Limitations and Possibilities for Growing Native and Exotic Maples in Poland

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ABSTRACT:

The Rogów Arboretum is specialized, among other plants, in maples. A collection was established in 1950 that has held the status of the Polish national maple collection since 1990. It has been under continuous development: each year it is supplied with new taxa and nowadays contains as many as about 100 species, subspecies and geographic varieties accompanied by 30 cultivars [in 2002]. The Arboretum is situated in central Poland, with the transitional (Atlantic – continental) climate prevailing, in Frost Hardiness Zone 6 according to the USDA classification. The most important factor limiting the possibilities for maples growing are the irregularly occurring severe winters, with long lasting periods of hard frost and minimum temperatures reaching from -27°C to -34°C. Spring frosts can also present problems.

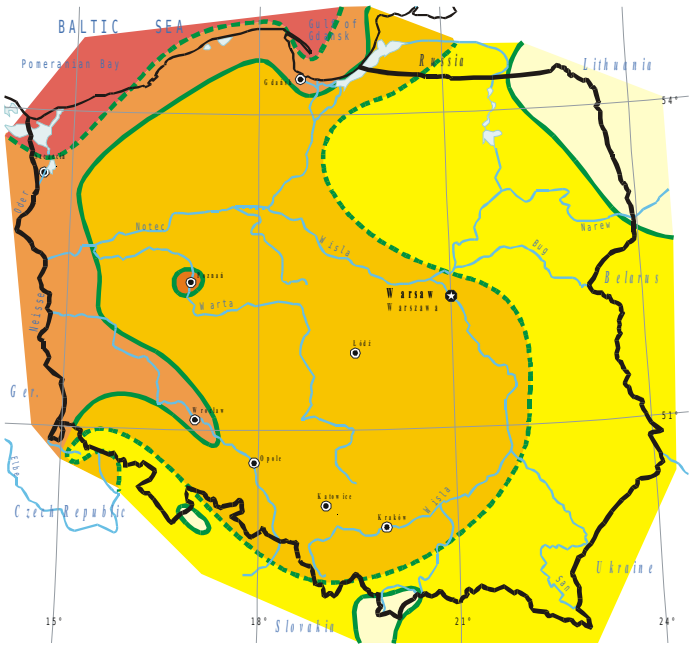

Fig. 1: Hardiness zones of Poland (according to Heinze and Schreiber 1984)

An assessment of frost hardiness, carried out using the Author's own four degree scale, was completed after the severe winter of 1986/87, when the mean January temperature fell to -12.4°C and the absolute minimum was -31.3°C. During the last 13 years [prior to 2000] the air temperature in Rogów was never below -22°C.

Zone 5b	-26.0°C – -23.4°C
Zone 6a	-23.3°C – -20.6°C
Zone 6b	-20.5°C – -17.8°C
Zone 7a	-17.7°C – -15.0°C
Zone 7b	-14.9°C – -12.3°C

Among the 74 species and subspecies (without cultivars) for which frost hardiness has been assessed, only 27 proved to be fully frost resistant and five more were only slightly damaged.

A majority of the heavily frost damaged maples

regenerate quickly from the injury within a period of a few years; some of them, however, need pruning to tend and shape their crowns. In Zone 7 the respective damage either does not occur or is milder by one class according to the author's assesment scheme.

Because of the cool climate and the climatic alterations of the Pleistocene, Poland does not have an exceptionally diverse array of native woody plants. There are 45 tree species, of which 7 are conifers as well as about 190 shrub species (including 3 conifers).

A majority of Poland's territory is located Zone 6 (USDA Frost Hardiness Zones). A small north-eastern region and some higher altitudes are in Zone 5, while rather narrow strips of the coastal land and the western part of the country are classified Zone 7 (Heinze and Schreiber, 1984).

NATIVE SPECIES

There are three native maple species in Poland: Norway maple (*Acer platanoides* L.), field maple (*Acer campestre* L.) and sycamore (*Acer pseudoplatanus* L.). Only the range of *A. platanoides* covers the whole country, reaching remote locations to the east and north. Both A. *pseudoplatanus* and *A. campestre* are limited in their northeastern Polish distribution. These are forest trees yet they constitute only a small part of most woodlands. Only the sycamore establishes monocultures in small areas of the mountains and hills, and this species also forms its own plant communities in association with Tilia. The two other species occur in the form of single- or group admixture in a number of associations in broadleaf forests and mixed broadleaf forests growing on fertile soils.

***Acer platanoides* L.** This is a fully frost resistant species over the entire area of the country. It occurs mainly in lowlands, reaching its limit at 1100 m a.s.l. Though its share in the forest is insignificant, it is one of the most commonly cultivated tree species outside forests, in towns, in rural terrain green belts or as a windbreak tree along roads. This species, together with limes [lindens], poplars and rowans has been used for planting along village roads as early as the XVIth century (Łuczyńska-Bruzda, 1995). Because of its prolific seed regeneration, it sometimes causes problems in towns, parks and gardens. The seed of maples from secondary sites, often of unknown origin and geographically alien, enter the local natural communities leading to genetic mixing and the emergence of new spontaneous populations (Boratyński and Filipiak, 1999). Norway maple in Poland may live up to 300 years; as many as 325 monument trees have been described, mainly in parks, of up to 520 cm circumference and 34 m height (Pacyniak, 1999).

