

## Land use changes in the town of Železná Ruda and its surroundings (Czech Republic) based on the analysis of historical maps from the period 1843–2005

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### Abstract

The article deals with the landscape evolution of the town of Železná Ruda and its surroundings in the Bohemian Forest (=Šumava Mts.) in the period 1843–2005. The research is based on the interpretation of historical topographic maps using GIS methods. This approach enabled quantitative evaluation of land use changes and landscape evolution in the study area.

*Key words:* land use changes, historical maps, landscape evolution, Šumava Mts., town of Železná Ruda

### INTRODUCTION

The present land use of the Czech Republic is spatially very much diverse. Quantitative evaluation of the land use, which reflects specific interactions between human activities and natural conditions, is an important part of landscape evolution research. To study landscape evolution/land use changes with quantitative methods, a cartographic research method appears to be the most suitable approach.

Land use changes and trends can be presented both statistically and cartographically. Cartographic visualization shows the number of land use changes that express landscape dynamics or landscape stability. This stability is represented by stable landscape elements, i.e. areas that do not display any land use changes during the period in question. Land use changes can be evaluated between different periods or during the whole studied period. Trends in landscape evolution are demonstrated on the maps by, e.g., succession of land use changes from forests to meadows and to arable land or vice versa. Maps also provide information about cultural landscape fragmentation due to road and railway network constructions.

Since 2005, we have dealt with quantitative evaluation of the evolution of the cultural landscape in the Czech Republic during the last 250 years, or more specifically from 1760 till present. This research is carried out in the frame work of the long term research project MSM 62933559101 “Research of biodiversity sources and indicators in a cultural landscape in the context of its fragmentation dynamics” supported by the Ministry of Environment of the Czech Republic. Within this project, a set of digital maps of land use for the whole Czech Republic, based on historical military maps, is created in the scale of 1 : 200 000 for the studied period 1760–2005.

A model study area – the town of Železná Ruda and its surroundings – was chosen for this

article (Fig. 1). Here, we studied land use changes in the shorter period (1843–2005) because of problematic georeferencing of the maps from the 1<sup>st</sup> Austrian military mapping (from 1763–1783). The maps in Figs. 2–7, representing land use in different time periods, are also in a bigger scale according to the original topographic maps (see below). The study area was chosen as a representative of low level industrialization, high-ranking nature values and leisure activity development.

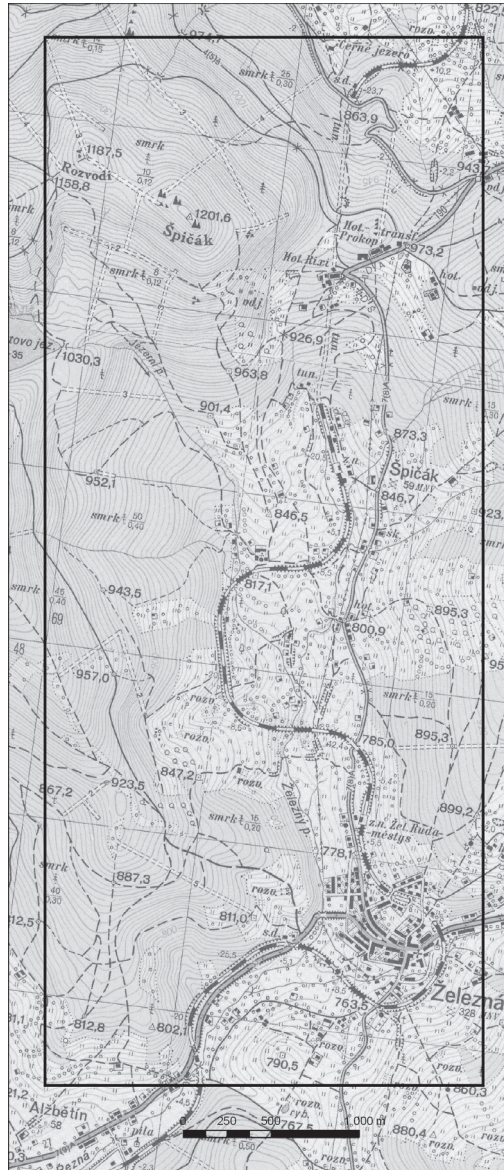


Fig. 1. The study area.

