

An integrated approach to catchment systems: mineral and organic sediment budgets

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Outline

Systematic evaluation of sediment production, transfer and storage in upland catchments → **sediment budget models**

Key Topics:

1. Contrasts between mineral sediment systems and organic-mineral sediment systems
2. Local floods in the uplands – Catcleugh, August 2002, Moor House, July 2002
3. Longer-term perspectives on sediment delivery
4. Stopping erosion of peatland gullies – lessons from sediment budgets
5. Benefits of sediment budgets for understanding upland erosion and sediment dynamics

Sediment Budget:

a sediment budget is a quantitative statement of the rates of sediment production, transport and discharge of detritus

The three elements needed to construct a sediment budget are:

- 1) Recognition and quantification of transport processes
- 2) Recognition and quantification of storage elements
- 3) Identification of linkages amongst transport processes

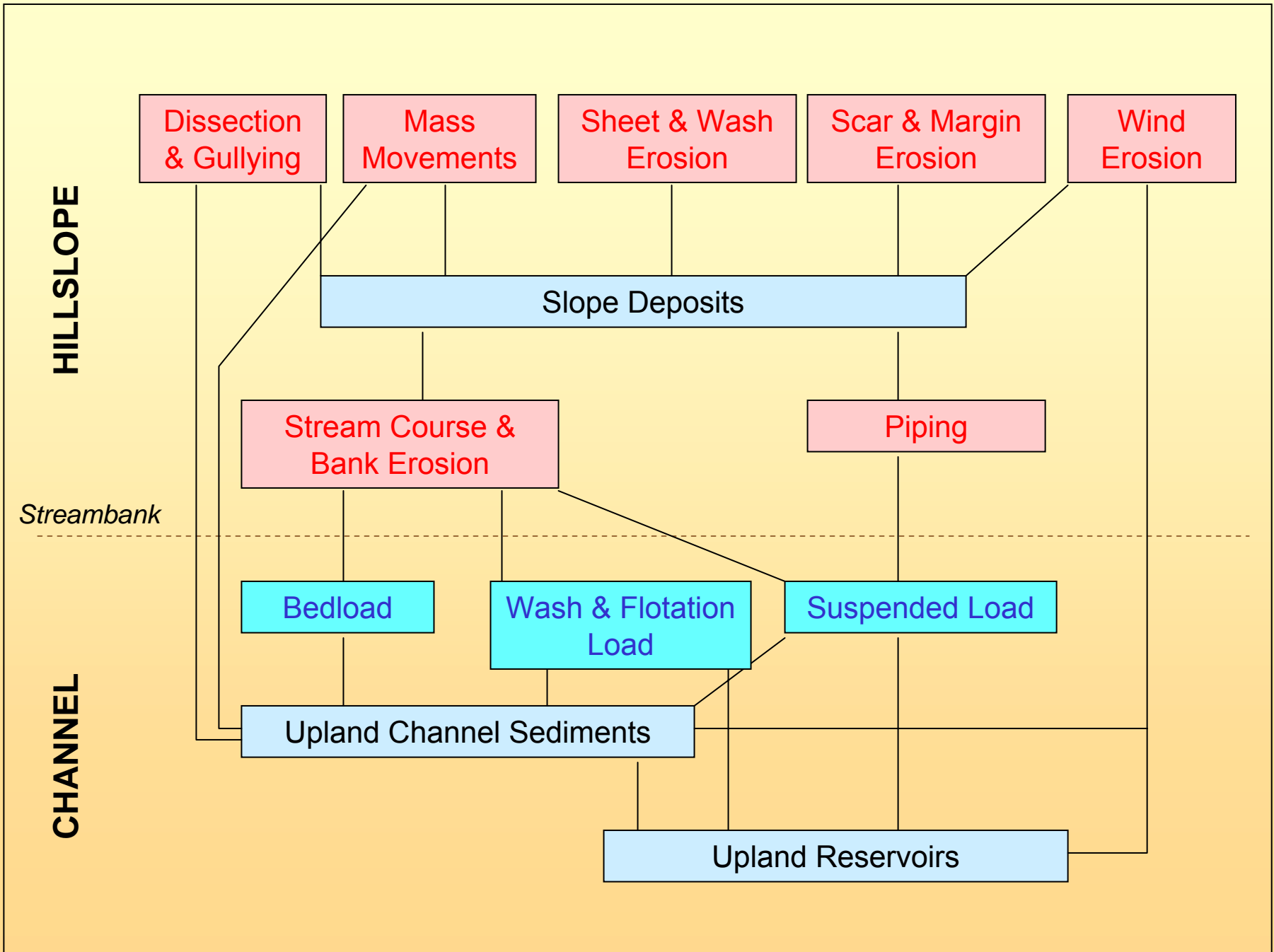


Sediment balance equation

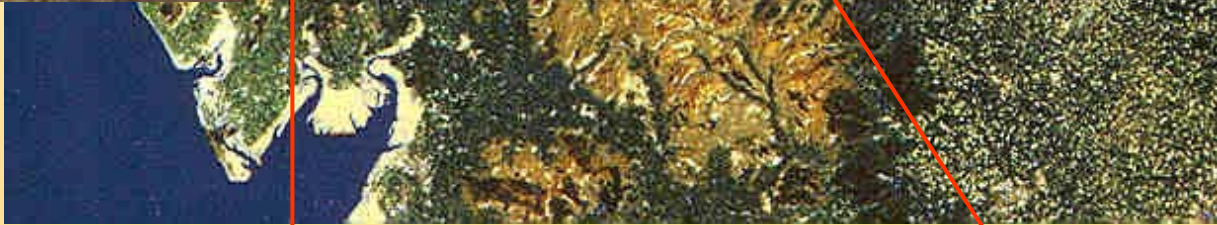
$$I + \Delta S = O$$

inputs + change in storage = outputs



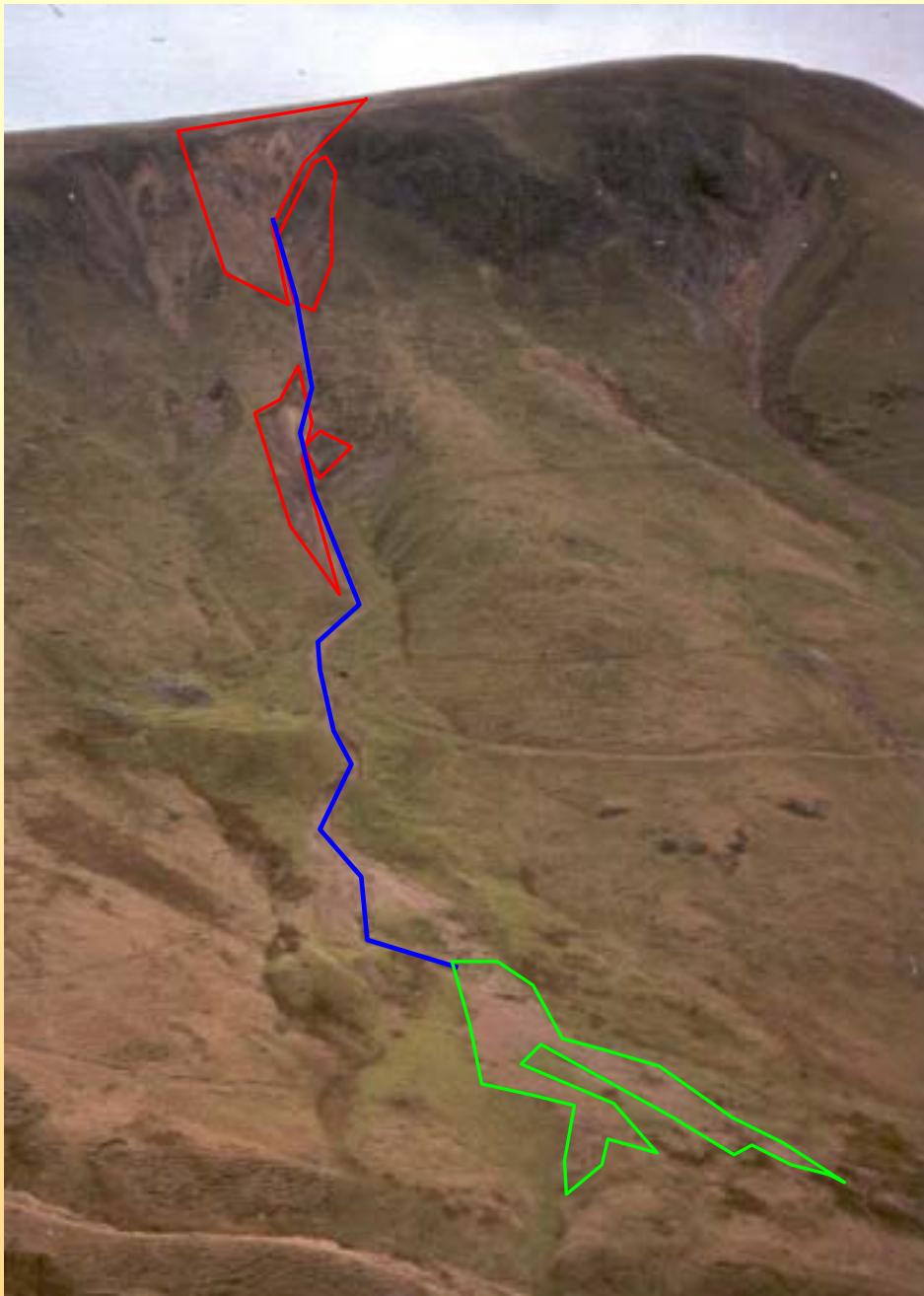


Study Sites



Iron Crag, Northern Fells

Moor House NNR

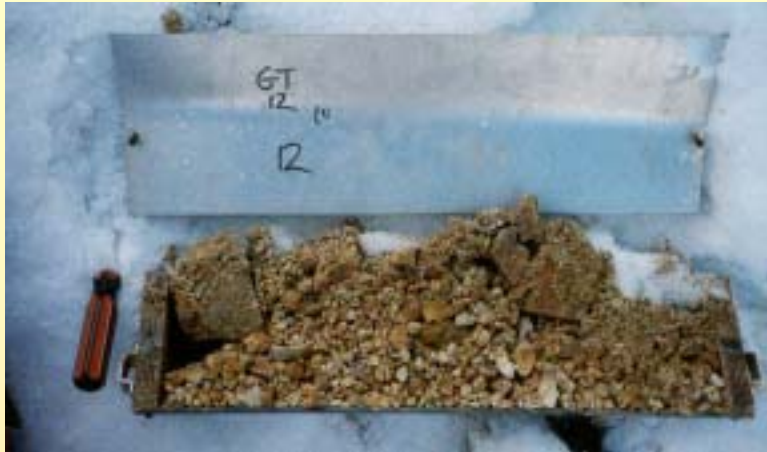


Gully and hillslope
sediment sources

Main channel

Active fan area

Gerlach Trough



Nets



Channel survey



Peg array

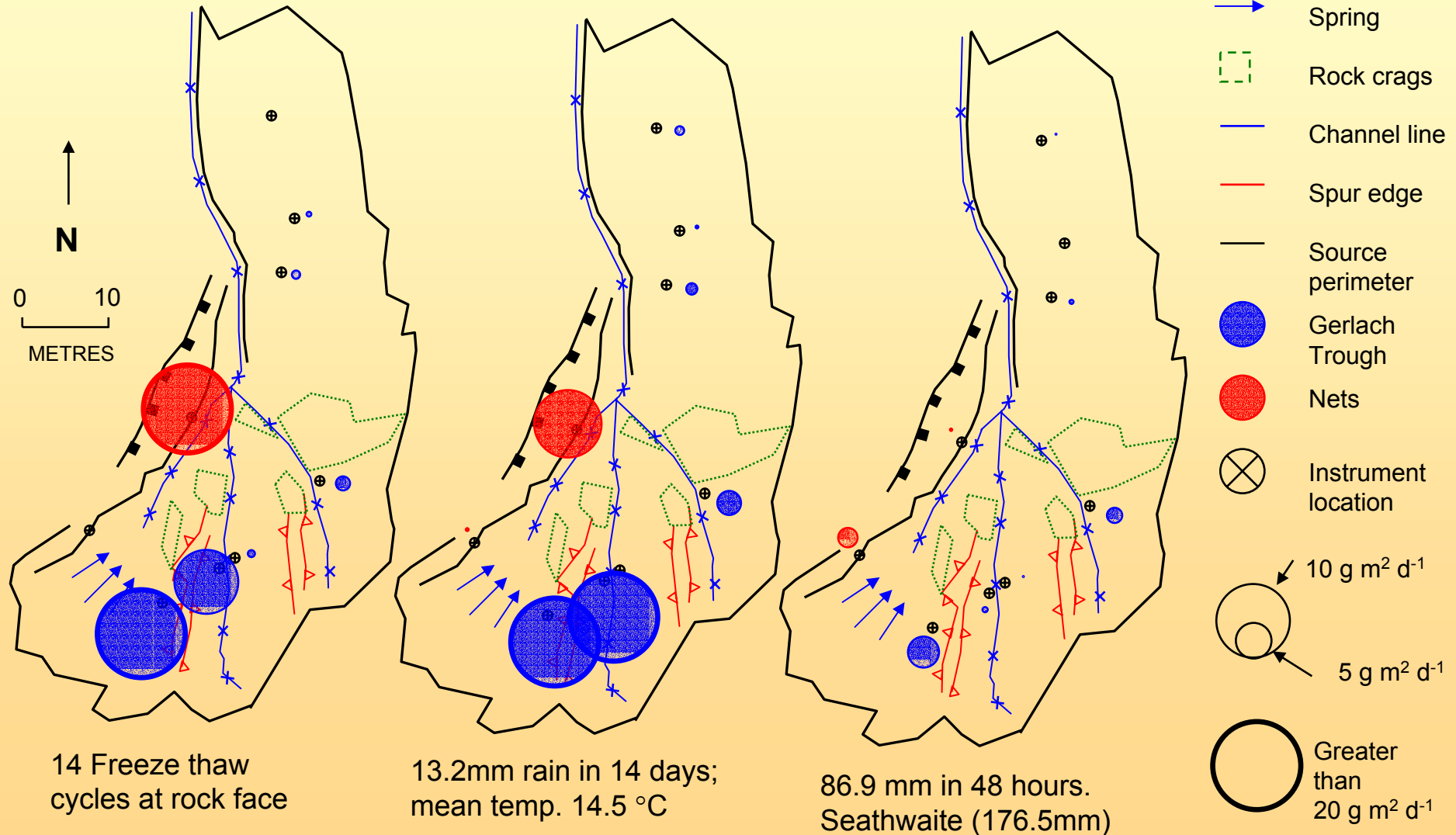


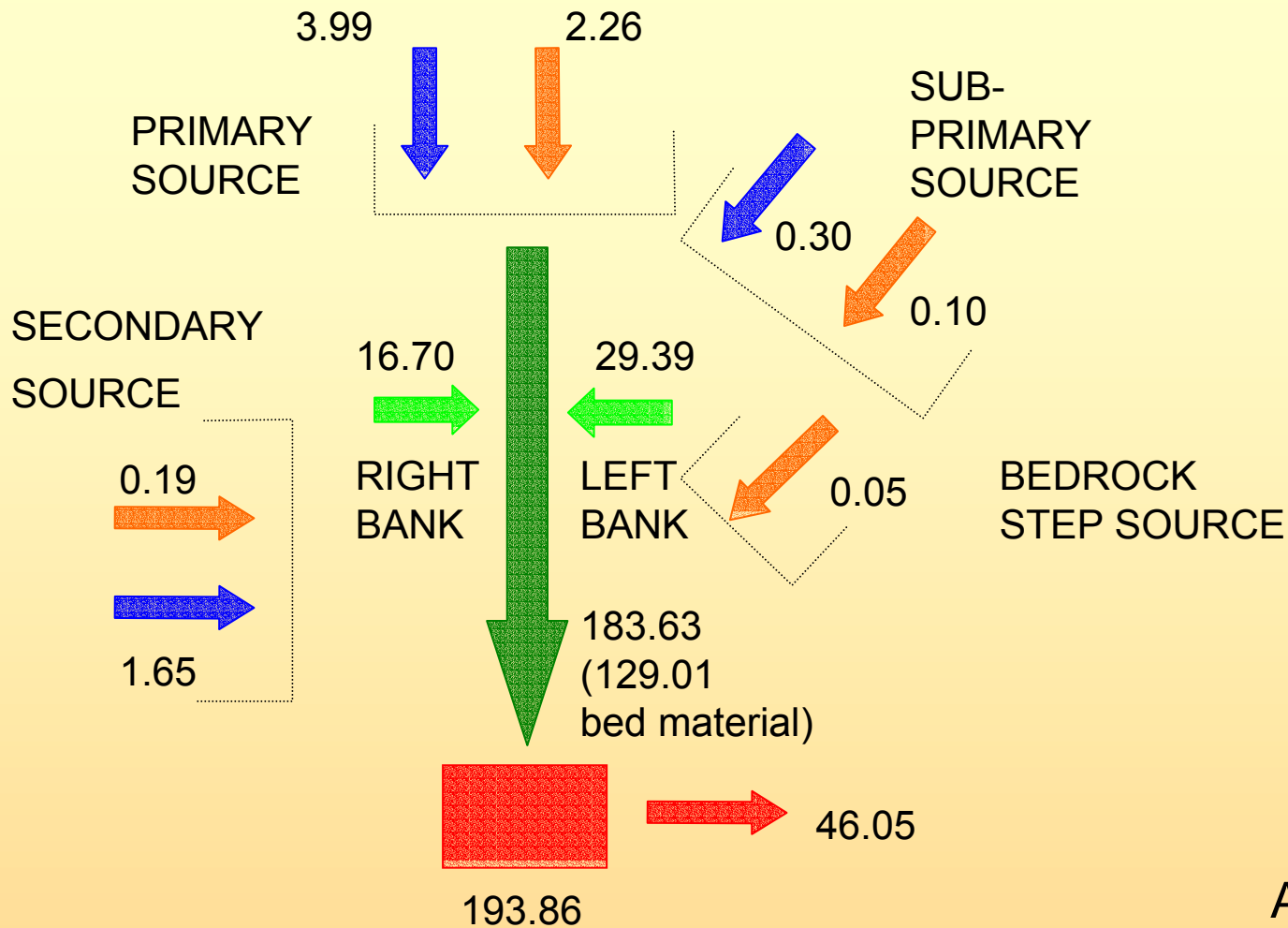
Spatial and event variability in Primary source sediment production

Freeze-Thaw :
Jan-Feb. 1999

Summer dryness: July 1999

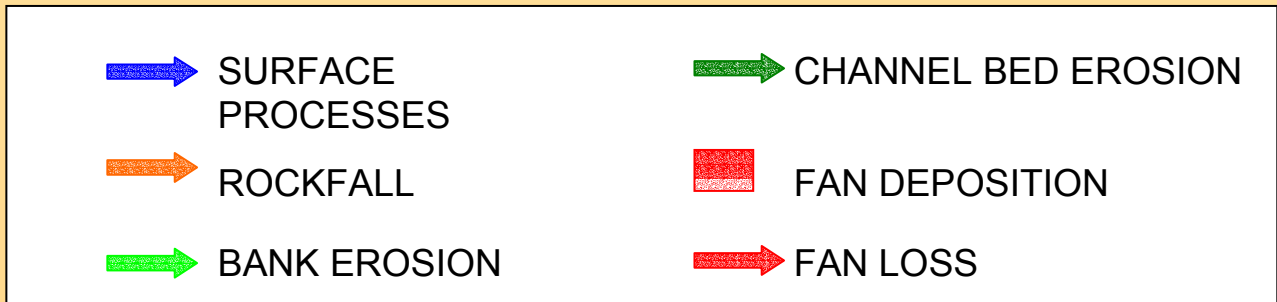
Rain storm:
November 1999.





