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Amount and characteristics of logging residues in selection cutting stand in the Northern forests of Iran

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Abstract

One source of woody material receiving much attention is logging residue. In this research amount and characteristics of logging residues were estimated by line intersect sampling in the selectively logged parcel in the northern forest of Iran. The results of this study showed that volume and weight of logging residues were 2.34 m^3 and 1.66 ton per hectare. This amount was about 18% of total selected volume to harvest in the logged parcel. Pieces with 35 cm in small end diameter and 70 cm in length have the most volume of logging residues in the logged parcel. The analysis of collected data showed means of volume, length and weight of pieces were 0.02 m^3, 1.17 m and 16.1 kg. In the northern forests of Iran each logging planning should be assessed regarding feasibility residue collection and transportation.

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Introduction

Logging residues are woody materials that left in the forest after timber harvesting (Howard and Setzer, 1989). Logging residues includes the tops of harvested trees, branches, wood that has an underdeveloped market or is a poor form and thus not marketable (Hall, 1998; Eker, 2011; Zakrzewski, 2011). Currently, wood contained in logging residues is suitable for use in many engineered wood products and potentially for other value-added products in future markets (Waddell, 2002). Logging residues are the most challenging bio-energy resource and a raw material for forest products industry. Logging residues on the base of size, quality and species can use in different wood industries such as particle board, parquet, paper, box making and chemical conversion or fuel uses. But, in ecological viewpoint, the forest ecosystem may actually benefit by leaving the logging residue in place. Logging residues contribute to the diversity and cover resources of a logged site (McComb, 2003). Logging residue, or course woody debris, is an important component of the habitat requirements for birds (Lohr et al., 2002), amphibians (Butts and McComb, 2000), and small mammals (Loeb, 1999). Nutrient cycling is certainly improved by natural decay of slash and erosion is reduced. Future site productivity can also be impacted by the additions or removals of logging residues. However, Logging residues in regular managed forests are still an underestimated source and hardly utilized but the interest of several parties is growing. Eventually, the amount of wood biomass in tree branches will also have to be quantified and accounted for within the harvest budget (Zakrzewski, 2011). The northern forests of Iran are known as one of the most basic resources for wood production and have a big share in supplying wood to the related industries. Commercial logging in these forests is accomplished within the legal framework of forestry management plan and annual removal is around 1 million m^3 per year. This amount is not sufficient for needs of internal wood industries and predicted in future years to increase imports of wood (Bayat Kashkooli *et al.*, 2008). The amount and characteristics of logging residues varies widely from stand to stand and also depends on silvicultural method, utilization standards, site condition, harvesting techniques and level of mechanization (Benson and Johnston, 1976; Remington, 1986; Howard and Setzer, 1989; Millard, 2001; Spinell and Hartsough, 2001). Selection cutting is the main silvicultural method in the northern forests of Iran. In these forests, logging operation is generally performed by using ground based skidding system. Chainsaw and cable skidder are two main logging machines for wood harvesting in these forests. The amount of logging residues in the clear cutting stands is more than selection cutting forests. Also, in the assortment method more volume of logging residues is remaining in the site than full length and whole tree methods. Wood has been and continues to be an important resource for the production of energy. One source of woody material receiving much attention is logging residue. To the land manager, utilization of logging residues can reduce the costs of postharvest treatments. The amount of logging residues on a particular harvest area or for a given year is directly related to economic conditions and export markets. For the economic and technical feasibility of using logging residue more detailed information is needed about the characteristics of residue materials. Estimation of costs, equipment, handling, and transportation of logging residues require a data base providing information about size, number of pieces, distribution and quality of these materials. Regardless of the source, an understanding of the amount and characteristics of the material is important to decisions concerning utilization or onsite retention to enhance other resource values (Howard and Setzer, 1989; Eker, 2011). The objective of this study was to estimating the volume, weight and number of logging residues and classifying by diameter and length in the selectively logged parcel.

