CHANGES IN THE EXTENT OF NON-FOREST WOODY VEGETATION IN THE NOVODVORSKO AND ŽEHUŠICKO REGION (CENTRAL BOHEMIA, CZECH REPUBLIC)

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ABSTRACT

Changes in the extent and occurrence of non-forest woody vegetation in the agricultural landscape of the Novodvorsko and Žehušicko region in the Central Bohemia during the last 60 years are presented in the paper. The study is based on a comparison of data (landscape structure indicators) from two time horizons – 1950 and the present (2011). Historical black and white aerial photographs from 1950 and color orthophotomaps from 2006 were used as data sources. Furthermore, the present state of the vegetation was investigated and specified by field mapping in 2011. The extent and changes of non forest woody vegetation were observed in natural (biochores) and cultural (landscape character areas) units with the aim to find out differences dependent on natural and cultural conditions. Results confirm that the quantity as well as the distribution of elements of non-forest woody vegetation changed during the last 60 years in an important way. Significant decrease in the area of non-forest woody vegetation and extinction of many important biotopes are among the main results of the work. The study provides strong evidence that changes in land use and landscape structure have a great influence on non-forest woody vegetation in all aspects. At the end of the paper, the reasons for the changes are discussed. In general, intensification and mechanization of agriculture has caused extinction of fine-grained landscape microstructure especially as to arable lands connected with removal of dispersed vegetation structures. Straightening of watercourses and destruction of meanders with their riparian vegetation has had the same effect.

Key words: non-forest woody vegetation, landscape changes, landscape structure indicators, landscape units

1. Introduction and literature review

Non-forest woody vegetation (NFWV) is an important part of landscape structure and a determining feature of landscape character. However, it has not received as much attention in recent years as topics such as land use or land cover changes, and also landscape character assessment. Hedges or hedgerows, linear features, are paid traditionally more attention especially in western European countries, for example Burel, Baudry 1995; Barr, Gillespie 2000; McCollin 2000; Jongman 2002.

Non-forest woody vegetation, or *scattered greenery*, in other words, is stable woody vegetation including the herbal floor, which is neither a forest, agricultural crop, nor, a part of vegetation of built-up areas in municipalities or in landscape (Bulíř 1981; Mareček 2005). Natural elements growing spontaneously as well as vegetation planted by human are included (Bulíř, Škorpík 1987; Machovec 1994).

Non-forest woody vegetation is divided according to shape into three categories (Sláviková 1984; Supuka et al. 1999; Trnka 2001):

- *Patches* – maximum area of 0.3 ha (small woods, groves, vegetation on wet sites, on abandoned lands or localities unsuitable for any economic use);
- *Linear elements* – minimal length of 30 m, width maximum 30% of length (alleys, riparian vegetation, linear vegetation along railways, on balks etc.);
- *Point elements* – one, up to three individuals of tree or shrub (solitairy, group of trees, shrubs).

Non-forest woody vegetation is a typical feature of many European agricultural landscapes (Meeus 1995; Burel, Baudry 1995). From a historical point of view, it was formed in following ways (Sklenička 2003):

- Retreat of forest – non-forest woody vegetation is a remnant of the original forest stands;
- Natural raid – (spontaneous) spreading of woody vegetation outside forest stands;
- Planting – intentional spreading by humans.

NFWV plays a crucial role in agricultural landscape. It provides many important functions such as soil-protective, stabilizing, hygienic, aesthetic, productive etc. Many studies focused on the importance and function of non-forest woody vegetation, for example Pollard et al. 1974; Forman, Godron 1986; Sláviková 1987; Supuka et al. 1999; Baudry et al. 2000; Trnka 2001; Sklenička 2003; Špulerová 2006 etc. In general, it has a positive influence on visual aspects of landscape structure and landscape character, because it makes landscapes more divergent and as a consequence the pattern (mosaic) is more varied as well. Furthermore, NFWV causes also increase of biodiversity due to providing food and refuge for many animal species in agricultural landscapes. So the impact of NFWV on landscape is generally very positive from biological and landscape-ecological point of view.

Forests, tree-lines (alleys), groves, riparian vegetation, windbreaks etc. are considered as important landscape features that complete the landscape image (Benčať, Jančura 2008) or landscape character (Flekalová 2010).

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Vorel (2007) concludes that NFWV belongs to the most significant landscape components because it supports diversity as well as creates aesthetically delightful points, areas and landscape sceneries (Demková 2011).

From recent studies, Molnárová (2008) evaluates structural attributes of hedgerows such as density, relative area, connectivity and other characteristics in three cadastres in the Plzeň Region, Southwestern Bohemia. The most recent work (Flekalová 2010) proposed how to include non-forest woody vegetation into the process of landscape character assessment.

Landscape features formed by humans in the past and still exist in the landscape are called *historical landscape structures (HLS)*. They are defined as a physical (material) part of immovable cultural heritage (Huba et al. 1988). Such relicts, remnants with long-term stability, identify not only the spatial structure but also the temporal structure of the landscape (Supuka et al. 1999). They represent a significant part of landscape memory.

