JOURNAL OF FOREST SCIENCE, *59*, 2013 (12): 475–478

Determination of correction coefficient of average skidding distance according to the existing road network in Alikia Soltan forest of Iran

M. Rezaei, F. Shafizade, M.A. Rezaei

Mazandaran province, Amol, Iran

ABSTRACT: One of the factors in planning forest roads is average skidding distance which is calculated in projects from the map, according to forest road density, however it has a low accuracy. In this study real average skidding distance and theoretical average skidding distance were measured to determine a correction coefficient in Alikia Soltan forest in Hyrcanian forest. In this study real average skidding distance was obtained by putting a meter on the axes of trails. Moreover, theoretical average skidding distance was calculated by means of road density according to the formula. Skid trails were recorded by GPS and overlaid to a topographic map by means of ArcGIS software. Results indicated that for the study area with the average slope of 27% and road density of 10.32 the correction coefficient is 2.1.

Keywords: theoretical average skidding distance; real average skidding distance; skid trails

The procedure of utilization is generally divided into four steps including: (*i*) cutting and transforming of trees; (*ii*) primary transportation or extracting wood from stands; (*iii*) loading wood products onto trucks; (*iv*) secondary transportation to factories. Primary transportation is the most expensive and complicated operation in this classification. This operation can be done either by ground – skidding or aerial cable – skidding.

But in Iran in Hyrcanian forests because of topographic conditions and inaccessibility to the facilities of aircraft skidding this operation is performed by ground skidding which is expensive (Sarikhani 2008). Lots of factors should be considered in the estimation of skidding costs when one of them is average skidding distance.

This factor is calculated theoretically according to road density and in a hypothetical situation in which parallel roads without linking were designed and products are dragged to both sides, however practically it is not possible, so by determination of real average skidding distance and correction coefficient, skidding distance is calculated more accurately. In Hyrcanian forest located in the north of Iran, extraction with ground skidding equipment is the most common system (Jour Gholami, Majnounian 2008). Wheeled skidders appeared in the early 1970's and are now the most widely used tractors in Hyrcanian forests (Bagheri, Naghdi 2009).

The major problem of wheeled skidders in a selective logging method is their requirement for a dense network of roads and skid trails (Naghdi, Bagheri 2009). Average skidding distance is the main factor that should be considered when we calculate the formula of a reasonable forest road (Zhixian, Zhili 1997).

Logging is the predominant form of human disturbance in mountainous forests (Lindenmayer 2009). Many steps are involved in the planning and execution of logging operations in mountainous forests of Iran. There are approximately 1,800,000 ha of broadleaved temperate forests in the north of Iran, the vast majority is in the mountainous area.

Of this, it has been estimated that 34% are unharvestable because they are in streamside zones or in a steep and rocky terrain, or occur in special protection zones for biodiversity protection; other areas are actually available for timber harvesting (Bagheri, Naghdi 2009). Minimization of total skidding and road construction costs is useful for

determining optimum road spacing and logging planning in Kheiroudkenar forest Nowshahr in the north of Iran (Ghaffarian, Sobhani 2008). The forest road networks can be evaluated by GIS and dense grid of field observations as well as skidding cost is reduced using linear programming (Najafi et al 2008). Road spacing on slopes depends on the underlying off-road transportation technology (Heinimann 1998).

In mountainous forests of Guilan province in Iran, the correction factor of skidding distance for the mean slope of 50% has been determined 2.75 (Mohammadalizade 2001). In Sweden Segebaden (1964) proposed the correction factor of 2.5 for a low-lying area to 4.5 for a mountainous area.

According to Abegg (1978) in Switzerland the correction factor of skidding distance for the flat area, hilly area and mountainous area is suggested to be 2, 2.5 and 3.5, respectively. According to FAO (1974) the correction factor was defined in the range from 1.6 to 2 for the flat area to more than 3.6 for steep slopes.

MATERIAL AND METHODS

Description of the site

The study was conducted in Alikia Soltan forest with an area of 1721 ha. The area extends from 36°18'00"N to 36°22'40"N in latitude and from 52°16'45"E to 52°19'55"E in longitude. The mean slope of Alikia Soltan forest is about 27%. The average annual temperature is 15.7%. The altitude ranges from 250 m a.s.l. to 950 m a.s.l. The climate is moist. The terrain consists of conglomerated stones mainly.

Measurement

The azimuth of the skid trail direction from road and depot junction to forest interior was measured with a compass on each node. Real (on slope) and horizontal distance between two stakes was taken after each 20 m with a meter. Moreover, the position of the skid trail junction on the road and depot was recorded by GPS. These skid trails were designed on a topographical map using Arc GIS software. The maximum distance of winching of skidders was 70 m. So, for each skid trail a buffer of 140 m was considered on the map based on the scale (Benes 1991).

