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CONTINUITY AND EXTINCTION OF AGRICULTURAL LAND IN THE SUDETES - A CASE STUDY IN THE LANDSCAPE OF HIGHLANDS AND MOUNTAINS.

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ABSTRACT

The Sudetenland has undergone a dramatic development in Czechia. Above all, the frontier regions of the then Czechoslovakia lost due to the decision on the displacement of the Sudeten Germans in 1945 almost 3 million native inhabitants, who left their settlement areas in several waves by 1947. This change affected up to 3 million hectares of agricultural land that became the state property. This had in many places eliminated the traditional way of farming and the disruption of ownership relations consequently led to the breaking of relations in the landscape. This case study focuses on the comparison of the development of the agricultural landscape of 4 selected cadastral areas on the border of Krkonoše and Jizera Mountains from the post-war period to the present. Selected areas of interest are pairs of comparable cadastres from areas affected by the displacement of the local German population and areas with a permanent population structure. This four sites covering a total area of 4052 ha were studied in Cool Landscape of Highlands and the Moderately Cold Landscape of Mountains. Historical and contemporary land-cover information was provided by aerial photographic images from 1953/1954 and aerial orto-photos from 1998 and 2015/2016. The results have shown that on all four of the areas there was a noticeable increase in forests on former agricultural land. However, the monitored areas differ in the continuity of agricultural land. Continuous agricultural land represents, in both areas affected by post-war displacement, approximately 55 % of the original agricultural land. Areas with a well-preserved population structure, on the other hand, show an overall continuity of agricultural land on about 71 % of the former area of agricultural land.

Keywords: Land cover change; Land use change; Analysis of historical ortophoto; Change trajectories; Sudetes; Depopulated areas

INTRODUCTION

The main aim of studying landscape changes is to understand the biophysical and human causes of changes in landscape coverage and dynamics affecting the structure and function of ecosystems. Understanding of the causes and consequences of changes in the landscape has been the objective of studies worldwide (Rindfuss *et al.*, 2004). In this context, landscape changes have become an important research topic in various areas from sustainable development at national level to management of individual ecosystems (Turner & Robbins,

2008). The subject of studies aimed at monitoring changes in the landscape is primarily the determination of causes of change, i.e. finding of immediate causes and driving forces concealed behind changes in the landscape itself and the characteristics of these changes (Geist & Lambin 2002; Skaloš *et al*. 2015). Driving forces and causes according to their nature can be divided into several groups or areas. Bürgi (2004) defines five major driving forces or causes that can be a source of change in the landscape. These are political, economic, cultural, technological and natural driving forces. Demographic changes can be one of the main driving forces of cultural change in the landscape (Hersperger *et al*., 2010). These can be immediate events, long-term trends, or directly particular decisions.

In terms of demographic changes, the Sudetenland has undergone a dramatic development in our territory. Above all, the frontier regions of the then Czechoslovakia lost due to the decision on the displacement of the Sudeten Germans in 1945 almost 3 million native inhabitants (Staněk & von Arburg, 2010), who left their original settlement areas in several waves by 1947. This change affected up to 3 million ha of agricultural land that became the state property (Bičík *et al.*, 2001). In spite of extensive colonizing attempts that took place until the 1950s, this massive interference caused the end of continuity of agricultural activities, especially in higher and less agriculturally convenient areas. This had in many places eliminated the traditional way of farming and the disruption of ownership relations consequently led to the breaking of relations in the landscape (Bičík *et al*., 2001; Weber, 2006). These periods of social and economic turmoil lead to an overall decline in the anthropogenic pressure on the landscape. They are characterized by a temporary and, in some places, permanent turning in the development of the secondary landscape structure characterized by the succession of bushes and forests on agricultural land (Míchal, 1994). This trend often leads to the disappearance of the typical features of the countryside of less-favored agricultural areas, to a decrease in the total area of agricultural land and the growth of forest areas (Lipsky, 1995). This not only changes the structure of the landscape, but there is also a loss of some typical biotopes bound to a specific way of management, such as - in conditions of Czechia - Montane *Trisetum* meadows and buckwheat pastures *(Cynosurus* pastures), which are susceptible to external influences (Chytrý *et al*., 2010).

