Plants in Urban Areas and Landscape
Slovak University of Agriculture in Nitra
Faculty of Horticulture and Landscape Engineering

DOI 10.15414/2014.9788055212623.35–39

# PHENOLOGICAL OBSERVATIONS OF *AILANTHUS ALTISSIMA* (MILL.) SWINGLE AT DIFFERENT URBAN AREAS

Ewa ZARAŚ-JANUSZKIEWICZ*, Barbara ŻARSKA, Beata FORNAL-PIENIAK, Edyta ROSŁON-SZERYŃSKA

Warsaw University of Life Sciences (SGGW), Poland

Urban space, due to its specific habitat conditions, is the space where the trees have difficult to grow. Therefore, a new species of trees are planted in cities. These species must cope with difficult urban conditions. Unfortunately, it oftenhappens that these new tree species well feeling in the city, begin to grow uncontrollably. These plant speces start to behave as invasive plants, they exclude other plant species from urban spaces, substantially affect the rate of biodiversity loss. There is also the possibility of passing such invasive plants from the cities to natural spaces (eg. *Acer negundo* and *Robinia pseudoacacia*). *Ailanthus altissima* (Mill.) Swingle is such a new and potentially dangerous species. *Ailanthus alitissima* may also appear in unusual places for its ecological optimum in the example of Warsaw. *Ailanthus* is a species of thermophilous and therefore urban conditions (heat island effect) favor the development of trees and increase its population size. Nevertheless, for several years occurence of *Ailathus* outside the Warsaw city are recorded. An example of such a position are urban forests at the northern border city. Observations were carried out since 2000. Such a location of the species may be indicative of adaptation to climatic conditions and the possibility of transition to natural stands. The main research tool are phenological observations of *Ailanthus altissima* at different urban areas. They allow us to conclude that plants growing in the central parts of the city have longer vegetation and stronger growth comparing to other urban areas observed. However, in locations situated on the outskirts of the city and urban forests trees plants often remain in the form of shrubs.

**Keywords:** *Ailanthus altissima*, invasive species, tree of heaven, phenology, urban conditions

## Introduction

Invasive plants and animals are in the modern world very important issue. Invasive species were considered second, after the destruction of habitats, the direct reason for the reduction of biodiversity. It is believed that invasive alien species could cost the global economy up to 5 % of global GDP (Pimental et al., 1999). Statistically, 10 species introduced to cultivation of one "escapes" to grow one "escapes". For 10 "fugitives" one bears fruit and reproduce. On 10 fruiting (naturalized) one is invasive.

Invasive alien species are plants, animals, pathogens and other organisms that are not native to the ecosystem and may cause damage to the environment or the economy or adversely affect human health. In particular, invasive alien species have negative effects on biodiversity, including the reduction or elimination of populations of native species through competition, food, predation or transmission of pathogens and interfering with the functioning of ecosystems. Invasive alien species imported or spread outside their natural habitats, impact on native biodiversity nearly all ecosystems of the earth and are one of the biggest threats to this diversity. From the seventeenth century, invasive alien species have contributed inter alia to the extinction of almost 40 % of animal species and many species of plants.

The problem of invasive alien species is constantly growing, mainly due to the expansion of global trade, transport and tourism, which may facilitate the introduction and spread of alien species in the environment. If for a given species new environment is sufficiently similar to the native, this species can survive and reproduce. Without encountering natural enemies or other restrictions species can become invasive: increase the area of its occurrence and displace native species. The damage increase further as a result of climate change, pollution, habitat loss and transforms environment by man.

Species can "travel" different ways using different "natural" media. Alien species get into the environment through deliberate or accidental release into the environment of animals and plants grown at home or in home gardens.

The most important sources of threat of biological diversity of introducted species are the plants, that after introduction into the wild nature reveal an ability to become established and spontaneous mastery and transformation of plant communities. The introduction of trees and shrubs is particular importance in this respect, because they can lead to long-term transformation of floristic composition and structure of forest and scrub phytocoenoses, especially if they are held for a long time, repeatedly and over large areas. A number of

*Correspodence: Ewa Zaraś-Januszkiewicz, Warsaw University of Life Sciences (SGGW), Faculty of Horticulture, Biotechnology and Landscape Architecture, Department of Environmental Protection, Poland, e-mail: ewa_zaras_januszkiewicz@sggw.pl

DOI 10.15414/2014.9788055212623.35–39

species used in forestry and agriculture were introduced deliberately by man in order to increase productivity and competitiveness in the market (eg *Quercus rubra*) or has been planted as ornamental plants in gardens and parks (eg *Acer negundo*). Often, these species just got out of control they expand and even spread in invasive manner. An example of such tree species is *Ailanthus altissima*.

