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The Ecological Potential of Poplars (*Populus* L.) for City Tree Planting and Management: A Preliminary Study of Central Poland (Warsaw) and Silesia (Chorzów)

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Abstract: Urban environments face escalating challenges due to uncontrolled urbanization, rapid population growth, and climate changes, prompting the exploration of sustainable solutions for enhancing urban green spaces (UGSs). For this reason, poplars (*Populus* L.), due to their rapid growth, wide range adaptability to environmental conditions and versatility of use, have emerged as very promising. This comprehensive review synthesizes current knowledge regarding poplar's application in urban landscapes, emphasizing its multifaceted contributions and benefits. However, challenges arise from the variable lifespans of different poplar cultivars, necessitating strategic management approaches. Selecting cultivars based on growth rates, root system characteristics, and adaptability to urban conditions is pivotal. Adaptive replanting strategies, incorporating species with varying lifespans, offer solutions to maintain continual greenery in urban landscapes. Collaborative efforts between researchers, urban planners, and policymakers are essential for devising comprehensive strategies that maximize benefits while addressing challenges associated with their variable lifespans. In conclusion, harnessing poplar's potential in urban greenery initiatives requires a balanced approach that capitalizes on their benefits while mitigating challenges. Further research and adaptive strategies are crucial for sustained and effective utilization to create resilient and vibrant urban landscapes.

Keywords: urban green spaces; urbanized landscape; urban environments; climate changes; aesthetical values of trees; *Populus* ×*berolinensis*

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1. Introduction

Trees play a crucial role in fostering sustainable urban ecosystems [1–13]. In urbanized and open landscapes, trees can provide a diverse range of ecosystem services—among others, the mitigation of environmental degradation and the enhancement of biodiversity. The impact of high greenery on cultural services is also invaluable [14–21]. Planting and maintaining trees in urban areas is widely recognized as a form of environmental biotechnology (phytoremediation)—the simplest and most direct means to reduce air, water, and soil pollution and increase carbon sequestration due to the vast biologically active surface areas that trees can produce [6,22–31].

Unfortunately, on average, in cities (downtowns), trees appear to have gradually decreasing lifespans or health and safety quality. Because of anthropopression, large, mature, and old trees are declining, and a percentage of new-planted trees do not compensate for the benefits of the old trees. In this way, very often, one large urban tree provides benefits equivalent to a few dozen young, new plantings [6,32–36]. At the same time, the need arises to obtain the effect of planting healthy and young trees as quickly as possible because only such specimens can provide the desired ecosystem services to face challenges like global climate changes [37–40]. Cities are mostly affected by poor soil properties and drought risks and are full of degraded areas after earlier periods of development. In this way, selected groups of trees available for heap difficult conditions must be considered in the future. Not all areas are able to be rained on or can be considered organic ground. Thus, as we look into the past, such obligations were not able to be met due to the poor conditions of the 20th century in Eastern Europe. However, some trees were first chosen for planting in such degraded areas where new developments were planned. In Polish cities, we have a lot of examples of the use of poplars and clones. Clones are represented mostly by *Acer negundo* L. and this species is mostly used in degraded areas and does not represent aesthetic value. On the other hand, we have observed other trees that are more ecologically valuable, which are poplars.

In such a context, poplar trees (*Populus* L.) have garnered attention in previous decades for their great potential to contribute significantly to the quality and quantity of urban greenery. It is just worth mentioning that before the Second World War, and then from the 1950s up to the end of 1970s, in some European countries (e.g., Poland or the Czech Republic), the mass afforestation of urbanized, industrial, and open landscapes was carried out with a significant share of poplars [41]. Difficult urban conditions make poplars valuable for introduction into UGSs because of their wide range of critical predispositions, including the following:

- Achieving quite large dimensions connected to rapid growth and an increase in biomass (e.g., LAI);
- Having a quick impact on the local microclimate, e.g., shading, transpiration, protection against wind and noise, etc.;
- Their phytoremediation abilities like the filtration of particular matter (PM) or gas pollution from air or the absorption of heavy metals from water and soil;
- Their high adaptability to various soil and water conditions;
- Their considerable tolerance for pollution of air, water, and soil;
- Their mass production of nursery material;
- Their good planting efficiency with the minimum necessary maintenance [41–44].

In general, the advantages of poplars, making them a promising planting material for improving urbanized landscapes, are connected to their rapid growth (allowing them to obtain a large amount of plant biomass in a relatively short time), their high adaptability to various soil conditions, and the diverse environmental benefits that they can provide [42–44].

On the other hand, the use of poplars in urban areas is limited due to some inconvenient features of these plants like their relatively short lifespans; low wood resistance (which makes them affected more by storms); shallow root systems, possibly damaging infrastructure; potential production of root suckers; quite long period of leaf fall (cleaning); relatively higher susceptibility to insect and fungal diseases; or production of seeds with cottony hairs, polluting the environment in the spring (only female specimens) [41–45].

In the context of urban environments, cities can expand the realized climatic niches of various species. This issue was demonstrated in a study involving five poplar species worldwide, *Populus balsamifera*, *Populus deltoides*, *Populus nigra*, *Populus tremula*, and *Populus tremuloides*, in cities across the globe [46]. Another research effort presents a global risk assessment of over 3000 tree species, including 19 poplar species planted in 119 cities worldwide. The study revealed that 15 species are potentially at risk due to increases in temperature in 100 cities globally [47]. Consequently, countries like China have noted the impacts of climate change on three poplar species, recognizing it as an important factor to be assessed, as indicated in the Global Ecology and Convention report [48].

Regarding the undoubted advantages of poplars (*Populus* L.) for diverse urban environments worldwide and keeping in mind their obvious limitations, the problem of to solve is how to ensure their optimal integration into urban green spaces (UGSs) for maximizing their environmental benefits, mitigating potential challenges, and ensuring their sustainable use. This publication aims to synthesize and critically examine the use of poplars in urban landscapes, emphasizing their aesthetic, ecological, economic, and social significance. Our goal was also to consolidate existing knowledge on utilizing poplars in urban greenery, identify critical areas for further research, and advocate for their strategic incorporation into urban planning for a more sustainable and resilient urban future.

Here, we have formulated our research thesis about the hypothesis that we aim to prove: the rational use of poplars in 21st-century cities worldwide, including those in Europe, the Middle East, and Asia, is essential for maintaining healthy greenery and urban woodlots. Proper selection of species/cultivars and their adaptation to habitat conditions are crucial for addressing ongoing climate change and enhancing quality of life for urban populations. While poplars are often undervalued in urban settings, their properties, such as rapid growth, large size, and tolerance to anthropogenic pressures, today make them invaluable in shaping urban forests amid changing climates.

2. Methodology

2.1. Research Framework

The research framework of the present study is described below. It consisted of a few main stages presented in Figure 1. The formulation of the main goal of our research allowed us to start the first stage of work. An extensive literature search was conducted to compile examples of research concerning poplars, especially in the context of their potential for use in urban green areas. Issues identified during the literature review led us to synthesize poplar species' traits, making them unique for use in diverse urban settings. It was also a theoretical background for case studies presented in the following stages of research. The next step involved collecting the results of field observation and investigations by the authors of woodlot forms consisting of various poplar taxa in urban areas. Field studies used techniques of dendrological inventories and included, among others, taxonomic identification, the spatial forms of woodlots (the horizontal and vertical structure), the measurement of parameters of representative trees by determining their conditions and health statuses, assessments of the dates of planting and the ages of representative trees, and photographic documentation. The analysis of collected data allowed us to show, in particular, one representative cultivar of balsamic poplar (*Populus ×berolinensis* (K. Koch) Dippel) for its up-and-coming use features in urbanized landscapes.