Material and method

Study area and logging operation

This study was conducted in parcel 35 of district 1 of Nav watershed in Guilan province in northern forest of Iran. The Nav watershed is located between 37°

38' 34" to 37° 42' 21" N and 48° 48' 44" to 48° 52' 30" E. The total surface area of parcel 35 is 39 ha which 7 ha is under protection, with the remainder being suitable for harvesting. Elevation of the study area is ranged from 1350 m to 1500 m with average annual precipitation of 950 mm and is dominantly covered by *Fagus orientalis* and *Carpinus betulus* stands. Average ground slope is 30 to 55%, canopy cover has been estimated as 85%, trees density and stock growth above 10 cm dbh (diameter at breast height) were 262 tree/ha and 176 m3/ha respectively. Shafaroud Company was harvesting performance in the study area. Total number and volume of marked trees in this parcel was 280 trees (8.8 trees/ha) and 413 m^3 (12.9 m^3/ha). During December and January of 2009, marked trees were felled using manual chain saw, topped at merchantable height or 20 cm DIB (Diameter inside Bark) and skidded in the shape of full length or long logs from stump area to roadside landings using Timber jack 450C wheeled skidder.

Sampling design and collection of data

The line intersect sampling has been widely used for estimating volume of logging residue and has been demonstrated to be efficient and unbiased (Martin, 1976; Van Wagner, 1982; Howard and Setzer, 1989; Hall, 1998; Marshal *et al.*, 2000; Lutes, 2002). The sample design used in this study consisted of 100 m line transacts located at each of 30 points on a systematic grid. The interval between grid points was 130 m. Both the initial starting point and the base line for the grid system were randomly selected to reduce bias. To reduce bias associated with piece orientation, each of the 30 line transects was randomly oriented along 45 degree azimuths. All qualifying residue intersected by the 100 m line transects was measured. Only pieces at least 4 cm in diameter inside bark and 30 cm long were considered measurable. Older dead pieces that were rotten to the point of losing their original form were excluded. Measurements recorded for each piece of residue were diameter (by 2 cm class) inside bark at the point of intersection with a transect line, at the middle of piece, large end and small end diameter and length of piece. The volume and weight of logging residues in each line transect was computed by following equations (Van Wagner, 1982):

$$W_i = (S\pi^2/8L)\sum_{j=1}^{n_i} d_{ij}^{\,2} \quad V_i = (\pi^2/8L)\sum_{j=1}^{n_i} d_{ij}^{\,2}$$

Where, V_j is volume (m^3/ha) in line transect j, L is length of line transect (100 m), d_{ij} is diameter inside bark (cm) of piece i in line transect j, n is number of pieces intersected in line transect j, W_i is weight (ton/ha) in line transect j, S is specific gravity of pieces (g/cm^3).

The number of pieces was computed by following equation (Van Wagner, 1982):

$$N_i = (\pi n_i)/(2L l_i)$$

Where, N_i is number of pieces per hectare in length class *i*, n_i is number of tallied intersections in length class *I*, L is length of sample line and *li* is midpoint of length class *i*,

The volume of each piece was computed by Huber formula as following (Van Wagner, 1982; Philip, 1994; Waddell, 1989; Waddell, 2002):

$$V = (d_m^2/4)\pi L$$

Where, *V* is volume (cm^3), d_m is diameter inside bark at the middle of piece (cm) and L is length of piece (cm). The weight of each piece was computed by following equation (Waddell, 1989):

$$W = (V)\times(GD)$$

Where, W is green weight of piece (kg), V is volume of the piece (m^3) and GD is green density of the wood (kg/m^3).

The ratio of residue volume to selected volume (RRS) was computed as RRH=(RV/SV)×100, where RV is residue volume (m^3/ha) and SV is selected volume (m^3/ha). The ratio of residue volume to number of selected trees (RRN) was computed as RRN=RV/NT, that RV is residue volume (m^3/ha) and NT is number of selected trees. The ratio of residue volume to sum of DBH (diameter at breast height) of selected trees (RRD) was computed as RRD= (RV/SDBH)×100, that RV is residue volume (m^3/ha) and SDBH is sum of diameter at breast height of selected trees (cm).