## METHODS

The following maps were used as the basis for the analysis of land use changes:

- Maps from 2<sup>nd</sup> Austrian military mapping (1836–1852) in the scale 1 : 28 800,
- maps from 3<sup>rd</sup> Austrian military mapping (1876–1880) in the scale 1 : 25 000,
- revised maps from 3<sup>rd</sup> Austrian military mapping (1918–1942) in the scale 1 : 25 000,
- Czechoslovak military maps (1952–1955) in the scale 1 : 25 000,
- Czechoslovak military maps (the 1970s) in the scale 1 : 25 000,
- Czechoslovak military maps (1988–1995) in the scale 1 : 25 000, and
- basic topographic maps (2005) in the scale 1 : 10 000.

Maps from the 2<sup>nd</sup> Austrian military survey were obtained in a digital form in cooperation with Geoinformatics Laboratory, University of J.E. Purkyně in the town of Most. Other map sets were scanned at the Brno branch of The Silva Tarouca Research Institute for Landscape and Ornamental Gardening (STRILOG). As for georeferencing, maps from the 2<sup>nd</sup> and 3<sup>rd</sup> Austrian military mapping were georeferenced at the Department of Geomatics (University of West Bohemia in Plzeň) with a topological accuracy  $m_{xy}$  of 13 m (see ČADA in ŠIMŮNEK 2006). Other map sets were georeferenced at the Brno branch of STRILOG, with a topological accuracy of 10 m (HAVLÍČEK et al. 2006).

Maps were processed in the ArcView programs, version 3.2 and 9.1, and the processing by manual vectorization.

The legend for the consequent land use maps results from the map symbol legends on the original maps. It is divided into ten categories: Arable land (1), Meadows and pastures (2), Orchards (3), Vineyards and Hop-fields (4), Forests (5), Waters (6), Rural built-up areas (7), Urban built-up areas (8), Leisure areas (9), and Other areas or others (0). Category 4 (Vineyards and hop-fields) does not occur in the study area and thus is not included in the figures, graphs and tables shown in the article.

## NATURAL CONDITIONS OF THE STUDY AREA

The study area has a rectangular form (2×6 km) and is situated in the southern part of Klatovy district, southwest of the town of Sušice, along the Czech-German border. It includes the town of Železná Ruda and the locality of Špičák.

Geomorphologically, the area exhibits a mountainous character and is situated in the Bohemian Forest and its subunits the Královský Hvozd Mts., Pancířský Hřbet ridge and Debrnická Hornatina highlands. The valley of the Regen River, running in a north-south direction, forms the axis of the area. The glacial cirque of Čertovo Lake lies in its western part. The highest point is the Špičák Mt. (1202 m a.s.l.), while the lowest point is represented by the Jezerní Potok stream above the Alžbětín village (725 m a.s.l.). Phytogeographically, the area belongs to Bohemian oreophyticum, district Šumava and subdistrict Královský Hvozd. Potential vegetation (NEUHAUSLOVÁ 1998) is represented by acidophilous beech and fir forests. In the geobotanical classification, the area belongs to mountainous acidophilous beech forest, herb-rich beech forest, alder carrs and floodplain forest and bog spruce forest. According to the biogeographical classification of the Czech Republic (CULEK 1996), the study area is part of the Šumava bioregion.

## HISTORICAL DEVELOPMENT

The settlement of Železná Ruda was founded on a trade route through the Bohemian Forest from Bohemia to Bavaria. The population was mainly German speaking. This was a result of political and economic development: after the defeat of Czech Protestants in the Battle of

Bílá Hora Mt. near Prague (1618) which led to their departure from the Bohemian Kingdom and thus enabled German-speaking colonists from Bavaria and Austria to colonise borderlands including the study area (ANDĚRA & ZAVŘEL 2003).