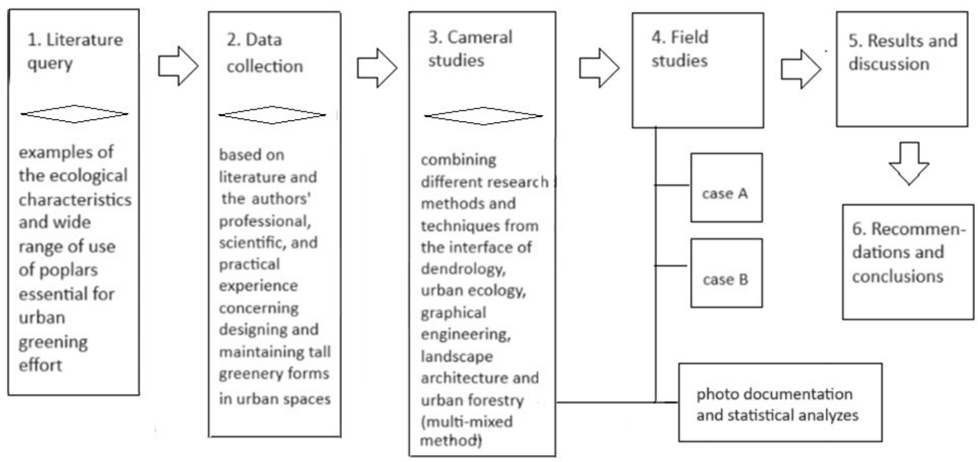

Figure 1. The research framework (the author's own elaboration).

The fourth step consisted of cameral studies of multi-mixed methods, combining different research methods and techniques from the interface of dendrology, urban ecology, graphical engineering, landscape architecture, and urban forestry.

Firstly, it consisted of a collection of archival photographs illustrating the Ziętek Promenade in Chorzów and Rakowiecka Street at the former headquarters of the Warsaw University of Life Sciences (WULS-SGGW) and the graphic processing of archive materials in GIMP and Inkscape graphical applications. The analysis of the photos was performed as follows:

Case A. Rakowiecka Street in Warsaw, Poland. Images from individual years (1925–2014) collected during the literature search were superimposed and aligned with the original 1930 photograph of the first tree planting next to the building, then scaled and aligned using perspective and grid tools in the GIMP graphics tool. The building's facade was measured using a Nikon laser rangefinder (model Forestry Pro 2, Nikon Vision Co., Ltd., Shanghai, China) for verification purposes. Then, the profile of the poplar at the entrance to the building was drawn for individual years, and the dimension was measured by reading the data from the grid. Subsequently, auxiliary illustrations were made showing the patterns of poplars in specific periods and the parameters obtained. On this basis, the ages of the trees were estimated.

Case B. The Ziętek's Promenade in Chorzów, Poland. First, three pictures illustrating the view of the even row of Berlin poplar trees were selected from the query literature (those from the 1950s, the transition from the 1950s and 1960s, and 2014). Then, the lengths and heights of characteristic elements in the field were measured with a rangefinder; lamps measured the distances between the poplars in the alley (dimensions similar to those of previous years). These dimensions were plotted based on illustrations, and then the heights and widths of the tree bark in specific periods were estimated. Average values for plant growth for each year were used, i.e., 1959, 1965, and 2014. Subsequently, auxiliary illustrations were made to show the patterns of poplars in specific periods and obtain parameters.

Secondly, we tested the relationship between the selected dendrometric parameters (e.g., height vs. age) using Statistica 13.0 software. A representative group of 10 young Berlin poplars from a newly replanted section of the Ziętek's Promenade measured in 2016, 2021, and 2023, as well as selected preserved poplars on Rakowiecka Street in Warsaw (data from 2012 and 2024), were subjected to a statistical study (Sperman's rank correlation analysis).

Finally, we discussed the results achieved and formulated concussions.

2.2. Materials and Methods

A mixed-method approach was employed in this study. The methods used can be divided into two groups: analytical and field-based methods.

The first group of methods involved a meticulous review of the literature data and its critical analysis. To address the gaps in our understanding of poplars' urban use, we diligently utilized major databases, employing a broad set of keywords indirectly related to these trees. This was carried out to explore and compile examples of the ecological characteristics and wide range of uses of poplars crucial for urban greening efforts. Various combinations of keywords, such as "urban green spaces", "green areas", "urban environments", "climate changes", "trees' values", "poplars", and "phytoremediation", were used to search online literature databases, including Scopus, ISI Web of Knowledge, EBSCO, and Google Scholar. Additionally, data collected in this research stage included the literature sources and the authors' professional, scientific, and practical experience in designing and maintaining tall greenery in urban areas.

An essential part of the fieldwork involved performing queries of archival sources (books, digital archives) to identify maps and historical photographs from locations selected for field studies (Case A and Case B). The obtained materials allowed for determining the growth rate of tree height over the past decades via comparison with other objects of known dimensions in precisely dated photographs.

In the fieldwork group, the authors conducted extensive long-term observations and detailed studies at both sites (Case A and Case B). The essential source of data comprised dendrological inventories conducted on Rakowiecka Street in Warsaw and the Ziętek's Main Promenade in Silesia Park in Chorzów (materials in the authors' collections). Tree inventories were conducted in similar seasons of the year (summer–autumn period), considering parameters such as trunk circumference at a height of 1.3 m, tree height, crown width, the assessment of health condition, and habit maintenance. The research material was obtained and supplemented with annual observations of tree conditions in the spring–summer and autumn periods. The Berlin poplars selected for this study grow linearly along street tree lanes and park promenades. Hence, tree applications in Cases A and B are comparable. Photographic documentation serves as supplementary material to field measurements. It is a valuable form of research documentation, allowing for the presentation of examples illustrating the research problem and the locations and objects of direct field studies.

The data gathered through both analytical and field-based methods provide robust material for statistical analysis. In this study, we employed correlation analysis using the *t*-test (after conducting a test of normal distribution compliance using the Shapiro–Wilk test). The data analysis was performed using the reliable Statistica 13.0 software.

3. Results and Discussion

Our review of scientific databases has shown that there is only very limited research devoted to the direct use of poplar cultivars in woodlots located in UGSs. But, indirectly, some of these studies also indicate the practical potential of poplars for use in anthropogenic environments. The conducted review of the literature revealed that poplars offer significant potential in current research for providing ecosystem services and mitigating pollutants in urban areas, recognizing for their role in improving air quality and acting as natural barriers for contaminant retention [41,49–53]. In cities, poplars are valuable trees for the following tasks:

- Obtaining quick visual results in urban green spaces and cityscapes;
- Reinforcing the environment and shaping a favorable microclimate in a relatively short time period;
- Covering and masking buildings and unattractive objects and views, e.g., warehouses, landfills and heaps, etc.

Integrating poplars into urban greenery initiatives presents challenges and opportunities that must be carefully navigated, including selecting species considering their environmental impacts [54], managing potential trace metal contamination [55], ensuring long-term maintenance, addressing community concerns, and recognizing ecological and psychological benefits for sustainable urban environments.

3.1. The Contribution of Poplars to the Urban Environment

As mentioned, urban landscapes in the 21st century suffer from deforestation, which stems from numerous factors. In context of rapid global climate changes (droughts, hurricanes, floods, etc.) and the need to develop sustainable urban environments, this phenomenon could be mitigated through comprehensive reforestation initiatives and the development of urban green spaces [56–60] connected to effective urban planning [58,59]. The expansion of urban areas and changes in land cover pose threats to urban vegetation, emphasizing the importance of sustainable management [61]. In this case, strategic tree selection is one of the necessary comprehensive solutions that provides ecosystem services such as carbon sequestration, biodiversity support, and air and water pollution mitigation. Poplars could stand out in this field due to their suitability for resolving the contemporary challenges facing urban and industrial environments [42–44] (Figure 2).

It has been proved that poplar trees can efficiently remove airborne particulate matter (PM) and associated metals through phytoremediation, contributing to urban air quality enhancement, while their adaptation to adverse environments and fast growth make them an interesting alternative for urban landscaping [52,53]. Cultivars of poplars—if used properly (carefully selected, e.g., in relation to spatial and site conditions)—could effectively improve air quality by capturing PMs, thereby reducing air pollution levels [62].

