

A targeted metacollection of Nordic gardens reveals horticultural endemism of threatened woody plants

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40 **Societal impact statement**

41 Living collections offer a last chance to conserve species at risk of extinction. We need to know
42 where threatened plants are held and coordinate to conserve them. We pulled together
43 information from 22 collections of trees and shrubs centred in the Nordics to compare species
44 and discover which could be used for conservation action. Of the thousands of individual
45 specimens representing hundreds of threatened species around a third have documented wild
46 origins. A few are common in collections, but most are rare and vulnerable to loss. We can now
47 act together to secure these essential resources for future generations.

48

49 **Summary**

- 50
- 51 • There is huge potential for bringing together international networks of Botanic Gardens
52 and Arboreta and pooling their resources for coordinated action to conserve threatened
53 species. Realising this potential requires effectively managing complex, largely
54 independently acquired data for tens of thousands of species and many more individual
55 plants with different wild or cultivated origins.
 - 56 • Here we describe the establishment of a metacollection of threatened, temperate
woody plant species held across 22 collections in Denmark, Finland, Greenland, Latvia,

Norway, and Sweden. We align taxonomic data to the World Flora Online to identify priority taxa and then compare accession-level data using Botanic Garden Conservation International's PlantSearch database to assess the conservation value of collections across the network.

- Taxonomic alignment reduced the numbers of apparently unique taxa recorded in names databases across the metacollection by 70% and numbers of threatened taxa by 36%. Going from names records to living plants, the metacollection includes 433 threatened taxa (a further reduction of 64%) represented by 3192 accessions spread unevenly across collections and taxa, 38% of which are wild or cultivated from wild origin. A third of the threatened taxa across the network are represented by single accessions (at a single site: horticultural endemics), most by three or fewer.
- Inconsistencies in data both inflate and hide rare species in collections. Taxonomic alignment and accession-level comparison reveals an urgent need to increase resilience through targeted exchange of conservation grade material. Through open data and standards, this regional metacollection can feed seamlessly into global conservation programmes.

Keywords

Arboreta; botanic gardens; BGCI PlantSearch; ex situ conservation; threatened species; World Flora Online

Introduction

The living plant collections of botanic gardens and arboreta have a vital role in communication, knowledge discovery, and conservation of plant diversity (Smith, 2019, 2016). In the ongoing biodiversity crisis (Secretariat of the Convention on Biological Diversity, 2020), they are an important tool in preventing species extinctions (Global Partnership for Plant Conservation, 2025). They provide safe sites for plants that are threatened in the wild through the impact of habitat transformation and climate change, and knowledge as well as genetic diversity of these collections can be used in restoration initiatives (Di Sacco et al., 2021; Mounce et al., 2017; Westwood et al., 2021). They can also demonstrate ecological tolerances that might hallmark successful assisted migration (Hällfors et al., 2012) or use in urban environments (Hirons et al., 2021).

89 However, individual gardens face challenges in leveraging their combined resources. They
90 collaborate in broader networks: regionally, internationally (such as under the auspices of
91 Botanic Gardens Conservation International – BGCI) or thematically (such as BGCI's Global
92 Conservation Consortia – GCC; Linsky et al., 2024), but the data underlying living plant
93 collections are complex and hard to align across institutions (Brockington et al., 2026). We need
94 comparable accession-level information for specimens to establish effective metacollections
95 (Griffith et al., 2019), and solutions for sharing data and material, particularly for threatened
96 species. Achieving that for the enormous numbers of taxa involved is a big task.

97 In the Nordic countries there is a tradition of regular communication between institutions. Many
98 collections are databased and some share common data standards (e.g. DarwinCore;
99 Wieczorek et al., 2012) and infrastructures (such as the specialist botanic gardens database
100 solution, IrisBG). Some institutions are already involved in GCCs (particularly those for
101 *Rhododendron*, *Sorbus*, and conifers) and other global initiatives for unifying botanical
102 information (such as the World Flora Online – WFO; Borsch et al., 2020) or presenting open data
103 (such as the Global Biodiversity Information Facility – GBIF). There is substantial potential for
104 bringing together existing networks, e.g., of botanic gardens and of arboreta (Turner-Skoff et al.,
105 2021), as well as crop gene banks or other repositories of living germplasm (all of which can
106 hold conservation grade collections) and all the relevant actors and data for coordinated action
107 on specific plant groups and topics.

108 Living plants collections have unique origins and histories in cultivation that can be
109 documented in enormous detail. Dedicated software such as IrisBG, BGBase, BRAHMS, or
110 Hortis offer extensive options for capturing and sharing information on botanic gardens
111 collections, including origins (wild or garden), documentation (including e.g. collection permits
112 and International Plant Exchange Network [IPEN] identifiers), current location, and monitoring
113 histories of accessions and even of individual plants. Such data are fundamental to
114 understanding the value and potential of the plants and collections that make up
115 metacollections, and they are needed at least at a basic level in order to compare collections to
116 one another. However, we cannot assume that it has been recorded consistently (or indeed at
117 all) between (or even within) collections. This is a substantial barrier to effective comparison.

118 Tools such as BGCI's PlantSearch offer a potential means of establishing global solutions for
119 comparing data on living plant collections. As of December 2025, PlantSearch had integrated
120 WFO for more effective parsing of plant names (Malcolm, 2026). Subsequent work focussed on
121 the development of an accession-level module representing more of the data that is essential

for conservation-grade metacollections that was released in August 2026. At the time of writing few collections have yet uploaded accession-level data. Existing metacollections are generally limited in scope, with focus on individual species such as *Amorphophalus titanum* (Murrell et al., 2025) or *Wollemia nobilis* (Offord and Zimmer, 2025).

