Implementation and monitoring of natural flood management in Scottish upland catchments.

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Introduction

- Land-use practices combined with extreme weather events have been linked to greater flood risk and associated problems (e.g. property damage, deposition and erosion) in upland areas.
- Natural flood management (NFM) and novel catchment engineering approaches are being applied and tested to tackle these problems.
- NFM: *"techniques that aim to **work with natural hydrological** and **morphological processes**, features and characteristics to manage the sources and pathways of flood waters…"* SAIFF, 2011).

Logie Burn, December 2012 flood

River Dee, April 2001 snowmelt event (courtesy of John Addy)

NFM in Scotland: the context

- Flood Risk Act (Scotland) 2009 is the main policy driver for NFM implementation where appropriate.

- Under Sections 19 and 20 of the act, types and locations of existing and potential NFM features have been identified at a national scale and publicised through SEPA (http://www.sepa.org.uk/flooding.aspx).

- Empirical research of NFM effectiveness and the practicalities of implementing it is needed to support policy objectives.

James Hutton NFM research aims

Funded by the Scottish Government to deliver over the course of 5 years (2011 to 2016):

1. pre- and post-intervention empirical data - to illustrate the impact of NFM measures on, hydrology, water quality and ecology.

2. a range of demonstration sites to illustrate techniques, opportunities and constraints of NFM at the catchment scale.

3. an assessment of the socio-economic barriers to NFM implementation concentrating on organisations involved with its implementation.

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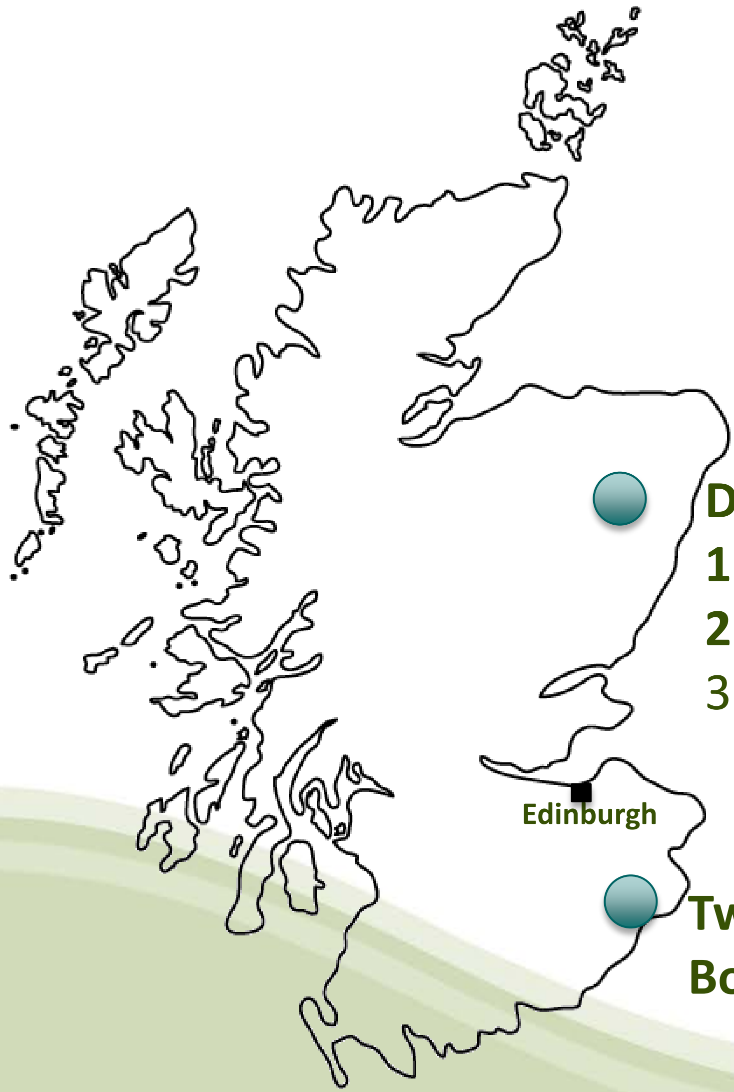


Dee catchment, Aberdeenshire:

