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Global Health:
A catchment systems approach

Ian Fuller, Mark Macklin, Russell Death & David Hayman

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Outline

- What do you mean, catchment systems?
- Consequences of catchment connections
  - Contaminant dispersal
  - Sediment dispersal
  - Pathogen dispersal
- Morphology and malaria
- Why we need a catchment approach

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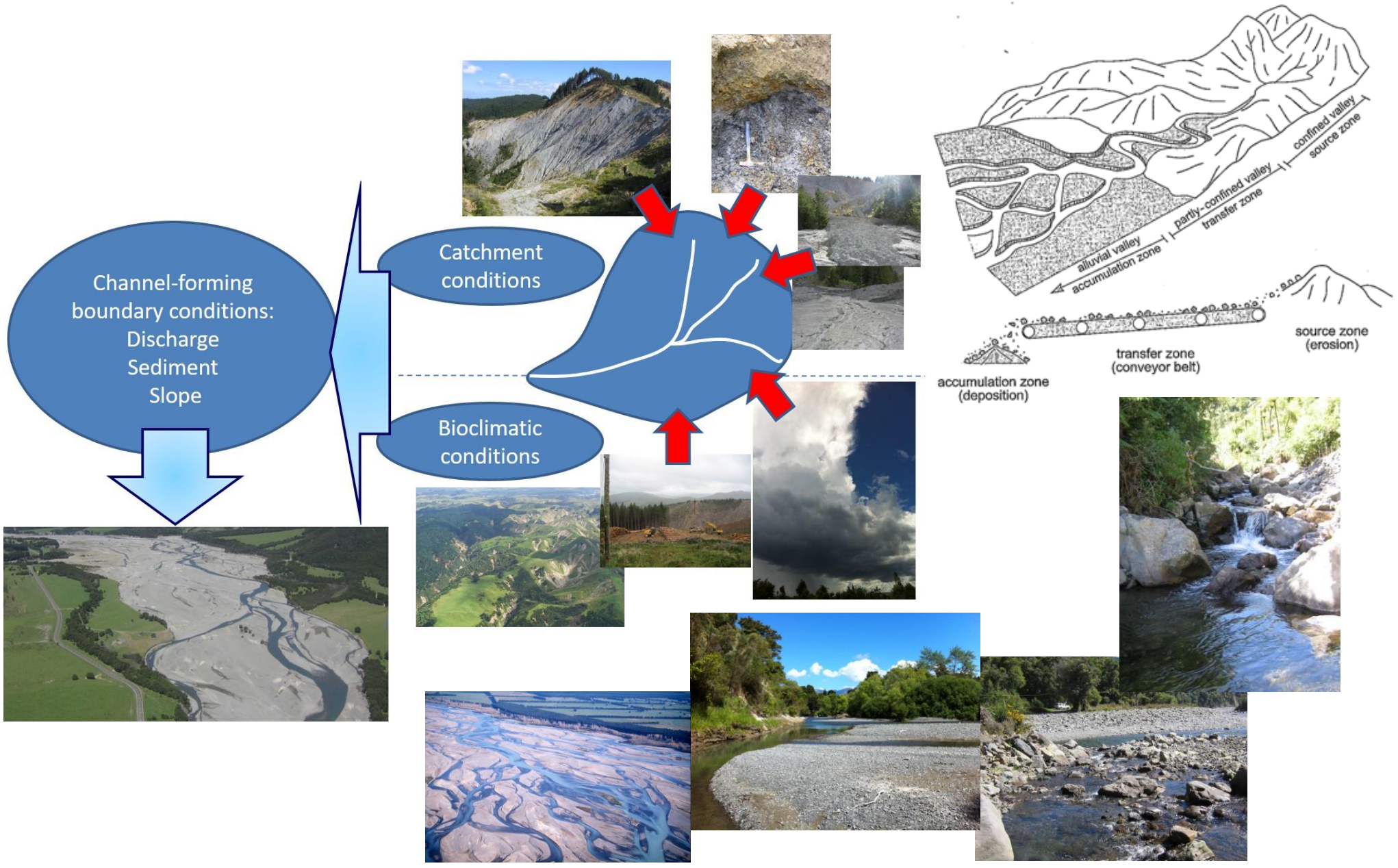
“If I am the river and the river is me, then emphatically I am dying.”

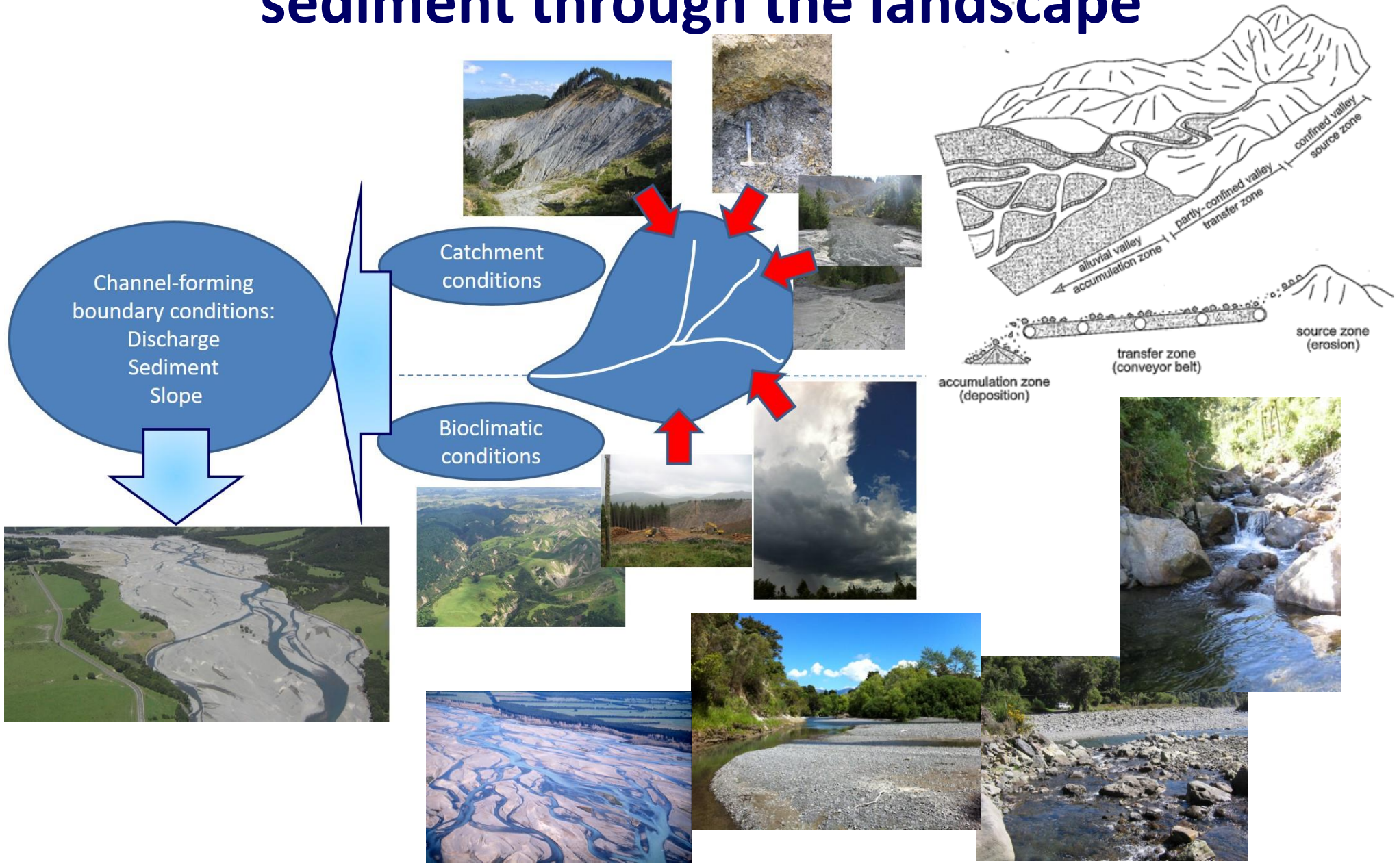
Māori elder, Turama Thomas Hawira, at the Waitangi Tribunal hearings for the Whanganui River, 2011, on observing dead fish, stagnant water, & algal blooms in the awa

quoted by: Anne Salmond (2014). Tears of Rangi: Water, Power, and People in New Zealand. *HAU: Journal of Ethnographic Theory*, *4*(3), 285-309.

