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Time Consumption of Skidding in Mature Stands Performed by Winches Powered by Farm Tractor

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Abstract – Nacrtak

The aim of the present research was to determine the characteristics of time consumption in skidding by winch. The research was conducted in pine, fir, spruce and beech mature stands. It covered the operation of skidding from the stand to the skid trail at the distance of up to 50 m. A time study was performed for skidding operations, timber volume and thinning intensity. The average time consumption of skidding in the operational time, assessed in the examined mature stands, amounted to approximately 18 min/m^3. Significant differences were observed in frequency levels between early thinnings (24 min/m^3) and late ones (13 min/m^3). The operational time structure for skidding by winch was characterized by a large share of auxiliary time: 71%. Out of that time, 30% was used for attaching and detaching the load and 36% for the transfer. Approximation was also done of the multiple regression equations. The equations described changes in skidding time consumption, i.e. the Empirical Efficiency Index (EST). The changes depended on environmental factors (stand, cutting category), elements of the working day structure (the share of a given time category in a shift) and task intensity (ratio of the number of harvested trees per area unit). The strongest correlations between the EST and the analyzed variables were observed for the factors related to the percentage of time required for attaching and detaching the load and factors related to operation intensity.

Keywords: work consumption, timber harvesting technologies, skidding, forest utilization

1. Introduction – *Uvod*

In the mid-1990s in Poland, the market economy led to the privatization of almost 100% of the felling work (Więsik 2000). This economy has entirely changed the idea of timber harvesting. In Poland, small, one- or two-person forest enterprises with insufficient capital prevail. Certification of forest enterprises has been conducted in recent years with the support of the State Forests' administration (Kapral 2000). One of the crucial aspects of assessment is the method of performing forest operations in accordance with the applicable regulations and standards. For many reasons, it is very important to know the appropriate time standards for performing a specific operation. This is often underestimated although it is useful for both foresters and forest enterprise owners. It allows for proper arrangement of tender procedures and for rational planning of operations that are to be carried out.

The amended Catalogues of Forest Work Time Standards, which have been in force in the State Forests units since 2003, are also useful for forest entrepreneurs. The tabular data in these standards present the average working conditions in the field. The data characterize the tasks connected with specific technological systems and timber harvesting technologies.

Most studies treat modeling of time consumption (productivity) in specific forest operations or in whole harvesting technologies as a relation between the volume of the harvested timber and a selected category of effective working time. This increases the precision of inference. On the other hand, it does not allow for assessing the joint effect of all factors on a given variable. The real picture of the phenomenon can be shown by the multi-criterion consideration of the analyzed relations.

The objective assessment of a given technology is connected with measuring the time of the examined operations. Full examination of the time needed to obtain a product (effective time, operational time, shift time) allows for complete assessment of the operations. The present research assumes that the operational time will provide a sufficient generalization. In each case, it is crucial to find the categories of time which significantly affect time consumption in a shift. This is the way to indicate the operations, which should be focused on, at the stage of shift optimization. The above-mentioned interdependence of specific categories of time should be reflected in their percentages, because they show specific features of a given technology and a given stand.

The introduction of work time standards has always attracted much interest (Cserjes 1989, Lukačka 1989, Döhrer 1998, Grzegorz 2003, Derek 2004, Kusiak 2006). Standardization has often been understood only as an element of control. However, it is also a tool used to plan properly the performance of economic tasks. For this reason, the use of time consumption catalogues by the State Forests encourages critical assessment of their standards.

2. Research aim and scope – *Cilj istraživanja*

Due to the changing technical capacities of timber harvesting and considering the necessity to update the quantification of the multi-criteria influence of the selected factors on the level of time consumption, an attempt was made to provide a preliminary assessment of this phenomenon. Constructing a time consumption model for different timber harvesting technologies would allow for making realistic time standards for performing individual operations and for undertaking research on such standardization that would be useful for both the State Forests as the employer and for forest enterprises as contractors.

The aim of the present study was to determine the characteristics of time consumption of skidding by Fransgård winch powered by a farm tractor (referred to as WINCH below). The modeling consisted in approximating the mathematical functions described by the following relation (1):

$$EST_{winch} = f(\text{stand structure, task intensity, elements of working day structure}) \qquad (1)$$

where:

EST_{winch} – the synthetic index of Empirical Technological Efficiency at the work stand: WINCH

The present research on skidding with the use of cable winches powered by farm tractors, commonly used in Polish forestry, shows the current technical capabilities of timber harvesting as performed by small forest enterprises with insufficient capital. The farm tractor is the most common equipment used for work in agriculture (in the broad sense of the term), and therefore also in forestry (Gil 2007). In Poland, about 65% of skidding operations are performed with the use of tractors.

