NAT. CROAT. | VOL. 22 | No 2 | 343–362 | ZAGREB | December 31, 2013

professional paper / stručni rad

MEETING TARGET EIGHT – *EX SITU* CONSERVATION OF CROATIAN THREATENED AND STATUTORILY PROTECTED PLANT SPECIES IN THE BOTANICAL GARDEN OF THE FACULTY OF SCIENCE, UNIVERSITY OF ZAGREB (CROATIA)

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Sandev, D., Mihelj, D. & Kovačić, S.: Meeting Target Eight – *Ex situ* conservation of Croatian threatened and statutorily protected plant species in the Botanical Garden of the Faculty of Science, University of Zagreb (Croatia). Nat. Croat., Vol. 22, No. 2, 343–362, 2013, Zagreb.

According to „Target 8" of *Global Strategy for Plant Conservation* (GSPC, 2011-2020), at least 75% of threatened plant species must be preserved in *ex situ* garden-collections, preferably in the countries of their origin, until 2020. The aim of the present study was to examine the list of Croatian threatened and statutorily protected plant species in *ex situ* conservation of the Botanical Garden (Faculty of Science, University of Zagreb). Out of 668 indigenous taxa of the Garden's native-plant collections, we found 208 strictly protected and protected species, which is 12.7% of all statutorily protected taxa in Croatia. In the categories RE, CR, EN and VU there are 31 species, constituting 13.1% of threatened taxa in Croatia in those categories. In all categories, we found 80 taxa listed in the *Red Book of Vascular flora of Croatia*, 24 taxa are identified in the European *Red List of Vascular Plants*, while 12 taxa are found in the IUCN-*Red List of Threatened Species in the World*. Serious efforts are yet to be made in *ex situ* conservation of Croatian threatened species, in order to achieve the goals of „Target 8".

Key words: *Global Strategy for Plant Conservation,* „Target 8", *ex situ,* plant collections, Zagreb Botanical Garden

Sandev, D., Mihelj, D. & Kovačić, S.: Ususret *„Cilju broj osam"*: *Ex situ* očuvanje hrvatskih ugroženih i zakonom zaštićenih biljaka u Botaničkom vrtu Prirodoslovno-matematičkog fakulteta Sveučilišta u Zagrebu. Nat. Croat., Vol. 22, No. 2, 343–362, 2013, Zagreb.

Najnovija *Globalna strategija očuvanja biljaka* (GSPC 2011.-2020.) postavila je pred botaničke vrtove jasne smjernice za *ex situ* zaštitu ugroženih biljnih vrsta. Među njima se posebno ističe „Cilj broj osam" („*Target 8*"), koji traži da se do godine 2020. barem 75% ugroženih biljnih vrsta čuva u *ex situ* zbirkama botaničkih vrtova, po mogućnosti u zemljama njihova podrijetla. U Botaničkom vrtu Prirodoslovno-matematičkog fakulteta Sveučilišta u Zagrebu po prvi puta izrađen je detaljan popis hrvatskih ugroženih i zakonom zaštićenih biljaka u *ex situ* zaštiti. Utvrđeno je 668 autohtonih biljnih svojti podrijetlom s hrvatskih staništa, od kojih 208 pripada kategoriji strogo zaštićenih i zaštićenih, što je 12,7% svih zakonom zaštićenih vrsta naše zemlje. U kategorijama RE, CR, EN i VU nalazi se 31 svojta iz naših zbirki, što čini 13,1% ugroženih biljnih vrsta Hrvatske u navedenim kategorijama. Ukupno, u Crvenoj knjizi vaskularne flore Hrvatske nalazi se 80 svojti iz zbirki Botaničkog vrta, na europskom Crvenom popisu 24 svojte, a 12 na IUCN-ovom popisu ugroženih vrsta svijeta. Jasno je da ćemo za realizaciju „Cilja broj osam" morati uložiti znatne dodatne napore.

Ključne riječi: *Globalna strategija zaštite biljaka*, „Cilj broj 8", *ex situ*, botaničke zbirke, Botanički vrt Zagreb.

INTRODUCTION

Approximately one-third of all known plant species (between 60,000 to 100,000) worldwide are threatened with extinction (Oldfield, 2010). Over the coming century, as many as two-thirds of the world's plant species will be in danger of extinction, while less than 20% of plant species gained their conservation status (Wyse Jackson, 2011). The most effective way to guarantee the long-term survival and evolution of plant species, and their associated ecological links, is to ensure that plants are maintained in vigorous populations in their native habitat or *in situ* conservation (Kramer *et al.*, 2011). Unfortunately, the threats to biodiversity continue to increase and actions on the ground have remained inadequate, giving the principles and theory of *ex situ* conservation the leading role in conservation (Given, 1987; Heywood, 1990; Maunder, 1994; Maunder *et al.*, 2004: Marris, 2006; Sharrock & Oldfield *eds*., 2010).

Facing the global plant extinction crises, the *Global Strategy for Plant Conservation* (GSPC 2010) was first adopted in 2002 by the Parties to the *Convention on Biological Diversity* (CBD), followed by the *European Strategy for Plant Conservation* (cp. Anonymous, 2003; Nikolić, 2006). The 16 output-oriented Targets of GSPC (Heywood *ed*., 1989) were the first internationally agreed for biodiversity conservation. By 2010, over 800 botanical gardens in 110 countries (around one-third of all existing botanical gardens) contributed to the *Botanic Gardens Conservation International* (BGCI) on-line *PlantSearch*-database www.bgci.org/plant_search.php, providing data on the living collections of botanical gardens around the globe. Many of them only recently focused their conservation work on local or regional flora (Anonymous, 2001; Kim, 2006; Huang, 2010; Sharrock & Oldfield *eds*., 2010; Anonymous, 2012c).

Following an in-depth review of progress towards the 16 Targets in 2010, the Parties to the CBD recognized that it was insufficient, in spite of the fact that significant progress had been made at all levels. It was therefore recommended that a consolidated update to the GSPC should be developed and extended to the year 2020, including updates to the 16 Targets (BGCI, 2012). One of the most significant aims for botanical gardens, out of the new 19 Targets of the GSPC 2011-2020, is „Target 8", calling for 75% of threatened plant species to be conserved in *ex situ* collections by 2020, and 20% available for recovery and restoration programs. Obviously, for some countries in the less biodiverse regions of the world that task is not too challenging – for others, exceptionally so.