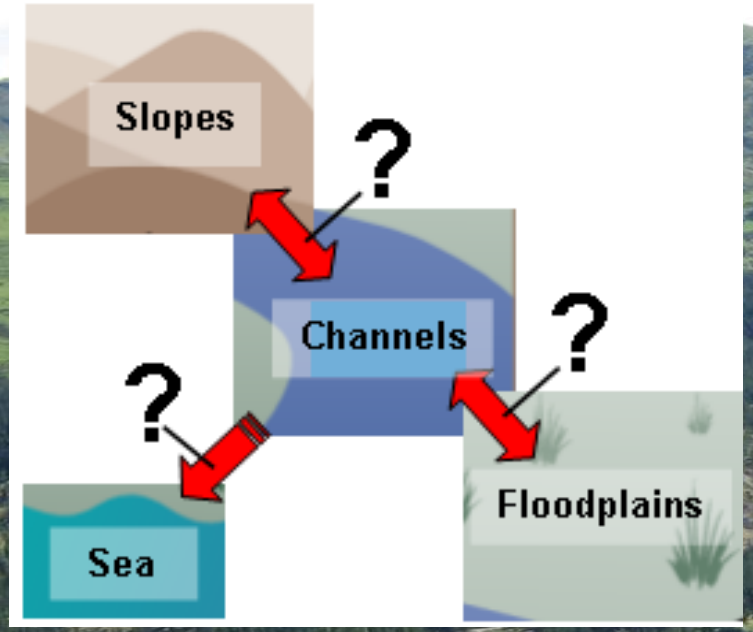
Q: What is a catchment system?



A: Connected cascade of water & sediment through the landscape



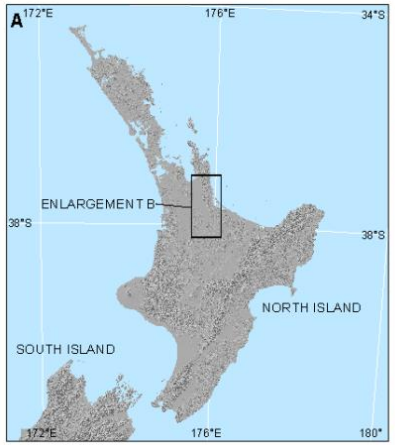
Connections have consequences

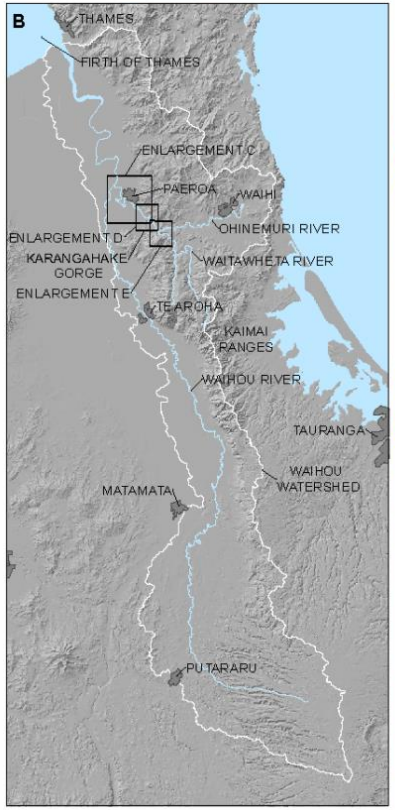


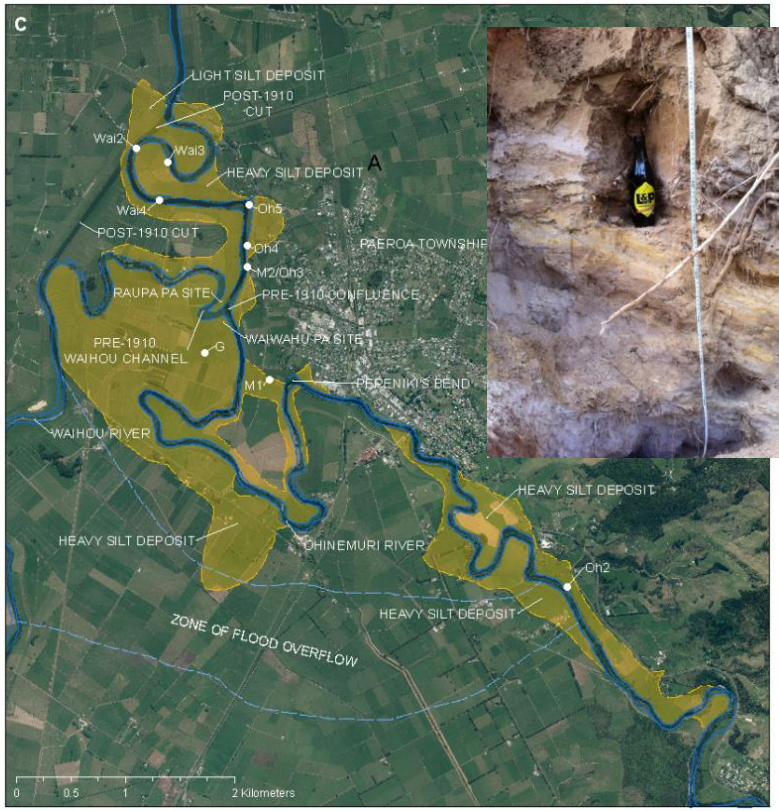
- When should connectivity be restored?
- What is being re-connected?
- What are the likely impacts on river health?
- What are the implications for human health?

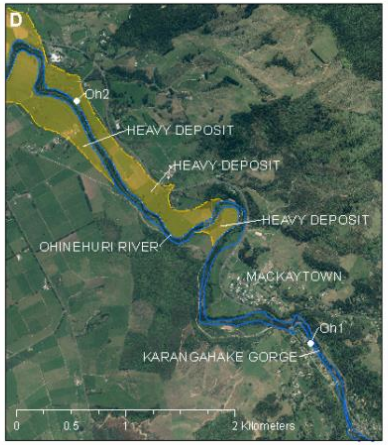
Connection of contemporary contamination

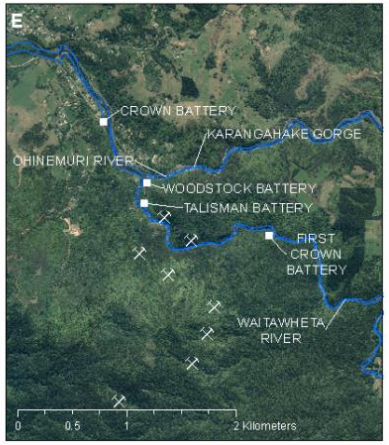
Connection of historic contamination:

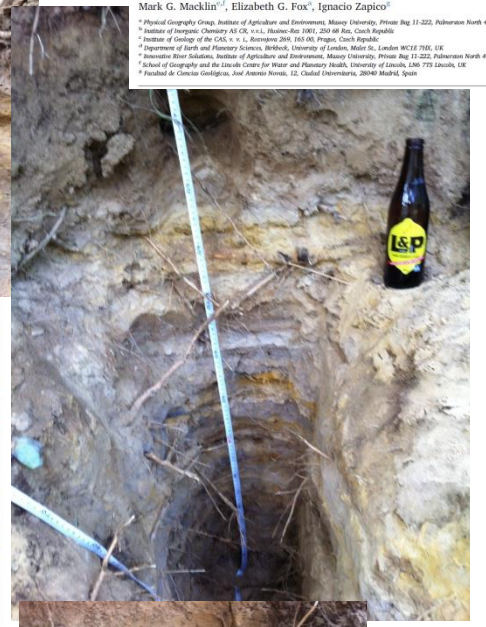


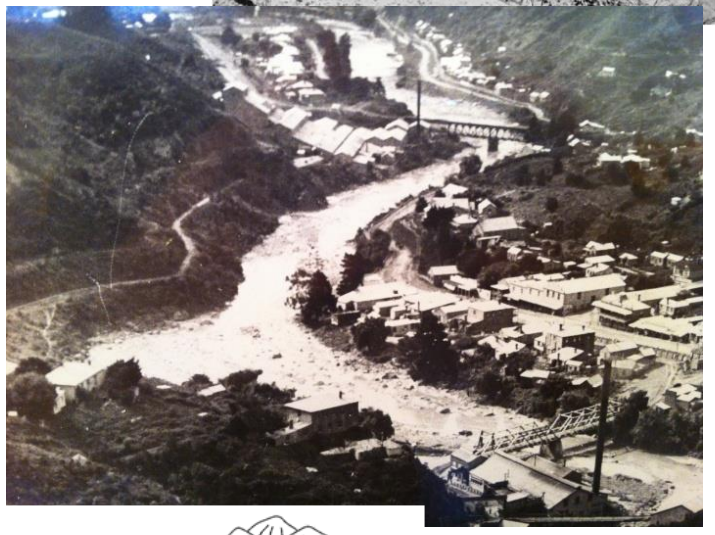


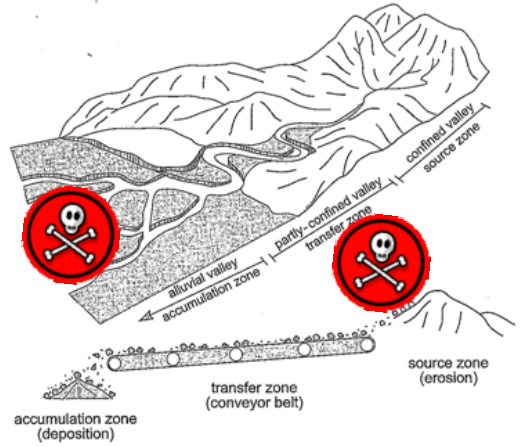






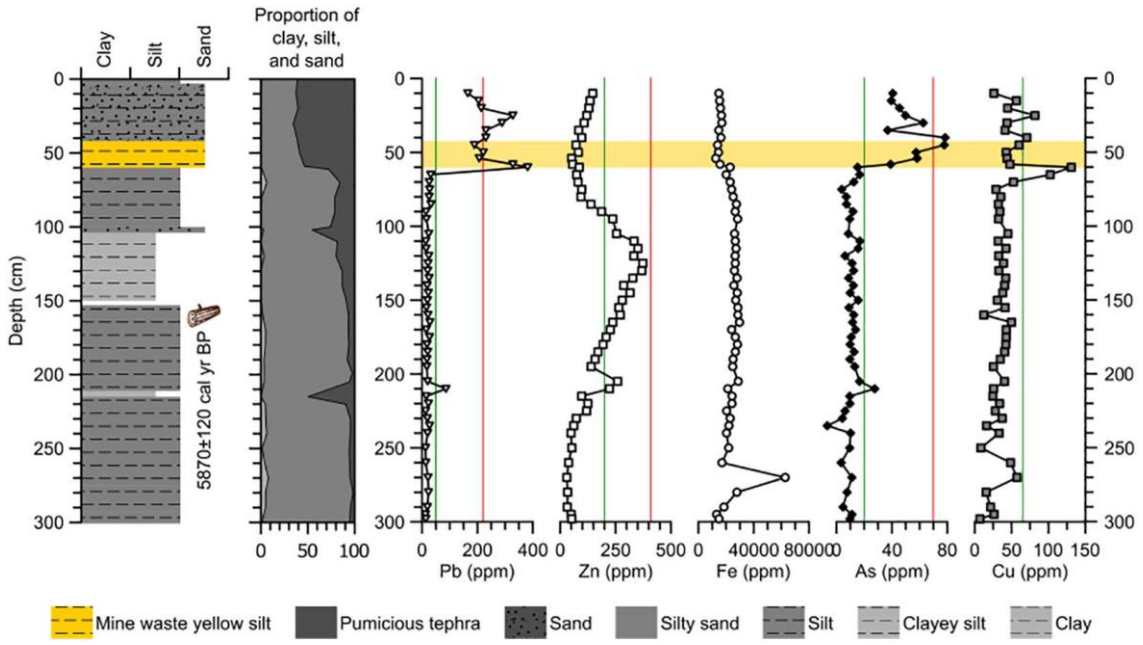




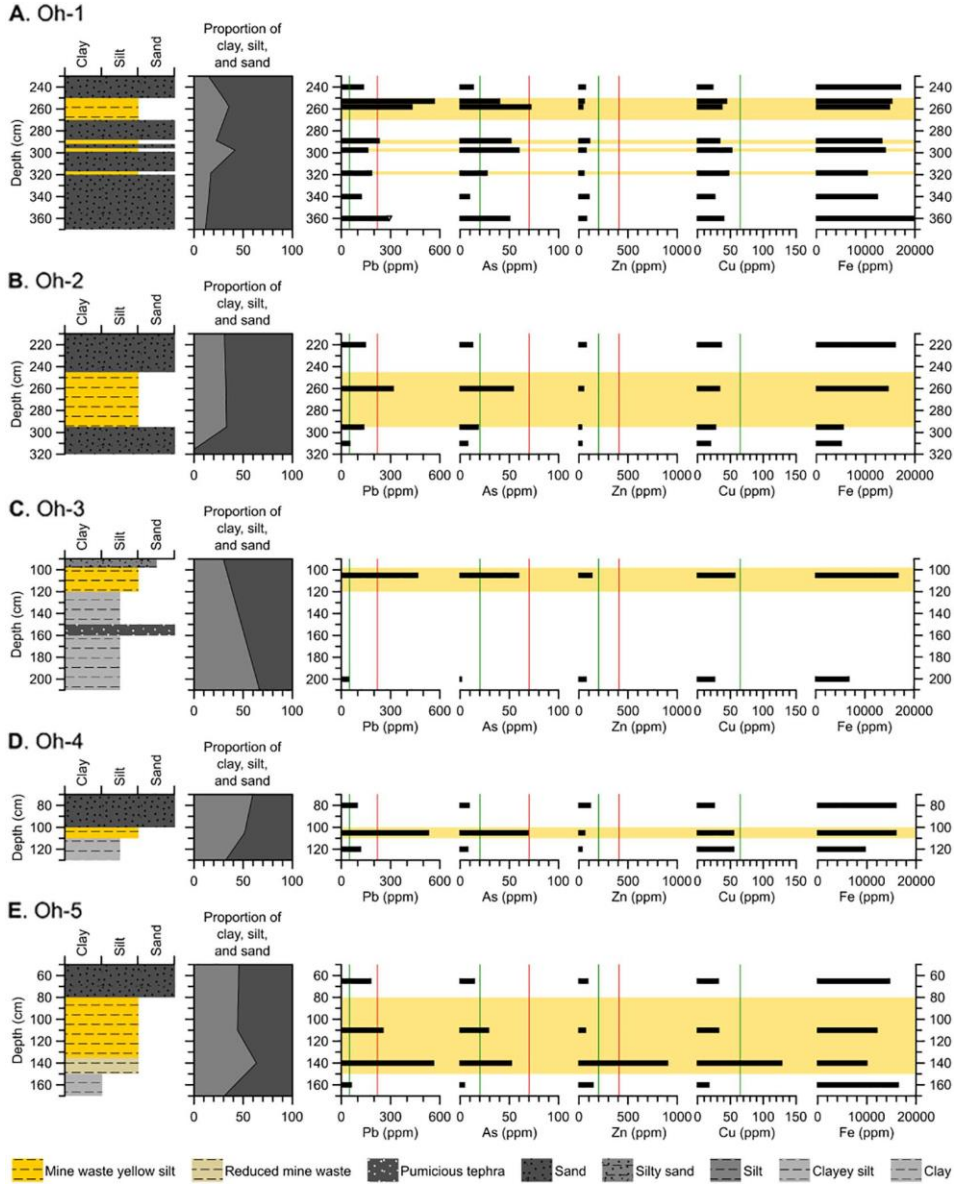


Coromandel contamination

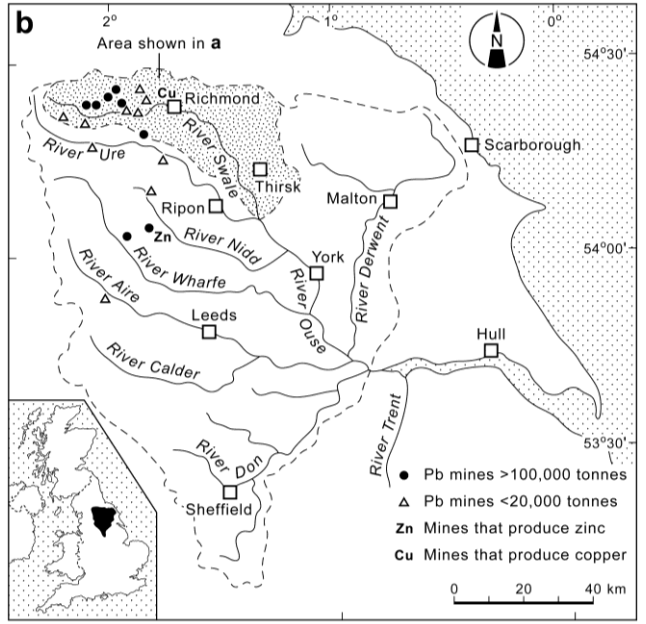
- **Dispersal & deposition of ~1.13 M m^3 in 1907 flood**

