Zbornik gozdarstva in lesarstva 74, s. 41 - 58

GDK: 305: 31 / 2(045)=20

Prispelo / *Recieved:* 20. 5. 2004
Sprejeto / *Accepted:* 23. 6. 2004

Izvirni znanstveni članek
Original scientific paper

EFFICIENCY OF GROUP WORK IN HARVESTING MOUNTAINOUS BROADLEAF THINNING STANDS

Željko ZEČIĆ*, Ante P. B. KRPAN**

Abstract:
Group work was researched for felling, processing, skidding and quality inspection activities in mountainous broadleaf thinning stands with approximately the same terrain and stand conditions. The stands were 55 and 70 years old. In the forest communities of the mountainous beech forest with dead nettle (*Lamio orvale – Fagetum sylvaticae*/Ht. 1938) and the forests of the sessile oak and horn beam with beech (*Epimedio – Carpinetum betuli var. Fagus sylvatica*/Ht. 1938/Borth.1963), the main tree species are beech and sessile oak with the addition of other broadleaf species. Productivity was examined in two groups. The first comprised of five workers (A) and the second of four workers (B). The first group was equipped with two tractors and three chain saws while the second used two tractors and two chain saws as well as other necessary equipment. The effective time of the cutters spent on felling ranged from 36 to 42.9%, finishing and measurement took up 21%, while the effective time for the tractors ranged from 42.4 to 59%. The effective time per tree ranged from 3.62 to 3.77 minutes, i.e. from 8.46 min/m^3 to 12.91 min/m^3 per unit. The daily output achieved by the Ecotrac and Torpedo tractors at a distance of 300 meters was 20.77.m^3/day for group A, while the optimised output was 67.02 m^3/day. The output achieved by both tractors in group B was 17.25 m^3/day while the optimised output was 30.72 m^3/day. The average performance per worker in group A was 4.15.m^3/day while the optimised performance was 8.38 m^3/day. For group B the average performance per worker was 4.31.m^3/day and the optimised performance was 7.68 m^3/day. The optimisation of the groups lowered the unit cost of production (300 m distance) for group A from 21.36 EUR/m^3 to 6.62 EUR/m^3, and for group B from 22.09 EUR/m^3 to 12.41 EUR/m^3.

Key words: group work, thinnings, time study, productivity, costs

PROIZVODNOST IN STROŠKI DELA PRI REDČENJIH GORSKIH SESTOJEV LISTAVCEV

Izvleček:
V raziskavi skupinskega dela v gozdarstvu smo se osredotočili na posek, izdelavo sortimentov, spravilo in nadzor kakovosti pri redčenju gorskih sestojev listavcev, ki rastejo na približno enakem terenu in v primerljivih sestojnih pogojih. Raziskava je bila opravljena v sestojih, starih 55 in 70 let. V gozdnih združbah gorskega bukovja z velecvetno mrtvo koprivo (*Lamio orvale – Fagetum sylvaticae*/Ht. 1938) in gozdovih gradna in navadnega gabra ter bukve (*Epimedio – Carpinetum betuli var. Fagus sylvatica*/Ht. 1938/Borth.1963), prevladujeta bukev in hrast ter druge drevesne vrste listavcev. Produktivnost smo preučevali na podlagi dela dveh skupin. Prvo skupino je sestavljalo pet delavcev (A), drugo skupino pa štirje delavci (B). Prva skupina je bila opremljena z dvema traktorjema in tremi motornimi žagami, druga skupina je uporabljala dva traktorja in dve motorni žagi ter drugo potrebno opremo. Efektivni delovni čas, ki so ga sekači porabili za posek dreves, je bil med 36 % in 42.9 %, dodelava in merjenje zavzemata 21 % časa na delovišču, traktorji pa so na delovišču efektivno delali med 42.9 in 59 %. Efektivni čas na drevo je bil od 3.62 do 3.77 minut, to je od 8.46 min/m^3 do 12.91 min/m^3 na enoto proizvoda. Dnevni učinek, ki so ga traktorji Ecotrac in Torpedo dosegli pri spravilni razdalji 300 metrov, je bil 20.77 m^3/dan na delovišču A, optimizirani učinek pa 67.02 m^3/dan. Dnevni učinek obeh traktorjev skupine B je bil 17.25 m^3/dan, optimizirani učinek pa je znašal 30.72 m^3/dan. Povprečni doseženi učinek posameznega delavca v skupini A je bil 4.15 m^3/dan, optimizirani učinek pa 8.38 m^3/dan. V skupini B je povprečni delovni učinek posameznega delavca znašal 4.31 m^3/dan, optimizirani učinek pa 7.68 m^3/dan. Z optimizacijo skupin so se stroški proizvodnje na enoto (na razdalji 300 m) zmanjšali z 21.36 EUR/m^3 na 6.62 EUR/m^3 za skupino A ter z 22.09 EUR/m^3 na 12.41 EUR/m^3 za skupino B.