Annual Sediment Budget: Iron Crag
Dec. 1998- Dec. 1999

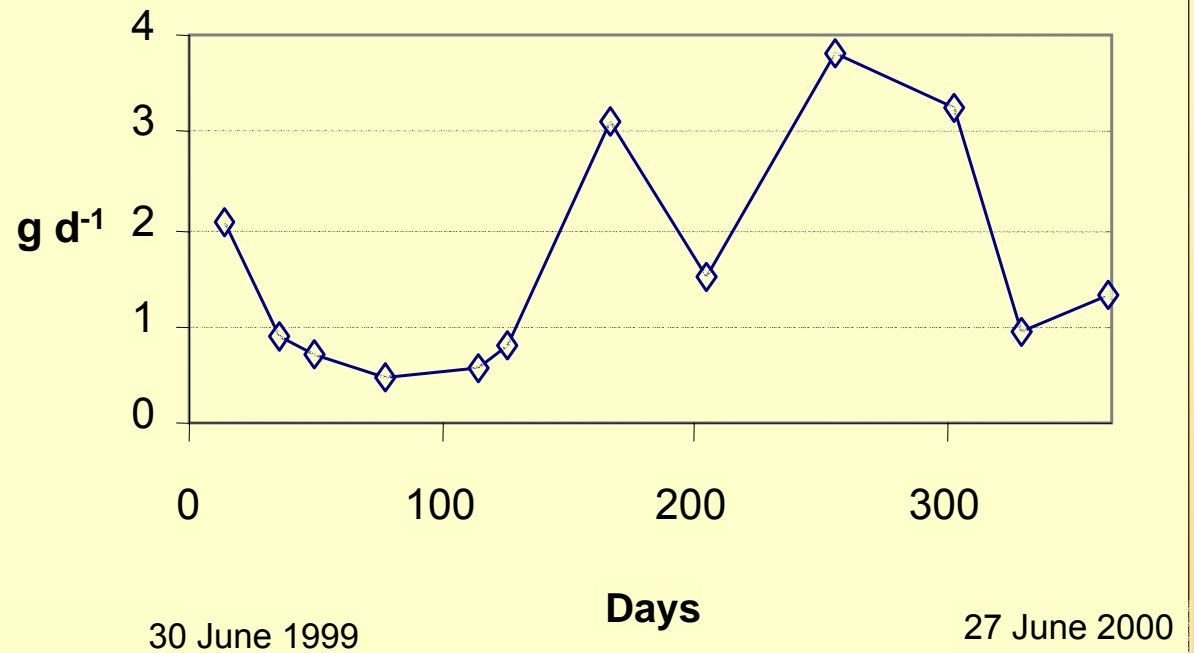
TONNES PER YEAR



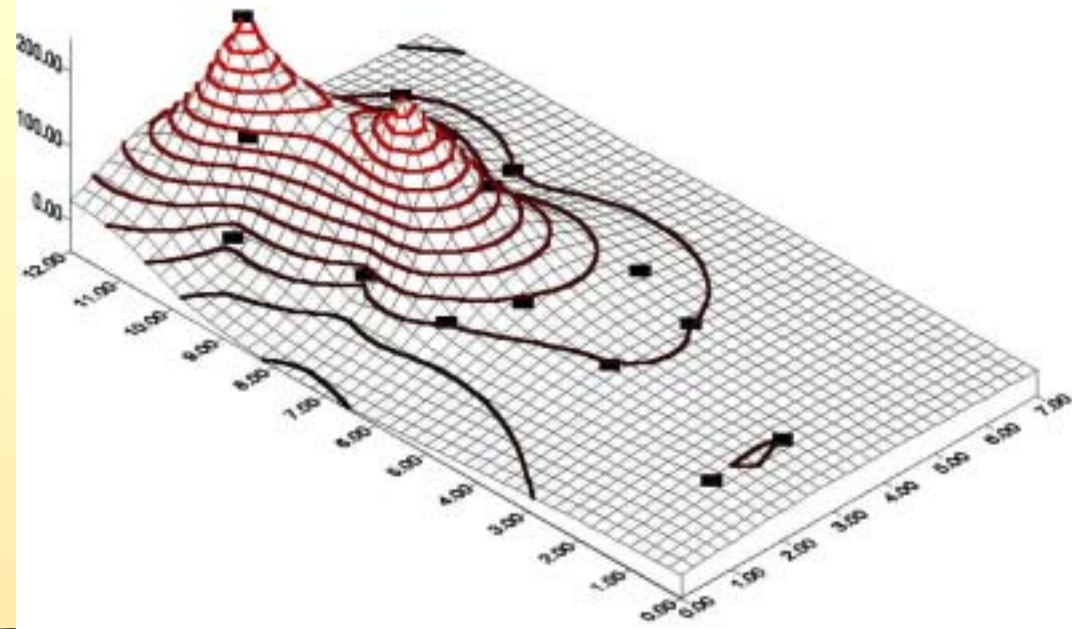
Rough Sike North Pennines

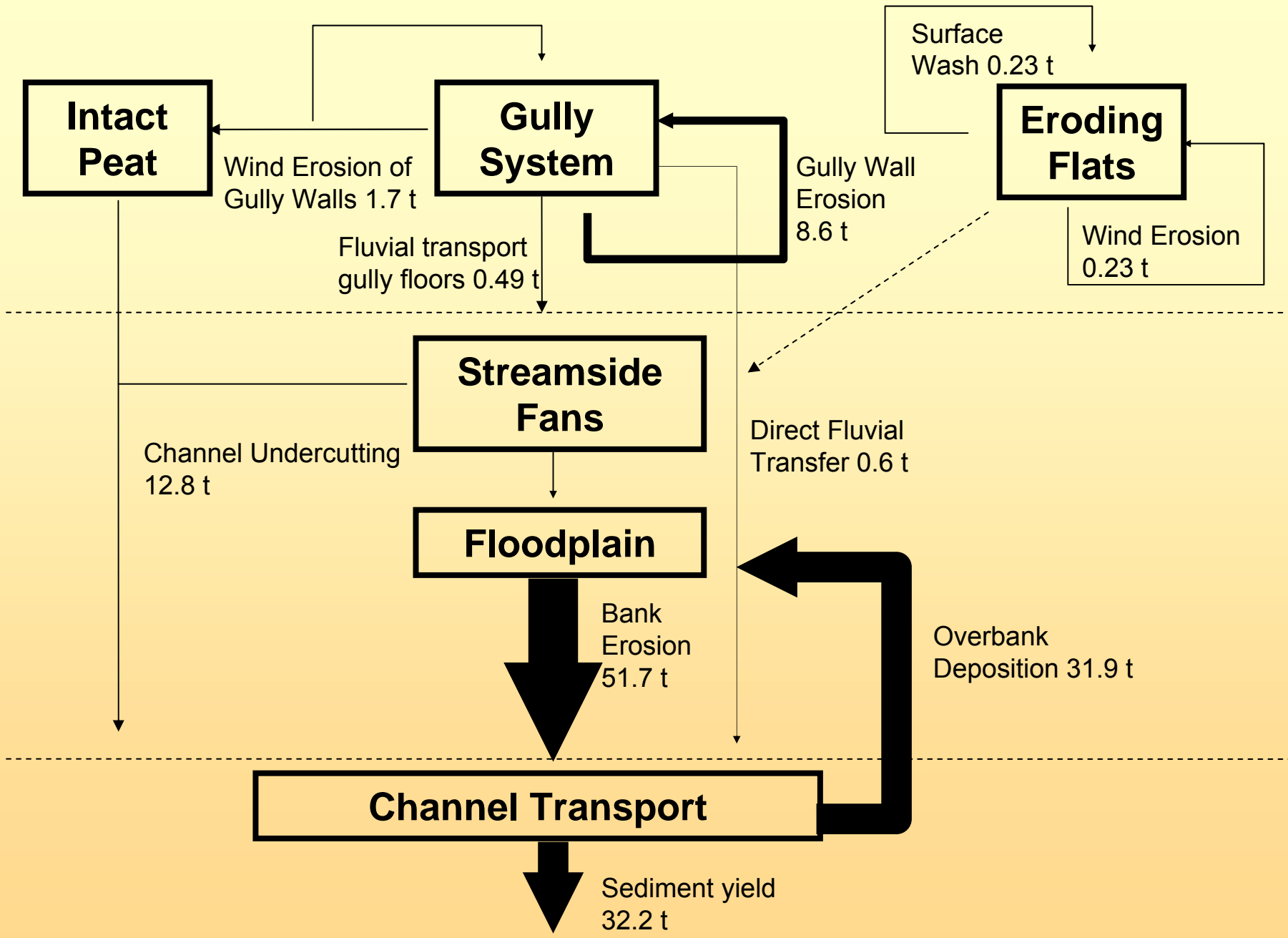


Sediment Production from Gully Walls



Monitoring deposition





Summary Sediment Budgets (% of sediment yield)

