Peatlands, their geomorphological characteristics and implications for engineering

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Reinforced Water - Engineering and Environmental Considerations in Construction over Peat, Edinburgh, 11 March 2008

Emphasis today:

Blanket mire – rain-fed peatland terrain

Geomorphic perspective on upland peatlands

Considers a range of geomorphic proceses – mainly slope instability

OUTLINE

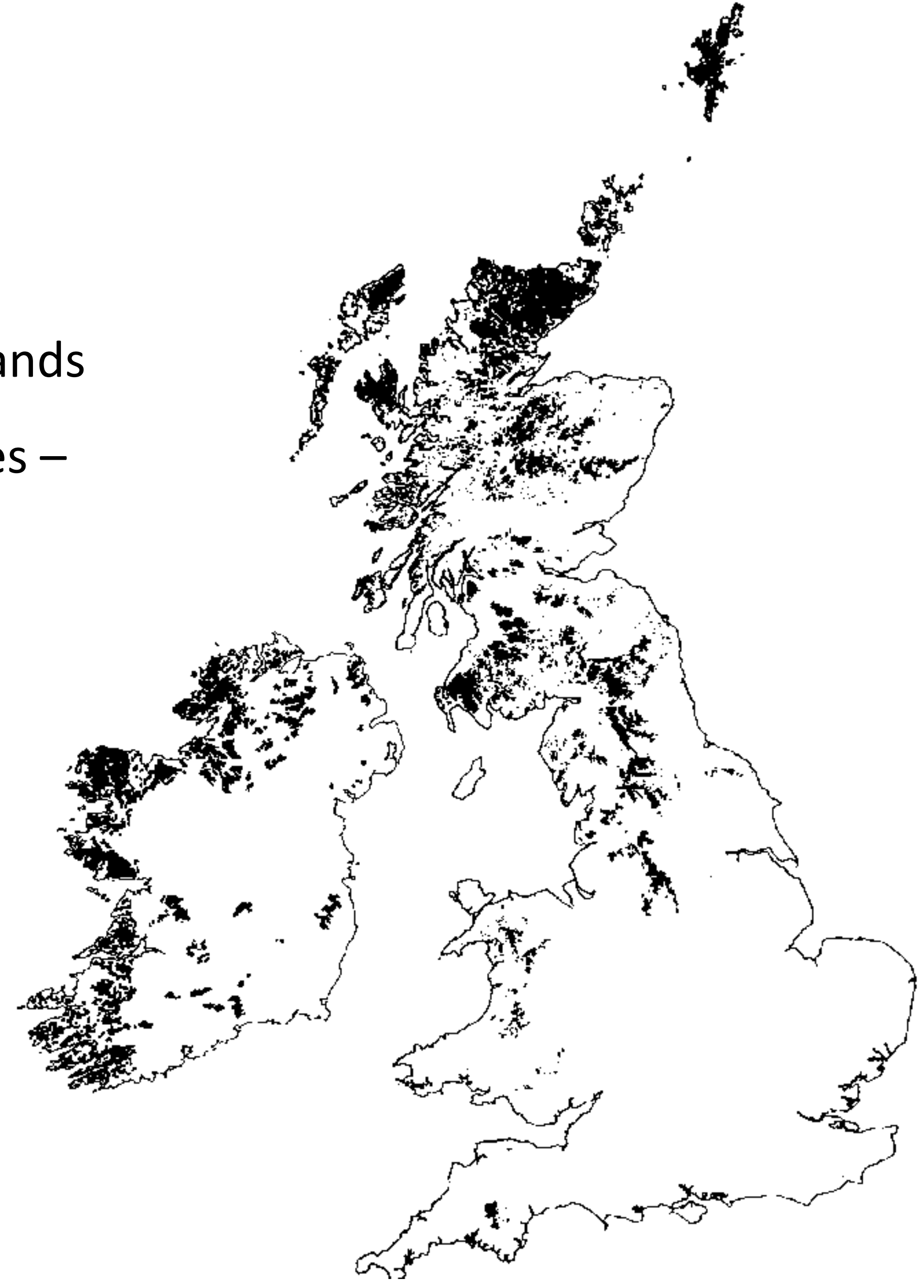
1.Upland peat geomorphic system

2.Hillslope instability –

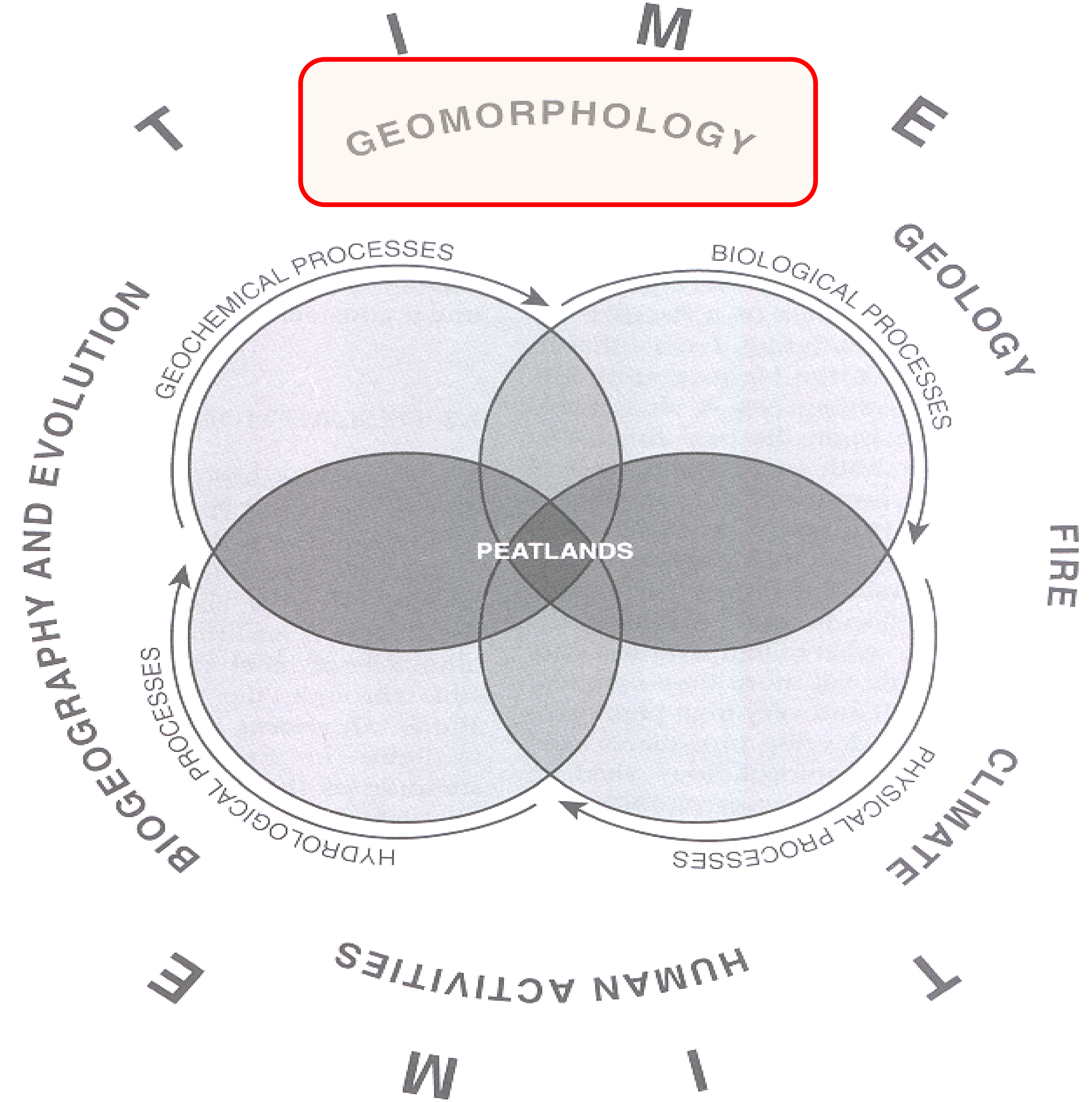
- Recognition
- Failure type

3.Links to the fluvial system

4.Peatland process regimes



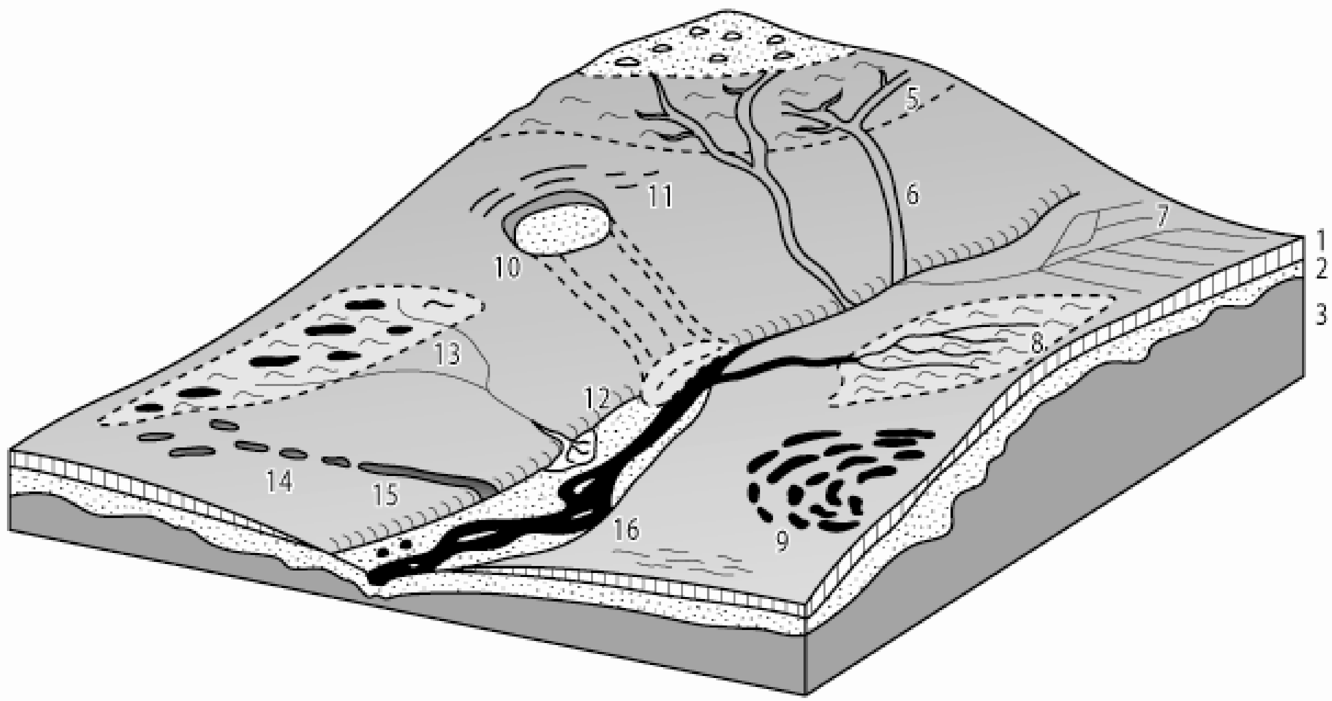
Extent of blanket peat in the British Isles   Source: Tallis et al. (1997)



After Warner (1996), Charman (2002)

