Landscape and vegetation in a military area – past and present

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Abstract

This paper presents current research in the former Ralsko military area (MA), which lies in the northern part of Bohemia (Czech Republic). MA Ralsko was founded in 1951 and army training took place there until 1991. The whole area presents an interesting example of landscape evolution impacted by strong socio-political movements. The landscape and its vegetation are studied from a historical point of view, where the history of the area, changes in land use and spontaneous vegetation succession are all observed together in order to gain an overall view, which will help in forming a future management strategy. Our interest focuses on the non-forested areas in the former MA Ralsko, especially on the former battle tank training grounds and the shooting range. These zones were originally an agricultural landscape with scattered settlements, villages and one small town, inhabited by a mainly German population. Nowadays the outlines of the villages are still visible in the midst of the grassy area, because remnants of buildings offer good conditions for shrubby overgrowth and trees. A 16 km long transect was set in the area of interest and six study sites were chosen along it, in the former villages. Small study areas were set up in and around each village, and the current state of the vegetation has been documented. The study areas were chosen in accordance with historical land use in the village (residential area, meadows, orchards, ponds, etc.) The land use changes since 1938 are studied from aerial photographs, and the analyses are maintained in the Geographical Informational System (GIS).

Key words: Land use changes; Natural succession; Military area; Grassy vegetation; Landscape management; GIS;

1. Introduction

Military areas (MAs) differ from ordinary cultural landscapes due to their specific history, characterised by enormous changes in land use, land cover and landscape structure. Two contrasting features characterize these areas: major surface disturbance connected with soil and bedrock contamination, generally by oily substances, and, on the other hand, well preserved areas with high biological value and great natural potential. MAs can often provide valuable habitats for endangered organisms highly specialised to open landscapes (Wanner and Xylander, 2003). Unlike other, more ordinary historical land use studies, MAs offer an extraordinary example for landscape ecology research, and are a real open-air laboratory for landscape and its vegetation (Vos and Meekes, 1999; Bičík and Kupková, 2001; Riezner, 2003).

After the passing of military activities, this type of land has to find a new type of utilisation under civilian administration. It is usually not easy to decide how to re-use such a huge space. Besides the lobbying of industrial and commercial interests and nature protection efforts, there is the possibility of serious landscape research, which can bring together nature protection, historical impacts,
socio-economic conditions and potential future development of the area.

To follow up the evolution of a cultural landscape, it is crucial to take into account not only historical considerations, but also the demographic characteristics and socio-economic conditions, because the history of a landscape history determines its current land use type (Winiwarter and Sonnlechner, 2003). Changing landscapes, especially changes in the way in which land is used, result in alterations to the landscape structure and, hence, also to the abiotic and biotic functions and potential of a landscape (Haase et al., 2007).

The changing landscape is very much a function of historic conditions. As Marcucci (2000) says, a more accurate metaphor is to think of landscapes as legacies. A landscape existing today results from previous conditions and events in that locale, and landscapes of the future will be legacies of the elements and processes occurring today. Furthermore, landscape planning can capture the critical genius of sustainability, as those long-term goals will best preserve options for future generations (Marcucci, 2000). The main goal of this study project is therefore to record the trends of natural succession and then to find a suitable exploitation for the area, because it is necessary to take into consideration not only changes in land use and land cover and the interests of nature protection, but also the current needs and demands of the people living there.

1.1 Demographical development

The former MA Ralsko covered about 200 square kilometres in a sporadically inhabited forest landscape in the northern part of the Czech Republic. While the area has been inhabited since the Neolithic period, the first historical record comes from the beginning of the 14th century. According to historical documents, the majority of the inhabitants, at least from the 17th century onwards, were of German-speaking origin (Schaller, 1790; Sommer, 1834). The situation has been subject to change, however, and after the first world war, Czech inhabitants flooded into the area.
During the second world war, the whole area became a part of the German Empire, and the Czech population was moved out (Vačkář, 1998). After the war the villages experienced a second big change in their population, when the Germans were sent away and the area was settled by Czechs. However, this immigration, though it was enforced by the new government, did not displace all the former inhabitants. MA Ralsko was set up just a few years later, in 1951, leading to the third big movement of the inhabitants (Collections of the Mnichovo Hradiště County Council, 1945-1948; Collections of the Vrchbělá Local People's Committee, 1951). All the villages were depopulated and partially or completely destroyed as a source of materials for the new military structures or as targets for shooting exercises (Military collections, 1951-1970).