Results and discussion

The results of this study showed that volume and weight of logging residues were 2.34±0.21 m^3/ha and 1.66±0.12 ton/ha (Table1). Also Number of pieces was computed 247±19 pieces/ ha. These residues are round wood from undersized stem sections and crown woods of felled trees. The ratio of residue volume to the selected volume (RRS) was computed 18.1%. The ratio of residue volume to the number of selected trees (RRN) was computed 0.27 m^3/tree and the ratio of residue volume to DBH of selected trees (RRD) was computed 1.19 m^3/100cm. Hesselink (2010) indicates that in northern Ontario approximately 25% of harvesting residue is left as standing residuals and on the ground as slash. Eker (2011) reported the available logging residue ratio was 3.67% for the total volume, while the average potential of residues was 6.6 tones, air dried per hectare for the studied stands in Turkey. Takashi *et al.* (2003) investigated the dry weight of logging residues in thinned stands of Japanese cedar (*Cryptomeria japonica*) of various ages and reported the dry weight of the logging residue in each stand was estimated at 13.1-38.4 ton/ha from plot inventories.

Table 1. Statistical parameters of volume, weight and number of logging residues.

Statistical parameters	Mean	Standard deviation	Confidence interval 95%
Volume (m^3/ha)	2.34	0.57	2.13 - 2.55
Weight (ton/ha)	1.66	0.31	1.54 - 1.78
Number (pieces/ha)	247	51	228 - 266

The suitability of logging residue for a given product usually depends on physical characteristics of the material. The statistical parameters of pieces characteristics are present in table 2. The means of volume and weight of pieces were 0.0275 m^3 and 16.14 kg. The mean of length of pieces is 117 cm. The mean of small and large end diameters were 8.5 and 41.1 cm (Table 2). These results indicated that many of pieces are suitable and usable for wood industries.

The means of diameter, length and weight of pieces indicated that Loggers can collect this residues using existing available equipment. For a given volume, harvesting many small pieces usually costs more than harvesting fewer large pieces. Equipment also differs in ability and efficiency of handling pieces of various sizes. Thus, the number of pieces of residue per acre by size class is an element in decisions on use (Howard and Setzer, 1989).

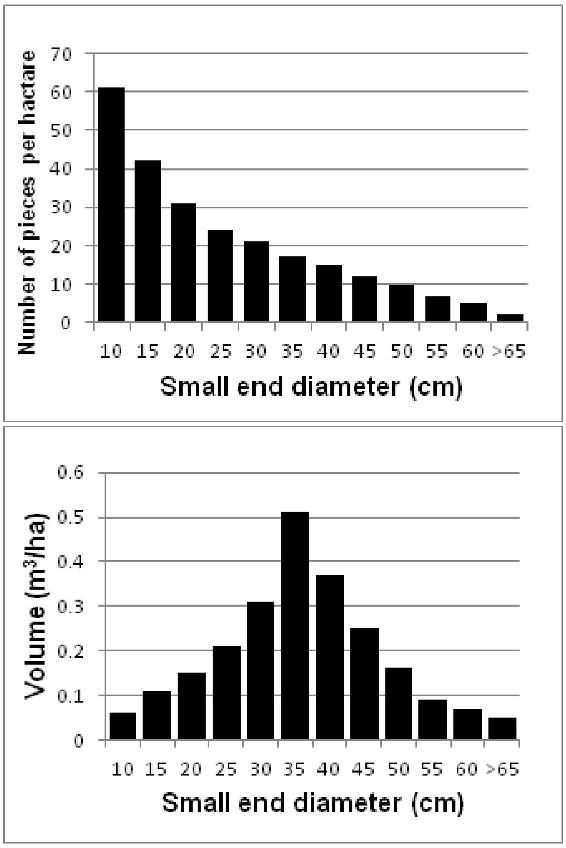

Fig. 1. Distribution of number of pieces (left) and volume (right) of residue per hectare on the base of small end diameter of pieces.

