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Understanding the hydrological impacts of upland peat restoration

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‘The Badlands of Britain’ (Tallis, 1997)

UK has 15% of world resource of blanket peatlands but much of it is severely eroded

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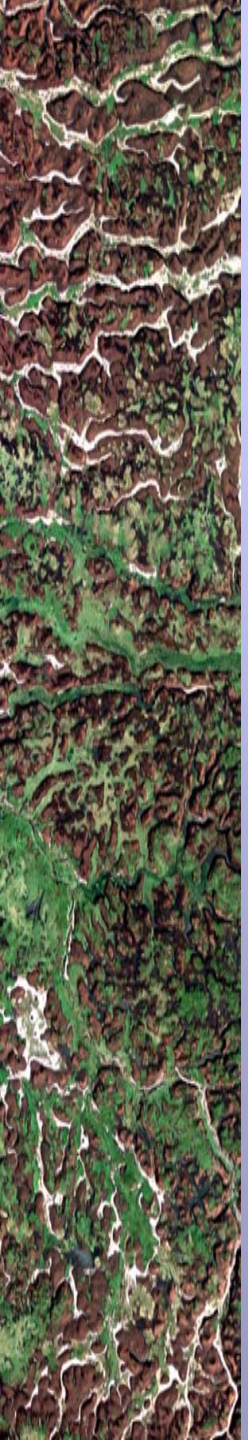

The blanket peat erosion mosaic

Moorland Restoration and Hydrology

- Bleaklow Restoration
- Reseeding with utility grass seed, lime and fertiliser
- Heather Brash

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Progress of re-vegetation over 3 years

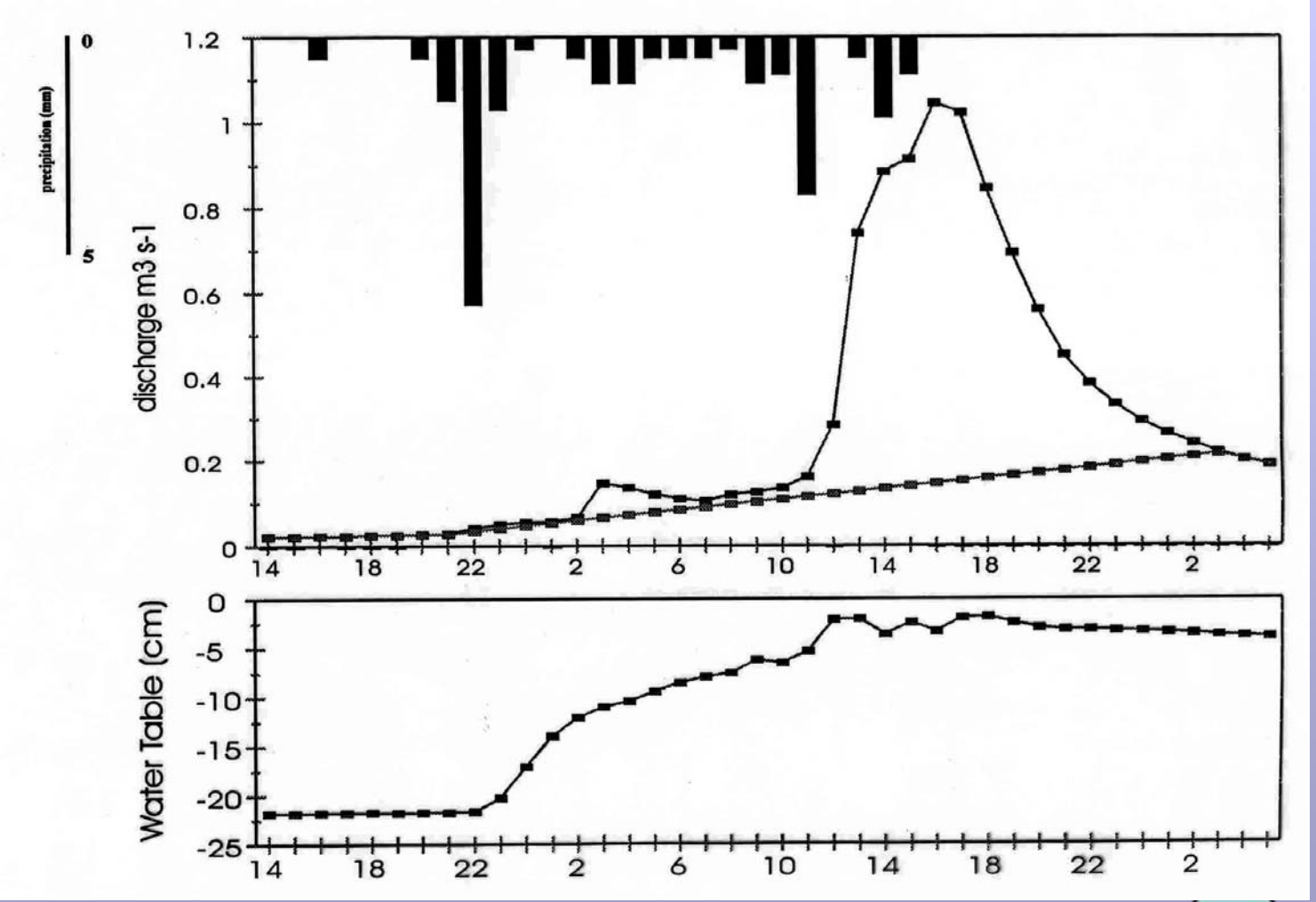
What we think we know about upland peatland hydrology

Runoff Generation Mechanisms

Runoff Pathways

Runoff Timing and Magnitude

Relation between runoff and water table



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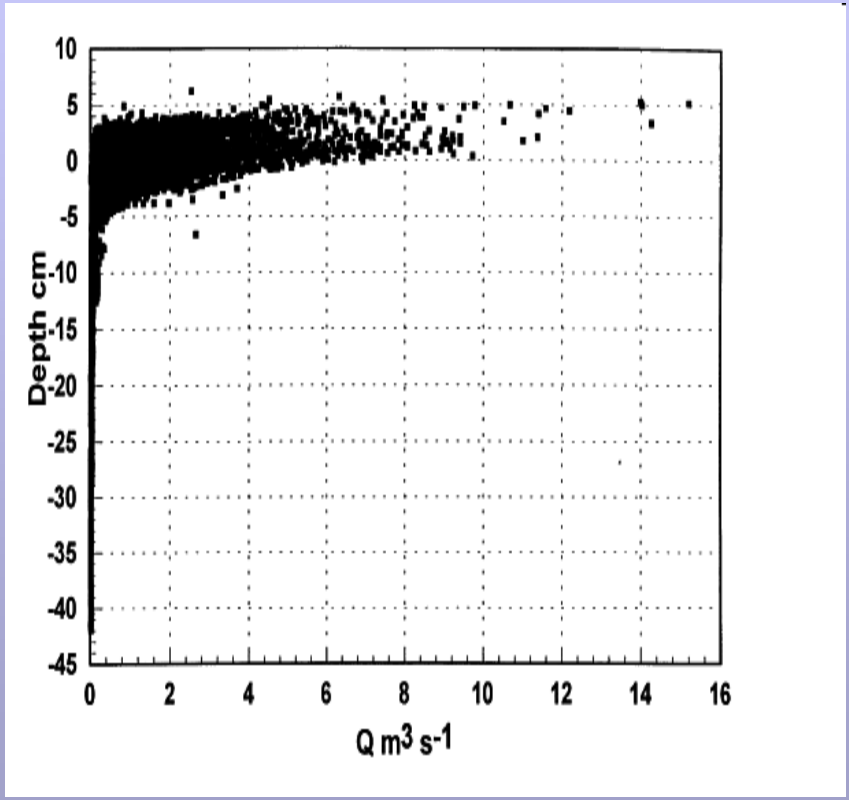
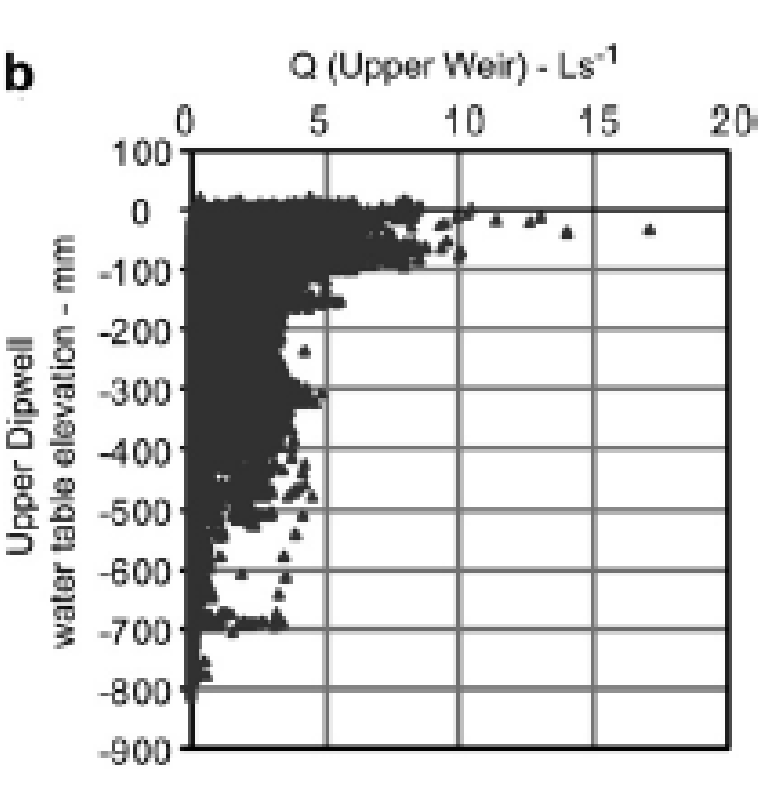
Runoff and water table





Trout Beck, Moor House Intact (Evans et al 1999)

Upper North Grain, Bleaklow, Eroded (Daniels et al 2008)

