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CHRONICLE

Ex situ plant conservation in the Department of Natural Flora of the M.M. Gryshko National Botanical Garden of the NAS of Ukraine

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Abstract

The study analyzes the experience of introduction and *ex situ* protection of rare and endangered plant species within the Department of Natural Flora of the M.M. Gryshko National Botanical Garden of the NAS of Ukraine. A new method for *ex situ* floristic protection based on population modeling in forest and steppe phytocoenoses is proposed.

National Botanical Garden (NBG) is the center of *ex situ* plant protection in Ukraine. Its collection of rare and endangered species, located on 53 hectares within the Department of Natural Flora, is the richest in Ukraine. The plants are cultivated on various phytogeographical plots, including "Lowland Forests of Ukraine", "Steppes of Ukraine", "Ukrainian Carpathians", "Crimea", "Caucasus", "Central Asia" "Altai", "Far East" as well as on the specialized plot "Rare Plants of the Flora of Ukraine." The collection was established to represent species facing a high risk of extinction in their natural habitats. Of great value are several narrowly distributed Ukrainian endemics, species known from the margins of their geographical ranges or known from single localities, all of which are preserved in this living collection.

An important aspect of *ex situ* plant protection is modeling the populations of rare and endangered species. The unique 80-year-old cultivated forest and steppe phytocoenoses in the NBG closely resemble natural vegetation and provide suitable habitats for many rare and endangered species, forming stable homeostatic introductive populations. The unique achievement of the Department of Natural Flora of the NBG demonstrates the strong potential of plant population modeling for restoring natural ecosystems disturbed by military activities.

Keywords: plant introduction, population modeling, rare plant species, endangered plant species

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Introduction

The development of a scientific background for floristic conservation is the current problem in botanical investigations. The rare and endangered species of natural flora need special attention. According to the plant protection strategy (Corlett, 2016), given the intensive anthropogenic pressure on ecosystems, the actual task is the *in situ* monitoring of populations of rare, endangered, and endemic species. Meanwhile, according to Target 8 of the Global Strategy for Plant Conservation (Sharrock & Jones, 2011), *ex situ* plant protection in botanical gardens plays a major role in the conservation of plants. This target is very important for Ukraine as the areas around the Black Sea are among the main centers of plant diversity in Europe. The purpose of this paper is to show the achievements of the Department of Natural Flora of M.M. Gryshko Botanical Garden of the National Academy of Sciences of Ukraine in *ex situ* plant protection.

Material and methods

The study was conducted at the M.M. Gryshko Botanical Garden of the National Academy of Sciences of Ukraine (NBG), which is located in the Central part of Kyiv City. The area belongs to the Right-Bank Forest-Steppe of Ukraine, a temperate climate zone.

The article analyzes inventory data of the living plant collections during 2020–2025 on various phytogeographical plots of the National Botanical Garden, including “Lowland Forests of Ukraine”, “Steppes of Ukraine”, “Ukrainian Carpathians”, “Crimea”, “Caucasus”, “Central Asia”, “Altai”, “Far East” as well as on the specialized plot “Rare Plants of the Flora of Ukraine”. To the list of protected species at Department of Natural Flora included taxa from: Red Book of Ukraine (MEPNRU, 2021); Appendix to the Berne Convention (1979); lists of regionally rare species protected in the city of Kyiv and

Kyiv region (Kyiv City Council, 2000, 2004; Kyiv Oblast Council, 2012); Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2025); IUCN Red List of Threatened Species (IUCN, 2025). The diversity of protected plants of the Caucasus flora, which grow on the phytogeographical area of the same name, was separately analyzed, taking into account the Red Books of Armenia (Tamanjan, 2011), Azerbaijan (Aliyev, 2013), and Georgia (Nikolaev, 1982). The names of taxa are given in accordance with the conservation lists.

Observations of the state of introduced populations were carried out using traditional methods (Zaimenko & Rakhmetov, 2022).

Results and discussion

In 1956, prominent Ukrainian botanist Sigizmund Kharkevich proposed to organize plant conservation in botanical gardens by establishing collections of rare species (Kotov & Kharkevich, 1956). In 1970, this initiative was implemented and, for the first time in Ukraine, a dedicated plot for rare and endangered plant species of the Ukrainian flora was created at the Central Botanical Garden of the Ukrainian Academy of Sciences (now the NBG).

Today, NBG is the largest *ex situ* plant protection center in Ukraine. The collection of rare and endangered species on the “Rare Plants of the Flora of Ukraine” plot includes 142 species, among them 108 rare and threatened species listed in the Red Book of Ukraine (Didukh, 2009; MEPNRU, 2021).

In the NBG, rare and endangered species are represented not only on the plot “Rare plants of the flora of Ukraine”, but also across several phytogeographical plots, including “Lowland forests of Ukraine”, “Steppes of Ukraine”, “Ukrainian Carpathians”, “Crimea”, “Caucasus”, “Central Asia”, “Altai” and “Far East”, which together cover 52 ha (Zaimenko & Rakhmetov, 2022). In total (Table 1), the living plant collection across these

Table 1. Protected plants in the Department of Natural Flora at M.M. Gryshko National Botanical Garden of the NAS of Ukraine.

