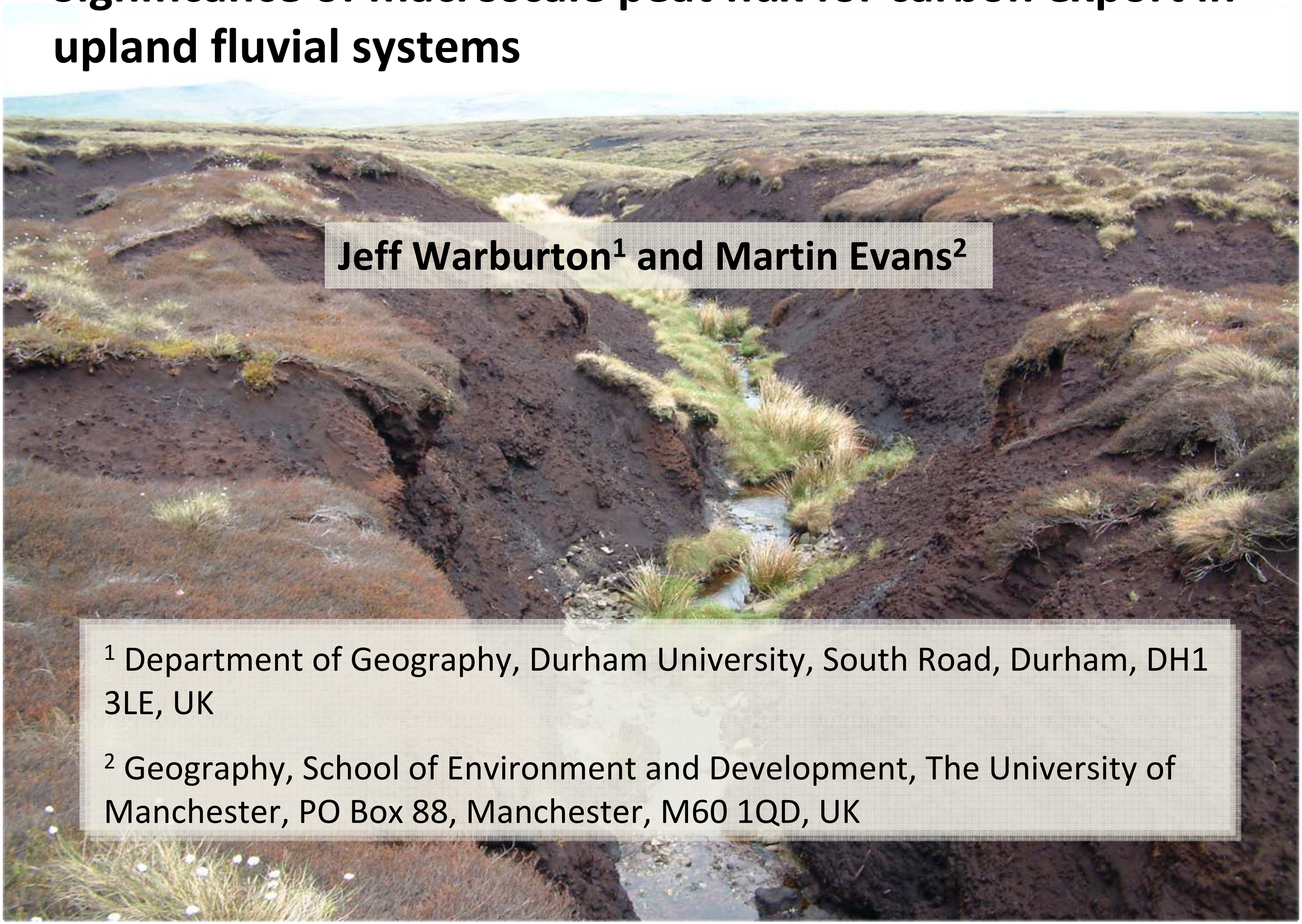
Significance of macroscale peat flux for carbon export in upland fluvial systems



Jeff Warburton[1] and Martin Evans[2]

[1] Department of Geography, Durham University, South Road, Durham, DH1 3LE, UK

[2] Geography, School of Environment and Development, The University of Manchester, PO Box 88, Manchester, M60 1QD, UK

Fluvial peat material flux

- Transient – rapidly transported in the active channel zone – transported long distances
- Geomorphically significant – erosion and sedimentation
- Important for instream habitat: short-term detrimental (fish kills); longer term new channel habitat and organic matter source
- Engineering problems – ‘management of flotation load’ e.g. culvert blockage, reservoir sedimentation and water quality

Outline:

- Peat erosion and carbon
- Geomorphology of peat and upland sediment budgets
- In-channel transport and dynamics of eroded peat
  - Fine material transport
  - Peat block dynamics
- Preliminary results of a new project

Peat

Deposit of partially decomposed or undecomposed organic material derived from plants.

Accumulation > Decomposition

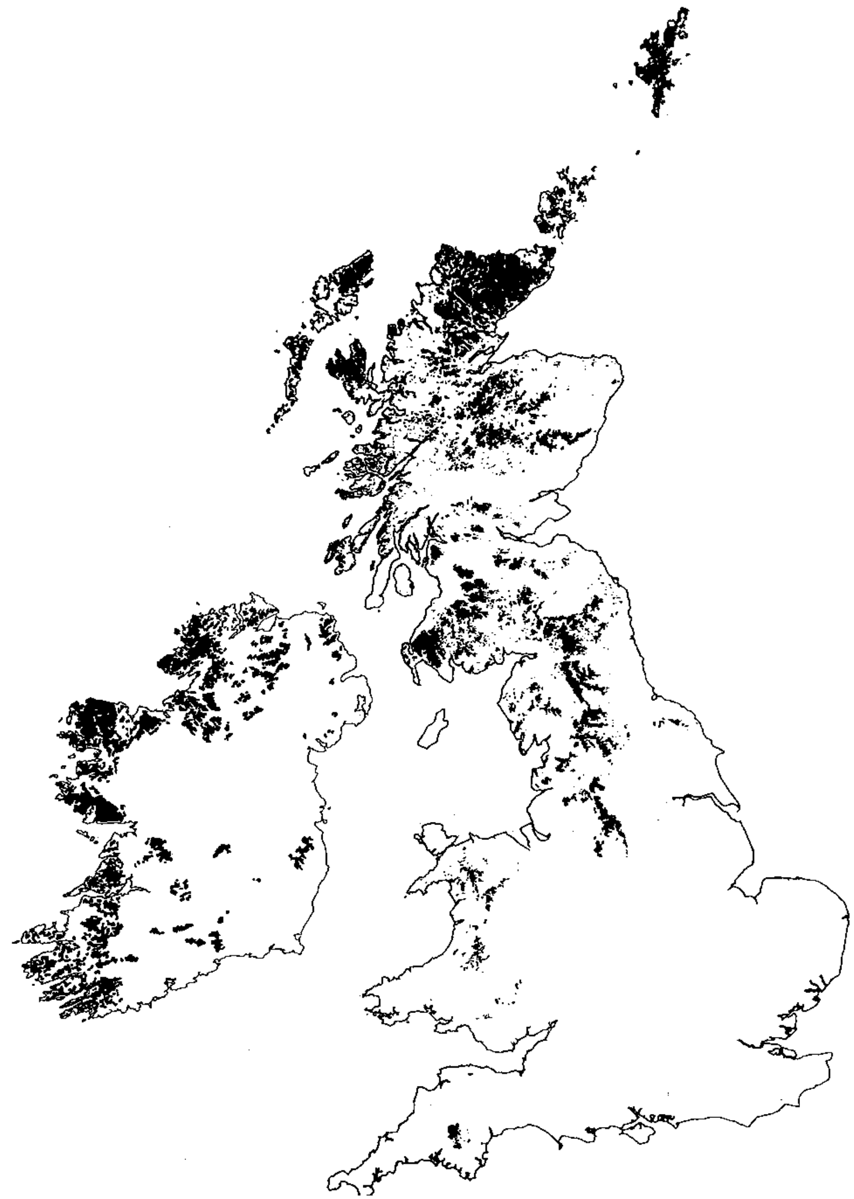
Waterlogged conditions

Peatlands cover 3 % of global land mass – mainly in higher lattitudes.