Ključne besede: skupinsko delo, redčenja, časovna študija, produktivnost, stroški

* dr., Department of Forest Harvesting, Faculty of Forestry, University of Zagreb, Svetošimunska 25, 10000 Zagreb, Croatia
** prof. dr., Department of Forest Harvesting, Faculty of Forestry, University of Zagreb, Svetošimunska 25, 10000 Zagreb, Croatia

VSEBINA
CONTENTS

1 INTRODUCTION
UVOD

Forestry work is often conducted by groups of workers whether it be in seed sowing, planting, tending or harvesting activities. Throughout the centuries tree felling and the forest product processing have been characterised by working in groups. This long period before the introduction of manual-machine and machine work is not only characterised by low educational, technical and technological levels but also by the strict division of work between the members of a group, hierarchy and poor co-operation. In areas in Croatia the felling and processing groups were frequently comprised of up to 15 members. With the introduction of chain saws (1963), the size of the groups was gradually reduced. Tomičić (1986) states that in the period from 1964 to 1967 in some parts of Croatia there were 3-8 workers on one chain saw. For the first time in 1969 technical standards were defined which allowed two workers on one chain saw. Later and lasting to this date the following combinations emerged: 2+1, 2+2 and 1+1.

During the intense development of mechanised wood extraction (from 1969 on) individual work prevailed in forest harvesting activities. The productivity compared to manual cutting and animal skidding was gradually increased to the point of technological saturation. The solution to the issue of increasing productivity with existing means was sought in new organisational forms and enhancement of technical and technological working conditions. Among other measures, group work was once again activated. It was defined as the work conducted by a group of people during the same period of time, at the same location and with the same production task. This type of work is conducted through simple or complex co-operation and is typical for all developed forms of production. Krivec (1979) warns Slovenian forestry workers of the need to introduce group work in felling, processing, skidding, quality inspection and shipment of forest products. In the same context Winkler (1990), also in Slovenia, warns of the need to re-group workers into complete units in order to avoid the negative aspects of individual work.

Croatia has its first experiences in 1981 and 1982. Already in 1984, 44% of the felling volume in one forest administration was cut and extracted through group work. In comparison to individual work the productivity was increased by 30-40%. A group consisted of four to twelve workers and a foreman. The groups were equipped with the necessary equipment for felling, processing, skidding, quality inspection and shipment of forest products.

Group work has been integrated in Croatia mainly because of the increase in productivity in comparison to individual work but also because of other benefits that arise from the work of well-harmonised groups.

Putting group work into effect in forest harvesting operations is a complicated task since complex tensions which appear in a group, pressure put onto a group or its members must be overcome. One of the main problems which must be resolved when forming a group is optimising the number of members and necessary equipment i.e. the dynamic adjustment to the stand and technological conditions of the work site.

2 WORK METHOD AND RESEARCH SITE DESCRIPTION
METODA IN OPIS OBJEKTA RAZISKAVE

The study centred on the work of two groups consisting of four and five workers conducting felling, processing, skidding and quality inspection activities in mountainous broadleaf thinning stands. The effective and delay times were defined as was productivity and the cost of work of the workers in a group. On the basis of effective times and allowance times the standard times were formulated as well as the daily performance. These were the elements used for optimising the size of the groups in the given conditions.

A time study was conducted by concurrently recording all the workers in a group. The repetitive timing method was used. The data was statistically processed using standard PC packages.

The work sites were in the Central Pannonian mountain region. A more detailed description of the locations and stand conditions of the work sites is given in Table 1. Research was conducted in forest communities of the mountainous beech forest with dead nettle (*Lambio orvale – Fagetum sylvaticae/*Ht. 1938) and the of the sessile oak and horn beam with beech (*Epimedio – Carpinetum betuli var. Fagus sylvatica/*Ht. 1938/Borh. 1963) where the main tree species are beech and sessile oak with the addition of other broadleaf species.

Some data on the work means used is given in Table 2.

Table 1: Position and stand characteristics of work site
Preglednica 1: Položaj in lastnosti sestoja v delovišču

		Work site A / Delovišče A		Work site B / Delovišče B	
Forest office / Gozdna uprava		Kutjevo		Pleternica	
Management unit / Gospodarska enota		Južna Krndija I		Sjeverni Dilj II	
Compartment / Oddelek Subcompartment / Odsek		55 a	56 a	46 b	47 d
Area, ha		37.92	37.32	18.24	18.4
Above sea level, m		500 - 750		150 - 250	
Tree species		Beech	Beech	Sessile Oak	Beech
Age, years		55	55	70	70
Rotation, years		100	100	120	100
Number of trees/ha		1017	768	778	935
Average d.b.h., cm		17	19	19	20
Average stand height, m		18	21	19	19
Average tree volume, m^3		0.408	0.595	0.538	0.597
Wood stock, m^3/ha		200	233	284	299
Annual increment, m^3/ha		10.9	11.9	10.6	9.3
10-year felling volume, m^3/ha		37	43	38	40
Type of felling		Thinning	Thinning	Thinning	Thinning
Average skidding distance, m		250		350	
Average winching distance, m		25	23	43	29
Distance between trees, m		9.8	13.0	12.9	10.7
Soil condition		Wet		Dry	
Terrain slope	maximum	30%		29%	
	average	12%		10%	