No.	Species / infraspecies	RBU	BC	K	CITES	IUCN
1	<i>Acer mandshuricum</i> Maxim.	-	-	-	-	+
2	<i>Acer pentapomicum</i> Stewart ex Brand	-	-	-	-	+
3	<i>Acer platanoides</i> subsp. <i>turkestanicum</i> (Pax) P.C.de Jong	-	-	-	-	+
4	<i>Aconitum lasiocarpum</i> (Rchb.) Gay	+	+	-	-	+
5	<i>Adonis vernalis</i> L.	+	-	+	+	+
6	<i>Adonis wolgensis</i> Steven	+	-	-	-	-
7	<i>Allium aflatunense</i> B.Fedtsch	-	-	-	-	+
8	<i>Allium decipiens</i> Fisch. ex Schult. & Schult.f.	-	-	-	-	+
9	<i>Allium lineare</i> L.	+	-	-	-	+
10	<i>Allium obliquum</i> L.	+	-	-	-	+
11	<i>Allium siculum</i> subsp. <i>dioscoridis</i> (Sm.) K.Richt.	+	-	-	-	-
12	<i>Allium strictum</i> Schard.	+	-	-	-	-
13	<i>Allium ursinum</i> L.	+	-	-	-	+
14	<i>Allium schoenoprasum</i> L.	-	-	-	-	+
15	<i>Allium ramosum</i> L.	-	-	-	-	+
16	<i>Alnus incana</i> L.	-	-	+	-	+
17	<i>Amygdalus nana</i> L. (<i>Prunus tenella</i> Batsch)	-	-	+	-	+
18	<i>Anacamptis morio</i> (L.) R.M.Bateman	+	-	-	+	+
19	<i>Anacamptis picta</i> (Loisel.) R.M.Bateman	+	-	-	+	-
20	<i>Anacamptis pyramidalis</i> (L.) Rich.	+	-	-	+	+
21	<i>Anemone sylvestris</i> L.	-	-	+	-	-
22	<i>Aquilegia vulgaris</i> L.	-	-	+	-	+
23	<i>Arum albispathum</i> Steven ex Ledeb.	+	-	-	-	-
24	<i>Arum besserianum</i> Schott	-	-	+	-	-
25	<i>Arum orientale</i> M.Bieb.	+	-	-	-	-
26	<i>Arundo donax</i> L.	-	-	-	-	+
27	<i>Asphodeline lutea</i> L.	+	-	-	-	-
28	<i>Asplenium scolopendrium</i> L. (<i>Phyllitis scolopendrium</i> (L.) Newm)	-	-	+	-	+
29	<i>Asplenium trichomanes</i> L.	-	-	+	-	-
30	<i>Atocion hypanicum</i> (Klokov) Tzvelev (<i>Silene hypanica</i> Klokov)	+	-	-	-	-
31	<i>Bellevalia sarmatica</i> (Pall. ex Georgi) Woronow (<i>B. speciosa</i> Woronow ex Grossh.)	-	-	+	-	-
32	<i>Betula dahurica</i> Pall.	-	-	-	-	+
33	<i>Betula klokovii</i> Zaver.	+	-	-	-	+
34	<i>Campanula carpatica</i> Jacq.	+	-	-	-	-
35	<i>Carex bohémica</i> Schreb.	+	-	-	-	-
36	<i>Carlina cirsioides</i> Klokov	+	-	-	-	-
37	<i>Celtis caucasica</i> Willd.	-	-	-	-	+

Table 1. Continued.

No.	Species / infraspecies	RBU	BC	K	CITES	IUCN
38	<i>Cephalaria litvinovii</i> Bobrov	+	-	-	-	-
39	<i>Cerastium biebersteinii</i> DC.	+	-	-	-	-
40	<i>Cerasus fruticosa</i> (Pall.) Woron. (<i>Prunus fruticosa</i> Pall.)	-	-	+	-	+
41	<i>Cerasus klokovii</i> Sobko (<i>Prunus fruticosa</i> auct. non Pall.)	+	-	-	-	+
42	<i>Chamaecytisus graniticus</i> (Rehmann) Rothm.	+	-	-	-	-
43	<i>Chamaecytisus podolicus</i> (Błocki) Klask.	+	-	-	-	-
44	<i>Clematis integrifolia</i> L.	-	-	+	-	-
45	<i>Colchicum autumnale</i> L.	+	-	-	-	+
46	<i>Colchicum fominii</i> Bordz.	+	+	-	-	+
47	<i>Colchicum triphyllum</i> Kunzes.l.	+	-	-	-	-
48	<i>Colchicum umbrosum</i> Steven	+	-	-	-	-
49	<i>Colchicum versicolor</i> Ker Gawl. (<i>Bulbocodium versicolor</i> (Ker Gawl.) Spreng.)	+	-	-	-	-
50	<i>Convallaria majalis</i> L.	-	-	+	-	+
51	<i>Corydalis cava</i> (L.) Schweig & Koerte	-	-	+	-	-
52	<i>Corydalis cava</i> subsp. <i>marshalliana</i> (Willd.) Hayek (<i>C. marshalliana</i> Pers.)	-	-	+	-	-
53	<i>Corylus colurna</i> L.	-	-	-	-	+
54	<i>Crambe koktebelica</i> (Junge) N.Busch.	+	+	-	-	+
55	<i>Crambe maritima</i> L.	+	-	-	-	+
56	<i>Crambe tataria</i> Sebeok	+	+	-	-	+
57	<i>Crataegus ambigua</i> C.A.Mey. ex A.K.Becker	-	-	-	-	+
58	<i>Crataegus pentagyna</i> Waldst. & Kit.	-	-	+	-	+
59	<i>Crataegus pojarkovae</i> Kossych	+	-	-	-	-
60	<i>Crataegus meyeri</i> Pojark (<i>Crataegus ucrainica</i> Pojark)	-	-	-	-	+
61	<i>Crataegus pontica</i> K.Koch	-	-	-	-	+
62	<i>Crataegus submollis</i> Sarg.	-	-	-	-	+
63	<i>Crocus angustifolius</i> West.	+	-	-	-	-
64	<i>Crocus banaticus</i> J.Gay.	+	-	-	-	-
65	<i>Crocus heuffelianus</i> Herb.	+	-	-	-	-
66	<i>Crocus reticulatus</i> Steven ex Adam	+	-	-	-	-
67	<i>Crocus speciosus</i> M.Bieb.	+	-	-	-	-
68	<i>Cyclamen coum</i> Mill. s.l. (<i>C. kuznetzovii</i> Kotov & Czernowa)	+	+	-	+	+
69	<i>Cydonia oblonga</i> Mill.	-	-	-	-	+
70	<i>Cypripedium calceolus</i> L.	+	+	-	+	+
71	<i>Dactylorhiza fuchsii</i> (Druce) Soó	+	-	-	+	+
72	<i>Dactylorhiza incarnata</i> (L.) Soó	+	-	-	+	+
73	<i>Dactylorhiza majalis</i> (Reichenb.f.) Nunt & Summer.	+	-	-	+	+
74	<i>Dactylorhiza sambucina</i> (L.) Soó	+	-	-	+	+
75	<i>Daphne cneorum</i> L.	+	-	-	-	-
76	<i>Daphne mezereum</i> L.	-	-	+	-	+

Table 1. Continued.