## Material and method

*Ailanthus altissima*, commonly known as tree of heaven, ailanthus, or in Standard Chinese as chouchun (Chinese: 臭椿; pinyin: chòuchūn; it means "foul smelling tree"), is a deciduous tree in the *Simaroubaceae* family. It is native to both northeast and central China and Taiwan. The tree grows rapidly and is capable of reaching heights of 15 metres in 25 years. However, the species is also short lived and rarely lives more than 50 years. In China, the tree of heaven has a long and rich history. It was mentioned in the oldest extant Chinese dictionary and listed in countless Chinese medical texts for its purported ability to cure ailments ranging from mental illness to baldness (Hu, 1979). The roots, leaves and bark are still used today in traditional Chinese medicine, primarily as an astringent.

In addition to its use as an ornamental plant, the tree of heaven is also used for its wood, medicinal properties, and as a host plant to feed silkworms of the moth *Samia cynthia*, which produces silk that is stronger and cheaper than mulberry silk, although with inferior gloss and texture. It is also unable to take dye (Duke, 1983). This type of silk is known under various names: "pongee", "eri silk" and "Shantung silk". Its production is particularly well known in the Yantai region of that province (Gill, 2004).

The pale yellow, close-grained and satiny wood of *Ailanthus altissima* has been used in cabinet work. It is flexible and well suited to the manufacture of kitchen steamers, which are important in Chinese cuisine for cooking mantou, pastries and rice. It is also considered a good source of firewood across much of its range as it moderately hard and heavy, yet readily available. The wood is also used to make charcoal for culinary purposes (Barclay, 2013). Because the trees exhibit rapid growth for the first few years, the trunk has uneven texture between the inner and outer wood, which can cause the wood to twist or crack during drying. Although the live tree tends to have very flexible wood, the wood is quite hard once properly dried (Keeler, 1900).

In Europe, the plant first appeared in 1751. In Poland 1808 in the Cracow Botanical Garden (Seneta, 1991), and the status of this specie is domesticated anthropophyte.

It is typically a thermophilic species, because in many Polish cities is more and more areas.

*Ailanthus alitissima* may also appear in unusual places for its ecological optimum in the example of Warsaw. Nevertheless, from several years locations of Ailathus outside the city are recorded. An example of such a position are urban forests in the northern border city.

The aim of this paper is to demonstrate the presence of *Ailanthus altissima* in Warsaw at three different urban zones: centrum, districts located peripherally and suburban areas. Further aim of the study is to demonstrate the strength grade adaptations to environmental conditions (mainly thermal) expressed as phenoloical phases duration at *Ailanthus altissima* at different urban zones.

The work was made observations regarding the presence of *Ailanthus altissima* in Warsaw. Spot on the city reported the presence of the specimen in the lane NS and EW-striking in the central part of the city. Belts had a width of about 2 km. Belts stretched from the border of the suburb area in the north of the city to the suburban area to the south of Warsaw. Similarly, on the east-west direction.

The main research tool are phenological observations. Phenological observations were carried out on mature individuals. Observations took place in 2005–2011. They were a group of individuals in to the town center (highly urbanized zone), are outside the city center and suburban area. The description of the main phenophases are as follow:

V – the growing phase (V1 – swelling and cracking buds; V2 – leaf stage; V3 – Phase fall leaves).
Fl – flowering phase.
Fr – fruiting phase (from fruit set to maturity).

The recorded duration of the given phases at each of the three locations were averaged and plotted.

## Results and discussion

### Occurrence of *Ailanthus alitissima* in Warsaw

They allow us to conclude that plants growing in the central parts of the city have longer vegetation period and stronger growth. However, in locations situated on the outskirts of the city and urban forests growing period is shorter, and plants often remain in the form of shrubs.

As a result of the observation noted that *Ailanthus altissima* definitely prefers locations associated with the onset of the heat island phenomenon. Locations are primarily the central part of the city, with a high degree of urbanization. Very often, the trees appear in the cracks between sidewalks and buildings, the hardened surfaces (eg concrete slab). They form dense thickets through intensive sprawling root system. In the central part of Warsaw, covered by the observations we reported 97 groups or individual trees. Most positions formed a group in which one can distinguish some plants planted intentionally (eg, parks, squares and green street-adjacent) and a group of spontaneously proliferating plants. These spontaneously occurring specimens are developed in vegetative (root suckers) or generative (seeds) way.

