ISSN : 0974 - 7451 Volume 8 Issue 3

Environmental Science
An Indian Journal

Trade Science Inc.

Current Research Paper

ESAIJ, 8(3), 2013 [83-87]

A practical sampling strategy for assessing woody debris in Fandoghlou forest, Iran

Farshad Keivan Behjou, Omid Ghafarzade Mollabashi*
Department of Range and Watershed management, Faculty of Agriculture Technology, (IRAN)
Natural Resources, University of Mohaghegh Ardabili, Ardabil, (IRAN)
E-mail : Omid_Ghafarzade@yahoo.com

ABSTRACT

Information on the amount, distribution, and characteristics of woody debris in forest ecosystems is in high demand by wildlife biologists, fire specialists, and ecologists. In recent years, a number of new methods have been proposed to sample woody debris in terrestrial ecosystems. In present study, three approaches within line intersect sampling including probability, Huber and Smalian approaches were compared for accuracy and efficiency in measuring of woody debris. The data were selected from recreational forests of Fandoughlou including hazel stands located in northwestern Iran. The results indicated that line-intersect sampling based on probability theory consistently provided estimates similar to the results of a 100% survey (high accuracy). This method also took the least amount of time and effort for map lay-out and field line location (high efficiency); therefore, line intersect sampling as an easy and quick survey method is proposed to monitor woody debris in the region.

KEYWORDS

Woody debris;
Line intersect sampling;
Probability;
Huber and Smalian approaches;
Fandoghlou forests.

INTRODUCTION

The past decade has experienced substantial interest in role of woody debris (WD) in danger of every ecosystem process[11]. Woody debris is widely recognized as an extremely important structural and functional component of forest communities[4,6,8]. Also, woody debris plays a key role in many aspects of ecosystem functioning; including habitat for wildlife and fungi, nursery site for seedling establishment, nutrient cycling, and soil stability. Woody debris includes whole fallen trees, fallen branches, and pieces of fragmented wood, stumps, standing dead trees (snags), and logging residues. This study focuses on sampling strategies for forest floor woody debris. The need to obtain efficient and reliable estimates of woody debris is obvious for practitioners who try to realize management goals. Many sampling designs for quantifying the woody debris have been used until now in other countries[2,12,15]. The most widely used method for sampling woody debris is the line-intersect method[7,13,14]. In addition, line intersect sampling is certainly the most flexible in its ability to assess many attributes associated with woody debris among the various sampling techniques for woody debris. One of its primary advantages is the many attributes that can be estimated without actual measuring of the specific attribute (e.g., the volume of WD can be estimated with only a measurement of cross-sectional area on individual pieces). In this method, diameter of intersected woody debris is measured at different points of a piece. The design options associated with the line intersect method are transect length, transect layout, and number of replicates. Brown[3] adapted the line-intersect method to estimate the volume and weight of logs for managing the fuels and predicting the fire behavior. Brown's sampling method was based on the line-intersect technique developed by Warren & Olsen[14] who evaluated the technique using matchsticks of equal length and diameter. Hazard and Pickford[5] found that the sampling effort is required to achieve the same precision as that increased six-fold when logs of variable length and shape were used. However, Hazard and Pickford[5] verified that the line intersect method produce unbiased estimates of woody debris when sampled using random location and orientation of line transects. The ministry of Forests of British Columbia uses a triangle with 30 m sides for determining fuel loading prior to a prescribed burn, while an 'L' shape with two 24 m lines is used in their Vegetation Resources Inventory[9]. Woldendorp[15]. compared alternative methodologies for measuring DCWD in a number of Australian forest types including woodlands. They also investigated line intersect sampling precision could be improved by extending the transect length used. Miehs et al. 2010 compared the efficacy of the line intersect and strip plot methods to sample properties of down coarse woody debris (DCWD) at woodland sites with different fire histories. Results of the study indicated that the line intersect method had 20% less variability in the data and was more quick to perform and makes it easier to locate individual pieces of DCWD than the strip plot method. Woody debris is notoriously difficult to study because of its patchy distribution[7].

A quantitative assessment of coarse woody debris will be more informative than a qualitative assessment, and a statistically valid strategy is desirable to estimate woody debris. This study has investigated alternative approaches within line intersect method for measuring woody debris in a recreational forest for first time in the study region.

