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Invasive neophytes in a part of the city of Hradec Králové, Eastern Bohemia

(Bachelor's thesis)

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2006

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ANNOTATION

ŠTAJEROVÁ K. (2006): Invazní neofyty v části města Hradce Králové, východní Čechy [Invasive neophytes in a part of the city of Hradec Králové, Eastern Bohemia. – Bachelor's Thesis, in English], Faculty of Biological Sciences, University of South Bohemia, České Budějovice, Czech Republic, 38 pp.

In this study, I mapped the occurrence of invasive neophytes in a strip transect from the city center of Hradec Králové to its outskirts. The aim was to qualify and quantify the performance of invasive neophytes in the study area. Abundances, invaded habitats and other characteristics of the species present were investigated. I also looked for any possible relation-ship between the species studied and the selected characteristics of the mapped squares (WATER, INDUSTRY, GREEN and ROADS).

This study was supported by grant no. 206/03/P155 of the Grant Agency of the Czech Republic.

"The history of plants involves the influence of climate on vegetation, the changes of climate endured by plants and how they have been preserved by Nature, migration plants, and finally their distribution over the globe. But more than wind, weather, seas, rivers and beasts promote the dispersal of plants – man does it."

(WILLDENOW 1792, translated by HERBERT SUKOPP)

I hereby declare that this thesis was worked up by myself alone with the use of cited references.

České Budějovice, 5 th May 2006

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INTRODUCTION

Homo sapiens has changed the landscape of the Earth so much that it is difficult to find any area which is intacta (FORMAN & GORDON 1993). Of the many plant species which have been transported by man into areas where they did not occur naturally, only a few are able to grow and establish themself outside of cultivations in a new area (STARFINGER 1998). The dispersal and establishment of non-native species in the world is considered as a part of global change (e.g. EDWARDS 1995, SUKOPP 1998, ZERBE *et al.* 2003, PYŠEK *et al.* 2002a) and it is also recognized as a serious threat to global biodiversity, crucially affecting native species and communities (PYŠEK & PRACH 2003).

The study of anthropogenic migrations started with the investigation of cultivated plants and those which had gone wild. Relationships between man and plants have been important in geo-botanical research since the middle of the 19th century (SUKOPP 1998). Since the 1980s biological invasions have received increasing attention worldwide and are nowadays a hot topic in contemporary ecology (PYŠEK 1995b, PYŠEK *et al.* 2004). The investigation of alien invasive plants has also become very important in many European countries – including the Czech Republic (ČERNÝ *et al.* 1998). Our territory is not among the most threatened countries in global terms but the influence of alien species growing quickly (PYŠEK & TICHÝ 2001).

The geographical position of the Czech Republic has made it a crossroads in Europe for plant invasions, between east and west and north and south, since early times; the intensive movement of people and goods has also contributed to the introduction of many species. The research on alien plants in this country started in the 1960s when the field was put on a solid footing by the founding of a specialized research section devoted to alien plants at the Institute of Botany in Průhonice (PYŠEK & PRACH 2003).

The alien flora of our territory is presented in the Catalogue of alien plants of the Czech Republic (PYŠEK *et al.* 2002b). It is the most comprehensive overview of Czech alien flora, but few species of the species in the catalogue are now considered to be problematic, e.g. *Arrhenatherum elatius.* To avoid potential misunderstanding, I did a survey of the approach of authors to the classification of alien species. Each particular taxon was carefully re-assessed to confirm alien or native status, invasive status and residence time by the application of relevant literature. Authors considered knowledge of species ecology and habitats occupied in the context of historical dynamics and the role it plays in the landscape. Only species occurring in the wild were envisaged, including escapees from the cultivated areas.

According to this work (Pyšek *et al.* 2002b), the Czech alien flora contains 1378 taxa belonging to 542 genera and 99 families. Accepting the totals of 1378 aliens and 2754 native species, it means aliens constitute 33.4% of the total number of taxa reported for the Czech Republic. Of these (1378 taxa), there are 24.1% archeophytes (arrived before 1500), while 75.9% are neophytes (introduced after 1500). There are 90 species defined as invasive: 76.7% are neophytes and 23.3% are archeophytes. Four neophytes and 188 archeophytes were classified as post-invasive (Pyšek *et al.* 2002b). It means that it was invasive in the past but ceased expand. For the total composition and structure of the Czech alien flora, see Table 1.

	Casual	Naturalized	Invasive	**Total**
Archeophytes	74	237	21	**332**
Neophytes	817	160	69	**1046**
Aliens total	**891**	**397**	**90**	**1378**

Table 1 Composition of the Czech alien flora. Hybrids are included (after Pyšek *et al.* 2002b).

According to Pyšek *et al.* 2002b, the vast majority of Czech archeophytes came from the Mediterranean region, whereas neophytes have their origin in all continents, with other parts of Europe excluding Central Europe (39.8%), Asia (27.6%), and North America (15.1%) contributing most taxa. In the taxonomic structure there are some differences between archeophytes and neophytes. The typical neophyte families are *Fabaceae, Solanaceae, Polygonaceae, Onagraceae* and *Amaranthaceae* while *Chenopodiaceae, Apiaceae, Scrophulariaceae* and *Caryophyllaceae* are more often represented by archeophytes. Annuals contribute to the total number of archeophytes (57.8%), significantly more than to that of neophytes (39.4%). Perennials (38.2%) and woody plants (14.1%) are more frequent among neophytes than archeophytes. As to the mode of introduction, 49.9% of aliens were introduced into the country accidentally, and 42.7% deliberately; the remaining 7.4% were likely introduced by both means (Pyšek *et al.* 2002b).

There are many definitions of an invasive species; e.g. Pyšek (1995b) gives 13 definitions from different authors. I prefer the definition used by Richardson *et al.*

(2000). They define invasive plants as naturalized species that produce reproductive offspring, usually in huge numbers, at considerable distances from the parent plants (approximate scales: > 100 m / < 50 years for taxa spreading by seeds and other propagules × > 6 m / 3 years for taxa spreading by roots, rhizomes, stolons or creeping stems). They have the potential to spread over a considerable area.

The spread of an invading non-native plant species into an area where it was absent before its introduction is influenced by both ecological and bio-geographical components. The spread could be divided into four steps (based on KOWARIK 1995a, PYŠEK 1996, FALIŃSKI 1998, WEBER 1998): *Introduction, Colonization, Naturalization and Spreading:*

1) *Introduction* is the first step during which a species has to penetrate its potential new territory, mainly by seeds or other diasporas.

2) *Colonization* is the formation of a persistent founding population by growth and reproduction (generative or vegetative). The main characteristics of an unsuccessful foot-hold are e.g. bad climatic conditions, predation of seeds or seedlings, and the influence of inter-specific competition.

3) *Naturalization* is the establishment of a new population in safe sites; all without obvious human help.

4) *Spreading* is the increase in numbers and sizes of populations. A successful invasion has exponential growth. A lag phase (two kinds can be distinguished), a time of adaptation and is accompanied by genetic mutations which occur e.g. before an explosive expansion.

However, each of these steps depends not only on the species' autoecology and interactions with other species, but it can be strongly influenced by human activities, such as the extent of plant and propagule introduction, or the distribution and infestation of several disjunct sites (WEBER 1998).

According to PYŠEK *et al.* (2004), the most recent research on plant invasions has explored the invasiveness of particular species and the vulnerability of various communities to invasions, many studies have revealed that ecosystem with anthropogenic disturbances, such as cities or densely populated areas, contains high numbers of alien species (ANDERSEN 1995, FALIŃSKI 1998, PYŠEK *et al.* 1998; SUKKOP 1998, GRIM *et al.* 2000).

The ecological approach considers a city as an ecosystem, characterized by its history, its structure and function, including both biotic and abiotic components, and the cycling and conversion of energy and materials. Cities also have their own spatial organization and distinctive patterns of change through time, which result in patterns of species behavior, population dynamics and the formation of communities, each of which is specific to the urban environment (SUKOPP 2002).

The botanical exploration of towns started with old town centers 140 years ago. In 1855, Deakin studied the flora of the Colosseum in Rome and found 420 taxa growing its ruins (BRANDES 1995), nowadays it was investigated by PIGNATTI *et al.* (1995). According to BRANDES (1995), DEHNEN-SCHMUTZ (1995), or SUKKOP (1998), other initial studies were carried out at castles or in gardens and parks The systematic investigation of old town centers, however, did not start until 1980 (BRANDES 1995).

Lots of information on plant invasions in temperate zones comes from urban and otherwise disturbed environments (PYŠEK *et al.* 2003). The human impact on the flora and vegetation of large cities and rural areas has been well analyzed (KIM *et al.* 2002); it is known that urbanization significantly influences the functioning of local and global ecosystems (ALBERTI 2005).

Nevertheless, in the Czech Republic (according to SUKOPP 2002, cited therein) only four complete lists of urban floras exist, they are available for the following cities: Prague, Brno, Plzeň and Most. The next problem is that there have been insufficient looking at the link between studies considering an urban invasive flora with their habitats, except for e.g. PYŠEK & PYŠEK (1995) who studied *Heracleum mantegazzianum* in different habitats in the Czech Republic, PYŠEK *et al.* (1995) made an overall analysis of the Czech alien flora, MIHULKA (1996), a study including part of the city of České Budějovice and VIŠŇÁK (1997) observing invasive neophytes in the Northern part of the Czech Republic. For many papers this is not the main topic, e.g. ANDERSEN (1995) who compared the dispersal strategies of alien and native species in the Danish flora, DAN *et al.* (1995) making an analysis of the flora in Tianjin, ZERBE & LEE (2000) investigated some cultivated plants in Korean farms gardens, ZERBE *et al.* (2003), a study of biodiversity in Berlin, CHOCHOLOUŠKOVÁ & PYŠEK (2003) made a historical overview of the flora of Plzeň, CLEMANTS & MOORE (2003) recorded patterns of species richness in the part of USA, DEUTSCHEWITZ *et al.* (2003) and KÜHN *et al.* (2004) investigated the flora in Germany, ZERBE *et al.* (2004) studying the species richness of a Korean city Chonju.

OBJECTIVES

The aim of this study is to qualify and quantify the occurrence of invasive neophytes in the city of Hradec Králové. According to PYŠEK (1992), the appropriate method to document changes between the city center and the outskirts is using of transects. That is why I chose to investigate a strip transect running from the city centre to the outskirts instead of studying the whole city.

This research was mainly focused on

- the performance of these species in the present land-use types,
- the other characteristics of the species present e.g. time of introduction, landscape classification, life history and family (taken from PYŠEK *et al.* 2002b),
- testing procedures of the influence of selected characteristics in mapped squares (WATER, INDUSTRY, GREEN and ROADS) on the species' distribution.

MATERIAL AND METHODS

STUDY AREA

The city of Hradec Králové is situated in the East of Bohemia (50° 11' N, 15° 52' E) - the geographical location is shown in FIGURE 1. In the national phytogeographical land classification, this area belongs to the Bohemian Thermophyticum (HEJNÝ & SLAVÍK 1988).

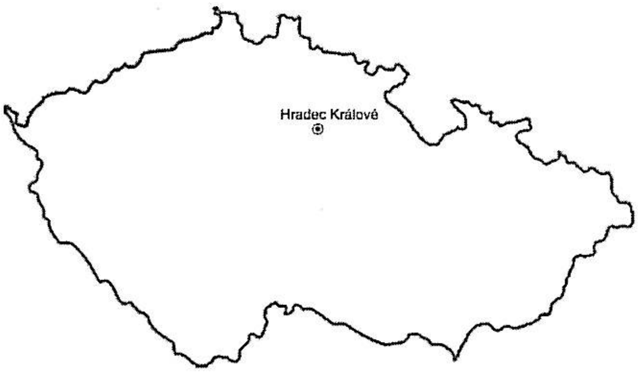
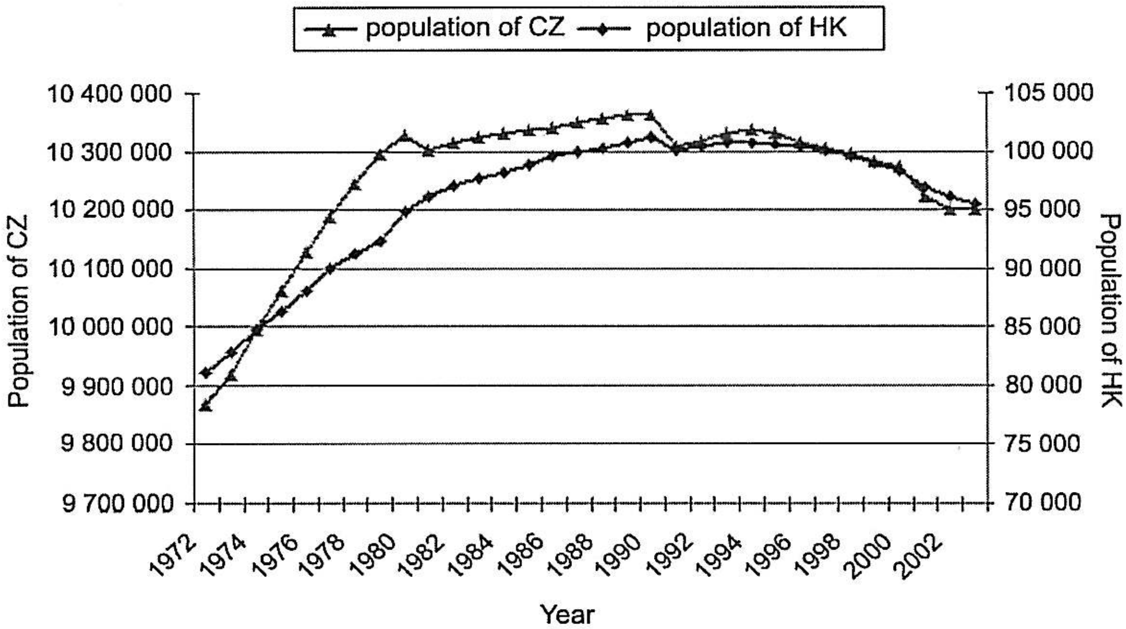


FIGURE 1 Geographical location of Hradec Králové

It lies on the most significant point in the Czech Basin, at the confluence of two rivers - Orlice and Labe. The river Orlice empties into Labe at an altitude of 227 m a.s.l. near Jirásek's gardens. The medial altitude of the study area is about 235 m a.s.l.; the highest point is 317 m a.s.l. and is near the city center. The population of Hradec Králové is nearly 100 000 inhabitants and the administrative urban area covers 105.6 km^2 (www.HK 2006). It is among the ten largest cities in the Czech Republic (GRAPH 1).

The city is situated in the climatic region characterized as warm and gently dry with moderate winters. Relative annual humidity is 76%, in summer days it is on average 71%. The mean annual amount of precipitation is about 600 mm and mean annual air temperature is 8 °C, temperature maximum (30.7.1994) 37.8 °C and minimum (9.1.1985) -24.7°C (www.CHU 2006). Dominant winds in summer days come from the west or north-west and likewise from the north or north-east (www.HK 2006).

Comparison of population development in the city Hradec Králové and in the Czech Republic (1972-2003)



GRAPH 1 Population trends in Hradec Králové and in the Czech Republic through the years 1972-2003. The graph was modified according to (www.HK 2006).

The history of the city has been very long; its beginnings date back to the year 1225. It was recorded at that time as a royal fortress town. It had already become the Centre of East Bohemia in the Middle Ages. It remained of importance in the centuries which followed, for example during the Hussite movement, later as the seat of bishops, as a military fortress (the battle at Chlum in 1866) etc. (www.HK 2006). Nowadays, Hradec Králové is a very important regional transport junction and generally one of the most important cities in the Czech Republic.

Botanically, Hradec Králové represents a relatively well studied city (FALTYSOVÁ *et al.* 2002). On the other hand, it is not available any overview of the urban flora. Current floristic research provides some valuable data but not enough about invasive neophytes.

CHOOSING THE STRIP TRANSECT AND LAND-USE TYPES

In order to put together a good survey of all alien invasive neophytes occurring in the city of Hradec Králové, I chose a strip transect of 4×2 km, including 200 sample plots (20 horizontal and 10 lateral squares) of size 200×200 m. I used city maps true-to-scale 1:10 000 and 1:5 000.

The study transect covered the whole distance from the city center to the outskirts. Figure 2 shows an aerial photograph showing the strip transect chosen, built-up area and **arable land** (4) can be distinguished. I also tried to cover the **city center** (1) and the **main railway station** (2) with a nearby **industrial zone** (3) because they are the main focal points of spreading. The study area also included rivers (Labe, Orlice), the Chaloupská svodnice stream and Labe's water-channel, often considered to be bio-corridors of spreading.

I examined the main railway station and all concerns except of RENA which denied me enter to the land around its buildings. On the other hand, I did not include small private sites like gardens (except for the public ones) and army barracks.

The approximate GPS position data of the study area are presented in TABLE 2. Their positions corresponds with the four corners of the strip transect.

50° 12' 56.43" N, 15° 46' 57.21" E	50° 13' 12.54" N, 15° 50' 14.89" E
50° 11' 52.88" N, 15° 47' 10.9" E	50° 12' 9.11" N, 15° 50' 28.81" E

TABLE 2 The approximate GPS position data of the study transect (www.BM-CZ 2006).

TABLE 3 shows the ten categories of land-use type which were selected for the chosen transect (in compliance with the studies of MIHULKA 1996, PYŠEK *et al.* 1998, STARFINGER 1998, ZERBE *et al.* 2004).

RUDERAL SITES	RAILWAY SITES
PARKS AND GARDENS	GRASS PLOTS
STREET BORDERS	WATER BORDERS
PLANT CULTIVATIONS	MEADOWS
FIELDS	FIELD BORDERS

TABLE 3 Categories of land-use type.

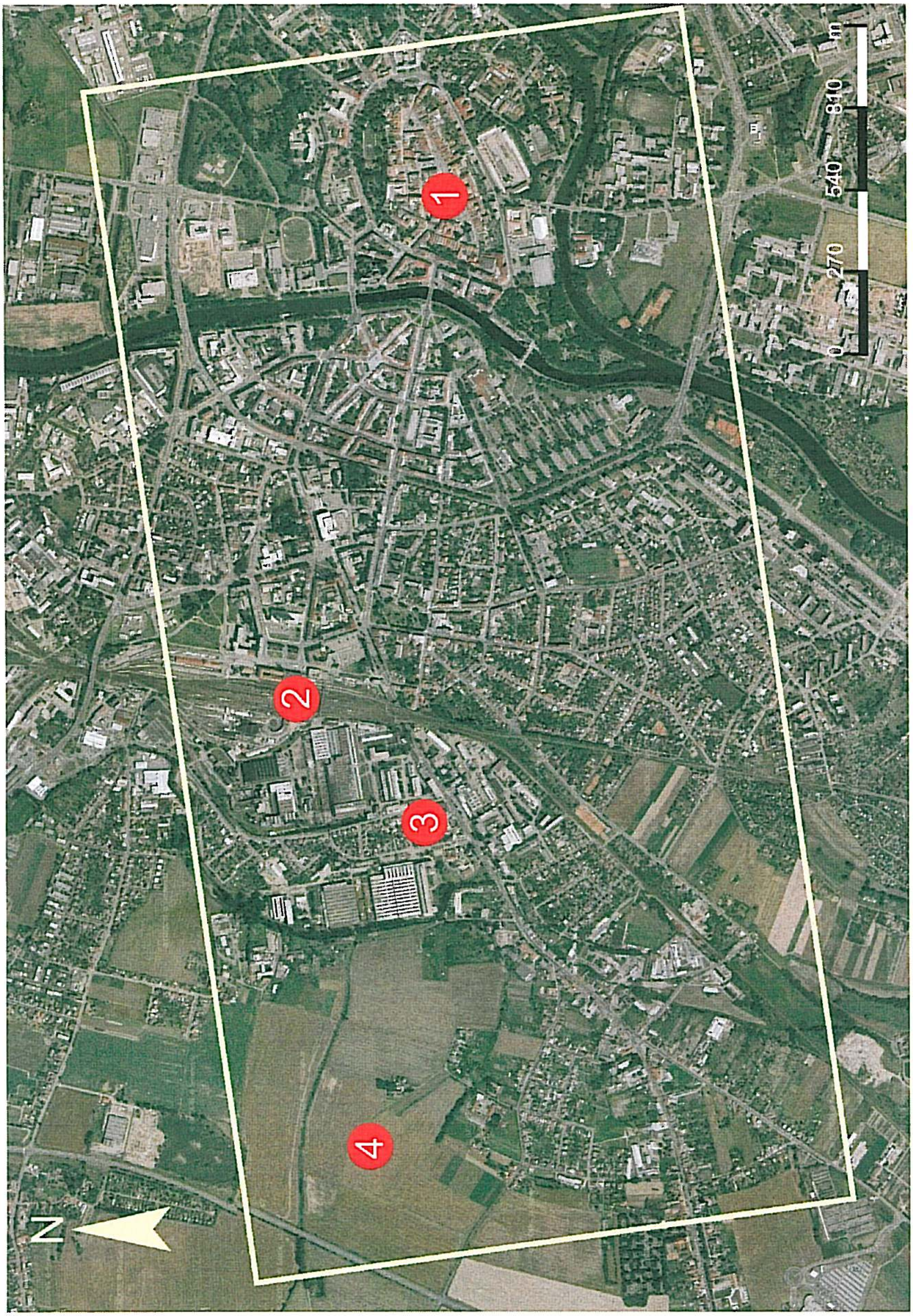


FIGURE 2 Aerial photograph showing the strip transect chosen in the city of Hradec Králové. Legend: (1) city center, (2) main railway station, (3) industrial zone, (4) arable land (www.BM-CZ).

The selected land-use categories were RUDERAL SITES - disturbed places near built-up areas, industrial facilities and dumps; PARKS AND GARDENS – the spontaneous vegetation of parks, flower plantations and public gardens; STREET BORDERS – the vegetation of road borders, pitches and pavements; PLANT CULTIVATIONS – areas under constant cultivation by man; FIELDS AND THEIR BORDERS – fields with crops and surrounding vegetation; RAILWAY SITES – vegetation near railway buildings and railway tracks; GRASS PLOTS – man-made grassy sites with compactive turf, WATER BORDERS – vegetation on the banks of rivers and other water sites, and MEADOWS – all types of meadows.

For all selected land-used types, aerial photographs with a mapping grid were made (APPENDIX 1). I recorded the presence and absence of habitats according to my source data.

I investigated all 200 sample plots during three months (July, August and September) in the summer of 2004.

FILL - FORMS

For each sample plot a fill-form was made. The abundances and habitats of each particular present species, its area per plot (m^2) and the whole biomass per plot (originally as a percentage enumerated to m^2) were estimated and recorded.

QUANTIFICATION OF OCCURRENCE **(X)**: **(A)** = area of each particular species per plot (m^2), **(B)** = area of whole biomass (total amount of greenery except for the "private" one) per plot (m^2). **(B/100)** = 100%...B → 1%...B/100 >>> the area of each particular species per the whole biomass in the plot (%). This number was used in statistical analysis.

$$X = A/(B/100)$$

For each plot, environmental characteristics selected were also estimated: INDUSTRY – vicinity of industrial facilities (in squares, 0 (the most distant square) - 12 (the nearest square)), WATER – vicinity of water sites (in squares, 0 (the most distant square) - 4 (the nearest square)), GREEN – extent of greenery within square (1-

sparse, 2-moderate, 3-wide) and ROAD – presence (1) or absence (0) of blacktops. I used an aeronautical chart of Hradec Králové (www.BM-CZ 2006).

DETERMINATION OF INVASIVE NEOPHYTES

Plant species were identified as alien invasive neophytes according to the Catalogue of alien plants of the Czech Republic (PYŠEK *et al.* 2002). The total of 64 invasive neophytes were tried to find (TABLE 4), I did not investigate four invasive neophytes classified as post-invasive (*Cytisus scoparius* subsp. *scoparius, Imperatoria ostruthium, Mimulus guttatus* and *Myrrhis odorata*) and water weed *Elodea canadensis.*

Information on the time of introduction, plant family, origin and life-history of invasive neophytes were taken from PYŠEK *et al.* (2002). The structure of alien flora with respect to origin is in the catalogue incomplete. Another problem is that a species distribution area sometimes covers more than one continent so I treated it as the representative of each of them. The structure of alien flora with respect to life-history is complete but the problem is that some species are the part of more than one life-history category. I regarded it as a representative of each of them.

Invasive alien species were determined by the relevant botanical literature, e.g. DOSTÁL (1958), HEJNÝ & SLAVÍK (1988, 1990, 1992), SLAVÍK (1995, 1997, 2000), SLAVÍK & ŠTĚPÁNKOVÁ (2004) and ROTHMALER (2000). I compared the indistinct specimens with herbarium specimens, problematic cases were consulted with Věra Samková of the East Bohemian Museum in Hradec Králové. Finally, I used synoptic taxon groups for the following species: *Cannabis* sp., *Epilobium* cf. *ciliatum, Erigeron* agg. and *Oenothera* spp. Other problematic taxons were *Populus canadensis* and *Fraxinus pensylvanica* but in these cases, I did not use any synoptic taxon group.

The aerial photograph with a mapping grid of SPECIES' DIVERSITY (APPENDIX 2) was made and the same maps were given for the thirty most frequent species (APPENDIX 3).

