

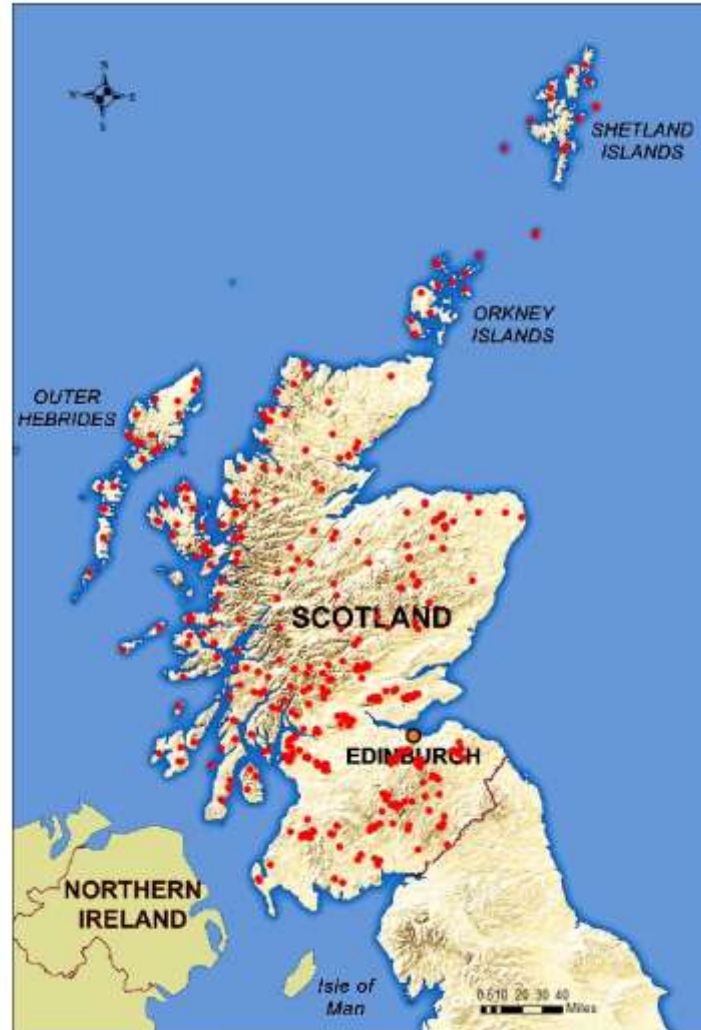
A Characterisation of Scottish Drinking Water Catchments

Understanding controls on raw water quality

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Hydro Nation Scholar, University of Dundee

SFG 100th meeting
Theme: The use & value of freshwaters
Friday 20/04/2018

Context



- Multiple and mounting pressures on water resources
- Insecurity of stable high quality drinking water supply
- Rising treatment costs
- Need to target mitigation measures
- Considering long-term water quality for investments

Key questions

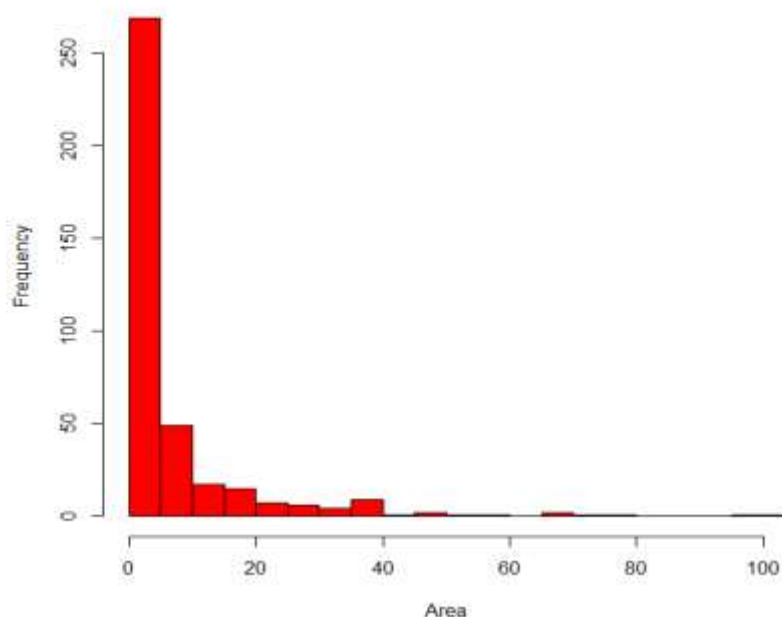
- What do the catchments that we use as drinking water resources in Scotland look like?
- What conditions and pressures act on their water quality?
- Where do we find these?
- How are catchments likely to change in future?
- What is the impact for raw water quality?

Scottish Water catchments

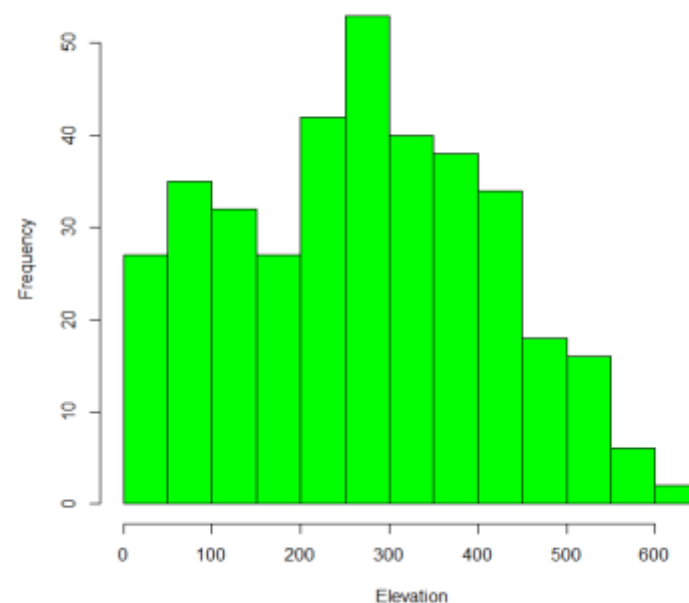
Area and topography

- 398 active catchments (141 rivers, 49 lochs, 146 impounding reservoirs, 21 springs, 41 boreholes)