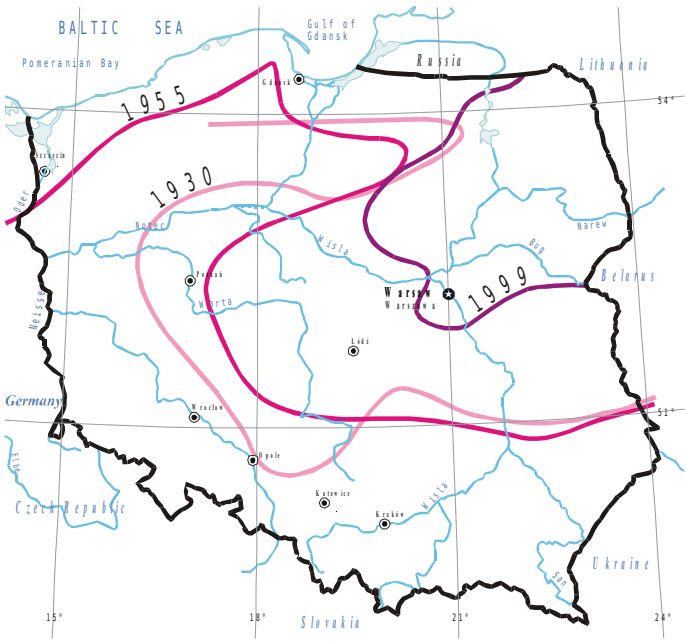

Fig. 2: Changes in natural and anthropogenic distribution range of Acer pseudoplatanus in Poland during the last 70 years.

Ornamental cultivars of Norway maple are rather infrequent in Poland. Currently 12 cultivars are grown of which six or seven have a relatively important role in gardening (Bugała, 1979; Seneta, 1991).

***Acer pseudoplatanus* L.** While this species does not occur in the whole of Poland, it has considerably increased its distribution range during the last few decades. The sycamore is present first and foremost in the mountains and the upland belt in the south of the country; in the Tatras its shrub form is seen up to 1590 m a.s.l. or in tree form 100-150 m lower. Compared with Norway maple and field maple, it requires more humidity in the soil and air, with at least 600 mm annual precipitation. Further it is less drought resistant than the Norway maple or field maple (Boratyński and Filipiak, 1999).

The sycamore has long been grown in towns and village greens, and as a road-side tree, yet is not as common as the Norway maple. Thanks to its ability for spontaneous regeneration it has become widely

domesticated throughout the Central-European Lowland, also entering also the natural forest communities. Its present distribution range in lowland Poland is mainly anthropogenic (Boratyński, 1999). It is not fully frost resistant in the whole of the country. In Rogów, one-to-three year old twigs were frost damaged and lack of florescence was observed after the temperature had fallen to -31°C; but the damage soon regenerated. In Poland sycamores live up to 350 years of age. 148 monumental trees have been described with a stem circumference of up to 510 cm and height up to 40 m (Pacyniak, 1999). The number of sycamore cultivars in Poland is rather small. The most common forms in nurseries are: f. *purpureum* Rehd., which is also present in forests, and f. *variegatum* Rehd., out of which two cultivars are most often encountered: 'Leopoldii' and 'Worley'.

***Acer campestre* L.** In Poland, the field maple is a lowland species. It never grows in spots elevated more than 700 m a.s.l. This species, like the sycamore, reaches its northeastern distribution limit in Poland. Its range is dispersed, only occuring more frequently in central and southeastern Poland. Many stands with field maple are secondary (anthropogenic) as a consequence of the fact that the species has been cultivated for many years . This species, characteristicly distinctly smaller than the two previously mentioned, occurs either at the forest edge or in the understory. It is present both in the wettest forests and in the xerothermic bush. Of the three domestic maple species, *A. campestre* is the most thermophilous. Its soil requirements are rather low and it survives droughts well.(Boratyński, 1999). Similarly to the sycamore, field maple is susceptible to frost damage but regenerates easily after injury (Tumiłowicz, 1993). The oldest maples in parks reach up to 315 years of age; a total of 23 monument field maples have been described, with stem circumference up to 508 cm and height to 27 m. Seven cultivars are planted; in natural sites f. *suberosum* Dumortier occurs rather frequently.

