Vegetation dynamics of anthropogenic habitats in settlements

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Synopsis

Vegetation dynamics of anthropogenic habitats in settlements is discussed on the basis of studies done by the author in Slovakia (urban areas in Trnava and Bratislava) and R. Bornkamm in Germany (urban areas of Berlin). Five types of ruderal plant communities were distinguished in relation to the position within the successional series (successional status). Bare soils (grounds) with pioneer vegetation and abandoned habitats with perennial vegetation are compared, and the vegetation is shortly characterized by qualitative and quantitative characteristics (life-forms, frequency and abundance, dominance, mean cover, biomass, population density, rate of changes, life strategy).

Ruderal vegetation, urban ecology, succession, anthropogenic habitats, early, middle and late succession stages, bare grounds, abandoned habitats

* Dedicated to Prof. Dr. Reinhard Bornkamm on the occasion of his 65th birthday.

Spontaneous vegetation in settlements is represented predominantly by ruderal plant communities growing on areas disturbed or severely influenced by man, viz. on anthropogenic habitats. These artificial, man-made habitats (ecotopes or »sociopes«) may be grouped into habitat types, differing by the effects of both anthropic and natural factors. Fundamental habitats groups distinguished in investigated regions on the basis of unifying ecological factors (ELIÁŠ 1980, 1981) are surveyed in Tab. 1.

During years anthropogenic habitats change due to human effects/activities, e.g. by disturbances. Vegetation colonized habitats are often damaged [disturbance sensu GRIME (1979) by partial or total destruction of the plant biomass], succession process is interrupted and succession has to start again from the beginning, initial stages (ELIÁŠ, 1979).

Ruderal vegetation represents a set of successional stages on different anthropogenic habitats. Ruderal communities are, therefore, considered as serial stages of succession, changing completely with time

Habitat Group	Unifying factor	Vegetation type
1. Trampled habitats	trampling	trampled communities (Plantaginetea)
2. Arable habitats	tillage	weed communities (Polygono-Chenopodietea, Secalinetea)
3. Ruderal habitats	enriching by refuses	nitrophytic communities (Artemisietea vulgaris, Sisymbrietea, Polygono-Chenopodietea)
4. Abandoned habitats	absence of human affects and opening to spontaneous succession	perennial communities (Agropyretea repentis, Artemisietea vulgaris, Meliloto-Artemisietea absinthii)
5. Ruined-area habitats	building material fall into ruins	annual and perennial communities (Sisymbrietea, Artemisietea)
6. Railway-yard habitats	pervious substrate exposed to sun	xerothermic herbaceous communities perennial semi-natural grasslands
7. Embankment habitats	sun-exposed excavated materials (slopes)	(Molinio-Arrhenatheretea, Agropyretea, Artemisietea)

Tab. 1
Main groups of anthropogenic habitats in Slovakia (ELIÁŠ 1981, 1982, 1986)

on a given site. Successional changes of ruderal vegetation are more affected by anthropic factors which play usually a dominant role.

The paper is based on ruderal vegetation investigations done in urban areas of Trnava town (ELIÁŠ 1978, 1979, 1983) and Bratislava city (ELIÁŠ 1982, KORMANÍKOVÁ, 1995) in Slovakia. The results are presented on general level and compared with the results obtained in urban areas of Berlin (BORNKAMM 1981, 1982, 1984, 1985, 1986, BORNKAMM, HENNING 1982, KOWARIK 1988) in Germany. The data from other urban areas (e.g. UBRIZSY 1955, DUVIGNEUAD 1975, PYŠEK 1977, SAILER 1990) are also considered.

1 Sucessional status of ruderal communities

Vegetation succession is a sequence of stages, characterized by changes in the dominant species and dominant life forms (KNAPP 1974). It is usualy considered by phytosociologists as a sequence of plant associations or of vegetation units below the association level (cf. BORNKAMM, 1985).

As BORNKAMM (1985) reported Warming in 1896 designated the following sequence of stages »annuals/biennials-perennial forbs and grasses-woody vegetation« as the overal sequence of series in a forest biome. Succession on ruderal habitats can differ widely, depending on type of ecotope, character and effect intensity of anthropogenic factor (e.g. disturbance) as well as on type of contact/neighbouring vegetation (ELIÁŠ 1979).

Succession on anthropogenic habitats was characterized by ELIÁŠ (1979) as a sequence of five successional stages, shortly described in Tab. 2. Succession on a certain habitat does not contain all successional stages introduced in Tab. 2., but it can reach higher/later stages much sooner. On very specific habitats the sequence of stages may be very different; it was described by ELIÁŠ (1979).

UBRISZY (1955) has shown ruderal series in progressive succession by the following sequence: summer annuals – overwintered annuals – biennials – geophytes and hemicryptophytes. He distinguished initial or annual communities – overwintering annual communities – biennial communities and communities of geophytes and hemicryptophytes – tall stem communities of hemicryptophytes – perennial communities.

