CREW CENTRE OF EXPERTISE FOR WATERS

The role of wetlands in Scotland mitigating hydrological extremes. Perspectives and opportunities.



Stephen Addy[1], Andrew McBride[2], Matt Hare[1], Robin Pakeman[1], Gillian Donaldson-Selby[1], Mike Rivington[1], Zisis Gagkas[1], Mohamed Jabloun[1], Mark E. Wilkinson[1] and Alan Lilly[1]

[1] The James Hutton Institute, [2] Land and Habitats Consultancy

Introduction

- Definition: ***"areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres"*** (Ramsar Convention Secretariat, 2016)

- Major influence on the hydrological cycle of catchments from mountains to the sea.
- In Scotland cover an estimated 2 million hectares (26%) of Scotland's land area.

Research context

- Dispersed and incomplete knowledge
  - Lacks an integrated focus linking health, buffering capacity, land use and climate change, and biodiversity, across a range of wetlands

--> What we were tasked with:

- **An assessment of a broad range of wetlands** with respect to their buffering capacities **for both high and low flows**
- To better understand the impacts of land use and climate change on such capacities and biodiversity

Research questions

- RQ 1: How do a broad range of wetlands in Scotland buffer extremes of water availability, focusing on both low and high flows?
- RQ2: How is this buffering capability compromised when wetlands are degraded due to land use conversion or climate change?
- RQ3: What are the impacts, caused by extremes of water availability, on the biodiversity of Scottish wetlands?
- RQ4: Are there opportunities or potential changes in land or water management, which could enhance this buffering capability of wetlands in Scotland?

Evidence sources

- Comprehensive literature review
- Indicator-based analyses of wetland hydrology and plant ecology
- National mapping of areas likely to be wetlands (DSM-HOST map)
- Analysis of past Scottish climate trends & climate projections
- Discussions with experts on health of Scotland's different wetlands (workshop in October 2021)

Wetland classification used

Lowland Wetland Habitats	Hydrological Wetland Type[1]
Raised bogs	Surface water depression
Transition mires and quaking bogs	Groundwater slope
Open water transition fens	
Base-rich fens	
Reedbeds and swamps	Groundwater slope/depression
Basin fens	Groundwater depression
Floodplain fens	Floodplain

Upland Wetland Habitats	Hydrological wetland type[1]
Blanket bog	Surface water slope
Wet heath	
Depressions on peat substances	Surface water depression
Base-rich fens, alkaline fens	Groundwater slope

Wet Woodland Habitats	Hydrological wetland type[1]
Fen woodland	Groundwater depression; Groundwater slope; Floodplain
Alder woodland	
Bog woodland	Surface water slope/depression

