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Using historical data to identify future water quality trends at a regional scale

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1. BACKGROUND

Climate change is expected to have a severe impact on water resources management in Australia [1]. This is expected to lead to increased frequency in extreme hydrological events such as droughts and floods, which will in turn contribute to higher risks of bushfires, fish kills, and water shortage for both humans and the environment. The potential impacts of these climate-change-induced extreme events on the quantity of water available to humans and the environment are relatively well understood. However, we have little understanding of the effect on the water quality of Australian rivers. This project aims to start filling this gap in our understanding.

2. AIMS

- To identify how droughts have affected Victorian river water quality over the last two decades.
- To explore the spatial variability of these impacts.
- To use these past observations as a basis to predict how river water quality across Victoria will be affected by climate change based on different catchment characteristics

3. DATA

Water quality data from 102 sites across Victoria from the last 20 years were studied. Five water quality parameters were studied:

I. Electrical Conductivity (EC)
II. Nitrates + Nitrites (NOx)
III. Total Kjeldahl Nitrogen (TKN)
IV. Total Phosphorus (TP)
V. Total Suspended Solids (TSS)

Water quality data values flagged as 'NV' (no value) and 'LT' (less than) were halved for later use.

4. DROUGHT PERIOD IDENTIFICATION

Periods of hydrological drought were identified using historical gridded rainfall data from AWAP over the last century. The drought period delineation algorithm from Saft et al. [2] was reproduced to obtain drought periods based on calculated annual rainfall anomalies (Fig. 1). Drought periods identified within the last 20 years corresponded to that of the Millennium Drought, and the focus of this study.

Drought periods were used to categorise water quality data temporally into different periods: Pre-drought, Drought, Post-drought, and Latest Drought (for catchments in which a new drought began after the end of the Millennium Drought).

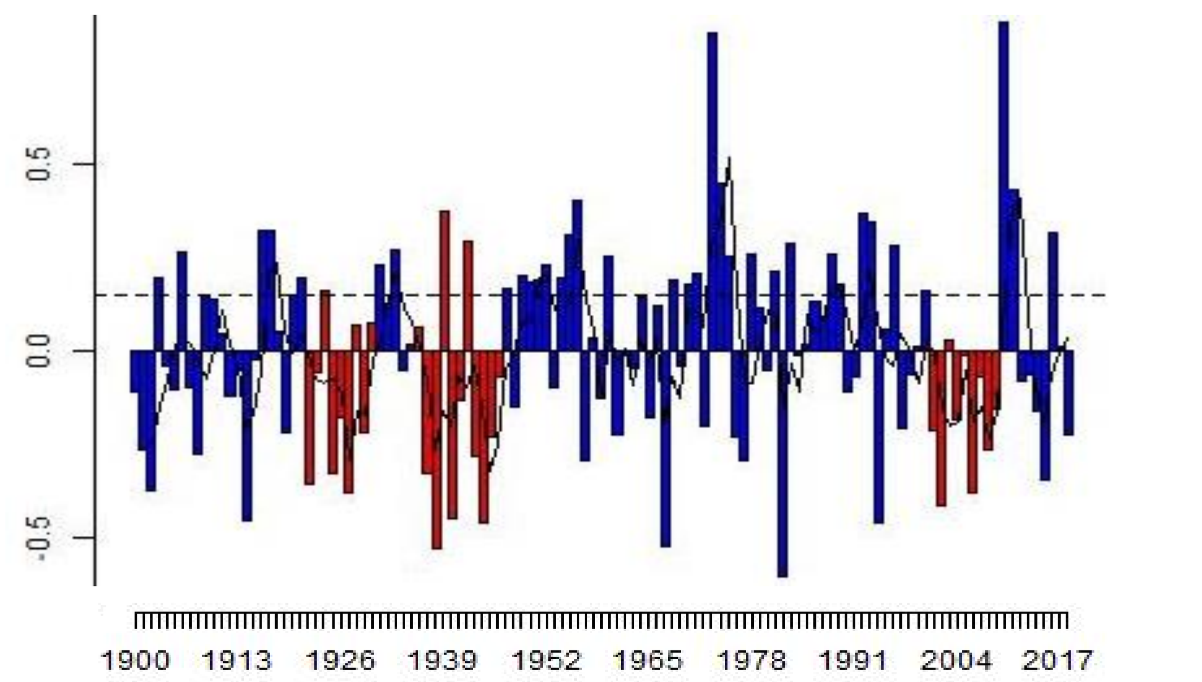

Fig. 1. Drought period identification based on rainfall anomaly (y-axis, %), with drought periods shown in red. Site #406214.

