Sediment supply as a key control on habitat change during managed floods: a proof of concept

L'apport de sédiments en tant que contrôle clé de la modification de l'habitat pendant les inondations gérées : une preuve de concept

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RÉSUMÉ

Les inondations gérées ont été de plus en plus utilisées pour réhabiliter les écosystèmes fluviaux en aval des barrages. Recherches ont mis en évidence l'amélioration des écosystèmes après la gestion des inondations (restauration des plaines d'inondation, des zones riveraines, augmentation de la biodiversité, entre autres), cependant, la composante eau-sédiments, en tant que principal moteur des processus morphologiques fluviaux, n'a pas fait l'objet d'un argumentaire particulier. Cette étude a examiné comment les processus eau-sédiments et transport se déroulent pendant une inondation gérée et le rôle de l'apport de sédiments dans la constitution d'habitats physiques pour les poissons. La zone d'étude est la rivière Spöl inférieure, dans le Parc National Suisse, en aval du barrage d'Ova da Spin. Cette section de la rivière est particulièrement intéressante car le principal affluent, la rivière Cluozza, modifie le régime d'approvisionnement en sédiments dans la partie aval. Dans cette recherche nous, avons analysé et quantifié les changements produits par les inondations gérées de 2018 et 2021. L'approvisionnement en sédiments, les processus de transport et l'adéquation de l'habitat ont été les principaux arguments de cette enquête. Nous nous sommes concentrés sur deux sections de rivière, une située en amont et une en aval de Cluozza. Nous mettons en évidence l'importance du rôle des processus d'approvisionnement et de transport des sédiments dans la diversité morphologique des tronçons et dans la disponibilité des habitats des poissons dans les mêmes conditions de débit.

ABSTRACT

Managed floods have been increasingly used as an effective practice to rehabilitate river ecosystems downstream of dams. A handful of studies have evidenced the improvements of ecosystems after managed floods (restoration of floodplains, wetlands, and riparian areas, increased biodiversity, increased fish abundance), however, the water-sediment component, as the main driver of fluvial morphological processes, hasn't been a particularly focused argument. This study investigated how water-sediment and transport processes occur during a managed flood and the role of sediment supply in the constitution of physical habitats for fish. The study area is the Lower Spöl river, in the Swiss National Park, downstream of the Ova da Spin dam. This section of the river is particularly interesting as the main tributary, the river Cluozza markedly modifies the sediment supply regime in the downstream reach. In this research, we analyzed and quantified the changes produced by the managed floods of 2018 and 2021. Sediment supply, transport processes, and fish habitat suitability were the main arguments of this investigation. We focused on two river sections, one located upstream and one downstream tributary Cluozza. We evidence the importance of the role of sediment supply and transport processes in the morphological diversity of the reaches and in the availability of fish habitats under the same flow conditions.

KEYWORDS

Habitat, managed floods, morphology, mountain stream, sediment supply

1 INTRODUCTION

Aquatic habitat is heavily influenced by deposition and erosion processes, products of the stream's transport capacity, and the rates of sediment supply into the stream. These processes have been heavily modified by the construction of dams and reservoirs. Therefore, simulating the characteristics of natural flow-sediment regimes is key to restoring ecological functions. In the last decades, managed floods have been emerging as an effective method. Several studies evidence the benefits of managed floods on biota; however, they tend to overlook the role of the abiotic (flow-sediment) component.

In this study, we assess how fish mesohabitat and hydro-morphological characteristics change after a managed flood event in two nearby reaches that are separated by a tributary. This tributary markedly modifies the sediment supply regime in the reach downstream. We then attempt to relate the observed changes to the differences in sediment mobility during the managed flood that we compute through a simplified hydraulic modeling approach.

1.1 Study site

The catchment of the River Spöl is located in the central Alps and flows through Italy and Switzerland. Our study sites are located below the Ova Spin reservoir, in the lower- Spöl, where the river flows through a deep, rocky gorge with no major tributaries until its confluence with the River Cluozza. Most part of the Cluozza flows into a confined valley with steep slopes that provide large amounts of sediments. Our first site is situated 500m upstream of the river Cluozza, while our second site is located about 1.5km downstream of the river Cluozza (see Figure 1). Since 2017, product of an agreement among the hydropower company and state authorities, the Ova Spin dam releases yearly floods aimed at improving ecological conditions.

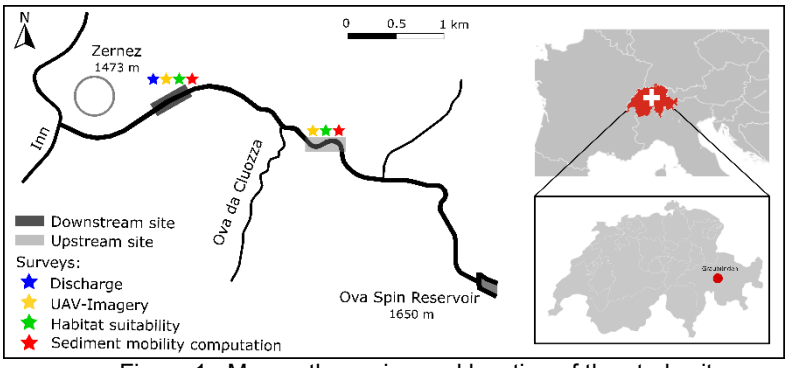

Figure 1.: Map or the region and location of the study sites.

