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Controls on spatial distribution of soil pipe outlets in heavily degraded blanket bog

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Introduction: MoorLIFE2020 D3

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Soil pipes ubiquitous in blanket peat (Holden, 2005)

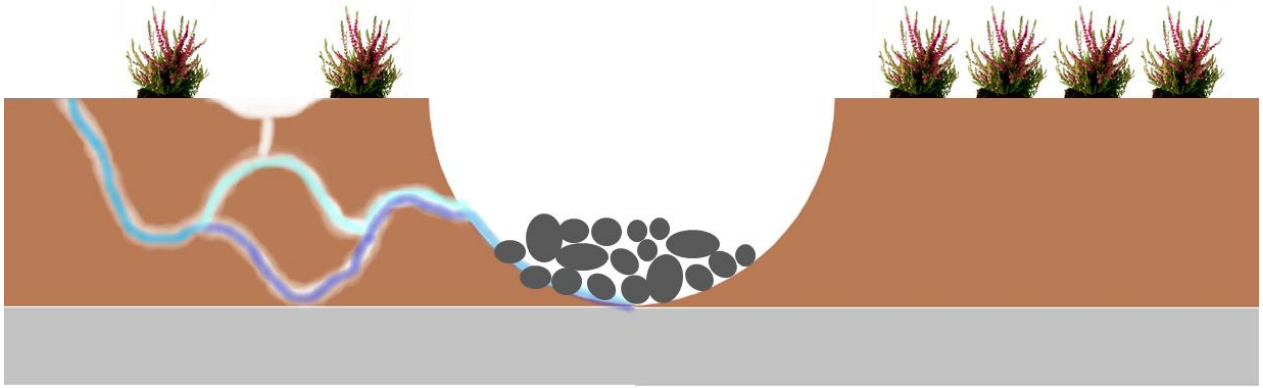
Peatland restoration aims to

- prevent loss of stored carbon
- eluviate downstream flood risk
- restore flora and fauna habitats

Gully blocking
- Slow the flow
- Rewetting
- Revegetation

(Parry et al. 2014)

Does blocking of soil pipes deliver the same benefits?



Introduction: MoorLIFE2020 D3

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Spatial distribution of soil pipes	Carbon export by soil pipes
Hydrological response of soil pipes	Implications blocking of soil pipes

Spatial distribution of soil pipes

1. assess spatial distribution of pipe outlet characteristics
2. determine process mechanisms that control pipe outlet frequency
3. Implications for peatland restoration