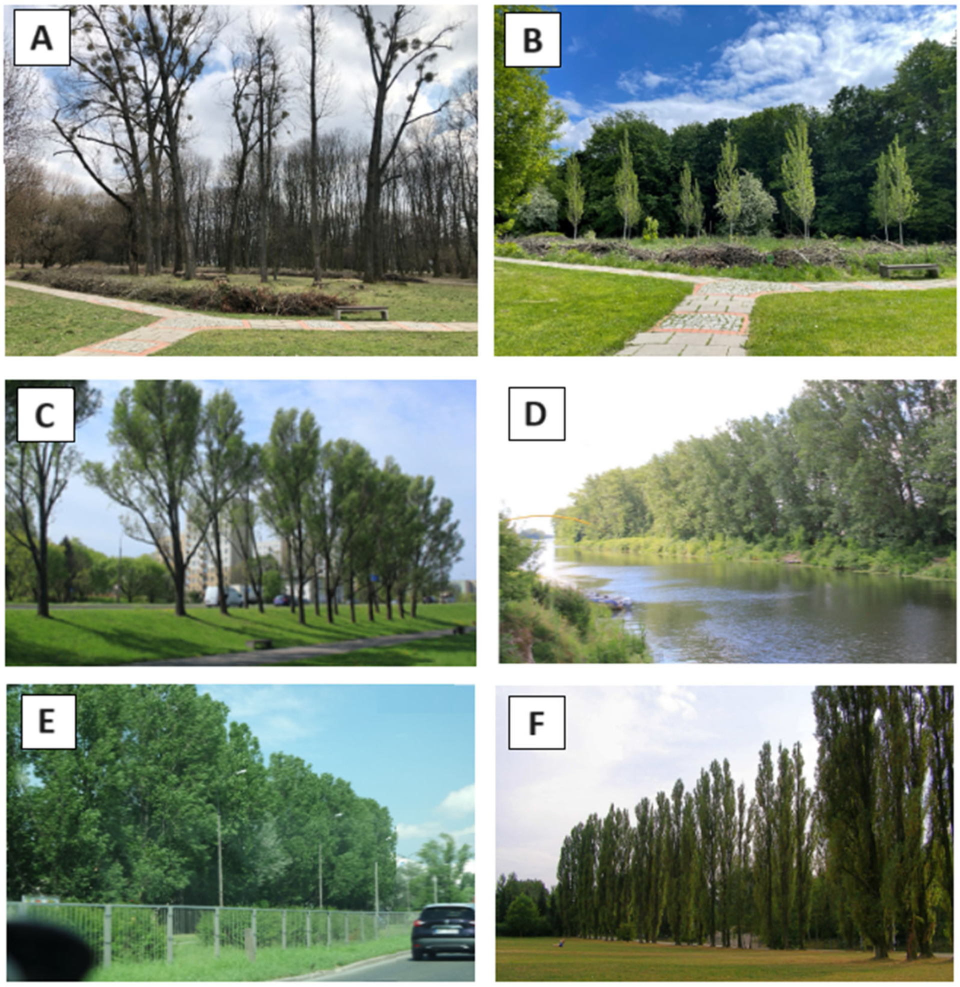

Figure 2. (**A**) Original group of *Populus ×canadensis* Moench (*P. ×euroamericana* Guiner) in Pole Mokotowskie Park, 2019, Warsaw, Poland, and (**B**) a new group of *Populus ×canadensis* 'Koster' in 2020 (author: J. Łukaszkiewicz). (**C**) *Populus simonii* Carrière 'Fastigiata' as urban street trees along a pedestrian route with sheltering functions (author: J. Łukaszkiewicz, 2018). (**D**) *Populus ×canadensis* Moench 'Marilandica' planted in by-water shelterbelts beside Żerański Canal, Warsaw, Poland (author: J. Łukaszkiewicz, 2016) and *Populus ×canadensis* Moench 'Marilandica' planted in by-water shelterbelts beside Żerański Canal, Warsaw, Poland (author: J. Łukaszkiewicz, 2016). (**E**) *Populus ×canadensis* Moench (*P. ×euroamericana* Guiner) as a high greenery screen for multi-story residential buildings with sheltering functions against the traffic on Sobieskiego Street, Warsaw, Poland (author: J. Łukaszkiewicz, 06.2019). (**F**) *Populus nigra* L. 'Italica' planted repeatedly in regular groups of four trees each, creating a green wall along the interior borders of the "Field of Mars", one of the most important interior areas of Silesia Park in Chorzów, Poland (author: B. Fortuna-Antoszkiewicz, 2014).

Poplars could also be effective at carbon sequestration by accumulating trace elements from polluted urban soils, serving as bioindicators for urban environmental pollution assessment [63]. Furthermore, poplar trees can modify soil microbial communities, enhance soil stability, and provide valuable habitats for ground beetles and entomofauna, enriching urban biodiversity [64].

Because of their fast growth, poplars could be pivotal for counteracting the urban heat island effect and improving urban microclimates. Urban tree cover supplemented with plantings of different poplar taxa could more quickly mitigate the urban heat island effect. Poplar trees enhance the urban thermal environment through transpiration, stimulating urban "cold islands" [65–70].

Of course, in the case of poplars in cities, their cultivation and maintenance is necessary. Considering diverse research findings to ensure the optimal growth and sustainability of poplars in urban settings while minimizing risks, effective maintenance practices such as pruning, soil amendment, and irrigation are crucial [71–78]. Challenges such as insect pests and heavy metal accumulation in poplar trees require the careful management and selection of clones, especially when monoculture plantations are planned to be introduced [63,79–82].

3.2. The Fast Increments of Poplars

In the past few decades, a lot of practical knowledge about the use of poplars in plantations or tree stands has been accumulated (e.g., [45,83]). For instance, in Central and Eastern Europe, first before the Second World War and then in a period from the 1950s to the 1970s, the mass afforestation of urban, industrial, and open landscapes was carried out, motivated by economic purposes, counteracting environmental degradation and improving landscape values (e.g., technical and shielding functions, phytoremediation, windbreaks, anti-snow, anti-erosion and others). In Poland, for instance, it is estimated that that at that time, the share of various poplars' taxa in shelterbelts and woodlots reached up to ¼ (25%) of total trees species [41,50,84–86]. The intended objective was to achieve the desired effect in the possible shortest possible time.

Traditionally, poplars have been considered to be one of fastest-growing trees in Europe and Asia (similarly to some willow species), e.g., *P. alba* L. and *P. nigra* L. 'Italica' increase in height by ±1.7 m/year (juvenile life phase), reaching a maximum rate of shoot elongation of ca. 17–25 cm/week (referenced to climate zone 6) [41,45,87,88].

The research from databases indicates that the use of poplar species in urban greenery initiatives, including *P. tomentosa*, *P.s alba* 'Berolinensis', and *P. nigra*, is driven by their rapid growth, strong adaptability, and tolerance to environmental stressors [53,89,90]. These species are favored for their ability to thrive in diverse urban settings, offering benefits such as flood tolerance and resilience to adverse conditions [53,91].

Populus tomentosa exhibits rapid growth and ecological adaptability, making it ideal for establishing greenery in urban areas [89]. Similarly, the hybrid triploid *P. alba* 'Berolinensis' demonstrates fast growth and high stress tolerance, making it suitable for urban forestry [53]. *P. nigra*'s flood tolerance further enhances its suitability for use in urban settings, particularly in flood-prone areas [91]. However, its susceptibility to diseases like leaf rust poses challenges [92]. Therefore, to ensure long-term success, general careful disease management is crucial when selecting poplar cultivars for urban greenery projects.

