Evaluating the provenance of fine sediment in degraded Freshwater Pearl Mussel habitats

CATCHMENT & RIVER SCIENCE WITH PLYMOUTH UNIVERSITY

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1. INTRODUCTION

- Freshwater Pearl Mussels (FWPM) are among the most critically threatened freshwater bivalves worldwide. In addition to their important roles in particle processing, nutrient release, and sediment mixing, they also serve as an ideal target species for evaluation of aquatic ecosystem functioning especially in the context of their symbiotic relationship with Atlantic salmon and brown or sea trout.
- Poor water quality, particularly eutrophication, and siltation are considered major contributory factors in the decline of the species hence management of diffuse water pollution from agriculture (DWPA) is a key priority in catchments that host FWPM habitats.
- Against this background, this study adopted a combined monitoring, surveying and sediment fingerprinting approach to determine the principal sources of fine sediment impacting FWPM habitats in the River Clun, a Special area of Conservation (SAC) for FWPMs in central western UK.

Image: Shropshire AONB

2. STUDY CATCHMENT

- The River Clun (Figure 1) drains a 272 km² catchment. Principal land use is sheep and cattle grazing although there are notable areas of cultivated land.
- In the lower reaches, the river is protected as a Special Area of Conservation (SAC) and Site of Special Scientific Interest (SSSI) for FWPM.
- It is hypothesised that, while FWPMs are reproducing, juveniles are not surviving in the channel bed gravel to emerge as adults which may be due to siltation.

