Peatland management impacts on flood regulation

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Key points are:

- Impact of management on flood regulation from peatlands depends on:
    - Type of peat
    - Its topographic and catchment location
    - The intensity and configuration of management
    - The location of management with respect to river channels – the same management on the same type of peat can have a very impact depending on where you are in the catchment and flood wave synchronicity
    - There is more than just ‘a type of management’ to think about – I push for us to think about the surface condition of the peat (degradation etc) - to which management may contribute - as this may impact velocities of overland flow.

- There are many ways in which a flood could be impacted by peatlands: for example, the peak could be reduced/increased, the timing could be delayed/sped up or the volume changed.

The type of peat and its location matters

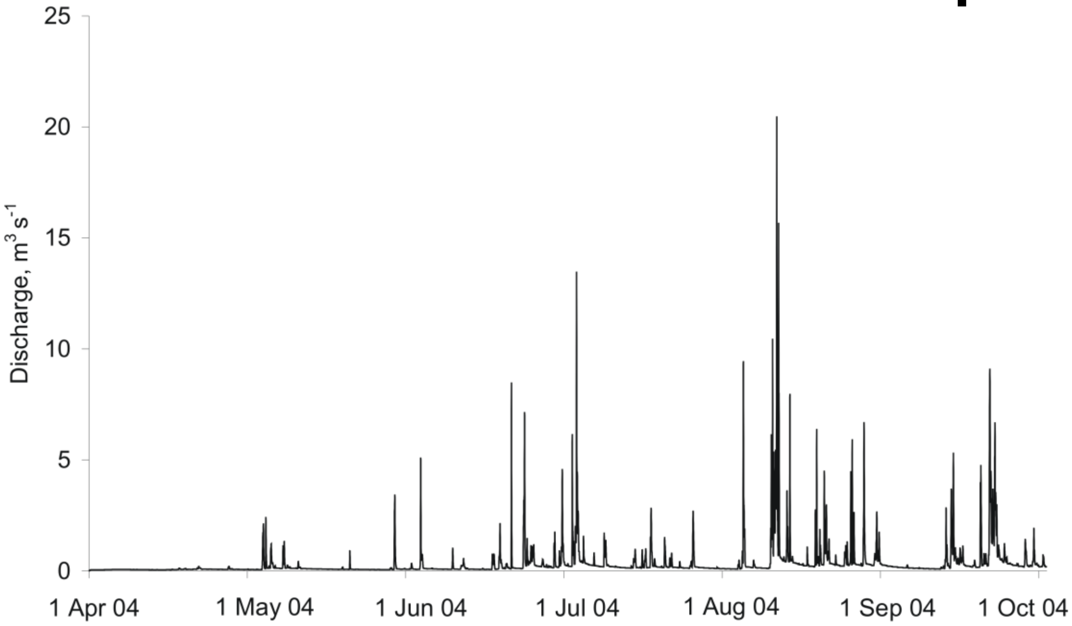
- Valley peats, lowland fens, raised bogs, blanket peat (lowland and upland) etc.
- Upland blanket peat is generally a source of flooding.
- Lowland fen could be a sink for flooding (and attenuate floods), but this really does depend on management and topographic setting.
- Valley mires may act as buffers for floods (or not, depending on season, and location).

- Flood storage service in some lowland peatlands (e.g. Somerset Levels and Moors)

- North Drain catchment Somerset Levels - water table levels pumped to 1-2 m below mean field level during the winter. Should all land owners raise water levels the 3.6 million m^3 of flood storage would not be available.

- Bullock and Acreman (2003) found that most, but not all, studies (23 of 28) show that floodplain wetlands reduce or delay floods, with examples from all regions of the world.
- For headwaters, around half of the studies (11 of 20 for flood event volumes and 8 of 13 for wet period flows) show that headwater wetlands increase the immediate response of rivers to rainfall, generating higher volumes of flood flow, even if the peak flow is not increased

Upland blanket peat (87 % of peat in UK) is source of quickflow



- High water tables (typically within 40 cm of the surface for 80 % of the time)
- Saturation-excess (‘overland flow’)
- Low hydraulic conductivity at depth

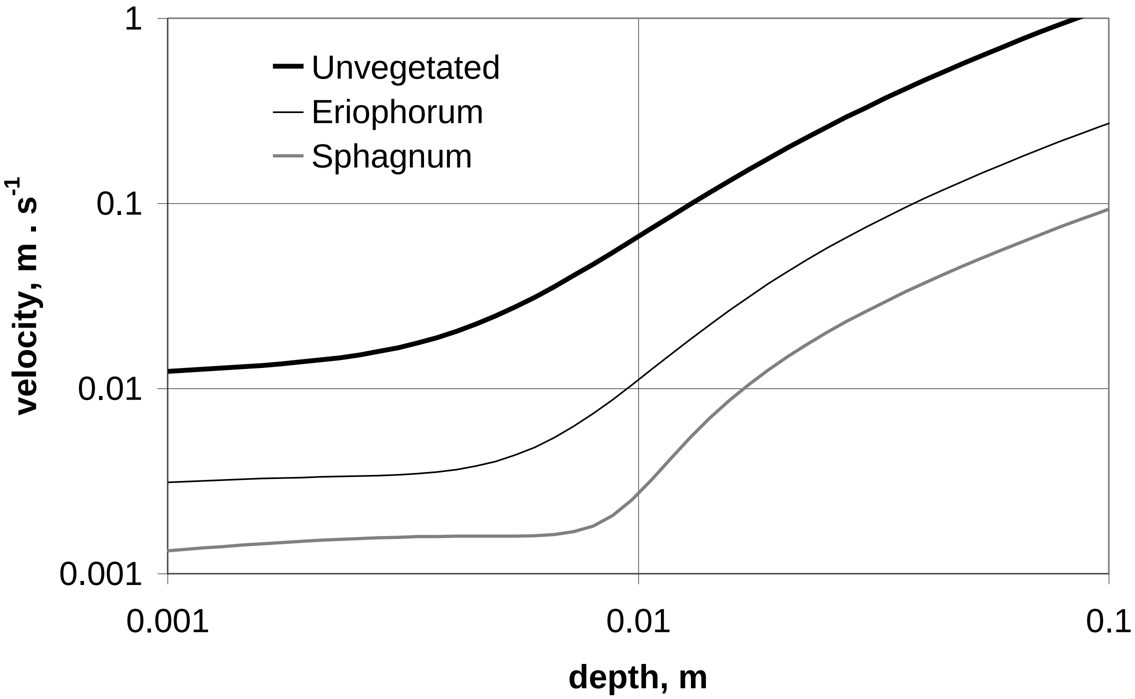
- Different vegetation types are also associated with different velocities of flow over the peat surface

- Velocity of overland flow in 1024 plots for different slopes and cover types and water depths

