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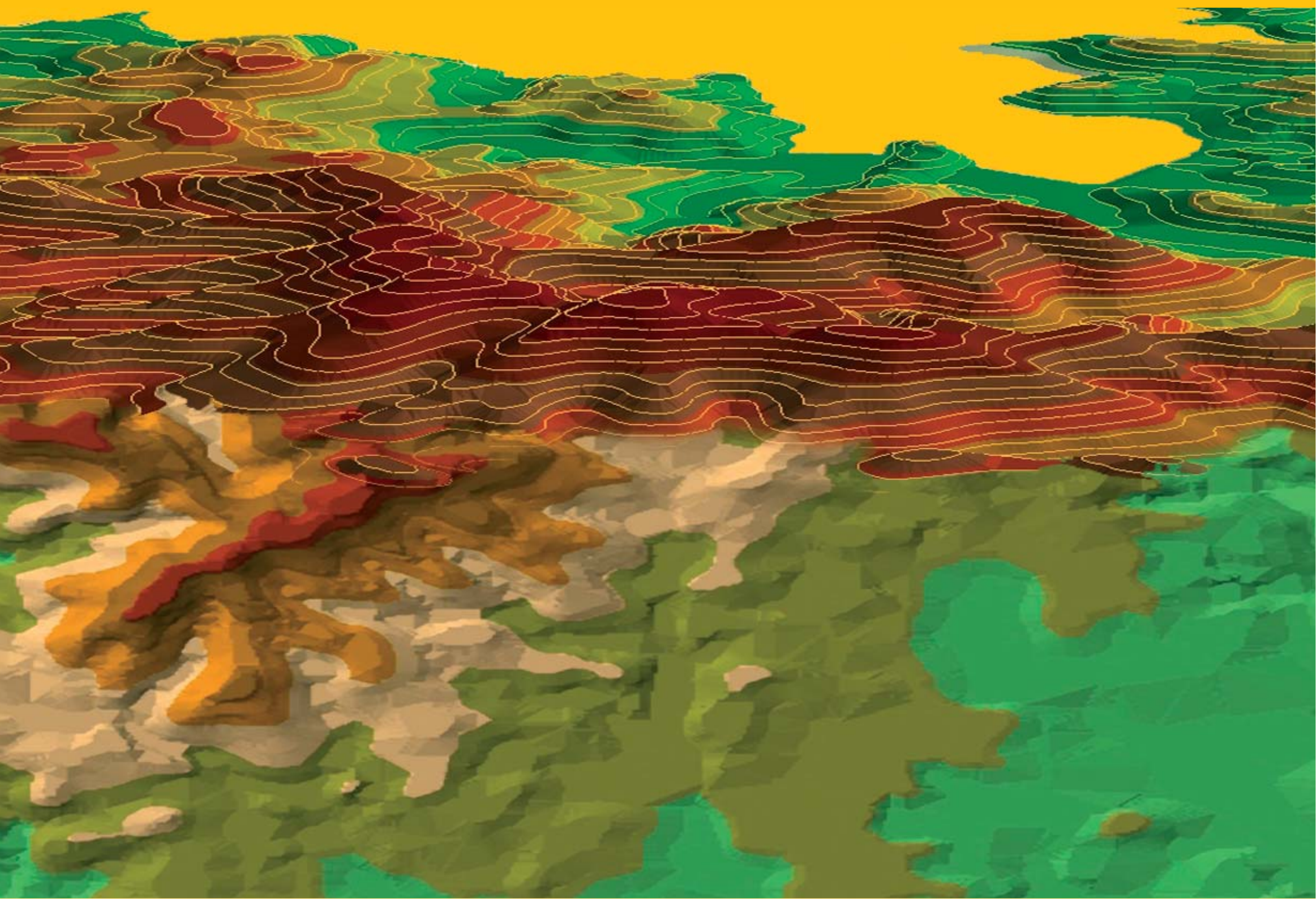

*Fig 1: Traditional village surrounded by open landscape, Czech Republic (Photo: K. Janečková Molnárová)*

*Fig 2: The aesthetics of rural settlements‘ interior, although a major factor in the overall aesthetics of the rural landscape, has been addressed by very few studies (Photo: K. Janečková Molnárová)*

Illustrations related to the paper by K. Janečková Molnárová et al.

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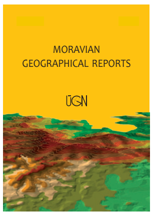


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# Rural identity and landscape aesthetics in exurbia: Some issues to resolve from a Central European perspective

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## Abstract

*Although perceptions of landscape aesthetics are currently attracting great research interest, some aspects of the topic have remained almost unexamined. This review highlights some less studied areas that are of particular importance for landscape management, with special focus on rapidly growing exurban areas. While the visual quality of the environment is undoubtedly one of the drivers that has been spurring the exurban development of rural settlements, much remains unknown about the perception of the visual quality of these settlements. Another pressing issue is the need to determine general principles of consensus formation concerning visual landscape preferences. This study concludes that in order to preserve the rural character of exurban landscapes, there is an urgent need to identify the aesthetic values that define the character of rural settlements and their importance to the stakeholder groups.*

***Key words:*** *landscape perception, visual quality assessment, exurban landscapes, judgement variability, Central Europe*

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## 1. Introduction: Rural identity in the context of the exurban settlement process

In its physical aspect, rural identity is based on site characteristics (Ihatsu, 2005), which are continually influenced by all events occurring within a territory. Rural identity is therefore, at the best of times, in a very dynamic equilibrium. Recent rapid developments have raised concerns for the protection of rural identity (Foley and Scott, 2014; Taylor, 2011; Vorel et al., 2003), however, especially in places where the exurban settlement process is taking place. In the post-socialist countries of Central Europe (Northern Croatia, the Czech Republic, the former East Germany, Hungary, Poland, Slovakia and Slovenia), the erosion of rural identity by exurbanisation is being accelerated by a building boom following 50 years of repression under the communist regime (Maier, 1998), and aided by a 50-year long severance of the landowners' ties to their land (Sklenicka et al., 2014).

### *1.1 The exurban settlement process*

The form of an exurban settlement process largely depends on the culturally and legally determined forms of settlement in the relevant area. In the USA, An et al. (2011) define exurban residential landscapes as "low-density settlements that are contiguous with metropolitan urbanised areas but disconnected from city services of sewer and water". In this context, LaGro (1998) notes that "residential development… routinely occurs beyond the boundaries of cities, villages and other incorporated communities". In the European context, exurban housing is usually built on the fringes of existing villages, taking advantage of the municipal amenities (where present), though often failing to accordingly contribute to these communities (Peltan, 2012).

In the post-socialist countries of Central Europe, the extent and the form of exurbanisation is determined by traditional settlement patterns, by policies implemented during the communist regime, and by land use policies adopted after the fall of the regime.

Traditional settlement patterns in the Central European countries date back to the late middle ages (Pánek and Tůma, 2009) and consist of relatively regularly distributed towns and villages with high settlement density, and also

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with open agricultural landscapes with a proportion of forest patches varying according to the natural conditions. The landscape outside settlements traditionally contained very few buildings. Where buildings were present outside of towns and villages, they mostly served agricultural purposes such as hay storage or shelter for animals. Residential houses were limited to special purposes such as hunting and game-keeping (Löw and Míchal, 2003). The open landscape was often divided into long-strip fields belonging to the individual farms (Sklenicka et al, 2009; Houfkova et al., 2015). This distinctive settlement pattern along with the remnants of field patterns is crucial in defining the landscape character and identity of Central European rural landscapes (Löw and Míchal, 2003), and is in stark contrast to the dispersed land use pattern which is prevalent, for example, in North America (LaGro, 1998).

Under the socialist regimes (1950s–1980s, the exact years vary from country to country), land use planning was centralised and held a very strong position in the Soviet Block (Litwina and Pluta, 2015; Maier, 1998). Despite the many limitations of planning during this period, urban sprawl and exurban development were almost non-existent in the Central and East European countries (Nussl and Rink, 2005). After the fall of the communist regime, however, individual countries adopted a wide range of land use planning policies. Extreme cases are represented by the Czech Republic, on the one hand, and Poland, on the other. In the Czech Republic, the legal measures regulating sprawl and exurban development are relatively strict, and are strongly enforced. Building Act No. 183/2006 requires detailed land-use plans to be drawn up for each municipality. These plans, which regulate land use both in the built-up area and in the surrounding open space, ensure the continuance of the traditional settlement pattern of incorporated municipalities, though it does not prevent an over-intensive exurban settlement process. Moreover, larger developments in the rural areas are subject to Visual Impact Assessment (Vorel et al., 2003), which is defined in the Nature Protection Act No. 114/1992 Sb.

In contrast, the Polish Planning Act No. 80/2003 cancelled the obligation to make local land-use plans. Consequently, all Polish land can be freely developed, provided that a neighbouring plot is developed with housing (however, 'neighbourhood' is not further defined in the Act), there is access by a public road, and no other law is violated (e.g. environmental restrictions) (Halleux et al., 2012). While the consequences of this provision have begun to make their mark in the Polish landscape (Kurek et al., 2015), both current European authors (Sklenicka et al., 2013; Špulerová et al., 2013; Nuga et al., 2015) and long-term experience from other parts of the world, especially North America (Brabec, 2001; LaGro, 1994; McHarg and Mumford, 1969) warn against unregulated development of rural areas.

The exurban settlement process is largely driven by incoming residents seeking amenities such as proximity to landscapes of high natural (Ryan, 2002) and aesthetic value (Gosnell and Abrams, 2011), or privacy (Taylor, 2011). Studies of the economic impact of amenity migration (e.g. Carruthers and Vias, 2005), however, describe negative impacts of this migration, and subsequent changes in land use, on the scenic quality of the landscape that originally attracted the exurbanites (Sullivan, 1994; Taylor, 2011). Other studies (Hurley and Walker, 2004 Walker and Fortmann, 2003) note that where this is the case, the exurbanites tend to control the use of natural amenity areas, disrupting socio-political relationships in these areas.

Hence, an influx of new inhabitants often results in the disruption or even destruction of rural identity (Ryan, 2002) and landscape character. In contrast, Gosnell and Abrams (2011) conclude that receiving communities can benefit from changes associated with newcomers, and that the increased human capital and diversity of values can create new opportunities for the continuation of rural communities.

### *1.2 Rural landscapes and their identity*

The rural character of a landscape has traditionally been defined by the predominant use of the landscape for food and fibre production (Löw and Míchal, 2003; Tilt et al., 2007; Thorbeck, 2012). But present-day rural landscapes are difficult to characterise with simple generalisations (Marcouiller et al., 2001). Some definitions focus on the remoteness of the landscape and the size of the population (e.g. USDA, 2004), while others emphasise economic structure and income-generating activities (Lapping et al., 1989). Arendt et al. (1994) state that a rural character is determined both by the physical characteristics of a place and by its sense of community. Hart (1998) draws attention to the importance of land division systems in determining rural character, illustrating the differences between English rural landscapes with their cluster villages, and American landscapes with their predominantly dispersed rural settlement. Notwithstanding these ambiguities, rural character has remained an important value in people's assessment of landscapes (Vorel et al., 2003; Walker and Ryan, 2008).

In order to preserve the rural character of places where the exurban settlement process is taking place, it is necessary first to find a way to define the important characteristics of rural identity. The role of individual architectural and landscape features in defining this identity has been described in detail in a large number of ethnographic and architectural studies (e.g. Eben Saleh, 2001; Purcell and Nasar, 1992). Moreover, rural identity is also strongly interconnected with the aesthetic quality of rural settlements and the surrounding open landscape. It is determined by relationships among these features (Frederick, 2007), as well as by the relationship between people and the physical environment (Bourassa, 1988). As was shown in a study by Hägerhall (2001), aesthetically valuable landscapes manifest stronger identity, as they evoke clear and precise mental images. This aspect of rural identity is of considerable complexity.

The importance of an aesthetically valuable environment to the well-being of humankind and society has been emphasised in a number of studies. Although these studies mostly focus on the landscape outside settlements, their results may be indicative of the values of aesthetic quality in rural and exurban landscapes. Kates (1967), Kurdoglu and Kurdoglu (2010) and Tveit (2009) maintain that an aesthetically valuable environment has a significant impact on people's well-being. According to Jessel (2006), the aesthetic quality of landscapes forms a substantial part of the cultural heritage. Florida et al. (2010) have shown that the visual aesthetic quality of a landscape is important for the overall contentment of the local community. Howley et al. (2012) found that there is broad public support for conserving the traditional rural landscape, as expressed by willingness to pay for agricultural activities that contribute to its protection. Last but not least, this quality is important for the tourist trade (Ewald, 2001). Protection of the visual aesthetic quality of a landscape may therefore be considered in the public interest.

On the diverse and rapidly evolving stage of current Central European landscapes, the protection of rural identity has become an urgent but increasingly complex issue. Experience from countries where similar processes started earlier can be helpful in avoiding the repetition of mistakes that have already been made elsewhere. The aim of this research project is therefore to review existing literature on rural identity and landscape aesthetics from the standpoint of the rural landscape, and to lay the groundwork for more effective protection of the rural identity of Central European farming landscapes, especially in the context of exurban settlement.

## 2. Basic approaches to identifying the visual aesthetic qualities of landscapes

Two basic approaches to the assessment of visual aesthetic qualities of landscapes have been established in recent decades: an approach based on expert evaluations; and an approach based on evaluations by the broader public. Both of these methods are mainly used for assessing landscapes outside settlements. They may also be used, however, for assessing settlements, inasmuch as a settlement is an integral part of a landscape. The expert-based approach works on the assumption that the aesthetic qualities of a landscape are independent of the observer (i.e. that the aesthetic value is an intrinsic quality of the landscape). Visual aesthetic qualities are then examined by identifying and quantifying landscape elements and characteristics with known aesthetic effects (e.g. Daniel, 2001; Jessel, 2006). The assessment is performed by experts, who assess a landscape on the basis of their own experience and defined criteria, which are usually grounded in general methodologies (Löw and Míchal, 2003; Swanwick and Land Use Consultants, 2002; USDA, 1995; Vorel et al., 2003), or are defined by the experts themselves. In any case, however, the criteria that are used should be based on previous extensive research that has proven their validity. Diverse criteria for visual aesthetic quality assessment (i.e. landscape elements and characteristics) are reported by many contributors, but such criteria are usually divided into groups of natural and cultural elements (Ryan, 2002).

In contrast, the approach based on evaluations by the broader public, also called perception-based assessment (Daniel, 2001; Frantál et al., 2016), is the outcome of a subjective approach, which considers aesthetic qualities to be a product of human perception (Lothian, 1999). Particular landscape elements and characteristics are regarded as stimuli that induce relevant psychological responses (i.e. a sensory perception and/or a perception arising from cognition) (Daniel, 2001). In this type of assessment, respondents within a sample area are asked to express their preferences for different landscape scenes. The basic issues addressed by studies of this type include the connection between visual preferences and scenic beauty (e.g. Clay and Smidt, 2004; De Val de la Fuente et al., 2006; Dramstad et al., 2006), or the differences in preferences for different landscape scenes (e.g. Arriaza et al., 2004; Van den Berg and Koole, 2006). Visual preferences are often assessed using open or structured interviews (e.g. Coeterier, 1996), or photo-based sorting procedures (e.g. Fyhri et al., 2009). Some studies use landscape evaluation in situ (e. g. Dearden, 1981). A number of authors, however, have found that this method can be replaced effectively by an evaluation based on landscape photographs (e.g. Palmer and Hoffman, 2001; Stamps, 1990; Stewart et al., 1984).

The approach based on evaluations by the broader public is more demanding than an expert-based approach in terms of time and money. But a perception-based assessment provides deeper knowledge about the causes and the stratification of the aesthetic preferences. Expert-based assessment usually results in landscapes being divided into just three categories: landscapes with low, medium and high aesthetic quality (Daniel, 2001). Moreover, the reliability and the validity of perception-based assessments are verifiable more easily, using statistical methods, than an expert-based assessment. Perception-based assessments are therefore most often used for scientific purposes.

In landscape management, expert-based assessment is widely used for determining the visual aesthetic qualities of a landscape (Ode et al., 2009). This approach benefits from low costs and low time demands. When based on well-defined criteria, expert-based assessment is sufficiently reliable and, at the same time, provides a complex insight into the character of a landscape. If, however, the criteria are poorly defined and are based purely on the experience of the experts, the results may not be reliable (Clay and Smidt, 2004). As Daniel (2001) points out, an important role of perception-based assessments is to diagnose pathological preferences for aesthetic qualities of landscape if these are inconsistent with other important values, such as values of an ecological, cultural or historical nature.

Expert-based assessment should therefore build on findings from perception-based research, through which factors driving the aesthetic perception of the wider public can be identified.

## 3. Factors influencing the aesthetic perception of landscapes

A rural landscape comprises a unique mix of natural and cultural values (Ryan, 2002). Even as landscape mediates our perception of the world, it also is a means by which we actively influence the world (Jorgensen, 2011). In recent decades, therefore, researchers have been prompted make a closer study of landscape aesthetic qualities.

From the theoretical point of view, Bourassa (1988) identified two principles of landscape aesthetics: the biological and the cultural. According to the biological principle, the highest aesthetic value is attributed to landscapes which appear to offer natural amenities such as prospect and refuge, whereas the cultural principle accentuates the aspect of cultural identity. Natural landscapes are experienced largely in biological mode, whereas urban landscapes are experienced primarily in cultural mode (Bourassa, 1990). Nassauer (1995) argues that while this theory accounts for some part of the empirical evidence, in many cases it is insufficient. Nassauer proceeds to outline four groups of theories explaining the formation of human preference for landscape: biological theories, information-processing theories, transactional theories and behavioural theories. She argues that behavioural theories, which emphasise the role of people as actors making landscapes, are the most useful in explaining people's landscape preferences.

Twentieth century research often used scenic quality as the measure of the attractiveness of a landscape (Tab. 1). Reflecting this research, a widely-used methodology presented in Landscape Aesthetics – A Handbook for Scenery Management (USDA, 1995), builds on the principle that people place a particularly high value on more scenic landscapes. Similarly, scenic quality is used as the main

| STUDY / METHODOLOGY | VARIABLES | | | | | | | | | | | | ASSESSMENT | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | landscape segments studied | | | landscape characteristics used to define landscape visual quality | | | | | | | Respondent characteristics | | | |
| | rural settlements – interior | rural settlements – exterior | landscape outside settlements | scenic beauty | natural elements | cultural elements | landscape structure | level of wilderness/ naturalness | neatness | stewardship | socio-demographic | experience and attitude | Evaluator | Instrument |
| Angilieri and Toccolini (1993) | | | X | | X | X | X | | | | | | P | P |
| Arriaza et al. (2004) | | X | X | X | X | X | | X | | | | X | E, P | P |
| Banski and Weslowska (2010) | X | | | | | X | | | | X | | | E | AL |
| Brush et al. (2000) | | | X | | X | | | | | | X | X | P | VS, P |
| Bulut and Yilmaz (2009) | | | X | | X | | | | | | X | | P | P |
| Clay and Daniel (2000) | | | X | X | X | | | | | | | | P | P |
| Clay and Smidt (2004) | | X | X | X | X | | | X | | | | X | E, P | P |
| Coeterier (1996) | | | X | X | X | | | X | | | | | P | V, P |
| De la Fuente de Val et al. (2006) | | | X | X | | | X | | | | | | P | P |
| Dramstad et al. (2006) | | | X | | X | | X | | | | X | | P | P |
| Fyhri et al. (2009) | | X | X | | X | X | | | | | | | P | P |
| Hammitt et al. (1994) | | | X | X | X | | | | | | | | P | P |
| Jessel (2006) | | | X | X | X | | X | | | | | | E | AL |
| Nassauer (1998) | | | X | X | | | | X | X | X | | | P | P |

*Tab. 1: The focus and the methods of major expert-based (E) and perception-based (P) studies and methodologies aimed at assessing the visual quality of rural landscapes*
*The following instruments have been used to evaluate visual quality: verbal questionnaires (V), photo-based questionnaires (P), questionnaires based on computer simulation (CS), questionnaires based on video sequences (VS), and landscape assessment while viewing actual landscape (AL);*
*Note: The table shows a major focus on landscapes outside settlements. Studies which are also concerned with the rural settlements themselves usually focus on the image of the settlement as seen from the surrounding open landscape. Visual preferences for the interior of rural settlements have only very rarely been studied. The most frequently-used characteristics for defining landscape visual quality are the presence and the characteristics of natural elements, followed by scenic beauty, the presence and the characteristics of cultural elements, and the level of wilderness, also expressed as the level of naturalness. Studies by authors based in the field of landscape ecology often focus on the relationship between landscape structure and its perceived beauty. The concepts of neatness and stewardship have also been addressed in several studies, primarily by American authors.*

| STUDY / METHODOLOGY | VARIABLES | | | | | | | | | | | | ASSESSMENT | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | landscape segments studied | | | landscape characteristics used to define landscape visual quality | | | | | | | Respondent characteristics | | Evaluator | Instrument |
| | rural settlements – interior | rural settlements – exterior | landscape outside settlements | scenic beauty | natural elements | cultural elements | landscape structure | level of wilderness/ naturalness | neatness | stewardship | socio-demographic | experience and attitude | | |
| Ode et al. (2009) | | | X | | X | | | X | | | X | X | P | CS |
| Pynnonen et al. (2005) | X | X | X | | X | X | X | X | X | X | | | P | AL |
| Rechtman (2013) | | | X | | | X | X | | | | X | X | P | P |
| Rogge et al. (2007) | | | X | X | X | X | | | | X | | X | E, P | P |
| Skřivanová et al. (2014) | X | X | X | X | X | X | | | X | | X | X | P | P |
| Strumse (1994) | | X | X | X | X | X | | | X | X | | X | P | P |
| Sullivan (1994) | X | | | | X | X | X | X | | | | X | P | P |
| Swanwick and LUC (2002) | | X | X | X | X | X | X | X | | | | | E | AL |
| Tveit te al. (2006) | | | X | X | | | | X | | X | | | E | AL |
| USDA (2004) | | | X | X | X | X | | X | | | | | E | AL, P, CS |
| Van den Berg and Koole (2006) | | | X | | | | | X | | | X | X | P | P |
| Vorel et al. (2003) | X | X | X | X | X | X | | | | | | | E | AL |
| Walker and Ryan (2006) | | | X | X | X | X | | | | | X | X | P | P |
| Sabik and Prytherch (2013) | X | X | X | X | X | X | X | X | X | X | | | P | P |

*Tab. 1 – continuing*

measure of aesthetic quality of the landscape in the method for assessing the visual impact on landscape character of proposed construction work or changes in land use (Vorel et al., 2003). Nassauer (1988), however, points out that while scenic beauty is an important aspect of landscape attractiveness, respondents also value apparent naturalness, neatness and conservation, especially in their local landscapes. In an article summarising aesthetic objectives relevant to agricultural policy, Nassauer (1989) accentuates the role of scenic quality, neatness and stewardship. The latter concept has become an important issue in the evaluation and protection of cultural landscapes. It has been reflected especially by American authors (Pynnonen et al., 2005; Strumse, 1994), but also in some recent European studies, e.g. by Sklenicka and Molnarova (2010) and by Tveit et al. (2006). The authors established nine key visual concepts for assessing the aesthetic qualities of landscape: stewardship, coherence, disturbance, historicity, visual scale, imageability, complexity, naturalness and ephemera.

Original studies concerning the visual aesthetic quality of open landscapes have become a central point of research interest (e.g. Angileri and Toccolini, 1993; Arriaza et al., 2004; Kaplan and Kaplan, 1982). As will be shown below, many authors have attempted to identify factors that have positive or negative impacts on the overall aesthetic effect of landscapes outside settlements. The landscape of rural settlements themselves, however, has been relatively neglected (Tab. 1).

Public attitudes toward landscapes outside settlements have been studied by a number of authors (e.g. Coeterier, 1996; Kaplan and Kaplan, 1982; Ode et al., 2009; Retchman, 2013). It has been found that the perception of these landscapes is strongly influenced by such elements as vegetation (Angileri and Toccolini, 1993; Swanwick, 2009), water elements (Bulut and Yilmaz, 2009; Dramstad et al., 2006; Hammitt et al., 1994) or meadows (Clay and Daniel, 2000), and also by the overall characteristics of the landscape. Clay and Smidt (2004) note that vividness, variety and unity are generally considered to be the most influential characteristics in this respect, while other authors have also emphasised openness (Rogge et al., 2007; Strumse, 1994), colour contrast (Arriaza et al., 2004), naturalness (Ode et al., 2009; Palmer, 2004; Van den Berg and Koole, 2006), typicality (Fyhri et al., 2009; Stamps and Nasar, 1997), or the age of structures (Tilt et al., 2007). Moreover, Svobodova et al. (2014) proved that landscape composition has a significant influence on visual preferences. According to Rogge et al. (2007) and Swannick (2009), for example, socio-demographic characteristics, such as age, profession, social and economic status or the environmental value orientations of the respondents, may also play an important role in shaping their visual perceptions of a landscape. As was noted above, little attention has been devoted to studies of visual preferences for rural settlement landscapes. While rural settlements are undoubtedly integral parts of rural landscapes (and at the same time they form landscapes of their own), research has mostly been focused on landscapes outside settlements. Where researchers have paid attention to rural settlements, they have studied them from the point of view of their architecture, and not as landscapes as such (Council of Europe, 2000). Moreover, respondents generally regard settlements as having the lowest aesthetic value (Stamps, 1994; Skřivanová et al., 2014). Nevertheless, settlements may be accorded relatively high preferences when they fit certain characteristics (Skřivanová et al., 2014), and for this reason they merit increased attention.

Nasar and Kang (1999) examined the aesthetic impacts of individual buildings, assessing 15 different architectural styles that are used in both urban and rural contexts in the USA. The results of the study show a preference for traditional forms across all studied groups. Similar conclusions have emerged from other studies, such as those by Stamps and Nasar (1997), Skřivanová et al. (2014), and Banski and Wesolowska (2010). In another study, Stamps (1994) examined the influence of context on aesthetic preferences. He concluded that the context is more important than the appearance of individual buildings, observing that buildings are better perceived in uniform contexts than in diverse contexts. Preference is shown for buildings that are adapted to their surroundings in terms of their scale and character. In the context of rural settlements, family houses are preferred (Sullivan, 1994). According to Sullivan, lot size and the presence of greenery are also important elements. Pynnonen et al. (2005) confirmed Sullivan's finding, stating that small lots are disturbing to rural character, while the presence of greenery helps integrate a new development into old structures. The importance of greenery was confirmed by Stamps (1997), who noted that the positive influence of greenery is greater than the negative influence of disturbing elements such as electricity wires or parked cars. Thorbeck (2012) notes the negative visual effect of animal housing barns and pole barns in the American rural landscape, as well as new patterns of residential development in these landscapes. Both of these phenomena are felt to lack visual connection to the character of the landscape.

In most preference-based studies on the visual quality of open landscapes, as well as rural settlements, respondent evaluations of the landscapes are based on photographs. In the European context, these photographs are often taken from vantage points, which are usually visited on foot. It is the underlying context of many European studies (Fyhri et al., 2009; Svobodova et al., 2012) and landscape assessment methodologies (Swanwick and Land use Consultants, 2002; Vorel et al., 2003) that people mostly appreciate the visual quality of a landscape while walking through it or engaging in other outdoor activities. In comparison, Nassauer (1989) notes: "the rural landscape is the primary setting for the most popular recreational activity, driving for pleasure" – in the North American context. This phenomenon is illustrated for example by Clay and Smidt (2004) and by Brush et al. (2000), who have conducted a study on group differences in the enjoy-ability of driving through rural landscapes, using video recordings to assess respondents' preferences for forest, farm or urban edge landscapes. In this study, the higher appreciation of rural landscape by farmers than by other groups of respondents was linked to the farmers' better knowledge of the landscape and of the agricultural processes operating in this landscape. Studies by Ryan (2002) and Tilt et al. (2007) focused on defining the elements that contributed to the perception of areas affected by exurbanisation as rural areas, without specifically addressing the perceived visual quality of these elements. Both studies accentuate the role of natural features. Tilt et al. also note the importance of traditional building materials and lot sizes. Several studies (e.g. Arriaza et al., 2004; Kaplan et al., 2006) also link perceived rural identity, as well as preference for rural landscapes, to the presence of active agriculture in the area. In a study of abandoned agricultural landscapes, Hunziker (1995) found a preference for partially re-afforested landscapes, but this preference was linked to the higher diversity of the successional landscapes. Fjelstad and Dramstad (1999) noted that as these landscapes lose their diverse character when they are without management, their attractiveness for exurbanites and second-home owners might decrease.

In a literature review on the phenomenon of exurbia, Taylor (2011) states that the search for the "rural idyll" is a powerful factor in the residential decisions and conservationist activities of exurbanites. The presence of natural elements (Champion, 1998; Hart, 1995) and low residential density (Berube et al., 2006; Ryan, 2002) are the most widely discussed aspects of this concept. Zabik and Prytherch (2013) found that residents of landscapes affected by exurbanisation preferred "the more rugged, sparsely populated areas… characterised by large blocks of public and private forest land, narrow valleys, small streams and farmland… While most people preferred areas of farmland and forests, village landscapes were still highly valued".

In a study of visual preferences and place attachment in an exurban context, Walker and Ryan (2008) confirmed the high preference for natural elements and agricultural features, which were also found most important in forming place attachment. Cultural elements such as churches, cemeteries or dirt roads were generally found less attractive and less important, although long-term residents placed more value on these features than did newcomers. Importantly, Walker and Ryan (2008) found a strong correlation between the place attachment of residents and their support for conservation planning. In a similar study in the Central European context, Skřivanová et al. (2014) found a strong preference for both natural and cultural landmarks.

While these findings are important overall, they provide only a narrow background for discussing the visual aesthetic qualities of a rural settlement. This discussion is highly important for the effective regulation of exurban development. We need first to identify rural settlement values (Ryan, 2002), in order to find out which values are worth protecting and even expanding.

## 4. Consensus in the perception of visual aesthetic qualities

As mentioned above, the main goal of studies concerned with the visual quality of landscapes is to identify elements or overall characteristics that have a positive or negative impact on perceptions of the landscape (e.g. Angileri and Toccolini, 1993; Bulut and Yilmaz, 2009; Clay and Smidt, 2004). Since any practical application of the results of landscape preference studies implies that there should be agreement among individuals (Hägerhall, 2001), consensus in judgments of landscape visual qualities is highly important. Aesthetic values are considered to be an important aspect of the rural character of a landscape, so consensus on these values can provide a basis for protective measures. Purcell and Lamb (1984) point out that if consensus in judgments of landscape visual qualities did not exist, it would make the legal and decision-making process much more complex and more difficult. In this case, the visual qualities of a landscape would be merely subjective, and it would be hard to justify their use as a basis for protecting the landscape. Although many authors consider consensus to be a crucial issue (e.g. Hägerhall, 2001; Purcell and Lamb, 1984; Stamps and Nasar, 1997), and Daniel (2001) predicted a serious focus on consensus building efforts in future landscape management, only a few recent studies have focused on this topic.

In his essay, Kates (1967) presumed a significant consensus among respondents on what is ugly, whereas beauty was presumed to be a fleeting, elusive, individual and subjective value. He concluded that beauty and ugliness are not the two extremes of a single scale, but that they are on two independent scales. Unlike beauty, he considered ugliness to be objective and definable. Dearden (1981), however, regarded beauty and ugliness as opposite extremes of a single scale, and proved that the level of consensus in landscape evaluation grew with the increasing perceived beauty of a landscape. This conclusion was confirmed in a study by Kalivoda et al., (2014). In contrast, Purcell and Lamb (1984) came to the conclusion that the level of consensus is connected neither with beautiful landscapes nor with ugly landscapes. They found that a high level of consensus occurred in the evaluation of uncomplicated, conflict-free landscapes. Some examples of possible conflict described in this study were golf courses or uncultivated areas, which were evaluated differently by respondents according their knowledge and paradigms. On the other hand, Hägerhall (2001) came to the conclusion that consensus is significantly influenced by the mental image of a specific landscape type (the study used the example of pastures), and that the more a landscape scenery conforms to the idealised mental image of a given landscape type, the higher is the level of consensus in the evaluation of its visual qualities.

In addition, a limited number of studies have focused on the influence of demographic characteristics on the level of consensus in landscape evaluation. While Hägerhall (2001) concluded that these factors do not significantly influence consensus, Kalivoda et al. (2014) found significant differences in judgment consensus for all tested characteristics: gender, age, occupation, type of residence (urban, suburban, rural), and level of education.

## 5. Conclusions

We have endeavoured to outline the broad field of rural identity and its connection to landscape aesthetics. We have particularly focused on research from the United States and Western Europe, for two reasons. Firstly, as in Central Europe, large parts of these areas have a moderate climate and predominantly agricultural land use. Secondly, major socio-political and economic changes leading to an acceleration of the exurban settlement process occurred in these countries several decades earlier than they did in the post-socialist countries of Central Europe. Literature on landscape development relevant to rural identity which followed these changes can therefore provide useful insights into the current development of the present-day Central European landscapes.

The overview presented in this paper raises two important issues that need to be resolved. The first of these is the need to consider the visual aesthetic quality of rural settlements. Studies concerned with settlement aesthetics have usually been conducted by architects and from an architectural point of view. Rural and exurban settlements are distinct landscapes, however, and as such they should be examined by the same means as are open landscapes. Most landscape-oriented studies focus on open landscapes, while very little research has been done on the visual aesthetic quality of rural settlement landscapes.

Secondly, this overview has demonstrated the need to determine the principles of consensus formation in the field of landscape aesthetic quality, in general, and in the context of rural and exurban landscapes, in particular. This is crucial for consensus-building efforts and for establishing what is the nature of general public interest in protecting landscape aesthetic values.

These conclusions are particularly important today, when there is extreme pressure on rural identity, which is by its nature far from static. Rapid exurban development, in particular, often leads to the loss of specific environmental characteristics, depriving the society of a part of its cultural heritage. There is an urgent need to identify the values defining the character of rural settlements and their importance to stakeholder groups, in order to form a basis for making informed rural planning decisions and for preserving the most valuable aspects of the rural character of exurban landscapes.