In this study characteristics of logging residues were analyzed by diameter, length, volume and number of pieces in the logged parcel. Economic factors are the main determinant to decide about logging residues. An important consideration in economic evaluations of the cost of collection of residues is volume per piece.

The results showed the most number of pieces have the lowest diameter and with increasing of diameter number of pieces was decreased (Fig.1). While, pieces with 35 cm diameter class in the small end have the most volume of logging residue in the logged parcel (Fig.1). Eker (2011) in Turkey forest harvesting suggested that coarse logging residues can be available as firewood in traditional utilization manner, but a thin material is left in the forest because of high collection and extraction costs.

Table 2. Statistical parameters of volume, diameter, length and weight of pieces

Statistical parameters	Max	Min	Mean	Standard deviation	Confidence interval 95%
Volume (m^3)	0.2120	0.0003	0.0211	0.0275	0.02 - 0.03
Small end diameter (m)	0.685	0.040	0.085	0.101	0.06 - 0.10
Large end diameter (m)	0.874	0.065	0.410	0.224	0.37 - 0.45
Length (m)	2.804	0.300	1.167	0.764	1.01 - 1.32
Weight (kg)	162.18	0.23	16.14	3.22	9.70 - 22.58

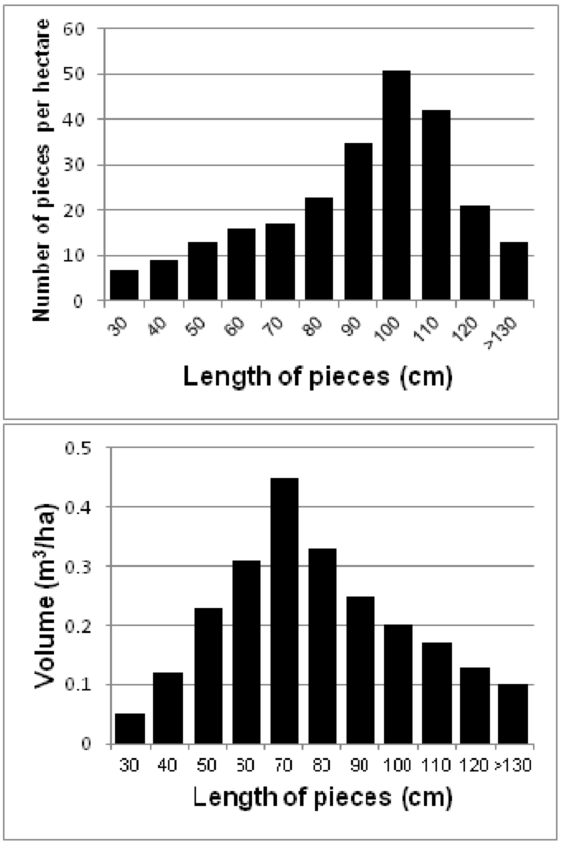

Fig. 2. Distribution of number of pieces (left) and volume (right) of residue per hectare on the base of length of pieces.

The analysis of distribution of number and volume of pieces on the base of pieces length showed the pieces with 100 cm length have the most number, while the pieces with 70 cm length have the most volume (Fig. 2). A large volume of woody biomass has traditionally remained on site after logging operation in the northern forests of Iran. The results showed that over 80% of the pieces volume are longer than 75 cm in length and would be usable for many of wood industries. Shorter pieces would be usable for fuel and fiber products, although collection and extraction of them may pose some technical and economic problems. About 126 pieces per hectare are longer than 100 cm in length. Over 80% of residues volume is larger than 25 cm in small end diameter. These woody materials are suitable and usable for forest products mills. The results showed that a considerable volume of logging residues remains on the site after timber harvest in the study area. Integrated harvesting systems could alter both the quantities of logging residues, as well as their costs (Puttock, 1995).