Croatia is home to more than 5000 species and subspecies, which puts our country in third position in Europe, after Albania and Slovenia, considering plant life diversity (Nikolić, 2005). A significant part of Croatian plant diversity is unique to the region, under threat, and of global importance to conservation (Topić & Šegulja, 2005). We have 377 (7.56%) endemics, among which 112 (2.24%) are Croatian stenoendemics (Nikolić *ed*., 2013a), as well as 1061 statutorily strictly protected and 572 protected wild plant species and subspecies (Anonymous, 2009a), which is 33% of total Croatian flora. According to the *Red Book of Vascular Flora of Croatia* (Nikolić & Topić *eds*., 2005; Nikolić *ed*., 2013b - the revision in preparation), Croatian national *Red List* contains 814 plant species. One species (*Dianthus multinervis* Vis.), an endemic from the small island of Jabuka, is considered to be extinct (EX) since the beginning of 20th century, while nine species are considered regionally extinct (RE). Last estimations (Nikolić *ed*., 2013b) calculate that of the 226 Croatian plant species directly threatened by extinction, 92 are critically endangered (CR), 62 endangered (EN) and 72 are considered to be vulnerable (VU). There are a further 184 plant species which are expected to be threatened with extinction in the near future (NT), 46 categorised as least concern (LC), and 348 as data deficient (DD).

Despite the small size (4.65 ha) of the Botanical Garden of the Faculty of Science, University of Zagreb (in further text „Botanical Garden"), and the fact that larger gardens are able to support more species, our older botanists become aware of the value of Croatian vascular flora very early. The first collection („the rockery") with indigenous karstic plants was raised in 1926 (Regula, 1997). However, in the first half of the 20th century, the focus was not on *ex situ* conservation management, but on collecting and growing native plant species for exhibition and educational purposes (Regula, 1997; Kim, 2006). The Botanical Garden also has a long tradition (since 1936) in international seed exchange, including of native seed collected in the wild, via *Delectus Seminum*-publications. To develop a model for the acquisition and exchange of living plant material, the botanic gardens community implemented a code of conduct, *International Plant Exchange Network* (IPEN), during the *Third European Botanic Gardens Congress* (Robbrecht & Bogaerts, 2004; Hohn, 2007). In 2009, we introduced the IPEN-numbers to our Botanical Garden for all plants in distribution, which we update yearly.

In this regard, the aim of our study was to: ***i)*** look through the Botanical Garden's native-plant collections, in order to inventory threatened, statutorily protected and other nationally and globally important species, ***ii)*** establish how far our Botanical Garden has progressed in achieving „Target 8" of GSPC 2011-2020, and ***iii)*** consider further steps for *ex situ* plant conservation.

METHOD

To answer the question „How far along is the Botanical Garden in meeting „Target 8" of GSPC 2011-2020?", we cross-checked our native plant-lists through the following:

1. *Red List of Threatened Species in the World* (Anonymous, 2012a),
2. Appendix II of the *European Red List of Vascular Plants* (Bilz *et al.*, 2011),
3. *Red Book of Vascular Flora of Croatia* (Nikolić *ed.*, 2013b),
4. *List of strictly protected and protected native plant species of the Republic of Croatia* (Anonymous, 2009a),
5. *Important Plant Areas* (IPA) in Croatia (Alegro *et al.*, 2010), based on two of its three criteria:

   A – Presence of threatened plant species: the site holds significant populations of one or more species that are of global or regional conservation concern (contains four subcriteria);

   B – Presence of botanical richness: the site has an exceptionally rich flora in a regional context in relation to its biogeographic zone; assembling:

   B1: threatened species, listed in the of *Red Book of Vascular Flora of Croatia*, and

   B2: endemic species, *sensu lato* (Nikolić, 2010).
6. Draft of *Proposal for Ecological Network* NATURA 2000 Croatia (Anonymous, 2013a – the Ordinance for *Ecological Network „Natura 2000"* for Croatia has not yet been proclaimed by the Government),
7. *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES-regulative): our native plant collections fits Appendix II, which lists species that are not threatened with extinction at present, but may become so if uncontrolled trade continues (http://www.cites.org/eng/resources/species.html; Bilz *et al.*, 2011).

Nomenclature of plant taxa follows *Flora Croatica Database* (Nikolić *ed.*, 2013a)

RESULTS

At the global scale, the best source of information on the conservation status of plants and animals is the IUCN *Red List of Threatened Species in the World* (Anonymous, 2012a). The Red List-categories are based on a set of quantitative criteria linked to population trends, population size and structure, and geographic range. Comparing the list of native plants growing in our Botanical Garden with the global *Red List*, we found 12 species. Two taxa from our collection are recently listed as NT (*Eryngium alpinum* L. and *Galanthus nivalis* L.) and nine as LC (*Marsilea quadrifolia* L., *Salvinia natans* (L.) All., *Scirpus maritimus* L., *Acorus calamus* L., *Ephedra major* Host, *E. fragilis* Desf., *Ophrys bertolonii* Moretti, *Taxus baccata* L. and *Trapa natans* L.) (Tab. 1). The Croatian monotypic stenoendem *Degenia velebitica* (Degen) Hayek is listed in the older IUCN-documents (Walter & Gillett, 1998) as vulnerable („V").

The *European Red List of Vascular Plants* (Bilz *et al.*, 2011) is a review of the conservation status of 1826 selected species of vascular plants native to Europe, or naturalized before the 16th century (AD 1500) (Anonymous, 2011). Among those, 23 species of a lower risk of threat have been identified in our Botanical Garden: four as NT, and 19 as LC. Again, *Degenia velebitica* is listed in the older documents (Anonymous, 1991) as vulnerable („V") (Tab. 1).

Tab. 1. Status of the indigenous plant species in *ex situ* collections of Botanical Garden, Faculty of Science (University of Zagreb, Croatia). **IUCN** – *Red List of Threatened Species of the World*. **EU-RL** – Appendix II of the *European Red List of Vascular Plants*. **HR-RDB** – *Red Book of Vascular Flora of Croatia*: RE – Regionally Extinct; CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern; DD – Data Deficient. ***Statutorily protected***: SP-strictly protected species; P-protected species. **IPA** – *Important Plant Areas*: A-globally threatened species; B1-threatened species from the *Red Book of Vascular Flora of Croatia*; B2-endemic species *s. l.* **NEM**-*National Ecological Network*. **Natura 2000**: EU-plant species important for EU; HR-plant species important for HR. **CITES** – Appendix II of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora*.

