Determination of Average Skidding Distance Using GIS

Vladimir Petković, Dane Marčeta, Darko Ljubojević, Jovan Kuburić

Abstract – Nacrtak

Transport of wood is one the most expensive components of wood production. It usually consists of three phases: winching, skidding and long-distance transport. The first and the second phase of transport are the most important in terms of costs. They depend on the distance between the tree-felling area in the forest and the nearest forest road. That distance is the skidding distance. Determination of the skidding distance is very important for forestry operational planning because it is an indicator of forest accessibility and it is directly connected with costs. The skidding distance can be obtained in several ways: by on-site measurement, by calculation using mathematical models and by using GIS software like ArcGIS 10. Skidding distance can be defined as geometric and real. Real skidding distance is a product of geometric skidding distance and skidding factor. Skidding factor depends on the terrain slope and presence of terrain obstacles. Geometric skidding distance can be obtained by using ArcMap module of ArcGIS 10 software, and it is defined as the distance between the compartment centroid and the nearest point on the forest road. In this research, the skidding factor was based on spatial analysis of Digital Terrain Model (DTM). The real skidding distance, calculated using ArcGIS 10 software, was compared with skidding distances from Operational Plans for eight compartments in the Management Unit »Bobija-Ribnik« in the Forest Management »Oštrelj-Drinić« Petrovac. The skidding factor for the given terrain conditions in the eight selected compartments was calculated as the relation between the real skidding distance from Operational Plans and geometric skidding distance gained by ArcGIS 10 software.

Key words: transport, skidding factor, DTM, GIS

1. Introduction and research problem *Uvod i problematika istraživanja*

Produced wood assortments must be transported to wood processing plants or to final users. Transport usually consists of three phases: winching or collecting timber, primary and secondary transport. Winching or collecting is a transport phase in which wood assortments are moved from the stamp to the secondary forest network (skidding trails, skidding roads or cable strips). Skidding is carried out by secondary forest transportation network (skidding trails, skidding roads or cable strips). Timber extraction (skidding, forwarding, etc.) is defined as timber transport on secondary transportation network to the forest landing site or to the forest road. Long distance transport is the transport of wood assortments, most often by trucks on forest and public roads to wood processing companies or final consumers. Transport is a very important and the most expensive component of the production of wood assortments. According to Sokolović and Bajrić (2013), transport costs account for up to 80% of wood assortment production costs. Cost ratio between road transport, skidding and winching is 1:10:100 (Ljubojević 2010). Jeličić (1983) says that skidding costs are 20–30 times higher than those of truck transport on forest roads. The average transport distance or the average skidding distance is the average distance between the felling site and forest road or forest landing site. When establishing the average extraction distance, it is usually assumed that wood is equally distributed all over the felling area or that it is concentrated in the gravity point of a given compartment / sub-compartment. To conclude, the average extraction distance is the distance between the center of gravity of the felling site (compartment/sub-compartment) and the forest road, thus defined as an average geometric extraction distance. The average geometric skidding distance is actually shorter than the real skidding distance because of terrain slope and obstacles, and should therefore be multiplied by the correction factor i.e. skidding factor. Analytic methods or modern GIS based tools are used for the determination of the average geometric skidding distance (Pentek et al. 2004, Pentek et al. 2005, Ljubojević 2010, Potočnik et al. 2011, Petković et al. 2015). Position, mutual distance and density of forest roads, as well as terrain and stand conditions, are the factors that influence the average extraction distance.

Klemenčić (1939) analyzed the influence of the shape of forest road network and skidding distance on the road of the same length and forest area and established the relation between the skidding length and skidding factor (Sokolović and Bajrić 2013). According to Jeličić (1983), for the same density of forest roads, lowland forests are better opened than mountain forests, because assortments could usually be extracted to both sides of the road in a straight line. In hilly-mountain conditions, the skidding distance is greater because of terrain slope, network layout and because skidding is usually done downhill (Sokolović and Bajrić 2013).

The average skidding distance could be determined as a weighted average, where weights are the felling sites or volume of timber that should be skidded to the forest road (Nikolić 1993). Based on the existing and optimal forest road density, the current and targeted average skidding distance could be calculated (Rebula 1981, Pičman 2007).

Cotemporary GIS based software provides easy, fast and accurate determination of the gravity center of an irregular surface and geometric distance from the forest road. Forming of appropriate GIS models (raster, vector and database) is the precondition for the calculation of the average transport distance.

The average geometric transport skidding distance, calculated analytically or GIS based, should be multiplied by the skidding distance factor in order to get the real average skidding distance. The real skidding distance is calculated according to equation:

$$S_{dS} = S_{dG} \times k_G \quad (1)$$

Where:

- S_{dS} real average skidding distance
- S_{dG} average geometric skidding distance
- k_G correction factor (Pentek et al. 2004, Pentek et al. 2005, Ljubojević, 2010, Potočnik et al. 2011, Petković et al. 2015).

According to Segebaden (1964), in Sweden the average skidding distance correction factor for lowland area is 1.2, and for mountain area 1.5. According to FAO (1974), the factor of distance extension is 1.6–2.0 for lowland area and 3.6 for steep terrain (Lotfalian et al. 2011). According to Nikolić (1993), the skidding factor k is 1.1 or 1.2 and distance extension because of terrain inclination is $1/\cos\alpha$; α – terrain inclination.