Contain 30% of global terrestrial carbon

Blanket mire – rain-fed peatland terrain (1-3 m deep)

Low density material



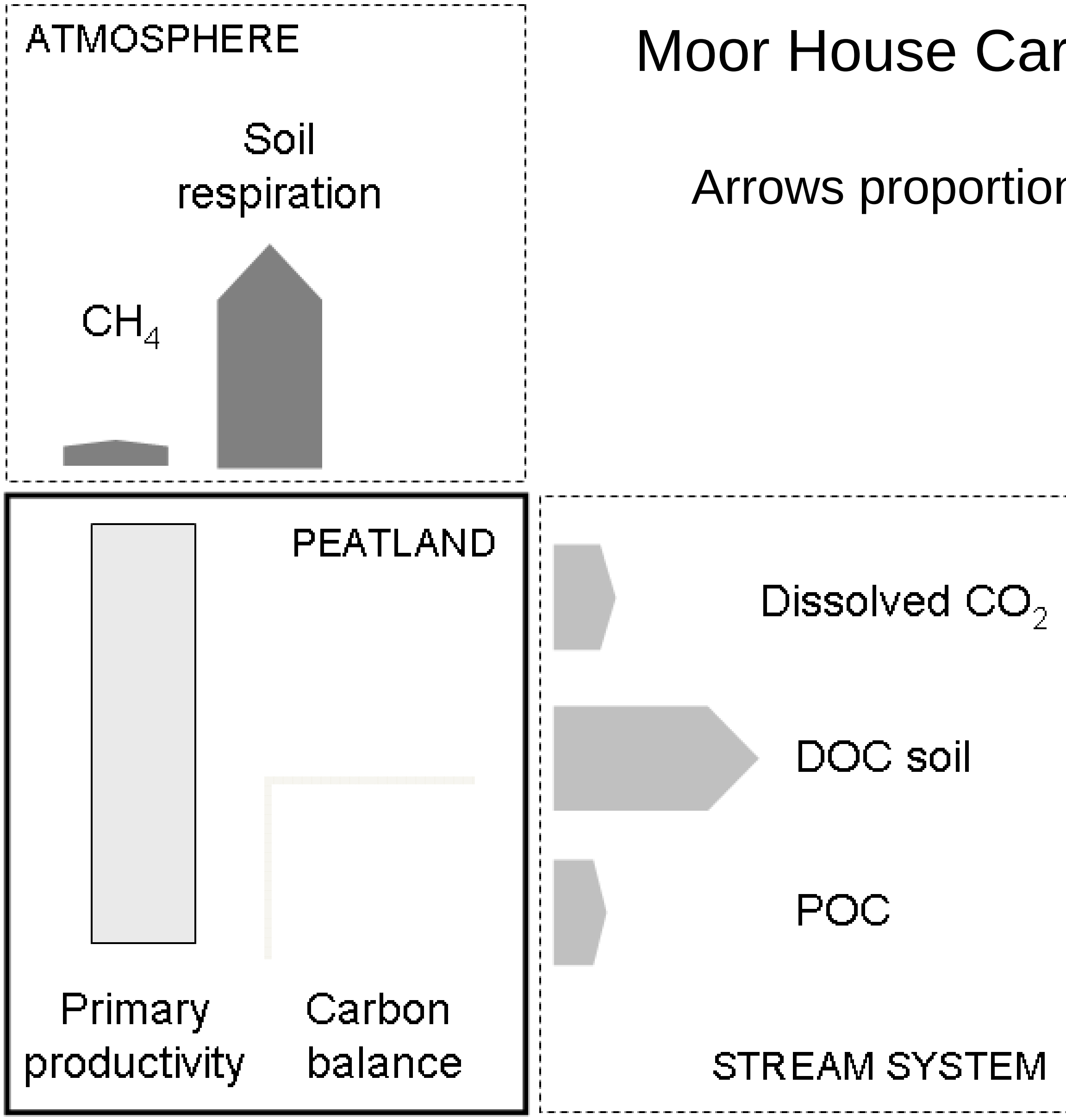
Extent of blanket peat in the British Isles

Source: Tallis et al. (1997)

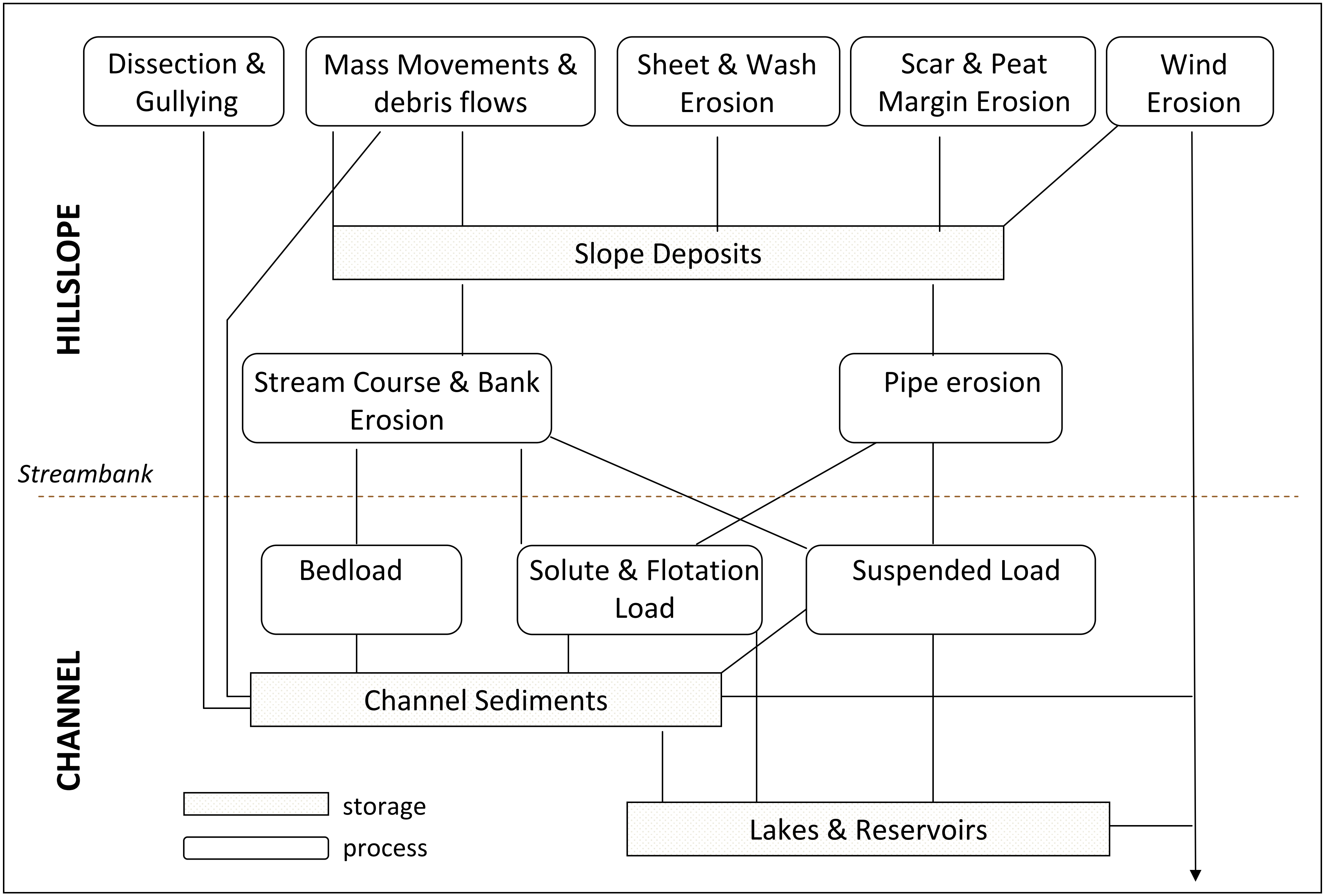
Moor House, Northern England (SEDIBUD Test Site)