Overal occurrence of phytocoena at a given successional stage can be considered as a successional status of an association and could be used for ecological characterization of plant communities (cf. ELIÁŠ 1984, 1986). PYŠEK and PYŠEK (1991) distinguished early, middle and late successional species and communities. On very general level we can separate short-living communities (annual, ephemeral, overwintered, biennial communities) and long-living communities (herbaceous perennial, woody communities).

2 Colonization and succession on anthropogenic habitats

Colonization of bare grounds and sucessional changes of vegetation on abandoned habitats are two very significant processes in urban areas. In this part we compare the habitat types and we characterize vegetation, using qualitative and quantitative characteristics (life-forms, frequency and abundance, dominance, mean cover, biomass, population density, rate of changes, life strategy).

Tab. 2
Successional stages of ruderal series on anthropogenic habitats (ELIÁŠ 1979)

Successional stage	Type of vegetation	Habitat features	Dominants	Duration
1st	pioneer annual	bare grounds new soil heaps	summer and overwintered annuals	1–2 years
2nd	biennial	transition	biennials	1–2 years
3rd	perennial herbaceous	waste places mineralized heaps	perennials	5
4th	perennial grasses	abandoned waste places	grasses	<10 5–10
5th	woody	long-term abandoned waste places	shrubs trees	>10

2.1 Bare Soils (Grounds)

represent two types of habitats by origin:

(1) anthropogenic habitats where previous above-ground vegetation was completely removed (usually with disturbance of soil surface and damage of plant roots in upper parts of the anthropogenic soils, substratum), and/or

(2) new habitats with imported soils, e.g. heaps of different arable soils or new thicker soil-layer, freshly covered previous soil surface. The soils are rich in nutrients, being transported from horticultural, agricultural, arable areas in the vicinity of a site or a town. These type of habitats occurr in urban areas with human management of public places.

Bare grounds are man-made habitats with high frequency and severe intensity of human disturbance. Bare soils represent, therefore, more or less habitats without above-ground vegetation. The vegetation was damaged and/or, as on arable soil (and other stype of substratum) heaps, it was not developed before. Vegetation development is limited by human disturbance (more or less periodical damage of plants and disturbance of soil surface) and succession is possible up to initial succession stages only.

The open, vegetation-free habitats are usually colonized by short-living plants. First year and second year pioneer species (sensu NUMATA 1979) occupy fertile disturbed soils. The pioneer vegetation is established from diaspores/propagules in soil (seed bank) and by growth of invaders from neighbouring places (immigrations).

Amounts of seeds in seed bank varied extremely in arable soils and in soils heaps, temporaly accumulated near building constructions. In Slovakia, for example, the numbers of seeds varied from 1.900 to 64.500 per square meter (ELIÁŠ 1991). However, the relationship between weed seed bank and weed infestation are complex and simple prediction are not feasible.

In first year of succession, the stands are characterized by a great number of annual weeds of arable soils. Stands of different species of annuals were observed, corresponding to the different soil types and seasons (BORNKAMM 1985). Summer annuals (Therophyta aestivalia) and autumn germinating species, e.g. wintergreen annuals (Therophyta hivernalia) and some bi-annuals, biennials (Therophyta bisannalia), are presented with high frequency and abudance. Perennials are present in a minority and usually in earlier ontogenetic phases (seedlings, young plants).

Vegetation differences in the sites started in the spring and summer may be due to the fact that free space became available at different seasons or at different years. BORNKAMM (1986) has shown that direct effects of the starting season were detected only in first two years of succession. But it was unclear in what manner the differentiation between terminal dominants may be related to the starting season.

Rate of changes in initial vegetation (floristic change and change of species cover sensu BORNKAMM 1981) on bare soils is rapid or very rapid. It was the cause UBRIZSY (1955) characterized the pioneer ruderal communities as remarkable mobile and dynamic weed communities.

Successional stage Habitat Community	Biomass Mean [kg m^{-2}]	 Range 	Height [m]	Density [i. m^{-2}]
1. Early successional stage				
Bare soils and fresh heaps				
Sisymbrietum sophiae	0.81	0.75–0.85	1.0	388–572
Atriplicetum tataricae	1.97		0.9	
Atriplicetum nitentis	2.17	1.70–2.40	1.5–2.2	92–190
Ivaetum xanthiifoliae	2.09	1.45–2.70	1.8–3.3	6–292
2. Middle successional stage				
Abandoned habitats				
Tanaceto-Artemisietum	2.13		2.2	75
Sambucetum ebuli	1.31	0.80–2.30	1.4–2.1	12–32
3. Late successional stage				
Abandoned habitats				
Agropyretum repentis	1.18	0.99–1.36	0.9	1780
Conyzo-Cynodontetum	0.86	0.79–0.90	0.30–0.5	

Tab. 3
Peak standing crop (seasonal maxima of dry biomass) of ruderal plant communities in SW Slovakia. Data are compiled from ELIÁŠ (1978).

