Artificial floods as a restoration tool: Long-term responses in the Sarine floodplain and Spöl River, Switzerland

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Introduction

Flow and sediment regimes are fundamental drivers of river ecosystem dynamics. **Hydropower regulation reduces disturbance frequency and promotes stable residual-flow conditions**, with consequences for habitat structure and benthic communities. Artificial floods can reintroduce ecologically relevant disturbance, but the persistence of their effects depends on the disturbance regime. We compare long-term macrozoobenthos responses in two morphologically contrasting regulated rivers to assess the role of **artificial floods in sustaining ecological change**.

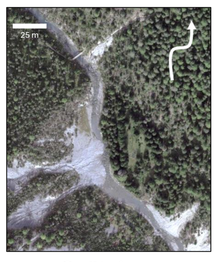
Study systems & Methods

The **Sarine** is a large **floodplain-type residual-flow river** with a pronounced sediment deficit and **irregular artificial floods since 2016**. The **Spöl** is a smaller **alpine mountain stream** with continued lateral sediment inputs and a **regular artificial flood programme from 2000–2016**. The system was affected by a sediment spill from the dam in 2013, and the flood programme was suspended after a PCB spill in 2016. Long-term seasonal monitoring quantified macrozoobenthos community composition and selected taxonomic orders in both systems. Biological responses were related to time since the previous flood, flood magnitude and duration.

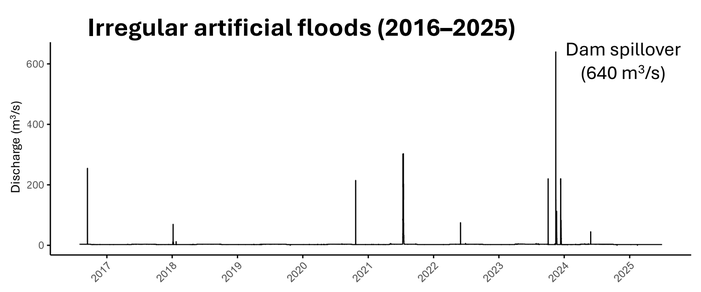
Different river types – contrasting disturbance regimes

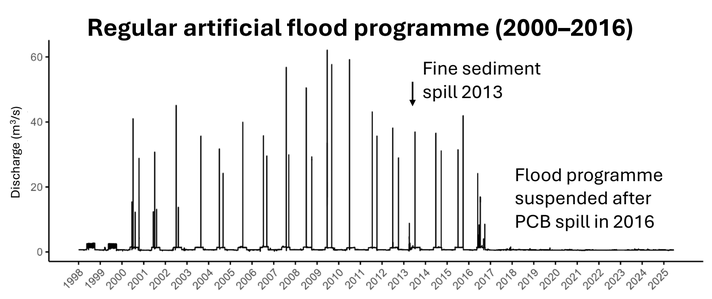
Sarine floods were irregular, including an exceptional dam spillover in 2023 (640 m^3/s). In the Spöl, the regular flood programme (2000–2016) was affected by a sediment spill from the dam in 2013, while a PCB spill in 2016 led to suspension of the flood programme.

