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# Influence of natural conditions on land use in the Vysočina region and its changes since the mid-19th century

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## Abstract

There are two main aims of this article: (1) to characterise the changes of the relationship between land use and natural conditions in the Vysočina region during last 150 years; and (2) to present one of many possible approaches to monitoring long-term development of spatial aspects of society-nature interaction, and to outline the approach both from the theoretical and methodological perspective.

The work is based on two data sources: (A) land use data for 1113 "Basic territorial units" (BTUs), approximately 6 sq. km on average, of the Vysočina region for the years 1845, 1948, 1990 and 2000. (B) To each BTU, values of three characteristics of natural conditions were assigned: official price of agricultural land (a complex indicator of the given area's suitability for agriculture), average altitude and average slope. The influence of natural conditions on land use was then measured with the help of several basic statistical methods.

At the end of the article it is emphasized that this quantitative method must be accompanied by some kind of "qualitative" approach which should be based especially on an understanding of behaviour of involved actors and their interaction with structures.

**Key words:** land use changes, natural conditions, Vysočina, Czech Republic

## 1. Introduction

The relationship between society and nature permanently changes. In the Czech Republic, and in other developed countries as well, strong and steady growth of the influence of society on its environment can be traced back to about the beginning of the Industrial revolution (even though the history of human impact on nature is understandably very long, and not always straightforward) – see e.g. Butlin (1993) for an overview.

However, there have been significant regional differences in this growth. Changes (increases) of the human press on nature are not equal everywhere; rather they differ according to the natural and social conditions of regions or localities. Nowadays, in the age of progressing globalisation and economic integration, this phenomenon is becoming more significant. On the one hand, spatially exposed and naturally favourable regions, suitable for agriculture, are being continuously intensified, but, on the other hand, large peripheral and non-fertile areas experience marginalization and extensification (depopulation, grassing-over, afforestation). These contradictory

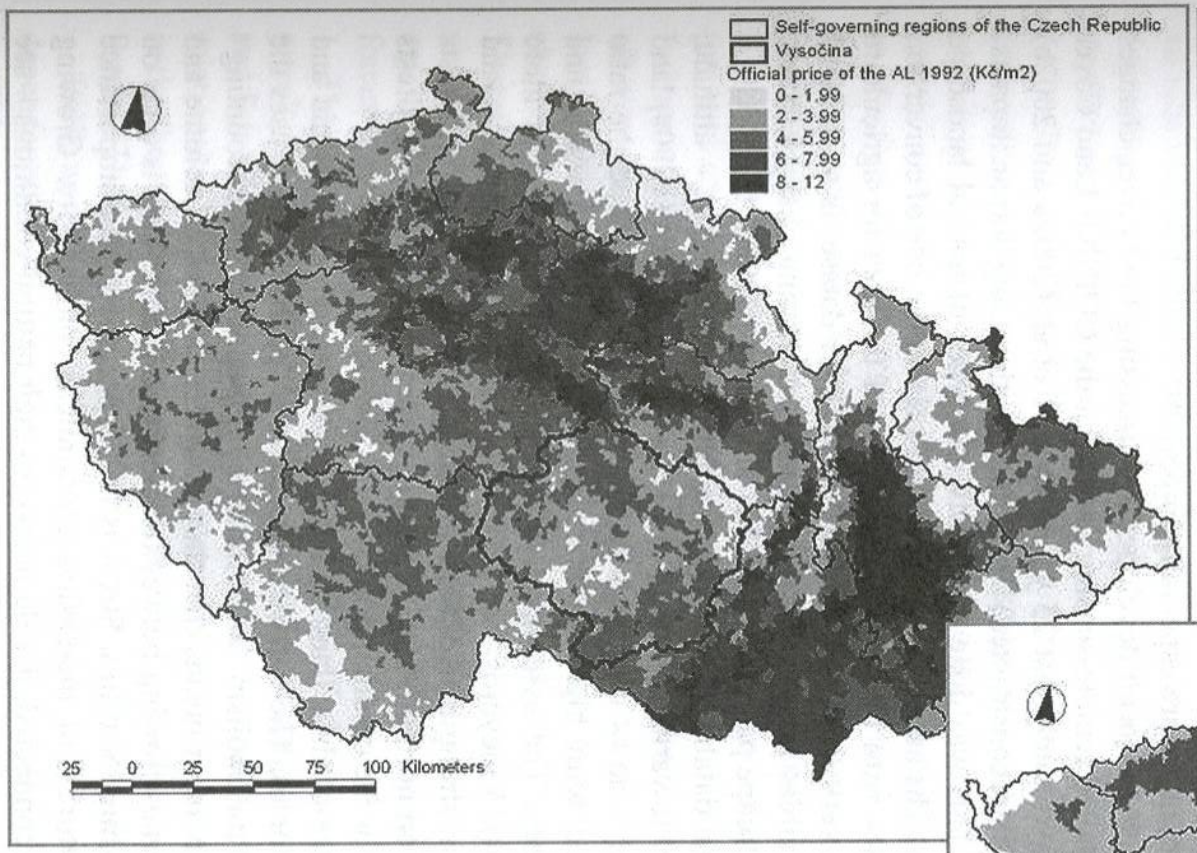
tendencies are becoming more and more important subjects of study for both natural and social sciences since people start to realize their ecological, economical and also aesthetical and cultural importance (see e.g. Sporrong et al. 1996).

One of the ways of tracing the history of human influence on nature is to study landscape and land use, since "land use is also a result of long-term nature–society relations" (Bičík et al. 2001, p. 65). With changing culture, politics, institutions, economy and technology (as "driving forces" for development – Jeleček 2002), human influence on the landscape and the structure and spatial distribution of land use changes as well. According to Bičík (1991), the changes in regional "pattern" of land use during last 150 years are the result, or a sign, of "heterogeneization of once homogenous system... thus, the differentiation of units increases (according to land use – JK) stemming from their varying functions and changing importance and needs" (Bičík 1991, p. 77).

Therefore, with changing human society, economy and technology, the structure of land use also changes in various regions (Mather 2002). In pre-industrial times, land use of all localities in the Czech Republic was relatively similar – there had to be a forest (wood for construction, fuel, tools etc.), arable land (nourishment of population) and grassland (nourishment of absolutely necessary domestic animals) everywhere. But then, thanks to growing traffic interconnection, integration and competition within the whole system, "specialization" of each locality on a particular land use type more suitable for local conditions was enabled (or enforced). In some places, urban function was preferred, other localities concentrated on agricultural (intensive or extensive), horticultural, silvicultural, recreational or other functions. "Products" of other land use types were easily transported. In this way, once local flows of energy and materials were "opened" and incorporated into a new system on a hierarchically higher level (Haberl et al. 2003, Krausmann et al. 2003).

As mentioned above, specialization of localities was based, beside others, on regional natural conditions. The changing influence of natural conditions on land use is in the focus of this article. It monitors the period since the mid-19$^{th}$ century until the present. This period has been chosen not only because of the availability of data but also because for the Czech lands the 1840s and 1850s can be considered a beginning of a more significant influence of industrialization and modernization on land use. Since the development of Czech lands during the socialism was to some extent specific, the whole time period was divided into three shorter ones, corresponding to different stages of societal development: 1845–1948 (free market), 1948–1990 (socialism) and 1990–2000 (transformation and return to a "normal" development). See Bičík et al. (2001).

Vysočina was chosen as a model territory. It is a self-governing region in the heart of the Czech Republic (see fig. 1 for more information). Vysočina is somewhat specific in the context of the whole country. The natural conditions are rather unfavourable – "Vysočina" means "Highland". It is a peripheral, conservative and economically weaker region. Its internal structure is characterised by a considerable homogeneity of both natural and social conditions. There were no radical changes in inner geographical structure during the monitored period – e.g. it was not influenced by the expulsion of the Czech Germans after the WW2. Nevertheless, in spite of these specifics, the results of this article could be generalised to a large extent.




*Vysočina and its comparision with the other 13 regions of the Czech Republic (year 2001):*

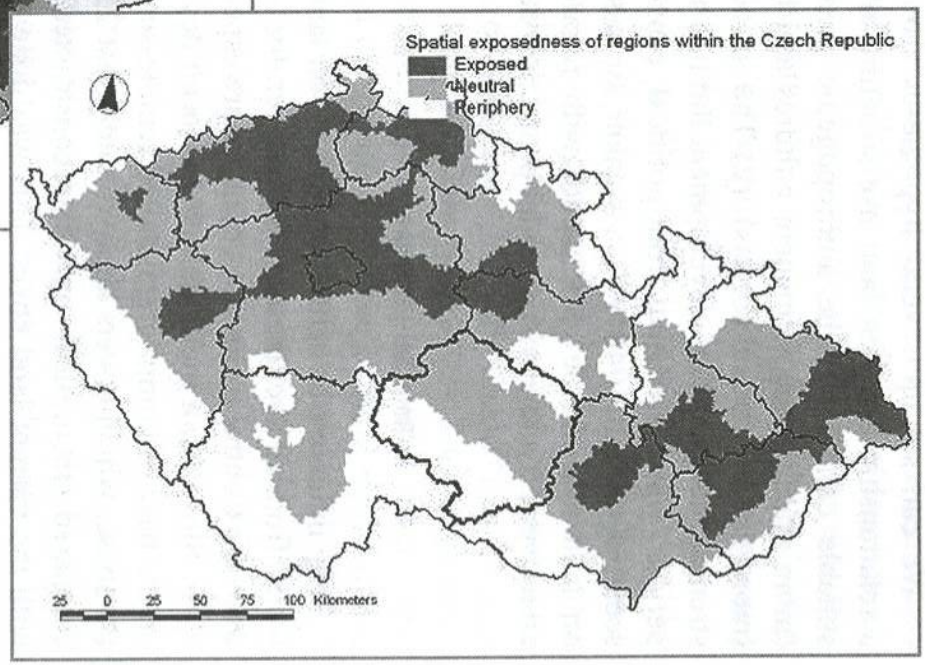
Average altitude 537 metres a.s.l. (3rd highest in the CR)

6924,6 km$^2$, 521 212 inhab., 75,3 inhab./km$^2$ (3rd lowest in the CR)

730 municipalities (2nd highest in the CR) with 713 inhab./municipality in average (lowest in the CR)

57,9 % urbanization (2nd lowest in the CR)

Employment in agriculture 12,1 % (in the whole CR 4,8 %)




*Position of Vysočina within the Czech Republic -*

Above: worse natural conditions (lying in the Bohemian-Moravian Highland)

Right: „inner periphery" (according to Hampl et al. 1987)

*Fig. 1* Vysočina and its position in the Czech Republic
*Source:* Database, Hampl et al. (1987), www.czso.cz

We can set up several hypotheses from these general facts. (1) There exists a relationship between land use structure and natural conditions. In naturally more suitable conditions, the anthropogenic pressure on landscape is more significant (more arable land, permanent cultures and built-up areas) than in worse conditions (more grasslands and forests). (2) The influence of natural conditions has gradually strengthened. (3) This development did not have the same power in all the monitored periods, which stemmed from political, economical and societal changes. (4) For the socialist period (1948–90), a weaker increase of the influence of natural conditions on land use can be anticipated, with regard to a smaller demand for economical effectiveness and environmental protection during this period.