Table 2: Technical characteristics of tractor, winch and chainsaw
Preglednica 2: Tehnične lastnosti traktorja, vitla in motorne žage

Tractor / Traktor		Torpedo TD 75A	Ecotrac V - 11 - 1030F
		Adapted agricultural / Kmetijski adaptirani	Skidder / Zgibnik
Tractor dimensions, mm length x width x height		4865 x 2040 x 2680	4400 x 1600 x 2300
Engine power, kW		51	33
Winch	Type	Igland 6000/2NM	SP Bratstvo Pucarevo
	Pulling effort, kN	2 x 55	2 x 35
Controlling		mechanical	mechanical
Rope length, m		70	40
Rope diameter, cm		13	12
Chainsaw		Stihl 044; 3,8 kW	

2.1 WORK SITE A
DELOVIŠČE A

Group A consists of five workers and a foreman. Two workers operate tractors; two workers conduct felling and a third worker is at the auxiliary storage. The cutters are equipped with a Stihl 044 chain saw and other necessary equipment. The timber is extracted using a skidder for thinnings – the Ecotrac V-11-1033F and an adapted agricultural tractor Torpedo TD 75A. The task of the cutters in the stand is to cut and process the trees as well as to prepare and hook the load of the tractors. An additional cutter accompanies each tractor. The cutter at the auxiliary storage measures and marks the extracted wood and, if necessary, finalises the assortment. The foreman supervises and directs the work of the group as well as classifies and records the produced wood. The workers are rotated monthly. The wood is processed using the assortment method and the cordwood is prepared as long wood. All the workers in a group are paid in accordance with the joint output on the basis of the amount of wood extracted to the auxiliary storage. The foreman is paid from overhead.

2.2 WORK SITE B
DELOVIŠČE B

This work site is also located on the slopes of the Central Pannonian mountains only at a lower sea level. Group B consists of four workers and a foreman. The group is equipped with the same type of chain saws and tractors as the workers in group A but the technology is different. One cutter cuts and processes the trees. The second finalises the logs, measures and marks the products. The cordwood is prepared as long wood. Tractor operators form and hook the load at the felling area themselves with the occasional assistance of the cutter. They also transport the load to the auxiliary storage themselves. The foreman supervises and directs the work of the group, classifies the assortments and records the output. In the same fashion as group A, the workers are paid in accordance with the joint output and the foreman is paid from overhead. The change in activities within the group is performed by agreement and usually in monthly cycles.

3 RESULTS
REZULTATI

3.1 DATA ON THE EXTRACTED WOOD
PODATKI O PRIDOBLJENEM LESU

Table 3 gives detailed information on the number of cycles and the total and average load values for both work sites. The average volume of the loads ranged from 1.11 m^3 to 1.58 m^3. The largest load was from the Torpedo tractor on work site B. The loads of the other tractors were equal. The average number of pieces in a load ranged from 7.5 to 11.1. The average diameter of the extracted logs on both work sites ranged only slightly from 18.0 cm to 18.6 cm whereas the average volume of the logs ranged from 0.140 m^3 to 0.148 m^3. The data shows homogenous average values of extracted logs on both work sites. The average loads are in accordance with the known values for wood extraction from thinning stands in mountainous conditions.

Table 3: Skidding volume data
Preglednica 3: Količine pridobljenega lesa

Skidding volume elements / Vplivni dejavniki pri spravilu lesa	Work site A / Delovišče A		Work site B / Delovišče B	
	Torpedo TD 75A	Ecotrac V 1033F	Torpedo TD 75A	Ecotrac V 1033F
	* - x - **	* - x - **	* - x - **	* - x - **
Number of cycles	137	131	56	47
Total timber volume, m^3	164.92	145.71	88.59	55.31
Number of pieces	1136	986	623	403
Total length of pieces, m	6 485.6	5 652.2	3 271	2 084.6
Average load volume, m^3	0.53 - 1.20 - 1.89	0.54 - 1.11 - 2.41	0.92 - 1.58 - 2.21	0.73 - 1.18 - 1.78
Average number of pieces per load	5 - 8.3 - 14	3 - 7.5 - 13	7 - 11.1 - 14	5 - 8.6 - 13
Average length of pieces, m	2 - 5.7 - 18	2 - 5.7 - 18	2 - 5.2 - 7,2	2 - 5.2 - 7
Average mid-diameter of pieces, cm	10 - 18.0 - 43	10 - 18.1 - 47	10 -18.6 - 47	10 - 18.4 - 35
Average volume of pieces, m^3	0.03 - 0.15 - 0.67	0.03 - 0.15 - 0.74	0.04 - 0.14 - 0.68	0.04 - 0.14 - 0.51

*Minimum – x Total or average - **Maximum

3.2 USE OF WORKING TIME AND ACHIEVED RESULTS
UPORABA DELOVNEGA ČASA IN REZULTATI

The effective times of the cutters at work site A used for felling, processing, preparing and hooking the load were 36% and 42.9%. The cutter at work site B achieved an effective time of 41.5% out of the total time spent at the work site. The cutters working on finishing and quality inspection both at the felling area (B) and at the auxiliary storage (A) had an effective time of only 20.7% and 21.4% out of the total time spent at the work site. The Ecotrac skidder on work site A worked effectively for 51.5% of the total time and the Torpedo tractor worked 59.0%. The effective time of the Ecotrac skidder on work site B was 42.4% and of the Torpedo tractor 50.9% out of the total time (Fig. 1).