5. C-Q LINEAR RELATIONSHIP

The behaviour of the different water quality parameters were characterised by their concentration(C)-discharge(Q) relationship [3]. Linear regressions were performed using log-transformed data between discharge and each WQ parameter at each site. The relationship between concentration and discharge is given by the relationship $log(C) = a + b\ log(Q)$. Separate linear regressions were performed for data in separate drought/non-drought periods (Fig. 2).

A p-value check (≤ 0.05) of the regression lines was done, with only the statistically significant regressions carried forward to the next stage of analysis. The direction of change of slope, *b*, and the intercept, *a*, of the linear regressions lines between drought/non-drought periods were then further analysed.

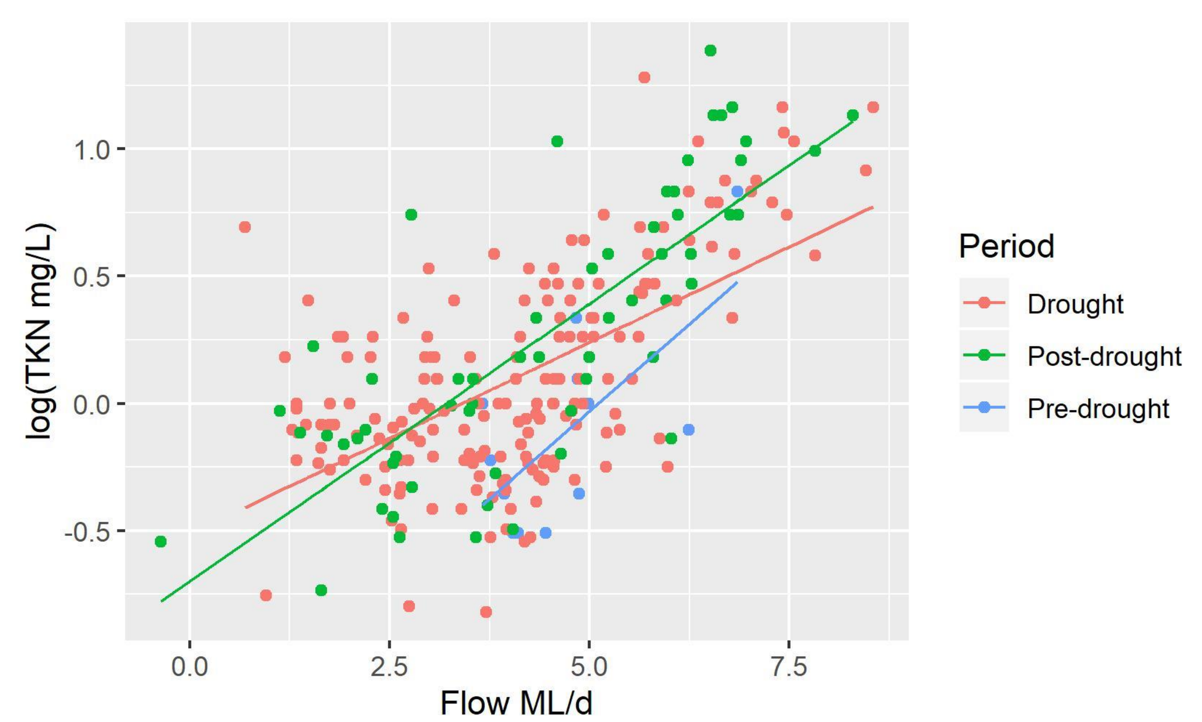

Fig. 2. C-Q linear relationship for different drought/non-drought periods. Site #236209.

6. ANCOVA ANALYSIS

ANCOVA analysis [4] was used to show if there was a significant change in slope/intercept from the first temporal period to the next (e.g. pre-drought to drought). Residual analysis of the ANCOVA process was also carried out, and sites in which there was evidence of biasedness and/or heteroscedasticity were removed from later analyses. Results are plotted spatially in Fig. 3, and summarized in Fig. 4.