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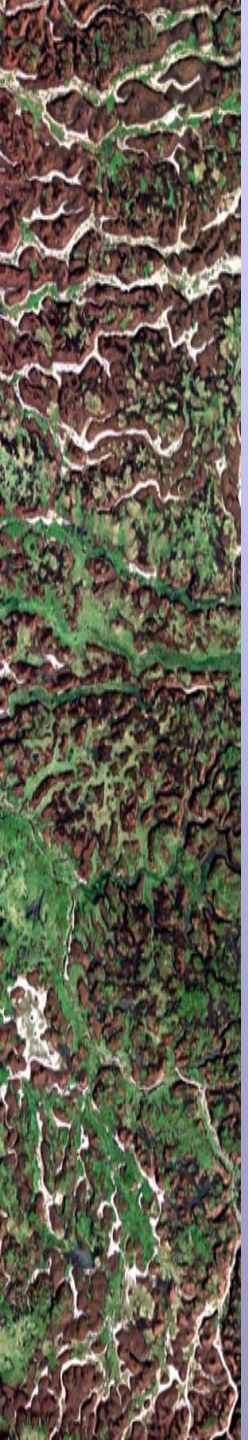

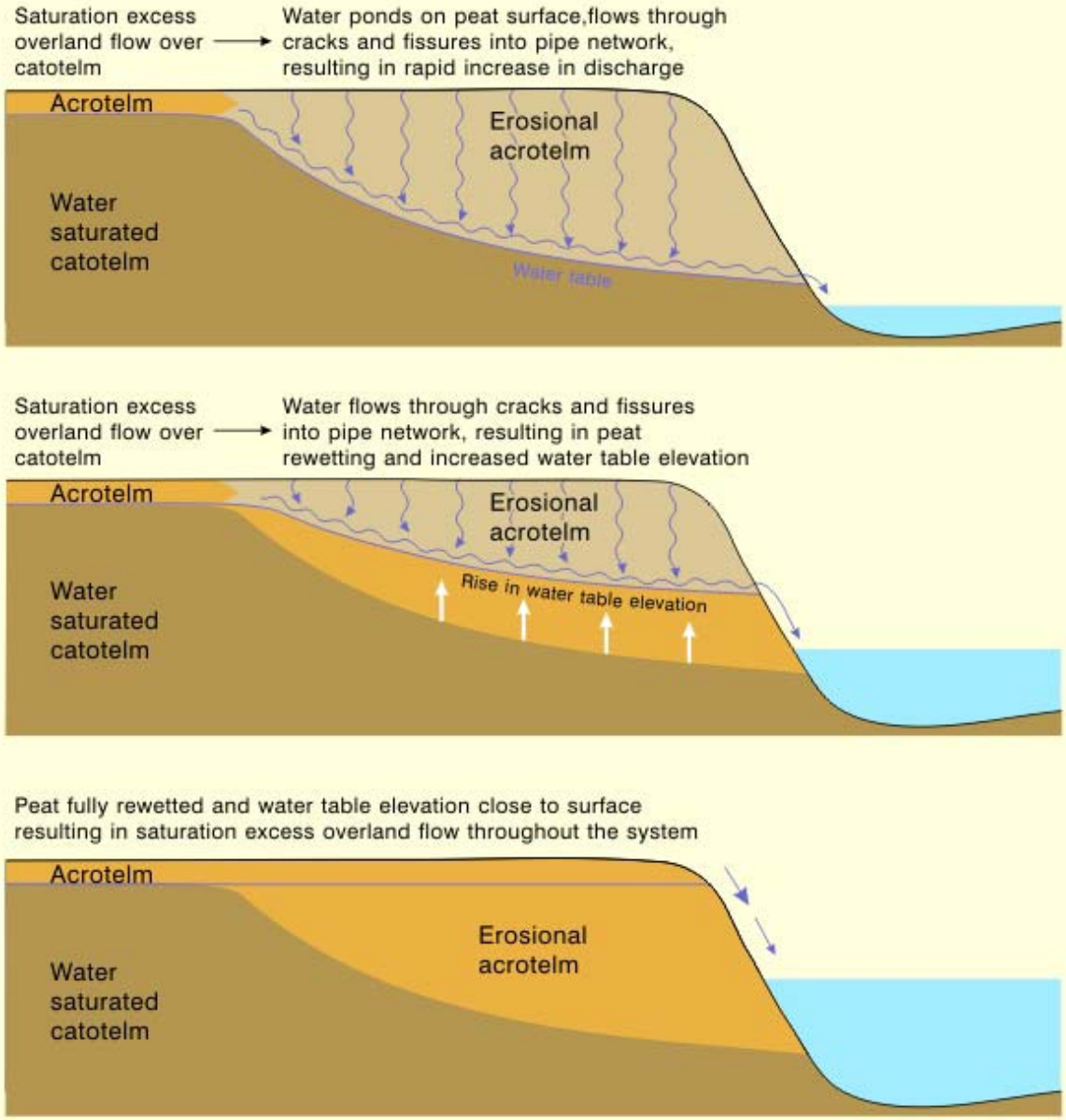
Intact blanket peat
Gully edge peat
Erosion Gully
Saturation excess overland flow over catotelm
Water ponds on peat surface,flows through cracks and fissures into pipe network, resulting in rapid increase in discharge
Acrotelm
Erosional acrotelm
Water saturated catotelm
Water table
Saturation excess overland flow over catotelm
Water flows through cracks and fissures into pipe network, resulting in peat rewetting and increased water table elevation
Acrotelm
Erosional acrotelm
Rise in water table elevation
Water saturated catotelm
Peat fully rewetted and water table elevation close to surface resulting in saturation excess overland flow throughout the system
Acrotelm
Erosional acrotelm
Water saturated catotelm


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Runoff Pathways

Source	Mean and standard deviation contribution to total plot runoff %
Overland Flow	84.47 (18.61)
1-5 cm depth flow	17.76 (18.64)
5-10 cm depth flow	0.74 (1.77)
10-50 cm depth flow	0.03 (0.07)

Holden and Burt, 2000

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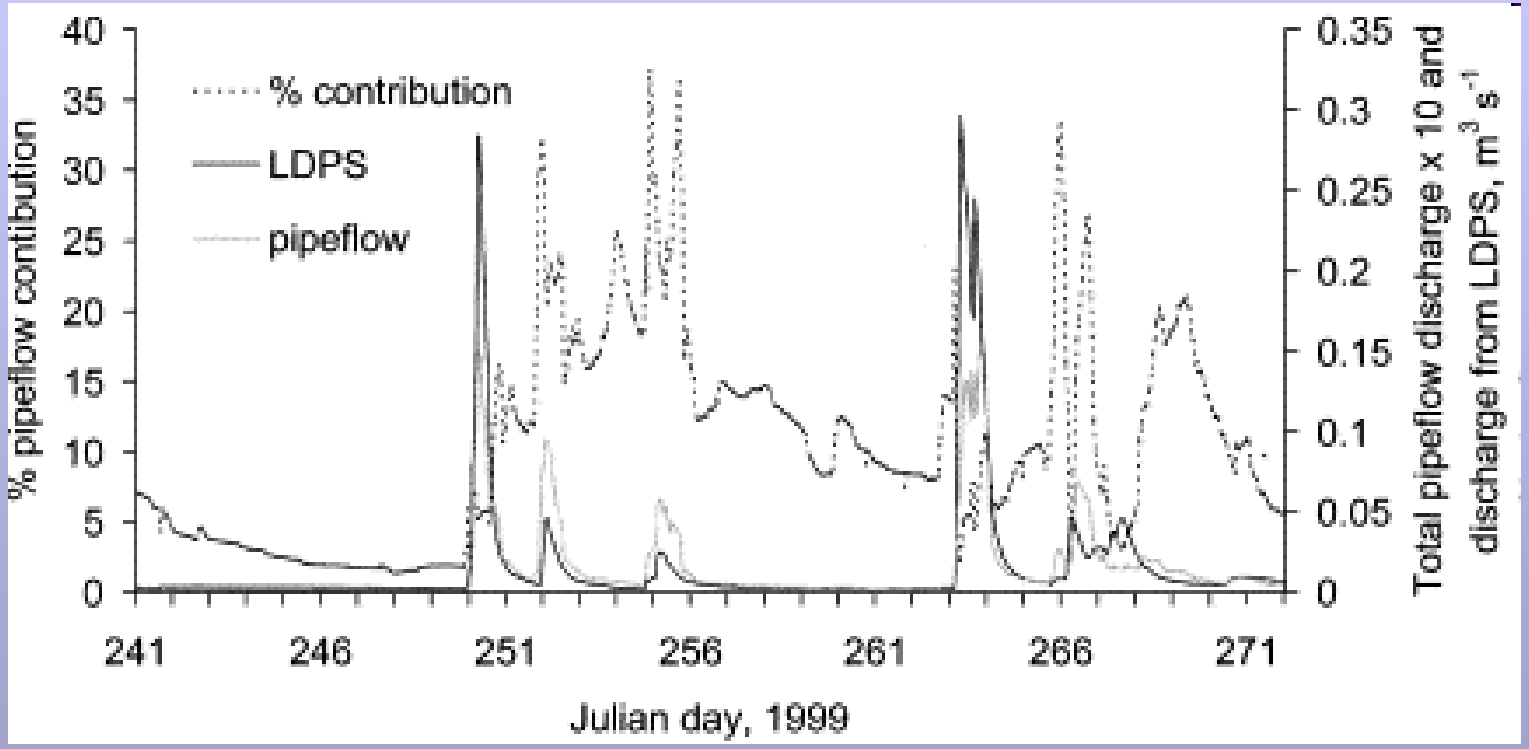
Importance of Pipeflow



Holden and Burt, 2001

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Runoff Magnitude and Timing – or…are peatlands sponges?