Species	Abbreviation	Family	1st	Land-use	Landscape	Abund	Intro	Origin	Life history
Acer negundo	AceNeg	Ace	1875	NSH	TM	la	d	AMN	t
Ailanthus altissima	AilAlt	Sim	1874	NSH	TM	sc	d	AS	t
Amaranthus powellii	AmaPow	Ama	1853	H	TM	la	a	AMC AMS	a
Amaranthus retroflexus	AmaRet	Ama	1818	H	TM	c	a	AMN AMC	a
Ambrosia artemisiifolia		Com	1883	H	M	la	a	AMN	a
Amorpha fruticosa		Fab	1932	S	TM	la	d	AMN	s
Angelica archangelica subsp.*archangelica*		Api	1517	NSH	T	la	d	E AS	b pe
Arrhenantherum elatius subsp. *elatius*	ArrEla	Gra	?	NSH	TM	c	a	E AS	pe
Aster lanceolatus		Com	?	SH	TM	c	d	AMN	pe
Aster novi-belgii		Com	1850	SH	TM	sc	d	AMN	pe
Aster × salignus		Com	1872	SH	TM	sc	d	?	pe
Aster versicolor		Com	?	SH	TM	r	d	?	pe
Bidens frondosa	BidFro	Com	1894	NSH	TM	c	a	AMN	a
Bunias orientalis		Bra	1856	SH	TM	la	a	E AS	b pe
Cannabis ruderalis	CanRud	Can	1868	H	M	la	a	AS	a
Conyza canadensis	ConCan	Com	1750	H	TM	c	a	AMN	a
Cuscuta campestris		Con	1883	H	TM	sc	a	AMN	a
Digitalis purpurea		Scr	1790	NS	T	la	d	E AS	b pe
Echinocystis lobata		Cuc	1911	NSH	T	la	d	AMN	a
Echinops sphaerocephalus	EchSph	Com	1871	SH	TM	c	d	E AS	pe
Epilobium ciliatum	EpiCil	Ona	1926	NSH	TM	c	a	AMN AMC	pe
Erigeron annuus subsp.*septentrionalis*	EriAnn	Com	?	H	TM	c	a	AMN	a b
Fraxinus pensylvanica	FraPen	Ole	?	NSH	TM	la	d	AMN	t
Galeobdolon argentatum	GalArg	Lam	?	NSH	TM	sc	d	?	pe
Galinsoga ciliata	GalCil	Com	1901	H	TM	c	a	AMC AMS	a
Galinsoga parviflora	GalPar	Com	1867	H	TM	c	a	AMS	a
Geranium pyrenaicum		Ger	1819	H	TM	c	ad	E AS	b pe
Helianthus tuberosus	HelTub	Com	1885	NSH	TM	c	d	AMN	pe
Heracleum mantegazzianum		Api	1862	NSH	TM	la	d	E	b pe
Impatiens glandulifera	ImpGla	Bal	1896	NSH	TM	la	d	AS	a
Impatiens parviflora	ImpPar	Bal	1870	NS	TM	c	d	AS	a
Juncus tenuis		Jun	1851	SH	T	c	a	AMN	pe
Kochia scoparia subsp.*scoparia*	KocSco	Chen	1819	H	M	sc	a	E AS	a
Lupinus polyphyllus	LupPol	Fab	1895	NS	T	c	d	AMN	pe

Species	Abbreviation	Family	1st	Land-use	Landscape	Abund	Intro	Origin	Life history
Lycium barbarum	LycBar	Sol	1870	NSH	TM	sc	d	E AS	s
Mahonia aquifolium	MahAqu	Ber	?	NSH	TM	la	d	AMN	s
Matricaria discoidea	MatDis	Com	1851	H	TM	c	a	AS	a
Oenothera biennis	OenBie	Ona	1831	SH	TM	c	ad	?	b a
Parthenocissus inserta	ParIns	Vit	1900	NSH	TM	la	d	AMN	s
Persicaria polystachya		Poly	?	SH	T	se	d	AS	pe
Physocarpus opulifolius	PhyOpu	Ros	1874	NSH	T	la	d	AMN	s
Pinus strobus	PinStr	Pin	1800	N	T	la	d	AMN	t
Populus × canadensis	PopCan	Sal	?	SH	TM	la	ad	?	t
Prunus serotina	PruSer	Ros	?	NS	TM	la	g	AMN	t s
Quercus rubra	QueRub	Fag	?	N	TM	sc	d	AMN	t
Reynoutria × bohemica	ReyBoh	Poly	1942	NSH	TM	c	ad	?	pe
Reynoutria japonica var. *japonica*	ReyJap	Poly	1892	SH	TM	c	d	AS	pe
Reynoutria sachalinensis	ReySac	Poly	1869	SH	TM	la	d	AS	pe
Rhus hirta	RhuHir	Ana	1900	SH	T	la	d	AMN	s t
Robinia pseudacacia	RobPse	Fab	1874	NSH	TM	c	d	AMN	t s
Rudbeckia laciniata	RudLac	Com	1859	NSH	TM	c	d	AMN	pe
Rumex alpinus		Poly	1819	SH	T	la	d	E AS	pe
Rumex longifolius		Poly	1961	SH	T	la	a	E	pe
Rumex thyrsiflorus	RumThy	Poly	?	NSH	T	la	a	E AS	pe
Sedum hispanicum		Cra	?	SH	TM	sc	d	E AS	pe
Sisymbrium loeselii	SisLoe	Bra	1819	H	TM	c	a	E AS AF	a
Solidago canadensis	SolCan	Com	1838	NSH	TM	c	d	AMN	pe
Solidago gigantea	SolGig	Com	1851	NSH	TM	c	d	AMN	pe
Symphoricarpos albus	SymAlb	Cap	?	NSH	TM	sc	d	AMN	s
Syringa vulgaris	SyrVul	Ole	1809	NSH	T	sc	d	E	s t
Telekia speciosa		Com	?	SH	T	sc	d	E	pe
Veronica filiformis		Scr	1938	SH	TM	sc	d	E AS	pe
Veronica persica		Scr	1809	H	TM	c	a	AS	a
Virga strigosa	VirSti	Dip	1864	H	TM	la	d	E AS	b

Table 4 Table of the invasive neophytes (according to Pyšek *et al.* 2002). Explanatory notes: *Abbreviation* – first three letters from genus and species (for the species present in the study area only); *Family* – family codes are formed by initial letters of the family name; *1st* – date of the first reported occurence in the wild; *Land-use* – N (natural habitat), S (seminatural habitat), H (human-made habitat); *Landscape* – T (traditional agricultural landscape), M (modern urban and industrial landscape); *Abund* – abundance type in the wild at the territory of the country: s (single locality), sc (scattered), la (locally abundant), c (common); *Intro* – introduction mode of the species into the country: d (deliberate-by planting), a (accidental), ad (both means); *Origin* – E (Europe), AS (Asia), AMN (North America), AMC (Central America), AMS (South America), AF (Africa); *Life history* – a (annual), b (biennial), s (shrub), t (tree), pe (perennial).

STATISTICAL ANALYSIS

For ordination analyses, I used the relevant software (Canoco for Windows 4.5) with default values, expect for the log-transformed species percentual abundance (LEPŠ & ŠMILAUER 2000).

I used a linear model of RDA (redundancy analysis) because a very short gradient was sampled and species appeared to have a linear response to environmental gradient.

The Monte-Carlo permutation test was used to evaluate whether the relationship between species and environmental characteristics was significant. The importance of each environmental characteristic was weighted by the process of forward selection.

I used CanoDraw 3.1 (ŠMILAUER 1992) and CANOPOST for visualization. Abbreviations of species names were composed from the first three letters of genera and species names which are listed in TABLE 4.

Statistics 6.0 was used for another analysis. I selected the non-parametric Spearman coefficient for testing correlations between environmental characteristics (INDUSTRY, WATER and GREEN). For this analysis, I did not include ROADS which resulted insignificant.

RESULTS

I tried to find the total of 64 invasive neophytes (water weeds and post-invasive species were not included) enumerated by PYŠEK *et al.* (2002). By the end of the study, 43 species was found in the strip transect from the city center to the outskirts in the city of Hradec Králové (TABLE 5). This constitutes approximately 67%.

SPECIES OBSERVED

TABLE 6 (consists of three partial tables) shows the frequencies of species occurrence recorded; the mean abundance of each species per the whole biomass in the plot and the sum of real abundances (m^2) for each species present in the whole study area. I found that the most frequent species in the whole area studied were *Solidago canadensis* (0.840) and *Conyza canadensis* (0.790). The next frequent species were *Galinsoga parviflora* (0.445), *Syringa vulgaris* (0.350) and *Erigeron* agg. (0.325). If we consider only woody plants, *Syringa vulgaris* (0.350), *Symphoricarpos albus* (0.240) and *Robinia pseudacacia* (0.230) were the most frequent species in the strip transect studied. Conversely, if we considered the mean abundance (sum of abundances / number of all squares where the species was recorded), then *Ailanthus altissima* (0.375%), *Syringa vulgaris* (0.181%), *Echinops sphaerocephalus* (0.178%), *Virga strigosa* (0.173%) and *Rhus hirta* (0.172%) covered on average the largest area per the whole biomass in one plot. The sum of real abundances (m^2) across all squares had different species ranking from the mean abundance. On the other hand, it roughly corresponds with the results in the first table. *Solidago canadensis* (634.8 m^2), *Reynoutria japonica* (455.9 m^2), *Parthenocissus inserta* (403.1 m^2), *Syringa vulgaris* (188.5 m^2) and *Conyza canadensis* (137.7 m^2) were the species with the highest abundance in the whole area studied. *Pinus strobus* had the lowest value of quantity in both categories last mentioned.

Species	Squares	RS	SB	PG	C	R	GP	WB	M	FB	F
AceNeg	**34**	5	18	0	26	0	3	1	0	0	0
AilAlt	**2**	0	1	0	2	0	0	0	0	0	0
AmaPow	**1**	0	1	0	0	0	0	0	0	0	0
AmaRet	**51**	5	35	0	0	4	6	0	0	3	2
ArrEla	**5**	1	3	0	0	0	0	1	1	0	0
BidFro	**36**	6	7	0	0	3	1	20	0	0	0
CanRud	**1**	0	0	0	0	1	0	0	0	0	0
ConCan	**158**	28	137	12	0	12	39	6	2	1	3
EchSph	**3**	0	1	0	3	0	0	0	0	0	0
EpiCil	**15**	2	7	0	0	1	0	5	0	0	0
EriSep	**65**	22	37	7	0	10	11	4	3	0	1
FraPen	**21**	6	11	0	1	1	0	6	0	0	0
GalArg	**1**	0	0	0	1	0	0	0	0	0	0
GalCil	**46**	2	37	3	0	1	5	2	0	0	0
GalPar	**89**	6	74	2	0	4	4	1	0	1	3
HelTub	**15**	8	7	0	0	2	0	0	0	0	0
ImpGla	**8**	0	0	0	0	0	0	8	0	0	0
ImpPar	**41**	13	12	5	0	2	2	10	0	2	0
KocSco	**3**	0	0	0	0	3	0	0	0	0	0
LupPol	**1**	0	0	0	1	0	0	0	0	0	0
LycBar	**7**	3	2	0	2	1	0	0	0	0	0
MahAqu	**18**	0	7	2	11	0	0	0	0	0	0
MatDis	**48**	0	47	0	0	1	0	0	0	0	0
OenBie	**29**	17	9	0	2	2	1	2	1	0	0
ParIns	**35**	8	26	2	4	1	0	1	0	0	0
PhyOpu	**2**	0	0	0	2	0	0	0	0	0	0
PinStr	**15**	0	0	0	15	0	0	0	0	0	0
PopCan	**32**	10	10	2	20	0	0	1	0	0	0
PruSer	**5**	0	2	2	4	0	0	0	0	0	0
QueRub	**19**	1	2	1	17	0	1	4	0	0	0
ReyBoh	**6**	5	1	0	0	0	2	0	0	0	0
ReyJap	**25**	13	8	1	0	1	2	5	0	0	0
ReySac	**1**	1	0	0	0	0	0	0	0	0	0
RhuHir	**28**	2	8	0	22	0	4	0	0	0	0
RobPse	**46**	13	11	4	34	1	5	1	0	0	0
RudLac	**1**	0	0	0	1	0	0	0	0	0	0
RumThy	**45**	13	19	1	0	12	6	8	3	0	0
SisLoe	**7**	1	4	0	0	2	0	0	0	0	0
SolCan	**168**	63	126	5	13	17	16	13	3	7	0
SolGig	**12**	3	4	0	1	1	0	4	0	0	0
SymAlb	**48**	8	12	1	31	2	0	1	0	0	0
SyrVul	**70**	7	25	4	49	2	1	0	0	0	0
VirStr	**2**	1	0	0	0	0	0	1	0	0	0
Total species in habitat		29	33	16	22	24	17	22	6	5	4

TABLE 5 Overview of the species present. Legend: SQUARES (sum of all squares in which the species was recorded), LAND-USE TYPES (sum of all squares with the partial land-use type in which the species was recorded): RS – ruderal sites, SB – street borders, PG – parks and gardens, C – cultivations, R – railways, GP – grass plots, WB – water borders, M – meadows, FB – field borders F – fields. For species' abbreviations, see TABLE 4.

Species	Frequence	Species	Mean abun	Species	Total abun
SolCan	0.840	*AilAlt*	0.375	*SolCan*	634.8
ConCan	0.790	*SyrVul*	0.181	*ReyJap*	455.9
GalPar	0.445	*EchSph*	0.178	*ParIns*	403.1
SyrVul	0.350	*VirStr*	0.173	*SyrVul*	188.5
EriSep	0.325	*RhuHir*	0.172	*ConCan*	137.7
AmaRet	0.255	*PhyOpu*	0.167	*RobPse*	132.6
MatDis	0.240	*SymAlb*	0.165	*HelTub*	112.8
SymAlb	0.240	*ParIns*	0.144	*AceNeg*	94.6
GalCil	0.230	*LycBar*	0.143	*RumThy*	90.9
RobPse	0.230	*ReyBoh*	0.134	*SymAlb*	74.3
RumThy	0.225	*FraPen*	0.130	*PopCan*	71.0
ImpPar	0.205	*PruSer*	0.126	*FraPen*	65.0
BidFro	0.180	*ImpPar*	0.123	*LycBar*	55.0
ParIns	0.175	*RobPse*	0.122	*EriSep*	52.2
AceNeg	0.170	*ImpGla*	0.121	*GalPar*	44.1
PopCan	0.160	*OenBie*	0.120	*ImpPar*	43.4
OenBie	0.145	*EpiCil*	0.120	*RhuHir*	36.8
RhuHir	0.140	*ReyJap*	0.119	*BidFro*	34.9
ReyJap	0.125	*AmaRet*	0.118	*ReyBoh*	27.0
FraPen	0.105	*MatDis*	0.117	*PruSer*	27.0
QueRub	0.095	*EriSep*	0.116	*OenBie*	17.2
MahAqu	0.090	*HelTub*	0.116	*AmaRet*	14.0
EpiCil	0.075	*SisLoe*	0.116	*QueRub*	14.0
HelTub	0.075	*GalCil*	0.115	*GalCil*	14.0
PinStr	0.075	*MahAqu*	0.115	*ImpGla*	12.8
SolGig	0.060	*SolCan*	0.114	*SolGig*	12.4
ImpGla	0.040	*BidFro*	0.114	*AilAlt*	12.0
LycBar	0.035	*RumThy*	0.114	*ArrEla*	8.0
SisLoe	0.035	*GalPar*	0.114	*MatDis*	3.8
ReyBoh	0.030	*ConCan*	0.114	*MahAqu*	2.5
ArrEla	0.025	*KocSco*	0.112	*PhyOpu*	2.0
PruSer	0.025	*SolGig*	0.110	*SisLoe*	1.7
EchSph	0.015	*AceNeg*	0.105	*EchSph*	1.5
KocSco	0.015	*PopCan*	0.100	*EpiCil*	1.3
AilAlt	0.010	*AmaPow*	0.083	*KocSco*	1.1
PhyOpu	0.010	*ReySac*	0.063	*AmaPow*	1.0
VirStr	0.010	*ArrEla*	0.052	*ReySac*	1.0
AmaPow	0.005	*QueRub*	0.006	*VirStr*	0.8
ReySac	0.005	*PinStr*	0.001	*PinStr*	0.3

TABLE 6 Quantity of the species present (cultivated ones are not included, I considered the invasive stadium only). Legend: Frequence – sum of all squares in which the species was recorded per the total number of squares, Mean abun –mean abundance of each species (sum of abundances / number of all squares where the species was recorded) per the whole biomass in the plot, Total abun – sum of real abundances (m^2) for each species present across the whole study area.

AERONAUTICAL CHARTS OF THE STRIP TRANSECT

APPENDIX 1 illustrates a distribution of all the present land-use types. Fields and their borders are situated on the left on the periphery (arable land). Ruderal sites, street borders, grass plots and cultivations are presented in the whole transect studied. Railway sites with the near industrial zone bisect the study area. The distribution of meadows, park and gardens, and water borders is also demonstrated.

The aerial photograph with a mapping grid of species' diversity (APPENDIX 2) outlines a decrease of invasive species on the gradient running from the city center (on the right side) to the outskirts (on the left side). A contrast between the center and the periphery is obvious. The main railway station and the near industrial zone halve the study area and have the highest number of species. From these sites to the left there is the lowest number of species – mainly arable lands.

APPENDIX 3 shows aerial photographs with a mapping grid for the thirty most frequent species. The color transition illustrates the performance of each particular species in the study area. It is shown how species expands from the cultivation into new areas where is subsequently seen during spreading only.

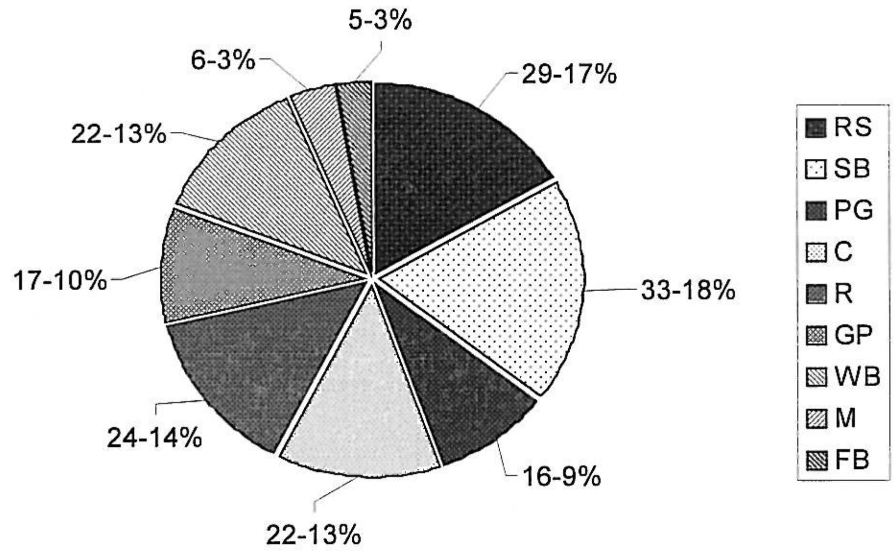
I did not include species with the occurrence less than six plots, these (13) species are resumed in TABLE 7. Half of them with the occurrence in one plot were found in cultivated areas. On the other hand, the most frequent species situated in cultivations were *Syringa vulgaris* (49), *Robinia pseudacacia* (34) and *Symphoricarpos albus* (31). If we consider only herbs, they were observed much less in cultivated areas, beside *Solidago canadensis* (13).

Species	Total	C	B	S
ArrEla	**5**	0	0	5
PruSer	**5**	3	1	1
EchSph	**3**	2	1	0
KocSco	**3**	0	0	3
AilAlt	**2**	1	1	0
PhyOpu	**2**	1	1	0
VirStr	**2**	0	0	2
AmaPow	**1**	0	0	1
CanRud	**1**	1	0	0
GalArg	**1**	1	0	0
LupPol	**1**	1	0	0
ReySac	**1**	0	0	1
RudLac	**1**	1	0	0

TABLE 7 Species which were not included in APPENDIX 3 with the occurrence less than six squares. Legend: (C) cultivation, (B) both (C+S), (S) spreading.

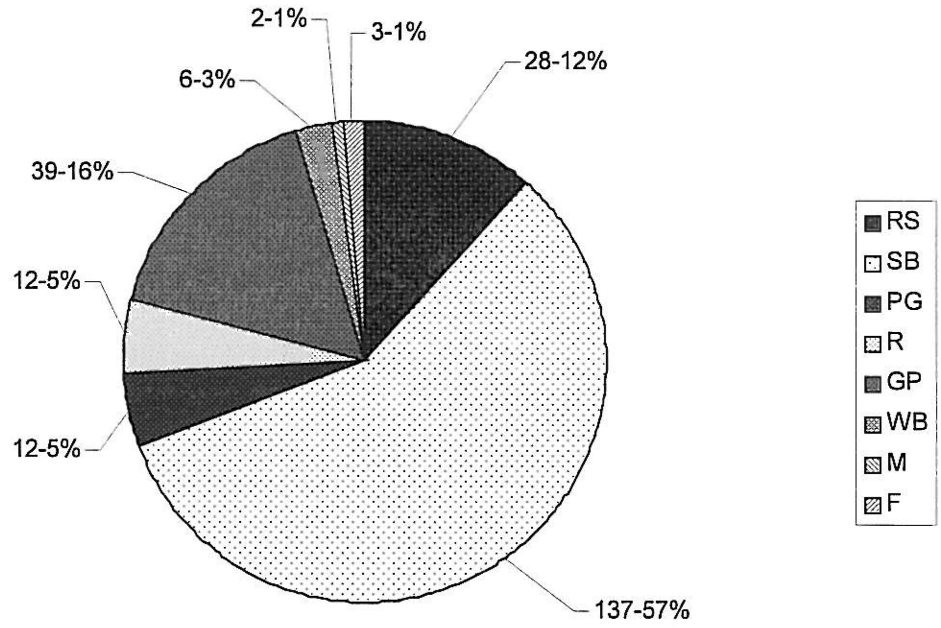
LAND-USE TYPES

GRAPH 2 shows the representation of species present in nine land-use types (fields are not included - having under one percent of species present). The maximum number was observed in street borders - 33 species (about 18%), ruderal sites – 29 species (17%) and railway sites – 24 (14%). I found 22 species on water borders and in cultivated areas. The lowest number of species present was recorded in meadows (6) and field borders (5), being about 3%.

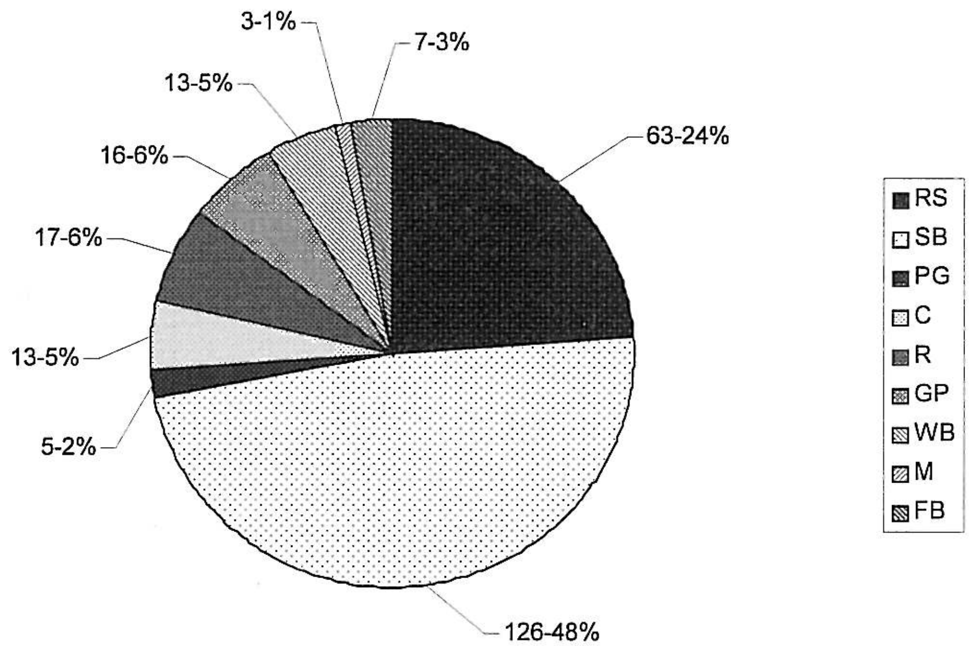


GRAPH 2 Numbers of the species present recorded in nine land-use types. Legend: RS – ruderal sites, SB – street borders, PG – parks and gardens, C – cultivations, R – railways, GP – grass plots, WB – water borders, M – meadows, FB – field borders.

(GRAPH 3, 4) show two graphs of the most frequent species present (*Solidago canadensis* and *Conyza canadensis*). This more or less corresponds with the common graph for all the species present. The strikingly frequent occurrence of *Solidago canadensis* (126) and *Conyza canadensis* (137) is also related to the common presence of their most preferred habitat – street borders which are also the most frequent habitat of all invasive species present.



GRAPH 3 Land-use types with occurrence of *Conyza canadensis*. Legend: RS – ruderal sites, SB street borders, PG – parks and gardens, R – railways, GP – grass plots, WB – water borders, M meadows, F – fields.



GRAPH 4 Land-use types with occurence of *Solidago canadensis*. Legend: RS – ruderal sites, SB street borders, PG – parks and gardens, C – cultivations, R – railways, GP – grass plots, WB – wate borders, M – meadows, FB – field borders.

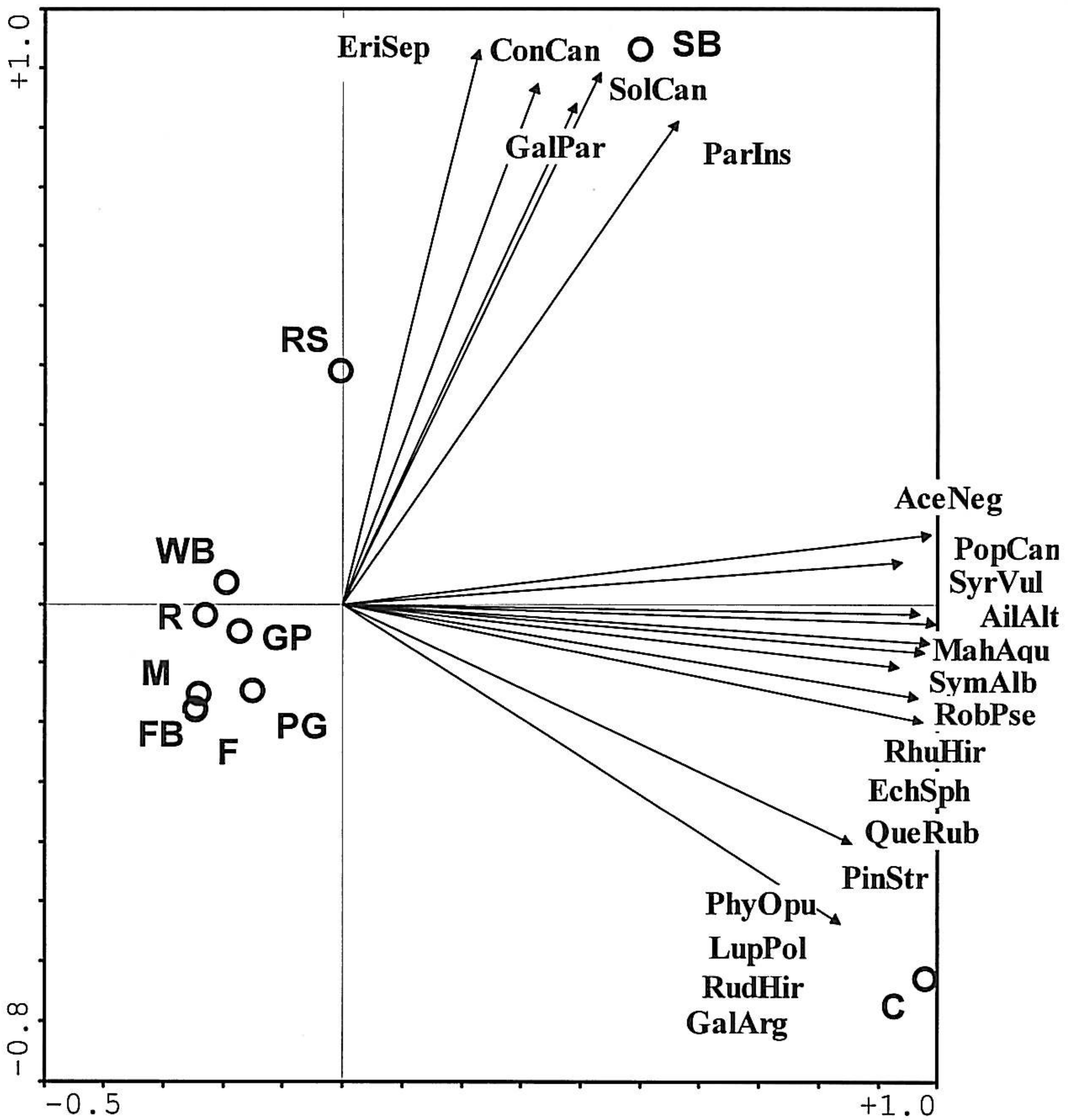


FIGURE 3 Redundancy analysis ordination diagram displaying the relation of species (thin arrows) and invaded habitats (circles) in the primary dataset: RS – ruderal sites, SB – street borders, PG – parks and gardens, C – cultivations, R – railways, GP – grass plots, WB – water borders, M – meadows, FB – field borders, F – fields. Only best-fitted species are shown. For species' abbreviations, see TABLE 4.

