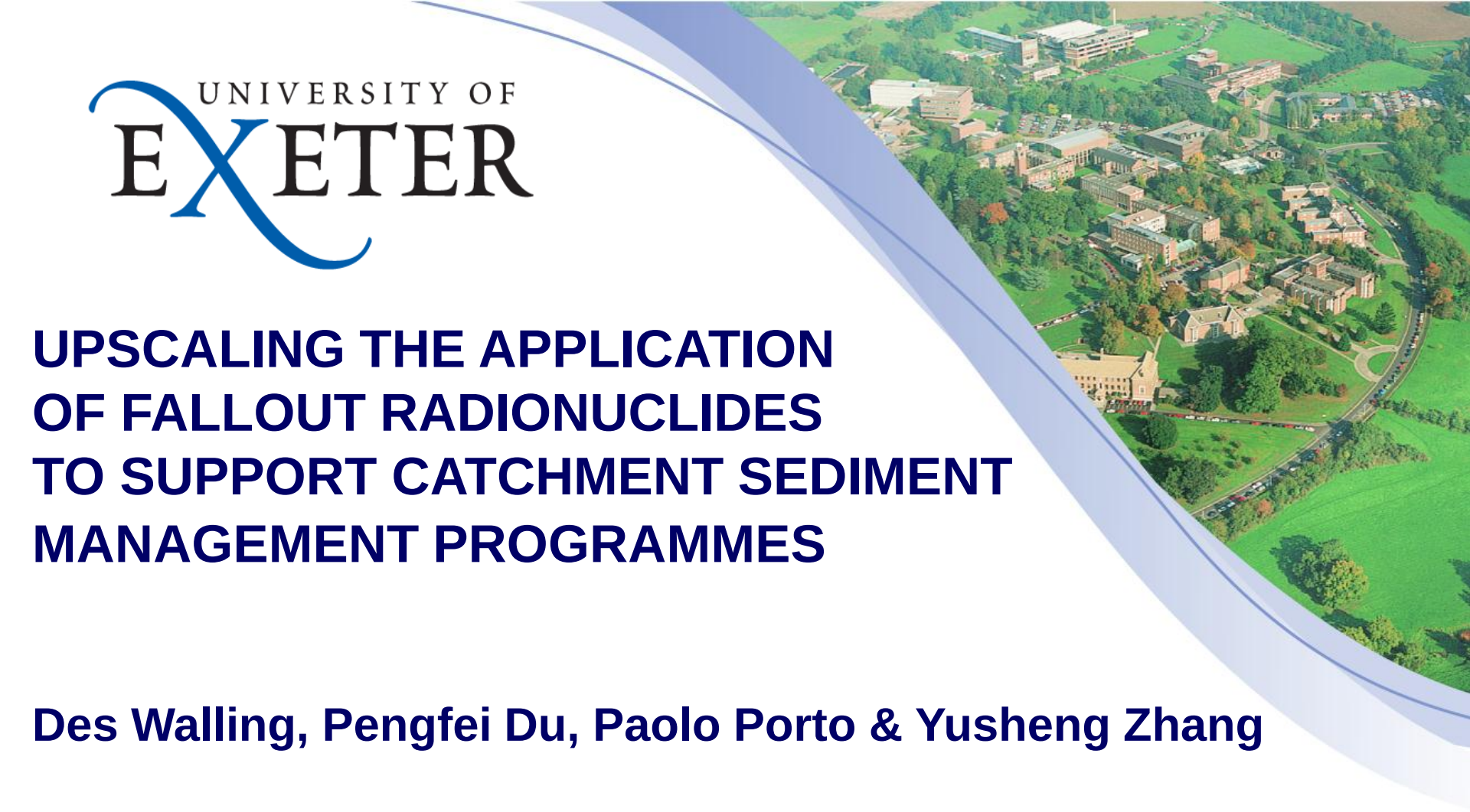


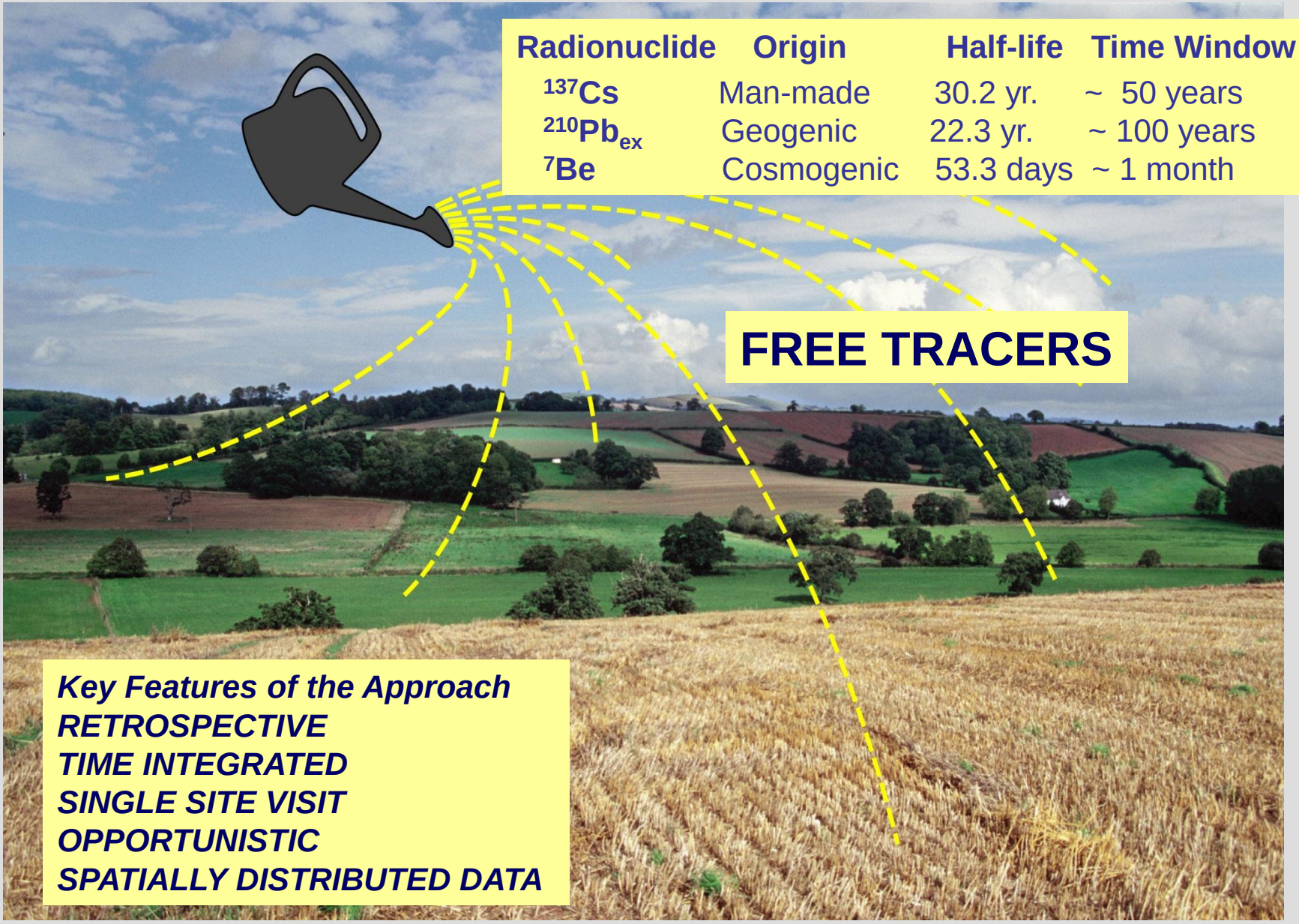
UPSCALING THE APPLICATION OF FALLOUT RADIONUCLIDES TO SUPPORT CATCHMENT SEDIMENT MANAGEMENT PROGRAMMES

Des Walling, Pengfei Du, Paolo Porto & Yusheng Zhang

Department of Geography

FAO / IAEA International Conference on Managing Soils for Food Security and Climate Change Adaptation and Mitigation, Vienna, Austria, July 23-27, 2012

The use of fallout radionuclides in soil erosion investigations



Radionuclide	Origin	Half-life	Time Window
^{137}Cs	Man-made	30.2 yr.	~ 50 years
$^{210}Pb_{ex}$	Geogenic	22.3 yr.	~ 100 years
^{7}Be	Cosmogenic	53.3 days	~ 1 month

