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Environmental stressors and stress as a natural/human interdisciplinary issue: a case study from the northwestern part of the Czech Republic

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Abstract

The article is concerned with landscape assessment from the point of view of the environmental (landscape) geography. It deals with theoretical background and a multi-criteria set of environmental stress indicators. Environmental stress represents an intersection of stressors from both ecological and social subsystems. It can be understood as a complex reflection of negative anthropogenic influences in spatial-temporal dimensions. Environmental stress assessment is monitoring negative influences on the ecological subsystem (topography, air, water, soil and biota) and on the social subsystem (demographic and economical variables). The case studies are located in the northwestern part of the Czech Republic, the Czech-German borderland. Negative anthropogenic effects on the landscape, (ecological or social stress changes in the landscape system) are monitored in the period of last 70 years during which the changes were most eminent. The presented methodological conceptualization enables to evaluate any random area also in terms of broader spatial and functional connections. Compared to other methodologies that evaluate the anthropopressures by monitoring of land use changes, the proposed procedure also enables to indicate driving forces significantly influencing conditions in chosen study areas.

Key words: environmental stressors – environmental stress – land use changes – driving forces – northwestern part of the Czech Republic

Introduction

The paper is concerned with landscape assessment from the point of view of the environmental (landscape) geography giving emphasis to the importance of the notion of stress. The term stress is mainly used in medical, physical, psychological and biological disciplines. It denotes a power system causing strain or producing distortions damaging the system which is influenced by it. The factor producing stress is called a stressor. Míchal (1993) called it an outer disturbing factor, at times he also explicitly used the notion of stressor. Stress is an effect of a stressor operating in a system. In a landscape system consisting of biotic, inorganic and human elements, stress represents all distortions present in such a system. Every impulse exceeding in its intensity the level of a physiological, ecological, or generally, a social or

economical standard can be defined as stress (or pressure, strain, disturbing force, trouble, and difficulty). It represents an extraordinarily powerful, intensive phenomenon in the deviations series of common fluctuations. The reaction to stress can be very intensive, but also absent (inert state). The ability to react determines also the ability to compensate (or remove) results of the stress. A first phase of the reaction to a stress is resulting from the principle of resilience. A next phase leads to resistance. In a last phase, the system either collapses (changing its character) or it compensates for the stress and continues to function. Thus, the stress can be wholly or incompletely compensated for in the systems, or the stress is not compensated for at all and the systems collapse. Ingegnoli (2002) argues that if the source of the stress acts in a continuous manner (i.e., chronically) or too strongly, it can endanger the "health state" of the landscape system. Given this specific orientation, the paper is structured as follows. First, we consider the notion of stressor in the context of landscape (environmental) system. Second, we indicate the character of chosen case study areas: the northwestern part of the Czech Republic (interwar so-called Sudetenland). Third, we elaborate in detail on methods and indicators used. Fourth, we specify results of our assessments of ecological stress development in the study areas. Finally, we discuss the used methodological approach and draw conclusions on results of our study.

Theoretical considerations

The theory of landscape ecological stressors was developed in Slovakia (see Landscape Atlas of the Slovak Republic, 2002; Šúriová and Izakovičová, 1995; Izakovičová, Miklós and Drdoš, 1997). Also Ingegnoli (2002), Lipský (1998), Antrop (2000) or Erickson (1999) use the terms environmental stressor, anthropo-pressure or landscape strain indicating degradation of natural landscape ecological conditions, and considering landscape pathology and anthropogenic disturbances as well. The level of stress influences active in the landscape is directly dependent on the character and number of environmental stressors. Natural stressors are currently present and active in the landscape in the form of natural disturbances (landslides, floods, radiation, volcanic activity, seismic processes) which the landscape can more or less accommodate. On the other hand, however, there is a large group of anthropogenic stressors. Šúriová and Izakovičová (1995) mark anthropogenic areas and lines (i.e., built-up areas, mining or intensively used agriculture areas) as primary anthropogenic stressors. Secondary anthropogenic stressors can be defined as features accompanying anthropogenic activity such as the number and type of produced waste, pollutants, noise, etc. Anthropogenic stressors can even create a connected system in the landscape, so-called territorial system of stressors that consists of core, territorial and line stressors (in contrast to "green ways").

Identifications of anthropogenic stressors and quantification of intensity of their influences reveal landscape levels of anthropogenic influence resulting from human disturbing impacts. The conceptualization in terms stress and specifying stressor enables the identification of causes and effects pointing out towards agents and their

effects in the landscape system. The concept of stress is a term broader in its meaning. It is referring both to stress in the ecological subsystem and the human landscape subsystem. We can conceptualize stress in concerning all (i.e., ecological and human) landscape components. Stressors include disturbances, but not only them. Stressors are also identified in land use areas transformed by anthropogenic activities, noise, odor, etc. It must be noted that stress in human subsystem (such as social pathological phenomena, delinquency, unemployment or divorce rate) and its consequences on the landscape character, landscape structure, and landscape ecological processes remains very often unnoticed although stress is a significant landscaping force influencing the landscape system (Hobbs, 1997, Risser, 1999). There are quantification efforts to specify a rate of anthropo-pressure from ratios of land use types or from intensities of anthropogenic influences on vegetation (Maruszczak, 1974, Skowronek et al., 2005). But, these efforts are only partial assessments of given environmental issues. However, the quantification of negative influences of men on the landscape can be one of the suitable indicators to assess and decide about future development in a given landscape (Conway, Lathrop, 2005, Nikodemus et al., 2005, Pauleit, Ennos, Golding, 2005).

Accordingly, we are asking the following research questions: (i) how will ecological and social stress evolve in different landscape types in various time periods? (ii) is it possible to integrate social and ecological stress into a comprehensive indicator telling about a complex negative impact of men onto both landscape subsystems? (iii) are or are not the developmental trends of both stress types related? (iv) which of them will have a greater dynamics of changes? (v) which reasons influence in the most striking way the changes in the intensity of stressors and in the subsequent occurrence of stress? (vi) where are we to look for the main driving forces?

Case study – Northwestern part of the Czech Republic

We analyze land use and environmental stress changes since the mid 20th century (see fig. 1) in three study areas of Czech–German borderland (the northwestern part of the Czech Republic) that are characterized by partially different development and mainly by different geographical conditions. The Czech territory stretching along the border with Saxony (Germany) was inhabited until the mid 20th century predominantly by the German-speaking population having in the region a population share over 90% of the total number of inhabitants. Immediately after the WWII, the German population was mostly transferred to eastern and western Germany. It is necessary to note that this huge population transfer changed in many important respects the character of the region, because there existed in the past more intensive economical, cultural and political relationships with Saxon towns than with the towns in the Czech Lands, i.e., Bohemia and Moravia. And this was not only at the time of Austria-Hungary, but after the foundation of Czechoslovakia in 1918 as well. The unique character of this so-called "Sudeten region" is reflected, among other things, in a different landscape character, peculiar folkways, and architecture. That is why, in connection with the former landscape development, now and then one speaks of so-called "Sudetenland landscape model". The landscape was interwoven with a dense

net of small built-up elements that usually reached a peak at some elevation dominant (an observation tower, a viewpoint or an inn). Tourists made use of spatially scattered accommodations of such as summer residences or family boarding houses. In consequence, there was not a tendency to concentration of accommodations in holiday resorts as that is in fact taking place now. The study areas of the northwestern part of the Czech Republic were areas of the North Bohemian administrative region established in 1960, and since 2000 they are with the Ústí County.

