## Future Project Outcomes

By January 2014, the current phase of the research project will have collected over a year's worth of monitoring data. The data collected will be used to:

- Quantify the water retention capacity of Culm grassland in relation to that of other land uses and land covers (wet woodland, invasive scrub and intensively managed grassland).
- At Stowford Moor, quantify the rate and volume of water leaving the catchment via stream discharge in relation to rainfall characteristics.
- Undertake further analysis to scale-up findings across the Culm NCA to determine the potential capacity for water retention by Culm grassland at a catchment scale.
- Highlight the role played by Culm grassland, notably in relation to water retention, which can inform future management practices by landowners and stakeholders, including flood alleviation and the payment for ecosystem services.

Culm grassland at Halsdon © Alan Puttock

This project has been supported by the Environment Agency, the Higher Education Innovation Fund and the Northern Devon Nature Improvement Area programme,supported by Defra, DCLG, Environment Agency, Forestry Commission and Natural England

Further Information

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# UNDERSTANDING THE HYDROLOGY OF CULM GRASSLANDS

Purple moor grass © Steve Day

**Key Ecosystem Service addressed:**

*Water Regulation*

**Additional Ecosystem Services:**

*Water quality*

*Carbon storage*

*Wildlife habitats*

*Green spaces*

**Service beneficiaries:**

*General public*

*UK Government*

*Water suppliers*

**Service Providers:**

*Landowners*

**Intermediates & knowledge providers:**

*Devon Wildlife Trust*

*University of Exeter*

*Natural England*

*Environment Agency*

Part of an ongoing research project led by the University of Exeter, the Environment Agency and the Devon Wildlife Trust, aimed at increasing understanding of the role played by Culm grasslands in the provision of key ecosystem services.

## Rationale for research

The sustainable management of water within the landscape, whether for maintaining the domestic and industrial water supply, or for limiting the damage of flooding is recognised as an ecosystem service of vital importance.

Flooding during the winter of 2012 is expected to cost insurers over £1 billion (Pricewaterhouse Coopers, 2012); leading to further increases in insurance premiums for the public. Moreover, the 2012 flooding was not a one-off occurrence; with the UK government currently spending approximately £800 million on flood and coastal defences each year (Department of Business Innovation and Skills). However, even with existing defences, damages averaging approximately £1.4 billion are incurred each year (Defra). The Environment Agency estimated widespread flooding in 2007 to have cost the economy a total of £3.2 billion. Recent years also saw prolonged periods of drought, with parts of the UK recording their lowest rainfall for 100 years during the winter of 2011/2012, whilst runoff for March 2012 was the lowest in a monitoring series stretching back to 1961 (Centre for Ecology and Hydrology). Whilst the exact cost of such droughts remains unclear, the lack of rainfall and associated limitations on water abstraction severely affected 2012 crop yields, with the National Farmers Union reporting a 14% reduction in wheat yields, resulting in a sharp rise in supermarket food prices.

Future climate change scenarios for the UK predict that the occurrence of extreme weather events will increase, resulting in more frequent extreme rainfall and longer periods of drought. Proposed strategies for managing water resources include increasing the retention of water within the landscape, thus reducing runoff and the subsequent risk of flooding, whilst maintaining flow in river networks, essential in times of drought. One such ecosystem, believed to have a high water storage capacity, is the Culm grasslands of North Devon and Cornwall.

Culm grassland at Stowford Moor © Alan Puttock

## Culm grasslands

Culm grassland (purple moor grass and rush pasture) is a habitat of international conservation importance. The Culm National Character Area (NCA) covers 3500 km$^2$ in South West England, with Devon supporting over 80% of the remaining Culm grassland found in England. Over the last 200 years, efforts to intensify agriculture have led to the drainage of large areas of land in South West England. Consequently, wet Culm grasslands have become highly fragmented, now covering only 1.4% of the Culm NCA, a 90% reduction since the 1950s. Traditionally, these Culm grasslands have been managed by light grazing and scrub management. Since 2008 Devon Wildlife Trust's Working Wetlands project has been working with landowners to manage, restore and recreate Culm. It is part of South West Water's Upstream Thinking initiative and is now augmented by the Northern Devon Nature Improvement Area programme. Intensive drainage of agricultural land increases the rate at which water leaves the landscape, reducing water storage and heightening the risk of flooding.

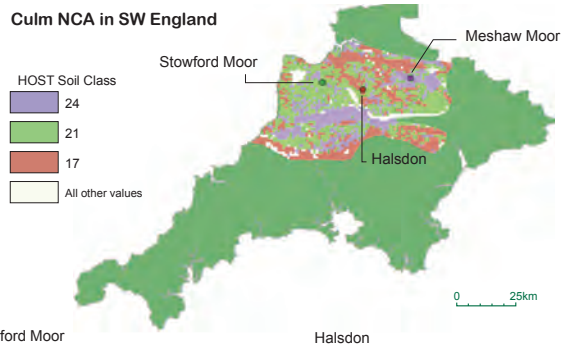
# UNDERSTANDING THE HYDROLOGY OF CULM GRASSLANDS

In contrast we hypothesise that pristine Culm grassland will act as a sponge, holding large amounts of water following rainfall and releasing this water slowly over time maintaining baseflow in channels, whilst reducing flooding. However, there is a need for further understanding of the hydrological functioning of Culm:

"From a hydrological perspective, Culm, or unimproved grasslands are amongst the most poorly understood ecosystems in the UK. As such, this research is critical to establish how these fragile landscapes function under changing climates, to store water and deliver clean water, as well as supporting valuable ecosystem services including biodiversity and carbon sequestration" Professor Richard Brazier (University of Exeter)

The flume at Stowford Moor © Alan Puttock

Dipwell and telemetry base station © Alan Puttock




Stowford Moor


Halsdon


Meshaw Moor


## Experimental framework

Analysis of existing Culm grassland, showed there to be relatively little variation in slope, elevation or mean rainfall across all 571 sites, environmental properties that would be expected to affect hydrological functioning. However, analysis did reveal Culm sites to be located across a variety of soil types, which it is hypothesised are a key control on hydrological functioning, particularly water retention and runoff.