Pentek et al. (2004) report that according to Abegg (1978) the distance extension coefficient is from 1.15 for lowlands to 1.65 for mountains, with 1.44 on average. The total coefficient for lowlands and hilly terrain is 1.8. Stankić (2010) established the correction coefficient for transport with forwarders from 1.2 to 2.5, or 1.3 on average. The average skidding factor for lowland and hilly terrain conditions is 1.475 (Petković et al. 2015).

Skidding factor varies from 1.101 to 2.687, depending on terrain slope and development of secondary forest transport network (Šipad-IRC 1987, Sokolović and Bajrić 2013).

When considering the importance of the average extraction distance as one of the four indicators of forest accessibility, besides absolute and relative forest accessibility and coefficient of efficiency of forest road network, then the skidding distance stands out as the most important transport component. The determination of the average skidding distance emerges as a very important part of planning of forest accessibility and harvesting. Construction of new forest roads in order to increase forest accessibility could be economically justified only if the average extraction distance is shortened (Sokolović and Bajrić 2013).

This research is based on the assumption that the average extraction distance determined in Operational Plans differs from the distance gained by ArcGIS, and that the skidding factor differs accordingly.

2. Research area – *Područje istraživanja*

The Forest Management Unit »Bobija-Ribnik« (MU »Bobija-Ribnik«) is located in the western part of the Republic of Srpska and belongs to the Forest Management »Oštrelj« Drinić (FM »Oštrelj« Drinić), placed in the municipality of Petrovac. The central coordinates are 44°30′26′′ N and 16°27′58′′ E. The main characteristics of MU »Bobija-Ribnik«, such as the surface of forests and forest land, surface of forest categories, geology and soil conditions, growing stock, etc., are taken from the Forest Management Plan (2013–2022) for the forest management area »Petrovačko«.

MU covers the internal Dinaric phytogeographical area, western-Bosnian limestone and dolomite area that belongs to the Euro-Siberian-North American region. MU stretches between the mountains of Grmeč in the north, Oštrelj in the northwest and Lom in the southwest. Beech and sycamore maple forests (*Aceri obtusati Fagetum*) are present in this area, while fir and spruce forests are the basic substrates. These forests represent the final stage in succession of the community *Piceo-Pinetum Illyricum* Stef. toward *Abieti-Fagetum Illyricum* or *Piceo-Abieti-Fagetum dinaricum*. Geological substrates are limestone and dolomite. Several types of soil are present, namely mollicleptosol, brown soil on limestone, illimerized soil and rendzina.

MU »Bobija-Ribnik« covers 4372.41 ha, of which 4188.59 ha is covered by high forests with natural regeneration (Fig. 1). These forests consist of the following stands: high secondary forests of beech in the area of beech and fir forest on mollicleptosol and luvisols (1109) with the surface of 605.35 ha; Forests of beech and fir with spruce on mollicleptosol and brown soil on limestone (1238) with the surface of 2367.66 ha and beech and fir forests on mollicleptosol and brown soil on limestone (1239) with the surface of 1215.58 ha. The average growing stock in high forests is 413.1 m^3/ha or 1,730,830 m^3 in total. The increment is 11.27 m^3/ha. The total length of forest roads is 65.47 km, while the total length of forest roads in high forests is 64.14 km. Accordingly, total forest accessibility is 15.18 km/1000 ha and high forest accessibility is 15.66 km/1000 ha. According to the harvesting plan for the whole Management Unit, it is planned to cut down 361,831 m^3 of wood in total or 297.77 m^3 of gross wood, or 70.06 m^3/ha in a 10-year period, of which high forests account for 357,836 m^3 of total wood or 294,442 m^3 (70.3 m^3/ha) of gross wood.

3. Methods – *Metode*

In this study, geometric transport distance is determined using spatial analysis in ArcGIS 10 software. Geometric distance is multiplied by the skidding factor to get the real average transport distance. Skidding factor is determined on the basis of inclination and characteristics of the forest area according to specific relief area, classified by altitude. According to Kalmeta (1983), lowlands are up to 200 m; hilly area is between 201–500 m; low mountains are between 501–1000 m; medium mountains are between 1001–1500 m and high mountains are between 1501–2000 m (Bertović 1999). Calculated in this way, geometric and real average transport distance is compared to the average extraction distance from official Operational Plans for compartments 19, 20, 21, 22, 37, 47, 48 and 22/1.

On the basis of the digital terrain model (DTM), rasters are formed in software ArcGIS 10, in module ArcMap 10. Resolution of the used DTM is 5x5 m. Using »Extract by Mask« tool, DTMs for specific area and altitudes are obtained. DTMs are classified according