FIGURE 3 illustrates relationships between the best-fitted invasive species and invaded habitats. The first two ordination axes explained 73.2% ($p<0.005$) of variation in the data set. Species crowded in the upper right corner represent the common alien ruderal flora preferring mainly street borders (SB), including e.g. *Solidago canadensis*, *Conyza canadensis* and *Galinsoga parviflora*. The species cluster in the lower right corner encompasses species recorded mostly from cultivations (C). They included woody plants e.g. *Acer negundo, Populus canadensis, Syringa vulgaris, Ailanthus altissima or Robinia pseuacacia;* and also herbs e.g. *Lupinus polyphyllus, Rudbeckia hirta, Echinops sphaerocephalus* or *Galeobdolon argentatum.*

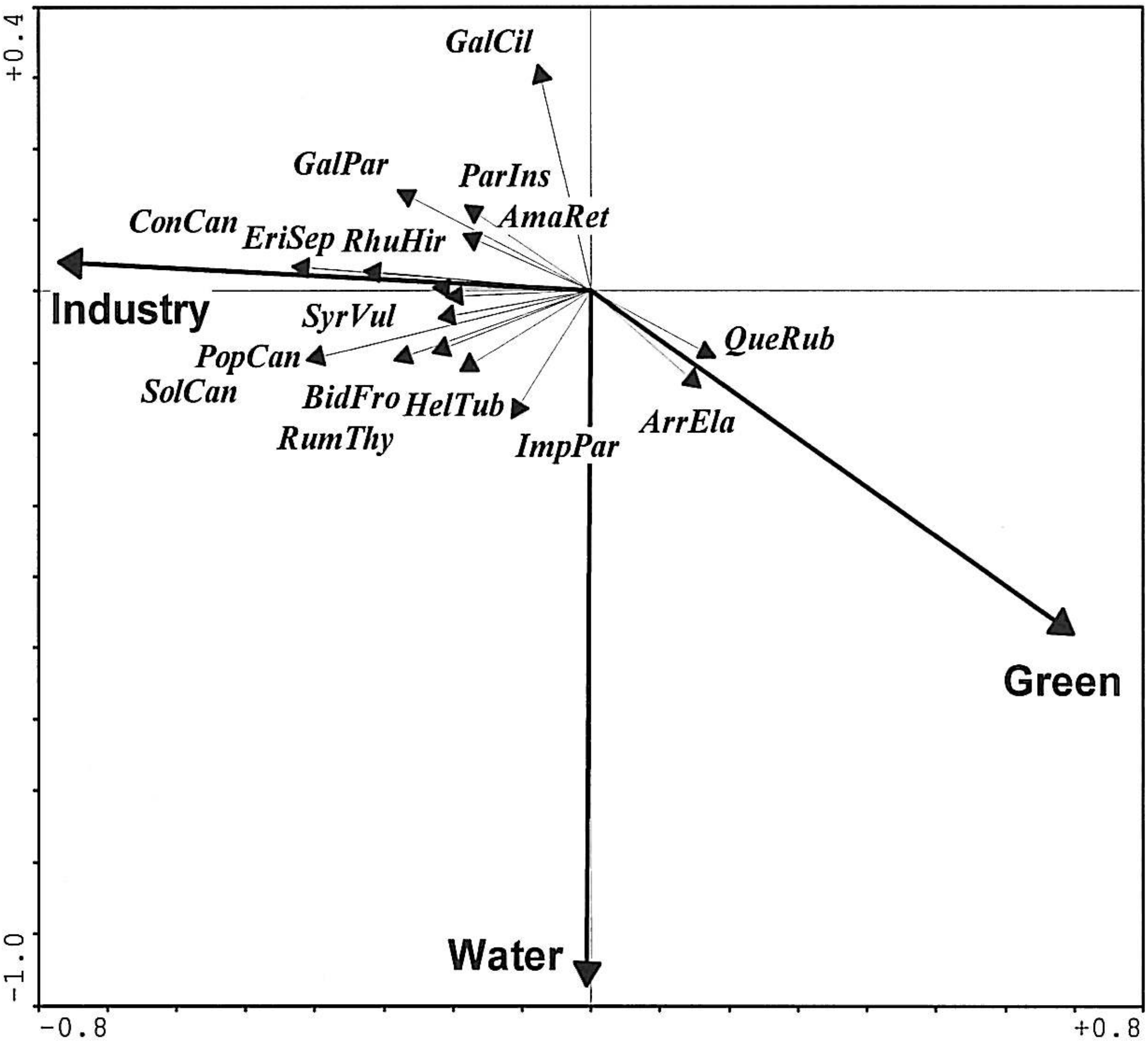


FIGURE 4 Redundancy analysis ordination diagram displaying the relation of species (thin arrows) in the primary dataset and the correlation pattern of selected environmental characteristics (thick arrows) of mapped squares: INDUSTRY – vicinity of industrial facilities (in squares, 0-12), WATER – vicinity of water sites (in squares, 0-4), GREEN – extent of greenery within square (1-sparse, 2-moderate, 3-wide). For species' abbreviations, see TABLE 4.

FIGURE 4 shows the relationships between the best-fitted invasive species and environmental characteristics selected of mapped squares (ROADS were not significant). The first two ordination axes explained 83.3% ($F_{Industry}$=4.18; F_{Water}=2.42; F_{Green}=3.01; $p<0.005$) of variation in the data set. The first ordination axis roughly corresponds to the gradient of industrial impact on vegetation increasing to the left (variable Industry). The second ordination axis shows the gradient of tendency to occur near water sites, increasing downwards (variable Water). *Galinsoga ciliata* preferred sites at a greater distance from water, *I. parviflora* together with *Bidens frondosa* reversely favoured sites in the immediate vicinity of water. *Arrhenatherum elatius* and *Quercus rubra*, most of all the recorded species preferred greenery (variable Green). Many alien species were observed mainly in the industrial zone only e.g. *Rhus hirta, Conyza canadensis* and *Syringa vulgaris.*

Variable	**Water**	**Green**	**Industry**
Water	1.000000	-0.269195	0.155249
Green	-0.269195	1.000000	-0.375127
Industry	0.155249	-0.375127	1.000000

TABLE 8 Matrix of correlations between the environmental characteristics. Spearman coefficient was used ($p < 0.005$).

TABLE 8 illustrates relations between environmental characteristics selected of mapped squares (WATER, GREEN and INDUSTRY). WATER and INDUSTRY were positively correlated. Others selected characteristics of the study area were negatively correlated. GREEN negatively correlated mostly with INDUSTRY, this is constructive.

Relatively low values of Spearman coefficient are probably caused by the large data set used (200 squares).

TIME OF INTRODUCTION

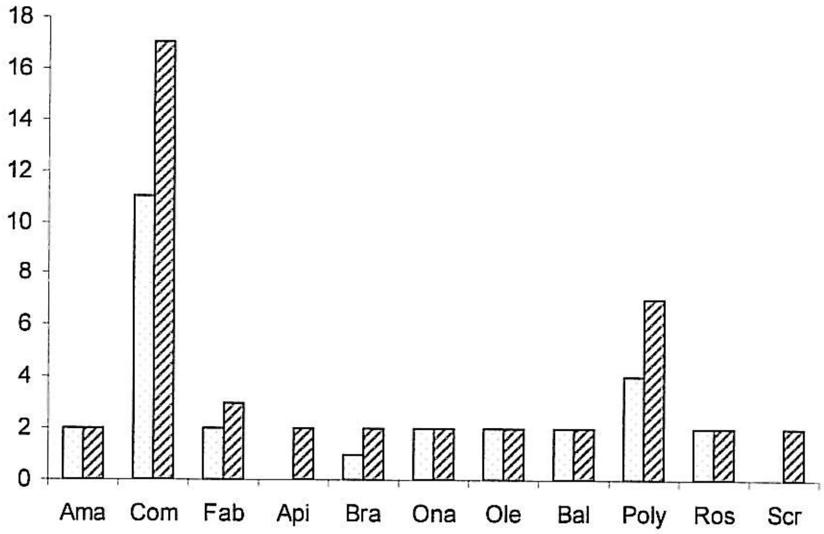
Conyza canadensis is the "oldest" alien species in the study area. In 1750 was recorded in the wild for the first time and it was introduced accidentally. The following species recorded in the wild of the Czech Republic were *Pinus strobus* (1800), *Syringa vulgaris* (1809), *Amaranthus retroflexus* (1818), *Kochia scoparia* subsp. *scoparia* (1819) and *Sisymbrium loeselii* (1819).

The "youngest" alien species found were *Reynoutria* × *bohemica* (1942), *Epilobium* cf. *ciliatum* (1926) and *Galinsoga ciliata* (1901). *Reynoutria* × *bohemica* was introduced by both means, accidentally and deliberately (by planting). For a total compendium, see TABLE 4.

Taxonomic structure

The 43 invasive neophytes recorded in the study transect belong to 24 families. All 64 invasive neophytes of the Czech Republic (*Elodea canadensis* and post-invasive species were not included) after PYŠEK *et al.* (2002b) are part of 32 families.

GRAPH 5 compares these two categories – the species present in the study area (spotted) with the total number of 64 invasive neophytes of our territory (shaded) according to PYŠEK *et al.* (2002b). Families with the present one species only are not included. The most represented families in both categories are *Compositae* (11 of 17) and *Polygonaceae* (4 of 7).



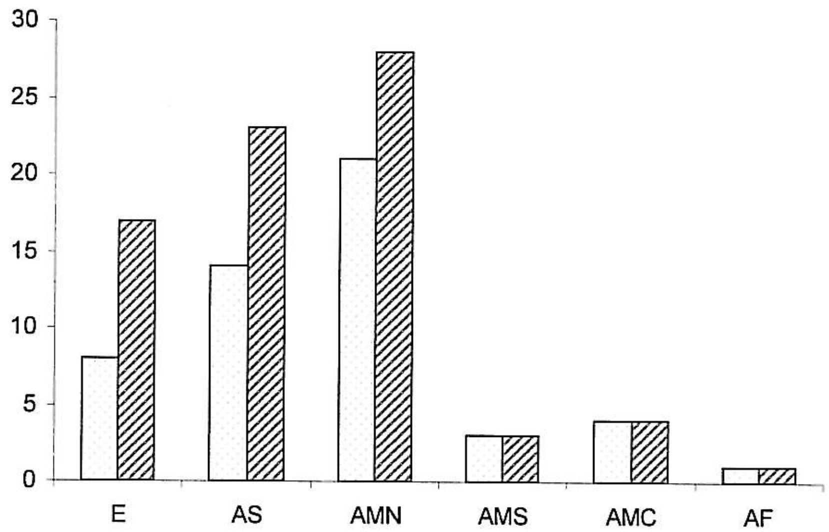
GRAPH 5 Comparison of the taxonomic structure of the 43 invasive neophytes present (spotted) with all 64 invasive neophytes (shaded) according to PYŠEK *et al.* (2002b). Legend: (Ama) *Amaranthaceae*, (Com) *Compositae*, (Fab) *Fabaceae*, (Api) *Apiaceae*, (Bra) *Brassicaceae*, (Ona) *Onagraceae*, (Ole) *Oleaceae*, (Bal) *Balsaminaceae*, (Poly) *Polygonaceae*, (Ros) *Rosaceae*, (Scr) *Scrophulariaceae*.

Origin

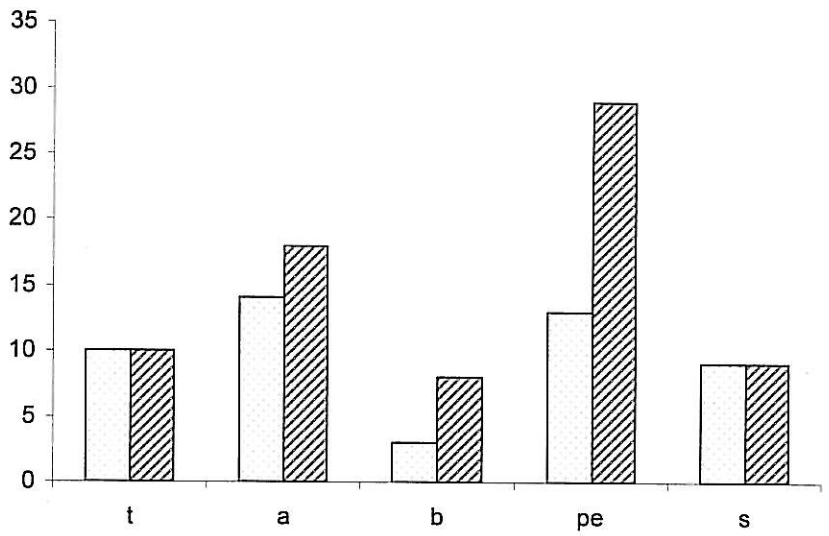
GRAPH 6 shows that most of the species from both categories come from North America (21 of 28) and lots of them from Asia (14 of 23) or Europe (8 of 17). The numbers of species coming from South America (3), Central America (4) and Africa (1) are identical for both categories.

LIFE HISTORY

GRAPH 7 illustrates that most of the invasive species found were either annuals (14 of 18) or perennials (13 of 29). This corresponds to the figure presented in the catalogue. Numbers of shrubs (9) and trees (10) are the same in both categories.



GRAPH 6 Comparison of the origin structure of the 43 invasive neophytes present (spotted) with all 64 invasive neophytes (shaded) according to PYŠEK *et al.* (2002b). Legend: (E) Europe, (AS) Asia, (AMN) North America, (AMS) South America, (AMC) Central America, (AF) Africa.



GRAPH 7 Comparison of the life history structure of the 43 invasive neophytes present (spotted) with all 64 invasive neophytes (shaded) according to PYŠEK *et al.* (2002b). Legend: (t) tree, (a) annual, (b) biennial, (pe) perennial, (s) shrub.

DISCUSSION

Urbanization has meant that natural areas have become cultivated and often overexploited and that nature has been removed as a dominant factor in the daily life of an increasing number of people (KONIJNENDIJK 2005). It is generally known that primarily urban areas are at risk from invasions. To avoid the consequences of invasions, we need predictive theories which can help us to set priorities for the control of invasive weeds introduced and allow us to predict the risk of future invasions (DAN *et al.* 1995, REJMÁNEK 1995). That is why flora and vegetation in settled habitats at present receive more attention, especially in Central Europe (PYŠEK 1995a).

A spatial heterogeneity, maximalized in the urban environment, is responsible for the overall high species (including invasive species) richness of towns (STOHLGREN *et al.* 1999). I investigated the city of Hradec Králové where I found 43 neophytes, which is about 67% of the total 64 invasive neophytes (except of water weeds and post-invasive species) in our territory (after PYŠEK *et al.* 2002b). It is a relatively high number but comparison with other studies is problematic because there are many definitions of invasive neophyte, for instance PYŠEK (1995b) gives 13 definitions used by different authors so "each study has its own number of invasive species". Another problem is that most authors, analyzing urban flora, studied all the alien species together (including invasive and non-invasive, archeophytes and neophytes) and compared their results with native flora, e.g. ANDERSEN (1995), CHOCHOLOUŠKOVÁ & PYŠEK (2003), ZERBE *et al.* (2004).

It is likely that the figure of 43 neophytes found is not a finite number, especially for a complete area of the city. I suppose that the number is higher. Nevertheless, I had not predicted the presence of the species *Telekia speciosa* or *Rumex alpinus* that are typical in highlands. On the other hand, *Bunias orientalis*, *Veronica filiformis* and *Veronica persica* were not recorded in the strip transect though they occur in the environs of Hradec Králové. The presence of *Bunias orientalis* was noted in 1998 and 2000 (SAMKOVÁ pers. comm.) and that of *Veronica filiformis* in 1990 (SAMKOVÁ pers. comm.). However, neither was found in the study area. *Veronica persica* was observed a number of times. This species was also recorded in the studied transect in 2000 (SAMKOVÁ pers. comm.) but not in 2004, which is strange because this species is plentiful in Eastern Bohemia and its determination is not problematic.

Railway stations are generally considered to be one of the focal points of alien plant expansion. *Ambrosia artemisiifolia* was recorded near railway tracks at the main railway station in 1973 (SAMKOVÁ pers. comm.) but it was not found during my investigation. Perhaps, this was the result of herbicides which are sometimes used along railway tracks or by some other chance. It is generally known that populations of short-lived invasive plants often occur in one place very briefly (DRAKE *et al.* 1989) so "by chance" could also be a reasonable explanation.

In this study, the most frequent and abundant species by far others were *Solidago canadensis* and *Conyza canadensis.* They are both among the "oldest" species according to the time of first occurrence in the wild of our country. *Conyza canadensis* is the longest established (time of introduction 1750) in the studied area (PYŠEK *et al.* 2002a) and not surprisingly. In accordance with other published studies (PYŠEK *et al.* 2003, PYŠEK *et al.* 2004) it was found that invasive neophytes that were introduced earlier are more abundant in a new area than those introduced more recently.

The "youngest" alien species in the strip transect studied was *Reynoutria* × *bohemica*, a hybrid between *R. japonica var. japonica and R. sachalinensis.* The herbarium specimen of one plant cultivated in the Botanical Garden of Charles University in Prague, represents the earliest record of the hybrid in the Czech Republic (MANDÁK *et al.* 2004). According to this work, the hybrid exhibits twice the rate of invasion of its parents. However, *Reynoutria japonica* was the most frequent species of this genus and also the second most abundant species in the study area. Nevertheless, a relatively low frequency of *Reynoutria* × *bohemica* could be little undervalued because of the problematic determination of the genus *Reynoutria*.

Many explanations for being a good invader exist, one can be that plants from the introduced range are more susceptible to some natural enemies and benefit more from insect removal than plants from the native range (MEYER *et al.* 2005). Also mycorrhizal fungi can be very useful in the process of invasion. JIN *et al.* (2004) researched on *Solidago canadensis* and suggested that certain arbuscular mycorrhizal fungi (AMF) species might have helped colonize newly-reclaimed habitats. The succession of belowground AMF communities may occur concomitantly with the development of the aboveground plant communities.

I have tested the presence of arbuscular mycorrhizal symbiosis (AMS) in some invasive neophytes. I found AMS frequently in genus *Galinsoga*. Conversely, in genus *Reynoutria* was not occurred so much (ŠTAJEROVÁ, in prep.). This promotes the statement of JIN *et al.* (2004) and also adverts to a possible connectedness with the time of introduction (the genus of *Reynoutria* was introduced later).

It is especially important to pay attention to the whole spectrum of habitats, including those of heavily disturbed sites, not only to those traditionally considered in nature conservation (PYŠEK 1995a). I determined ten categories of habitat in the study area. The maximum number of species was observed in street borders and ruderal sites. The two most frequent species *Solidago canadensis* and *Conyza canadensis* were also related to the common presence of the most preferred habitat of all alien species – street borders. This result corresponds to other studies. In Chonju for example, the highest percentage of non-native species was found in more or less densely built-up areas, industrial areas, and in trading estates (ZERBE *et al.* 2004). These habitats offer warmer and drier conditions than natural habitats and are suitable habitats for plants and animals from warmer regions of the world (SUKOPP 2002). Many plants that were previously rare have become permanent members of these land-use types (SUKOPP 2002). As regards management, these habitats are further potential sources of spread. This is confirmed by the increase in the importance of transport sites over time (PYŠEK *et al.* 1998). But if we consider APPENDIX 1, it is suprising that grass plots were the second most frequent habitat but with the occurrence of seventeen species only. This number was probably reduced by cutting or by a low offer of free patches. Most of the grass plots looked quite well maintained during my investigation.

Conversely, the lowest number of species was found in fields and their borders. These results indicate a higher invasibility for settlements and a low invasibility for arable areas. The low proportion of records from arable land could be explained by the role of these habitat types in harbouring archeophytes (KOWARIK 1995b, PYŠEK et al. 1998) which were not investigated in this study. SUKKOP & WERNER (1983) concluded that most of the present-day invasive neophytes spread best in cities and industrial areas whereas many archeophytes, when introduced as weeds, do better in rural areas.

A decrease in invasive species on the gradient running from the city centre to the outskirts was not so clear. It is probably caused by the presence of industrial facilities in the centre of the study area. However, the difference between the city centre and the periphery was obvious (see APPENDIX 2). This trend is much clearer in the city of Berlin where there is an increasing proportion of alien species on the rural-urban gradient (up to 50% of all species) in the centre. This may be explained by a corresponding change in the intensity of human impact which is presumably higher in cities than on the periphery (KOWARIK 1995b). For the distribution of the thirty most frequent species on the gradient - city center versus periphery, see Appendix 3.

FIGURE 3 illustrates mainly the species which prefer ruderal sites, street borders and cultivations. The species found to be most present were observed in the first two habitats mentioned above. Conversely, *Galeobdolon argentatum, Lupinus polyphyllus* and *Rudbeckia laciniata* were observed only in the cultivated areas. These introduced plants widely cultivated usually dominate in this land-use type and also dominate over native ones (SUKOPP 2002).

I recorded a strange occurrence of *Cannabis* spp. This species was found as a crop at the main railway station, a very atypical habitat. I suppose that it must have been *Cannabis sativa* subsp. *indica* rather than *Cannabis ruderale,* which has the status of invasive neophyte. However, plants were too small for the exact determination.

'The factors influencing native and non-native plant diversity in urban areas are not the same. Non-native species diversity is more complicated and appears to be significantly influenced by factors regarding the settlement of the city, e.g. date of settlement, type of industry etc. (CLEMANTS & MOORE 2003). Water dynamics as well as human transportation activities together with other common strong disturbances might explain the high richness patterns of alien flora as well as of native species in these habitats (PLANTY-TABACCHI *et al.* 1996, DEUTSCHEWITZ *et al.* 2003). My results correspond to this trend. FIGURE 4 shows relationships among the best-fitted invasive species and the selected characteristic of mapped squares - INDUSTRY, WATER and

GREEN. *Impatiens parviflora* together with *Bidens frondosa* often occurred in the vicinity of water, this corresponds with BURKART (2001) while *Galinsoga ciliata* did not at all. Many species preferred industrial areas e.g. *Rhus hirta* and *Syringa vulgaris*, this is in agreement with works of e.g. MIHULKA (1996) and ZERBE *et al.* (2004). On the other hand, there were species which were "naturalised" in greenery e.g. *Quercus rubra*. According to the Spearman coefficient, WATER and INDUSTRY were positively correlated. This points to their distribution together in the study area as well as the negative correlation corresponds to the different placing of INDUSTRY and GREEN.

PYŠEK *et al.* (1995), DI CASTRI (1990) confirm the fact that there is not single characteristic which can reliably predict the success of any particular species as an invader. Invasive neophytes have various characteristics which help them during its expansion but it is not any species with the best combination of these characteristics. In my opinion, it could be considered as TRADE OFF.

The „IDEAL INVASIVE NEOPHYTE" of the study area might have these characteristics - belongs to family *Compositae* or *Polygonaceae,* is annual or perennial, native to North America, introduced before 1800 and prefers street borders or ruderal sites. The success of many species of *Compositae* can be explained at least partly by their adaptation to dispersal by wind (ANDERSEN 1995).

According to VIŠŇÁK (1997), each area has its own best successful invasive neophytes, in the studied area probably being *Solidago canadensis*. This species well corresponds with the characteristics mentioned above.

The most successful alien tree species in the urban environments in Europe and Asia is THE BLACK LOCUST *(Robinia pseudacacia)* which is an N_2 fixing species (KOWARIK 1995b). This strategy is very useful in urban areas and this alien species was also very abundant in the city of Hradec Králové. According to the sum of abundances (see TABLE 6), *Robinia pseudacacia* was in second place in the ranking of the evergreen woody species. But if we consider results of other quantitative categories, there are many differences. The first and third categories roughly correspond together while the mean of abundance is different. It points out that the most frequent species do not create monocultures.

The present results suggest the key role of disturbances in association with a high habitat and structural heterogeneity of invasive species diversity in the area studied in Hradec Králové.

In this territory, alien plants do not mean a serious problem. The greenery of Hradec Králové is kept in good repair. I observed that the parks and public gardens were not the sources of spreading. On the other hand, I found quite a large bearing of *Impatiens parviflora* and *Reynoutria japonica* on the bank of the river Orlice in Jirásek gardens. This occurrence is apparently promoted by this river. It corresponds to the statement that rivers are generally considered as bio-corridors of alien plants' spreading. Secondly, the large ruderal sites are now being built upon. Most of ruderal alien species e.g. *Conyza canadenis*, *Populus canadensis, Erigeron* agg. and *Robinia pseudacacia* are being replaced by e.g. the scientific library and the underground car park.

CONCLUSION

I found 43 invasive neophytes in the strip transect studied in the city of Hradec Králové. A decrease of invasive species on the gradient from the city center to the periphery was not completely demonstrated but the contrast between the center and its outskirts was obvious. Most of alien species were occurred in the industrial zone which halves the study area.

A list of the species present including invasive neophytes with varied characteristics (e.g. time of introduction, origin and family) and ecological requirements, I observed that the most frequent species far ahead others were *Solidago canadensis* and *Conyza canadensis*. The strikingly frequent occurrence of these two species was also related to the common presence of the preferred habitat of all the species present – street borders. Conversely, the minimum was found in fields and their borders (arable land).

Most of alien species belong to the plant families *Asteraceae* and *Polygonaceae*, native to Northern America, and are annuals or perennials. This roughly corresponds with results of PYŠEK *et al.* (2002b) who investigated alien flora of the Czech Republic.

The quantitative results showed that the frequency and the total abundance of invasive species more or less tally together while the mean of abundance is different. It points out that the most frequent species do not create monocultures.

With a high probability, the environmental characteristics of mapped squares, which were used in the statistical analysis, influence the distribution of species. On the other hand, different factors, e.g. temperature, moisture or human impact, were not considered. A complex of all these factors could have the influence on species' distribution but one which would differ from species to species.

OUTPUTS OF THIS THESIS

1. Herbarium specimens of invasive neophytes for the East Bohemian Museum in Hradec Králové.

2. An aeronautical chart showing the places mostly threatened by invasive neophytes for AOP (Pardubice).

3. ŠTAJEROVÁ K., MIHULKA S. & MARTÍNKOVÁ J.: Invasive neophytes in a part of the city of Hradec Králové. – in prep. (APPENDIX 4 – enclosed the summary).

4. ŠTAJEROVÁ K.: Changes in composition of alien flora in the city of Hradec Králové during last 150 years. – in prep.

A photo on the last page shows that although scientists regard on alien plants as the threat of native ones, the nature has absolutely different view. In this picture, stems of *Reynoutria* sp. hide the nest of *Turdus merula* from potential enemies.

(Photo: Pavel Ondrejček)

ACKNOWLEDGMENT

I would like to express my sincere thanks to Stanislav Mihulka for leading my thesis and for his priceless help and comments on the manuscript; to Petr Šmilauer, Jan Šuspa Lepš and Jana Martínková for consultation on the statistics.

Other helpful comments on the manuscript were provided by my biology teacher Ivo Králíček, my friends Pája Ondrejček, "tia" Romana and my sister-in-law Lada Štajerová – a word of thanks is due to them.

I am very thankful to Věra Samková (East Bohemian Museum) for her extensive help with determination and for giving me dates on species studied; and to my proof reader Chris Steer correcting my English.

I would like to warmly thank the staff of our library for their willingness to help and the managers of companies who allowed me to enter to the private land around their buildings.

Very special thanks are due to my family and to Lukáš Sekerka for help & support during the never-ending writing process and also to my brother Michael for the color-print in this thesis.

This study was made with the support of grant no. 206/03/P155 of the Grant Agency of the Czech Republic.

REFERENCES

- A -

ALBERTI M. (2005): The effects of urban patterns on ecosystem function. – International Regional Science Review 28(2): 168-192.

ANDERSEN U.V. (1995): Comparison of dispersal strategies of alien and native species in the Danish flora. – In: Pyšek P., Prach K., Rejmánek M. & Wade M. (eds.), Plant Invasions: General Aspects and Special Problems, p. 61-70, SPB Academic Publishing, Amsterdam.

- B -

BRANDES D. (1995): The flora of old town centers in Europe. – In: Sukopp H., Numata M. & Huber A. (eds.), Urban Ecology as the Basis of Urban Planning, p. 49-58, SPB Academic Publishing, Amsterdam.

BURKART M. (2001): River corridor plants (Stromtalpflanzen) in Central European lawland: a review of a poorly understood plant distribution pattern. – Global Ecology and Biogeography 10(5): 449-468.

- C, Č -

CHOCHOLOUŠKOVÁ Z. & PYŠEK P. (2003): Changes in composition and structure of urban flora over 120 years: a case study of the city of Plzeň. – Flora 198: 366-376.

CLEMANTS S. & MOORE G. (2003): Patterns of species richness in eight Northeastern United States cities. – Urban Habitats 1(1): 4-16.

ČERNÝ Z., NERUDA J. & VÁCLAVÍK F. (1998): Invazní rostliny a základní způsoby jejich likvidace. – MZČR, Praha, 43 pp.

- D -

DAN H., RUSONG W. & TINGGUI T. (1995): An analysis of the flora in Tianjin. – In: Sukopp H., Numata M. & Huber A. (eds.), Urban Ecology as the Basis of Urban Planning, p. 59-69, SPB Academic Publishing, Amsterdam.

DEUTSCHEWITZ K., LAUSCH A., KÜHN I. & KLOTZ S. (2003): Native and alien species richness in relation to spatial heterogeneity on a regional scale in Germany. – Global Ecology and Biogeography 12: 299-311.

DI CASTRI F. (1990): On invading species and invaded ecosystems: the interplay of historical chance and biological necessity. – In: di Castri F., Hansen A.J. &

Debussche (eds.), Biological Invasions in Europe and the Mediterranean Basin, p. 3-16, Kluwer Academic Publishers, Dordrecht.

DEHNEN-SCHMUTZ K. (1998): Medieval castles as centres of spread of non-native plant species. – In: Starfinger U., Edwards K., Kowarik I. & Williamson (eds.), Plant Invasions: Ecological Mechanisms and Human Responses, p. 307-312, Backhuys Publishers, Leiden.

DOSTÁL J. (1958): Klíč k úplné květeně ČSR. – ČSAV, Praha, 982 pp.