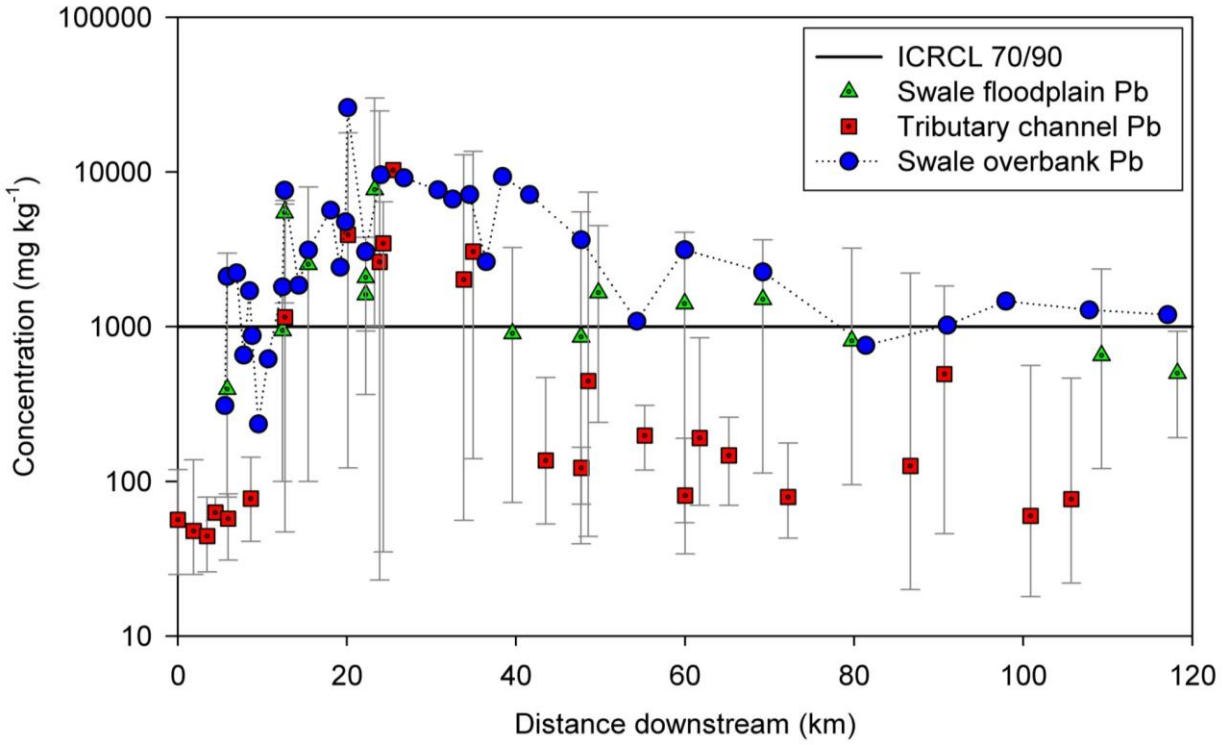


Vertical green and red lines show the interim sediment quality guidelines (ISQG) for aquatic ecosystems: ISQG-low (green) and ISQG-high (red) concentrations for Pb, Zn, As, Cu



Connecting contaminants:
Yorkshire Ouse Millennium Floods:





Mean contaminant metal concentrations in floodplain sediments (mg/kg)

River systems affected by historical metal mining

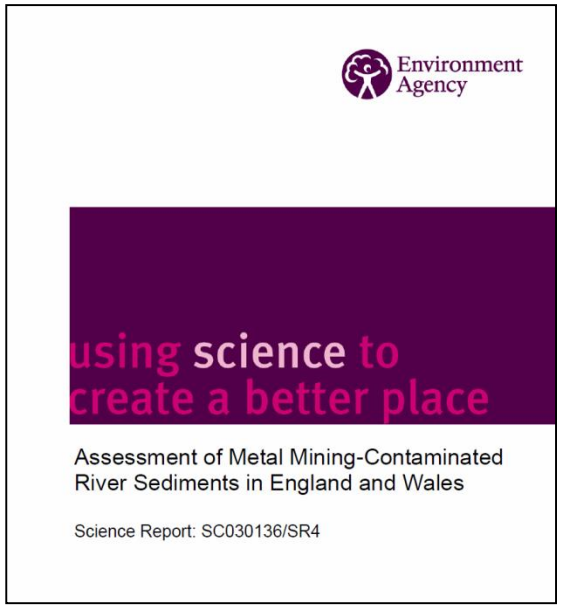
River	Pb	Zn	Number
Swale, northern England	**1360**	**970**	314
Tyne, northern England	**2830**	**5500**	93
Ystwyth, Wales	**1800**	530	24

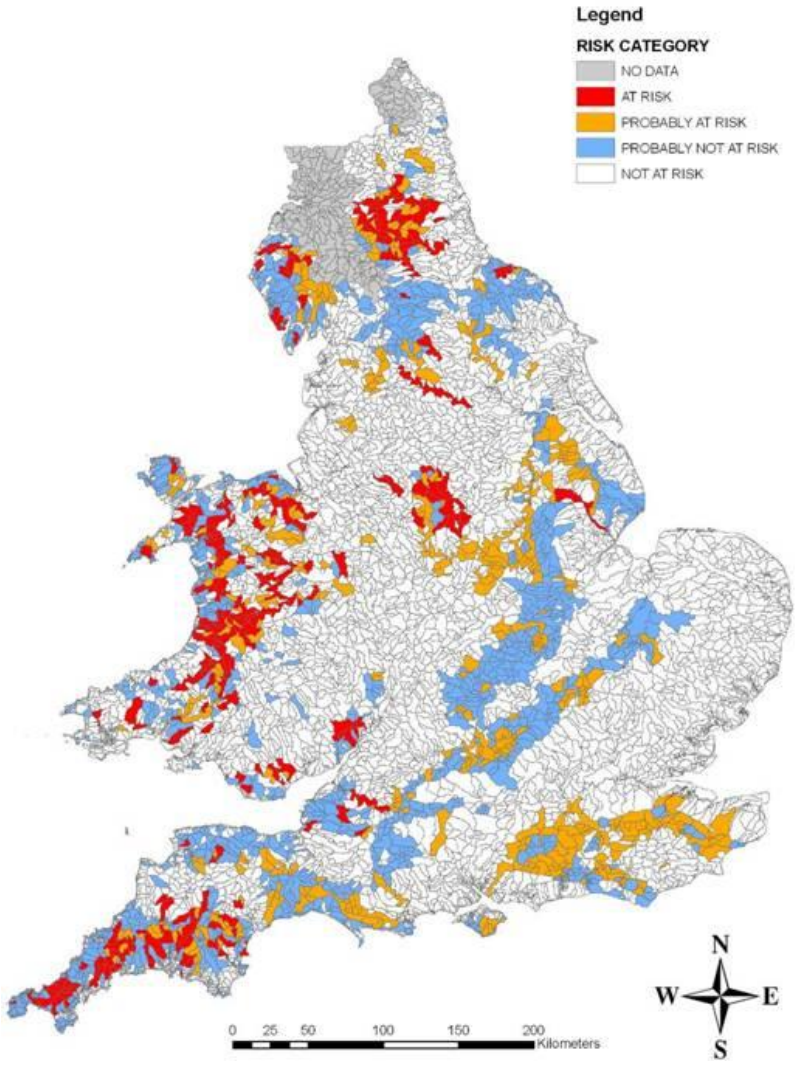
River systems affected by tailings dam failures

River	Pb	Zn	Number
Guadiamar, SW Spain	1000	1200	29
Someş, NW Romania	200	850	18

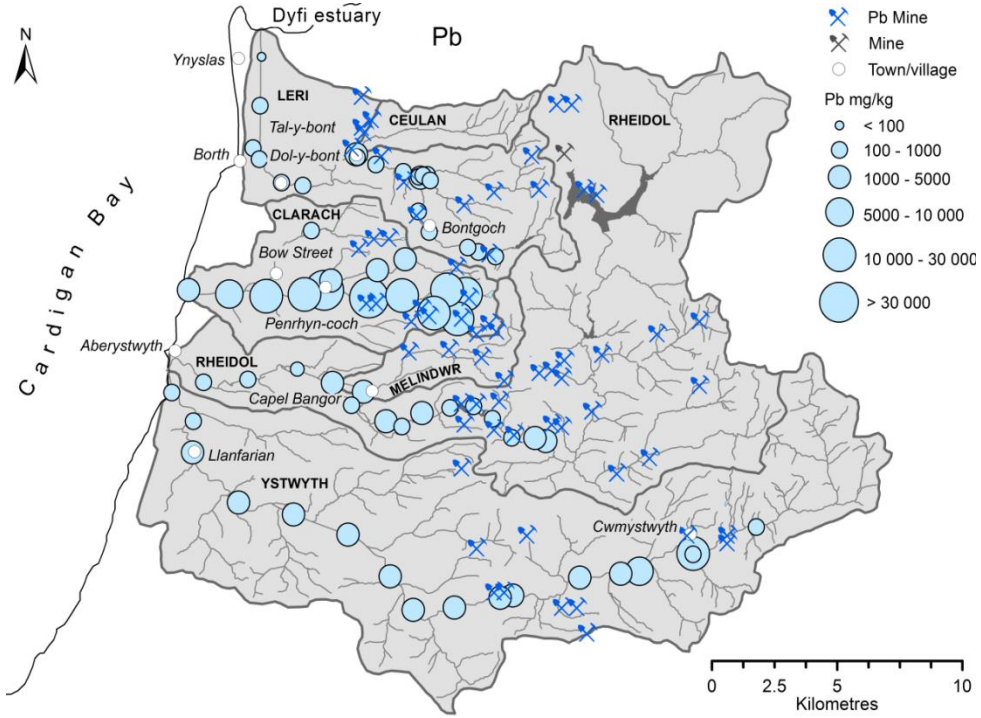
Environmental significance of historical mine waste in UK floodplains: implications of climate change