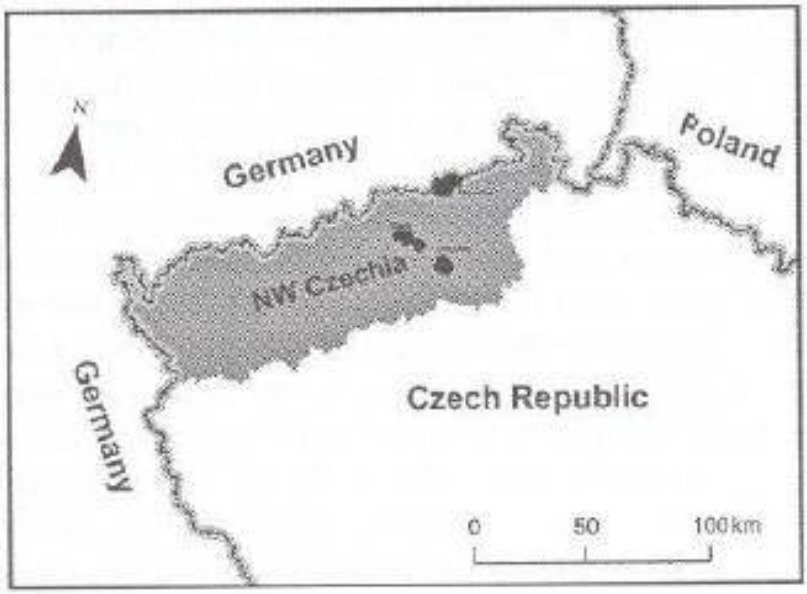

Fig. 1 Study areas Bilinsko, Petrovicko and Trebenicko in the northwestern part of the Czech Republic

There were several reasons for choosing these study areas. The Northwestern part of the Czech Republic was in the past a sort of "barometer" which revealed fundamental changes in the development of the Czech rural landscape, more specifically at the beginning of these changes resulting from the processes of industrialization and urbanization that occurred in close connection with developments in Saxon towns in the mid 19th century and brought ecological problems. The ecological stress particularly intensified in the 1950s of the last century, and some 30 years later it reached in the national territory critical values. All natural landscape components were disturbed and damaged. The negative impact was quite manifest and can be indicated in terms of health and sociological aspects of the inhabitants also today. It is therefore little surprising that in this region, first actions directed against the totalitarian.

One of the strongest stressors influencing the study region is represented by large brown coal mining area and linked up with concentrated energy industry. Emissions from numerous heat power stations influenced not only nearest areas, but all the northwestern part of the Czech Republic and at the times of the highest intensity emissions they crossed the Czech-German borders causing significant ecological problems at the scale of Central Europe.

The first study area of Bílinsko represents case study area with environmental stress of the highest intensity. The area is territory of the town of Bílina and its wider surrounding including destroyed settlements. The second study area is the area of

Petrovicko representing a different type of territory, because it is a hilly border area, located to the northwest of Ústí nad Labem, the major regional city. The area of Petrovicko represents similar mountainous areas in the Ore Mountains marked by a dynamical development until the end of 19th century, followed by subsequent stagnation of both economical and demographical development, and after World War II by significant regressive trends, and general changes in landscape functions and landscape character. The third study area is the area of Třebenicko representing an intensively agriculturally exploited landscape type where the landscape function remained stable during its whole development. Slightly regressive population trends corresponded to similar agricultural areas of Central Europe. Due the available historical data on environmental stress and stressors activity, the three study areas were delineated within the borders of administrative units. Other important criteria for delineations of the study areas were a roughly comparable area and a "natural gravity field" or social identification with local node ("gravity center") of the larger territory. Accordingly, the areas of Bílinsko, Petrovicko and Třebenicko represent different landscape types in the northwestern part of the Czech Republic.

Bílinsko (total area 4600 ha) occupies a favorable and exposed geographical position in the Most brown coal basin on the regional economic and settlement developmental axis under the ridge of Ore Mountains (Chomutov – Ústí nad Labem axis). The undulating and currently wholly deforested landscape lies at the altitude of approximately 200 m above the sea level and the relief is in the northern and eastern part of the area dramatically influenced anthropogenic factors owing to extensive surface mining activities. The river of Bílina flows through the centre of Bílinsko area and along the river there is a historical trade trail. Archeological data indicate prehistoric settlement. A Slavonic stronghold used to be there in the 10th century. Population distribution is marked by an extreme polarity and by population concentration in one built-up area. At the present time, there is a very high level of employment in industry (43%) a low level in agriculture. The Petrovicko area (6400 ha) is after WWII, a very peripheral in the eastern part of the Ore Mountains. After 1989 and following the opening of D8 motorway (international transportation axis Prague – Berlin) the geographical position improved dramatically. From the east, the sandstone rock town of Tisá sand stone walls (a landscape protected area) extends to the plateau with a high rate of forest areas alternating with managed meadows. The hill of Špičák (723 m above the sea level) dominates the northwestern part of the study area. There are abundant sources of underground water drained into the water supply system for urban agglomerations under the Ore Mountains ridge. The sparse density of settlements corresponds with the extremely low population density (20 inhabit. per km^2). The Petrovicko area is characterised by a lower number of "natives" (only 36% of inhabitants living in the place of their birth), by an extremely low rate of people employed in industry (20%) and by a high rate of houses used namely for recreational activities (28%). The area of Třebenicko (3600 ha) with a largely flat and little forested landscape has an intensively exploited agricultural landscape: a mosaic of intertwined plots of fields, orchards and groves. The north steep slopes of the volcanic sedimentary complex of the Bohemian Central Mountains (a landscape protected area) extend to the Třebenicko study area. The warm and low precipitation climate in a low altitude

and fertile chernozem soils are good conditions for intensive agricultural use. The Třebenicko area has a high ratio of older population (19.2% of 3800 inhabitants are older than 60), an above-average share of „natives" indicating a high level of stability of population (49% of inhabitants living in the place of their birth), a higher proportion of employees in agriculture (9%) and a comparatively low share of employees in industry (25%).

Methods

The negative influences of human beings on the landscape system (i.e., changes in environmental stressors causing ecological or social stress in landscapes) can be generally structured by references to different characteristic periods of human history (see Agnew, Livingstone, Rogers, 1996). We can distinguish four basic evolution stages in societal development of the northwestern part of the Czech Republic (see also Hampl 1998):

- The pre-industrial period characterized by determinations of the ecological subsystem of settlement distribution and structure and economical activities. The human sub--system of human activities played in this period a quite passive role in comparison to the following stages. The primary sector employment (agriculture, ore mining, and forestry in mountain areas) was dominating and a low development dynamics was characteristic. Limiting impacts of natural environment and low spatial mobility influenced importantly part the distribution of population. The settlement structure was characterized by a low level of hierarchical organization. In comparison with the following stages, the population was distributed relatively evenly and the variation range in population size of individual settlements was not extreme.
- The industrial society development based on secondary sector expansion was characterized by a distinct dynamics of changes. Limiting conditions of natural environment were gradually overcome and the role of socio-geographical factors was increasing (Berry, 1973; Broek, Webb, 1978). The ecological and human subsystems were often competing (fig. 2). An urbanization process was intensifying and leading to increasing spatial mobility. This so-called extensive form of urbanization took first place I the 19th century in the northwestern part of the Czech Republic that has intensive connections with the urbanization process in the settlement structure in Saxony. Also the process of industrialization started in this part of the country in the territory of Děčínsko from where the industrialization process was spreading I the second half of the 19th century to other regions of the northwestern part of Bohemia, i.e., from the east towards the west and from there into Inner Bohemia.
- The totalitarian period (i.e., the German occupation and the communist period) in the Czech Republic was characterized by a final phase of the industrial society that was a deviation from the development towards a post-industrial society taking place in Western Europe in spite certain features of emerging post-industrial society that were already revealing. From the long-term perspective of European societal development the changes taking place this period in the northwestern part of the

Czech Republic lead to a break in the existing developmental continuity. The break started with the expulsion of the German-speaking population after the WWII implying a massive depopulation of the settlement structure, deserted housing resources and destruction of numerous historical and ecclesiastical landmarks. At the same time, identification of "new-settlers" from regions in Inner Bohemia with the landscape weak, and this was shown in the disappearance of many local customs and traditions. The historical relationships with settlements in Saxony were suppressed dramatically. At the foothills of the Ore Mountains the large scale open pit brown coal mining and associated heavy industries (mainly energy and heavy chemical productions) were intensified. In the lower fertile areas there was introduced and intensified mass agricultural production.