FREE TRACERS

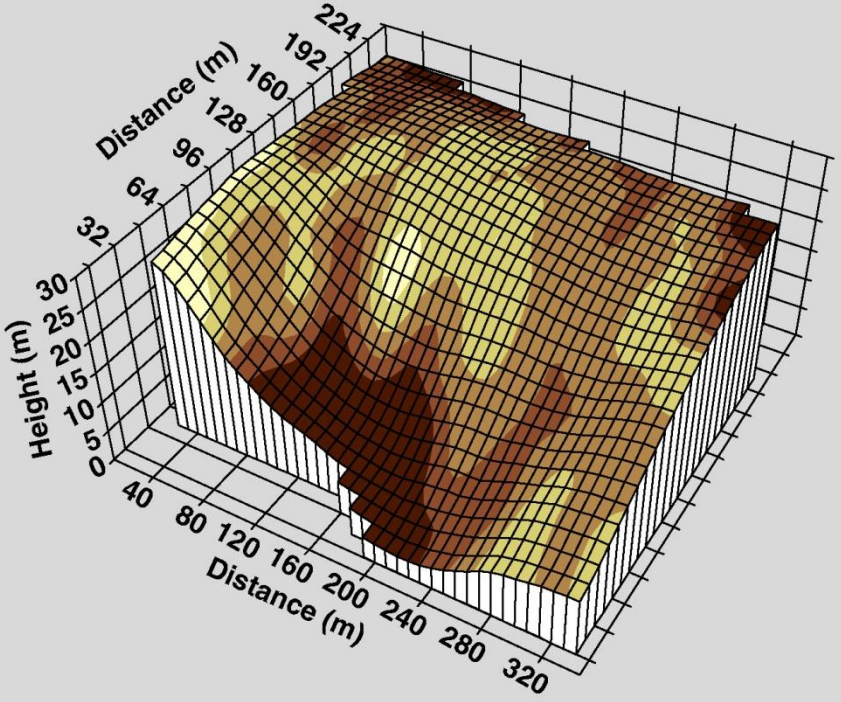
Key Features of the Approach
RETROSPECTIVE
TIME INTEGRATED
SINGLE SITE VISIT
OPPORTUNISTIC
SPATIALLY DISTRIBUTED DATA

Handbook for the Assessment of Soil Erosion and Sedimentation Using Environmental Radionuclides

Edited by
F. Zapata

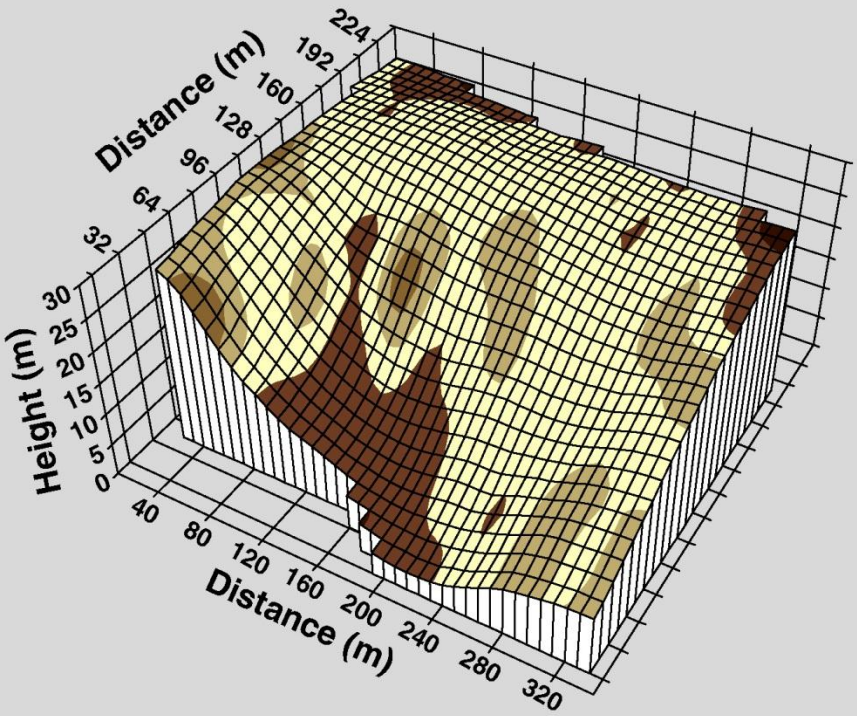
Kluwer Academic Publishers

The Field-scale approach



^{137}Cs inventory (Bq m^{-2})

2600
2333
2067
1800



^{137}Cs-estimated soil redistribution rate (kg m^{-2} yr^{-1})

1.0
0.0
-1.0
-2.0

RATES OF SOIL REDISTRIBUTION WITHIN THE STUDY FIELD ESTIMATED FROM Cs-137 MEASUREMENTS

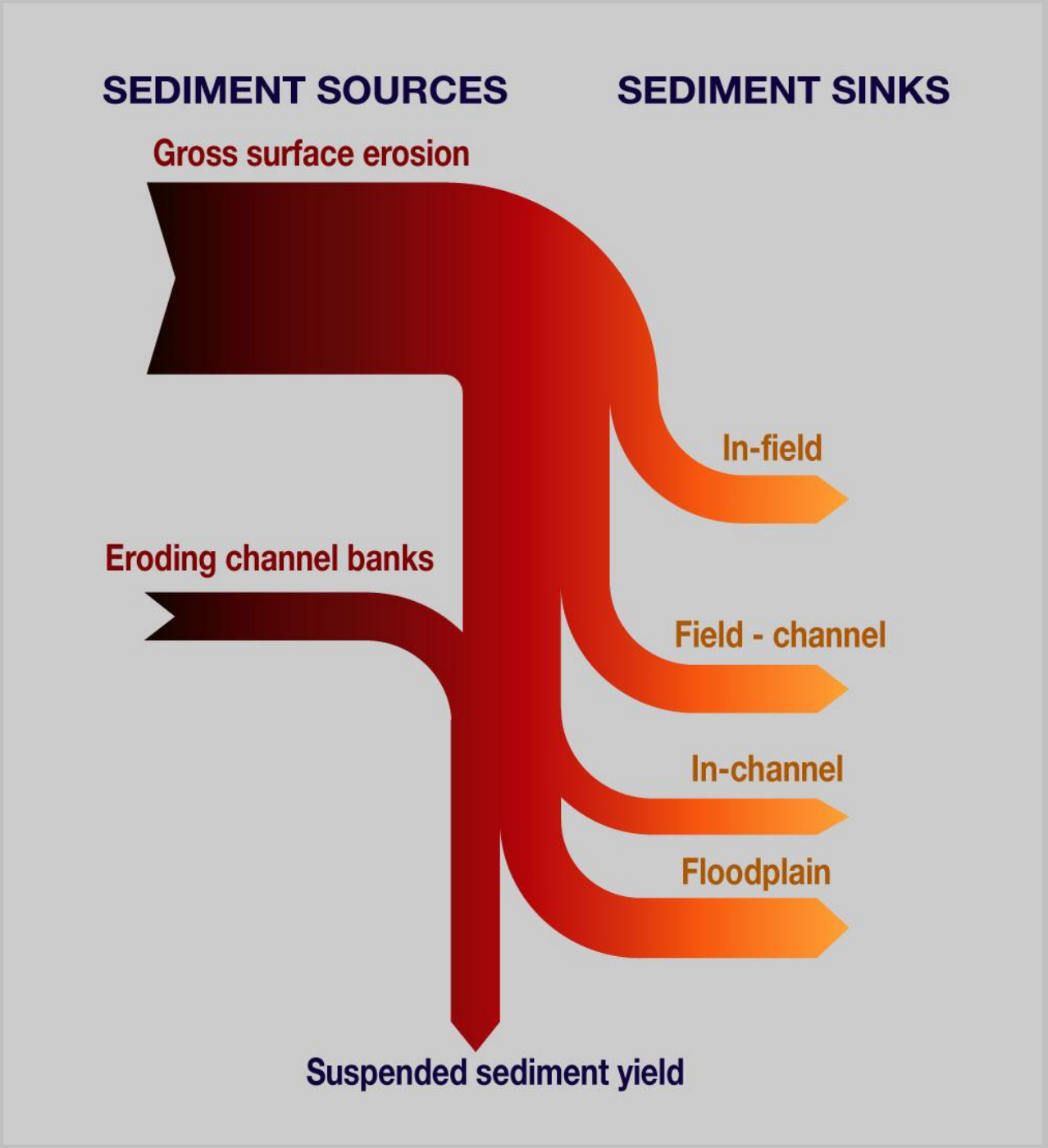
Measure	(kg m^{-2} $year^{-1}$)
Range of redistribution rates	- 4.5 to +2.0
Mean erosion rate for eroding areas	-1.1
Mean deposition rate for depositional areas	0.69
Net soil loss	-0.48
Sediment delivery ratio	0.83