Iron Crag

Rough Sike

Slopes

Gully erosion

Bank erosion

Channel erosion

Floodplain and Fan storage

Hillslopes

Channel

Yield

100 %

100 %

t a⁻¹

46

32

t km⁻² a⁻¹

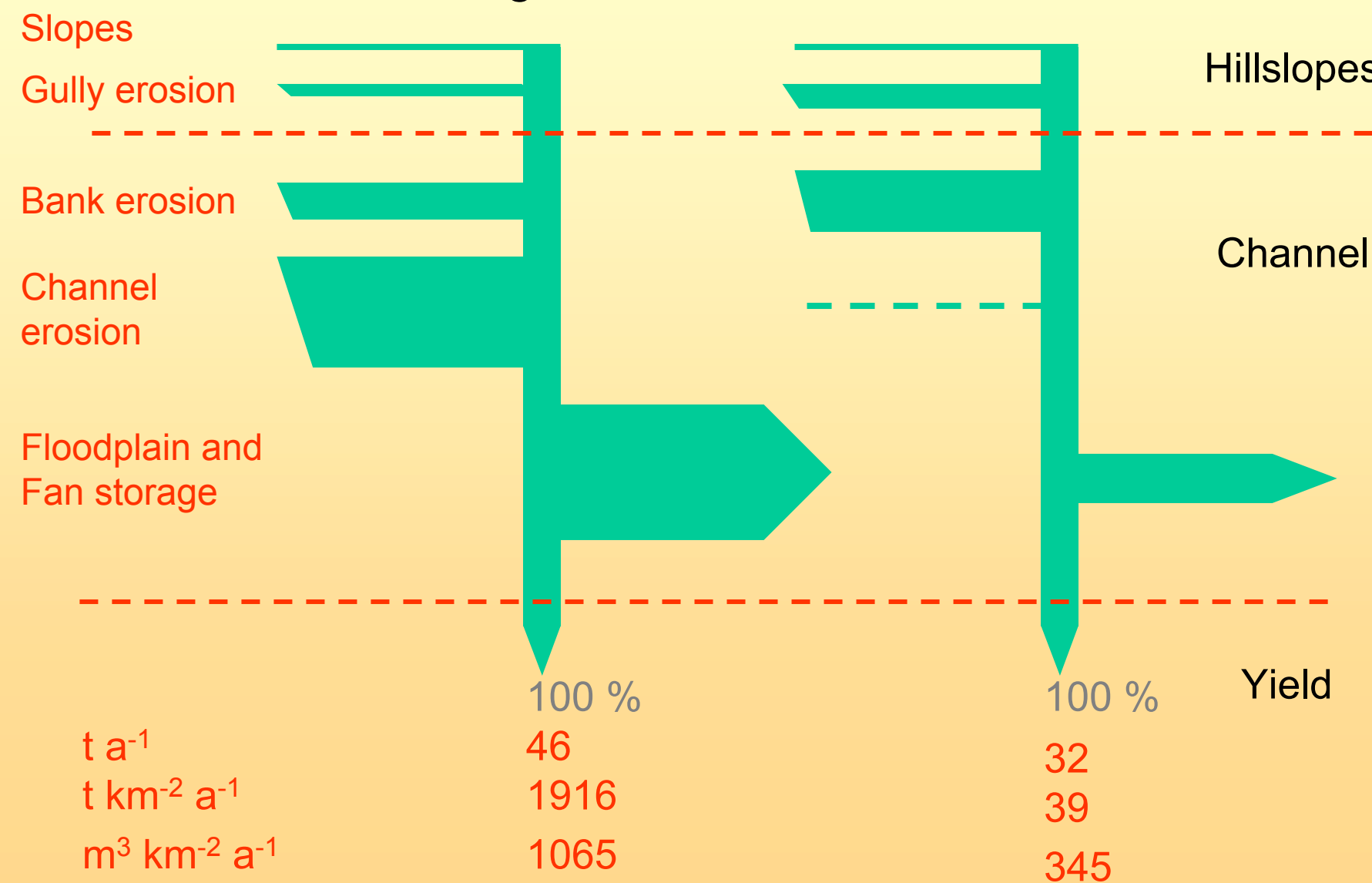
1916

39

m³ km⁻² a⁻¹

1065

345



Investigation into the source of fine sediment contamination, Catcleugh Reservoir, Northumberland

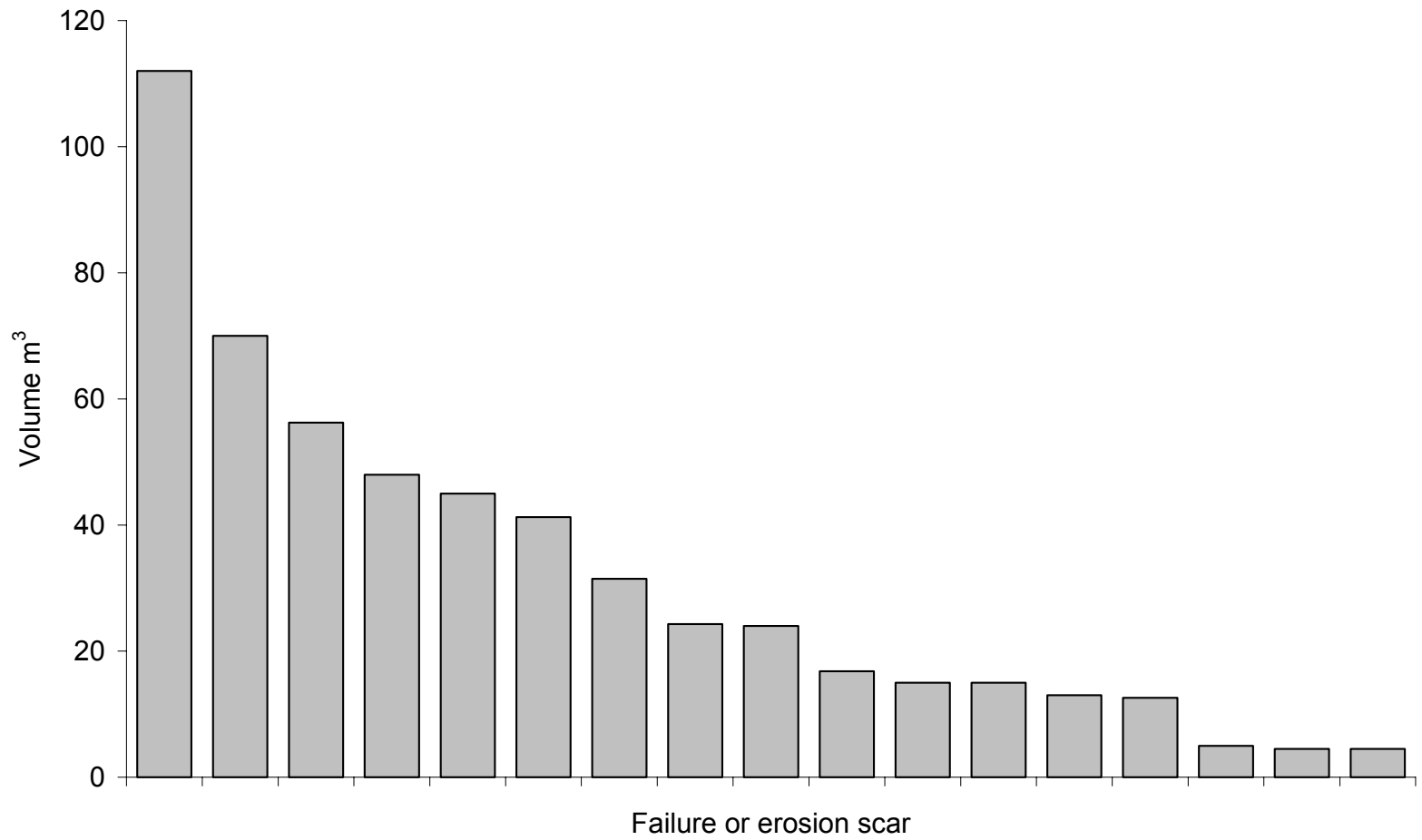
- Flood of 2nd August 2002
- Peak inflow of $50 \text{ m}^3 \text{ s}^{-1}$
- Over a 12 hour period it is estimated 958 MI entered the reservoir (approximately 10% of the reservoir volume)
- A second storm event on 21/22 October 2002 caused a similar rise in reservoir levels and resulted in similar problems.