Conclusion

In this research amount and characteristics of logging residues were estimated in selectively logged parcel in the northern forest of Iran. The results of this study showed that volume and weight of logging residues were 2.34 m^3 and 1.66 ton per hectare. According to a research in three parcel that harvested by selection silviculture method volume of logging residue were reported 2.78, 4.86 and 5.32 m^3/ha in northern forests of Iran (Keivan Behiou *et al.*, 2007). The amount of logging residues on a particular harvest area is directly related to logging intensity and site condition such as size and number of felled trees, topography and soil condition and forest road density. The results of this study showed about 18% of selected volume to harvest were remained as logging residue in the forest. Also the results indicated by felling and extraction of each selected tree about 0.27 m^3 woody material was remained in the forest. This amount is considered without of stump volume and branches of lower than 4 cm in diameter. The Nav forest is one of the best forest stands in northern Iran, which plays an important role in national wood production. Policy and public sentiment are coalescing to promote renewable energy. The most economically available source in north of Iran is woody biomass. Thus, when a parcel is harvested as a selection cutting, logging residue could be collected and transported to a landing close to transport road. Before marketing studies and economic analyses of the feasibility of residue utilization can be made, it is first necessary to learn something about the quantities, characteristics, value and accessibility of the residue. Important parameters for the value of logging residue are diameter and length of pieces. The analysis of collected data showed means of volume, length and weight of pieces were 0.02 m^3, 1.17 m and 16.1 kg. Studies suggest new markets may significantly increase the amount of harvested total stand biomass (Hess and Zimmerman, 2001). The areas that need for more raw materials in the fuel, paper, board and sawn product industries have prompted a closer look at the residue utilization. Estimation of costs, equipment, handling, and transportation of logging residues require a data base providing information about size, number of pieces, distribution and quality of these materials. The results of this study showed that the pieces with 35 cm in small end diameter and 70 cm in length have the most volume of logging residues in the logged parcel. Information of the amount and characteristics of the material is important to decisions concerning utilization or onsite retention to enhance other resource values. Leaving logging residuals in forest stands result to infested insects in production forests (Bolding and Landford, 2001) and increase fire hazard (Spinelli and Hartsough, 2001). Iran is a country with relatively poor forest resources. The utilization of logging residues could support energy resource, fuel reduction in forest floor, employment and site preparation (Eker, 2011). Utilization of logging residue requires careful planning. In the northern forests of Iran each logging planning should be assessed regarding feasibility residue collection and transportation. Harvesting of forest residue is integrated harvesting system that could alter both the quantities of logging residues, as well as their costs. Collection of logging residue has the potential of generating a lot of usable biomass. In northern forests of Iran loggers can collect this slash using existing available equipment.

References

Bayat kashkoli A, Rafeghi A, Azizi M, Amiri S, Kabourani A. 2008. Estimate of timber and wood products export and import trend in Iran. J. Agric. Sci. Nat. Res. **15(1)**, 73-83.

Benson RE, Johnston C. 1976. Logging residues under different stand and harvesting conditions, Rocky Mountains. USDA For. Serv. Res. Pap. INT-181,15p.

Bolding CM, Lanford BL. 2001. Forest fuel reduction through energy wood production using a small chipper/CTL harvesting system. Appalachian hardwoods; managing change: Proceedings of the 24th annual Council on Forest Engineering meeting. Corvallis, OR: Council on Forest Engineering, 65-70.

Butts SR, McComb WC. 2000. Associations of forest-floor vertebrates with coarse woody debris in managed forests of western Oregon. J. Wildlife Manage. **64**, 95-104.

Eker M. 2011. Assessment of procurement systems for unutilized logging residues for Brutian pine forest of Turkey. Afr. J. Biotech. **10(13)**, 2455-2468.

