Monitoring the effectiveness of connected ponds at fine sediment and phosphorus retention in a lowland agricultural stream

John Robotham, Gareth Old, Ponnambalam Rameshwaran, David Sear, David Gasca-Tucker, Helena Soteriou, James Bishop, Ann Berkeley, David McKnight, Joanne Old, Matt Childs

EGU21-7370 (Session HS9.2) *Contact: johrob@ceh.ac.uk*

Image: David Gasca-Tucker

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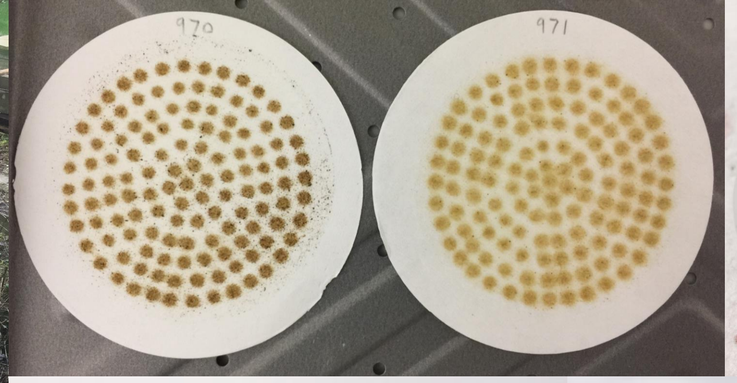


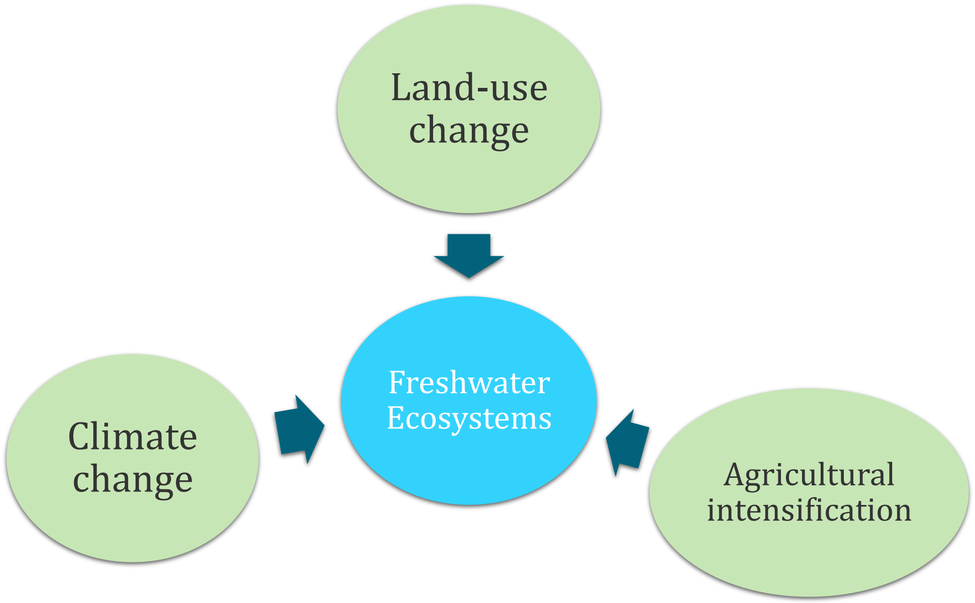
Context & Rationale

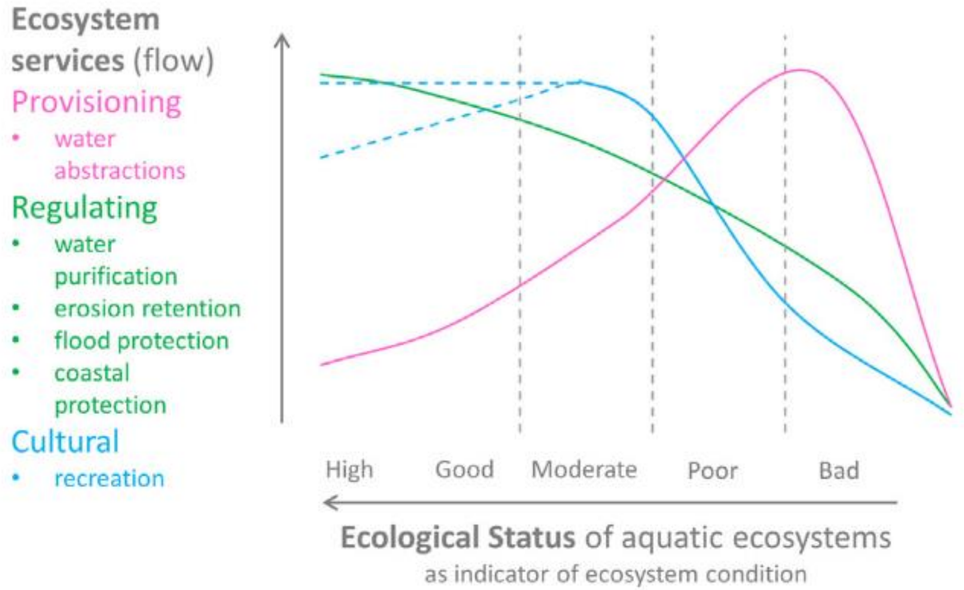
Key Issues:

- Diffuse agricultural pollution degrades stream water quality and ecological status
- Excess fine sediment and nutrient (P and N) loading from run-off
- Delivery of pollutants is intensified during storm events
- Climate change is predicted to increase frequency/magnitude of extreme events and thereby exacerbate P loading (Ockenden et al., 2017)

Research gaps:

- Are connected (on-line) ponds effective mitigation measures in different catchment settings?
- How do extreme hydrological events influence pollutant retention?





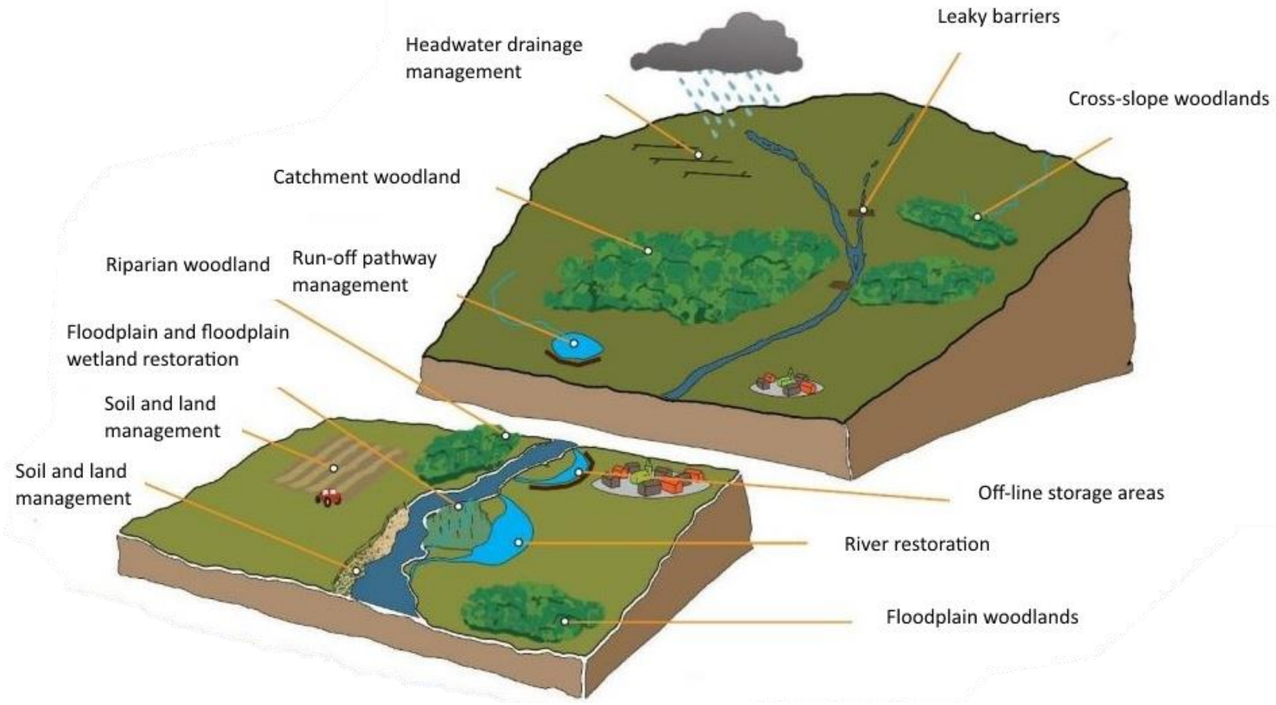
Grizzetti *et al.* (2019)

Study Aims

- Evaluate the ability of connected ponds to filter/trap sediment and P in runoff and streamflow and reduce contributions to downstream loads
- Quantify accumulation rates of sediment and P in ponds
- Identify potential controls on trapping and retention of sediment/P in ponds

This study is part of a PhD research project assessing the effectiveness of low-cost nature-based solutions (e.g. Natural Flood Management) to mitigate sediment and nutrient pollution in a lowland catchment.

