Influence of working conditions on overlapping of cutting and ground skidding in group work

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Abstract – Nacrtak

This research deals with the influence of working conditions on the duration of cutters participation in group work skidding. Two main theoretical assumptions were considered. First, working conditions that decrease the skidding efficiency increase the time of cutters assistance, because the group as a whole strives to improve efficiency, and second, the duration of assistance to the working group is specific regardless of working conditions. The research included 5 places of research (compartments) in Slovenian state forests, with 3 working groups consisting of two cutters and a cable skidder driver. All working groups used the cable skidder IWAFUJI–T41. The model included 100 cycles of downhill timber skidding. We have established that the duration of cutters assistance is reciprocal to the skidding distance, average bunching distance and number of logs in the load. The model accounts for 40.7% of the whole variability. After excluding the influence of working conditions between the groups, there are no typical differences in the duration of cutters assistance. Results imply that the number of working group members should be adjusted to working conditions. On the other hand, insignificant differences of cutters assistance duration between the groups show that the mere group daily standard is a motivational factor big enough for the rationalization of group work of workers who are not additionally educated and qualified for group work.

Keywords: *group work, cutting, skidding, working conditions, multivariate analysis*

1. Introduction – *Uvod*

Regardless of new technologies, such as cut-to-length logging, the traditional way of logging (use of chainsaw and cable skidder) will remain an important working technology in future, especially in the forests with difficult terrain conditions, in smaller private forests where personal work represents the essential profit for the owner, and in forests with small private patches of land. The fundamental characteristic of group work, as one of the organizational forms of traditional logging, is the group work with at least two members, who simultaneously do the cutting and ground skidding, and also assist each other. We estimate that this kind of method represents the prevailing organizational form, according to the amount of work and quantity of timber cut in Slovenian state forests.

In practice the size of working group depends especially on the capacity of skidding means. Therefore, the working groups are usually bigger with the use of cable skidders as opposed to the use of adjusted farm tractors. The reason lies in the relatively high price of skidding means. For the purpose of increasing the utilization of skidding means, the workers in a group have a group daily standard (expected daily efficiency) and receive piece-rate payments. Thus, the workers, as circumstances require, are »forced« to participate in a working phase that represents the bottleneck for the optimal group work efficiency. Therefore, the working time structure and overlapping of cutting and skidding processes change from group to group (Klun and Poje 2000).

With this research we have tried to add some new knowledge to relatively poorly studied relations between cutting and ground skidding in group work, and also highlight the problem of group work form

in altering working conditions in the forest, with the purpose of including the ergonomic and economic work organization as additional starting points.

2. Previous research – *Dosadašnja istraživanja*

In Slovenian forestry, the group work has been introduced to cutting and ground skidding process in the early 1970s. With complete mechanization of timber skidding that occurred around 1970, the tractor work efficiencies started to decrease, especially with cable skidders. Thus, the precondition for forming the new working processes was made, suggesting cutting and skidding group work. The group work demands a highly skilled worker, who is able to perform any kind of work in the group. This requires additional and constant education, and also employment stability for workers. This can only be achieved with better evaluation of forest work (Krivec 1979).

Since 1979, different authors have theoretically and practically considered group work from different perspectives. Križ (1984) describes the reasons for introducing group work and group work experience in the company Posestvo Snežnik. Organizational forms of group work have changed from I+2 (1 tractor driver, 2 cutters), I+3, to II+6, and in extreme cases up to II+12. The reasons for introducing group work were the increased timber cut stocks in forests and unused co-worker in skidding process; whereas the reasons for increase of the later group were timber volume composition at the roadside landing and additional but unused group leader. Kerneža (1999) in his later research in the same company, states that the efficiency of cutting and skidding with adapted farm tractors in smaller groups has increased with respect to larger groups, whereas the trend is quite the opposite in the skidding process with cable skidders.

Cimperšek (1987) emphasizes that the reliability of working means is the most important production factor and also adds that the workers' premium pay based on quantity and disregarding the quality, economy and damage decrease has an adverse effect on the worker. The work performance in this case is a routine one. Only after the change of remuneration mode the process of mass innovation can begin.

Korbar (1988) theoretically discusses the form and conditions of group work organization, and advantages and disadvantages of this kind of work. As essential advantages he highlights humanization, synchronization that enables the implementation of forest management plans and shortens the time from the cut to the timber sale. The work gets intellectually more demanding and enables workers' creativity and innovation, strengthens the sense of responsibility, increases performance and improves the worker's relationship to forest and working means. The conditions for group work are proper working means, quick flow of material and information, physically and psychically fit workers with adequate knowledge.

By comparing individual and group cutting and skidding work, Kruh (1989) states the rationalization of chainsaw working time, unproductive time, time for wood bunching from the point of view of the cable skidder, and also the whole time required for cutting and skidding. He defines the decrease of unproductive time as the disadvantage of group work, because it decreases the time for breaks and other worker's needs.

Winkler (1990) sees the optimal form of working group as the complex working group that performs all works on the permanent, smaller forest surface, with strict cutting and skidding time synchronization with silviculture performed only in specific time periods.

When determining the standard times for the organizational form I+2 and skidding timber with cable skidder IWAFUJI T–41, Klun and Poje (2000a, 2000b) establish that the efficiency of wood bunching and work on roadside landing is lower in comparison with traditional organizational form I+1 (one driver and one helper – hooker). The reason lies in the assistance of tractor driver to cutters and additional time required for timber classifying at the roadside landing. Indirectly, they also establish as follows: cutters participate in ¾ of all recorded cycles of the skidding process; according to working operations where the cutters participate in the skidding process, each group has a specific working method; the time cutters spend participating in a bunching process during the timber skidding at the same time depends on the number of logs in the load, the average piece volume and the distance in wood bunching process, and separately on the skidding distance.