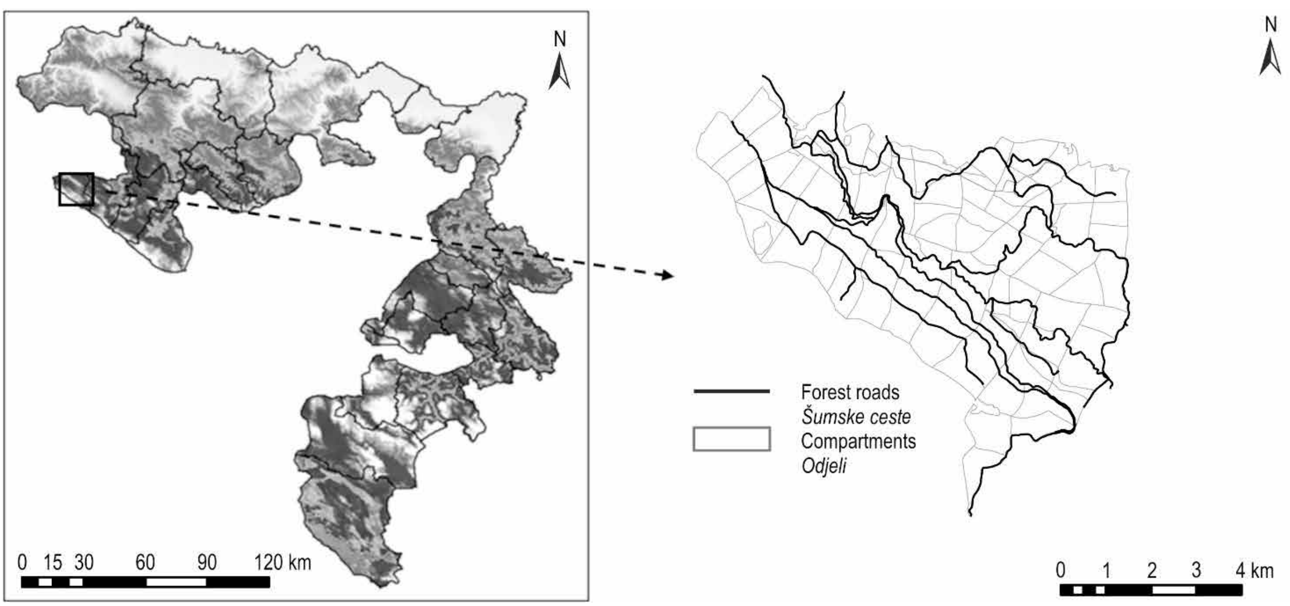

Fig. 1 Location of MU »Bobija-Ribnik« on the map of the Republika of Srpska
Slika 1. *Položaj gospodarske jedinice (GJ) »Bobija–Ribnik« na karti Republike Srpske*

to altitude and maps of the relief area and their surfaces are created. Terrain slope raster is classified in five categories: ≤15%, 16–30%, 31–45%, 46–60% and ≥60%, and using »Reclassify« tool, relative shares of slope categories are determined. The first step in the determination of the Average Geometric Transport Distance in ArcGIS software is to determine the compartment gravity center using the »Feature to point« tool. It is then necessary to determine the center of gravity of each compartment with regard to the nearest point on the forest road as well as establish the skidding direction. Therefore, the real average skidding distance is the product of geometric skidding distance and skidding factor. This factor is established as an average value of the average skidding factor, which depends on the slope and developing lines (ŠIPAD-IRC 1987), and relief skidding factor, which ranges between 1.2 for lowland area and 1.7 for submountain area according to Lepoglavec (2014). Multiplying the share of a specific relief area and slope in the whole management unit and skidding factor for a given relief area and terrain slope, the skidding factor for each relief area and slope class was obtained. The final skidding factor is the average value of individual factors. The length of skidding trails, cutting volume, terrain conditions and similar data were taken from official Operational Plans.

4. Results and discussion – *Rezultati s raspravom*

Altitude obtained after spatial analysis of 5 x 5 DTM varies from 603 m to 1372 m (Fig. 2).

Classification of DTM according to altitude resulted in two relief areas: low mountains and middle mountains. So, this area essentially belongs to the mountain relief area (Table 1) (Fig. 3).