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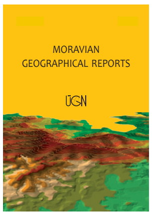


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DE GRUYTER OPEN

# Impacts of natural hazards on an early industrial community: A case study of North Bohemia and its implications for long-term vulnerability assessment

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## Abstract

*Regional databases of natural hazards and their social impacts have been increasingly established from documentary data to provide a rationale for the adoption of new disaster risk reduction strategies. This approach is extended in this article by pointing out factors that may underlie the changes in social vulnerability to natural hazards and that may cause non-homogeneities in long-term vulnerability assessments. We use the newly-established historical multi-hazard database for North Bohemia, based on a thorough search in a local newspaper. Altogether 275 records reporting 599 individual hazard events were analysed with respect to their relative direct social impact. Finally, we discuss the uncertainties resulting from the use of documentary data, and illustrate how long-term changes in social vulnerability are influenced by time-dependent societal understanding of what is considered a hazard. This, in turn, accentuates the dynamics of cultural factors that should be considered when designing new risk reduction strategies.*

***Key words:*** *natural hazards; vulnerability; documentary data; risk reduction, North Bohemia, Czech Republic*

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## 1. Introduction

Natural hazards represent a broad spectrum of disturbing events with potentially adverse impacts on society. Although the social impacts of and responses to hazard events have long been recognised, a rigorous approach to the social dimension of these phenomena was a relative latecomer to the research agenda. Following pioneering research by White (1936, 1942), human ecological approaches (Kates and Wohlwill, 1966; Burton et al., 1978; Hewitt, 1983), as well as developmental and structural approaches (Sen, 1981; Cutter, 1996), have led to a paradigmatic shift from hazard-based to vulnerability-based mitigation strategies (Sarewitz et al., 2003). Social vulnerability has become a central concept in assessing the potential impacts of natural hazards. Despite its varying definitions (Cutter, 1996; Adger, 2006; Hufschmidt, 2011; Lei et al., 2014), vulnerability can be generally expressed as a potential loss based on sensitivity and exposure to stress.

Among the questions central to vulnerability studies is the variations in human occupance of hazardous zones and approaches to adjust to risk in different geographical settings (Cutter, 1996). These research foci have brought new challenges in developing vulnerability mapping tools and, at the same time, have pointed to the influences that economic and societal development may have on vulnerability levels across countries (Wisner et al., 2004). On the other hand, the variability of vulnerability through time remains rather unclear, or as Cutter (1996, p. 534) noted "… the temporal dimension remains one of the least studied aspects of vulnerability".

## 2. Theoretical departures and research aims

### *2.1 The temporal dimension of vulnerability*

Cutter and Finch (2008) analysed spatio-temporal changes in social vulnerability to natural hazards using the SoVI (Social Vulnerability Index) for the USA from 1960–2000, while Hufschmidt (2011) compared seven common vulnerability models, where the majority included the dimension of time. Most of the vulnerability models, however, were applied to society in a 'single' developmental stage and not in a broader historical perspective, which would enable consideration of the role societal learning has in risk reduction (Pfister, 2009). Such

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learning may incrementally result in new risk reduction strategies but can also cause a paradigmatic shift toward new strategies when assumptions and principles of societal organisation change (see Bateson, 1972; Argyris and Schön, 1978; Voss and Wagner, 2010 for single-loop and double-loop learning). Finally, as a result of changing risk reduction strategies, we can assume that vulnerability may gain different meanings through time in terms of type of loss and entities affected.

The time-developmental constraints in vulnerability assessments are well illustrated in ongoing discussions of regional environmental change. The research agenda in the geosciences has introduced attempts to establish time-series of natural hazards derived from documentary data (Raška et al., 2014). This trend is most apparent in historical climatology and historical hydrology (e.g. Pfister et al., 2008; Brázdil, 2009; Glaser et al., 2010), but databases and time-series of historical landslides have been established as well (e.g. Guzzetti et al., 1994; Ibsen and Brunsden, 1996; Klose et al., 2015; Raška et al., 2015). Although the databases and the time-series of natural hazards have been explored with respect to their social impacts, research in this domain is still not frequent (Dolák et al., 2015). In the study of social impacts from historical hazard events, emphasis has been mainly placed on three facets of the problem: reconstructing long-term variability in impacts at regional, national and international scales (e.g. Wanner et al., 2004; Dolák et al., 2015; Aceto et al., 2016); understanding vulnerability levels during extreme climatic periods (e.g. Pfister and Brázdil, 2006); and discussing the opportunities provided by historical experiences for current disaster risk reduction discourse (e.g. Raška and Brázdil, 2015).

The possible effects of learning (i.e. adoption of risk reduction strategies) on the homogeneity of long-term vulnerability assessments have been rather neglected. In particular, although methods to analyse relative direct impacts of natural hazards have been established (cf. Salvati et al., 2010; Caloiero et al., 2014), scarcely any attention has been devoted to the underlying conditions which influence long-term variability in vulnerability to natural hazards (e.g. Klose et al., 2016). Moreover, most studies have been oriented to the assessment of individual natural hazards, whereas the cumulative and cascading impacts of multiple hazards have not been studied extensively to date.

### *2.2 Research aims*

In summary, from the above, while serious gaps in the historical treatment of vulnerability may be seen from a social science perspective, the geosciences, in turn, have been successful in completing long time-series but have paid only limited attention to the conditions underlying vulnerability. One primary motive of this paper, then, is to encourage further discussions about the links between geo-scientific and social scientific approaches to vulnerability. Although we see possible benefits for both sets of disciplines involved, our perspective in this paper stems from the experience of creating an historical multi-hazard database.

In particular, we argue that while there are notions of the availability, contents and limits of documentary data for historical disaster research in the geosciences, only limited attention has been devoted to the interpretative frameworks for these studies (e.g. Hufschmidt et al., 2005). For example, some established time-series have been analysed in terms of their statistical properties, showing the growing numbers of casualties and property damage for individual hazards through time, interpreted as a general increase in social vulnerability. The aim of this paper is to illustrate that such an approach is insufficient if researchers do not pay attention to the underlying social and technological factors of vulnerability, and such findings may, therefore, lead to misinterpretations of observed changes in vulnerability. In order to fulfil this objective, we use a newly-established database of natural hazards for the latter part of the $19^{th}$ century in North Bohemia (Czech Republic), which was based on a thorough search of local newspapers. The hazards are analysed in terms of their occurrence, social impacts and severity. Finally, we discuss the factors that influenced social vulnerability to natural hazards and how the changing nature of these factors may bias long-term vulnerability assessment.

## 3. Material and methods

### *3.1 Case study area*

The study area is located in the northern part of the Czech Republic (Fig. 1; the area is ca. 2,500 $km^2$) and is unique in its susceptibility to and frequency of various natural hazards in the context of Central Europe.

Landslides occur mainly on steep slopes with specific lithologies consisting of Neogene volcanites with weak layers of volcaniclastics and underlain by Mesozoic sandstones (Rybář et al., 2000). Localities with exposed sandstone rock walls in the Děčínská vrchovina Highland suffer from catastrophic rock-falls (Klimeš, 2011). The hydrological hazards are caused mainly by riverine floods of the Labe (Elbe) River (recent floods in 2002, 2006, 2010 and 2013: Brázdil et al., 2006) and flash floods on small water streams running from the Krušné hory Mts. in the North and from the volcanic terrain of the České středohoří Mts. in the South (Minářová et al., 2015; Raška and Brázdil, 2015). Due to long-term open-pit brown coal mining and extensive industry, the region is densely populated. The largest city of the region is Ústí nad Labem (Fig. 1), with a population of ca. 93,000 but the conurbation of the nine most populous cities in the study area (each of which is located less than 20 km from one another) has a total population of ca. 400,000 according to the 2011 census. Settlements are mainly concentrated in basin locations and in deeply eroded river valleys due to topographic suitability, which influences vulnerability to particular hazards (floods, landslides and rock-falls in the valleys, shallow landslides and subsidence near the mining sites).

### *3.2 Building the catalogue*

The availability of accurate data on loss and damage outcomes associated with multiple hazards is fundamental for effective disaster risk management (Dilley and Grasso, 2016). Creating catalogues and databases of historical natural hazards, then, represents a necessary step in the assessment of long-term changes in natural hazard impacts. In many cases, relics or even proxy indicators of past natural hazards in urbanised areas have been erased or transformed by human activity (Raška et al., 2015), and documentary proxies often remain the only source of information. Although they are exploited extensively (e.g. Glade et al., 2001), critical attention must be paid to their interpretation in terms of both objective (e.g. availability and technical quality) and subjective (e.g. agenda setting, purpose of origin, and language style) factors that influence their content (Tropeano and Turconi, 2004).

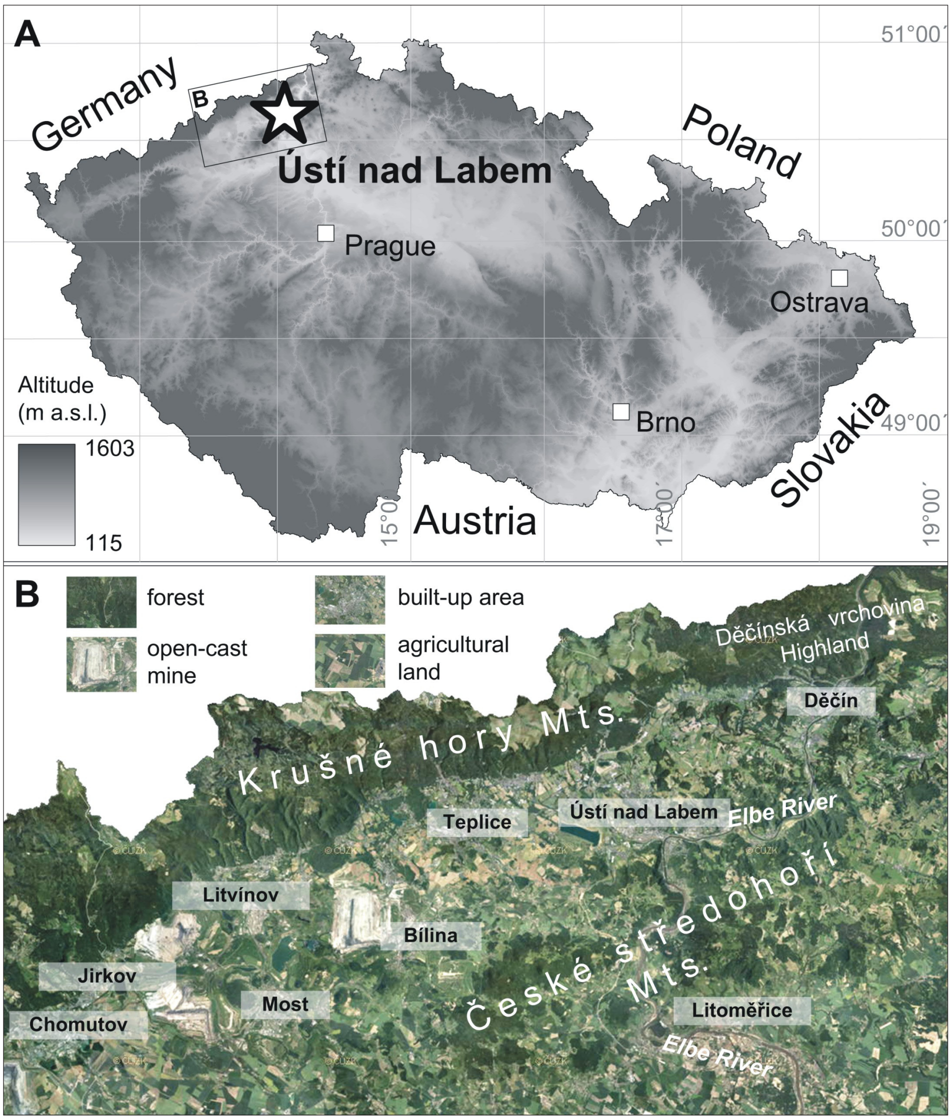


*Fig. 1: Location of the study area: A – location of the study area with shaded DEM (digital elevation model) in the background; B – major topographic features with land cover in the background and major settlements*
*Source: authors' compilation*

In this research, the local newspaper, Aussiger Anzeiger, available in a regional archive, was used as the main data source for the creation of the database of historical multi-hazards. This newspaper was selected as it represents the oldest periodical publication in the region and one of the oldest in the whole country. It was published in the German language during the years 1856–1902 with a periodicity of seven days (until 1873) and three days (from 1874), and printed in new gothic font (so-called Schwabach). The newspaper volume for 1871 is not preserved in the archive, and three other volumes are incomplete (eight months are missing for 1868, three months for 1872 and six months for 1900). The relevance of the source for natural hazard studies was validated during a previous survey (see Raška et al., 2015), which showed that local newspapers have (i) high sensitivity towards local events, (ii) a rapid publication process, and (iii) sufficient content related to social impacts of and responses to natural hazards.

The newspapers are not digitised, hence the extraction of information was based on manual searches using the key words listed in Table 1. The assignment of the described events to broader categories was carried out to reduce possible inaccuracies in the descriptions made by authors of the newspaper articles, while still keeping in mind possible nuances among the hazard types (e.g. floods and overflow). To assess the relation of various natural hazards and their combined impact on society, the database was designed as a multilevel catalogue. Each record consisted of a list of individual events, which were described in one or more articles. For example, if a torrential rain and a flood were described in the newspapers, they constituted one record consisting of two events. Each of these events might have been described in more subsequent articles; however, all of the articles were searched for reference to social impacts. This structure for the catalogue enabled assessment not only of the occurrence of the individual natural hazards (i.e. hazard events), but also their combination (i.e. record).

For each natural hazard event, the following information was recorded: hazard type, date, location, social impacts, and response. Social impacts were divided into the following categories: (i) fatality, (ii) damaged/affected building, (iii) damaged/affected lots, (iv) affected other property. These categories are certainly not complete, but they are considered as the major direct social impacts in disaster statistics (EEA, 2010; Dilley and Grasso, 2016), while indirect impacts may also include agricultural losses, road damage, etc.

| Natural hazard/related event | Original terms included | Group |
|---|---|---|
| Earthquake | Erdbeben, Erdschütterung | geological |
| Landslide | Erdrutschung, Rutschung, Erdsenkung, Schwimmsandeinbruch, Schwimmsand, Erdeinbruch | geological |
| Rock-fall | Felssturz, Felsabsturz, Felsrutschung | geological |
| Flood | Hochwasser | hydrological |
| Overflow | Überschwemmung, Überfluten | hydrological |
| Rainstorm | Ungewitter, Gewitter | meteorological |
| Extreme rainfall (torrential rain) | Wolkenbruch, Regen, Niederschlag, Regenguss, Gussregen, Platzregen, Gussregen, Regenwetter | meteorological |
| Lightning | Blitzschlag, Blitz | meteorological |
| Windstorm | Orkan, Sturmwind, Sturm | meteorological |
| Hailstorm | Hagel, Hagelwetter, Hagelstuck, Hagelschauer, Hagelschlag | meteorological |

*Tab. 1: The original German terms used to describe various natural hazards in the Aussiger Anzeiger newspaper and assigned hazard group. Source: authors' compilation*

(Bíl et al., 2014; Klose et al., 2016). In some cases, it was also possible to find supplementary information about the estimated financial losses.

### 3.3 Data processing

With regard to the multilevel character of the catalogue, data processing was performed at two levels. First, for the level of individual events (e.g. landslide, torrential rain, flood, etc.) in the newspapers, their temporal occurrence was evaluated using the indicators of frequency (*f*) and recurrence (*rc*) as follows:

Frequency (*f*) $$f = \frac{H}{N}$$

Recurrence (*rc*) $$rc = \frac{N}{H}$$

where $N$ is number of years in the studied period and $H$ is number of hazard events.

While the two reciprocal indicators mentioned above are frequently used in time-series analyses, we also proposed a simple indicator for the time-regularity of individual events. This is because standard frequency indicators may be biased by the time-limited calamities of hazard events within the whole studied period. The regularity (*rg*) indicator is designed as a standard deviation of intervals between individual consequent events:

$$rg = \sqrt{\frac{1}{N} \times [(x_1 - \bar{y})^2 + (x_2 - \bar{y})^2 + \cdots + (x_N - \bar{y})^2]}$$

where $N$ is number of intervals between hazard events, $x$ is length of interval between two hazard events in years and $\bar{y}$ stands for average length of intervals between hazard events. The presence of a hazard event in the null year (i.e. 1855) was assumed, while the end of the period was calculated as the last occurrence of the hazard event.

The assessment of the social impacts of past natural hazards is always challenging because the documentary data does not include standardised records of impacts through time and for different hazard types. In this respect, the documentary records modify reality by constructing the severity of, and the agency and responsibility for, the event (cf. Brandström et al., 2008; Raška et al., 2014). Moreover, the availability of documentary data varies highly through time (Guzzetti et al., 1994), and therefore affects the reliability of any time-series of social impacts. The assessment of social impacts in this study was based on a modified methodology proposed by Caloiero et al. (2014), which enables an assessment of relative direct impact. The method was applied both to individual events and to their combination. The impact score ($I_{score}$) for an individual event (or their combination) is then calculated as a weighted ratio of its cumulative impacts and maximal recorded impacts:

$$I_{score} = \left(\frac{F_j}{F_{max}} + \frac{Bdam_j}{Bdam_{max}} + \frac{Ldam_j}{Ldam_{max}} + \frac{OPaff_j}{OPaff_{max}}\right)/4$$

where $F_j$ (Fatality), $Bdam_j$ (Building damage), $Ldam_j$ (Lot damage), and $OPaff_j$ (Other property affected) are the values of the damage indicators for the hazard type or specific combination of hazard events, $j$, and $F_{max}$, $Bdam_{max}$, $Ldam_{max}$, $OPaff_{max}$ are the maximum values of the damage indicators.

The impact score gives an image of the cummulative severity of hazard events or their combination for the whole period. Along with it, we calculated an efficiency score ($E_{score}$), which – depending on data availability – provides a clue for understanding the intensity of direct impacts from individual events:

$$E_{score} = \left(\frac{Bdam_j}{Baff_j} + \frac{Ldam_j}{Laff_j}\right)/2$$

where $Bdam_j$ (Building damage), $Ldam_j$ (Lot damage), $Baff_j$ (Building affected), and $Laff_j$ (Lot affected) are the indicators of damaged and affected buildings and lots by the hazard type or specific combination of hazard events.

## 4. Results

### 4.1 The structure of the catalogue

The search in the newspaper resulted in the creation of a catalogue with 275 records that occurred from 1856–1902, including 599 individual hazard events in 41 different combinations. A clear increasing trend may be seen from the time-plot of hazard event occurrence in Figure 2, which shows that meteorological hazard events are most frequent

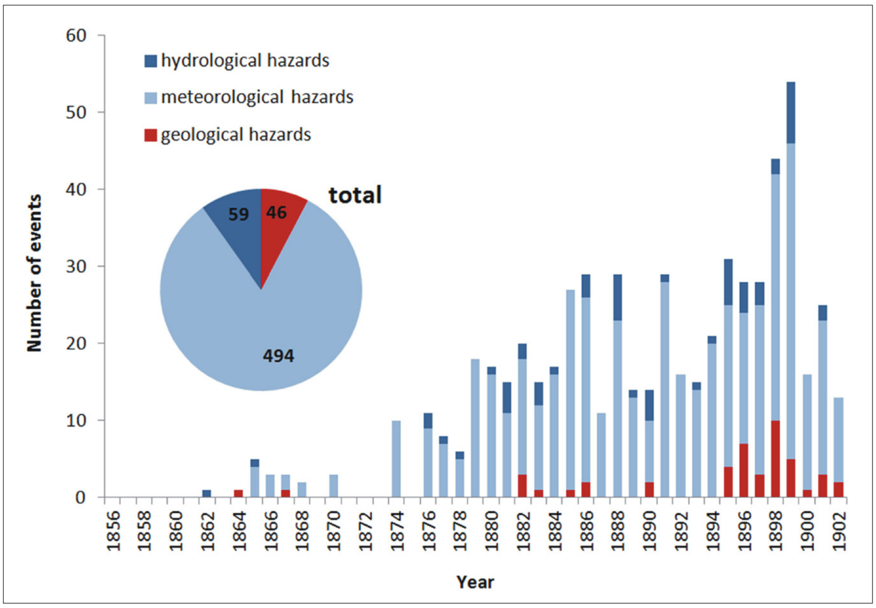


*Fig. 2: Total number of hazardous events recorded (pie chart) and temporal occurrence of hazardous events in the studied period (bar chart), by hazard group (terminology from above Tab. 1)*
*Source: authors' calculations*

in general (comprising 82.5% of the total), followed by hydrological (9.8%) and geological (7.7%) events. On the other hand, there are several cases of geological hazard events that were represented by more articles, which denote the social relevance of these events. For example, the landslide (and subsidence) in the town of Most on July 24, 1895, was reported in 21 consequent articles, and the landslide at Větruše hill in the municipality of Ústí nad Labem on August 26, 1899, was described in 17 articles. A similar extent of content description was found only for a limited number of hydrological hazard events, such as the flood in Ústí nad Labem in September, 1890, with 13 articles referring to flood and 22 to high water level.

#### 4.2 Temporal occurrence and triggers

Temporal frequency was assessed by three indicators for three periods (Tab. 2), i.e. 1856–1902 (the whole period under study), and the sub-periods of 1856–1876 and 1877–1902, which denoted a change in editorial policy. The most frequent hazard events were meteorological (rainstorm, extreme rainfall, lightning, hailstorm), whereas geological hazard events were recorded only sporadically (e.g. only 3 cases of earthquakes). This results in a total recurrence of 0.28 years for rainstorm, for instance, and 15.33 years for earthquake. Considering the time-regularity of hazard events, rainstorms and lightning were the most regular during 1856–1902 with a standard deviation of event-free intervals of only 1.58 years. In contrast, *rg* values for earthquakes and landslides were 17.72 and 7.85 years, respectively.

The occurrence of individual hazard events during the year is shown in Figure 3 and it is in agreement with the occurrence of triggers for particular hazards. The specific date (month and day) was not assigned in 14 cases and in two other cases the date was shown indirectly, referring to the 'last week' and to Christian calendar events. Among geological hazards, both landslides and rock-falls display slightly higher frequency during the late winter and spring months, resulting from freeze-thaw cycles (rock-falls) and from snow melt and precipitation totals that influenced the water saturation of soils and regolith. Hydrological

| Index | Period | EQ | LS | RF | FL | OF | RS | ER | LT | HS | WS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequency (f) | 1856–1902 | 0.07 | 0.67 | 0.26 | 0.78 | 0.50 | 3.57 | 2.33 | 3.13 | 1.15 | 0.57 |
| | 1856–1876 | 0.00 | 0.00 | 0.10 | 0.15 | 0.05 | 0.65 | 0.15 | 0.65 | 0.05 | 0.15 |
| | 1877–1902 | 0.12 | 1.19 | 0.38 | 1.27 | 0.85 | 5.81 | 4.00 | 5.04 | 2.00 | 0.88 |
| Recurrence (rc) | 1856–1902 | 15.33 | 1.48 | 3.83 | 1.28 | 2.00 | 0.28 | 0.43 | 0.32 | 0.87 | 1.77 |
| | 1856–1876 | n.a. | n.a. | 10.00 | 6.67 | 20.00 | 1.54 | 6.67 | 1.54 | 20.00 | 6.67 |
| | 1877–1902 | 8.67 | 0.84 | 2.60 | 0.79 | 1.18 | 0.17 | 0.25 | 0.20 | 0.50 | 1.13 |
| Regularity (rg) | 1856–1902 | 17.72 | 7.85 | 4.90 | 2.41 | 4.56 | 1.58 | 2.45 | 1.62 | 3.51 | 3.03 |
| | 1856–1876 | n.a. | n.a. | 3.00 | 2.87 | n.a. | 3.00 | 2.87 | 3.09 | n.a. | 5.91 |
| | 1877–1902 | 8.34 | 3.47 | 2.95 | 1.07 | 1.07 | 0.00 | 1.07 | 0.00 | 0.49 | 0.85 |

*Tab. 2: Indices of temporal occurrence of individual natural hazards and hazard-related events during the entire study period (grey) and two sub-periods (white). Legend: EQ – earthquake, LS – landslide, RF – rock-fall, FL – flood, OF – overflow, RS – rainstorm, ER – extreme rainfall, LT – lightning, HS – hailstorm, WS – windstorm, n.a. – data for calculation are not available*
*Source: authors' calculations*

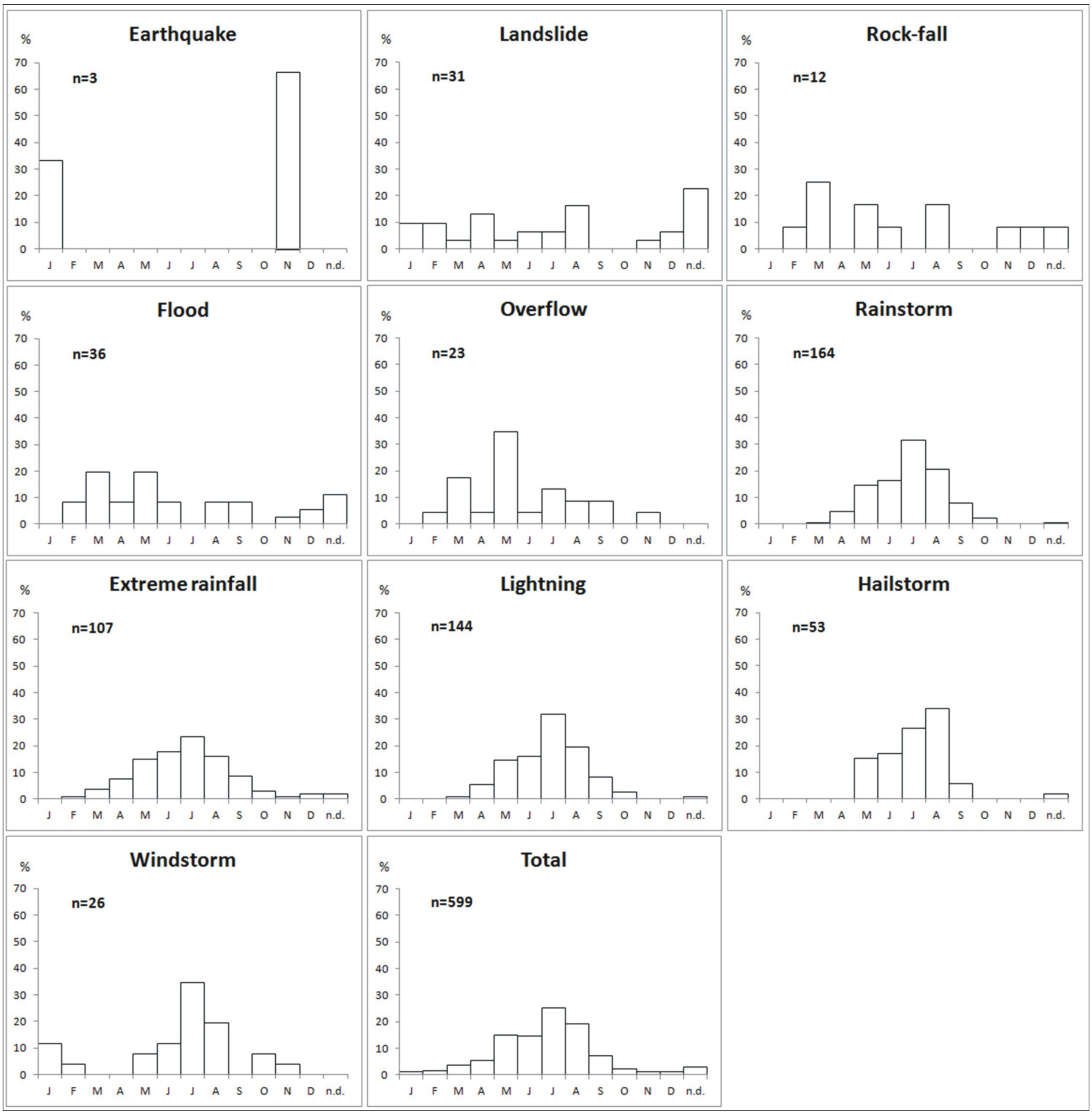


*Fig. 3: The frequency of individual natural hazards and hazard-related events, by month over the entire studied period. Source: authors' calculations*
*Note: n.d. = not dated events*

hazards have two maxima that correspond to spring (snowmelt) and summer (torrential rains) sub-periods, which are typical for Central European hydrological regimes (cf. Brázdil, 2006). Meteorological hazard events displayed highest frequencies in the summer months, namely in July (rainstorm and extreme rainfalls, lightning and windstorm) and in August (hailstorm).

### 4.3 Social impacts of natural hazards

The studied natural hazards resulted in some extreme impacts on lives and property. Various hazards caused 42 fatalities in total, which is almost one fatality per year (Fig. 4). The most threatening hazards are the meteorological ones, followed equally by hydrological and geological hazards.

Table 3 and Figure 5 provide a more detailed view on the relative direct impacts caused by individual hazard events. First, Table 3 enables the comparison of different hazard events in terms of their impacts ($I_{score}$) and intensity of these impacts ($E_{score}$). The highest values were obtained for rainstorms, present in 21 hazard combinations within 164 records and causing 31 fatalities and frequent losses of buildings, property and lots (mostly gardens), followed by lightning, which was present in 14 combinations within 144 records and causing 33 fatalities, but with lower impacts to property and lots. On the contrary, earthquake, rock-falls, floods and overflow scored lower in terms of their relative direct impacts. This needs a special explanation, particularly for floods. The study area experienced a catastrophic flood in 1890, which also affected large parts of the Czech Lands in the Vltava (Moldau) and Labe (Elbe) river catchments (cf. Brázdil, 2006; Brázdil et al., 2012). The reconstructed impact of this flood, however, is based on extent rather than on real expenses (see also the Discussion section, below). Moreover, the floods often affect

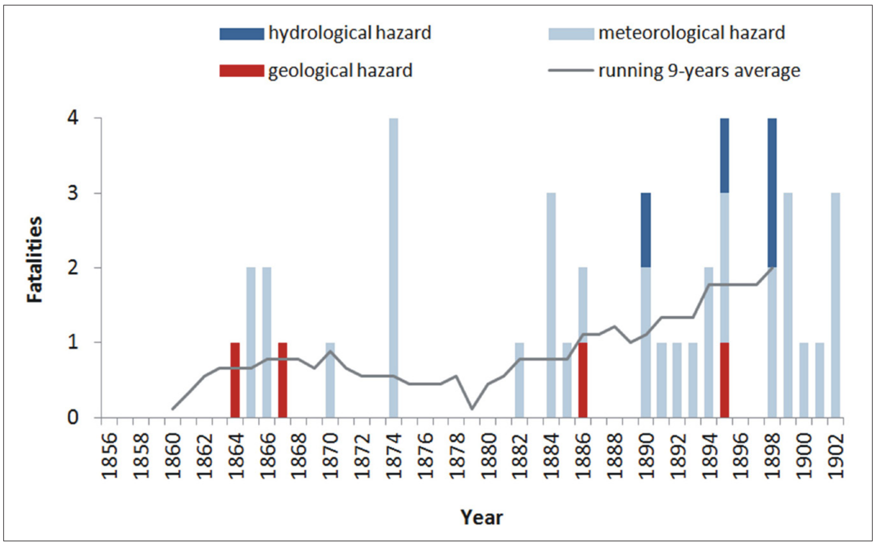


*Fig. 4: Number of fatalities due to particular groups of natural hazards. The total number of fatalities over time is indicated as a 9-year running average. Source: authors' calculations*

| | Comb. | Records | F | Baff | Bdam | Laff | Ldam | OPaff | Iscore | Escore |
|---|---|---|---|---|---|---|---|---|---|---|
| Earthquake | 2 | 3 | 0 | 2 | 1 | 0 | 0 | 2 | 0.01 | – |
| Landslide | 2 | 31 | 1 | 9 | 9 | 30 | 16 | 5 | 0.18 | 0.77 |
| Rock-fall | 2 | 12 | 3 | 3 | 3 | 3 | 2 | 2 | 0.06 | 0.83 |
| Flood | 6 | 36 | 4 | 9 | 4 | 11 | 4 | 6 | 0.10 | 0.40 |
| Overflow | 9 | 23 | 4 | 11 | 3 | 13 | 7 | 5 | 0.11 | 0.41 |
| Rainstorm | 21 | 164 | 31 | 110 | 61 | 37 | 34 | 62 | 0.97 | 0.74 |
| Extreme rainfall | 21 | 107 | 6 | 58 | 32 | 44 | 35 | 32 | 0.55 | 0.67 |
| Lightning | 14 | 144 | 33 | 112 | 62 | 18 | 17 | 61 | 0.87 | 0.75 |
| Hailstorm | 15 | 53 | 10 | 24 | 13 | 30 | 29 | 16 | 0.40 | 0.75 |
| Windstorm | 13 | 26 | 5 | 14 | 11 | 15 | 14 | 10 | 0.22 | 0.86 |

*Tab. 3: Frequencies of particular hazard events and their social impacts. Legend: Comb. – number of hazard combinations in which the hazard appeared; Records – number of records including the hazard event. Social impacts are shown as numbers of records with fatalities (F), buildings affected ($B_{aff}$), buildings damaged ($B_{dam}$), lots affected ($L_{aff}$), lots damaged ($L_{dam}$) and other property affected ($OP_{aff}$). For $I_{score}$ and $E_{score}$ (impact and efficiency scores): see text. Source: compiled and calculated by authors*

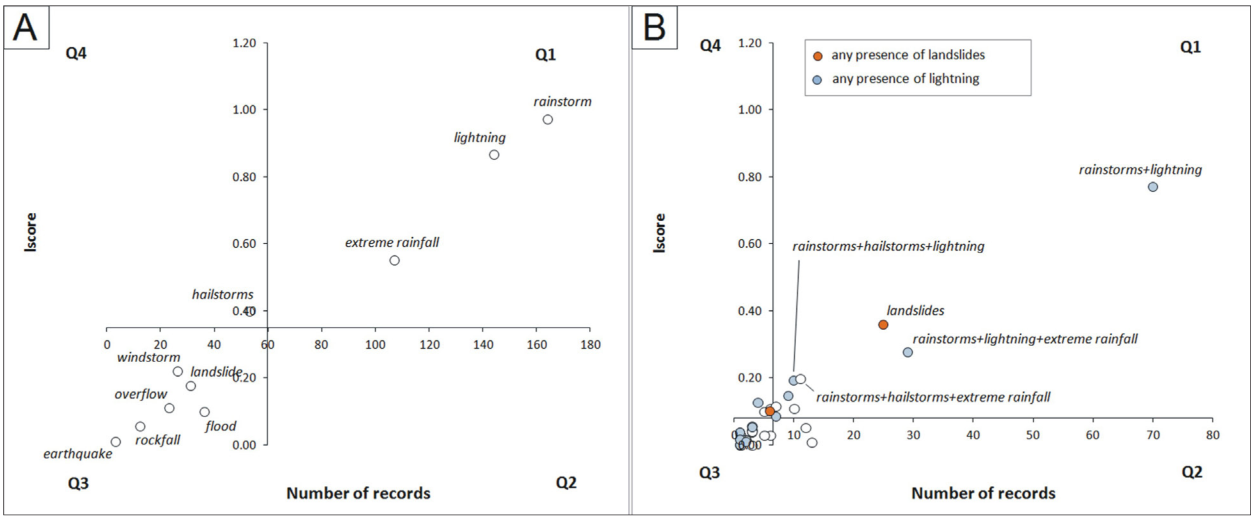


*Fig. 5: Classification of events according to their relative direct impact at the level of: (A) individual hazard events; (B) recorded combinations of hazards. Legend: Quadrants Q1 – high frequency/high impact events; Q2 – high frequency/low impacts events; Q3 – low frequency/low impact events; Q4 – low frequency/high impacts events. Number of records = number of records in which the combination or hazard type appeared. Impact score (Iscore): see text. Note: the origins of the axes are placed at the average values of the variables. Source: calculated by authors*

an extensive area and properties but do not necessarily damage or destroy the buildings, which stands in contrast to landslides or rock-falls, as illustrated by their $E_{score}$ values in Table 3.