The settlement is mentioned in 1569 for the first time when the first iron-mills were founded. Iron ore resources were small and quickly exhausted, therefore the iron-mills were replaced by glassworks, and potash production started in the village of Špičák in the second half of the 17<sup>th</sup> Century. Mills were gradually surrounded by rural settlements and started to create a local economic centre called “Na hutích”. From 1757 it was called Hofmark Eisenstein or Markt Eisenstein. The Czech name Železná Ruda is mentioned from 1845 (LUTTERER et al. 1982). The prosperity of the glassworks during the 1820s was connected with Johann Georg Hafenbrädl. The production of glass and potash needed a large amount of wood. Excessive logging together with cattle and pig grazing in the forests resulted in vast clear-felled areas that were not able to self-recover. These areas were therefore artificially reforested with spruce plantations. However, these plantations were very sensitive to harsh climatic conditions and were damaged by snow and wind and pest attacks in the following decades.

Livestock production was the typical agriculture in the 18<sup>th</sup> and 19<sup>th</sup> Centuries. The area supplied the market mainly with fat-stock and draught cattle. Cereals, vegetables and other crop production served only for the local population.

An important event in the history of the town of Železná Ruda was the construction of a railway and a tunnel through the Špičák Mt. in 1877, which simplified connection with this mountainous area. The railway increased the number of visitors and, as a consequence, an expansion in tourist activities and the development of hostels, guesthouses and hotels (HÄUPLER & KALINA 2000).

Another milestone in the history of the town of Železná Ruda and its surroundings was represented by the period of World War II followed by the transfer of the German speaking population and resettlement by Czechs. This meant an interruption in the continuity of the economic development and local traditions. The new inhabitants did not have the experience, courage or patience for life in the harsh mountain conditions. The next event, proclamation of a closed border military zone in 1948, further deepened the economic recession of the area. The landscape was also influenced by two events within collectivization of agriculture resulting from central state planning: firstly, several areas were turned into arable land and secondly, large cowsheds with yearlong lairage were built.

The situation changed after 1990 when the borders were reopened. Both domestic and international tourism developed very rapidly and also the agricultural policy transformed to a more sustainable one.

## **RESULTS OF THE LAND USE DEVELOPMENT ANALYSIS BASED ON HISTORIC MAPS**

In the following text, we describe the results of the analysis of map sets and the state of the landscape in individual time periods (see also Table 1 and Figs. 1–9).

The processing of maps from the 2<sup>nd</sup> Austrian military mapping in this part of the Czech Republic is difficult due to the cross-hatching that overlays the boundaries of land use categories. The analysis of these maps shows that the majority of the study area was used for agriculture. About 49% of the area was covered by meadows and pastures; forests covered 36%. Rural built-up areas formed 1% of the total area, including the town of Železná Ruda, which received the status of a small town only in 1848. Arable land was concentrated around the settlement; meadows and pastures were situated in a greater distance. Forests covered steep slopes at higher altitudes.