In the first period, from 1951 until 1968, the MA was utilised by the Czech national army. It was used quite extensively, with activities focused only on a few parts of the area. Some parts of the forest had to be cleared, but the Vrchbělá tank firing range and the Židlov shooting range were set up on old agriculture land (Military collections, 1951-1970). After 1968, the Soviet army took control of the MA, and in the course of the next 20 years military activities in the area were intensified, as was the construction of a new residential and service infrastructure (Blažková, 1997).

In 1991, as a consequence of the political changes, the last Soviet soldiers left the MA and the Ralsko region finally came back under civilian administration. The necessary pyrotechnic surveys were carried out, and the most polluted sites were recovered (Dafílková, 1998). However, the area as a whole was found to be in good natural condition, with a high proportion of forest cover. Moreover, the absence of fertilisation and the special disturbance regime on the training fields had led to the spontaneously development of vegetal formations. When military exploitation came to an end, the process of natural succession started rapidly and even the most disturbed grounds were quickly overgrown (Husáková et al., 2001).

Nowadays the area is available for tourism, as attempts to establish huge industrial and commercial projects there have been successfully resisted. However, the required infrastructure for tourism is still missing. It now seems necessary to establish conditions which will not only enable the region to develop but will also be friendly to the

Figure 2. Aerial photograph of Olšína (Wolschen) village. The first photograph, from 1938, shows a prosperous living village. The second, from 2003, presents the current state of the locality: the overgrowth on the ruins still preserves the shape of the former village.
local nature.

1.2 Natural conditions

The former MA Ralsko forms a transition land between two bioregions. The predominant northern bioregion is characterised by sandy, siliceous slates and low-productivity soils, while the smaller southern bioregion consists of better soils on a loess cover. A few neo-volcanic hills, characterised by diverse rich vegetation, grow out of the sandstone layers.

The most extended type of potential vegetation is the Vaccinio vitis-idaeae-Quercetum association, predominantly pines (Pinus silvestris L.) and birch trees (Betula pendula Roth). The undergrowth is dominated by wavy hair grass (Avenella flexuosa L.), heather (Calluna vulgaris L.) and blueberry (Vaccinium myrtillus L.), in some cases cranberry (V. vitis-idaea L.) (Petříček and Kolbek, 1984; Neuhäuslová et al., 2001).

The volcanic hills are covered by herb-rich beech forests of the Melico-Fagetum or Dentario enneaphylli-Fagetum association, and towards the conversion to sandstone plains there are also some acidophilous beech forests of the Luzulo-Fagetum association. Herb-rich or forest steppe pine woods are found on the sunny slopes (Petříček and Kolbek, 1984; Neuhäuslová et al., 2001).

The ruderalised grass and shrubby vegetation that nowadays covers the former training grounds - originally old fields and other cultivated areas - is discontinued in some places by canopy closure. The lightly undulating terrain of the former training grounds forms a prairie-like landscape, unique in Central Europe. The forests are under continual management, and artificial pine and spruce plantations are predominant. The non-forested areas and the forest margins are the focus of our research.

2. Methods

2.1 Two aspects of the research

Current research in the former MA Ralsko has
concentrated on the southern part, specifically on the surface of the former Vrchbělá battle tank range and the former Židlov tank shooting range. Židlov is currently used as a deer reservation. The high concentration of grazing animals presents an important distinctive value between the two former training grounds.

Figure 4. Changes in land use and land cover in Vrchbělá. Three maps from 1938, 1975 and 2003 show the most significant changes in landscape structure and land use: the small fields from 1938 were transformed into the tank range. After 1991, the tank range changed into an unmanaged grassy plain which, gradually and spontaneously, has become overgrown by shrubs and a young forest.

Land use and land cover changes since the 18th century have been evaluated on the whole grass areas of the Vrchbělá and Židlov training grounds and also around the town of Kuřívody. Old maps are used, in particular the First (1764-1768) and the Second (1836-1852) Military Survey Map, as well as the register of the Stable Cadastre (1843). These sources, created during the period of the Austro-Hungarian monarchy, are a good resource for studies of changes in land use. They provide a sound geographic basis, with sufficient resolution in terms of geometry and contents for medium-scale projects (Haase et al., 2007).

