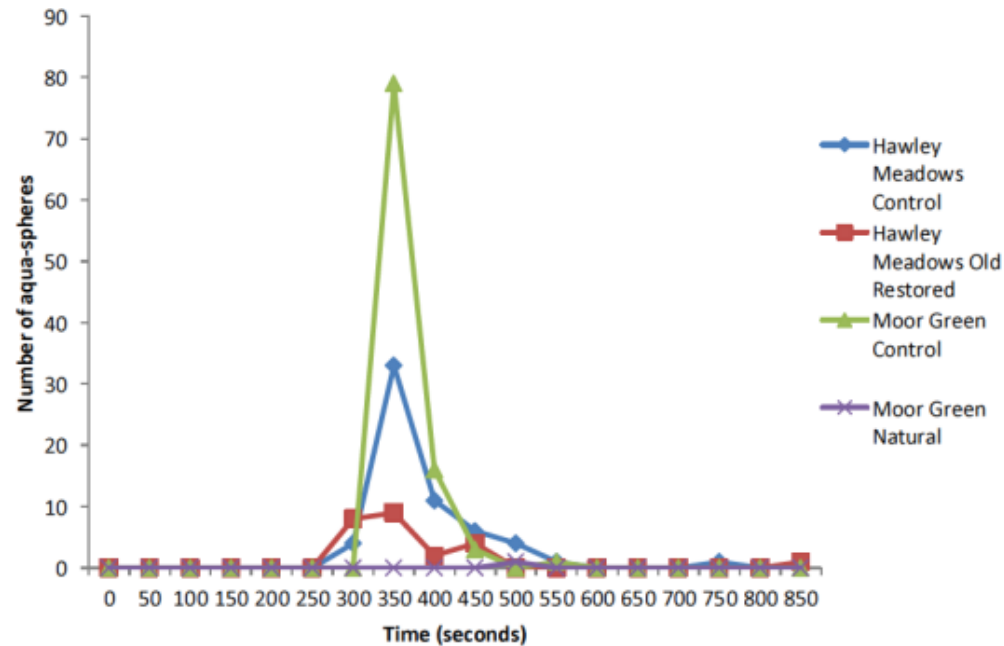
- Much lower hydraulic and substrate diversity in restored channels compared to natural channel.
- Morphological features (scour pools and gravel bars) at Moor Green were absent at Hawley Meadows.
- Hawley Meadows restored reaches – higher range of velocities and lower substrate depths than control.
- At Hawley Meadows, greatest flow diversity at HMNR associated with LWD of higher orientations and larger dimensions.
- Organic matter content highest at HMOR, followed by the natural wood reach.
- Substrate characteristics at HMNR similar to the control.



Results

Hydraulic Retention

- Greater hydraulic retention in the natural wood channel compared to the restored reach.
- Improvement was evident between HM old restored and the HM control.
- The alteration of flow dynamics in LWD channels promoted flow tracer retention within marginal, low-flow areas.
- Effective flow conveyance reduced retention in the control reaches.



Conceptual Diagram

Conceptual model formed initial research hypothesis.

