

Improving understanding of hydrological and biogeochemical processes controlling the effectiveness of two-stage ditches in reducing eutrophication

Experimental setup and preliminary results

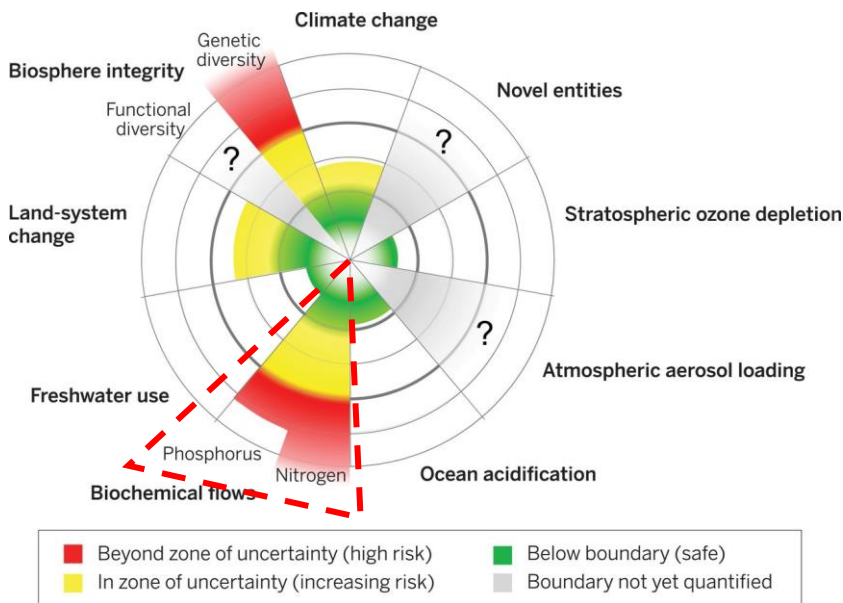
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Background

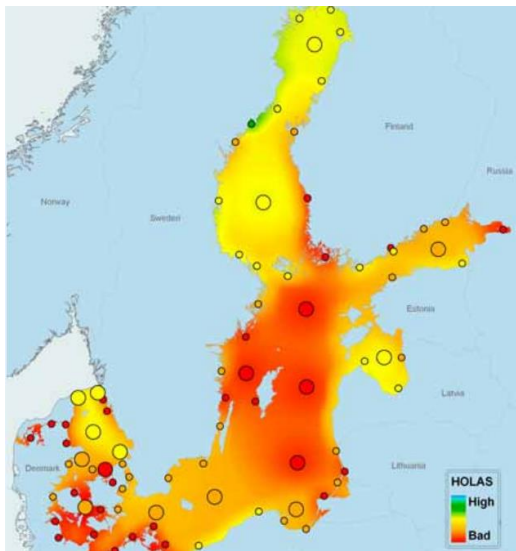


Steffen et al., 2015

The N and P load in aquatic ecosystems is globally exceeding the threshold for sustainable human development and is expected to increase due to more extreme weather with a changing climate

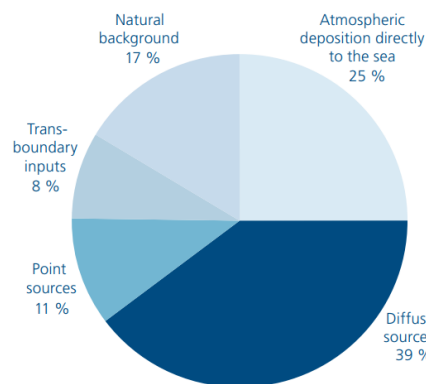
The Baltic Sea region show similar trends despite efforts to combat eutrophication since 1980s

Agricultural use of fertilizer is the main driver of diffuse N and P pollution into the Baltic Sea, requiring intensified mitigation efforts on agricultural land