Finally, the combination of $I_{score}$ and frequency of the individual hazard events and their combinations, shown in Figure 5, allows for the consideration of social vulnerability to manifold natural hazards based on the threat they posed. The individual hazard events and their combinations are classified as four types by the quadrants in the diagrams:

1. Q1 – high frequency/high impact events;
2. Q2 – high frequency/low impacts events;
3. Q3 – low frequency/low impact events; and
4. Q4 – low frequency/high impacts events.

The assessment of individual hazard events in Figure 5A shows that three are classified as high frequency/high impact (rainstorm, lightning and extreme rainfall), whereas all others except hailstorms are classified as low frequency/low impact events. Because the majority of hazard events that occur in combination are frequently of a causative nature (e.g. see temporal occurrence of hazard events during the year in Section 4.2), Figure 5B provides a classification of combination hazard events. The resulting values confirm the frequency statistics and impact scores shown above. The most threatening combination of hazard events in terms of their impacts and frequency in the study period was rainstorm with lightning. The most threatening combinations of hazard events are those which include hailstorms and landslides, which are also located in Q1.

It must be noted, however, that frequency of hazards (or their combinations) and $I_{score}$ are related due to nature of the documentary data. First, the source data are originally narratives transformed into binary record (presence or absence of particular impact) for each type of the impact. Such transformation always results in uncertainties. Second, more frequent reference to social impacts may be caused equally by more frequent occurrence of these impacts, as well as by higher medial attention devoted to frequent hazards; thus adding further uncertainties to the database. Therefore, a quantitative temptation to provide the regression statistics between frequency and $I_{score}$ (or between any other indices) is a kind of misconception and would provide biased results (cf. Burke, 2005, p. 36–37).

## 5. Discussion

### 5.1 Reliability of the dataset

Based on this current research, we note the following two factors that may limit the reliability of datasets created from documentary proxies. First, it must be emphasised that any time-series reconstructed from documentary proxies does not directly relate to the occurrence of the natural hazards, but to their description in the analysed sources. While partly self-evident, this point is overlooked in the scholarly literature. Therefore, the results of the newspaper search constitute a time-series of articles (perhaps, a social reflection of hazard events) rather than a time-series of the events themselves. Although such a comment may be counter-posed by saying that the documentary record must reflect real events, the absence of any such reflection as well as possible duplicities in such reflections, results in uncertainties. With respect to duplicities, two types may occur: (i) two or more local reports may refer to one single event from different perspectives (e.g. Elliott and Kirschbaum, 2007; Bíl et al., 2014), or (ii) two or more reports in sources with different territorial coverage may refer to one single event, which is known as the up-scaling and down-scaling effect (e.g. Guzzetti et al., 1994; Raška et al., 2014).

Secondly, the combination of different sources (Raška et al., 2014) and agenda setting in sources with editorial boards and/or documents underpinned by political, economic or social goals, result in significant variations in the language style and structure (e.g. McCombs and Shaw, 1972; Brandström et al., 2008). Finding a standardized sequence of reports on social impacts and disaster relief is possible only in some cases (see for example, Raška and Brázdil, 2015, for a series of reports on historical disaster relief funding). Considering the lack of standardization in documentary records in terms of injuries, expenses or figures relating to damaged infrastructure, the social impacts of historical natural hazards may be evaluated on the basis of relative direct damage (Aceto et al., 2016). This enables comparisons between the severities of various natural hazards in terms of their aggregated social impacts, but does not refer to the costs of the damage. Therefore, some hazard events may rank lower than expected (e.g. the 1890 flood in this paper). The specification of costs would be possible by a complementary search in other documentary proxies (e.g. municipal reports or bills), but these are available only for the most disastrous events.

### 5.2 Implications for long-term vulnerability assessment

The aim of this paper was to present an empirical case study showing the limits arising from the assessment of long-term variations in social vulnerability to natural hazards. In this respect, it must be noted that social vulnerability to natural hazards is herein expressed as the severity of their social impacts. Certainly, this is a more generalised approach because it does not take into account different impacts of natural hazards across groups, for example for groups with varying demographic, economic or ethnic characteristics (Cutter, 1996), or for those with different capacities to cope with the impacts of hazards (Hewitt, 1983). On the other hand, it represents a pragmatic and valid concept when studying the impact of hazard events on historical communities because only scarce data may be found for social structure in historical statistics (the first modern census in the Czech Lands was in 1869), and explicit reports on disaster relief exist only for the most severe hazard events (e.g. financial collections, exhibitions and physical help after the 1890 flood in this study). If this approach is accepted, then the implications of the research results basically stem from two arguments.

Firstly, as explained in the preceding section, there is an argument that relates to the non-standardised nature of documentary proxies that do not permit building a reliable time-series of the social impacts of natural hazards. Moreover, the growing availability of sources through time results in an increase in the documented social impacts of natural hazards, and may result in higher observed vulnerability in terms of its absolute values. The second argument is that the long-term changes in the social impacts of natural hazards are underscored equally by a growing population's exposure to these events, the adoption of new risk reduction strategies (individual and organisational learning: Pfister, 2009), as well as by understanding what may even pose a hazard. All of these factors result in non-homogeneities in any vulnerability time-series. To document these factors, Table 4 shows a simplified comparison of historical and current hazards, as referred to in this study and in current statistical reports.

Changing environmental conditions and increasing exposure to natural hazards due to population growth and urbanisation has been traditionally recognized in the literature (e.g. Brunsden and Thornes, 1979; Hufschmidt et al., 2005; Fuchs et al., 2013; Klose et al., 2015). In this study area, the population grew 4.3 times between 1869 and 2011. In the largest centre (Ústí nad Labem), this growth was represented by an increase of the urbanised area in the Q100 flood zone of the Labe (Elbe) River by approximately 200 ha. In contrast to growing exposure resulting from urbanisation, the role that adoption of new reduction strategies plays in vulnerability change through time is less addressed.

Two examples can be presented in order to illustrate the influences that social and technological development have on vulnerability. Firstly, significant changes in the factors underlying vulnerability to natural hazards are related to legislation. With respect to flood risks, for example, the first attempt to limit construction activities in flood-prone areas through territorial planning tools is registered in 1976 in Czechoslovakia. The law (Act 50/1976) noted that the function of an area may be changed following flood impacts (i.e. ex-post changes). Only lately, in Act No. 135/2001 and Act No. 183/2006, have preventive measures been included in territorial planning; thus, growing exposure to floods due to urbanisation was rigorously reflected in legislation only in the last two decades. The second example is that the increasing technical requirements of buildings have changed the vulnerability to particular natural hazards significantly. While the first lightning conductor was installed in the 1770s in Czech Lands, it only became widely adopted with new technical norms published in 1950s. During the 19$^{th}$ century, lightning thus still represented the most frequent threat to most households, but it does not cause any remarkable risks at the present.

| Database | Highest frequency | Highest number of fatalities | Highest economic impacts | Highest insured losses |
|---|---|---|---|---|
| Historical hazards in this study (1856–1902) | rainstorm with lightning | lightning | flood | Not known |
| Current hazards (EM-DAT 1993–2016) | riverine flood | climatological (heat wave) | flood | meteorological (hailstorm) |
| Current hazards (EEA 1998–2009) | meteorological (storm) | climatological (heat wave) | meteorological (storm) | meteorological (storm) |

*Tab. 4: Comparison of historical (this study) and current (Guha-Sapir et al., 2016, for the Czech Republic; EEA, 2010) natural hazards with the highest social and economic impacts*
*Sources: authors' compilation (this study); EM-DAT (Guha-Sapir et al., 2016); current hazards (EEA, 2010)*

Finally, the homogeneity of the time-series is influenced by the very definition of natural hazards in different time periods. The most obvious difference between historical and current understandings of hazards lies in the current extension of meanings to include slow-onset hazards. Most profoundly, climatic hazards such as heat and cold waves currently represent the major events with extensive direct impacts on populations (e.g. EEA, 2010). In contrast, if reported in the past, they were described mainly in terms of their agricultural impacts and were not considered a hazard or disaster. For this reason, we argue for further research devoted to changes in vulnerability based on multi-hazard databases.

## 6. Conclusions

The present research has pointed out the bias resulting from the use of time-series to assess long-term changes in social vulnerability to natural hazards, as well as from the use of such assessments as a rationale for the design of new risk reduction strategies and scenarios. First, we reconstructed the social impacts of multiple natural hazards on a historical community in North Bohemia. Using the local newspapers, a total of 275 records reporting 599 hazard events were found and were assessed in terms of their relative direct damage, and classified according to their frequency and social impacts. The highest relative direct impacts were reconstructed for rainstorms and lightning, which can be contrasted to current statistics (highest impacts by floods, heat waves, hailstorms), which illustrates the changing nature of social vulnerability to natural hazards through time.

Second, the implications of multi-hazard databases and time-series for vulnerability studies were discussed. Our main findings relate to possible non-homogeneities in multi-hazard time-series, which are caused by two principal factors: (i) lack of standardisation in reporting the hazard events (partly emerging from the combination of documentary data of very different types); and (ii) social and technological factors underlying the social impacts of various hazards in individual historical periods. While the first factor emphasises the bias caused by the varying quality and changing availability of documentary data through time, the second points to the limited representativeness of long-term vulnerability assessment if researchers do not take into account the role of urbanisation, social and technological conditions (expressed by legislation and technical norms), as well as understandings of what poses as a hazard as proclaimed through risk reduction policies. In this respect, our findings call for a broadening of interdisciplinary approaches in the evaluation of currently established time-series of natural hazards, so that they can be used to support the decisions on design and adoption of new risk reduction strategies.

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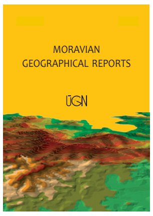


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# Comparison of the current state of non-forest woody vegetation in two contrasted case study areas in Central Europe

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***Abstract***

*Non-forest woody vegetation (NFWV), as a part of green infrastructure, has gained a great deal of attention in recent years. Despite its importance in many productive and non-productive functions, an inventory (collection of quantitative and qualitative data) on a national or even on a local level is not available in many European countries. The main aim of this study is to carry out a comparison of two study areas (lowland and upland) from the perspective of the current state of NFWV. We investigate qualitative attributes of NFWV, its relation to environmental conditions and its spatial pattern. After manual vectorization of orthophotos, qualitative data were collected in the field. Using statistical and landscape-ecological methods, the relation between NFWV and environmental conditions, as well as its spatial pattern were assessed. Substantial differences in character and in the spatial pattern of NFWV were identified between the study areas. NFWV in the upland area has a higher proportion (2.6%) than in lowland study area (1.5%), and it also has a more heterogeneous spatial structure. Statistical analysis points to a significant relation between the NFWV and land cover types in both study areas. A significant relation between NFWV and soil types was identified only in the upland area, however, while an association with potential natural vegetation was found in the lowland study area.*

***Key words:*** *non-forest woody vegetation, landscape metrics, spatial analysis, inventory, Central Europe*

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## 1. Introduction

Trees growing outside forests have received increased attention worldwide in recent years. They grow in diverse environments around the world, but the highest importance is ascribed to those areas where forests have never been recorded, or conversely, where they have disappeared. Although forests still remain a traditional topic of research and public interest, trees outside forests have emerged as a significant research issue for two main reasons. First, they have ecological impacts far beyond the proportion of land they occupy (Manning et al., 2006; Fischer et al., 2010). Second, little is known about their dynamics. In general, their areal extent has been rapidly changing worldwide since the 1950s (Bélouard and Coulon, 2002; Hidalgo and Kleinn, 2002; Manning et al., 2009). The main drivers of land use changes are mechanisation and intensification of agriculture on the one hand, and extensification and land abandonment on the other (McDonald et al., 2000; Plieninger et al., 2006; Kümmerle et al., 2006).

Trees are crucial to economic and environmental, as well as human, well-being (Editorial, 2000), but their inventory (collection of quantitative and qualitative data) is missing. The term trees outside forests, according to FAO (2001), includes all trees growing on land not defined as forest and other wooded land with an area less than 0.5 ha. It also comprises trees in urban areas, including parks and gardens, as well as permanent tree crops such as fruit trees and orchards.

This study is focused on non-forest woody vegetation (NFWV) with an area of less than 0.3 ha, which includes stable woody vegetation that is not a forest, nor an agricultural crop or a part of any built-up area in the landscape (Bulíř and Škorpík, 1987; Mareček, 2005). This term has become very popular in many research fields such as landscape planning, landscape architecture, landscape ecology or biology. NFWV is an important feature of the rural landscape because it affects not only the water infiltration and retention but it also provides microclimate, soil and biodiversity protection. It plays a significant role

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for organisms living in agricultural landscapes because it provides food, refuge and serves as a corridor or natural source for seeds (regeneration) (McCollin et al., 2000; Manning et al., 2006). It often forms a basic element of an ecological network as an essential part of the green infrastructure. NFWV supplies people with wood, flowers, fruits, but also serves as shelter, protection against wind and erosion or as demarcation of property boundaries (Harvey and Harber, 1999; Baudry et al., 2000; Mojsej and Petrovič, 2013). Moreover, it contributes to the scenic beauty of landscape and has recreational and educational functions (Hunziker, 1995; Špulerová, 2006).

Recently, many studies have investigated scattered trees, hedgerows and other types of NFWV. Most of them have focused on spatiotemporal changes in the distribution and composition (Burel and Baudry, 1990; Kristensen and Caspersen, 2002; Plieninger et al., 2012; Demková and Lipský, 2015; Skaloš et al., 2015). Other work has aimed at the relation to biodiversity (Burel, 1992; McCollin et al., 2000; Fischer and Lindenmayer, 2002; Ernoult and Alard, 2011), hydrological cycles (Eldridge and Freudenberger, 2005; Ryszkowski and Kedziora, 2007; Chandler and Chappell, 2008), microclimate (Gill et al., 2007; Sánchez et al., 2010), management and conservation (Boffa, 2000; Plieninger et al., 2003; Manning et al., 2006), or landscape memory and heritage (Schama, 1995). Only a few publications refer to methods of inventory and assessment of trees outside forests (Kleinn, 2000; Hidalgo and Kleinn, 2002; Schnell, 2015).

Nonetheless, little is known about the extent and current state of NFWV. Neither monitoring nor an inventory of NFWV on a local or even a national level is supported in the Czech Republic, Slovakia or in most other European countries. An exception is Great Britain where a regular monitoring of hedgerows is provided by the Countryside Survey (1990, 2000, 2007) on the state level (Barr and Gillespie, 2000). Only a few research studies on a local or regional level in the Czech Republic and Slovakia provide specifically quantitative information (Skaloš and Engstová, 2010; Diviaková, 2010; Demková and Lipský, 2012). The last estimates of NFWV in the Czech Republic and Slovakia were published in the 1980s (Vaníček, 1985; Moldan et al., 1990). After 1989, political and socio-economic changes resulted in dramatic landscape change (urbanisation, landscape abandonment, motorway construction etc.) (e.g. Bičík et al., 2001) that affected the amount and quality of NFWV. The Landscape mapping in 1995 in the Czech Republic was an exception, during which all the landscape features were recorded, including the NFWV throughout the entire country. The NFWV was not processed separately however (Pellantová et al., 1994). Afterwards, the Landscape mapping was replaced by the NATURA 2000 mapping, which focused only on selected landscape segments. Moreover, legislation concerning trees outside forests has changed as well. Evidence on a large scale will enable us to assess the importance of NFWV for landscape functioning and its dynamics. Also Hidalgo and Kleinn (2002) highlighted an inventory providing quantitative and qualitative data about NFWV as crucial for developing management options to help sustain tree cover in general.

Despite many studies concerning different aspects of NFWV, there are still questions that have not been addressed until today. What is the relation between NFWV and natural conditions? Does it depend on any special relief attribute, soil type, degree of nature conservation, etc.? What is the current state of riparian vegetation, alleys, solitary trees, and groves?

The main aim of this study is to assess the current state of NFWV in two study areas, the Kutnohorsko Region (Czech Republic) and the White Carpathians (Slovakia), representing distinct landscape types (lowland and upland area). More specific aims are to investigate the differences between these two regions with respect to:

a. the qualitative attributes of NFWV (shape, formation, crown cover, and habitat type);
b. relation of NFWV to environmental conditions (soil, land cover and potential natural vegetation types); and
c. the spatial pattern of NFWV.

We expect differences in the qualitative attributes of NFWV because the study areas are distinct in natural and socio-economic conditions, and in spatial pattern as well because of different land use and history. We expect a higher proportion and a more variable spatial structure of NFWV in the upland region because of variable relief and extensive land use.

## 2. Materials and methods

### *2.1 Study areas*

Two distinct landscape types were chosen as study areas – a lowland area of the Kutnohorsko Region (KH), Czech Republic, and an upland area of the White Carpathians (WC), Slovakia (see Fig. 1). In recent years, detailed research projects have been carried in these study areas (e.g., Lipský et al., 2011; Skaloš et al., 2011; Demková, 2011). Moreover, spatiotemporal changes in the distribution and composition of NFWV after 1950 were investigated in both study areas (Demková and Lipský, 2013, 2015).

The flat relief of the KH study area is formed by the wide alluvial plains of the rivers. Slopes of the Železné hory Mts. extend over the northeastern edge of the study area (for further information see Tab. 1). A mosaic of soil types has developed in the lowland depending on substrate. Fluvisols and cambisols predominate, but also chernozems and rendzic leptosols are represented in the area (Tab. 1). The soil mosaic closely corresponds to the distribution of potential natural vegetation, in which alluvial softwood and hardwood forests in the alluvial plains prevail (*Ulmeto-Quercetum*, *Pruneto-Fraxinetum*). The central part of the study area is covered by oak-hornbeam woodland (*Hercynian Melampyro nemorosi-Carpinetum*) with patches of pine-oak woodland (*Pineto-Quercetum*) on sandy substrate. Silverfir-oak (*Abieto-Quercetum*) and woodrush-oak (*Luzulo albidae-Quercetum*) woodland cover the slopes of the Železné hory Mts. (Neuhäuslová, 1998).

At present, an intensively farmed landscape with a dominant share of arable land prevails (Tab. 1). Most of the study area has a specific landscape character, however, with a diverse landscape structure due to a higher proportion of forest, as well as aesthetically motivated landscape formations around the Kačina and Žehušice castles founded in the 18th and 19th centuries (Lipský et al., 2011). Subsequently, the Landscape Conservation Area Žehušicko was declared open in 1996 in the southern and central part of the study area.

The WC study area is located in the upland terrain (for further information, see Tab. 1). Among soil types cambisols predominate, followed by regosols and rendzic leptosols

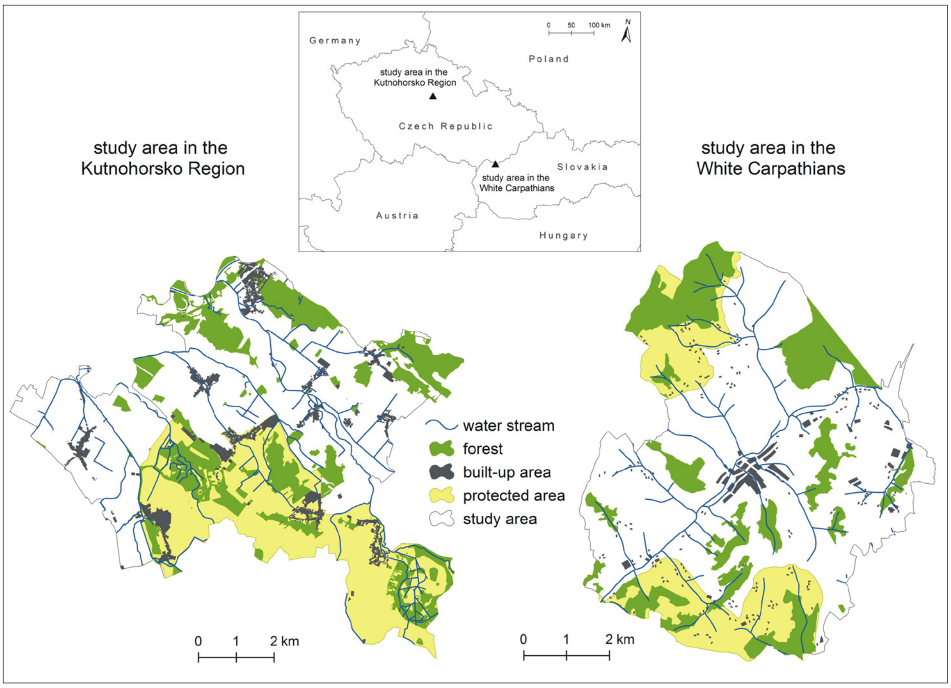


*Fig. 1: Location of the study areas*
*Source: authors´ elaboration*

| | KH | WC |
|---|---|---|
| **Geographical coordinates** | 49.9852850N, 15.3281789E | 48.7993900N, 17.4691500E |
| **Area** | 60.5 $km^2$ | 51.5 $km^2$ |
| **Altitude** | 200–320 m a.s.l. | 250–610 m a.s.l. |
| **Soil types*** | Cambisols (20.3%) | Cambisols (55.1%) |
| | Fluvisols (42.0%) | Regosols (10.7%) |
| | Chernozems (12.7%) | Rendzic leptosols (7.2%) |
| | Rendzic leptosols (3.2%) | Phaeozems (3.0%) |
| | Kastanozems (1.0%) | Fluvisols (0.2%) |
| | Forest land and urban area (20.8%) | Forest land and urban area (23.8%) |
| **Land cover**** | Arable land (65.2%) | Arable land (40.5%) |
| | Pastures (2.0%) | Permanent crops (0.5%) |
| | Woodland (19.0 %) | Pastures (19.7%) |
| | Landscape principally occupied by agriculture with significant areas of natural vegetation (6.8%) | Landscape principally occupied by agriculture with significant areas of natural vegetation (14.3%) |
| | Sport and leisure facilities (1.0%) | Complex cultivation pattern (0.7%) |
| | Urban area (6.0%) | Woodland (22.0%) |
| | | Urban area (2.3%) |
| **Potential natural vegetation***** | *Ulmeto-Quercetum* (6.4%) | *Alnion glutinosae* (11.9%) |
| | *Pruneto-Fraxinetum* (48.2%) | *Carpathian Carici pilosae-Carpinetum* (69.5%) |
| | *Hercynian Melampyro nemorosi-Carpinetum* (31.6%) | *Fagetum* (16.1%) |
| | *Pineto-Quercetum* (5.1%) | *Abieto-Fagetum* (2.5%) |
| | *Abieto-Quercetum and Luzulo albidae-Quercetum* (8.7%) | |
| **Nature and landscape conservation** | Landscape conservation area Žehušicko (35.5%) | Protected landscape area White Carpathians (24.5%) |

*Tab. 1: Basic characteristics of the study areas*
*Source: authors' compilation*
*Notes: KH – Kutnohorsko Region, WC – White Carpathians; * KH, WC: Soil maps; ** KH, WC: CORINE Land Cover data (2006); *** KH: Neuhäuslová (1998), WC: Maglocký (2002)*

(Tab. 1). Phaeozems cover narrow alluvial plains. Water streams are accompanied by submontane and montane alder floodplain forests (*Alnion glutinosae*). Carpathian oak–hornbeam woodland (*Carpathian Carici pilosae-Carpinetum*) covers the majority of the study area except for the highest parts where submontane beech (*Fagetum*) and fir-beech (*Abieto-Fagetum*) forests interfere (Maglocký, 2002).

A mosaic of fields, grasslands, orchards and forest (Tab. 1) was formed as a consequence of forest-agricultural activities of the past centuries and the dispersed type of settlement called "crofts", a typical feature of the White Carpathians. Although the intensification of agriculture has affected the upland region as well, the share of arable land has been continuously decreasing in favour of permanent grasslands. Due to high social and cultural as well as natural diversity, the Protected Landscape Area White Carpathians was declared in 1979.

### 2.2 Data sources

Data about the area of NFWV were collected by manual vectorisation of aerial images and orthophotos. All images were transformed into the S-JTSK coordinate system. NFWV in the study area KH was digitised from the 2010 orthophotos available from the Czech Environmental Information Agency (ground resolution 0.5 m), and in the WC study area from the 2006 aerial images obtained from the Topographical Institution of the Slovak Republic (aerial images were orthorectified with the final pixel resolution of 0.476 m).

Digitisation of NFWV proceeded according to spatial criteria (Bulíř and Škorpík, 1987; Sláviková, 1984; Supuka et al., 1999) in ArcMap 10.0 (ESRI Inc., 2010):

- Patch features – groups of trees and shrubs with a maximum area of 0.3 ha (small woods, groves, vegetation on marshland, on abandoned lands or localities unsuitable for any economic use);
- Linear features – one or more lines of woody vegetation with a minimum length of 30 m, a maximum width of 30 m, but up to 30% of the length (alleys, riparian vegetation, linear vegetation along railways, on balks, etc.); and
- Point features – one to three individual trees or shrubs.

The area of NFWV was set down as a projection of the tree or shrub crown. The length of linear features was measured along the centerline of the element. The data were collected only for non-forest areas and outside urban localities.

The present state of NFWV was verified and mapped in the field during the growing seasons of 2010 and 2011 in order to collect qualitative information on its character. The following attributes were described:

- Formation – tree, shrub or mixed (according to Sláviková, 1987; Kolařík et al., 2003);
- Crown cover – continuous, gapped, solitaire (according to Sláviková, 1987; Kolařík et al., 2003); and
- Habitat type – water streams and water areas, roads and railways, wet sites and springs, erosive depressions, balks, plot boundaries, unused, abandoned sites, technical constructions, secular or religious monuments, designed landscape (for more information see Demková and Lipský, 2012, 2015).

After that, we analysed the relation of NFWV to the following environmental conditions:

- soil types derived from the Soil maps 1 : 5,000 (Soil Science and Conservation Research Institute, Slovak Republic; Research Institute for Soil and Water Conservation, Czech Republic) and named according to IUSS Working Group WRB (2006) nomenclature;
- land cover types derived from the CORINE Land Cover data 2006 (Slovak Environment Agency 1 : 50,000; Czech Environmental Information Agency 1 : 100,000);
- potential natural vegetation types derived from the Maps of potential natural vegetation 1 : 500,000 (Maglocký, 2002; Neuhäuslová, 1998); and
- nature and landscape conservation (protected landscape area, landscape conservation area).

### 2.3 Data analysis

NFWV in the study areas was compared based on its attributes (shape, formation, crown cover, habitat type). For the purpose of comparison, the area of each class was divided by the area of the study site ($m^2/km^2$).

The relationship between the areal extent of NFWV and environmental conditions (categorical explanatory variables) was explored by the non-parametric Kruskal-Wallis one-way analysis of variance at a confidence level $p = 0.05$. Statistical analyses were performed using STATISTICA (StatSoft Inc., 2009).

In order to evaluate differences in spatial pattern and internal interactions of individual NFWV units between study areas, basic landscape metrics (Tab. 2) were measured using the ArcGIS extensions Patch Analyst 5.1 (Rempel et al., 2012) and V-LATE 2.0 beta (Lang and Tiede, 2003). Such metrics have been widely used in landscape ecology as indicators of landscape heterogeneity, connectivity or fragmentation (Botequilha-Leitão et al., 2006; Skaloš and Engstová, 2010; Mallinis et al., 2011).

## 3. Results

### 3.1 Current state of non-forest woody vegetation in the study areas

The proportion of NFWV in the KH study area is 1.5%, while in WC 2.6% (Tab. 3). All three shape classes (linear, patch, point) have higher proportion in the study area WC (Fig. 2). Linear features have the highest proportion of the NFWV in both study areas (85% in WC and 88% in KH).

In WC, NFWV is connected especially with agrarian balks, erosive depressions and plot boundaries, which have only low representation in KH. A more balanced representation in both study areas is seen for NFWV along roads, water streams and water areas or on wet sites. In KH, it is also related to designed landscapes, and to secular and religious monuments with very low proportions, but they are not presented at all in the WC study area (Fig. 2).

From the aspect of formation (Fig. 2), mixed vegetation (trees and shrubs together) dominates in both study areas (mainly in linear and patch features). NFWV in KH has a higher proportion of tree formation (particularly in point and patch features). On the contrary, shrub formations have higher representation in WC. Continuous crown cover dominates in WC, while gapped NFWV is slightly more abundant in KH. In particular, linear features along roads, water streams and drainage channels in KH are not continuous. The solitary NFWV has only very small representation in both study areas (Fig. 2).

| Metrics | Units | Description | Function |
|---|---|---|---|
| Class area proportion | % | The proportion of the class area in the study area | Fragmentation |
| Patch density | No/km$^2$ | The number of polygons in the class per square km (total area of the study area) | Landscape heterogeneity, fragmentation |
| Mean patch size | m$^2$ | The average area of all polygons in the class | Habitat size, fragmentation |
| Edge density | m/ha | The total edge of all edge segments in the class to the total area of the study area | Ecotones, edge effect |
| Mean nearest neighbour distance | - | The average of distances from a patch to the nearest neighbouring patch of the same class (based on edge-to-edge distance) for each class | Degree of isolation, connectivity |
| Shannon's diversity index | - | The sum, across all classes, of the proportional abundance of each class multiplied by that proportion | Landscape heterogeneity |
| Relative length of linear vegetation | km/km$^2$ | The total length of all linear features to the total area of the study area | Connectivity |

*Tab. 2:Landscape metrics used for spatial pattern analysis*
*Source: authors' compilation (after McGarigal et al., 2002; Botequilha-Leitão et al., 2006; Skaloš and Engstová, 2010)*

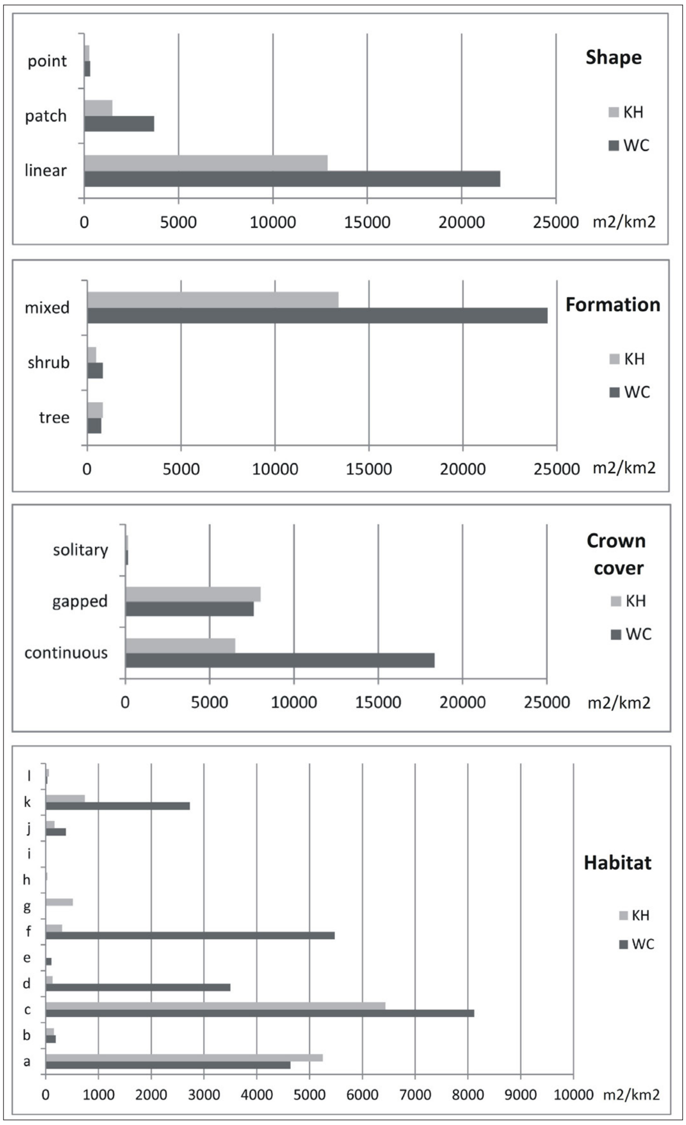


*Fig. 2: Areal representation of non-forest woody vegetation in the White Carpathians and the Kutnohorsko Region according to mapped attributes (in m$^2$/km$^2$ of the study area). Source: authors' calculations*
*Legend: KH – Kutnohorsko Region, WC – White Carpathians; a – roads; b – wet sites; c – water streams and water areas; d – erosive depressions; e – stone balks; f – balks; g – designed landscape; h – religious monuments; i – secular monuments; j – unused places, abandoned; k – plot boundaries; l – technical constructions*

| NFWV | Class area proportion (%) | | Patch density (No/km$^2$) | | Mean patch size (m$^2$) | | Edge density (m/ha) | | Mean nearest neighbour distance | | Shannon's diversity index | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | KH | WC | KH | WC | KH | WC | KH | WC | KH | WC | KH | WC |
| Linear | 1.3 | 2.2 | 7 | 12 | 1,735 | 1,804 | 44 | 39 | 38 | 40 | - | - |
| Patch | 0.2 | 0.4 | 2 | 13 | 722 | 293 | 2 | 8 | 158 | 77 | - | - |
| Point | 0.03 | 0.03 | 6 | 10 | 48 | 32 | 1 | 2 | 113 | 79 | - | - |
| Total | 1.5 | 2.6 | 15 | 35 | 953 | 742 | 47 | 48 | 83 | 65 | 0.42 | 0.48 |

*Tab. 3: Spatial pattern of non-forest woody vegetation in the study areas expressed by landscape metrics (KH – Kutnohorsko Region, WC – White Carpathians)*
*Source: authors' calculations*

### 3.2 Relation of non-forest woody vegetation to environmental conditions

The relations between NFWV and environmental conditions vary widely in the study areas. While in WC the distribution of NFWV is significantly affected by soil and land cover types (soil types: H(5, 1809) = 55.659; $p < 0.0001$; land cover: H(3, 1809) = 13.756; p = 0.0033), in KH it is significantly related only to land cover types (H(4, 928) = 9.536; p = 0.0490). Despite the non-significant relation of NFWV to soil types (H(4, 928) = 2.123; p = 0.7131), it is evident that linear vegetation in KH relates to chernozems, while point and patch features are associated particularly with fluvisols occurring on the alluvial plains. The same relations were determined in WC for phaeozems. On the other hand, the lowest proportion of NFWV is on cambisols in both study areas. In terms of land cover, NFWV has a higher proportion in extensively farmed landscape types, such as land principally occupied by agriculture, with significant areas of natural vegetation and pastures in both study areas. Furthermore, a high proportion was recognized in complex cultivation patterns in WC and in sport and leisure facilities in KH (in this case, the park around Kačina castle).