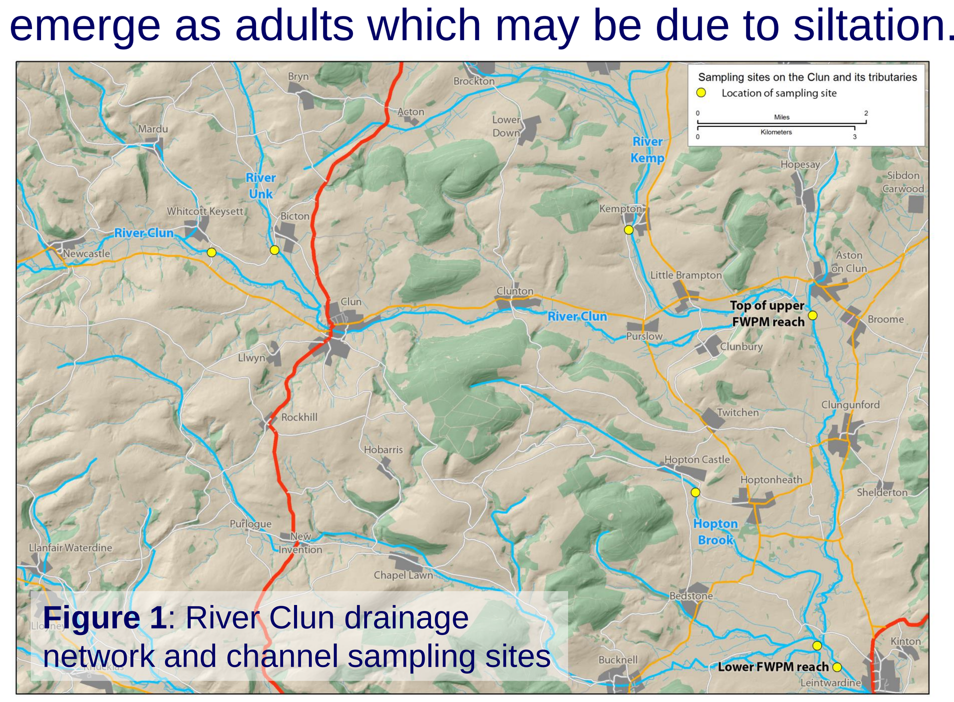

Figure 1: River Clun drainage network and channel sampling sites

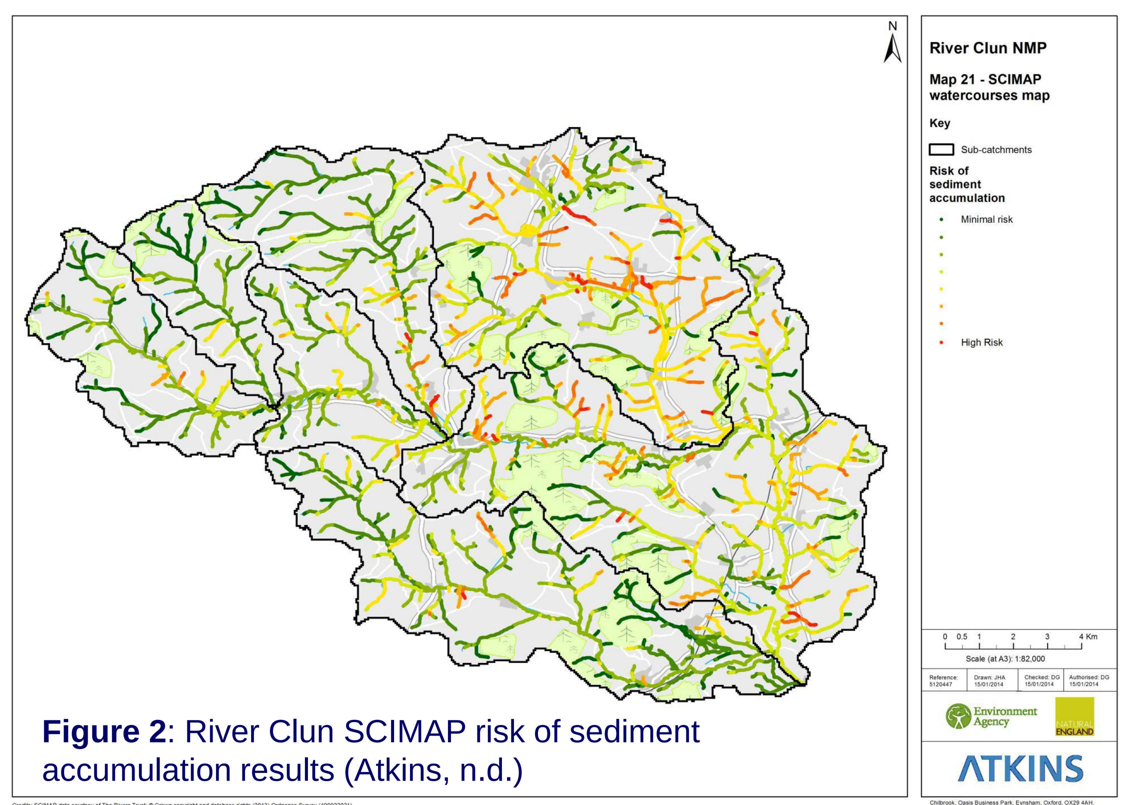

Figure 2: River Clun SCIMAP risk of sediment accumulation results (Atkins, n.d.)

- Outputs from the SCIMAP model (Figure 2) suggested that the main sediment contributing areas were within 2 key sub-catchments, the Kemp and Unk and areas around the main stem channel near FWPM habitats
- This formed the basis of a sub-catchment to catchment-scale fingerprinting approach alongside channel walkovers

3. APPROACH

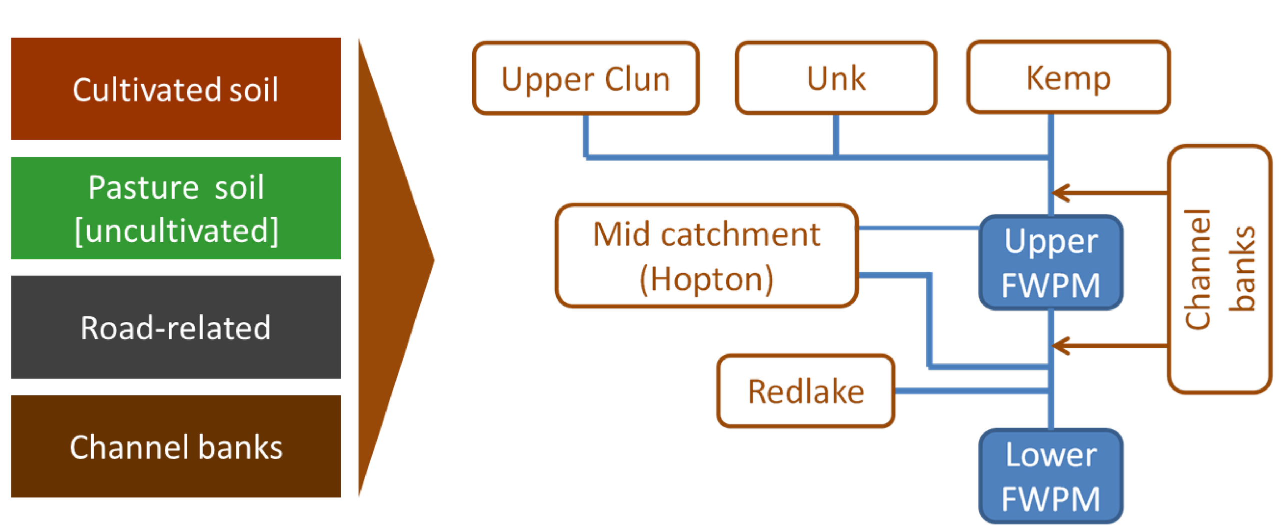

Figure 4 (above): subcatchment scale experimental design showing link between target FWPM reaches on the main channel and primary sources via subcatchment outlets