## 2. Relevant literature

The influence of natural conditions on land use is understandably in focus of many works from all over the world. However, for us those research activities and experience from the Central European countries are especially important.

In Slovakia, a methodology has been developed for assessing land cover changes on the base of comparing detailed remote-sensing data from the CORINE Land Cover Database, which covers approximately last 25 years. Oťahel' et al. (2002a and 2002b) compared a theoretical "natural (reconstructed) landscape" (without any human impacts) with the current land cover. This was done in 11 different types of natural landscape – from lowlands to mountains. The authors drew a conclusion that the rate of conversion of natural landscape decreases with decreasing suitability of the area for agriculture and settlement; which is not very surprising. Nevertheless, their dataset is so detailed and comprehensive that it enables us to assess many other interesting characteristics, including e.g. density of landscape patches (Oťahel' et al. 2002b, p. 108).

Šúri (2003), with the same database, examines the influence of a relief – altitude, slope and aspect of a locality towards the cardinal points – on a current (1990s) land cover of Slovakia. He clearly shows that with growing altitude and slope the ratio of land categories connected with higher anthropogenic pressure (settlement and agricultural patches) decreases. The assessment of the influence of aspect is more interesting (Šúri 2003, p. 54). Vineyards, for instance, have a strong southern and western orientation, which is strengthened with increasing altitude. Conifer forests remain preserved especially on northern slopes; on the contrary, broad-leaved forests do not show any preference for the cardinal points.

Thanks to compatible base of data (land cadastre), the research in Slovenia and Austria are more important for us. The Austrian approach is specific since it uses the methods of "socio-economic metabolism" and "material and energy flow accounting" (MEFA) for land use assessment. It means that they consider changes of volume and structure of energy and materials flowing between society and nature. This is done on different spatial levels, including localities. Stress is laid especially on the importance of modernization of agriculture and increasing economical connectivity. Growing specialization of localities is connected, beside others, to their natural conditions – see e.g. Haberl et al. (2003) and Krausmann et al. (2003).

In Slovenia, many works can be found, describing the influence of natural conditions on land use changes. Gabrovec and Kladnik (1997) show an unambiguous dependence of current (1994) land use and its recent changes (1961–94) on division of Slovenia into seven "natural geographic units". Consequently, these authors evaluate the influence of various natural factors – lithology (quality of bedrock and soil), climate types and altitude – on current land use pattern. The clearest is the effect of altitude.

Petek (2002) examines land use changes in Slovenia from 1896 to 1999 at the cadastral level. He distinguishes four types of changes: afforestation, grassing over, intensification and urbanization. Consequently, he compares the importance of these types of changes in nine "types of landscape" – from coast and lowlands to mountains. Besides that, he also assesses the changes of land use within and outside "less favorite areas". A similar methodology is used by Petek and Gabrovec (2002). They emphasize the problem of rapid and strong urbanization in Alpine plains; and, on the other hand, extensification and thus wastage with and disappearance of the cultural landscape in Dinaric and Mediterranean regions and in Slovenian Alps. Gabrovec et al. (2001) examine the dependence of land use changes in Slovenia in the years 1896–1999 on various natural factors, and, once more, they analyse current state of land use pattern according to altitude. Nonetheless, it must be noted that most of these works lack explanatory and theoretical depth.

In the Czech Republic, Vondruška (1984) quantitatively assessed the changing influence of natural conditions on landscape and agriculture. Within a representative sample of 353 Czech villages, he examined the relationship between the pattern of the "rustic" (serfdom, peasant) agriculture in the first half of the 19$^{th}$ century (according to the data from the "stable cadastre") and natural conditions – altitude, type of relief, climatic zone and vegetation level. His interesting results and observations are underpinned by a deep knowledge of historical context. One of the author's statements is especially interesting for us: that (p. 78) "the influence of natural environment (on land use – JK) was decreasing with the advance in production factors" and that "advance in markets, outsets of farming specialization and market production – these all were manifestations of the liberating dependence of orientation of agriculture on local natural conditions". This is contradictory to the premises of this article (see chapter 1). Nevertheless, Vondruška assessed only the serfdom farming in his work. Therefore, as the author himself says (p. 100), the results "have not a general validity", since "the management of bigger estates, more market-oriented and specialized on a particular type of production, was in basic dimensions influenced by different driving forces".

The influence of altitude, slope and so-called "production potential" and "official price" of agricultural land on the current area of agricultural land is assessed by Zeman and Střeleček (1996). However, their article is rather methodological. Nowadays, the relationship between natural conditions and land use changes in the Czech Republic is in the focus of a group of geographers at the Faculty of Science, Charles University in Prague. Their research profits from a unique database (see chapter 3.1):

Bičík and Kupková (2002) used a method of "weighed averages" to confirm the dependence of land use development in the Czech Republic on the quality of natural conditions, expressed by "official price of agricultural land". They described many

"driving forces" of this development; and showed that with growing suitability of an area for agriculture the share of arable land and built-up areas had grown and the share of forests and grasslands had decreased. This dependence has strengthened since the mid-19th century. It is interesting that the shrinkage of arable land during the socialist period was most significant in the mountains, which contradicts the commonly repeated statement that the loss of arable land occurred especially in fertile regions, as a result of ruthless urbanization and mining. The authors also argue that (p. 31) "totalitarian period in Czechia from a point of view of agricultural land development was similar to the other developed countries".

These ideas were further analysed by the same authors (Bičík and Kupková 2003) in a case study of the Semily district (Northern Bohemia). They examined the influence of natural conditions – productivity of agricultural land – on land use changes, also with the help of a correlation analysis. Altogether, since the mid-19th century the area of arable land has increased in regions with high quality of natural conditions, whereas the area of grasslands has increased in less fertile regions.

Štych (2003) studied a dependence of land use changes in the Czech Republic since the mid-19th century on altitude. He showed that until 1948 the development was more intensive in lowlands and less hilly regions (influence of free market's powers); whereas during socialism the changes of landscape were more profound in highlands and mountains – extensification, marginalization. The later trend continued also after 1990 in a form of afforestation and especially grassing-over. Generally, during the whole period the main trends were (a) a concentration of arable land and built-up areas into lowlands, and (b) an outflow of economical activities from mountains and highlands. Similar results were also achieved by Mareš and Štych (2005). They stressed the reversal of a historical trend of grassland shrinkage after 1990, especially at higher altitudes. During this decade, the area of grasslands increased by up to one third in some regions.

### 3. Data and methods

I use several terms in this article which must be precisely defined and explained.

(A) "Grasslands" or "permanent grasslands" involve meadows and pastures. "Permanent cultures" include orchards, gardens, vineyards and hop-gardens. "Agricultural land" (AL) consists of arable land, grasslands and permanent cultures. "Remaining areas" represent various areas for transport, bare or non-fertile land, rocks, bushes and other fallow, non-cultivable or non-used lands.

(B) By "land use" I mean an overall macrostructure of landscape in a particular spatial unit, or, in other words, shares of different land use types (forest, arable land etc.) in it. Landscape microstructure, shape and interactions of patches, or their ecological quality, are not taken into account (see Lipský 1999). Thus, land use becomes an indicator of economical and functional specialization of a region.

(C) "Intensity of land use" is not understood as a real input of energy, materials or labour into a land unit; but as a degree of alternation of a given land use type by society. In the Czech Republic, with a certain simplification, the intensity of land

use increases in this direction: forested and water areas → grasslands → permanent cultures → arable land and remaining areas → built-up areas. Thus, intensity of land use is considered an indicator of a rate of anthropogenic impact on landscape (CES – see chapter 3.2).

### 3.1 Data base

Two sources of data were used in this work: (a) land use data and (b) characteristics of natural conditions. Land use data have their origin in an extensive, uniquely detailed and long-term database, created and used at the Faculty of Science, Charles University in Prague. For an overview of methodology and data processing see e.g. Bičík (1995), Bičík et al. (2001) or Bičík and Jeleček (2003).

By application of this methodology, 1299 cadastres of Vysočina were merged into 1113 so-called "Basic Territorial Units" (BTUs, 6.2 sq. km in average). For the years 1845, 1948, 1990 and 2000, the dataset contains information about macrostructure of land use in each of these 1113 BTUs – areas of eight basic categories (arable land, permanent cultures, meadows, pastures; forested areas; water areas, built-up and "remaining" areas), which can be aggregated into three complex categories (agricultural, forested and "other" areas). Both areas of BTUs and land use classification are fully comparable in all four used time horizons.

Each BTU is therefore composed of one, two, or sporadically more cadastres, and thus can be treated as a "locality" – the smallest socio-geographical unit. We can join various socio-economic or natural characteristics to this database in order to assess their influence on land use changes in every BTU. In our case, three indicators of natural conditions were added to each of these 1113 BTUs: official price of agricultural land, altitude and slope.

