



NETL Life Cycle Inventory Data

Process Documentation File

Process Name: Broadcast Burning Stemwood
Reference Flow: 1 kg of Stemwood, broadcast burned
Brief Description: Air emissions from the combustion of stemwood that is broadcast burned

Section I: Meta Data

Geographical Coverage: United States **Region:** Inland West
Year Data Best Represents: N/A
Process Type: Auxiliary Process (AP)
Process Scope: Gate-to-Grave (End-of-Life) Process (GE)
Allocation Applied: No
Completeness: Individual Relevant Flows Captured

Flows Aggregated in Data Set:

- Process Energy Use Energy P&D
 Material P&D

Relevant Output Flows Included in Data Set:

- Releases to Air: Greenhouse Gases Criteria Air Other
Releases to Water: Inorganic Organic Emissions Other
Water Usage: Water Consumption Water Demand (throughput)
Releases to Soil: Inorganic Releases Organic Releases Other

Adjustable Process Parameters:

stem_flame *[dimensionless] Fraction of stem that combusts in flame phase*
stem_smolder *[dimensionless] Fraction of stem that combusts in smoldering phase*
stem_residual *[dimensionless] Fraction of stem that combusts in residual phase*

dry_frac	<i>[dimensionless] Fraction of wood that that is dry forest</i>
ef_pm_dry_fl	<i>[kg/kg] Emission factor for PM in flame phase for dry forest</i>
ef_pm10_dry_fl	<i>[kg/kg] Emission factor for PM10 in flame phase for dry forest</i>
ef_pm25_dry_fl	<i>[kg/kg] Emission factor for PM2.5 in flame phase for dry forest</i>
ef_co_dry_fl	<i>[kg/kg] Emission factor for CO in flame phase for dry forest</i>
ef_co2_dry_fl	<i>[kg/kg] Emission factor for CO₂ in flame phase for dry forest</i>
ef_ch4_dry_fl	<i>[kg/kg] Emission factor for CH₄ in flame phase for dry forest</i>
ef_nmhc_dry_fl	<i>[kg/kg] Emission factor for non-methane hydrocarbons in flame phase for dry forest</i>
ef_ec_dry_fl	<i>[kg/kg] Emission factor for elemental carbon in flame phase for dry forest</i>
ef_oc_dry_fl	<i>[kg/kg] Emission factor for organic carbon in flame phase for dry forest</i>
ef_nox_dry_fl	<i>[kg/kg] Emission factor for NO_x in flame phase for dry forest</i>
ef_nh3_dry_fl	<i>[kg/kg] Emission factor for NH₃ in flame phase for dry forest</i>
ef_voc_dry_fl	<i>[kg/kg] Emission factor for VOCs in flame phase for dry forest</i>
ef_so2_dry_fl	<i>[kg/kg] Emission factor for SO₂ in flame phase for dry forest</i>
ef_meth_dry_fl	<i>[kg/kg] Emission factor for methanol in flame phase for dry forest</i>
ef_form_dry_fl	<i>[kg/kg] Emission factor for formaldehyde in flame phase for dry forest</i>
ef_pm_dry_sm	<i>[kg/kg] Emission factor for PM in smoldering or residual phases for dry forest</i>

ef_pm10_dry_sm	<i>[kg/kg] Emission factor for PM10 in smoldering or residual phases for dry forest</i>
ef_pm25_dry_sm	<i>[kg/kg] Emission factor for PM2.5 in smoldering or residual phases for dry forest</i>
ef_co_dry_sm	<i>[kg/kg] Emission factor for CO in smoldering or residual phases for dry forest</i>
ef_co2_dry_sm	<i>[kg/kg] Emission factor for CO₂ in smoldering or residual phases for dry forest</i>
ef_ch4_dry_sm	<i>[kg/kg] Emission factor for CH₄ in smoldering or residual phases for dry forest</i>
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ef_ec_dry_sm	<i>[kg/kg] Emission factor for elemental carbon in smoldering or residual phases for dry forest</i>
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ef_voc_dry_sm	<i>[kg/kg] Emission factor for VOCs in smoldering or residual phases for dry forest</i>
ef_so2_dry_sm	<i>[kg/kg] Emission factor for SO₂ in smoldering or residual phases for dry forest</i>
ef_meth_dry_sm	<i>[kg/kg] Emission factor for methanol in smoldering or residual phases for dry forest</i>

