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TRAFFIC LOADING OF FOREST ROADS, RESULTING FROM FOREST MANAGEMENT

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Abstract

Not all the traffic on forest roads results from forest management, yet in this article only the traffic deriving from forest management is discussed. The traffic loading of a certain forest road depends on the area of forest, which is made accessible by this very road. The ownership and yield of forest influence upon the frequency and structure of traffic as well. On forest roads, the personal traffic is much more frequent than the truck traffic. In fact the truck traffic decreases gradually, yet the loading of a road by a single truck ride is increased.

Key words: forest roads, frequency of traffic, structure of traffic, traffic loading

PROMETNA OBREMENITEV CEST ZARADI GOSPODARJENJA Z GOZDOM

Izvleček

Po cestah v gozdu poteka promet, ki izhaja iz gozdarskih in negozdarskih dejavnosti. V razpravi je obravnavan promet, ki ga zahteva gospodarjenje z gozdom. Prometna obremenitev določene ceste je odvisna predvsem od površine gozda, ki ga cesta odpira. Na obseg in strukturo prometa vpliva tudi lastništvo in donosnost gozda. Na gozdnih cestah prevladuje osebni promet, obseg tovornega prometa se zmanjšuje, pač pa narašča prometna obtežba cest pri posamezni vožnji tovornega vozila.

Ključne besede: gozdne ceste, obseg prometa, struktura prometa, prometna obremenitev

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1 INTRODUCTION

Forests usually spread over large areas of country. For this reason, the forest communications of different types and qualities have to be built, to make forest management and exploitation of various goods on the entire forest area possible. Forest roads represent the basic traffic network in forests, to which the thoroughfares of a lower rank are connected (forest ways, skidding trails and - in the mountain regions - the cableway lines as well).

From the traffic point of view, only the forest road network will be discussed in this article. The roads handicap forests in two ways: as unnatural constructions, changing certain parts of forest, and directly - by traffic moving through forests. For planning of a road it is necessary to be acquainted with the frequency of traffic, its structure and time distribution as well as with the impacts of traffic on the environment of the road. On the basis of the data about the anticipated frequency and structure of traffic, a decision can be made on the choice of technical parameters of the road, its stabilisation, the quality of building, etc. If acquainted with the traffic loading of roads, it is possible to evaluate the costs of the road's maintenance more accurately, while the traffic is - beside precipitation water - the main cause of surface deteriorations of communications.

From the data about traffic, its impact on the environment of a road could be evaluated. Unfortunately, a great majority of impacts are negative ones. Some of these are:

- the noise, upseting forest animals and the trippers and picknickers arriving to forests to find quietness;
- the exhaust gases, influencing upon the environment with their annoying smell and noxious substances;
- the dust, rising from macadam roads and polluting their environment;
- the disturbance to natural migrations of forest animals etc.;
- the traffic accidents, in which either animals or people are hurt...

For evaluation of influence of traffic upon the quality of a road and upon the quality of its environement, the entire quantity of the actual and the expected traffic has to be known. In this article, only the traffic deriving directly from forest management is discussed. The traffic, resulting from some other activities in forests (hunting, recreation...) will not be discussed, and neither will be the traffic, which only is indirectly connected to forests (local traffic for example). The frequency of traffic on certain forest roads can be very high, due to some non-forestry activities. Because of that, the traffic frequency can not be referred to as a constant or an average value; it has to be defined for every forest road separately.

The structure of traffic, deriving from forest management, does not remain constant in a longer period of time. Even though in a certain forest the same works have to be performed and equal quantities of timber are extracted year after year, the methods and ways of forest work change, because of the technological development. The means of communication change as well, and with them the possibilities of

arriving to forests for forest work and the possibilities of removal of timber as well. The data about the structure of traffic for a certain forest road network in a defined time period also have documentary value, since the traffic, resulting from diverse activities, in many a case indicates their technological and organizational development.

2 THE METHODS OF DATA GATHERING

2.1 Gathering of the data concerning the traffic on public roads

The necessity of gathering of data about the traffic loading of roads first appeared as an important factor of planning of the major public roads. A special road service has sistematically gathered the data about traffic on the state road network of Slovenia since 1954. Gathering of the data about the traffic is based on counting of the vehicles (the traffic census), which is done at certain locations in certain time intervals. The census is usually performed by persons who count the traffic "manually", yet recently more and more automatic counters are used. The traffic loading of a road is the average annual quantity of vehicles, passing a certain road section per day. From the data gathered it is possible to evaluate the frequency and structure of traffic, its time variations, the stage of its growth and some other parameters about the traffic streams. The frequency of traffic is the number of vehicles (a daily average normally). The structure of traffic are the shares of various types of vehicles.

2.2 Gathering of the data concerning the traffic resulting from forest management

The course of traffic on forest roads is rather different from the traffic course on public roads. Its main characteristic is, that the frequency of traffic decreases more or less constantly from the starting point of the forest road network towards its end. This characteristic is especially obvious in case of closed mountain regions with numerous valleys, where the course of road network resembles very much to the course of nervure at the lower surface of an oak leaf.

Certainly a traffic census on forest roads would give more accurate and reliable results about the loading of forest roads, but such a method of data gathering would be very time-consuming and expensive. In our study the inquiry method was used. With it, all the information necessary for an (indirect) evaluation of the frequency and structure of traffic, deriving from forest management, could be gained.