The present research was conducted in pine, beech, fir and spruce stands. The scope of the operations, limited to the stands of early and late thinning, made it possible to optimize the time consumption model in a group of stands that had the highest share of area and volume. In such stands the performance of timber harvesting operations is particularly difficult, especially concerning the part of skidding operations from the stem to the skid trail. This is affected by the spatial structure of such stands as well as by the volume and dimensions of logs. In the stands of middle age classes, the largest problems occur with the determination of the appropriate levels of time standards, used in job tenders by the State Forests.

3. Methods – *Metode istraživanja*

The research plots of the present research were situated within the Regional Directorate of the State Forests in Cracow, the Regional Directorate of the State Forests in Katowice and the Forest Experimental Station in Krynica (Tab. 1).

In the areas chosen for their full density and uniformity of forest taxation features (breast-height diameter, height) and for their species composition, experimental plots of 0.5 ha and dimensions 50 × 100 m each were set up so that the longer side of each plot was adjacent to the skid trail. On each plot, at 32 circular plots of 50 m^2 each, complete stock-taking was done of all trees thicker than 7 cm.

The equipment used in the present research was Fransgård V6000GS winch powered by a Pronar 5112 farm tractor. The timber was harvested in the tree length system (TLS) (Laurow 2000). Cable skidding was performed in the direction towards the skid trail at the maximum distance of 50 m. No additional equipment, such as skidding tongs or skidding sledge, was used to facilitate skidding and each item was attached to the collective rope by means of standard attachment ropes with slide locks. One collective rope was used for the skidding of maximum 6 logs. The winch operator performed the skidding from the skid

Table 1 Characteristics of stands on sample plots
Tablica 1. *Sastojinske značajke na pokusnim plohama*

Forest Inspectorate *Šumski predjel*	Thinning *Prorede*	Forest district *Gospodarska jedinicat*	Compartment *Odjel/odsjek*	Forest area, ha *Površina šume,* ha	Forest site type *Vrsta šume*	Species *Glavna vrtsa drveća*	Age , yr *Dob,* god.	Stocking of stand *Obrast*	Crown density *Sklop*	DGB, cm *Srednji prsni promjer,* cm	Height, m *Srednja visina stabla,* m	Stand quality – *Bonitet*	Large timber, m^3/ha *Zrela stabla,* m^3/ha
Dąbrowa Tarno-wska	Early *Rane*	Wał Ruda	68d	5.19	Fresh Mixed broadleaved forest *Mješovita šuma*	Pine *Bor*	25	0.9	Full crown closure *Gust sklop sastojine*	13	12	Ia	140
	Late *Kasne*	Wał Ruda	58d	4.96	Moist mixed coniferous forest *Mješovita šuma četinjača*	Pine *Bor*	45	0.7	Moderate crown closure *Umjereno gust sklop sastojine*	22	20	Ia	200
Gorlice	Early *Rane*	Dominikowice	48a	30.46	Mountain forest *Planinska šuma*	Fir *Jela*	47	1.0	Full crown closure *Gust sklop sastojine*	18	17	I	202
	Early *Rane*	Dominikowice	45b	26.01	Mountain forest *Planinska šuma*	Fir *Jela*	47	1.1	Moderate crown closure *Umjereno gust sklop sastojine*	18	17	I	73
	Late *Kasne*	Małastów	316g	5.62	Mountain forest *Planinska šuma*	Fir *Jela*	97		Broken crown closure *Nepotpuno sklopljena sastojina*	45	21	III	146
	Late *Kasne*	Małastów	300c	8.07	Mountain forest *Planinska šuma*	Fir *Jela*	97	0.6	Broken crown closure *Nepotpuno sklopljena sastojina*	36	24	III	239
Sucha	Early *Rane*	Juszczyn	333b	6.37	Mixed mountain forest *Mješovita planinska šuma*	Beech *Bukva*	47	1.1	Moderate crown closure *Umjereno gust sklop sastojine*	15	19	I	182
LZD	Late *Kasne*	Tylicz	152a	6.49	Mountain forest *Planinska šuma*	Beech *Bukva*	70	1.1	Moderate crown closure *Umjereno gust sklop sastojine*	30	26	I	444
Nowy Targ	Early *Rane*	Stańcowa	245c	9.19	Mixed mountain forest *Mješovita planinska šuma*	Spruce *Smreka*	25	1.0	Full crown closure *Gust sklop sastojine*	7	8	I.5	10
	Late *Kasne*	Stańcowa	250d	1.74	Mixed mountain forest *Mješovita planinska šuma*	Spruce *Smreka*	60	1.2	Moderate crown closure *Umjereno gust sklop sastojine*	24	23	I	503

trail. The basic technical data of Fransgård V6000GS winch powered by a Pronar 5112 farm tractor are presented in Table 2.

