Controls on upland channel morphology within the River Dee drainage basin

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1. INTRODUCTION

- Scottish rivers exhibit some of the greatest diversity of form and process within the UK reflecting the wide range of physical controls that exist between and within different catchments (Werrity and McEwen 1997). The geology, glacial history, hydrology and to a certain extent the land use of a catchment represent key controls on fluvial processes and form. In Scottish upland catchments the legacy of Pleistocene glacial erosion and deposition in particular, forms an important long term geomorphic control on valley bottom gradient, valley confinement and boundary sediment character. Combined with the hydrological control of stream power, these factors influence the ratio of sediment supply to transport capacity within a river in a way that creates morphologically distinct channel reach types, often at relatively fine spatial scales. Whilst the importance of these controls on channel morphology is well known within the context of Scotland, a comprehensive understanding of such landscape controls and their affect on channel morphology is lacking.
- Channel reach morphology is a major influence on the availability and quality of sedimentary habitat for spawning Atlantic salmon (Salmo salar). This is a critical stage in the salmon life cycle that recruitment to populations depends upon. Thus improvement in the understanding of landscape and reach scale controls has potential application in improving the prediction of the distribution of potential salmon spawning sedimentary habitat in river systems, which could in turn aid fisheries management.

2. OBJECTIVES

- To investigate channel reach distribution in a variety of upland catchments that exhibit different landscape evolution histories within the Dee drainage basin (2300km²), an important Atlantic salmon river in north-east Scotland (Figures 1 & 2).
- To identify and understand the hierarchy of landscape controls acting on channel reach morphology at three different scales: catchment, valley segment and reach.
- To characterize in detail reach scale sedimentary and hydraulic controls on channel reach morphology in particular of alluvial reach types that are associated with salmon spawning habitat.
- To ultimately produce a model that characterizes the range of these different controls to aid predication of the character and distribution of channel reach morphology.

Figure 1: The upper River Dee in the Cairngorm Mountains

3. STUDY AREA

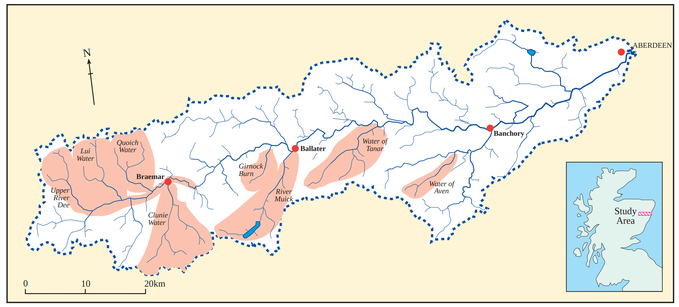

Figure 2: The Dee catchment and highlighted areas of study

	Upper Dee	Lui	Quoich	Clunie	Muick	Girnock	Tanar	Aven
Area (km²)	58	64	61	105	110	31	96	30
Relief (m)	900	892	877	742	955	629	814	684
Mean Channel slope (m/m)	0.014	0.021	0.029	0.019	0.020	0.018	0.023	0.037

Table 1: Study areas

4. METHODOLOGY

- 8 upland catchments were investigated in the Dee catchment including the upper River Dee mainstem (Table 1).
- Distribution of channel reach morphology, large woody debris and hillslope sediment sources were mapped using a GPS.
- Channel morphology classified using an expanded version of a process based classification scheme devised by Montgomery and Buffington (1997) (Table 2).
- GIS used to produce channel reach morphology maps and facilitate valley topography analysis (valley gradient and width) using a combination of aerial photo and DTM analysis.