Authors state that the need for introducing group work has changed through time. While in the 1970s there were tendencies for the humanization of work, today the aim is to decrease expenses and increase flexibility, and thus enable the increase of innovation flow in companies and working processes. Therefore, the group work seems ideal for raising productivity and quality on one hand and for decreasing expenses on the other hand. By participation of forest workers in planning, organization and control, possibilities arise for the utilization of unused innovation and talent potentials (Lewark et al. 1996). With greater participation of workers in company's

activities, partial responsibility shifted to workers, and additional education in German ThüringenForst, the company has managed to improve working environment and joy at work, decrease delays and increase workers' self control in highly mechanized cutting and skidding processes. In four years the positive effects of group work were seen in greater harvester (44%) and forwarder (49%) utilization (Findeisen 2002).

Utilization of working means influences the optimal size of working groups. Zečić and Marenče (2005) have developed a mathematical model for optimal group size, conducting cutting, skidding processes and simultaneous timber manipulation on roadside landings. They state that with skidding distance from 150 m to 650 m the optimal working group consists of 6 cutters (5.3), 5–7 tractor drivers (5.1–6.7) and 1 cutter – group leader.

3. Theoretical basis and research aims – *Teorijske osnove i cilj istraživanja*

Cutting and skidding group work consists of two working processes that are, unlike the individual work, partly overlapping. Apart from safe and ergonomically designed work, one of the main aims of group work is also to maximize the effect. It means that the sum of cutting time (t_c), skidding time (t_s), and the time when these two phases overlap (t_{c-s}) has to be minimal (Fig. 1). All times depend on working conditions and working technology. However, only a part of skidding time is irrespective of organizational form of group work (or the group size), because it is mostly connected to the capacity of skidding means (unloaded drive, loaded drive, winching).

When working technology, organizational form and skidding means are unchanged, the time of both processes overlapping depends on cutting and skidding working conditions. Disadvantageous cutting working conditions (smaller trees, dense stands) in general decrease the cutters involvement time in skidding process and increase tractor drivers' involvement time in cutting process, and vice versa when the skidding conditions are disadvantageous (long skidding and bunching distances, low timber concentrations, steep terrain and skid trails). Utilization rate of skidding means is thus greater in disadvantageous skidding conditions, because it enables cutters' help to tractor driver.

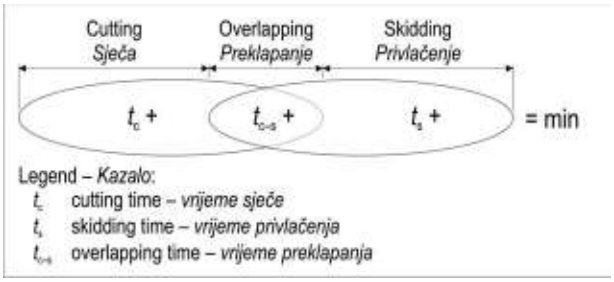

Fig. 1 Cutting and skidding group work scheme
Slika 1. *Skica sječe i privlačenja drva u skupnom radu*

The assumptions mentioned above are true, if groups consider only working conditions and if their specific work realization or work method has no influence on the rationality of work. The existing research (Klun and Poje 2000) and the fact that groups were not additionally educated for group work, show that the differences could exist between groups regarding cutter's involvement in skidding process (and also the tractor driver in cutting process), being more a consequence of self-taught working method than of rational approach.

According to the enumerated theoretical assumptions considering group work and data adequacy, we limited our research only to analysis of cutters' involvement in skidding process and set two basic hypotheses:

⇒ Working conditions factors (skidding distance, bunching distance, skidder short movements distance during formation of full load, the number of logs in the load and the load volume) increase the duration of cutters' assistance to the tractor driver.

⇒ The duration of cutters' assistance is different according to different working groups, even if the influence of working conditions is included in the comparisons.

The positive answer on the first hypothesis would enable us to optimally form the working group size according to effectiveness and difficulty of work. The confirmation of second hypothesis would advise us on the need of workers' education for group work and relevance of income or group daily efficiency as a motivational factor.

4. Research places – *Mjesta istraživanja*

The research was limited to 9 places (compartments) in Slovenian state forests situated on the altitude from 470 m to 1070 m, where the characteristics of high Karst prevail (Table 1). In lower parts, communities *Querco-, Blechno-* and *Hacquetio- Fagetum* prevailed, whereas in higher parts sub-association of forest communities *Abieti-Fagetum* prevailed. The average volume of tree selected to cut ranged from 0.63 to 2.03 m^3/tree, and from 1.71 to 4.10 m^3/tree in

Table 1 Compartment characteristics
Tablica 1. *Značajke istraživanih odjela*

Place *Mjesto*	Compartment – Forest management unit *Odjel – Gospodarska jedinica*	Surface area, ha *Površina odjela,* ha	Altitude, m *Nadmorska visina,* m	Mean cut tree, m^3 *Srednje sječno stablo,* m^3	Group *Skupina*
1	61 – Grintovec	32.10	450-510	1.05	4
2	121 – Grintovec	43.30	780-870	2.03	1
3	49 – Mozelj	43.74	470-620	0.63	2
4	74 – Mozelj	40.59	520-600	0.86	3
5	143 – Mozelj	40.86	530-620	0.73	3
6	48 – Stojna	56.28	900-1070	1.02	2
7	90 – Grčarice	65.81	740-830	1.22	6
8	100 – Grčarice	33.90	800-900	4.10	6

Fig. 2 Group work with skidder IWAFUJI–T41
Slika 2. *Rad skupine sa skiderom IWAFUJI-T41*

compartments with sanitation cut (subjects 8 and 9). The compartment surface ranged from 32 ha to 66 ha; however the research comprised only a part of these surfaces.