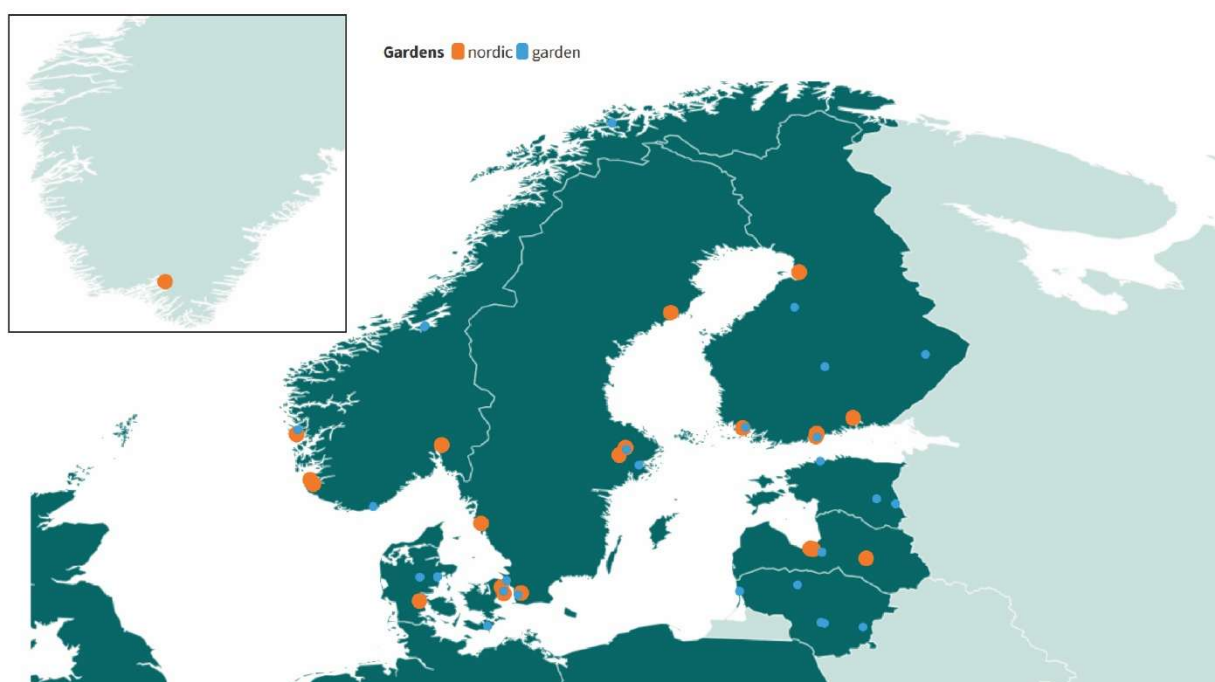
Botanical gardens and arboreta need to coordinate to set priorities both for data standards and for species. Irrespective of the availability of tools, progress towards effective metacollections will require focussed effort on data quality at individual institutions. With limited resources, progress might be achieved stepwise, with important milestones in the form of individual secured taxa and advances in knowledge, through the collaboration of specialist collections and staff. Such partnerships can range from local to global in scope (Pearce et al., 2020), but regional networks offer the chance to focus on local themes, such as threatened native plant diversity and regional effects of climate change.

We aim to establish an effective means for sharing and comparing data for plants held across Nordic collections, using open data and standards that can ultimately feed seamlessly into global solutions. Here, we report on the process and results of identifying priority temperate woody taxa and synthesising a Nordic meta-collection with particular focus on using the results for conservation of threatened species.

Materials and Methods

The gardens represented in our network are spread across the Nordic region Fig. 1. They include university botanical gardens, public municipal collections and not-for-profit gardens and arboreta with diverse aims and thus also levels of documentation (Appendix 1, including database solutions used in the different collections).

Fig. 1. Map of gardens and arboreta contributing to the metacollection (larger orange dots; Greenland inset) and other regional collections (smaller blue dots), generated in Flourish (see <https://public.flourish.studio/visualisation/29847892/> for an interactive version)



Source: [World Bank](#)

Our overarching aim was to find priority plant species held between the different collections: those a) of greatest conservation importance (the focus of this paper) and b) with potential for assisted migration (relevant for future work). The former are represented by IUCN red list threat assessments. The latter might be identified as (non-native) taxa already held in multiple collections.

Having selected priority taxa, we needed to compare accession-level data for those taxa. Particularly for threatened species, it was important to summarise wild versus garden origins and to estimate diversity within species in the meta-collection. For effective comparison of both names and accessions it was necessary to identify inconsistencies and gaps in the available data. We aimed to establish routines for sharing data both amongst gardens and in the public domain, collaboratively developing existing tools and resources, primarily the World Flora Online (WFO) and BGCI's PlantSearch.

Names data:

Names data in collections is typically documented as accessions are obtained and is not removed thereafter. It can therefore represent more taxa than are currently held and can give an indication of those that, for whatever reason, did not persist in the collection. Each collection

170 provided lists of names of taxa (some already filtered to represent just woody trees and shrubs).
171 These were qualified with taxon authorships in some but not all cases.

172 We used names data provided by the WFO (The World Flora Online Consortium et al., 2025),
173 aiming to implement a “Nordic Arboretum taxonomic backbone” to consistently interpret
174 names represented in the different collections. These names lists were compared using the
175 WFO name matching tool (<https://list.worldfloraonline.org/matching.php>, accessed
176 26/08/2026). Ambiguities and inconsistencies were identified and returned to the gardens with
177 possible resolutions along with WFO identifiers for all names. In case of ambiguities, (which
178 were more of an issue in collections where there was no stored authorship) likely resolutions
179 were reached based on closest nomenclatural matches and preferring accepted over unplaced
180 or synonymous names. We excluded cultivars and indeterminate names (e.g. denoted ‘cf.’ or
181 ‘aff.’). Once WFO IDs were attached to collections names we parsed them through the WFO ID
182 expander (<https://list.worldfloraonline.org/expander.php>, accessed 26/08/2026) to get the
183 accepted taxonomic status, accepted species and other data.

184 We summarised both prior to and after automated and (where necessary) manual corrections to
185 names (including applying synonymy following WFO), counting the numbers of names
186 represented in each collection and across the metacollection. We summarised the numbers of
187 names of different taxonomic status (i.e., ‘accepted’, ‘deprecated’, ‘synonym’, and ‘unplaced’;
188 following WFO) used in the different gardens; numbers of unique names, numbers represented
189 in single versus multiple collections (including those held across most or all of the collections),
190 and numbers of taxa by IUCN threat status (IUCN, 2025). After the June 2026 WFO and 2026
191 IUCN Red List releases the data was updated.

192 Having summarised numbers of threatened taxa across collections, we were able to decide on a
193 threshold for degree of threat within which each collection would deliver realistic numbers of
194 accessions to prioritise in subsequent steps: we opted to include all threatened categories. To
195 ensure that the lists were maximally comparable, we excluded remaining non-woody taxa
196 primarily by comparing to life form data (based on World Catalogue of Vascular Plants; WCVP
197 and the Global Tree Assessment). In addition, taxa kept permanently under glass (particularly at
198 UCPN and UiB) were excluded (those at the University of Oslo [UiO] had already been excluded
199 through earlier filtering within UiO’s own database).

200 *Accessions data:*

201 We based our target standards for accessions-level data on a draft version of BGCI’s
202 PlantSearch accessions module (subsequently published in BGCI’s Guide to Accessioning

Living Collections; Malcolm, 2026). The fields are listed in Appendix 2. These include information on 1) names (genus, species, etc. disambiguated with author/WFO identifier; cultivar) and (regional) data associated with names (regulations such as CITES or other restrictions); 2) source (e.g. collection, accession identifiers, provenance type); 3) origin in the wild (e.g. collector, locality including lat/long coordinates and elevation [which enables cross checking of coordinates]); and 4) current status (e.g. numbers of individuals, dates of accessioning and last checking).