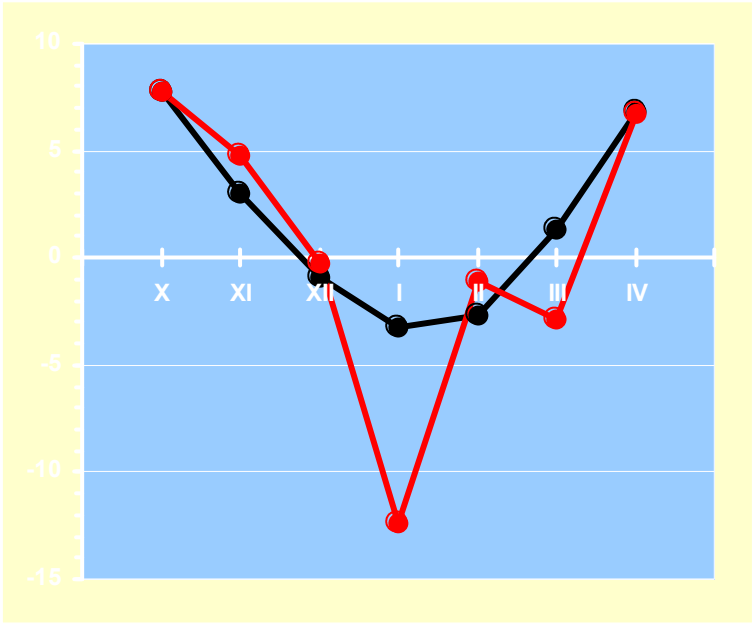

Fig. 3: January mean temperature during 1986/87 winter in Poland (red line). The black line indicates January mean temperature during the last 55 years. Horizontal lines mark 5°C intervals with the central axis at 0°C.

THE CLIMATE AT ROGÓW

In the Rogów Arboretum, where the cool climate is characteristic of the central part of Poland, the national collection of maples was established in 1950. The results of the growing experience gained from the collection form the background for this paper, though other data were also used, compiled from the rich bibliography on maples growing in other botanical gardens and parks located in various parts of Poland.

The Arboretum is located in the Central Polish Plains, in the subregion of Rawa Upland (51°49'N and 19°53'E) and at elevation from 185 to 197 m a.s.l. It occupies a previously forested area, and is still covered with a thinned Scots pine forest, 70 to 140 years old, with Norway spruce, hornbeam and oaks as accompanying species. This provides good microclimatic conditions for the introduction of Acer species. The soils were developed on the post glacial formation, at the region of a ground moraine. They are forest soils, grey-brown podzolic, of different mechanical composition, fertile and acidic.

The climate of Central Poland is transitional in character: in this region the influences of both maritime (Atlantic) climate and continental climate are present. In wintertime, depending on air mass circulation, either severe 'Siberian' weather or mild, green winter – characteristic of Western Europe – can occur. In summertime recurrent winds from the east bring droughts. The climate is variable both between years and between seasons.

The local climate of Rogów can be characterised on the basis of the data derived from a 55-year series of

observations at the Rogów meteorological station (Bednarek, 1993). The mean annual air temperature is 7.2°C. The mean temperature during January is -3.2°C and that of July 17.3°C. The lowest ever temperature of -34.0°C was recorded in 1929, while the mean annual minimum temperature is -20.4°C, an equivalent of Zone 6 of the USDA Frost Hardiness Zones. The average yearly number of frost days is 128, the number of days with maximum air temperature below 0°C is 47, and the growing period is 212 days long (that is from April 5th till November 1st). The highest temperature was recorded in August 1992: 36.2°C. The mean annual precipitation is 596 mm, varying considerably between years from 404 to 832 mm, and the number of days with snow cover amounts to 65 (varying from 37 to 113). [All figures as of 2002.]

Late frosts may occur until mid-June and early frost may occur as early as late August. During the last years, a period of warming often occurs in January or February. Occasionally, however, severe winters occur with the mean temperature of January or February varying from -8°C to -14.3°C, and minimal temperatures from -27 to -34°C. The last very severe winter occurred in 1986/87, with a January mean temperature of -12.4°C, a minimal temperature was of -31.3°C and snow cover depth of 30 cm. According to the data of the local weather station this was the coldest winter since 1945.

This rather detailed description of the climatic condition prevailing in Central Poland is necessary considering that low temperatures during the winter months and frosts are the most important factors limiting the potential for cultivation of many species of trees and shrubs. The subsequent assessment of frost resistance of selected maple species has been substantially based upon observations of injuries caused by the 1986/87-winter season and the performance of those tree species under cultivation in the open for at least 15-20 years.

NON-NATIVE MAPLE SPECIES

Excepting the above-described three endemic maple species, no other of Europe's maple species are important for practical cultivation Polish forests. Originating in the south of Europe, a great majority of them are not fully hardy and could only be grown in the warmest regions of the country. Of this group of maple species, the most commonly cultivated has been *Acer tataricum* L. This species, being fully frost resistant in Zone 6, also has rather low soil fertility requirements and is drought resistant. It usually forms small to medium trees to 12 m high, usually multi-stemmed, and with lateral branches starting at low heights. In old-growth trees, stems and branches may even reach 50-cm diameter. Even more commonly seen is an Asian subspecies, ssp. *ginnala* Wesm., which is often used for barrier trees and hedges.

Only in a few botanical gardens may one meet *Acer heldreichii* Orph., and ssp. *trautvetteri* Murr. The first is fully frost resistant in Zone 6, while the latter may be insignificantly frost damaged during extremely hard winters. In western Poland one may rarely see the French maple (*Acer monspessulanum* L.). This species performs well in Zone 7, sometimes even reaching 15 m height and 60 cm diameter (DBH), but in Zone 6 it is subject to rather severe frost damage and it does not grow as high (Seneta, 1991; Bugała, 1979; Tumiłowicz, 1993).