The data were gathered in 4 forest enterprises, performing the forest management in public forests (with the joint area of 25.800ha) and in another 4 forest enterprises, which take care of the private forests (with the joint area of 59.700ha). With the

inquiry, the following information were gained:

- The number of persons of a forestry enterprise, whose work is connected with going to forests. The staff was classified by the type of forest work and by the way of travelling to forests (the vehicle used).
- In case of private forests, we also were interested in the number of arrivals of private forest owners to forests, the purpose of their arrival (the type of forest work to be done) and the vehicles used. The areas of forest estates (over 3ha) and the socio-economic positions of the owners were taken into account.

With the inquiry, the data about the frequency and structure of traffic, resulting from transport of workers to forests were gathered. The data about the traffic, resulting from removal of timber, were completed with the data about the types and average carrying capacities of trucks, which are most often used in Slovenian forestry.

Due to organizational differences of the forestry service, various ways of arriving to forests and diverse ways of removal of timber, the traffic in public forests and the traffic in private forests are discussed separately.

3 THE TRAFFIC, DERIVING FROM FOREST MANAGEMENT WITH PUBLIC FORESTS

In 1990, 365 187ha of forests were public property in Slovenia - that is 35.3% of the entire forest area. The major part (87.1%) of public forests are productive forests. Until lately, the forest enterprises took care of these forests (an average area of 5.370ha per forest enterprise). These enterprises - together with the enterprises in charge for private forests - were joined in a common forest economy organization. In 1991 a reorganization of forestry service in Slovenia has begun. Due to the anticipated denationalization, the share of public forests will decrease sig nificantly. This will certainly cause changes in the recent organizational form in forestry.

The frequency and structure of traffic could be evaluated most easily, if the entire traffic is classified by the purpose of arrivals of vehicles to the forest. All the vehicles have to be taken into consideration, irrespective of the forestry organization they belong to.

By its purpose, the following classification of traffic was done:
- transport of people for the work in forests
- transport of materials, tools and machinery
- removal of timber from the forest

3.1 Transport of people for the work in forests

For transport of people, who perform either physical work, supervision or planning, to the forests, the vehicles as passenger cars and vans are used. The professionals (forestry engineers) and the major part of technical employees (technologists and workmasters) only use passenger cars, while the forest workers mainly arrive by vans and only rarely by passenger cars. In the beginning of the eighties, some forest enterprises bought small coaches for transport of workers to forests, but these coaches have later been given up gradually.

The average number of arrivals of different types of vehicles to a certain forest area per year, was calculated from the data of the inquiry by the following formula:

$$N = \frac{a.b.k}{s}$$

N - the number of arrivals of a certain type of a vehicle for transport of people, to a certain area (1000ha for example), per year
a - the number of people, working at this area
b - the average number of arrivals of an individual to the forest per year
k - the coefficient of influence of the forest yield (the forest yield is expressed by the net annual cut)
s - the number of personals, arriving by a single vehicle

The number of arrivals of vehicles was evaluated for each type of a vehicle separately: for every individual team of workers, for various types of forest work, for different forestry organizations and for different degrees of forest yield. The results are presented in Table 1.

Table 1: The annual number of arrivals of vehicles for transport of people to a public forest (per 1000 ha of forest).

Forestry organization	Teams of workers	Type of a vehicle	Forest yield		
			2 m^3/ha	4 m^3/ha	6 m^3/ha
forest enterprise	professionals	car	59	66	72
	technical employees	car	159	198	238
	forest workers	car	40	59	79
	forest workers	car	59	89	118
joint forestry organization	professionals	car	6	7	8
	construction workers (builders of forest roads)	car	62	81	99
		van	6	8	10
together		car	326	411	496
		van	65	97	128
together		pasenger vehicles	391	508	624

The results show, that for the execution of all work (with an exception of timber removal) in a forest of a medium yield (an annual cut of 4.0m^3/ha) and an area of 1000ha, 508 arrivals of passenger cars are needed per year. Actually only 81% of this number are the arrivals of passenger cars, while the remnant 19% are the arrivals of vans. The results are only valid as an average; due to the great variety of working conditions, the actual results for individual forest enterprises could deviate significantly from the resultes presented.

3.2 Transport of materials, tools and machinery

For forest work, diverse machines and tools are used, and some types of work also require a supply of material (saplings, fuel...). The majority of tools and a part of material is transported to forest together with the workers, so that there is no need for any extra transport. Yet in some cases extra transports are a necessity - as for example for transportation of explosives, maintenance of machinery (services), transfers of larger devices, sometimes also for the warm food supply... Extra transports are also required for maintenance of the existing roads and other communications (also the spreading of roads in winter) and all the works by building of the new ones.

The number of arrivals to a forest area of 1000ha per year, classified by the types of vehicles and the forest yield, is presented on Figure 1.