Conversely, the relation between NFWV and potential natural vegetation was detected in WC as non-significant (H(4, 1809) = 8.659; p = 0.0702), but in KH as significant (H(5, 928) = 20.052; p = 0.0012). Among potential natural vegetation types in KH, the highest proportion of NFWV relates to elm-oak woodland (*Ulmeto-Quercetum*) (especially patch and point NFWV) and bird cherry-ash woodland (*Pruneto-Fraxinetum*) (mainly linear vegetation in the alluvial plains).

Differences in the relative area of NFWV between the protected and unprotected areas of both study areas are significant in all three NFWV shape types. A higher proportion of patch and point vegetation is found inside the Landscape Conservation Area of Žehušicko in KH, while linear NFWV has a higher proportion outside the protected area. On the contrary, a higher representation of all NFWV shape types is located outside the Protected Landscape Area of the White Carpathians.

### 3.3 Spatial pattern of non-forest woody vegetation

The landscape metrics point to higher heterogeneity in the WC study area, expressed by a higher patch density in all NFWV classes, higher class area proportion for linear and patch vegetation, as well as by slightly higher Shannon's diversity index of NFWV (Tab. 3). Comparing the study areas, substantially higher patch density was detected for patch vegetation in WC. On the contrary, mean patch size of patch vegetation is two and half times higher in KH. Nevertheless, linear and point vegetation has similar mean patch size in both study areas (Tab. 3). The mean nearest neighbour distance index of point and patch vegetation is higher in KH, which corresponds closely with patch density. Both metrics point to a lower connectivity of these classes in KH. On the other hand, linear NFWV shows similar values in both study areas. The relative length of linear vegetation is higher in KH (2.2 km/km$^2$) than in WC (1.8 km/km$^2$). Therefore, the edge density of linear NFWV is higher in KH as well (Tab. 3).

## 4. Discussion

Considerable differences in the current state of NFWV were recognized between the KH and WC study areas. The higher proportion of NFWV in the study area WC (2.6%) than in KH (1.5%) results from natural conditions that determine land use. KH represents an intensively farmed landscape where NFWV is still considered to be a barrier or negative feature. This confirms the extent of NFVW just on agricultural land, which is substantially larger in WC (3.4%) than in KH (2.1%). According to Machovec (1994), NFWV should cover at least 1.5% of agricultural land to properly provide environmental functions. The proportion of NFWV in KH is higher than this limit as a consequence of the alluvial landscape character (riparian vegetation in alluvial plains) and the landscaping activities in the past around Kačina and Žehušice castles (castle parks and game reserves), which were preserved to the present. On the other hand, there are parts with large open fields where NFWV is absent. The distribution of NFWV in this study area is substantially uneven. Therefore it is necessary to fill the gaps and set measures that eliminate wind erosion and increase the retention ability of the landscape.

The current state of NFWV is related to its historical development, which was investigated in previous studies (Demková, Lipský, 2012, 2015). Since the 1950s, NFWV has rapidly decreased in both study sites due to collectivisation and land re-allotment during the communist era. Lack of protection of this vegetation in the latter period led to the removal of a lot of natural features such as NFWV or wet sites, which hindered the intensification of agriculture and increasing building development. Moreover, land abandonment, typical for upland areas, caused overgrowth of non-forested sites with NFWV and their transformation to forest (Plieninger et al., 2006; Kümmerle et al., 2006; Demková, Lipský, 2015). In recent years, a small increase in NFWV has been recognised in the upland study area, particularly due to enlarging existing vegetation (especially linear features).

As mentioned above, NFWV was not protected during the socialist era, only in cases of special historical, cultural or natural value. Absence of any legislative protection resulted in the decrease of NFWV, as documented by Demková and Lipský (2012, 2015). NFWV in general has started to be an integral part of nature conservation as trees outside forests since the 1990s, which prevented them from unreasonable removal and subsequently contributed to their better current condition. Even so, management measures for their maintenance are still absent. Manning et al. (2009) emphasise that management should be an integral part of conservation objectives and agricultural activities in modified landscapes as well.

Linear vegetation is the dominant shape class of NFWV in both study areas. Its relative length reaches higher values in KH than in WC even though the area is smaller. Alluvial plains in KH, which comprise about 40% of the study area, provide appropriate conditions for riparian vegetation. Many linear features, however, do not form continuous cover, especially those along the roads and drainage channels. In WC, continuous linear vegetation dominates particularly along the erosive depressions, plot boundaries and agrarian balks, while it is mostly gapped along the water streams and roads. In this context, we would like to point out the restoration needs of old and absent vegetation in both study areas.

Among the mapped attributes of NFWV, the habitat type of NFWV is partially determined by land use. In both study areas, vegetation along roads, streams and water areas dominates. There are habitat types, however, that can be considered typical for their study area. In KH, NFWV is connected with landscaping activities, while in WC it relates to erosive depressions and agrarian balks, especially stone balks.

The designed landscape around the castles with managed parks in KH has contributed to a higher concentration of tree vegetation in that study area (especially patch and point features), which is still managed (elimination of succession). Conversely, a higher concentration of shrub formation is found in WC where shrubs spread naturally by succession caused by landscape abandonment.

With respect to the relation of NFWV and environmental conditions, the results of this study support some of the conclusions of Sklenička et al. (2009), who also investigated relations between hedgerows and natural conditions. Their results confirm a higher relation of hedgerows to extensively farmed landscape types such as grasslands and a mosaic of fields, grasslands and orchards, which corresponds with our findings. On the other hand, they also noted the dependence of hedgerows on soil fertility, where a higher proportion of NFWV was on less fertile soils. Our results show the opposite. It comes from a high proportion of riparian vegetation in both study areas growing on fertile soil types, such as fluvisols and phaeozems, and other vegetation growing on chernozems.

The assumption that nature and landscape conservation (protected landscape area, landscape conservation area) contributes to a higher concentration of NFWV was not confirmed in both study areas. Only patch and point vegetation have higher proportions in the protected area of the KH study area. This NFWV is a result of the previously-mentioned landscaping activities around the castles and has a specifically aesthetic function. Linear vegetation is more concentrated outside of the protected area because a larger area of alluvial plains lies out of the protected area.

In WC, the relation between NFWV and geomorphological attributes such as altitude, slope and aspect was investigated as well (Demková and Lipský, 2015). Unfortunately, it cannot be compared with KH because of the flat relief with minimal altitude.

Landscape structure affects ecological processes (McGarigal et al., 2002). In this study, landscape structure is more heterogeneous in the WC study area than in KH. It seems also to be less fragmented in WC although the mean patch size shows higher values in KH. Lower patch density in KH in comparison with WC, causes a higher index of mean nearest neighbour distance (Tab. 3). This index represents a simple expression of the degree of isolation among features of the same class. It does not take into account their size and counts only distances between two features (Botequilha-Leitão et al., 2006). Nevertheless, both metrics point to the low density of smaller vegetation features in the KH study area, which plays an important role for optimal functioning of the landscape, its ecological stability and landscape character as well. On the other hand, the relative length indicates a higher connectivity of linear vegetation in KH. Skaloš and Engstová (2010) also compared patch density of NFWV and the relative length of tree alleys between two different study areas and concluded that the lowland study site had higher values of both metrics (relative length of tree alleys 1.8 km/km$^2$; patch density 86 No/km$^2$) than the upland study site (relative length of tree alleys 0.5 km/km$^2$; patch density 11 No/km$^2$). In comparison, however, NFWV in their study also comprises NFWV inside the village. Nevertheless, patch density in the lowland study site is markedly higher in their study than in ours, probably due to purposeful planting activities intended to increase biodiversity (Skaloš and Engstová, 2010).

A classification of NFWV according to prevailing woody plants (trees and shrubs), shape (linear, point and patch) and spatial criteria was also used by Plieninger et al. (2012). They distinguished eight classes of NFWV based on all three attributes combined. By contrast, many studies are only concerned with tree vegetation – scattered trees, isolated trees or trees outside forests (Bellefontaine et al., 2002; Levin et al., 2009; Manning et al., 2009; DeMars et al., 2010). Other studies concentrate on linear elements such as hedgerows (Burel, 1992; Barr and Gillespie, 2000; McCollin et al., 2000; Sklenička et al., 2009; Sánchez et al., 2010). Skaloš and Engstová (2010) and Skaloš et al. (2015) included not only scattered woody vegetation in the open landscapes, but also settlement vegetation in their research projects.

To determine the NFWV, the method of manual digitalisation of aerial photographs was applied, which is very laborious on the one hand but precise as it enables one to identify individual tree crowns. The same method was used by several other authors (Kleinn, 2000; Plieninger et al., 2012; Skaloš et al., 2015, etc.). Even Brown and Fisher (2009) concluded that manual digitisation is the most reliable method of mapping trees outside forests, although it is very time-consuming. In both of our study sites, aerial photo interpretation was verified during the field mapping in order to collect data about the condition of NFWV.

The two study areas, which were chosen to compare the current state of NFWV, have been recently investigated in terms of spatiotemporal changes of NFWV (Demková, Lipský, 2012, 2015). Although they represent just two landscape types - intensively farmed lowland and extensively used forest-agricultural upland - they provide a sufficient amount of data for testing the hypothesis. A comparison of the two contrasting types of study sites from the viewpoint of NFWV was also published by Skaloš and Engstová (2010) and Plieninger (2012). Both of these studies, however, present long-term changes in rates and distribution of NFWV, not a comparison of the current state from different perspectives. In this context, it will be beneficial to include in the research more localities of the same landscape type across the country, or more distinct landscape types to compare and verify the findings. Another challenge will be to apply additional methods of delineating NFWV (i.e. the official classification according to the Land Cadastre) and not only delineation based on spatial criteria.

## 5. Conclusions

Comparing two different study areas, we found that the proportion of NFWV in the lowland study site is lower than in the upland study site. Lowland NFWV is more gapped, isolated and its distribution is greatly unbalanced. Only linear vegetation shows a similar density in comparison with the upland area. Among habitat types, agrarian balks (especially stone balks), and erosive depressions were identified as typical for the upland study area, while in the lowland area NFWV connected with designed landscapes and monuments is very common. The differences between the study sites result from distinct natural conditions that influenced the different historical development of land use. The results also show a significant relation of NFWV to land cover types (especially to extensively farmed land cover types), partially to soil types, and to potential natural vegetation. More study sites are necessary, however, to verify these results in future research.

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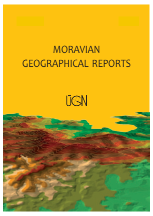


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# Environmental factors influencing the distribution of agricultural terraces: Case study of Horný Tisovník, Slovakia

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## Abstract

*The cadastral district of Horný Tisovník represents a traditionally managed Carpathian mountain agricultural landscape with extensive terraces. It was historically governed by two counties with different feudal economic systems – agricultural and industrial. This paper aims to enrich traditional methods in environmental history. We applied geospatial statistics and multivariate data analysis for the assessment of environmental factors influencing the distribution of agricultural terraces. Using linear models, the hypothesis was tested that the terrace distribution is functionally related to selected factors (affiliation to the historic counties; average altitude and slope; distance from water, buildings and settlements; units of natural potential vegetation; and current land use). Significantly greater amounts of terraces were located in the agricultural county compared to the industrial county. A principal component analysis showed the coincidence between the current agricultural land use and higher concentrations of terraces occurring in lower altitudes, closer to settlements and buildings, and within the unit of Carpathian oak-hornbeam forests. These findings regarding the most significant factors influencing the distribution of terraces are used in proposals for incentives to improve the management of the traditional agricultural landscape.*

***Keywords:*** *agricultural terraces, traditional landscapes, environmental history, multivariate analysis, Slovakia*

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## 1. Introduction

Landscapes rich in agrobiodiversity are often the product of complex farming systems that have developed in response to the unique physical conditions of a given location, as well as to cultural and social influences (Altieri, 1999). Traditional agricultural landscapes (TALs), characterised by a complex stratified palimpsest of patterned human activity through time, are physical records of agriculture, risk management strategies, building technology, environmental change and historical ecology (Ericson, 2003). Agricultural terraces are valued from the cultural and historical viewpoints as specific features of TALs (Špulerová and Petrovič, 2011).

The terraced field is the most frequent landform that developed after contour ploughing (Stankoviansky, 2001). Terraced slopes have long formed integral elements of Mediterranean landscapes. To northern Europeans, such a landscape often evokes romantic and idyllic images. In reality, however, these landscapes are better perceived as human responses to a harsh and demanding environment (Rolé, 2007). Agricultural terraces in Slovakia form a relevant part of agricultural history, yet their function in the traditional agricultural landscape, as well as their conservation, is under-researched. There are official policy documents that focus to some extent on TALs (Špulerová and Petrovič, 2011), and in 2005 Slovakia adopted the European Landscape Convention (CoE, 2000), which proclaimed the preservation and the maintenance of the characteristic Slovakian landscape types. TALs, however, are not subject to any specific national protection policy (Slámová et al., 2013), even though they do represent a significant part of a Slovakian landscape typology.

Terrace soils are distinctive features of the agricultural landscape in Europe. A considerable number of papers on terraced systems and soils were reviewed, with a focus on Southern Europe. A complete inventory of terraced areas is not available, however, and the total terraced surface is therefore unknown (Stanchi et al., 2012). Terraces deserve considerable research investment to understand how

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different historical and environmental contexts affected their cycles of construction, use and abandonment (Bevan et al., 2013). Comprehensive studies on agricultural landscapes with terraces, interpreting their context with respect to the natural environment, including human interactions, however, have appeared in the last ten years in Slovakia (Lieskovský et al., 2014; Lieskovský et al., 2015).

This article aims to examine the historical and natural factors influencing the distribution of terraces in a Slovakian case study area. In this context, we present the implementation of methodologies from landscape ecology into the field of environmental history. Environmental history is a relatively new scientific field, which has developed recently in Slovakia (Holec, 2014; Hronček, 2014). Classic works of earlier environmental historians often lacked scientific credibility, as traditional historians interpreted a history mainly from written materials and such an approach has its limits in the reconstruction of many of the most interesting aspects of past environmental relations (Lewis, 2014). Today, environmental history seeks to incorporate new approaches to previous methodologies. In this article, geospatial and statistical analysis are employed in exploring the context among terraces and several examined factors.

## 2. Objectives of the research

The main aim of this article is to assess the impact of various environmental factors on the establishment and distribution of relict agricultural terraces in the study area in light of their historical genesis. Interest from researchers in this topic has increased in recent decades. For example, McCane et al. (2010), Fall et al. (2012) and Quintus et al., (2015) have reported results on relationships among terraces and settlements. Agnoletti et al. (2015) evaluated the influence of natural factors on terraces, while Bevan et al. (2013) used a broad-spectrum approach. In this work, we focused on the assessment of relationships among terraces and selected factors from natural and human environments using multivariate analysis.

We selected and tested environmental factors which could hypothetically influence the distribution of terraces in the cadastral district of Horný Tisovník. The following factors were chosen on the basis of previously published works and also the characteristics of the study area: a) affiliation to the historic counties of Divín or Modrý Kameň; b) average altitude; c) average slope; d) distance from water; e) distance from buildings and settlements; f) natural potential vegetation (Carpathian oak-hornbeam forest, sub-mountainous beech forest or beech and fir-beech forest); and g) current land use (forests classified as 'JPRL' - units of the spatial division of forests' and 'OLP' – 'other wooded land'; agricultural land).

The National Forest Centre (Slovakia) (NFC) specified both forests categories for the purpose of forest management planning and Slovak acronyms were applied in the article. 'OLP' units correspond with agricultural land overgrown with a forest which still has not been classified as a forest bearing productive and protective functions (NFC, 2015).

The cadastral district was historically governed by two counties with different feudal economic systems - agricultural and industrial. Affiliation to the historic counties was interpreted according to known literature (Balasa, 1960). We assumed that different economic systems influenced terrace distribution in the countryside. Hypothetically, an agriculturally-based county would prefer agricultural land with terraces on gentle slopes; at lower altitudes, terraces would be found predominantly in the southern part of the county. Similar research has been conducted by de Blois et al. (2001): models of relationships among determinants of vegetation cover in two agro-forested landscapes that had differed by some environmental factors and historic land use, confirmed the dominant effect of historical factors on vegetation patterns.

Further, we tested terrace distances from water and settlements in order to show that positive relationships would be expected in the study area according to known data from previous research conducted in similar traditionally-used agricultural areas in Slovakia (Lieskovský et al., 2015). A south-north geo-climatic gradient, combined with ascending altitude (from the south to the north of the cadastral district), could hypothetically affect the establishment the terraces in the study area: hence, an examination of terrace distribution within units of natural potential vegetation was carried out. Generally, soil types are considered to be a relevant agronomic factor in an agricultural survey. In the case of the study area, we did not examine the relationship between soil types and terraces, as cambisols and cultisoils prevail and no specific influence of soil types on terrace distribution would be expected.

## 3. Study area of Horný Tisovník

TALs cover an area of 56,068 ha of Slovakia, which is 11.43% of the total area (49,035 km$^2$) (data from Atlas of the Slovak Republic, Miklós and Hrčiarová, 2002). Terraces are typical forms of landscape mosaic of the traditional agrarian ("plough land – meadow – grazing") landscape archetype in Slovakia. They have persisted predominantly in marginal agricultural sub-mountainous and mountainous areas, and, even there, only locally (Hreško et al., 2010).

The cadastral district of Horný Tisovník is located in the Western Carpathian Mountains in central Slovakia: almost half of the agricultural land is traditionally managed (Fig. 1) and an extensive terrace system spreads on the slopes of the mountains. It lies in the region of the Central Slovakian Neovolcanites where andesitic and pyroclastic rocks prevail. Tuffs and tuffites occur locally. Slightly fertile, slightly deep and deep modal cambisols, and neutral-to-acid cultisols spread over the terraces in the study area. Rankers and pseudogleyic cambisols occurred only locally (Miklós and Hrnčiarová, 2002).

The district is divided into western and eastern parts by the Tisovník water course. This stream also formed the administrative boundary between two former counties of the district: Modrý Kameň and Divín (Fig. 1). The first interactions between a human population and the landscape are assumed to have been established in the Middle Bronze Age (1500 to 1200 BCE) near Bralo Hill (723 m a.s.l.) (Balasa, 1960). During the 14$^{th}$ and 15$^{th}$ centuries, settlement in the mountainous areas of northern and central Slovakia, including the Tisovník district, was supplemented by shepherds of Romanian and Ruthenian origin in a process known as the Wallachian colonisation. Over the next century, the colonisation expanded to the west and the bearer of it was then the Slovak population (Špulerová et al., 2014).

The first written record of the villages of Dolný Tisovník and Horný Tisovník dates back to the year 1548. After

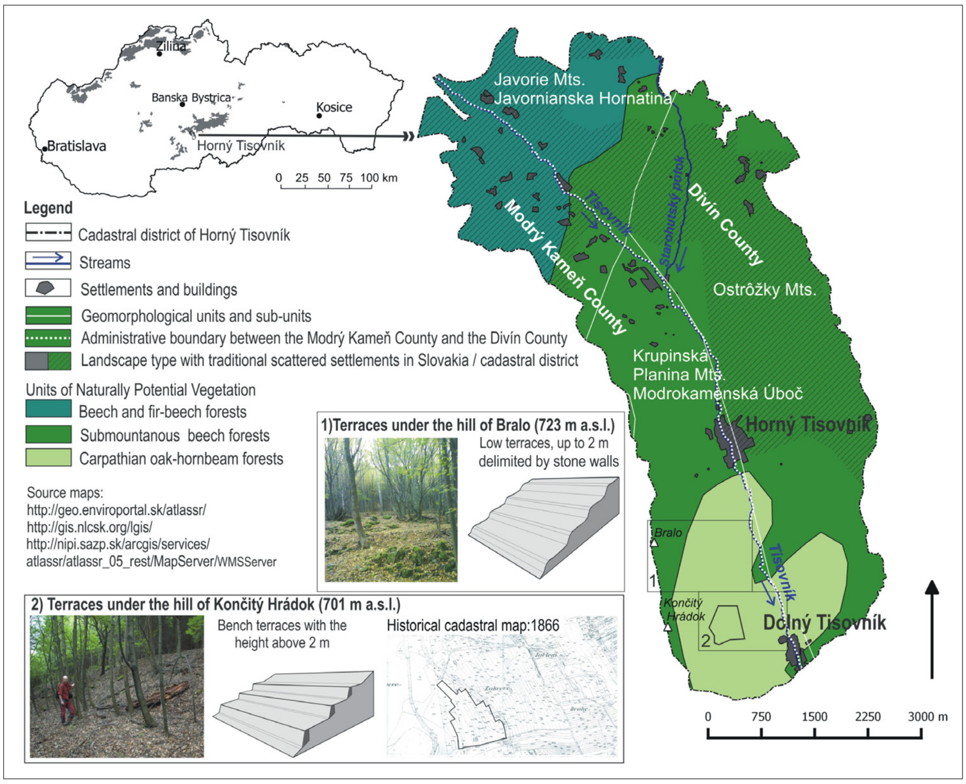


*Fig. 1: Traditional agricultural landscapes, natural and historical units and boundaries of the study area*
*Source: Compiled by authors*

that date, the study area was divided into counties and terrace farming was established[1]. Scattered settlements were formed concurrently with terrace farming activities, beginning in the 16th century in Modrý Kameň County, while pastoral and industrial activities prevailed in Divín County. The formerly dense natural forests were gradually cut down during the Balassa family administration from the 16th to the 19th centuries. A large part of the timber production was processed locally (sawmill, charcoal burning) or transported to the wider Hungarian Empire (Alberty et al., 1989). During the 19th century, three glassworks were founded and the demand for wood increased. This is when the population peaked (Borovszky, 1911).

An unfavourable geographical position, with difficult access to the relevant residential and economic centres and communications, resulted in a cadastral district in the marginal regions (Horňák and Rochovská, 2007). In the studied district, extensive farming prevails; almost half (48.19%) of the district (31.17 $km^2$) is covered by a traditional agricultural landscape with scattered settlements (15.02 $km^2$) (Miklós and Hrnčiarová, 2002).

According to existing typologies (Lasanta et al., 2013), we identified the following types of terraces in the field (2010):

1. terraces represented by small slope gradients that are delimited by herbaceous vegetation or a wall made from stones that were removed from cultivated fields (under Bralo Hill); and
2. bench terraces on higher slope gradients which are built up by stones (Končitý Hrádok Hill) (Fig. 1).

## 4. Methods and data

In the following sections, we describe: (i) the data collection procedures for the terraces still present in the study area and the comparison of terrace distributions between current and historical maps; and (ii) the process of data collection, multivariate analysis and correlations of the environmental factors influencing terrace distribution in the countryside.

Descriptive statistics were processed using a free and open source geographic information system (GIS), Quantum GIS (QGIS), version QGIS 2.8.3 Wien. Public raster maps were accessed by a QGIS web map server (WMS) client and selected data were digitised and saved as vector files. The coordinate reference system S-JTSK (Fero) /Krovak (EPSG code 2065) was applied in all maps.

Testing the influence of the chosen factors on terrace distribution (terrace length in a grid cell) encompassed the following steps: extracting the data from maps by QGIS 2.8.3 Wien; pre-processing data in MS Excel; correlation, analysis of variance (ANOVA), and linear regression analysis by the statistical discovery software JMP 7.0.1 for Windows (SAS, 2015); and visualisation of demonstrated relationships by RDA ordination using the licensed CANOCO for Windows 4.52 (Ter Braak and Šmilauer, 2003).

### 4.1 Terraces data

Varotto and Ferrarese (2008) provided the concept of new classification instruments for a comparative assessment of terraced landscapes within the European Interreg ALPTER project. In this article, we only applied basic parameters

[1] County is a historical territorial unit whose Slovak equivalent is "župa", respectively “stolica” as a territorial unit of the feudal government. Both historical territories had regional dimensions.In this paper we use the term county instead of a manor, although the examined areas (Modrý Kameň and Divín) represent territorial units at a lower administrative level (so called "panstvo").

characterising the density of terraces. Our GIS survey on terraces limited data acquisition from publicly available maps. Thus, only basic geospatial parameters of the terraces were calculated and analysed: frequency [n]; length [km], [percentage]; and density [km/km$^2$]. Terraces were digitised from topographic 'ZM' maps (1 : 10,000) provided by Geoportál (2015).

A visual comparison of the current land use of terraces and historical land use of terraces reported on maps of the second military mapping (1819–1827; 1837–1858) (SEA, 2015) was carried out in two localities where terraces were identified in the field (2010).

In the next steps, a terrace's length in a grid cell was used as an expression of terrace distribution and analysed as a dependent variable in linear models (analysis of variance, linear regression and multivariate analysis). Geospatial data about terrace length was estimated in a vector grid (100 × 100 m) covering the whole study area. The grid was generated by QGIS Research Tool, Vector Grid. Raw GIS data were pre-processed in MS Excel 2010.

### *4.2 Testing environmental factors*

(i) Affiliation to historic county: There were two possible affiliations in the Tisovník district: Modrý Kameň and Divín. Modrý Kameň County historically focused on crop production on agricultural terraces. On the other hand, in Divín County industrial production was preferred. Historic counties were digitised according to known archival sources (Martuliak, 2006) and vectorised.

(ii) Terrain (altitude and slope): Altitude as another tested factor has been shown by Dobrovodská (2006) to limit agriculture in several localities in the Carpathian Mountains in Slovakia. Slope steepness is considered to be not only a determinant for building terraces but also a crucial factor affecting terrace preservation and the preservation of traditional arable fields in general. Previous analyses showed that fields with slopes steeper than 11 ° remained in small parcels and were not collectivised (Lieskovský et al., 2014). Terrain parameters such as the average slope [°] and the average altitude (absolute) [m a.s.l.] were derived from the digital terrain model (DTM) with a resolution 10 × 10 m per pixel (DTM 3.5) using the Zonal statistics QGIS plugin. A DTM provides a bare earth representation of terrain or surface topography and it is a vector data set composed of regularly spaced points and natural features. DTM 3.5 was provided by The Geodesy, Cartography and Cadastre Authority of the Slovak Republic, under the license contract No. 55-11-2290/2015. The resolution of the DTM 3.5 corresponds with the resolution of topographic 'ZM' maps (1 : 10,000) (Geoportál, 2015), which were used for the vectorisation of terraces. Contour lines derived from the DTM 3.5 correspond with hypsographic data of 'ZBGIS' maps (Geoportál, 2015) which are currently the most accurate maps in Slovakia.

(iii) Distance from watercourses, settlements and buildings: The geological substrate of neovolcanic formations (prevailing in the study area) constitutes poor conditions for surface water accumulation. Thus, the distance of terraces from watercourses is considered to be a limiting factor for their establishment in the study area. Distance from settlements can be a factor in terrace foundation as well as their preservation. Lieskovský et al. (2015) characterised distances of terraces from settlements as an important factor for their preservation in the case of TAL with dispersed settlements and TAL with arable land and grasslands. Distances of terraces from watercourses, settlements and buildings were calculated within buffer zones with a regular interval of 100 m using QGIS plugin Multi Ring Buffer. Settlements and buildings were digitised from the 'ZBGIS' maps (Geoportál, 2015), interpreted by polygon centroids and their frequency [n] was evaluated.

(iv) Potential natural vegetation: Potential natural vegetation (Miklós and Hrnčiarová, 2002) reflects geo-climatic and soil conditions and also the basic agronomic potential of the area. In the studied cadastral district, there is ascending altitude from south to the north, which is mirrored in the occurrence of different potential vegetation types. Carpathian oak-hornbeam forests potentially occur southernmost, sub-mountainous beech forests in the central part, and beech and fir-beech forests in the northern part (Fig. 1). We vectorised existing raster maps of potential natural vegetation and the vector maps were used for further analysis.

(v) Current land use: Based on the study of Agnoletti et al. (2015) from the Mediterranean region, terraces can be found both in areas of utilised agricultural land use and in forests and semi-natural areas.

The occurrence of terraces was analysed in agricultural and forest land use. Forest landscape was differentiated into general forests, which we designated as 'units of the spatial division of forests' (JPRL) and 'other wooded land' (OLP) (categorisation according to NFC, 2015). OLP is land not classified as "Forest", spanning more than 0.5 hectares, with trees higher than 5 m and a canopy cover of 5–10%, or trees able to reach these thresholds in situ, or with a combined cover of shrubs, bushes and trees above 10%. It does not include land that is predominantly under agricultural or urban land use (FAO, 2010). OLPs are characterised by the overgrowing of agricultural land with a forest which has arisen and significantly increased since the 1980s in Slovakia (Kurčíková, 2013). OLP units correspond with land covered by successive vegetation that has undergone the reforestation process and still has not been classified as a forest bearing productive and protective functions.

### *4.3 Analysing the distribution of terraces and impacts of factors*

The MS Excel sheet prepared for the analysis had 3,200 rows, each representing one grid cell of the study area. In each row, there was one column with the terrace length and 12 columns representing the level or category of tested factors in the given grid cell.

To examine the correlations among the occurrence of terraces and tested factors, Spearman's rho-correlation coefficients were calculated. We applied statistical tools to identify significant relationship among geospatial variables in 3,200 squares of the study area. We assumed that positive autocorrelations between neighbouring squares appear but testing spatial dependency among variables was out of the scope of this article. However, identification of significant spatial clusters in the countryside would be realized in further work and enrich current research.

Linear regression was used to test the impact of continuous numeral factors (average slope, average altitude, distances of terraces from watercourses, settlements and buildings, units of land use and naturally potential vegetation). The null hypothesis tested was that the independent variables have no effect on terrace length. One-way ANOVA was used for the nominal category of historical county, with the two possible values of '1' or '0' in the analysis. The null hypothesis was that the terrace length is the same in both historic counties (Divín or Modrý Kameň). The nature of the impact (whether positive or negative) is provided by the variance explained by the regression model (indicated by the F-statistic), as well as the significance of the impact.

The relationships found between terrace length and the chosen factors, as well as among the factors themselves, were further visualised by the CANOCO programme using PCA ordination (principal component analysis). Originally, this program was developed and is used for the visualisation of ecological communities' composition of species and testing factors underlying these compositions. This research demonstrates other possible ways to apply this software in the field of environmental history, likewise enriching the landscape ecology. Using this software requires modification of the categorical variables entering the PCA analysis: each unit of the plot is analysed as one sample with 13 characteristics (first is the [dependable] terrace length in the specific unit, and the 12 other variables are the aforementioned tested factors): see Table 1.

## 5. Results

### *5.1 Characteristics of the terraced landscape*

(i) The characteristics of the terrace spatial distribution: Terraces are most positively influenced by the natural environment, particularly by the geo-climatic gradient, approximated in the study by potential natural vegetation, but also by slope, water availability or land use. The highest density (12.29 km/km$^2$) was found in the Carpathian oak-hornbeam forests. This unit exhibited the most favourable natural conditions for agriculture: the average altitude reached the lowest value and the average slope reached the second lowest value (458 m a.s.l. / 11.68 °) of any evaluated units. We found terrace walls covered by trees on historical maps of the second military mapping as well, as they were confirmed in the field (Fig. 2). Roots of trees strengthened terrace walls and improved the erosion control effectiveness of terraces. The lowest density was observed on the other hand in the sub-mountainous beech forests and beech-fir forests (3.37 km/km$^2$) in the northern part of the cadastral district (Tab. 2).