Soil type influences hydrology via its impact upon infiltration rates, water storage, subsurface drainage and surface runoff. The hydrology of soils type system (HOST) is used to classify soils according to their physical characteristics. Our analysis has revealed that over 90% of Culm grassland sites are located on three main HOST types, which formed the basis of site selection. Sites were also selected so that the hydrological functioning of Culm could be compared to other key land uses within the Culm NCA - wet woodland, scrubland and intensively managed grassland.

The location of study sites is illustrated above. At each study site; 10x10m plots have been created (3 replicates at each site) and sampled for soil characteristics influencing water storage (soil depth, bulk density, organic matter, soil moisture and particle size).

Each study site has 9 instrumented dipwells (3 within each plot) which are used to monitor the water table level and how this changes in response and relation to rainfall events. Additionally, Stowford Moor is equipped with an instrumented flume which allows the amount and rate of water leaving the catchment to be quantified.

All monitoring equipment connects to a 3G telemetry network, providing researchers at the University of Exeter with an almost 'live' data feed on a 15 minute sampling interval.

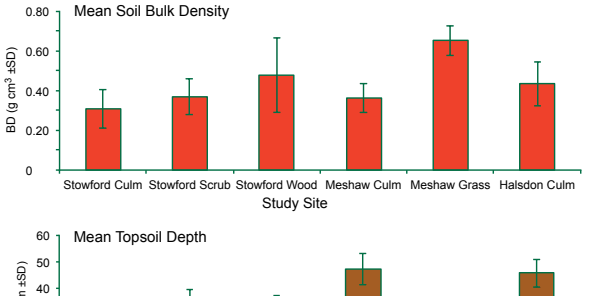
UNDERSTANDING THE HYDROLOGY OF CULM GRASSLANDS

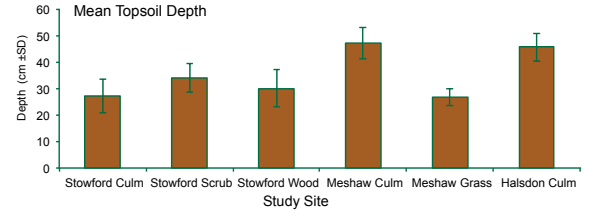
## A snapshot of early results

A field campaign to select monitoring sites, in addition to collecting soil samples for laboratory analysis, was completed in July 2012. Following site selection and characterisation sampling, dipwells, flume and the supporting instrumentation and telemetry network were installed and went 'live' in October 2012.

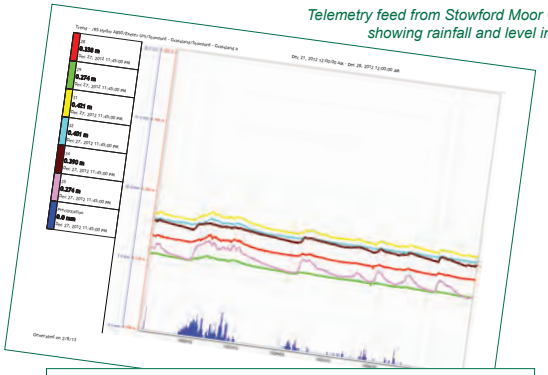
Laboratory analysis of characterisation soil samples has now been completed (120 samples per site), allowing investigation into variation in soil characteristics across the study sites. As illustrated (right), preliminary analysis shows variation between monitoring sites, based upon soil type and land cover. Results at Meshaw show mean soil moisture content (70 %) and soil depth (47 cm) in Culm to be significantly ($p<0.05$) higher than in the intensively managed counterpart. At Stowford, results also found soil moisture to be significantly higher ($p<0.05$) under Culm (76 %) than either scrub (mean 69 %) or woodland (mean 60 %). Additionally, results from Stowford also show soil properties to be more evenly distributed under grassland than either scrub or woodland. These results illustrate the greater water storage capacity of Culm grasslands when compared to both intensively managed grassland on similar soils and both scrub and woodland sites.

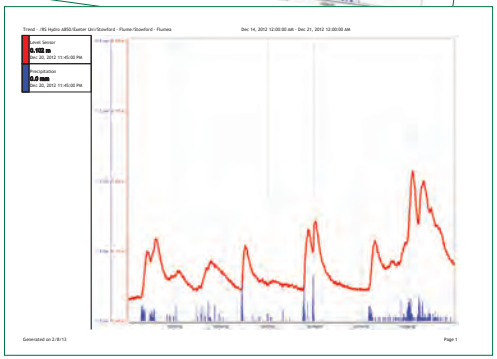
It is too early in the project to produce detailed values regarding water retention, whether with regard to the volume of water stored within the soil or the time for which it is held. Screen shots (right) demonstrate the information provided by the live telemetry feed. However, water table levels across all sites show a positive correlation to rainfall ($p<0.05$). Early results also indicate Culm soils exhibit a less flashy response to rainfall than their intensively managed, scrub and woodland counterparts. Such results suggest that well-managed Culm may attenuate downstream flood risk more than either intensively managed grasslands or Culm grasslands that have scrubbed-up or developed mature woodland cover.




*Telemetry feed from Stowford Moor Culm site showing rainfall and level in dipwells*





*Telemetry feed from instrumented flume at Stowford Moor showing rainfall and flow depth.*