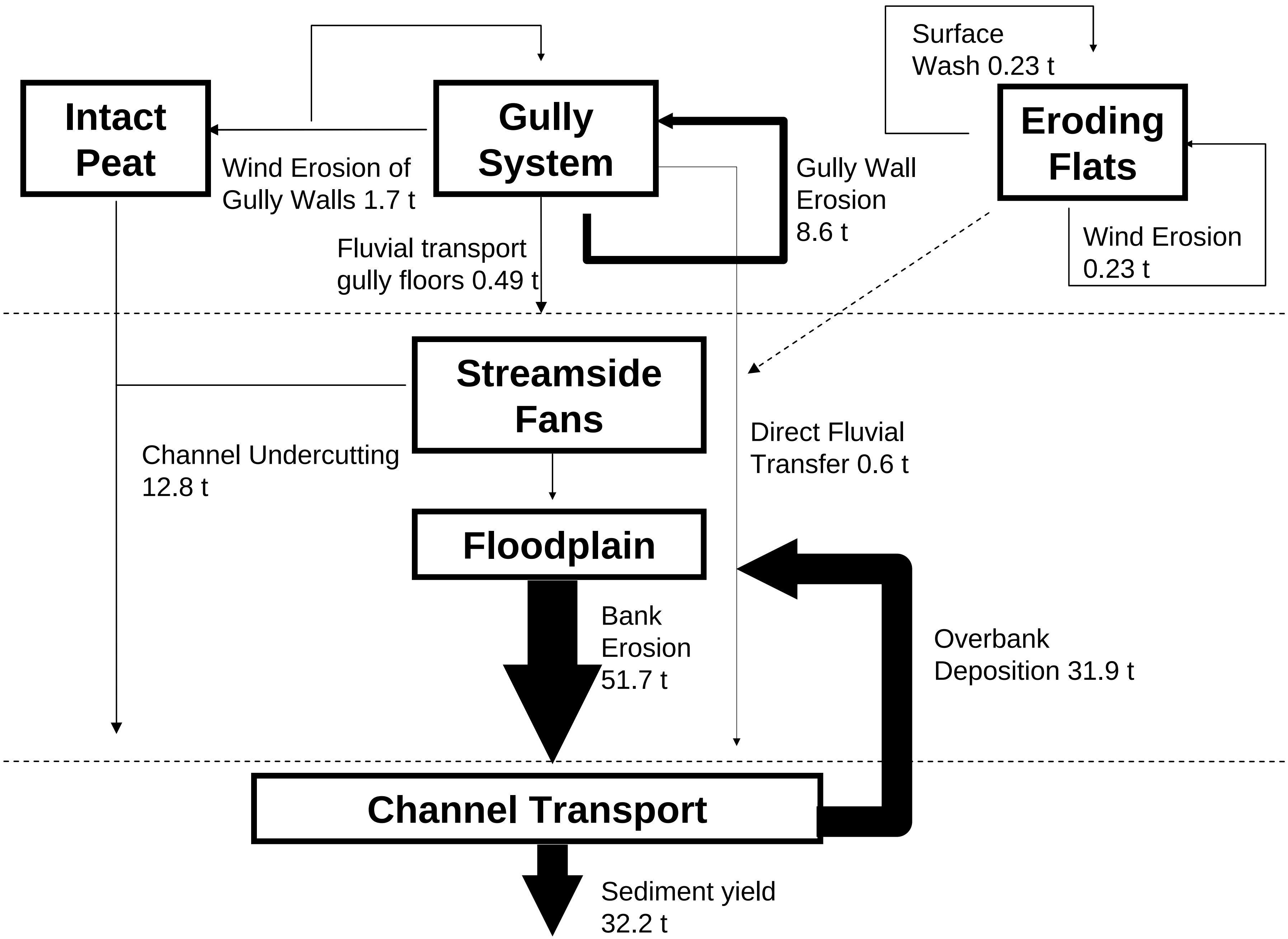
Moor House Carbon Budget

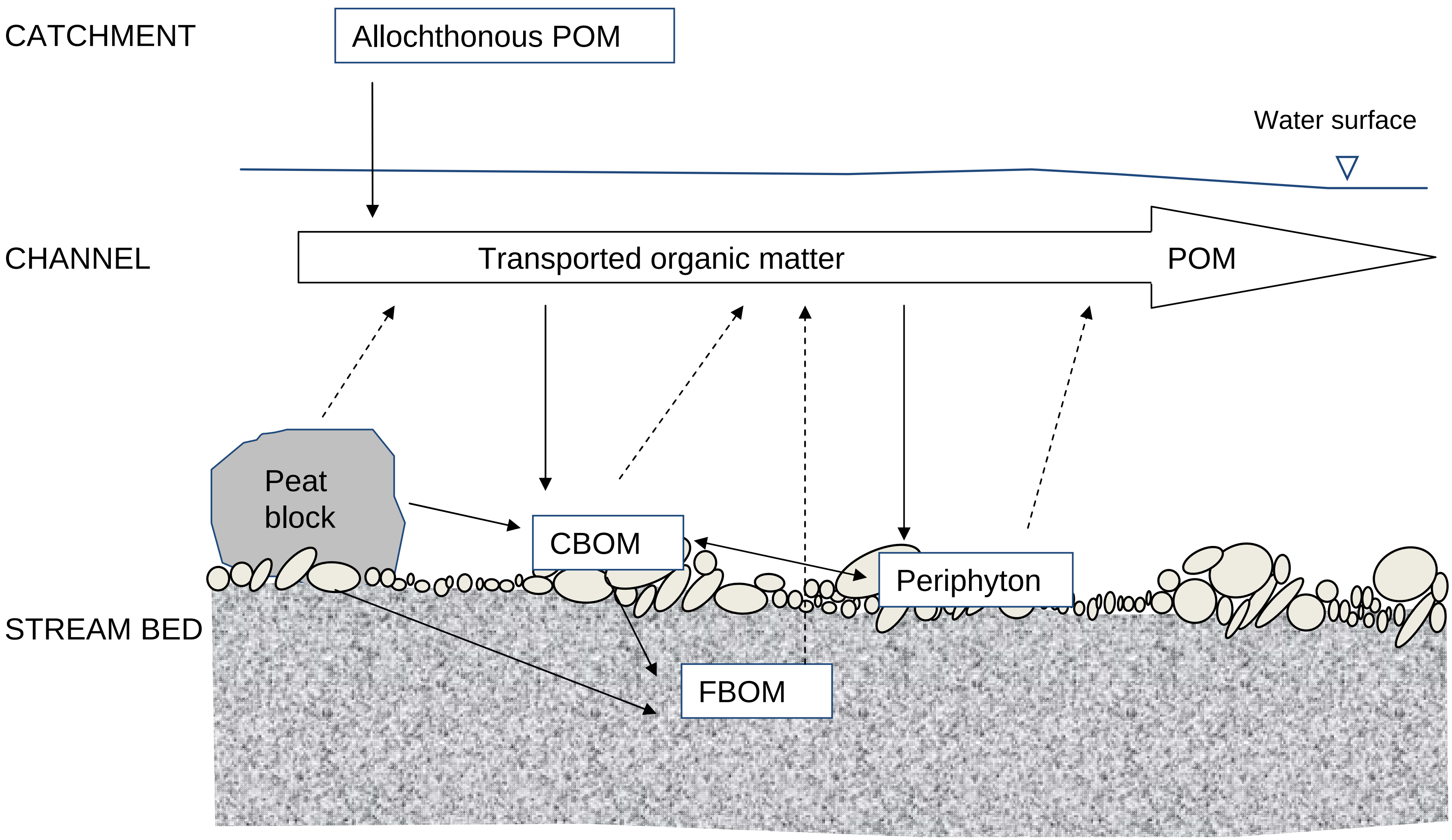
Arrows proportional to fluxes



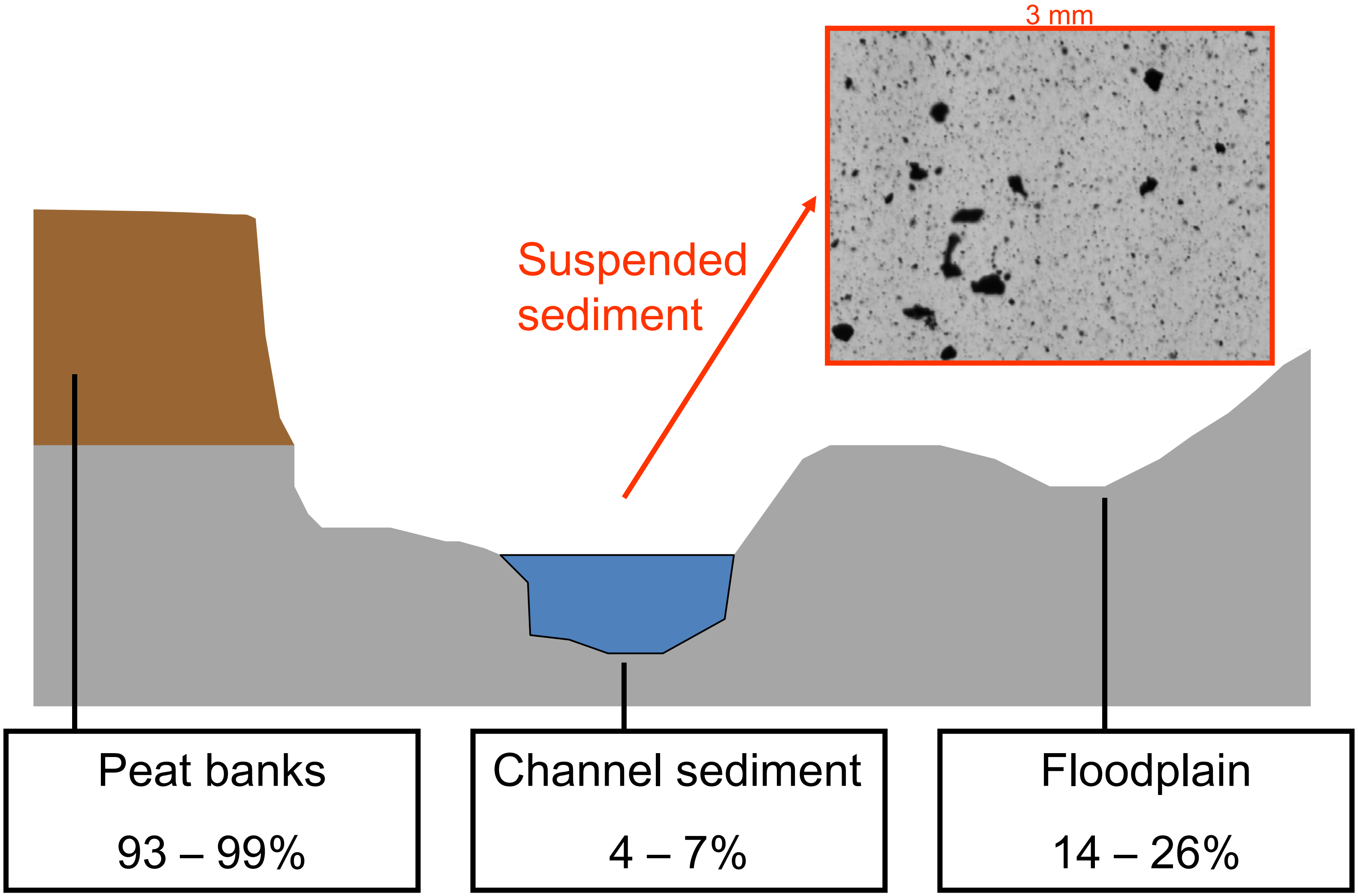
Peatland Geomorphic System



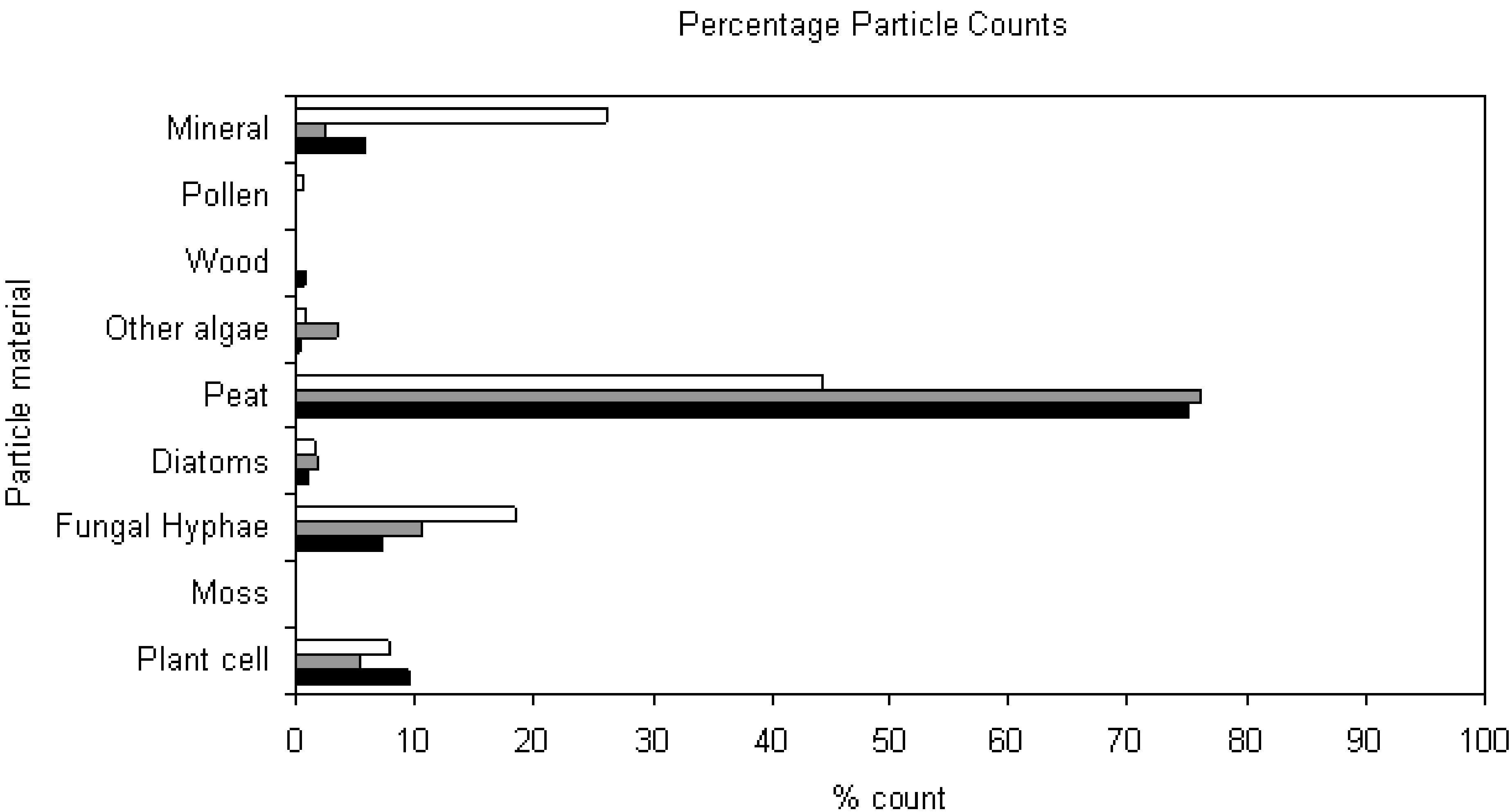

Intact Peat
Gully System
Eroding Flats
Surface Wash 0.23 t
Wind Erosion of Gully Walls 1.7 t
Gully Wall Erosion 8.6 t
Wind Erosion 0.23 t
Fluvial transport gully floors 0.49 t
Streamside Fans
Channel Undercutting 12.8 t
Direct Fluvial Transfer 0.6 t
Floodplain
Bank Erosion 51.7 t
Overbank Deposition 31.9 t
Channel Transport
Sediment yield 32.2 t


CATCHMENT
Allochthonous POM
Water surface
CHANNEL
Transported organic matter
POM
Peat block
CBOM
Periphyton
STREAM BED
FBOM

Organic storage – Rough Sike (Moor House)



Loss on ignition values (%)



Microscopic counts of suspended organic matter collected in the three mass flux drift samplers (Crowe and Warburton, 2007)

