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Occupation of production area by forest road network

Diploma Thesis

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DIPLOMA THESIS ASSIGNMENT

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Forestry, Water and Landscape Management

Thesis title

Occupation of production area by forest road network

Objectives of thesis

The work aims to quantify the occupation of production area, which requires the existence of a forest road network. Production area in this case is not perceived as the earth's surface, but as a stand canopies. Occupation of production area will therefore change with the age.

Methodology

A literature review dealing with categories of forest roads and their impact on the environment will be elaborated. Furthermore will be measured occupation of crown area due to the existence of forest roads by GIS software. Research will take place on the school forest enterprise in Kostelec n.Č.l..

The proposed extent of the thesis

min. 70 pages

Keywords

occupation of production area, forest roads network, main forest roads

Recommended information sources

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Declaration

I declare that this thesis on topic Occupation of production area by forest road network was developed independently by me under the leadership of Ing. Jaroslav Tománek, Ph.D. and I used only the sources that I mention in the list of sources.

I am aware by the publication of this thesis I agree to its publication in according with Act no. 111/1998 Coll. about universities, as amended, and regardless of the outcome of its defense.

In Prague, 10. 4. 2017 ………….…………………

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Abstract

The diploma thesis presents a situation of occupation of the production area by forest road networks in selected study territory called Voderadské Bučiny close to Kostelec nad Černými lesy in 2016/2017. The work is divided into two parts, theoretical and practical. The theoretical part deals with the explanation and familiarization of the basic concepts regarding forest roads, categorization and their impact on the environment.

The practical part was solved by terrain research in the chosen area. There were evaluated, measured and mapped the entire forest road network using measuring equipment and camera. Data from the research was subsequently placed into the program ArcGIS. The results of the work were detailed drawn maps of the forest road network divided into many individual sections. Then the values were exported to be represented in tables and graphs and to perform other calculations.

Based on the data we can see a detailed analysis of values concerning the relationship between production area of forest road network and occupation in investigated area and think thereby any change to improve the relationship between them to the benefit of both sides the economic and also the environment one.

Key words: occupation of production area, forest roads network, main forest roads

Abstrakt

Diplomová práce prezentuje sutiaci záboru produkční plochy lesní cestní sití ve vybraném modelovém území lesů Voderadských bučin u Kostelce nad Černými lesy v roce 2016/2017. Práce je rozdělena do dvou částí, a to teoretické a praktické. Teoretická část se zabývá vysvětlením a seznámením se základními pojmy ohledně lesních cest, kategorizací a jejich vlivem na životní prostředí.

Praktická cast, byla vyřešena pomocí teréního průzkumu ve zvolené oblasti. Zde byla zhodnocena, změřena a zmapována celá lesní cestní sít pomocí meřících pomůcek a fotoaparátu. Data z provedeného výzkumu byla následně zanesena do program ArcGis. Výsledkem práce byly vyhotoveny detailní mapové podklady lesní cestní site rozdělené do mnoha jednotlivých úseků, vyexportování hodnot pro znázornění v tabulkách a grafech a provedení dalších výpočtů.

Na základě zjištěných údaju můžeme pozorovat detailní rozbor hodnot týkající se vztahu mezi produkční plochou lesní cestní site a záborem ve zkoumané oblasti a zamýšlet tak případnou změnu ke zlepšení vztahu mezi nimi k prospěchu jak ekonomické stránce ta k životnímu prostředí.

Klíčová slova: zábor produkční plochy, lesní cestní sít, hlavní lesní cesty

Content

List of abbreviations used in the text:

UHUL - (IFM) – Institute of forest management - Ústav pro hospodářskou úpravu lesů

CR – Czech Republic

LCS – (FRN) forest road network- lesní cestní sít

FR – forest road

List of figures, tables and graphs:

Figures

Tables

Graphs

1. Introduction

Thesis deals with the occupation of the production area of forest road networks. This is a topic that is relatively well explored, but there is room for new knowledge. Forest has always been an integral part of human life on Earth and humanity provides immense numbers of advantages in its management. An important element in effective forest management are forest structures – especially forest roads. Without high quality of forest road network it would be impossible to effectively moving closer in and transport the wood and other forest products from the forest. The density and quality of forest roads are the first signs of forest management maturity. The ratio between the density and quality should play an important role in the construction planning, so the wood production function of forest is not too distorted. In other words, proper design and layout of forest roads is positive in economic terms, thus trying to minimize the occurrence occupation of production areas and at the same time leads to lesser impact on the environment.

The Czech Republic has about 160,000 km of forest road network. However the mentioned roads are not only for transportation of the material, but also are used for the passage of special vehicles (eg. ambulance, fire trucs, etc.), and last but not least are increasingly used for recreational purposes. Already during the construction of roads may create effects that limit future sealing of the forest area of forest road network, therefore decreases production area in the locality. But they are also important factors that act on the nearby roads after their completion. The main factors affecting the subsequent occupation of large production areas we could count on the species composition around the edges of forest roads as well as soil erosion and disturbance of the water system of the forest.

2. Aims of the thesis

The work is aimed on influence of forest roads on reducing of the forest production area so-called as occupation. The aim of this work is to investigate and determine the value of occupation caused by the forest road network in the surveyed area.

The theoretical part describes the basic concepts related to forest road network with a detailed analysis, categorization, history and important types of standards for the present time period. There is also described the definition of occupation of production area. Further focused on effects of forest roads on the environment. The point is mainly soil erosion and disruption of water regime in the forest, but also discussed is the disruption of land occupation and influence while the actual construction of the road.

The practical part is a field survey of the study area in the forests of Voděradské bučiny close to Kostelec nad Černými lesy and its mapping. Putting of the measured values into ArcGIS and with its help create a map data materials with attribute tables and with all the necessary values. Then calculated the values, process counting of the occupation, the effects of individual sections, types of roads etc. Making tables and graphs from the obtained values tells us about the situation between occupation of the production area in the forest and the forest road network.

3. Literature review

3.1 Definition of basic terms

Forest road network - According to ČSN 73 6108 forest road network is a transport equipment of any kind used to link forest complexes with a network of public roads. Also used to make shorter collecting of timber or other products from the forest. It is also needed to transport people and materials in connection with forest management and other purposes. As part of the road network we must also consider forest dumps (ČSN 73 6108, 2016).

Forest management - These include forestry economics and legal standards in forestry. It is an independent economic unit. The main forest management are Lesy ČR, state enterprise. Forests of the Czech Republic, state enterprise (LČR) was founded on January 1, 1992 Ministry of Agriculture of the Czech Republic. The main activity of the company is managing more than 1.3 mil. Ha of forest property owned by the state (almost 86% of the area of state forests) and care for more than 38,000 kilometers of waterways and streams (a significant increase km of watercourses under management compared to previous a flight from 1. 1. 2011 due to the transfer of stewardship ZVHS as part of its transformation). Annual harvest, on average about 7 million m3 of wood, which represents about 72% of the current increment. Enterprise based in Hradec Kralové and its organizational structure has three levels. The first stage consists of a headquarters, the other 12 regional offices - Regional Headquarters (RH), four forest enterprise (FE), a Seed enterprise (SE) and six administrations streams (AS). The third stage of the organizational structure consists of 75 forest management (FM) (LESY ČR a, 2015).

The basis of the company's forestry strategy of sustainable forest management based on maximum use of the creative forces of nature that ensure the continuous and balanced fulfillment of production functions entrusted forests. The aim of the company is the creation of stable, high-quality, spatial and grouply aged mixed forests.

LČR also provide an important service for owners of small private forests, and the performance of the statutory functions for professional forest manager on their properties. As the only subject in the Czech Republic LCR introduced internal qualifications for professional forest managers.

LČR funds are invested in the restoration of forests damaged by air pollution in border areas in the restoration and maintenance of forest roads, which todays are not only for forest management, but also for hiking and cycling (LESY CR b, 2015).

3.2 Forest roads

Forest roads are used in different ways. Their use brings with it not only economic benefits, but a number of other positive or negative effects stemming from their multipurpose use, the construction, maintenance or existence itself. The paths are part of the landscape and play an important role in the formation of the landscape composition. Some studies have shown a link between pathways and their effect on ecological processes and the structure of the landscape (SAUNDERS et. Al. 2002).

Roads connecting the important industrial centers, cultural or natural sites, enabling the supply and transportation of products and to ensure the economy is essential. Part of the whole system, and targeted communication and making accessible forests. Within the forest management road are recorded by Institute of Forest Management (IFM- ÚHUL). (VOLNÝ, 2013)

Forest road network is a transport equipment of all kinds used to link forest complexes with a network of public roads, to zoom in and weighing timber and other products from the forest to transport people and material in relation to forest management, respectively. and for other purposes (ČSN 73 6108, 2016). Among the forest road network includes forest landfill used for temporary preservation of wood.

Forest road is a private road, which is part of a forest road network is intended for removal of timber, transportation of persons, material for the passage of special vehicles (fire, medical service), but can also serve other purposes (ČSN 73 6108, 2016).

Regarding the Forest Act (DVOŘÁK, 2009) describes the situation as follows: Forest Act does not contain a definition of forest roads. In practice can be exchanged for forest road line approach, meaning the space where it was weighed timber from the forest, and who has realized after removal of timber used to transport or to ride on any means of transport.

With the recreational function is linked to over 90% of visits to the forest (MZe 2011).

In addition to forest roads that serve mainly forestry purposes, they are found in the forest and forest trails and paths that provide primarily recreational function (eg. Hiking, cycling and others). Their origin is initially often very arbitrary and are made exclusively with natural materials (wood, stone, forest land). During their artificial construction, however, the ČSN 73 6018 defined how should look like (eg. Hedge against adverse effects of water).

Construction and maintenance of forest roads represents an important and substantial investment to complement management of forests. In this sense, it needs careful planning to minimize the costs. Minimizing the total length of roads in the forest reduces the construction of roads, reducing maintenance costs and reduces the occupation of forest land plots (MURRAY, 1998).

In making and implementing forest road network is not just about the technical parameters of tertiary roads and the level of technology used in their construction, or the design of these devices, but it is a complex combining knowledge from biological, technical and economic sciences to achieve the objective, which is to create basic conditions for rational forest management (KVASŇOVSKÝ, 2004).

3.2.1 History

Purposeful construction of forest roads occupies in the history of forests and forestry only a small period of time. In terms of timber transport it was not a forest road network needed for a long time. From the abundance of forests is gaining by slashing and burning area for growing crops, as it is today in some developing countries. Wood needed to be mined at the edges of forests, and has been transported with the help of animal and human power after snow, water or soil (BENEŠ, 2002).

Due to higher demand for wood and timber development inevitably also developed a method transporting wood. The material had to be transported over greater distances from the stands, to meet the needs of society. Mankind was made to help the forces of nature.

The most common way was sledding shortened the strains of specially adapted road steeper with the help of gravitational forces. Efficacy was limited seasonality. That deal called. Wooden chutes where with the help of wooden troughs timber was transported to the desired location.

In areas with waterways edited or built foresters navigable streams on which (eg. With the help of rafts or water slides) transported chopped logs. An example might be the Schwarzenberg Canal in the Šumava National Park.

Last but not least way, exploited today, the animal form of transport - especially horses.

With the advent of the railways began to build a narrow gauge railway line to transport timber. They already provide a much safer way of handling the timber.

After the introduction of the railroad in the woods there was a period of great exploitation in remote mountain, yet hard to reach areas (MATYÁŠ, 1957).

The development of forest roads occurred in the 20th century after the onset of automobile traffic.

3.2.2 Meaning of the forest roads

Forestry is practiced in most areas from the tropics to the cold regions. Forest roads provide access to the forests and support the activities of the management and use of forests. Paths are essential for many forestry operations, including transport mining equipment to the individual sites of mining and transport timber sawmills (Forman et al., 2003).

Accessibility of forests is essential to achieving the tasks of forest management. Without disclosing the woods and forests, most forest production could not be implemented. Access requests to the forests are dependent on management objectives, geographic location, the extraction method used, and other internal factors. Paths provide basic access to active economy forest resources. Forestry and logging, recreation and fire protection, as well as additional activities are largely dependent on the accessibility of forests and forest forest roads (Hay, 1998).

Forest paths are used for a wide variety of purposes. These include the possibility of obtaining forest products, visit the forest, hiking, hunting and more. Use of forestry products is not possible without a proper road network. During the construction and operation of roads but there is a need to remember the pros and cons but, since the construction of forest roads are also affecting neighboring forest stands (Pfeffer, 1981).

In recent years, with the increase in tourism development, especially cycling demands on forest roads and increase their usefulness. Communication is not a priority, built for cycling, but its implementation will also create safe cycling routes. This is the construction and maintenance of existing tertiary roads (field and forest roads). These routes are marked with bike and as already mentioned above, can be both paved and unpaved. In certain locations can be built so called Trail for mountain biking (Cyklodoprava, 2012-2014).

Potočník (1998) defined the fifteen most important uses of forest roads, which are valid even today:

forestry

- access and interconnection villages
- hunting
- accessing of cottages and cottages areas
- accessing of farms
- accessing of hunting cottages
- accessing of reservations with freely living animals
- accessing of mountain cottages
- transit use
- turistic use
- police use
- agricultural use
- military use
- use for collection forest fruits
- use for sport and recreation

Forest roads are used in different ways. Their use brings with it not only economic benefits, but also a number of positive or negative effects that result from their multipurpose use, the construction, maintenance or existence itself. The paths are part of the landscape and play an important role in the formation of the landscape composition. Some studies have shown a link between pathways and their effect on ecological processes and the structure of the landscape (Saunders et al., 2002).

3.2.3 Current access of forest in CR

Forest road network is nowadays in most forests in the Czech Republic is relatively underdeveloped. In our country is practically not found not made available to areas that should economic importance. Quality and accessibility of existing rationality, however, remains in question (PIPKOVÁ et. al, 2006).

Of the total area of forest land Czech Republic occupy 2,630,320 hectares forests and the 50,888 hectares (less than 2%) are other land needed for the operation of forestry (such as forest paths, clearings, dumps and warehouses of wood, forest nurseries and seed plantation, the ground occupied by buildings operational etc.) (ROČEK, 2000).

Table no.1: Forest road network in the CR (DOBIÁŠ, 2003)

class of the forest road		**number of km**	**%**	**density ($m*ha^{-1}$)**	**note**
forest owners	1L	11 919,10			Forest road network (LCS) (pulpwood roads)
	$2L_1$	22 900,80			
other owners	1L,2L	11 979,70			
subtotal		46 799,60	29,25	18	aprox 1/4 of FRN (ratio 1:3,4)
3L		41 700,40			Permanent approach road (temporary FRN)
4L		71 500			
subtotal		113 200,40	70,75	42,67	
Total		160 000	100	60,31	FRN

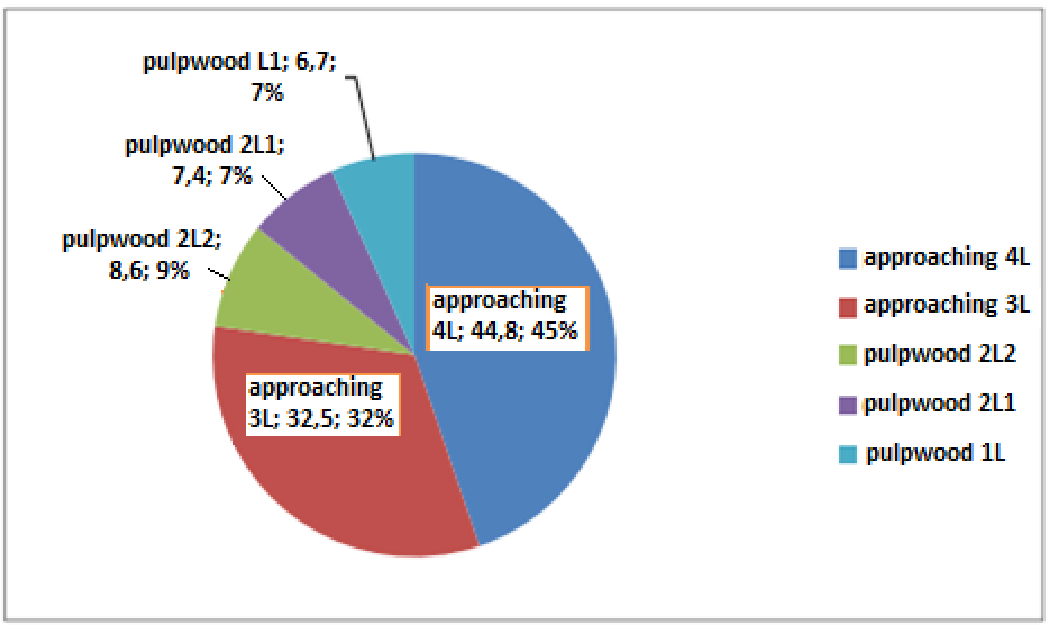
According to the table in 2003 in the Czech Republic 160,000 km of forest roads. pulpwood roads (1L and 2L) used for transport of timber trucks occupy less than 30%. Almost the same proportion there are ways 3L and widespread paths are paths 4L, which is almost 45%.

3.2.4. Forest roads and their registration

Forest roads records by Management Institute Forest in Brandys nad Labem (UHUL). As well as forest paths tertiary roads municipal authority registers the cadastral area. Forest path is also a purposeful way. Cadastre records targeted as the site of trips only. As land is recorded unpaved roads, for example. Footpath or road where the ruts. The building is a private road associated with ground solid foundation and as such is not subject to registration in the Land Registry. Within the national forest inventory, which ensured in the years 2001 - 2004 FMI, was also the inventory and distribution of various forest roads.

The inventory of the investigated frequency of forest roads and their condition. The inquiry was not kind of property.

Graph no.1: Pie chart of forest roads (Národní inventarizace lesů ČR 2001 - 2004)



3.2 Categorization of forest roads

Category of forest road– forest road with the same spatial arrangement, designed for the same maximum (design) speed vehicles DOBIÁŠ, 2003).

Forest roads are often divided by two ways (by ČSN 73 6018 and by ÚHUL). By ČSN 73 6108 are divided:

a) Traffic importance and purpose

b) According to the layout of

Institute for economic activity, five groups of similar but not identical to the standard no. 73 6108.

3.2.1 Dividing of roads by ČSN 73 6108

3.2.1.1 Update of standards ČSN 73 6108 Forest road network

Standard ČSN 73 6108 are used for designing forest roads, which are essential means of making forest in the country. Standard specifies the basic requirements for the design of the individual elements of forest roads 1st and 2nd class and sets the basic conditions for the construction, reconstruction, repair, maintenance and rehabilitation of forest roads. It also specifies requirements for the design of forest svážnic (3L), technological lines (4L) and forest trails (ČSN 73 6108, 2016).

Previous Standard ČSN 73 6108 Forest road network was launched in 1996 and replaced the repealed industry standards ON 73 6108 Designing forest haul roads from 1975. After twenty years of use there is a need to update this standard. The main reasons for the update were:

- transport timber is currently being implemented by other types of truckloads than underlying its standard CSN 73 6108 in 1996 (815 Tatra tractors and Liaz 111.800 s with semitrailers)
- change in legislation, which referenced standard;
- change the social perception of non-production functions of forests and increased use of road networks for leisure activity (ČSN 73 6108, 2016).

A clear definition of forest roads not included in the Act no. 289/1995 Coll., On forests and on amending certain laws (the Forest Act), as amended. This law states are primarily what a forest transportation. The mentioned issue is dealt with in the provisions of Section 34 of the relevant law. Here it is stated that the forest is a right, "Approximation, storage and transport timber (hereinafter" forest transport ") must be carried out so as to avoid undue damage to the forest and other land." (Act no. 289/1995 Coll.) . Another possible definition is also the one that gives the Ministry of Agriculture Decree no. 433/2001 Coll., Laying down technical requirements for buildings to fulfill the functions of the forest no. 433/2001 Coll .: "purpose-built road, which is part of the LDS, intended for the transport of the wood, the transport of persons, material for the passage of special vehicles (fire and medical services), but can also serve other purposes "(Decree no. 433/2001 Coll.).

Pulpwood forest road - mostly single-lane represents the utility road that creates transport links within the forest complexes and a transport point of view, ensuring safe year-round or seasonal operation.

Forest approach road - is always a purpose-built single-lane road, which creates transport links within the forest complexes, the most common approach combines the lines with roadside paths. Forest line approach - is part of a forest road network is used exclusively for clearing wood harvested from forests and subsequent approximation. Usually combines growth with approach roads or forest landfills. Passed over rough terrain without removing the top layer of soil.

Forest distribution network - a network of natural and artificial boundary lines of a permanent unit of the spatial distribution of forest (valleys, rivers, roads, clearings). Forestry landfill - modified or unmodified storage area of the road, for temporarily storing or handling of the timber prior to removal.

Roadway of forest road - outlined with several layers of processed building materials, its construction ensures resistance for operation of the vehicle design.

Operating strengthening of forest road - firming lane road incorporating building materials, providing the necessary resistance for the required operation technology. Other terms include road base, longitudinal and transverse slope of the road verges, ditches and svodnic forest roads and, not least, maintenance of forest roads. Definitions of terms clearly stated standard ČSN 73 6108.

3.2.1.2 By transport importance and purpose

Forest roads

forest roads 1. class (designation 1L)

forest roads 2. class (designation 2L)

Traffic routes for forest production function

forest herded ways (designation 3L)

technological lines (designation 4L)

e) forest trails

a) forest roads 1. class (designation 1L)

Haul routes to enable its spatial arrangement and technical facilities year-round operation design vehicles (assuming winter maintenance). The paths are each provided with a ground of various building materials. The minimum lane width is 3.0 m, the width of the free path of at least 4.0 m. The maximum longitudinal inclination of the vertical alignment path is 10% in extreme mountain sites on short sections of up to 12% (ČSN 73 6108, 2016).

Figure no.1: Forest road 1L

b) forest roads 2. class (designation 2L)

Haul routes to enable its spatial arrangement and the necessary technical equipment at least seasonal operation of vehicle design. A road surface is recommended according to the underlying soil bearing capacity to provide operating solidification or single dusty ground surface. On substrates can be viable even without operational consolidation. The minimum lane width is 2.5 m, a free minimum track width of 3.5 m. The maximum longitudinal inclination of the vertical alignment path depends on the morphology of the terrain, on the type of underlying soil, the load and the type of paved surface. Does not exceed 12%.

Figure no.2: Forest road 2L

c) Forest herded ways (designation 3L)

Used to skidding, they are passable for tractors, skidders and skidding special funds. The smallest free width forest herded way is 3.0 m. The limiting factor is the resistance substrate and its susceptibility to erosion. The roadway is not proposed; Forest herded way surface may be provided with reinforcement operation or modification of underlying soils according to ČSN 73 6133 full length or in a certain place, or it can be completely without modification. Forest herded way should bear the principal longitudinal and transverse drainage earth formation. Forest herded ways are proposed passing bay. The maximum permissible longitudinal slope depends on the morphology of the terrain and the quality of drainage. Unpaved forest herded way the longitudinal slope lane that exceed 10% for non-cohesive soils; on cohesive soils, only 8%. Section with a large longitudinal slope should be adjusted as paved forest herded ways and establish the longitudinal and transverse drainage. In this case the greatest longitudinal gradient 16%. Forest svážnice not considered tertiary roads by the relevant regulation (ČSN 73 6108, 2016).

Figure no.3: Forest herded way 3L (El toro, 2016)

d) Technological lines (designation 4L)

Technological lines are typically used to skidding of the forest. They are usually temporary; build operatively in relation to the scope and method of educational and felling in the forest. They are usually held after the fall line; Maximum gradient used is given by the approaching means (tractors, skidders technique, horse, etc.). The surface is always unpaved, usually does not remove the upper organic layer. Excavation work is carried out only in exceptional cases. The width of the process line is at least 2.0 m; without technical facilities or with only minimal technical equipment (eg. drainage). Passing bays are proposed. Technological lines are not considered tertiary roads by the relevant regulation (ČSN 73 6108, 2016).

Figure no.4: Technological lines 4L

e) Forest trails:

Forest trails are designed to conform to the parameters of forestry operations; Other trails in the woods (for recreational use) are designed according to relevant regulations. A trail may be reinforced accordingly or may be without reinforcement; the route of forest trails can be individual steps or stairs. In unfavorable field conditions must be ensured trail against the adverse effects of surface water. Minimum or maximum value of the longitudinal or transverse slope is not set. Passing bays are proposed. Forest trails are not considered tertiary roads by the relevant regulation (ČSN 73 6108, 2016).

Figure no.5: Forest trails (Wikipedia, 2010)

3.2.1.3 By spatial arrangement

According to the spatial arrangement of the forest road divided into different categories which are characterized by the fraction X / Y. Numerator expresses the free width of the path metric and the denominator design speed in kilometers per hour. For forest roads 4th grade is given free passage way. (...) the code refers to a class trip, a written letter,, L "indicates that this is a forest road (ČSN 73 6108, 2016).

Table no.2: Labeling of classes and categories FR (ČSN 73 6108, 2016)

Lesní cesty 1. třídy	1 L – X/Y
Lesní cesty 2. třídy	2 L – X/Y
Lesní cesty 3. třídy	3 L – X/Y
Lesní cesty 4. třídy	4 L – X

3.2.2 Dividing of FR by UHUL

According to the National Forest Inventory in the Czech Republic, 2001-2004 FR are divided as follows:

1L class - pulpwood road to enable year-round pick, always with the roadway.

2L1 class - pulpwood road to allow seasonal to permanent operation with the operational reinforcement or dusty surface.

2L2 class - pulpwood road allowing only seasonal traffic on unpaved subsoil,.

Class 3L - forestry and approach routes passable for tractors, skidders and skidding special agents with limited technical facilities.

Class 4L - by cleaning roads (lines) without technical facilities, the width of at least 1.5 - 3 meters without humus covering removal, passable only for horses, tractor, or special funds used for the evacuation of the timber stand (VAŠÍČEK, 2002).

Table no.3: Characteristics of forest roads (UHUL, 2016)

species	class	operational capability	min. width of crown	max. Slope	min. R	kind of surface	purpose and use
			m	%	m		
pulpwood roads	1L	permanent	4	10-12%	15	dust-free road	whole year
	2L 1	seasonal to permanent	3,5	10-12%	15	easy roadway with dusty surface	seasonal for wood
	2L2	seasonal	3,5	8-10%	15	on viable natural substrates	seasonal for wood
approaching roads and lines	3L	seasonal	3	8-10%	15	terrestrial partly padded	approaching
	4L		1,5			terrestrial without humus	approaching

3.2.3 Kinds of surfaces of FR

In practice, it is possible to meet a wide range of surfaces, forest roads. The various kinds of characteristics of forest roads in Table no.3. The road surface is meant a cover or upper part of the road and also hardening operation, which is intended for direct maneuvering of vehicles. To select the type of surface of forest roads is determinative of its use, it is therefore necessary to determine carrying capacity of forest roads and suitability of the material used for reinforcement. The types of road surfaces are sorted summarized in Table no.4. The surface of the road may also occur herbage. There are distinguished three types of surfaces, namely the roadway without grass (without vegetation), the road is covered with grass cover (vegetation), just ruts are free of vegetation or the road is covered in grassland and other vegetation.

Table no.4: Surface of roads (UHUL, 2016)

number of code	describtion
100	The road surface is bearable without reinforcement or only a partial hardening
200	The road surface is reinforced freely navezeným original material (gravel) or material of biological origin - operating solidified, it is naturally paved road
300	road surface reinforced freely navezeným, unoriginal or environmentally harmful materials
400	the road surface is hard That Means it is covered with a hard surface (asphalt, concrete, concrete panels)

3.3 Indicators of FRN in CR

Density, spacing percentage of forest roads and forest access are primary indicators of maturity forestry. For the correct ratio they minimize costs and also spared the environment.

Division of vegetation is also linked directly to concentrating timber. Subtle ways harvesting practices, development of large areas, and restoring vegetation on the slopes, especially steep, puts on skidding without significant damage claims, so it is necessary to create a sufficiently stable dense transport network, supplemented as necessary and temporary routes or lines (ROČEK, 2000).

The density of forest road network is given in m / h or km / 100 ha, or spacing (distance) routes, or average skidding and cleared tract distances. Basic theoretical relationship determining the density of forest road network is expressed as follows: the denser the network of forest roads, the shorter the approach distances (and thus lower the cost of skidding), the denser the network of roads, the higher the cost of maintenance, and vice versa. Finding optima in this reciprocal relationship is solved density forest road network (ROČEK, 2000).

The total amount of forest roads, their spatial distribution and the prescribed technical characteristics, must be sufficient to allow high-quality management of forest ecosystem with a minimum initial and additional investment. Construction and maintenance of forest road networks, creating a very important element of the total expenditure relating to forestry. The aim is to build a spatially well-placed network of forest roads whose technical parameters allow performing all the tasks designated a management plan for the forest area (NEVEČEREL et al., 2007).

The density of forest roads:

$$H = l / F$$

H = density of FR [m/ha]

l = lenght of FR [m]

F = area of region [ha]

Spacing of forest roads:

$$D = 10000 / H$$

D = spacing of FR [m]

H = density of FR [m/ha]

Percent accessibility is the percentage ratio of forest vegetation area accessible to the total gravitational field. The accessible area having a width of about respiratory tract theoretical spacing calculated from the density of road network (TOMÁNEK, 2009).

$$Š = 5000 / H$$

Š = width of buffer (packaging area of roads) on one side

H = density of FR[m/ha]

Percent accessibility vegetation is then calculated as the ratio of the total area determined. To evaluate the utility of transportation road network using percentages making it possible to use a 5-degree classification (TOMÁNEK, 2009):

Table no.5: Classification of access of stands (TOMÁNEK, 2009)

till 65 %	inadequate access
65 – 70 %	little satisfactory
70 – 75 %	satisfactory
75 – 80 %	very satisfactory
over 80 %	extremely satisfactory access

3.5 Construction of forest roads

In the history of the construction of forest roads and paths realized by hand with reinforcing mainly stet rocks. To overcome the waterlogged stretches of forest roads are used so called rollings. Poval was considered across the road and the poles were formed or tyčkovinou. The technology was later replaced by a hardcore surface grinding stone quarries and import coarse crushed stone directly to the site. Handmade work machine began to recede. This also disappeared technology development plank roads (Hrůza, 2015)

Forest road network reflects selected method of forest management. Today they use special equipment called forest ,,harvesters,, combined with a skidder and highway trucks. For comparison with the past, when mining and approach the tree could a man with a horse or a tractor and pick-up truck was used to know the right to increase the quality and capacity of forest roads. For this reason, is currently under reconstruction mainly old haul routes. Improve their pulpwood parameters such as the width, the pitch ratio - descent, averages and bearing curves. The new forest roads are built only in poorly accessible or inaccessible locations. During the reconstruction and construction of new forest roads respect the requirements of management of protected areas, the department of water management, environment and other (Hrůza, 2015).

Forest roads, unlike public roads with low traffic volume and are built in a different natural environment, the unfavorable shape of the terrain does not allow for complete technical equipment of buildings. Forest roads are so specific communications that require special technical and economic approach to its construction. This issue falls within the scope of foresters and forest managers, rather than road projects as it might seem, since it is a technical issue (Hanák a kol., 2002).

In short there is mention of the progress of construction of new forest roads as the main point of this work is the reconstruction of existing forest roads. The construction of forest roads is first necessary to carry out thorough preparation. It is important to build a polygon axis routes. New building forest roads is the approach to forest complexes, which are usually not available distinctive landmarks, so the focus axis polygon done using a triangle, which is assembled from the top and two trees that are damaged building. Plotting the collateral is in the batter board scheme project, which are drawn all the values needed for the establishment of detailed points of the axis of the road. Using the measure of cross-sections of the project are in different points of the route identified dimensions of the strip that must be cut down the path and then paint marks its boundary trees. Working to clean up the lane then resumes axis marking waypoints to indicate which way the road leads (Dobiáš, 2003).

After preparation of project documentation, consisting of longitudinal and transverse inclinations forest paths, ensuring drains through crash barriers and culverts, the construction done. There is also a previous meeting with the relevant authorities and discuss the zoning of the building with the appropriate building permits.

In terms of the construction of forest roads today can not be ignored important elements of the building such as longitudinal slope forest roads, forest roads verges, crash barrier, road gutter, and trativod or drainage. Their characteristics are listed below (Lesy ČR c), 2015):

- longitudinal slope forest roads: a shift path of the road surface from the horizontal plane in the direction of stationing path given in percent; if the value of the longitudinal inclination in the direction of positive stationing routes - these are the pitch, if negative - it is a descent.

- forest road verges: support the edges of the road or traffic reinforcement; in extended shoulder catch are fitted safety equipment and other equipment journey; by design distinguishes shoulder paved and unpaved

- forest road crash barrier: natural, wood, concrete or steel transverse dewatering device which removes surface water from the surface of forest path in a trench or on the ground below the path

- Road gutter forest roads: open deep drainage facilities generally less than 15cm reinforced concrete blocks, stone tiles, etc .; on forest roads class 3 and 4 can be designed and furrows unpaved - (terrestrial)

- Road ditch forest roads: open drainage device more than 15 centimeters deep; according to the sectional shape of the trench recognizes trapezoidal and triangular; by surface treatment can be either paved or unpaved

- Trativod, drainage: a covered drainage facilities regulating water regime under the road surface and draining into another drainage device.

3.6 Occupation of forest land

Forest roads are important for forest management. Besides the positive effects bring about negative effects forest roads. One of them is the loss of forest land due to the construction of roads in forest areas (POTOČNÍK, 2008).

One of the negative effects of forest roads is the loss of forest land (CALISCAN, 2013).

Forest land is a valuable fertile material. Any construction of forest roads is created by the occupation and gives rise to damage to the forest stand. In place of management of forest roads are mined trees and land ceases to serve as a place to grow trees. It is important to note that production occurs mainly in the crown of trees. After cutting down the lane is therefore reduced production area, but over time the vacancy surrounding trees covered with their crowns and resume production area.

Younger trees are, regardless of its kind able to develop faster treetops and then grow into phase toll age faster (POTOČNÍK, 2008).

It is therefore desirable to design a forest road network so that they are offset by the positives and negatives. By (KLČ, 2007) is the essence of tracing the slope of forest roads make maximum mutual compliance with the essential requirements of the most appropriate solutions with optimally balanced path towards a slope in the minimum range of earthworks.

Examples 1 km of forest Lesni haul road occupy approximately 1 hectare of forest land to which, after removal of stumps odhumusovani and create an unfavorable situation from the viewpoint of nature (BENEŠ, 1986).

As the "occupation of land designated for forestry" is called and withdrawal of properties fulfilling the functions of the forest, which is the release of the land for other uses and also restrict the use of land for the fulfillment of forest functions, which is a condition where the affected land can not be fulfilled some functions forest in the normal range (as stated in § 15/1 of Forest Act).

Withdrawal or restriction (occupation) may be permanent or temporary. Permanent means a permanent change of land use, the land temporarily released for other purposes for the period specified in the decision pursuant to § 13/1 of the Forest Act.

The rules for administrative proceedings to revoke the land fulfillment of forest functions or restrict the use of land for the fulfillment of forest functions are set out in § 16 of the Forest Act. Withdrawal of land fulfillment of forest functions is charged (§ 17 and § 18 of the Forest Act attachmenx).

The issue of annexation of land intended to fulfill forest functions is further regulated in the Ordinance on the particulars of the application for withdrawal or restriction and details on the protection of land intended to fulfill forest functions, which in his § 1 establishes the limit for the withdrawal and the abbreviation "occupation".

State administration of forests crucial pursuant to § 16 of the Forest Act will assess the economic and social justification for the request and the possible consequences of the occupation to fulfill forest functions (§ 3 of the requisites of dispossession or limitation and details on the protection of land intended to fulfill forest functions).

The Forest Code, the word "occupation" appears in one place, at § 3/13 point. c) according to which, the legal and natural persons performing construction, mining and industrial activities are required to continuously create prerequisites for subsequent reclamation loose surfaces; after the end of the occupation of the land for other purposes immediately carry out reclamation of the land concerned so that they can be returned to the fulfillment of forest functions (BPPP, 2016).

Figure no.6: Representation of the occupation while FR contruction (POTOČNÍK, 2008)

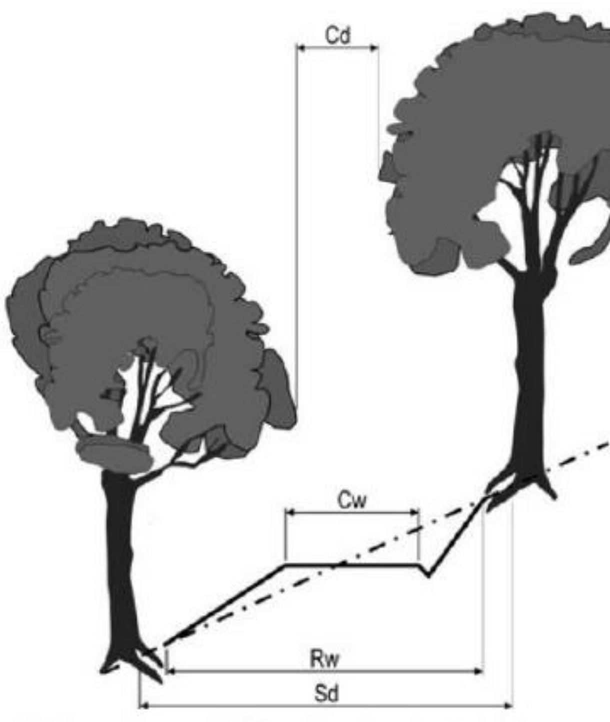


Figure no.7: Production area of newly built FR

Figure no.8: Production area of older FR

According to POTOČNIK (2008) (according to local ecological conditions) of forest roads was relatively vacant space quickly fills the tops of the surrounding trees. Filling the following positive ma esthetical, technical and commercial effects:

- Forest road becomes a part of the forest
- damage resulting from construction of roads is healed
- Construction of roads affected vegetation is more stable
- Green forest path pall protects against direct sunlight and against the damaging effect of precipitation

3.7 Influence of forest roads on the environment

Like every building disrupts the natural processes of nature and the forest roads no exception have their share in the transformation of the landscape. The question of construction, optimization, density and overall effects of FR deal foresters, scientists and conservationists. According to ČSN 73 6108 (2016) is already in the design of forest road network must also be based on the potential impacts of the construction on the environment and landscape.

Many authors in the literature points to the negative impact especially earth approach roads to the natural environment, the increased extent of soil erosion, silting on waterways and reservoirs suspended load, decrease in production forest areas and other negatives roads and facilities in forest (KLČ, 2006).

Because of environmental impacts when planning the network of forest roads should take into account the environmental effects. In recent years, increasing public awareness of the impact of forest roads on the environment (TAMPEKIS et. al., 2015).

Poorly constructed forest roads can cause significant environmental impacts, including road surface erosion, sediment erosion, water pollution, slope failure, fragmentation of ecosystems into smaller more isolated factions. Therefore, designers should consider when designing roads only economic costs, but they should think of sustainable forest environment (TAMPEKIS et. al., 2015).

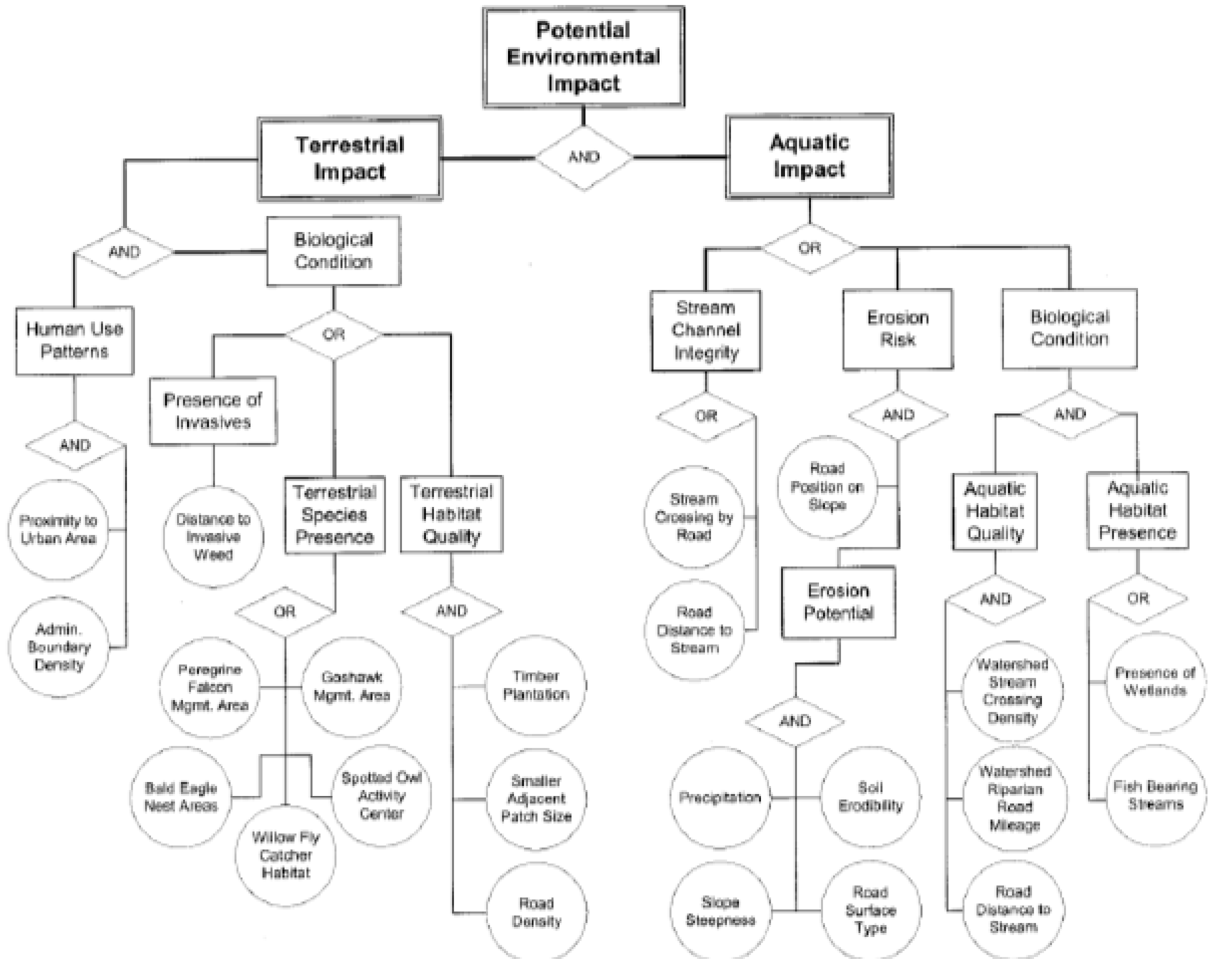
Construction of roads has all forest operations in one of the biggest opportunities to affect lasting environmental impact on the landscape. For this reason, there must be many different factors into account in their planning (FANNIN, 2003).

Ecological balance of the forest is adversely affected by landslide and construction work. Man created pastures can have significant impacts on wildlife. Felling trees in the forest road stretch has poured both the forest and the road itself (CALISCAN, 2013).

Dvorščák (1986) showed that failure in the implementation of design parameters of forest roads in many cases causes significant damage to the natural environment (KLČ, 2006).

Road networks are different potential and actual risk to the natural systems of which they are a part. Factors such as the location of roads and their use, geomorphology and ecosystem processes may affect the level of risk (GIRVETZ, 2003).

Figure no.9: The effects of forest roads on the environment (GIRVETZ, 2003)



Description: Basic knowledge used for EMDS analysis paths. Define a rectangular frame assertion (double border) and the sub-claims (simple border) circles define spatial data used to evaluate the sub-claims. AND and OR linkage refers to the types of logic of relationships between concepts and basic data (GIRVETZ, 2003).

3.7.1 Erosion

Erosion or disruption, disruption may be described as a complex natural process resulting from exposure to water, wind, ice and other erosive agents. There is a disruption of the soil surface, the transfer of soil particles and their subsequent establishment (JANEČEK, 2008).

The most frequent causes of erosion are severe atmospheric precipitation, resulting in disturbance of the surface denuding and soil particles. Another common cause is anthropogenic influences or otherwise - human activity. It has a major impact soil erosion.

Many experts in the field of crop production, but also water, consider the forest and forest land protected as sufficiently protected against erosion in its deliberations and suggest the existence of zero erosion, whereby in its calculations begin to model the effect of erosion from the border with the rest of the forest land. In fact, many types and forms and negatively formed is reflected in a forest area, especially in mining and transport of forest roads erosion (KLČ, 2006).

The biggest source of water erosion are all types of buildings exposed to road traffic and score the slopes where it is most effective and also the aesthetic incorporation of the building into the landscape the most appropriate measure of their greening grassing (HANÁK, 2000).

Stormwater runoff from forested areas artificially influenced by forest road networks. Currently, forest paths necessary for intensive forest management and forest protection. The discharging rainwater and erosion of forest roads (DOBIÁŠ, 2005).

Generally, the erosion damage increase with increasing longitudinal gradient of forest roads and at increasing the flow of water. Under otherwise identical conditions, the magnitude of these losses affected underlying soil grain composition (DOBIÁŠ, 2005).

Unpaved forest roads damaged by erosion caused by accumulated rainwater that flows over the crown. Water is accumulated in the transport tracks created especially for tractor-drawn tribes. In general, damage caused by erosion increases with increasing slope and speed increases runoff. In an otherwise identical conditions affected the extent of damage to the structure of the subsoil (DOBIÁŠ, 2005).

Table no.6: Percentage of types of erosion on roads (KLČ et. al., 2007)

Erosion of forest road	Representation
Without erosion	83,50%
Longitudinal erosinal scratches	15,10%
Lateral erosinal scratches	0,20%
Landslide, swampy surface	1,20%

Soil is one of the main resources of the biosphere. As limited and irreplaceable natural resource at its destroyed or damaged becomes a limiting factor in the development of society. Tim soil that creates habitat plant enables accumulation of solar energy. On the ground produced organic matter serves many ways, whether directly or indirectly, to the needs of man (VOJAČEK, 1990).

KUKAL (1964) Based on the data of weathering in different conditions found that the rate of soil formation on the Earth's surface is about 100 cm per 1,000 years.

Water erosion causes not only ecological damage, but damage to the surface transport structures reduces their ability to meet the traffic demands of forestry.

Surface and subsurface stormwater is a critical rupture element forest road network. On the destruction to be involved in their erosive action (NEJEZCHLEB, 2008).

Water erosion is the kinetic energy of the rain drops falling on the soil surface and the mechanical strength of surface run-off water. Loosening of soils is accompanied by relocation of release material (VOJAČEK, 1990).

The largest source of water erosion of soil in all types of transport structures baring slits embankment and slopes where it is most effective, and also in terms of aesthetics incorporated the building into the landscape the most appropriate measure of their greening grassing (HANAK, 2000).

Builder erosion furrows in flysh areas have biggest accelerator effect approaching means in the forest (especially tractors) brinelling supports the construction of forest roads (JARABAČ, 1980).

JUŠKO (2008) found in models of forest roads with gravel roadway annual loss of material with a thickness of 2.3 mm.

When forest inventory conducted in 2001 - 2004 it was found that in the Moravian-Silesian Region 63.4% of forest roads does not have signs of erosion. Longitudinal grooves erosion has 31.8% paths. Landslides, gullies and the like. Encountered with 3.3% forest path. Transversely erosion gully were Moravian-Silesian region recorded in 0.7% Forest path (UHUL, 2017)

3.7.2 Effect of water regime

Economic activity in the forests, especially mining, transport timber and artificial regeneration, has together with natural processes (erosion, nutrient leaching) the adverse impacts on water resources and coastal communities. These impacts are collectively referred to as the cumulative effects of human activities in watersheds, abbreviated cumulative effects. The cumulative effects of forestry operations are multiplied over time and space, where there was a logging (POŠTULKA, 2007).

Influence of water regime is another negative effect of forest roads. Their structure and being itself directly affect the natural flow of water forest. Inevitably, - if the water flow is interrupted and the water (e.g. using improper drainage elements) diverted elsewhere arise wetlands while dry - barren surfaces.

3.7.3 Removal of sediments

Soil loss is not a problem ecological and repairing roads to be then economic. Erosion problem extends to other fields, such as water management, where the material causes silting of water reservoirs and surface water quality deterioration.

MIDRIAK ET AL. (1985) found that long-term average loss of soil from the paths of approach flysh zone is 0.177 m3.r-1 of 1 meter profile land routes.

Soil and sediment runoff setting is currently the most discussed topic in the literature.

Forest roads have been identified as the main source of sediment production from forest areas, considering that more than 90% of all produced sediments originating from a forest roads (GRACE, 2002; GRACE, CLINTON, 2007).

Unpaved forest roads are known as a major source of sediment delivered to a river basin (RACKLEY, CHUNG, 2008).

The influence of the longitudinal profile trips to the proportion of deposits in the surrounding water sources examined by ARUGA ET AL. (2005) and suggested optimal longitudinal slope of forest roads.

SWIFT (1988) states that the greatest loss of soil have new paths that are not weedy bottom and road is a gravel or compacted. It also states that surface vegetation protecting forest road crossings, survives 20 to 30 vehicles per month.

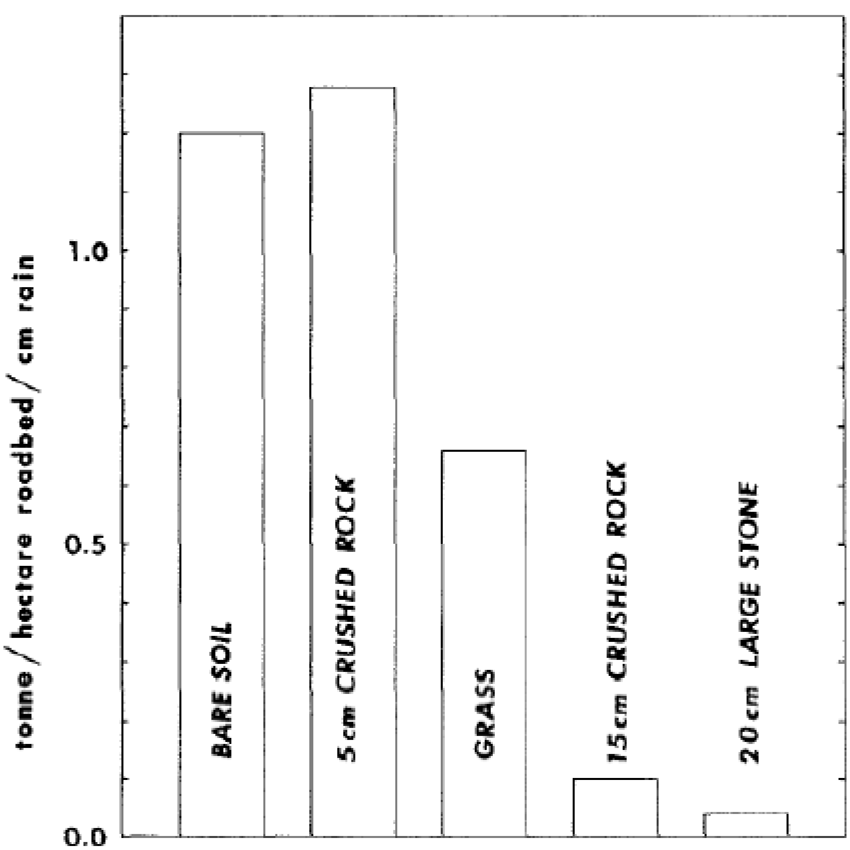
BUZEK (1981) monitor the amount of suspended solids in streams coming from forest land in the basin Ostravice and Morávka in Beskydy. He found that the forest roads released during rainfall more suspended solids than from riverbeds. Result is increased silting of watercourses and dams and other waterworks suspended load.

Production forecasts sediments from forest roads is necessary to determine their effect on river and assigning terrestrial and aquatic flora and fauna (KAHKLEN, 2001).

Comparison runoff from land without vegetation and vegetation conducted HOLY, VAŠKA (1970). They found a significant effect on the grass surface runoff, the research object with a slope of 44.5% to 96% drained rainwater less than an equally large areas without vegetation.

SWIFT (1984) examined soil loss from forest roads with various surfaces on the test subjects found soil loss in tonnes per hectare per cm rainfall. Soil loss from forest roads with various surfaces shown in the graph no. 2.

Graph no.2: Soil loss by surface t*ha-1 in cm of precipitation (SWIFT, 1984)



Research on Slovak soil erosion devoted ZACHAR (1970).

KAHKLEN (2001) developed and tested methods designed water transport of sediments originating from forest roads.

Vegetation on the course of action and intensity of erosion processes is reflected protect the soil surface from the direct impact of raindrops and from the effects of wind, support, however, rainwater into the soil, slow runoff and improve physical, chemical and biological soil properties (HOLY, 1994).

Exposed soil erosion is the area on which vegetation can not hold. The cause is mainly failure to comply with the projected slope during construction.

BURROUGHS, KING (1989) Erosion investigated and, as active agents found: straw with bituminous tack, networking straw, straw, erosion control mat, wood chippings or pebbles etc.

CLINE ET AL. (1981) examined the effectiveness of anti-erosion measures. Found after application of sediment erosion reduction by 60% of the embankment slope, about 2.5% of the lane, and 15% of the slope excavation and trenches.

MEGHAN ET AL. (1991) same as BURROUGHS, KING (1989) found that the largest production of sediments from the slopes of the road after construction and time is reduced.

ARUGA ET AL. (2001) It states that forest roads and dewatering can in turn be beneficial for capturing land from the slopes and prevent its erosion from the stands, also states the benefits for biodiversity.

The action of erosion control materials on elementary drainage areas of forest roads investigated by DVORŠČAK, HRIB (1996) and on the basis of his research suggested remediation schemes and the erosion of security based on the use of natural materials such as straw, branches and mining waste. Protection against erosion of the soil surface suggested solutions such materials or their combination with an erosion control network.

SWITALSKY ET AL. (2004) dealt with environmental benefits and threats related to the decommissioning of temporary and permanent forest roads. I was interested in their reclamation and afforestation.

3.7.4 Slope failure

Influence of forest roads on the stability of habitats in Sloping Ground dealt ALLISON ET AL. (2004), it warns that the road built in Sloping Ground stability habitat decreases in four ways:

1) overloading embankment slope on the side
2) increasing inclination on the edges of paths and slopes
3) removing material from the top of the slope
4) redirection and concentration of the water flow.

BORGA ET AL. (2005) studied the effects of forest roads on surface landslides in pitched terrain. This effect evaluated algorithm based on the size of rainfall in the area of forest roads, subsoil, slope, terrain and other factors.

The slopes of the old stabilized violation or potential landslides sensitive to natural factors, or the intervention of anthropogenic character. A survey of landslides, which in our country has been developed in the last 20-25 years shows that 90% of them originated with the direct or indirect involvement of anthropogenic factor (KLČ ET AL., 1989).

3.7.5 Impact on animals and plants

Forest roads can cause a wide range of impacts on the lives of wild animals. Some species such as the wolf and grizzly bear are adversely affected by repeated encounters with people (GUCINSKI, 2001).

Thanks to forest roads may increase the incidence of poaching, collisions with vehicles and finally moving terrestrial vertebrates that have an impact on many large mammals, including, for example, polar reindeer, bighorn sheep, pronghorn American grizzly bear and wolf (GUCINSKI, 2001).

It is estimated that one million vertebrates are killed each year on the road in the US. Direct mortality of large mammals on forest roads is generally low, except domesticated (GUCINSKI, 2001).

Forest roads pose a greater danger to the slow-moving, migratory vertebrates than in mammals. Almost all species of reptiles seek ways for cooling or warming the body. However, vehicles killed a lot of them, decreasing their population (GUCINSKI, 2001).

Although we found the tree diversity as a positive influence affecting the number of birds across habitats, the number of birds along forest roads was higher than deeper in the forest, but rather lower than the forest edges (ŠÁLEK, 2010).

Invasive species

Forest paths facilitate biological invasion such that foreign exotic plant and animal species invade disturbed location along the path. Transmits to them by dispersing the wind, water, vehicles and other human activities. Forest roads may be the first point of entry for exotic species into new environments. It will serve as a kind of corridor for animals and plants in their way further into the new environment. Invasion of exotic species has significant biological and environmental impact in the case of these species replace native species, or disrupt the structure and function of the ecosystem (GUCINSKI, 2001).

A similar method also works erosion forest monocultures. And not only go on alien species. In the vegetation grows where only one tree species and allow their stocking invade other, the emergence of new ways to help disrupt mentioned monoculture and creates an opportunity for attachment of other trees. This may be all vegetation such. Reinforced and better withstand adverse conditions.

3.7.6 Impact while construction of FR

During the construction of forest roads when using any technology interferes with the natural environment. Whether the increased noise of construction machinery, harvesters, chainsaws, etc., Or the leaking oil and fuel. For example, in chain saws, however, according to the law of obligations to the oil in them were used within 21 days of 80% biodegradable. Pressure on similar ecological changes based on an awareness of how serious damage to the Earth's.

From the Forest Act no. 289/1995 Coll. (§ 13 para. 3, letter. D, § 32 para. 8) an obligation to use only biodegradable oils for lubrication chains of chainsaws and biodegradable hydraulic fluid. In the future, it can be assumed tightening existing requirements and extension of validity and other operating charges of forestry machinery (SKOUPÝ, 2000).

The operation of internal combustion engines generates emissions that act negatively on vegetation around the building. Especially industrial machines suffer from high fuel consumption.

During the period of construction is several times increased movement of people and machines than normal. Their influence, with proper behavior, but not in comparison with other influences important role. It is important to ensure respect for the surrounding trees, as well as in mining following works to not unnecessarily damaged.

Since the duration of construction work compared to the life of the road basically negligible, the environmental impacts are not as essential as such. erosion.

3.7.7 Other impacts by forest road network

In addition to the impact on forest roads already mentioned increasing erosion, breach of slopes and diminishing of production area is often studied the influence of forest roads on the ecosystems in which they are located. A further, more a positive effect is to increase the biodiversit by so-called Border effect.

LUGO, GUCINSKI (2000) argues that the creation of a new road or road network in the country is equivalent to adding a new ecosystem to ecosystem already exists.

MORTENSEN ET AL. (2009) It states that the road plays a big role in the spread of invasive species.

Many authors have also dealt and deals with the effects of forest roads on populations of animals, for example RYTWINSKI and FAHRIG (2007), DUNN and DANOFF-BURG (2007), ORTEGA (2002).

4. Methodics

4.1 Data materials

As data bases have been used to-date maps of forest roads for the area surveyed forests south west of Kostelec nad černými lesy. Part of the investigated forest complex is a National nature reservation Voděradské bučiny. Forest paths were obtained in digital format from the server UHUL (http://www.uhul.cz/) and subsequently printed at a scale of 1:30 000. It was also printed many detailed maps for later better orientation in the field obtained from the website mentioned above portal uhlu.cz and www.mapy.cz.

On the main page of that website UHUL was chosen category Maps and Data Catalog, and then mapping information. Here you can find links to many of map catalogs, however, they were only used two sources to map and Information about the forest and map Regional plans of forest development. In the first-mentioned map Information about the forest were only observed treeline at a given location for later transfer into the program ArcGis. Map Regional plans of forest development has been used to represent the actual forest roads in the area of interest on the underlying orthophoto and for later use in the field and ArcGIS.

Data basis was also used viewing service WMS orthophoto, which is provided as a public service of viewing current data product Ortofoto Czech Republic. The service meets the technical guidelines for INSPIRE viewing service v. 3.1 and also meets the standard OGC WMS 1.1.1. and 1.3.0. and it is provided by The Czech Office for Surveying, Mapping. Orthophoto map was used for working with the ArcGIS 10.2.2, where served as the base map in coordinate system GCS_WGS_1984. On this map was then entered measured data of forest roads, which were subsequently processed for further use.

4.2 Devices and software

In the field, it was necessary to measure the width of forest roads on which we used traditional tape measure. Further for measuring of the distance was used properly set bicycle tachometer with centimeter accuracy. For later check and put of the measured data of forest roads in the ArcGIS program were all forest roads mapped using GPS (Global Positioning System) device 20 eTrex from firm Garmin, borrowed from the

Faculty of Environmental CULS for purposes connected with the completing of the thesis. To record the type of surface of forest roads were using classical camera mobile phone BenQ.

To process all the data measured in the field were used mapping software ArcGIS from Esri 10.2.2. Its unpaid student version that the school provides, I requested at the CULS.

For processing tabular data was used software Excel 2010. Some of these data were input data for the creation of graph outputs.

4.3 Field data collecting and processing

4.3.1 Width measurement of forest roads

Forest roads were divided into 35 different sections. Before the start of each section measuring forest roads were first reviewed by the road surface. Forest roads in our surveyed area were divided on the terrestrial and gravel as well as asphalt. Gravel with terrestrial roads were measured from the beginning of production area usually located slightly behind the drainage ditch (Figure no.10). In the case of forest roads in the area quite flat with no ditch, measurement was made to the nearest tree trunk. The asphalt road was measured using the same method except for the difference that in the distance was calculated a value separately from the beginning of production area to the edge of the road and the same on the other side, soo we obtained a separate value for the width of the road (Figure no.11).

Measurement of forest roads started on each section at a point 0, where was measured exact width. From that point, the tachometer was reset and began measuring the distance of the section. Further measurements were made in each case at 100 and 250 meters. From the point of exceeding 250 meters of the exact forest road was measured every 250 meters (thus 250, 500, 750, etc.) until the final point where the road finished and was crossed or another section. At the final location was always written the final distance and measured last width for exact section. Except in the methods of measurement was a rapid change in width in some sections. In these cases, was wrote down the exact distance of locations where the change was recorded and width of the forest roads was measured.

All 35 sections a their changes according to surface change during the trail were documented by camera and writted down to the notes also with distance details where the change was found.

Figure no.10: Measuring sample of terrestrial and gravel FR

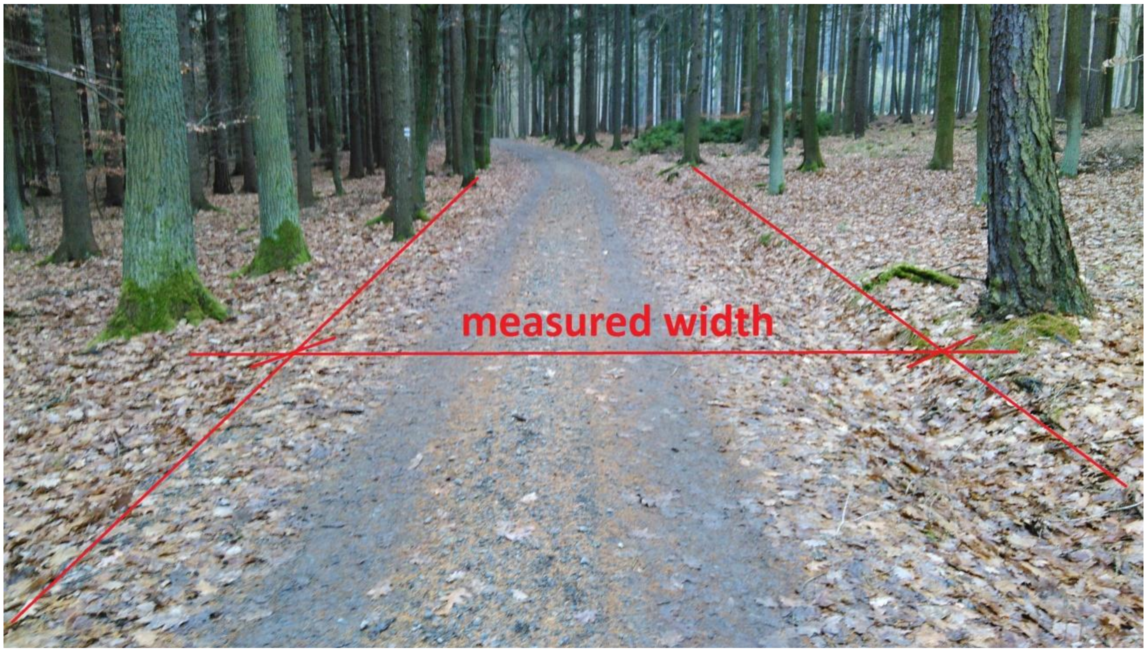


Figure no.11: Measuring sample of asphalt FR

4.3.2 Work with data in ArcGIS

4.3.2.1 Imput of the data into the program

The initial step after launching a new project in ArcGis was importing of online orthophoto map to the program in the coordinate system GCS_WGS_1984. This step was performed via the function ArcCatalog where the WMS server was connected to also as selected ortophoto map. For all the auxiliary lines was created shapefiles named auxiliary lines.

The initial step of putting the data of forest roads on the ortophoto map creating of 3 new polyline shapefiles in the same coordinate system GCS_WGS_1984. These shapefiles represent 3 different kinds of forest roads devided according to surface (terrestrial, gravel and asphalt), which were identified by field research. They are conducted by axis of the roads for later use with polygons. Shapefiles of roads were identified with different colors for better orientation.

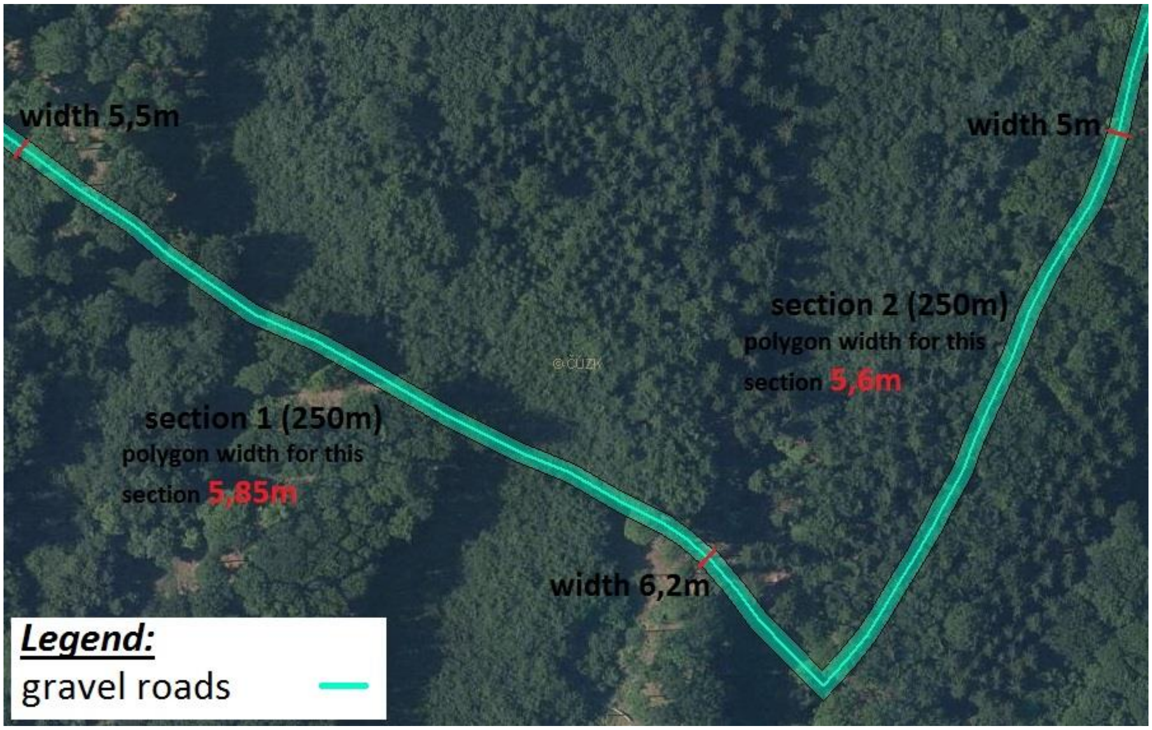
When putting of individual sections of forest roads to the program using the Edit - Start editing was followed as: Roads that were purely visible on the orthophoto map were copied by the axis. Places that were not recognizable from orthophoto map (thus hidden under crowns of trees) were processed by averaging of data from GPS measurements and data obtained from the above-mentioned website of the Institute of Forest Management (UHUL) for the most accurate representation (Figure no.12).

Figure no.12: Detail of axis of FR according to different types of surface

The next step was to create a polygon with a width of the sections of forest roads. To this were made 3 new layers of polygon again divided according to the type of terrain (terrestrial, gravel and asphalt). To the asphalt roadway was added extra-side polygon showing the sides of the roadways for precise marking of the width. For the most accurate entry of data was always used averaged value between each parts of the forest road section. For example: at 500 meters was measured forest road width 5 meters and at 750 meters was 6,2 so for this section was calculated value of width 5,6 m. These individual sections then created together form of polygons of all roads with exact widths in exact sections (Figure no.14).

Figure no.13: Detail of FR areas accoring to different types of surface

Figure no.14: Example of FR width averaging



4.3.2.2 Marking of forests and extra areas

From the website UHUL was used map of Forest management scheme which determined actual boundary of the forest in the studied area. So new shapefile polygon Forests was created to over cover the area of forest. Next shapefile which was created was polygon layer called Extras. It was used to mark all extra areas within the surveyed forest area, such as water areas, buildings, other communications etc. (Figure no.15).

Figure no.15: Detail of forest marking and extra spaces

4.3.2.3 Marking of occupation

To mark the occupation of the production area of forest road network we worked in individual polygons of roads. Here, we marked on orthophoto map polygons where was clearly saw a forest road or larger dark area between the trees crown. These places showed that the production area is limited in exact part soo that part was marked by occupation polygon.

After marking the occupation in all polygons of forest roads we used the function Clip in Editor. It allowed us two finishing edits of the project. First, we used a function Clip for polygon layers Forest and Extras and erased Extras layer from the Forest one. As the second step was function Clip with layer Forests and layer showing the occupation of the production area. The final result was then polygonal layer Forest containing production forest area minus occupation of production area by forest road network and also minus all the extra spaces located on the territory of the examined area of forest (Figure no.16). As an additional area the under part of occupation of production area was separately marked landing places on the forest road network (Figure no.17).

Figure no.16: Detail of occupation in the forest

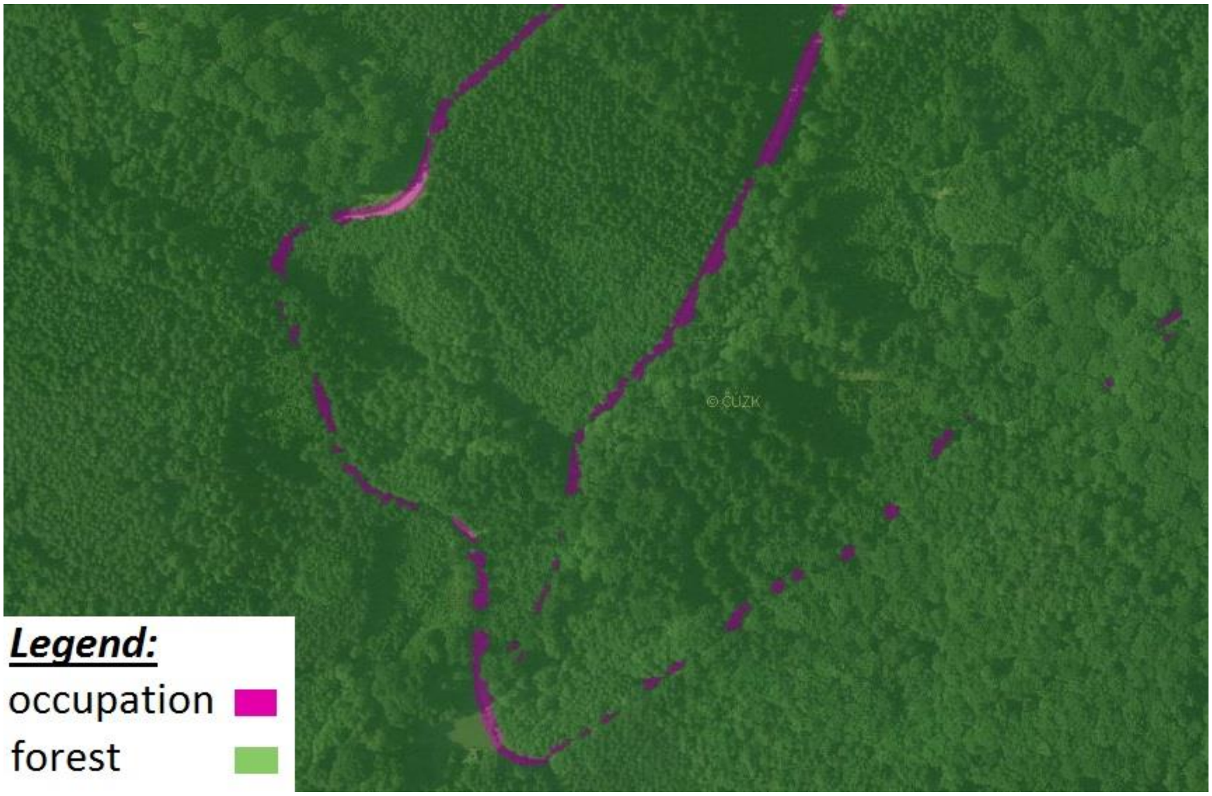


Figure no.17: Detail of occupation and landing in the forest

4.3.3 Values exporting

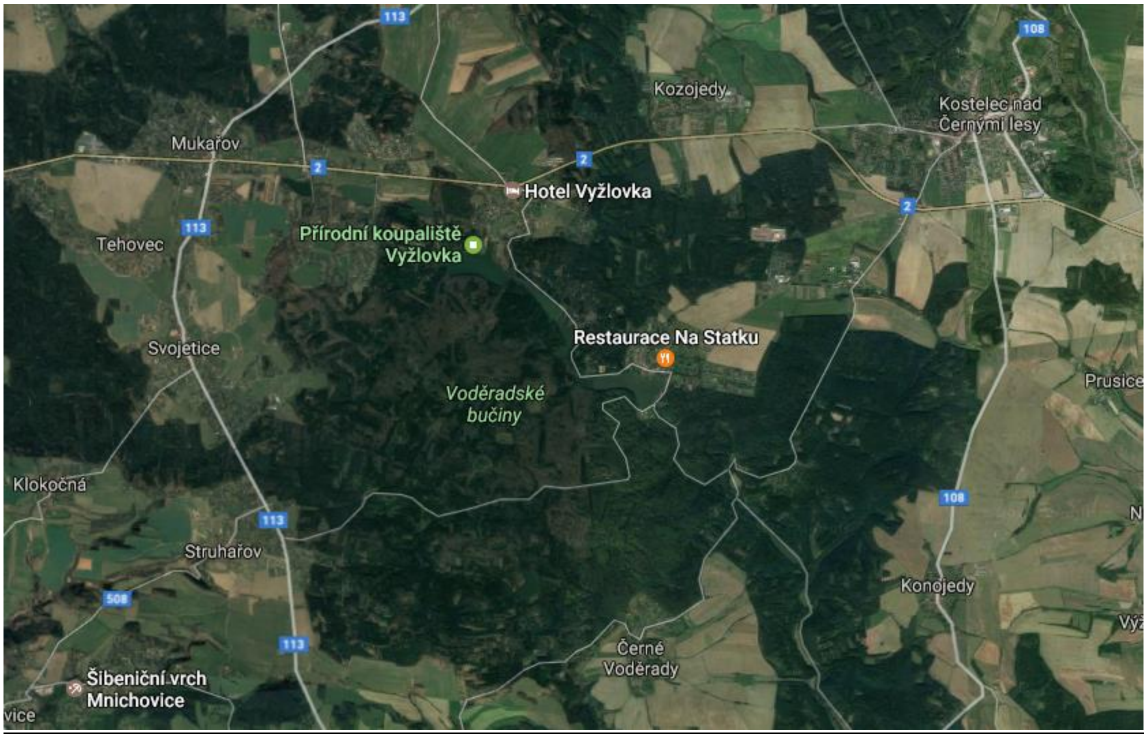
From made data bases were from the ArcGIS program exported attribute tables and all the other available data. These data were then moved to program Microsoft Excel 2010 to create tables and grapths from them.

4.4 Characteristics of the area

The area is located in the national nature reserve Voděradské bučiny, which is located in the district of Prague-east primarily on the territory of of the village Černé Voděrady (on northwest its also touching municipalities of Vyžlovka and Lounovice), approximately 30 km southeast of Prague. (By the end of 2006 Černé Voděrady and Vyžlovka belonged to the district Kolín.)

Figure no.18: Localization of the area - Czech Republic – Prague-east (UUR, 2015)

Figure no.19: Localization of the area - Voděradské bučiny (Goggle maps, 2017)



The object of protection are extensive beech forest and manifestations frost weathering. Reservation was declared in 1955, it covers an area of 658 ha, altitude is from 350 to 500 meter up the sea.

Voděradské bučiny is large forest complex situated on the right side of the bank of Jevany stream. Forest consists predominantly beech, supplemented by summer oak, hornbeam, also aspen occurs, basswood and birch. In the forest there is many bird species such as Dryocopus martius, Columba oenas or hawk.

Part of the territory consists of non-intervention untreated surfaces. Reserve serves as a research object of the Faculty of Forestry and Wood of Czech Agricultural University in Prague.

5. Results

5.1 Basic indicatior of FR in selected area

Density, spacing of forest roads and theoretical approach distance are one of the primary indicators of the forest management maturity. While keeping the correct ration it minimalized the cost and also spare the enviroment. Values for the each category are calculated below.

Density of FR:

H= l / F H= 37030/2300,466 **H=16,1[m/ha]**

H = density of FR [m/ha]

l = lenght of FR [m]

F = area of surveyed territory [ha]

Spacing of FR:

D=10000/H D=10000/16,1 **D=621,1 [m]**

D = spacing of FR [m]

H = density of FR [m/ha]

Theoretical approach distance:

dt=D/4 dt=621,1/4 **dt=155,3 [m]**

D = spacing of FR [m]

dt = Theoretical approach distance [m]

Values of FR density, FR spacing and theoretical approach distance suggests that the whole area is relatively optimally dimensioned by forest roads. As example, the optimal spacing of forest roads is between 400 to 600 m. In comparison with the rest of the Czech Republic this area is normal.

5.2 Map result values

5.2.1 FR distribution by type of surface

Selected tested area Voděradské bučiny of total area 2300.5 ha was divided into 35 separate sections of forest roads and divided by colors into 3 different kinds of surfaces on terrestrial, gravel and asphalt (Figure no.20).

For more closer map divided into detailed plots with different sections depending on the type of forest roads can be found in Appendix no.1 to 10.

Figure no.20: FR Distribution by type of surface

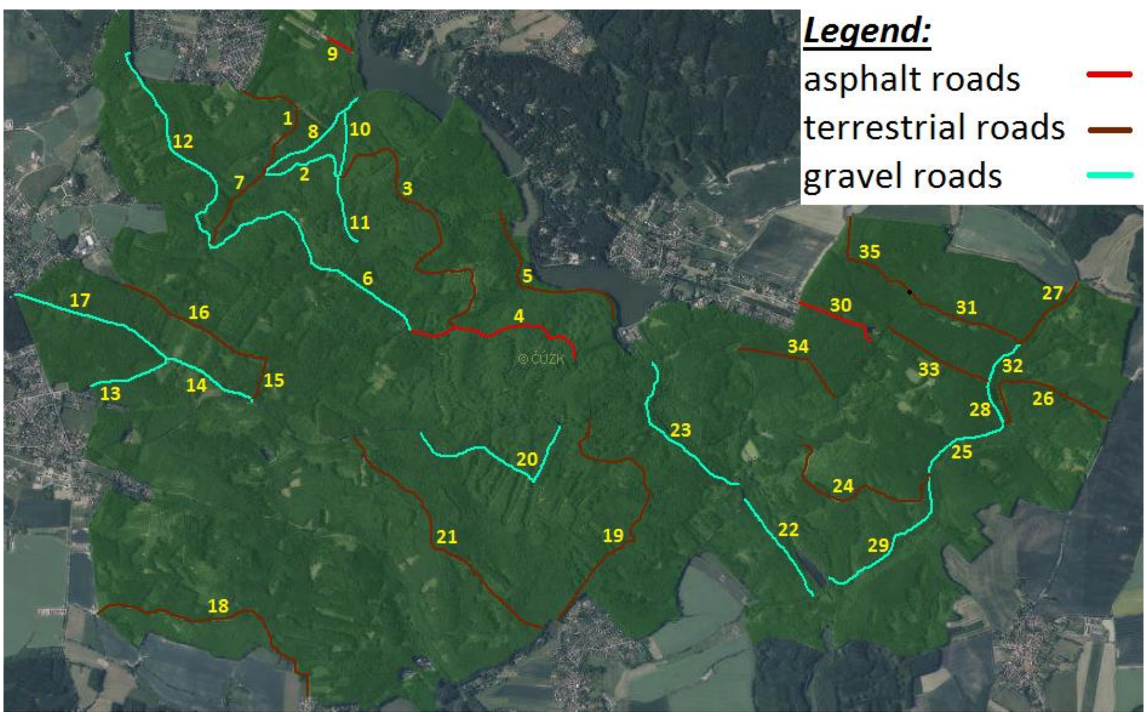


Table no.7 contains detected distribution into individualy measured sections by type of forest road and also by surface conditions of individual forestroad sections.

From the table we can see that in most of the study area can be found terrestrial and gravel roads with the occasional exception of asphalt roads, which represents minimum value of forest roads. On the other hand in case of surface condition we can observe that most of the forest roads are sufficiently paved only 7roads were evaluated in poor insufficient condition therefore only availableto access by heavy technique.

Table no.7: FR distribution by type and kind of the surface

number of section	type of forest roads	surface of forest roads
FR_1	terrestrial	poorly paved
FR_2	gravel	poorly paved
FR_3	terrestrial	sufficiently paved
FR_4	asphalt	sufficiently paved
FR_5	terrestrial	sufficiently paved
FR_6a	asphalt	sufficiently paved
FR_6b	gravel	sufficiently paved
FR_7	terrestrial	poorly paved
FR_8	terrestrial	poorly paved
FR_9	asfalt	asphalt and panel
FR_10	gravel	turbid or hard
FR_11	gravel	turbid or hard
FR_12	gravel	sufficiently paved
FR_13	gravel	sufficiently paved
FR_14	gravel	sufficiently paved
FR_15	terrestrial	sufficiently paved
FR_16	terrestrial	sufficiently paved
FR_17	gravel	sufficiently paved
FR_18	terrestrial	sufficiently paved
FR_19	terrestrial	sufficiently paved
FR_20	gravel	sufficiently paved
FR_21	terrestrial	poorly paved
FR_22	gravel	poorly paved
FR_23	gravel	sufficiently paved
FR_24	terrestrial	sufficiently paved
FR_25	gravel	sufficiently paved
FR_26	terrestrial	sufficiently paved
FR_27	terrestrial	poorly paved
FR_28	gravel	sufficiently paved
FR_29	gravel	sufficiently paved
FR_30	asphalt	asphalt and panel
FR_31	terrestrial	turbid or hard
FR_32	gravel	sufficiently paved
FR_33	terrestrial	poorly paved
FR_34	terrestrial	sufficiently paved
FR_35	terrestrial	poorly paved

5.2.2 Length and area of individual FR sections

Table no.8 shows the lengths (m) of the individual sections and also the surface area (m^2) from attribute tables exported from ArcGis program. Those value were obtained from lengths and widths in field measuring. For both values was added column with percentual image of above mentioned values. In the lowest part of the table are 2 total values after summation of all lengths and areas in surveyed area.

Table no.8: Length and area of individual FR sections

number of section	length (m)	length (%)	area of FRN (m^2)	area of FRN (%)
FR_1	940	2,5	6297	2,5
FR_2	710	1,9	4495	1,8
FR_3	3130	8,5	17039	6,6
FR_4	960	2,6	8102	3,2
FR_5	1330	3,6	11904	4,6
FR_6a	250	0,7	2086	0,8
FR_6b	2000	5,4	13930	5,4
FR_7	640	1,7	4951	1,9
FR_8	850	2,3	6819	2,7
FR_9	190	0,5	1262	0,5
FR_10	460	1,2	3367	1,3
FR_11	580	1,6	3361	1,3
FR_12	1710	4,6	12177	4,7
FR_13	590	1,6	3567	1,4
FR_14	680	1,8	4751	1,9
FR_15	280	0,8	1840	0,7
FR_16	1120	3,0	8670	3,4
FR_17	1160	3,1	7688	3,0
FR_18	2000	5,4	12065	4,7
FR_19	2090	5,6	14021	5,5
FR_20	1380	3,7	9194	3,6
FR_21	2020	5,5	12027	4,7
FR_22	850	2,3	8896	3,5
FR_23	1270	3,4	8787	3,4
FR_24	1440	3,9	8896	3,5
FR_25	700	1,9	5233	2,0
FR_26	1090	2,9	8663	3,4
FR_27	620	1,7	4033	1,6
FR_28	690	1,9	2376	0,9
FR_29	1210	3,3	8374	3,3
FR_30	630	1,7	6770	2,6
FR_31	790	2,1	6103	2,4
FR_32	340	0,9	2724	1,1
FR_33	850	2,3	6129	2,4
FR_34	660	1,8	5139	2,0
FR_35	820	2,2	4942	1,9
Total	**37030**	**100**	**256678**	**100**

5.2.3 Distribution of FR by class and function

Figure no.21 shows the whole forest road network in surveyed area. The roads are marked with same numbers as in previous case because it has the same sections. Other extra roads which were not included in this work because they are just proposed roads so dont exist so we dont cout with them. Forest roads are of class L2L it is a seasonal type roads at some periods are hard to reach. On the other hand from L1L road that are for heavy technology and other vehicles accessible the whole year. It is seen that in are around Voděradské bučiny is mostly L2L class of forest roads. These 2 forest classes were then devided by function of individual FR on technological and connective, technological local and collecting (table no.9).

Figure no.21: Distribution of FR by class

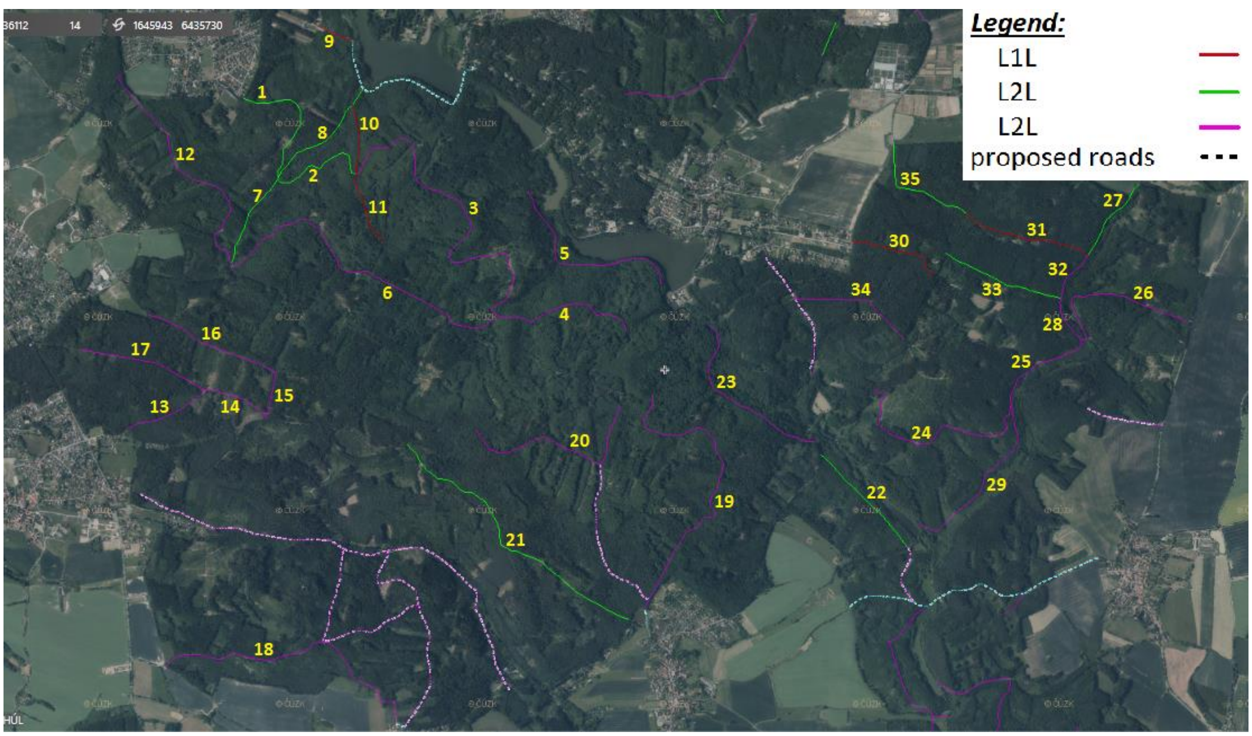


Table no.9: Distribution of FR by class and function

number of section	class of the forest roads	road function
FR_1	L2L	technological and connective
FR_2	L2L	technological and connective
FR_3	L2L	technological and connective
FR_4	L1L	technological local
FR_5	L2L	technological local
FR_6a	L2L	technological and connective
FR_6b	L2L	technological and connective
FR_7	L2L	technological and connective
FR_8	L2L	technological and connective
FR_9	L1L	collecting
FR_10	L1L	collecting
FR_11	L1L	collecting
FR_12	L2L	technological and connective
FR_13	L2L	technological local
FR_14	L2L	technological and connective
FR_15	L2L	technological and connective
FR_16	L2L	technological and connective
FR_17	L2L	technological local
FR_18	L2L	technological and connective
FR_19	L2L	technological local
FR_20	L2L	technological and connective
FR_21	L2L	technological local
FR_22	L2L	technological and connective
FR_23	L2L	technological local
FR_24	L2L	technological and connective
FR_25	L2L	technological and connective
FR_26	L2L	technological local
FR_27	L2L	technological and connective
FR_28	L2L	technological and connective
FR_29	L2L	technological local
FR_30	L1L	collecting
FR_31	L1L	collecting
FR_32	L2L	technological and connective
FR_33	L2L	technological and connective
FR_34	L2L	technological local
FR_35	L2L	technological and connective

5.2.4 Occupation values of individual sections

Table no.10 contains calculated values about occupation of production area in each section showed in square meter and in column next to in percentage. The lowest row of table no.10 shows the total value of occupation in surveyed area.

Table no.10: Occupation values of individual sections

number of section	occupation (m^2)	occupation (%)
FR_1	2774	2,9
FR_2	568	0,6
FR_3	4720	5,0
FR_4	2458	2,6
FR_5	3720	3,9
FR_6a	740	0,8
FR_6b	5908	6,3
FR_7	1816	1,9
FR_8	1329	1,4
FR_9	918	1,0
FR_10	1023	1,1
FR_11	893	0,9
FR_12	5465	5,8
FR_13	2192	2,3
FR_14	3088	3,3
FR_15	896	1,0
FR_16	2595	2,8
FR_17	3451	3,7
FR_18	6871	7,3
FR_19	2035	2,2
FR_20	1883	2,0
FR_21	3843	4,1
FR_22	2591	2,8
FR_23	3212	3,4
FR_24	5713	6,1
FR_25	2502	2,7
FR_26	4803	5,1
FR_27	1766	1,9
FR_28	1251	1,3
FR_29	2946	3,1
FR_30	1820	1,9
FR_31	2074	2,2
FR_32	1392	1,5
FR_33	1202	1,3
FR_34	1781	1,9
FR_35	1975	2,1
Totals	**94214**	**100**

5.2.5 Total values according to the surface type

For visible differences between total values for length, area and occupation of forest road was built Table no.11. The largest representation in the forest road network on the investigated area have a terrestrial, then gravel and last asphalt roads. These values are in all three cases folded the same because terrestrial roads have rapidly higher length of over the others so that why all the other values like area and occupation are the same high amount. Values are also shown graphically (graph no.3) and for expresing in percentual values was made Table no.12 and Graph no.4.

Table no.11: Total values according to the surface type

surface type	total length (m)	total area (m^2)	total occupation (m^2)
terrestrial	20670	139538	49913
gravel	14330	98920	38365
asphalt	2030	18220	5936
total	37030	256678	94214

Graph no.3: Total values according to the surface type

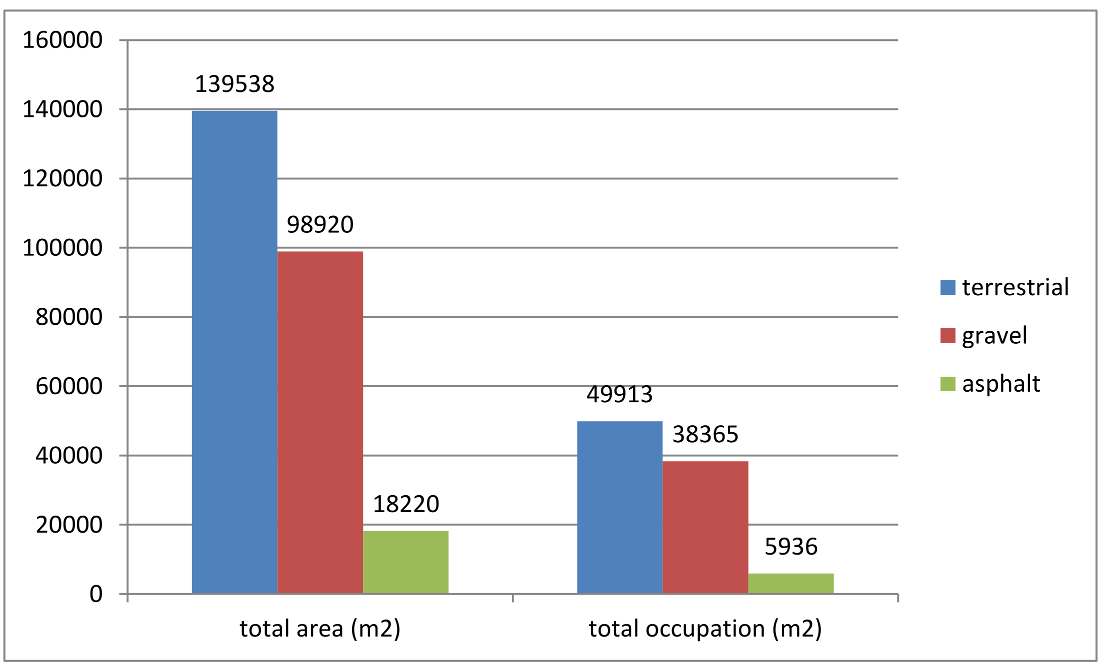
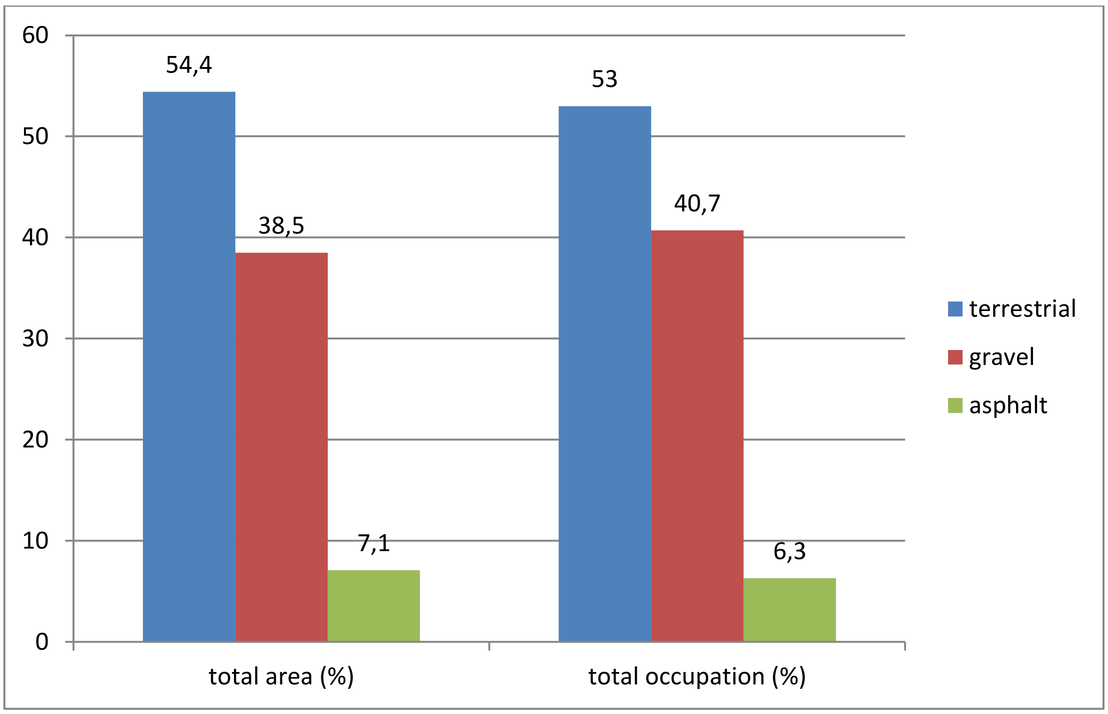


Table no.12: Total values according to the surface type in %

surface type	total length (%)	total area (%)	total occupation (%)
terrestrial	55,8	54,4	53
gravel	38,7	38,5	40,7
asphalt	5,5	7,1	6,3
total	100	100	100

Graph no.4: Total values according to the surface type in %



5.2.6 Total values of FR according to the class

The same distribution of FR measured values as in previous case only here were forest roads compared according to their classes L1L and L2L. Much larger are have roads L2L so also all the values are significaly higher than the other type L1L because of small occurrance in this forest territory.

Exported values are below in Table no13. Followed by graphical representation (graph no.5). Values expression of forest road by class in procentage was shown in Table no.14 and graphicaly in Graph no.6.

Table no.13: Total values of FR according to the class

class of FR	total length (m)	total area (m^2)	total occupation (m^2)
L1L	3610	28965	9186
L2L	33420	227713	85028
total	37030	256678	94214

Graph no.5: Total values of FR according to the class

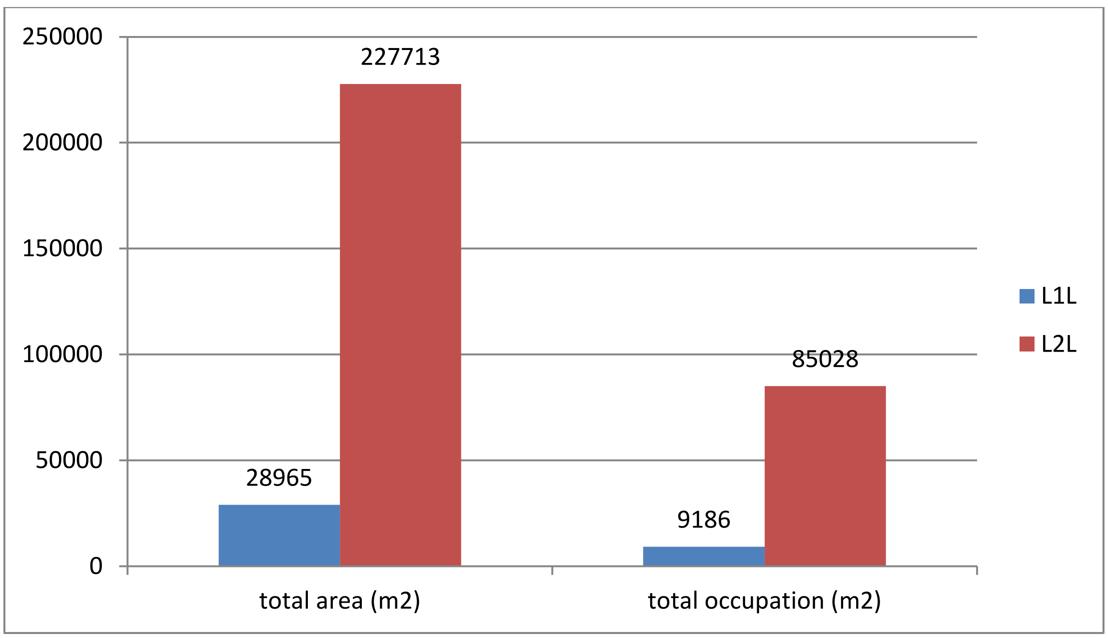
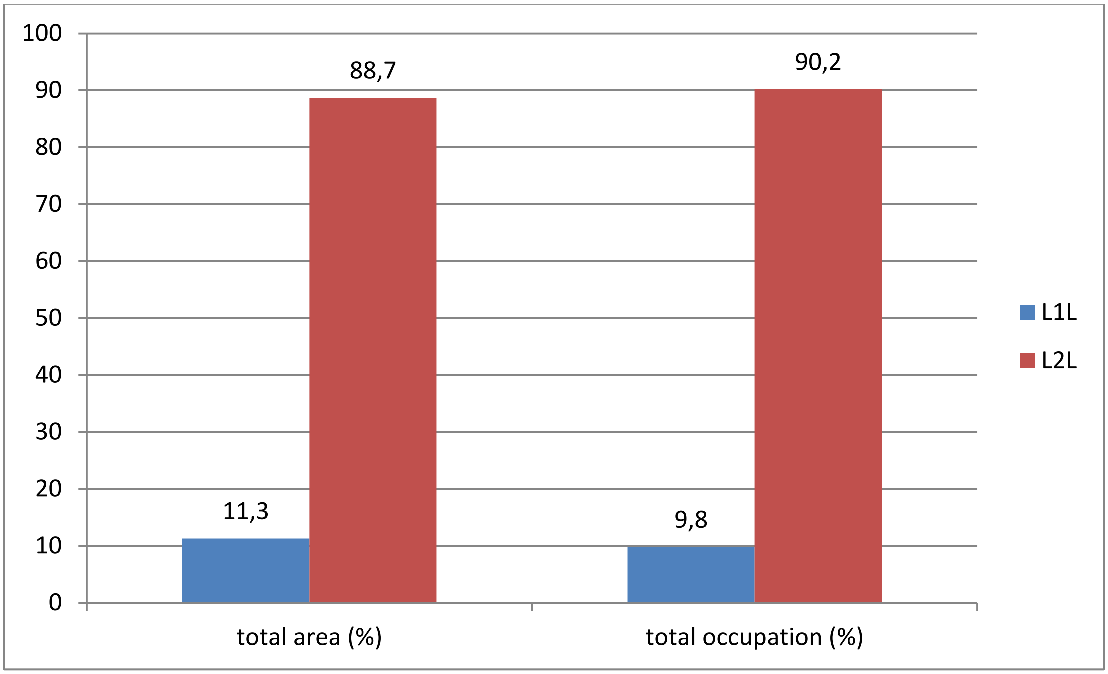


Table no.14: Total values of FR according to the class in %

class of FR	total length (%)	total area (%)	total occupation (%)
L1L	9,7	11,3	9,8
L2L	90,3	88,7	90,2
total	100	100	100

Graph no.6: Total values of FR according to the class in %



5.2.7 Occupation of FR by single surface type

To determine which surface of the road has the greatest occupation effect and which on the other hand the smallest was performed calculation which results are shown in table below (table no.15). Calculation was made by detection of percentual total value of occupation for each surface type where was the total area of the single type taken as 100 percent.

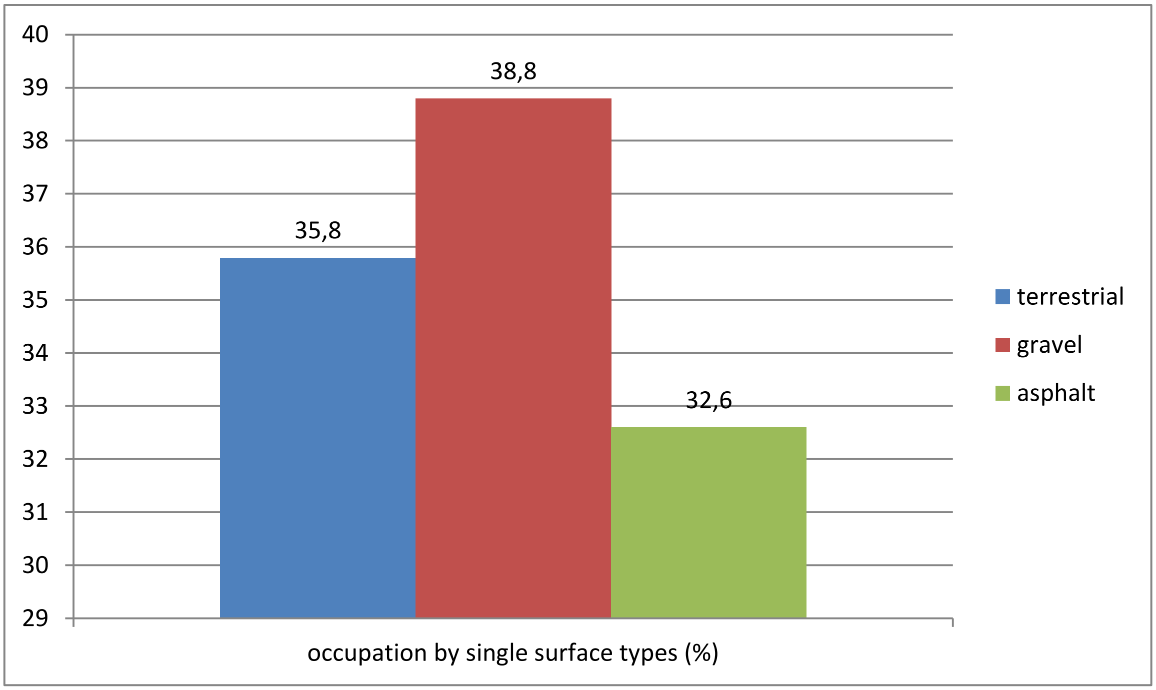
However there were not found significant differences between individual surfaces. From the calculated results can be seen that the smalles reduces on production area have asphalt roads. Slightly 3% more is occupied by occupation cause by the terrestrial roads and the type with the biggest occupation area in our case were found gravel roads which are occupying almost 39% of the production area.

Different determined percentage values are shown in Graph no.7.

Table no.15: Occupation by single surface type

surface type	total area (m^2)	total occupation (m^2)	surface type occupation (%)
terrestrial	139538	49913	35,8
gravel	98920	38365	38,8
asphalt	18220	5936	32,6

Graph no.7: Occupation by single surface types



5.2.8 Important total values

Table no.16 shows all important values obtained from exporting attribute tables from ArcGIS for each layer. Forest with occupation then value of pure forest (forest without occupation) therefore useable production area. The third value is forest without occupation and also without forest roads area. Followed by a single value of the total occupation area. Landing, which is in the next table added to the occupation becuase its a part of it. Extras are areas such as constructions, water areas and also roads in surveyed areawhich are not taken as forest once. On the bottom of the table are listed the total values on the studied territory. Table also contains both units square meter and hectares.

Table no.16: Summary of total values

	m^2	ha
forest with occupation	22866592	2286,7
forest without occupation	22772378	2277,2
forest no occupation no FR	22515700	2251,5
occupation	94214	9,4
landing	5413	0,5
extras	132656	13,3
Total surface area	**23004661**	**2300,5**

As the most important final values of this work were selected as follows (Table no.17). Landing was added to occupation becasue it its part. Forest production area is the total area, which is not limited by forest roads and is able to perform the production function. And also extra areas mentioned already above. These three values are considered as one of the most important results of the whole thesis.

Table no.17: Overview of the main values

	m^2	ha	(%)
forest production area	**22766965**	**2277,2**	99,0
occupation	**99627**	**9,9**	0,4
extra areas	**132656**	**13,3**	0,6

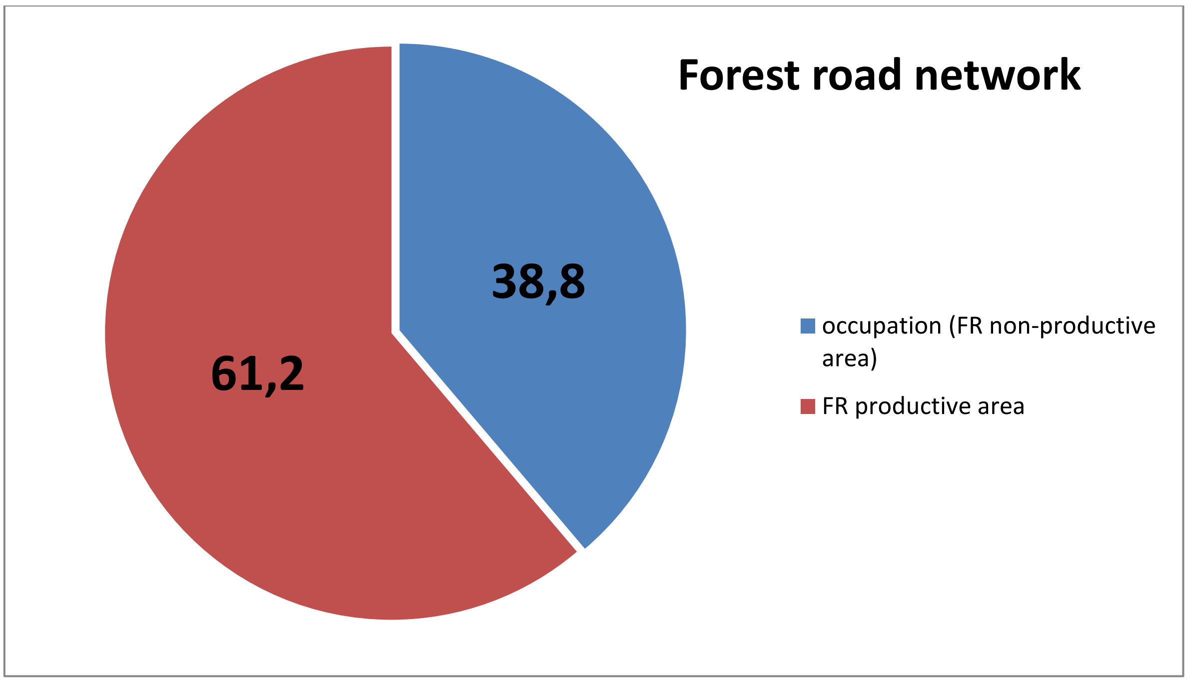
5.2.9 Productive and non-productive area

Table no.18 shows the pure area of forest road network in examined area on which is shown which part of this area is used for production area of forest road network and on the other hand which one is not productive so means that it is occupation. It is clearly seen that the production area of the forest road network is 61,2 % significantly larger than occupation which takes the rest which is just 38,8 % (graph no.8).

Table no.18: Productive and non-productive area of forest roads network

	m^2	ha	(%)
Forest road network	256678	25,7	100
occupation (FR non-productive area)	99627	9,9	38,8
FR productive area	157051	15,8	61,2

Graph no.8: Productive and non-productive area of forest roads network



6. Disscusion

Thesis deals with the problematic of occupation of the production area of forest road network. From historical perspective it is quiet an interesting area because forestry in Czech Republic has a long tradition. One of the most important part of forest management is forest contruction and mainly investment construction of forest road network. The basis of optimal management of forests and forest stands is their rational access by forest road network which can in some cases reduce production area in that locality.

Investigate resulting values show that the occupation of production area by forest road network does not reach a great values thus i would not include it among the elements which are significaly influencing the prodution area.

The total occupation of production area of forest by forest road network was in one examined territory of Forest management Ostravice around 1,16%. Occupation of production area was considered according to the meaning of forest haul roads as insignificant. In the territory was calculated that 1 km of haul roads with adjacent landings and storages will take approximately 0,44 hectares (Tománek, 2011).

In comparison with the obtained data in this work were found out similar values regarding to the percentage occurrence of forest road networks 1,12%. 1km of forest roads with all the storages, landings and other placesconnected to the forest management occupies about 0,26 ha. There is certain value difference because of the different measured territory, different types of roads and also mostly cause of more detailed analysis executed in this paper. That was done on individual roads in great details, since it was the main topic of thesis.

Hoever the occupation has low values and practically i nour case doesnt rapidly limit the production area there is many options how to prevent occupation even more and yet achieve optimum accessibility of forests. For example by calculating the optimal density of roads, by design of suitable surfaces and classes of forest roads before their construction or also by some specific species composition aroud chosen forest roads.

Under optimal accessibility of forests we understand ideal distribution routes of foreest roads, traffic lanes, special-purpose land and air communications with their optimal structure (Abundance and composition, means representation of different types of roads) implemented within forest road network so that length of the cunstructed communication and their area (occupation of production area) was the lowest and at the same time is achieved the highest percentage of access considerated area and optimal approachable distance for the application of various technologies of wood transport out of the forest (Klč, 2006).

7. Conclusion

Thesis dealt with issue of occupation of prodution area by forest road network. From the current point of view it is quite an interesting area because forestry has in Czech Republic very long tradition. The main aim is to tryeliminate the occupation as much as possible to get the maximum possible production areas. This can be achieved thanks to calculations comparing the maximum possible production area with the most economically effective density of forest road network.

Work in the literary recherche mentions not only basic definitions to clarify the terms but it also deals with ways of forest roads using, forest roads history and their importance. It also discuss all the categorizations of forest roads and with it associated the most important standarts and their new chenges ehich happened during the last year. For completing were mentioned the msot significant formulas for calculation of the main indicators regarding to the forest roads.

The second half of the theoretical part was focused more on describtion of the effect of forest roads on the environment. The intention was to find besides the negative impacts the possitive once. In several cases was found alot positive effects. These include the rapid growth of young tree crowns.

Part of the metodics involved a close look at the way which were achieved the results. From terrain mapping and measuring in forest territory of Voderadské bučiny close to Kostelec nad Černými lesy to following processing of all measured data and creating of map materials in ArcGIS program with the values and structure of the forest road network. The resultsof mathematical calculations also as ocularly identified information confirmed that forest roads have different effects on the occupation of the production area due to exact type and class of forest roads.