Away from the city center *Ailanthus altissima* frequency of occurence decreases. There has been following number of grupus or individual trees of *Ailanthus altissima* in parts: S – 14 (including 4 positions

DOI 10.15414/2014.9788055212623.35–39

in the outer part of the city), N – 12 (including 2 positions in the outer part of the city), W – 17, E – 9.

However, the most interesting is the presence of *Ailanthus altissima* in suburban zone, including forests within urban forests, such as the Mlociny Park north of Warsaw. As explained by phenological observations, the averaged results are presented in the form of charts, *Ailanthus* shows a certain, limited ability to adapt to growth in terms of less conducive thermal conditions.

Comparing the average duration of each phenological phases can be seen that the specimens growing in central parts of the city have increased the length of the vegetative and generative phases in relation to the other location. In case V2 phase difference between the copies of rising in the center of the city and suburban areas is up to 20 days. Similarly, the phase Fr – fruits in the center were formed earlier and ripened earlier than in the suburban area.

These observations show that the environmental conditions in the central parts of the city assisting the processes synanthropisation and confirm the thermal preferences of the species. However, do not preclude the adaptation of the species to a less comfortable thermal conditions. In the case of specimens growing in the outer parts of the city can be observed that the plants do not create the form of trees. Probably stronger frosts, especially those from the early autumn period and spring, which take place in Polish climatic conditions, effectively limit the growth of plants. As a result, the plants are retained on the stage of the shrubs.

It should be emphasized that the adverse thermal conditions for this species does not eliminate it, and do not constitute an obstacle to the self-renewal plants and independent distribution in terms natural or semi-natural. The *Ailanthus* propagules are seeds, but the tree forms many root suckers, through which plants form dense clusters.

With the length of each phenological phases can draw a very important conclusion. Copies of growing in the center of the city start to vegetate earlier (this is a difference of up to about 7 to 10 days). Similarly, the end of the growing season – specimens growing in the suburban area of vegetation end about 14 earlier compared to specimens growing in the city center.

Currently on Polish territory is cultivated more than 2500 species (warieties no included) of trees and shrubs, what represents the number of about 10-fold higher than the number of native woody species. Relatively few of them so far revealed an ability to become established,

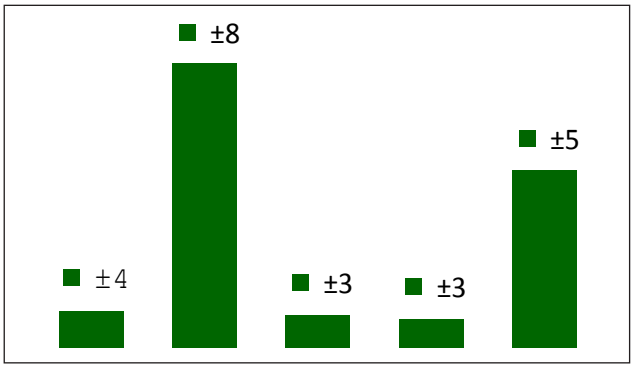


**Figure 1** *Ailanthus* in central part of Warsaw [Lok. 1] – the duration of each phonological phases (number of days with the standard deviation)

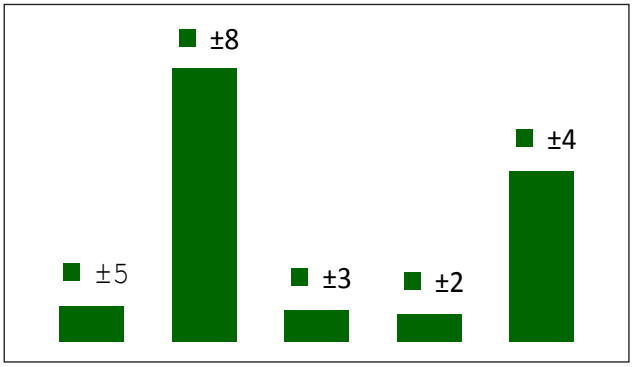


**Figure 2** *Ailanthus* in peripheral districts [Lok. 2] – the duration of each phonological phases (number of days with the standard deviation)