Official price of agricultural land ("price_92") expresses theoretical financial income from farming on a given land-plot, in Czech crowns per square meter (CZK/sq. m.). It is based on estimated natural productivity of land, enriched by several up-to-date monetary indicators (potential expenses and costs, income tax, interest rate etc.). In this work, official price is understood as a complex characteristic of land's suitability for agricultural activities from the viewpoint of natural conditions. Czech Ministry of Agriculture issues updated values of official price of AL every year. The variant from 1992 was used in this work. Transfer from cadastres to BTUs was done by weighing; the area of AL of cadastres in 1990 was used as a weight. The result is shown in fig. 2.

Altitude and slope data were taken from GIS model of relief of the Czech Republic, calculated by Štych (e.g. Štych 2003 or Mareš and Štych 2005). This model determined average, minimum and maximum altitude for each cadastre in Vysočina. From average altitudes of cadastres, average altitudes of BTUs ("altitude") were calculated, as a weighed average (weight was the overall area of cadastre).

From minimum and maximum altitudes of cadastres, these characteristics for BTUs were determined – the highest value of maximum altitude and the lowest value of minimum altitude of all cadastres in a given BTU. "Range" (in metres) was then calculated as a difference between maximum and minimum altitude in a BTU. The problem of "range" is that its value depends on the BTU's area – the larger unit, the

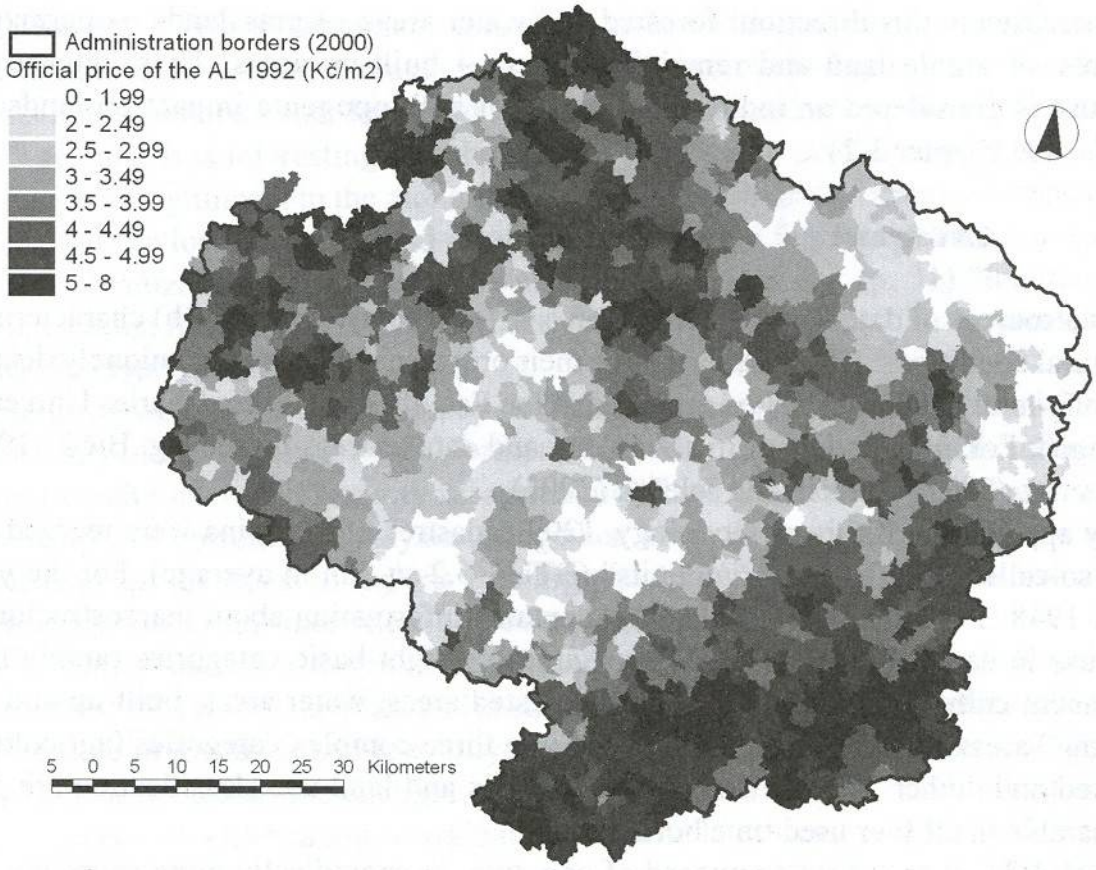



*Fig. 2* Official price of agricultural land (1992) in BTUs of Vysočina
*Source:* Database of the project GA ČR no. 205/01/1420

bigger extremes of altitude can be included. Thus, to describe the relief more precisely, the average slope ("slope") was then calculated from "range". It is an angle (in degrees), defined as:

$$tg\beta = \frac{R}{a} \qquad [°]$$

(where $\beta$ is average slope, $R$ is "range" (m), and $a$ is length of a side of a square whose area equals the overall area of given BTU). This indicator is still influenced by its aggregated character – it is not a real slope in the sense of average slope of all patches of a given BTU, but only an angle of an imaginary surface sloping from the highest to the lowest point of BTU. However, it is precise enough for our research. Cartograms of average altitudes and slopes of BTUs in Vysočina are shown in fig. 3.

Only these three previously mentioned characteristics of natural condition have been used. Nonetheless, we have to bear in mind that land use changes are influenced by many other natural factors – aspect of slope, climate (which correlates with altitude in the Czech Republic to a large extent), quality of bedrock and soils, etc. Thus, altitude and slope must be understood only as imperfect morfometrical imitations of real natural conditions, which are much more complex. But, on the other hand, I consider the three chosen indicators still representative enough to enable us to confirm or refuse the above-stated hypotheses.

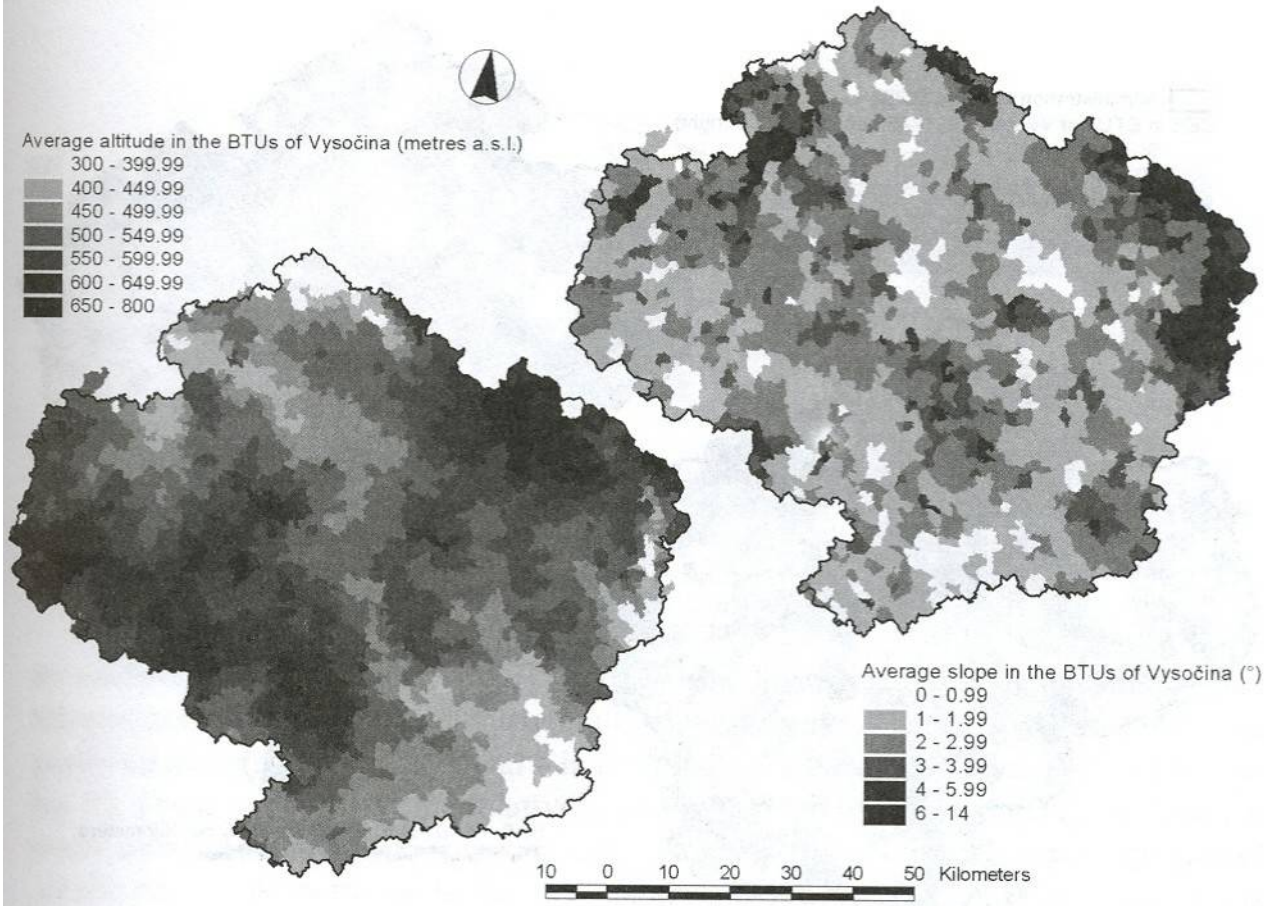



*Fig. 3* Average altitude (left) and average slope (right) in BTUs of Vysočina
*Source:* GIS model of average, minimum and maximum altitudes of cadastres of the Vysočina region