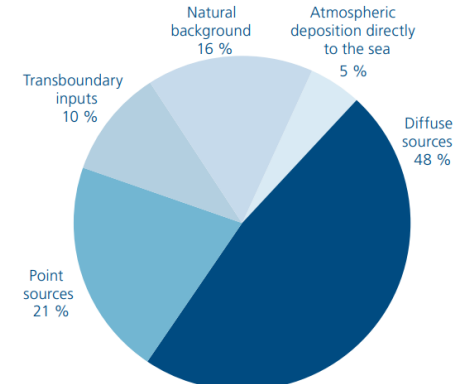


HELCOM, 2010

A Sources of nitrogen inputs to the Baltic Sea

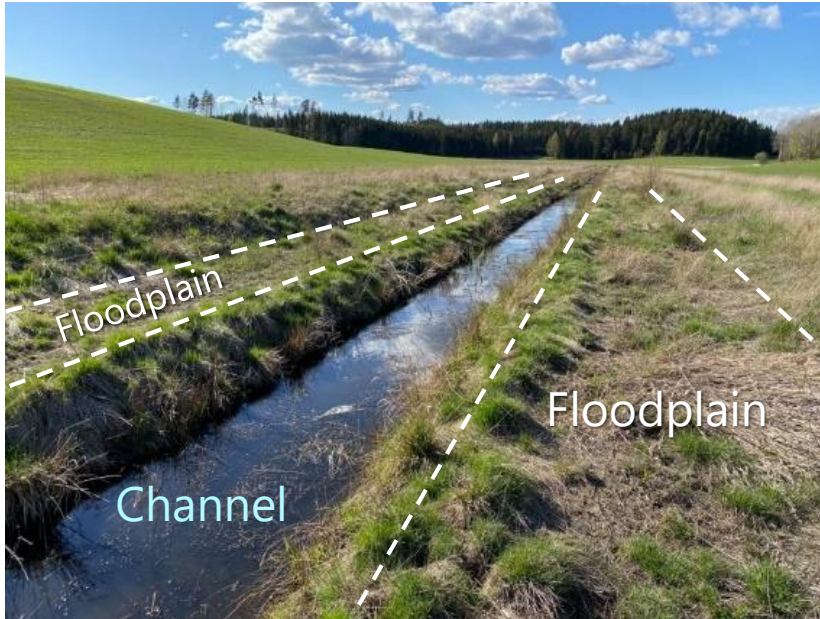


B Sources of phosphorus inputs to the Baltic Sea



HELCOM, 2010

Two-stage ditches



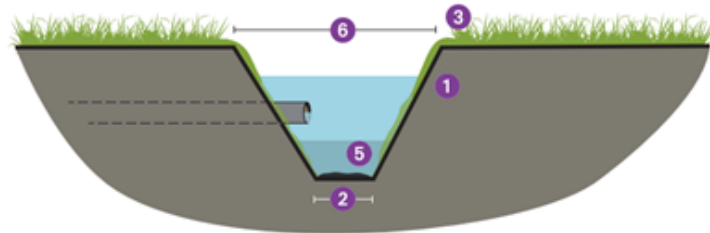
Hallberg, 2020

Two-stage ditches with associated floodplains is a novel mitigation measure in Sweden, aimed at increasing water retention in agricultural streams by distributing water onto floodplains during high flows

Studies from US Midwest have reported N, P and SS retention through sedimentation^{1,2,3,4}, denitrification^{3,5,6} and biotic uptake^{2,7} on floodplains

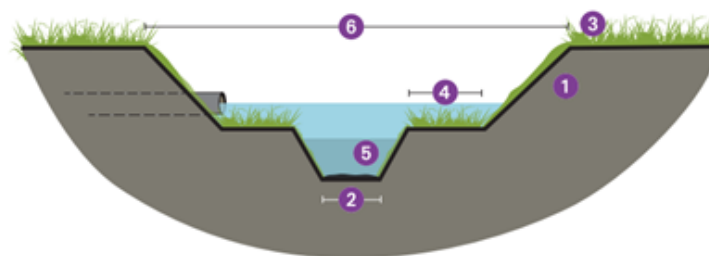
Two-stage ditches are further designed to prevent flooding and increase bank stability as compared to traditional ditches

a. Traditional ditch



- 1 Slope
- 2 Bed width
- 3 Ditch crest

b. Two-stage ditch



- 4 Terrace
- 5 Main channel
- 6 Top width

Jordbruksverket, 2016

- ¹ Davis et al., 2015
- ² Kindervater et al., 2019
- ³ Mahl et al., 2015
- ⁴ Hodaj et al., 2017
- ⁵ Roley et al., 2012a
- ⁶ Speir et al., 2020
- ⁷ Trentman et al., 2020

Are floodplains stable over time?



