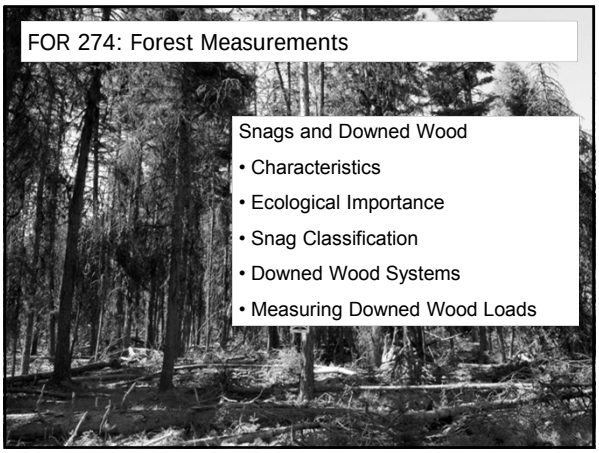
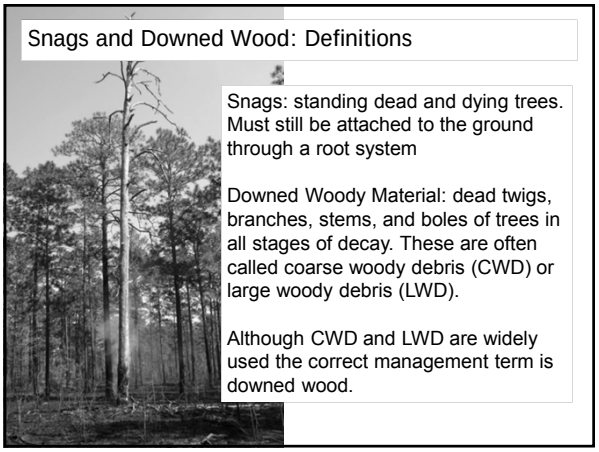


FOR 274: Forest Measurements

Snags and Downed Wood

- Characteristics
- Ecological Importance
- Snag Classification
- Downed Wood Systems
- Measuring Downed Wood Loads

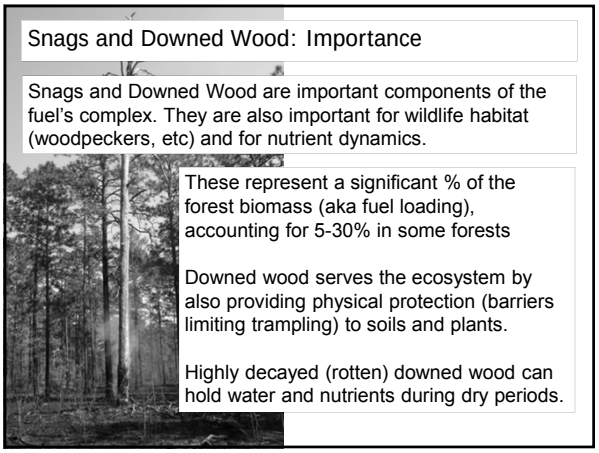


Snags and Downed Wood: Definitions

Snags: standing dead and dying trees. Must still be attached to the ground through a root system

Downed Woody Material: dead twigs, branches, stems, and boles of trees in all stages of decay. These are often called coarse woody debris (CWD) or large woody debris (LWD).

Although CWD and LWD are widely used the correct management term is downed wood.



Snags and Downed Wood: Importance

Snags and Downed Wood are important components of the fuel's complex. They are also important for wildlife habitat (woodpeckers, etc) and for nutrient dynamics.

These represent a significant % of the forest biomass (aka fuel loading), accounting for 5-30% in some forests

Downed wood serves the ecosystem by also providing physical protection (barriers limiting trampling) to soils and plants.

Highly decayed (rotten) downed wood can hold water and nutrients during dry periods.

Snags and Downed Wood: Importance

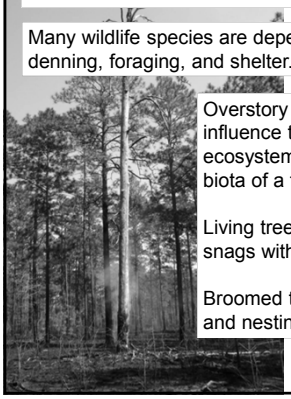
Table 2. Inputs of coarse woody debris (CWD) and other aboveground litter types in northern coniferous forests.