### 3.2 Data-processing

Describing the evolution of land use structure according to the eight basic categories would excessively increase the length of this article. Furthermore, we should concentrate on the overall aspects of society-nature interaction. Thus, the influence of natural conditions on land use in its detailed structure is shown only for the most recent time horizon – 2000 (see figs 6, 8 and 10). To assess the changes, I decided to characterise land use with the "coefficient of ecological stability" (CES, e.g. Bičík 1995). It is an aggregated indicator, describing the structure of land use in one unit and one time horizon by one number. The shares of the eight basic land use categories on the whole area of a spatial unit are weighed by given coefficients (Bičík 1995, see below), which schematically express ecological "stability" of the given category, or intensity of its use by society, respectively:

$$\mathrm{CES} = \sum_{i=1}^{n=8} ces_i \times a_i$$

(where $ces_i$ is the coefficient for category $i$ (arable land 0.14, permanent cultures 0.34, meadows 0.62, pastures 0.68, forested areas 1.00, water areas 0.79, built-up areas 0.00 and "remaining" areas 0.14) and $a_i$ is the share of category $i$ in the whole unit's

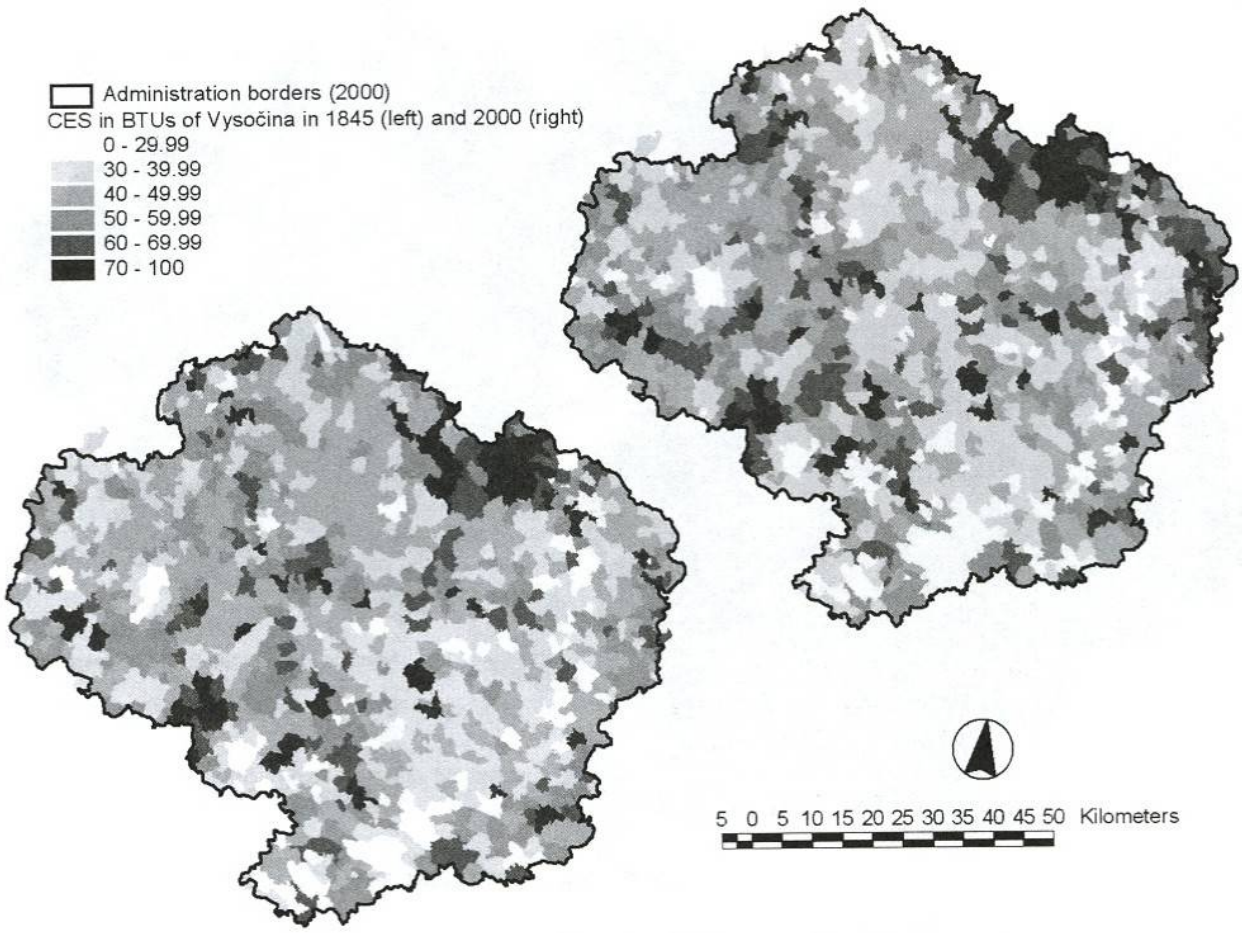



*Fig. 4* Coefficient of ecological stability (CES) in BTUs of Vysočina in 1845 (left) and 2000 (right)
*Source:* Database of the project GA ČR no. 205/01/1420

area in %). This index ranges from 0 to 100. The higher CES, the ecologically more stable unit – less colonized by society, closer to a "natural" state, which is generally forest in Czech conditions. As an example, cartograms of CES in the first and last time horizons of the assessed period are shown in fig. 4.

Besides problematic "evaluation" of the categories with the coefficients, the biggest disadvantage of this coefficient is that it understandably does not take into account landscape microstructure. A spatial unit (BTU) is as a "black box" into which we cannot see. CES is not able to inform about the internal variability of each land use category, nor about the massive negative ecological changes occurring in Czech landscape during the socialist period – Lipský (1999). Thus, CES should be used only as a general indicator of land use intensity, of anthropogenic pressure on the environment, of a rate of nature's conversion by human society, not as a real measure of an abstract "ecological stability". CES is simply a summarizing characteristic of the result of society – nature interaction in the given spatial unit.

The core of this article lies in a quantitative assessment of relation between spatial patterns of CES in given years and the three used natural characteristics. A "model" of influence of natural conditions on land use is demonstrated in fig. 5.

Altitude and slope are two basic factors. They are almost fully independent (fig. 5), which makes Vysočina specific in the frame of the Czech Republic. It is probably caused

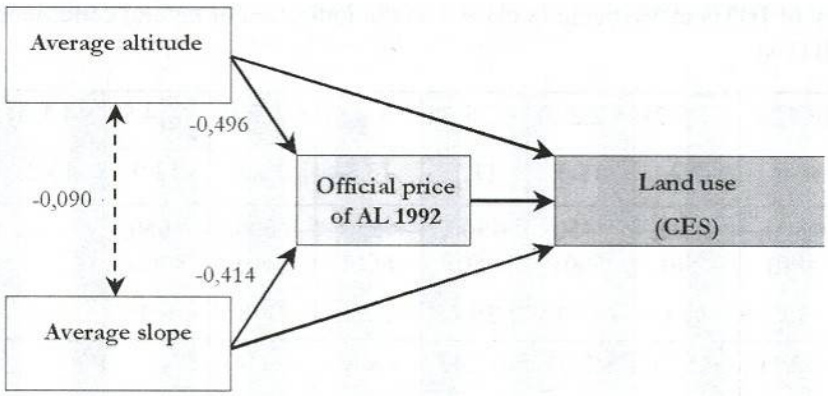



*Fig. 5* "Model" of influence of assessed natural conditions on land use
*Note:* figures represent the values of Pearson's correlation coefficient between given independent variables in Vysočina.

by a relative flatness of relief – Vysočina is like an upland plateau. Steeper and "wilder" terrains are rare, concentrated partly in the highest areas (above 700 metres a. s. l.) and partly on the edges of the highland – in river valleys (Svratka, Jihlava, Sázava etc., see fig. 3). These river valleys are relatively deeply cut into the plain, and can be found in lower areas. An advantage of this specificity of Vysočina is that we can (statistically) clearly distinguish between the influence of altitude and slope on land use – their effects do not coincide or interfere. There exists a strong positive correlation between altitude and slope in other Czech regions – e.g. for the districts in Southern Bohemia 0.44, according to Zeman and Střeleček (1996).

The official price of AL is a complex indicator of natural conditions. Understandably, it is influenced by altitude and slope to some extent (besides that also by climate, aspect and especially by soil conditions). As can be seen in fig. 5, approx. 25% of variability of price_92 is determined by altitude and approx. 17% by slope in Vysočina. Both these basic indicators together determine ("create") 46% of the official price of AL. All three natural characteristics influence land use directly, and altitude and slope also indirectly, through the official price, which is sketched in fig. 5.

Influence of natural conditions on CES in each time horizon was assessed with the help of simple statistical methods. "Weighed averages" is the basic tool – see Bičík and Kupková (2002). For each indicator of natural conditions, all BTUs of Vysočina were divided into classes according to the values of this indicator (see tab. 1). The rules for these three divisions were as follows: (a) borders between classes are round numbers (e.g. not 342.5 but 350 m. a. s. l.); (b) class widths are either the same or at least somehow systematic for each indicator (e.g. twice wider on the margins than in the middle of the distribution); (c) extremes are stressed (classes on the margins contain less BTUs than those in the middle); (d) natural breaks in the distribution are taken into account. Consequently, CES was calculated in each class for all four time horizons. This process resulted in graphs, each with four curves (one for each time horizon), demonstrating how CES evolved in the classes of the given indicator of natural conditions – see figs 7, 9 and 11.