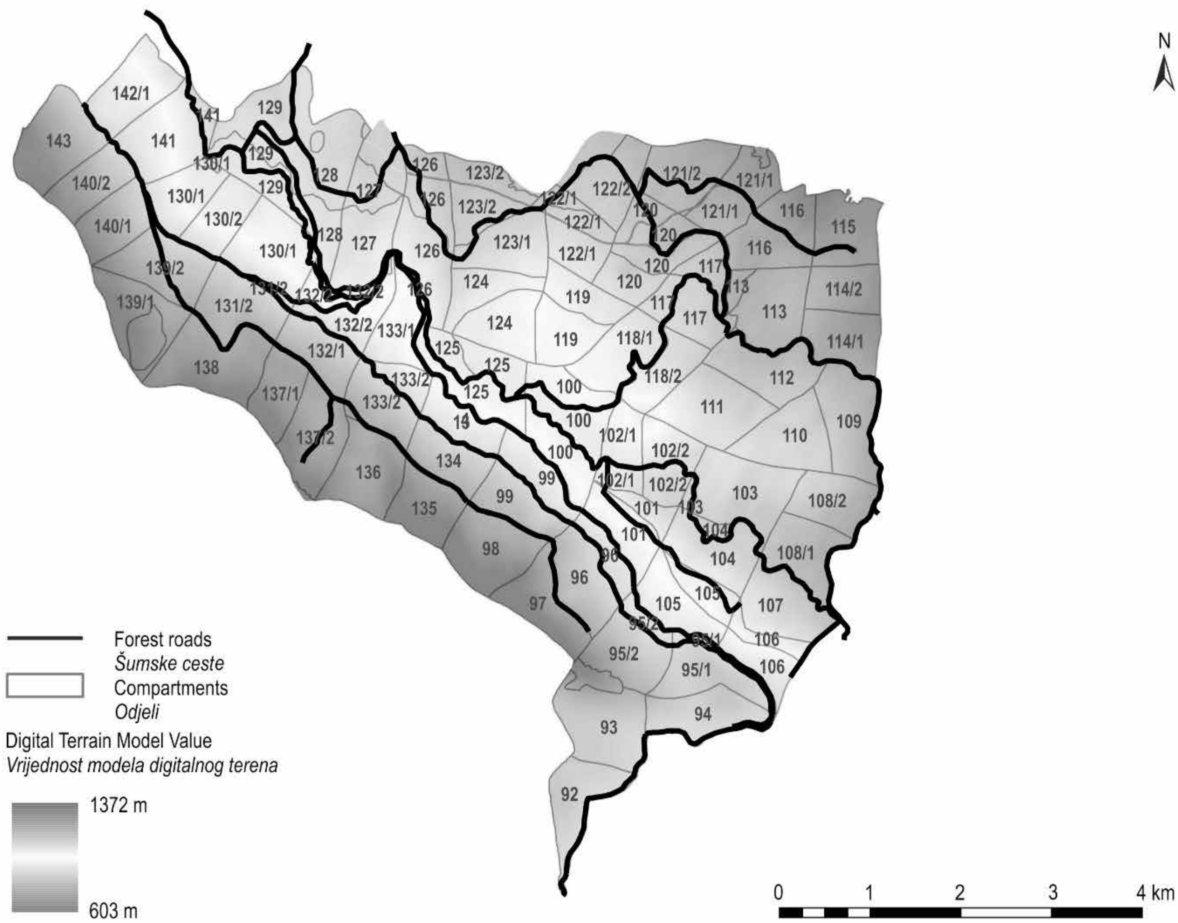

Fig. 2 Map of altitude of MU »Bobija-Ribnik«

Slika 2. *Kartografski prikaz vrijednosti nadmorskih visina za GJ »Bobija–Ribnik«*

Table 1 Relief area
Tablica 1. *Reljefno područje*

Relief area – *Reljefno područje*	DTM 5 × 5m	
	ha	%
Low mountains – *Nisko planinsko*	2727.50	64.1
Middle mountains – *Srednje planinsko*	1529.13	35.9
Total – *Ukupno*	4256.63	100

Table 2 Relief slope
Tablica 2. *Nagib reljefa*

Slope – *Nagib*	DTM 5 × 5m	
	ha	%
0–15%	1 817.55	42.7
16–30%	1 812.15	42.6
31–45%	580.93	13.6
46–60%	42.96	1
>60%	3.04	0.07
Total – *Ukupno*	4 256.63	100.00

Slope is classified in five classes (Table 2) (Fig. 4).

Geometric skidding distance obtained in ArcMap 10 module is from 143 m to 875 m, and the average value for MU »Bobija-Ribnik« is 315 m. The skidding distance is multiplied by the corresponding skidding factor in order to get the real average skidding distance. Relief raster and slope are used to determine the average skidding factor of geometric skidding distance. Skidding factor is calculated for relief area of low and middle mountains based on relative share in the total area (Table 3).