DRAKE J.A., MOONEZ H.A., DI CASTRI F., GROVES R.H., KRUGER F.J., REJMÁNEK M. & WILLIAMSON M. (eds.) (1989): Biological Invasions: A Global Perspective, John Wiley & Sons, Chichester, 525 pp.

- E -

EDWARDS K.R. (1995): A critique of the general approach to invasive plant species. – In: Starfinger U., Edwards K., Kowarik I. & Williamson (eds.), Plant Invasions: Ecological Mechanisms and Human Responses, p. 85-94, Backhuys Publishers, Leiden.

- F -

FALIŃSKI J.B. (1998): Invasive alien plants and vegetation dynamics. – In: Starfinger U., Edwards K., Kowarik I. & Williamson (eds.), Plant Invasions: Ecological Mechanisms and Human Responses, p. 23-32, Backhuys Publishers, Leiden.

FALTYSOVÁ H., MACKOVČIN P., SEDLÁČEK M. *et al.* (2002): Královéhradecko. – In: Mackovčin P. & Sedláček M. (eds.), Chráněná území ČR - V. svazek, Agentura ochrany přírody a krajiny ČR a EkoCentrum Brno, Praha, 410 pp.

FORMAN R.T.T. & GORDON M. (1993): Krajinná ekologie. – Academia, Praha, 583 pp.

- G -

GRIMM N.B., GROVE J.M., PICKETT S.T.A. & REDMAN CH.L. (2000): Integrated approaches to long-term studies of urban ecological systems. – BioScience 50(7): 571-584.

- H -

HEJNÝ S. & SLAVÍK B. (eds.) (1988): Květena České republiky 1. – Academia, Praha, 557 pp.

HEJNÝ S. & SLAVÍK B. (eds.) (1990): Květena České republiky 2. – Academia, Praha, 540 pp.

HEJNÝ S. & SLAVÍK B. (eds.) (1992): Květena České republiky 3. – Academia, Praha, 542 pp.

- J -

JIN L., GU Y.J., XIAO M., CHEN J.K. & LI B. (2004): The history of *Solidago canadensis* invasion and the development of its mycorrhizal associations in newly-reclaimed land. – Functional Plant Biology 31(10): 979-986.

- K -

KIM Y.M., ZERBE S. & KOWARIK I. (2002): Human impact on flora and habitats in Korean rural settlements. – Preslia, Praha, 74: 409-419.

KONIJNENDIJK C.C. (2005): New perspectives for urban forests: introducing wild woodlands. – In: Kowarik I. & Körner S. (eds.), Wild Urban Woodlands, p. 33-45, Springer-Verlag, Berlin.

KOWARIK I. (1995a): Time lags in biological invasions with regard to the success and failure of alien species. – In: Pyšek P., Prach K., Rejmánek M. & Wade M. (eds.), Plant Invasions: General Aspects and Special Problems, p. 15-38, SPB Academic Publishing, Amsterdam.

KOWARIK I. (1995b): On the role of alien species in urban flora and vegetation. – In: Pyšek P., Prach K., Rejmánek M. & Wade M. (eds.), Plant Invasions: General Aspects and Special Problems, p. 85-103, SPB Academic Publishing, Amsterdam.

KÜHN I., BRANDL R. & KLOTZ S. (2004): The flora of German cities is naturally species rich. – Evolutionary Ecology Research 6: 749-764.

- L -

LEPŠ J. & ŠMILAUER P. (2000): Mnohorozměrná analýza ekologických dat. – Faculty of Biological Sciences, České Budějovice, 102 pp.

- M -

MANDÁK B., PYŠEK P. & BÍMOVÁ K. (2004): History of the invasion and distribution of Reynoutria taxa in the Czech Republic: A hybrid spreading faster than its parents. – Preslia, Praha, 76: 15-64.

MEYER G., CLARE R. & WEBER E. (2005): An experimental test of the evolution of increased competitive ability hypothesis in goldenrod, *Solidago gigantea*. – Oecologia 144(2): 299-307.

MIHULKA S. (1996): Invazní rostliny v dílčím krajinném úseku. – [Invasive plants in a partial sector of landscape. – Master's Thesis, in Czech] dep. at Faculty of Biological Sciences, University of South Bohemia, České Budějovice, Czech Republic, 38 pp.

- P -

PLANTY-TABACCHI A.M., TABACCHI E., NAIMAN R.J., DEFERRARI C. & DECAMPS H. (1996): Invasibility of species-rich communities in riparian zones. – Conservation Biology 10: 598-607.

PIGNATTI E., PIGNATTI S. & LUCCHESE F. (1995): The plant cover of archeological sites in Central Italy. – In: Sukkop H., Numata M. & Huber A. (eds.), Urban Ecology as the Basis of Urban Planning, p. 43-48, SPB Academic Publishing, Amsterdam.

PYŠEK A. (1995a): Approaches to studying spontaneous settlement flora and vegetation in Central Europe: a review. – In: Sukkop H., Numata M. & Huber A. (eds.), Urban Ecology as the Basis of Urban Planning, p. 23-39, SPB Academic Publishing, Amsterdam.

PYŠEK P. (1992): Settlement outskirts – may they be considered as ecotones?. – Ekológia, Bratislava 11: 273-286.

PYŠEK P. (1995b): On the terminology used in plant invasion studies. – In: Pyšek P., Prach K., Rejmánek M. & Wade M. (eds.), Plant Invasions: General Aspects and Special Problems, p. 71-81, SPB Academic Publishing, Amsterdam.

PYŠEK P. & PYŠEK A. (1995): Invasion by *Heracleum mantegazzianum* in different habitats in the Czech Republic. – Journal of Vegetation Science 6: 711-718.

PYŠEK P., Prach K. & Šmilauer (1995): Relating invasion success to plant traits: an analysis of the Czech alien flora. – In: Pyšek P., Prach K., Rejmánek M. & Wade M. (eds.), Plant Invasions: General Aspects and Special Problems, p. 39-60, SPB Academic Publishing, Amsterdam.

PYŠEK P. (1996): Synantropní vegetace. – MŽPČR, Frýdek-Místek, 90 pp.

PYŠEK P. (1998): Alien and native species in Central European urban floras: a quantitative comparison. – Journal of Biogeography 25: 155-163.

PYŠEK P., PRACH K. & MANDÁK B. (1998): Invasions of alien plants into habitats of central European landscape: an historical pattern. – In: Starfinger U., Edwards K., Kowarik I. & Williamson (eds.), Plant Invasions: Ecological Mechanisms and Human Responses, p. 23-32, Backhuys Publishers, Leiden.

PYŠEK P., TICHÝ L. (2001): Rostlinné invaze. – Rezekvítek, Brno, 40 pp.

PYŠEK P., JAROŠÍK V. & KUČERA T. (2002a): Patterns of invasion in temperate nature reserves. – Biological Conservation 104: 13-24.

PYŠEK P., SÁDLO J. & MANDÁK B. (2002b): Catalogue of alien plants of the Czech Republic. Preslia, Praha, 74: 97-186.

PYŠEK P. & PRACH K. (2003): Research into plant invasions in a cross-roads region: history and focus. – Biological Invasions 5: 337-348.

PYŠEK P., SÁDLO J., MANDÁK B. & JAROŠÍK V. (2003): Czech alien flora and the historical pattern of its formation: what came first to Central Europe? – Oecologia 135: 122-130.

PYŠEK P., RICHARDSON D.M. & WILIAMSON M. (2004): Predicting and explaining plant invasions through analysis of source area floras: some critical considerations. – Diversity and Distributions 10: 179-187.

- R -

REJMÁNEK M. (1995): What makes a species invasive?. – In: Pyšek P., Prach K., Rejmánek M. & Wade M. (eds.), Plant Invasions: General Aspects and Special Problems, p. 3-13, SPB Academic Publishing, Amsterdam.

RICHARDSON D.M., PYŠEK P., REJMÁNEK M., BARBOUR M.G., PANETTA F.D. & WEST C.J. (2000): Naturalization and invasion of alien plants: concepts and definitions. – Diversity and Distributions 6: 93-107.

ROTHMALER W. (2000): Excursionsflora von Deutschland. – Spektrum Akademischer Verlag, Berlin, 753 pp.

- S -

SLAVÍK B. (eds.) (1995): Květena České republiky 4. – Academia, Praha, 529 pp.

SLAVÍK B. (eds.) (1997): Květena České republiky 5. – Academia, Praha, 568 pp.

SLAVÍK B. (eds.) (2000): Květena České republiky 6. – Academia, Praha, 770 pp.

SLAVÍK B. & ŠTĚPÁNKOVÁ J. (eds.) (2004): Květena České republiky 7. – Academia, Praha, 767 pp.

STARFINGER U. (1998): On success in plant invasions. – In: Starfinger U., Edwards K., Kowarik I. & Williamson (eds.), Plant Invasions: Ecological Mechanisms and Human Responses, p. 33-42, Backhuys Publishers, Leiden.

STOHLGREN T.J., BINKLEY D., CHONG G.W., KALKHAN M.A., SCHELL L.D., BULL K.A. OTSUKI Y., NEWMAN G., BASHKIN M. & SON Y. (1999): Exotic plant species invade hot spots of native plant diversity. – Ecological Monographs 69: 25-46.

SUKOPP H. & WERNER P. (1983): Urban environment and vegetation. – In: Holzner W., Werger M.J.A. & Ikusima I. (eds.), Man's Impact on Vegetation, p. 247-260, Junk publishers, The Hague.

SUKOPP H. (1998): On the study of anthropogenic plant migrations in Central Europe. – In: Starfinger U., Edwards K., Kowarik I. & Williamson (eds.), Plant Invasions: Ecological Mechanisms and Human Responses, p. 43-56, Backhuys Publishers, Leiden.

SUKOPP H. (2002): On the early history of urban ecology in Europe. – Preslia, Praha, 74: 373-393.

- Š -

ŠMILAUER P. (1992): CanoDraw user's guide v. 3.0. – Microcomputer Power, Ithaca, USA, 118 pp.

ŠTAJEROVÁ K. (in prep.): The arbuscular mycorrhizal symbiosis of invasive plants in the Czech Republic.

- V -

VIŠŇÁK R. (1997): Invazní neofyty v části České republiky. – In: Pyšek P. & Prach K. (eds.), Invazní rostliny v české flóře, p. 105-115, ČBS, Praha.

- W -

WEBER E. (19 98): The dynamics of plant invasions: a case study of three exotic goldenrod species (*Solidago* L.) in Europe. – Journal of Biogeography 25: 147-154.

- Z -

ZERBE S. & L EE Y.M. (200 0): Cultivated plants in farm gardens reflecting cultural history and current development of the rural landscape-Korean highland villages as example. – Archiv für Naturschutz Landschaftsforschung 39: 191-214.

ZERBE S., MAUER U., SCHMITZ S. & SUKOPP H. (2003): Biodiversity in Berlin and its potential for nature conservation. – Landscape and Urban Planning 62: 139-148.

ZERBE S., CHOI I. & KOWARIK I. (2004): Characteristics and habitats of non-native plant species in the city of Chonju, Southern Korea. – Ecological Research 19: 91-98.

PERNAMENT ELECTRONIC SOURCES:

www.BM-CZ (2006): http://www.mapy.cz/ - web pages of aerial photographs.

www.HK (2006): http://www.hradeckralove.org/ - web pages of the city of Hradec Králové.

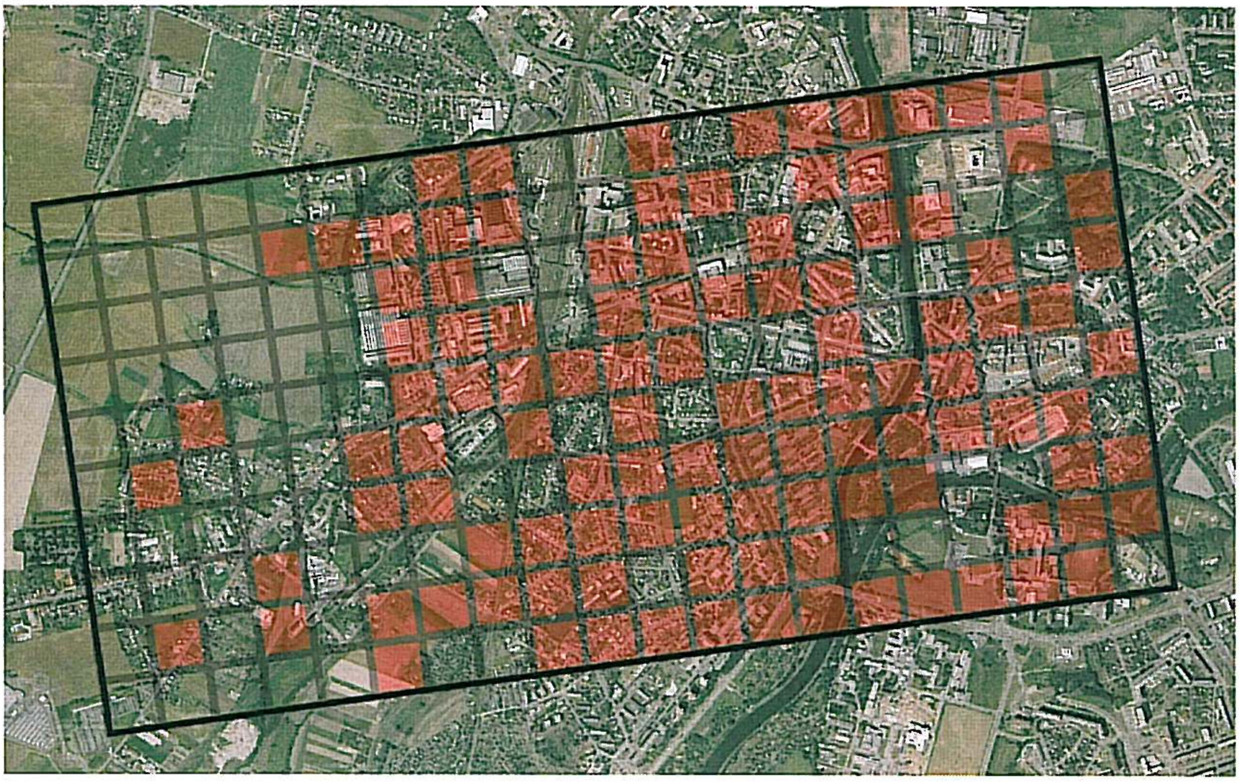
www.CHU (2006): http://www.chmi.cz/chmi.html - web pages of the Czech hydrometeorological institute.

MAPS:

1:10 000 (2003): Sheets no. 13-22-23, 13-24-03. – Český úřad zeměměřický a katastrální, Pardubice.

1:5 000 (2003): Sheets no. 061160, 061161, 061170, 061171. – Český úřad zeměměřický a katastrální, Pardubice.

APPENDIX 1 Aerial photographs with a mapping grid for ten present land-use types (1 square 200×200 m).



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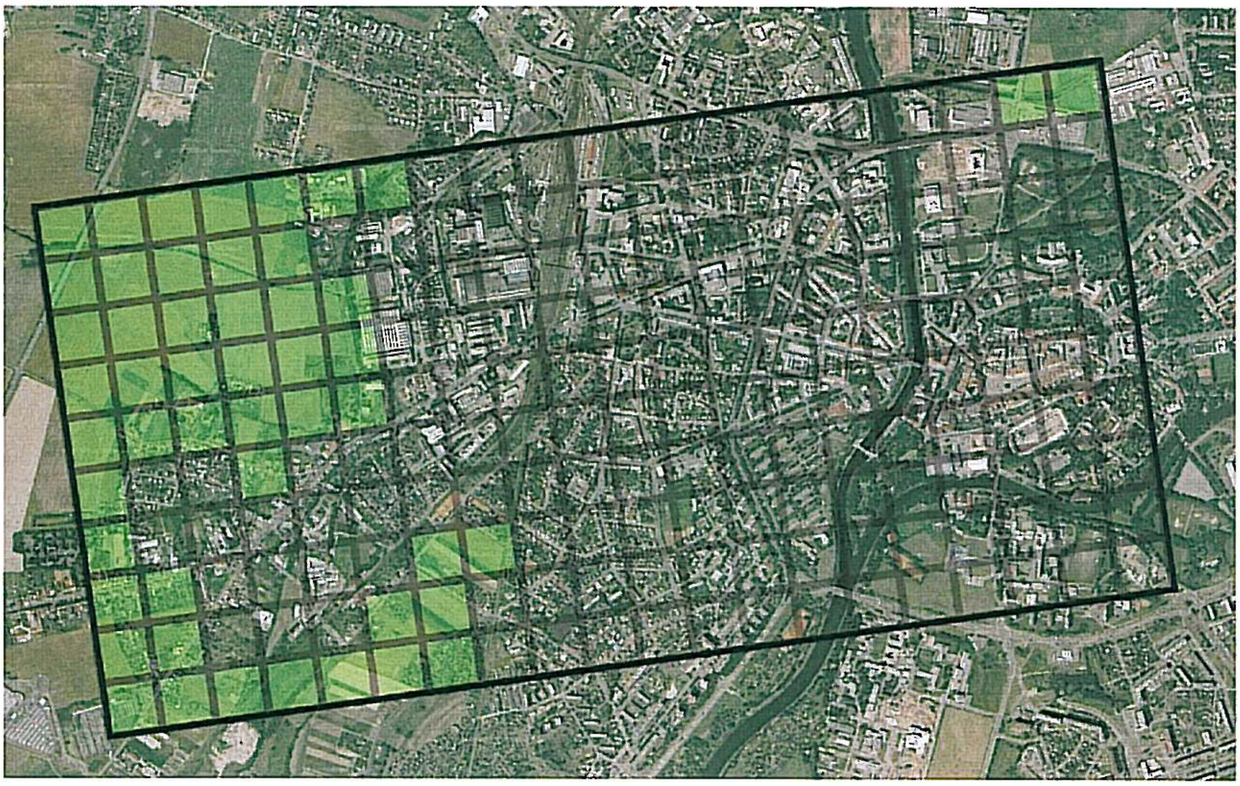
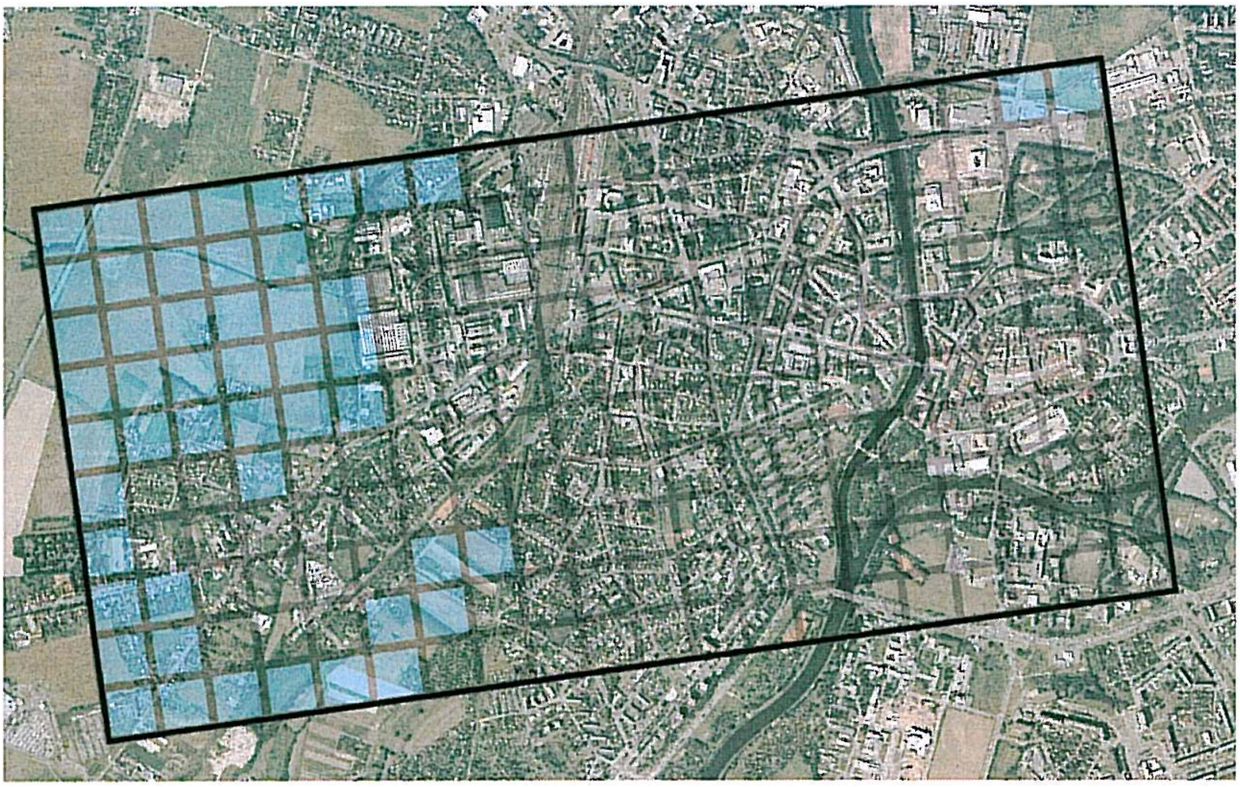
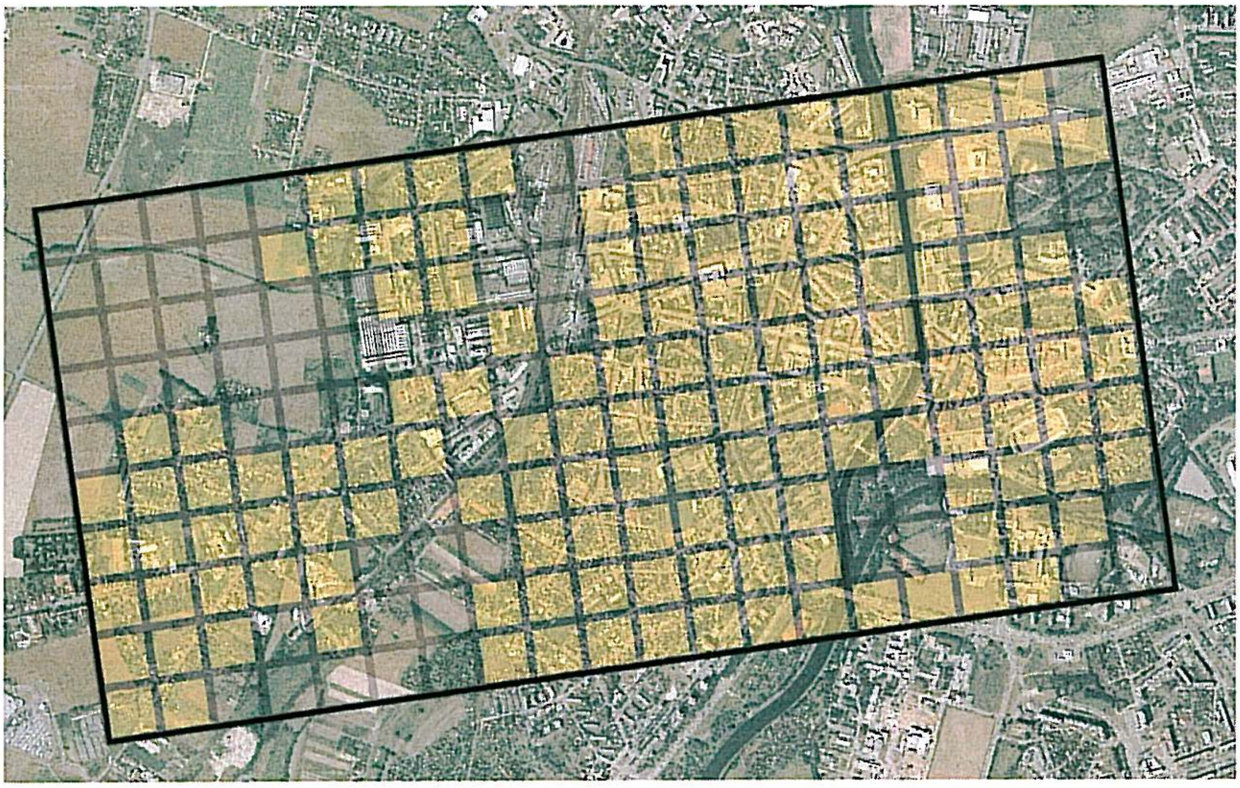


