DENDROBIOLOGY
2006, vol. 55, 11–17

Anna Cedro, Grzegorz Nowak

Effects of climatic conditions on annual tree ring growth of the *Platanus* × *hispanica* 'Acerifolia' under urban conditions of Szczecin

Received: 04 November 2005, Accepted: 29 January 2006

Abstract: Szczecin harbours Poland's largest London plane tree population. The London plane trees growing in Szczecin's Żeromski Park were subjected to dendroclimatological research (analyses of signature years and response function). The study was based on a composite site chronology, signed ZER, spanning 105 years (1900–2004); the mean annual tree ring growth was 2.59 mm. Precipitation, particularly that in late winter-early spring and in the summer months was found to be a factor decisive for the tree's cambial activity. A high sum of precipitation during the periods mentioned induced positive growth responses in the trees. Thermal conditions during the growth period proved to be another factor controlling the annual tree ring growth, as shown by linear relationships. The tree ring growth-climate relationships in the population under study as well as the between-parks differences in the London plane tree response can be explained by differences in habitat conditions. The trees under study grow in the vicinity of a busy, frequently repaired street and are surrounded by pavement and/or hardened road surface, which greatly limits the infiltration of moisture supplied by precipitation.

Additional key words: tree ring width, signature years analysis, response function analysis, meteorological conditions

Address: A. Cedro, Laboratory of Climatology and Marine Meteorology, Institute of Marine Science, Faculty of Natural Science, University of Szczecin, Wąska 13, 71-415 Szczecin, Poland,
e-mail: Anna.Cedro@univ.szczecin.pl
G. Nowak, Department of Dendrology and Landscape Architecture, Agricultural University, Janosika 8, 71-424 Szczecin, Poland, gnowak@agro.ar.szczecin.pl

Introduction

With its ca 25 ha area, Żeromski Park is one of Szczecin centre's largest greens. The park was created by merging the former municipal cemetery in the district of Grabowo, the former cemetery of the French reform community in Szczecin, and a park which, since the 1820s, had been under construction in the vicinity of the Royal Gate. The first cemetery in the area was formed in the early 19th century, while Żeromski Park itself, encompassing all those areas, began taking form about 100 years later. In the early 19th century, the park was adorned by a rustic-style inn that served as an elegant beer house. At present, the building is taken up by a restaurant and a hotel (Stachak and Nowakowska 1996, Stachak et al. 2000).

The park features numerous interesting trees and shrubs, including many species of foreign origin. Particularly noteworthy are the maples (*Acer* sp.) and oaks (*Quercus* sp.) as well as fabacean (*Fabaceae*) trees;

besides, fairly numerous are the London plane trees (*Platanus* × *hispanica* 'Acerifolia') which form, i.a., a grove along the park's border with Matejki Street (Stachak and Maślak 1989, Stachak and Nowakowska 1996, Stachak et al. 2000).

The London plane tree characteristics

The genus *Platanus*, belonging to the family Platanaceae, is represented by 6–10 species growing in Europe, Asia, and North America. The London plane tree (*Platanus* × *hispanica* Mill. ex Münchh. 'Acerifolia'), most frequently grown in Poland, is a hybrid of the American buttonwood [American sycamore – *Platanus occidentalis* L.)] and the oriental plane (*Platanus orientalis* L.) – Krüssmann (1962), Bugała (2000), Seneta and Dolatowski (2004).

The London plane tree has been grown in Europe since 1634 (Hereźniak 1992). According to the author quoted, the London plane tree has been reported from Poland since 1806 when the first trees were planted in the Cracow Botanical Garden. On the other hand, Szymanowski (1953) reported the oldest Polish London plane trees to be found at Nieborów (since 1770), Dobrzyca (since 1780), and Łańcut (1770–1780). The London plane tree is abundant in Szczecin. As shown by a preliminary study on the species' abundance, the town boasts more than 700 specimens, which, in the light of papers by Szymanowski (1953), Ołtuszewski (1956), Krzysik et al. (1973) and Czekalski and Kacprzak (1986), shows this to be the most abundant Polish population.