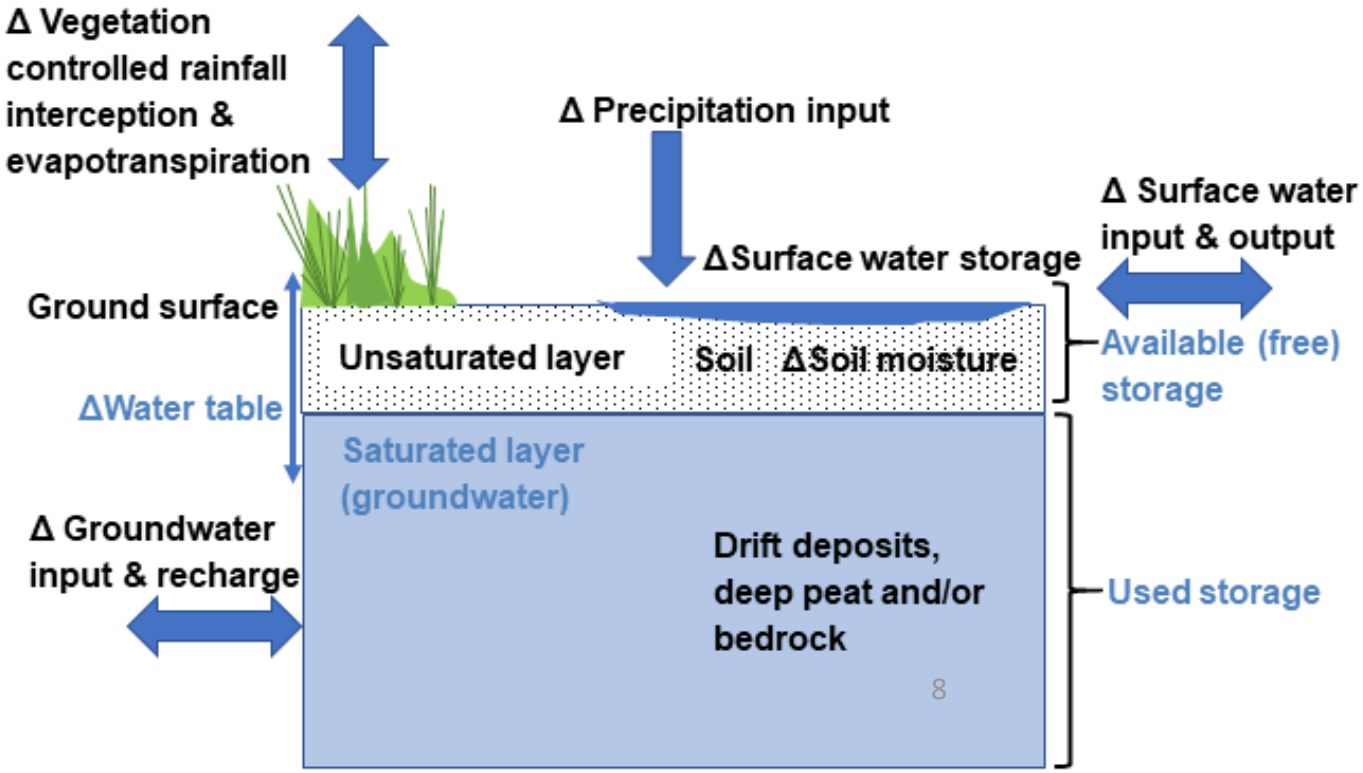
Wet Grassland/flood plain Meadow Habitats	Hydrological wetland type[1]
Fen meadow	Groundwater slope; Floodplain
Wet meadows, marshy grassland	Floodplain
Transition grasslands	
Transition saltmarsh	

[1] Acreman and Bullock *The role of wetlands in the hydrological cycle.* (2003) HESS 7

RQ 1: How do a broad range of wetlands in Scotland buffer extremes of water availability, focusing on both low and high flows?

CREW CENTRE OF EXPERTISE FOR WATERS

- Wetland water balance = the sum of water inputs minus outputs
- Inherent characteristics of wetland determines ratio of ***used*** and ***available (free)*** storage of water. Thus ability to buffer.



Key points on buffering

- Buffering capacity varies in time and space. Also is site and catchment specific; a certain wetland type can function differently in different locations.
- Wetlands hypothetically can buffer floods through storing water and slowing its movement.
- Wetlands can also buffer droughts by storing water and releasing it.
- However wetlands can also be areas with high runoff and reduce the buffering of droughts by increasing water losses through evapotranspiration.

Assessing the buffering capacity of wetlands

CREW CENTRE OF EXPERTISE FOR WATERS

Wetland habitat	Water holding capacity	Low flows buffering rating	HOST Base-flow index rating[1]	Confidence level / Refs[3]	High flows buffering rating	Stand-ard % runoff rating[2]	Confidence level / Refs[3]
Uplands							
Blanket bog	PHWT	Low	Low	Medium; Evans 1999; Soulsby et al., 2006; Tetzlaff et al., 2007	Low (potentially good in the short-term following dry periods in summer)	High	High; Acreman and Holden, 2013; Bullock and Acreman, 2003; Boelter and Verry, 1977; Tetzlaff et al., 2007; Scheliga et al., 2018
Wet heath	PHWT	Low	Low	Low	Low	High	Low
Depressions	PHWT	Low	-	Low; Acreman and Macartney, 2009	Low	-	Low; Acreman and Macartney, 2009

Assessment of buffering capacity of wetland habitat types (RQ1)

- Knowledge on the buffering capacity of the 18 specific wetland types considered was limited, thus a cautious assessment was made.