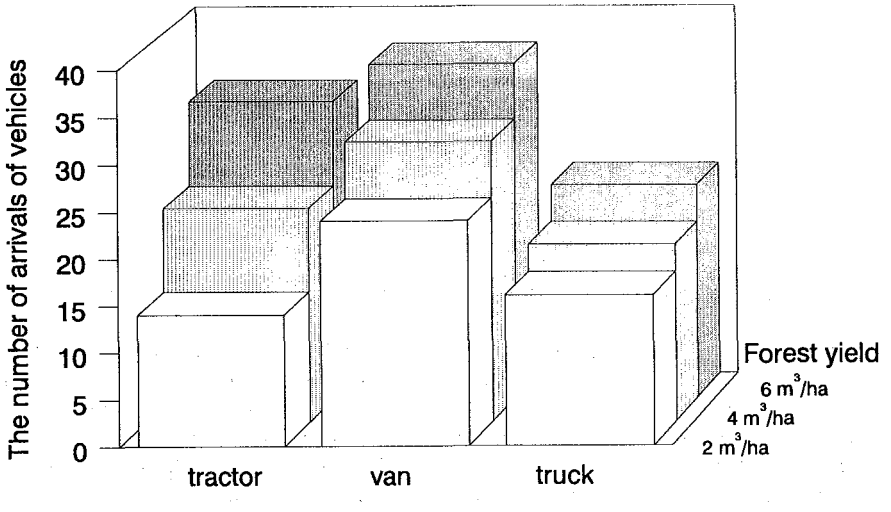

Figure 1: The annual number of arrivals of vehicles for transport of material (per 1000ha of forest)

3.3 Removal of timber

The most accurate result of forest management, which can as well be financially evaluated, is the producted timber, which is later removed from the forest as forest timber assortment. In the past diverse means of transport were used for the removal of timber. Nowadays various trucks are used for transport of great quantities of timber, only for small quantities - usually for home use - also the tractors with trailers are used.

For removal of timber from public forests, only the trucks are used in Slovenia (either solo trucks or trucks with trailers). As it could be observed from the data concerning the forestry mechanization, which are gathered every second year (REMIC, 1971, 1980, KOŠIR and co-workers, 1989), the carrying capacity of trucks for removal of timber increases gradually (the useful carrying capacity). The average carrying capacity and the shares of various types of trucks used in the last 20 years are presented on Figure 2 and Figure 3.

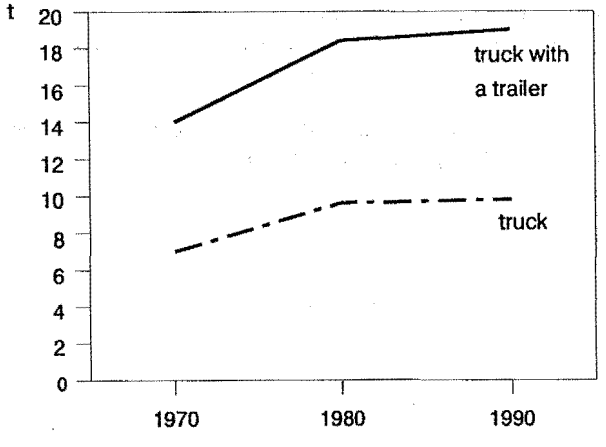

Figure 2: The average carrying capacity of trucks used for removal of timber

If the average carrying capacity of trucks, the relations of different types of vehicles and the forest yield are taken into consideration, the number of arrivals of vehicles for timber removal to a certain forest area per year can be calculated. For the removal of timber from 1000ha of the forest of a yield of 4.0m^3/ha, 136 arrivals of trucks with the carrying capacity of 10t and 139 arrivals of trucks with trailers (the carrying capacity of 19t) - that is together 275 trucks - are necessary. The number of arrivals of trucks changes proportionally with the changed forest yield.

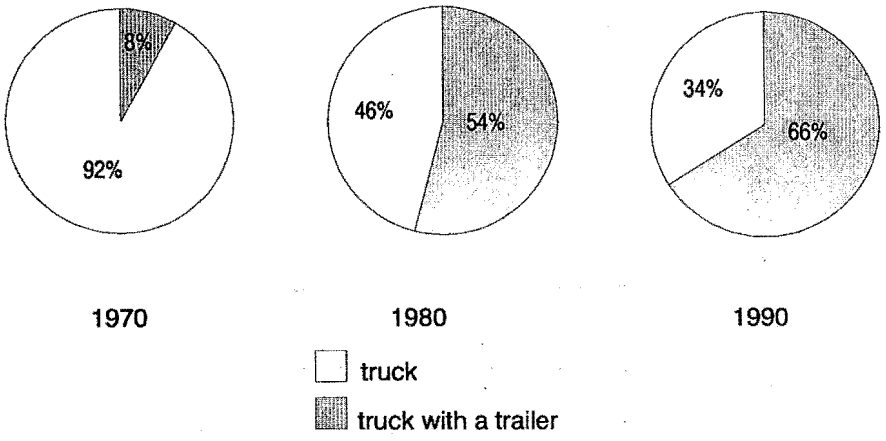

Figure 3: The share of trucks by the removal of timber

3.4 Analyse of traffic by its purpose and its structure

From the existing data about the number of arrivals of vehicles to forests, the arrivals of vehicles can be classified according to their purpose. The situation is showed on Figure 4.