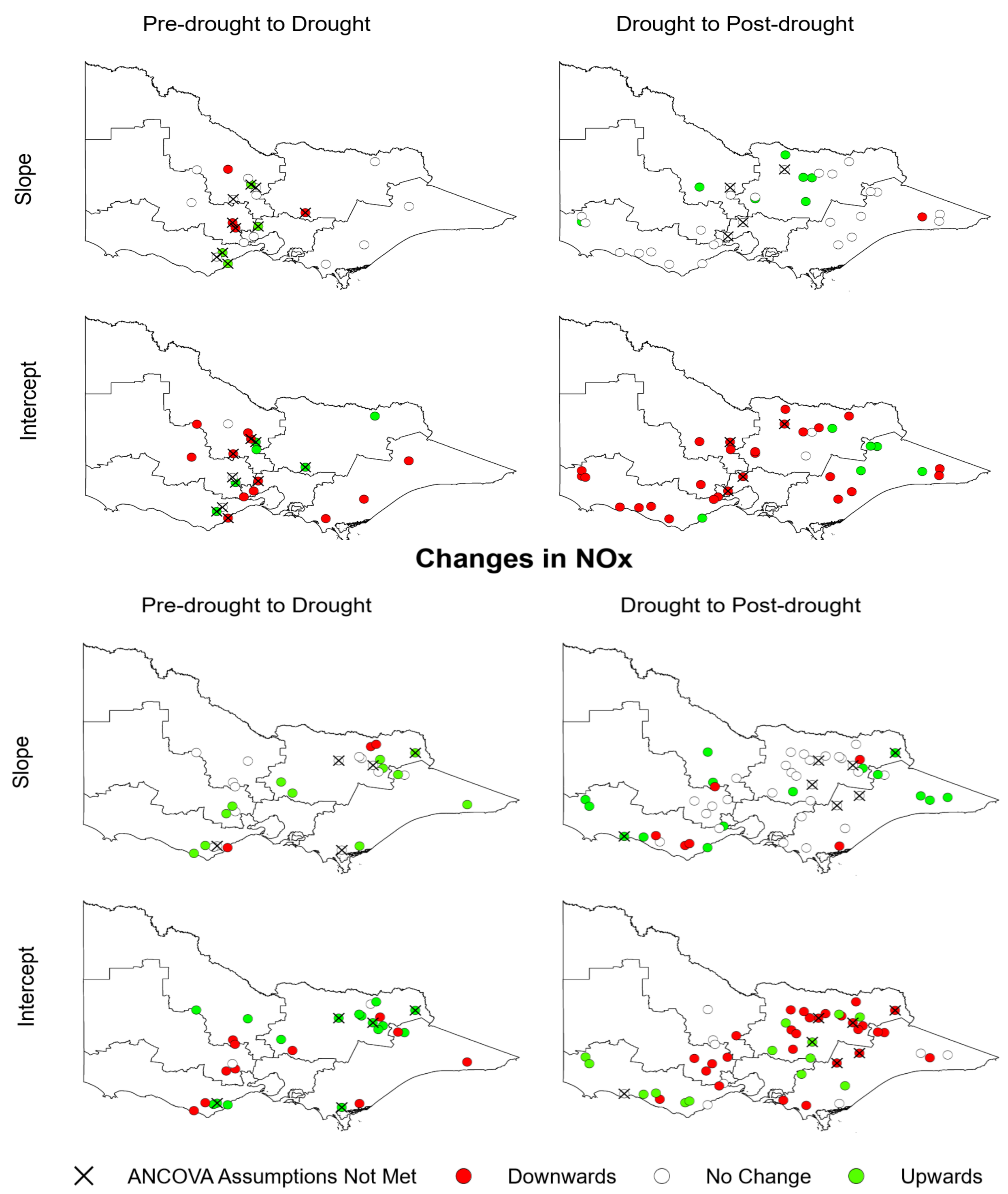

Fig. 3. Spatial distribution of change in slope/int. - EC (top), NOx (bottom).