The London plane tree is a long-lived, sturdy tree with a broad, low-lying, extensive canopy and a characteristically greyish, patchy bark peeling off in large flakes from the trunk and branches. When exposed, the cork cambium is creamy-olive in colour. The trees has large, palmate, five-lobed leaves in alternate arrangement, which turn yellow in autumn and fall off relatively late in the season (Grubow 1954, Seneta and Dolatowski 2004).

The London plane tree grows best on clayey and clayey-sandy, fertile, deep, and sufficiently moist soils. It requires warm and sunny sites; the young plants are sensitive to low temperatures. The species is resistant to urban and industrial pollution and to dry air (Krüssmann 1962, Bugała 2000, Seneta and Dolatowski 2004).

The London plane tree is most suitable for large parks where it is planted as singletons on lawns or in groves to line promenades, boulevards, and avenues; it is also used to adorn various important sites, e.g., entrance gates and buildings (Grubow 1954, Bugała 2000, Seneta and Dolatowski 2004).

Methods

The samples were collected by drilling the trees at the height of 1.3 m above the ground level with Pressler's increment borers. The boreholes were treated with a fungi- and bacteriocide (Lac-Balsam) and protected with wooden pegs of diameter identical to that of the borer. The tree ring widths were measured to 0.01 mm. Subsequently, the composite site chronology was put together by using the commonly applied dating techniques (Cook and Kairiukstis 1992, Kaennel and Schweingruber 1995, Zielski and Krąpiec 2004, Cedro 2004). The chronology was indexed to eliminate an age trend, if present (Holmes 1983, 1994). The resultant composite chronology served as a basis for dendroclimatological analyses, involving signature years and response functions. The signature years were such ones in which more than 90% of the trees examined showed identical growth trends (increasing in positive years and decreasing in negative years; Blasing et al. 1984, Walanus 2002). The response function analysis was performed for a 16-month-long period (from June of the year preceding growth to September of the year of growth), using meteorological data (mean air temperature and monthly sum of precipitation) collected over 1948–2000 at the station in Szczecin-Dąbie.

Results

Chronology

The dendrochronological curve, denoted ZER and representing the *Platanus* ×*hispanica* 'Acerifolia' trees from the Żeromski Park in Szczecin, was put together from 12 individual dendrograms yielded by 20 trees sampled. The resultant chronology consists of 105 increments and spans the period of 1900–2004 (the year of sampling, i.e., 2005, was not included in the chronology because cambial activity was in progress during the field work, for which reason the 2005 tree-growth ring had not been fully developed yet) – Figs 1 and 2. The chronology shows a number of years with the minimum annual growth ring widths (1929, 1934, 1940–44, 1954, 1963, 1976, 1987, and 1989) as well as years with radial increments higher than the average (1927, 1931, 1939, 1945–46, 1966–68, 1971, 1979, 1988, and 1997) – Fig. 1. The tree-growth ring width of the trees examined averaged to 2.59 mm, which was by 1.5 mm less than the ring width found in the London plane tree growing in the Jasne Błonia Park (Cedro, in press). During the first three decades of the 20th century, the ring width ranged within 4–7 mm; it was only in the second half of that century that it dropped below 2 mm. The chronology presented served as a basis for subsequent dendroclimatological analyses of signature years and response functions.