Histogram of catchment area in km²



Histogram of catchment mean elevation

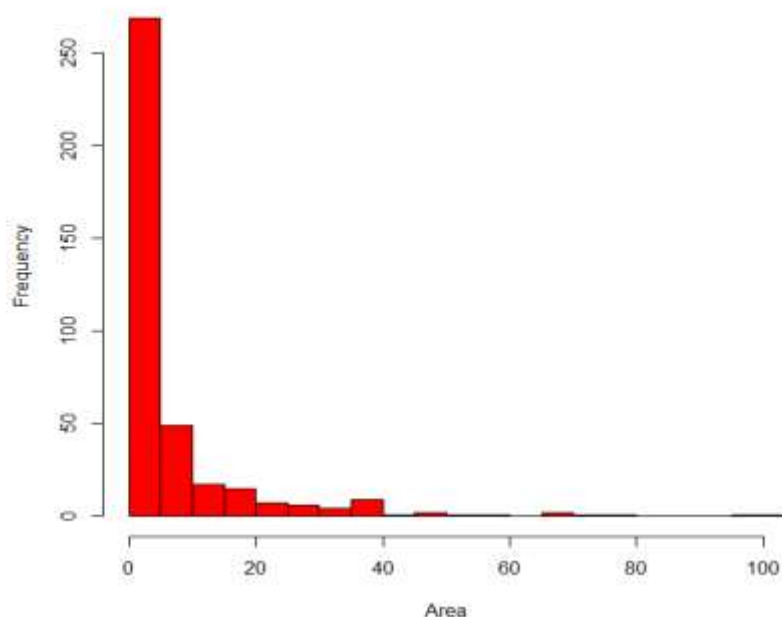


Scottish Water catchments

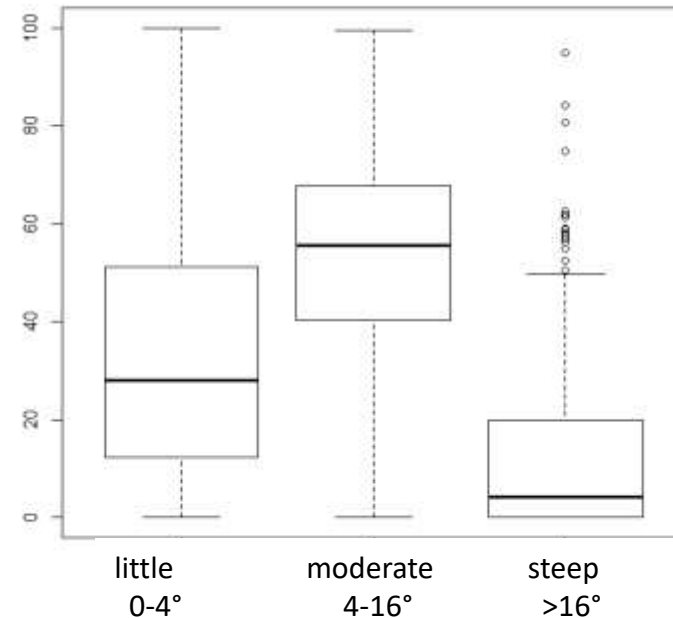
Area and topography

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Histogram of catchment area in km²