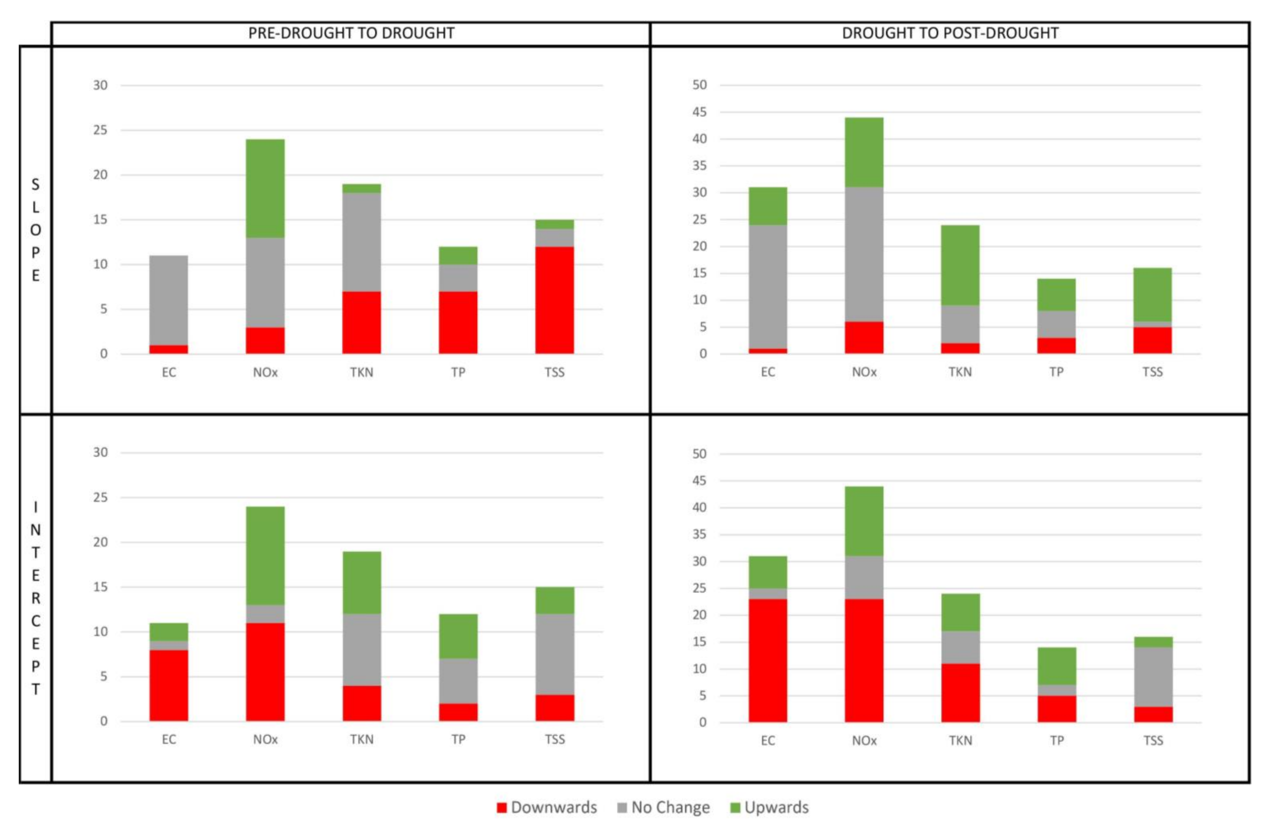

Fig. 4. Summary count of sites slope/int. change direction for all 5 parameters.

7. RELATION TO CATCHMENT CHARACTERISTICS

To investigate if changes in slope/intercept between periods of drought for different sites could be correlated to different catchment characteristics [5], boxplots were plotted and visually compared. An example of this is in Fig. 5 below.