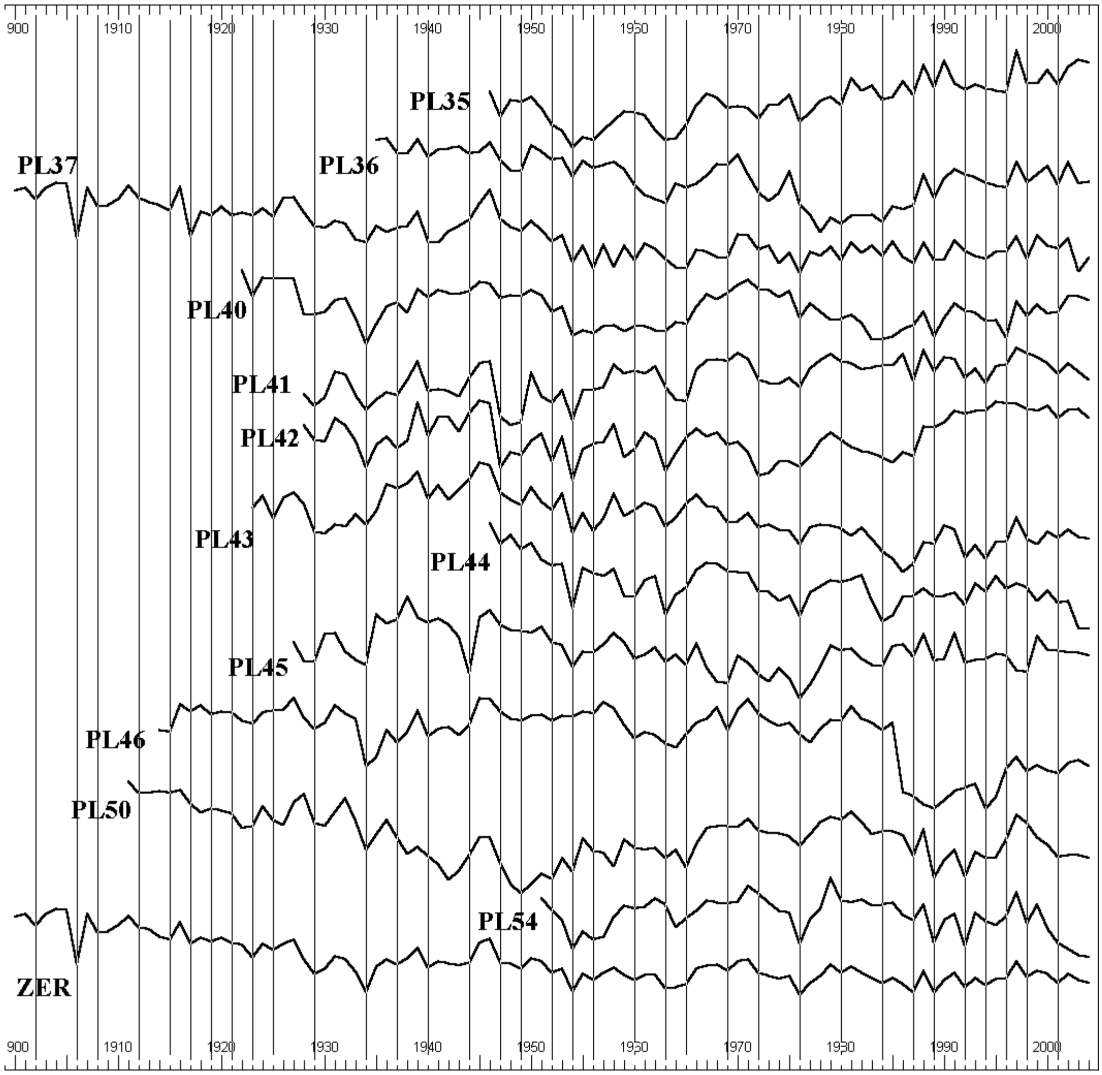

Fig. 1. Dendrochronological patterns forming the ZER London plane tree chronology in Szczecin's Żeromski Park

