RESOURCES *for the* FUTURE

Wildfire Risk Reduction in the Draft Energy Innovation Act: Appendix

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This Appendix accompanies an RFF issue brief: "Wildfire Risk Reduction in the Draft Energy Innovation Act."

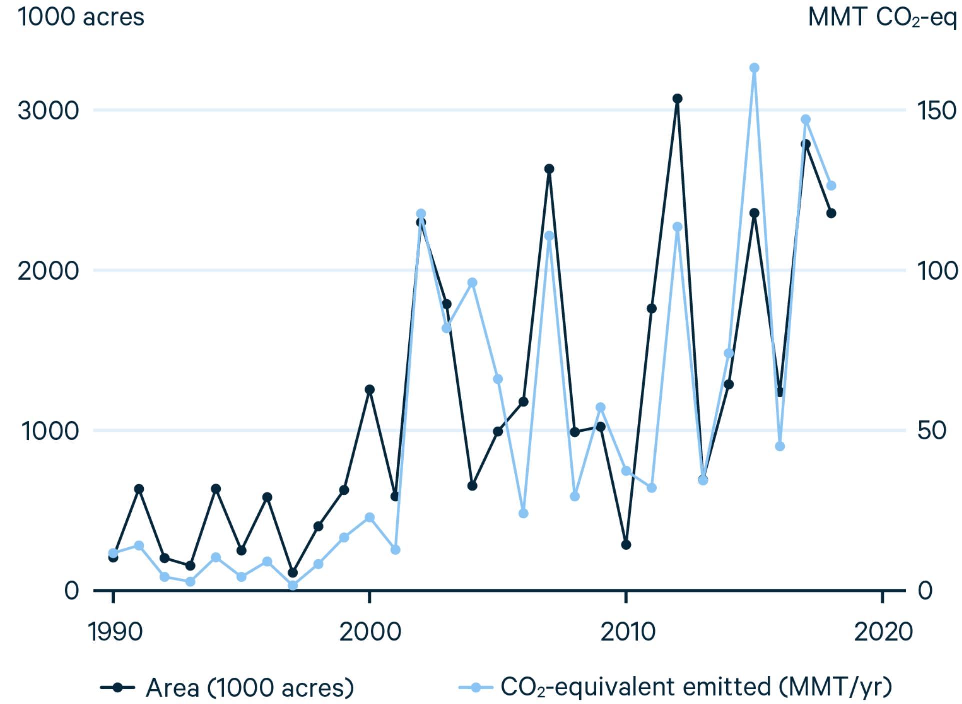
A full accounting of wildfire reduction effects on carbon emissions builds from an understanding of the recent history of wildfire emissions and forest carbon cycling in the US Wildfire emissions are tracked by the EPA's Greenhouse Gas Inventory Report (GHGIR)[1] and derive from the following formula:

$$Emissions = Area\ burned \times fuel\ available \times combustion\ factor \times emission\ factor \quad [1]$$

Area burned is taken from the Interagency Monitoring Trends in Burn Severity (MTBS) data system and arrayed by fire severity class, fuel availability is developed from the US Forest Service Forest Inventory and Analysis (FIA) dataset and combustion factors depend on the severity of burning (e.g., a ground fire or a crown fire). The emission factor varies by forest (fuel) type and provides estimates for various types of greenhouse gas emissions. Wildfire emissions and estimated burn area from 1990 through 2018 (including Alaska) are reported in Figure 1 and show an upward trend in wildfire emissions. Over the last five years of the dataset (2014-2018) annual area burned averaged 2.161 million acres and annual emissions averaged 106 MMT CO_2 eq.