The abandonment of less fertile areas can be observed throughout Europe. The long-term depopulation and the subsequent change in landscape structure during the 20th century were recorded in Spain (Fernández Ales,1991), in the Polish Carpathians (Kozak, 2003; Bucala, 2014), the Polish Sudetes Mountains (Latocha, 2009) and also in Italy (Falcucci *et al*., 2007). However, the areas affected by the displacement of Sudeten Germans in the territory of the Czech Republic are a unique case for several reasons. Above all, the demographic change itself happened very quickly. Almost 3 million people left the vast areas in less than 2 years, representing about a quarter of the Czechoslovak population at that time, and this change affected almost all types of agricultural areas except for the most fertile ones. However, the spatial context of the displaced areas is also interesting. Due to the clearly demarcated areas dominated by the German population (Staněk & von Arburg, 2010), there are often two cadastral territories in a comparable landscape type (Romportl *et al.*, 2013), which were completely depopulated and, on the other hand, such territories that only were affected marginally by this sudden drop in the population. This represents a unique opportunity to compare the impact of demographic change on the development of the countryside.

This case study focuses on the comparison of the development of the agricultural landscape of selected cadastral areas on the border of Krkonoše and Jizerské hory from the post-war period to the present. In particular it seeks to answer the following questions:

- What are the trajectories of agricultural land developments in highland and mountain areas?
- How do the trajectories of areas affected by displacing people differ from the trajectories of areas which remained inhabited.

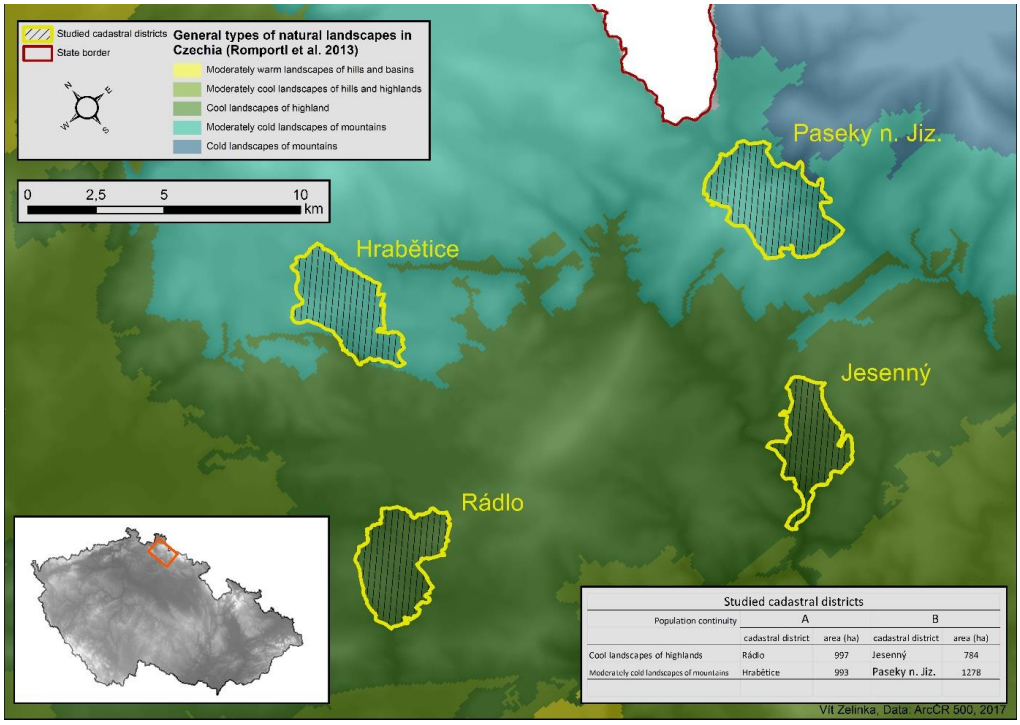
The development trajectory is analyzed using GIS on the basis of black and white orthophotographs from 1953/1954, which represent the state of the landscape shortly after the displacement of the Sudeten Germans and the current orthophotographs from 2015/2016 accompanied by field mapping.