Sarine floodplain



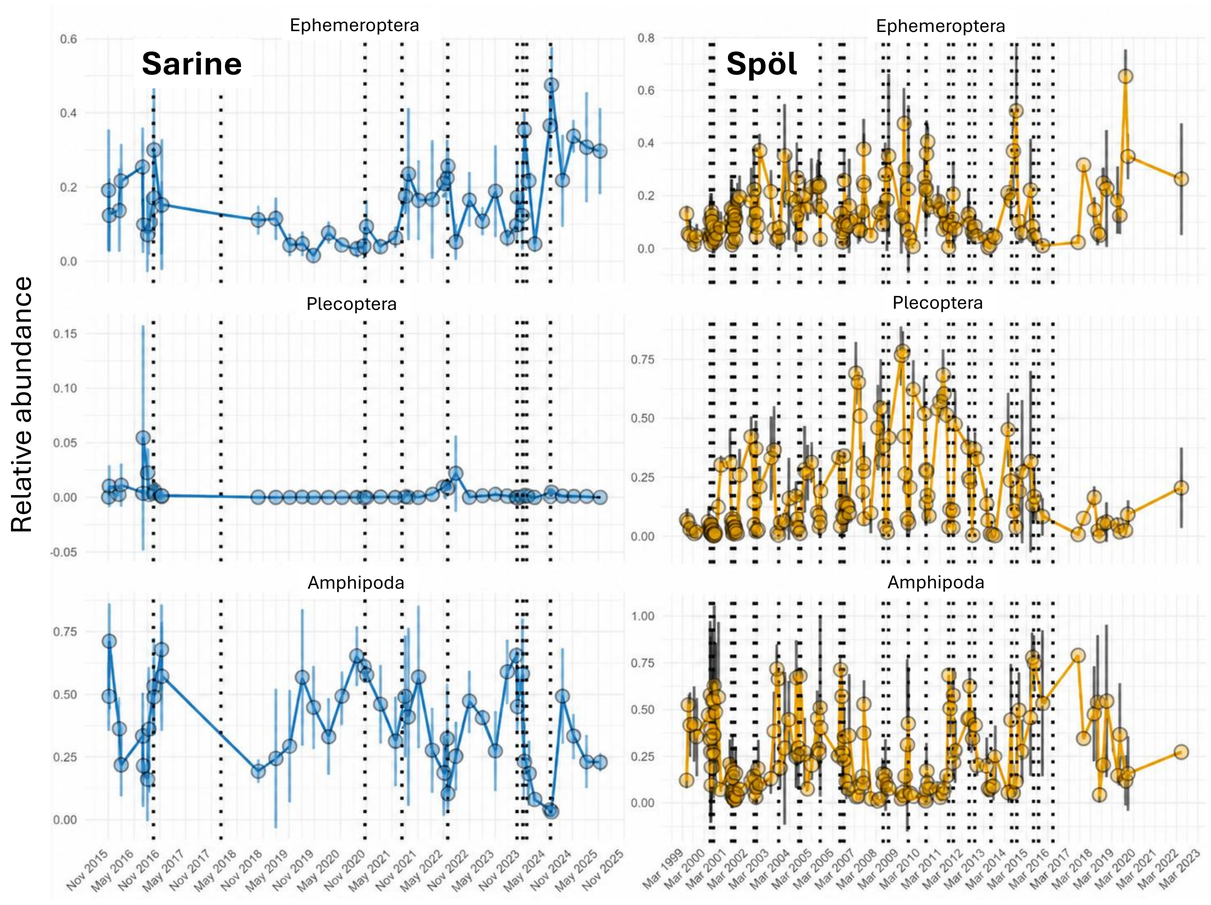
Spöl river





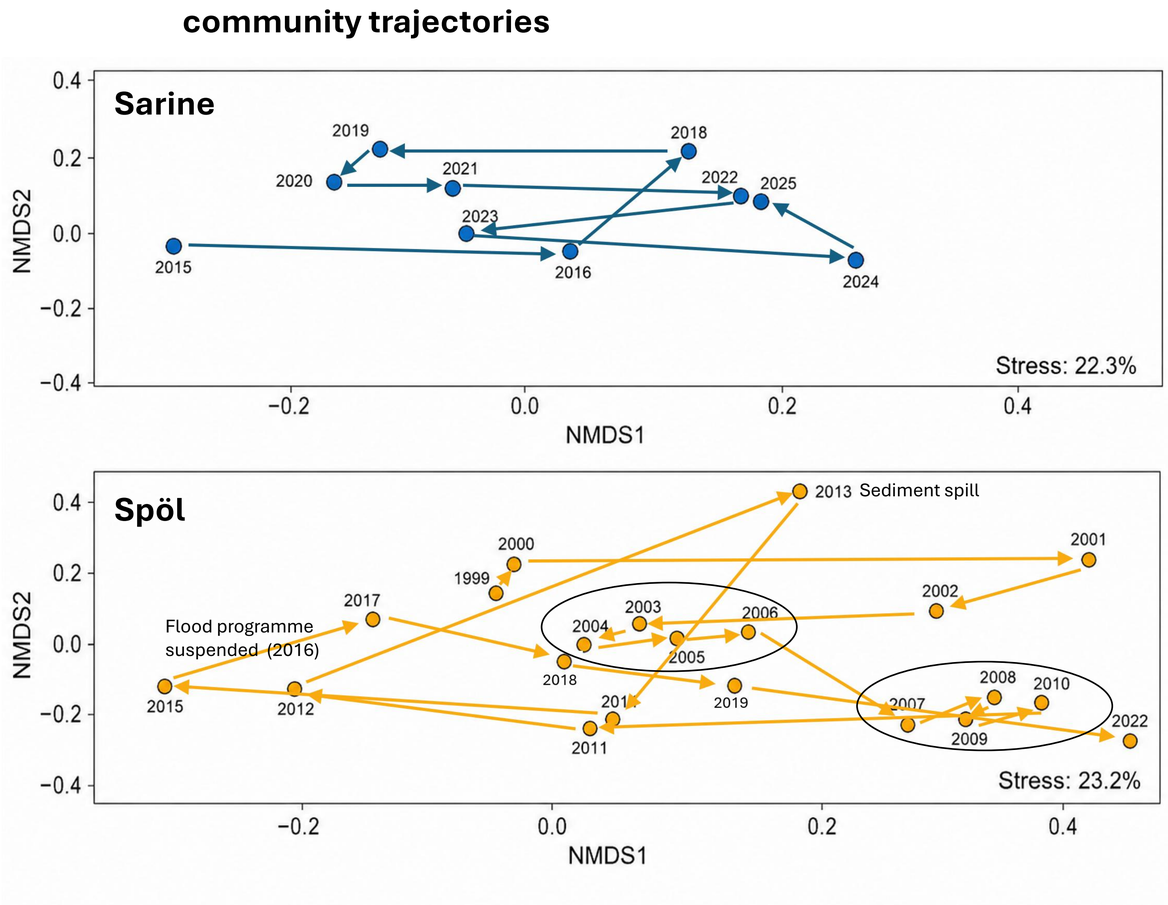
Results

Order-level responses: transient vs. maintained disturbance effects



Macrozoobenthos orders show contrasting responses to artificial flood regimes (dotted lines). In the **Sarine**, **irregular floods produce transient shifts**, with Ephemeroptera (more commonly associated with lotic conditions) increasing after disturbance, Amphipoda (more commonly associated with stable, low-flow conditions) recovering during longer stable-flow periods, and Plecoptera (more commonly associated with lotic conditions) remaining scarce. The strong response after the closely spaced 2023–24 events suggests that the high magnitude of the 2023 dam spillover may have contributed. In the **Spöl, recurrent floods maintained disturbance-driven conditions**, with Plecoptera becoming abundant during regular flooding and declining after flood interruption, while Amphipoda became more prominent.

Community responses: contrasting flood regimes shape community trajectories



NMDS trajectories show contrasting whole-community responses to artificial flood regimes. In the **Sarine**, community positions were strongly related to time since the previous flood (R^2 = 0.66, p = 0.003), indicating **clear disturbance–recovery dynamics**. In the **Spöl, distinct multi-year community states emerged**, particularly in 2003–2006 and 2007–2010 (circles). The 2013 sediment spill caused a marked deviation, followed by renewed community reorganisation. Following suspension of the flood programme after the 2016 PCB spill, community composition became more variable, indicating a less persistent community state.

Manage a flood regime – not individual flood events

Repeated artificial floods are required to sustain ecological change in regulated rivers. Long intervals between floods allow communities to recover towards stable residual-flow conditions, whereas **recurrent flooding can maintain disturbance-driven community states**. Because floods also mobilise and redistribute sediment, their effectiveness depends on the **sediment regime and sediment availability**. This is particularly important in sediment-deficient systems such as the **Sarine**, where a **regular flood programme must be combined with sediment replenishment** and adapted to local river morphology.