In the selected compartments we monitored the work of 6 working groups with organizational form I+2, meaning that the tractor driver and 2 cutters formed a group. For skidding, all groups used cable skidder IWAFUJI-T41 without remotely controlled winch. The maximal average age and working experience difference within groups were 8.7 and 13.5 years, 7 respectively.

In general, the cutting process proceeded in such a way, that the majority of work was done by the cutters. Only in some specific and more difficult operations, clearing the lodged tree or activities to meet the forest regulations (pile up branches) for example, tractor driver assisted them. Regarding skidding process, the tractor driver managed all working operations, i.e. empty and fully loaded drive and winching logs, and also the majority of remaining work operations, all by himself. The cutters assisted mainly in wood bunching process. The work particularity is the additional cutting and timber assortment done at the roadside landing by the tractor driver. The workers had to meet the group productivity expressed in daily timber quantity on the roadside landing (by the forest road).

5. Methods of research – *Metode istraživanja*

The time studying was done in 29 days, in summer months of 1996 and 1997. During that period, on the skidding distance of 1000 m, we recorded 218 timber skidding cycles, of which 78 under uphill skidding, 114 downhill skidding, and 26 level skidding categories (Table 2). The work was done by two researchers, one recorded the duration of individual working operations by using the snap back timing, whereas the other measured the volume of loads, the controlling time, and evaluated the bunching, stand movement and movement of skidder on roadside landing distances. The time study was made with 4/1000 of minute accuracy, whereas the error between recording and controlling time did not exceed 5%.

Due to considerable difference between the number of recorded cycles by working groups, especially by individual skidding categories (Table 2), our analysis, out of all recorded timber skidding cycles, included 100 downhill cycles recorded in groups 2, 3, and 4 on the subjects 1, 3, 4, 5, and 6. The categories of skidding were calculated as weighted average incline in the direction of skidding with skidding

Table 2 Structure of recorded cycles regarding skidding direction
Tablica 2. *Struktura snimljenih turnusa s obzirom na smjer privlačenja*

Group *Skupina*	Number of cycles - *Broj turnusa*			
	All *Svih*	Uphill *Uzbrdo*	Level *Bez nagiba*	Downhill *Nizbrdo*
1	25	4	12	9
2	33	-	-	33
3	56	17	5	34
4	42	-	9	33
5	10	10	-	-
6	52	47	-	5
Sum - *Ukupno*	218	78	26	114

distance as weight (uphill >5%, –5%≤ level ≥+5%, downhill <–5%).

The overlap of cutting and skidding in group work was the reason for adding two new operations to »traditional« skidding operations, naming them assistance to cutters and cutters assistance. Due to the fact, that during recording the tractor driver was the priority, the cutters assistance was noted only in case of his inactivity or where one or both cutters assisted in timber skidding. In theory, the time values of cutters assistance should change according to working conditions or working methods within the group. These values served us as a dependant variable in our further analysis.

For the independent variables we used the factors influencing the cutters participation in timber skidding process i.e. the factors from the first hypothesis. The skidding distance was measured as the distance between the spot where the full load was made and the spot for timber unhooking (roadside landing). The average bunching distance was calculated as the average of distances required for bunching of individual logs in the load. Short movements distance equals the sum of all skidder movements in the stand during the formation of full load and depends on the timber concentration. The number of logs in the load and the load volume are calculated as the sums of individual logs.

6. Results – *Rezultati*

The comparison of average duration of cutters assistance among groups (Table 3) showed that there are differences between the groups (p <0.000). The Welch test was used for testing the equality of means because the Levene test of homogeneity of variances showed that the differences among the variances are significant (p = 0.021). By applying the posterior difference tests among the means (Tukey HSD), we found out that the cutters assistance differences are only characteristic between the groups 2 and 3, and 2 and 4, whereas there are no statistically confirmed differences between groups 3 and 4.

With average values of working condition factors we can infer that the working conditions differ by working groups and that they are generally lower for the group 3, which has also lower cutters assistance value in comparison to other two groups. It is necessary to stress here that the average values can also indicate the danger of stratified data, not only by working group but also by the individual factor. In such case we cannot establish precisely whether the differences of cutters assistance are the consequence of studied factor or the specific group work method. In our case this happened with the skidding distance, which is the consequence of the sampling method (Fig. 3). Primarily, we used the data for the standard time calculation and had the

Table 3 Average values and correlation between cutters assistance and working condition factors
Tablica 3. *Prosječne vrijednosti i korelacija između pomoći sjekača te čimbenika radnih uvjeta*

Group *Skupina*	Cutters assistance *Pomoć sjekača*	Skidding distance *Udaljenost privlačenja*	Bunching distance *Udaljenost skupljanja*	Skidder moving *Premještanje skidera*	No. of logs in the load *Broj trupaca u tovaru*	Load volume *Obujam tovara*
	min	m	m	m	pcs. - *kom.*	m^3
2	9.31	694	11.5	12.3	9.0	3.64
3	4.47	189	8.6	15.8	7.6	2.57
4	6.18	313	14.4	31.4	7.8	3.83
Pearson correlation - r *Pearsonova korelacija - r* (Cutters assistance - *Pomoć sjekača*)		0.332 (**)	0.222 (*)	0.086	0.564(**)	0.096