- The development towards a post-industrial society in the Czech Republic was in stated characterized by intensive development of communication and information contacts (pressure on transport and communication nets) and by expanding tertiary sector (services and tourism) of the economy. Increasing integration of the settlement system was taking place. Tendencies to depopulation were spatially rearranged through population concentration in large urban centers ("gravity centers and major urban nodes") and in their surrounding areas (Hampl et al., 2001). Geopolitical changes leading to opening western borders of the Czech Republic changed geographical conditions and resulted also in the promotion of formerly peripheral areas near the Czech-Germany borderland. In many of the border areas tourism ("recreation industry") became a main driving force or chance to improve local economic and social conditions.

We are dealing in this paper with the last period of the development of an industrial society (i.e., with the totalitarian period) and with the post-industrial stage in which important changes in the ecological and social stress in the study areas took place and can be documented. Figure 2 shows in a simplified way the changing relationship between the ecological subsystem and the human subsystem in the above-indicated periods of the pre-industrial, the industrial and the post-industrial developments.

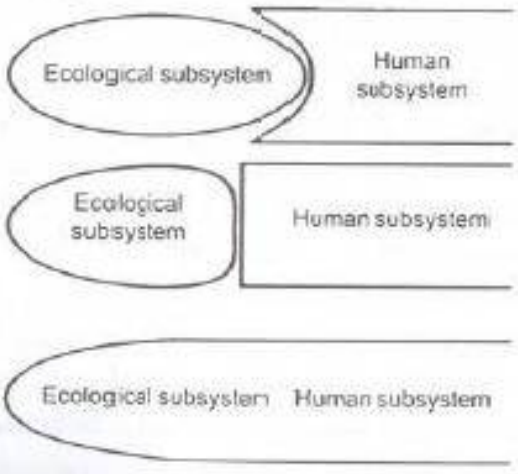

Fig. 2 Changing relationship between the ecological subsystem and the human subsystem in periods of pre-industrial, industrial and post-industrial development

According to the methodical procedure of ecological and social stress accounting we divide the period of the second half of the 20th century (i.e., the totalitarian and post-industrial periods) into five time horizons for which there are available reliable databases. Approximately in 1950 the final stage of the industrial period began when the levels of environmental stressors start in the totalitarian phase to intensify dramatically. The two following time horizons (1970 and 1980) indicate dynamic changes that took further place in the totalitarian era. These trends ended in 1990 when the post-industrial development started to intensify.

The methodological concept of environmental stress reflects both the stress in the ecological subsystem (ecological stress) and the stress in the human subsystem (social stress). Not only the total value of stress is important, but also the proportions of ecological and alternatively social stress in different time intervals. The stress identified in the study areas indicates the influence of the stressors located both within the area and the ones beyond its boundaries. Obviously, effects of environmental stressors do not respect administrative boundaries. From the terminological point of view the term stress is in accordance with the internationally recognized methodological concept derived on the basis of the European Environmental Agency (see Jesinghaus, 1999). Therefore, the environmental stress accounting reflects the anthropogenic pressures in the DPSIR scheme ("Driving forces – Pressures – State – Impact – Response").

A fundamental point of the methodological procedure is to choose adequate indicators, representing particular features in the ecological and human subsystems (see Anděl, 1993). Having in mind that individual indicators do not have similar indicative power (some of indicators document even multifunctional effects), it is methodically correct to give them different weights. The task to specify indicators and their weights was given to an expert evaluating committee composed of leading Czech and foreign experts (from the Czech Republic, Germany, Poland and Slovakia). The selection of adequate indicators was also limited by the time horizon, because it was necessary to have available valid data about their levels in the opening time periods of monitoring. The calculation of stress is made in correspondence with similar methods on the basis of rating points. Maximum interval of the chosen indicator for the monitored area is divided into quartiles. Values are assigned as follows: in range of low values (quartiles $Q_1 = 0$), below average values ($Q_2 = 1$), above-average values ($Q_3 = 2$) and high values ($Q_4 = 3$). These are multiplied by corresponding weights (1 or 2). Obviously, the hierarchical level is important here, because in evaluating the environmental stress the variation interval for individual indicators with higher hierarchy level increases and it can have even a different scale of rating points. The environmental stress assessment is valid for the selected study areas of the northwestern part of the Czech Republic. Analogically, naturally with defining individual intervals of specific quartiles, the same methodology can be used for any other territory. By a correlation analysis significant autonomy of individual environmental stress indicators was confirmed, because Pearson's correlation coefficient did not exceed the value of 0.6.

For the purpose of calculating the ecological stress present in individual landscape components we indicated at first the degradation degree of the relief and soils (see

fig. 3). For the Northwestern part of the Czech Republic a distinctive transformation of anthropogenic topography is typical (e.g., the surface mining of brown coal and quarries for building stone – trachyt and phonolites) which has resulted not only in the functional disturbances of the ecological subsystem, but also in a devaluation of total visual quality of landscape (Balej, 2004). The presence of illegal and controlled dumping land-fills was evaluated with the help of 0–3 points. The potential of water and wind soil erosion was calculated by means of a equation defined by Wischmeier and Smith (1978). Air quality was indicated on the basis of data about imission concentrations (solid materials, SO_2 and NO_x) and also by the indicator of air pollution from local sources (namely from houses heated by solid energy sources). Surface waters quality is assessed by a quality indicator of the water in streams. Ecological stress present in land cover landscape component reflects imission zones of forest areas (proportion of forest areas with deteriorated health state, according to the defoliation of treetops in %) and ecological stability index, it is ratio of relatively stable nature land use types (forests, meadows and pastures, marshes and water bodies) to instable land use types (built-up areas, fields, transport lines and other types). As regards the completeness of information about the stress in the ecological subsystem the barrier effect calculation and the presence of noise or odor cannot be omitted. First of all, there was calculated landscape fragmentation by transportation barriers in terms of as transportation lines density (railways and roads) with individual stages weighed by the intensity of traffic (number of vehicles or trains in 24 hours).