A constant time study of the operations was conducted with the working day method during skidding (Monkielewicz and Czereyski 1971, Sajkiewicz 1981). Time was measured with the use of PSION Workabout computer with specialist »Timing« software for conducting time studies (Sowa et al 2007). The registered duration of specific operations was assigned to given categories according to BN-76/9195-01 in the National Forest Equipment System (Botwin 1993). The outline of the classification of the operational work time and the adopted symbols are presented in Table 3.

Table 2 Technical data of Fransgård V6000GS winch powered by a Pronar 5112 farm tractor

Tablica 2. *Značajke vitla Fransgård V6000GS i ATP-a Pronar 5112*

Fransgård V6000GS		
1.	Height / width, mm *Visina / širina,* mm	860/1700
2.	Weight, kg *Težina,* kg	550
3.	Pulling force, kN *Vučna sila,* kN	60
4.	Power consumption, kW *Potrebna snaga,* kW	37–67
5.	Rope diameter, mm *Promjer užeta,* mm	11
6.	Rope length, m *Duljina užeta,* m	50–120
7.	Winding speed (at 540 min^{-1}), m/s *Brzina užeta (pri 540* okretaja/min*)*, m/s	0.5–1.3
8.	Height (without safety shield), mm *Visina (bez zaštitnoga okvira),* mm	1660
9.	Total height, mm *Ukupna visina,* mm	2400
Pronar 5112		
10.	Dimensions: length / width / height, mm *Dimezije: duljina / širina / visina,* mm	4130/1960/2560
11.	Front/rear wheel track *Prednji/stražnji kotači*	1570-1730/1500-1800
12.	Weight, kg *Težina vozila,* kg	4040
13.	Engine type – *Vrsta motora*	Diesel 60 kW/2300 min^{-1}

On completion of the field work, the volume of the obtained timber was calculated, stock-taking was performed of the trees remaining on the circular plots and the intensity of planned thinning was determined (2), (3).

$$W_{iip} = \frac{I}{L} \quad 100 \tag{2}$$

$$W_{sip} = \frac{W_{iip}}{W_{mip}} \tag{3}$$

Where:

I – number of trees before felling on circular plots,

L – number of trees removed from circular plots,

W_{iip} – index of quantitative harvesting intensity,

W_{mip} – index of harvesting intensity in terms of volume (W_{mip} = timber volume removed from circular plots / timber volume before felling on circular plots *100 %).

The W_{sip} index, expressed in this way, reflects spatial distribution of the harvested volume on a timber handling site. For specific stands, the W_{szt} index, which described the number of trees removed from 1 ha, was determined.

In order to obtain more stable results, time consumption was calculated by relating the obtained timber volume to the operational time T_{02} (4) (Giefing and Gackowski 2001).

$$T_c = \frac{T_{02}}{M} \tag{4}$$

Where:

T_c – time consumption,

T_{02} – operational time,

M – timber volume.

In order to achieve accordance of the time consumption, calculated for specific sections, with the normal distribution as well as due to the lack of uniformity of variance, analysis of differences of the mean values of time consumption was conducted using the parametric *t*-Student test. Examination of the dependence of the time consumption observed at work stands on stand characteristics, felling intensity indexes, timber characteristics and factors of the working day structure was conducted using multiple regression procedures. The significance of null hypotheses H_0 was determined for the level of significance $\alpha = 0.05$. Statistical calculations were done using STATISTICA 6 PL program.

4. Results – *Rezultati*

The research was carried out in 24 plots, 3 in each selected stand for each thinning category. Felling intensity was determined at 768 measurement points (circular research plots), where stock-taking of 4,360 trees was performed. The harvesting resulted in the removal from the circular plots of 620 trees, which constituted about 14% of their number and 145 m^3, i.e. over 9% of the volume of trees recorded before the operation.

Table 4 presents the mean values of the index of the total harvesting intensity W_{sip}, calculated for the analyzed conditions.

Table 3 Work time classification

Tablica 3. *Turnus rada*

T_{02} – Operatio-nal work time *T_{02} – Operativno vrijeme rada*	T_1	Effective worktime *Efektivno radno vrijeme*	T_{13}	Time of skidding *Vrijeme privlačenja drva*
	T_2	Auxiliary time *Pomoćna vremena rada*	T_{21}	Time of waiting for help in task execution or for the end of other activities *Vrijeme čekanja (za pomoć pri radnoj operaciji ili da završi neka druga radna operacija)*
			T_{22}	Time of walking in workplace *Vrijeme kretanja radnika po radilištu*
			T_{23}	Time of load attachment and detachment *Vrijeme vezanja i odvezivanja drva*
			T_{24}	Time of unlocking skidded timber *Vrijeme oslobađanja zapelih tovara*