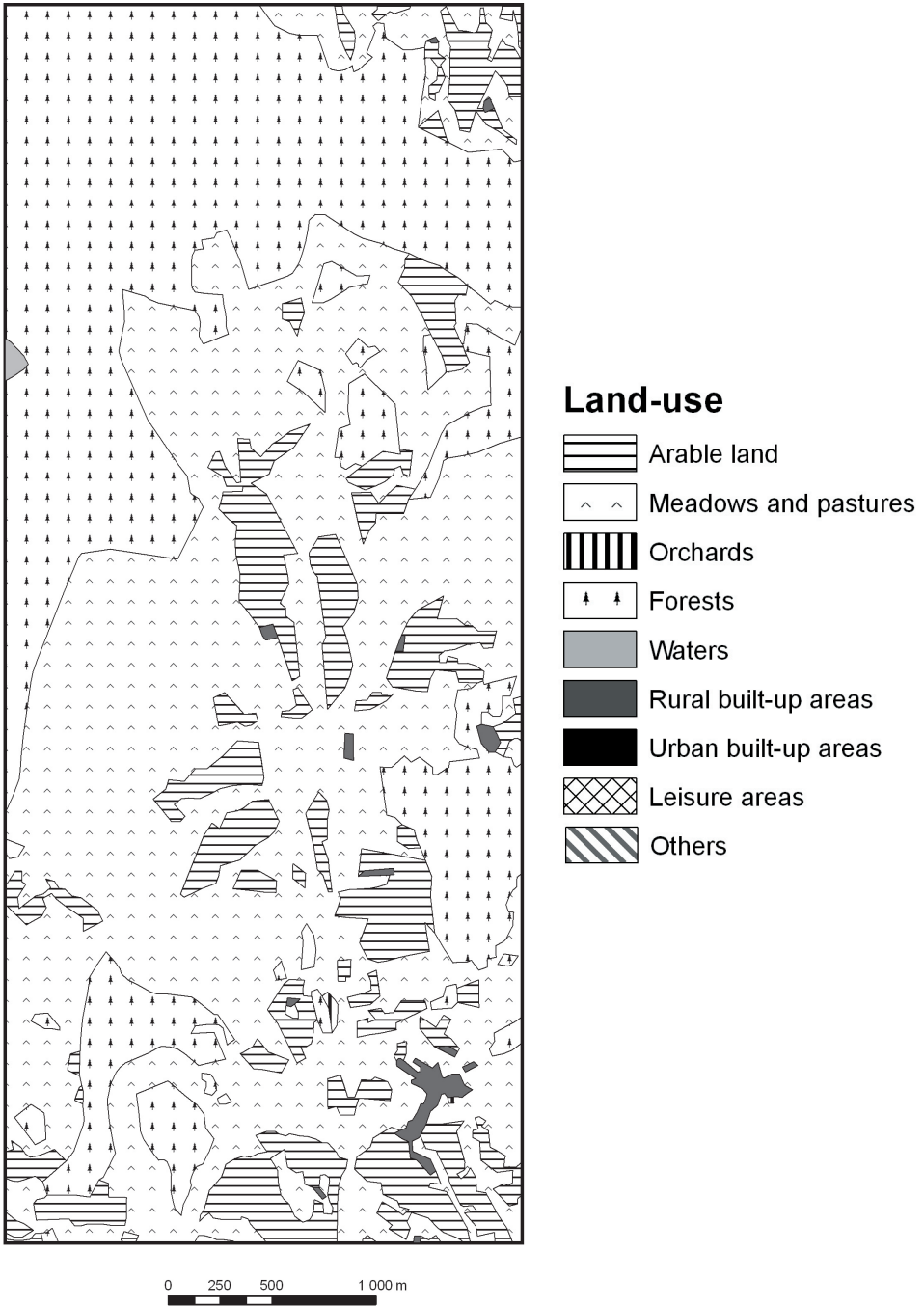
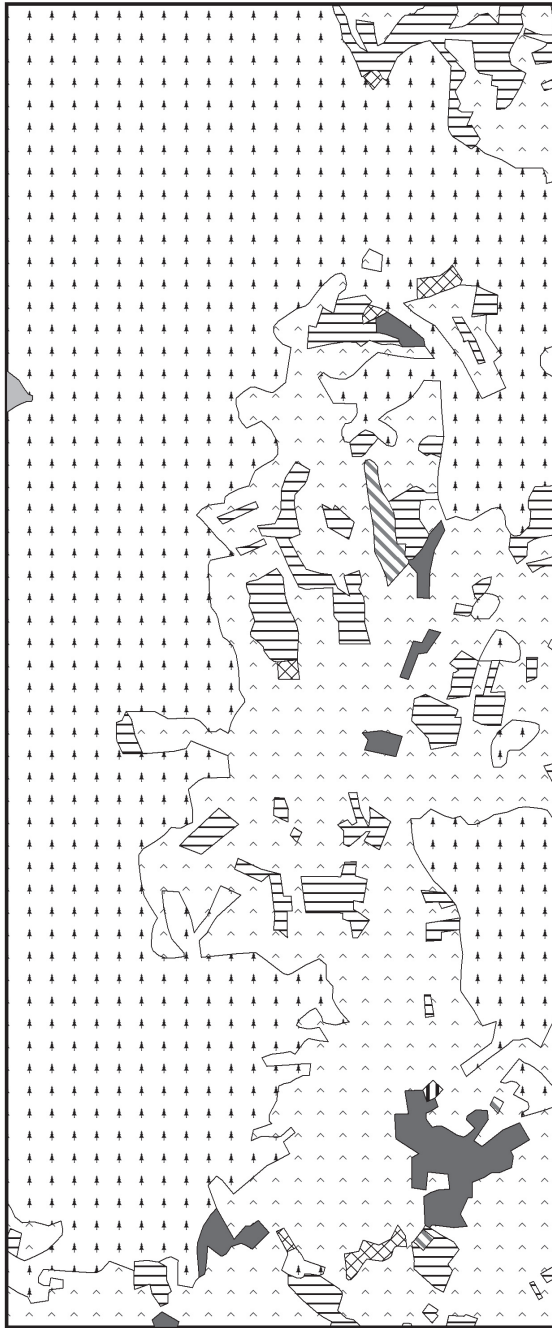


Fig. 2. Land use in the study area in 1843. The legend applies also for Figs. 3–7.



