Burning Questions: Estimating the Impacts of BC's Wildfires on Carbon Stores

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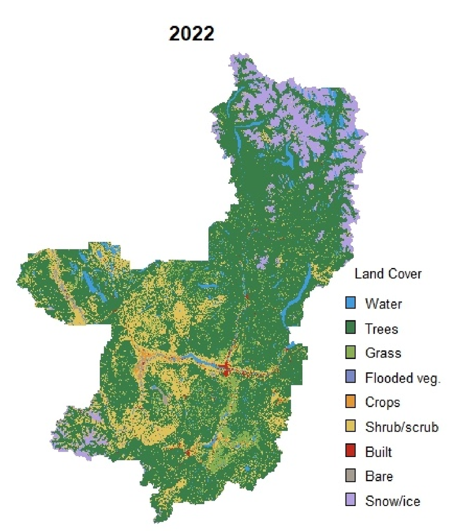
MOTIVATION



This study aims to assess the cost of wildfires on the natural environment's ability to sequester carbon. It represents the first endeavour to explore the impact of wildfires on ecosystem services (ES) in British Columbia (BC). ES are the potential benefits derived from processes of the natural environment, for example, pollination, stormwater regulation, and food provision (Costanza et al., 1997). Climate change is expected to cause less precipitation, earlier snow melt, and increased fuel aridity, leading to increased frequency and intensity of wildfires (Parisien et al., 2023).

DATA AND METHODS

I used three primary data sources in my analysis: the Dynamic World (DW) Land Use and Land Cover Dataset (Brown et al., 2022), the National Burned Area Composite (NBAC) (Canadian Forest Service, 2024), and a biophysical table of carbon storage by vegetation and region type from Ruesch and Gibbs (2008). To satisfy computational limits, I limited my study region to the Thompson Nicola Regional District. With these sources, I can determine when and where fires occurred, which land types they affected, and how much carbon the relevant vegetation stored. Additionally, I can form 5km by 5km grid cells to serve as the units for my analysis to identify the causal effect of wildfires on changes in land cover and carbon storage.

Using a difference-in-difference methodology, adapted by Callaway and Sant'Anna (2021), I can identify the causal effect of fires on land cover changes. The estimated cost of this loss is obtained by multiplying this by an estimate of the social cost of carbon.

RESULTS AND DISCUSSION

The results of the Callaway and Sant'anna estimates are displayed in Table 1. The event study figures suggest that parallel trends are satisfied for both the shrub and forest specifications, and that fires cause decreases in the forested area and increases in the shrub area. However, the lack of a consistent post-exposure trend implies that there might be heterogeneity by year. The heterogeneity may be a result of hotter and drier climates, which Parks and Abatzoglou (2020) find lead to both larger and more severe fires. Since my data can only determine the area of fires, and land cover changes may also be a function of severity, this could explain the results. Following the accounting specified, I generate the estimated costs in Table 2.

CONCLUSION

Climate change is expected to cause increases in the cover and severity of fires. These fires impose significant costs. However, their effect on the natural environment's capacity to store carbon is understudied. Using data from Dynamic World, the National Burned Area Composite, and the Ruesch and Gibbs (2008) biophysical table, and a difference in difference technique along with estimates of the social cost of carbon from Environment and Climate Change Canada, I estimate a cost of **$51,410,309**. This result is almost entirely driven by the loss in 2021. Future work could incorporate measurements of the severity of fires, and projections of the effects of fires on future carbon flows.

