

WOODY PLANTS OF THE MAIN PART OF THE BEČOV BOTANICAL GARDEN

DRVENASTE BILJKE GLAVNOGA DIJELA BOTANIČKOG VRTA BEČOV

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Abstract

The Bečov Botanical Garden is one of the three botanical gardens in district Karlovy Vary (Czech Republic). The garden was established in 1918 by duke Heinrich Beaufort–Spontini as landscape park and rockery. For decades the garden was neglected and abandoned, and it was unveiled to the public in 2005. Two parts of the original area were chosen for this study – the former landscape park and the slope with rockery. In total, 471 woody plants were recorded, 104 of them were coniferous and 367 broad-leaved species. There are 22 families, 40 genera and 85 of taxa in total, 30 of them belonging to gymnosperms and 55 to angiosperms. Some of the trees planted at the time of the founding of the garden have remained until today: Amur cork tree (*Phellodendron amurense* Rupr.), katsura (*Cercidiphyllum japonicum* Siebold et Zucc.), hardy kiwi (*Actinidia arguta* /Siebold et Zucc./ Planch. ex Miq.), Jezo spruce (*Picea jezoensis* /Siebold et Zucc./ Carrière), and Engelmann spruce (*P. engelmannii* Parry ex Engelm.).

KEY WORDS: dendrological evaluation; Bečov Botanical Garden; Bečov nad Teplou; coniferous trees; broad-leaved trees; Czech Republic

INTRODUCTION

UVOD

Historical gardens and parks have a great importance in terms of nature and landscape protection (Jebavý 2007; Miller *et al.* 2016). Apart from conservation, as well as the scientific research and education, they represent a natural habitat for a wide range of other organisms, serve public welfare, and contribute to popularization, planting and maintenance of plants (Pinheiro *et al.* 2009; Reš *et al.* 2009; Idžojtić *et al.* 2010, 2011, 2013; Nodilo 2011; Poljak *et al.* 2011; Zebec *et al.* 2014).

Trees are of exceptional importance in plant collections, i.e. they benefit people, and are associated with social, economic and cultural values (Oldfield and Newton 2012). They play an important role in improving various environmental

factors in urban areas, such as: temperature, humidity, and dust content (Praus 2011). In general, people feel calmer in natural environments and green colours have pleasant effect on their senses. Additionally, singing birds, rustle leaves, and the combination of light and shade or scenery, can also have a major effect on the human wellbeing (Hurych *et al.* 1984; Praus 2011).

The Bečov Botanical Garden was established in 1918 by duke Heinrich Beaufort–Spontini as landscape park and rockery. The garden was fully operating as private garden for duke's family and guests until 1945. It is important to note that the Bečov Botanical Garden served for plant testing for the Průhonice Park, i.e. one of the most valuable botanical collections of domestic and exotic tree and shrub taxa in the Czech Republic. Last modifications to the Bečov Botanical

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Garden were made in 1935. Active maintenance of the garden area was stopped after World War II until 2005. Nowadays, the garden is gradually reconstructed by the Berkut organisation. In 2014 the garden is accepted as a regular member of the Union of Botanic Gardens of the Czech Republic. The garden is interesting not only from dendrological and historical point of view, but it has an important social function as well. It became a place for student education and a natural promenade for public visitors. Making the garden accessible to the public is crucial for various types of botanical gardens (e.g. Nodilo 2011; Poljak *et al.* 2011).

Presented paper is a result of studies conducted in this garden in last 12 years: flora of historic rock garden (Špaková 2010), reconstruction of rock garden (Špaková 2012), history and future (Svoboda 2014), and current state of woody plants (Špaková 2016). The most valuable part of the Bečov Botanical Garden is the central historical part, because many of the originally planted trees are still present. The presented work provides a comprehensive overview of the woody plants in the central part of the garden.

STUDY AREA AND RESEARCH METHODS PODRUČJE I METODE ISTRAŽIVANJA

Location – Lokacija

The Bečov Botanical Garden is located in the north-western part of the Czech Republic, near Bečov nad Teplou. In this paper are presented the tree and shrub species from former landscape park and the slope with rockery. The main reason for choosing these two parts is the existence of the original maps from the 1930s. This area geomorphologically belongs to Slavkovský les unit and Bečovská vrchovina subunit (Brandos 2009), where granite and granodiorite basic rocks can be found. Altitude is 505–545 MASL, and climate is characterized as mild to warm, with mean annual temperature above 6 °C and mean annual precipitation of 700 mm. Phytogeographically, area belongs to Kaňon Teplá (INSPIRE 2016). More complex and detailed characteristics and history of the garden can be found in Špaková (2012).