Fandoghlou forests with an area around 1000ha are located on the north-western of Iran. The knowledge of coarse woody debris amount will help forest managers understands the impact of forest management practice on the quantity of woody debris. The primary objective of this study was to determination of the most appropriate approaches for measuring WD to estimate the volume, density, and projected area in a recreational forest ecosystem by comparing the precision, bias, and efficiency of estimates obtained from three approaches within the line intersect method.

EXPERIMENTAL

Study site

The research was conducted on a hazel dominated forest in Fandoghlou in Ardabil, Iran (38°24´N, 48°35´E) with the area of 59ha. The stand was dominated by hazel (*Corylus sp.*), hornbeam (*Carpinus betolus*), and beech (*Fagus orientalis*) (TABLE 1). Average annual rainfall is 430mm, and the average annual temperature is 10°C. The study site is a recreational forest with an altitudinal range from about 1320 to 1600m.

TABLE 1 : Species composition of the study area

Specie	percentage of stand	basal area (m^2/ha)	diameter at collar area (cm)
Hazel	91.5	8.1	7
Hornbeam	6.5	3.1	12
Beech	2	0.8	10

Methods

At first, complete count of pieces was applied in the region. After that, a total of 230 sampling points were located in the study area. For the purpose of this study, WD was defined as downed woody material with a minimum diameter of 5 cm and a minimum length of 50 cm. A 50 meter line intersect transect and a 50*50 meter grid were setting in the region. Transects were systematically located and oriented within forest and were established a minimum of 30 meter from the roads. For the line transect method, all pieces of WD intersecting the transect line were measured. Three different measurement methods including probability theory (measuring the diameter of pieces in intersected point), Huber, (measuring the diameter of pieces at mid-point of pieces) and Smalian (measuring the diameter of pieces at small-end and large-end of pieces) was applied. Also, the length was recorded for each piece of WD. Trees that had fallen and broken were tallied as two pieces if the pieces were not touching; otherwise, each fallen tree was considered one piece. Only pieces whose central axis lay above the ground were tallied[3]. Each piece was painted at both its large and small ends where the diameter measurements were taken. Diameters were measured to the nearest millimeter. Lengths of pieces were measured to the nearest decimeter between the painted diameter marks. For large logs with their root systems still attached, the large-end diameter was measured just above the butt swell, whereas the length was measured along the entire bole from the root wad out to the 5cm small-end diameter.

The order of implementation was randomly determined at each sampling point. The first employed measurement method was timed with a stopwatch. The subsequent methods were performed at each sampling point that were not timed to avoid a potential underestimation of the time requirement for the method because of foreknowledge of the location and characteristics of pieces of woody debris already tallied. Estimation of pieces per hectare (No./ha), volume per hectare (m^3/ha), projected area per hectare (m^2/ha) and sample standard errors were calculated for each method. Volume of individual pieces, projected area, and number of pieces per hectare were calculated using formulas (1), (2), and (3).

$$Y_i(m^3/ha) = \frac{\pi^2}{8L} \times \sum_{j=1}^{m_j} \frac{d_{ij}^2}{\cos\lambda_{ij}} \quad (1)$$

Where: II: consonant amount (3.14); L: length of line transect (m); d_{ij}: diameter of CWD piece j crossed by line transect I (m); λ_{ij} : acute angle from the horizontal of CWD piece j crossed by line transect I (degrees); Y_i: volume per hectare based on line transect i (m^3/ha)

$$Y_i(m^2/ha) = \frac{50\times\pi}{L} \times \sum_{j=1}^{m_j} \frac{d_{ij}}{\cos\lambda_{ij}} \quad (2)$$

II: consonant amount (3.14); L: length of line transect (m); d_{ij}: diameter of CWD piece j crossed by line transect I (m); λ_{ij} : Acute angle from the horizontal of CWD piece j crossed by line transect I (degrees); Y_i: projected area per hectare by CWD based on line transect I (m^3/ha)

$$Y_i(piece/ha) = \frac{10000\pi}{2\times L} \times \sum_{j=1}^{m_j} \frac{1}{(l_{ij} \times \cos\lambda_{ij})} \quad (3)$$

II: consonant amount (3.14); L: length of line transect (m); λ_{ij} : Acute angle from the horizontal of CWD piece j crossed by line transect I (degrees); Y_i: number of pieces per hectare based on line transect I (no./ha)

Testing for bias in estimates was performed relative to 100% census. Therefore, bias in field implementation with 100% census was assumed to be zero. Also, standard error for volume per hectare, number of pieces per hectare, and projected area per hectare was calculated for each method. Standard error was calculated as:

s_x^2 is the sampling variance of an estimate

$$s_x^2 = (X_i - X)^2 / n\text{-}1 \quad (4)$$

And bias[2] is

$$\text{Bias} = X_{100\%} - X_s \quad (5)$$

Where $X_{100\%}$, Xs are the amounts of 100% census and sampling methods, respectively.