1. **Logie Burn**
2. **River Dee at Mar Lodge**
3. Tarland Burn

Tweed catchment, Scottish Borders: Bowmont Water

Bowmont Water

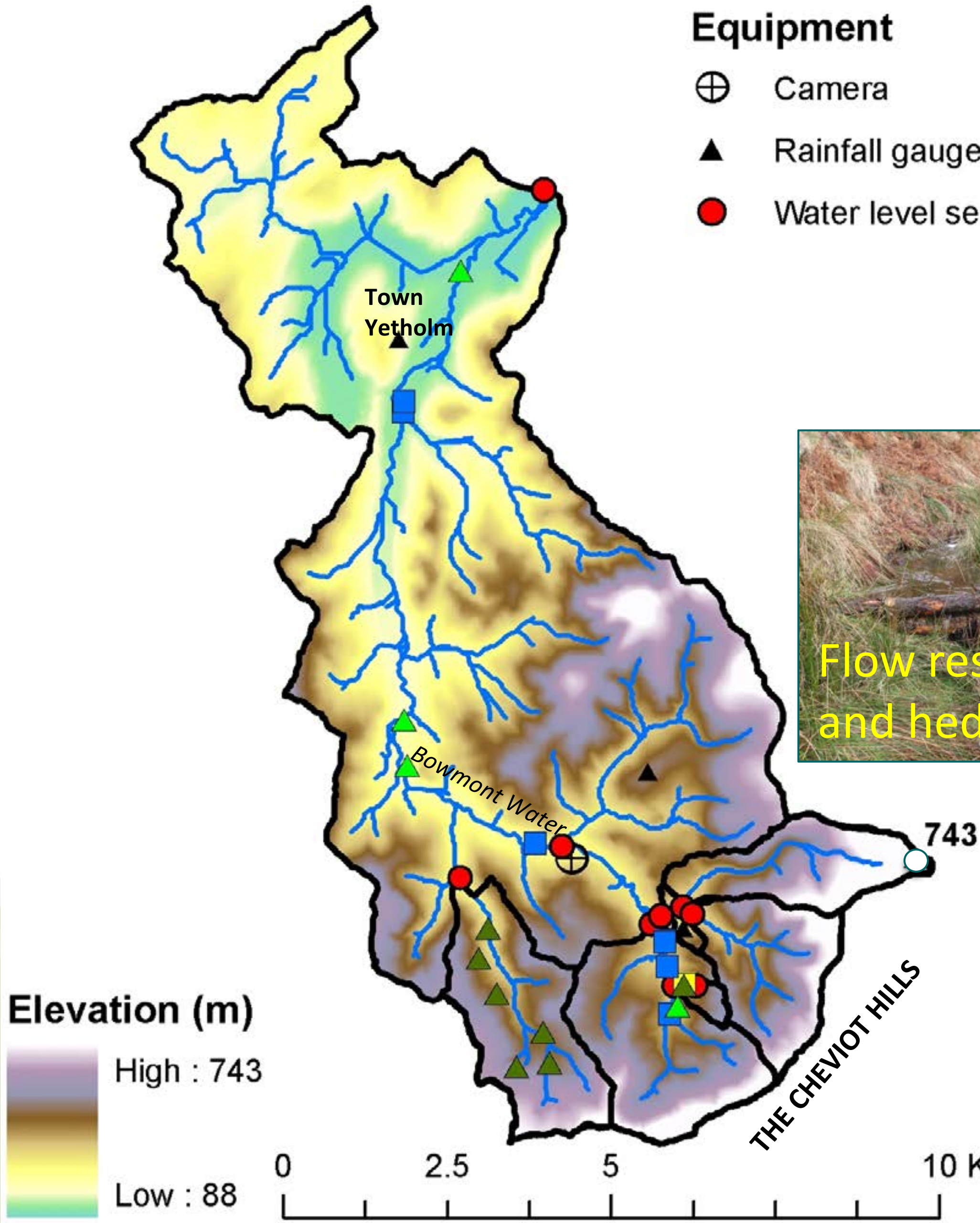
- Steep, responsive upland catchment (87 km^2), dominated by sheep grazing and very active channel geomorphology.
- Flooding in Sept 2008 (1 in 200 year) and July 2009 caused huge damage and disruption.
- Since early 2012, implementation and monitoring (geomorphology and hydrology) of NFM measures.


Post July 2009 flood, Bowmont Water (courtesy of Gordon Common)


Post Sept 2012 flood

Middle Bowmont Water (53 km^2)

Bowmont NFM measures and monitoring



Wooden structures

- Wood incorporation is potentially a way of reinstating natural geomorphic processes and delivering flood management benefit.
- A lack of evidence and guidance in a UK context.
- Six types of wooden structure trialled: three types to protect banks, one type to control channel grade, one type to trap sediment and one to restrict flows.