The catchment-scale perspective
(Sediment problems and sediment management)

- On-site versus off-site issues
- Physical impacts – channel and reservoir
- sedimentation, degradation of aquatic ecosystems
- Sediment-associated nutrients and contaminants
- Sediment sinks

A NEED TO UPSCALE

The Catchment Sediment Budget



Upscaling the application of fallout radionuclides to support catchment sediment management programmes

- Extrapolating field-scale estimates of soil erosion rates
- Broad scale or low density sampling to establish catchment sediment budgets
- Quantifying the importance of river floodplains as sediment sinks

IAEA CRP D1.20.11

Extrapolating field-scale estimates of soil erosion rates

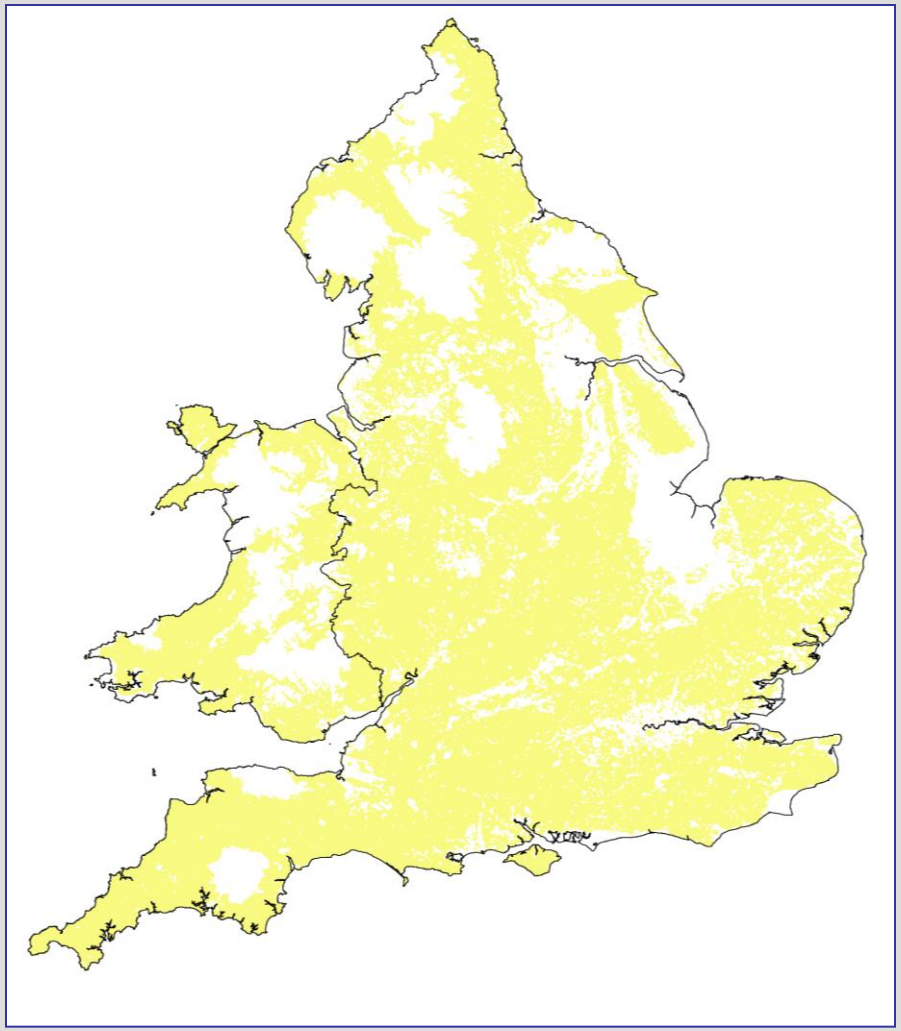
- Refined sampling protocols - *To obtain reliable and meaningful estimates of the soil erosion rates within a particular field based on a small number of cores*
- Sampling a range of fields - *To obtain information on the range of soil erosion rates and the influence of key controls*
- Extrapolation of the results

Walling, D.E. and Zhang, Y. (2010) A national assessment of soil erosion based on caesium-137 measurements. *Advances in Geoecology* 41, 89-97.

A National Scale Soil Erosion Inventory

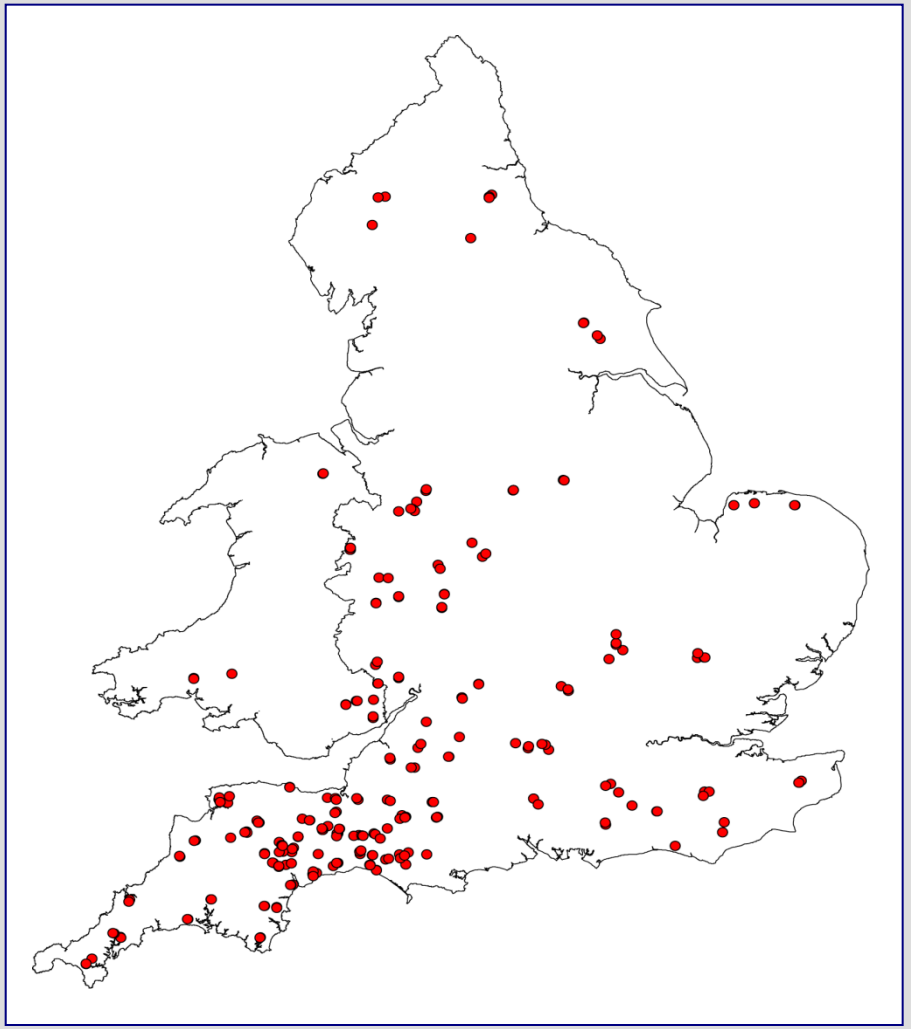
The Study Area

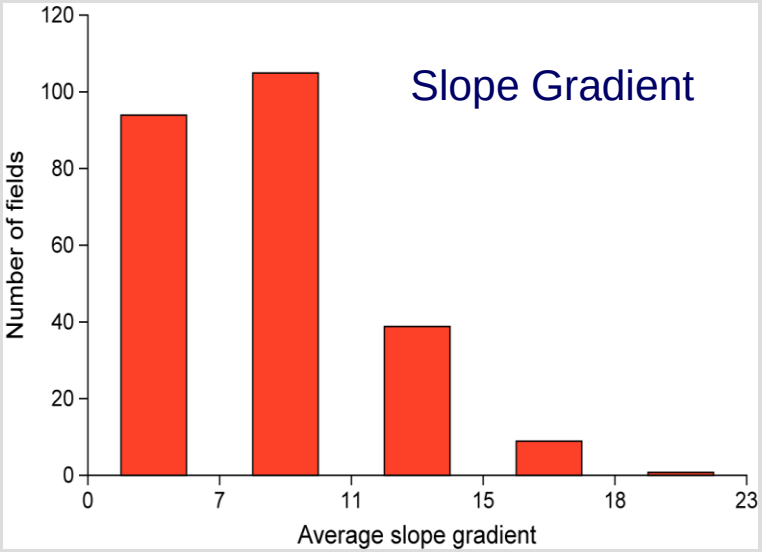
Excludes forest areas, urban areas, areas of open water, flat areas (< 1 degree slope), upland areas (>300 m) and National Parks