Working With Natural Processes in catchments

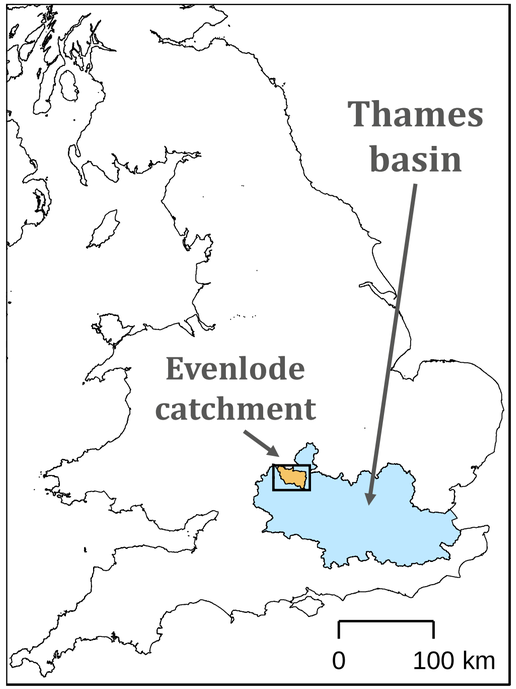


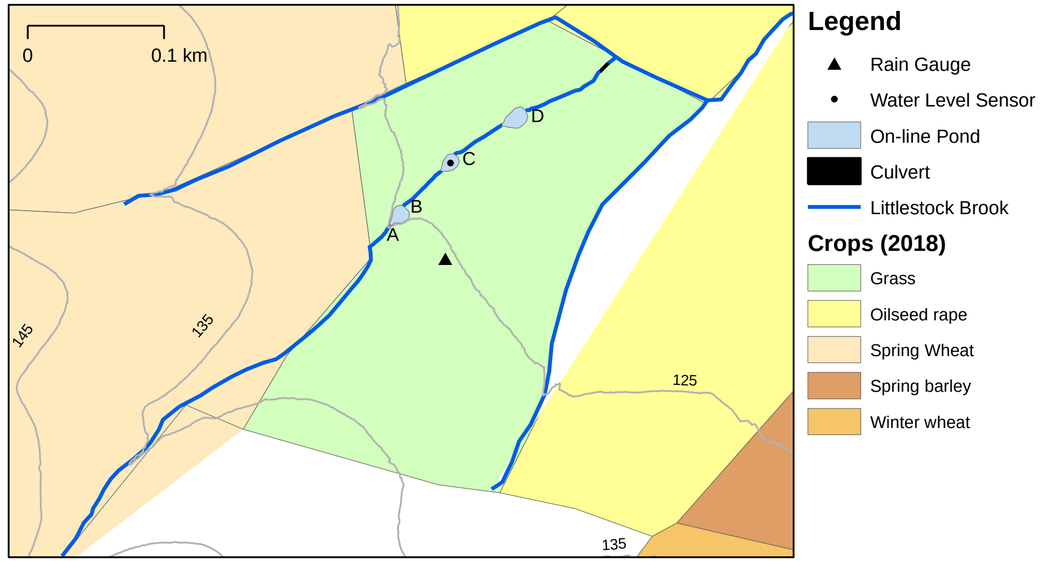
Environment Agency (2018)

Study Area

- Littlestock Brook, tributary of the River Evenlode in the upper Thames basin
- Lowland catchment with slowly-permeable clay soils, arable land-use, ‘flashy’ hydrology
- Ponds constructed and connected to stream in 2018 (contributing area 0.3 km^2)
- Downstream catchment (3.4 km^2) outlet monitored since 2017

- Study area part of pilot scheme for Natural Flood Management and diffuse pollution mitigation
  - On-line ponds
  - Leaky dams
  - Field bunds (43,000 m^3)
  - Woodland planting (13.61 ha)
  - Cover crops & No till





