print [1] | pdf [2]

Welcome editorial by the REFORM Coordinator [3]

Dear reader,

Many colleagues find it hard to believe that nearly 4 years have passed and that the REFORM project will be ready within less than 3 months from now. It can also be considered a sign that the cooperation within REFORM has been very constructive and productive: if the work is inspiring and challenging then time flies. This is our one but last newsletter. It informs you about the well appreciated international conference and summer school, REFORM's contribution to economics of river restoration, Ph.D. research and one of our flagship case studies.

Since our previous newsletter the major event has been - of course - our final conference 'Novel Approaches to Assess and Rehabilitate Modified Rivers' attended by 170 participants from 26 countries. Two items refer to this event: 'Spotlight on River Restoration' and the interviews with two renowned colleagues from the United States who both presented a keynote during the conference: Stan Gregory and Phil Roni.

The conference was preceded by a summer school "Restoring regulated streams linking theory and practice" for students and early career researchers. The young participants very much liked the programme. We had the opportunity to record all lectures allowing a wide audience to make use of REFORM's results for assessing the hydromorphological status and impacts on ecological and restoration planning and evaluation. We invite you to use it and communicate it to interested colleagues.

The REFORM project also addresses the economic aspects of river restoration. Roy Brouwer (VU, Amsterdam) introduces one of our deliverables which focuses on the costs and benefits of restoration. There is not much experience across Europe with social cost-benefit analysis in this particular area. To this end, a guidance document has been prepared.

Despite the great advancement the WFD has brought to improve the ecological status of aquatic ecosystems, many regret the disregard of riparian zones and floodplains that are so important to river ecosystem functioning. Mattie O'Hare (CEH, Edinburgh) and Annette Baattrup-Pedersen (Aarhus University) coordinated the research for better guidance on how to identify impacts of hydromorphological degradation on riparian ecosystems.

In our serial on Ph.D. research within REFORM, Sabine Scheunig (IGB, Berlin) introduces her research on the interaction between aquatic macrophytes and hydromorphology. Different vegetation management approaches will be investigated to enhance self-sustainability, increase river health and reduce maintenance costs. Anette Baisner Alnoee (Aarhus University) investigates the role of restoration for stream ecosystem functioning: little is known on how stream restoration affects functional parameters such as stream metabolism, organic matter breakdown rates or nutrient uptake rates by different stream organisms.

The serial on REFORM case studies moves to Sweden where longitudinal connectivity has been improved and the amount of available salmonid habitat have been enlarged in the River Mörrumsån. It serves as an excellent example of how stakeholders with different interests joint forces and reached an agreement between fish migration and hydropower production.

The last 3 months of our project will be dedicated to finalising several deliverables, which will be ready on time and are particularly relevant for the application of the results of REFORM. Furthermore we organise a workshop on e-flows and sediment dynamics (Rome, 8-10 September) and give input to the ECOSTAT workshop on hydromorphology (Oslo, 12-13 October). In our last newsletter we will inform on these final results and how they will be available after REFORM has finished. I do hope you

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enjoyed reading our newsletters and that it helps and stimulates you to further explore our results.

On behalf of the REFORM team,

Tom Buijse, REFORM Coordinator

For further information:

Tom Buijse

REFORM final conference - a major success! [4]

From 30th June to 2nd July 2015, the **very successful final conference** of the REFORM project on 'Novel Approaches to Assess and Rehabilitate Modified Rivers' took place in the Conference Center Hof van Wageningen, in the Netherlands. This scientific conference was organized to highlight the importance of the benefits of river restoration and was opened by Jaap Kwadijk, scientific director of Deltares and Peter Glas, President of the Dutch Association of Regional Water Authorities.

An inspiring scientific programme

170 participants from **26** countries shared experiences, aspirations, challenges, analytical frameworks and new approaches to enhance the success of river restoration and to come to a better understanding of the consequences of hydro-morphological changes to the ecological status of running waters. The conference attracted universities and research institutes, environmental management organisations, NGOs and consulting firms in the field of river restoration.

15 keynote lectures from Europe, North America and New Zealand, **58 oral** presentations in breakout sessions and **38 posters** provided the ingredients and inspiration for **animated conversations** during the breaks.

Among others, evidence outlined by the conference speakers and participants gave fundamental insights into how rivers work, and presented a wide span of research from global to catchment and all the way down to the species level. It became evident that attention is shifting towards reflecting on the river in its **full scope including the role of the riparian zone and the floodplain for ecosystem functioning**. Keynote and oral presentations made a case for the need to develop more **process-oriented restoration measures**, and to consider hydromorphological changes and their evolution both in terms of space and time.

A lot of **inspiration** for further work was given by presentations on the **application of biotic indices for the assessment of river ecological conditions** as well as by a multitude of case studies presented on the achievements by restoration and mitigation practices in Europe and beyond.

The conference also provided a platform for exchanging experiences and ongoing work on the **challenging issues of socioeconomic assessments** related to river restoration, tools and strategies for more closely **linking science to the practitioner level.**

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Social programme and field trip highlights

The conference dinner was hosted in the hotel ‘De Wageningsche Berg’ offering wonderful views of the river Rhine and its floodplains as well as an inspiring speech by Professor **Geoff Petts** (Vice Chancellor of University of Westminster) on the **history of river restoration**.

The conference closed with a field excursion, attended by **100** people, to two 'Room for the river' projects:

- ‘Waalsprong’ at Nijmegen where flood protection and urban development are the main objectives (http://www.ruimtevoordewaal.nl/en/room-for-the-river-waal/ [5]) and
- The floodplain rehabilitation ‘Millingerwaard’ where in addition to flood protection improving nature is very important (https://www.ark.eu/kom-kijken/gelderse-poort/millingerwaard [6]; in Dutch)

The excursion came with exceptionally high temperatures, so the participants appreciated the farewell refreshing boat trip on the Rhine giving another perspective on the river and its floodplains.

Where to find further information

The conference proceedings can be found on the REFORM conference website [7].

We would like to thank very much all participants for their active participation, contributions and very positive feedback that made this conference such a successful event.

For further information:

Eleftheria Kampa, Ecologic Institute

Tom Buijse, Deltares

River restoration in US and Europe: Interviews with two of our conference keynote speakers [8]

Dr. Phil Roni and Dr. Stan Gregory were interviewed during the REFORM Final Conference and shared their views on river restoration in the US and Europe, on the importance of monitoring and the strengths of the REFORM project.

***Dr. Philip Roni** has 25 years experience as a fisheries scientist and leads the Watershed Program at the NOAA Northwest Fisheries Science Center in the US, where he directs the research of more than 20 scientists conducting habitat research. At the REFORM Final Conference [9], Dr. Roni gave a keynote speech on "Key considerations for measuring river restoration success: Lessons from Western North America".*

***Dr. Stan Gregory** is an Emeritus Professor and Distinguished Professor of Fisheries in the Department of Fisheries & Wildlife at Oregon State University. He has studied streams, rivers, and lakes in the Pacific Northwest, and has been leading studies of the Willamette River for the last 20 years. At the REFORM Final Conference [9], he gave a keynote speech on "Anticipating future trajectories of floodplain rivers and human systems in river restoration.*

In your opinion, what are the good elements about river restoration in Europe and in the US? How do the two continents compare to one another?

Stan: Overall, I think similarities between the two continents outnumber the differences. Our similarities in restoration approaches stem from the **fundamental principles** of hydrology, geomorphology and ecology, which are consistent between North America and Europe. The key

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concepts bind us together in a common framework; when advances are made in Europe which are based on those fundamental principles, we can apply them (or decide on the degree to which they can be applied) on our systems and vice-versa.