Bank protection

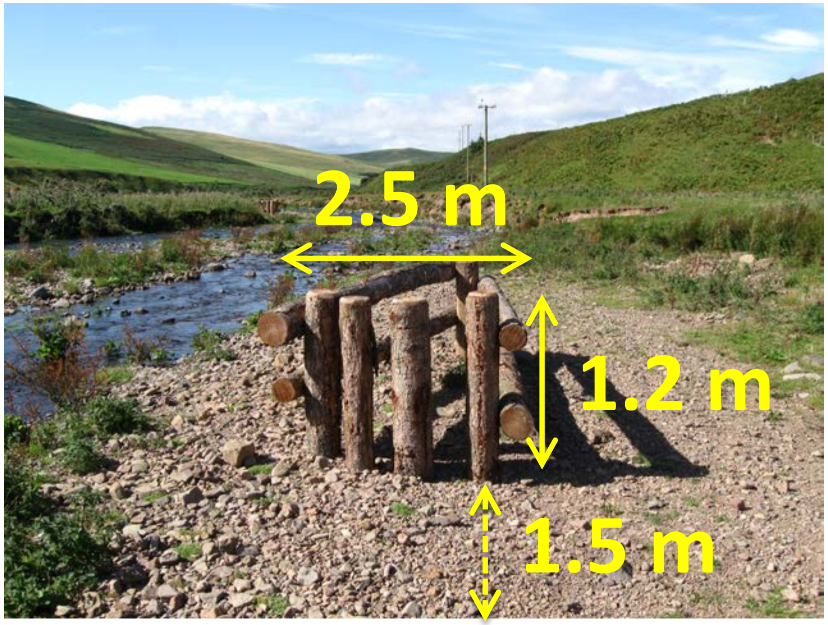
Grade control

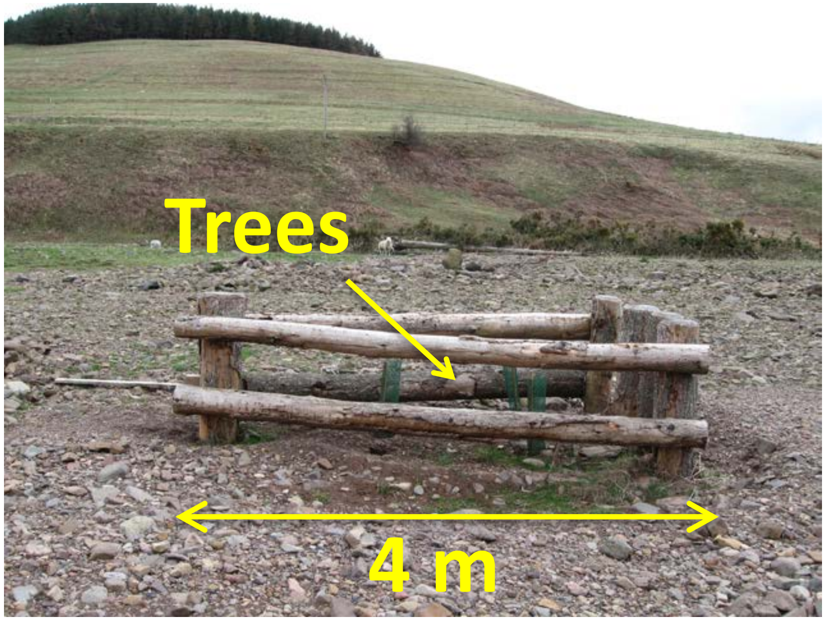
'Bar apex' sediment trap

Bar apex structures: key questions

1. Do the responses match expectations? I.e. do they capture sediment and make a difference to conveyance capacity downstream?
2. Do the structures last and how long do they hold on to the sediment and debris?
3. Do they have other benefits e.g. for gravel bar habitats and attenuating flows?
4. How could their placement and design be improved?

Bowmont: bar apex engineered 'log jam' (ELJ) structure





- Designed to mimic the effects of naturally occurring log jams and trap sediment; a lack of research into their effectiveness.

- 45 built in July 2012 across different catchment scales: 4 km^2, 28 km^2 and 64 km^2.

Structure survival (Aug 2012 – Jan 2014)

Total intact: 34

Total damaged: 6

Total destroyed: 5

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Bar apex deposition effects (Aug 2012 – Jan 2014

Total no deposition: 15

Total minor deposition: 25

Total major deposition: 5

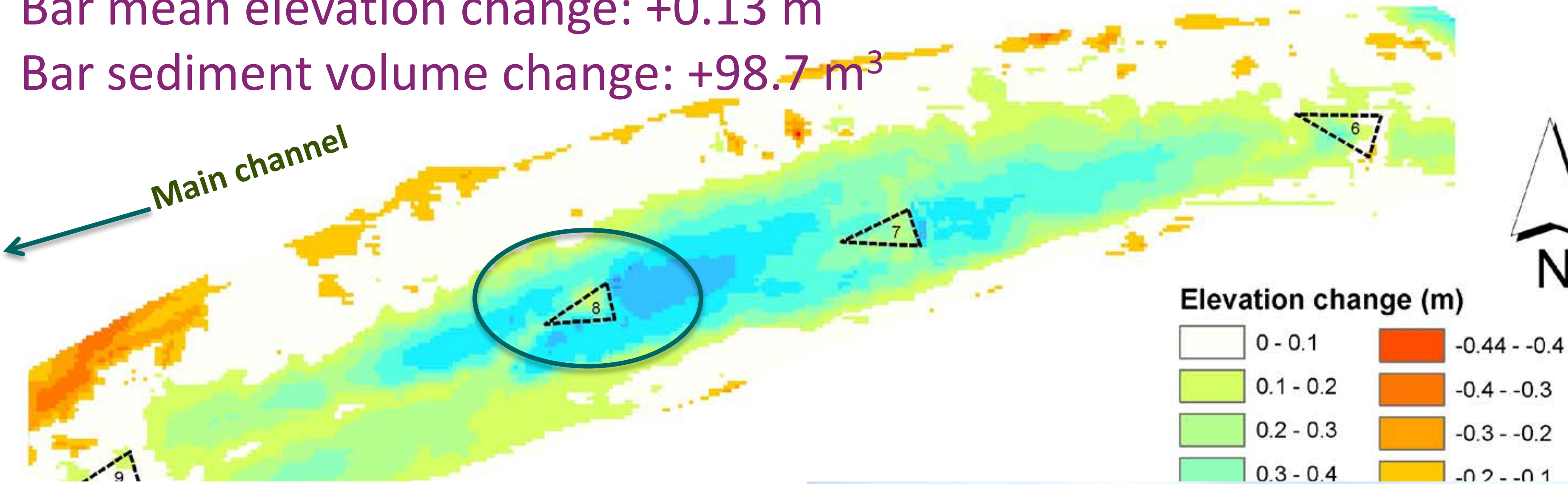
Swindon Haugh reach (28 km^2)

- Jul 2009 - Oct 2012: mean 0.25 m of aggradation (max 0.56 m)
- 2007 – 2013: up to ~20 m of active channel widening