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Methods

1. Storm water sampling at inlets/outlets of each pond
   i. ~Fortnightly grab sampling in baseflows
   ii. Automatic water samplers triggered in 4 storm events
   iii. Suspended Sediment Concentration (SSC)
   iv. Total Phosphorus concentration (TP)

2. Sediment traps deployed within ponds
   i. 5 x traps per pond
   ii. ~Monthly collection of deposited sediment
   iii. Analysis of sediment, P and organic matter
   iv. Analysis of particle size distribution

3. High-resolution monitoring at downstream catchment outlet
   i. SSC, TP, and discharge

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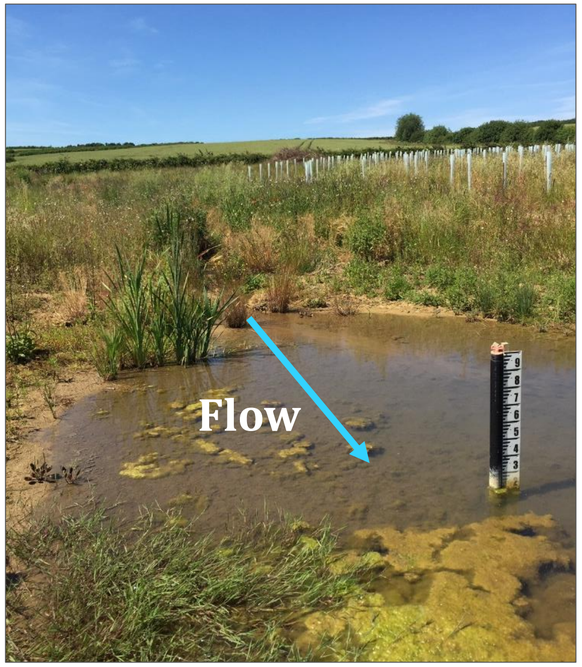
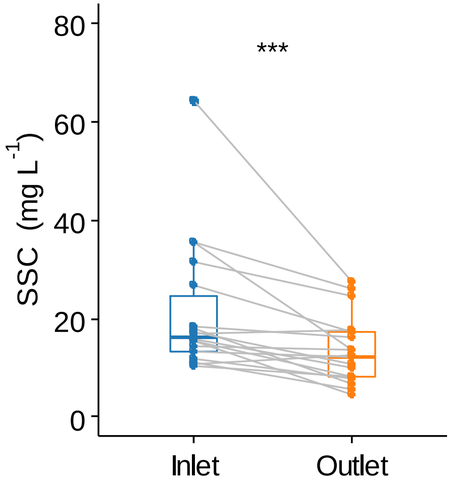
Results - Baseflow

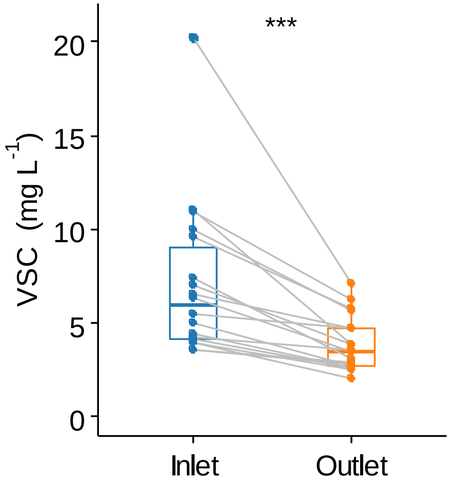
- Significant reduction in suspended solids at pond outflow ($p < 0.05$, paired samples t-tests)
- No significant reduction in Total P
  - Mean outflow TP concentration higher than mean inflow TP concentration
  - Likely due to fine particulate P staying in suspension