Official reports on the state of the environment and a negative influence of socialist agriculture on the landscape specify early after 1990 drastic figures giving the evidence about the clearing and liquidation of non-forest woody vegetation from agricultural landscape: "4,000 km of lines of wood vegetation, 3,600 ha of scattered greenery, 49,000 km of balks and 158,000 km of field roads were removed from the Czech rural landscape" (Moldan et al. 1990). In the mid-eighties the total area of non-forest woody vegetation in the Czech Republic was only about 0.3–0.5% of the country's territory (Trnka 2001).

The rapid decrease in the area of non-forest woody vegetation in open agricultural landscape concerns not only former socialist countries. Increased intensification of agriculture including mechanization, the use of agrochemicals etc. after World War II was recorded in Eastern as well as Western Europe (Pollard et al. 1974; Barr et al. 1986). McCollin (2000) points out the loss of 158,000 km of hedges in England between 1984 and 1994, i.e. one-third of the total length existed in 1984. Jongman (2002) remarks that the total length of linear vegetation decreased by 80% in the Netherlands in 80 years (1900–1980).

The main aim of the paper is to compare the distribution and areal extent of non-forest woody vegetation in 1950 and in the present. According to the literature review and previous works (Demková, Lipský 2012; Lipský 1995 and others) we suppose that its areal extent has decreased and spatial distribution has changed (some elements disappeared and new ones originated). The partial aim is to find out how much has proportion of NFWV changed in the relation to natural conditions as well as evaluate if the amount or areal extent of NFWV depends on some kind of territorial nature and landscape protection. Since NFWV is a determining feature of landscape character (Vorel 2007; Benčať, Jančura 2008) we suppose also that landscape character units will differ from each other in proportion of NFWV. Finally we assume that few elements of NFWV preserved until today, could be considered as historical landscape structures.

2. Methods and study area

Non-forest woody vegetation was identified by the method of manual interpretation on orthophoto-air photographs from 2006 (CENIA) and on historical black and white aerial photos from 1950 (VÚKOZ Průhonice) on the basis of an application of visual criteria and size parameters (defined below). All elements of NFWV identified on the orthophotomaps from 2006 were mapped and investigated in the field during vegetation periods 2010 and 2011 according to proposed mapping methodology in order to obtain information about the current state and species composition of vegetation (Demková, Lipský 2012).

Non-forest woody vegetation was divided by shape into three categories (Sláviková 1984; Trnka 2001; Supuka et al. 1999):

- Point elements – one, up to three individuals of tree or shrub;
- Patches – minimal area of 50 m^2, maximum area of 0.3 ha;
- Linear elements – minimal length of 30 m, width maximum 30% of length.

The area of NFWV was set down as a projection of the tree or the shrub crown. In the case of the linear elements their lengths were counted. The area of linear vegetation was calculated from width estimated from orthophotomaps. In addition to size parameters (area, length), basic indicators of landscape structure such as quantity (number), average size and density (porosity) of spatial elements as well as share of single categories of NFWV were counted. Density (porosity) was calculated as the area of point and patch elements (m^2) and length (m) of linear vegetation per 1 square kilometer of the study area.

Within the digitalization a special classification of development of non-forest woody vegetation was created to obtain information about its existence during the last 60 years. The following classes were distinguished, inspired by Elznicová, Machová (2010):

a. elements existing both in 1950 and 2011 as NFWV;
b. new elements of NFWV (existing only in 2011);
c. extinct elements of NFWV(existing only in 1950);
d. elements existing in 1950 as NFWV, changed into forest or other continuous vegetation by 2011;
e. elements existing as a part of other continuous vegetation in 1950, changed into NFWV by 2011.

In the second section of the paper, changes in the share of non-forest vegetation in selected natural and cultural units such as biochores, Landscape Memorial Zone Žehušicko and landscape character areas are analyzed. Biochores (Culek et al. 2005) are typological biogeographical units representing similar geomorphological, geological

and vegetation conditions of the territory, whereas landscape character areas are individual territorial units delimited on the basis of geographical maps and subjective visual characteristics (see Lipský et al. 2013). The Landscape Memorial Zone Žehušicko was declared in 1996 with the aim to preserve a specific type of cultural landscape with signs of historical landscape design.

From 12 biochores presented in the study area, only 5 representative biochores with a share of more than 5% were chosen to analyze differences in the occurrence of NFWV depending on natural conditions:

2Nh – loam alluvia of the 2nd altitudinal vegetation zone (36%);
2RV – plains on blown sands of the 2nd altitudinal vegetation zone (13.7%);
2Do – waterlogged depression on neutral volcanic rocks of the 2nd altitudinal vegetation zone (8.3%);
2RN – plains on gravels of the 2nd altitudinal vegetation zone (7.4%);
2RE – plains on loess of the 2nd altitudinal vegetation zone (6.7%).