Fig. 3. Land use in the study area in 1878 (for legend, see Fig. 2).





0 250 500 1 000 m

Fig. 4. Land use in the study area in 1924 (for legend, see Fig. 2).

The maps of the 3<sup>rd</sup> Austrian Military mapping are from 1878. A coloured version, which is more suitable for vectorization than black-and-white copies, is available. However, the transition between different colours is aggravated by colour quality and time. Thus, while forests are well recognizable, it is very difficult to distinguish between meadows and pastures, on the one side, and arable land on the other side. Another problem, similar to that with the 2<sup>nd</sup> Austrian military maps, is with cross-hatching that, especially in steep mountainous terrain, overlays the boundaries of land use categories. Overall, it is possible that a proportion between arable land, and meadows and pastures shows some discrepancies.

In this period, more than 50% of the study area was covered by, continuous forest, while smaller patches basically did not occur. More than 30% of the area was covered by meadows and pastures; in this case they were formed by grasses and herbs used for agriculture. Arable land represented 15% of the study area and was surprisingly concentrated in relatively large blocks. This could be caused by the above mentioned interpretation difficulties. Urban built-up areas consisted of the town of Železná Ruda, even though its character was rural. Rural built-up areas were then represented by farms and estates. A railway station, a quarry near the railway and two cemeteries belonged to the category 0 (others) and covered 0.42%. The proportion of waters was insignificant and consisted of the eastern part of Čertovo Lake (0.1% of the total area).

The land use pattern was influenced by relief and climate. Higher altitudes and especially eastern slopes were covered by forest, while agricultural areas were situated in the valley bottoms, lower parts of the slopes or eventually rose further up on southern and western hillsides.

The revised 3<sup>rd</sup> military map from 1924 is only a black-and-white copy, but easy to read. Elevations are given by contour lines that simplify vectorization and land use interpretation. Minor problems occur with an interpretation of shrubs but these are included either in category 2 (when there is a symbol for meadows or pastures) or 1 (with no other symbol).

As in the previous period, the largest area was covered by the forests (57% of the total area). Their area even increased at the expense of arable land. A similar situation occurred with meadows and pastures – here again, the increase to 34% was at the expense of arable land. The area of arable land thus was only 6.34%. The total area, its size and distribution of arable land more or less agreed with the above-mentioned historical development. Separate fields were distributed along the whole clear-cut area, and at the same time corresponding elevations were used for crops. An interesting fact is the local increase in the area of the village of Hamry in the northeastern part of the study area. A relatively significant increase was noted for the built-up areas of the town of Železná Ruda (1.1%). Rural built-up areas also increased (0.7%). On the contrary, category “others” slightly decreased (0.37%) due to a mistake (omission of a quarry). Surprisingly, the water areas, which were considered to be stable, also decreased (0.08%). Leisure areas (0.4%) were delimited for the first time and they included hotels, chalets and restaurants. A bigger leisure area was situated to the southwest of the town of Železná Ruda and was called Lázně (Spa).

The basic spatial distribution of forest and non-forest areas did not change. Important features of this period were the development of the town of Železná Ruda and leisure the areas.

The Czechoslovak military maps from 1952 show a completely different situation. Because of World War II and especially of the transfer of the German speaking population and proclamation of a closed border zone, some kind of landscape “naturalization” occurred and resulted in a simplified land use pattern. The maps on their own are graphically clear and there are no problems with interpretation.





0 250 500 1 000 m

Fig. 5. Land use in the study area in 1952 (for legend, see Fig. 2).



0 250 500 1 000 m

Fig. 6. Land use in the study area in 1989 (for legend, see Fig. 2).