Biomass of early herbaceous vegetation (1–3 years) was reported by LIETH (1974) to be 331–449 g m^{-2} (above-ground productivity). In western Slovakia, ELIÁŠ (1978) found peak standing crop (seasonal maxima of dry biomass) of annual ruderal vegetation 400 to 2500 g m^{-2}. The highest values were determined in tall herbaceous communities, dominated by fast-growing annual species (Tab. 3).

Pioneer vegetation on bare soils is dominated by short-living plants. This group of plants is presented here with high frequency and biomass, mean cover and number of individuals (population density). Population density varied from 300 to 600 individuals per m^2 (ELIÁŠ, 1983). Maximal height of dominant plants could reached 1 to 2 (3) m (cf. Tab. 3).

The dominant plants in early stages of colonization of anthropogenic habitats are ruderal dominants (annual herbs) sensu GRIME (1979) with large seed reserves, rapid rates of germination, growth and seed production. The annual dominants form frequently monodominant dense stands of reproductive specimens. They partcipate in stand biomass by more than 60% (ELIÁŠ, 1983). The root:shoot ratio remained high, nearly 6 (BORNKAMM 1984, 1985, ELIÁŠ, 1983).

Bare grounds are habitats with permanent occurrence of early successional stages of ruderal vegetation. Severe disturbance usually interrupt successional processes, vegetation is completely damaged and new bare areas are free for new colonization and early succession.

2.2 Abandoned habitats

differ from »bare« soils by frequency and intensity of human disturbance and by competition. Abandoned habitats are open to succession by absence or by low frequency of disturbances. Disturbance is only episodic or temporal, and of low intensity. On the sites abandoned for many years (10–20 and more) there are good conditions for establishment of perennial ruderal vegetation, belonging to several middle and late successional stages. Typical sequence of vegetation was observed and called »ruderal series« (UBRIZSY 1955).

Perennials invaded the habitats by supply of seeds (seed source) and very frequently by rhizomes and other types of clonal growth (cf. BORNKAMM, 1985, ELIÁŠ 1992). Dominant plants on abandoned habitats are competitive dominants sensu GRIME (1979), viz. perennnial rhizomatous herbs.

Perennial vegetion on abandoned sites in urban areas is dominated by long-living plants. First, perennial herbaceous forbs form usually diversified stands, dominated by geophytes and hemicryptophytes by life-forms. In middle and late successional stages perennial grasses become dominant, starting a long period of ruderal and/or semi-natural grassland vegetation. Woody species are not very frequent in the vegetation and transition from the perennial to the woody stage may be very long.

The changes of perennial stage on the abandoned habitats is slow. Floristic composition becomes more and more stable and the similarity between subsequent years is high (BORNKAMM 1986). Stabilized vegetation types (the stage does not change) represent dense stands of perennial species with clonal growth. BORNKAMM (1984) has shown a stable high forb community dominated by Solidago canadensis. Dense grass stands dominated by Calamagrostis epigejos were found by PYŠEK (1977), ELIÁŠ (1979) and others.

Biomass primary productivity of late herbaceous vegetation (3–10 years) was estimated to 685–1031 g m^{-2}. (LIETH 1974). DUVIGNEAUD (1975) and DUVIGNEAUD and DENAEYER-DE SMET (1977) found around 1000 g and more dry mass per m^2 for perennial ruderal vegetation in Brussels (Solidaginetum giganteae, Tanaceto – Artemisietum). Biomass accumulation in succession (MAJOR 1974) was supported by BORNKAMM (1981, 1984). In urban area of Berlin biomass of ruderal vegetation amounted on the average to 1000–1500 g m^{-2}. In western Slovakian's settlements seasonal maxima of dry mass of ruderal perennial vegetation varied between 800 and 2200 g m^{-2} (ELIÁŠ, 1978, 1983, Tab. 3). The shoot : root ratio decreased to unity (BORNKAMM 1984, ELIÁŠ, 1983).

Perennial plants occurr on abandoned habitats with high frequency and biomass, mean cover and number of individuals. Population density varied from 12 to 75 individuals. m^{-2} for perennial forbs and from 100 to 1000 stems (ramets). m^{-2} for perennial grasses (ELIÁŠ, 1983). Maximal height of dominant plants could reached 1 to 2 (2.5) m (cf. Tab. 3). Some perennial forbs (e.g. Solidago canadensis) and grasses (e.g. Calamagrostis epigejos) form frequently monodominant dense stands of reproductive specimens. They partcipated in stand biomass by more than 40 – 80 – 95 % (ELIÁŠ, 1983).

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