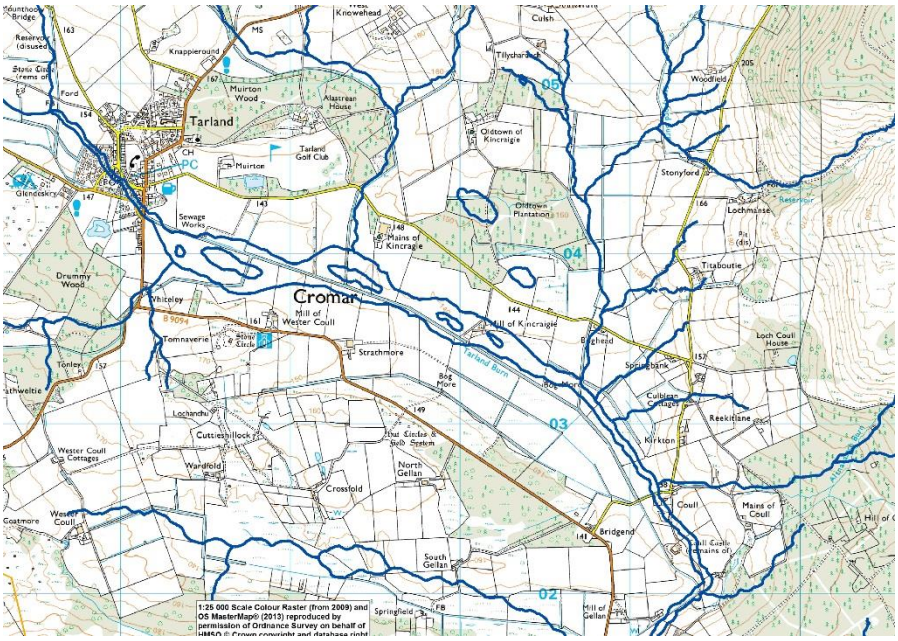

Tarland Burn 'Restoration'

Preliminary Monitoring Recommendations

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Internal Report CEH - JHI

Work Undertaken by CEH as part of the RESAS programme.

Cover figure indicates the historical course of the Tarland Burn overlain on its current course.

Contents

Background

The Tarland Burn is a small tributary of the river Dee in Aberdeenshire. Over the last 200 years a section of the river was straightened, over-deepened and disconnected from its floodplain. This will have reduced instream habitat diversity; removed instream bars, caused the loss of riparian wetland areas, contributed to the arterial drainage of the surrounding floodplain, changed the channel's flood conveyance capacity and significantly altered fluvial geomorphological processes.

There is a plan to meander the Burn and by doing so restore some aspects of the instream habitat with the primary aim of improving EU Water Framework Directive water quality targets which are fundamentally based on the ability of the system to support life; aquatic plants, invertebrates and fish. The current state of the biological quality is moderate while the support element, hydromorphology, is bad. It should be noted that current monitoring of BQEs is not especially sensitive to hydromorphological alteration and a 'moderate' status does not necessarily reflect the impact caused by the channel modifications made to the Tarland Burn.

As a 'restored' river provides services well beyond the support of WFD BQEs it is worth considering how other ecosystem services may also change with the restoration; these include flood conveyance, sediment storage, and enhanced riparian and floodplain habitats which both support biodiversity and can contribute to the appeal of the site to eco-tourists. A brief outline of research partners that could address these questions is identified in the section, 'Tarland as an experimental Platform'.

Before restoring – stressor & process analysis

'*if you build it* they *will come*' Kevin Costner Field of Dreams after Woodward 2015

There is a wide spread assumption that physically enhancing a river will improve BQE scores. This is often based on the false assumption that the only significant stress to the system is physical alteration. Many rivers are subject to multiple stresses. **Before planning and executing a restoration project it is important to identify the key stressors on the system.** Nutrient input and fine sediment delivery are two possible stressors to the Tarland Burn. Water quality is considered 'good' although the actual P levels should be checked as P is not limiting until it reaches quite low concentrations; 70 – 140 ugl^{-1}.

Restoration may also fail to meet desired objectives because there is a lack of suitable source populations to recolonise the site in the surrounding area. If this is the case introduction of desired species may be necessary. **The status of source populations of BQEs for re-colonisation should be considered**.