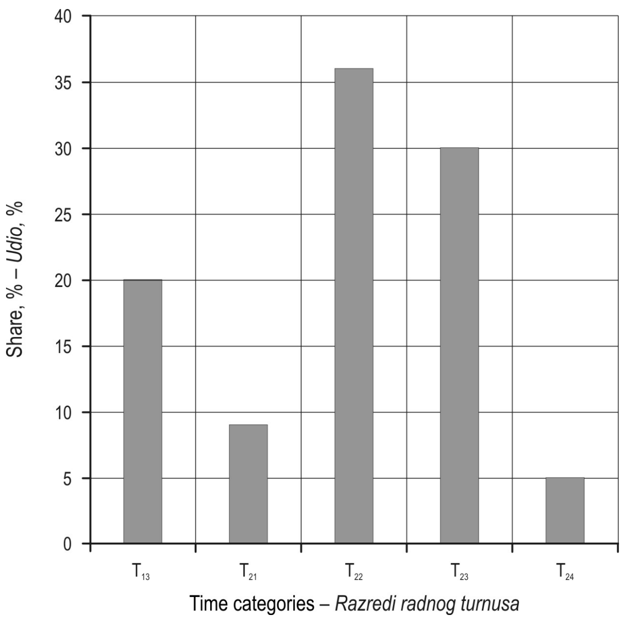

Fig. 1 The structure of operational work time for skidding performed with the farm tractor

Slika 1. *Udjeli vremena tijekom radnoga turnusa*

Table 4 Indexes of quantitative harvesting intensity W_{iip} and the total harvesting intensity W_{sip} in the analyzed stands

Tablica 4. *Udio broja (W_{iip}) i volumena (W_{sip}) posječenih stabala na primjernim plohama*

Stand – *Sastojina i vrsta prorede*	W_{iip}	W_{sip}
Beech, late thinning – *Bukva, kasne prorede*	8.45	0.79
Fir, late thinning – *Jela, kasne prorede*	8.86	1.25
Pine, late thinning – *Bor, kasne prorede*	10.12	1.18
Spruce, late thinning – *Smreka, kasne prorede*	8.06	2.09
Beech, early thinning – *Bukva, rane prorede*	16.00	1.33
Fir, early thinning – *Jela, rane prorede*	10.66	1.43
Pine, early thinning – *Bor, rane prorede*	13.70	1.29
Spruce, early thinning – *Smreka, rane prorede*	9.70	1.86
Early thinning – *Rane prorede*	11.74	1.50
Late thinning – *Kasne prorede*	9.09	1.30
Total – *Ukupno*	10.77	1.47

The W_{iip} index reached higher values in the early thinning stands. Its level ranged from 9.7 to 16. In all cases, the percentage of the number of removed trees was always higher than the volume removed. The analyzed index reached the highest values in early thinning in beech and pine stands. The highest value W_{sip}, i.e. 2.09, was observed in spruce stands in late thinning whereas the lowest one, amounting to 0.79, was observed for the late thinning in beech stands. The mean W_{sip} values were by almost 20% higher in early thinning stands. The highest values were observed in spruce stands (W_{sip} = 2.09 in late thinnings and W_{sip} = 1.86 in early thinnings), where in both categories the W_{sip} was much higher than in the other cases. The W_{sip} index, when calculated individually for each research plot, was then included in the equations of regression describing the time consumption of timber harvesting (*EST*).

During harvesting and skidding operations, a time study was conducted for the operations performed during work on the research plots. The measurement base of the duration of the distinguished operation