No.	Scientific name	IUCN	EU-RH	HR-RDB	Statutorily protected	IPA	NEM	Natura 2000	CITES
1	*Acanthus balcanicus* Heywood et I. Richardson				P				
2	*Acorus calamus* L.	LC		LC	P				
3	*Adiantum capillus-veneris* L.			NT	P				
4	*Allium victorialis* L.		LC		P				
5	*Anemone hortensis* L.				P				
6	*Anemone nemorosa* L.				P				
7	*Anemone ranunculoides* L.				P				
8	*Anemone sylvestris* L.			CR	SP	B1	+	HR	
9	*Anemone trifolia* L.				SP				
10	*Anthyllis vulneraria* L. ssp. *praepropera* (A.Kern.) Bornm.				SP				

11	*Aquilegia vulgaris* L.				P				
12	*Arum italicum* Mill.				P				
13	*Arum maculatum* L.				P				
14	*Aruncus dioicus* (Walter) Fernald				P				
15	*Asarum europaeum* L.				P				
16	*Asparagus tenuifolius* Lam.		LC	NT	P				
17	*Asphodelus albus* Mill.				P				
18	*Aster sedifolius* L. ssp. *illyricus* (Murb.) Merxm.			DD	SP	B2			
19	*Astragalus muelleri* Steud. et Hochst.			NT	SP	B2			
20	*Astragalus monspessulanus* L. ssp. *illyricus* (Bernhardt) Chater				SP	B2			
21	*Berberis vulgaris* L.				P				
22	*Betonica officinalis* L.				P				
23	*Butomus umbellatus* L.		LC	NT	P				
24	*Calamintha glandulosa* (Req.) Benth.				P				
25	*Calamintha nepetoides* Jord.				P				
26	*Caltha palustris* L.		LC		P				
28	*Campanula fenestrellata* Feer			NT	SP	B2			
29	*Campanula istriaca* Feer			NT	SP	B2			
30	*Campanula justiniana* Witasek			NT	SP	B2			
31	*Campanula portenschlagiana* Roem. et Schult.			NT	SP	B2			
32	*Campanula poscharskyana* Degen			NT	SP	B2			
33	*Campanula tommasiniana* C. Koch			NT	SP	B2			
34	*Carex divisa* Huds.			EN	SP	B1	+	HR	
35	*Carex panicea* L.			VU	SP	B1		HR	
36	*Carum carvi* L.				P				
37	*Centaurea crithmifolia* Vis.			NT	SP	B2			
38	*Centaurea friderici* Vis. ssp. *jabukensis* (Ginzb.et Teyber) Greuter			NT	SP	B2			
39	*Centaurea ragusina* L.			NT	SP	B2	+		
40	*Centaurea spinosociliata* Seenus			NT	SP	B2			
41	*Clematis integrifolia* L.			VU	SP	B1		HR	
40	*Clematis recta* L.				P				
42	*Colchicum autumnale* L.				P		+		
43	*Colutea arborescens* L.				P				
44	*Convallaria majalis* L.				P				
45	*Convolvulus lineatus* L.			CR	SP	B1	+	HR	
46	*Corydalis bulbosa* (L.) DC.				P				
47	*Corydalis solida* (L.) Swartz				P				
48	*Cotinus coggygria* Scop.				P				

49	*Crocus vernus* (L.) Hill				P				
50	*Cyclamen hederifolium* Aiton				P				+
51	*Cyclamen purpurascens* Mill.			NT	P				+
52	*Dactylorhiza majalis* (Rchb.) P.F.Hunt et Summerh.		LC	EN	P	B1		HR	+
53	*Degenia velebitica* (Degen) Hayek	V*	V**	EN	SP	A, B1, B2	+	EU	
54	*Dianthus carthusianorum* L.				SP				
55	*Dianthus caryophyllus* L.				SP				
56	*Dianthus integer* Vis.			VU	SP	A, B1, B2		HR	
57	*Dianthus petraeus* Waldst. et Kit.				SP				
58	*Dianthus petraeus* Waldst. et Kit. ssp. *petraeus*			VU	SP	B1		HR	
59	*Dianthus sylvestris* Wulfen in Jacq. ssp. *nodosus* (Tausch) Hayek				SP				
60	*Dianthus sylvestris* Wulfen in Jacq. ssp. *sylvestris*				SP				
61	*Dianthus velebiticus* Borbás				SP	B2			
62	*Digitalis ferruginea* L.			VU	SP	B1		HR	
63	*Digitalis grandiflora* Mill.			NT	P				
64	*Doronicum orientale* Hoffm.			NT	P				
65	*Dryopteris filix-mas* (L.) Schott				P				
66	*Ephedra fragilis* Desf. ssp. *campylopoda* (C. A. Mayer) Asch. et Graeb.	LC		NT	P				
67	*Ephedra major* Host	LC		NT	P				
68	*Eranthis hiemalis* (L.) Salisb.			NT	P		+		
69	*Erica herbacea* L.				P				
70	*Eryngium alpinum* L.	NT	NT	LC	SP	A	+	EU	
71	*Eryngium campestre* L.				P				
72	*Erythronium dens-canis* L.				P				
73	*Euonymus europaeus* L.				P				
74	*Fritillaria meleagris* L.			VU	SP	B1	+	HR	
75	*Galanthus nivalis* L.	NT	NT	LC	P				+
76	*Galium odoratum* (L.) Scop.				P				
77	*Galium verum* L.				P				
78	*Genista tinctoria* L.				P				
79	*Gentiana asclepiadea* L.			NT	P				
80	*Gentiana clusii* Perr. et Song.			NT	P				
81	*Gentiana cruciata* L.				P				
82	*Gentiana lutea* L. ssp. *symphyandra* (Murb.) Hayek			EN	SP	A, B1	+	HR	
83	*Geranium dalmaticum* (Beck) Rech.f.			CR	SP	A, B1, B2			
84	*Geranium macrorrhizum* L.				P				