MATERIAL AND METHODS

Definition of areas of interest

For the case study, a total of 4 historical cadastral territories were selected, which fall into higher landscape types as defined by Romportl *et al*., (2013). Selected areas of interest (Fig. **1**) fall under type 4 and 5 (Romportl *et al*., 2013), i.e. the Cool Landscape of Highlands and the Moderately Cold Landscape of Mountains. Selected areas of interest are pairs of comparable territories from areas affected by the displacement of the local German population (A) and areas with a permanent population structure (B). The boundaries of selected areas of interest are formed by the cadastral boundaries according to the Imperial imprints of the Stable Cadastre provided by the Czech Office for Surveying and Cadastre (CÚZK, 2016). These boundaries of cadastral areas correspond to the time the census of 1 December 1930, from which the demographic information about individual areas was drawn *(Statistický lexikon obcí v republice Československ>*, 1934). As territories representing displaced areas, such cadastres were selected, where the population accounted for by German nationality represented more than 80 %. As areas with a traditional population structure areas with more than 80 % of the population of Czech nationality were chosen. For the landscape type of Highlands, it is the Cadastral Territory of Rádlo (displaced) and Jesenný (remained inhabited). For landscape type of Mountains the cadastral area of Hrabětice (displaced) and Paseky nad Jizerou (remained inhabited) were chosen (Fig. 1). All these territories are located in the Liberec region, which was severely hit by post-war displacement. Until now, the Liberec Region has been the second least populous region in the Czech Republic (CSO, 2011) and between 1930 and 1950 its population density dropped almost to a third (Bičík *et al*., 2015).

Fig. 1: Studied cadastral districts localisation with the context of Czechia.
Population continuity refers to the depopulation after World War II: depopulated areas (A), areas with remained inhabited (B). General types of natural landscapes according to Romportl *et al*. (2013).



Data sources

Historical and contemporary land-cover information was provided by aerial photographic images from 1953/1954 and aerial orthophotos from 1998 and 2015/2016. Additional field mapping was also carried out on selected cadastral areas.

1953/1954

The post-war time horizon is represented by the black and white aerial orthorectified images from 1953/1954 (CENIA, 2012), for the purpose of this study. This is an important time point in the development of our country, including Sudetenland. During this period, the removal of the German population from borderland and inland had already been completed (Staněk & von Arburg, 2010). But the images also depict the landscape condition before the collectivization of agriculture, which had a huge impact on the landscape structure (Demková & Lipský, 2015; Demková & Lipský, 2015; Bičík *et al.*, 2015). During this period, the so-called double-tracked or multi-tracked development of the landscape also started, when some more distant and less fertile areas were abandoned, while the intensification of agriculture took place on fertile areas (Lipsky, 1995). In displaced areas, however, the images do not make it possible to distinguish farmland into grasslands and arable land, because many fields have been transformed into a wasteland due to a lack of population. Still, the pictures generally capture the structure of the landscape as it was in the pre-war period and basically represent the landscape after the Industrial Revolution.

1998

Land use in nineties was determined on the basis of aerial orthorectified pictures from 1998 (ČÚZK, 2016). This time horizon represents the period from the fall of communism to the accession of the Czech Republic to the European Union.

2015/2016

The current LULC was determined on the basis of aerial orthorectified pictures from 2015/2016 (ČÚZK, 2016). Additional field mapping on selected locations was conducted in July and August 2016.

Data and analyses processing

Based on the background data from the aforementioned time horizons, vectorization of polygons of selected land cover types was performed in the environment of ArcGIS 10.3 (ESRI, 2014). For the purposes of this study, a specific land cover mapping key was used. On monitored historical cadastral areas total of 10 types of land cover have been distinguished (see

Table **1**) Due to the focus of the study on agricultural area similar to other studies (Forejt *et al.*, 2017; Demková & Lipský, 2015) vectorization was not performed in the entire studied territory, but only in the areas with the agricultural land either in present (2015/2016), 1998 or in the time horizon 1953/1954. Vectorization over raster data was performed in the form of a so-called backward interpretation (Skokanová, 2015), when subsequent overlapping analyzes do not produce sliver polygons. Sliver polygons do not represent a real change in the landscape (Skokanová, 2015) and therefore require further repairs and processing (e.g.: Grossmann & Mladenoff, 2007).

Table 1: Land cover classification categories.

