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Renaissance of a rural artifact in a city with a million people: biodiversity responses to an agro-forestry restoration in a large urban traditional fruit orchard

Jakub Horák[1] · Jiří Rom[2] · Patrik Rada[1] · Lenka Šafářová[1,3] · Jitka Koudelková[4] · Petr Zasadil[4] · Josef P. Halda[1,5] · Jaroslav Holuša[1]

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Abstract The rural landscapes surrounding large cities are rapidly becoming incorporated into the urban environment. The most conspicuous changes involve green spaces, such as former agro-forestry systems like fruit orchards. In this paper, we assess the influence on biodiversity of restoring a large urban traditional fruit orchard as reflected by six selected taxa: plants, lichens, butterflies, beetles, orthopteroids and birds. The study was performed in Prague, which is the capital city of the Czech Republic and has more than a million inhabitants. We studied the effect of orchard renewal in 45 patches (15 for birds and 30 for other taxa). The majority of taxa responded positively to the restoration. The restoration had a significant positive effect on the species richness of lichens, butterflies and beetles. All taxa showed significantly altered species compositions, and the number of red-listed species increased. Orchards have a high potential for multi-functional use. Orchards are productive agro-forestry systems and host numerous possible human activities. Therefore, orchard restoration also has a social aspect. Moreover, our research in this artificial ecosystem revealed that its restoration increased the biodiversity and conservation potential of the associated areas.

Keywords Urban green space · fruit tree · green infrastructure · species richness · citizen activities

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✉ Jakub Horák
jakub.sruby@gmail.com

1 Faculty of Forestry and Wood Sciences, Czech University of Life Sciences Prague, Kamýcká 1176, CZ-165 21 Prague, Czech Republic

2 Environmental Protection Department, City Hall Prague, Jungmannova 35/29, CZ-110 01 Prague, Czech Republic

3 East Bohemian Museum in Pardubice, Zámek 2, CZ-53002 Pardubice, Czech Republic

4 Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Kamýcká 1176, CZ-165 21 Prague, Czech Republic

5 Muzeum and Gallery of Orlické hory, Jiráskova 2, CZ-516 01 Rychnov nad Kněžnou, Czech Republic

Introduction

Former rural agricultural or agro-forestry land at the peripheries of large cities has become an increasingly important part of the urban environment as a green infrastructure. Urban green spaces, such as parks, lawns, street avenues or orchards, have numerous functions, and the most important are environmental, social, health or even aesthetic functions (Konijnendijk et al. 2006). Plants in urban greenings reduce many pollutants in the environment, and they create specific microclimates by decreasing wind, airborne dust, traffic noise or solar irradiation (Akinshina and Azizov 2008; Elmqvist et al. 2015; Li et al. 2015). Thus, the care, development and monitoring of the actual status of urban green spaces are important issues in every city (Akinshina and Azizov 2008).

The creation of new green spaces in urban areas is not easy, although the restoration or renewal of former agricultural, agro-forestry or forest land that is now absorbed by the cities represents such an opportunity. The renewal or restoration of such habitats could focus on either individual species (e.g., threatened or flagship) or entire communities likely to be found in an area (Miller and Hobbs 2007). The urban green spaces mostly consist of relatively small but important areas. Former agro-forestry land, such as fruit orchards in Europe, is a highly important and often biodiverse urban habitat type, and orchards have been reported promote communities from forests (e.g., saproxylics; Horák 2011, 2014a) and open habitats (Horak et al. 2013); such characteristics are important for the possible renewal or restoration of urban greening. For example, to support viable populations that were located in the area before the restoration, the availability of resources must be ensured, including standing dead trees that serve as suitable nesting and feeding sites for dead wood-dependent species over several years. An important fact connected with such restorations is the improvement of landscape connectivity for species that require multiple habitats or for species seeking a new suitable environment for living in the restored area. This connectivity could also increase the biodiversity of a restored area (Miller and Hobbs 2007).

Considering the biodiversity of urban greenings, all possible organisms within such habitats must be identified. One group could be formed by species that have adapted to these environments, such as birds and plants. These species are occasionally referred to as apophytes, or a group of native species that are dependent on disturbed land. A number of some species could evolve in the green space because of human influence, and their natural habitat is unknown. These species (especially plants) exclusively found in artifacts are called anecophytes (McKinney 2008; Melles et al. 2003; Muller et al. 2010). Certain urban greenings, such as orchards, appear to be current hot spots of taxa diversity because of their complex structure (Horak 2014b). The main significance of a hot spot in a highly urbanized landscape is related to the ability support original populations of organisms that are capable of moving from the hot spot to surrounding areas if the associated living conditions improve because of renewal or restoration. Nevertheless, urban orchards are also significant for species migrations and may act as a stepping stone or ephemeral food source (Horak 2014a). This information should lead to the use of additional groups of organisms (i.e., multi-taxa approach) in evaluations of the influence of urban greening interventions (Muller et al. 2010).