Chattlehope Burn catchment and reservoir inlet

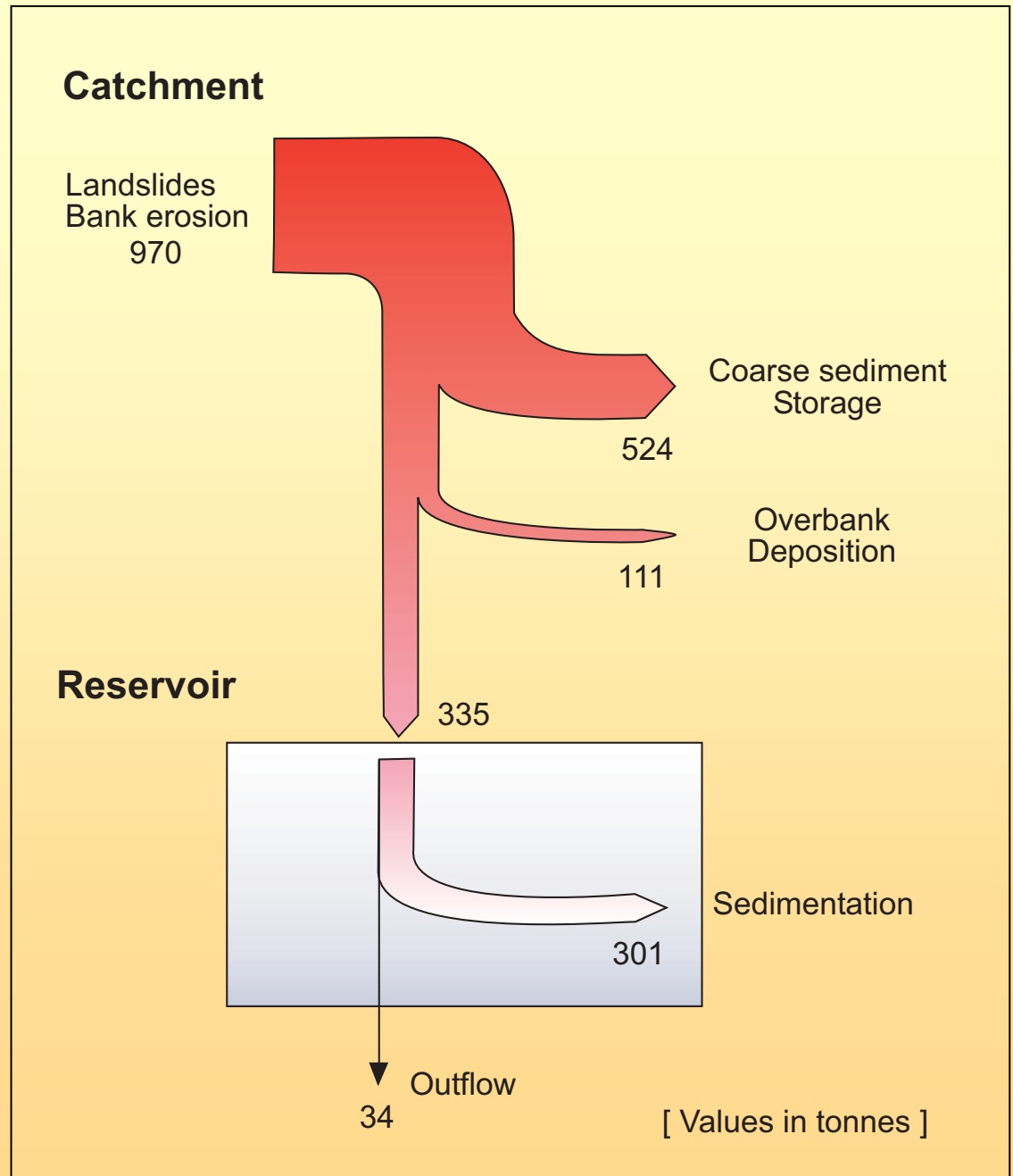


Large-scale slope failures in Chattlehope Burn

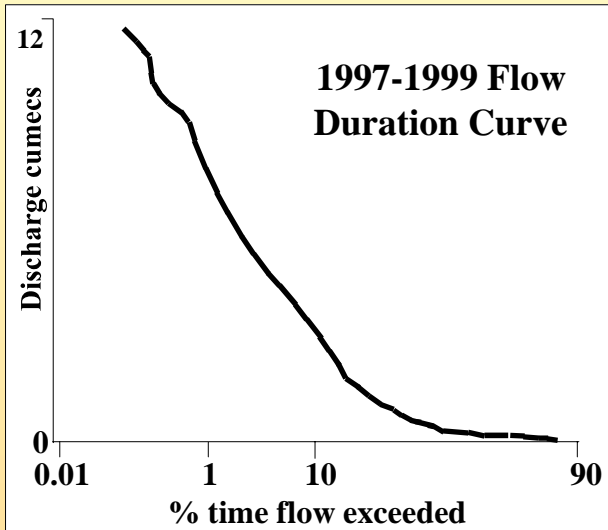




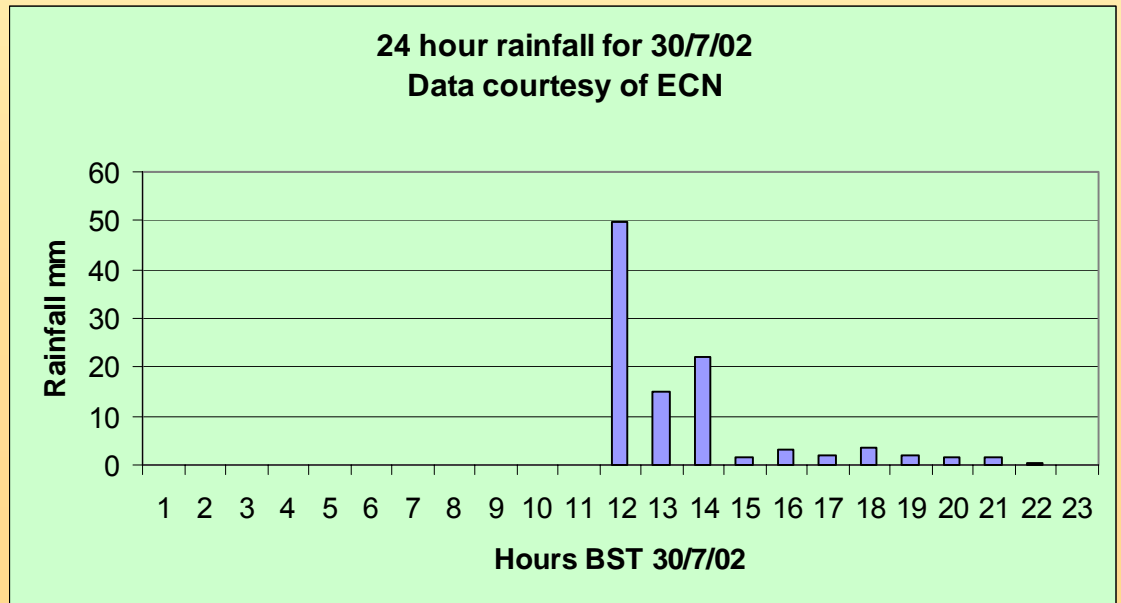
Chattlehope Burn and Catcleugh Reservoir sediment budget, August 2002



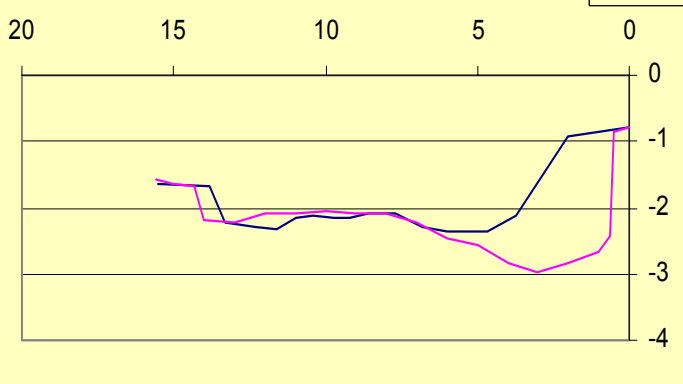
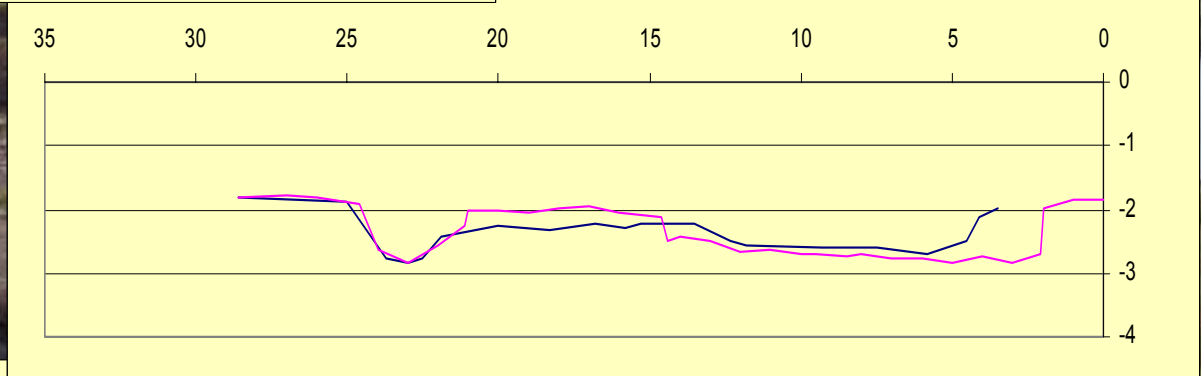
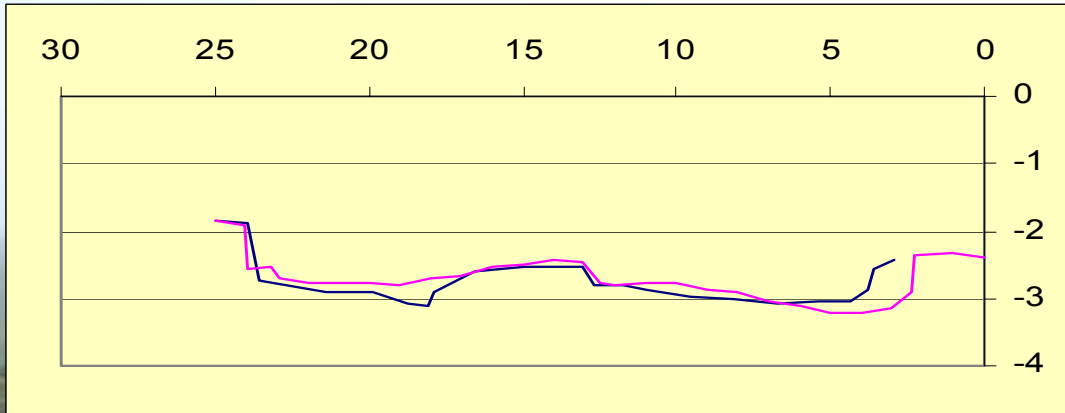
Trout Beck Flood 30 July 2002