- Empirical data used to produce a model for peatland flow

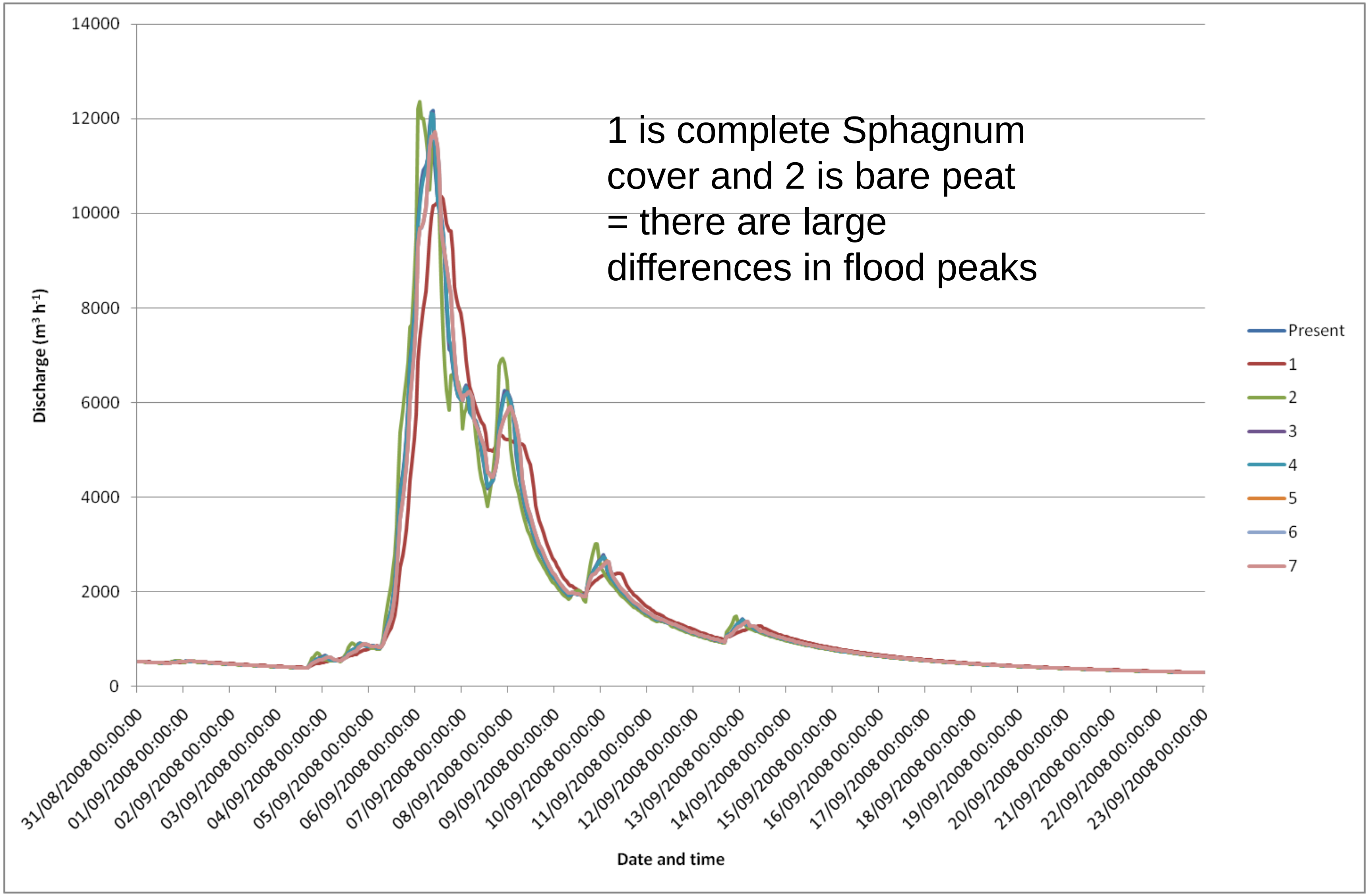
- A first order estimate of Darcy-Weisbach roughness and mean velocity can be based on a single parameter for each peat surface cover.

Example shown here is a modelled relationship between mean flow depth and velocity on a 10 % gradient.



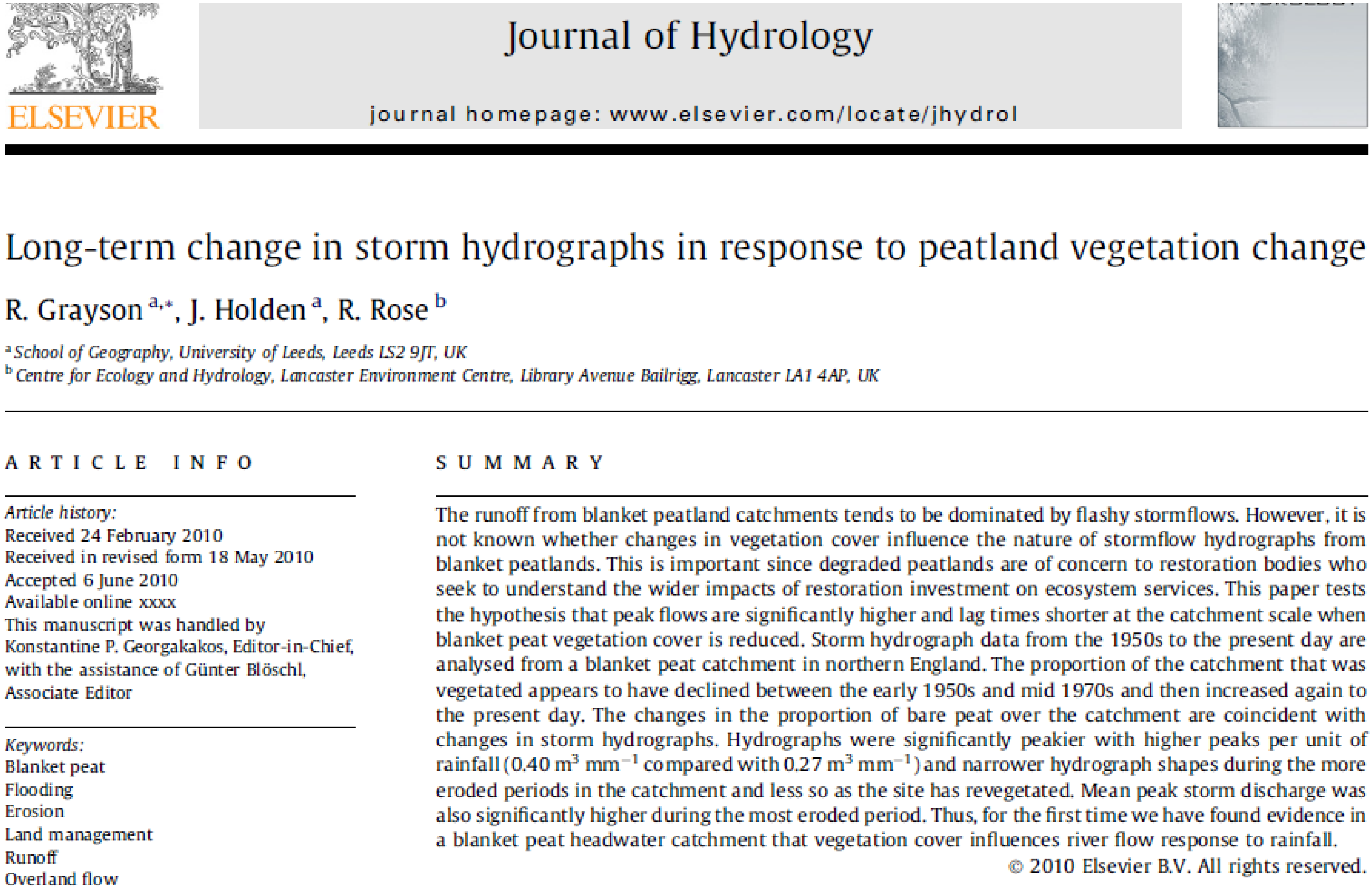
Holden et al (2008) Water Resources Research

The simulated hydrographs generated using for each vegetation re-establishment and management scenario in the Hollinsclough catchment



1 is complete Sphagnum cover and 2 is bare peat = there are large differences in flood peaks

Is there really a signal of vegetation change within the hydrograph at the catchment scale?