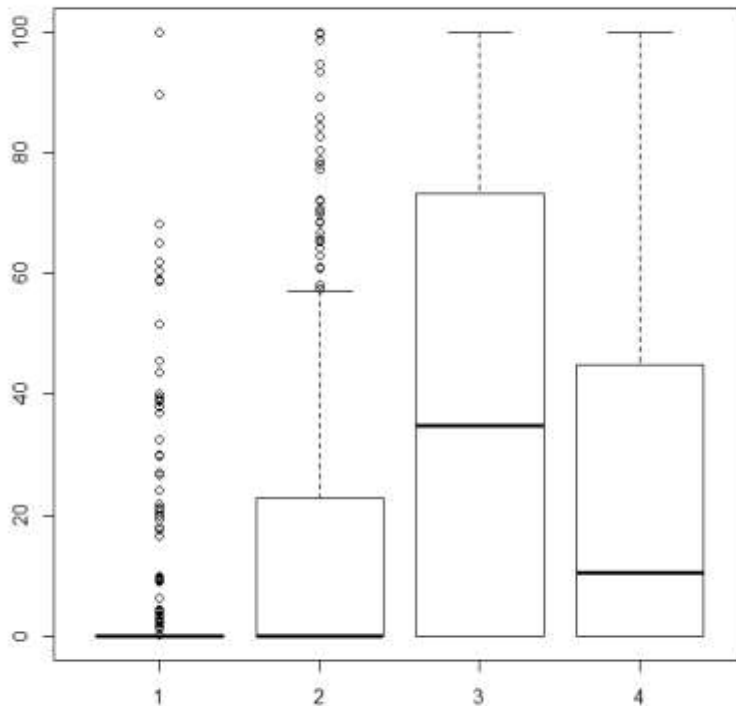
Distribution of slopes



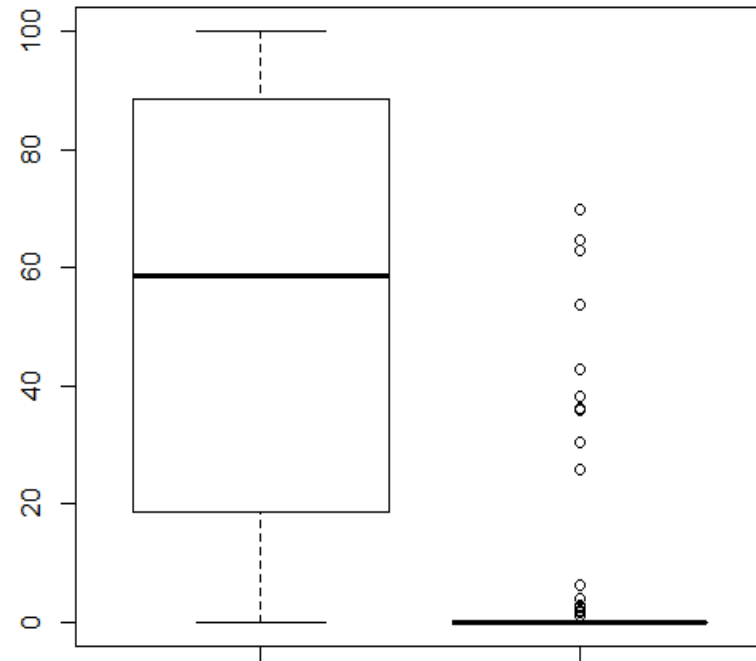
Scottish Water catchments

Soils

Distribution of HOST classes



Percentage of 1) peaty soil and 2) eroded peat soil



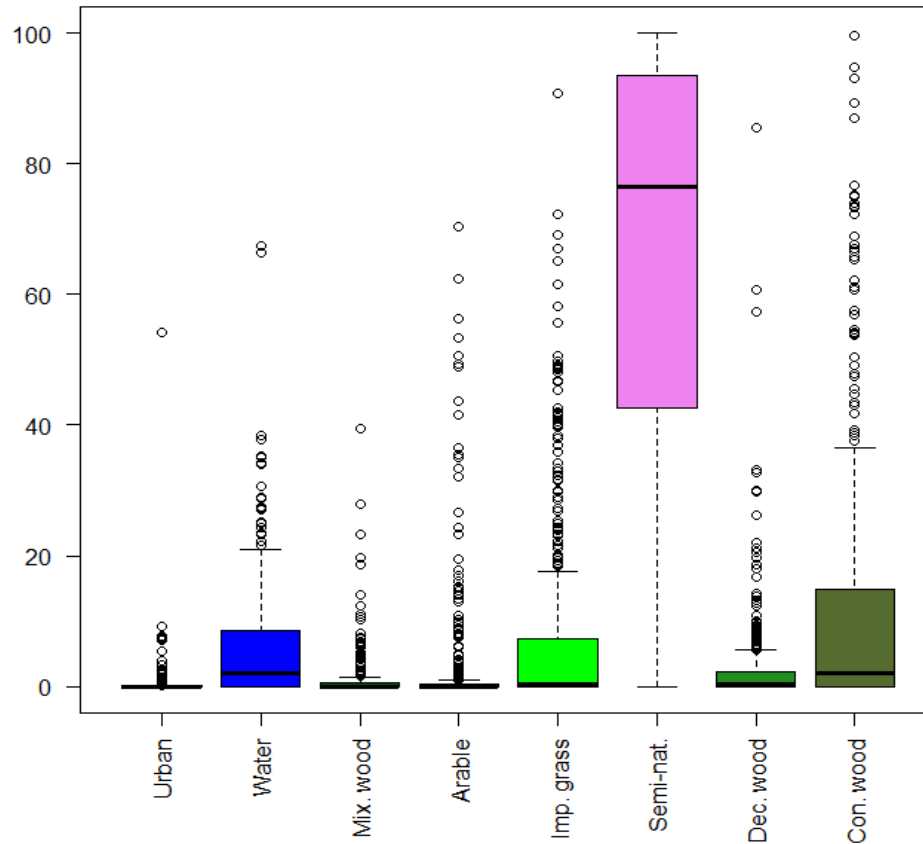
Classes 1-4: Combinations of HOST classes moving from relatively well drained soils (1) to increasingly poorly drained soils (4).

Scottish Water catchments

Land cover and use



Distribution of land cover

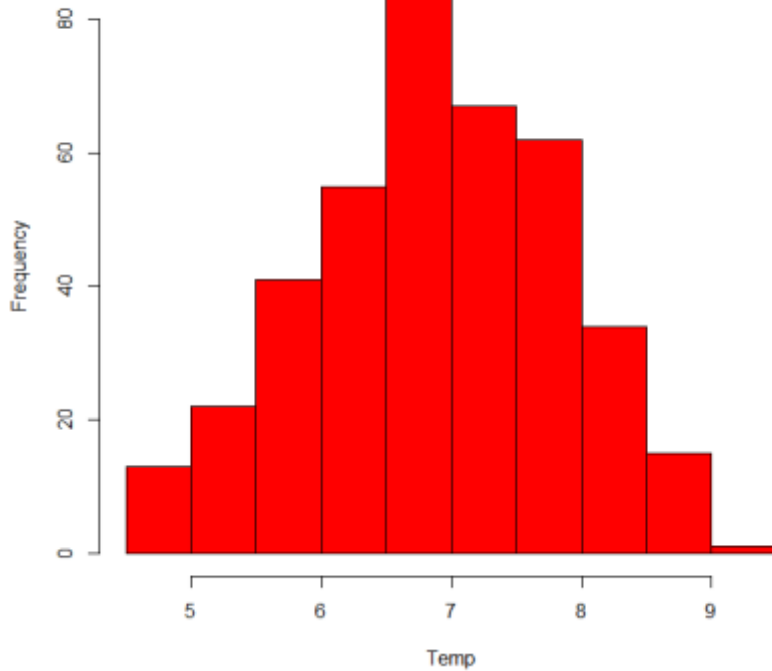


- Most catchments highly dominated by natural and semi-natural land cover
- Most catchments have low urban area cover
- Arable areas slightly underrepresented compared to Scotland as a whole (average 2.7% to app. 8.9%)