Social stress assesses social aspects which are seen with respect to human being as negative ones. Therefore, a set of social stress indicators must reflect basic features of

Tab. 1 Indicators of ecological stress

INDEX	GROUP	INDICATOR	SPECIFICATION	WEIGHT*
A1	Relief and soils degradation	Degree of anthropogenic transformation	Presence of anthropogenic landforms in %	2
A2		Potential aeolian and water erosion	degree	1
A3		Dumping places	degree	2
A4	Air pollution	Air pollution SO2, NOx, air dust	mcg/m^{-3}	2
A5		Local sources of air pollution	$tons/km^{-2}$	1
A6	Water quality	Surface water course quality	quality factor	2
A7	Biota	Forestal air pollution zones	prevailing category A, B, C, D, E, F	1
A8	Other stress	Ecological stability index	ratio of relatively stable and unstable land	1
A9		Noise and emission	intensity and frequency of traffic	2
A10		Barriers	length of artificial-transportational ways km/km^2	2

*according to the assessment made by team of international experts

- 1st phase of the totalitarian period – the *initial* phase (1950–1964) – without large heat energy sources and with a lower intensity of industrialization, only with local influences of industrial plants;
- 2nd phase of the totalitarian period – the *accelerating* one (1964–76) – setting in operation of power plants: Tušimice I (1964), Ledvice, Prunéřov I (1967), Počerady I (1970), escalating the surface mining in the lower Ore Mountains lignite basin, some first indications of a large scale forest disturbances (Czech-German borderland);
- 3rd phase of the totalitarian period – the *culminating* one (1977–85) – setting in operation of other power plants: Tušimice II (1977), Počerady II (1977), Prunéřov II (1982) – slopes and ridges of the Ore Mountains become maximally stressed, culminating pollution in the basin area;
- 4th phase of the totalitarian period – the *regressive* one (1985–91) – modernizing and reconstructing of some power station blocks, the general decrease of the emissions productions in the Northwestern part of the Czech Republic;
- 1st phase of the post-industrial period (1991–98) – desulphurization of 20 power station blocks and the elimination of 1190 MW of output, a very rapid decrease of emissions of noxious agents into the air by all ten largest emitters;
- 2nd phase of the post-industrial period (after 1999) – stagnation (or fluctuation) of the emissions production and implementation of alternative energy sources.

At the time of the ecological stress culmination of the most of landscape components in the Czech Republic (i.e., during the first half of the 1980s) the northwestern part of the republic was having a share of 27% in the solid emissions volume of the whole Czechoslovakia and 47% in the volume of SO_2 emissions. In this area there was a more than two times higher average of immission SO_2 concentrations than in the whole country, in the case of solid materials it was more than by 63%. The intensity and the culmination of the largest (supra-regional or better still almost provincial or international) stressors is shown by the emissions per area unit, where the northwestern part of the republic had 3.5 times higher emissions per sq km than was the average level in former Czechoslovakia. Moreover, there took place extreme concentration of stressors in Most and Chomutov districts where a half of the solid emissions was emitted; in Chomutov district also a half of the SO_2 emissions and NO_x of the whole northwestern part of the republic. The districts were leading in terms of tons of emissions in a year per sq km The Most exceeded 13 times and the district Chomutov more than 10 times average production of specific emissions of all districts. In spite of differences in decreasing of emissions in various parts of the Czech Republic, the districts ranking and their approximate rate in the region under our study emissions have remained nearly the same until nowadays, with a certain tendency towards equalization. Still the highest volume of SO_2 emissions is produced in Chomutov district (37%) and Most district (25%), of NO_x emissions in Chomutov district 41%, the proportion of emissions of solid materials in Chomutov district is still 25%, and in Most district it is "only" about 10%. The rate of the emission production in northwestern part of the Czech Republic has decreased regarding solid emissions to 10% and regarding SO_2 approximately to 30% of the Czech total volume.

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According to the classification of air pollution sources in the period of the pollution culmination (1977–185), 83% of solid and 92% of gas stressors (SO_2 96%, NO_x 98%) emissions in the northwestern part of the Czech Republic were stressors from so-called REZZO1 category (sources with outputs more than 5 MW). Despite of technological reductions of pollution – first of all in power plants – in 2001, the stressors from the REZZO1 category produced in the total emissions of solid polluting materials with 50%, in NO_x with 82% and in SO_2 with 93%. For the comparison, in the national total these shares of the REZZO1 sources are more balanced: in the case of solic polluting materials 27%, regarding SO_2 77%, and regarding NO_x 44%. Accordingly, it is still possible to claim that the largest stressors of the air landscape component in the northwestern part of the Czech Republic are the sources from the REZZO1 category and that in this category the dominant producers of the sulfur dioxide and nitrogen oxide emissions still are the heat electrical power stations (especially those in Počerady, Tušimice, Prunéřov, Komořany, and Ledvice).

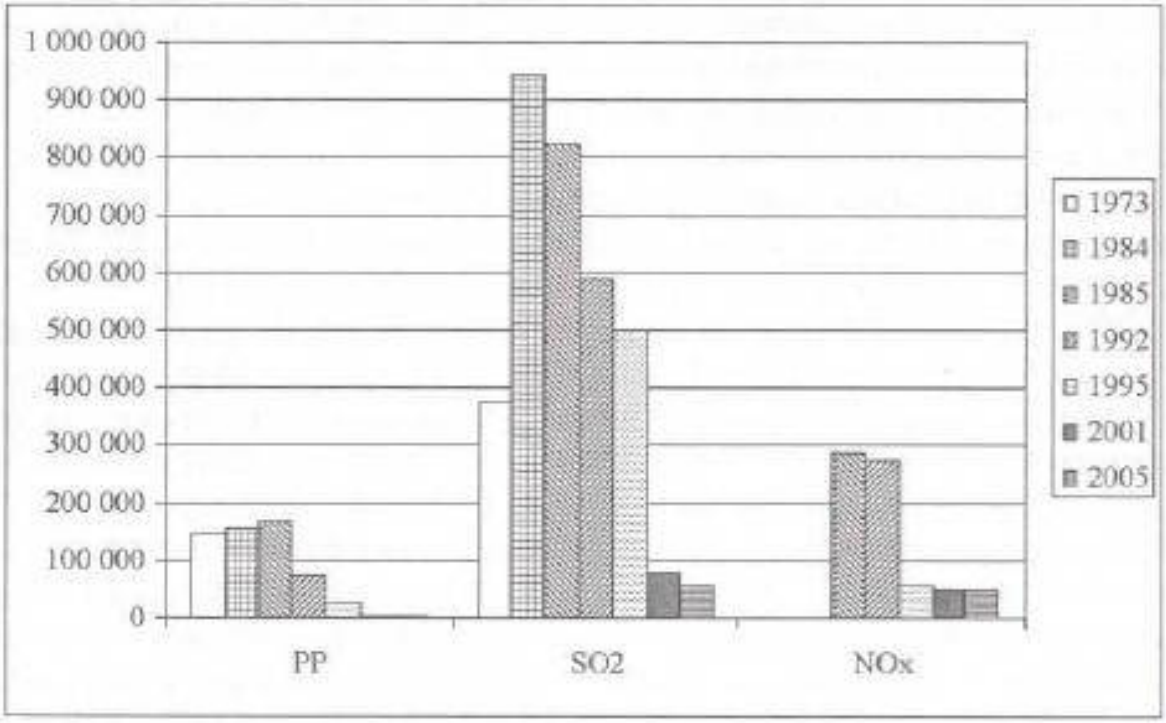

Fig. 3 The eight largest stressors of solid emissions, SO_2 and NO_x (in tons per year)

In 1995–97 there were desulphurized altogether 20 power plant blocks in the study region and 1190 MW of output was taken from production in 1991–98 and in many blocks a new technology of fluidized bed boilers was introduced. In consequence, I terms of the level at the beginning of the 1990s, the emissions of SO_2 decreased by 92%, the emissions of solid particles by 95%, the emissions of nitrogen oxide by 50% and those of carbon oxide by 77%. Regarding the emissions of sulfur dioxide and nitrogen oxides in the period 2000–2004 there are indicated slightly declining or stagnant tendencies in the region and the Czech Republic (see fig. 5).

The topography in the northwestern part of the Czech Republic, with its brown coal mining basin below the Ore Mountains elongated in the southwest-northeast direction

and with prevailing western and northwestern winds and the location of the study areas to the east of the main stressors means that the pollution coming from 100–180 meter high chimneys of the main heat stations and electric power plant, have given namely the areas of Bílinsko and Petrovicko under the strong stress pressures, and less the are of Třebenicko which is "hidden" in the "shadow" of the ridge of Central Bohemian Mountains. The only important air stressor found directly inside this study area is the Lafarge cement works that is exploiting there vast bed of Mesozoic calcareous marbles. This stressor causes in the Třebenicko study area higher concentrations of solid particles in the air. Generally, it can be claimed that in the majority of cases the immission concentrations of SO_2 and PM_{10} reached lower values than they were in 1970. Figure 6 documents that the immission concentration of SO_2 in the period of their culmination (1980–85) reached the values from 70 Kg to m^3 in the Třebenicko area to 150 Kg to m^3 in the Bílinsko area and later were tending to decreased very dynamically till 2000 due to the decreasing impact of the above-indicated largest stressors.