Over the last 20 years, there has been increasing interest and pressure in developing **interdisciplinary approaches** in northern Europe and in the US. We quickly learned that projects designed only by fish biologists were quite often weak, because they weren't strong in the physical sciences; likewise we saw projects designed by engineers that were ecological nightmares. On both continents, we have acknowledged the importance of interdisciplinary and multidisciplinary approaches.

We also rediscovered some of the same kind of principles, such as the **importance of conserving the healthy parts of our ecosystem**. Sometimes we rush too quickly to restore and to put a bandage on a damaged part of the system, ignoring that we are losing a healthy part of the system. Sound landscaping and sound river management is a balance of conserving the healthy parts and restoring the damaged parts. That recognition is emerging on both continents.

The other aspect that is emerging on both continents is that **people are part of rivers and landscapes** and that we cannot restore river ecosystems separate from humans. Future hope lies in the commitment of the people who live along those rivers and are committed to keeping them healthy. So there is growing recognition of the importance of societies as an integral part of restoration and not something external to it.

If I could point to some differences, I would say that **Europe** is doing particularly well, in terms of the **common context and structure provided by the European Union and the Water Framework Directive**. As a result of EU funding for environmental research, I see wonderful collaborations between different countries and different cultures. It is fascinating to observe cultural influence on the way we view approaches for restoration. There is a certain degree of consistency, but at the same time I can see a different focus of restoration in the Netherlands, different approaches in Germany or France and a different spin in countries like Italy.

In addition, the **development of information and data collectively** and under a common framework in the EU right now is impressive, e.g. data on types of rivers, geomorphology, hydrology, water quality, pollutants, barriers, dams, fish communities and macro-invertebrates. This is a strength that I don't see anywhere else in the world. The requirements for research projects like REFORM, to include a certain minimum number of EU countries and in the same time work with advisory boards with representatives from other continents is an extremely strong approach. In a way, I am quite envious of the integration, cultural and disciplinary diversity in EU projects!

In **North America**, one of the good aspects is the **growth in interdisciplinary research** which got an earlier and stronger start than in Europe. It is happening not because of a requirement but in a more inherent way, because we see the value in having multiple disciplines involved. Also some of the best **reviews and early synthesis of information** related to restoration came from the US. One of the things found in early synthesis work was that quite often we did not identify goals and objectives, and there was no guiding vision of restoration. I now see REFORM and other EU projects taking this earlier work to the next level. Another strength in the US, especially in terms of conservation and landscape level ecology, is the **long term ecological program** of the National Science Foundation with sites both in the US and around the world (including the Antarctica). These sites serve as an earth system observatory for a long period of time to support the development of long term ecological research.

Phil: It is hard to point out what is better in the US versus Europe. There are similar challenges to river restoration, and there are similar success stories in both places.

In the US, we have the general approach of giving **funding to local groups** to do restoration. The argument behind this grassroots approach is that the people that live in the catchments should know best. The problem with that is that local groups often do not have the larger perspective of the specific catchment or basin. Restoration tends to be very opportunistic, as local groups are constrained largely by what they can do quickly and who is going to go along with it (in terms of

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cooperation with land owners and local organizations). Local groups often start with a demonstration project with one land owner on board who is willing to cooperate and others follow later on, if they are convinced to join. And so it may take 10 to 15 years to get some of the really high priority projects realized and this is not because of technical obstacles. It is about education and building trust.

In addition, in the US, it is difficult to concentrate restoration efforts because there is the political tendency to **spread funding across a region** in many different watersheds. We call this the peanut butter approach, i.e. we get a little bit everywhere, instead of concentrating efforts in a few key watersheds. In my opinion, if we put a lot of effort for ten years into one place (watershed or sub-catcment), we could really make a big difference in terms of recovering a watershed or an endangered population of salmon or other fish. When you have a catchment of 500km of stream, and you restore 2 km, it is not enough to make a difference. It might make a difference in those 2 km, but you need to do much more to have a large response in the whole watershed, e.g. for a whole population of migratory fish, like salmon or eel.

In comparative terms, **in Europe**, you are **much ahead of us when it comes to floodplain restoration,** you've been re-meandering and pulling back levies for decades, because of the large amount of lowland rivers and floodplains that you have. We have spent a lot more time on smaller streams and headwater streams, because we have so a lot of public land mainly in mountainous areas. That has changed now and we are also working more on larger rivers.

Further, the **WFD in Europe is a very strong tool** and probably the most comprehensive legislation in the world for habitat protection. We are still struggling in that respect. The big drivers in the US are the Clean Water Act, which was passed in the early 70s and the Endangered Species Act (also in the early 1970s). The Clean Water Act looks at water quality and is primarily driven by temperature, pollutants, dissolved oxygen and sediment, but it does not include the biological components. A final point is that river restoration objectives in Europe try to integrate more people's expectations, while in the US, we tend to try to restore rivers to pre-European conditions because of the availability of large areas of public lands, shorter history of human impacts, and availability of relatively pristine areas to serve as a target.

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Photo: Placed logs in a stream to help restore in-channel habitat and reconnect floodplain wetlands in Washington State (photographer: Phil Roni)

Phil, in your keynote speech, you emphasized the importance of monitoring for successful restoration. How can we ensure that monitoring is done in a more efficient way?

Phil: In the US, the tendency has been to give funding to local groups to do the monitoring. The problem with this is that many local groups are very good at doing restoration, but not so good at doing the monitoring. It is done as an add-on, and over the years, a lot of money is spent on monitoring, but it does not really add up to much, because it is not well thought out.We have watershed councils and each one of those often does a different type of monitoring and uses different protocols. There is also not a lot of incentive for them to complete the monitoring and publish the results.

According to my experience, **monitoring is better done by a third party** that works together with the local groups. A third party can be a university, agency, or private consulting company. Sometimes private companies are more efficient at it, because they are more interested in doing what is defined in their contract. Universities often add their own research agenda on top of the monitoring and the monitoring programme can drifts away from its original objective (though this can happen with private companies as well!). The advantage of having a third party in charge of monitoring is also that it ensures monitoring gets the right priority and is done in a consistent way, especially in terms of having all data in a database that can be accessed by different groups later on.

Stan, on another note, could you give us your opinion on the key contribution of the REFORM project to river restoration science and practice?

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Stan: REFORM exhibits very well the strength of EU programs in terms of interdisciplinary and cross-cultural comparisons. It is also **very strong in developing guidelines for measurement approaches as well as conceptual frameworks** for looking at hydrology, geomorphology, vegetation and aquatic biological communities. As we project our guiding vision into the future when implementing restoration projects, there is always a very fundamental uncertainty: Will restoration be effective and are we doing the right things? The strength of the REFORM work is in clearly stating the fundamental concepts, the framework and the guidelines for measurements, to give people guidance and understanding why restoration might be succeeding or failing and how restoration can be improved.

Another advantage of REFORM's fundamental concepts clearly laid out in its framework is that this will provide **a foundation for scientists to take the next steps** beyond REFORM towards an even better approach for river restoration. The real question will be how much we will see people using the products of REFORM as a springboard, twisting them and creating something new in the next 5 to10 years.

As a final note, it is a challenge for REFORM to be able to release its concepts and results in a form that also decision makers, practitioners, the informed public and community groups can understand. However, I believe that REFORM has thought about this as well as including education as part of the project.

Phil Roni and Stan Gregory were interviewed on 30 June 2015 by Eleftheria Kampa (Leader of Dissemination and Stakeholder Involvement of REFORM, Ecologic Institute) at the REFORM Final Conference in Wageningen.

For further information:

Eleftheria Kampa, Ecologic Institute

REFORM Summer School – Lectures available online [10]

The REFORM summer school was held on 27-29 June 2015 in Wageningen, The Netherlands and was aimed at students and early career researchers, covering the topic "Restoring regulated streams linking theory and practise". Experts in a range of disciplines such as hydrology, morphology and ecology addressed key topics for cost-effective river rehabilitation planning, discussing problems and solutions. The 3 day programme was interactive, it encouraged group discussions and participants applied theory to practice by drafting a restoration strategy. The summer school was attended by 12 participants.