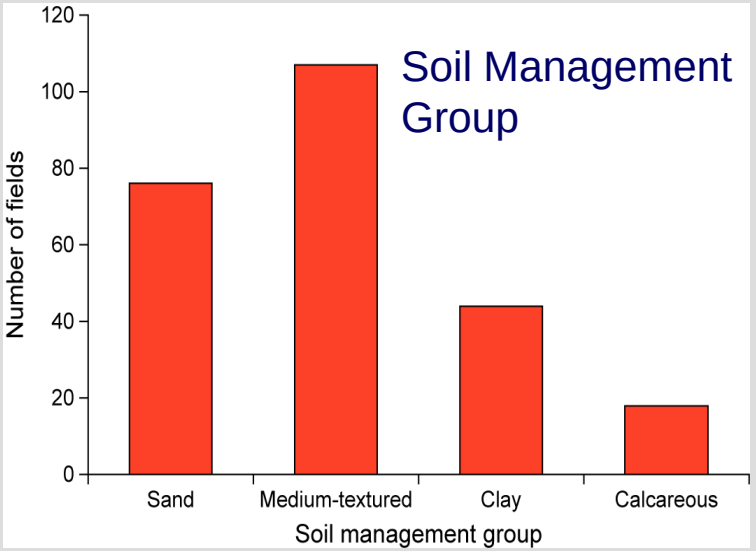


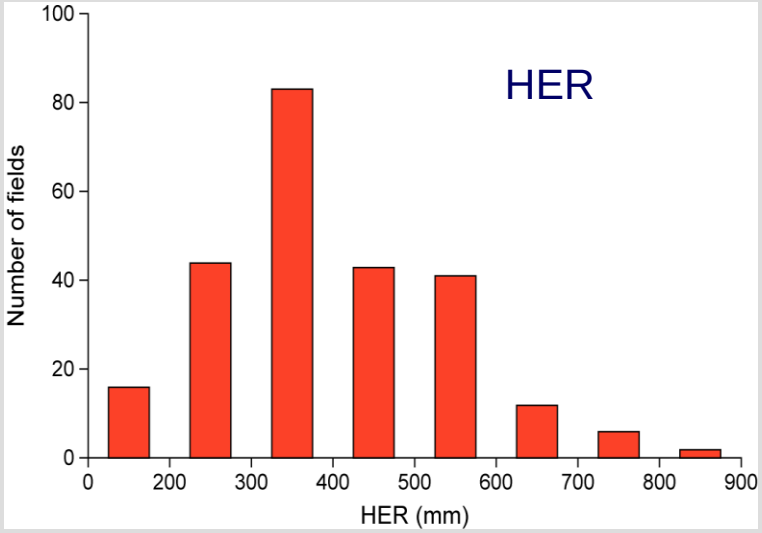
The Sampling Locations

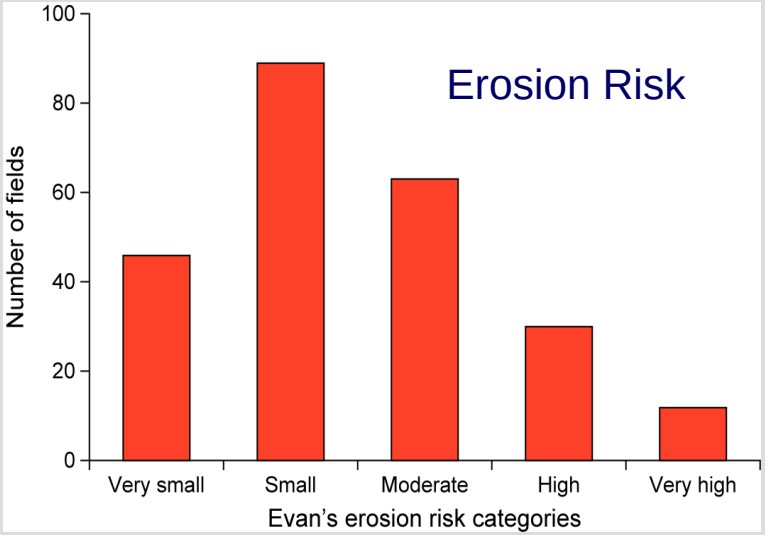
Includes 248 fields




Slope Gradient
Number of fields
120
100
80
60
40
20
0
0
7
11
15
18
23
Average slope gradient

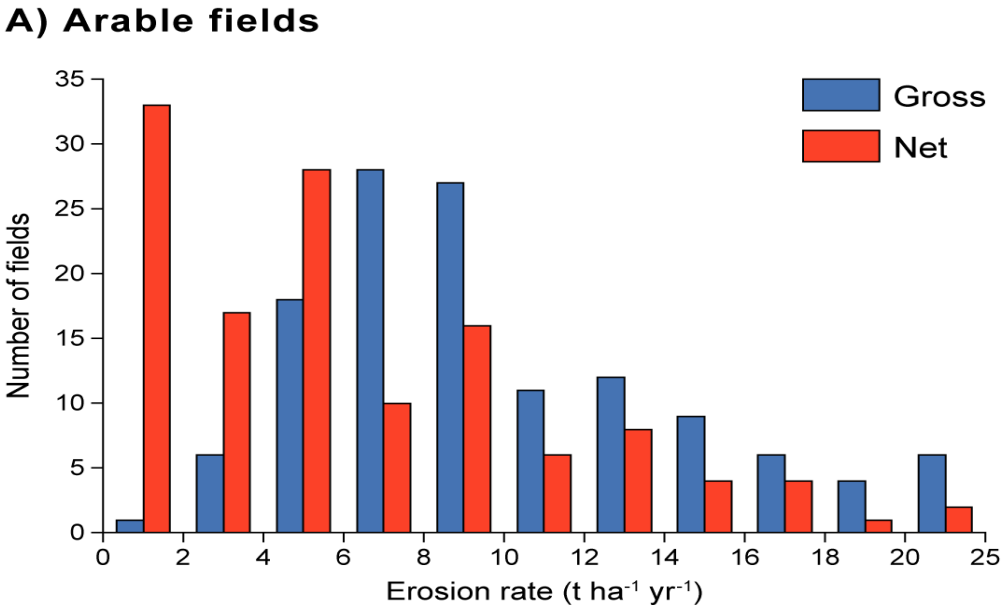

Soil Management Group
Number of fields
120
100
80
60
40
20
0
Sand
Medium-textured
Clay
Calcareous
Soil management group