Study site: Upper North Grain

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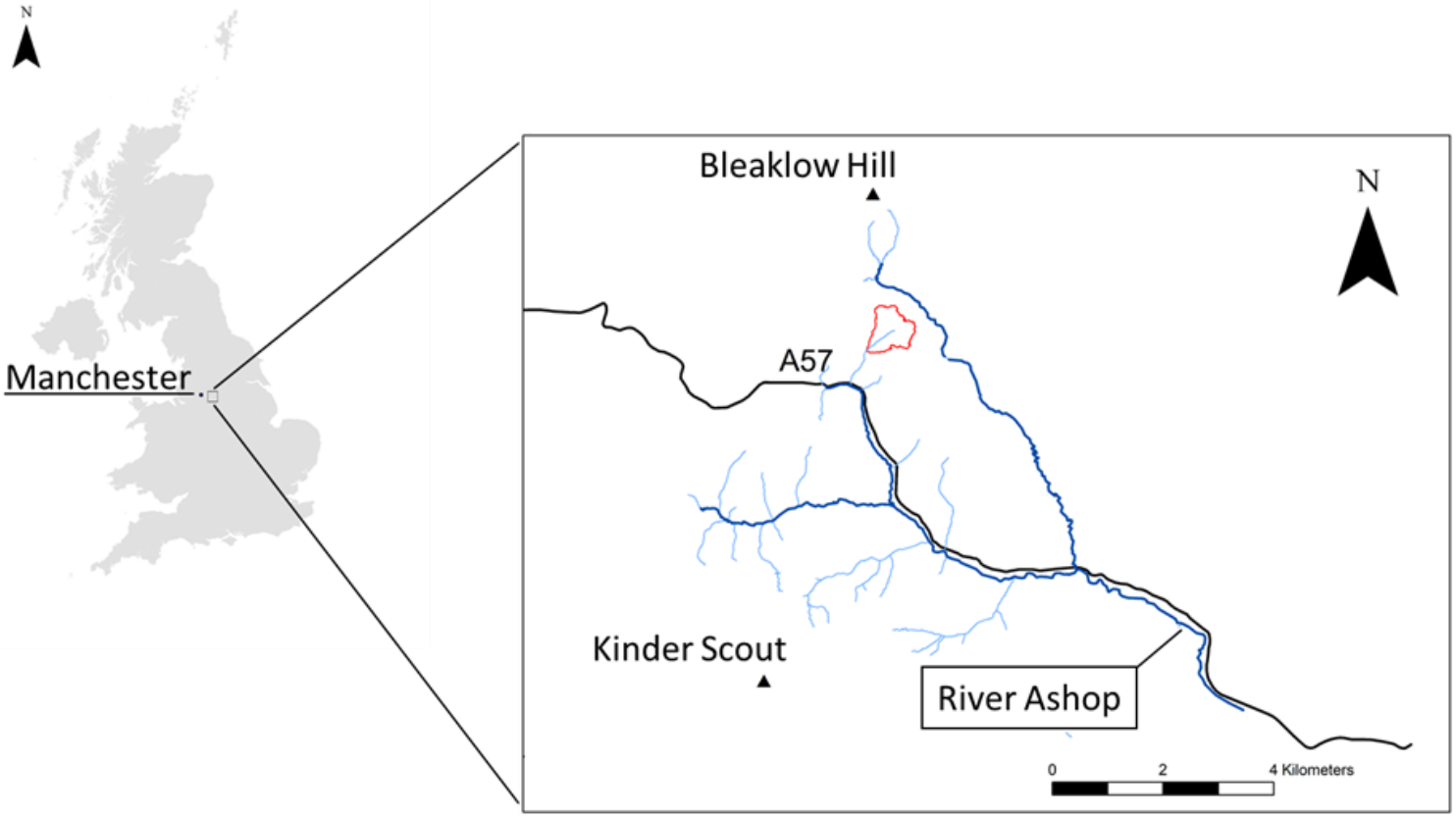
0.49 km^2 headwater east of Manchester,
~ 1300 mm annually



Spatial distribution of soil pipes

(Regensburg et al., in review)

Study site: Upper North Grain

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Onset erosion: Early Medieval Warm Period
~950-1250 AD (Tallis, 1995; Tallis, 1997)

Loss of vegetation cover due atmospheric deposition:
1800 AD – present (Yeloff et al., 2006)

Peat depth up to 4 m at places, but all gullies incised to the bedrock.

Before 2017:

~90 pipes identified across catchment (Goulsbra, 2010)

Soil pipes appeared to actively output DOC to streams
(Goulsbra, 2010; Wallet, 2004)

(Regensburg et al., in review)

Methods

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12 surveys | 12/2017 - 09/2019

Walking survey

Pipe outlet characteristics: e.g. GPS location, diameter, streambank slope, and depth to roof

LIDAR 0.5 m x 0.5 m (2014) was used to derive DTM, drainage networks, and aspect

(Regensburg et al., in review)

Data processing: pipe outlet location

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Streambank Type	Location
IN GULLIES: streambanks in gullies with two banks on "left- and right-hand side"	**HEAD:** pipe outlet occurred where streambank showed signs of headward retreat at the pipe outlet
BETWEEN GULLIES: streambanks between gullies on "exposed edges of the blanket bog that faced the main drainage stem"	**EDGE:** pipe outlets occurred on fairly uniform stretches of streambank

(Regensburg et al., in review)

Data processing: outlet shape

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OUTLET SHAPE = axis dependent