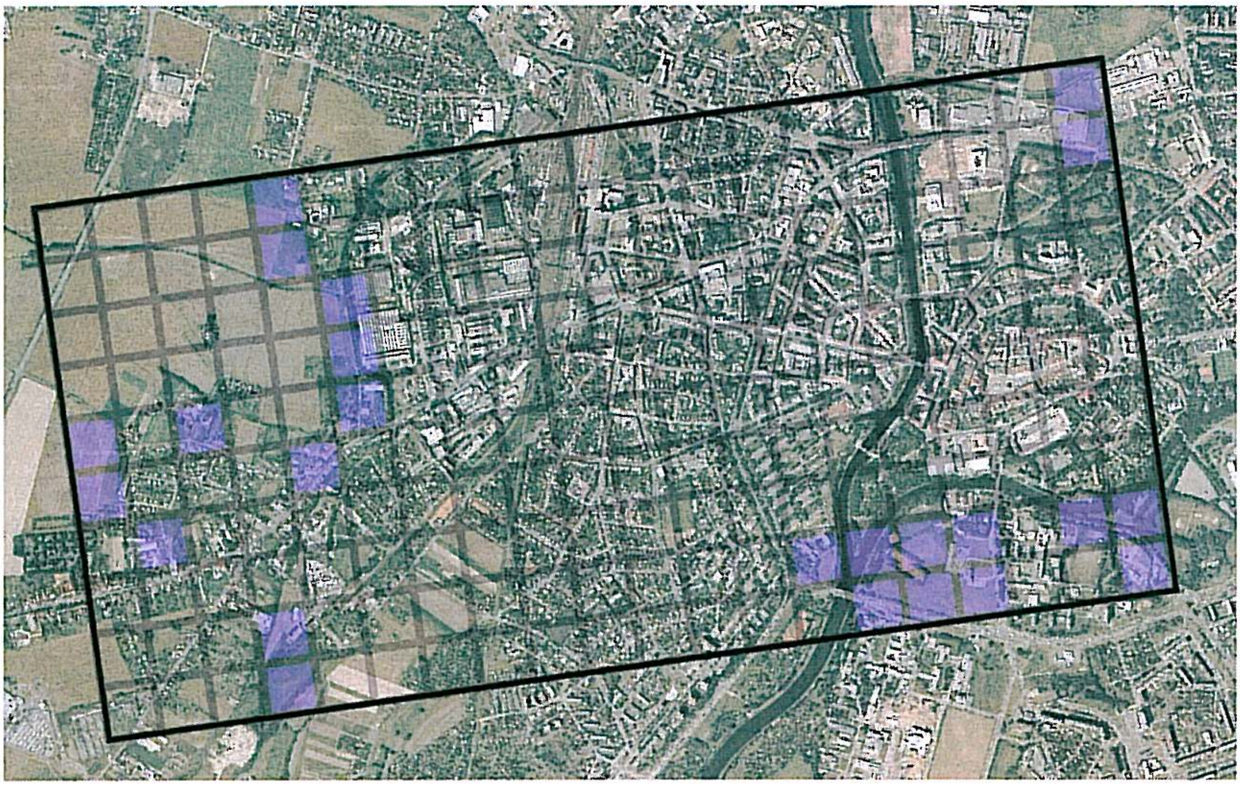
FIELDS



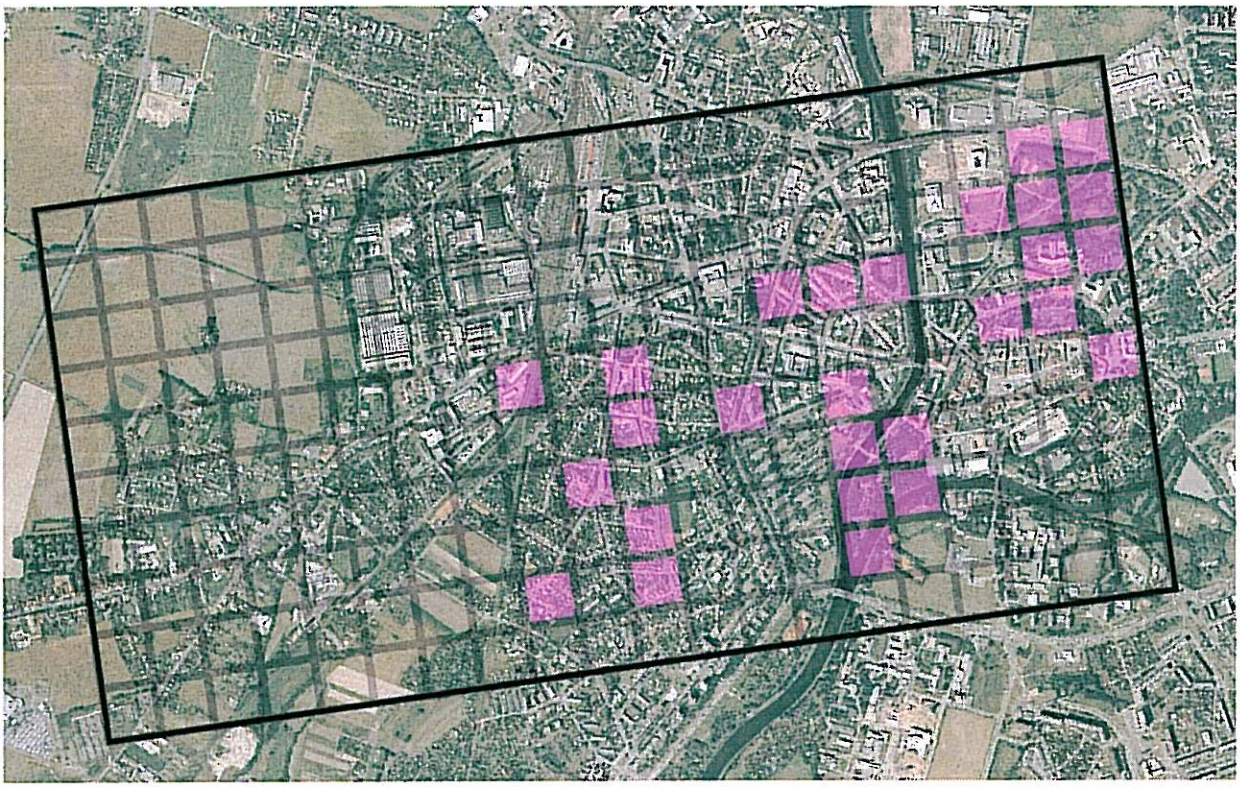
FIELD BORDERS



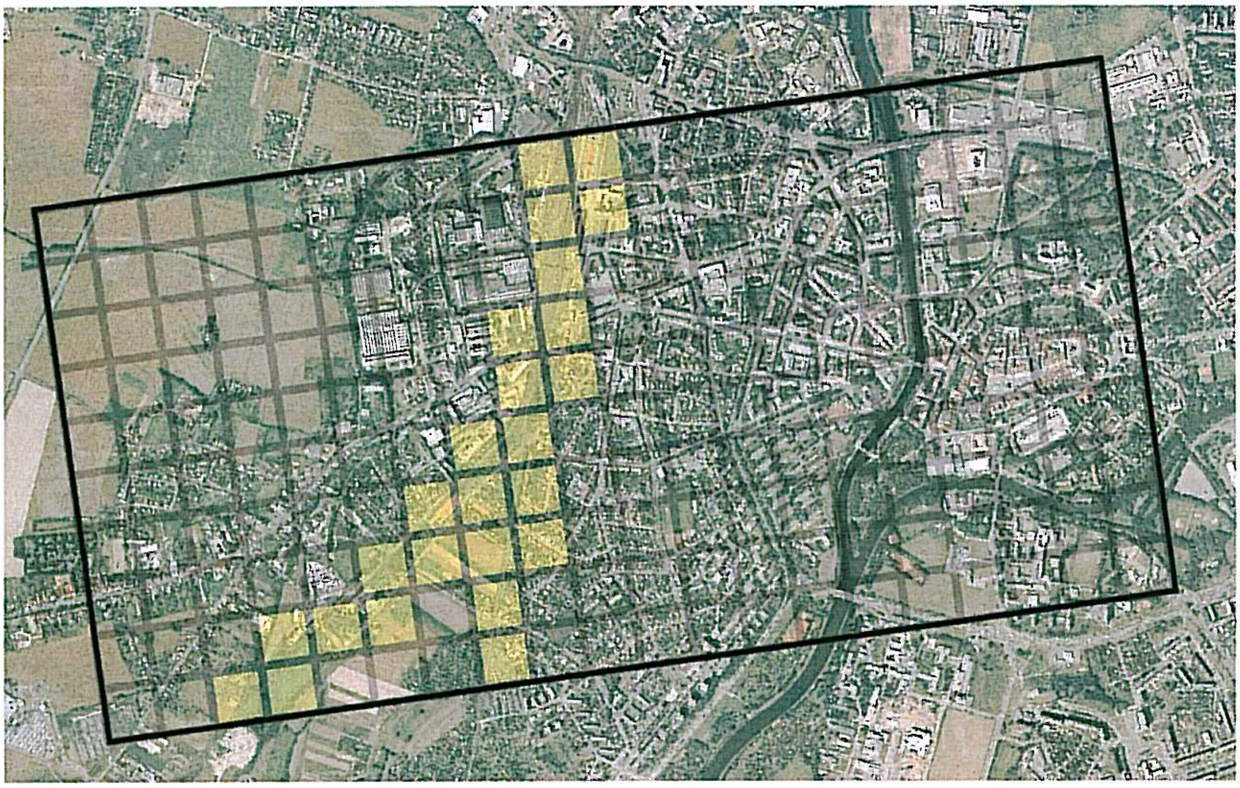
GRASS PLOTS



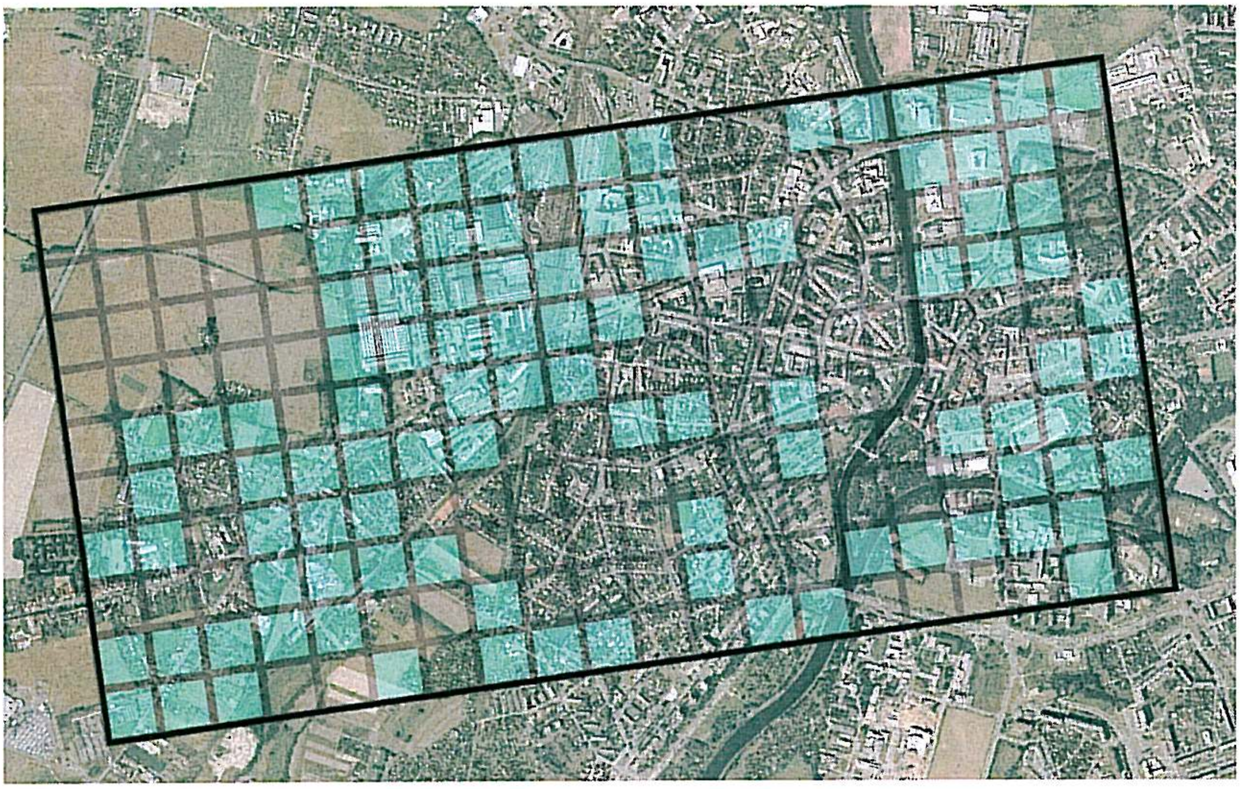
MEADOWS



PARKS AND GARDENS

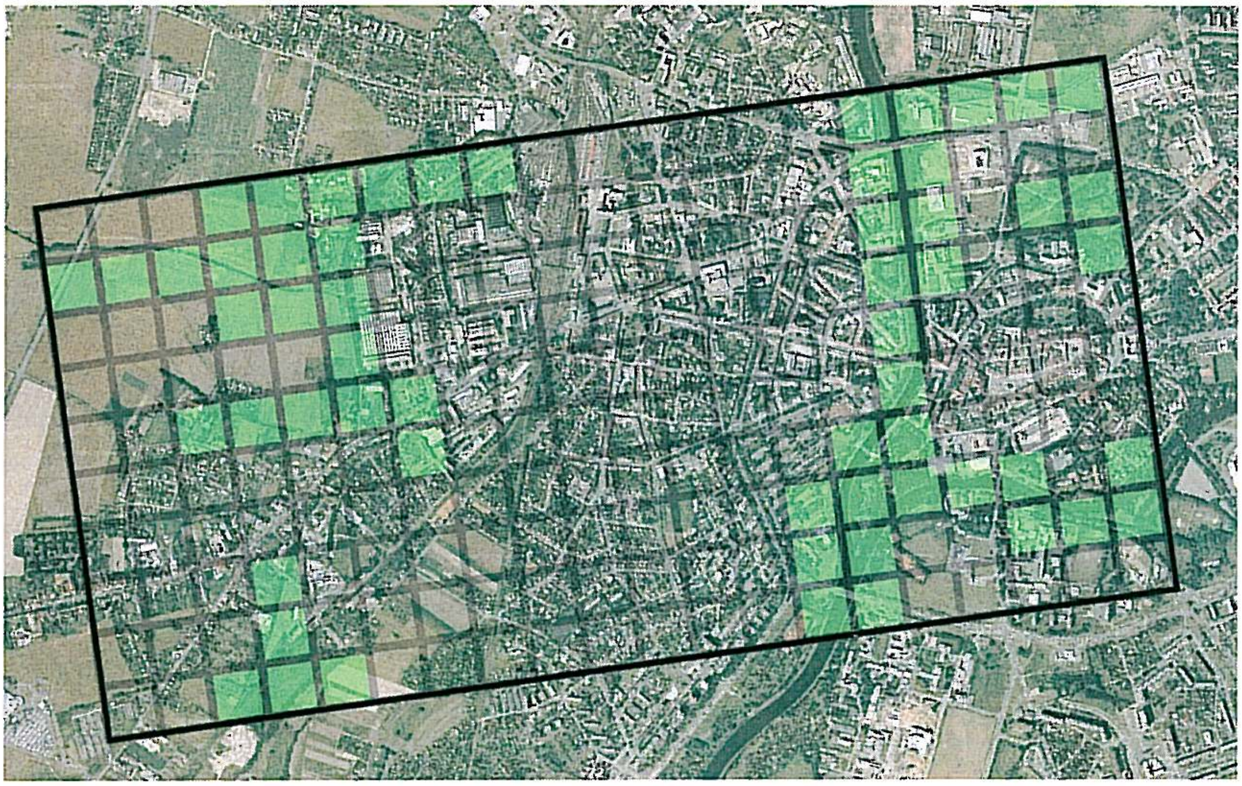


RAILWAY SITES

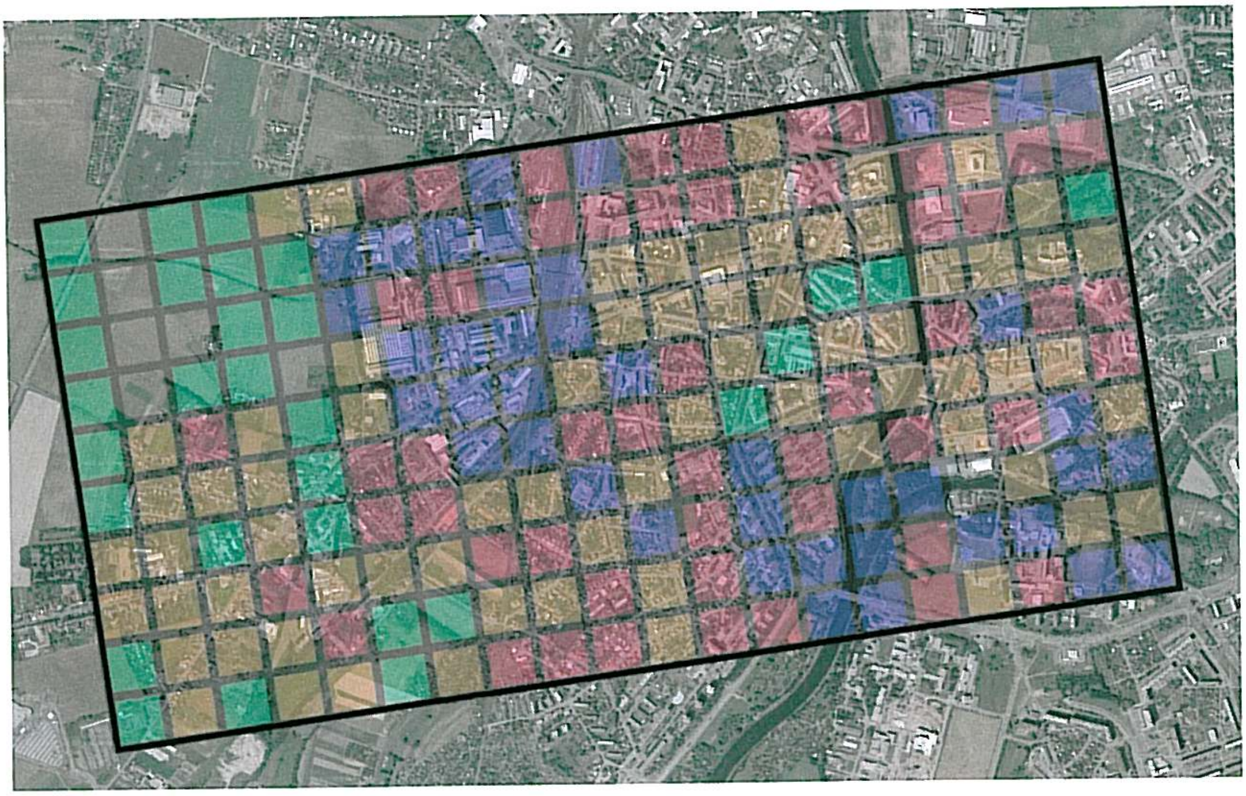


RUDERAL SITES

STREET BORDERS

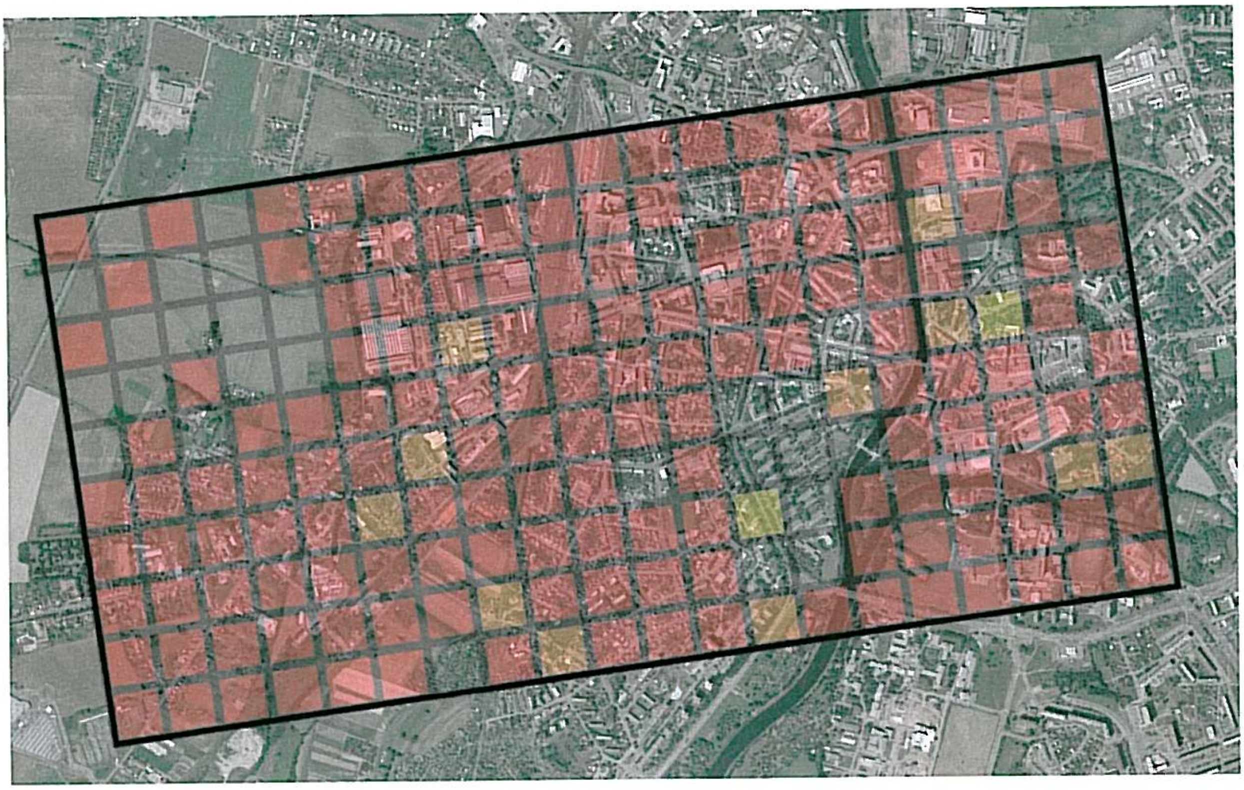


WATER BORDERS

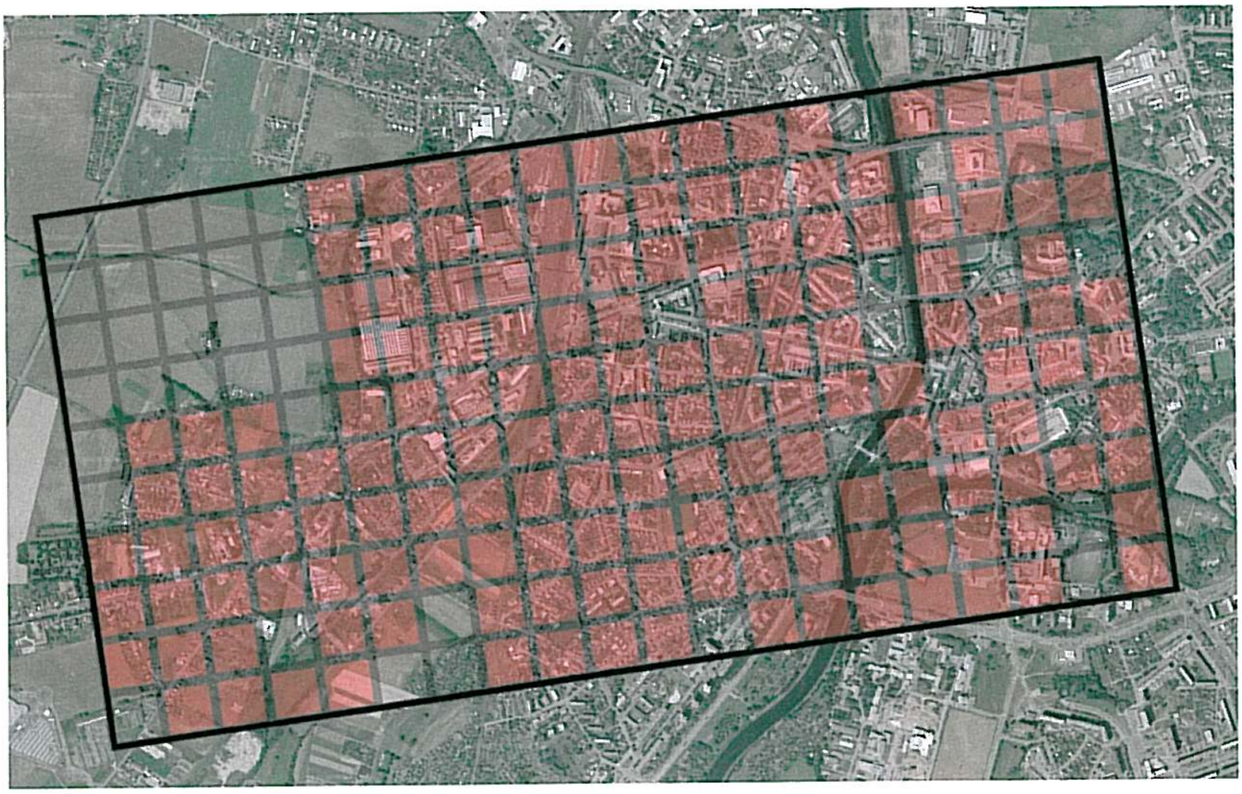


Appendix 2 Aerial photograph with a mapping grid of species' diversity. Legend: Violet: X ≥ 10 (X=number of species in the studied sample plot), **Red:** 6 < X ≤ 9, Yellow: 3 < X ≤ 6, **Green:** 0 < X ≤ 3. Vacant sample plots have no records.

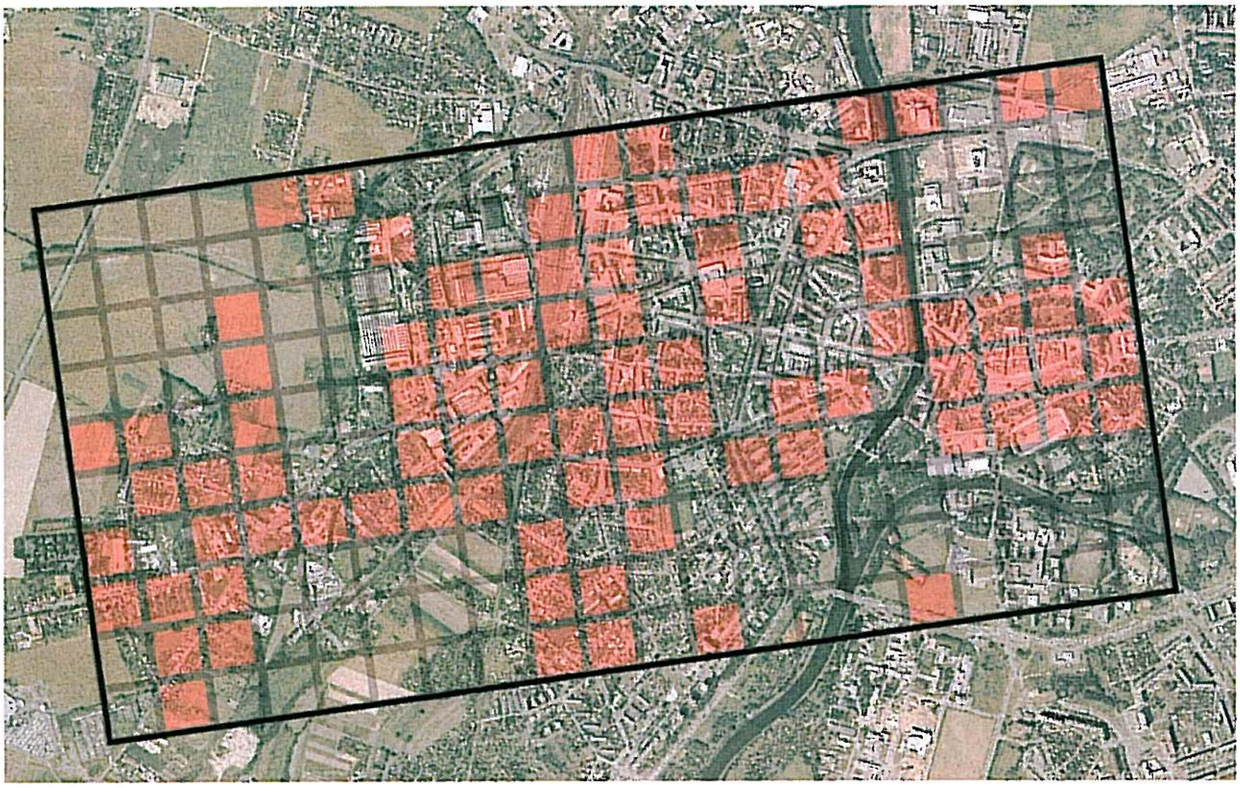
APPENDIX 3 Aerial photographs with a mapping grid for the thirty most frequent species (including species which occurred on more than five sample plots). Legend: **RED** – the species was observed during the spreading only, ORANGE – the species was observed in the cultivation from which it expanded into new areas, YELLOW - the species was observed in non-expansive cultivation only.