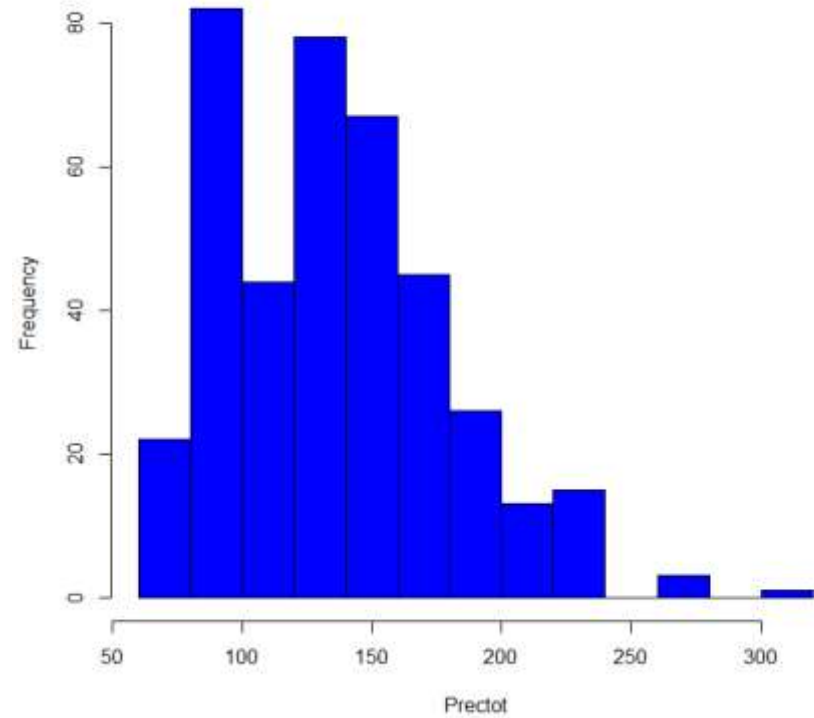
Scottish Water catchments

Climate

Mean annual temperature



Mean monthly total rainfall



Scottish Water catchments

Water quality



- 154 catchments were selected for analysing water quality
- For this subset, 8 parameters are sampled for all: aluminium, colour, pH, iron, manganese, coliform bacteria, *E. coli* bacteria, and turbidity
- For the time period 2011-2016
- With differing sampling regimes (3-monthly to weekly)

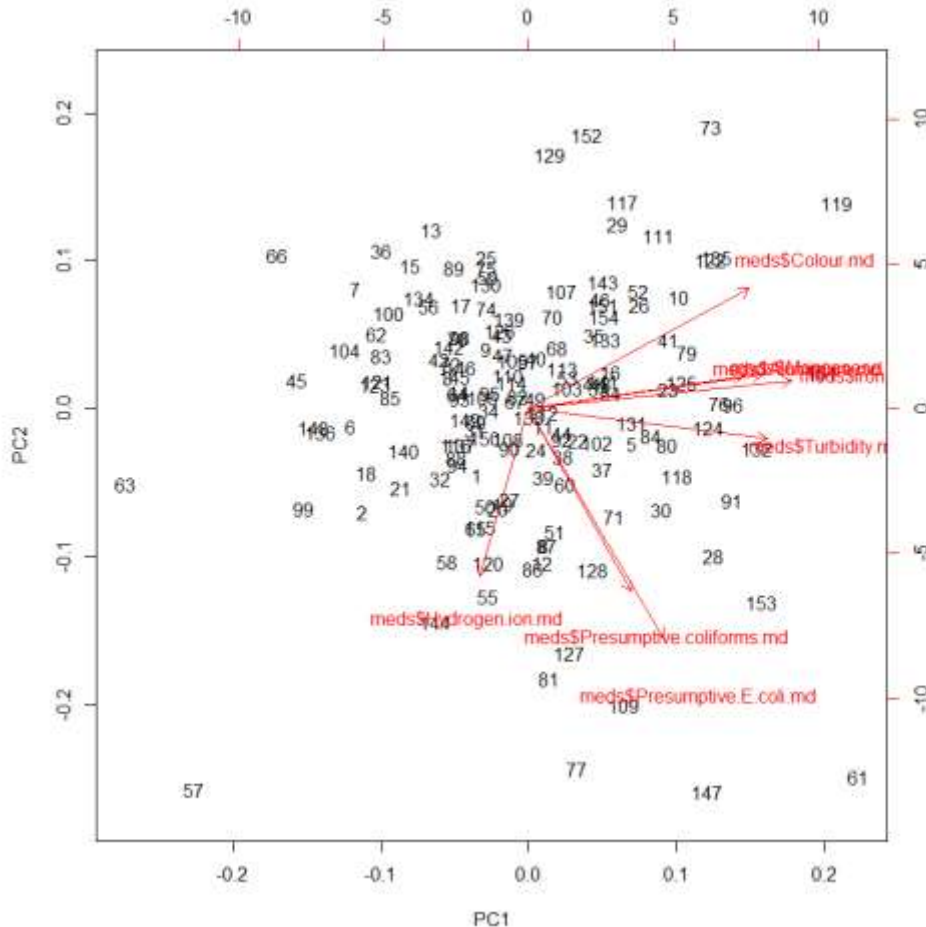
Data analysis

Key issues

- Different sample sizes
- Very skewed distributions within catchments as well as catchment medians
- Data for some catchments show seasonal patterns
- Very high outliers
- Of interest are middle points of the data as well as extremes

Data analysis

PCA



	PC1	PC2
Aluminium	0.38874736	0.09091455
Colour	0.39772264	0.32999396
pH	-0.08877231	-0.45999315
Iron	0.47550459	0.07632708
Manganese	0.42141568	0.09137342
Coliforms	0.18465621	-0.50215671
E.coli	0.24425592	-0.63099790
Turbidity	0.43053106	-0.08215960

Variability explained:

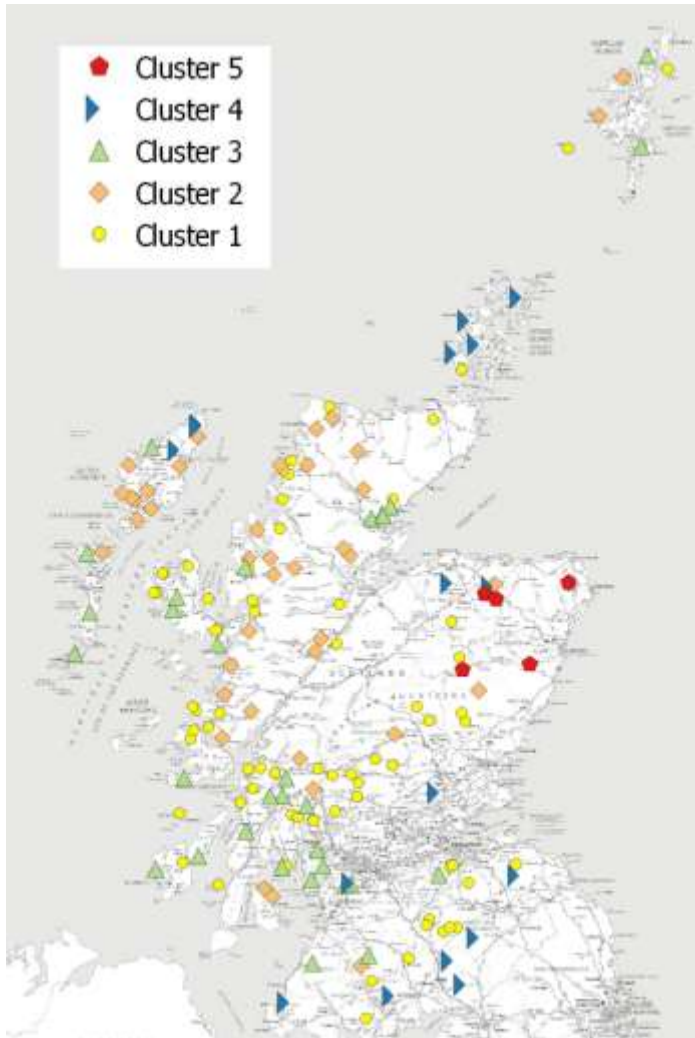
PC1: 46%

PC2: 20%

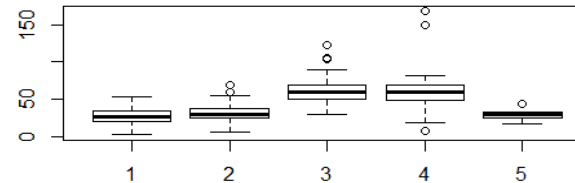
Total: 66%

Data analysis

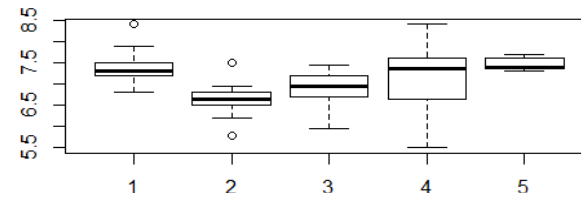
Cluster Analysis



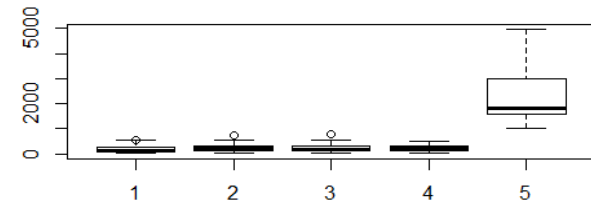
Colour median value by cluster (MediansScaled)



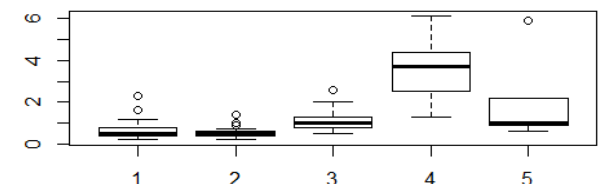
pH median value by cluster (MediansScaled)



Coliform median value by cluster (MediansScaled)

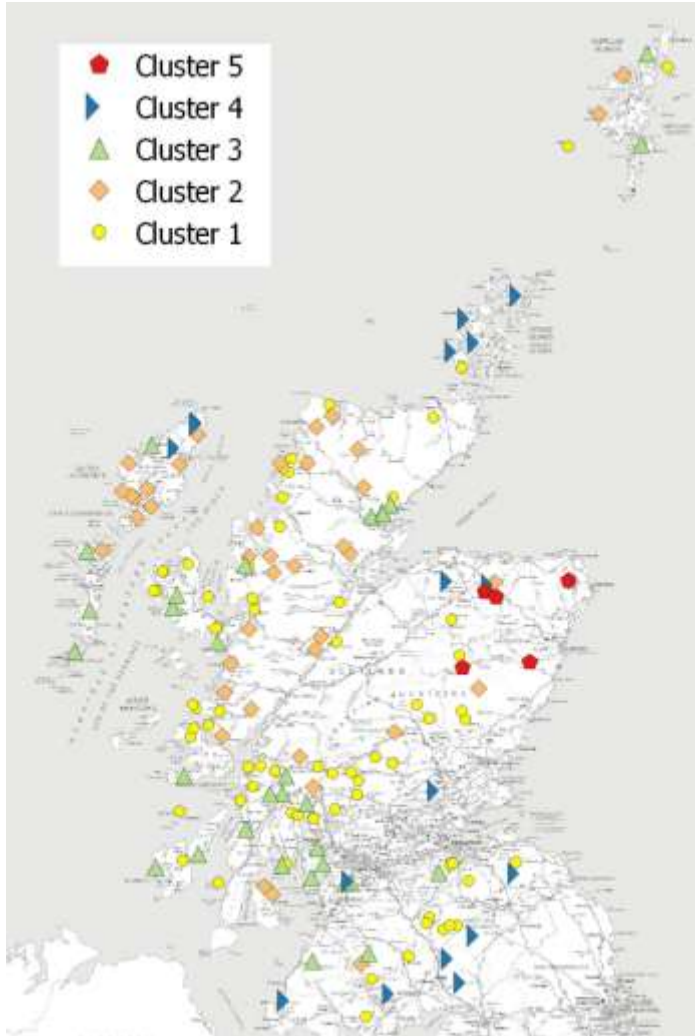


Turbidity median value by cluster (MediansScaled)

