Does land use affect pathogen presence in New Zealand drinking water supplies?

B. J. Phiri[b], **R.G. Death[a*]**, P. J. Biggs[b] , D. J. Prattley[b] , A. B. Pitab , M. A. Stevenson[c], D.T.S. Hayman[b], M.T. Davis[a,b], A.D. Canning[d] and N. P. French[b]

[a] Innovative River Solutions, School of Agriculture and Environment, Massey University, Private Bag, 11 222, Palmerston North 4442, New Zealand
[b] Molecular Epidemiology and Public Health Laboratory, Hopkirk Research Institute, Massey University, Private Bag, 11 222, Palmerston North 4442, New Zealand
[c] Asia-Pacific Centre for Animal Health, Faculty of Veterinary and Agricultural Sciences, The University of Melbourne, Parkville, VIC 3010, Australia
[d] Wellington Fish and Game, P O Box 1325, Palmerston North 4440, New Zealand

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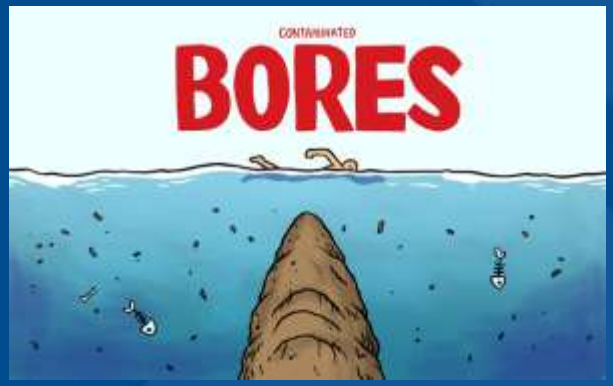
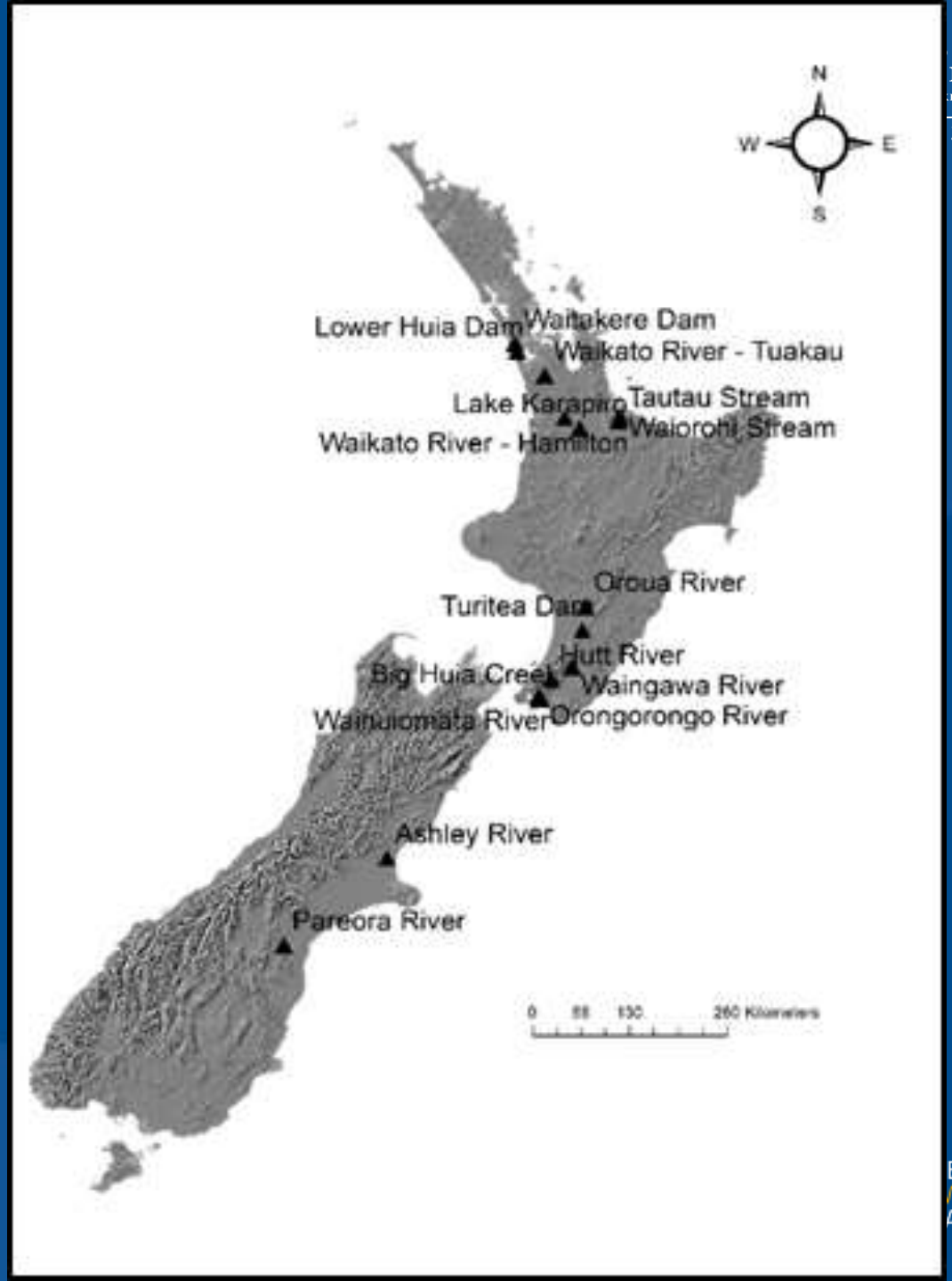
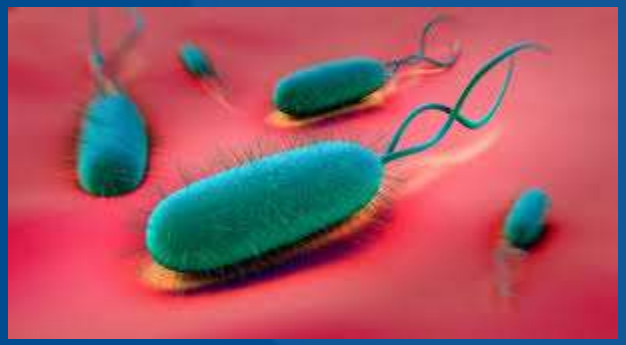
Water quality is a (the) major topic of environmental concern in New Zealand