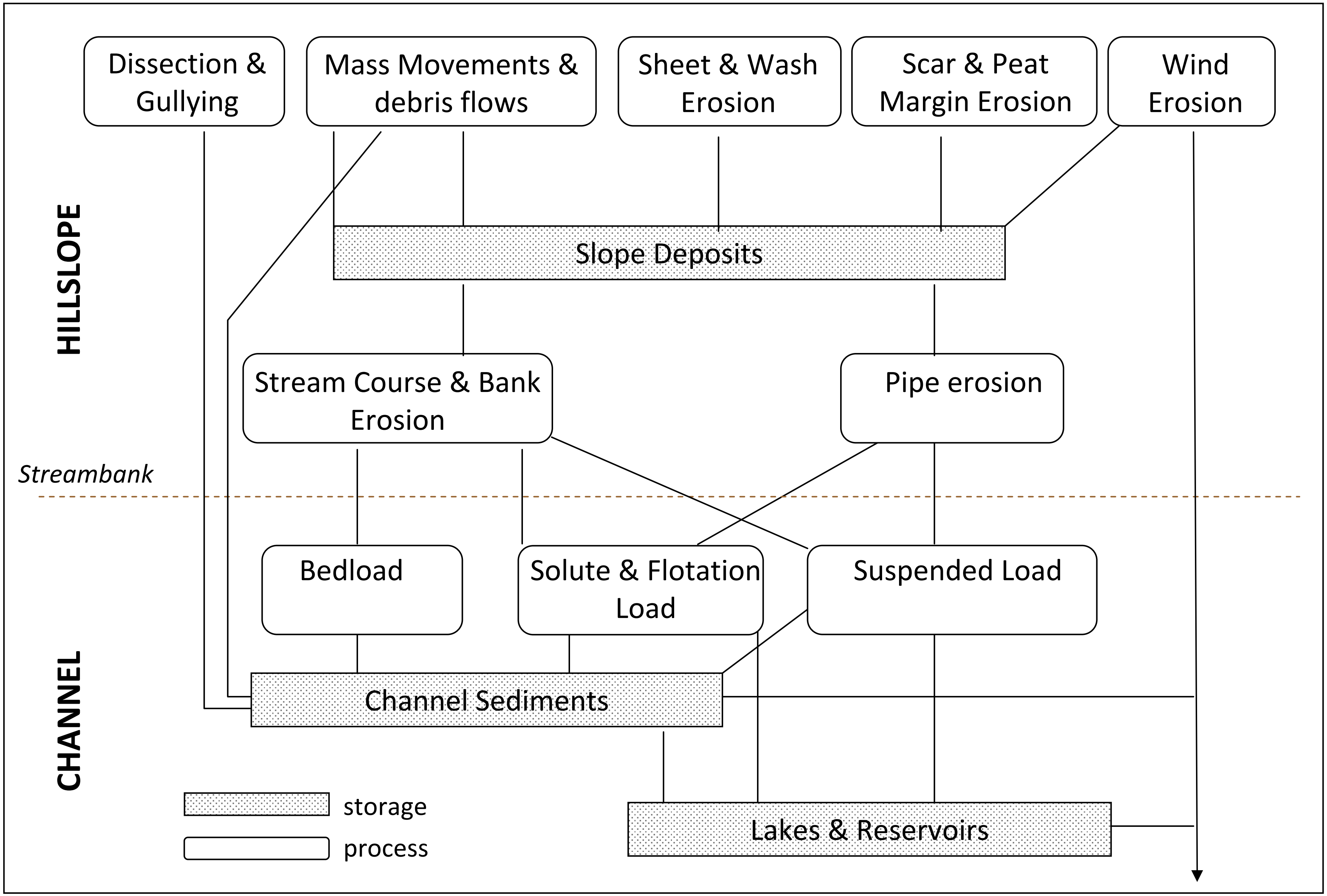
The Problem: Burnhope Burn August 2006

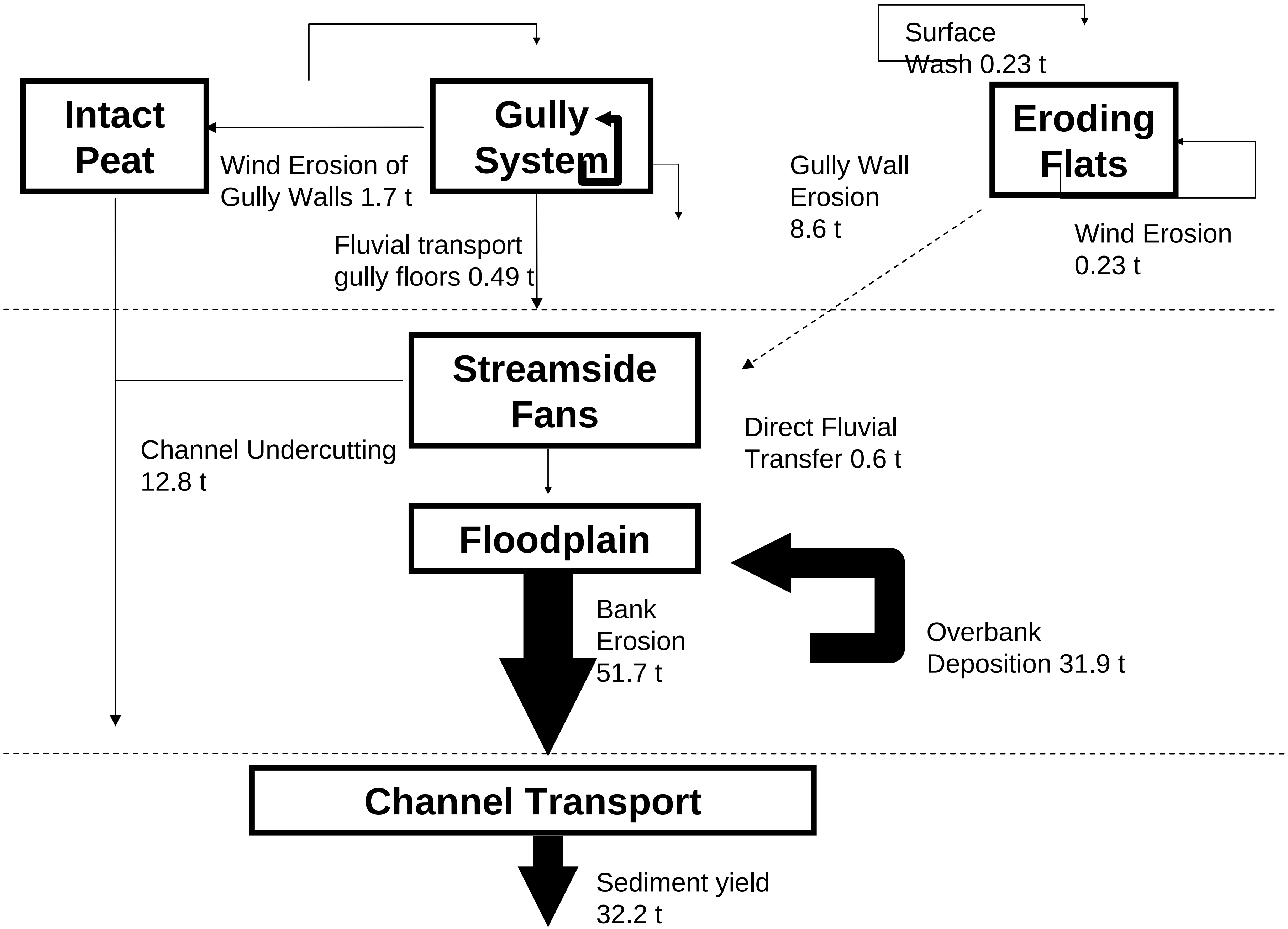
Landsystems approach - engineering geomorphology



1 Peat deposits
2 Glacial / periglacial deposits (substrate)
3 Bedrock
4 Deflation surface remnant peat hummocks
5 Gully (Type I)
6 Gully (Type II)
7 Artificial channels (grip network)
8 Peat haggs
9 Bog pool complex
10 Peat mass movement
11 Peat tears and tension cracks
12 Valley side peaty debris fan
13 Eroded pool and hummock complex
14 Collapsed pipe system
15 Peat block sedimentation
16 Upland river system (mineral sediment)

Peatland Geomorphic System




Surface
Wash 0.23 t
Intact
Peat
Gully
System
Eroding
Flats
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
Direct Fluvial
Transfer 0.6 t
Channel Undercutting
12.8 t
Floodplain
Bank
Erosion
51.7 t
Overbank
Deposition 31.9 t
Channel Transport
Sediment yield
32.2 t