Peat Block Deposition Forms

Shadow

Crescent

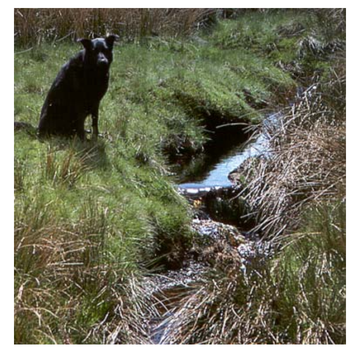
Perched

Armoured

Drape

Embedded

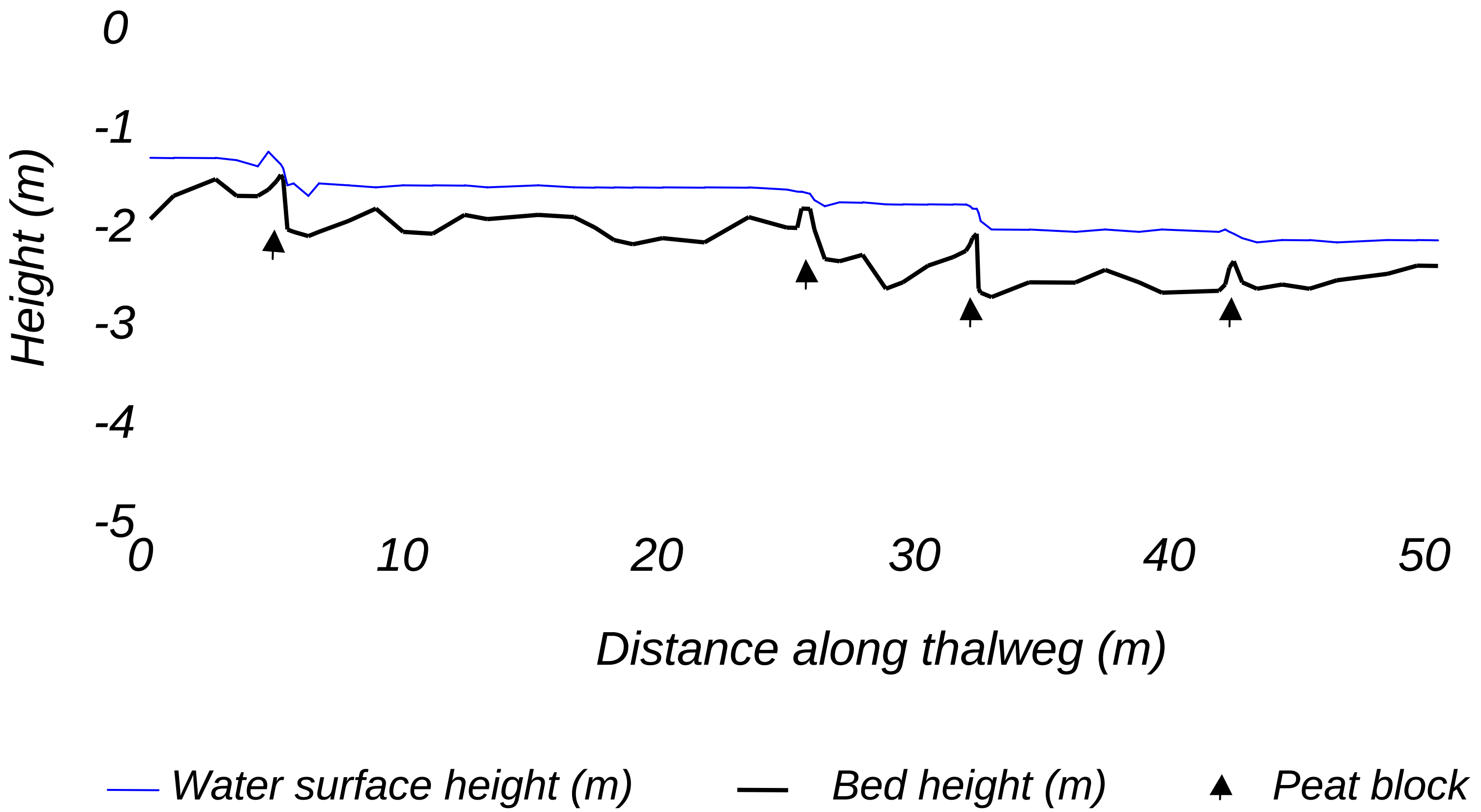
Cluster

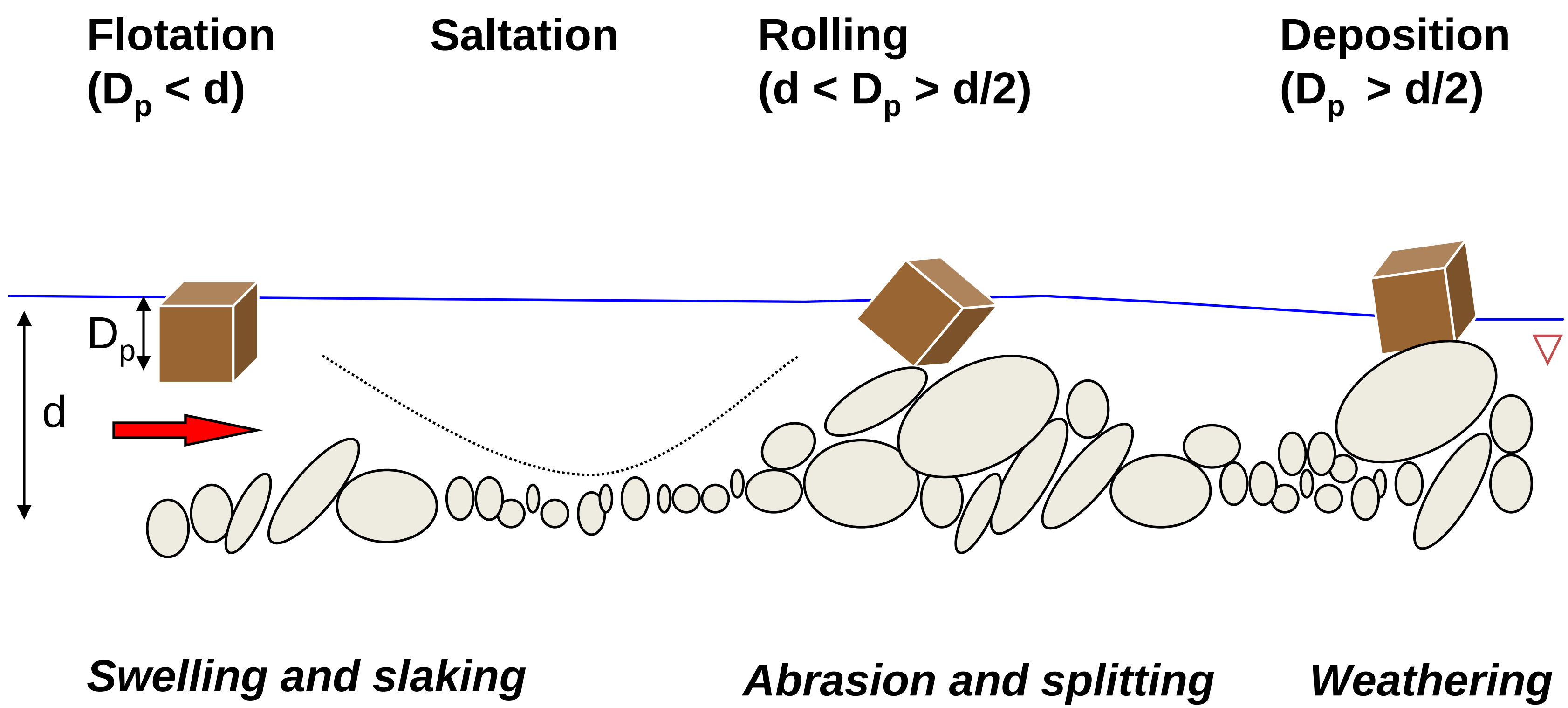


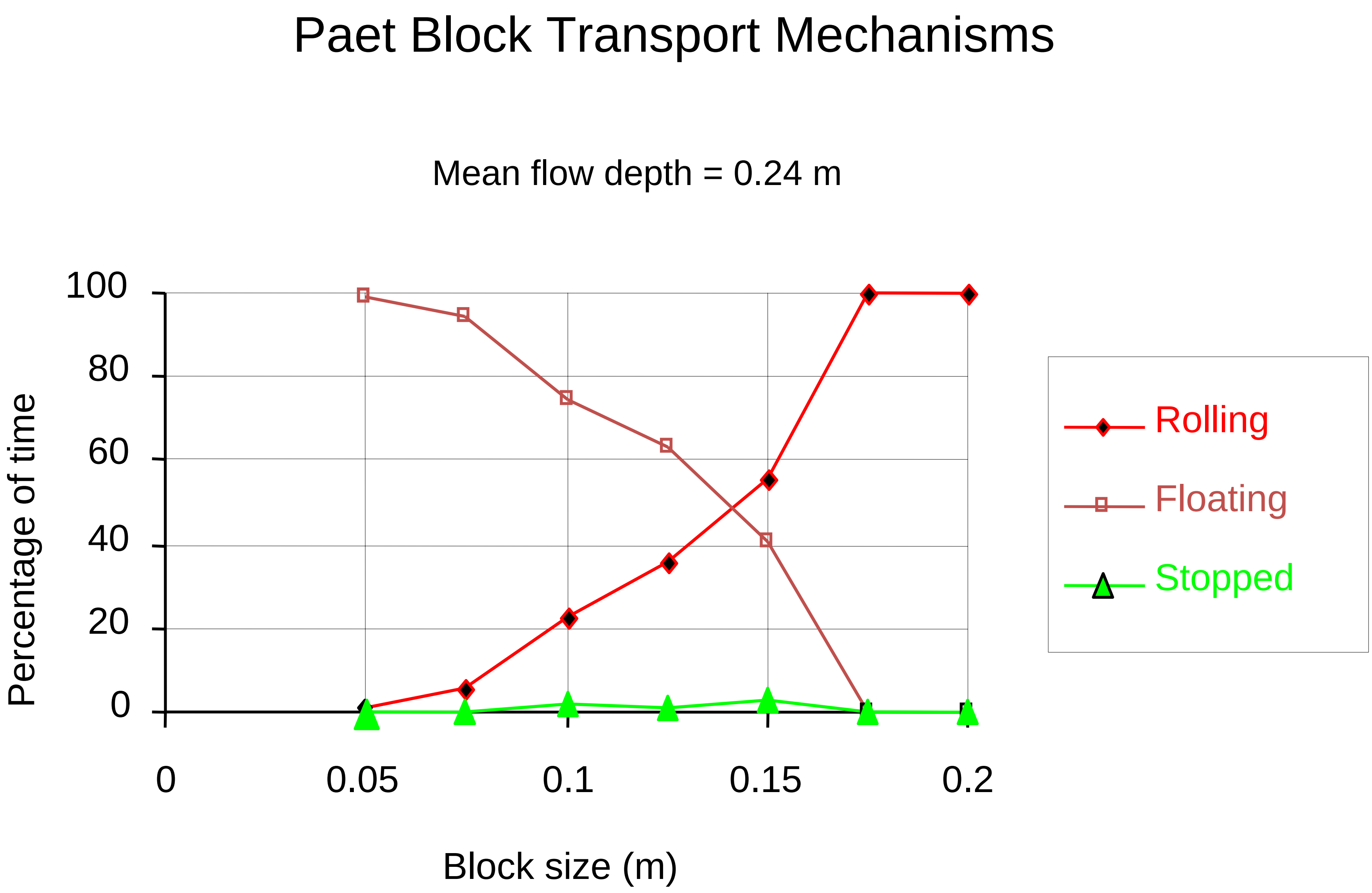
Step

Control of secondary and primary sedimentation

Rough Sike Long Profile




Flotation
(D_p < d)
Saltation
Rolling
(d < D_p > d/2)
Deposition
(D_p > d/2)
D_p
d
Swelling and slaking
Abrasion and splitting
Weathering


Paet Block Transport Mechanisms
Mean flow depth = 0.24 m
Percentage of time
100
80
60
40
20
0
0
0.05
0.1
0.15
0.2
Block size (m)
Rolling
Floating
Stopped

New Project Monitoring Framework

Three scales:

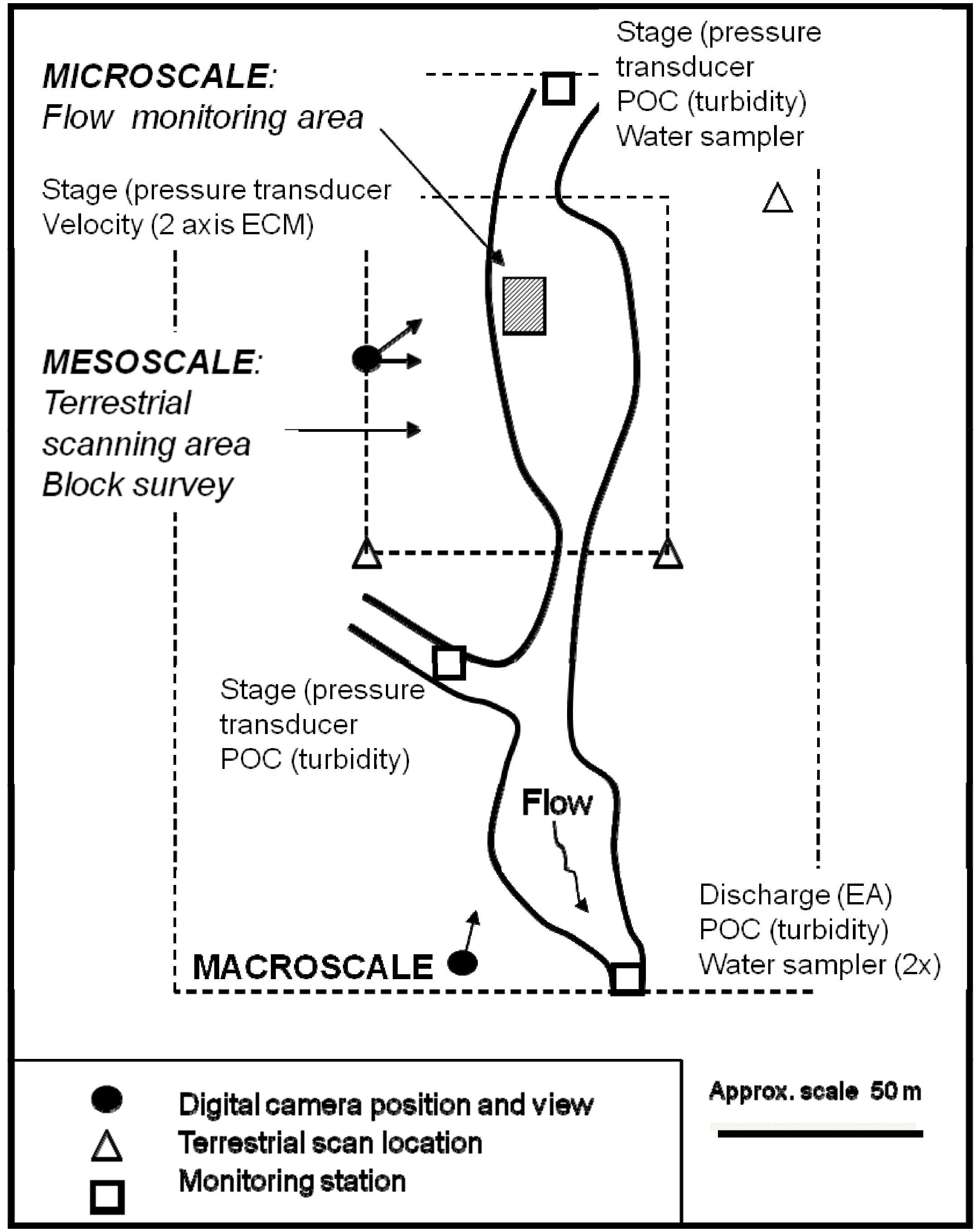
Macro

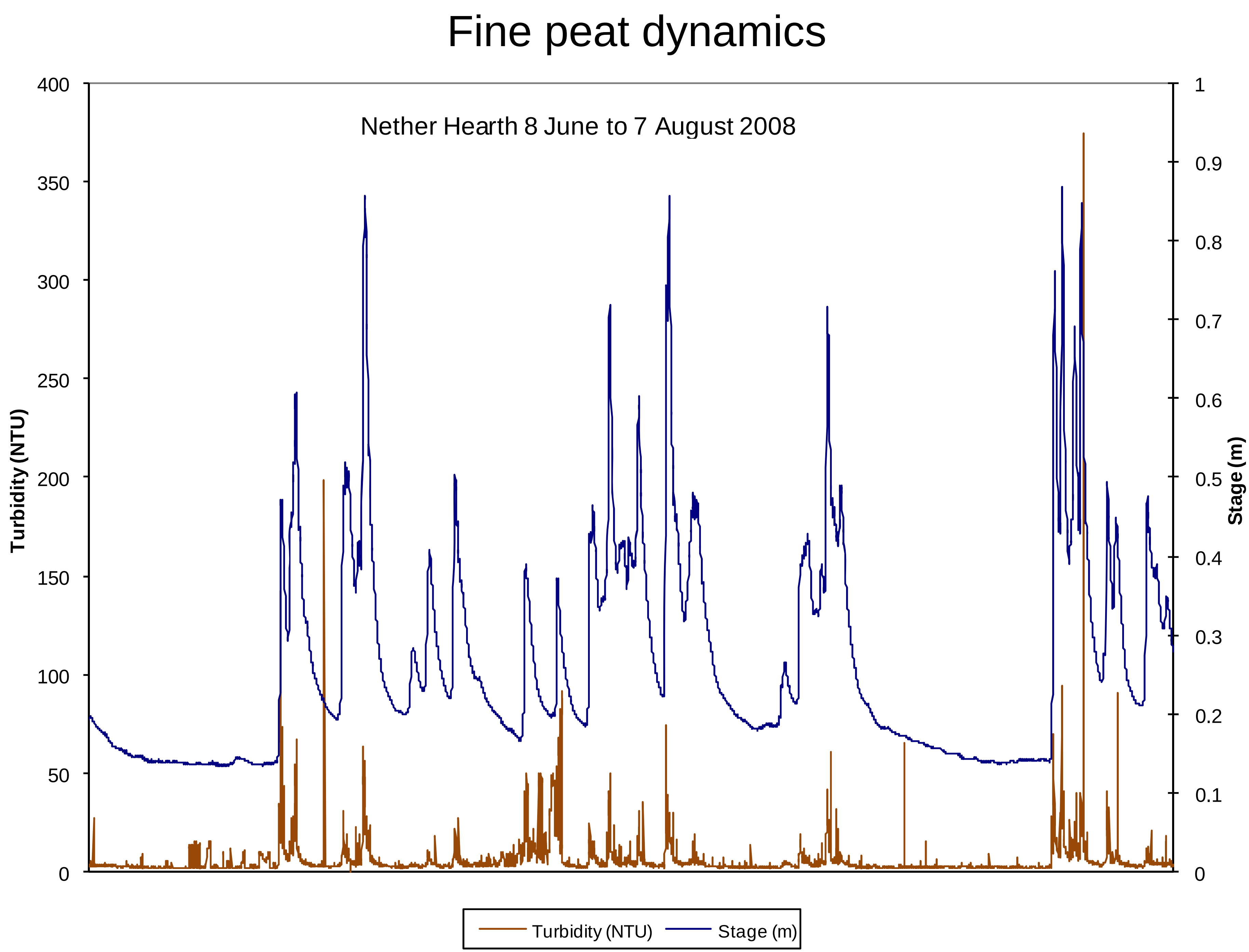
Meso

Micro

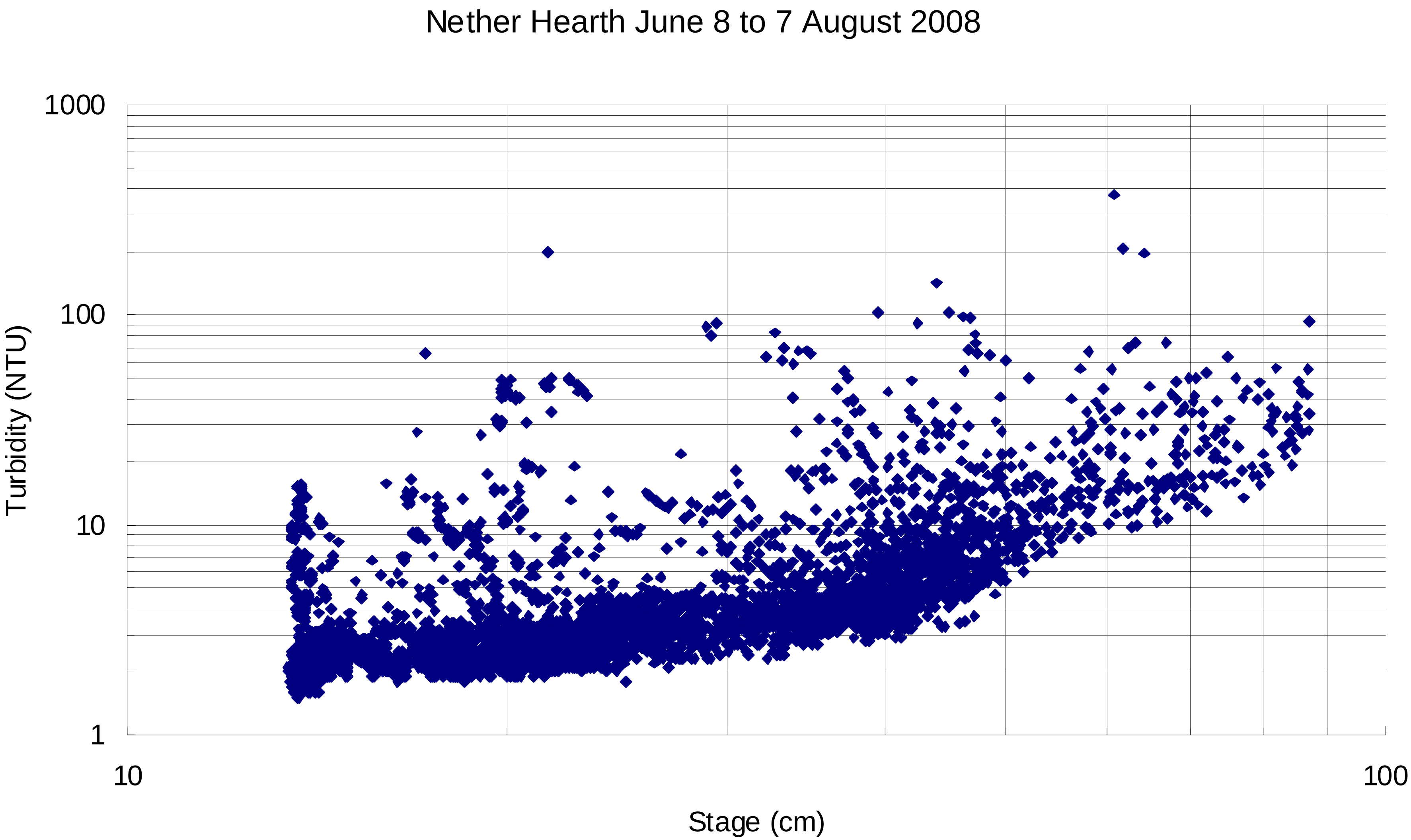
18 month period

Aim: to determine the significance of peat block transport in the catchment material flux





Fine peat dynamics
Nether Hearth 8 June to 7 August 2008
Turbidity (NTU)
Stage (m)
400
350
300
250
200
150
100
50
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Turbidity (NTU)
Stage (m)


Nether Hearth June 8 to 7 August 2008
1000
100
10
1
Turbidity (NTU)
10
100
Stage (cm)