ef_form_dry_sm	<i>[kg/kg] Emission factor for formaldehyde in smoldering or residual phases for dry forest</i>
ef_pm_wet_fl	<i>[kg/kg] Emission factor for PM in flame phase for moist forest</i>
ef_pm10_wet_fl	<i>[kg/kg] Emission factor for PM10 in flame phase for moist forest</i>
ef_pm25_wet_fl	<i>[kg/kg] Emission factor for PM2.5 in flame phase for moist forest</i>
ef_co_wet_fl	<i>[kg/kg] Emission factor for CO in flame phase for moist forest</i>
ef_co2_wet_fl	<i>[kg/kg] Emission factor for CO₂ in flame phase for moist forest</i>
ef_ch4_wet_fl	<i>[kg/kg] Emission factor for CH₄ in flame phase for moist forest</i>
ef_nmhc_wet_fl	<i>[kg/kg] Emission factor for non-methane hydrocarbons in flame phase for moist forest</i>
ef_ec_wet_fl	<i>[kg/kg] Emission factor for elemental carbon in flame phase for moist forest</i>
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ef_nh3_wet_fl	<i>[kg/kg] Emission factor for NH₃ in flame phase for moist forest</i>
ef_voc_wet_fl	<i>[kg/kg] Emission factor for VOCs in flame phase for moist forest</i>
ef_so2_wet_fl	<i>[kg/kg] Emission factor for SO₂ in flame phase for moist forest</i>
ef_meth_wet_fl	<i>[kg/kg] Emission factor for methanol in flame phase for moist forest</i>
ef_form_wet_fl	<i>[kg/kg] Emission factor for formaldehyde in flame phase for moist forest</i>
ef_pm_wet_sm	<i>[kg/kg] Emission factor for PM in smoldering or residual phases for moist forest</i>

ef_pm10_wet_sm	<i>[kg/kg] Emission factor for PM10 in smoldering or residual phases for moist forest</i>
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ef_nox_wet_sm	<i>[kg/kg] Emission factor for NO_x in smoldering or residual phases for moist forest</i>
ef_nh3_wet_sm	<i>[kg/kg] Emission factor for NH₃ in smoldering or residual phases for moist forest</i>
ef_voc_wet_sm	<i>[kg/kg] Emission factor for VOCs in smoldering or residual phases for moist forest</i>
ef_so2_wet_sm	<i>[kg/kg] Emission factor for SO₂ in smoldering or residual phases for moist forest</i>
ef_meth_wet_sm	<i>[kg/kg] Emission factor for methanol in smoldering or residual phases for moist forest</i>

ef_form_wet_sm

[kg/kg] Emission factor for formaldehyde in smoldering or residual phases for moist forest

Tracked Input Flows:**Tracked Output Flows:**

Stemwood, broadcast burned [Insert]

Reference flow

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_Broadcast_Burning_Stemwood_2013.01.xlsx*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

This unit process provides a summary of relevant input and output flows associated with broadcast burning stemwood. The reference flow of this unit process is: 1 kg of Stemwood, broadcast burned

Boundary and Description

Stemwood that is broadcast burned produces a number of atmospheric emissions that may cause human health and environmental impacts. Emissions depend on if the wood is burning with a flame or smoldering. Additionally, some fraction of the stemwood may not burn, and will end up as residue. For stemwood, 60 percent burns with a flame, 30 percent smolders, and 10 percent ends up as residual.

Broadcast burning is typically practiced in national forests. This unit process can account for either moist or dry conditions, represented by emissions from mixed conifer or ponderosa/lodgpole trees. The default value is for a 50/50 mix when the type of forest is not known.