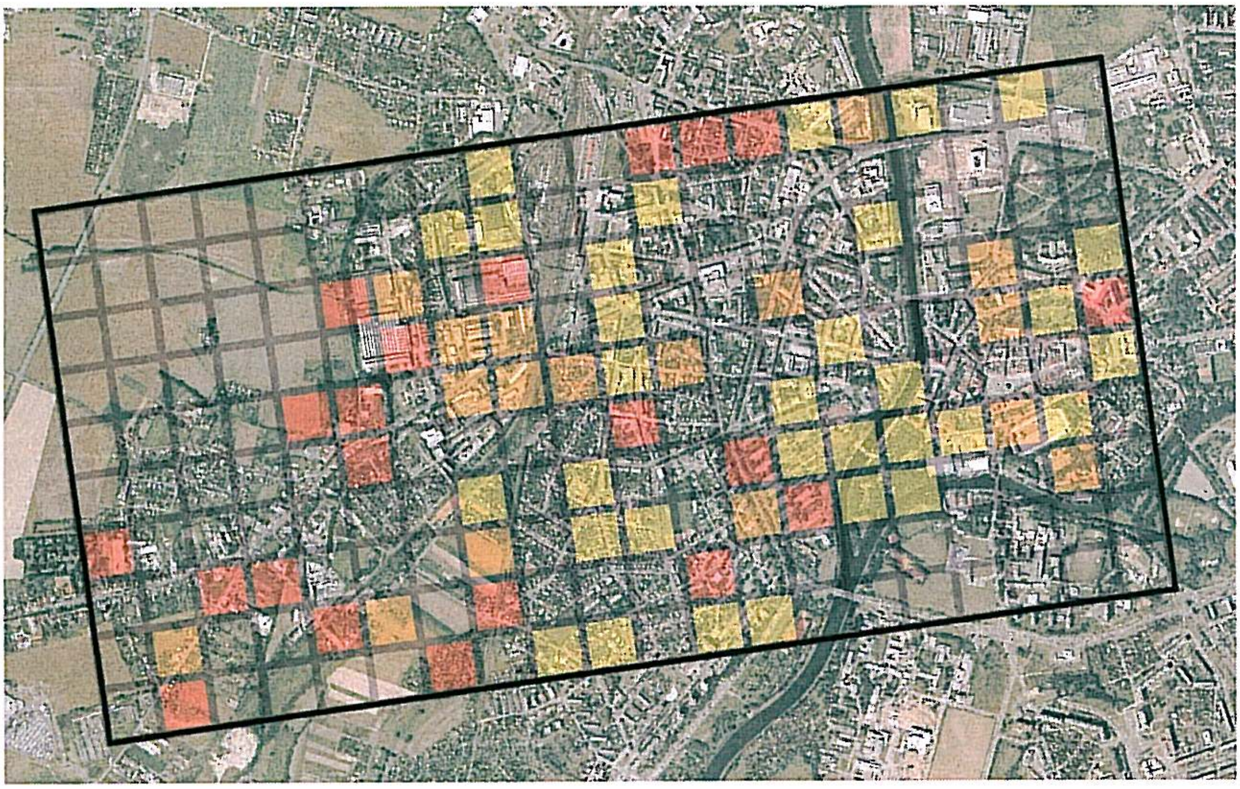
SOLIDAGO CANADENSIS (168 sample plots)



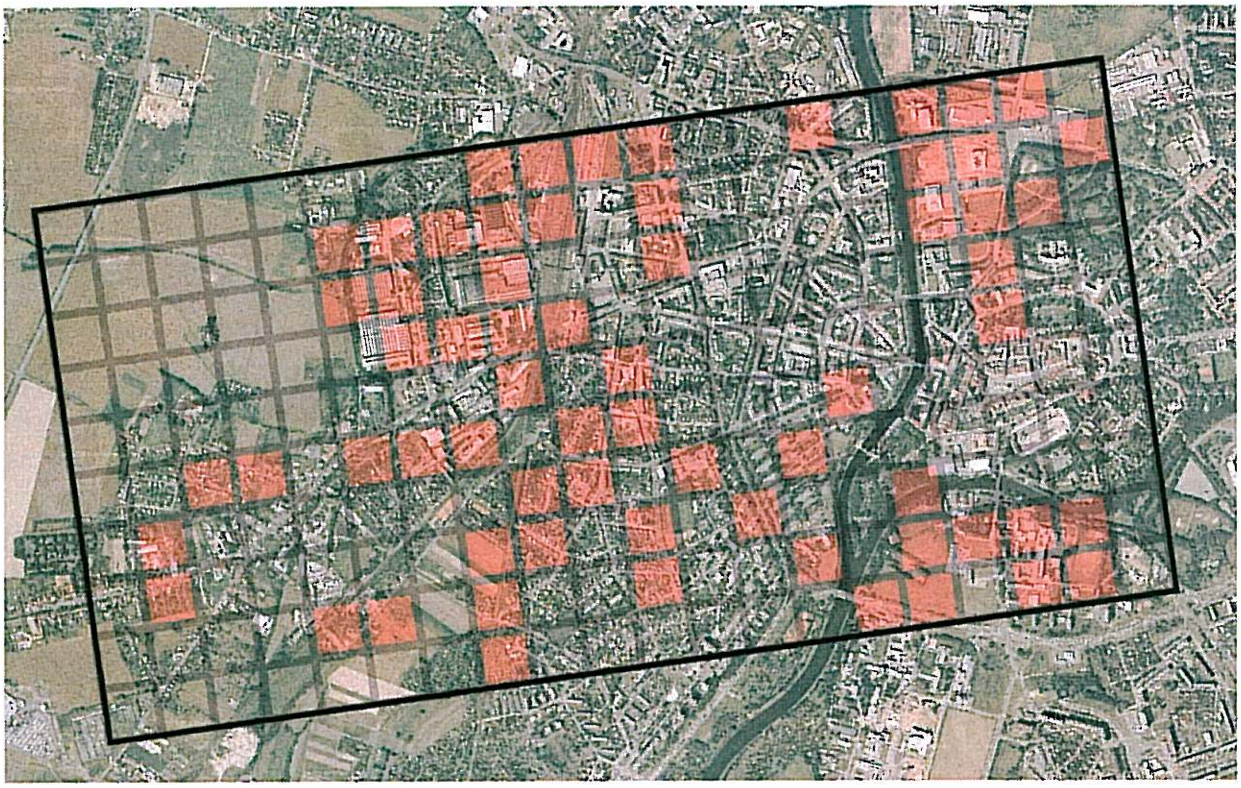
CONYZA CANADENSIS (158 sample plots)



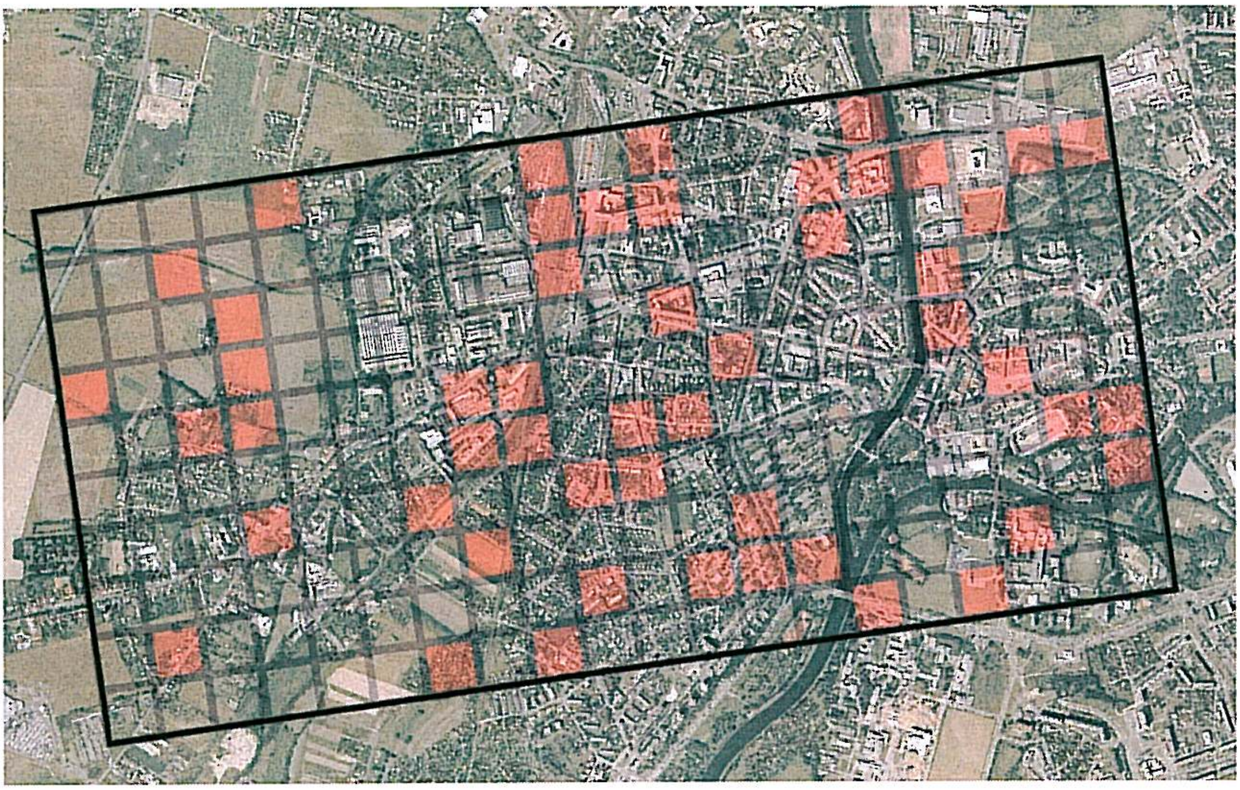
Galinsoga parviflora (89 sample plots)



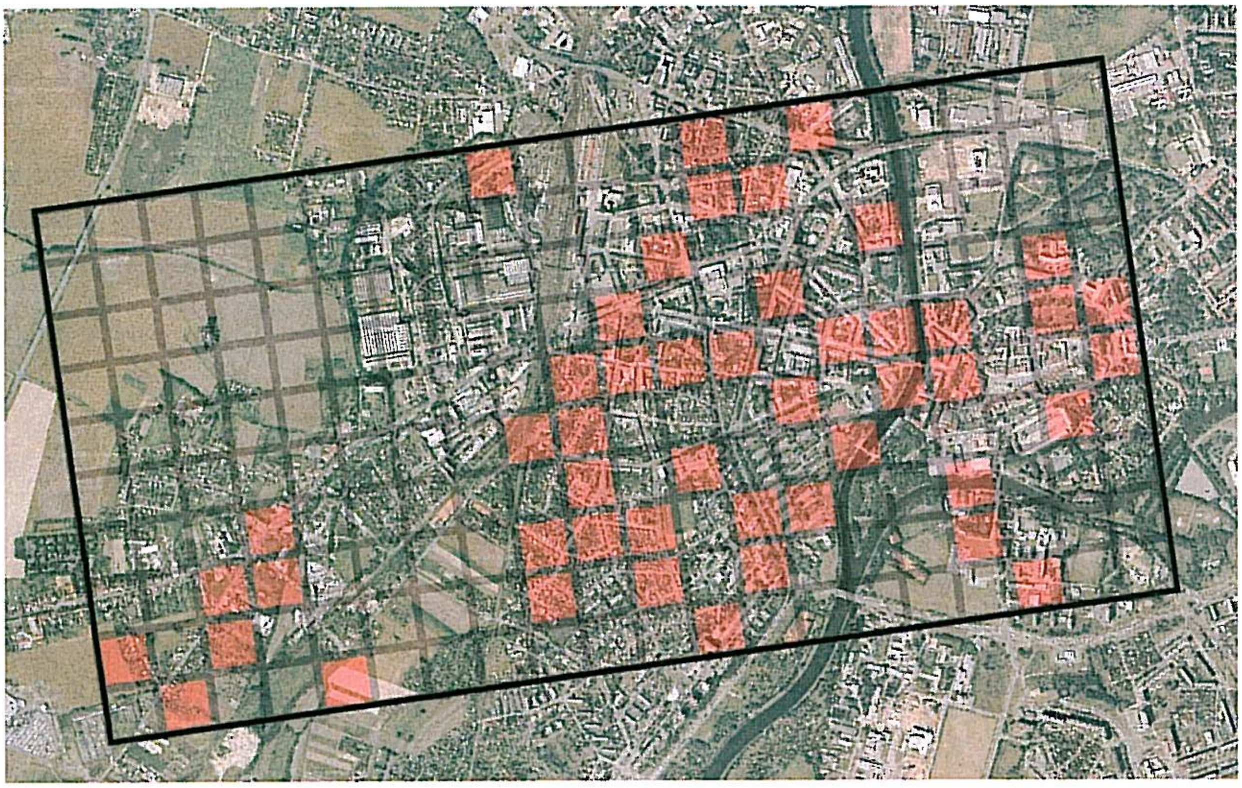
Syringa vulgaris (70 sample plots)



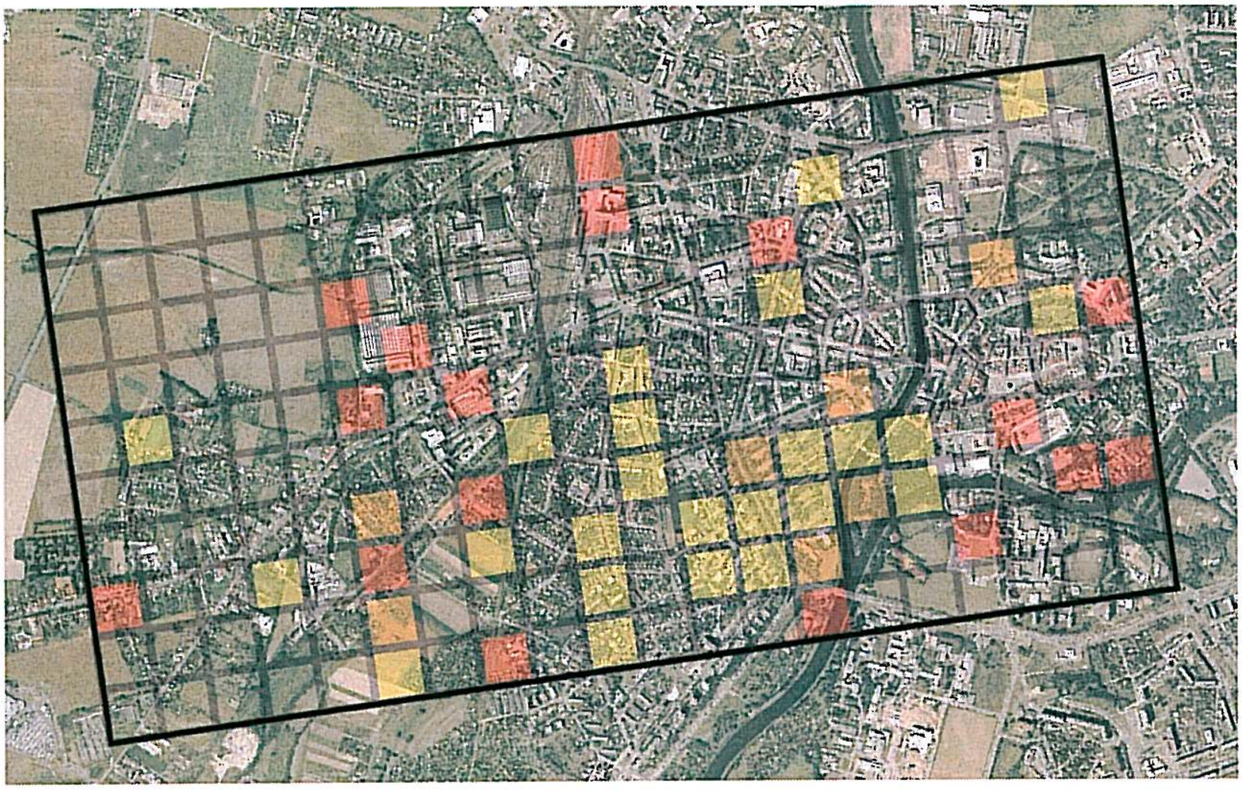
***ERIGERON* AGG.** (65 sample plots)



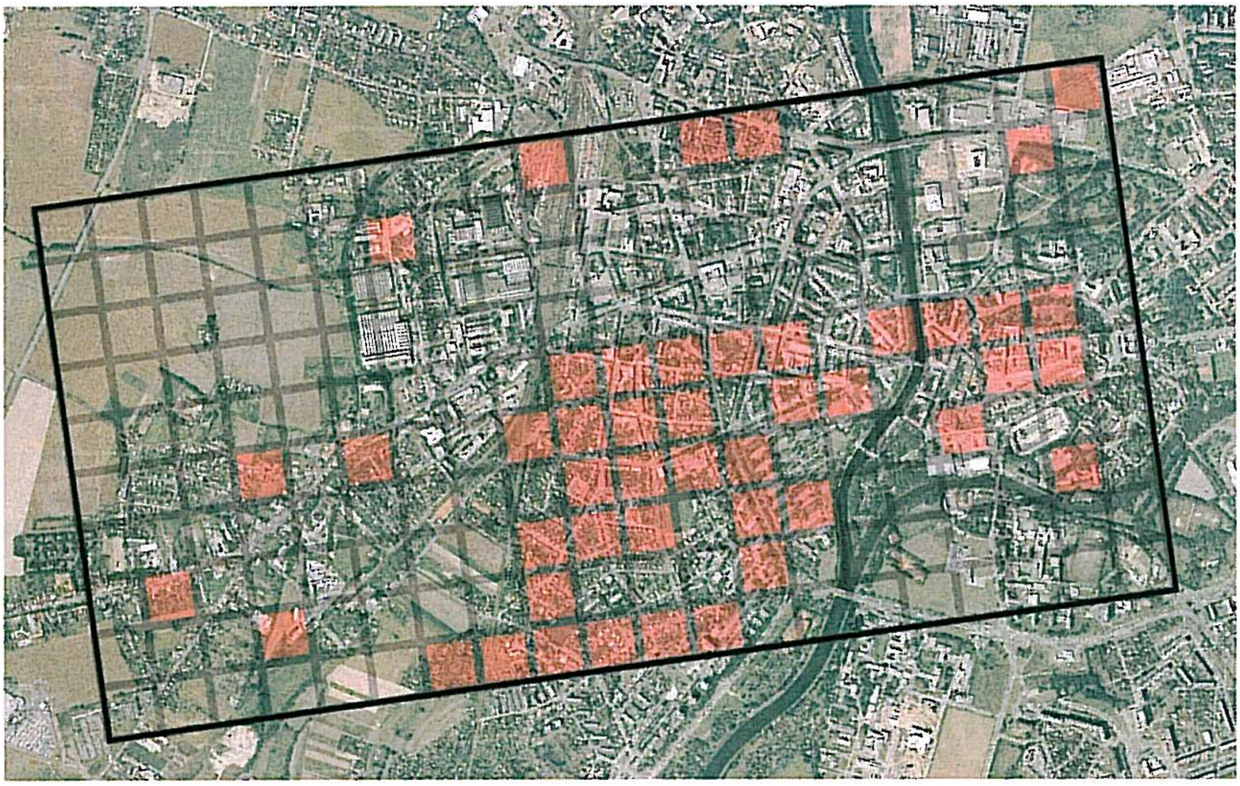
AMARANTHUS RETROFLEXUS (51 sample plots)



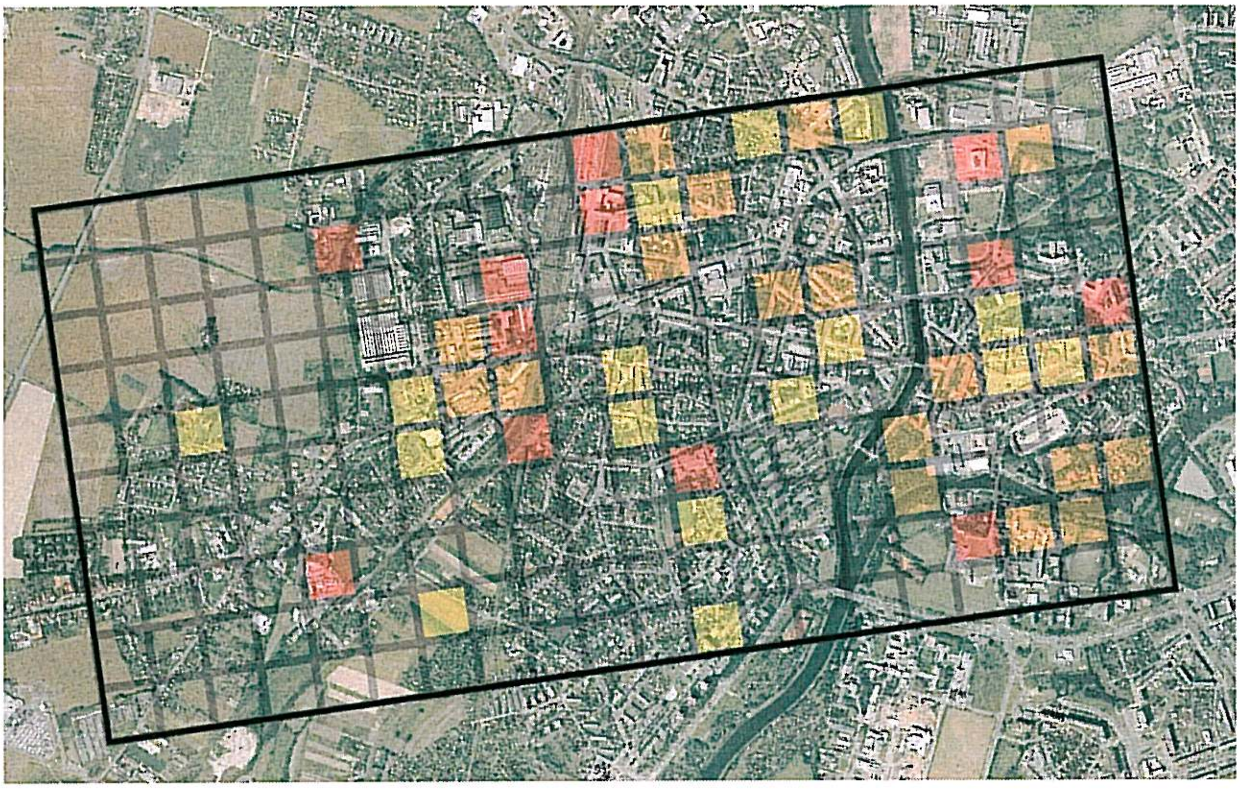
Matricaria discoidea (48 sample plots)



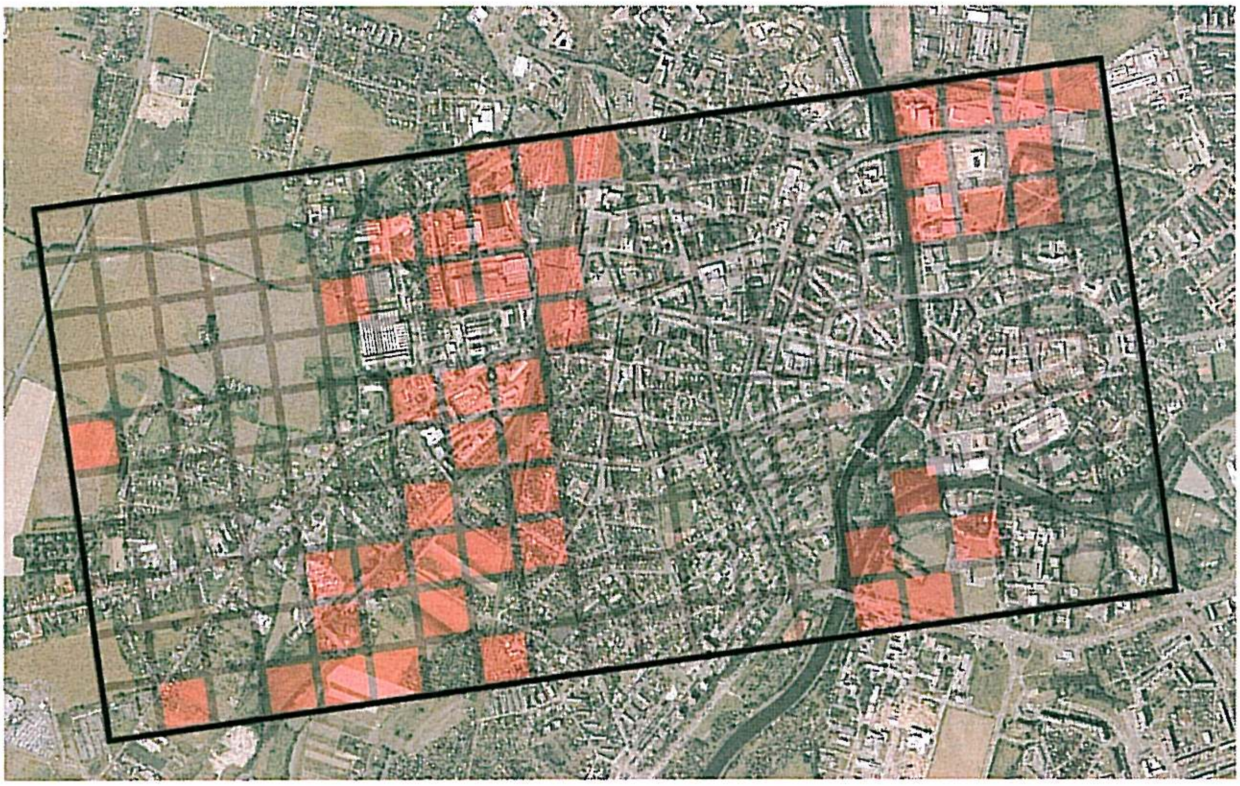
Symphoricarpos albus (48 sample plots)



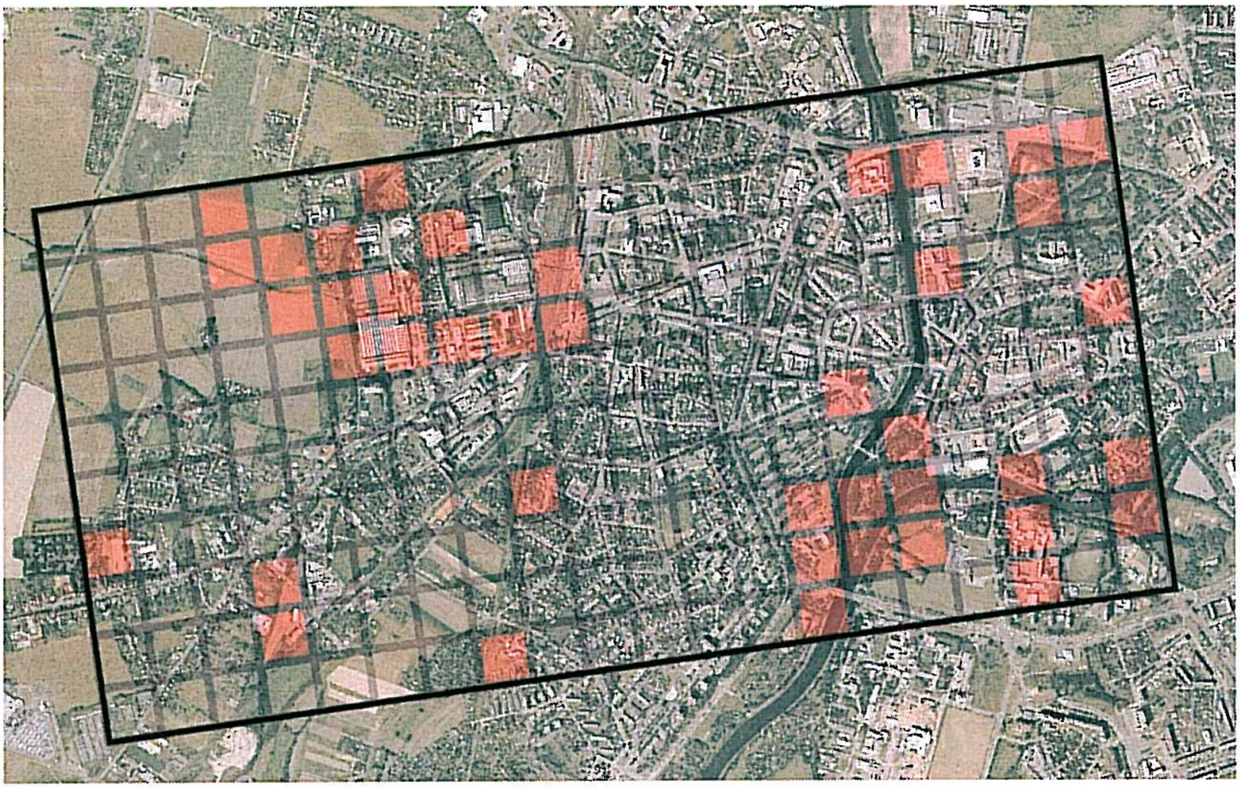
Galinsoga ciliata (46 sample plots)



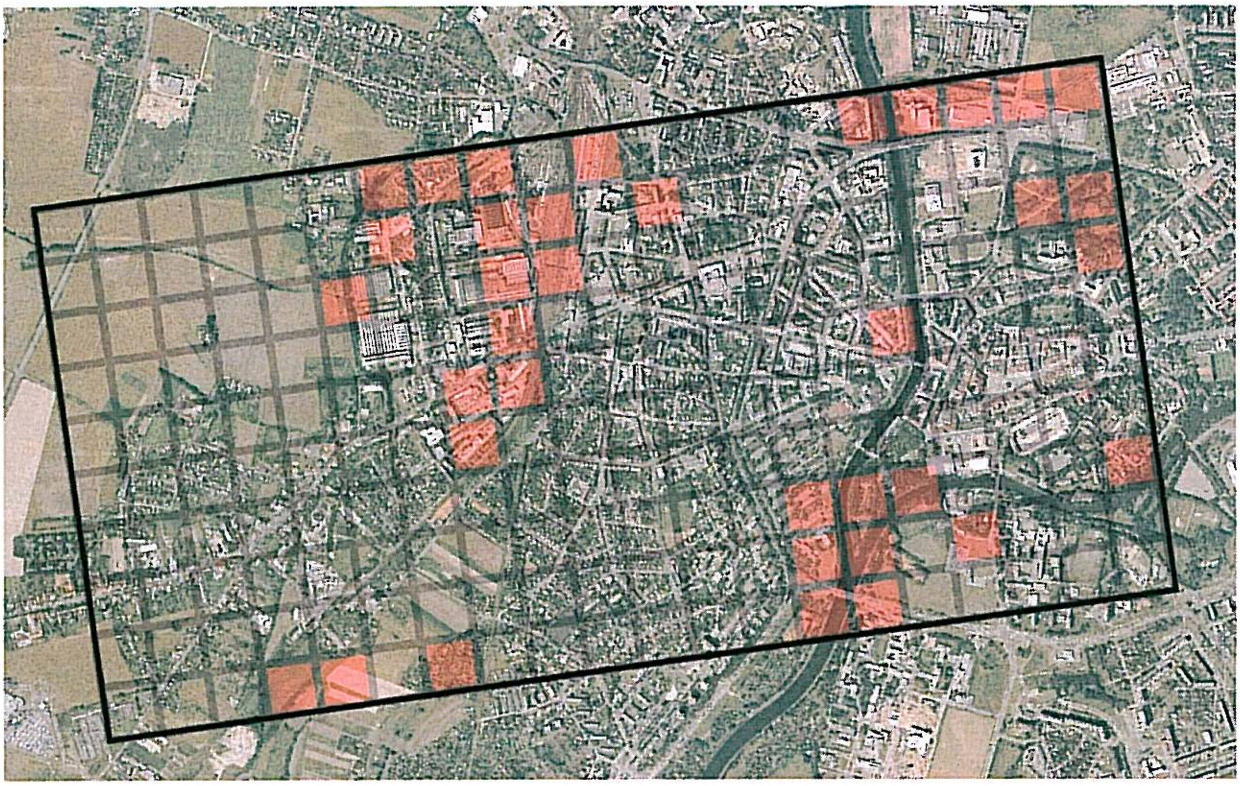
Robinia pseudacacia (46 sample plots)