Standard measures of BQEs are not always sensitive to changes in assemblage which are a result of restoration work. This is a particular concern for benthic invertebrates where samples provide an aggregation of within site mesohabitats in a single sample. **Its best to provide 'Before' invertebrate data in a disaggregated form.**

It is also important to understand how the planned changes to a site may influence fluvial geomorphological processes. A channelized reach, like that at the Tarland Burn, has a clear local

impact on river form. However it will also have an impact on long term fluvial geomorphological processes which will shape the river at the site and beyond in the long term. **Those fluvial geomorphological processes should be considered as they can impact the selection and location of sampling sites.**

A flow chart indicating the assessment steps to determine hydromorphological process and condition can be found in REFORM Report D3.4, located here. (Baattrup-Pedersen, Annette; et al 2015).

Hypotheses to be tested

1. The re-meandering of the Tarland Burn will increase instream habitat diversity creating the conditions for shifts in the benthic invertebrate, macrophytes, fish and benthic algae (BQE) assemblages.
    a. There will be a measurable increase in the presence of riffle – pool type sequences and associated channel bars.
    b. Increases in mesohabitat (pool, riffle, macrophytes) will determine an increase in mesohabitat specific benthic algae and invertebrate assemblages.
    c. Localised diversification of the macrophytes community will be observed with increased shallow marginal habitat supporting specialist species in those areas.
2. The re-meandering will increase the dynamic nature of some instream features
    a. The establishment and colonisation of bar features by plants will be characterised by hydrologically driven events and plant colonisation dynamics.
3. The roughness characteristics of the site will be significantly altered.

Experimental Design

Irrespective of the parameter to be measured the basic experimental design recommended for restoration projects is a full BACI design; Before, After, Control, Impact. The fundamentally hypothesis is the restoration project shows a statistically significant difference in the parameter in question following restoration.

The 'impact' or 'treatment' site is the one where the restoration is undertaken, the control is a comparable, independent site and both are sampled before restoration and, ideally for a considerable period after restoration.

Sites are not replicates in the Tarland study where only a single site is to be restored. Sufficient independent replicates must be generated within sites and ideally need to be independent of one another and their number identified by power analysis of a pre-monitoring set of samples. Setting independent samples in a rivers is tricky as they are spatially interconnected but it is possible if care is taken.

Controls

The control can take two forms for a restoration project; a 'classic' control which is similar in all ways to the test site but does not undergo the restoration 'treatment'. In the case of the Tarland an ideal 'classic' control would be a straightened section of Burn in an adjacent catchment with similar landuse. The classic type of control is useful in proving the 'treatment' effected a change.

The second type of control is a 'target' control. A Burn which is currently in the desired condition is used as a control. It is used to provide an end point for the 'treatment' site. This is useful in river restoration projects as it can be some years before the system settles down post intervention and the trajectory of change at the restoration can be checked. Globally the environment is going through a period of rapid change and climate change adds uncertainty to the stability of any target system condition. In the context of these rapid changes it is advisable to identify a suitable 'target' control. Insh marshes has some of the desirable characteristics but is not an ideal match. The SERCON baseline survey may include some suitable locations.

The Site

The substrate changes from Tarland downstream to Coull. At Coull the trapezoid channel is circa 4 m deep. There is a small amount of *Sparganium erectum* in the channel with lush *Phalaris arudinacea* dominating the channel edge. Upstream at Tarland the substrate is gravel/cobble mix which, within half a mile starts to turn to fine sands. Downstream the sediment is all fine silt and sand. In the upper reaches of the site the bed undulates but doesn't meander. The shallows are pseudo-riffles while the deeper bits have finer substrate. Upstream there is patchy riparian tree cover while downstream there is no riparian tree cover and a wide buffer margin exists. As some of the desired habitats will be absent from the 'treatment' site it makes sense to carry out preliminary sampling and characterisation at the control site(s).

Parameters

Mesohabitat distribution

The distribution of mesohabitats should be mapped within the site. Substrate size within these mesohabitats should be measured. The method used is not critical to the assessment of BQEs and can be driven by resource and technical capacity. The ideal would be a lidar type survey while at the other end of the scale a walk through assessment using annotated hand drawn maps measured by pacing,

with visual assessments of the substrate on the Wenthworth scale. Sequential RHS surveys should be considered as a means of mapping the entire Tarland restoration reach and the control sites, if no other options are available.