Acer opalus Mill. and ssp. *obtusatum* Gams suffer bad injuries from severe winters even in Zone 7 and is not recommended for growing in Poland, nor is *Acer velutinum* Boiss recommended. *Acer cappadocicum* Gled. is more cold resistant, but this species is seldom grown in Poland – excepting in the western part of the country where one may even encounter large sized trees. More sensitive to frost are the two subspecies of *cappadocicum*: ssp. *lobelii* Murr., and ssp. *divergens* Murr. Both of them are very seldom in Poland however and they have been introduced into cultivation only very recently. Little information can be given on *Acer hyrcanum* Fisch. et Mayer, a species that has been under cultivation for just 10 years now. Its subspecies *stevenii* Murr. has proved fully cold resistant under the conditions at Rogów (Seneta 1991, Bugała 1979, Tumiłowicz 1993).

Far more important in Poland are those maple species from North America and Eastern Asia. Some of the American species have been grown for nearly 200 years as ornamental trees in parks and gardens; a few of them have become naturalized in our landscape. Among the most commonly grown non-native maples in Poland are *Acer negundo* L. and *Acer saccharinum* should be listed. Boxelder was first introduced to Poland

in 1808 and has quickly spread out over the whole area of the country since. This was facilitated by the species' full cold resistance, its natural regeneration ability via self-sowing and its low soil requirements. However this is a short-lived tree, of little ornamental value, with poor quality and usability of wood. It is no good for planting along roads because of its low stability – frequently branches crack and entire trees fall. In parks often individuals are met of stem circumference as large as 375 cm and up to 20 m tall, however old-growth trees are rotten in the bottom parts of their stems. The negative peculiarity of the species is its high potential for expansion that leads to it spontaneously entering natural forest communities. This invasive maple becomes domesticated commonly in old parks, in abandoned or poorly tended landscaped terrain, at forest edges and particularly in the wet carr-type forests, along river valleys where it supersedes the domestic tree and shrub species. The common belief is that the species is useless and should be removed, with an exception of a few ornamental varieties characteristic of colourful and laciniated leaves (Danielewicz 1993, Seneta 1991, Boratyński 1999).

Silver maple (*Acer saccharinum* L.) has been growing in Poland since 1807 as a fully frost resistant tree all over the country. It can be planted as a park tree, particularly its variety 'Laciniatum Wieri', in exposed spots in large parks to emphasize the nice shape of the tree. This species has however proved to be inappropriate as a road or street tree. In many parks there are old growth and large-diameter trees of circumference reaching even 530 cm and height to 32 m; alleys of a few tens of old-growth trees also exist.

Fully frost resistant, yet rarely seen, are the two North American species, *Acer rubrum* (red maple), in cultivation in Poland since1813, and *A. saccharum* (sugar maple) – grown since the year 1770. Red maple is present only in botanical gardens and infrequent parks. Old specimens reach to 270 cm stem circumference and 22 m height. Sugar maple is somewhat more commonly seen in parks and it grows to larger dimension compared with the former species. Some of the recent cultivars identified in the last few years are not yet known in Poland. Black sugar maple (ssp. *nigrum* Desm.) is extremely rare in Poland, while ssp. *floridanum* Desm. and ssp. *leucoderme* Desm. were completely frozen during the severe winter 1986/87.

At the end of 19th century an attempt was made to introduce sugar maple to forests. In two Forest Districts of western Poland the remnants of the experiment have survived to the present day: small groups and clumps of trees, characterised by the maximum dimensions of 26 m height and 60 cm DBH at the age of 85 years. A rich, self-sown, naturally regenerated young generation of trees has been observed beneath the shelter of the old-growth trees (Tumiłowicz 1971). In the forest segment of the Rogów Arboretum, small stand populations of *Acer rubrum*. *A. saccharum* and *A. saccharinum* are present. The best performance, growth and quality, occurs in young red maples: at the age of 27 years the mean DBH was 14.6 cm and the mean height was equal 16.5 m (Tumiłowicz and Szymczak, 1997).

Almost all the species from the section and series *Palmata* have their representatives in the Rogów Arboretum, and a majority of them are present in many gardens and parks of western and central Poland. From this group of species – very important in landscaping – only the Korean maple (*Acer pseudosieboldianum* Kom.) is fully frost resistant in Zone 6. This underestimated species, infrequently grown in Poland, may successfully replace *Acer palmatum* and *A. japonicum* in the cooler regions of our country. This species is of nearly as great in ornamental value as the two others, its foliage becomes coloured, yellow-to-red, in the autumn, but some of the dry brownish leaves are retained during the winter. These maples, amounting to about 30 individuals of different provenance, have reached sufficient age to yield seed able to germinate. The only cultivar –'Kolumna' – was named at the Rogów Arboretum (Tumiłowicz, 1994).