Careful planning of the course has made it possible to use the course outputs for those interested in teaching river restoration, wherever river or stream restoration projects are available. The complete PowerPoint presentations [11] and the video-recorded lectures are available online (see Summer Course | REFORM Rivers | 2015 [12]) and can be used for teaching and training purposes.

DAY 1- FIELD VISIT

Participants were taken to two contrasting restoration projects, Hierdense Beek and Lunterse Beek. During the field visit experts overviewed the reasons for river degradation and the restoration

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options applied at each of the sites. Participants were encouraged to ask questions and initiate discussions to solve problems and produce strategies to meet specific environmental and societal objectives.

Site 1 Hierdense Beek (Photographer: Tom Buijse)

The Hierdense Beekis a lowland stream situated on the north site of the Veluwe; the largest push moraine in The Netherlands. It does not meet the requirements of the EU Water Framework Directive, with main problems being the desiccation of wetland nature causing the stream to incise, pile planking, straight stream path, too much discharge dynamics, fish migration bottlenecks and high nutrient levels. Restoration measures were selected according to the “Building with nature” concept, to make use of natural processes as an alternative to constructing instant solutions. The main measures applied at Hierdense Beek were to shallow the stream by introducing sand, insertion of dead wood to increase structure, restoration of historical meanders, restoration of the natural spring sources by filling excavated channels and better use of natural depression as inundation areas.

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Site 2 Lunterse Beek (Photographer: Tom Buijse)

Lunterse Beek is a relatively small stream degraded by water quality problems, channelisation, widening and deepening. Furthermore, land use changes have resulted in deforesting, urbanisation, agriculture and river regulation. Due to these changes the water barely flows and almost stands still in summer. Maintenance is another disturbance factor, several times a year all vegetation, dead trees and sometimes sediment are removed. Two sites were visited at Lunterse Beek:

Upstream project: Wittenoord

The goal of the restoration program was to introduce moderate discharge dynamics and stable, diverge habit patterns through hydrological and morphological measures. The main measures were reduction of the depth and width of the creek, creation of an inundation zone and the introduction of dead wood.

Downstream project: Wolfswinkel Klein-Engelaar

The goal was to convert the straight and deep channel to a meandering shallow stream and bring back flow velocity and variation. In summary, a historical stream was reconnected to the river, during high flow water can flow over a division structure and access the main river reducing peak flow in the newly meandered section. The river was also reconnected to its flood plain.

DAY 2 - LECTURES

During the second day of the programme participants were taught how to plan restoration schemes, considering two main planning stages 1) catchment scale and 2) project specific scale. The theory for assessing degradation, identifying suitable restoration measures and other stages of the planning process were taught and discussed. A number of tools and guidelines for best practice, to measure performance and determine appropriate targets for river restoration were discussed through a sequence of lectures:

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- Restoration planning, Prof Ian Cowx
- Hydromorphological Framework, Prof Angela Gurnell
- Hydromorphological assessment, Prof Massimo Rinaldi
- Biological assessment, Dr Christian Wolter
- Hydromorphological degradation and impact on biota, Dr Nikolai Friberg
- Selection of restoration measures, Dr Jochem Kail
- Applying REFORM, Dr Gertjan Geerling

Lectures were recorded and are available for viewing on the video channel of STOWA [13] (Netherlands Foundation for Applied Water Research) under the title: Summer Course | REFORM Rivers | 2015 [12].

DAY 3 – PLANNING RESTORATION SCHEMES

In groups, participants planned restoration schemes using the knowledge they acquired from the previous two days. Each group chose one of the restoration schemes from the field visit and discussed current restoration measures and possible options for their improvement. They were also encouraged to use the REFORM WIKI [14], a knowledge and information web-based tool developed to guide practitioners through the planning stages of river restoration. The Summer School ended with participants presenting their restoration schemes and a fruitful discussion.

One group of summer school participants preparing a presentation on restoration schemes (Photographer: Tom Buijse)

For further information:

Natalie Angelopoulos (UHULL)

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Cost-effective restoration measures that promote wider ecosystem and societal benefits [15]

Introduction

River restoration projects make use of scarce public funds, and two important policy questions therefore are: (1) how to select between alternative plans for river restoration based on their cost-effectiveness and (2) how to convince policymakers and the public that river restoration provides value for money? Economists have developed methods and tools that aim to inform on the societal costs and benefits of public investment projects such as river restoration. The first question can be answered with the help of a cost-effectiveness analysis, while the second question is answered with the help of a cost-benefit analysis (CBA). However, despite the existence of many manuals on the calculation of costs and benefits of water related projects, no specific guidance exists related to river restoration. There is also not much experience across Europe with social cost-benefit analysis in this particular area. To this end, REFORM researchers developed a guidance document (D5.2) on '*Cost-effective restoration measures that promote wider ecosystem and societal benefits* [16]', targeted at practitioners, that takes account of the specific characteristics of the costs and benefits of river restoration.

Key methodological issues in the estimation of river restoration costs and benefits

The guiding principle underlying a CBA to inform policy and decision-making is rather simple, namely that the net benefits (i.e. total benefits minus total costs) of a river restoration project should be positive. If not, the costs exceed the benefits and it would hence not be beneficial to carry out the project. To get to a comparison of costs and benefits of river restoration projects, one has to go, however, through a number of important steps and sometimes make heroic assumptions, as outlined below:

Steps in cost-benefit analysis (Brouwer and Pearce, 2005):

1. Problem definition
2. Definition project and baseline scenario ('with' and 'without' situation)
3. Identification of exogenous developments
4. Estimation of investment costs and running costs
5. Identification of project impacts
6. Estimation and valuation of project impacts
7. Set-up cost-benefit balance sheet
8. Sensitivity and uncertainty analysis

One of the key methodological issues in carrying out a CBA for a river restoration project is found in the *ex ante* assessment of the causal link between the restoration measure, its hydrological and ecological impacts, and the final effects on the delivery of ecosystem services and their economic valuation.

The question what the local ecosystem and wider societal benefits of river restoration are, as for example depicted in the picture below, is often not easily answered. This requires insight in the interaction between hydro-morphological and ecological processes on the one hand, and the identification of different beneficiaries of the river restoration project and the plurality of values they may hold for river restoration on the other hand. The broader societal value is often not just found in the recreational value of a restored river trajectory to local visitors, but may also be related to important indirect values such as reduced flood risks downstream or the value attached by people

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living outside the restored area to the mere fact that a river's integrity is restored, maintained or kept intact. The latter is also referred to as so-called 'non-use' values by environmental economists.

The difficulty in measuring and quantifying such non-use values in monetary terms is much harder than the direct, tangible use benefits such as increasing fish catch rates (provisioning service), indirect use values such as a river's improved nutrient or storm water retention capacity (regulating services), or its recreational use benefits (cultural service).

Figure 1: Restored river Chiese in Italy (Source: Panoramio.com)

Other challenges include in step 2 the definition of the baseline or reference scenario 'what would happen with ecological quality and ecosystem services over time *without* the restoration measures' or the assessment of the broader economic costs of changes in, for example, flow rates on commercial shipping or hydropower generation. The latter make up the so-called opportunity costs of river restoration, i.e. the benefits that will be foregone when restoring river stretches. Related to this, an important question in the context of the European Water Framework is when costs become disproportionate.