Calculations

The road density, road spacing and theoretical mean skidding distance in our study area were calculated using the following formulas.

$$RD = L/S \quad (1)$$

$$RS = 10{,}000/RD \quad (2)$$

$$SD = 2{,}500/RD \quad (3)$$

where:
RD – road density (m·ha^{-1}),
L – total length of forest road (m),
S – the area of study forest (ha),
RS – road spacing (m),
SD – theoretical mean skidding distance (m).

The real mean skidding distance in our study area was calculated using the formulas:

$$ASD_r = \frac{\sum_{i=1}^{n}(L_i \times D_i)}{\sum_{i=1}^{n} D_i} \quad (4)$$

$$ASD_r = \frac{\sum_{i=1}^{n} d_i\left(\frac{Md_i + md_i}{2}\right)}{\sum_{i=1}^{n} d_i} \quad (5)$$

where:
ASD_r – real mean skidding distance (m),
Md_i – farthest distance of skidding to depot (m),
md_i – nearest distance of skidding to depot (m),
L_i – mean skidding distance in each depot (m),
D_i – total length of skid trails diverged from each depot (m).

The correction factor of mean skidding distance (μ) was calculated from the division of real mean skidding distance by theoretical mean skidding distance Eq. (6):

$$\mu = ASD_r/SD \quad (6)$$

RESULTS AND DISCUSSION

One major decision in road network planning is to determine under what terrain conditions a ground-based extraction system should be applied (Lotfalian et al. 2011). Slope and topography which affect the forest road network were considered as correction factor (terrain factor) by Segebaden (1964). Optimal road spacing is an important factor in logging planning to help minimize the total cost of harvesting and roading (Ghaffarian et al. 2009). Results indicated that the road density and road spacing in our study area were 10.3 m·ha^{-1}

Table 1. Mean skidding distance in depots (in m)

Depot No.	Total length of skid trail	Real mean skidding distance
1	1677.25	661.18
2	443.2	221.6
3	868.9	419.23
4	1,047.25	380.89
5	1,307.75	653.87

and 971 m, respectively (Table 1). The value of road density and road spacing was obtained as below:

$$D = L/S = 2{,}340/227 = 10.3 \quad (7)$$

$$S = 10{,}000/RD = 10{,}000/10.3 = 971 \quad (8)$$

Kanzaki et al. (1990) described a high-density path network in a steep mountain area which supports an intensive, high-quality forest in Osaka, Japan. In this network, the road density was 222.94 m·ha^{-1}, correction factor of real skidding distance was 1.215 m·ha^{-1}. Data showed that the correction factor approaches 1.0 as the road density is increased. Heiniman (1998) reported that road spacing on slopes depends on underlying off- road transportation technology. Planning of individual roads within proposed logging blocks is more focused on technical considerations such as detailed terrain conditions and on achieving an optimum skidding distance (Klasen 2006). In this study the theoretical mean skidding distance and real mean skidding distance were 243 m and 528.67 m, respectively (Table 2).

$$SD = 2{,}500/RD = 2{,}500/10.3 = 2431 \quad (9)$$

$$ASD_r = \frac{\sum_{i=1}^{n}(L_i \times D_i)}{\sum_{i=1}^{n} D_i} = \frac{2{,}825{,}431.767}{5{,}344.35} = 528.67 \quad (10)$$

$$ASD_r = \frac{\sum_{i=1}^{n} d_i\left(\frac{Md_i + md_i}{2}\right)}{\sum_{i=1}^{n} d_i} = \frac{2{,}825{,}441.101}{5{,}344.35} = 528.67 \quad (11)$$

In this research the real mean skidding distance and theoretical mean skidding distance were measured to calculate the correction factor of skidding distance. Results showed that the factor for Alikia Soltan forest in the Hyrcanian zone was 2.1.

$$\mu = ASD_r/SD = 528.67/245 = 2.1 \quad (12)$$

In mountainous forests of Guilan province in Iran, the correction factor of skidding distance for the average slope of 50% has been determined 2.72 (Mohammadalizade 2001). Lotfalian (2001) used the coefficient of 3.1 to correct the theoretical skidding distance in Sangdeh forest of Iran. In Sweden Segebaden (1964) proposed the correction factor of 2.5 for a low-lying area to 4.5 for a mountainous area. According to Abegg B (1978) in Switzerland the correction factor of skidding distance for flat area, hilly area and mountainous area was suggested to be 2, 2.5 and 3.5, respectively. According to FAO (1974) the correction factor was defined in the range from 1.6–2 for a flat area to more than 3.6 for steep slopes. The skidding distance models including Down, Up, Strdown, Strup programmed in the Turbo Basic language to work with raster Digital Terrain Model are tools to help the road planners to judge the efficiency of existing or planned road network while consider-

Table 2. Real mean skidding distance in depots (in m)