Impact of Moorland Management on Runoff Burnt Hill, Conway and Millar (1960)

Order of catchment flashiness is:

Drained/burnt eroded
Drained
Natural
Natural

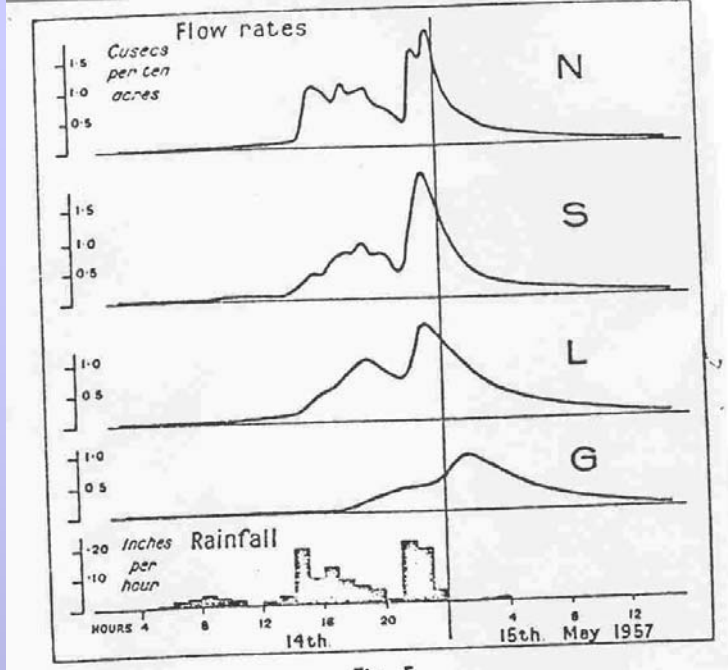
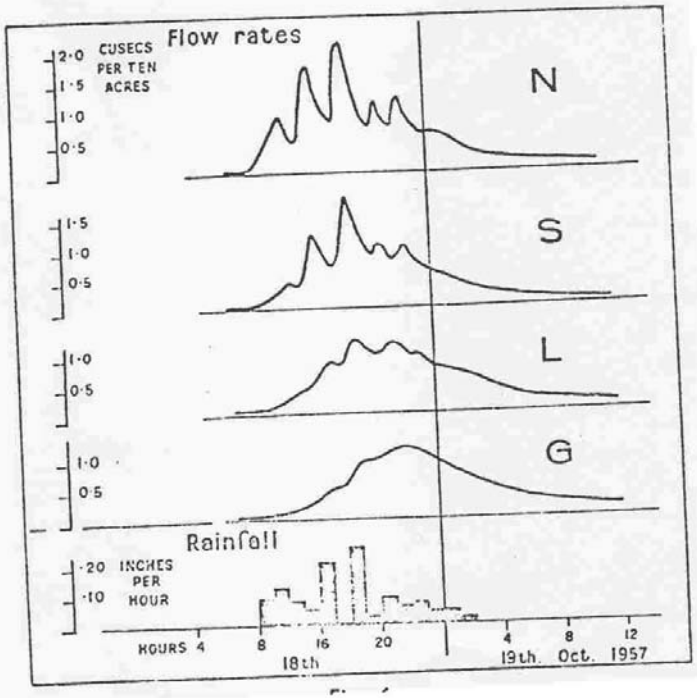
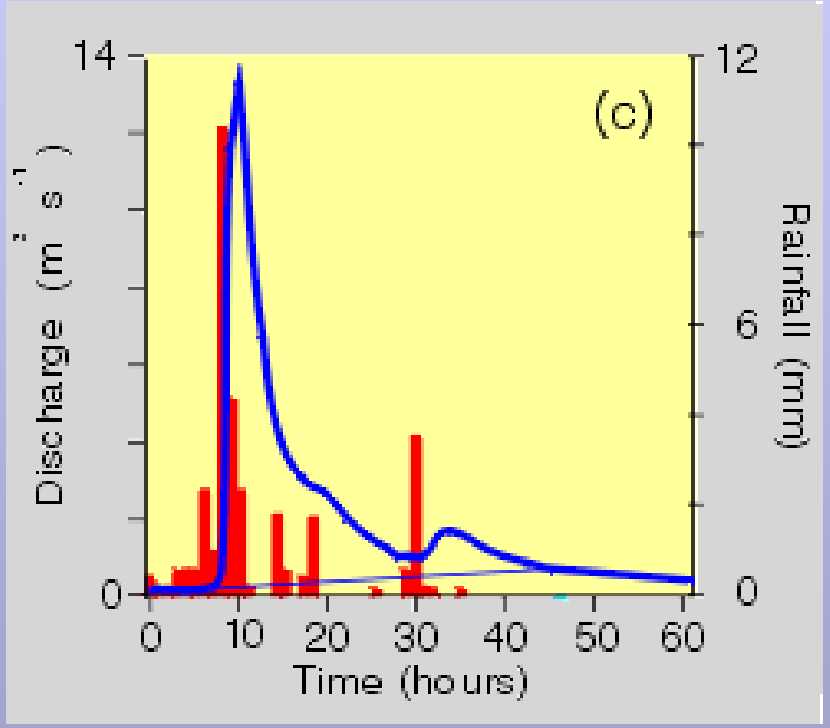


Fig. 5
Data as in Fig 4, for 14th and 15th May 1957



Hydrograph Form

- Short Lag Times
- Short time to peak
- Rapid recession
- High ROP



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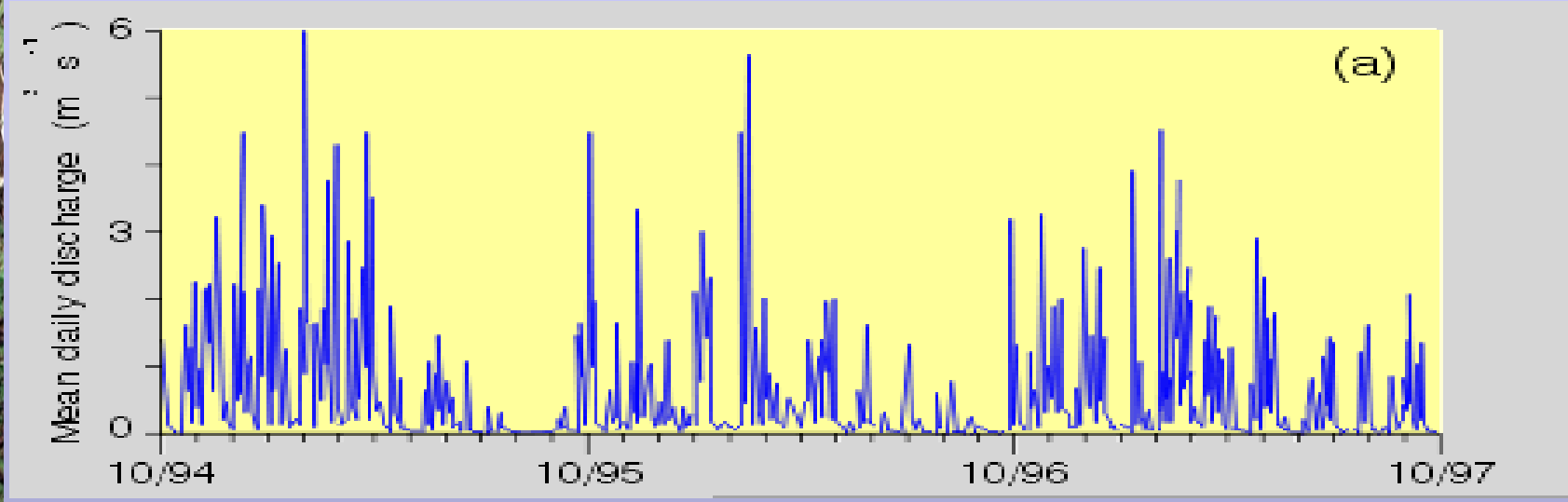
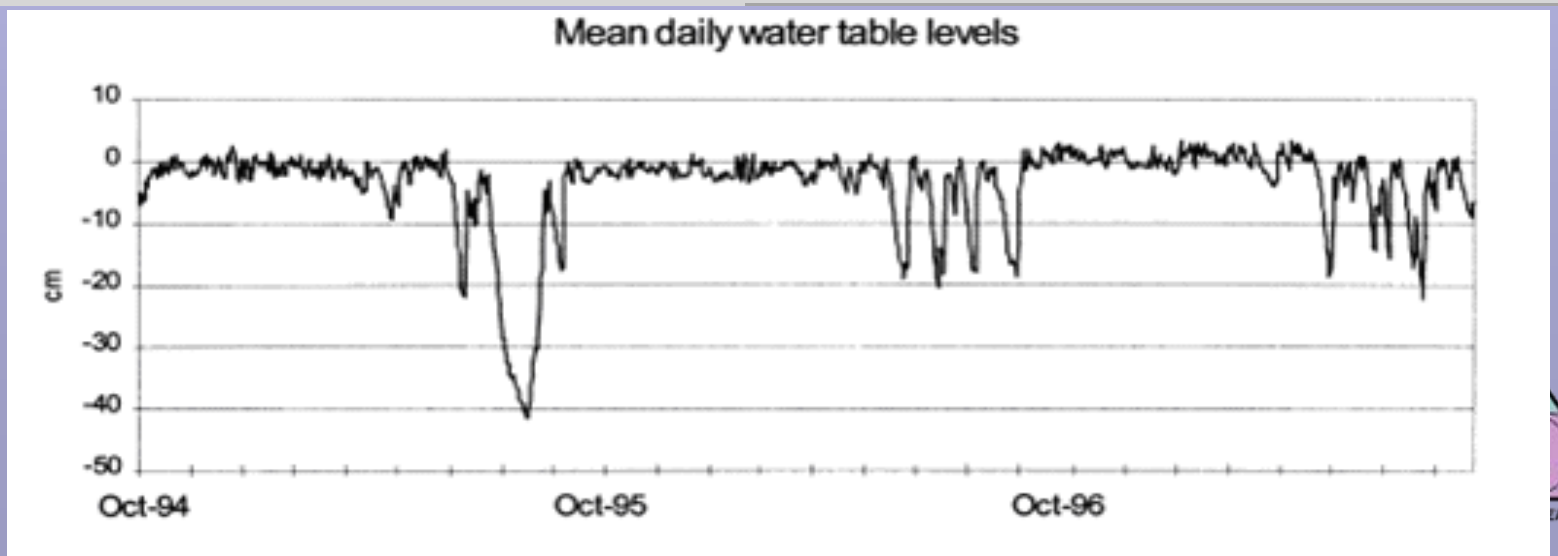
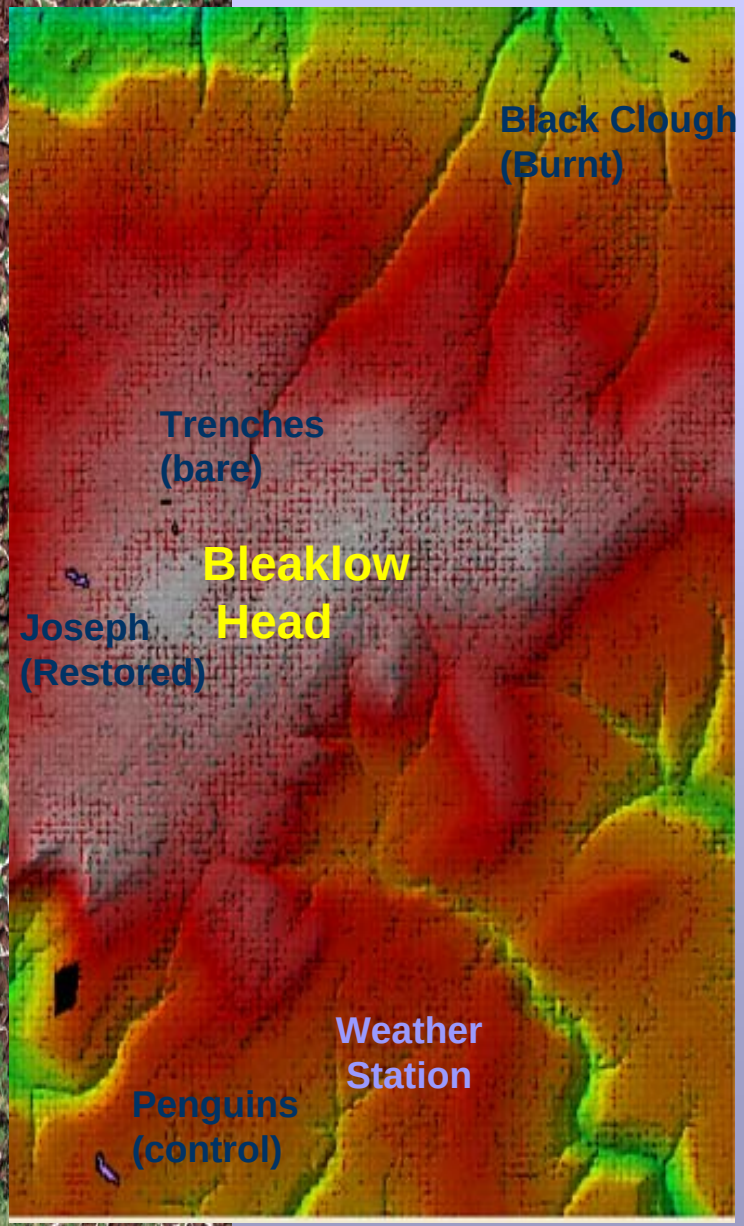
Annual Regime