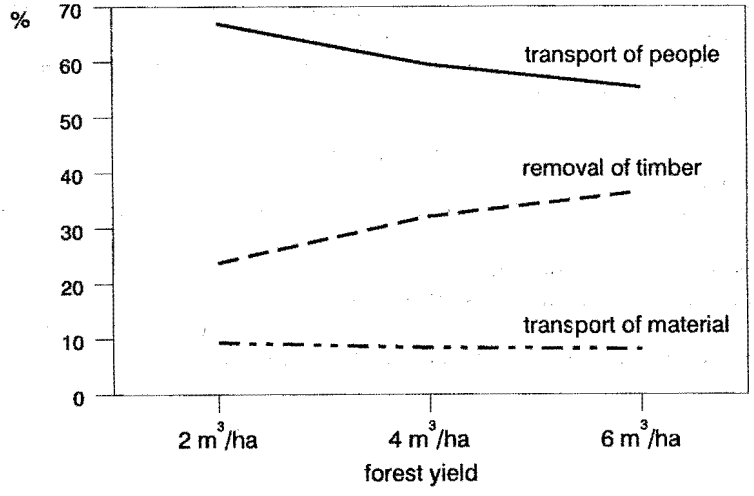

Figure 4: The shares of traffic by its purpose transport of people, transport of material

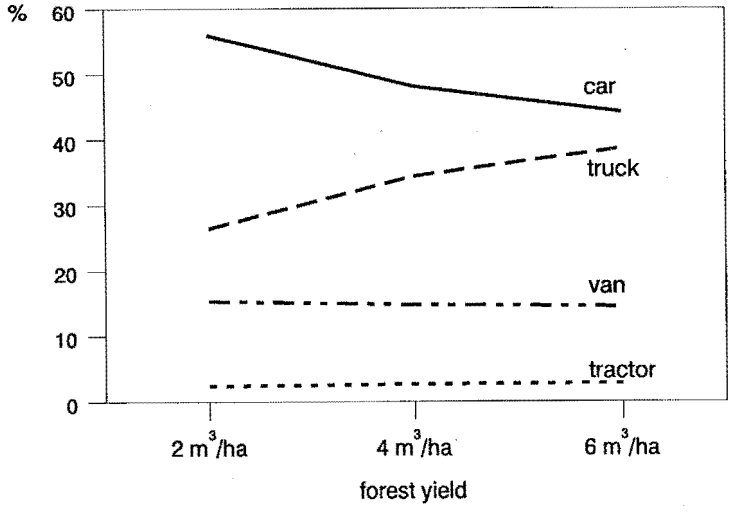

Figure 5: The shares of traffic by its structure

With regard to Figure 4, the following conclusions could be made:

- Within the traffic, deriving from the management with public forests, the greater part (60%) is connected to the transport of people. With the increased forest yield this share decreases, yet anyway the number of arrivals of passenger cars to forest increases.
- The share of traffic, resulting from removal of timber is about 30% and increases with the increased forest yield.
- The traffic, resulting from transport of materials and equipment (machines, tools) is small (about 8%).

On Figure 5 the traffic is classified with regard to the type of vehicles and the forest yield. The conclusions are:

- Cars represent almost 50% of traffic, but this share decreases with the increased forest yield.
- Vans represent 15% of traffic.
- Light vehicles represent almost 2/3 of traffic.
- Heavy vehicles (trucks) represent 1/3 of traffic. The share of trucks within the whole traffic increases with the increased forest yield.

4 THE TRAFFIC DERIVING FROM FOREST MANAGEMENT WITH PRIVATE FORESTS

The major part of forests in Slovenia are private property (64.7%) and with social changes this share will even increase. As the structure of forest estates is rather variegated it is obvious that the traffic, deriving from the management of private forests is very heterogeneous as well. With our evaluations we try to represent the average conditions in traffic frequency and structure. Due to that, obtained results are valid for averaged circumstances, and are not valid for individual cases.

The private forest owners usually come to their forests to perform forest work (from cultivation to timber removal) and to colaborate with the district forester or other technical staff of forest enterprises. The forest enterprises execute all the work connected with planning, building of forest roads (and sometimes of the skidding trails) and the works which are not done by the owner himself (or in his own organization). The share of works, executed by the forest owner himself depends on many factors, among which the socio-economical status of the owner is the most important one. For their arrival to forest, the owners usually use cars or tractors. Selection depends on work that has to be done.

In Table 2 the data about annual frequency of traffic per 1000ha of private forest are presented. The data are classified with regard to the executant of work, the types of work and the cutting yield.

Table 2: The annual number of arrivals of vehicles to a private forest (per 1000 ha of forest)

The executant of work	Type of work	Type of a vehicle	Forest yield		
			2 m^3/ha	4 m^3/ha	6 m^3/ha
	silviculture	car	86	86	86
		tractor	36	36	36
by the	felling and skidding	car	72	144	215
		tractor	107	213	318
forest	removal of timber	tractor with tra.	81	162	243
		truck	23	46	70
owner	other activities	car	3	3	4
		tractor	3	3	4
	silviculture	car	115	157	182
		van	10	10	10
	felling and skidding	car	9	17	26
Forestry		van	13	25	38
		tractor	5	11	16
ogranization	removal of timber	truck	45	90	135
		truck with trail.	46	92	137
	building and	car	62	81	100
	maintenance of	van	6	8	10
	forest roads	van	16	19	23

The following explanation has to be added to Table 2:

- all planning in forests is regarded as one of the silvicultural activities
- the help of forest owner by building of the forest roads is regarded as one of the "other activities"
- in case of removal of timber for home use, the carrying capacity of $9m^3$ of timber was beared in mind for a truck and a carrying capacity of $3.5m^3$ for a tractor with trailer

The classification of traffic with regard to the type of forest work is presented in Figure 6 and Figure 7. On Figure 6 the annual number of arrivals of vehicles, with purpose of executing different works, to an area of 1000ha, with regard to the cutting yields, is presented. The number of arrivals connected to silviculture and to other activities is only slightly dependent on the cutting yield., while the number of arrivals for execution of cutting, skidding and removal of timber increases proportionally to the greater annual cut.

