Disrupting longitudinal connectivity: a case study of historical valley sedimentation due to dam building in the Weald, UK.

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1. Introduction

Floodplains naturally accumulate sediment episodically due to overbank sedimentation during floods above bankfull capacity. In the UK this generally gives rise to sediment accumulation rates of a few mm per year and these rates are of a similar magnitude to those of UK reservoir sedimentation (Pulley *et al*., 2018). The immediate and long term impacts on down valley or longitudinal connectivity is relatively poorly documented. We address this gap by examining the impact of reservoirs that have existed in southern England since Mediaeval times and were built to drive the local iron industry or for powering mills. These ponds have very rapid sedimentation rates and their influence often extends upstream for over a kilometre with the creation of wetlands.

2. Study Location, Materials and Methods

The focus of this paper is on valley and reservoir sedimentation upstream of the ~400 year old Lurgashall Mill Pond which was constructed on a tributary of the River Rother (the River Lod sub-catchment which covers an area of ~ 32 km^2 [Figure 1A]). Land use in the catchment (Table 1) is a mixture of arable and grazed farmland with a significant amount of managed and broad leaved woodland. Headwater gradients are steep (>>6^o) and soils in the lowland areas are sandy (developed over Cretaceous greensand) and are classified as being at moderate risk of erosion. Sediment cores from the pond and floodplain were retrieved using either Russian (Figure 2) or percussion corers at locations given in Figure 1 B. In the laboratory, cores were sliced at between 1 and 2 cm depth increments, dried and analysed for a range of properties including dry bulk density, particle size by laser granulometry, loss on ignition, ^{137}Cs activities and a range of geochemical and mineral magnetic properties (see Walling & Foster 2016; Foster *et al*., 2019 for a review of methods).

Table 1 Catchment Land Use (data from Collins *et al*. (2012)

Urban (%)	Water (%)	Woodland (%)	Rough Grazing (%)	Improved Grazing (%)	Arable (%)
4.9	0.9	41.8	3.9	29.8	18.6