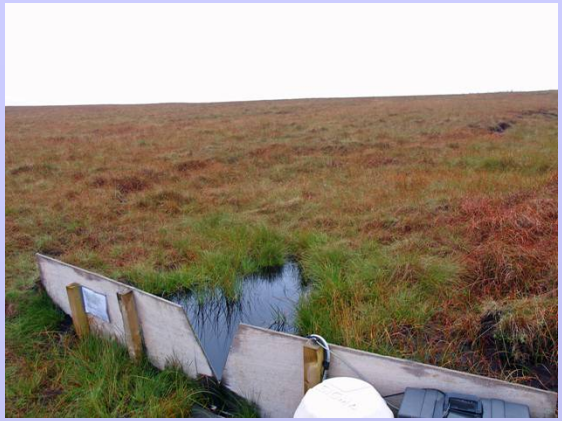
- Rapid Response
- Flow closely linked to rainfall patterns





Restoration Study Catchments





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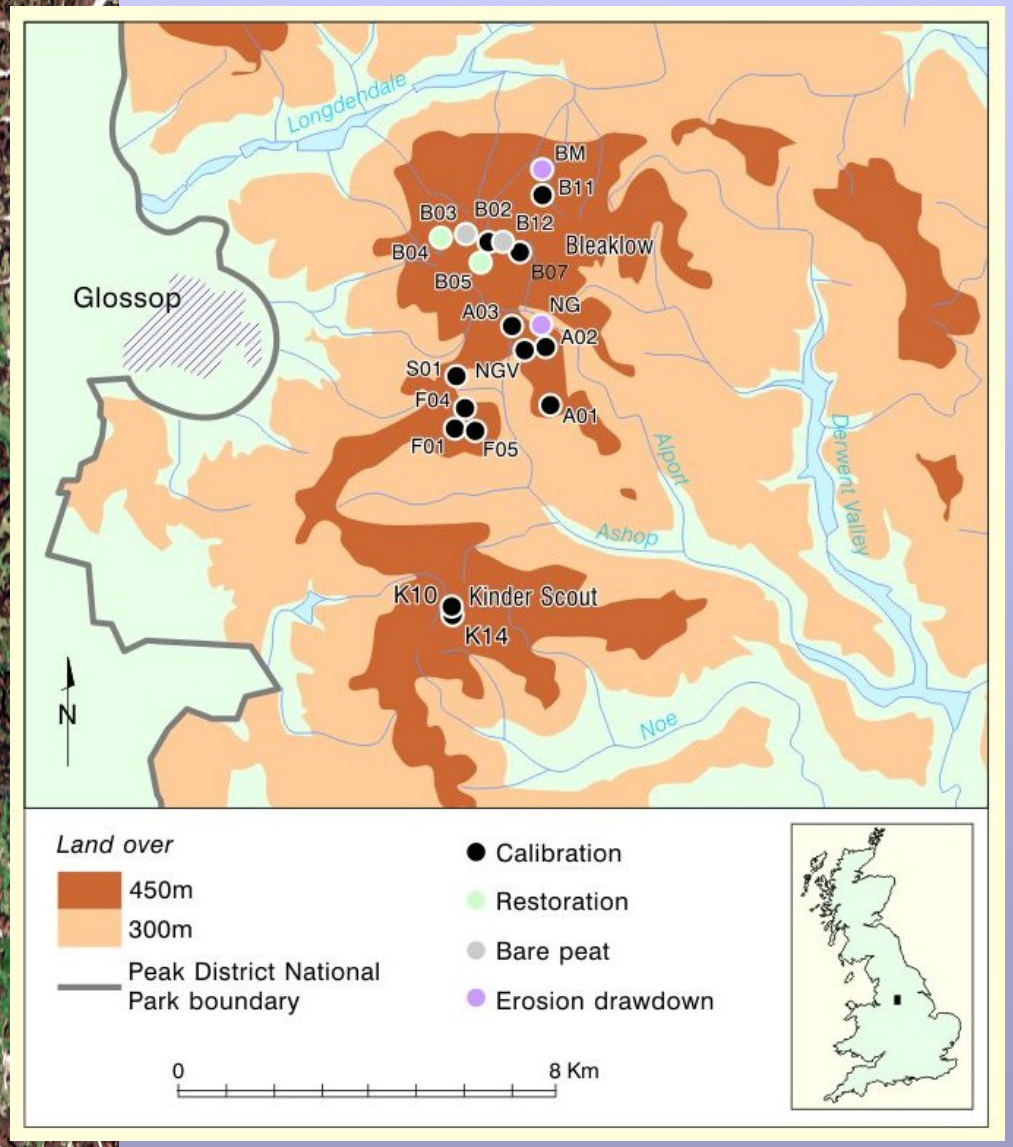
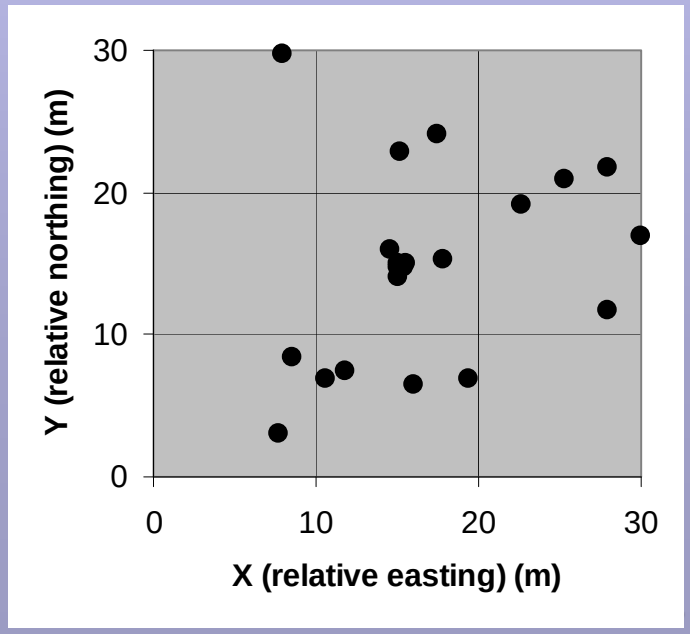
Runoff Ratios from Bleaklow Micro-catchments