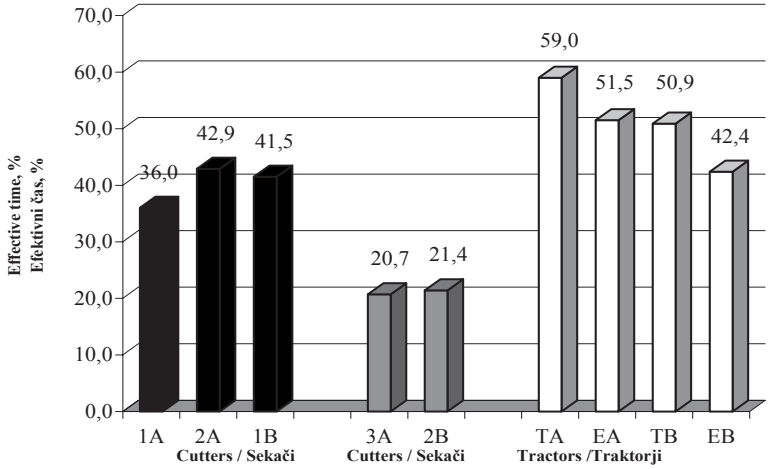

Figure 1: Effective time of cutters and tractors at work sites
Slika 1: Efektivni čas sekačev in traktorjev na deloviščih

The effective time per tree was from 3.62 min (B) to 3.77 min (A), and per product unit from 8.46 min/m^3 (B) to 12.91 min/m^3 (Table 4). The total time per tree ranges from 8.60 min (cutter 2A) to 10.49 min (cutter 1A). The daily average of trees cut ranged from 45.8 to 55.8 trees. The use of total time per product unit was lowest by cutter 1B and amounted to 20.37 min/m^3, while the highest was 35.92 min/m^3 by cutter 1A. The average daily output for cutter 1A was 13.36 m^3/day and for cutter 1B 23.56 m^3/day. The daily output for both workers at work site A was 29.16 m^3/day.

The work site A tractors had a joint output of 20.77 m^3/day and at work site B 17.25 m^3/day. The average output per worker in group A was 4.15 m^3/day and in group B 4.31 m^3/day.

The results show an unacceptable level for used time of all the workers in both groups as well as significant reserves available for improving productivity and lowering costs of harvesting thinning stands.

Table 4: Realized cutter´s productivity by tree and production unit (m^3)
Preglednica 4: Učinki sekača izraženi v št. dreves in kubaturi (m^3)

	Work site A / Delovišče A		Work site B / Delovišče B
	Cutter / Sekač 1A	Cutter / Sekač 2A	Cutter / Sekač 1B
Effective time, min/tree	3,77	3.69	3.62
Delay times, min/tree	6.72	4.91	5.10
Total time, min/tree	10.49	8.60	8.72
Trees/day	45.7	55.8	55.0
Tree volume, m^3	0.292	0.301	0.428
Effective time, min/m^3	12.91	12.26	8.46
Delay time, min/m^3	23.01	16.31	11.92
Total time, min/m^3	35.92	28.57	20.37
Daily output m^3/day	13.36	16.80	23.56
	29.16		

3.3 FORMULATED PERFORMANCE OF THE CUTTERS AND TRACTORS

NORMIRANI UČINKI SEKAČEV IN TRAKTORJEV

For formulating the time standards and daily performance of the groups we used the effective time achieved at the work sites and the allowance times for tractors and cutters at both work sites. Table 5 shows the time standards per tree and product unit for cutters. The allowance time for cutters equals in average 65.8% and for tractors 26.4% of the effective time.

The average formulated daily performance for both tractors on work site A for a distance of 300 m is 33.51 m^3/day (Table 6). In comparison to the average achieved times the formulated output for tractors at work site A is 66.3% higher and for work site B as high as 78.4%. In this case the average achieved output per worker would increase by 2.62 m^3/day at work site A and 3.28 m^3/day at work site B.

The daily output for the tractors was calculated taking into account the skidding distances which ranged from 50 to 550 m. The output is shown in table 7 giving the daily performance of the cutters and tractors.

With a standard time from 6.00 min/tree (B) to 6.25 min/tree (A) the cutters can cut from 76.8 to 80.0 trees during an 8-hour working day. With an average volume of cut trees and the calculated time standards, cutters at work site A can jointly achieve an output of 46.04 m^3/day, while one cutter at work site B can achieve 34.24m^3/day.