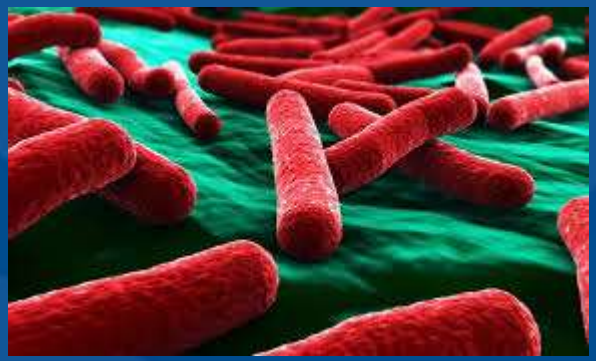


Samples were collected from the water abstraction point at each of 16 study sites every three months between 2009 and 2019



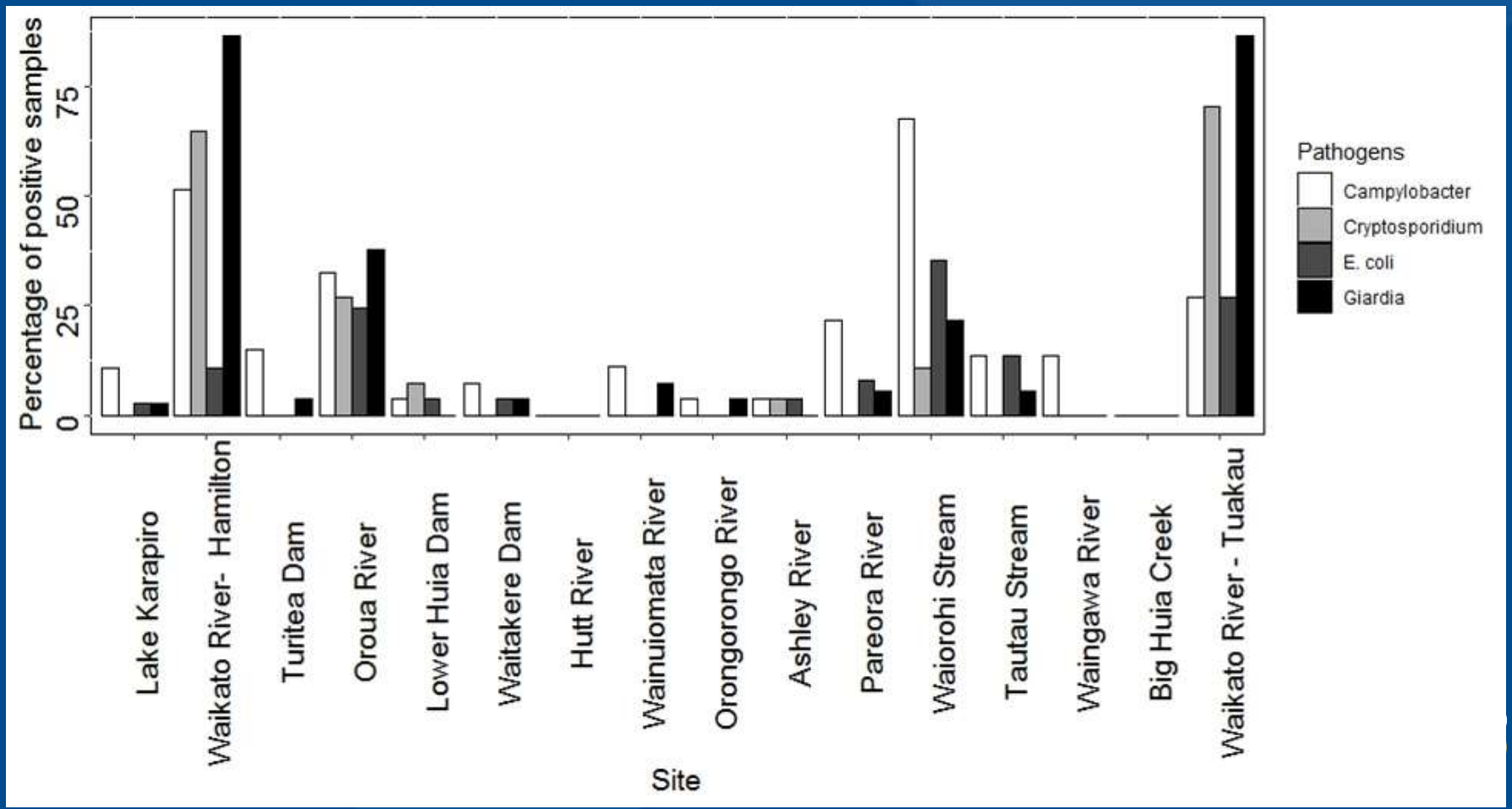


Four microbes *Campylobacter sp.*, *Escherichia coli*, *Cryptosporidium* and *Giardia* were measured with standard techniques.



Two sites on the Waikato River, the Oroua River and Waiorohi Stream had all four microbes present, often in high numbers.

Other sites, such as the Hutt River and Big Huia Creek in Wellington, never had pathogenic microbes or unsafe levels of *E. coli*.