3.3. The Short Lifespan of Poplars

One of the controversies that has arisen in relation to poplars is the very short lifespan of these trees. Short-lived (a few dozen years) status is mainly characterized by taxa that are hybrids of botanical species or their varieties, including cultivated varieties or hybrids (cultivars are marked as 'cv' and hybrids are marked with '×' preceding the second part of systematic name), e.g., *P. nigra* L. 'Italica', *P. simonii* Carrière 'Fastigiata'), or *P.* ×*canadensis* Moench (*P.* ×*euroamericana* Guiner) [41,87]. Species that are definitely more durable, achieving medium- and long-lived status (life expectancy of ±150 (200) years in natural conditions), are the following:

- Typical botanical species, e.g., white poplar (*P. alba* L.) and black poplar (*P. nigra* L.);
- The intra- and inter-sectional hybrids of the balsam poplar *TACAMAHACA* and some cultivated varieties, e.g., *P. simonii* Carrière and *P. maksymowiczii* Henry, as well as balsam poplar hybrids, e.g.,: *P.* ×*berolinensis* Dippel, and hybrids like 'NE 49' and 'NE 42' (Table 1).

Table 1. Selected examples of the balsam poplars section (*TACAMAHACA*) species and hybrids used, among others, in the afforestation of urban landscapes (authors' elaboration based on [84–86,93,94]).

Balsam Poplar Section (*TACAMAHACA*)	
Subsection	**Selected Representative**
American balsam poplars	*P. balsamifera* (syn. *P. tacamahaca*) *P. trichocarpa*
Asian balsam poplars	*P. simonii* *P. maximowiczii* *P. laurifolia*
Intra- and inter-sectional hybrids of balsam poplars	Europe: *P.* ×*berolinensis* (K. Koch) Dippel 'Berlin'—Berlin poplar (male hybrid) *P.* ×*berolinensis* (K. Koch) Dippel 'Petrowskyana'—Berlin poplar—so-called "Tsar's"; *P.* ×*berolinensis* 'Razumovskyana' (both are female hybrids s) USA (in the 1920s by E.J. Schreiner and A.B. Stout—the so-called Schreinerian hybrids): Populus 'NE 49' or 'Hybrid 194' (*P.* x 'Hybrid 194') (male hybrid) Populus 'NE 42' or 'Hybrid 275' (*P.* x 'Hybrid 275') (male hybrid) Populus 'NE 44' or 'Hybrid 277' (*P.* x 'Hybrid 277') (male hybrid) Populus 'Androscoggin' (male hybrid), 'Geneva', 'Oxford' (female hybrids)

3.4. The Use of Berlin Poplar in the Afforestation of Urban Landscapes—Field Research

Regarding the literature on the use of poplars in urban conditions [84–86,93,94], our field research (Section 2) focuses on one selected cultivar—the Berlin poplar (Section 3.3). Our decision to study this particular cultivar was dictated by its many interesting characteristics, making it, in the past, a good choice for planting in cities. Therefore, by examining selected locations in Poland, we wanted to determine how the Berlin poplar performed in urban conditions. This cultivar was bred around 1870 in the botanical garden in Berlin as the male form of *Populus* ×*berolinensis* (K. Koch) Dippel 'Berlin'. Then, at the end of the 19th century, at the Petrovsko-Razum Agricultural Academy near Moscow, female forms were bred: *P.* ×*berolinensis* (K. Koch) Dippel 'Petrowskyana' (*P.* ×*petrowskyana* (Regel) C. K. Schneid.—the so-called Tsar's poplar) and *P.* ×*berolinensis* (K. Koch) Dippel 'Razumovskyana'. It tolerates dry urban environments and dry soil very well; it has also been successfully tested on a gravel–sand base with an inaccessible groundwater level. It grows well even in sloping localities. Conversely, *P.* ×*berolinensis* (K. Koch) Dippel is susceptible to cancer, as it is planted in locations with high groundwater levels, prone to flooding or with high air moisture levels. This cultivar is suitable for urban areas due to its narrow oval crown, which will keep its shape even when old. It has a straight, continuous trunk. That is why it is especially recommended for planting in lines or rows, e.g., along streets or avenues. Berlin poplar wood is stronger than that of other poplar species and cultivars. That is why these trees growing in the alleys do not suffer much from fractures in the canopy. Despite the inhibiting factors of the urban environment, this poplar can grow very fast, reaching up to 30 m in height and achieving a trunk diameter of 1.0 m at breast height (DBH). Leaves can also accumulate PM from the air, so Berlin poplars also possess phytoremediation abilities.

Berlin poplar's lifespan varies, though in good health, it can easily reach over 60 years and even more (as indicates our observations). However, exchanging overmatured trees over 40 years old for younger specimens is sometimes advisable in urban areas. Such a policy of exchanging older generations of trees is similar to how urban plantations are maintained. A distinctive feature of the female forms of the Berlin poplar is the production of seed down, which is abundantly secreted by the trees in May. In the context of these trees' use, especially in streets, avenues, and squares, this is a very undesirable factor, which may require abandoning the use of female forms in urban areas. Attention should also be paid to the shallow root systems of these trees, which may cause damage to paved surfaces, and as a consequence, they should be planted in locations that allow sufficient space for rooting (e.g., wide grassy sections along streets, etc.). During past decades, Berlin poplars were used in urban locations in Central European countries, like the Czech Republic or Poland.

As, compared to many other species and cultivars, Berlin poplars are much better suited for planting in cities, our research was focused on two representative locations in Poland where such trees have been used in the context of the urban environment. The first research area is Rakowiecka Street in Warsaw, and the second is the great Ziętek Promenade in Silesia Park in Chorzów.

Case A. The research area of Rakowiecka Street in Warsaw, Poland.

Rakowiecka Street in Warsaw began to be intensively built in the second half of the 19th century, and this process culminated in the 1950s (Figure 3). The characteristic number 8 building of the WULS-SGGW's (Warsaw University of Life Sciences) headquarters was partially put into service in 1929. In 1930, Rakowiecka Street was upgraded, with road infrastructure with green belts planted with Tsar's Berlin poplars female hybrids (*Populus ×berolinensis* (K. Koch) Dippel 'Petrowskyana'—*P. ×petrowskyana* (Regel) C. K. Schneid.); the young trees were 3.5 m high, with spacing of 8.0–10.0 m in each row [95].

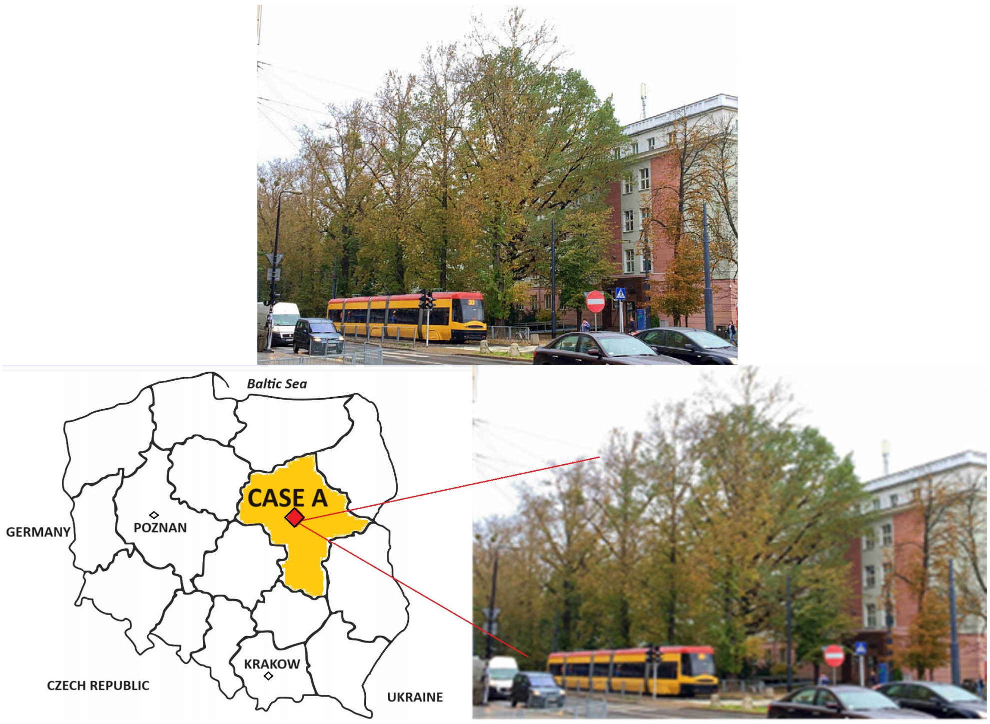

Figure 3. The magnificent streetside row of *Populus ×berolinensis* (K. Koch) Dippel 'Petrowskyana' along Rakowiecka Street, Warsaw, Poland (Case A)—the adjusted size of the trees relative to the street scale is visible (author: J. Łukaszkiewicz, September 2017).