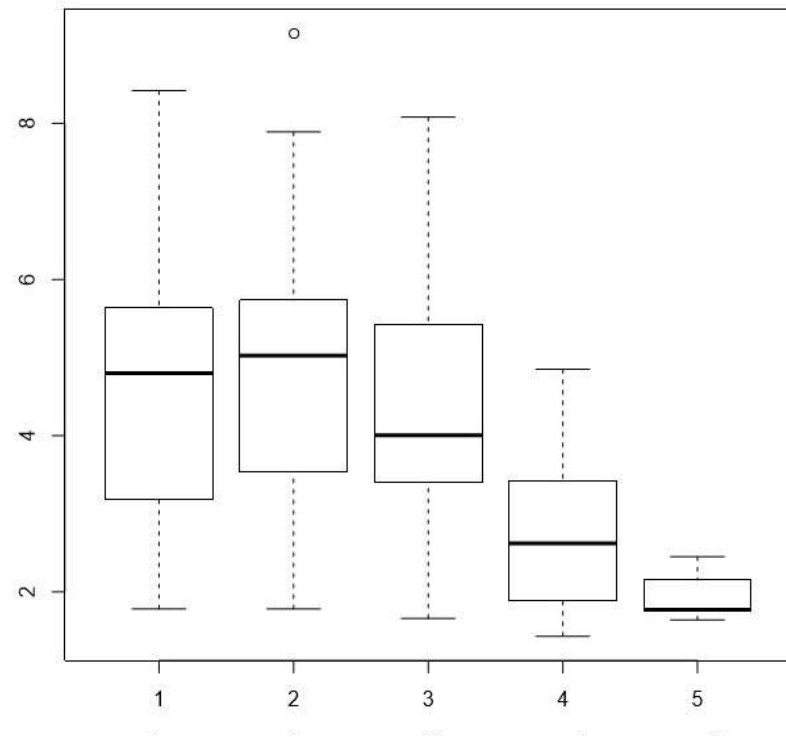


Data analysis

Cluster Analysis

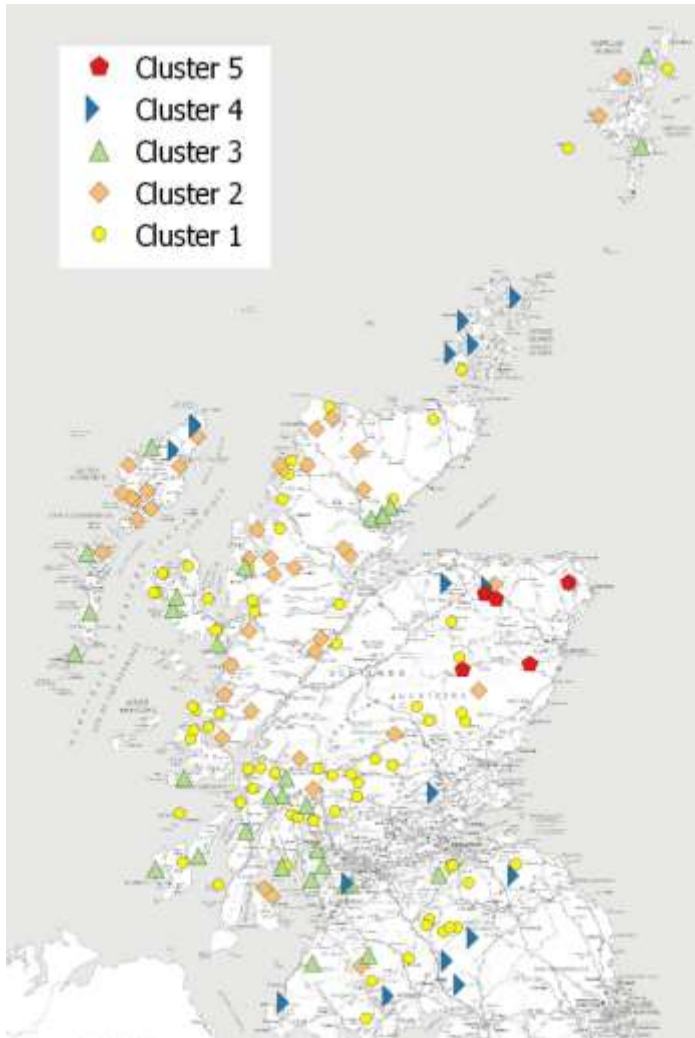


Mean no of days with above 10mm rainfall by cluster (all scaled medians)

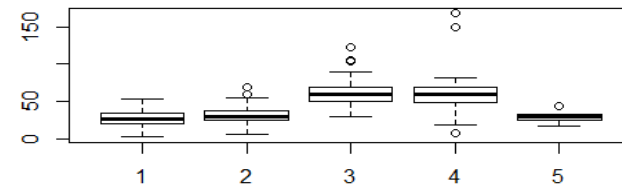


Data analysis

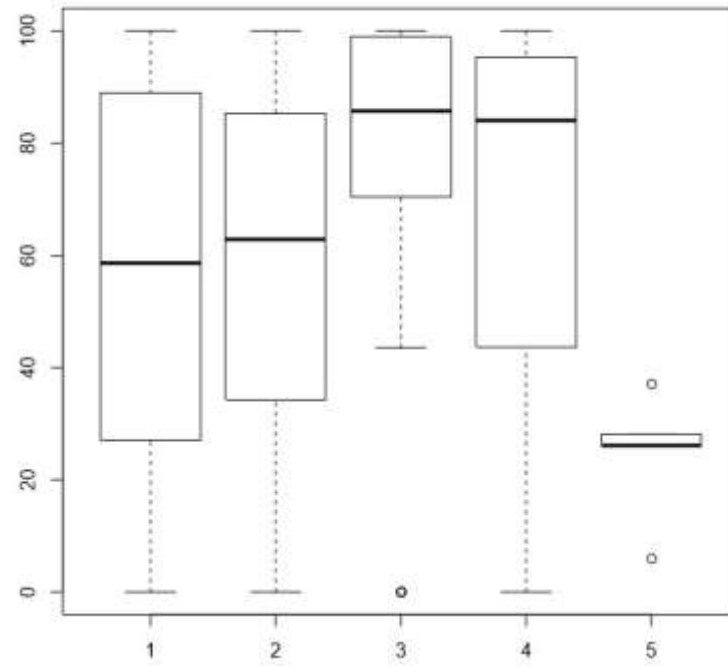
Cluster Analysis



Colour median value by cluster (MediansScaled)

