UNIVERSITY of NEW HAMPSHIRE
Cooperative Extension

Estimating Volume of Downed Trees

Using Perpendicular Distance Sampling

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This fact sheet summarizes a quick and efficient method to estimate the volume of potentially salvageable timber blown over by heavy winds. Volume estimates in damaged stands can be used to determine 1) the feasibility of a salvage harvest and 2) the volume of trees damaged by the event. This description presumes an understanding of standard methods for estimating standing timber.

Perpendicular distance sampling (PDS) can be used in wind-damaged forests to estimate volumes of down, salvageable timber. In many cases this method of sampling may prove to be the fastest and most efficient method of determining salvageable volume. Other methods have been used to measure down wood, such as line intercept sampling, fixed area sampling and others, but none have performed as well as PDS when estimating the volume of down wood. Besides the efficiency of PDS, the other methods may pose a threat to safety in these hazardous stands. For example, line intercept sampling requires a line be walked causing travel over and under unstable trees and logs. As for other methods, you must actually measure the log in order to estimate volume. **PDS for the most part requires little measurement, if any, and little movement from the sample point**.

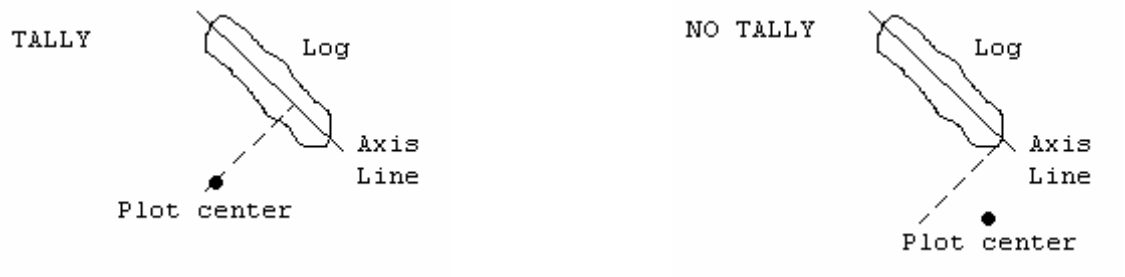
Using PDS to sample down wood is the same as using variable radius plot sampling or point sampling to sample standing trees. In point sampling, trees are sampled proportional to their cross-sectional area. In PDS, down logs are sampled proportional to their volume– the greater the log's volume, the more likely it is to be sampled. In point sampling, a basal area factor is used to determine stand basal area. In PDS, a volume factor is used to determine estimated stand volumes for down wood. The volume factor (VF) is a constant that is multiplied by the number of sampled logs in each plot. For example, if a VF of 100 ft^3/acre is used and 5 logs are sampled in one plot, the estimated volume per acre based on that one plot is 500 ft^3/acre.

BASIC PROCEDURE

This procedure was developed to provide accurate estimates of coarse woody material (CWM) volume without ever measuring a piece of CWM. In theory PDS is similar to how variable radius point sampling (VRPS) estimates overstory basal area. To use the method:

1. Lay out your sample points. PDS can be added to an inventory cruise or whenever sample points are visited. The points can be laid in any method– systematically, randomly, etc.
2. At each sample point, the observer spins around scanning the forest floor for logs.
3. Logs are tallied under two conditions:

1. The observer can make a right angle (90 degrees) with the log and the sample point. The point where this right angle can be formed is known as the log's perpendicular point, and
2. The distance from the sample point to the perpendicular point is within the limiting distance.



The solid line indicates the axis of the log. The dashed line indicates the limiting distance. Even though the log in the "NO TALLY" situation is within the limiting distance, based upon the orientation of the log, a perpendicular line cannot be made with the log and the sample point.

If these two conditions are met, the log is tallied– just like a tree is tallied when using a prism or angle gauge in VRPS. Volume on a unit per area basis is estimated multiplying the number of tallied logs at each point by the volume factor, then averaging all of the sample points. For example:

	# Logs Tallied	VF	Volume/acre
Point 1	4	300 ft^3/ac	1200 ft^3/ac
Point 2	7	300 ft^3/ac	2100 ft^3/ac
Point 3	5	300 ft^3/ac	1500 ft^3/ac
			1,600 ft^3/acre average
		or	12,800 board feet
		or	19 cords

Based upon this three point cruise, the stand would have an estimated 1600 ft^3/ac of CWM. To convert cubic feet to cords or board feet, use commonly accepted conversion factors.

Although any fixed conversion factor should be used with care, the following are presented as "rules of thumb".

To convert cubic feet to thousand board feet international ¼ inch rule multiply cubic foot volume by 0.008

To convert cubic feet to cords, multiply cubic foot volume by 0.012 (assumes 85 cubic feet of solid wood per cord)

VOLUME FACTOR

The volume factor (VF) is the factor the number of tallied pieces of CWM is multiplied by to get the estimate of volume per area. Since the PDS method is relatively new, few field studies have been conducted to determine the optimal VF for the New England landscape. If a small VF is chosen, such as 50 ft^3/acre, too many logs will be tallied at each point and time will be wasted. If a large VF is chosen, such as 3000 ft^3/acre, too few pieces are tallied and data may be too variable. For now, start with a VF of 100- 400 ft^3/acre and adjust after a few cruises.