Effectiveness of ELJs – Bar 2

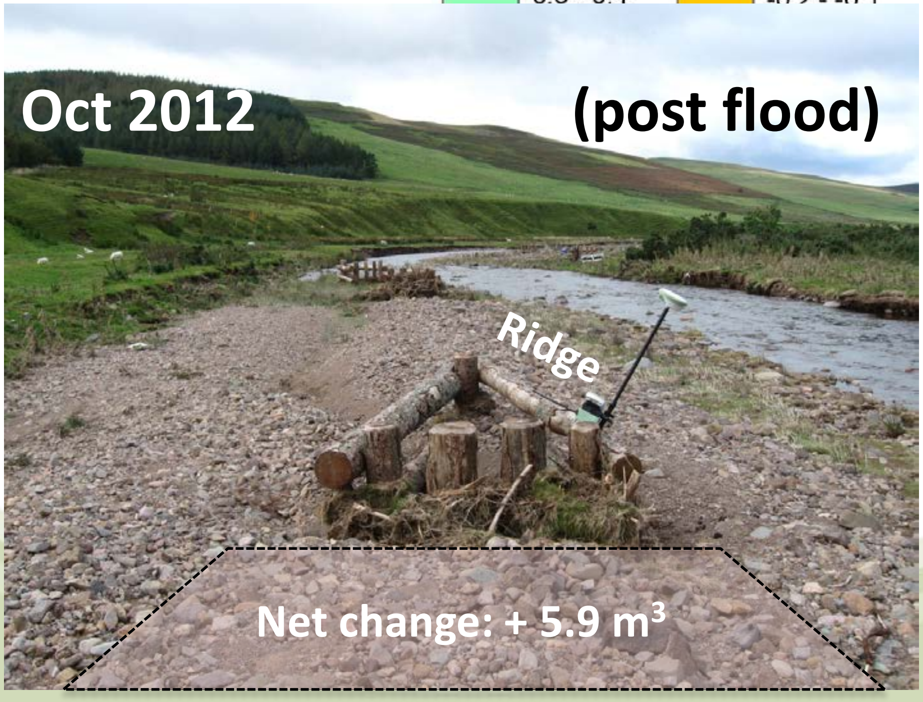
Bar mean elevation change: +0.13 m

Bar sediment volume change: +98.7 m^3

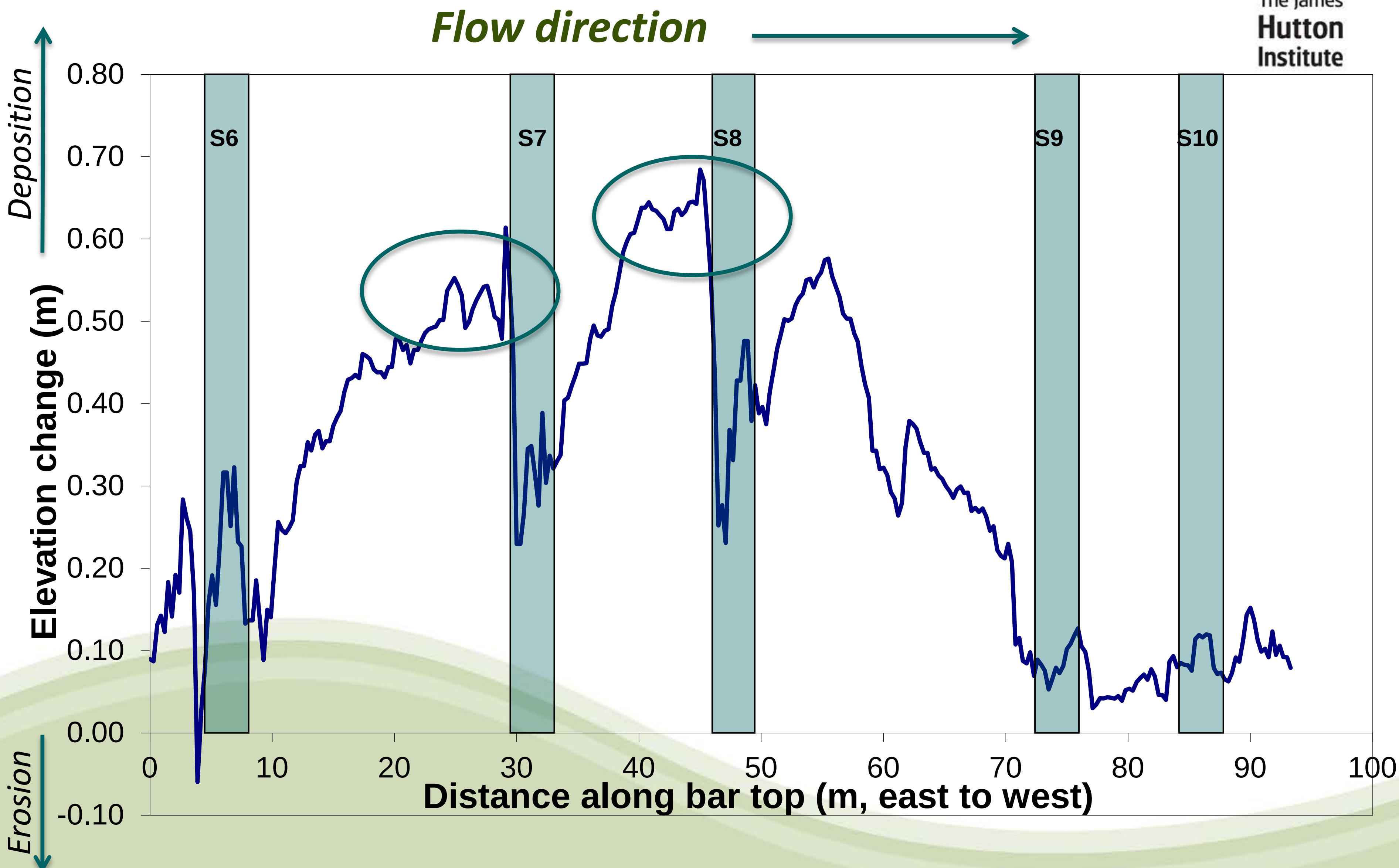


Aug 2012

Oct 2012 (post flood)



Bar 2 geomorphic responses



Swindon Haugh time lapse camera

Logie Burn project

- Poor ecological status and account for ~30% of the lowland channel network in Scotland
- A lack of evidence to confirm the potential benefits of reversing physical habitat degradation in such systems – needed to underpin effective river restoration
- Logie Burn restoration project is an example of re-meandering to deliver multiple benefits

Pre-intervention (April 2011)

Pre-intervention (June 2011)

Logie Burn monitoring (July 2011 – onwards)