The source data were processed in the GIS environment and consequently adjusted using contingency table. Following statistical analyses were performed in software Statistica. Before performing statistical evaluations, all sets of data were checked for their normal distribution by the Shapiro-Wilk test (Shapiro, Wilk 1965) and by visual analysis of histograms. Since almost all of the datasets do not meet the criterion of normality, differences in the area and density (porosity) of elements of NFWV in individual landscape units between the defined time horizons were analyzed using Kruskal-Wallis one-way analysis of variance (Kruskal, Wallis 1952) (K-W test) at a confidence level p = 0.05.

2.1 Study area

The area under investigation is situated in the north-eastern part of the district Kutná Hora in the eastern part of the Central Bohemia. It is comprised of 12 cadastral units with a total area of 60.5 km^2 (Figure 1). From a geomorphological point of view, the territory is a part of the Čáslavská kotlina basin with an altitude of 200–239 m a. s. l. Železné hory Mts interferes into the north-eastern edge of the study area with a maximal elevation of 320 m a. s. l. The flat relief of the basin is formed by wide alluvial plains of the lower streams of the rivers Doubrava, Klejnárka and Labe in the north of the territory. Despite the simple geological and geomorphological structure, a mosaic of soil types has developed in the lowland depending on substrate. Fluvisols and Cambisols predominate, but also Chernozems and Rendzinas are represented in the area. The area is comprised of 10 biochores of the second vegetation degree and 2 biochores of the third vegetation degree in the spur of the Železné hory Mts (Culek et al. 2005).