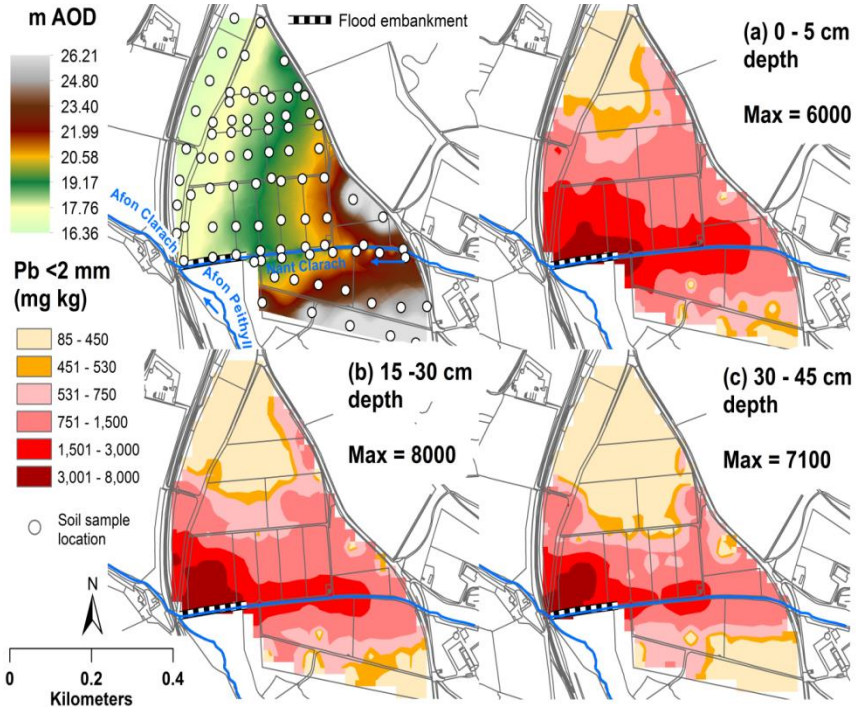
- 12,000 km^2 of river catchments in northern England alone affected by historical metal mining.
- Most of the severely affected river systems are in the north & west of UK where the greatest increase in flooding is expected to occur in the next 10-50 years.
- Floodplain sediments contaminated by mine waste represent a major diffuse source & (because of increased flooding) are likely to become (or already are) the predominant supplier of sediment-associated metals in many catchments.



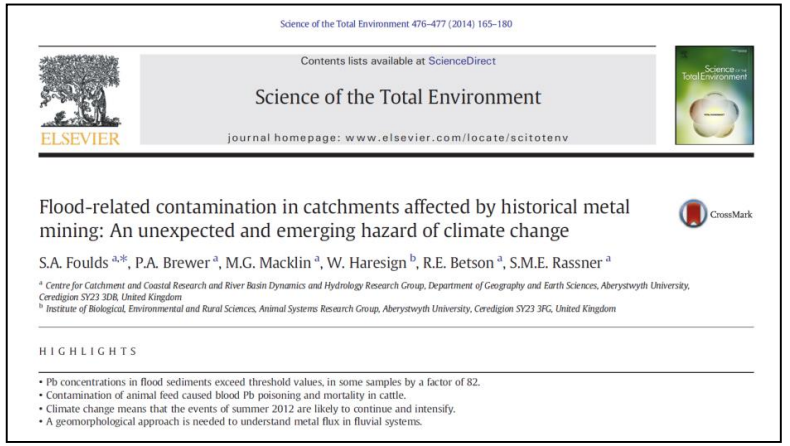


Mid-Wales floods June 8th-9th 2012





Pb sediment concentrations (mg kg^{-1}) in the lower Clarach catchment at 0-5, 15-30 and 30-45 cm below ground level.



Science of the Total Environment 476–477 (2014) 165–180

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

ELSEVIER

Flood-related contamination in catchments affected by historical metal mining: An unexpected and emerging hazard of climate change

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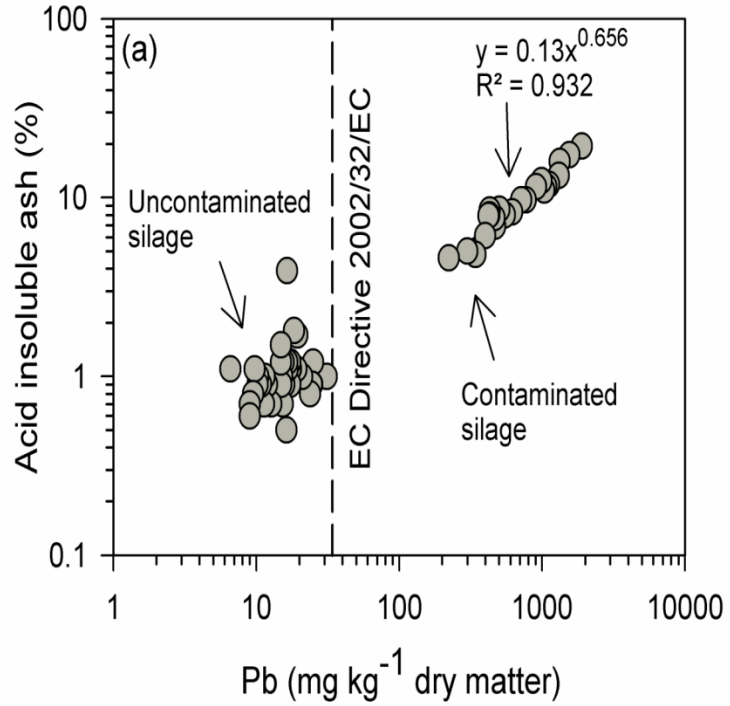
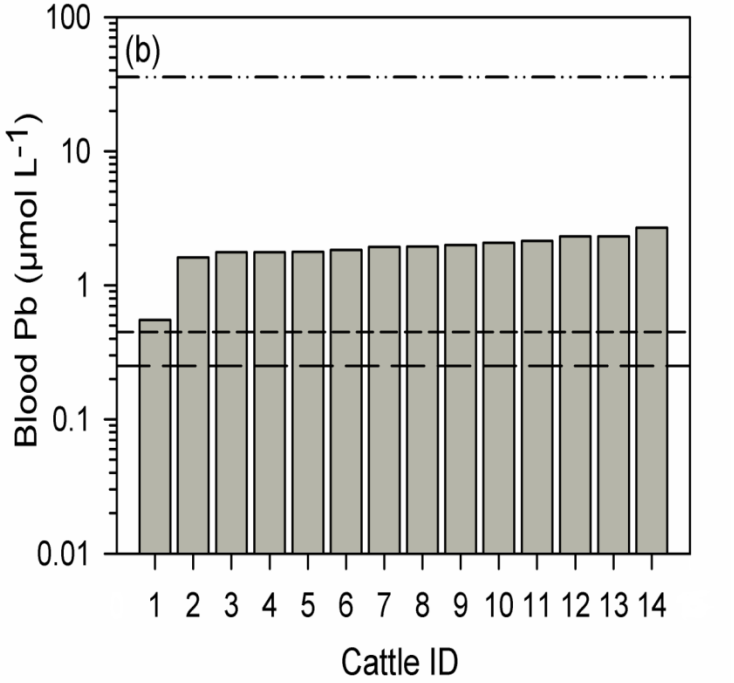
[b] Institute of Biological, Environmental and Rural Sciences, Animal Systems Research Group, Aberystwyth University, Ceredigion SY23 3FG, United Kingdom

HIGHLIGHTS

- Pb concentrations in flood sediments exceed threshold values, in some samples by a factor of 82.
- Contamination of animal feed caused blood Pb poisoning and mortality in cattle.
- Climate change means that the events of summer 2012 are likely to continue and intensify.
- A geomorphological approach is needed to understand metal flux in fluvial systems.