(ii) Testing effects of environmental factors on terraces by linear regression: Terraces were mostly built in sites of the Carpathian oak-hornbeam forests, where today agricultural land use predominates or in some places covered currently by so-called other wooded land (OLP). The occurrence of terraces is also positively correlated with increasing distance from buildings of settlements. The most significant negative relationship was observed among length of terraces and higher average altitude, and beech and fir-beech forests that are currently covered by production forests (JPRL). On the other hand, the negative relationship was significantly lower in areas with steeper slopes, increasing distance from watercourses and sub-mountainous beech forests (Tab. 3).

(iii) Differences in terraces distribution in the two historic counties: The density of terraces was significantly higher in Modrý Kameň County (9.14 km/km$^2$) than in Divín County (4.40 km/km$^2$). In comparison with Divín County, Modrý Kameň County's average altitude is lower, the plots have milder slope and the watercourses are closer. Up to the present, agricultural land use has a higher proportion here than in Divín County (Tab. 3).

| Factors | Measurement of value | | Range of variation | Unit of measurement |
|---|---|---|---|---|
| | Categorical | Continuous | | |
| *Historic units* | | | | |
| – affiliation to the historic county of Divín | X | | 1 (yes) or 0 (no) | |
| – affiliation to the historic county of Modrý Kameň | X | | 1 (yes) or 0 (no) | |
| *Limiting distances* | | | | |
| – the distance from water | | X | 100–1,000 | [m] |
| – the distance from buildings and settlements | | X | 100–1,550 | [m] |
| *Natural conditions* | | | | |
| – the average altitude | | X | 348.10–816.10 | [m a.s.l.] |
| – the average slope | | X | 2.03-28.87 | [°] |
| – naturally potential vegetation 'Carpathian oak-hornbeam forests' | | x* | 0–100 | [%] |
| – naturally potential vegetation 'beech forests' | | x | 0–100 | [%] |
| – naturally potential vegetation 'beech and fir-beech forests' | | x | 0–100 | [%] |
| *Current land use* | | | | |
| – **current land use 'forests classified as JPRL' | | x | 0–100 | [%] |
| – ***current land use 'forests classified as OLP' | | x | 0–100 | [%] |
| – current land use 'agricultural land' | | x | 0–100 | [%] |

*Tab. 1: Characteristics of environmental factors influencing the distribution of agricultural terraces*
*Source: authors' compilation and calculations*
*Notes: * The lower case 'x' represents a proportion from 100%; ** JPRL – 'units of the spatial division of forests', OLP – 'other wooded land' (categorisation according to NFC, 2015); *** OLP land is the difference between land parcels, registered as JPRL and land parcels registered only as forests. OLP units correspond with agricultural land overgrown with a forest which still has not been classified as a forest bearing productive and protective functions.*

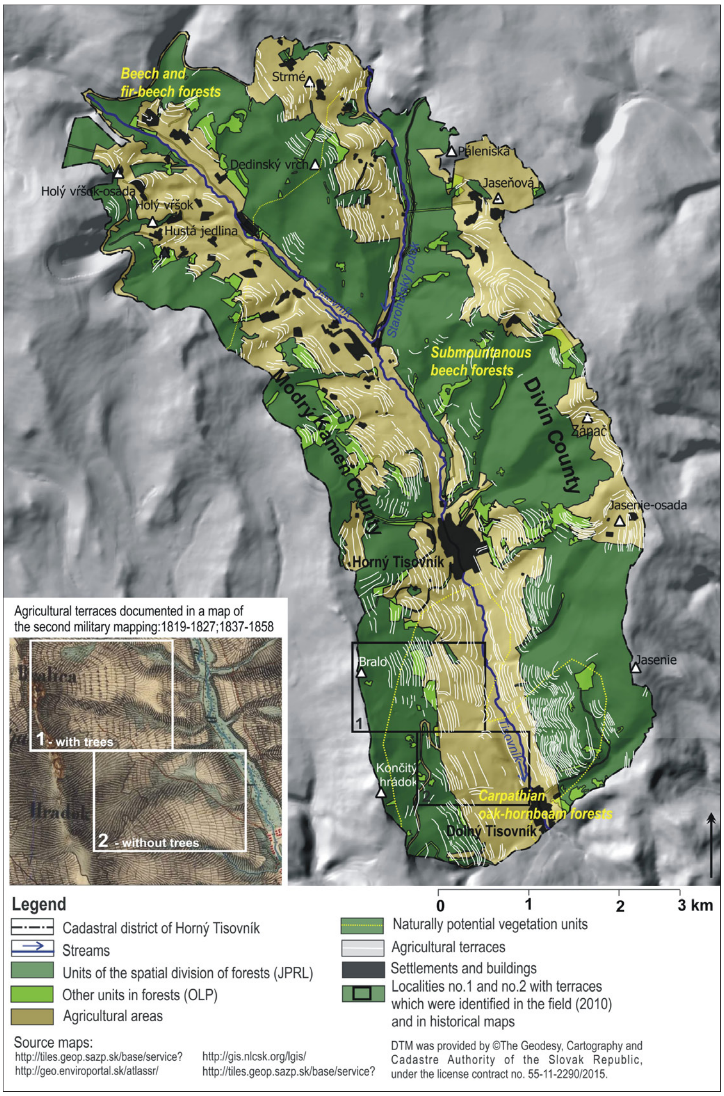


*Fig. 2: Spatial distribution and types of terraces in the cadastral district of Horný Tisovník*
*Source: authors' compilation*

| Geospatial parameters | | Agricultural terraces in units of the cadastral district of Horný Tisovník | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Length of terraces | | Area of units | | Density of terraces | Average altitude of terraces/ units | Average slope of terraces/ units |
| | | [km] | [%] | [km$^2$] | [%] | [km/km$^2$] | [m a.s.l. ] | [°] |
| Cadastral district | | 195.63 | 100.00 | 31.17 | 100.00 | 6.28 | 557/592 | 13.67/14.09 |
| Current land use | *Forests JPRL | 78.84 | 40.30 | 17.78 | 57.04 | 4.43 | 560/604 | 15.38/12.92 |
| | **OLP within forests | 17.79 | 9.09 | 1.98 | 6.35 | 8.98 | 581/584 | 15.80/14.69 |
| | Agricultural land | 116.79 | 59.70 | 13.39 | 42.96 | 8.72 | 554/560 | 12.49/11.06 |
| Potential natural vegetation | Carpathian oak-hornbeam forest | 61.10 | 31.23 | 4.98 | 15.98 | 12.27 | 460/458 | 12.82/11.68 |
| | Sub-mountainous beech forests | 114.06 | 58.30 | 20.11 | 64.52 | 5.67 | 586/597 | 14.13/14.57 |
| | Beech and fir-beech forests | 20.47 | 10.46 | 6.08 | 19.50 | 3.37 | 679/683 | 13.58/14.48 |
| Historic counties | Divín | 82.82 | 42.34 | 18.83 | 60.41 | 4.40 | 595/625 | 14.14/14.63 |
| | Modrý Kameň | 112.81 | 57.66 | 12.34 | 39.59 | 9.14 | 504/542 | 13.66/13.28 |

*Tab. 2: The distribution of agricultural terraces in relation to environmental factors*
*Source: authors' calculations*
*Note: *JPRL – 'units of the spatial division of forests'; OLP –'other wooded land' (categorisation according to NFC, 2015); **OLP land is the difference between land parcels, registered as JPRL and land parcels registered only as forests*

| Factors (variables)* | One-way ANOVA: Distribution of terraces expressed in length [m] as dependent variables; County as categorical independent variable | | | | Linear regression: Length [m] is dependent variable and the impact of various factors (independent variables) on it is tested | | |
|---|---|---|---|---|---|---|---|
| | Divín County (mean) | Modrý Kameň County (mean) | F | p | Positive/negative relationship | F | p |
| Length of terraces | 56.2 | 64.9 | 3.1 | 0.047 | | | |
| Carpathian oak – hornbeam forests | 14.0 | 16.5 | 2.0 | -- | + | 293.9 | < 0.0001 |
| Agricultural land use | 33.3 | 52 | 68.3 | < 0.001 | + | 206.9 | < 0.0001 |
| Distance of terraces from settlements and building | 559.0 | 540.6 | 1.5 | -- | + | 79.1 | < 0.0001 |
| **OLP within forests | 5.5 | 6.8 | 2.7 | -- | + | 14.1 | 0.0002 |
| Sub-mountainous beech forests | 61.4 | 59.1 | 1.6 | -- | – | 5.1 | 0.0234 |
| Water distance | 428.8 | 387.6 | 6.7 | 0.0012 | – | 7.5 | 0.0062 |
| Average slope | 14.4 | 13.4 | 16.2 | < 0.001 | – | 11.9 | 0.0006 |
| JPRL of forests | 59.5 | 44.0 | 45.2 | < 0.001 | – | 101.2 | < 0.0001 |
| Beech and fir forests | 24.6 | 24.4 | 0.47 | -- | – | 131.3 | < 0.0001 |
| Average altitude (m a. s. l.) | 603.1 | 590.7 | 5.31 | 0.005 | – | 166.5 | < 0.0001 |

*Tab. 3: Testing effects of environmental factors on terraces*
*Source: authors' calculations*
*Notes: *The list of variables is ordered according to the linear regression overall test statistic F; ** JPRL – 'units of the spatial division of forests'; OLP –'other wooded land' (categorisation according to NFC, 2015); F = value of F test statistic; p = significance level (probability): -- = p > 0.05*

### 5.2 Correlations among the factors influencing terrace distribution: CANOCO visualisation

Visualised correlations among the factors influencing terrace distribution in both counties (Divín and Modrý Kameň) indicated the existence of significant relationships between terrace distribution and some of examined factors. As we can see in the CANOCO visualisation (Figs. 3a and 3b), terraces in Divín County were situated not only in the Carpathian oak hornbeam forest, where agricultural land use prevails today, but also in the sub-mountainous beech forest, which is currently forested. They would occur on steeper slopes there. The first canonical axis explains 47.7% of the variance in the data, the second 43.6%: together they explain 91.3% of the variance (3a).

In Modrý Kameň (3b) the terraces would predominantly be situated in the Carpathian oak hornbeam forests at lower altitudes on gentle slopes, where agricultural land prevails today. Their occurrence was negatively correlated with higher altitudes, steeper slopes, and, correspondingly with the unit of sub-mountainous beech and beech and fir forests and increasing distance from watercourses. The first canonical axis explains 72.5% of the variance in the data, the second 17.4%: together they explain 89.9% of the variance.

Divín and Modrý Kameň would not differ in the remaining factors – for example, the relative distribution of all types of potential vegetation was similar in both counties. There

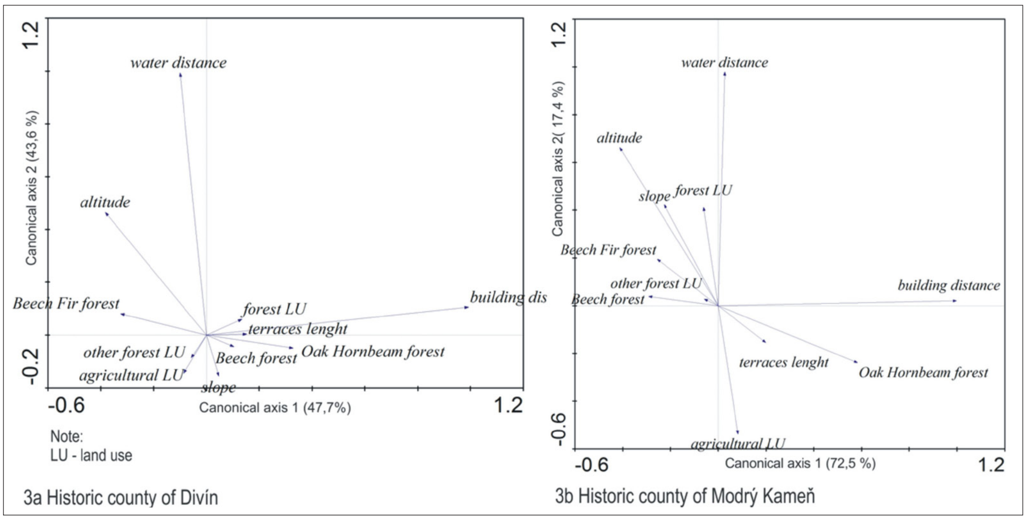


*Fig. 3: Visualised correlations (CANOCO) among the factors influencing terrace distribution in both counties – Divín (3a) and Modrý Kameň (3b) using the CANOCO ordination method (principal component analysis)*
*Source: a uthors' calculations*

are other similarities as well: settlements are similarly dispersed in both counties, and the other wooded lands occur in similar percentages there.

Correlations among all tested factors are summarised in Table 4. Positive correlations, in general, exist among the increasing distance from watercourses, rising altitude, slope steepness, the units of natural potential vegetation represented by sub-mountainous beech forests and in higher altitude by beech and fir forests. In high altitude areas, the current land use consists of forests (JPRL and OLP within forests) and settlements and buildings. While the southernmost Carpathian oak-hornbeam forests comprised only 54 buildings and the single village of Dolný Tisovník, sub- mountainous beech forests comprised 365 buildings and the village of Horný Tisovník. Beech and beech-fir forests comprised 159 buildings, which were dispersed on the slopes, and no villages had developed there.

From the negative correlations, we see that the Carpathian oak-hornbeam forests and current agricultural land uses do not occur at higher altitudes, but near the watercourses and on gentle slopes. The negative correlation of decreasing watercourse distance and steep slopes shows that the steep slopes of the foothills of the valley, close to watercourses, were not used for agriculture. The current agricultural land use probably respects the traditional enclave that had developed in the lower elevations and also closer to the position of settlements and buildings (its area shrinks with the increasing distance from buildings and settlements).

## 6. Discussion

Economic growth and prosperity most often are at the expense of the natural environment. On the other hand, humans changed 'natural' landscapes into semi-natural or cultural ones, and in the course of time these

| | | **Slope average** | **Altitude average** | **Historic county** | | **Potential vegetation units forests (% of grid cell)** | | | **Current land use (% of grid cell)** | | | **Water distance** | **Building distance** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Divín | Modrý Kameň | Carpathian oak-hornbeam | Submountainous beech | Beech and fir | Forests *(JPRL) | Other forests (OLP) | Agri-cultural land | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | r | | | | | | | | | | | | |
| | p | | | | | | | | | | | | |
| 2 | r | 0.2039 | | | | | | | | | | | |
| | p | 0.0001 | | | | | | | | | | | |
| 3 | r | 0.0641 | 0.1588 | | | | | | | | | | |
| | p | 0.0002 | 0.0001 | | | | | | | | | | |
| 4 | r | – 0.154 | – 0.2582 | – 0.9126 | | | | | | | | | |
| | p | 0.0001 | 0.0001 | 0.0001 | | | | | | | | | |
| 5 | r | – 0.2089 | – 0.5229 | – 0.2729 | 0.2832 | | | | | | | | |
| | p | 0.0001 | 0.0001 | 0.0001 | 0.0001 | | | | | | | | |
| 6 | r | 0.1467 | – 0.0495 | 0.2653 | – 0.2733 | – 0.5228 | | | | | | | |
| | p | 0.0001 | 0.0046 | 0.0001 | 0.0001 | 0.0001 | | | | | | | |
| 7 | r | 0.0089 | 0.496 | – 0.0721 | 0.0725 | – 0.2466 | – 0.6972 | | | | | | |
| | p | | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | | | | | | |
| 8 | r | 0.5589 | 0.1574 | 0.1639 | – 0.2295 | – 0.0807 | 0.1719 | – 0.1275 | | | | | |
| | p | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | | | | | |
| 9 | r | 0.0932 | – 0.0184 | – 0.0195 | 0.0079 | – 0.0264 | 0.0419 | – 0.0255 | 0.1977 | | | | |
| | p | 0.0001 | | | | | 0.0163 | | 0.0001 | | | | |
| 10 | r | – 0.5324 | – 0.2736 | – 0.1546 | 0.2301 | 0.1347 | – 0.0545 | – 0.0513 | – 0.8997 | – 0.1625 | | | |
| | p | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0018 | 0.0033 | 0.0001 | 0.0001 | | | |
| 11 | r | – 0.0547 | 0.4782 | 0.2822 | – 0.3611 | – 0.1646 | 0.0678 | 0.0613 | 0.1386 | – 0.0615 | – 0.2233 | | |
| | p | 0.0017 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0004 | 0.0001 | 0.0004 | 0.0001 | | |
| 12 | r | – 0.0621 | – 0.337 | 0.0128 | – 0.0212 | 0.4063 | – 0.0602 | – 0.2733 | 0.0697 | – 0.0619 | – 0.0373 | 0.0159 | |
| | p | 0.0004 | 0.0001 | | | 0.0001 | 0.0006 | 0.0001 | 0.0001 | 0.0004 | 0.0329 | | |

*Tab. 4: Summary table of correlations among the factors influencing terrace distribution*
*Source: authors' calculations*
*Note: * JPRL – 'units of the spatial division of forests'; OLP –'other wooded land' (categorisation according to NFC, 2015); p-value is not shown, where p > 0.05*

acquired an intrinsic value. It is often said that knowledge of environmental history is a prerequisite for future management (Nienhuis, 2008). The sources from which environmental history is to be written can and must themselves be placed into the interaction model to connect it to the critical method that lies behind every truth-claiming statement about the past (Hoffman, 2014). This article comprises a basic evaluation of the density of terraces and brings new insights into the environmental factors influencing the foundation of the terraces, as well as partially indicated reasons for their current abandonment.

The basic attributes of the terraces: length (195.6 km) and density (6.3 km/km$^2$) were worth considering in the cadastral district of Horný Tisovník for this particular research. In comparison, Swiechovicz (2002) indicated the density of terraces within the range from 0.8 km/km$^2$ to 1.0 km/km$^2$ in a similar Carpathian sub-mountain agricultural landscape in the water catchment area of Stara Rzeka in Poland. In Italy, Agnoletti et al. (2015) reported a high density of terraces in the Mediterranean Tuscany region (40 km/km$^2$), where terraces occur more frequently than in Carpathian countries. The comparison of a terrace density among similar agricultural landscapes, however, is problematic due to several reasons as noted by Varotto and Ferrarese (2008). The quality of scientific evidence crucially depends on the technical and technological equipment used for data acquisition and their further applications in different research areas (Chudy et al., 2014). In the case of the study area, the accuracy of terrace data could be improved. Currently, we use the DTM 3.5 which represents a corrected DTM 3 that had a hypsographic accuracy ± 2.5 m (locally worse) (Geoportál, 2015). Thus, an application of light detection and ranging scanners, professional global satellite navigation systems or photogrammetric methods has become a challenge for our future research.

Every landscape has a unique history and distinct characteristics. Landscape history shows complex and many-sided histories, indicating periods of relative stability alternating with periods of transformations (Renes, 2015). Our findings led us to the conclusion that the parallel existence of different feudal management systems implied the evolution of the specific ‘agriculturally industrial’ type of cultural landscape in the cadastral district.

A significantly greater amount of terraces was found in Modrý Kameň County than in Divín. These counties differed also in the average levels of some factors. For example, the current land use in Divín today is predominantly forest, while in Modrý Kameň it is agricultural land. This might be connected with the overall features of the landscape in the counties. Divín lies at a higher altitude and its plots have an on-average steeper slope, while the plots of Modrý Kameň are closer to water streams. Altitude exhibited negative correlations with terraces in all cases. Therefore, we can sustain the statement by Dobrovodská (2006) that it is a limiting factor for agriculture in the Carpathian Mountains. The terraces’ length positively correlated with steeper slopes in Divín County, where wood-processing, industrial and pastoral activities prevailed.

The primary reason for the expansion of agricultural terraces, beginning in the 16$^{th}$ century, was industrial growth. Intensive agricultural activity initiated erosion processes, which were reported in archival materials. Alberty et al. (1989) documented, moreover, the relocation of washed-up soil from the cultivated fields and transportation back by animal carriages or manually by inhabitants in wicker baskets in the study area. Midriak (2008) observed the average intensity of water erosion processes in the study area; 15 $m^3 . ha^1 . yr^{-1}$ (1.5 $mm . yr^{-1}$) on the deforested land (previous 100–150 years) on andesitic rocks (580–675 m a.s.l.). These findings correspond with official standards and limits on permitted soil erosion rates declared in the executive regulation No. 59/2013 on Land Use and Protection (Ministry of Agriculture and Rural Development of the Slovak Republic, 2013). Panagos et al. (2015), however, within the frame of conservation practices on steep slopes, recommended the application of policy instruments of Good Agricultural Environmental Conditions to all Member States implementing contour farming in slopes of less than 10% (5.72 °). Stone walls and grass margins positively affect reductions in soil loss, as reported by Panagos et al. (2015). Slope steepness of more than 11 ° was observed to be one of the essential and conditional factors determining terrace preservation in current land use (Lieskovský et al., 2014) in Slovakia. These investigations correspond with our results. Terraces were preserved in agricultural land use with an average slope of 11 ° up to the present and have to be retained in the future.

On the other hand, nearly half of the terrace length within JPRL (17.78 km$^2$) and OLP (1.98 km$^2$) (78.84 km; 40.30%) was covered by forests due to recent natural succession processes in the cadastral district. In Italy, Agnoletti et al. (2011) presented similar results on progressive rural area abandonment in the Lamole study area (Italy), where they documented around 40% of the terracing lost in only fifty years, and 10% of those still remaining are affected by secondary successions following the abandonment of farming activities. The vanishing of traditional landscapes with its typical features (farming terraces, olive yards, and upland grasslands, etc.) is a phenomenon in many European countries. It has been recorded over the past 50 years in many Mediterranean countries (Sluis et al., 2014; Agnoletti, 2014; Petanidou et al., 2008), some countries in Western Europe (Garzía-Ruiz and Lana-Renault, 2011) and without doubt in former Soviet Union countries, as well as in the case of Slovakia (Lieskovský et al., 2015). Corresponding to findings of previous authors, we have also confirmed terrace abandonment in the cadastral district of Horný Tisovník.

Although we observed a negative relationship between terrace distribution and distance from buildings within the cadastral district, the factor of the terraces’ availability should be considered when future terrace management is planned, as pointed out by Lieskovský et al. (2015). Further, we expected that terraces would be predominantly built in the vicinity of water resources. Correlations of distances between terraces and watercourses, however, did not show any significant associations. Therefore, correlations of distances between terraces and watercourses should also be enriched by the distances of terraces from water springs. Water springs data were not available for this research and the analysis should be repeated including this information in the future.

The distribution of terraces is correlated positively with Carpathian oak-hornbeam forests and lower altitudes. Natural conditions in this forest unit were the most suitable for agricultural activities in the past. Therefore, we expected that colonisation started from the southern part of the cadastral district. The Carpathian oak-hornbeam forests predominantly cover intra-mountain basins and the foothills of mountains in Slovakia. This unit covers 11,907.51 km$^2$ (24.28%) (data from the Atlas of the Slovak Republic, Miklós and Hrčiarová, 2002) of the total territory of Slovakia (49,035 km$^2$) and it is relatively less represented in the study area (15.98%). No survey has been carried out to examine the positive relationship between terraces and the Carpathian oak-hornbeam forests in Slovakia. Therefore, on the basis of our results, such research is required in the near future.

## 7. Conclusions

Ordination methods are frequently used in biogeographic studies. Later, multivariate statistics gradually spread into landscape ecology research, and this article represents their broader application in the field of environmental history.

We observed evident differences in terrace distribution within both historical territories governed by different feudal economic systems with different natural conditions. Significantly, a greater amount of terraces was found in Modrý Kameň County than in Divín. These counties differed also in the average levels of some factors. For example, the current land use in Divín today is predominantly forest, while in Modrý Kameň it is agricultural land. This might be connected with the overall landscape features: Divín lies at a higher altitude and its plots have on-average steeper slopes, while the plots of Modrý Kameň are closer to water streams.

With respect to natural conditions, we found that terraces are most positively influenced by the ecological potential of the area. They were mostly built in sites of the Carpathian oak-hornbeam forests, where today agricultural land use predominates or in some places covered currently by so-called other wooded lands (OLP). Carpathian oak-hornbeam forests comprise the unit, natural conditions were the most suitable for agricultural activities in the past, and where actively used agricultural land persists today. On the other hand, terraces were significantly less represented in areas with higher altitudes, greater slopes, plots at greater distances from watercourses, and those within the unit of potential natural vegetation of Sub-mountain Beech forests and Beech-Fir forests that are currently covered by the production forests (JPRL).

Agricultural terraces were historically built also in the sites currently classified as OLP, on slopes steeper than the average slope of the evaluated terraces. Most likely due to steep slopes, terraces here were abandoned and reforested. It is interesting that the distribution of the OLP units within forests, which occurred similarly in both historic counties, indicated that land abandonment phenomena do not depend on the historic economic systems of the counties. The density of terraces in the OLP was comparable with the density of agricultural land use, due to the steep slopes of terraces within these units that were reforested. The overgrown land of OLP should be re-cultivated back to agricultural land or converted to forest land to avoid irregularities in the real estate register (Kurčíková, 2013).

The current situation of land use in agricultural landscapes allows us to recommend a management plan in terms of multifunctional landscapes. The results of this research project have three implications for future landscape planning:

1. Terraces played a fundamental erosion role in reducing soil loss in the past. In any case, they have to be protected in the agricultural landscape on the basis of incentives proposed within land consolidation projects;
2. The OLPs within forests, where the steepest terraced slopes were found, are expected to be delimited to the JPRL units meeting an appropriate functional use of future forests (production and protective functions). The effectiveness of forest services should be reinforced by the forest management plans; and
3. Terraced landscapes, which meet cultural and natural values, are a potential and interesting resource for the development of mountain areas (Lasanta et al., 2013). Spatial planning documentations are considered to be alternative comprehensive instruments to other plans for the area of development strategies, coordinating multisectoral activities within the territory. Inclusion of landscape values into spatial plans introduces an opportunity to promote local identities and to support landscape quality. The conservation of the cultural features of agricultural landscapes can add value to tourism and provide local and regional food products. Preserved rural landscapes also help maintain the quality of life for rural residents by providing viable communities and economies and the positive values associated such landscapes (Agnoletti, 2014).

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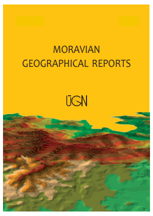


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# Analysis of the development of land use in the Morava River floodplain, with special emphasis on the landscape matrix

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***Abstract***

*The results of an analysis of land use development in the Morava River floodplain (Czech Republic) using GIS from 1836 to the present, are the subject of this article. The results are based on the analysis of historical maps, using the landscape matrix assessment of the Morava River floodplain. The final analyses were processed from land use maps of the floodplain at a scale of 1 : 25,000 in five time horizons. These maps were compared with the present state of landscape by GIS methods. The study area was assessed according to five geomorphological areas from the northern/higher part to the southern/lower part of floodplain. In 1836 the landscape matrix of the floodplain was composed of meadows and forests. Forest components decreased minimally but the changes are more important. The grassland area (meadows and pastures) decreased but arable land, as well as settlements, increased very significantly. In the 1950s the landscape matrix was composed of a mosaic of alluvial forests, meadows and arable land. Currently, the predominant landscape matrix consists of arable land and isolated forest complexes.*

***Keywords:*** *historical maps, land use changes, floodplain, GIS, Morava River, Czech Republic*

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## 1. Introduction

Issues of land use in the floodplains of large rivers are a permanent subject of geographic research since these areas have considerable economic and ecological importance and were affected by human activities in the course of historical development. Land use includes those human activities that affect the spatial dimensions and which causes changes in the geo-ecological conditions of land. Studying the dynamics of development and land use change is important with respect to management planning, as well as for ecosystem services in floodplain areas. This paper focuses on landscape changes in specific floodplain areas of the Morava River in the Czech Republic (CR). This research project is based on an interpretation of historical maps compared with contemporary maps, using methods based on geographical information systems (GIS).

## 2. Theoretical background

The landscape matrix is the dominant background land use/land cover type of a landscape. Applications of the concept of the landscape matrix (Forman and Godron, 1986) were developed as the patch matrix model (PMM) in the 1980s in order to quantify landscape structure (McGarigal et al., 2009). The PMM can be considered as one of the first conceptual models for landscape structure (Farina and Belgrano, 2006). Because the PMM has compatibility with data models in GIS, landscape structure based on the PMM is useful as an indicator of biodiversity (Dauber et al., 2003). The quantification of spatial and compositional aspects of PMM promoted the developments of numerous landscape indicators (Gergel, 2004), which can be applied in conservation practice, e.g. in nature reserve design (Clark and Slusher, 2000).

Landscape changes under PMM are influenced by natural conditions and socioeconomic factors. Many authors have assessed the influence of environmental drivers on landscape changes or structure and their analysis of driving forces of land use (Druga and Falťan, 2014; Havlíček et al., 2014; Machar, 2012a). Opršal et al. (2016) analysed changes in landscape use and the related significance of some natural factors using three municipal cadastral areas in Moravia, CR. Environmental and socioeconomic drivers have been

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associated with PMM: for example, in a study of marginal agricultural landscapes in Portugal (Van Doorn and Bakker, 2007), and a study of farmland abandonment in eastern China (Wu and Zhang, 2012). A study of a Swedish agricultural landscape (Gustavsson et al., 2007) shows how changes in management from mowing to grazing a century ago may cause diversity declines similar to abandonment that occurred 40 years ago. In this context, Benjamin et al. (2005) notes that changes in intensity of land-use contribute to a large range of habitat modifications, plant community fragmentation and changes in landscape structure.

Geoinformation technology (GIT) encompasses the modern processing of spatial data and support of PMM by means of information technology. The rapidly evolving information society sees GIT becoming an integral part of many fields of human activities, among them science subjects, which study spatial distribution of various phenomena, their characteristics and relations. GIT has applications primarily in geographic information systems, remote sensing, global positioning systems and computer cartography (Tomlinson, 2003; Longley et al., 2010).

A geographic information system (GIS) allows for the collection, processing and management of geographic data related to natural and human resources, aids deeper understanding of the field, yields more accurate information, is capable of a high-precision representation of reality in a computer environment, and makes decision-making processes easier (Al-Adamat et al., 2010; Pechanec et al., 2015). It also allows its users to model a number of natural processes, thus facilitating the planning of the utilisation and predictions of natural resources management development (Kubíček et al., 2011).

The Czech Republic has a sufficient amount of data sources representing the landscape and its features (Machar, 2012b). Their availability, up-to-datedness and a highly diverse structure (with respect to both content and format), however, pose some problems. The accuracy and detail of input data influence the quality of consequent analyses and outputs (Hlásny, 2007). Overviews of individual datasets available in the CR and suitable for landscape analyses are presented by Pauknerová and Kučera (1997) and Pechanec (2012).

Digital landscape maps play a key role in GIS, as their primary focus is the integration of several environmental phenomena and their temporal and spatial modelling (Tomlinson, 2003; Pechanec et al., 2011a). With respect to implementation, such GIS must be equipped with a relevant (expert) database. Landscape maps are cartographic models of spatial differentiation and integration at the landscape level of the Earth, changes in its structure from place to place and dynamic trends. They should include cartographical principles (Brus et al., 2010). In addition, maps of contemporary (current) landscape also provide information on land use and they are an essential source of much information for any landscape study (Hrnčiarová, 2001; Kolejka, 1987; Pechanec et al., 2011b).

The process of landscape analysis evaluates its structure, function and dynamics. Particularly in the case of development studies and actual landscaping projects, the interest areas must be evaluated not only with respect to the proportional representation of individual forms of land use, but also with respect to the spatial distribution of individual forms of land use, as well as the number, shape and orientation of partial landscape segments (Hanna, 1999). Substantiated structured landscaping measures may be proposed only on the basis of a detailed analysis of the current land use, with the physical geographic relations in the area taken into account (Brail and Klosterman, 2001). GIS offer a wide spectrum of spatial analyses and modelling, which find excellent application in landscape studies (Zhang et al., 2011), as well as in the analyses of habitats of individual plant and animal species and their mutual relations (Nelson and Boots, 2005; Liang et al., 2011). They allow researchers to conduct complex assessments of time-changeable characteristics (Antwi et al., 2008; Otýpková et al., 2011; Machar et al., 2014), assessments partly derived from the evaluators' subjective perceptions (aesthetic characteristics) or evaluations of groups of features, such as geosystem complexes which create conditions for preserving biodiversity (e.g. Carlson et al., 2004; Hamilton, 2005; Pechanec et al., 2014). Apart from the basic user interface, GIS allows the application of specialised modules and tools for landscape structure analyses.

The application of GIS in landscape management brings several benefits: both for confrontation and communication among specialists who used to take landscape-oriented decisions only within the narrow scope of their individual professions; they help visualise problems and hazards; and, these systems allow the simulation of effects that some phenomena might have and thus help minimise incorrect decisions.

With respect to the efficiency of using geoinformation technology in landscape management, the application of analytical tools is desirable thanks to the speed and exactness of processing they offer. The major strength of GIS is manifested particularly in the process of creating new information layers (maps) from data already obtained, with the possibility of alternative scenario modelling (Pechanec et al., 2011a; Zhang et al., 2011).

PMM has been applied as well at the national level in the Slovak Republic (Feranec and Nováček, 2009) and in the historical context of mountain Slovak landscapes (Hresko et al., 2015). In Central Europe, there are numerous regional and local studies which specify changes in landscape matrices: for example, in Austria by Krausmann et al. (2003); Kowalska (2012) in the middle Vistula River valley in Poland; Hohensinner et al. (2004) around the Danube River; and Deák (2007) who covers habitat changes and landscape use in the South-Tisza-valley, Hungary. Changes in post-war agricultural land use in the former East Germany in connection with the Elbe flood peaks are described by van der Ploeg and Schweigert (2001) and Feranec et al. (2010). The results show close relationships between changes in socio-economic metabolism and changes in land use and land cover.