Costs of river restoration

Water policies are often evaluated primarily on the basis of their financial or budgetary costs. These are the financial means and monetary flows needed to carry out river restoration projects over a certain time period to pay for the labour, machinery, fuel and other material costs. These financial costs can generally be assessed relatively easily compared to the broader economic costs of river restoration, related for instance to shipping or hydropower. The deliverable addresses the important question what costs of river restoration projects should be accounted for and how should they be assessed? There exist various and partly overlapping classification and assessment schemes. The WFD embraces the concept of 'full cost' assessment that would include the above mentioned direct financial costs, the costs associated with damage to the water environment, associated costs caused to other users and the opportunity costs of water use.

In D5.2 a practical cost typology has been developed with an emphasis on the distinction between recurring and non-recurring costs in order to allow for insight into how costs develop over time. An example of non-recurring costs of river restoration is to carry out the restoration works at a single

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time, through "one-off" measures. A river restoration project may, however, also require significant future maintenance (recurring costs), which are often not budgeted for.

Estimating the wider array of non-recurring and recurring costs and taking into account discount rates and depreciation forms the basis of a proper cost assessment. After the respective cost data have been gathered, they can inform a cost-effectiveness analysis to support the selection of the least cost-way to restore alternative river stretches or different rivers.

Benefits of river restoration

The calculation of all costs and benefits, including environmental effects, often also referred to as the broader social costs and benefits, is a more difficult task. Social CBA is a widely applied method for evaluating public policies, since government interventions are often related to the provision of public goods, having an impact on society as a whole. Such impacts should consequently be valued and evaluated from society's perspective, not only from the perspective of the investor like a government or water authority. Restored or 'natural' river corridors typically have the potential to provide a wide range of ecosystem services. It is the wider social value attached to these ecosystem services that is often missing in information that aims to support river restoration policy and decision-making.

Many of these ecosystem service benefits related to restored rivers can only be estimated in monetary terms using non-market valuation techniques. Examples include the travel costs of recreational visitors to restored sites or the use of so-called stated preference methods where visitors and also non-visitors are asked in surveys for their hypothetical willingness to pay (WTP) for river restoration benefits. This WTP is used as an indicator of the economic 'non-market' value attached to the goods and services provided by restored river systems to society as a whole.

A limited number of such non-market valuation studies exists, which were summarized and synthesized in a structured way in a meta-analysis in the deliverable D5.2. Four groups of variables were identified that represent different determinants of the variation in the nonmarket values found in the literature, namely (i) the characteristics of the ecosystem services provided by river restoration, (ii) the characteristics of the river and the location where the restoration took place, (iii) the socio-economic characteristics of the population of ecosystem service beneficiaries, and (iv) the characteristics of the valuation methodology. The mean WTP value in these existing studies is €70 per household per year (in 2013 price levels), while the median value is just over half of this, namely €43 per household per year. This implies that a wide variation in the values is found in the existing literature. This is illustrated in Figure 2 at country level, where mean WTP varies from €11 for Korea to €118 for Scotland. The values demonstrate at the same time another important challenge in making costs and benefits comparable: contrary to the unit costs of river restoration measures, which are expressed per m, m^2 or m^3, the associated unit values for the benefits are expressed in euros per household per year.

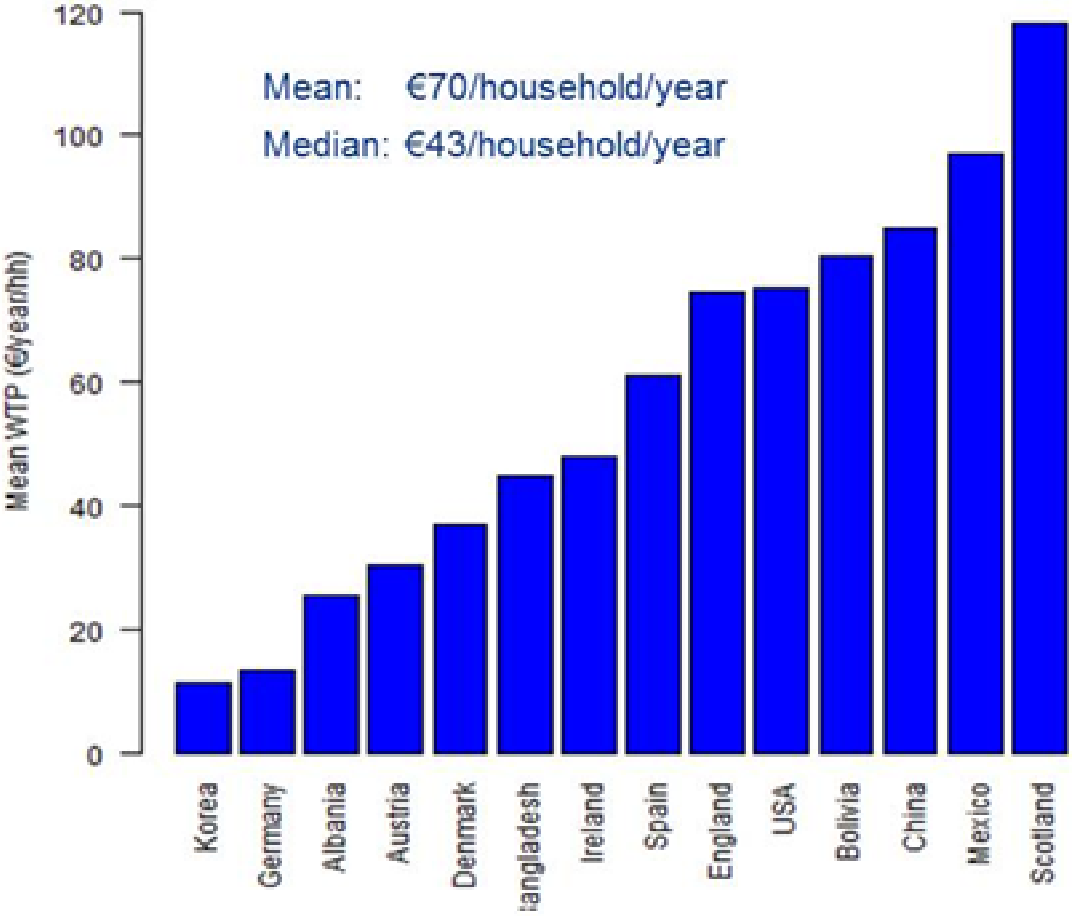

Figure 2: Mean willingness to pay (WTP) for river restoration found in the existing literature across countries (Brouwer et al., 2015)

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Onno Kuik, VU Amsterdam

What's wrong with my river? [17]

How does one tell *what's wrong with one's river*, hydromorphologically speaking, that is? Sometimes the issues are clear at the first glance. For instance, one might commonly assume that a concrete lined channel will have depleted biota and that some restoration work will be necessary before it can reach good ecological status. In other occasions the degradation issues might not be so evident. In such cases, first appearances can be misleading and a few complications may arise.

The recently produced deliverable D3.4 of REFORM, a Guidance to detect impact of HyMo degradation on riparian ecosystems *[18]*, addresses such possible complications and includes guidance on how to identify impacts of hydromorphological degradation on riparian ecosystems. In addition, many of the findings gathered in the document are directly relevant to assessing in-stream conditions. The deliverable is written with end-users in mind and includes a generic 5 step approach to understanding impact. The deliverable includes lessons learned from several good case study examples which illustrated and inspired the 5 step approach.

The history of hydromorphological impacts is written in the landscape and on maps. In this regard they differ from, for instance, nutrient pollution where one must use models to hindcast the pre-impact condition. Good quality maps date back to the early 1800s for many parts of Europe and they will have been updated over time, charting a river's response to hydromorphological degradation. Aerial photographs can supplement map data. The first step of our approach is the assembly of such data to create a timeline for the river. In addition to the purely physical features one can often identify areas of wetland associated with a dynamic interaction between river and floodplain. Some of the changes to rivers in Europe have been so long in existence and so extensive that there is no longer any local knowledge of what the original condition of the system was.