- Primary sources were collected across the catchment with sample sets stratified by sub-catchment. Low order and high-order (Figure 3 left) channel bank material was collected in two separate groups.
- Samples of suspended sediment and channel bed stored sediment were collected at sub-catchment outlets and within FWPM beds in the main Clun river channel.
- Samples were analysed for fallout radionuclides (FRNs) and major and minor geochemical elements by WD-XRF to derive tracer signatures
- Fallout radionuclide (FRN) and geochemical tracing methods were adopted independently.
- Results were interpreted within the framework of catchment walkover surveys and siltation surveys.

4. ANALYSIS

- Primary source signatures were compared to material from sub catchment outlets and material stored in the FWPM reaches across a full calendar year (spring, summer, autumn, winter).
- A heirarchical Bayesian unmixing model (Semmens and Stock, 2015) was used permitting sites, seasons and sediment type to be evaluated against source terms as inter-related sediment mixture groups.

Figure 3 (right): Sampling bed sediment (left), in-situ Phillips suspended sediment samplers (middle) and channel bank erosion (right)

5. RESULTS AND DISCUSSION

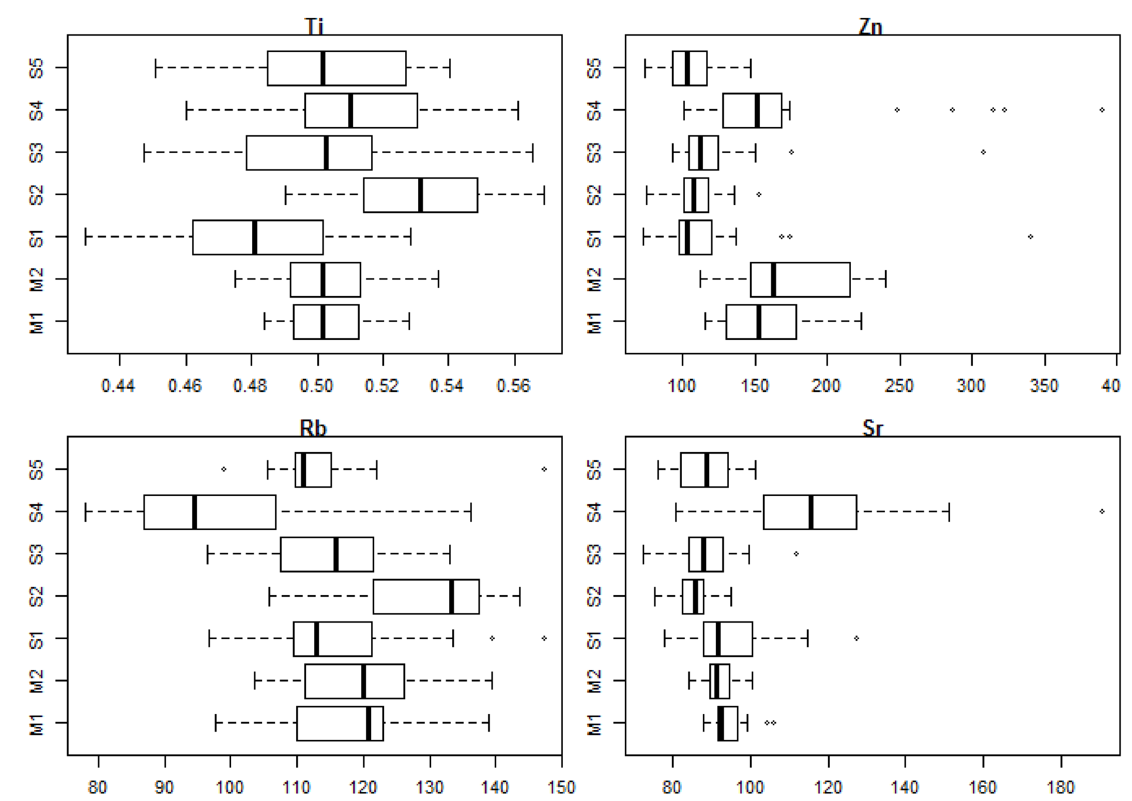

Figure 4: Illustrative examples of tracer boxplots comparing Source term range (S1, S2…) to Mixture range (M1, M2) where Zn demonstrates non conservative tracer behaviour