- The majority were found to have limited buffering capacities for low and high flows when in a healthy state in agreement with previous reviews (Bullock and Acreman, 2003).

- However, there are a number of wetland types that do provide good but variable high and/ or low flow buffering capacity….

Wetlands with the best buffering potential

CREW CENTRE OF EXPERTISE FOR WATERS

Drought buffering

Potentially help buffer both droughts and floods

Flood buffering

Blanket bogs

- Restoration has been proven to help reduce flooding but uncertainties remain.

- In a saturated, healthy state, they have limited buffering capacity

- But many are not in a healthy state

  → Their restoration should increase buffering capacity at certain times given their extent.

RQ2: How wetland buffering capability compromised when wetlands are degraded due to land use conversion or climate change?

CREW CENTRE OF EXPERTISE FOR WATERS

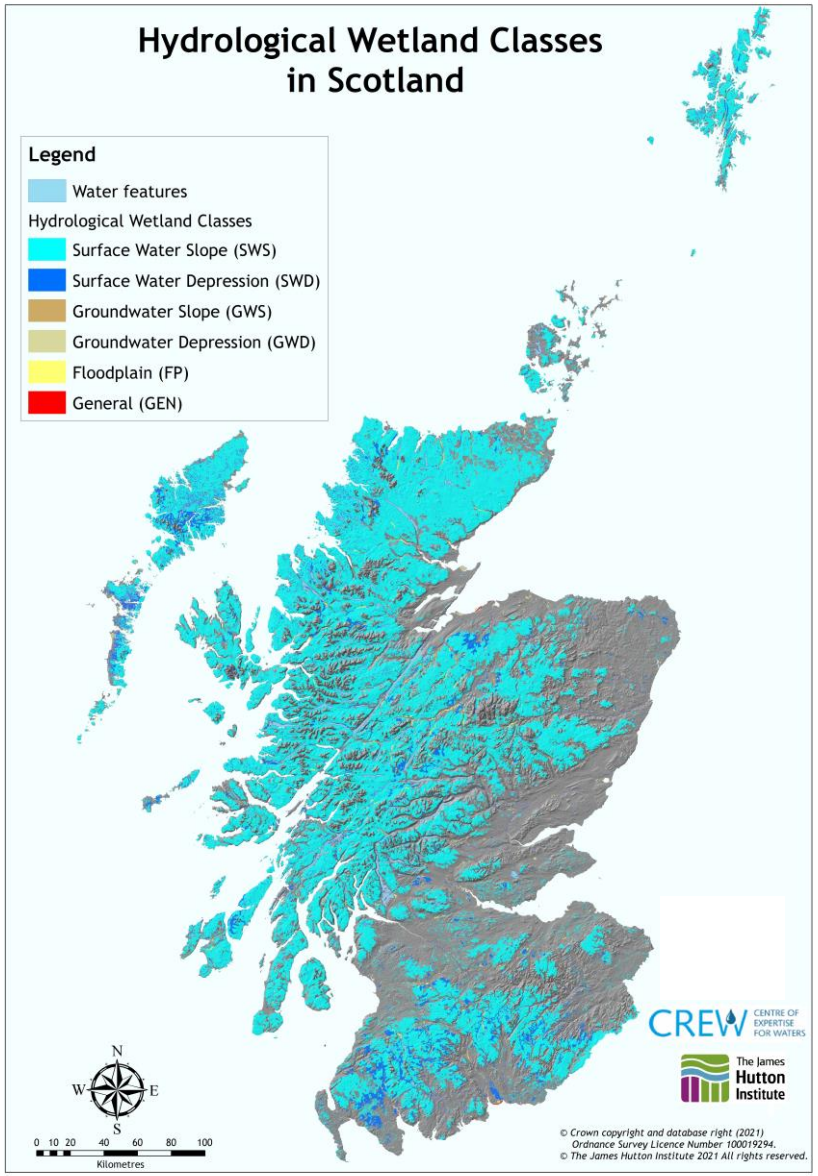
Defining health

- Condition of a wetland is a visible manifestation of health and often the result of historical impact.
- Wetland health includes condition assessment but should measure processes and their effects. Difficult to define.
- Particularly important in a changing climate of extremes.
- Based on NatureScot SCM data, over 40% of Scotland's best wetland sites are in unfavourable condition.