There is another area where hydromorphological impacts differ from nutrient pollution. Hydromorphological alteration (e.g. a dam or a channelized section) may impact a number of different hydromorphological processes. Those impacts can take time to develop, which is another good reason to look at historic data. There are some relatively common syndromes which can be identified. For example, rivers below dams often have reduced flooding, this can lead to vegetation encroachment (see Figure 1) which can be so drastic as to make the river change its channel type (e.g. from braided to single thread). In this and other processes, vegetation can play a key role. Riverine vegetation is not just a biological quality element; it interacts with fluvial geomorphological processes to structure our river habitats.

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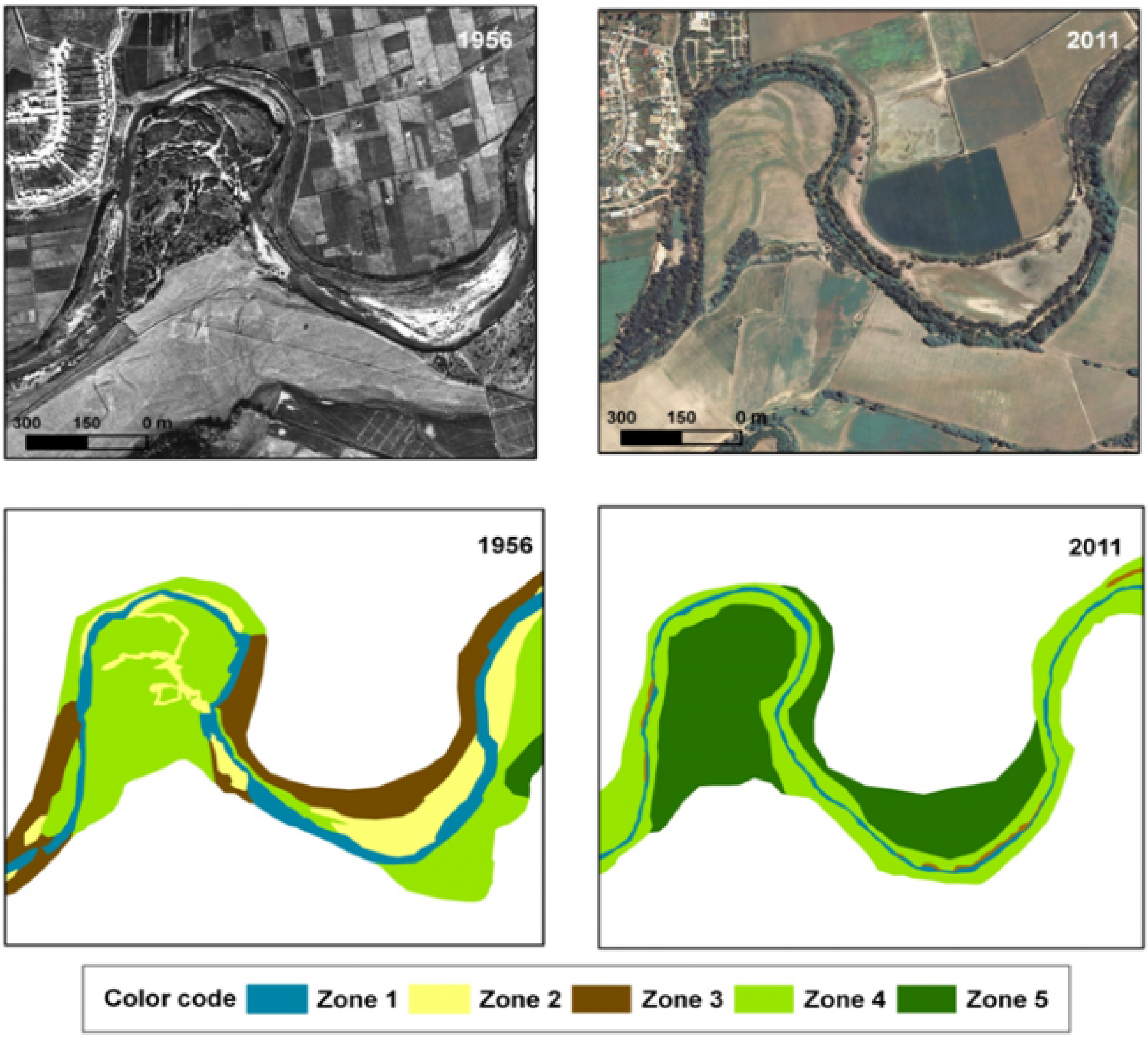

Figure 1. The River Guadalete Spain. The site was subject to damming upstream shortly after 1956. Vegetation encroached. The vegetation zones are based on Gurnell et al. (2014b) and indicate significant differences in the interactions between vegetation and hydrological processes over time (Photographs and diagrams from REFORM partner UPM).

The next step in our plan is to understand the cumulative impact of anthropogenic interventions on hydromorphological processes over time. A key step is identifying what river type one's system would be under natural conditions and what the river type is now.

The next steps include understanding the biota that are supported under natural conditions. For lowland river types in particular one needs to look widely for a biota in good condition, as the changes are so widespread. A decision then needs to be made regarding what is achievable and desirable. That decision can now be made in the context of correctly understanding the physical processes at play. Here we recommend physically modelling the planned remediation, if you have the resources! The details of how one fixes their river must be grounded in a thorough understanding of their system and the steps we describe facilitate that understanding.

REFORM deliverable D3.4 also includes some intriguing studies that deepen our understanding of how diverse biota are supported by hydromorphology. From the Danube delta we learn the importance of connectivity between the main channel and floodplain lakes in supporting a diverse fish fauna. Lessons from the Scottish study elucidate how riparian invertebrate communities respond to flooding and riparian vegetation structure. The implications for management of these systems and our other findings are discussed in the report.

As we move forward and more and more rivers across Europe undergo restoration, our knowledge will grow and fresh challenges will be met. For now though there is a simple, if challenging, set of guidelines to work on. To all stakeholders, good luck with your endeavors.

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PhD research in REFORM – Interactions between aquatic macrophytes and hydromorphology in rivers [19]

About "PhD research in REFORM"

In the newsletter items dedicated to PhD research in REFORM, PhD students introduce the topic and the initial results of their research.

Introduction

The distribution of aquatic macrophytes strongly depends on the physical conditions of the river. Macrophytes act as ecosystem engineers, influencing flow velocity, water depth, sediment scouring and sedimentation. Furthermore, they play a vital role for other biota in river ecosystems, providing food and shelter for many macroinvertebrates and fish. Yet, only few restoration projects involve post-project monitoring of aquatic macrophytes. Therefore, there is a lack of understanding how macrophytes respond to restoration measures over time, which is essential for restoration projects to sustainably meet their aims.

Objectives

The main goal of this research is to better understand the interactions between aquatic macrophytes and river hydromorphology with a focus on restoration. In this way, the work is meant to contribute to increase the effectiveness of river restoration. Moreover, different macrophyte management approaches will be investigated to enhance self-sustainability, increase river health and reduce maintenance costs.

Approach

An extensive literature study has been conducted to summarise the different aspects of the interactions mentioned above, especially in restored river reaches.

To promote the added value of post-project monitoring of macrophytes in restoration projects, an analysis of macrophyte responses to different kinds of restoration was performed. The study covered 20 restored river reaches across Europe. To avoid general conclusions being restricted to the dispersal area of certain species, the focus was set on growth forms.

Figure1: The lowland river Spree near Mönchwinkel, Brandenburg (Germany) (Photo: Jan Köhler)

Macrophytes displace water and increase roughness in the river, so cutting aquatic weeds lowers the water level and increases the discharge capacity. This practice is regularly performed in the German lowland river Spree as a flood prevention measure. Conducted in an extensive way, this measure constitutes a severe interference with the fragile ecosystem (see Figure 2).