Objectives

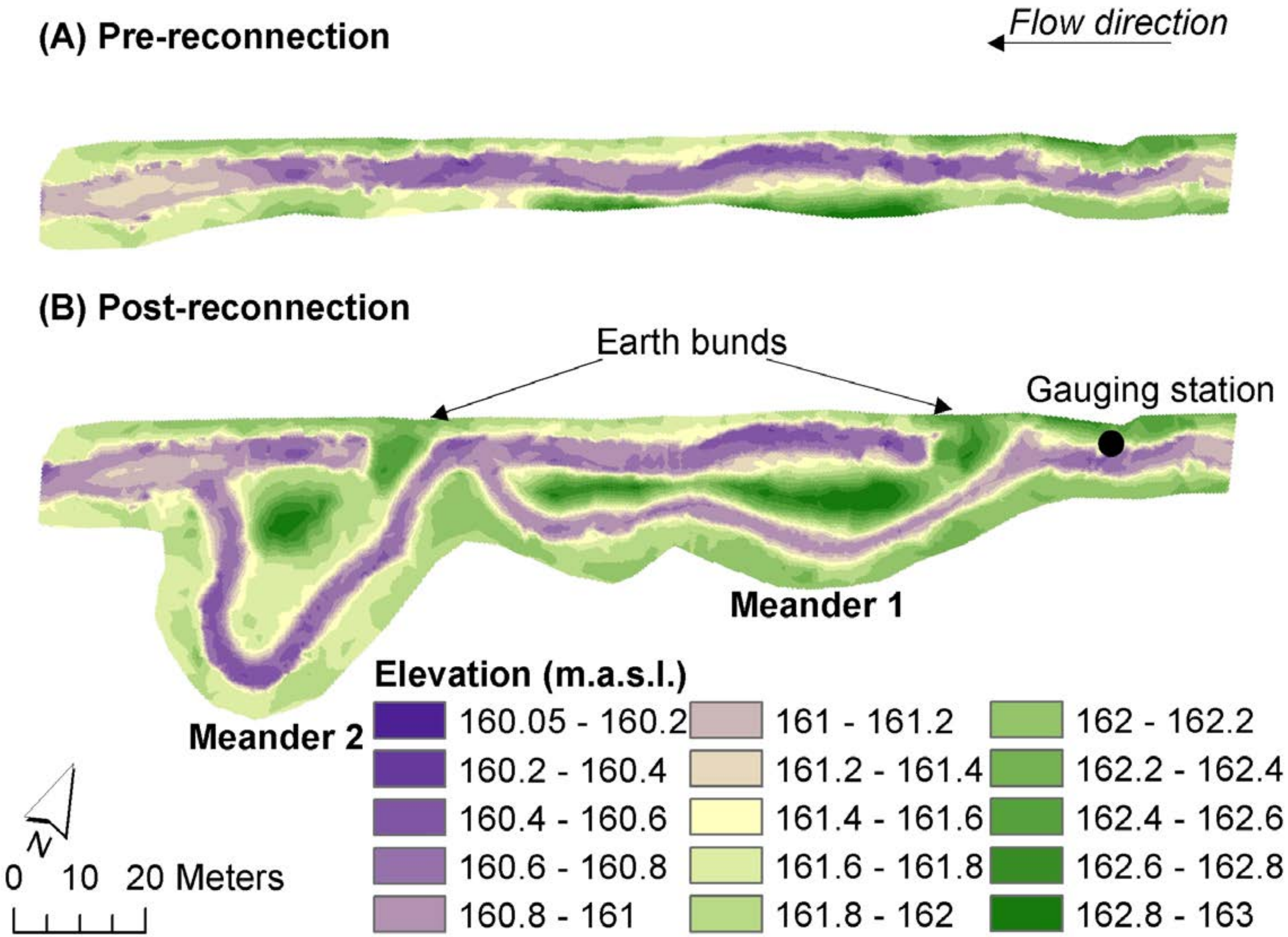
- Restoration project objectives:

1. To restore channel morphology, improve river habitat and to enhance riparian habitat diversity
2. To reduce fine sediment and nutrient (particularly phosphorous) transfer into Loch Davan by enhancing channel sediment deposition
3. To demonstrate this type of restoration more widely

- Research objectives:

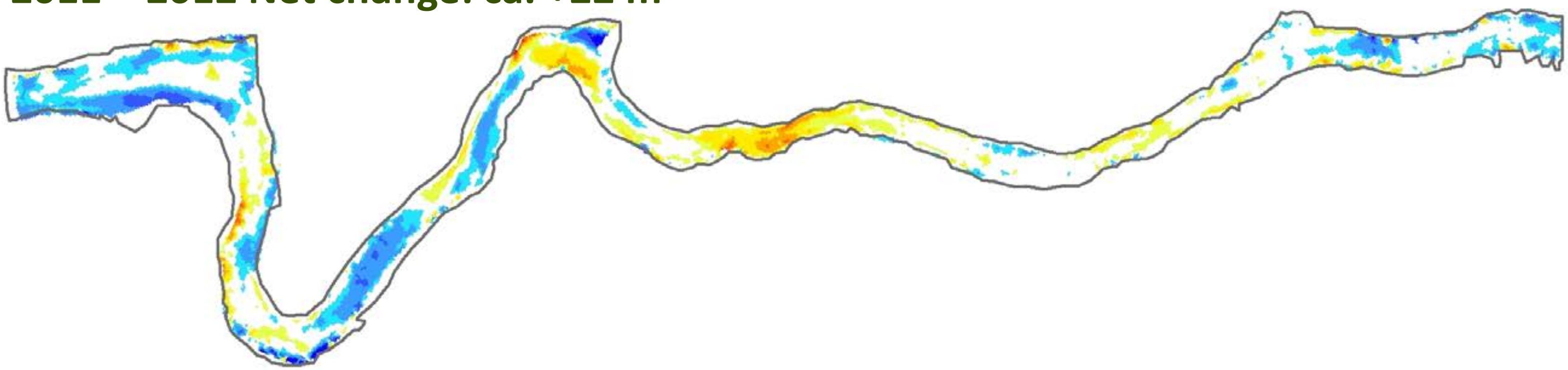
1. To assess the types and rates of channel morphological adjustment and the implications for habitat provision for lampreys and salmonids
2. To assess the ability of the reach to attenuate and delay peak flows and store phosphorous (P)