In the Czech Republic, several authors have studied the temporal and spatial development of the landscape matrix at various scales, drawing on similar methods (Demek et al., 2008; Cebecauerová, 2007; Havlíček et al., 2012; Machar et al., 2009). Historical analyses conducted in various areas were based on the study of cartographic materials and other archive documents (e.g. Lacina et al., 2007 in Železna Ruda town and its surroundings; Skaloš et al., 2011 in the lowland area of Nové Dvory and Žehušice; Demek et al. 2012, in the south-eastern part of the CR). Skokanová et al. (2012) studied the development of land use and the main processes in the area around Zlín. Bičík et al. (2015) introduced an analysis of the socio-economics factors. There are many studies applying the PMM at the regional scale in specific areas, such as the catchment area (e.g. Kilianová et al., 2009, in the Trkmanka catchment). In addition, Machar (2013a) studied long-term changes in the landscape matrix in the Morava River floodplain under anthropogenic impact; Demek et al. (2008) evaluated landscape changes in the Dyjskosvratecky úval Graben and Dolnomoravský úval Graben; and Havlíček et al. (2009) demonstrated long-term changes in land use in the Litava River basin.

The principal aim of this article is to present the application of PMM to analyse changes in the alluvial landscape. It is particularly timely in the context of the increasing frequency of flood events in the alluvial plains of rivers of Central Europe. At present, the Morava River floodplain is an example of a cultural landscape in which most ecosystems are affected by the socio-economic activities of society.

## 3. Materials and methods

### 3.1 Study area

The study area represents the alluvial landscape of the Morava River in the Czech Republic. The Morava River floodplain has been defined based on geological maps at the scale of 1 : 50,000 for project No. 206/97/0162: "Recovery of ecological continuum of Morava River" (Štěrba, 1999). The Morava River is a left tributary of the Danube River. It is the main river of the eastern part of the Czech Republic – Moravia, which derives its name from it. The river originates on the Kralický Sněžník Mts. in the north-eastern part of Pardubice Region, near the border between the Czech Republic and Poland, and has a vaguely southward trajectory. The lower part of the river's course forms the border between the Czech Republic and Slovakia, and then between Austria and Slovakia (see Fig. 1).

The length of the Morava River from its source to the confluence with the Dyje River at the border of the Repblic is about 270 km. The Morava River feeds the Danube River with an average discharge rate of 120 $m^3.s^{-1}$ gathered from a drainage area of 26,658 square kilometres. The Morava River is unusual in that it is a European black water river. The river's longest tributary is Dyje River (Thaya River), flowing in at the tripoint of Austria, the Czech Republic and Slovakia. The biggest tributary from the left is Bečva River.

The Morava River floodplain is only a few metres wide in the upper reaches and widens gradually towards the south up a width of several kilometres. The boundary of the study area was formed by the boundary of the Quaternary fluvial sediments of the Morava River according to Štěrba et al. (1999). The surface area of the studied floodplain was 635.7 square kilometres, and the elevation ranged from 900 m a. s. l. (narrow floodplain of the Morava in the Kralický Sněžník Mts.) to 151 m a. s. l. (confluence of the Morava and Dyje Rivers).

Adjustments to the river stream were carried out first on the middle part, in the first half of the nineteenth century, and the lower part was regulated at the end of the century. From 1969 to 1976 the Morava River was regulated between Hodonín town and Lanžhot village. In 1977, the last summer flood occurred. Changes at the Dyje and Morava Rivers confluence were finished in 1988, and the last meanders were cut. For two decades, regardless of climatic conditions, water levels inevitably dropped and ground water levels have decreased (Tab. 1). In the period under review, the Morava

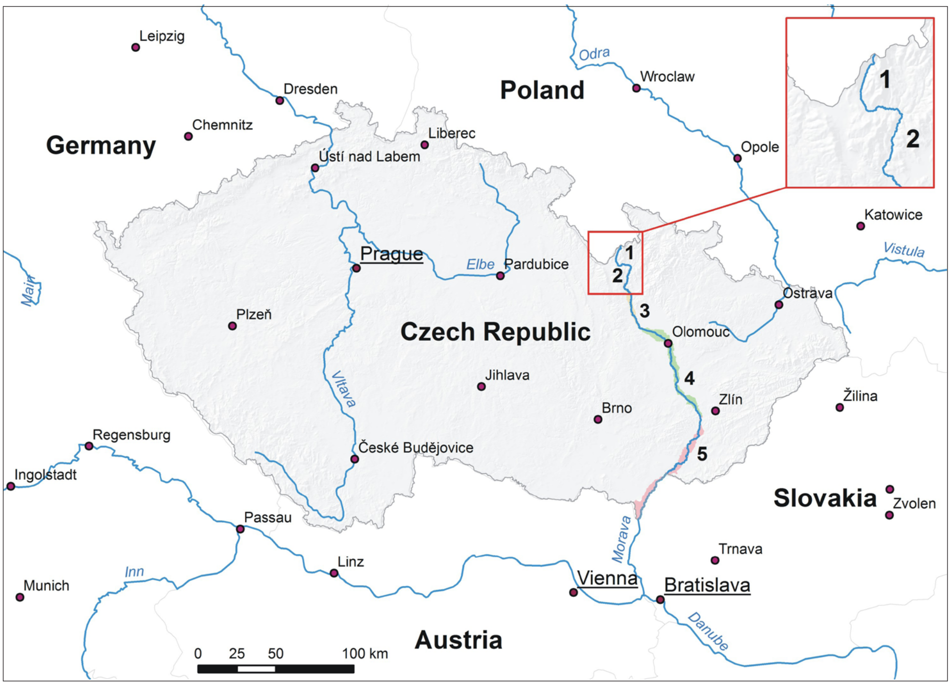


*Fig. 1: Location of the Morava River and sectors of the Morava River floodplain (Sector 1 – Kralický Sněžník Mts.; Sector 2 – Branenská vrchovina Highland; Sector 3 – Mohelnická brázda Furrow; Sector 4 – Hornomoravský úval Graben; and Sector 5 – Dolnomoravský úval Graben). Source: authors*

| | 1836 | 1877 | 1953 | 1999 | 2010 |
|---|---|---|---|---|---|
| Length of Morava River | 334.9 | 329.5 | 285.4 | 268.0 | 269.3 |
| Length change | | – 5.3 | – 44.2 | – 17.3 | 1.3 |

*Tab. 1: Length of the Morava River (km). Source: authors' calculations*

River was reduced approximately by 67 km. The largest interventions were conducted in the first half of the 20th century on the middle and lower part of river. The most affected parts were Mohelnická brázda Furrow (Sector 3; about 6 km), Hornomoravský úval Graben (Sector 4; 13 km) and Dolnomoravský úval Graben (Sector 5; 48 km).

Regulated water beds with impermeable shores prevent replenishment of ground water by soaking. The level of ground water is the main determinant of the quality of the root systems of floodplain forest, mainly of oak and ash. The depth of the root systems of main bottomland woody plants of age 51–104 years does not reach over 2 m (Bagar and Klimánek, 1999), so when ground water level drops, the conditions of bottom land woody plants deteriorate. Research in this area has shown that some growth reactions of ash and oak are affected by the lowered level of ground water (Maděra and Úradníček, 2000).

In order to carry out further spatial analysis, the floodplain area was split/divided into five sectors named after geomorphological units (see Mackovčin et al., 2009), as follows: Kralický Sněžník Mts. (Sector 1) – northern, the highest part of the floodplain in the source area of the Morava River (a wide valley floor filled with river sediments); Branenská vrchovina Highland (Sector 2) and Mohelnická brázda Furrow (Sector 3), representing the upper parts of the middle course of Morava River; and Hornomoravský úval Graben (Sector 4) and Dolnomoravský úval Graben (Sector 5), wide floodplain of the lower course of the Morava River (Fig. 1).

### 3.2 Data and methods

Assessment of the temporal changes was carried out in the GIS environment at a uniform scale of 1 : 25,000. Map sheets of the 2nd military mapping from 1836–1840, the 3rd military mapping from 1876–1878, and state maps at 1 : 5,000, derived from the period around 1953, were analysed. Further, field investigations from 1995–1997 (Štěrba et al., 1999), and the situation from 2010 were used. Cartographic materials used as a base layer for floodplain condition around 1836 were the sheets of the 2nd military mapping. This Second military mapping, called Franz's, was carried out in Moravia in 1836–1840 (1842–1852 in Bohemia) using a fathom scale of 1:28,800. Its base layer is the stable land registry, founded by patent in 1817. Numeric geodetic mapping in Moravia and Silesia was carried out by trigonometrical points of 1st to 3rd degree of St. Stephan's system (Císař et al., 1966). The pantographically-shrinked contents of the land registry map (1 : 2,880) were used as a graphical topographical base layer. From the military point of view, important topographical data (surfaces) were denoted using 11 colours and landscape configuration was shown using Lehmann hatching. Altitudes in Vienna fathoms were shown only for trigonometrical points (Boguszak and Šlitr, 1962).

Another base layer was comprised of maps from the 3rd military mapping from 1876 to 1880. This third military mapping was carried out in the entire Austria-Hungary Empire in the second half of the 19th century (1867–1887) at the scale of 1 : 25,000 (Čapek et al., 1992). In the period 1876–1878, a topographical map of Moravia was created at the scale of 1 : 25,000, from which other maps were derived (special 1 : 75,000, general 1 : 200,000, and brief 1 : 750,000).

In 1946 the unified map works on "State map economic 1 : 5,000" (SMH-5) were started. Topography is shown in this SMH-5 map, altimetry is expressed using spot heights, and contour lines are shown with base interval of 1 m. Its prints have three colours: topography is grey, altimetry is brown, and description is in black. Because the map could not be created quickly, in 1950 the decision was made to create a temporary map work of the entire area of the state (except areas already shown in the economic map) called: "State map 1 : 5,000-derived" (SMO-5) (http://geoportal.cuzk.cz/). For this map, the original print has two colours – contents in black and contours in brown (Boguszak and Císař, 1961). Topographical and topical contents of these maps at the scale of 1 : 5,000 were manually transferred into base maps of scale 1 : 25,000. The sheets position was derived from a planned (but according to a personal communication from R. Čapek, never published) map at 1 : 50,000, which was divided into 10 columns and 10 layers of map sheets at 1 : 5,000 (Hojovec et al., 1987). For the creation of the map of floodplain soils of the Morava River around 1953, 264 map sheets of State map 1 : 5,000-derived (SMO-5) were used.

The situation from 1999 was taken from national project No. 206/97/0162: "Recovery of ecological continuum of Morava River" (Štěrba et al., 1999). For this project, base layers were supplied by single municipalities, where the Morava River flows. The authors of the grant task had digital maps of soil utilisation and the river network at their disposal. Digitalisation of these maps was carried out from maps at the scale of 1 : 25,000, published around 1994. After improvements in accuracy and the addition of information gathered by field investigation, these maps were considered as representing conditions in 1999.

The current condition (2010) was created using a combination of digitalisation of aerial imagery, base map layers of the national portal CENIA, and field investigations. These methods were used for the creation of actual floodplain land use of the Morava River in 2010. The prevalent method was the interpretation of orthophotomaps. Field investigation was used mostly for obtaining additional information in areas hard to interpret and unclear areas. Areal imagery was taken by GEODIS BRNO, s. r. o. in the period 2008–2010, their transfer was carried out using a WMS web services via the national geoportal run by CENIA agency. WMS is a map service which enables views of map layers in intranet or Internet environments (Longley et al., 2010).

The categories used in forming the landscape matrix were identified based on an available visual key (Skaloš et al., 2011). Within the study area, the following categories were identified: Forests, Meadows, Pastures, Arable land, Gardens and Orchards, Urban areas, Water surface and Transport areas or others. The level of classification used here reflects the best possible level that can be identified on old maps (Mackovčin, 2009).

Forest areas were mapped without differentiation of coniferous and broad-leaved forests. Small forests and bosques were classified as forests if their size was at least 1.5 ha (linear dimension at least 0.5 cm). Bushes and bushy formations were classified on one of the military maps, but were not used on maps from the 1950s; therefore, their areas were also included in the forest category. Boundaries of land utilisation are lines between adjacent areas, used for different purposes, which do not comprise another line element. Meadows and pastures were identified based on their symbology in maps.

The cartographic contents of the digital historical maps were compared with a digital map of the current land use of the Morava River floodplain, and thus the information on the representation of all mapped land use categories in different time periods was obtained. This information was organised into a data system that allows analysis of changes in the evolution of the landscape and individual landscape elements, in the studied time period.

The digitisation was followed by the processing of a detailed network of digitised lines. Each point was assigned by coordinates and an unique identifier to which additional descriptive information was linked. Each point was then assigned information from the table of codes expressing the use of the area. Finally, the names of towns, forest units and water courses were created in the ArcGIS attribute table. After further necessary topological adjustments, a digital map was created which could be then statistically analysed using traditional GIS tools. The resulting statistical data (number of individual spots, their size, sum, length of water courses, etc.) were processed into tables and graphs that allowed interpretation of results.

## 4. Results

### *4.1 Development of land use in the entire floodplain area of the Morava River*

From 1836 to 2010 the entire floodplain of the Morava River has witnessed evolutionary periods from the land use point of view (Tab. 2). The most significant trend is the growth of areas of arable land during this period, reaching its peak at the end of 20th century, with a slight subsequent decrease. The dynamics of the growth of arable land has its effect also in the spatial structure of the land. At the beginning of the period, the matrix of land is formed by meadows and pastures (47.54%), forests (27.89%) and arable land (21.5%). Towards the end of 19th century (1877), meadows and pastures still cover the majority of the land (38.72 %), but the area of arable lands (189.45 square kilometres, i.e. 29.8% of the floodplain area) is already higher than the area of forests (158.2 square kilometres, i.e. 24.89%). In the 1950s, arable land already covered the majority of the area (37.77%), with meadows and pastures (26.81%), the area of which had surpassed the forest areas (23.89%). Arable lands (51.87% of the Morava River floodplain in 1999) are dominant at the end of 20th century. Forest areas are the second highest percentage (25.53%), while meadows and pastures cover only 8.48% of the area. At present (2010), the lands of the Morava River floodplain are covered by arable land at 47.14% and forests at 27.81%, while meadows and pastures cover only 7.94% of the area.

Changes in land use also affect changes in the appearance and character of the land, land structure and biodiversity, in each part of the floodplain. The floodplain character, descending and widening along the water stream, is changing along with changing physical geographical conditions and its use. Therefore, one can find quantitative differences in particular parts of the floodplain of the Morava River.

In this floodplain, the surface is constituted mostly from stable ecosystems – meadows, pastures and forest ecosystems. From the species point of view, completely changed agroecosystems, i.e. fields, have dominated the area since second half of the 20th century.

In 1836, the Morava River floodplain was relatively well preserved from the ecological point of view. Most of the surface area was composed of meadows, pastures and forests. Arable land prevailed in the Morava River floodplain in the second half of the 20th century. The trend of a growing area of human settlements within the floodplain is discernible over the whole time period.

Changes of land use in the Morava River floodplain from 1836 to the present are shown in Table 2. The table shows that spatial changes of different land use categories in the Morava River floodplain in different time periods are visible. Forests represent the most stable areas. The maximum decrease of their surface area by 25.43 square kilometres (i.e. 4.00%) was recorded in 1953 as compared to the situation in 1836. At the present, forests cover 27.81% of the Morava River floodplain. The area of forests decreased by about 0.08% between the time periods, however, the trend has reversed since 1953.

Meadows and pastures, which accounted for 302.22 square kilometres (i.e. 47.54%) at the beginning of the studied period, almost disappeared from the alluvial landscape. Over time, their area has declined to only 53.94 square kilometres (i.e. 8.48%). The loss of these important landscape elements in the Morava River floodplain was caused by their conversion to arable land. The area of arable land increased 2.5 times during the studied time period (from 21.5% to 51.87%), which is a notable increase. Furthermore, a substantial portion of arable land has been added in the last decades compared to previous periods.

A very large increase in settlements was recorded. Their size increased from an original 16.3 square kilometres (i.e. 2.56%) to 75.54 square kilometres (i.e. 11.88%) in 2010. The size of urban areas within the floodplain has increased sharply since the turn of the 19th and 20th century and especially in the second half of the 20th century. This

| | 1836 | | 1877 | | 1953 | | 1999 | | 2010 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | km sq. | % | km sq. | % | km sq. | % | km sq. | % | km sq. | % |
| Forests | 177.27 | 27.89 | 158.20 | 24.89 | 151.84 | 23.89 | 162.30 | 25.53 | 176.79 | 27.81 |
| Meadows and Pastures | 302.22 | 47.54 | 246.13 | 38.72 | 170.45 | 26.81 | 53.94 | 8.48 | 50.47 | 7.94 |
| Arable land | 136.65 | 21.50 | 189.45 | 29.80 | 240.08 | 37.77 | 329.72 | 51.87 | 299.68 | 47.14 |
| Gardens and orchards | 0.85 | 0.13 | 7.03 | 1.11 | 14.18 | 2.23 | 0.47 | 0.07 | 3.46 | 0.54 |
| Settlements | 16.30 | 2.56 | 23.41 | 3.68 | 38.22 | 6.01 | 66.23 | 10.42 | 75.54 | 11.88 |
| Water surfaces | 2.02 | 0.32 | 10.85 | 1.71 | 18.78 | 2.95 | 22.65 | 3.56 | 28.49 | 4.48 |
| Transport areas | 0.39 | 0.06 | 0.63 | 0.10 | 2.15 | 0.34 | 0.39 | 0.06 | 1.27 | 0.21 |
| **Total** | **63,570** | **100** | **63,570** | **100** | **63,570** | **100** | **63,570** | **100** | **63,570** | **100** |

*Tab. 2: Development of land use in the Morava River floodplain*
*Source: authors' calculations*

change can be explained by the development of industry, whose production facilities were located in the floodplain. Since the 1950s, when large-scale agriculture originated and agricultural cooperatives were established, the area of settlements has been enlarged by these economically and agriculturally used areas. Residential areas of towns and cities have expanded too, which is related to population growth and migration into them.

Transport areas (railway stations and their adjacent transshipment and manipulation areas) were mapped within the built-up areas. Some railway stations, which were located outside of town in the 19th century, are now part of the urban area. New rail lines have been built over time. The surface area of transport infrastructure has therefore increased from an original 0.06% (in 1836) to the current 0.21% of the floodplain area.

The extent of floodplain forests is rather stable in the area of interest. Despite that, the extent of floodplain forests decreased (1836–1953) but then increased to their original extent. Generally, changes in forest areas happened within single parts of the forest. Only in one case was there a complete clearance of an isolated complex of floodplain forest. On the other hand, it happened only in a few cases that the current extent of single sections of forest is the largest in the period under consideration; 124.7 square kilometres of forest areas (i.e. 19.6% of the territory in the period of 1836–1953) and 115.9 square kilometres of forest areas (i.e. 18.2% of the territory in the period 1936–1999) were stable areas, i.e. they remained forest areas in the period. When expressing the persistence (the proportionate representation of stable areas relative to the areas at the starting point), the persistence of forest areas is 70.3 (1836–1953) and 60.4 (1936–1999) which can be rated as high stability. Settlements can be rated similarly. Water surfaces and meadows and pastures, on the other hand, have a very low persistence.

### *4.2 Land use changes in the five sectors of the Morava River floodplain, 1836–1999*

When changes are observed in the defined sectors of the Morava River floodplain, they are very different. In areas which were mostly covered by arable land at the beginning of the period, changes are minor. Conversely, areas with a high percentage of grassy areas have undergone major changes.

Meadow and pastures formed 47.54% of entire area in the period 1836–1840 (Fig. 2), and almost 28% of the surface was forested. In contrast with ancient forestation, the actual forest area is not large but in this period it is the largest observed. The spatial pattern is not uniform – the most forested area is in the south – Dolnomoravský úval Graben (Sector 5).

The northern part of the Morava River floodplain on the slopes of Kralický Sněžník Mts. (Sector 1) is covered by forests, and in open valleys we can find meadows. In areas where the floodplain widens, near Červený Potok village, we can see fields as well. Forest areas in this area are located only at the edges of the floodplain, where they descend from valley slopes. In comparison, the floodplain in Branenská vrchovina Highland (Sector 2) has a very small percentage of forests (1.9%). The major vegetation components in this part of the floodplain are meadows and pastures (46.7%). Very little forest and bosques can be found in Sector 3, Mohelnická brázda Furrow, only 0.6%. From Stavěšice village southwards there are meadows, which are then connected to the forest areas of the Litovelské Pomoraví Protected Landscape Area (PLA).

In Hornomoravský úval Graben (Sector 4) forests form 25.9% of the area, but their distribution is uneven. In the northern part of this sector, mostly forests of the Litovelské Pomoraví PLA are located, but in the floodplain segment between Olomouc city and Tovačov town there are no forests except for the pheasantry Království. In contrast, larger forest areas are located in the southern part of Hornomoravský úval Graben (Sector 4). In this sub-area, an almost continuous forest area is located on the left bank of the Morava River. There is an important complex of continuous forests between the Morava and Malá Bečva Rivers. Meadows and pastures, the prevailing vegetation component (41.8%), are located unevenly. In most cases they follow the forests of water streams. Dolnomoravský úval Graben (Sector 5), has a high percentage (38.5%) of forests, most of them located in the area of the confluence of the Morava and Dyje Rivers, much of it a quite preserved complex.

In the period of the 3rd military mapping (Fig. 3), meadows and pastures still cover the major part of the Morava River floodplain area, 38.7% of the total area. Arable land covers almost one third of the floodplain and 24.9% are forest areas. Settlements are located mostly on the outskirts of the floodplain, covering only the edge or a small part of it, although some settlements are exceptions, e.g. Olomouc city, Uherské Hradiště city, etc. Water surfaces cover only 1.7% of the floodplain.

The highest altitudes in the floodplain areas of the Kralický Sněžník Mts. (Sector 1) are covered by forests, followed by meadows at 68%. The floodplain land use is significantly changing, with arable land forming a majority. Forest areas in Sector 2 (Branenská vrchovina Highland) in the floodplain are located only marginally (0.16%), only as line of riparian woods following river beds, and in the Mohelnická brázda Furrow (Sector 3) forests are also rare (1.5%).

When the Morava River enters Hornomoravský úval Graben (Sector 4), the floodplain widens and the river bifurcates into arms that flow from north-west to south-east through the forests and meadows of the Litovelské Pomoraví PLA. Forests and meadows cover 50% of the area of this local floodplain. The floodplain segment south of Olomouc is the most cultivated part, as arable land forms 60% of the area. Forest areas cover only 2% of this section. The southern part of the Hornomoravský úval Graben (Sector 4) is covered by forests at about 27%, and the forests are surrounded by meadows and pastures, which form 45% of the area of this floodplain segment.

In the northern part of Dolnomoravský úval Graben (Sector 5) a very colourful mosaic of various uses is found. In the vicinity of the Morava River bed, one finds meadows (53%) and forests (21%). Arable land, which forms around one third of the area, is located often at the edge of the floodplain, only rarely near the water stream and mostly near settlements. In the southern part, the land appearance changes dramatically – from a heterogeneous mosaic to large continuous units. Forests form 50% of the area, 43.9% consists of meadows, following the forests from the western side.

In the period of mid-20th century (Fig. 4) arable land forms the majority use of the floodplain of the Morava River, taking up to 37%. Forest areas are recorded at their smallest extent in this period, having dropped to 23.89%. Meadows and pastures take up an area of 170.45 square kilometres, i.e. 26.81%. Sources of spatial information are scarce in showing vegetation as neither coastal forests nor as dispersed vegetation is recorded. Forest areas are drawn in a detailed way within the larger scale, but with no information about the type (coniferous – broad-leaved).

The northern part of the study area at the slopes of Kralický Sněžník Mts. (Sector 1) is characterised by forests, which together with small forests and bosques in the valley floodplain up to Hanušovice town, form 23.5% of the area. They are located near the water stream, or descend from valley slopes down to the floodplain borders. In comparison, Branenská vrchovina Highland (Sector 2) is highly arable: arable land forms 33.6% of the area, while forest areas comprise only 2.4%.

The Morava River floodplain in Mohelnická brázda Furrow (Sector 3) is highly arable – arable land forms over 52%. More grassland is located to the south, where meadows are followed by the forests of the Litovelské Pomoraví PLA, but overall there is only a small percentage of forests (3.15%).

In some areas of (Hornomoravský úval Graben) (Sector 4) meadows are almost absent. Forests are condensed into larger bodies (Litovelské Pomoraví PLA, Království, Tovačovský Forest), comprising up to 21% of the area. The northern part of Dolnomoravský úval Graben (Sector 5) is mostly arable around the settlements, but the southern forests and meadows form a majority, covering together more than 75% of the floodplain area.

Some elements are missing in the base layers for land use from 1999 (Fig. 5). Pastures were excluded from grasslands and the category of gardens and orchards is included as a

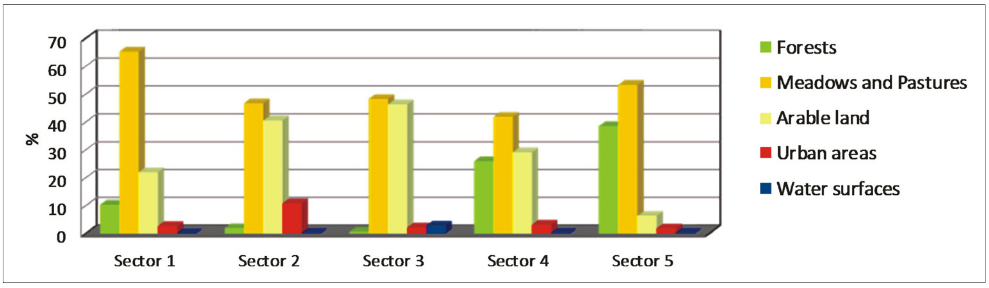


*Fig. 2: Land use in floodplain sectors of the Morava River in 1836–1840 (in %)*
*Source: authors' calculations*

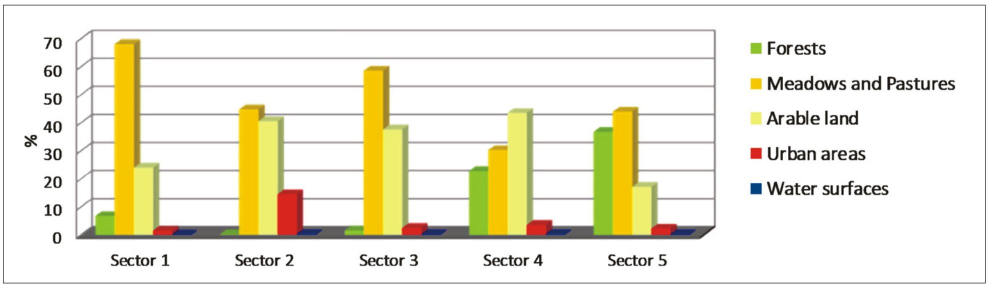


*Fig. 3: Land use in floodplain sectors of the Morava River in 1876–1880 (in %)*
*Source: authors' calculations*

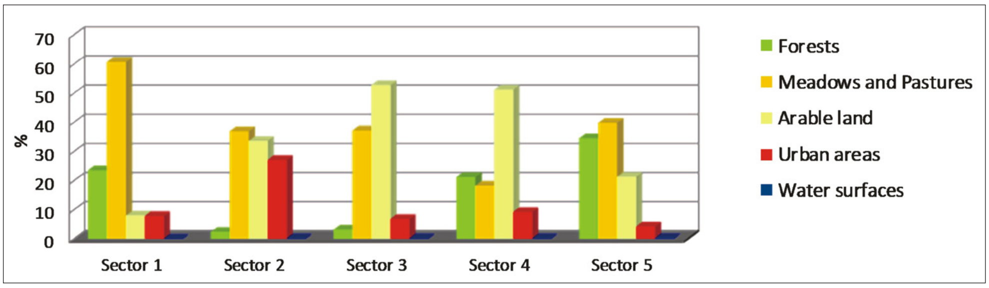


*Fig. 4: Land use in floodplain sectors of the Morava River in 1953 (in %)*
*Source: authors' calculations*

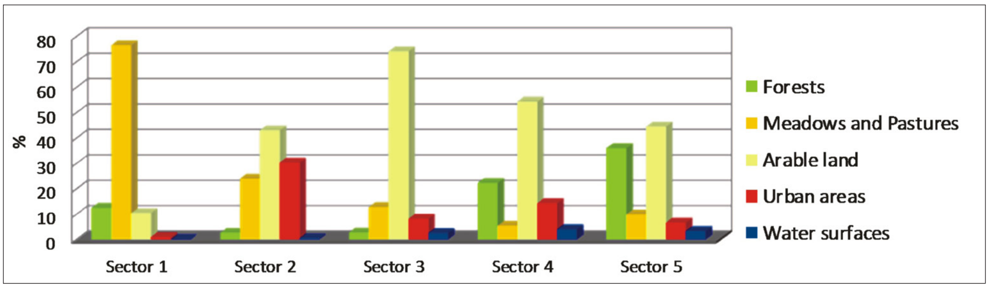


*Fig. 5: Land use in floodplain sectors of the Morava River in 1999 (in %)*
*Source: authors' calculations*

part of settlements. The dominant type of land use within the Morava River floodplain at the end of 2nd millennium is arable land, comprising almost 52% of the area, with the second highest category as forests with 25.5% of area. Meadows form 8.5% and settlements around 10.4% of the area. Water surfaces are an eminent land element, covering 3.6% of Morava River floodplain.

In Kralický Sněžník Mts. (Sector 1), forests are located in the lower floodplains at lower altitudes as the forests descend to the edges of the floodplains from surrounding slopes (Fig. 5). In this sector 12.4% of the area in total is forested. The floodplains in Branenská vrchovina Highland (Sector 2) have an area with very low percentage of forests (2.6%), a small percentage of meadows (24%), but high percentage of arable land (43%). In Mohelnická brázda Furrow (Sector 3) arable land covers 74% of the area, and along water streams meadows are located, covering more than 12.7% of this segment. Forests are also located around streams as a part of coastal vegetation, on old, overgrowing dead arms. Apart from areas along water streams, they are located only around Bohuslavice village. The cover is 2.5% in total.

Hornomoravský úval Graben (Sector 4) at this time is covered by arable land to 54.2%. Forests are located in complexes such as the Litovelské Pomoraví PLA, Království, Cítovský or Bítovský Forest – 22% in total, while the middle part of this sector – from Olomouc city to Tovačov town – has only 11% forests.

Arable lands (44.9%) dominate in Dolnomoravský úval Graben (Sector 5), in its northern part in particular, and forests are distributed evenly. In the northern part of the sector around 22% of the area is comprised of several forest complexes; in the southern part they form a compact body with an area of 68 square kilometres, i.e. 49% of this segment.

#### *4.3 Present land use situation*

The dominant type of land use in the Morava River floodplains was arable land in 2010, forming more than 47% of the area (Fig. 6). Forest areas comprise 27.8% of the area, which is close to forest conditions at the beginning of 19th century. Meadows and pastures cover almost 8% and settlements cover 11.88% of the area, which confirms the rising trend of built-up areas in the floodplains. Water surfaces cover 4.5% of the Morava River floodplains.

In the Kralický Sněžník Mts. (Sector 1), the Morava River floodplains traverse forests, and at lower altitudes in the valley floodplains forests descend to their boundaries from valley slopes and cover 12.8% of the area. The floodplains in Branenská vrchovina Highland (Sector 2) have a very low percentage of forests (3%), as forests are located around water streams as part of coastal vegetation, and in the vicinity of old, overgrowing dead arms. Apart from areas along water streams, they are located only around Bohuslavice village. Forest areas in Sector 3 (Mohelnická brázda Furrow) comprise more than 3% of the floodplain area.

Arable lands cover the majority (almost 54%) of the Hornomoravský úval Graben (Sector 4), but forests form almost 23% of the floodplain area, in complexes such as Litovelské Pomoraví PLA, Království, Cítovský or Bítovský Forest. Dolnomoravský úval Graben (Sector 5) is currently covered by arable land at about 44%, mostly in its northern part. Forests are distributed evenly: in the northern part of this sector about 22% of the area is forested in several complexes; in the southern part, they form a compact body with an area of 68 square kilometres, i.e. 40% of this segment. In sector 5, Dolnomoravský úval Graben forest areas cover 36.8% of the floodplains areas in total.

## 5. Discussion

The patch matrix model (PMM) provides a key to understanding land use systems and changes by interpreting quantitative landscape indicators (Hoechstetter et al. 2008). The PMM approach is limited to a two-dimensional representation of landscape structures, although efforts have been made to incorporate higher dimensions into its landscape representation (Stupariu et al., 2010). In the frame of analysis of historic landscape patterns, the PMM is reduced to available or interpretable data of land use classes (Kienast, 1993), such as shown in the Morava River floodplain Machar (2013b). But this disadvantage cannot be a handicap if our emphasis is on the evaluation of the human view of landscape, as in this article.

The lack of general relations between landscape structure and ecological processes can be overcome using the gradient model (GM), which represents landscape structure on the basis of continuous data, where the only discrete unit is a pixel or grid cell in a raster-based data model (McGarigal and Cushman, 2005). The GM represents landscape structure as continuous data, which usually originated from remote sensing, and using GM landscape models should help to improve our understanding of species-landscape interactions (Cushman et al., 2010). GM-based models, however, usually evaluate only one variable of interest in the landscape - such as elevation or habitat quality for single species or green vegetation density – but this corresponds only to one land-cover type or category in the PMM (Lausch et al., 2015).

In European floodplains, the history of human press on the landscape plays a major role in shaping landscape structure (Trémolieres and Schnitzler, 2007). High land-use intensity in floodplain areas tends to control or fix vegetation patterns and landscape structure both in space and time. Such anthropogenic-dominated landscapes are primarily composed of homogenous areas with distinct boundaries

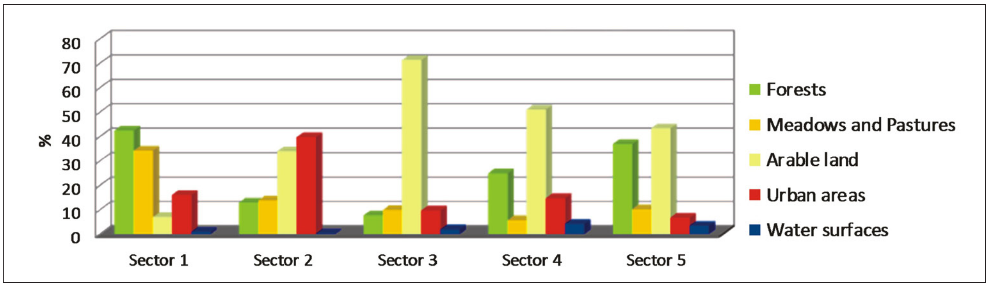


*Fig. 6: Land use in floodplain sectors of the Morava River in 2010 (in %)*
*Source: authors' calculations*

in a specific matrix. The resulting landscape structure in this landscape is therefore best represented with the PMM approach, distinguishing patches of uniform land-cover delineated by sharp boundaries (McGarigal et al., 2009). This is the main reason why we used the PMM in order to assess historical changes in landscape structure in the Morava River floodplain.

