Damage to Young Forest Due to Harvesting in Shelterwood Systems

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Abstract – Nacrtak

Different types of shelterwood system and group selection forests were studied to discover the extent of damage caused by logging. Motor-manual cutting and mainly tractor skidding were included. Sampling transects were used to estimate the damage to young forest and remaining stands. The whole research area was regenerated on average 31%, of which 21% was damaged. We found a higher density of designated and undesignated skid trails on larger regeneration areas. Damage to young forest and damage to remaining productive stands were compared. In this respect the whole rotation period was divided into three time intervals, the first of which designated a mixed pattern of young forest area and younger phases prior to commercial thinning, in which the last of the old mature trees are removed. The second phase is a mix of currently productive stands and some young forest, in which the first and second commercial thinnings begin, until the final stage, in which young forest becomes increasingly abundant and perspective. In the last period, damage to productive stands is high (around 70%), since they have accumulated over a long time period. The fact that better forest stand opening with skid trails means less damage to young forest, but slightly more damage to mature stands suggests the conclusion that the abundance and position of young forest patches should dictate the density and position of skid trails.

Keywords: shelterwood, young forest, damage, harvesting, motor-manual, skid trail

1. Introduction – *Uvod*

The share of close-to-nature stands in Slovenia is fairly high, on average. Clear felling with artificial regeneration has been forbidden since 1949 (Perko 2005). The idea of co-natural practice has been slowly developing and this development can be followed through many forest acts since then. In recent decades, the actual practice has mainly been inspired by silvicultural practice (selective thinning) in other countries (Mlinšek 1968). There have, however, been some modifications (Kotar 2005), which were necessary because the terrain, sites, forest stand conditions, ownership and other factors of forest management, including technical level, differ from those in other countries. Natural regeneration is the premise on which the philosophy of silviculture rests. The way of regeneration follows the goals of each owner, be they uniform shelterwood forest on large areas, shelterwood forest with group regeneration or regeneration more like selection forest (Matthews 1999). Adaptation to the natural conditions is thus very good and flexible. Cutting starts with the first commercial thinning (often too late from the silvicultural point of view) and ends when the entire area under the remains of the old stand is covered with young forest. Private forests are managed according to the wishes and needs of the owner. There are, of course, many exemptions (Krč 1999), where the actual situation requires artificial intervention in the regeneration process.

The prevailing technology is motor-manual cutting and extraction with adapted agricultural tractors or cable skidders, some of them made in Slovenia. The cut-to-length method has already been used in many places, but the technology is still developing. Modern all-terrain cable cranes are used in some more mountainous parts of the country. The shelterwood system, just like selection forest, requires very good accessibility of forest with forest roads, skid roads and skid trails. In state forests there are more than 25 m/ha of forest roads and around 100 m/ha of permanent skid roads (Košir 2003). Accessibility in private forests is at least half that in state forests (Medved 2003).

In this article, skid roads and skid trails will be combined in the same category of designated skid trails. Designated skid trails can be understood as potentially or even predominantly permanent forest thoroughfares (depending on terrain features) – skid roads. Designated skid trails on difficult terrain are regularly built before forest operations commence, on easy terrain they are marked in the stand and on the map, and trees are removed. On the other hand, undesignated skid trails are not permanent thoroughfares, since they serve the actual needs of thinning and they are chosen by the tractor operator. Undesignated skid trails are not built, but can be sometimes a necessity if the pattern of permanent skid trails (designed through operational planning) is inadequate.

Silvicultural planning is a valuable tool that has been used in state forests for at least three decades. It can be seen through prescriptions in the silvicultural plan whether a specific young forest area is important enough to be part of future stand development or not. It is essential to know in which direction felled trees can be moved without damaging the young forest and remaining trees. In some cases, this simply cannot be done. Timber harvesting is performed many times during the rotation period and, consequently, damage to the remaining stand accumulates and tends to reach as much as the total number of trees (Košir and Cedilnik 1996, Košir 1996, Košir 2001). The practice of too frequent thinning has already been criticised, and possibilities of improvement discussed (Košir 1998a, Košir 1998b, Košir 2001).

Many stands, mostly in small patches, have a proportion of young forest in addition to more or less adult trees. According to silvicultural goals, this young forest is a potential candidate for a new stand in the next rotation period. Such young forest is also subject to damage, which is less visible, but equally important. We therefore measured damage to the young stand under the cover of the old stand and combined this damage with the damage to the productive stand. It is equally important to make studies of damage due to traditional motor-manual and tractor skidding, in order to have a reliable basis for future comparisons with more advanced mechanized cutting and timber forwarding techniques. Damages are connected with moving – falling or trasport of heavy loads. When felling trees, the direction of fall can be somehow chosen so as to work safely, enable further transport and minimize damage. Directional felling is therefore dependent upon tree chacteristics and position in relation to skid trail network. Damages are directly related to greater or smaller probability of contact between the load and remaining trees or regenerated area. In this context different degrees and extent of damages could be expected. Our principal goal has been however to reveal the degree of probability for damage to appear in mature (Košir 2001) and in regenerated stands.

2. Methods – *Metode*

Damaged young forest has been considered as a regenerated area on the transect on which healthy new forest cannot develope – in the future. This happens for two reasons: 1) damaged young plants (uprooted, broken, etc.) or 2) displaced or damaged upper layers of soils together with plants. In both cases previous studies indicated that area (in m^2) is a better measurement criteria than the number of damaged plants.

This paper only deals with studies that were conducted in state forests. Research took place at four sites, in order to balance terrain and stand structure differences:

⇒ NW site with mostly Alpine conditions, predominantly spruce stands;

⇒ NE site with mountainous terrain, spruce is the predominant species;

⇒ SE site with hilly and ravine terrain, stands of beech and other broadleaf species;

⇒ SW site on High Karst, silver fir – beech forest predominates.

Among many cutting units, those in which normal thinning had taken place (no salvage cuttings etc.) were selected. We studied the working units for which good silvicultural and operational plans were available. Most of the stands had the characteristics of different shelterwood systems, but in some areas of silver fir – beech forest on High Karst, certain peculiarities of group selection forest distinguished these stands from the others.

Damage caused by logging was measured immediately after operations had been finished. In some places time studies took place before damage was measured. In each working unit we first surveyed the area and analysed the density of the designated skid trails, together with skid trails used by the tractor driver without previous planning (undesignated or »wild« skid trails). The maps of working units with skid trails position were the basis for making a sampling plan along the used skid trails. We used a systematic sampling method of 20–40 m long and 4 m wide transects (20 m in young forest only, 30 m in polewood only, 40 m in mature stand possibly with young forest), which lay perpendicular to skid trails at a distance of 50 m (Robek and Košir 1996, comparable to: Han and Kellog 2000).

Table 1 Number of transects according to age class

Tablica 1. *Broj primjernih ploha po dobnim razredima*

Age class, years *Dobni razredi, godine*	Number of all transects *Ukupan broj primjernih ploha*	Number of transects with young forest *Broj primjernih ploha s mladim sastojinama*	Number of transects with damaged young forest *Broj primjernih ploha s oštećenim mladim sastojinama*	Share of transects with young forest in number of all strips, % *Udjel primjernih ploha s mladim sastojinama u odnosu na ukupan broj primjernih ploha, %*	Share of transects with damaged young forest in number of transects with young forest, % *Udjel primjernih ploha s oštećenim mladim sastojinama u odnosu na broj primjernih ploha s mladim sastojinama, %*
<20	1	1	-	100	-
20–39	11	1	-	9	-
40–59	112	5	4	4	80
60–79	422	53	42	13	79
80–99	385	100	66	26	66
100–119	90	41	26	46	63
120–139	26	7	5	27	71
>140	121	74	56	61	76
Total – *Ukupno*	1168	281	199	24	71

The aim of the method was to measure the damage in the remaining stand (count of injuries larger than 10 cm^2) and also to estimate the damage to young forest area, which was present in many cases under the cover of adult trees. For each logging unit a string of variables was gathered, calculated, estimated or measured. Young stand damage included: broken, severely bent, compressed, injured or in any other way disturbed young trees, with a poor hope of recovery.

The following assumptions were made when choosing the logging unit in which measurements were taken:

⇒ Measurements were carried out in state owned stands in which silvicultural planning has been updated and operational planning is obligatory;

⇒ Operations were conducted with professional machinery, equipment and skilled workers employed by forest enterprises;

⇒ Minimum cut per hectare in the working unit was 15 m^3/ha;

⇒ Young forest damage was recorded when such young forest was described in silvicultural plans as potentially perspective or important.

This article presents an analysis of young stand damage measured in the same transects as damage to productive stand. The age class was computed on the basis of the number of trees in each transect, on premises taken from common growth tables for the purpose of classifying each transect in the stand, since the majority of Slovenian forests are more or less mixed in terms of age and tree species.

3. Results – *Rezultati*

3.1 Young forest damage – Oštećenje mlade sastojine

The research covered 51 working units with an average 23 transects per unit. The average working unit had 11.45 ha, which makes a total area of 584 ha covered by sampling in different parts of the country. Within this area, around 140 ha of young forest was found and measured for damage (Table 1). The assumption that young forest is not important during the »thinning« phase is simply not true. The applied mosaic structure gives importance to almost any presence of young forest. This raises the question of whether this silvicultural practice is really co-natural and whether it is rational. The often discussed question is whether we still need a trained forester for forest management, if the real situation is a randomized (managed by nature) pattern of development phases.

Each working unit was classified into a forest management type such as: uniform shelterwood system, group shelterwood system or group selection forest. This classification is approximate, since in reality many stands do not follow a strict pattern, bearing in mind the size and natural regeneration method. A much larger sample would be required for investigating distinctions among these tree forest management systems. In the analysis we, therefore, used an average value for all three systems, since they are really all shelterwood-systems. The age classes in the following tables and figures are approximate, but the analysis showed that age classes give us a good general picture.

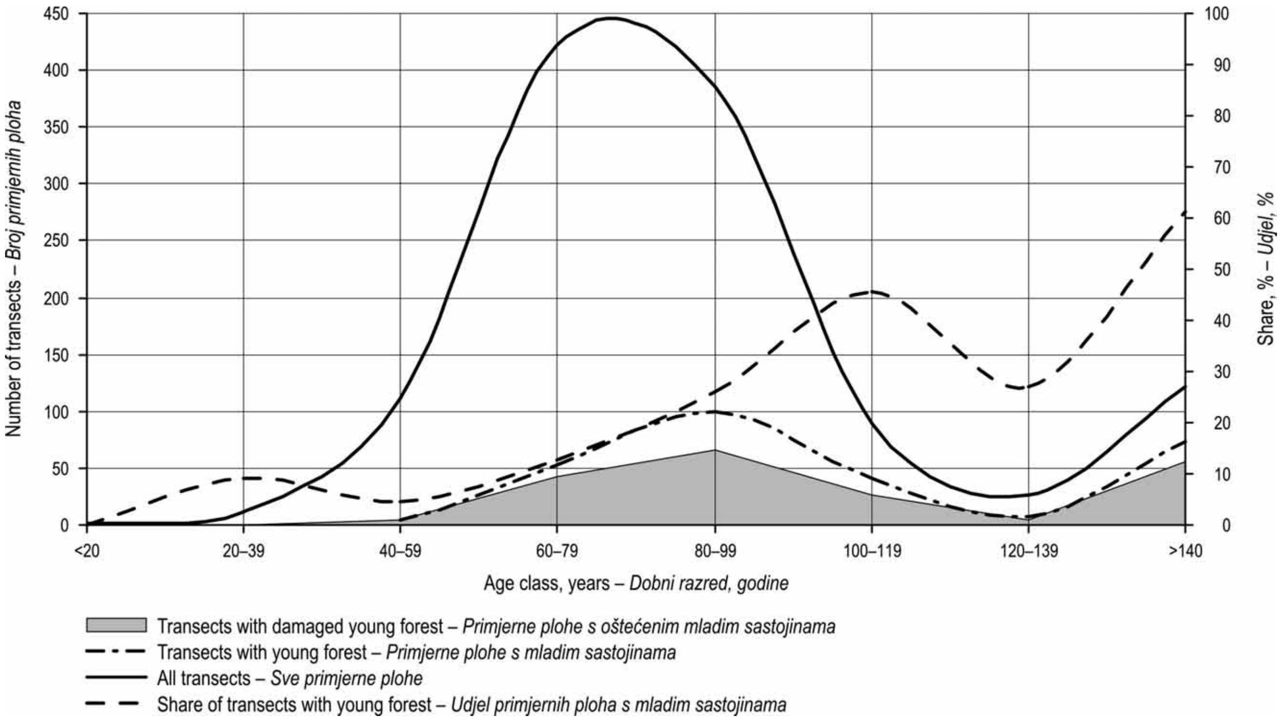

Fig. 1 Number of transects according to age class and share of transects with young forest

Slika 1. *Broj primjernih ploha s obzirom na dobni razred i udjel primjernih ploha s mladim sastojinama*

At the beginning of the new rotation period (age class less than 39 years) the share of regenerated area should normally be larger, but in older classes this dependency becomes weaker (Fig. 1). In the very late stage of the stand, the share of regeneration area reaches only one third of the stand area, but more than 60% of all observed strips. This is presumably due to random dispersion of young forest patches under the canopy of older stands. Such a random pattern makes silvicultural and operational planning difficult, not to speak of environmentally friendly logging. Optimal access to felled timber and directional felling can hardly be planned in detail, but forest operations must be performed without unnecessary damage.

In all transects where young forest was found (Tables 1 and 2, Fig. 1) some damage to young forest was recorded. The main source of damage is skidding, in which heavy loads are moved through the stand. Felling and processing trees causes some damage, but this damage can be understood as a constant when comparing different skidding means (Table 3). Tractor skidding is made entirely on the ground, which is why this method results in higher damage to young forest. Cable cranes normally lift the front end of the timber, which reduces the contact between the load and the ground surface. We have paid more attention to tractor skidding, since this is the predominant skidding form in the research area.

On average, the regenerated area in stands with more than 50% conifers was 34% and in stands where broadleaf prevail 27%. Analysis showed that damaged young forest in coniferous stands is 19% and in broadleaf stands 21%, which is not a significant difference. Analysis also showed that in coniferous stands the average cut was 31 m^3/ha and in predominantly broadleaf stands 41 m^3/ha per thinning. These cut concentrations are low, but we must take into account that thinning is done repeatedly, often more than once in ten years of forest management plan period.

The impact of the logging technique on remaining stand has to be understood as complex (Leinss 1991, Frohm 1993, Spinelli 1999). Skidding, as a part of logging, means transport through the forest. This means also taking into consideration, in addition to machines and techniques, the way the machine approaches the tree or timber. A closer look at the true interrelation between silvicultural and operational planning in respect of young forest damage can be achieved by examining tractor skidding only. Designated skid trails in coniferous stands were 161 m/ha and in broadleaf stands 139 m/ha. Undesignated

Table 2 Distribution of young forest damage according to age class and forest management system

Tablica 2. *Raspodjela oštećenja mladih sastojina po dobnim razredima i načinu gospodarenja*

Age class, years *Dobni razredi, godine*	Group selection forest system *Grupimično preborno gospodarenje*	Group shelterwood system *Oplodne sječe na malim površinama*	Uniform shelterwood system *Oplodne sječe na velikim površinama*	Average *Prosječno*
Young forest area – *Površina mladih sastojina*, m²/ha				
<20	–	–	–	–
20–39	–	–	500	500
40–59	1400	–	750	1140
60–79	2455	2158	4321	2842
80–99	2747	2862	3186	2934
100–119	2279	5077	3278	3385
120–139	1500	2417	–	2286
>140	2097	4467	4200	3430
Average – *Prosječno*	2387	3311	3621	3056
Damaged young forest – *Oštećene mlade sastojine*, m²/ha				
<20	–	–	–	–
20–39	–	–	–	–
40–59	228	–	750	359
60–79	492	475	658	538
80–99	557	718	642	635
100–119	416	1025	564	667
120–139	750	194	–	305
>140	327	1030	882	713
Average – *Prosječno*	448	735	722	627
Damaged young forest, % of regenerated area – *Oštećene mlade sastojine, % od pomladne površine*				
<20	–	–	–	–
20–39	–	–	–	–
40–59	16	–	100	31
60–79	20	22	15	19
80–99	20	25	20	22
100–119	18	20	17	20
120–139	50	8		13
>140	16	23	21	21
Average – *Prosječno*	19	22	20	21
Share of stripes with young forest, % of all stripes number – *Udjel primjernih ploha s mladim sastojinama, % od ukupnoga broja primjernih ploha*				
<20	–	–	–	–
20–39	–	–	13	9
40–59	14	–	6	4
60–79	12	17	10	13
80–99	24	32	24	26
100–119	48	59	32	46
120–139	14	50	0	27
>140	59	60	64	61
Average – *Prosječno*	25	26	22	24

Table 3 Average of damaged regeneration area according to skidding means

Tablica 3. *Prosječno oštećenje pomladne površine s obzirom na sredstvo privlačenja drva*

Age class, years *Dobni razredi, godine*	Skidding means – *Sredstvo privlačenja drva*		
	Tractor *Traktor*	Cable crane *Žičara*	Average *Prosječno*
	% of damaged regeneration area *% oštećene pomladne površine*		
40–59	31	–	31
60–79	20	9	19
80–99	21	19	20
100–119	24	13	20
120–139	45	7	13
>140	21	21	21
Average – *Prosječno*	21	16	20

skid trails were also used in coniferous stands to a greater extent (55 m/ha) than in predominantly broadleaf stands (44 m/ha).

On average, the relative proportion between designated and undesignated skid trails shows that a greater share of undesignated skid trails can be expected in the middle of the rotation period (Fig. 2) and at the very end of stand life. Young forest expressed as a regeneration area percentage has an increasing tendency toward the end of the rotation period, and the same is true of the share of damaged young forest area.

The principal goal of operational planning is to designate enough skid trails for normal work, and no undesignated skid trails should be tolerated. This is, of course, more theory than practice. During our measurements it was often difficult to assess whether a particular undesignated skid trail had been used because of inadequate operational planning, or was a »wild« skid trail, used by a tractor driver for higher efficiency or comfort without respect to stand and young forest damage.

The impact of secondary forest opening on young forest damage is shown in Fig. 3. The dependencies are fairly reliable, and the conclusions that follow are:

⇒ The larger the area of regeneration, the larger the area of damaged young forest.

⇒ The larger the area of regeneration, the higher must be the density of designated skid trails.

⇒ The larger the area of regeneration, the more skid trails were recorded. In addition to a higher density of designated skid trails, a higher density of undesignated skid trails also occurs. The two trends are almost parallel.

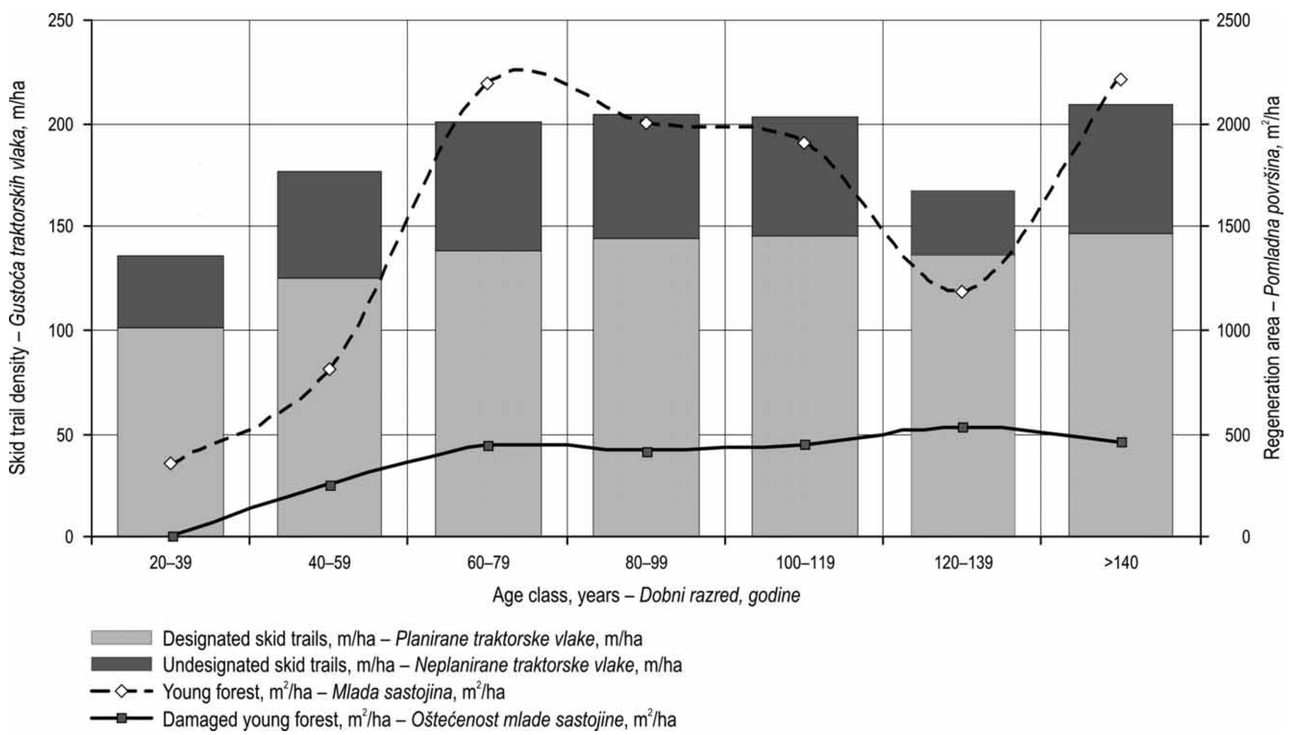

Fig. 2 Planning and actual use of skid trails as a potential cause of young forest damage

Slika 2. *Planirane i stvarno korištene traktorske vlake kao mogući uzrok oštećenja sastojine*

⇒ Relative damage to young forest rises with increased regeneration area, and reaches its maximum at 1700 m^2/ha (= 17% of the stand area) and thereafter decreases again.

The relation between access to felled timber and the possibility of damage to young forest is influenced by the position and abundance of existing regeneration areas and possible positions of skid trails. Although designated skid trails try to avoid regenerated areas, damage to young forest tends to increase from designated skid trail densities ranging between approximately 100 m/ha and 140 m/ha. Higher densities obviously arrange timber transport more successfully, in such a way that relative damage to young forest decreases to about 20% of the regenerated area. Designated skid trails have a stronger impact on relative damage to young forest: too low densities require higher densities of unplanned passes of tractors and cause more damage to the regenerated area, while higher densities are reflected in lower relative damage to young forest. It is a controversial issue but the results show that when the density of undesignated skid trails increases, damage to young forest decreases, on average. The problem can also be understood in this way: tractor skidding has two main operations that risk causing damage – timber bunching with a winch and traveling empty or loaded with timber towards the forest road. Damage from dragging timber is concentrated along skid trails, while bunching is the main cause of damage between skid trails, where damage to young forest has been assessed. When skid trail density is higher, there is less bunching (shorter distances) and, consequently, less damage. A higher skid trail density, on the other hand, means greater temporary loss of productive forest area.

3.2 All stand damages – Oštećenje cijele sastojine

In this section, the connection between productive stand damages and young forest damages is discussed, since these damages occur at the same time and should not be treated separately. The boundary between young forest and productive stands was 10 cm DBH. Damage to the remaining stand tends to increase through the rotation period. This has already been proven by model (Košir and Cedilnik 1996, Košir 1996) and field observations (Košir 2000). The main reason for this is the accumulating nature of damage. A comparison of total stand damage (damage to trees that accumulates during the rotation period) due to harvesting with damage to young forest of the same age shows that total stand damage clearly increases with the forest age, while young stand damage does not show such a tendency.

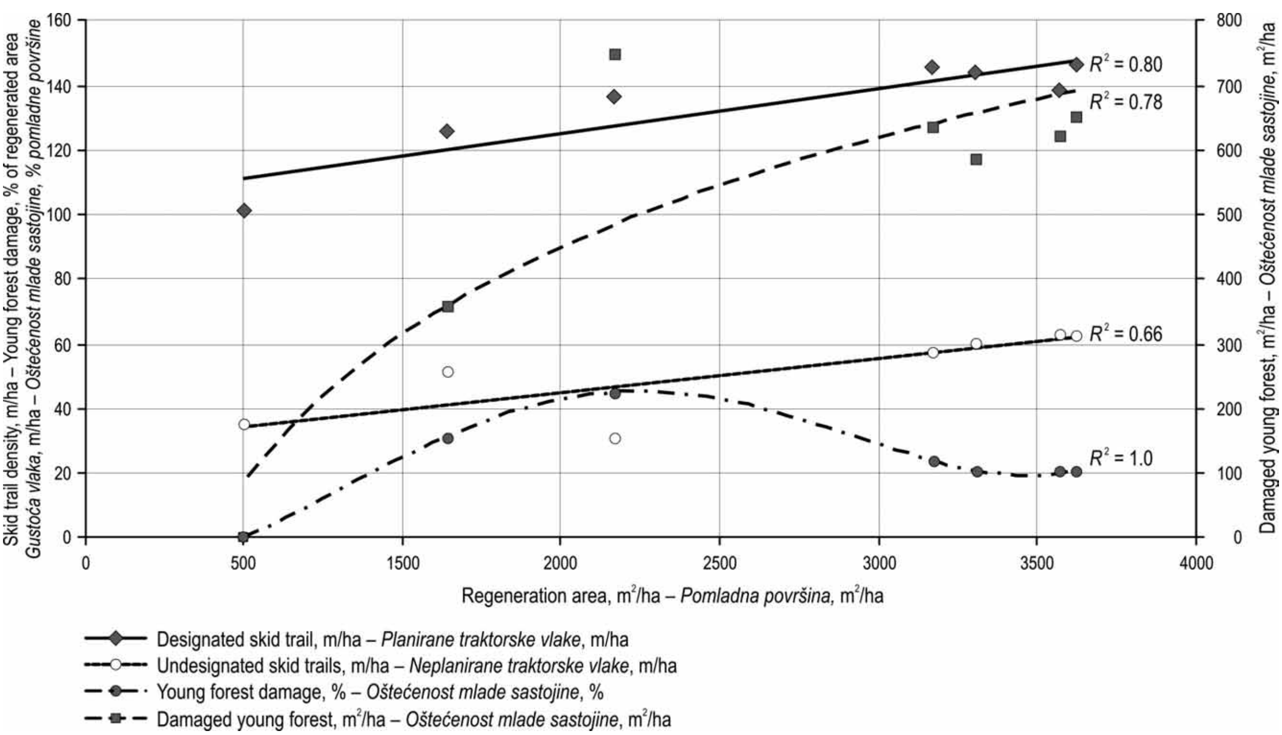

Fig. 3 Relations between designated and undesignated skid trails and damage to young forest

Slika 3. *Ovisnost planiranih i neplaniranih traktorskih vlaka o oštećenosti mladih sastojina*

The results show that the share of damage to young forest (new generation) decreases towards the end of the regeneration period and, at the same time, the share of damage to pole-wood starts to increase. When a new regeneration period starts, the share of damage to new young forest starts to climb again. It seems that different factors govern damage to young forest and in young stands where more or less normal thinning has begun.

The answer might be simple: damage to remaining stand is expressed as the number of damaged trees (or as the share of remaining trees), while damage to young forest is expressed as damaged area (or as the share of damaged area). The number of trees per hectare and area of canopy projection (cover) are connected, since the cover is close to 1 in dense stands during the rotation period, while at the end of the rotation period, when regeneration cutting begins, the cover is much less (tends to reach 0 at the end of regeneration felling, observing only the old stand). These trends are logical, but have to be confirmed with more measurements, so as to make clearer the distinction between young forest and the early stages of a new developing stand.

In this respect, the whole rotation period can be divided into three time intervals (Fig. 4 and Fig. 5):

⇒ In the first phase, when the young forest develops and slowly becomes a future stand, damage goes from zero (when no cutting takes place), increasing momentarily as the last of the old trees are removed, and decreasing because there is a time when little or no thinning is done.

⇒ The second phase, when young forest is present but is not perspective, is when the existing stand is of interest. The first commercial thinning begins. Damage rises according to cutting intensity and skid trail planning and use. The first cutting causes the first stand damage to trees (DBH>10 cm), which are mingled in groups with young forest stages. Thinning continues and stand damage accumulates correspondingly.

⇒ In the final stage, when the young forest becomes perspective, damage decreases as ever fewer adult trees are present in the regenerated area. The majority of adult trees have already been damaged, many of them more than once.

The analysis showed that there is no significant difference in young forest distribution among age classes based on forest management systems. This is due to the mosaic distribution of development phases, whereby the distinction between different forest management types is not always transparent. It is of major importance for practical foresters to know which part of the forest is to be regenerated in the current and next cutting, and where the best routes for timber transport are today and in the future.

The question related with the previous chapter is whether there is a connection between forest skid

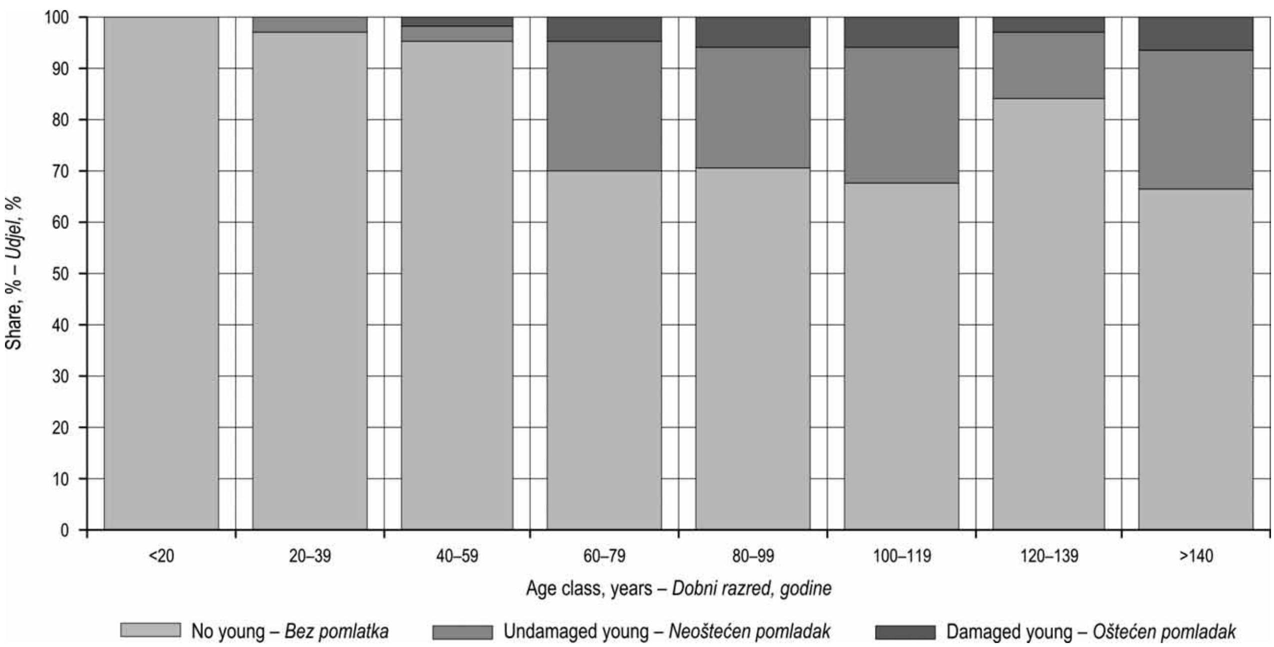

Fig. 4 Development of damage in a forest stand according to approximate age

Slika 4. *Razvoj oštećenja sastojine s obzirom na njezinu približnu dob*

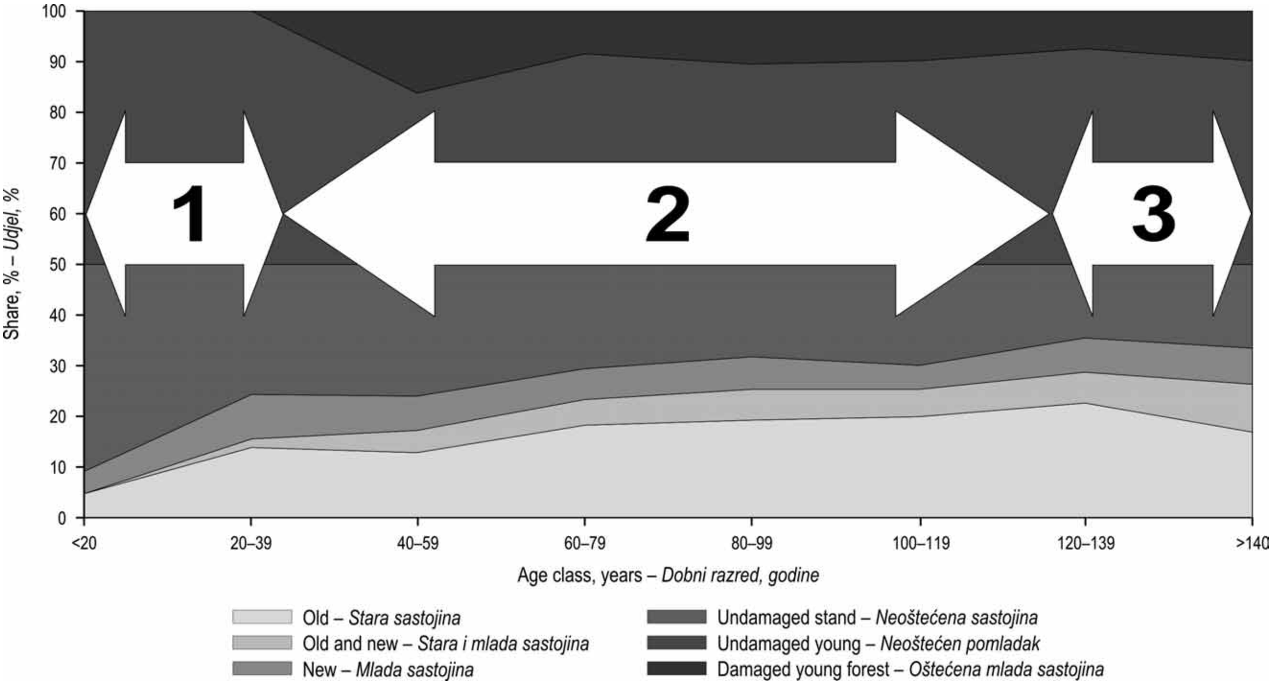

Fig. 5 Development of relative damage in a forest stand according to approximate age

Slika 5. *Razvoj relativne oštećenosti sastojine s obzirom na njezinu približnu dob*

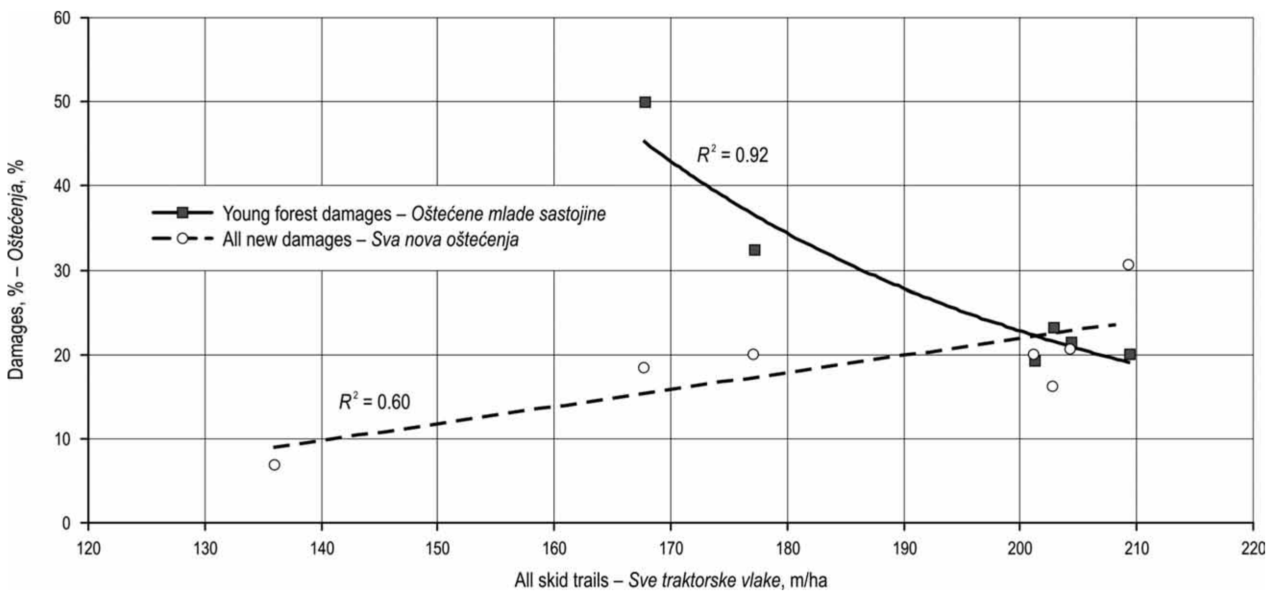

Fig. 6 Damages to a productive stand (DBH>10 cm) and young forest in relation to skid trail density

Slika 6. *Ovisnost oštećenja proizvodnoga dijela sastojine (DBH>10 cm) i mlade sastojine o gustoći traktorskih vlaka*

trail density and damage to stands – on young and on mature trees. The impact of skid trail density on damage to young forest has already been discussed above. Here we compare this relation to the correlation between skid trail density and new damage to the remaining stand. All new damage corresponds to all injured remaining trees, regardless of the fact that some of them have already been injured during previous thinning.

Fig. 6 shows damage to a productive stand in relation to skid trail density. The conclusions are as follows: better forest stand accessibility with tractor skid trails means less damage to young forest, but slightly more damage to the mature stand. The two curves match at a skid trail density around or a little more than 200 m/ha.

4. Discussion and conclusions – *Rasprava i zaključci*

Further analysis should be focused on damages due to new harvesting methods. Damages of mature stands have been already studied. A more detailed study should be carried out of damages of young forest under the cover in selection cutting. The transect method should be replaced with other types of sampling like circular areas. Mechanized cutting brings several significant changes into our expectation of probable young forest appearance: 1) easier directional felling (this fact is in favor of smaller damages), 2) shortwood production and extraction and 3) heavy machines with greater ground pressure in combination with 4) greater share of area necessary for machine movement (this fact increases the probability of damaging young forest). We can also expect that the types of damaged young forest will change (use of broad tires, track chains for rear drive and chains for front drive).

The used sampling method is suitable for motor-manual felling and tractor or cable skidding, where the density of secondary forest opening is relatively low or, in other words, where the average distance between skid trails is relatively large. From our field measurements and from other sources (Butora and Schwager 1986) we know that the possibility of greater damage is higher close to skid trails and damage is lower midway between skid trails. This method of sampling would not be suitable for the cut-to-length method, since skid trails are very dense, and each strip would cross several skid trails. It would be better to use the Frödig method, which can be easily adapted to our needs (Frödig 1992, Košir and Robek 2000). The sampling method should change in future research, when different harvesting and silvicultural systems will be compared. Young forest is important as the foundation of the next stand and carries information to the future. It will be necessary to organize measurements in such a way as to enable us to make a reliable distinction between different types of forest management, but also to include different types of damages. This will be possible in practice, but also difficult, because of the mosaic mixture of tree composition and development phases.

Young forest appears under the cover of more or less mature trees in almost every development phase of stands, regardless of the forest management system. When first thinning begins, damage to the remaining stand together with young forest starts to accumulate. New damage to the remaining stand is divided into injuries to previously undamaged trees, and injuries to those that have already been injured more than once. This damage accumulation is more evident and easier to measure on trees that compose the actual productive stand, while old damage to young forest is less visible, which means that we can only assess current damage to young forest. The density of young forest is high, as well as the vitality. In general it is impossible to determine the influence of a certain share of damaged young trees on the future stand development, since new seedlings fill the gaps and replace missing or severely damaged young trees.

Tree felling, bunching and skidding are sensitive operations in terms of damage to young forest, especially in a mature stand. Proper forest area opening is therefore essential. Silvicultural and operational planning have precisely this task – to make timber transport not only technically possible, but also environmentally friendly – causing the least possible damage. A comparison of the relative area of damaged young forest to total regenerated area (m^2/ha) shows that a larger area of damaged young forest can be expected on a larger regeneration area. The trend is not linear since relative damage to young forest rises with increased regeneration areas, and after a maximum at around 17% of the regenerated area, decreases again. With a higher share of regeneration area, the need for more detailed forest opening (higher density of designated skid trails) is more important. This is also reflected in the fact that we found a higher density of undesignated skid trails in such cases.

Links between previous research on remaining stand damage (DBH>10 cm) and young forest damage is also interesting since it is connected with numerous questions of reasonable and close-to-nature forest management. We divided the whole rotation period into three time intervals, the first of which is a mixed pattern of young forest area and younger phases, mostly prior to commercial thinning, when the last of the old mature trees are removed. The second phase represents a mix of present productive stand and some young forest, which is normally less important as a productive or protection function carrier, when the first and second commercial thinning take place (and productive stand damages start to increase) until the final stage, when young forest becomes more and more abundant and perspective. Productive stand damage is high since it has been accumulating over a long period. The fact that better forest stand opening with skid trails means less damage to young forest but slightly more damage to the mature stand suggests that the abundance and position of young forest patches actually dictate the density and position of skid trails.

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Sažetak

Oštećenja mladih sastojina nakon pomlađivanja metodama pod zastorom krošanja

Istraživanje se bavi utvrđivanjem razine oštećenja sastojina po završetku pridobivanja drva pri različitim načinima gospodarenja šumama (oplodne sječe na malim, odnosno velikim površinama te grupimične preborne sječe). Istraživanje je provedeno na četiri područja radi obuhvata terenskih i sastojinskih različitosti:

⇒ *SZ dio Slovenije, većinom alpski predjeli, prevladavaju smrekove sastojine*

⇒ *SI dio Slovenije, planinski predjeli, prevladavajuća je vrsta smreka*

⇒ *JI dio Slovenije, razvedeni brdski tereni, sastojine bukve i tvrdih listača*

⇒ *JZ dio Slovenije, područje visokoga krša, jelovo-bukove sastojine.*

Obuhvaćeni sustav pridobivanja drva zasnovan je na ručno-strojnoj sječi i izradbi drva motornom pilom te na privlačenju drva skiderom. U ovom radu traktorske vlake i traktorski putovi shvaćaju se kao jedinstvena kategorija – planirane traktorske vlake, koje predstavljaju mrežu mogućih ili čak pretežito trajnih (izgrađenih) sekundarnih šumskih prometnica u skladu s operativnim planovima. Neplanirane se traktorske vlake ne grade, služe trenutačnim zahtjevima proreda, a posljedica su odluka vozača skidera koje on donosi zbog nezadovoljavajućega rasporeda planiranih traktorskih vlaka u sječnoj jedinici.

Za procjenu oštećenosti mlade sastojine (mladik, letvik) i preostalih dubećih stabala nakon sječe korištena je metoda uzorkovanja primjernim plohama. Mladom oštećenom sastojinom na primjernim plohama smatra se sastojina koja se u budućnosti ne može razviti u novu zdravu šumu zbog dvaju razloga: 1) oštećenosti mladih biljaka, 2) premještanja i oštećivanja gornjih slojeva tla zajedno sa samim biljkama. U oba slučaja studije su pokazale da je za mjeru oštećenosti bolje koristiti jedinicu površine (m^2) nego broj oštećenih biljaka (stabala).

Nastala su oštećenja mjerena odmah po završetku radova. U svakoj je istraživanoj sječini analizirana gustoća planiranih traktorskih vlaka, ali i gustoća neplaniranih (tzv. »divljih«) traktorskih vlaka koje su napravili sami vozači skidera, te njihov utjecaj na oštećenost sastojine. Sistematskim uzorkom primjerne su plohe širine 4 m postavljane okomito na traktorske vlake s međusobnim razmakom od 50 m. Duljina je primjernih ploha u mladim sastojinama (letvik) iznosila 20 m, u srednjodobnim sastojinama (stupovlje) 30 m te u zrelim sastojinama 40 m.

Pri izboru sječina prikladnih za istraživanje vodilo se računa da:

⇒ *sastojine pripadaju državnim šumama koje podliježu uzgojnim radovima i u kojima je operativno planiranje obvezno*

⇒ *radovi budu izvođeni s profesionalnim strojevima i opremom te sa školovanim radnicima zaposlenima u šumarskom poduzeću*

⇒ *najmanja sječna gustoća bude 15 m^3/ha*

⇒ *budu zabilježena oštećenja mladih sastojina koje su s uzgojnoga stajališta smatrane važnim i perspektivnim.*

Oštećenja su mjerena u 51 sječnoj jedinici, s prosjekom od 23 primjerne plohe po jedinici. Ukupno su uzorkom obuhvaćena 584 ha (prosječno 11,45 ha po sječini). Od ukupne površine uzorka mlade sastojine zauzimaju 140 ha ili 31 % (tablica 1).

Pretpostavka da su oštećenja stadija mladih sastojina pri izvođenju proreda nevažna, nije točna jer upravo mozaična struktura istraživanih sastojina postavlja pitanje da li su ti uzgojni radovi opravdani. Na svim *primjernim plohama s razvojnim stadijima mlade sastojine (tablica 1 i 2, slika 1) pronađena su oštećenja čiji je glavni uzrok bio privlačenje drva, dok sječa i izradba uzrokuju manje oštećenje koje je stalno kada se usporede različita sredstva privlačenja drva (tablica 3). Oštećenje je mlade sastojine kod četinjača iznosilo 19 %, a kod listača 21 % površine. Gustoća mreže planiranih traktorskih vlaka u sastojinama četinjača iznosila je 161 m/ha, a u sastojinama listača 139 m/ha. Gustoća mreže neplaniranih traktorskih vlaka u sastojinama četinjača je 55 m/ha te 44 m/ha u sastojinama listača.*

Radi lakšega poimanja oštećenja razvojnih stadija mladih sastojina (udjel od površine) koje se razvijaju pod zastorom krošanja zrelih stabala, koja su također predmet oštećenja (broja stabala), ophodnja je podijeljena u tri faze (slike 4 i 5):

⇒ *Mlada sastojina raste i polako počinje predstavljati buduću sastojinu, oštećenja se kreću od 0 (u slučaju izostanka sječe) uz porast do trenutka sječe zadnjega zreloga stabla te se opet smanjuju zbog rijetkih proreda.*

⇒ *Mlada je sastojina formirana i započinju komercijalne prorede, oštećenja rastu s porastom intenziteta sječe i gustoće mreže traktorskih vlaka. Prva sječa uzrokuje i prva oštećenja na stablima (prsni promjer >10 cm) koja su grupimično uklopljena s mladim stadijima buduće šume. Prorede se nastavljaju i oštećenja sukladno tomu rastu.*

⇒ *U posljednjoj fazi oštećenja se smanjuju jer je sve manje zrelih stabala za sječu na pomladnoj površini. Većina zrelih stabala ima više od jednoga oštećenja.*

Veća gustoća traktorskih vlaka omogućuje bolju kretnost i mogućnost prihvata drva sredstvima sekundarnoga transporta tako da se oštećenost mlade sastojine smanji na 20 % pomladne površine. Istraživanje je pokazalo da se kod povećane gustoća neplaniranih traktorskih vlaka oštećenja u sastojini u prosjeku smanjuju. U slučajevima kada je gustoća planiranih traktorskih vlaka velika, manje su udaljenosti skupljanja drva vitlom, a time i manje oštećenja, no ipak se s većom gustoćom gubi i više proizvodne površine šumskoga tla. U prosjeku se očekuje više neplaniranih traktorskih vlaka u sredini i na kraju ophodnje (slika 2).

Rezultati pokazuju da se udio oštećenja u mladoj sastojini smanjuje kroz ophodnju, a u isto vrijeme se povećava u srednjodobnoj sastojini. Razlog tomu je što se oštećenja u mladoj sastojini prikazuju udjelom oštećene površine (m^2), dok se oštećenja dubećih stabala prikazuju brojem oštećenih stabala.

Buduća bi se istraživanja trebala usmjeriti na mehaniziranu sječu i izradbu drva. Oštećenja dubećih, zrelih stabala za sječu već su istraživana te treba istražiti oštećenja mladih sastojina (pod zastorom krošanja stabala).

Strojna sječa i izradba drva sustavom harvester – forvarder donosi nekoliko važnih promjena u predviđanjima strukture oštećenja budućih mladih sastojina:

⇒ *lakše usmjereno rušenje stabala, što dovodi do manjih oštećivanja*

⇒ *obvezna primjena sortimentne metode izradbe drva (forvarder)*

⇒ *teška vozila s velikim dodirnim tlakovima*

⇒ *veći udjeli površine pod mrežom sekundarnih šumskih prometnica nužnih za kretanje vozila.*

Također se može očekivati da će se vrste oštećenja mladih sastojina promijeniti zbog upotrebe širih guma i lanaca na prednjim i stražnjim pogonskim kotačima.

Bolja otvorenost šuma znači i manje oštećenja mladih sastojina, ali i više oštećenja zrelih stabala, što nameće zaključak da položaj i zastupljenost pomladne površine i te kako trebaju utjecati na gustoću i položaj traktorskih vlaka.

Ključne riječi: oplodne sječe, mlade sastojine, ručno-strojno pridobivanje drva, traktorske vlake

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