*Tab. 1* Frequency of BTUs in Vysočina in classes of the indicators of natural conditions (in % of the total number of 1113 BTUs)

| **Official price of AL 1992** (CZK/m$^2$) | (0;1.5) | <1.5;2) | <2;2.5) | <2.5;3) | <3;3.5) | <3.5;4) | <4;4.5) | <4.5;5) | <5;5.5) | <5.5;8) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 5.8 | 7.2 | 11.3 | 11.1 | 13.3 | 12.5 | 13.9 | 13.2 | 7.6 | 4.0 |
| **Average altitude** (m a.s.l.) | <300, 400) | <400, 450) | <450, 500) | <500, 550) | <550, 600) | <600, 650) | <650, 800> | | | |
| | 3.9 | 10.1 | 17.4 | 26.4 | 23.2 | 12.8 | 6.3 | | | |
| **Average slope** (°) | <0.1) | <1.2) | <2.3) | <3.4) | <4.6) | <6.14) | | | | |
| | 7.6 | 32.1 | 29.6 | 16.2 | 9.2 | 5.3 | | | | |

See the text for explanation

The second method is Pearson's parametrical correlation coefficient (R) between CES in a given year (dependent variable) and given natural factor (independent variable). Thanks to the big number of cases (1113), all correlations found were statistically significant already on the level $\alpha = 0.01$. The obvious problem of spatial auto-correlation was not considered in this paper. However, following the evolution of correlations during the time still enables us to clearly assess changes of power, or even of direction, of the influence of each independent variable on spatial structure of land use intensity.

Finally, I summarised the changing influence of natural characteristics on the Coefficient of ecological stability by Multiple Regression Analysis (MRA). CES in each year entered the MRA as a dependent variable, and all three natural indicators were inserted as independent variables. Assessed were then not only the individual β-coefficients of the influence of independent variables, but also the development of the overall determination of the "model" ($R^2$) – see below.

## 4. Results and discussion: overall influence of natural conditions

The current land use pattern in Vysočina according to natural conditions is depicted in fig. 6. The graph in fig. 7 shows how the overall influence of natural conditions on changes of land use structure in Vysočina has developed during last 150 years. Several important, although not very surprising, facts stem from these graphs (see also Bičík and Kupková 2002 for the whole Czech Republic).

Firstly, there really exists a positive relationship between the intensity of land use and the quality of natural conditions. It means that the rate of anthropogenic pressure on landscape increases with growing suitability of a locality for agriculture – forest areas and grasslands are shrinking and, on the contrary, the share of arable land and permanent cultures is growing (fig. 6). It is caused especially by economic effectiveness of this pattern – revenues from a unit of area are higher in more fertile regions, and thus it is more profitable to use them more intensively. It is a logical consequence of the influence of the so-called "differential rent", which was introduced into land use issues by K. Marx (for a commentary see e.g. Rozenberg 1981, p. 469–498).

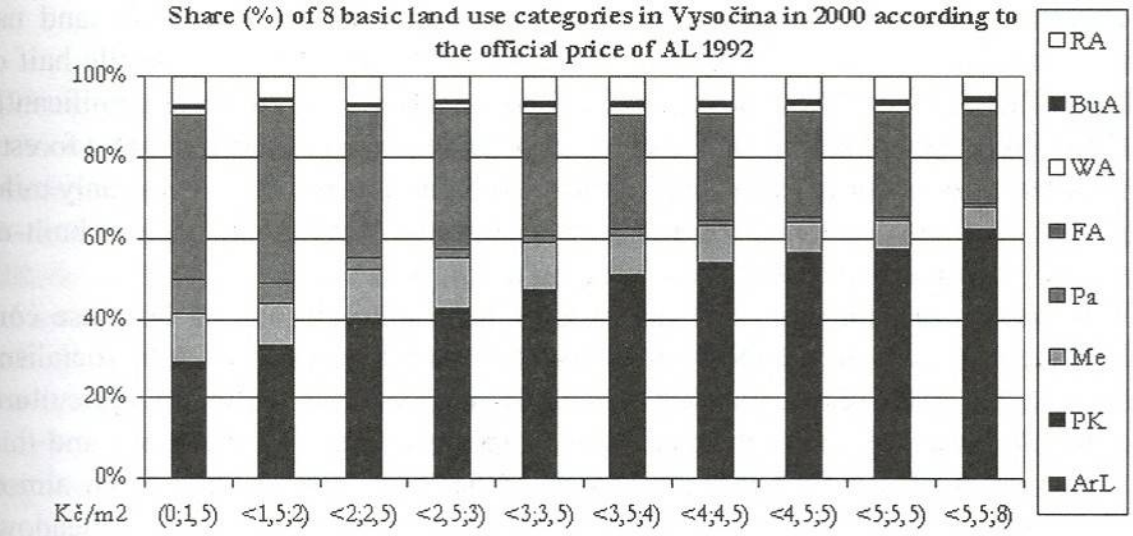



*Fig. 6* Land use in Vysočina in 2000 according to the official price of AL 1992

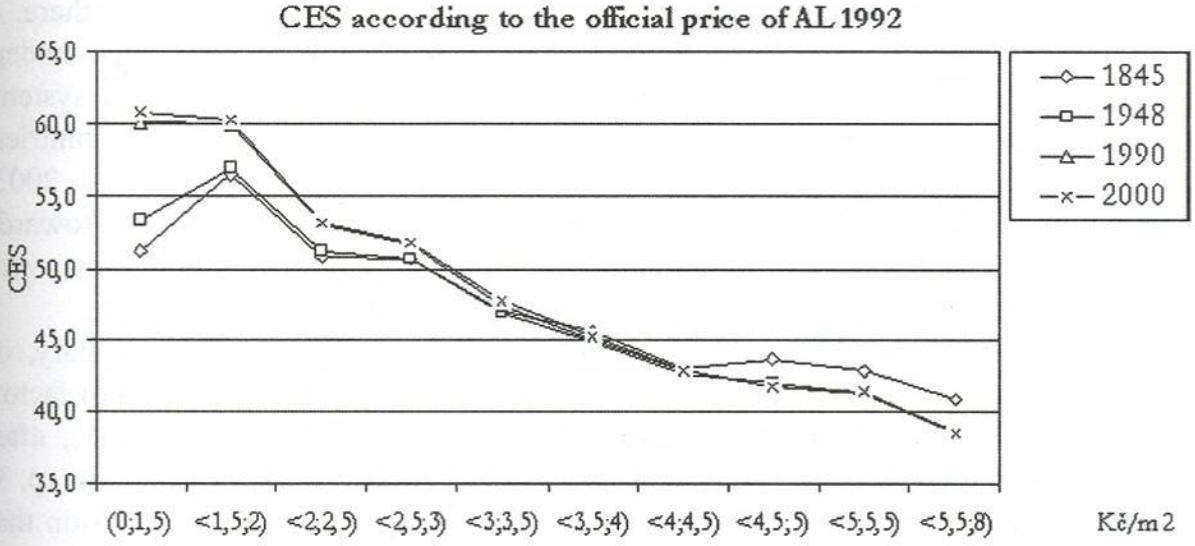



*Fig. 7* Development of the coefficient of ecological stability (CES) according to the official price of AL 1992

Secondly, the importance of natural conditions has been growing during last 150 years. It is expressed by a gradual increase of the "incline" of the curve in fig. 7. This trend can be considered positive both economically and ecologically. However, we have to distinguish individual time periods due to different driving forces here:

Between the years 1845–1948, the most important changes occurred in the most fertile third of the region (the official price of AL above approx. 4.00 CZK/sq. m.). A growth of anthropogenic pressure occurred here, especially a conversion of pastures into arable land and/or "remaining" areas. It was a period of market economy, and thus of competition and market forces. These forces were demonstrated by a more intensive use of fertile regions for agriculture and settlement, and by the beginning of abandonment of traditional "mixed" (cropping-pastoral) farming methods. Land use changes were not significant in less favoured areas.

During socialism (1948–1990), the influence of natural conditions on land use continued to increase. However, this time it was manifested in the less fertile half of Vysočina (official price of AL below 3.00 CZK/sq. m.). Here, land use was significantly extensified – the share of arable land decreased to the detriment of meadows and forests. On the contrary, in the more fertile half of the region this extensification was only mild, and, in addition, there continued the withdrawal of pastures and the increase of built-up and "remaining" areas, typical of the preceding period as well.

It may seem surprising that the influence of natural conditions on land use continued to increase also in so ineffective and "unnatural" system as was socialism. Nevertheless, the main reason for that was a massive industrialization of agriculture. It led, among others, to: (a) a cheaper, easier and more intensive transport, and thus to a concentration; (b) a further fading away of pastoral farming, and to an almost complete separation of crop and animal husbandry (shift of the remaining meadows and pastures to worse natural conditions); and (c) abandonment and afforestation of areas not accessible or cultivable by succeeding heavy mechanization. A continuing concentration of population in large, especially district, towns also led to depopulation of rural areas in worse natural conditions, and thus to shrinkage of arable land there.

Therefore, actually, this positive land use trend was rather a result of huge modernization, mechanization and large-scale concentration than of the political system. Furthermore, the development of land use pattern was similar in Western countries, and under free-market conditions even significantly stronger (Krausmann et al. 2003, Sporrong et al. 1996). Thus, thanks to the tendencies of the socialist system towards equalization and conservation, the structure of land use in Vysočina was rather preserved – especially the extensification of less favoured areas was not sufficient.

However, on a general level, the political influence seems only secondary, or modifying. The universal modernization is probably the underlying (ultimate) factor, as was stated above (Bičík and Kupková 2002). Also Haberl et al. (2001), after a comparison of directed and market economy effects on land use, concluded that (p. 3) "... the basic trajectories are astonishingly similar, giving rise to the speculation that transitions in the major features of socio-economic metabolism (...) are reflected in land-use changes".

Stable land use marks the transformation period (1990–2000) in Vysočina. Nevertheless, it is apparent (fig. 7) that there were some minor changes in the worst natural conditions. The share of grasslands slightly increased to the detriment of arable land there, and therefore the anthropogenic impact slowly decreased.

However, any consequences of restored competition and market forces after 1989 have not appeared in land use of Vysočina yet. These forces should have increased efforts to use land more effectively, and thus should have led to a more significant growth of the influence of natural conditions. Also the government's supports and subsidies seem to have small effects. The reasons (if we do not consider the lower reliability of cadastral data after 1990) probably lie in the specifics of Vysočina – it is a peripheral, conservative and economically weaker region. All these features have precluded a more profound transfer of labour from agriculture to other sectors, to subdue farming, and in this way to extensify land use by afforestation or grassing-over in less fertile and naturally more valuable localities (Jančák and Götz 1997).