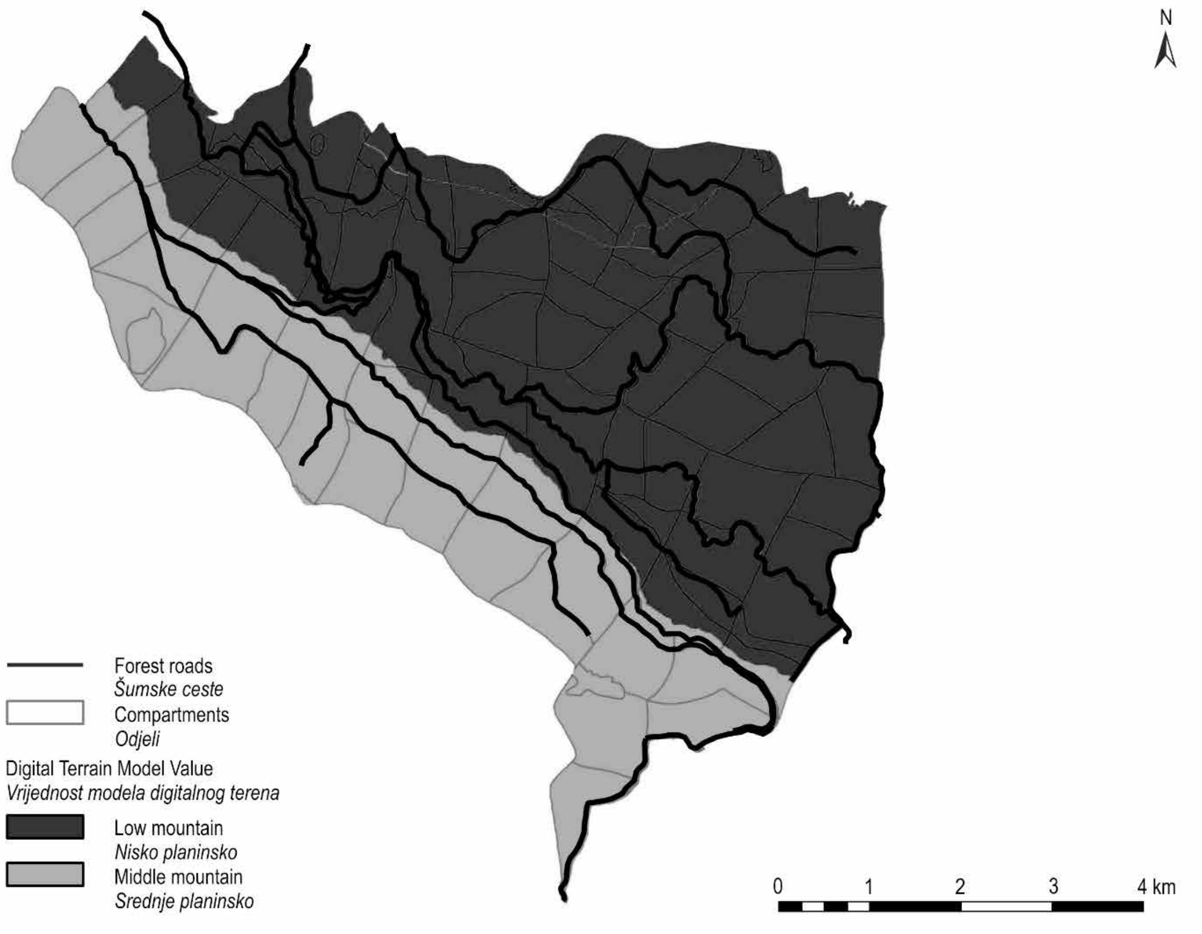

Fig. 3 Map of relief area
Slika 3. *Kartografski prikaz reljefa područja istraživanja*

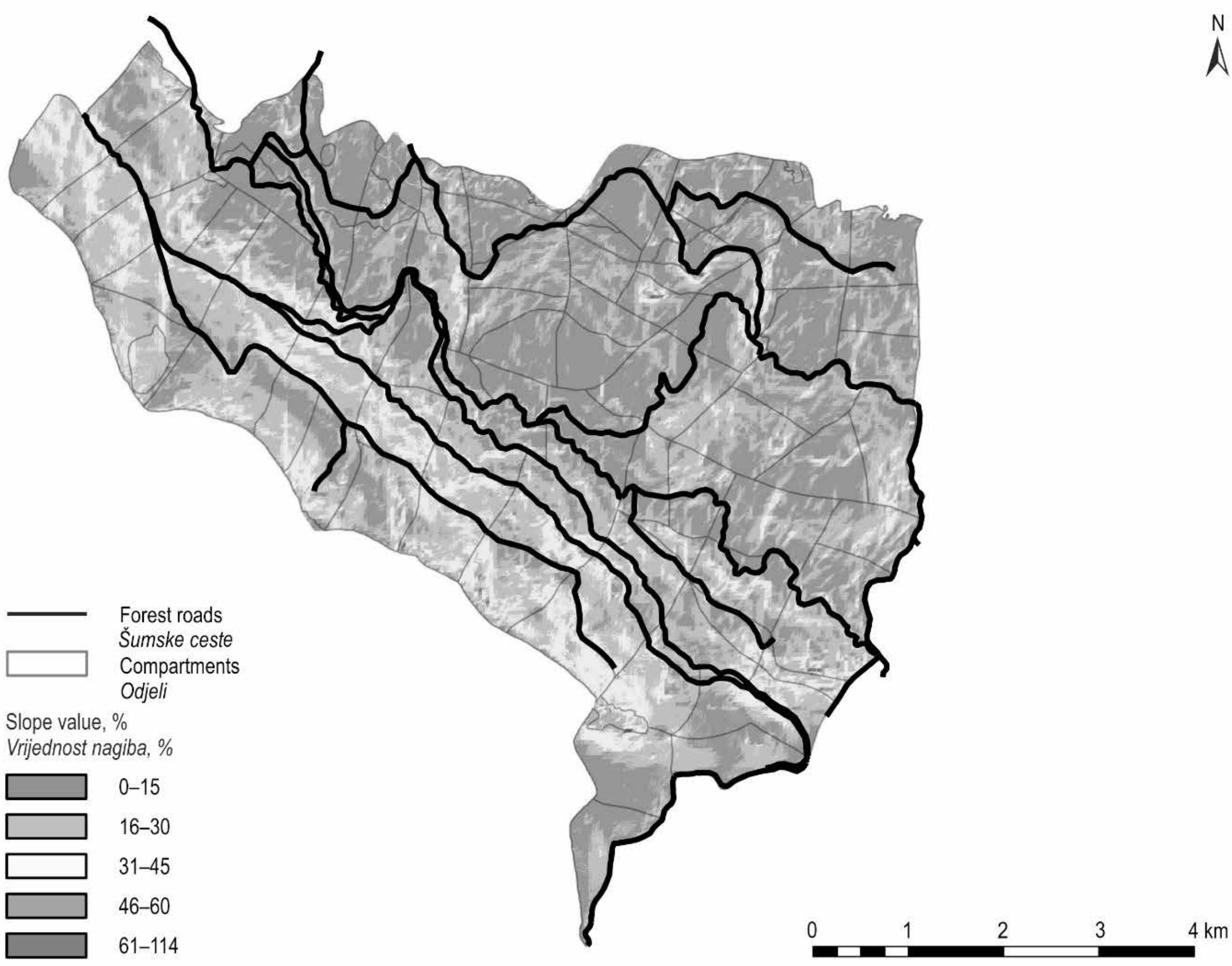

Fig. 4 Slope in research area
Slika 4. *Kartografski prikaz nagiba reljefa*

Table 3 Skidding factors for relief area
Tablica 3. *Faktor privlačenja za reljefno područje*

Relief area *Reljefno područje*	Skidding factor *Faktor privlačenja*	DTM 5 × 5m
Low mountains *Nisko planinsko*	1.55	0.64 (0.99)
Middle mountains *Srednje planinsko*	1.7	0.36 (0.61)
Total – *Ukupno*		1.60

Table 4 Skidding factor by slope categories
Tablica 4. *Faktor privlačenja po kategorijama nagiba*

Slope *Nagib*	Skidding factor *Faktor privlačenja*	DTM 5 × 5m
0–15% (7.5%)	1.1035	0.43 (0.47)
16–30% (22.5%)	1.2305	0.43 (0.52)
31–45% (37.5%)	1.3625	0.14 (0.185)
46–60% (52.5%)	1.5815	0.01 (0.02)
60–114% (87.5%)	2.3265	0.0007 (0.002)
Total – *Ukupno*		1.197

The average skidding factor is calculated on the basis of the relative share of slope categories in the total area and distance extension due to obstacles (Table 4).