No.	Species / infraspecies	RBU	BC	K	CITES	IUCN
77	<i>Daphne sophia</i> Kolenicz.	+	-	-	-	-
78	<i>Delphinium elatum</i> L.	+	-	-	-	-
79	<i>Delphinium pallasii</i> Nevski	+	-	-	-	-
80	<i>Delphinium sergii</i> Wissjul.	+	-	-	-	-
81	<i>Dianthus hypanicus</i> Andrz.	+	+	-	-	+
82	<i>Dictamnus albus</i> L.	+	-	-	-	+
83	<i>Dianthus gratianopolitanus</i> Vill.	+	-	-	-	-
84	<i>Draba aizoides</i> L.	+	-	-	-	-
85	<i>Dracocephalum ruyschiana</i> L.	+	+	-	-	+
86	<i>Echinops exaltatus</i> Schrad.	+	-	-	-	-
87	<i>Epipactis helleborine</i> (L.) Crantz	+	-	-	+	+
88	<i>Epipactis palustris</i> (L.) Crantz	+	-	-	+	+
89	<i>Eremurus spectabilis</i> M.Bieb.	+	-	-	-	-
90	<i>Erythronium dens-canis</i> L.	+	-	-	-	-
91	<i>Euonimus nana</i> Bieb.	+	-	-	-	-
92	<i>Euphorbia volhynica</i> Besser ex Racib.	+	-	-	-	-
93	<i>Festuca heterophylla</i> Lam.	+	-	-	-	+
94	<i>Festuca pallens</i> Host.	+	-	-	-	-
95	<i>Fraxinus ornus</i> L.	+	-	-	-	+
96	<i>Fraxinus sogdiana</i> Bunge	-	-	-	-	+
97	<i>Fritillaria grandiflora</i> Grossh.	-	-	-	-	+
98	<i>Fritillaria meleagris</i> L.	+	-	-	-	-
99	<i>Fritillaria montana</i> Hoppe	+	-	-	-	+
100	<i>Fritillaria ruthenica</i> Wikstr.	+	-	-	-	-
101	<i>Gagea pusilla</i> (F.W.Schmidt) Schult. & Schult. f.	-	-	+	-	-
102	<i>Gagea transversalis</i> Steven (G. <i>paczoskii</i> (Zapal.) Grossh.)	-	-	+	-	-
103	<i>Galanthus</i> × <i>alleni</i> Baker	-	-	-	+	-
104	<i>Galanthus alpinus</i> Sosnowsky	-	-	-	+	-
105	<i>Galanthus angustifolius</i> Koss	-	-	-	+	-
106	<i>Galanthus elwesii</i> Hook. fil.	+	-	-	-	-
107	<i>Galanthus krasnovii</i> A.P.Khokhr.	-	-	-	+	-
108	<i>Galanthus lagodechianus</i> Kem.-Nath.	-	-	-	+	-
109	<i>Galanthus nivalis</i> L.	+	-	-	-	+
110	<i>Galanthus plicatus</i> M.Bieb.	+	-	-	-	+
111	<i>Galanthus woronowii</i> Losinsk.	-	-	-	+	-
112	<i>Genistella sagittalis</i> (L.) Gams (<i>Genista sagittalis</i> L.)	+	-	-	-	+
113	<i>Geranium phaeum</i> L.	-	-	+	-	-
114	<i>Gladiolus imbricatus</i> L.	+	-	+	-	-
115	<i>Gladiolus tenuis</i> M.Bieb.	+	-	-	-	-

Table 1. Continued.