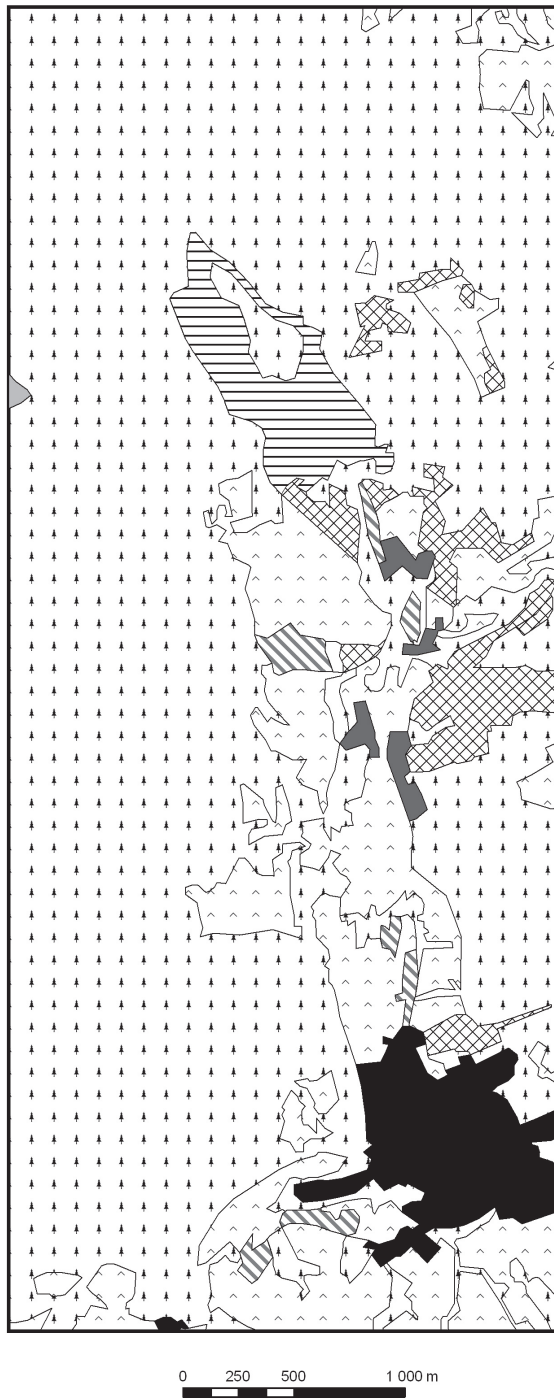


Fig. 7. Land use in the study area in 2005 (for legend, see Fig. 2).

A further increase in the area of forests is noteworthy (62%). This increase was caused mainly by the changes in the area of Špičácké Sedlo saddle around the Rixi, Prokop, and Sirotek hotels, and to a lesser degree in the eastern edge of the study area and above the village of Hamry in the northeast. The arable land completely disappeared. Because of this, the area of pastures and meadows remained stable (33.2%), although many areas were forested. The rural built-up areas increased significantly (1.68%). This increase was caused partly by the better legibility of the map and partly because the areas, interpreted as leisure areas (separate hotels) in the previous map, were included in this category. A pronounced increase was recorded for the urban built-up areas of the town of Železná Ruda (2.86%). On the contrary, other areas did not change (0.38%). An interesting, and so far inexplicable, decrease in the water area of Čertovo Lake reached 0.04%.

The landscape recorded significant changes, especially in the proportion of forest and non-forest areas and in the proportion of arable land and meadows and pastures. The forest extended mainly on to the slopes of Špičák Mt. Arable land ceased to exist. A revision of rural built-up areas is needed as well as an explanation of the decrease in the water area of Čertovo Lake.

The Czechoslovak military maps from 1989 show a different situation again. The basic problem of these maps is represented by a conspicuous increase in arable land by 10.2% (according to the symbol used). This is because this category appears in areas where, according to the local conditions (steep slopes, wetlands) and from information from the locals, it could not appear and also never did. The probable explanation of this inconsistency is the low quality of mapping. However, it is possible that some suitable areas were indeed used as arable land.