The street buildings and rows of poplars survived in general the destruction of World War II. In the 1940s, the trees were large enough to provide shade for the WULS-SGGW building and protection against noise and pollution from the street [95] (Figure 4). However, in the late 1970s, specific problems were already noticed related to the collision of rapidly growing trees with the infrastructure of the buildings and the traction network [96]. In addition, another problem was the shallow root system of the poplars that lifted the paving slabs. Trees were planted too shallowly, and permeable surfaces were not used. One of the significant inconveniences of lining the street with the female form of Berlin poplar (*Populus ×berolinensis* (K. Koch) Dippel 'Petrowskyana') was the annual abundant release of seed down (cotton-like), which disturbed people and caused much littering of the street and apartments in nearby houses. In the following years, Berlin poplars were gradually felled during infrastructure modernization projects or due to weather anomalies. In 2024, only a few trees remain from the avenue that existed in past decades, which are the subject of our further measurement and analysis.

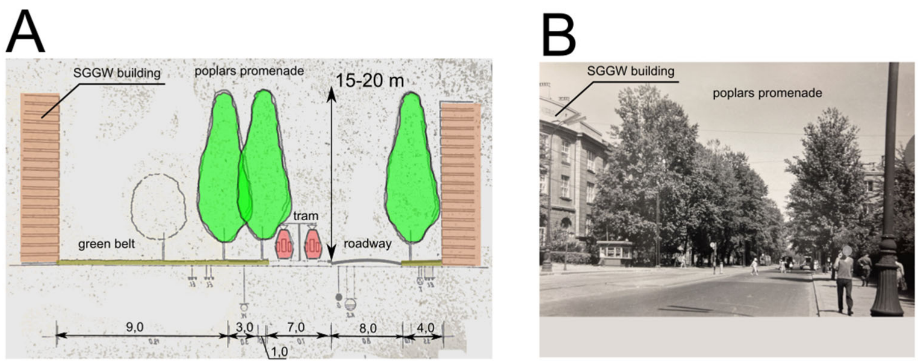

Figure 4. The cross section of Rakowiecka Street in Warsaw, in an eastwards direction (**A**), lined with two-sided rows of *Populus* ×*berolinensis* (K. Koch) Dippel 'Petrowskyana' (1973)**,** and a view of Rakowiecka Street near the WULS-SGGW's headquarters building (**B**) in 1973 [95].

We analyzed historical iconographic materials [96,97] and performed field measurements, i.e., measurements of trees, the street, and the facade of the WULS-SGGW building. The results are presented in Figures 5–8 and Table 2. Figure 8a, using evidence from 1925, shows the measured heights of the building's floors during field tests. Based on the analysis of the remaining illustrations (Figure 5B–H), it can be concluded that the trees planted in the 1920s and 1930s were homogeneous plant material with equal parameters (height of approximately 3.5 m). The trees reached the windows of the high ground floor of the WULS-SGGW building (Figure 5B). In 1937, it can be seen that the trees reached the windows of the first floor of the WULS-SGGW building, reaching a height of approximately 8.5 m (Figure 5C). In 1939, the trees reached the windows of the second floor of the WULS-SGGW building, reaching a height of approximately 11.0 m (Figure 8D). In the illustration from 1947, the trees reach the roof of the SGGW building, reaching a height of approximately 20 m (Figure 8E). In 1955, the trees obscured the SGGW building and reached a height of approximately 21 m (Figure 5F). In 1975, the trees were already mature and reached a height of approximately 22–25 m (Figure 5G). At the beginning of the 21st century, the poplars remaining from the original forest cover had already reached their maximum size; in 2012, their height was 24.0 m, while in 2017, it was 28.0 m, and in 2024, it was 30.5 m. Due to collisions with buildings and technical infrastructure, the trees were cut, and their shapes were deformed. The illustration from 2017 shows partial losses in the street trees, and the trees in the planted avenue were becoming old and falling out (Figure 5H).

Field measurements showed that *Populus* ×*berolinensis* (K. Koch) Dippel 'Petrowskyana' trees planted in 1920s and 1930s along Rakowiecka Street in Warsaw (section Boboli Street—Niepodległości Av.) achieved, in 2013, an average trunk girth of 220–235 cm (measured at 1.3 m—breast's high), and in 2024, they achieved an average girth of 241.3 cm (Table 2). Tree age parameters were calculated and correlated with illustrations in individual years and heights (Figure 6). On this basis, it was estimated that in 1930, the trees were approximately 3 years old; in 1937, they were approximately 8–10 years old; in 1937, they were approximately 12 years old; in 1947, they were approximately 20 years old; in 1955, they were approximately 28 years old; in 1975, they were approximately 48 years old; and in 2017, they were already approximately 90–95 years old. Now, in 2024, they are approx. 97–102 years old. The figure shows averaged values or those rounded to the upper or lower values for better data visualization.

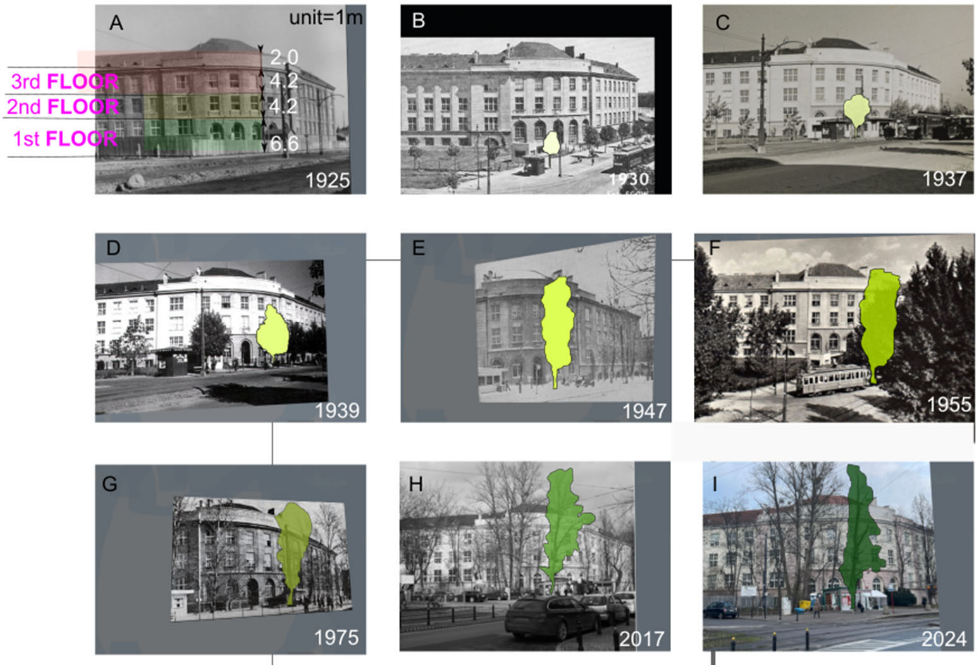

Figure 5. The sequence of illustrations (**A**–**I**) of Rakowiecka Street in Warsaw showing the growth of *Populus* ×*berolinensis* Dippel 'Petrowskyana' (1925–2024) near the WULS-SGGW's former headquarters building [authors' own elaboration based on historical photos of Rakowiecka Street in Warsaw (photos from [97] and own photo: Łukaszkiewicz, 23 February 2024)].