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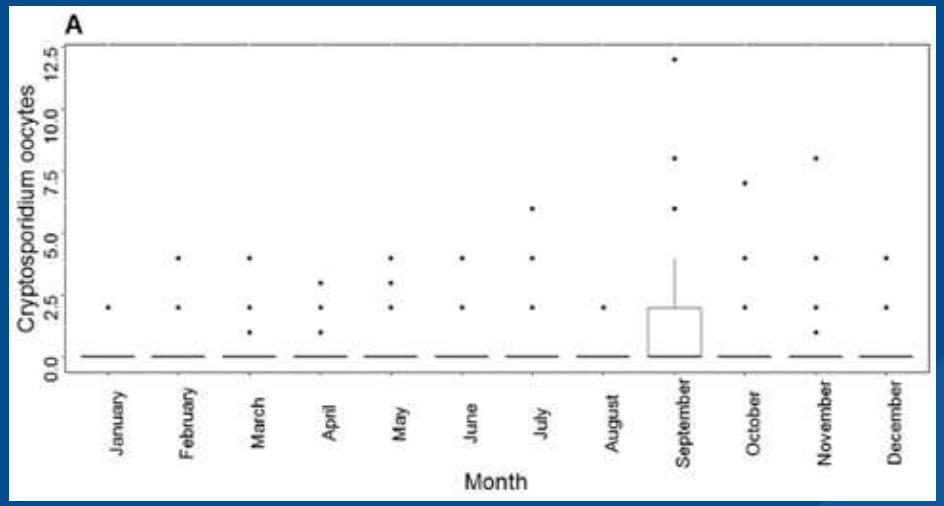
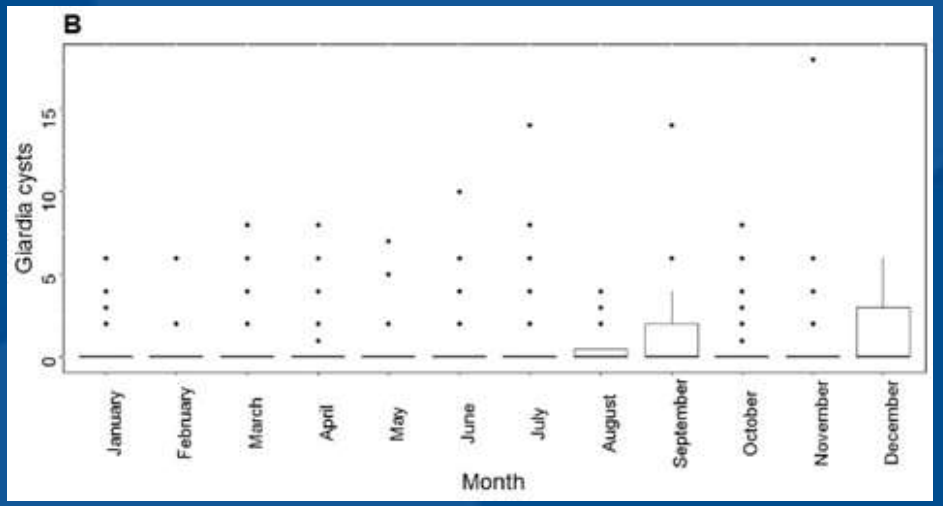
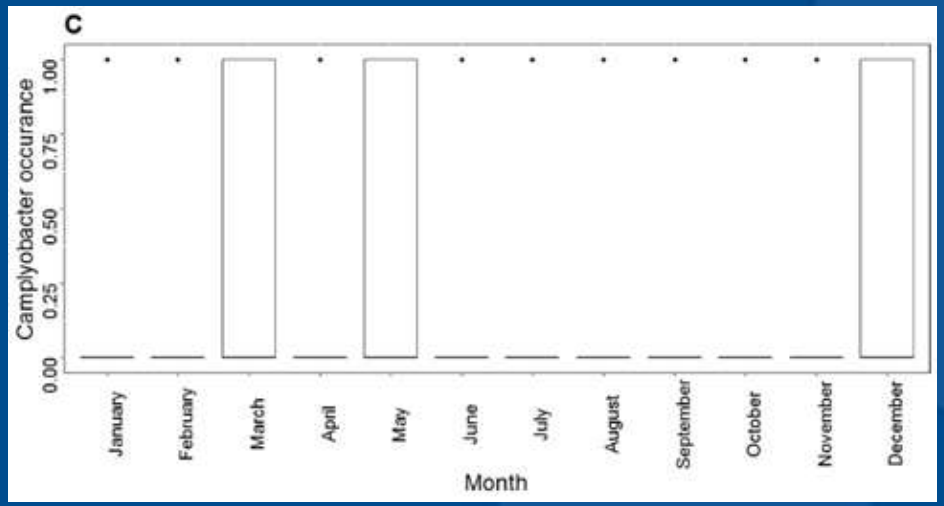
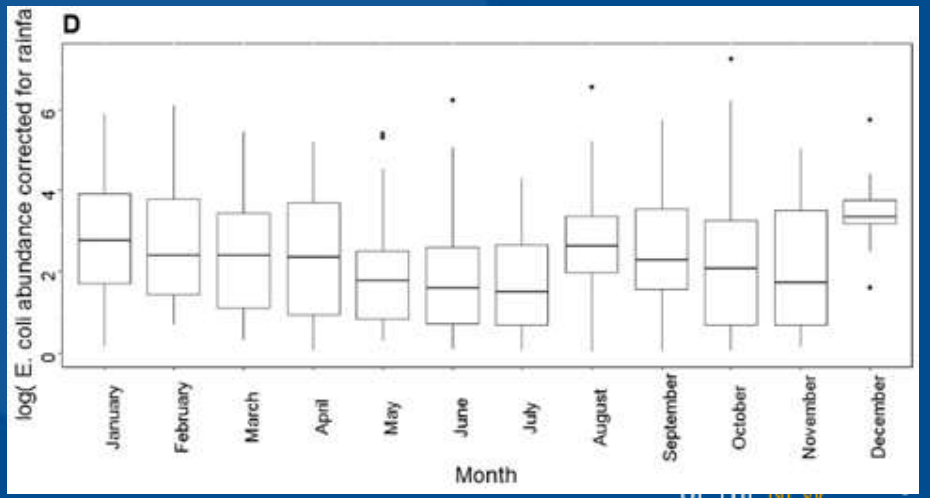
Seasonal patterns

