

The Importance of the Small Stream Network: An Introduction

What are Small Streams?

Small streams have been defined in many different ways but they are generally considered to lie within the headwaters of rivers extending only a few kilometres from their source. Most are therefore first or second-order (Strahler) streams (see Fig. 1) with small catchment areas and narrow channel widths (generally <3m).



Fig. 1: Strahler stream order

Types of Small Streams

Most small streams in Ireland are perennial, flowing in all seasons in response to rainfall that is also generally well distributed through the year. Although less common, some streams are temporary, flowing for only a part of the time. Temporary streams include both intermittent streams which only flow during certain parts of a year and ephemeral streams which typically only flow during flood events. Headwater flows arise from several different sources: seepage from soils (including peatlands), subsoils and aquifers, springs and lake outlets. Differences in geomorphic, hydrological, precipitation and ecological conditions lead to their broad instream habitat heterogeneity.



Fig. 2: Typical upland headwater stream



Fig. 3: Small lowland stream



Fig. 4: Temporary stream in summer

Small Streams represent 77% of the length of the Irish river network

Of the 74,000 km of river channels in Ireland, 38,623 km (52.2%) are 1st order streams and a further 18,120 km (24.5%) are 2nd order streams.

Small streams provide us with many important benefits

Described as the 'capillaries of the landscape's vascular system', small streams collect and distribute water and various other materials to the lower reaches of the river network. They provide us with many goods and benefits, so-called ecosystem services. Some of the important, well known but often poorly described benefits are:

Water Provision

Small streams collect and deliver a considerable (>70%) volume of water to downstream river reaches and lakes, where the water becomes available for abstraction.

Control the Supply & Transport of Water & Nutrients

Small streams capture flood water and regulate flow downstream. They may contribute to groundwater recharge, providing hydrological connectivity between terrestrial and downstream aquatic ecosystems, controlling the transport of sediment and nutrients (nitrogen, N, and phosphorus, P) as well as water between river and land, and

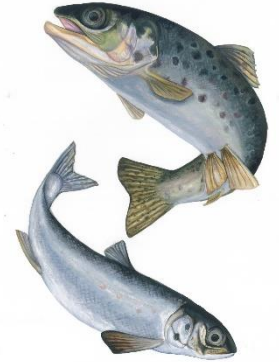
playing a vital role in the supply and transport of water and nutrients to the downstream river network and its floodplains.

Their large benthic surface area relative to the overlying water volume, the close contact and exchange of water within the hyporheic zone, combined with their large spatial extent mean that headwater streams can be important 'hotspots' for nutrient and organic matter processing within river catchments.

Retention and cycling of P and N in headwater streams provides an important 'ecosystem service', by transforming and regulating downstream delivery of nutrients and modifying their form and timing of delivery in ways that can help reduce ecological impacts on downstream receiving waters.

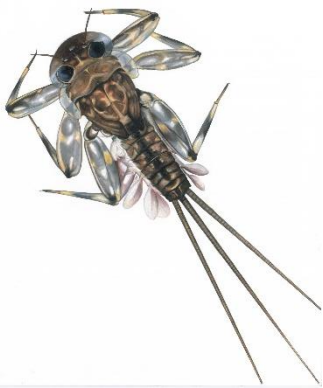
Spawning & Nursery Habitat for Salmonids

A number of fish species (e.g. eels) can be found in small streams but they are best known for the important spawning habitat they provide for brown trout and salmon. The juveniles of trout can spend several years in these streams before migrating downstream where they become the catchable fish that support angling.



Support High Catchment & Regional Biodiversity

The aquatic biota of small streams include species that are unique to the upper part of the river network, species that occur there but also in larger rivers, species that move into headwaters seasonally and those that migrate there to complete particular life history stages (e.g. salmonids for spawning). Small streams may individually support naturally low (<20) numbers of macrofaunal species but collectively the network of headwater streams can make a large contribution to catchment and regional biodiversity. Studies in Ireland have shown that almost one third (29%) of a catchment's macroinvertebrate biodiversity can be unique to headwaters while others are common to reaches further downstream, and are therefore important sources of species to repopulate downstream reaches that have been impacted by pollution or habitat degradation.



Cultural Services

Small streams have an aesthetic value in the landscape and contribute to a sense of place. They are important for recreation where there are bank-side walking routes but also to angling in downstream reaches. They are enjoyed for the aquatic and riparian wildlife they support.