No.	Species / infraspecies	RBU	BC	K	CITES	IUCN
116	<i>Glaucum flavum</i> Crantz	+	-	-	-	-
117	<i>Glechoma hirsuta</i> Waldst. & Kit.	-	-	-	-	+
118	<i>Gymnadenia conopsea</i> (L.) R.Br.	+	-	-	+	+
119	<i>Gymnospermium odessanum</i> (DC.) Takht.	+	-	-	-	-
120	<i>Hepatica nobilis</i> Mill.	-	-	+	-	+
121	<i>Hyacinthella leucophaea</i> (Koch) Schur	-	-	+	-	-
122	<i>Inula helenium</i> L.	-	-	+	-	+
123	<i>Iris hungarica</i> Waldst. & Kit.	-	+	+	-	-
124	<i>Iris pineticola</i> Klokov	+	-	-	-	-
125	<i>Iris pontica</i> Zapł.	+	-	-	-	-
126	<i>Iris pumila</i> L.	-	-	+	-	-
127	<i>Iris pseudacorus</i> L.	-	-	+	-	-
128	<i>Iris sibirica</i> L.	+	-	+	-	-
129	<i>Isopyrum thalictroides</i> L.	-	-	+	-	-
130	<i>Juglans regia</i> L.	-	-	-	-	+
131	<i>Juniperus communis</i> L.	-	-	+	-	+
132	<i>Juniperus exelsa</i> M.Bieb.	+	-	-	-	+
133	<i>Juniperus foetidissima</i> Willd.	+	-	-	-	+
134	<i>Larix dahurica</i> Turcz. ex Trautv. (<i>L. gmelinii</i> (Rupr.) Kuzen.)	-	-	-	-	+
135	<i>Larix polonica</i> Racib. (<i>L. decidua</i> var. <i>polonica</i> (Racib. ex Wóycicki) Ostenf. & Syrach)	+	-	-	-	+
136	<i>Juniperus sabina</i> L.	-	-	-	-	+
137	<i>Leucojum aestivum</i> L.	+	-	-	-	+
138	<i>Leucojum vernum</i> L.	+	-	-	-	+
139	<i>Lilium martagon</i> L.	+	-	-	-	-
140	<i>Listera ovata</i> (L.) R.Br. (<i>Neottia ovata</i> (L.) Bluff & Fingerh.)	+	-	-	+	+
141	<i>Lonicera caerulea</i> L.	+	-	-	-	+
142	<i>Lunaria rediviva</i> L.	+	-	-	-	-
143	<i>Malus baccata</i> (L.) Borkh.	-	-	-	-	+
144	<i>Malus niedzwetzkyana</i> Dieck ex Koehne	-	-	-	-	+
145	<i>Malus sieversii</i> (Ledeb.) M.Roem.	-	-	-	-	+
146	<i>Melica transsilvanica</i> Schur	-	-	+	-	-
147	<i>Muscari neglectum</i> Guss	-	-	+	-	-
148	<i>Onoclea struthiopteris</i> (L.) Roth (<i>Matteuccia struthiopteris</i> (L.) Tod.)	-	-	+	-	+
149	<i>Onosma polyphylla</i> Ledeb.	+	+	-	-	+
150	<i>Orchis purpurea</i> Huds.	+	-	-	+	+
151	<i>Ornithogalum boucheanum</i> (Kunth) Aschers.	+	-	-	-	-
152	<i>Ornithogalum umbellatum</i> L.	-	-	+	-	-
153	<i>Paeonia daurica</i> Andrews	+	-	-	-	-

Table 1. Continued.

	Species / infraspecies	RBU	BC	K	CITES	IUCN
154	<i>Paeonia tenuifolia</i> L.	+	+	-	-	+
155	<i>Phelypaea coccinea</i> (M.Bieb.) Poir. (<i>Orobancha coccinea</i> M.Bieb.)	+	-	-	-	-
156	<i>Picea abies</i> (L.) Karst.	-	-	+	-	+
157	<i>Picea schrenkiana</i> Fisch. & Mey.	-	-	-	-	+
158	<i>Pinus cembra</i> L.	+	-	-	-	+
159	<i>Pinus koraiensis</i> Siebold & Zucc.	-	-	-	-	+
160	<i>Platanthera bifolia</i> (L.) Rich.	+	-	-	+	+
161	<i>Platanthera chlorantha</i> (Cust.) Rchb.	+	-	-	+	+
162	<i>Platycladus orientalis</i> (L.) Franco	-	-	-	-	+
163	<i>Polystichum braunii</i> (Spenn.) Fée	-	-	+	-	+
164	<i>Primula farinosa</i> L.	+	-	-	-	+
165	<i>Primula veris</i> L.	-	-	+	-	+
166	<i>Prunus armeniaca</i> L.	-	-	-	-	+
167	<i>Prunus cerasifera</i> Ehrh.	-	-	-	-	+
168	<i>Pulsatilla patens</i> Wend. s.l. (<i>P. latifolia</i> Rupr.)	+	+	+	-	+
169	<i>Pulsatilla pratensis</i> (L.) Mill.	+	-	-	-	-
170	<i>Quercus petraea</i> (Mattuschka) Liebl.	-	-	+	-	+
171	<i>Rhododendron luteum</i> Sweet	-	-	+	-	+
172	<i>Rosa spinosissima</i> L.	-	-	+	-	-
173	<i>Salix arbutifolia</i> Pall. (<i>Chosenia arbutifolia</i> (Pall.) A.Skvorts.)	-	-	-	-	+
174	<i>Salvia scabiosifolia</i> Lam.	+	-	-	-	-
175	<i>Schivereckia podolica</i> (Besser) Andr. ex DC. (<i>Draba podolica</i> (Besser) Rupr.)	+	+	-	-	+
176	<i>Scilla bifolia</i> L.	-	-	+	-	+
177	<i>Scilla siberica</i> Haw.	-	-	+	-	-
178	<i>Scopolia carniolica</i> Jacq.	+	-	-	-	+
179	<i>Scutellaria altissima</i> L.	-	-	+	-	-
180	<i>Securigera elegans</i> (Pančić) Lassen	+	-	-	-	-
181	<i>Sempervivum globiferum</i> L. (<i>Jovibarba sobolifera</i> (Sims) Opiz)	+	-	-	-	-
182	<i>Sempervivum marmoreum</i> Griseb.	+	-	-	-	+
183	<i>Sempervivum montanum</i> L. (incl. <i>S. carpathicum</i> Wettst. ex Prodan)	+	-	-	-	-
184	<i>Silenanthe zawadskii</i> (Herbich) Griseb. & Schenk	+	-	-	-	-
185	<i>Silene sytnikii</i> Krytzka, Novosad & Protopopova	+	-	-	-	-
186	<i>Silene viridiflora</i> L.	+	-	-	-	-
187	<i>Sophora alopecuroides</i> L.	+	-	-	-	-
188	<i>Spiraea polonica</i> Błocki	+	-	-	-	-
189	<i>Staphylea pinnata</i> L.	+	-	-	-	+
190	<i>Sternbergia colchiciflora</i> Waldst. & Kit.	+	-	-	-	+
191	<i>Stipa capillata</i> L.	+	-	-	-	-
192	<i>Stipa pennata</i> L.	+	-	-	-	-

Table 1. Continued.

