THE EFFECT OF WILDFIRE ON FORESTED CATCHMENT WATER QUALITY: EMPIRICAL VERSUS MECHANISTIC MODELS

bushfire&natural HAZARDSCRC

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INTRODUCTION

Wildfire removes the surface vegetation, releases ash, increases erosion and runoff, and therefore effects the hydrological cycle of a forested water catchment. It is important to understand changes in water quality in fire-impacted catchments and how they recover post-fire. Two approaches were used to detect the long-term effect of fire on water quality using an empirical approach consisting of linear mixed models (LMM) and a mechanistic model, the Soil and Water Analysis Tool (SWAT). Ten years of pre-fire and ten years of post-fire data were available for modelling. The focus was discharge, total suspended sediments (TSS), total N (TN) and total P (TP). LMMs are a regression method that accounts for the auto-correlation in residuals commonly found in time series data. The SWAT model is one of the most widely used models for predicting the long-term impact of land use change on catchment flow and water quality using spatially distributed catchment data (land use, slope and soil type) and climate data. However, compared to mechanistic model, it require more specific data and longer processing time.

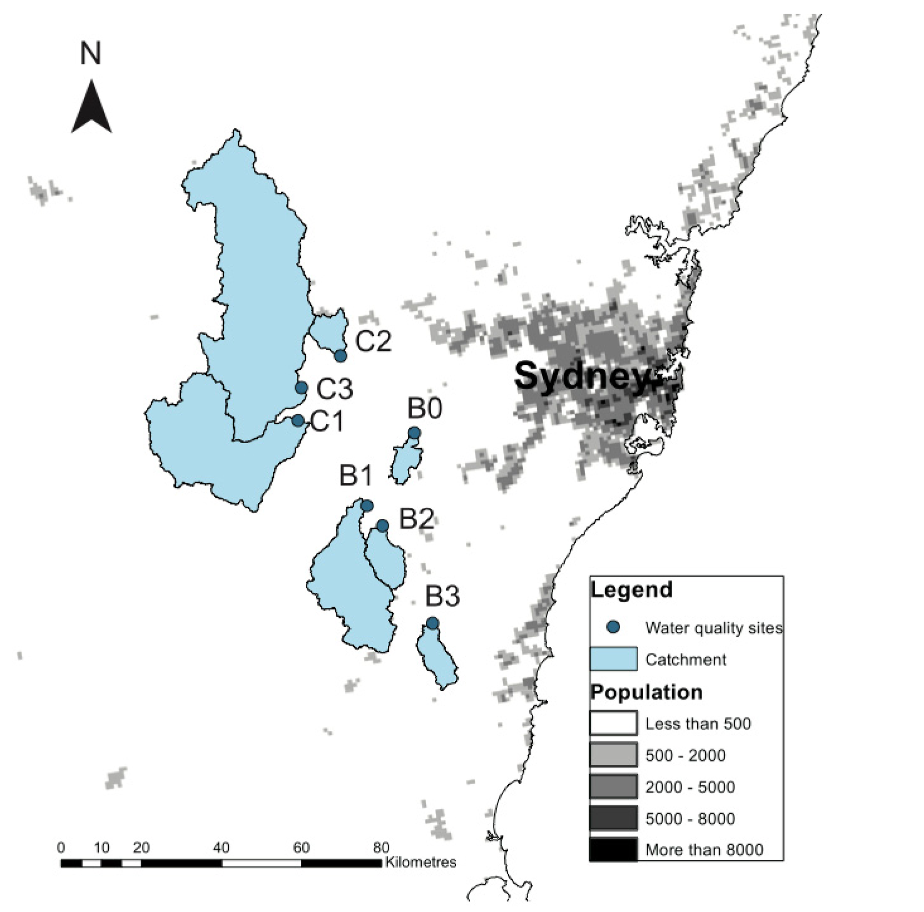

Figure 1 Catchment boundaries and stream gauging stations

EMPIRICAL MODEL:

Seven linear mixed model were built for three of control catchments (C1, C2 and C3, Figure 1) and four burnt catchments (B0 – B3, Figure 1) For the 10 year pre-fire period and the 10 year post-fire period. A fire dummy variable (0 for pre-fire, 1 for post-fire) was created together with other event related variables and flow to predict TSS, TN and TP. The LMM method calculates the fire effect on water quality and the significance of other discharge related predictors. This predicts a long-term average estimate of the effect of fire on water quality. Differences between the results in the burnt and unburnt catchments were used to distinguish between the natural effects of weather and the effect of fire.