32% mean reduction of SSC



40% mean reduction of suspended organic solids



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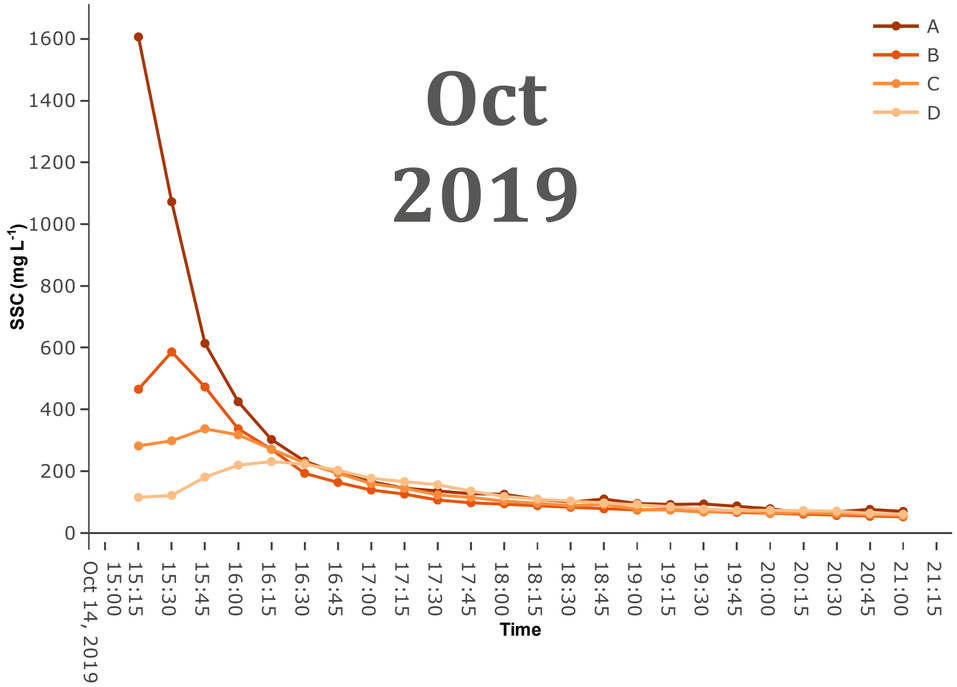
Results - Stormflow

- Retention of sediment and TP during sampled storm events varied
  - Decreased SSC peak downstream of ponds in October 2019 event
  - Increased SSC peak downstream of middle pond (trace C) in February 2020 event

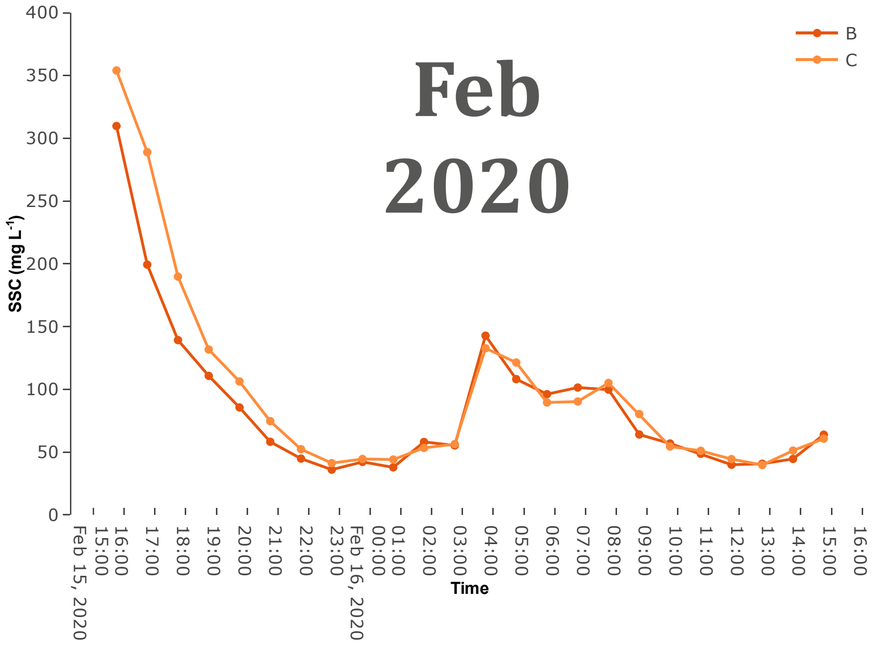
- Net sediment loss from the ponds occurred following a winter period of above average rainfall/flows
  - Flushing of deposited material from prior events
  - Overtopping of ponds

- Likely controls on retention:
  - Event magnitude
  - Preceding events and accumulations
  - Pond volume capacity