	Species / infraspecies	RBU	BC	K	CITES	IUCN
193	<i>Succisella inflexa</i> (Kluk) G.Beck	+	-	-	-	-
194	<i>Syringa josikaea</i> Jacq.f.	+	+	-	-	+
195	<i>Tamarix ramosissima</i> Ledeb.	-	-	-	-	+
196	<i>Tamarix szovitsiana</i> Bunge	-	-	-	-	+
197	<i>Taxus baccata</i> L.	+	-	-	-	+
198	<i>Taxus cuspidata</i> Siebold & Zucc.	-	-	-	+	+
199	<i>Torminalis glaberrima</i> (Gand.) Sennikov & Kurtto	+	-	-	-	-
200	<i>Trifolium lupinaster</i> L.	+	-	-	-	-
201	<i>Trifolium rubens</i> L.	+	-	-	-	-
202	<i>Tulipa bifloriformis</i> Vved.	-	-	-	-	+
203	<i>Tulipa fosteriana</i> W.Irving	-	-	-	-	+
204	<i>Tulipa kaufmanniana</i> Regel	-	-	-	-	+
205	<i>Tulipa micheliana</i> Hoog	-	-	-	-	+
206	<i>Tulipa ophiophylla</i> Klokov & Zoz (T. <i>biebersteiniana</i> Schult.f. s.l.)	+	-	-	-	-
207	<i>Tulipa praestans</i> H.B.May	-	-	-	-	+
208	<i>Tulipa quercetorum</i> Klokov & Zoz. (T. <i>biebersteiniana</i> Schult.f. s.l.)	+	-	-	-	-
209	<i>Tulipa schrenkii</i> Regel (T. <i>gesneriana</i> L. s.l.)	+	-	-	-	-
210	<i>Tulipa urumiensis</i> Stapf	-	-	-	-	+
211	<i>Viola alba</i> Besser	+	-	-	-	-
	Total	126	14	43	24	112

Note. RBU – Red Book of Ukraine (MEPNRU, 2021); BC – Appendix to the Berne Convention (1979); K – lists of regionally rare species protected in the city of Kyiv City and Kyiv Region (Kyiv City Council, 2000, 2004; Kyiv Oblast Council, 2012); CITES – Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2025); IUCN – IUCN Red List of Threatened Species (IUCN, 2025).

phytogeographical plots and the “Rare plants of the flora of Ukraine” plot consists of 1251 species and infraspecies, including 211 rare and endangered representatives. The collection includes 126 species listed in the Red Book of Ukraine (Didukh, 2009; MEPNRU, 2021), 43 species that are protected in the Kyiv City and Kyiv Region, 14 species listed in the Annexes of the Bern Convention, 24 species included in CITES, and 112 species on the IUCN Red List (Table 1).

Thus, the NBG holds unique living collections of rare species in Ukraine and serves as the country’s largest center for *ex situ* plant conservation. The primary goal in establishing these collections has been to preserve and represent species at high risk of

extinction in their natural habitats. Endemics occurring in the flora of Ukraine (e.g., *Atocion hypanicum* and *Euphorbia wolhynica*), species known from only a few localities in Ukraine (e.g., *Iris germanica* and *Lonicera caerulea*), and species occurring at the margins of their natural ranges (e.g., *Aconitum lasiocarpum*, *Galanthus plicatus*, and *Fritillaria montana*) are of particular phytosozological importance (Melnyk, 2014).

An important aspect of *ex situ* plant protection is modeling the populations of rare and endangered species in cultivated phytocoenoses. Phytogeographical principles of the foundation collection of living plants permit the representation not only of some species of natural flora, but also the plant

Table 2. Floristic diversity of Ukraine represented *ex situ* on the phytogeographical plots and on the “Rare Plants of the Flora of Ukraine” plot of the M.M. Gryshko National Botanical Garden of the NAS of Ukraine.

Plot	Total number of species	Number of species listed in the Red Book of Ukraine (Didukh, 2009; MEPNRU, 2021)
Rare plants of the flora of Ukraine	142	108
Lowland forests of Ukraine	360	23
Steppes of Ukraine	347	20
Ukrainian Carpathians	260	17
Crimea	248	17

communities with phytocoenotic relations among the species. The phytogeographical plots “Lowland Forests of Ukraine”, “Steppes of Ukraine”, “Ukrainian Carpathians”, and “Crimea”, established in the 1940s, have now developed into 80-year-old cultivated forest and steppe phytocoenoses that closely resemble natural ecosystems in their structure.

Rare species of the Ukrainian flora – *Allium ursinum*, *Galanthus elwesii*, *Galanthus nivalis*, *Galanthus plicatus*, *Dictamnus albus*, *Ornithogalum boucheanum*, *Scopolia carniolica*, *Staphylea pinnata*, and *Tulipa quercetorum* on the “Lowland Forests of Ukraine” plot; *Euonymus nanus*, *Lunaria rediviva*, *Scopolia carniolica*, and *Syringa josikaea* on the “Ukrainian Carpathians” plot; *Adonis vernalis* (Gritsenko, 2023), *Crocus reticulatus* (Gritsenko, 2020), *Gymnospermium odessanum* (Gritsenko, 2022), and *Paeonia tenuifolia* on the “Steppes of Ukraine” plot; *Asphodeline lutea*, *Crocus speciosus*, and *Salvia scabiosifolia* on the “Crimea” plot; and *Colchicum autumnale*, *Crocus angustifolius*, *Leucojum vernalis*, *Epipactis helleborine*, *E. palustris* (Gnatiuk, 2024; Gnatiuk et al., 2024) on the “Rare Plants of the Flora of Ukraine” plot – have found favorable conditions for growth and development in the NBG (Table 2). These species have formed stable, homeostatic introductive populations whose age structures (Fig. 1) closely resemble those of their natural populations in forest and steppe ecosystems of Ukraine (Melnyk et al., 2018).