85	*Geum urbanum* L.				P				
86	*Gladiolus illyricus* W.D.J. Koch				SP				
87	*Globularia alypum* L.			NT	P				
88	*Gymnadenia conopsea* (L.) R.Br.		LC		P				+
89	*Helichrysum italicum* (Roth) G.Don				SP				
90	*Helleborus atrorubens* Waldst. et Kit.			LC	SP	B2			
91	*Helleborus multifidus* Vis.				SP				
92	*Helleborus multifidus* Vis. ssp. *istriacus* (Schiffn.) Merxm. et Podl.				SP	B2			
93	*Helleborus niger* L. ssp. *macranthus* (Freyn) Schiffner			VU	SP	A, B1, B2		HR	
94	*Hepatica nobilis* Schreber				P				
95	*Herniaria glabra* L.				P				
96	*Hieracium pilosella* L.				P				
97	*Hippophaë rhamnoides* L.			RE	SP				
98	*Ilex aquifolium* L.			VU	SP	B1		HR	
99	*Iris adriatica* Trinajstić ex Mitić			NT	SP	B2			
100	*Iris croatica* Horvat et M.D.Horvat			VU	SP	A, B1, B2		HR	
101	*Iris germanica* L.				SP				
102	*Iris graminea* L.				SP		+		
103	*Iris illyrica* Tomm.			LC	SP	B2	+	HR	
104	*Iris pallida* Lam.				SP				
105	*Iris pseudacorus* L.		LC		SP				
106	*Iris pseudopallida* Trinajstić				SP	B2			
107	*Iris sibirica* L.				SP	B1	+		
108	*Laurus nobilis* L.				P				
109	*Lavandula latifolia* Medik.				P				
110	*Leucanthemum atratum* (Jacq.) DC. ssp. *platylepis* (Borbás) Heywood				SP		+		
111	*Leucojum aestivum* L.				P				
112	*Leucojum vernum* L.				P				
113	*Lilium carniolicum* Bernh. ex Koch			VU	SP	B1	+	HR	
114	*Lilium martagon* L.			VU	SP	B1	+	HR	
115	*Lilium martagon* L. ssp. *cattaniae* (Vis.) Degen				SP	B2		HR	
116	*Limonium dictyophorum* (Tausch) Degen			NT	SP	B2			
117	*Linaria vulgaris* Mill.				P				
118	*Lonicera caprifolium* L.				P				
119	*Lythrum salicaria* L.		LC		P				
120	*Marrubium vulgare* L.				P				
121	*Marsilea quadrifolia* L.	LC	NT	EN	SP	A, B1	+	EU	

122	*Matteucia struthiopteris* (L.) Tod.				SP				
123	*Melissa officinalis* L.				P				
124	*Melittis melissophyllum* L.				P				
125	*Melittis melissophyllum* L. ssp. *albida* (Guss.) P.W.Ball				P				
126	*Menyanthes trifoliata* L.		LC	EN	SP	B1		HR	
127	*Micromeria juliana* (L.) Benth. ex Rchb.				P			HR	
128	*Moltkia petraea* (Tratt.) Griseb.				SP				
129	*Myricaria germanica* (L.) Desv.			CR	SP	B1			
130	*Nepeta cataria* L.				SP				
131	*Nuphar lutea* Sibth. et Sm.		LC		P				
132	*Nymphaea alba* L.		LC		P				
133	*Onosma echioides* (L.) L. ssp. *dalmatica* (Scheele) Peruzziet N. G. Passal.				SP	B2			
134	*Ophrys bertolonii* Moretti	LC	LC	VU	SP	B1	+	HR	+
135	*Ophrys sphegodes* Mill.		LC	VU	SP	B1		HR	+
136	*Orchis morio* L.			NT	SP				+
137	*Ornithogalum comosum* L.				P				
138	*Osmunda regalis* L.			CR	SP	B1			
139	*Paeonia mascula* (L.) Miller			NT	SP				
140	*Papaver rhoeas* L.				P				
141	*Parapholis incurva* (L.) C.E.Hubb.			VU	SP	B1		HR	
142	*Paris quadrifolia* L.				P				
143	*Petteria ramentacea* (Sieber) C. Presl				SP	B2			
144	*Phlomis fruticosa* L.			NT	P				
145	*Physalis alkekengi* L.				P				
146	*Pinguicula alpina* L.				P				
147	*Pinus nigra* Arnold ssp. *dalmatica* (Vis.) Franco			NT	SP	A, B2			
148	*Plumbago europaea* L.				P				
149	*Polygonatum multiflorum* (L.) All.				P				
150	*Polygonatum odoratum* (Mill.) Druce				P				
151	*Polypodium vulgare* L.				P				
152	*Polystichum aculeatum* (L.) Roth				P				
153	*Primula auricula* L.			NT	P				
154	*Primula veris* L. ssp. *columnae* (Ten.) Lüdi			NT	P				
155	*Pulicaria dysenterica* (L.) Bernh.				P				
156	*Pulsatilla pratensis* (L.) Miller ssp. *nigricans* (Störck) Zam.			CR	SP	B1	+	HR	
157	*Ranunculus acris* L.				P				
158	*Ranunculus ficaria* L. ssp. *calthifolius* (Rchb.) Arcang.				P				

159	*Ranunculus lanuginosus* L.				P				
160	*Ranunculus repens* L.		LC		P				
161	*Reseda lutea* L.				P				
162	*Rosa canina* L.				P				
163	*Rosa gallica* L.				P				
164	*Rosa pendulina* L.				P				
165	*Ruscus aculeatus* L.		LC	LC	P				
166	*Ruscus hypoglossum* L.			NT	P				
167	*Ruta graveolens* L.				P				
168	*Salvinia natans* (L.) All.	LC	LC	NT	P	A			
169	*Sanguisorba minor* Scop. ssp. *muricata* Briq.				P				
170	*Sanicula europaea* L.				P				
171	*Saponaria officinalis* L.				P				
172	*Satureja subspicata* Vis.			LC	P				
173	*Satureja visianii* Šilić				SP	B2			
174	*Scirpus maritimus* L.	LC		NT	P		+	HR	
175	*Scopolia carniolica* Jacq.				P				
176	*Sedum acre* L.				P				
177	*Sedum telephium* L. ssp. *maximum* (L.) Krock.				P				
178	*Sempervivum tectorum* L.				SP				
179	*Serapias istriaca* Perko				SP	B2			+
180	*Serapias lingua* L.		LC		SP				+
181	*Seseli tomentosum* Vis.			NT	SP	B2			
182	*Sesleria tenuifolia* Schrad. ssp. *kalnikensis* (Jav.) Deyl				SP	B2			
183	*Sibiraea altaiensis* (Laxm.) C. K. Schneid. ssp. *croatica* (Degen) Degen			NT	SP	B2	+	HR	
184	*Sternbergia lutea* (L.) Ker Gawl. ex Spreng.		LC	NT	P				+
185	*Stipa bromoides* (L.) Dörfl.				SP				
186	*Stipa pennata* L. ssp. *eriocaulis* (Borbás) Martinovský et Skalický				SP				
187	*Stratiotes aloides* L.		LC	VU	SP	B1		HR	
188	*Suaeda maritima* (L.) Dumort.			VU	SP	B1		HR	
189	*Symphytum tuberosum* L.				P				
190	*Tamus communis* L.				P				
191	*Tanacetum cinerariifolium* (Trevir.) Sch.Bip.				SP	B2			
192	*Taxus baccata* L.	LC		VU	SP	B1		HR	
193	*Teucrium chamaedrys* L.				P				
194	*Teucrium montanum* L.				P				
195	*Thalictrum minus* L.				P				