Retention



Loss



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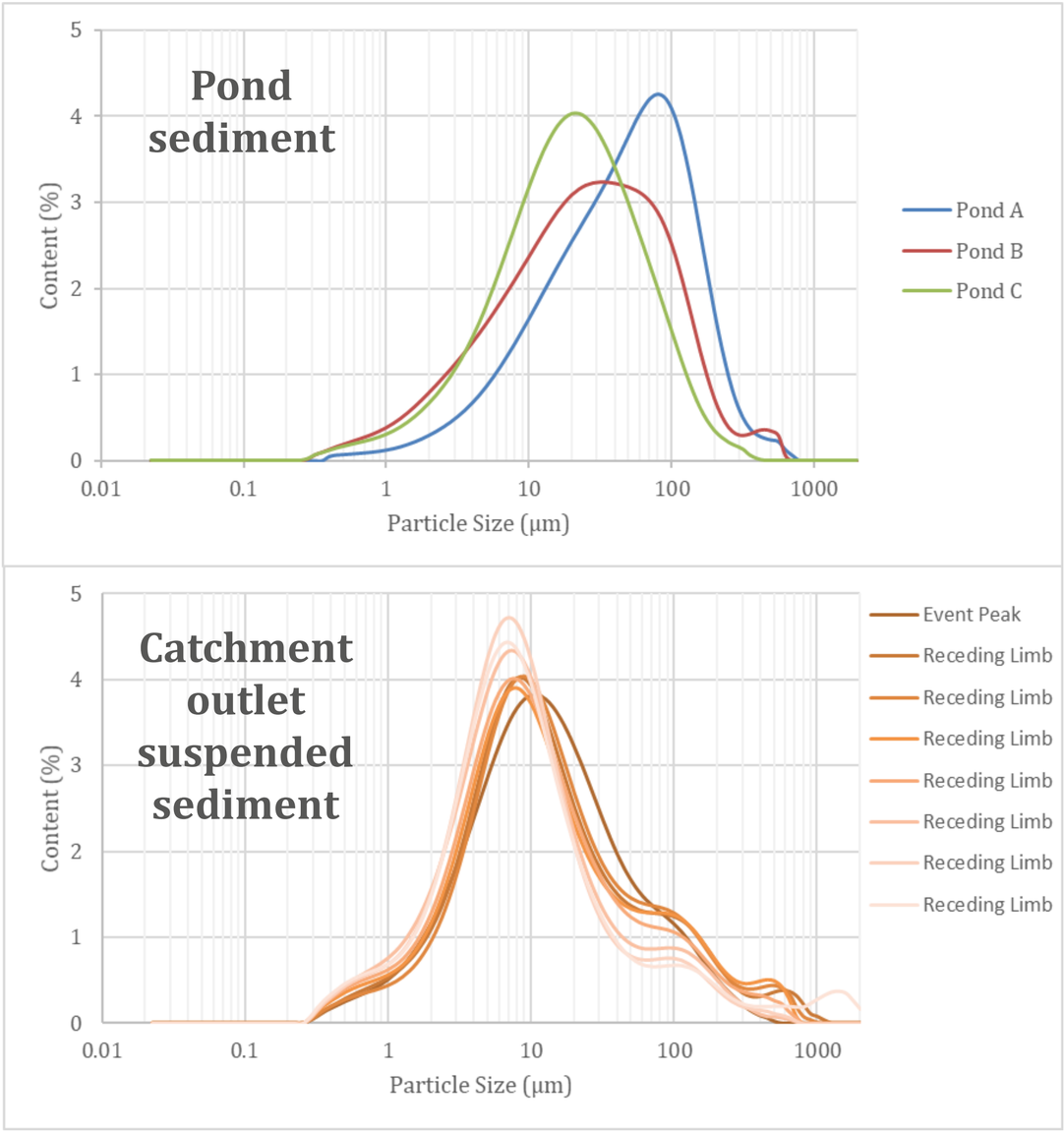
Results – Sediment/P Trapping

- Significant difference between particle size distributions of deposited sediment in each pond
  - Ponds sequentially filter out coarser particles and organic matter
- Suspended sediment downstream shows smaller average particle size compared to deposited sediment
  - Ponds less effective at retaining very fine particles e.g. clays (< 2 µm)

- Sediment P content positively corelated with organic matter content in each pond
  - Potential autochthonous sources of P from decomposition of aquatic vegetation/algae