Overall, our experience demonstrates that modeling populations of rare and endangered species within cultivated forest and steppe phytocoenoses is an effective method for *ex situ* conservation of plant diversity.

Our achievements in *ex situ* plant conservation in Ukraine demonstrate the effectiveness of this approach. The successful introduction of plant species from the Caucasus, Central Asia, the Altai Mountains, and the Far East – and the subsequent modeling of the vegetation of these regions within the phytogeographical plots of the National Botanical Garden – indicates that *ex situ* conservation of plant species from outside Ukraine can also be highly effective. Particularly noteworthy is the experience gained in introducing and conserving Caucasian plant species *ex situ*. The phytogeographical plot “Caucasus” was established in the botanical garden on an area of 6 ha (Kharkevich, 1962, 1966).

Over many years, up to 1973, the curator of the “Caucasus” plot introduced approximately 1,600 species of Caucasian flora. Many of these species – primarily those from deserts, arid sparse forests, and alpine meadows – did not survive. In contrast, species originating from mountain forest and steppe communities have thrived and continue to grow successfully in the “Caucasus” plot to the present day. Currently, the collection in the “Caucasus” plot comprises 441 Caucasian plant species and infraspecies (Shynder, 2015; Didenko & Shynder, 2023), including 45 species listed in the Red Data Books of Armenia, Azerbaijan, and Georgia (Table 3).

The unique 80-year-old cultivated forest and steppe phytocoenoses in the NBG are suitable habitats for many rare and endangered species of Caucasian flora. Rare forest species such as *Arum rupicola*, *Cyclamen coum*, *Dioscorea caucasica*, *Epimedium pinnatum*, *Erythronium caucasicum*, *Fritillaria grandiflora*, *Galanthus alpinus*, *Galanthus woronowii*, *Helleborus caucasicus*, *Lilium*

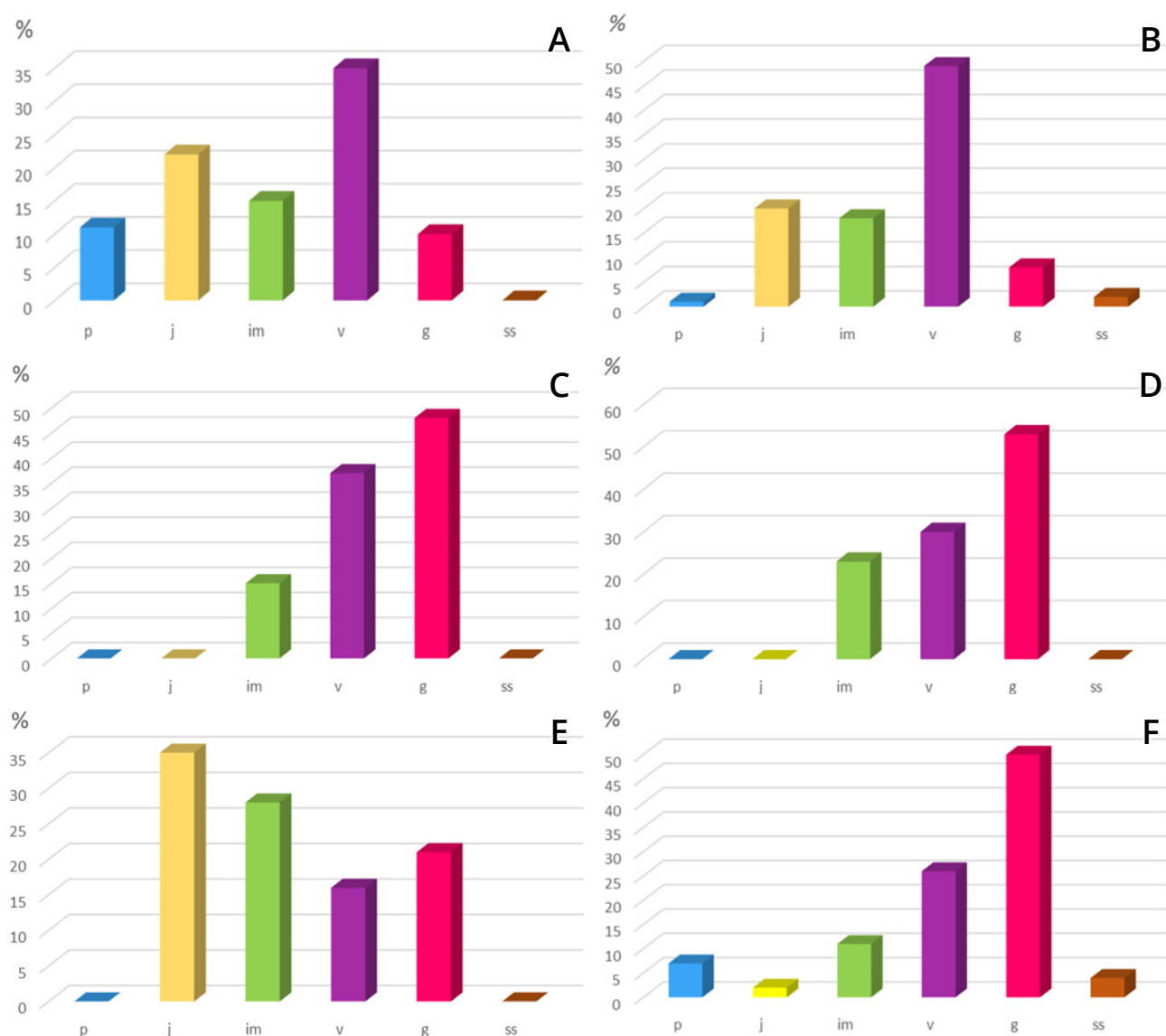


Figure 1. Spectra of ontogenetic states of of introductive populations on the plots at the Department of Natural Flora of the M.M. Gryshko National Botanical Garden of the NAS of Ukraine: **A** – *Crocus speciosus* on the plot "Crimea"; **B** – *Paeonia tenuifolia* on the plot "Steppes of Ukraine"; **C** – *Scopolia carniolica* on the plot "Ukrainian Carpathians"; **D** – *S. carniolica* on the plot "Lowland forests of Ukraine"; **E** – *Fritillaria grandis* on the plot "Caucasus"; **F** – *Colchicum autumnale* on the plot "Rare Plants of the Flora of Ukraine". **Ontogenetic states:** p – seedlings; j – juvenile plants; im – immature plants; v – virginal plants; g – generative plants; ss – subsenile plants.