We sent to each collection an individual priority list of threatened taxa represented in their own data. Each collection then returned accession-level data available for those taxa. We summarised the data that corresponded to PlantSearch accession fields and noted the different databases/formats in which the data is maintained. We discussed online and at a SNS-funded meeting in August 2026 issues arising from this process including data ownership and sharing and shortfalls in necessary resources.

Having established priorities for taxa and for data, individual collections consulted on practical solutions (where needed) and into the growing season of 2026 prioritised updating data. We tested importing the accessions data into PlantSearch and exporting data for direct comparison; pending registering outstanding partners in GardenSearch and developing accession number systems for those lacking such (but prior to final publication) the dataset will be uploaded to PlantSearch with accessions flagged under the metacollection “Nordic Arboreta”.

Results

Names data:

Numbers of taxa represented in gardens data and changes following the matching process are presented in Table 1 and summarised in Fig. 2. Abbreviations for gardens are as follows:

Rhododendron Breeding and Testing Nursery “Babīte” (University of Latvia Botanical Garden):

Babīte; University of Bergen, Arboretum and Botanical Garden: **Bergen**; Botanical Garden of

University of Copenhagen: **Copenhagen**; Geografisk Have, Kolding: **Kolding**; Göteborgs

botaniska trädgård: **Göteborg**; Arboretum Groenlandicum: **Greenland**; Horticultural Gardens

(Faculty of Life Sciences), University of Copenhagen: **Frederiksberg**; Hørsholm Arboretum:

Hørsholm; Kalsnava Arboretum: **Kalsnava**; Lund University Botanical Garden: **Lund**; Meilahti -

Helsinki city arboreta: **Meilahti**; Arboretum Mustila: **Mustila**; Niskala - Helsinki city arboreta:

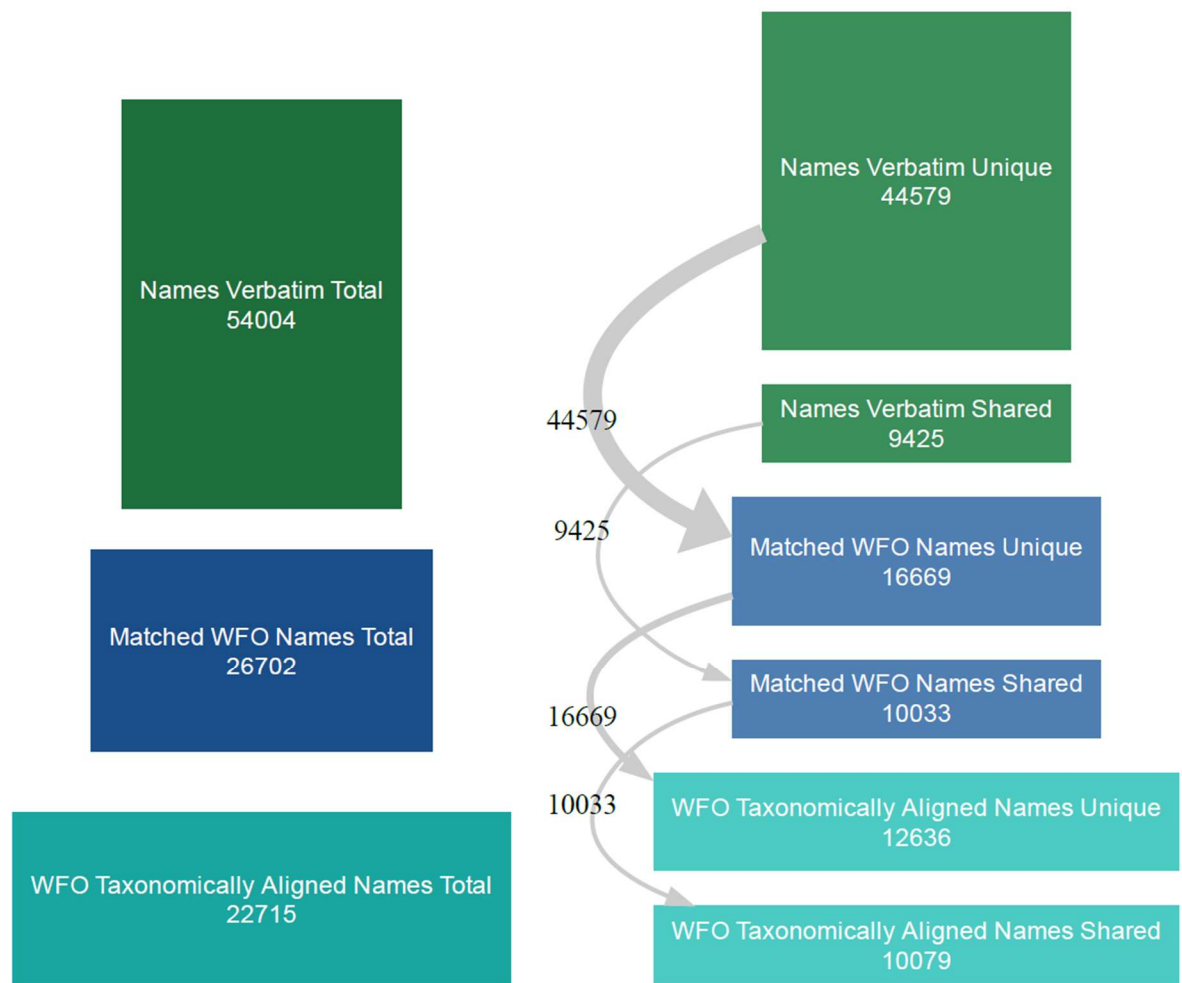
Niskala; Rogaland Arboretum: **Rogaland**; Stavanger Botanical Garden: **Stavanger**; Stiftelsen Arboretum Norr: **Norr**; The Linnaeus Garden - Uppsala University: **Uppsala**; Turku Botanical Garden: **Turku**; University Botanical Garden (Oslo): **Oslo**; Stiftelsen Ekolsunds Slott och Park: **Ekolsund**; University of Latvia Botanical Garden: **Latvia**; University of Oulu Botanical Gardens: **Oulu**.

Table 1. Numbers of names and their taxonomic status per garden based on the WFO June2026 classification. Some gardens, e.g. Oslo, pre-filtered their names data to woody taxa only, so the numbers are not representative of collections as a whole. Ekolsund figures tbc.

Taxonomic Status	Ba bit e	Berg en	Cope nhag en	Ekol sun d	Frede riksbe rg	Kold ing	Göte borg	Gree nlan d	Hørs hol m	Kals nava	Latvi a
accepted	230	8909	6636	459	3030	718	870	70	1114	655	367
synonym	24	2453	1340	16	609	146	147	1	231	159	101
unplaced	3	328	209	7	101	27	15	1	20	24	7
deprecated	1	16	12	0	11	0	0	0	1	0	0

Taxonomic Status	Lun d	Meil ahti	Must ila	Nisk ala	Norr	Oslo	Oulu	Roga land	Stav ange r	Turk u	Upp sala
accepted	920	140	820	196	320	650	364	941	9125	1014	4446
synonym	161	31	214	44	52	95	72	195	2585	256	507
unplaced	14	6	18	2	4	8	6	21	321	32	86
deprecated	1	1	2	0	0	0	0	3	35	1	3

Fig. 2. Numbers of taxa: distinct names, those recorded in single collections, and those shared across multiple collections following correction and taxonomic alignment.