Old aerial photographs (from 1938, 1953 and 1975) and the ortho-photo from 2000 are used as the basic source for observations from the 20th century. The dates of the aerial photographs take into account the dates of the significant changes in the study area and the availability of suitable photographs. There is no reason to assume that historical sequences of aerial photographs capture the complete evolution of the transition from one steady state to another (Brook and Bowman, 2006), but it is important to retain the main characteristics of each period that we would like to describe.

A transect has been set up in the north-east – south-west direction in the middle of the former Židlov shooting range, along the old road from Kuřívody to the destroyed villages. The transect then continues through Kuřívody to the former Vrchbělá tank range. Six main research posts are located along this transect. They were chosen on the basis of the location of the former villages.

Smaller study plots, where the current vegetation is observed, have been set up in each of these localities. These plots represent different types of historical land use, as identified by a spatial aspect study. The following old land use categories are used here: village residential areas, gardens, orchards, meadows and pastures, fields, ponds, and communications. Floristic lists are made for each category that is present in the localities. Plant records are established on plots where mature associations have already formed or where the presence of some spectacular species indicates an interesting process of spontaneous vegetal succession. The floristic investigation was made over three vegetation seasons (2005, 2006 and 2007).

A comparative analysis of potential and actual vegetation will be performed in the GIS environment, and this will enable us to observe the consequences of the changes in land use. GIS is useful for comparing maps of current and potential vegetation, because quantification of landscape changes is the first step toward interpreting the changes in vegetation (Carranza et al., 2003).

A map will be created and the spatial analysis of changes in land use/land cover changes will be elaborated in the Geographical Informational
Systems environment, using ArcGIS and GRASS software. The user friendly Arc GIS software, produced by ESRI, has been well established already. Other software programmes are now establishing themselves, e.g., GRASS, which is already widely used. Grass is a free open-source tool, accessible to everyone (Grohmann, 2004). It is well known mainly for its potential raster analyses and its easy interfacing with additive programs (Bivand, 2000; Garzón et al., 2006). The new series of GRASS 6 has a graphical user interface, unlike the older series (Estarlich and Trilla, 1998).

2.2 Current state of the vegetation

The results of three years of terrain observations are presented here, divided into three groups: wood species (types and distribution, domestic and invasive species), their persistence and dispersion in the environment, and more or less established vegetal associations.

Distribution of woody species

Three main factors influence the distribution of woody species in the former training grounds: habitat conditions, old land use, and grazing activities. These factors differ between the Židlov and Vrchbělá study areas. The former Vrchbělá tank range is more or less a plain, which falls steeply to the valley where the village of Vrchbělá originally lay. Before the MA was established, there were fields, meadows and small forested spots in the plain. The former Židlov shooting range, on the other hand, has an undulating terrain where villages had been scattered along the main road that passed through the area.

In the Židlov area, the ruins of the villages are mainly overgrown by trees and shrubs. The old trees from the former villages serve as a skeleton for other species, and the ensemble retains the shape of the village residential area. We consider as old trees those which are more than 60 years old and undoubtedly took part in life of the village. There are mainly limes (*Tilia sp.*)) and maples (*Acer platanoides L.*), occasionally also chestnut (*Aesculus hippocastanum L.*), beech (*Fagus sylvatica L.*), spruce (*Picea abies L, Picea pungens Řegelm*), in rare cases Douglas fir (*Pseudotsuga glauca Mayr*), etc. We made a list of these trees and we also selected some that we propose for special protection.

In the shrubby overgrowth of the village residential area we identified the following species: sycamore maple (*Acer pseudoplatanus L.*), lilac (*Syringa vulgaris L.*), rowan (*Sorbus sp.*), elder (*Sambucus nigra L.*), willow (*Salix sp.*), alder (*Alnus sp.*), European aspen (*Populus tremula L.*), hornbeam (*Carpinus betulus L.*), sessile oak (*Quercus petrea L.*), European beech (*Fagus sylvatica L.*), common snowberry (*Symphoricarpos albus L.*) etc. The presence of, e.g., clematis (*Clematis vitalba L.*) was significant. In the surroundings of the villages we find mainly hawthorns (*Crataegus sp.*) and wild roses (*Rosa sp.*) in a large quantity, and also some blackthorn (*Prunus spinosa L.*). Unlike similar studies of the vegetation in ruined villages (Vojta, 2006), no high overgrowth of ash (*Fraxinus excelsior L.*) was observed, except in the village of Židlov, where ash and willow are predominant.

Apart from in the former village area, woody vegetation is mainly concentrated on lower ground, where it serves as a day refuge for animals.

Figure 5. Nibbled forms, mainly of hawthorns, blackthorns and wild-roses, are frequently found in the higher-lying grounds of the former Židlov shooting range.
The growth is formed by the following species: *Salix spec. div.*, *Alnus glutinosa L.* ev. *A. incana L.*, *Betula pendula L.*, *Fraxinus excelsior L.*, etc. In general, however, the vast surface areas of Židlov are significantly impacted by the dense concentration of grazing feral animals, which seem to play an important role in inhibiting the natural succession. Nibbled forms are frequently observed on the higher-lying ground, but the nibbling is highly selective. It has been observed that the animals (deer, roe-deer, fallow-deer and mouflons) prefer hawthorn, blackthorn and wild-rose, rather than alder, salix, birch and elder. The situation in the Vrchbělá tank range is completely different. Here, there is a faster rate of natural succession which is not inhibited by such a great number of grazing animals. The forest gradually spreads on to the grassy plain. In the northern part, approximately one third of the whole area is already more or less covered by 15-year-old growth. In this part we find sandy soils, and the growth mainly consists of pine (*Pinus silvestris L.*) and birch (*Betula pendula L.*). Heather (*Calluna vulgaris L.*), blueberry (*Vaccinium myrtillus L.*) and wavy hair grass (*Avenella flexuosa L.*) are predominant on the bottom floor. The ensemble forms a spectacular young taiga-like forest landscape. Heather also covers many surfaces away from the trees, together with bushes of *Sarrothamnus scoparius L.* This rapid overgrowth can be explained by the lower density of grazing animals and also by the vegetal composition, where there is a less attractive food supply.

**Domestic and invasive species**

This section of our study deals with domestic species such as fruit trees and ornamental garden flowers. These have survived for more than fifty years without cultivation, and some of them show such power that they can nowadays be considered as invasive species. Among trees and shrubs, e.g., apple, pear, cherry, plum and currants, we find many individuals that have retained their fertility even though they have not been managed at all for many years. The occurrence of bladdernut (*Staphylea pinnata L.*) and dwarf elderberry...
(Sambucus ebulus L.) in the village area is also interesting, because they may have stood, for example, in front of a house as an ornamental woody species. Lilac (Syringa vulgaris L.) and common snowberry (Symphoricarpos albus L.) are typical species that settled well after abandonment and show good fertility and a strong ability to sprawl on the ruins and along the roadsides.

Some cultivated garden plants have also competed successfully with the natural species. Some geophytes and Asteraceae seem to have been the most successful among the cultivated plants. All these plants can be found in the former village residential area, presumably on or around the old gardens. The following plants have been found there: Inula helenium L., Hemerocallis fulva L., Viola odorata L., Aster lanceolatus Willd, Narcissus sp., Iris germanica L., Galanthus nivalis L., etc. They occur in a range of localities.

Our vegetation study has taken a special interest in the invasive, originally domestic, species that range over large areas inside and outside the former villages, since the impact of the invasion has varied from site to site (Vanderhoefen et al., 2006). Three major species show strong characteristics of invaders: scotch broom (Sarothamnus scoparius L.), lupin (Lupinus polyphyllus Lindl.) and goldenrod (Solidago canadensis L.), and to a much less extent S. gigantea Ait.). All of these species are originally cultivated garden plants, which have sprawled out and now form an undesirable component in the vegetation.

Sarothamnus and Lupinus have left the former villages and now affect the grassy plains. Neither of these species is popular among the grazing animals, so their invasion is not inhibited by this factor. However, Sarothamnus does not show strong resistance to frost, which freezes its roots during a long winter (Husáková et al., 2001). Thus there are many dead shrubberies on the vast plains of MA Ralsko. Lupinus, in contrast, disperses on the grassy plains, and also encroaches along the communications and in the former village area. Its resistant, well portable seeds with good fertility seem to do well in these conditions (Valtonen, et al. 2006).

Solidago is found in and around the village area. It spreads along the communication routes, but it does not appear in the open grassy plain. There is a significant difference between two species of goldenrod: Solidago canadensis L. and Solidago gigantea Ait. Both are perennial plants, originally from North America but now widely distributed in Europe, Asia and Australia by intentional or unintentional introductions (Weber, 2001; Dong et al., 2006).

Solidago canadensis L. is characterised by its strong clonal growth in diverse habitats. Its successful colonization in new habitats is therefore assumed to be associated with its great capacity for vegetative propagation, particularly when it invades vegetated habitats (Dong et al., 2006). It is also suggested that Solidago gigantea Ait. can achieve high invasive success across a wide range of soil fertility levels, as it is known to have a broad tolerance to light, temperature, soil moisture and chemical properties (Weber and Jakobs, 2005; Vanderhoeven et al., 2006). It mostly colonizes disturbed habitats, such as river banks, wastelands, railway and road embankments, reflecting the advantages of open and ruderal sites for successfully occupying new habitats (Jakobs et al., 2004).

However, when these two species of goldenrod occur together, as in the conditions of MA Ralsko, it seems that S. canadensis L. is a more aggressive invader and radiates along the roads far from the villages, while the resistance of S. gigantea is limited to the former residential area. Another invasive species that has started to establish itself in the former MA Ralsko is black cherry (Prunus serotina Ehrh.), originating from North America. It ranges around Kuri vody, and thanks to its ability to sprawl easily as a bird-dispersed plant (Deckers et al., 2005), we can presume that it will disperse in future.

**New or renewal vegetal associations**

In the former MA Ralsko, newly created or re-established vegetation associations are already occurring and are fascinating to observe. The floristic lists and plant records have been helpful in observing and identifying major trends in plant succession.

Besides the pioneer and weedy associations with common species such as Achillea millefolium L., Potentilla argentea L. and Malva moschata L. some rich-species associations can already be diagnosed, namely an association of dry, moderately acidophilous grass Koelerio-Phleion phleoidis with indication species such as Lazula...

In the surroundings of the village, in the old fields and meadows or pastures, we can find mainly the Arrhenatherion type, typical for mezophilous meadows. The dominant species appear to be: Arrhenatherum elatius L., Dactylis glomerata L. or Alopecurus L. or Briza media L., and in some places also Calamagrostis epigeios L. In terms of floristic composition and physiognomy, the spontaneously developed grass in places where there were old fields and meadows is similar to the regularly-mown Arrhenatherion meadows outside the MA, where the land has been under continual cultivation. The reason for this can only be a matter of speculation, but one of the important influences could be the rather poor raw soil.

The presence of Calamagrostis epigeios L. in the area is spectacular. In some places it tends to dominate the vegetation, while not far away, in apparently similar conditions, Calamagrostis is completely absent. A further study of this phenomenon should be made.

Other types of plants range in wet depressions, which are the remains of village ponds or of newer reservoirs made during military exploitation. Some of the wet depressions are just a consequence of battle exercises. The plants vary from hygrophilous toward hydrophilous species in accordance with the amounts of available water. The first type of plants includes Cirsium oleraceum L., C. palustre L., Festuca gigantea L., Galium palustre L., Holcus lanatus L., Juncus articulatus L., J. efusus L., Lysimachia nummularia L., Malachium aquaticum L., Ranunculus repens L., Urtica dioica L., etc. The water species include Alisma plantago-aquatica L., Batrachium cinnaturn Sibth., Glyceria fluviatins L., Lemna minor L., Lycopus europaeus L., Potamogeton natans L., Spirodela polyrhiza L., etc. Important discoveries were made in the woody vegetation and forested edges along the grassy grounds. There is a highly remarkable presence of young trees that grow spontaneously in favoured sites such as the ruins of the villages, forest edges or wet depressions. For example, the occurrence of young Quercus petraea L. saplings favours the theory of Quercetum as potential natural vegetation.

The pine wood association of Brachypodium pinnatum, found on sunny south-facing slopes, seems to be just a secondary form of Central European oak woods, or of their pine period during the natural restoration cycle. Potentilla alba L. is an example of a diagnostic species.