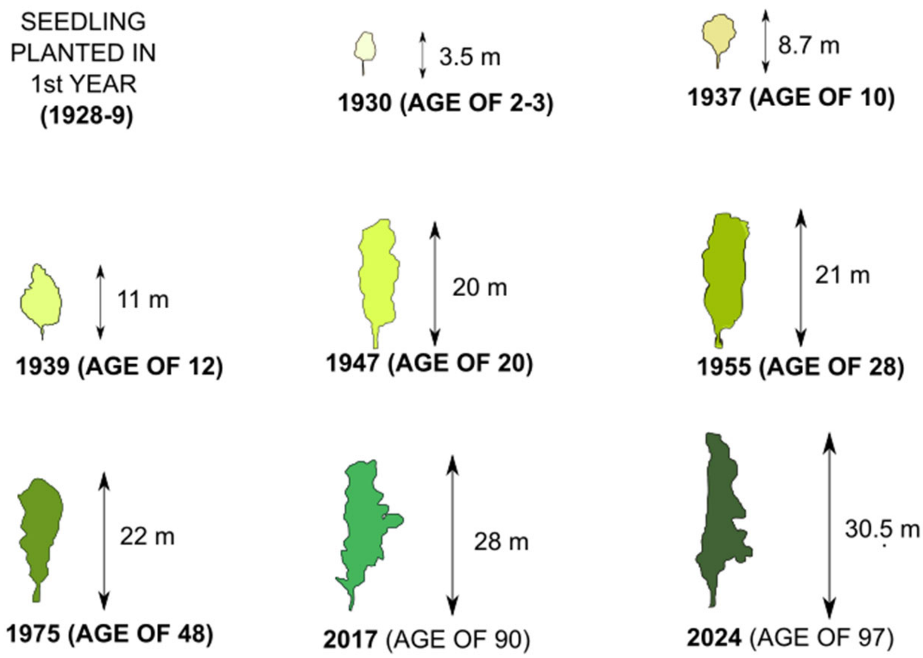

Figure 6. The schematic habits and estimated heights of *Populus* ×*berolinensis* (K. Koch) Dippel 'Petrowskyana' trees along Rakowiecka Street in Warsaw in the chosen years of the period 1930–2024, located near the WULS-SGGW's former headquarters building. The authors' elaboration was based on the pictures in Figure 8 (photos A-I [97] and their own photo: Łukaszkiewicz, 23 February 2024).

Figure 7. The form of a high, even wall of male hybrid poplars: *Populus* ×*berolinensis* (K. Koch) Dippel 'Berlin' in Silesia Park's Ziętek Promenade, Chorzów, Poland (Case B) (B. Fortuna-Antoszkiewicz, May 2014).

Table 2. Descriptive statistics of the parameters of the studied Berlin poplars near the SGGW building on Rakowiecka Street in Warsaw in 2012 and 2024 (n—number of selected trees, *t*-test; *p*—statistical significance; SD—standard deviation).

Parameter	**Year**	**Age [Years]**	**Descriptive Statistics**			***t* Test**
			Mean (+/−SD)	**Me**	**Min–Max**	
height [m]	2012 [n = 16]	85	23.87 (1.86)	224.00	20.0–27.0	$p = 0.0175$ $t = -2.536$
	2024 [n = 12]	97	25.5 (1.40)	25.60	23.5–27.5	
circumference [cm] at 1.3 breast height	2012 [n = 16]	85	225.87 (50.98)	224.00	116.00–321.00	$p = 0.4341$ $t = -0.794$
	2024 [n = 12]	97	241.33 (50.93)	244.50	146.00–339.00	

Table 2 shows the descriptive statistics of average measurements of tree height and trunk circumference at a height of 1.3 m and compares the significance of the differences in the average values of these measurements. In order to compare the significance of differences between the average values of tree height and trunk circumference at a height of 1.3 m, Student's *t*-test was used (after performing a test of compliance with the normal distribution using the Shapiro–Wilk test). In the case of the data from 2024, the number of trees (n = 12) was lower than in 2012 (n = 16) because some trees fell due to weather anomalies, poor health, or infrastructure modernization. Based on the results obtained, it can be concluded that in the tested sample, both the trunk circumferences and the heights of the trees increased over the 12 years, but statistically significant growth was only observed in the case of height.

We also checked whether the increase in tree height and circumference depended on the spacing between the examined trees; Spearman's rank correlation analysis was used. The average spacing between the examined trees was 10.3 m, the smallest distance between them was 8.0 m, and the largest distance was 16.0 m (SD = 2.25 m). A negative relationship was observed in the case of height, but despite the coefficient value r = 0.64 indicating a relatively significant relationship, it was statistically insignificant ($r = -0.64$; $t = -2.21$;

$p = 0.0627$). In the case of trunk circumference, a similar direction of relationship was observed, which was also statistically insignificant, but the strength of this relationship was much weaker (r = −0.14; $t = -0.36$; $p = 0.7256$). This direction means that as the distance between trees decreases, the value of the analyzed parameters increases.

Case B. The research area of Ziętek Promenade in Silesia Park in Chorzów, Poland.

Silesia Park (The Voivodship Park of Culture and Recreation in Chorzów, Poland), with a total area of ca. 600 ha, was established on land of poor quality, partially degraded by mining and metallurgy industries. The main objective was to improve the quality of life for residents of Silesia by creating the bulk enclave of greenery combined with a versatile program for active recreation in this partially degraded area. After many years, Silesia Park has become an example of successful restoration and naturalization of the anthropogenic landscape [98,99].

The Ziętek Promenade in Silesia Park is the main, wide walkway connecting the most attractive park program elements, and it is the backbone of the park's composition. Regular tree arrangements, such as multi-row bosquets in a checkerboard pattern, are the leading theme of the spatial composition. The original design, including vegetation, is preserved and visible. The main feature of that park section is a magnificent double row of male hybrid Berlin poplars (*Populus ×berolinensis* (K. Koch) Dippel 'Berlin'). It runs along the banks of the Park's great pond, constituting a uniform "living wall", which ideally fits the scale of the vast park's interior. In 2016, at the end of the promenade near Al. Główna, a section of an old poplar row was exchanged for plantings of new trees of the same specimen [6,98–100].

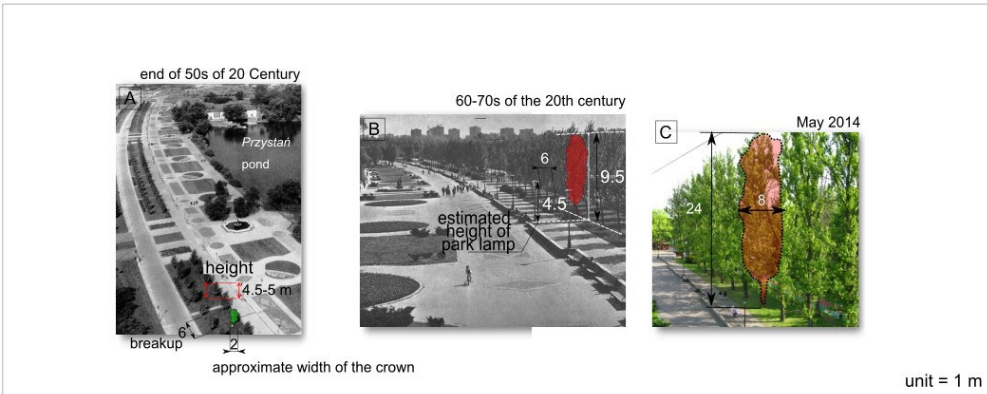

Figure 8. The analyzed sequence of historical photographs of Silesia Park in Chorzów, Poland, showing the double row of Berlin poplars (*Populus ×berolinensis* (K. Koch) Dippel 'Berlin') in the Park in Chorzów (the authors' elaboration): (**A**) a view of the promenade from the late 1950s [101], (**B**) a view of the promenade from the 1960s or 1970s [102]; (**C**) a view of the avenue of adult poplars in 2014 (photo by J. Łukaszkiewicz, 2014) [98].