Species	Stand age (years)	Boles	FWD	NWD	GV	CWD%	Reference
Mass ($g \cdot m^{-2} \cdot year^{-1}$)							
Abies balsamea	50–60	170	305	375		20	Sprugel 1984
	Mortality period	1780	350	300		73	Sprugel 1984
	47	25					Lang 1985
	81	82					Lang 1985
Abies lasiocarpa – Picea engelmannii	>350	48	49	103	5	24	Laiho and Prescott 1999
Picea glauca	120	7	80	124	26	3	Laiho and Prescott 1999
Picea contorta	90	68	90	150	56	22	Laiho and Prescott 1999
Pseudotsuga menziesii	60–100	135–392					Sollins 1982
	450	480–960[a]	130–180	170–280		56–66	Grier and Logan 1977
Pseudotsuga menziesii + others	450	266–395					Sollins 1982
Tsuga heterophylla – Picea sitchensis	105	274					Sollins 1982
Nitrogen ($g \cdot m^{-2} \cdot year^{-1}$)							
Abies balsamea	50–60	0.284					Sprugel 1984
Abies lasiocarpa – Picea engelmannii	>350	0.067	0.296	0.874	0.071	5	Laiho and Prescott 1999
Picea glauca	120	0.006	0.330	0.830	0.318	1	Laiho and Prescott 1999
Pinus contorta	90	0.049	0.151	1.026	0.637	4	Laiho and Prescott 1999
Pseudotsuga menziesii	450	0.39	0.38	1.41		18	Sollins et al. 1980
Phosphorus ($g \cdot m^{-2} \cdot year^{-1}$)							
Abies lasiocarpa – Picea engelmannii	>350	0.002	0.024	0.059	0.005	2	Laiho and Prescott 1999
Picea glauca	120	0.001	0.028	0.121	0.067	1	Laiho and Prescott 1999
Pinus contorta	90	0.003	0.014	0.089	0.105	3	Laiho and Prescott 1999
Pseudotsuga menziesii	450	0.06	0.05	0.38		12	Sollins et al. 1980

Laiho and Prescott (2004)

Snags and Downed Wood: Importance

Many wildlife species are dependent on snags for nesting, denning, foraging, and shelter.



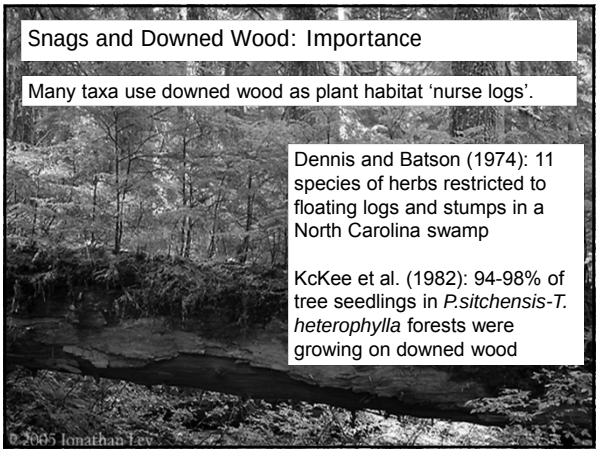
Overstory and understory vegetation influence the structure and function of ecosystems and therefore shape the biota of a forest (Hunter 1999)

Living trees with decay can function as snags within an ecosystem

Broomed trees can provide food, cover, and nesting habitat for many species

Snags and Downed Wood: Importance

Many taxa use downed wood as plant habitat 'nurse logs'.

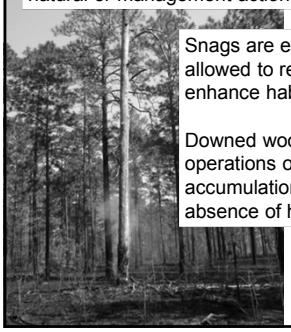


Dennis and Batson (1974): 11 species of herbs restricted to floating logs and stumps in a North Carolina swamp

KcKee et al. (1982): 94-98% of tree seedlings in *P.sitchensis-T. heterophylla* forests were growing on downed wood

