Maintenance of forest road network by natural forest management in Tokyo University Forest in Hokkaido

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Abstract – Nacrtak

Forest road network in the Tokyo University Forest in Hokkaido plays an important role in selling low price trees, and has a key role in intensive forest management. Forest road network also contributes to water conservation and biodiversity. Experience shows that when a road is constructed along the contour line, the road surface of filled bank becomes lower than the original level regardless of the road standard. This happens because the filled bank is soft so that shrinkage occurs caused by repeated log transportation and by rainwater erosion affecting lower surfaces. Periodical maintenance is important. On the other hand, the maintenance of all-season forest roads for heavy truck transport is expensive as can be seen in Slovenia. In conditions of public free and unlimited access to forests, the standard of forest road maintenance is higher. If we consider that unlimited access to forests means higher personal standard and higher quality of modern life, then the higher cost of wood extraction is not the most important condition of multi-purpose and natural forest management.

Keywords: *forest road standard, maintenance, natural forest management, selection cutting, truck transport*

1. Introduction – *Uvod*

If only high price trees are harvested, forest productivity, health and diversity will decrease in natural forest management. A selection cutting system in a natural forest will not be successful without forest road network. The management and operations of felling, planting, and tending should be carried out for the improvement of forests, and in other words, quality, health and productivity of the remaining stands should be better than before the repeated harvesting. This paper shows a successful example of maintenance of forest road network in the natural forest management of the Tokyo University Forest in Hokkaido. Description is also given of a specific categorization of forest roads in Slovenia based on multiple use of forest roads.

2. Site – *Područje istraživanja*

The Tokyo University Forest in Hokkaido is situated in the central part of Hokkaido, 43 °N, 142 °E. The area covers 22,800 ha; at an altitude ranging between 200 m and 1,460 m, and the management area is 19,800 ha. The main scope of research of the University Forest management is how to achieve sustainable harvesting and at the same time provide environmental protection, preserve natural diversity and ecosystem.

The forest is located in the mixed forest zone between the cool-temperate and sub-boreal zone with coniferous and broad-leaved species. The annual precipitation is 1,230 mm, and the average depth of snow from November to April is about 1 m. The base rock is mainly welded tuff, and hornfels from shale stone, metamorphic rock from green rock, and lime stones can also be seen. About 40 species are treated as valuable forest management trees. For the last 100 years, the forest has gradually been improved to a high productive multi-layered forest, in which the original natural diversity and high stock volume have been preserved. Now an average stand of 250 cubic meters for selection cutting system has 800 trees consisting of 20 species (DBH > 5 cm). The percentage of conifer is about 55 % in volume (Miyamoto and Igarashi, 2004).

The Tokyo University Forest in Hokkaido is divided into two working sections. The 1st working

section (10,700 ha) is located at the lower elevation area and the average annual increase in stand volume is 2 %. The 2nd working section is located at the higher elevation and the annual growth rate is 1 %. Both in the 1st and 2nd working section, the cutting volume is restricted within the growth increment during 10 and 20-year rotation, respectively. The forest is classified into three types of stand, »selection cutting stand«, »clear cutting stand« and »supplemental planting stand«. The classification depends on whether natural regeneration is possible or not, and whether the quality of the existing trees is high or not. In the selection cutting stand, the 1st section, the cutting intensity is 16 % in volume every 10 years, and in the selection cutting stand, the 2nd section, it is 17 % every 20 years. In the clear cutting stand natural regeneration is almost impossible, and most of the trees are bad in quality; therefore clear cutting is required before plantation. Planting species are almost exclusively made of conifers grown in the University Forest nursery, whose parents come from the University Forest. In the supplemental planting stand, it is difficult to achieve natural regeneration, but the remaining trees are in good condition, and therefore group selection cutting and planting are practiced.

In 1950, felling and bucking were carried out by hand saws, pre-hauling by man and horse especially in winter, stacking by men, and transportation by forest railways of a total length of 80 km. Now in 2005, felling is carried out by chainsaws, pre-hauling by small tractors and transportation by trucks. A grapple skidder is also used for pre-hauling and a grapple-saw for bucking. In 1955 forest railways started being converted into forest roads, and they reached a total of 930 km in 2004. Nowadays, the density is 41 m/ha. The existence of a forest road network in a high density natural forest management provides the possibility of selling even standing trees at a low price.