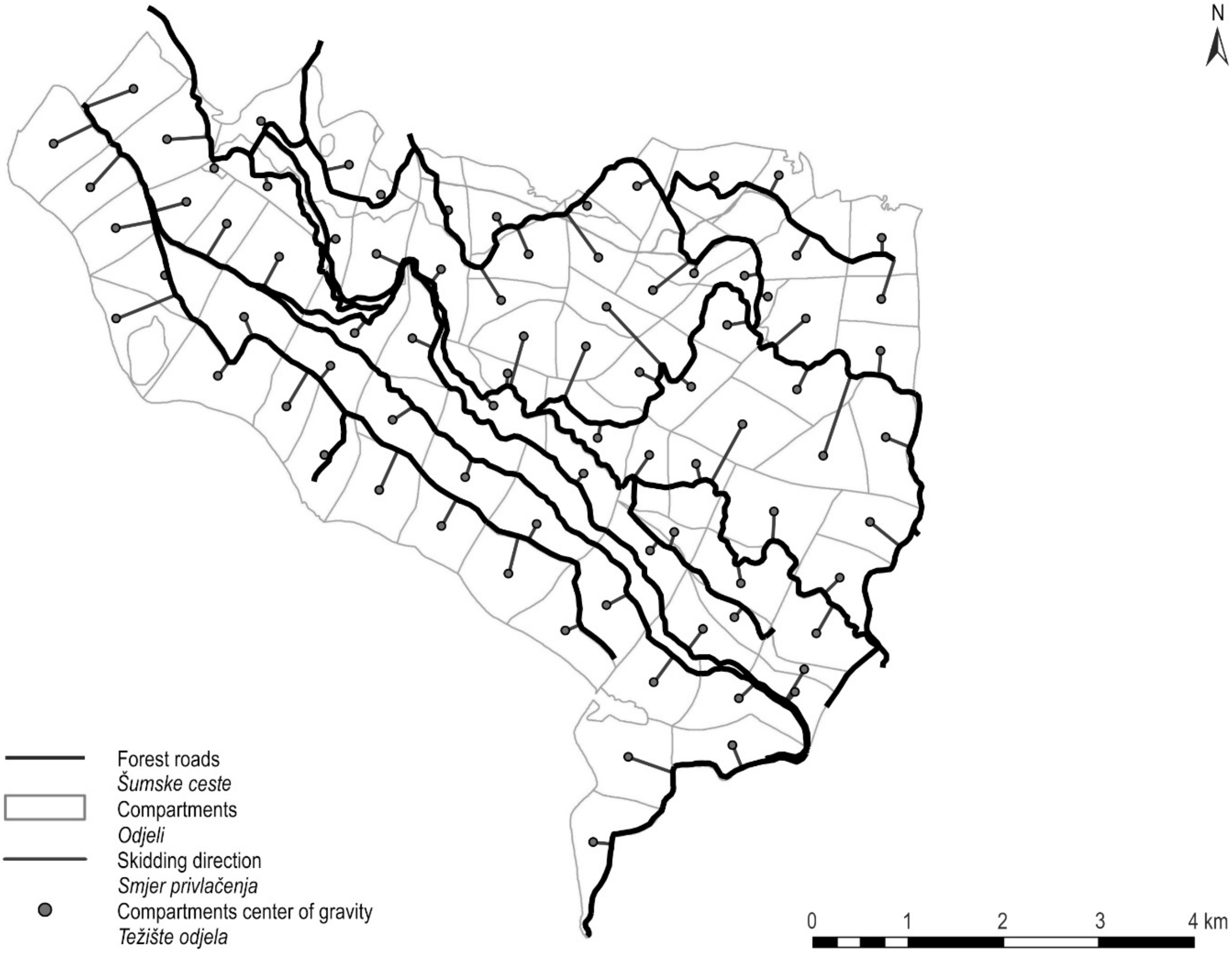

Fig. 5 Map showing center of gravity of compartments and skidding directions in MU »Bobija-Ribnik«
Slika 5. *Kartografski prikaz težišta odjela i smjera privlačenja u GJ »Bobija–Ribnik«*

The total average skidding factor is 1.2 (1.197). The average skidding factor of geometric skidding distance is 1.4. According to Segebaden (1964), the average skidding factor is 1.35, according to Abbeg it is 1.44 (Pentek et al. 2004) and 1.46 (Lepoglavec 2014).

The total average skidding factor is multiplied by geometric distance for each compartment and in that way the real average skidding distance is calculated; it is 447 m (204–1242 m).

The calculated skidding distances are compared with distances established in official Operational Plans for the compartments involved (Table 5).

When foresters measure transport distances with the purpose of preparing Operational Plans, the usual procedure in practice is to round distances to the nearest whole number, which can have a negative effect on accuracy. The reason for such a practice lies in the so called Standard Times for Forestry Work (2002), used by local forestry, where skidding depends on skidding distance, winching distance and average load volume.