Treatment reach morphology (2011)

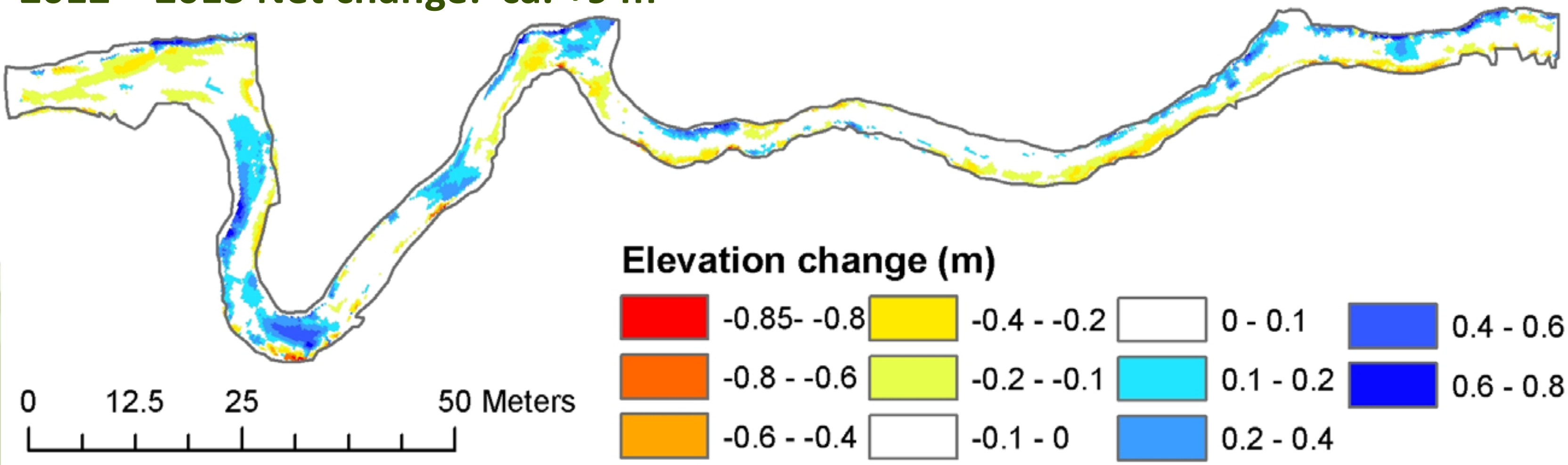


Topographical change

2011 – 2012 Net change: ca. +22 m^3

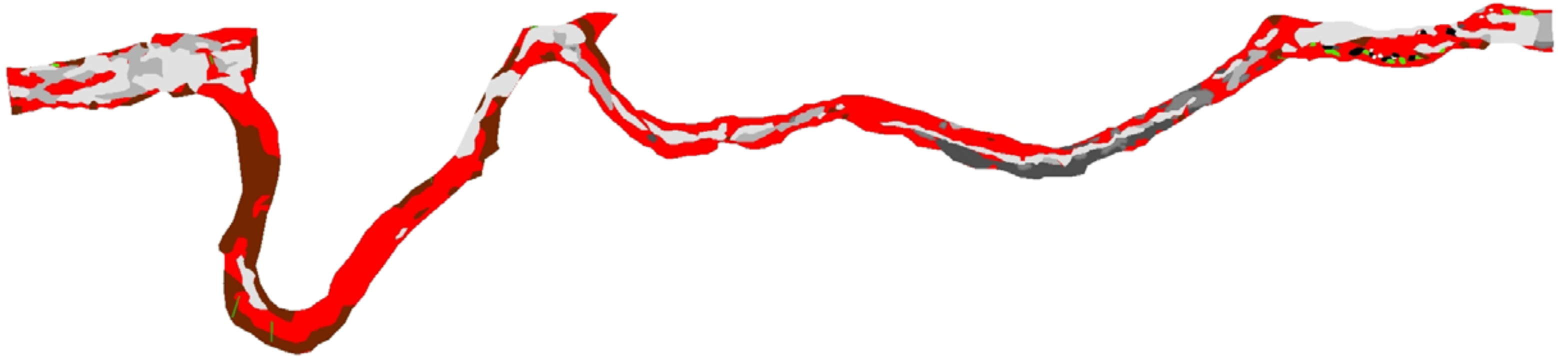


2012 – 2013 Net change: ca. +9 m^3

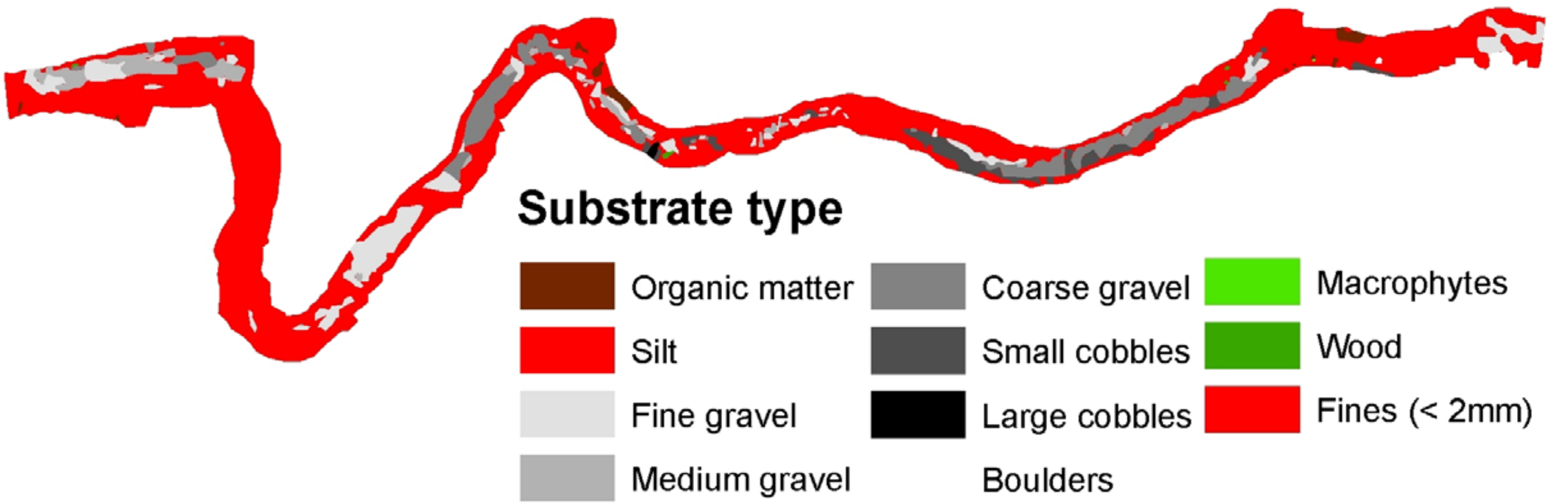


Substrate change

2011 – fines: 47% of area, Shannon-Wiener diversity index: 1.46



2013 – fines: 74% of area, Shannon-Wiener diversity index: 0.97



Re-meandering = flood risk mitigation and other multiple benefits?

- Changes of channel morphology and flow resistance charted will have implications for water conveyance capacity.