The aim of this paper was to identify the influence of the restoration on biodiversity of a large traditional fruit orchard in Prague as reflected by six selected taxa. Our particular questions regarding the aim of the paper were as follows:

(i) Does restoration increase species richness?
(ii) Does restoration change the composition of species?
(iii) How many species are specific to the pre- and post-stages of the intervention, and how many were resistant?
(iv) How does the restoration influence the occurrence of red-listed species?

Materials and methods

Study site

The study site was located close to the center of Prague (50.0969 N; 14.5010E) and situated on an oblong (west-east orientation) hill called Třešňovka (Cherry tree orchard), and its elevation is from 240 to 265 m a. s. l. This traditional fruit orchard is more than 10 ha and represents the second largest orchard in Prague. The fruit orchard was surrounded by a mosaic of urban environment, including city highways, blocks of flats, industrial areas, allotments and other urban green spaces. The orchard is visible in the first aerial photographs of this territory taken as early as 1945, although it was most likely established at the time of the Third Military Mapping Survey (1877–1880). Although its surroundings experienced significant changes from a rural environment (SÚKHMP 1848) to a highly urbanized environment, the extent of the orchard remained approximately equivalent. The most conspicuous change occurred immediately after the Velvet revolution (1989) in the Czech Republic when the orchard was no longer used to ripen fruit (approximately in 1992) and became abandoned (Fig. 1a). Currently, the orchard is the property of the Prague City. The orchard is dominated by cherry trees (*Prunus avium*; 99%) and only partly by walnut (*Juglans regia*) and pear (*Pyrus communis*) trees. Before the restoration, approximately 80% of the orchard was overgrown by shrubs and forest

Fig. 1 Conditions of the traditional fruit orchard study site in Prague (**a**) before and (**b**) after the restoration. The pictures were taken at the plateau from the central path in August 2014 (**a**) and April 2016 (**b**)

trees, and certain edges had completely lost the typical orchard structure. Half of the trees were newly planted during the restoration (Fig. 1b), whereas only 5% are mature. The remaining trees are over-matured or dead trees. Cherry trees were planted in an 8 × 8 m rhomb spacing design.

Study taxa and sampling

We studied six taxa that were selected because of their disparate ecological requirements, dispersal patterns and indication abilities. All taxa were sampled using standard biodiversity sampling methods in 2014 before the restoration and in 2016 after the restoration in 30 patches. Only birds were sampled in 15 sites because of their high dispersal and potential overlap among suitable patches. Patches were distributed throughout the entire orchard and were randomly stratified as follows: approximately one third on the northern slope, one third on the southern slope and one third at the plateau. Because the study primarily focused on the biodiversity conditions before and after restoration, we sampled the taxa at the same time in a particular season in the same number of patches. According to the various sampling opportunities in a particular year, the taxa were not sampled in permanent plots but were randomly selected each year. This sampling strategy was primarily adopted because of the limited accessibility of scrubby vegetation for sampling in the first year and damage of permanent marks caused by the mechanization during the restoration.

Plants were selected as the traditionally studied group and sampled at the end of the summer in 1 × 1 m grids.

Lichens were selected as sedentary taxa with high bioindication potential. Lichens were sampled in the beginning of the autumn in patches with a 10-m radius on time-limited survey walks (10 min per patch).

Butterflies (Lepidoptera) were studied as a medium-dispersal taxon that is highly connected with vegetation. These species were sampled from the end of the spring to the beginning of autumn on six occasions using the same method used for lichens.

Floricolous (flower-visiting) beetles (Coleoptera) were studied as medium-dispersal taxa and considered suitable taxa for agro-forestry habitats because of their interconnection with dead wood and flowering plants. Floricolous beetles were sampled six times in the same manner as butterflies.

Orthopteroids (Orthoptera) were selected as potentially more sedentary taxa of insects. Orthopteroids were sampled using direct visual and audio observations and vegetation sweeping in the beginning of autumn in the same manner as lichens.

Birds were selected as high-dispersal taxa. They were sampled using direct visual and audio observations (except for the birds that flew over) during the 15-min survey period. Birds were sampled in patches with a 25-m radius during two visits in each season (at the end of spring and at the beginning of summer).

Study environment

This study was focused on determining the difference between the two studied years, which represented the period when the orchard was abandoned (first year) and the period when the orchard was restored (second year). However, to control for the influence of changes in the environment, we selected other environmental characteristics that may have an influence on the studied taxa.

The effect of slope direction was studied for all taxa except birds. An ordinal scale was applied, with −1 for the northern slope, 0 for the plateau and 1 for the southern slope. We also studied the effect of flowering intensity on butterflies and beetles. We used the mean value calculated from all visitations for a particular patch using a five-category ordinal scale (Horák 2016). The extent of grassland cover (in %) in a particular patch was also studied for all insect taxa. Because the environment was changing during the second season, we used the mean value for a particular patch that was derived from measurements in April and June. We also studied the potential effect of weather conditions on butterflies and beetles and applied an ordinal scale, with 1 for cloudy sky, 2 for partly cloudy sky and 3 for clear sky during the visit to a particular patch. The data were represented by the mean values from all visits.