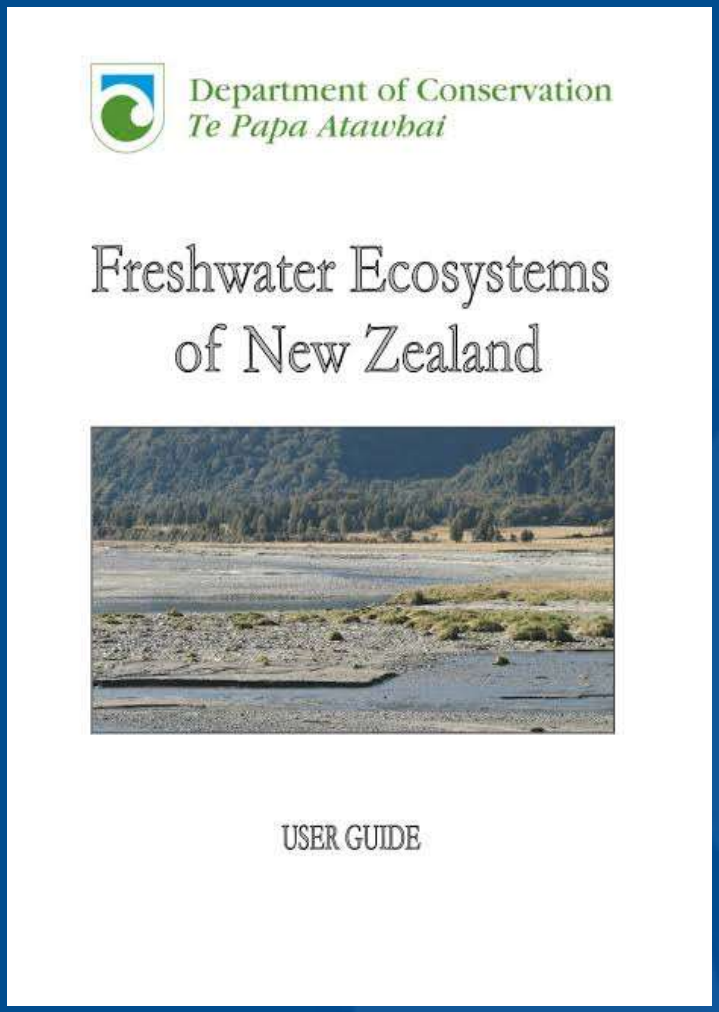


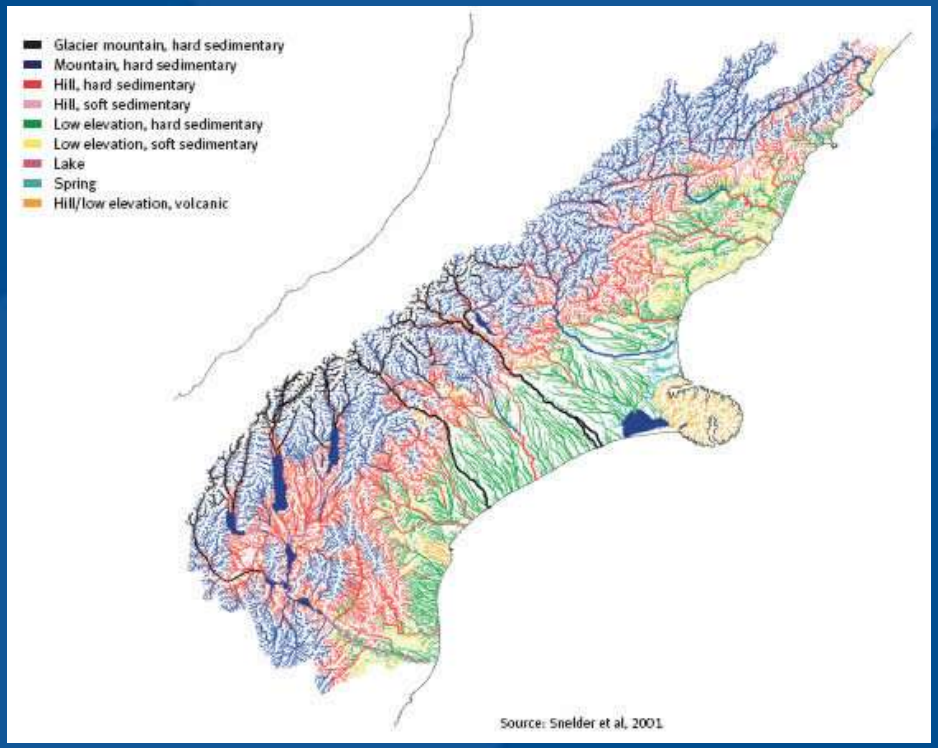






Large number of GIS variables linked with New Zealand rivers





Easting	**Full NZMG Easting**
Northing	Full NZMG Northing
DHB	District Health Board
Ecoli_pred	E coli collected
Ecoli_rain_pred	E coli/rainfall
Rain	Rainfall
Deficit	Soil deficit
Runoff	Runoff
Season	Season
Month	Month
Ruminants	Number of ruminants
Rum_density	Ruminants/catchment area
Dairy_density	Dairy/area in dairy
pop11	Population in 2011
ORDER_	Stream order
DISTSEA	Distance to the sea
CATCHAREA	catchment area
SegJanAirT	Summer (January) air temperature (degrees C) – used in the absence of robust estimates of water temperature
SegMinTNorm	Average minimum daily air temperature (degrees C) normalised with respect to SegJanAirT – negative values indicate strongly seasonal climates and positive values indicate weakly seasonal climates
SegFlow	Mean annual flow (m^3/sec), derived from hydrological models, provided by Jochen Schmidt, NIWA, 2006
SegFlowVariability	Mean annual 7-day low flow (m3/sec), derived from hydrological models, provided by Jochen Schmidt, NIWA, 2006 – see http://wrenz.niwa.co.nz/webmodel/ for details.
SegSlope	Segment slope (degrees), derived from GIS calculation using length and difference between upstream and downstream elevation for each segment
SegRipShade	Riparian shading (proportion), the likely degree of riparian shading derived by using national, satellite image-based vegetation classification to identify riparian shading in each segment, with the degree of shading then estimated from river size and expected vegetation height
SegCluesN	Nitrogen concentration (ppb) as estimated from CLUES, a leaching model combined with a regionally-based regression model, implemented within a catchment framework (Woods et al., 2006)
	Average slope (degrees), from mid-point of each river segment to the coast, differing from the original REC estimates of downstream slope