In the first step, we analyzed iconographic materials and performed field measurements. The results are presented in Figures 8 and 9 and Tables 3 and 4. Based on the data obtained, it can be concluded that the trees planted in the 1950s on the Park's promenade reached heights of 4.5 m at the end of the 1950s (the estimated year was 1959), which were equal to the height of the park lamp (Figure 8A). On this basis, the remaining parameters were estimated: widths equal to 2.0 m and spacing equal to 6.0 m. Next, the average height of poplars in the 1960s and 1970s was estimated (the estimated year was 1965), which was 9.0 m, and the width of the crown was 6.0 m because the trees touched each other with their crowns, building a homogeneous wall-like row of trees (Figure 8B,C). In turn, the analysis of photos and our own field tree inventory from 2014 shows that their parameters were, on average, as follows: height—approx. 24.0 m; crown width—ca. 8.0 m; mean trunk girth at 1.3 m—ca. ± 197 cm [98].

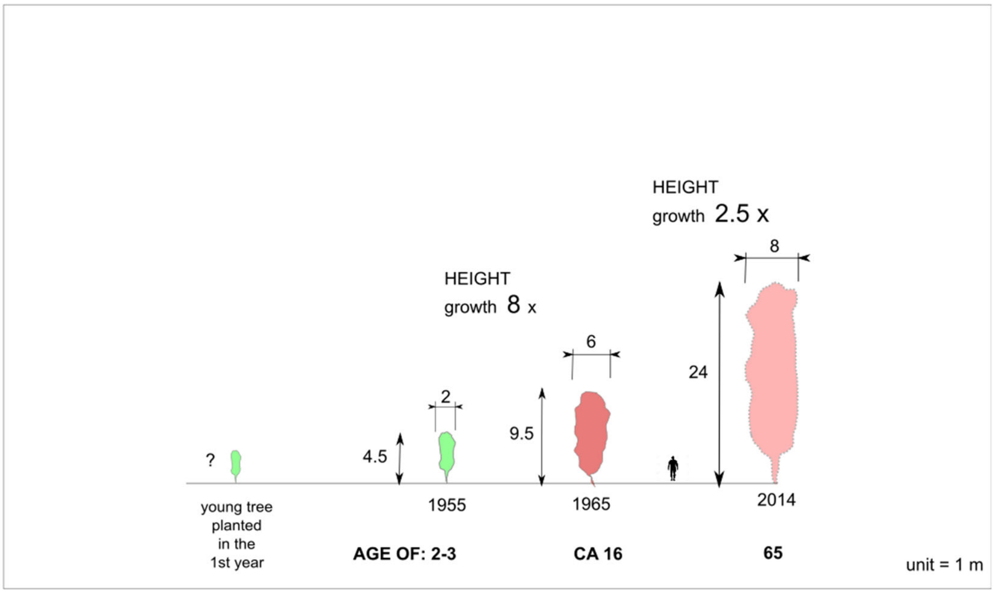

Figure 9. The increase in the height and spacing of the crowns of historic Berlin poplars (*Populus ×berolinensis* (K. Koch) Dippel 'Berlin') in Silesia Park in Chorzów in the years 1955–2014 (authors' elaboration based on [98,101,102]).

Table 3. Case B. Descriptive statistics of the parameters of young studied Berlin poplars from the Ziętek's Promenade in Silesia Park in Chorzów in 2016, 2021, and 2023 (n—number of selected trees; SD—standard deviation).

Parameter	Year	Age [Years]	Descriptive Statistics		
			Mean (+/−SD)	Me	Min–Max
height [m]	2016 [n = 10]	3	4.96 (0.10)	5.0	4.8–5.1
	2021 [n = 10]	8	8.40 (0.51)	8.5	7.6–9.5
	2023 [n = 10]	10	13.90 (0.42)	14.0	13.5–14.5
circumference [cm] at 1.3 breast height	2016 [n = 10]	3	12.90 (0.87)	13.0	12.0–14.0
	2021 [n = 10]	8	63.65 (6.11)	62.0	57.0–76.0
	2023 [n = 10]	10	79.80 (5.12)	82.0	74.0–86.0
crown average diameter [m]	2016 [n = 10]	3	2.17 (0.26)	2.0	2.0–2.5
	2021 [n = 10]	8	4.50 (0.33)	4.5	4.0–5.0
	2023 [n = 10]	10	7.90 (0.26)	8.0	7.5–8.2

Table 4. Case B. Descriptive statistics of the parameters of the examined poplars on the Ziętek's Promenade in Chorzów Park in 2016, 2021, and 2023 (*t*-test; *p*—statistical significance; SD—standard deviation).

Age	Parameter	Growth/1 Year	Correlation		
			R(X.Y)	*t*	*p*
2–8	height [m]	0.69	0.9740	16.1	<0.0001
	circumference 1.3 [cm]	10.15	0.9831	20.1	<0.0001
	crown diameter [m]	0.66	0.9689	14.6	<0.0001
8–10	height [m]	0.83	0.9853	20.8	<0.0001
	circumference 1.3 [cm]	5.38	0.8146	5.1	<0.0002
	crown diameter [m]	1.33	0.9837	19.8	<0.0001

On this basis, the ages of the trees were assessed approximately: ±3 years in 1959, ±10 years in 1965, and ±65 years in 2014 (Figure 9). Knowing the poplars' average height for individual years, it can be concluded that these trees, with favorable conditions for development (city park space), achieved their most significant growth of 8.5 times in approximately 6–10 years (between 1959 and 1965) and achieved relatively slower growth during the mature phase of life—over the next ca. fifty years (between 1965 and 2014), growth was equal to only 2.5 times. For better data visualization, the following figure uses average values or extreme ranges (Figure 9).

Due to the ageing of the original poplars and for safety reasons, the gradual replacement of trees on the Ziętek's Promenade began in 2016 (Figure 10). Following the original project assumptions, new Berlin poplars of the same variety were planted in place of the old trees. In the first section of the poplar row, replaced on April 2016, 37 new young poplars were planted (planting material with a girth of 12–14 cm).

Figure 10. The perfect condition of young (**a**) Berlin poplar trees ((*Populus ×berolinensis* (K. Koch) Dippel 'Berlin') planted in exchange for one section of the Ziętek's Promenade in Chorzów in 2016, together with a general view (**b**) of the promenade's main walkway (author: J. Łukaszkiewicz 2018).

Our next step was to value descriptive statistics, estimated for measurements collected from ten newly planted Berlin poplars (*Populus ×berolinensis* (K. Koch) Dippel B'erlin') in 2016, 2021, and 2023. Based on the results obtained, it should be concluded that with age, there is a systematic increase in all the parameters examined (height, trunk circumference, crown width).

Next, the average annual increase in the studied parameters and the strength of the relationship between age and the average growth rate of the studied trees was estimated. Sperman's rank correlation analysis was used to estimate the strength of the relationship, and the growth rate was estimated by using the obtained average values of the studied characteristics and dividing them by the appropriate number of years. Table 3 summarizes the results of these analyses. They show that between the fifth and eighth years of life of Berlin poplars, the trunk circumference grows most intensively, while in the following years, trunk growth slows down in favor of crown growth (Table 4).

The conducted field observations of older *Populus ×berolinensis* specimens from Warsaw's Rakowiecka Street (Case A) and the Ziętek's Promenade in the Silesia Park in Chorzow (Case B) reveal their resilience in urban settings, with some specimens surviving for up to 100 years. While trees planted in the 1930s on Rakowiecka Street have largely perished, Berlin poplars in Chorzów have shown durability over several decades [103]. However, urban conditions in Warsaw have led to premature fall-outs, with trees succumbing as early as age 40 [103].