Potential perspectives for applications of the PMM currently suggest studies based on the joining of historical land structure changes with mathematical models for prediction of the future development of floodplain ecosystems (Simon et al., 2014), which can be implemented by landscape conservation management of the floodplain (Machar, 2010). The future predicted changes in floodplain landscape under climate change (Tockner and Stanford, 2002) enable researchers to consider the PPM based on GIS as a support decision tool for landscape management, as demonstrated in a case study from the Morava River floodplain by Kopecká et al. (2013).

The historical development of land use in the study area of the Morava River floodplain has been strongly influenced by social and economic conditions. These factors represent a possible influence on differences in the development of land use in the Czech Republic (CR) and in the study area. The first difference in the land use structure (Tab. 3) is the very high percentage of meadows in the Morava River floodplain, which already in 1836/1845 exceeded the Czech average by 33.73%. It can be explained by natural conditions – the floodplain with its high ground water level and frequent floods did not allow other uses. Waterlogged meadows provided fodder but it was not necessary, and probably not even technically possible, to cultivate them. This also explains the low representation of arable land (compared to the country as a whole) and its location in acceptable parts of the floodplain. The initial low share of forests in the floodplain is surprising, as well as the following development tendency (relatively stable) compared to the CR. In the studied time period, the share of forests increased by 4.9% in the CR but decreased by 4% in the Morava River floodplain (status as of 1953).

It is worth noting that the share of built-up areas in the floodplain greatly exceeds their average share in the CR. It is five times higher even though some settlements are only partly situated within the floodplain. This situation can be explained by the location of ancient human dwellings and settlements in the proximity of rivers that were providing water and livelihood (Rulf, 1994). The settlement structure is therefore denser in the floodplain and its neighbourhood.

There are several different trends in the development of individual forms of land use in the CR and the floodplain in the studied period. Example of changes are visible on Figure 7 in Sector 4, Hornomoravský úval Graben, where the number of changes were calculated between 1877, 1953, 1999 and 2010. The momentuos loss of meadows and pastures in the Morava River floodplain and the dramatic increase in the area of arable land, which currently exceeds the average share in the CR by 9% indicate strong pressure on highly productive land in recent decades. The area of arable land in the floodplain increased by 219.3% of the original area (status in 1836). In contrast, in the CR it decreased to 79% of the original area (status in 1845). Meadows and pastures represent very dynamic land use categories in the Morava River floodplain. Their area decreased to 16.7% of the original size, while the biggest decrease was recorded in the second half of the 20$^{th}$ century. The reduction of the area of forests, which were also transformed to arable land, has increased the difference in the share of forests in the floodplain and the CR. The trend of decreasing area of forests was reversed in the mid-19$^{th}$ century in the CR, but the same cannot be said for the Morava River floodplain, where this trend had not reversed before 1953.

There is a gradual upward trend in the size of built-up areas in the CR, as the size of built-up areas has increased by 278.3%. In the floodplain it has increased by 464%, while up to 1953 the area increased only by 234.5%. The increase in the area of settlements in the floodplain is relatively recent, when there was a development of industry, large-scale agriculture and housing construction. Flood risk was underestimated, probably due to drier climatic conditions in the 20$^{th}$ century and awareness of the water management paradigm. Even so, floods are a natural factor in the development of floodplains and their vegetation cover.

It is interesting to monitor the development of water bodies. In the CR, the area of lakes, reservoirs and ponds has increased by 230%, whereas in the Morava R. floodplain they represent the most dynamic land use category. Their size has increased by 1,400%. This huge increase is linked to the formation of water reservoirs in the areas of extracted fluvial sand and gravel, which were established in the floodplain in relation to the development of the construction industry in recent decades.

| | **MRF** | **CR** | **MRF** | **CR** | **MRF** | **CR** | **MRF** | **CR** | **MRF** | **CR** |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1836 | 1845 | 1877 | 1897 | 1953 | 1948 | 1999 | | 2010 | |
| Forests | 27.89 | 28.80 | 24.89 | 28.90 | 23.89 | 30.20 | 25.53 | 33.40 | 27.81 | 33.70 |
| Meadows and Pastures | 47.54 | 17.60 | 38.72 | 14.20 | 26.81 | 12.90 | 8.48 | 11.30 | 7.94 | 12.5* |
| Arable land | 21.50 | 48.20 | 29.80 | 51.60 | 37.77 | 49.90 | 51.87 | 39.30 | 47.14 | 38.14 |
| Gardens and orchards | 0.13 | 1.10 | 1.11 | 1.50 | 2.23 | 1.90 | 0.07 | 3.00 | 0.54 | 3.04 |
| Urban areas | 2.56 | 0.60 | 3.68 | 0.70 | 6.01 | 1.10 | 10.42 | 1.96 | 11.88 | 1.67 |
| Water surfaces | 0.32 | 0.90 | 1.71 | 0.50 | 2.95 | 0.60 | 3.56 | 1.99 | 4.48 | 2.07 |
| Other | 0.06 | 2.80 | 0.10 | 3.00 | 0.34 | 3.40 | 0.06 | 9.05 | 0.21 | 8.89 |
| **Total** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

*Tab. 3: Comparison (in %) of the development of land use in the Morava River floodplain (MRF) and the Czech Republic (CR) over time. Sources: authors' calculations and Czech Statistical Office*
*Note: *Since 2000 Czech Statistical Office does not record areas of 'Meadows and Pastures', but mark them in summary as 'Grasslands'*

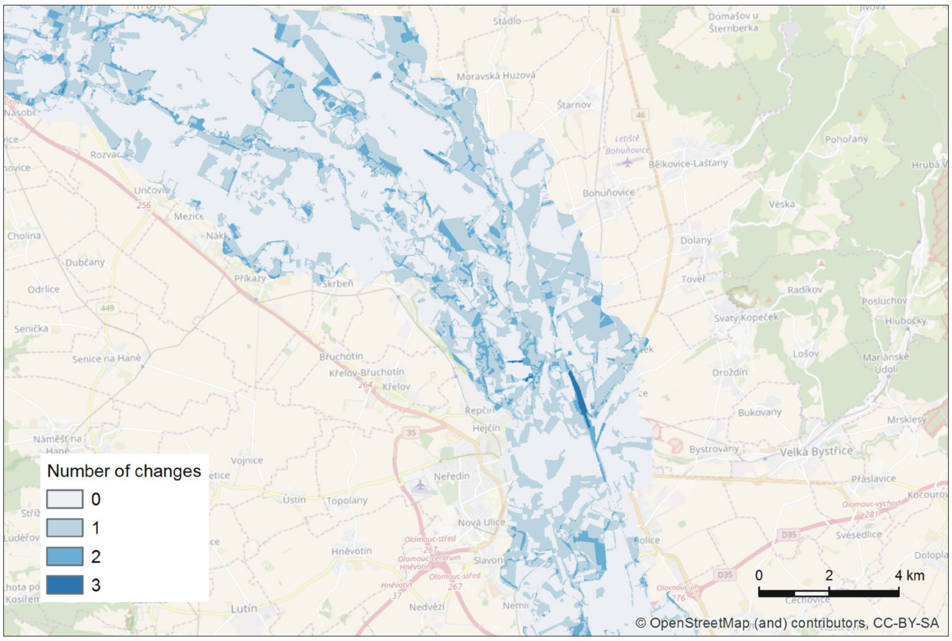


*Fig. 7: Number of changes in the Hornomoravský úval Graben (Sector 4) between 1877, 1953, 1999 and 2010*
*Source: authors' calculations*

When we compare the results of this study to the general development trends of the cultivated rural landscape in the CR, we can see that overall landscape heterogeneity and ecological stability increased during the 20th century (Lipský, 1995). The change in the observed landscape attributes in the study area in the first half of the 20th century was triggered by the transition from the 'coppice with standards' forest type to that of a high production forest (Machar, 2009). The intensive and centuries-old forest management processes in the floodplain forests of the Morava River is a conditionally natural state of the floodplain forest geobiocenoses, with unusually high biodiversity (Maděra et al., 2013).

The development dynamics of Central European floodplains is very rapid (Máčka, 2009; Salvati and Tombolini, 2013), from which follows a very dynamic ecological stability in the floodplains themselves. This was described by Buček and Lacina (1994, pp. 28–50) as the "fluvial dynamic series of successional floodplain biotopes". Research on the development of land use in the floodplains of European rivers provides similar results, despite the diversity of investigated areas, their size, scale, time periods and processing methods. Although such research projects may differ in their objectives and their methods, the results show similar trends in development.

In the last ten years there have been changes in the basin that are minor. One identifiable trend is the slight increase in grassland in the form of dry polders, as reactions to the devastating floods in 1997 and 2001 (Brus et al., 2013).

The dynamics of the various categories indicating the development of land use is influenced by many natural and socio-economic factors. In South Moravia Skokanová et al. (2012), Demek et al. (2008) set the category vineyard and hop field, and recreational area category in the second half of the 20th century. Lacina et al. (2007) used comparable categories distinguishing between built-up rural / urban built-up areas. The development trends of the forests, arable areas and grasslands are therefore comparable to many conducted studies in South Moravia. Moreover, legends are similar with the definition provided by Mackovčin (2009).

## 6. Conclusions

In the area of the Morava River floodplain in the period from 1836 to 1999, some important changes in the areas of forms of land use and their spatial arrangement are observable. Meadows and pastures, which formed the major proportion (47.54%) of the land at the beginning of the investigated period, currently comprise only one fifth of its original area (7.94%). For forests, the area decreased by 4% at most by 1953, and since then has increased to its current value of 27.81%. Arable land is a very dynamic form of land use and its area has increased from an original 21.5% to 51.87% by 1999 and currently at 47.14%. The built-up area has recorded a great increase, with a share that has changed from 2.56% in 1836 to 11.88% now. The most dynamic change is reported for water surfaces, because at the end of 19th century old ponds had ceased to exist and in the second half of 20th century new water surfaces were created as a result of submerged sandy gravel quarries. Regulation of the Morava river bed began before 1836 (straightening and barraging of the stream between Kroměříž city and Kvasice village) with shortening by 10 km, and the largest technical alterations were observed around 1900, when the river was shortened by 60 km in total.

From the analysis of relations between river bed adjustments and land use changes we can observe certain links. Forest areas did not go through such extreme changes as was the case for meadows. We can assume, however, that in the composition of species or the condition of forest ecosystems, we can track responses to altered local conditions.

Urban areas have grown greatly: their total area in the floodplain has increased by 464%, which, given current conditions, cannot be assessed as a satisfactory situation. From the analyses carried out and computed coefficients of ecological stability (Kilianová et al. 2012), it follows that the land of the Morava R. floodplain has low ecological stability.

Land use changes in the Morava River floodplain have affected the overall appearance of the landscape impressively. During the last 175 years, the Morava River floodplain has changed from an extensively used agricultural landscape with prevailing permanent grassland to an intensively used agricultural landscape dominated by arable land.

Changing the landscape structure affects the performance of the ecosystem services provided by the river landscape. Further research is required on the rate of decline in the performance retention and sedimentation function in biophysical and economic units.

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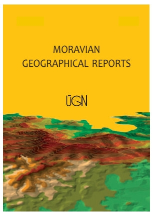


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## REVIEW ESSAY

# Energy landscape research – Lessons from Southern Europe?

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*The Moravian Geographical Reports does not often publish Book Reviews (let alone essays), but this new book on "Renewable Energies and European Landscapes"[1] is a well-deserved exception to the rule! It is an edited collection of essays gathered together by Frolova (University of Granada, Spain), Prados (University of Sevilla, Spain) and Nadaï (Centre International de Recherche sur l'Environnement et le Développement: CIRED –CNRS, France), based on a series of Workshops organised under the auspices of several agencies (from both Spain and France) in the period from 2007 to the present. In particular, the Spanish Network on Renewable Energies and Landscape (RESERP) began in 2010, with an emphasis on wind and solar power. Published by a well–respected agency, the question can be clearly stated at the outset: Do the editors fulfil their ambitious agenda of providing case studies of value for the emerging research on landscapes of renewable energies of Europe, writ large, i.e. beyond the 'Southern European' environment? Or: what is the 'added value' of the Southern European cases?*

## 1. Introductory remarks

Such a question is of great interest for all energy geography researchers today, as their work can be viewed as, minimally, concerned not only with the 'local', but also with the larger-scale implications of their findings for global issues of energy and climate change and economic development and … effectively, of societies, as we might know them, today. The conflation of 'local' and 'global', particularly as time is always co-present with space, then, is a crucial aspect of any geographic study today – with respect to energy, or with respect to any of the many aspects of the structure- and process-oriented elements of society, again, as we might know them, today. Clearly, this is one of the problematic issues facing any critical geographer.

So, there are many ways to approach an expanded review of this book. As the 'reviewer', I have chosen 'my' way (with apologies to Frank Sinatra) and I have used an epistemological viewpoint to highlight some of the issues contained in this book: initially, my concerns were to identify some of the elements of 'content' and 'context' in the 'debate' about 'renewable energy' and 'energy landscapes', in order to highlight successes and failures in this particular endeavour. 'Content' clearly refers to "What is this book about?", but 'context' is more diffuse, although it inevitably influences my evaluation of the 'content' as I believe strongly that my perspectives on 'context' give meaning to what I read as 'content'. In the final analysis and given space constraints, I have determined that the content of this book is well worth evaluating on its own merits. Hence, I am presenting my fuller review and evaluation of the subject book as an essay. Context, as always, can wait until a later time.

## 2. Content

To say the least, the content of this book is expansive and encompassing. It does not concern itself solely with the 'Southern European' experiences with renewable energy, although approximately 80% of its pages do just that. The remaining one-fifth of the content is comprised of a general overview of the (implicit) research design in Chapter 2 ["Landscapes of Energies, a Perspective on the Energy Transition" by Nadaï and Prados], and general local context and sometimes theoretical context provided for each of the case studies in the subsequent 13 chapters.

There are in total 31 contributors, most of them university or related professionals (94%), hence the approaches tend to be somewhat academic in nature. As for the countries these authors represent: Spain, 54%; France, 29%; Portugal, 7%; and Italy, 10%.

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[1] Frolova, M., Prados, M. J. & Nadaï, A. [eds.] (2015). Renewable Energies and European Landscapes. Lessons from Southern European Cases. Dordrecht, Netherlands: Springer, 299 pp. Doi: 10.1007/978-94-017-9843-3.

The issue of a 'Southern European' perspective on energy landscapes can be broadly accepted, although there is a chapter [Chapter 12: "Wind Energy and Natural Parks in European Countries (Spain, France and Germany)" by Deshaies and Herrero-Luque] which is clearly comparative in nature and extends the 'Southern' as far north as the Baltic and the North Seas! The French case studies are likely to be regarded as somewhat 'mixed': in Chapter 5, Labussière and Nadaï ["Wind Power Landscapes in France: Landscape and Energy Decentralization"] use the cases of the Département of Averyon in the region of the Midi-Pyrénées (clearly south-west France), and the Département of Eure-et-Loire, which contains the cathedral city of Chartres, for which 'Southern' is a bit of a stretch. Regardless, by and large, we are dealing with 'Southern Europe', and in particular Spain: approximately 42% of the content is located in Spain.

The structure of the book is well characterised by the editors in their opening chapter ["Emerging Renewable Energy Landscapes in Southern European Countries" by Frolova, Prados and Nadaï] and can be represented as follows.

The book has five parts covering the following areas (% of total content):

- Part 1: the conceptualisation of renewable energy landscapes (13%);
- Part 2: the development of new energies and emerging landscapes (26%);
- Part 3: (traditional) hydro-power and mountain landscapes (20%);
- Part 4: (questions about) renewable energies and protected landscapes (21%); and
- Part 5: renewable energy landscape planning tools and their application (20%).

For many (if not most?) researchers in the renewable energies field, immediately one is struck by the inclusion of "hydro-power and mountain" landscapes. But it has the same representation as the "tools" (Part 5), which sets up an interesting opposition. Clearly, for most instances of renewable energy landscapes, the material or bio-physical aspects (topography, climate, etc.) of 'landscape' cannot be ignored. How to integrate understandings of the physical environment into the socio-political realm of renewable energy landscape creation is crucial to the development of such landscapes. The ways in which this conundrum is tackled in this book can now be approached by a more systematic overview of each contribution.

### 2.1 Conceptualisation

Chapter 1 (Frolova, Prados and Nadaï, 2015) provides an extensive overview of the field and research area, as well as an explication of the book's structure. Accordingly, they note that the Southern European experiences in renewable energies have been a distant cousin to the reports emanating from North-Western Europe and North America. The book aims to set the record straight, especially with respect to the enormous development of renewable energies in Spain! Apart from this country focus, there is a wide range of such renewable energies represented – not only the usual well–reported wind power schemes, but also solar power (both solar photovoltaic and solar thermoelectric), hydro-power, and various forms of agro-energies (biomass, biogas and biofuel). Nonetheless, wind power developments take prime attention (6 of the 13 chapters subsequent to the introductory two: 46% of that content), followed by solar power (31%), and then one chapter on agro-energy and two on hydropower. Thus, over three-quarters of the book concerning specific types of renewables reports on wind and solar power, perhaps a typical and representative proportion of the content of such reports.

This chapter provides a very full overview of not only the field of research on renewable energies but also the specific contributions of each chapter. For the general overview, the presentation is fairly standard in terms of the coverage on general concepts (~11 pages), then their application to the Southern European context (~4 pages), then the specifics of each chapter (~4 pages), with a final evaluation of the future (~2 pages). So, we see a narrowing down from generalities to regional specifics to case study specifics, and hopefully some meanings for "the future". I think most readers would agree that this is a reasonable way to bring the overall problems of renewable energies and their attendant landscapes to the fore: take a set of case studies, contextualise them adequately in their regions/countries, and attempt to draw out some meanings for the future. The chapter accordingly deserves a full account of its content.

A key element in this approach depends, of course, on the definition of landscape. The authors conceptualise this issue in a striking manner (*ibid.*, p. 10):

> Although landscape is approached in a different manner in each country, the policies for protecting it have been developed since the end of the nineteenth century along three main lines of thinking (Bouneau and Varaschin, 2012 ):
>
> - The picturesque paradigm, which considers landscape as a part of heritage endowed with a visual dimension, akin to *veduta* in painting. From this perspective, landscape has to be protected from visual interferences (co-visibilities) that could alter its visual appearance.
> - The environmental paradigm, which considers landscape as a part of the environment, a natural habitat for wildlife and flora. It aims to protect this 'natural' landscape through the management of protected areas of different sizes (natural parks, biosphere reserves, etc.).
> - The cultural paradigm, which considers landscape as the result of the interaction between nature and society. Landscape is a part of the environment that has been shaped and endowed with shared meaning and values through cultural representations and territorial practices.

It is this third approach, which is also found in the European Landscape Convention (Olwig, 2007), which informs the perspectives on landscape in the book since the perceptions of local inhabitants reflect the intimate relations of nature and society, locating such perceptions in local cultures, identities, memories and values. Clearly, the scene is set – once we 'scale-up' from locality to broader regional and national concerns with respect to energy planning and policy directives – for potential conflicts or disagreements between local and non-local concerns. This approach acknowledges the complexity of landscape: "renewable energy landscapes … as heterogeneous and multidimensional – i.e. material, social, institutional, political and historical – processes embedded into a local area" (Frolova, Prados and Nadaï, 2015, p. 11), as well as the problems such a view poses for analysis of "the relations between the processes that underlie the energy transition and the issues raised by the transformations they induce" (*ibid.*). The authors assert that this is the "analytical strand" upon which the book is based.

It is, of course, a very difficult task. In their broad overview, the editors acknowledge the difficulties involved in using case studies to demonstrate larger scale issues of policy and planning for renewable energy, as there is a clear gap between national or regional planning systems built on engineering or economic considerations and land-use planning at the local level, as at such a level the considerations change to values, representations and identities which are not seen as part of the larger scale systems. It could even be said that such scalar differences are realised at the local level when the residents affected by such changes feel that they are 'pawns' in some larger scale game that is played for the benefit of other regions outside of their own. Such power inequalities are clearly part of the 'problem' of renewable energy developments, but the political economy of the energy transition is not taken up in an explicit manner in this book.

Subsequent sections of this chapter outline the different types of renewable energy landscapes in Southern Europe – wind power, hydropower, solar PV and thermoelectric power, and agro-energy (biomass, biofuel and biogas) – which are covered by the various case studies. In their view, the lessons learned from the case studies "point to the complex, interwoven nature of the processes through which the joint assembly of a renewable energy capacity and a culturally shared landscape can be achieved" (*ibid.*, p. 12). Clearly, the case of the relatively traditional renewable landscapes of hydropower stand out as largely historical cases of benefits able to be realised 'quickly' (better electricity supplies available), and as the resultant of a 'co-production' of landscapes now seen as beneficial in and of themselves (tourism and cultural heritage benefits). In contrast, the new renewable energy landscapes do not appear to bring such advantages for the local populations (climate change is not on the horizon?).

Such an historical difference is one key to understanding some of the distinctions that can be made between traditional hydropower landscapes and those of the new renewables, and much relates back to the power differences indicated earlier. The case of wind power is exemplary in this instance as it was the first developed beyond small scales of application, becoming 'industrialised' and large scale … and capitalist … and the first decentralised energy technology to

> concentrate hazards – in the form of very large clusters of very large turbines – while distributing the benefit of electricity primarily to far-off populations who do not experience… the altered views, land-use changes, ecosystem damage, noise, optical effects, and risk of accidents that come from the 400-foot high structures (*ibid.*, p. 14).

And, since it was the first renewable energy technology, it can be seen as part of the development of "a new political and economic order in rural Europe: the increasing liberalisation of the electricity market and sector" (*ibid.*), indicative, perhaps, of "our capacity to decentralise landscape and energy governance" (*ibid.*). This latter linkage to governance issues could be an important by-product of the flourishing of wind power in Europe and other countries, as problems in wind power projects siting and local acceptance have to be viewed in a broader context.

Solar power landscapes resulted from the next major development in renewable energy as the change from small- to larger-scale systems began in the first decade of this century. As in many countries, the initial major expansion was encouraged by incentive systems of feed-in tariffs which have proved to be too expensive in the last six or seven years. Solar PV ground-mounted plants and thermoelectric plants are, however, not compatible with existing land uses, unlike wind turbines. In this sense, they reflect some of the ambiguities with energy crops, competing with food production in that potential agricultural land is taken out of the rural system. Attempts to resolve such difficulties by establishing relevant guidelines for identifying the impacts of solar power developments in rural areas can be an imposition on local land-use planning authorities which are not well-equipped to handle the problems. Again, governance issues can arise.

Bio-energy landscapes are seen as a special case by the authors as biofuel production changes the very nature of local agricultural systems, making them more industrial in nature. Hence, bioenergies, as a form of renewable energy, can be contrasted with other forms of renewables in that they clearly involve agricultural policies as much as energy policies, or more broadly, environmental policies. Since they are expected to contribute to a greater extent to natural gas targets in the future, regulatory issues might be expected to increase in the future as well, as such cross-sectoral differences in policy can easily result in discrepancies in programming. In fact, it seems that the case of bioenergy landscapes are as different from 'normal' (i.e. wind and solar) renewable energy landscapes as the historical hydropower landscapes – in that they demonstrate a different set of factors influencing their development, just as water power landscapes did in the past. In fact, the authors assert that

> (T)he lack of integration of the policies regulating the development of biogas plants along with other more global issues, such as competition between energy and food production (for land and water), environmental degradation (through GHG emissions, soil and water resource degradation, biodiversity loss, etc.) and its social consequences (through land rights infringements, local and regional food security impacts, etc.), raised doubts about the authenticity of their environmental and socioeconomic credentials (*ibid.*, p. 16).

Following this expansive and well presented introduction to the various renewable energy systems covered in the book, the authors outline the case studies, asserting that "the issues arising from landscape practices and values … must be addressed for all kinds of renewables" and that "the analysis of the various pathways of transition to renewable energy requires a broader knowledge of this question" (*ibid.*, p. 16). The reader will certainly agree with such a proposition and might expect, then, a brief presentation of the nature of each case study/chapter in the following pages. What we have, instead, is more than a brief introduction – rather there is an relatively full account of the main points of each chapter, fulfilling what the authors describe as the intent of this first chapter, to assess "the differences and/or similarities in the case studies, policy, landscape culture and institutional contexts uncovered in the various contributions to this book in order to compare their results" (*ibid.*, p. 17). It is of course the authors'/editors' prerogative to decide how to organise their work, but I would have approached this structuring of content somewhat differently – briefly outlining the cases (the choice of which should clearly be left to the second chapter) and leaving a more extended comparative discussion of 'lessons learned' and 'implications for the future' to a final chapter, building hopefully on what the reader has judged for herself from each case study. In this book, we have no final summary chapter. The coverage in the case studies is outlined below in Sections 2.2–2.5.

The second chapter in this Part 1 on conceptualisation is co-authored by Alain Nadaï and Maria-José Prados (2015), who discuss the ways in which cross-national comparisons could be approached. As with other chapters in the book, there is an Abstract (also for Chapter 1), which gives the book the impression of a series of separate journal articles – rather than the integrated overall appraisal implicitly promised at the outset. The authors make the assumption that cross-national comparisons can be based on the analysis of the energy landscapes that have 'emerged' at the 'crossroads' of the development of renewable energy technologies and changes in current landscapes. Hence, the discussion tends to be double-edged: (i) as a process approach to technological development and the ways it interacts (or does not) with changing notions of landscape, which is a useful context for discussions of renewable energy development; and (ii) as a systems approach that tries to deal with the complexities of interactions as they exist and change between defined entities, especially in the policy and planning systems.

In this context there is a very useful review and evaluation of recent literature in the area of renewable energy landscapes, with some interesting comments about the roles of local and national governance, and more recently supranational processes that have resulted in a 're-articulation' of landscapes, the vectors of which are wind power projects. This is because

> they are locally sited but they are conceived, designed, and developed in relation with national and transnational processes, actors, and networks. So, in some ways, the "places" of our landscapes, in the sense of the web of relations which underlay these landscapes, become reconfigured in this process: climate change, climate energy policies, and the liberalisation of the electricity sector have become part of the making of landscape. (*ibid.*, p. 29)

This is an extremely valuable insight because it opens the path to conceptualising landscape in a different way – to become almost like a process itself in reconfiguring, in turn, the entities and relations that underlie its evolution. But of course, the landscape did exist before the siting of renewable energy facilities and it is the traditional, perhaps largely cultural, landscape that can often bear witness to social perceptions opposed to plant location. Siting problems have been reported in many research publications but an over-attention to locality can miss the larger context in which renewable energy landscapes have emerged: besides the usual 'developer' vs. 'local population' syndrome, larger scale issues such as the conflict between energy policy/planning and spatial/land use planning processes need to be addressed – again at varying scales. The authors contend that if there is not some merging, perhaps even a reconciliation of these two sets of interests (and actors/entities), then landscape becomes **the** central issue in the debates as the two sets of discourses are effectively opposed to each other.

The authors also attempt to bring into the discussion recent trends in cultural geography (largely) in terms of the development of so-called hybrid geographies, and forays to attempt to overcome the distinctions made between representational and relational landscapes (*ibid.*, pp. 34–36). They even go so far as to suggest a "daring, yet inspiring, parallel" between their well-drawn distinctions between "system vs. process approach to technology, on the one hand, and representational vs. nonrepresentational approaches to landscape, on the other hand" (*ibid.*, p. 35). This reviewer feels that this is an unnecessary sidestep in the development of their argument which essentially rests (in my view) on power and scalar discrepancies as realised at local levels of implementation of renewable energy projects. As they say, planning or more broadly policy concerns: "prove that the core issue at the crossroad between energy transition and landscape is that *energy landscapes rarely fit in existing landscape qualifications*" (emphasis in original, p. 36). One might well add that although the situation will vary by country, in all locations renewable energy facilities are 'noteworthy' in being fully material and above the ground!

Their conclusion certainly resonates more with some possible amalgam of their identified system and process approaches to renewable energy development: "cross-national comparison of landscapes of energies should be attentive to the type of landscape tradition at work in each country but also account for the fact that the development of renewable energy projects endows these traditions with a renewed existence" (*ibid.*, p. 37). While it is not quite clear what a 'renewed existence' might be, controversies or conflicts over facility siting will vary by country (or even by region) as the 'traditions' vary so much. Hence, they conclude that the variability in landscape traditions strongly affects the methods used in the analysis of siting conflicts, and, one could add, especially if the impact of a 'renewed existence' only adds to the variability.

In this chapter, then, we have an illuminating and thorough discussion of many aspects of renewable energy development and why it is important to view such changes from a well-founded theoretical perspective. I am interpreting their work as providing a general broad framework for renewable energy case studies, as they say it "aims at discussing the way in which cross-national comparison shall be approached" (*ibid.*, p. 26). It does do so however, in a very loose manner as there are no directives on how such comparisons can be made. By this comment I mean that the normal approach to research design in such a case would be to elaborate some theoretical framework (which they have done, by and large), which would then be used to define parameters of interest for further research, including criteria for the **choice** of case study areas (which they have not done). The implicit research design for this study is a comparative case study design, which is inevitably instrumental in nature (i.e. the purpose of the cases is to illuminate or verify the theoretical framing). Even with the 'traditions' and the 'renewed existences' only adding variance to the phenomena of interest, some analytical factors (such as 'degree of conflict', etc.) could have been used to aid in the design. Sadly, they are absent.

### 2.2 New energies / emerging landscapes

Part Two of the book comprises four chapters, two on wind power (Spain and France), one on solar power (Spain) and one on agro-energies (Italy). They demonstrate well the differences between national contexts for renewable energy developments.

In the case of wind power, for example, it is clear that in the Spanish case (Baraja-Rodríguez, Herrero-Luque and Pérez-Pérez, 2015), there was a very favourable investment climate, a developing industry for facility infrastructure and generous feed-in tariffs which lead to a ten-fold increase in installed capacity from 2000 to 2011, resulting in Spain placing second to Germany in Europe and in fourth position behind China and the United States in world rankings. This massive development is well recorded in this largely historical chapter, which also shows that the developments were quite disparate between regions, a difference that appears to be largely attributed to regional heterogeneity in governance structures. In fact, the distinctive 'territorial cultures' have resulted in distinctive landscapes, as the authors demonstrate that the only common factors in accounting for regional differences within Spain have been the lack of regulatory control and the limited inputs from public participation. At the same time there has been an interesting reversal of general social awareness of landscape in the country in that rural space has been afforded new functions and even new landscapes, which in turn generate new discourses of land, identity and belonging, which only add to the distinctively disaggregated nature of Spanish geographic space. The economic crisis clearly exacerbated such trends.

The authors' contention that the Spanish case is so unique in Europe is documented as well by three interesting case studies: (1) the Cantabrian mountain range running across the North of the Iberian Peninsula and acting as a natural frontier between Atlantic and Mediterranean Spain; (2) the Ebro Valley, in particular the two high plains of La Muela and La Plana, about 20 km away from the important inland city of Zaragoza; and (3) the province of Cadiz, in the south-west corner of Andalusia (with its huge coastline on two seas, the Mediterranean and Atlantic Ocean). These case studies not only illustrate different bio-physical environments but also different urban and touristic situations, and illustrate their findings that "the deployment of wind energy has helped to liven the territorial debate and has contributed to the slow awakening of social awareness as to the value and importance of landscape in Spain" (*ibid.*, p. 45).

For these authors, one key issue concerns the limited public participation in wind power developments, with a rather illuminating conclusion (*ibid.*, p. 59):

> In any case the result is that windmills are now part of the landscape in numerous Spanish regions. Their deployment has produced new discourses, new social practices and relations, many of which are clearly in their favour. In rural areas with impoverished economies, windmills are often viewed as a source of income for institutions and for local people, as a way of moving the area into the modern economy, presenting an image of clean energy and sustainability to such an extent that in the pioneering areas in which windmills have now been installed for some years, they have become symbols of the local identity."

A rather different approach to wind power development is seen in the French case study presented by Labussière and Nadaï (2015). As in the Spanish case, there is an interesting history of the development of wind power in France through various national directives, in this case more directly related to concerns about global climate change in which renewable energy clearly plays a major role. In fact, it is the directives from the European Union which have resulted in regulations that were quite unusual in that attention was directed to policy articulated in its territorial dimensions. For many if not most members of the EU, this raised tensions between overall directives and the territorial bases of planning, not only but in particular for renewable energy projects.

Perhaps especially in France, but also in many jurisdictions, the impact of climate change is seen in challenges to the centralization of governance structures: "… a cultural shift regarding a kind of management that was traditionally centralized… they reflect the gradual emergence of a decentralized energy policy and raise the issue of its territorial governance"(ibid., p. 83). In France in particular, these changes are associated with the widespread acceptance of the European Landscape Convention, which places an emphasis on 'everyday landscapes' and

> … on a more opened governance of heritage policies; it introduces management and development issues at the heart of landscape policies. Termed "the just landscape" by some analysts, the ELC is seen as an innovative paradigm for landscape policies, which develops the dominant normative approach to landscape toward a more collective management of landscapes (Olwig, 2007). In some ways, wind power development provides a testing ground for such views (*ibid.*, p. 86).

As the authors demonstrate effectively, the dominant paradigms evident in landscape planning and protection were organised around what they define as the "state landscape", which consisted of "numerous concentric figures" expressing "the state's normative power" (*ibid.*, p. 87). Such representations were organised around so-called 'heritage elements', but the plans for wind power developments disrupted such patterns. Hence, we have conflict, often seen locally but more importantly, a reflection of the differential powers in landscape protection and energy planning emanating from higher governance levels. And more generally, the paradox that after more than ten years of one of the highest feed-in tariffs in the world, the installed capacity in France is still low.