Acer palmatum in the Rogów Arboretum (a total of more than 200 specimens of various provenance) becomes rather severely frost damaged during hard winters, including death of single branches, stem cracks and necroses. However large variations are observed in the level of injury, depending on both provenance and planting site. A majority of trees regenerated well from the damage. At the age of 50 years, the trees are up to 9 m high and produce rich seed crops: hundreds of seedlings may be observed. In the western regions of Poland, in Zone 7, *A. palmatum* is considered frost resistant, and the largest individual in our country is 36 cm DBH and 13.5 m tall. Those varieties of japanese maple belonging to the Dissectum group, and particularly so Linearilobum, are most frost sensitive compared to other types (Tumiłowicz, 1993). The performance of *Acer circinatum* Pursh, *A. japonicum* Thunb., *A. sieboldianum* Miq., and *A. shirasawanum*

Koidz are similar during severe winters. The latter has the characteristic of rich natural regeneration (Tumiłowicz, 1992). Ascribing the majority of species in this series to Zone 5 (Gelderen et al. 1994) seems too optimistic.

Regarding the series *Sinensia*, similar frost sensitivity is characteristic for *Acer campbellii* ssp. *sinense* de Jong, *A. oliverianum* Pax and A. *olivaceum* Fang et Chiu; of these, the first mentioned two species may produce florescence and viable seed in the periods between severe winters.

Of the 15 species and subspecies belonging to the section *Macrantha* present in the Rogów Arboretum, the greatest potential for landscaping should be attributed to *Acer pensylvanicum* L. and A. *tegmentosum* Max. These are fully frost resistant and their ornamental, white striped bark is very pronounced, while less so with the similarly frost resistant *A. micranthum* and *A. tschonoskii*. The very decorative *A. davidii*, *A. rufinerve* and *A. capillipes* are not fully hardy in Zone 6.

Of the five species in section *Trifoliata*, four have been grown in Poland. *Acer triflorum* Kom., and *A. mandshuricum* Max. are fully frost resistant in Zone 6, but they are only rarely encountered in infrequent botanical gardens. The introduction of *Acer triflorum* to Poland began as late as 1974 (the Rogów Arboretum). Two individuals of the species survived the harsh 1986/87 winter without any injury (Tumiłowicz 1993).

Acer griseum was introduced to Poland in 1931 but none survived after World War II. The next introduction took place in 1974 at Rogów Arboretum, where a total of 32 trees are growing today in a couple of groups. This may contribute to the unexpectedly high germination rates of their seed (cross fertilization); the seed germination rate after two years of stratification is as high as 20%. The Arboretum has had in their possesion a few hundred seedlings between 1-4 years old. Those trees that suffered severe damage following the 1986/87 winter have subsequently regenerated the injuries well, despite the fact that some of them had been frozen as far down as the snow cover level. At this writing they are up to 5 m tall. No such damage was observed that winter in Zone 7 (NW Poland). The examples of *Acer griseum* samaras variability were described in the Rogów Arboretum (Tumiłowicz 1998). The response to severe winters has been similar from *Acer maximowiczianum* Miq., still rare in Poland.

Two maple species that are fully frost resistant in Zone 6, from the section *Parviflora*, series *Caudata*, have been grown: *A. caudatum* ssp. *ukurunduense* Murr. and *A. spicatum* Lam. These are rather invasive species, with rich self-sowing natural regeneration. The first of these shows the tendency toward naturalization.

In the *Glabra* section, *Acer glabrum* Torr. and ssp. *douglasii* Wesm. as well as *A. argutum* Max. and *A. barbinerve* Max. are fully frost resistant in the climate of central Poland. They are only of minor importance for collections, without any practical use in landscaping. *Acer stachyophyllum* Hiern together with its subspecies ssp. *betulifolium* de Jong is susceptible to severe frost injuries during hard winters in Zone 6.

Acer carpinifolium S et Z., though attributed to Zone 3 (Gelderen et al. 1994), sustains cold injury during severe winters in Rogów, down the snow cover level, but then regenerates well in subsequent years. Even in the milder climate of western Poland (Zone 7) the frost damage is considerable. Individuals of this species keep their dry brown foliage till the spring.

A few more maple species belonging to a number of different sections are worth mentioning, even if they are seldom grown and don’t play an important role in landscaping, they are valuable for collection purposes.

Acer diabolicum Bl., an extremely rare maple species in Poland, is subject to frost damage during severe winters. Two specimens from Japanese seed growing closely to one another in Rogów, each 22 years old, produce viable seed.

A single 19-year old *Acer sinopurpurascens Cheng.* individual grown from seed obtained from the Shanghai Botanical Garden, is at this writing 6 m tall and produces empty seed. This juvenile specimen survived covered with snow the 1986/87 winter without any injury.

Acer pauciflorum Fang. Two individuals, both 13 years of age and originating from seed collected in indigenous sites (Zheijang Province, China), successfully survived cold reaching even to -21°C. As of this writing they are 1.7 m tall and have not yet born seed.

Acer pseudosieboldianum ssp. *takesimense* de Jong. A single specimen, originating from seed collected on Ullung Island (South Korea), has reached the height of 2.5 m at 7 years of age.