All forest roads in the University Forest in Hokkaido have a transportation capacity of 11-ton trucks. The road width is 4–5 m. The forest roads are classified into three classes by frequency of use and importance, and namely the »main road«, »management road« and »operation road«. The standards of these three roads are almost the same, but their function and maintenance requirements are different.

The main roads are constructed along main rivers or calm ridges and they are connected to public roads (Miyamoto and Igarashi, 2004). The University Forest is divided into 105 compartments, and each compartment consists of several sub-compartments according to natural topographic conditions. They have 11 main road routes of 114 km passing through 7–12 compartment boundaries. In non-snow seasons, 11-ton hauling trucks are always able to pass through. Weeds along roadside are cleared every year. The management roads are constructed through 5–6 compartments or their boundaries, and they are also connected to main roads or public roads. Their total length is 370 km. According to the forest management plan, about 70-80 % of them are regularly used and weeds are cleared. The operation roads are constructed in the blank space of roads and pass through 1–4 compartments. Their total length is 440 km. In the 1st section (low elevation), operation roads are maintained every ten years, i.e. two years before selection cutting for enabling the survey of forest resources. In the 2nd section, the interval is 20 years. These roads are usually covered with tall weeds and bush. They are sometimes damaged by rain.

From 1995 to 2004 the average gravels supplied for the maintenance of the pavement surface was 0.485 m^3/m per year for the section of 11,474 m/year. The annual cut was about 39,000 m^3.

3. Results and discussion – *Rezultati i rasprava*

3.1. Forest roads in Tokyo University Forest in Hokkaido – *Šumske ceste u šumama Tokijskoga sveučilišta na Hokaidu*

The main roads are maintained every year. The surface is in good condition (Figure 1). The management roads are maintained every 10 years, this being the rotation year of selection cutting (Figure 2). Figure 3 shows the maintenance of road surface. After repeated log transportation and due to rainfall, road surface of filled bank has become lower than the original level especially when the road is located along the contour line (Figures 4 and 5).

Figure 1 Well maintained main forest road (Maeyama, constructed in 1968. Base rock is welded tuff.)

Slika 1. *Dobro održavana glavna šumska cesta (Maeyama, sagrađena 1968. Geološka je podloga izgrađena od ignidrita.)*

Figure 2 Well maintained main forest road (Higashiyama-honryu, constructed in 1967. Base rock is welded tuff, metamorphic green rock andecite. Pavement is shale stone.)

Slika 2. *Dobro održavana glavna šumska cesta (Higashiyama-honryu, sagrađena 1967. Osnova su geološke podloge ignidrit i metamorfni zeleni kamen andezit. Gornji je stroj izveden od školjkastoga vapnenca.)*

Figure 3 Maintenance (Gravels are supplied for the surface of pavement. The average volume of gravels is about 0.49 m^3/m.)

Slika 3. *Održavanje (Gornji je stroj nasipan tucanikom u količini od oko 0,49 m^3/m šumske ceste.)*

The operation road is usually constructed along the contour line, and the road surface of filled bank has also become lower than the original level within 4 years after log transportation (Figures 6 and 7).

When the road is constructed along the contour line, the road surface of filled bank becomes lower than the original level regardless of the road standard. This is because the filled bank is soft so that shrinkage occurs caused by repeated log transportation and by rainwater erosion affecting lower surfaces both in the management and operation roads. Lowered shoulder is not only dangerous but also decreases the speed of trucks.

From the forest management point-of-view, the advantages of high density forest roads and appropriate maintenance in the natural forest management are as follows: easy way to choose trees to be cut, possibility of harvesting, planting and thinning