monadelphum, *Paeonia caucasica*, *Staphylea colchica*, *Taxus baccata* and rare steppe species such as *Adonis vernalis*, *Crambe cordifolia*, *Crocus reticulatus*, *Eremurus spectabilis*, *Iris aphylla*, *Paeonia tenuifolia* have formed stable introductive populations with homeostatic age structure over many years, closely resembling the populations of this species in natural habitats (Melnyk & Didenko, 2020).

Thus, the "Caucasus" plot in the NBG represents a unique center for plant introduction and plays an important role in the *ex situ* conservation of Caucasian flora.

Of particular phytosociological significance is the introductive population of the narrowly distributed endemic *Fritillaria grandiflora* from the Talysh Mountains, which naturally occurs at a single locality near Lerik village in Azerbaijan. In 1959, Sigizmund Kharkevich collected planting material of this species from its natural habitat and introduced it into the "Caucasus" plot of the botanical garden. *Fritillaria grandiflora* has adapted well to the climatic conditions in Kyiv and now forms a stable, homeostatic population with a complete ontogenetic spectrum within artificial

Table 3. Plant species of the Caucasus flora listed in the Red Books of Georgia, Armenia, and Azerbaijan.

No.	Species	Georgia	Armenia	Azerbaijan
1	<i>Acer ibericum</i> M.Bieb.	+	-	-
2	<i>Anemone ranunculoides</i> L.	-	+	-
3	<i>Arum rupicola</i> Boiss.	-	+	-
4	<i>Asperula taurine</i> (Pobed.) Ehrend.	-	+	-
5	<i>Buxus colchica</i> Pojark.	+	-	+
6	<i>Castanea sativa</i> Mill.	+	+	+
7	<i>Clematis vitalba</i> L.	-	+	-
8	<i>Corydalis marschalliana</i> (Pall. ex Willd.) Pers.	-	+	-
9	<i>Corylus colurna</i> L.	+	+	+
10	<i>Dioscorea caucasica</i> Lipsky	+	-	-
11	<i>Erythronium caucasicum</i> Woronow	+	-	-
12	<i>Fritillaria grandiflora</i> Grossh.	-	-	+
13	<i>Gagea lutea</i> (L.) Ker Gawl.	-	+	-
14	<i>Galanthus alpinus</i> Sosnowsky	-	+	-
15	<i>Galanthus lagodechianus</i> Kem.-Nath.	-	+	-
16	<i>Gleditsia caspica</i> Desf.	-	-	+
17	<i>Gymnospermium smirnowii</i> (Trautv.) Takht.	+	-	-
18	<i>Hippophae rhamnoides</i> L.	+	-	-
19	<i>Iridodictium reticulata</i> M.Bieb	-	-	+
20	<i>Juglans regia</i> L.	+	-	-
21	<i>Juniperus foetidissima</i> Willd.	+	-	+
22	<i>Juniperus sabina</i> L.	-	+	-
23	<i>Lilium caucasicum</i> (Miscz. ex Grossh.) Grossh.	+	-	-
24	<i>Lilium monadelphum</i> M.Bieb	+	-	-
25	<i>Pachyphragma macrophyllum</i> (Hoffm.) N.Busch	-	+	-
26	<i>Padus avium</i> Mill.	-	-	+
27	<i>Paeonia mlokosewitschii</i> Lomakin	+	-	+
28	<i>Paeonia tenuifolia</i> L.	-	+	-
29	<i>Paeonia wittmanniana</i> Hartwiss ex Lindl.	+	-	-
30	<i>Parrotia persica</i> (DC.) C.A.Mey	-	-	+
31	<i>Phedimus stoloniferus</i> (S.G.Gmel.) 't Hart	-	+	-
32	<i>Pinus kochiana</i> Klotzsch ex K.Koch	-	-	+
33	<i>Primula vulgaris</i> L.	-	+	-
34	<i>Pterocarya pterocarpa</i> (Michx.) Kunth ex Iljinsk.	+	-	+
35	<i>Quercus castaneifolia</i> C.A.Mey	-	-	+
36	<i>Quercus imeretina</i> Steven ex Woronow	+	-	-
37	<i>Quercus macranthera</i> Fisch. & C.A.Mey.	+	-	-
38	<i>Rhododendron luteum</i> Sweet	-	-	+
39	<i>Staphylea colchica</i> Steven	+	-	-

Table 3. Continued.

No.	Species	Georgia	Armenia	Azerbaijan
40	<i>Staphylea pinnata</i> L.	+	+	-
41	<i>Taxus baccata</i> L.	+	+	+
42	<i>Telekia speciosa</i> (Schreb.) Baumg.	-	-	+
43	<i>Tulipa biebersteiniana</i> Schult.f.	+	-	+
44	<i>Ulmus glabra</i> Huds.	+	-	-
45	<i>Ulmus minor</i> Mill	+	-	-
Total		23	17	17

broadleaf forests. This population occupies an area of 30 m², with a density ranging from 10 to 65 individuals per m² (Melnyk & Didenko, 2020). Thanks to successful population modeling of *Fritillaria grandiflora*, the conservation of this narrowly distributed endemic of the Caucasian flora has improved significantly. Today, there is more than one population in the world. One of them is the one created by scientists of the NBG. This achievement of Ukrainian botanists is a testimony to the international importance of *ex situ* plant protection through modeling plant populations within artificial phytocoenoses.