A total of 72,111 names were represented in the original gardens data, of which 54,004 were distinct, 44,579 were only found in a single collection and 9,425 were found in more than one collection. Some gardens filtered the names data to represent only trees and shrubs; others provided comprehensive lists.

After name matching to the WFO, the total distinct names dropped to 26,702 across collections (c. 50%), of which 16,669 names were found in a single collection (reduced 63%) and 10,033 were found in more than one (increased 7%). After taxonomic alignment, distinct names dropped to 22,715 (reduced 58% from the original numbers) and those found in a single collection decreased to 12,636 (reduced 72%), but those found in more than one collection increased to 10,079 (increased 7%) (Fig. 2).

All collections data included a proportion of names considered deprecated, synonymous or unplaced under WFO (Table 1). In addition, most collections data included names that could not initially be matched. These included some names that were missing on WFO but could be found by reference to other names databases. As a result, we newly added 125 names to WFO. Expected mismatches included cultivars, trade names, and hybrid formulae that are not treated under WFO (15,555); “indet” names (provisional names where the plant had not been sufficiently identified, ranging from identified only to genus to entirely unknown; 3,925) and those that were sufficiently ambiguous that they could not be resolved without checking by individual curators (usually due to homonyms and incomplete authorship when name matching; 1558). There were 76 instances of lacking or incorrect WFO data for which a match could be made once authorship or name orthography was updated.

The top 14 shared names along with their conservation status and the numbers of gardens at which they are kept are presented in Table 2. Most are not of conservation concern (Least Concern) but one (*Tsuga canadensis*) is Near Threatened and one (*Magnolia kobus*) is Data Deficient. Half are conifers.

Table 2. Most shared taxa, the numbers of gardens at which they are kept, and their conservation status.

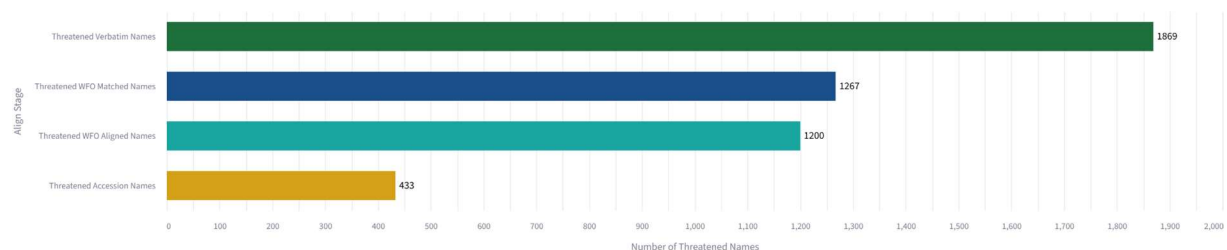
Name	Number of gardens	Red List Status
<i>Quercus robur</i> L.	21	Least Concern
<i>Pinus sylvestris</i> L.	21	Least Concern
<i>Sorbus aucuparia</i> L.	21	Least Concern
<i>Magnolia kobus</i> DC.	20	Data Deficient
<i>Quercus rubra</i> L.	19	Least Concern
<i>Thuja occidentalis</i> L.	19	Least Concern
<i>Taxus cuspidata</i> Siebold & Zucc.	19	Least Concern
<i>Taxus baccata</i> L.	19	Least Concern
<i>Larix kaempferi</i> (Lamb.) Carrière	19	Least Concern
<i>Tsuga canadensis</i> (L.) Carrière	19	Near Threatened
<i>Pseudotsuga menziesii</i> (Mirb.) Franco	19	Least Concern
<i>Picea abies</i> (L.) H.Karst.	20	Least Concern
<i>Acer platanoides</i> L.	19	Least Concern
<i>Hamamelis virginiana</i> L.	19	Least Concern

290 Numbers of threatened taxa changed following taxonomic alignment, impacting all collections
 291 holding 8 or more such taxa (Appendix 3). In several cases this changed the numbers of CR taxa.

Accessions data:

Of 1200 WFO aligned threatened taxa in names databases, 433 (36%) were documented with accession data (Fig. 3; i.e. 767 have been recorded in one or more gardens but are not currently documented as living plants in the metacollection).

Fig. 3. Numbers of names of threatened taxa represented in the verbatim data; as WFO matched names; as WFO aligned names; and as WFO aligned names of accessions (i.e. records of living plants). Threat status is tracked back from the status known from WFO aligned names, so would not necessarily be known from the verbatim data alone.



The synthesised accession-level data for threatened taxa are included in Appendix 4 (<https://doi.org/10.5281/zenodo.23764541>; along with archive records of original names and accessions data) and will be uploaded to BGCI PlantSearch. Table 3 presents a summary of accession-level data received for these taxa (in several cases following rounds of improvement), including the number of PlantSearch fields (out of 26) represented in the datasets. The highest number of fields represented was 22, but the only consistently omitted field was “Wild Occurrence Restriction” (relating to masking of sensitive distribution data). The population of these fields (when included) with data was often incomplete, in part because those relating to wild origins do not apply to garden or unknown origin plants; in part due to inconsistent data entry or simple omission. The total number of accessions of threatened woody taxa held across collections was 3192 (as summarised in Table 4; Appendix 4).

Around 27% of unique accessions are clearly flagged as wild (W) and a further 11% as wild derived (Z), with 24% garden origin (G) and 38% unknown (U) or not coded. Currently missing data is potentially retrievable from free-form text fields, with 54% of accessions including information under ‘Country’ (which can suggest wild origin) and 55% including information

under ‘external source’ (often referring to a source institution from which more information might be cross-referenced).

Table 3. Summary of accessions-level data per collection, including numbers of accessions and names, proportions of wild, garden, and unknown origin, and numbers of PlantSearch fields represented in each dataset.

