

# FFI Surface Fuels–Piles Protocol Description

This protocol is based on the method described in Guidelines for *Estimating Volume, Biomass, and Smoke Production for Piled Slash* (Hardy) with further additions from *Estimating Volume, Biomass, and Potential Emissions of Hand-Piled Fuels* (Wright).

Pile volume is estimated using one of the pile shape volume equations provided in the referenced publications. Machine pile volume is converted to pile loading using packing ratio and wood density. When estimating hand pile loading, a correction factor is applied to correct for overestimate of volume and regression equations are used to convert pile volume to loading.

## Data Field Definitions

### *Sample Attributes*

- *Sample Area*: Area where pile data is collected. This field is used to calculate loading per area and proportion of sample area covered by piles. Decimal number. English units-acres, metric units-hectares
- *Collected By*: Field crew information. Text
- *Entered/Verif. By*: Data entry/verification information. Text
- *UV Descriptions*: Describes the data saved in the UV sample attribute field. Text

### *Method Attributes*

- *Pile number (Required)*: Sequential pile number. Integer
- *Pile count (Required)*: Number of piles with this shape and these dimensions. Integer
- *Pile type (Required)*: Machine-Machine piled material (default) or Hand-Hand piled material.
- *Pile composition (Required)*: Material that makes up most of the burnable material in the pile. Conifer (default) or Hardwood/shrub.
- *Pile shape (Required)*: General pile shape. See table below for codes and shape names.
- *Width 1 (Required)*: First measurement of pile width. See Table 1 for the required dimensions for each pile shape (also shown on the FFI interface when hovering the mouse cursor over the dimension field labels). English units-feet, metric units-meters. Two decimal places.
- *Width 2*: Second measurement of pile width. English units-feet, metric units-meters. Two decimal places.
- *Length 1*: First measurement of pile length. English units-feet, metric units-meters. Two decimal places.
- *Length 2*: Second measurement of pile length. English units-feet, metric units-meters. Two decimal places.
- *Height 1*: First measurement of pile height. English units-feet, metric units-meters. Two decimal places.
- *Height 2*: Second measurement of pile height. English units-feet, metric units-meters. Two decimal places.

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- *Packing ratio (Required)*: Fraction of the pile volume that is occupied by burnable material. Hardy found the packing ratio of machine-piled material ranged from 0.06 to 0.26 and suggested using 0.10 to 0.25 depending on material type and size, and pile arrangement. Range: 0.0 to 0.4. Two decimal places.
- *Specific gravity (Required)*: Average specific gravity of the burnable material. A table in Hardy ranges from 0.30 to 0.58. Range: 0.2 to 0.65. Two decimal places.
- *Soil Contamination*: The amount of noncombustible material in the pile: C-Clean, A-Average, M-Moderate or H-High.

Table 1. Pile shape and required dimensions.

Pile Shape	Code	Width 1	Width 2	Length 1	Length 2	Height 1	Height 2
Half-sphere	HS	Required				Required	
Paraboloid	PA	Required				Required	
Half-cylinder	HC	Required		Required		Required	
Half-frustum of cone <sup>1</sup>	HF	Required	Required	Required			
Half-frustum of a cone w/round ends	CR	Required	Required	Required			
Half-ellipsoid	HE	Required		Required		Required	
Irregular solid	IS	Required	Required	Required	Required	Required	Required

<sup>1</sup>Hardy (1996) includes separate equations for calculating the volume of this shape: 1) based on heights and 2) based on widths. FFI only supports the equation based on widths.

### Calculations used in FFI Reports and Analysis

- Machine pile volume: Geometric volume calculated using pile dimensions (see references for equations)
- Machine pile mass: Sum load of all piles  

$$\text{Pile mass (tons)} = \text{Pile vol} * \text{packing ratio} * \text{specific gravity} * (64.2 \text{ lb ft}^{-3} / 2000 \text{ lb ton}^{-1})$$

$$\text{Pile mass (Mg)} = \text{Pile vol} * \text{packing ratio} * \text{specific gravity}$$
- Hand pile volume: Geometric volume with correction based on pile size and pile composition (see Table 2)
- Hand pile mass: Calculated using the regression equations in Table 2.

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Table 2. Hand pile volume and mass calculations (from Wright et al. 2009.)

Equation <sup>a</sup>	Adjusted R <sup>2</sup>	Root MSE <sup>b</sup>	Percentage bias	Precision
1. If $GV < 1$ , $TV = \exp(0.2106) \times GV$				
2. If $GV \geq 1$ , $TV = \exp(0.2106 + 0.7691 \times \ln[GV])$	0.79	0.253	0.206	0.270
3. If conifer, $W = \exp(4.4281 + 0.8028 \times \ln[TV])$	0.59	0.353	0.292	0.438
4. If shrub/hardwood, $W = \exp(3.0393 + 1.3129 \times \ln[TV])$	0.64	0.534	0.468	0.647

<sup>a</sup>TV = true volume (m<sup>3</sup>); GV = geometric volume (m<sup>3</sup>); W = weight (kg); ln = natural logarithm (base e).

<sup>b</sup>MSE = Mean squared error.

- Machine and Hand pile load: Sum load of all piles on a per area basis.  
Pile load = Pile mass/Sample area
- Machine and Hand pile area = Two-dimensional area of the pile (calculated with length and width only)
- Ground area fraction= proportion of sample area covered by piles.  
Pile area/Sample area/43560 ft<sup>2</sup> ac<sup>-1</sup>  
Pile area/Sample area/10000 m<sup>2</sup> ha<sup>-1</sup>

## Example Data and Report

Surface Fuels - PI

SAVE | CANCEL | DELETE | DELETE VISIT | IMPORT CSV | EXPORT CSV

Visited: Yes

Sample Area: 1

Collected By:

Entered/Verif. By:

UV1 Description:

UV2 Description:

UV3 Description:

Comment:

View	Pile Num.	Pile Count	Pile Type	Pile Composition	Pile Shape	Width 1	Width 2	Length 1	Length 2	Height 1	Height 2	Pack. Ratio	Spec. Grav.	Soil Cont.	Comment
▶	1	1	Machine	Conifer	HS	12				12		0.3	0.3	A	
	2	1	Hand	Conifer	HS	12				12		0.3	0.3	A	
*															

## Surface Fuels - Piles Summary

Macroplot	Monitoring Status	Machine Piles		Hand Piles					
		Pile Load (tons/acre)	Pile Mass (tons)	Pile Area (sq. ft.)	Ground Area Fraction	Pile Load (tons/acre)	Pile Mass (tons)	Pile Area (sq. ft.)	Ground Area Fraction
TestMP1	PostTreatmentYear1	10.16	10.16	113.10	0.0026	1.91	1.91	113.10	0.0026

## References

Hardy, Colin C. 1996. Guidelines for estimating volume, biomass, and smoke production for piled slash. Gen. Tech. Rep. PNW-GTR-364. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 28 p. (14 p. and 14 p.)

Wright, Clinton S.; Balog, Cameron S.; Kelly, Jeffrey W. 2009. Estimating volume, biomass, and potential emissions of hand-piled fuels. Gen. Tech. Rep. PNW-GTR-805. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 23 p.