Emissions from Decomposition of un-utilized forest management residuals

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Un-utilized residual biomass not consumed in pile burns decomposes over time resulting in CH4 and CO2 emissions. To provide a full picture of the emissions from residual material produced from commercial timber harvesting in California, we must account for decomposition of unutilized logging residuals left on-site that are not burned.

$$
\begin{aligned}
LR_d &= LR - LR_{piles} - LR_{bio} \\
&\text{where:} \\
LR_d &= \text{Logging residuals subject to anerobic decomposition} \\
LR &= \text{Total logging residue reported by TPO} \\
LR_{piles} &= \text{Logging residues combusted in anthropogenic pile burns} \\
LR_{bio} &= \text{Logging residues used to produce bioenergy}
\end{aligned}
$$

To calculate the Greenhouse Gas (GHG) emissions from decomposition of piles, we use the following equation.

$$
\begin{aligned}
CO_2e_{decomp} &= (LR_d \times C_{LR} \times CO2_{ratio}) + (LR_d \times C_{LR} \times CH_{4ratio} \times GWP_{CH_4}) \\
&\text{where:} \\
CO_2e_{decomp} &= \text{Carbon dioxide equivalent emissions from decomposition of logging slash} \\
C_{LR} &= \text{Carbon fraction of biomass: 0.5} \\
CO2_{ratio} &= \text{Fraction of carbon released as } CO_2\text{: 0.61} \\
CH_{4ratio} &= \text{Fraction of carbon released as } CH_4\text{: 0.09} \\
GWP_{CH_4} &= \text{Global warming potential of methane: 56}
\end{aligned}
$$

To establish the fraction of logging residue that is left to decompose, residues burned and used in bioenergy are subtracted from total logging residuals produced from roundwood harvest. **?** report bioenergy consumption in the state (Table 1).

year	Percent of roundwood harvest used in bioenergy
2000	2.4
2006	3.6
2012	8.2

Table 1: % volume of wood diverted to Bioenergy use by year

The availability of data for bioenergy consumption of logging residuals does not allow us to precisely estimate the consumption for years other than reported by **?**. In this analysis, for years that bioenergy consumption is reported, I use that value. As the states biomass energy infrastructure began to consume substantial amounts of residual in the early 1980's (**?**), we assume that the average consumption from the 3 years reported is representative annual consumption. For years before 1980, we assume no bioenergy consumption. This approach is less than ideal as there has been a great deal of variability in the appetite for logging residuals from biomass power plants. Un-utilized logging residues are estimated from logging residuals not used in bioenergy (Table **??**). These results are based on a normal probability distribution for logging residual generation from roundwood harvest. This is one of several factors contributing to instances where bioenergy consumption is greater than logging residues produced. Other factors include:

- Lack of temporal resolution in bioenergy consumption
- Consumption by biomass power plants of in-woods residuals produced from forest management that did not result in commercial roundwood harvest

Year	Logging Residues	Bioenergy	Unutilized Logging Residuals
1978	1.56564	0	1.56564
1979	1.2689	0	1.2689
1980	0.756188	0.348909	0.40728
1981	0.556558	0.294654	0.261904
1982	0.320001	0.255616	0.064385
1983	1.19463	0.370302	0.824331
1984	1.28008	0.391033	0.889043
1985	0.834831	0.421028	0.413803
1986	1.34222	0.470321	0.871901
1987	1.80944	0.496235	1.3132
1988	0.275234	0.514982	-0.239748
1989	1.27182	0.487854	0.78397
1990	1.19944	0.443414	0.756022
1991	0.641766	0.352327	0.289439
1992	0.564071	0.327846	0.236225
1993	0.532689	0.316598	0.216091
1994	0.571306	0.255396	0.31591
1995	0.249442	0.254293	-0.004851
1996	0.300928	0.250654	0.0502744
1997	0.3554	0.264659	0.0907408
1998	0.186836	0.230584	-0.0437481
1999	0.20601	0.236429	-0.0304188
2000	0.447945	0.109927	0.338018
2001	0.234992	0.17677	0.0582215
2002	0.357945	0.186364	0.171581
2003	0.29514	0.183387	0.111754
2004	0.155414	0.188128	-0.0327142
2005	0.250076	0.190224	0.0598525
2006	0.225896	0.136793	0.0891028
2007	0.167812	0.179306	-0.0114946
2008	0.161299	0.151297	0.0100027
2009	0.078976	0.088771	-0.009795
2010	0.150674	0.128029	0.022645
2011	0.133867	0.142034	-0.00816644
2012	0.190052	0.249688	-0.0596362
2013	0.172895	0.181402	-0.00850613
2014	0.158662	0.161662	-0.00300087

Table 2: Probabilistic disposition of logging residuals from roundwood harvest in CA. Volume in million bone-dry tons.

To estimate the emissions from decomposition of logging residuals that are not burned, an estimate of consumption of biomass in pile burns would be necessary. In theory, the California Air Resources Board (CARB) (**!** ((**!**)CAP} inventory could provide an estimate using the ratio of **PM!** (**PM!**) to biomass consumed. However the CARB-derived pile burn estimate far exceeds the volume of logging residuals from the California Board of Equalization (BOE) historical harvest data (Table **??**)

CARB estimate (BDT)	BOE estimate (BDT)
901423.23	553110.26

Table 3: Comparison of annual pile-burned biomass from forestry by CARB with BOE-derived estimate of loggin residuals produced from timber harvest.

This is likely due to in part to the fact that the CARB estimate includes non-commercial forest management activity.