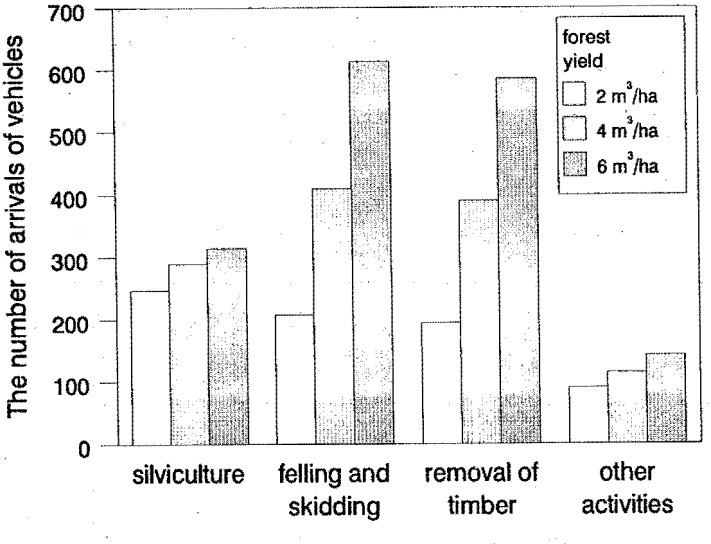

Figure 6: The annual number of arrivals of vehicles with regard to the type of work

The relations among the quantities of traffic, resulting from the different types of forest work, are showed in Figure 7. In a forest with small annual cut, the greatest part of traffic is connected to silvicultural activities (with the planning included). On the forest roads opening private forests with larger annual cut, prevails the traffic connected to cutting, extraction and removal of timber. It is typical for the traffic in private forests, that a great part of it is connected to removal of timber. For timber removal - especially in case of home use - tractors with trailers are also used beside trucks. The share of this kind of traffic would even be greater, if the owners didn't turn the advantage of every arrival to the forest for loading and removal of at least small quantities of small-sized wood.

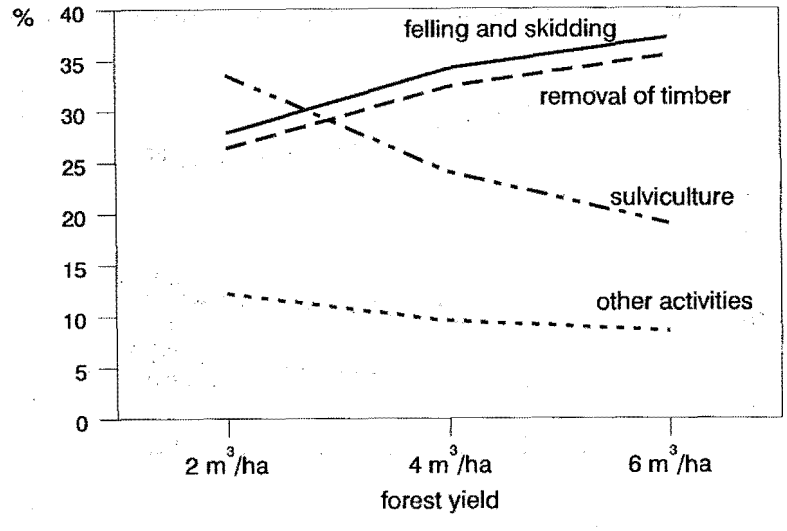

Figure 7: The shares of traffic by the types of work

Similarly as for public forests, the structure of traffic was also analysed for private forests. the situation is showed on Figure 8. Within the traffic, the vehicles for transport of people are prevailing, and among them the cars (40% of the entire traffic). The vans are not used very often. Compared to the situation in public forests, the tractors are much more frequently used in private forests. The tractors are used for arrivals to forest or for removal of timber. The share of trucks within the whole traffic is 20%, and among these about 1/3 are trucks with trailers.

5 THE TRAFFIC LOADING OF FOREST ROADS, RESULTING FROM FOREST MANAGEMENT

5.1 The annual traffic loading

There is not much traffic on the forest roads, especially if compared to the public roads. The traffic loading of forest roads is presented as a number of vehicles per road section per year. If the shape of forest road network and the character of traffic, deriving from forest work are taken into consideration, it could be concluded, that loading of forest roads is twice as high as the number of arrivals of vehicles to forest. The dependence of the number of arrivals of vehicles to forest on the forest yield and the ownership has already been studied as the previous phase of this study. The loading of forest roads can be calculated.

On Figure 9 the loading of a road opening 1000ha of forest with annual cut of

4m³/ha is presented. The situation in private forests and the situation in public forests are presented separately. Beside the loading also the structure of traffic is present.