Relative efficiency (E) for all method was calculated as

$$E = t_1 * s_{x2}^2 / t_2 * s_{x2}^2 \quad (6)$$

Where t indicates the mean time required per sample point for one of two sampling methods and s_x^2 is the sampling variance of the estimates. Relative efficiency is the time required to achieve any specified confidence limit width using one method, expressed as a fraction of the time required to achieve the same confidence limit width using another method. Line intersect sampling were compared relative to 100% inventory (E = 1). Thus, when E>1, 100% census is more efficient than the method to which it is being compared. When E <1, 100% census is less efficient than the method to which it is being compared. Times were obtained for all methods at line intersect sampling point; the mean time requirement for each method was measured.

RESULTS

Estimation of number of pieces per hectare, volume per hectare, and projected area per hectare are given for each measurement method in TABLES 2, 3 and 4. In addition, summary statistics are given for estimates of each variable and for each method in TABLES 2, 3 and 4. Some differences among the estimates obtained with sampling, were found to be statistically significant using ANOVA and Duncan test, indicating a potential difference in bias in field implementation of the three measurement methods in the region. The results of ANOVA and Duncan tests indicated that there is no significant difference between the estimations which resulted from probability theory approach and 100% inventory (TABLES 2, 3 and 4). Where bias in field implementation relative to 100% survey was found, it always resulted in underestimates for each variable and measurement method. If estimates obtained with line intersect sampling are accepted as accurate measure, this result suggests that bias in field implementation was the likely result of non-detection errors on the part of the search-based methods.

Mean time, requirement per measurement method with line intersect sampling was partially driven by time spent to search for candidate pieces of woody debris, which appears to increase as the theoretical area of inclusion of pieces of woody debris increases for a given method. Relative efficiency scores (E) are given for each of three variables and three measurement methods in TABLE 5. As expected, E for each sampling method varied based on the variables of interest, size and distribution of pieces of woody debris, and stand conditions. In general, a method was most efficient for sampling woody debris where the variable of interest and the probability of selection of an individual piece of woody debris into the sample were coincident[10].

TABLE 2 : Estimates of volume per hectare (m^3/ha) and summary statistics for each sampling method

Measurement method	Volume (m^3/ha)	bias	Standard deviation	p-value
100%	0.86^a			
LIS_P	0.94^a	-0.08	0.18	0.000
LIS_H	1.04^a	-0.18	0.20	
LIS_S	1.43^b	-0.57	0.36	

TABLE 3 : Estimates of projected area per hectare (m^2/ha) and summary statistics for each sampling method

Measurement method	Projected Area (m^2/ha)	Bias	Standard eviation	p-value
100%	223.23^a			
LIS_P	233.95^a	-10.72	64.26	0.000
LIS_H	311.51^b	-88.28	63.37	
LIS_S	315.01^b	-91.78	70.44	

TABLE 4 : Estimates of piece per hectare (no./ha) and summary statistics for each sampling method

Measurement method	Pieces (no./ha)	Bias	Standard deviation	p-value
100%	325.88^a			
LIS_P	325.87^a	+0.01	62.80	0.000
LIS_H	418.58^b	-92.70	93.29	
LIS_S	423.14^b	-92.26	68.32	

TABLE 5 : Relative efficiency scores (E) for each sampling method and compartment.

Variable	LIS_P	LIS_H	LIS_S
Volume/ha	0.77	1.06	1.54
Pieces/ha	0.94	1.22	1.71
Projected area/ha	0.98	1.19	1.86

Note: E for 100% survey is 1.00.