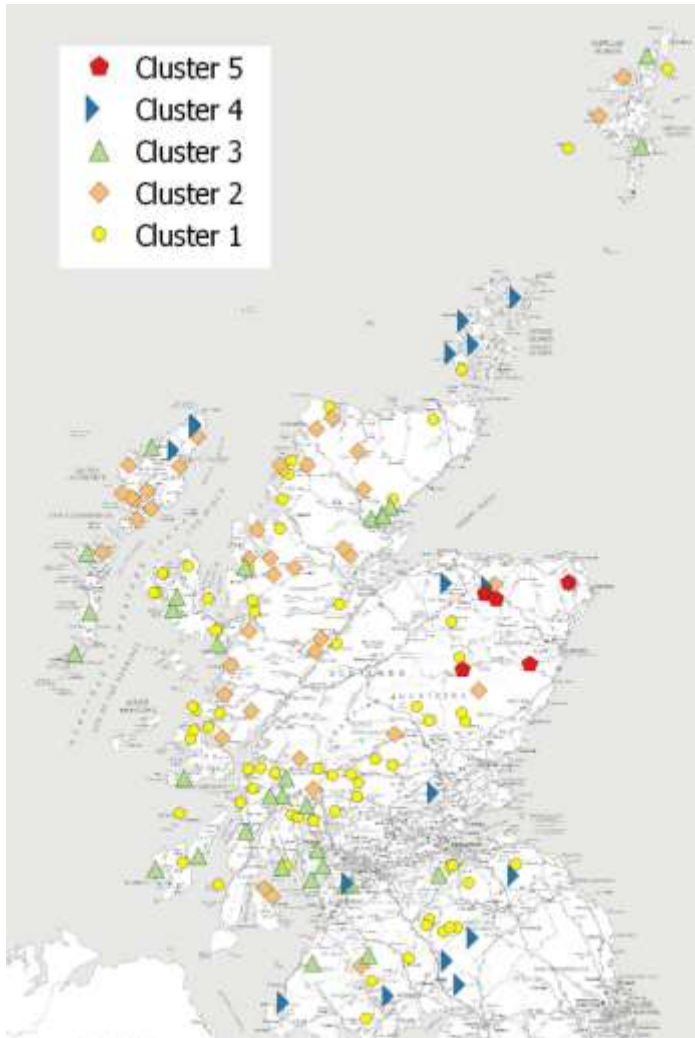


Peat component by cluster (all scaled medians)

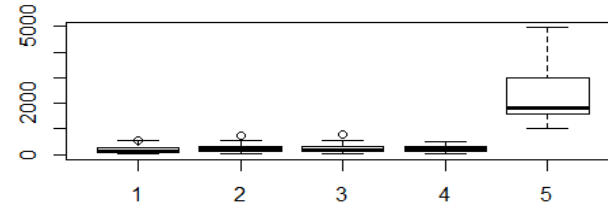


Data analysis

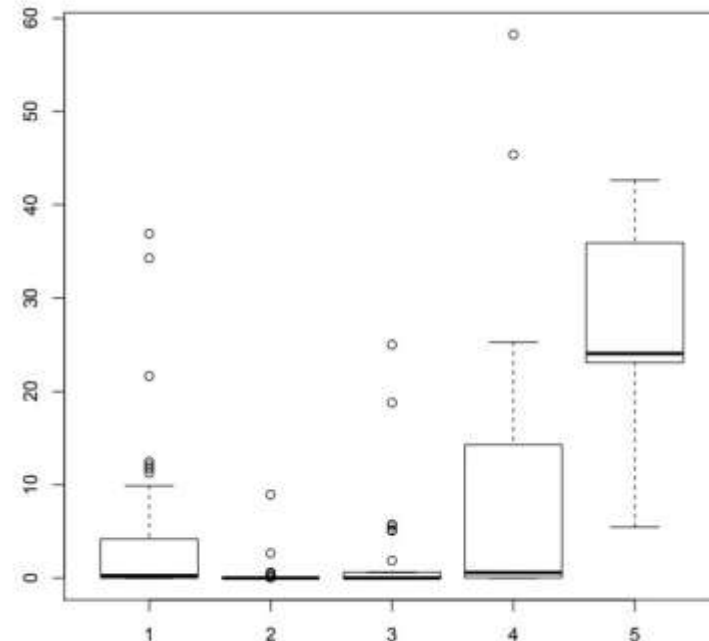
Cluster Analysis



Coliform median value by cluster (MediansScaled)