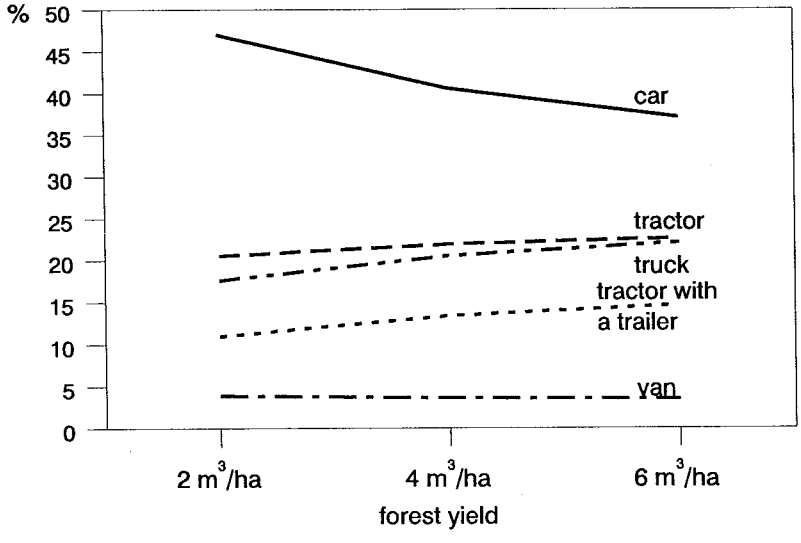

Figure 8: The shares of traffic by the types of vehicles

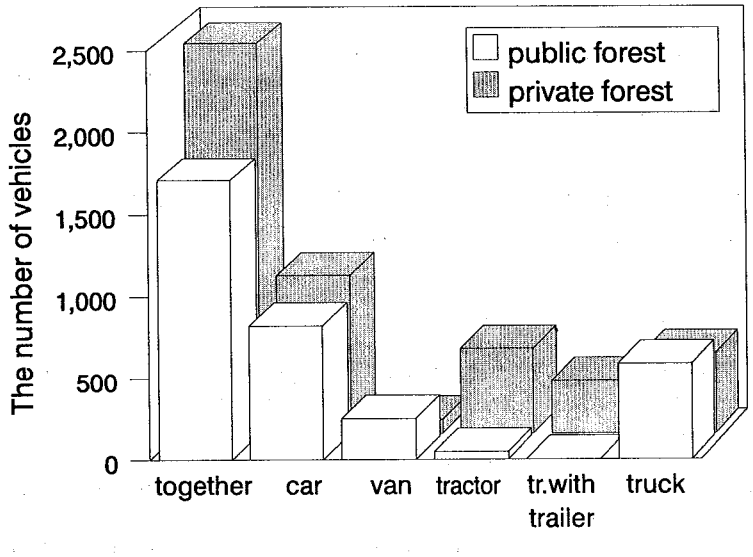

Figure 9: Traffic loading of a road, resulting from forest management (1000ha, annual cut of 4 m³/ha)

From Figure 9, the following conclusions could be derived:

- The total loading of roads is for 40% higher in private forests, than in public forests.
- The structure of traffic in private forests is rather different from the structure of traffic in public forests.
- Cars are the prevailing type of a vehicle in both types of forest.
- The loading of roads by trucks is rather similar in both types of forests.

The situation, showed on Figure 9 is only valid for traffic in forests with an annual cut of $4m^3/ha$. With a change of forest yield the loading of roads, which make the forest accessible is changed as well. A linear dependence exists between forest yield and the forest road loading, which can be expressed with the following equations:

$Y = 272.5\ x + 621$ for public forests
$Y = 457.5\ x + 561$ for private forests

Y - the average annual traffic loading of a road, which results from forest management
x - forest yield (the average net annual cut per 1ha of forest)

5.2 The annual transported quantity

For definition of the necessary road stabilization and for estimation of the costs of maintenance, the knowledge about frequency and structure of traffic is not sufficient; the weight of vehicles and their loads should be taken into consideration as well. In other words - we are interested in the transported quantity. The term "transported quantity" expresses the sum of weights of the vehicles (loaded vehicles), that pass a certain road section due to forest management.

In our calculations, some characteristics of the vehicles, which are most widely used in forestry, were taken into consideration:

- the weight of vehicles
  - car 0.9t
  - van 1.5t
  - truck with equipment 10.1t
  - truck with a semitrailer 12.9t
  - tractor 4.0t
  - tractor with a trailer 4.3t
- some other weights
  - $1m^3$ of timber - an average 1.0t
  - 1 worker 70kg
  - worker's equipment 10kg

By all the calculations it was presupposed, that the vehicles returned by the same road as they had already used for their arrival to forest.

The average quantity transported per year is showed on Figure 10. The presentation is valid for the roads, opening 1ha of forest of the annual cut of 4.0m³/ha.