In a field experiment, our aim is to detect changes in the food web via stable isotope analysis after removing the macrophytes. In this method, the ratios of stable carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) isotopes of organisms are determined. This allows for a clear distinction between the primary food sources (e.g. aquatic and terrestrial plants, epiphyton) because of their different isotopic signatures, which depend on the nutrient source. Heavier isotopes (^{13}C and ^{15}N) are processed more slowly than lighter ones during metabolism and therefore become enriched in the organism. As a consequence, ^{13}C and ^{15}N accumulate in the food chain and the isotopic signature can be used as a tracer for the position in the food web.

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Figure 2: Staff of the local water management association removing mowed aquatic macrophytes from the river Spree, Brandenburg (photo: Jan Köhler).

Furthermore, we will quantify the limiting effects of shading by woody riparian vegetation on macrophyte growth. Aquatic vegetation mapping and light measurements in the river Spree will be conducted. Additionally, long-term data on the annual amount of macrophytes being removed from the river and on discharge being influenced by the cutting will be analysed. By combining these results with the insights gained on the shading effects of bank vegetation, we aim to demonstrate planting of riparian trees as the more environmentally sound option for macrophyte management in order to prevent floods.

Preliminary Results

So far, our review has covered 170 studies from across the world, in which we found quantitative data on the environmental requirements of 176 aquatic macrophyte species. Based on this compilation and further studies describing the influence of macrophytes on their environment, we were able to generally illustrate these interactions in an easily accessible way (Figure 3).

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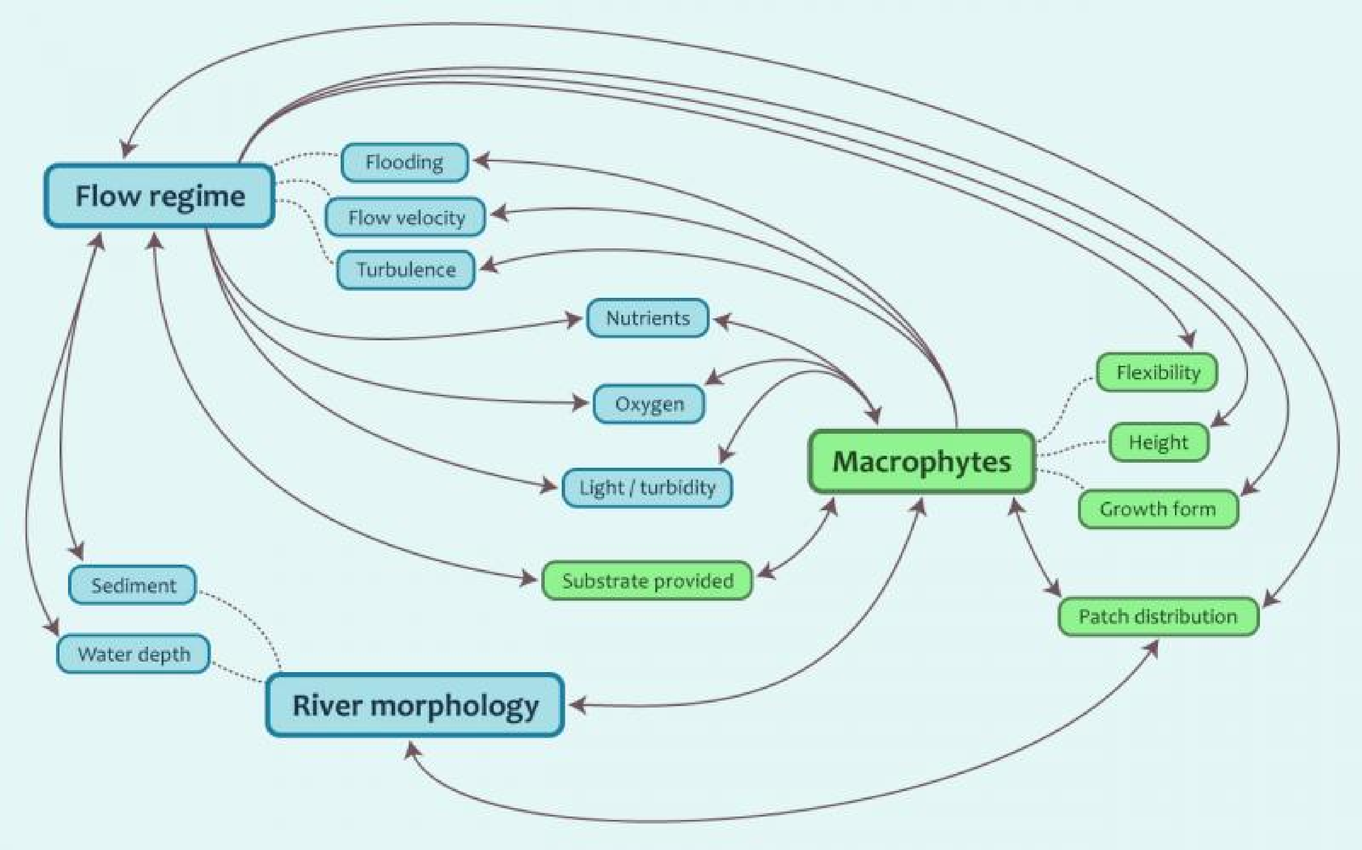

Figure 3: Outline of the interactions between aquatic macrophytes and river hydromorphology (figure: Sabine Scheunig).

Quantifying restoration effects, a higher species richness (about 92%) and a higher Shannon diversity (about 38%) of the helophyte community – emergent plants growing on the edge of water bodies where the water level fluctuates – were found in the restored reaches compared to adjacent degraded ones. This was observed especially in rivers where widening was carried out. The work also showed a correlation between these parameters and the improvement of hydromorphological variables. These results emphasise the suitability of helophytes as indicators for effective river restoration. In particular, they reflect the connectivity between the river bed and its adjacent area.

Stable isotope analysis for studying the food web in the river Spree is in its final stages. Field experiments to quantify shading impacts on macrophytes are underway.

Further links

REFORM Deliverable 1.3 [20]: Review on ecological response to hydromorphological degradation and restoration

REFORM Deliverable 4.3 [21]: Effects of large- and small-scale river restoration on hydromorphology and ecology

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PhD research in REFORM - The effect of stream restoration on metabolism, leaf breakdown rate and macroinvertebrate species composition [22]

About "PhD research in REFORM"

In the newsletter items dedicated to PhD research in REFORM, PhD students introduce the topic and the initial results of their research.

Introduction

It is well known that stream restoration affects the streams both physically and chemically (Violin et*al.*, 2011). On the other hand, little is known about how stream restoration affects functional parameters such as stream metabolism, organic matter breakdown rates or nutrient uptake rates by different stream organisms. Therefore, in order to comprehensively assess the effect of stream restoration, further research is needed that compares these functional parameters in restored versus impacted and natural streams.

Objectives

This PhD research had two main objectives. First, comparing functional parameters (metabolism and organic matter breakdown rates) and macroinvertebrate species composition in three different stream types: channelized, natural and restored streams.
Second, determining the dispersal potential of macroinvertebrates and macrophytes at 10 restored reaches to explore the possible impacts of restoration on the spatial distribution of biodiversity.

Approach

For the analysis of functional parameters, stream metabolism was measured at one location in nine streams (three for each stream type mentioned above). This was done by measuring diurnal changes in dissolved oxygen. Furthermore, organic matter decomposition as leaf breakdown was measured in six channelized, six natural and four restored streams by using two types of bags containing beech leaves; one with small mesh size for bacterial breakdown and one with bigger mesh size for both bacterial and macroinvertebrate breakdown (Fig. 1).

Macroinvertebrate samples were collected to compare species composition and the number of shredders in the reach in the 16 streams, and to examine if there was a link between the breakdown rate and the species composition. Macroinvertebrates were collected in the main stream channel and in the margin in order to identify different potential compositions in the two habitat types.