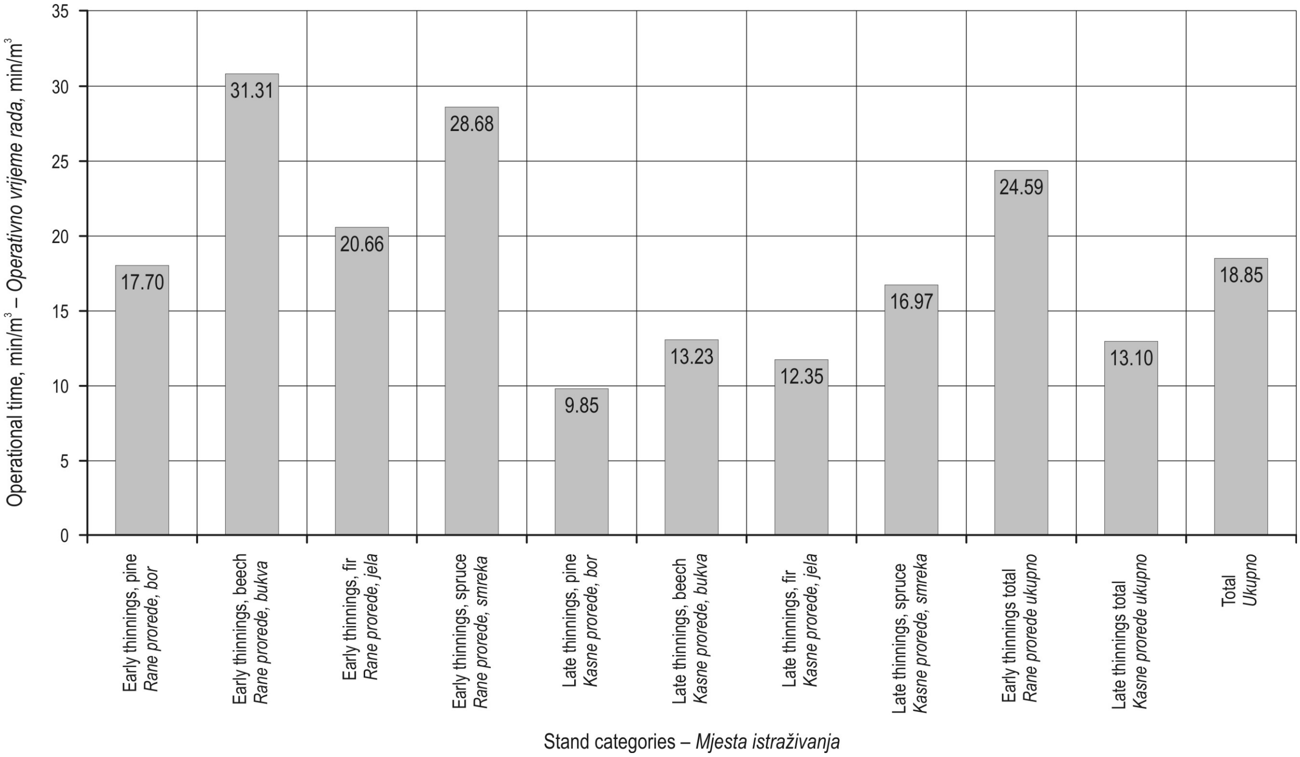

Fig. 2 Time consumption calculated for the analyzed work-stand
Slika 2. *Operativno vrijeme rada*

categories included 7,034 cases whose total time exceeded 70 hours. Part of the measured shift time (the time category) was included in the equations describing the time consumption of timber harvesting (*EST*). The coefficient of the use of the operational shift time was on the level of approximately 0.75, which points to considerable reliability of the equipment used and to good work organization. Fig. 1 presents the percentages of operations observed in the operational time at the examined work-stand.

The examined skidding operations were characterized by a very high (36%) share of the time of walking in the workplace (T_{22}). When walking, the winch operator extended the collective rope and fastened a few skidded logs with attachment ropes (between 4 and 6 at a time), which imposed long walking times. The skidding operation itself was not time-consuming (T_{13} amounted to 20%) but the auxiliary operations of attaching and detaching logs increased the time consumption considerably (30%). Fig. 2 presents the time consumption calculated for the analyzed work-stand. The results of the differentiation analysis of the mean time consumption values in subsequent sections are presented in Table 5.

Skidding operations were performed with the mean time consumption of 18.45 min/m^3, which was a value close to the time consumption observed in the skidding technology where winches were powered by chainsaw (Szewczyk 2009). The mean time consumption of skidding was low. Under such conditions, low timber volume was achieved in the early thinning. Statistically significant differences were observed between the levels of time consumption in the early-thinning stands (24.59 min/m^3) and the late-thinning stands (13.10 min/m^3). The lowest time consumption was observed in late-thinning pine stands (9.85 min/m^3) and the highest in early-thinning beech stands (31.31 min/m^3).

The level of time consumption is one of the factors that allows for determination of usefulness of a given technology to perform specific forest management tasks. For this reason, the term time consumption will be replaced below by another, proposed by the present authors, namely *EST* – the synthetic index of *Empirical Technological Efficiency* (Szewczyk 2010). In this case, the *EST* coefficient is the time consumption assessed on the basis of stand parameters, skidded timber, working day structure. The parameters of the equa-

Table 5 Significance of differences between the mean time consumption values in the operational time for skidding with the use of the farm tractor in stands with late (right up) and early (left down) thinning

Tablica 5. *Razlike u srednjim vremenima privlačenja drva u ranim i kasnim proredama (SD – značajna razlika, ID – beznačajna razlika)*

Species – *Vrsta drveća*	Pine – *Bor*	Beech – *Bukva*	Fir – *Jela*	Spruce – *Smreka*
Pine – *Bor*	*X*	*ID*; $p = 0.07$	*ID*; $p = 0.12$	*ID*; $p = 0.07$
Beech – *Bukva*	*SD**; $p = 0.02$	*X*	*ID*; $p = 0.70$	*ID*; $p = 0.15$
Fir – *Jela*	*SD*; $p = 0.04$	*ID*; $p = 0.10$	*X*	*ID*; $p = 0.06$
Spruce – *Smreka*	*ID*; $p = 0.16$	*ID*; $p = 0.78$	*ID*; $p = 0.31$	*X*

tions (Tab. 6) allowing for the approximation of the *EST* level were estimated for factors related to the features of the stand, skidded timber and elements of the working day structure. Table 6 also presents the values: *R*, R^2, Std error, test values and the probability level *p*.