47 potential variables

Artificial intelligence

Machine Learning

Big Data

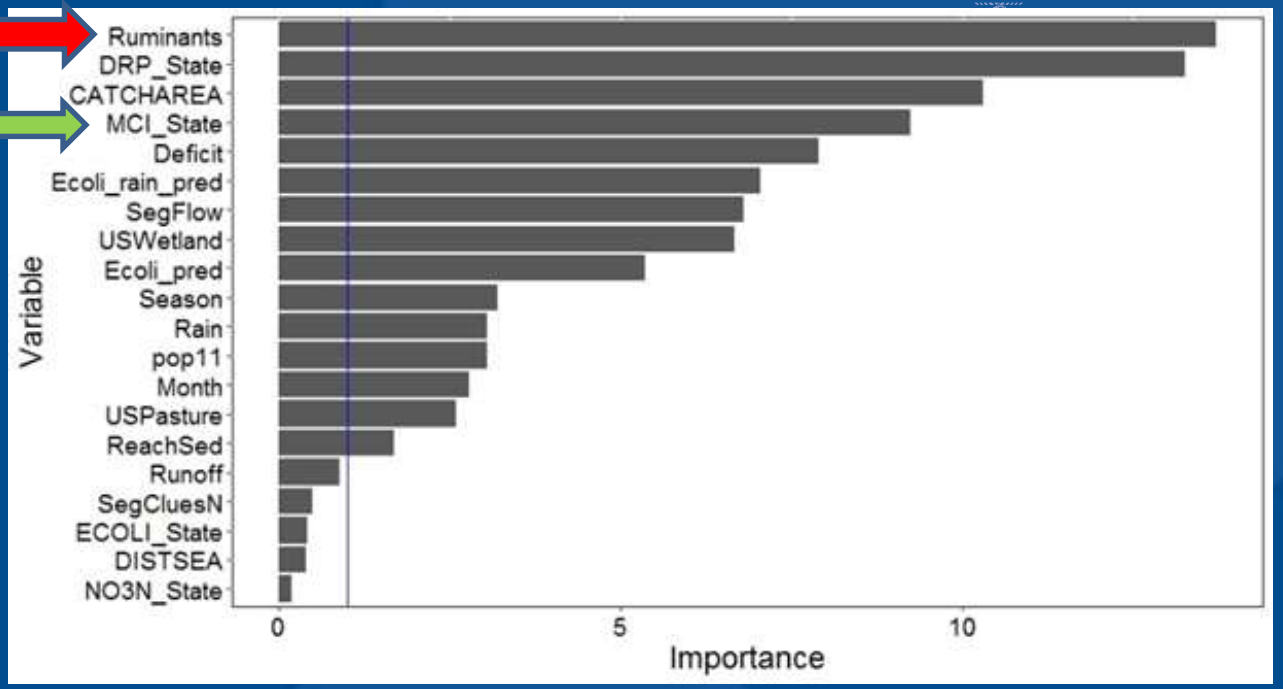
Non-linear modelling

= Boosted Regression Trees

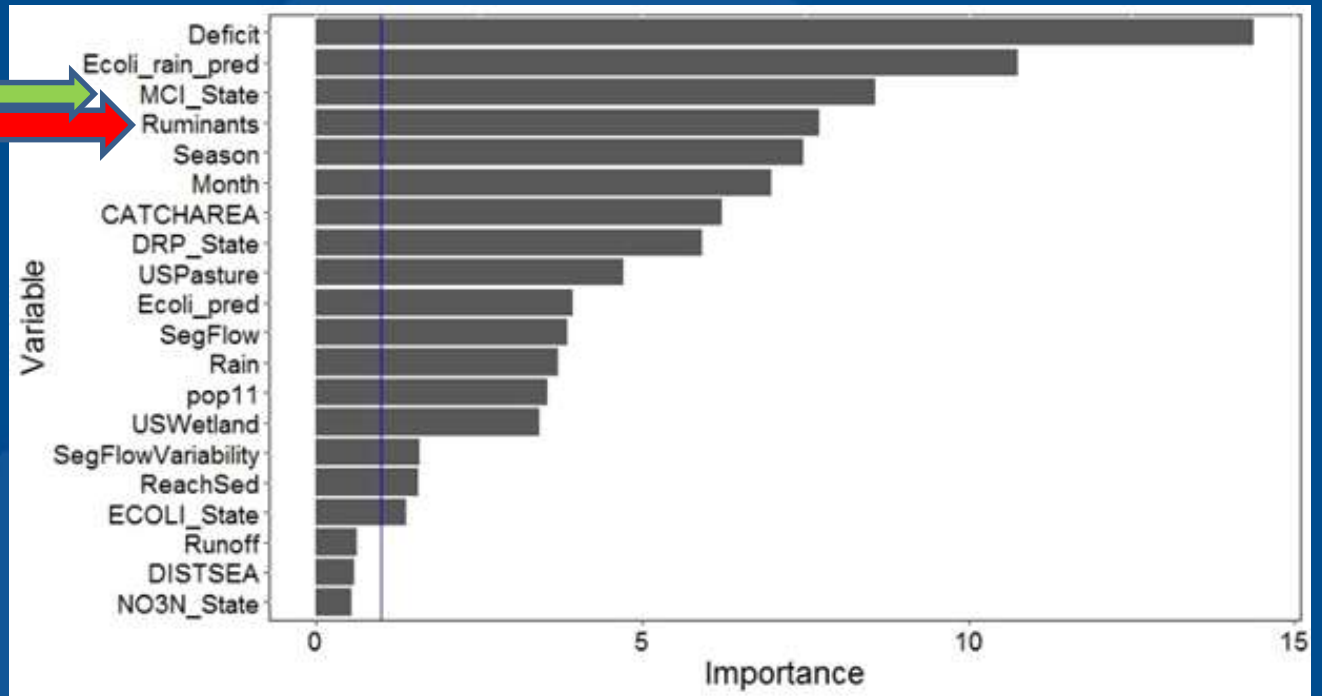
Artificial intelligence is already in widespread use