Hall P. 1998. Logging residue at landings. N. Z. J. For. Sci. **43(1)**, 30-32.

Hess G, Zimmerman D. 2001. Woody debris volume on clear cuts with and without satellite Chip Mills. South. J. Appl. For. **24(4)**, 173-177.

Hesselink TP. 2010. Increasing pressures to use forest biomass: A conservation point of view. For. Chron. **86 (1)**, 28-35.

Howard JO, Setzer TS. 1989. Logging residue in southeast Alaska. USDA Forest Service, Res. Pap. PNVV-RP-405. 36p.

Keivan Behiou F, Sobhani H, Zobeiri M. 2007. Volume and weight assessment of residual by Line Intersect Sampling (Case study: Chafrroud watershed). Iranian J. Nat. Res. **60(1)**, 103-114.

Loeb SC. 1999. Responses of small mammals to coarse woody debris in a southeastern pine forest. J. Mammalogy. **80(2)**, 460-471.

Lohr SM, Gauthreaux SA, Kilgo JC. 2002. Importance of coarse woody debris to avian communities in loblolly pine forests. Cons. Bio. **16(3)**, 767-777.

Lutes DC. 2002. Assessment of the line transect method: An examination of the spatial patterns of down and standing dead wood. USDA Forest Service Gen. Tech. Rep. PSW-GTR-181, 665-675.

Marshall PL, Davis G, LeMay VM. 2000. Using line intersect sampling for coarse woody debris. Technical Report, 003, Research section, Vancouver Forest Region, British Columbia Ministry of Forests.

Martin AJ. 1976. Suitability of the line intersect method for sampling hardwood logging residues. USDA For. Serv. Pap. NE-339. 6p.

McComb WC. 2003. Ecology of coarse woody debris and its role as habitat for mammals. Cambridge University Press, 374 - 404 Pp.

Millard T. 2001. Transport of logging slash and sediment in S5 and S6 streams near Boston Bar, Chilliwack Forest District. Vancouver Forest Region Tech. Rep. TR-012. Nanaimo, B.C. 16p.

Nurminen T, Korpunen H, Uusitalo J. 2006. Time consumption analysis of the mechanized cut to length harvesting system. Silva Fennica. **40(2)**, 335-363.

Philip MS. 1994. Measuring trees and forests. 2nd edition, CAB International, Wallingford, Oxford, UK.

Puttock GD. 1995. Estimating cost for integrated harvesting and related forest management activities. Biomass and Bioenergy, **8(2)**, 73-79.

Remington SB. 1986. Amount and characteristics of logging residue on harvested areas in Vermont. Nor. J. Appl. For. **3 (2)**, 63-65.

Spinelli R, Hartsough B. 2001. A survey of Italian chipping operations. Biomass Bioenergy, **21(6)**, 433-444.

Takashi K, Urara M, Hiroki I, Kazuki S, Osamu S. 2003. Estimating the dry weight of logging residues in thinned stands of *Cryptomeria japonica*. J. Jap. For. Soc., **85 (2)**, 108-113.

Vainio P, Tokola T, Palander T, Kangas A. 2009. A GIS based stand management system for estimating local energy wood supplies. Biomass Bioenergy, **33**(9), 1278-1288.

Van Wagner CE. 1982. Practical aspects of the line intersect method. Can. For. Serv. Inf. Rep. PI-X-12, 18 P.

Waddell DR. 1989. Estimating Load Weights With Huber's Cubic Volume Formula: A Field Trial. USDA For. Serv. Res. No. PNW-RN-484, 12p.

Waddell KL. 2002. Sampling coarse woody debris for multiple attributes in extensive resource inventories. Ecol. indic. **1(3)**, 139-153.

Zakrzewski WT. 2011. Estimating wood volume of the stem and branches of sugar maple (*Acer saccharum* Marsh.) using a stem profile model with implicit height. For. Sci., **57(2)**, 117-133.