Land use impacts

Prediction of climate change impacts on wetlands

CREW CENTRE OF EXPERTISE FOR WATERS



+

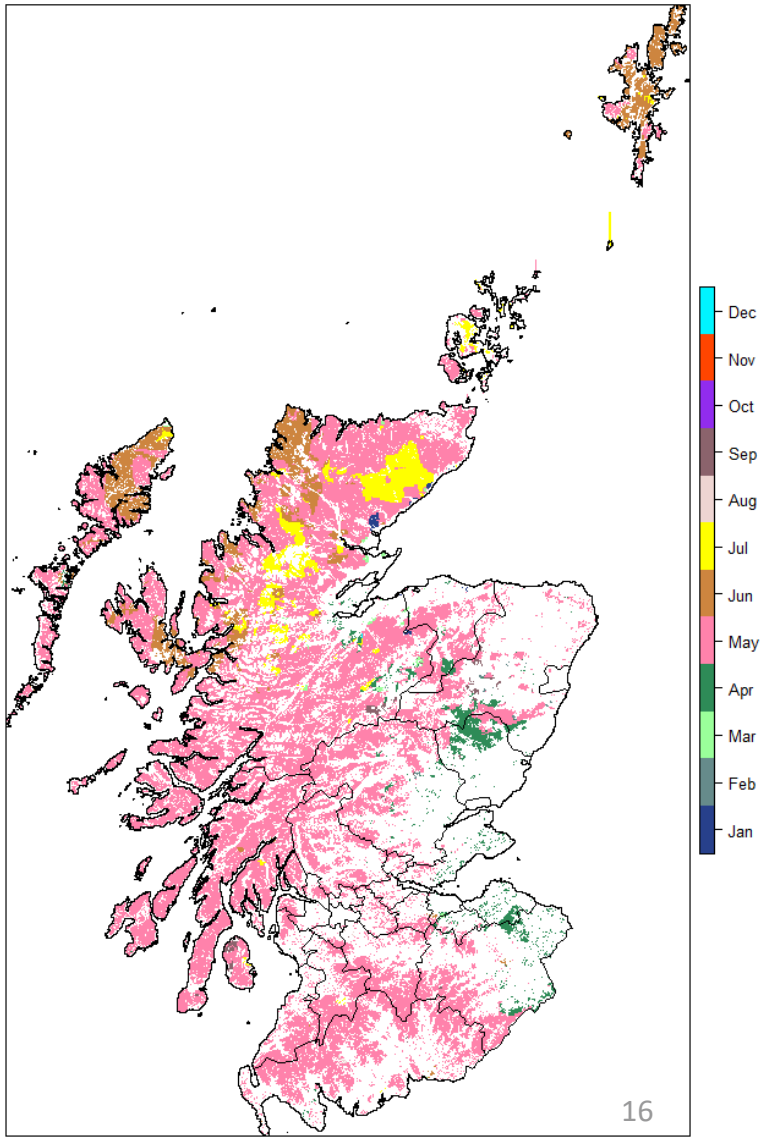
UK Climate Projections 2018

+

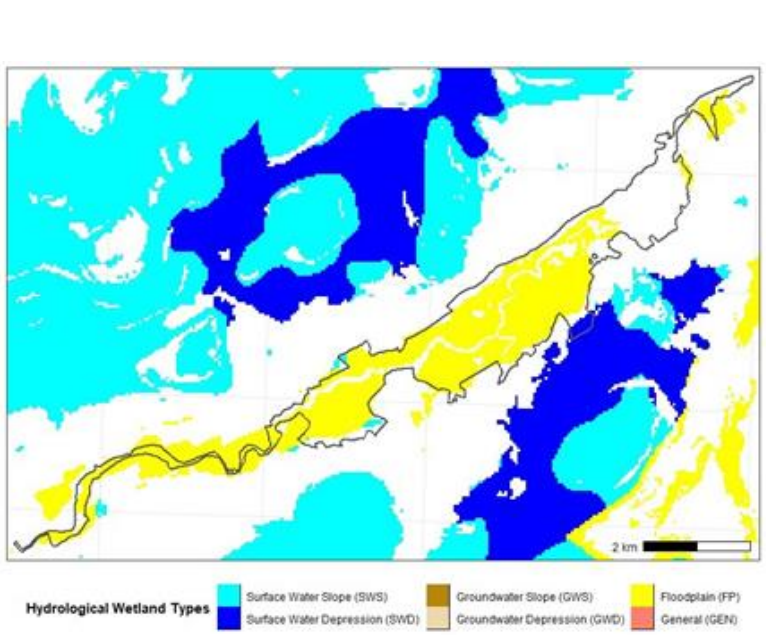
Met Office 1 km grid. precip. & temp data