Important variables linked with

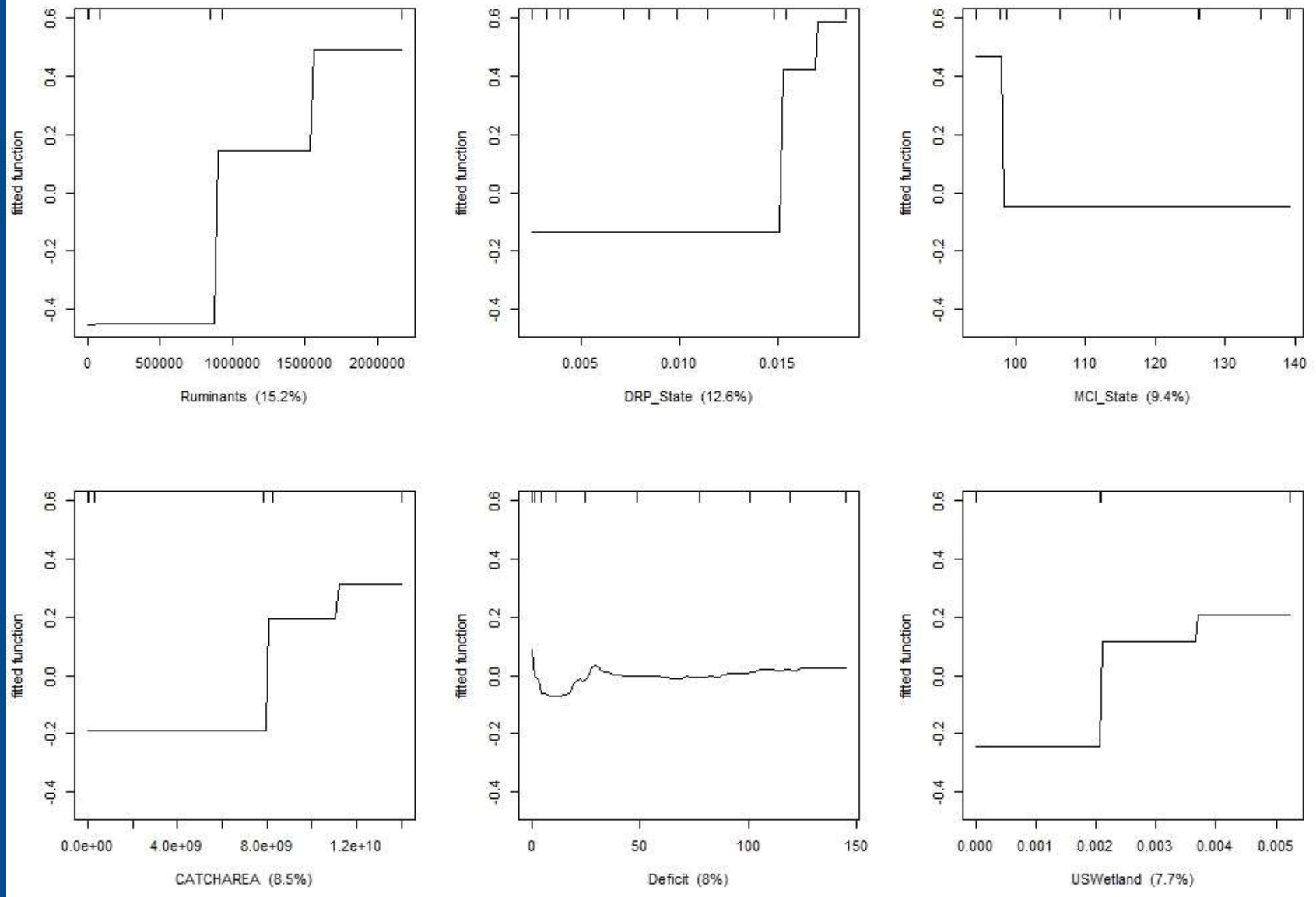
Giardia
CV r = 0.71



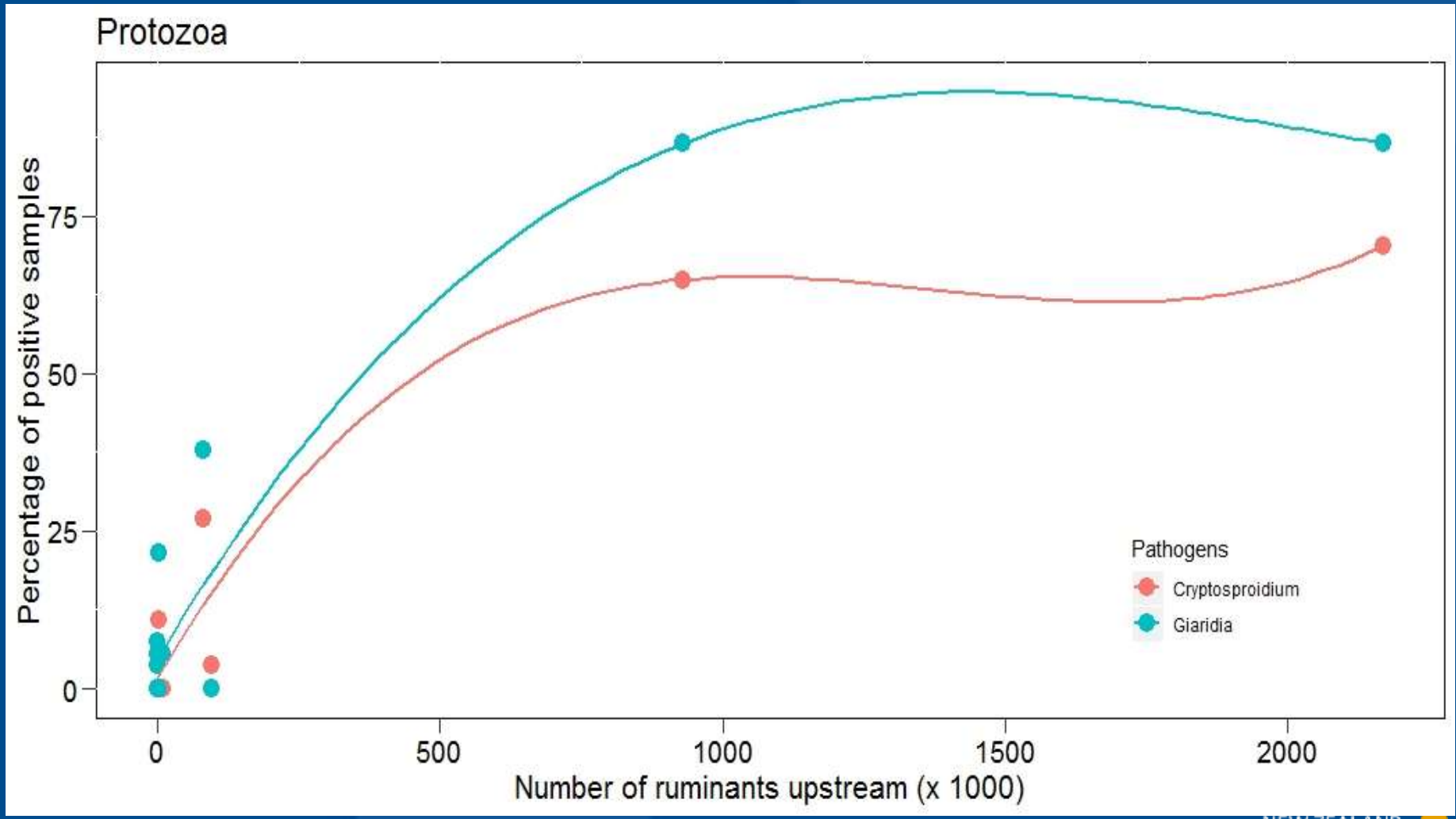
Cryptosporidium
CV r = 0.61



What happens to predictions if we