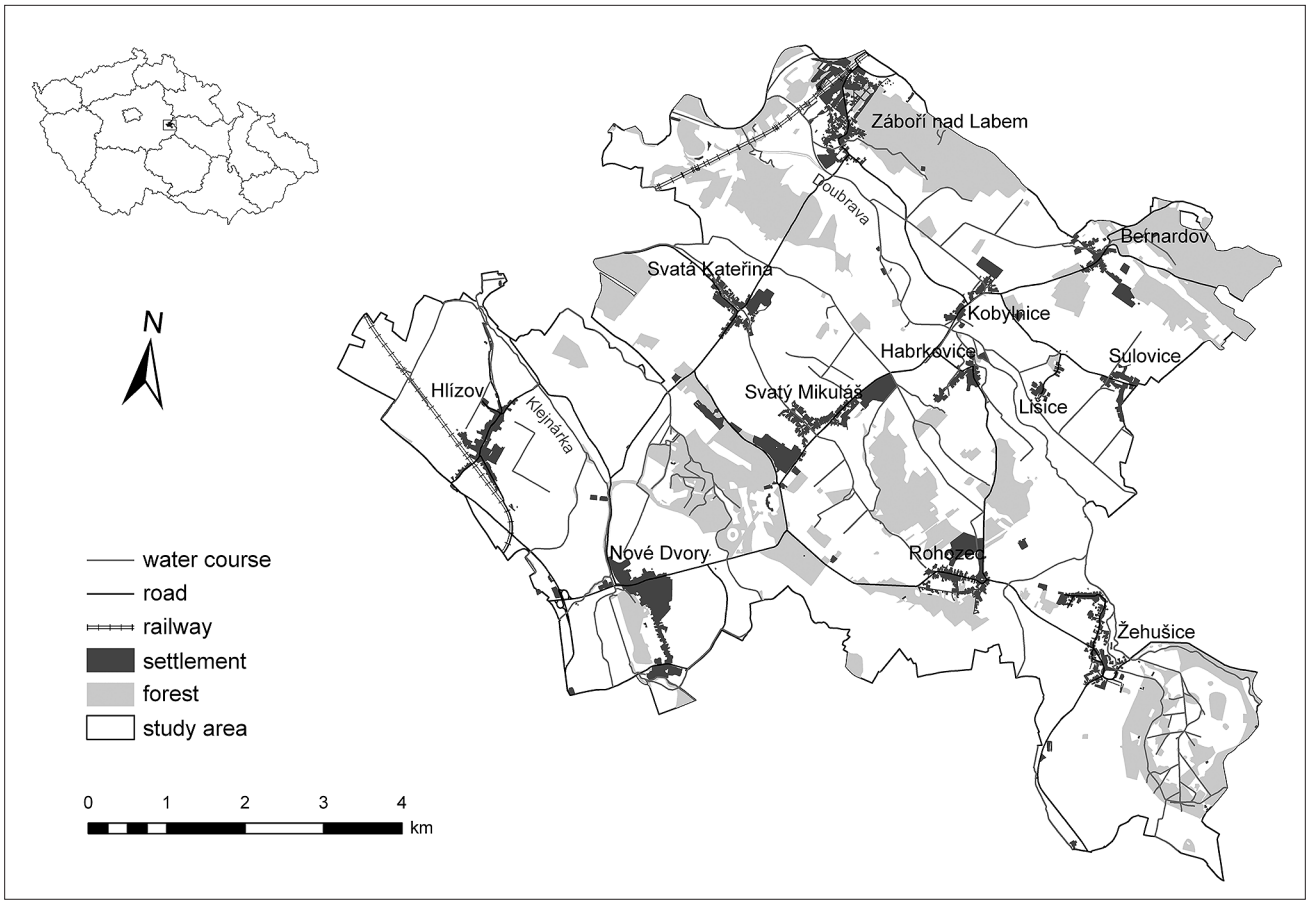

Fig. 1 Map of the study area

At present, an intensively used agricultural landscape with a dominant share of arable land prevails in the study area. However, in comparison with the rest of the Čáslavská kotlina basin, most of the study area has a specific landscape character with a more varied landscape structure due to a higher proportion of forest as well as aesthetically motivated landscape formations around the Kačina and Žehušice castles in the 18th and 19th centuries (Lipský et al. 2011). Consequently, the Landscape Memorial Zone Žehušicko was declared in 1996 in the southern and central part of the study area. Recently, the park and game preserve around the Kačina castle with a total area of 196 ha became a NATURA 2000 site as well.

3. Results

The distribution of non-forest woody vegetation changed in the last 60 years. As it was supposed, the number of elements of NFWV as well as their areal extent decreased in all categories. The total area of point elements and patches decreased together by more than 40 thousands of square meters and the total length of linear elements decreased by 32 km (Table 1). Although the length decreased by 20% in comparison to present, the area sank only by 4%. This is caused by enlarging of their width due to changes in practice of agricultural management on surroundings agricultural plots and no maintenance of the greenery. According to K-W test only changes in the area of linear and patch elements are statistically significant.

Due to the changes a lot of point elements disappeared, especially those which were situated on the plot boundaries. The original trees, probably fruit trees, were replaced by shrubs of elder near extra high voltage towers. Point elements of NFWV in the alluvial plain of the Klejnárka river in cadastral territory Hlízov and the Brslenka stream in the cadastral territory Žehušice disappeared completely.

Almost 60% of patches of NFWV existing in 1950 disappeared from the landscape (Figure 2). Approximately one-third of patches became a part of forest or other continuous vegetation, the rest (23%) disappeared completely because it was changed into arable land. More than 40% of all patches were preserved till present. Most of them are situated on localities not suitable for agriculture (waterlogged or elevated habitats). New patches appeared also due to land abandonment, mostly covered by ruderal vegetation.

In 1950 the relics of riparian vegetation of former meanders of water streams Doubrava and Stará Doubrava were observed in the landscape. These very significant biotopes were also destroyed due to the intensification and mechanization of agricultural production. Modification (straightening) of riverbeds caused extinction of line vegetation as well (especially the Labe river). Other linear elements existing in 1950 indicated the course of plot boundaries or boundaries of cadastral territories. There were also more field roads or roads accompanied by continuous vegetation in comparison with the present landscape.

New linear elements are observed along new roads, artificial water canals (very sporadically) or around the flooded sandstone pit near Žehušice. Modified water courses such as the Doubrava river are nowadays accompanied by new riparian vegetation.

Decrease in the number of point elements and patches of NFWV were observed (Table 2). But the average size of both categories increased, in case of point elements not as much as in case of patches. The majority of patches were smaller in 1950 (72% with the area up to 500 m^2) whereas in 2011 the ratio of the smallest patches sank to 50%. Only a half of large patches, with the area more than 1,500 m^2, existing in 1950 were preserved until the present. The others were removed. Density (porosity) decreased in all categories of NFWV as well.

Figure 3 demonstrates changes in proportion of NFWV in 5 representative biochores in 1950 and 2011. The highest proportion of linear elements in biochores 2Nh (alluvia) and 2RE (plains on loess) and the highest proportion of point elements in the biochore 2Nh were recorded in both observed time periods. This is caused by riparian vegetation along water streams and remnants

Tab. 1 Comparison of size parameters and percentage of non-forest woody vegetation in 1950 and in 2011

Category of NFWV	Area (m^2)		Share of the total area (%)		Change (m^2)	Change (%) (1950 = 100%)	Statistical significance of change (p)
	1950	2011	1950	2011	1950/2011	1950/2011	1950/2011
Point elements	20,953.5	17,285.0	0.035	0.030	−3,668.5	−17.5	0.7418
Patches	99,917.2	93,482.5	0.165	0.155	−6,434.7	−6.5	0.0001
Linear elements	799,992.0	768,294.0	1.32	1.27	−31,698.0	−4.0	0.0001

Tab. 2 Changes in landscape structural indicators of non-forest woody vegetation between 1950 and 2011

	Number of elements		Average size (m^2)		Density (area in m^2 and length in km) per 1 km^2 of the study area	
	1950	2011	1950	2011	1950	2011
Point elements	483	357	43.4	48.4	346.6	285.9
Patches	197	127	507.2	736.0	1651.5	1545.2
Linear elements	–	–	–	–	2.65	2.12