Snags and Downed Wood: Formation

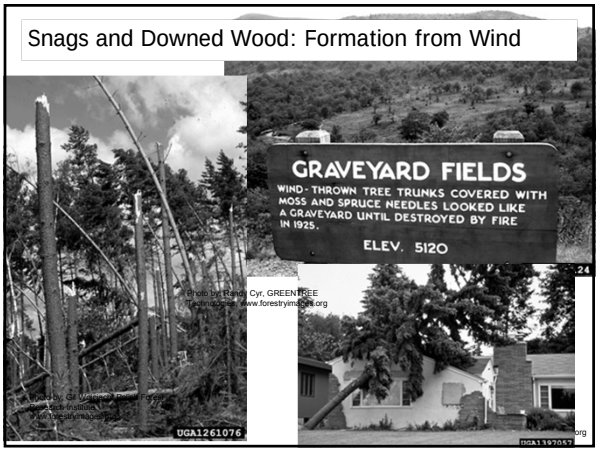
Snags and Downed Wood are generally formed as a result of natural or management actions.



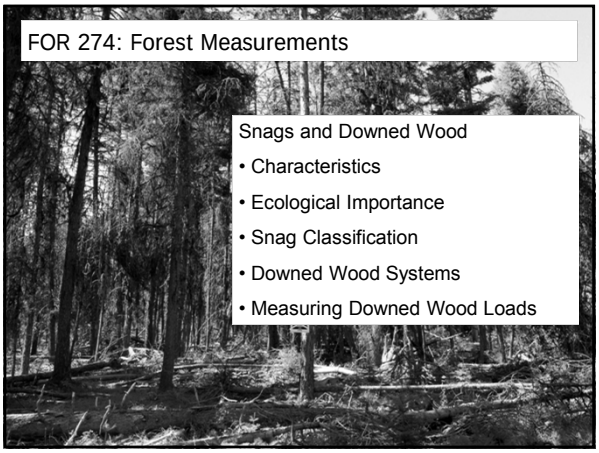
Snags are essentially dead trees that are allowed to remain in the stand (typically to enhance habitat)

Downed wood can include slash from forest operations or natural debris, which refers to accumulation of woody material in the absence of harvesting.

Snags and Downed Wood: Formation from Wind



FOR 274: Forest Measurements



Snags and Downed Wood

- Characteristics
- Ecological Importance
- Snag Classification
- Downed Wood Systems
- Measuring Downed Wood Loads

Snags: Classification Systems

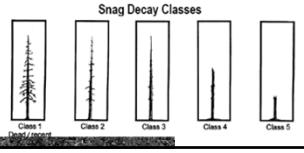
Snags are generally classified by their amount of decay, their time since death, and whether they have limbs present.

Snag Decay

Code	Bark	Heartwood Decay	Sapwood Decay	Limbs	Top Breakage	Bole Form	Time Since Death
1*	Tight, intact	Minor	None to incipient	Mostly Present	May be present	Intact	≤5 years
2	50% loose or missing	None to advanced	None to incipient	Small limbs missing	May be present	Intact	>5 years
3	75% missing	Incipient to advanced	None to 25%	Few remain	Approx. 1/3	Mostly intact	>5 years
4	75% missing	Incipient to advanced	25%+	Few remain	Approx. 1/3 to ⅔	Losing form, soft	>5 years
5	75%+ missing	Advanced to crumbly	50%+ advanced	Absent	Approx. ⅔+	Form mostly lost	>5 years

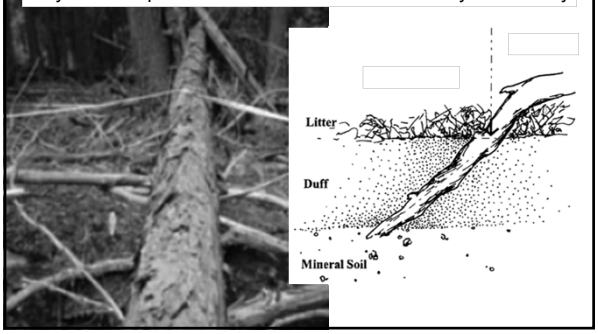
*Implies recent mortality, within the last 5 years.