196	*Thymus pulegioides* L.				P				
197	*Trapa natans* L.	LC	NT	NT	P	A			
198	*Triglochin maritimum* L.			CR	SP	B1		HR	
199	*Trollius europaeus* L.			NT	P		+	HR	
199	*Tulipa sylvestris* L.			NT	P				
200	*Verbascum sinuatum* L.				P				
201	*Veronica austriaca* L. ssp. *jacquinii* (Baumg.) Eb.Fisch.				SP				
202	*Viburnum lantana* L.				P				
203	*Vicia ochroleuca* Ten. ssp. *dinara* (K. Malý) Rohlena				SP	B2			
204	*Vinca minor* L.				P				
206	*Vincetoxicum hirundinaria* Medik. ssp. *adriaticum* (Beck) Markgr.			LC	SP	A, B2			
207	*Viola odorata* L.				P				
208	*Viola suavis* M.Bieb. ssp. *adriatica* (Freyn) Haesler				SP	B2			

* acc. to Walter & Gillett, 1998
** acc. to Anonymous, 1991

The collection of Croatian native statutorily strictly protected and protected species (Anonymous, 2009a) in our Botanical Garden currently includes 208 species and subspecies (Tab. 1), belonging to 75 families and 141 genera. The families with the larger number of taxa are: Ranunculaceae (22 species), Lamiaceae (16 species), Iridaceae (11 species) and Asteraceae (10 species). It is important to note that 87% of strictly protected and protected native species grown in Botanical Garden are well documented, with reference to origin and date of collection, which is a precondition for a valuable *ex situ* collection. Out of the total of 208 statutorily protected taxa, 80 (38%) are listed in the *Red Book of Vascular flora of Croatia* (Nikolić *ed*., 2013b). Out of the nine Croatian regionally extinct (RE) species, one still grows in our Botanical Garden: a Sea-buckthorn (*Hippophaë rhamnoides* L.) collected in 1954 at the original locality (Drava river banks, NW Croatia). Seven native taxa from the Botanical Garden collections are critically endangered in Croatia (CR): *Anemone sylvestris* L., *Convolvulus lineatus* L., *Geranium dalmaticum* (Beck) Rech. f., *Myricaria germanica* (L.) Desv., *Osmunda regalis* L., *Pulsatilla pratensis* (L.) Miller subsp. *nigricans* (Störck) Zam. and *Triglochin maritimum* L. Six other taxa are endangered (EN): *Carex divisa* L., *Dactylorhiza majalis* (Rchb.) P. F. Hunt et Summerh., *Degenia velebitica* (Degen) Hayek, *Gentiana lutea* L. subsp. *symphyandra* (Murb.) Hayek, *Marsilea quadrifolia* L. and *Menyanthes trifoliata* L., while 17 are considered to be vulnerable (VU) (Tab. 1). In total, 31 taxa growing in Botanical Garden are listed in the categories RE, CR, EN and VU, representing 13.1% of directly threatened taxa of Croatian indigenous flora. Furthermore, 49 species from our native collections are listed in less concern categories (NT, LC and DD) (Tab. 1).

Statutorily protected areas in Croatia include two Strict Reserves, eight National Parks, 11 Nature Parks and 80 Special Reserves, which cover 5.95% of Croatian territory (Anonymous, 2013c; Tab. 2). Croatia also has 94 Important Plant Areas (IPAs), covering

Tab. 2. Statutorily protected and conserved nature areas in Croatia with the number of threatened plant taxa originating from those areas, growing in the Botanical Garden, Faculty of Science (University of Zagreb, Croatia). pSCI - proposed Sites of Community Importance in accordance with the Habitat Directive; BG – Botanical Garden, Faculty of Science (University of Zagreb, Croatia).

Type of protected areas in Croatia	Total number of protected areas in Croatia	% of country area	Number of taxa in BG, originating from the area
National parks	8	1.02	22
Strict reserves	2	0.03	2
Nature parks	11	4.4	62
Special reserves	80	0.5	?
Important plant areas (IPA)	94	16.9	67
National Ecological Network (NEM) - sites	1510	47	22
Natura 2000 - sites (pSCI)	756	28.6	13

? - no data available

16.9% of the country (Alegro *et al.*, 2010; Tab. 2). In this investigation, IPA-criteria A, B1 and B2 were checked for taxa of our native plant collections. From 621 species included in observed IPA-criteria, the collections of Botanical Garden include: 12 (21.1%) taxa of criterion A, 31 (13.7%) of criterion B1 and 38 (11.2%) taxa of criterion B2 (Tab. 1). Ten threatened species in *ex situ* conservation in our Botanical Garden are present in only one IPA, such as the endemics *Geranium dalmaticum* (Beck) Rech. f. (Pelješac peninsula, S Croatia), *Centaurea fridericii* Vis. subsp. *jabukensis* (Ginzb. et Teyber) Greuter and *C. crithmifolia* Vis. (both from the island of Jabuka, S. Croatia). Five species of *Campanula* genus are recorded in less than five IPAs, while *Campanula tommasiniana* C. Koch exists in only one IPA (Mt Učka Nature Park, SW Croatia). A further 24 threatened species are present in less than five IPAs, f. e. *Degenia velebitica* (Degen) Hayek (found in only three sites in Croatia) or globally threatened *Eryngium alpinum* L. (found in five IPAs in Croatia). As much as 75% of threatened species grown in our Botanical Garden are found in fewer than 10 IPAs, f. e. globally threatened *Marsilea quadrifolia* L. and *Salvinia natans* (L.) All.