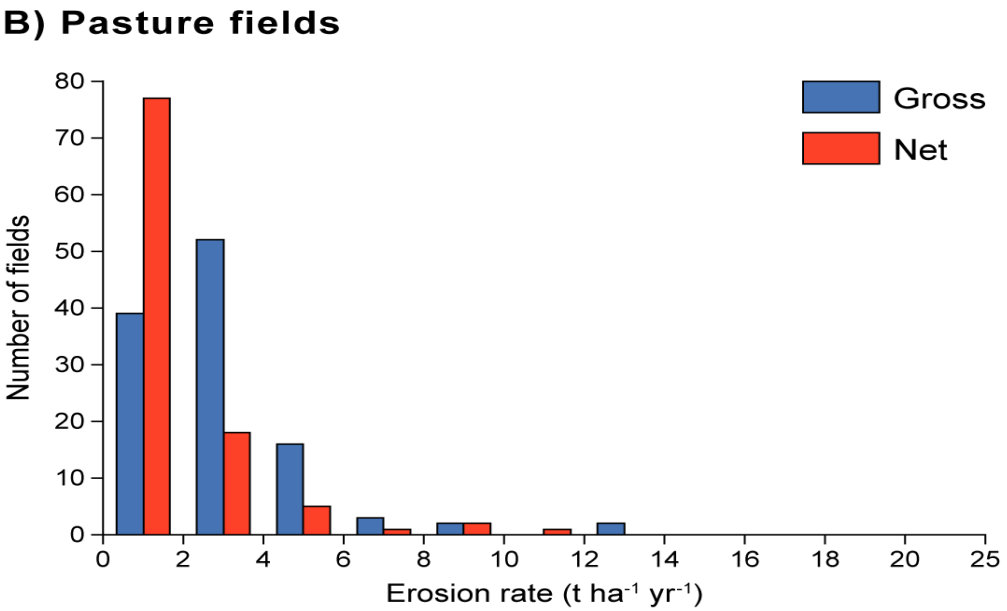

HER
Number of fields
100
80
60
40
20
0
0
200
300
400
500
600
700
800
900
HER (mm)


Erosion Risk
Number of fields
100
80
60
40
20
0
Very small
Small
Moderate
High
Very high
Evan's erosion risk categories