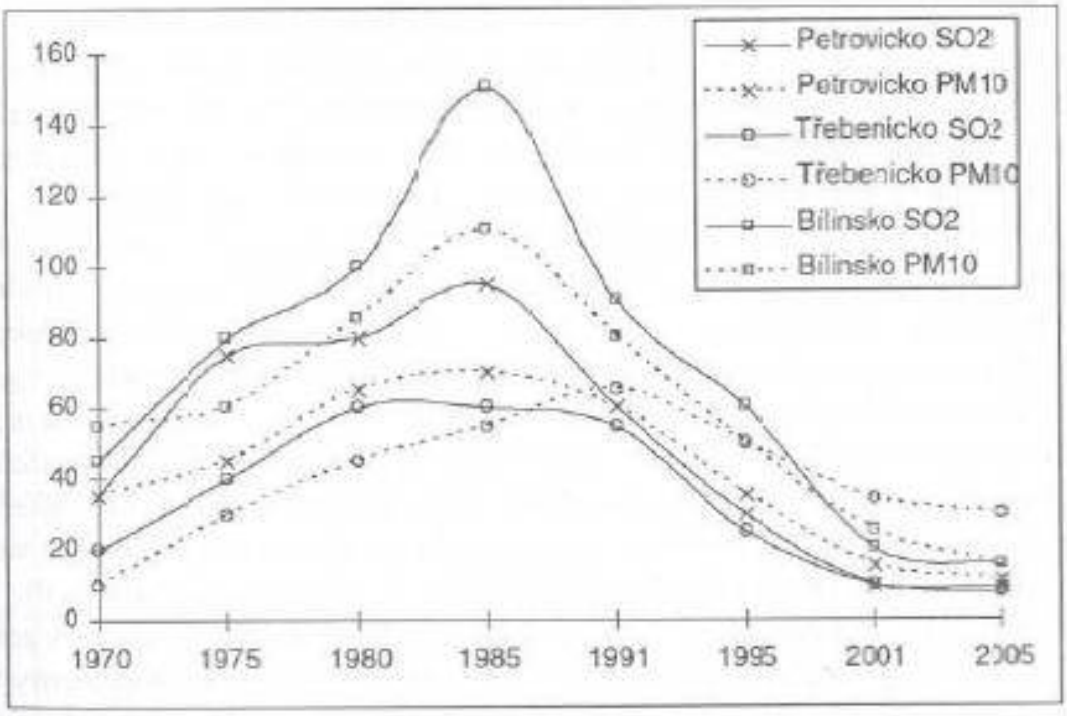

Fig. 4 Average SO_2 anc PM_{10} concentrations in three study areas (Kg.m^3 per year)

Beside the abcve largest air stressors and there are polluting concentrations of numerous chemical and food-processing plants along the Elbe river, expanding urban agglomerations, intensive use agricultural areas including mass animal breeding in the Elbe river region and the Eger river region, resulting in low quality of the surface waters in the region. Only one third of population in the northwestern part of the Czech Republic was connected to a sewage processing plant (SPP) in 1985. As a result, the quality of waters worsen in monitored streams in 1970–85. This can be documented by changing streams ranking according to specific quality classes of water. The length of streams in the northwestern part of the country given to the 1st (best) quality class decreased in the period by a half, the length of streams in the 2nd and 3rd classes

decreased by 20%, the length of streams in the 3rd and 4th class increased by 38% and the length of stretches rankec into 4th quality class increased even by 65%. Sewage waters capacity recorded in 1970–85 increased by 70%. From this point of view it is obvious that the very long delay in building of sewage processing plants in large urban agglomerations was responsible for these tendencies. It must be noted that in the main regional city housing 100 000 inhabitants (the city of Ústí nad Labem) the sewage processing plant started to operate in 1998. However, only several years later (in 2005) already almost 70% of inhabitants of the northwestern part of the Czech Republic were connected to sewage processing plants.

The history and extent of camage of the forest growth by immissions necessitated to create of so-called quality zones. In the most afflicted area of the Ore Mountains (their eastern part) random timber harvesting reached in the 1989–98 period 78% of the total timber harvesting (the highest levels by the end of the 1980s). Emissions were responsible for 47% and nature disturbances for 31%. In the period of culmination of immission concentrations (i.e., in 1981–85) the region had already more than 3 times higher share of forests endangered by immissions than was the Czechoslovak average. The area of damaged forest growth in the Ore Mountains gradually grew from 0.4 thousand ha in 1939, 20 thousand ha in 1959, 69 thousand ha in 1970 and to 170 thousand ha in 1985. The area of damaged forest growth classified in the worst damage category (so-called zone A) increased in the period 1970–85 4.8 times (namely the territory of the Ore Mountains plateau and ridges above 800 m above the sea level), the area classified as zone B 4.6 times (a relatively narrow belt under the plateau and high slopes). In the lowest locations and slopes of the Ore Mountains up to the altitude of 650–700 m, relatively most spruce tree growth survived in a normal age structure (so-called zone C). The most exposed areas in the region were thus the upland plateaus where forest growth suffered from rainfall with a very low pH factor. At the beginning of the 1980s the major part of the eastern Ore Mountains was classified as the B quality zone, the northern part of the northwestern part of the country even into the A category. The area of forest growth in the study area of Petrovicko was classified as the B zone, but the eastern part as the A zone. In the 1990s only very small parts of the forests could move from the A category to the B category or from the C to the B category. Even the satellite data show some stagnation or a slight deterioration of the forest growth in the period 1984–2005. The stressed forest growth in the Bílinsko study area was seriously damaged due to the highest immission concentrations. They were ranked into the A category, less exposed territories like small isles into the B category. Interpretations of remote sensing data indicated that this situation did not changed much in the 1990s till 2005. In the area of Třebenicko, forests are in larger enclaves only in the northern part and have been classified in the C category.

The growing intensity of traffic (measured in individual roads stages by the number of vehicles in 24 hours) reveals more and more prominently its stressing influence on the landscape in the region in the second half of the 20th century. It has influenced not only the growing barrier landscape structure leading to fragmentation, but also the quality of other components of the ecological subsystem (thus air and biota). The situation in the area of Petrovicko is in 2007 already influenced by a newly opened the motorway D8

from Ústí nad Labem across the area of Petrovicko to Dresden (Germany). In all study areas the intensity of traffic increased importantly: approximatly three times.

We must emphasize again that the analysis of the changing ecological stress indicates dynamic changes in the impact of the most prominent stressors power plants producing multiplicative stressing effects in various landscape components (fig. 7). The dramatic increase of the ecological stress until 1990 is due to the air pollution and the increasing deterioration of forest growth areas, to increasing anthropogenic soil and relief transformations and the decreasing quality of surface streams. On the other hand, there took place after 1990 a significant dynamic decrease of the ecological stress in all study areas. However, this tendency has bee compensated by the stressing effect of the increasing traffic intensity, by intensified noise and transport emissions, the expanding landscape fragmentation, the high degree of anthropogenic relief and soil transformation and the little improving health state of the forest growth areas. In the second half of the 20th century, the extent of the ecological stress changes reaches its maximum values in the area of Třebenicko (more than 300%), in the area of Petrovicko (almost 300%) and in the area of Bílinsko (more than 200%). It is clear that among these three study areas, the area of Bílinsko represents an extremely affected territory its damaged ecological subsystem. The relevant data indicating the situation in this area reach the highest levels of values of monitored indicators of the ecological stress.