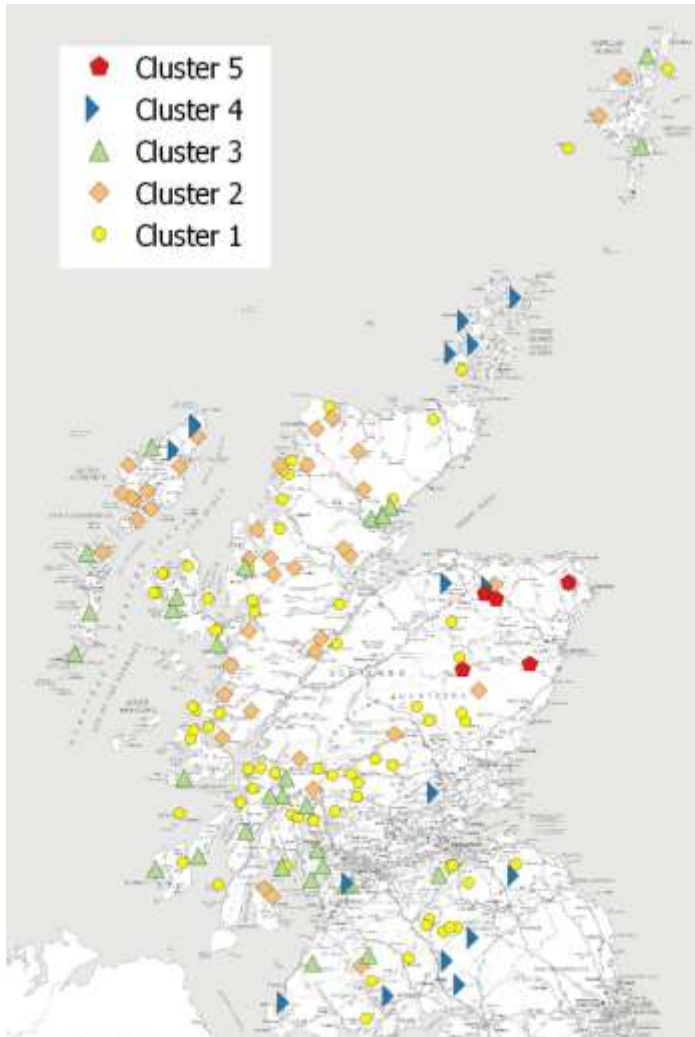


Improved grassland cover by cluster (all scaled medians)

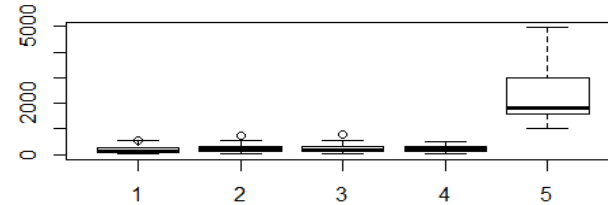


Data analysis

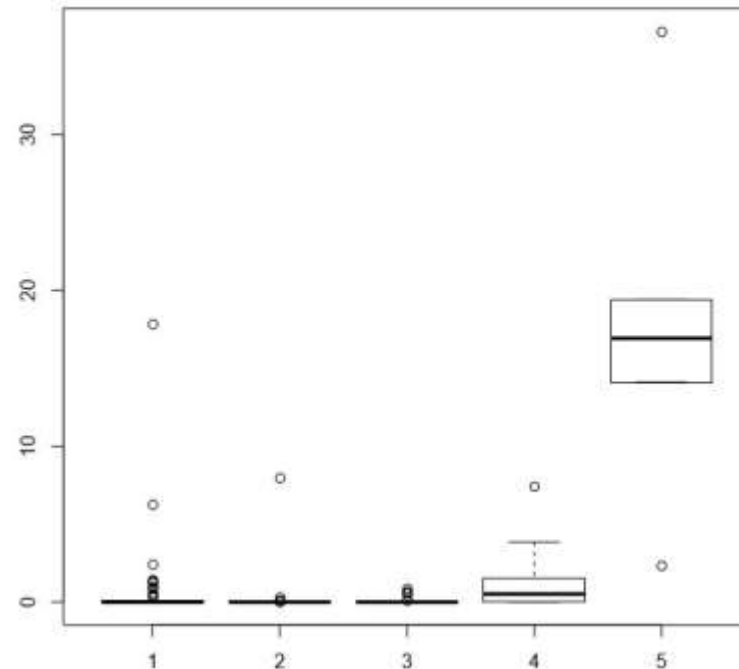
Cluster Analysis



Coliform median value by cluster (MediansScaled)



Arable cover by cluster (all scaled medians)



Data analysis

Regression trees

Colour – medians and 95th percentiles

SlopeSteep > 20.18

+--yes: **SlopeSteep > 36.5**

| +--yes: [16.230769, 37.126923]: 13

| +--no: [29.113636, 57.518182]: 22

+--no: **Peat > 81.69**

+--yes: [58.803571, 130.653571]: 28

+--no: [37.755556, 74.476667]: 45

RMSE: [19.21, 47.33]

R²: [0.57, 0.55]

Coliforms – medians and 95th percentiles

Arable > 17.83

+--yes: [3975, 11355]: 2

+--no: **ImprovedGrass > 36.91**

+--yes: [1017.5, 5627.5]: 2

+--no: **SlopeLittle > 86.41**

+--yes: [355, 5405]: 3

+--no: [207.683168, 1649.757426]: 101

RSME: [231.84, 1569.79]

R²: [0.91, 0.69]

Data analysis

Regression trees

Turbidity – medians and 95th percentiles

PrecdaysAnnual > 1.64

+--yes: SlopeLittle > 40.0

| +--yes: HOST4 > 88.62

| | +--yes: [4.35, 28.335]: 2

| | +--no: [1.449828, 6.342948]: 29

| +--no: Arable > 0.28

| +--yes: [1.063333, 6.977833]: 12

| +--no: [0.580952, 2.061675]: 63

+--no: [6, 65.7625]: 2

RMSE: [0.63, 5.95]

R²: [0.82, 0.84]

Risk assessment

Lead questions

- DOC release from peatland – contributing conditions and climate change
- Expansion of areas suitable for (more intensive) agriculture through climate change

Risk assessment

Information and use

Catchment management opportunities:

- Catchments that are sensitive to change can be monitored and investigated further
- Areas with the potential for successful restoration can be identified
- Benefits and trade-offs of managing for water quality can be described and communicated

A Characterisation of Scottish Drinking Water Catchments

Thank you for listening!

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