One axis exceeded the other > 5 cm

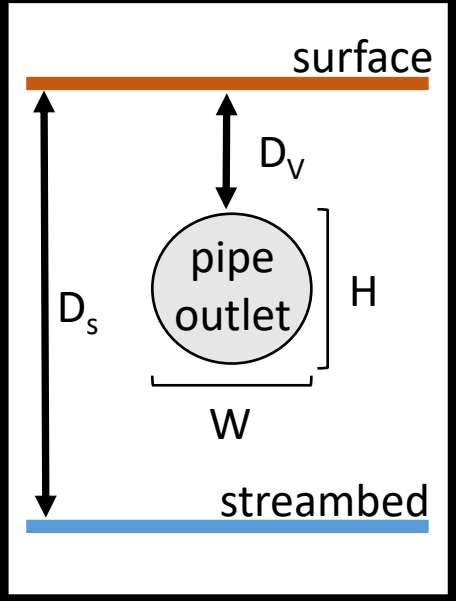
- Horizontally lenticular (h)

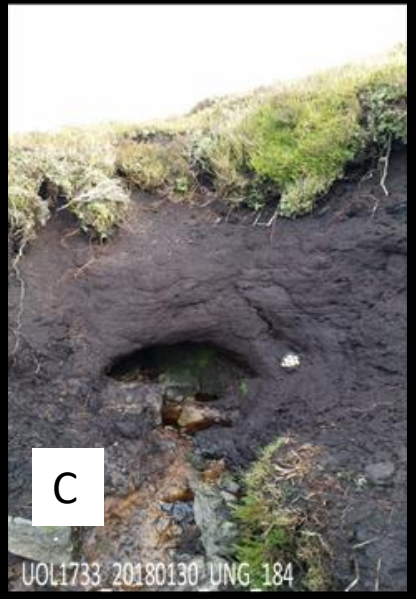
- Vertically lenticular (v)

Difference axis < 5 cm

- Circular (c)

(Regensburg et al., in review)