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Long-term change in storm hydrographs in response to peatland vegetation change

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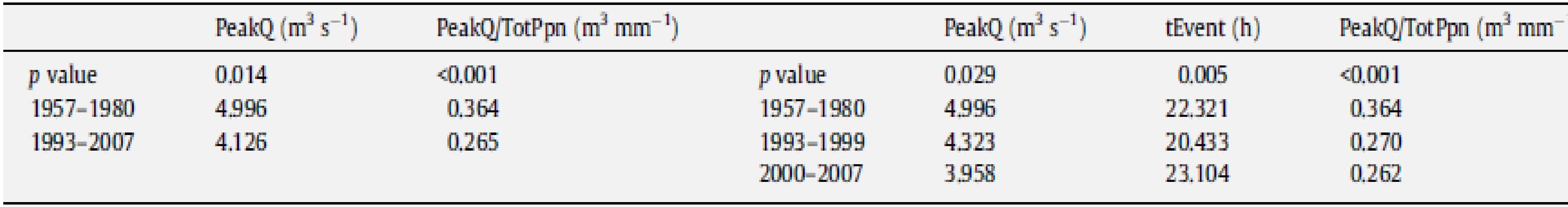
SUMMARY

The runoff from blanket peatland catchments tends to be dominated by flashy stormflows. However, it is not known whether changes in vegetation cover influence the nature of stormflow hydrographs from blanket peatlands. This is important since degraded peatlands are of concern to restoration bodies who seek to understand the wider impacts of restoration investment on ecosystem services. This paper tests the hypothesis that peak flows are significantly higher and lag times shorter at the catchment scale when blanket peat vegetation cover is reduced. Storm hydrograph data from the 1950s to the present day are analysed from a blanket peat catchment in northern England. The proportion of the catchment that was vegetated appears to have declined between the early 1950s and mid 1970s and then increased again to the present day. The changes in the proportion of bare peat over the catchment are coincident with changes in storm hydrographs. Hydrographs were significantly peakier with higher peaks per unit of rainfall (0.40 m^3 mm^{-1} compared with 0.27 m^3 mm^{-1}) and narrower hydrograph shapes during the more eroded periods in the catchment and less so as the site has revegetated. Mean peak storm discharge was also significantly higher during the most eroded period. Thus, for the first time we have found evidence in a blanket peat headwater catchment that vegetation cover influences river flow response to rainfall.



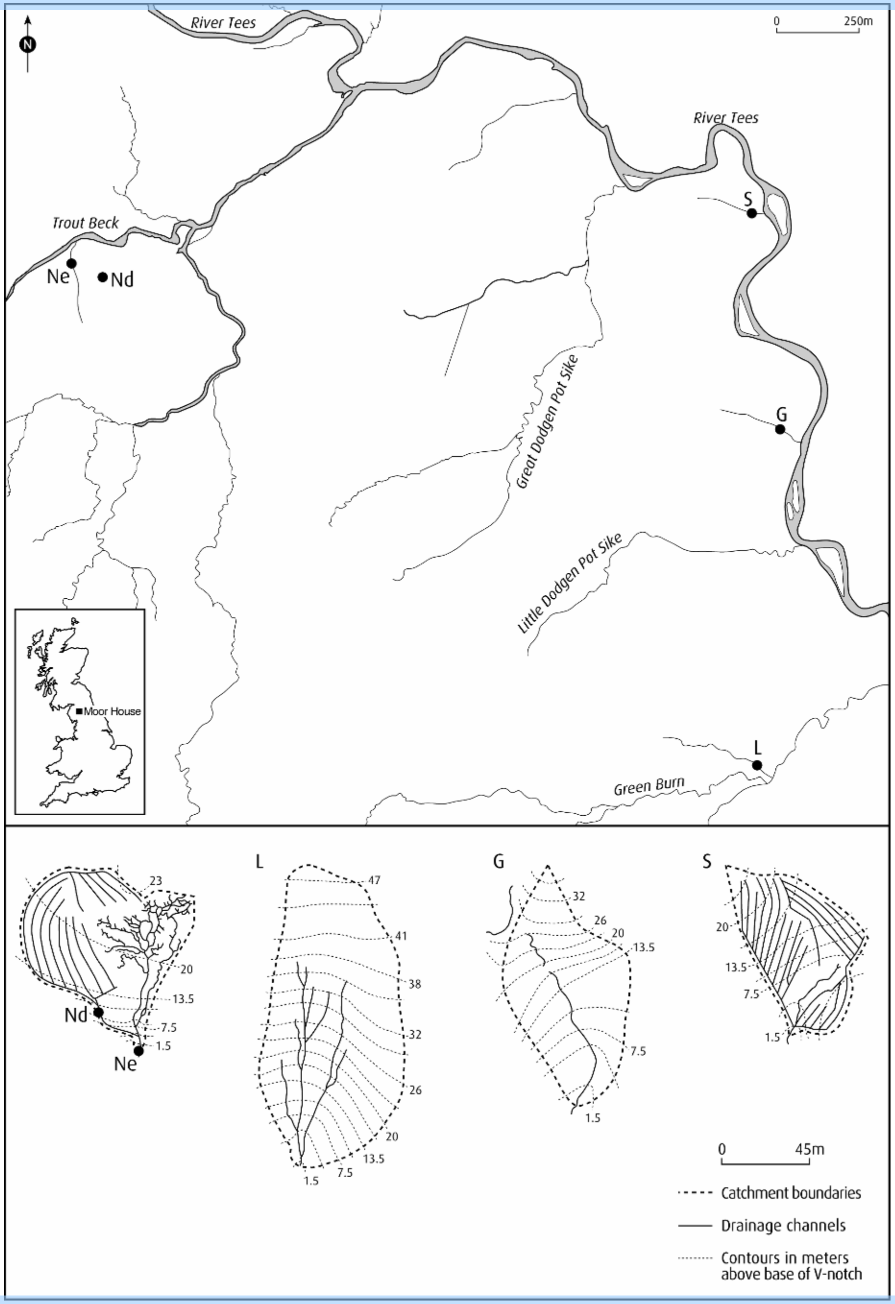
	PeakQ (m^3 s^{-1})	PeakQ/TotPpn (m^3 mm^{-1})		PeakQ (m^3 s^{-1})	tEvent (h)	PeakQ/TotPpn (m^3 mm^{-}
p value	0.014	<0.001	p value	0.029	0.005	<0.001
1957–1980	4.996	0.364	1957–1980	4.996	22.321	0.364
1993–2007	4.126	0.265	1993–1999	4.323	20.433	0.270
			2000–2007	3.958	23.104	0.262

