

Assessing SWAT model sensitivity to fire-related soil organic carbon changes using digital soil mapping products

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Q 1: What is the effect of fire intensity on soil organic carbon (soil C)?

Q 2: Does a change in soil C affect water quality and quantity in forested catchments?

Q 3: The soil and water assessment tool (SWAT) is a useful tool for predicting changes in water quantity and quality resulting from land use change, however, is it sensitive to fire-related changes in soil carbon?

PRESCRIBED FIRE

1. Pre- and post-fire soil samples were collected from sites burnt by prescribed fire; 27 pairs (burnt and unburnt) of soil samples were collected from seven sites in NSW
2. Carbon and clay content was measured
3. Burn severity was calculated based on satellite images
 - Burn severity: Normalized Burn Ratio (NBR).
 - Satellite images: Australia Geoscience Data Cube
4. A regression model was built:
Post-fire soil carbon = f (Initial soil carbon * % Soil clay * Burn severity)

NBR

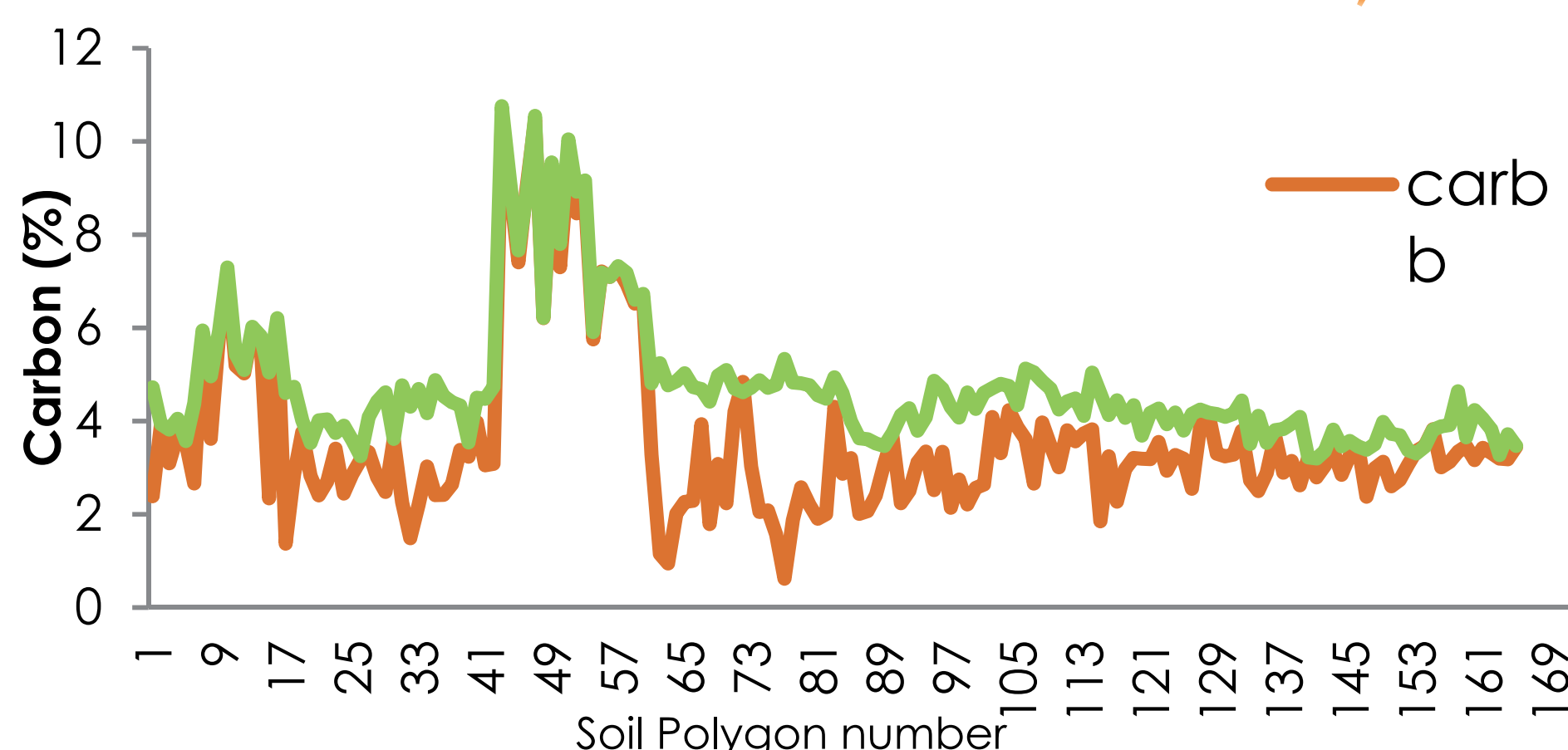
$$\text{Post - fire soil carbon} = 0.89 \times \text{PreC} + 4.2 \times \Delta\text{NBR} - 1.8 \times \text{PreC} \times \Delta\text{NBR}$$