Statistical analyses

Analyses were performed using R 2.0.3 and CANOCO 4.5.

Species data for a particular taxon were used as dependent variables with appropriate data distributions. Gaussian distributions were used for plants and birds, Poisson distributions were used for lichens, beetles and orthopteroids and quasi-Poisson distributions were used for butterflies. The pure effect of restoration on the species composition was calculated using randomized canonical correspondence analyses (CCAs) for all taxa except beetles. Because of the short gradient length in detrended correspondence analysis (DCA), we used redundancy analysis (RDA) for beetles. For plants and lichens, we used 0 for absence and 1 for presence in a patch. For the other taxa, the observed abundance was used. Generalized linear models were used to evaluate the restoration effect together with the potential impacts of other environmental variables.

Results

We identified 65 plant species, 25 lichen species, 17 butterfly species, 19 beetle species, 12 orthopteroid species and 18 bird species before the restoration and 108 plant species, 33 lichen species, 21 butterfly species, 27 beetle species, 14 orthopteroid species and 16 bird species after the restoration of the traditional fruit orchard (Appendix A,B,C,D,E,F).

The studied taxa (except for birds) indicated that the number of specific species in the year after the intervention was greater that of the previous year. However, several taxa (lichens, orthopteroids and birds) exhibited the highest number of overlapped species (Fig. 2). Furthermore, in the case of all taxa studied, the difference in species composition between the two studied periods was significantly different (Fig. 2).

After the restoration of the orchard, the mean number of species increased for lichens, butterflies, beetles and orthopteroids, whereas the mean number of species decreased for plants and birds (Fig. 3).

The difference in species number before and after restoration remained statistically significant for four groups when included in the generalized linear models together with other important environmental characteristics. Lichens were richer in species the year after the orchard was restored but were not influenced by the slope. Butterflies and beetles were also more species rich in the second year and positively driven by increases in the flowering intensity of the patch. Butterflies were favored by more suitable weather conditions. Bird species numbers were negatively influenced by the restoration of the orchard. Plants and orthopteroids did not respond to the studied independent variables (Table 1).

The data show that three of the five red-listed species that were present before the restoration were not observed after the restoration. Nevertheless, five species were newly identified after the restoration (Table 2).

Discussion

The majority of the studied taxa showed an increased number of species after the restoration of the abandoned orchard, indicating the positive response of biodiversity indices to the restoration of this rural artifact in the highly urbanized environment of Prague.

Direct connections with the results

The higher number of specific species in the second period might indicate that restoring this type of agro-forestry green space may lead to the creation of a new type of habitat that is suitable for new species or helps increase the latent population densities of overlooked species to densities that can be detected during commonly used biodiversity surveys. High number of species shared in both years indicated the taxa that are more sedentary or resistant to the restoration. This response was not surprising for lichens, which are good environmental indicators (e.g. air pollution), especially in long-term studies. A surprising result was the low response of orthopteroids, which was likely related to the prolonged spread of propagules (i.e. moving of females and laying of eggs) to the newly established sites for oviposition compared with that of other insects (e.g. Kočárek et al. 2013).

Important species group responses

An increase in species numbers is not the only factor related to successful biodiversity action. The difference in species composition for all taxa between the studied periods is another important factor for the future management of the orchard. Hence, future management activities must implement suitable conservation actions, especially for the target species (i.e. carefully selected). From a general perspective, the status of these species as welcomed (red-listed species or flagship species) or unwanted (alien species) is not important.

Red-listed associates

Monitoring the status of red-listed species before and after biodiversity action is an important issue, and determining the number of red-listed species in important groups that vanished from and arrived at the site after restoration is the