### 5. Altitude and slope – contradictory tendencies

The overall development of the influence of natural conditions on land use pattern in Vysočina was outlined in the previous section. But how has changed the importance of altitude and slope – two factors which, beside others, form up these conditions (fig. 5, see closer chapter 3 for the discussion)? The results are visualised in figs. 8 and 9 (altitude) and figs. 10 and 11 (slope).

Firstly, it is obvious that the anthropogenic pressure on landscape weakens (the "ecological stability" strengthens) with growing altitude and slope – arable land, permanent cultures and built-up areas diminish to the detriment of forest and grasslands in higher and more sloping areas (figs. 8 and 10). In general, it is a result of market competition and other economic forces, as were described in chapter 4.

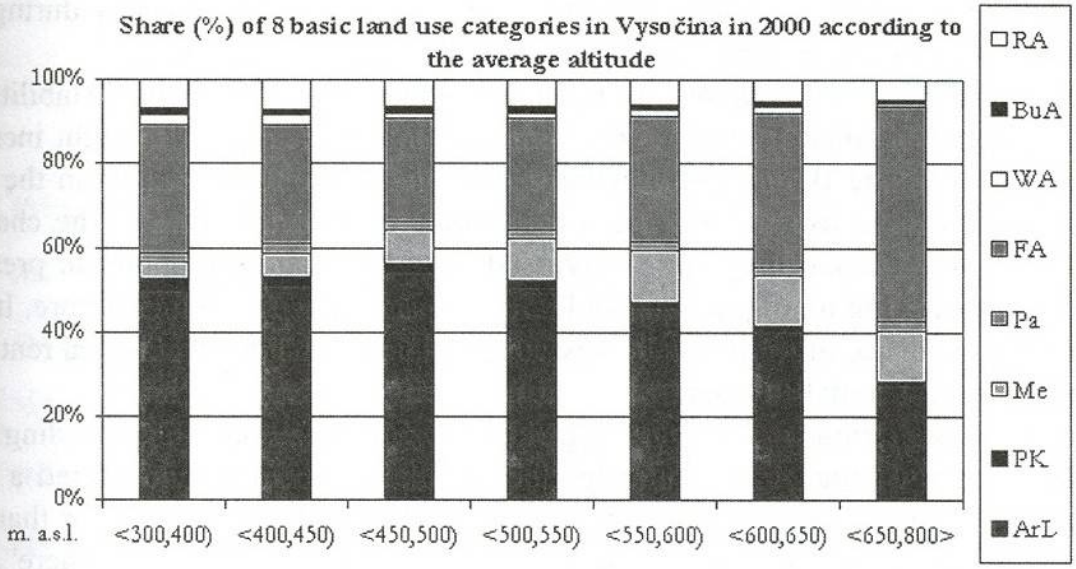



*Fig. 8* Land use in Vysočina in 2000 according to the average altitude

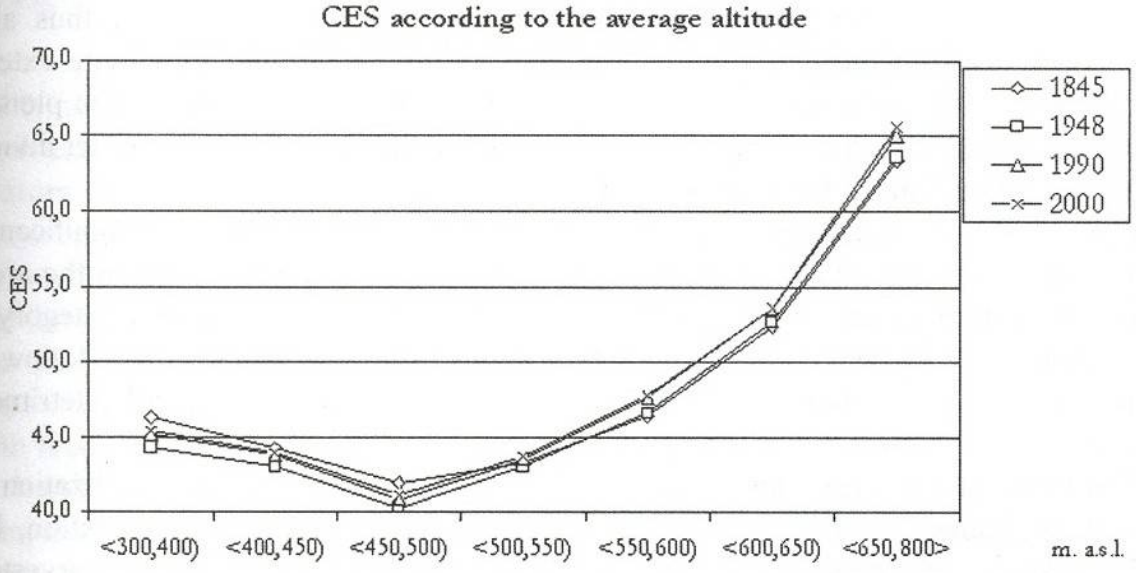



*Fig. 9* Development of the coefficient of ecological stability (CES) according to the average altitude

Interestingly, maximum intensity of land use is not reached at the lowest altitudes, but in BTUs lying between ca 450 and 500 metres a. s. l. (see fig. 8 and 9). It is probably specific for the region of Vysočina and needs further explanation. As already mentioned, altitude and slope are almost independent variables in Vysočina (fig. 5); nevertheless, a more rugged terrain can be found in river valleys. Korčák (1938) noticed that (p. 77–78) "The Bohemian-Moravian Highland has a character of a flat plateau, into which the rejuvenated river valleys were deeply cut; they remain forested and often restrict transport; whereas the cultural space itself, with fields and villages, is the plain (at average altitudes – J. K.)". The occurrence of these steep valleys, non-suitable for agriculture and thus more forested than ploughed, is highest at lower altitudes, up to 450 metres a. s. l.

However, the development of the influence of these two variables on land use pattern is the most important issue for us. From the graphs in figs. 9 and 11 we can deduce that the dependence of CES on slope has been rising significantly during last 150 years; whereas the importance of altitude has been rather stagnating.

In the years 1845–1948 there was an apparent decrease of "ecological stability" in lower (up to approximately 500 metres a. s. l.) and flatter areas, and a slight increase of it in more sloping BTUs. Put together, the situation was the same as in the case of natural conditions as a whole (the official price of AL – chapter 4): the changes were rather weaker, and they were expressed by a growing anthropogenic pressure (especially ploughing up of pastures) in locations more suitable for agriculture. It was a typical consequence of the growing pressure of competition (the differential rent) and modernization of animal husbandry.

The socialist period (1948–1990) significantly differed from the preceding one. The influence of altitude stagnated (fig. 9) – BTUs of all altitudes suffered a mild extensification, especially afforestation of agricultural land. The reason for that was the socialist tendency for equalisation, production of "everything everywhere", and unnatural conservative tendencies of the non-market system. Economic and environmental questions were put aside because of the "need" for maximal volume of agricultural production and food self-sufficiency of Czechoslovakia. Altitude, which actually represents variations in climate and soil conditions here, and thus also differences between plots in fertility and profitability of farming to a large extent, was therefore not important for the socialist system. During this period, even plots at altitudes above 700 metres a. s. l. in Vysočina, right on the Great European water divide, were considered "ideal" for intensive large-scale cropping.

Conversely, the influence of slope on landscape macrostructure rose significantly during socialism (fig. 11). The anthropogenic pressure strongly declined in the areas with more sloping terrain. Arable land diminished here (in the most sloping category to less than one half) to the detriment of meadows, forests, "remaining" areas (fallow or abandoned land etc.), and in BTUs with the slope of more than 4° even to the detriment of pastures, which almost disappeared elsewhere.

The reason for the growing influence of slope is obvious. The industrialization of agriculture, especially the replacement of horsepower by heavy mechanization, led to the abandonment of steeper plots, non-accessible for ordinary tractors, harvesters and other modern specialised farm machinery. Furthermore, irregular shapes of many

