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Scotland River Temperature Monitoring Network: providing analysis, tools and advice to guide bank-side tree planting to manage river temperature under climate change

<https://www2.gov.scot/Topics/marine/Salmon-Trout-Coarse/Freshwater/Monitoring/temperature/temperature.data@marlab.ac.uk>

Background

River temperature is important to Atlantic salmon and Brown Trout. There are concerns that rising temperatures under climate change will negatively affect Scotland's salmonid populations. In 2018 ca. 70% of Scotland's rivers experienced temperatures which exceeded temperature thresholds for thermal stress in salmon. Bankside tree planting, is one of very few practical management options that can be applied to protect rivers from high temperatures. However, in times of constrained resources, it is important that trees are planted where they can have the greatest benefits. In particular river managers need to know where rivers are hottest, where they are most sensitive to climate change and where tree planting can have the greatest benefits. The Scotland River Temperature Monitoring Network (SRTMN) was set-up to address this evidence need. The purpose of this email is to provide a brief overview of the tools available from this project and how they may be used to strategically plan tree planting.

What is the Scotland River Temperature Monitoring Network and how can it help us manage the impacts of climate change on freshwater systems?

The Scotland River Temperature Monitoring Network was established in 2013 as a collaboration between Marine Scotland, Fisheries Trusts, District Salmon Fishery Boards and the University of Birmingham. SRTMN is a strategically designed, quality controlled network of > 220 river temperature dataloggers. The data collected from the network has been used to develop cutting edge river temperature models. These can be used to predict river temperatures across Scotland's rivers and to develop user friendly management tools for prioritising tree planting where (1) river temperatures are hottest (2) where river temperatures will change most under climate change (3) Where bankside trees would have the greatest effect in reducing river temperature extremes.

What tools and information are available from SRTMN to prioritise tree planting and support river managers?

The Scotland River Temperature Monitoring Network web pages (<https://www2.gov.scot/Topics/marine/Salmon-Trout-Coarse/Freshwater/Monitoring/temperature>) provide information on **the network**, the **scientific outputs** of the work (peer reviewed publications), links to **management tools** (e.g. interactive mapping to prioritise tree planting locations based on river temperature and climate sensitivity) and **advice** (e.g. user friendly leaflets that explain how to use the tools). It is also possible to plot, visualise and export data from the network (including information on

potential impacts on fish) through our SRTMN R ShinyApp. A short overview of these tools is provided below.

Leaflets: The following leaflets provide an overview of the network and the ways in which the outputs can be used to inform policy and management of rivers

[The Scotland River Temperature Monitoring Network \(SRTMN\)](#)
[Where should we plant trees to protect rivers from high water temperatures?](#)
[Summer 2018 river temperatures](#)

SRTMN R Shiny Application: This interactive R Shiny [Application](#) allows SRTMN data to be explored. A range of metrics can be mapped at national or catchment scales. Plots and underlying processed data can be exported.

Interactive mapping tools: Data and analysis from SRTMN has been used to produce a variety of river temperature descriptors, which can be used to support management decisions. For example, interactive maps of river temperature and climate sensitivity provide tools for river managers to plan and prioritise riparian planting when combined with the leaflets above. Full details and description of the mapping tools can be found [here](#), however in brief these layers include:

1. SRTMN – Predictions of maximum daily river temperatures for the hottest day between July 2015 and June 2016. (Where is hottest)
2. SRTMN – Predictions of maximum daily river temperatures for the hottest year in the last 20 years (2003). (Where is hottest – under extreme air temperature conditions)
3. SRTMN – Predictions of the change in river temperature that would result from a 1°C increase in air temperature. (Where is most sensitive, where will change most)
4. SRTMN - Management priority on a scale of 1:9 where 1 is highest priority (i.e. high river temperature and high climate sensitivity) and 9 is lowest.

These layers have been made available in the following interactive formats:

Mapping layers available on NMPI: The [National Marine Plan Interactive \(NMPI\)](#) is an online interactive tool that allows you to browse spatial data layers, generate maps and save them as images. This is particularly useful if you want to make use of the numerous layers available on NMPI (including detailed background mapping) or if do not have access to your own GIS.

A list of the SRTMN layers available on NMPi can be found [here](#).

You open layers of interest within NMPi by clicking on 'Access this map on NMPi' in the 'Links and Resources' table at the bottom of the page.

To select multiple layers within NMPi click on the 'View Layers to Add/Remove' button within the Layer Control box (first left hand box). Click on the + button to expand the layer grouping and click on the left hand boxes to select a layer (a green tick will appear). Note that all of the SRTMN layers can be found under Climate Change / Scotland River Temperature Monitoring Network (SRTMN). Further instructions on how to use NMPi can be found [here](#).

Mapping layers available as a WMS: A 'Web-based mapping service' (WMS) allows you to load georeferenced images into your own GIS environment, via the internet. SRTMN layers have been made available as WMS layers so that different river temperature descriptors can be overlain with other spatial datasets and queried within the users own GIS.

A list of the SRTMN layers available as WMS layers can be found [here](#). The 'WMS' icon on the left hand side of the 'Download and links' table, can be used to identify layers that are available as a WMS.

To add the WMS into your own GIS you would do on of the following:

For ArcGIS: Open to 'Catalog Window'; expand 'GIS Servers' and double click 'Add WMS Server'. Next copy and paste the WMS link for the layer of interest (found via the link above) into the 'URL' box. Click 'Ok'. The WMS layers of interest can then be dragged into the ArcGIS table of contents.

For QGIS: Click 'Layer'; 'Add WMS/WMTS Layer' and click 'New'. Next copy and paste the WMS link for the layer of interest (found via the link above) into the 'URL' box. Click 'Ok'. Click 'Connect'. Select the 'Image Encoding' of your choice and click 'Add'. The layer will now be added in your QGIS Canvas.

It is also possible to load WMS layers into R using either 'Leaflet' and the 'addWMSTilesor' function or by running R alongside GRASS and using the 'r.in.wms' function.

How can I use these tools to decide where to plant trees?

Our 'Where to plant trees' leaflet

(<https://www2.gov.scot/Topics/marine/Publications/TopicSheets/tslist/treeplant>) explains how you would use our complimentary models to inform tree planting. In brief this involves:

1. Using the outputs from statistical models (NMPI/WMS layers), which describe large scale (>km) temperature variability and climate sensitivity, to prioritise parts of your catchment.
2. Using the results from our deterministic models, which identify the processes controlling T_w and the effects of management actions (including shading by trees) at finer spatial scales (metres to kilometres), to inform precise planting locations.

We have tools in development that will streamline this process further by combining the SRTMN layers with the results of a simplified process based model to create a single prioritisation layer.

If you have any queries please contact temperature.data@marlab.ac.uk and someone from our team will be in touch.