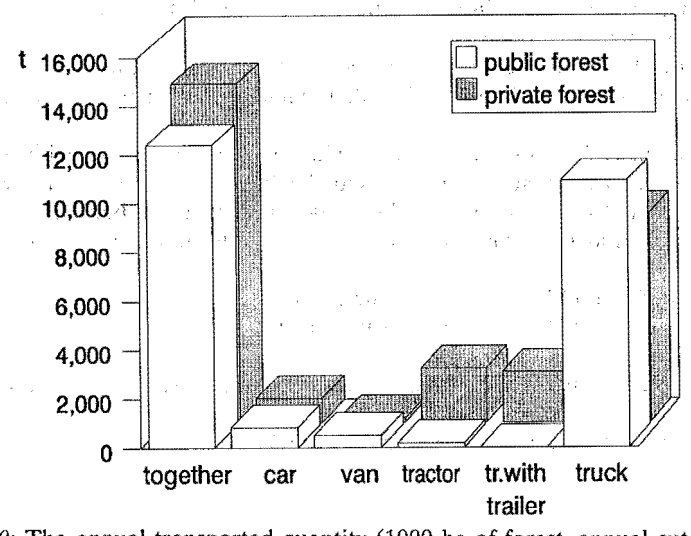

Figure 10: The annual transported quantity (1000 ha of forest, annual cut of 4 m³/ha)

The conclusions are:

- The forest management, performed on 1ha of forest of the annual cut of 4.0m³/ha, results in traffic with an annual transported quantity of 12t - 14t.
- The annual transported quantity for private forests is for 13% higher than for public forests.
- On forest roads, the truck traffic contributes the most to the transported quantity, especially the traffic by removal of timber. Among all the vehicles, the trucks - either loaded or unloaded - are the heaviest ones. A loaded truck with trailer for example, weighs 31t. For vehicles of such a great weight, the roads have to be well stabilized. On the insufficiently stabilized roads or in unsuitable weather conditions, so heavy vehicles cause deteriorations on the road surface.
- The removal of timber from public forests with an annual cut of 4.0m³/ha represents 87% of the annual transported quantity, and the removal of timber from private forests of the same annual cut 76% of the annual transported quantity.

When discussing the road traffic, derived from forest management, the season changes of its frequency also have to be considered. The season dynamics itself shows the difference in traffic between public and private forests. In public forests the work is done rather evenly through the whole year, the activity is only decreased in winter. In private forests, the season changes are quite evident. Two maximums exist - the first one in spring, from March till the end of May, and the second one in

autumn, from September till the end of November. From the view of preservation of forest roads, the spring traffic maximum is disadvantageous, because the roads - especially those, which are not very well stabilized - are soaked and thus their bearing strenght is lower. The danger of damages to roads is very high.

6 THE DIAGRAM OF TRAFFIC LOADING OF FOREST ROADS

On the basis of the data about the frequency and structure of traffic, derived from forest management, a diagram of traffic loading could be made for a single road or the entire forest road network.

On Figure 11 an example of such a diagram is showed for a road through a forest, with a side road. In the coordinate system of diagram the ground plan length of the road is presented on the abscissa and the area of forest, which is made accessible by the road from its end to the point, where traffic loading is studied (the point A on figure 11), is showed on the ordinate. When for a certain point of the network the cumulative area of forest is known, the traffic loading for this point can be defined, if the frequency of traffic, resulting from forest management with 1ha of forest of a known annual cut and ownership is known as well. The traffic loading of a road increases gradually from its end to its exit from forest (point D), but the increasement jumps up with every joined side road (point C). Of course the diagram of traffic loading only shows the average values for a longer time period, which could deviate significantly from the real loading of road sections in a shorter time period.

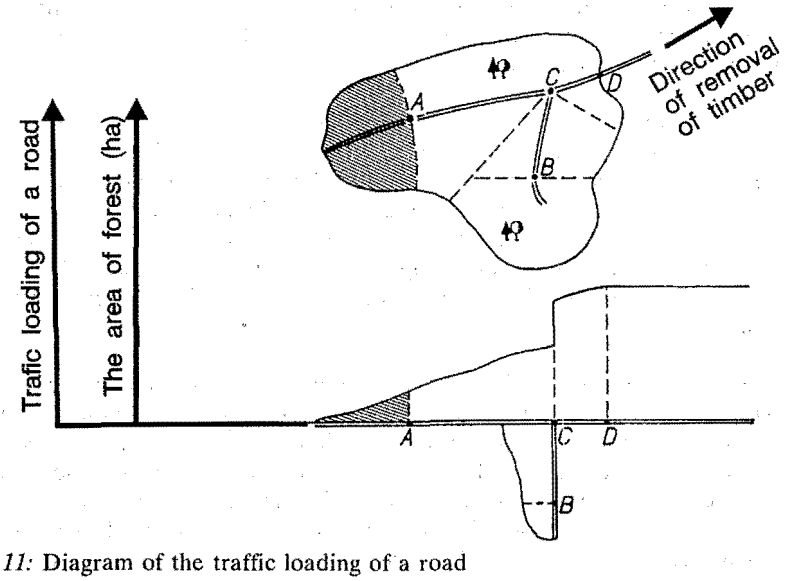

Figure 11: Diagram of the traffic loading of a road

In general it could be said, that the traffic loading of forest roads, resulting from forest management is relativelly small. Forest road network in a mountain region was studied thoroughly, so that a comparison with the traffic loading of public roads could have been done. For the studied forest road network in a mountain region, the following data were gathered:

• the area of forest	1.658ha
• the length of forest road network	32.5km
• the road density	19.6m/ha
• the number of road sections	23
• an average length of a road section	1413m
• an average area of forest, opened by a single road section	72.1ha
• the cumulative area of forest, opened by a single road section	311.4ha

In the studied area we presuposed that 35% of forests were public and 65% of forests were private property, with annual cuts of $4.5m^3$/ha and $3.3m^3$/ha respectively (as was the average for Slovenia in 1990). On the basis of the previously gathered data, an average traffic loading of roads was calculated - the loading was 621 vehicles.