Collections of the Botanical Garden's native plants include 34 taxa from the Draft of *Proposal for Ecological Network NATURA 2000* (Anonymous, 2013a). Tab. 1 shows that 79.4% of these species (both of EU and Croatian (HR) national significance) are facing the risk of extinction in the following categories: four as critically endangered (CR: *Anemone sylvestris*, *Convolvulus lineatus*, *Pulsatilla pratensis* subsp. *nigricans* and *Triglochin maritimum*), six as endangered (EN: *Carex divisa*, *Dactylorhiza majalis*, *Degenia velebitica*, *Gentiana lutea* subsp. *symphyandra*, *Marsilea quadrifolia* and *Menyanthes trifoliata*), 17 as vulnerable (VU), two as least concerned (LC) and two as nearly threatened (NT; Tab.1).

CITES-regulations consider the international trade of endangered species, providing a framework for countries to establish national legislation to implement the convention.

The trade for all the species listed in Appendix II should be controlled in the form of export permits and re-export certificates should be or are required. Our collections held 11 taxa listed under Appendix II: *Galanthus nivalis* L., *Sternbergia lutea* (L.) Ker Gawl. ex Spreng., *Cyclamen purpurascens* Mill., *C. hederifolium* Aiton, and seven members of the orchid family (Orchidaceae), which is included in Appendix II as a whole. Native orchid species are short-lived in garden conditions, so we currently grow *Serapias lingua* L., *Dactylorhiza majalis* (Rchb.) P. F. Hunt et Summerh., *Gymnadenia conopsea* (L.) R. Br., *Ophrys sphegodes* Mill. and *Ophrys bertolonii* Moretti from the CITES-Appendix II, as well as *Serapias istriaca* Perko and *Orchis morio* L., which are not specifically listed, but belong to the same family.

DISCUSSION

In 2007, Pautasso & Parmentier compared botanical gardens in 124 countries around the world, to establish data on the relation between species richness, size and age of botanical gardens. They found that species richness significantly increases with increasing area and age of botanical gardens. Accordingly, the Botanical Garden of the Faculty of Science (University of Zagreb), with more than 5000 taxa in growth is above the average in species richness; in botanical gardens worldwide, species richness is on average 4000. Furthermore, the year of establishment (which is 1889) is old compared to the average year of establishment of the botanical gardens in the world (which is 1923). However, with the total area of 4.65 ha, our Botanical Garden is far below the average size of the botanical gardens in the world, which is 45 ha (Pautasso & Parmentier, 2007). In this small area, it is virtually impossible to fulfil the requirements of minimum viable population to preserve genetic diversity for *ex situ* conservation of each species: 10-20 for trees, 40-50 for shrubs and 100-200 for herbs (Oostermeijer *et al*., 1994, 1996; Fu, 2006; Aguilar *et al*., 2008). In comparison, the Beijing Botanical Garden policy for *ex situ* conservation (Zhiming, 1993; Xu, 1997) would be much more appropriate for our Garden: according to that, the number of individuals of each race is usually not less than five for trees, 10 for shrubs and 20 for herbs. Short-living species are expected to be most strongly affected, as the number of generations in isolation is a crucial factor for the magnitude of genetic erosion in a population (Aguilar *et al*., 2008). That can particularly affect some of our endemic short-lived perennials, like Croatian stenoendemic *Degenia velebitica* (Degen) Hayek (Strgar 1979; Šegulja *et al*., 2005), or native orchids.

Ex situ collections in botanical gardens are vitally important as an insurance policy against extinction in the wild (Dubova *et al*., 2010). *Ex situ* conservation of plant genetic resources can be achieved through different methods, such as seed banks, field gene banks (artificially created model-biotopes), *in vitro* storage methods, pollen banks and DNA banks (Hamilton, 1994; Kingson & Walden, 2005; Probert *et al*., 2009; Puchalski *et al*., 2011). The only so far well-developed way of *ex situ* conservation in botanical gardens is a field-gene bank or living collection (Hurka *et al*., 2004; Harris *et al*., 2009). This type of conservation has its advantages and disadvantages. Living collections are often the only available option for the conservation of important germplasm. When displayed, the plants have an important educational value: to raise public awareness about the threatened flora of the region and to provide easy-access for horticulture (Hajoš *et al*., 2003; Stamenković, 2008; Karlović, 2009). The main limitation is that living collections require a great deal of space and are difficult to maintain and protect from natural disasters (Sharrock, 2011). By contrast, seed-banking provides an alternative

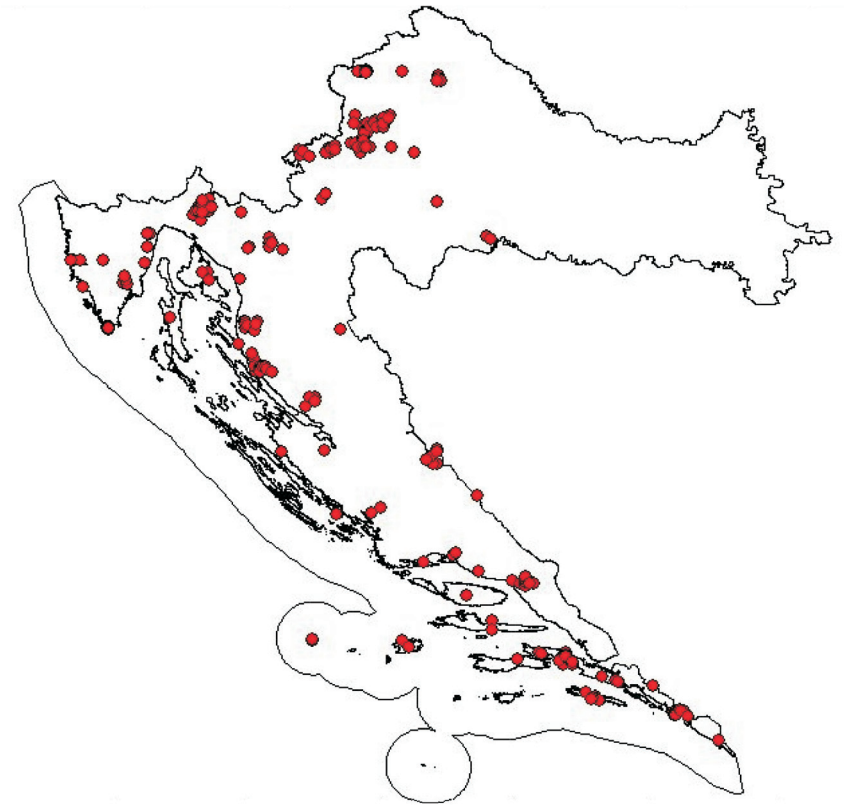

Fig. 1. Origin of statutorily protected (protected and strictly protected) vascular plant species in *ex situ* collections of the Botanical Garden, Faculty of Science (University of Zagreb, Croatia) – *an overview.*