Acer robustum Pax. One 35 year old individual grows in Rogów. This tree was grown from seed obtained from the Botanical Garden in Peking. Growing under a half-shelter, the tree is at present 4 m tall; it has not had florescence so far. Its leaves, shining green on both sides, have tufts of white, silky hairs in the vein junctions.

Dipteronia sinensis Oliv. – the second genus in *Aceraceae* family. The first successful introduction to Poland was in 1973, to the Rogów Arboretum and in the NW Poland. This species suffers frost damage during severe winters in Rogów: it is injured down to the snow level, but regenerates well. So far it has not produced florescence. In Zone 7, on the other hand, the species has performed well, reaching up to 6 m height and producing viable seed (Tumiłowicz 1993, Seneta 1996).

A few maple hybrids growing in Rogów are also worthy of note. *Acer x freemanii* Murr – single individuals were found in the abundant population of *Acer rubrum*, the latter originated from seed from Forest Co., Wisconsin, USA. *Acer conspicuum* van Gelderen et Oterdoom. A few specimens emerged spontaneously self-sown, and are growing under the shelter of 46 year old individuals of *Acer davidii* and *A. pensylvanicum.* They have intermediate character features of the two parent species. *Acer heldreichii* ssp. *trautvetteri* Murr. x *A. pseudoplatanus* L. A total of six individuals, aged 27, originated from seed collected from the single (now 60-years-old) individual of ssp. trautvetteri, which grows in the vicinity of an individual of *A. pseudoplatanus* in the Przelewice Arboretum, NW Poland. These trees, showing the features of both parent species, grow within a single stand of trees, and have reached sizes of 18-27 cm DBH and up to 17 m height.

KEY TO THE REGISTER

The below-presented register covers the species, subspecies and geographical varieties of maples, growing in the Rogów Arboretum. The record is supplemented with the following information: year of introduction, the origin (source) of seed: **BG** – Botanical Gardens, **N** – Nature; and the characteristic is accompanied by the assessment of frost hardiness.

An original grouping system was applied for this study. Four classes were defined, each containing maple species of similar frost tolerance level. In case of different damage types among specimens of one taxon, the prevailing type of damage had the prime significance for the classification:

A – no damage or insignificant damage (e.g., tops of one-year-old shoots frozen);

B – moderate damage (one-year old and older shoots frozen; injuries are being well regenerated and by the end of growing period they become almost invisible);

C – severe damage (old shoots frozen, the regeneration process is weak and long lasting. Dead branches and necroses are present, the plant is deformed and needs tending measures. All shoots are frozen to the snow line/ground level but new shoots spread well from the undamaged parts);

D – whole plant frozen.

THE LIST OF MAPLE SPECIES GROWING IN THE ROGÓW ARBORETUM

The source: **N** – Wild (Natural Source), **BG** – Botanical Gardens,

A-**D** – Valuation of the frost hardiness

Taxon *	**Year Planted**	**N**	**BG**	**Frost hardiness**
I. **Section** *Parviflora* Koidz. (1911)				
3. **Series** *Caudata* Pax (1886)				
A. caudatum Wall. (1830) ssp. *multiserratum* (Maxim.) A.E.Murray (1982)	1994	+	-	?
A. caudatum ssp. *ukurunduense* (Trautv. et Meyer) A.E.Murray (1966)	1962	+	+	A
A. spicatum Lam. (1786)	1958	+	+	A
II. **Section** *Palmata* Pax (1885)				
4. **Series** *Palmata*				
A. circinatum Pursh (1814)	1948	+	+	C
A. japonicum Thunb. ex Murray (1784)	1960	-	+	C
A. palmatum Thunb. ex Murray (1784) ssp. *palmatum*.	1952	-	+	C
A. palmatum ssp. *amoenum* (Carriére) Hara (1954)	1952	-	+	C
A. palmatum ssp. *matsumurae* Koidz. (1911)	1958	-	+	C
A. pauciflorum W.P.Fang (1932)	1987	+	-	?
A. pseudosieboldianum (Pax) Kom. ssp. *pseudosieboldianum*.	1973	+	+	A
A. pseudosieboldianum ssp. *takesimense* (Nakai) P.C. de Jong (1994)	1994	+	-	?
A. pubipalmatum W.P.Fang (1932)	1989	-	+	?
A. robustum Pax (1902)	1965	-	+	C
A. shirasawanum Koidz. (1911) var. *shirasawanum*.	1938	-	+	C
A. shirasawanum var. *tenuifolium* Koidz. (1911)	1981	+	+	C
A. sieboldianum Miq. (1865)	1961	-	+	C
5. **Series** *Sinensia* Pojark. (1933)				
A. campbellii ssp. *sinense* (Pax) P.C. de Jong (1994)	1965	-	+	C
A. erianthum Schwer. (1901)	1998	-	+	?
A. olivaceum W.P.Fang et Chiu (1979)	1984	-	+	C
A. oliverianum Pax (1889) ssp. *oliverianum*.	1966	-	+	C
IV. **Section** *Macrantha* Pax (1885)				
A. capillipes Maxim. (1867)	1957	-	+	C
A. caudatifolium Hayata (1911)	1976	-	+	C-D