N

Reported hydrological effects of peatland drainage

	Temp Store	Flood peak	annual runoff	Meas. scale	Proc. Meas.	Process discussion
Lewis 1957	↓	↑	↑	C	X	storage
Oliver 1958		↑		C	X	storage
Howe 1960		↑	↑	X	X	X
Conway & Millar 1960	↓	↑	↑	H	X	Storage, burning
Mustona 1964		↑		H	X	X
Burke 1967	↑	↓	↑	H	WT	storage
Howe et al. 1967		↑	↑	C	X	drainage density
Baden & Egglesmann 1970	↑	↓		H	X	storage, OLF
Inst. of Hydrology 1972		↑	↑	C	X	storage
Moklyak et al. 1975	↑ ↓	↑ ↓	↑ ↓	C	X	YES - lots
Heikurainen 1976	↑	↓		H	X	X
Ahti 1980	↓	↑		H	X	drainage density
Robinson 1986	↓	↑	↑	H	X	YES - lots
Newson & Robinson 1983		↓	↑	C	X	Catch. character.
Guertin et al. 1987		↑		X	X	X
Gunn & Walker 2000	↓	↑	↑	H	X	veg. changes

Holden et al. (2004) Progress in Physical Geography



Conway and Millar (1960) showed drainage:

-increased peak flows

-Increased annual water yield

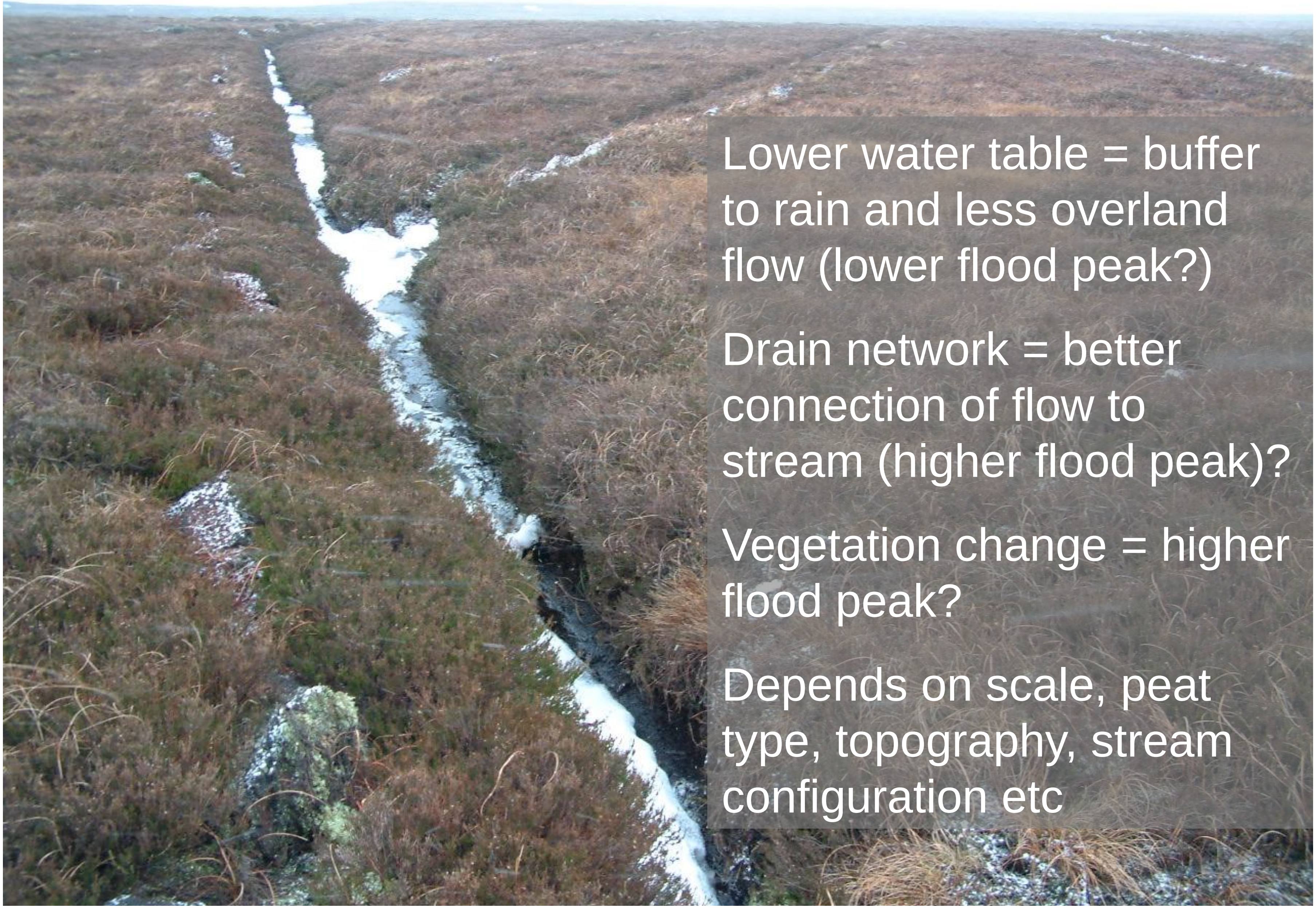
- decreased low flows

Data from initial few years after drainage compared with control catchments

Long-term river flow change?

- For exactly the same catchments as Conway and Miller:
- Compared data from 1950s with 2002-2004
- No change for undrained catchments in water yield or storm hydrograph characteristics
- Drained catchments had changed:
  - Significantly increased yield (15 %)
  - Lower peak flows
  - Longer recession limbs
- Short-term studies immediately after drainage do not capture full nature of hydrological response and caution needed if predicting long-term change

Holden et al (2006) J. Environmental Quality



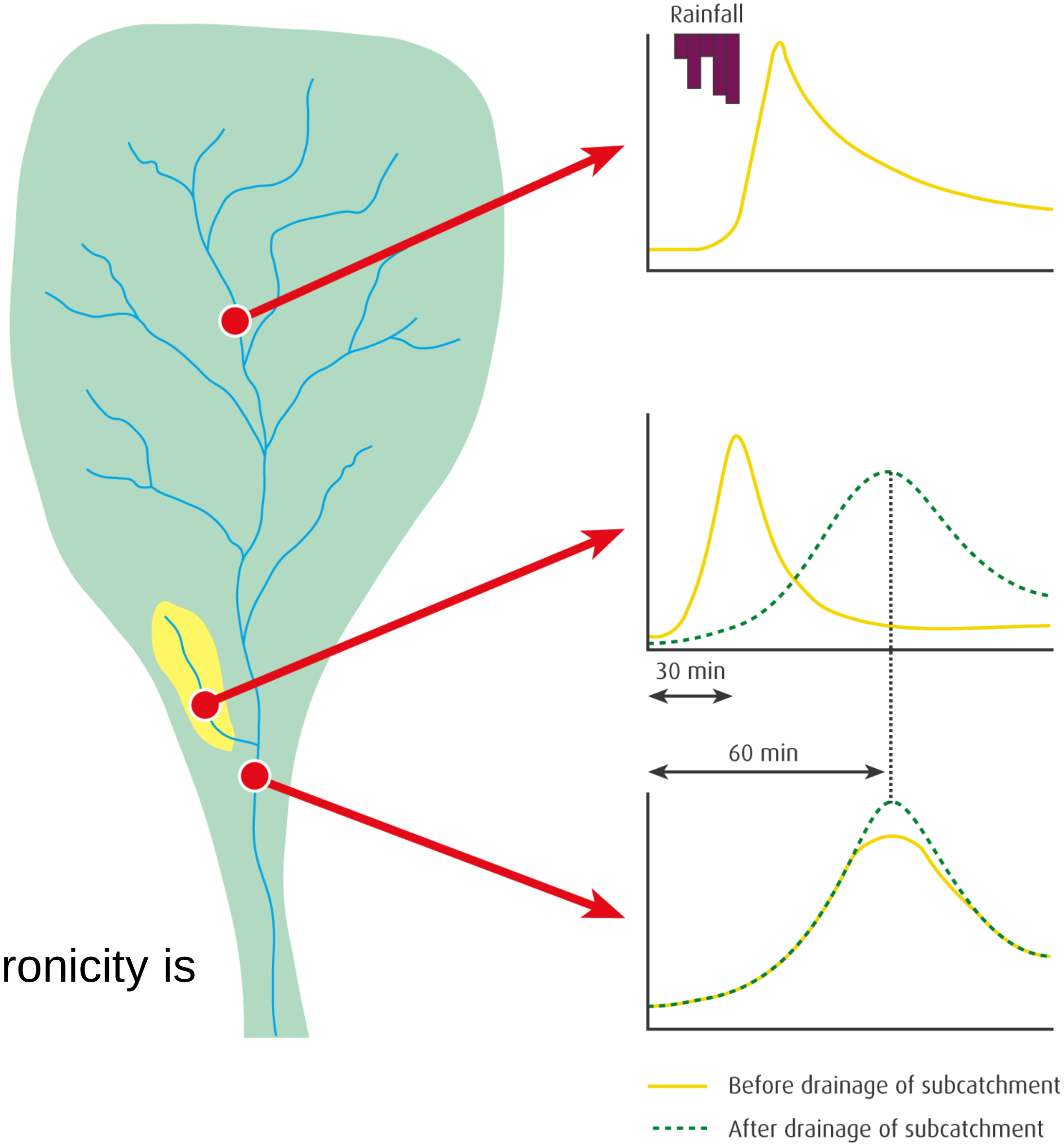
Lower water table = buffer to rain and less overland flow (lower flood peak?)