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

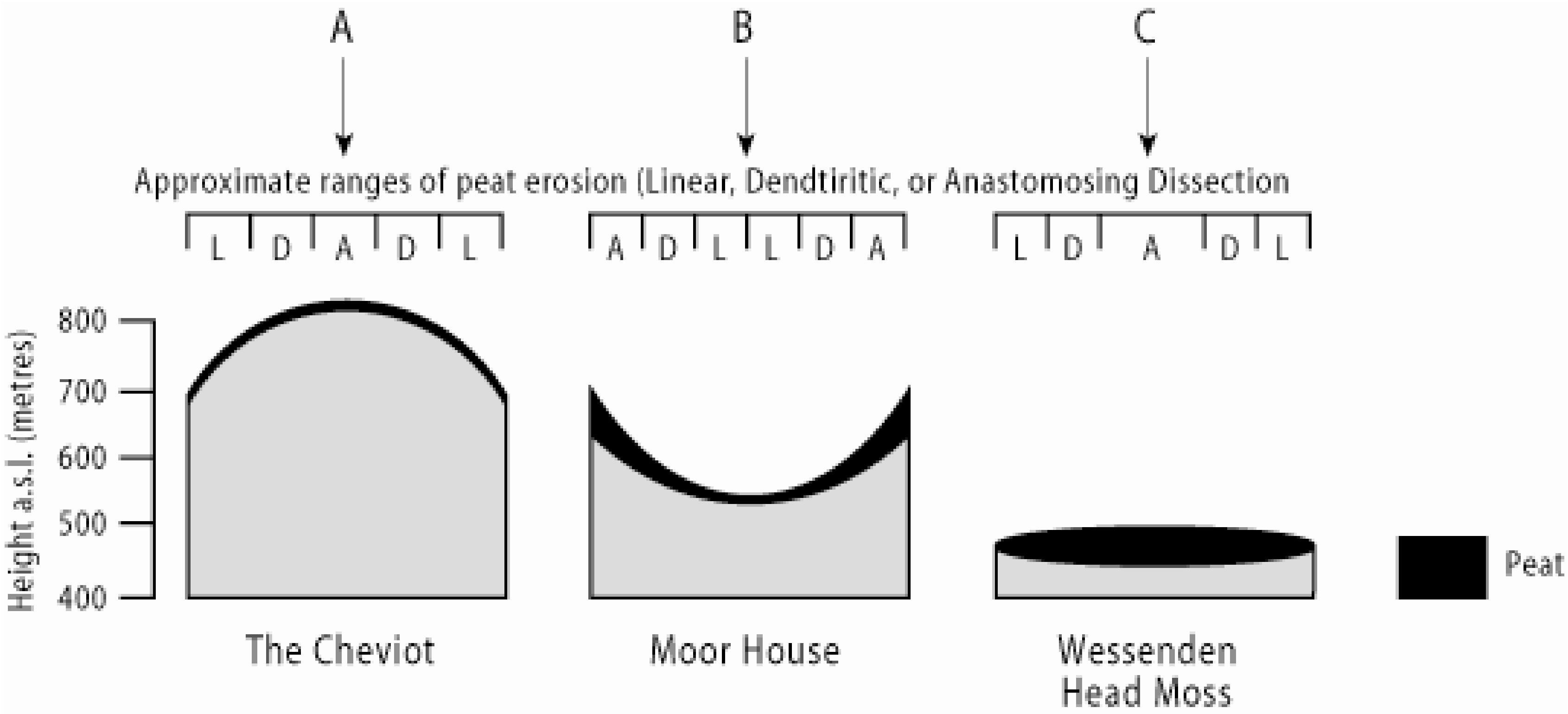
Creep

Shrinkage & desiccation

Thermal behaviour

These properties control the nature of physical processes

Significance of topography



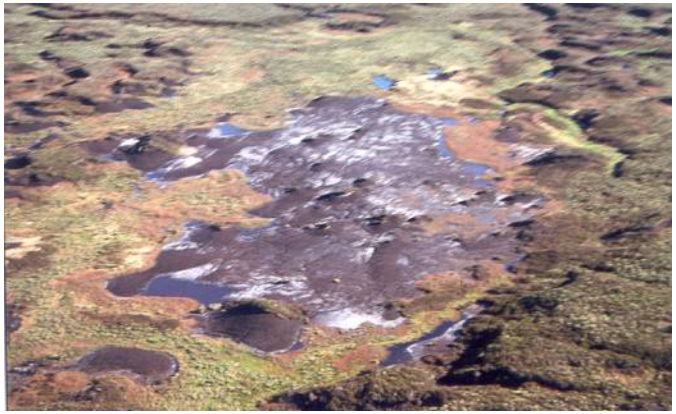
Scale, process and form

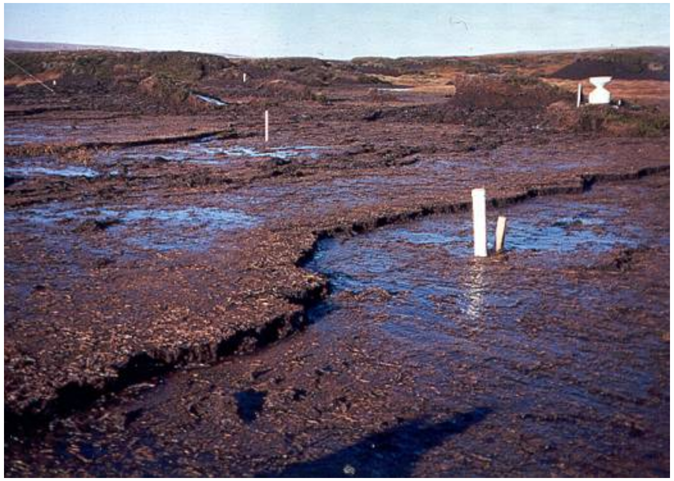
Three scales:

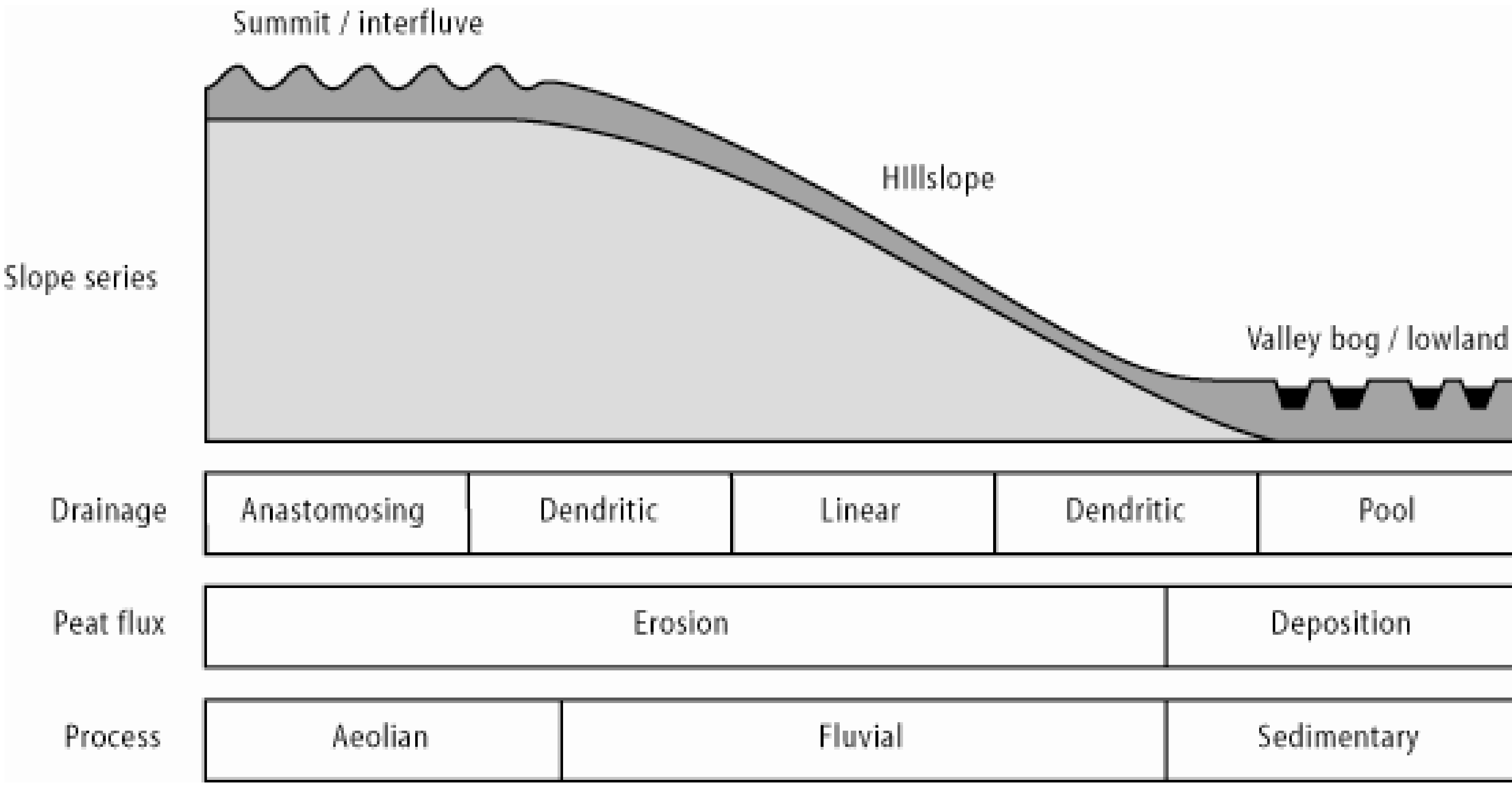
Macro – region / catchment scale

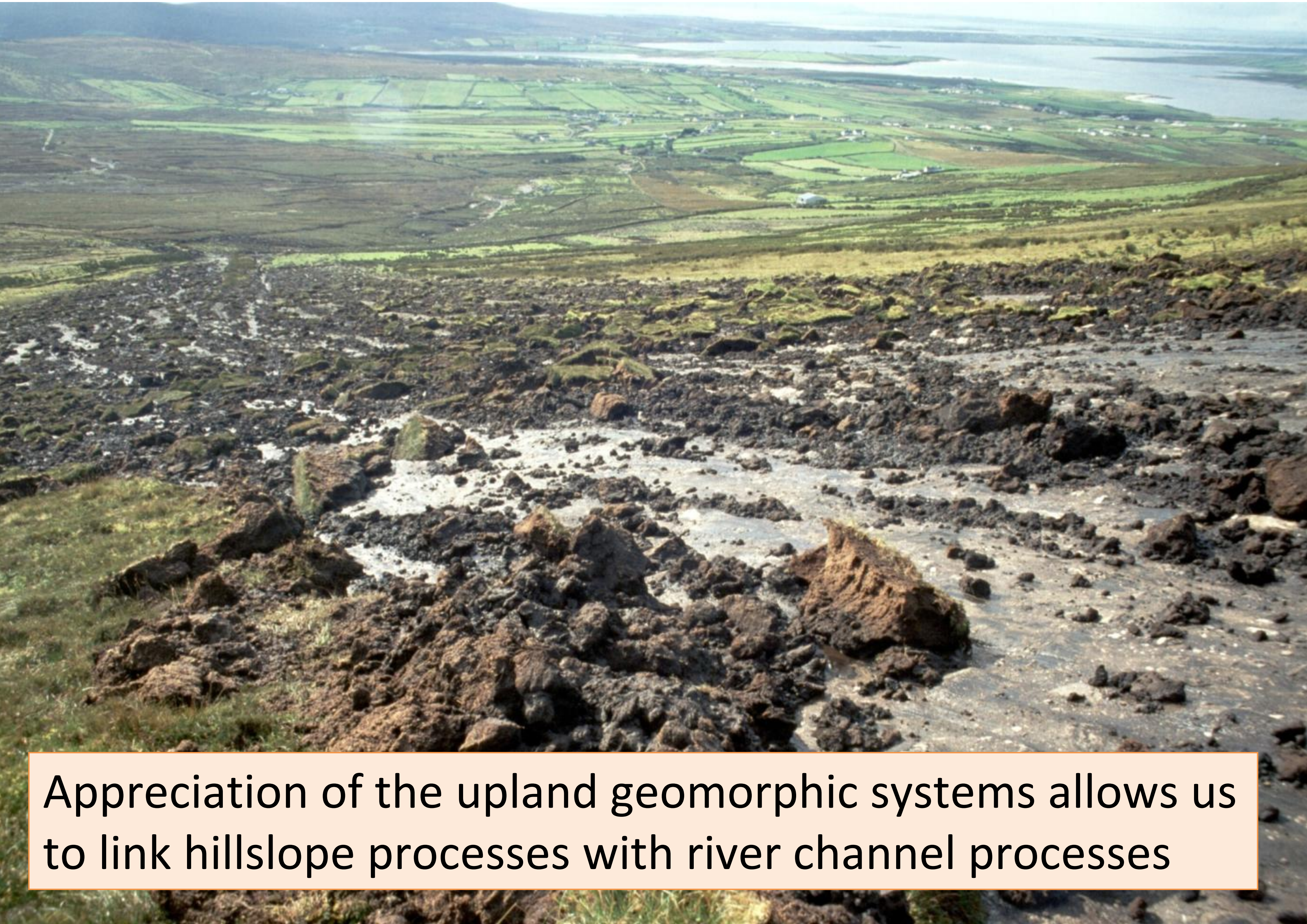
Meso – slope / channel scale

Micro – material / structure scale






Summit / interfluve
Hillslope
Slope series
Valley bog / lowland
Drainage
Anastomosing
Dendritic
Linear
Dendritic
Pool
Peat flux
Erosion
Deposition
Process
Aeolian
Fluvial
Sedimentary

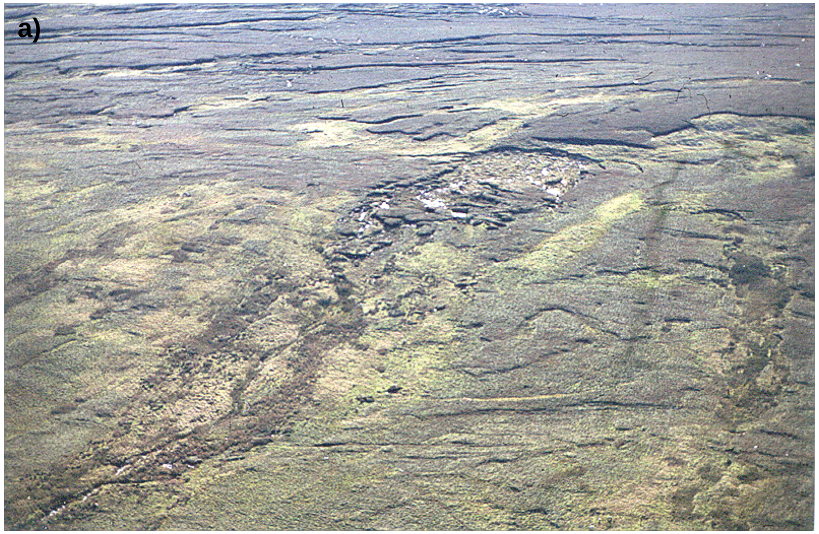


Appreciation of the upland geomorphic systems allows us to link hillslope processes with river channel processes