The area of forests increased again (66.9%). We excluded the forests on the slopes of the Špičák Mt. from this category and included them together with the complex of ski pistes into the category of leisure areas. Thanks to the increase in arable land and forests, the category of meadows and pastures significantly decreased to less than a half (14.4%). The leisure areas were delimited again and their extent substantially increased (3.77%). Apart from the complex of ski pistes on the slopes of the Špičák Mt., it included the hotels with their surroundings and chalets. A decrease in the rural built-up areas in comparison with the situation from 1952 was caused by unclear distinction between residential and farm buildings and also by the incorporation of hotels into the leisure areas. A very slight increase in the area of the town of Železná Ruda (2.95%) reflected the town stagnation. The area of others nearly doubled (0.69%), which was caused by the construction of agricultural sites and production areas. The area of Čertovo Lake remained stable (0.04%).

An important change in the landscape evolution was represented by the creation of the ski complex in the area of the Špičák Mt. and by the increase in the area of category “others”. The large proportion of arable land should be critically revised.

The basic topographic maps of the Czech Republic from 2005 represent a very accurate and graphically transparent base. This accuracy and transparency paradoxically constitutes a problem because many details, elusive on previous map sets, might influence the final results and thus must be generalized.

The area of forests reached 71% of the total area. In comparison with the previous period, the arable land was again absent. Despite this fact, the proportion of category 2 remained stable (14.5%). This was caused by incorporation of meadows around hotels or chalets and on the ski pistes into the category of leisure areas. At the same time, with the exception of ski pistes on the slopes of the Špičák Mt., these pistes are used as meadows or pastures during the summer period. The increase in the leisure areas is evident (9.39%). Development of tourism resulted in the development of the town of Železná Ruda, whose area increased

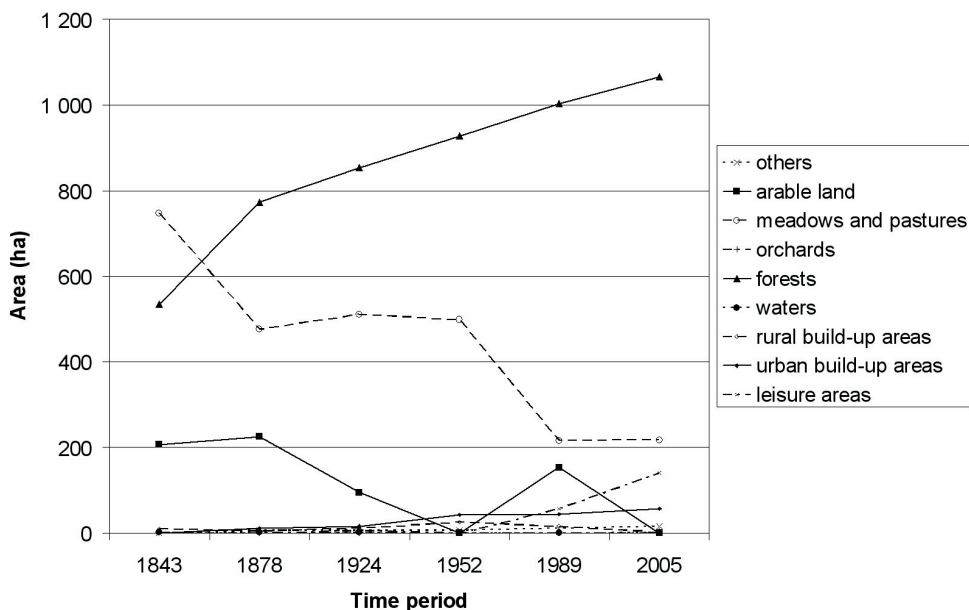


Fig 8. Land use changes in the study area.

by 3.78%. The proportion of other areas also increased (1.03%) but this increase probably resulted from more detailed maps. A significant decrease was recorded for the rural built-up areas (0.15%). The reason is simple – transformation of residential buildings into guesthouses that belong to the category of leisure areas. The area of Čertovo Lake increased (0.065%), which was very likely due to the use of a more detailed map.

Further simplification of landscape structure and texture is characteristic for the period after 1989. Human activities are more spatially concentrated. But anthropogenic pressure on these areas is greater: intensive landscape modification in the surroundings of hotels, guesthouses and chalets, construction of ski pistes, cableways, etc. Thanks to the opening of border controls and tourism, the area of the town of Železná Ruda is increasing, even though some of the impacts are disputable, e.g. the large number of brothels.