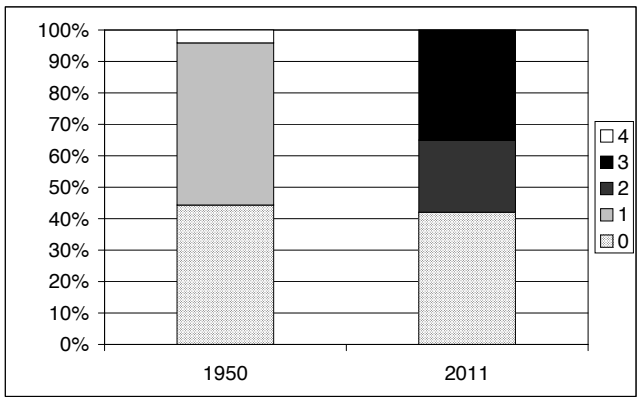

Fig. 2 Classification of development of patch elements in 1950 and 2011 in percentage
Explanatory notes to the figure: 0 – elements existing both in 1950 and in 2011; 1 – new element (existing only in 2011); 2 – vanished elements (existing only in 1950); 3 – elements existing in 1950, changed into forest or other continuous vegetation till 2011; 4 – existing in 1950 as other continuous vegetation, changed into NFWV till 2011.

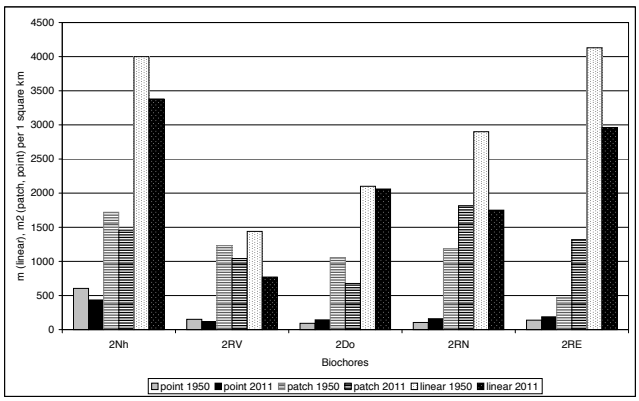

Fig. 3 Changes in density of non-forest woody vegetation in biochores
Explanatory notes to the figure: linear elements are expressed in m per 1 km^2, point and patch elements in m^2 per 1 km^2; 2Nh – loam alluvia of the 2nd altitudinal vegetation zone; 2RV – plains on blown sands of the 2nd altitudinal vegetation zone; 2Do – waterlogged depression on neutral volcanic rocks of the 2nd altitudinal vegetation zone; 2RN – plains on gravels of the 2nd altitudinal vegetation zone; 2RE – plains on loess of the 2nd altitudinal vegetation zone.

of solitary trees on meadows. In 1950, the highest share of patches was in the alluvial biochore 2Nh as well, but it decreased by 18% by 2011. On the contrary, a considerable increase of patches was observed in biochores 2RN (plains on gravels) and 2RE (plains on loess) due to enlargement of abandoned agricultural lands. By contrast, the density of linear elements decreased substantially in all biochores, which is a result of the intensification of agricultural production.

The K-W test confirmed significant differences in the proportion of NFWV between two observed time horizons in the biochore 2Nh (alluvia) and 2RV (plains on blown sands) in all three categories, in the biochore 2Do (waterlogged depression) only as to the linear vegetation. Other changes are not statistically significant.

The comparison of the share of elements of NFWV in the Landscape Memorial Zone (LMZ) Žehušicko, which comprises 35.5% of the study area, and in the rest of the study area is demonstrated in the Table 3.

As it was expected, there is a difference in the proportion of elements of NFWV between the LMZ and the rest of the territory in all categories. Substantially higher share of point elements and patches is observed in LMZ (it is approx. doubled) and they have larger average size there as well. On the other hand, linear vegetation elements have a surprisingly lower proportion in LMZ in both time periods. It is caused by higher density of water courses and roads (which are mostly accompanied by woody vegetation) outside the LMZ.

Lastly, changes in the share of elements of NFWV in 11 landscape character areas delimited in the study area (after Lipský et al. 2013) were observed (Figure 4).

Landscape character area A1 was delimited as predominantly forested landscape so it is logical that all patches and point elements existing in 1950 disappeared and were replaced by forest. Landscape character area B1 represents the alluvial floodplain of the Labe river with rather high density of all categories of NFWV. Although the decrease in the distribution of elements of NFWV in the landscape character area D2 Kačina, which represents forested landscape (a former game park) around the Kačina castle, was markedly, the K-W test does not confirm it as statistically significant (Table 4). On the other hand, there has been observed an increase in density of patches as well as of point elements in landscape character areas E1 and E2. Current patches of NFWV are related to terrain roughness, especially elevations, or to abandoned lands. Changes in both landscape character areas are significant as well.