Land cover category	Comments
Agricultural lands	This category aggregates arable land with meadows and pastures.
Non-forest woody vegetation	This is the non-forest woody species vegetation such as hedges, bushes growths, bank growths, alleys, overgrown limits and windbreaks. This type of LC further divides the above-mentioned non-woody (NFWV) vegetation into two subcategories: areal and line according to Demková and Lipský (2015).
Forest areas	Forest areas of a various age and origin.
Orchards, gardens and green in urban areas.	Intensively or extensively cultivated orchards and gardens. Also, coniferous tree nurseries.
Succession mixed cover	The cover-mixed succession of shrubs and herbaceous vegetation according to Raška *et al.* (2016).
Rural roads	Unpaved rural and forest roads.
Roads and railroads	Paved roads, railways and paved parking areas.
Built-up areas	Residential and non-residential built-up areas, farmsteads, technical equipment warehouses and factories.
Other areas	Sports, industrial and agricultural areas, cemeteries, landfills, quarries and dumps.

The spatio-temporal analysis of changes was performed using ArcGIS 10.3 software using the tool *Itersect* (ESRI, 2014). The agricultural areas were then divided into three categories, which represent different developmental trajectories according to their space-time dynamics. Agricultural areas have thus been divided into continuous (present both in 1953/1954, 1998 and 2015/2016) extinct (present in 1953/1954 but transformed into a different category of land cover by 2015/2016) and new (created by 2015/2016 from a different category of the land cover) according to Skaloš *et al*. (2015). For vector data of both time horizons, the area of each polygon and land cover category was calculated using ArcGIS 10.3 software. Information on areas of particular types of land cover and their changes throughout a certain period of time is the basic data for monitoring changes in the landscape (Skaloš *et al*., 2011).

RESULTS

Overall change (1953/1954 and 2015/2016)

The change in the total area of agricultural land in the areas of interest between 1953/1954 and 2015/2016 is relatively intense both in displaced and population-preserved areas. The displaced and non-displaced cadastral territories belonging to the landscape type Highlands and to the landscape type Mountains (Romportl *et al*., 2013) lost in the period of 1953/1954 – 2015/2016 large areas of agricultural land throughout their territories.

The difference in the loss of agricultural land between displaced and non-displaced areas is still noticeable. The displaced territories (Rádlo and Hrabětice together) have so far lost as much as 43.6 % of the agricultural areas existing in the post-war period. On the other hand, the total loss of agricultural land in comparable non-displaced areas (Jesenný a Paseky n. Jiz.) only was 27 %. For each cadastral area, the loss of agricultural land relatively to the cadastral territory is captured in the

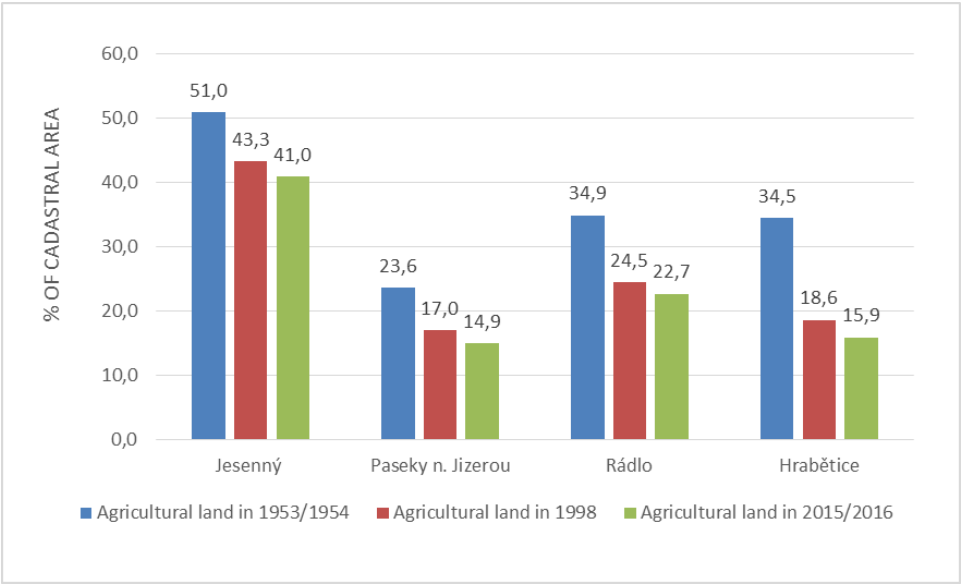
Table **2** and Fig. 2. This compares the total area of agricultural land in the time horizon 1953/1954, 1998 and 2015/2016. Current areas (2015/2016) also include areas of agricultural land that can be indicated as newly created. As we can see below, these newly formed areas represent a negligible part of the current land area.

