Curriculum Vitae

OSOBNÍ ÚDAJE

Ing. Johana Vardarman (Zacharová)

+420 776 809 029

vardarman@fzp.czu.cz

Kamýk 64, Litoměřice, 412 01

nar. 30/12/1987

ODBORNÁ PRAXE

09/2016 - dosud	Vědecko-technický pracovník projektu - TAČR č. TH02030523: Vývoj geoinformačního portálu invazních nepůvodních druhů. Hlavní řešitel: doc. Ing. Kateřina Berchová, PhD. - *správa GIS dat*
02/2015 - 06/2016	Technický pracovník projektu - EHP-CZ02-OV-1-024-2015: Monitoring stavu evropsky významných druhů rostlin a živočichů a druhů ptáků v soustavě Natura 2000. Hlavní řešitel, Agentura ochrany přírody a krajiny ČR, odpovědný řešitel za FŽP ČZU prof. RNDr. Vladimír Bejček, CSc. - *správa GIS dat*
04/2014 - 12/2014	*spoluřešitelství* - IGA FŽP ČZU „Aspekty kontinuity dřevinných porostů v krajině"
10/2014 - 12/2014	Administrativní zabezpečení projektu TAČR.
05/2014 - 09/2014	Administrativní práce v rámci projektového týmu FŽP ČZU - *zapojení se do psaní návrhů projektů, administrativní činnost.*
01/2011 - 03/2011	Pracovní stáž v rámci Erasmus LLP. EnviroCentre Ltd., Glasgow, Velká Británie. Web: www. envirocentre.co.uk - oddělení zabývající se vodním prostředím, *zpracovávání dat v prostředí GIS*

VZDĚLÁNÍ

2013 - dosud	DOKTORANDSKÉ STUDIUM V OBORU APLIKOVANÁ A KRAJINNÁ EKOLOGIE Katedra aplikované ekologie, Fakulta životního prostředí, Česká zemědělská univerzita v Praze. - *pedagogické a výzkumné aktivity zaměřené na krajinnou ekologii, GIS a DPZ* ▪ Téma dizertace: *Aspekty důsledků krajinné změny pro ochranu přírody a krajiny*
2010 - 2013	NAVAZUJÍCÍ MAGISTERSKÉ STUDIUM V OBORU REVITALIZACE KRAJINY Fakulta životního prostředí, Univerzita Jana E. Purkyně v Ústí nad Labem. ▪ Téma diplomové práce: *Zhodnocení historického vývoje krajinné struktury a sídel Verneřického středohoří.*
09/2009 - 01/2010	STUDIJNÍ POBYT V RÁMCI ERASMUS LLP Fakulta ekológie a environmentalistiky, Technická univerzita vo Zvolene, Slovensko.
2008 - 2010	BAKALÁŘSKÉ STUDIUM V OBORU OCHRANA ŽIVOTNÍHO PROSTŘEDÍ Fakulta životního prostředí, Univerzita Jana E. Purkyně v Ústí nad Labem. ▪ Téma bakalářské práce: *Změny v krajinném rázu SHP v ústeckém a teplickém okrese z hlediska hydrických rekultivací.*

PUBLIKAČNÍ VÝSTUPY

Impaktové publikace:

VARDARMAN, J. – BERCHOVÁ-BÍMOVÁ, K. – PĚKNICOVÁ, J. 2018. The role of protected area zoning in invasive plant management. *Biodiversity and Conservation*. Online: 1–19 (First Online: 23 January 2018)

SKALOŠ, J. – NOVOTNÝ, M. – WOITSCH, J. – ZACHAROVÁ (**VARDARMAN**), J. – BERCHOVÁ, K. – SVOBODA, M. – KŘOVÁKOVÁ, K. – ROMPORTL, D. – KEKEN, Z. **2015.** What are the transitions of woodlands at the landscape level? Change trajectories of forest, non-forest and reclamation woody vegetation elements in a mining landscape in North-western Czech Republic. *Applied Geography*. 58: 206-216.

Publikace SCOPUS:

SKALOŠ, J. – **VARDARMAN**, J. **2016.** European wood-pastures in transition – a social-ecological approach. *Forests Trees and Livelihoods*. 24 (2): 1-3. (BOOK REVIEW)

ZACHAROVÁ, J. **2015.** Aspects of woody vegetation presence of the Czech agricultural landscape functionality. In *15th International Multidisciplinary Scientific Geoconference SGEM 2015, Informatics, geoinformatics and remote sensing. Volume II. Geodesy and mine surveying, cartography and GIS 18.06.2015, Albena, Bulgaria.* Sofia, Bulgaria: International Multidisciplinary Scientific GeoConference SGEM, s. 729-736.

2014, J. – ELZNICOVÁ, J. **2014.** USE OF GIS FOR THE ASSESSMENT OF LANDSCAPE STRUCTURE AND SETTLEMENTS DEVELOPMENT IN THE VERNERICKE STREDOHORI MTS.. In *14th SGEM GeoConference on Informatics, Geoinformatics and Remote Sensing 19.06.2014, Albena, Bulgaria.* Neuveden: SGEM. 1047-1054.

Recenzované publikace:

ZACHAROVÁ J. – POKORNÝ R. **2010.** Zhodnocení vlivu hydrických rekultivací Jezero Milada a Jezero Bílina na krajinný ráz okresů Teplice a Ústí nad Labem. *Studia Oecologica*, 4(4): 110-118.

ZACHAROVÁ J. – POKORNÝ R. **2010.** *Inventarizace hydrických rekultivací v okresech Teplice a Ústí nad Labem a jejich hodnocení metodou BVM a EVVM. Studia Oecologica*, 4(4): 119-126.

Aktivní účast na konferenci:

PĚKNICOVÁ, J. – VARDARMAN, J. – BERCHOVÁ-BÍMOVÁ, K. **2015**. Modelování šíření invazních rostlin v chráněných územích. In: Harabiš, F. et Solský, M. (eds): Kostelecké inspirování 2015. sborník abstraktů ze VII. ročníku konference 19.-20. 11. 2015. Česká zemědělská univerzita v Praze, FŽP.

ZACHAROVÁ, J. **2014**. Vliv dřevinné vegetace na funkčnost české zemědělské krajiny. In: HARABIŠ F. & SOLSKÝ, M. (eds.): *Kostelecké inspirování 2014*. Sborník abstraktů z VI. ročníku konference 20. – 21. 11. 2014. Česká zemědělská univerzita v Praze, FŽP.

ZACHAROVÁ, J. **2014**. Use of remote sensed data for landscape functionality assessment. In: MOKROŠ, M. (ed): *Abstracts of Forum of Young Geoinformaticians 2014*. Sborník z mezinárodní konference Forum of Young Geoinformaticians 2014, 5. - 6. 6. 2014, Zvolen, Slovensko.

ZACHAROVÁ, J. **2013.** Zhodnocení historického vývoje krajinné struktury a sídel Verneřického středohoří. In: *GISÁČEK 2013*. Sborník z konference organizované Institutem geoinformatiky VŠB – TUO, Fakultou hornictví a geologie, 9. 5. 2013 v Ostravě, VŠB – TUO, Ostrava.

ZACHAROVÁ, J. **2013.** Zhodnocení historického vývoje krajinné struktury a sídel Verneřického středohoří. In: *Student GIS Projekt 2013*. Sborník z konference organizované společností ARCDATA PRAHA, s.r.o. 21. 9. 2013 v Brně, Praha. s. 93 – 103.

NOVÁK, K., VAJSOVÁ, E., ZACHAROVÁ, J. **2011.** Informační systém Severozápadních Čech pro správu historických mapových podkladů. In: *Digitální technologie v geoinformatice a kartografii.* Sborník ze studentské konference organizované Stavební fakultou ČVUT v Praze, 18. 10. 2011, ČVUT, Praha. P. s. 60-73.

Účast na konferenci v posterové sekci:

PETRUS, D. – VARDARMAN, J. – PĚKNICOVÁ J. – HÖNIGOVÁ, I. – BERCHOVÁ-BÍMOVÁ K. **2016.** Application of species distribution models for selected special protected areas threatened by invasive species. NEOBIOTA 2016 - 9th International Conference on Biological Invasions. http://www.neobiota2016.org, 14.-16.9. 2016, Vianden, Luxembourg (neaktivní účast)

PĚKNICOVÁ J. – VARDARMAN J. – BERCHOVÁ-BÍMOVÁ K. **2015**. Modelling of IAS spread as management tool in protected areas. 13th International Conference: Ecology and Management of Alien Plant Invasions, http://www.emapi2015.hawaii-conference.com/, 20. - 24. 9. 2015, Havajské ostrovy (neaktivní účast)

ZACHAROVÁ, J. **2013.** Zhodnocení historického vývoje krajinné struktury a sídel Verneřického středohoří. Konference Student GIS Projekt 2013 organizovaná společností ARCDATA PRAHA, s.r.o. 21. 9. 2013, Brno.

NOVÁK, K. – VAJSOVÁ, E. – ZACHAROVÁ, J. **2011.** Informační systém Severozápadních Čech pro správu historických mapových podkladů. Konference Student GIS Projekt 2011, ARCDATA PRAHA, s.r.o. 21. 9. 2013, Praha.

ZAPOJENÍ SE DO PROJEKTŮ

- IGA UJEP v Ústí nad Labem *"Geodatabáze severozápadních Čech pro správu historických mapových podkladů"* (2010 - 2012) – spoluřešitelství; http://most.ujep.cz/iga2010
- Program aplikovaného výzkumu a vývoje národní a kulturní identity (NAKI): „*Rekonstrukce krajiny a databáze zaniklých obcí v Ústeckém kraji pro zachování kulturního dědictví*“ (2012 - 2015); http://projekty.geolab.cz/naki/obce - dílčí zapojení
- IGA FŽP ČZU „Aspekty kontinuity dřevinných porostů v krajině“ - spoluřešitelství (2014)

JAZYKOVÉ ZNALOSTI

ANGLIČTINA (*aktivně) - úroveň C1*
FRANCOUZŠTINA (*pasivně) - úroveň A2*

DALŠÍ DOVEDNOSTI a JAZYKOVÉ ZNALOSTI

MS Office (Excel, Word, PowerPoint), internet
ArcGIS (včetně extenzí Spatial and 3D Analyst, několik certifikátů z ESRI kampusu)
Základy QGIS, IDRISI Andes
řidičský průkaz skupiny B

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What are the transitions of woodlands at the landscape level? Change trajectories of forest, non-forest and reclamation woody vegetation elements in a mining landscape in North-western Czech Republic

J. Skaloš [a, *], M. Novotný [a], J. Woitsch [c], J. Zacharová [a], K. Berchová [a], M. Svoboda [b], K. Křováková [a], D. Romportl [d], Z. Keken [a]

[a] Czech University of Life Sciences, Faculty of Environmental Sciences, Department of Applied Ecology, Kamycká 1176, 165 21 Praha 6, Suchdol, Prague, Czech Republic
[b] Czech University of Life Sciences Prague, Faculty of Forestry and Wood Sciences, Department of Forest Ecology, Kamycká 1176, 165 21 Praha 6, Suchdol, Prague, Czech Republic
[c] Institute of Ethnology, Academy of Sciences of the Czech Republic, Na Florenci 3, 110 00 Prague, Czech Republic
[d] Charles University in Prague, Faculty of Science, Vinicna 7, CZ-128 44 Prague, Czech Republic

A R T I C L E I N F O

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A B S T R A C T

This study answers the following research questions: 1) What are the change trajectories of woody vegetation elements at the landscape level? 2) What are the differences in change trajectories amongst the various categories of forest, non-forest and reclamation woody vegetation? 3) How do the change trajectories differ in mining and non-mining landscapes? The study area, measuring 209.6 km^2, is located in the north-western part of the Czech Republic and may be broken down into 76.8 km^2 of mining landscape and 132.8 km^2 of non-mining landscape. Brown coal mining began in this region during the second half of the 18th century and led to the radical transformation of the landscape, including woodlands, during the second half of the 20th century. The source data for this study was obtained from the original stable cadastre maps (1842) and the landscape field mapping performed in 2010. The various woody vegetation elements (forest, non-forest, and reclamation woody plants) and land use/cover (LULC) categories were identified. The GIS symmetrical difference tool was subsequently used to perform an overlay analysis for the individual woody vegetation elements in order to study the change trajectories and to obtain information about the woodlands that have remained unchanged (continuous), the ones that have disappeared (extinct), and the ones that have newly appeared in the landscape (recent). In the case of the non-mining landscape, the total proportion of woodlands has increased (from 17 to 32%), but there has been a decline in the overall volume of forest woody plants found in these areas (from 93 to 74%). As far as the mining landscape is concerned, there has also been an increase in the area covered by woodlands (from 10 to 20%), however, the proportion of forest woody plants has decreased to a much greater extent (from 90 to 31%). From the perspective of extinct woody vegetation, 23.3% of all types of woodlands in the mining landscape may be classified as such, as compared to 10.8% in the non-mining landscape. The primary causes of this decline are mining activities and newly built-up areas. More continuous woody vegetation may be found in the non-mining landscape (42.1%) as compared to the mining landscape (15.4%). Recent woody vegetation, which has primarily replaced grasslands and partially arable land, prevails in both the mining (61.3%) as well as the non-mining (47.1%) landscapes. Different categories of woodlands (forest, non-forest, and reclamation woody vegetation elements) exhibit various change dynamics due to their different structure and the functions they serve. At the most basic level, there has been an overall increase in the occurrence of woodlands in the studied areas. However, once GIS spatial analysis is applied it is possible to see more complex processes in the development of woodland areas as characterised by gains and losses, and it is possible to identify mining and agricultural extensification as the two most significant factors behind the historical changes. Mining leads to a direct decrease in the area of woodlands; conversely, the spontaneous succession of vegetation resulting from agricultural extensification and forest reclamation facilitates woodland recovery. Forest reclamation and reforestation are essential on order to ensure the time continuity of woodlands in both

* Corresponding author.
E-mail address: skalos@knc.czu.cz (J. Skaloš).

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types of landscape, i.e. mining and non-mining. The study presented in this paper proves that it is relevant to analyse the changes occurring in different woodland categories separately. The same methodology may be applied when studying the change dynamics of other important landscape elements, such as wood pastures and wetlands.

Introduction

Woodlands refer to ecologically (Le Coeur, Baundry, Burel, & Thenail, 2002; Orlowski and Nowak, 2007) and historically (Rackham, 2007) significant landscape segments that are heterogeneous in their structures (Forman & Godron, 1986; Lafortezza, Chen, Sanesi, & Crow, 2008) and in their functions (Skaloš et al., 2014). Not only are woodlands used for wood production, they also fulfil a wide range of non-production related functions in the landscape, e.g. aesthetic, land-forming, and eco-stabilizing (McCollin, 2000). Non-forest woody vegetation elements (solitary trees, small woodlots, tree alleys, etc.) play a key ecological role, particularly in heavily exploited landscapes (Bulíř & Škorpík, 1987). In addition, these elements provide information about the historical utilization of the landscape, including the extensive use of trees for various purposes by traditional society (Krčmářová, 2012), and they play a key role from the perspective of landscape memory and heritage (e.g. Schama, 1995).

The landscape, including woodlands, underwent radical transformation in most European countries during the Holocene period as a result of anthropogenic pressure and changes in natural conditions (Bender, 2005; Brůna, Wild, Svoboda, Heurich, & Müllerová, 2013; Bürgi and Russell, 2001; Bürgi & Schuler, 2003; Hooke & Kain, 1982; Ihse, 1995; Lipský, 1995; Ohlson & Tryterud, 1999; Pelorosso, Leone, & Boccia, 2009; Schulte, Liebman, Asbjornsen, & Crow, 2006; Sklenička, Janovská, Šálek, Vlasák, Molnarová, 2014; Sklenička, Molnarová, Pixová, Šálek, 2013; Sklenička, Šímová, Hrdinová, Šálek, 2014). There are only a relatively few modern studies that focus on the development of woodlands in the Czech Republic and elsewhere in Central Europe. These include, for example, interdisciplinary papers combining different research fields, e.g. ecology, landscape ecology, history, and forestry (Bürgi, Gimmi, & Stuber, 2013; Müllerová, Szabó, & Hédl, 2014; Szabó, 2010, 2012; Szabó & Hédl, 2013), and single-subject works, such as the landscape-focused studies published by Plieninger, Schleyer, Mantel, and Hostert (2012), and Skaloš, Engstová, Trpáková, Šantrůčková, and Podrázský (2012). The work published by Plieninger et al. (2012) provides an outstanding analysis of the long-term change trajectories of woody vegetation in an agricultural landscape in eastern Germany. However, this study monitored only trees outside of forests and over a limited time span (1964–2008). Patru-Stupariu, Angelstam, Elbakidze, Huzui, and Andersson (2013) employed the forest history perspective and spatial pattern analysis to identify potential high conservation value forests in Romania, but their study focused only on forest woody vegetation. The composition of forest vegetation species in relation to long- and short-term forest changes were analysed by e.g. Jamrichová et al. (2013), Vild, Roleček, Hédl, Kopecký, and Utínek (2013), and Plieninger and Schaich (2014). In addition, comprehensive works applying a historical research perspective have been published covering some Central European countries. These include the synthesis published by Agnoletti (2000); Woitsch (2010) in the Czech Republic; Broda (2000) in Austria; Weinberger (2001) in Germany, and Koller (1975) in Poland.

Despite relatively advanced forest history research and other works focussing on the analysis of spatial changes in the landscape (e.g. Huzui, Călin, & Pătru-Stupariu, 2012; Khromykh and Khromykh, 2014; Seabrook, McAlpine, & Fensham, 2007; Spanò & Pellegrino, 2013), the studies that have been published do not fully apply spatial change analysis to woodland trajectories at the level of the individual woody vegetation elements, which would help to understand the long-term dynamics of woody vegetation within the overall landscape context. In addition, the existing studies do not consistently and systematically distinguish between the different categories of woody vegetation (forest, non-forest, and reclamation woody plants). This may in fact be viewed as a research challenge, because these elements are diverse in their structure, the functions they serve, and their historic dynamics (Forman & Godron, 1986; Lafortezza et al., 2008; McCollin, 2000). Consequently, this study aims to fill this existing research gap by expanding the current methodological approach to include an analysis of the detailed change trajectories of woodlands through using old maps, field surveys, and GIS. As woodlands do reflect historical actuality, we believe that we must become familiar with the change trajectories of the past in order to understand their long-term dynamics. This information may become a source of inspiration for future forest and landscape management.

To meet this overall aim, the study will answer the following specific research questions:

1) What are the change trajectories of woody vegetation elements at the landscape level?
2) What are the differences in the change trajectories amongst the various forest, non-forest and reclamation woody vegetation elements?
3) How do the change trajectories differ in mining and non-mining landscapes?

Materials and methods

Study area

The study area of 209.62 square kilometres is located in the Sokolov district, in the north-western part of the Czech Republic, close to the border with Germany (Fig. 1). It consists of 49 historic cadastral territories, in which all major types of extant woody vegetation and other types of LULC may be found. This area includes landscapes that have been extremely exploited by brown coal surface mining (76.77 km^2, or 36.6%) as well as those that have not been directly affected by mining at all (132.85 km^2, or 63.4%). Brown coal mining began in the Sokolov district during the second half of the 18th century. Deep opencast mining became the prevalent method in the mid-1900s and led to the consequent radical transformation of all existing landscape elements, including woodlands (Majer & Matějček, 1985; Matějček, 1984).

Source data

The old Stable Cadastre Maps (SALSC, 2010), drawn using a scale of 1:2,880, were used to identify the characteristics of the historical landscape. These were the first geodetically objective maps made of the Czech territory and provide information about land use/cover

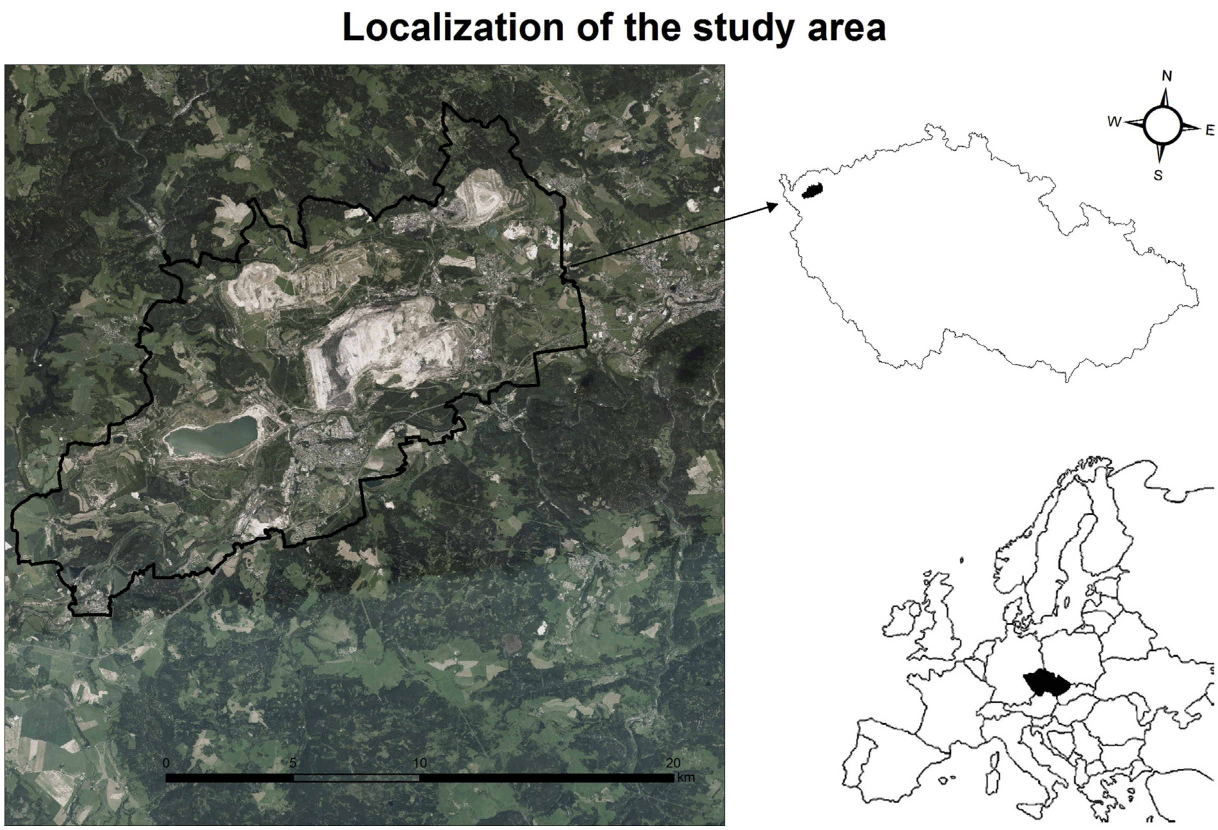

Fig. 1. Localization of the study area.

and ownership structure (Semotanová, 2002). As a result, GIS may be used to analyse these maps and the spatial changes in the LULC and woodlands areas. The stable cadastre maps (imperial prints) were obtained as digital data in raster format with a high resolution of 300 dpi, which made it possible to interpret them in detail. The ArcGIS 10 (ESRI) software was used to georeference the maps to the S-JTSK (Krovak East North) coordinate system on the basis of the orthophotomap of the Czech Republic (SALSC, 2010). An affine transformation was applied, and the distortion of angles and lengths was minimized. The maps were then aligned using rubber sheeting. The interpretation of the historic woodlands and LULC categories (Appendices 1 and 2) was performed using the legend for the georeferenced stable cadastre maps. The identified features were subsequently digitised as polygons with a LULC category assigned in ArcGIS 10 (ESRI) to create a vector-based map of the LULC for the 1842 time horizon.

The data for the LULC and woody vegetation characteristics in 2010 was obtained from the field mapping of the study area in July and August 2010, using current orthophotomaps in combination with the classification keys (Appendices 1 and 2). The field mapping was carried out at a scale of 1:2000 (close to the 1:2880 used for the stable cadastre maps). Polygon landscape elements were identified according to the criteria for LULC and woody vegetation types (Appendices 1 and 2). These features were then visually digitised using the orthophotomaps to create a vector-based map for the 2010 time horizon.

The interpreted features contained in the database were updated to include the attributes of the woody vegetation and LULC elements, i.e. the code of the relevant LULC and woody vegetation elements according to the classification key (Appendices 1 and 2), including area sizes stated in hectares. All elements were interpreted as polygon features, regardless of whether they were enclaves or corridors in the landscape (Forman & Godron, 1986). However, tree alleys and riparian vegetation were not analysed, as they are shown only schematically on the stable cadastral maps. Consequently, it is not possible to objectively define them as polygons, which is necessary for GIS spatial analysis. The next step consisted of the verification and correction of the data captured in the GIS. In order to minimize spatial inaccuracies, all polygons smaller than 30 m^2 were deleted (e.g. Skaloš and Engstová, 2010).

Interpretation of woody vegetation elements and LULC categories

We approached the topic from the landscape ecology perspective. LULC categories and woody vegetation elements are understood to be the segments that form the landscape structure (Forman & Godron, 1986). Only polygon features of woody vegetation (e.g. forests and landscape woodlots) are taken into account.

Woody vegetation elements

For the purposes of this study, woodlands are defined as land that is mostly covered with dense stands of trees and shrubs (Merriam-Webster, 2013). Woodlands are strictly differentiated into forest, non-forest (spontaneous succession of woody plants), and reclamation woody vegetation (see Appendix 1). In the landscape unaffected by mining, what we generally term reclamation woody vegetation refers to the new young forests established through afforestation. The woody vegetation elements included on the stable cadastre maps are delimited using the map key, which distinguishes between forest and non-forest woody vegetation (landscape woodlots and thickets). During the field mapping, the functional criteria of the vegetation as well as stand height and age were taken into account in order to distinguish between forest, non-forest, and reclamation woody vegetation elements. The differentiation was not based on the official classification according to the Land Cadastre of the Czech Republic, and no area size criteria were applied. The study focused only on woody vegetation elements in the open landscape with regard to their importance for landscape and nature conservation, forestry, and the reclamation of land affected by mining. Consequently, urban non-forest woody vegetation (gardens and parks) and orchards were not monitored. Historic and current woody vegetation categories have been unified so that it was possible to analyse changes between similar categories (Appendix 1).

Other LULC categories

Other types of LULC were monitored to analyse the change trajectories of woodlands at the landscape level (Appendix 2). Change trajectories provide information about the LULC categories that have replaced extinct woodlands and about those that have been supplanted by recent woodlands. For this reason, the study area landscape was also delineated into individual elements according to LULC type. These elements were delimited either by land plot borders according to the Stable Cadastre Map (1842), or by the actual borders of the landscape elements identified during the field observation (2010). Historic and current LULC categories have been unified to enable the analysis of changes in similar categories (Appendix 2).

Spatio-temporal analysis in GIS

The objective of the GIS spatial analysis (e.g. Huzui et al., 2012; Khromykh and Khromykh, 2014; Seabrook et al., 2007; Spanò & Pellegrino, 2013) was to analyse the spatio-temporal change trajectories of woodlands between 1842 and 2010. Change trajectories provide information on spatial-temporal transitions in woody vegetation elements and other types of land use/cover in the landscape. The bi-temporal analysis was performed using ESRI's ArcGIS 10.2 software suite (Arc Toolbox functions). All of the woody vegetation elements were categorised according to their spatio-temporal dynamics into continuous (present in both 1842 and 2010), extinct (present in 1842, but transformed into another type of LULC by 2010), and recent (newly established woodlands, i.e. a different type of LULC existing in 1842 and transformed into forest woody vegetation by 2010). The transitory changes that occurred between these two points in time were not studied. The outputs comprise the vector-based maps showing the extent of continuous, extinct, and recent woody vegetation elements, and the database tables containing the information about the woody vegetation segments (their type according to spatio-temporal dynamics, i.e. continuous, extinct or recent; the type of LULC in 1842 and the type in 2010, and the size of the relevant area in hectares). This database information makes it possible to analyse the spatio-temporal changes in woody vegetation at the level of the individual landscape elements.

The output from the source data interpretation (see Sections Source data and Interpretation of woody vegetation elements and LULC categories.) was used to generate ESRI shapefiles (.shp) for the woody vegetation elements existing in 1842 and in 2010. An overlay analysis was performed using ESRI's ArcGIS 10.2 software (Overlay Arc Toolbox – Analysis Tools – Intersect), and the shapefiles were generated for the woody vegetation polygon layers from both time horizons, i.e. 1842 and 2010. These overlapping polygons represent continuous elements. Based on the detailed woody vegetation classification system (Appendix 1), it is possible to determine the changes that occurred in the continuous woody vegetation elements in the woodland sub-categories between 1842 and 2010.

The non-overlapping woody vegetation elements were analysed using the same procedure in GIS, but, in this case, the symmetrical difference tool (Arc Toolbox – Analysis Tools – Overlay) was used to delimit extinct and recent woody vegetation elements. At the same time, the LULC categories which replaced extinct woody vegetation and those that were supplanted by recent woodlands were identified (Fig. 2).

Data computation and statistical analysis

The data set was divided into two parts according to the landscape affected by mining (76.8 km^2) and the landscape not affected by mining (132.9 km^2), and the parts were analysed separately. The percentage cover was calculated for each category of woody elements, i.e. continuous, extinct and recent, and the dynamics of the individual categories were compared. The areas of replaced and replacing LULC categories were determined for extinct and recent woody elements, respectively.

The comparison of the areas of continuous, extinct and recent woody elements was examined using two-way repeated measure analysis of variance (ANOVA) without interactions, where mining, point in time (1842 and 2010), and the type of woody element were used as factors, and the area size of the elements, adjusted through logarithmic transformation, was used as the response. The interactions between the factors were excluded from the analysis, as they had previously been found to be insignificant. After the completion of the aforementioned ANOVA, Tukey's HSD test for multiple comparisons was performed. The area sizes of elements of a particular type, with respect to both the point in time and trajectory changes, were compared using contingency tables and the chi-square test. The analysis was performed using the original data (areas were measured in hectares).

Results

Overall changes in woodlands

The woodlands located in the study area underwent quite dramatic transformations with regard to both areal and spatial changes (Fig. 3). An increase in the overall proportion of woodlands may be seen both in the non-mining landscape (from 17 to 32% of the total area) as well as in the landscape affected by coal mining (from 10 to 20% of the total area; chi-square = 8220.5, df = 1, p-value $< 10^{-6}$). In the non-mining landscape, while the proportion of the total area comprising forest woody vegetation has increased (from 16 to 24%, chi-square = 308.5, df = 1, p-value $< 10^{-3}$), the proportion of forest woody vegetation in all types of woodland areas has decreased from 93 to 74%. A similar trend may be seen in the mining landscape with regard to the total proportion of forest woody vegetation in all types of woodland areas, which has dropped substantially from 90 to 31%. This may be explained by the fact that, in both types of landscape, the occurrence of forest, non-forest (spontaneous succession of woody plants), and reclamation woody vegetation has increased due to "communicating vessels". However, as far as the mining landscape is concerned, the overall proportion of forest woody vegetation has decreased from 9 to 6% of the total area (chi-square = 89.9, df = 1, p-value $< 10^{-3}$). In the landscape affected by mining, the representation of non-forest woody vegetation (spontaneous succession of woody plants) has increased from 10 to 29% in all types of woodland areas and from 1 to 6% in relation to the total area. An increase is seen for this category in the non-mining landscape as well, where the non-forest woody vegetation cover has increased from 7 to 13% in all types of woodland areas and

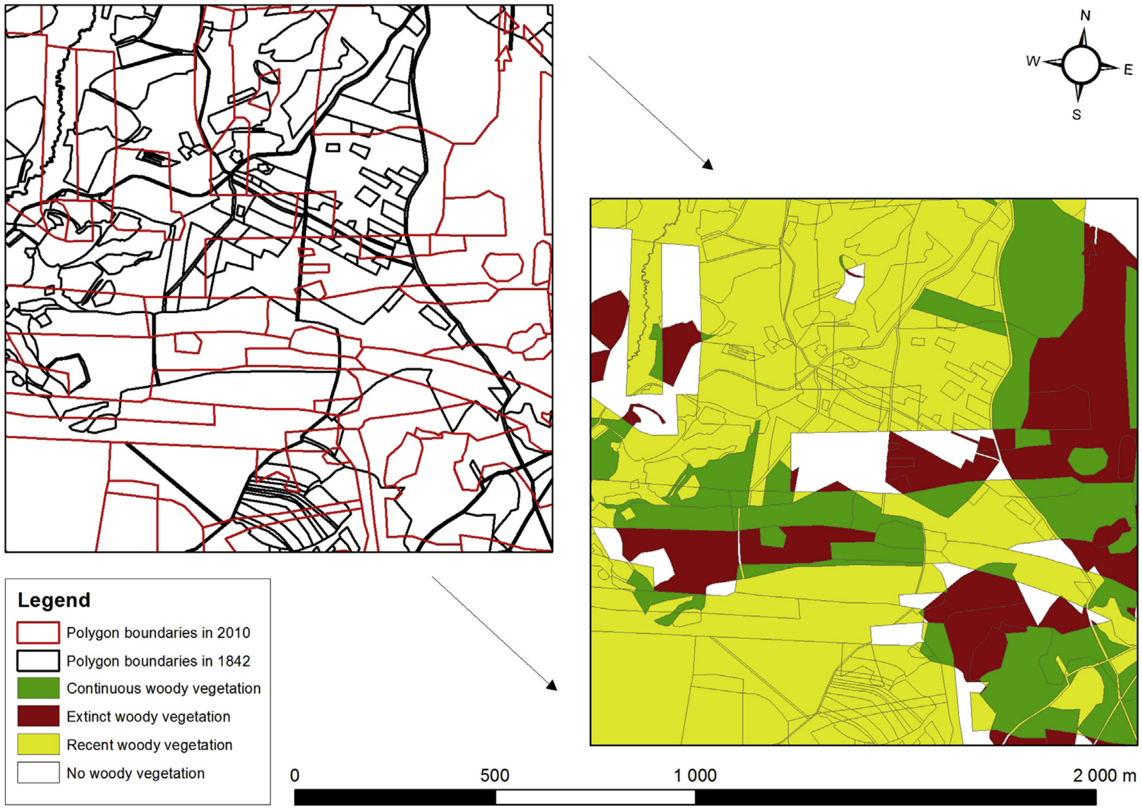

Fig. 2. Graphical abstract showing the results of the spatial analysis procedure in GIS at the level of individual polygons.

from 1 to 4% in relation to the total area (chi-square = 29.2, df = 1, p-value = 0.0062). Currently, in the mining landscape, the proportion of forest reclamation elements is 41% in all types of woodland areas and 8% of the total area. As far as the present-day non-mining landscape is concerned, the proportion of forest reclamation elements, formed mostly by new young forest stands resulting from afforestation, is 13% in all types of woodland areas and 4% of the total area.

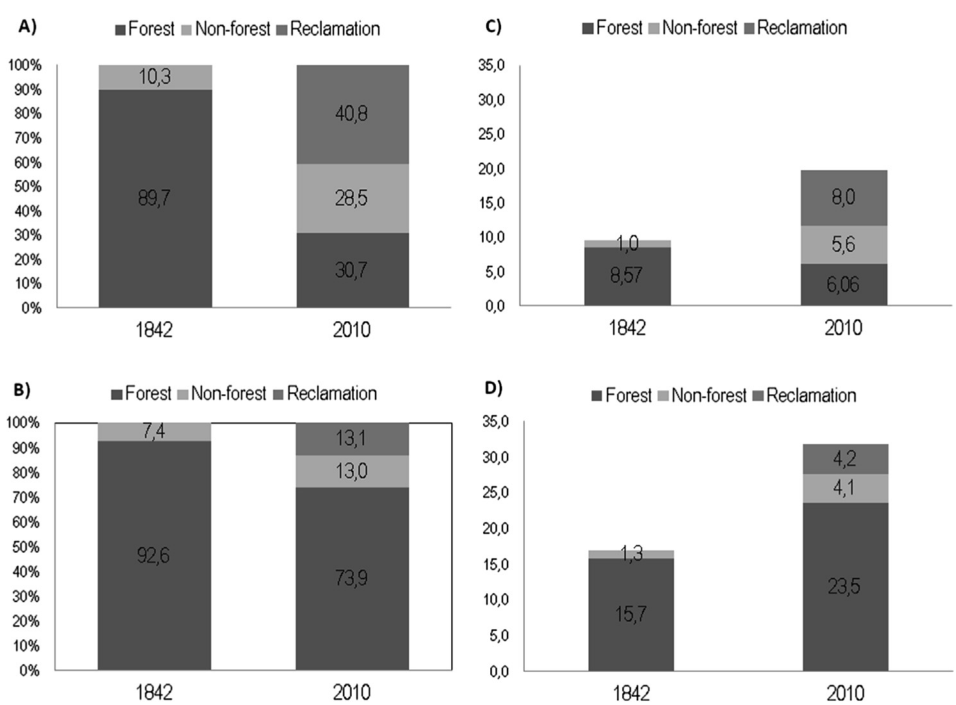

Fig. 3. Changes in the proportion of different categories of woodlands between 1842 and 2010: A) in the mining landscape, in relation to the total area of woodlands; B) in the non-mining landscape, in relation to the total area of woodlands; C) in the mining landscape, in relation to the total area; D) in the non-mining landscape, in relation to the total area.

Spatio-temporal changes in the different woody vegetation categories

In the areas unaffected by mining, there is a significantly higher proportion of continuous woody vegetation, specifically 42.1% of all types of woodland areas, as compared to only 15.4% in the mining landscape (chi-square $= 1162.6$, df $= 1$, p-value $< 10^{-6}$). Conversely, the proportion of extinct woody vegetation in the non-mining landscape is lower than in the mining landscape (10.8% as compared to 23.3%; chi-square $= 927.3328$, df $= 1$, p-value $< 10^{-6}$). The same applies to recent woodlands (47.1% versus 61.3% in the non-mining and mining landscapes respectively; chi-square $= 8.6266$, df $= 1$, p-value $= 0.003$) (Fig. 4, Table 1).

The patches of continuous forests in the non-mining landscape (no change in LULC between 1842 and 2010) are substantially larger than those patches with a different type of change trajectory (ANOVA, $F_{(2,\ 1342)} = 291.2$, $p < 10^{-6}$). In the landscape affected by mining, the newly established forest cover is significantly smaller than the patches of continuous and extinct woody elements. This is because areas where larger forest stands were located in the past started to be reforested only after the mining activities were terminated (Fig. 4).

Continuous woody vegetation

In the landscape unaffected by mining the vast majority of continuous woody vegetation elements have remained unchanged and consist of forest woody plants (87%). Forest woody vegetation has been transformed to reclamation woody plants (mostly young forest stands) to a much lesser extent (5%). Woodland continuity represented by changes from non-forest to forest woody vegetation (3%) and vice versa (3%) rarely occurs.

Table 1
Proportion of different categories of woodlands in the mining and non-mining landscapes (based on the spatial analysis performed using GIS).

Category	Mining landscape			Non-mining landscape		
	Number of elements	Area (hectares)	%	Number of elements	Area (hectares)	%
Continuous	702	690,3	15.4	1275	2665,3	42.1
Extinct	835	1045,9	23.3	1181	683,7	10.8
Recent	8168	2755,1	61.3	9761	2977,5	47.1
Total	9705	4491,3	100.0	12,217	6326,6	100.0

Transformations from one non-forest type of vegetation to another are even less frequent (1%). In contrast, the continuity of woodlands in the landscape disturbed by surface coal mining has, for the most part, occurred through the transformation of forest woody vegetation either to reclamation woody plants (33%) or to non-forest woody vegetation (28%). As far as the individual continuous woody vegetation elements are concerned, the original forest woody vegetation has remained unchanged to a lesser extent (24%) in the mining landscape than in the non-mining landscape (87%; chi-square $= 1861.146$, df $= 1$, p-value $< 10^{-6}$). Non-forest woody vegetation has either remained constant (6%) or changed into reclamation vegetation (7%). Forests have supplanted non-forest woody vegetation to a comparable extent as in the landscape unaffected by mining (2%). The comparison of original areas of particular trajectories shows highly significant differences for both mining and non-mining landscapes (mining areas: chi-square $= 13.1$, df $= 2$, p-value $= 0.0014$; non-mining areas: chi-square $= 161.2$, df $= 2$, p-value $< 10^{-6}$). (Tables 2 and 3).

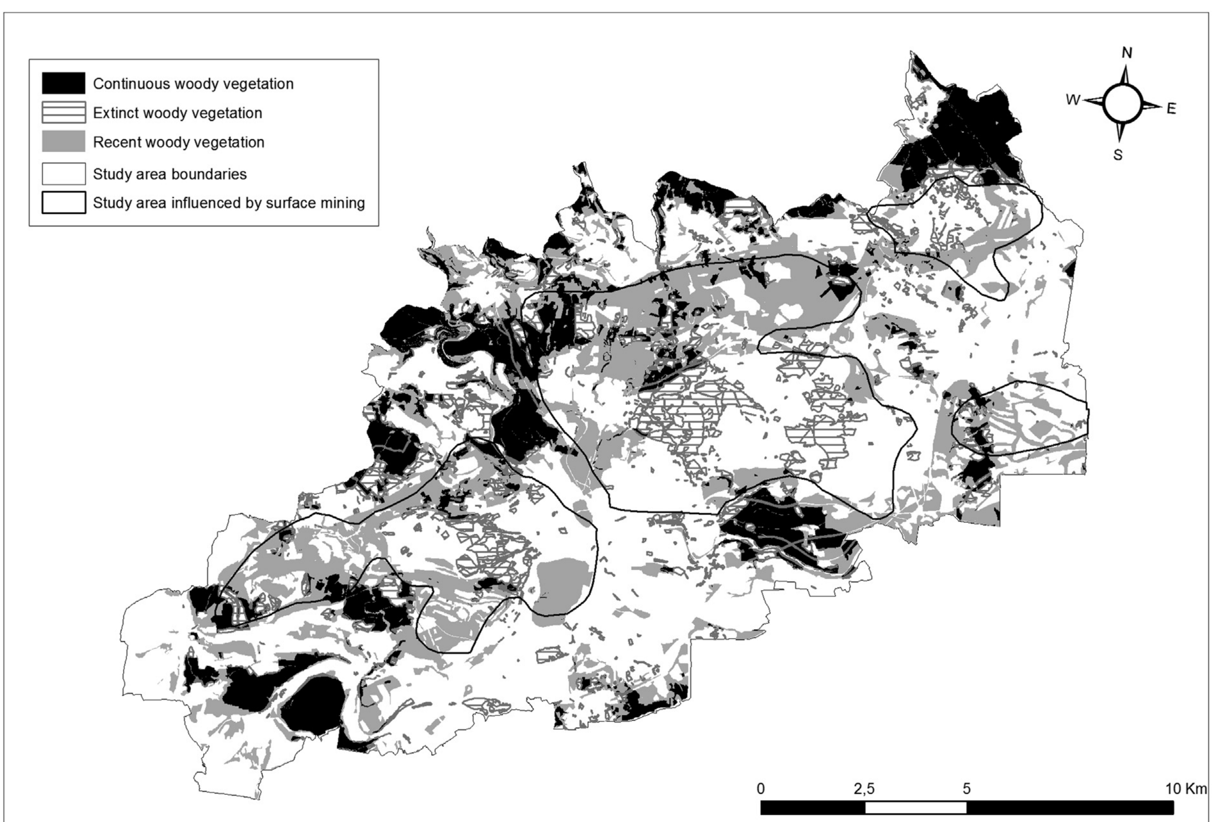

Fig. 4. Occurrence of continuous, extinct, and recent woody vegetation in the study area.

Table 2
Change trajectories amongst the different categories of woody vegetation elements (forest, non-forest, and reclamation woody vegetation) in continuous woodland areas in the mining landscape (as a percentage of continuous woodlands).

Type of the change	Hectares	%
Forest 1842 – Reclamation 2010	230,0	33.3
Forest 1842 – Non-forest 2010	193,8	28.1
Forest 1842 – Forest 2010	166,4	24.1
Non-forest 1842 – Reclamation 2010	48,9	7.1
Non-forest 1842 – Non-forest 2010	40,0	5.8
Non-forest 1842 – Forest 2010	11,1	1.6
Total	690,3	100.0

Table 3
Change trajectories amongst the different categories of woody vegetation elements (forest, non-forest, and reclamation woody vegetation) in continuous woodland areas in the non-mining landscape (as a percentage of continuous woodlands).

Type of the change	Hectares	%
Forest 1842 – Forest 2010	2315,8	86.9
Forest 1842 – Reclamation 2010	128,6	4.8
Non-forest 1842 – Forest 2010	89,9	3.4
Forest 1842 – Non-forest 2010	77,5	2.9
Non-forest 1842 – Non-forest 2010	31,5	1.2
Non-forest 1842 – Reclamation 2010	22,0	0.8
Total	2665,3	100.0

Extinct woody vegetation

Extinct woody vegetation refers to woodlands that disappeared from the landscape between 1842 and 2010. In the landscape unaffected by mining, forests have primarily been replaced by built-up areas (36% of the extinct woody vegetation), arable land (13%), mining areas (12%), permanent grassland (9%), and barren land (9%). The disappearance of non-forest woody vegetation is also due to built-up areas (7%). The frequency of other types of changes is negligible. In the landscape affected by mining, forests have, for the most part, given way to mining areas (54% of the extinct woody vegetation), barren land to a lesser extent (15%), bodies of water (6%), and permanent grassland (6%). The frequency of other types of changes is negligible. The comparison of original areas of particular trajectories shows highly significant differences for both mining and non-mining landscapes (mining area: chi-square $= 87.9$, df $= 6$, p-value $\leq 10^{-6}$; non-mining areas: chi-square $= 79.4$, df $= 6$, p-value $< 10^{-6}$).

Recent woody vegetation

The occurrence of woodlands in the mining and non-mining study areas has increased overall since 1842, with the largest increase recorded for reclamation woody plants and a lower increase in the case of non-forest woody vegetation. Forest woody vegetation increased only in the landscape undisturbed by mining. However, the GIS spatial analysis reveals the complexity of these changes and provides more detailed information about recent woody vegetation. In the non-mining landscape, forests, reclamation woody plants (mostly new young forest stands resulting from afforestation), and forest woody vegetation have increased primarily at the expense of grasslands (50%, 48%, and 47% of the total area of recent woodlands, respectively), and arable land (44%, 44%, and 43%). In the landscape disturbed by mining, reclamation woody plants and forest woody vegetation have mostly supplanted grasslands (49% and 52% of the total area of recent woodlands respectively), and arable land (43% and 37%). In contrast to the non-mining landscape, non-forest woody vegetation elements have replaced arable land (48%) and grasslands (45%). The comparison of original areas of particular trajectories shows highly significant differences for both mining and non-mining landscapes (mining area: chi-square $= 78.9$, df $= 6$, p-value $\leq 10^{-6}$; non-mining areas: chi-square $= 82.6$, df $= 6$, p-value $< 10^{-6}$).

Discussion

The changing face of the Sokolov landscape

Surface brown coal mining has played a significant role in shaping the landscape in the study area since the 1950s (Frouz, Pöpperl, Přikryl, & Štrudl, 2007; Richter & Pecharová, 2013). This influence, together with land recovery and landscape revitalization, have been studied by, for example, Häge (1996), Menegaki and Kaliampakos (2012), Sklenička and Charvátová (2003), Svobodová, Sklenička, Molnárová, and Šálek (2011), Toomik and Kaljuvee (1994), Skaloš and Kašparová (2012), Brom, Nedbal, Procházka, Pecharová, et al. (2012). The increase in extraction sites and reclamation areas, mainly at the expense of former arable land and grasslands, is only one of the effects of the surface coal mining activities (Skaloš et al., 2014). Woodlands have always been an important part of the studied landscape, and, as such, they have also been seriously affected by mining activities. Forest management and land use extensification are two other factors that have had an impact on the occurrence of different categories of woodlands. As far as the non-mining landscape is concerned, the size of the woodland areas has increased due to a higher proportion of forest woody vegetation cover. In the case of the mining landscape the woodland areas have become larger as a result of the expansion of reclamation woody vegetation and the spontaneous succession of woody plants. Although mining activities were indeed a direct cause leading the decrease in the size of the woodland areas, subsequent reclamation activities have led to the recovery of woodlands. This reclamation, performed after the termination of coal extraction activities, also changed the structure of the woodlands (i.e. the proportions of the various vegetation categories) thanks to the reduced areas of forest, reclamation, and non-forest woody vegetation elements.

Gains and losses in woodlands

It is apparent that the overall occurrence of woodlands has increased in both the mining as well as the non-mining landscapes. However, upon further investigation, the detailed GIS analysis reveals that complex trends exist with regard to the transformations that have taken place in all woodland categories (i.e. forest, non-forest, and reclamation vegetation elements). The same level of complexity may be seen in the spatio-temporal change trajectories of woodlands at the landscape level. GIS-based spatial analysis may thus be used to shed more light on the complex change processes that occur in woodlands, rather than only referring to the simple bi-temporal changes in a particular woodland area. The comprehensive history of the woodlands in the studied landscape reveals contradictory trends, characterized by gains and losses in the area covered by woodlands and their spatial distribution, due to the effects of different driving forces. Overall, gains prevail in the study area, as the occurrence of woodlands has increased from 10 to 20% in the mining landscape, and from 17 to 32% in the non-mining landscape. Also, recent woodlands occupy 61.3%, and 47.1% of all woodlands in the mining and non-mining landscapes respectively. In spite of the mining and thanks to forest reclamation activities, the spontaneous succession of woody plants, and reforestation, the overall balance in the area covered by woodlands is positive. Gains are represented by emerging recent woody vegetation elements, which have, for the most part, supplanted arable land and sites formerly covered by permanent grassland in 1842. In the non-mining landscape, the majority of these elements consist of forest land (69.2%), which is an indication that forest management and reforestation are important driving forces behind the increase in woody vegetation. However, as 46.8% of the recent woodlands in the mining landscape consist of reclamation woody elements, it is apparent that primarily mining activities, followed by forest reclamation, have definitely played a role in the shaping of the woodlands in this landscape. Thanks to forest reclamation, there are 2560 ha of newly occurring reclamation woody vegetation elements in the study area landscape (of which 1687 ha are in the mining landscape and 874 ha in the non-mining landscape, primarily due to inaccuracies in the delimitation of the mining areas). This type of reclamation is one of the most frequently applied methods for revitalizing land that has been disturbed by surface coal mining (apart from agro-technical measures and other types of land restoration). This figure agrees with the area of 1800 ha of new forest reclamation elements reported for the Sokolov region by Frouz et al. (2007). In addition, as non-forest woody vegetation (resulting from the spontaneous succession of woody plants) is the second most prevalent woody vegetation type in the mining and the non-mining landscapes (making up 29.7% and 16.9% of the total area of recent woodlands in the two landscape types respectively), it is possible to say that the expulsion of the German population (Beranová Vaicová, 2005; Mikšíček, 2006) and agricultural extensification (Lipský & Kukla, 2012), which leads to the landscape being overgrown as a result of the spontaneous succession of woody plants, are also important factors behind the woodland changes. Losses, on the other hand, are represented by extinct woody vegetation elements, which have been determined to correspond to 23.3% of the mining landscape and 10.8% of the non-mining landscape in the study area. To a large extent, the extinct woodlands were identified in locations affected by mining (Fig. 4). The largest losses of woodland areas are a direct result of mining activities and urbanization (in the mining and non-mining landscapes respectively), as, in both cases, primarily woodlands were replaced. These processes occur in conjunction with the relative spatio-temporal stability of continuous woody vegetation (which makes up 15.4% and 42.1% of all woodland types in the mining and non-mining landscapes respectively). Continuous woodlands consist primarily of managed forests in the non-mining landscape, and reclamation woody vegetation elements in the mining landscape, where they are an important stabilizing factor. For the most part, continuous woodlands are located at the outer edges of the non-mining landscape, which has helped to support the time stability of continuous woodlands.

In 2010, the occurrences of woodlands in both the non-mining landscape (30%) as well as the mining landscape (20%) are less than the figure for forest land in the Czech Republic as a whole (33.5%, CSO, 2013). However, the area of real forest cover could be even smaller, as, according to the Land Registry, forest cover includes only forest vegetation, while in the study area all types of woodlands are included in this category, including areas of non-forest woody vegetation (the spontaneous succession of woody plants), reclamation vegetation, and forest woody vegetation. Reclamation woody elements up to 10 years of age are not included in the area of forest land (CSO, 2013). For this reason, this category was not included in either the forest or the non-forest woody vegetation.

Differences in change between forest, non-forest and reclamation woody vegetation elements

As they vary in their structures, functions, and consequently in the way they are managed, forest, non-forest and reclamation woody vegetation elements have been found to have different change trajectories (Forman & Godron, 1986; Lafortezza et al., 2008; Skaloš et al., 2014). The different roles played by woodlands in the landscape, i.e. production, environmental, erosion control, and aesthetic functions, (Bulíř & Škorpík, 1987) substantially influence the nature of the management regime that is applied. As a result, different woodland areas have various change dynamics.

Differences between the mining and the non-mining landscapes

Generally speaking, surface mining reduces the area of woodlands found in the landscape. In addition, it tends to increase the occurrence of non-forest woody vegetation (resulting mainly from the spontaneous succession of woody plants) and reclamation woody vegetation in all types of woodlands at the expense of forest land. In both the mining as well as the non-mining landscape, new woodlands have occurred primarily at locations, which, in 1842, were used as grassland, and, to a lesser degree, arable land. Only non-forest woody vegetation has newly appeared in the mining landscape, mainly supplanting what was arable land in 1842.

An increase in the occurrence of reclamation woody vegetation is also partially apparent in the non-mining landscape for two main reasons: 1) the boundaries of the mining area were taken from the landscape typology published by CENIA (2013), which may have resulted in certain inaccuracies in the delimitation of the mining area. As a result, mining areas, with all of the typical consequences, may have also existed even outside of the defined boundaries of the mining landscape; and 2) some confusion may arise when differentiating between newly established forest elements and forest reclamation elements, as some are very similar. Given that these two types of vegetation cannot be clearly distinguished, we have included young forest elements from the non-mining landscape together with the reclamation woody plants from the mining landscape as “reclamation” woody vegetation. This category in the landscape unaffected by mining primarily consists of the newly established young forests resulting from afforestation.

Summary of driving forces

Apart from the classical concept presented by Forman and Godron (1986), land change may also be understood as the land's response to variously classified driving forces, i.e. socioeconomic, political, technological, natural, cultural, direct, and indirect (Bičík & Kupková, 2013; Brandt, Primdahl, & Reenberg, 1999; Bürgi, Hersperger, & Schneeberger, 2004; Hersperger, Gennaio, Verburg, & Bürgi, 2010). In this study, driving forces have been divided into large-scale driving forces (affecting the landscape from the international or national perspective), and small-scale driving forces (which are very explicit and, for the most part, area-specific) (Milanova, Himiyama, & Bičík, 2005).

Large-scale (general) driving forces

As the investigated period was not divided into shorter time periods, the large-scale driving forces may generally be characterized as those processes that change the relationship between mankind and the landscape from the determinative level (the dependence of mankind on nature and landscape structures) to the competitive level (mankind, or more specifically, society as a key factor in the transformation of the landscape). These processes have been in play in central Europe since the second half of the 19th century and primarily consist of the following: industrialization, urbanization, agricultural intensification, and the associated decreases in agricultural land (Bičík, Jeleček, & Štěpánek, 2001). Their consequences include the gradual depopulation of rural areas, the growth of urban settlements, the formation of large-scale industrially-urban landscape structures, and the general tendency of the non-urban landscape to be transformed into areas of woody vegetation that occur primarily due to the spontaneous succession of woody plants. During the second half of the 20th century, some of these processes were even significantly intensified as a result of the socio-economic circumstances in totalitarian Czechoslovakia and the other Socialist states. The collectivisation of agriculture, which led to centralised mass production, did not significantly affect the area covered by this study, however, the focus on metallurgy, heavy machinery industries, and brown coal energy, which was promoted by the Council for Mutual Economic Assistance (COMECON), had a major impact (Jeleček, 2002).

Small-scale (local) driving forces

The small-scale driving forces are identified at the level of regional and natural and cultural landscape structures, particularly with regard to significant historical, economic and social characteristics of the study area. In general, they intensify the effects of the large-scale driving forces, sometimes to an extreme degree. For the purpose of this study, the most significant small-scale driving forces are associated with the large reserves of brown coal in the study area, and its extraction, processing and use in the energy sector. Underground coal mining was identified as the main cause of urbanization and industrialization in the region during the 19th century, and surface coal mining as the main cause of large-scale landscape changes after 1950. Within the context of historical and socio-economic driving forces, we should mention: 1) the relatively good forest management (Nožička, 1962) implemented by the major forest owners in the region until the 1920s (the Nostic-Rieneck aristocratic family); and 2) the expulsion of the local German-speaking population (Sudeten Germans) after World War II, which had a crucial impact on the region's development during the second half of the 20th century. The study area was inhabited primarily by ethnic Germans until 1946 (about 94% of the population). During the 1946-1947 period, approximately 46,000 people were forced to leave the region, while only about 15,000 new settlers arrived, primarily in the larger towns (Nosková, 1991; Prokop, 1994; Staněk, 1991). The result of this massive population exchange led to the final extreme depopulation of the area and the immediate extinction of several small villages and dozens of buildings in the late 1940s and early 1950s (Beranová Vaicová, 2005; Mikšíček, 2006). The subsequent extensification of land use resulted in an increase in the spontaneous succession of woody plants and vegetation cover. In addition, the aforementioned events facilitated large-scale land use changes, particularly with regard to creating vast opencast mines and large industrial complexes, as it was not necessary to resolve any issues concerning land purchases and the relocation of the population.

Discussion about the methodology

The results from this study have been largely influenced by the different nature of the source data, i.e. the old stable cadastre maps, which show the ownership of the individual plots of land, versus the orthophotomaps of the Czech Republic, which display the actual segments existing in the landscape and are used to monitor the current landscape. This same issue has been described and discussed in previous studies (e.g. Skaloš and Engstová, 2010; Skaloš et al., 2012; Plieninger et al., 2012).

The LULC and woody vegetation categories from the stable cadastre map legend must be made compatible with those used for current landscape monitoring (see Section Interpretation of woody vegetation elements and LULC categories), as this is a key prerequisite for analysing the changes in identical categories of LULC and woodlands. Since the LULC categories in the current landscape are interpreted at a much higher level of detail as compared to the relatively unrefined LULC categories used for the stable cadastre maps (Semotanová, 2002), the data for the study had to be simplified to a certain extent. It must also be noted that the study is not comprehensive, as its scope is reduced by focussing only on polygonal woodland elements (i.e. forests, small landscape woodlots, and spontaneous succession involving woody plants) and it does not include woody vegetation corridor features (riparian forests, tree alleys, etc.). The reason for this is that the stable cadastre maps record woody vegetation corridor elements only schematically, and this makes it impossible to perform the quantitative spatial analysis in GIS.

The study results were also partially influenced by the inclusion of scattered woody vegetation elements, which usually fall into the category of non-forest woody vegetation (e.g. small landscape woodlots), under forest stands. This was due to the fact that the main criterion for the classification of woody vegetation elements in this paper was the physiognomy of the vegetation, not the size or location of individual elements. The classification of woodlands may significantly influence the results of similar studies and future research should attempt to quantify this effect.

The use of different source data (the old stable cadastre maps on the one hand, and the mapping of the current state of landscape on the other), combined with the subsequent unification of the classification legend result in the fact that certain monitored categories of woodlands may be “hidden” in other unmonitored categories of LULC. For example, whereas in the current landscape it is possible to distinguish elements of spontaneous woody vegetation succession, on the old stable cadastre maps this category is not explicitly specified in the map key and, if spontaneous woody vegetation succession did occur in any area, it was most likely included under barren land. This uncertainty makes it impossible to objectively monitor the spontaneous succession category on the stable cadastre maps. As the barren land category includes other types of LULC in addition to woodlands, the monitoring of it as a land use category would introduce too many errors into the study.

Only two time horizons (1842 and 2010) were used to analyse the spatio-temporal change trajectories of woodlands. Therefore, the results from the study provide information only on the absolute long-term dynamics of woodlands between 1842 and 2010, rather than on the detailed dynamics of the transitory changes that occurred between the two time horizons. If the term “change dynamics” is used, it refers to the dynamics of the transformations between different types of woody vegetation and other LULC elements, not between the time horizons. In order to come closer to determining the “temporal change dynamics” of woodlands, more source data from multiple time horizons must be used in future research. It will also be necessary to use the same type of source materials (only aerial photos, only maps, etc.) for obtaining LULC and woodlands data that are more compatible.

Given that surface coal mining began in the Sokolov region during the second half of the 20th century, the use of existing historic aerial images (i.e. from the 1960s and 1980s) would be the most relevant for completing a multi-temporal study providing a detailed evaluation of the dynamics of the landscapes and woody vegetation disturbed by surface coal mining in the area (rather than the old stable cadastre maps and orthophotos). The authors of the study presented in this paper are currently performing this type of research and the use of the aforementioned historical aerial photos is included in their research plan. The results will be published in the near future.

Despite the existence of several important works dealing with the analysis of spatial changes in the landscape (e.g. Khromykh and Khromykh, 2014; Spanò & Pellegrino, 2013; Huzui et al., 2012; Seabrook et al., 2007), the studies published to date have not fully utilized spatial change analysis for woodland trajectories at the level of the individual woody vegetation elements. The methodology proposed in this study makes it possible to perform a relatively efficient detailed analysis of spatial-temporal woodland changes in the landscape. However, the core part of the methodology, with only a few minor adjustments, may be applied in the same way to other important landscape elements, such as built-up areas, grasslands, wetlands, etc. The proposed methodological procedure should also be verified by applying it under the diverse natural and cultural conditions existing in the different types of landscape found in the Czech Republic. Another challenge will be to use additional methods to differentiate forest and non-forest vegetation (e.g. the official classification used by the Land Cadastre of the Czech Republic and GIS methods) and not only the visual criteria used for this study.

Conclusions

The landscape in the study area underwent radical transformations between 1842 and 2010. The same may be said regarding the changes in the extent and the spatial distribution of the woodlands as a result of different, often conflicting, driving forces and factors. The occurrence of woodlands increased overall – both in the landscape affected by mining as well as in the areas where no mining activities were carried out. In the case of the former, the primary reason may be found in the proliferation of reclamation woody elements and the spontaneous succession of woody plants as a result of surface coal mining activities. In the latter, the area with woodland cover expanded mainly thanks to afforestation.

However, the study results show that, in addition to the absolute areal changes, it is also important to analyse the spatio-temporal changes at the landscape level, as these transitions (change trajectories) may shed new light on the complex history of woodland areas. Surface coal mining, the extensification of landscape use, and the acceleration of urbanization have all played a key role in shaping the landscape, including woodlands. Newly established (recent) forests and areas covered by self-seeded woody plants have mostly replaced the grassland areas that existed in 1842. Forest reclamation, carried out after the termination of mining activities, is a key factor that has essentially ensured the continuity of woodland development in the mining landscape. In the areas unaffected by mining, this function continues to be fulfilled by forests and through forest management. The causes leading to the reduced occurrence of woodland vegetation also differ between the mining and the non-mining landscapes. Whilst in the case of the former, coal extraction is the major factor, in the latter this role is played by urbanization. Different categories of woodlands (forest, non-forest, and reclamation woody vegetation elements) exhibit various change dynamics due to their different structures and the functions they perform. The study has proved that it is relevant to analyse changes in the different woodland categories separately, and this same process may, at a general level, be applied to the study of other landscape types. It is equally important to monitor the development of woodlands in mining and non-mining landscapes separately, as mining activities play a key role in determining the occurrence and prevalence of woodlands.

The main benefit of this study lies in the fact that it has proven that GIS analysis tools may be effectively used to reveal that what at first appears to be the seemingly clear development of woodland areas may in fact be more complex and variable with regard to the spatial transitions (change trajectories) of woodlands, the occurrence of forest, non-forest and reclamation woody vegetation elements, and difference between the mining and non-mining landscapes. Change trajectories help us to understand woodland dynamics at the landscape level. The method used for this study may be applied to any other important landscape elements whose dynamics in the landscape are of interest (e. g. water bodies, wetlands). The methodology may also be used to monitor the success of reclamation activities and all other types of ecosystem restoration. These findings are of great value if we want to obtain a deeper understanding of woodland dynamics at the landscape level, including knowledge about the processes of change and stability, which will lead to a better understanding of the human-landscape system and its dynamics.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.apgeog.2015.02.003.

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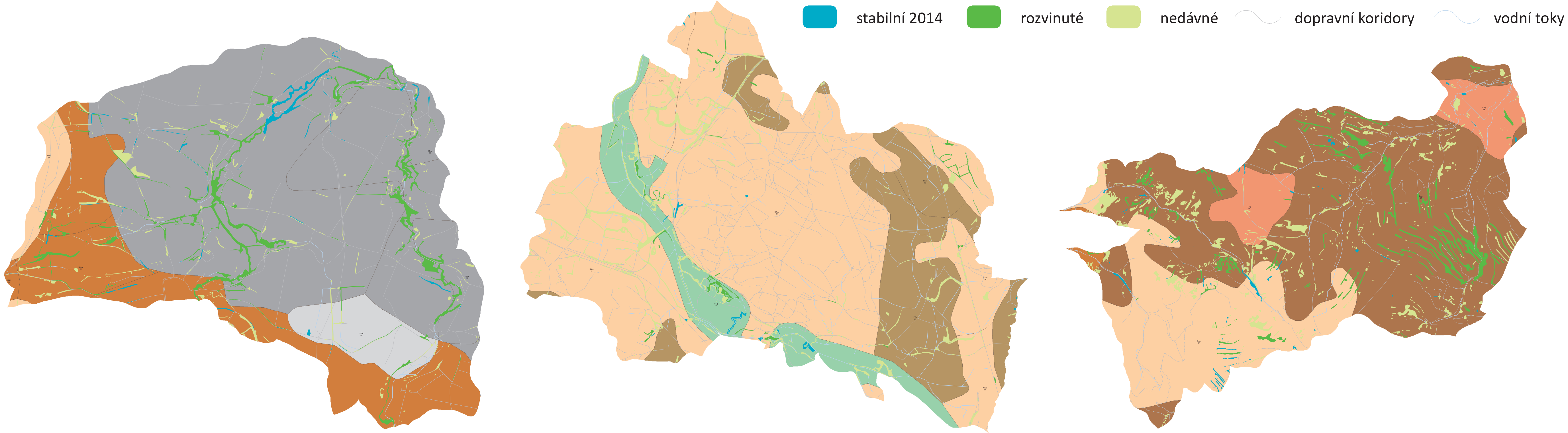
PŘÍLOHA 2: Upravený klasifikační klíč LU/LC použitý v analýze dynamiky dřevinné vegetace na Sokolovsku

1842 — podkategorie dle Císařských otisků stabilního katastru	KATEGORIE	2010 — mapované podkategorie na podkladu ortofotomapy 2008
pole (role)	**ORNÁ PŮDA**	holá půda strniště pšenice ječmen oves žito + tritikale kukuřice řepka hrách bob brambory mák směska pšenice, ječmen, oves směska oves a hrách směska oves, hrách a jetele směska oves a bob jetele
suché louky mokré louky louky s ovocnými stromy pastviny obecní pastviny	**TRVALÉ TRAVNÍ POROSTY**	suché louky mezofilní louky vlhké a podmáčené louky mezofilní louka s nálety dřevin mezofilní louka s četnými ostrůvky lada zapojená sukcesní stádia lučního typu
močály močály s rákosím	**MOKŘADY**	rákosiny, ostřice v nivě vrbiny, olšiny v nivě
mlází, remízky křoviny	**MIMOLESNÍ DŘEVINNÁ VEGETACE**	nálety dřevin *Calamagrostis* s rozptýlenou zelení nálety dřevin do 1 m nálety dřevin do 2 m nálety dřevin do 3 m nálety dřevin do 4 m nálety dřevin do 5 m nálety dřevin do 6 m nálety dřevin do 7 m nálety dřevin do 8 m nálety dřevin nad 10 m ruderální vegetace s náletem dřevin subxerofytní porosty s náletem dřevin
zelinářské zahrady pole (role) s ovocnými stromy	**TRVALÉ KULTURY**	sady, zahrady
smíšené lesy jehličnaté ledy listnaté lesy	**LESN POROSTY**	listnaté lesy jehličnaté lesy smíšené lesy paseky, mýtiny
jezera rybníky řeky potoky	**VODNÍ PRVKY**	vodní toky řeky rybníky hydrické rekultivace

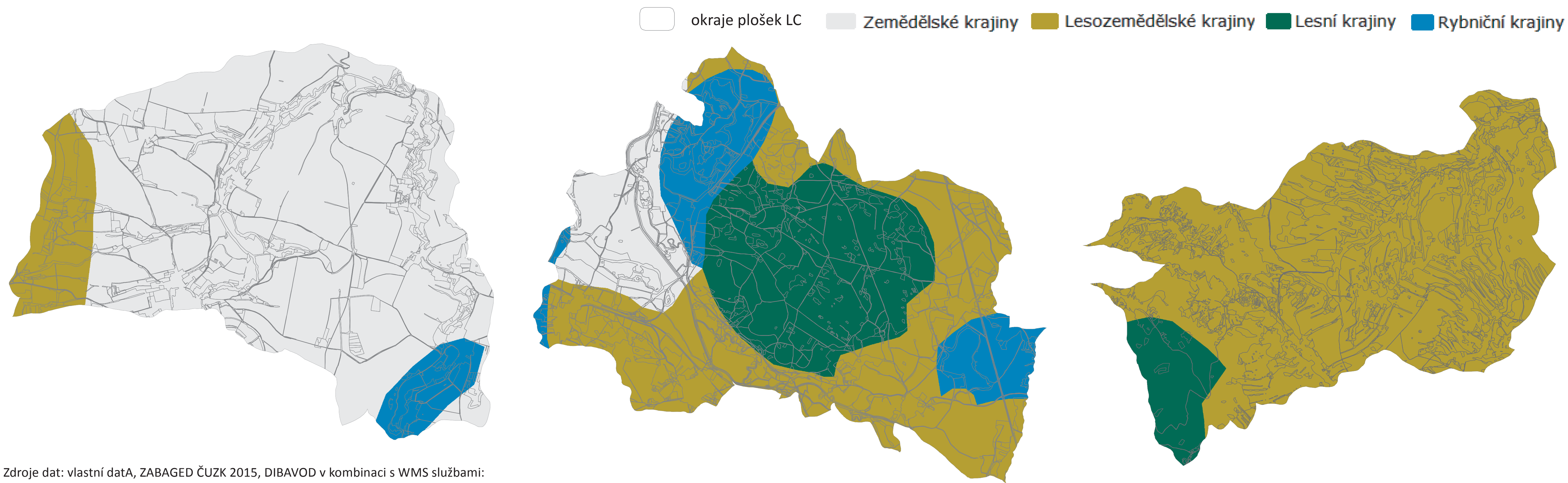
1842 — podkategorie dle Císařských otisků stabilního katastru	KATEGORIE	2010 — mapované podkategorie na podkladu ortofotomapy 2008
neplodná půda a holé skály	**NEPLODNÁ PŮDA**	polozapojená sukcesní stádia lada (půdy uložené do klidu) ruderály (hnojiště, smetiště) sukcesní plochy s převahou *Calamagrostis* subxerofytní porosty přechod mezofilní louky na ruderální obnažená dna a břehy skrývka ornice holá výsypka
kostely budovy významné budovy zděné budovy nezděné nádvoří štěrkovna, pískovna, kamenolom mosty silnice cesty hřbitovy	**ZPEVNĚNÉ A TĚŽEBNÍ PLOCHY**	souvislá zástavba městského typu roztroušená zástavba vesnického typu komunikace lom pískovna, holé lomové povrchy
	REKULTIVAČNÍ DŘEVINNÉ POROSTY	lesnická rekultivace vyšší než 2 m – jehličnatá lesnická rekultivace vyšší než 2 m -listnatá lesnická rekultivace vyšší než 2 m – smíšená lesnická rekultivace 1-2 m – jehličnatá lesnická rekultivace 1-2 m -listnatá lesnická rekultivace 1-2 m – smíšená lesnická rekultivace 0,5-1 m – jehličnatá lesnická rekultivace 0,5-1 m -listnatá lesnická rekultivace 0,5-1 m – smíšená lesnická rekultivace do 0,5 m – jehličnatá lesnická rekultivace do 0,5 m -listnatá lesnická rekultivace do 0,5 m – smíšená lesnická rekultivace suchá

PŘÍLOHA 2:

A Pedologické podmínky v zájmových územích v souvislosti s prostorovou distribucí plošek MDV



B Rámcové krajinné typy dle využití v kontextu hranic plošek krajinného pokryvu v zájmových územích



Zdroje dat: vlastní datA, ZABAGED ČUZK 2015, DIBAVOD v kombinaci s WMS službami:
A: Půdní typy CENIA 2018 - dostupné z: http://geoportal.gov.cz/ArcGIS/services/CENIA/cenia_typy_pud/MapServer/WMSServer
B: Typologie krajiny dle Löw et al. 2006 CENIA 2018 - dostupné z: http://geoportal.gov.cz/ArcGIS/services/CENIA/cenia_typologie_krajiny/MapServer/WMSServer;
vytvořeno v dubnu 2018 v Praze

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ORIGINAL PAPER

The role of protected area zoning in invasive plant management

Johana Vardarman[1] · Kateřina Berchová-Bímová[1] · Jana Pěknicová[1]

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Abstract As anthropogenic pressure on the landscape increases, invasive alien species (IAS) pose a growing threat to areas designed to protect high biodiversity habitats. In order to assess the present danger of IAS spread, we examined 23 Czech sites of community importance (SCI) within Natura 2000 protected areas (PA) over 2015 and mapped the occurrence of four IAS: *Solidago* spp. (goldenrod), *Impatiens glandulifera* (Himalayan balsam), *Heracleum mantegazzianum* (giant hogweed) and *Fallopia* spp. (Japanese knotweed). The model areas were divided into five monitoring zones, graded by conservation importance and habitat disturbance level (core area [A], broader core area [B], semi-natural habitat [C], anthropogenically affected habitat [D], anthropogenically degraded habitat [E]). Despite a high number of IAS occurrences (3222 localities), habitats of European importance (zone A) showed a relatively low level of invasion (< 0.3% total area). Highest IAS occurrence number was in SCI border areas and disturbed habitats (zones C and E). There was a significant positive correlation between level of invasion inside and outside SCIs, related to human activities such as logging and urbanisation. A strong effect for watercourse vicinity was noted for the occurrence of *I. glandulifera* and *Fallopia* spp.; but not for *H. mantegazzianum* and *Solidago* spp. A stratified management approach, employing zones delimitation to assess what threat pose IAS to the PA objects of conservation, can be useful to prioritize control measures in IAS local action plans.

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✉ Johana Vardarman
vardarman@fzp.czu.cz

[1] Department of Applied Ecology, Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Kamýcká 129, Prague 6 – Suchdol 165 21, Czech Republic

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Introduction

Invasive alien species (IAS) represent one of the biggest threats to biodiversity and interconnected ecosystem services (Davis 2003; Vilà et al. 2011) and have the potential to significantly affect economic systems and human health (Simberloff et al. 2013; Pimentel et al. 2005). IAS can cause losses in biodiversity through a reduction in community species number or by causing changes in ecosystem nutrient cycling at microbial or higher plant levels (Souza-Alonso et al. 2016; Wang et al. 2017; Ruwanza et al. 2015). Those IAS classified as "transformers", i.e., strongly competitive IAS with the ability to alter local environmental conditions, represent one of the most significant contributors to species diversity loss (Lucy et al. 2016; Wang et al. 2017). The presence of such species can cause a cascade of changes, sometimes resulting in large-scale declines, or even destruction, of indigenous communities and habitats (Vítková et al. 2017; Strong and Ayres 2013). Roy et al. (2017) also argued that greater attention needs to be focused on pathogens transferred by IAS that affect biodiversity after their introduction into new regions.

Certain ecosystems are considered to be more prone to invasion (Richardson et al. 2007; Chytrý et al. 2008b), especially man-made habitats and those with a high level of disturbance (Pyšek et al. 2010). Stohlgren et al. (1999) also pointed out that areas of high native plant species richness and cover and areas with high soil fertility were also likely to be highly prone to invasion. The extent or severity of IAS presence in an ecosystem is termed the habitat level of invasion, which will also be influenced by the degree of concordance between the original habitat and the invaded habitat, competitive ability of the invasive species and the level of competition in the vegetation community present (Chytrý et al. 2005). Community invasibility is defined as the vulnerability of a habitat and given communities to invasion (Williamson 1996; Lonsdale 1999). This ecosystem characteristic will be influenced by local abiotic conditions (Lonsdale 1999; Richardson et al. 2000) and IAS propagule pressure (i.e., the number of non-native propagules reaching the site; e.g., Levine et al. 2003). Many invasive plant species can spread rapidly over a considerable distance from the parent population, colonising both natural and semi-natural communities (Pyšek et al. 2004; Richardson et al. 2007). Such invasions of semi-natural and natural habitats can result in significant ecosystem changes, even in rare and locally protected ecosystems hosting endangered plant and animal species (Pyšek et al. 2013). Colonisation of a relatively undisturbed mature community usually requires the invasive taxon to surmount factors preventing their spread (McNeely et al. 2001), such as geographical, environmental or reproductive barriers and disturbed natural habitats (Richardson et al. 2000); moreover, some communities may resist invasion through biotic resistance (Levine et al. 2004).

The level of threat from IAS, and particularly invasive plant species, increases considerably along with propagule pressure. Distance from spreading vectors, such as watercourses, roads or railways, and distance from inhabited areas are also considered important factors for IAS spread (Křivánek et al. 2004; Pyšek et al. 2012a; Hodkinson and Thompson 1997; Lundgren et al. 2004), as they considerably increase IAS propagule pressure along their routes (Lonsdale 1999; Levine et al. 2003).

A significant factor in IAS spread at all scales is disturbance (Zurlini et al. 2013; Waldner 2008; Theoharides and Dukes 2007; Stohlgren et al. 2006; Lambdon et al. 2008), wherein the changes brought on by the disturbance cause a distortion in competitive relations between the existing species, thus destabilising the community (Davis et al. 2005). Those habitats and vegetation types most prone to disturbance are those with fluctuating resources, and especially those comprising eutrophic habitats (Pyšek et al. 2012b). Many IAS first establish a foothold in disturbed habitats and then spread on to semi-natural communities (McNeely et al. 2001). At a global level, significant factors affecting the spread of IAS include anthropogenic disturbance, agricultural expansion and changes in farming techniques (Waldner 2008), along with shifts in landscape composition and loss of semi-natural communities (Gámez-Virués et al. 2015). Recent land-use trends show an increase in the level of impact on landscape caused by anthropogenic factors, particularly as regards urban sprawl and landscape fragmentation (EEA 2015). Further, climate change is, and increasingly will be, an important factor in the spread of IAS, with potential "biome shifts" allowing IAS to overwinter in warmer regions (Diez et al. 2012).

Despite the mass of information now available on the subject of IAS (or perhaps because of it), the way in which issues connected with IAS are approached is complex and sometimes contradictory. In addition to the growing body of scientific literature, there are now numerous databases archiving information on the occurrence, distribution and ecology of a growing number of IAS around the world (e.g., Pyšek et al. 2008; Lucy et al. 2016; DAISIE 2017; GISD 2017; Seebens et al. 2017). At present, the higher plants are by far the most thoroughly studied group (see Pyšek et al. 2008; Van Kleunen et al. 2015). There are several reasons for this, including easy determination of species in the field, simple methods needed to monitor their spread and the relative ease of studying their ecological characteristics. Even in this relatively homogeneous and clearly defined group, however, the ecological diversity of individual species means that it is often not easy to predict where and when species will spread and what impact the invasion will have. The complexity of the problem is exacerbated by the differing ecology of invasive plant species, their different responses to habitats and their disturbance level, ecosystem susceptibility to invasion and local spreading vector effects. All these factors increase the difficulty of predicting IAS spread (Catford et al. 2011).

Likewise, the methods used to treat, manage, contain and mitigate IAS are similarly complex and contradictory. In line with the European Union's legislative framework regarding IAS (EU Regulation No. 1143/2014, EC Regulation No. 708/2007) and Czech nature conservation priorities, recognised methodological procedures and tools for the tracking of IAS must be used in order to effectively assess their impact on different environmental components. Prevention of IAS spread is specifically highlighted as an objective in Czech national documents, including the State Environmental Policy 2012–2020 (objective 3.2), the State Nature and Landscape Protection Program (D8 measures), the Strategy for Biological Diversity Protection in the Czech Republic 2016–2025 (objective 2.3) and the National Action Plan for Climate Change (objective 19). In this respect, there appears to be a lack of relevant and comparable information on IAS spread and functional measures needed to protect habitats and biodiversity. At the same time, there is a lack of consistent data on the effectiveness of eradication measures or systematic attempts to eliminate such species. Likewise, if nature conservancy authorities are to implement the measures mentioned above, their actions must be based on relevant, assessable and current data, which are extremely hard to obtain.

The monitoring of IAS distribution and spread, and the provision of effective nature protection measures, is of growing importance (Genovesi et al. 2013). Indeed, IAS are presently considered the second most urgent treat to biodiversity in European PAs (Pyšek et al. 2013). Czech nature protection authorities, along with their European counterparts, have introduced a range of legislative measures to hinder IAS spread. In 2016, for example, the Czech authorities introduced the Black, Grey and Watch (alert) Lists of invasive species (Pergl et al. 2016b) as a means of prioritising the threat from IAS; and by the end of the same year, Pergl et al. (2016a) had published a series of recommended methodologies for mapping and monitoring IAS in the Czech Republic. Both of these studies emphasise the need for repeated and continuous monitoring of IAS spread indicators, from initial identification of species of concern through mapping of large-scale regional spread and long-term monitoring of each species' population dynamics. In particular, the mapping and evaluation of IAS occurrence in regions of high nature conservation value is a high priority in ongoing biological invasions control mechanisms (Latombe et al. 2016).

In Europe, biodiversity conservation is mainly undertaken through the use of protected areas (PAs), particularly those designated under Natura 2000 [a European network of high-quality conservation sites based on European Commission (EC) Directives 2009/147/EEC on the conservation of wild birds and EC Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora]. There are two types of Natura 2000 site, both of which include natural and semi-natural habitats: Sites of Community Importance (SCI) and Special Protection Areas (SPA), together covering 18% of the EU land surface area (EC 2017). Overall, 25% of the EU's terrestrial land is protected, including Natura 2000 and PAs under national designations (Gaston et al. 2008). A particular requirement of sites containing habitats of European importance, as subjects to conservation effort, is that all human activities negatively affecting protected communities should be eliminated (Hochkirch et al. 2013). Increasingly, such 'negative manifestations of human activity' are coming to include the spread of IAS introduced through anthropogenic activities (Hobbs and Huenneke 1992).

In a recent survey of PA management authorities, aimed at assessing the level to which Central European PAs had been overrun by IAS, Braun et al. (2016) concluded that at least 80% of all Czech PAs were undertaking management measures to control at least one IAS (mostly Japanese knotweed *Fallopia japonica* var. *japonica*; giant hogweed *Heracleum mantegazzianum* and Himalayan balsam *Impatiens glandulifera*). Their findings indicate that presence of IAS is not dependent on year of PA foundation or PA size, although study of Pyšek et al. (2003) oppose in respect of PA's foundation effect on presence of IAS as the longer established PA include generally better preserved ecosystems capable of higher resistance to IAS spread. Penetration of alien species into PAs, its buffering effectiveness and sustainability to reduce incursions of alien plants, started to be addressed recently (Foxcroft et al. 2010). Despite the long tradition of nature conservation in Europe and the Czech Republic, the number of European studies focused on level of invasion in small-scale PAs is relatively low (Foxcroft et al. 2014). Both the Czech Republic and Slovenia are among the few countries for which data on the presence of non-native and IAS in PAs has been published (Pyšek et al. 2002b, 2003, 2013). Despite the availability of relatively detailed data on occurrence of neophytes and archaeophytes in the Czech Republic (300 PAs mapped; Pyšek et al. 2002b, 2004), it remains difficult, if not impossible, to determine in which habitat types IAS occur and whether or not they have invaded the edges or core areas of PAs. Without such information, it will be impossible to ensure the effectiveness of measures aimed at management or control of IAS, including the installation of buffer zones aimed at preventing IAS spread (e.g., Cole et al. 2016).

The aim of this study was to determine the actual level and spatial distribution of IAS in Czech model SCIs and their immediate surroundings, and to use these data to assess the threat IAS presently pose to Czech PAs. In doing so, we attempt to answer three specific questions:

– Which semi-natural and protected habitat types are the most invaded by selected invasive alien plant species?
– Does habitat vulnerability outside the PAs affect habitat vulnerability of habitats within the SCI?
– What is the effect of habitat disturbance level on the level of invasion as regards spread vector distance and environmental characteristics?

Methods

Data collection and processing

Seven IAS taxa were mapped in and around (1 km buffer) the SCIs chosen for this study: *H. mantegazzianum*; the knotweeds *F. japonica* var. *japonica*, *F. sachalinensis*, and the hybrid *Fallopia* × *bohemica*; *S. canadensis* and *S. gigantea*; and *I. glandulifera*. In all cases, we used the plant species nomenclature of Květena ČR (Slavík et al. 1997, 2004), IAS being defined according to EU Directive No. 1134/2014.

The SCIs were chosen based on preliminary known general presence of IAS as these species are diversely distributed within the regions of the Czech Republic (Chytrý et al. 2009; Pyšek et al. 2012b). The variety of environmental conditions available (e.g., geomorphology, presence/absence of watercourses, differences in land cover) was also taken into account when choosing the SCIs. In total, 23 SCIs were chosen in five main regions (Fig. 1): Karlovy Vary (KAR 1–3), Ústí nad Labem (Labské pískovce—LP, Kopistská výsypka—KP), Central Bohemia (Kokořínsko—KK), Plzeň (Křivoklátsko—KRI) and South Bohemia (TREB). In total, almost 629 km^2 were mapped during the vegetation season of 2015, of which 241 km^2 lay within the 23 SCIs. In all cases, a detailed presence/absence survey was undertaken on foot and all occurrences of IAS were recorded on a Garmin Oregon global positioning system (GPS; maximum accuracy 7 m). Individual species data were then downloaded into ArcGIS (ESRI) software 10.4.1 and the points more precisely positioned through manual relocation using ortophotomap in the GIS environment. Presence of individual plants or small groups of individual plants of the same species were recorded as a single point occurrence, while the outermost points of larger patches were used to delineate the area covered by a large number of individuals of the same species. The GPS locations were then converted to vector polygon shape files by buffering point features by 0.5 m and connecting the outermost points of occurrence to create a minimum convex polygon layer. A geodatabase for each model area (including the respective SCIs) was then created. Distance from spreading vectors, such as roads and watercourses, was then calculated for each IAS occurrence point using ZABAGED road network data provided by the Czech Office for Surveying, Mapping and Cadastre (COSMC: http://www.cuzk.cz/en) and watercourse data from the T. G. Masaryk Water Research Institute hydroecological information system (TGM WRI: http://heis.vuv.cz/). The Natura 2000 Habitat Mapping Layer (HML), provided by the Nature Conservation Agency of the Czech Republic (NCA CR: http://www.nature.cz), was used as the main source for spatial delineation of PA conservation objects. This layer contains uniformly classified European habitat types based on the Habitat Catalogue of the Czech Republic (Chytrý et al. 2010) and the Habitat Assessment Handbook and Floristic Approach (scale 1:10,000; on occasion, coarser habitat classifications were used and these are outlined in Electronic Supplementary Material 1). While these layers do not entirely cover all the mapped model regions, all natural

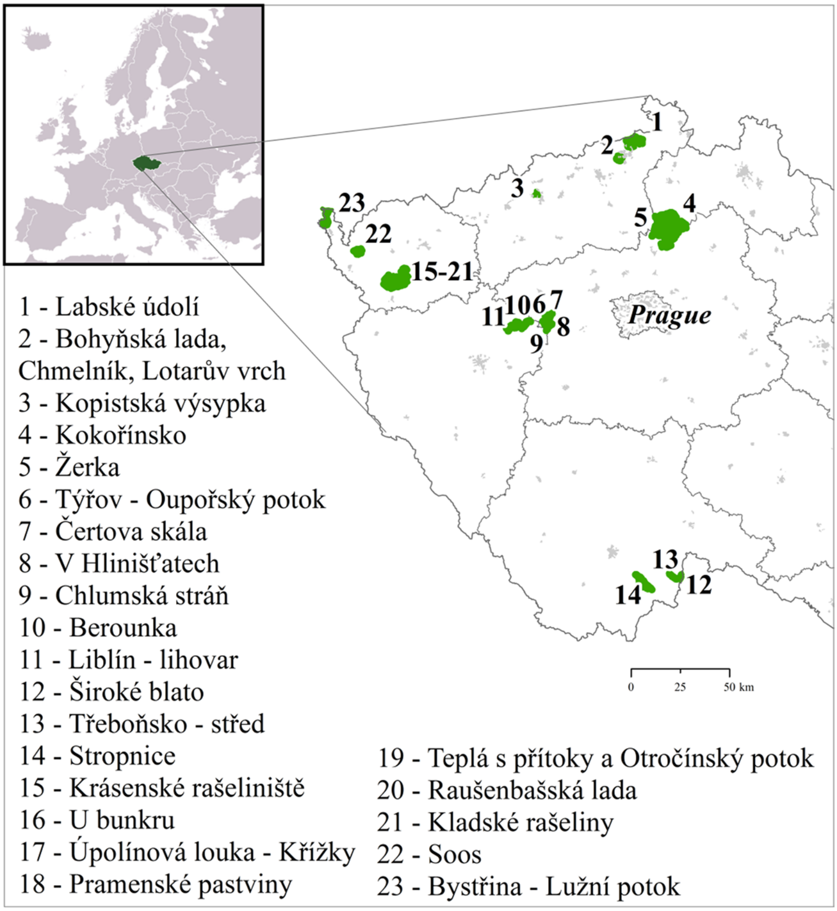

Fig. 1 Model areas surrounding mapped sites of community importance in the Czech Republic

habitats are detailed. Information on land-use in the model areas was obtained from the Consolidated Layer of Ecosystems (CLE) provided by the NCA CR (©CzechGlobe, ©NCA CR 2013), using its own data and that provided in ZABAGED—©COSMC 2012, Corine Land Cover 2006—©EEA 2006, Urban Atlas 2006—©EEA 2006 and DIBAVOD—©TGM WRI 2012). We used the 1:10 000 layer distinguishing 41 land use categories for those parts of model areas for which data on habitat type outside the PA was missing.

Data and statistical analysis

Using the HML and CLE data, we designated five monitoring zones representing habitats of different preservation importance and varying degrees of anthropogenic pressure, the monitoring zones being delineated for each SCI particularly. The HML layer was threated as the base layer as it provided more detailed information on local habitats, while the CLE was used as a supplementary layer supplying data missing in the HML layer. Zone A (SCI core area) included habitats subjected to the PA conservation efforts, i.e., habitats of European importance (based on HML data) based on documentation available on the Natura 2000 website (NCA 2017). Zone B (SCI broader core area) included all other semi-natural HML habitats (also mosaic habitats but not those affected by anthropogenic activities) within the borders of the SCI. Zones A and B both varied in their spatial distribution and were not necessarily spatially compact (see examples in Fig. 2). Both zones A and B represented PA core areas, containing the most vulnerable habitats supposedly free of IAS. For the purposes of analysis, zones A and B were considered to be inside the PA, while zones C, D and E were counted as outside the PA, though they occasionally crossed over the PA boundaries. Zone C (semi-natural habitats) included the remaining areas of semi-natural HML habitat (including mosaic habitats but not those affected by anthropogenic activity and non-mapped areas within HML) outside the boundary of the SCI and selected semi-natural CLE land-use categories inside and outside the SCI (see Table 1). Zone D comprised habitats affected by anthropogenic activity (from HML) and selected CLE categories situated inside and outside the SCI but still having some vegetation cover, while zone E consisted of soil-sealed land categories (see Table 1). For a list of HML and CLE categories included in each monitoring zone, see Electronic Supplementary Material 2.

Generalised linear mixed models (GLMM; Zuur et al. 2009) were used to analyse the occurrence data, with dependent variables represented by the number of IAS locations and area of IAS presence (a separate model was created for each response), and

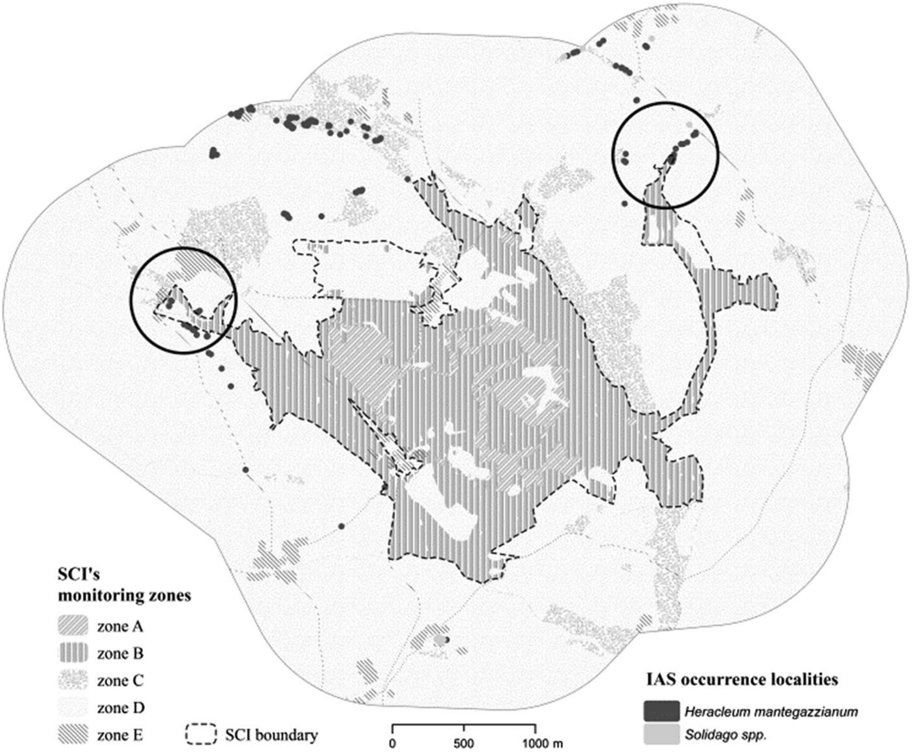

Fig. 2 Location of monitoring zones inside and outside the Soos site of community importance. Areas at high risk of invasive alien species spread are marked (circled) as priority monitoring sites for the species of interest

Table 1 Specification of habitat categorization within monitoring zones

Monitoring zone category	Habitats within the zone (for full list see Electronic Supplementary Material 2)
A—core area	Subject of PA protection (differ for particular SCI)
B—broader core area	Vulnerable natural habitats within PA (based on HML)
C—semi-natural habitats	Alluvial meadow, dry grassland, mesic meadow, heath, alluvia, oak and oak-hornbeam forest, ravine, beech, dry pine, spruce and bog forest, natural shrub vegetation, wetlands and littoral vegetation, peatbogs and springs, swamps, water body macrophytes, natural watercourses and natural rocks
D—anthropogenically affected habitats	Urban nature, artificial urban green areas (parks, gardens, cemeteries), arable land, orchards and gardens, hop fields, vineyards, intensive grassland, intensive coniferous, broad-leaved and mixed forest plantation, shrubs with ruderal vegetation, anthropogenically influenced waterbodies, anthropogenically influenced watercourses and artificial rocks
E—habitats degraded by human activities	Impervious surfaces, continuous and discontinuous urban fabric, industrial and commercial units, transport units, dumps and construction sites and artificial urban green areas such as recreation and sports areas

factors such as habitat type, region, elevation, protection zone, location and distance from watercourse, road and inhabited area used as predictors. Zero inflated models (ZI; Rice 1989) were employed due to the high level of zeros in the dataset. The models were evaluated using both Akaike information criterion (AIC) and likelihood ratio tests and simplified using posterior merging of factors levels. The following best fit models were chosen in accordance with the rules of parsimony and standard methods of model residual diagnostics: (1) Number of positive occurrences ~ Region + Species, with total area of SCI as covariate and using Poisson distribution of response variable; and (2) Area of IAS presence ~ Region + Species, with species and total area of SCI as covariates, using geometrical distribution of the response variable due to its semi-continuous character. In the interpretation of ZI model results, we mainly focused on count data. The means for regional factors were compared using Bonferroni correction (Rice 1989). The relationship between IAS presence and environmental characteristics was assessed using canonical correspondence analysis (CCA), with invaded habitat, IAS location inside or outside the SCI, elevation and distance to watercourse, road or inhabited area used as predictors. Response variables were log $(y + 1)$ transformed due to a non-linear increase in IAS presence in suitable environment types (Ter Braak and Šmilauer 2014). Level of invasion within each SCI was evaluated based on the number of occurrences within each monitoring zone. The area of each IAS locality was subjected to regression analysis to reveal whether the habitat vulnerability outside the PAs affected habitat vulnerability of the habitats inside. As the total area of each zone differed considerably, all variables were log-transformed prior to analysis. The regression model was then evaluated using standard residual diagnostics. To assess the influence of invasion in particular protection zones on level of invasion in zone A, the area of invasion in zone A was correlated with that in the other zones (i.e., A vs. B, A vs. C, etc.) using Spearman's correlation coefficient.

While species of *Solidago* and *Fallopia* were distinguished during mapping, they were pooled for some statistical tests (e.g., GLMM) as they were often found as mixed populations and their ecological characteristics and effects on the habitat were similar (*Solidago* spp.) and occurred with low abundance (*Fallopia* spp.).

All statistical analyses were undertaken using the R programme (R Development Core Team 2015), Statistica 12 (StatSoft®) and Canoco 5 (Ter Braak and Šmilauer 2014).

Results

Character of IAS invasion within model areas

We recorded 3229 IAS occurrences overall (1547 *S. canadensis*, 269 *S. gigantea*, 804 *I. glandulifera*, 400 *H. mantegazzianum*, 118 *F. japonica* var. *japonica*, 84 *Fallopia* × *bohemica* and 7 *Fallopia sachalinensis*). Of these, 42% were situated within the SCI boundary and 58% within the 1 km buffer zone (Table 2).

Overall, the summary of IAS occurrence does not fully reflect the level of invasion in each SCI due to high variability in the representation of particular species within different SCIs. *Solidago* spp., for example, were found at the highest number of localities (1826) and covered the largest area (61.3% of total area invaded by all species), while *I. glandulifera* was found at 804 localities but represented only 19.4% of total area invaded. In comparison, *H. mantegazzianum* was present at only 400 localities but covered a similar area of 18.3%. Taxa of the genus *Fallopia* were found at the lowest number of localities (209) and had the smallest total invaded area (1%) within SCIs and their surroundings (Table 3). The average size of each *H. mantegazzianum* invasion locality was 906 m^2, considerably larger than those of *I. glandulifera* (477 m^2), *Solidago* spp. (669 m^2) and *Fallopia* taxa (ca. 100 m^2) (counted from basic data pool).

Statistical analysis (ZI models) of IAS presence in each SCI revealed significantly different levels of invasion between three groups of regions (I, II, III; Fig. 3), with differences found both in the number of localities and invaded area (number of localities mean: group I = 1.85, group II = 2.85, group III = 4.35, $p < 10^{-6}$; invaded area mean: group I = 7.582 m^2, group II = 10.925 m^2, group III = 13.605 m^2, $p < 0.001$; both using Bonferroni correction of level comparisons). As the number of IAS localities does not show abundance of species in particular SCIs, the same analysis was employed with area of IAS as the response variable. While the results suggest a strong influence for differences in geomorphology, land-use and localised spreading of individual species in different regions, 'species' was not distinguished as a statistically significant factor using ZI models.

Semi-natural and protected habitat types were most invaded by the selected invasive plant species, with *Solidago* spp. predominantly associated with categories such as intensive grassland, discontinuous urban fabric and transport units (based on CLE). Overall, land-use change appeared to be the main initiator of invasion, with *Solidago* spp. being particularly invasive on uncultivated land, unmowed meadows and abandoned fields and in large openings created by large-scale logging of forest stands. In comparison, *H. mantegazzianum* was mostly found in intensive grassland, mesic meadows and close to roads, while *I. glandulifera* appeared to prefer wetlands, littoral vegetation, natural watercourses and natural shrub vegetation. *Fallopia* spp., which occurred relatively rarely in the mapped SCIs, mainly invaded alluvial and intensive mixed forest, intensive grassland and areas of transport (see Electronic Supplementary Material 3 for more details and Electronic Supplementary Material 4 for maps of IAS spatial distribution in and outside selected SCI).

Table 2 Number of invasive alien species in sites of community interest (SCI) and their surroundings

No.	Site of community importance	SCI area (km^2)	Mapped area (km^2)	Number of occurrences (outside/inside SCI)				Total number of occurrences
				Solidago spp.	*Impatiens glandulifera*	*Heracleum mantegazzianum*	*Fallopia* spp.	
10	Berounka	1.4	48.1	12/0	53/14	0	4/0	83
9	Chlumská stráň	1.2	13.1	5/0	11/0	0	0	16
2	Bohyňská lada, Chmelník, Lotarův vrch	3.8	16.8	11/1	0	0	10/0	22
23	Bystřina–Lužní potok	11.3	30.1	129/33	0	5/0	17/7	191
21	Kladské rašeliniště	26.7	58.5	0	0	57/12	0	69
4	Kokořínsko	95.5	226.8	554/249	5/0	0	44/30	882
3	Kopistská výsypka	3.3	6.4	60/20	0	0	10/0	90
	Krásenské rašeliniště	1.5	10.3	2/0	3/0	0	0	5
1	Labské údolí	13.2	52.3	316/78	27/493	0	3/34	951
18	Pramenské pastviny	0.005	3.4	0	0	0/34	0	34
20	Raušenbašská lada	5.0	19.2	1/0	0	32/0	0	33
12	Široké blato	1.0	5.3	1/0	0	0	0	1
22	Soos	4.6	22.5	15/0	0	96/7	0	118
14	Stropnice	12.7	43.0	26/13	3/14	0	13/4	73
19	Teplá s přítoky a Otročínský potok	1.1	14.5	0	0	27/0	0	27
13	Třeboňsko–Střed	1.1	16.6	17/1	7/8	0	1/0	34
6	Týřov–Oupořský potok	13.4	44.6	27/0	10/0	0	2/0	39
16	U bunkru	0.6	8.3	0	0	26/0	0	26
17	Úpolínová louka–Křížky	6.9	23.8	0	0	0/9	0	9

Solidago species and taxa of the genus *Fallopia* and *Solidago* are listed as genera, despite being mapped individually. Number of occurrences = number within a 1 km buffer zone of the SCI/number inside SCI boundaries. Total number of occurrences = number of localities in each SCI model area (*note* some localities are in the buffer zone of more than one SCI)

Table 3 Total area over which particular invasive alien species occur (m^2) within monitoring zones of different SCIs

SCIs monitoring zone category	*Solidago* spp.	*Impatiens glandulifera*	*Heracleum mantegazzianum*	*Fallopia* spp.	Percentage of invaded area (%)
A	57,233	122,719	31,208	4224	0.30
B	118,408	71,160	1699	1757	0.27
C	401,438	114,961	154,050	3336	0.40
D	471,413	47,767	97,121	7120	0.16
E	165,742	27,292	78,285	2548	0.95
Total invaded (%)	1,214,234	383,899	362,363	18,985	0.27

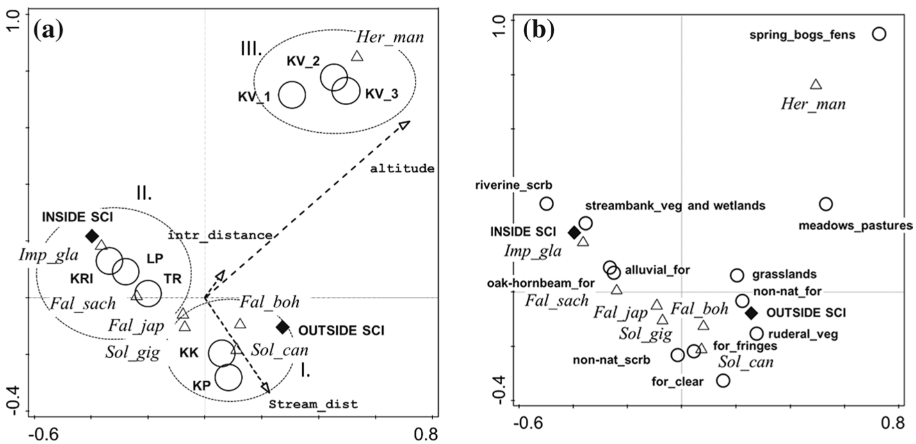

Fig. 3 Canonical correspondence analysis (CCA) biplot showing presence/absence of invasive species as response variables and **a** environmental characteristics or **b** habitats as predictors; species abbreviations: *Fal_jap—Fallopia japonica* var. *japonica*, *Fal_sach—F. sachalinensis*, *Fal_boh—F.* × *bohemica*, *Imp_gla—Impatiens glandulifera*, *Her_man—Heracleum mantegazzianum, Sol_can—Solidago canadensis*, *Sol_gig—S. gigantea*. The black diamonds indicate invasive alien species sites located inside and outside sites of community importance (SCI), i.e., in zones A, B, C, D or E (for details see the "Methods"). **a** Environmental characteristics: arrows show increasing altitude, distance from urban areas (intr_dist) and distance from stream (stream_dist). Localities: the circles indicate individual SCIs (KAR_1-3, KK, KP, KRI, LP, TR—for full names see the "Methods" section); dashed circles indicate groups of SCIs divided using CCA. **b** Habitats (following Chytrý et al. 2010): for detailed information about habitats included in the categories, see Electronic Supplementary Material 1

Role of environmental variables in PA zoning

The IAS mapped in this study differed both in distribution and main habitats invaded (Fig. 3; Electronic Supplementary Material 4). The CCA response variables described 26% of all variability in IAS distribution, with altitude, distance from stream, zoning (inside SCI [zones A, B]; outside SCI [zones C, D, E]) and group locality identified as significant predictors ($p < 0.002$). As with ZI (see previous section), CCA also revealed stratification of SCIs into three main groups (Fig. 3a). Group I associated invasion with presence of streams and geomorphology, with *I. glandulifera* the most significant IAS. In such localities, zoning did not correspond with level of disturbance, rather IAS (*F. japonica* var. *japonica*, *F. sachalinensis*) tended to be tied more directly to habitats in contact with water (Fig. 3b), placing them mainly in the protected habitats of zones A and B (inside the SCI). Group II was determined by the presence of *Solidago* spp. and *F.* × *bohemica*, and Group III (characterised as mesic and sub-mountainous or as lowland farmland) by presence of *H. mantegazzianum*, which mainly occurs in the western part of the Czech Republic (at higher altitude than other SCIs) in association with meadows and pastures (Fig. 3; see Fig. 2 for an example of *H. mantegazzianum* spatial distribution within the Soos SCI in western Bohemia). Zoning in Groups II and III corresponded with the level of anthropogenic influence and habitat disturbance, with IAS predominantly being found in zones D and E (outside the SCI; CCA, $p = 0.002$), in contrast with Group I ($p = 0.138$).

Level of IAS invasion in monitoring zones

Overall, the number of IAS in different habitats did not correspond well with their level of invasion (i.e., the area affected by each IAS) as several individuals tended to be found very close together. When the area of IAS invasion was recalculated as the area of each habitat (average = 535 m^2, range 1–65,750 m^2) differentiated into monitoring zones, just 0.3% of protected habitats of European importance were affected by IAS in the core area (zone A) and just 0.27% within the broader core area (zone B). Outside the SCI, just 0.4% was invaded within zone C, 0.16% of zone D and 0.95% of zone E (Table 3). In total, IAS affected just 0.27% of the overall area mapped. While *H. mantegazzianum* was mostly found in marginal areas and in habitats affected by anthropogenic activity (i.e. zones C, D and E), *I. glandulifera* was found in all monitoring zones, with an apparent preference for habitats affected by anthropogenic activity (zones D and E) and often occurring in more than one habitat type within the core areas (zones A and B). Likewise, *Solidago* spp. were mainly located in marginal zones C and D, while *Fallopia* spp. were predominantly found in marginal zone D, though their second highest level of occurrence was in zone A, occurrences corresponding with the species' habitat preferences (see above; Table 3; see Electronic Supplementary Material 4 for maps of IAS spatial distribution in and outside some SCI).

In general, regression analysis indicated positive dependency between IAS occurrence in the SCI core area (zone A) and occurrence of the same species in zones C and D (Fig. 4). Likewise, the model including area invaded in zones E and D as an independent variable explained 85% of variability in area invaded in zone A (log area IAS A = 0.55 (log area IAS E) + 0.27 (log area IAS D), $R^2 = 0.85$) for all species studied. Overall IAS spatial distribution in zones C, D and E outside the PAs corresponded with a high level of invasion within zones A and B inside the PAs (Table 4). There was a strong statistical correlation (Spearman's correlation coefficient) between area invaded in the core area and the non-protected surroundings for *H. mantegazzianum* and *S. canadensis*. Further, there was a positive correlation between zones A and B for *I. glandulifera* and *F. japonica* var. *japonica* occurrence in habitats such as river banks and wetlands, both of which are conservation objects within the SCIs (Table 4; Figs. 3, 4). Likewise, there was a positive correlation between zone A and zones C, D and E for *H. mantegazzianum*, *S. canadensis* and *S. gigantea* occurrence in semi-natural habitats, such as grasslands, meadows, forest edges and forest logging clearances (field observations) (Table 4; Figs. 3, 4), though these are generally not conservation objects.

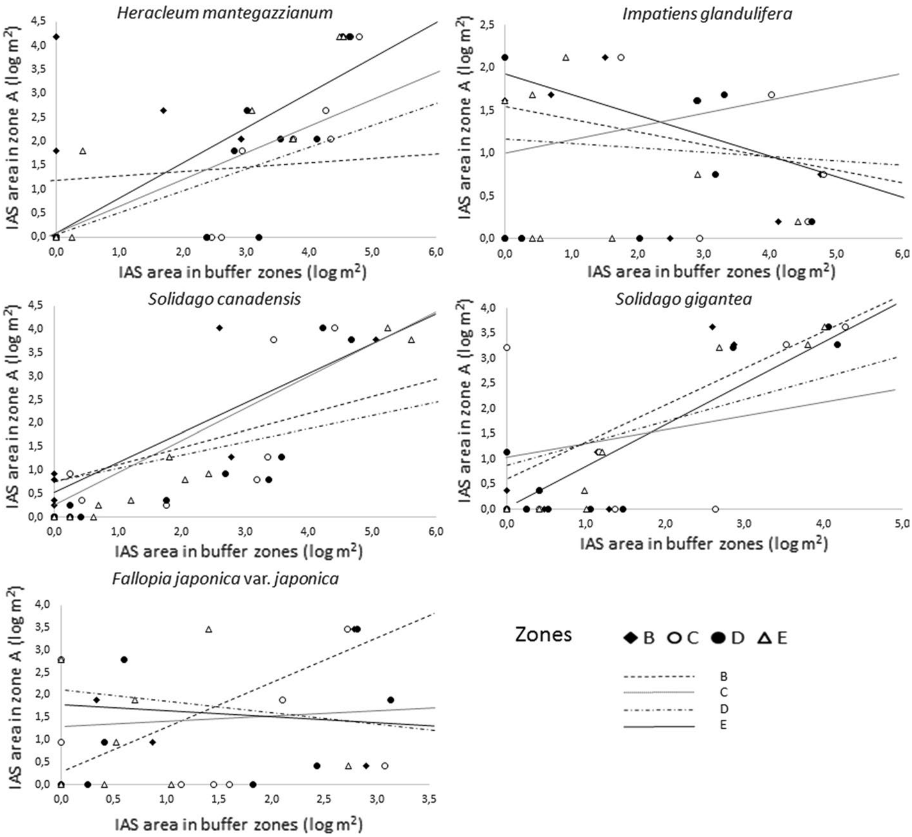

Fig. 4 Relationship between level of invasion in the core area (zone A) of sites of community importance (SCI) and area invaded in other SCI protection zones (buffer zones = zones B, C, D and E) for each invasive alien species. *X axis* area invaded in protection zones other than zone A, *Y axis* area invaded in protection zone A

Table 4 Spearman's correlation coefficient for comparisons between the invaded area in SCI monitoring zones—zone of category A (SCI core area) and other protection zone categories (B–E)

Species	Invaded area correlation coefficient			
	A–B	A–C	A–D	A–E
Heracleum mantegazzianum	**0.58**	**0.91**	**0.84**	**0.94**
Impatiens glandulifera	**0.53**	0.29	0.20	– 0.22
Solidago canadensis	**0.76**	**0.91**	**0.93**	**0.94**
Solidago gigantea	0.48	0.47	0.48	**0.78**
Fallopia jap. var. *jap.*	**0.68**	0.10	0.22	0.18

Numbers in bold indicate statistically significant correlations ($p < 0.05$). For detailed information on zoning see the "Methods"

Discussion

All seven taxa of the invasive neophyte plant species mapped in this study are among the most widely managed IAS within Central European protected areas (Braun et al. 2016). In our study, of the 200 km^2 total area invaded, 21.5 km^2 occurred in zone A and 19.2 km^2 in zone B, together representing just 0.5% of the total area mapped and highlighting the fact that most localities of occurrence were small in extent, usually comprising several individuals. In total, 42% of confirmed invasion localities were found inside SCI boundaries and 58% in the buffer areas surrounding the PA, confirming the findings of Pěknicová and Berchová-Bímová (2016) and Timmins and Williams (1991), who state that IAS are mostly located along the edges of PAs. While the present level of invasion is relatively low, it is clear that early detection of these localities is essential to prevent them serving as sources for the wider invasion spreading of such species.

The rate of spread of indigenous species and invasion of non-indigenous species will be affected by many factors that differ along spatial and temporal scales, making generalisation difficult. Such factors may include climate and local weather patterns, vegetation structure, resource availability, the number of species present in secondary regions, propagule pressure and associated ecosystem processes such as competition, disease and adaptation (Foxcroft et al. 2007). Nevertheless, the decrease in number of neophytes with altitude observed in this study corresponds with the findings of previous studies, such as those by (Becker et al. 2005; Beniak et al. 2015), as does the role of road networks acting as spread vectors, especially when such roads enter protected areas (Rice 1989; Okimura et al. 2016). Long-distance seed dispersal along roads has long been recognised as a routine, rather than occasional, phenomenon (Von Der Lippe and Kowarik 2007). Likewise, we also noted a positive relationship between IAS occurrence and proximity to streams (Catford et al. 2011; Foxcroft et al. 2007; Richardson et al. 2007), especially for *I. glandulifera* (Čuda et al. 2017) and *Fallopia* spp. (Mandák et al. 2004), these species showing a strong preference for such habitats and the streams subsequently acting as spread vectors. Study of Meek et al. (2010) concerning level of invasion in context of land-use found out that riparian zone adjacent to agricultural land had the greatest IAS cover, while those bordering urban land the highest alien species richness.

In general, a higher number of alien neophytes appear to occur in and around human-made habitats (Deutschewitz et al. 2003; Lososová et al. 2006; Lambdon et al. 2008); however, while building density was an important factor in the occurrence of certain IAS in the study of Catford et al. (2011), we found no evidence for this in our study (using distance from built-up areas). The effect of surrounding landscape on IAS presence was confirmed by study of Jarošík et al. (2011) on example of large-scale PA, Kruger National Park in South Africa. The park boundary acting as a human impact buffer as level of invasion in PA was affected by the landscape outside the park. Character of landscape, habitat types and spreading vector presence were determined as crucial predictors from outside the park. Following these facts stratified zoning can serve as guidelines for management and areas in high-risk of IAS presence identification.

When addressing the level of anthropogenic disturbance in habitats by using monitoring zone grading (zone A—least disturbed to zone E—most disturbed), we noted a strong positive correlation between level of invasion in the surrounding landscape (typically represented by farming and other anthropogenic activities) and the level of invasion in protected habitats; highlighting the need for effective zoning policies to prevent spread of IAS and protect valuable habitats within the SCI. This was particularly evident in areas where invasion was not determined by geomorphology or where IAS do not invade PA priority habitats (e.g., protected rivers and river banks invaded by *I. glandulifera* or *F. japonica* var. *japonica*). An effect of habitat preferences of the mapped IAS and SCIs' is visible on results of CCA analysis (Fig. 3). Our results suggest that IAS were able to spread into semi-natural habitats from sites in zones D and E, where intensive disturbance or land-use changes were ongoing (Fig. 4). In particular, urban and garden landscape transition zones near the SCI were important sources for *Solidago* spp. Along with known spreading vectors such as watercourses, roads and urbanised land, forestry activity also played a crucial role in the degree of IAS propagation. Logging activity in particular appears to act as a strong dispersal vector in forest stands of all conservation categories (including zone A). Until now, there has been no detailed analysis of forest management data highlighting the role of forest cleaning and timber transport in the spread of IAS.

Our results suggest that the best defence against IAS is to prevent their spread into habitats in direct proximity to PAs by prioritising IAS control in the border zones, focusing especially on potential spread vectors. This is in line with previously published results suggesting a close relationship between semi-natural habitats surrounding PAs and low levels of invasion within those PAs (Jarošík et al. 2011; Crall et al. 2013). In the Czech Republic, for example, Pyšek et al. (2002a) noted a lower number of neophytes in small PAs (18%) than in the surrounding landscape (85%), while Crall et al. (2013) stated that neophyte invasion level at individual sites ranged from 0 to 25% of all species present, though they also noted that specific locations showed too much variation to suggest general patterns. This was largely confirmed by our own study in that, while it was possible to recognise geographical and geomorphological factors influencing the level of invasion at individual SCIs, we were unable to confirm any general trend in the occurrence of individual IAS. It is also possible that our choice of model areas had an influence on the proportion of some IAS mapped (e.g., the low presence of *Fallopia* taxa in the selected SCIs in contrast to its overwhelming presence in Northern Bohemian and Moravian SCIs (Mandák et al. 2004). Jarošík et al. (2011) suggested to distinguish PA surroundings and its inside parts. Two management approaches were differentiated, one concerning surroundings of the PA, where countryside should be managed in respect to prevent IAS intrusion into the PA; another one directed inside the PA boundary, especially for small-scale ones, where prioritization of the localities for targeted monitoring and rapid response eradication efforts are crucial for functional prevention of IAS spread in valuable habitats. However, this may not be the case where invasive species occur within protected habitats as any attempt to eradicate IAS in such areas could threaten the very species being protected. Similarly, efforts to eradicate IAS that spread along watercourses based on upper stretch monitoring and zonal protection of localities downstream may also prove impractical as elimination of propagule pressure in the downstream stretch would require long-term intensive measures covering the whole watershed.

Undoubtedly, human impact is one of the most influential factors affecting IAS spread (Catford et al. 2011). Within prevention of IAS spread into PAs, the monitoring efforts should be aimed at specific localities of PA boundary coming across urban sites, such as garden colonies or discontinuous urban land. While variation in IAS occurrence in different regions makes the proposal of generalised measures for SCI protection difficult; mapping and, if possible, elimination of IAS from those areas surrounding the SCI is a clear priority. Habitat suitability models could be applied in order to define those locations most threatened by IAS dispersal and to select those areas most in need of regular monitoring (Pluess et al. 2012). For the determination of areas prone to invasion, it is possible to use both data on habitat type and geomorphological characteristics (Braun et al. 2016). On the other hand, several general approaches for predicting invasion risk at the landscape level have been proposed for different taxonomic groups that do not employ habitat data (Catford et al. 2011). However, our results showed high variability in those environmental factors having a significant impact on IAS spread, even when mapping seven vascular plant taxa. Indeed, in a number of cases, SCI geomorphology and presence of strong spreading vectors, in combination with presence of preferred habitat type, was the main factor determining area invaded, making any generalisation at the local scale, much less the landscape level, extremely complicated.

In conclusion, we urgently recommend that the IAS surveillance and appropriate management methods to be implemented with the provision of best practice examples (Chytrý et al. 2008a), with use of local approaches leading to functional action plans.

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ELECTRONIC SUPPLEMENTARY MATERIAL 1

Generalised habitat group categories employed in the analysis (based on Natura 2000 habitat mapping layer categories; for a detailed description of the habitat codes, see Chytrý et al. 2010)

Habitat group category abbreviation	**Habitat group category name**	**Habitats included within the category group**
Riverine_scrb	Riverine willow scrubs and carrs	*K1 Wilow carrs* *K2 Riverine willow shrubs*
Xeric_scrb	Mesic and xeric shrub vegetation	*K3 Tall mesic and xeric scrub* *K4A Low xeric shrub, primary rock vegetation with Coroneaster spp.* *K4C Low xeric vegetation (other secondary vegetation)*
Alluvial_for	Alluvial forests	*L1 Alder carrs* *L2 Ash-alder alluvial forests*
Oak_hornbeam_for	Oak and oak-hornbeam forests	*L3 Oak-hornbeam forests* *L6 Thermophilous oak forests*
Rav_beech_acid_for	Ravine, beech and acidophilous oak forests	*L4 Ravine forests* *L5 Beech forests* *L7 Acidophilous oak forests*
Pine_spr_for	Pine and spruce forest	*L8 Dry pine forests* *L9 Spruce forests*
Bog_for	Bog forest	*L10 Bog forests*
Streambank_veg and wetlands	Streambank vegetation and wetlands - reed beds and bank vegetation	*M1 Reed and tall-sedge beds* *M2 Vegetation of hygrophilous herbs* *M3 Vegetation of perennial amphibious herbs* *M4 River gravel banks*
Spring_bogs_fens	Springs Bogs and fens	*R1 Springs* *R2 Fens and transitional mires* *R3 Raised bogs*
Cliffs_screes	Cliffs, stable and mobile boulder screes	*S1 Cliffs and boulder screes* *S2 Mobile screes*
Caves	Caves open and not open to public	*S3 Caves*
Meadows_pastures	Meadows and pastures	*T1.1 Mesic Arrhenatherum meadows* *T1.2 Montane Trisetum meadows* *T1.3 Cynosurus pastures* *T1.4 Alluvial Alopecurus meadows* *T1.5 Wet Cirsium meadows* *T1.6 Wet Filipendula grasslands* *T1.7 Continental inundated meadows* *T1.8 Continental tall-forb vegetation* *T1.9 Intermittently wet Molinia meadows* *T1.10 Vegetation of wet disturbed soils*
Grasslands	Various types of grasslands	*T2 Nardus grasslands* *T3 Dry grasslands* *T5 Sand a shallow soil grasslands*
For_fringe	Forest fringe vegetation	*T4.1 Dry herbaceous fringes* *T4.2 mesic herbaceous fringes*
Vernal_ther_suculent_veg	Vernal therophyte and succulent vegetation	*T6 Vegetation of vernal therophytes and succulents*
Salt_marsh	Inland salt marsh	*T7 Inland salt marshes*
Heath	*Lowland to montane heaths*	*T8.1 Dry lowland and colline heaths* *T8.2 Secondary submontane and montane heaths* *T8.3 Vaccinium vegetation of cliffs and boulder screes*
Stream_reserv_veg	Stream and reservoir vegetation	*V1 Macrophyte vegetation of naturally eutrophic and mesotrophic still waters* *V2 Macrophyte vegetation of shallow still waters* *V3 Macrophyte vegetation of oligotrophic lakes and pools* *V4 Macrophyte vegetation of water streams*
Urban_areas	Urbanised areas	*X1 Urbanises areas*
For_clear	Forest clearings	*X10 Clearings with an undergrowth of the original forest* *X11 Clearings with nitrophilous vegetation*
Early_succession	Stands of early successional woody species	*X12 Stands of early successional woody species*
WV_open_land	Woody vegetation outside forests and human settlements	*X13 Woody vegetation outside forest and human settlements*

Water_vithout_veg	Streams and water-bodies without vegetation	*X14 Streams and water-bodies without vegetation of conservational importance*
Intens_agric	Intensively managed agricultural land	*X2 Intensively managed fields* *X3 Extensively managed fields* *X4 Permanent agricultural crops* *X5 Intensively managed meadows*
Ruderal_veg	Herbaceous ruderal and sporadic vegetation	*X6 Anthropogenic areas with sporadic vegetation outside human settlements* *X7 Herbaceous ruderal vegetation outside human settlements*
Non-nat_scrb	Scrub with ruderal or alien species	*X8 Scrubs with ruderal or alien species*
Non-nat_for	Forest plantations with allochthonous trees	*X9 Forest plantations of allochtonous trees*

Corresponding author: Johana Vardarman

Department of Applied Ecology, Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Kamýcká 129, Prague 6 – Suchdol, CZ-165 21, Czech Republic; e-mail: vardarman@fzp.czu.cz

ELECTRONIC SUPPLEMENTARY MATERIAL 2

Categories for the Habitat Mapping Layer and Consolidated Layer of Ecosystems within monitoring zones of particular Sites of Conservation Interest (habitat data provided by the Nature Conservation Agency of the Czech Republic (http://www.nature.cz).

SCI Bohyňská lada, Chmelník, Lotarův vrch	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	T1.1 Mesic *Arrhenaterum* meadows T1.9 Intermittently wet *Molinia* meadows T3.4D Broad-leaved dry grasslands without important occurrence of orchids and without *Juniperus communis* T3.4C Broad-leaved dry grasslands with important occurrence of orchids and without *Juniperus communis* S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes L2.2A Ash-alder alluvial forests, typical stands L3.1 Hercynian oak-hornbeam forests L4 Ravine forests
B	L5.1 Herb-rich beech forests L6.5B Acidophilous thermophilous oaks forests with *Genista pilosa* L7.1 Dry acidophilous oak forests M1.1 Reed beds of eutrophic still waters R1.4 Forest springs without tufa formation T1.3 *Cynosurus* pastures T1.5 Wet *Cirsium* meadows T5.5 Acidophilous grasslands on shallow soils V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V2C Macrophyte vegetation of shallow and still waters (other vegetation)
C	T5.5 Acidophilous grasslands on shallow soils T4.2 Mesic herbaceous fringes T3.4D Broad-leaved dry grasslands without important occurrence of orchids and without *Juniperus communis* T1.9 Intermittently wet *Molinia* meadows T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T1.3 *Cynosurus* pastures T1.10 Vegetation of wet disturbed soils T1.1 Mesic *Arrhenatherum* meadows S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes R1.4 Forest springs without tufa formation M1.7 Tall-sedge beds L7.1 Dry acidophilous oak forests L5.4 Acidophilous beech forests L5.1 Herb-rich beech forests L4 Ravine forests L3.1 Hercynian oak-hornbeam forests L2.2 Ash-alder alluvial forests K1 Wilow carrs K2.1 Willow scrub of loamy and sandy river banks K3 Tall mesic and xeric scrub Mosaic of habitats 310 Alluvial meadows 530 Swamps 407 Beech forests 405 Oak and oak-hornbeam forests 404 Intensive mixed forests 403 Alluvial forests 330 Mesic meadows 510 Wetlands and littoral vegetation 412 Natural shrub vegetation 320 Dry grasslands

	406 Ravine forests 630 Natural water courses
D	210 Arable land 220 Orchards and gardens 250 Intensive grasslands 401 Intensive coniferous forests 402 Intensive broad-leaved forests 414 Introduced shrub vegetation 620 Human influenced water bodies
E	120 Discontinuous urban fabric 130 Industrial and commercial units 140 Transport units 150 Dump and construction units 180 Artificial urban green areas - recreation and sport areas

SCI Bystřina - Lužní potok	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	V3 Macrophyte vegetation of oligotrophic lakes and pools T1.6 Wet *Filipendula* grasslands
B	K1 Wilow carrs K3 Tall mesic and xeric scrub L2.2 Ash-alder alluvial forests L5.4 Acidophilous beech forests L9.2A Bog spruce forests L9.2B Waterlogged spruce forests M1.1 Reed beds of eutrophic still waters M1.5 Reed vegetation of brooks M1.7 Tall-sedge beds R1.2 Meadow springs without tufa formation R1.4 Forest springs without tufa formation R2.2 Acidic moss-rich fens R2.3 Transitional mires T1.1 Mesic *Arrhenaterum* meadows T1.3 *Cynosus* pastures T1.5 Wet *Cirsium* meadows T1.9 Intermittently wet Molinia meadows T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* T8.2B Secondary submontane and montane heaths without occurrence of *Juniperus communis* V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V4A Macrophyte vegetation of water streams, with currently present water macrophytes Mosaic of habitats
C	K1 Willow carrs K2.1 Willow scrub of loamy and sandy river banks L10.1 Birch mire forests L2.2 Ash-alder alluvial forests L5.4 Acidophilous beech forests L7.1 Dry acidophilous oak forests L9.2A Bog spruce forests L9.2B Waterlogged spruce forests M1.1 Reed beds of eutrophic still waters M1.5 Reed vegetation of brooks M1.7 Tall-sedge beds Mosaic of habitats R1.4 Forest springs without tufa formation R2.2 Acidic moss-rich fens R2.3 Transitional mires T1.1 Mesic *Arrhenaterum* meadows T1.2 Montane *Trisetum* meadows

	T1.3 *Cynosus* pastures T1.5 Wet *Cirsium* meadows T1.9 Intermittently wet *Molinia* meadows T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa, Salvinia natans, Statiotes aloides, Hydrocharis morsus-rarae*) V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V4A Macrophyte vegetation of water streams, with currently present water macrophytes 310 Alluvial meadows 330 Mesic meadows 350 Heaths 403 Alluvial forests 404 Intensive mixed forests 407 Beech forests 409 Spruce forests 412 Natural shrub vegetation 510 Wetlands and littoral vegetation 520 Peatbogs and springs 530 Swamps 630 Natural water courses
D	210 Arable land 250 Intensive grasslands 401 Intensive coniferous forests 402 Intensive broad-leaved forests 414 Introduced shrub vegetation 620 Human influenced water bodies 640 Anthropogenically influenced water courses
E	120 Discontinuous urban fabric 140 Transport units 150 Dump and construction units

SCI Kladské rašeliny	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	R3.1 Open raised bogs R2.2 Acidic moss-rich fens R2.3 Transitional mires L9.2A Bog spruce forest L10.4 *Pinus rotundata* bog forests
B	L2.2 Ash-alder alluvial forests L5.4 Acidophilous beech forests L8.1B Boreo-continental pine forests, other stands L9.2B Waterlogged spruce forests M1.1 Reed beds of eutrophic still waters M1.3 Eutrophic vegetation of muddy substrata M1.5 Reed vegetation of brooks M1.7 Tall-sedge beds M2.1 Vegetation of exposed fish pond bottoms R1.2 Meadow springs without tufa formation R1.4 Forest springs without tufa formation S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes T1.1 Mesic *Arrhenatherum* meadows T1.3 *Cynosurus* pastures T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa, Salvinia natans, Statiotes aloides, Hydrocharis morsus-rarae*) V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important

	macrophyte species V3 Macrophyte vegetation of oligotrophic lakes and pools V4A Macrophyte vegetation of water streams, with currently present water macrophytes
C	K1 Willow carrs K3 Tall mesic and xeric scrub L2.2 Ash-alder alluvial forests L2.2A Ash-alder alluvial forests, typical stands L2.2B Ash-alder alluvial forests, degraded stands L4 Ravine forests L5.1 Herb-rich beech forests L5.4 Acidophilous beech forest L8.1B Boreo-continental pine forests, other stands L9.1 Montane Calamagrostis spruce forests L9.2A Bog spruce forests L9.2B Waterlogged spruce forests M1.3 Eutrophic vegetation of muddy substrata M1.5 Reed vegetation of brooks M1.7 Tall-sedge beds M2.1 Vegetation of exposed fishpond bottoms Mosaic of habitats R1.2 Meadow springs without tufa formation R1.4 Forest springs without tufa formation R2.2 Acidic moss-rich fens R2.3 Transitional mires S1.2 Chamophytic vegetation of siliceous cliffs and boulder screes T1.1 Mesic *Arrhenaterum* meadows T1.3 *Cynosus* pastures T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T1.9 Intermittently wet *Molinia* meadows T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* T8.2B Secondary submontane and montane heaths without occurrence of *Juniperus communis* V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa, Salvinia natans, Statiotes aloides, Hydrocharis morsus-rarae*) V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V3 Macrophyte vegetation of oligotrophic lakes and pools V4A Macrophyte vegetation of water streams, with currently present water macrophytes 404 Intensive mixed forests 530 Swamps 630 Natural water courses 720 Natural rocks
D	170 Artificial urban green areas – parks, gardens, cemeteries 210 Arable land 250 Intensive grasslands 401 Intensive coniferous forests 402 Intensive broad-leaved forests 414 Introduced shrub vegetation 620 Human influenced water bodies
E	120 Discontinuous urban fabric 130 Industrial and commercial units 140 Transport units

SCI Kokořínsko	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	V5 *Charophycae* vegetation T3.3D Narrow-leaved dry grasslands without importance occurrence of orchids T1.1 Mesic *Arrhenaterum* meadows T1.6 Wet *Filipendula* grasslands

	T3.4D Broad-leaved dry grasslands without important occurrence of orchids and without *Juniperus communis* T3.5B Acidophilous dry grasslands without important occurrence of orchids T6.1B Acidophilous vegetation of spring therophytes and succulents (without dominance of *Jovibarba globifera*) M7 Herbaceous fringes of lowland rivers R2.1 Calcareous fens S1.2 Chamophytic vegetation of siliceous cliffs and boulder screes S3B Caves not open to public L2.2A Ash-alder alluvial forests, typical stands L5.4 Acidophilous beech forest
B	K1 Wilow carrs K2.1 Willow scrub of loamy and sandy river banks K3 Tall mesic and xeric scrub L1 Alder carrs L2.2 Ash-alder alluvial forests L2.2A Ash-alder alluvial forests, typical stands L2.2B Ash-alder alluvial forests, degraded stands L3.1 Hercynian oak-hornbeam forests L4 Ravine forests L5.1 Herb-rich beech forests L5.4 Acidophilous beech forest L6.1 Peri-Alpidic basiphilous thermophilous oak forests L6.4 Central European basiphilous thermophilous oak forests L6.5B Acidophilous thermophilous oak forests without *Genista pilosa* L7.1 Dry acidophilous oak forests L7.2 Wet acidophilous oak forests L7.3 Subcontinental pine-oak forests L8.1A Boreo-continental pine forests with lichens on sand L8.1B Boreo-continental pine forests, other stands L8.2 Forest-steppe pine forests L9.2B Waterlogged spruce forests M1.1 Reed beds of eutrophic still waters M1.3 Eutrophic vegetation of muddy substrata M1.5 Reed vegetation of brooks M1.7 Tall-sedge beds M7 Herbaceous fringes of lowland rivers Mosaic of habitats S1.2 Chamophytic vegetation of siliceous cliffs and boulder screes T1.1 Mesic *Arrhenaterum* meadows T1.10 Vegetation of wet disturbed soils T1.3 *Cynosus* pastures T1.4 Alluvial *Alopecurus* meadows T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T3.3D Narrow-leaved dry grasslands without significant occurrence of orchids T3.4D Broad-leaved dry grasslands without significant occurrence of orchids and without *Juniperus communis* T3.5B Acidophilous dry grasslands without significant occurrence of orchids T4.1 Dry herbaceous fringes T4.2 Mesic herbaceous fringes T5.3 *Festuca* sand grasslands T5.5 Acidophilous grasslands on shallow soils T6.1B Acidophilous vegetation of vernal therophytes and succulents without dominance of *Jovibarba globifera* T8.1A Dry lowland and colline heaths with occurrence of *Juniperus communis* T8.1B Dry lowland and colline heaths without occurrence of *Juniperus communis* T8.3 *Vaccinium* vegetation of cliffs and boulder screes V1C Macrophyte vegetation of naturally eutrophic and mesotrophic still waters with *Utricularia australis* or *U. vulgaris* V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa, Salvinia natans, Statiotes aloides, Hydrocharis morsus-rarae*)

	V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V2A Macrophyte vegetation of shallow still waters with dominant *Batrachium* spp. V4A Macrophyte vegetation of water streams, with currently present water macrophytes V5 *Charophyceae* vegetation
C	K1 Wilow carrs K3 Tall mesic and xeric scrub L1 Alder carrs L2.2 Ash-alder alluvial forests L2.2A Ash-alder alluvial forests, typical stands L2.2B Ash-alder alluvial forests, degraded stands L3.1 Hercynian oak-hornbeam forests L4 Ravine forests L5.1 Herb-rich beech forests L5.4 Acidophilous beech forests L6.1 Peri-Alpidic basiphilous thermophilous oak forests L6.5B Acidophilous thermophilous oak forests without *Genista pilosa* L7.1 Dry acidophilous oak forests L7.2 Wet acidophilous oak forests L7.3 Subcontinental pine-oak forests L8.1A Boreo-continental pine forests with lichens on sand L8.1B Boreo-continental pine forests, other stands L8.2 Forest-steppe pine forests L9.2B Waterlogged spruce forests M1.1 Reed beds of eutrophic still waters M1.3 Eutrophic vegetation of muddy substrata M1.5 Reed vegetation of brooks M1.7 Tall-sedge beds M7 Herbaceous fringes of lowland rivers Mosaic of habitats S1.2 Chamophytic vegetation of siliceous cliffs and boulder screes T1.1 Mesic *Arrhenaterum* meadows T1.10 Vegetation of wet disturbed soils T1.3 *Cynosus* pastures T1.4 Alluvial *Alopecurus* meadows T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T1.9 Intermittently wet *Molinia* meadows T3.1 Rock-outcrop vegetation with *Festuca pallens* T3.3D Narrow-leaved dry grasslands without significant occurrence of orchids T3.4D Broad-leaved dry grasslands without significant occurrence of orchids and without *Juniperus communis* T3.5B Acidophilous dry grasslands without significant occurrence of orchids T4.1 Dry herbaceous fringes T4.2 Mesic herbaceous fringes T5.3 *Festuca* sand grasslands T5.5 Acidophilous grasslands on shallow soils T6.1B Acidophilous vegetation of vernal therophytes and succulents without dominance of *Jovibarba globifera* T8.1B Dry lowland and colline heaths without occurrence of *Juniperus communis* T8.3 *Vaccinium* vegetation of cliffs and boulder screes V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa*, *Salvinia natans, Statiotes aloides, Hydrocharis morsus-rarae*) V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V4B Macrophyte vegetation of water streams with potential occurrence of aquatic macrophytes or with natural or semi-natural bed 310 Alluvial meadows 320 Dry grasslands 330 Mesic meadows 340 Alpine grasslands

	350 Heaths 403 Alluvial forests 404 Intensive mixed forests 405 Oak and oak-hornbeam forests 406 Ravine forests 407 Beech forests 408 Dry pine forests 412 Natural shrub vegetation Natural shrub vegetation 510 Wetlands and littoral vegetation 530 Swamps 610 Macrophyte vegetation of water bodies 630 Natural water courses 720 Natural rocks
D	170 Artificial urban green areas – parks, gardens, cemeteries 210 Arable land 220Orchards and gardens 250 Intensive grasslands 401 Intensive coniferous forests 402 Intensive broad-leaved forests 414 Introduced shrub vegetation 620 Human influenced water bodies 640 Anthropogenically influenced water courses 710 Artificial rocks
E	110 Continuous urban fabric 120 Discontinuous urban fabric 130 Industrial and commercial units 140 Transport units 150 Dump and construction units 180 Artificial urban green areas – recreation and sport areas

SCI Krásenské rašeliniště	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	R3.1 Open raised bogs R3.2 Raised bogs with *Pinus mugo* R3.3 Bog hollows R3.4 Degraded raised bogs R2.2 Acidic moss-rich fens R2.3 Transitional mires L9.2A Bog spruce forest L9.2B Waterlogged spruce forest
B	K1 Wilow carrs L10.1 Birch mire forests M1.3 Eutrophic vegetation of muddy substrata M1.7 Tall-sedge beds R1.2 Meadow springs without tufa formation R1.4 Forest springs without tufa formation T1.1 Mesic *Arrhenaterum* meadows T1.3 *Cynosus* pastures T1.5 Wet *Cirsium* meadows T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* V3 Macrophyte vegetation of oligotrophic lakes and pools
C	K1 Wilow carrs K3 Tall mesic and xeric scrub L10.1 Birch mire forests L2.2 Ash-alder alluvial forests L5.4 Acidophilous beech forests L7.1 Dry acidophilous oak forests L9.2A Bog spruce forests L9.2B Waterlogged spruce forests

	M1.3 Eutrophic vegetation of muddy substrata Mosaic of habitats R1.2 Meadow springs without tufa formation R1.4 Forest springs without tufa formation R2.2 Acidic moss-rich fens R2.3 Transitional mires T1.1 Mesic *Arrhenaterum* meadows T1.3 *Cynosus* pastures T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* T8.2B Secondary submontane and montane heaths without occurrence of *Juniperus communis* V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V2C Macrophyte vegetation of shallow still waters, other stands 404 Intensive mixed forests 530 Swamps 630 Natural water courses
D	250 Intensive grasslands 401 Intensive coniferous forests 402 Intensive broad-leaved forests 414 Introduced shrub vegetation 620 Human influenced water bodies 640 Anthropogenically influenced water courses 710 Artificial rocks
E	120 Discontinuous urban fabric 140 Transport units 150 Dump and construction units

SCI Labské údolí	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	S1.2 Chamophytic vegetation of siliceous cliffs and boulder screes S3B Caves not open to public L2.2A Ash-alder alluvial forests, typical stands L4 Ravine forests L5.4 Acidophilous beech forest L8.1A Boreo-continental pine forests, other stands Mosaic with above-mentioned habitats of concern
B	L2.2 Ash-alder alluvial forests L2.2B Ash-alder alluvial forests, significantly altered stands L3.1 Hercynian oak-hornbeam forests L5.1 Herb-rich beech forests L7.1 Dry acidophilous oak forests L7.3 Subcontinental pine-oak forests L8.1B Boreo-continental pine forests, other stands L9.2B Waterlogged spruce forest R1.4 Forest springs without tufa formation R2.3 Transitional mires T1.6 Wet *Filipendula* grasslands V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa*, *Salvinia natans, Statiotes aloides*, *Hydrocharis morsus-rarae*) V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V2C Macrophyte vegetation of shallow still waters, other stands V4B Macrophyte vegetation of water streams with potential occurrence of aquatic macrophytes or with natural or semi-natural bed
C	K1 Wilow carrs K3 Tall mesic and xeric scrub L10.1 Birch mire forests

	L2.2 Ash-alder alluvial forests L2.2A Ash-alder alluvial forests, typical stands L2.2B Ash-alder alluvial forests, degraded stands L3.1 Hercynian oak-hornbeam forests L4 Ravine forests L5.1 Herb-rich beech forests L5.4 Acidophilous beech forests L7.1 Dry acidophilous oak forests L7.3 Subcontinental pine-oak forests L8.1A Boreo-continental pine forests with lichens on sand L8.1B Boreo-continental pine forests, other stands L9.2B Waterlogged spruce forest M1.1 Reed beds of eutrophic still waters M1.7 Tall-sedge beds M6 Muddy river banks Mosaic of habitats R2.3 Transitional mires S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes T1.1 Mesic *Arrhenaterum* meadows T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa, Salvinia natans, Statiotes aloides, Hydrocharis morsus-rarae*) V2C Macrophyte vegetation of shallow still waters, other stands V4B Macrophyte vegetation of water streams with potential occurrence of aquatic macrophytes or with natural or semi-natural bed 310 Alluvial meadows 330 Mesic meadows 403 Alluvial forests 404 Intensive mixed forests 405 Oak and oak-hornbeam forests 406 Ravine forests 407 Beech forests 408 Dry pine forests 409 Spruce forests 412 Natural shrub vegetation 510 Wetlands and littoral vegetation 610 Macrophyte vegetation of water bodies 630 Natural water courses 720 Natural rocks
D	170 Artificial urban green areas – parks, gardens, cemeteries 210 Arable land 250 Intensive grasslands 401 Intensive coniferous forests 402 Intensive broad-leaved forests 414 Introduced shrub vegetation 620 Human influenced water bodies 640 Anthropogenically influenced water courses
E	120 Discontinuous urban fabric 130 Industrial and commercial units 140 Transport units 180 Artificial urban green areas – recreation and sport areas

SCI Raušenbašská lada	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	T1.1 Mesic *Arrhenaterum* meadows T1.6 Wet *Filipendula* grasslands T1.9 Intermittently wet *Molinia* meadows T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* R2.2 Acidic moss-rich fens

	S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes L9.2B Waterlogged spruce forest
B	K1 Willow carrs L2.2 Ash-alder alluvial forests L2.2A Ash-alder alluvial forests, typical stands L8.1B Boreo-continental pine forests, other stands L9.2A Bog spruce forests L9.2B Waterlogged spruce forests M1.3 Eutrophic vegetation of muddy substrata M1.5 Reed vegetation of brooks Mosaic of habitats R1.2 Meadow springs without tufa formation R1.4 Forest springs without tufa formation T1.1 Mesic *Arrhenaterum* meadows T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T4.2 Mesic herbaceous fringes
C	K1 Willow carrs K2.1 Willow scrub of loamy and sandy river banks K3 Tall mesic and xeric scrub L10.2 Pine mire forests with *Vaccinium* L2.2 Ash-alder alluvial forests L2.2A Ash-alder alluvial forests, typical stands L2.3B Hardwood forests of lowland rivers, significantly altered stands L5.4 Acidophilous beech forest L8.1B Boreo-continental pine forests, other stands L9.2A Bog spruce forests L9.2B Waterlogged spruce forests M1.3 Eutrophic vegetation of muddy substrata M1.5 Reed vegetation of brooks M1.7 Tall-sedge beds Mosaic of habitats R1.2 Meadow springs without tufa formation R1.4 Forest springs without tufa formation R2.2 Acidic moss-rich fens R2.3 Transitional mires S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes T1.1 Mesic *Arrhenaterum* meadows T1.3 *Cynosus* pastures T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T1.9 Intermittently wet *Molinia* meadows T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* T4.2 Mesic herbaceous fringes V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa, Salvinia natans, Statiotes aloides, Hydrocharis morsus-rarae*) 404 Intensive mixed forests 530 Swamps 630 Natural water courses
D	170 Artificial urban green areas – parks, gardens, cemeteries 250 Intensive grasslands 401 Intensive coniferous forests 414 Introduced shrub vegetation 620 Human influenced water bodies
E	120 Discontinuous urban fabric 130 Industrial and commercial units 140 Transport units 150 Dump and construction units

SCI Soos	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	T7 Inland salt marshes V1C Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (with *Urticularia australis* and *U. vulgaris*) V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa, Salvinia natans, Statiotes aloides, Hydrocharis morsus-rarae*) V3 Macrophyte vegetation of oligotrophic lakes and pools V5 *Charophycae* vegetation R2.3 Transitional mires R2.4 Peatsoils with *Rhynchospora* alba L2.2A Ash-alder alluvial forests, typical stands L10.1 Birch mire forests L10.2 Pine mire forests with *Vaccinum* L10.3 Pine forests of continental mires with *Eriophorum* L10.4 *Pinus rotundata* bog forests Mosaic with above-mentioned habitats of concern
B	K1 Willow carrs L1 Alder carrs L7.1 Dry acidophilous oak forests L7.2 Wet acidophilous oak forests L7.3 Subcontinental pine-oak forests L8.1 Boreo-continental pine forests M1.1 Reed beds of eutrophic still waters M1.2 Halophilous reed and sedge beds M1.7 Tall-sedge beds R1.2 Meadow springs without tufa formation T1.1 Mesic *Arrhenaterum* meadows T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T1.9 Intermittently wet *Molinia* meadows T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V4A Macrophyte vegetation of water streams, with currently present water macrophytes
C	L10.1 Birch mire forests L2.2 Ash-alder alluvial forests L7.2 Wet acidophilous oak forests L7.3 Subcontinental pine-oak forests M1.3 Eutrophic vegetation of muddy substrata M1.7 Tall-sedge beds M2.1 Vegetation of exposed fishpond bottoms Mosaic of habitats R2.2 Acidic moss-rich fens T1.1 Mesic *Arrhenaterum* meadows T1.3 *Cynosus* pastures T1.5 Wet *Cirsium* meadows T1.9 Intermittently wet *Molinia* meadows V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa, Salvinia natans, Statiotes aloides, Hydrocharis morsus-rarae*) V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V4A Macrophyte vegetation of water streams, with currently present water macrophytes V4B Macrophyte vegetation of water streams with potential occurrence of aquatic macrophytes or with natural or semi-natural bed 310 Alluvial meadows 330 Mesic meadows 403 Alluvial forests 404 Intensive mixed forests 405 Oak and oak-hornbeam forests

	410 Bog forests 412 Natural shrub vegetation 510 Wetlands and littoral vegetation 530 Swamps
D	210 Arable land 250 Intensive grasslands 401 Intensive coniferous forests 402 Intensive broad-leaved forests 414 Introduced shrub vegetation 620 Human influenced water bodies 710 Artificial rocks
E	120 Discontinuous urban fabric 130 Industrial and commercial units 140 Transport units 150 Dump and construction units 180 Artificial urban green areas – recreation and sport areas

SCI Stropnice	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	L2.2A Ash-alder alluvial forests, typical stands T1.1 Mesic *Arrhenaterum* meadows T1.6 Wet *Filipendula* grasslands T1.9 Intermittently wet *Molinia* meadows T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa, Salvinia natans, Statiotes aloides, Hydrocharis morsus-rarae*) V4A Macrophyte vegetation of water streams, with currently present water macrophytes M2.1 Vegetation of exposed fishpond bottoms V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V2C Macrophyte vegetation of shallow still waters (other vegetation) V4B Macrophyte vegetation of water streams, with potential occurrence of macrophytes or with natural or semi-natural bed Waterbodies not included in HML (with respect to subject of protection) Mosaic with above-mentioned habitats of concern.
B	K1 Willow carrs K2.1 Willow scrub of loamy and sandy river banks L1 Alder carrs L2.2B Ash-alder alluvial forests, degraded stands L3.1 Hercynian oak-hornbeam forests L5.4 Acidophilous beech forest L7.1 Dry acidophilous oak forests L7.2 Wet acidophilous oak forests L7.3 Subcontinental pine-oak forests M1.1 Reed beds of eutrophic still waters M1.4 Riverine reed vegetation M1.7 Tall-sedge beds R2.2 Acidic moss-rich fens R2.3 Transitional mires T1.3 *Cynosus* pastures T1.4 Alluvial *Alopecurus* meadows T1.5 Wet *Cirsium* meadows
C	K1 Willow carrs K3 Tall mesic and xeric scrub L1 Alder carrs L10.1 Birch mire forests L2.2 Ash-alder alluvial forests L2.2A Ash-alder alluvial forests, typical stands L2.2B Ash-alder alluvial forests, significantly altered stands

	L5.4 Acidophilous beech forests L7.1 Dry acidophilous oak forests L7.2 Wet acidophilous oak forests L7.3 Subcontinental pine-oak forests L9.2B Waterlogged spruce forest M1.1 Reed beds of eutrophic still waters M1.3 Eutrophic vegetation of muddy substrata M1.7 Tall-sedge beds M2.1 Vegetation of exposed fishpond bottoms Mosaic of habitats R2.2 Acidic moss-rich fens R2.3 Transitional mires T1.1 Mesic *Arrhenaterum* meadows T1.10 Vegetation of wet disturbed soils T1.3 *Cynosus* pastures T1.4 Alluvial *Alopecurus* meadows T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T1.9 Intermittently wet *Molinia* meadows T3.5B Acidophilous dry grasslands without significant occurrence of orchids T4.2 Mesic herbaceous fringes T5.5 Acidophilous grasslands on shallow soils V1C Macrophyte vegetation of naturally eutrophic and mesotrophic still waters with *Utricularia* a*ustralis* or *U. vulgaris* V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa*, *Salvinia natans*, *Statiotes aloides*, *Hydrocharis morsus-rarae*) V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V2C Macrophyte vegetation of shallow still waters, other stands V4B Macrophyte vegetation of water streams with potential occurrence of aquatic macrophytes or with natural or semi-natural bed 404 Intensive mixed forests 530 Swamps 630 Natural water courses
D	170 Artificial urban green areas – parks, gardens, cemeteries 210 Arable land 250 Intensive grasslands 401 Intensive coniferous forests 402 Intensive broad-leaved forests 414 Introduced shrub vegetation 620 Human influenced water bodies
E	110 Continuous urban fabric 120 Discontinuous urban fabric 130 Industrial and commercial units 140 Transport units 150 Dump and construction units 180 Artificial urban green areas – recreation and sport areas

SCI Týřov - Oupořský potok	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	K4A Low xeric shrub, primary rock vegetation with *Cotoneastes* spp. T1.1 Mesic *Arrhenaterum* meadows T3.1 Rock-outcrop vegetation with *Festuca pallens* S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes S2B Mobile siliceous screes L2.2A Ash-alder alluvial forests, typical stands L2.3A Hardwood forests of lowland rivers, slightly altered stands L2.3B Hardwood forests of lowland rivers, significantly altered stands L3.1 Hercynian oak-hornbeam forests

	L4 Ravine forests L5.1 Herb-rich beech forests L5.4 Acidophilous beech forests
B	K3 Tall mesic and xeric scrub L6.5B Acidophilous thermophilous oak forests without *Genista pilosa* L7.1 Dry acidophilous oak forests L8.1B Boreo-continental pine forests, other stands M1.4 Riverine reed vegetation S1.4 Tall-forb vegetation of fine-soil-rich boulder screes S1.5 *Ribes alpinum* scrub on cliffs and boulder screes T1.1 Mesic *Arrhenaterum* meadows T1.3 *Cynosus* pastures T1.6 Wet *Filipendula* grasslands T3.5B Acidophilous dry grasslands without significant occurrence of orchids T5.5 Acidophilous grasslands on shallow soils T8.1B Dry lowland and colline heaths without occurrence of *Juniperus communis* V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V4B Macrophyte vegetation of water streams with potential occurrence of aquatic macrophytes or with natural or semi-natural bed
C	K1 Willow carrs K2.1 Willow scrub of loamy and sandy river banks K3 Tall mesic and xeric scrub L1 Alder carrs L2.2 Ash-alder alluvial forests L2.2A Ash-alder alluvial forests, typical stands L2.2B Ash-alder alluvial forests, degraded stands L3.1 Hercynian oak-hornbeam forests L4 Ravine forests L4A Ravine forests, typical stands L5.1 Herb-rich beech forests L5.4 Acidophilous beech forests L6.5B Acidophilous thermophilous oak forests without *Genista pilosa* L7.1 Dry acidophilous oak forests L7.2 Wet acidophilous oak forests L8.1B Boreo-continental pine forests, other stands M1.1 Reed beds of eutrophic still waters M1.4 Riverine reed vegetation Mosaic of habitats S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes T1.1 Mesic *Arrhenaterum* meadows T1.3 *Cynosus* pastures T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T1.9 Intermittently wet *Molinia* meadows T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* T3.1 Rock-outcrop vegetation with *Festuca pallens* T3.4D Broad-leaved dry grasslands without significant occurrence of orchids and without *Juniperus communis* T3.5B Acidophilous dry grasslands without significant occurrence of orchids T5.5 Acidophilous grasslands on shallow soils V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa, Salvinia natans, Statiotes aloides*, *Hydrocharis morsus-rarae*) V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V2C Macrophyte vegetation of shallow still waters, other stands V4B Macrophyte vegetation of water streams with potential occurrence of aquatic macrophytes or with natural or semi-natural bed 310 Alluvial meadows 330 Mesic meadows 403 Alluvial forests

	404 Intensive mixed forests 405 Oak and oak-hornbeam forests 406 Ravine forests 407 Beech forests 412 Natural shrub vegetation 630 Natural water courses 720 Natural rocks
D	170 Artificial urban green areas – parks, gardens, cemeteries 210 Arable land 250 Intensive grasslands 401 Intensive coniferous forests 402 Intensive broad-leaved forests 414 Introduced shrub vegetation 620 Human influenced water bodies
E	110 Continuous urban fabric 120 Discontinuous urban fabric 130 Industrial and commercial units 140 Transport units 180 Artificial urban green areas – recreation and sport areas

SCI Úpolínová louka - Křížky	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	T1.6 Wet *Filipendula* grasslands T1.9 Intermittently wet *Molinia* meadows T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* T8.2B Secondary submontane and montane heaths without occurrence of *Juniperus communis* R2.2 Acidic moss-rich fens R2.3 Transitional mires S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes L9.2B Waterlogged spruce forest
B	K1 Willow carrs K2.1 Willow scrub of loamy and sandy river banks K3 Tall mesic and xeric scrub L2.2 Ash-alder alluvial forests L2.2B Ash-alder alluvial forests, degraded stands L5.4 Acidophilous beech forests L8.1B Boreo-continental pine forests, other stands L9.2B Waterlogged spruce forest M1.1 Reed beds of eutrophic still waters M1.3 Eutrophic vegetation of muddy substrata M1.4 Riverine reed vegetation M1.7 Tall-sedge beds Mosaic of habitats R1.4 Forest springs without tufa formation S1.3 Tall grasslands on rock ledges T1.1 Mesic *Arrhenaterum* meadows T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T5.5 Acidophilous grasslands on shallow soils V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa, Salvinia natans, Statiotes aloides, Hydrocharis morsus-rarae*) V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V3 Macrophyte vegetation of oligotrophic lakes and pools V4A Macrophyte vegetation of water streams, with currently present water macrophytes
C	K1 Willow carrs K2.1 Willow scrub of loamy and sandy river banks K3 Tall mesic and xeric scrub L2.2 Ash-alder alluvial forests

	L2.2B Ash-alder alluvial forests, degraded stands L4 Ravine forests L5.4 Acidophilous beech forests L8.1B Boreo-continental pine forests, other stands L9.2A Bog spruce forests L9.2B Waterlogged spruce forests M1.1 Reed beds of eutrophic still waters M1.3 Eutrophic vegetation of muddy substrata M1.4 Riverine reed vegetation M1.7 Tall-sedge beds Mosaic of habitats R1.2 Meadow springs without tufa formation R1.4 Forest springs without tufa formation R2.2 Acidic moss-rich fens R2.3 Transitional mires S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes S1.3 Tall grasslands on rock ledges T1.1 Mesic *Arrhenaterum* meadows T1.3 *Cynosus* pastures T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T1.9 Intermittently wet *Molinia* meadows T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* T4.2 Mesic herbaceous fringes T5.5 Acidophilous grasslands on shallow soils V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis*, *U. vulgaris*, *Aldrovanda vesiculosa*, *Salvinia natans*, *Statiotes aloides*, *Hydrocharis morsus-rarae*) V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V4A Macrophyte vegetation of water streams, with currently present water macrophytes 404 Intensive mixed forests 530 Swamps 630 Natural water courses 720 Natural rocks
D	170 Artificial urban green areas – parks, gardens, cemeteries 210 Arable land 250 Intensive grasslands 401 Intensive coniferous forests 414 Introduced shrub vegetation 620 Human influenced water bodies
E	120 Discontinuous urban fabric 140 Transport units

SCI Kopistská výsypka	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	Mosaic of habitats with V5 *Charophyceae* vegetation
C	M1.1 Reed beds of eutrophic still waters Mosaic of habitats V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species 530 Swamps 630 Natural water courses
D	401 Intensive coniferous forests 402 Intensive broad-leaved forests 250 Intensive grasslands 414 Introduced shrub vegetation 620 Human influenced water bodies
E	120 Discontinuous urban fabric 130 Industrial and commercial units

	140 Transport units 150 Dump and construction units 180 Artificial urban green areas – recreation and sport areas

SCI Žerka	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	Mosaic of habitats T3.4D Broad-leaved dry grasslands without significant occurrence of orchids and without *Juniperus communis*
B	K3 Tall mesic and xeric scrub L3.1 Hercynian oak-hornbeam forests L7.3 Subcontinental pine-oak forests L8.2 Forest-steppe pine forests Mosaic of habitats T1.1 Mesic *Arrhenaterum* meadows T1.4 Alluvial *Alopecurus* meadows
C	K3 Tall mesic and xeric scrub L3.1 Hercynian oak-hornbeam forests L5.1 Herb-rich beech forests L7.1 Dry acidophilous oak forests L7.3 Subcontinental pine-oak forests L8.2 Forest-steppe pine forests Mosaic of habitats S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes T1.1 Mesic *Arrhenaterum* meadows T3.4D Broad-leaved dry grasslands without significant occurrence of orchids and without *Juniperus communis* T4.1 Dry herbaceous fringes 310 Alluvial meadows 320 Dry grasslands 404 Intensive mixed forests 405 Oak and oak-hornbeam forests 407 Beech forests 408 Dry pine forests 412 Natural shrub vegetation 720 Natural rocks
D	210 Arable land 250 Intensive grasslands 401 Intensive coniferous forests 402 Intensive broad-leaved forests 414 Introduced shrub vegetation 620 Human influenced water bodies 640 Anthropogenically influenced water courses
E	110 Continuous urban fabric 120 Discontinuous urban fabric 130 Industrial and commercial units 140 Transport units 180 Artificial urban green areas – recreation and sport areas

SCI Čertova skála	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	L3.1 Hercynian oak-hornbeam forests L4A Ravine forests, typical stands L5.1 Herb-rich beech forests T1.1 Mesic *Arrhenaterum* meadows Mosaic with habitats of the conservation concern
B	L6.5B Acidophilous thermophilous oak forests without *Genista pilosa*

	L7.1 Dry acidophilous oak forests M1.4 Riverine reed vegetation V4B Macrophyte vegetation of water streams with potential occurrence of aquatic macrophytes or with natural or semi-natural bed
C	K3 Tall mesic and xeric scrub L2.2 Ash-alder alluvial forests L3.1 Hercynian oak-hornbeam forests L4A Ravine forests, typical stands L5.1 Herb-rich beech forests L6.5B Acidophilous thermophilous oak forests without *Genista pilosa* L7.1 Dry acidophilous oak forests L7.2 Wet acidophilous oak forests L8.1B Boreo-continental pine forests, other stands M1.4 Riverine reed vegetation Mosaic of habitats S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes T1.1 Mesic *Arrhenaterum* meadows T1.3 *Cynosurus* pastures T3.1 Rock-outcrop vegetation with *Festuca pallens* V4B Macrophyte vegetation of water streams with potential occurrence of aquatic macrophytes or with natural or semi-natural bed 404 Intensive mixed forests 630 Natural water courses
D	401 Intensive coniferous forests 402 Intensive broad-leaved forests 250 Intensive grasslands 414 Introduced shrub vegetation 210 Arable land
E	120 Discontinuous urban fabric 140 Transport units

SCI Chlumská stráň	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	L3.1 Hercynian oak-hornbeam forests L4A Ravine forests, typical stands V4A Macrophyte vegetation of water streams, with currently present water macrophytes Mosaic with habitats of the conservation concern
B	L2.2 Ash-alder alluvial forests L4A Ravine forests, typical stands L5.4 Acidophilous beech forests L6.5B Acidophilous thermophilous oak forests without *Genista pilosa* L7.1 Dry acidophilous oak forests L8.1B Boreo-continental pine forests, other stands M1.4 Riverine reed vegetation M4.1 Unvegetated river gravel banks S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes T1.1 Mesic *Arrhenaterum* meadows V4A Macrophyte vegetation of water streams, with currently present water macrophytes
C	K2.1 Willow scrub of loamy and sandy river banks K3 Tall mesic and xeric scrub L2.2 Ash-alder alluvial forests L2.2B Ash-alder alluvial forests, degraded stands L3.1 Hercynian oak-hornbeam forests L4A Ravine forests, typical stands L6.5B Acidophilous thermophilous oak forests without *Genista pilosa* L7.1 Dry acidophilous oak forests L8.1B Boreo-continental pine forests, other stands M1.1 Reed beds of eutrophic still waters M1.4 Riverine reed vegetation

	M4.1 Unvegetated river gravel banks Mosaic of habitats S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes T1.1 Mesic *Arrhenaterum* meadows T1.4 Alluvial *Alopecurus* meadows T3.5B Acidophilous dry grasslands without significant occurrence of orchids V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa, Salvinia natans, Statiotes aloides, Hydrocharis morsus-rarae*) V4A Macrophyte vegetation of water streams, with currently present water macrophytes 404 Intensive mixed forests 630 Natural water courses 720 Natural rocks
D	170 Artificial urban green areas – parks, gardens, cemeteries 210 Arable land 250 Intensive grasslands 401 Intensive coniferous forests 402 Intensive broad-leaved forests 414 Introduced shrub vegetation 620 Human influenced water bodies 710 Artificial rocks
E	110 Continuous urban fabric 120 Discontinuous urban fabric 130 Industrial and commercial units 140 Transport units 180 Artificial urban green areas – recreation and sport areas

SCI Berounka	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	L3.1 Hercynian oak-hornbeam forests L4A Ravine forests, typical stands V4A Macrophyte vegetation of water streams, with currently present water macrophytes Mosaic with habitats of the conservation concern
B	K2.1 Willow scrub of loamy and sandy river banks K3 Tall mesic and xeric scrub L2.2 Ash-alder alluvial forests L3.1 Hercynian oak-hornbeam forests L4A Ravine forests, typical stands L5.4 Acidophilous beech forests L6.5B Acidophilous thermophilous oak forests without *Genista pilosa* L7.1 Dry acidophilous oak forests L8.1B Boreo-continental pine forests, other stands M1.1 Reed beds of eutrophic still waters M1.4 Riverine reed vegetation M4.1 Unvegetated river gravel banks S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes T1.1 Mesic *Arrhenaterum* meadows T1.4 Alluvial *Alopecurus* meadows T1.5 Wet *Cirsium* meadows V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa, Salvinia natans, Statiotes aloides, Hydrocharis morsus-rarae*) V4A Macrophyte vegetation of water streams, with currently present water macrophytes V4B Macrophyte vegetation of water streams with potential occurrence of aquatic macrophytes or with natural or semi-natural bed
C	K2.1 Willow scrub of loamy and sandy river banks K3 Tall mesic and xeric scrub L2.2 Ash-alder alluvial forests L2.2B Ash-alder alluvial forests, degraded stands L3.1 Hercynian oak-hornbeam forests L4 Ravine forests

	L4A Ravine forests, typical stands L4B Ravine forests, secondary stands L5.4 Acidophilous beech forests L6.5B Acidophilous thermophilous oak forests without *Genista pilosa* L7.1 Dry acidophilous oak forests L7.3 Subcontinental pine-oak forests L8.1B Boreo-continental pine forests, other stands M1.1 Reed beds of eutrophic still waters M1.4 Riverine reed vegetation M4.1 Unvegetated river gravel banks Mosaic of habitats S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes T1.1 Mesic *Arrhenaterum* meadows T1.3 *Cynosus* pastures T1.4 Alluvial *Alopecurus* meadows T1.5 Wet *Cirsium* meadows T3.1 Rock-outcrop vegetation with *Festuca pallens* T3.5B Acidophilous dry grasslands without significant occurrence of orchids T5.5 Acidophilous grasslands on shallow soils T6.1B Acidophilous vegetation of vernal therophytes and succulents without dominance of *Jovibarba globifera* V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa*, *Salvinia natans*, *Statiotes aloides*, *Hydrocharis morsus-rarae*) V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V4A Macrophyte vegetation of water streams, with currently present water macrophytes V4B Macrophyte vegetation of water streams with potential occurrence of aquatic macrophytes or with natural or semi-natural bed 310 Alluvial meadows 404 Intensive mixed forests 412 Natural shrub vegetation 530 Swamps 630 Natural water courses 720 Natural rocks
D	170 Artificial urban green areas – parks, gardens, cemeteries 210 Arable land 250 Intensive grasslands 401 Intensive coniferous forests 402 Intensive broad-leaved forests 414 Introduced shrub vegetation 620 Human influenced water bodies 710 Artificial rocks
E	110 Continuous urban fabric 120 Discontinuous urban fabric 130 Industrial and commercial units 140 Transport units 150 Dump and construction units 180 Artificial urban green areas – recreation and sport areas

SCI Široké blato	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	L10.1 Birch mire forests L10.2 Pine mire forests with *Vaccinium* L10.4 *Pinus rotundata* bog forests L9.2A Bog spruce forests R2.3 Transitional mires Mosaic with habitats of the conservation concern
B	L2.2B Ash-alder alluvial forests, degraded stands T1.9 Intermittently wet *Molinia* meadows

	V4A Macrophyte vegetation of water streams, with currently present water macrophytes
C	L10.1 Birch mire forests L10.2 Pine mire forests with *Vaccinium* L10.4 *Pinus rotundata* bog forests L2.2B Ash-alder alluvial forests, degraded stands L9.2A Bog spruce forests L9.2B Waterlogged spruce forests M1.5 Reed vegetation of brooks M1.7 Tall-sedge beds Mosaic of habitats R2.3 Transitional mires T1.1 Mesic *Arrhenaterum* meadows T1.5 Wet *Cirsium* meadows T1.9 Intermittently wet *Molinia* meadows T5.3 *Festuca* sand grasslands T5.5 Acidophilous grasslands on shallow soils V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species 404 Intensive mixed forests 630 Natural water courses 720 Natural rocks
D	250 Intensive grasslands 401 Intensive coniferous forests 620 Human influenced water bodies 640 Anthropogenically influenced water courses
E	120 Discontinuous urban fabric 150 Dump and construction units

SCI U bunkru	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	R2.3 Transitional mires Mosaic with habitats of the conservation concern
B	L10.1 Birch mire forests L2.2 Ash-alder alluvial forests L9.2B Waterlogged spruce forests R1.4 Forest springs without tufa formation R2.2 Acidic moss-rich fens R2.3 Transitional mires T1.1 Mesic *Arrhenaterum* meadows T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* T8.2B Secondary submontane and montane heaths without occurrence of *Juniperus communis* V4A Macrophyte vegetation of water streams, with currently present water macrophytes V5 *Charophyceae* vegetation
C	K1 Willow carrs K3 Tall mesic and xeric scrub L10.1 Birch mire forests L2.2 Ash-alder alluvial forests L5.4 Acidophilous beech forests L9.2B Waterlogged spruce forests M1.7 Tall-sedge beds Mosaic of habitats R1.2 Meadow springs without tufa formation R1.4 Forest springs without tufa formation R2.2 Acidic moss-rich fens R2.3 Transitional mires S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes S1.3 Tall grasslands on rock ledges

	T1.1 Mesic *Arrhenaterum* meadows T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* T5.5 Acidophilous grasslands on shallow soils V1G Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without important macrophyte species V4A Macrophyte vegetation of water streams, with currently present water macrophytes V4B Macrophyte vegetation of water streams with potential occurrence of aquatic macrophytes or with natural or semi-natural bed 404 Intensive mixed forests 530 Swamps 630 Natural water courses 720 Natural rocks
D	250 Intensive grasslands 401 Intensive coniferous forests 402 Intensive broad-leaved forests 414 Introduced shrub vegetation 620 Human influenced water bodies
E	140 Transport units 150 Dump and construction units

SCI Pramenské pastviny	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	L9.2B Waterlogged spruce forests R2.2 Acidic moss-rich fens R2.3 Transitional mires S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes T1.6 Wet *Filipendula* grasslands T1.9 Intermittently wet *Molinia* meadows T2.3B Submontane and montane *Nardus* grasslands wit hout *Juniperus communis*
B	L8.1B Boreo-continental pine forests, other stands Mosaic of habitats T1.1 Mesic *Arrhenaterum* meadows T1.5 Wet *Cirsium* meadows V4A Macrophyte vegetation of water streams, with currently present water macrophytes
C	L9.2B Waterlogged spruce forests M1.5 Reed vegetation of brooks Mosaic of habitats R1.4 Forest springs without tufa formation S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes T1.1 Mesic *Arrhenaterum* meadows T1.3 *Cynosus* pastures T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T1.9 Intermittently wet *Molinia* meadows T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* T5.5 Acidophilous grasslands on shallow soils V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa, Salvinia natans, Statiotes aloides, Hydrocharis morsus-rarae*) V4A Macrophyte vegetation of water streams, with currently present water macrophytes 404 Intensive mixed forests 630 Natural water courses
D	250 Intensive grasslands 401 Intensive coniferous forests 414 Introduced shrub vegetation
E	120 Discontinuous urban fabric 140 Transport units

SCI Teplá s přítoky a Otročinský potok	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	L9.2B Waterlogged spruce forests R2.2 Acidic moss-rich fens S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes T1.1 Mesic *Arrhenaterum* meadows T1.9 Intermittently wet *Molinia* meadows T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa, Salvinia natans, Statiotes aloides, Hydrocharis morsus-rarae*) Mosaic with habitats of the conservation concern
B	K1 Willow carrs L2.2 Ash-alder alluvial forests L2.2A Ash-alder alluvial forests, typical stands L2.2B Ash-alder alluvial forests, degraded stands L8.1B Boreo-continental pine forests, other stands M1.3 Eutrophic vegetation of muddy substrata M1.4 Riverine reed vegetation M1.5 Reed vegetation of brooks Mosaic of habitats R1.4 Forest springs without tufa formation T1.1 Mesic *Arrhenaterum* meadows T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands
C	K1 Willow carrs K2.1 Willow scrub of loamy and sandy river banks K3 Tall mesic and xeric scrub L10.2 Pine mire forests with *Vaccinium* L2.2 Ash-alder alluvial forests L2.2A Ash-alder alluvial forests, typical stands L2.2B Ash-alder alluvial forests, degraded stands L4 Ravine forests L5.4 Acidophilous beech forests L8.1B Boreo-continental pine forests, other stands L9.2B Waterlogged spruce forests M1.3 Eutrophic vegetation of muddy substrata M1.4 Riverine reed vegetation M1.5 Reed vegetation of brooks M1.7 Tall-sedge beds Mosaic of habitats R1.2 Meadow springs without tufa formation R1.4 Forest springs without tufa formation R2.2 Acidic moss-rich fens R2.3 Transitional mires S1.2 Chasmophytic vegetation of siliceous cliffs and boulder screes S1.3 Tall grasslands on rock ledges T1.1 Mesic *Arrhenaterum* meadows T1.3 *Cynosus* pastures T1.5 Wet *Cirsium* meadows T1.6 Wet *Filipendula* grasslands T1.9 Intermittently wet *Molinia* meadows T2.3B Submontane and montane *Nardus* grasslands without *Juniperus communis* T4.2 Mesic herbaceous fringes T5.5 Acidophilous grasslands on shallow soils V1F Macrophyte vegetation of naturally eutrophic and mesotrophic still waters (without *Urticularia australis, U. vulgaris, Aldrovanda vesiculosa, Salvinia natans, Statiotes aloides, Hydrocharis morsus-rarae*) 404 Intensive mixed forests 530 Swamps 630 Natural water courses 720 Natural rocks

D	170 Artificial urban green areas – parks, gardens, cemeteries 250 Intensive grasslands 401 Intensive coniferous forests 402 Intensive broad-leaved forests 414 Introduced shrub vegetation 620 Human influenced water bodies
E	120 Discontinuous urban fabric 140 Transport units 150 Dump and construction units

SCI Třeboňsko - střed	
Monitoring zone	Categories included in the Habitat Mapping Layer and Consolidate Layer of Ecosystems
A	L10.1 Birch mire forests L10.2 Pine mire forests with *Vaccinium* L2.2A Ash-alder alluvial forests, typical stands L2.3B Hardwood forests of lowland rivers, significantly altered stands L5.4 Acidophilous beech forests L9.2A Bog spruce forests R2.3 Transitional mires T5.3 *Festuca* sand grasslands V3 Macrophyte vegetation of oligotrophic lakes and pools Mosaic with habitats of the conservation concern
B	L9.2B Waterlogged spruce forests M1.4 Riverine reed vegetation T1.1 Mesic *Arrhenaterum* meadows T1.4 Alluvial *Alopecurus* meadows T1.5 Wet *Cirsium* meadows T1.9 Intermittently wet *Molinia* meadows V4A Macrophyte vegetation of water streams, with currently present water macrophytes
C	K1 Willow carrs K2.1 Willow scrub of loamy and sandy river banks L1 Alder carrs L10.1 Birch mire forests L10.2 Pine mire forests with *Vaccinium* L2.2A Ash-alder alluvial forests, typical stands L2.2B Ash-alder alluvial forests, degraded stands L5.4 Acidophilous beech forests L7.1 Dry acidophilous oak forests L7.3 Subcontinental pine-oak forests L8.1B Boreo-continental pine forests, other stands L9.2A Bog spruce forests L9.2B Waterlogged spruce forests M1.1 Reed beds of eutrophic still waters M1.4 Riverine reed vegetation M1.5 Reed vegetation of brooks M1.7 Tall-sedge beds Mosaic of habitats R2.3 Transitional mires T1.1 Mesic *Arrhenaterum* meadows T1.4 Alluvial *Alopecurus* meadows T1.5 Wet *Cirsium* meadows T1.9 Intermittently wet *Molinia* meadows T5.2 Open sand grasslands with *Corynephorus canescens* T5.3 *Festuca* sand grasslands T5.5 Acidophilous grasslands on shallow soils T6.1B Acidophilous vegetation of vernal therophytes and succulents without dominance of *Jovibarba globifera* 404 Intensive mixed forests 530 Swamps

	630 Natural water courses
D	210 Arable land 250 Intensive grasslands 401 Intensive coniferous forests 414 Introduced shrub vegetation 620 Human influenced water bodies 640 Anthropogenically influenced water courses 710 Artificial rocks
E	120 Discontinuous urban fabric 130 Industrial and commercial units 140 Transport units 150 Dump and construction units 180 Artificial urban green areas – recreation and sport areas

ELECTRONIC SUPPLEMENTARY MATERIAL 3

Percentage (%) of invasive alien species occurrence within different land use categories (based on the consolidated layer of ecosystems [CLE] categories provided by Nature Conservation Agency of the Czech Republic (http://www.nature.cz).

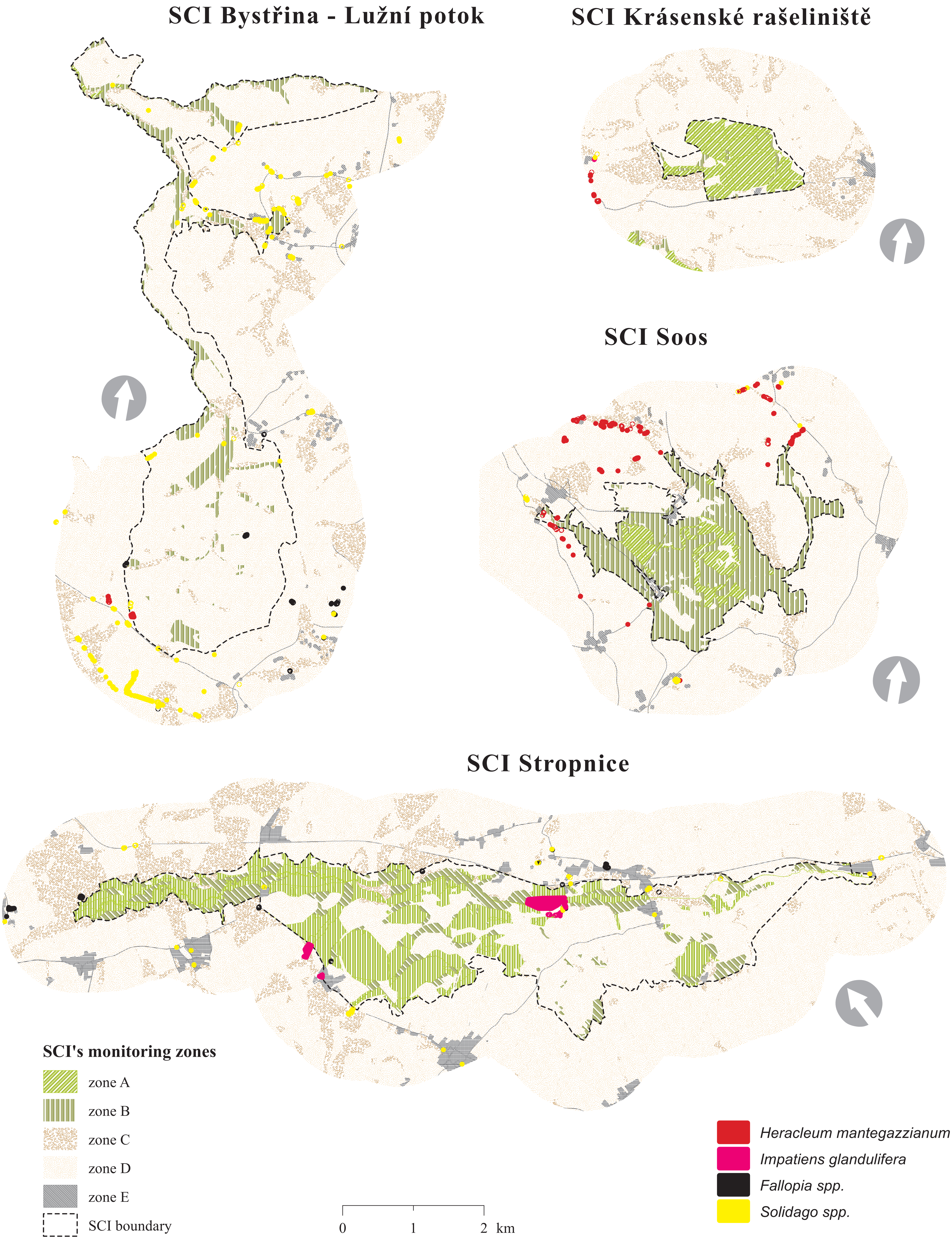
CLE category	*Solidago* spp.	*Impatiens glandulifera*	*Heracleum mantegazzianum*	*Fallopia* spp.
Discontinuous urban fabric	11	0	3	9
Industrial and commercial units	0	0	1	2
Transport units	10	3	13	10
Dumps and construction units	0	0	0	0
Artificial urban green areas - recreation and sport areas	1	0	0	0
Arable land	2	0	0	0
Orchards and gardens	0	0	0	1
Intensive grasslands	22	6	26	10
Alluvial meadows	8	4	5	6
Dry grasslands	1	0	0	0
Mesic meadows	6	4	22	6
Heaths	0	0	0	0
Intensive coniferous forest	6	1	5	4
Intensive broad-leaved forest	2	2	0	6
Alluvial forest	7	5	7	16
Intensive mixed forest	7	3	8	11
Oak and oak-hornbeam forest	6	2	0	6
Ravine forest	0	2	0	0
Beech forest	1	6	0	1
Dry pine forest	0	0	0	0
Natural shrub vegetation	2	9	0	1
Introduces shrub vegetation	2	6	2	3
Wetlands and littoral vegetation	1	20	0	2
Peatbogs and springs	0	0	0	0
Swamp	0	1	0	2
Macrophytes in waterbodies	1	0	0	0
Human influenced waterbodies	0	0	0	0
Natural water courses	2	25	7	4
Anthropogenically influenced water courses	1	0	0	0
Natural rocks	1	0	0	0

Corresponding author: Johana Vardarman

Department of Applied Ecology, Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Kamýcká 129, Prague 6 – Suchdol, CZ-165 21, Czech Republic; e-mail: vardarman@fzp.czu.cz

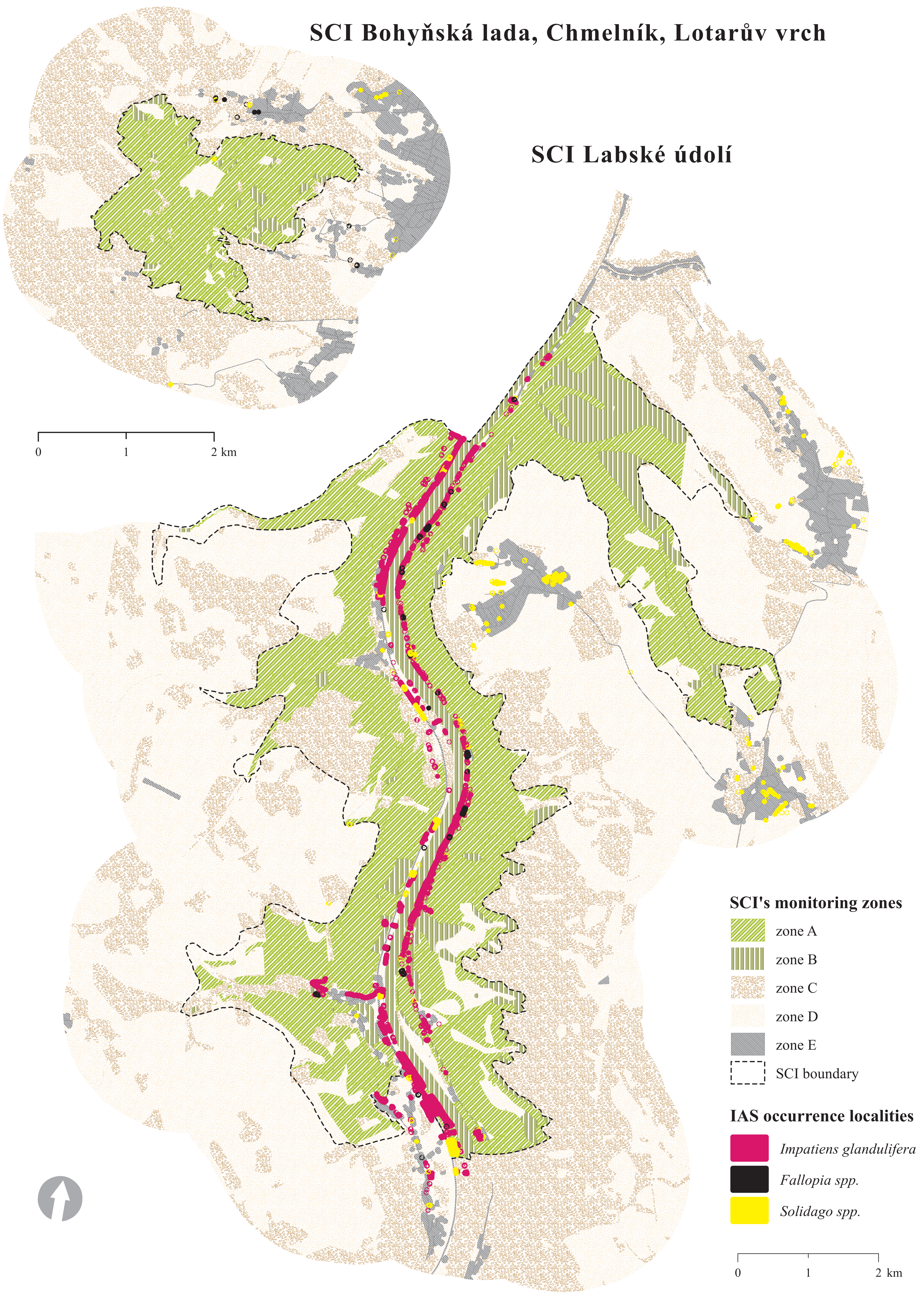
ELECTRONIC SUPPLEMENTARY MATERIAL 4:

IAS spatial distribution in context of monitoring zones



ELECTRONIC SUPPLEMENTARY MATERIAL 4:

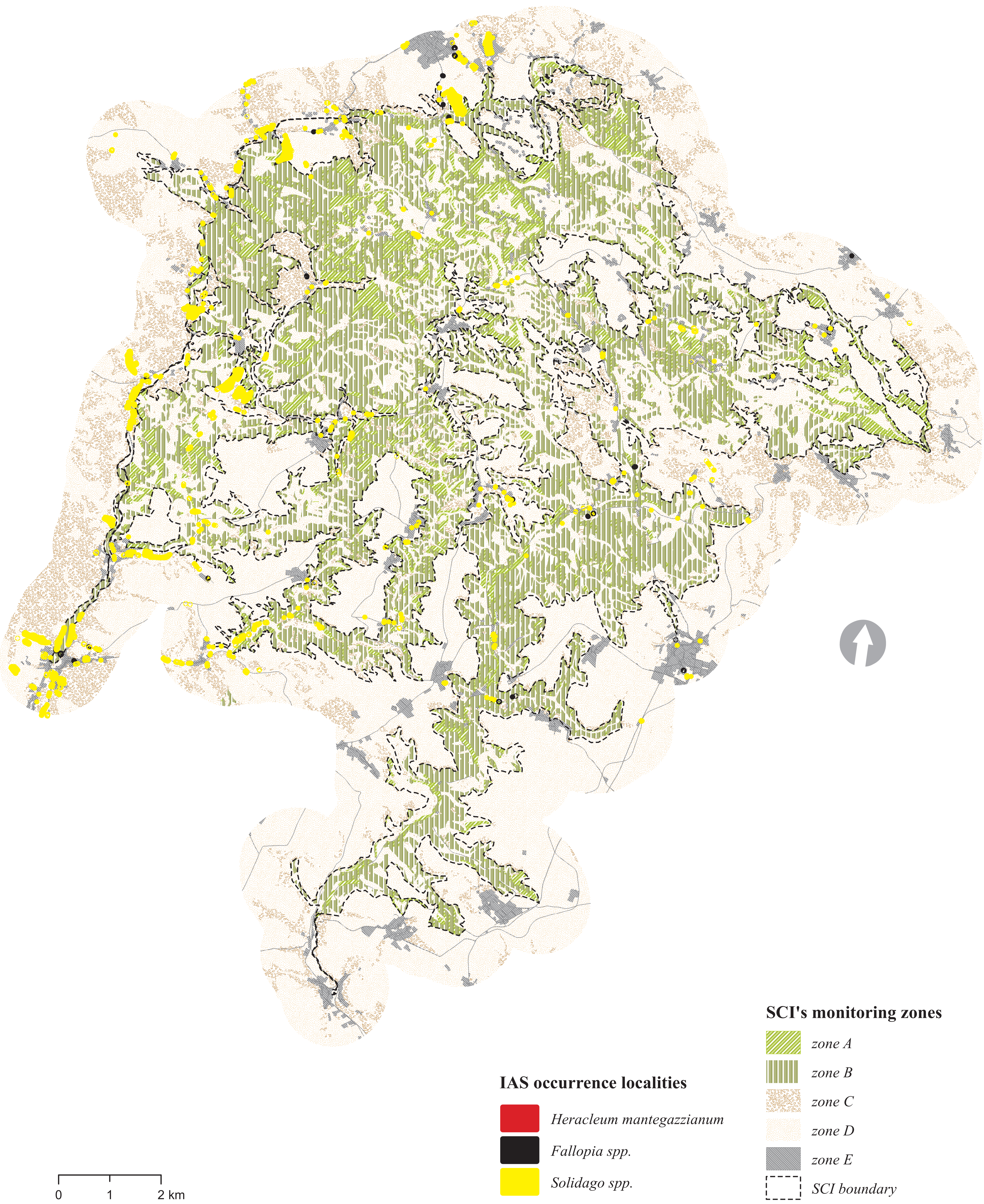
IAS spatial distribution in context of monitoring zones



ELECTRONIC SUPPLEMENTARY MATERIAL 4:

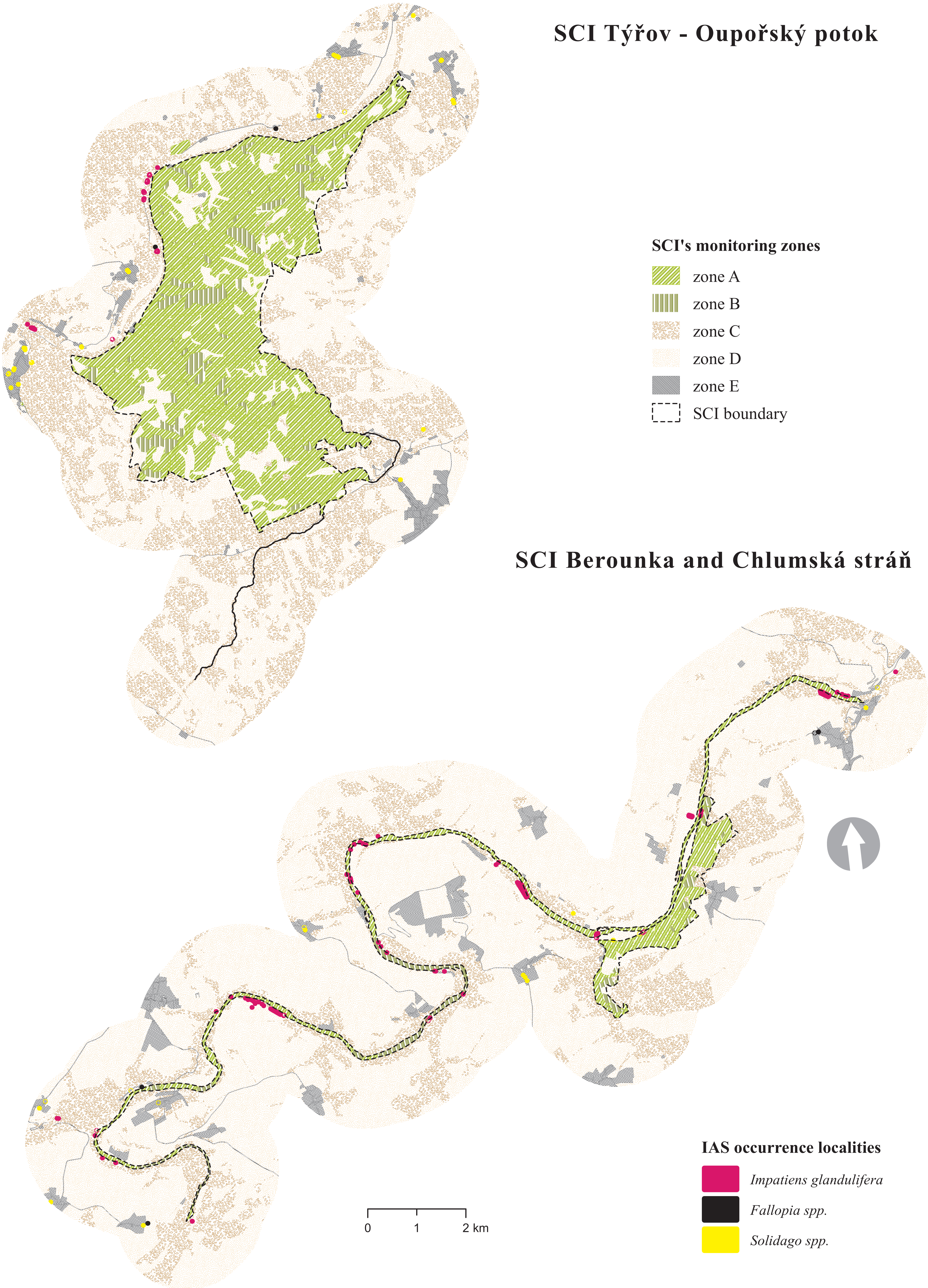
IAS spatial distribution in context of monitoring zones

SCI Kokořínsko



ELECTRONIC SUPPLEMENTARY MATERIAL 4:

IAS spatial distribution in context of monitoring zones



HOW THREATENED ARE PROTECTED AREAS OF NATURA 2000 NETWORK BY INVASIVE ALIEN PLANT SPECIES?

the case study of SCIs in the Czech Republic

EMAPI 14
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Czech University of Life Sciences Prague
Faculty of Environmental Sciences

Johana VARDARMAN, Kateřina BERCHOVÁ-BÍMOVÁ, Jana PĚKNICOVÁ

Department of Applied Ecology, Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Kamýcká 129, Prague 6 – Suchdol, CZ-165 00, Czech Republic

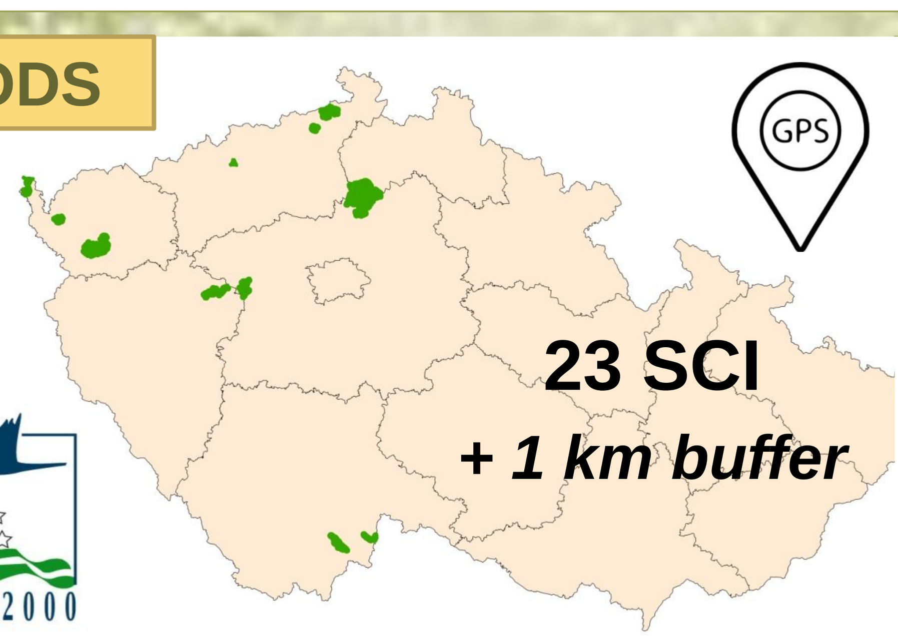
INTRODUCTION

Protected areas (PA) as carriers of high-level biodiversity habitats are at risk of invasion spread. There is an urgent need of the IAS spread prevention in localities of bio-diversity conservation. This re-search focused on analysis of selected **IAS occurrences inside and in the close surroundings** of 23 chosen Sites of Community Importance (SCIs), **Natura 2000 network elements**. The aims were to determine the actual level of invasion and spatial distribution of IAS in model SCIs and their surroundings, their connection to spreading vectors and geo-morphology, and to use this data to assess the threat IAS presently pose to Czech PAs. We tried to answer questions:

» Is habitat vulnerability outside PA affecting habitat vulnerability within it?

» Does zone level of invasion reflects its protection status?

METHODS



- Presence of IAS was mapped in total on 629 km^2 from which 241 km^2 within SCI
- SCI and their surrounding was divided into 5 protection zones (Tab. 1) - habitats graded by their importance for nature conservation and anthropogenic disturbance level
- Selected eenvironmental factors and IAS spreading vectors' distance also included in the analysis
- GLMM were used to analyse the occurrence data
- The relationship between IAS presence and their environment was assessed by canonical correspondence analysis (CCA)
- Relation between each protection zone was evaluated by Spearman's correlation coefficient

A - SCIs core area	*habitats which are subjects of conservation efforts of particular SCI*
B - broader SCIs core area	*other HML habitats within SCIs boundary*
C - semi-natural habitats	*HML habitats not affected by anthropogenic activity outside SCI and nature-close categories of CLE*
D - anthropogenically affected habitats	
E - habitats degraded by human activities	

Tab. 1: Protection zones of SCIs – area of the PA and its buffer was divided in protection zones based on the Natura 2000 Habitat Mapping Layer (HML) and Consolidated Layer of Ecosystems (CLE) provided by NCA of the CR (© CzechGlobe © NCA CR 2013 using its own and data: ZABAGED © COSMC 2012, Corine Land Cover 2006 © EEA 2006, Urban Atlas 2006 © EEA 2006, DIBAVOD © TGM WRI 2012)

RESULTS

- 3 222 IAS occurrences recorded in total - 42% of of them situated within the SCI boundary and 58% within the 1 km buffer zone (see summarizing table in supplementary material)
- Presence of IAS differ significantly in three SCIs' groups - the groups of SCIs were distinguished based on regional geographical and geomorphological characteristics and CCA results (see Fig. 1):

Group I - *I. glandulifera* the most significant IAS, zoning do not corresponds with level of disturbance, IAS tied more directly to habitats in contact with water, placing them mainly in protected habitats of zones A, B and C (inside the SCI) – see Fig. 2b.

Group II - presence of *Solidago* spp. and *F. × bohemica*, IAS predominantly in zones D and E (outside the PA).

Group III - *H. mantegazzianum* present, western part of the Czech Republic, at higher altitude than other SCIs, in association with meadows and pastures; mesic, sub-mountainous or lowland farmland, mostly in zones D and E (see Fig. 2a).

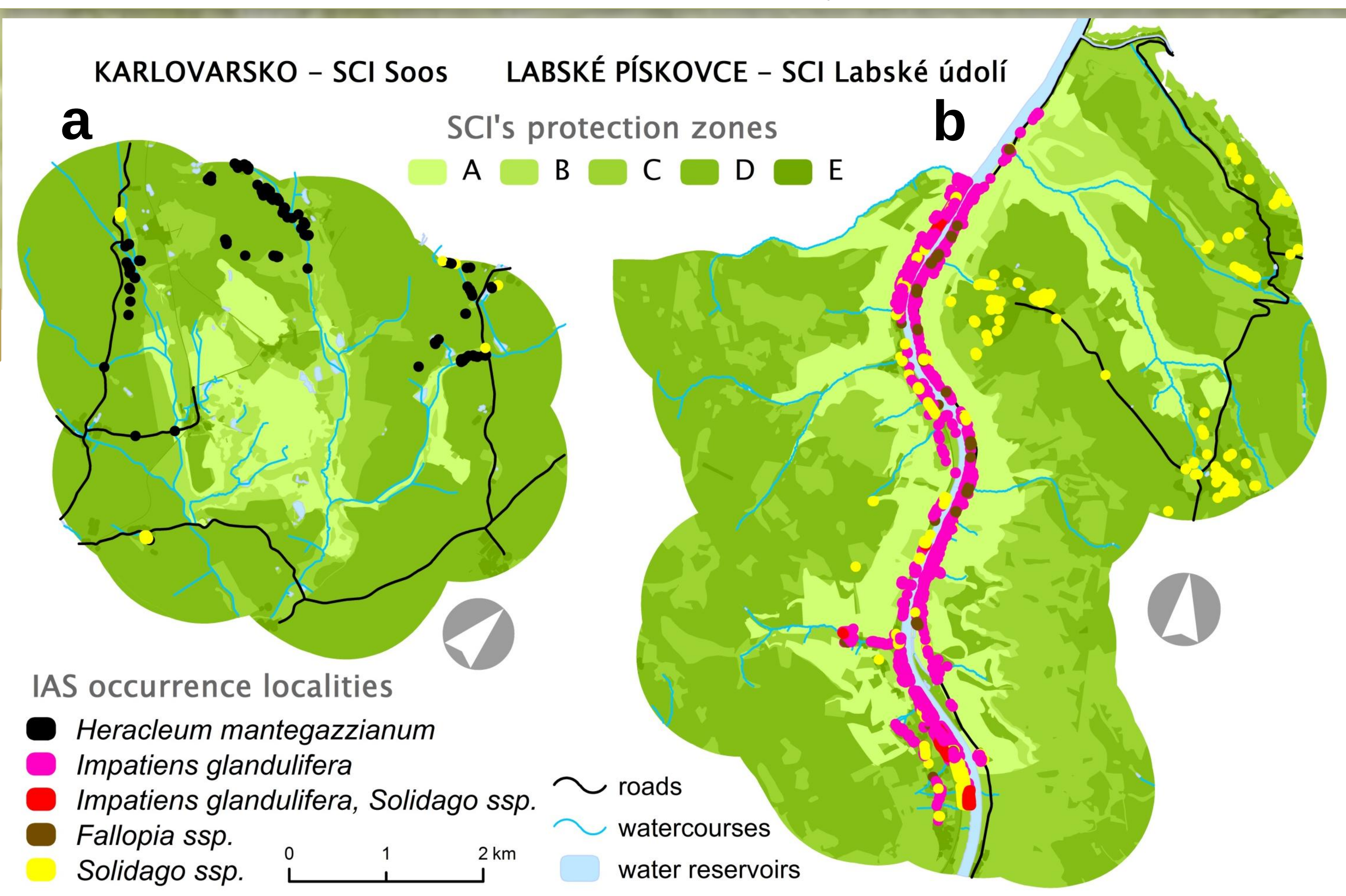


Fig. 2: IAS occurrences spatial distribution in context of protection zoning of SCIs and their surroundings – a) SCI Soos as example of Group III, b) SCI Labské údolí as example of Group I.

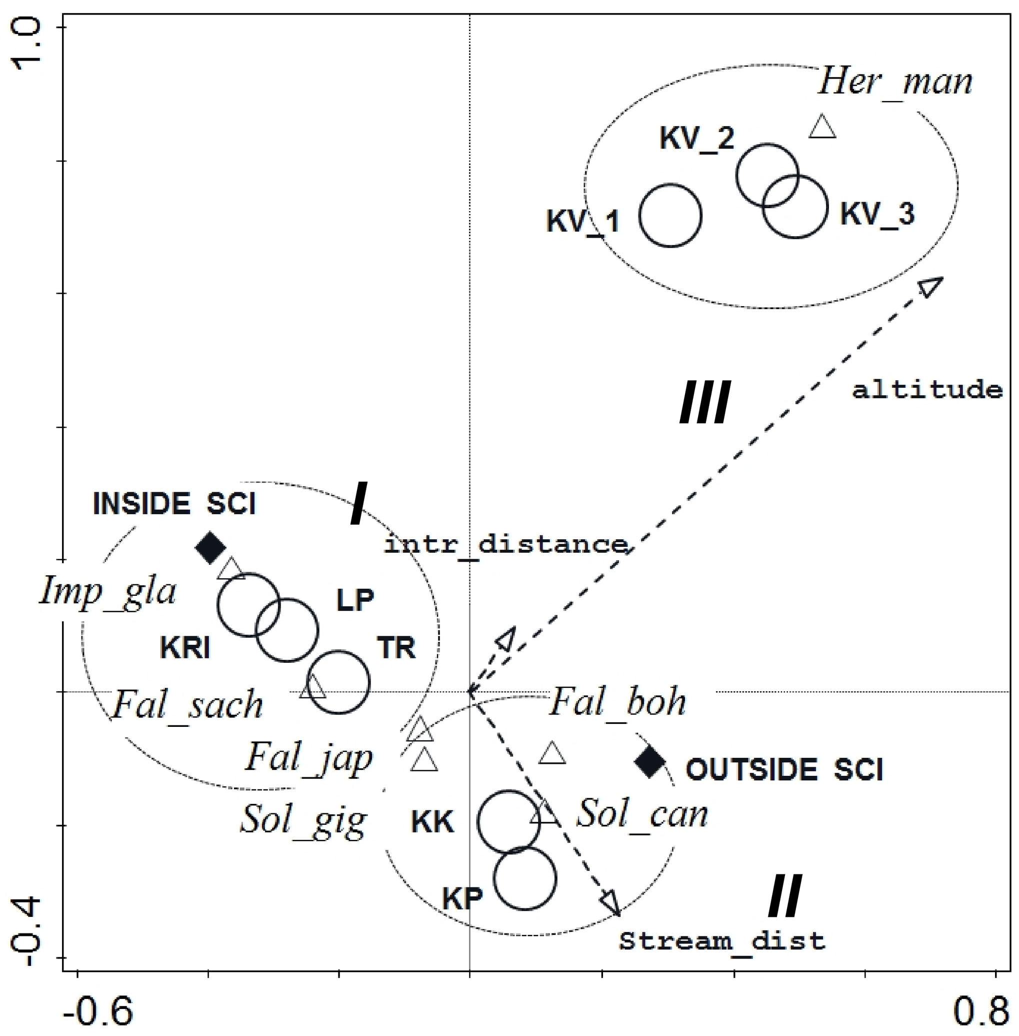
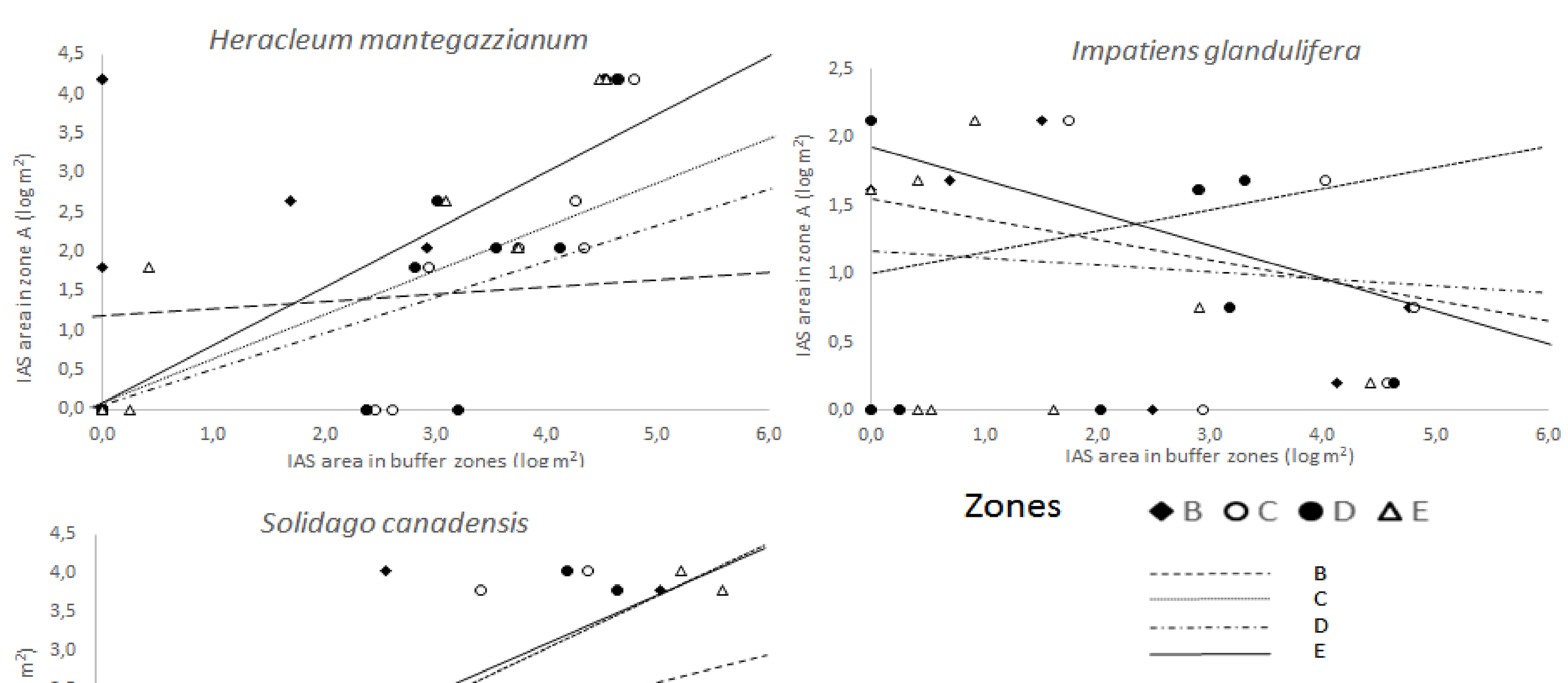


Fig. 1: Biplot of CCA results, where presence/absence of particular invasive species are shown as response variables and environmental characteristics as predictors; location Inside_SCI - zones A, B, C or Outside_SCI - D, E are distinguished. circles show particular SCIs locations: Karlovarsko - KAR 1 - 3, Labské pískovce - LP, Kopistská výsypka - KP, Kokořínsko - KK, Křivoklátsko - KRI, Třeboňsko - TREB; dashed circles show groups of SCIs; distance from urban areas - intr_dist, distance from stream - stream_dist.

- Only **0.3 % of protected habitats** of European importance were affected by IAS in the core area (zone A).
- In total, only **0.27 % of the total mapped area** was affected by IAS; the average area of all IAS localities was 535 m^2 (from 1 to 65 750 m^2).
- Strong statistical **correlation** was found between **area invaded** in the protected core area and in the **non-protected** surroundings (see Tab. 2 and Fig. 3)

SPECIES	Invaded areas' correlation coefficient			
	A-B	A-C	A-D	A-E
H.mantegazzianum	**0.58**	**0.91**	**0.84**	**0.94**
I. glandulifera	**0.53**	0.29	0.20	-0.22
S. canadensis	**0.76**	**0.91**	**0.93**	**0.94**
S. gigantea	0.48	0.47	0.48	**0.78**
Fallopia jap. var. jap.	**0.68**	0.10	0.22	0.18

Tab. 2: Spearman's correlation coefficients reflecting comparisons between the invaded area in SCI protection zone category A and other protection zone categories. Numbers in bold indicate statistically significant correlations ($p < 0.05$).



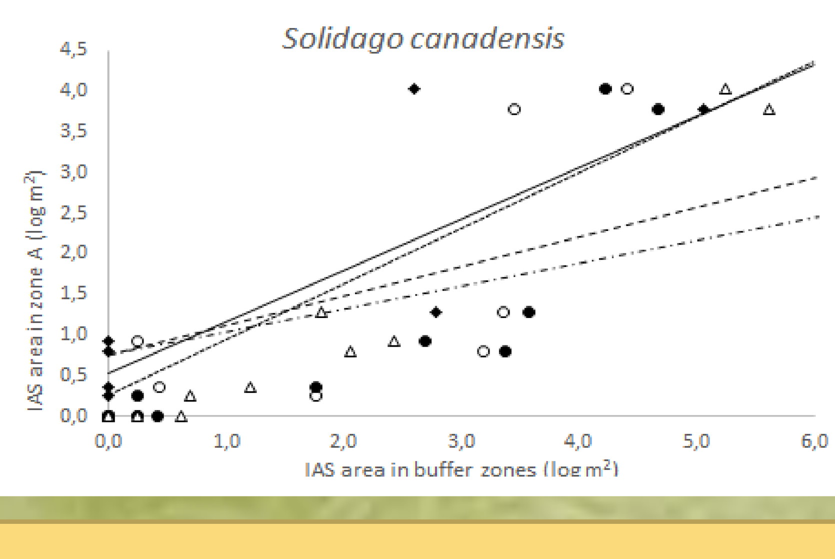


Fig. 3: Correlation between level of invasion in the core area of SCI and area invaded in other SCI protection zones for each IAS; X axis = *area invaded in protection zones other than zone* A, Y axis = *area invaded in protection zone A*

CONCLUSIONS

» Natura 2000 habitats are **invaded at a low level**, the IAS localities were found predominantly in the **marginal areas of the SCIs**

» there is a clear **dependence between the level of invasion in the SCI core and in the surrounding area**, thus an effective zoning has the potential to protect valuable habitats inside the PA when managed properly (except SCIs copying waterstreams)

» **zonal protection** of localities downstream may prove impractical without managing propagule pressure in the **whole watershed**

» **individual approach to management** of particular SCIs in context of surrounding landscape is **necessary** to adopt for Natura 2000 habitats protection

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SUPPLEMENTARY MATERIAL OF POSTER:

HOW THREATENED ARE PROTECTED AREAS OF NATURA 2000 NETWORK BY INVASIVE ALIEN PLANT SPECIES? the case study of SCIs in the Czech Republic

Number of invasive alien species in sites of community interest (SCI) and their surroundings. *Number of occurrences = number within a 1 km buffer of the SCI / number inside SCI boundaries. Total number of occurrences = numbers of localities in each SCI model area (some localities are in the buffer zone of more than one SCI).*

Site of Community Interest	SCI area (km^2)	Mapped area (km^2)	Number of occurrences (outside / inside SCI)				Total number of occurrences
			Solidago spp.	*Impatiens glandulifera*	*Heracleum mantegazzianum*	*Fallopia* spp.	
Berounka	1.4	48.1	12/0	53/14	0	4/0	83
Chlumská stráň	1.2	13.1	5/0	11/0	0	0	16
Bohyňská lada, Chmelník, Lotarův vrch	3.8	16.8	11/1	0	0	10/0	22
Bystřina – Lužní potok	11.3	30.1	129/33	0	5/0	17/7	191
Kladské rašeliniště	26.7	58.5	0	0	57/12	0	69
Kokořínsko	95.5	226.8	554/249	5/0	0	44/30	882
Kopistská výsypka	3.3	6.4	60/20	0	0	10/0	90
Krásenské rašeliniště	1.5	10.3	2/0	3/0	0	0	5
Labské údolí	13.2	52.3	316/78	27/493	0	3/34	951
Pramenské pastviny	0.005	3.4	0	0	0/34	0	34
Raušenbašská lada	5.0	19.2	1/0	0	32/0	0	33
Široké blato	1.0	5.3	1/0	0	0	0	1
Soos	4.6	22.5	15/0	0	96/7	0	118
Stropnice	12.7	43.0	26/13	3/14	0	13/4	73
Teplá s přítoky a Otročínský potok	1.1	14.5	0	0	27/0	0	27
Třeboňsko – střed	1.1	16.6	17/1	7/8	0	1/0	34
Týřov – Oupořský potok	13.4	44.6	27/0	10/0	0	2/0	39
U bunkru	0.6	8.3	0	0	26/0	0	26
Úpolínová louka – Křížky	6.9	23.8	0	0	0/9	0	9