A. crataegifolium Sieb. et Zucc. (1845)	1958	-	+	C
A. davidii Franch. (1885) ssp. *davidii*.	1954	+	+	C
A. davidii ssp. *grosseri* (Pax) P.C. de Jong (1994)	1957	-	+	C
A. micranthum Sieb. et Zucc. (1845)	1967	+	+	A
A. pectinatum ssp. *forrestii* (Diels) A.E.Murray (1977)	1994	-	+	?
A. pectinatum ssp. *laxiflorum* (Pax) A.E.Murray (1977)	1973	-	+	C
A. pectinatum ssp. *maximowiczii* (Pax) A.E.Murray (1977)	1988	+	-	?
A. pectinatum ssp. *taronense* (Hand.-Mazz.) A.E.Murray (1977)	1997	-	+	?
A. pensylvanicum L. (1753)	1954	+	+	A
A. rufinerve Sieb. et Zucc. (1845)	1955	+	+	C
A. tegmentosum Maxim. (1857)	1972	-	+	A
A. tschonoskii ssp. *koreanum* A.E.Murray (1977)	1994	+	-	?
A. tschonoskii Maxim. (1886) ssp. *tschonoskii*	1972	+	+	A
V. **Section** *Glabra* Pax (1885); emend. Momot. (1962)				
7. **Series** *Glabra*				
A. glabrum ssp. *douglasii* (Hook.) Wesm. (1890)	1962	+	-	A
A. glabrum ssp. *douglasii* var. *torreyi* (Greene) Smiley (1921)	1993	-	+	?
A. glabrum Torr. (1828) ssp. *glabrum*	1956	-	+	A
8. **Series** *Arguta* (Rehder) Rehder (1949)				
A. argutum Maxim. (1867)	1976	-	+	A
A. barbinerve Maxim. (1867)	1972	+	+	A
A. stachyophyllum ssp. *betulifolium* (Maxim.) P.C. de Jong (1994)	1959	-	+	C
A. stachyophyllum Hiern in Hook.f. (1875) ssp. *stachyophyllum*	1986	+	+	C
VI. **Section** *Negundo* (Boehmer) Maxim. (1880)				
9. **Series** *Negundo*				
A. negundo ssp. *californicum* var. *texanum* Pax (1886)	1997	+	-	?
A. negundo ssp. *interius* (Britton) A. et D. Loeve (1954)	1970	-	+	A
A. negundo L. (1753) ssp. *negundo*.	1948	-	+	A
10. **Series** *Cissifolia* (Koidz.) Momot. (1962)				
A. cissifolium (Sieb. et Zucc.) K.Koch (1864)	1958	-	+	C
A. henryi Pax (1889)	1964	-	+	C
VII. **Section** *Indivisa* Pax (1885)				
A. carpinifolium Sieb. et Zucc. (1845)	1955	-	+	C

VIII. **Section** *Acer*				
11. **Series** *Acer*				
A. caesium Wall. ex Brandis (1874) ssp. *caesium*.	1998	+	-	?
A. heldreichii Orph. ex Boiss. (1856) ssp. *heldreichii*	1969	-	+	A
A. heldreichii ssp. *trautvetteri* (Medvedev) A.E.Murray (1982)	1972	-	+	B
A. pseudoplatanus L. (1753)	1948	+	-	A-B
A. velutinum Boiss. (1846)	1975	-	+	C
12. **Series** *Monspessulana* Pojark. (1933)				
A. hyrcanum Fisch. et C.A.Mey. (1837) ssp. *hyrcanum*	1990	+	+	?
A. hyrcanum ssp. *stevenii* (Pojark.) A.E.Murray (1969)	1975	+	+	A
A. monspessulanum ssp. *ibericum* Yalt. (1967)	1959	-	+	C
A. monspessulanum L. (1753) ssp. *monspessulanum*	1953	+	+	B-C
A. monspessulanum ssp. *turcomanicum* (Pojark.) A.E.Murray (1969)	1959	-	+	C
A. obtusifolium Sibthorp et Smith (1809)	1998	-	+	?
A. opalus ssp. *obtusatum* (Willd.) Gams (1925)	1949	-	+	C
A. opalus Mill. (1768) ssp. *opalus*	1948	+	+	C
13. **Series** *Saccharodendron* (Raf.) A.E.Murray (1970)				
A. saccharum Marshall (1785) ssp. saccharum	1955	+	+	A
A. saccharum ssp. *floridanum* (Chapm.) Desmarais (1952)	1970	+	-	D
A. saccharum ssp. *grandidentatum* (Torr. et Gray) Desmarais (1952)	1970	+	+	C
A. saccharum ssp. *leucoderme* (Small) Desmarais (1952)	1973	+	-	D
A. saccharum ssp. *nigrum* (Michaux f.) Desmarais (1952)	1958	+	+	A
IX. **Section** *Pentaphylla* Hu et Cheng (1948)				
15. **Series** *Trifida* Pax (1886)				
A. buergerianum Miq. (1865) ssp. *buergerianum*	1985	-	+	C-D
X. **Section** *Trifoliata* Pax (1885)				
16. **Series** *Grisea* Pojark. (1933)				
A. griseum (Franch.) Pax (1933)	1974	-	+	C
A. maximowiczianum Miq. (1867)	1949	-	+	C
A. triflorum Kom. (1901)	1974	-	+	A
17. **Series** *Mandshurica* Pojark. (1933)				
A. mandshuricum Maxim. (1867)	1965	+	+	A
XI. **Section** *Lithocarpa* Pax (1885)				
18. **Series** *Lithocarpa*				
A. diabolicum Blume ex K.Koch (1864)	1960	-	+	C