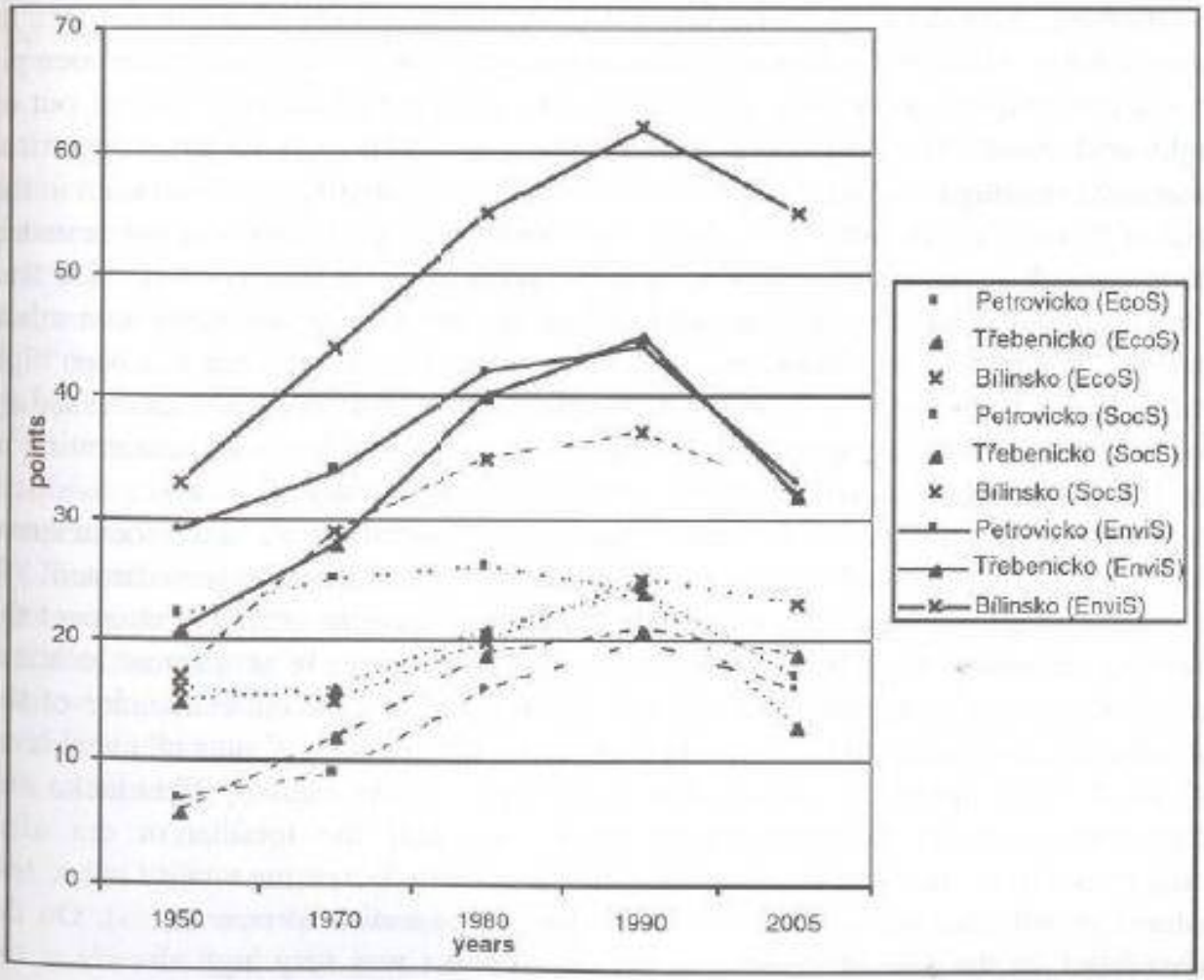

Fig. 5 Development of the ecological (EcoS), social (SocS) and environmental (EnviS) stresses in study areas in 1950–2005

The whole totalitarian period stretching from the German occupation (1939) and the period of communism (1948–1990) represents the final stage of the industrial society in the Czech Republic. As regards the northwestern part of the country this period brought a break in the regional development demonstrated in the dynamic increase of ecological and social stresses This significant change was shown by the dramatic up growth of the anthropogenic stressors impacts associated with strong migration population movements, by the transfer of the German population in 1945–1947 and subsequent resettlement of the borderland. The transfer of the German population and the new settlers from the Czech interior have had as a change both quantitative and qualitative character of the regional population. The resettlement was realized only in part. Population numbers between 1930 and 1950 indicate a population deficit in the area of Petrovicko of about 72%, in the area of Bílinsko of 30% and in the area of Třebenicko of 25%. As a result of this transfer and resettlement there took place important changes in ethnic, age and economic compositions of the population. The new population can be characterized by certain negative specific features: higher ethnic heterogeneity, unfavorable educational structure and higher levels of social pathology (delinquency, drug dependence, higher divorce rate, etc.). On one hand, larger urban centers developed as gravity centers were growing dynamically, and on the other hand, there was taking place a "collapse" of the structure of smaller settlements. A number of settlements were abandoned due to the limited post-war resettlement, namely in the territory of the Czech-German borderland. In the area of Petrovicko two thirds of settlements disappear completely. As a result of the open pit brown coal mining in the area of Bílinsko only the town of Bílina remained out of eight settlements. It is important to note that new settlers missed some historical awareness relating to the landscape. Even in 1990, the share of population born in the area of Petrovicko was only 25%. As a consequence, the population not stable and is characterized by a high migration turnover. During the totalitarian period there was a high negative migration balance as a result of movement of young generation urban centers. This has been reflected in the vitality index. The divorce rate has been high and the share of incomplete families increasing. The social stress has been marked by continuing increases during the whole totalitarian period and has been accelerating in the 1980s reaching its maximum levels at the end of the decade.

The post-industrial period is characterized by dynamic decrease in the social stress and a return to the level from the beginning of totalitarianism can be indicated. We monitor changes taking place in the individual study areas in order to document the most recent tendencies. These are associated with differences in geographic location, population, social and ecological factors. The crucial point in the tendencies of the social stress is the year 1990 when the study areas were close to almost identical level of social stress (about 25 points). The social stress in the areas of Třebenicko and Bílinsko accelerated dynamically in the second half the totalitarian era after a stagnation in the first half of that period (namely due to decreasing vitality index, low natural growth and particularly due to the loss of migration attractiveness). On the other hand, in the area of Petrovicko the social stress was very high already at the beginning of the totalitarian era and after a distinctive increase in its first half (the loss of migration attractiveness) a phase of stagnation followed. In the post-industrial

period, the social stress in the study areas has shown quite different tendencies. The area of Třebenicko has shown the most dynamic decrease in social stress. The area has become migration attractive again. The natural growth has increased and surprisingly also the educational structure of population has bee improving. The area of Pertovicko has shown similar tendencies and moreover, moreover the share of inhabitants born in the area significantly has increased improving ad consolidating social stability of the whole area. The situation I the area of Bílinsko is different, because there positive changes in the social stress have been taking place with great difficulties.

On the basis of our analysis of the changes in the ecological, social and environmental stresses and considering also the factors of geographical location we can draw a very simplified typology (see Tab. 3):

Tab 3 Current typology of study areas in terms anthropogenic stressors effects and environmental, ecological and social stresses (1950–2005).