Tree identification – Determinacija stabla

For tree and shrub identification following monographies were used: Horáček (2007) and Hieke (1978a, 1978b, 2008). Cultivars were determined according to the original planting plans (Koditek 1908–1937). Geographical origin of the taxa was also recorded (e.g. Tafra *et al.* 2012). Woody plants are alphabetically listed in the Table 1, according to Erhardt *et al.* 2016, with standardized abbreviations of authors of scientific plant names according to Brummitt and Powell (1992). The plant list includes cultivar names according to the List of Names of Woody Plants: International Standard ENA 2016–2020 (Hoffman 2016) and the RHS Horticultural Database (2017).

Basic dendrological and dendrometric characteristics of researched taxa – Osnovne dendrološke i dendrometrijske značajke istraživanih svojti

Furthermore, tree and shrub height, as well as the trunk diameter, height of the first branch, and crown characteristics were evaluated. The tree height, as well as the distance from the ground to the first branch was measured digitally using a laser rangefinder (Bosch DLE 40 Professional Manuals, 2017), with values rounded to the nearest metre. Trunk girth was measured at 1.3 m from ground level, with values rounded to the nearest centimetre. Finally, trunk diameter was calculated from the trunk girth and sorted into 13 categories.

Tree ages were estimated using available data, i.e. planting year for some species was found in the original plans and records (Koditek 1908–1937). On the other hand, ages of the other trees were estimated as described in Kubišta (2014). Trees growth rates were found in Machovec *et al.* (2005) and Sochorová and Šindelář (2007). Estimated ages of individual trees were arranged into seven categories.

Tree damages were estimated and recorded, these significant properties were observed: pests, fungi, location of the tree growth, secondary crown, double crowns, exposed roots, and year of planting (Tomiczek 2005; Uhlířová *et al.* 2004; Holec and Beran 2012). The crown characteristics was taken from specialised literature Hieke (1978a, 1978b, 2008), Horáček (2007) and Větvička and Matoušková (1992).

RESULTS AND DISCUSSION RESULTATI I RASPRAVA

Tree species – Drvenaste svojte

In the Bečov Botanical Garden, on two fields, 85 different taxa of 40 genera were determined. Of these, 56 taxa are deciduous, whereas the others are evergreen. The most represented genera are: *Acer* (eight taxa), *Picea* (eight taxa), *Pinus* (seven taxa), and *Abies* (four taxa). In total, 471 woody plant specimens were recorded, with 104 coniferous (22%) and 367 broad-leaved (78%). All woody plant species occurring in the central part of the garden are shown in Table 1.

Origin based dendrological flora analysis indicates the dominance of autochthonous Central European taxa (43%), followed by the taxa from North America (20%), Asia (13%), South-East Europe (6%) and South Europe (2%). Cultivars were represented with 16%. The most frequent species from Central Europe were: *Alnus glutinosa* (11%), *Picea abies* (7%) and *Betula pendula* (6%). These three species were probably not planned to be in such an extent in the garden, and their self-propagation contributed to their current representation. Common alders are mostly found in wet parts of the garden, since soil moisture is crucial for its spreading and development (Pilát 1953; Horáček 2007). Appearance based den-

Table 1. List of woody plants in the main part of the Bečov Botanical Garden. The list of taxa, number of individuals and their percentages are presented.**Tablica 1.** Popis drvenastih biljaka u glavnom dijelu Botaničkog vrta Bečov. Prikazan je popis taksonomskih kategorija, broj pojedinačnih biljaka i njihov postotak.