Dispersal potential (thereby meaning the potential of present species dispersing from nearby reaches) of macroinvertebrates and macrophytes on the restored reaches was studied by comparing species composition on the reach with species composition upstream and in neighbour catchments.

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Figure 1: The two types of leaf bags used for measuring leaf breakdown rate (photo: Anette B. Alnoee)

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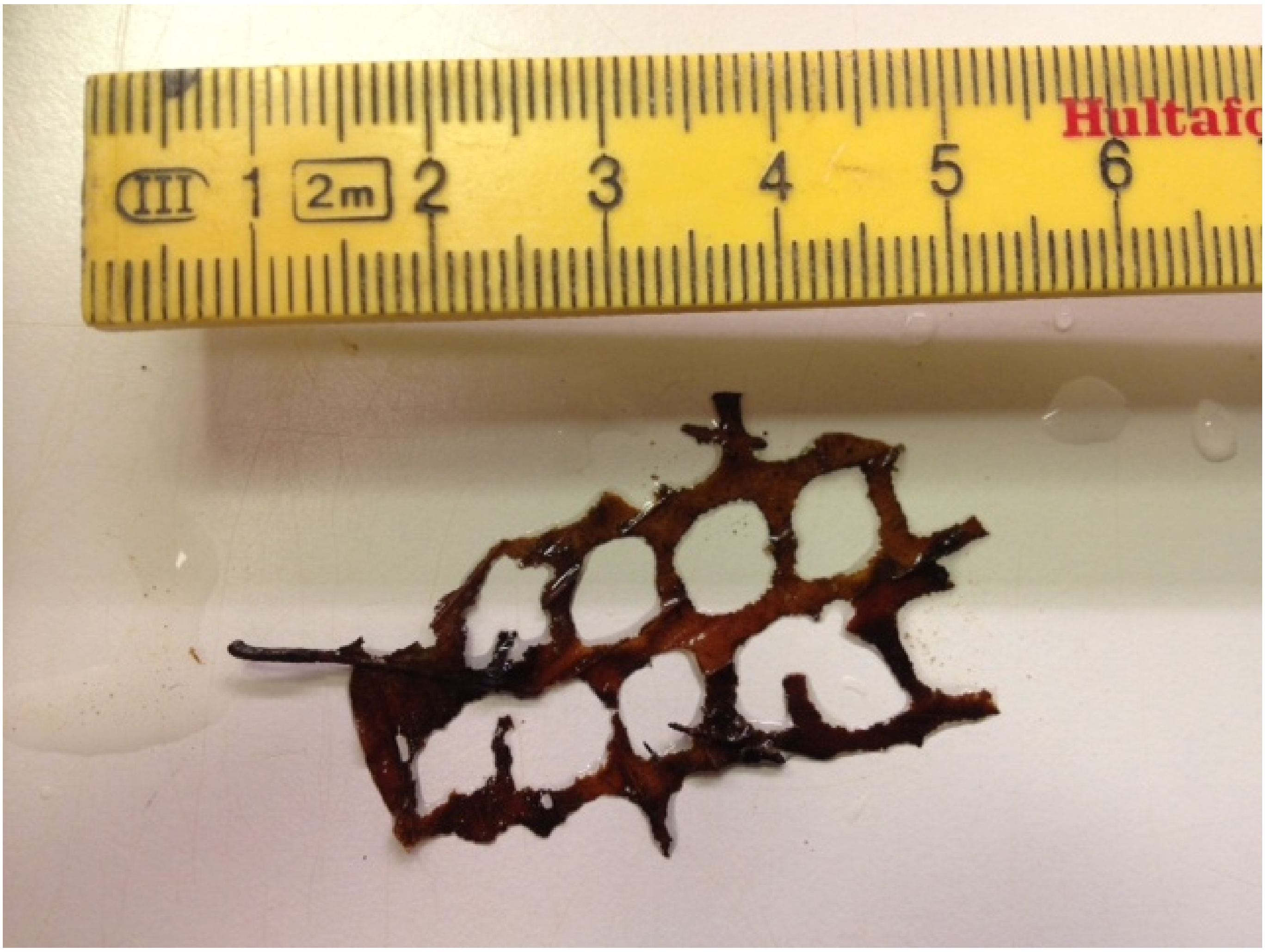

Figure 2: Holes occurring in a leaf from the bag with bigger mesh size (photo: Anette B. Alnoee)

Preliminary Results

Preliminary results show that there were no differences in metabolism between channelized, natural and restored reaches. Furthermore, there was no difference in breakdown rates between the various reaches. This was found for both types of leaf packages (big or small mesh size). Other factors were controlling the metabolism, such as the cover of all plants and number of submerged and emergent plants. Parameters affecting leaf breakdown rate were nutrient concentrations, substrate type and catchment size.

On the other hand, macroinvertebrate species had the tendency to differ in composition between the channelized, natural and restored reaches for samples collected in both the main channel and in the margin (Fig. 3, o vs Δ and □) , but there was no overlap of macroinvertebrate species between the main stream channel and the margin habitat was found (Fig. 3, blue vs. red dots).

Preliminary results on the dispersal potential of the macrophytes and macroinvertebrates are not available yet.

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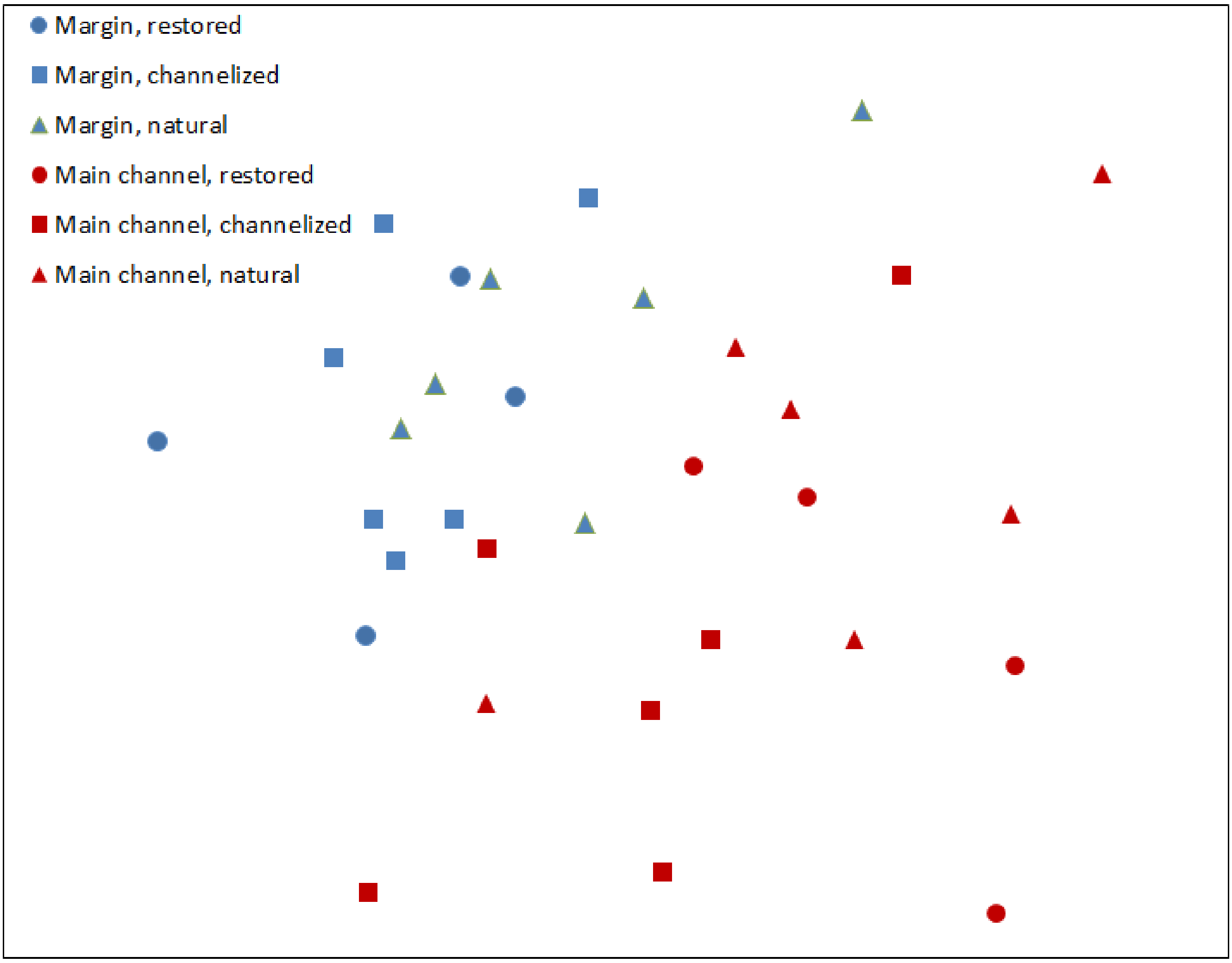