Table 2: Overall change of Agricultural land for studied cadastral districts between 1953/1954, 1998 and 2015/2016.

	Remained inhabited				Displaced			
	Jesenný		Paseky		Rádlo		Hrabětice	
	Area (ha)	%of cadastral area	Area (ha)	%of cadastral area	Area (ha)	%of cadastral area	Area (ha)	%of cadastral area
Agricultural land in 1953/1954	400,2	51,0	301,7	23,6	337,4	33,9	342,3	34,5
Agricultural land in 1998	339,5	43,3	217,1	17,0	244,0	24,5	184,5	18,6
Agricultural land in 2015/2016	321,2	41,0	191,0	14,9	226,1	22,7	157,5	15,9

The cadastral area of Hrabětice, where the area of agricultural land fell by almost half of its original area (compare 342.3 ha in the post-war period and 157.5 ha in 2015) has a key share in the loss of agricultural land in displaced areas. No other monitored area has experienced such a decline in agricultural land. Agricultural land losses between 1953/1954 and 2015/2016 in all other monitored areas, irrespective of their landscape type and of whether these are displaced or non-displaced areas, ranged from about 9 to 11% of the total area of the cadastre surveyed.

Fig. 2: Overall change of Agricultural land for studied cadastres between 1953/1954, 1998 and 2015/2016. Areas with preserved population: Jesenný and Paseky. Depopulated areas: Rádlo and Hrabětice.



Continuity of agricultural lands

The continuity of agricultural land differs between areas affected by population displacement and areas with a well-preserved population structure. In displaced areas, continuous agricultural land accounts for 55.5 % of the total area of the agricultural land in the post-war period. This value is noticeably higher in non-displaced areas where the continuous agricultural land amounts to 71.2 % of its original size (Fig. 3). The areal distribution of agricultural land with various developmental trajectories in the monitored areas is shown in Fig. 4 and Fig. 5.

Fig. 3: Continuous and extinct agricultural land between 1953/1954 and 2015/2016 in areas with preserved population (Jesenný, Paseky n. Jizerou) and depopulated areas (Rádlo, Hrabětice)

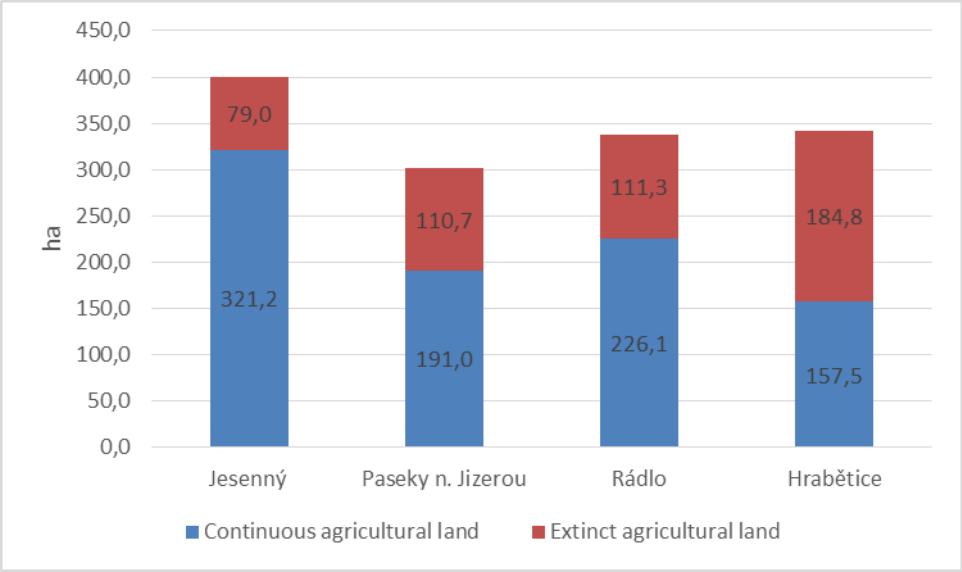


Fig. 4: Continuous, extinct and recent agricultural land between time horizons 1953/1954 and 2015/2016 in depopulated areas (A) and in areas with preserved population (B). Cadastres in the Cool landscapes of highlands.