By contrast, on sunny slopes with a permanently eroded surface, rich in calcic ions, herb-rich or forest steppe pine woods are found. The well-developed undergrowth contains the class of Festuco-Brometea with particular species: Festuca pallens Host, F. rupicola Heuffel, Potentilla arenaria Borkh., Galium glaucum L., Anthicrum ramosum L., Biscutella laevigata L., Sesleria varia Jacq., Artemisia campestris L., Carex humilis Leysser, Koeleria macrantha Ledehe, The Pyrolaceae L. family or Trientalis europaea L. is typically present.

3. Results

These first steps in our study of land use and vegetation have already led to some interesting preliminary results and observations. First, it should be stated the former battle training fields are now generally in good condition. There are no longer grassless plots, and massive overgrowth can be seen everywhere as a phase of the natural succession. The grass formations tend to create quite interesting associations, which are not yet completely established.

However, during military exploitation of the area, vegetal associations dependent on repetitious disturbance developed in this area (for example the association of Polygonion avicularis) (Husáková et al., 2001). After the termination of military activities these formations became endangered.

The overgrowth of trees and shrubs cannot be considered as unambiguously positive. As far as biological diversity, diversity of habitats and diversity of landscape are concerned, we must consider the current trend of rapid overgrowing as unsuitable. Grasslands play a vital role in the structure and functioning of the overall landscape (Lemaire, 2005). Oligotrophic and unfragmented open landscapes are important habitats for a variety of highly specialised endangered species. Due to the agricultural policy in Central Europe, these open lands are scarce and their occurrence is expected to decrease further (Wanner and Xylander, 2003). The military training grounds of
the former MA Ralsko are thus a unique phenomenon in Central Europe.

Moreover, cultural landscape, with open surfaces of fields and meadows, bounded the consequences of the history of the area should not be overlooked. Throughout the centuries it has been a living by forests. We believe that it is worthwhile to conserve this open phenomenon in a mainly forested landscape for cultural reasons, and not to erase the history that it represents.

Well-established invasive species are another problem. The invasive success of a non-native species depends on the characteristics of the introduction events, species attributes and ecosystem properties (Lake and Leishman, 2004). The former MA Ralsko seems to offer good conditions for their dispersion. We have observed this event from the landscape perspective, which helps to provide a comprehensive view of the situation. Analysing an invasive spread from a landscape ecological perspective is an important challenge in plant invasion ecology (Deckers et al., 2005). Such invasions are likely to reduce overall diversity and have in fact been identified as one of the major drivers of global change (Swift et al., 2004). In our case, some of these species helped the natural succession to start quickly, while some of them, namely Solidago, remain in the former village grounds as witnesses of the old settlement.

5. Conclusions

The first steps in the study have shown the main evolutionary trends and the current state of the landscape and its vegetation cover. We will continue with this type of study, with a deeper focus on the process and trends of natural succession.

A comparison of the two areas, Židlov and Vrchbělá shows us the key role of grazing animals in the growth of trees and shrubs. The high density of grazing animals in the Židlov deer reservation (the former shooting range) appears to be an important factor in controlling the spontaneous overgrowth. This is in accordance with other
studies that have shown significant differences between non-grazed vs. grazed areas (Bernués et al., 2005). On the other hand, in other places it has been found that grazing reduces but does not stop the increment of shrub vegetation (Bartolomé et al. 2000). In the case of the Žďalov area, it is unclear why some sites are not influenced by grazing. It would also be rather complicated to estimate what density of grazing animals would be appropriate to protect open grassy spaces from shrubs.

In the former Vrchbělá tank range, some clearing of the overgrown shrubs and young trees is recommended, otherwise this terrain will become totally covered by woody vegetation. The spread of invasive species also needs to be dealt with. Intervention is recommended mainly in the former village residential area.

Meanwhile, new functions are increasingly important for maintaining the physical and social landscape in rural areas. European landscapes are increasingly appreciated as leisure commodities (Buijs et al., 2006), and the area of former MA Ralsko has a high potential for tourist exploitation (soft or extensive tourism). However, there is a lack tourist infrastructure (accommodation, restaurants, information centres) to support this idea. Nevertheless, tourism could provide employment opportunities for people living in and around this former military area.

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