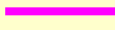



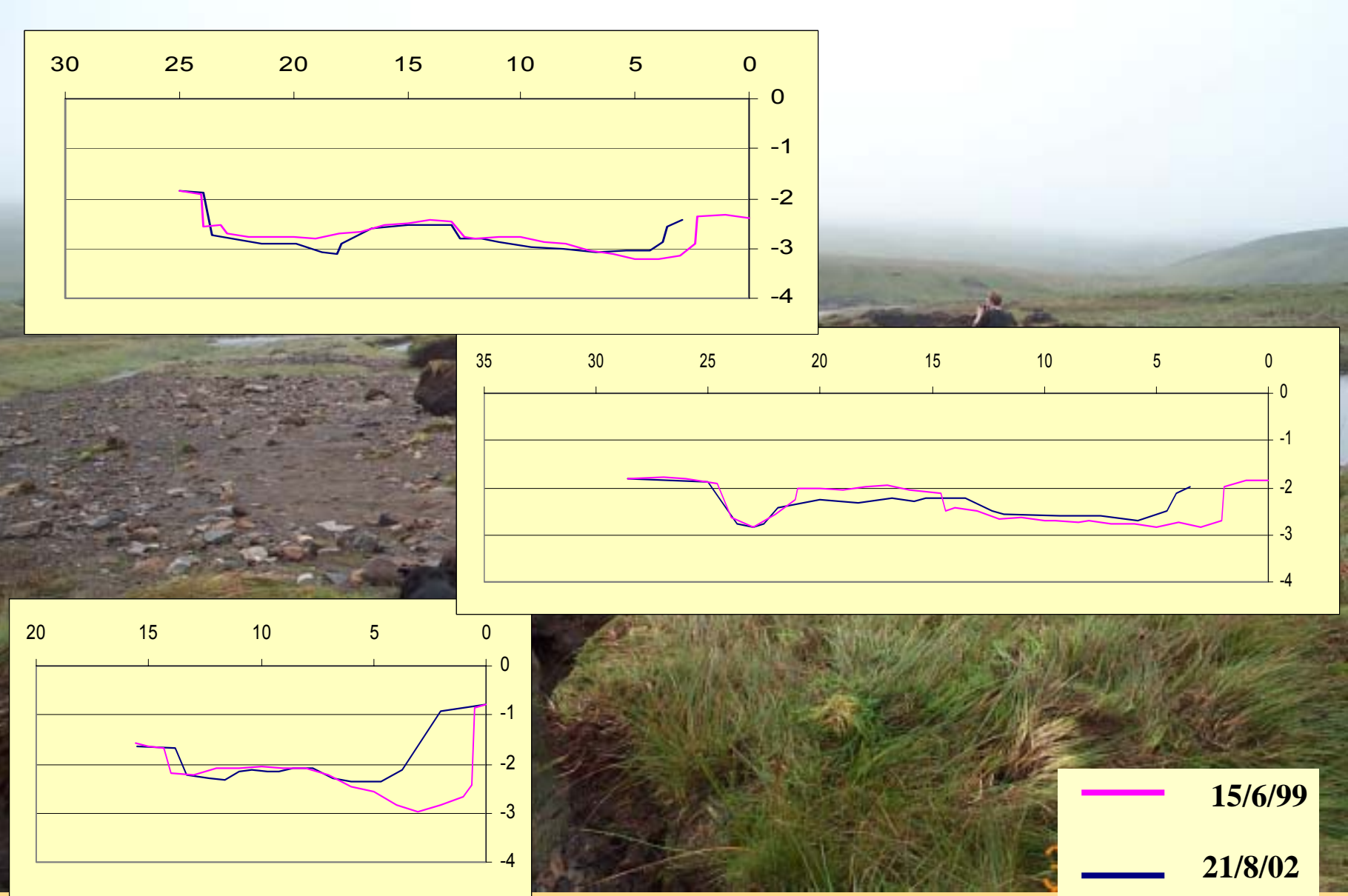
Estimated Q $30 \text{ m}^3\text{s}^{-1}$



Effects of Trout Beck Flood 30/7/02



 15/6/99
 21/8/02



22/9/00



21/8/02



Estimate of Rough Sike Sediment Yield

| | |
|---------------------|----------------------------|
| Crisp (1960) | 93 t a⁻¹ |
| (2000) | 32 t a⁻¹ |



Examples of gully cut and fill sequences

Hermitage Water



Hen Hole, Cheviot



Bloodybush, Cheviot

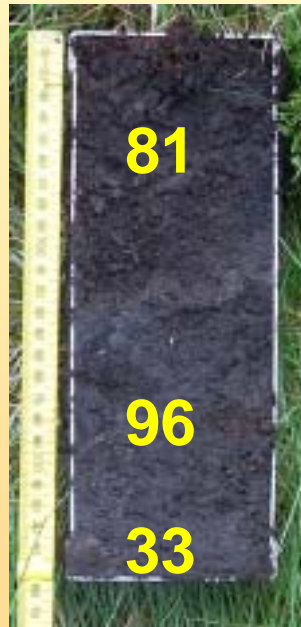
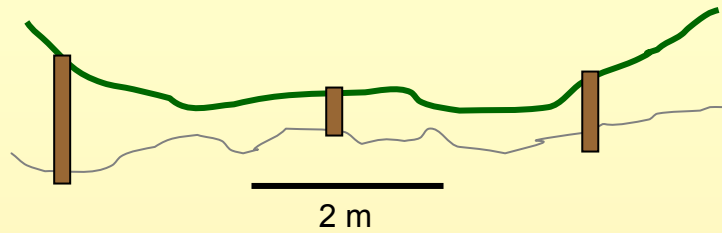


Burnt Hill gully - historical change 1958 to 1998



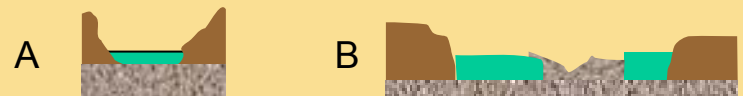
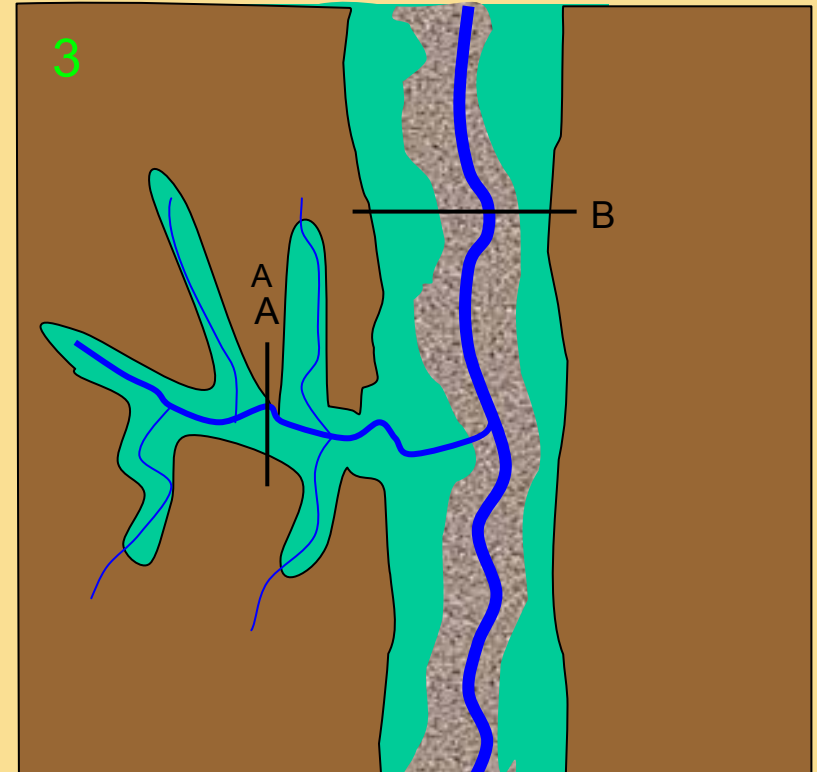
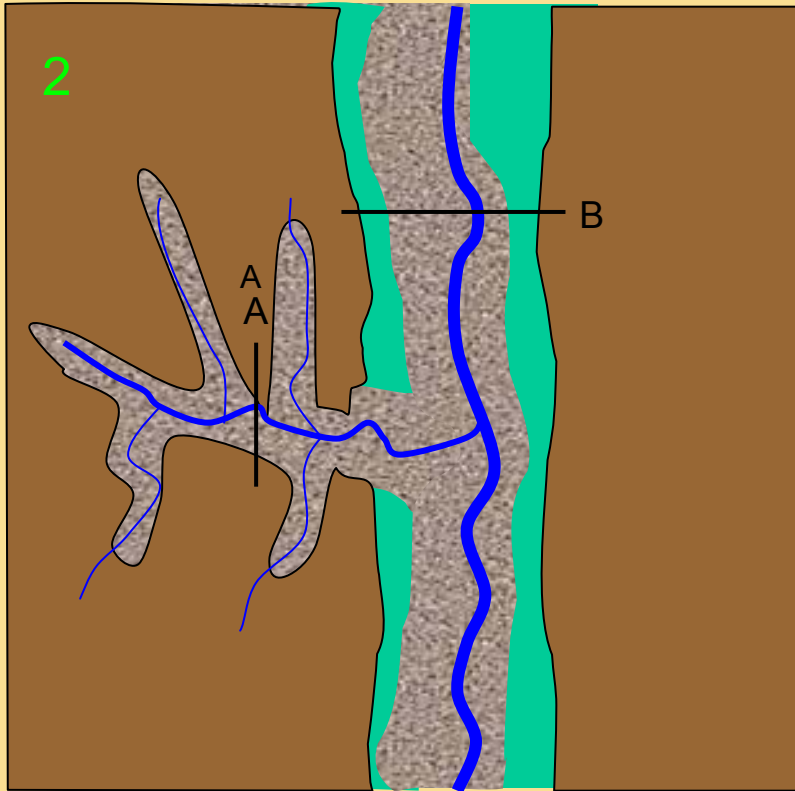