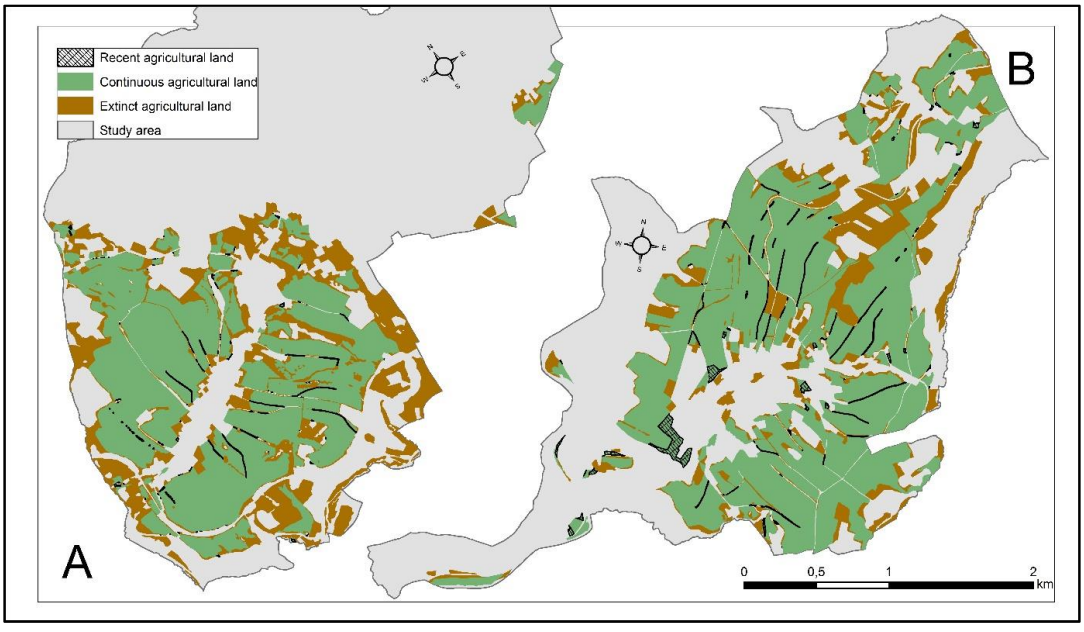
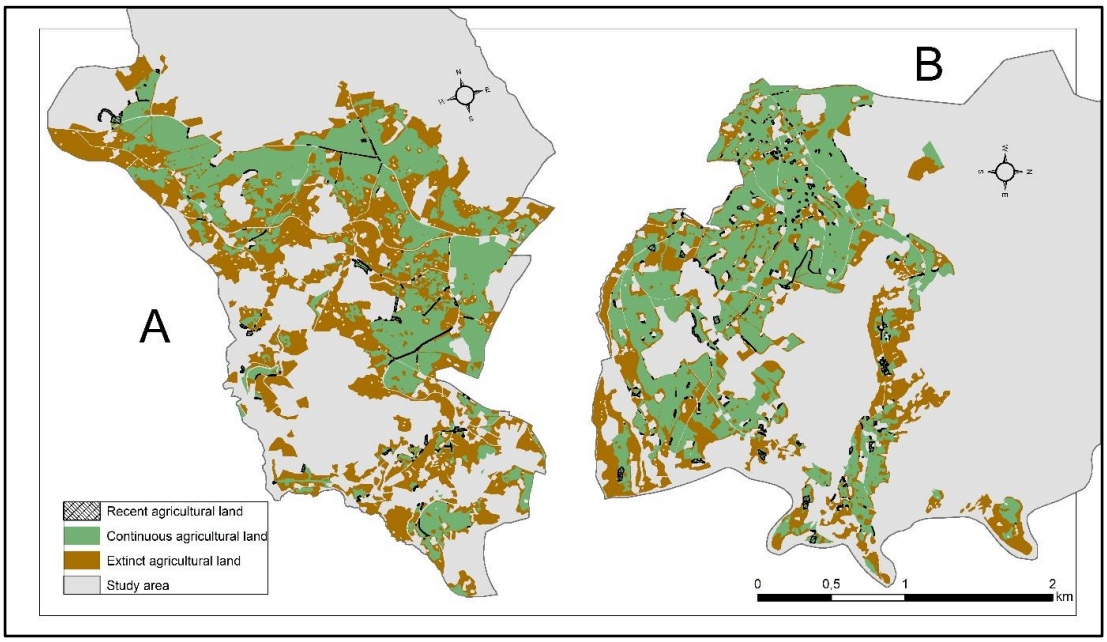


Fig. 5: Continuous, extinct and recent agricultural land between time horizons 1953/1954 and 2015/2016 in depopulated areas (A) and in areas with preserved population (B). Cadastres in the Moderately cold landscapes of mountains.