Table 5: Standard times and formulated outputs of cutters
Preglednica 5: Normativi in dnevni učinki sekačev in traktorjev

	Work site A / Delovišče A		Work site B / Delovišče B
	Cutter / Sekač 1A	Cutter / Sekač 2A	Cutter / Sekač 1B
Effective time, min/tree	3.77	3.69	3.62
Allowance, min/tree	2.48	2.43	2.38
Standard time, min/tree	6.25	6.12	6.00
Trees/day	76.8	78.4	80.0
Average tree volume, m^3	0.292	0.301	0.428
Effective time, min/m^3	12.91	12.26	8.46
Allowance, min/m^3	8.49	8.07	5.56
Standard time, min/m^3	21.40	20.33	14.02
Daily output m^3/day	22.43	23.61	34.24
	46.04		

Table 6: Formulated cycle time, standard times and daily outputs for tractors on skidding distance 300 m
Preglednica 6: Časi ciklusov, normativi in dnevni učinki pri spravilu straktorjem na razdalji 300 m

	Work site A / Delovišče A		Work site B / Delovišče B	
	Torpedo	Ecotrac	Torpedo	Ecotrac
Effective time, min	26.85	25.71	35.79	32.09
Allowance, min	7.09	6.79	9.45	8.47
Total time, min	33.94	32.5	45.24	40.56
Load, m^3	1.20	1.12	1.58	1.18
Standard time, min/m^3	28.28	29.02	28.63	34.37
Formulated daily output m^3/dan	16.97	16.54	16.76	13.96
	33.51		30.72	

The formulated time standards and daily outputs of cutters and tractors at work site B have been confirmed as approximately optimal. With the existing group structure at work site A it was not possible to synchronise the performance of the cutters and tractors since the cutter performance at every distance was much higher than the tractor performance.

3.4 OPTIMAL GROUP MODELS
OPTIMALNI MODELI SKUPINE

As has already been mentioned, Table 7 show the ratio between the daily performance of the cutters and tractors at specific skidding distances. The same table shows the changes in unit costs with regard to the skidding distances.

The data show that the group at work site A is not harmonised. The performance of the two cutters which cut and assist in loading is higher, regardless of the distance, than the realistic capacities of the tractor from 18% at a 50 m distance to 57% at 550 m.

The organisational structure having 4 tractors and 4 cutters, 3 of which conduct felling activities and one conducting quality inspection and marking activities, is much closer to the optimal structure since the performance is synchronised with a 10% tolerance at distances ranging from 100 to 400 m. With this kind of optimisation even the cutter conducting inspection would increase the portion of effective time within the total working time.

The configuration at work site B would be closer to optimal if the work was conducted more rationally (formulated performance) since the performance of the cutter and two tractors is synchronised with a 10% tolerance at distances ranging from 50 to 300 m. In order to synchronise the felling and skidding output at larger skidding distances the model must be adjusted.

Table 7: Optimal daily outputs of cutters and tractors and cost per unit depending on skidding distance
Preglednica 7: Optimalni dnevni učinki sekačev in traktorjev ter stroški na enoti glede na spravilno razdaljo

Work site A /Delovišče A					Work site B / Delovišče B			
Skidding distance	3 cutters	4 tractors	Proporti on	Cost per unit	1 cutter	2 tractors	Proporti on	Cost per unit
Spravilna razdalja	3 sekači	4 traktorji	Delež	Stroški na enoto	1 sekač	2 traktorja	Delež	Stroški na enoto
m	m^3/day			EUR/m^3	m^3/dan			EUR/m^3
50	69.06	78.06	0.88	5.68	34.24	36.09	0.95	10.56
100	69.06	75.58	0.91	5.87	34.24	34.70	0.99	10.98
150	69.06	73.26	0.94	6.06	34.24	33.65	1.02	11.33
200	69.06	71.04	0.97	6.24	34.24	32.61	1.05	11.69
250	69.06	68.98	1.00	6.43	34.24	31.64	1.08	12.05
300	69.06	67.02	1.03	6.62	34.24	30.72	1.11	12.41
350	69.06	65.20	1.06	6.80	34.24	29.88	1.15	12.76
400	69.06	63.46	1.09	6.99	34.24	29.05	1.18	13.12
450	69.06	61.80	1.12	7.18	34.24	28.29	1.21	13.47
500	69.06	60.24	1.15	7.36	34.24	27.59	1.24	13.81
550	69.06	58.76	1.18	7.55				

3.5 GROUP WORK COSTS
STROŠKI SKUPINSKEGA DELA

The total cost of a group is the sum of the costs for every worker, the used equipment and means. Since the performance of a group is calculated on the basis of the amount of product hauled onto the auxiliary storage, the main factor for calculating the unit cost is the performance of the tractor.