Snag Decay Classes



Downed Wood: Classification Systems

Downed wood are generally classified by the degree to which they are incorporated into the litter and duff and by their decay



Downed Wood: Classification Systems

Downed wood are generally classified by the degree to which they are incorporated into the litter and duff and by their decay

Log Decay

Code	Bark	Twigs	Texture	Shape	Wood Color	Portion of log on ground
1*	Intact	Present	Intact	Round	Original	None, elevated on supporting points
2	Intact	Absent	Intact to soft	Round	Original	Parts touch, still elevated, sagging slightly
3**	Trace	Absent	Hard large pieces	Round	Original to faded	Bole on ground
4**	Absent	Absent	Soft blocky pieces	Round to oval	Light brown to faded brown	Partially below ground
5**	Absent	Absent	Soft, powdery	Oval	Faded light yellow or gray	Mostly below ground

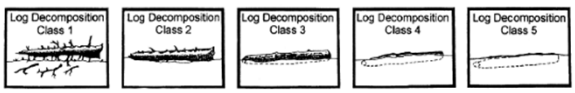
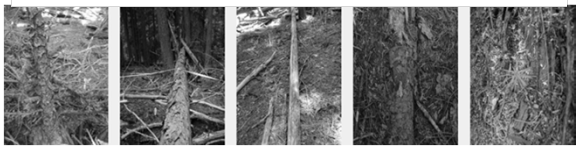
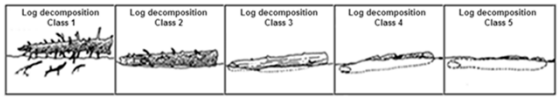


Table and Figures from USDA Forest Service common Stand Exam Users Guide

Downed Wood: Classification Systems





DEGREE OF DECAY

Bark Intact	Bark Absent
Structurally Sound	Not Sturcturally Sound
Branches Present	Branches Absent
No Invading Roots	Rooted Throughout
No Established Vegetation	Trees, Shrubs, and Moss Present

Table adapted from work by Fogel et al 1973, Maser et al 1979

Downed Wood: Classification Systems

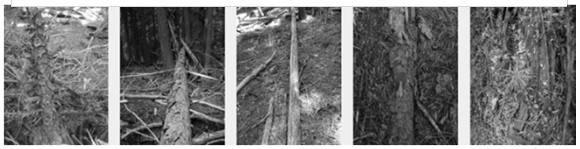


Table FL-3. Use these descriptions to determine the decay class where the log crosses the sampling plane.

Decay Class	Description
1	All bark is intact. All but the smallest twigs are present. Old needles probably still present. Hard when kicked
2	Some bark is missing, as are many of the smaller branches. No old needles still on branches. Hard when kicked
3	Most of the bark is missing and most of the branches less than 1 in. in diameter also missing. Still hard when kicked
4	Looks like a class 3 log but the sapwood is rotten. Sounds hollow when kicked and you can probably remove wood from the outside with your boot. Pronounced sagging if suspended for even moderate distances.
5	Entire log is in contact with the ground. Easy to kick apart but most of the piece is above the general level of the adjacent ground. If the central axis of the piece lies in or below the duff layer then it should not be included in the CWD sampling as these pieces act more like duff than wood when burned.

Downed Wood: The Fogel Classification System

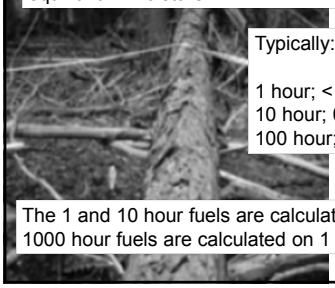
Feature	Log Decay Class 1	2	3	4	5
Bark	Intact	Intact	Trace	Absent	Absent
Twigs <.003 m	Present	Absent	Absent	Absent	Absent
Specific Gravity	.474	----	.420	.222	.046
Texture	Intact	Intact, partly soft	Hard, large pieces	Soft, small, blocky pieces	Soft, powdery
Wood Color	Original Color	Original color	Reddish brown or original color	Reddish or light brown	Red-brown to dark brown
Epiphytes	None	None	Conifer seedlings	*Vaccinium*, moss, TSHE seedlings	*Vaccinium*, moss, TSHE seedlings
Invading roots	None	None	Conifer seedlings	*Vaccinium*, moss, TSHE seedlings	*Vaccinium*, moss, TSHE seedlings
Fungi fruiting	Similar to class 4	*Cyathus, Tremella Mycena, Collybia, Polyporus Fomes, Pseudohydnum*	*Polyporus, Polyporellus, Pseudohydnum, Fomes*	*Cortinarius, Mycena, Marasmius*	Cortinarius Collybia, Cantharellus