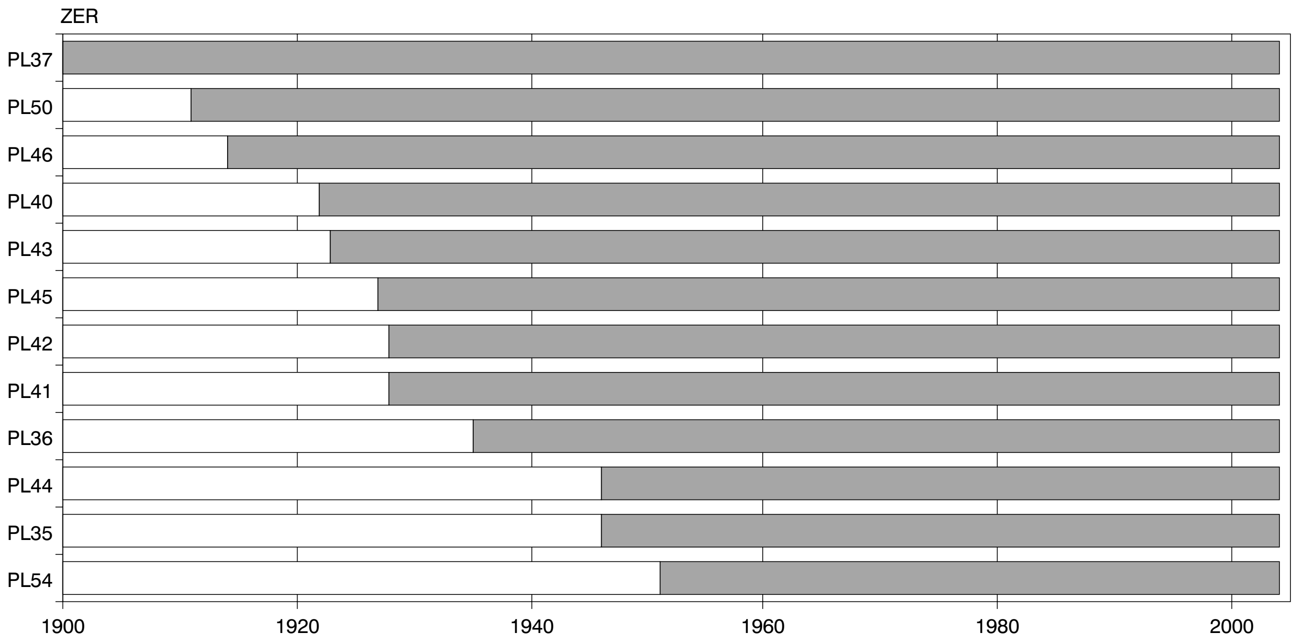

Fig. 2. Dendrochronological dating of growth sequences in the London plane trees yielding the ZER chronology

Results of dendroclimatological analyses

Signature years

Analysis of signature years allowed to identify 19 years showing an identical growth trend in most of the trees examined; in majority (14) of those years, the trend is negative due to the reduced ring growth width (Fig. 3). Analysis of meteorological conditions in the individual years allowed to relate the positive signature years to wet summers (particularly to June precipitation exceeding the multiannual mean) as well as to high precipitation in February–March. The air temperature proved less important in eliciting a positive growth trend; a positive response to winter and May temperatures higher than the respective means was observed. The year 1950 is an example of a positive signature year, characterised by a warm winter and warm May as well as by the annual sum of precipitation and the sums of precipitation in February, June, and July higher than the respective means.

Negative signature years occurred in periods featuring low sums of precipitation. In particular, a dry beginning of the summer and a deficiency of humidity in summer months resulted in reduced annual growth. Another factor inducing the presence of negative years involved cold winter months as well as a low annual air temperature mean. The year 1976, with the annual temperature average lower than the multiannual mean by 0.6°C, exemplifies those years characterised by such meteorological situations; the winter 1976 was severe, the sum of precipitation in that year being lower than the multiannual average (particularly dry were the summer months).

Response function analysis

The strength of the relationship between the characteristics analysed (annual tree ring growth and meteorological conditions), as expressed by the coefficient of determination (r^2), amounted to 67%, i.e., 67% of variation in the annual tree ring growth can be explained by weather conditions prevailing at the end of the preceding year and during the current growth year (Fig. 4). The coefficient of determination for the Zeromski Park London plane tree population was by 13% higher than that found in the conspecific population growing in the Jasne Błonia Park in Szczecin (Cedro, in press). The curves depicting the consecutive correlation and regression coefficients, both with respect to the temperature and precipitation, are dominated by positive values; this means that an increase in temperature or precipitation in a given month is accompanied by increased tree ring growth. Cambial activity is controlled primarily by atmospheric precipitation. The positive and statistically significant correlations and regressions in February, March, and June as well as in August and November of the year preceding the growth season evidence positive responses of the London plane tree growth to increased precipitation. Results obtained for the air temperature, too, demonstrated linear relationships with warm winters and warm early spring (February and March), as well as with warm May and August, all of which enhance the London plane tree's cambial growth.