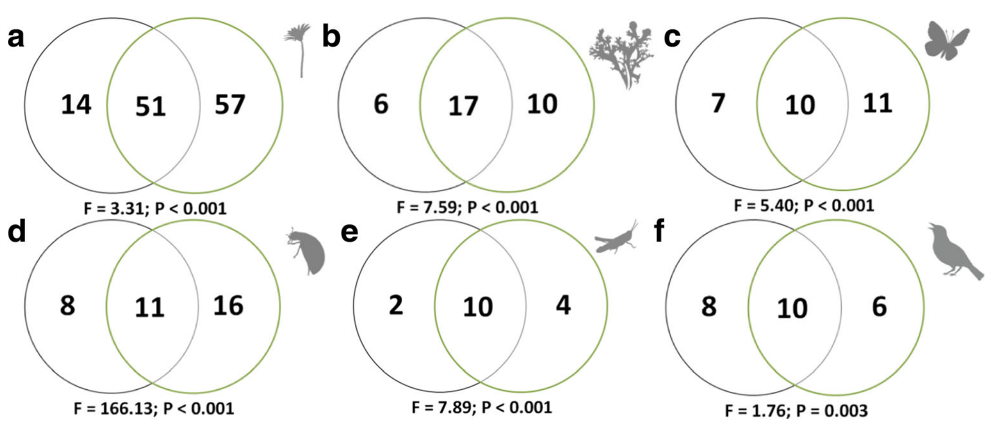

Fig. 2 Number of species of the different taxa found in a traditional fruit orchard in Prague. The number of species of **a** plants, **b** lichens, **c** butterflies, **d** beetles, **e** orthopteroids and **f** birds before the restoration is indicated in gray and after the restoration is indicated in green, and the gray-green overlap area indicates shared species for both time periods. F and *P*-values were derived from the species composition analyses performed via CCAs (**a**, **b**, **c**, **e**, **f**) and RDA (**d**)

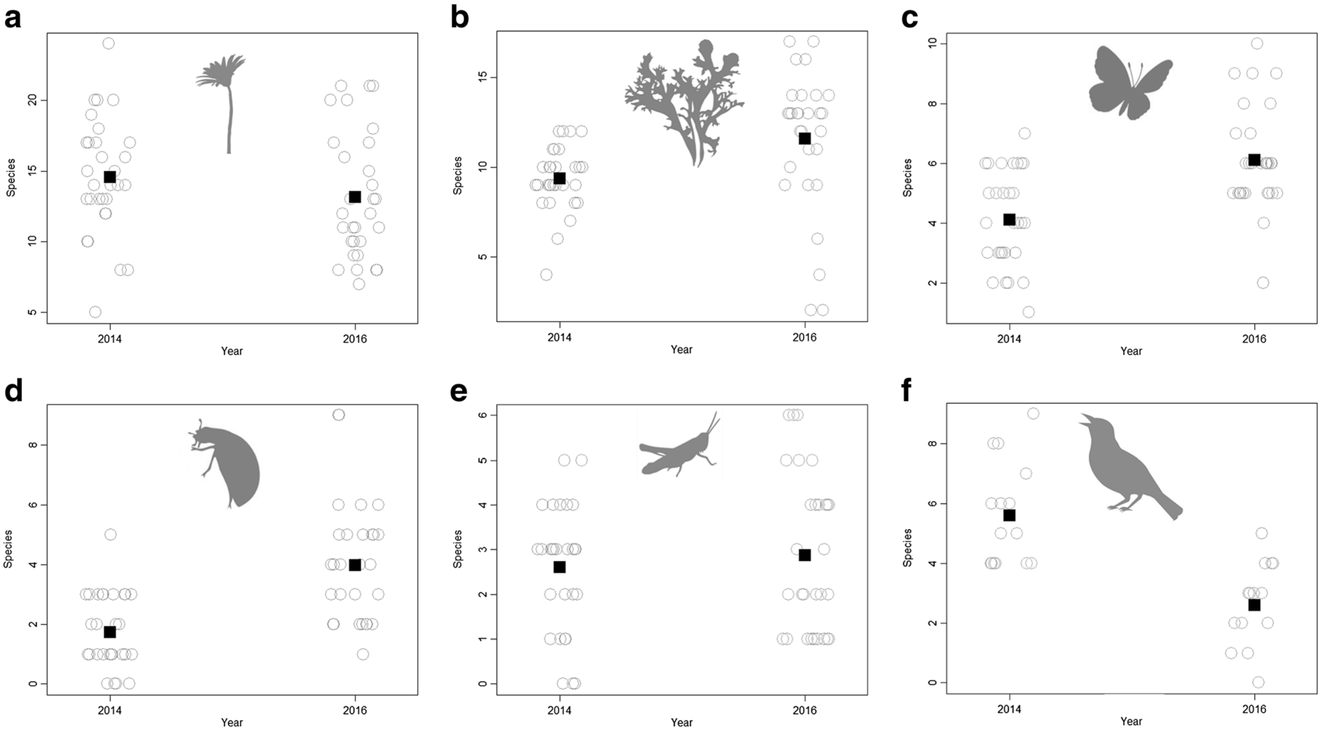

Fig. 3 Difference in species richness in the studied taxa between the two studied years in a traditional fruit orchard in Prague: **a** plants, **b** lichens, **c** butterflies, **d** beetles, **e** orthopteroids and **f** birds. Squares are the mean values per studied patch; bubbles are the true values. Note that the y-axes are not shown on the same scale in all panels

first task. Although seven red-listed species were observed in the orchard after the restoration, the possible loss of three species (two birds and one beetle) represents the most important information.