Downed Wood: The Maser Classification System

Feature	Log decay class				
	Class 1	Class 2	Class 3	Class 4	Class 5
Bark	Intact	Intact	Trace	Absent	Absent
Twigs ≤ 3 cm	Present	Absent	Absent	Absent	Absent
Texture	Intact	Intact to partly soft	Hard, large pieces	Small, soft, blocky pieces	Soft and powdery
Shape	Round	Round	Round	Round to oval	Oval
Color of wood	Original color	Original color	Original to faded color	Light to dark brown or faded brown, grey, or yellow	Light to dark brown or faded grey or yellow
Portion of log on ground	Log elevated on branches	Log elevated on branches but slightly sagging	Log is sagging near ground or touch ground	Log is touching ground or partially buried	Log is nearly completely buried

Downed Wood: Classification Systems

When considering downed wood for fire management we often talk about the time-lag classes. These classes are based on the time it takes a fuel particle to reach 2/3 of its equilibrium moisture.



Typically:

1 hour; < 0.25 inch diameter
10 hour; 0.25 < X < 1.0 inch diameter
100 hour; 1.0 < X < 3.0 inch diameter

The 1 and 10 hour fuels are calculated hourly, while 100 and 1000 hour fuels are calculated on 1 and 7 day averages

FOR 274: Forest Measurements

Snags and Downed Wood

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Downed Wood: Brown's Transect

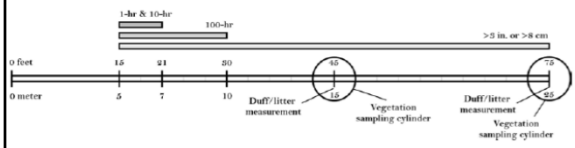
We typically calculate surface woody fuel loading via the line intercept method, often called the Brown's Transect.

Notes:
- Include downed woody material under 6 feet in height
- Your sampling protocol will determine over what length you tally your 1, 10, 100, and 1000 hour fuels.
- Your sampling protocol will determine at what lengths you measure duff and litter depths.

Brown (1974)

Downed Wood: Brown's Transect

In the FIREMON protocol this is how we typically measure the downed wood in the Brown's transects. The specific location of the duff and litter measurements are arbitrary.



Based on these measurements, we can calculate the fuel loading by fuel lag class. NOTE: many transects are needed to obtain measurements at a high accuracy.

Downed Wood: Brown's Transect

The line intercept method can provide weights and volumes per acre for all diameter size classes. The method also provides depth of fuel and duff at locations along the line.

Main Steps:
1. Decide sampling length and direction (random)
2. Run tape for length.
3. Tally (avoid disturbing the area) small diameters "on way out" and measure large "on way back"
4. Measure slope
5. Calculate fuel loading

Brown (1974)

Litter and Duff: Depth

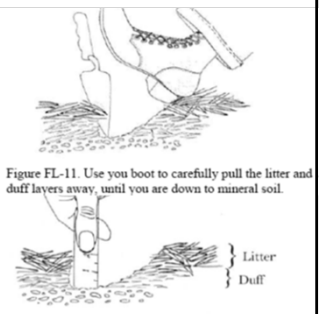
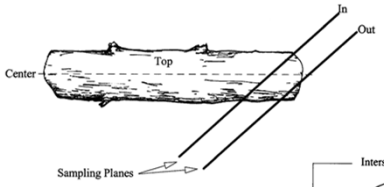


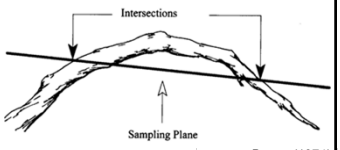
Figure FL-11. Use you boot to carefully pull the litter and duff layers away, until you are down to mineral soil.

Figure FL-12. Use a plastic ruler to estimate duff and litter depth. Place the zero end at the intersection of the mineral soil and duff layer, then mark top of the litter layer using your thumb or finger. In this illustration the duff/litter depth is 2 in. (5 cm). and the proportion of that depth that is litter is about 50 percent.

