The Impact Of Extreme Events On Freshwater Ecosystems: executive summary and policy brief

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Overview

Extreme weather events – such as major floods, prolonged droughts and intense heatwaves – affect people and properties directly. The disruption caused to society makes immediate media headlines but, in the longer term, policy-makers need to understand the full implications of more frequent, and more extreme events as our climate changes.

The impact of extreme events on the ecological health of our freshwater systems is less obvious but, nevertheless, very important. Freshwater ecosystems provide a wide range of benefits to society. These include water purification, water supply, food, and flood control. Crucially, we need these 'services' more than ever during extreme events, but degraded or disrupted freshwater ecosystems are less able to provide them. This will mean that the effects on society are magnified.

The *Impact of Extreme Events on Freshwater Ecosystems* summarises current knowledge about the physical and biological effects of extreme weather patterns, and outlines a range of land management strategies that can be used to mitigate these effects. Many of our rivers and lakes have been greatly modified in the past and, in places, this has made the effects of floods and droughts worse. However, there are practical steps that can, and are, being taken to manage land and water more wisely to the benefit of both society and ecosystems. Improving habitat structure and encouraging natural processes in the landscape can result in a 'win-win' situation by creating more refuges for wildlife while reducing the consequences of extreme floods and drought.

Key messages

Extreme weather is likely to become more common as a result of climate change – especially periods of intensive rainfall and prolonged dry spells.

Freshwater systems are particularly susceptible to these changes. Ecosystem services are seriously disrupted when conditions go beyond normal bounds.

Human activities influence the severity of these impacts by reducing the ability of freshwater ecosystems to withstand and recover from extreme events.

Flooding and drying out are natural features of freshwater ecosystems, but when these become more frequent and more intense, aquatic plants and animals are less able to recover.

Effects of extreme events on freshwater ecosystems

The amount and quality of water can be greatly affected and habitats for wildlife may become seriously degraded.

Some species may be lost locally, especially where extreme events disrupt breeding; non-native invasive species are often able to take advantage of this, so extreme events can cause the type of animals and plants to change.

Major floods will increase inputs of domestic, agricultural and industrial pollution to rivers and lakes and reduce water quality. Erosion will re-shape river channels and affect the movement of sediment.

Droughts will increase levels of pollution, hinder fish movement, and expose water plants to damage, ultraviolet light, heat stress or frost; many species will become stranded; the physical structure and chemical composition of river and lake beds will change as they dry out.

Policy implications

To maximise benefits to Society, we need to ensure that freshwater ecosystems are resilient to extreme events.

The European Union Water Framework Directive (2000/60/EC) is helping to increase the ecological quality of lakes and rivers; the EU Floods Directive (2007/60/EC) provides a mechanism for balancing ecological impacts alongside direct human effects by taking advantage of nature's own capacity to absorb excess water.

Wise use of land and effective water management can provide multiple benefits; these include providing refuges for wildlife and reducing soil erosion and pollution.

Natural Flood Management and Sustainable Drainage Systems (see right) at the landscape scale can provide a more sustainable, longer term solution to pollution events and flooding than traditional 'end-of-pipe' solutions and 'hard engineering' fixes.

The three principles of Natural Flood Management and Sustainable Drainage Systems are: slow water down, encourage infiltration and encourage natural processes.

Wiser use of water for industrial, agricultural and domestic purposes will reduce the effects of drought.

Water-friendly farming can be used to improve the natural water retention capacity of land, reducing the need for abstraction.

Best practice in the construction industry can be used to reduce water demand and storm water run-off, reducing flooding and pollution.

Policy tools (e.g. best practice guidance, agri-environment schemes, urban planning) should be used to incorporate resilience to extreme events into the natural and built environments.