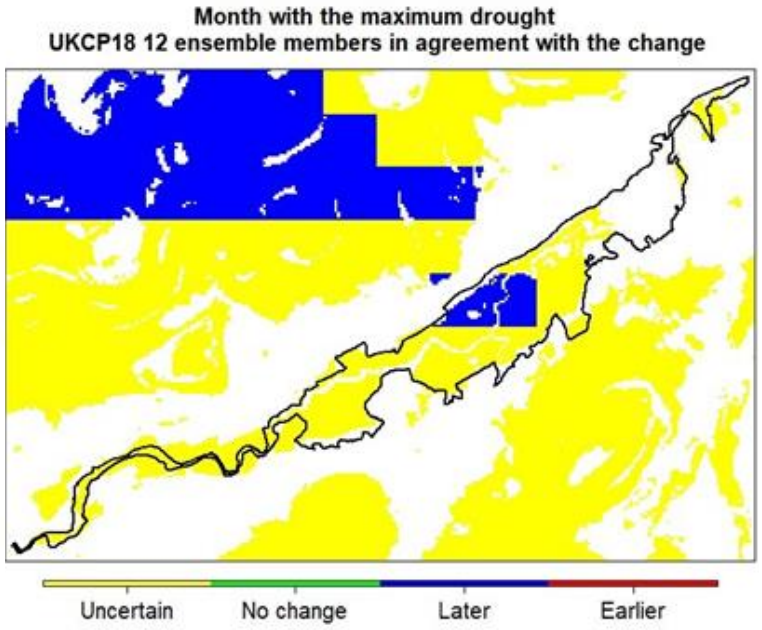
=

Driest month
Baseline period

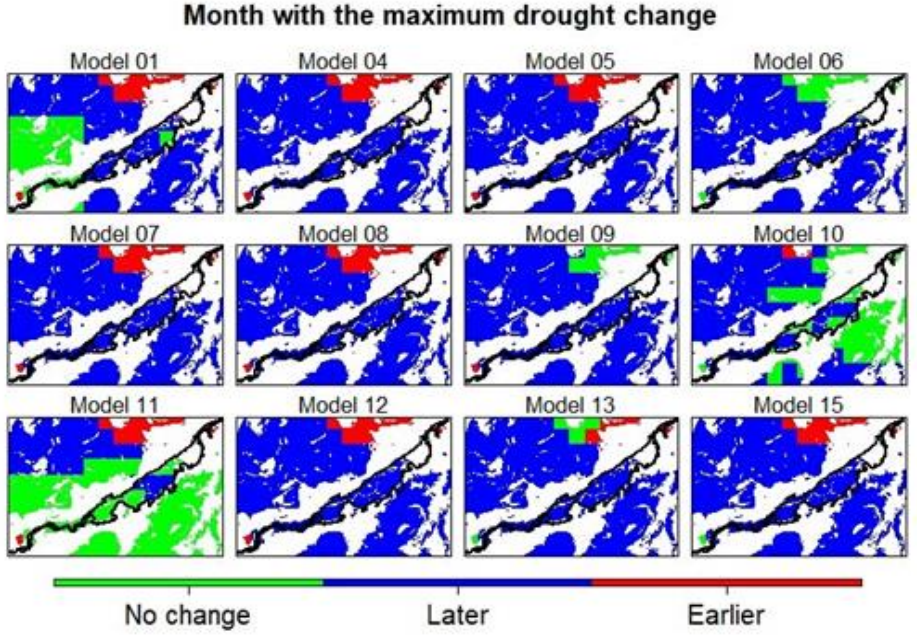


Location specific example: Insh Marshes





Agreement map
(all 12 climate simulations)



x12 climate simulations

Possible to estimate future climatic conditions to guide which land management can be conducted to protect wetland health.

Assessment of the impacts of land use and climate change on wetland buffering (RQ2)

- Impact of climate and land use change on buffering will depend on the site-specific health/type of the wetland and the timing and nature of the impact(s).
- Anticipated greater droughts especially in south and east.
- Anticipated greater flooding in winter months and in north-west.
- Land use impacts (e.g. drainage) may be harder for wetlands to recover from, than drought impacts affecting vegetation cover and soil moisture.
- **Predicted that 10/18 wetland habitat types are at risk.** Wetlands are more resilient to impacts when they are larger (individually and in total extent across a catchment) and connected to other wetlands or watercourses.

RQ3: What are the impacts, caused by extremes of water availability, on the biodiversity of Scottish wetlands?

Ellenberg indicator values

- Ideally, we have hydrological data from a site and detailed niche descriptions for species to assess and predict effects.
- Instead, we can use Ellenberg indicator approach.
- Moisture index (F) runs from:
  - 1 – plants of sites that are extremely dry to
  - 12 – submerged plants, permanently or almost constantly underwater

Impacts of water extremes on biodiversity (RQ3)

- 98 of 700 species on the Scottish Biodiversity List (SBL) in the two highest categories of concern “conservation action needed” and “avoid negative impacts”
- We can identify plant species at risk in each community and if they are rare species or not.
- Most wetland vegetation communities possess some species at risk of being affected by increased dryness and some at risk of increased wetness.
  - ➢ Implications for buffering capacity (e.g. changes in sphagnum cover).
- However, we don't know enough about site hydrology and species composition to make predictions. Monitoring is key to understanding impacts in a particular site.

RQ4: Are there opportunities or potential changes in land or water management, which could enhance this buffering capability of wetlands in Scotland?

CREW CENTRE OF EXPERTISE FOR WATERS

Favourable policy environment:

- Land Use Strategy 3
- Scottish Climate Change Action Programme 2
- The Climate Change Plan 2018-2032
- National Planning Framework 4
- The Scottish Biodiversity Strategy post 2020: a statement of intent
- National Peatland Action Plan
- Flood Risk Management (Scotland) Act 2009
- Green recovery

Focus on main benefits (esp. for peatland):

- Net carbon emissions savings
- Biodiversity
- Flood risk management
- Climate change mitigation and adaptation