The real average skidding distance S_d determined in Operational Plans in the investigated compartments is 350 m. The average geometric skidding distance $S_{dG,}$ determined in ArcGIS 10 software is 298.5 m, and the real average skidding distance S_{dS} is 418 m, with the skidding factor of 1.307. Considering that the skidding factor calculated on the basis of DTM is 1.4, it can be assumed that the average skidding factor for this area is 1.35.

The relation between the average skidding distances, determined in two ways, shows that skidding distances in Operational Plans are 7% lower than those calculated in ArcGIS.

Table 5 Average skidding distances and relations between them
Tablica 5. *Srednje duljine privlačenja i međusobni odnos*

Compartment *Odjel*	S_d, m	S_{dG}, m	S_{dS}, m	$S_d/S_{dG} = k_G$	S_d/S_{dS}
92	300	187	262	1.604	1.145
93	600	515	721	1.165	0.832
102/1	200	288	403.2	0.694	0.496
118/1	400	199	278.6	2.010	1.436
118/2	300	149	208.6	2.013	1.438
126	300	241	337.4	1.245	0.889
130/1	300	381	533.4	0.787	0.562
130/2	400	428	599.2	0.935	0.667
	350	298.5	417.9	1.307	0.93

S_d – Real, average skidding distance in Operational Plans – *Stvarna prosječna udaljenost privlačenja u osnovi gospodarenja*

S_{dG} – Average geometric skidding distance calculated in ArcGIS – *Prosječna geometrijska udaljenost privlačenja izračunata u ArcGIS-u*

S_{dS} – Real average skidding distance calculated in ArcGIS – *Stvarna prosječna udaljenost privlačenja izračunata u ArcGIS-u*

k_G – Skidding factor – *Faktori privlačenja*

5. Conclusions – *Zaključci*

Results show that ArcGIS 10 could be used for the determination of geometric and real average skidding distance, both for the management unit and for specific compartments. On the basis of terrain conditions, the average skidding factor was calculated and geometric S_{dG} and real S_{dS} skidding distances were compared with the skidding distance from Operational Plans S_d, calculated by forest practitioners. The assumption that real average skidding distances calculated in ArcGIS S_{dS} differ from distances in Operational Plans S_d has been confirmed with an 8% difference. By comparison of S_{dG} with $S_{d,}$ the skidding factor of 1.307 was obtained for the investigated compartments, which differs from the correction factor of 1.4 calculated on the basis of terrain conditions. Accordingly, the average factor of 1.35 can be considered as relevant for the given conditions. This factor is in accordance with other researches, referenced in this study.

GIS software can be very useful in planning of forest openness and thereby for establishing average extraction distances. Forest openness planning requires precise information about terrain conditions, forest infrastructure, stand, etc. One of the main problems of local forestry is the lack of information about secondary forest transport network in digital shape, such as position, length and state of skidding roads and skidding trails. This data is necessary for the determination of real extraction distances and skidding factors.

Defining skidding distance is crucial for skidding costs, and its determination should be approached very responsibly. Some recommended steps are as follows:

⇒ forming of comprehensive cadastre of forest roads
⇒ forming of cadastre of secondary forest network
⇒ forming of GIS databases for forest management units
⇒ optimization of primary and secondary forest road network.

6. References – *Literatura*

Bertović, S., 1999: Reljef i njegova prostorna raščlamba. Šumarski, list 123(11–12): 543–563.

Jeličić, V., 1983: Šumski putevi i ceste, SIZ odgoja i usmjerenog obrazovanja šumarstva i drvne industrije SRH. Zagreb, 1–193.

Kalmeta, R., 1983: Nazivi brdo i brijeg u hipsoametrijskom sustavu nazivlja za uzvisine. Jezik, 31, Zagreb.

Lepoglavec, K., 2014: Optimizacija primarne i sekundarne šumske prometne infrastrukture nagnutih terena. Doktorski rad, Sveučilište u Zagrebu, Šumarski fakultet, Zagreb, 1–266.

Ljubojević, S., 2010: Principi otvaranja šuma u zavisnosti od terenskih uslova i načina prirodne obnove, Seminar na temu – »Sistemi gazdovanja u šumarstvu i njihova praktična primjena«. Agencija za šume Republike Srpske, Banja Luka, 39–51.

Lotfalian, M., E. H. Zadeh, S. A. Hosseini, 2011: Calculating the correction factor of skidding distance based on forest road network. Journal of Forest Science, 57(11): 467–471.

Nikolić, S., 1993: Iskorišćavanje šuma. Univerzitet u Beogradu, Šumarski fakultet, Beograd, 1–262.

Pentek T., D. Pičman, I. Potočnik, P. Dvorščak, H. Nevečerel, 2005: Analysis of an existing forest road network. Croatian Journal of Forest Engineering, 26(1): 39–50.

Pentek, T., D. Pičman, H. Nevečerel, 2004: Srednja udaljenost privlačenja drva. Šumarski list, 128(9–10): 545–558.

Petković, V., D. Marčeta, S. Španjić, M. Kosović, 2015: Određivanje srednje distance privlačenja primjenom GIS-a u nizijsko-brdskim uslovima. Glasnik Šumarskog fakulteta Univerziteta u Banjoj Luci, 23: 5–14.

Pičman, D., 2007: Šumske prometnice. Sveučilište u Zagrebu, Šumarski fakultet, Zagreb, 1–460.