Result

- All LMMs found discharge to be a significant predictor for predicting water quality.
- Models for predicting TSS were generally found to include event-related predictors.
- The back transformed coefficient of the "fire" dummy variables in each model provided the predicted fire effect for each catchment in the 10 years post-fire period (Table 1).

Table 1 LMM coefficients

	TSS	TN	TP
C3	1.46	X	X
C1	X	X	X
C2	X	0.37	0.1
B2	1.84	2.88	2.45
B3	X	0.7	1.13
B1	3.32	1.35	X
B0	1.32	X	X
Average control	1.23	1	1
Average burned	1.87	1.48	1.40
Net change	0.64	0.48	0.40

MECHANISTIC MODEL:

Due to data availability, five catchment were modelled, two for control (C1 and C2) three for burnt (B0,B2 and B3) using climate data (solar radiation, temperature and wind) and spatial data (DEM, land use and soil type) to predict the change in water quality and quantity. Post-fire flow and water quality data are used to validate the model. A change in model performance between pre- and post-fire indicate a fire effect.

Result

- All models showed good predictions for flow and TSS during the calibration period (Table 2).
- During calibration period, C1 shows a relatively lower Nash-Sutcliffe Efficiency, This may be due to:
  1) Poor climate data: rain gauge locate 25 km away from monitoring point.
  2) Bias in the water quality data: more samples were taken during the rising limb during the calibration period than validation period. This might result in the model over-predicting TSS especially for events with less than one day duration.
- Both control catchments had a lower NSE for the validation period. This might indicate poor model performance during periods of low rainfall. However, control catchments still showed a much higher NSE for TSS prediction especially for C2.
- B3 was the most severely burnt catchment, showed the worst NSE result during post-fire period.

Table 2 Nash-Sutcliffe Efficiency values for calibrated and validated models.

Catchment	Calibration		Validation	
	Flow	TSS	Flow	TSS
C1	0.75	0.13	0.23	-0.05
C2	0.72	0.83	0.57	0.57
B2	0.64	0.57	0.19	0.04
B3	0.76	0.41	-1.17	-0.01
B0	0.57	0.78	0.26	-0.05
Average C	0.735	0.48	0.40	0.26
Average B	0.65	0.59	-0.24	-0.0066

CONCLUSION:

- Fire has short- and long-term effects on forested catchment water quality.
- Both models showed a significant change in water quality in burnt catchments. This indicated an effect of fire on water quality
- SWAT models indicated a change in the ability of the model to predict flow for burnt catchments during the post-fire period. This might indicate a change in catchment hydrogical cycle due to fire.
- Catchment B3 showed no significant effect of fire on TSS, however, the SWAT model showed the most significant flow change in catchment B3 during post-fire period. This might explained the the significant change in flow which biased the effect of fire in the LMM.

NEXT STEPS:

- Modify SWAT by changing land use and soil carbon content to simulate the effect of fire fire effect
- Build different scenarios in SWAT to examine the effect of fire location and climate change.

"Investigating the impact of bushfires on ecosystem processes and natural resources is one of the research priorities for NPWS. Exploring the differences between empirical versus mechanistic models help to clarify which tools are better suited for modelling fire effects on water quality of catchments; ultimately improving decision making processes and minimizing the impacts of hazard reduction and suppression activities."

-- **Felipe Aires**
NSW National Parks and Wildlife Service

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