Key recommendations for current policy

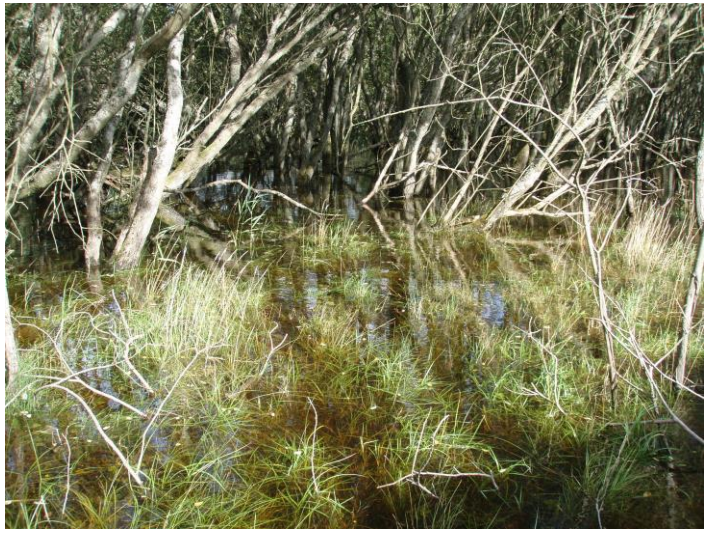
CREW CENTRE OF EXPERTISE FOR WATERS

1. Prioritise restoration and maintenance of key wetland types (e.g. floodplain fens, swamps and reedbeds), within and outwith designated sites, in areas vulnerable to drought and flooding.
2. In parallel create, restore and expand healthy networked wetlands of all other types where opportunities arise.
3. Invest in local human resources to restore, maintain and respectfully manage wetlands as part of the green recovery plan.
4. Create catchment partnerships of land managers and businesses.
5. Maintain ongoing wetland monitoring to meet dynamic policy needs.
6. Adapt restoration approaches.

New policy recommendations

CREW CENTRE OF EXPERTISE FOR WATERS

1. **Identify and maintain reliable funding sources for enabling wetland restoration needs.**
2. **Review the current system of Site Condition Monitoring.** Focus on measuring wetland health and functions. Re-evaluate the current designated site series and its purpose.
3. **Complete the Scottish Wetland Inventory.** Invest in site-specific assessment, long-term monitoring and earth observation data. Develop a network of reference sites.
4. **Strengthen the National Planning Framework from a wetland perspective.**
5. **Redesign agri-environmental schemes to integrate wetlands to deliver the ecosystem services they bring.**
6. **Raise the policy profile of wetlands in Scotland.**



Outputs

Main report with eight technical appendices

Policy note

Available at: https://www.crew.ac.uk/publication/moderating-extremes-water-availability-review-role-functioning-wetlands

Acknowledgments

CREW Project Managers: Pauline Lang, Sophie Beier (2021), Nikki Dodd (2020-21) and Pauline Laing (2021-22).

The Project Steering Group members: were Deborah Spray and Sue Marrs (NatureScot),Clara Lines Diaz and Lindsay MacMillan (Scottish Water), Claire Campbell (Scottish Environment Protection Agency), Deborah Garft and Heather McCabe (Scottish Government).

October 2021 Workshop attendees: NatureScot, Scottish Water, Scottish Environment Protection Agency, Scottish Government, The James Hutton Institute, Land and Habitats Consultancy, Wetlands International, University of Dundee, Tweed Forum, Dee Catchment Partnership, Tarland Wetlands Group, Spey Catchment Initiative, Cairngorms National Park Authority, Forestry and Land Scotland, Scottish Land and Estates, Uppsala University, Swedish Meteorological and Hydrological Institute, Swedish University of Agricultural Sciences and University of Zurich.

CREW CENTRE OF EXPERTISE FOR WATERS

Find out more

www.crew.ac.uk

FOLLOW US ON twitter **@CREW_Waters**

Connect with us on LinkedIn **linkedin.com/company/crew-scotland/**

Land and Habitats Consultancy
www.landandhabitats.co.uk

Land & Habitats
Resilient Ecology

The James Hutton Institute

Scottish Government
Riaghaltas na h-Alba
gov.scot