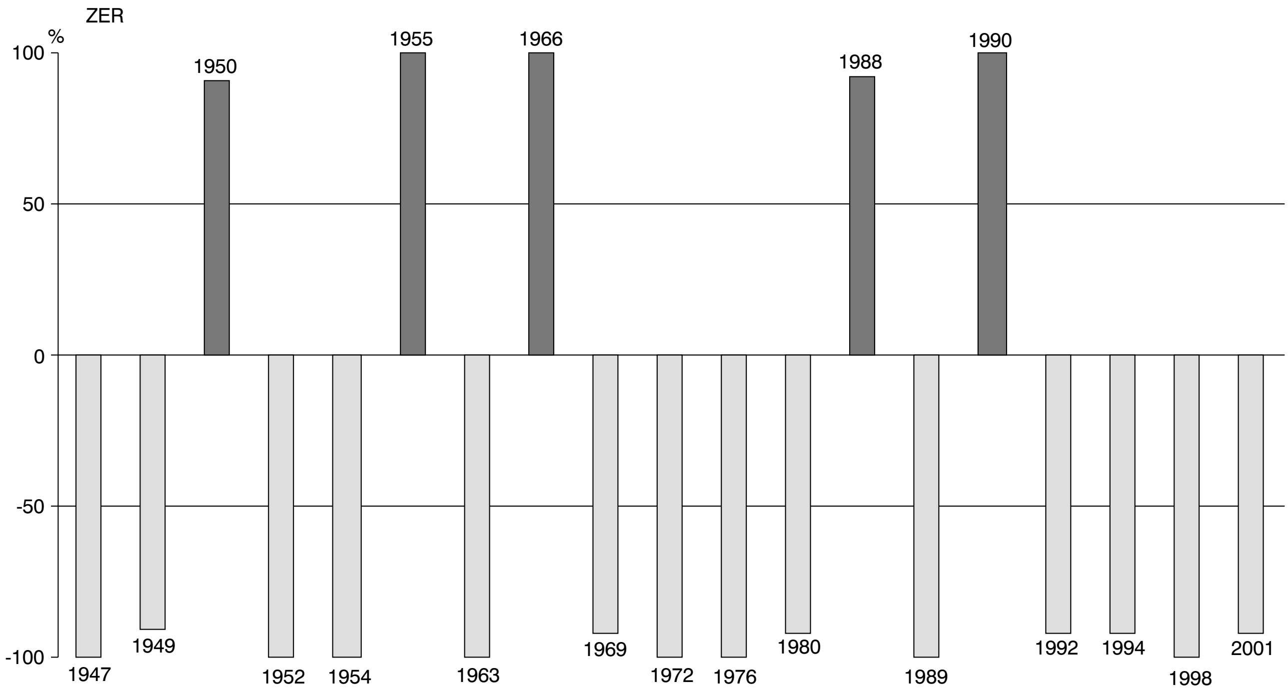

Fig. 3. The occurrences of signature years in the London plane tree chronology

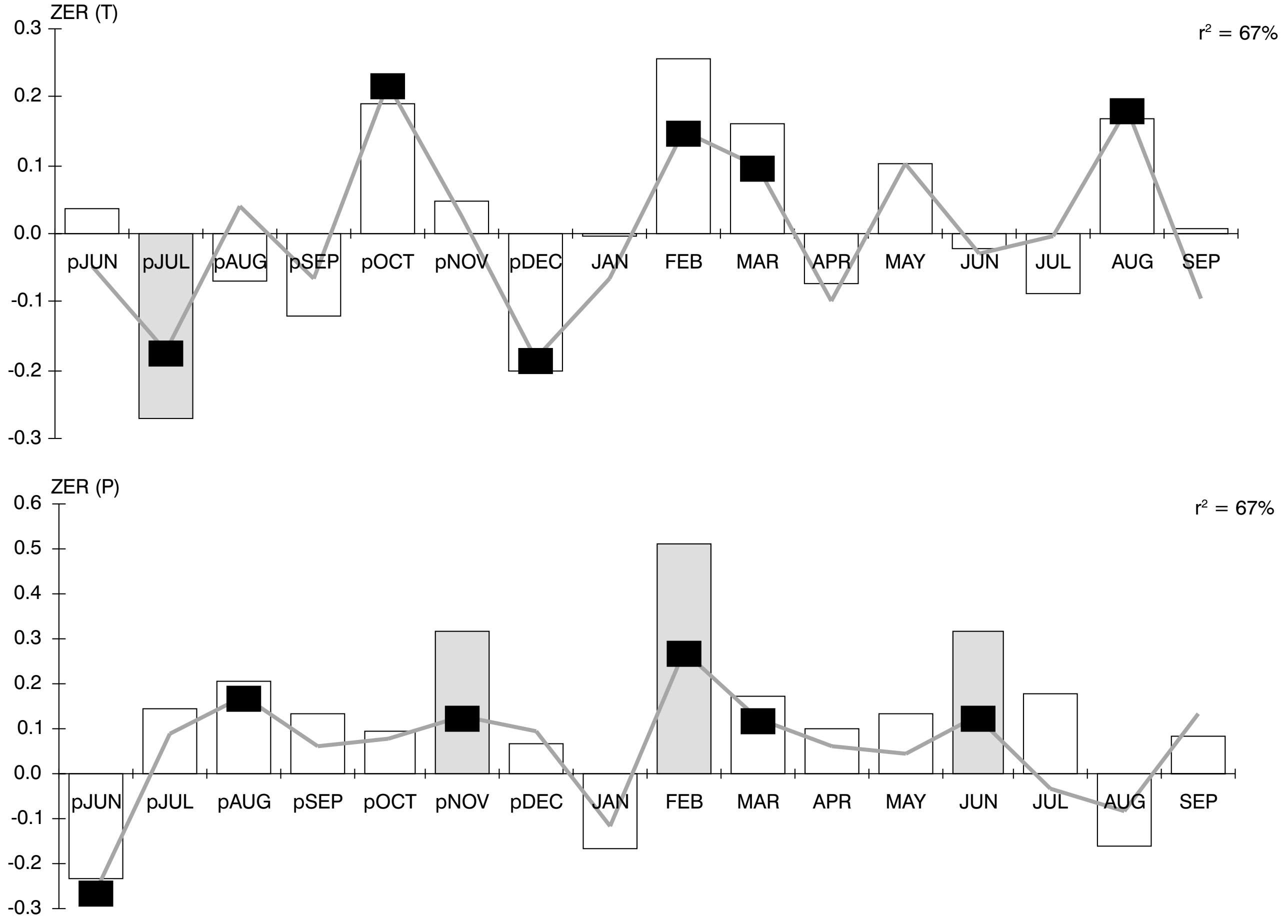

Fig. 4. Response function and correlation coefficients of relationships between the cambial growth and temperature (T) and precipitation (P); bars show values of the Pearson correlation coefficients, lines represent regression coefficients. Statistically significant values at $\alpha = 0.05$ are indicated by grey bars and black squares

Summary of the results and discussion

The tree ring growth-climate relationship for the London plane tree population studied demonstrated a decisive effect of precipitation on annual tree width increments. High precipitation, coupled with winter and early spring air temperatures higher than the respective means (associated with frequent advection of moist and warm Atlantic air masses) and well as with high June temperature enhance positive growth responses. High temperatures during the growth season additionally enhance the London plane tree ring growth.