model key variables while holding all others constant?



The more ruminants in the catchment the more protozoa

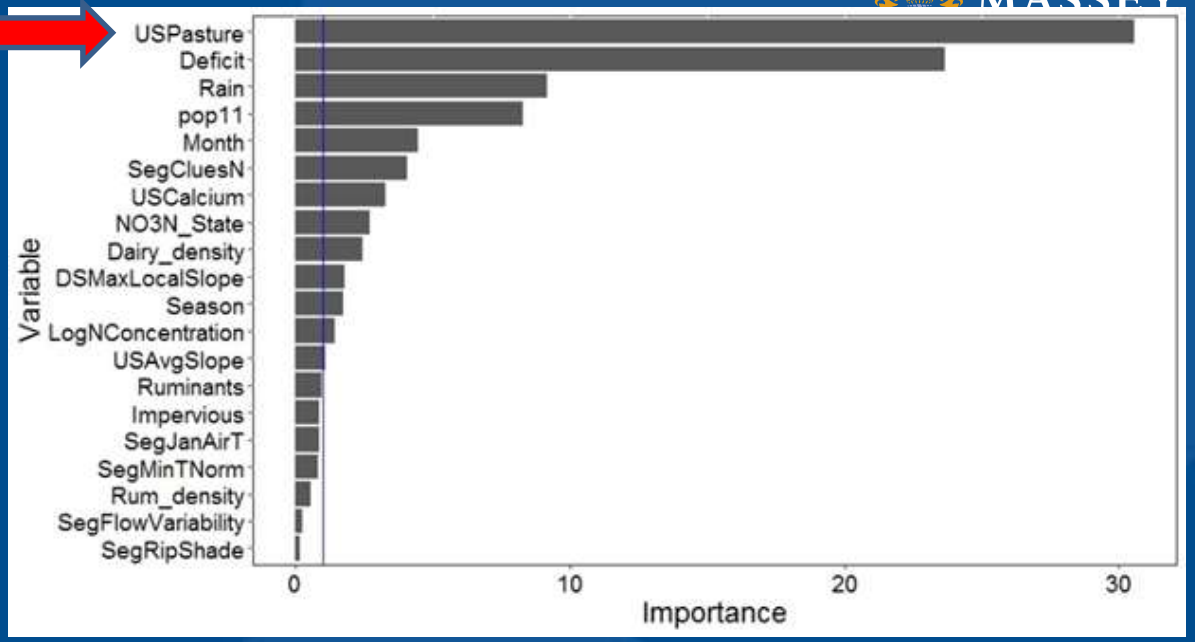


Protozoa were more prevalent in waterways with:

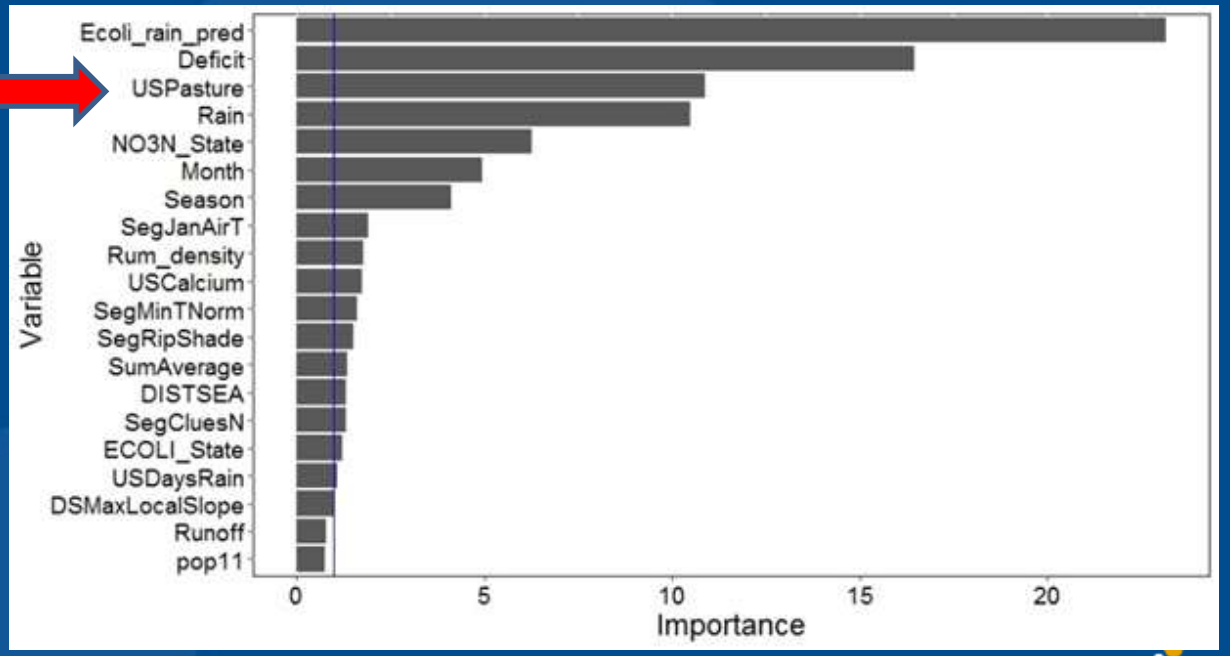
1. Lower water quality,
2. Higher numbers of ruminants in the catchment, and
3. In September and December.

Important variables linked with

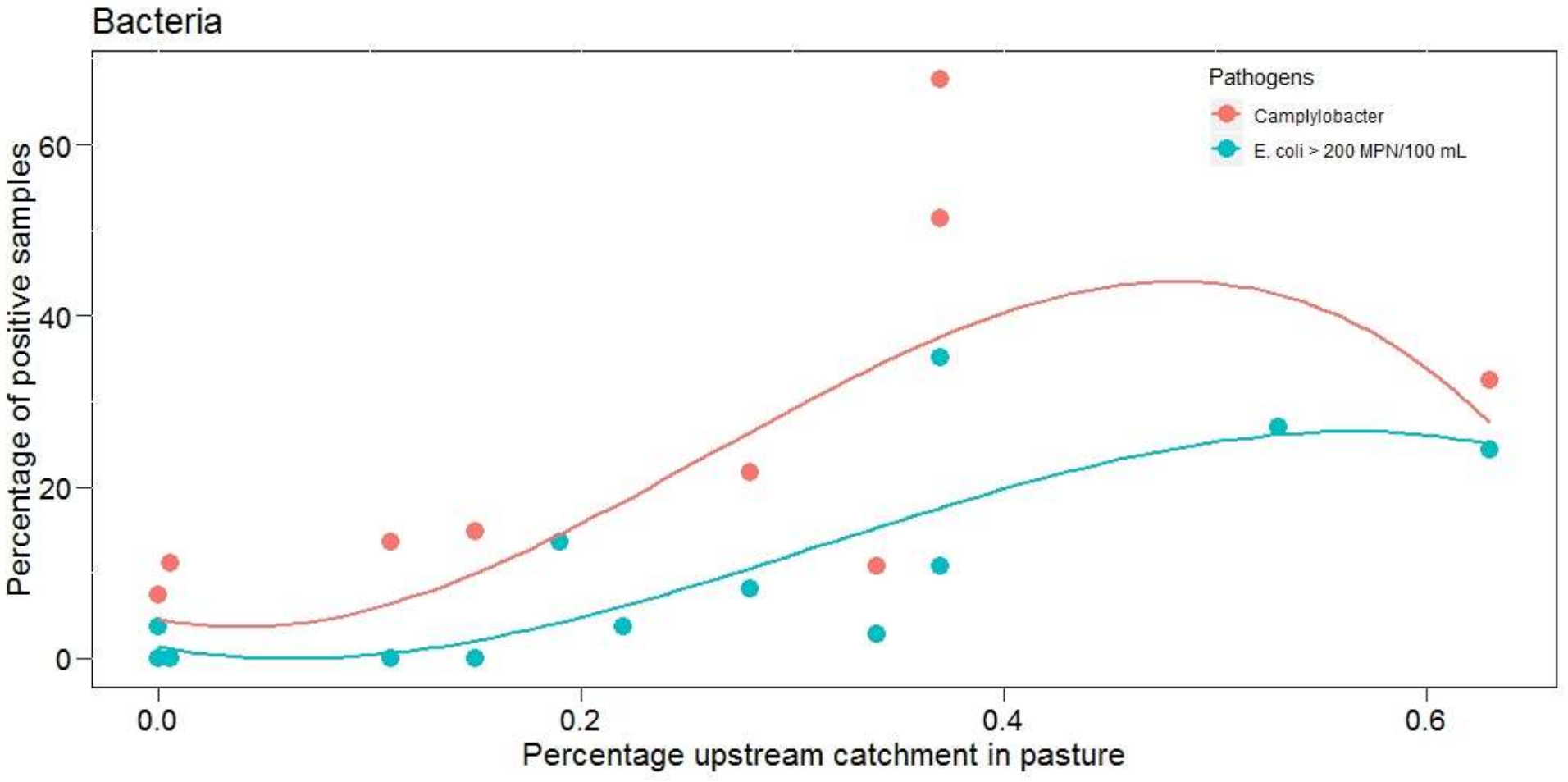
E. coli corrected for rainfall
CV r = 0.51



Campylobacter sp.
CV r = 0.47



The more of the catchment in pasture, the greater the presence of pathogens



Summary

1. Pathogens are more abundant at some water supply sites than others.
2. Frequency of specific pathogen prevalence is weakly correlated with the prevalence of the other microbes. But in general, sites with pathogens tended to have all of them present.
3. Protozoan abundance was strongly linked with the number of ruminants in the catchment, but also ecological health of the waterway.
4. Bacterial abundance was most strongly linked with rainfall and the percent of the catchment in pasture.
5. Although drinking water at all these sites is treated, the recent outbreaks of drinking water contamination highlight that water managers also need to consider management of the water supply catchment to ensure safe drinking water.