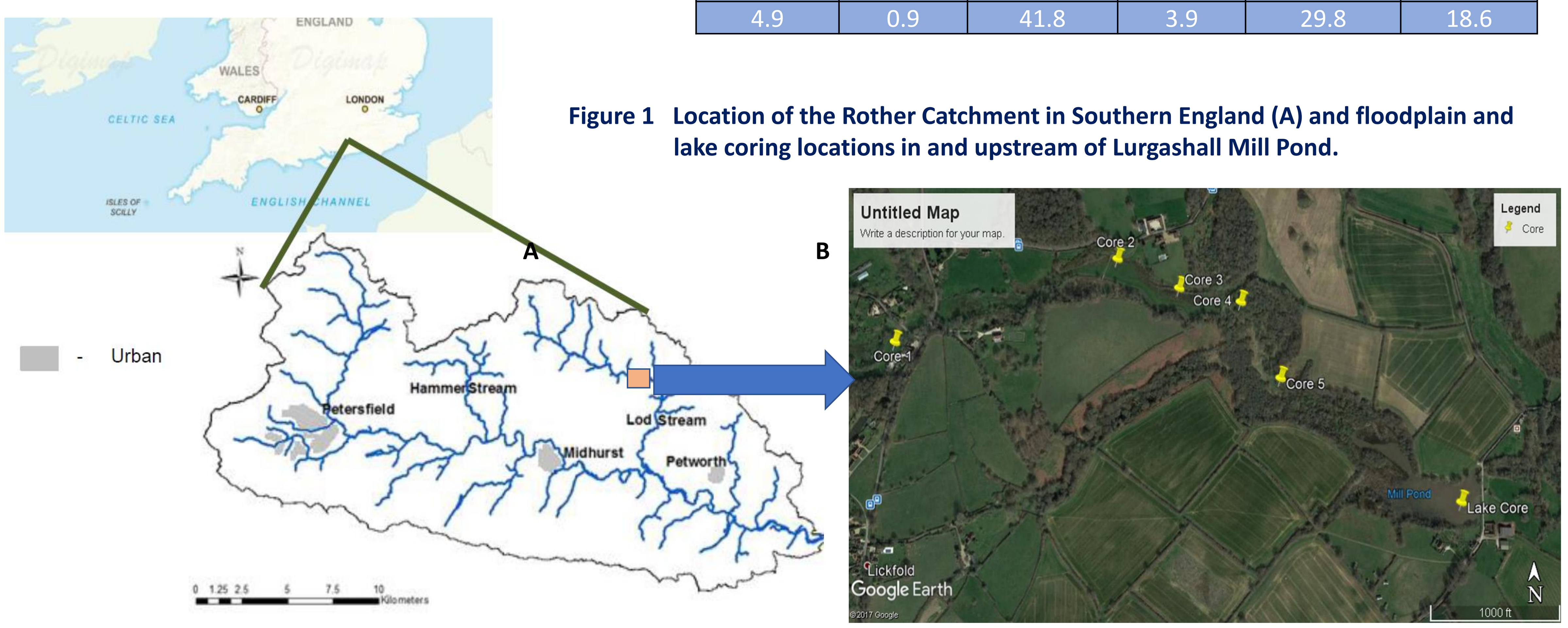


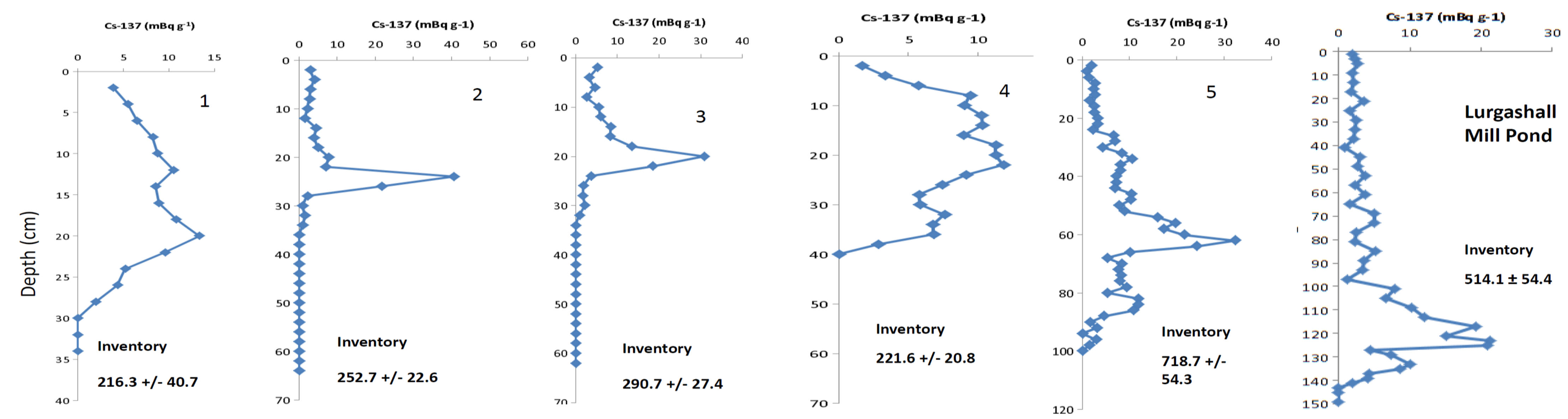
Figure 1 Location of the Rother Catchment in Southern England (A) and floodplain and lake coring locations in and upstream of Lurgashall Mill Pond.

Figure 2 Russian coring Lurgashall Mill Pond (A) following a dam breach and water level drawdown in 2013 (B). Bathymetric survey following refilling of the pond to normal water level at the spillway (C)

3. Results

Russian coring in the pond revealed over 5.5 m of reservoir sediment had accumulated behind the ~8m high dam wall. Sedimentation has left an average water depth today of <0.5 m (Figure 2C) giving an estimated trap efficiency of <5% Despite the low trap efficiency, we have identified rapid sedimentation in the reservoir (~1.4 m since 1954) and for a distance of some ~2 km upstream in the floodplain using ^{137}Cs dated lake and floodplain sediment cores (Figure 4). 137Cs inventories in all cores are much higher than the reference inventory for the Rother catchment of ~ 150 mBq cm^{-2} (Foster *et al*., 2019). Since the first occurrence of ^{137}Cs in 1954 to the coring undertaken in 2014, we estimate an accumulation rate of between 1250 and 1450 t of sediment annually in the floodplain and mill pond equating to a sediment yield of 40-45 t km^{-2} yr^{-1}. This is higher than the most recent range of yield estimates for the whole Rother of 20-30 t km^{-2} yr^{-1} (Sear, 1996).

Figure 4 ^{137}Cs Profiles from floodplain and pond cores located in Figure 1B



4. Discussion and Conclusion

It is well documented that the flux of sediment from headwater catchments is significantly disrupted by the presence of reservoirs and that the 'hungry' downstream river (sensu Kondolf, 1997) impacts on sediment delivery, particle size, channel response and river ecology (e.g. Petts & Gurnell, 2005; Boardman & Foster, 2011; Foster *et al*., 2019). Published research also highlights the global impact of reservoirs on sediment delivery to the oceans which is also significantly reduced despite evidence that erosion rates in many parts of the world have increased substantially (e.g. Syvitski *et al*., 2005). Few areas of the UK report excessively high rates of soil erosion and sediment yield yet the Rother catchment has several ponds where sediment accumulation rates lie well above the UK norm (Pulley *et al*., 2018). The current study suggests that estimating pond or reservoir storage alone significantly underestimates the impact of the reservoir on downstream sediment delivery due to the change in the gradient of the valley upstream of the open water body and the ability of this large area to trap additional sediment. Clearly this and other ponds in the Weald have protected the River Rother for over 400 years from excessive sediment inputs. As their trap efficiency has significantly diminished, such protection will diminish in effect in the very near future.

5. References

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