Botanical name	Family	Number	Percentage [%]
<i>Abies concolor</i> (Gordon) Lindl. ex Hildebr.	Pinaceae	13	2,76
<i>Abies nordmanniana</i> (Steven) Spach	Pinaceae	2	0,42
<i>Abies procera</i> Rehder	Pinaceae	1	0,21
<i>Abies veitchii</i> Lindl.	Pinaceae	1	0,21
<i>Acer platanoides</i> L.	Sapindaceae	1	0,21
<i>Acer platanoides</i> L. 'Dissectum'	Sapindaceae	24	5,1
<i>Acer platanoides</i> L. 'Crimson King'	Sapindaceae	2	0,42
<i>Acer platanoides</i> L. 'Schwedleri'	Sapindaceae	1	0,21
<i>Acer pseudoplatanus</i> L.	Sapindaceae	1	0,21
<i>Acer pseudoplatanus</i> L. 'Atropurpureum'	Sapindaceae	13	2,76
<i>Acer saccharinum</i> L.	Sapindaceae	1	0,21
<i>Acer tataricum</i> L.	Sapindaceae	1	0,21
<i>Actinidia arguta</i> (Siebold et Zucc.) Planch. ex Miq.	Actinidiaceae	1	0,21
<i>Aesculus hippocastanum</i> L.	Hippocastanaceae	8	1,7
<i>Alnus glutinosa</i> (L.) Gaertn.	Betulaceae	50	10,62
<i>Betula papyrifera</i> Marshall	Betulaceae	1	0,21
<i>Betula pendula</i> Roth	Betulaceae	27	5,73
<i>Carpinus betulus</i> L.	Betulaceae	25	5,31
<i>Cercidiphyllum japonicum</i> Siebold et Zucc.	Cercidiphyllaceae	1	0,21
<i>Chamaecyparis lawsoniana</i> (A. Murray) Parl.	Cupressaceae	2	0,42
<i>Chamaecyparis pisifera</i> (Siebold et Zucc.) Endl.	Cupressaceae	2	0,42
<i>Chamaecyparis pisifera</i> (Siebold et Zucc.) Endl. 'Plumosa'	Cupressaceae	1	0,21
<i>Cornus mas</i> L.	Cornaceae	1	0,21
<i>Corylus avellana</i> L.	Betulaceae	1	0,21
<i>Corylus avellana</i> L. 'Aurea'	Betulaceae	5	1,06
<i>Cotoneaster integerrimus</i> Medik.	Rosaceae	4	0,85
<i>Crataegus monogyna</i> Jacq.	Rosaceae	1	0,21
<i>Daphne mezereum</i> L.	Thymelaeaceae	9	1,91
<i>Deutzia</i> Thunb. spp.	Hydrangeaceae	1	0,21
<i>Euonymus europaeus</i> L.	Celastraceae	2	0,42
<i>Fagus sylvatica</i> L.	Fagaceae	6	1,27
<i>Fagus sylvatica</i> L. 'Atropunicea'	Fagaceae	5	1,06
<i>Fagus sylvatica</i> L. 'Pendula'	Fagaceae	1	0,21
<i>Hedera helix</i> L.	Araliaceae	1	0,21
<i>Juniperus communis</i> L.	Cupressaceae	1	0,21
<i>Larix decidua</i> Mill.	Pinaceae	2	0,42
<i>Larix kaempferi</i> (Lamb.) Carrière	Pinaceae	4	0,85
<i>Ligustrum vulgare</i> L.	Oleaceae	1	0,21
<i>Lonicera nigra</i> L.	Caprifoliaceae	3	0,64
<i>Lonicera xylosteum</i> L.	Caprifoliaceae	9	1,91
<i>Phellodendron amurense</i> Rupr.	Rutaceae	1	0,21
<i>Philadelphus coronarius</i> L.	Hydrangeaceae	10	2,12