Burnt Hill gully trench



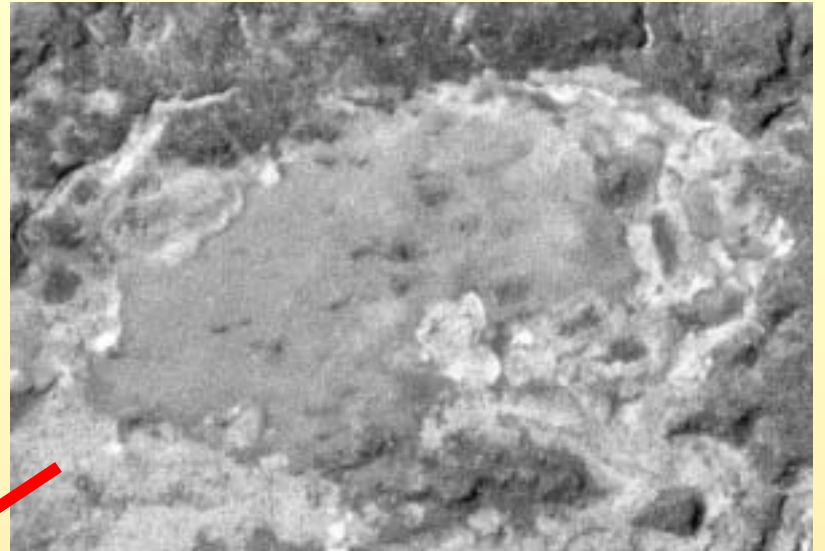
% Loss on ignition values

Fluvial decoupling of peat erosion

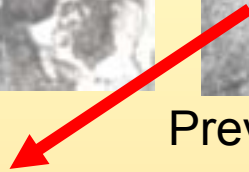




1950



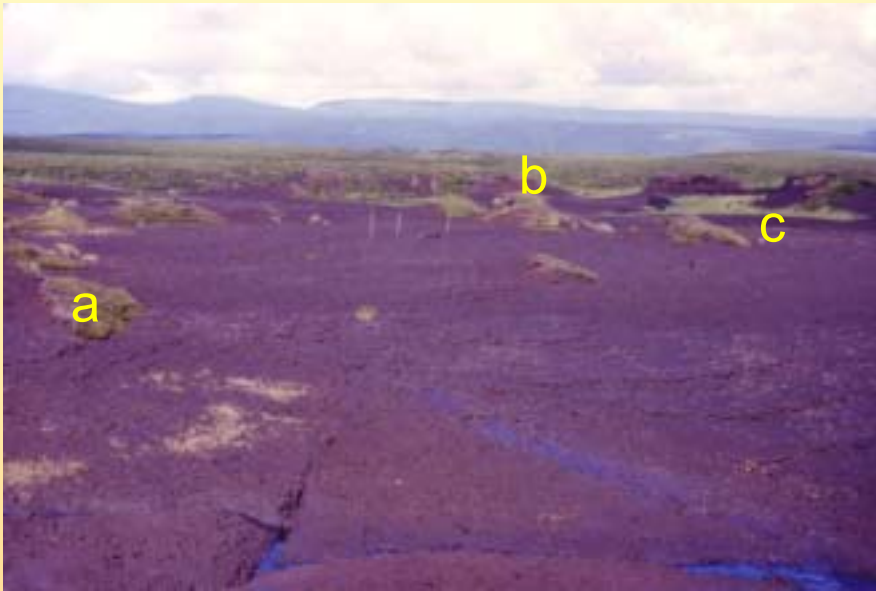
1995



Prevailing wind



Moss Flats Deflation

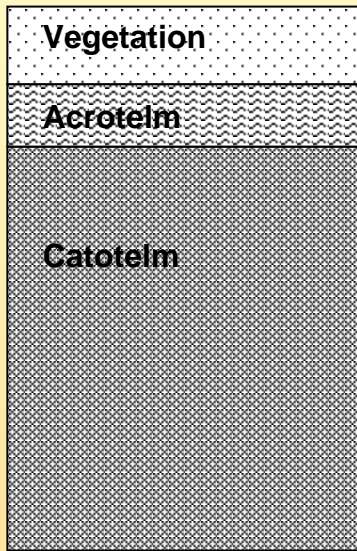


1963

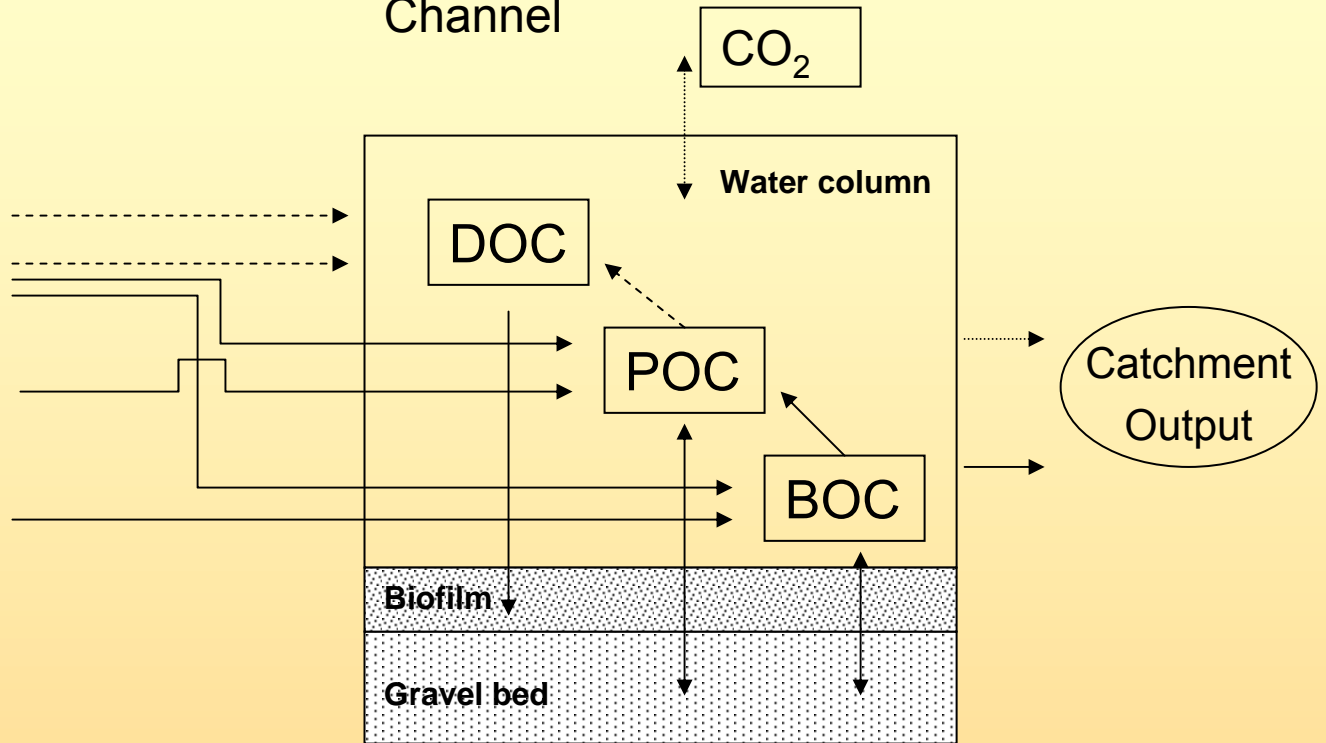


2000

Blanket Peat



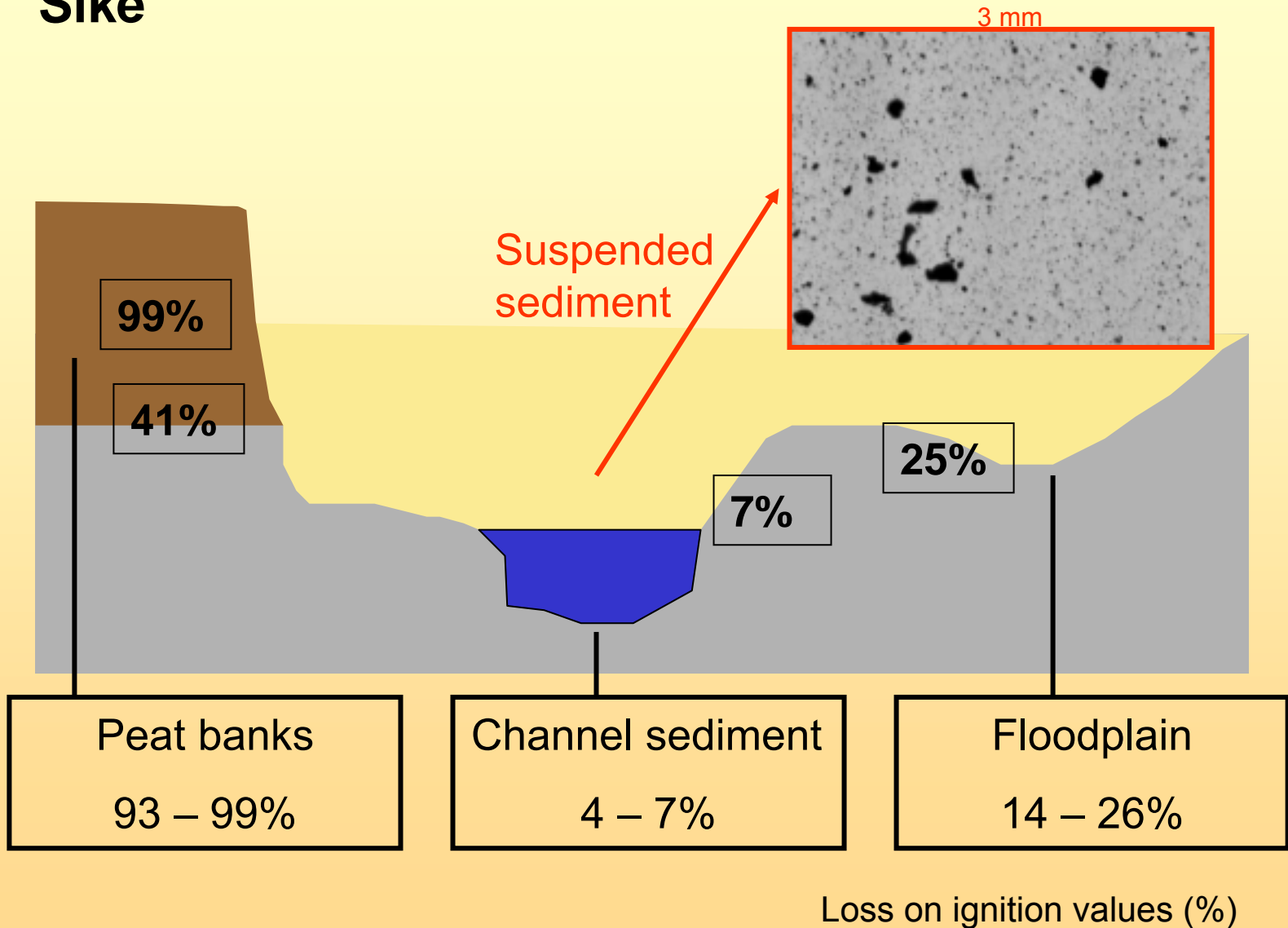
Channel



 *Solute pathway*

 *Sediment pathway*

Organic sediment sources – Rough Sike



Estimates of the present C balance for the blanket peat covered Moor House Catchment.

| C flux component | Rate g m ⁻² | | |
|--|------------------------|-------------|-------------|
| | Model A | Model B | Model C |
| Net Primary Production minus decomposition | + 27 | + 27 | + 27 |
| SCP deposition | + 0.03 | + 0.03 | + 0.03 |
| Dissolved Organic Carbon | -10 to - 20 | -10 to - 20 | -10 to - 20 |
| Particulate Organic Carbon | - 56 | -19 | -12 |
| Net C balance | - 39 to - 49 | - 2 to - 12 | 5 to -5 |

NOTES:

Model A – Based on Garnett (1998) using an estimate of POC flux based on Crisp (1966).

Model B - Based on Garnett (1998) but using an estimate of POC flux based on Evans and Warburton (2001)

Model C - Based on Garnett (1998) but using an estimate of POC flux based on Evans and Warburton (2001) with a lower estimate (30 %) for the C content of the particulate load.

Limiting erosion of peatland gullies: Lessons from sediment budget approaches

Two Points of Conventional wisdom

- Peat erosion is catastrophic and irreversible
- All bare peat is a problem