and convenient way of storing and maintaining genetic diversity (Wilman, 2012; Anonymous, 2013b). Seed-banks require much less space, the seeds are well conserved and protected, but the expenses are much higher. While the number of species represented in living collections is high, the genetic diversity that is present in the wild populations of these species is often not well represented in botanical garden collections (Havens *et al*., 2006; Anonymous, 2012b). Moreover, as the impacts of climate change accelerate, priority for *ex situ* conservation should also be given to the species that are potentially vulnerable, even if these are not yet considered threatened. Therefore, botanical gardens need to be very concerned with creating reserve collections *ex situ* as an insurance policy (Schulman & Lehvävirta, 2011).

The nature of living plant collections and on-going *ex situ* efforts in our Botanical Garden is to make collection inventories a moving target. Our collection of native species is extensive and representative of Croatian wild flora, predominately of the Mediterranean and Alpine regions (Fig. 1). The reason for this is, above all, historical: there are four original and statutorily protected rockeries in our Botanical Garden, in which the native plants are grown: the Karstic, Sub-Mediterranean, Mediterranean, and (very

small) Alpine, with literally nowhere to expand. Therefore, over the decades, most field- and collecting-trips were to the coastal and mountainous parts of Croatia, particularly those statutorily protected (Fig. 1, Tab. 2), which are inhabited by a high number of nationally significant (protected, endemic) indigenous plant species.

This investigation provides important information about threatened plants in the native plant collections of our Botanical Garden (Tab. 1), and also quantifies the genetic diversity and representative sampling of collections. *Ex situ* living plant collections of our Botanical Garden are represented by one or more plants per species, often collected in several localities. While only genetically diverse and representative collections are appropriate to directly support *in situ* conservation (e.g., reintroduction), living collections represented by several individuals from known sources serve important indirect conservation purposes primarily through research, horticulture and education - unfortunately, they do not have direct conservation value (Kingson & Waldren, 2005; Caujapé-Castells & Pedrola-Monfort, 2004). The same is true for the native plant collections of our Botanical Garden.

We must conclude that our Botanical Garden is still far from achieving „Target 8" of GSPC 2011-2020: our research identifies only 13.1% (31 species) of Croatian threatened taxa from the categories RE, CR, EN and VU in *ex situ* conservation of the Garden. These results are below the global average of 23% (Sharrock *et al*., 2010) and not even slightly comparable to the European average of 42% (Sharrock & Jones, 2009). What are the reasons for such low percentage of Croatian threatened plants in *ex situ* growth of the Botanical Garden today? We believe that the answer to that question is rather complex:

Vast flora - Croatian flora is very rich in plant taxa, making it difficult for the botanical gardens to achieve the proposed high percentage of species in *ex situ* conservation. F. e., Vishnevska *et al*. (2011) presented a list of endangered plants in the *ex situ* collection of the Latvian University Botanical Garden, which maintains 50.4% of all Latvian vascular plant species in an *ex situ* collection. However, that is only 120 species, 58% of the total number of species that we currently grow in our *ex situ* collections.

History of the Garden - Today, botanical gardens through the world are committed to containing the spread of threatened plant species (Sharrock & Oldfield *eds*., 2010), but important parts of their collections remain historical, dating from the era when collecting plants from other continents was fashionable. Although Croatian botanists never botanized in distant regions, approximately 70% of our collections consist of plant species from other countries and continents, due to the seed exchange via *Delectus Seminum* publications. By contrast, the collections of Croatian native plants were founded rather late, mostly after the Second World War (Regula, 1997).

Inadequate financial support and the Croatian War of Independence - During the 1970s and 1980s the finances of the Garden were scanty, and then came the Croatian War of Independence (1991-1995), which further decreased the number of species in all of our collections. Several unfavourable circumstances combined during that period: lack of staff and money needed for maintaining the existing collections, the impossibility of working and collecting in the field because of war activities and, even after the end of the war, the presence of minefields spread across Croatia – a peril that still exists today. The *ex situ* conservation programs were stepped up in the Garden only during the last decade, when we laid stress on our work on Croatian threatened, rare and endemic plant species (Naumovski & Stamenković, 2004; Stamenković & Naumovski, 2005; Stamenković, 2008; Juretić *et al*. 2009; Stamenković *et al*., 2010; Sandev *et al*., 2013).

Artificial ecosystem – Recently, extensive pollution (the Garden is situated in the centre of the City) and stiff statutory obligations joined with the still inadequate budget and research/staff-equipment in limiting our work seriously to improve the collections. Despite being tended, (any) Botanical Garden is after all an artificial ecosystem, founded in an urbanized area and unfavourable microclimate, where the presence and location of most plants is the result of a gardener's decision (Pautasso & Parmentier, 2007). It can be considered a plant meta-population network, where man controls most exchanges (Tait *et al*., 2005; Schwartz *et al*., 2006; Wania *et al*., 2006).

After a forthcoming revision of Croatian *Red Lists*, the total number of Croatian native plant species facing a real risk of extinction could be only higher than today's 226. Obviously, to reach at least 75% of CR, EN and VU taxa in *ex situ* conservation by 2020, which means at least 178 species to recent calculations, is not a work for a single botanical garden. It is important to emphasize, that of approx. 9,000 globally threatened species thriving in botanical garden collections, around one-third could be found in only one garden (Sharrock, 2011). If *ex situ* collections are considered an 'insurance policy', questions must be asked if single-location collections are sufficiently secure. The focus and challenge for the coming decade must therefore surely be not only to increase the number of threatened plants in *ex situ* collections, but also on assessing and ensuring the conservation value of such collections (Maunder *et al*., 2001; MacKay *et al*., 2010; López-Pujol *et al*., 2006). Unfortunately, for now, there is no other *ex situ* collection in Croatia of any size comparable to the one in our Botanical Garden, and our results in conserving native plants are modest. All Croatian gardens and arboreta must find space and resources to establish and secure native plant collections. At this moment we do not know how many species are grown in Croatian botanical gardens in total, much less how many of them are native, threatened and statutorily protected.