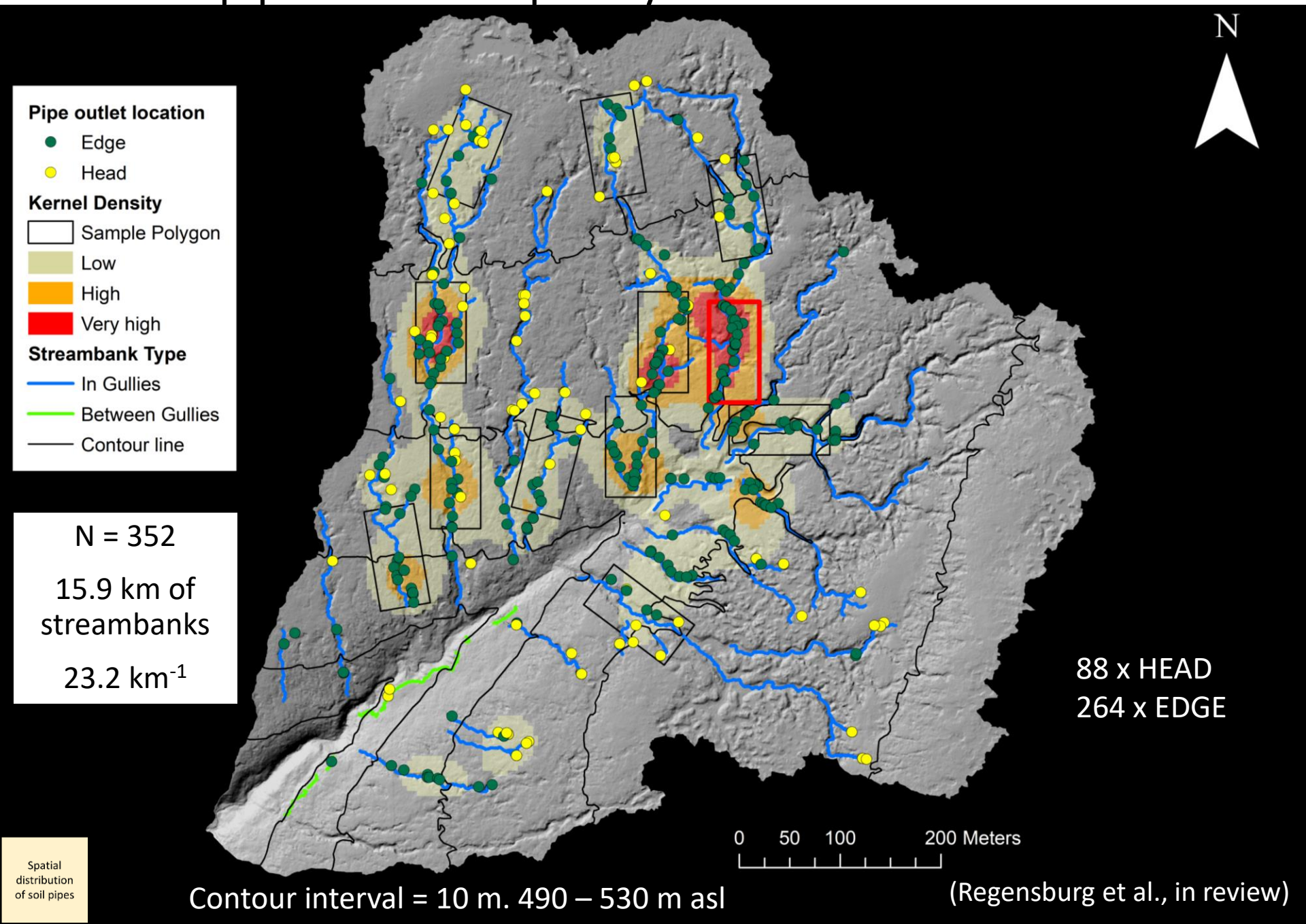




Streambank Type	IN GULLIES	IN GULLIES	BETWEEN GULLIES
Location	HEAD	EDGE	HEAD
α (˚)	30	45	90
D_s (cm)	276	230	no data
D_V (cm)	23	76	110
H (cm)	7	14	30
W (cm)	6	5	50
Aspect	southwest	east	southwest

(Regensburg et al., in review)