Extinction of agricultural lands

Trajectories of land development, which represent the extinct agricultural land, bring us closer to the reasons for the decline of agricultural land and indicate the driving force behind these changes. For detailed trajectories of the development of extinct agricultural land between 1953/1954 and 2015/2016 for each cadastre see. For spatial distribution of extinct agricultural lands within the studied areas see Fig. 4 and Fig. 5. The loss of former agricultural land (agricultural land in 1950s) between the time horizons 1953/1954 and 1998 varies from 15.2 % to 46 % (Jesenný 15 %, Rádlo 27,7 %, Paseky n. Jizerou 28 %, Hrabětice 46). The loss of agricultural land between the time horizons 1998 and 2015/2016 was the following: Jesenný 4,7 %, Rádlo 5,2 %, Paseky n. Jizerou 8,7 %, Hrabětice 8 %. The dominant type of transformation of agricultural land between 1953/1954 and 2015/2016 is the conversion into the forest. This type of trajectory covers more than 50 % of the extinct agricultural land in all studied areas. Considering the ratio of areas of the extinct and original agricultural land 1953/1954 it represents bigger share in displaced regions (see and Fig. 6). The increase of the forest area at the expense of agricultural land with respect to the area of agricultural land in the time horizon 1953/1954 is noticeable in the cadastral territories of the higher landscape type– Paseky n. Jiz. 21,5 %, Hrabětice 31,9 % (compared to Jesenný 14,9 %, Rádlo 16,9 %). The comparison indicates a slight increase in forest areas in displaced areas compared to non-displaced areas, more noticeable in higher areas. The second strongest group of trajectories is the trajectory agricultural land - orchards and gardens. This type of trajectory is more common in cadastres falling within Moderate Cold Landscapes of Mountains both in displaced and non-displaced regions (Hrabětice, Paseky n. Jiz.). With regard to abandonment and extinction of agricultural land, the displaced areas indicate a higher ratio of succession areas on the agricultural land to the original area of

agricultural land: Rádlo 4,5 %, Hrabětice 4,1 % (compared to Jesenný 0,6 %, Paseky nad Jizerou 2,5 %). The non-forest woody vegetation spread to former agricultural land in all studied areas. Farmland Trajectory – the non-forest woody vegetation only forms a small part of the former agricultural land and ranges from 1.9 % to 3.4 %. For a given type of trajectory, as with other types of trajectories of extinct agricultural land, there is no traceable difference between displaced and non-displaced areas.

Table 3: Type of change of extinct Agricultural land in studied cadastral districts between 1953/1954 and 2015/2016. Depopulated areas (Rádlo, Hrabětice) and in areas with preserved population (Jesenný, Paseky n. Jiz.). Note: %AL50 means percent of the Agricultural land on the cadastre in 1950s.

	Cool landscapes of highlands						Moderately cold landscapes of mountains					
	Jesenný			Rádlo			Paseky			Hrabětice		
Type of cahnge of Agricutural land	Area (ha)	%	%AL50	Area (ha)	%	%AL50	Area (ha)	%	%AL50	Area (ha)	%	%AL50
Non forest woody vegetetion	7,5	8,7	1,9	8,8	7,8	2,6	10,3	8,9	3,4	9,2	4,9	2,7
Forest	1,6	68,7	14,9	56,9	50,5	16,9	64,8	56,0	21,5	109,0	58,1	31,9
Water surface	0,0	0,0	0,0	0,7	0,6	0,2	0,2	0,1	0,1	0,0	0,0	0,0
Gardens, orchards and urban green	10,8	12,5	2,7	18,8	16,7	5,6	27,4	23,7	9,1	43,7	23,3	12,8
Succession mixed cover	2,3	2,7	0,6	15,2	13,4	4,5	7,4	6,4	2,5	14,0	7,5	4,1
Field roads	0,9	1,0	0,2	0,3	0,3	0,1	0,4	0,3	0,1	0,2	0,1	0,1
Road, railway, infrastructure	1,1	1,3	0,3	4,0	3,6	1,2	2,9	2,5	1,0	7,0	3,7	2,0
Build-up areas	1,6	1,8	0,4	2,0	1,8	0,6	1,9	1,6	0,6	2,5	1,4	0,7
Other	2,8	3,2	0,7	6,1	5,4	1,8	0,4	0,4	0,1	1,9	1,0	0,6
IN TOTAL of Agricultural land	86,5	100	22	112,9	100	33	115,7	100	38	187,6	100	54,8