Eroded floodplains

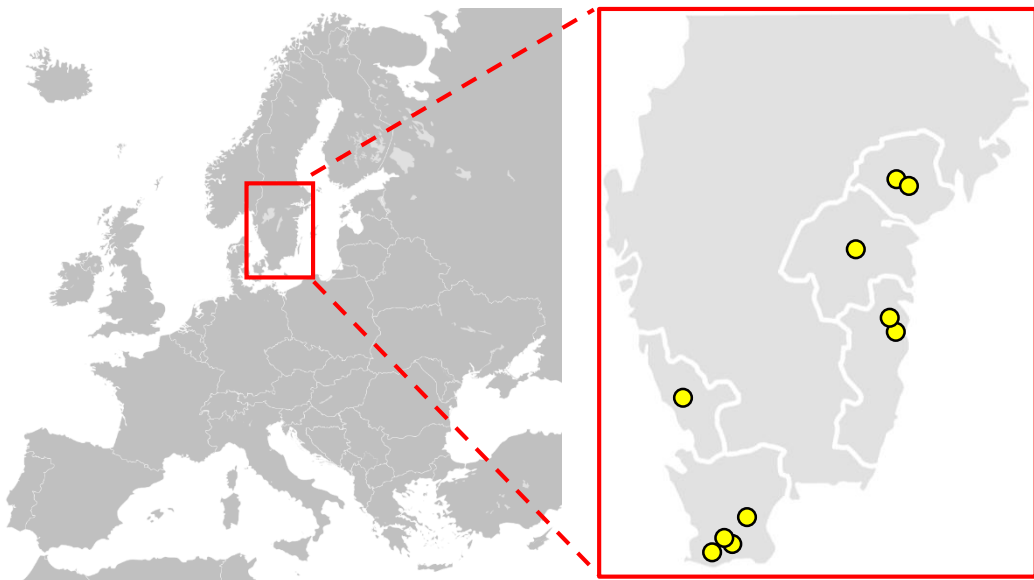


Observations in some Swedish two-stage ditches indicate problems with eroding floodplains, hampering their capacity to retain nutrients and sediments

In this project we will quantify changes in channel and floodplain geometry and link it to

- 1) Soil characteristics
- 2) Hydrology and climate
- 3) Vegetation establishment
- 4) Water quality

Evaluation of Swedish two-stage ditches

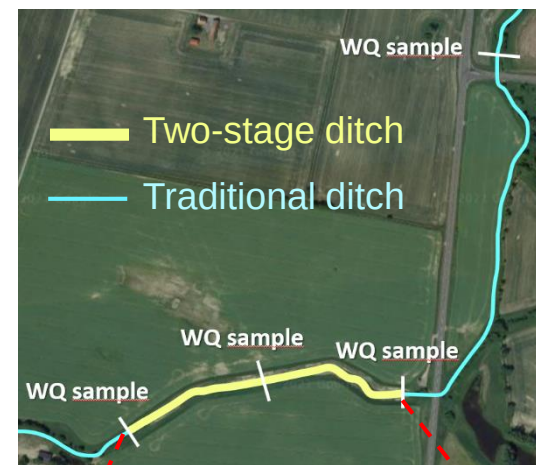


Construction of two-stage ditches in Sweden started in 2010, about 20 reaches exist in the country today