As conclusion a also a major findings were determined values for only pure area of forest road network in studied territory which shows what part of this area is used as productional area of forest road network and on the other hand which part is not productional so it is the occupation. From the final value we can see that production area in territory of forest road networks is used here substantially bigger part up to 61,2% compared to the occupation which represents 38,8% of the total forest roads size of surface 25,7 ha.

8. References

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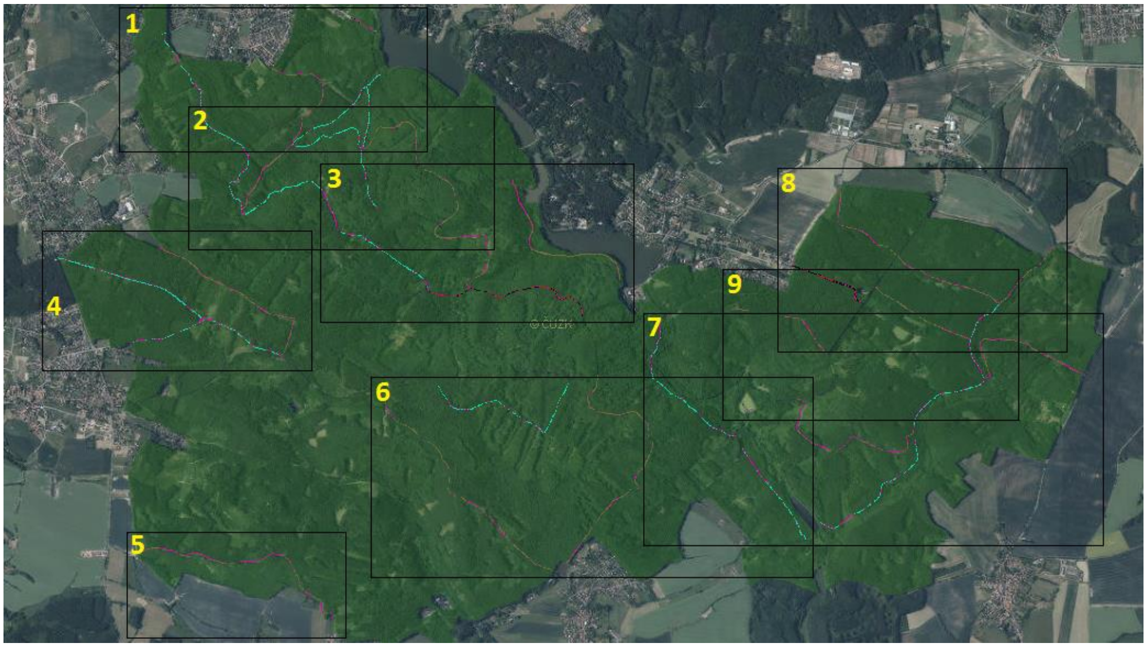
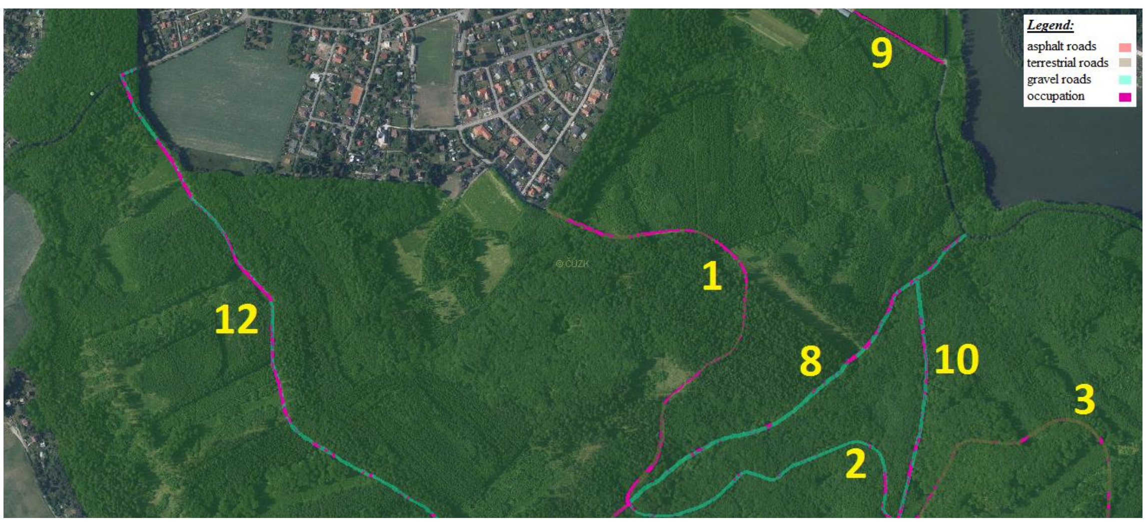
Appendices:

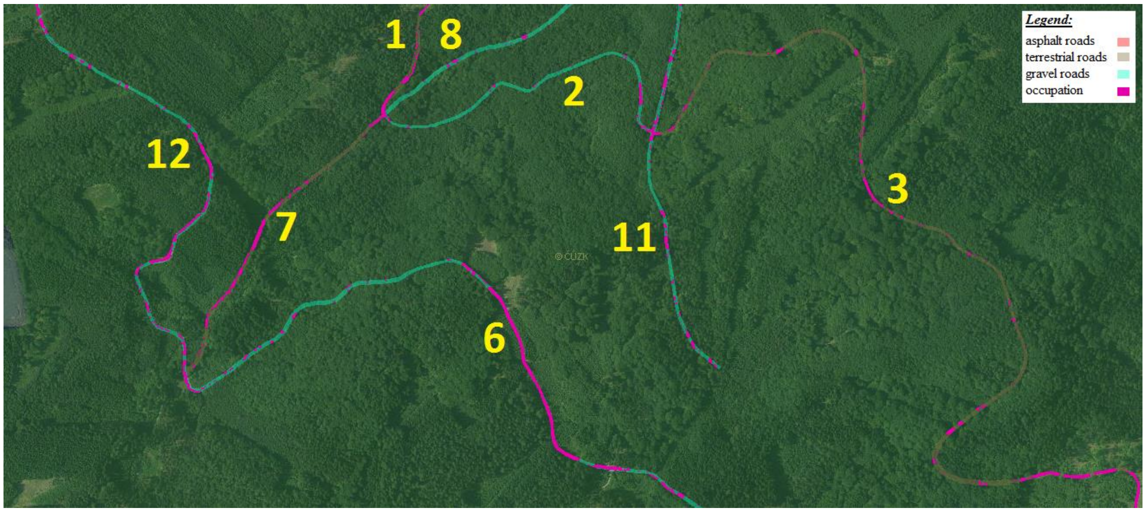
Appendix no.1: Map of sections of detailed areas further listed in annex



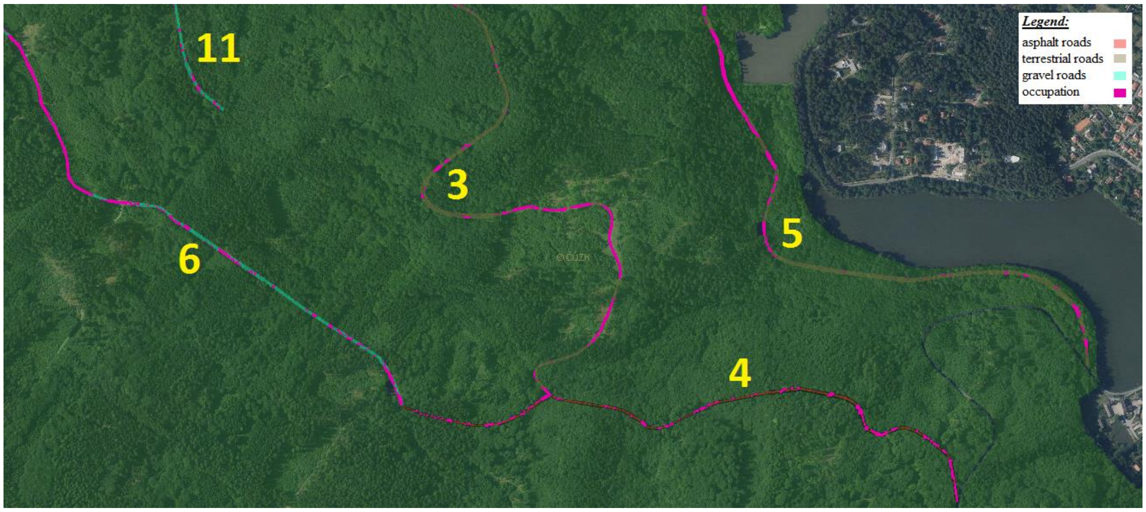
Appendix no.2: Detailed map of section no.1



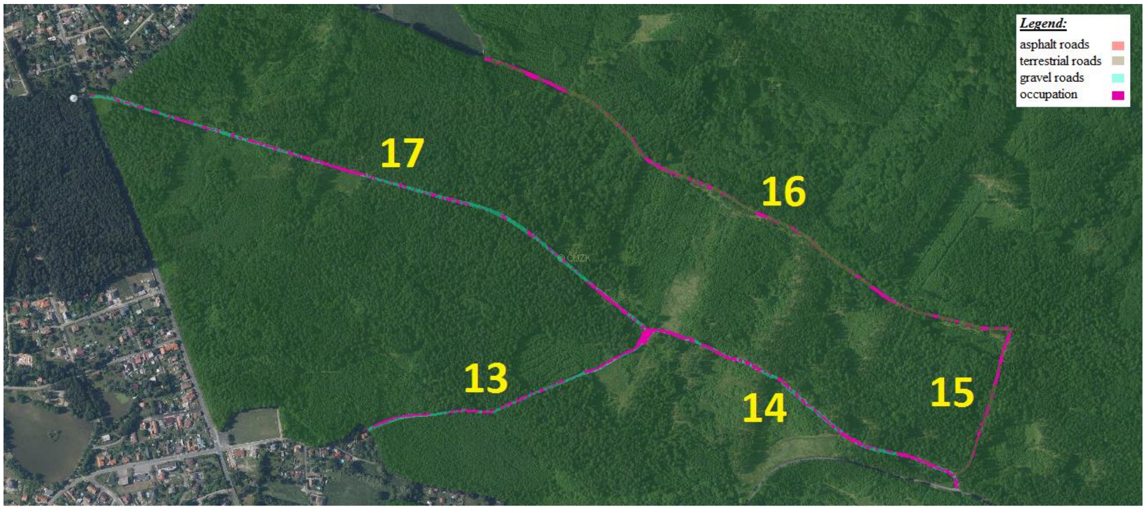
Appendix no.3: Detailed map of section no.2



Appendix no.4: Detailed map of section no.3

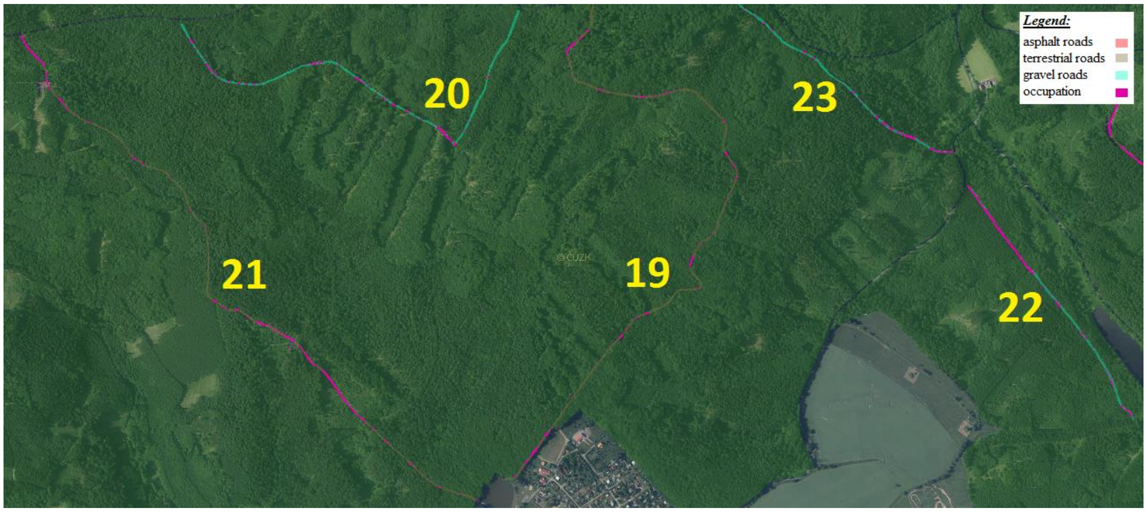


Appendix no.5: Detailed map of section no.4

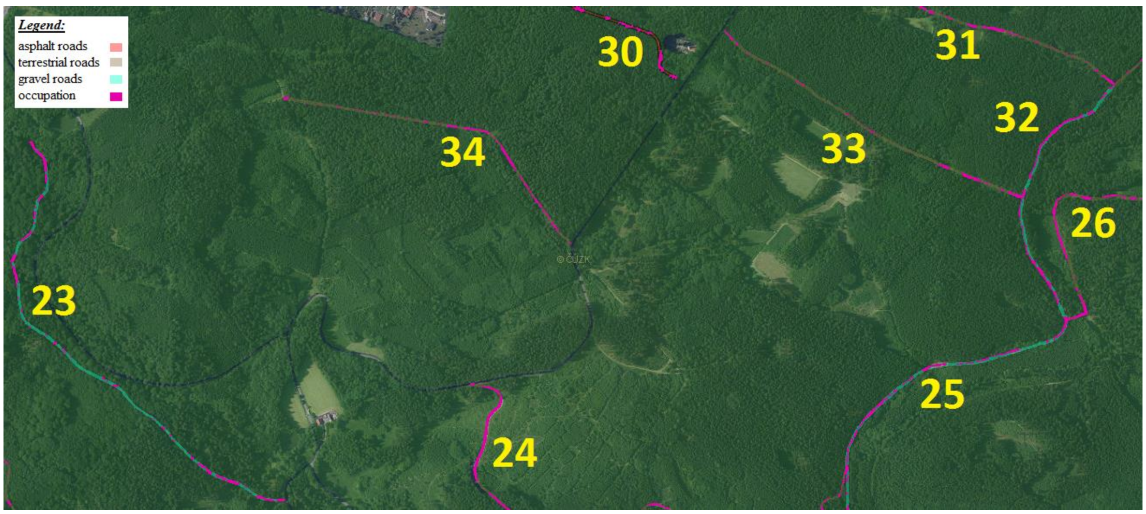


Appendix no.6: Detailed map of section no.5

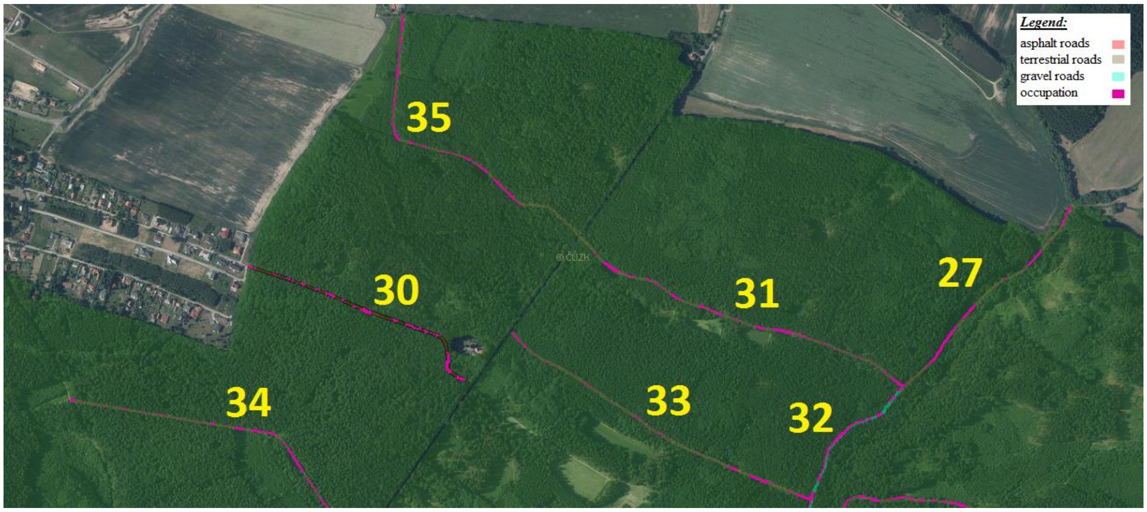
Appendix no.7: Detailed map of section no.6



Appendix no.8: Detailed map of section no.7



Appendix no.9: Detailed map of section no.8



Appendix no.10: Detailed map of section no.9