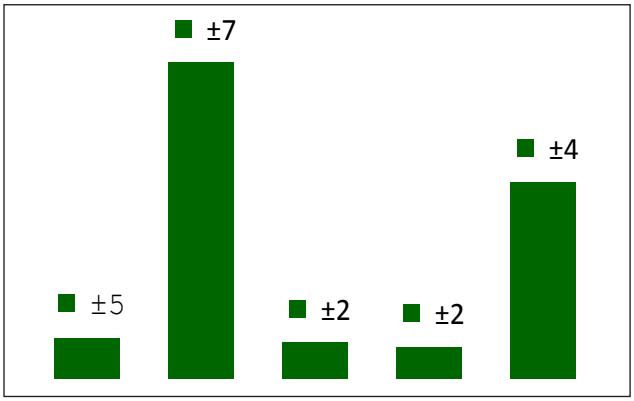


**Figure 3** *Ailanthus* in suburban zone [Lok. 3] – the duration of each phonological phases (number of days with the standard deviation)

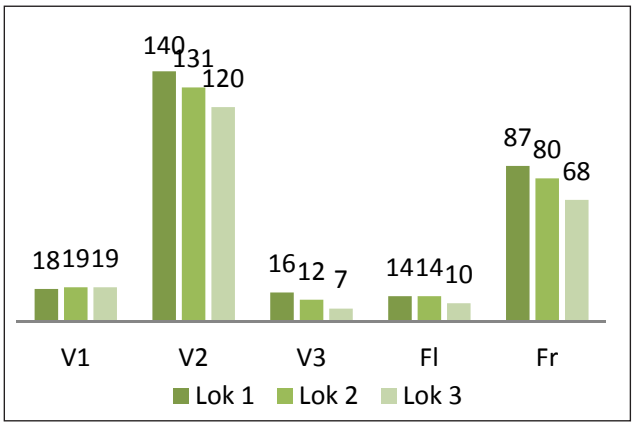


**Figure 4** Comparison of the duration of the all phenological phases at all locations

DOI 10.15414/2014.9788055212623.35–39

**Figure 5** Self-seeding *Ailanthu altissimas* at the street curb on the car parking in central part of Warsaw
Photo: Zaraś-Januszkiewicz, 2011

**Figure 6** Thickes of *Ailanthus altissima* root suckers
Photo: Zaraś-Januszkiewicz, 2011

but can not be ruled out that others in the future demonstrate such a property, because in the case of the above mentioned group of plants it can develop after several decades after the introduction.

From the point of view of the diversity of local or regional alien species is always a real or potential threat to indigenous species: introduces new interactions in ecosystems, habitats is often acts reductively on native species, where it is often difficult to know in advance the degree of aggressiveness and ability to penetrate alien species into natural or semi-natural ecological systems (Olaczek, 2000). Such a phenomenon has been observed in the case of *Ailanthus altissima*. *Ailanthus altissima* is extremely competitive: producing up to 350 000 seeds per year, a very fast growing, drowning out other plants growing near, and even special producing toxins that prevent their development. Its root system is so strong that it can cause destruction of the foundations and sewers.

The process of synantropisation is especially intensive in urban areas. Due to the specific habitat conditions they are somewheat, difficult to accept by native vegetation, but acceptable to the species of foreign origin, recruiters from areas of similar habitat conditions for urbanareas, particularly in terms of heat. Interest in the flora of urban areas has been shown for almost 200 years (Jackowiak, 1998; Pyšek, 1989; Sudnik-Wójcikowska, 1998a). The species composition of urban vegetation and its function in the urban ecosystem as well as the role of man are significant because these factors affect ecological conditions and changes in urban areas.

In Warsaw tree-of-heaven, like in Wrocław, grew in a variety of habitats. The greatest number of its locations were found in quarters with high-rise and high-density residential areas, it means in central part of city, where the highes occurrence was recorded.

Downtown areas, they often grew in places associated with streets green areas, because *Ailanthus* tolerates soil salinity conditions. Tree of heaven grew also in industrial quarters, *Ailanthus* are especially often found in the vicinity of parks, which have been deliberately planted.

The vegetation of the city keeps undergoing transformation over time as a result of the changing ecological conditions.

The hemeroby structure of habitats where tree-of-heaven grows in Warsaw, Poznań or Wrocław agrees with data from Berlin, where the tree was also usually found in the same habitats (Kowarik and Böcker, 1984).