Case study

Extreme Events and the Freshwater Pearl Mussel

Background

The freshwater pearl mussel is one of the longest-lived invertebrates known. Individuals can survive for over 100 years. They have a complicated life-cycle partly parasitic on salmonid fish hosts (Atlantic salmon and brown trout). The adult mussels live buried or partly buried in the bed of unpolluted, low nutrient, fast-flowing rivers and streams. They feed by filtering fine organic particles from river water.

Due to its exacting requirements, close links with fish populations and filter feeding habit, the freshwater pearl mussel is a highly sensitive indicator species, a barometer of the quality of the rivers that it populates.

Once widely distributed throughout Scotland, the freshwater pearl mussel is now extinct in most of the lowlands, and scarce elsewhere except for a handful of Highland rivers. For many of the remaining populations worldwide there is no evidence of recent juvenile recruitment, in common with the situation worldwide.

Populations have suffered substantial declines as a result of:

- Water pollution, including nutrient enrichment
- Pearl fishing (illegal since 1998)
- Sedimentation from soil erosion, affecting the suitability of gravel and sand beds for juvenile mussels
- Habitat removal and alteration
- Declines in populations of of salmon and trout
- Conifer plantations, which can damage habitat and exacerbate the effects of acidification

Scotland's rivers support some of the largest and most important freshwater pearl mussel populations. Actions taken within Scotland will have a direct consequence for the global survival of this highly endangered species.

How do extreme events affect freshwater Pearl Mussel populations?

Any increase in the frequency and intensity of extreme floods and droughts is likely to harm freshwater pearl mussel populations. Moderate floods can have a positive effect in cleaning silt build up, but severe floods can remove large numbers of mussels from their beds and are potentially disastrous for small populations. Floods can also increase the delivery of sediment and other pollution. Droughts can concentrate pollution, reduce oxygen availability and leave mussels stranded, with equally disastrous impacts for populations that are not recruiting.

To protect freshwater pearl mussel populations, channel structure should not be altered in ways that impede water flow, increase flooding, or reduce the distribution of suitable substrates. Measures to conserve the freshwater pearl mussel must also include the host fish. Catchments with known populations of freshwater pearl mussels should be protected from alterations to land drainage and activities that increase siltation or the speed of run-off.

The principals of Natural Flood Management and Sustainable Drainage Systems (slow water down, encourage infiltration and encourage natural processes) are likely to benefit freshwater pearl mussels.

A Freshwater Pearl Mussel stranded by drought (Photo: © Susan Cooksley)

Case study

The impacts of extreme events on Loch Leven

Background

Loch Leven is a large shallow lake in the lowlands of Scotland. The loch has considerable conservation value locally and on an international scale. It is also of great economic importance as a sports fishery, tourist attraction and water supply to downstream industry. The loch is often referred to as the "jewel in the crown" of Scotland's freshwater resources.

The amenity value of the loch depends on its water quality and this is affected by extreme weather events, including high/low rainfall, temperature extremes and high wind speeds. The frequency and extent of these are all likely to increase under climate change.

High rainfall events flush large amounts of plant nutrients into the loch from agricultural and sewage sources within the catchment. They may also cause flooding around the shoreline, which damages property and destroys the nesting sites of aquatic birds. In contrast, low rainfall events reduce the rate that water flushes through the system, reducing the availability of water to downstream industry, and encouraging summer de-oxygenation and increases in nutrient release from the sediments. As a result, toxic algal blooms are more likely to occur during low rainfall events, and the availability of food and habitat for fish and birds will be reduced.

The loch is better buffered against the impacts of extreme temperature events than of rainfall events, because these tend to be short term and water tends to heat up slowly. However, as Loch Leven is already under pressure from long term increases in water temperature due to climate change, any short term heat waves will exacerbate the problem.

Because the loch is shallow and relatively exposed, extreme wind events affect the ecology and water quality of the loch. Very high winds disrupt aquatic plants beds, reducing habitat availability for fish and aquatic birds. They also increase the turbidity of the water by re-suspending sediments from the bottom of the loch.