Figure 3: Non-metric Multi-Dimensional Scaling (NMS) showing macroinvertebrate data for channelized, natural and restored streams in the margin and main channel habitats of the streams. NMS is a measure for how identical or different the macroinvertebrate composition in two streams or sampling places are, so two plots close to each other are more identical than two plots far away from each other.

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Violin C.R, Cada P., Sudduth E.B., Hassett B.A., Penrose D.L. and Bernhardt E.S. (2011) Effects of urbanization and urban stream restoration on the physical and biological structure of stream ecosystems. *Ecological Applications*, 21, 1932-1949.

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Restoration of longitudinal connectivity and salmonid habitat in River Mörrumsån (Sweden) [23]

River Mörrumsån is located in southern Sweden, flowing into the Baltic Sea, and is one of the REFORM river restoration case-study sites. River Mörrumsån has an annual mean flow of 27 m^3/s at the river mouth and a catchment area of 3369 km^2 (figure 1). The ecological status of the river is moderate in its lower reaches. This qualification results primarily from a lack of verified reproduction of the freshwater pearl mussel (*Margaritifera margaritifera*), since the parameters for nutrients and chemical status (excluding Hg) are good.

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[24]

Figure 1. Location of the restored site at Hemsjö in River Mörrumsån in southern Sweden.

The river has long been an important reproduction site for Baltic salmon and sea trout. The main bulk of Baltic salmon migrates to the Gulf of Bothnia and into the large rivers of northern Sweden (and to a lesser extent to northern Finland) to spawn. However, nearly 50% of the total smolt production of the sub-population of Baltic salmon that spawn in rivers flowing directly into the Southern Baltic is believed to originate in River Mörrumsån. It is probably **the best-known salmon-bearing river in Sweden** and sports fishing for salmon and sea trout in the Mörrumsån is internationally renowned.

At the same time, the Mörrumsån has been substantially exploited for hydropower production similar many Swedish rivers. This started in the late 19^{th} century and continues to this day, creating numerous migration barriers and greatly reducing the reproduction area available for spawning runs of migrating anadromous salmonid fish. In 1945 the hydropower dam in River Mörrumsån located nearest to the sea (Marieberg hydropower plant) was equipped with a functioning fish ladder. Since then, the lowermost of the two hydropower plants located upstream from Marieberg, at Hemsjö (Hemsjö nedre hydropower plant), became the first definite barrier for fish migrating from the sea. The Hemsjö nedre hydropower plant is located ca. 20 km from the river mouth. In the old water rights agreement no minimum flow was set for the natural channel connecting the two hydropower stations at Hemsjö, meaning that the river section could run completely dry at times.

Restoration measures

In the early 1990s the Swedish board of fisheries raised the issue that longitudinal connectivity should be restored at Hemsjö to increase the available spawning area for Baltic salmon and sea trout in the river. After negotiations, predominantly outside of court, with the energy company owning the hydropower stations at Hemsjö and the legal right to utilize this river stretch for hydropower production (E.ON), an interest group (The River Mörrumsån Fish Conservation group) was created with the joint goal to protect and promote the salmonid fish population in River Mörrumsån. E.ON was a partner of this group together with the Swedish Agency for Marine and Water Management

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(formerly the Swedish board of fisheries) and several other Swedish government agencies and private corporations. After years of planning, testing and evaluating different restoration strategies, the construction of two fishways (nature-like partial width rock ramps) at Hemsjö nedre and Hemsjö övre hydropower stations started in 2003 (figure 2). A new water rights agreement was also established for Marieberg, Hemsjö nedre and Hemsjö övre hydropower stations. Among other provisions, the agreement stipulated that:

- A minimum flow of 0.5, 1 or 3 m^3/s (depending on the season) should be directed through the fishways at Hemsjö övre and Hemsjö nedre hydropower dams and through the natural channel.
- For five weeks in the spring, when the smolt migrate to the sea, hydropower generation should be reduced to half the available potential or ceased completely at the three hydropower stations.

The cost for these restoration measures and the reduction of hydropower output in the affected stations was shared by the partners of the interest group. The River Mörrumsån Fish Conservation group has remained active after the intial restoration measures. This has facilitated e.g. the installation of automatic fish counters at the Marieberg and Hemsjö övre fishways as well as the addition of hundreds of cubic meters of salmonid spawning gravel to areas in the former dry channel between Hemsjö nedre and Hemsjö övre and to other stretches of the river in 2004, 2005, 2006, 2010 and 2012 (figures 3 and 4).

Figure 2. Nature-like partial width rock ramp constructed at Hemsjö nedre hydropower dam in River Mörrumsån in 2003-2004. Photo by Frauke Ecke, SLU.

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Figure 3 + Figure 4: Overview of parts of the restored stretch in River Mörrumsån (left), also visible is the man-made channel feeding the Hemsjö övre hydropower station. To the right a photo of a restored stretch during a flow episode when more than the dictated minimum flow of 1 m^3/s has been directed through the natural channel. Salmonid spawning gravel was added here in 2010. Photos by Frauke Ecke, SLU.

Restoration success

Results from the automatic fish counters at Marieberg and Hemsjö övre fishways have revealed that on average about 50% of the spawning migrating salmonid fish that pass through the fishway at Marieberg hydropower dam continue upstream through the fishways at Hemsjö nedre and Hemsjö övre hydropower dams. On average ca. 550 salmonid fish (293-954) are recorded in the fish counter at Hemsjö övre each year (2007-2013). The creation of new migration routes at Hemsjö nedre and Hemsjö övre hydropower stations has opened up an additional 10 km of the river and increased the area available for salmonid reproduction with about 20 ha (equivalent to ca 50% of the total available habitat). Spawning salmonid fish have been observed on almost all of the gravel beds that were created in the former dry channel between the hydropower stations and upstream of Hemsjö after the restorations. Young salmon and trout have been caught by electrofishing (total 21 samplings in 2010-2012), sometimes in very high densities (>2 individuals/m^2).

Field sampling was carried out in a subsection of the restored stretch between Hemsjö nedre and Hemsjö övre as part of WP4 of REFORM. Results showed that several organism groups displayed a greater diversity in the restored stretch compared to a non-restored similar river stretch located further upstream, e.g. fish, macrophytes and benthic invertebrates.

The restoration has also been hailed in Sweden as an example of successful cooperation between private stakeholders and government agencies, or financial interests vs. environmental concerns, in ecological restoration.

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Mörrums kronolaxfiske [26]

REFORM WIKI [27]

VISS
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[24]

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