Results of the dendroclimatological research conducted on the London plane trees growing in the Jasne Błonia Park provided evidence on the dominant influence of thermal conditions during the growth season on the tree ring growth. Effects of pluvial conditions were evident in dendrograms only under extreme conditions (long-lasting droughts or very high sums of precipitation in the growth season) – Cedro (in press).

Differences between the two parks may be explained by invoking different habitat conditions the London plane trees experience in the parks. In the Żeromski Park, the London plane trees grow now next to a very busy street (Matejki Street, Fig. 5) in the city centre or, for about 20 years, have been surrounded by pavement plates and curbs because the street was then broadened by additional two traffic lanes at the expense of the park area, thus bringing the car traffic close to the plane tree grove. At that time, too, the pavement used by pedestrians was removed; in addition, trees and shrubs growing on the fringe of the park, along the tramway track, were removed as well (Fig. 6). The storm drain system in place there, together with inability of the precipitation-derived water to penetrate the soil over a large part of the park's area, result in a rapid elimination of most of the precipitation-derived water away from the plane tree root zone. Repairs of the road or pavement surfaces, repeated every few years, damage the root systems. Another factor rendering the London plane trees sensitive to the amount of precipitation may involve the presence of salts and other contami-

Fig. 5. London plane trees on Matejki Street

Fig. 6. London plane trees growing along pedestrians and the tramway track

nants penetrating the soil from the road surface because the plane trees grow, on the average, only 1–1.5 m away from the border of the road (Schmitz and Eckstein 1991, Eckstein 1997, Schmitt et al. 1998). Intensive precipitation during winter and in early spring (February and March) results in the removal of harmful salts and other soluble substances toxic for the trees.

The Jasne Błonia Park's London plane trees grow under different habitat conditions. They are surrounded by lawn belts, the paths in their vicinity have no hardened surfaces, and the narrow streets nearby are not as busy as Matejki Street, thus penetration of the precipitation-derived water into the soil is not as severely restricted.

The trees examined were found to differ fairly markedly in their health state; only some of them bore no large damage. Most specimens featured damages in the form of open or closed stem cracks (decayed heartwood) or cavities along the entire trunk length. Some trunks showed also mechanically damaged cambial cork and xylem. Some of the canopies carried dead branches.

The London plane tree growing in Szczecin is most frequently affected by diseases inflicted by abiotic factors; e.g., the root system and stem may be damaged by hardening of the soil around the trunk, by degraded soil quality, and by increased soil salinity. At most sites, the soil is not sufficiently enriched with humus due to, i.a., raking of leaves from around the trees to remove the overwintering fungal spores. The array of adverse biotic factors includes fungal diseases occurring annually, at different intensities (plane tree anthracnosis, leaf scorch, and stem necrosis) and insect invasions, e.g., the plane leaf miner, a butterfly. The danger presented by the pest mentioned is serious, particularly for young trees (Madej et al. 2000).

References

Blasing T.J., Solomon A.M., Duvick D.N. 1984. Response functions revisited. Tree-Ring Bulletin 44: 1–15.

Bugała W. 2000. Drzewa i krzewy. PWRiL, Warszawa: 398–400.

Cedro A. 2004. Zmiany klimatyczne na Pomorzu Zachodnim w świetle analizy sekwencji przyrostów rocznych sosny zwyczajnej, daglezji zielonej i rodzimych gatunków dębów. Oficyna In Plus, Szczecin: 30–36.

Cedro A. (in press). Growth dynamics of the London plane-tree (*Platanus* ×*hispanica* 'Acerifolia') from the 'Jasne Błonia' Park in Szczecin (NW Poland).

Cook E.R., Kairiukstis A. 1992. Methods of dendrochronology. Kluwer Academic Publishers: 97–162.

Czekalski M., Kacprzak E. 1986. Występowanie i fenologia platana klonolistnego (*Platanus* × *acerifolia* Willd.) na terenie miasta Poznania. Polskie Towarzystwo Przyjaciół Nauk, Wydział Nauk Rolniczych i Leśnych, Prace Komitetu Nauk Rolniczych i Leśnych, 61: 11–20.