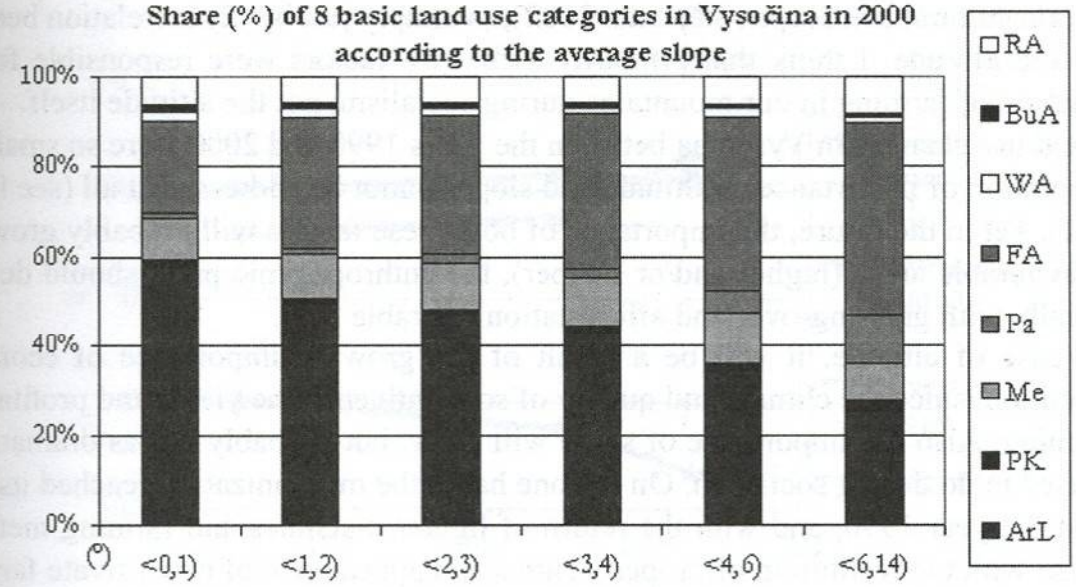



*Fig. 10* Land use in Vysočina in 2000 according to the average slope

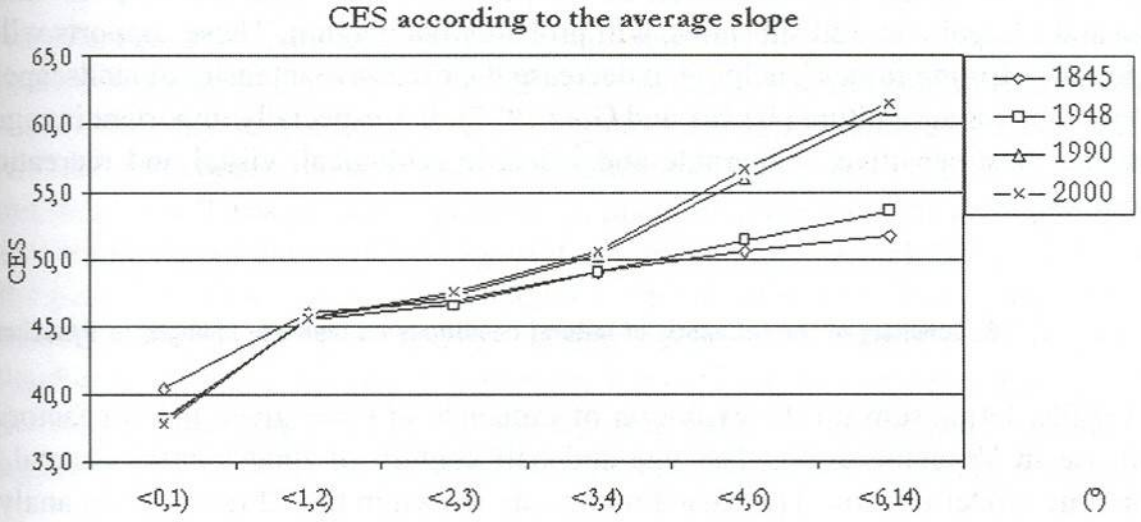



*Fig. 11* Development of the coefficient of ecological stability (CES) according to the average slope

fields in more undulating landscape were simplified, smoothed or straightened. In particular, small patches of arable land with complex or unsuitable shapes, too steep or stony, between woodlands, within them or on their margins, were left lying fallow (for secondary succession) or afforested. That is why arable land on the steepest plots was replaced by pastures, forests and "remaining areas", comprising various scrublands and fallows. It was not possible to till these plots anymore with heavy mechanization, and thanks to growing yields in more suitable regions it was not necessary. Thus, paradoxically, technology, and not ecological considerations underpin these changes with favourable ecological effects (lower erosion etc).

Here, we can see the advantage of choosing Vysočina for this case study. In regions comprising mountain ranges on the borders of the Czech Republic (see fig. 1), the dependence of land use changes on altitude would be falsely determined either by (1) the expulsion of the Czech Germans after the WW2, which lead to desolation of the

mountain cultural landscape (Štěpánek 2002); or simply just by (2) correlation between slope and altitude. I think that primarily these two factors were responsible for the diminution of farming in our mountains during socialism, not the altitude itself.

Land use changes in Vysočina between the years 1990 and 2000 were so small that the evolution of importance of altitude and slope cannot be addressed at all (see figs. 9 and 11). Yet in the future, the importance of both these factors will probably grow – in less favourable areas (higher and/or steeper), the anthropogenic press should decline, especially with grassing-over and afforestation of arable land.

In case of altitude, it will be a result of the growing importance of economic competition, since the climate and quality of soils influence the yields and profitability of farming. Also the importance of slope will grow, but probably not as dramatically as it used to do during socialism. On the one hand, the mechanization reached its peak around the year 1990, and with the return of lighter machines and farming methods, and also with the restitution of property rights and appearance of new private farmers, a return of permanent grasslands to the detriment of shrublands and fallows in steeper areas will be possible. But, on the other hand, due to the risk of erosion and floods, a pressure to further extensification of steeper plots, also with the help of various state and EU policies and subsidies, will probably outweigh it. These supports will be important "driving forces", helping to decrease the excessive intensity of landscape use of Vysočina for agriculture (Jančák and Götz 1997). It is especially important in regions with the most sensitive, vulnerable and valuable ecological, visual and recreational resources.

### 6. Summary of the influence of natural conditions on land use changes in Vysočina

Finally, let us sum up the evolution of influence of three given natural factors on land use in Vysočina during last one and half century of fundamental societal and economic modernization. The basic findings are shown in fig. 12 (correlation analysis) and fig. 13 (multiple regression analysis). From these figures, the following conclusions can be drawn:

(A) There exists a positive relationship between the quality of natural conditions and the intensity of land use – the anthropogenic pressure on landscape decreases with growing altitude and slope. On a general level, this is a result of the so-called "differential rent" (economic competition – incomes and expenses; concentration and specialization).

(B) The overall influence of natural conditions has been strengthening. It is positive both from economic and ecological viewpoints. In figs. 12 and 13, this trend is represented by the growing importance of the official price of AL, and in fig. 13 also by the determination of the whole "model". According to these calculations, all three used indicators of natural conditions together statistically explained ca 10% of the differences in CES (or, in other words, in the rate of use of the environment of Vysočina by society) in 1845, ca 14% in 1948, and almost 23% in 2000. Therefore, we can very roughly say that the power of natural conditions doubled in the monitored period.

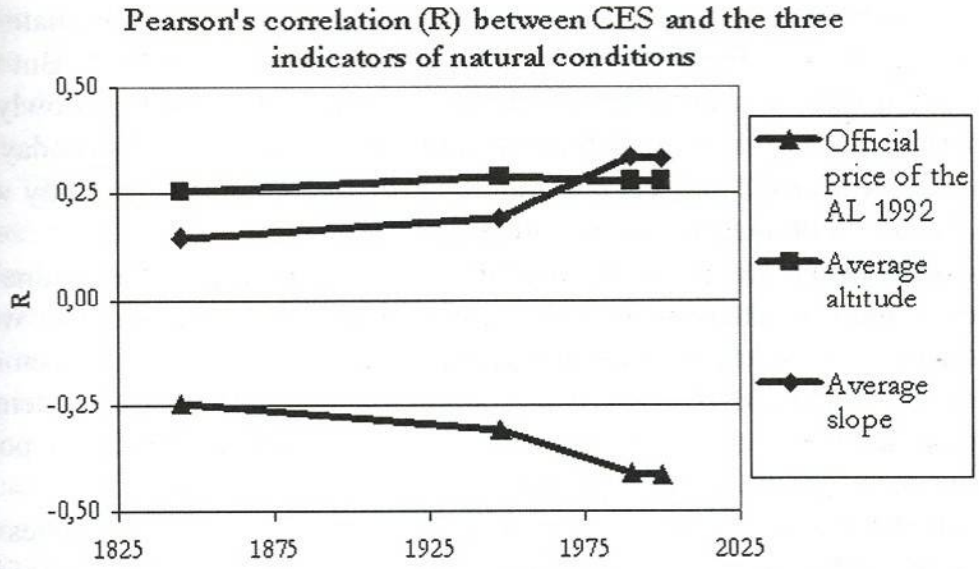



*Fig. 12* The evolution of the influence of natural conditions on the land use pattern in the Vysočina region (I)

(C) This general trend was modified by different "driving forces" of development in each assessed period. Until 1948, the influence of the monitored natural characteristics was growing only very slowly, since, when considering agriculture, it was a natural, traditional and conservative period. The main trend was intensification in lower and flatter localities. It was a result of growing competition pressure in the economic system of free trade, and of the so-called "agricultural revolution" (Jeleček 2002). After 1948, in the period of rapid and dynamic changes – often destroying values produced by the preceding system – the development became faster and stronger. Nevertheless, the strengthening of power of natural conditions did not stem from the functioning of free trade mechanisms anymore, but one-sidedly from industrialization and mechanization of agriculture. This enforced extensification in and abandonment of steeper areas.

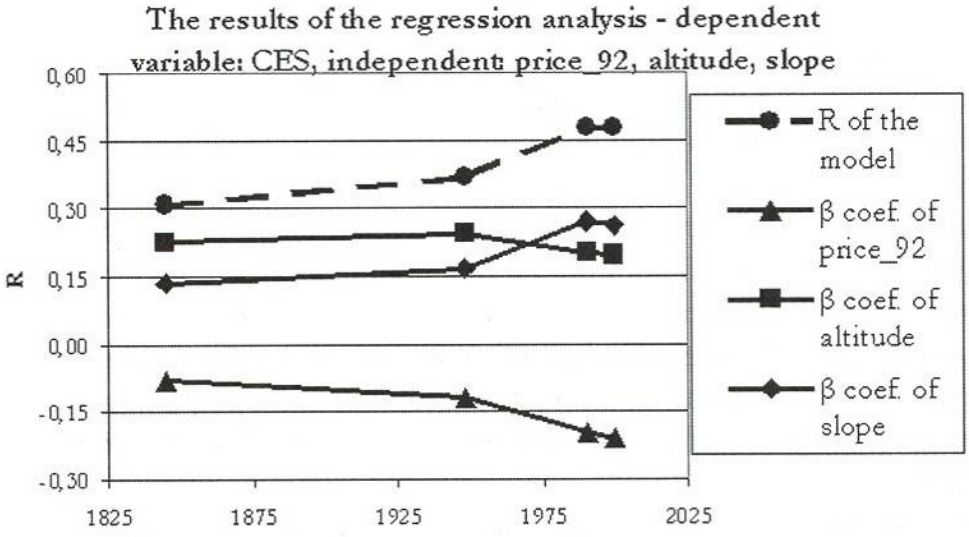



*Fig. 13* The evolution of the influence of natural conditions on the land use pattern in the Vysočina region (II)

Thus, as can be seen in figs. 12 and 13, altitude (soil fertility and climate, in other words) was the decisive factor for land use pattern until the year 1948. But then, the importance of altitude stagnated or even declined, and it was slope that slowly became more important for the macrostructure of landscape in Vysočina. Nowadays, minor changes are typical of the conservative and peripheral Vysočina, especially when our assessment is based on inaccurate and out-of-date cadastral figures.