Skid trail No.	Real length of skid trail	Nearest distance of skidding	Farthest distance of skidding	Real mean skidding distance
1	1,053	0	1,053	526.5
1.1	64	778.45	842.45	810.45
1.2	153.15	778.45	931.6	855.025
1.3	100	884.05	984.05	934.05
1.4	97	819.15	916.15	867.65
1.5	210.1	819.15	1,029.25	924.2
2	443.2	0	443.2	221.6
3	798	0	798	399
3.1	27.6	628.35	655.95	642.15
3.2	43.3	628.35	671.65	650
4	675.05	0	675.05	337.52
4.1	372.2	273.45	645.65	459.55
5	1,307.75	0	1,307.75	653.87

ing the real skidding distance and the proposed technology of skidding (Tucek, Pacola 1999).

CONCLUSION

Average skidding distance for forest stands is an important parameter for determination of the optimum road density (Lotfalian et al 2011). In conclusion, the road spacing of 971 m in Alikia Soltan forest resulted in a theoretical mean skidding distance of 243 m. As the real mean skidding distance in our study area is 528.67 and the mean slope is 27%, the correction factor was estimated to be 2.1.

Acknowledgements

The authors would like to thank Dr. Samia for his cooperation in this research. We acknowledge the invaluable help of engineer Sheikhpoor from a wood and paper company for providing the data base collection of the region.

References

Abegg B. (1978): Estimation of the optimal forest road density in skidder terrain. Mitteilungen, ***54***: 101–213.

Bagheri I., Naghdi R. (2009): Efficiency evaluation of ground skidding system and determining the optimum forest road density in Caspian forest (Northern Iran). International Journal of Natural and Engineering Sciences, ***3***: 74–80.

Benes J. (1991): Accessibility of forest in the hilly country. Forestry, ***37***: 245–266

FAO (1974): Logging and Log Transport in Tropical High Forest. Rome, Food and Agriculture Organization of the United Nations: 90.

Ghaffarian M.R., Stampfer K., Session J. (2009): Comparsion of three methods to determine optimal road spacing for forwarder-type logging operations. Journal of Forest Science, ***55***: 423–431.

Ghaffarian M.R., Sobhani H. (2008): Optimum road spacing of ground based skidding operations in Nowshahr, Iran. Caspian Journal of Environmental Science, ***6***: 105–112.

Heinimann H.R. (1998): A computer model to differentiate skidder and cable-yarder based road network concepts on steep slopes. Journal of Forest Research, ***3***: 1–9.

Jour Gholami M., Majnounian B. (2008): Productivity and cost of wheeled skidder in Hyrcanian Forest. International Journal of Natural and Engineering Science, ***2***: 99–103.

Klassen A. (2006): Planning, location, survey, construction and maintenance for low-impact forest roads. Fourth Technical Procedures Manual: 63–74.

Kanzaki K., Ohasik., Dekit T., Miyake T. (1990): On capillary path system in steep mountain areas. International Journal of Forest Engineering, ***2***: 17–25.

Lindenmayer D. (2009): Forest Pattern and Ecological Process. Collingwood, Commonwealth Scientific and Industrial Research Organization: 308.

Lotfalian M., Zadeh E.H., Hosseini S.A. (2011): Calculation the correction factor of skidding distance based on forest road network. Journal of Forest Science, ***57***: 467–471.

Mohammadalizadeh K.H. (2001): Investigation and planning of skid trail network and calculating distance and correction coefficient in Guilan forest. [MSc Thesis.] Rasht, University of Guilan: 109. (in Persian)

Naghdi R., Bagheri I. (2007): Evaluation of tree length and assortment logging methods with respect to timber production in Caspian Forest in the Northern Iran. Asian Journal of Plant Science, ***6***: 46–50.

Najafi A., Sobhani H., Saeed A., Makhdoon M., Marvi Mohadjer M. (2008): Planning and assessment of alternative forest road and skidding networks. Croatian Journal of Forest Engineering, ***29***: 63–73.

Sarikhani N. (2008): Forest Utilization. 3th edition. Tehran, Tehran University Press: 776. (in Persian)

Segebaden G.V. (1964): Studies of Cross Country Transportation Distances and Net Extension. Stockholm, Skogshögskolan: 90.

Tucek J., Pacola E. (1999) Algorithms for skidding distance modelling on a raster digital Terrain Model. International Journal of Forest Engineering, ***10***: 67–74.

Zhixian Z., Zhili F. (1997): The method of calculating average skidding distance. Journal of Forestry Research, ***8***: 47–49.

Received for publication December 29, 2012
Accepted after corrections November 5, 2013

Corresponding author:

Mahdi Rezaei, MSc, Mazandaran province, Rezvan 39 st, Morvarid 5, Amol 4613839376, Iran
e-mail: mehdei.r@gmail.com