In the applied model, most variables were stable (terrain features) while others, related to the stand (intensity indexes W_{sip}, W_{szt}) and to the working day structure (percentages of times T_{13}, T_{22}), were taken into consideration. Selection of a set of independent variables in equations approximating the work consumption level was based on the assumption that it should be jointly influenced by factors related to: stand structure (stand, cutting category - early or late thinning), elements of the working day structure (the share of specific time categories in a shift) and volume of harvested timber. Therefore, developing the equations generally consisted in removing those factors that did not significantly affect the estimated time consumption from the widest possible range of independent variables. It was always done so as to make all groups of variables visible in the equations. To sum up, the method applied was multiple backward stepwise regression.

Table 6 Parameters of the regression equations of the EST index

Tablica 6. *Regresijska analiza indeksa EST*

Nr. *Br.*	*EST*	Equation – accuracy of adjustment Parametri regresije					Independent variables Nezavisne varijable					
		R	R^2pop	*F*	*p*	Error ± *Pogreška* ±	Variable – *Varijable*	*B*	Beta β	Error std. *Pogreška*	*t*	*p*
1	Early thinning *Rane prorede*	0.66	0.41	21.98	0.00	14.36	*Constant*	50.34	–	6.61	7.61	0.00
							T_{22}, %	-129.1	-0.64	20.30	-6.36	0.00
							W_{szt}	0.04	0.25	0.02	2.55	0.01
2	Late thinning *Kasne prorede*	0.78	0.59	29.35	0.00	3.93	*Constant*	11.84	–	2.09	5.65	0.00
							T_{13}, %	27.43	0.30	7.72	3.55	0.00
							T_{22}, %	-27.27	-0.47	4.98	-5.48	0.00
							W_{sip}	2.39	0.41	0.51	4.71	0.00
3	Total *Ukupno*	0.64	0.39	26.69	0.00	11.73	*Constant*	30.85	–	3.36	9.18	0.00
							0 = Late thinning – *Kasne prorede* 1 = Early thinning – *Rane prorede*	6.62	0.22	2.84	2.33	0.02
							T_{22}, %	-75.43	-0.49	10.90	-6.91	0.00
							W_{szt}	0.03	0.26	0.01	2.71	0.01

Predicting the level of time consumption on the basis of the volume of a single piece of timber, the number of pieces skidded in a single cycle and e.g. the skidding distance obviously yield fairly precise results under specific stand conditions. However, such an approach does not consider the spatial distribution of the volume of skidded timber on a plot or the method of work in a shift. Such factors are included in the model proposed in the present study.

The strongest correlations between the *EST* level at the work-stand of the WINCH OPERATOR in mature stands were found for the following variables: walking time T_{22} (β = -0.49) and W_{szt} (β = 0.26). The estimated time consumption in early-thinning stands should be by about 6 min/m^3 higher in comparison with late-thinning stands. An increased share of walking time T_{22} in a shift results in a decrease in time consumption (parameter -75.43), which at first sight seems incorrect as the T_{22} time is the auxiliary time rather than the effective time. However, it must be noted that at the analyzed work-stand this time is connected with walking in order to attach to the rope several logs, which are then skidded together as a bunch. Thus its higher share results in higher volume of one load of skidded timber, which lowers the level of time consumption. This phenomenon was better visible in the case of assessing the *EST* in early-thinning stands (β_{T22} = -0,64), which is understandable considering lower volume of a single log. This would point to the need to carry out skidding of whole bunches of logs on a rope in stands of younger age classes.

The analyzed spatial relation (multiple independent variables) is presented in this study as a polynomial relation of the first degree of multiple variables. For the purpose of assessing the time consumption for forestry operations, the linear regression model is the most frequently used by researchers (Häberle 1990, Samset 1990, Lukáč et al. 2000, Bibliuk 2004, Messingerová 2005, Sowa et al. 2009, Sowa and Szewczyk 2008, Szewczyk 2010). The total time consumption of timber harvesting technologies, taking into consideration the various operations involved, may be assessed by totaling appropriate multiple regression equations calculated for specific operations (Zečić and Marenče 2005). This may be the method of predicting the level of time consumption for different technological variants (logical from the point of view of work organization).

In the present study, the *EST* index was expressed as several linear functions of multiple variables. There are always two groups of variables, which generally characterize a stand and the character of stand management operations (the first group), as well as the percentages of the selected elements of the working day structure in the operational time, describing the basic characteristics of timber harvesting technologies (the second group). Their changes are due to differentiation of stand features and, since the examined times are generally the skidding times, they complement the variables included in the first group. Such a comprehensive approach is an innovative solution, proposed by the present authors.

5. Conclusions – *Zaključci*

The average time consumption of skidding by means of the cable winch powered by a farm tractor in the operational time, assessed in the examined mature stands, amounted to approximately 18 min/m^3. Significant differences were observed in the levels of time consumption between early thinning (about 24 min/m^3) and late thinning (13 min/m^3). Differences in measurements of time consumption between early and late thinnings could have resulted from different volumes of single timber pieces and from different distances between trees that remained in the stand.

The structure of the operational time of skidding by means of the cable winch in mature stands was characterized by a large share of auxiliary times T_2: 80%, of which the walking time T_{22} accounted for as much as 36% while load attaching and detaching T_{23} accounted for 30% of the time.

An equation of multiple regression was elaborated for the purpose of describing the changes in the level of time consumption of skidding, namely the *Empirical Technological Efficiency* index (*EST*). The *EST* depends on environmental factors (stand, felling category), elements of the working day structure (the share of an appropriate time category in a shift), characteristics of the harvested timber (volume) and operation intensity (the W_{iip} indexes of quantitative harvesting intensity and the W_{sip} index of total harvesting intensity). The strongest correlations between the *EST* and the analyzed variables were established for the factors connected with the percentage of walking time T_{22}, which is related to the binding of a larger number of timber pieces, skidded in a single cycle.

High time consumption of the examined skidding technology and a large share of the time of waiting for help indicate difficult work conditions in stands of middle age classes, where the skidded logs are frequently blocked and problems occur in connection with controlling the skidding from the skid trail.

The measurements of thinning intensity, used for the approximation of the *EST*, may be determined prior to forest management operations based on the data from the Forest Management Regulations and Standing Timber Assessment. It allows for the rational design of the most effective technological solutions. This makes it possible to apply the results directly in given field conditions of timber harvesting.

6. References – *Literatura*

Bibliuk, N. I., 2004: Forestry transport in Ukrainian Carpathians: main stages and tendencies of development. Proceedings of conference: Forest engineering: new techniques, technologies and the environment, Lwiw, Ukraine 2004, 183–191 p.

Botwin, M., 1993: Podstawy użytkowania maszyn leśnych, Wydawnictwo SGGW, Warszawa, p. 1–120.

Cserjes, M., 1989: Az erdészeti munkanormák készitése és alkalmazása, Erdeszeti Kutatasok 38: 209–213.

Derek, J., 2004: Normy w górę, ceny później, Trybuna Leśnika 2: 10.

Döhrer, K., 1998: Prämien-Zeitlohn für die Waldarbeit, AFZ Wald, Jg. 53(22): 1350–1353.

Giefing, D. F., Gackowski, M., 2001: Ekonomiczna efektywność pozyskiwania drewna krótkiego w drzewostanach III kl. wieku w zależności od zastosowanych urządzeń zrywkowych, Polska Akademia Umiejętności, Prace Komisji Nauk Rolniczych 3: 17–26.

Gil, W., 2007: Badania porównawcze ciągników rolniczych jako środków zrywkowych w wybranych zakładach usług leśnych, Zeszyty Naukowe Akademii Rolniczej im. Hugona Kołłątaja w Krakowie 435: 1–128.

Grzegorz, C., 2003: Nowe katalogi pracochłonności, Las Polski 24: 21.

Häberle, S., 1990: Grundzüge forstlicher Zeitstudien und ihrer Auswertung, Forstarchiv, Jg. 61, H.1: 27–32.

Kapral, J., 2000: Wytyczne Lasów Państwowych w zakresie kooperacji z sektorem usług leśnych oraz sposoby jego wspierania. Proceedings of conference: Prywatny sektor usługowy w leśnictwie – Stan i perspektywy rozwoju. Międzynarodowe Targi Bydgoskie »Sawo«, Akademia Rolnicza w Poznaniu, Stowarzyszenie Przedsiębiorców Leśnych w Gołuchowie. Tuchola, Polska 2000, p. 9–18.

Kusiak, W., 2006: Spotkanie przedsiębiorców leśnych z Dyrektorem Generalnym Lasów Państwowych, Przegląd Leśniczy 4: 9–11.

Laurow, Z., 2000: Systemy pozyskiwania drewna – nazwy i określenia, Głos lasu 8: 10–11.

Lukáč, T., Tajboš, J., Koreň, J., 2000: Analýza prevádzkových parametrov traktora LKT 81 Turbo Eko, Journal of Forest Science 46(6): 265–274.

Lukačka, M., 1989: Ako dalej v normotvornej činnosti? Les 9: 21.

Messingerová, V., 2005: Technológia vzdušnej dopravy dreva v lesnictve. Technicka Univerzita vo Zvolene, Lesnicka Fakulta, p. 81–87.