Figure 1: Unit Process Scope and Boundary

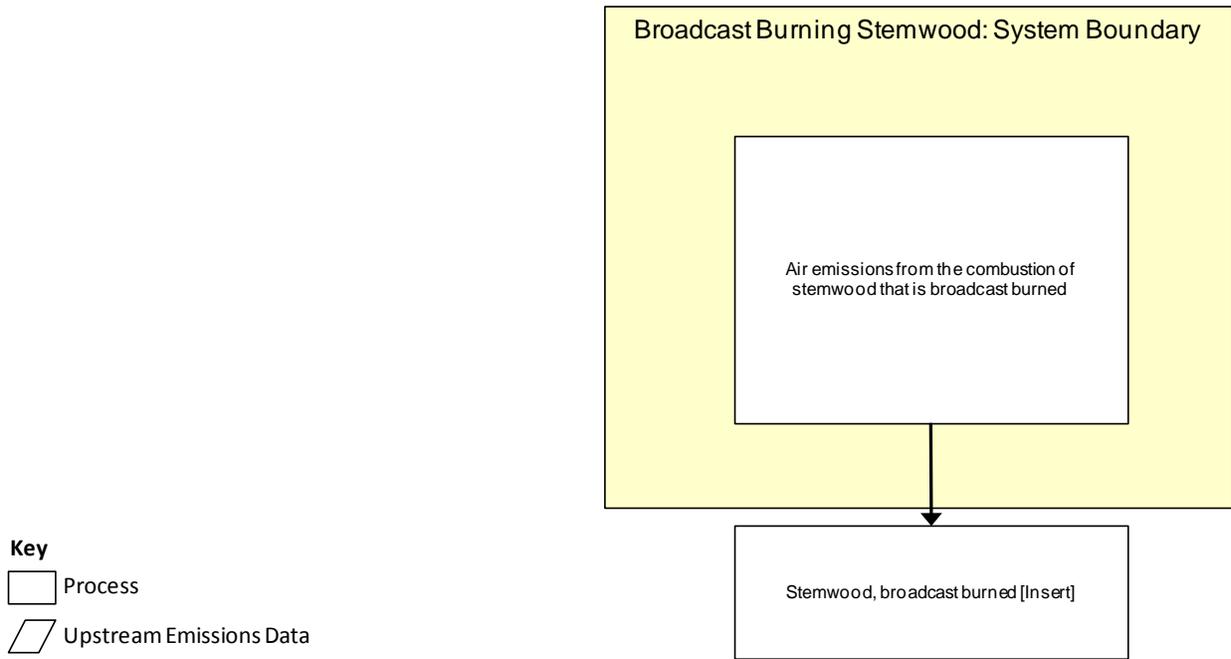


Table 1: Dry Stemwood Broadcast Combustion Factors

Emission Species	Flame (kg/dry kg)	Smolder (kg/dry kg)
PM	9.40E-03	2.43E-02
PM10	5.75E-03	1.84E-02
PM2.5	5.00E-03	1.71E-02
CO	4.45E-02	1.43E-01
CO2	1.70E+00	1.49E+00
CH4	1.50E-03	7.30E-03
NMHC	1.80E-03	4.80E-03
Elemental Carbon	3.60E-04	1.23E-03
Organic Carbon	2.70E-03	9.23E-03
NOx	2.50E-03	2.50E-03
NH3	3.25E-04	1.04E-03
VOC	3.78E-03	1.21E-02
SO2	8.30E-04	8.30E-04
Methanol	4.41E-04	1.41E-03
Formaldehyde	7.12E-04	2.28E-03

Table 2: Wet Stemwood Broadcast Combustion Factors

Emission Species	Flame (kg/dry kg)	Smolder (kg/dry kg)
PM	1.10E-02	1.68E-02
PM10	5.85E-03	1.27E-02
PM2.5	4.80E-03	1.18E-02
CO	2.65E-02	1.37E-01
CO2	1.73E+00	1.51E+00
CH4	1.50E-03	8.80E-03
NMHC	1.60E-03	6.60E-03
Elemental Carbon	3.46E-04	8.50E-04
Organic Carbon	2.59E-03	6.37E-03
NOx	2.50E-03	2.50E-03
NH3	1.93E-04	9.96E-04
VOC	2.25E-03	1.16E-02
SO2	8.30E-04	8.30E-04
Methanol	2.62E-04	1.35E-03
Formaldehyde	4.24E-04	2.18E-03

Table 3: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Carbon dioxide [Inorganic emissions to air]	1.83	kg
Outputs		
Stemwood, broadcast burned [Insert]	1.00	kg
Carbon dioxide [Inorganic emissions to air]	1.63	kg
Methane [Organic emissions to air (group VOC)]	4.12E-03	kg
Carbon monoxide [Inorganic emissions to air]	7.71E-02	kg
NM VOC (unspecified) [Group NM VOC to air]	3.30E-03	kg
Dust (unspecified) [Particles to air]	1.43E-02	kg
Dust (PM10) [Particles to air]	9.68E-03	kg
Dust (PM2.5) [Particles to air]	8.72E-03	kg
Elemental carbon [emission to air]	6.28E-04	kg
Organic carbon [emission to air]	4.71E-03	kg
Nitrogen oxides [Inorganic emissions to air]	2.50E-03	kg
Ammonia [Inorganic emissions to air]	5.63E-04	kg
VOC (unspecified) [Organic emissions to air]	6.55E-03	kg
Sulphur dioxide [Inorganic emissions to air]	8.30E-04	kg
Methanol [Group NM VOC to air]	7.63E-04	kg
Formaldehyde (methanal) [Group NM VOC to air]	1.23E-03	kg

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows.

Embedded Unit Processes

None.

References

Johnson *et al.* 2012

Johnson, L., Lippke, B., & Oneil, E. (2012). Modeling Biomass Collection and Woods Processing Life-Cycle Analysis. *Forest Products Journal*, 62(4), 258-272.

Battye *et al.* 2002

Battye, W and R Battye. 2002. Development of Emissions Inventory Methods for Wildland Fire. Final Report for Environmental Protection Agency, Research Triangle Park, North Carolina. EPA Contract No 68-D-98-046. February. 77p.

Prichard *et al.* 2006

Prichard, S, R Ottmar and G Anderson. 2006. Consume 3.0 User's Guide. Pacific Wildland Fire Sciences Laboratory, Pacific Northwest Research Station, USDA Forest Service. Seattle, Washington. 231p.



Section III: Document Control Information

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