INDICATOR	Bílinsko	Petrovicko	Třebenicko
Geolocation	regionally exposed	semi periphery	periphery
Location (altitude in m above sea level)	basin (195–215)	mountainous (450–750)	lowland (170–260)
The level of EcoS	high	low	relatively low
The level of SocS	high	relatively low	low
The level of EnviS	EcoS>SocS	EcoS>SocS	EcoS = SocS

1st type – regionally exposed areas with prevailing mining and urban landscape functions characterized by high ecological and social stress, in which the ecological stress exceeds the social stress significantly;

2nd type – the semi periphery with recreational landscape function and a low level of stress in which the social stress is exceeding the ecological stress;

3rd type of the periphery with an agricultural landscape function in which the ecological and the social stress reach balanced values.

The results of our analysis indicate the given types as representative areas of larger territorial units of the northwestern part of the Czech Republic (so-called former Sudetenland). The 1st type represents polycentric core basin areas under the ridge of Ore Mountains with the dominating energy industry and mining function. The 2nd type represents the Ore Mountains plateaus, the greater part a marginal territory abandoned and after the transfer of the German population permanently significantly depopulated with weakened historical relations to the landscape. The 3rd type is typical for territories characterized by intensively managed agricultural landscape with fertile soils suitable for plant production.

Discussion and conclusions

The results of our analysis suggest that in 2010 the immission concentrations can decrease to 10 Kg in m^3. In a few next years there can still be expected a slight decrease

in the ecological stress and then rather a stagnation. However, there may be even a minor increase. In the connection with a planned increase in electric power output and opening of new heat power station blocks in a few next years there can emerge possible changes in the concentrations of sulfur dioxide or nitrogen oxides. Increasing traffic intensity will definitely contribute to their future rise. The variability in immission concentrations of solid polluting particles in the air and in particular in rural areas and during winter months, will depend also on the use of ecologically more freandly fuels in households. The emissions in the air possess many multiplicative or synergy effects not only in the other ecological but also the human subsystem components. For example, the insulation intensity is decreased by higher presence of dust particles in the air. Under microclimatic conditions the air circulation often declines and the frequency of winter temperature inversions increases and more condensation nuclei in the atmosphere bring more fogs. The influence of the precipitations acidity on chemical soil characteristics belongs among the most prominent impacts on other landscape components. Due to the acid rainfalls the pH factor of soils in the northwestern Czech Republic decreased on average during the 1971–1981 approximately by 0.5 degree. An improving tendency cannot be anticipated given the current levels of the indicators of the anthropogenic soil and relief transformations.

It can be expected that the health state of the forest growth will stay in its current state given the stagnation of the soil pollution. In association with the global climatic changes the secondarily planted spruce tree monocultures in lower locations will suffer from a more distinctive damage. The intensity of line stressors tends to increase. Since the 1980s, the frequency of transport increased two times and in the study areas even three times. This has clear stress effects and tends to cause a higher landscape fragmentation between communications lines with a more intensive traffic. The noise and emissions from the transport will thus also increase.

The social stress is influenced by many factors of the social, economical and ecological or psychological character. Any assessment of possible future development is therefore a rather difficult task. If the present development trends will continue, only a small decrease in the social stress can be expected. Presumably strong individual tendencies are going to prevai.. A more dynamic decrease can be expected in attractive localities in terms of nature and culture located close to regional development axes than in direct surroundings of large urban centers or in peripheral locations. This holds true especially for the group indicator specifying population changes and spatial mobility (positive migration balance and decreasing migration turnover), in part also for economical features (decreasing unemployment and improving educational index). In peripheral areas that are missing any impulse for further development in the post--industrial era will remain problem areas. There a high level of unemployment, an increasing negative migration balance, a low vitality and educational indexes can still be characterizing such areas. The question whether further development of urban centers such as Bílina can lead to significantly lower levels of ecological and social stress, because a lot will depend on the conception of energy policy of the Czech Republic and on its regionalized impacts.

The range of driving forces of the environmental stress development is wide and complex (Tab. 4). The determining driving forces in the region in the first phases of

Tab. 4 A scheme of main forces active in the northwestern part of the Czech Republic

	Year	Driving forces	EcoS	SocS	EnviS
Totalitarian period	1945	transfer of Germans, disruption of historical ties, traditions and customs, break off across-the--border cooperation	high landscape permeability, fine grained mosaic of patches	loss of he relation s of man to the landscape	xx
	1948	central planning, the end of private property, 1st collectivization wave, depletion of settlement structure, new colonization	landscape unification – collective openfields	high migration turnover	xxx
	1970	chemical industry development, 2nd collectivization wave, development of quarry coal and wall stone mining	growing air and river pollution	negative migration balance	xxxx
Postindustrial period	1980	development of second dwelling, power engineering, construction of prefab housing estates, dynamical decrease of surface water quality	culmination of air and surface stream pollution, forest decline, monoculture planting	effort to steady population – "death grant", prefab housing estates	xxxxx
	1990	market economy, privatization and restitution, building of sewage processing plants, gasification, rehabilitation of landscape	improvement of air and surface streams quality	lowering of migration turnover, increase of natives	xxxxxx
	2005	building of transport infrastructure, tourism develoment, suburbanization and urbanization tendencies, reclaiming works, damping of surface mining	noise and traffic emissions, disturbed forest growths, anthropogenic transformation of soil and relief, fragmentation	positive migration balance, strengthening of identity of man with landscape	xxx

the totalitarian period were the German population transfer and the subsequent insufficient resettlement. These developments were breaking the continuity of the landscape trajectory of regional historical relationships and the awareness of the population of the landscape. The period following the 1948 communist takeover was characterized by the abolition of private properties, collectivization and by negative development tendencies in the settlement structure of the regior. The environmental stress increased importantly by "unification" or "homogenization" of the landscape (both in function and structure) and by high migration turnover resulting in instability of settlement. New settlers from the Czech interior were often not tending to care about their landscape of living and ask: "is a landscape a scene we are looking at, or a world we are living in?" (Wylie, 2007). They were usually leaving to some other place at the first opportunity. The third stage of the totalitarian era (after 1970) is characterized by the high pressure on the ecological subsystem (the intensive development of the open pit brown coal mining, energy and chemical industries). The ecological stress increased dynamically having as a consequence also the loss of the landscape attractiveness and leading to huge negative migration balance. This tendency culminated in the threat of an ecological disaster in the 1980s when the

culmination of air and water pollution and forests decline was taking place. The serious distortion of the ecological subsystem resulted in decreasing population health quality and diseases. In order to stabilize population in the most polluted districts of the region, the communist regime introduced so-called stability bonuses for workers and professionals, financial bonuses that were familiarly referred to as "death grants".

In the post-industrial period the predominant driving forces have been stimulated by the introduction market economy and privatization and with ecological investment and regulations. The air quality and water in river has become markedly better, the mining has been limited and the landscape reclaimed. The improvement of the environmental quality has been reinforced by higher level tourism attractiveness and by positive migration. The identity of inhabitants with the landscape has been improving.

Therefore we can identify between the totalitarian period and the post-industrial periods essential differences in the environmental stress development. While in the totalitarian era there was typical a dynamic increase in the ecological stress and a certain delay in the intensive social stress, in the current post-industrial period we can identify a decrease in the ecological stress and again with a certain delay also of the social stress. Regarding the ability to balance the human stress influences, these results together with the amplitude of changes in the ecological stress in comparison with the social stress we can undoubtedly indicate a higher dynamics of the ecological subsystem and a longer persistence of development tendencies of the social subsystem. This conclusion can be linked up with higher "vulnerability" of the ecological subsystem and greater complexity and development intricacies of the social subsystem. An important role is undoubtedly also played by mutual interactions between social items and human subsystem components when certain trends can be counterbalanced by opposite tendencies. It also must be stated again that the air or water quality changes are important ecological subsystem components can be realized over a relatively shorter time horizon, whereas in the changes in the stress in the social subsystem can usually be reached only over a relatively long time horizon. Similar differences can be identified also in respect some individual components of the ecological subsystem. It seems that inorganic components likewise are subject to development changes more quickly than biotic ones. The stress caused by polluted air decreases far more dynamically than the stress induced by the deterioration of forest growth or soil acidification. This can be documented by the continuing bad health of forests in the Ore Mountains even after a rapid decrease of immission concentrations in the 1990s.