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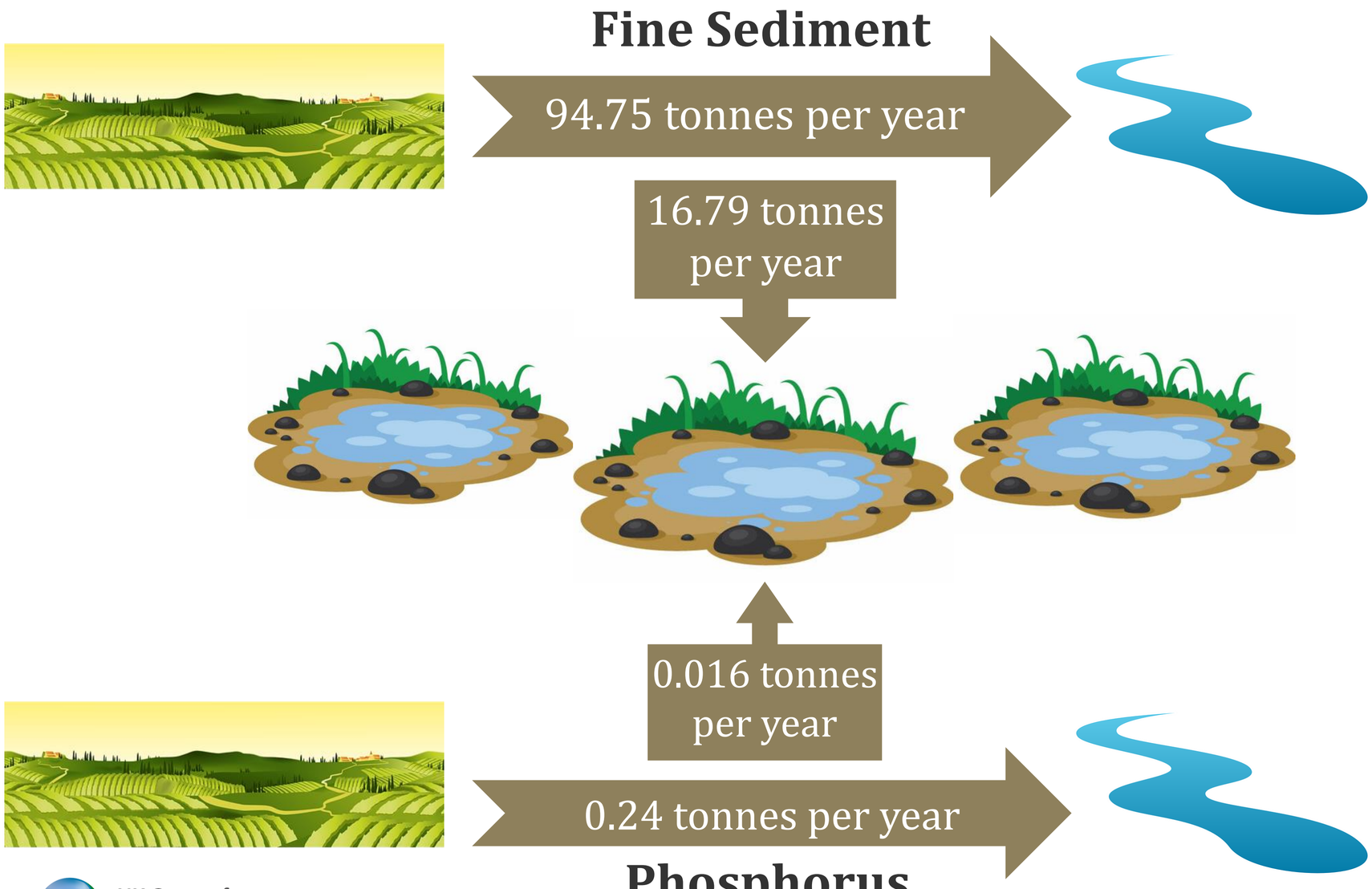
Results – Sediment Budget Context



Estimated sediment trapped by the on-line ponds = 17.7 (±6)% of annual downstream catchment flux in 2019

Estimated P trapped by the on-line ponds = 6.6% of annual downstream catchment flux in 2019

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Conclusions

- Effectiveness of pond features can be highly variable (retention/loss) over different storm events and conditions.
- Regular management and sediment removal is required to reduce risk of sediment remobilization and export.
- On-line ponds can rapidly accumulate and store sediment and P, but they are not a panacea or simple solution for diffuse pollution mitigation.

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References

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Thank you

johrob@ceh.ac.uk

@JohnLovesRivers

Image: David Gasca-Tucker