A. sinopurpurascens Cheng (1931)	1981	-	+	?
A. sterculiaceum ssp. *franchetii* (Pax) A.E.Murray (1969)	1965	-	+	C
19. **Series** *Macrophylla* Pojark. ex Momot. (1962)				
A. macrophyllum Pursh (1814)	1969	+	+	C
XII. **Section** *Platanoidea* Pax (1885)				
A. campestre L. (1753)	1926	-	+	A-B
A. cappadocicum Gleditsch (1785) ssp. *cappadocicum*	1971	-	+	B
A. cappadocicum ssp. *divergens* (Pax) A.E.Murray (1978)	1981	-	+	C
A. cappadocicum ssp. *lobelii* (Tenore) A.E.Murray (1982)	1972	-	+	C
A. cappadocicum ssp. *sinicum* (Rehder) Hand.-Mazz. (1933)	1996	-	+	?
A. longipes ssp. *amplum* (Rehder) P.C. de Jong (1994)	1995	+	-	?
A. longipes Franch. ex Rehder (1905) ssp. *longipes*	1995	+	-	?
A. miyabei Maxim. (1888) ssp. *miyabei*	1957	-	+	B
A. mono Maxim. (1857) ssp. *mono*	1966	+	+	B
A. mono var. *mayrii* (Schwerin) Nakai (1930)	1998	+	-	?
A. mono ssp. *okamotoanum* (Nakai) P.C. de Jong (1994)	1993	-	+	?
A. platanoides L. (1753) ssp. *platanoides*	1926	+	-	A
A. platanoides ssp. *turkestanicum* (Pax) P.C. de Jong (1994)	1991	-	+	?
A. tenellum Pax (1889)	1972	-	+	B
A. truncatum Bunge (1833)	1973	+	+	B-C
XIV. **Section** *Ginnala* Nakai (1915)				
A. tataricum ssp. *aidzuense* (Franch.) P.C. de Jong (1994)	1957	-	+	A
A. tataricum ssp. *ginnala* (Maxim.) Wesm. (1890)	1948	-	+	A
A. tataricum ssp. *semenovii* (Regel et Herder) A.E.Murray (1982)	1959	+	+	A
A. tataricum L. (1753) ssp. *tataricum*	1948	+	+	A
A. tataricum ssp. *tataricum* var. *torminaloides* Pax (1886)				
A. tataricum ssp. *tataricum* var. *slendzinskii* Raciborski (1888)				
XV. **Section** *Rubra* Pax (1885)				
A. rubrum L. (1753)	1948	+	+	A
A. saccharinum L. (1753)	1948	+	+	A

Dipteronia sinensis Oliv. (1889)	1975	-	+	C

** Classification follows de Jong from van Gelderen et al., 1994.*

MAPLE HYBRIDS

A. x *conspicuum* van Gelderen et Oterdoom (1994)
A. x *freemanii* A.E.Murray (1969)
A. heldreichii ssp. *trautvetteri* (Medvedev) A.E.Murray (1982) x *A. pseudoplatanus* L. (1753)

THE LIST OF MAPLE SPECIES FROZEN AFTER 1-3 YEARS OF OUTDOOR CULTIVATION

A. distylum Sieb. et Zucc. (1845)
A. campbellii Hook. et Thomson in Brandis ex Hiern in Hook.f. (1875) ssp. *campbellii*.
A. campbellii ssp. *sinense* var. *pubinerve* (Rehder) W.P.Fang (1932)
A. elegantulum W.P.Fang et Chiu (1979)
A. tonkinense ssp. *kwangsiense* (W.P.Fang et Fang f.) W.P.Fang (1979)
A. cordatum Pax (1889)
A. fabri Hance (1884)
A. coriaceifolium H.Lév. (1912)

HYBRIDS PRESENT IN THE ROGÓW ARBORETUM

A. x *conspicuum* Gelderen et Oterdoom
A. x *coriaceum* Bosc ex Tausch
A. x *freemanii* A.E.Murray
A. x *hillieri* Lancaster
A. x *pseudo-heldreichii* Fukarek et Celjo
A. truncatum Bunge x *A. platanoides* L.
A. davidii ssp. *grosseri* (Pax) P.C. de Jong x *A. tegmentosum* Maxim.
A. pectinatum ssp. *forrestii* A.E.Murray x *A. rufinerve* Siebold et. Zucc.
A. japonicum Thunb. x *A. pseudosieboldianum* Kom.
A. pensylvanicum L. x *A. capillipes* Maxim.

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