During the monitoring of the landscape development in the northwestern part of the Czech Republic it is necessary to take into account also the quality of its individual landscape components which were usually for a period of 40 years of the totalitarian period importantly influenced and modified by the human stress influences (Bičík, Jeleček, 2003). Considering the ecological subsystem of the landscape system, it is indispensable to stress the key importance of the human influences in order to avoid misjudgments during the monitoring and analysis of the landscape structure development. Such a more complex approach to the monitoring of the changing environmental stress in different study areas has to take into account negative effects of inhabitants living in study areas and affecting the landscape system of the areas. However, it must also be noted that many of the negative influences have been caused

by stressors located far from the borders of the study areas and subsequently transferred to them. The research urgency of interactions between the ecological stress and the social stress is shown in numerous studies indicating that in the areas of higher ecological stress there are higher levels of occurrence of allergic diseases, infant and newborn mortality or lower average life expectancy and so on (see HELEN – Health, Life Style and Environment, 2006).

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References

AGNEW, J., LIVINGSTONE, D., ROGERS, A. (1996): Human Geography – an Essential Anthology. Blackwell Publishing, Oxford.

ANDĚL, J. (1993): Towards methods of environmental quality assessment (in Czech). In: Geografie – Sborník ČGS 98, no. 1, 25 –33.

ANTROP, M. (2000): Changing patterns in the urbanized countryside of Western Europe. In: Landscape Ecology 15, 257–270.

BALEJ, M. (2004): Ecological stress on a landscape: case study from Eastern Ore Mts. In: Michalczyk, Z.: Badania geograficzne w poznawaniu srodoviska. UMCS, Lublin, 461–469.

BALEJ, M., ANDĚL, J., JEŘÁBEK, M. (2004): Eastern Ore Mts. – geographical assessment of a peripheral area (in Czech). In: Acta Universitatis Purkynianae, UJEP, Ústí nad Labem, 252–259.

BERRY, B.J.L. (1973): The Human Consequences of Urbanization. St. Martines Press, N. York.

BIČÍK, I., JELEČEK, L. (2003): Long Term Research of LUCC in Czechia 1845–2000. In: Jeleček, L., Chromý, P., Janů, H., Mikšovský, J., Uhlířová, L. (eds.) Dealing with diversity. UK, Praha, 224–230.

BROEK, J.O.M., WEBB, J.W. (1978): A Geography of Mankind. New York.

CONWAY, T.M., LATHROP, R.G. (2005): Alternative land use regulations and environmental impacts: assessing future land use in an urbanizing watershed. In: Landscape and Urban Planning, 71, 1–15.

ERICKSON, D.L. (1999): Rural land use and land cover change. In: Land Use Policy, 12, 223–236.

HAGGETT, P. (1975): Geography: A Modern Synthesis. N. York.

HAMPL, M., et al. (2001): Regional development: specific features of the Czech transformation, European integration and general theory (in Czech). PřF UK, Praha.

HELEN – Health, Life Style and Environment (2006): The Center of Environmental Health. Prague.

HOBBS, R. (1997): Future landscapes and the future of landscape ecology. Landscape Urban Planning, 37, 1–9.

INGEGNOLI, V. (2002): Landscape ecology: a widening foundation. A holistic unifying approach. Springer-Verlag, New York.

IZAKOVIČOVÁ, Z., MIKLÓS, L., DRDOŠ, J. (1997): Landscape ecological conditions of sustainable development (in Slovak). VEDA, Bratislava.

JESINGHAUS, J. (1999): A European system of environmental pressure indices. First volume of the environmental pressure indices handbook, the indicators. European Commission, Brussels.

Landscape Atlas of the Slovak Republic (2002) (in Slovak). Bratislava, MŽP SR, Banská Bystrica: SAŽP.

LIPSKÝ, Z. (1998): Landscape ecology for students of geographical disciplines (in Czech). Karolinum, Praha.

MICHAL, I. (1993): Ecological stability (in Czech). Brno, Veronika.

NIKODEMUS, O., BELL, S., GRÍNE, I., LIEPINŠ, I. (2005): The impact of economic, social and political factors on the landscape structure of the Vidzeme Upland in Latvia. In: Landscape and Urban Planning, 70, 57–67.
PAULEIT, S., ENNOS, R., GOLDING, Y. (2005): Modeling the environmental impacts of urban land use and land cover change – a study in Merseyside, UK. In: Landscape and Urban Planning, 71, 295–310.
RISSER, P.G. (1999): Landscape ecology: Does the science only need to change at the margin? In: Klopatek, J.M., Gardner R.H. (eds.), Landscape ecological analysis – Issues and applications. Springer-Verlag, New York, 3–11.
SKOWRONEK, E., KRUKOWSKA, R., SWIECA, A., TUCKI, A. (2005): The evolution of rural landscapes in mid-eastern Poland as exemplified by selected villages. In: Landscape and Urban Planning, 70, 45–56.
ŠÚRIOVÁ, N., IZAKOVIČOVÁ, Z. (1995): Territorial system of anthropogenic stress factors in landscape ecological planning. In: Ekológia, 14 (2), 181–189.
WYLIE, J. (2007): Landscape. Routledge, London.

Résumé

Environmentální stresory a stres jako interdisciplinární otázka: případová studie ze severovýchodní části České republiky

Při sledování vývoje struktury krajiny severozápadních Čech nelze, kromě kvantitativního zastoupení jednotlivých kategorií skladebných prvků, nebrat v úvahu i jejich kvalitu. Minimálně po dobu 40 let byly tyto prvky velmi výrazně ovlivňovány a modifikovány především negativním působením člověka. Proto tento, nejen pro přírodní složky krajiny, stresující antropogenní vliv je natolik nezanedbatelný, že absence jeho uvažování při sledování vývoje horizontální struktury krajiny by zcela jistě vedla k mylným závěrům. Účelem takového postupu není jen monitoring vývoje působení antropogenních stresorů přítomných v modelových územích, nýbrž i těch nacházejících se mimo ně, které ovšem svým stresujícím účinkem je výrazně ovlivňují. Bez nich by totiž nebyl postižen veškerý negativní stres v území se projevující. Mnohé z negativních vlivů jsou vyvolávány stresorem nacházejícím se daleko od hranic vybraných území.

Naléhavost výzkumu přítomnosti ekologického stresu ve spojení se stresem sociálním potvrzují četné studie, které prokazují, že v oblastech s vyšší přítomností stresu v ekologickém subsystému se objevuje např. vyšší procento porodů dětí s nižší porodní hmotností a vyšší procento dětí narozených předčasně, nižší úroveň celkové i specifické imunity a častější nemocnost, častější výskyt onemocnění horních i dolních dýchacích cest (včetně akutních respiračních onemocnění), vyšší výskyt alergických onemocnění, nižší vitalita a kvalita spermií, vyšší celková, kardiovaskulární i nádorová úmrtnost, vyšší kojenecká i novorozenecká úmrtnost, přibližně o 3 až 4 roky kratší střední očekávaná délka života než průměr v Česku, větší délka pracovní neschopnosti, vyšší rozvodovost, vyšší sebevražednost a podobně. Vyjmenované důsledky tak podtrhují opodstatněnost sledování míry ekologického a sociálního stresu v jejich vzájemném propojení.