The daily output of group A (5 workers) is calculated by the equation	Ta = 3tc + 2tt
The daily output of group B (4 workers) is calculated by the equation	Tb = 2tc + 2tt
The daily output of optimised group A (8 workers) is calculated	Toa = 4tc + 4tt
The daily output of optimised group B (4 workers) is calculated	Tob = Tb

Clarification of the above abbreviations:

Ta and Tb - daily costs for groups A and B
Toa and Tob -daily costs for optimised groups A and B
tc – daily cost of one cutter with a chain saw
tt – average daily cost of tractor and operator

The daily costs of the groups in EUR are:

Ta = 3 x 62.48 + 2 x 128.08 = 443.60 EUR/day
Tb = 2 x 62.48 + 2 x 128.08 = 381.12 EUR/day
Toa = 4 x 62.48 + 4 x 128.08 = 762,24 EUR/day
Tob = Tb = 381.12 EUR/day

a) The actual unit cost of production – skidding distance 300 m

Group A:	daily cost of group: 443.60 EUR/day achieved daily outputper tractor 20.77 m^3/day unit cost 21.36 EUR/m^3
Group B:	daily cost of group: 381.12 EUR/day achieved daily outputper tractor 17.25 m^3/day unit cost 22.09 EUR/m^3

b) Unit costs of production for groups with formulated output of tractors – skidding distance 300 m

Group A:	daily cost of group: 443.60 EUR/day formulated daily output for tractor 33.51 m^3/day unit cost 13.24 EUR/m^3
Group B:	daily cost of group: 381.12 EUR/day formulated daily output for tractor 30.72 m^3/day unit cost 12.41 EUR/m^3

c) Unit production cost for optimal groups – skidding distance 300 m

Group A: The daily output for an optimal combination of three cutters plus one conducting inspection activities and four tractors (Table 7) shall be used in calculating the unit cost. The unit cost shall apply to a skidding distance of 300 m.

The daily cost of a group is 443.60 EUR/day
The optimal tractor output is 67.02 m^3/day
The unit cost is 6.62 EUR/m^3

Group B: The data used is the formulated performance for group B since Table 7 illustrates that the current structure of the group with formulated performance is almost optimal.
The unit cost is 12.41 EUR/m^3.

The comparison of costs in this analysis points to the possibility of applying group work in harvesting thinning stands located in areas with special cost sensitivity. By optimising group A the unit cost (with a skidding distance of 300 m) can be lowered from 21.36 EUR/m^3 and 13.24 EUR/m^3 to 6.62 EUR/m^3. By optimising the groups the daily performance of each individual comes close to 8 m^3/day, which lowers the cost of harvesting thinning stands to a tolerable level. Despite the fact that the output is formulated by the capacities of the tractors, in order to lower the costs it is necessary to harmonise the performances of the cutters and the tractors.

4 CONCLUSIONS
ZAKLJUČKI

Group work in felling, processing**,** quality inspecting and extracting was introduced into Croatian forestry in 1981. This increased productivity in comparison to individual work by 40%.

The researched groups consisted of four (work site B) and five (work site A) workers and conducted their activities in mountainous thinning broadleaf stands. Each group was supervised and directed by a foreman.
In the group of five workers two cutters were tasked with cutting trees, processing assortments and binding logs, one cutter was tasked with finishing, measuring and marking activities at the auxiliary storage, and two were tractor operators.

In the group of four workers one conducted the cutting and processing, the second measu-

red and marked the roundwood in the stand and two were tractor operators.

For extraction the groups used Ecotrac V-11-1030F skidders for thinnings and the Torpedo TD 75A tractor. The tractors were equipped with double drum winches. All cutters used Stihl 044 chain saws.

The effective time of the cutters at the work sites was 36% to 42.9%, the effective time of the workers conducting inspection was 20.7 % and 21.4%, and the tractors had an effective time from 42.4% to 59.0%, which is considered to be an unacceptably low ratio.

The average volume of the tractor loads ranged from 1.11 m^3 to 1.58 m^3 and the average volume of the logs ranged from 0.140 m^3 to 0.148 m^3. The average diameters ranged from 18.0 cm to 18.6 cm.

At work site A the tractors had a joint output of 20.77 m^3/day and at work site B 17.25 m^3/day. The average skidding distance was 300 m. The formulated performance was 33.51 m^3/day and 30.72 m^3/day.

Two cutters on work site A had a daily output of 29.16 m^3/day and the one cutter on work site B had 23.56 m^3/day. The formulated outputs for cutters were 46.04 m^3/day (A) and 34.24 m^3/day (B).

The structure of group A was not harmonised since the formulated output for skidding distances from 50 to 550 m differed from 18% to 57%. An optimally structured group has 3 + 1 cutters and 4 tractors. The optimised output of the tractors (300 m) is 67.02 m^3/day. The structure of group B in the given circumstances was significantly more harmonised and very close to optimal.