Statistical analyses based on parameters like tree height, trunk circumference, and crown growth indicate significant changes in the early years of a tree's life, with a clear correlation between tree age and growth parameters observed in the Ziętek's Promenade in the Silesia Park in Chorzow. Older trees in Warsaw also showed increases in height and trunk circumference, albeit they were statistically significant only for the height parameter. Growth rates decrease notably after the eighth year of a tree's life, with advanced-age trees exhibiting slower growth [103].

Despite limitations in this study's scope, it suggests a rapid increase in tree size in the initial years of growth, allowing for replacing older trees prone to felling or decay. Considering the lifespan of *Populus ×berolinensis*, young trees could replace older specimens within 37 years for height growth or 24 years for trunk circumference. However, sustained care can enable these trees to thrive even in poor urban conditions, as seen on Rakowiecka Street. Although trunk circumference measurements have proven valuable for determining tree growth, older trees may also require height measurements to obtain more reliable growth results. It is crucial to conduct precise measurements, especially when assessing tree growth in urban environments.

The selected examples demonstrate the potential applications of poplar trees, such as those in Chorzów's Silesia Park, which fulfil their functions effectively. Careful selection of tree species adapted to local conditions is essential to avoid previous mistakes in urban forestry. Regularly monitoring and using ecological surfaces are recommended to mitigate infrastructure damage caused by rapid tree growth.

While rapid growth may lead to visually appealing urban greenery, caution is advised in selecting tree species and managing their lifespans. Replacing older trees with younger specimens ensures the continuity of urban greenery, while slower-growing species like lime or maple contribute to the diversity and longevity of urban forests.

Flexibility in managing old trees is necessary for overmatured poplars, as rigid approaches may lead to unnecessary removals. The introduction of tree replacement patterns, often used in many Western countries, where similar species are used to preserve the unique character of urban green spaces, should be promoted.

3.5. Poplar in Cities as Suitable but Under-Rated Trees in Urban Greenery

Our review of scientific databases has shown that very little existing research is devoted to using poplar cultivars in woodlots in urban green spaces (UGSs). This is, among other things, due to some long-lasting myths that these trees are unsuitable for keeping in cities, e.g., because they are not aesthetically valuable and are very short-lived. In fact, concerning global climatic changes, poplars can offer various ecological benefits in urban or industrial areas, such as improving air quality and carbon sequestration due to their fast growth, as well as achieving big sizes and having high adaptability to unarboristic site conditions [104–107].

The presented cases of *Populus ×berolinensis* indicate that using such trees is reluctantly recommended nowadays in the context of providing sufficient support for mitigating urban heat islands and improving the local microclimates of streets, avenues, parks, etc. [103]. Integrating poplars into urban landscapes also contributes to their sustainability [108,109], and their fast growth and adaptability make them suitable for urban areas [100,110–112]. However, their variable lifespans pose challenges for sustained urban greenery [113,114]. In such a case, the careful selection of cultivars and management practices is crucial [115,116]. Also, collaborative efforts are needed for effective urban greenery planning and devising comprehensive strategies that maximize the benefits provided by poplars while addressing challenges associated with their diverse lifespans [115].

Considering that street trees have an average life expectancy of 13–20 years (e.g., [117]), the so-called short lifespans of some taxons/cultivars of poplar are not a factor that neglects their efficient usage in urban areas. The variable lifespans of poplars might necessitate more frequent replanting cycles (the urban plantation-like system) after a few decades when they mature [100]. Their quick growth and establishment align with the urgency of creating green spaces and forests in urban areas, addressing immediate environmental concerns, and fostering a more sustainable and livable urban landscape [118–120].

3.6. Benefits of Poplars against Other Species for Cities

Notably, the deterioration in the visual condition of trees in Poland during the 1990sand the 20th century, more generally, was attributed partially to inadequate management systems. Managers often struggled to keep pace with emerging trends, and legal frameworks sometimes needed clarification. In Poland, decisions regarding tree planting in urban areas are made by local authorities, which may require more representation from urban forestry specialists like landscape architects or foresters.

Furthermore, poplar trees are not a recent addition to urban landscapes. They were successfully introduced to cities in the 20th century. Still, they were eventually supplanted by other species, such as maples (primarily *Acer* sp.) and linden trees (*Tilia* sp.), due to their susceptibility to fragility and poor sanitation. However, relying solely on these alternative species may not be sustainable, as they struggle to adapt to climatic changes and temperature fluctuations, as evidenced by recent urban ecology research. Therefore, there is a need to revert to proven varieties of poplar trees, capable of rapid growth and surviving up to 100 years in challenging urban conditions, as exemplified by preserved specimens in Warsaw.

Despite evidence supporting the need for replacement after 60 years, this practice is not widely adopted in Poland due to a misguided trend termed the "civilization of the environment". This involves a pseudo-protection of trees, particularly by older capital residents, perpetuating outdated practices. Indeed, we also observe that society's involvement in these issues has become more relevant. However, its opinion should not undermine the opinion of forestry specialists. Therefore, educating society in this area is essential, as it has been a good practice for many years, especially in Western European countries. Thus, this education should also be implemented in Poland [121], and a return to some old varieties and best practices, including maintenance procedures and monitoring, is essential to ensure the sustainability of urban greenery.

Our research underscores the significance of poplars as a valuable but often overlooked species in urban environments. While modern studies recommend only a few species for urban planting, monocultures pose risks to city landscapes. Furthermore, as emphasized in our revised paper, it is crucial to reintroduce species historically planted in significant locations. However, these arguments require further elaboration and more substantial justification.

Our study also highlights the water sensitivity of poplar trees and emphasizes the need for improved urban green management practices. Despite the challenges posed by the diverse global distribution of poplar species, addressing common environmental issues can facilitate future research on a worldwide scale.

In summary, while poplar trees were once favored for planting in the 20th century, they are rarely selected in contemporary urban forestry due to past mismanagement and misconceptions. However, their exclusion based on past mistakes must be addressed, and efforts should be made to incorporate them into future urban planting initiatives.

4. Conclusions

The following conclusions underscore the intricate balance between the advantages and challenges of integrating poplar trees into urban environments, underscoring the necessity for comprehensive and adaptable strategies in urban greening efforts:

- Berlin poplars serve, in the presented research, as exemplars of trees that have been successfully utilized in parks and urban street settings. They exhibit rapid growth even under adverse urban conditions, such as drought, limited rooting space, and pollution exposure.
- While poplar trees can demonstrate acceptable longevity in urban conditions, their survival rates mayvary between park and street environments, e.g., urban stressors have caused the premature decline of *Populus ×berolinensis* on Rakowiecka street in Warsaw (Poland).
- The literature and empirical evidence suggest that poplar trees' alleged short lifespans are less pronounced in downtowns, where trees struggle to reach maturity. It prompts a call to recognize various poplar cultivars as resilient tree species capable of enhancing urban biodiversity.
- Proper management practices, including root system care and selective pruning, are crucial for effectively utilizing poplar trees in urban green spaces, such as street tree lanes and park alleys. The selection of poplar cultivars tailored to specific urban functions is paramount for achieving the desired outcomes. Careful consideration should be given to avoiding female cultivars that produce abundant seed down.
- Given their rapid growth, adaptability, and positive environmental impact, poplar trees can be readily replaced in urban spaces through cyclic renewal practices akin to urban plantation schemes. A notable example is the reforestation of the main promenade in Silesia Park in Chorzów (Poland), where young poplar saplings are estimated to completely replace large old trees over 25 m in height within approximately 20 years. This highlights their significant role in urban landscapes from both ecological and aesthetic perspectives.
- Our studies on the growth of *Populus ×berolinensis* (Cases A and B) are of a pilot nature. However, the obtained results encourage continued research into the wide use of poplars in cities in the context of challenges related to climate change and maintaining tree cover in urban forests and urban green spaces in the future.

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