(D) As already mentioned (see B), the three assessed indicators "determine" (in statistical sense) land use pattern in Vysočina from almost one quarter. In other words, the macrostructure of landscape in Vysočina is from 75% influenced by other factors. These include e.g. other natural characteristics (soils and bedrock, climate – temperature and precipitation, aspect of slope) and socio-economic factors (density of population, demographic development, spatial exposedness, economic power), etc.

However, institutions (system of land possession, tenure and use, subsidies and supports) and cultural/behavioural factors (relationship to land, talent and élan of involved actors) also seem to be very important – see e.g. Chromý (2003). Unfortunately, these factors are hard to quantify. Land use must be understood as a result of individual decisions of concrete actors (stakeholders), who tend to follow the structural factors, assessed in this work, only to some extent. For the actors, opportunities, motivations, knowledge, abilities and constrains are very important; and also local lore, traditions, values, beliefs, etc. The future research in the development of our landscape should be primarily focused on these qualitative issues and factors.

## 7. Conclusions

The aim of this article was not only to characterise the changes of the relationship between land use and natural conditions in the Vysočina region during last 150 years but also to show one possible approach to assessment of long-term evolution of spatial aspects of the interaction between nature and society. I tried to draw the reader's attention to opportunities and constrains of quantitative approach. On the one hand, this statistical method ("empirical structuralism" according to Walmsley and Lewis 1993) can reveal some patterns and connections. But, on the other hand, it is too rough and simplified, and thus has to be accompanied by a qualitative approach, which focuses primarily on processes and behaviour of actors.

The question remains, to what extent it is possible to generalize our results from the Vysočina region. The specifics of Vysočina (traditionalism, peripherality, stability of settlement system, internal homogeneity of both natural and social conditions) had without any doubt two important consequences: (i) the land use changes were less intensive than elsewhere (spatially exposed areas, mountains, border regions influenced by the expulsion of Germans); and also (ii) their determination by natural conditions was weaker. Nevertheless, the overall trend may be considered general (compare to Bičík and Kupková 2002).

Several hypotheses were stated in chapter 1. They were more or less confirmed by this research (see chapter 6). Only in case of hypothesis (4), the specifics of the socialist period may have been overestimated. The political "driving forces" of

that times seem to have only modified the general trend, common for all developed countries – extensification of land use in less favoured areas (afforestation, grassing over, abandonment) – but were not able to reverse this phenomenon.

The basic principle of this crucial phenomenon is a diversification of localities in their land use. This heterogenization, as was commented in chapter 1, still accelerates, as the globalisation and (economic) integration deepens. On the one hand, this causes a growth of competition pressure, leading to specialization of a territory on a particular activity (landscape use), most suitable and appropriate from the viewpoint of preconditions. And, on the other hand, the integration is accompanied by easier and cheaper transport, which in turn enables specialization and increases profits from it. One of the mentioned preconditions, influencing specialization of the given locality, is suitability of a territory for agricultural production, expressed by a set of natural factors.

Therefore, the growing influence of natural conditions on land use pattern cannot be understood as an expression of deepening natural determinism. Actually, the opposite is true – the decline in the dependence of society on local natural conditions enabled the land use, once inevitably relatively homogenous ("everywhere everything – arable land, pastures, forest"), to become more effectively adapted to different natural conditions. It stemmed from the changes in "socio-economic metabolism" – from the substitution of ineffective, scattered and locally bound energy sources (biomass, sunshine, wind and water) by effective, free and spatially transferable sources of energy (fossil fuels, nuclear energy, mineral resources and artificial fertilizers). This crucial historical shift caused a dramatic increase in agricultural yields and the productivity of labour, an opening of formerly local energy and material flows, and a growth of competition and cooperation between regions (e.g. Krausmann et al. 2003 or Haberl et al. 2003).

Natural conditions thus can neither be understood as "driving forces" nor causes of changes. They only co-determine regional impacts of societal changes – of changes in the "mode of production" (Jeleček 2002 or Mather 2002) in a structuralist perspective, or of people's behaviour in the "humanistic" view.

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**List of abbreviations**

| | |
|---|---|
| AL | – agricultural land (chapter 3.) |
| ArL | – arable land |
| a.s.l. (m. a.s.l.) | – metres above the sea level (altitude) |
| BTU | – Basic territorial unit (chapter 3.1) |
| BuA | – built-up areas |
| CES | – Coefficient of ecological stability (chapter 3.2) |
| CZK/sq.m. (Kč/m$^2$) | – Czech crowns per one square meter (official price of AL) |
| FA | – forested areas |
| Me | – meadows |
| Pa | – pastures |
| PK | – permanent cultures (chapter 3) |
| RA | – "remaining" areas |
| WA | – water areas |

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## VLIV PŘÍRODNÍCH PODMÍNEK NA VYUŽITÍ PLOCH V KRAJI VYSOČINA A JEHO ZMĚNY OD POLOVINY 19. STOLETÍ


Résumé

Cíle tohoto příspěvku byly dvojí: (1) charakterizovat změny vztahu mezi využitím ploch a vybranými charakteristikami přírodních podmínek v rámci kraje Vysočina za uplynulých 150 let; a (2) nastínit jeden z možných přístupů ke sledování dlouhodobého vývoje prostorových aspektů interakce společnost – příroda, a zarámovat jej po stránce teoretické i metodologické.

Práce vycházela ze dvou datových zdrojů: (A) Údaje o využití ploch (8 kategorií) pro 1113 „základních územních jednotek" (ZÚJ/BTU) kraje Vysočina za roky 1845, 1948, 1990 a 2000. Pro zpřehlednění byl počítán tzv. „koeficient ekologické stability" (KES/CES), který jedním číslem vyjadřuje celkovou strukturu využití ploch v dané jednotce v jednom časovém horizontu. (B) Ke každé ZÚJ byly přiřazeny hodnoty třech vybraných, nicméně reprezentativních charakteristik přírodních podmínek: úřední ceny zemědělské půdy (komplexní ukazatel vhodnosti území pro zemědělství), průměrné nadmořské výšky a průměrné sklonitosti. Vliv přírodních podmínek na využití ploch byl hodnocen jednoduchými statistickými metodami. Bylo zjištěno, že:

(I) Mezi kvalitou přírodních podmínek a intenzitou (strukturou) využití ploch existuje pozitivní závislost – s klesající vhodností pro hospodaření, rostoucí nadmořskou výškou i sklonitostí klesá v území antropogenní tlak na krajinu. To je v obecné rovině důsledkem působení různých ekonomických mechanismů, zvláště konkurence a koncentrace, resp. tzv. „diferenciální renty".

(II) Celkový vliv přírodních podmínek postupně sílil. To je ekonomicky i ekologicky pozitivní. Všechny tři užité charakteristiky přírodních podmínek ovlivňovaly („způsobovaly") rozdíly v KEV v roce 1845 z 10 %, v roce 1948 ze 14 % a v současnosti z 23 %. Růst vlivu přírodních podmínek na využití ploch je tedy obecným důsledkem rostoucí dělby práce, konkurence a kooperace mezi regiony (lokalitami), jejich propojenosti a specializace. Za tím stojí proměna „socioekonomického metabolismu" – modernizace ekonomiky a zemědělských technologií, zjednodušování a zlevňování dopravy apod.

(III) Tento obecný trend byl v jednotlivých kratších sledovaných obdobích modifikován odlišnými politickými a společenskými „hybnými silami" vývoje. Do roku 1948 byly změny pozvolné, šlo zejména o intenzifikaci v přírodně příznivějších – nižších a méně sklonitých polohách. To bylo projevem růstu vlivu ekonomických tlaků, tj. diferenciální renty, v podmínkách fungování tradičního, konzervativního volného trhu. Po roce 1948, v období rychlých a dynamických změn za socialismu, vývoj zmohutněl. Zesilování vlivu přírodních podmínek již ovšem nebylo dáno působením normálních ekonomických mechanismů, ale jednostranně zejména mechanizací a industrializací zemědělství. Ta si vynutila extenzifikaci a opouštění sklonitějších poloh.

Do roku 1948 byla tak pro rozložení využití ploch rozhodující nadmořská výška (tj. v českých podmínkách klima a kvalita půd). Po roce 1948 ale její význam stagnoval až klesal, a významnějším faktorem pro makrostrukturu krajiny se v kraji Vysočina postupně stala sklonitost.

Na závěr příspěvku bylo konstatováno, že specifika kraje Vysočina v rámci České republiky měla vliv na to, že změny využití ploch byly zřejmě menší než jinde, a že i jejich ovlivnění přírodními podmínkami je slabší; nicméně že celkový trend byl zřejmě obecný. Zároveň bylo zdůrazněno, že užitá statistická metoda musí být doplněna i přístupem kvalitativním, vycházejícím předně z pochopení jednání a motivací aktéra.

Je to proto, že využití ploch musí být chápáno jako výsledek individuálních rozhodnutí konkrétních aktérů (uživatelů a majitelů pozemků, místních, krajských, státních i nadstátních orgánů, nevládních a neziskových organizací apod.). Tito aktéři přitom sledují dané „strukturální" či „objektivní" faktory, hodnocené v této práci, pouze do určité míry. Pro činnost aktéra jsou velmi významné také motivace a znalosti, příležitosti, možnosti a omezení; a také místní tradice, systémy hodnot a víry, zažité vzorce chování a navyklé způsoby řešení nastalých problémů a situací, významy připisované různým místům a činnostem apod. Další výzkum využití ploch by měl být proto primárně zaměřen na tato „kvalitativní" či kulturní a behaviorální témata a faktory, spíše než na další využívání metody kvantifikace, respektive „empirického strukturalismu".