Peat block dynamics - experiment: three-axis accelerometer

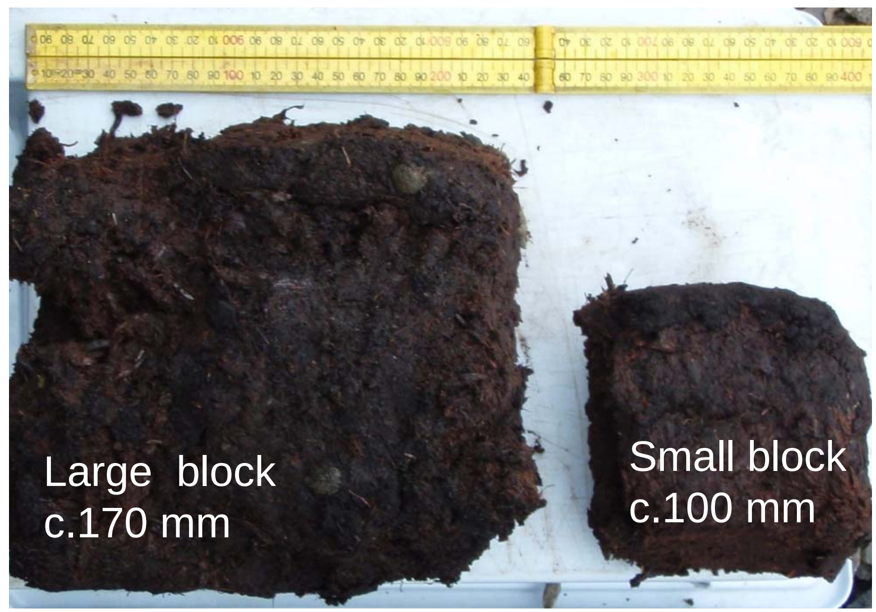
River reach 34 m (pool, riffle)