The center of a big city is warmer than the surrounding areas. There occurs the so – called urban thermal island. Its formation is controlled by a variety of factors, like the warming effect of buildings resulting from heat absorption during the day and its emission in the evening, additional heat emission sources generated by industry, and most importantly, the heating of houses. A consequence of the thermal island existence is the appearance of thermophilic plant species, i.e., with higher temperature requirements, and locally even an expansion of some of them. Those species include tree-of-heaven, traveller's-joy (Czekalski and Kidawska, 2003) and buddleia (Kownas, 1958). The distribution of tree-of-heaven in Warsaw, like in Wrocław in 1998–2001, was concentrated in areas where air temperature was higher. Presumably the heat factor had a decisive influence on such a distribution, because tree-of-heaven has been shown to be a typical thermal indicator associated the warmest areas of Central European cities and highly industrialised regions, e.g., in Duisburg, Berlin, Leipzig, Halle and Zurich, as well as on the French coast of the Mediterranean and the Ruhr Basin in Germany (Kowarik, 1983a, 1983b; Kowarik and Böcker, 1984; Kunick, 1984; Landolt, 1991a, 1991b; Sudnik-Wójcikowska and Moraczewski, 1993; Sudnik-Wójcikowska, 1998a). In Poland data on distribution tree-of-heaven in urban areas were presented by Pacyniak (1976) and Sudnik-Wójcikowska (1998b) for Warsaw and Łódź.

However, in the last decade there apperance the *Ailanthus* outside the urban heat island. This may indicate

DOI 10.15414/2014.9788055212623.35–39

either climate change, expressing a growing balance of thermal and systematic warming of the climate, as well as the adaptation of the species to less favorable thermal conditions. This phenomenon is extremely unfavorable, because the species is characterized by a large expansiveness, begins to appear in semi-natural and natural forest complexes.

The Wrocław population of the tree-of-heaven, the largest in Poland, is probably associated with its introduction to Berlin in 1797 (Kowarik and Böcker, 1984). The tendency of population will increase *Ailanthus* can also be seen in other Polish cities, but the population from Wrocław of tree-of-heaven is excellent subject for studies on the biology, ecology and possible applications of tree-of-heaven in urban areas. In Poland, it is recommended for planting along broad avenues and streets, and in squares and parks of western, central and southern Poland (Bugała et al., 1984). Its soil requirements are modest; it can grow in dry, low fertility, and trans-formed antropogenic soils with a high admixture of rubble. It often sows itself and regenerates in places where other plants are unable to grow. It displays an excellent ability to adapt, also to the difficult urban and industrial conditions continually changing under the human impact. Sukopp (1972) and Sudnik-Wójcikowska (1998a, 1998b) classified tree of heaven as a thermophilic species, i.e., growing the warmest areas in many Central European cities.

## Conclusion

1. The central part of the city, with the associated heat island, represent the most advantageous place for self-growth plant, sow and create thickets by root suckers. This process each year is increasing and the trend is noticeable expansion of the population of *Ailanthus.*
2. The duration of the growing season of *Ailanthus* in the central part of the city comes to about 180 days. In the case of suburban areas, this period is reduced to about 150 days.

## References

BARCLAY, E 2013. The Great Charcoal Debate: Briquettes Or Lumps? NPR. Retrieved 25 May 2013, from http://www.npr.org/blogs/thesalt/2013/05/24/186434261/the-great-charcoal-debate-briquettes-vs-lumps

BUGAŁA, W. – CHYLARECKI, H. – BOJARCZUK, T. 1984. Dobór drzew i krzewów do obsadzania ulic i placów w miastach z uwzgldnieniem kryteriów rejonizacji. In Arboretum Kórnickie, vol. 29, 1984, pp. 35–62.

CZEKALSKI, M. – KIDAWSKA, G. 2003. Występowanie powojnika pnącego (*Clematis vitalba* L.) we Wrocławiu (Dolny Śląsk). In Rocznik Dendrologiczny, vol. 51, 2003, pp. 131–142.

DUKE, J. A. 1983. *Ailanthus altissima*. Handbook of Energy Crops. Purdue University Center for New Crops & Plant Products, 1983.

GILL, B. 2004. *Ailanthus.* WoodSampler. Woodworker's Website Association. Retrieved 2010-02-07 http://www.woodworking.org/WC/Woods/004.html

HU, S. 1979. *Ailanthus altissima*. In Arnoldia, vol. 39, 1979, no. 2, pp. 29–50.