Drain network = better connection of flow to stream (higher flood peak)?

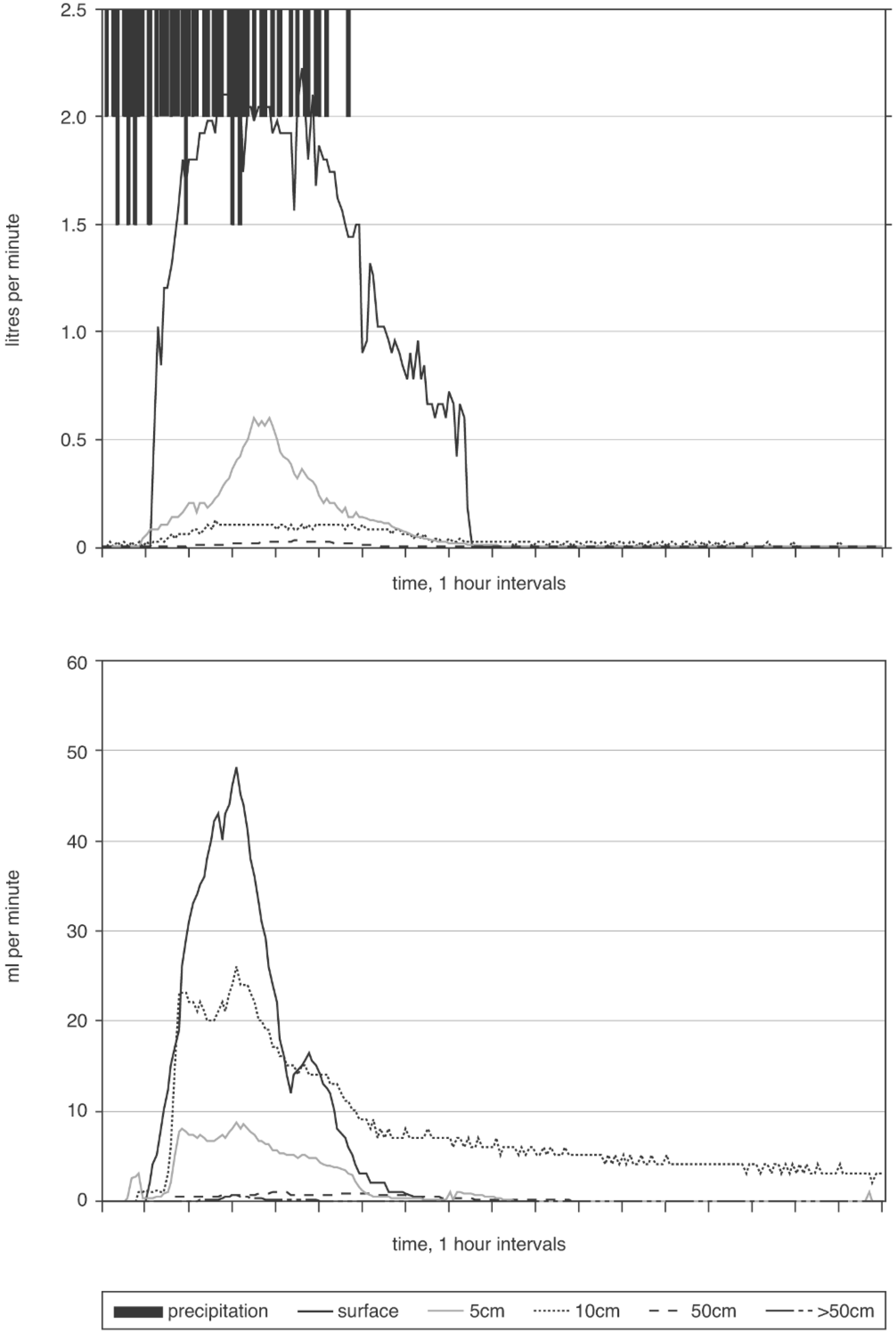
Vegetation change = higher flood peak?

Depends on scale, peat type, topography, stream configuration etc

Geography of the catchment - flood-routing



Flood wave synchronicity is crucial



intact

% runoff from Oct 2002-2004 from different peat layers:

0-1cm	76 %
1-5cm	17 %
5-10cm	6%
10-50cm	1 %
50 cm +	0 %

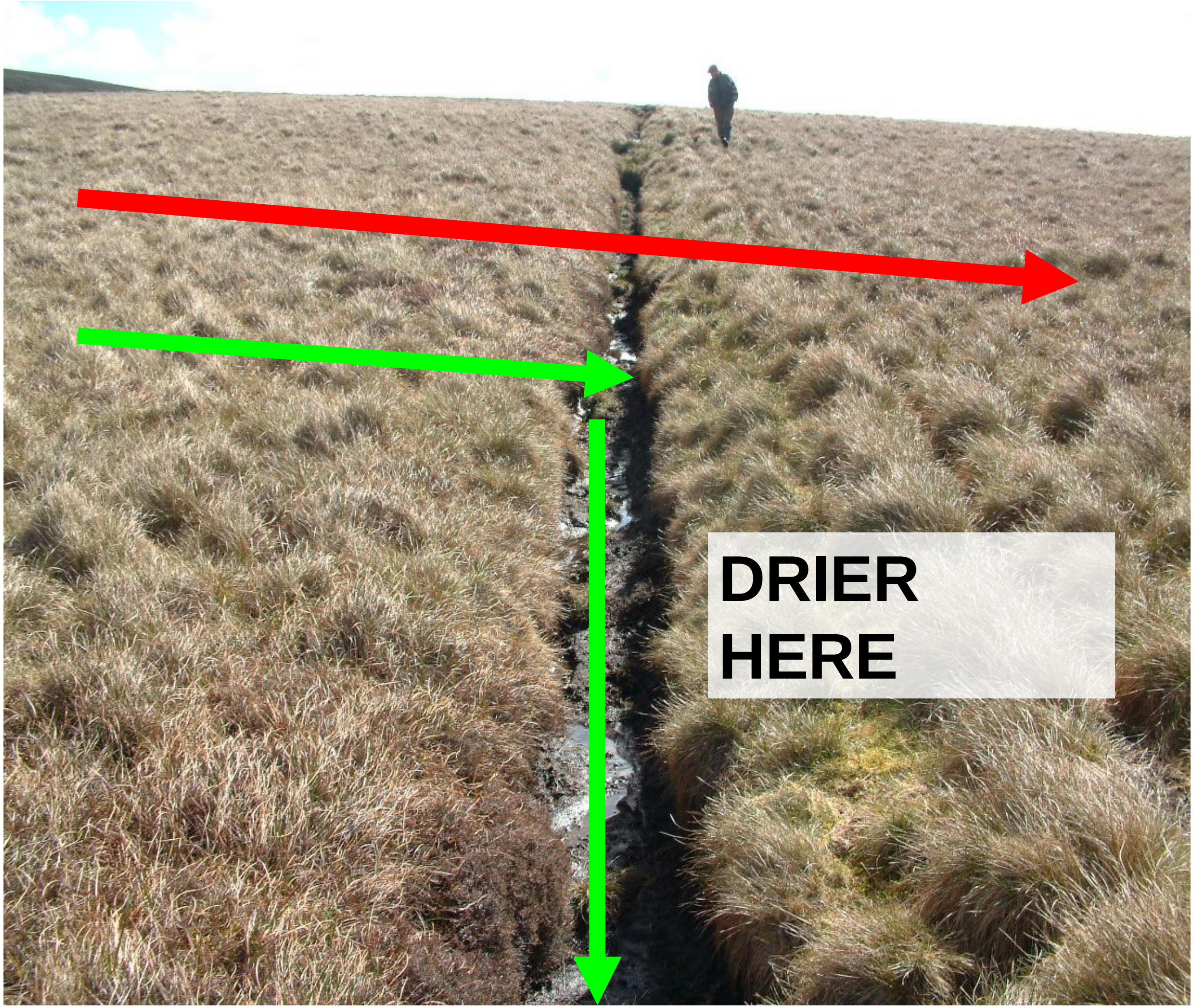
drained

% runoff from Oct 2002-2004 from different peat layers:

0-1cm	37 %
1-5cm	12 %
5-10cm	25%
10-50cm	15 %
50 cm +	11 %

- Modelling work has suggested that drain blocking could reduce flood flows downstream (Ballard et al., 2010 Journal of Hydrology).

- But this may depend on the angle of the drains with respect to the slope (Lane and Milledge in press)



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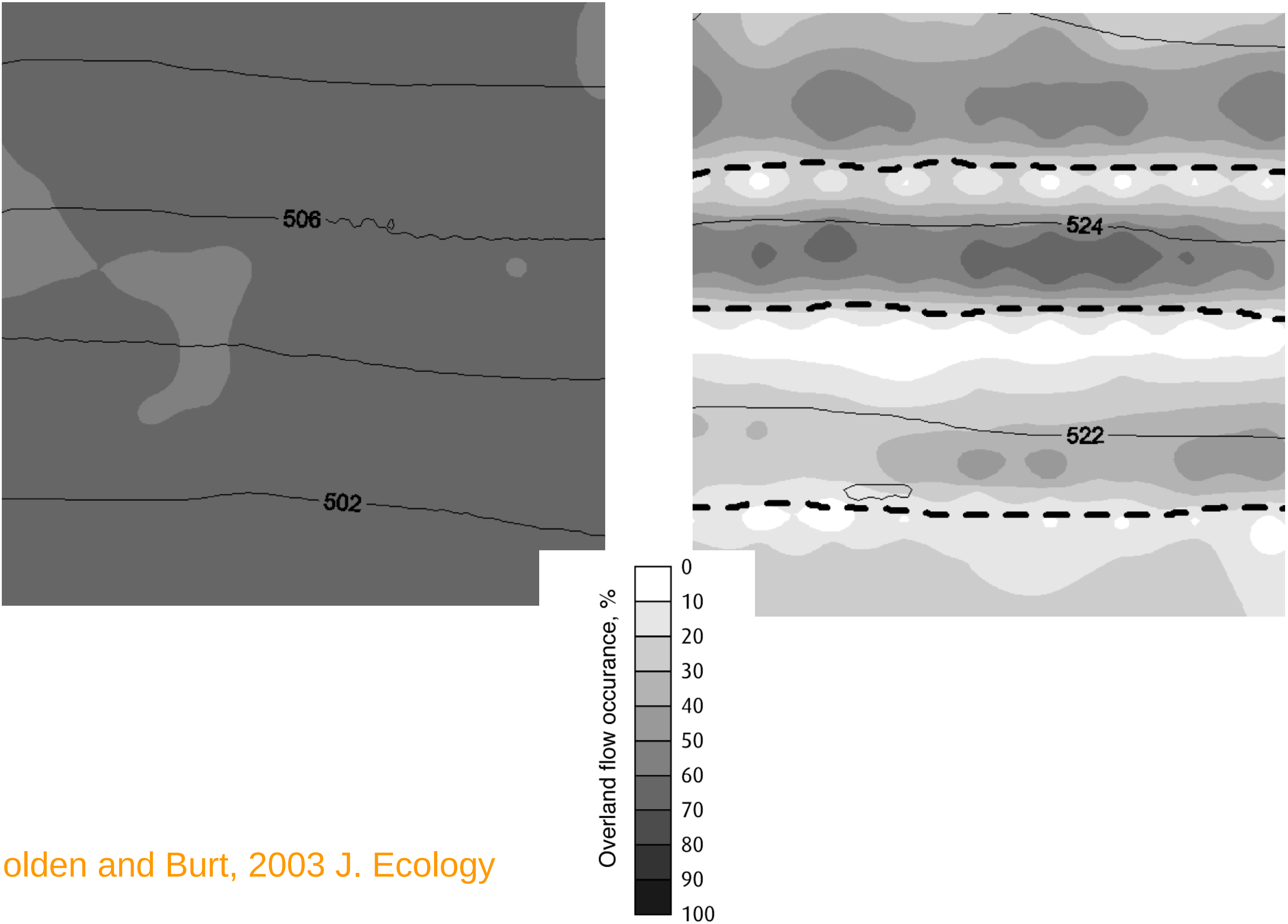
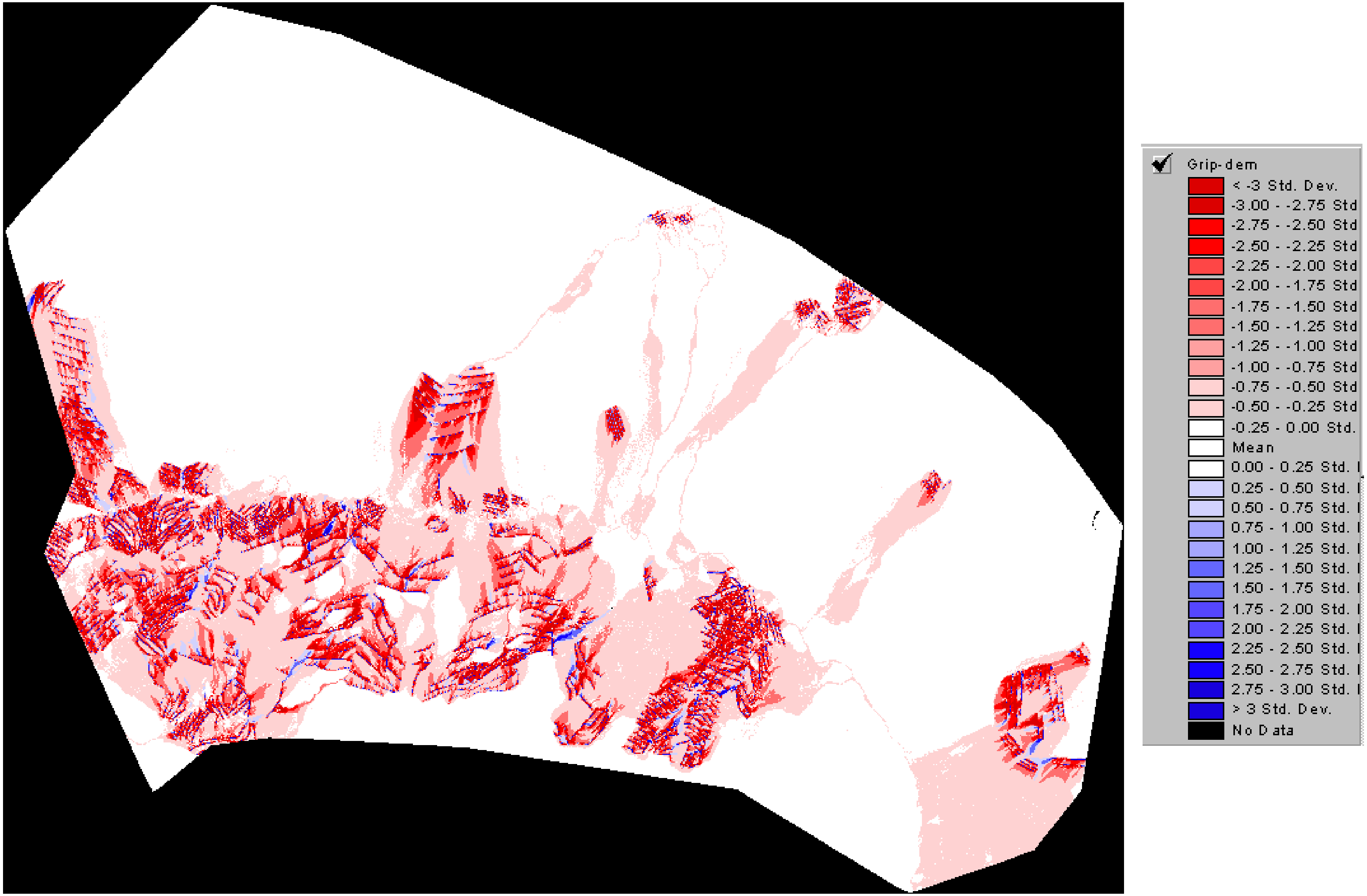