<i>Philadelphus</i> L. spp.	<i>Hydrangeaceae</i>	1	0,21
<i>Physocarpus opulifolius</i> (L.) Maxim.	<i>Rosaceae</i>	2	0,42
<i>Picea</i> A. Dietr. spp.	<i>Pinaceae</i>	2	0,42
<i>Picea abies</i> (L.) Karst.	<i>Pinaceae</i>	32	6,79
<i>Picea abies</i> (L.) Karst. 'Cupressina'	<i>Pinaceae</i>	2	0,42
<i>Picea abies</i> (L.) Karst. 'Rothenhaus'	<i>Pinaceae</i>	1	0,21
<i>Picea engelmannii</i> Parry ex Engelm.	<i>Pinaceae</i>	1	0,21
<i>Picea jezoensis</i> (Siebold et Zucc.) Carrière	<i>Pinaceae</i>	1	0,21
<i>Picea pungens</i> Engelm.	<i>Pinaceae</i>	1	0,21
<i>Picea pungens</i> Engelm. 'Argentea'	<i>Pinaceae</i>	1	0,21
<i>Pinus cembra</i> L.	<i>Pinaceae</i>	1	0,21
<i>Pinus jeffreyi</i> Balf.	<i>Pinaceae</i>	1	0,21
<i>Pinus mugo</i> Turra	<i>Pinaceae</i>	4	0,85
<i>Pinus nigra</i> J.F. Arnold	<i>Pinaceae</i>	3	0,64
<i>Pinus nigra</i> subsp. <i>pallasiana</i> (Lamb.) Holmboe	<i>Pinaceae</i>	2	0,42
<i>Pinus ponderosa</i> P. Lawson et C. Lawson	<i>Pinaceae</i>	1	0,21
<i>Pinus sylvestris</i> L.	<i>Pinaceae</i>	4	0,85
<i>Populus nigra</i> L.	<i>Salicaceae</i>	2	0,42
<i>Populus tremula</i> L.	<i>Salicaceae</i>	9	1,91
<i>Prunus cerasus</i> L.	<i>Rosaceae</i>	5	1,06
<i>Prunus padus</i> L.	<i>Rosaceae</i>	18	3,82
<i>Pseudotsuga menziesii</i> (Mirb.) Franco	<i>Pinaceae</i>	5	1,06
<i>Pseudotsuga menziesii</i> var. <i>glauca</i> (Beissn.) Franco	<i>Pinaceae</i>	1	0,21
<i>Quercus robur</i> L.	<i>Fagaceae</i>	15	3,18
<i>Quercus robur</i> L. 'Fastigiata'	<i>Fagaceae</i>	1	0,21
<i>Quercus rubra</i> L.	<i>Fagaceae</i>	5	1,06
<i>Ribes petraeum</i> Wulfen	<i>Grossulariaceae</i>	1	0,21
<i>Ribes uva-crispa</i> L.	<i>Grossulariaceae</i>	1	0,21
<i>Salix fragilis</i> L.	<i>Salicaceae</i>	9	1,91
<i>Sambucus nigra</i> L.	<i>Caprifoliaceae</i>	10	2,12
<i>Sambucus racemosa</i> L.	<i>Caprifoliaceae</i>	9	1,91
<i>Sorbus aucuparia</i> L.	<i>Rosaceae</i>	1	0,21
<i>Spiraea chamaedryfolia</i> L.	<i>Rosaceae</i>	1	0,21
<i>Staphylea pinnata</i> L.	<i>Staphyleaceae</i>	5	1,06
<i>Symphoricarpos albus</i> (L.) S.F. Blake	<i>Caprifoliaceae</i>	4	0,85
<i>Thuja occidentalis</i> L.	<i>Cupressaceae</i>	7	1,49
<i>Thuja plicata</i> Donn ex D. Don	<i>Cupressaceae</i>	1	0,21
<i>Tilia cordata</i> Mill.	<i>Tiliaceae</i>	23	4,88
<i>Tilia platyphyllos</i> Scop.	<i>Tiliaceae</i>	4	0,85
<i>Tilia tomentosa</i> Moench	<i>Tiliaceae</i>	20	4,25
<i>Tsuga canadensis</i> (L.) Carrière	<i>Pinaceae</i>	4	0,85
<i>Ulmus laevis</i> Pall.	<i>Ulmaceae</i>	1	0,21
<i>Ulmus glabra</i> Huds.	<i>Ulmaceae</i>	2	0,42
Total		471	100

dendrological flora analysis indicates the dominance of trees (58 of taxa; 68.2%), followed by the shrubs (25 taxa; 29.4%), and woody climbing plants (2 taxa; 2.4%).

The current composition of species does not fully correspond with the theory of configuration of phenological groups of garden plants (Bulíř 2011). Current species do not cover the long-established phenological seasons of full bloom and full coloration. Suitable tree species in the main part of Bečov Botanical Garden are: *Corylus avellana*, *Staphylea pinnata*, *Aesculus hippocastanum*, *Philadelphus coronarius*, *Cercidiphyllum japonicum* and *Phellodendron amurense*. In addition, according to Idžojtić *et al.* (2011) to obtain good results in arranging an area, it is necessary to apply a series of principles: unity and harmony, simplicity, balance, proportion, gradual and natural change, repetition, harmony of forms etc. Likewise, there are many criteria according to which plants for ornamenting an area can be selected (Idžojtić *et al.* 2010, 2011, 2013; Poljak *et al.* 2011): size; form; life-span of leaves; leaf shape, size and colour; flower shape, size, colour and scent; fruit shape, size, colour, scent and structure; bark colour and texture; twig colour and shape; foliage, flowering and fruit-bearing period; edibility and aromaticity of certain plant parts; negative effects; growth speed; maintenance demands; resistance to diseases and pests; ecological demands etc.