Table 4 demonstrates significant decrease in density of linear elements in landscape character areas C2, D2 and E2, which represent the core area of the LMZ Žehušicko. In 1950 there were observed much more linear woody structures along roads, field paths and on the plot boundaries. Some other linear elements disappeared because of merging with forest as it was observed in the former game park around the Kačina castle and in the game-preserve Žehušice. In contrast, a considerable increase in the share

Tab. 3 Share of non-forest woody vegetation in Landscape Memorial Zone Žehušicko and in the rest of the study area in 1950 and 2011

	Point elements (in % of the study territory)		Patches (in % of the study territory)		Linear elements (in km per 1 km^2 of the study territory)	
	1950	2011	1950	2011	1950	2011
LMZ Žehušicko	0.07	0.04	0.24	0.24	2.47	1.65
The rest of the territory	0.02	0.02	0.13	0.11	2.74	2.38

Tab. 4 Statistical significance of the Kruskal-Wallis test for non-forest woody vegetation and landscape character areas

Landscape character areas	Point elements	Patch elements	Linear elements
A1 Zábořské bory	**0.0053**	0.1172	**0.0143**
A2 Bernardov	0.1228	0.0617	0.9486
B1 Záboří – Starý Kolín	0.4978	**0.0163**	**0.0002**
C1 Dolní Doubrava	0.1549	**0.0257**	**0.0001**
C2 Žehušice	0.2291	0.0544	**0.005**
C3 Svatý Mikuláš a Kateřina	0.8753	0.0563	**0.0001**
D1 Severní část ke Starému Kolínu	0.2482	x	0.7589
D2 Kačina	0.6687	0.8389	0.0834
D3 Kamajka	**0.0393**	0.1266	**0.0251**
E1 Hlízov	**0.0105**	0.1495	**0.0001**
E2 Nové Dvory	0.0352	0.0126	0.0016

Marked (bold) relations are significant at the confidence level p = 0.05, x – no data.

of NFWV is registered in landscape character areas A1 and D3. Both landscape units are predominantly covered by forest or arable land and the share of linear elements was the lowest in 1950. Nowadays there is a road or field road accompanied by these vegetation structures. Except of landscape character areas A2 and D1, all changes of linear NFWV are statistically significant.

Some vegetation landscape structures linked up with historical artefacts in the landscape like old dams of former fish ponds, old roads, wayside cross, memorials and other landmarks were preserved until the present in the study area. They form an integral part of these historical landscape structures. But most vegetation historical landscape structures were destroyed during the observed period and land use as well as the total landscape structure of the study area has become homogenized (Lipský et al. 2011).

4. Discussion

Identification of non-forest woody vegetation was carried out on the basis of visual interpretation of aerial photographs. Air photos from 1950 are black and white with worse resolution, which makes interpretation more difficult. In case of color orthophotomaps, the interpretation of vegetation structures is more accurate.

Decrease of the extent of non-forest woody vegetation during the last 60 years in all categories was observed in the study area. In case of linear and patch elements it was confirmed as statistically significant. Many elements of NFWV were destroyed during the period of socialist agriculture as it is outlined in literature of many authors (see Lipský 1995). The decrease is caused by land use changes connected with the intensification of agriculture in the second half of the 20th century. The method of cultivation, structure of field crops, harvesting methods, methods of livestock farming as well as other agricultural processes have been radically altered during the last 50 years with concomitant effects on landscape structure. Socialist collectivization of agriculture has caused the extinction