Results: pipe outlet frequency



Spatial distribution of soil pipes

Results: pipe outlet locations

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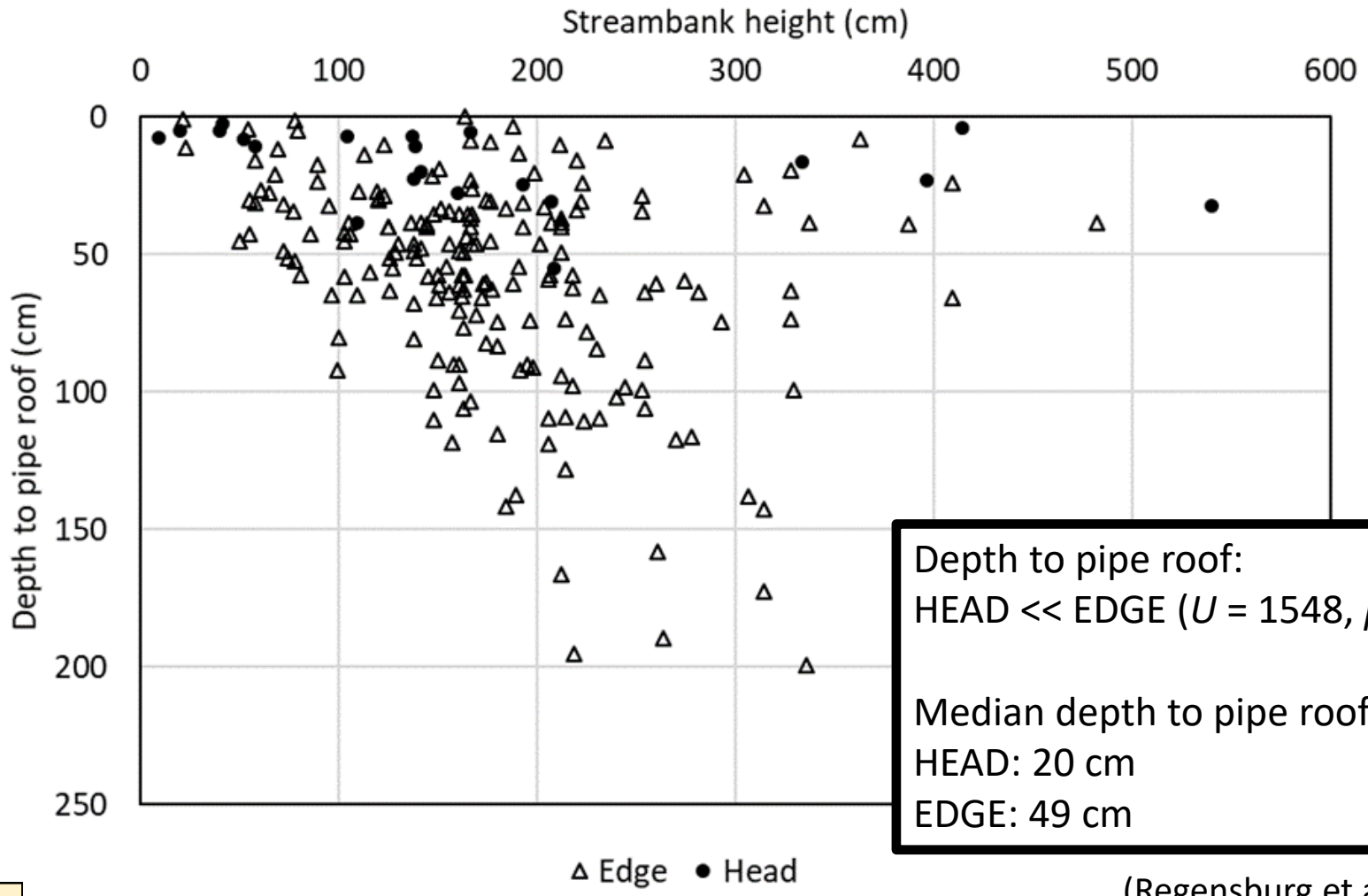

Depth to pipe roof:
HEAD << EDGE (U = 1548, p < 0.001)

Median depth to pipe roof:
HEAD: 20 cm
EDGE: 49 cm

(Regensburg et al., in review)

Results: pipe outlet shape

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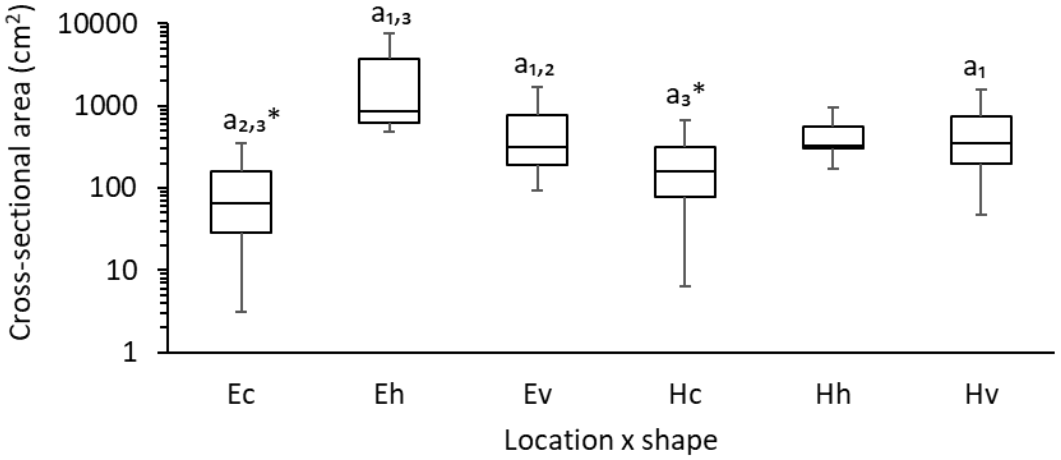

EDGE << HEAD
(U = 12396, $p < 0.001$)

Median cross-sectional area:
HEAD: 292.2 cm^2
EDGE: 91.1 cm^2

72 % circular (median: 75 cm^2)