Hillslope instability

Fresh evidence – is often the key to diagnosis

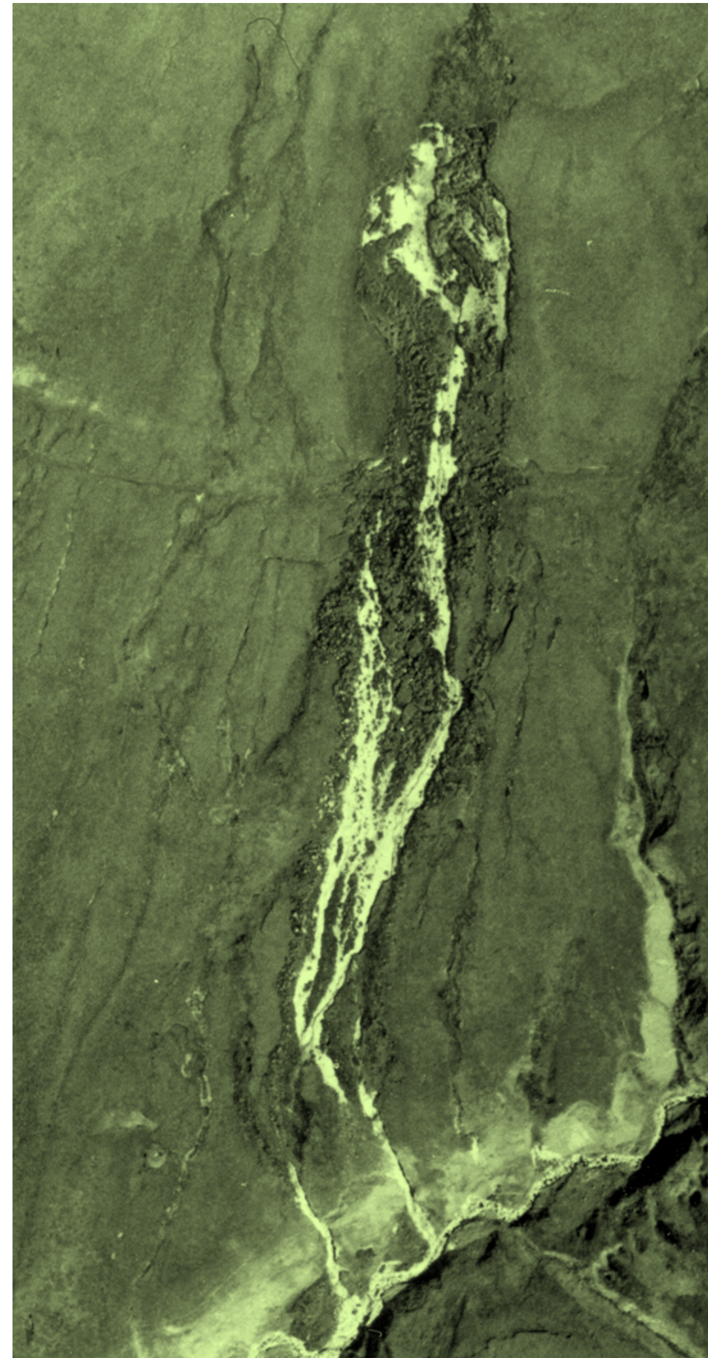
Peat mass movements – not always as obvious



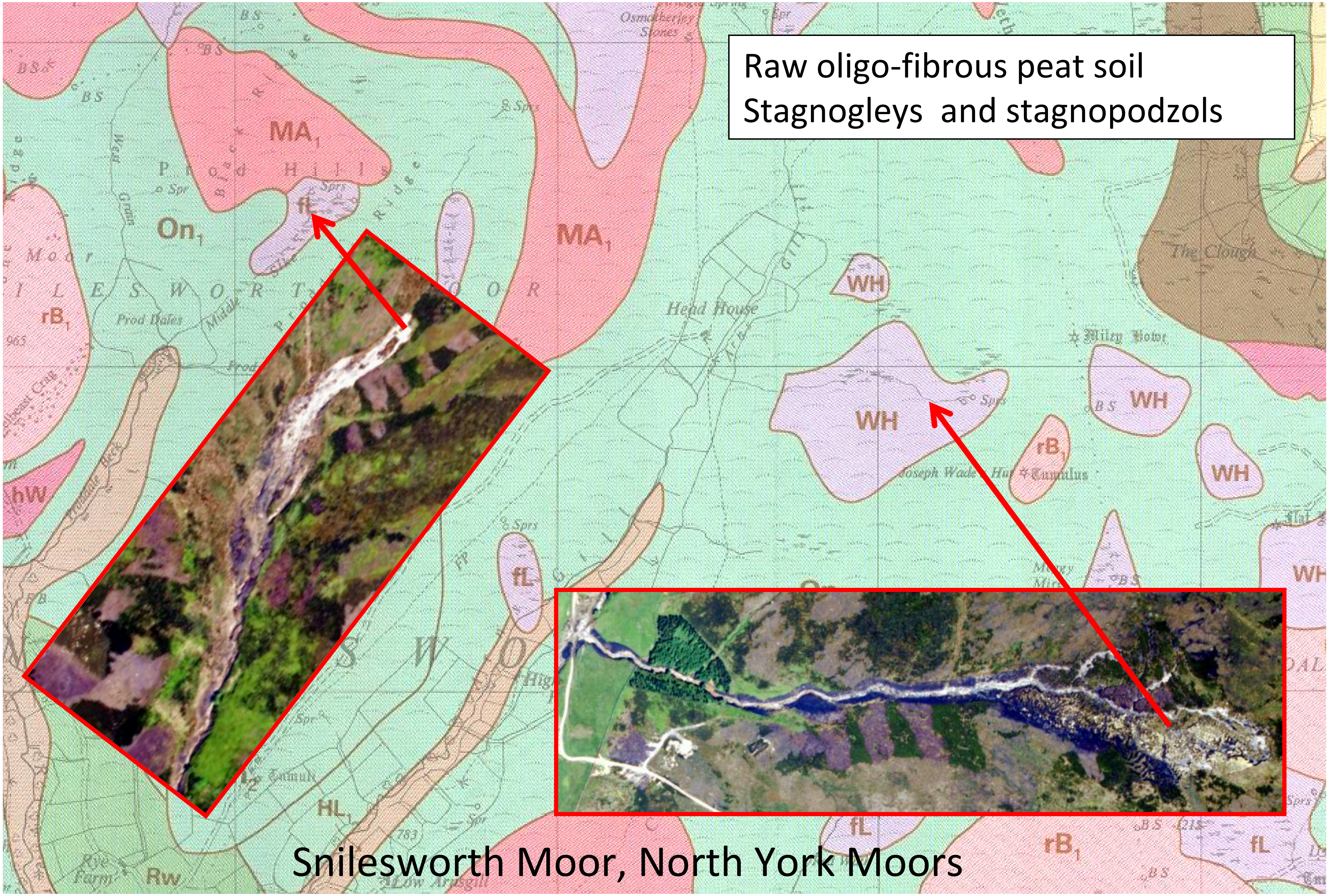
Recognition:
shallow surface hydrology

Harthope Peat Slide, Upper Teesdale, North Pennines, 1995

Failure along a pre-existing flush amd drainage line



Recognition: soil type and drainage



Raw oligo-fibrous peat soil
Stagnogleys and stagnopodzols

Snilesworth Moor, North York Moors

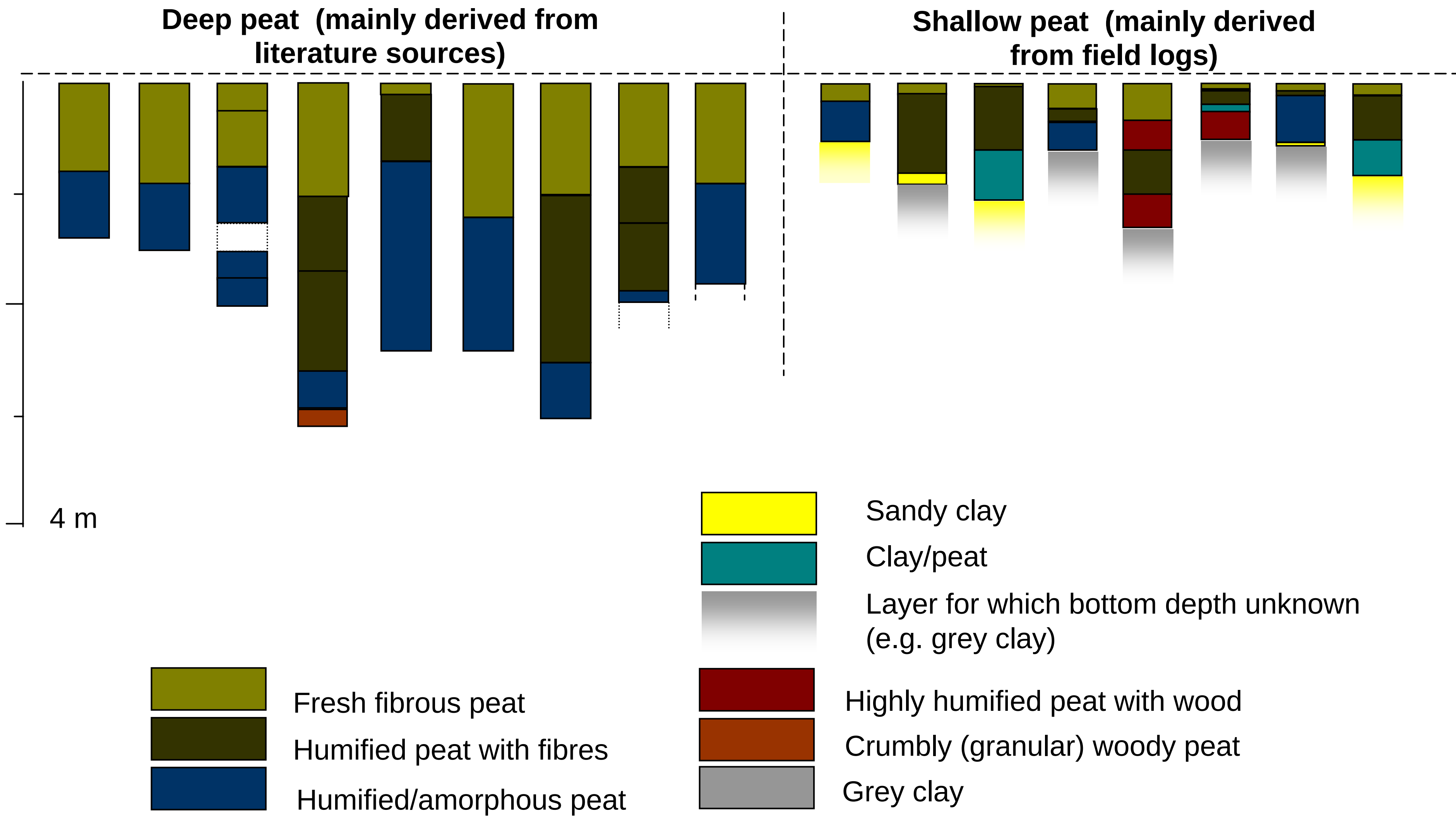
Peat landslides - North York Moors, June 2005