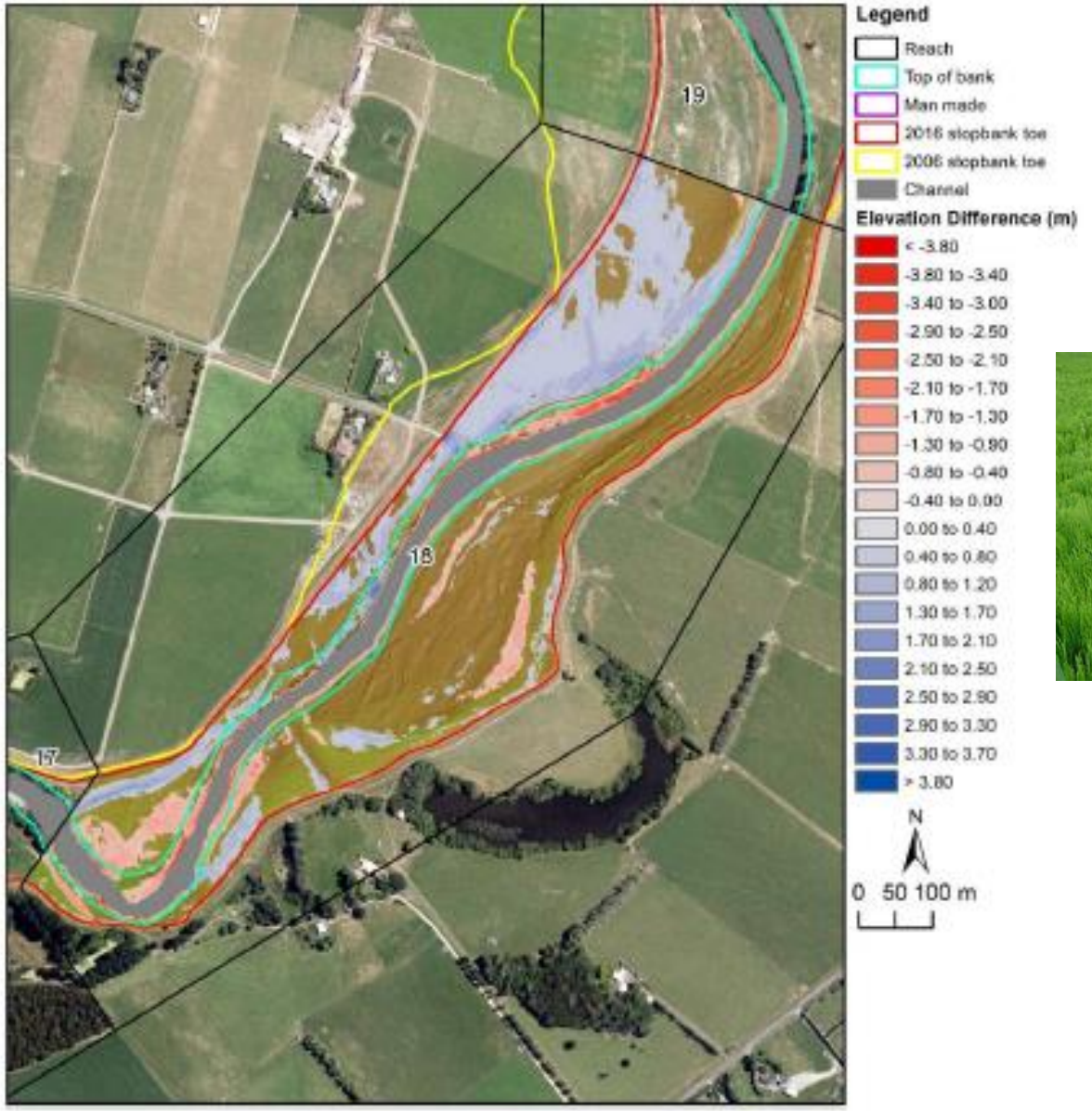
Pb concentrations (mg kg^{-1} dry matter) and percentage acid insoluble ash (silica) in silage bales cut in June 2012 in the lower Clarach catchment.

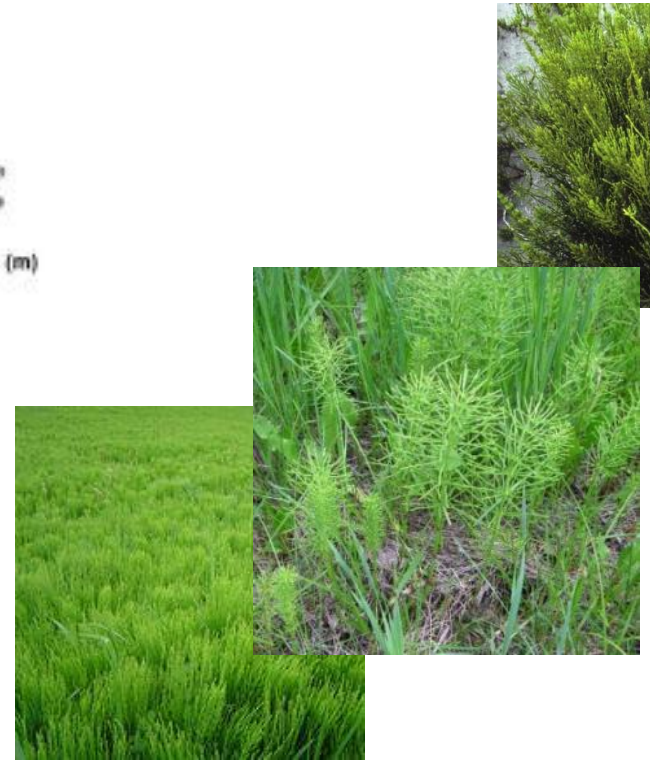


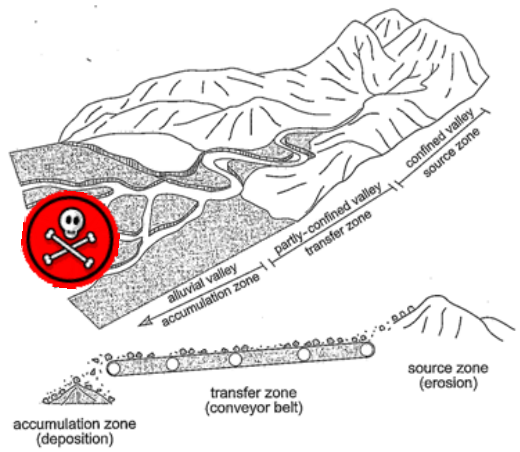
Blood Pb concentrations in cattle that were fed contaminated silage from the Clarach catchment.

Threshold values for animals allowed to enter the food chain unrestricted (<0.25 µmol L^{-1} (long dashed line)) and those to be excluded (>0.45 µmol L^{-1}(short dashed line)) are also shown. The upper dashed line indicates the Pb concentration in offal (kidney) from an animal that died after being fed contaminated silage (35.57 µmol L^{-1}).