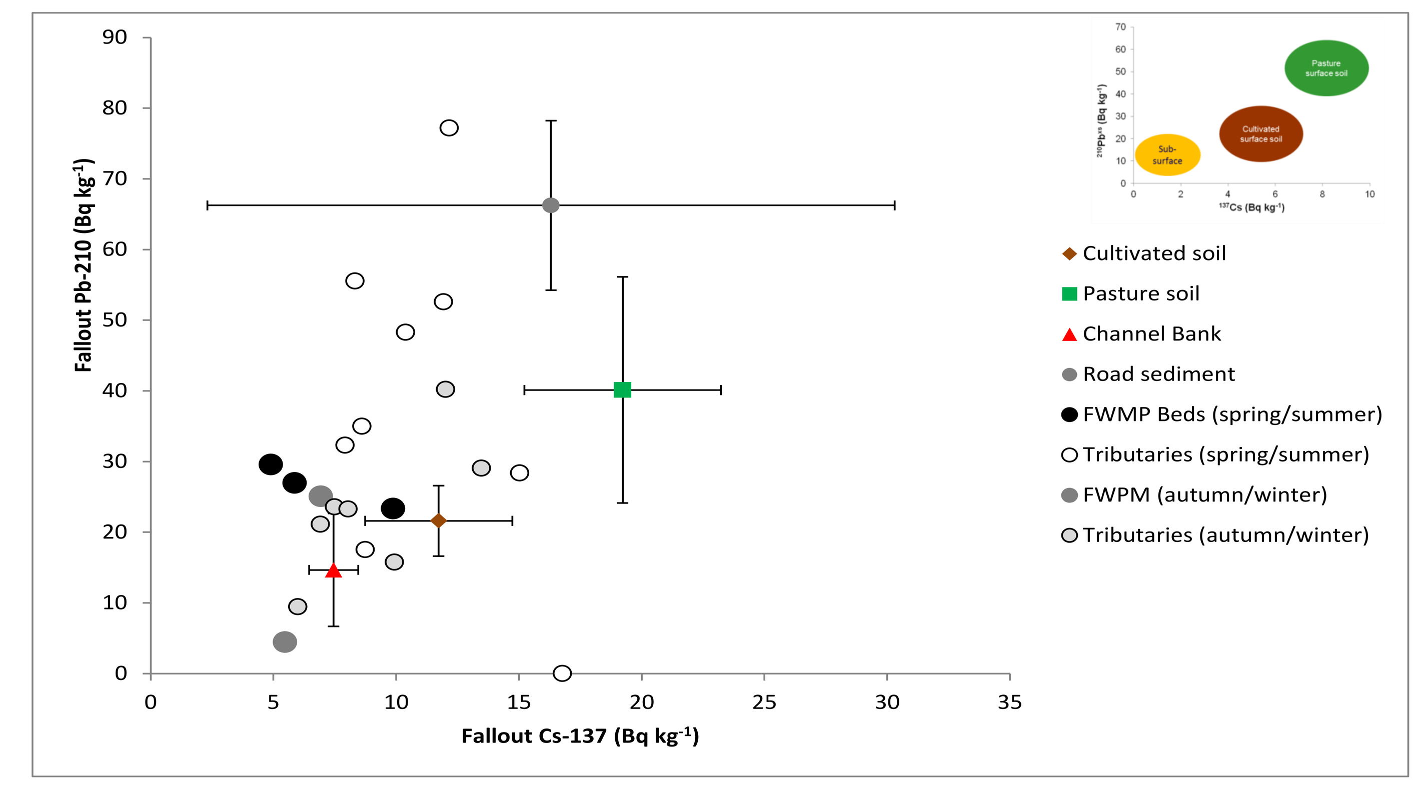

Figure 5: comparison of channel sediments to primary source FRN signatures

- Geochemical tracer (n = 25) selection was based on EDA approaches (Fig. 4) with elements that appeared to show non-conservative behaviour (e.g. Zn) being removed from analysis.
- Fallout radionuclide data implied a strong influence of cultivated soil in sub catchments ,with a road-sediment signal indicating conveyance path (Fig. 5), and influence of bank erosion in main channel sediments.
- This was supported by geochemical fingerprinting data which demonstrated cultivated soil transported by road as a key soil in e.g. the Kemp subcatchment (Fig. 6 left). The main channel also showed a strong cultivated signal in spring, summer an autumn but winter signals were dominated by channel bank erosion inputs (Fig. 6 right)