Recognition: looking to the past

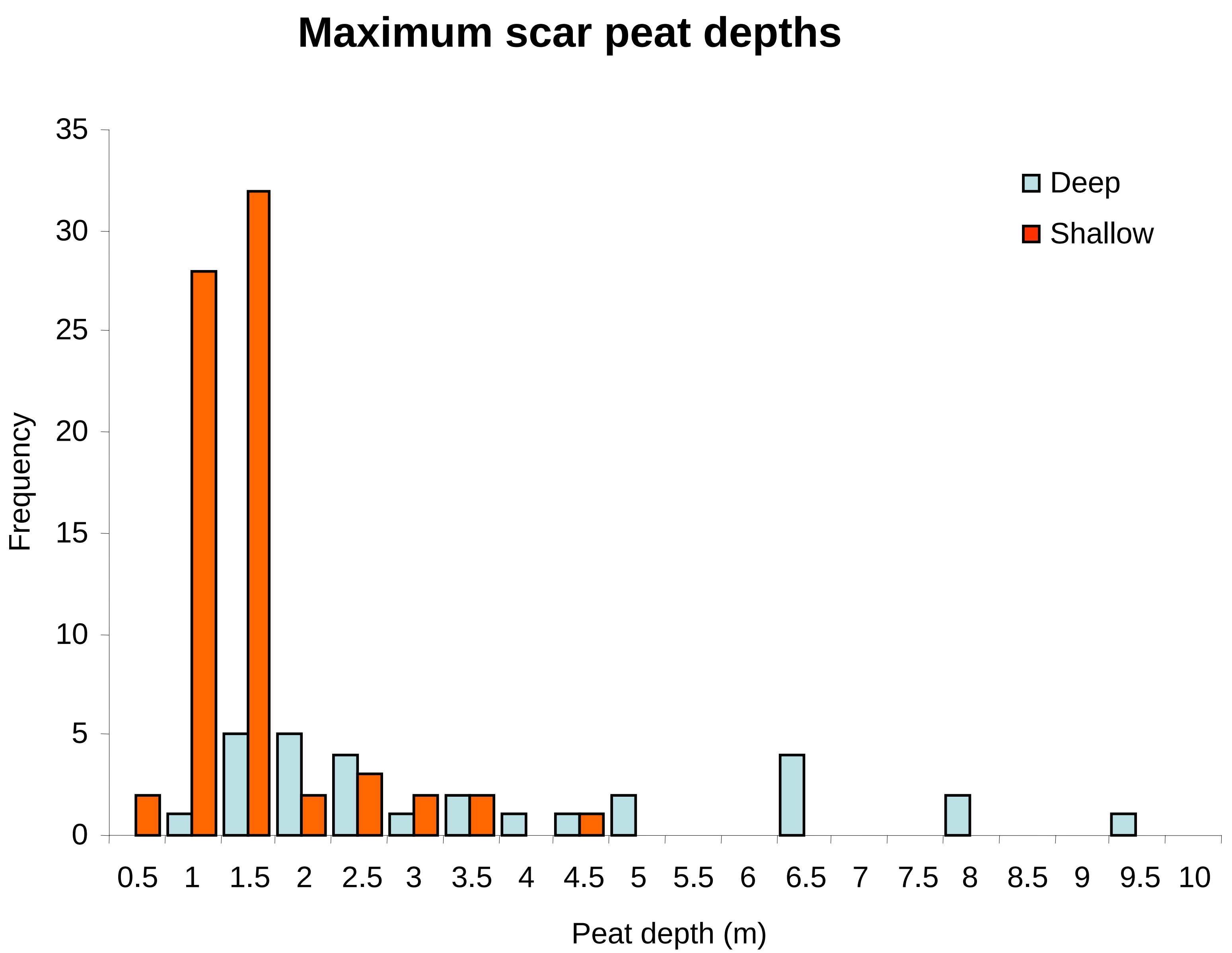
Bloodybush Edge, Cheviot 1893 (Source: British Rainfall, 1894)


Spot the peat failure?

Wide variety of peat hillslope instabilities

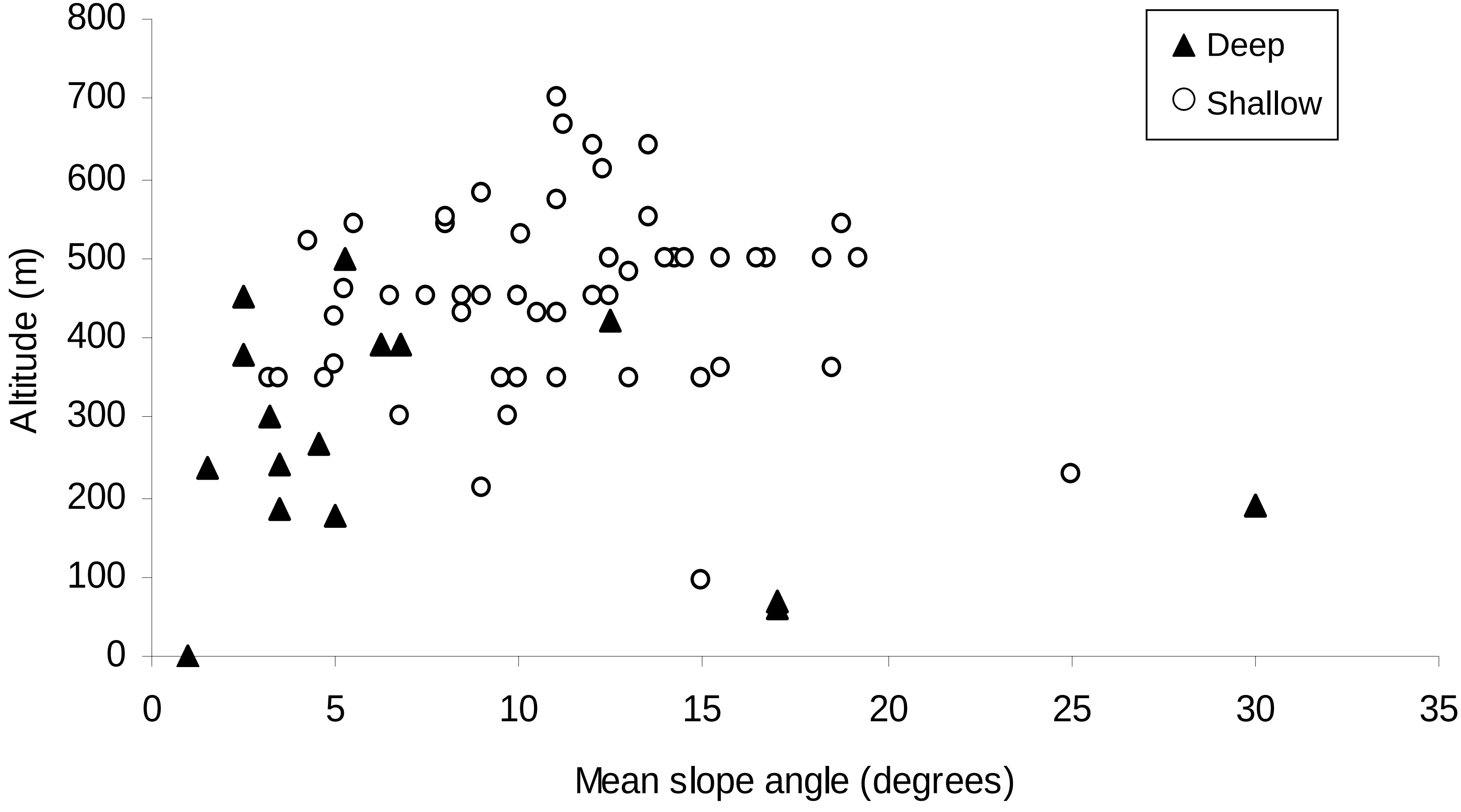


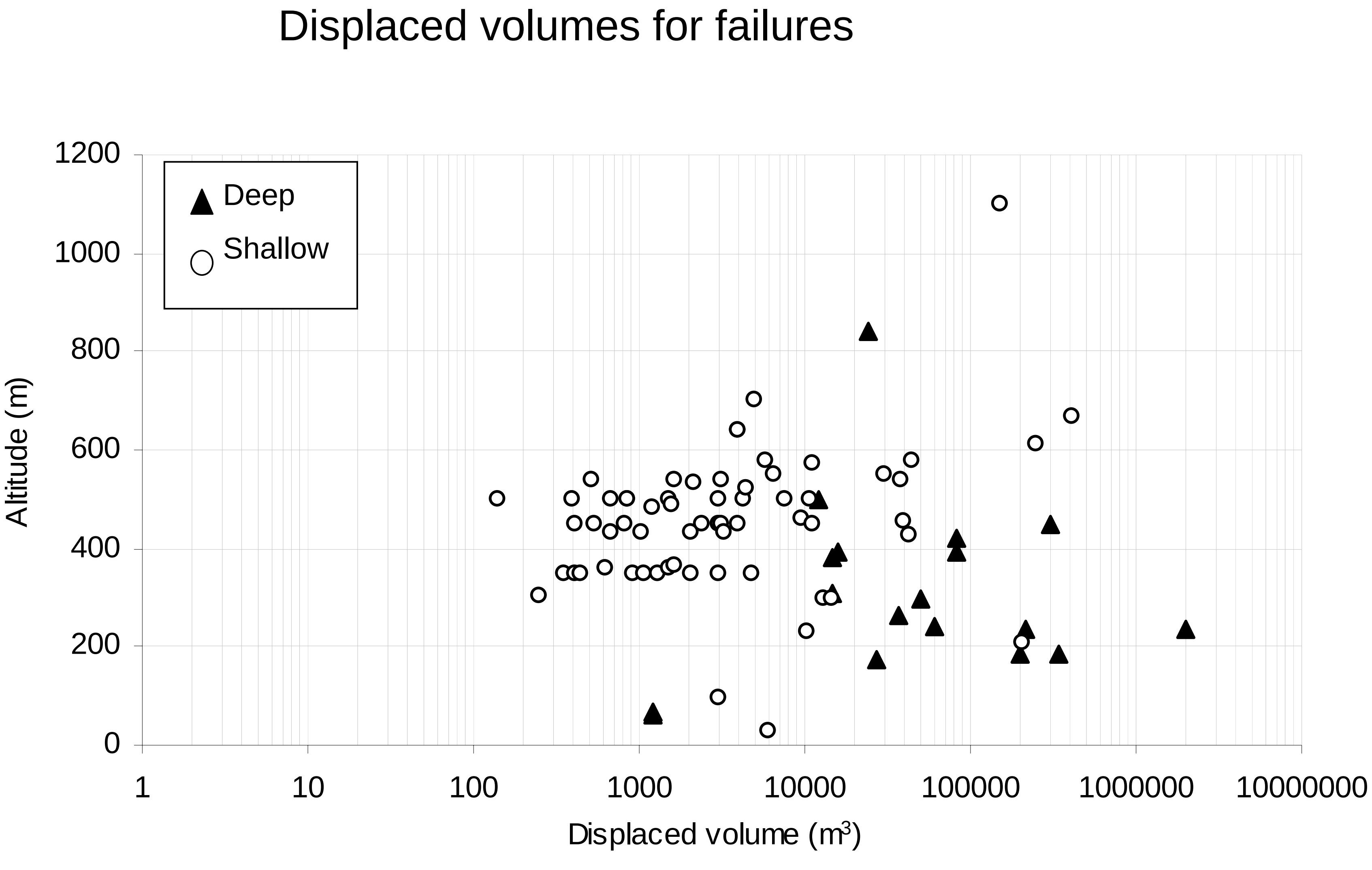
Schematics of peat stratigraphy for peat failures



