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ESTIMATE OF COMBUSTION EFFICIENCY IN A FOREST CLEARING EXPERIMENT IN THE MANAUS REGION

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Carbon dioxide generation rates are among the most significant parameters to evaluate and quantify the impact of forest clearing processes on the environment. These rates are calculated based on the average carbon content of the biomass and the total mass above the ground, knowing that only a certain portion of the carbon reacts to carbon dioxide and other gases. This portion is basically the combustion efficiency and depends on the type of forest, on how the trees were cut and piled, on the material size and on the biomass moisture content, among others.

The total mass above the ground per hectare is the first difficult variable to quantify in order to determine the overall CO_2 rates. It varies from place to place because lower portions of the terrain contain larger amounts of water. Another difficulty is imposed by the combustion efficiency, which is the portion of biomass converted to gas during combustion. Fearnside (1992) reported that the above ground biomass carbon released to the atmosphere by the combustion process during the first burning is 28.4% and by biological decay is 69.0%. Seiler and Crutzen (1980) stated that, considering trunks to contain more than 90% of the biomass, the burning efficiency is on the order of 25%. The procedure proposed by OECD (1991) indicates a combustion efficiency of 45%, a value that accounts for reburning.

This paper describes the results of a forest clearing combustion experiment performed at INPA's Tropical Silviculture Experimental Station. A one hectare area was prepared from July to October of 1991 and burned on November 03 of the same year. The total above ground biomass fresh and dry weights were measured for 20% of this area and the total above ground biomass weight calculated by extrapolation. Samples of 47 trunks were selected before and after the fire and their carbon and hydrogen content determined in a CHN analyzer.

The amount of carbon converted to gas was calculated considering that all of the leaves and the smaller branches (those whose average diameters were lower than 10 cm) burned with 100% combustion efficiency. The efficiency for trunks and larger branches was estimated from a carbon mass balance before and after the test, by computing the maximum loss of carbon that could have occurred in this case. The results are presented in terms of maximum possible efficiency for the experiment.

Table 1 shows fresh and dry weights of above-ground biomass. In the table, ϕ stands for diameter, M1 for small trees with heights below 1 m and M2 for small trees with diameters below 5 cm. The total fresh and dry weights of the area were 726,933 kg/ha and 424,354 kg/ha, respectively. Trunks account for 59.6% of the biomass, while branches account for 29.4%. Trunks and large branches, which are only slightly burned during the forest clearing process, add to 78.5% of the above-ground biomass.

The carbon contents of the components of the biomass (branches, bushes, leaves, litter and liana) and the maximum contribution of each to the carbon combustion efficiency (n_c) are shown in Table 2. In the table, C^* is the average carbon content of the particular component of the tree (trunk, branch, etc) and C^{**} is the percentage of carbon in that particular component in relation to the total amount of carbon in the test site (for trunks with $\phi > 30$ cm, for example, 50.37% = 102,504/203,448).

For the trunks and large branches, it was observed that the maximum depth of the burned layer was 5 mm. Therefore, estimates of maximum values of n_c in the parts were computed considering that 5 mm were consumed and that all of them had diameters of 30 cm (for trunks diameters larger than 30 cm) and 10 cm (for trunks with diameters smaller than 30 cm and branches with diameters larger than 10 cm). The carbon content of samples taken from the selected trunks after the test remained practically unchanged if the material burned in the outside layer were removed. No definitive estimate could be made

Table 1. Fresh and dry weights of test site biomass.

	Fresh weight (kg/ha)	H_20 (%)	Dry weight (kg/ha)	Dry weight (%)
Trunks, $\phi > 30$ cm	342,330	38.3	211.218	49.77
Trunks, $\phi < 30$ cm	68,856	39.3	41,796	9.85
Branches, $\phi > 10$ cm	133,660	40.0	80,196	18.90
Branches, $\phi < 10$ cm	76,463	41.7	44,578	10.50
M1, H < 1 m	1,057	55.0	476	0.11
M2, H > 1 m, $\phi < 5$ cm	16,559	40.5	9,852	2.32
Leaves	10,235	51.9	4,923	1.16
Litter	68,340	62.5	25,655	6.05
Liana	9,433	40.0	5,660	1.33
Total	726,933		424,354	

Table 2. Maximum contribution of each biomass component to carbon gasification efficiency.

	C* (%)	C (kg/ha)	C** (%)	n_c (%)
Trunks, $\phi > 30$ cm	48.53	102,504	50.37	1.67
Trunks, $\phi < 30$ cm	48.53	20,284	9.97	0.98
Branches, $\phi > 10$ cm	48.53	38,919	19.13	1.87
Branches, $\phi < 10$ cm	48.53	21,634	10.63	10.63
M1, H < 1 m	46.54	222	0.11	0.11
M2, H > 1 m, $\phi < 5$ cm	46.83	4,614	2.27	2.27
Leaves	50.41	2,482	1.22	1.22
Litter	39.30	10,082	4.95	4.95
Liana	48.53	2,747	1.35	1.35
Total		203,448		25.05

on small branches and liana and, therefore, they were considered to burn completely. Leaves and litter were observed to burn almost completely.

The maximum combustion efficiency of the test, calculated adding the efficiency of each individual part, was 25.05%, which is very close to the 25% reported by Seiler and Crutzen (1980). However, in their study about 90% of the biomass was concentrated on trunks (in contrast to the 59.6% of the Manaus test site). The amount of carbon emitted to the atmosphere by the burning process is, therefore, a maximum of 50,975 kg/ha (0.2505 * 203,488 kg/ha, see Table 2).

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