Fig. 6: Paseky n. Jizerou in 2017 and in 1950s (photo: V.Zelinka (1), author's archive (2))

Sources of recent agricultural land

The recent agricultural areas are part of today's agricultural land, but they were included in other categories of landscape coverage in the time horizon 1953/1954. Due to the current area of agricultural land, it only forms an slight part of it in individual cadastral territories: Jesenný 7,5 ha (2,3 %), Rádlo 1,5 ha (0,7 %), Paseky n. Jiz. 5 ha (2,6 %) a Hrabětice 2,8 ha (1,8 %). In the vast majority of cases, the area of recent agricultural land formerly consisted of field roads, non-forest woody vegetation and also orchards that have ceased to exist through the transformation into large-scale socialist agriculture.

CONCLUSION

The disappearance of agricultural land in less fertile areas and the increase in forest area is a general trend across Europe. There are a number of studies that show the trend of abandoning agricultural land at higher altitudes (e.g.: Latocha, (2012); Bucala, (2014); Falcucci *et al*., (2007), Fernández Ales, (1991)). The results of this comparative study in this case are therefore consistent with the conclusions of other authors. On all four of the areas surveyed, there was a noticeable increase in forests on former agricultural land. However, the monitored areas differ in the continuity of agricultural land. Continuous agricultural land represents, in both areas affected by post-war displacement, approximately 55 % of the original agricultural land in the post-war period. Areas with a well-preserved population structure, on the other hand, show an overall continuity of agricultural land on about 71 % of the former area. It should be noted that a large part of the extinct agricultural land in the displaced areas is located on the higher of the two cadastral territories (Hrabětice), where the total difference of agricultural areas between the periods 1953/1954 - 2015/2016 is as much as 50 %. The predominant type of conversion of agricultural land between 1953/1954 and 2015/2016 is the transformation in the forest. This type of trajectory covers more than 50 % of the extinct agricultural land in all studied areas. Compared to the area of the original agricultural land in 1953/1954, the conversion into the forests represents a greater share in displaced areas. The increase in the forest area relative to the area of agricultural land in the time horizon 1953/1954 is more noticeable in cadastral territories of the higher landscape

type – Paseky n. Jiz. 21,5 %, Hrabětice 31,9 % of former farmland (compared to Jesenný 14,9 %, Rádlo 16,9 %). The comparison of forest increase when looking at map data is interesting. Here a difference in the way forest areas expand to farmland is obvious. While in non-displaced areas there is a visible controlled planting of the forest, displaced areas tend to be affected by the spontaneous growth in the form of spreading forest edges and raiding on farmland. However, further studies based, for example, on forest management plans would be needed to further clarify these differences. The displaced areas show a higher ratio of succession areas on the agricultural land to the original area of agricultural land: Rádlo 4,5 %, Hrabětice 4,1 % (compared to Jesenný 0,6 %, Paseky nad Jizerou 2,5 %). These succession areas, however, represent abandoned land in relatively recent times, and cannot be related to post-war displacement. They represent rather the impacts of the transformation process in agriculture after 1989. In all areas there is the comparable amount of newly built-up area on former agricultural land, the transformation into transport infrastructure and other types of trajectories of extinct agricultural land. Newly developed agricultural areas are also comparable in all studied areas and represent only a negligible part of the current agricultural land. These areas consist of former field roads, remnants, and extensive orchards extinct under the influence of socialist farming in the countryside. Generally speaking, based on the comparative study thus designed, it is difficult to trace significant and appreciable differences in the development of the landscape coverage of displaced and non-displaced areas, in spite of the fact that some trends and development trajectories suggest divergent developments to a certain extent.

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