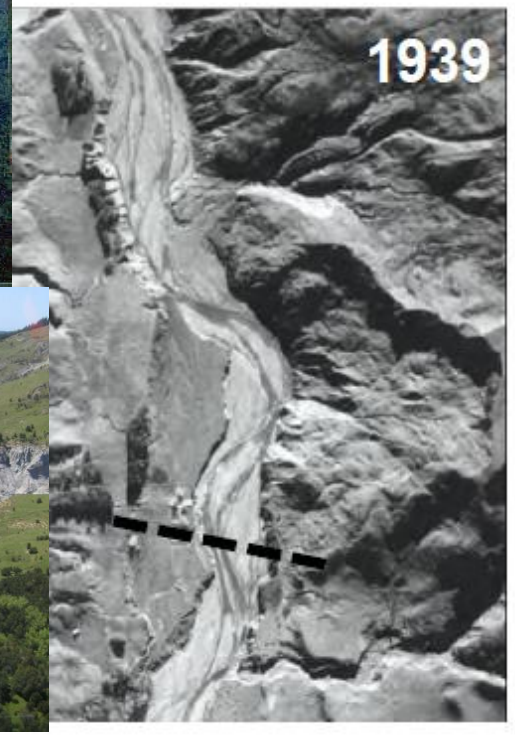
Connecting contaminants: biotic

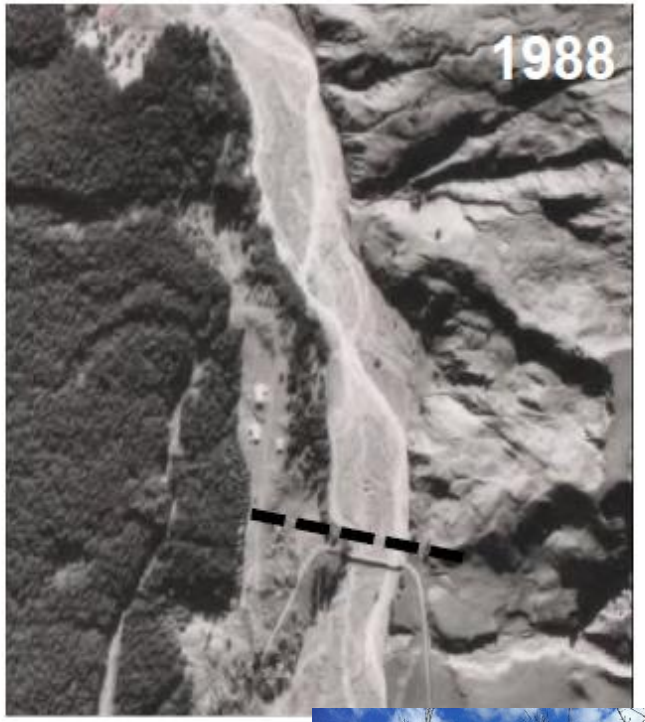


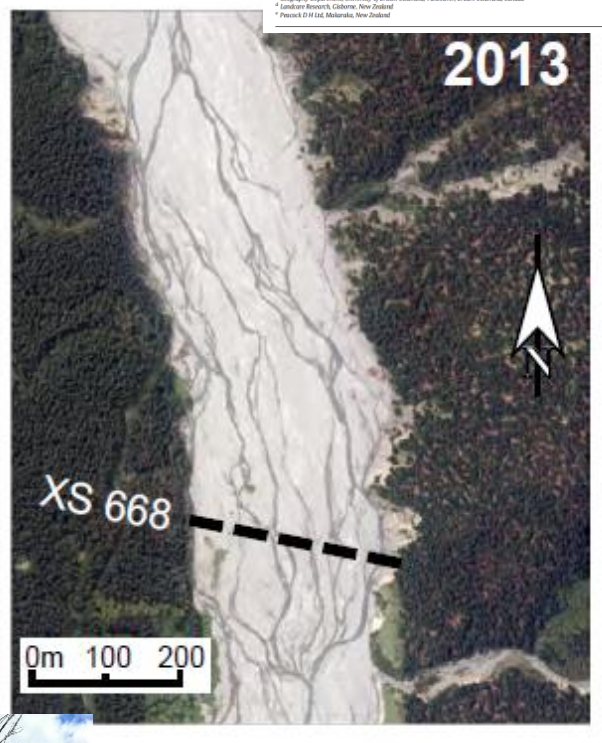


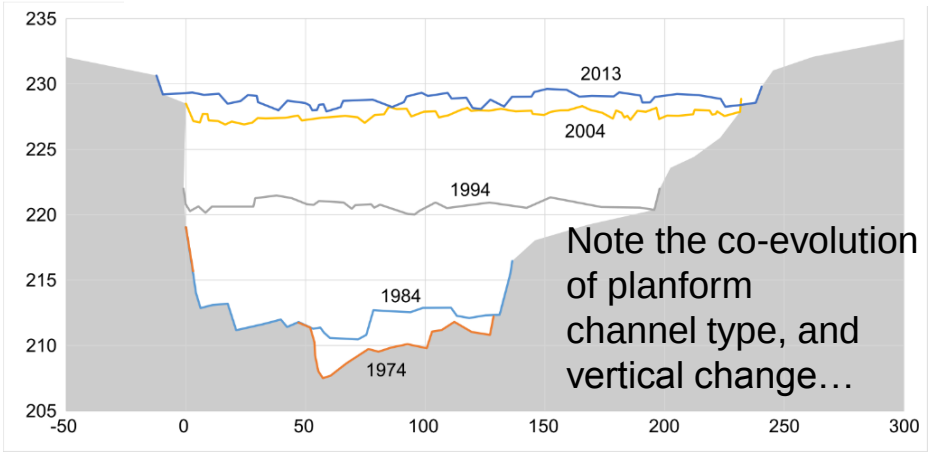


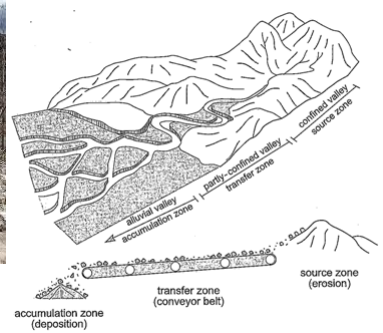
Connecting & dispersing sediment











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Reaction and relaxation in a coarse-grained fluvial system following catchment-wide disturbance

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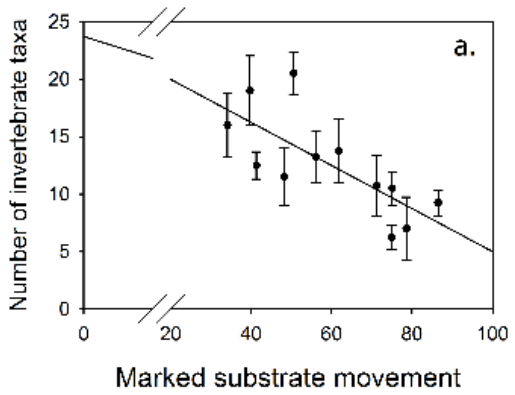
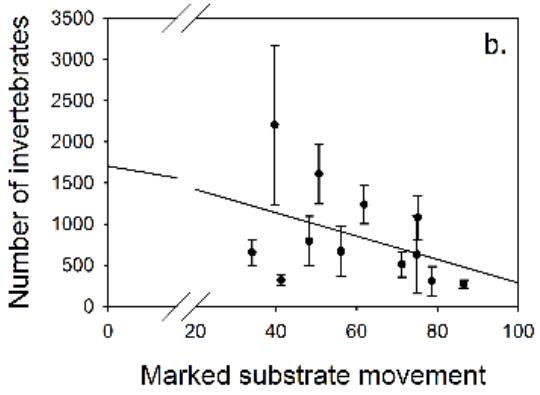
Impacts on river health

Impacts on river health





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SPECIAL ISSUE ARTICLE

WILEY

The science of connected ecosystems: What is the role of catchment-scale connectivity for healthy river ecology?

Ian C. Fuller[1] | Russell G. Death[2]

Human disease increasingly coming from poor catchment management imperatives

Five die in US lettuce E. coli outbreak

4:58 pm on 2 June 2018 Share this

Five people have now died in a major E. coli outbreak in the US involving romaine lettuce, with 197 cases reported across 35 states.

HAWKE'S BAY TODAY

Havelock North water crisis death in a false sense of security

13 Oct, 2018 6:05am 3 minutes to read

Jean Sparksman.

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Charlie Mitchell · 10:25, Aug 27 2016

Water supply to be permanently chlorinated in parts of Selwyn

By Georgia O'Connor Harding - April 18, 2018

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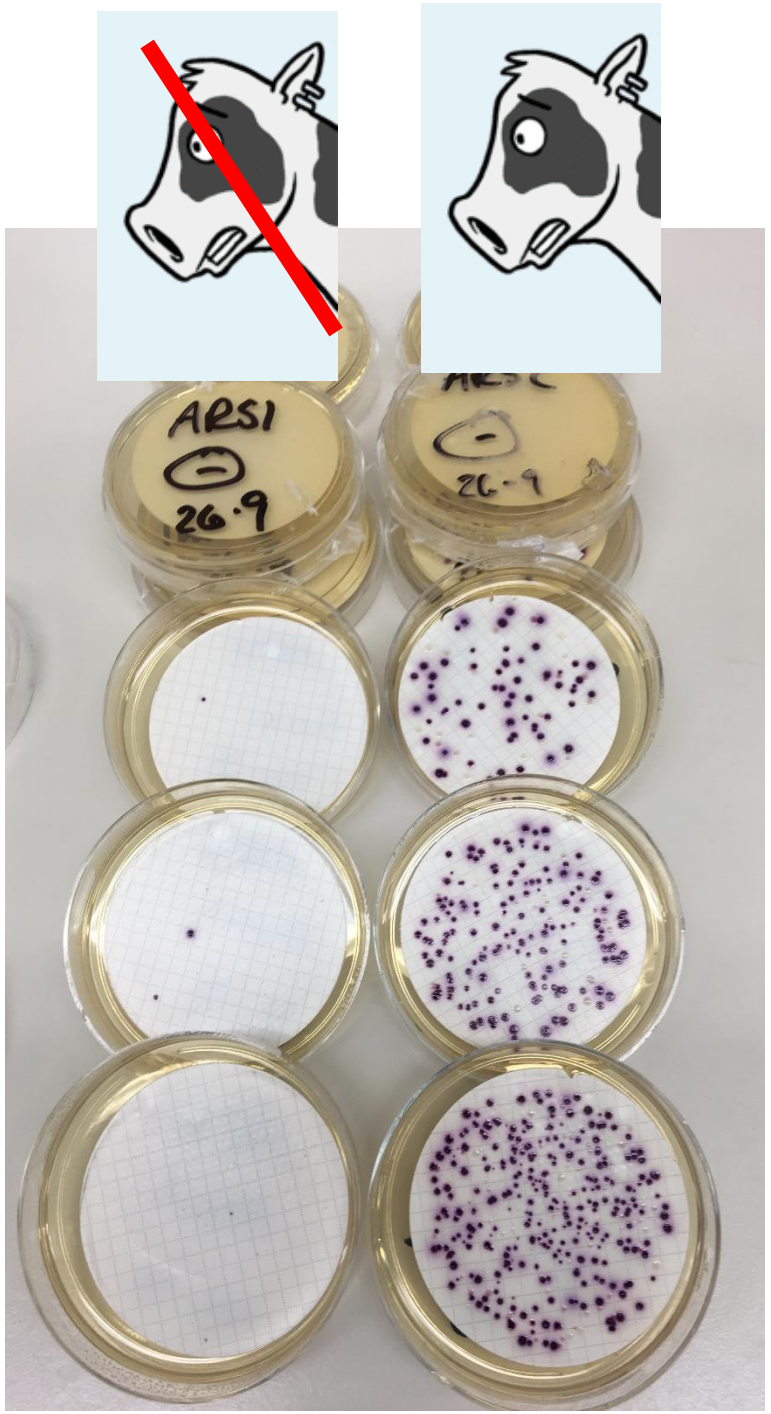
CLEANSE: Water supplies to be permanently chlorinated in Malvern has upset residents.