Reach group	Bedrock	Mixed bedrock /alluvial	Transport alluvial	Response alluvial
Reach types	Bedrock	Bedrock/cascade Bedrock/step pool Bedrock/plane bed	Cascade Step pool Plane bed	Pool riffle Dune ripple Wandering Braided
Examples	Bedrock 	Bedrock/step pool 	Cascade 	Pool riffle 

Table 2: Representation of channel reach classes and associated physical controls

Increasing sediment supply and sensitivity

Increasing transport capacity, channel slope and confinement

5. RESULTS

- Longitudinal, valley width and stream power profiles differ notably between catchments primarily reflecting different glacial denudation histories which form an important control on channel reach group distribution differences between catchments (Figures 3 & 4).
- Within individual catchments, distribution of channel morphology is spatially variable reflecting the variability of valley topography which in turn affects the sediment transport and sediment supply regimes (Figure 5).
- Particular reach groups are generally associated with discrete ranges of mean valley width and slope (Figure 6).

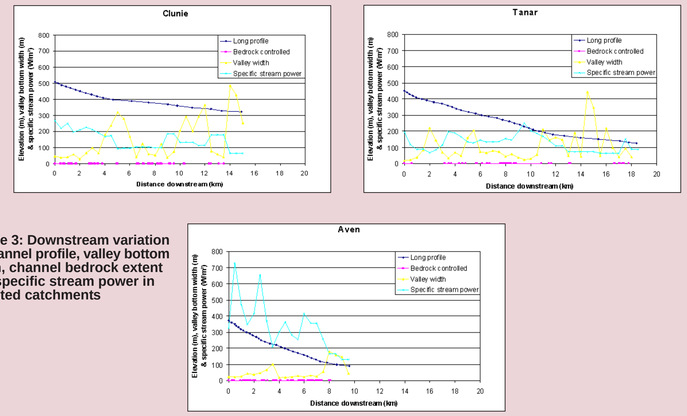

Figure 3: Downstream variation in channel profile, valley bottom width, channel bedrock extent and specific stream power in selected catchments

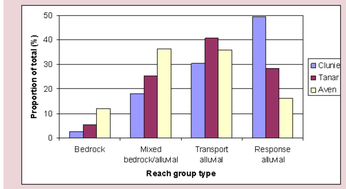

Figure 4: Channel reach group distributions in selected study catchments

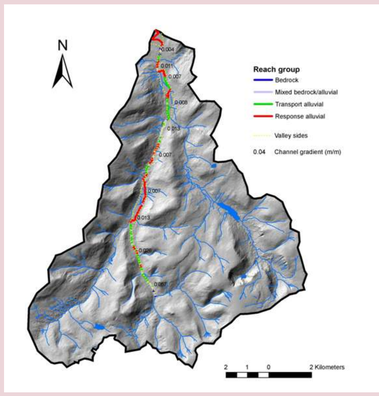

Figure 5: Reach group type distribution and valley topography of the Clunie Water

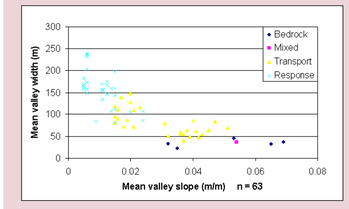

Figure 6: Reach group type and valley topography relationships

6. CONCLUSIONS

- Geomorphic surveys reveal the high spatial variability of channel reach morphology within the catchments studied is significantly related to a suite of valley and local scale landscape controls.
- Differences in the concentration of channel reach morphology between different catchments occur due to different spatial patterns of such intra- catchment controls.
- Downstream channel succession at the catchment scale is not evident reflecting the variable nature of intra catchment valley topography.
- Broadly speaking, a spectrum of catchment types exists ranging from those dominated by stable bedrock and transport reach types to those dominated by dynamic response reach types.

7. FURTHER WORK

- Continuation of GIS based analysis of catchment and valley segment scale controls on channel reach morphology distribution for other catchments.
- Analysis of finer, reach scale sedimentary and hydraulic controls on various channel reach morphologies within different catchments and valley settings.

References:

(1) Montgomery, D.R. and Buffington, J.M. (1997) Channel reach morphology in mountain drainage basins. *Geological Society of America Bulletin.* 109, 596-611

(2) Werrity, A. and McEwen, L.J. (1997) Fluvial landforms and processes in Scotland. In *Fluvial Geomorphology of Great Britain.* (K.J. Gregory ed.) Chapman and Hall pp. 21-32

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