LIMITING DISTANCE

The limiting distance (LD) is determined by the size of the volume factor and the diameter of the log at the perpendicular point– just as the limiting distance in VRPS is determined by the size of the basal area factor and the diameter of the tree.

In most instances, the limiting distance table can be used to determine whether or not to tally the log. For borderline trees, use the following formula:

LD = K * perpendicular cross-sectional area of the log

Where K is a constant = 43,560/ (2 * VF) and
Perpendicular cross-sectional area = 0.005454 * perpendicular diameter^2 (in inches)

SHORTCOMINGS

PDS has two shortcomings. This method cannot be used to estimate the number of logs per acre in a stand and the limiting distance of larger diameter logs can be large. To estimate the number of logs per acre and tie other attributes to that statistic, a simple fixed area plot can be used. Logs whose large end falls within the boundaries of the fixed area plot are counted. An average of the plot statistics are made to estimate stand level statistics. Also, with the log count, the observer can note species, grade, and other useful attributes.

DIAMETER LIMITED PERPENDICULAR DISTANCE SAMPLING

To address large limiting distances, a version of PDS has been created called diameter limited perpendicular distance sampling (DLPDS). This method sets a distance which the observer will not look past to scan for logs. For example, if a distance of 1 chain (66 feet) is set, the observer will not consider any logs past 1 chain from the sample point, even if the log is perpendicular to the sample point and falls within the limiting distance. DLPDS reduces the number of logs potentially missed because they are too far away to be seen.

- Distance limited perpendicular distance sampling is a safe and efficient method that can be used to estimate coarse woody material without leaving the sample point.
- Perpendicular angles, diameter at the perpendicular points and distances from the sample point can be determined through ocular estimates, reducing time sampling and travel in hazardous conditions.
- Limited distances shouldn't be memorized. Instead a limiting distance table can be printed and attached to a clipboard or tally card.
- "Borderline" logs should be measured and not just estimated to determine whether or not they should be sampled to ensure quality data.
- While DLPDS cannot estimate number of pieces per acre, a fixed area plot can be established at the sample point to estimate number of pieces per unit area while DLPDS estimates volume.
- Sampling designs can be tailored to the salvage operation. For example, if you are only interested in sawlogs, ignore any log incapable of producing a sawlog and don't tally logs whose diameter at the perpendicular point are under the small end diameter of a sawlog.

Limiting Distance Table

VF 100		VF 200		VF 300		VF 400	
Dia in	LD ft	Dia in	LD ft	Dia in	LD ft	Dia in	LD ft
4	19.0	4	9.5	4	6.3	4	4.8
5	29.7	5	14.8	5	9.9	5	7.4
6	42.8	6	21.4	6	14.3	6	10.7
7	58.2	7	29.1	7	19.4	7	14.6
8	76.0	8	38.0	8	25.3	8	19.0
9	96.2	9	48.1	9	32.1	9	24.1
10	118.8	10	59.4	10	39.6	10	29.7
11	143.7	11	71.9	11	47.9	11	35.9
12	171.1	12	85.5	12	57.0	12	42.8
13	200.8	13	100.4	13	66.9	13	50.2
14	232.8	14	116.4	14	77.6	14	58.2
15	267.3	15	133.6	15	89.1	15	66.8
16	304.1	16	152.0	16	101.4	16	76.0
17	343.3	17	171.6	17	114.4	17	85.8
18	384.9	18	192.4	18	128.3	18	96.2
19	428.8	19	214.4	19	142.9	19	107.2
20	475.2	20	237.6	20	158.4	20	118.8
21	523.9	21	261.9	21	174.6	21	131.0
22	574.9	22	287.5	22	191.6	22	143.7
23	628.4	23	314.2	23	209.5	23	157.1
24	684.2	24	342.1	24	228.1	24	171.1
25	742.4	25	371.2	25	247.5	25	185.6
26	803.0	26	401.5	26	267.7	26	200.8
27	866.0	27	433.0	27	288.7	27	216.5
28	931.3	28	465.6	28	310.4	28	232.8
29	999.0	29	499.5	29	333.0	29	249.8
30	1069.1	30	534.5	30	356.4	30	267.3

ADDITIONAL RESOURCES:

Ducey, M.J., Williams, M.S., Roberge, S.S., Kenning, R.S., Gove, J.H. (In Press) Distance limited perpendicular distance sampling for coarse woody material: theory and field results.

Williams, M.S. and Gove, J.H. (2003) Perpendicular distance sampling, another method of sampling coarse woody debris. Canadian Journal of Forest Research, 33,1564-1579

Williams, M.S., Ducey, M.J., and Gove, J.H. (2005) Assessing surface area of coarse woody debris with line intersect and perpendicular distance sampling. Canadian Journal of Forest Research, 35,949-960

Williams, M.S., Valentine, H.T., Ducey, M.J., and Gove, J.H. (2005) Additional results for perpendicular distance sampling. Canadian Journal of Forest Research, 35,961-966