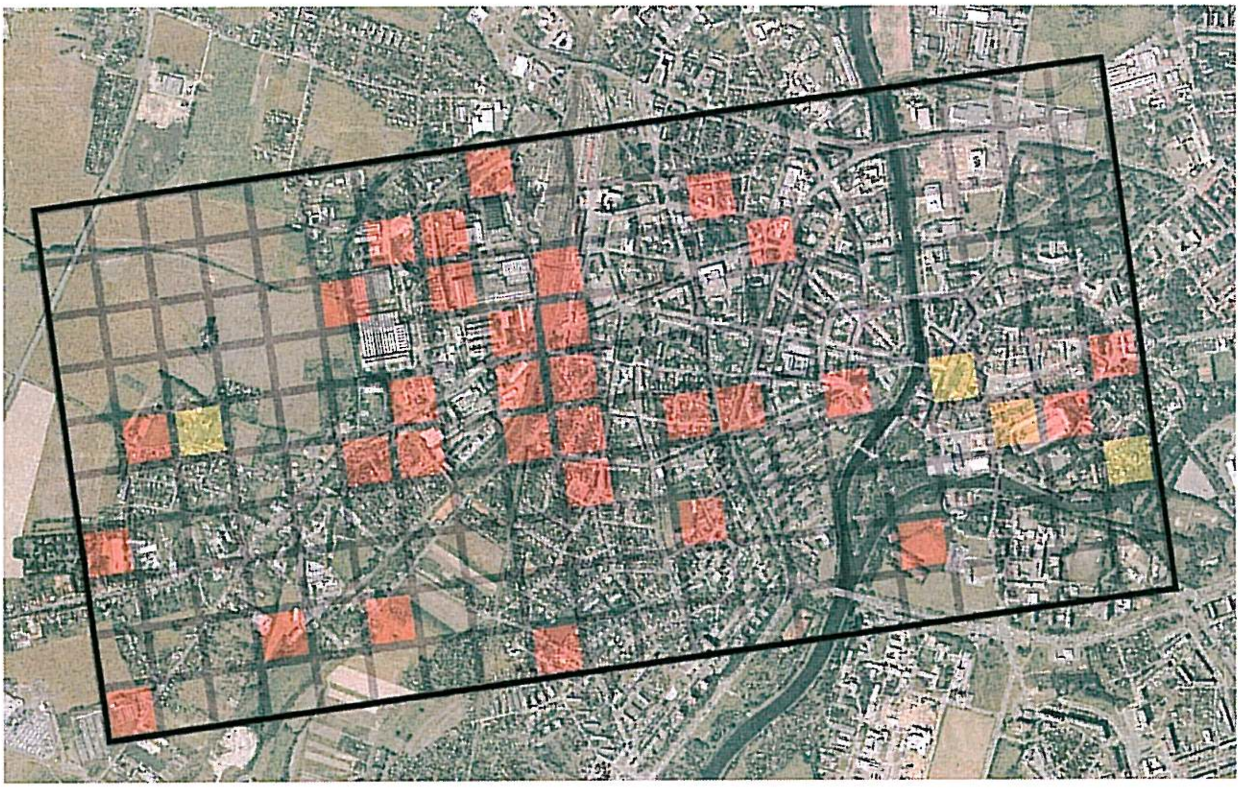
RUMEX THYRSIFLORUS (45 sample plots)



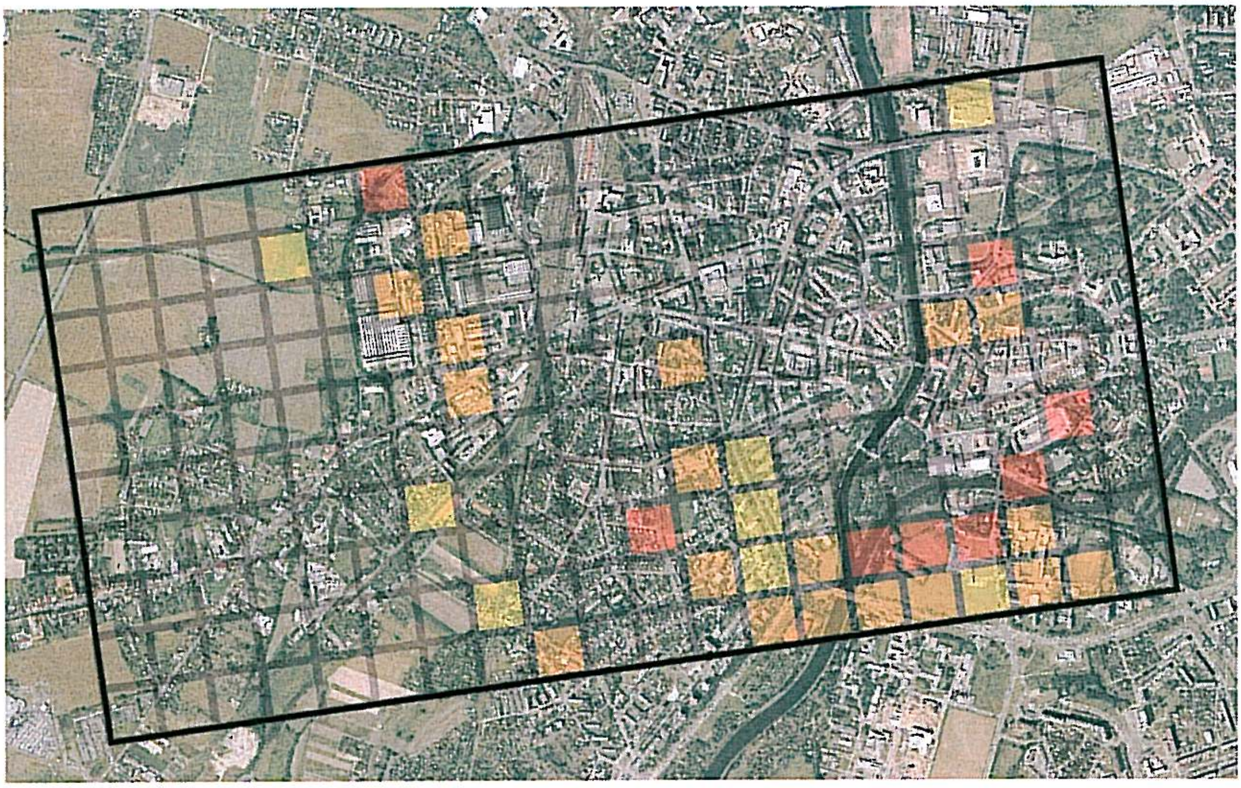
IMPATIENS PARVIFLORA (41 sample plots)



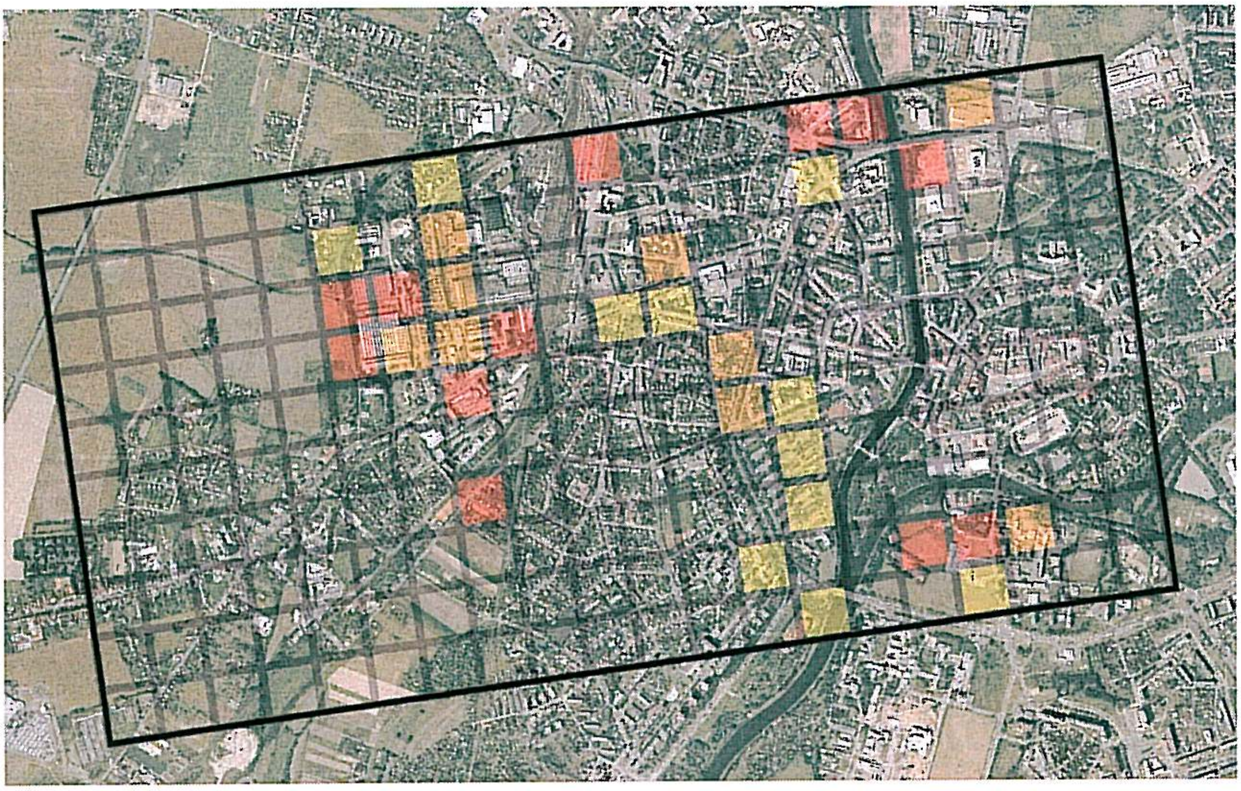
Bidens frondosa (36 sample plots)



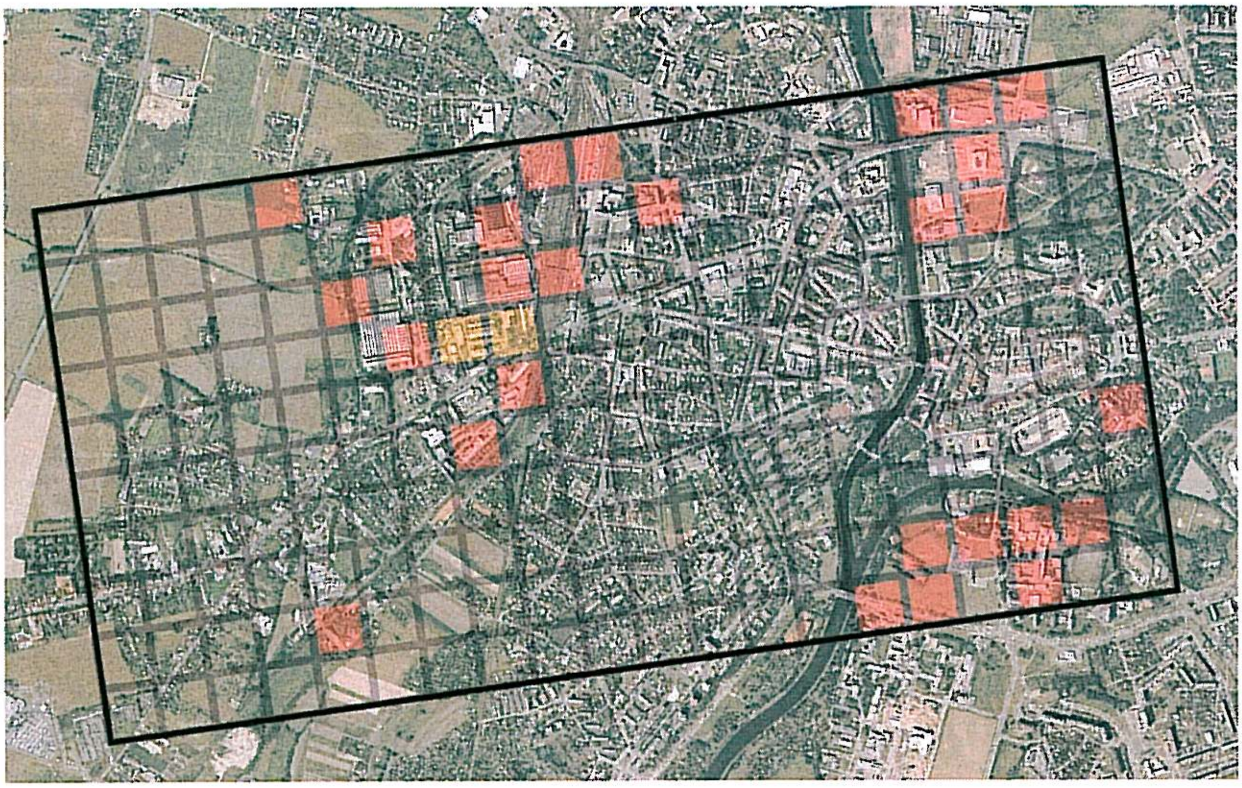
Parthenocissus inserta (35 sample plots)



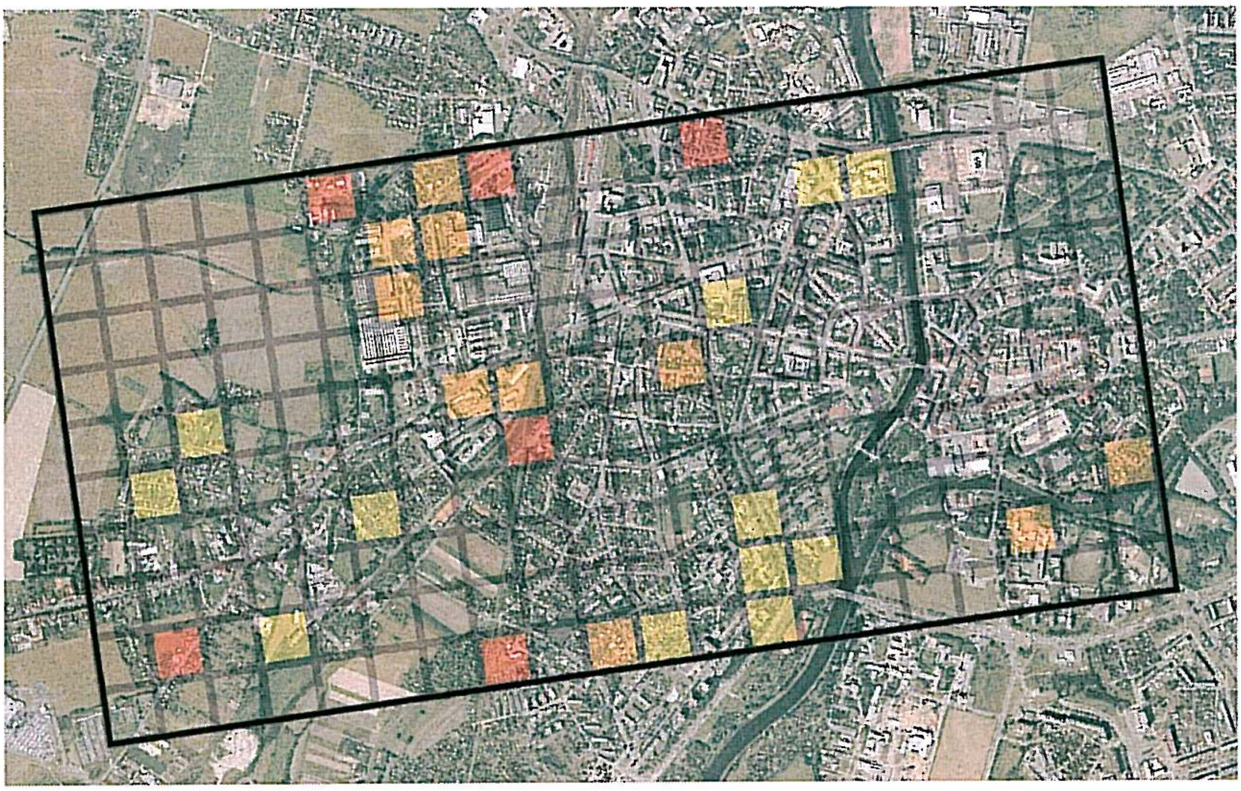
Acer negundo (34 sample plots)



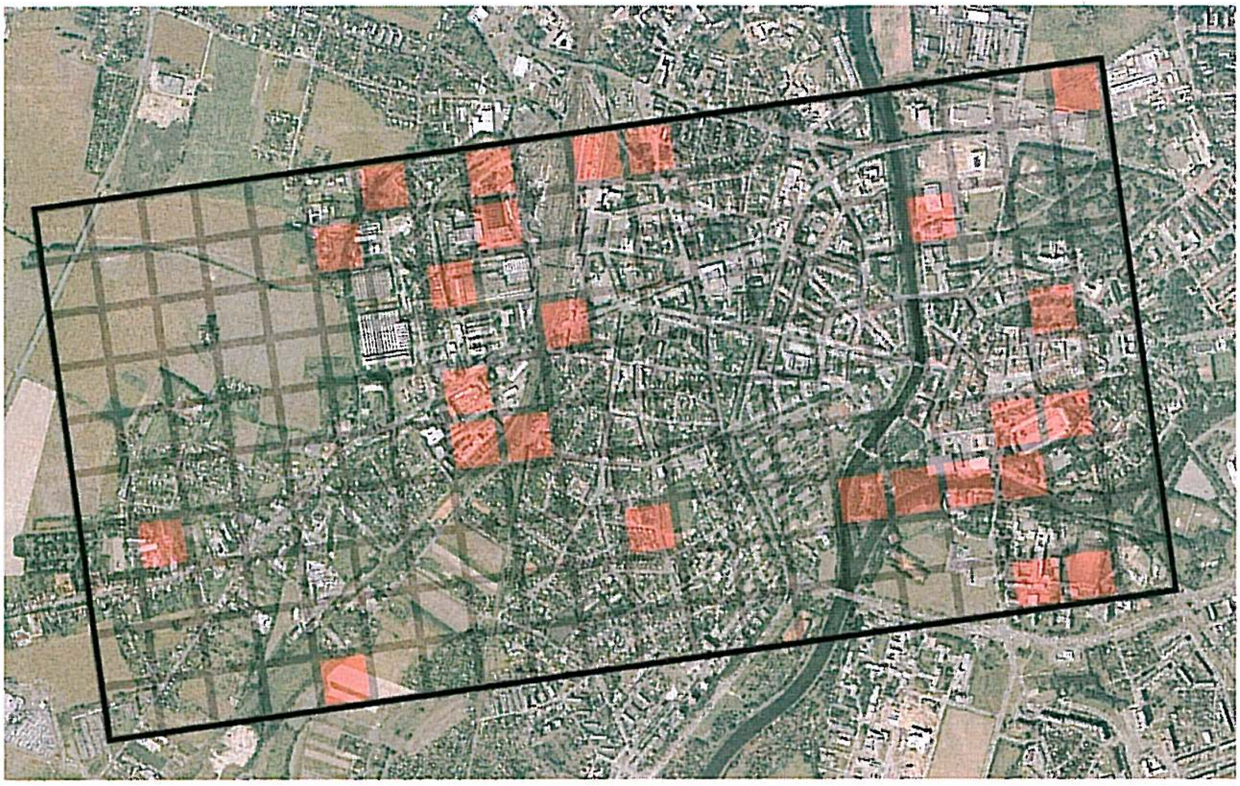
Populus canadensis (32 sample plots)



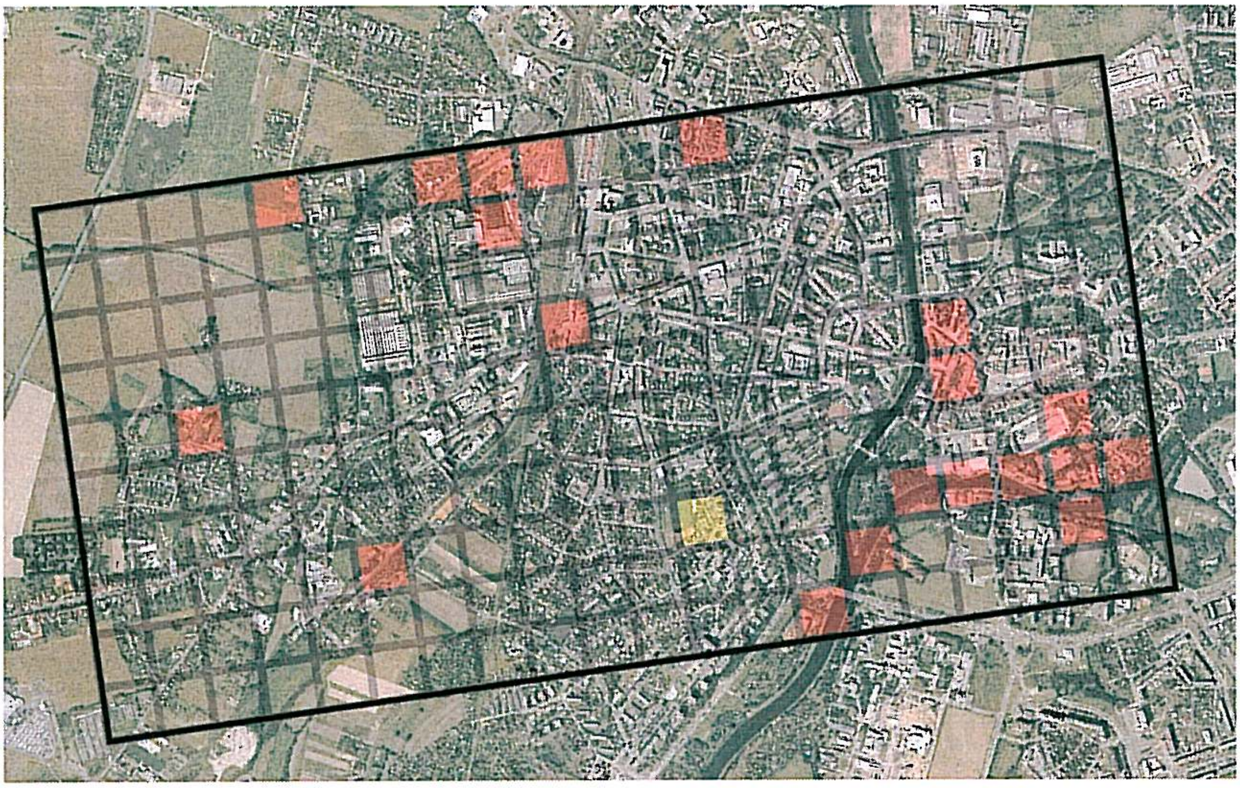
***OENOTHERA* SPP.** (29 sample plots)



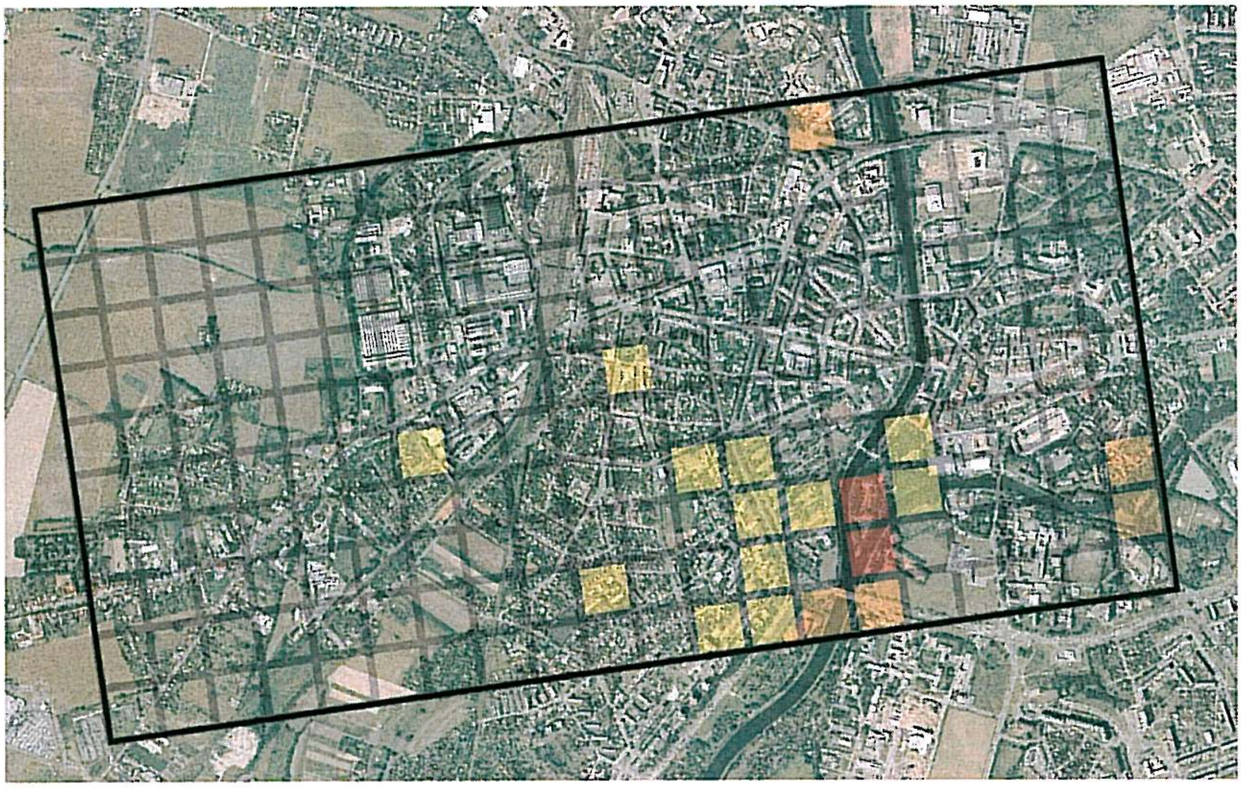
RHUS HIRTA (28 sample plots)



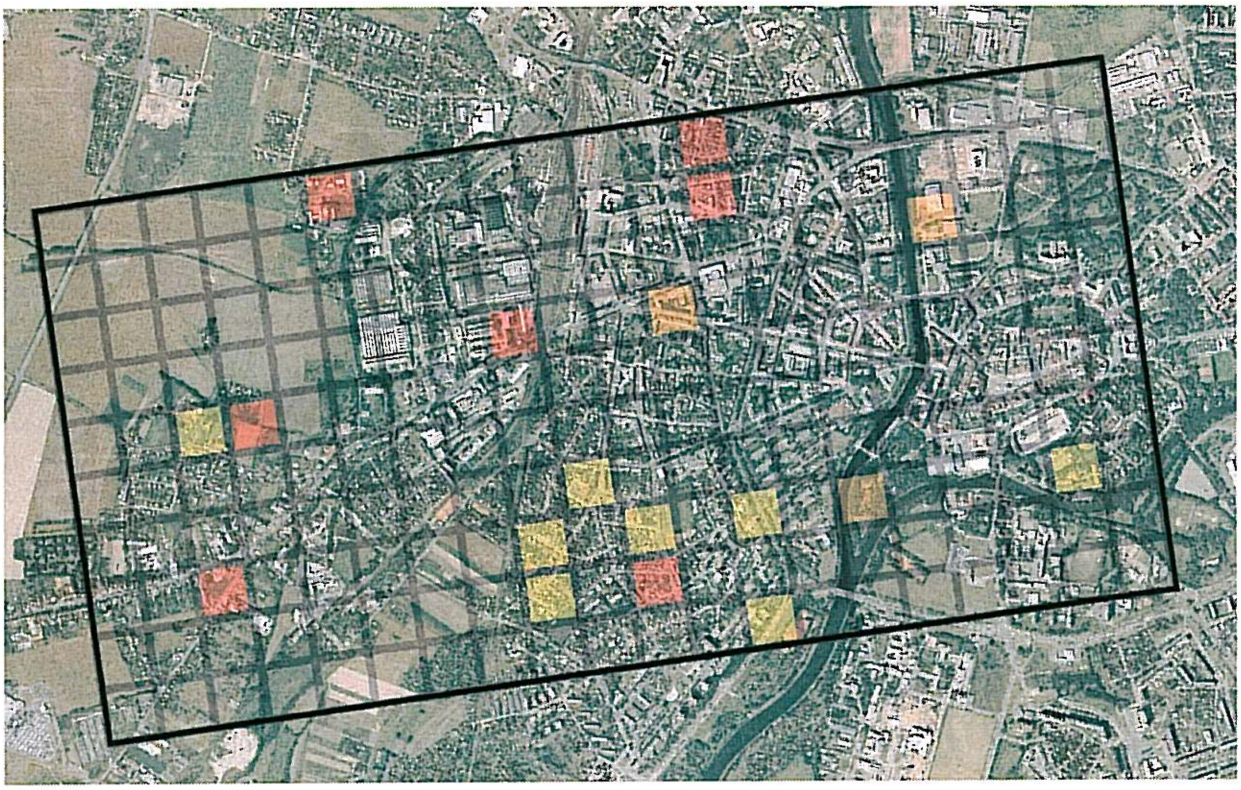
Reynoutria japonica (25 sample plots)