Downed Wood: Brown's Transect

Only include a piece of the sampling line intersects the center and if the plane intersects a curved piece twice, count each time



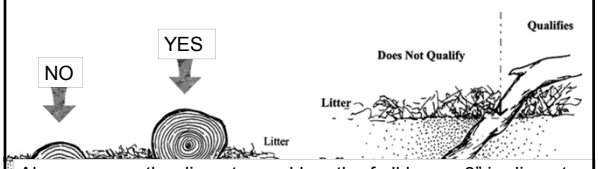


Do not include cones, bark flakes, needles, leaves, grasses, or forbs

Brown (1974)

Downed Wood: Brown's Transect

Include downed woody logs if the center is above the surface. Include twigs and branches if in the litter layer. Include aerial downed wood if below 6 feet above the surface.

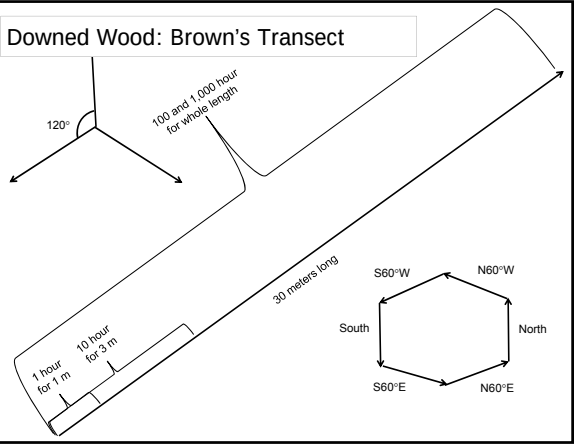


Also measure the diameter and length of all logs > 3" in diameter. Generally, we also estimate the % of species within the entire sampling frame.

Mineral Soil

Brown (1974)

Downed Wood: Brown's Transect



Downed Wood: Field Sheets and Calculation

								Litter Depth (in)		Duff Depth (in)	
Transect	1-hr	10-hr	100-hr	Sound Diam. (in)	Sound Length (ft)	Rotten Diam. (in)	Rotten Length (ft)	3 ft	9 ft	3 ft	9 ft
1	12	8	8	5	38			1.2	1.4	0.5	0.7
				4	21						
						6	18				
2	6	12	11	11	32			0.8	1.1	1	0.8

Equation for fuel 0 to 3 inches:

$$\text{Tons/Acre} = (11.64 * n * d^2 * s * a * c) / L$$

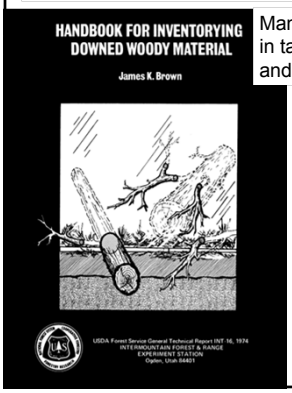
Equation for fuel 3 inches and greater:

$$\text{Tons/Acre} = (11.64 * \Sigma [d^2]* s * a * c) / L$$

Where: c = slope correction factor (1 for flat slopes), n = tally for that size class, d^2 = mean square diameter, s = specific gravity, L = length of transect, a = non-horizontal angle correction factor.

Brown (1974)

Downed Wood: Obtaining the Constants



Many of these constants are found in tables contained in Brown (1974) and more recent works.

Brown (1974)

Downed Wood: Slope Factor, c

$$c = \sqrt{1 + \left(\frac{\text{Percent slope}}{100}\right)^2}$$

Table 1.--*Slope correction factors for converting weight/acre on a slope basis to a horizontal basis*

Slope	Correction factor	Slope	Correction factor
Percent	*c*	*Percent*	*c*
0	1.00	60	1.17
10	1.00	70	1.22
20	1.02	80	1.28
30	1.04	90	1.35
40	1.08	100	1.41
50	1.12	110	1.49

Brown (1974)

Downed Wood: Mean square diameters, d^2

Table 2.--*Squared average-quadratic-mean diameters for nonslash and slash ground fuels*