Collection	#Accs	#Names	W%	Z%	G%	U%	#fields of 26
Babite	43	37	14	12	26	49	4
Bergen	440	219	45	18	28	9	22
Copenhagen	121	89	26	7	65	1	22
Ekolsund	52	38	2	25	19	54	15
Göteborg	230	102	45	20	30	5	18
Greenland	2	2	0	0	0	100	6
Hørsholm	306	115	48	4	23	25	17
Kalsnava	104	53	2	0	94	4	5
Kolding	111	42	2	4	29	66	3
Latvia	33	33	9	6	0	85	3
Lund	129	61	1	2	2	95	14
Meilahti	13	5	0	0	0	100	2
Mustila	828	152	25	12	0	64	8
Niskala	19	14	0	0	0	100	2
Norr	35	22	37	0	63	0	8
Oslo	92	40	20	5	7	68	22
Oulu	44	17	45	16	14	25	5
Rogaland	328	146	30	17	29	23	5
Stavanger	53	44	4	13	32	51	10
Turku	114	54	5	4	90	1	5
Uppsala	95	50	13	3	9	75	18

The top 10 shared threatened plants are listed in Table 4, including the numbers of gardens (with names data, and with living accessions), and the numbers of W/Z (omitting Fredriksberg – data currently unavailable). Six of 10 taxa are conifers. In several cases the count of gardens with

living accessions was lower than that of gardens with names records, generally indicating that an attempt had been made to cultivate the taxon but is not reflected in records of plants currently alive. The 10 most shared threatened *Rhododendron* taxa are listed in Appendix 5 and are shared between up to 11 different gardens.

Table 4. The top 10 shared threatened plants across the metacollection, their threat status (Near Threatened: NT; Endangered: EN; Critically Endangered: CR), the numbers of gardens (with names data, and with living accessions), and the numbers of wild (W) and wild derived (Z) origin.

Name	Red List Status	Number of gardens (names / accessions data)	Number of accessions (total / W and Z)
<i>Tsuga canadensis</i> (L.) Carrière	NT	18 / 18	69 / 26 (38%)
<i>Juglans cinerea</i> L.	EN	17 / 14	75 / 18 (24%)
<i>Fraxinus americana</i> L.	CR	16 / 16	49 / 24 (49%)
<i>Metasequoia glyptostroboides</i> Hu & W.C.Cheng	EN	16 / 16	89 / 40 (45%)
<i>Pinus peuce</i> Griseb.	NT	16 / 16	80 / 30 (38%)
<i>Picea omorika</i> (Pančić) Purk.	EN	16 / 16	66 / 16 (24%)
<i>Abies homolepis</i> Siebold & Zucc.	NT	16 / 15	61 / 20 (33%)
<i>Abies koreana</i> E.H.Wilson	EN	16 / 15	125 / 75 (60%)
<i>Ginkgo biloba</i> L.	EN	16 / 14	74 / 2 (3%)
<i>Fraxinus excelsior</i> L.	NT	16 / 14	70 / 16 (23%)

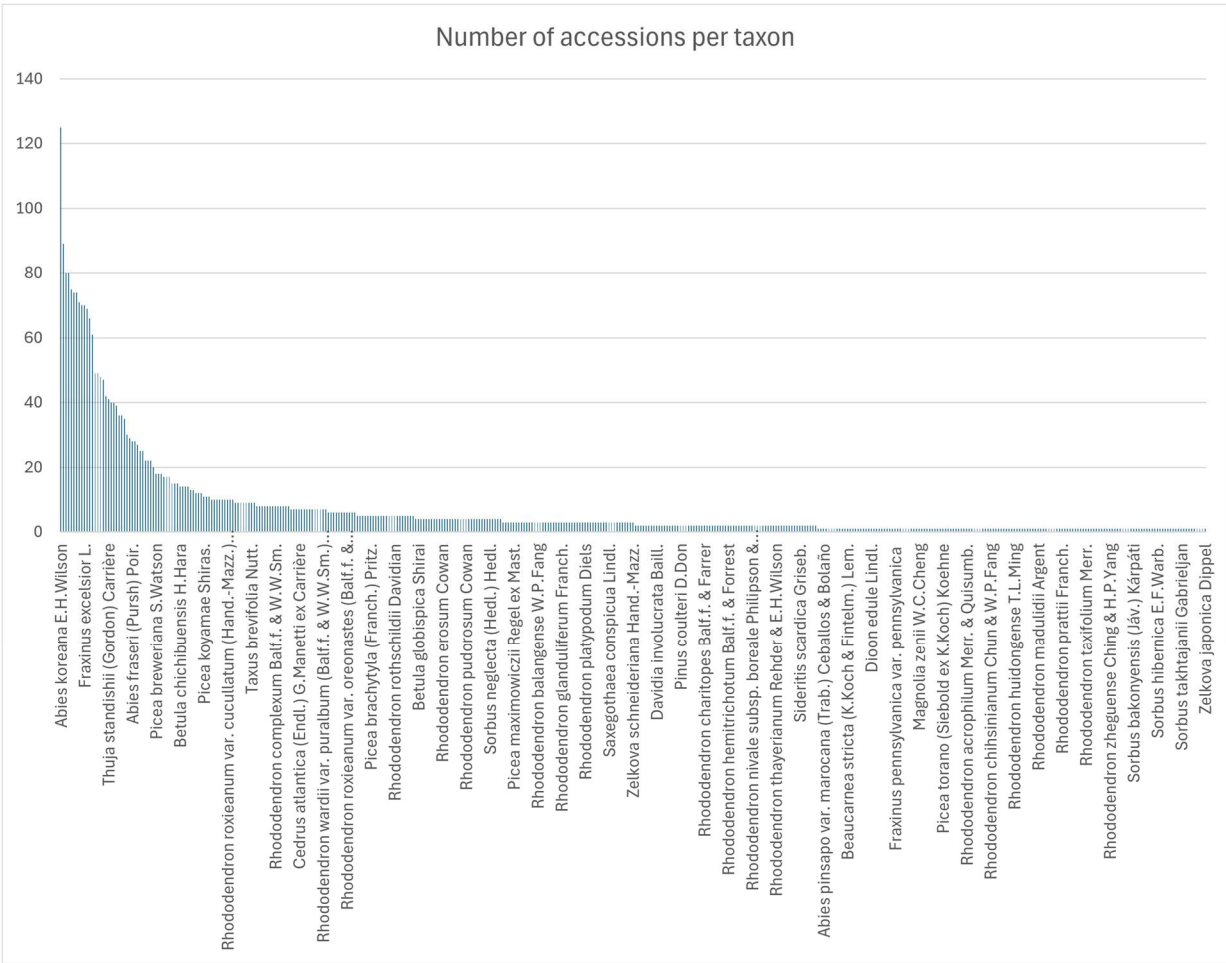
One example of accessions data for CR *Fraxinus americana* is illustrated in Fig. 4.

Fig. 4: Part of the *Fraxinus americana* accessions data, illustrating the different ways in which wild (highlighted darker green) or garden (lighter green) origins are documented: by provenance type, under external source (including some apparent wild origin information and reference to other partners in the metacollection, but without in this case examples of shared accession numbers), with reference to collectors and locality, and rarely with elevation and/or precise coordinates. Several different wild localities in the USA and Canada are represented. Some of the currently empty cells could be populated either by simple reformatting (to allow summary e.g. by state/province), georeferencing (from locality information to allow mapping), or cross-referencing (from collectors, external sources, and identifiers).