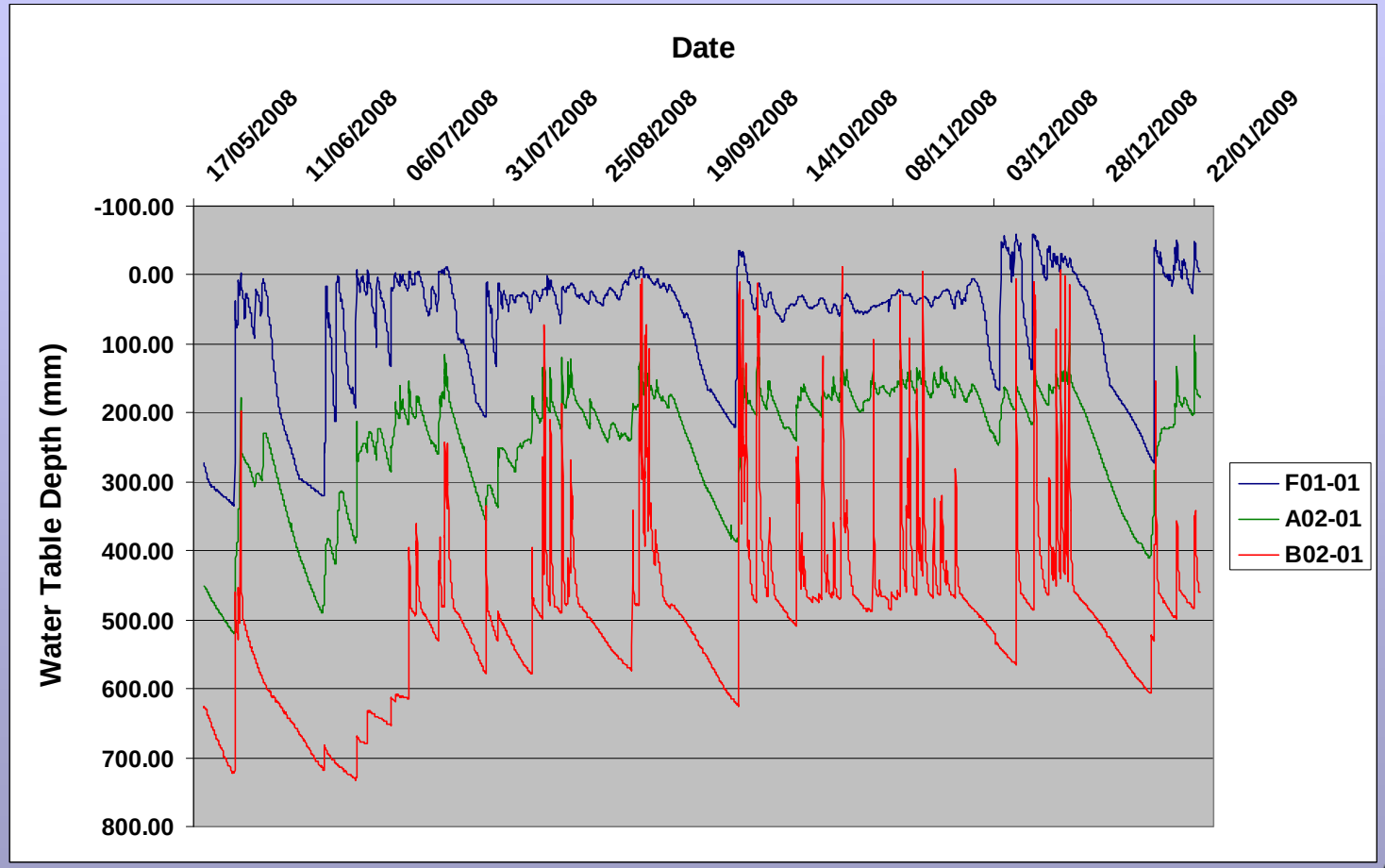
	storm start	Precip	API	JN	JS	P	WH	D	TN	TS
3q-07										
	13/08/2007	78.67	17.80	0.24	0.01	0.31	-	-	1.13	-
	02/09/2007	28.02	24.26	0.38	0.03	0.27	-	-	0.85	-
	19/09/2007	34.04	15.50	0.21	0.27	0.26	-	-	0.51	0.17
	21/09/2007	28.62	36.21	0.25	0.40	0.25	-	-	0.39	0.22
	23/09/2007	30.21	38.80	0.79	0.37	1.05	-	-	1.37	1.31
4q-07	07/10/2007	36.37	30.70	0.55	0.00	0.39	-	-	0.66	-
	27/10/2007	21.31	11.80	0.61	0.04	0.32	-	-	1.29	-
	07/11/2007	7.42	16.20	0.38	0.00	0.22	-	-	1.30	-
	08/11/2007	7.42	22.00	0.47	0.17	0.31	-	-	1.91	-
	10/11/2007	19.80	25.30	0.39	0.06	0.27	-	-	1.33	-
	20/11/2007	19.60	29.30	0.67	0.02	0.66	-	-	1.27	-
	27/11/2007	54.96	28.80	0.48	0.05	0.38	-	-	0.28	-
	05/12/2007	68.24	55.30	0.48	0.09	0.26	-	-	1.35	-
2q-08	27/05/2008	2.61	6.10	0.07	-	-	-	-	-	-
	02/06/2008	13.05	33.80	0.37	-	0.38	1.26	0.26	1.87	-
	21/06/2008	11.65	17.30	0.67	-	0.26	1.10	0.04	-	-
3q-08	16/07/2008	61.19	38.80	0.59	-	0.39	1.13	1.69	-	-
	17/08/2008	26.64	60.40	0.45	0.03	0.33	1.04	1.12	1.54	-
	05/09/2008	57.09	39.90	0.53	-	0.60	-	0.99	-	-
	12/09/2008	8.44	84.00	0.60	0.30	0.34	1.90		0.80	-
4q-08	07/10/2008	11.86	101.80	0.41	0.16	0.27	2.12	0.81	-	-
	21/10/2008	16.52	47.50	0.30	0.18	0.32	1.34	0.48	-	-
	Mean			0.45	0.13	0.37	1.41	0.77	1.12	0.57

The Dark Peak Water Table Project





Water table behaviour



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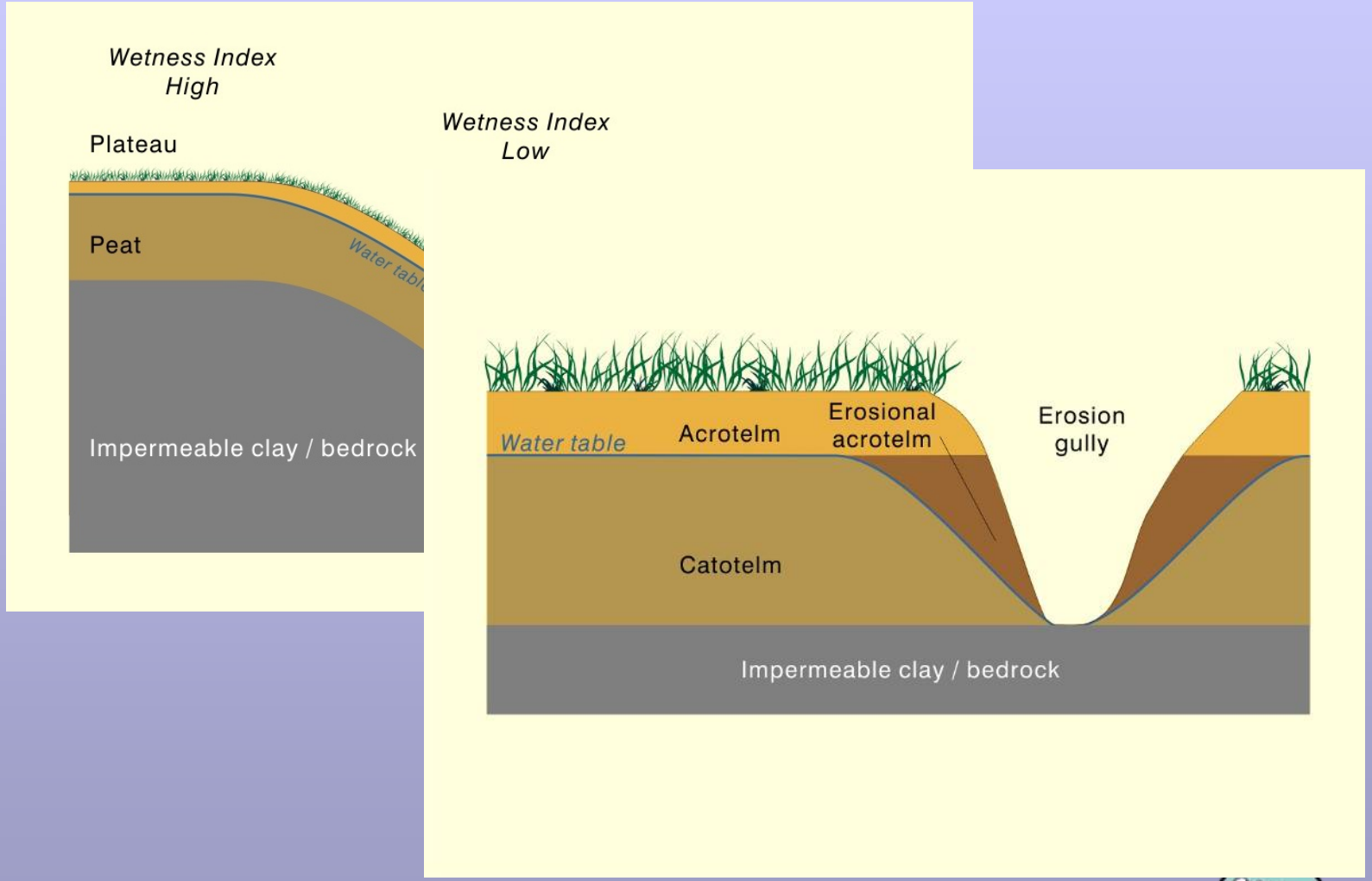
Controls on Water table



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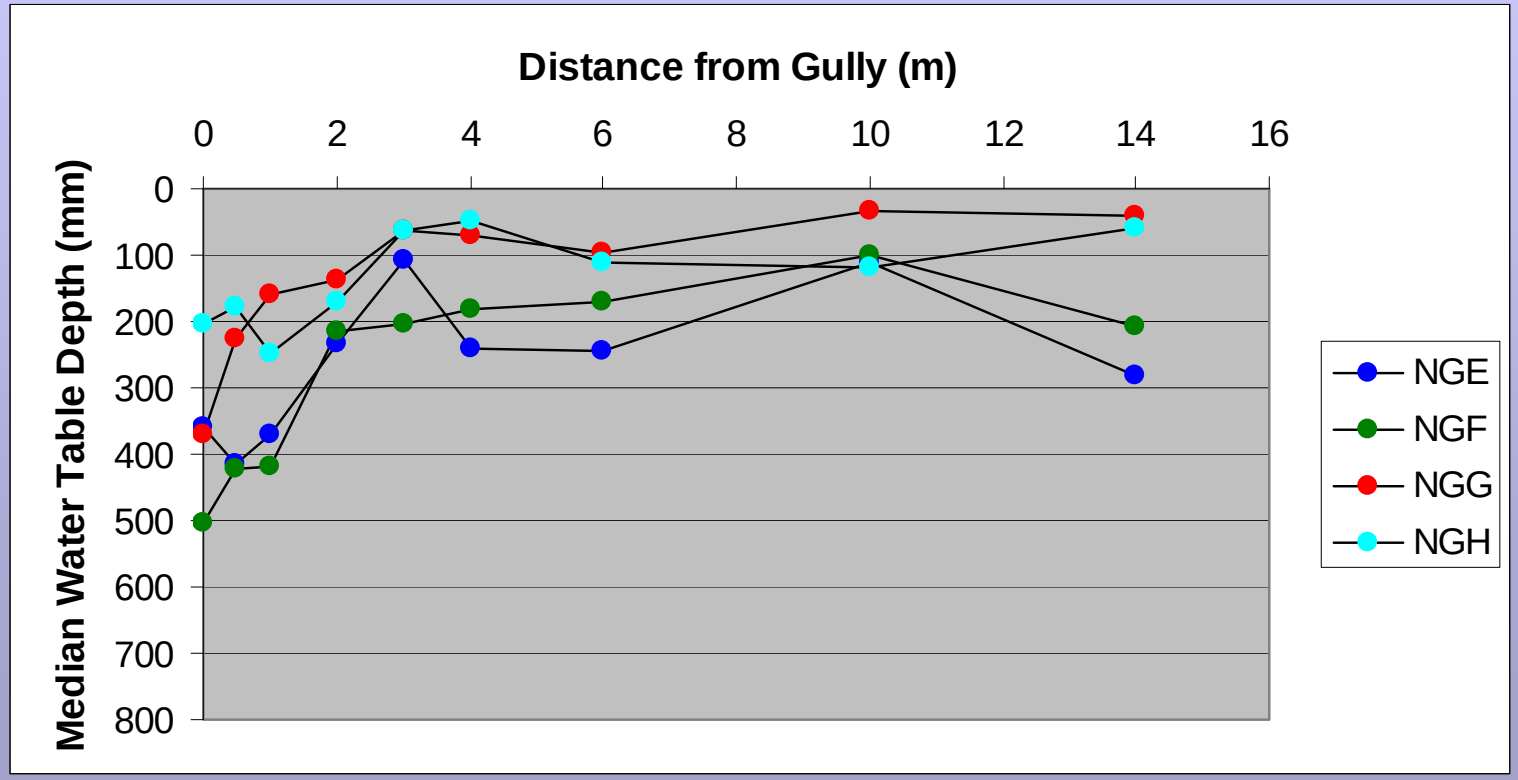
Extent of gully edge drawdown



