Hierarchical controls on river channel morphology in montane drainage basins in the Cairngorms, Scotland

Authors: **Addy, S.J., Hartley, A.J and Soulsby, C.**

E-mail: **s.j.addy@abdn.ac.uk**

Homepage: http://www.ac.uk/geography/hydrology

NORTHERN RIVERS INSTITUTE
School of Geosciences
University of Aberdeen
Aberdeen
AB24 3UF

1. INTRODUCTION

Scottish upland rivers exhibit some of the greatest diversity of process and form in the UK reflecting the diversity of landscape evolution history, climate and landuse (Werritty and McEwen; 1997). However, the relationships between key landscape controls and channel morphology, although widely recognized, are not fully understood in a Scottish context. This study aims to identify and quantify the range of geomorphic, geological and landuse controls on channel morphology within the River Dee drainage basin (2300 km^2), north-east Scotland. Nine semi-natural upland sub catchments were selected for investigation. Controls on channel morphology are considered at three different spatial scales: catchment, valley segment and reach. Understanding of these controls will form the basis for creating a region specific model that can potentially predict channel morphology using remote means. In addition, this has implications for understanding the physical template that governs riverine ecosystems and predicting the character and distribution of particular habitats (e.g. salmon spawning habitat).

2. OBJECTIVES

- To investigate channel reach distribution in a variety of upland catchments that exhibit different landscape evolution histories within the Dee drainage basin (2300km^2), an important Atlantic salmon river in north-east Scotland (Figures 1 & 2).
- To identify and understand the hierarchy of landscape controls acting on channel morphology at three different scales: catchment, valley segment and reach.
- To characterize the morphology of a range of channel reach types in a variety of different landscape settings.
- To ultimately produce a GIS based model to aid predication of the character and distribution of upland channel morphology.

Figure 1: The upper River Dee in the Cairngorm Mountains

3. STUDY AREA

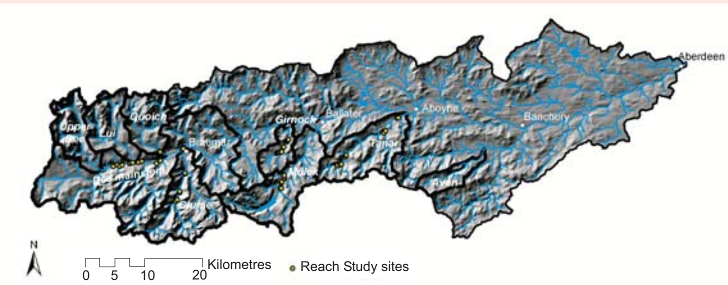


Figure 2: The Dee catchment and studied sub-catchments

Catchments	Upper Dee	Lui	Quoich	Clunie	Muick	Girnock	Tanar	Aven	Dee mainstem
Area (km²)	58.4	63.5	59.4	105.4	105.4	31	95.8	29.6	584.7
Stream order	5	5	5	5	5	3	5	4	6
Mean slope (°)	17.8	13.8	13.7	14.6	14.6	9.5	10.6	9.4	13.5
Mean elevation (m)	798.1	693.4	720.1	668.2	668.2	406	449	429.1	653.1
Drainage density (km/km²)	3.17	1.8	1.78	1.66	1.66	1.24	1.36	1.49	1.8

Table 1: Studied sub-catchments

4. METHODOLOGY

- 8 upland tributaries were investigated in the Dee catchment in addition to a section of the upper River Dee mainstem (Table 1).
- Channel morphology mapped using an expanded version of a process based classification scheme devised by Montgomery and Buffington (1997).
- The morphology of 51 reaches in a variety of catchments and valley settings were investigated in detail. Channel slope, geometry and bed sediment attributes measured. In addition, GIS used to assess the influence of local valley controls.

5. RESULTS

- 18 reach types in total identified including those that are transitional in form between the main types identified by Montgomery and Buffington (1997) and mixed bedrock-alluvial morphologies. Similar reach types consequently amalgamated into 7 reach group classes for greater clarity. These classes are distinguishable but overlap is present (Table 2).
- Channel morphology distribution is to a degree scale related reflecting the gradual downstream shift of channel slope and valley width controls as stream order increases (Figures 3 & 4).
- Slope-area plot of 177 selected reaches reveals that channel morphology is organized within broadly defined process domains reflecting the importance of sediment supply and transport capacity controls on distribution (Figure 5).
- The discontinuous nature of longitudinal profiles and distribution of local controls strongly influence channel morphology distribution within catchments. This mainly reflects the glacial history which influences valley topography and the distribution of channel parent material. (Figures 6 & 7).