One of the interesting taxa in the Bečov Botanical Garden is *Phellodendron amurense* from North-East Asia. Only one specimen was planted which survived dilapidation and breaking of its double trunk by whirlwind in 1980s. Its vitality is the result of root sucker growth (Špaková 2010). This tree, known as the Amur cork tree of gardener Koditek, was awarded as “Hero tree of the Czech Republic” in 2006. Likewise, *Cercidiphyllum japonicum*, found in the original 1908–1935 planting plan, survived in this area to the present day. One specimen originally had five trunks but two of them were broken in 2005 (Svoboda 2014). According to Jašková (2011) multiple-trunks are the main characteristic of this species. Furthermore, there is one big specimen of *Actinidia arguta*, 18 m high, growing on a slope. It was planted here earlier than in the Průhonice Park to test its surviving rate (Špaková 2010; Kreyling *et al.* 2015). From coniferous trees, *Picea jezoensis* is another specimen planted in Bečov nad Teplou earlier than in Průhonice. There is also quite rare *Picea engelmannii*, which is nowadays used as seed production tree.

Dendrological and dendrometric characteristics of the researched taxa – *Dendrološke i dendrometrijske značajke istraživanih svojti*

Average height of inventoried woody plants was 15.3 m. The average height of trees was 18 m, and of shrubs 2.5 m. Tree heights were categorised in ranges as shown in Figure 1A. Average height of the first skeletal branch was 6 m. Most

trunk diameters were distributed in 31–40 cm range (20%) as shown in Figure 1B. Age of all trees was estimated according to method of Kubišta (2014). Most abundant tree ages were in 20–40 years (33% of trees) and 40–60 years range (29,5%) as shown in Figure 1C. This is probably result of a long-term neglect of the Bečov Botanical Garden which allowed plants to grow freely and easily colonized empty habitats within park, prominently wind-dispersal tree species. The oldest trees in Bečov Botanical Garden are: *Acer pseudoplatanus* and *Picea engelmannii* (100–120 years). Ultimately, results of this age-class method were compared with the exact years of planting of individual trees in the park. Data were generally similar, and significant differen-

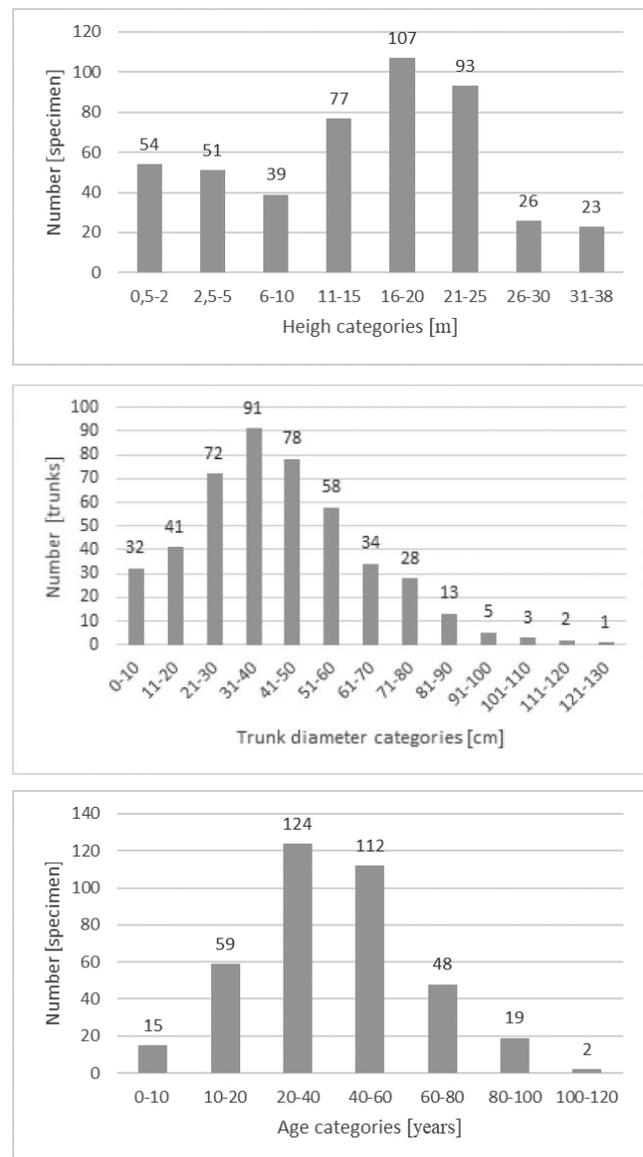


Figure 1. (A) Height of trees in the main part of the Bečov Botanical Garden; (B) Tree trunk diameter in the main part of the Bečov Botanical Garden; and (C) Age of trees in the main part of the Bečov Botanical Garden.