Documented Erosion Rates

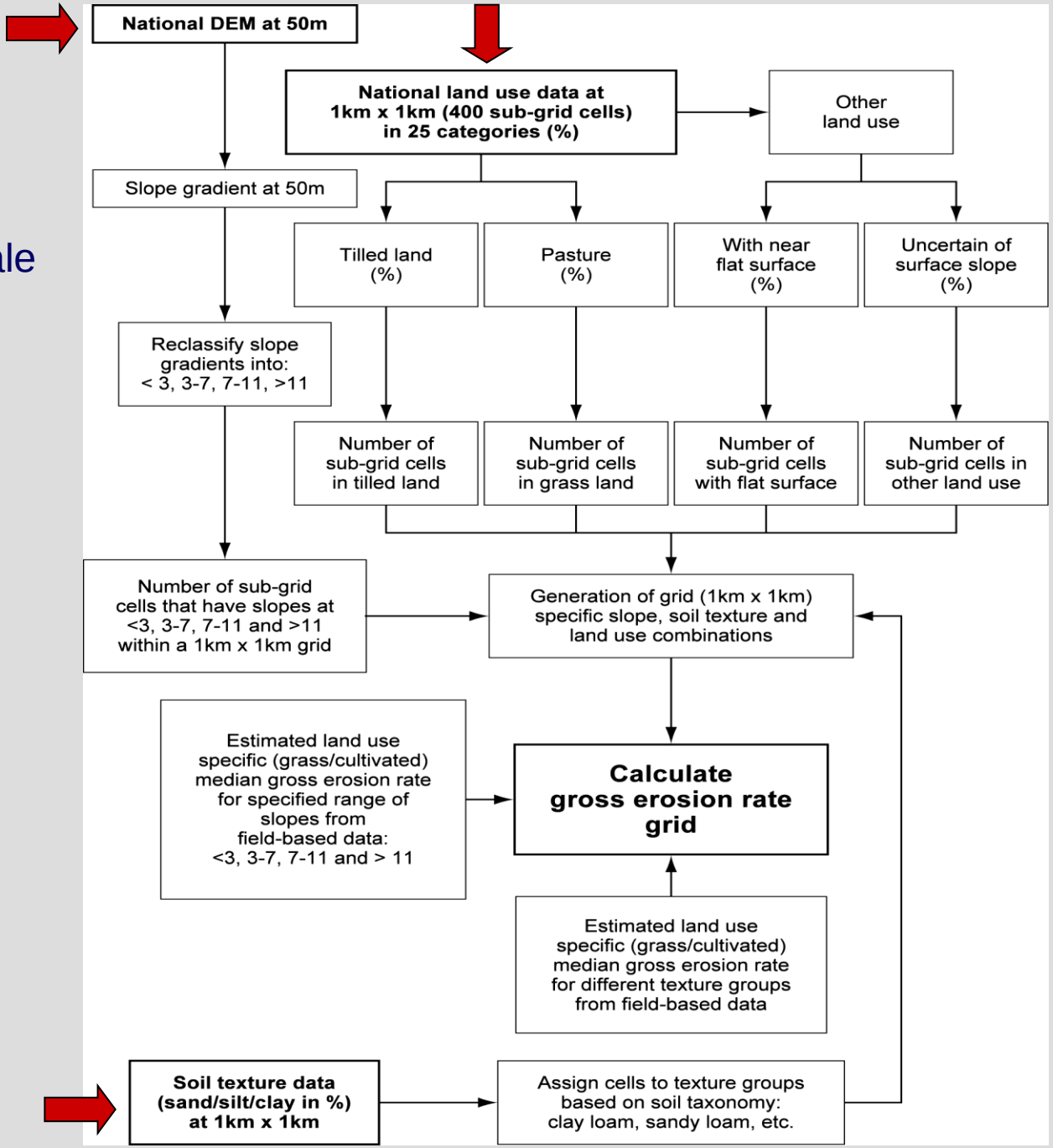
248 fields



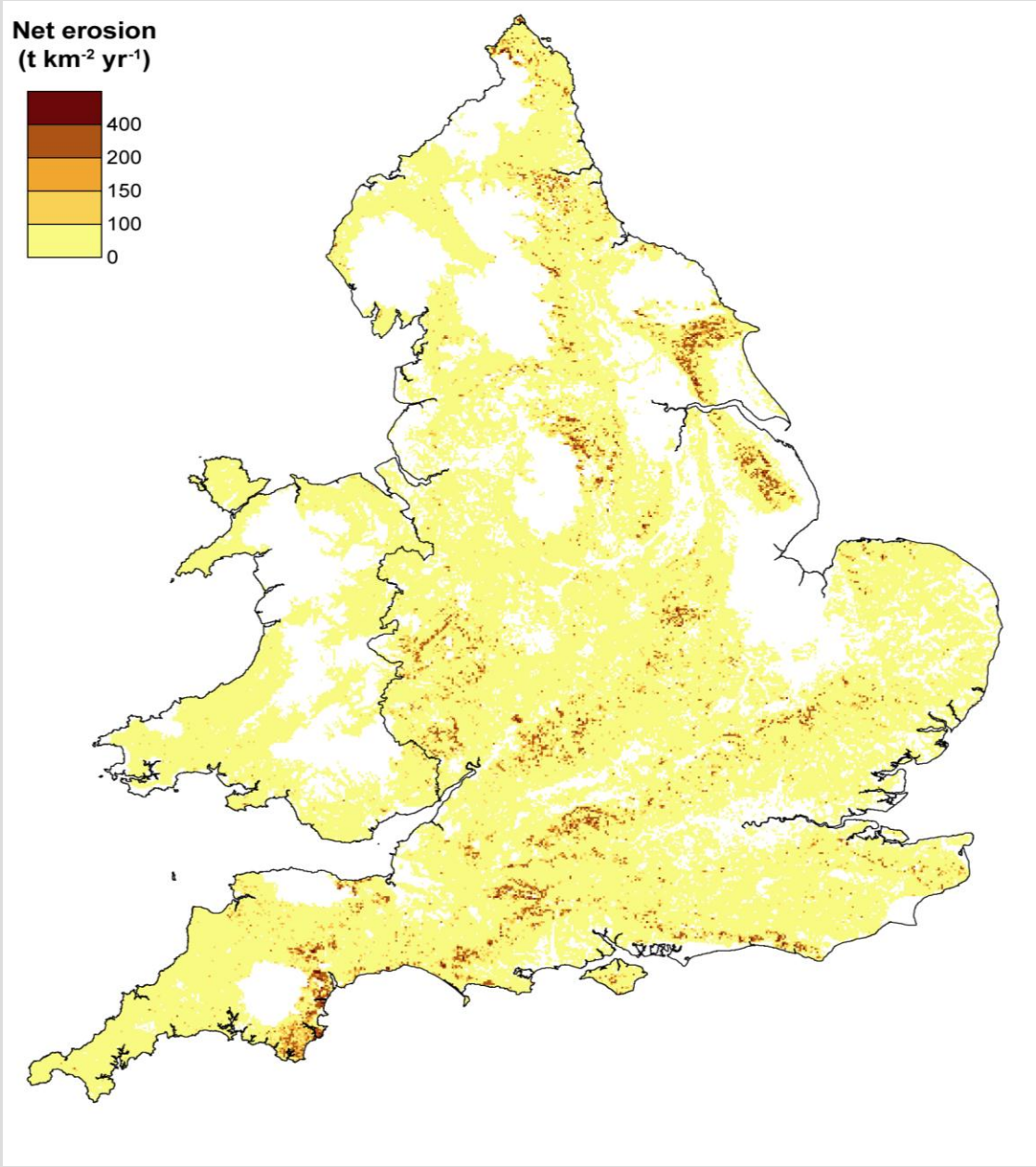


NATIONAL SCALE EXTRAPOLATION

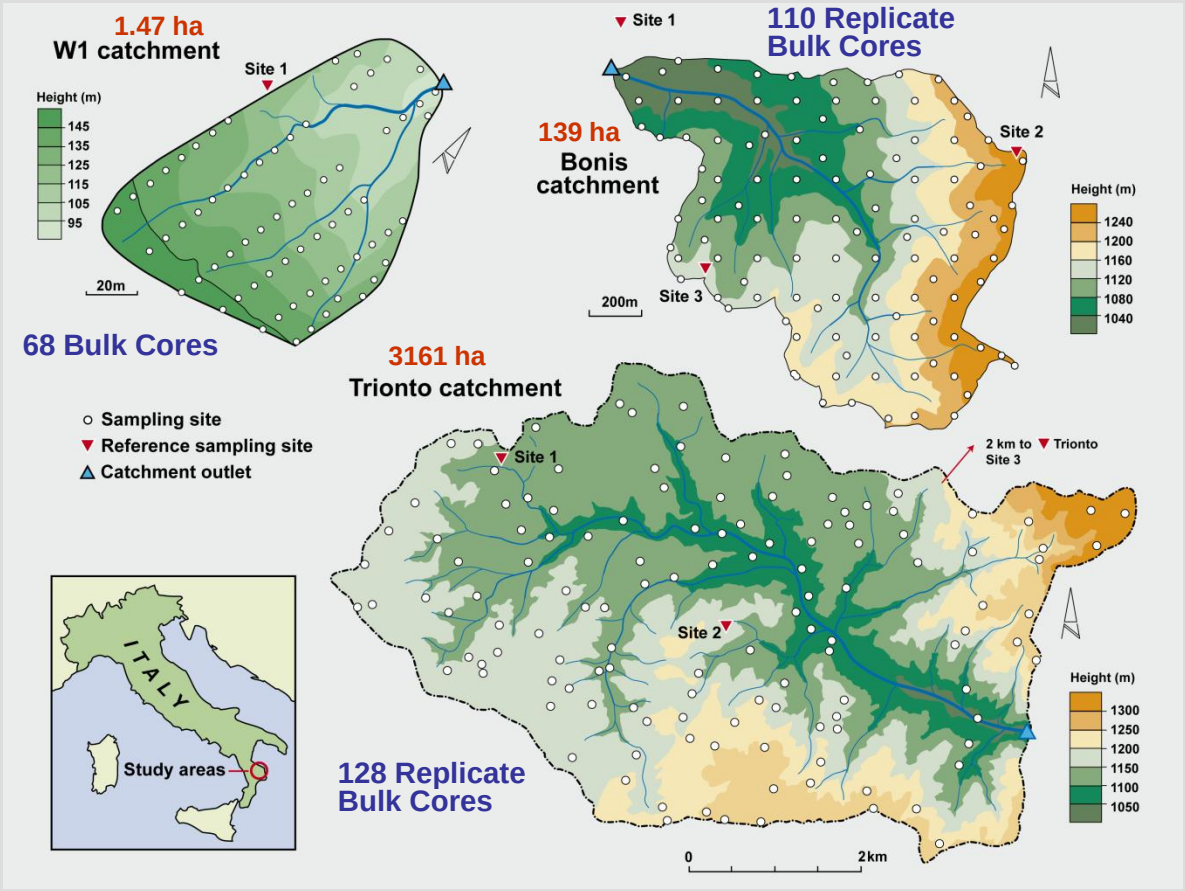
The typology used for extrapolating the field scale erosion rate data to the national scale
(Boxes with bold text Indicate existing datasets)



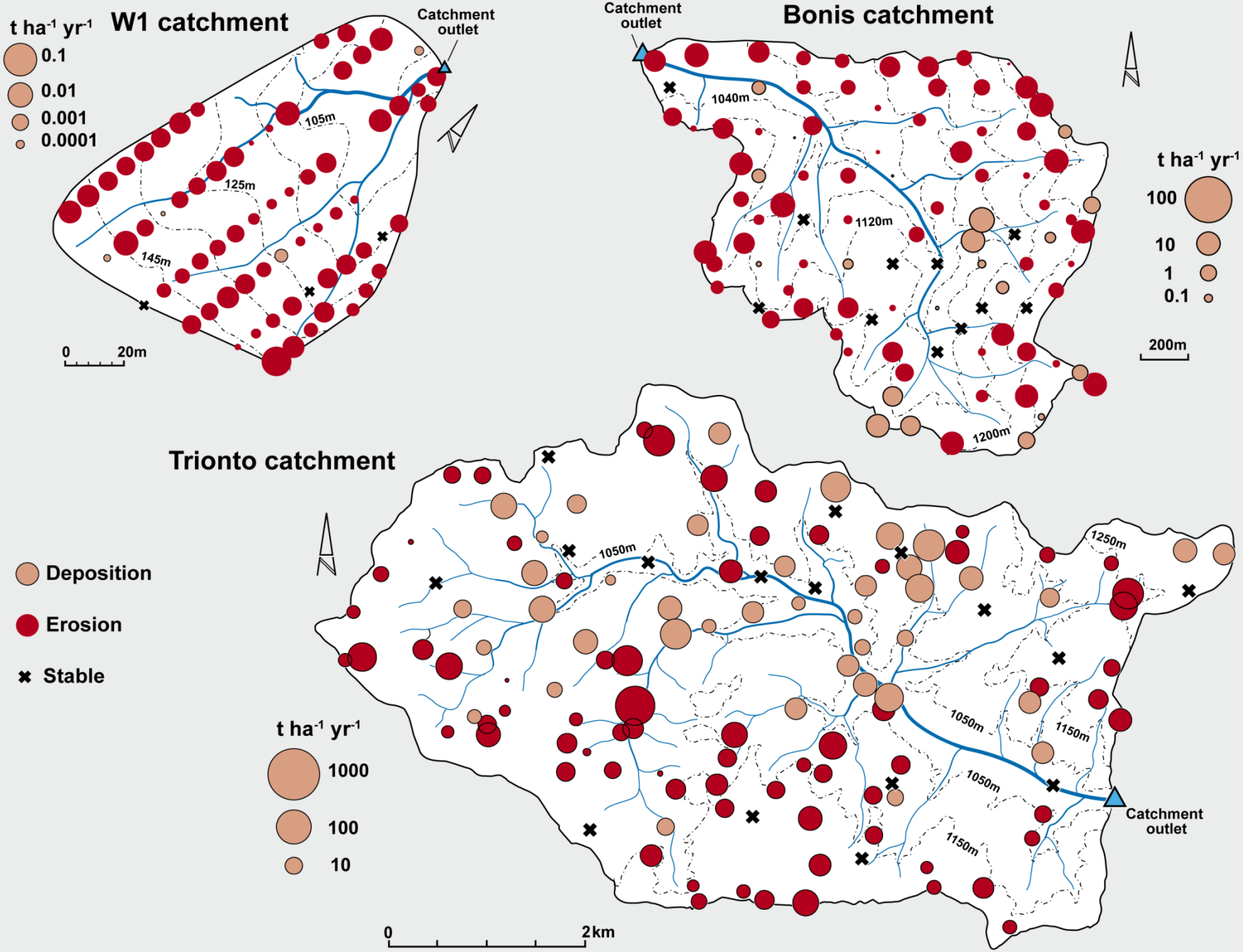
A national map of net erosion rates for a combination of cultivated and pasture land use