Collection	Accession Number	Provenance	External Source	External Number	Collectors	Country	State/Province	County	Municipality	Locality	Latitude	Longitude
Göteborg	1870-1842	Cultivated from wild	HÖRSHOLM		[162]	US	Connecticut			Cann. River		
Göteborg	1875-9723	Wild	Rudin		[162]	US	New Hampshire			Raymond		
Göteborg	2009-0776	Wild	HOLDEN			US	OH			Lake Co., the Holden Arboretum, woodland edge near entrance	42.11187°	-81.28117°
Hersholm	1936-0489	G	OTTAWA			Canada				Ottawa		
Hersholm	1937-0489	G	TORONTO			Canada				Toronto		
Hersholm	1938-1307	U	Petawawa Forest Experiment Station			Canada				Ontario, Chalk River, Petawawa Forest Experiment Station		
Hersholm	1948-008	G	S 307-18 TRAE 3			Denmark				Hersholm Arboretum		
Hersholm	1950-0129	U	W. C. Nielsen coll.			USA				Wiscasset, Maine		
Hersholm	1950-0129	U	W. C. Nielsen coll.			USA				Wiscasset, Maine		
Hersholm	1960-0905	W	TH SPRINGEN COLL.			Canada				Nova Scotia, Indian Creek		
Hersholm	1976-0238	U	Lars Rudin collecting trip to USA			USA				New Hampshire, Raymond		
Hersholm	1976-0238	U	Lars Rudin collecting trip to USA			USA				New Hampshire, Raymond		
Hersholm	1983-0135	W	GUELPH ARBORETUM, Guelph, Canada			Canada				Ontario, Brant County, Brantford	43	80
Hersholm	1983-0135	W	GUELPH ARBORETUM, Guelph, Canada			Canada				Ontario, Brant County, Brantford	43	80
Kolonia	3031	Garden	HJ. Budačanský									
Kolonia	3288	Wild	CA, Toronto University, wild origin									
Kolonia	4464	Garden	CZ, Kolice									
Lund	0000-4822	Unknown										
Lund	0000-4819	Unknown										
Lund	0000-4822	Unknown										
Lund	0000-4831	Unknown										
Lund	0000-4833	Unknown										
Nickala	P-33005-413	Unknown	Hankkijäpellä: Hannu Kortteineni Lääpäläho: -									
horr	4300	Wild	University of New Brunswick, Canada			CA				New Brunswick, Canada		
horr	4370	Garden	Arboretum Muttla, Finland									
horr	P25	Wild	Arboretum Muttla, Finland			USA				Portage la Prairie, Manitoba, Canada		
Oulu	85-871	Wild	GUELPH ARBORETUM, UNIVERSITY, ONTARIO, CANADA Canada, Ontario, Kent Co., Newrich Tp., 43° 27' N 81° 51' W, 176 m, open woods near Lake Erie shoreland.									
Rogersland	G-1990-147	Garden										
Turku	http://mus.utu.fi/AE.10220	G	GÖTTINGEN: FORSTBOTANISCHER GA. 112	1999-0799								
Turku	http://mus.utu.fi/AE.11156	G	TURKU BOTANICAL GARDEN	2003-0819								
Turku	http://mus.utu.fi/AE.11342	G	TURKU BOTANICAL GARDEN	2004-0400								
Turku	http://mus.utu.fi/AE.12929	W	MONTREAL [QUEBEC] HXV 282: 1AR: 212 (Parc National d'OKA)	2010-0088				Canada				
Turku	http://mus.utu.fi/AE.4064	G	TORONTO, ONTARIO M55 3B2: SEED: 318	1977-3239								
Bergen	W-1992-0713	Wild	Jardin Botanique de Montreal, Montreal, Quebec, HXV 282	11-1991-92/206		CA	Quebec			Montreal		
Orio	A-1947-148	Wild	Dep Agric. Ottawa 1947			USA	Ontario			Panama		
Copenhagen	F1870-2174	Wild	Arboretum Lierhøved			USA	Massachusetts			Amherst		
Uppsala	Unilabv408	Unknown	Unknown									
Uppsala	1874-2479	Wild	Freiburg									
Uppsala	2007-1056	Wild	Horden Arboretum			US	Ohio			USA: Ohio (Geauga Co., The Horden Arboretum, woodland edge bordering Horden Fd., 979 ft., 41°36' 63" N, 82°54' 346" W, s.n. 3 Nov. 2004.	42.60617°	-81.26676°
Uppsala	2000-1242	Wild	The Morton Arboretum			US				USA: Near the bank of French Creek River, Buncombe County, 648 m, 35°30' 21" N, 82°52' 28" W.	35.50626°	-82.89026°
Ekolund	2012-070	G										
Muttla	109-02-229	W				USA	Quebec	Ste-Aimée-Bellevue	Morgan Arboretum			
Muttla	109-02-212	W				USA	Quebec	Ste-Aimée-Bellevue	Morgan Arboretum			
Muttla	109-02-238	W				USA	Quebec	Ste-Croix	Domaine Joly de Lussigny			
Muttla	109-02-276	W				USA	Quebec	Ste-Aimée de Beaupré	Kaup, Ukropi, 15m 362 varietal			
Muttla	109-09-786	W				USA	New York	Minneapolis	Bellevue Mt.			
Muttla	109-09-839	W				USA	New York	Adirondack Park	Blue Mt. Lake			
Muttla	109-10-009	W				USA	Manitoba	Portage la Prairie				
Muttla	109-12-018	W				USA	New York	Saratoga Lake				
Muttla	109-12-077	W				USA	Quebec	Ste-Aimée	Tatnapouchie			
Muttla	109-91-151	W				USA	Ontario					
Muttla	109-92-226	W				USA	Manitoba	Morden	Gustaf			
Muttla	109-97-412	W				USA	Quebec	Chalk River	Morden Research Station			
Muttla	Opac86-P1.581	W										

The distribution of numbers of accessions per threatened taxon is presented in Fig. 5. The average number of accessions per threatened taxon is 7.4 with median 3. Around a third (147) are represented by single accessions in the metacollection including 57 *Rhododendron* and 21 *Sorbus* taxa, and 70 by just two, including 39 *Rhododendron* and 4 *Sorbus*.

Fig. 5: The distribution of numbers of accessions per threatened taxon in the metacollection (only a subset of 433 names shown; full data in Appendix 4)



Discussion

Our results illustrate how current management of living plant collections hinder and limit effective comparison of data between gardens (Brockington et al., 2026), and how this impacts our knowledge of the state of ex situ collections of threatened species. However, they also show the potential for rapid improvement of this situation with a collaborative approach and targeted action.

On the importance of aligning names data: Gardens data includes numerous taxa that have accumulated over time from different sources: they inevitably include synonyms, errors, and omissions. Particularly where names lack qualifying authorities, it is impossible to disambiguate homonyms without risk of error. For example, matching on the name *Sorbus japonica* yields two possibilities: *Sorbus japonica* (Decne.) Hedl, a synonym of *Micromeles*

japonica (Decne.) Koehne or *Sorbus japonica* (Maxim.) Koehne A synonym of *Sorbus commixta* Hedl.. Ultimately, there is an unavoidable workload for scientific curators to improve documentation and – in some cases – revisit individual collections to confirm their identities. However, many inconsistencies could be fixed with limited effort using openly available tools from the WFO.