JACKOWIAK, B. 1998. The hemeroby concept in the evaluation of human influence on the urban flora of Viena. In Phytocoenosis, vol. 10 (N.S.), 1998, pp. 79–93.

KEELER, H. L. 1900. *Simaroubàceae – Ailanthus* family. Our Native Trees and How to Identify Them. In New York: Charles Scriber's Sons. pp. 36–40. Retrieved 2010-02-07, from http://books.google.ca/books?id=93Zw4qMOsaUC&pg=PA36

KOWARIK, I. – BÖCKER, R. 1984. Zur Verbreitung, Vergeschartung und Einbürgerung des Götterbau- mes (*Ailanthus altissima* [Mill.] Swingle) in Mietteleuropa. In Tuexenia, vol. 4, 1984, pp. 9–29.

KOWARIK, I. 1983a. Flora und Vegetation von Kinderspielplätzen in Berlin (West) – ein Beitrag zur Analyse städtischer Grünflächentypen. In Verh. Berl. Bot., vol. 2, 1983, pp. 3–49.

KOWARIK, I. 1983b. Zur Einbürgerung und zum pflanzengeographischen Verhalten des Götter- baumes (*Ailanthus altissima* (Mill.) Swingle) im französischen Mittelmeergebiet (Bas – Languedoc). In Phytocoenologia, vol. 11, 1983, no. 3, pp. 389–405.

KOWNAS, S. 1958. Zarośla Buddleja variabilis na gruzowiskach Szczecina. In Rocznik Dendrologiczny, vol. 12, 1958, pp. 461–464.

KUNICK, W. 1984. Verbreitungskarten von Wildpflanzen als Bestandteil der Stadtbiotopkartierung dargestellt am Beispiel Köln. In Verhandlungen der Gesellschaft für Ökologie, vol. 12, 1984, pp. 269–275.

LANDOLT, E. 1991a. Die Entstehung einer mitteleuropäischen Stadtflora am Beispiel der Stadt Zürich. In Ann. Bot., vol. 49, 1991, pp. 109–147.

LANDOLT, E. 1991b. Distribution patterns of flowering plants in the city of Zürich. Modern ecology: basic and applied aspects. In Elsevier Publ., 1991, pp. 807–822.

OLACZEK, R. 2000. Różnorodność biologiczna a problem introdukcji obcych gatunków. In: T. Bojarczuk, W Bugała (red.), Bioróżnorodność a synantropizacja zbiorowisk lesnych, Materiały Zjazdu Sekcji Dendrologicznej Polskiego Towarzystwa Botanicznego – referaty, doniesienia, postery, Wirty, 2000, pp. 7–13.

PACYNIAK, C. 1976. Rodzaj *Ailanthus* Desf. w Polsce i jego znaczenie dla zadrzewie miejskich. In Rocznik Dendrologiczny, vol. 29, 1976, pp. 113–120.

PIMENTAL, D. – LACH, L. – ZUNIGA, R. – MORRISON, D. 1999. Environmental and economic costs associated with non-indigenous species in United States. Retrieved January 1999 from http://www.news.cornell.edu/releases/Jan99/specoes_costs.html

PYŠEK, P. 1989. On the richness of Central European urban flora. In Preslia, vol. 61, 1989, pp. 329–334.

SENETA, W. 1991. Drzewa i krzewy liciaste (A–B). Warszawa : Wyd. Nauk. PWN, 1991.

SUDNIK-WÓJCIKOWSKA, B. – MORACZEWSKI, I. R. 1993. Floristic evaluation of anthropopressure zones in Warsaw. In Feddes Repertorium, vol. 104, 1993, pp. 81–92.

SUDNIK-WÓJCIKOWSKA, B. 1998a. Czasowe i przestrzenne aspekty procesu synatropizacji flory na przykładzie wybranych miast Europy rodkowej. Warszawa : Wyd. UW, 1998.

SUDNIK-WÓJCIKOWSKA, B. 1998b. The effect of temperature on the spatial diversity of urban flora. In Pthytocoenosis, vol. 10 (N.S.), 1998, pp. 97–105.

SUKOPP, H. 1972. Wandel von Flora und Vegetation in Mitteleuropa unter dem Einflu des Menshen. In Ber. Landwirsch., vol. 50, 1972, pp. 112–130.