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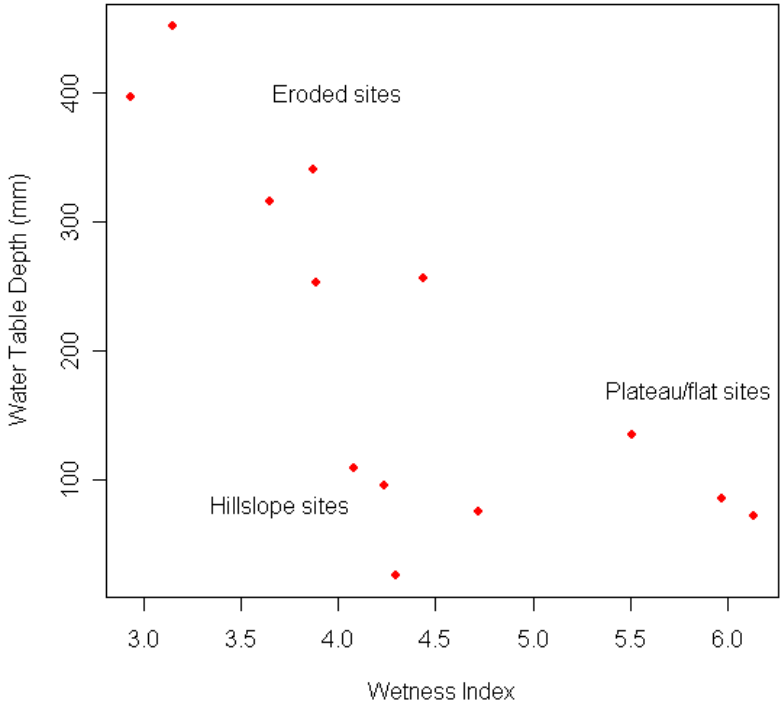
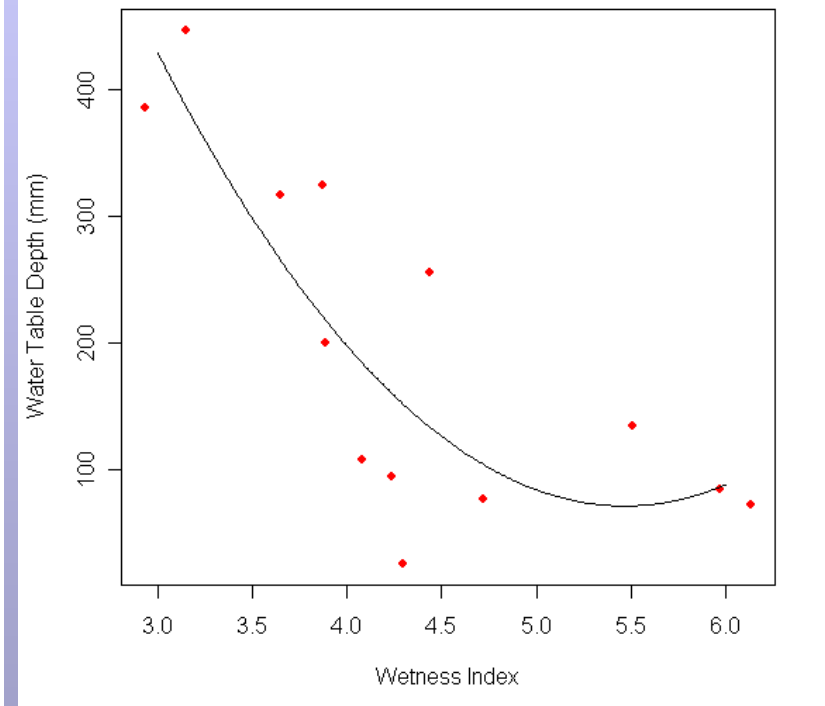
Wetness index and water table





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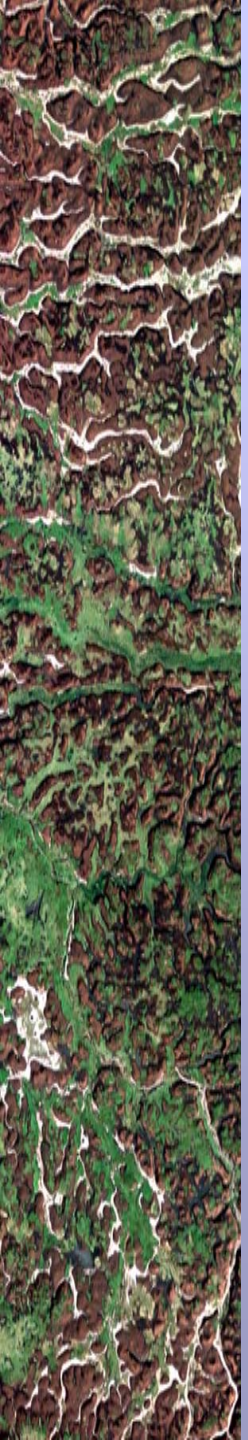

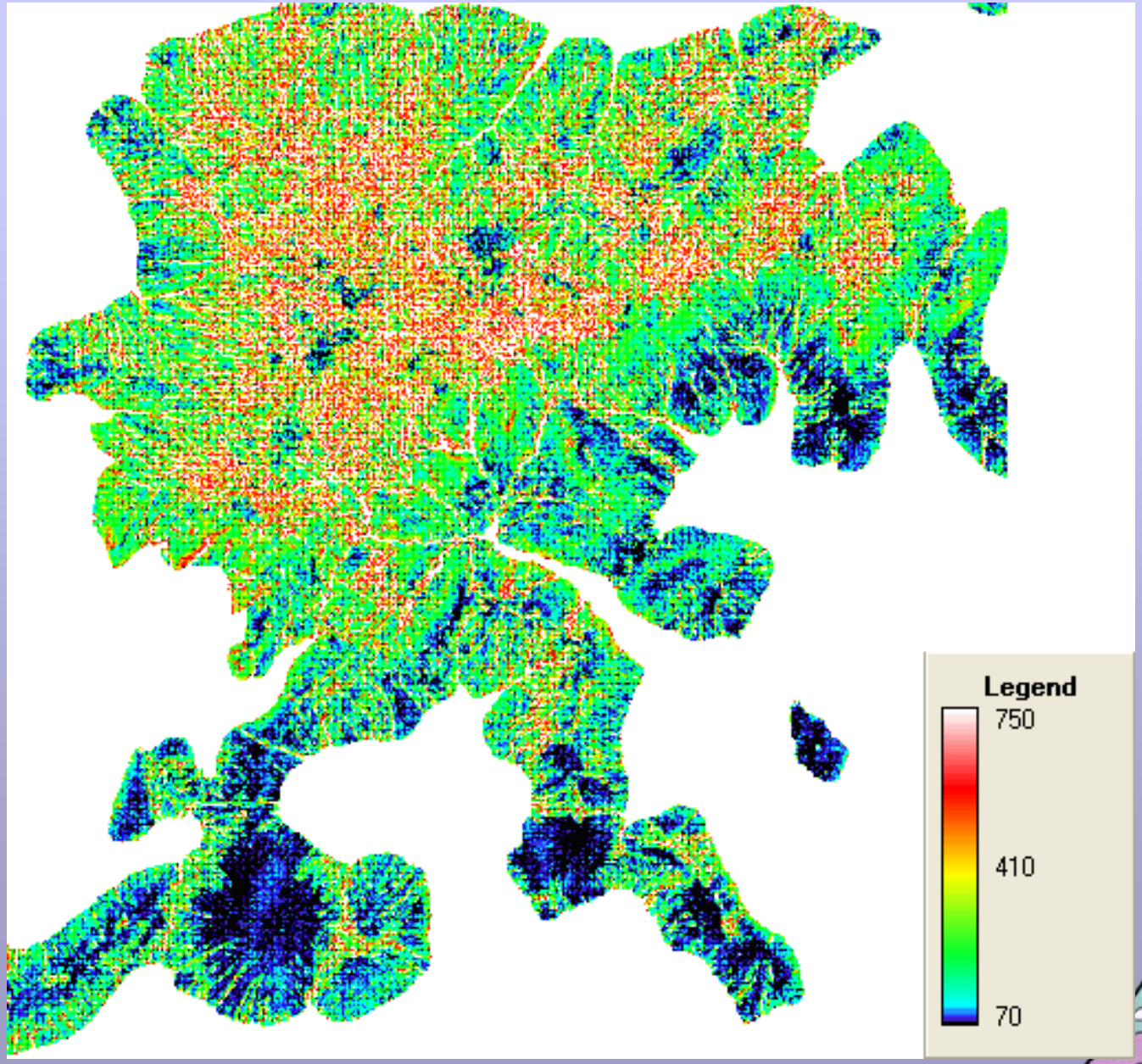

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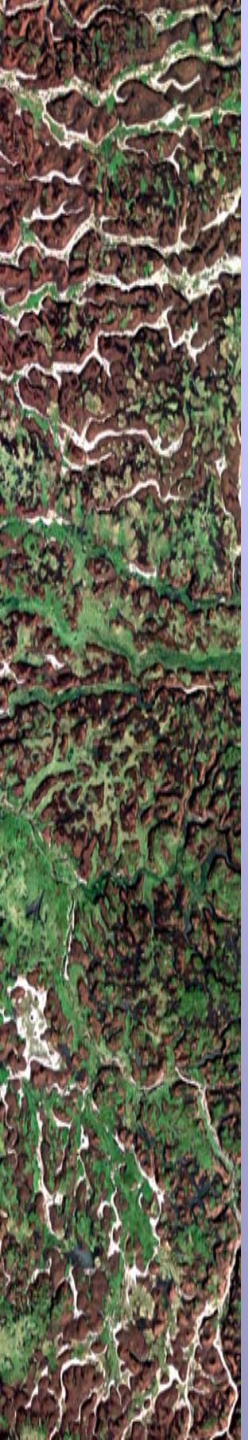