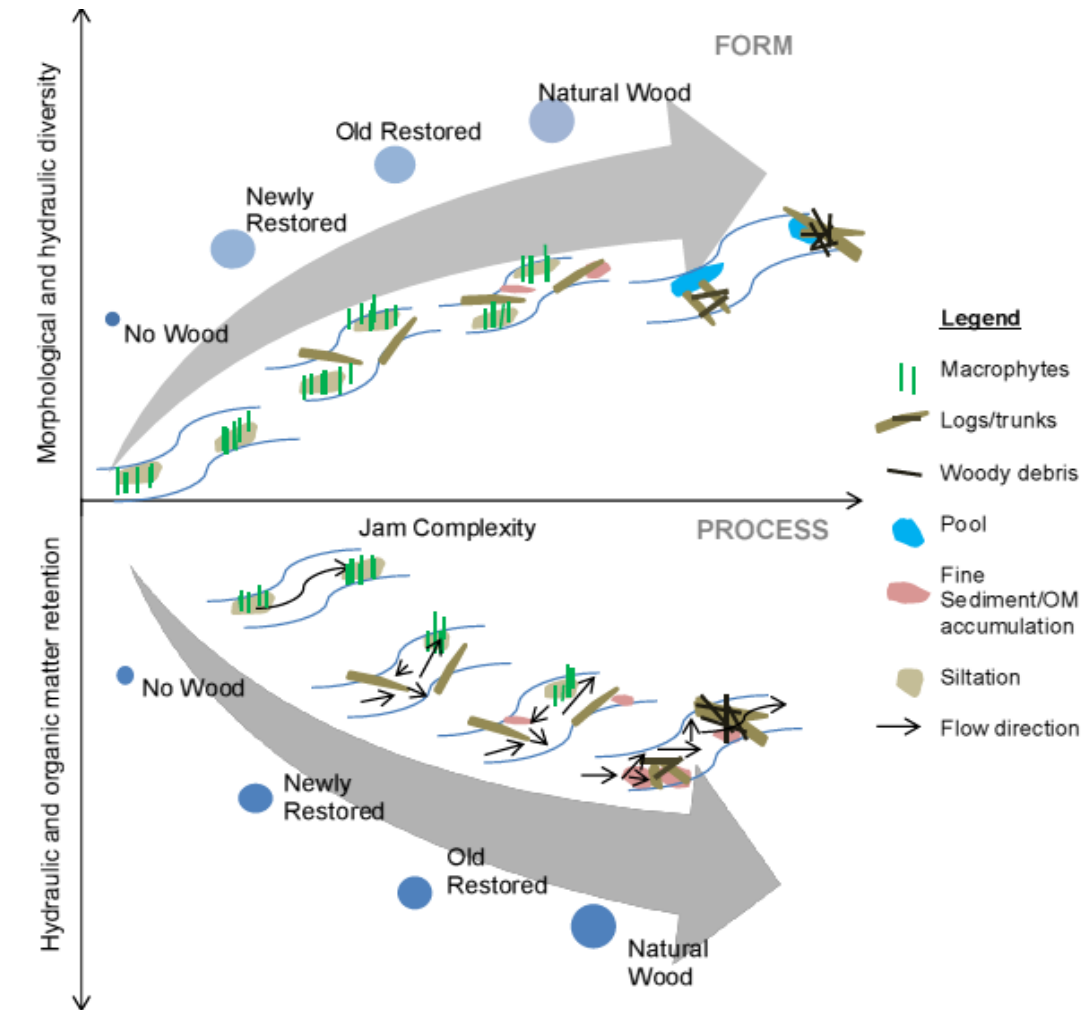
Improvement of flow and sediment diversity in a succession from no wood, to restored, to natural.

Minimal hydraulic roughness in non-woody channels.

Restored LWD will aid hydraulic diversity but simplicity of wood likely to impede large changes to channel form and process.

Complexity of flow and morphology highest in natural wood channel.

Research largely confirmed this hypothesis.



Research Summary

Form

No Wood

Uniform channel form.
Variety of substrate calibre and depth, initiated by siltation within emergent macrophyte beds.

Newly Restored (after 3 months)

LWD positioned at a variety of orientations.
Flow deflection.
Increased hydraulic diversity at the mesoscale and microscale.
Initial bed scour.

Old Restored (after 5 years)

Subdued hydraulic conditions, with only localised accelerations of flow diversity.
Scour and bar deposition increasing gravel exposure.

Natural

Large, complex jam structures with >3 pieces incorporated.
High morphological and hydraulic diversity.

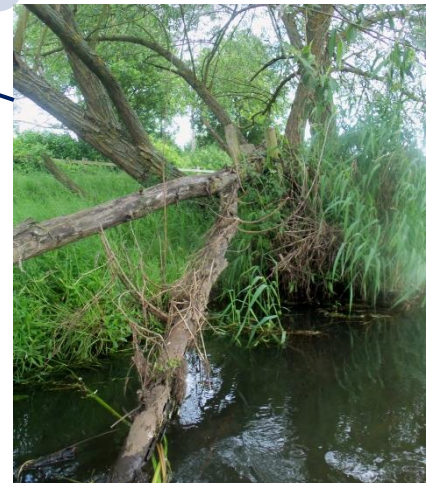
Process

Low OM retention.
Limited flow retention except in areas of emergent macrophytes.

No apparent OM retention.

Extensive organic matter retention and improved hydraulic retention.
Development of a dynamic equilibrium.

High hydraulic retention and organic matter storage.



Conclusions and Management Recommendations

- Evidence largely supports the hypothesis; improvements in channel form and process linked to increasing jam complexity.
- Enhancements of restored channels were significant.
- Wood restorations have potential to contribute to achieving Good Ecological Potential within heavily modified channels, helping to achieve the aims of the WFD.
- Hydraulic and organic matter retention were evident at HMOR, indicating a dynamic equilibrium between the flow and sediment regime.
- Recent restorations (March 2012) show a hydraulic response yet a delayed substrate adjustment.
- Channel coverage and orientation of wood are the most significant LWD properties influencing hydromorphological change.
- Case-specific approach required in order to balance environmental gains and socio-economic risk.
- Post-project appraisal and monitoring required.

References

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