The Bee beetle (*Trichius fasciatus*) was only observed as single individual in the flowering gap at the southern slope at the beginning of summer of the first year. Knowledge related to the requirements of this species are rather anecdotal, although adult bee beetles are mostly found in low population densities and often as single individuals (e.g. Mertlik 2009). The larvae of this species are saproxylic and utilize old dead wood or mold in tree cavities. Thus, the absence of this species in the year of restoration did not directly indicate the loss of this species. Future management to improve dead wood conditions, such as retaining hollowed trees and leaving snags and dead branches in piles, is highly recommended.

The loss of the Lesser spotted woodpecker (*Dendrocopos minor*) and the Grey-headed woodpecker (*Picus canus*) is questionable and was likely caused by the commonly used study method, which is suitable for overall bird communities but not for detailed studies on woodpeckers. Moreover, a decreasing trend of the Grey-headed woodpecker and Lesser spotted woodpecker population densities has been observed in Prague (Šťastný et al. 2006). One Grey-headed woodpecker was observed by our group (JR) during the control of management activities in the second year. Other suitable sites in addition to orchards likely host the insect prey species for these birds, and birds can easily disperse to these sites.

Table 1 Response of the studied taxa to the restoration and changing environment in a traditional fruit orchard in Prague

Group	Year	Slope direction	Flowering	Grassland	Weather
Plants	−1.40	−1.16	-	-	-
Lichens	2.57*	−1.01	-	-	-
Butterflies	4.09***	0.88	3.11**	0.59	2.78**
Beetles	2.30*	−0.96	1.97*	−0.86	0.50
Orthopteroids	0.84	1.74	-	0.52	-
Birds	−5.30***	-	-	-	-

Values are t or z values from the generalized linear models

- indicates the variable was not studied for a particular taxa

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

Table 2 Red-listed species and their presence before and after the restoration of the traditional fruit orchard in Prague

Taxa	Species	Category	Abandoned	Restored
Plants	*Armeria elongata*	C4a (NT)		Yes
Lichens	*Pertusaria amara*	NT		Yes
	Caloplaca obscurella	NT		Yes
	Candelariella reflexa	NT	Yes	Yes
	Pseudevernia furfuracea	NT		Yes
	Physcia aipolia	EN	Yes	Yes
Butterflies	*Iphiclides podalirius*	VU		Yes
Beetles	*Trichius fasciatus*	NT	Yes	
Birds	*Dendrocopos minor*	VU	Yes	
	Picus canus	VU	Yes	

Red-listed categories are based on actual Czech Red lists (Farkač et al. 2005; Grulich 2012; Liska et al. 2008; Plesník et al. 2003)

However, the possible increase of saproxylic insects, which represent the primary food species for woodpeckers, under the recommended management strategies would promote increased populations of these birds.

Flagship species for similar urban green spaces

The second important question regarding the future of such green spaces is the selection and future presence of potential flagship species. Flagships are charismatic species that engender public interest and sympathy, and they can be used for public conservation campaigns (Simberloff 1998); thus, their careful selection and conservation would lead to a better understanding of similar interventions in urban habitats. These species are often conspicuous and have the potential for environmental education. However, of all of the observed species at the restored orchard, at least one butterfly, one orthopteroid and one bird exhibited high potential as a flagship species.

The first species is the Scarce swallowtail (*Iphiclides podalirius*) butterfly, which is red listed in the Czech Republic. This species is highly conspicuous and well recognized by the public. Moreover, its activity coincides with the end of the school year in the Czech Republic, when pupils and teachers frequently take school trips. Thus, this butterfly species can be successfully used for environmental education. Moreover, the abandonment of orchard-like habitats represents a possible threat to the survival of this species (Benes et al. 2002).

The second potential flagship is the Blue-winged grasshopper (*Oedipoda caerulescens*). Although this species is not endangered, it is interesting because of its two colorations: a cryptic color displayed when the insect is on the ground and a conspicuous coloration of blue wings that are revealed when flying. The abundance and presence of this species in close proximity to paved surfaces indicates the educational potential of this species; moreover, because the species is present at the beginning of the school year, it has the same potential for use in environmental education as mentioned above for the butterfly. Although this species is not red listed, it represents a pioneer species in open and disturbed habitats and is threatened by succession (Kočárek et al. 2013). However, the Blue-winged grasshopper is not as well connected with orchard-like green spaces as the scarce swallowtail.

The third species with the potential for designation as a flagship species in the city orchard is the Common redstart (*Phoenicurus phoenicurus*). This species is also not threatened, but it is a conspicuous and unmistakable bird that often searches for open forests, parkland and garden areas. Thus, this species is common in orchards. Current and future management activities in the orchard are highly suitable for this species (Šťastný et al. 2006).

Potential role of alien species

The third question pertains to an issue caused by changes in species composition, primarily plant species, namely the establishment and spread of alien species. Thus, target alien species that are favored under disturbed conditions should be monitored. The majority of these species are favored by 'disturbed and abandoned' types of interventions (Timmins and Williams 1991). Thus, the most important factor is the establishment of future permanent management activities at these sites, such as mowing or grazing.