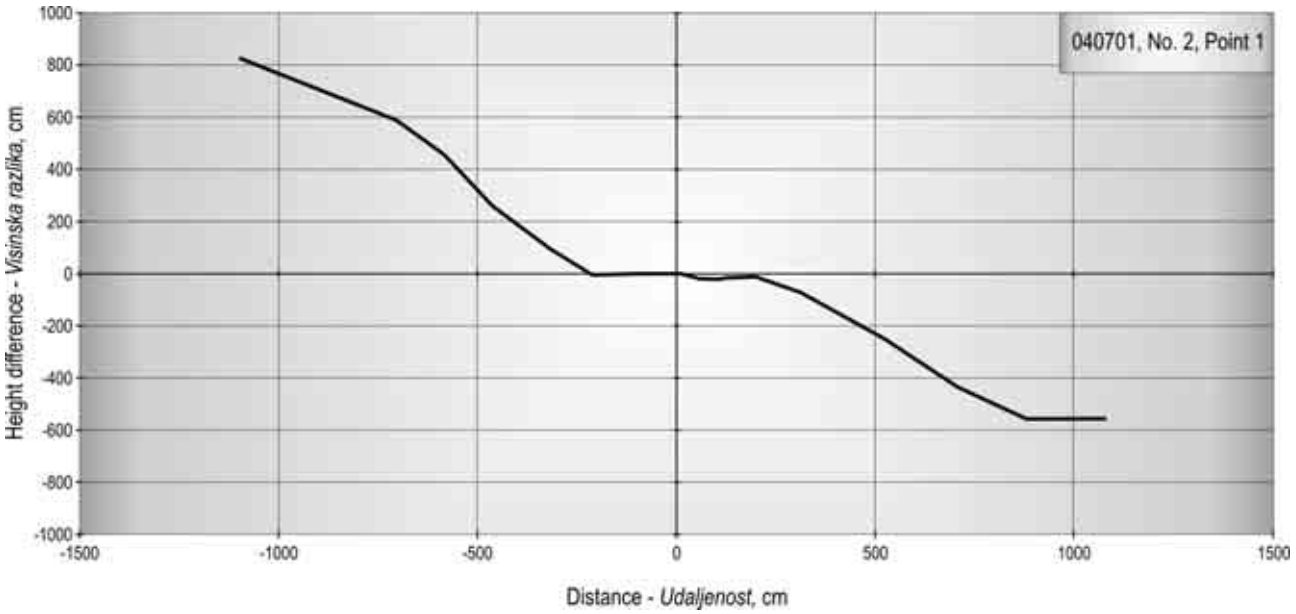

Figure 4 Management road (Maeyama, constructed in 1968. In the course of maintenance it was renewed in 1990, and used for log transportation in 1992. The 2nd working section. Base rock is welded tuff.)

Slika 4. *Sporedna šumska cesta (Maeyama, sagrađena 1968. Održavana je 1990, a 1992. se koristila za prijevoz izrađenih trupaca. Druga radna sekcija. Geološka je podloga izgrađena od ignidrita.)*

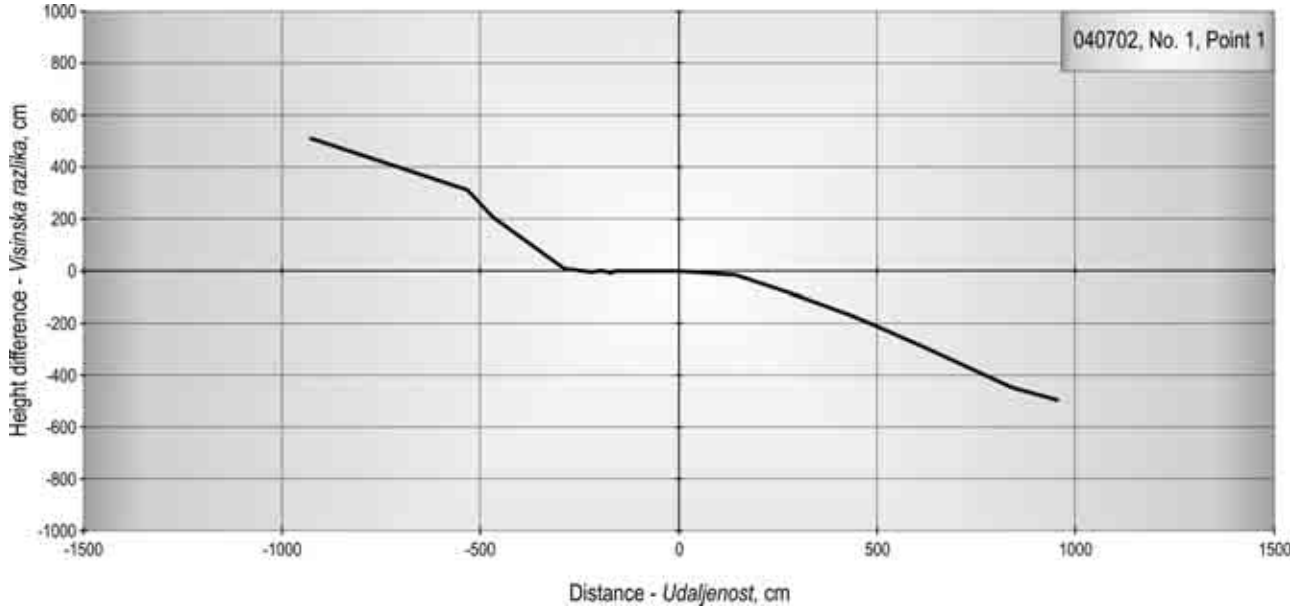

Figure 5 Management road (Okunosawa, constructed in 1970. In the course of maintenance it was renewed in 1993, and used for log transportation in 1995. The 2nd working section. Basic rock is welded tuff, and surface rock is phyroclastic flow – volcanic ash and pumice, and pavement is shale stone.)

Slika 5. *Sporedna šumska cesta (Okunosawa, sagrađena 1970. Održavana je 1993, a 1995. se koristila za prijevoz izrađenih trupaca. Druga radna sekcija. Temelj je geološke podloge ignidrit, površinski se javlja piroklastični tok – vulkanski pepeo i plovučac, a gornji je stroj izveden od školjkastoga vapnenca.)*

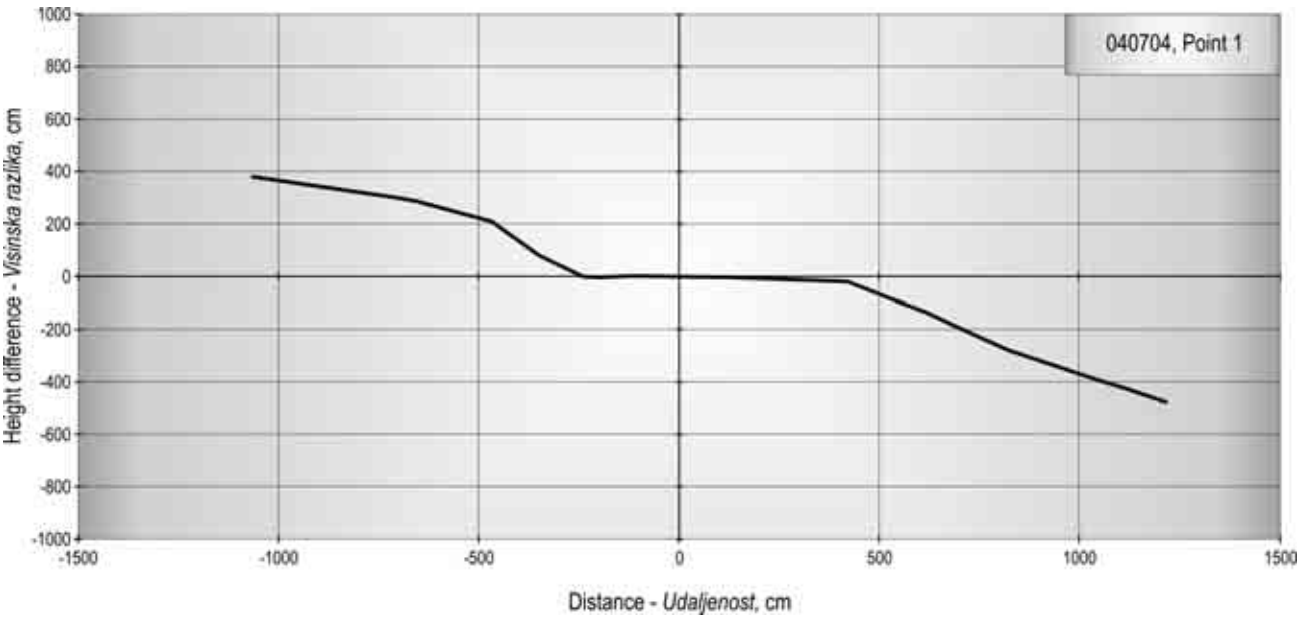

Figure 6 Operation forest road (San-no-yama, constructed in 1968. In the course of maintenance it was renewed in 1998, and used for log transportation in 2000. The 1st working section. Base rock is hornfels from shale stone.)

Slika 6. *Prilazna šumska cesta (San-no-yama, sagrađena 1968. Održavana je 1998, a 2000. se koristila za prijevoz trupaca. Prva radna sekcija. U geološkoj je podlozi hornfeld od školjkastoga vapnenca.)*

at a low cost, as well as the possibility to sell standing trees at a low price because of low harvesting costs. The forest road network in the Tokyo University Forest in Hokkaido plays an important role in selling low price trees, and hence these forest roads are indispensable for an intensive forest management. Periodical maintenance is crucial.

Forest roads are also a significant contribute to water conservation and biodiversity. For example, the side ditches and drainage wells may catch the soil

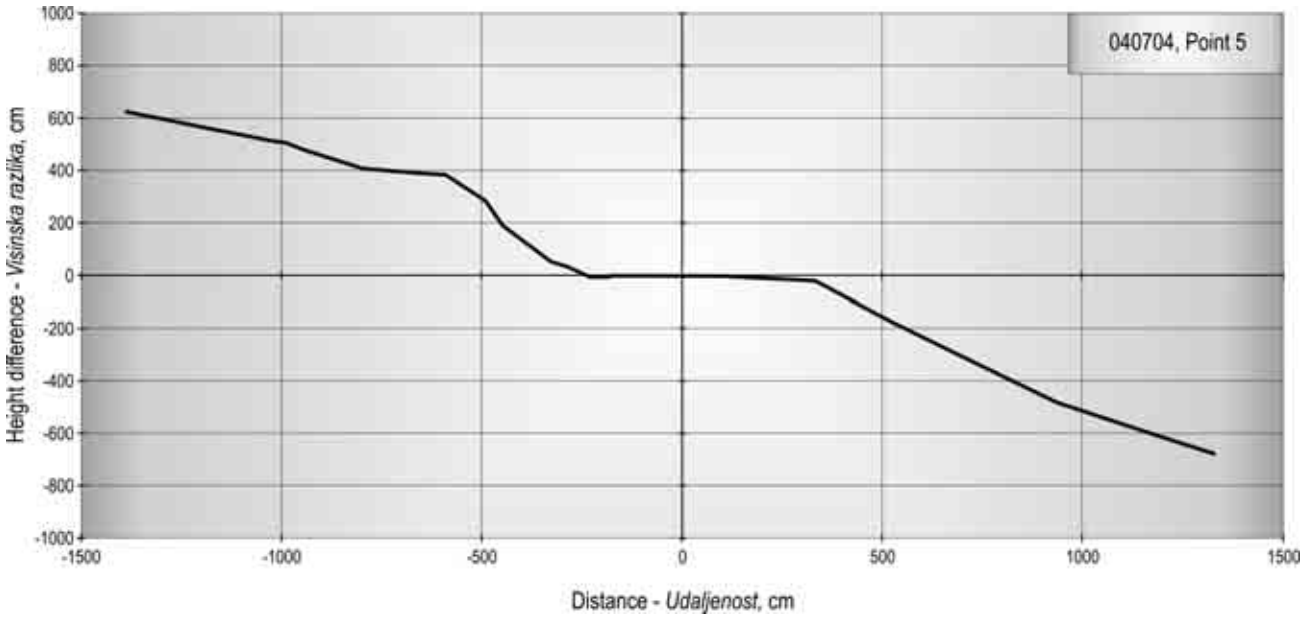

Figure 7 Management road (San-no-yama, constructed in 1968. In the course of maintenance it was renewed in 1998, and used for log transportation in 2000. The 1st working section. Base rock is Metamorphic rock from green rock.)

Slika 7. *Sporedna šumska cesta (San-no-yama, sagrađena 1968. Održavana je 1998, a 2000. se koristila za prijevoz trupaca. U geološkoj je podlozi metamorfni zeleni kamen.)*

from upper slopes and prevent it from flowing out of the forest (Aruga et al., 2001). If a road has high ability of drainage, it will have enough function of dispersal drainage. Opening up by road construction can be regarded as the formation of continuous canopy gap, and forest roads can behave similarly to row or line thinning (Sakai et al., 2003). The gap accelerates the increase of stock volume in front of the road. The increased photosynthesis in front of the road increases the amount of leaves, and this also results in the growth of roots. Increased roots will make porous soil and hold soil and rocks. Porous soil and increased litter retain more water. This is shortly the environmental conservation effect of forest roads. It is feasible to invest more aggressively in road construction when the forest has high land productivity and if the road cost can be kept low (Sakai et al., 2003).

3.2. Forest roads in Slovenia – *Šumske ceste u Sloveniji*

3.2.1. Categorization of forest roads on the basis of their multiple use – *Kategorizacija šumskih cesta temeljem njihove višestruke uporabe*

Forest road management and maintenance of forest roads is specific regarding the public importance of forest roads as e.g. in Slovenia (Potočnik, 1998). All forest roads in Slovenia are free to use not only for forestry purposes but also for non-forestry purposes - i. e. opening up of farms, tourism, recreation etc. – which means higher cost of their regular maintenance (Potočnik, 2002a). Therefore specific and unique categorization of forest roads on the basis of their multiple use was implemented as well as the system of their maintenance (Potočnik, 2002b). Hence, the basic idea of multipurpose management of natural forests was extended to forest roads. The categories of forest roads are as follows:

Category 1: Mark GI/1. Public use of forest roads is stressed and predominating. Public traffic is present daily and it is important for the life of people. Uses like opening up of farms, villages, mountain cottages and other tourist objects and transit use of forest roads are also covered by group GI/1. High level of exploited transportability is significant. The group represents 14.6 % of the entire length of the analyzed forestry roads. The group GI/1 would account for 1,850 km of all forest roads in Slovenia.

Category 2: Mark GI/2. Public use of forest roads is important, but not as much as to make local communities take over their maintenance. This group covers the uses for the purpose of tourism, sport, recreation, police, army, agriculture, gathering, opening up of hunting cottages and others. The group GI/2 represents 16.2 % of the entire length of the analyzed forest roads. The level of exploited transportability of forest roads is variable and has a local character. The group GI/2 would account for 2,050 km of all forest roads in Slovenia.

Category 3: Mark GII. This group is the most extensive and represents 69.2 % of the entire length of the analyzed forest roads (8,750 km in Slovenia). The use is increasingly rising due to the management of forest's ecosystem (not only forest management but wildlife management as well). The combination of uses is professionally correct. According to the extension of the group it is reasonable to divide it into 2 subgroups: the main forest roads (GII) and the side forest roads (GIII). The average traffic load of 12 vehicles per forestry exploited day is proposed as the limit value between the main and side forest roads (up to the junction of a forest road to a public road).

3.2.2. Standards of maintenance, road equipment and way of use of forest roads – *Standard održavanja, cestovna oprema i uporaba šumskih cesta*

The group of forest roads with different traffic load has to comply with specific requirements (technical elements, standards of maintenance and road equipment). Forest roads with marked public traffic have to comply with different standards prescribed for such forest roads. Therefore, wider frames of standards of maintenance, road equipment and way of use are defined as follows:

a. Category GI/1

Public traffic is predominating. Due to the nature of traffic, local communities take over their management. Regular maintenance and whole-year-lasting transportability should be ensured. In case local communities are not in a position to take over their management, roads are classified as category GI/2.

b. Category GI/2

Maintenance: transportability of roads should be ensured the whole year. Regular maintenance of carriage-way, culverts, ditches, etc. and winter maintenance (plowing, sanding) should be ensured.

Road equipment: at the beginning of the forest road marks should be placed showing that the road is a forest road, with necessary sign-posts and other warnings (speed limit, general warnings, allowed axle pressure, etc.). In front of dangerous sites, signs of warnings and metal parapets should be placed.

Way of use: no limits for personal traffic, possibility of truck traffic limits regarding temporary restriction of axle pressure (after long-lasting rains and during the period of thawing).

c. Category GII

Maintenance: transportability of roads should be ensured the whole year. Regular maintenance of carriage-way, culverts, ditches, etc. and winter maintenance (plowing, sanding) should be ensured.

Road equipment: at the beginning of the forest road marks should be placed showing that the road is a forest road, the category of the forest road, necessary sign-posts and other warnings (speed limit, general warnings, allowed axle pressure, etc.). In front of dangerous sites, signs of warnings and metal parapets should be placed.

Way of use: no limits for personal traffic, possibility of truck traffic limits regarding temporary restriction of axle pressure (after strong rains and during the period of thawing).

d. Category GIII

Maintenance: only regular maintenance of culverts, ditches, etc. should be ensured. Maintenance of carriage-way and winter maintenance are irregular – according to needs of the forest management. Transportability of roads should not be necessarily ensured the whole year.

Road equipment: roads have no signs and road furniture.

Way of use: roads can be closed for public traffic. Roads could be closed for truck traffic after strong rains and during the period of thawing.

Such approach means higher costs of forest road maintenance especially if it is taken into consideration that all roads are gravel surfaced all-season roads. Generally all roads are designed to ensure 40-ton truck transport with semitrailors with standard carriageway width of 3.0 – 3.5 m. From a strictly economic point of view such solution seems to be not the most rational. But on the other hand the Slovenian foresters have to take care about 1.1 million ha of forests out of 2.0 million ha of the total country area and some 12.000 km of gravel surfaced forest roads. In such small-scale country managing forests only for wood production with no regards for other users of forest benefits is simply not an option - even though it implies a higher cost of wood production.

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Sažetak

Održavanje mreže šumskih cesta u šumama Tokijskoga sveučilišta na otoku Hokaidu

Jedan je od preduvjeta pravilnoga i kvalitetnoga gospodarenja šumama svakako i dobro planirana, projektirana, izgrađena i održavana mreža šumskih cesta. U ovom je radu, uz razredbu šumskih cesta u Japanu, a s posebnim osvrtom na istraživano područje, prikazan model uspješnoga održavanja mreže šumskih cesta u prirodnim šumama Tokijskoga sveučilišta na otoku Hokaidu. Novim je pristupom izrađena raščlamba šumskih cesta u Sloveniji temeljem njihove višestruke uporabe i u šumarstvu i izvan šumarstva.

Sve su šumske ceste u sveučilišnim šumama otoka Hokaida dimenzionirane za opterećenje kamiona nosivosti 11 t. Širine su planuma od 4 do 5 m. Prema kriterijima učestalosti uporabe (frekvencije prometa) i važnosti šumske se ceste razvrstavaju u tri glavna razreda: glavne šumske ceste, sporedne šumske ceste i prilazne šumske ceste. Propisane tehničke značajke i standard gradnje za sve tri su kategorije šumskih cesta gotovo jednaki; razlika se očituje u njihovoj osnovnoj zadaći, frekvenciji i intenzitetu prometa te u konačnici u troškovima radova održavanja u razdoblju amortizacije šumskih cesta.

Trase glavnih šumskih cesta prate ili glavne vodotokove ili izražene grebene i uvijek se odvajaju od javnih cesta. Otvaraju većinom 7–12 odjela. U sveučilišnoj je šumi 11 trasa glavnih šumskih cesta ukupne duljine 114 km. Za kamione su nosivosti 11 t prohodne čitave godine osim u vrijeme visokoga snijega. Pojas se uz šumsku cestu čisti svake godine.

Sporedne šumske ceste odvajaju se ili od javnih ili od glavnih šumskih cesta i otvaraju 5 – 6 odjela. Ukupna im je duljina na istraživanom području 370 km. Oko 70–80 % sporednih šumskih cesta je, prema Programu gospodarenja, u stalnoj uporabi te se sukladno tomu i redovito čiste od pomlatka i korova.

Prilazne šumske ceste otvaraju 1–4 odjela. Ukupna im je duljina u sveučilišnim šumama 440 km. Održavaju se svakih deset u prvoj gospodarskoj jedinici (održavanje se u načelu obavlja dvije godine prije provođenja sječe) odnosno svakih dvadeset godina u drugoj gospodarskoj jedinici. Prilazne su šumske ceste obično zarasle u grmlje i korov, a često su oštećene od oborinskih voda.

Jednom postignuta optimalna gustoća šumskih cesta, koje su zbog redovitoga i kvalitetnoga održavanja u dobrom stanju, rezultira nižim troškovima svekolikih šumskih radova uz mogućnost snižavanja prodajne cijene proizvedenih drvnih sortimenata te na taj način povećanja konkuretnosti na tržištu drva. Investiranje je u otvaranje šuma šumskim cestama, posebno na neotvorenim područjima, moguće provesti u kratkom razdoblju kada su troškovi izgradnje šumskih cesta niski, a vrijednost etata (njegova kakvoća) visoka.

U obzir pri raspodjeli kako troškova izgradnje tako i troškova održavanja šumskih cesta treba svakako uzeti i njihovu višestruku uporabu. Drugim riječima, potrebno je obaviti raščlambu šumskih cesta prema njihovoj uporabi s obzirom na različite (javne) korisnike izvan šumarstva i te rezultate iskoristiti pri raspodjeli troškova izgradnje i održavanja (koji javnom uporabom šumskih cesta rastu), ali i pri definiranju standarda pojedine kategorije šumskih cesta. To je posebno značajno za šumske ceste s izraženim općekorisnim funkcijama, najčešće smještene blizu većih gradova. Takav je pristup, primjenjiv u Japanu, proveden u Sloveniji.

U Sloveniji su, prema navedenom kriteriju, izdvojeni ovi glavni razredi šumskih cesta:

GI/1. Kod ovoga razreda šumskih cesta prevladava njihova javna uporaba i nešumski promet. Javni je promet svakodnevan, a razred je šumskih cesta GI/1 vrlo bitan za život ljudi u području koje otvara. Osnovne su funkcije ovoga razreda šumskih cesta: pristup farmama, planinskim kućama, turističkim objektima, selima te tranzitni promet.

GI/2. Javna je uporaba i udio nešumskoga prometa na šumskim cestama ovoga razreda značajna, ali ta uporaba nije toliko naglašena kao kod razreda GI/1, odnosno lokalna uprava nije zainteresirana za sudjelovanje u pokrivanju troškova održavanja. Koriste ih športaši, rekreativci, vojska, policija, poljoprivrednici, skupljači šumskih plodova, planinari i vikend-turisti. Razina je nešumskoga prometa promjenjiva, lokalnoga i sezonskoga karaktera.

U treći se razred ubrajaju šumske ceste kod kojih značajno prevladava uporaba pri gospodarenju šumskim ekosustavom. Taj je razred, poradi svoje veličine i uočenih različitosti, razdijeljen u dvije podskupine: glavne šumske ceste GII i sporedne šumske ceste GIII. Za razgraničenje dviju navedenih podskupina primijenjen je kriterij dnevnoga broja šumskih kamiona, za prijevoz obloga drva, na spoju šumske i javne ceste. Ako je taj broj 12 ili veći, radi se o šumskoj cesti podskupine GII, a ako je manji od 12, tada je riječ o šumskoj cesti podskupine GIII.

Kolnička je konstrukcija svih razreda šumskih ceste u Sloveniji jednako dimenzionirana s obzirom na nesmetano, cjelogodišnje odvijanje kamiona s poluprikolicom ukupne mase 40 t. Širina je kolnika od 3 do 3,5 m s gornjim strojem izrađenim od nevezanoga kamenoga materijala (u dva makadamska sloja). Takav pristup otvaranju šuma nije racionalan jer se svi razredi šumskih cesta izgrađuju i održavaju s istim standardom bez obzira na karakter prometa, prometno opterećenje i frekvenciju prometa.

Ukupna je površina Slovenije 2 milijuna ha; od toga 1,1 milijun ha otpada na šume i šumsko zemljište. Oko 12 000 km šumskih cesta s izvedenim gornjim strojem od nevezanoga kamenoga materijala te oko 9 000 km javnih cesta koje utječu na otvorenost slovenskih šuma daje prosječnu otvorenost od približno 20 m/ha. Financiranje kvalitetnoga održavanja tolike količine primarne šumske prometne infrastrukture isključivo od prihoda ostvarenoga prodajom drvnih sortimenata nije moguće. Stoga treba razmisliti o novim modelima financiranja održavanja šumskih cesta, poglavito onih razreda kod kojih je prevladavajuća nešumarska (javna) uporaba.

Ključne riječi: *standardi šumskih cesta, održavanje cesta, prirodno gospodarenje šumama, selektivne prorede, kamionski prijevoz*

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