** Correlation is significant at the 0,01 level (2-tailed) - *Korelacija je statistički značajna uz razinu značajnosti 0,01 (dvosmjeran test)*

* Correlation is significant at the 0,05 level (2-tailed) - *Korelacija je statistički značajna uz razinu značajnosti 0,05 (dvosmjeran test)*

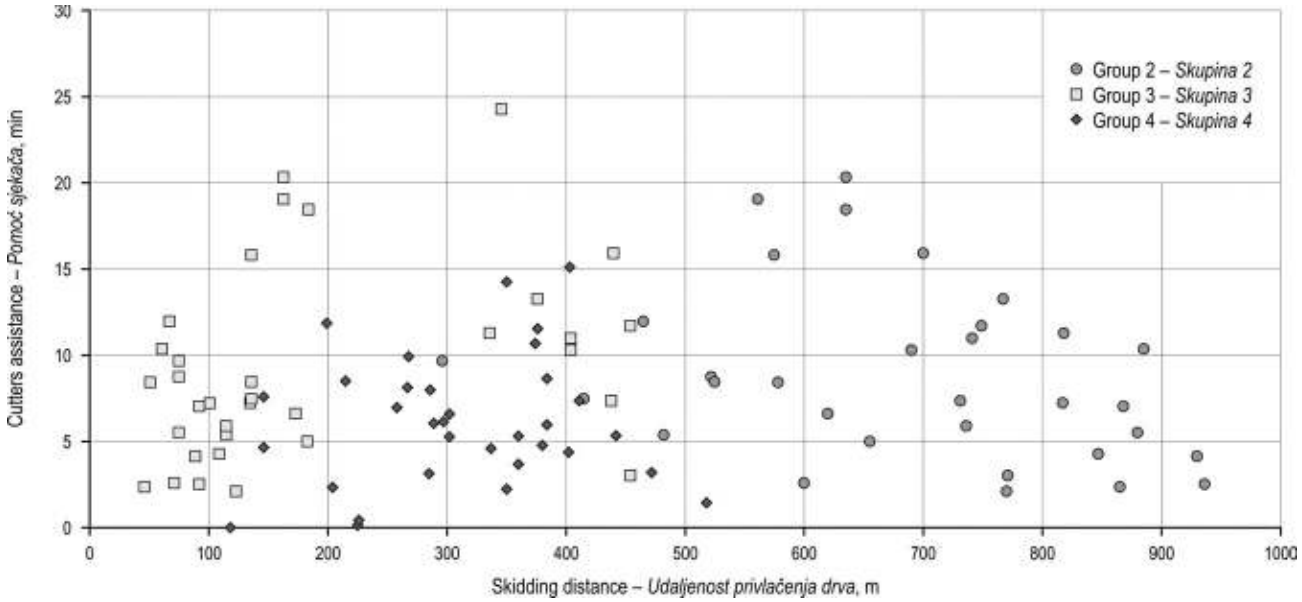

Fig. 3 Cutters assistance according to skidding distance by groups

Slika 3. *Ovisnost pomoći sjekača o udaljenosti privlačenja po skupinama*

only goal to record some cycles every 100 m of skidding distance.

Figure 3 shows that the data on cutters assistance by groups is within different skidding intervals, meaning that we can conclude that the cutters assistance increases with the increase of skidding distance. Taking into consideration the theoretical basis and research projects of other authors (Zečić and Marenče 2005), we can state with strong likelihood that the shown cutters assistance differences depend also on the skidding distance and not just on the working method or organization of individual groups.

Studying the linear dependence among individual factors and cutters assistance (Table 3), we found out that the cutters assistance increases with the increase of all working condition factors, according to positive value of correlation coefficient (r). Correlations are statistically confirmed with skidding and bunching distance, and with number of logs in the load. The values of correlation coefficients are relatively low, thus indicating the weak correlation of cutters assistance with working condition factors. Correlation values among working condition factors were 0.306 at the most, enabling the use of all factors in multivariate regression. By applying linear multivariate regression, we tried to establish the influence of individual working condition factor on cutters assistance with the constant value of other factors.

By applying the stepwise method of multivariate regression, we established that the skidding distance, average bunching distance, and the number of logs in the load (Table 4) simultaneously influence

Table 4 Coefficients and correlations of multiple linear regression

Tablica 4. *Koeficijenti i korelacije multivarjantne linearne regresije*

Factors *Faktori*	Coefficients – *Koeficijenti*			*t*	Significant *Značajnost*	Partial correlation *Parcijalna korelacija*
	B	Std. Error *St. pogreška*	Beta			
Constant – *Konstanta*	–3.038	1.272	–	–2.388	0.019	–
Skidding distance – *Udaljenost privlačenja drva*	0.004	0.002	0.233	2.924	0.004	0.286
Bunching distance – *Udaljenost skupljanja drva*	0.138	0.056	0.193	2.452	0.016	0.243

cutters assistance. With every meter of timber skidding, the cutters assistance increases by 0.004 minute, with every meter of bunching distance by 0.139 minute and with every additional log in the load by 0.780 minute. Small differences between partial regression coefficients, showing the correlation between cutters assistance and working condition factor with constant value of other two factors, and Pearson correlation coefficients (Table 3) indicate that each factor directly influences cutters assistance. The number of logs in the load accounts for 25% of total variability, the skidding distance 5% and the bunching distance 4% (the square of part correlations). Multivariate model accounts for 40.7% of cutters assistance variability ($p < 0.000$).