These broader distinctions at policy and programming levels are well exemplified in two case studies presented by the authors. These cases – from the Eure-et-Loir département, which includes Chartres Cathedral, and the département of Aveyron in southwest France, which is one of the windiest French départements, illustrate well the authors' principal arguments: "… France cannot jointly support landscape policy and wind power policy without challenging the former because of the new visual relations generated by the latter." (*ibid.*, p. 87). In other words, the challenges brought about by global climate change are registered in many localities by necessary changes in higher level governance structures, by some sort of policy 'de-coupling' that overcomes the disjunctions brought about by the stimulus itself. As the authors conclude, any sort of "technological dream of an "a-social" power generation technology, leaving us untouched and unchanged, resembles the Arcadian landscape: it is a utopia. It does not exempt us from the social and political work necessary to renew our relationship with energy."(*ibid.*, p. 91).

We note that such a call for energy geography research is critical in its essential epistemological elements: 'in our work, we research in order to work for change'. This is one of the few remarks of such a nature in this book, yet it is surely most welcomed.

In this part of the book on new energies and landscapes, it is perhaps inevitable that some strong similarities emerge regardless of the exact type of renewable energy under consideration. For example, in their Chapter 4 on solar photovoltaic power in Spain, Mérida-Rodríguez, Reyes-Corredera, Pardo-García and Zayas-Fernández (2015), a similar history of rapid expansion due to a relatively absent regulatory system, as in the case of wind power (see above), is recounted. Up to 2008 the growth in photovoltaic energy installations in Spain is described as exponential; with the economic crisis, however, as well as an increase in regulatory powers, there has been a relative stagnation. Compared to other countries, the ground-mounted solar PV plants have dominated the landscape and considerably changed many rural environments. The chapter does not present any original case study materials, but does review a large number of such studies, especially more recent ones that address directly the social impacts of the facilities. This turn to including the public in the decision-making process for plant installations is quite new and reflects increasing concerns over social, ecological and landscape impacts.

Regardless, the authors conclude on a generally positive note:

> research done so far in Spain shows a broad public acceptance of renewable energies and in particular of solar PV power due to its positive environmental connotations and the benefits it is perceived to bring to the economic development of the area in which it is located, although concerns were also shown about its high cost. There seems also to be a certain lack of knowledge and wariness regarding photovoltaic energy, largely as a result of its recent arrival on the scene, and a rejection on aesthetic grounds of its formal components (shape, colour) and its industrial nature (*ibid.*, p. 76).

This is an interesting conclusion in that the notion of the visual landscape re-enters the picture. The 'formal components' relate to the *veduta* referenced earlier in the review of the meanings of landscape by Bouneau and Varaschin (2012). Clearly, there is a challenge here for solar PV proponents, in both rural and urban situations.

The final chapter in Part Two of the book deals with the interesting and relatively new agro-energy landscapes. Ferrario and Reho (2015) examine these landscapes in the Veneto region of northern and north-eastern Italy in a very comprehensive study that shows the importance of several layers of EU and national and regional governance structures and policies on the development of agro-energies:

> European policies on agroenergy can be viewed in different ways: on the one hand, they represent a synergy between energy policies sustaining renewables and agricultural policies subsidising multifunctionality, and on the other they reveal the extreme difficulty Europe has in coordinating sectoral policies with regional and spatial planning and in evaluating and controlling the consequences of such policies both locally and globally. (*ibid.*, p. 97).

The Veneto appears to be almost a showcase example of the conflicts that have arisen with respect to agro-energies because of the spatial proximity of both urban and rural areas, intermixed to a very strong degree:

> Our work seeks to highlight the connection between government policy, landscape transformation and public perceptions, in three steps: we firstly analyse regional policies funding agroenergy development; secondly, we survey in quantitative and qualitative terms the landscape transformations caused by agroenergy development; and thirdly, we analyse one of the most contested new landscapes, that of biogas, in order to explore the reasons behind the conflict in greater depth (*ibid.*, p. 96).

In many ways this is one of the most satisfying chapters in the book in that it adequately accounts for the legislative and regulatory context at different scales, which in many ways afforded the strong development of biogas plants in the region and the transformations in the landscape. It is also very rewarding in its excellent coverage of the conflicts engendered by the development of biogas plants. In part these conflicts stem from what the authors call 'coexistence conflicts', as activities such as factories and farming used to co-exist well, but today with the arrival of many biogas facilities so close to residents "(T)he agrourban landscape is in deep crisis" (*ibid.*, p. 100). At the same time as providing these sobering thoughts, the authors do see a way out of the problem as it has in effect been produced by conflicting policies (i.e. the sectoral approach to agriculture does not speak to sectoral energy policies) at macro levels of concern, but also by local administrative policies that appear to be indifferent to landscape change. Essentially, they seek a new approach to local conflicts, one that would "build a spatially fairer, more democratic renewable energy system. If this happened, the new landscape of carbon neutrality would be accepted more easily because it would *represent* a fairer and more democratic process" (emphasis in original, *ibid.*, p. 112). It would, of course, be a different landscape!

### *2.3 Hydro-power and mountains*

Part III of the book deals with relationships between hydropower development and mountain landscapes in southern Europe. There are three chapters with locations distinct enough for useful comparisons: Chapter 7 (Frolova, Jiménez-Olivencia, Sánchez- del Árbol, Requena-Galipienso and Pérez-Pérez, 2015) covers the Sierra Nevada mountain range in Andalusia (southern Spain); Briffaud, Heaulmé, André-Lamat, Davasse and Sacareau (2015) present an interesting historical study of the French central Pyrenees at the beginning of the twentieth century; and the Piave river basin in the Italian Eastern Alps is subject to critical scrutiny by Ferrario and Castiglioni (2015). These three locations adequately demonstrate the overall scope of the book in that landscape differences are seen as both space and time dependencies, and that much can be learned from public reactions to previous landscape changes (as in the construction of hydro plants) that is of value in interpreting current attitudes and perceptions of renewable energy facilities.

The Spanish case study is a very well documented account of small hydro developments in the Sierra Nevada in the past and of wind and solar projects more recently. Close attention is paid to the ways in which the various projects were received by local populations (both positively and negatively), using documentary information, fieldwork and in-depth interviews with different stakeholders. One consistent finding was that landscape values play an important role in affecting positive **or** negative reactions to proposals. For example, older hydro plants have become "part of the cultural heritage and have acquired a certain symbolic value, to the extent that they need to be managed as an integral part of any landscape restoration programme" (*ibid.*, p. 132), a finding that illustrates that historical and social contexts need to be taken into account in forming any direct conclusions on the effects of renewable energy facilities on landscapes. Effectively, the role of landscape values is highlighted in this important contribution, and yet the reactions of stakeholders to wind power facilities were often mixed, with some saying they had no impact on the landscape.

This case also shows the strong relationship between energy facilities and tourism:

> Although the most common perception of the relationship between tourism and renewables is that the building of energy infrastructures in a particular area could cause it to lose its attractiveness for tourists, this link is far more complex and some energy infrastructures have in fact contributed to the development of tourism in Sierra Nevada. In the same way, as many industrial landscapes related with hydroelectricity have now become historical landscapes with a significant heritage and tourism value, the emerging renewable power landscapes could themselves become an important part of the local scenery, forming a future 'historic landscape' (*ibid.*, p. 133).

The historical study of hydro-electric developments in the Pyrenees is a fascinating detour from the other studies in the book. Attention is focussed on the Bigourdane area of the central Pyrenees and especially the Cauterets valley, the upper valley of the Gave de Pau and its tributaries (Briffaud, Heaulmé, André-Lamat, Davasse and Sacareau, 2015, p. 136), and there is an in-depth study of the protected site of Gavarnie. Initially, the proposals met with very strong resistance from preservation groups arguing in terms of landscape protection, but also from the point of view of protection of the tourist industry. The authors state that

> (I)n this study our analysis focuses on the interactions within the landscape/hydropower/tourism triangle and the ambivalence of their construction using the words and actions of those directly involved. We shall demonstrate the key role played by conflictuality, a key component of this construct, by analysing how the different groups of stakeholders tried to project their own action into this space and inscribe their own point of view on the territory, thus revealing different ways of understanding the local conditions that give rise to the development and the formation of an identity (*ibid.*, p. 136).

Interesting, one might say? Yes, in that a similar statement could well be formulated to describe any current investigation of the same situation (except, perhaps, for the strange use of 'conflictuality'?)! In fact, some of the arguments described in this chapter could just as easily be used today by opposing stakeholders in renewable energy debates. The strength of the arguments used by these authors, however, is compelling:

> … conflicts that occurred here between the period just prior to the First World War and immediately after the Second contributed to creating both spatial and social partitions and in so doing created new socio-spatial relations that were an integral part of a new relationship with resources in the high mountain areas. By socio-spatial relations, we are referring to social relations which take the form of a relationship with space, which are an integral part of it and/or legitimised by it. We are describing a space that illustrates social relations and at the same time also represents the matter, the symbol and the setting for these relations (*ibid.*, p. 136).

The conflicts under study in this chapter emerged from concerns of an environmental nature (the nature/society problematique expressed as concerns over 'natural balance' and 'regulation', largely seen in the form of forestry policies) compared to those more directly related to landscape. There was a "constant back and forth" between these two approaches or paradigms that gave rise to "representations that differ not only as a result of diversity in sensitivities or interests, but also because they are grounded on fundamentally dissimilar ways of understanding reality" (*ibid.*, p. 150). The truths emerging from this historical study are just as relevant today.

The final chapter in this part of the book on mountain landscapes is primarily concerned with the northern hydrographical basin of the Piave River in the Veneto region in north-eastern Italy, where the hydroelectric potential of the main river and its largest tributaries has been exploited for more than one hundred years. Ferrario and Castiglioni (2015) take up the challenge of investigating two cases of small hydropower developments through a landscape lens: the centralina di Vigo was developed by the municipality of Vigo di Cadore in 2005 and is now in use; in comparison, the centralina del Mis was developed by a private company on land inside the Dolomiti Bellunesi National Park in 2008, but its construction was cancelled in 2012 as a result of opposition by environmental associations. The analysis was based on three kinds of sources: informal interviews with stakeholders, on-line documents (press, associations, promoters and municipalities' websites) and fieldwork at the sites (*ibid.*, p. 165).

As in the case of biogas facility development discussed above for the same region (Ferrario and Reho, 2015), the impact of supra-local policies effectively undermines the objectives of integrating energy into the landscape, even in the face of much more local detail in this case. The authors comment succinctly that "landscape is a concept with a multitude of meanings. Its main peculiarity lies in the fact that it belongs to the spheres of both reality and representation" (Ferrario and Castiglioni, 2015, p. 157). Such complexity can, however, be seen as an advantage of taking a landscape approach:

> (I)t enables us to consider different issues and mediate between them (such as fairness, both in the case of outsider and local exploitation). This helps avoid 'yes/no' discussions, polarised positions that necessarily lead to conflicts, and instead allows us to think in terms of 'how', taking into account and respecting all the different values at stake (*ibid.*, p. 170).

### *2.4 Protected landscapes*

Natural parks, special heritage landscapes, national parks – the names vary but essentially we are talking about protected landscapes and, as many are also in mountainous areas, the potential for wind power, in particular, is very high. This Part Four of the book contains two case studies involving wind power and one of solar PV facilities.

The only case study from Portugal is presented by Afonso and Mendes (2015), an unusual contribution as well in using an ethnographic approach. Especially in northern Portugal, there is an evident overlap between protected areas and sites of high potential for wind power development. The authors identified three case study areas which had recently experienced such developments and where there had been strong controversies: (i) the Natural Park of Aire and Candeeiros Mountains, where the wind farm was located on communal lands and subject to the criticism that the residents had not been compensated sufficiently for the negative impacts; (ii) the Natura 2000 site of Arga Mountain (NW Portugal), where three turbines were relocated after opposition mounted on their intrusion into a symbolic landscape regarded as highly religious in nature; and (iii) the Natural Park of Montesinho (NE Portugal), where the conflicts again centred on building on communal lands and who had the right to make the decisions (*ibid.*, p. 176).

The detailed local accounts were generated from regular visits to the field, interviewing key informants (local citizens, technicians, the mayors and chairs of parish councils, representatives from both regional and national environment and conservation organisations, and entrepreneurs from the wind power companies). There is an enormous variety of opinions expressed, some favourable, others not, and many related to what appear to be very long-standing antagonisms between (non-local) conservation and protection agencies and local residents with respect to the management of the commons or communal lands (*baldios*):

> Local populations do recognize the commons as collective property. They know every other neighbour that is allowed to make use of it according to customary uses and knew their former owners. On the other hand, the natural park introduced a new conception of "collective property," that is, the notion that local landscape and natural resources also belong to the "national community" and even – through the Natura 2000 Network – to the "Europeans" (*ibid.*, p. 185).

Thus, both scale and property rights are brought strongly into a politicised argument, but in fact the situation is more nuanced than that. For example, in the second case study site of the 'Holy Mountain', plans were changed to relocate three turbines:

> The main section of the wind farm is located on a plateau – the Chă Grande – that the surrealist poet António Pedro once described as a "quiet atmosphere of sensitive ruins." This is a very evocative place, with its religious temples and pastoral landscape, full of vestiges of cultural and geological past, a place full of ruins. In the environmental impact assessment (EIA) submitted by the promoters, the "presence of the wind turbines" – all twelve – was already invoked as a negative result of the construction of a wind farm. Nevertheless, the EIA also mentioned that this impact over the landscape is "a subjective matter" (*ibid.*, p. 186).

There is also an interesting argument based on this ethnographic approach that is not recorded explicitly (to my knowledge) elsewhere in the book: economic benefits are often brought to bear on siting decisions, especially in relatively deprived rural locations, but in fact it is more than that from a landscape viewpoint as it can be seen as a process "through which that energy is endowed with a qualification and an economic value cannot be understood without taking into account the social and cultural relations in which it is being embedded" (*ibid.*, p. 177). Indeed, what wind power brought to these communities was a revitalisation of traditional collective rights, reinvigorating 'almost obsolete communitarian structures' as an 'assembly of neighbours' negotiated with developers. Such local empowerment, of course, could find its impacts in revitalised landscapes as local populations would find reinforcement for their beliefs that the "landscape" was "a legacy from their ancestors and a tangible place from which to extract a livelihood" (*ibid.*, p. 189).

The second chapter (12) on wind power in this section of the book is quite different in its social scientific and somewhat distanced language: Deshaies and Herrero-Luque (2015) examine developments in natural parks in three countries – Spain, Germany and France. One might think this comparison would be relatively straightforward but difficulties arise with the level of decision-making powers vested in regional governments, which vary greatly between the countries. Further difficulties emerge with the timing of registration of the parks (some of which had wind power plants already established before their formation as parks), as well as their designation/level of significance with respect to the protected landscape.

Clearly, siting issues predominate in the discussion: wind power turbines are 'OK' if they are located away from the central most aesthetic parts of the parks, so when they are located in parks, they tend to be on the peripheries. The opposition voices tend to concentrate on the visual impacts of large turbines, especially those of more recent construction. Thus, 'protected areas' can be seen as reflections of relatively 'immutable non-changing traditional landscapes of great cultural and natural value', sometimes including the effects on wildlife and even the possible development of green tourism. Add the economic arguments ('wind power profits go to those not resident in our area') and we have many examples of strong opposition movements to wind power in these protected areas.

The general impression that one has from this analysis of the 'wind power vs. protected areas' debate is that it is extremely variable. Many examples are provided which appear to be almost contradictory to each other, as local factors result in a different resolution of the siting issues. Thus, an overall finding is that

> (W)ind farms have been installed in natural parks in all of these countries. In France and Spain, this development has been restricted to small areas considered of low cultural and natural heritage value. In Germany, by contrast, some natural parks have a high concentration of wind farms, while others remain free of any wind power development (*ibid.*, p. 217).

The diversity of presence/absence of wind farms in natural parks is perhaps daunting if one wishes, as these authors do, to "analyse the relationship between natural park policy and wind power development in order to identify the causes of conflict and to determine the principal factors affecting the deployment of wind farms in protected landscapes" (*ibid.*, p. 218). Certainly, the various conflicts are well covered in this chapter, often substantiating the conclusions of Pasqualetti (2011) with respect to characteristic reasons for opposition. In general, one might be able to say that the natural parks have limited the development of wind farms on their territories but the variability in the phenomena of interest is such that broader conclusions cannot be made. This is unfortunate as one could easily define a research model in which the dependent variable would be 'presence/absence' (or even numbers) of a wind power facility in a natural park (which would be the 'places' or row entries/cases under examination), including a number of well-known independent variables for the parks (e.g. size, significance level, etc.), i.e. a logistic regression model. Given the acknowledged variability, such a model might not have a high level of explanatory power, but the effects of the various factors could be estimated, as well as the possible contextual effects of 'nation'. Certainly, as approximate as it may be, it would be an improvement on the listings of distinct site differences offered by the authors. In brief, their account is interesting but it is not analytical and therefore does not really add to our general understanding of the issues.

The final chapter (11) to be discussed here is again quite different in both language and intent, as Perrotti (2015) examines the development of solar PV installations in the vicinity of a protected area in the hinterland of the town of Bari, in the Puglia (Apulia) region in southern Italy. The Alta Murgia National Park was established in 2004 and is itself located in a larger Site of Community Importance (SCI) and a Special Protection Area ("Murgia Alta" SPA), which was established in 1998 and is part of the Natura 2000 network of protected areas. In examining solar PV power development on agricultural lands both inside and outside of the boundaries of the protected area, Perrotti effectively establishes an interesting research design of 'cases within a case' based on the principle of extreme variation (my interpretation, not hers!).

As in several other chapters in this book, there is relatively full coverage of the various layers of governance, from national to regional to local, that are represented in the landscape of Alta Murgia, with a strong recognition of the linkages between the various levels. But the exposition goes beyond the usual accounts, working from the metaphor of the 'particularly worthy' landscapes of the protected area in comparison to the 'everyday' landscapes that lie at its borders. The distinctly different decision-making processes operating 'within' and 'without' the Park, are extremely well accounted for, serving to intensify in many ways the distinctions between the two types of landscapes. The political forces that reinforced the 'meaning' of a Rural Park stressed the 'natural' in the sense of the relations between the biophysical environment and its human utilization over time, i.e. an ideology that surpassed the usual nature conservation. In contrast, outside the park one witnessed the

> development of solar PV power plants in "not particularly worthy" landscapes. This tendency is especially prominent in zones that are close to protected areas. In this context, unprotected areas have been considered as the opposite – or even the "negative" – of the conterminous protected areas, without consideration for the specific qualities inherent in these landscapes and their aesthetic and ecological values. These "other" spaces have been seen as merely not specially and not particularly worthy landscapes. For this reason, they have progressively become a sort of land reservoir for those activities that could not be established within in the protected areas (sic, *ibid.*, p. 196).

In fact, the 'land reservoir' was changed drastically as investors took advantage of the generous feed-in tariff system (as elsewhere) in converting the traditional agricultural landscape into a series of solar panel enclaves. In brief, the 'everyday landscape' of the Alta Murgia was transformed into a new energy landscape, more industrial in nature, hence distancing it even more from the 'worthy' ones inside the park boundaries. It is interesting, as the author notes, that such landscape changes appear to be in conflict with the supra-level directives of the European Landscape Convention, which is widely recognised for its acknowledgement of the qualities of 'everyday' landscapes.

Drawing largely from the work of Nadaï and Labussière (2013) in the sense of finding new ways to conceptualise (and actualise) the planning process for renewable energy installations, Perrotti acutely questions 'what type of landscape' should be subject to planning processes. In terms of the better established procedures for planning the siting of wind power plants, Perrotti highlights the distinctions made by Nadaï and Labussière in terms of 'constraint' and 'positive' approaches to planning – that the difference "lies not in the absence of recourse to constraint maps in the second but rather in how they are introduced into the planning process" (*ibid.*, p. 196) – which can be interpreted as siting solar PV installations **with** the landscape rather than **into** or perhaps **on to** the landscape. A particularly valuable case is made for the Alta Murgia in terms of integrating the traditional stone walls, as at the historical site of Quite, into planning processes:

> In the very different karstic landscape of the Alta Murgia region, it is more the *stasis* of geological time than the *kinesis* of the local living forces that could reactualize the heterogeneous network of relations between the local entities. The geomorphological features of the Alta Murgia landscape and the specific lithological character of its calcareous soil (and subsoil) have influenced the development of a site-specific typology of architecture and a typical spatial organization for the local rural settlements. Hence, it is on these transcalar and transtemporal entities (geology and lithology) that planners should focus to conceive new spatial configurations of the everyday energy landscapes in Alta Murgia (*ibid.*, p. 210).

In terms of the substantive contributions to our knowledge of the development of renewable energy landscapes from this book, Perrotti's contribution must occupy the first rank.

### *2.5 Landscape planning tools*

The fifth and final part of this book comprises three case studies of the implementation of landscape planning and assessment tools, with examples drawn entirely from Spanish experiences.

In Chapter 13, Andrés-Ruiz, Iranzo-García and Espejo-Marín (2015) address the issues surrounding the development of solar thermoelectric power and its attendant landscapes. Unlike solar PV landscapes, the solar power stations have differential impacts on the landscape largely as a function of the technology used. Spain was one of the first countries to develop such technologies, starting in the late 1970s with the first facility for testing concentrated solar radiation – the Almería Solar Platform (PSA), supported by the International Energy Agency. Together with government-supported research and development in the Almería Solar Electric Power Plant, Spain was the first country to demonstrate the experimental proof of the technical feasibility of the technology.

The result has been the rapid expansion of this form of renewable energy in Spain, accounting for over 2% of the electricity consumed in the country. Solar thermoelectric landscapes have become quite common in the southern part of the country, as the technology requires high levels of annual sunshine. Legislative initiatives in favour of renewable energy aided in the rapid expansion, producing changed agricultural landscapes and also some conflicts, as the plants require large amounts of space as well as a secure supply of water. The visual impact on the landscape might appear to vary with respect to the technology used, but the authors contend that the character of the changed landscape

> does not depend so much on the type of technology used as on whether or not the plant is installed in a self-contained geographical area, whether there is a succession of closely sited plants or whether it contributes to create a collective image. In order to define the different configurations of helio-landscapes,

> three factors must be taken into consideration: the topographic characteristics of the area in which the plant is installed, the concentration factor and public perception (*ibid.*, p. 244).

Such 'helio-landscapes' (i.e. including solar PV installations) have also engendered conflicts related to flora and fauna disturbances, as well as the need to be near transmission lines, some of which had to be newly constructed.

There are many repeated lessons to be learned (again!) from the introduction of (yet) another new technology in the 'industrialisation' of traditional rural areas from this chapter. Although the report is primarily phrased in technical language, the authors do recognise the need "to implement territorial planning policies specific to this technology and to establish administrative procedures that include a real process of social participation in which local stakeholders are actively involved in the decision-making process (*ibid.*, p. 252). Nonetheless, the discussion is primarily inwardly focused to the case of Spain: for example, 15 of the 16 references are in the Spanish language.

In Chapter 14, Mérida-Rodríguez, Lobón-Martín and Perles-Roselló (2015) discuss solar PV developments in Spain in terms of the landscapes of Andalusia, stressing the need for a more integrated approach to the planning and installation of these facilities. The approach in this chapter seems to be more akin to landscape architecture than spatial planning, as a basic criticism that they level against developments to date is the lack of integration with extant landscapes. Indeed, they contend that "rapid proliferation of photovoltaic plants has made their effective control in territorial planning difficult" and "only protected areas have remained unaffected by this phenomenon, while the expansion in ordinary landscapes, by contrast, has occurred in a disorganised, uncontrolled way with no landscape management" (*ibid.*, p. 261), fully laying the blame for this not only on local administrations but also on the economic objectives of the proponents. Their case study of Andalusia is instructive in that the very rapid expansion of solar PV plants (now accounting for more than one-third of electricity generation) has affected a variety of landscapes and could therefore contain some important lessons more generally. In addition, the researchers examined landscape impacts themselves, as well as carrying out a survey of affected populations in four study sites.

For landscape evaluation, the research demonstrated that

> there are five variables: location and site of the installations, density, overall design, design of the component parts and internal organisation of these components. These variables in turn give rise to three methodological phases: identification of the landscape features of photovoltaic plants, analysis of their impacts and proposals for landscape integration (*ibid.*, p. 256).

They demonstrate that the landscape impacts can be seen as 'intrinsic' (i.e. to the site) and 'extrinsic' in terms of the changes in visual conditions. Both types of impact are evaluated extensively by the researchers, in a series of detailed recommendations about the effects of size, density, alignments, etc. Importantly for their objectives, they note that many impacts could be ameliorated by better design and management. This conclusion appears to be validated by the public surveys, which found

> an important imbalance between the positive public perception of the economic and productive benefits of photovoltaic plants and the negative perception of their effects on the landscape. The perceived negative consequences on the landscape do not however prevent an overall positive rating. To some extent these negative consequences are considered an inherent part of energy development, and some interviewees even cited a widely held principle in rural communities, namely, the freedom of the owner to use the land for whatever purpose he/she deems fit (*ibid.*, p. 270).

It is interesting that the authors do not see this 'imbalance' as negative, since "seemingly contradictory opinions must be seen as an opportunity rather than as a problem: there is a positive opinion about the general nature of the installations that can be extended to their location and their outward appearance" (*ibid.*, p. 270). Hence, the call for better, more integrated designs that match the landscape as understood and lived by residents with the new facilities, i.e. planning with the landscape, echoing the desires of Perrotti described above.

This interesting chapter represents another departure from the 'normal' discourses in the renewable energy literature in its attention to landscape architectural details, and while some critics may downplay this approach as some sort of engineering 'technological optimism', there is an added element of public opinion to account for the suggested changes to planning processes. In addition, the chapter could well have more general appeal: more than one-half of its references are in the English language.

The final chapter (15) in the book is on the role of Geographical Information Systems (GIS) in the development of renewable energy systems, especially wind power (Díaz-Cuevas and Domínguez-Bravo, 2015). The authors are relatively ebullient in their support for GIS, extolling virtues that appear to be emphasised in the case of Spain's endorsement of the techniques at most levels of governance. The description afforded to these techniques by the authors: ".. effective wind power planning must identify exclusion areas according to technical (network connection, wind energy potential, noise, etc.) and biological criteria (protection of bird and bat species) and then select suitable areas in terms of wind, infrastructure and landscape conditions" (*ibid.*, p. 280), appears to define what was called a 'negative' planning approach earlier by Perrotti. But the authors are more sanguine in their support for GIS, noting that multi-criteria evaluation techniques are also of equivalent value in siting decisions, and that

> it is necessary to establish a referential conceptual framework for each of the renewable energies before GIS can be used **at each scale and for each territory**. This conceptual framework should establish the contents and criteria that must be taken into account in each location model built using GIS. These criteria must be defined by the authorities responsible for territorial and landscape quality, who must take the opinion of local stakeholders into account. In the case of landscapes, these criteria must not be limited to mere visibility analysis or the prohibition of renewable energy plants in scenic landscapes and must include public perception and participation, given that landscapes are dynamic and changing both in their configuration and their social requirements (*ibid.*, pp. 291–292, emphasis added).

Importantly and in addition to 'internal' considerations in the applications of GIS, they stress that any GIS approach must be reviewed in context: firstly, that the ELC has stipulated that any landscape is worthy of consideration, even the most 'everyday'; and that results from the application of GIS (e.g. with respect to 'viewshed', for example) should be regarded as relatively limited compared to 'real world' perceptions.

The analysis reported by these authors is quite limited – overviews of the applications of GIS at various scales in Spain, albeit limited to rather methodological concerns. Even for the two areas in Andalusia with recorded applications – La Janda and Jerez de la Frontera – there is limited empirical evidence presented. At the same time, some intriguing implications for incorporating the public into decision-making processes using GIS are discussed, especially work on 3-D presentations of views under different scenarios. This aspect of participatory planning might have been developed further by the authors, for the benefit of non-Spanish speaking readers – only one-third of the references are in the English language.

To some extent, this chapter is similar to the other two in this final part of the book in that it relies on relatively technical language even though some nods to public participation are included. In short, reliance on technical expertise is still seen as the principal way to plan energy landscapes. Also, in comparison to the other chapters in the book, these are quite 'internally oriented', i.e. to the Spanish experience *per se*. There are relatively few of the concerns with multi-scalar issues seen in the rest of the book. The fact that there is no final chapter does not help, of course – but then, where would the editors have placed these three chapters? There is no doubt that technical inputs to renewable energy siting issues are important, but in reality they tend to be closer to the social impacts than what seems the case here.

## 3. In the guise of a summary

Given the broad expanse of both topics and approaches under consideration in this book, it is quite difficult to find some good summary conclusions. Let me try to do this by outlining and commenting on what the editors chose to present as their 'Challenges Ahead' in their first chapter, to bring this essay to some interim closure.

Several challenges are outlined by the editors. Frolova, Prados and Nadaï (2015, p. 20) assert that renewable energy landscapes are 'here to stay' in that they "have become an essential element of the scenery of southern Europe today and should be treated as such. Protecting all emblematic landscapes from all forms of renewable energy development is not possible, nor is it a necessary or legitimate goal." They also contend that landscape protection in general terms should evolve, presumably in its legislation and implementation, to take renewable energy into account. In brief, there are some direct policy implications that could be drawn from the various case studies.

There are also challenges concerning the ways in which renewable energy installations 'fit' into the landscape. Drawing on the historical account of hydropower development (Chapter 8), it is clear that those structures and the landscapes they have created are regarded as heritage landscapes today because of "their multi-scalar embedding in the pre-existing local landscapes" (*ibid.*, p. 20). The comparison is then drawn to current energy landscapes where the embedding is directed from higher levels using economic market-driven rationales, rather than respecting public interest and local economic development. Taking this argument one step further, they feel that there is evidence from several of the case studies "that that there are variables – such as scalar integration or benefit sharing – that could be acted upon in order to improve the ways in which renewable energy projects could be integrated into future energy landscapes" (*ibid.*). It is not clear to this reviewer exactly how this might be done, although they do mention "possible ways of addressing the material aspects of renewable energy devices (size, colour, display) and their siting, which in turn requires a broader reconsideration of the often nationally based practices of landscape protection" (*ibid.*) – presumably referring to the more landscape architectural approach seen in Chapter 14 and the solar PV installations in Spain (Chapter 4).

I believe that the notion of scalar integration is in fact more broadly significant for their research, in the sense that many of the case studies reveal a lack of such integration as the various levels of governance do not speak to each other effectively. One major indication of this is the centralised nature of landscape protection in many of the countries, often predicated on traditional visual aspects of landscape rather than the relational human factors that create the landscape. Add to 'centralised', 'sectoral', and we have a compounding effect whereby economic and agricultural policies are organised vertically, supported by the dominant socio-technical planning apparatus which is also top-down and emanating from 'the centre'. Clearly from the work by Labussière and Nadaï (2015, Chapter 5) these 'Paris and the French desert' effects are found in many of the countries under scrutiny here. Even the relatively decentralised system in Spain does not help in resolving this situation as one repeats the syndrome at lower levels in the governance hierarchy.

Many critical theorists would argue that if the problem is due to governance issues, then research should be oriented to changing the system. The editors make a similar suggestion:

> These findings suggest the need to open the governance of landscape protection. Landscape should be integrated into territorial planning of energy as a transversal element, rather than having a separate sector-based policy, as happens in several countries. Landscape should not be considered as a fixed immutable domain that must be protected from all change. It should rather be approached as a social process, a realm that evolves within a framework of justice and democracy, in order to promote the integration of renewable energy projects as part of local territory (*ibid.*, p. 21).

There could be some important changes at a local level if these ideas saw fruition, as is evidenced in some of the Spanish case studies and perhaps most strongly in the single Portuguese study (Chapter 10), where a revitalised communitarian structure resulted from proposed changes to local landscapes. In fact, there is a very important aspect to nearly all of these accounts of locality responses to proposed change – the appeal to values, cultural values, heritage values, social values, landscape values … perhaps indicative of the strength of residents' identities, rooted in their lives, families, histories and their landscapes. Supporting change 'from the ground up' would appear to be a reasonable motif for future energy landscape research. Clearly, here is a call for more participatory forms of research, perhaps participatory action research endeavours, working with local groups to counter the pervasive powers from 'the centre'.

Apart from these important political factors that emerge (in my reading) from the research reported in this book, there is a very strong epistemological challenge identified by the editors:

Some of the authors contributing to this book address an even more radical challenge, by calling for a reappraisal of the dominant engineering approach to energy that treats it as a quantifiable output, capacity and commodity. Such technoeconomic notions and language separate energy from its flux, dynamics and relational dimension. The stories of the different renewable energy projects and planning experiences presented in this book point to differences in the materiality and in the relationality of renewable energies. Another concept of energy may allow for a better appraisal of this relational dimension and of the varying ways in which renewable energy projects may cohabit with existing land uses or displace them (ibid., p. 21).

This is perhaps the greatest challenge for energy landscape research in the future, but given political economic realities, is such a change – another concept of energy – likely? What would such a challenge look like for the residents of potentially affected localities? Perhaps it is a further call for the critical involvement of geographers in landscape research, re-orienting our efforts to changing the current inequalities of power in local renewable energy developments affecting landscapes. If so, it is, in my view, the most important 'value added' aspect of this excellent contribution to the research literatures on energy landscapes.

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*Fig 4: Still used terraces in the area of Horný Tisovník (Photo: M. Slámová)*

*Fig 5: Overgrown terraces in the area of Horný Tisovník (Photo: M. Slámová)*

Illustrations related to the paper by M. Slámová et al.

*Fig. 8: Oblique aerial view of meandering stream of the Morava River in the Protected Landscape Area Litovelské Pomoraví. (Photo P. Holub)*

*Fig. 9: The Morava River with natural fluvial development and floodplain forests east from the Litovel – the Protected Landscape Area Litovelské Pomoraví (Photo K. Poprach)*

Illustrations related to the paper by H. Kiliánová et al.