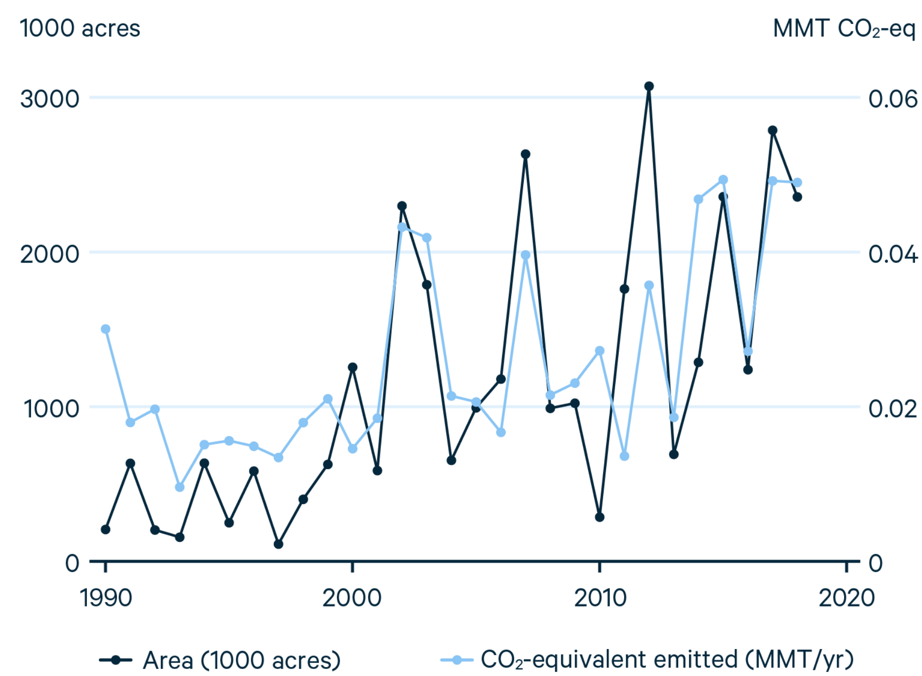
[1] The GHGIR is the nation's record of greenhouse gas emissions and carbon sinks and provides the metrics through which progress on emission reductions is measured.

Figure 1. Total area of wildfire and CO_2 emissions from wildfires in the United States, 1990-2018



Source: EPA Greenhouse Gas Inventory Report

Figure 2. Rate of emissions per unit area for the United States, as defined by data in Figure 1



Using the data in Figure 1 we can estimate an overall emission rate, in this case excluding Alaska, that shows a general upward trend in emissions per acre and substantially higher emission rates associated with peak fire years, reflecting an increase in both the area and the intensity of wildfires during these years (Figure 2):

$$[2] \qquad Emission\ Rate = \frac{Emissions}{Area\ Burned}$$

Since 2010, the emission rate during low fire years averaged 0.025 MMT CO_2 eq/1000 acres. The emission rate during high fire years averaged, 0.05 MMT CO_2 eq/1000 acres reflecting the effects of extreme fire behavior during peak years (increased intensity).

These emission data provide estimates of release of CO_2 to the atmosphere by forests, but the total change in atmospheric carbon is defined by all resulting changes in the forest carbon sink, including effects on forest growth or sequestration rates. The forest carbon sink (FCS) is defined as the sum of carbon sequestered (SC) in forest biomass (net of non-fire emissions) and carbon stored in new harvested wood products (HWPC) minus any wildfire emissions to the atmosphere (EC).[2]

$$[3] \qquad FCS = SC + HWPC - EC$$

The effects of fire treatments on FCS are defined by comparing a base case (B) with the case where fuel treatments are increased (T)[3]:

$$[4] \qquad \Delta FCS = [SC_T - SC_B] + [HWPC_T - HWPC_B] - [EC_T - EC_B]$$

$$[5] \qquad \Delta FCS = \Delta SC + \Delta HWPC - \Delta EC$$

We expect that emissions would decline due to fuel treatments so ΔEC is negative and would increase the forest carbon sink. Carbon sequestration in the long run would likely be reduced by fuel treatments that remove forest biomass, so ΔSC is likely to be negative. If fuel treatments include harvests of merchantable products, then carbon stored in products would increase, so ΔHWPC is likely to be positive.

[2] While the carbon sequestered in forests is typically measured as growth minus all emissions (e.g., harvesting, insects, blowdown, fire), here we define CS as net of fire emissions to explicitly consider fire effects.

[3] Fuel treatments would have both short run and long run effects. Forest growth responses in burned forests play out over several decades for example and treatment effects may have limited duration, especially for prescribed fire treatments.

Estimation

We approximate the total effects of fuel reduction programs on the forest carbon sink or net emissions using the three components described in equation [5]: change in carbon sequestration, change in harvested wood products carbon, and change in emissions.

Emission Effects—ΔEC

Change in emissions resulting from a fuel treatment program is defined by the extent to which the treated area alters the area, pattern, and intensity of wildfire. The Bill proposes treatments on 10 million acres of forests with high hazard potential or about 25 percent of the 42 million acres of high hazard land on public forests or about 20 percent of the 51 million acres on all forest ownerships. The literature provides no estimates of treatment efficacy at such large scales, but simulation studies indicate that strategically placed fuel treatments on 10-20 percent of a large landscape can alter fire regimes, with limited effects on area burned but strong effects on fire severity (see Ager et al. 2020).