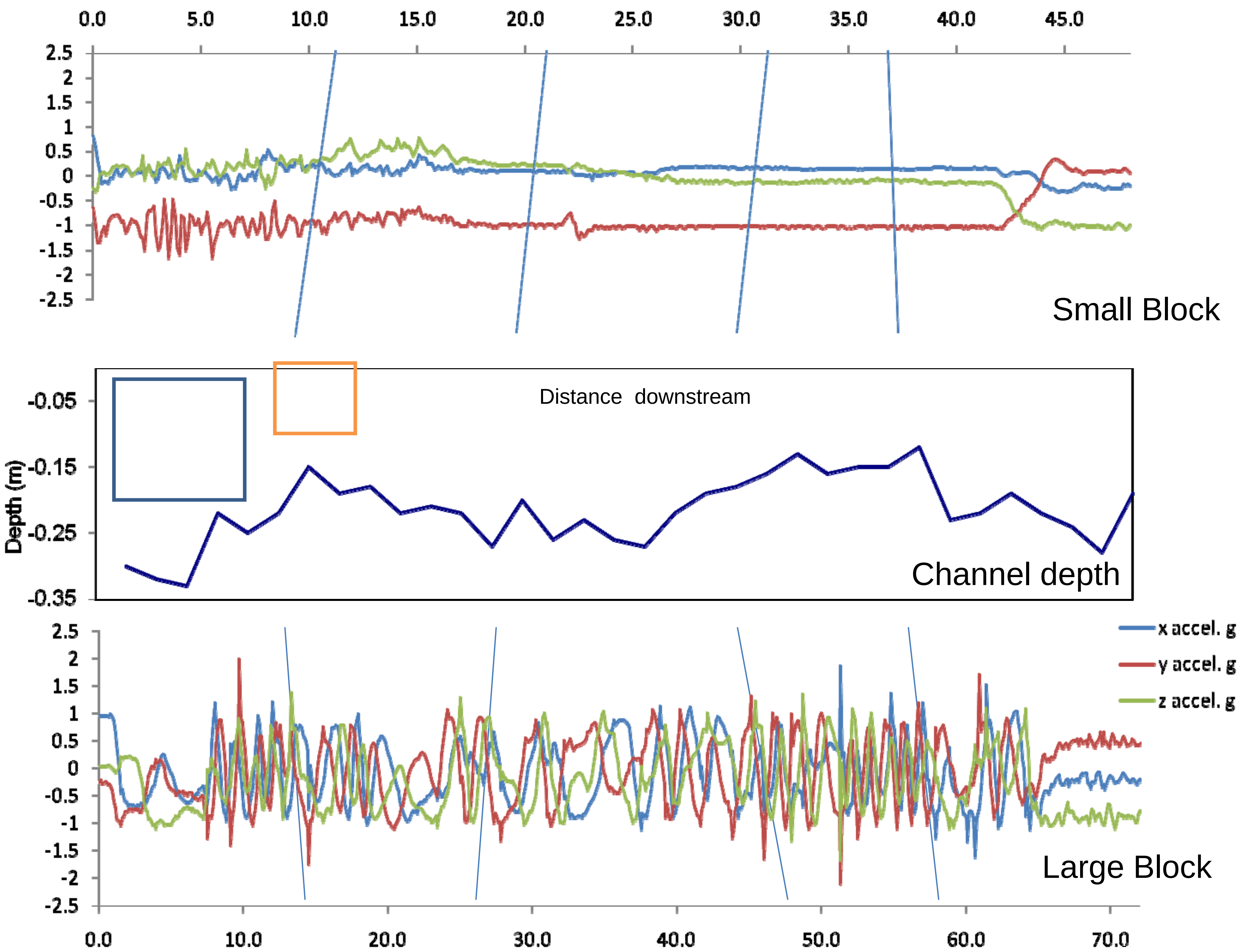
Slope 1.5°

Width 4-6 m

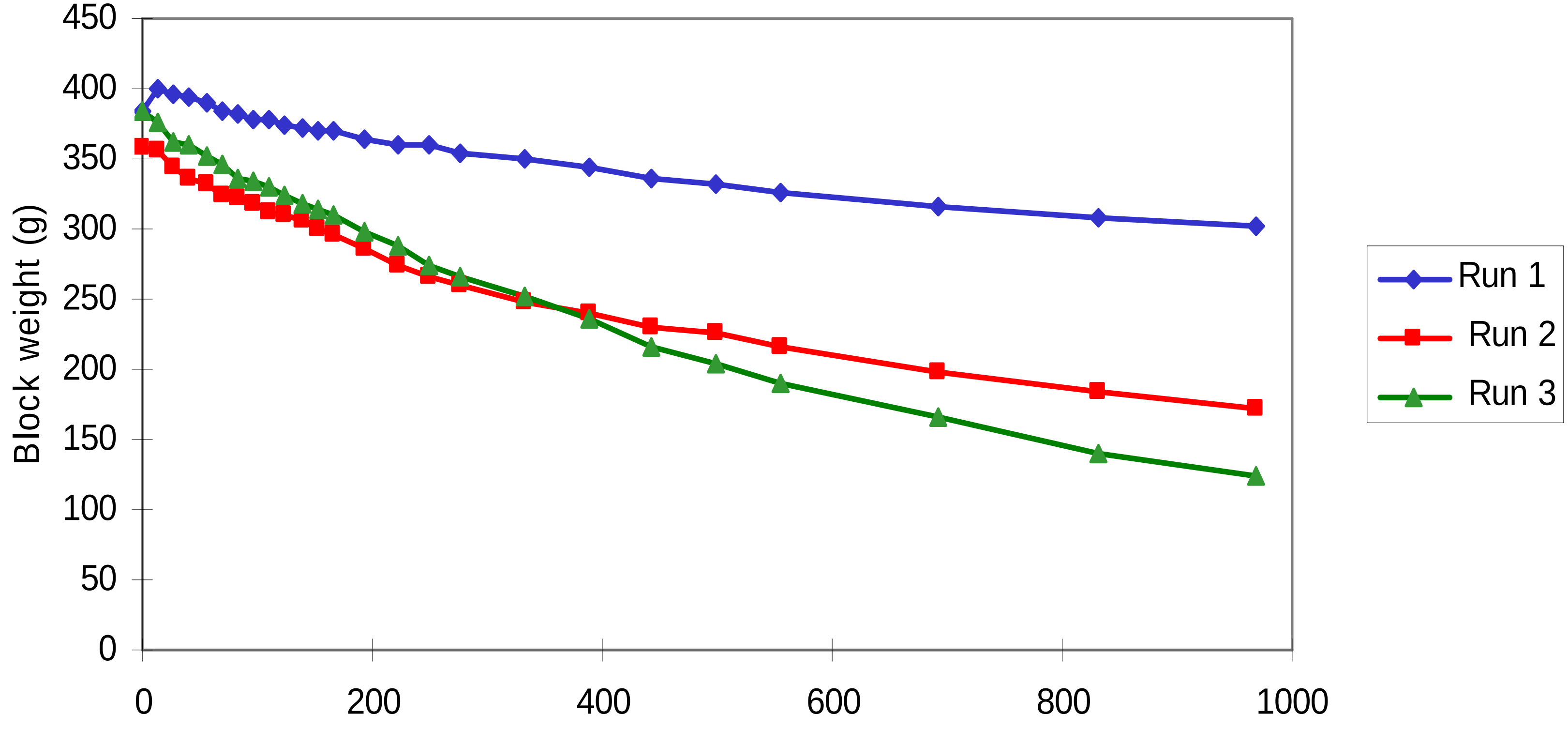
Depth 0.12 – 0.34 m

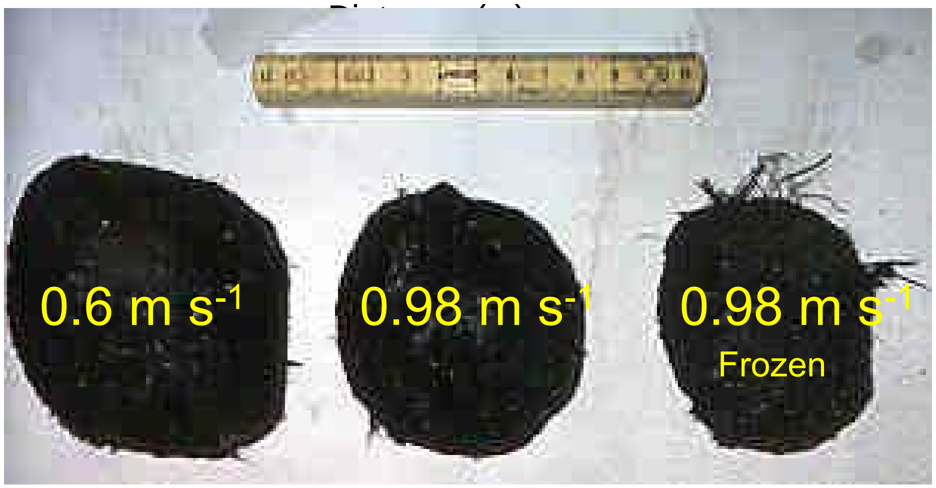
Discharge 0.9 $m^3 s^{-1}$




0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
Small Block
Distance downstream
Depth (m)
-0.05
-0.15
-0.25
-0.35
Channel depth
x accel. g
y accel. g
z accel. g
Large Block
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0

Extremely rapid peat block abrasion – experimental studies





Conclusions

1. Peat erosion is an important process in many upland areas and is important for terrestrial carbon loss
2. Because of the special character of peat – transport dynamics differ markedly from mineral sediments
3. In constructing sediment budgets this needs to be acknowledged and appropriate measurement techniques developed
4. Peat block transport (BOC) has not been fully measured in eroding peatlands and is not included in terrestrial upland carbon budgets