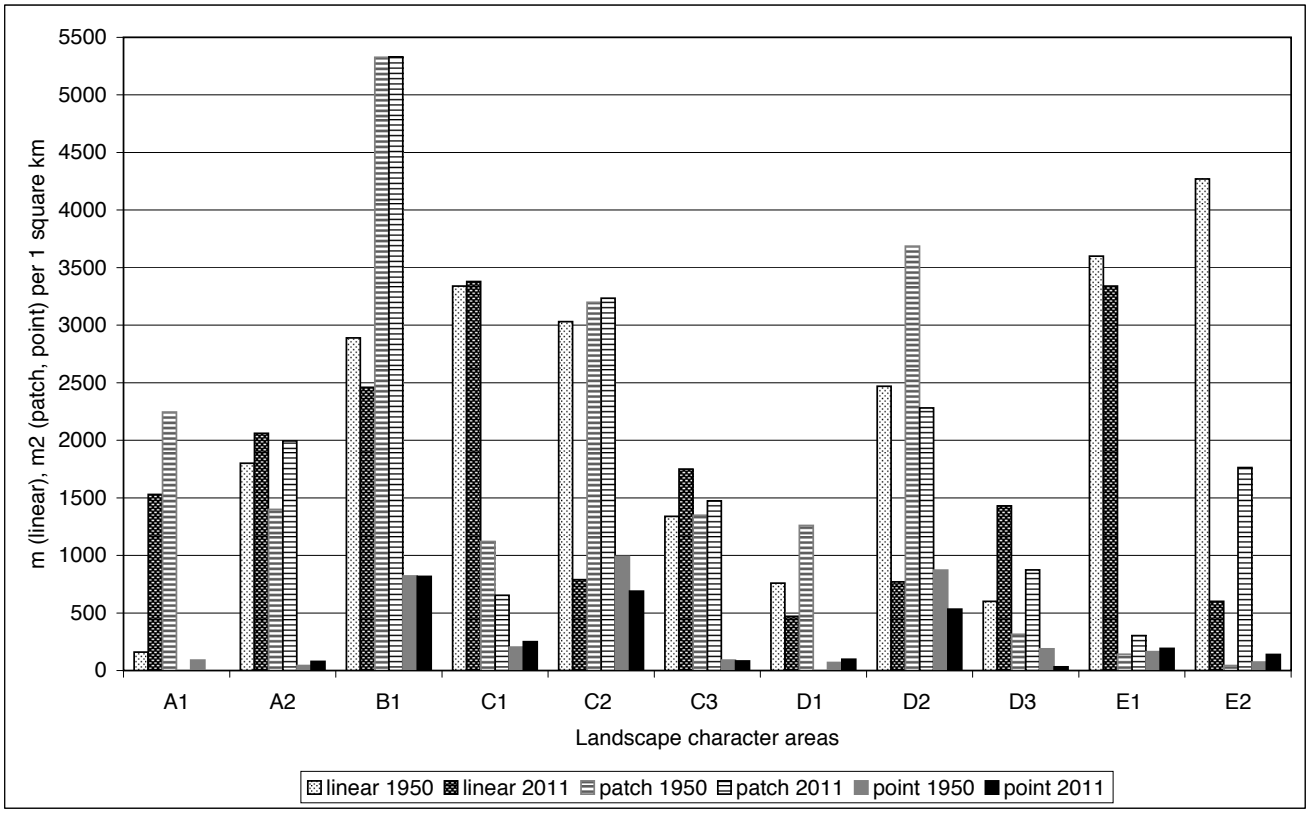

Fig. 4 Density of elements of non-forest woody vegetation in landscape character areas in 1950 and 2011
Explanatory notes to the figure: linear elements are expressed in m per 1 km^2, point and patch elements in m^2 per 1 km^2; related names of landscape character areas are in table 4.

of microstructure of arable land by the merging of small fields with big blocks of arable land, which is closely linked with the removal of everything including vegetation (trees or other biotopes). Parcels of arable land were unified so they would not to be interrupted by meadows, shrubs or other elements hampering efficient cultivation. During the transition to socialist large-scale production, landscape structure changed rapidly towards its significant simplification. The size of agricultural holdings was increased 50 times, plenty of meadows in floodplains were ploughed and most of the permanent vegetation structures in the open agricultural landscape were removed. The traditional character of the Czech rural landscape with its small-scale mosaic of patches has changed into large-scale landscape of collective openfields (Lipský 1995; Meeus 1995).

Density of linear elements decreased by 20%, which is similar to the results of Molnárová (2008). But the total area of NFWV sank only by 4.5%, while patch elements recorded the highest decrease (17.5%). These changes were caused not only by intensification of agriculture but also by afforestation. The forest area increased from approx. 9.9 km^2 to 11.5 km^2 (by 16%) in the last 60 years, mostly due to afforestation of adjacent fields. Some elements of NFWV joined the forest. From ecological point of view it should be consider as positive, but in the context of NFWV it could be perceived as a loss of small biotopes in agricultural landscape as well as change (loss) of visual (aesthetic) landscape qualities.

Research in western European countries recorded length reduction of hedgerows by 23% between 1984 and 1990 in Great Britain (Barr, Gillespie 2000), while in Brittany (France) it was 35% between 1952 and 1985 (Burel, Baudry 1990). It seems to be more dramatic in comparison with our results, but differences may be caused by different methodology: our study does not concern only hedgerows.

Relation of NFWV to natural conditions presented by biochores was recognized. The highest share of all categories of NFWV is in alluvial plains along water courses with linear vegetation structures. But at the same time, significant decrease of NFWV in all categories was confirmed in alluvia and plains of blown sands. Destruction of vegetation due to intensification of agriculture or afforestation was mostly presented in these two biochores.

High proportion of NFWV in alluvia is also caused by the presence of the game park Žehušice, which is nature protected area. This fact confirms the starting hypothesis that NFWV is more supported and better preserved in areas under some kind of nature or landscape protection, as it was documented on the example of the Landscape Memorial Zone Žehušicko as well.

Although statistical evaluation of changes of NFWV does not show significant changes in all cases, it does not mean that there were no noticeable landscape structure changes. The number of patch and point elements sank as well as length of linear vegetation. From landscape with remnants of meanders accompanied by riparian vegetation and solitaires of trees on meadows has become open unified landscape with monofunctional use. The K-W test is only auxiliary tool for accurate quantification of changes in this study.

The paper presents results about development of NFWV in a small study area but none of the research in the Czech Republic has assessed such relations so far. There is only one study about development of structural attributes of hedgerows (Molnárová 2008). Therefore the results cannot be placed into a broader context. This is the first time that such data have been available at the local or regional scale in the Czech Republic and Slovakia as well. For more accurate differentiation of trends in landscape development under differing political doctrines, it would be possible to use aerial photographs from approx. 1990. These data are generally available for the whole country territory. But according to our experience from the area under investigation, the trends in landscape development did not change essentially here.