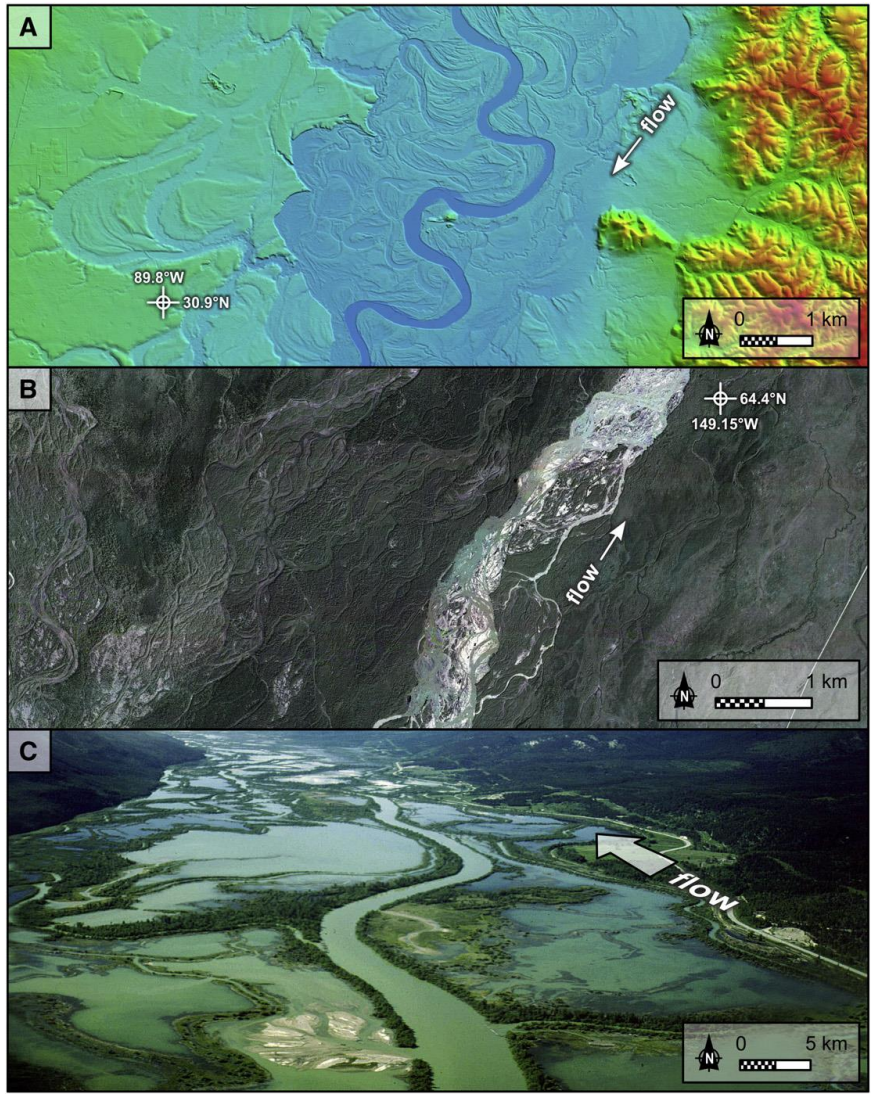
Morphology & malaria:
Water and the negative relief of rivers & floodplains

*There is a **range of scales** that provide different habitats*:

puddles, pools, channel reaches (flowing & stagnant), connected networks, lake margins

*A **range of forms** provide water-filled negative relief:*

Main rivers	Swales left by sedimentation
Secondary through channels	Backwater (cut-off) arms
Tributary channels	Inactive old channels
Channel margin slack water zones	Eroding tie (connecting) channels
Large flood basin lakes	Internal drainage networks
Human water storages	Wetland organic pools and ponds



Hydrological and geomorphological controls of malaria

Some Contrasts in the Regional Geography of Malaria in India and Pakistan
Author(s): A. T. A. Learmonth
Source: *Transactions and Papers (Institute of British Geographers)*, No. 23 (1957), pp. 37-59
Published by: Blackwell Publishing on behalf of The Royal Geographical Society (with the Institute of British Geographers)
Stable URL: http://www.jstor.org/stable/621155

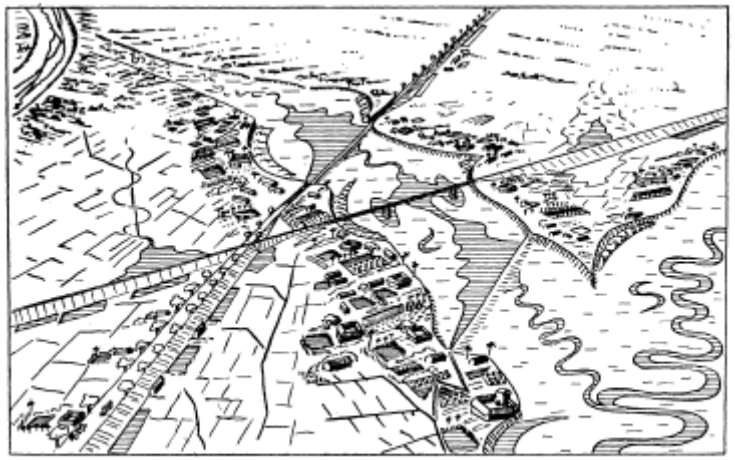
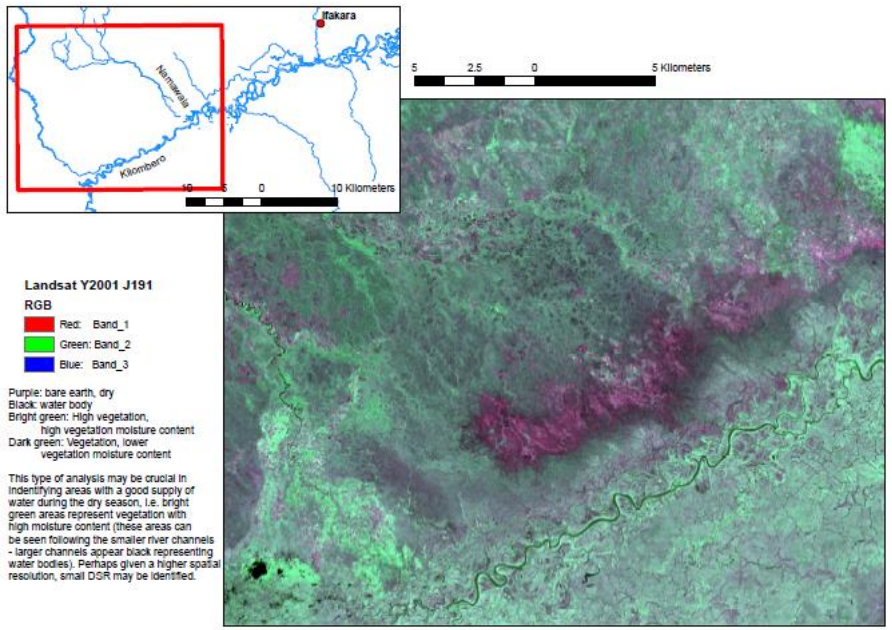


FIGURE 16—Breeding-places of *A. philippinensis* round settlements in West Bengal (from A. T. A. and A. M. Learmonth (1955), Fig. 5).



Long understood that river habitats, especially water bodies (WBs) in river channels and on floodplains, have a fundamental control on freshwater invertebrates and fish communities.

BUT the explicit link between river flooding and sedimentation dynamics that create WBs that provide habitats for mosquitoes in the dry season (dry season refugia) has not been made.

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Hydrological and geomorphological controls of malaria transmission

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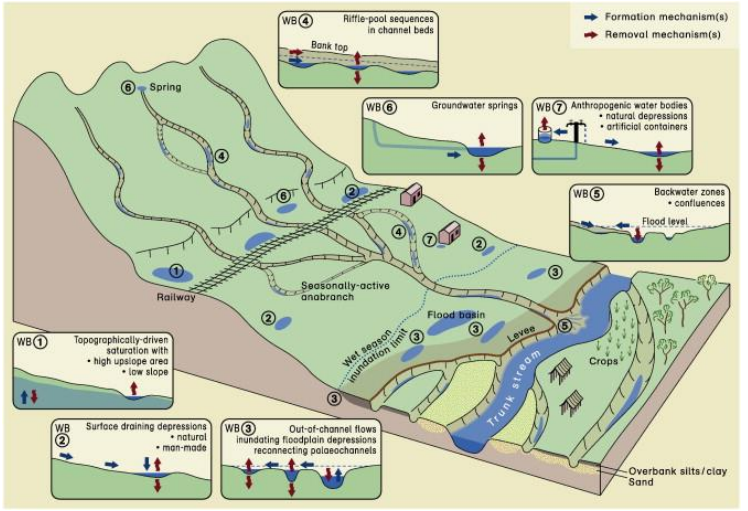


Why we need a catchment-framed, integrated & interdisciplinary approach

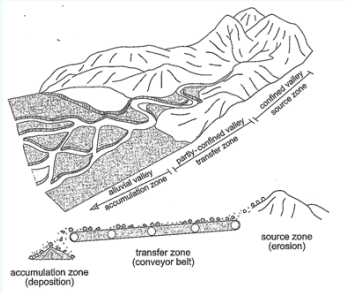
Flow regime change

Floods
Droughts
Climate change

Hazardous material input

Metal pollutants
Industrial, urban & agricultural pollutants
Contaminants of emerging concern
AMR

Catchment system



Morphological change

Bank erosion & entrenchment
Sedimentation & aggradation

Disease transmission

Malaria Cholera
Dysentery Typhoid
Schistosomiasis
Leptospirosis
Cryptosporidiosis

Human intervention may ***increase*** safety (as through floodway engineering or building refuge platforms), or inadvertently ***decrease*** it (as through spreading pollution, pathogens, AMR, disease).

Unhealthy and unsafe rivers = threat to health