From the review of the Republic Direction for Roads (Promet 90) it could be seen, that the average loading of regional roads in Slovenia for 1990 was 1481 vehicles. The traffic loading is presented as an average value of daily traffic (in a year), expressed by the number of vehicles. Unfortunately, the traffic loading of local roads is not studied on a republic level.

The comparison of traffic on regional and on forest roads shows, that the average annual loading of a forest road is 870 x smaller, if only the traffic, resulting from forest management is taken into account.

The traffic, deriving from forest management, changes through a longer period of time - by its frequency, its structure and the weight of vehicles. In past, the personal trafic (personal cars, vans) increased quickly., till it reached a certain level, above which it will only rise slowly in the future. Such a development only occurs in case of traffic, resulting from forest work, and not for any other traffic on forest roads. The excursion traffic on forest roads for example, will certainly keep rising in future - due to the rise of standard of living, the more free time and the greater need for recreation.

The situation in truck traffic is entirely different from the situation in personal traffic. Due to the greater carrying capacity of trucks, the truck traffic has already been decreasing for a longer period of time (while the transported quantity of timber remains more or less the same). The annual traffic loading of roads also decreases gradually, because the same quantity of timber is removed by a smaller number of trucks with greater carrying capacity. Yet, of course, the road loading by a single drive increases significantly, due to the increased weight of the fully loaded trucks.

The following data represent the situation by removal of timber from public forests in Slovenia in the last 20 years:

	Situation 1970	1990
- The carrying capacity of an average truck, used for removal of timber	7.1t	15.5t
- The transported quantity by one no-load and one full-load drive of an average truck	27.1t	39.9t
- The number of vehicles needed for timber removal from 1000ha of forest with an annual cut of $3m^3$/ha in one year	423	194
- Decreasment of the traffic, resulting from timber removal		54%
- Decreasment of the annual transported quantity		32%
- Increasment of the transported quantity by one no-load and one full-load drive of an average truck		47%
- Increasment of weight loading of a road by a single full-load drive of an average truck		62%

From these data it is evident, that the frequency of truck traffic (number of vehicles), resulting from removal of timber from public forests in Slovenia, decreased for a good half in the last 20 years and the annual transported quantity for almost one third of the value in 1970.

In the next 10 years, any significant changes of traffic loading of the roads, resulting from truck traffic by timber removal, are not to be expected. Greater differences are expected for certain local forest road networks, because of the changed proprietorship and different market mechanisms.

7 SUMMARY

For the correct planning of a road and the choice of adequate technical parameters for it, the expected freqency, structure and seasonal dynamics of traffic for this road should be known. This knowledge also makes the evaluation of impacts of traffic upon the environment of the road possible. In the article, only the traffic, resulting from forest management is discussed.

The data concerning the traffic on public roads are, gathered by traffic census. In our study, the data were gathered by inquiry, carried out in 8 forestry enterprises. Bacause of different ways of arriving to forests and different ways of timber removal, the traffic in public forests and the traffic in private forests were studied separately.

In public forests we distinguished three types of traffic by its purpose: transport of people (60% of the traffic), transport of materials and equipment (10%) and removal of timber (30%). In case of transport of people, cars are prevailing with 80%, while the vans are only used in 20%. 66% of timber is removed from the forest by trucks with trailers and 34% by trucks alone. Due to the forest management, 865 vehicles

arrive yearly to a public forest of the area of 1000ha and annual cut of 4.0m^3/ha; among these vehicles, 48% are cars, 34% are trucks and 15% are vans.

In private forests the traffic differs significantly from the traffic in public forests - by the frequency and structure as well as by the season dynamics. The forest owners contribute 58% to the whole traffic and the forestry enterprises 42%. The prevailing vehicle is a car (41%), the vans are rare (4%), but there are rather a lot of tractors (35%). The tractors are used either for mere arrivals to forest or for removal of timber - for home use mainly. The trucks contribute 20% to the traffic in private forests. For forest management in a private forest of an area of 1000ha and an annual cut of 4.0m^3/ha, approx. 1200 arrivals of vehicles per year were noted.

The traffic loading of roads is expressed with the average number of vehicles, passing a certain road section in one year. The results show, that the loading of roads in private forests is for 40% greater than the loading of roads in public forests. Yet in general, the forest roads are not heavily loaded by traffic. A detailed study of a forest road network in mountain region with an area of 1658ha and road density of 19.6m/ha showed, that the loading of a forest road (with traffic resulting from forest management) is in average 870 x smaller than traf fic loading of an average regional road in Slovenia.

For determination of the necessary stabilization of a road, the transported quantity, derived from the number of vehicles and their weight, should also be known. From forest management with every ha of forest of an annual cut of 4.0m^3/ha, a yearly traffic of 12 - 14t results - in public forests 87% of the traffic and in private forests 76% of the traffic is connected to the removal of timber.

The traffic changes through a longer period of time - by its frequency, its structure and the weight of vehicles. The passenger traffic increased quickly in the past, reached a certain level and will not rise significantly any more in the future. The truck traffic decreases due to the greater carrying capacity of the trucks, but the weight loading of roads by a single full-load drive of a truck increases (for the same reason).

8 LITERATURE

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