The benefits of investing time in consistent naming are substantial: First, it dramatically (>70%, here) reduces the numbers of taxa recorded inconsistently that might otherwise be treated as unique to single collections ('horticultural endemics'). It is therefore essential for any realistic assessment of horticultural rarity. Once curators have correctly parsed names and included collections in PlantSearch, they can see how many other collections worldwide are documented as holding the same taxa and more reliably identify their own potential horticultural endemics. We identified several cases (as of PlantSearch data in August 2026), all taxa of *Sorbus* s.l. and of *Rhododendron* (both subjects of dedicated BGCI Global Conservation Consortia) (*Aria pannonica* (Kárpáti) Sennikov & Kurtto; *Aria stenophylla* (M.Proctor) Sennikov & Kurtto; *Hedlundia hazslinszkyana* (Soó) Sennikov & Kurtto; *Hedlundia subpinnata* (Hedl.) Sennikov & Kurtto; *Hedlundia takhtajanii* (Gabrieljan) Mezhenkyj; *Karpatisorbus pseudovertesensis* (Boros) Sennikov & Kurtto; *Rh. sanguineum* var. *didymum* (Balf.f. & Forrest) T.L.Ming; *Rh. mianningense* Z.J.Zhao). Ongoing work with an updated ex situ gap analysis of *Rhododendron* (Marion McKay, pers. comm.) identified three taxa not previously documented and unknown from collections outside our network: *Rh. × burjaticum* Malyshev; *Rh. flavantherum* Hutch. & Kingdon-Ward; and *Rh. aureum* var. *hypopitys* (Pojark.) D.F.Chamb.

Second, once corrected and made consistent with the WFO plant list, lists of names could be compared to linked data on WFO and on BGCI, including IUCN threat status and ThreatSearch, and taxa of concern flagged for action. Keeping up to date with the changing threat status of taxa in collections is impossible without linked up data, and some of these results came as a surprise and call to action to our network's curators.

Through checking datasets, we were even able to identify and fix errors in the WFO: adding 125 names that were missing and correcting a further 76. This virtuous cycle of shared data improvement benefits everyone through FAIR (Wilkinson et al., 2016) access to regular updates of the WFO. Taxonomists in our network contribute to improving the WFO through the collaborative Taxonomic Expert Networks (e.g. for Ericaceae). These can negotiate consensus on controversial names in principle. However, individual curators do not have to agree e.g. on

407 the delimitation of genera in *Sorbus* s.l.: we can interpret both accepted names and synonyms
408 consistently by employing WFO as a taxonomic backbone.

409 *On the importance of aligning accession-level data:* By including information on origins of
410 individual accessions, particularly distinguishing those sourced from the wild (W or Z) from
411 those of garden origin (G), curators are able to identify which material may be suitable for
412 reintroduction or other programmes, and at which collections such material might be available
413 and benefit from securing at independent sites.

414 The extent of the challenge for data comparability is even greater when moving beyond taxa to
415 accession-level data. Of the 26 data fields prioritised for BGCI's PlantSearch, the maximum
416 represented in our data was 22 and half the datasets included 10 or fewer. The information
417 available was heterogeneous in quality and completeness, collected and documented in
418 different ways over many years. Most (19) datasets included accession numbers; several
419 collections introduced or improved their identifier systems during this work. Most (19) also
420 included a field with description of the source of the material, and many (15) explicitly
421 distinguished provenance types (W, Z, G, U or equivalents). However, there is inconsistency
422 both between and within individual datasets. The information on source of material often
423 includes both garden and wild origins without separate fields that render that information
424 directly comparable (e.g., qualifying wild origin separately with locality and/or coordinates).
425 There are also substantial backlogs in digitisation, with data stored in ways that do not facilitate
426 access, and of updating of information, for plants that may or may not still be alive. Examples
427 described in Appendix 2 and further illustrated for *Fraxinus americana* in Fig. 4 are probably
428 common.

429 There are not necessarily easy solutions to these challenges: resources must be found for
430 labour-intensive curation. However, progress can be made, even with limited resources, when
431 there are clear priorities. Several of our network were able to survey manageable lists of
432 endangered taxa within the limited period of this project. We could identify both widely and
433 rarely shared threatened taxa and compare accessions information, revealing contrasting
434 numbers and origins of accessions between taxa. The taxa most widely shared across the
435 metacollection are often represented with numerous individual accessions: there are between
436 49 and 125 accessions each of the top 10 most widely shared threatened taxa. However, most
437 are represented by much smaller numbers and many with just single accessions. Some
438 commonly held species, such as *Ginkgo biloba* L. and *Picea omorika* (Pančić) Purk., are widely
439 cultivated from garden-origin material. However, 60% of the 125 accessions of *Abies koreana*

E.H.Wilson are of wild origin. Current gaps in the data suggest that with greater focus on consistent record keeping, more existing material will yet be revealed to be conservation grade.

Conserving plant diversity into an uncertain future: With notable exceptions as above, individual gardens rarely hold numerous accessions or specimens of the same taxon. Often, the remit is to display a broad diversity of taxa to the public or for use in teaching. For conservation of threatened species (or potentially useful ones) this is unfortunate: we need to conserve representative genetic diversity (Griffith et al., 2015; Khoury et al., 2019). Another challenge is the limited lifespans of individual plants in collections. Even long-lived trees only survive on average 20 years in botanic gardens, and even those with priority conservation status are only maintained a few years longer (Cano et al., 2025). To conserve viable numbers of representative individuals over long time frames we need to find new ways of working.

Context is important here: If we compare directly to best practice in forestry for widespread and abundant tree species it is clear that the numbers of individuals required to maintain genetic diversity over generations with a dynamic conservation approach (EUFORGEN, 2026; Koskela et al., 2013) are well beyond anything that would realistically be achieved in botanic gardens. However, requirements are not consistent between species (Hoban et al., 2020) and threatened species are by definition represented by far fewer remaining populations. Furthermore, the soberingly short half-lives of trees in collections apply to individual gardens acting alone. With targeted propagation and sharing of existing material as well as horticultural knowledge, limited genetic diversity of some plants can be maintained in static conservation (i.e., avoiding sexual reproduction and crossing and/or selection in cultivation) long term. *Erica verticillata* P.J.Bergius was maintained independently in botanic gardens decades after it became extinct in the wild but without awareness of its status (Hitchcock and Rebelo, 2017). We need not and should not rely on such good fortune for the hundreds of threatened taxa in our safekeeping.