Table 1. Area of land use categories in the study area in the individual time periods.

| Land-use base (ha) \ Year | 1843   | 1878   | 1924   | 1952   | 1989    | 2005    |
|---------------------------|--------|--------|--------|--------|---------|---------|
| others                    | 0.00   | 6.36   | 5.55   | 5.70   | 10.39   | 15.35   |
| arable land               | 206.56 | 226.05 | 95.06  | 0.00   | 152.53  | 0.00    |
| meadows and pastures      | 747.98 | 476.32 | 511.55 | 498.08 | 216.14  | 217.80  |
| orchards                  | 0.92   | 0.00   | 0.48   | 0.00   | 0.00    | 0.00    |
| forests                   | 533.86 | 773.08 | 853.24 | 927.52 | 1003.51 | 1066.16 |
| waters                    | 1.28   | 1.70   | 1.17   | 0.60   | 0.65    | 0.98    |
| rural built-up areas      | 9.36   | 5.14   | 10.65  | 25.24  | 15.96   | 2.21    |
| urban built-up areas      | 0.00   | 11.35  | 16.33  | 42.85  | 44.29   | 56.67   |
| leisure areas             | 0.00   | 0.00   | 5.96   | 0.00   | 56.53   | 140.84  |

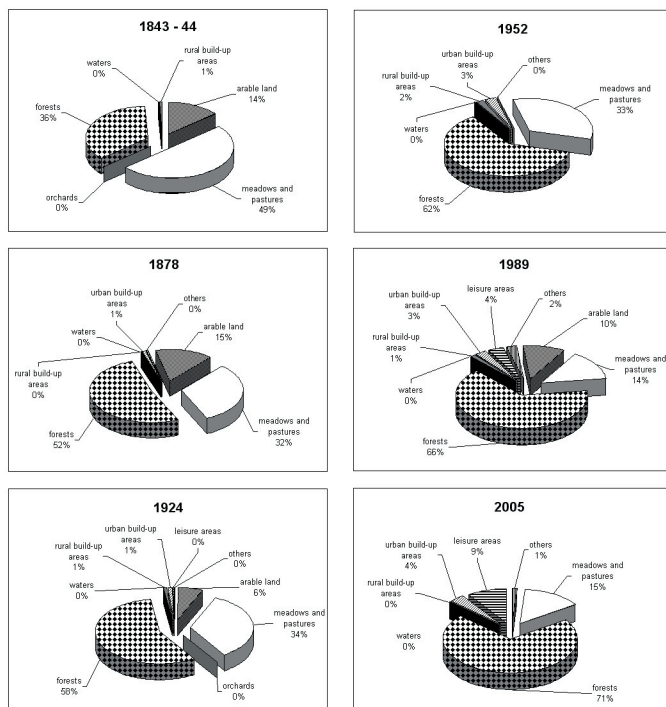


Fig 9. Proportion of land use categories in the study area in the individual time periods.

## CONCLUSIONS

The study area is characterised by a continual increase in the area of forests up to the present 71% of the total area. The only exception in this continuity was the period between 1843 and 1878 when the proportion jumped by 16% (from 36% to 52%). Consequently, the non-forest area decreased due to technological progress, economic pressure, population concentration into larger settlements (enlargement of the town of Železná Ruda), and certain globalization processes. The area of meadows and pastures decreased from 31.75% to 14.5%. This decrease has occurred only during the last 60–65 years. At the same time, arable land was abandoned. The fluctuation in the area of arable land between the individual time periods (10% in 1989) was partially influenced by the political regime and partially by evident mistakes in the applied map basis. The town of Železná Ruda is one of the Czech tourist centres and this is clearly documented by the increase of leisure areas up to 9.39%. This increase is partially at the expense of agricultural land. The increase in the category “others” is connected with the social-economic development, especially construction of production areas.

Generally, the present landscape represents healthy surroundings, however, in comparison with the past, it is less diverse and not so picturesque. The reintroduction of cattle breeding with electric fencing has resulted in the landscape becoming impenetrable and inaccessible. On the other hand, one important feature of the present landscape is an increase of scattered greenery in the forms of windbreaks, baulks and solitaires.



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