Since we wanted to find out whether the working method within the groups had any influence on cutters assistance, we excluded the influence of working conditions (skidding and bunching distance, and the number of logs in the load) from cutters assistance. By comparing the means of the residues by groups after regression, we established that there are no statistically characteristic differences between the groups in cutters assistance (Welch, $p = 0.998$), meaning that we explained all the differences in cutters assistance, established at the beginning of this chapter, with the differences in working conditions.

7. Discussion – *Rasprava*

With this research we proved that working conditions determined by skidding distance, bunching distance and number of logs in the load influence the cutters participation in timber skidding in group work. There are no differences in work methods between work groups that would reflect themselves in absolute values of cutters assistance. The result does not negate differences in the group work methods, established by Klun and Poje (2000a, 2000b) with the comparison of cutters assistance frequency within individual operation, because the comparison of absolute values provides us with a general answer to the assistance increase with changing of working conditions and other conditions, while the frequency distribution of assistance within groups answers to the differences of the method for achieving maximal group effect.

The research results can be applied to logging organization, especially in work arrangement and education of workers, and directly in measurement and defining the standards for group work. When defining organizational form for cutting and skidding in group work we also need to take into consideration working conditions, i.e. skidding distance, bunching distance and the number of logs in the load. By increasing the value of the above factors, the timber skidding becomes a bottleneck for total effect of the group, leading to greater need for additional skidding capacities or inversely, decreasing the need for additional cutters. Also Zečić and Krpan (2004), and Zečić and Marenče (2005) came to similar conclusions, but mainly in regard to skidding distance. When determining the group size, that has the common standard determined on the basis of daily timber quantity on the roadside landing, the basic principle of maximal means utilization for timber skidding has to be followed. On the other hand, it means that a cutter or two cutters should also participate in skidding process in good working conditions for timber skidding, which is frequently impossible, due to great skidding effectiveness (not utilization). With better working conditions for timber skidding, the cutters cut the pre-determined quantity of timber with great difficulty. For adjustment of cutting and skidding processes in practice, the sum of cutting daily standard times in all working conditions has to be lower than with timber skidding process. For increasing group efficiency and productivity, it is necessary to provide detailed planning of working sites and adjustable size of working groups. Beside positive effects, these arrangements can also have negative consequences, especially in the increased effect control and more precise work planning. For successful introduction of the changed working method, it is necessary to achieve positive attitude of workers to planned changes.

Since cutters assistance between groups according to working conditions is not different, cutters within groups participate in timber skidding process in the same way, although they are not additionally educated for group work. It is obvious that the motive for bigger salaries is by itself a motivation big enough to demand rational behavior of workers according to working conditions. However, the workers should be informed about the risks related to group work. The greater number of workers on the same site and intertwining processes of cutting and skidding demands the increased and constant work and coworker movement control, and also the need for worker qualification for cutting and skidding. Special attention should also be paid to a decrease of work difficulty, especially in extreme working conditions in skidding process (i.e. good and bad working conditions). Both instances can cause »burnout« of workers because of cutting and skidding non-adjustment.

Classic division of cutting and skidding can lead us to false and misleading conclusions when studying group work efficiency. Due to overlap of cutting and skidding, apart from traditional working operations

the new arise, whereas synergetic effects prevent the simple sum of standard times. The same holds true for the division of productive and unproductive time within working processes. For example, from the cutters standpoint the participation in the skidding process is regarded as unproductive time, or delay because of organization, whereas from the group work standpoint, it is regarded as productive time, necessary for effect increase of group work.

The ergonomic and economic development of group work with existing »traditional« work technology still has its potential. Apart from flexible work groups adjustable to working conditions according to size (Zečić and Marenče 2005) and capability of various forest work performance (Winkler 1990), it is reasonable to at least try to follow the recommendations for workers participation in planning process and decision making, and constant education (Krivec 1979, Lewark et al. 1996). This brings better relationships between group members and between group and company, and also increases the information flow and innovation possibilities.

8. Conclusion – *Zaključak*

Group work is still one of the most perspective organizational forms in forest work. This is not only true for »traditional« form where chainsaws and different kinds of tractors are used, but also for highly mechanized technologies with harvesters and forwarders. The aim of group work is to increase work efficiency by simultaneously decreasing, or at least preserving the level of work difficulty.

The simultaneous cutting and skidding processes, and the common group daily standard cause cutting and skidding overlap. On one hand this depends on cutters and capacity of skidding means, and on the other hand on working and environmental conditions and specific method of group work. In this research of group work we focused on the influence of working conditions on cutters participation in timber skidding process.

The research took place in decreased range on 5 places of research in Slovenian state forests, where we conducted time studies of timber skidding with IWAFUJI–T41 tractor in 3 working groups, with two cutters and one tractor driver. In our analysis we included 100 cycles of downhill timber skidding.

With multivariate analyses we confirmed the hypothesis that three working condition factors simultaneously influence the duration of cutters participation in timber skidding process. Thus with every meter of timber skidding, the cutters assistance is increased by 0.004 minute, with every meter of bunching distance for 0.139 minute and with every additional log in the load by 0.780 minute. The number of logs in the load has the greatest influence on the assistance duration. Multivariate model accounts for 40.7% of variability. After eliminating the working condition influence on cutters assistance, we disproved the hypothesis that the groups have a duration-specific work method, as other research projects have indirectly indicated.

The results can be applied to define the working group size that depends on all three factors at the same time and not only on the skidding distance as the other researchers suggested. By increasing all three factors, the skidding means becomes a bottleneck for the whole group effectiveness, which basically means that we have to increase the timber skidding capacity, or decrease the number of cutters. The size flexibility of the working group brings the need for more detailed work organization. Insignificant differences between cutters assistance duration in different groups mean that the group daily efficiency is a motivational factor big enough for the rational work. The result does not exclude education and qualification of workers for safe group work and also the need for decreasing work difficulty.

