Headwaters are the ephemeral and permanently-flowing tributaries feeding a river system. Various definitions exist, based on location (within 2.5 km of source), catchment area (<10 km²) or stream ‘order’, but however defined, headwaters make up the largest portion of river length across the country (estimated at around 70%) and so can be considered the essential ecological foundation for healthy functioning river systems. Varying greatly in character, they are vital both as habitat in their own right and as a support-system for the downstream rivers that they feed.

Freshwater and terrestrial wetland habitats are formed by the flow and retention of water in the landscape. Their nature is determined by landform and hydrological pathways, the characteristics of the water supply, and climatological and biological influences which generate a mosaic of rivers, lakes, wet grasslands, reedbeds and other habitats of various degrees of wetness and types of hydrochemistry.

The UK Biodiversity Action Plan (published in 1994), described the biological resources of the UK which were identified as being the most threatened and required conservation action – our priority species and habitats. Detailed plans set out actions to protect and restore our threatened wildlife, and work continues today, as a key part of the delivery within Biodiversity 2020 and the Water Framework Directive (WFD).

Across catchments, action to enhance our many freshwater habitats is intrinsically linked; with works to rivers able to benefit wetland habitats and vice versa. Delivery on a catchment scale can take account of these synergies, and can look to secure opportunities to achieve biodiversity benefits across the full range of habitats present within a catchment.

**WFD AND B2020 SYNERGIES: VERY ACHIEVABLE**

As for rivers, targets for Good Ecological Status under the Water Framework Directive focus on the physico-chemistry (pH, temperature, nutrients) and biology (aquatic plants, invertebrates, fish) of headwaters. Status improvements under WFD can contribute to all targets under Outcome 1 of Biodiversity 2020 which calls for Priority Habitats to be maintained in favourable condition, degraded ecosystems to be restored and areas of importance for biodiversity and ecosystem services to be safeguarded. Such improvements can also benefit a wide range of species that are the focus of B2020 Outcome 3. Whilst many headwaters fall outside of the formal WFD monitoring network, their protection and enhancement is integral to the objectives of the Directive and can make a significant improvement to the status of monitored water bodies downstream.
NATURAL ECOSYSTEM FUNCTION IN HEADWATERS

The habitat mosaics typical of naturally functioning larger rivers can be seen in miniature within headwater streams, including both in-channel and riparian habitats. Habitat features and species assemblages change as environmental character changes downstream, just as they do in the larger rivers into which they feed. Highly dynamic and diverse, the character of headwaters also varies across the country, ranging from high gradient, naturally treeless cascades in the uplands to chalk winterbournes in lowland England. They are strongly influenced by their catchments and often, in contrast to more heavily-modified downstream reaches, have avoided extensive canalisation and erosion control measures, remaining hydrologically connected to their adjacent floodplain habitats.

Natural headwater streams are highly connected to the springs and flushes that feed them, providing a wetland transition zone of high conservation importance.

In the uplands, intact peat moorland supports a complex mosaic of wet and dry biotopes, including dystrophic (peat-stained) pools and headwater streams of high biodiversity value. Historic gripping and burning of moorland has severely degraded this mosaic, causing degradation of streams through excessive soil erosion and river bed siltation. Eroded peat and nutrients are also carried downstream, impacting the freshwater communities below. Water retention within the moorland is impeded, exacerbating low flows and compounding high flows in the downstream river network. Grip-blocking is therefore vital for restoring upland moorland including the pools and stream network that form a key part of the natural habitat mosaic.

In the lowlands, intact valley mire systems support a wealth of biodiversity in a patchwork of spring, flush, runnel, fen, bog, swamp and wet woodland. Species supported by these systems include the southern damselfly and the scarce blue-tailed damselfly, whose nymphs exploit the shallow runnels running off mires into the stream system. Flush and mire habitats gradually give way to stream habitat as water collects in surface and sub-surface pathways and flows down the valley.

The permanence of flowing water has a major bearing on the flora and fauna, with ephemeral sections favouring a range of species adapted to a seasonally dry channel, such as certain stoneflies, scarce mayflies and crane-flies.

The presence of riparian trees and woody material within the channel is a critical component of the habitat mosaic, adding a high degree of characteristic habitat complexity through the creation of debris dams, exposed tree root systems and channel sinuosity. This provides niches for a wide range of species, particularly for lower plants and invertebrates.

In wooded headwater streams, leaf litter provides the main natural nutrient source and generates a food web based on leaf-shredding, dominated by freshwater shrimps and stoneflies. In treeless upland streams, attached algae replace leaf litter as the most important food source, supporting invertebrates with a scraping or grazing feeding habit. Such factors fundamentally affect the composition of the biological assemblage.
In open lowland headwater streams, better habitat opportunities are created for higher plants, including the chalk winterbourne specialist brook water-crowfoot. Headwater streams provide a disproportionate amount of marginal habitat for their length compared to larger rivers, and this is exploited fully in open lowland streams by encroaching species such as brooklime and water-cress. In turn this provides an additional habitat niche for plant-dwelling invertebrates such as the nymphs of the southern iron blue mayfly.