Physical & Water chemistry

It is understood that JHI will continue their routine monitoring, which includes measures of discharge and water chemistry sampling.

Benthic invertebrates

To characterise the benthic invertebrate assemblages of the mesohabitats surber (330mm x 310mm) samples should be taken, with the substrate within the quadrat disturbed for 2 minutes. The number of surber samples required to indicate differences between mesohabitats should be ascertained by a pre-sampling regime in autumn 2016 or spring 2017. Ten samples per habitat type should be indicative and not all samples need be processed if the data are analysed in parallel with sample processing. Samples should be curated for future studies – for example those concerned with food web analysis. The locations of the samples should be random.

An annual sample of benthic invertebrates is sufficient to assess BQE status, either in autumn or spring. Beware comparing spring to autumn samples is not ideal and so once one season is chosen it will become the default sampling season thereafter.

It would be useful, if resource allows, to take kick samples using the standard SEPA methodology, for comparative purposes. These samples should taken in the same areas as the surber samples.

Macrophytes & riverine vegetation

There are few instream macrophytes at the treatment site. A random sampling of mesohabitats using 1m sq quadrats is recommended in a manner analogous to the invertebrate sampling, however it will need to be augmented by recording the instream conditions where the few macrophytes which are present are found. Measure velocity immediately upstream of the stand (0.4 depth 50s averages), substrate type (on the Wenthworth scale) in the stand and outwith separately. In addition 4 MTR surveys should be carried out per major habitat – upstream coarse habitat and downstream fine sediment habitat in the Tarland. The instream vegetation should also be mapped, CEH can provide detailed advice and examples on how this is best undertaken.

As a separate piece of work, at 200m intervals transects across the channel should be marked and the channel cross section described. The vegetation composition should be described using quadrats for each vegetation assemblage and the height and width of these vegetation bands recorded. Vegetation height should also be measured. Late summer is ideal for both forms of vegetation monitoring.

Benthic algae

Algae should be recorded, where possible using the standard SEPA monitoring technique. As parts of the channel are made of fine sediment where it is not practical to sample the substrate, it is proposed that Chlorophyll is extracted from fixed amounts of surface sediment. There are a number of methodological variants that could be used and the final choice should be informed by the extent of benthic algal growth observed in the spring / summer period. The standing crop of benthic algae will exhibit a strong seasonal pattern which will be overlain by the effects of instream growing conditions, disturbance from high flows are likely to reduce the crop. Avoid sampling where in the 2 weeks proceeding sampling instream flows have created mean cross sectional velocities in excess of 0.2 ms^{-1} , in the slower reaches.

Fish

Fish sampling is to be carried out by the local Fisheries Trust and the final sampling strategy will need to be determined through discussion with them. The whole of the Tarland and the proposed control sites are suitable for electrofishing – of relatively uniform dimensions and wadeable. Standard zippen estimates for reaches of fixed length should be recorded. The length of the reaches is best determined by the Fisheries Trust – on the proviso that the aim here is to have a reach of sufficient length to record the presence of fish at relatively low densities. The reaches should be located to represent the different bed substrate types. It does not make sense to sample all the individual meso-habitats identified for invertebrates, some are just too small. However the sections of coarser substrate at the upstream end and the sections of finer sediment at the downstream end of the Tarland restoration site should be represented in the sampling and replicate reaches of each sampled, ideally a minimum of 4 reaches per each of these two major habitat types should be sampled. The timing of sampling will be determined by the availability of the Fisheries Trust, however both the Tarland restoration site and the control sites should be sampled as close in time as possible.

Tarland as an experimental platform

The Tarland Project will, in time, represent a BACI experimental platform which is attractive to a range of researchers. Scotland, the UK and Europe, across the academic and governmental research sectors, can provide the research expertise to make full use of the facility. Full BACI designed approaches are rarely rare and therefore of widespread interest.

The site has potential to focus on more detailed analysis of BQE dynamics and also other system responses. There are various international actors who could be approached to involve the Tarland in broader networks of river restoration sites.

References

Baattrup-Pedersen, Annette; et al 2015 Guidance on how to identify impacts of hydromorphological degradation on riparian ecosystems. Deliverable 3.4 of REFORM (REstoring rivers FOR effective catchment Management), a collaborative project (large-scale integrating project) funded by the European Commission within the 7th Framework Grant Agreement 282656. European Commission, 187pp. (CEH Project no. C04493)