Holden and Burt, 2003 J. Ecology

Area of catchment with topographic index affected by drains



Lane, Brookes, Holden and Kirkby (2004) Hydrological Processes

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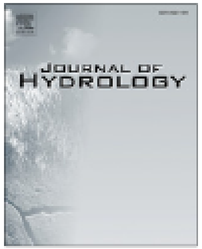

Recovery of water tables in Welsh blanket bog after drain blocking: Discharge rates, time scales and the influence of local conditions

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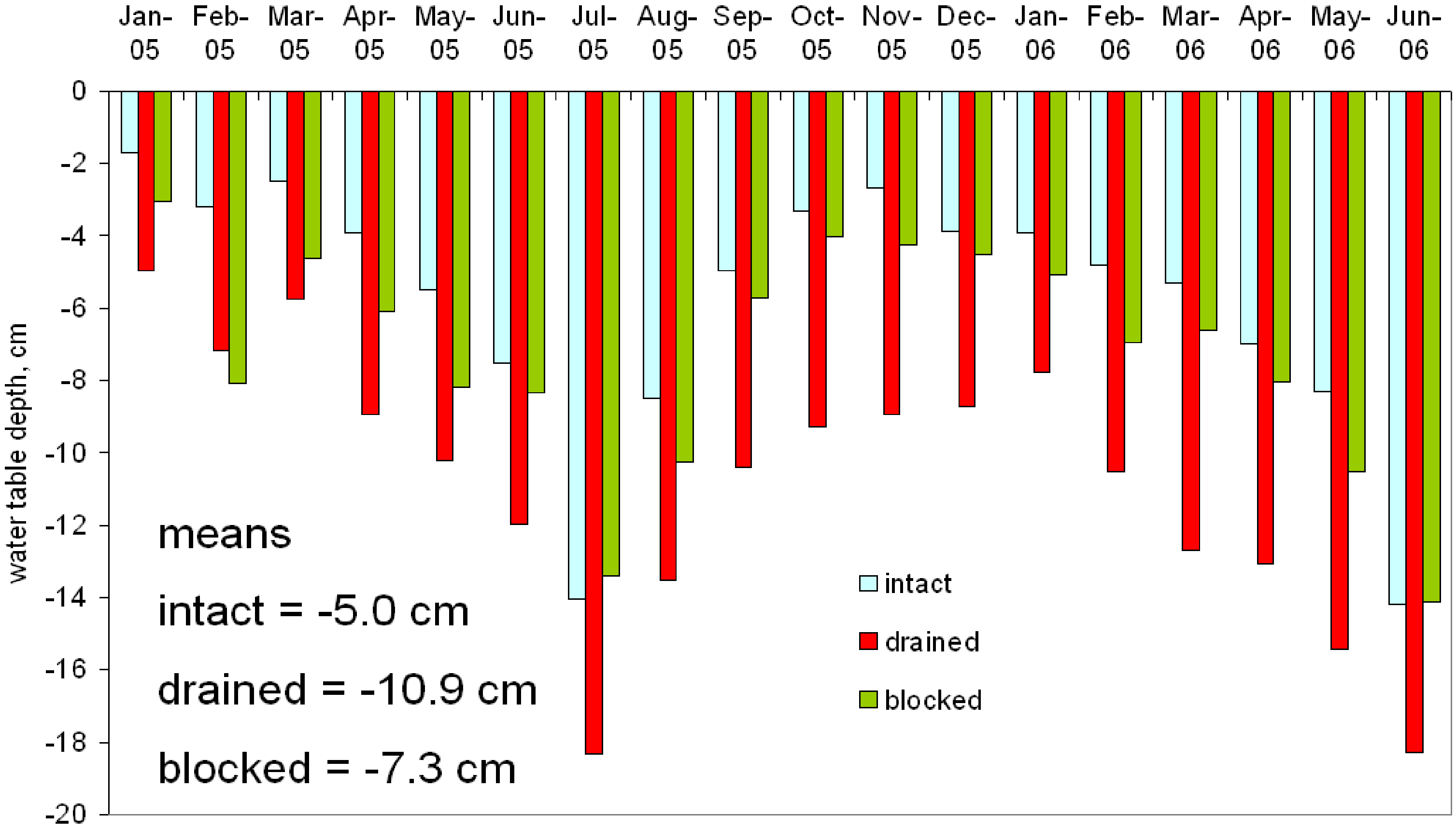
SUMMARY