Maximum scar peat depths
Frequency
0
5
10
15
20
25
30
35
Deep
Shallow
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
10
Peat depth (m)

Mean slope angle and altitude for failures

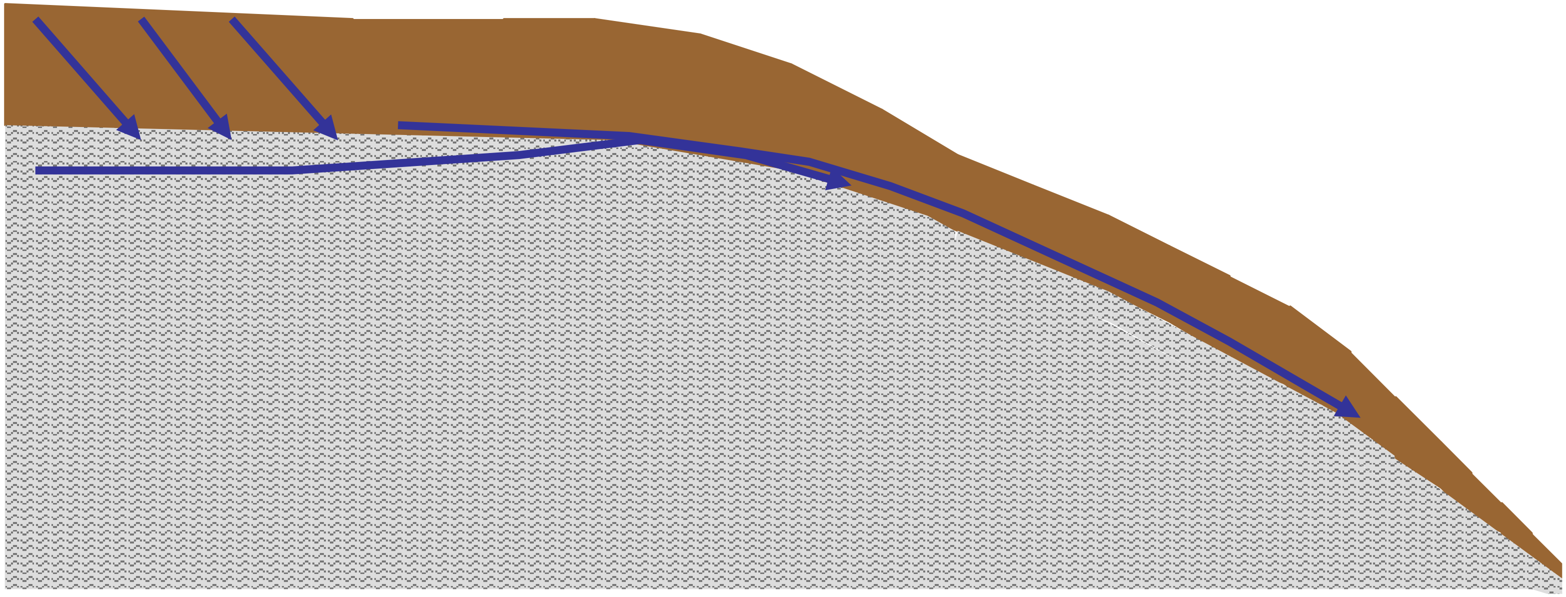




Displaced volumes for failures
Deep
Shallow
Altitude (m)
0
200
400
600
800
1000
1200
1
10
100
1000
10000
100000
1000000
10000000
Displaced volume (m3)

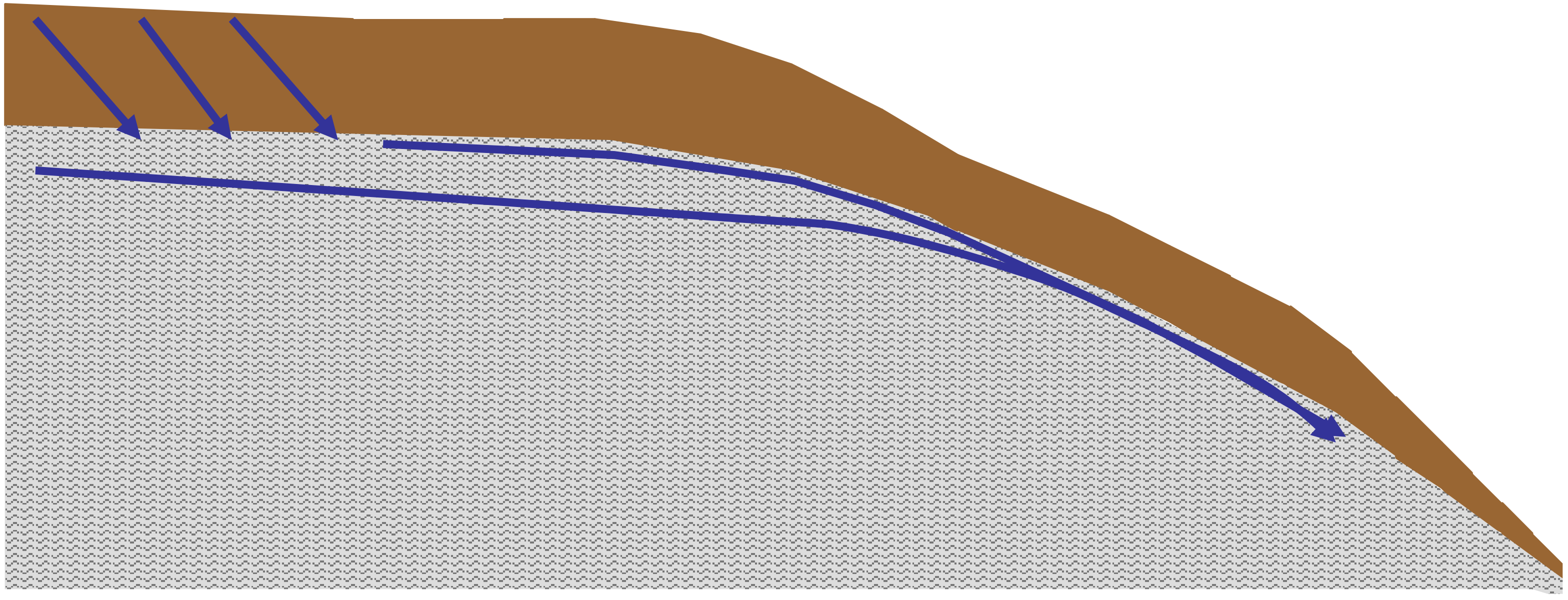
Where did it fail?