9. References – *Literatura*

Cimperšek, M., 1987: Skupinsko delo v gozdni proizvodnji (Group work in forestry production). Gozdarski vestnik 45(6): 277–284.

Findeisen, E., 2002: ThüringenForst-Erfahrung zur teilautonomen Gruppenarbeit in der hochmechanisierten Holzernte (ThuringenForst – experiences with partial autonomous group work for highly mechanized timber harvesting). Forstechnische Informationen 4: 37–43.

Kerneža, J., 1999: Učinki sečnje in spravila lesa pri Snežnik d.d. po letu 1980 (Wood cutting and timber logging productivity in joint stock company Snežnik by the year 1980). BSc. Thesis, University of Ljubljana – Biotechnical Faculty, Department of Forestry and Forest Resources, p. 30.

Klun, J., Poje A., 2000a: Spravilo lesa z zgibnim traktorjem IWAFUJI T–41 in poškodbe pri sečnji in spravilu (Timber skidding with IWAFUJI T–41 skidder and stand damage due to cutting and logging operations). BSc. Thesis, University of Ljubljana – Biotechnical Faculty, Department of Forestry and Forest Resources, p. 150.

Klun, J., Poje A., 2000b: Spravilo lesa z zgibnim traktorjem IWAFUJI T–41 (Timber skidding with IWAFUJI T–41 skidder). Gozdarski vestnik 58(7–8): 291–303.

Korbar, U., 1988: Skupinsko delo v gozdni proizvodnji (Group work in forestry production). BSc. Thesis, University of Ljubljana – Biotechnical Faculty, Department of Forestry and Forest Resources, p. 49.

Krivec, A., 1979: Učinkovitost in oblikovanje novih organizacijskih postopkov pri spravljanju lesa s traktorji (Efficiency and modeling of new organizational methods by wood extraction with tractors). Gozdarski vestnik 37(7–8): 315–323.

Križ, A., 1984: Izkušnje skupinskega dela v gozdarstvu na posestvu Snežnik, Kočevska Reka (Experience with work group in forestry in company Posestvo Snežnik, Kočevska Reka). Gozdarski vestnik 42(6): 266–270.

Kruh, A., 1989: Posamično in skupinsko delo v gozdni proizvodnji (Individual and group work in forestry production). BSc. Thesis, University of Ljubljana – Biotechnical Faculty, Department of Forestry and Forest Resources, p. 35.

Lewark, S., Strömquist, L., Kastenholz, E., Meier, D., 1996: Mit teilautonomen Gruppen zu höherer Effizienz und Qualität der Waldarbeit? (Semi-autonomous groups for higher efficiency and quality in forest work). Forstechnische Informationen 11: 109–115.

Winkler, I., 1990: Skupinsko delo v gozdni proizvodnji (Group work in forestry production). Zbornik gozdarstva in lesarstva 35: 69–82.

Zečić, Ž., Krpan, P. B., 2004: Efficiency of group work in harvesting mountainous broadleaf thinning stand. Zbornik gozdarstva in lesarstva 74: 41–58.

Zečić, Ž., Marenče, J., 2005: Mathematical models for optimization of group work in harvesting operation. Croatian Journal of Forest Engineering 26(1): 29–37.

Sažetak

Utjecaj radnih uvjeta na preklapanje sječe i privlačenja drva pri skupnom radu

Klasično pridobivanje drva u kojem se sječa i sortimentnom metodom izradba drva obavljaju ručno-strojnim radom uz primjenu motornih pila lančanica, a privlačenje drva skiderom, zadržat će, kao način rada, svoju važnost i u budućnosti, posebno u šumama koje se odlikuju teškim terenskim radnim uvjetima te u manjim šumama privatnih šumoposjednika. Osnovne značajke skupnoga rada, kao jednoga od organizacijskoga oblika pridobivanja drva, jesu rad u skupini najmanje dvaju radnika koji istodobno obavljaju sječu i izradbu te privlačenje drva te pri tome pomažu jedan drugomu. Opisani je način rada pretežit organizacijski oblik pridobivanja drva u slovenskim državnim šumama.

Veličina radne skupine ovisi ponajviše o kapacitetu stroja koji se koristi pri privlačenju drva.

Radnici u radnoj skupini imaju jedinstven (očekivan) dnevni učinak te svi primaju jednaku naknadu za rad zasnovanu na ostvarenim rezultatima. Na taj su način radnici motivirani sudjelovati u onim fazama rada koje se pokažu kao »usko grlo« pri ostvarivanju optimalnoga dnevnoga učinka.

U slovenskom je šumarstvu skupni rad u proces pridobivanja drva uveden ranih 70-ih godina prošloga stoljeća. Skupni rad zahtijeva svestranoga radnika koji je sposoban obaviti bilo koji posao u svojoj radnoj skupini. Od 1979. godine mnogi su se autori, u Sloveniji i u drugim europskim državama bavili, bilo na teoretskim postavkama bilo praktičnim istraživanjima, skupnim radom (Križ 1984, Cimperšek 1987, Korbar 1988, Kruh 1989, Winkler 1990, Lewark i dr. 1996, Kerneža 1999, Klun i Poje 2000a, Klun i Poje 2000b, Findeisen 2002, Zečić i Marenče 2005 i drugi).