DISCUSSION

This study is the first report of woody debris in Fandoghlou forest. The results indicated that the line intersect sampling is relatively unbiased and precise estimators for most of the piece characteristics under the tested conditions. Besides, its proved that line intersect method was more quick to perform and made it easier to locate individual pieces of woody debris in recreational forest. The results of ANOVA and Duncan tests indicate that line intersect sampling based on probability theory was found to be an efficient method for estimating the total volume, total number of pieces, and also projected area per hectare of woody debris. Miehs[7] indicated that line intersect method is more precise than strip plot method. Further analysis of the data should clarify appropriateness of each method under different conditions. In stands judged to have light amounts of woody debris, line intersect sampling based on probability theory can always be the preferred method. In contrast, Bate[1] suggested the strip plot method was more accurate than the line intersect method. Despite, Bate[1] and Woldendorp[15] recommended fixed area plots instead of line intersects for increase of accuracy. In this study, the bias estimates showed that estimates which obtained with line intersect sampling based on probability theory were consistently lower than from line intersect sampling based on Huber and Smallian approaches in all cases. This suggests that line intersect sampling based on probability theory is matched for use in recreational forests. The focus of this study has been on consideration of the line intersect method accuracy for quantification of woody debris as line intersect sampling strategies are as diverse as the forests in which the methods are implemented. Transect length must be sufficiently long to account for these factors, and this length should be 50 m or smaller in recreational forests stand conditions. Single line transects (with an appropriate number of replicates across the forest) can give estimates with an acceptable level of accuracy provided the transect length spans the spatial heterogeneity in woody debris. The sampling technique adopted in woody debris studies will also be dependent on research objectives. For example, in situations where information about the abundance of stags or trees is also required, the strip plot would be more suitable[1]. Sampling approaches for woody debris need to be effectively integrated with methods for assessing other forest biomass pools such as life over storey and understory biomass, leaf litter and soil or other structural values.

REFERENCES AND FOOTNOTES

[1] L.J.Bate, T.R.Torgersen, M.J.Wisdom, E.O.Garton; Performance of sampling methods to estimate log characteristics for wildlife, Forest Ecology and Management, **199**, 83-102 **(2004)**.

[2] J.K.Brown; A planar intersects method for sampling fuel volume and surface area, For.Sci., **17**, 96-102 **(1971)**.

[3] J.K.Brown; Handbook for inventorying downed woody material, Gen.Tech.Rep.INT-16, Ogden, UT, Intermountain Forest and Range Experiment Station, Forest Service, U.S.Department of Agriculture, 24 **(1974)**.

[4] M.E.Harmon, J.F.Franklin, F.J.Swanson, P.Sollins, S.V.Gregory, J.D.Lattin, N.H.Anderson, S.P.Cline, N.G.Aumen, J.R.Sedell, G.W.Lienkaemper, Jr.K.Cromack, K.W.Cummins; Ecology of coarse woody debris in temperate ecosystems, Adv.Ecol.Res., **15**, 133-302 **(1986)**.

[5] J.W.Hazard, S.G.Pickford; Simulation studies on line intersect sampling of forest residue, Part II.Forest Science, **2(32)**, 447-470 **(1986)**.

[6] B.C.McCarthy, R.R.Bailey; Distribution and abundance of coarse woody debris in a Managed forest landscape of the central Appalachians, Can.J.For.Res., **24**, 1317-1329 **(1994)**.

[7] A.Miehs, A.York, K.Tulhurst, J.Stefano, T.Bell; Sampling downed coarse woody debris in fire-prone eucalypt woodlands, Forest Ecology and Management, **259**, 440-445 **(2010)**.

[8] R.N.Muller, Y.Liu; Coarse wood debris in an old-growth deciduous forest on the Cumberland plateau, southeastern Kentucky, Can.J.For.Res., **21**, 1567-1572 **(1991)**.

[9] P. L.Marshall, G.Davis; Using line intersect sampling for coarse woody debris, Technical report, 1-34 **(2000)**.

[10] H.T.Schreuder, T.G.Gregoire, G.B.Wood; Sampling methods for multi resource forest inventory. JohnWiley&SonsInc., NewYork, **(1993)**.

[11] T.A.Spies, J.F.Franklin, T.B.Thomas; Coarse woody debris in Douglas-fir forests of western Oregon and Washington, Ecology, **69**, 1689-1702 **(1988)**.

[12] G.H.Stewart, L.E.Burrrows; Coarse woody debris in old growth temperate beech (Notho fagus) forests of New Zealand, Can.J.For.Res., **24**, 1989-1996 **(1994)**.

[13] C.E.Van Wagner; The line intersect method in forest fuel sampling, Forest Science, **14(1)**, 20-26 **(1968)**.

[14] W.G.Warren, P.F.Olsen; A line intersect technique for assuming logging waste, For.Sci., **10**, 267-276 **(1964)**.

[15] G.Woldendorp, R.J.Keenan, S.Barry, R.D.Spencer; Analysis of sampling methods for coarse woody debris, Forest Ecology and Management, **198**, 133-148 **(2004)**.