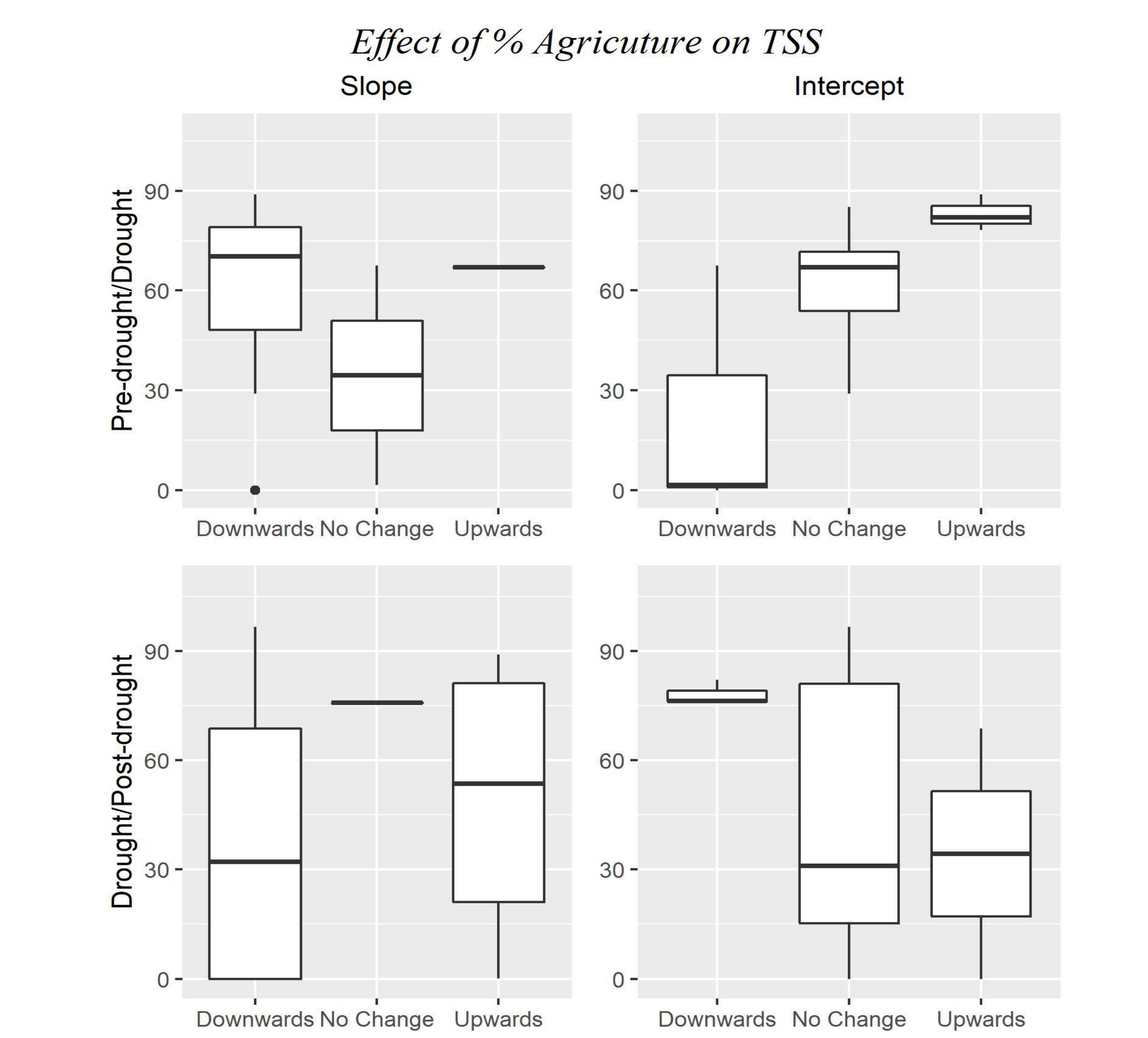

Fig. 5. Comparing effect of % agriculture on changing TSS C-Q relationship.

- More correspondence with changes in intercept than slope, except TP.
- **EC** – likely upwards change in intercept after drought if higher erosivity/%pasture, lower slope/% agriculture.
- **NOx** – likely no change in intercept moving into drought if higher % agriculture, irrigation, road use, horticulture and pasture.
- **TKN** – likely no change in intercept after drought if lower % agriculture, but higher %woodland.
- **TP** – Slope (1) into drought – likely no change in slope in higher horticulture, (2) out of drought – likely downwards change if higher daily flow/variation in daily flow, likely no change if lower agriculture. Intercept (3) into drought - likely downwards change if higher % woodland, (3) out of drought – Likely downwards change if higher daily flow.
- **TSS** – likely downwards change in intercept going into drought if higher % woodland, and if lower % agriculture (upwards if higher %, no change if ~70%),

8. OUTCOMES

Varying effects of drought on C-Q slope/intercept. Percentage agriculture has most correlation with changes, but further investigation is required for more conclusive results.

REFERENCES

[1]B. Henley et al., "Amplification of risks to water supply at 1.5 °C and 2 °C in drying climates: a case study for Melbourne, Australia", *Environmental Research Letters*, vol. 14, no. 8, p. 084028, 2019. Available: 10.1088/1748-9326/ab26ef.
[2]M. Saft, A. Western, L. Zhang, M. Peel and N. Potter, "The influence of multiyear drought on the annual rainfall-runoff relationship: An A Australian perspective", *Water Resources Research*, vol. 51, no. 4, pp. 2444-2463, 2015. Available: 10.1002/2014wr015348 [Accessed 24 December 2020].
[3]J. Knapp, J. von Freyberg, B. Studer, L. Kiewiet and J. Kirchner, "Concentration-discharge relationships vary among hydrological events, reflecting differences in event characteristics", 2020. Available: 10.5194/hess-2019-684 [Accessed 24 February 2020].
[4]"R Companion: Analysis of Covariance", Rcompanion.org, 2020. [Online]. Available: https://rcompanion.org/rcompanion/e_04.html. [Accessed: 24- Feb- 2020].
[5]A. Lintern et al., "Understanding the spatial variability in catchment dynamics: a case study of 107 stream catchments in Victoria, Australia", in *MODSIM2017, 22nd International Congress on Modelling and Simulation*, Hobart, 2018.