- $r^2 = 0.59$
- Soil Clay not significant factor

WILDFIRE

1. SWAT models were built for three catchments located southwest of Sydney, NSW, burnt by wildfire during summer 2001/2002
 - Median values of plant available water content (AWC), bulk density (BD), clay, sand, silt and organic C content were calculated from Soil Landscape Grid of Australia (SLGA) and used as inputs for SWAT
 - Model calibrated with observed flow and sediment data for a 10-year period pre-fire
2. Simulations were done for 1 year post-fire to create an unburnt soil scenario
3. NBR calculated for soil polygons in each catchment
4. Regression model from prescribed fire was used to predict post-fire soil carbon and a burnt soil scenario was simulated using SWAT

Carbon, flow and sediment change in SWAT



*carb: unburnt samples; carb b: burnt samples

Figure 1 Soil carbon change after fire

		Flow		Sediment	
		Unburnt Soil C	Burnt Soil C	Unburnt Soil C	Burnt Soil C
Catchment 1	Min	0	0	0	0
	Mean	0.14	0.14	13	14
	Max	14	14	183	188
Catchment 2	Min	0	0	0	0
	Mean	0.4	0.4	0.4	0.4
	Max	11	11	2.4	2.4
Catchment 3	Min	0.06	0.06	0	0
	Mean	0.94	0.94	0	0
	Max	60	60	0	0

Table1 Flow (m³/s) and sediment (Metric Tons/Day) output simulated during fire post-fire year

Post-fire C was calculated for each soil polygon for the three study catchments. Of the 173 soil polygons involved, 8 showed a small increase in soil C, 6 showed no change and the remaining 159 polygons showed a decrease in soil C, the greatest decrease being 88%. On average, there was a 23% decrease in soil C. The change in soil C pre-fire (carb) compared to post-fire (carb b) is shown in Figure 1. A change in soil C after fire can lead to a change in soil erodibility (soil loss rate per erosion index). In this study, the change in soil C post-fire resulted in only a minor change in the soil erodibility factor. The minimum soil erodibility factor increased from 0.15400 to 0.15423 and the maximum erodibility factor increased from 0.16500 to 0.16525. The change in soil C content did not result in any observable change in the simulated flow according to the model (Table 1). This is expected as soil C does not impact on any SWAT parameters related to stream flow simulation. No change in sediment was observed in Catchment 2 or Catchment 3, however, an increase in mean and maximum sediment output was found in Catchment 1. This is likely to be due to great slope in catchment 1.

End User Statement:

Biomass burning is one of the main causes of carbon loss in the soil and could lead to increased erosion and runoff. SWAT models can be used to predict long-term impact of land use change on catchment flow and water quality as well as testing "what-if" scenarios. Fire in water catchments needs to be dealt with on a case-by-case basis so land managers can choose the best options to increase the mass of carbon in soil and retain water in the system. The availability and application of suitable models to test changes in water quality and quantity is essential to provide better management options.

-- Dr. Felipe Aires
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