The presence of certain non-indigenous species, such as Watermelon (*Citrullus lanatus*), may be interesting for the public, and the optimal conditions for a number of non-indigenous species are observed in different habitats than orchard (e.g., Annual fleabane, *Erigeron annuus*), other species show a considerable potential for wide dispersal, including Canadian horseweed (*Conyza canadensis*) and Canadian goldenrod (*Solidago canadensis*). Canadian horseweed has high invasive potential for permanently disturbed habitats and open rocky spaces, and Canadian goldenrod is highly invasive in abandoned grasslands (e.g. Pyšek et al. 2012). Thus, active management (e.g. manual weeding of the former and mowing together with grazing for the latter) is needed to suppress the potential spread of these species.

Human perspective on agro-forestry rural artifacts in a city

In addition to providing biological and ecological knowledge, the renaissance of an agro-forestry system in a large city provides a historical view of the city's past (Hammersley and Westlake 1996). The restoration of these rural artifacts inside the urban environment of Prague provides a glimpse of the historical conditions of green spaces within the city and the biota they hosted before they were abandoned, cut or forested.

In addition to providing information on the past, another interesting notion is the present use of this city fragment by the public (Konijnendijk et al. 2006). Unfortunately, only subjective observational data were available for public visits to this orchard before restoration; however, in the year after the restoration, a considerable amount of various human activities were observed.

Bikers started to use the orchard for training, and a plan is in place to host an international competition in the future. The orchard is often used by maternal schools for walks and games. High visitor activity was observed during the fruit ripening period, which provided a free and diverse food supply, and groups related to the use of urban green spaces began supporting community fruit gathering events. Children and young people were observed gathering the cherries in the crowns of trees. Numerous people walk their dogs and jog in the area. These sample activities are only a small representation from a list of wide-ranging human activities and illustrate the important social aspect of successful urban space renewals.

Management activities

The restoration of the traditional orchard was simple in the beginning. Woody vegetation (excluding grafted fruit trees) was cut and partly retained on the edges. Fruit trees were pruned, and their branches and dead trees were retained. The orchard had been partly occupied by homeless people, and all of the garbage was removed. Then, new fruit trees were planted in the empty spaces. During the summer, the orchard was mowed and the plant material was removed. These activities were the starting-point for future management.

In the future, a greater understanding of all of the above-mentioned species (e.g. promoting red-listed and flagship species and suppressing aliens) is needed to retain the present structure of the orchard. The main goal is the suppression of shrubs using cutting (and only partially retaining flowering solitaries) and the use of sheep grazing (because sheep do not damage fruit trees compared with other domestic animals). Regarding other activities in the orchard, the rotation grazing of sheep is the most likely option. The future plan also involves the establishment of small houses for sheep herders, who will be selected from among homeless individuals interested in this management activity. A plan is also an place for an environmental information center. The presence of pioneer species (e.g. lichens and grasshoppers) might be also support by the biking community (e.g. Weiss et al. 2016).

Conclusions

Multi-functional ecosystems are the focus of the present environmental agenda. As illustrated here, traditional fruit orchards have a high potential for multi-functional uses. In addition to the promotion of biodiversity and productivity of the agro-forestry system, which represents a free resource for citizens, numerous possible human activities can be hosted in this area. In addition, the positive social aspect of this restored artifact cannot be ignored. The restoration of this somewhat artificial ecosystem indicates the potential for increasing biodiversity and conserving green spaces using a multi-taxa approach.

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Table A1

Occurrence of plants in years in a traditional fruit orchard in Prague.

Species	**2014**	**2016**
Pimpinella saxifraga s.str.	Yes	Yes
Setaria pumila		Yes
Luzula campestris	Yes	
Carduus crispus		Yes
Heracleum sphondylium	Yes	
Betula pendula		Yes
Aegopodium podagraria		Yes
Alliaria petiolata		Yes
Knautia arvensis		Yes
Centaurea stoebe s.lat.		Yes
Centaurea jacea	Yes	Yes
Quercus robur	Yes	Yes
Crataegus sp.	Yes	Yes
Lamium purpureum	Yes	
Lathyrus pratensis	Yes	Yes
Pyrus communis agg.		Yes
Dianthus carthusianorum	Yes	Yes
Fragaria vesca	Yes	Yes
Fragaria viridis		Yes
Fraxinus excelsior	Yes	Yes
Acer platanoides		Yes
Hieracium sp.	Yes	Yes
Hieracium pilosella	Yes	Yes
Trifolium campestre		Yes
Trifolium pratense	Yes	Yes
Trifolium repens	Yes	Yes
Trifolium arvense	Yes	Yes
Lolium perenne	Yes	Yes
Plantago lanceolata	Yes	Yes
Plantago media	Yes	
Plantago major		Yes
Lapsana communis		Yes
Alchemilla sp. 1		Yes
Urtica dioica		Yes
Festuca rubra		Yes
Festuca ovina	Yes	
Festuca valesiaca		Yes
Geum urbanum	Yes	Yes
Spergularia rubra		Yes
Poa pratensis	Yes	Yes
Poa annua		Yes