Pri skupnom radu, kao organizacijskom obliku pridobivanja drva, za razliku od individualnoga rada, preklapaju se sječa i izradba s privlačenjem drva. Uz zahtjev sigurnosti i ergonomske orijentiranosti, za skupni je rad posebno važno postizanje najveće moguće učinkovitosti. To znači (slika 1) da je zbroj vremena sječe i izradbe drva, privlačenja drva i vremena kada dolazi do preklapanja tih dviju faza rada minimalan. Navedena vremena ovise o radnim uvjetima u sječini te primijenjenom postupku rada (samo je dio vremena privlačenja drva: vožnja neopterećenoga zglobnoga traktora, vožnja opterećenoga zglobnoga traktora i privitlavanje, neovisan o organizacijskom obliku skupnoga rada, a ponajviše pod utjecajem tehničkih značajki primijenjenoga zglobnoga traktora).

Kada su način rada, organizacija rada i tip zglobnoga traktora određeni i stalni, tada na vrijeme preklapanja obaju radnih procesa utječu radni uvjeti koji se javljaju pri sječi i izradbi te pri privlačenju drva. Loši radni uvjeti pri sječi i izradbi drva (tanka stabla, gusta sastojina) općenito smanjuju udio sjekača pri privlačenju drva te povećavaju udio traktorista u sječi i izradbi drva; vrijedi i obrnuto kada su uvjeti privlačenja drva loši (velika udaljenost privlačenja, mala sječna gustoća, strm teren, veliki uzdužni nagib traktorskih putova).

Ovim je istraživanjem dan prilog dosada relativno slabo istraženim odnosima između sječe, izradbe i privlačenja drva pri skupnom radu, osvijetljen je problem promjenjivih radnih uvjeta u šumi (od sječine do sječine) uz uva-

žavanje ergonomskih, ekonomskih i organizacijskih čimbenika. Istraživanja su ograničena na udio sjekača u privlačenju drva. Postavljene su dvije hipoteze:

- ⇒ *Čimbenici radnih uvjeta (udaljenost privlačenja, udaljenost privitlavanja, premještanje zglobnoga traktora pri oblikovanju tovara, broj komada trupaca u tovaru i obujam tovara) povećavaju vrijeme preklapanja sječe i izradbe s privlačenjem drva (pomoć sjekača traktoristu).*
- ⇒ *Vrijeme trajanja pomoći sjekača traktoristu različito je od radne skupine do radne skupine (bez obzira na to što su različiti radni uvjeti uzeti u obračun).*

Potvrda prve hipoteze omogućila je optimizaciju radne skupine sukladno učinkovitosti rada i težini radnih uvjeta. Pozitivan odgovor na drugu hipotezu upućuje na potrebu izobrazbe radnika u skupni te ističe važnost dnevnoga učinka skupine kao motivacijskoga čimbenika.

Istraživanja su provedena u devet odjela u slovenskim državnim šumama na nadmorskim visinama od 470 do 1070 m. Osnovni su podaci o istraživanim odsjecima prikazani u tablici 1. U odjelima 1 – 7 provedena je redovita, a u odjelima 8 i 9 sanitarna sječa stabala. Praćen je rad šest skupina radnika, a svaka se radna skupina sastojala od jednoga traktorista i dvaju sjekača (1 + 2). Za privlačenje je korišten zglobni traktor IWAFUJI–T41 bez daljinski upravljanoga vitla. Najveća prosječna dobna razlika između radnih skupina bila je 8,7 godina, a najveće prosječno radno iskustvo između radnih skupina 13,5 godina.

U pravilu su glavninu sječe i izradbe obavljali sami sjekači, tek kod specifičnih i najzahtjevnijih radnih operacija ili radnih operacija propisanih zakonom (npr. uhrpavanje grana), traktorist je pomagao sjekačima. Većinu je radnih operacija privlačenja drva obavljao traktorist, sjekači su mu pomagali pri oblikovanju tovara. Povremeno je dodatno prerezivao trupce traktorist na pomoćnom stovarištu. Dnevni učinak skupine predstavlja izrađeno drvo na pomoćnom stovarištu.

Terenska su mjerenja obavljana 29 dana tijekom ljetnih mjeseci 1996. i 1997. godine. Na udaljenosti je privlačenja od 1000 m snimljeno 218 turnusa privlačenja, od čega 78 uzbrdo, 114 nizbrdo te 26 na terenu bez utjecaja nagiba (tablica 2). Prosječan nagib traktorskoga puta određen je kao aritmetička sredina pojedinih nagiba na tom traktorskom putu, a duljine pojedinoga nagiba uzete su kao težine. Traktorski put prosječnoga uzdužnoga nagiba većega od +5 % predstavljao je privlačenje uzbrdo, traktorski put prosječnoga uzdužnoga nagiba manjega od –5 % predstavljao je privlačenje nizbrdo, a traktorski put prosječnoga uzdužnoga nagiba između navedenih vrijednosti odredio je privlačenje drva po terenu bez utjecaja nagiba.

Zbog značajnih razlika između snimljenoga broja turnusa privlačenja drva između radnih skupina (posebno s obzirom na smjer privlačenja drva: uzbrdo, nizbrdo, ravno) daljnja je analiza uključila 100 turnusa privlačenja drva nizbrdo, snimljenih u radnim skupinama 2, 3, 4 na mjestima istraživanja 1, 3, 4, 5 i 6. Udaljenost privlačenja drva mjerena je od mjesta konačnoga formiranja tovara do mjesta odvezivanja tovara (pomoćno stovarište). Prosječna udaljenost privitlavanja izračunata je kao prosjek udaljenosti privitlavanja pojedinoga trupca u tovaru. Premještanje zglobnoga traktora pri formiranju tovara predstavlja zbroj svih pomicanja stroja u sastojini do formiranja punoga tovara. Obujam je tovara zbroj obujma svih trupaca u tovaru.