3 % horizontally lenticular (median: 597 cm^2)

25% vertically lenticular (median: 339 cm^2)

Ec << Ev << Eh

Hc < Hv

Ec << Hc

(Regensburg et al., in review)

Results: aspect

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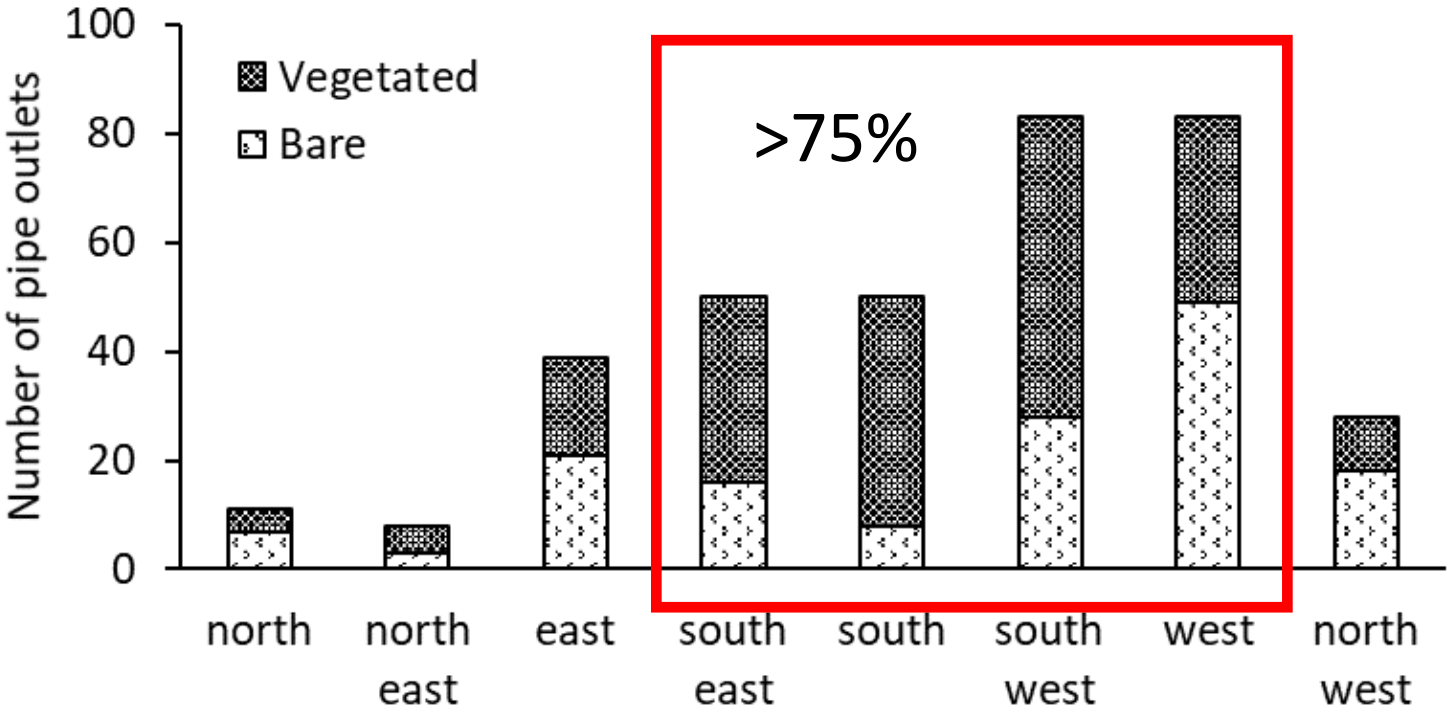

Opposite pairs of aspect:

N vs S ($\chi^2(1) = 24.934$, $p < 0.001$)
NE vs SW ($\chi^2(1) = 61.813$, $p < 0.001$)
E vs W ($\chi^2(1) = 15.869$, $p < 0.001$)
SW vs NW ($\chi^2(1) = 6.205$, $p = 0.013$)

(Regensburg et al., in review)

Discussion: pipe outlet frequency

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Methods to derive pipe outlet frequency not always clear.