Size class (inches)	Nonslash: Cover type[1]	Nonslash: Average d^2	Slash: Species[1]	Slash: Average d^2
		Inches^2		*Inches*^{2}
0 - 0.25	PP	0.0342	PP, LP	0.0248
	LP	.0201	L	.0149
	S, DF, AF, C	.0122	DF, GF, C, S	.0122
	L	.0149	Composite[2]	.0151
	Composite	.0151		
0.25 - 1	LP	.344	PP, C	.317
	S, DF, AF, C	.304	DF, GF, LP, L, S	.278
	L, PP	.238	Composite	.289
	Composite	.289		
1 - 3	PP, AF	3.12	LP	3.50
	S, DF, C, LP	2.87	DF, PP, GF	2.83
	L	2.17	L, C, S	2.30
	Composite	2.76	Composite	2.76

[1]/PP=ponderosa pine (*Pinus ponderosa*); LP=lodgepole pine (*Pinus contorta*); S=Engelmann spruce (*Picea engelmannii*); DF=Douglas-fir (*Pseudotsuga menziesii*); L=western larch (*Larix occidentalis*); GF=grand fir (*Abies grandis*); C=western redcedar (*Thuja plicata*); AF=subalpine fir (*Abies lasiocarpa*).

[2]/All composite values are averages of nonslash and slash fuels with each cover type and species weighted equally.

Brown (1974)

Downed Wood: Specific gravity, s & angle, a

Diameter class (*inches*):	0-0.25	0.25-1	1-3	3+Sound	3+Rotten
Specific gravity :	0.48	0.48	0.40	0.40	0.30

Table 3.--*Average secant of nonhorizontal particle angles for correcting orientation bias for slash*

Size class (*inches*)	Species[1]	Average (a): Fresh slash	Average (a): 1-year and older slash
0 to 0.25	PP	1.25	1.25
	Others	1.40	1.15
0.25 to 1	PP	1.25	1.25
	Others	1.13	1.13
1 to 3	PP	1.22	1.22
	Others	1.10	1.10
3+	All (an assumption)	1.00	1.00

[1]/PP=ponderosa pine; Others=based on data for Douglas-fir, lodgepole pine, Engelmann spruce, western redcedar, western larch, and grand fir.

Brown (1974)

Downed Wood: Example Calculation

								Litter Depth (in)		Duff Depth (in)	
Transect	1-hr	10-hr	100-hr	Sound Diam. (in)	Sound Length (ft)	Rotten Diam. (in)	Rotten Length (ft)	3 ft	9 ft	3 ft	9 ft
1	12	8	8	5	38			1.2	1.4	0.5	0.7
				4	21						
						6	18				
2	6	12	11	11	32			0.8	1.1	1	0.8

Equation for Transect 1 (50'), 1-hr fuels of PIPO on flat ground:

Tons/Acre = (11.64 * n * d^2 * s * a * c) / L

= (11.54 * 7 * 0.0342 * 0.48 * 1 * 1) / 50

= 0.027 tons / ac

Brown (1974)

Downed Wood: Example Calculation 2

Size Class	Constant	n	d^2	s	a	c	nℓ	Tons/acre
0 - 0.25	11.64	7	0.0122	0.48	1.40	1.00	24.00	0.03
0.25 -1	11.64	20	0.304	0.48	1.13	1.00	24.00	1.60
1-3	11.64	4	2.87	0.40	1.10	1.00	40.00	1.47
		$\sum d^2$ for 3+						
3+ Sound	11.64	176		0.40	1.00	1.00	200	4.10
Total Fuel Loading = 7.20 tons/acre								
Duff Depth = 0.53 in								
Litter Depth = 2.18								

Brown (1974)

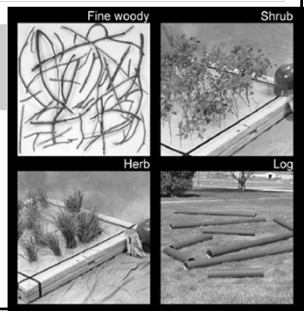
Downed Wood: Photo Guide

In a similar manner to fuel photo guides used to estimate surface and canopy fuel loading, photo guides exist to estimate downed wood.

The Photoload Sampling Technique:

Estimating Surface Fuel Loadings From Downward-Looking Photographs of Synthetic Fuelbeds

Robert E. Keane and Laura J. Dickinson



Downed Wood: Photo Guide