Potočnik, I., V. Petković, D. Marčeta, D. Ljubojević, 2011: Generalni projekat (Master plan) otvaranja šuma u Republici Srpskoj. Univerzitet u Banja Luci, Šumarski fakultet, Banja Luka.

Rebula, E., 1981: Optimal openness of forests. Mehanizacija šumarstva, 3–4(5): 107–119.

Segebaden, G., 1964: Studies of cross-country transport distances and road net extension. Studia Forestalia Suecica, 18: 1–70.

Soković, Dž., M. Bajrić, 2013: Otvaranje šuma. Univerzitet u Sarajevu, Šumarski fakultet, 1–250.

Standard Times for Forestry Work, 2002: Public Forestry Company »Šume Republike Srpske« a.d. Sokolac.

Stankić, I., 2010: Višekriterijsko planiranje izvoženja drva forvarderima iz nizinskih šuma Hrvatske. Doktorski rad, Sveučilište u Zagrebu, Šumarski fakultet, Zagreb, 1–123.

Studija otvaranja Gospodarske jedinice »Bobija-Ribnik«, RO »Šipad-Oštrelj« OOUR Šumarstvo, 1987: »Šipad-Irc« Sarajevo, OOUR biro za projektovanje Banja Luka: 1–50.

The Forest management plan (2013–2022) for forest management area »Petrovačko«, 2012: Public Forestry Company »Šume Republike Srpske« a.d. Sokolac, Forest Management »Oštrelj-Drinić«.

Sažetak

Određivanje srednje udaljenosti privlačenja drva pomoću GIS-a

Transport drva najskuplji je dio pridobivanja drva, koji uglavnom sadrži tri faze: skupljanje drva, privlačenje drva te daljinski transport drva, najčešće kamionskim skupovima. Prva i druga faza, koje se odvijaju pri privlačenju drva, a koje se još nazivaju i primarni transport, najvažnije su sa stajališta troškova, koji ovise o prosječnoj udaljenosti između šumskoga radilišta, tj. sječine i najbliže šumske ceste odnosno pomoćnoga stovarišta. Ta se udaljenost naziva srednja udaljenost privlačenja drva. Utvrđivanje srednje udaljenosti privlačenja drva izuzetno je važno za operativno planiranje u šumarstvu jer je to pokazatelj otvorenosti šuma i u izravnoj je vezi s troškovima pridobivanja drva. Vrijednost srednje udaljenosti privlačenja može biti utvrđena na više načina: izmjerom na terenu, izračunavanjem uz pomoć matematičkih modela te uz pomoć GIS-ovih programskih paketa, kao što je ArcGIS 10. Srednja udaljenost privlačenja drva može se iskazivati kao geometrijska i/ili stvarna. Srednju stvarnu udaljenost privlačenja drva čini umnožak srednje geometrijske udaljenosti privlačenja drva i faktora privlačenja drva. Faktor privlačenja drva ovisi o nagibu terena (vertikalna korekcija terena) te prisutnosti prepreka na površini (horizontalna korekcija terena) s koje se privlači drvo. Srednja geometrijska udaljenost privlačenja drva izračunata je pomoću modula ArcMap u računalnom programu ArcGIS 10 i definirana je kao udaljenost između težišta odjela i najbliže točke na šumskoj cesti. U ovom je istraživanju faktor privlačenja drva dobiven na temelju prostorne analize digitalnoga modela reljefa (DMR), odnosno na temelju nagiba i nadmorske visine terena. Stvarna srednja udaljenost privlačenja drva dobivena pomoću računalnoga programa ArcGIS 10 uspoređena je sa srednjim udaljenostima izračunatim u izvedbenim projektima osam uzorkovanih odjela u gospodarskoj jedinici »Bobija–Ribnik«, Šumarija »Oštrelj–Drinić« Petrovac, Republika Srpska. Zaključno, faktor privlačenja drva za terenske uvjete u osam uzorkovanih odjela izračunat je kao odnos između stvarne srednje udaljenosti privlačenja drva iz izvedbenih projekata i geometrijske srednje udaljenosti privlačenja drva izračunate pomoću Geografskoga informacijskoga sustava (GIS).

Ključne riječi: transport drva, faktor privlačenja drva, DMR, GIS

Authors' addresses – *Adrese autorâ:*

Vladimir Petković, MSc.*
e-mail: vladimir.petkovic@sfbl.org
Dane Marčeta, PhD.
e-mail: dane.marceta@sfbl.org
University of Banja Luka, Faculty of Forestry
Bulevar Vojvode Stepe Stepanovića 75
78000 Banja Luka
BOSNIA AND HERZEGOVINA

Ljubojević Darko, MSc.
e-mail: darkoljubojevic@gmail.com
Public Forestry Company »Šume Republike Srpske«
a.d. Sokolac
Forest Management »Prijedor«
Vožda Karađorđa 4/2
79101 Prijedor
BOSNIA AND HERZEGOVINA

Jovan Kuburić, mag. ing. sliv.
e-mail: jovan.kuburic@gmail.com
Public Forestry Company »Šume Republike Srpske«
a.d. Sokolac
Forest Management »Oštrelj-Drinić«
Centar 10
79290 Petrovac-Drinić
BOSNIA AND HERZEGOVINA

* Corresponding author – *Glavni autor*

Received (*Primljeno*): July 3, 2017
Accepted (*Prihvaćeno*): July 18, 2017