Interface failure



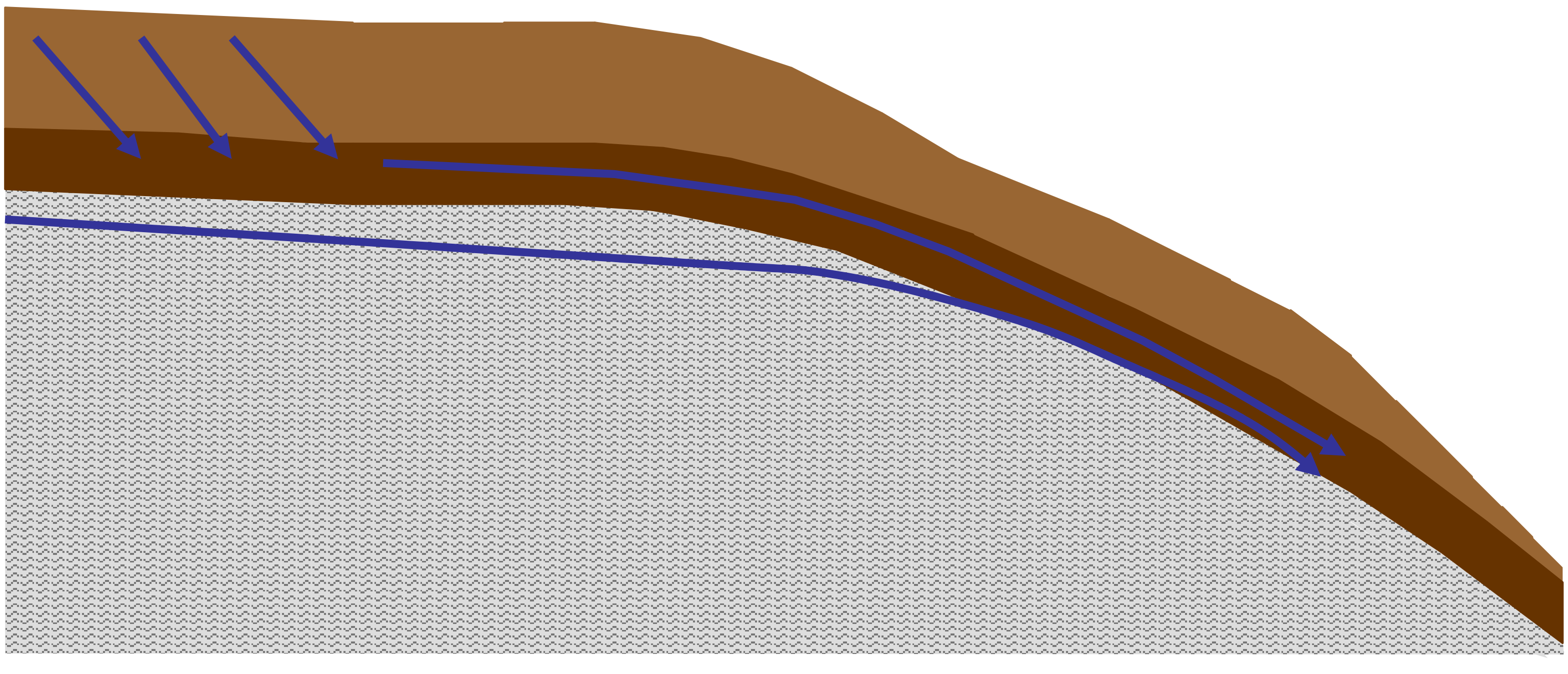
Harthope, North Pennines, 1995

Substrate failure



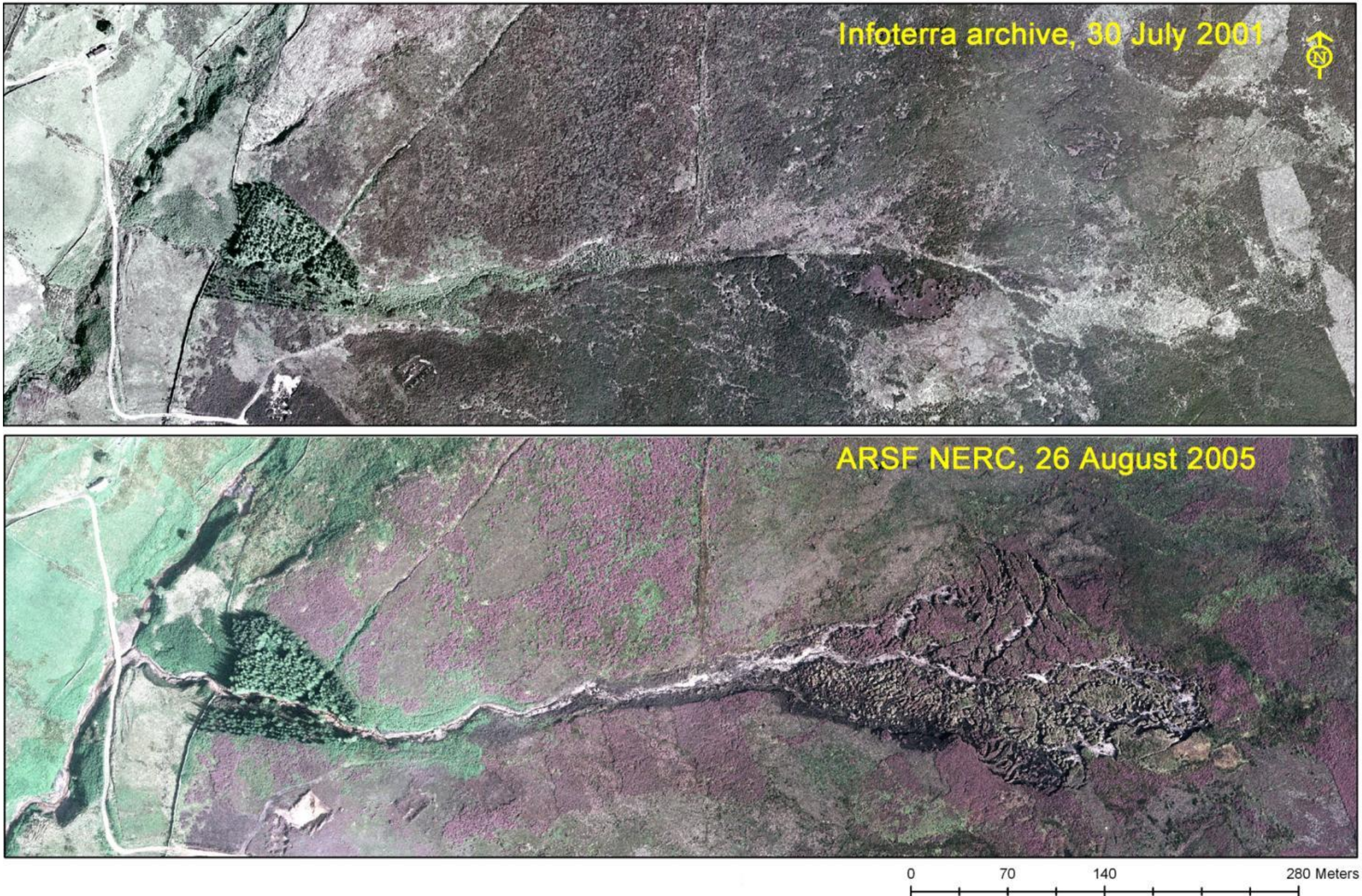
Shetlands, 2003

Lower peat failure



Slieve Rushen, Co Cavan, 1965

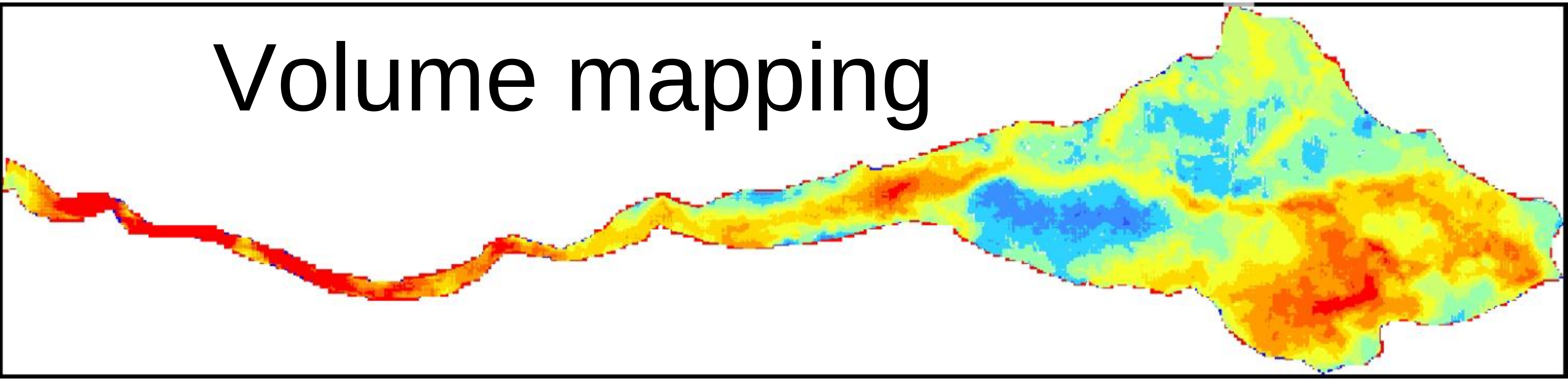
Peatland hillslope change – inputs to the fluvial system



North Yorkshire Floods 19 June 2005 – Valley Deposits

70 mm of rain between 4.15 and 7 pm

Volume mapping



Comparison of Infoterra (July 2001) with NERC ARSF (August 2005) automatically extracted DEMs

- Rise 0 - 0.5 m
- Rise 0.5 - 1 m
- Rise 1 - 1.5 m
- Rise 1.5 - 2 m
- Rise more than 2 m
- Drop more than 3 m
- Drop 2.5 - 3 m
- Drop 2 - 2.5 m
- Drop 1.5 - 2 m
- Drop 1 - 1.5 m
- Drop 0.5 - 1 m
- Drop 0 - 0.5 m

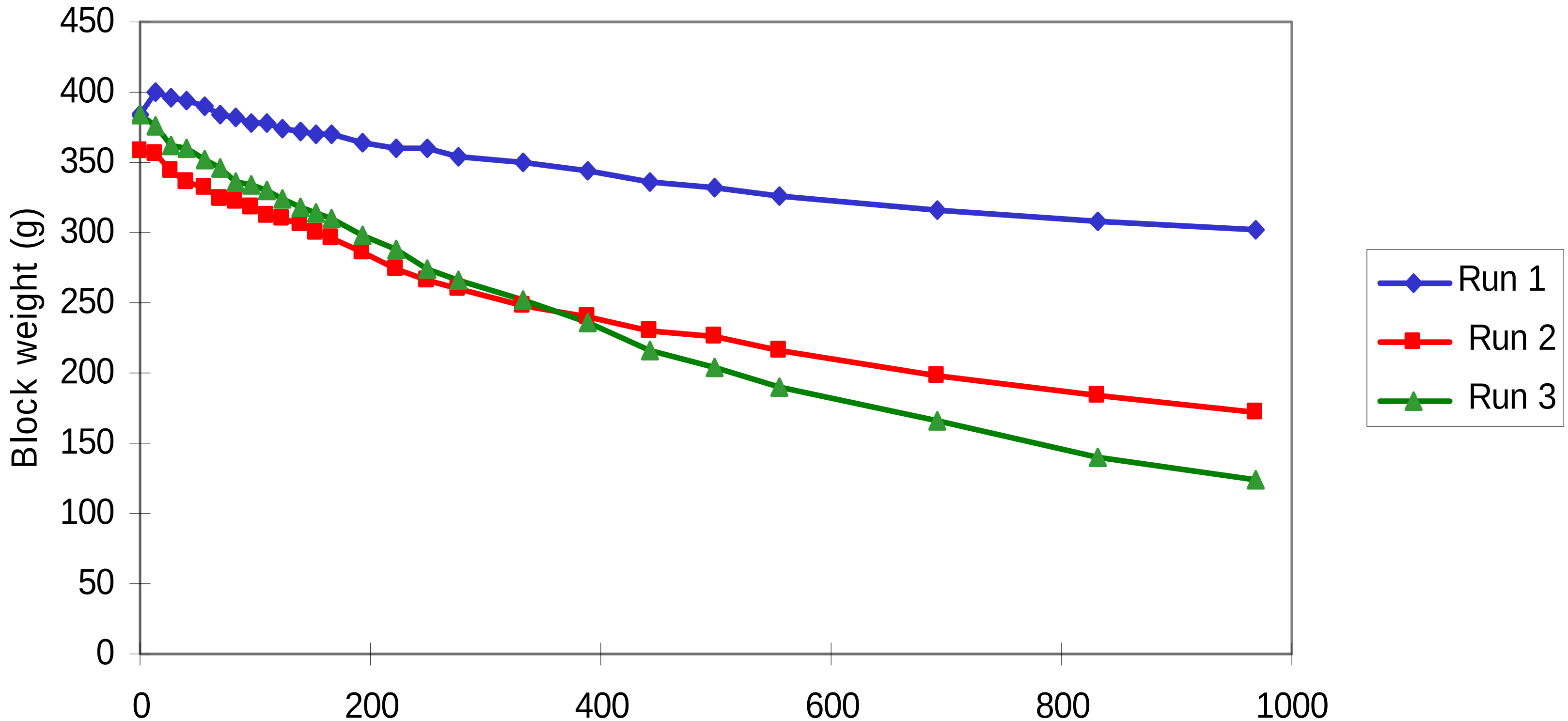
0 40 80 160 Meters

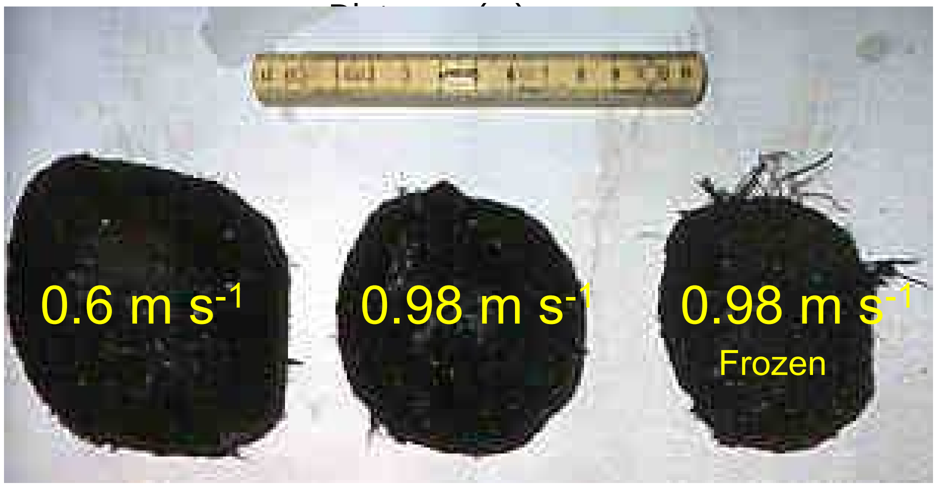
Estimated total volume loss: 42,000 cubic metres