The catastrophic expansion of areas for intensive economic use – including forest logging, wetland drainage, afforestation of steppe slopes, quarrying and waste dumps, construction sites, and, most devastatingly, the destruction of landscapes caused by military actions of Russian occupation forces – has threatened the survival of rare species in their natural habitats. To prevent the loss of unique floristic diversity, it is essential not only to establish new protected areas but also to form plant populations within forest and steppe phytocoenoses (Figs. 2 & 3). The experience gained in plant population modeling and the unique living plant collections of the Department of Natural Flora at the National Botanical Garden can serve as a scientific foundation for the post-war restoration of landscape ecosystems.

Conclusions

Based on the analysis of the rare component of the living plant collections on the phytogeographical plots “Lowland Forests

of Ukraine,” “Steppes of Ukraine,” “Ukrainian Carpathians,” “Crimea,” “Caucasus,” “Middle Asia,” “Altai,” and “Far East,” which together cover an area of 52 ha, as well as in the “Rare Plants of the Flora of Ukraine” plot in the Department of Natural Flora at the NBG, it was established that the collection includes 126 species listed in the Red Book of Ukraine, 43 species are protected in the Kyiv City and Kyiv Region, 24 species listed under the CITES Convention, 14 species included in the Appendices of the Bern Convention, and 112 species listed in the IUCN Red List. Hence, the Department of Natural Flora of the NBG is the largest center for *ex situ* plant conservation in Ukraine.

Since the collection was established to represent species at high risk of extinction in their natural habitats, particular value is attributed to the narrowly distributed endemics, species known from single localities, and those occurring at the margins of their geographical ranges that are included in the living collection. Notable examples include *Aconitum lasiocarpum*, *Euphorbia volhynica*, *Iris germanica*, *Fritillaria grandiflora*, *F. montana*, *Galanthus elwesii*, *G. plicatus*, and *Lonicera caerulea*.

An important aspect of *ex situ* plant protection is the modeling of the populations of rare and endangered species. The unique 80-year-old cultivated forest and steppe phytocoenoses in the Department of Natural Flora of the NBG provide suitable habitats for many rare and endangered species. Rare forest and steppe species (i.e., *Adonis vernalis*, *Crocus reticulatus*, *Euonymus nanus*, *Galanthus elwesii*, *G. nivalis*, *G. plicatus*, *Gymnospermium odessanum*, *Leucojum vernum*, *Lunaria rediviva*, *Paeonia tenuifolia*,



Figure 2. Protected herbaceous plants in the Department of Natural Flora at M.M. Gryshko National Botanical Garden of the NAS of Ukraine. **A** – *Euphorbia volhynica*, endemic of Ukrainian flora; **B** – *Lonicera caerulea*, species known from a single locality in Ukraine; **C** – *Iris germanica*, species known from a single locality in Ukraine; **D** – *Atocion hypanicum*, endemic of Ukrainian flora; **E** – *Osmunda regalis*, species known from a single locality in Ukraine; **F** – *Fritillaria grandiflora*, species known from a single locality and endemic of the Caucasian flora.



Figure 3. Protected woody plants of Carpathians flora in the Department of Natural Flora at M.M. Gryshko National Botanical Garden of the NAS of Ukraine. **A** – *Fraxinus ornus*, species known from a single locality in Ukraine; **B** – *Syringa josikaea*, endemic of the Carpathian flora.

Staphylea pinnata, and *Tulipa quercetorum*), as well as rare species of Caucasian flora (i.e., *Erytronium caucasicum*, *Fritillaria grandiflora*, *Galanthus caucasicum*, *G. woronowii*, *Helleborus caucasicus*, *Paeonia caucasica*, and *Staphylea colchica*) have formed stable introductive populations with homeostatic age structures closely resembling those of their populations in natural habitats.

The unique achievements of the NBG provide strong evidence of the potential of plant population modeling in cultivated forest and steppe phytocoenoses for the *ex situ* conservation of floristic diversity, particularly for the restoration of landscape ecosystems following severe destruction caused by military actions of occupying forces.

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Охорона рослин *ex situ* у відділі природної флори Національного ботанічного саду імені М.М. Гришка НАН України

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Проаналізовано досвід інтродукції та охорони рідкісних і зникаючих видів рослин *ex situ* у відділі природної флори Національного ботанічного саду імені М.М. Гришка НАН України. Запропоновано новий метод флористичної охорони *ex situ* шляхом моделювання популяцій у лісових та степових фітоценозах.

Національний ботанічний сад (НБС) є центром захисту рослин *ex situ* в Україні. Колекція рідкісних та зникаючих видів на фітогеографічних ділянках "Ліси рівнинної частини України", "Степи України", "Українські Карпати", "Крим", "Кавказ", "Центральна Азія", "Алтай", "Далекий Схід" та на ділянці "Рідкісні рослини флори України" на площі 53 га у відділі природної флори НБС є найбагатшою в Україні. Ця колекція була створена з метою представлення видів рослин з високим ризиком зникнення з природних середовищ існування. Велику цінність мають представлені в нашій колекції живих рослин деякі вузькі українські ендеміки, види, відомі з меж їхніх географічних ареалів або з окремих місцезнаходжень.

Важливим аспектом захисту рослин *ex situ* є моделювання популяцій рідкісних та зникаючих видів. Унікальні 80-річні культивовані лісові та степові фітоценози у НБС дуже схожі на природну рослинність і є придатними середовищами існування для багатьох рідкісних та зникаючих видів, які сформували стабільні гомеостатичні інтродукційні популяції. Ці досягнення відділу природної флори НБС є вагомим свідченням перспективності моделювання популяцій рослин з метою відновлення природних екосистем, порушених військовими діями.

Ключові слова: інтродукція рослин, моделювання популяцій, рідкісні види рослин, зникаючі види рослин