The average achieved output per worker was 4.15 m^3/day (A) and 4.31 m^3/day (B), the average formulated output was 6.70 m^3/day (A) and 7.68 m^3/day (B) and the average optimised output per worker was 8.38 m^3/day (A) and 7.68 m^3/day (B). Although the output of a tractor is a significant element in formulating the output of a group for reasons of lowering the costs, it is necessary to harmonise the outputs of the cutters and the tractors in regard to the skidding distance.

Only through optimising the groups does the average output per worker sufficiently increase (approximately 8 m^3/day) for the costs of harvesting thinning stands to remain at an acceptable level.

5 POVZETEK

Delo v gozdarstvu pogosto opravljajo skupine delavcev, pa naj gre za setev semena, sadnjo, nego ali pa za pridobivanje lesa. Za posek drevja in izdelavo gozdnih sortimentov je stoletja značilno prav skupinsko delo. Za dolgo obdobje pred uvedbo ročno-strojnega in strojnega dela, je poleg nizke izobrazbene, tehnične in tehnološke ravni, značilna stroga delitev dela med člani skupine, hierarhija in slaba kooperacija. Na Hrvaškem so skupine imele do 15 delavcev. Z uvajanjem motornih žag (1963) se velikost sekaških skupin postopoma zmanjšuje. Leta 1969 so prvič uvedli tehnične norme za dva delavca z eno motorno žago. Rešitve za povečanje produktivnosti z obstoječimi delovnimi sredstvi so iskali v novih organizacijskih oblikah in izboljšanju tehničnih in tehnoloških pogojev za delo. Skupno delo je opredeljeno kot delo skupine delavcev, ki sočasno nas istem prostoru in na skupnem proizvodu delajo na skupni proizvodni nalogi. V hrvaško gozdarstvo so ga uvedli leta 1981. S tem se je proizvodnost dela glede na posamično delo povečala do 40 %.

Raziskovali so skupine, sestavljene iz štirih (B) in pet delavcev (A) pri redčenjih v gorskih sestojih. Vsako skupino vodi in nadzira delovodja. V skupini petih delavcev sta dva sekača zadolžena za posek drevesa, izdelavo sortimentov in privezovanje hlodovine, en sekač je odgovoren za dodelavo, merjenje in označevanje oblega lesa na pomožnem skladišču, dva delavca pa sta traktorista.

Za spravilo lesa ima skupina zgibni traktor za redčenja Ecotrac V-11-1030 F in traktor Torpedo TD75A. Traktorja sta opremljena z dvobobenskim vitlom, vsi sekači pa z motornimi žagami Stihl 044.

Doseženi efektivni čas sekačev znaša na delovišču A 36 % oziroma 42,9 % delovnega časa. Sekač na delovišču B je dosegel efektivni čas 41,5 % časa, prebitega na delovnem mestu. Sekači, ki so delali na izdelavi in prevzemu so delali efektivno samo 20,7 % (B) oziroma 21,4 % (A) časa, prebitega na delovnem mestu. Traktor Ecotrac je na delovišču efektivno delal 51,5%, traktor Torpedo pa 59 % časa. Na delovišču B je traktor Ecotrac v skupnem času porabil 42,4 %, traktor Torpedo pa 50,9 % efektivnega časa.

Efektivni čas sekača na enoto proizvoda se giblje od 8,86 min/m^3 (B) do 12,91 min/m^3 Poraba skupnega časa je najmanjša pri sekaču 1B, in sicer 20,37 min/m^3, največja pa 35,92 min/m^3 pri sekaču 1 A. Dnevno so posekali povprečno 45,8 do 55,8 dreves. Povprečni dnevni učinek sekača 1A je bil 13,36 m^3, sekača 1B pa 23,56 m^3 oziroma vseh sekačev 29,16 m^3.

Traktorji so na delovišču A dosegli skupni učinek 20,77 m^3/dan, na delovišču B pa 17,25 m^3/dan. Povprečni doseženi učinek posameznega delavca je 4,15 m^3 (A) in 4.31 m^3 (B), srednji oblikovani učinek je 6,7 m^3/dan (A) in 7,68 m^3/dan (B), srednji optimizirani učinek na delavca pa 8,38 m^3(A) in 7,68 m^3/dan /B). Čeprav je za učinek skupine odločilen učinek traktorja, je treba zaradi znižanja stroškov nujno uskladiti učinke sekača in traktorja glede na spravilno razdaljo.

Rezultati kažejo nedopustno nizko raven izrabe delovnega časa vseh izvajalcev v skupinah A in B in na znatne rezerve za povečevanje proizvodnosti in znižanje stroškov pridobivanja lesa pri redčenjih.

Za oblikovanje časovnih norm in dnevnih učinkov skupin je uporabljen efektivni čas, dosežen na deloviščih ter dodatni časi za traktorje in sekače na obeh deloviščih skupaj. Dodatni čas pri sekačih znaša znaša povprečno 65,8 %, za traktorje pa povprečno 26,4 % efektivnega časa.