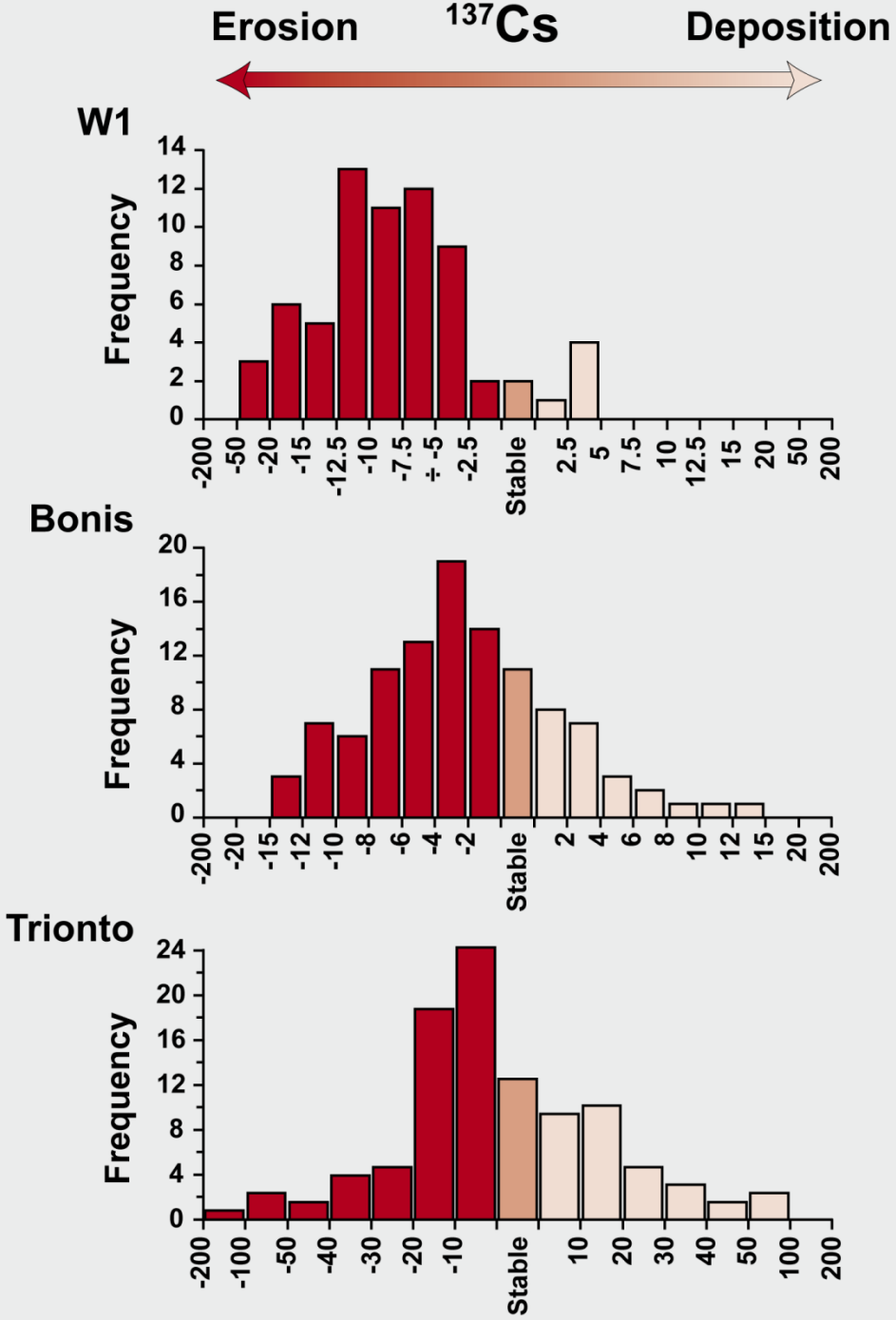


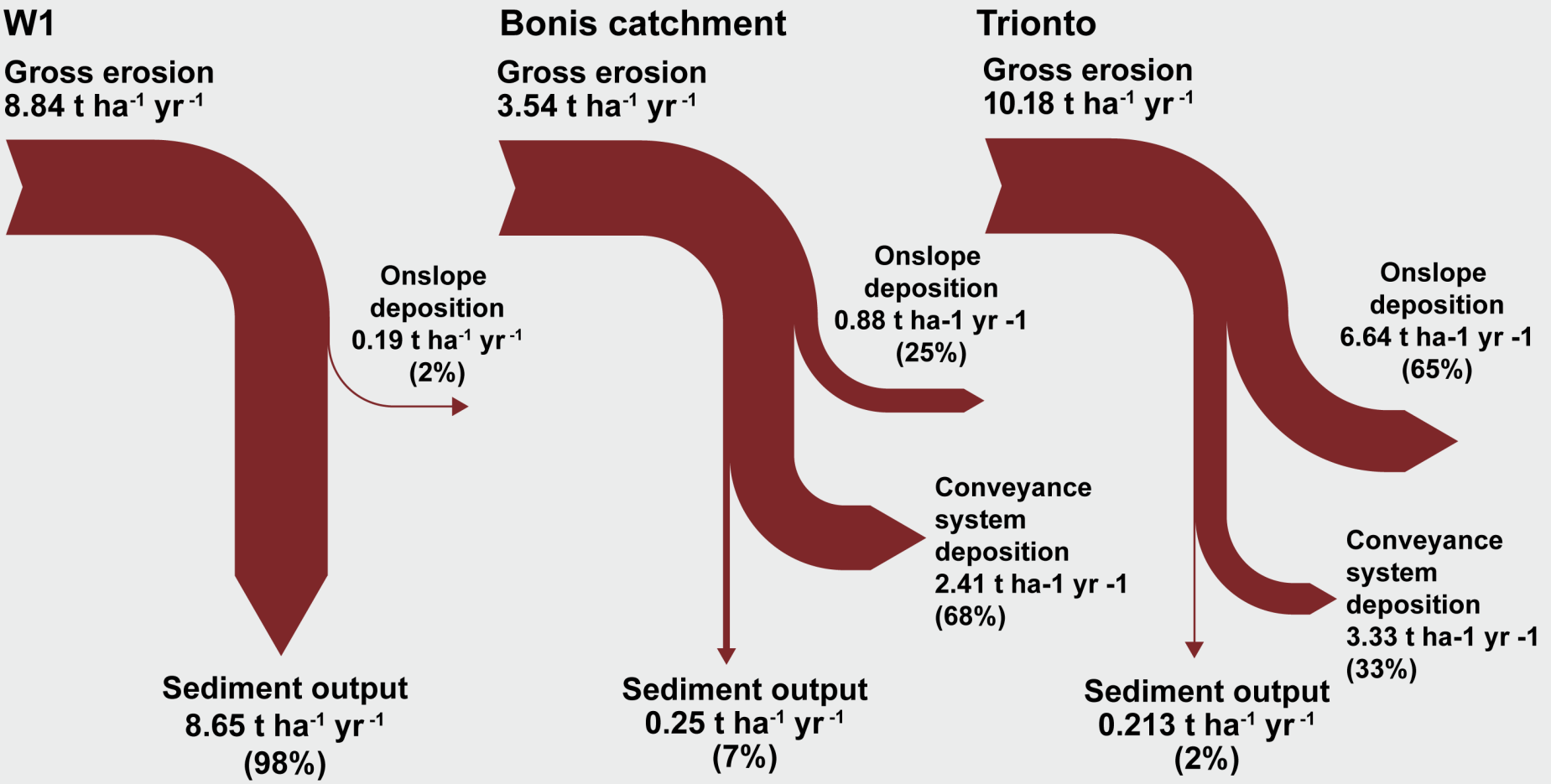
Using Low Density Sampling to Establish Catchment Sediment Budgets



Porto, P., Walling, D.E. and Callegari, G. (2011) Using ^{137}Cs measurements to establish catchment sediment budgets and explore scale effects. *Hydrological Processes* 25, 886-900.