Eckstein D. 1997. The city trees in Hamburg: study objects for dendrochronology over the last twenty years. In: Dendrochronologia: una scienza per l'ambiente fra passato e presente (Eds. Urbinati C. & Carrer M.). Atti del XXXIV Corso di Cultura in Ecologia: 211–218.

Grubow W.I. 1954. Platanovye – Platanaceae Lindl. In: Derevya i kustarniki SSSR Vol. III, ed. S.J. Sokolov, Izdatelstvo Akademii Nauk SSSR, Moskva-Leningrad: 241–256.

Hereźniak J. 1992. Amerykańskie drzewa i krzewy na ziemiach polskich. In: Rośliny pochodzenia amerykańskiego zadomowione w Polsce, ed. A.U. Warcholińska, Łódzkie Towarzystwo Naukowe, Łódź: 97–150.

Holmes R.J. 1983. Computer-assisted quality control in tree-ring dating and measurement. Tree-Ring Bulletin 43: 69–78.

Holmes R.J. 1994. Dendrochronology Program Library. Users Manual. University of Arizona, Tucson.

Kaennel M., Schweingruber F.H. 1995. Multilingual Glossary of Dendrochronology. WSL FNP, Haupt: 50, 211, 292, 331.

Krüssmann G. 1962. Handbuch der Laubgehölze, band II. Verlag Paul Parey, Berlin und Hamburg: 219–223.

Krzysik H., Pittner T., Rybałtowska Z., Sprężyna J. 1973. Platan klonolistny (*Platanus* × *acerifolia* Willd.) na terenie zieleni Wrocławia. Roczniki Dendrologiczne 27: 195–200.

Madej T., Błaszkowski J., Tadych M., Maciołek W., Gołębiecki K. 2000. Platan klonolistny [*Platanus* × *acerifolia* (Aiton) Willd.] – współkomponent drzewostanu Szczecina. Zdrowotność. Drzewa, Krzewy, Park. Polskie Towarzystwo Chirurgów Drzew – NOT, Kraków: 24–33.

Ołtuszewski W. 1956. Jeszcze o najstarszych platanach w Polsce. Roczniki Dendrologiczne 11: 309–313.

Schmitt U., Möller R., Eckstein D. 1998. Der jahreszeitliche Aktivitätswechsel des Kambiums von Stadt- und Waldbäumen. Jahrbuch der Baumpflege: 248–251.

Schmitz E., Eckstein D. 1991. Erfassung und Bewertung von Vitalitätsmerkmalen an Parkbuchen in Hamburg. Das Gartenamt 40: 440–445.

Seneta W., Dolatowski J. 2004. Dendrologia. Wydawnictwo Naukowe PWN, Warszawa: 225–226.

Szymanowski T. 1953. Najstarsze platany klonolistne (*Platanus acerifolia* Willd.) w Polsce. Roczniki Dendrologiczne 9: 230–238.

Stachak A., Grinn U., Haas-Nogal M., Kubus M., Nowak G., Nowakowska M. 2000. Zieleń Szczecina - ilustrowany przewodnik dendrologiczny. Oficyna In Plus, Szczecin: 13–38, 53, 200–202.

Stachak A., Maślak B. 1989. Drzewa i krzewy parków centrum Szczecina. Roczniki Dendrologiczne 38: 73–103.

Stachak A., Nowakowska M. 1996. Park Żeromskiego w Szczecinie oraz Wały Chrobrego z sąsiednimi ulicami. Przewodnik. Forum Środowiska „Zieleń Miejska", Zamek Książąt Pomorskich, Szczecin, 13–14 września 1996.

Zielski A., Krąpiec M. 2004. Dendrochronologia. PWN, Warszawa: 158–176.

Walanus A. 2002. Instrukcja obsługi programu TCS. Program TCS do obliczania lat wskaźnikowych. Kraków.