Monkielewicz, L., Czereyski, K., 1971: Analiza metod ustalania technicznych norm pracy przy pozyskaniu i transporcie drewna, Prace Instytutu Badawczego Leśnictwa 390: 1–77.

Sajkiewicz, A., 1981: Ekonomika pracy. Państwowe Wydawnictwo Ekonomiczne. Warszawa, 446 p.

Samset, I., 1990: Some observations on time and performance studies in forestry, Meddeleser fra Norsk Institut for Skogforskning 43(5): 1–80.

Sowa, J. M., Kulak, D., Szewczyk, G., 2007: Costs and efficiency of timber harvesting by NIAB 5-15 processor mounted on a farm tractor, Croatian Journal of Forest Engineering 28(2): 177–184.

Sowa, J. M., Szewczyk, G., Stańczykiewicz, A., Grzebieniowski, W., 2009: Pracochłonność pozyskiwania drewna w drzewostanach ze śniegołomami. Leśne Prace Badawcze vol. 70(4): 429–434.

Sowa, J. M., Szewczyk, G., 2008: Czasochłonność pozyskiwania drewna z użyciem procesora NIAB 5-15 w drzewostanach trzebieżowych. Acta Agraria et Silvestria, series Silvestris (XLVI): 53–66.

Szewczyk, G., 2009: Możliwości wykorzystania wskaźników intensywności trzebieży w kategoryzacji warunków pracy dla wybranych technologii pozyskiwania drewna na ręczno-maszynowym poziomie zmechanizowania. Acta Agraria et Silvestria, series Silvestris (XLVII): 27–44.

Szewczyk, G., 2010: Czasochłonność zrywki konnej w drzewostanach trzebieżowych. Sylwan CLIV(1): 52–63.

Więsik, J., 2000: Prywatyzacja wykonawstwa prac leśnych w Polsce, Las Polski 23: 10–12.

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

Utrošci vremena prilikom privlačenja drva ATP-om u proredama zrelih sastojina

Ovim se istraživanjem raščlanio utrošak vremena prilikom privlačenja drva adaptiranim poljoprivrednim traktorom Pronar 5112 s ugrađenim vitlom Fransgård V6000GS u ranim i kasnim proredama. Značajke vozila i pripadajućega vitla prikazane su u tablici 2. Istraživanje je provedeno u državnim šumama grada Krakówa, Katowica i pokusnih šumskih sastojina u Krynici u zrelim borovim, jelovim, smrekovim i bukovim sastojinama (značajke sastojina prikazane su u tablici 1). Sastojine su odabrane zbog zadovoljavajuće gustoće sklopa i dimenzija stabala. Postavljene su pokusne plohe veličine 50 × 100 m (0,5 ha površine) tako da je dulja stranica pokusne plohe bila prislonjena uz traktorsku vlaku. Na svakoj plohi postavljene su 32 plohice, površine 50 m^2 svaka, na kojima su izmjerena sva stabla deblja od 7 cm prsnoga promjera. Korištena je stablovna metoda izradbe drva, a duljina skupljanja drva vitlom bila je do najviše 50 m. Proveden je studij rada i vremena pri privlačenju drva te je prosječno (operativno) vrijeme iznosilo 18,85 min/m^3. Vrijeme radnih operacija mjerilo se pomoću računala PSION Workabout i programskoga paketa »Timing«. Turnus rada prikazan je kroz efektivno vrijeme rada (privlačenje drva) i pomoćna vremena (vrijeme čekanja, kretanje radnika po radilištu, vezanje tovara i odvezivanje privučenoga drva), što je i prikazano u tablici 3. Uočene su značajne (signifikantne) razlike prilikom privlačenja drva u ranim (24,59 min/m^3) i kasnim (13,10 min/m^3) proredama (tablica 5). Udio je pomoćnih vremena najveći, čak 71 %, od čega 30 % pripada vezanju i odvezivanju tovara, a 36 % kretanju radnika po radilištu (slika 1 prikazuje postotne udjele vremena radnih operacija). Udio ukupnoga vremena, ovisno o vrsti prorede (rane/kasne) i mjestu istraživanja, prikazan je na slici 2. Regresijska analiza izmjerenih vremena prikazuje utjecaj pojedinih čimbenika radilišta na proizvodnost, tzv. empirijski indeks učinkovitosti, tj. EST. Razlike nastaju zbog sastojinskih prilika (tablica 1), sastavnica turnusa rada i količine posječenoga drva W_{iip} i W_{sip} (intenziteti sječe prikazani su u tablici 4). Najjača združenost podataka primijećena je između vremena potrebnoga za vezanje i odvezivanje tovara i intenziteta sječe u pojedinoj sastojini.

Ključne riječi: utrošak vremena, privlačenje drva, tehnologije pridobivanja drva, korištenje šuma

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