Peatland practitioners and scientists have increasingly recognised the damage resulting from various management methods, and the need to restore peatlands to achieve several potential benefits. Many of the hoped-for benefits of peatland restoration, such as Carbon storage, biodiversity conservation and water quality improvements, are thought to depend on a reinstatement of high water tables that had been reduced by drainage. Despite the current emphasis on restoring drained peatlands, many of the predicted responses to restoration are still not adequately proven and the mechanisms behind them still uncertain. This study reports on water table and discharge responses to drain blocking restoration of a degraded Welsh upland blanket bog. Restoration work and monitoring were designed to permit a novel catchment scale control-intervention experimental design. An information theoretic approach to examining the data provided evidence of increases in water retention and water tables within the bog after restoration. But the study also demonstrated the importance of small and large scale topography in determining the degree of these responses. The increases in water storage after restoration produced lower discharge rates observable at the level of both drains and hill streams; as well as greater water table stability, reduction in peak flows and increases in water residency after rainfall. Crucially, this study showed strong catchment scale differences in response, and a very gradual recovery of water tables, both of which highlight the need for more studies to be carried out at the landscape scale and over longer time periods.

Slow recovery of water tables – also seen in Wharfedale study – 6 years after blocking

Often well beyond the duration of monitoring programmes



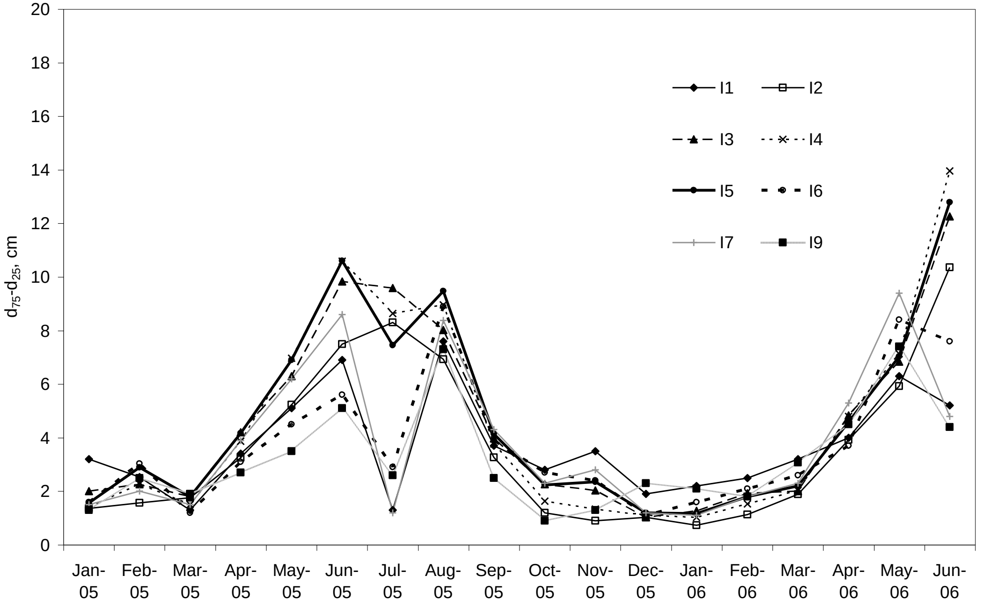
means

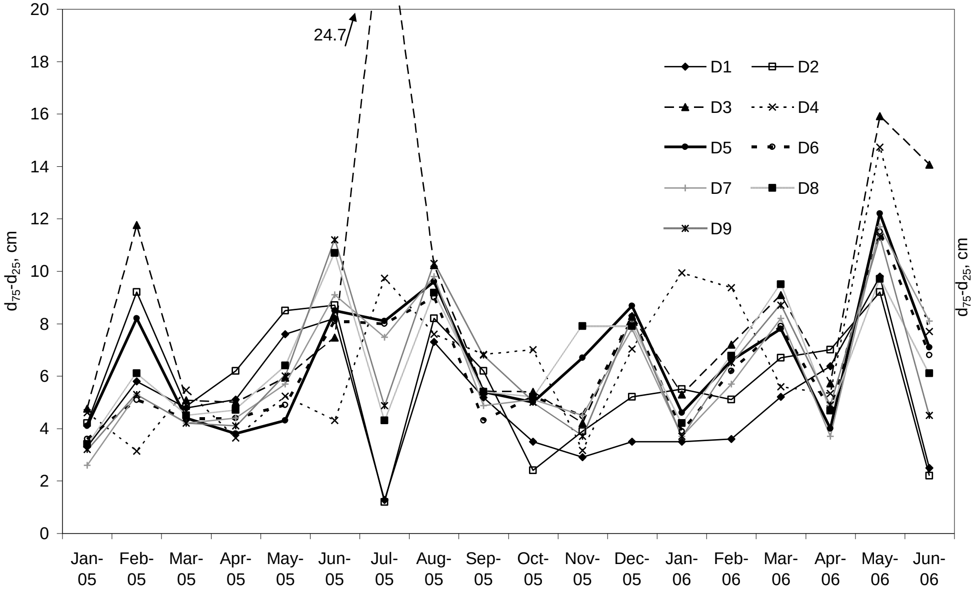
intact = -5.0 cm

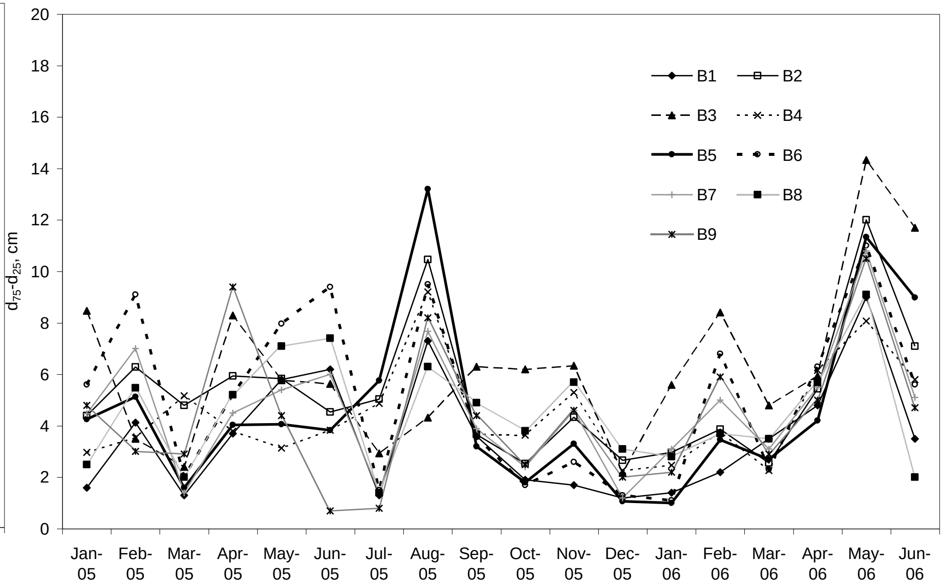
drained = -10.9 cm

blocked = -7.3 cm

Interquartile range patterns in water table for each month







From Acreman and Holden in prep (and diagram is not quite finalised)