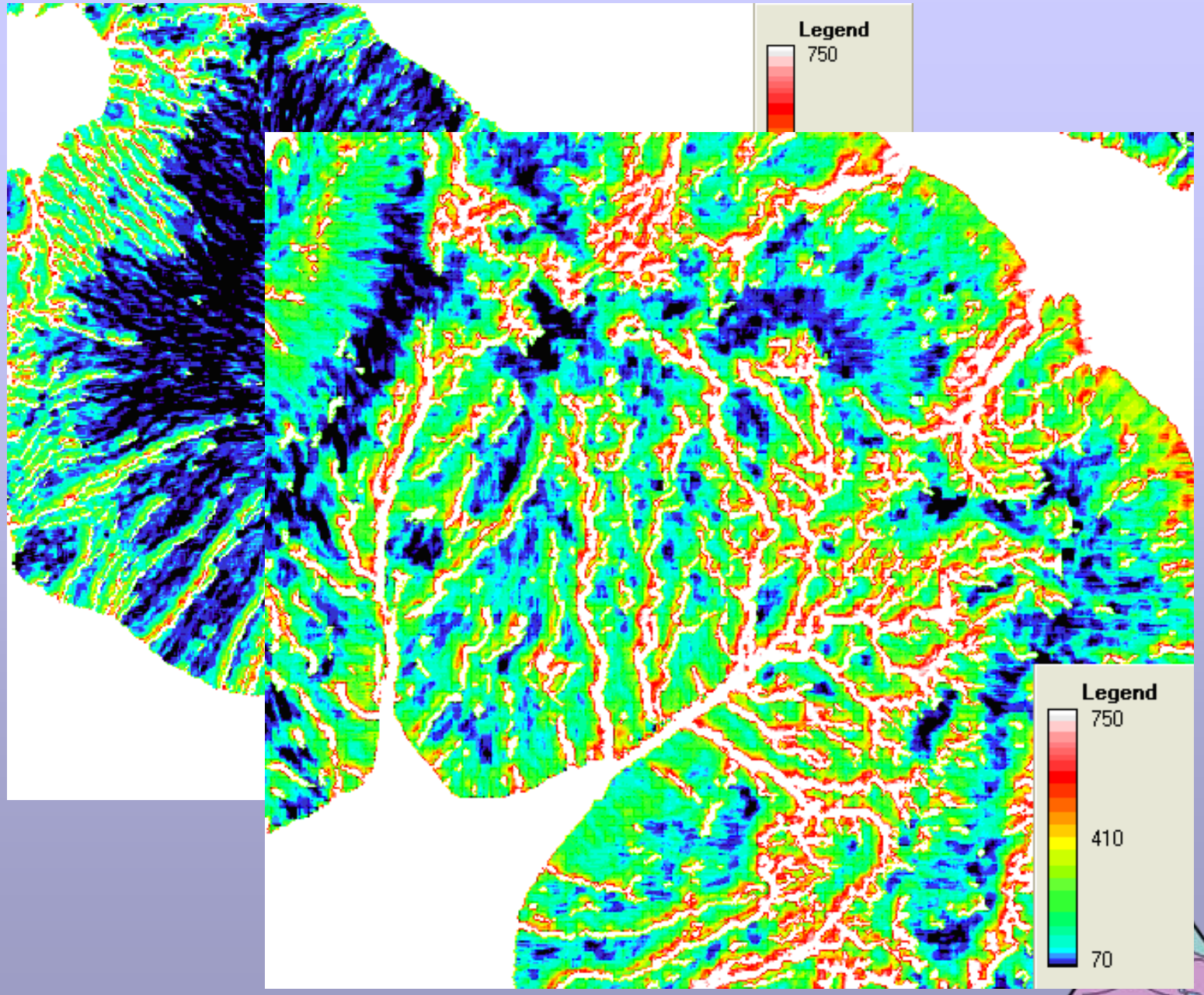

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Bare peat and restored (revegetated) sites

Does restoration affect water table?

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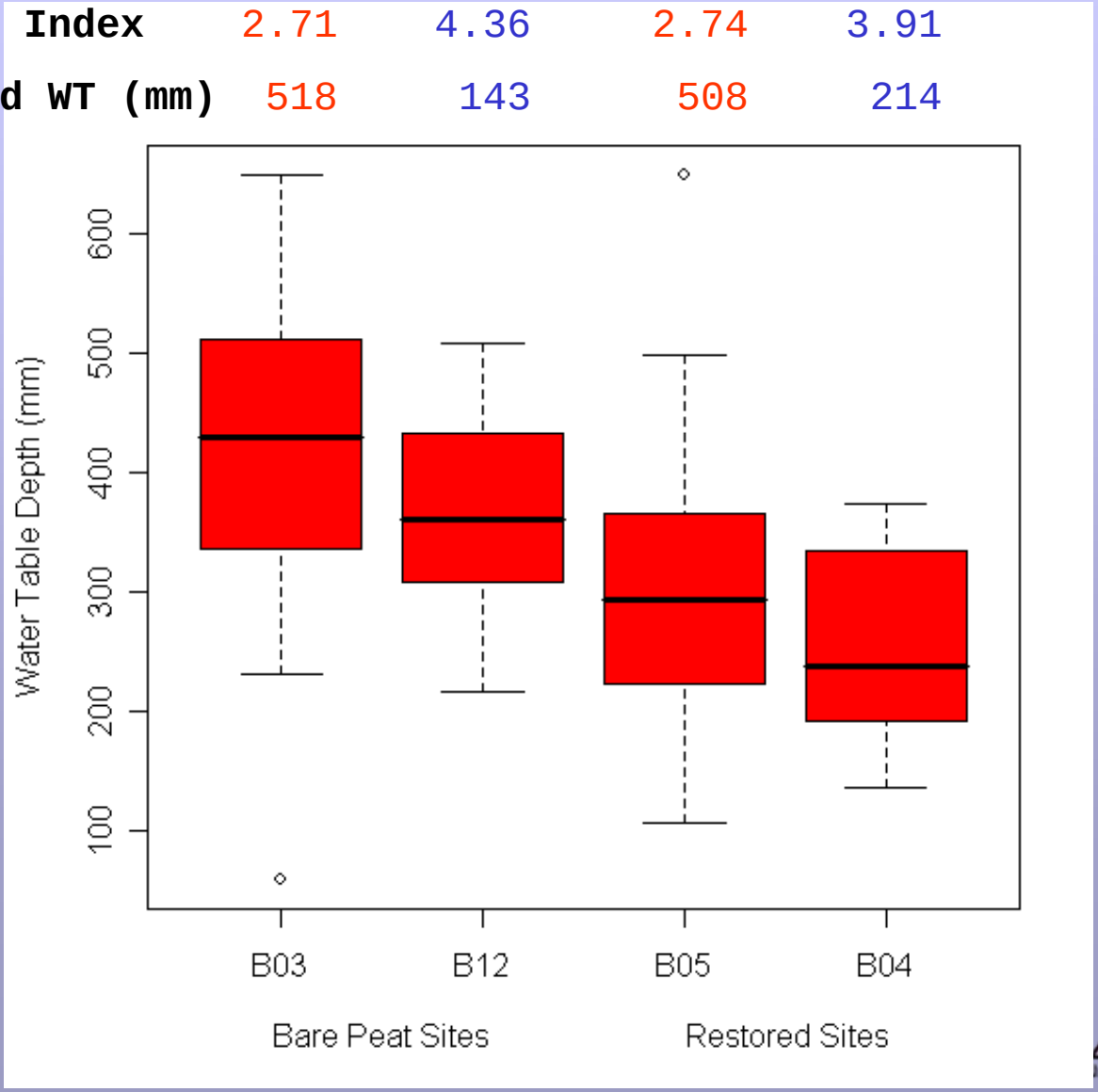
Water tables at bare peat and restored sites

Wetness Index	2.71	4.36	2.74	3.91
Modelled WT (mm)	518	143	508	214



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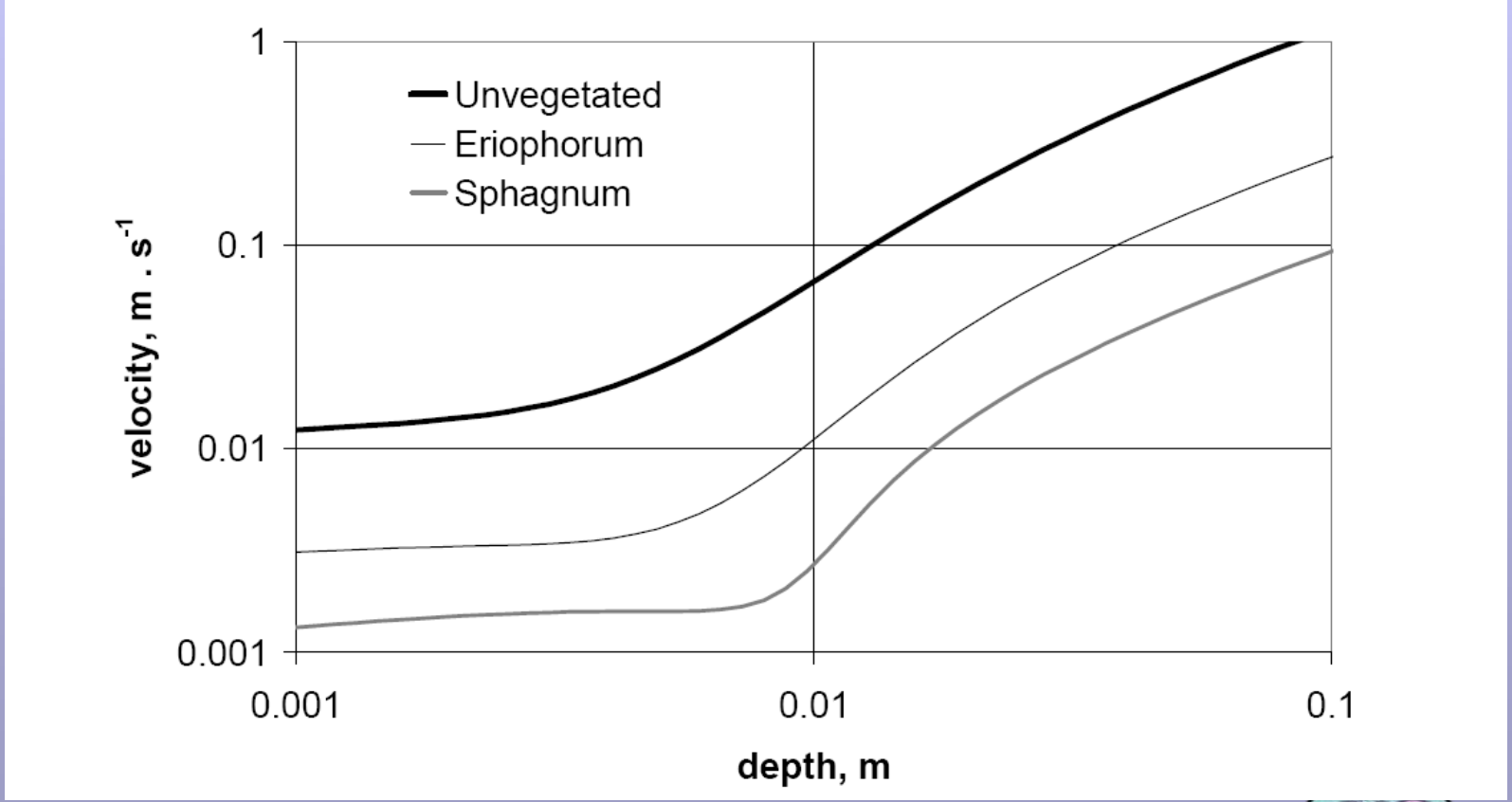
Re-vegetation and Runoff Velocity