Povprečni oblikovani dnevni učnek za oba traktorja na delovišču A, pri razdalji zbiranja 300 m znaša 33,53 m^3, za delovišče B 30,72 m^3. Oblikovani učinek je tako glede na povprečni doseženi učinek traktorja na delovišču A večji za 66,3 %, na delovišču B pa celo 78,4 %.V tem primeru bi se povprečni doseženi učinki na delavca v skupinah povečali za 2,6 m^3/dan v delovišču A in 3,28 m^3/dan v delovišču B.

Ob časovni normi 6,00 min/drevo(B) do 6,25 min/drevo(A), lahko sekači v dnevnem osemurnem delu posekajo od 76,8 do 8,00 dreves na dan. Pri povprečnem obsegu posekanih dreves lahko sekači v delovišču A dosežejo učinek 46,04 m^3/dan, en sekač v delovišču B pa 34,24 m^3/dan.

Učinki dveh sekačev na delovišču A, ki poleg sečnje oskrbujejo tudi traktor pri nakladanju, so večji na vseh razdaljah od realnih možnosti traktorja, in sicer za 18 % na 50 m do 57 % na razdalji 550 m. Organizacijska oblika 4 traktorji in 4 sekaći, od katerih 3 sekajo, 1 pa prevzema in označuje hlode, je blizu optimuma, s toleranco 10 % so sinhronizirani na spravilno razdaljo 100-400 m. O taki optimizaciji bi tudi sekač pri prevzemu povečal delež efektivnega časa v delovnem času. Na delovišču B se postavljena konfiguracija skupine približuje optimalni, učinki sekača in dveh traktorjev so v mejah tolerance 10 % sinhronizirani na razdaljah 50 do 300 m.

Skupni stroški skupine so seštevek stroškov vsakega izvajalca, uporabljene opreme in de-

lovnih sredstev. Ker učinek skupine merimo s količino proizvodov, spravljenih na pomožno skladišče, je za določanje posamičnega stroška odločilen učinek traktorja. Pri izračunu posamičnega stroška uporabimo dnevni strošek za optimalno kombinacijo treh sekačev + en sekač pri prevzemu in štirje traktorji. Posamezni strošek proizvodnje optimiranih skupin na spravilni razdalji 300 m v skupini A znaša 6,62 EUR/m^3, v skupini B pa 12,41 EUR/m^3.

Primerjava stroškov kaže na možnost uporabe skupnega dela v posebno stroškovno občutljivem območju izkoriščanja sestojev v redčenju. Z optimizacijo skupine A je mogoče posamezni strošek (na razdalji 300 m) zmanjšati od 21,56 EUR/m^3 oz. 13,14 EUR/m^3 na 6,62 EUR/m^3. Z optimiziranjem skupin se povprečni dnevni učinek člana skupine približuje 8 m^3/dan, s čemer stroške izkoriščanja v sestoju z redčenjem spravimo na sprejemljivo mero. Kljub dejstvu, da učinek diktirajo možnosti traktorja v skupini, je zaradi zniževanja stroškov nujno uskladiti učinke sekača in traktorja.

Prevedel: Iztok Winkler

6 REFERENCES
VIRI

Barns, R.M., 1958, Motion and Time Study, Fourth edition, John Wiley&Sons, Inc., p. 1-665.

Krivec, A., 1979, Učinkovitost in oblikovanje novih organizacijskih postopkov pri spravljanju lesa s traktorji (Neue Formen der Arbeitsorganisation bei Holzruecken mit Traktoren). *Gozdarski vestnik*, XXXVII, 7-8, p. 305-360.

Lewark, S., Stromquist, L., Kastenholz, E., Meier, D.,1996, Mit teilautonomen gruppen zu hoherer Effizienz und Qualitat der Waldarbeit. *Forsttechnische Informationen*, No. 11, p. 109-115.

Rebula, E., 1998, Tehnologija u šumarstvu na početku idućeg tisućljeća (Forestry Technology at the Beginning of the Next Millenium. Mechanisation of Forestry). *Mehanizacija šumarstva* XIII, 3-4, p. 31-41.

Timinger, J., Wippermann, H.J., 1976, Anleitung für forstliche Arbeitsstudien, Datenermittlung, Arbeitsgestaltung. REFA, Darmstadt, p. 1-107.

Tomičić, B., 1986, Razvoj mehanizacije, tehnologije i organizacije rada u iskorišćivanju šuma, u šumskom gospodarstvu "Mojca Birta" u Bjelovaru (The Development of the Mechanisation, Technology and Organisation of Work in the Exploitation in "Mojca Birta" Forest Enterprise in Bjelovar). *Šumarski list*, CX 1-2, p. 29-44.

Winkler, I., 1990, Skupinsko delo v gozdni proizvodnji (Group Work in Wood Production*). Zbornik gozdarstva in lesarstva*, Ljubljana, 35, p. 69-82.

Zečić, Ž., 1998, Skupni rad pri proredama u sastojinama Požeškog gorja s posebnim osvrtom na privlačenje drva traktorima (Teamwork in thinning stands of the Požega mountains with special reference to tractor skidding). Masters Thesis, Faculty of Forestry Zagreb, p. 1-161.