View over Loch Leven (Photo: © Bryan Spears)

Natural Flood Management

Natural Flood Management (NFM) harnesses natural ecological and hydrological processes to reduce flooding. Most of the techniques employed are already components of existing best practice in farming, forestry, river restoration and natural habitat management.

Techniques include:

- Reforesting hill slopes
- Planting dense woodlands in gullies
- Modifying agricultural practices
- Restoring river channel meanders
- Allowing target low-lying areas to flood
- Controlling excessive erosion
- Managing large woody debris in watercourses

This approach enables most current land uses to continue, while introducing controls in key areas. Incorporating NFM into the EU Floods Directive has ensured that its aims are closely aligned with those of the EU Water Framework Directive.

Sustainable Drainage Systems (SuDS)

Sustainable Drainage Systems apply a similar approach to NFM, but in urban areas. Water flow is managed above ground rather than being drained from urban areas through a combined sewerage or storm water system. Relatively low-cost techniques can be used to slow down runoff, including:

- Increased use of permeable surfaces, including permeable asphalt and paving
- More ponds and wetlands
- Greater recycling of roof runoff and grey water
- Increased use of swales and infiltration trenches in low-lying tracts of land next to impermeable surfaces
- Setting any necessary hard flood defenses back from the channel.

The overall effect is reduced runoff rates and increased groundwater recharge. However, SuDS provide additional benefits by increasing pollutant retention and reducing storm-water discharge. Similar approaches can be used in rural areas to reduce diffuse pollution from agriculture and provide on-farm water resources.

Case study

Natural Flood Management in Scotland

Insh Marshes is an internationally-important floodplain wetland at the confluence of several energetic mountain rivers in the River Spey catchment in Scotland.

Such floodplain mire systems were once common in Britain but most similar river valleys have now been drained, and their flow regimes controlled. The conservation status of the marshes relies on the regular inundation of the land, but the downstream community of Aviemore relies on the wetland for flood protection.

The Royal Society for the Protection of Birds (RSPB) Scotland now owns and manages the site for the benefit of both biodiversity and to protect the downstream community from flooding. The marshes regularly flood during winter and spring, acting as a natural flood reservoir, with floodwater covering some 1000 ha at a depth of 2m. Flood risk is reduced to neighbouring settlements including parts of Aviemore, which is an important base for the local tourism economy. The reserve itself adds approximately £200,000 to the local economy through tourism, angling and management of the reserve. The cost of hard engineering to provide similar protection was estimated at £1.3M.

The Insh Marshes (Photo: © John MacPherson/SNH)

Case study

Sustainable Drainage Systems (SuDS) in Scotland

A SuDS demonstration project on the edge of Dunfermline has been in place since the late 1990s, supporting a large residential and commercial development and providing the basis for detailed research into the use of SuDS that has since been used elsewhere in the UK.

The Dunfermline Eastern Expansion is a 5.5km^2 site between junctions 2 and 3 of the M90 which will be developed over the next 20 years as a mixture of industrial, commercial, residential and recreational areas.

The Dunfermline Eastern Expansion (Photo: © Nigel Willby)

A comprehensive SuDS design has been incorporated into development plans to cope with the size and timescale for the development. A network of retention basins, swales, detention ponds and wetlands is now largely in place.

Clay soils limit the potential for infiltration methods, but where possible residential roads are served by soakaways. Much of the road system is drained using offlet kerbs, filter drains and swales, which discharge into detention basins and wetlands which also serve adjoining housing areas. Ponds and basins attenuate storm water flows. A wetland has been constructed in a public park with recreation amenities. Innovative drainage solutions include using the open space in the centre of a roundabout as a detention basin. Barrier planting and shallow reed fringes improve safety around open water. The ability of the system to attenuate and treat water is being monitored.

The cost of a conventional drainage system for the development would have been prohibitive. A new 5km long sewer, draining into the River Forth, would have to have been built.

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