Holden et al 2008 *Water Resources Research*

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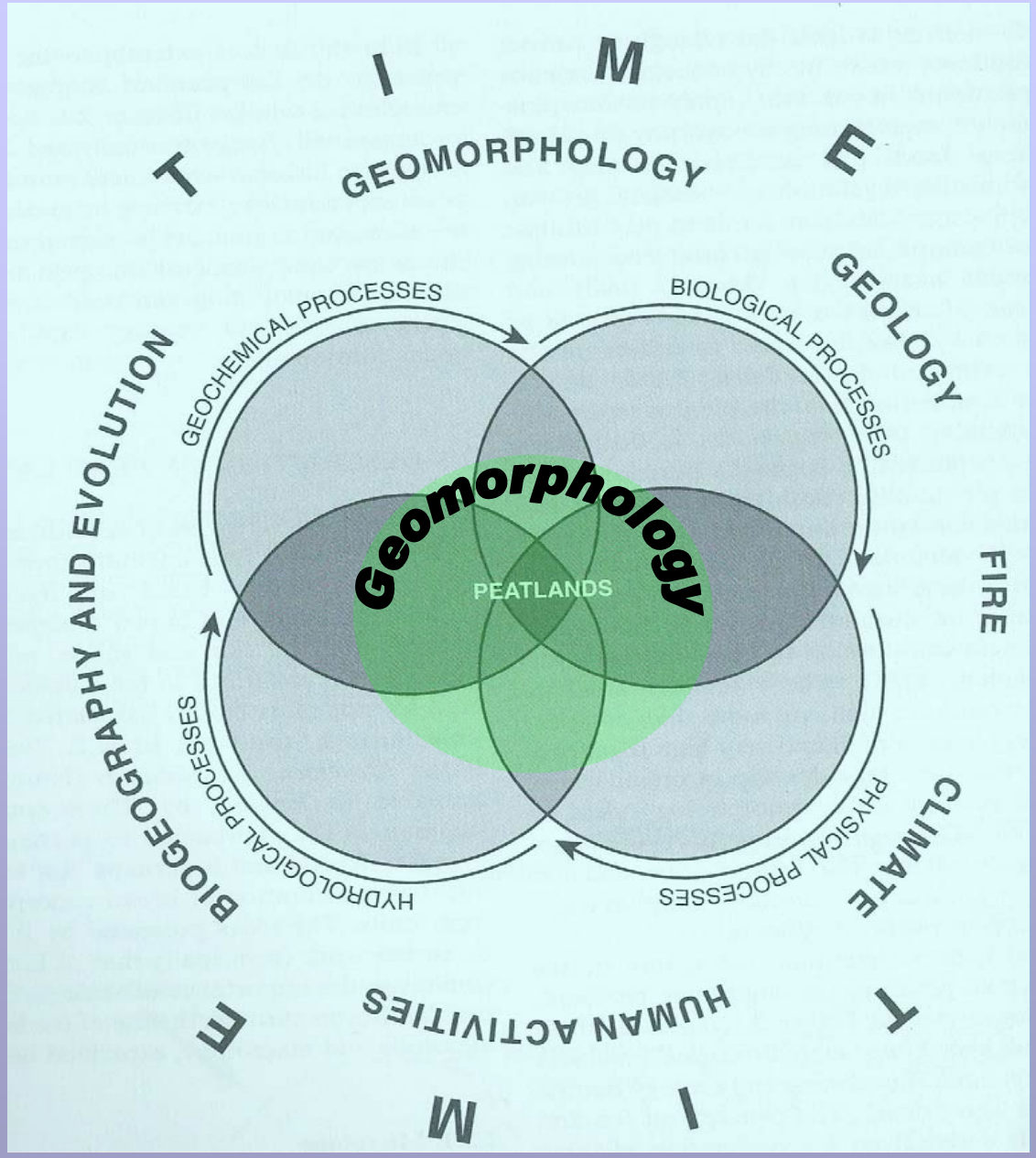
Research questions

- If restoration raises water tables
  - What is the mechanism – evaporation?
  - Effect on runoff generation and ROP?
- If restoration reduces overland flow velocities
  - Effect on timing of runoff delivery
- Need to examine the full water balance of restoration sites.

Conclusions

- Whilst peatlands do not act as a sponge as commonly envisaged there are hydrological benefits to moorland restoration. There are also potential mechanisms by which moorland restoration might mitigate runoff
- The key to understanding these effects at the site scale is integrated monitoring of the full catchment water balances at restoration sites –initial work planned as part of MS4W
- Upscaling site scale understanding remains a major research challenge
- Doubtful that hydrological degradation is fully reversible – gullies and pipes



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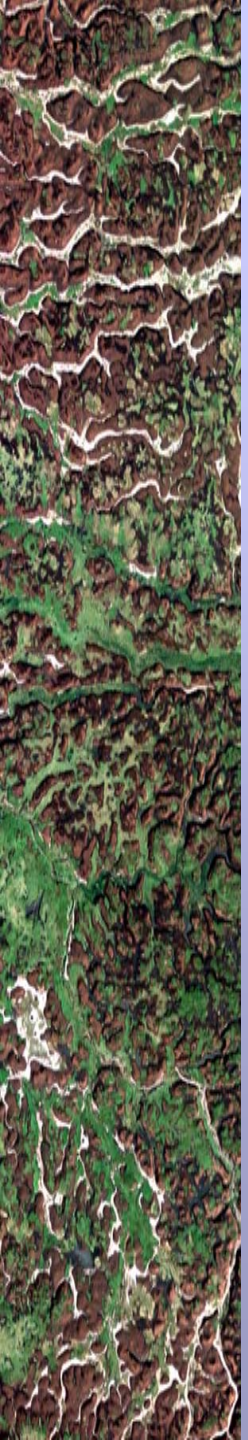
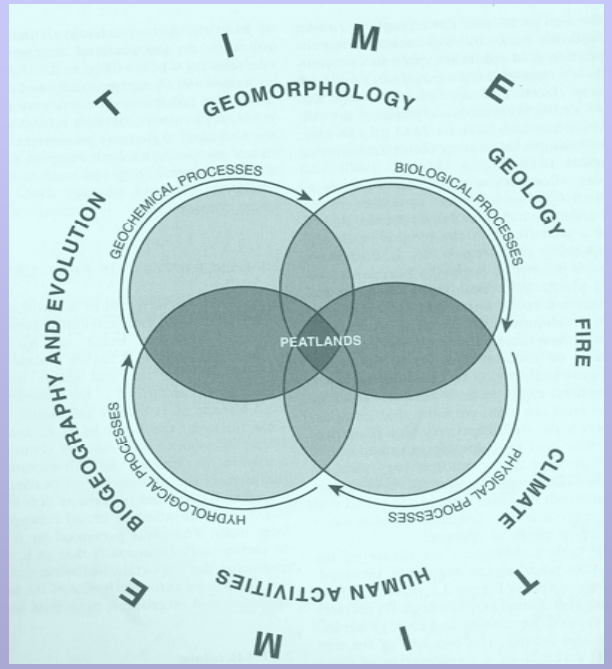
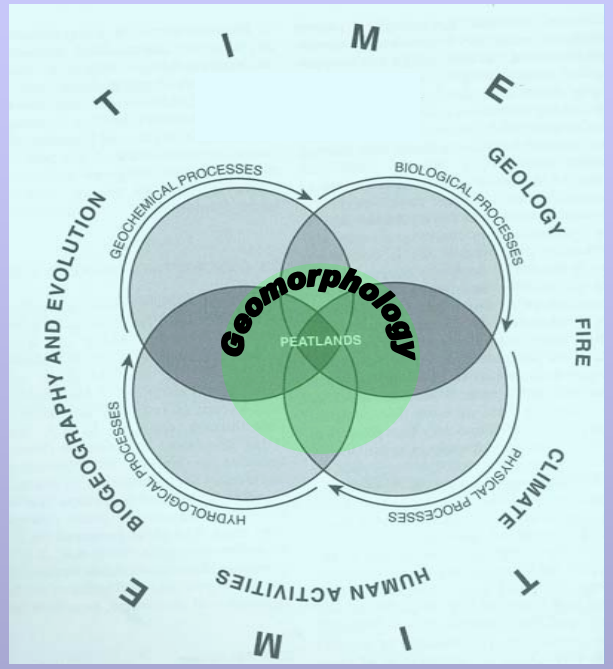


Re-vegetating

Intact

Eroding





Low POC Losses
Carbon sequestration

High POC Losses
Reduced Carbon Storage

High water table/Runoff mitigation?

Low water table/ Increased runoff?

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