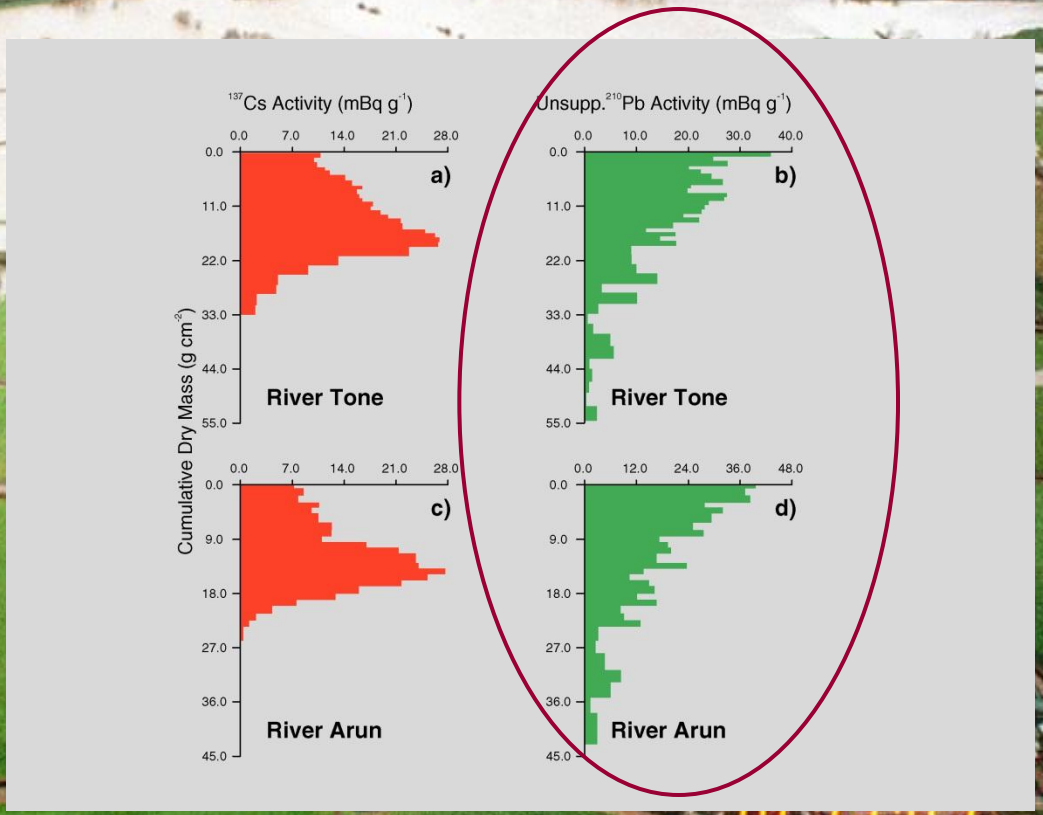

W1 catchment
t ha-1 yr-1
0.1
0.01
0.001
0.0001
Catchment outlet
105m
125m
145m
0
20m
Bonis catchment
Catchment outlet
1040m
1120m
1200m
t ha-1 yr-1
100
10
1
0.1
200m
Trionto catchment
Deposition
Erosion
Stable
t ha-1 yr-1
1000
100
10
1050m
1250m
1150m
Catchment outlet
0
2km


Erosion
137Cs
Deposition
W1
Frequency
14
12
10
8
6
4
2
0
-200
-50
-20
-15
-12.5
-10
-7.5
÷ -5
-2.5
Stable
2.5
5
7.5
10
12.5
15
20
50
200
Bonis
Frequency
20
16
12
8
4
0
-200
-20
-15
-12
-10
-8
-6
-4
-2
Stable
2
4
6
8
10
12
15
20
200
Trionto
Frequency
24
20
16
12
8
4
0
-200
-100
-50
-40
-30
-20
-10
Stable
10
20
30
40
50
100
200


W1
Gross erosion
8.84 t ha-1 yr -1
Onslope
deposition
0.19 t ha-1 yr -1
(2%)
Sediment output
8.65 t ha-1 yr -1
(98%)
Bonis catchment
Gross erosion
3.54 t ha-1 yr -1
Onslope
deposition
0.88 t ha-1 yr -1
(25%)
Conveyance
system
deposition
2.41 t ha-1 yr -1
(68%)
Sediment output
0.25 t ha-1 yr -1
(7%)
Trionto
Gross erosion
10.18 t ha-1 yr -1
Onslope
deposition
6.64 t ha-1 yr -1
(65%)
Conveyance
system
deposition
3.33 t ha-1 yr -1
(33%)
Sediment output
0.213 t ha-1 yr -1
(2%)

River Floodplains as Sediment Sinks

Estimating Floodplain Sedimentation Rates



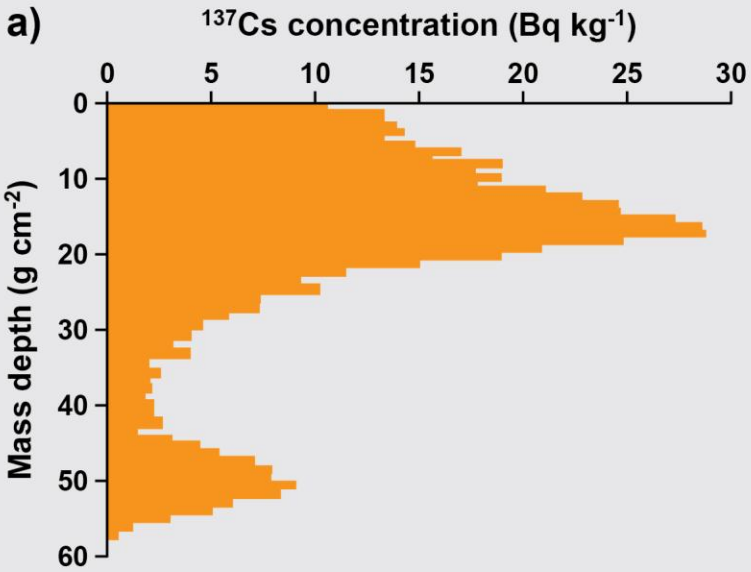
Du, P. and Walling, D.E. (2012) Using ^{210}Pb measurements to estimate sedimentation rates on river floodplains. *J. Environmental Radioactivity* 103, 59-75.

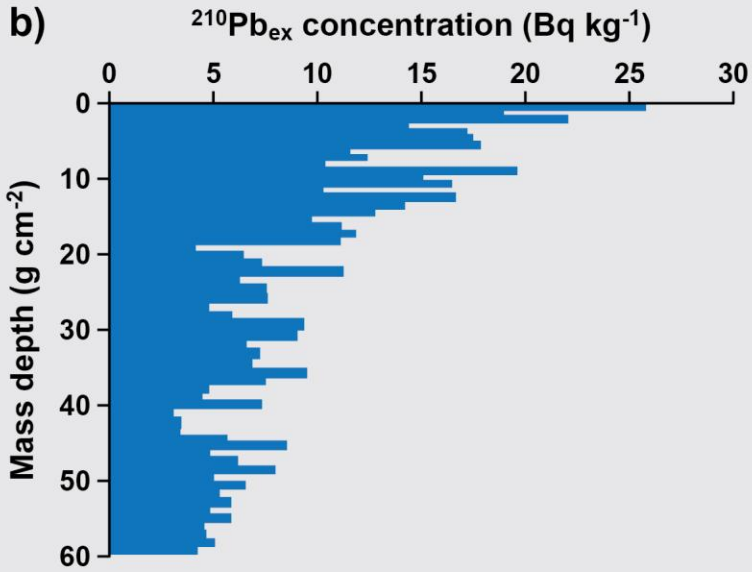

1,2 River Axe near Whitford bridge
3 River Culm near Rewe
4 River Torridge near Sheepwash
5,6 River Severn near Welshpool
7 River Severn near Tewkesbury
5,6
Birmingham
7
London
4
3
1,2
Exeter
0
150km

Photo by Penny Mayes

P

RIVER SEVERN AT WELSHPOOL





Estimated Sedimentation Rate (g cm^{-2} year^{-1})

	^{137}Cs	^{210}Pb
1986 - 2009	0.70	
1963 - 1986	1.38	
1950 - 2009		1.14

CONCLUSIONS

- New questions, new approaches
- Sediment budgets
- Upscaling
- Some examples
- Considerable scope for further development and coupling with other techniques e.g. sediment source tracing

THANK YOU