- Difficult to assess these effects directly because of woody debris input.


- Analysis of sediment size, P concentrations and morphology is ongoing

River Dee floodplain reconnection

- Floodplain restoration site on a large mainstem river (~50 m wide) involving 3 breaches of a flood levee at a catchment scale of 367 Km^2.
- Monitoring pre- and post reconnection water storage and geomorphic responses. Started in June 2013. Levee breaching planned for summer 2015.

Mar Lodge

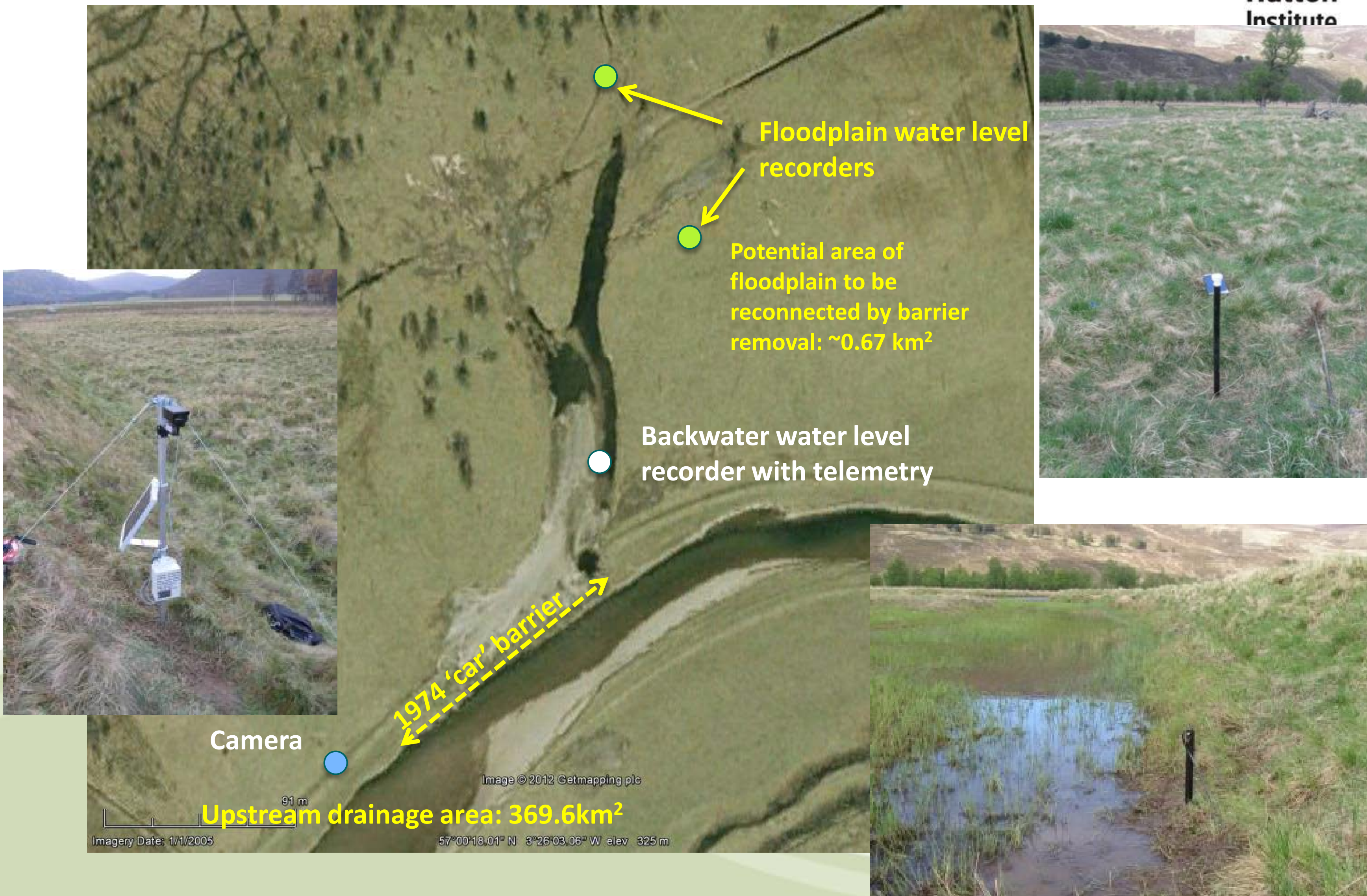
- Aims of monitoring:

1.How does floodplain water storage and connectivity change following embankment removal?