Headwater streams are limited in the diversity of their fish assemblages but are a key habitat for the European protected species brook lamprey and bullhead, for which parts of the UK are major strongholds. Headwaters also provide critical spawning and juvenile habitat for other fish, including brown and sea trout and Atlantic salmon.

Downstream river sections are inherently influenced by the supply of water, sediment and species from the headwater streams that feed them. Although a proportion of invertebrate taxa found in catchments are exclusive to headwaters, many other species are also found in downstream rivers, where populations are constantly topped with individuals drifting down from the headwaters above.

The geomorphological characteristics of a river’s middle reaches are in part determined by the type and scale of sediment supply generated by the upstream catchment. This influence declines in reaches further downstream as a progressively greater area of the drained catchment contributes to the river’s sediment load and as substrate eroded by the river channel itself becomes increasingly important. This said, even in the lowest river sections, many fish and invertebrate species are reliant on the headwater processes that sustain supplies of coarse substrates in which they shelter or spawn. Similarly the relatively low supply of fine sediment generated by natural headwater stream/mire systems is critical to avoiding excessive siltation in downstream river reaches. A classic example is chalk streams, where gravels with low silt levels provide spawning opportunities for salmonids and play host to a range of specialist chalk river plants and invertebrates associated with gravel substrates.

A similar longitudinal pattern is observed for water supply; the natural flow regime of a headwater is influenced by the effects of climate, geology and soil type, most noticeably giving rise to the intermittent stream sections nearest the source. These are termed ephemeral, or more specifically winterbourne in chalk landscapes. They flow only when winter groundwater levels and rainfall combine, and recede in the summer along a gradient of least inundated (upstream) to most inundated (approaching the perennial head). Downstream flows are progressively added to as channels combine, fed by an increasingly larger proportion of the catchment, and so are decreasingly influenced by the flow signatures of the individual headwaters. Plant and animal assemblages are distributed along this spectrum of wetness according to their habitat preferences and life cycle strategies, with some species highly resistant to long periods of dryness and others not.

Impacts upon the headwater channels can therefore be damaging to these middle and lower river reaches, which are dependent upon the natural hydrological, hydrochemical and sedimentary processes of the headwaters.
HEADWATERS CAN PROVIDE A REFUGE FOR THREATENED SPECIES LIKE THE NATIVE WHITE-CLAWED CRAYFISH

PRESSURES ON OUR HEADWATERS

As for rivers more broadly, headwaters are never completely physically destroyed in the way that a wood or meadow can be, as water falling on the catchment will always require a route by which to drain away. However, habitat extent and quality can be significantly reduced by anthropogenic impacts.

Although broadly facing the same pressures as the river resource as a whole, the impacts upon headwaters can be more pronounced. The effects of excessive inputs of nutrients and other pollutants can be more severe due to the lower water volumes of headwaters which have a lesser dilution capacity than the lower river. As a result, both upland and lowland headwater streams are still slowly recovering from the legacy of acidification from sulphur deposition, while acidification stress from on-going nitrogen deposition remains.

The more pronounced flow signatures of headwaters, and especially ephemeral sections, can be significantly altered by impoundments or abstractions, exacerbating or masking peak or low flows, altering temperature regimes, and sometimes fundamentally altering the nature of the river channel. For example, groundwater abstractions can lead to downstream contraction of headwaters and can alter the position of the perennial head. The impacts upon the headwater’s specialist plants and animals, adapted to withstand seasonal drought, can be extreme.

Drainage can also have a severe effect on headwaters, typically associated with the loss of mire and flush habitats from which the streams arise. Channels are artificially extended into mire areas that are consequently drained and lost, and the channels created are of poor quality. Where the drained land is given over to intensive grazing or arable, the channels can quickly deliver resulting sediment and pollutants to freshwater habitats downstream. The invertebrate communities of upland headwaters suffer from heavy organic siltation associated with drainage works, particularly the drainage (‘gripping’) and burning of peat moorlands.

Headwater streams are typically amongst the last places in a catchment to be invaded by non-native species, because of their remoteness and natural inaccessibility. They are therefore often critical refuges for native species that are threatened by predation, competition and disease from non-natives (e.g. the white-clawed crayfish, water vole). However, the increasing spread of non-natives means that the pressure of invasion is growing all the time.