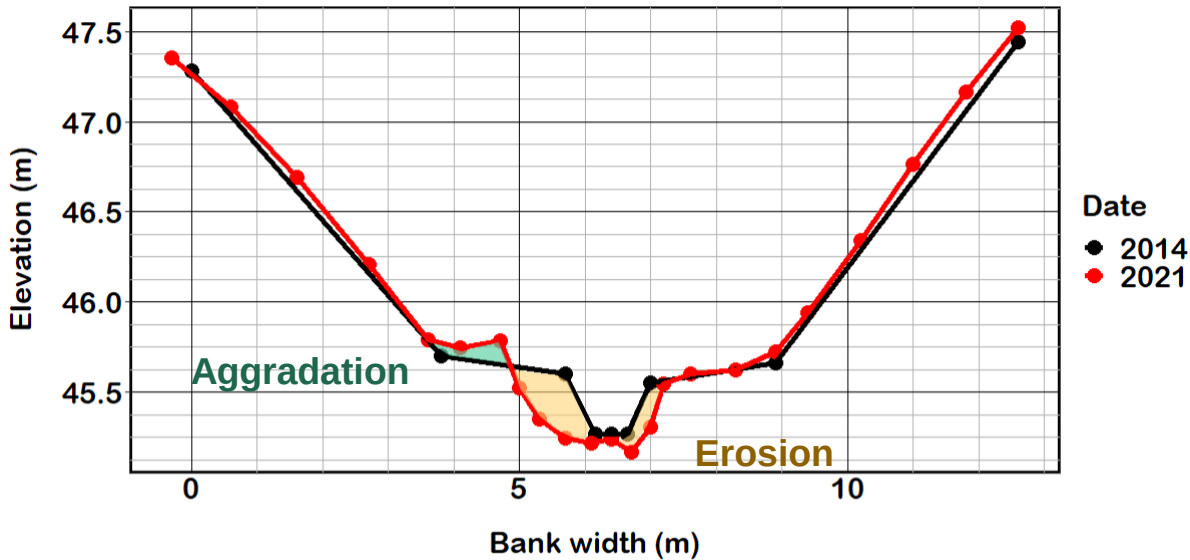
Our project is the first comprehensive evaluation of their nutrient mitigation efficiency and fluvial stability, comprising 10 reaches in Mid-Eastern and Southern Sweden

We have set up monthly water grab sampling (WQ sample), coupled with high frequency sensors to monitor water quality and flow over 3 years.

Existing cross section profiles since construction are compared with new profile measurements to determine changes in fluvial stability



Fluvial stability – method



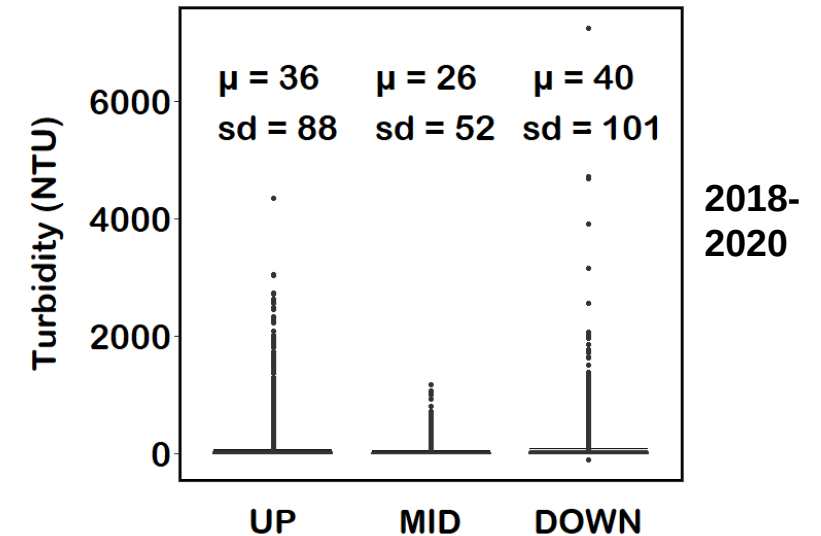
Changes in profile geometry since construction are calculated as cross section area for 10-15 profiles in each two-stage reach to determine if 1) floodplains are stable and promote sedimentation and 2) channels are stable and retain drainage capacity

In the example profile there is a net erosion for both channel and floodplains (preliminary result)

	Change in cross section area (%)
Channel	-71.2
Left floodplain	-9.5
Right floodplain	-0.3

This is coupled with high-frequency turbidity measurements

In the same stream as above there is high variation and no decrease in turbidity, indicating occasional resuspension of sediments at both up and downstream of the two-stage ditch





Acknowledgement



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We thank Sheryl Åström for assistance with field data collection

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<https://www.slu.se/en/departments/soil-environment/research/agricultural-water-management-/two-stage-ditches-in-sweden/>

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