To achieve better results in *ex situ* conservation of Croatian wild flora, we propose the following:

1. to organize regular annual meetings of all Croatian botanical gardens' staff, at which conservation issues can be discussed,
2. to emphasize the need for proper long-term seed storage and the establishment of permanent seed-banks of Croatian threatened plants, in accordance with the Kew Botanic Gardens' *Millennium Seed Bank*-project protocols (Anonymous, 2013b),
3. to establish a national database of *ex situ* collections of Croatian threatened plants in botanical gardens, in order to establish a „zero-state" and to keep track of the progress,
4. to ensure permanent funding, necessary for expanding and maintaining native plant collections, and for establishing new botanical collections, dedicated to conservation of Croatian flora.

Results of this and future assessments are necessary to support and guide strategic actions that will help to conserve Croatian flora, both *ex situ* and *in situ*. Joining the European Union in 2013, Croatia took on many obligations, among them, the obligation to preserve its native plants in the best possible way.

ACKNOWLEDGEMENTS

We wish to thank our colleagues from the Botanical Garden of the Faculty of Science (University of Zagreb), Vanja Stamenković and Biserka Juretić, for sharing data on the

collections, as well as Nina Vuković (Botanical Department of the Faculty of Science, University of Zagreb) for preparing the map of origin of plant species in Botanical Garden. The thanks extend to two anonymous reviewers, who helped with constructive comments.

Received June 19, 2013

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SAŽETAK

Ususret „*Cilju broj osam*": *Ex situ* očuvanje hrvatskih ugroženih i zakonom zaštićenih biljaka u Botaničkom vrtu Prirodoslovno-matematičkog fakulteta Sveučilišta u Zagrebu

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Jedan od glavnih ciljeva svjetskih botaničkih vrtova do kraja ovoga desetljeća slijediti je smjernice *Globalne strategije za očuvanje biljaka* (*Global Strategy for Plant Conservation*, GPSC 2011-2020). Jedna od 19 smjernica, poznata kao „Cilj broj osam" („*Target 8"*), propisuje da bi botanički vrtovi do 2020. godine u uzgoju (*ex situ* očuvanje) trebali imati najmanje 75% ugroženih samoniklih biljnih svojti matične zemlje. Slijedom toga, glavni cilj ovoga istraživanja bio je utvrditi „nulto stanje" u Botaničkom vrtu Prirodoslovno-matematičkog fakulteta Sveučilišta u Zagrebu: izraditi detaljan popis ugroženih i zakonom zaštićenih svojti hrvatske flore, podrijetlom s domaćih staništa, u zbirkama samoniklih biljaka Hrvatske.

U zbirkama Botaničkog vrta Prirodoslovno-matematičkog fakulteta Sveučilišta u Zagrebu trenutačno raste 668 samoniklih biljnih vrsta (iz 75 porodica i 141 roda) sabranih na prirodnim staništima, od kojih je 118 zakonom zaštićeno, a 90 strogo zaštićeno (ukupno 208). U Crvenoj knjizi vaskularne flore Hrvatske pronađeno je ukupno 80 svojti iz zbirki Botaničkog vrta PMF-a, od kojih se jedna (*Hippophaë rhamnoides*) smatra regionalno izumrlom (RE). U kategorijama CR, EN i VU nalazi se 30 vrsta iz naših zbirki, što ukupno čini 13,1% ugroženih vrsta naše zemlje: sedam svojti nalazi se u kategoriji kritično ugroženih (CR), šest u kategoriji ugroženih (EN), a 17 u kategoriji osjetljivih (VU) svojti u Republici Hrvatskoj. Na europskom Crvenom popisu nalaze se 24 svojte: jedna (*Degenia velebitica*) u starijoj kategoriji osjetljivih („V"), četiri u kategoriji nisko rizičnih (NT), a 19 svojti u kategoriji najmanje zabrinjavajućih (LC). Na IUCN-ovom svjetskom popisu ugroženih vrsta nalazi se 12 svojti iz zbirki samoniklih vrsta Botaničkog vrta PMF-a: degenija ponovo u starijoj kategoriji osjetljivih („V"), dvije u NT, a devet u kategoriji LC. O značajnoj ugroženosti biljnih vrsta i potrebi za *ex situ* zaštitom govori i činjenica da je 10 biljnih vrsta pronađeno u samo jednom, a 24 u manje od pet Botanički važnih područja Hrvatske (IPA). CITES-regulative trgovanja živim biljkama obuhvaćaju 11 naših vrsta.

Analizom podataka nalazimo kako u uzgoju Botaničkog vrta PMF-a danas imamo samo 13,1% ukupnog broja zaštićenih i strogo zaštićenih biljnih vrsta u Republici Hrvatskoj (kategorije CR, EN i VU). Razlozi za to su različiti. Primjerice, Botanički vrt PMF-a osnovan je 1889. s namjerom uzgoja - prije svega - egzotičnih biljnih vrsta s raznih strana svijeta, kakav je bio običaj širom Europe u drugoj polovici 19. stoljeća. Sam Vrt, prema svjetskim standardima, površinom je više nego skroman (4,65 ha), kao i površine-kamenjare namijenjene uzgoju autohtonih biljnih vrsta, koje nemaju prostora za širenje. Ciljani uzgoj i *ex situ* zaštita vrijednih hrvatskih samoniklih biljnih svojti započeo je tek prije desetak godina, i to uz ozbiljne poteškoće, kao što su neadekvatno financiranje, nedostatak stručnog kadra, nedostatak prostora za preduzgoj, nedostupnost pojedinih dijelova Hrvatske nakon ratnih aktivnosti i sl. I napokon, Hrvatska je flora iznimno bogata, treća najbogatija u Europi, tako da 75% ugroženih vrsta – što iznosi oko 178 svojti, prema važećim mjerilima – nije nimalo lako doseći. To, naravno, i nije posao za samo jedan botanički vrt: svi hrvatski botanički vrtovi i arboretumi trebali bi pokrenuti koordinirane aktivnosti na uzgoju autohtonih vrsta, kako bi se do 2020. barem polovica ugroženih vrsta naše zemlje našla u *ex situ* očuvanju. Danas ne znamo ni koliko biljnih vrsta raste u našim botaničkim vrtovima, kamoli koliko hrvatskih, ugroženih i zakonom zaštićenih. Ovaj je rad tek prvi korak približavanja tom cilju.