Characteristics	Colluvial (C)	Bedrock (B)	Mixed (M)	Transport alluvial high slope (TH)	Transport alluvial low slope (TL)	Response alluvial (R)	Wandering/ braided alluvial (W)
Slope (m m^{-1})	0.062 - 0.198	0.041 - 0.093	0.047 - 0.116	0.031 - 0.077	0.014 - 0.029	0.0059 - 0.009	0.013 - 0.024
Confinement	ca. 1	ca. 1	ca. 1	1 - 4	5 - 8	6 - 13	9 - 14
D50 (mm)	na	na	82 - 106	95 - 136	91 - 109	53 - 79	59 - 72
Typical drift cover	Regoltih/peat	Glacigenic/bedrock	Glacigenic/bedrock	Glacigenic/mixed	Mixed/alluvium	Alluvium/mixed	Alluvium/mixed

Table 2: Characteristics of channel morphology based on field and GIS investigations

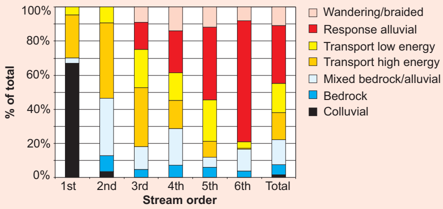
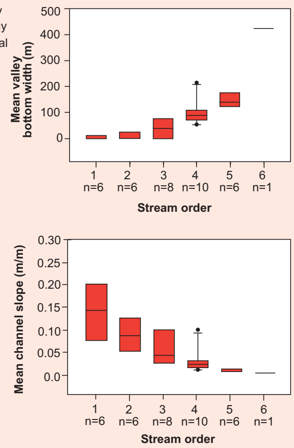


Figure 3: Reach group classes ordered by stream (Strahler)



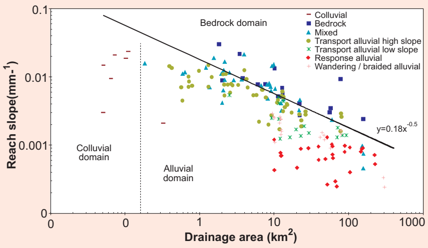


Figure 5: Slope-area plot of 177 reaches selected across the study area

Figure 4: Mean channel slope and valley bottom width by stream order

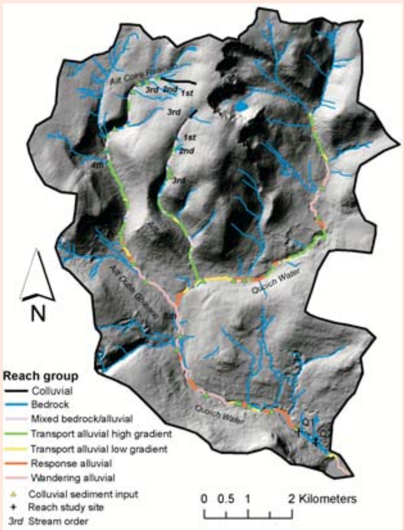


Figure 6: The distribution of channel morphology in the Quoich catchment

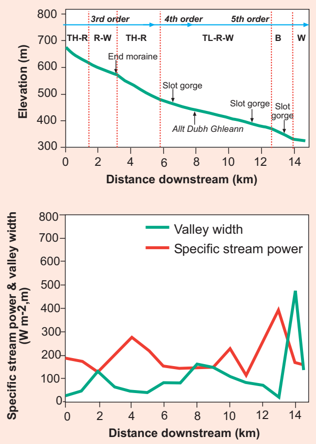


Figure 7: Longitudinal charachteristics of the Quoich Water mainstem

6. CONCLUSIONS

- A large number of channel reach types are identified across the study area. Amalgamation of similar types reveals that the distribution of alluvial channel types is broadly scale related. However the detailed distribution of channel morphology needs to be considered at smaller scales.
- The spatial distribution of channel reach morphology within the sub-catchments studied is highly variable reflecting the influence of a suite of valley and local scale landscape controls that are primarily related to the glacial history.

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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