Threats to the Benefits Provided by Small Streams

Small streams are highly vulnerable to pollution and other human induced disturbances because of their high connectivity with adjacent land.

- **Low dilution capacity:** makes lowland headwater streams vulnerable to nutrient and sediment inputs from septic tanks and small rural waste treatment plants, as well as from agricultural point and diffuse sources.
- **Vulnerability to channel modification:** low order streams are often channelized into straight ditches and are subject to direct field runoff from tile drains – this accelerates water transfers and causes loss of connectivity with potential sites for P sorption and denitrification. Channelisation to improve the efficiency of water transit modifies water flow velocities, reducing transient storage, and also reduces connectivity between the channel and floodplain, thus diminishing the capacity for in-channel and overbank nutrient retention. Furthermore, Ireland has a dense road network with numerous culverts on small streams which can lead to inputs of heavy metal and other contaminants as well as loss of biological connectivity where culverts and weirs act as barriers to the movement of sediment and migratory species as well as movement by fish and other species within river systems for feeding and to find suitable habitat.



- **Vulnerability to environmental change:**

Increasing prevalence of droughts and extreme summer low flows exacerbates the low baseflow dilution capacity of headwater streams. Greater magnitude and frequency of extreme high flows and floods promote stream scouring and reduce nutrient retention capacity in headwater streams. They also promote greater mobilisation of 'legacy' nutrient stores within the catchment, and increase the loadings of carbon and other nutrient inputs from terrestrial stores. High flows can result in increased stream-bank erosion and delivery of sediments from soil disturbance associated with agriculture and forestry.

Key review papers for further information

- J. Biggs, S. von Fumetti, M. Kelly-Quinn (2017). The importance of small waterbodies for biodiversity and ecosystem services: implications for policy makers. *Hydrobiologia* 793, 3-39 (doi: [10.1007/s10750-016-3007-0](https://doi.org/10.1007/s10750-016-3007-0))
- W. D. Riley, J. Biggs, A. L. Collins, H. P. Jarvie, J. I. Jones, M. Kelly-Quinn, S. J. Ormerod, D. A. Sear, R. L. Wilby, S. Broadmeadow, C. D. Brown, P. Chanin, G. H. Copp, I. G. Cowx, A. Grogan, D. D. Hornby, D. Huggett & G. M. Siriwardena (2018). Small Water Bodies in Great Britain and Ireland: Ecosystem function, human-generated degradation, and options for restorative action. *Science of the Total Environment* 645, 15, 1598-1616. Open Access : <https://doi.org/10.1016/j.scitotenv.2018.07.243>

Introducing SSNet

-Managing the small stream network for improved water quality, biodiversity and ecosystem services protection

Considerable knowledge gaps relate to many of the aforementioned benefits that small streams provide. In addition to this, water pollution problems in the small stream network affect water quality downstream and are likely to limit our ability to achieve the objectives of the Water Framework Directive.

SSNet is an EPA-funded research project led by researchers in University College Dublin with partners in Trinity College Dublin, the Centre for Ecology and Hydrology and Queen Mary University of London in the UK.

The overall objective of the research is to build a science-informed knowledge base on the role of small streams in water quality, biodiversity and ecosystem services protection to inform policy, measures and management options to meet the WFD objectives and other regulatory targets.

The project will collect new data to

- Determine the effects of nutrient processing, cycling and export of nutrients in headwaters on nutrient status further downstream.
- Build an integrated understanding of the physical character and dynamics (hydromorphology) of headwater streams across Ireland.
- Determine the contribution of small streams to catchment biodiversity and the role of hydromorphology and hydrochemistry in controlling their biodiversity potential. One of the tasks looks to the future and the potential for using emerging DNA tools in biodiversity and water quality monitoring. This is important given current developments in this area and the challenges of monitoring the extensive small stream network. In this regard we will also explore options for increased engagement of citizen science in monitoring the physical and ecological health of small streams
- Model the level of intervention in the small stream network required to have a measurable effect throughout a catchment on both water quality (N, P & sediment) and flows, biodiversity protection and overall delivery/maintenance of ecosystem services.
- Explore options for increased engagement of citizen science in monitoring the physical and ecological health of small streams.
- Make recommendations for the management of the small stream network.

Follow us on Twitter  [@SSNetResearch](https://twitter.com/SSNetResearch) and on our website: www.ucd.ie/ssnet

Contact for further information: mary.kelly-quinn@ucd.ie



Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin