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M. Sc. THESIS

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DIPLOMA THESIS ASSIGNMENT

Kapuka Alpo Mpande

Thesis title

Forest cover change in the Czech Republic - trajectories, drivers

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Objectives of thesis

1) Forest cover change analysis, defining trajectories
2) Analysis of drivers behind the forest cover chnages

Methodology

Study area

The study will be based on the case study analysis. The concrete study area will be delimited respecting the basic methodological criteria.

Source data

Statistical data on forest cover changes.

Observed characteristics

Basic characteristics of the forest cover macrostructure.

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DECRALATION:

I Alpo Kapuka Mpande hereby declare that I solely worked on this master thesis as one of the prerequisite requirements for the M.Sc. degree at the Faculty of Forestry and Wood Sciences, Czech University of Life Sciences Prague. I have carried out different studies that are connected with my research on my own; thus I declare that I only used those materials as references in my work.

Alpo Kapuka Mpande

Prague, 30 April 2014

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ABSTRACT:

There are many forces that act individually or together to create changes in the forest and landscapes. This Thesis serves as a case study to assess the spatial changes in forest cover in the entire Czech Republic. Main questions: How much did the forest cover change in macrostructure? And what are the main driving forces behind these changes? The study aims to provide answers to these questions through forest cover change analyses. This can be useful in forest management and planning. The study was carried out in the Czech Republic which is located in the Centre of Europe with neighbouring countries Austria, Germany, Slovakia and Poland. Due to its location, Czech Republic has undergone a lot of forest cover changes, it's important and interesting to analyse this changes. The data was collected from the database of land-use of the Czech Republic. The main variables observed in the study were: the total forest cover change (ha and %) and changes in intensity (ha/year). The forest cover in the Czech Republic increased well from 1845 -1990. Between 1990 and 2000, there was a very small increase in forest. The highest increase in forest occurred in the year 1948-1990 and lowest was from 1990-2000. The year 1948-1990 also saw the highest intensity in forest cover change than the other years. The drivers that contributed to these changes are mail from human impact and socio-economic factors.

Key words: Forest cover; Czech Republic; Drivers; Trajectories; GIS; Forest development.

ABSTRAKTA:

Existuje mnoho příčin, které samostatně nebo společně působí k vytvoření změn v lesích a krajinách. Hlavním cílem této studijní práce je zaměření se na vývoj lesů v celé České republice, na jeho trajektorie a příčiny. Hlavní otázky: Jaká je změna v makrostruktuře lesních porostů a jaké jsou hlavní příčiny za těmito změnami? Práce usiluje o poskytnutí odpovědí na tyto otázky prostřednictvím analýz o změně lesních porostů. To může být užitečné při hospodaření v lesích a jeho plánovaní. Práce byla provedena v České republice, která se nachází v centru Evropy sousedící se zeměmi, Rakousko, Německo, Slovensko a Polsko. Díky své poloze, prošla Česká republika mnoho změnami lesního porostu, je proto velice důležité a

také zajímavé, tyto změny analyzovat. Data byla získaná z databáze - Využití půdy České republiky. Hlavní pozorované změny v této studiní práci byly: změny celkového lesního porostu (ha a %) a změny v intenzitě (ha/rok). Lesní porost se v České Republice od roku 1845 - 1990 zvýšil. V letech 1990 - 2000 byl naopak nárůst lesů velmi malý. K nejvyššímu nárůstu lesů došlo v letech 1948 - 1990 a nejnižší byl v letech 1990-2000. Nejvyšší intenzita změny ve vývoji lesa byla zaznamenána v roce 1948 – 1990 a to více než kdy předtím. Mezi hlavním příčiny, které přispěly k těmto změnám byly lidské vlivy a sociálně-ekonomické činnosti.

Klíčová slova: lesní porost; Česká republika; příčiny; trajektorie; GIS; Vývoj lesa.

Table of Contents:

1. Introduction

Forest cover changes gradually all over the world including that of the Czech Republic and it's influenced by different factors (driving factors). These factors can be natural or caused by humans. Driving factors can be divided into two groups, Natural factors and socio-economic factors. There are also many other factors that contribute to the forest cover change or land use in general for example country border areas (Iron Curtain). On the other hand border regions are usually political motivated.

Forest cover change had followed different paths (trajectories) for the past years, with the influence of different activities that had occurs many years ago or recently occurred. Therefore, it's important for us to study and try to understand these trajectories, to understand how much did the forest cover changed in past years, in which areas of the country did it change more or less.

1.1 Land use and land cover change

Land-user and land-cover (LULC) change is a common aspect impacting local to global scale processes which usually involves satisfying human daily needs and the protection of ecosystem (Sleeter et al.2012). This land use and land cover change has been growing as a main focus area in international or global change research, and in some part of the world like the USA, it has been shown to have direct impact on weather and climate systems, surface radiation and biogeochemical cycling.

Several studies have been recently converged to identify the rising importance of distant drivers of land cover change, interrelation between social-ecological systems that are separated geographically and indirect consequences of land use change (Meyfroidt et al. 2013). Local and nation-scale interventions to promote sustainable land use may have unforeseen effects to a displacement of land use within and across the globe. Causes in forest cover change have evolved over time, and in some part of the world, small scale farmers supported by the government were seen as the main actors in forest cover change. Normally, forest cover change and other land use change are regarded as domestic issues. With the increase of

globalization and urbanization, the agents of forest cover and land use change have changed, for example in Latin America and South East Asia (Meyfroidt et al. 2013).

According to a study carried out on Land cover change between 1973 to 2000 in Conterminous United States, it shows that the LULC change was relatively rare, affecting only about 8.6% of the nation's land area cover over the period for 27 years of the study. Early researches of reforestation and forest transitions defined it as national scale shifts from shrinking to expansion of forest areas. It also focused on local and national scale processes: agricultural intensification and industrialization driving labour scarcity in agriculture and concentrating production on the most suitable land, scarcity of driving forest driving tree plantation, forest intensification and forest protection.

1.2 Forest cover changes around the world

1.2.1 Background of forest cover change

Although global rates of tropical deforestation remain critically high, there have been some decline over the period from 2000-2010, and many tropical developing countries have recently been through a forest transition (Lambin, Meyfroidt 2011). When people talk about forest transitions, they usually generalize about ways in which the extents of forest land change as societies undergo industrialization and urbanization (Rudel et al. 2010). The term forest transition was first brought up by Alexander Mather, who carried out a series of historical studies to illustrate the concept of forest transition. While historical analysis shows that these forest recoveries to date have only managed to recover about half of the forest that was historically lost and that a forest transition does not usually start until historically present forests had been reduced to small areas (Rudel et al. 2005).

Mather's idea was a very smart and was a very useful as a way to compile the changes and historical relationship between forests and societies. The idea contains significant value, particularly the period when the decline in forest contributes to both shocking losses in biodiversity and the rapid change in climate together with the rapid increase in human population.

1.2.2 Importance of Forest Transition

The effects of forest transition on hydrological cycles, soil conservation, climatic change and also the effect of biodiversity are important issues. While the effects of increase in forest on stream flow appears to depend on the size of the watershed (Rudel et al. 2005). Forest cover increases transpiration rate, reduces soil erosion and improve water quality by reducing sediment loads. Forest transition also helps to reduce the increase in greenhouse gases in the atmosphere by increasing carbon sequestration through the substitution of relatively carbon-rich secondary forest agricultural land with low carbon concentration. As the secondary age and biomass per hectare increases, the amount of carbon sequestered per hectare also increases (Houghton et al. 2000).

The impact of forest transition on biodiversity differs from place to place. In many places, endemic species can go extinct with earlier conversation of old growth forests into fields and invasive species will have established themselves in the disturbed habitats (Rudel et al. 2005). The re-emergence of secondary forests on uncultivated lands allows a lot of species to recolonize an area and extend the range of some species through migration and seed dispersal and regrowth help to reduce ecological fragmentation and also prevent additional extinctions. Due to the variety of importance of forest transitions, it can be easy to adopt the existence of forest transition in an uncritical way.

1.2.3 Land cover-Forest cover change (Transitions)

The point of change in forest transition happens when deforestation disappears and reforestation commences. The main focus on the forest-nonforest distinction, forest transition represents a subset of land use transition (Foley et al., 2005). With the increase in the desire to understand the circumstances that contribute to the forest recovery, analysts started investigating the forces that have contributed to the forest cover change both general and context specific ways. The shrinking of the world's forests is one of the main environmental issues of the day (Mather, 1992). In some areas economic development created many job not related to farming and this leads to farmers pulling off of the farmlands, prompting the regeneration of the forest in old area or fields (Rudel et al. 2005). In some places with shortage of forest cover, governments and landowners were forced to plant more trees in fields

A new era of large scale of land clearance dawned around 1050 AD and continued until around 1300. Some estimates that the forest area fell by half between 1000 and 1300. Land cover changes are often conceived as simple irreversible conversions from one cover type to another, and deforestation would be a total and permanent change from dense forest landscape to an area with low tree cover and agricultural expansion would mean the transition to permanent cultivation (Benoit, Lambin 2000). Land cover and land use change are most often non-continuous in space and leads to complex landscape mosaics and mixtures of forest cover type.

1.2.4 Forest cover change in developed world

In many developed countries, the area of forest is now increasing after a long periods of decline. (Bray, Klepeis 2005*)* described the term forest transition as observed historical processes of forest cover change as the society become more developed and industrialized. In the past 2 centuries, population growth, urbanization and industrialization have induced a prolonged decline and the partial recovery in forest cover in many regions for the globe. According to (Mather, 1992), the distribution of forest cover change is connected to a nation's social and economic growth. The point of change in this transition happens when the proportion of reforestation is more than that of deforestation. In some countries like New Zealand, 82% of pre-human was covered in indigenous forest and this figure has dropped to about 24%, and a total reduction in area of about 71% of the original forest (Ewerset al.2006).

Generally, in many developed countries forest cover declined at a rapid rate during the first stage of economic development, followed by a steady stabilization and consecutive trend toward forest transition (Mather, 1992; Rudel, et al. 2005). Historical researches have proven that the recoveries in forests have been only half of the forest that was previously lost, and that transition in forest usually does not initiate before historically present forests are decreased to smaller areas (Rudel, et al. 2005).

1.2.5 Forest cover change in developing world

While forest transitions were originally projected to have taken place only in industrialized countries, current studies shows different forms of forest transition in developing countries like Brazil. Many European countries went through forest change from deforested areas to forests after the so called Black Death in the mid-14th century. In the modern day's forest declined to 3 % of the land area in Scotland, 4% in Denmark and 7 % in China before the reverse occurred.

Meanwhile, New Zealand, South Korea and the United States had large areas covered in forest (Rudel et al. 2005). While forest transition has occurred in many countries, they are unavoidable. The circumstance in which they take place differs from area to area and in come place forest transition has never taken place yet. Forest transition meticulously defines the changes of forest cover in northern Europe between 1850 and 1980, but until up to date, it does not give a description of the historical changes in forest cover in southern Europe (Mather, 1990). In the Mediterranean basin, a combination of changing biophysical and socio-economic aspects over a period of centuries denoted to the gradual decrease in forest cover without any improvement until the last 3 decades of the 20th century

Forest recovery is a global trend and a great restoration of the world's forest underway despite the dominance of deforestation. In many parts of the world, deforestation is still a major issue, but the increase of forests recoveries and the ecological and the livelihood importance of secondary forests in general have been also acknowledged by the FAO. Some countries are showing ongoing deforestation; while others show forest recovery and others exhibit dynamic landscapes that are nonetheless relatively stable in terms of forest cover area.

1.3 Drivers of forest cover change and fragmentation

Forest cover change is a non- random process that reflects the particular history and conditions of a given location. According (Bürgi et al. 2004), driving forces are referred to as any forces that roots changes observed in landscape, they are the significant processes in the trajectories of landscape. Looking at land-cover change in general, drivers relating these changes can be physical environment forces such as soil properties, altitude, slope or availability of rainfall, or forces from

society and economy. In some cases, woody vegetation covers are affected by fire events and water availability or human impacts.

1.3.1 General forces contributing to forest cover change

Many studies have been conducted to elaborate the causes of land use cover change in different parts of the world for instance (Turner et al. 1990; Turner, Meyer 1994; Lambin et al. 1999; Geist. 1999, Lambin et al. 2001). Changes in land-use are caused by various, collaborating drivers from different stages of the complex human-environment interaction over time and space. It may not be easy to analyze a single factor that dominates the land-use land cover process in certain period. Driving factors can be linked as original chains or they can operate individual but together or different factors can also intervene in synergetic factor combination.

Originally, forest decline in extent as a growing number of cultivators, with the help from loggers, cleared forested lands and turned them in fields the purpose of meeting the increasing demands for food supply and other good for the populations in big cities. There are many forces that cause changes in the landscape. These forces can be from the point view of socioeconomics, technological, political, and natural and can even be cultural (Bürgi, Hersperger, Schneeberger 2004*).* In the Carpathian regions, some studies suggest that that the main drivers in land use cover change were institutional and economic factors during the period of interwar and the forest continued to increase after the collapse of socialism, other factors were socio-economic and demographic related (Munteanu et al. 2014).

There are many activities that took place that contributed to the transition and change in landscape. First, farm workers left their farms for better paying non-farm jobs. This loss of workers in farmland increased the pay of the remaining workers and made more agricultural enterprises less profitable. Farmers left their more remote, less productive farmlands and pastures. This land was converted to forests. The loss of farm workers for urbanization and economic development was described by some analysts like Polanyi (1944) as “the great transformation” (Mather, 1992).

In another situation that led to forest cover change was the loss of forest during agricultural expansion which created an offset tendency. This is one of the main reasons of the increase in forest in India (Foster, Rosenzweig 2003). Many

politicians' speeds up this type of reforestation when they create programs to reforest marginal lands in respond to floods and rising prices for forest products.

The main cause of changes in the southern America was urbanization. One of the leading causes of change in forest is the so called suburbanization. This causes permanent forest change, with millions of acre are lost to urbanization during the 1990s, according the National Land Cover Dataset (NLCD). The rapid increase in population and increase in cities contribute and help continue the decrease in forest cover. The US Forest Service also estimates that suburban encroachment will force approximately 12 million acres of southern forest from 1992-2020 and an additional 19 million acres between 2020 and 2040.

1.3.2 Collapse of socialism and its impact on forest cover

One of the most extreme recent episodes of land cover change that resulted in a huge rate of land use change took place after the collapse of socialism in the countries of former Soviet Union and central and Eastern Europe. The socialistic land use system was strongly subsidized in these countries with a guaranteed output and input prices and high land labour inputs. After the collapse of socialism, state support disappeared and agricultural production reduced in value in many areas. This resulted in economic collapse or reduction and many rural migrations.

Large areas of land use were abandoned and experienced succession and have reverted to young forest. Today, agricultural land use in Russia, Central and Eastern Europe is below the potential yields under given environmental condition. Due the recent increase in global agricultural commodity prices, abandoned land use in former socialist countries today represent an attractive source of income and increasingly becoming targets for investors.

1.3.3 Human impacts on forest cover

The bond between human activities, social systems and ecological systems are the main factors affecting the forest cover change in part if the world. Complication of these socio-ecological aspects are not well understood my many. Community livelihood activities to improve welfare and maintain food availability are the main remote drivers of land and forest cover change in countries like

Indonesia. Accidental fire from uncontrolled slash and burn system is one of the main mechanisms of forest cover change, while forest access, commodity prices and rainfall patterns are the external driver of this forest change.

One of the main environmental concerns is the hasty expansion of croplands and pastures as a result of tropical and subtropical forest and different adverse results for biodiversity. Culture is another driving force that causes changes in landscapes. It's one of the most intricate dimensions of changes in the environment. Some authors suggest that there are always driving forces that are behind the change in landscape and it's advisable to differentiate between primary, secondary and tertiary driving forces.

The practice of shifting cultivation, which is normally done in humid tropics, in areas with steep slopes and low population density is one of the primary causes of tropical deforestation (Geist, Lambin 2002*)*. However, some researchers have found out that this cultivation practice does not contribute to deforestation because within this system the fallow time is long enough for secondary forest to re-occupy the abandoned areas.

1.3.4 Socio-economic forces

Political changes in the Soviet Union during the year 1991 give an unusual situation of drastic developments in social and economic conditions, and this give a good opportunity of study the impacts of socio-economic on forest cover change. The forces of socio-economic are based on economy, for instance the market economy and globalization and some international agreements on marketing in today's world. The developments in technology have changed the landscape in many ways. (Kienast et al. 2004) predicted that in the future, Information technology might also become another contributing force.

Market requirements and prices are often used by agricultural economists to explain the land–use change. There is proof that increase in prices for agricultural goods leads to rapid agricultural expansion and causes deforestation. As frontier agriculture becomes profitable, the existing population and migrants from other locations begin to move resources into forests. Technology in agriculture is also believed to have a direct influence on the land-use for example in farming areas and

indirectly on product and prices. Some studies have proved that technical changes in higher land productivity reduce pressure on the forest and slow down deforestation or even stimulate reforestation (Muller, Zeller 2002).

Additionally, governmental actions are also believed to have an impact in the land-use cover change. Some policies intent to promote sustainable forest management, for instance the establishment of nature reserves and protected areas, financing reforestation practices, prohibition of timber or log export, building irrigation system and the use of upgraded crop types.

1.4 History of land use change in the Czech Republic

To understand the current state of forest cover or land use in general and predict its future, historical perspective is of very important. Studies such as regional land use make it more easy and possible to compare the vitality and the structure of the driving forces of land use change at different spatial levels (Bičik et al. 2001). Information on historical land use of the Czech Republic are available for the years that represent the most important state of current or modern Czech History.

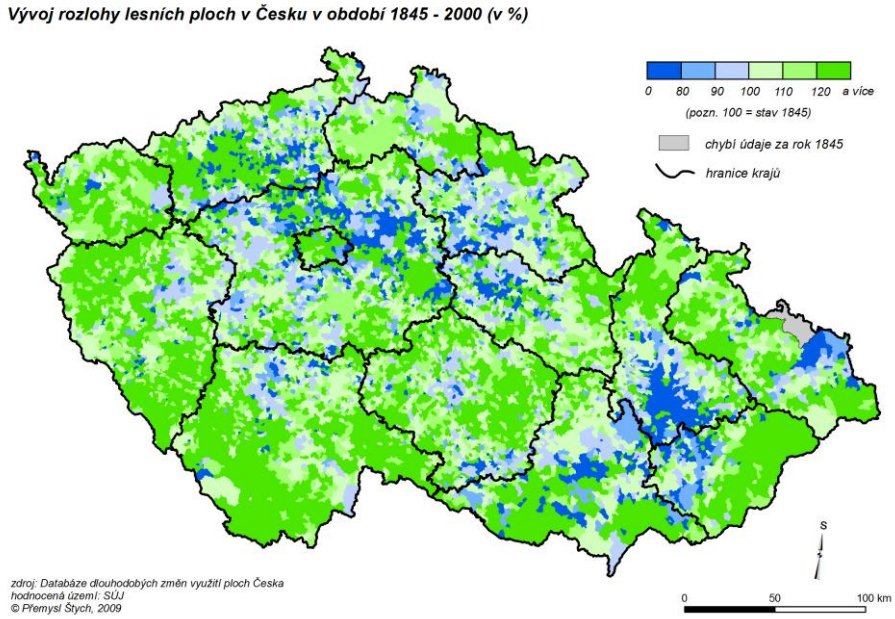
The Czech Republic is one of the smaller countries in Europe. However it has great natural riches such as forest biocenosis. Forest is a very important asset of the Czech Republic with a long history and serving many purposes for the country and its people. The current situation of forest cover in the Czech Republic is the results of historical developments such as the affiliation of humans and the environment, which occurred many years ago. One of the most significant events that changed human interaction with nature in the Czech Republic was the adoption of Forest Policy in 1754, which set up regulations for forest management (Skaloš et al. 2013).

1.4.1 Changes from 1845-1948-1990

This is the period of industrial development, agricultural boom and the rise of conditions of market economy. The year 1845 is the year of land -use in final period of feudal era, the year 1896 is the year of technological-scientific revolution in agriculture and 1948 is known as the year of communist revolution. All this developments influenced land-use and forest cover in different ways (Štych, Hofman 2012). Forested area remained stable at about 30 percent (Lipský, 1995). According

to (Skokanová et al. 2012), arable land was the prevalent land use category until the 1950s, while forest was the second largest.

Figure 1.1: Forest cover change in Czech Republic during the year 1845-2000 (in %).



Source: database LUCC UK Prague

The vast regions, primarily in the frontier, became practically uninhabited and despite resettlement efforts, this meant a decrease of agricultural land, in particular arable land and the increase in forest as well as meadows and pastures (Bicík, 2001). Fertile low lands along the rivers were damaged by the location of chemical industries and power plants, waste material from mines (Jeleček, 1994). Environmental changes were higher during the 1970s due to the broad changes or development in the economy (Kopačka, 1992). Most of this decreases in arable land occurred in mountainous areas, with the highest share of arable land occurring toward the end of 19th century with about 51.6%.

According to (Jeleček, 1995), while the percentage of arable land was extended by 7.1% in the period of 1845-1882, it reduced by 1.8% in the next period from 1882-1897. The cultivation of land caused damage to natural ecosystem and started large-scale soil erosion; this effect also depended on the type of crops or plants been cultivated, with corns and root crops like potatoes and sugar beets being the biggest cause of erosion (Bičik et al. 2001).

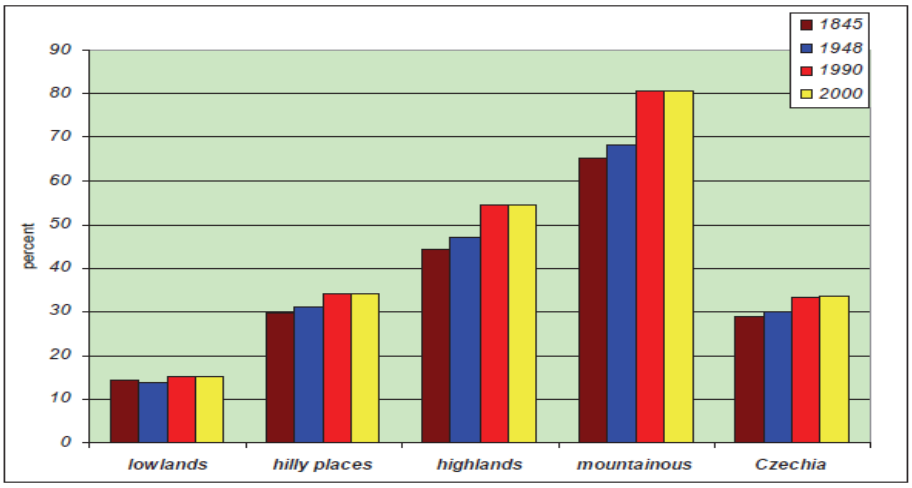
Table 1.1: Share of selected land-use categories in the Czech territory 1845-1999 in (%)

Year	AL	PC	PGL	AGL	FA	OA
1845	48.2	*1.1*	**17.6**	66.9	*28.8*	4.3
1897	**51.6a**	1.5	14.2	**67.3**	28.9	*3.8*
1929	50.6	1.5	13.4	65.5	30.0	4.5
1948	49.9	1.9	12.9	64.7	30.2	5.1
1961	42.7	2.6	12.6	57.9	32.7	9.4
1970	42.1	2.7	11.8	56.6	33.0	10.4
1990	41.0	**2.9**	*10.5*	54.4	33.3	12.3
1999	*39.3b*	3.0	12.0	*54.3*	**33.4**	**12.3**

AL- arable land; **PC**- permanent cultures; **PC**- permanent grassland (meadows); **AGL**- agricultural land; FA- forested areas; **OA**-other areas (*source: Bičík et al.2001*)

Values in bold are the maximum level from 1845-1999
Values in italics are the minimum level from 145-1999

Figure 1.2: show the shares of forest cover change according to the altitude



Source: Database LUCC UK Prague

The reduction in agricultural and arable land in frontier regions was mostly the results of post-war political reasons. A large number of fields were converted to pastures and meadows. These developments brought positive changes, especially in the hilly frontier regions (Bičík, Štěpánek 1994). On the other hand, large areas of agricultural land were lost in Northern part of Bohemia, in the fertile land of the Ore Mountains due to coal mining and industries works (Bičík, 1988).

Table 1.2: Land-use change in Czech Republic during periods 1845-1948-1990 (in 1000 ha and %)

Land–use category	1845-1948		1948-1990		1990-1999		1845-1999	
	Ha	%	Ha	%	ha	%	ha	%
AL	108	28	-704	-17.9	-129	-4.0	-725	-18.9
PC	59	65.6	76	51.0	11	4.9	146	162.2
Me	-17	-23	-142	-19.8	87	15.1	-72	-9.8
Pa	-335	-54.0	-47	-15.5	28	10.9	-374	-56.8
AGL	-205	-3.9	-817	16.0	-3	-0.1	-1.025	-19.3
FC	**103**	**4.5**	**247**	**10.4**	**4**	**0.2**	**364**	**15.5**
WA	-24	-33.3	3	6.3				
BUP	39	84.8	41	48.2	33	26.2	113	245.7
RA	41	18.1	526	197.0				
OA	56	16.3	570	142.0	-3	-0.3	623	181.1

Note: **AL**-arable land; **PC**-permanent cultures (gardens, orchards, vineyards); **PGL** - permanent grassland; **Me** - meadows; **Pa**- pastures; **AGL**- agricultural land; **FC**- forest land; **WA** - water areas; **BuA** - built-up-areas; **RA** - remaining areas (roads, Railroads, plots of land used in industry and agriculture surrounding buildings, coal carriers, etc); **OA** - other areas

Table 1.3: Average change of land-use categories per year in Czechia (in ha)

Land use category	*period*			
	1845-1948	1948-1990	1990-1999	1845-1999
AL	1049	-16762	-14333	-4708
PC	573	1809	1222	948
Me	-165	-3381	9667	-468
Pa	-3447	-1119	3111	-2429
AGL	-1990	-19425	-333	-6656
FC	**1000**	**5881**	**444**	**2298**
WA	-233	71	-	-
BUP	379	976	-	734
RA	398	12524	-	-
OA	544	13571	-333	4045

(Source; Bičík at el, 2001)

1.4.2 Changes from 1990 – 2000 (the reintroduction of market economy)

The Structure, functions and other characteristics of landscape in central Europe results from long-term changes. At the start of the 20th century, arable land covered more than 75% of the agricultural land in the Czech territories compared to other countries in Europe. Agriculture makes up 2/3 of the country and in areas that

are more productive, agriculture raised up to 80-90%. While the area of forest cover stayed stable at about 30% (Lipský, 2000). There were a lot of changes in land-use, for example, many fishponds and pastures were converted into arable land, while meadows were just concentrated in wet areas

1.4.3 Changes in urban areas

1989 saw the begging of economic process in the Czech Republic and the problem of usage and change of urban areas became more significant. Before the revolution known as the velvet revolution in 1989, the growth of urban areas like cities in the surrounding landscape was of limited due to many forces typical of the socialist system. Sources of income were allocated by special policies for settlement structure and the law for land preservation was very severe. Nevertheless, after 1989 with the re-introduction of a market economy, private and land market, residual activities raised, in commercial, industrial and infrastructure usage of the space in sub urban areas. The tension on landscape and settlement activities on fertile soils has rapidly increased in the mid-1990s (Štych, 2011).

1.4.4 Land-use change in border areas of Czech Republic

The study of forest cover change close to the Iron Curtain gives a clear comparison of land use development of the Czech Republic and that of the neighbouring countries like Austria. The changes that took place on both sides of the border differ. The relocation of German rulers from the borderland, installation of Iron Curtain caused significant changes in landscape and the settlement abandonment in the Czech Republic in the 20th century. On the other hand, land cover in Austria was not too extreme, compared to that of the Czech Republic (Štych, 2011).

As described in table 1.2 and 1.3 above, the main changes after the year 1990 in land- use includes the decrease in agricultural and arable land. The total decrease is seen as the largest decrease compared to that from 1845-1999, the state of meadows and pastures started to increase seriously, especially in the highland and mountainous areas, other increases were the residual and built-up areas and finally the forest cover continues to expand slightly. Studies based on land-cover change along the Iron curtain have shown different patterns in land cover along the borders of Czech Republic, especially on the eastern and western parts. Land-cover was more

intense in the east side after the 90s, while the highest intensity in land-cover change was confirmed in the Czech Borders, but these changes were results of afforestation that occurred in these areas (Kupková et al. 2013).

1.5 The current state of land-use /land cover in the Czech Republic

There had been a lot of changes in the Czech forest for the past century. For instance, the natural stable forest have been changed and replaced by unstable spruce and pine monoculture, and this does not perform the same functions as the natural or semi-natural forest. (Sádlo, Pokorný 2003) proposed that the modern changes in the landscape and vegetation are of equal in size to the main changes that happened during the time of Neolithic agriculture and after the medieval colonization. The main current causes in landscape changes are connected with decline in small scale disturbance caused mainly by ways of management in agriculture and forestry.

Nowadays, species of light demanding and stress tolerant from the forest and oligotrophic grasslands of the 20th century are invading species poor vegetation that are occupied by nutrient demanding species. Moreover, the current landscapes are defined by strong disturbances of spatial extent, supporting fast spreading species and many areas are abandoned for the purpose of encouraging succession. The reduction in forest cover slowed down in the mid-19th century. At the beginning of 20th century, arable land represented about 75% of the agricultural land in the Czech territories; this is more than in any other European countries at that time.

1.5.1 Forested land and forest protection in the Czech Republic

The Czech forest cover now stands at about 34% of the total area of the country, of this 0.3% is categorized as primary forest. This is the most diverse and carbon-dense forest (FAO). These figures have been increasing steadily for the past years. This is due to the increase in importance of the forests. The forest is managed in a very sustainable way.

Table 1.4

Forests Owned by State

State Organisation with the Right to Manage / Authorized to Manage	Forest Area (1,000 ha)	%
Forests of the Czech Republic, S.E.	1 359,1	86,0
Military Forests and Farms of the Czech Republic, S.E.	126,6	8,0
Administrations of National Parks	89,9	5,6
Office of the President of the Republic	6,0	0,4
Total	**1 581,7**	**100,0**

Source: Ministry of Agriculture

For the purpose of sustainable forest management, new policies and new system of maintenance and subsidies for private forest owners were adopted. The relocation of part of the forest back to the church means that another 6% of the forest will require the right management (FAO, 2003). The complete change in forest did not involve only giving back part of the forest to the owner, but it also took steps like creating legal entity Forests of the Czech Republic. Small part of the state forest is being proposed for privatization for the purpose of integration of scattered holdings. An important share of the forest belonging to the state is considered to be a balance factor, which can bring positive results in areas affected by pollution and improve timber market and social economic activities.

Table 3.5

Changes in Forest Ownership (% of total forest land)

Owner	1999	2000	2001	2002	2003	2004	2005
State	64,3	63,1	61,5	60,7	60,5	60,0	59,8
Municipalities	13,0	13,6	14,4	15,0	15,1	15,4	15,5
Regional Governments			0,2	0,2	0,2	0,2	0,2
Church							
Forest Co-operatives	0,9	0,9	0,9	1,0	1,0	1,0	1,0
Public Universities		0,3	0,3	0,3	0,3	0,3	0,3
Private	21,8	22,1	22,7	22,8	22,9	23,1	23,2
Total area (1,000 ha)	**2 634**	**2 634**	**2 634**	**2 639**	**2 644**	**2 646**	**2 647**

Source: COSMC (Czech Office for Surveying, Mapping and Cadastre), Ministry of Agriculture

The Czech forests are classified in 3 categories. A commercial forest that makes 76.1 %, protected forests takes 2.9% of the forest cover and special purpose forests with 21%. There are also preconditions for sustainable forest management in

the Czech Republic, this includes the preparation of Regional Plans of forest development, Forest management plans (FMP) are mandatory for forest bigger than 50 ha, for smaller forest properties, Forest Management Guidelines are used. Forest management rule states that the area of clear cut of the forest should not exceed 1 ha, and its width must be less than 2 times average height of the felled stand. It is prohibited to reduce the forest stand density during felling under 0.7 of stocking. Intentional clear cuttings in the forest stands under the age of 80 years old is prohibited and the clear cut areas on forest land must be reforested within 2 years.

Table 3.6

Forest Species Composition (ha and % of Total Timber Land)

Tree Species	Year					
	2000	2001	2002	2003	2004	2005
Spruce	1 397 013 54,1	1 395 328 53,9	1 391 970 53,8	1 385 122 53,5	1 381 407 53,2	1 376 387 53,1
Fir	23 138 0,9	23 020 0,9	23 092 0,9	23 363 0,9	23 534 0,9	23 918 0,9
Pine	453 159 17,6	451 911 17,5	450 224 17,4	449 092 17,4	447 013 17,3	445 270 17,2
Larch	97 170 3,8	98 053 3,8	98 397 3,8	99 285 3,8	99 707 3,9	99 784 3,9
Other Conifers	4 587 0,2	4 484 0,2	4 906 0,2	5 095 0,2	5 617 0,2	5 674 0,2
Total Conifers	**1 975 065 76,5**	**1 973 099 76,3**	**1 968 588 76,1**	**1 961 957 75,8**	**1 957 278 75,5**	**1 951 036 75,3**
Oak	163 761 6,4	164 930 6,4	166 603 6,5	168 278 6,5	169 150 6,5	169 768 6,6
Beech	154 791 6,0	157 381 6,1	160 976 6,2	164 797 6,4	168 212 6,5	172 047 6,6
Birch	74 560 2,9	74 629 2,9	74 505 2,9	74 750 2,9	74 447 2,9	74 074 2,9
Other Broadleaves	186 185 7,1	199 347 7,6	188 865 7,2	195 388 7,4	194 064 7,5	197 663 7,6
Total Broadleaves	**576 808 22,3**	**583 125 22,5**	**590 949 22,8**	**600 213 23,2**	**606 983 23,4**	**613 552 23,7**
Total excl. Clear-cut Area	**2 551 873 98,8**	**2 556 224 98,8**	**2 559 538 98,9**	**2 562 171 99,0**	**2 564 261 99,0**	**2 564 588 99,0**

Source: Forest Management Institute

The Czech government supports in the forest management by providing services and financial subsidies. The forest act elaborates different actions or activities that are entitled to receive financial support for the state. The state also contains Forest Administration Bodies: District offices, Ministry of Agriculture and the Ministry of Environment which is responsible for national parks and supervisions of forest.

2. Main aims of the thesis

This study deals with the research of long term forest cover change in the Czech territory for the four time horizons (1845, 1948, 1990, and 2000). The main aim of this thesis is to evaluate the macrostructure changes in forest cover and its driving forces by analysing data on forest cover. It serves as a case study to assess the spatial changes in forest cover in the entire Czech Republic.

Main questions of the thesis:

1) How much did the forest cover change in macrostructure?
2) What are the main driving forces behind these changes?
3) The distributions of forest cover change in climatic regions of the Czech Republic.

The study does not only evaluate the forest cover changes in the whole country, but it also analyzes the distribution of these changes in 6 different climatic regions covering the country during the time period of the study. This is to find out the trends in forest cover change in different geo-climatic zones of the Czech Republic by comparing forest cover change in different random selected areas from each climate zone. The fundamental objective of this research was to analyze the change in forest cover and their causes.

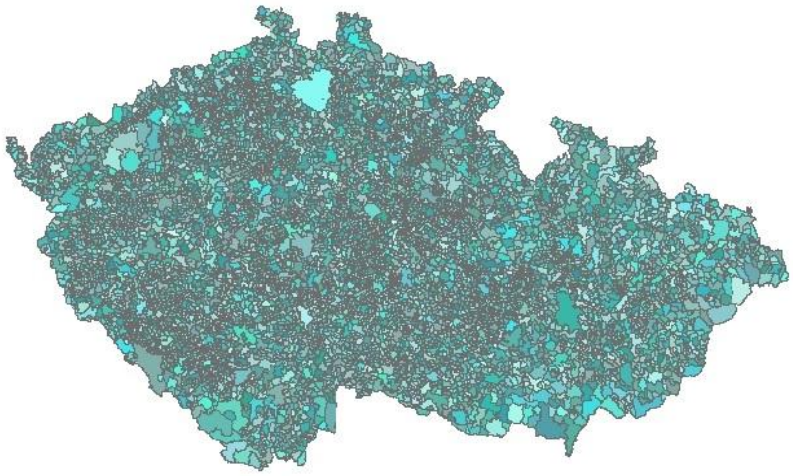
3. Methodology

3.1 Study Area

This master thesis was carried as case study focused on the entire territory of the Czech Republic. There are many factors that have contributed to the forest cover change in this territory. For the purpose of comparison of forest cover change in different part of the country, Basic Territorial Units or rather different cadastres (ZÚJ in Czech language) were chosen at random from each Climatic zone. The Czech Republic lies in the centre of Europe with a total area of 78866 km^2 and a population of about 10 513 209 (Sept.2012). It is a land-locked country and located in the zone of temperate broad-leaved deciduous type of forest which is in the south-east border on the forest steppe zone. Today, the vegetation situation is affected mostly by abiotic factors, for instance soil type, climate, geology, human activities and other

historical processes. The country shares its borders with Germany, Poland, Slovakia and Austria.

Figure 3.1: Basic Territorial Units (BTUs) of the Czech Republic



3.2 Data collection – source and methods

Data for this research was collected from the database of land use/land cover change in the Czech Republic (LUCC UK Prague), The database of long-term land-use changes in the Czech Republic 1845-2000 (Bičík et al. 2001; Kabrda, 2008). The database was developed by a team with their leader Mr. Ivan Bičík and it was sponsored by several other project of the Grant Agency of the Czech Republic. This is a statistical database, which summaries data based on land -use changes in hectares from different Basic territorial Units based on statistic from the Real Estate Cadastres *(*Kabrda, 2008). The data were extracted from different cadastral statistics.

The database of land-use/land-cover represents the land use for the whole Czech territory. The whole area of Czech Republic is divided into about 8903 Basic Territorial Units (BTUs) and each BTU contains 1 or more cadastres. The structure of land-use representing each BTU is recorded from four time horizons and they represent the main historical landmarks that took place in the Czech territory and they are: 1845 - this represent the first impact of modernization on land use, 1948– Communist revolution, 1990-known as the Velvet revolution and 2000 - time of

transformation. The Land use categories in the database are divided into eight main categories as follow: arable land, pastures, permanent cultures, meadows, water areas, Forest areas, built –up areas and finally remaining areas. For the purpose of this study, the interest and most important category was forest land.

3.3 Monitored land-use/cover categories

The Land use categories in the database are divided into eight categories as follow: arable land, pastures, permanent cultures (including: Vineyards, gardens, orchards and hop-gardens), meadows, water areas, Forest areas, built –up areas and finally remaining areas (including: non-productive land, bare land, infrastructure, mines and others). For the purpose of this study, the interest and most important category was forest land. The whole eight categories are sorted in three main categories:

1) Agricultural land - made up of arable land, permanent cultures, meadows
2) Forested areas,
3) Others - including water areas, built up areas and remaining areas.

Due to the fact that this study is only concerned with forest cover change, only the second category was considered. This study also follows some methodological processes from other studies done in similar studies.

3.4 Data analysis

The data extracted from the land use change cover database were in the form of a shapefile. I decided work with them in the Geographic Information System (GIS). The shapefile contained a table, which contained all the needed information based on the forest cover change. The shapefile included a list of all the BTUs that cover the whole area of Czech Republic. For each BTU, the following information is shown in the table: a) The total area in hectares for each time horizon (1845, 1948, 1990 and 2000), b) The total forest cover in hectares for each time horizon.

This information was used to represent the whole area of Czech Republic, where the total area of all the BTUs was calculated and this represent the total area of the Czech territory and the total forest cover for all the BTUs represent the total

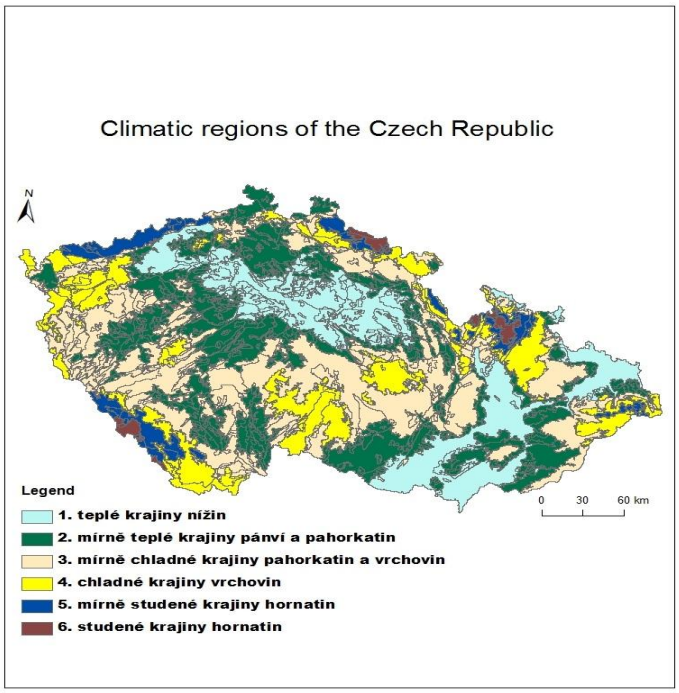
forested area of the whole country represented in each time horizon. This calculations were performed in excel.

3.5 Monitored Climatic Regions

Comparisons of forest cover change in different climatic regions of the Czech Republic were made. A shapefile containing information on the different climatic regions that cover Czech Republic was also provided by the office of LULC in Prague (LUCC UK Prague database). Using this shapefile a map was created in ArcGIS10 (fig.5.2), showing the following climatic region of the country:

- Teplé krajiny nížin - **Warm landscape lowlands**
- Mírně teplé krajiny pánví a pahorkatin - **Slightly warm and hilly landscape pans**
- Mirně chladné krajiny pahorkatin a vrchovin - **Relatively cool hilly landscape**
- Chladné krajiny vrchovin - **Cool highlands landscape**
- Mirně studené krajiny hornatin - **Moderately cold upland landscape**
- Studené krajiny hornatin - **Cold upland landscape**

Figure 3.2: Climatic regions covering the Czech Republic



Each BTU was allocated to a certain climatic region in which it lies. The shapefiles with data on climatic regions and the shape file containing forest cover in

different BTUs were loaded in Arc GIS 10 and were georeferenced, giving them the right geographical coordinates, using the appropriate ArcGIS functions, the two shapefile were joined and this allocated each BTU to the climatic region that it belongs. For the reasons of comparison, a number of BTUs were selected at random. This is to compare how the forest cover had changed in different BTUs within the same climatic region.

3.6 Observed characteristics (change in hectares, in %, change intensity in hectares/year)

For each of the BTU selected, different parameters or useful information were calculated for example, from each BTU the following was determined for each time horizon:

- Total forest covers change in hectares (ha) and in percentages (%)
- Trend in forest cover – Forest cover change between 1845-1948, 1948-1990 and 1990-2000 in hectares (ha) and in percentages (%). This was to show by how many hectares did the forest increased or decreased between those time horizons. This is also known as the absolute changes in forest cover between individual time horizons
- Forest cover change intensity in hectare per year (ha/year) – This shows the intensity or the rate at which the forest changed per one year. The intensity was calculated using the following formula: $I = DP/DN$, where I = intensity of changes in forest cover, DP = difference in the forest cover area between two neighbouring time horizons, DN = number of years between two neighbouring time horizons (Skaloš et al. 2011).

4. Results

4.1 Total forest cover change in the whole Czech Republic

Figure 4.1 and 4.2 shows the forest cover change in the Czech Republic during the time period from 1845 – 2000 in hectares and percentages. We can see that the forest cover in the Czech Republic increased from the year 1845 to 1990. The change in forest cover strongly continued until the 1990 and after this time the

forest cover seems to be a bit stable. The figure shows that there is almost the same percentage of forest cover in 1990 and 2000 with only a small increase.

Figure 4.1: Shows the forest cover change in the Czech Republic from 1845-200 in (ha).

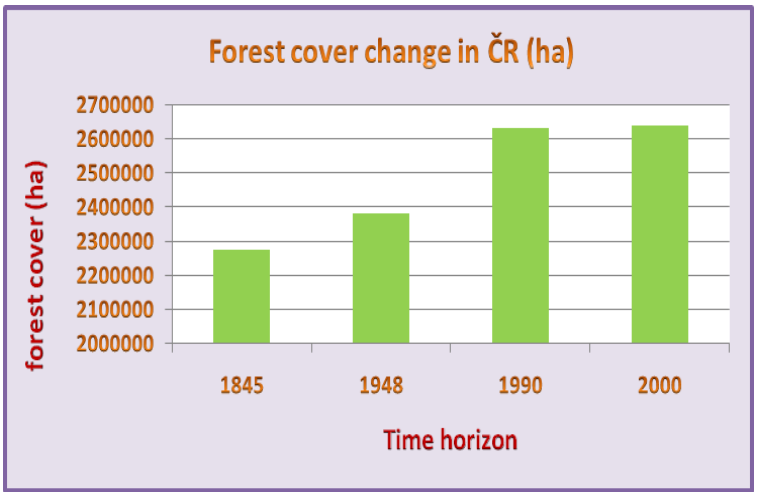
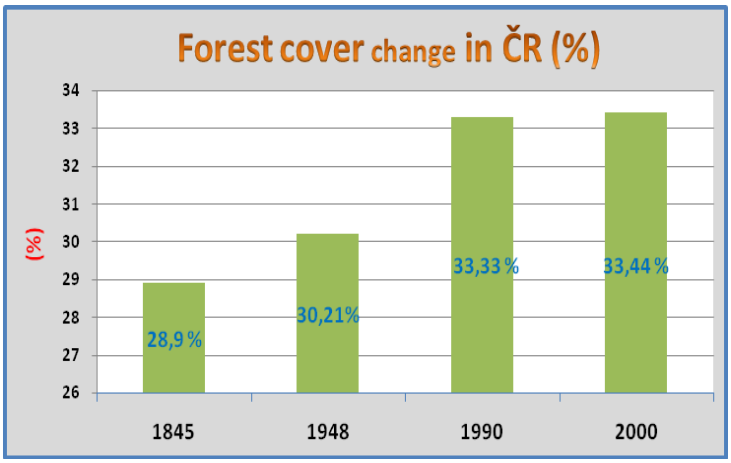


Figure 4.2: Shows the forest cover change in the Czech Republic from 1845-200 in (%).



4.2 Trends in forest cover in the whole Czech Republic

The trends in forest cover change are one of an important and interesting issue to look at. In figure 4.3 and 4.4, we can see the trends that took place in the forest cover change in hectares and percentages. In the year 1845-1948, the forest increased by 106550 ha and this is about 1,3% increase , between 1948-1990 it

increased by 246089 ha or 3,12 % , and between 1990-200 it increased only by 8533 ha making about 0,11 %. The most important year in the development of forest being the year 1948-1990, as this time horizon recorded the highest increase in forest, and the lowest being the time of 1990-2000.

Figure 4.3: shows the trends in forest cover change in the Czech Republic in (ha).

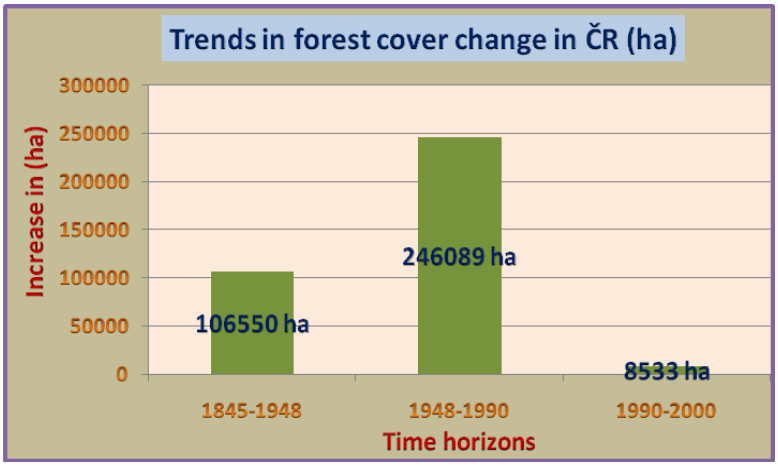
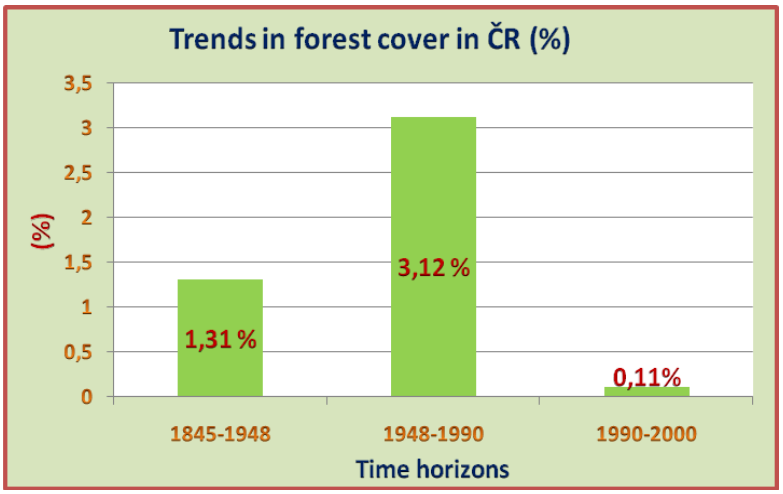


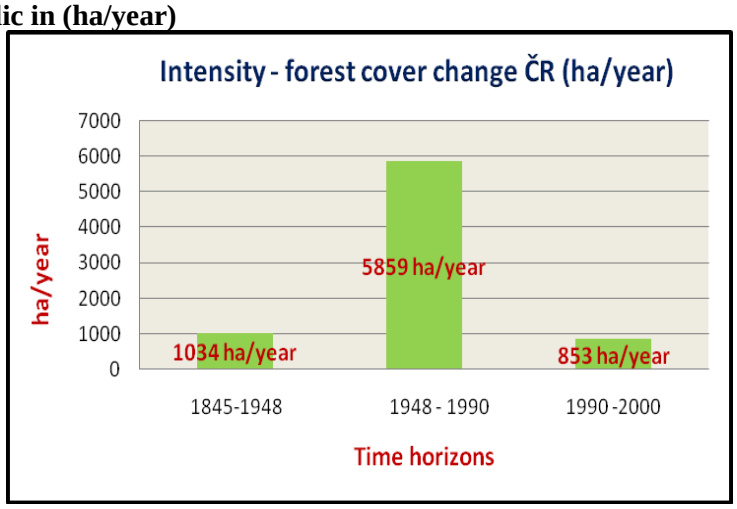
Figure 4.4: shows the trends in forest cover change in the Czech Republic in (%).



4.3 The intensity of forest cover change

The intensity at which the forest cover changed in hectares per year is shown in figure 4.5. The highest rate of forest cover was recorded during the time period from 1948-1990 with an increase of about 5859 ha/year and the lowest intensity of forest cover was from the period 1990-2000, with less than 1000 ha per year.

Figure 4.5: shows the intensity at which the forest cover changed in the Czech Republic in (ha/year)



4.4 Trends in forest cover in climatic regions

Figure 4.9 shows the total forest cover in each climatic zone in % for the time period 1845-2000. As we can see from the figure, the highest percentages of the forest cover in the climatic zones occurred in the cool hilly areas from 1845-2000, with more than 30 % of its total area was under forest cover and the rest of the climatic zones had less than 25 % of their total areas as forest, with Cold upland landscape being the lowest in forest cover in all the time periods. There have been some decreases in forest cover in certain areas or BTUs of the Czech territory (Fig.4.6; 4.7 and 4.8).

Figure 4.6: forest cover in the Czech BTU-Černovice in (ha)

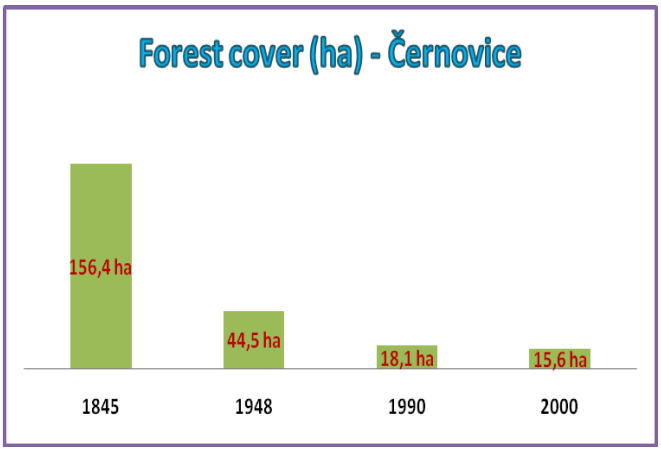


Figure 4.7: forest cover in the Czech BTU- Černovice in (%)

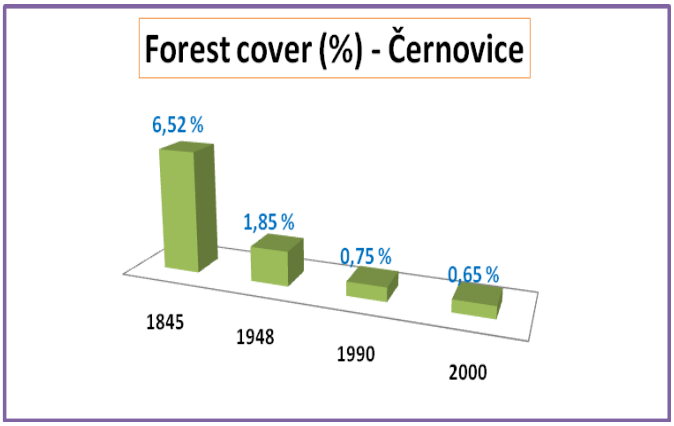


Figure 4.8: shows the Trend (decrease) of foreest cover change in (ha) in the area of Černovice – Czech Republic

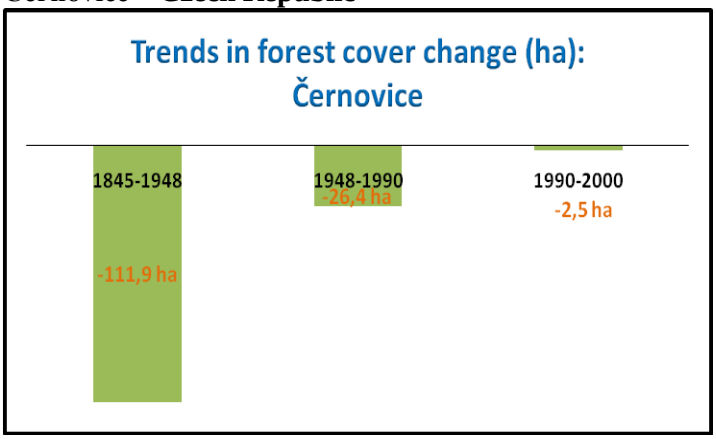


Fig.4.10 shows the trends in forest cover in climatic regions. The highest increase in forest cover took place in the year 1948-1990 in the cool highland areas, which recorded an increase in forest of more than 80000ha between that time periods, followed by the cool hilly areas. The overall situation is that, all climatic regions experienced the highest increase in forest in the year 1948-1990 than in other time horizons.

Relatively cool hilly landscape areas saw the highest increase in forest between the years 1845-1948 than any other climatic region, while Warm lowlands landscape experienced a decrease in forest cover during this period. The period 1990-2000 recorded the lowest increase in forest cover in all climatic regions. We can see that the areas from this climatic zone have one thing in common, they all experienced declines in forest cover in the period 1845-1948(Appendix 12). In most of the

climatic regions, it can be seen that the highest intensity in forest cover took place in the years 1948-1990.

Figure 4.9: Percentages of forest cover in each climatic region in the year 1845, 1948, 1990 and 2000

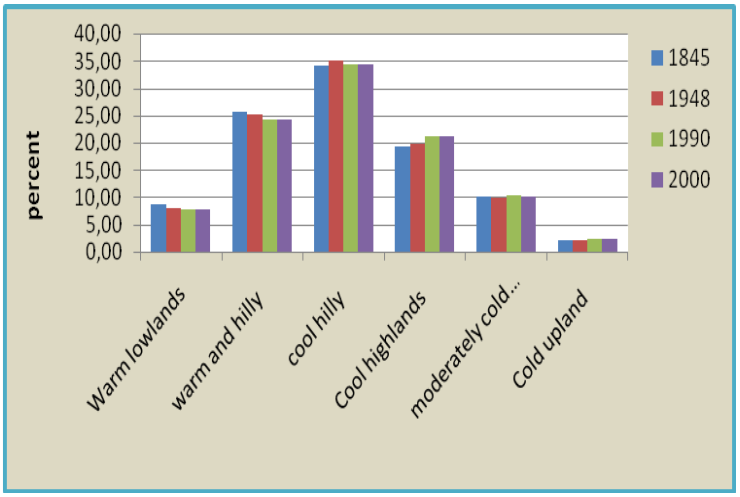
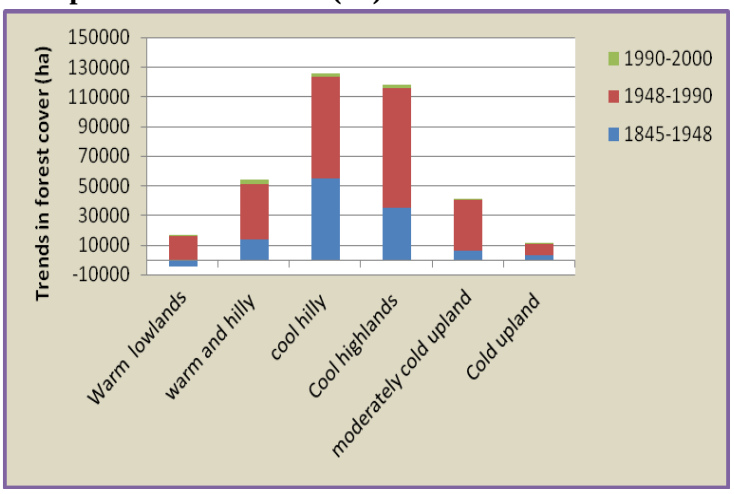


Figure 4.10: Trends in forest cover in the climatic regions of Czech Republic for the time period 1845 -2000 in (ha)



5. Discusions

5.1 Discussion on results

Its very important to conduct researches on forest cover change and try to identify the main drivers (forces) behind the chnage in forest cover. The result shows very intresting trends in the forest cover change in the Czech Republic. Its obvious that this trends in forest cover had been caused by many factors. Due to its position

in the center of the continent, the Czech Teritorry had experienced many unexpected historical changes. The results of this thesis shows distribution of forest cover change in climatic regions and it proves some of the early studies for example (Bičík, 1988) stated that the increase of forest cover was concentrated in the mountains area of the Czech region, and the results of this thesis tend to prove this somehow. Changes in land-use are influenced mainly by socio-economic changes, climatic coniditions and other invironmental developments. Despite the fact that Czech Republic experienced decline in forest in some areas, the overall forest cover contuined to increase. This shows that the forest cover was increasing at a high rate than the rate at which the forest was being lost.

5.2 Driving forces behind forest cover change

The Czech Forests were remarkable changed in the course of colonisation and afterward the technical developments. Their conditions were considerably changed by impacts resulting from human. The changes in the economy brought effects in political structures, economic and social changes. The release of harmful gasses from the so called Black Triangle Region was one of the main of air polution in Europe during the 1990s (Bridgman et al. 2002), which also had an impact on the Czech forests. This explains the slow inccrease in forest cover in the 1990-2000 in the Czech Repblic.

In the first half of the 19th , basic changes in landscape and the environmental was influenced by the industrialization processes, this was followed by urbanization and population growth. Other factors also influenced the change in landscape such as agricultural revolution(Bičík et al. 2001). The period from 1945–1948 was influenced by large scale population movements in all of Central and Eastern Europe. As a result of this movement of Czech Germans from Czechoslovakia, about 3 million hectares of their land was taking by the state and remains state properties up to today (Bičíket al. 2001). According to a study by (Sklenicka et al. 2014) on the changes in landscape in border regions of Czech and Austria, they suggest that since the two countries share almost the same environmental conditions, the main changes in their border areas were caused by socio-economic and political conditions.

Post-war development resulted in a high decrease in agriculture and arable land in the 1950s in the border areas settled by ethnic Germans. According (Štych,

2007), the increase in forest in high lands after 1948 was influenced by the beginning intensive afforestation in the country. In lowlands, the extensive construction project had a great influence in forest cover. In the second half of the 19th century new developments were introduced, such in industry, population and transportation. The decrease in forest in the between the period 1845-1948 in the warm lowlands can be connected to the intensive farming in these areas, but the situation started to change after the year 1948 which saw an increase in forest cover. Continual afforestation over time in the hilly areas contributed to the stabilization of forest these areas.

After 1948, changes in forest cover was mainly influenced by different factors such as the general economic tendencies. The change in landscape was also influenced by other activities like industrial plants, mining and housing as the population increased, more space was needed for settlement purpose, this also explain the decrease in forest in lowlands, as this areas wee suitable for formaing and settlement. On the other hand, the increase in forest in hilly areas and mountains are mainly because of lack of human interventions, for this reason, the forest was allowed time to grow. Landscape changed swiftly during the progression to large-scale socialistic production, resulting in significant simplification (Lipsky, 2000).

5.3 Discussion on Methodology

The methods used in this thesis was a very useful method and was the appropriate way to analyse forest cover change in the Czech Republic. By calculating the intensity of the forest cover in the whole country, it provide us with useful information on the rate of forest cover change in hactres per year. With GIS software, it was relevant to compaly a map showing the different climatic regions, as part of the monitored areas of the study.

The method analyses forest cover including areas that have never been included bbefore in the past reasches like changes in climatic regions and it provides useful expanded information in this matter. The study and the method used was somehow limited, due to the lack of detailed information on the distribution of forest cover within the BTUS. This study also confirms and it does not contradict with other studies by different authors regarding the changes in forest cover in the Czech Republic. For example, (Skokanova et al. 2012), by using analytical maps of land-use from the 1950s it can be seen that forest cover was the second lagest category

after arable land, but later forest overcame arable land and forest was concetrated in large complex.

6. Conclusions

6.1 Conclusions on results

This thesis clearly shows that the forest cover in the Czech republic had undergone dynamic changes. The results provide a lot of important information regading forest cover change in the Czech Republic. From this study we can gain knowlegde on the main forces that transformed the forest to the way it is today. It provides important information on the trajectories that took place in the forest sector. This can help us to understand the reasons for the current state of the forest and we can use this information to predict the forest state in the future.

By know the past and present state of the forest and the forces shaping this forests, we can try to analyse our actions toward the forest for future generations. The results shows very interesting historical trends of changes in macrostructure in the forest cover of the Czech Republic. This study has proved in some extend , how the forest changed in the past years and the study give knowlegde on the intenity of forest cover. This is important for the management purpose or for the purpose of decision making, as it can help to identify and tackle the main forces that causes negative effect in the forest.

6.2 Conclusions on the methodology

A lot of studies have been carried out to study the forest cover changes in Czech Republic in respect to different factors (Bičík, Karda 2007; Štych, 2007; Skokanová et al. 2012; Jeleček, 1994). However, this studies did not emphasize on the forest cover change in different climatic regions of the country. But this study has managed to include analysis of forest cover in this areas.

The land–use /land cover database of the Czech Republic provide very useful data on the forest cover change in the country dating from the year 1845. On the other hand, the methodology was limited by the data source, because the database only shows inforamtion for a certain BTU(in Czech ZÚJ) in general. While this

BTUs contain a lot of cadastres. The database is available in a simple complex, in which you can put a name of cadastre or its code and the database searches for the required cadastre and it finds the BTU in which the required cadastre belongs with a table showing different land-use categories.

If I want to know the distribution of forest cover in a certain BTU or how much percentage of forest did each cadastre within the BTU contributed to the total forest cover, I can not find this information in the database. The database also does not show the changes and distributions in forest plots and patches within each BTU, that can help to analyze the forest cover change in more details. This issue is left for futher studies and as a recommandetion or a suggetion on how to improve the database, so that it can provide more detailed information on land-use change.

7. REFFERENCE

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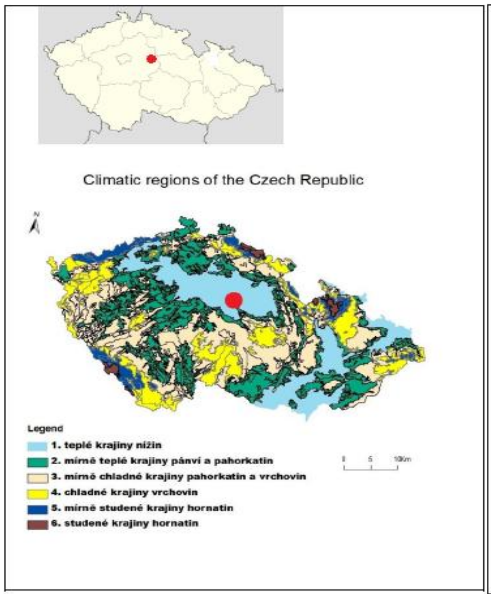
8. Appendix

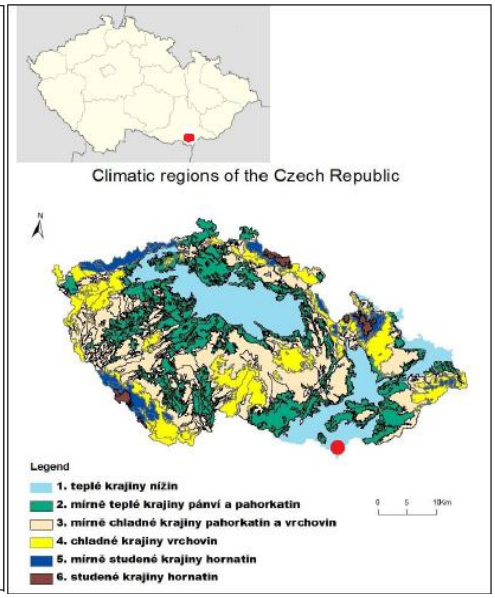
Climatic regions covering Czech Republic with selected BTUs (ZÚJ)

Appendix 1: Teplé krajiny nížin – **Warm landscape lowlands**

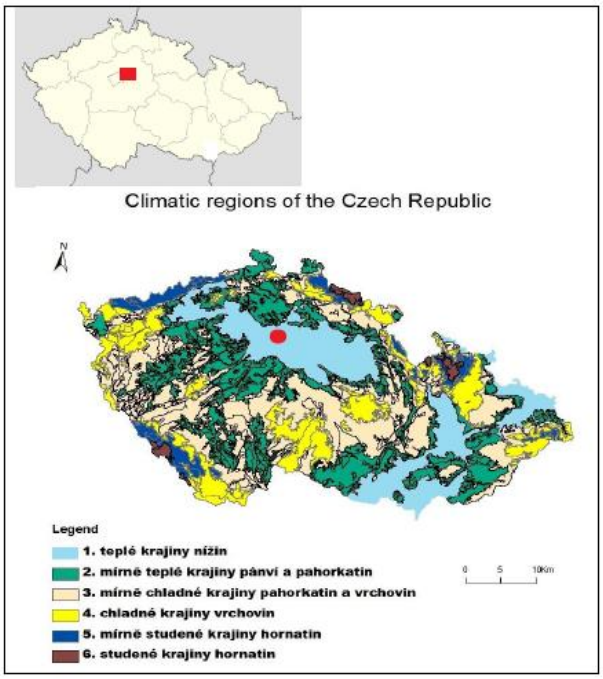
a) Krakovany



b) Břeclav

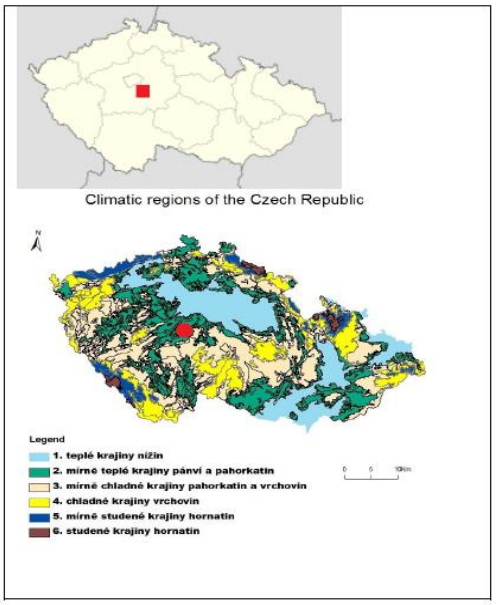


c) Čelákovice

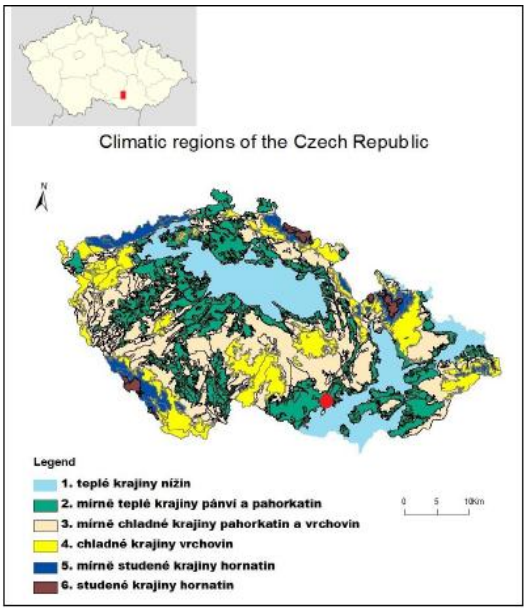


Appendix *2:* Mírně teplé krajiny pánví a pahorkatin- **Slightly warm and hilly land scapepans**

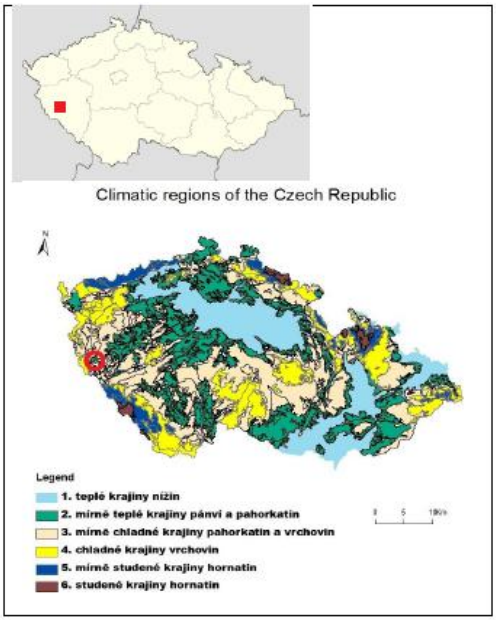
a) Benešov u Prahy



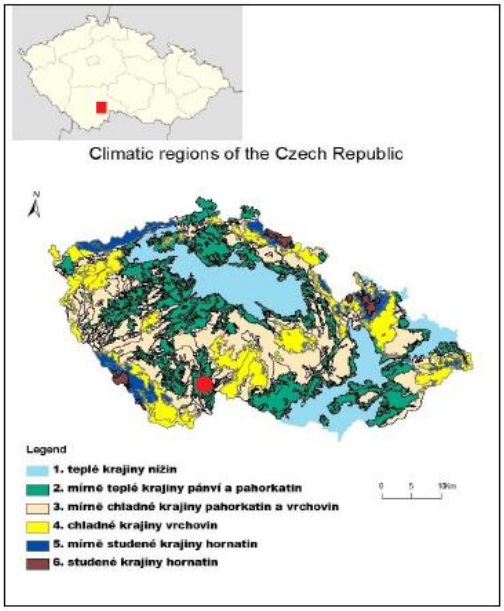
b) Letkovice



c) Horšov

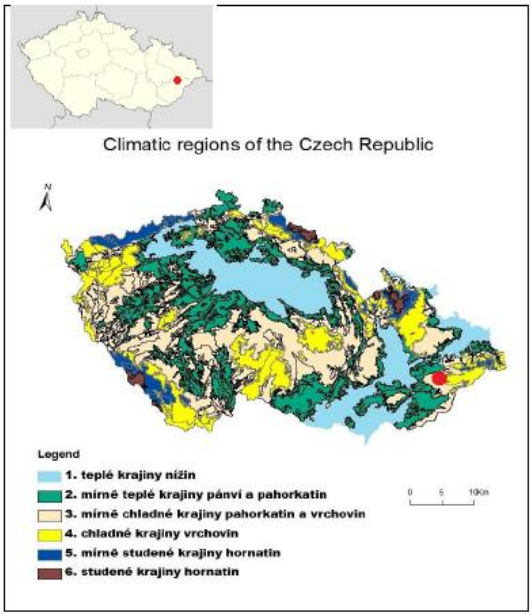


d) Stará Hlína

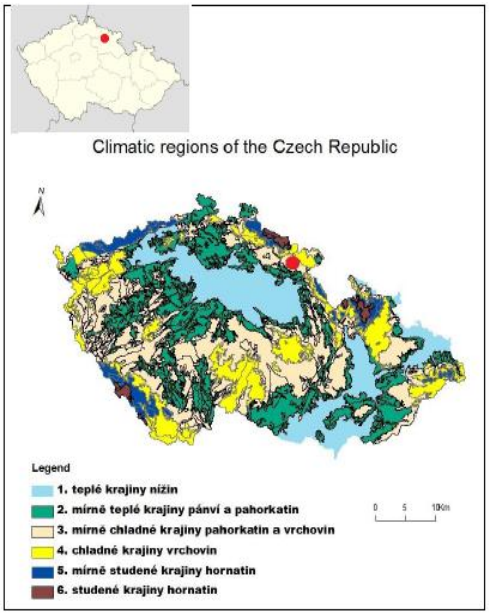


Appendix 3*:* Mirně chladné krajiny pahorkatin a vrchovin – **Relatively cool hilly landscape**

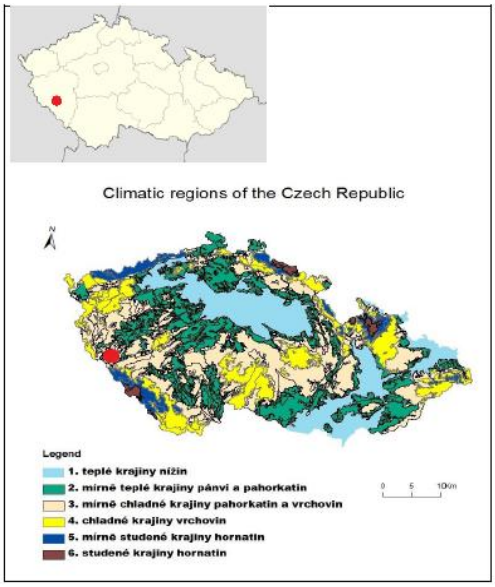
a) Oznice



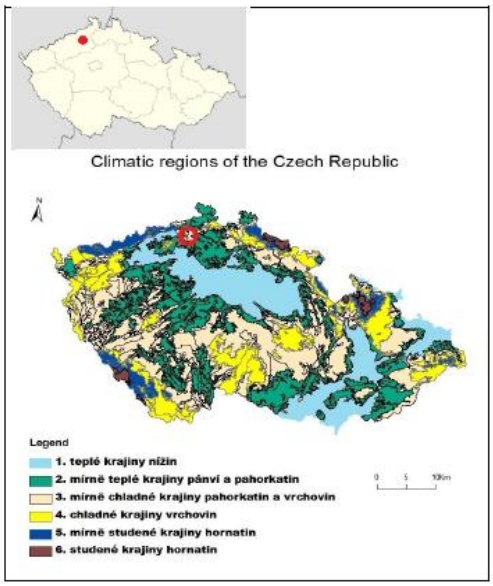
b) Borovnička



c) Koloveč

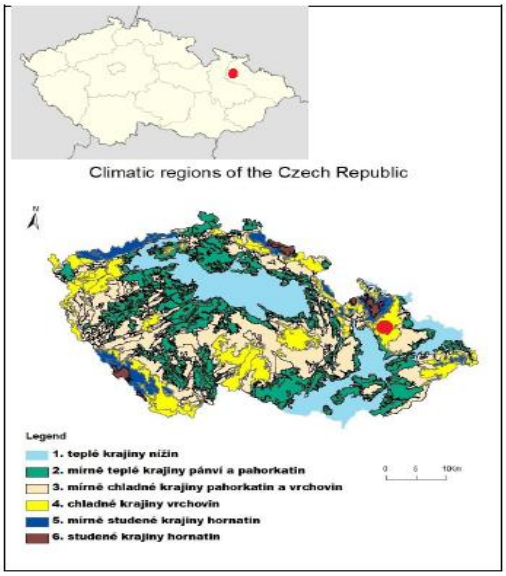


d) Rýdeč

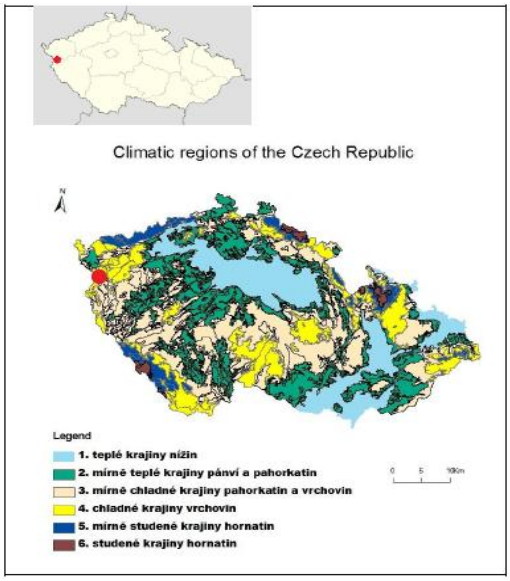


Appendix 4: Chladné krajiny vrchovin - **Cool highlands landscape**

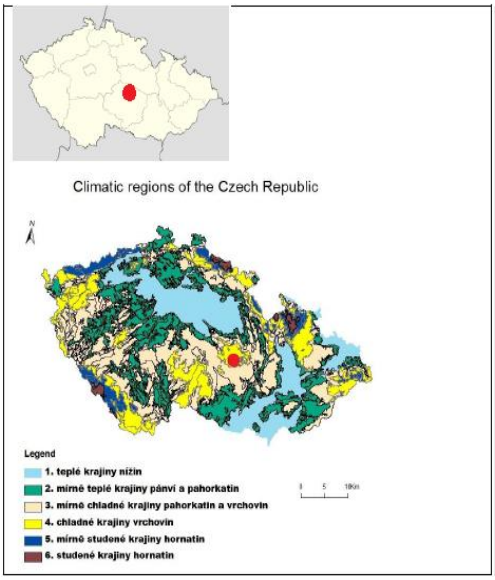
a) Dolní Moravice



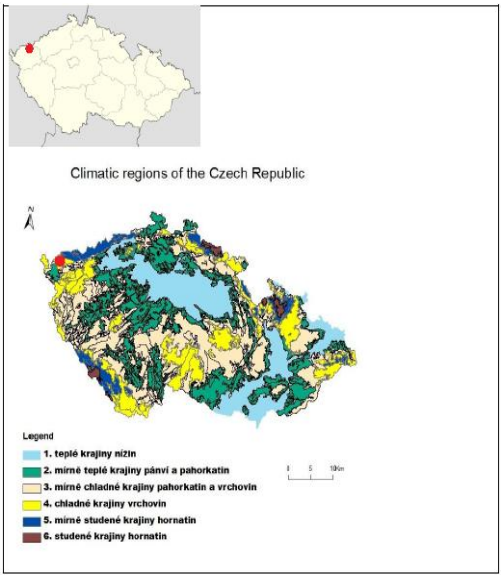
b) Chodovská Huť



c)Nové Vilémovice

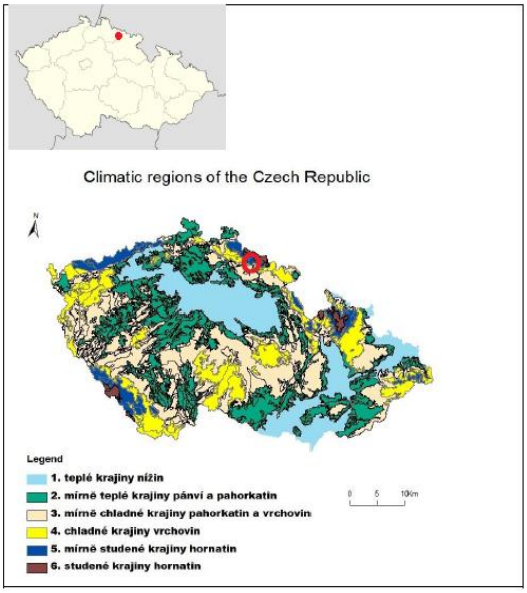


d) Vlčí Jámy

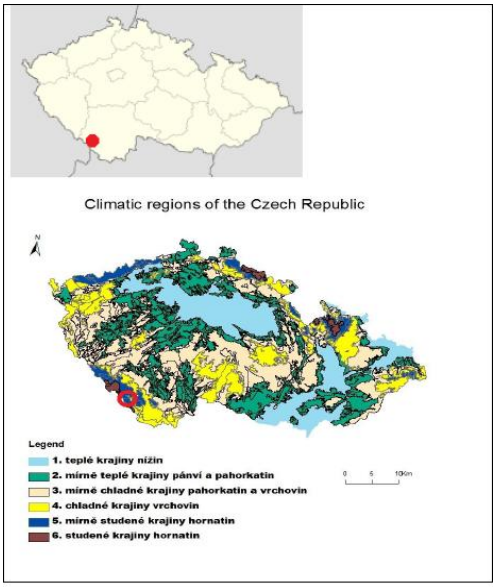


Appendix 5: Mirně studené krajiny hornatin - **Moderately cold upland landscape**

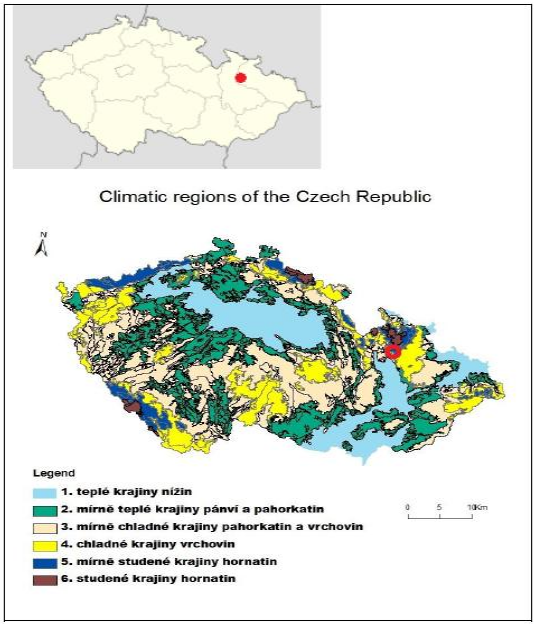
a)Přední Labská



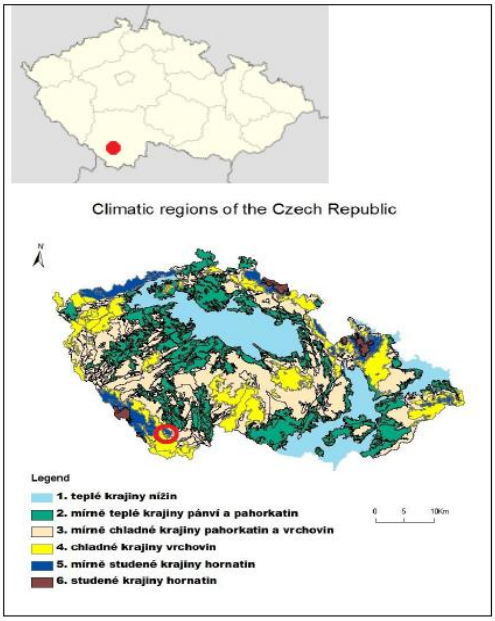
b) České Žleby



c) Dobřečov

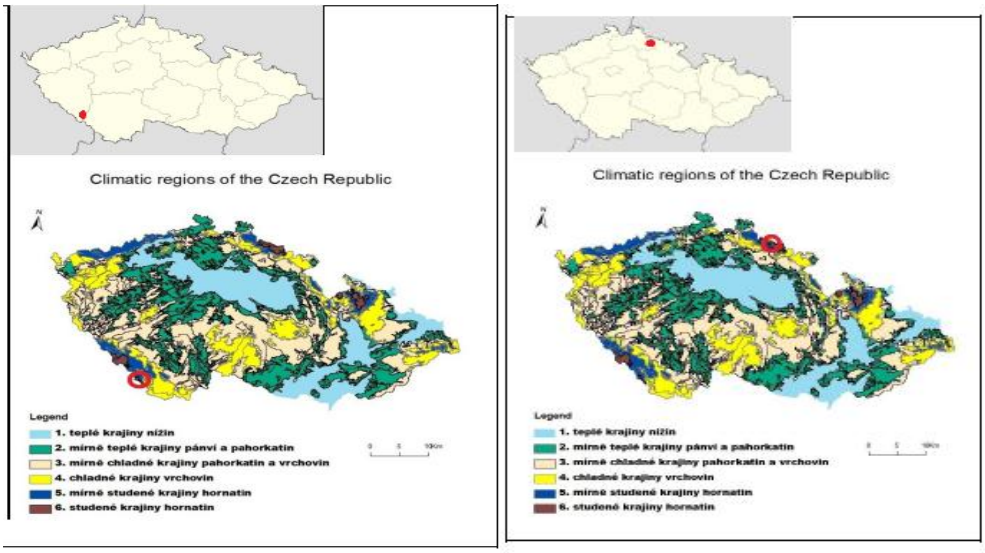


d) Chvalšiny

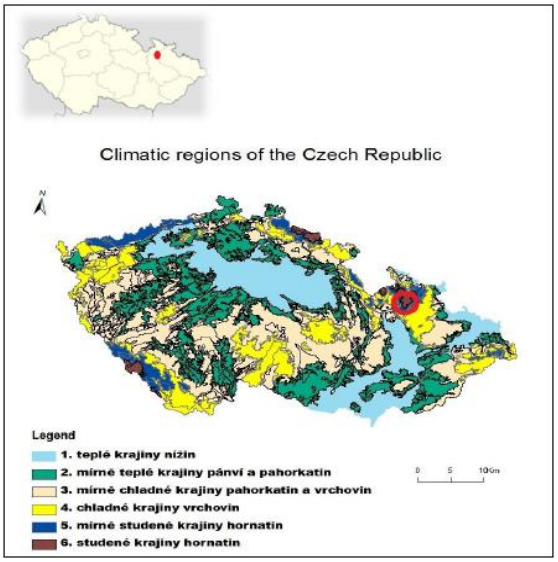


Appendix 6: Studené krajiny hornatin - **Cold upland landscape**

a) Horská Kvilda **b) Dolní Rokytnice**



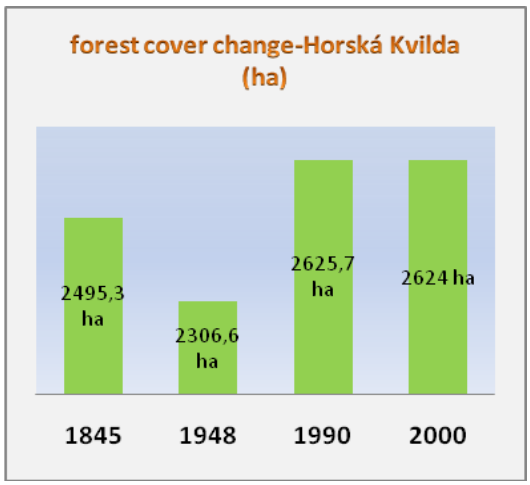
c) Kouty nad Desnou

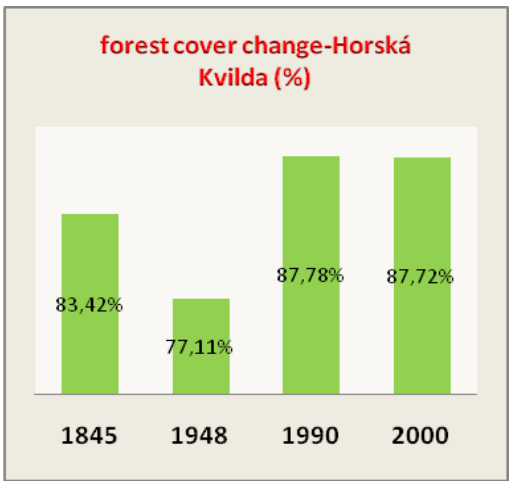


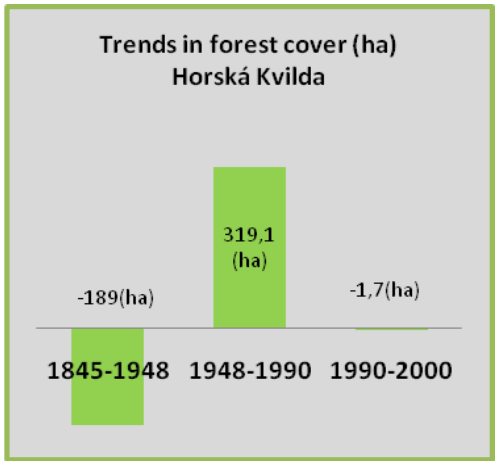
Comparisons of forest cover change in selected areas in different 6 climatic regions.

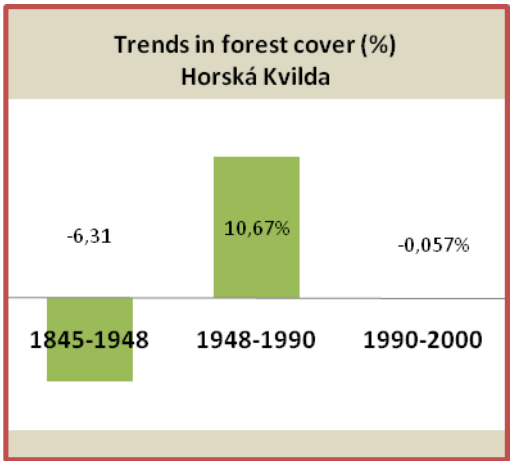
Appendix 7: Studené krajiny hornatin - **Cold upland landscape**

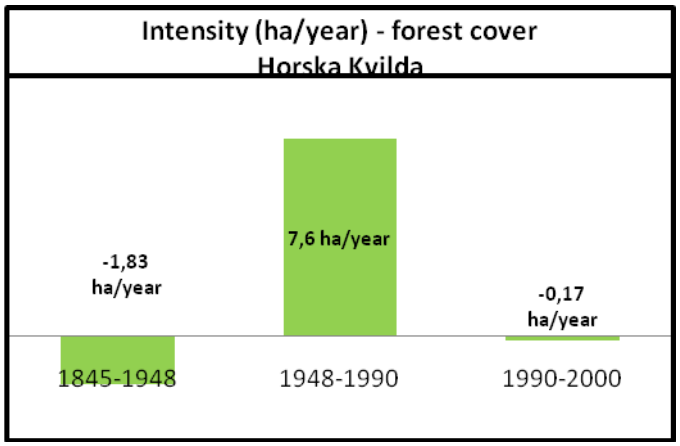
a) Horská Kvilda



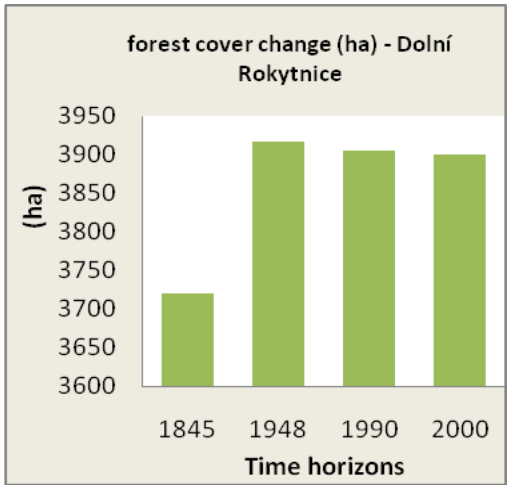


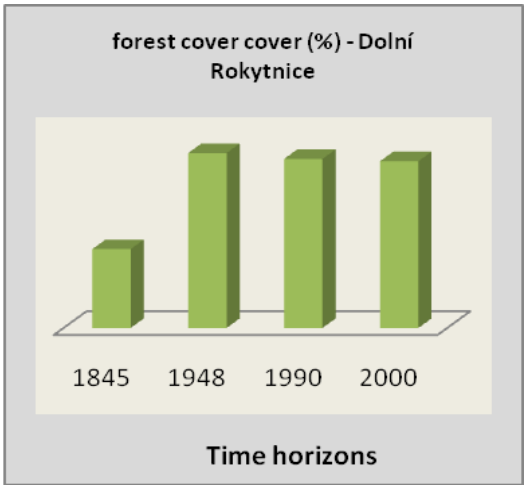


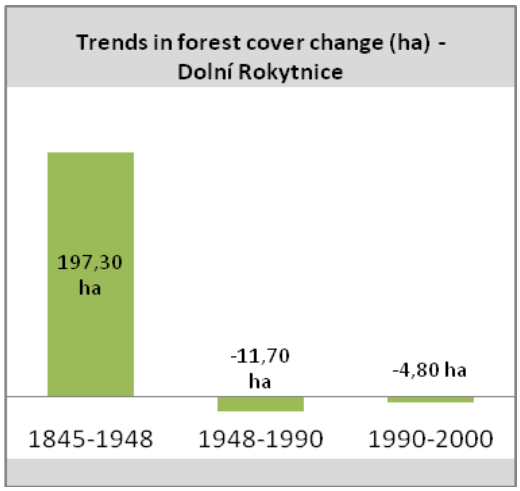


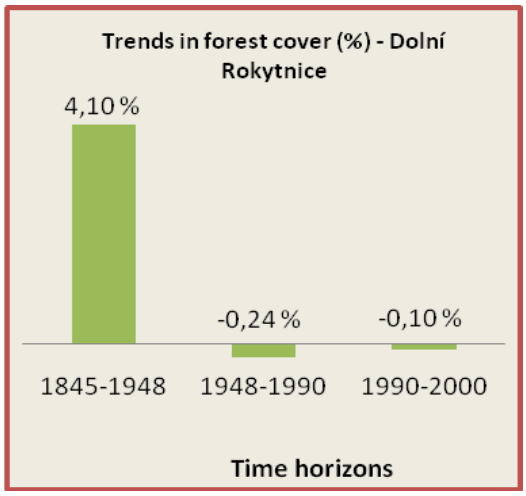


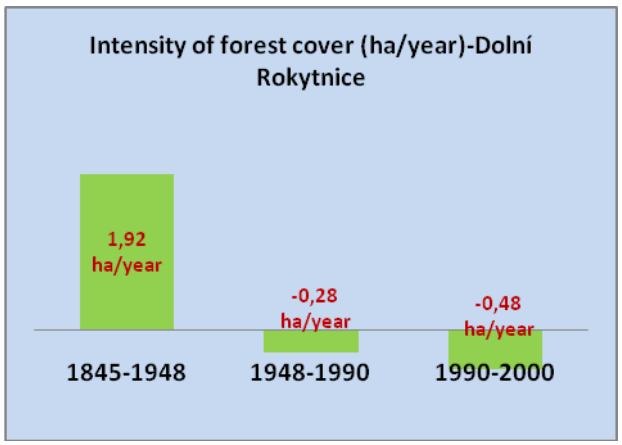
b) Dolní Rokytnice



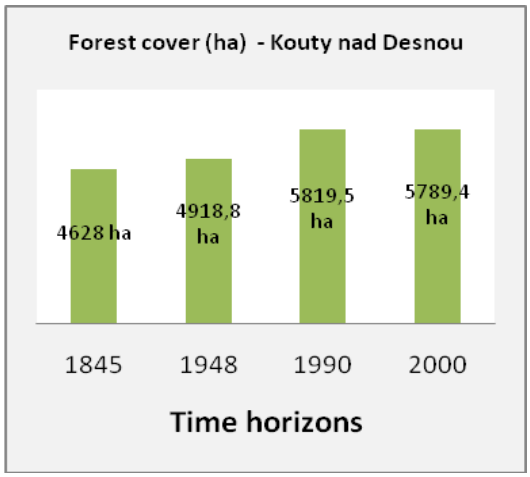


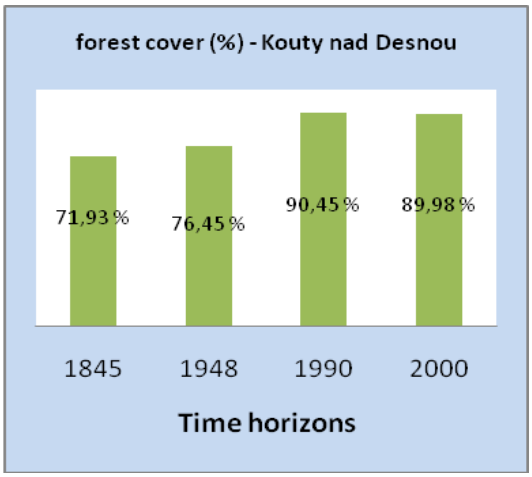


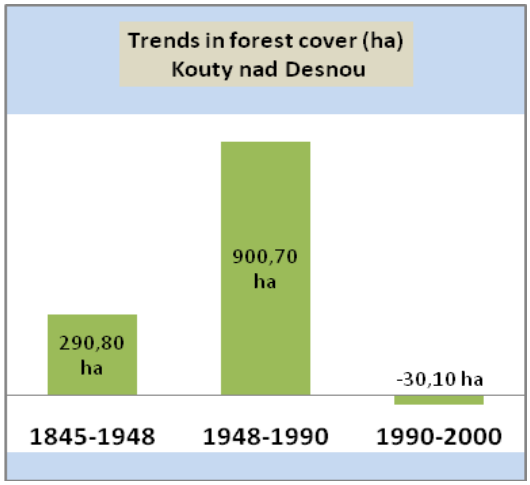


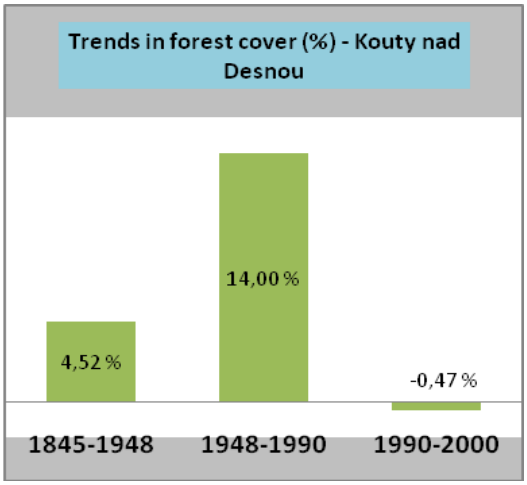


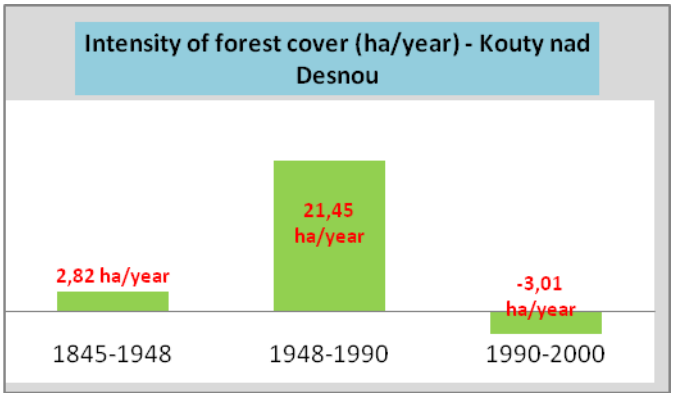
c) Kouty nad Desnou





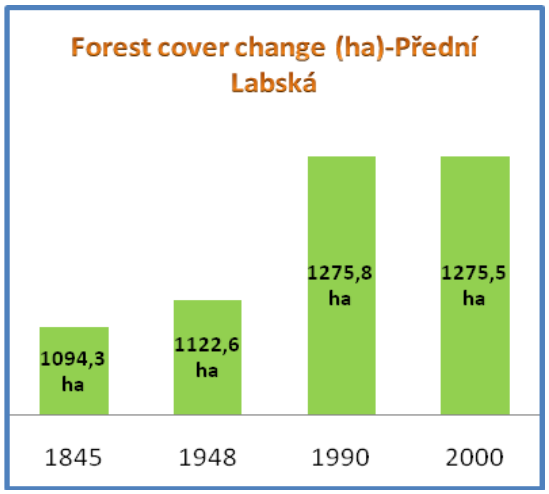


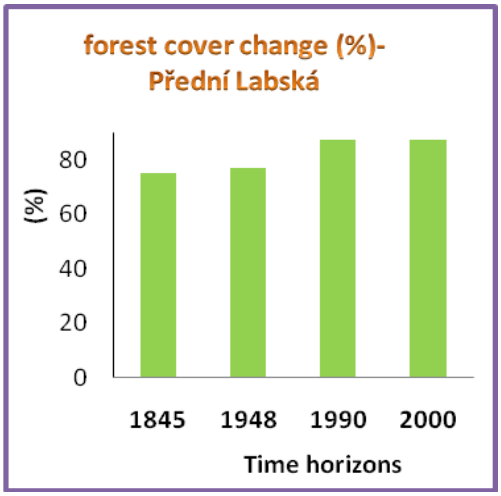


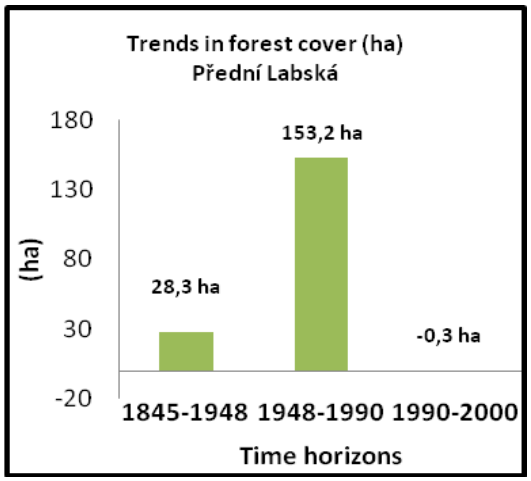


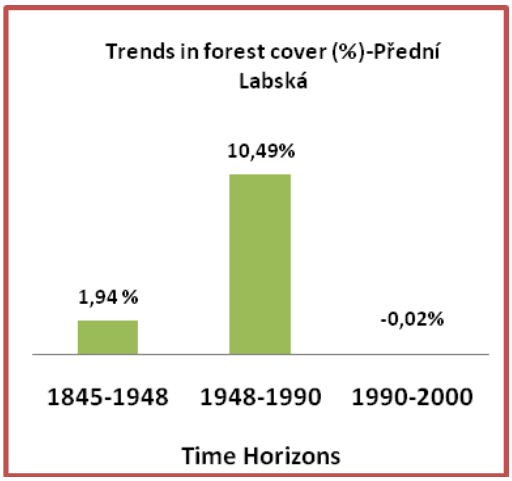
Appendix 8: Mirně studené krajiny hornatin - **moderately cold upland landscape**

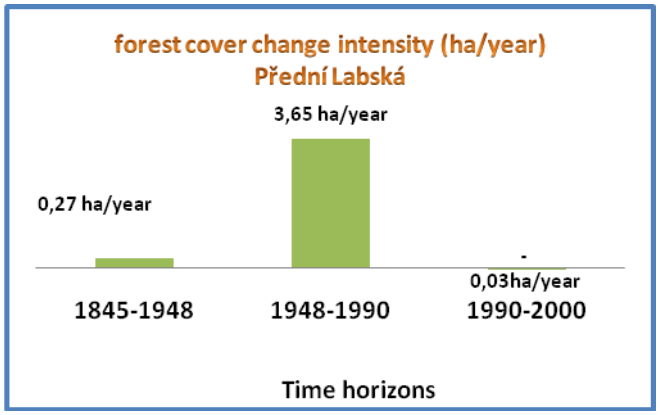
a) Přední Labská



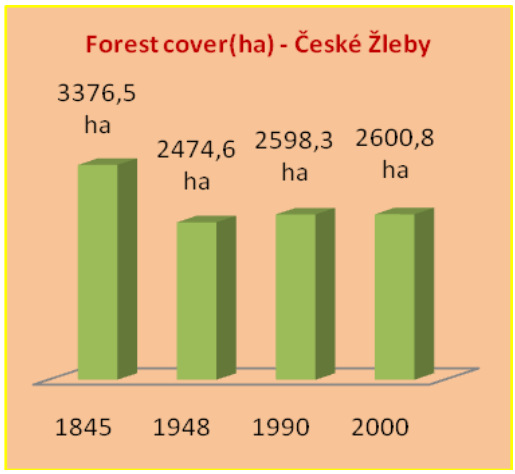


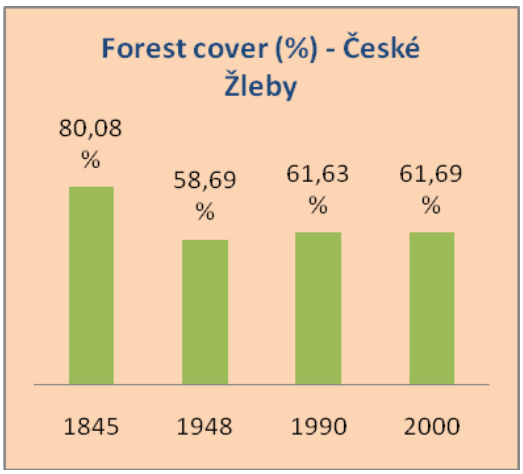


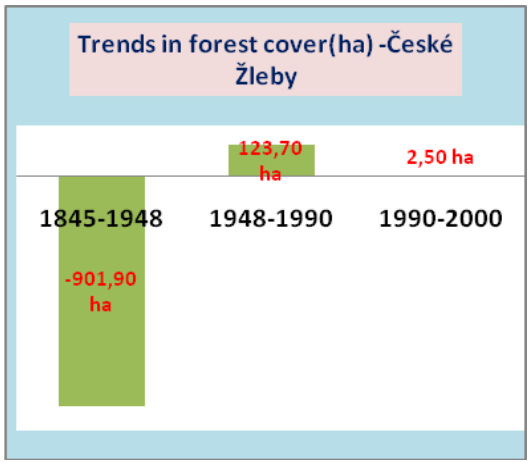


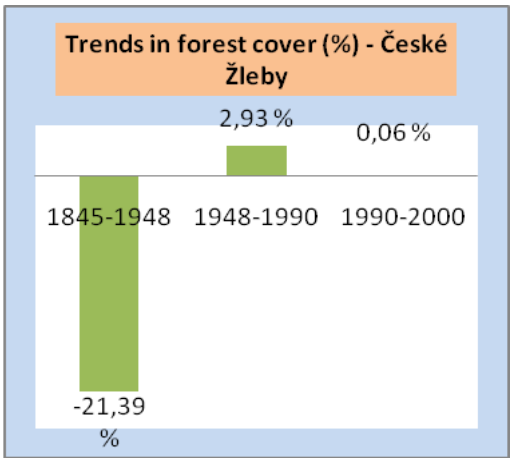


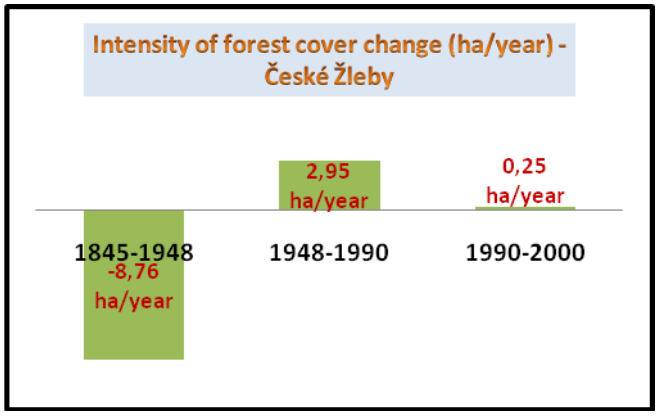
b) České Žleby



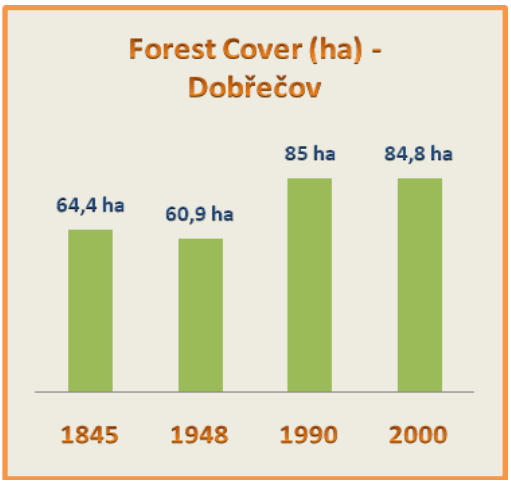


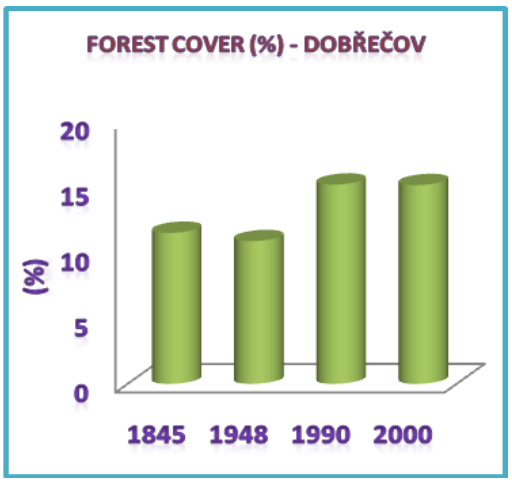


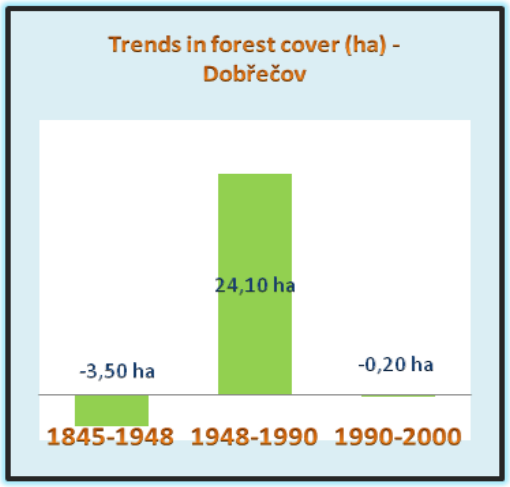


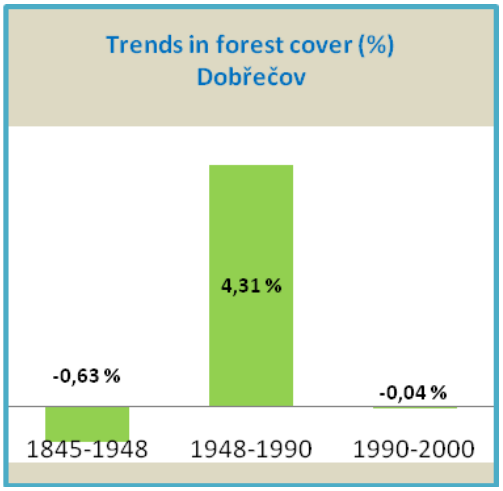


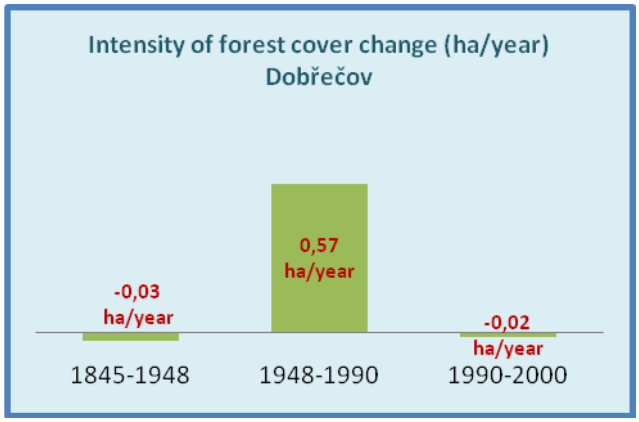
c) Dobřečov


Forest Cover (ha) - Dobřečov
64,4 ha
60,9 ha
85 ha
84,8 ha
1845
1948
1990
2000

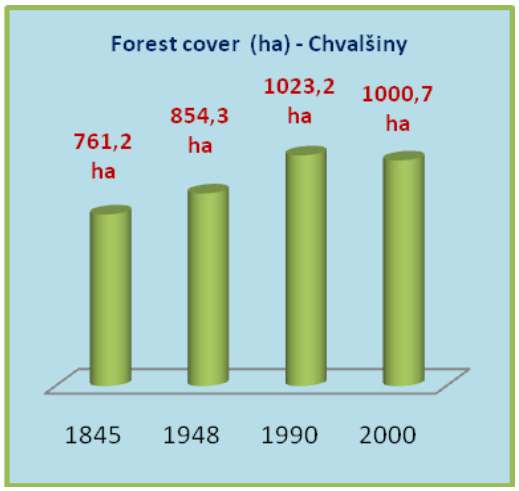

FOREST COVER (%) - DOBŘEČOV
20
15
10
5
0
(%)
1845
1948
1990
2000

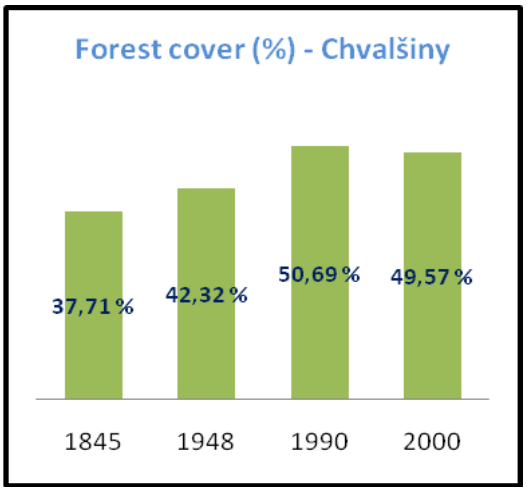

Trends in forest cover (ha) - Dobřečov
-3,50 ha
24,10 ha
-0,20 ha
1845-1948
1948-1990
1990-2000

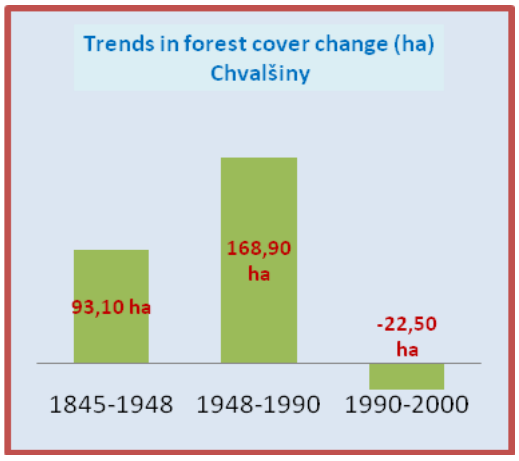

Trends in forest cover (%) Dobřečov
-0,63 %
4,31 %
-0,04 %
1845-1948
1948-1990
1990-2000

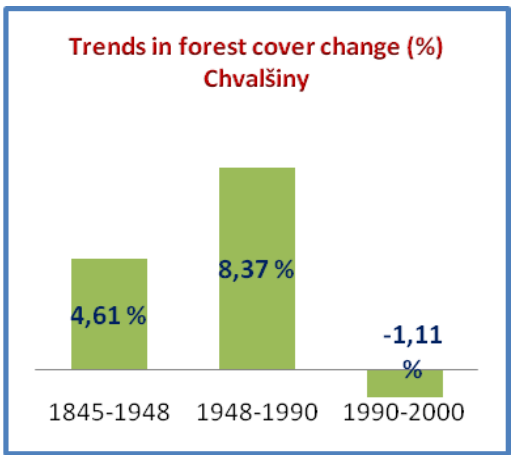

Intensity of forest cover change (ha/year) Dobřečov
-0,03 ha/year
0,57 ha/year
-0,02 ha/year
1845-1948
1948-1990
1990-2000

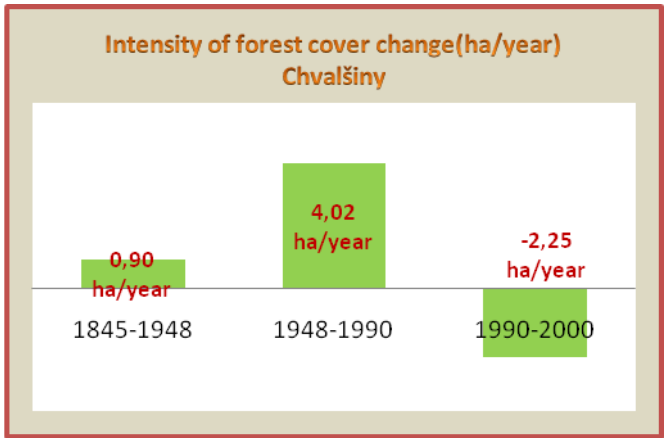
d) Chvalšiny


Forest cover (ha) - Chvalšiny
761,2 ha
854,3 ha
1023,2 ha
1000,7 ha
1845
1948
1990
2000


Forest cover (%) - Chvalšiny
37,71 %
42,32 %
50,69 %
49,57 %
1845
1948
1990
2000

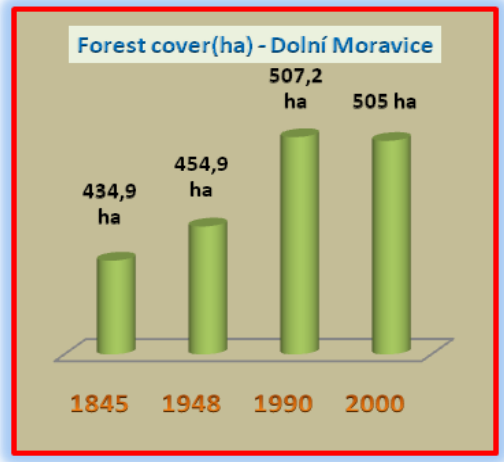

Trends in forest cover change (ha)
Chvalšiny
93,10 ha
168,90 ha
-22,50 ha
1845-1948
1948-1990
1990-2000

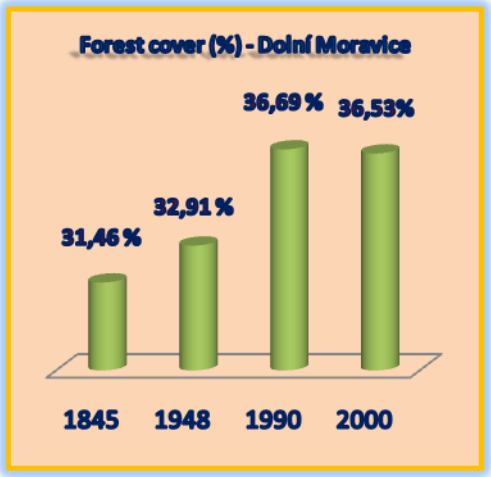

Trends in forest cover change (%)
Chvalšiny
4,61 %
8,37 %
-1,11 %
1845-1948
1948-1990
1990-2000

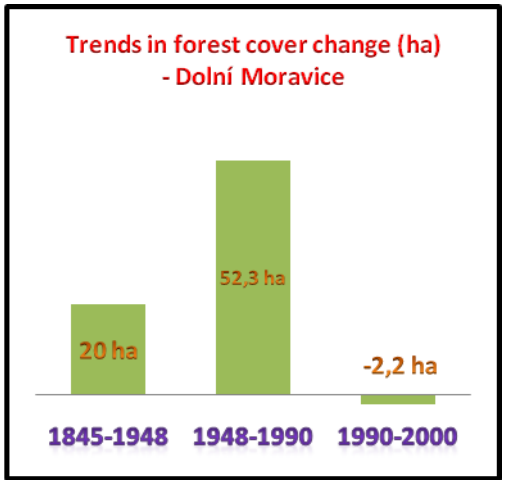

Intensity of forest cover change(ha/year)
Chvalšiny
0,90 ha/year
4,02 ha/year
-2,25 ha/year
1845-1948
1948-1990
1990-2000

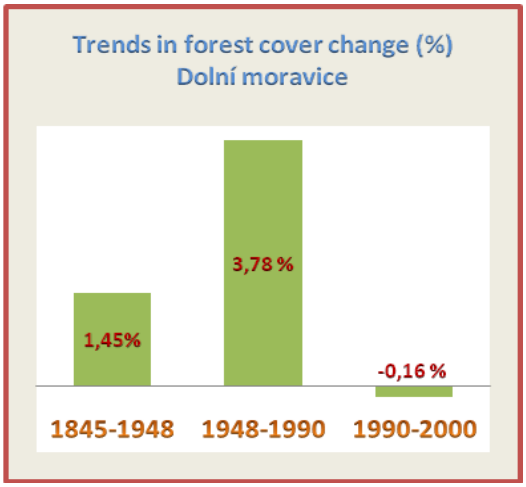
Appendix 9: Chladné krajiny vrchovin - **Cool high landsland scape**

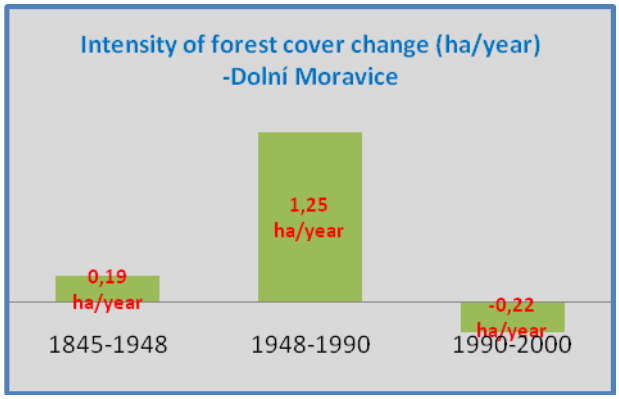
a) Dolní Moravice



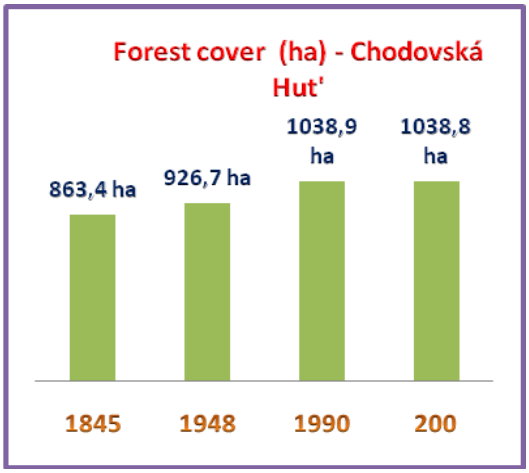


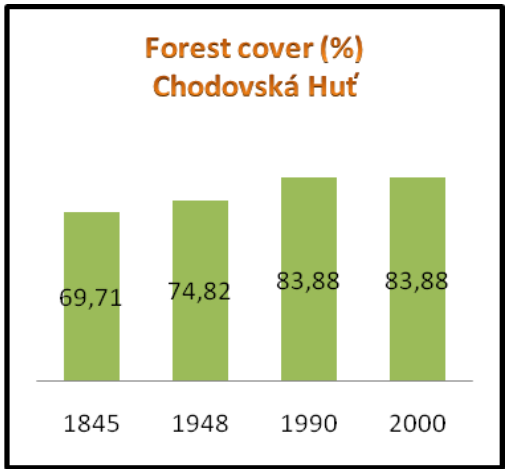


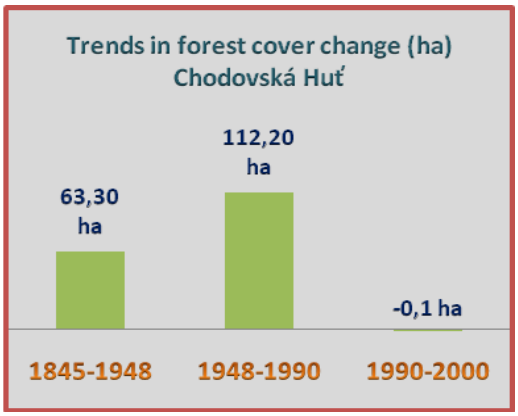


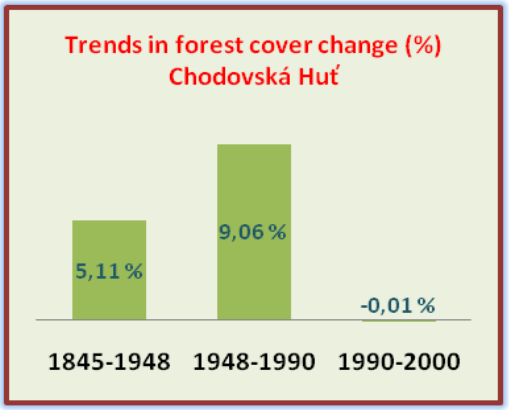


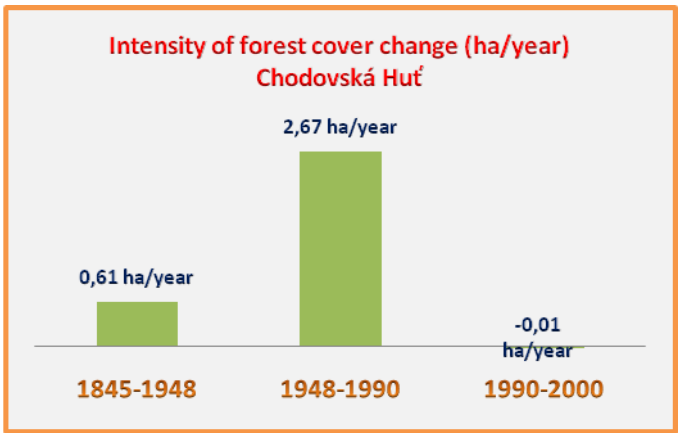
b) Chodovská Huť



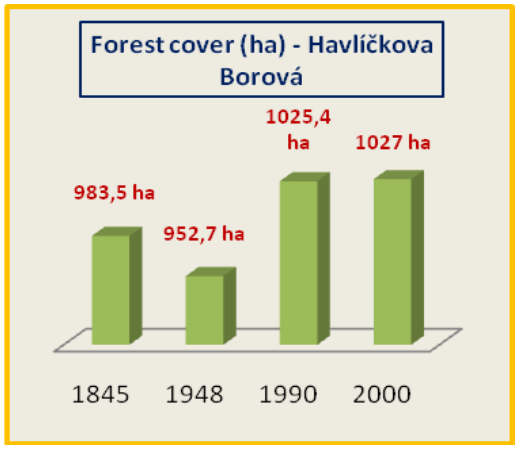


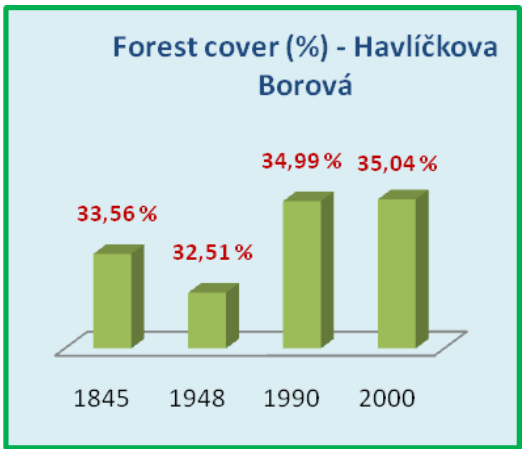


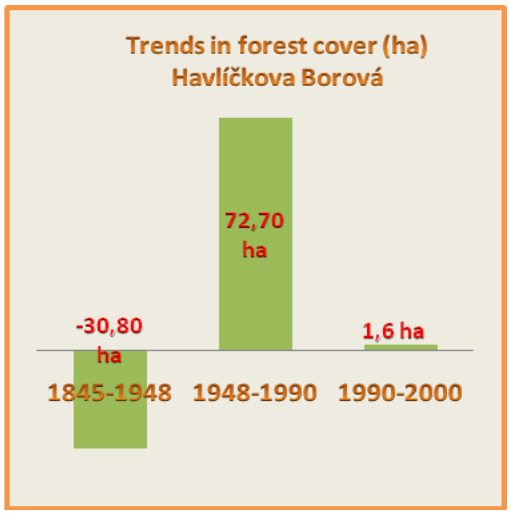


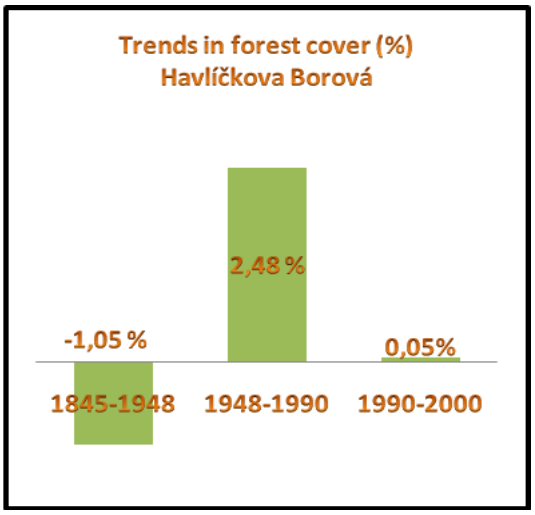


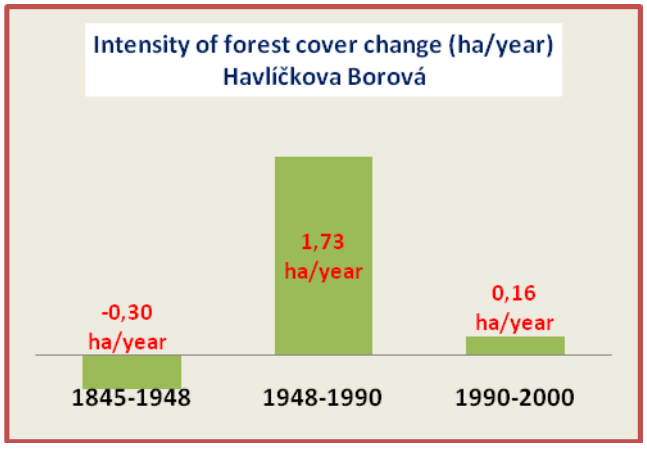
c) Havlíčkova Borová



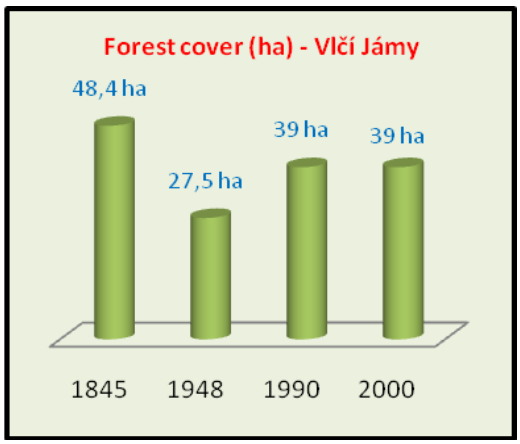


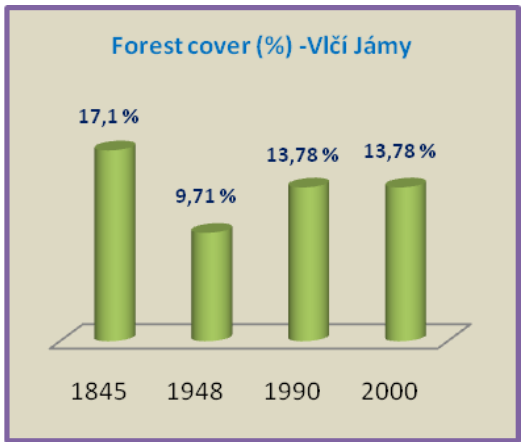


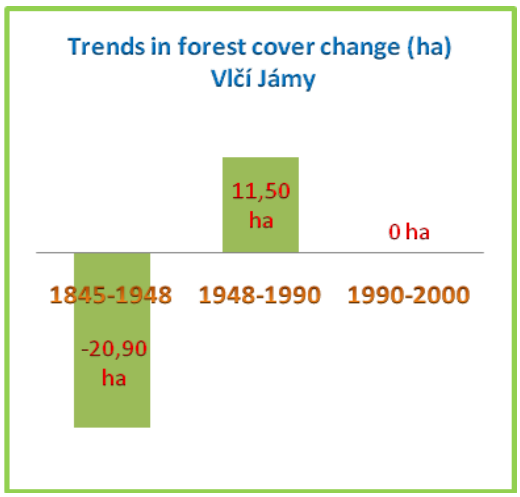


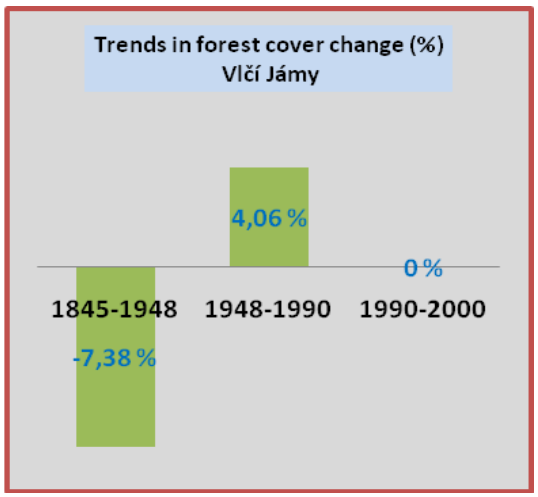


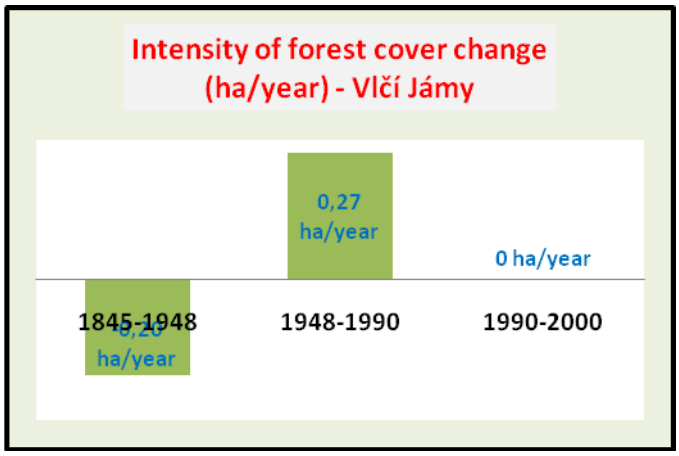
d) Vlčí Jámy


Forest cover (ha) - Vlčí Jámy
48,4 ha
27,5 ha
39 ha
39 ha
1845
1948
1990
2000


Forest cover (%) -Vlčí Jámy
17,1 %
9,71 %
13,78 %
13,78 %
1845
1948
1990
2000

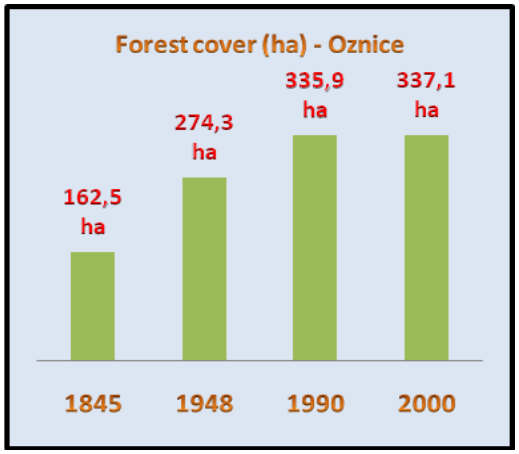

Trends in forest cover change (ha)
Vlčí Jámy
11,50 ha
0 ha
1845-1948
1948-1990
1990-2000
-20,90 ha

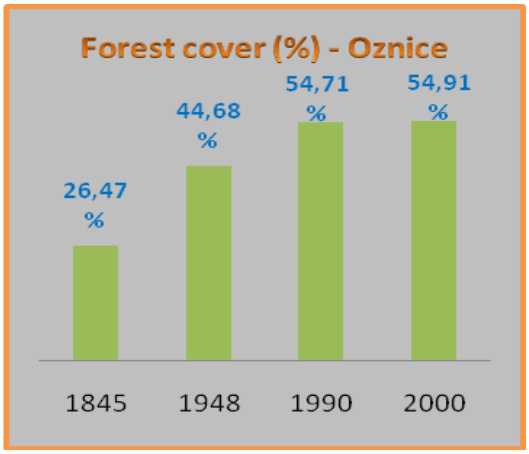

Trends in forest cover change (%)
Vlčí Jámy
4,06 %
0 %
1845-1948
1948-1990
1990-2000
-7,38 %

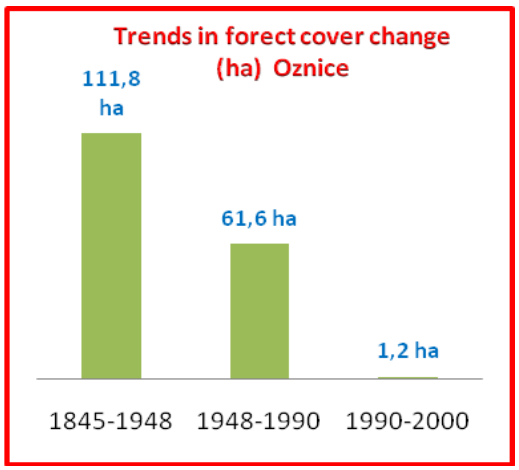

Intensity of forest cover change
(ha/year) - Vlčí Jámy
0,27 ha/year
0 ha/year
1845-1948
1948-1990
1990-2000
ha/year

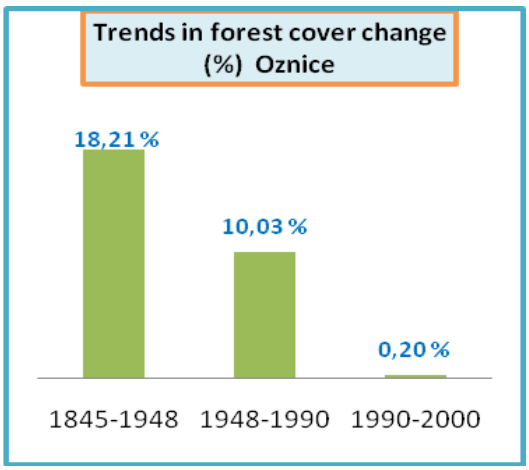
Appendix10: Mirně chladné krajiny pahorkatin a vrchovin - **Relatively cool hilly landscape**

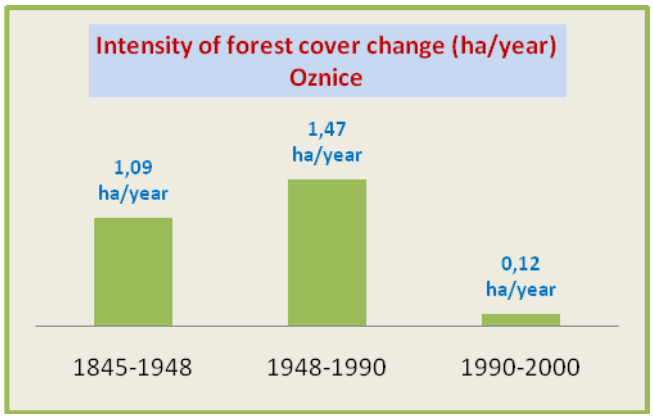
a) Oznice



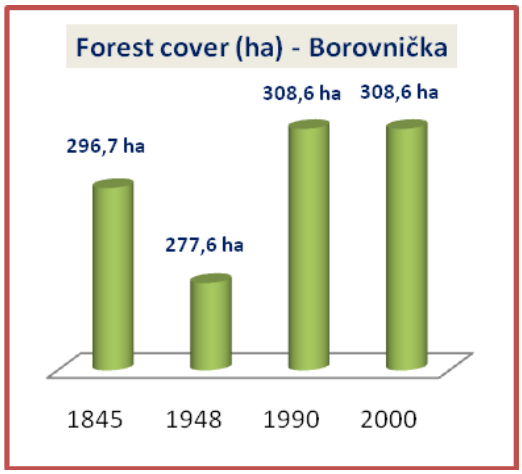


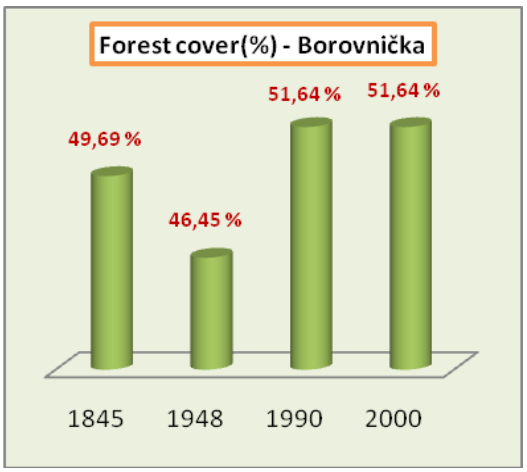


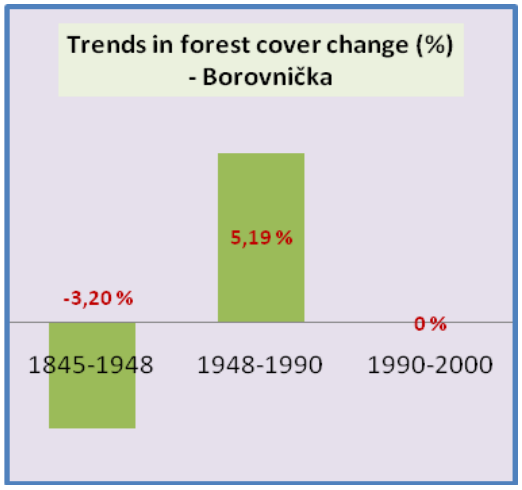


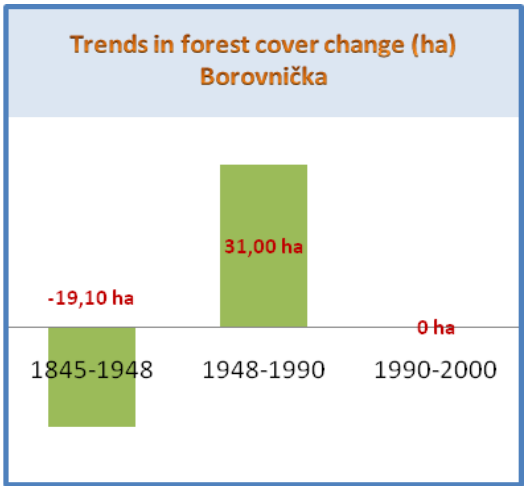


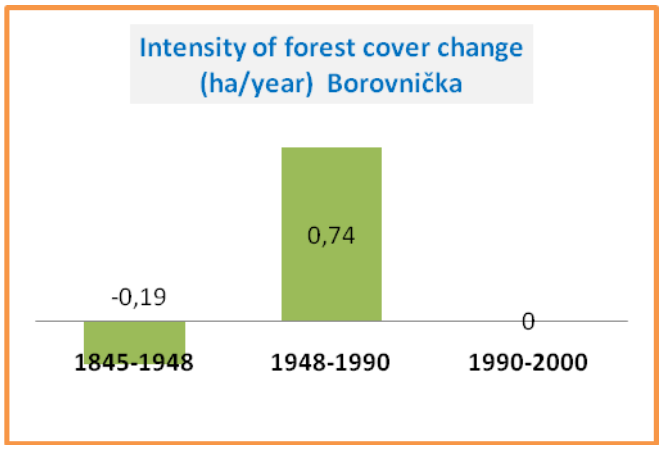
b) Borovnička



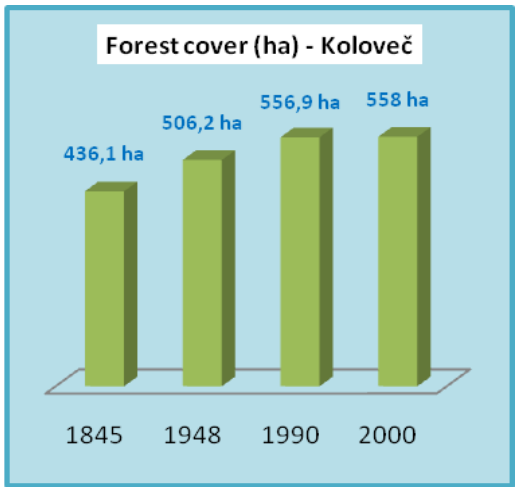


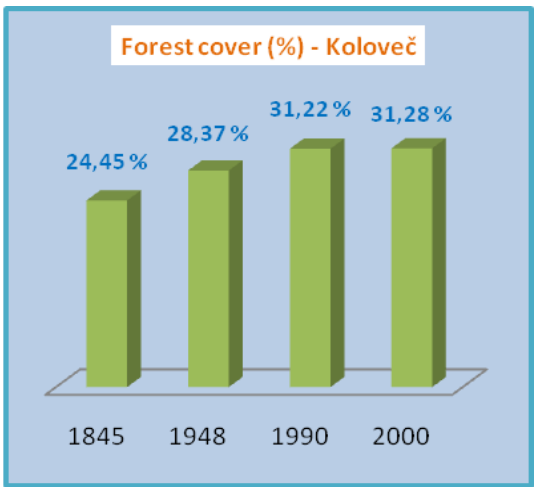


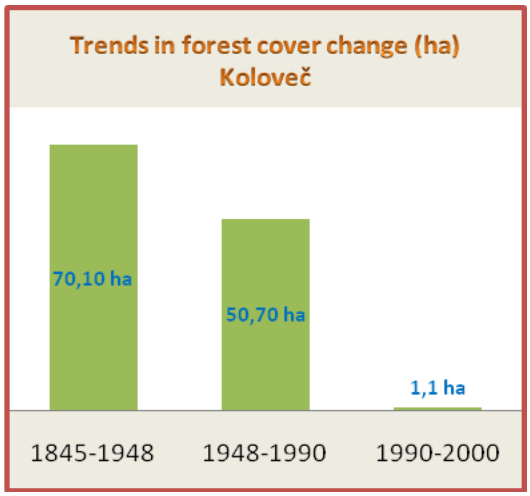


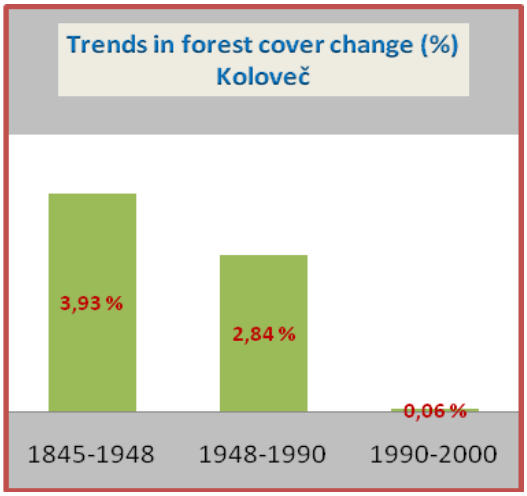


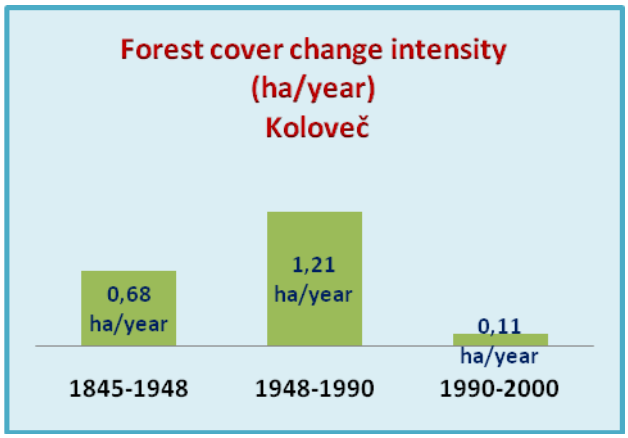
c) Koloveč


Forest cover (ha) - Koloveč
436,1 ha
506,2 ha
556,9 ha
558 ha
1845
1948
1990
2000

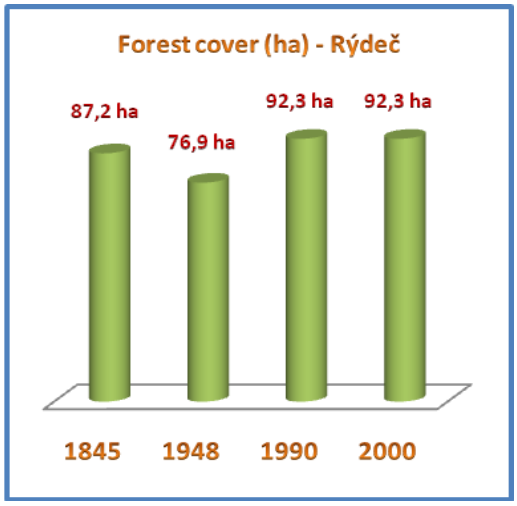

Forest cover (%) - Koloveč
24,45 %
28,37 %
31,22 %
31,28 %
1845
1948
1990
2000

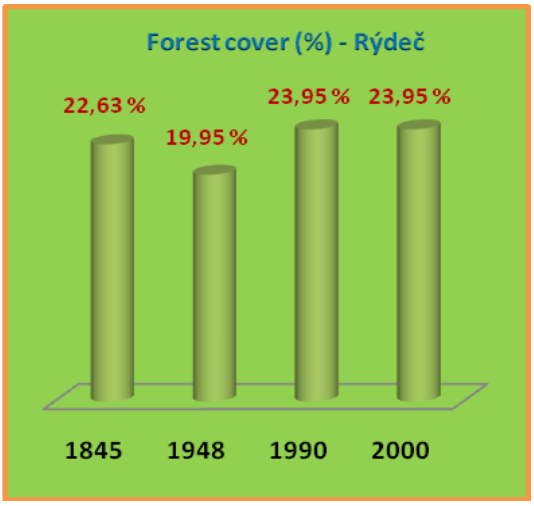

Trends in forest cover change (ha)
Koloveč
70,10 ha
50,70 ha
1,1 ha
1845-1948
1948-1990
1990-2000

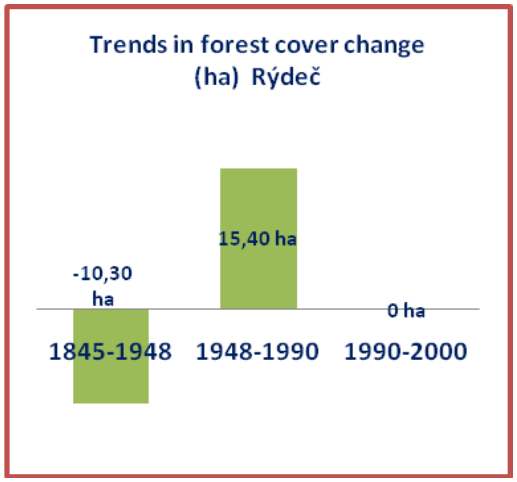

Trends in forest cover change (%)
Koloveč
3,93 %
2,84 %
0,06 %
1845-1948
1948-1990
1990-2000

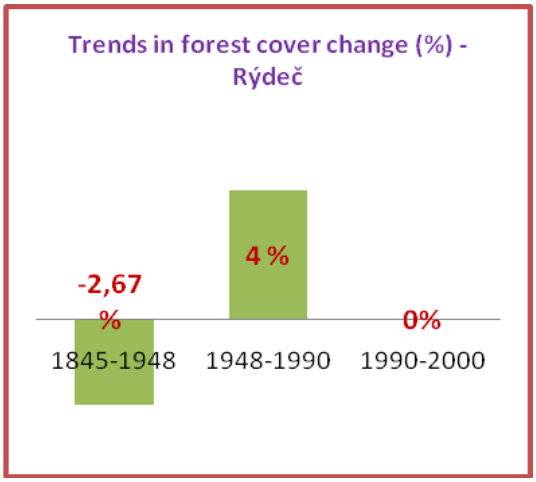

Forest cover change intensity
(ha/year)
Koloveč
0,68
ha/year
1,21
ha/year
0,11
ha/year
1845-1948
1948-1990
1990-2000

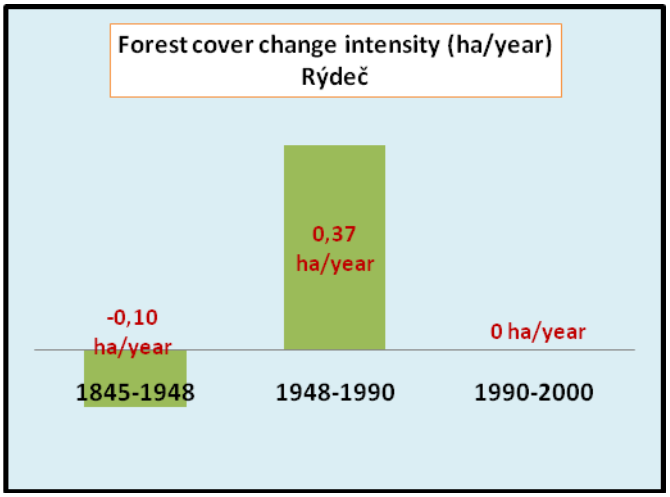
d) Rýdeč


Forest cover (ha) - Rýdeč
87,2 ha
76,9 ha
92,3 ha
92,3 ha
1845
1948
1990
2000


Forest cover (%) - Rýdeč
22,63 %
19,95 %
23,95 %
23,95 %
1845
1948
1990
2000

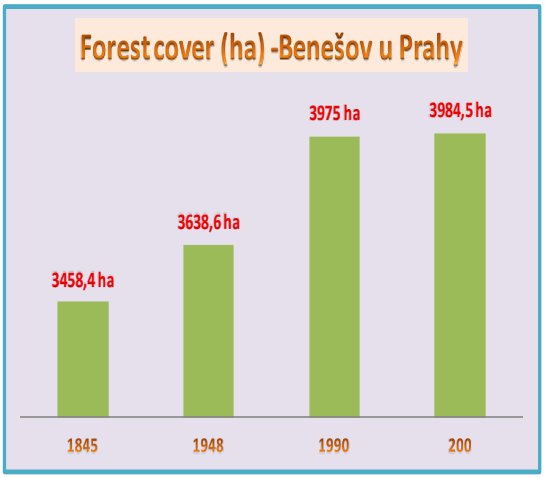

Trends in forest cover change (ha) Rýdeč
-10,30 ha
15,40 ha
0 ha
1845-1948
1948-1990
1990-2000

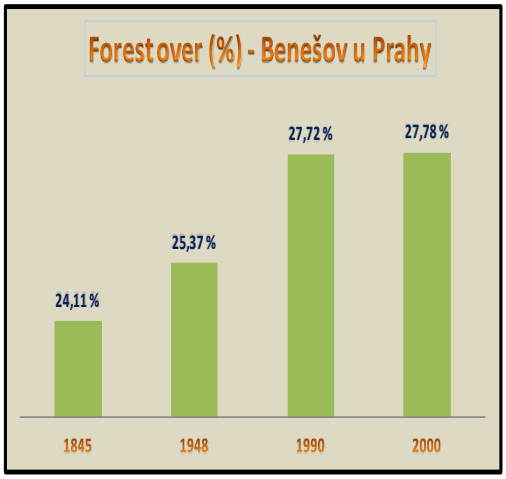

Trends in forest cover change (%) - Rýdeč
-2,67 %
4 %
0%
1845-1948
1948-1990
1990-2000

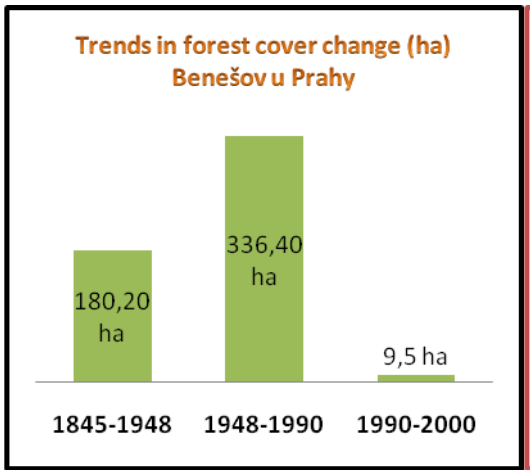

Forest cover change intensity (ha/year) Rýdeč
-0,10 ha/year
0,37 ha/year
0 ha/year
1845-1948
1948-1990
1990-2000

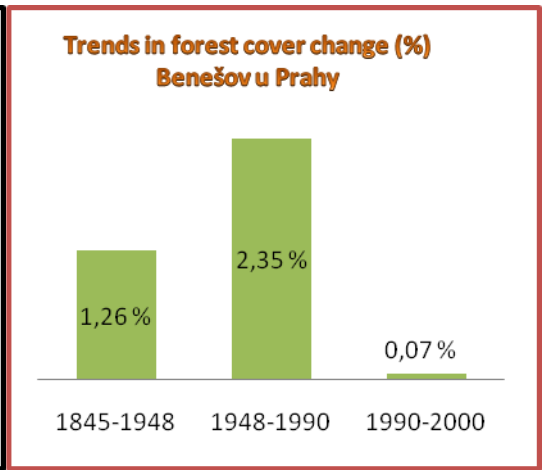
Appendix 11: Mírně teplé krajiny pánví a pahorkatin - **Slightly warm and hilly landscape pans.**

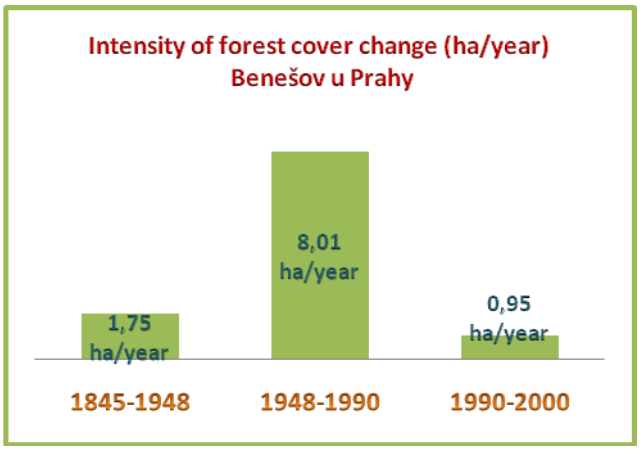
a) **Benešov u Prahy**



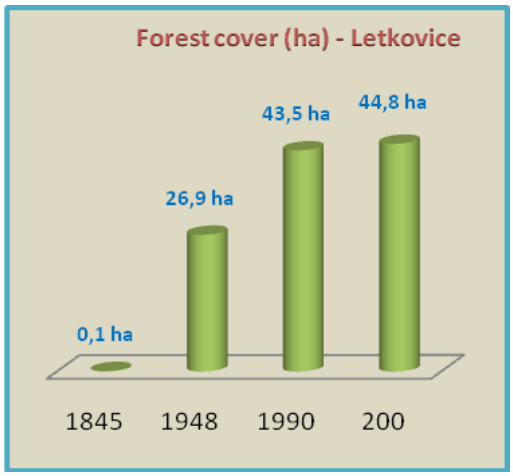


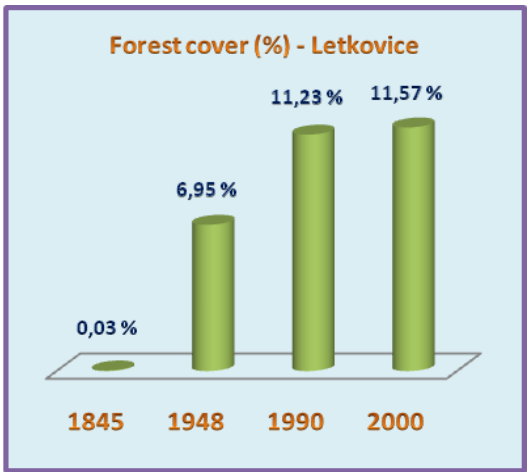


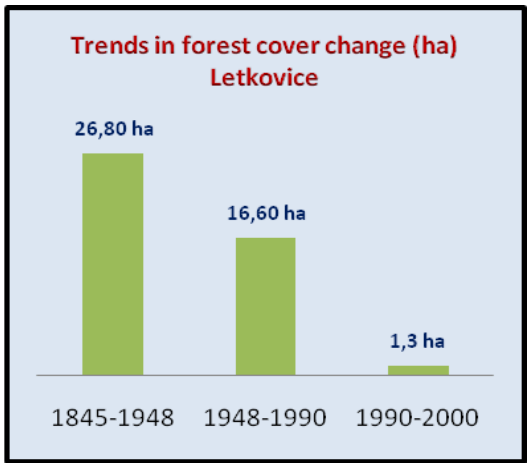


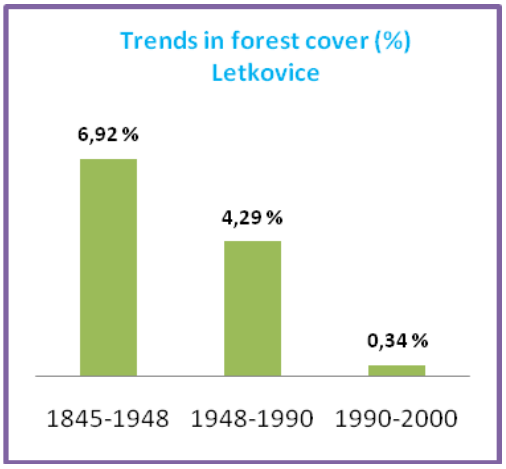


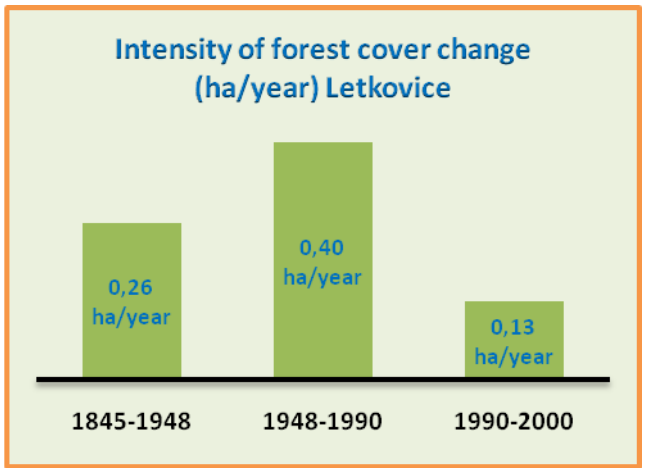
b) Letkovice


Forest cover (ha) - Letkovice
0,1 ha
26,9 ha
43,5 ha
44,8 ha
1845
1948
1990
200

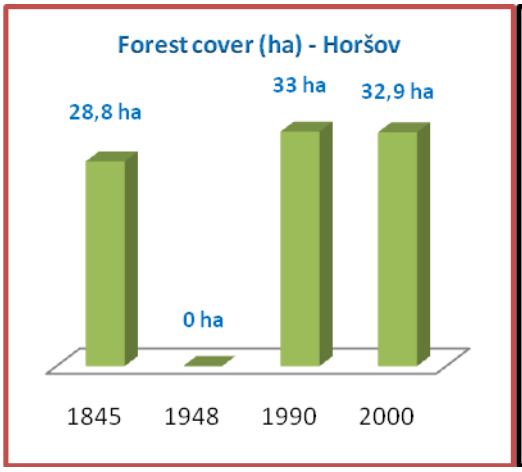

Forest cover (%) - Letkovice
0,03 %
6,95 %
11,23 %
11,57 %
1845
1948
1990
2000

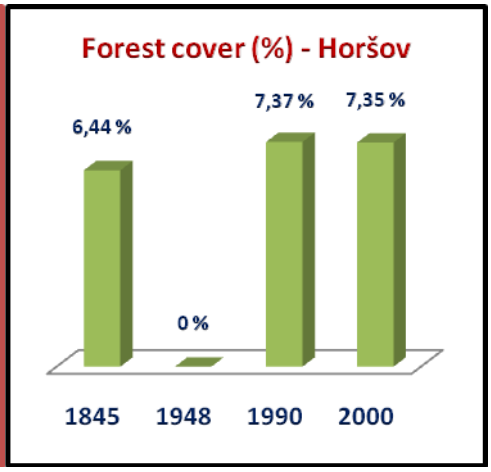

Trends in forest cover change (ha)
Letkovice
26,80 ha
16,60 ha
1,3 ha
1845-1948
1948-1990
1990-2000