FIGURES

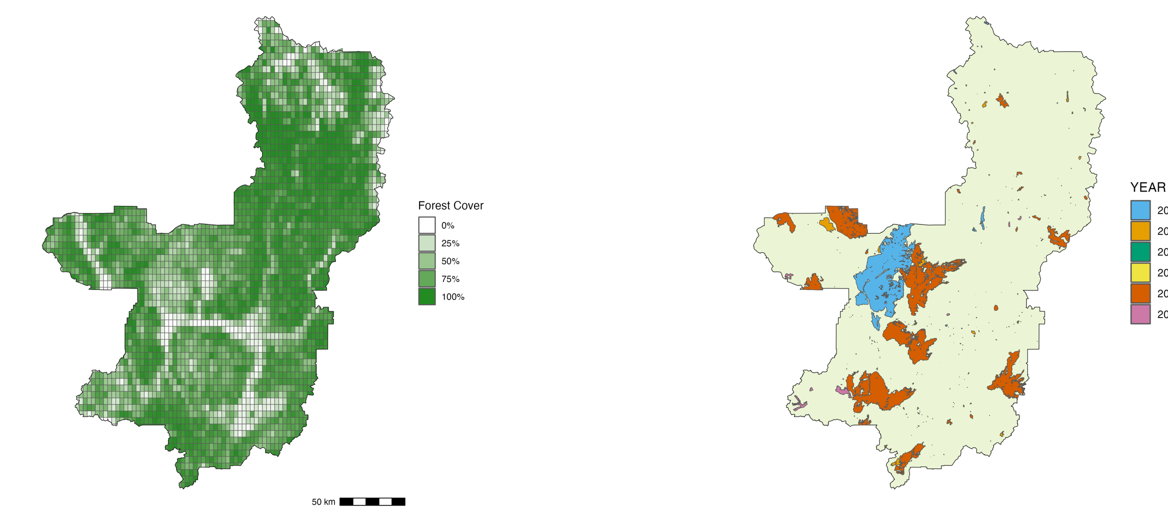


Figure 1. Zonal Forest Cover and Burned Area by Year

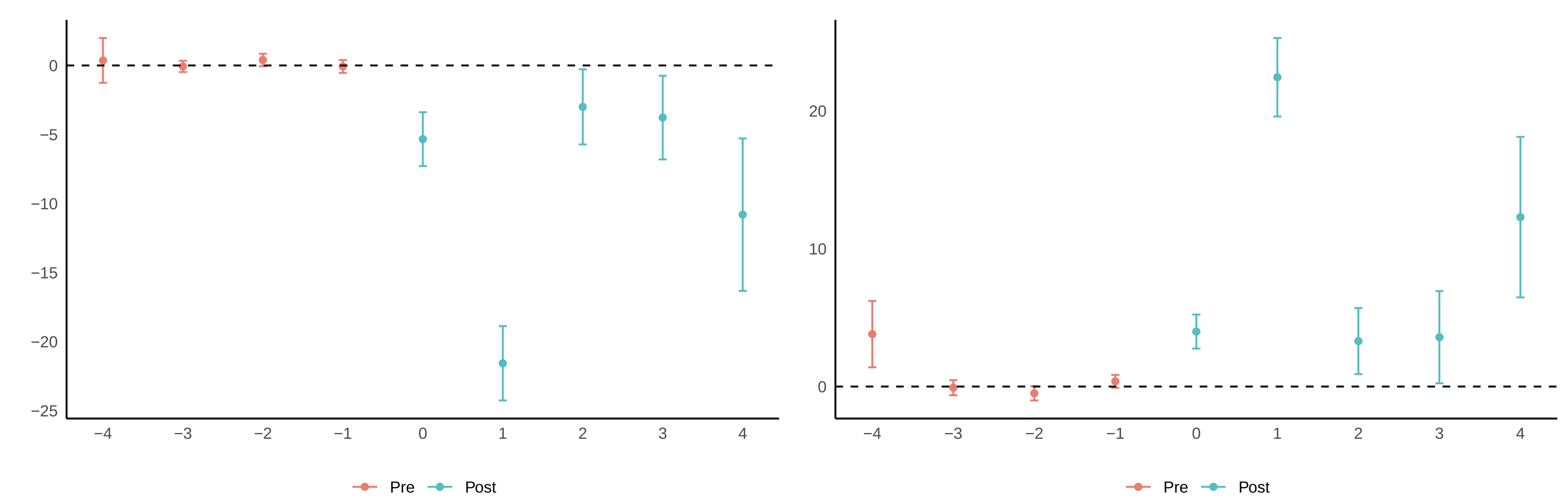


Figure 2. Event Studies for Forest and Shrub Change from Exposure to Fires

Table 1. Effects of Wildfires on Forest and Shrub Cover; Callaway and Sant'anna Estimator

	Forest			Shrub		
Year	ATE	SE	95% CI	ATE	SE	95% CI
2018	-4.37	0.99	(-6.63, -2.11)	5.09	0.77	(3.30, 6.89)
2019	-1.55	1.47	(-4.54, 1.44)	2.08	1.40	(-1.18, 5.34)
2020	-4.12	3.27	(-11.42, 3.18)	0.62	3.94	(-8.58, 9.82)
2021	-15.89	0.91	(-17.93, -13.86)	15.58	0.77	(13.79, 17.37)
2022	-2.59	0.67	(-4.09, -1.09)	-0.90	0.89	(-2.96, 1.17)

Table 2. Estimated Cost of the Loss of Carbon Stock in the Thompson Nicola Regional District (In 2024 USD)

Year	Johnson, 2020	ECCC, 2024	Stern, 2006	Tol, 2008	Nordhaus, 2019	Average
2018	811,318	668,098	438,586	126,246	251,033	459,056
2019	8,981	7,396	4,855.30	1,397	2,779.02	5,081
2020	7,868	6,479	4,253.78	1,224	2,434	4,452
2021	61,411,112	50,570,381	33,197,974	9,555,980	19,001,471	34,747,384
2022	191,814	157,954	103,692	-29,847	59,350	108,531
Total	62,431,096	51,410,309	33,749,362	9,714,696	19,317,069	35,324,506

Deriving The Estimated Value of Carbon Storage Change

$$\text{Burned Area}_{R,t} = \sum_i (\text{Burned Percent}_{i,R,t} * \text{Area}_{i,R,t})$$

$$\text{Forest Cover Change}_{R,t} = \text{Burned Area}_{R,t} * \text{ATT}_{\text{FOREST},t}$$

$$\text{Shrub Cover Change}_{R,t} = \text{Burned Area}_{R,t} * \text{ATT}_{\text{SHRUB},t}$$

$$\text{Net Carbon Storage Change}_t = \sum_R (\text{Forest Cover Change}_{R,t} * \text{Forest Carbon Storage}_R) - \sum_R (\text{Shrub Cover Change}_{R,t} * \text{Shrub Carbon Storage}_R)$$

$$\text{Result}_t = \text{Social Cost of Carbon} * \text{Net Carbon Storage Change}_t$$

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