5. The preliminary results described here have the potential to evaluate the significance of this component and better understand its transport dynamics

Acknowledgements

NATURAL ENVIRONMENT RESEARCH COUNCIL

Environment Agency

Durham University

UK Environmental Change Network

Peat Characteristics

Geosystem properties

High water content

Permeability

Bulk density

Organic content

Micromorphology

Gas content

pH

Geotechnical properties

Index properties

Consolidation (Primary and Secondary)

Mechanical properties - organic matter

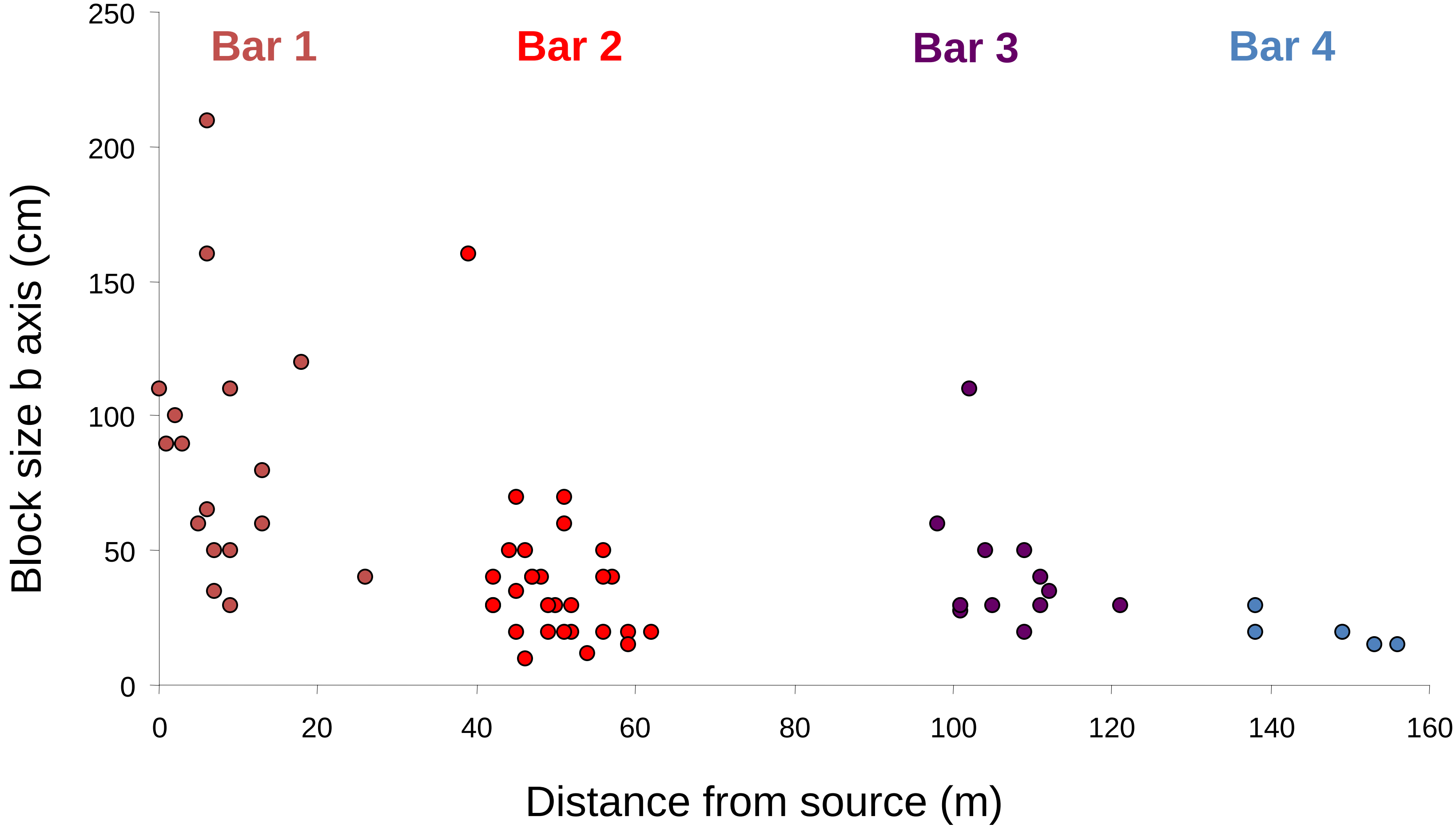
Flow properties

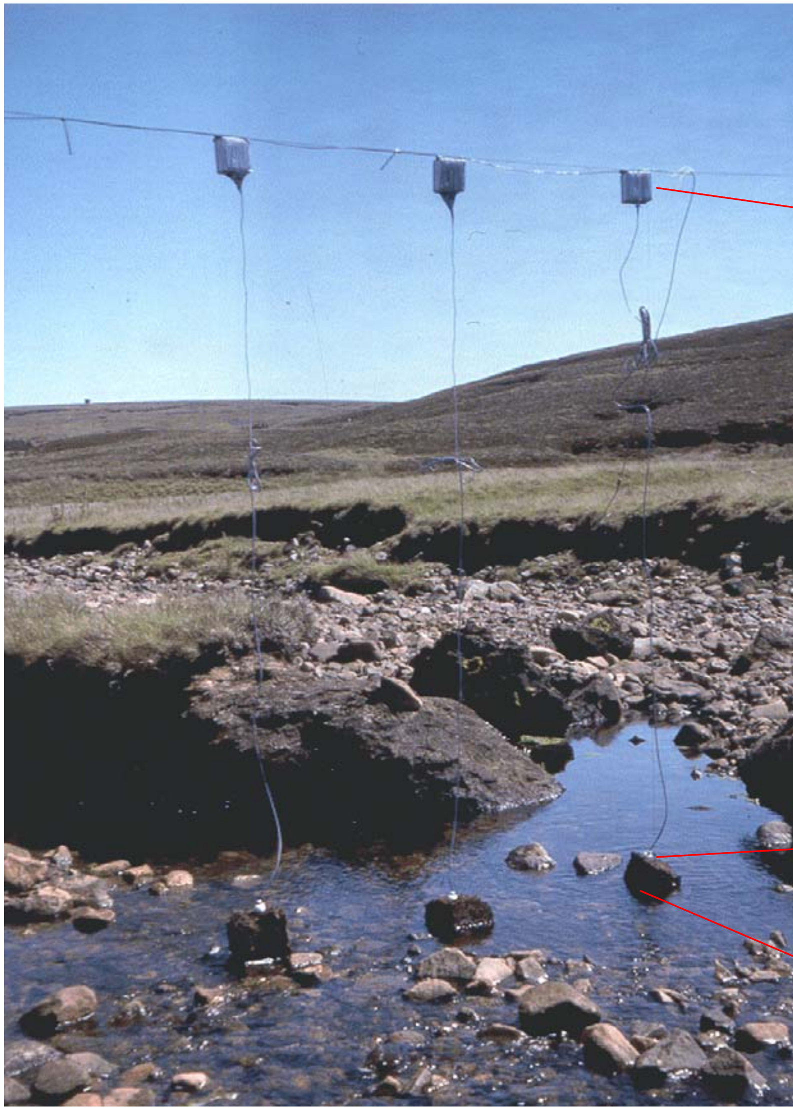
Creep

Shrinkage & desiccation

Thermal behaviour

These properties control the nature of physical processes


Bar 1
Bar 2
Bar 3
Bar 4
Block size b axis (cm)
0
50
100
150
200
250
0
20
40
60
80
100
120
140
160
Distance from source (m)



Peat Block Initial Motion