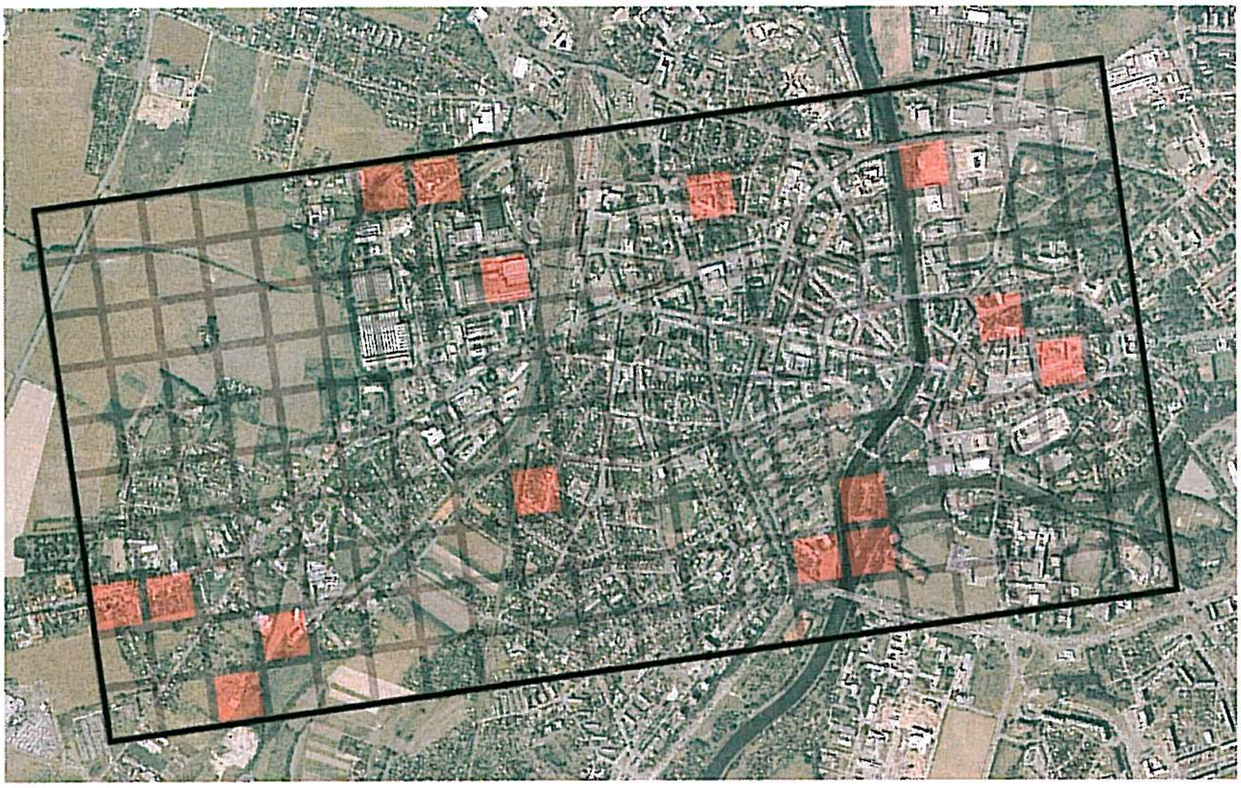
Fraxinus pensylvanica (21 sample plots)



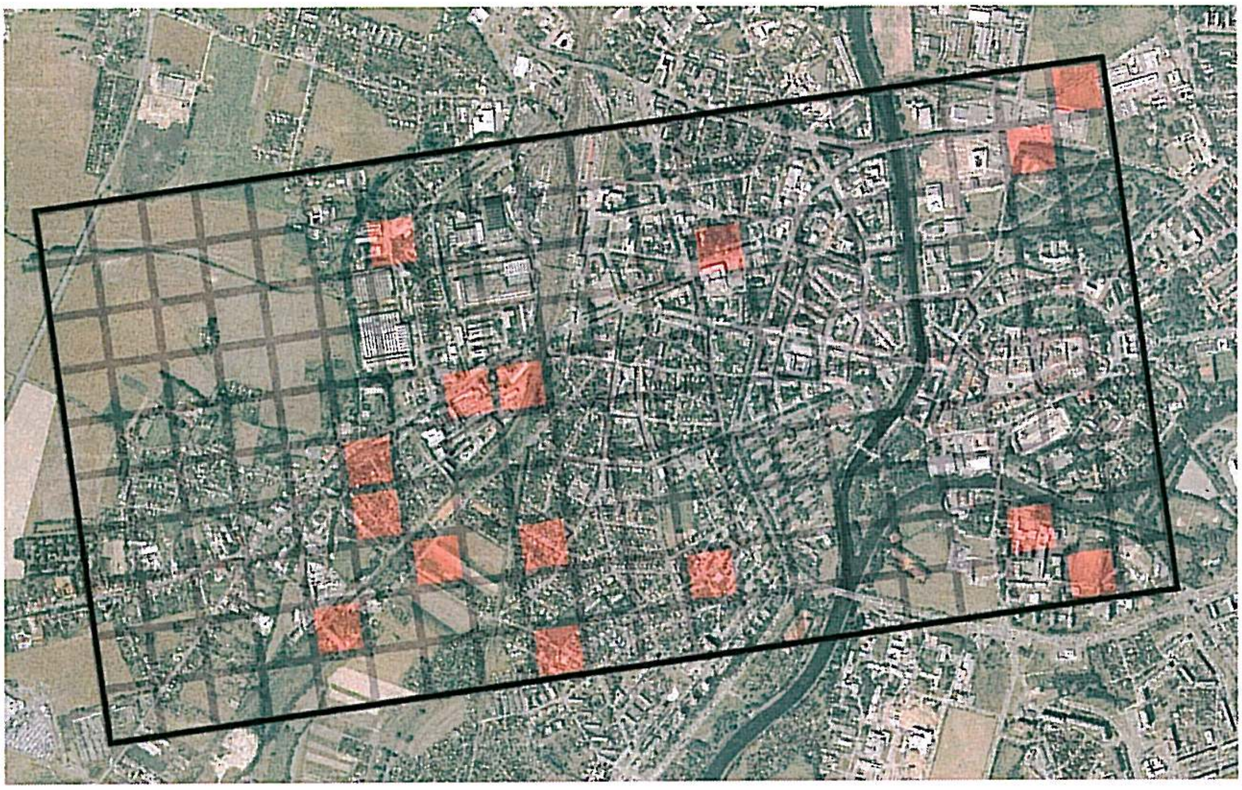
QUERCUS RUBRA (19 sample plots)



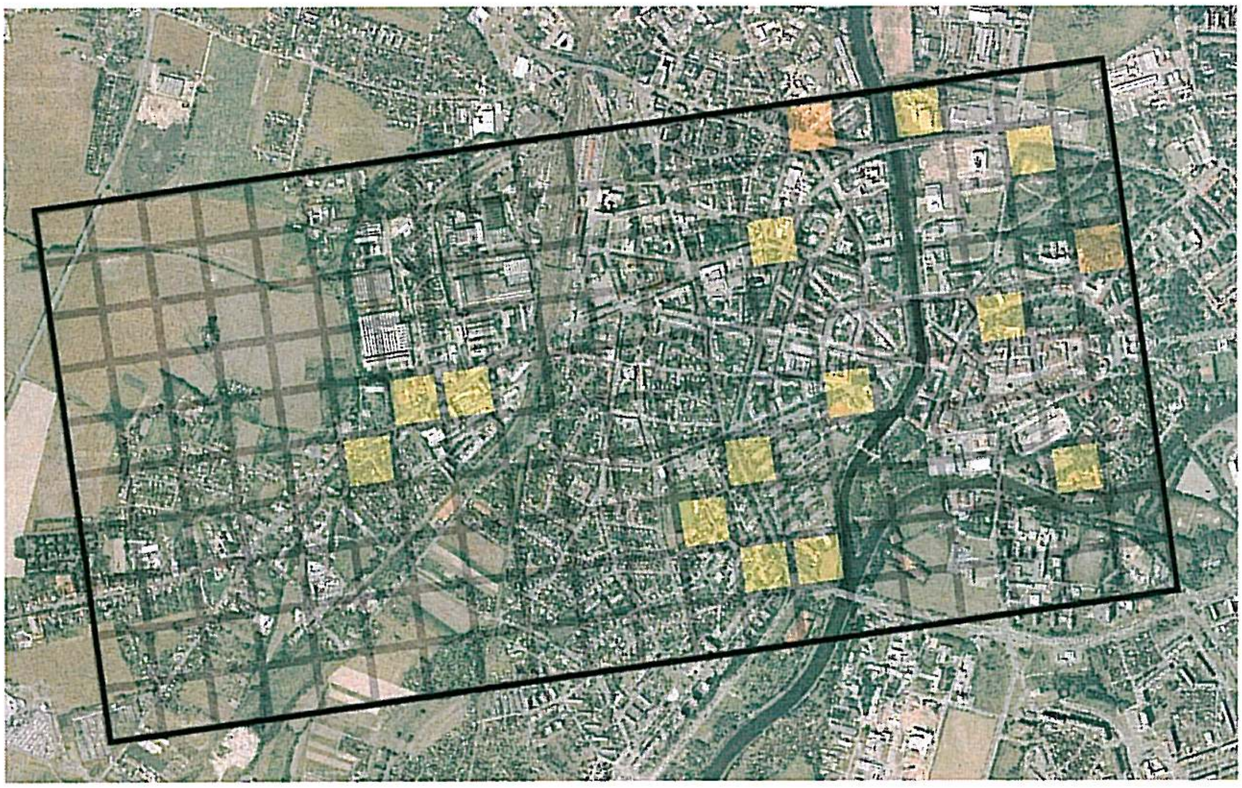
MAHONIA AQUIFOLIUM (18 sample plots)



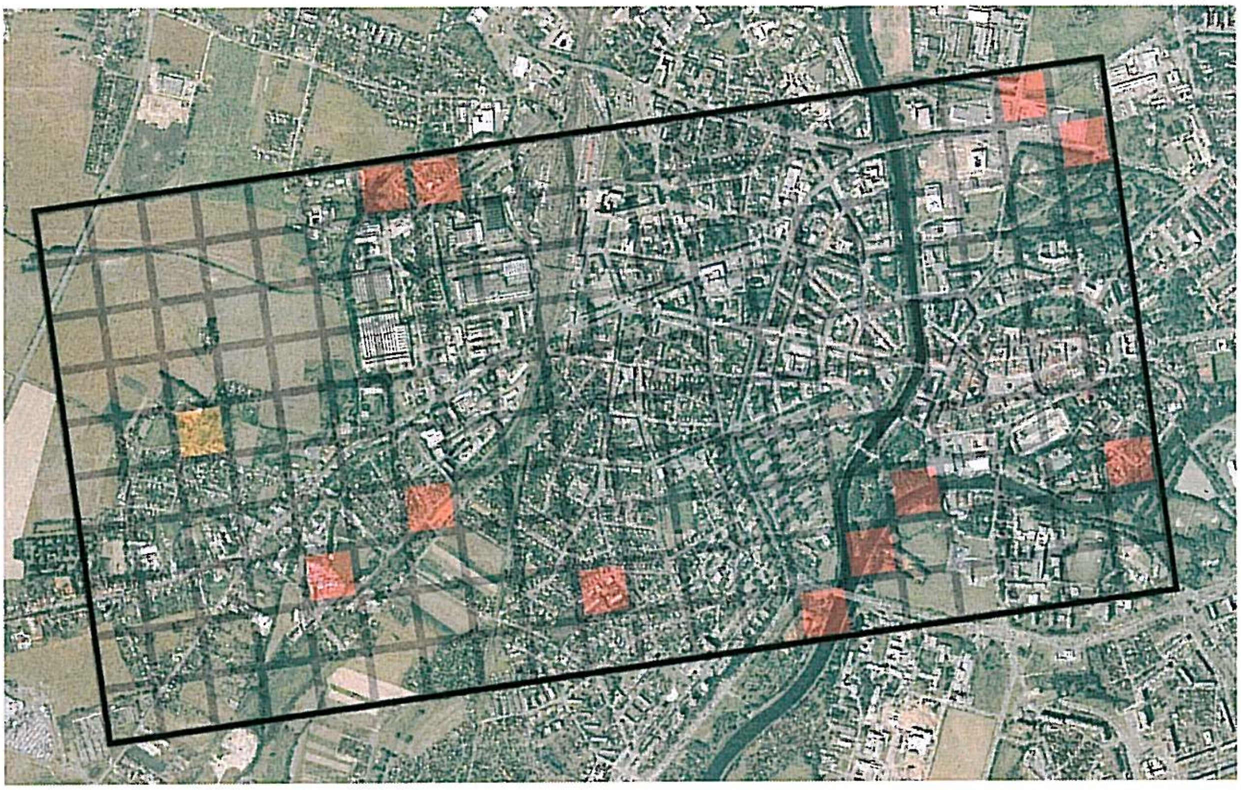
EPILOBIUM* CF. *CILIATUM (15 sample plots)



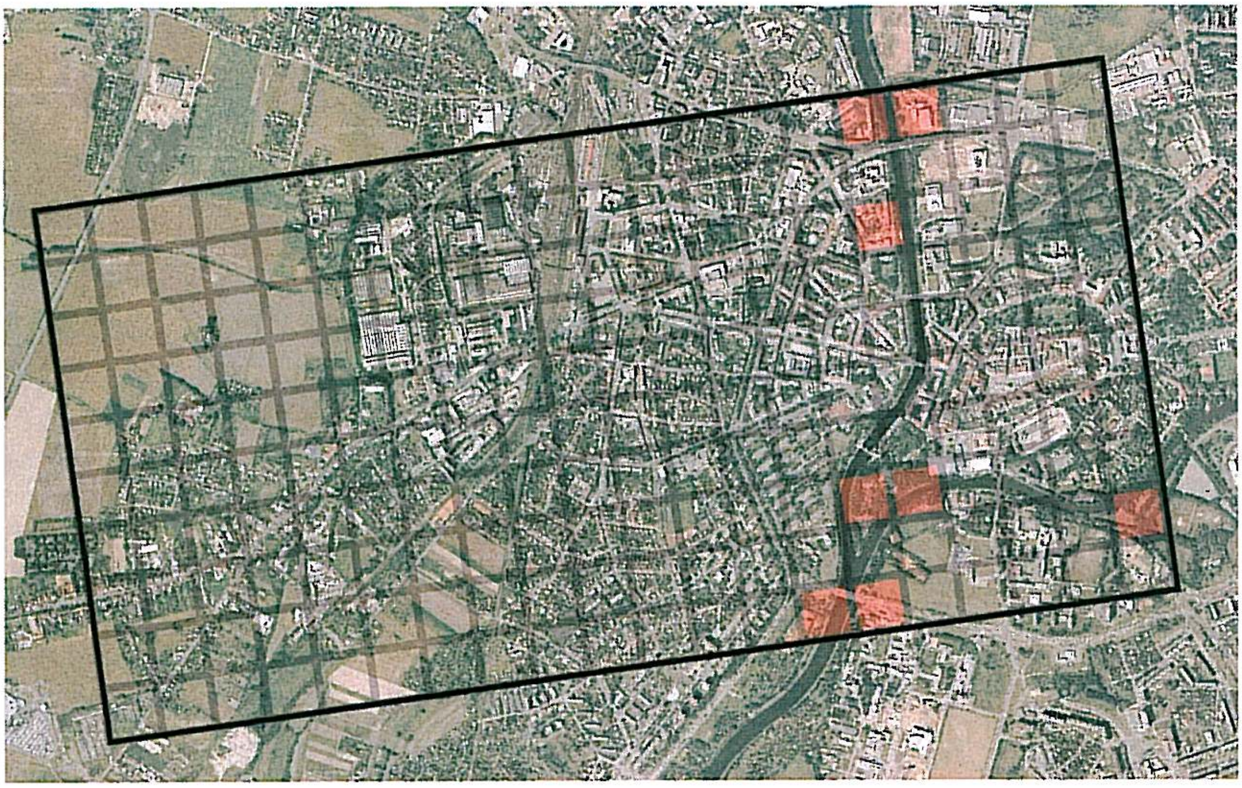
HELIANTHUS TUBEROSUS (15 sample plots)



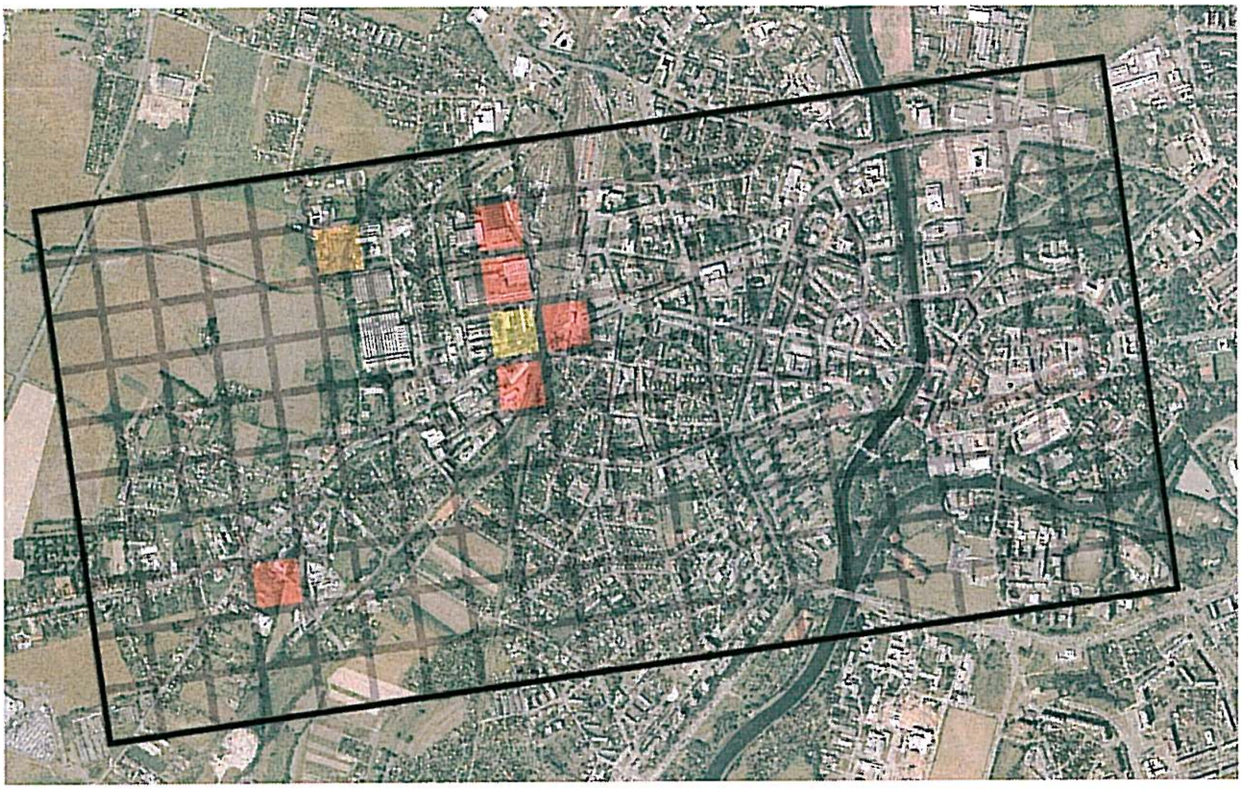
Pinus strobus (15 sample plots)



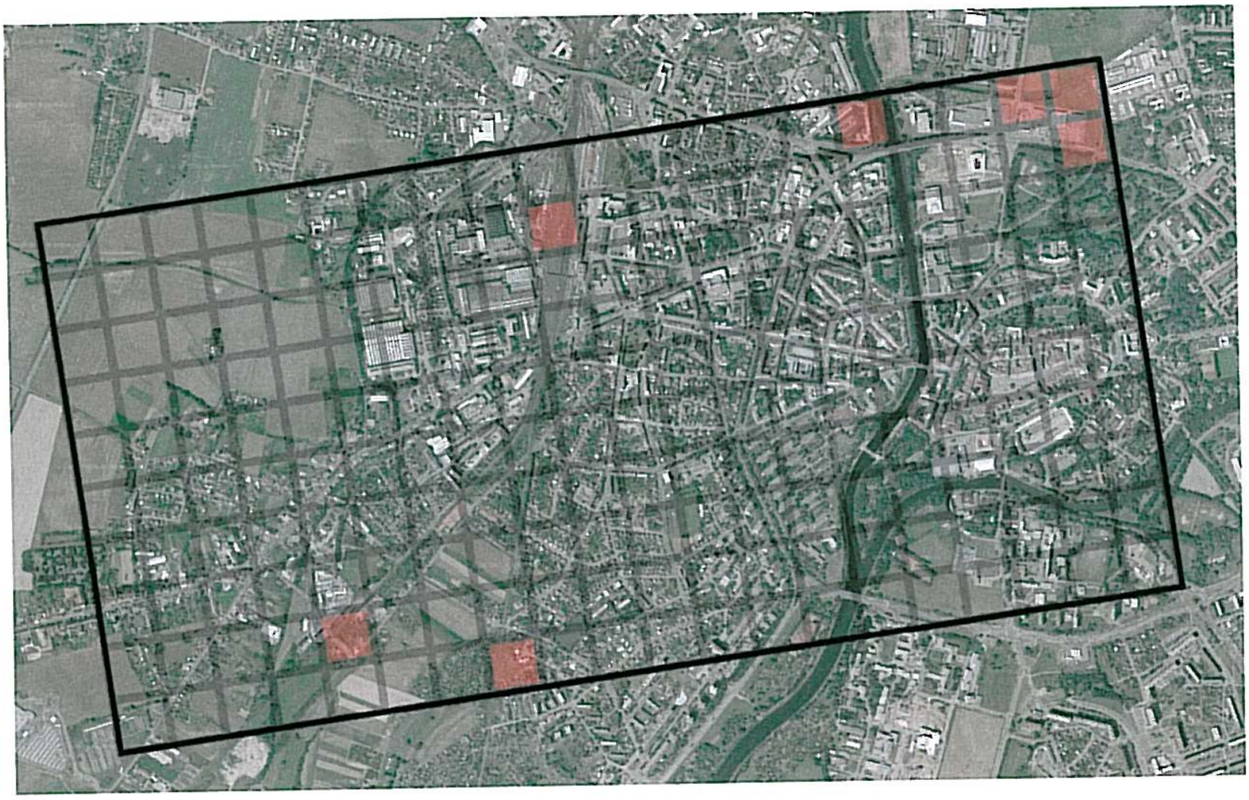
Solidago gigantea (12 sample plots)



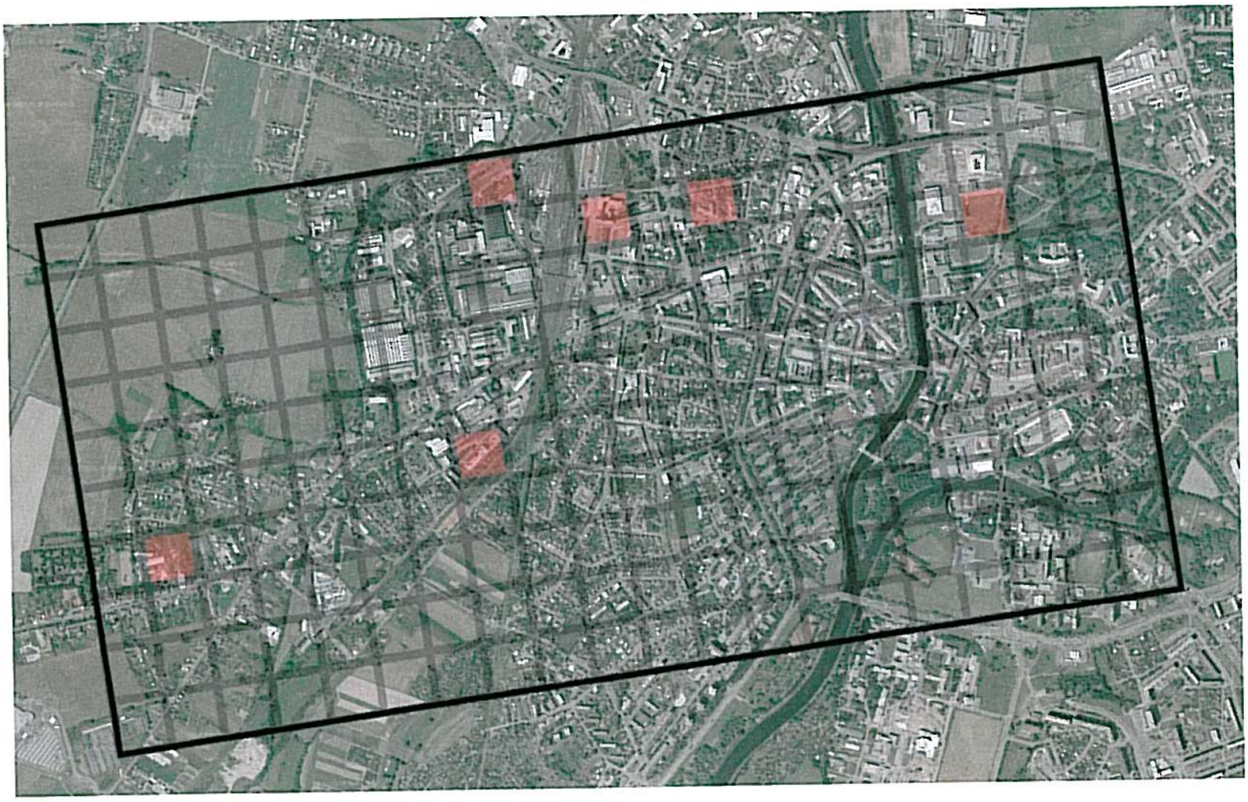
IMPATIENS GLANDULIFERA (8 sample plots)



LYCIUM BARBARUM (7 sample plots)



SISYMBRIUM LOESELII (7 sample plots)



REYNOUTRIA × BOHEMICA (6 sample plots)

APPENDIX 4 ŠTAJEROVÁ K., MIHULKA S. & MARTÍNKOVÁ J.: Invasive neophytes in a part of the city of Hradec Králové. – in prep.

Invasive neophytes in a part of the city of Hradec Králové, Eastern Bohemia

Invazní neofyty v části města Hradce Králové, východní Čechy

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There are only few studies which consider invasive plants linking with their habitats. In this study, the occurrence of invasive neophytes in the strip transect running from the city center to the outskirts was mapped. Our project was realized in a part of the city of Hradec Králové. There was chosen the transect 4 × 2 km which was divided into 200 sample plots. This research was mainly focused on the performance of invasive neophytes in the present land-use types and other characteristics of the species present e.g. time of introduction, life history and family. We found 43 alien species from the total number of 64 invasive neophytes (except of water weeds and post-invasive species) occurring in the Czech Republic (according to PYŠEK *et al.* 2002), it constitutes approximately 67%. We observed that the most frequent species far ahead others were *Solidago canadensis* and *Conyza canadensis*. Most of the invasive neophytes belong to the plant families *Asteraceae* or *Polygonaceae*, are native to Northern America and are annuals or perennials. Most invaded habitats were street borders (33 species) and ruderal sites (29 species). Statistical analysis illustrated the performance of invasive species in the present habitats and showed that the selected characteristics of mapped squares (WATER, INDUSTRY and GREEN) had the significant influence on the species' distribution.

Keywords: urban flora, life strategy, abundance, origin, invasive neophytes, transect