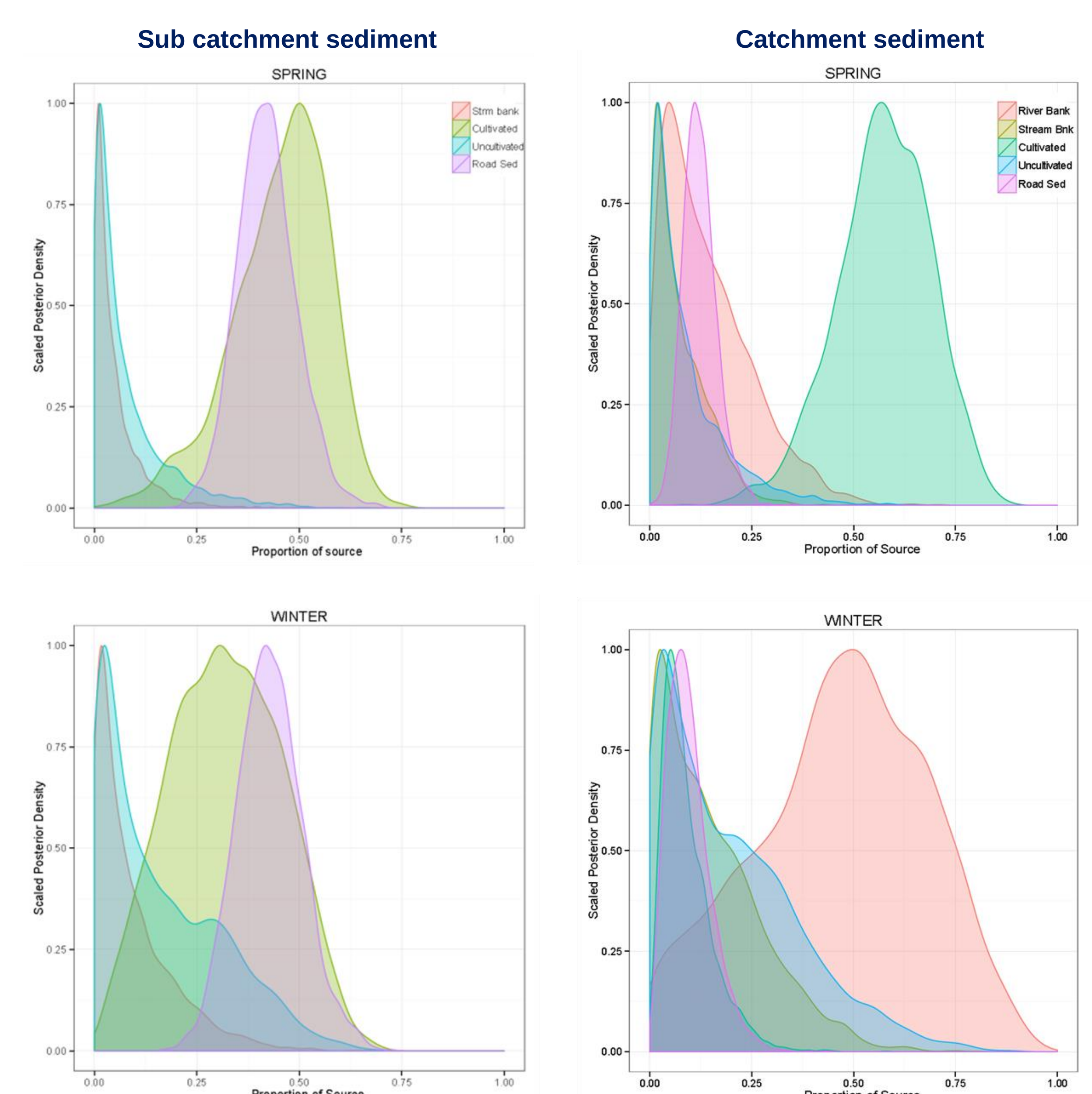

Figure 6: Unmixing model outputs showing most likely source contributions at the sub-catchment (left) and catchment (FWMP beds) (right) scales, in summer and winter.

CONCLUSIONS

- In addition to reinforcing the need for DWPA measures and reduction in surface wash onto roads, the study highlighted the seasonal role of channel bank erosion in local siltation of Clun FWPM beds.
- Efforts to reduce bank erosion need to consider catchment wide drivers e.g. increased peak flow as well as local drivers e.g. livestock and riparian vegetation loss.
- The results informed targeted management of fine sediment problems relating to both DWPA and riparian corridor management.