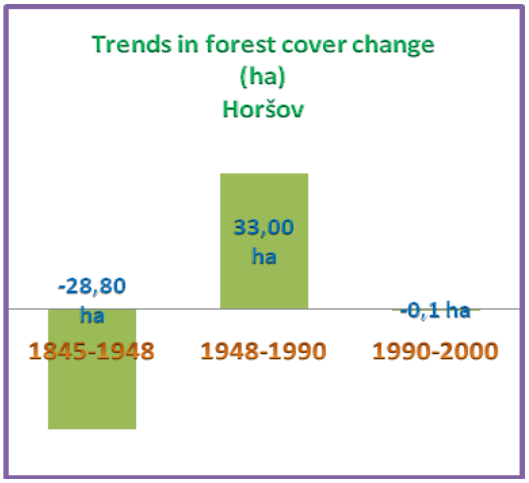

Trends in forest cover (%)
Letkovice
6,92 %
4,29 %
0,34 %
1845-1948
1948-1990
1990-2000

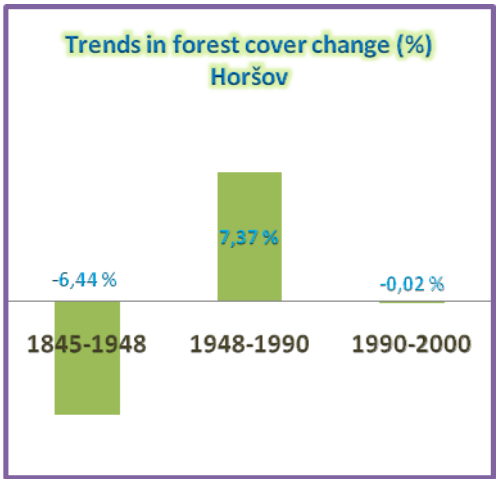

Intensity of forest cover change
(ha/year) Letkovice
0,26
ha/year
0,40
ha/year
0,13
ha/year
1845-1948
1948-1990
1990-2000

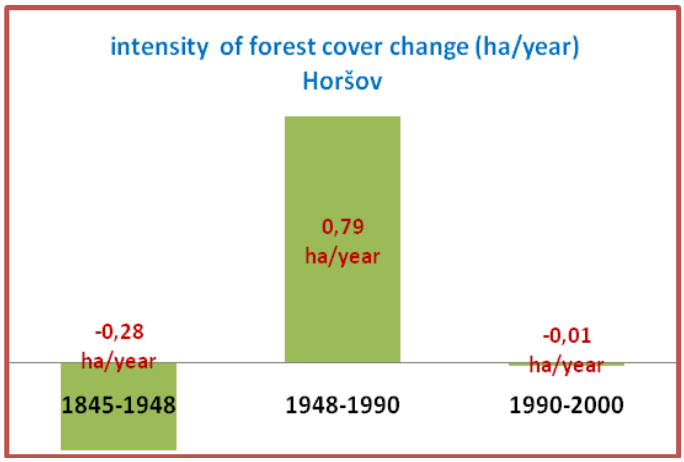
c) Horšov


Forest cover (ha) - Horšov
28,8 ha
0 ha
33 ha
32,9 ha
1845
1948
1990
2000

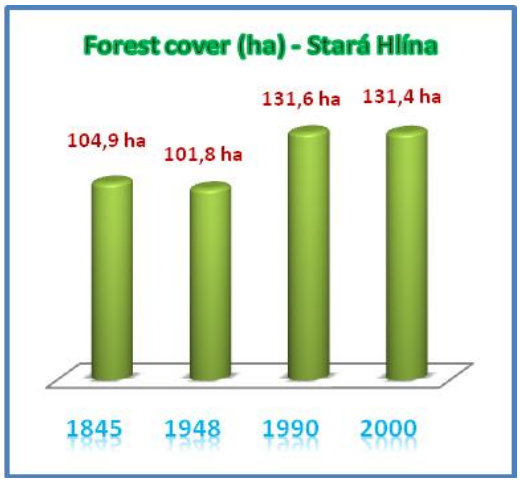

Forest cover (%) - Horšov
6,44 %
0 %
7,37 %
7,35 %
1845
1948
1990
2000

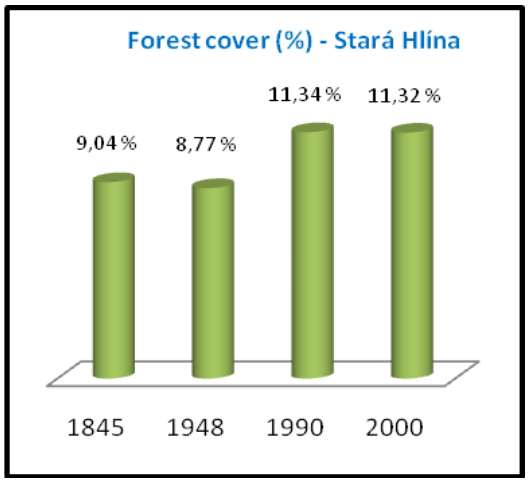

Trends in forest cover change (ha)
Horšov
-28,80 ha
33,00 ha
-0,1 ha
1845-1948
1948-1990
1990-2000

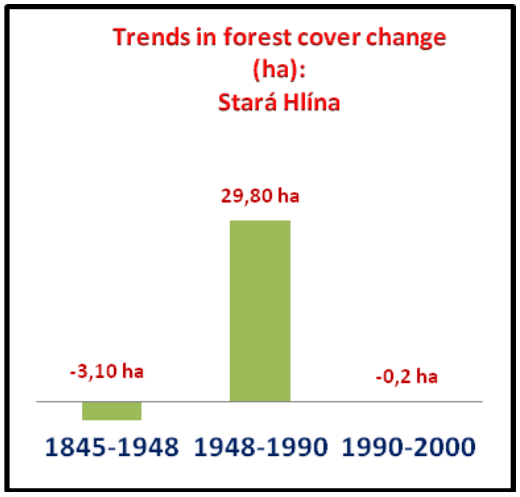

Trends in forest cover change (%)
Horšov
-6,44 %
7,37 %
-0,02 %
1845-1948
1948-1990
1990-2000

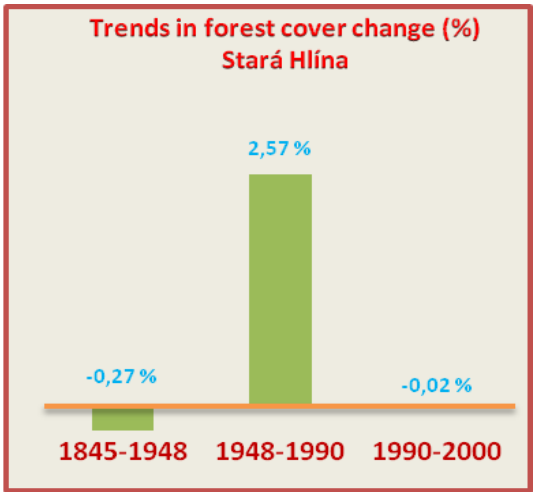

intensity of forest cover change (ha/year)
Horšov
-0,28 ha/year
0,79 ha/year
-0,01 ha/year
1845-1948
1948-1990
1990-2000

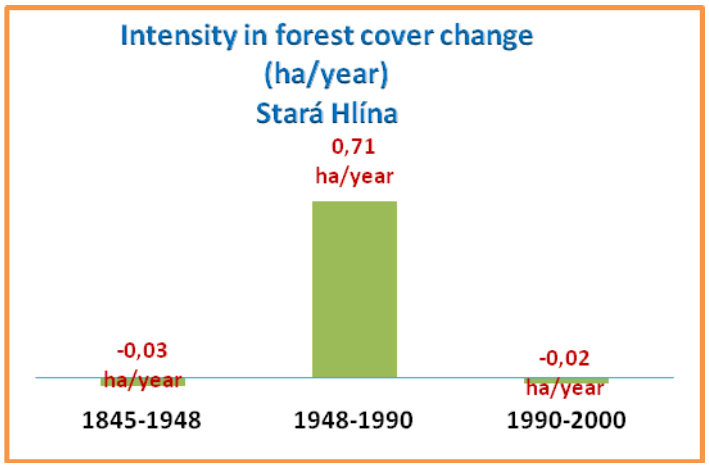
d) Stará Hlína





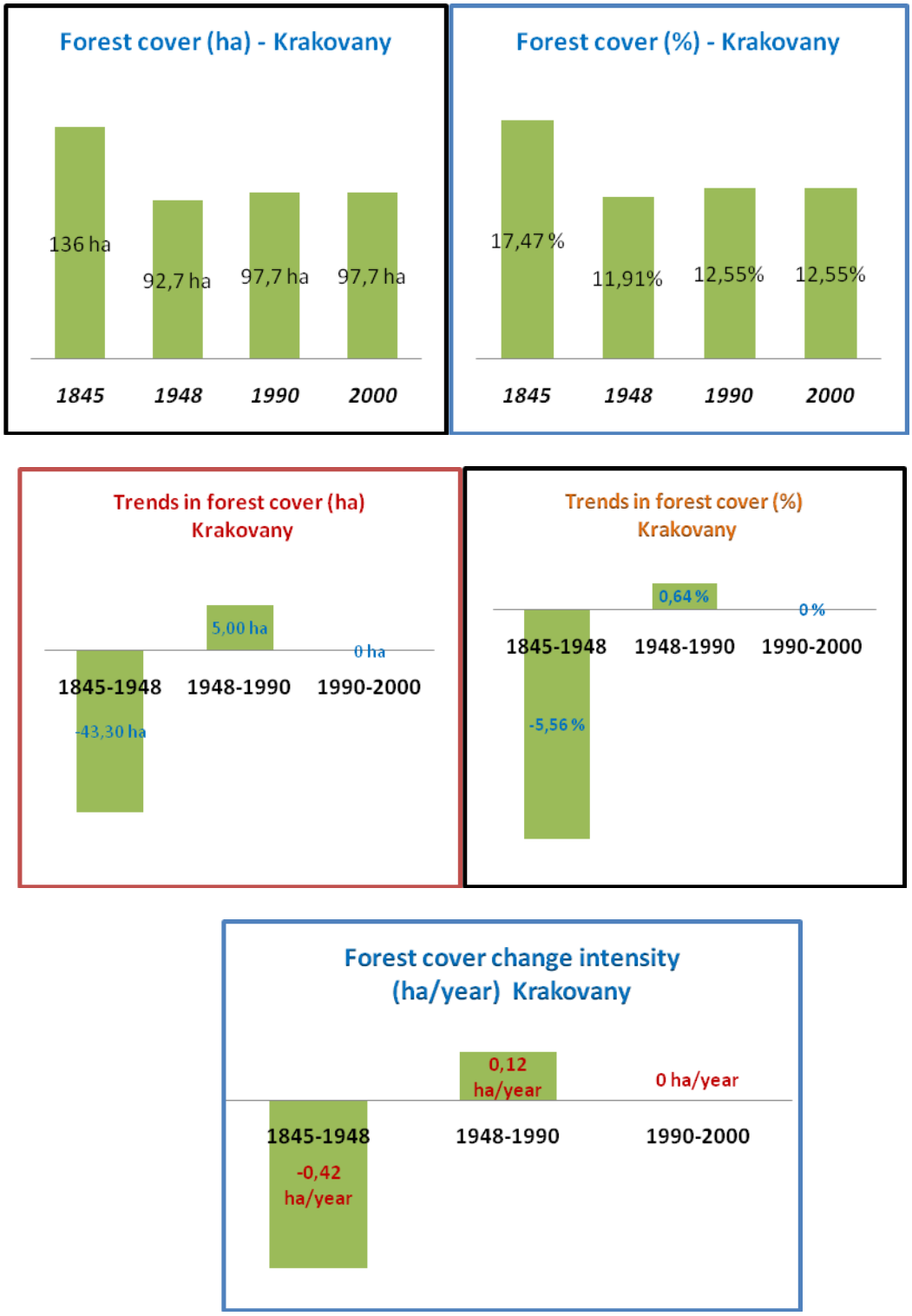




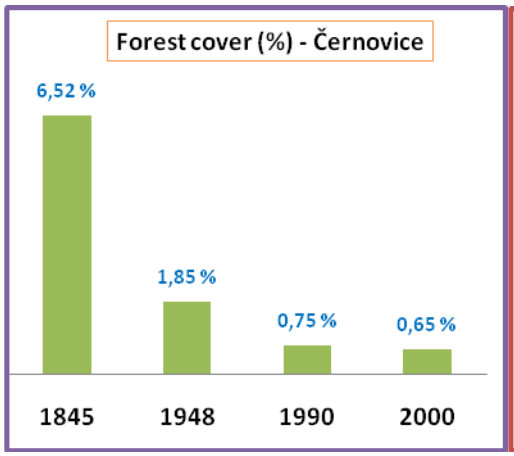


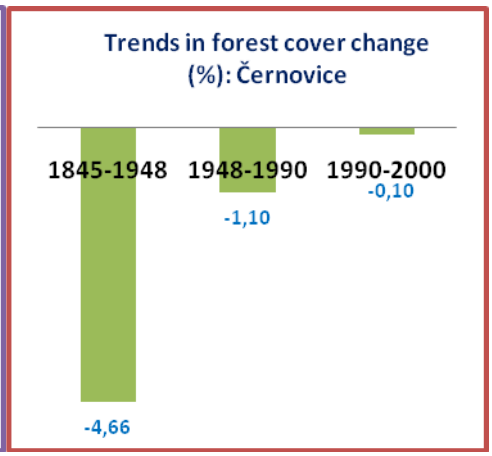
Appendix 12: Teplé krajiny nížin – **Warm landscape lowlands**

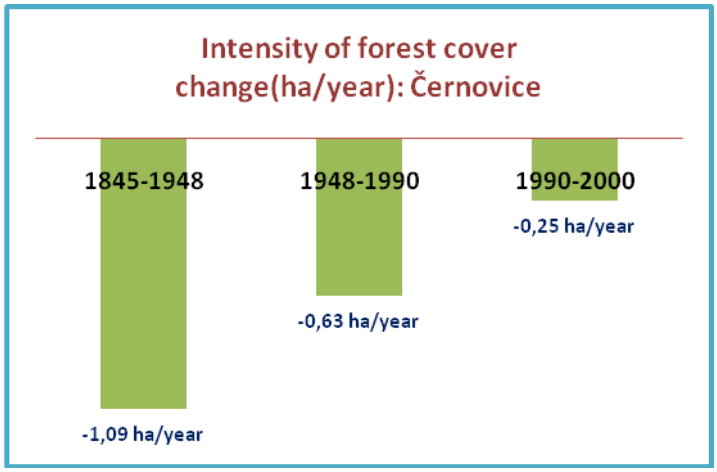
a) Krakovany



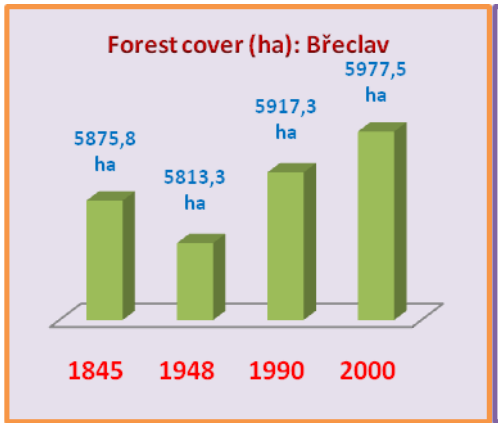
b) Černovice

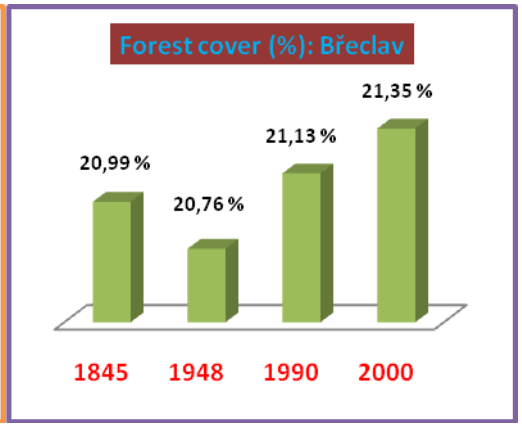

Forest cover (%) - Černovice
6,52 %
1,85 %
0,75 %
0,65 %
1845
1948
1990
2000

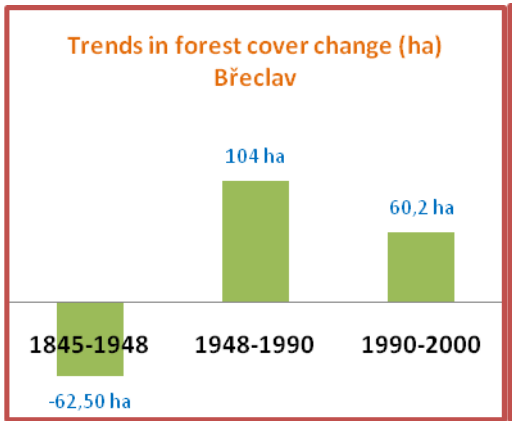

Trends in forest cover change (%): Černovice
1845-1948
1948-1990
1990-2000
-4,66
-1,10
-0,10

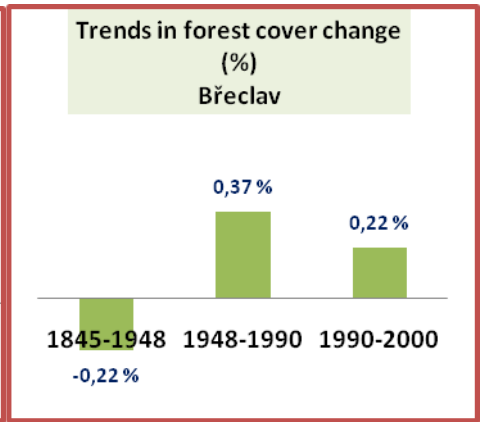

Intensity of forest cover change(ha/year): Černovice
1845-1948
1948-1990
1990-2000
-1,09 ha/year
-0,63 ha/year
-0,25 ha/year

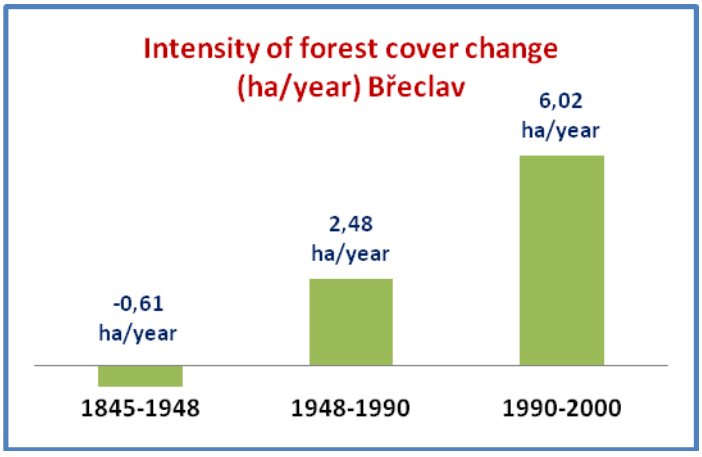
b) **Břeclav**


Forest cover (ha): Břeclav
5875,8 ha
5813,3 ha
5917,3 ha
5977,5 ha
1845
1948
1990
2000


Forest cover (%): Břeclav
20,99 %
20,76 %
21,13 %
21,35 %
1845
1948
1990
2000


Trends in forest cover change (ha)
Břeclav
104 ha
60,2 ha
1845-1948
1948-1990
1990-2000
-62,50 ha


Trends in forest cover change (%)
Břeclav
0,37 %
0,22 %
1845-1948
1948-1990
1990-2000
-0,22 %


Intensity of forest cover change (ha/year) Břeclav
-0,61 ha/year
2,48 ha/year
6,02 ha/year
1845-1948
1948-1990
1990-2000

c) Čelákovice