Slika 1. (A) Visine stabala u glavnome dijelu Botaničkog vrta Bečov; (B) Prsni promjeri debala u glavnom dijelu Botaničkog vrta Bečov; i (C) Starost stabala u glavnome dijelu Botaničkog vrta Bečov.

ces were found only for *Thuja plicata*. Year of planting according to Koditek (1908–1937) was 1923, while according to Machovec *et al.* (2005) this tree is classified in the 20–40 years age range.

Crown characteristics were evaluated as well. In most cases shrubs had a typical appearance of habit. On the other hand, tree crowns were frequently changed as the result of the natural development which led to tight growth of woody plants in the area. Elongated and flag-like crowns were found very often.

Damages and pests – Štete i štetnici

Extensive crowns damages occurred especially in 2005 and 2013, as the consequences by whirlwinds. During our investigation, different mechanical damages were recorded, such as: broken branches, damaged roots, hollows, bark absences and pressure growth branches. Damages by climate were mainly due to the weather conditions like whirlwind, drought causing dry branches and dieback of the crown. From anthropogenic damage there were vandalism or fire. Secondary crown was detected in 31% of all woody plants in Bečov Botanical Garden. In addition, we recorded 16% of woody plants growing in slope and 6% having exposed roots. Damages from different organisms were detected in 9% of woody species. Some of the Ascomycete fungi found in the Bečov Botanical Garden are bioindicators of air cleanliness. For example, the genus *Rhytisma* attacks only maples in the area with clean air (Svobodová 2009). By contrast, some of the fungi species found in the garden indicate bad state of trees, such as: *Fomes fomentarius* (L.) Fr., *Laetiporus sulphureus* (Bull.) Murrill, and *Trametes hirsuta* Wulfen (Pilát).

CONCLUSION ZAKLJUČAK

We recorded 85 taxa and 471 specimens of woody plants in the Bečov Botanical Garden. Evaluation has shown that some interesting woody plants from the original planting plan between 1908–1935 survived in this area to the present day. Most interesting taxa are: *Phellodendron amurense*, *Cercidiphyllum japonicum*, *Actinidia arguta*, *Picea jezoensis* and *Picea engelmannii*. Average age of trees is 20–40 years as the result of the neglecting of the garden and the self-propagation of wind-dispersal tree species. Nevertheless, after 2005 fito-sanitary treatments of woody plants were carried out, and present state of the garden is not final, i.e. every year there are planted new woody plants in both evaluated parts.

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SAŽETAK

Botanički vrt Bečov, osnovan 1918. godine, jedan je od tri botanička vrta u općini Karlovy Vary (Češka). Vrt nije bio održavan u razdoblju od 1945. do 2005. godine. Za istraživanje su odabrana dva dijela izvornoga područja – prijašnji park i obronak s kamenjarom u kojem se nalaze biljke s područja Europe, Azije i Sjeverne Amerike. Izvršena je osnovna dendrološka i dendrometrijska istraživanja.

Ukupno je zabilježena 471 drvenasta biljka, od kojih su 104 četinjače i 367 listače. Determinirano je 30 svojta četinjača iz devet rodova te 55 svojta listača iz 31 roda (Tablica 1). Dendrološko i dendrometrijsko vrednovanje drvenastih biljaka u glavnom dijelu Botaničkog vrta Bečov pokazalo je prosječne dendrometrijske parametre te prosječne parametre stanja stabala (Slika 1). Prosječna starost stabala iznosila je 20–40 godina. Ova činjenica ukazuje na 60 godina propadanja prvotno posađenih svojti, kao i na abundantnost razvoja prirodne vegetacije u tom periodu. Nakon 2005. provedeno je liječenje drvenastih biljaka. Istraživanjem smo utvrdili da su neke zanimljive drvenaste vrste preživjele u ovom području od vremena osnutka vrta, 1908. i 1935., od kojih izdvajamo: amurski barhat (*Phellodendron amurense*), japansko Judino drvo (*Cercidiphyllum japonicum*), kivi (*Actinidia arguta*) te smreke (*Picea jezoensis* i *P. engelmannii*). Trenutno stanje vrta nije konačno, svake godine se u oba istraživana dijela sade nove drvenaste biljke.

KLJUČNE RIJEČI: dendrološko vrednovanje; Botanički vrt Bečov; Bečov nad Teplou; golosjemenjače; kritosjemenjače; Češka Republika