UNG shows best estimate for heavily degraded blanket bog.

Blanket peat catchments	Pipe frequency (km^{-1} stream bank)	Cross-sectional area of pipes (m^{-2} km^{-1} Streambank)	Catchment Area (ha)
Upper North Grain	23.2	0.73	49
160 blanket bog sites across UK (Holden, 2005)	19.7	0.556	?
Little Dodgen Pot Sike, North Pennines (Holden and Burt, 2002)	9.5	0.026	44
Cottage Hill Sike, North Pennines (Holden et al., 2012a) *	31.69	0.308	17.4

*** Only observations form 2010**

(Regensburg et al., in review)

Discussion: location of pipe outlets

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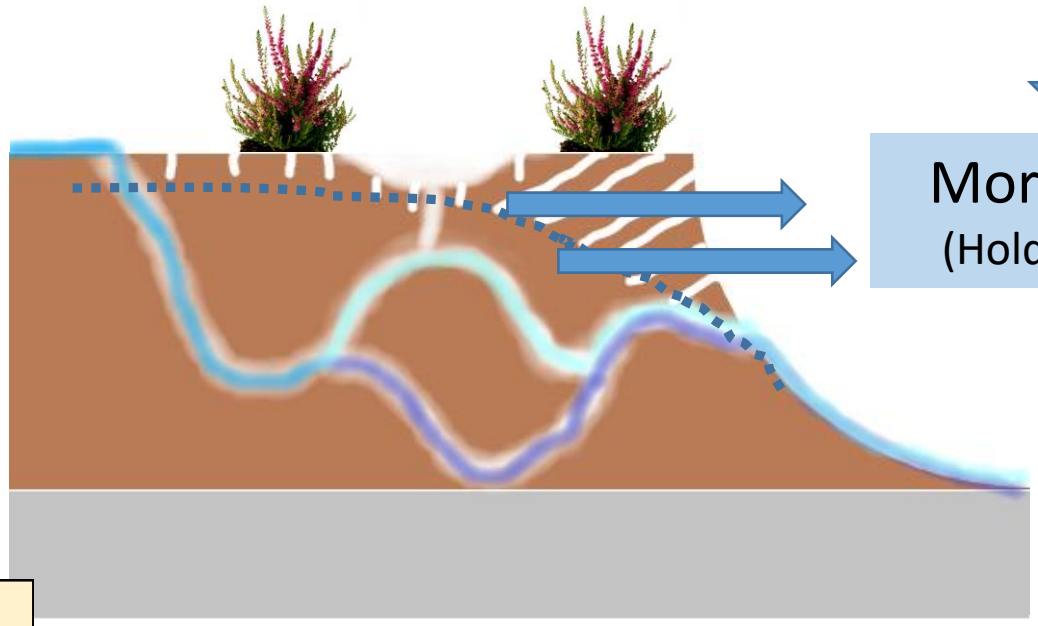
Controls on pipe outlet frequency at EDGE locations:

Water table drop → Aspect → Desiccation cracking → More piping (Holden, 2006)

Daniels et al. (2008)



(Regensburg et al., in review)

Discussion: implications

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Pipes are part of a natural state of UNG

- Too many to block them all -> new strategy?!

Explore the use existing practices to prevent the initiation of new pipes

→ gully reprofiling and subsequent revegetation or protective covering of exposed peat (Parry et al., 2014)

- Reprofiling of streambanks stabilizes steep streambank slopes, prevents sheet and rill erosion, and buries pipe outlets.
- Revegetation of bare streambanks provides cooling effect on peat, helps inhibit desiccation effects on streambank

(Regensburg et al., in review)

Conclusions

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N pipes: EDGE >> HEAD

particularly in deeply eroded gullies.

1. location strong control of pipe outlet frequency, size, shape and depth of pipes issuing onto streambanks

2. aspect strong control of frequency on southeast, south, southwest and west facing streambanks

3. desiccation-cracking possible control for pipe outlet frequency

(Regensburg et al., in review)

Questions?

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#blockingpeatpipes

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