Treatments are expected to alter area burned (AB) and the emission rate (ER; equation [2]) for the conterminous 48 states:[4]

$$\Delta EC = AB_T \times ER_T - AB_B \times ER_B$$

We assume that reductions in area burned will range from a low case of no change in area to a high case of 20 percent, bounded by the portion of high hazard area treated. The base case for area burned in the CONUS is defined as the average between 2010 and 2018 (1.76 million acres/yr). We assume that treatments will lower the intensity of wildfire from an average emission rate of 0.044 MMT CO_2 eq (2014-2018) to a range from 0.022 (50 percent reduction and consistent with lower rates over the last decade) to 0.033 (25 percent reduction and consistent with the average rate for the previous decade). We then account for the non-carbon emissions from wildfires (methane and nitrous oxides) which have averaged about 12 percent of CO_2 emissions according to the GHGIR (Table 6-15).

Carbon Sequestration Effects—ΔSC

We next address how much of emissions would be reabsorbed by regrowth in forests. This requires some insights into the growth dynamics of the forest inventory, and we rely on a study by Coulston and Wear to develop regrowth ratios.

[4] We assume no fuel treatment effect on wildfire in Alaska and assume its emission values remain constant.

Coulston and Wear (2016) along with subsequent analysis by Haight et al. (2020), evaluate the net change in the forest carbon sink due to wildfires that includes the feedbacks to forest growth responses. They examine a scenario where wildfire is reduced by 10 percent over historical rates and simulate resulting net change in carbon stocks over 35 years, accounting for changes in both growth and emission dynamics. They find that a 10 percent reduction in wildfire incidence from historical levels with no change in fire intensity would lead to an increase in the carbon sink of about 7 MMT CO_2 eq/yr from 2015 to 2050. Comparing this estimate with emissions records in Figure 1, a 10 percent reduction in average emissions over the last ten years would amount to about a 10 MMT reduction in overall emissions. With the caveat that these two estimates are derived with different datasets (but using common measures), they imply that the forest carbon sink would increase by about 70 percent of the estimated reduction in emissions. We assume that the range of effects is between 50 percent (low efficacy) and 70 percent (high efficacy).

Harvested Wood Products Effects—ΔHWPC

Fuel treatments may be accomplished through either prescribed fire or mechanical treatments where trees are cut and removed from the site. In the case of the latter, harvested material may be used to produce wood products with long term storage (or burned for bioenergy). Long term storage of carbon in wood products augments the total forest carbon sink and current harvested wood carbon sinks amount to about 95 MMT CO_2 eq/yr in the US (GHGIR).

The Bill proposes 50 percent mechanical fuel treatments, mainly in the western US where current markets for products are limited. Accordingly, we assume that the change in carbon stored in harvested wood products would range from no change to an increase of 5 MMT CO_2 eq/yr.

Total Effects—ΔFCS

Estimates of treatment effects are summarized in Table 1. Base case wildfire emissions are defined as the average over the previous five years (106.5 MMT CO_2 eq / yr). Treatment scenarios yield wildfire emissions that range from 43 to 80 MMT/yr and emission reductions that range from 27 to 64 MMT/yr. After accounting for the recapture of some emitted carbon by forests and potential for increased storage in wood products, the net effect on the forest carbon sink is between 11 and 50 MMT/yr with a midpoint estimate of 30 MMT/yr.

According to the GHGIR, the US forest carbon sink has averaged 630 MMT/year, so proposed treatments would increase the annual sink between 2 and 8 percent.

Table 1. Estimates of net change in US forest carbon sink for a range of treatment effects

		Treatment effects	
	Base case	Higher efficacy	Lower efficacy
Area burned (million acres)	2.16	1.73	2.16
Emission Rate (MMT CO_2 eq/1000 acres)	0.044	0.022	0.033
Emissions (MMT CO_2 eq) = AB x ER	95.08	38.03	71.31
Non-CO_2 emissions	11.41	4.56	8.56
Total emissions	106.49	42.60	79.87
Emissions reductions (MMT CO_2 eq)	--	-63.90	-26.62
Sequestration Effect (MMT CO_2 eq)	0	19.17	10.65
Harvested wood product effects (MMT CO_2 eq)	0	-5	0
Total effect on sink (MMT CO_2 eq)	0	-49.73	-10.65

References

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