The Moor House Sediment Budget suggests otherwise with important implications for management strategies

The blanket peat erosion mosaic



Complex response



Initiation of gully re-vegetation



Initiation of gully re-vegetation

Block Failure



Initiation of gully re-vegetation
Sediment accumulation and raised water table



Initiation of gully re-vegetation
Colonisation by *Eriophorum angustifolium*



Initiation of gully re-vegetation
Eventual re-establishment of more diverse vegetation



Initiation of gully re-vegetation
Infilling of the original gully



Or.....
secondary
erosion



Artificial Gully Blocks



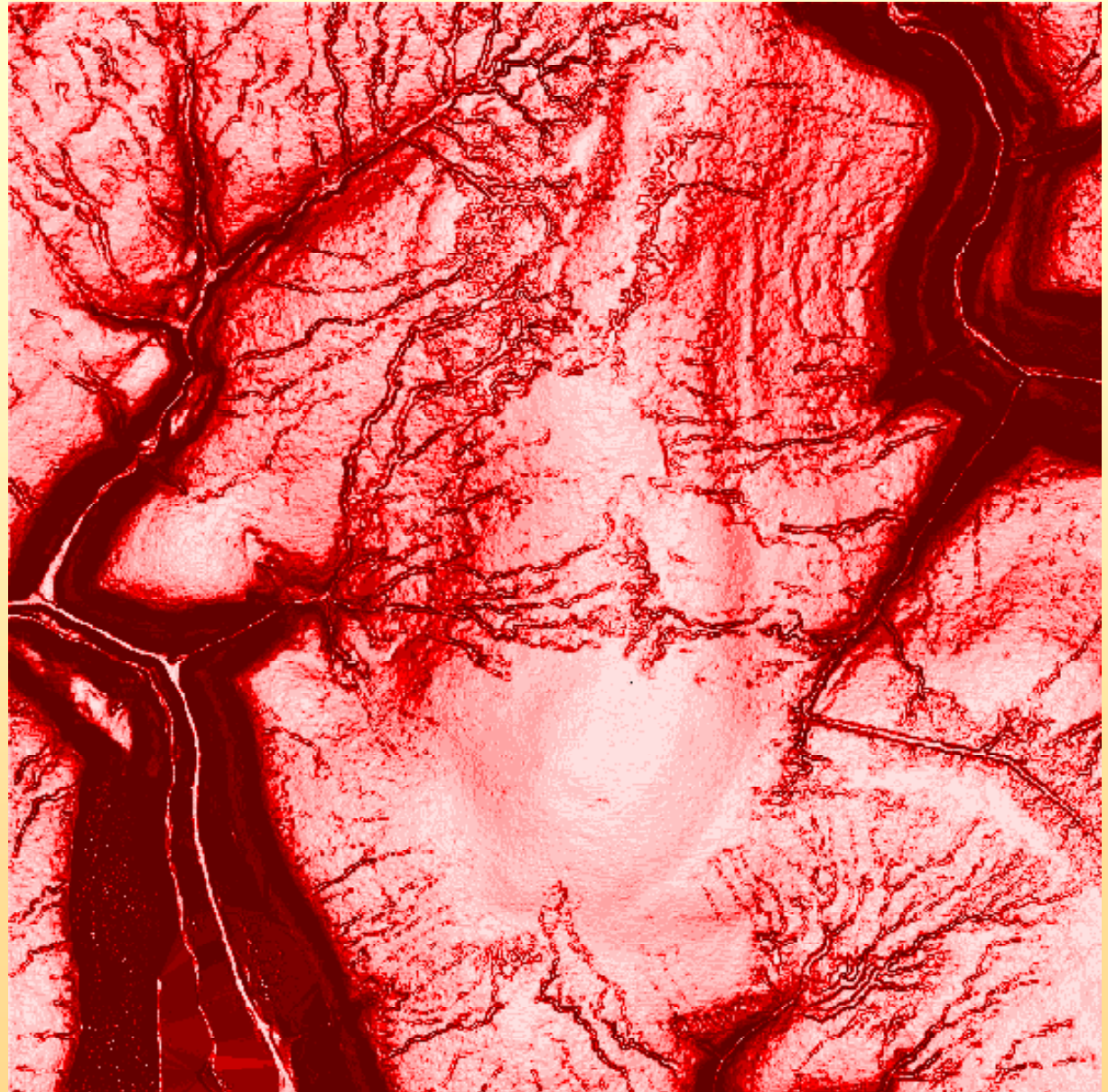
National Trust High Peak Estate
in collaboration with English
Nature and with scientific input
from Upland Environments
Research Unit at Manchester
University

Identifying
Intervention
Points

Use of LIDAR

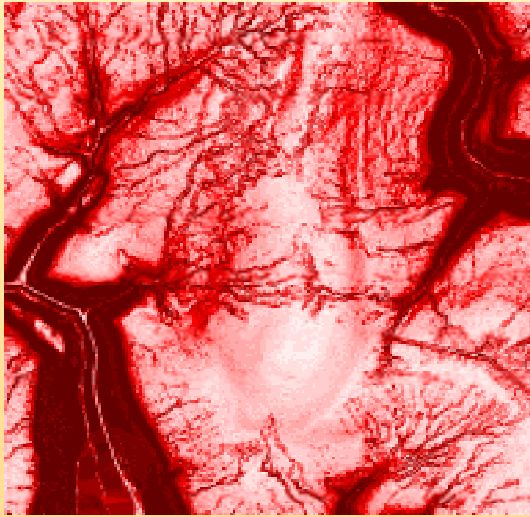
Locating gullies

Identifying
appropriate
slopes



Identifying Intervention Points

Re-vegetation
and connectivity



Developing landscape scale approaches to intervention

Application of landscape ecology metrics to determine connectivity



Benefits of Sediment Budgets

- Provide an understanding of current sediment production and transport regime in a catchment
- Provides a rigorous methodology of erosion assessment
- Places measurements of erosion in a proper geomorphological context
- Establishes erosion rates in relation to clearly defined timescale
- Indicate the likely effects of planned land-use on the sediment regime

MAFF / DEFRA 2000/2002

National Survey Upland Erosion in England and Wales