Fluvial organic material flux

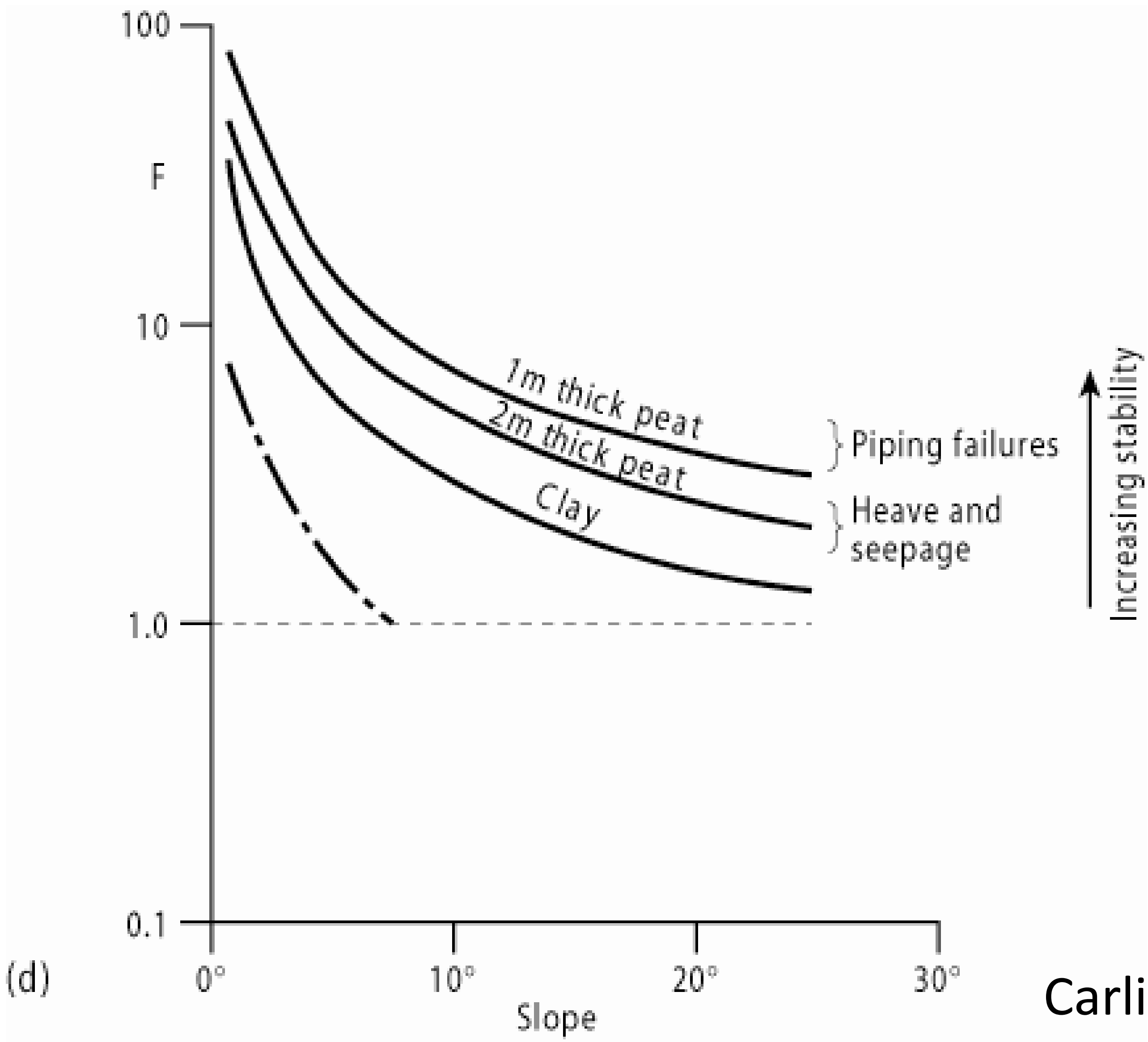
- Fairly transient – rapidly transported in the active channel zone – transported long distances
- Important for instream habitat: short-term detrimental (fish kills); longer term new channel habitat and organic matter source
- Engineering problems – ‘management of flotation load’ e.g. culvert blockage,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

Extremely rapid peat block abrasion – experimental studies

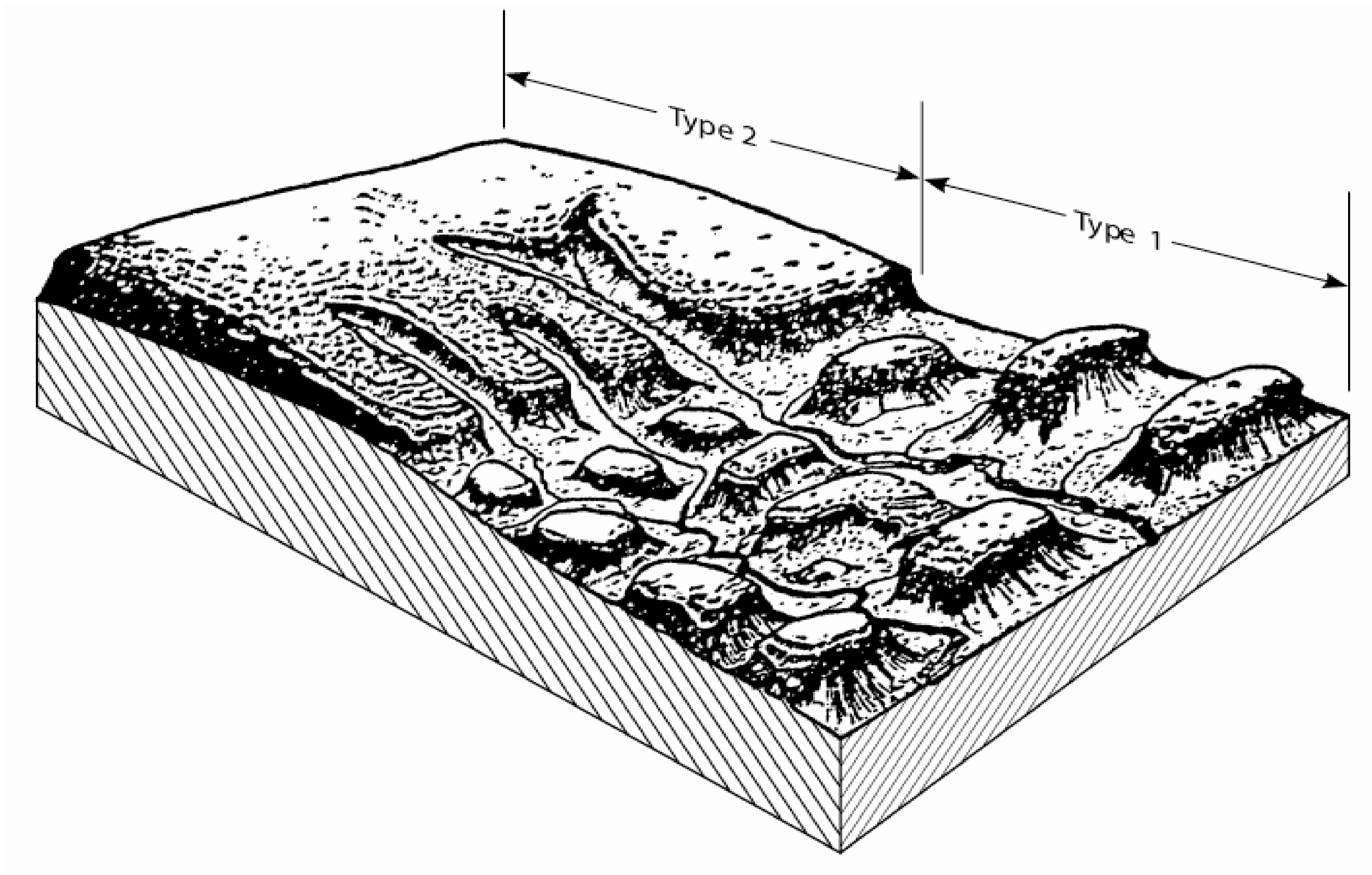




Peatland geomorphic process regimes and thresholds



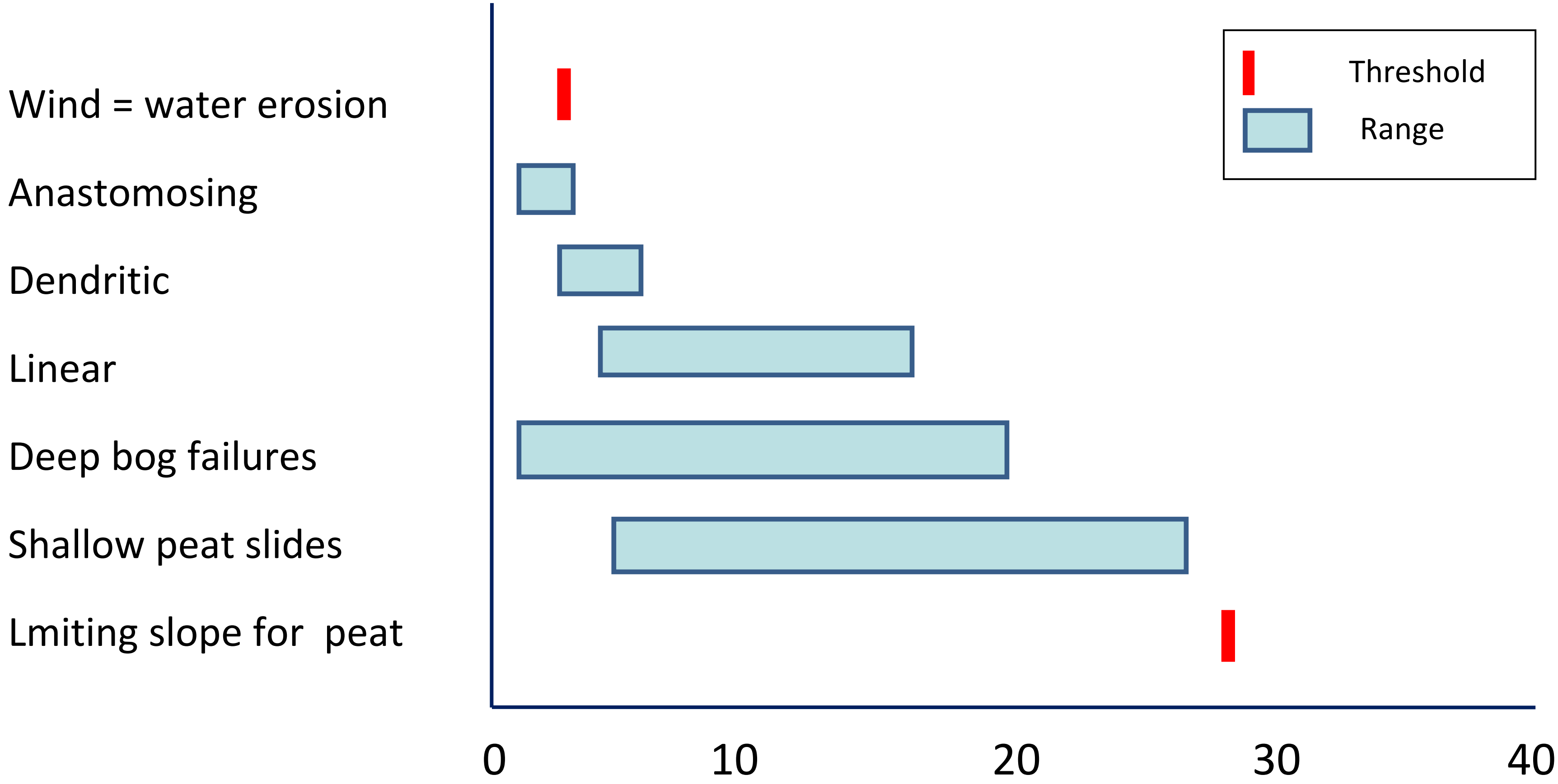
Carling (1986)



Type 1 dissection occurred in deep peat areas on nearly flat ground.
Type 2 dissection occurred on sloping ground where peat depths were shallower.

Geomorphic thresholds and ranges for peatland processes

Significance of slope - significance of peatland form



Work in progress - needs development

Acknowledgements

Collaborators

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NATURAL ENVIRONMENT RESEARCH COUNCIL

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