Species	**2014**	**2016**
Poa compressa		Yes
Linaria vulgaris		Yes
Lactuca serriola		Yes
Arctium sp.		Yes
Citrullus lanatus		Yes
Leontodon autumnalis	Yes	
Holcus mollis	Yes	
Chenopodium sp.		Yes
Chenopodium album agg.		Yes
Sonchus asper		Yes
Sonchus oleraceus		Yes
Potentilla reptans	Yes	Yes
Daucus carota	Yes	Yes
Fallopia dumetorum		Yes
Juglans regia		Yes
Carex hirta	Yes	Yes
Rubus sp.	Yes	Yes
Arrhenatherum elatius	Yes	Yes
Symphoricarpos albus		Yes
Taraxacum sect. *Ruderalia*	Yes	Yes
Cirsium vulgare		Yes
Cirsium arvense		Yes
Artemisia vulgaris		Yes
Clematis sp.		Yes
Pulmonaria officinalis agg.		Yes
Myosotis arvensis		Yes
Glechoma hederacea	Yes	Yes
Potentilla argentea	Yes	Yes
Euphorbia cyparissias	Yes	Yes
Ranunculus acris		Yes
Agrostis capillaris	Yes	Yes
Agrostis cf. *stolonifera*	Yes	
Ligustrum vulgare	Yes	Yes
Stellaria media		Yes
Stellaria graminea		Yes
Elytrigia repens	Yes	
Achillea millefolium agg.	Yes	Yes
Agrimonia eupatoria	Yes	Yes
Lepidium ruderale		Yes
Anthemis arvensis		Yes
Cerastium holosteoides	Yes	Yes
Cerastium arvense		Yes
Veronica chamaedrys	Yes	Yes
Rosa sp.	Yes	Yes

Species	**2014**	**2016**
Syringa vulgaris		Yes
Silene vulgaris		Yes
Juncus bufonius		Yes
Crepis biennis		Yes
Prunus spinosa	Yes	Yes
Koeleria macrantha	Yes	Yes
Dactylis glomerata	Yes	Yes
Oxalis fontana	Yes	
Lotus corniculatus	Yes	Yes
Rumex sp.		Yes
Rumex acetosa		Yes
Bromus hordeaceus	Yes	Yes
Cornus sanguinea	Yes	Yes
Galium album	Yes	Yes
Galium verum	Yes	Yes
Convolvulus arvensis	Yes	
Anthoxanthum odoratum	Yes	Yes
Torilis japonica	Yes	Yes
Armeria elongata		Yes
Hypericum perforatum	Yes	Yes
Trisetum flavescens	Yes	Yes
Polygonum aviculare agg.		Yes
Erigeron annuus	Yes	Yes
Conyza canadensis		Yes
Vicia hirsuta	Yes	Yes
Vicia sepium	Yes	Yes
Vicia cracca		Yes
Vicia sativa	Yes	Yes
Vicia angustifolia		Yes
Viola hirta		Yes
Viola odorata	Yes	Yes
Chelidonium majus		Yes
Tanacetum vulgare	Yes	
Epilobium sp.		Yes
Calluna vulgaris	Yes	
Solidago canadensis	Yes	Yes
Campanula rotundifolia	Yes	

Table A2

Occurrence of lichens in years in a traditional fruit orchard in Prague.

Species	2014	2016
Verrucaria muralis	Yes	Yes
Buellia aethalea	Yes	
Amandinea punctata		Yes
Pertusaria amara		Yes
Cladonia coniocraea		Yes
Cladonia fimbriata	Yes	Yes
Lecania cyrtella	Yes	Yes
Caloplaca obscurella		Yes
Lecanora saxicola	Yes	Yes
Caloplaca oasis	Yes	Yes
Lecanora pulicaris		Yes
Lecanora conizaeoides	Yes	Yes
Lecanora dispersa	Yes	Yes
Lepraria incana		Yes
Lecidea fuscoatra	Yes	
Lecidella carpathica	Yes	
Bilimbia sabuletorum	Yes	
Hypocenomyce scalaris	Yes	Yes
Candelariella reflexa	Yes	Yes
Candelariella aurella		Yes
Parmelia sulcata	Yes	Yes
Hypogymnia physodes	Yes	Yes
Melanelixia fuliginosa	Yes	Yes
Pseudevernia furfuracea		Yes
Physcia aipolia	Yes	Yes
Physcia adscendens	Yes	Yes
Physcia dubia	Yes	
Xanthoria candelaria	Yes	
Physcia tenella	Yes	Yes
Phaeophyscia orbicularis	Yes	Yes
Xanthoria parietina	Yes	Yes
Micarea micrococca		Yes
Placynthiella icmalea		Yes

Table 3

Occurrence of butterflies in years in a traditional fruit orchard in Prague.