U tablici 3 prikazane su prosječne vrijednosti i korelacija između trajanja vremena pomoći sjekača i čimbenika koji određuju radne uvjete. Usporedbom prosječnoga trajanja vremena pomoći sjekača između radnih skupina uočavamo razlike ($p < 0{,}000$), a primjenom razlikovnoga testa sredina (Tukey HSD) dokazano je kako je prosječno vrijeme trajanja pomoći sjekača statistički značajno između radnih skupina 2 i 3 te 2 i 4, dok nema statističke potvrde razlike između radnih skupina 3 i 4. Prema prikazu na slici 2 može se zaključiti da vrijeme pomoći sjekača traktoristu raste s povećanjem udaljenosti privlačenja drva, odnosno s velikom vjerojatnošću možemo tvrditi da na vrijeme pomoći sjekača traktoristu osim metode rada i organizacije pojedine skupine utječe i duljina udaljenosti privlačenja, što se podudara s teoretskim postavkama i rezultatima istraživanja drugih autora (npr. Zečić i Marenče 2005).

Proučavanjem linearne ovisnosti između individualnih utjecajnih čimbenika radnih uvjeta i trajanja vremena pomoći sjekača otkrili smo da duljina vremena pomoći sjekača raste s porastom svih utjecajnih čimbenika, a sukladno pozitivnoj vrijednosti koeficijenta korelacije (r). Korelacija je statistički ispitana za udaljenost privlačenja, udaljenost privitlavanja i broj komada trupaca u tovaru. Vrijednosti koeficijenata korelacije relativno su niske, što indicira slabu korelaciju između trajanja vremena pomoći sjekača i individualnih utjecajnih čimbenika radnih uvjeta. Primjenom linearne multivarjantne regresije (tablica 4) želio se ispitati individualni utjecaj pojedinoga čimbenika radnih uvjeta (uz stalne vrijednosti ostalih čimbenika radnih uvjeta) na trajanje vremena pomoći sjekača. Utvrđeno je da udaljenost privlačenja, udaljenost privitlavanja i broj komada trupaca u tovaru istodobno utječu na pomoć sjekača.

Sa svakim metrom privlačenja trajanje vremena pomoći sjekača raste 0,004 min., sa svakim metrom privitlavanja trajanje vremena pomoći sjekača raste 0,139 min., a sa svakim dodatnim trupcem u tovaru za 0,780 min.

Broj komada trupaca u tovaru pokazuje varijabilnost od 25 %, udaljenost privlačenja 5 %, a udaljenost privitlavanja 4 %. Multivarjantni model ima varijabilnost trajanja vremena pomoći sjekača od 40 do 7 %. Statistički je dokazano (Welchovim testom, p = 0,998) da na trajanje vremena pomoći sjekača ne utječe radna metoda unutar pojedine skupine već samo radni uvjeti.

Rezultati provedenoga istraživanja primjenjivi su pri organizaciji skupnoga rada u pridobivanju drva, u izobrazbi radnika te za mjerenje i određivanje učinkovitosti skupnoga rada. Pri organizaciji skupnoga rada posebnu pažnju treba usmjeriti određivanju radnih uvjeta u sječini imajući na umu ove čimbenike: udaljenost privlačenja, udaljenost privitlavanja i broj komada trupaca u tovaru. Povećavanjem vrijednosti nabrojenih čimbenika privlačenje drva postaje »usko grlo« pri ostvaraju propisanih dnevnih učinaka skupine. Navedeni je problem moguće riješiti povećanjem kapaciteta privlačenja drva ili suprotno, smanjenjem broja sjekača. Do sličnih su zaključaka, ali pretežno u svezi s udaljenošću privlačenja drva, došli Zečić i Krpan (2004) i Zečić i Marenče (2005).

Pri optimizaciji radne skupine radi ostvarivanja njezina propisanoga dnevnoga učinka nastoji se postići najveća moguća učinkovitost zglobnoga traktora. Za povećanje učinkovitosti radne skupine nužno je detaljno planiranje radova. Skupni rad sa stajališta sigurnosti pri šumskom radu nosi određene negativnosti i opasnosti. Radnici moraju biti osposobljeni za obje faze rada: sječu i izradbu te privlačenje drva, preklapanje sječe i izradbe s privlačenjem drva traži povećan i stalan rad, potreban je poseban oprez zbog većega broja radnika i stroja/strojeva koji se kreću na malom području i dr.

Treba povesti računa o ergonomskom i ekonomskom razvoju skupnoga rada. Preporučuje se uključivanje radnika u postupak planiranja i donošenja odluka te njihova stalna izobrazba (Krivec 1979, Lewark 1996). Tako će odnosi između radnika u radnoj skupini, ali i odnosi između radnika i poslodavca postati bolji i kvalitetniji, ubrzat će se protok informacija i povećati mogućnost inovacija i unapređenja.

Skupni je rad, uistinu, jedna od najperspektivnijih organizacijskih oblika šumskoga rada, i to ne samo za »klasično« pridobivanje drva gdje se sječa i izradba obavlja ručno-strojnim radom uz primjenu motornih pila lančanica, a privlačenje drva različitim tipovima zglobnih traktora, već i za visokomehanizirano pridobivanje drva uz uporabu harvestera i forvardera.

Ključne riječi: *skupni rad, sječa, privlačenje, radni uvjeti, multivarjantna analiza*

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Received (*Primljeno*): November 15, 2007
Accepted (*Prihvaćeno*): December 6, 2007