2 METHODS

2.1 MesoHABSIM

Can be defined as a combination of data collection strategies and analytical techniques that allow a user to compute how much habitat is available for selected fauna under specific environmental circumstances. It defines Meso-scale units as areas where an animal can be observed for a significant portion of their diurnal routine, making use of a robust geomorphological classification (Hydromorphic units - HMUs) to define mesohabitats. It allows the assessment of temporal and spatial variability of habitat in response to changes in the flow and sediment supply regime.

2.1 Sediment mobility computation

First, we estimate the grain size distribution of the surface bed using the pebble count procedure. It consists of randomly selecting and measuring a minimum of 100-bed particles and developing a size distribution curve for each different geomorphic unit in the wet river channel. Then, we elaborated modeled bed load initiation using two different approaches: (a) Van Rijn-Rouse to estimate shield number, and (b) Barthust approach for the computation of the critical unit discharge.

2.2 Flow and topographic data

To estimate discharge, we used a combination of bathymetric, electromagnetic, and surface velocity radar measurements. As for the topographic data, UAV-acquired geo-referenced imagery was used to derive orthoimagery before and after the managed floods using Structure from Motion (SfM). The orthoimages were used to visually assess and quantify relevant morphological changes.

3 RESULTS

3.1 Hydromorphological characteristics

Surveys at both sections were carried out before and after flood at similar flow conditions (Figure 2). Results show that the managed flood was not able to significantly modify the stream. Distribution of HMU and wet areas remained virtually the same with slight variations in the distribution of water depths and velocities.

3.2 Fish habitat suitability

We modeled mesohabitat suitability for the brown trout (native) for both reaches. At the upstream site, pre-flood habitat conditions were already low, with approximately 25% suitable area. After the flood we observe improvements in habitat suitability, with an average increase of 40% more area. In contrast, at the downstream section suitable area for fish was basically inexistent. Post-flood, we evidence minor improvements in fish habitat. In general, fish habitat suitability conditions for the river at both study sites are extremely poor. Results can be observed in Figure 2.

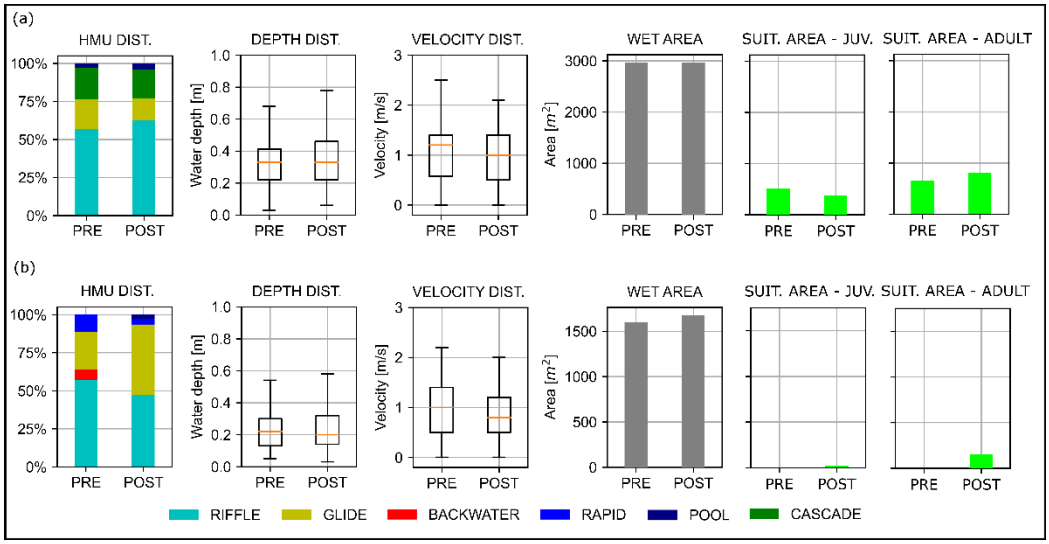

Figure 2. HMU, water depth, velocity distribution, wet area, suitable area for juvenile and adult brown trout - before and after 2021 managed flood. (a) upstream section, (b) downstream section

4 CONCLUSION

In this research, we studied the morphological and fish habitat dynamics linked to an ecological flood at two reaches of the same river subject to very different supply regimes. Our work shows that the flood was not able to significantly modify the reach upstream of the tributary, while downstream we observe strong variations in the distribution and arrangement of HMU. The upstream reach characteristics allowed for the incidence of suitable areas, yet the flood was unable to strongly modify morphological characteristics, hence, the creation or modification of new suitable areas. In contrast, at the downstream reach, the modified sediment supply regime coupled with the flood allowed for a high dynamicity of the riverbed, however, this combination was still not capable to develop nor maintain stable habitat conditions, mainly due to the absence of cover and refugia. Habitat suitability for fish in the lower Spöl seems rather insensitive to the main characteristics of the individual flood (magnitude, releasing scheme, duration), as it is mainly controlled by the strong disequilibrium between the high sediment supply from the tributary and the reduced transport capacity by the flow regime in the river.

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