KEY PRESSURES ON HEADWATERS

**DRAINAGE:** Drainage of mire and flush habitats from which headwaters arise can result in heavy organic siltation and the delivery of pollutants downstream

**POLLUTION:** Excessive inputs of nutrients and other pollutants can severely affect headwaters as they hold less water, so have less dilution capacity

**IMPOUNDMENT:** Impoundments, such as dams, alter natural flow and temperature regimes, and the nature of the river channel, impacting habitat niches

**HABITAT LOSS:** Historic gripping and burning of moorland has resulted in the loss and degradation of peatland headwaters, impacting habitats downstream

**INVASIVE SPECIES:** Non-native and invasive species can impact characteristic biological communities through direct competition or the alteration of habitats

**ABSTRACTION:** Abstraction of water for supply and consumption alters natural flow regimes, often exacerbating peak or low flows and affecting species

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KEY MANAGEMENT MESSAGES

• RESTORATION OF NATURAL PROCESSES

Measures that restore natural processes – natural flow, geomorphological and water quality regimes – allow expression of a characteristic and self-sustaining mosaic of river biotopes, and provide the best opportunities for priority species to survive in a changing climate. A catchment-scale approach encourages practitioners to consider how the river system would operate under natural processes as a foundation for planning restoration.

• LARGE-SCALE PERSPECTIVE

Running water ecosystems are complex, physically connected habitats, with conditions dependent on those upstream and across the catchment. In the case of headwaters, restoring flow, sediment and water quality regimes is therefore key, not only to the quality of the headwater habitat, but also to the downstream river system into which the headwaters feed.

• IN-CHANNEL STRUCTURES

Weirs and dams have a range of physical effects on river habitats, as well as blocking the free movement of some species. Their impact in headwaters can be great, not only because they fundamentally alter characteristic flow signatures but also because they can interrupt the natural supply of water, sediment and even species to the river downstream. Structure removal should be the aim wherever possible, with modification to minimise all impacts the next best option.

• RIPARIAN VEGETATION

A patchy mosaic of riparian vegetation can incorporate long and short swards, trees and shrubs, and bare ground created by natural river processes. Tree cover won’t always be a natural component of bankside vegetation (e.g. on peat), but where it is appropriate, cover can have a major effect on maintaining thermal regimes in headwater streams in the face of climate change, which threatens to eliminate many cold water species from parts of their English range. The value of riparian trees in mitigating against rising air temperatures can be more prominent in the smaller headwater channels, where increases above the broad minimum target of 30% tree cover (to promote climate change resilience) are particularly consistent with restoring natural ecosystem functioning. Trees also provide the leaf litter and woody debris that some nutrient-poor headwater streams rely on for their productivity, supporting characteristic biological communities adapted to this condition. In addition, the re-wooding of headwater valleys can also help to regulate the delivery of water, nutrients and sediments to freshwater and wetland habitats further down the catchment.

• MANAGEMENT OF LARGE WOODY MATERIAL

‘Woody debris’, as a critical component of a naturally functioning stream ecosystem, can be more easily retained in headwater streams. Lower hydraulic energies mean material is at low risk of becoming dislodged and causing damage or flood risk downstream. ‘Passive’ restoration of woody debris is the best means of providing woody material in headwater systems; including tree-planting to generate native woody input over time, and leaving material in situ where it falls. Active introduction of woody material, in patterns consistent with natural river function, is a good interim measure whilst riparian trees (that will provide a future natural supply) are maturing.

• ENSURE EPHEMERAL HABITATS ARE CATERED FOR

Seasonally variable habitats like winterbournes can house much of the biodiversity of rivers. Natural seasonal flow and water level recession is essential for their maintenance. This requires careful management of abstraction and the removal of impounding structures wherever possible.

• AIM TO AVOID BANKSIDE FENCING

Whilst bankside fencing protects in-channel fauna from the sediment and nutrient inputs (poaching and bank erosion) or physical disturbance (trampling) caused by high intensity livestock grazing, the ruderal bankside vegetation which results is of low conservation value. In addition, close bankside fencing can interfere with natural stream behaviour and encourage measures to be taken to stop lateral channel movement. Reducing grazing pressure to a suitable level is often preferable to bankside fencing. However, in the headwaters, flush and mire habitats are highly vulnerable to grazing pressure and the impact of livestock needs to be carefully considered. Where needed, fencing that is well set back from the bankside and allows scope for occasional access by livestock provides the greatest scope for characteristic marginal and riparian habitats to develop.

• UNDERSTANDING THE LOCATION OF EXISTING FRESHWATER BIODIVERSITY

To maximise the benefits of restoration work, and eliminate damage to priority or endangered species, it is important to obtain a clear picture of the distribution of local freshwater biodiversity, (indeed, this knowledge is legally necessary for some species). Practitioners should take account of standing water, running water and wetland biodiversity. Specialist advice can be valuable; for example, work being undertaken by the Freshwater Habitats Trust to identify ‘Important Freshwater Areas’ could inform local delivery.

REFERENCES AND FURTHER READING

- A narrative for conserving freshwater and wetland habitats in England
- Climate Change Adaptation Manual – Rivers and Streams

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