Species	**2014**	**2016**
Anthocharis cardamines	Yes	
Aphantopus hyperantus	Yes	Yes
Aricia agestis	Yes	
Carterocephalus palaemon	Yes	Yes
Coenonympha pamphilus	Yes	Yes
Colias cf. *hyale*		Yes
Gonepteryx rhamni		Yes
Inachis io		Yes
Iphiclides podalirius		Yes
Issoria lathonia	Yes	
Lasiommata maera		Yes
Leptidea cf. *reali*	Yes	Yes
Lycaena tityrus		Yes
Maniola jurtina	Yes	Yes
Melanargia galathea		Yes
Ochlodes sylvanus	Yes	
Pararge aegeria	Yes	
Pieris brassicae	Yes	Yes
Pieris napi	Yes	Yes
Pieris rapae	Yes	Yes
Polyommatus icarus	Yes	Yes
Pyrgus malvae	Yes	
Thymelicus lineola		Yes
Thymelicus sylvestris		Yes
Vanessa atalanta		Yes
Vanessa cardui	Yes	Yes
Zygaena angelicae		Yes
Zygaena filipendulae	Yes	

Table 4

Occurrence of beetles in years in a traditional fruit orchard in Prague.

Species	2014	2016
Meligethes aeneus	Yes	Yes
Dasytes plumbeus	Yes	Yes
Lygistopterus sanguineus		Yes
Mordella aculeata	Yes	Yes
Tomoxia bucephala	Yes	Yes
Cidnopus pilosus	Yes	
Agrypnus murinus	Yes	
Agriotes ustulatus	Yes	Yes
Anthaxia quadripunctata		Yes
Anthaxia nitidula	Yes	Yes
Valgus hemipterus		Yes
Cryptocephalus sericeus		Yes
Ceutorhynchus assimilis	Yes	Yes
Byturus ochraceus	Yes	
Chrysomela populi		Yes
Larinus turbinatus		Yes
Cantharis cf. *pellucida*	Yes	
Rhagonycha fulva	Yes	Yes
Trichodes apiarius		Yes
Anthrenus verbasci		Yes
Adonia variegata		Yes
Coccinella septempunctata	Yes	Yes
Harmonia axyridis		Yes
Oedemera femorata	Yes	Yes
Oedemera podagrariae		Yes
Oedemera virescens	Yes	Yes
Cortodera humeralis	Yes	
Pseudovadonia livida		Yes
Stenurella bifasciata		Yes
Stenurella melanura		Yes
Dinoptera collaris	Yes	
Clytra quadripunctata		Yes
Trichius cf. *fasciatus*	Yes	
Oxythyrea funesta		Yes
Cetonia aurata	Yes	

Table 5

Occurrence of orthopteroids in years in a traditional fruit orchard in Prague.

Species	**2014**	**2016**
Leptophyes albovittata	Yes	
Conocephalus fuscus		Yes
Phaneroptera falcata	Yes	Yes
Pholidoptera griseoaptera	Yes	Yes
Metrioptera roeselii	Yes	
Platycleis albopunctata	Yes	Yes
Tettigonia viridissima		Yes
Chorthippus albomarginatus		Yes
Omocestus haemorrhoidalis	Yes	Yes
Chorthippus brunneus		Yes
Chorthippus dorsatus	Yes	Yes
Chorthippus biguttulus	Yes	Yes
Oedipoda caerulescens	Yes	Yes
Chorthippus paralellus	Yes	Yes
Chorthippus apricarius	Yes	Yes
Chorthippus mollis	Yes	Yes

Table 6

Occurrence of birds in years in a traditional fruit orchard in Prague.

Species	**2014**	**2016**
Phasianus colchicus	Yes	Yes
Phylloscopus collybita	Yes	Yes
Phylloscopus trochilus	Yes	
Turdus philomelos		Yes
Columba palumbus	Yes	Yes
Streptopelia decaocto		Yes
Turdus merula	Yes	Yes
Sylvia atricapilla	Yes	Yes
Sylvia curruca	Yes	
Fringilla coelebs	Yes	
Falco tinnunculus		Yes
Phoenicurus phoenicurus		Yes
Garrulus glandarius	Yes	Yes
Sturnus vulgaris	Yes	
Carduelis carduelis		Yes
Pica pica	Yes	Yes
Dendrocopos minor	Yes	
Troglodytes troglodytes		Yes
Parus major	Yes	Yes
Cyanistes caeruleus	Yes	Yes
Passer domesticus	Yes	
Passer montanus	Yes	Yes
Picus canus	Yes	
Carduelis chloris	Yes	