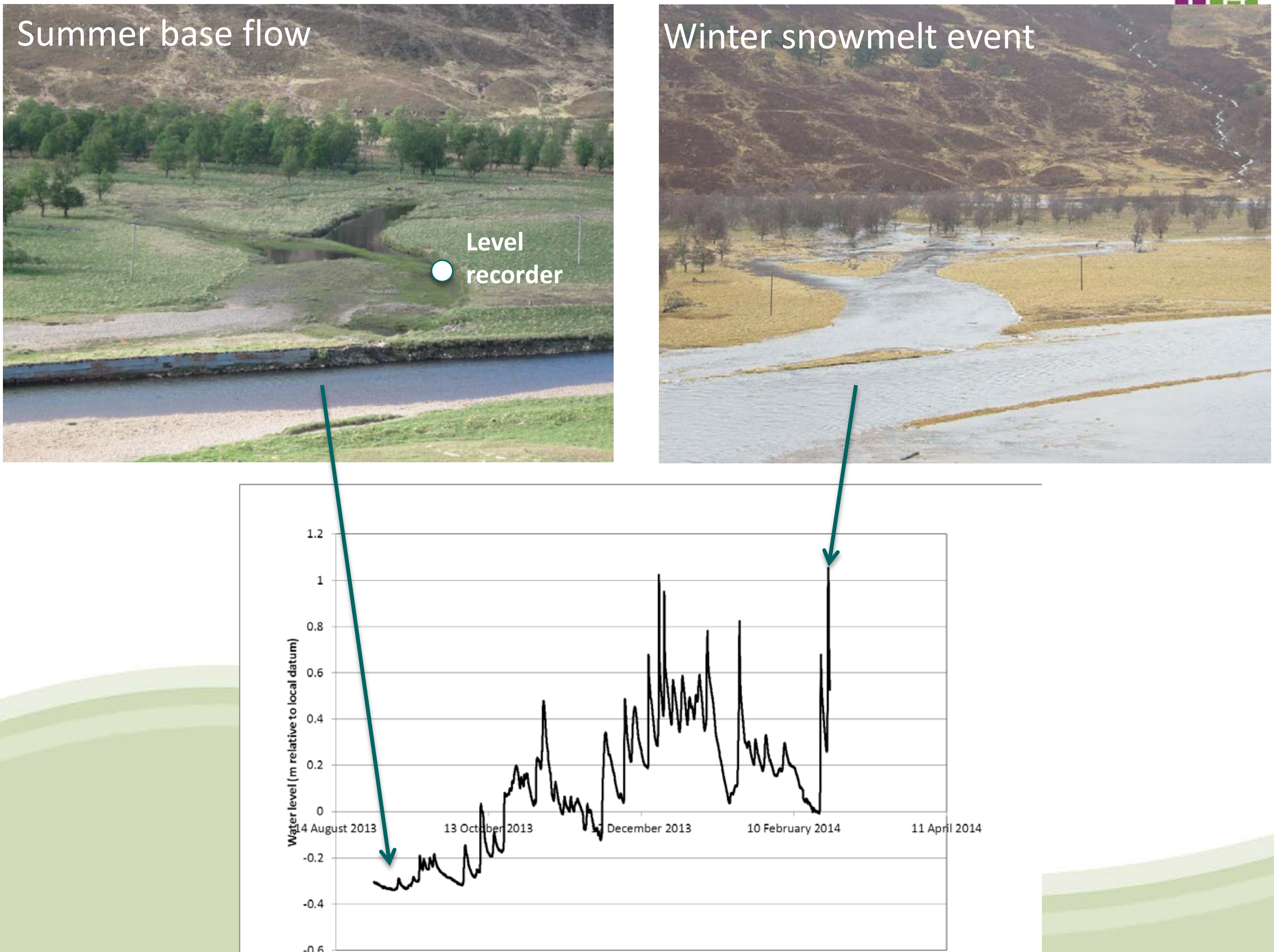
2. How does the morphology change and what are the implications of this for water movement (and habitats)?

3. Does the reconnection attenuate flows downstream in the mainstem?

Dee: Assessment of pre-intervention floodplain water storage dynamics



Backwater water level record



Summary

- A need for long term and empirically based monitoring to capture the multiple benefits of the full suite of NFM measures in different environments.
- Initially, we need to understand effectiveness at the local scale then use data informed modelling to predict catchment scale effects.

  Challenges

- Implementation of NFM features and evidence gathering take time. Science has not yet fully delivered as a result.
- Socio-economic barriers can hamper implementation of measures and in turn delay and alter monitoring programs.
- Uncertainty and difficulty of monitoring in dynamic catchments - potential for new approaches (e.g. use of time-lapse cameras).

Acknowledgements

SEPA, EA, Cheviot Futures, SNH, the Scottish Government, RRC, Tweed Forum, the Dee Catchment Partnership, the landowners and farmers at the study sites.

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More information

Researching barriers to NFM implementation:
http://www.hutton.ac.uk/research/projects/Exploringbarrierstonaturalfloodmanagement

Bowmont Water monitoring project:
HTTP://BOWMONT.HUTTON.AC.UK

Logie Burn RESTORE case study:
http://riverwiki.restorerivers.eu/wiki/index.php?title=Case_study%3ALogie_Burn_Restoration_Project