There is always a lack of data about these biotopes and without their evidence it is not possible to protect them adequately. Further research is required at the national scale. Great Britain where the Countryside Surveys provide a rich source of data about hedgerows (e.g. Barr et al. 1993) could serve as good example.

5. Conclusion

This work has documented the following findings:

- decrease in proportion of non-forest woody vegetation in the study area since 1950 until the present (areal extent, quantity), although not every change is statistically significant;
- only 42% of original NFWV (existing in 1950) were preserved until today (mostly out of arable land);
- loss or destruction of NFWV was caused by socialist intensification of agriculture accompanied by re-allotment of land as well as land-consolidation and other land use changes;
- loss of original function and importance of NFWV (nowadays no longer essential as a source of wood and fruit or for demarcation of field boundaries);
- new occurrence of NFWV in relation to environmental conditions (on abandoned and unused lands);
- proportion and distribution of elements of NFWV is influenced both by natural conditions (primary landscape structure), land use changes (secondary landscape structure) as well as legislative nature and landscape protection measures (tertiary landscape structure).

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RÉSUMÉ

Vývoj nelesní dřevinné vegetace v krajině Novodvorska a Žehušicka (Střední Čechy)

Rozptýlená zeleň (nelesní dřevinná vegetace stromů a keřů) je významným prvkem krajinné struktury, podílí se na její funkčnosti a pestrosti, zvyšuje biodiverzitu krajiny a je určujícím znakem krajinného rázu. Během posledních 60 let došlo k velkým změnám ve struktuře a rozšíření rozptýlené zeleně v krajině. Zatímco v minulosti byly dřeviny do volné krajiny cílevědomě vysazované v podobě alejí, remízků i solitérů, v období socialistického zemědělství byla tato vegetace v důsledku zcelování pozemků a intenzifikace zemědělství naopak likvidovaná, protože byla vnímaná jako překážka souvislého obdělávání zejména orné půdy. Potvrzují to i výsledky této studie, realizované na příkladu intenzivně využívané zemědělské krajiny ve středních Čechách. Zájmové území leží v povodí dolních toků Doubravy a Klejnárky a zaujímá přes 60 km^2.

Porovnáním současného stavu se stavem v roce 1950 bylo zjištěno, že v tomto území se snížilo zastoupení rozptýlené zeleně ve všech kategoriích (bodové, liniové a plošné prvky). Plocha bodových prvků se snížila o 17,5 %, plošných o 6,5 % a liniových o 4 %. Jako statisticky významné byly vyhodnoceny změny v případě liniové a plošné vegetace. Po napřímení vodních toků zmizely z krajiny zbytky břehových porostů bývalých říčních meandrů, vlivem kolektivizace zmizely liniové vegetační prvky na hranicích pozemků. Tato ztráta byla částečně nahrazená nově vysazovanými stromořadími podél cest nebo nesouvislými porosty na březích upravených vodních toků a umělých melioračních kanálů. V krajině se zachovaly některé vegetační struktury vázané na význačné artefakty, které můžeme označit jako historické krajinné struktury. Příkladem jsou liniové porosty dřevin na hrázích bývalých rybníků, podél starých cest nebo skupiny či solitéry dřevin vázané na místní krajinné dominanty jako jsou kříže, boží muka apod.

Rozšíření, struktura a hustota prvků rozptýlené zeleně v krajině závisí jednak na přírodních podmínkách (primární krajinná struktura), dále na způsobu využívání krajiny (sekundární krajinná struktura) a konečně také na legislativních limitech a stupni ochrany daného území (terciérní krajinná struktura). Studie potvrdila, že nejvyšší zastoupení prvků rozptýlené vegetace je v biochorách údolních niv a v charakteristických prostorech krajinného rázu vymezených v údolních nivách Labe a dolní Doubravy. Potvrdilo se, že v krajinné památkové zóně Žehušicko, vyhlášené na ochranu kulturní krajiny s významnými stopami starých krajinářských úprav je vyšší zastoupení prvků rozptýlené zeleně než v okolní nechráněné krajině mimo krajinnou památkovou zónu.

Za posledních 60 let došlo nejen ke snížení rozsahu (hustoty) rozptýlené zeleně v krajině, ale také ke změně jejího významu a funkce. V minulosti byla využívaná k účelům, které jsou dnes převážně nevýznamné a druhořadé (zdroj dřeva, případně květů nebo jiných částí rostlinné biomasy, sběr ovoce, vyznačení hranic pozemků apod.). V současnosti převládá její funkce estetická, krajinotvorná. Úbytek rozptýlené zeleně ve volné krajině je částečně kompenzován současným šířením nelesní dřevinné vegetace v krajině procesem sukcese na opuštěných a nevyužívaných plochách.

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