On the benefits for individual collections: Our network includes a range of collections with diverse remits: university gardens with focus on research and teaching; non-profit organisations with focus on public events; government run parks and conserved areas and even historic sites. However, we share common challenges: in particular limitations in resources, such as staffing, but also challenges in horticulture, including shifts to renewable resources; pests and diseases; and invasive species. There is a strong need to work together in order to achieve the critical mass needed to address these effectively and to be resilient despite changing circumstances.

Botanic gardens access to material is increasingly limited and internationally such collections are no longer expanding (Cano et al., 2025). Even the larger collections are geographically

473 restricted and vulnerable as single sites, and they have greater numbers of unique taxa and
474 accessions at risk of loss. Resources will always be limited compared to the scale of the task of
475 effectively securing the large numbers of threatened species.

476 Sharing of both expertise and – ultimately – plant material will enable gardens to improve the
477 qualities of their collections without necessarily expanding efforts. Where gardens do have
478 resources and opportunities to expand or renew through collection, targeted efforts and
479 improved sharing and communication of data and material will increase their impact.

480 *On monitoring and assessing future progress:* There is a minimum of comparable information
481 needed within and across gardens to have an accurate and current picture of shared and unique
482 taxa and diversity within them. Our results illustrate how even WFO-informed name-based
483 summaries can deliver an overly optimistic picture of the state of collections for ex situ
484 conservation: only about a third of threatened names in databases corresponded to digital
485 records of (hopefully still) living accessions. We can now show our individual and joint coverage
486 of threatened woody temperate plant taxa. By agreeing on key information needed to document
487 conservation (and research) grade material and on a means to share and compare the data (e.g.
488 through PlantSearch) we can demonstrate our progress toward important goals in ex situ
489 conservation. Even where such data is incomplete, such as is the case in our network,
490 effectively lining up the existing information can provide an overview of gaps and allow
491 prioritisation of efforts.

492 At the level of individual gardens, we should aim to increase numbers of accessions of key
493 threatened taxa and the proportions of those of wild origin. This is achievable through exchange
494 even without obtaining new collections. Past sharing of material within the network is apparent
495 in the data (Fig. 4): this should be encouraged and guided (for example to represent proxies for
496 genetic diversity; Hanson et al., 2017). By reporting numbers of actively shared accessions, we
497 can promote the activities that increase useful redundancy and reduce horticultural endemism
498 (currently threatening at least a third of 433 threatened taxa across the network). We can aim to
499 improve data completeness, focussing our limited resources on (potentially) wild origin
500 accessions of threatened taxa. Two important elements that we did not address in this first
501 analysis but should be included in future updates are recency of status updates and
502 specimen/individual-level data including method of propagation. This will give us an even more
503 realistic and detailed assessment of the current state of our most important collections and of
504 redundancy/genetic diversity within them.

Conclusions: In establishing the Nordic metacollection we have identified unique and important living collections of temperate woody plants which we can now collaborate to safeguard against both threat in the wild and the risk of loss in cultivation. By acting together, we are collaboratively improving our data, information management, and communication across the network. By adopting open data standards, we are enabling future expansion to more species and further international partners, such as the Global Conservation Consortia, for which this metacollection will be an important set of safe sites, particularly for *Rhododendron*, *Sorbus*, and conifers. In this way we can leverage the strengths of our regional network in a global context. We can show the importance of specific future steps, such as monitoring and sharing of priority material, and document our progress to achieving them. In a period of accelerating climatic change and biodiversity crisis, as well as increasing pressure on living plant collections this action is highly timely.

Acknowledgements

This joint Nordic project has been supported by the Nordic Council of Ministers / SNS.

Author Contribution

Design of the research: MDP, AE; data collection: MDP, HLA, JB, RKB, LB, IWJ, TJ, TK, AL, NL, ØL, NAM, SO, FR, JR, AR, JS, IS, JS, HS, LS, JU, TZ; data analysis: AE, MP, PM; writing the manuscript: drafting: MDP; revision and final approval: all authors.

Data availability statement

Data analysed for this research are available as supplementary materials (appendices including an openly available data archive on Zenodo: <https://doi.org/10.5281/zenodo.23764541>) and will be shared through BGCI PlantSearch (available to all registered Botanic Gardens).

Conflict of interest statement

We confirm that there are no conflicts of interest relating to the work.

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Supporting information

Appendix 1: Arboreta and gardens included in the Nordic metacollection and their means of maintaining data.

Collection	Database
Arboretum (https://gardensearch.bgci.org/garden/4200) and Botanic Garden (https://gardensearch.bgci.org/garden/4199), University of Bergen, Norway	IrisBG (https://irisbg.com/)
Hørsholm Arboretum, Denmark (https://gardensearch.bgci.org/garden/6383)	Custom
Arboretum Groenlandicum (https://gardensearch.bgci.org/garden/6429).	Custom
University of Copenhagen Botanical Garden, Denmark (https://gardensearch.bgci.org/garden/5449)	IrisBG
Horticultural Gardens (Faculty of Life Sciences), University of Copenhagen, Denmark (https://gardensearch.bgci.org/garden/2586)	Custom
Geografisk Have, Kolding, Denmark (https://gardensearch.bgci.org/garden/7269)	Custom (MS Access / Wordpress webpage; see notes)
Oulu University Botanic Garden, Finland (https://gardensearch.bgci.org/garden/3929)	Unikko (developed by students 2005-2007, works on current platforms but in need of update)
University of Turku, Finland (https://gardensearch.bgci.org/garden/3930)	Kotka Collection Management System (https://wiki.helsinki.fi/xwiki/bin/view/digit/Kotka%20Collection%20Management%20System/)
Arboretum Mustila, Finland (https://gardensearch.bgci.org/garden/3928)	Custom (MS Excel with partial card database; see notes)
City of Helsinki, Finland (https://vihreatsyliit.fi/en/meilahden-arboretum/ , https://vihreatsyliit.fi/en/niskala-arboretum/)	Puurekisteri Microstation database, MS Excel
University of Oslo Botanical Garden, Norway (https://gardensearch.bgci.org/garden/4198)	IrisBG
Stavanger botanic garden (https://gardensearch.bgci.org/garden/4196)	IrisBG

Rogaland Arboretum, Norway (https://gardensearch.bgci.org/garden/7237)	IrisBG
Lund University Botanical Garden, Sweden (https://gardensearch.bgci.org/garden/4347)	Hortis
Stiftelsen Arboretum Norr, Sweden (https://www.arboretum-norr.se/)	Custom
Linnaean Gardens of Uppsala, Sweden (https://gardensearch.bgci.org/garden/4349)	Bg-Base
University of Gothenburg, Sweden (https://gardensearch.bgci.org/garden/4348)	IrisBG
Stiftelsen Ekolsunds Slott och Park, Sweden (https://gardensearch.bgci.org/garden/7264)	Custom
University of Latvia Botanical Garden, Latvia (https://gardensearch.bgci.org/garden/6479)	Custom
Rhododendron Breeding and Testing Nursery “Babīte”, University of Latvia Botanical Garden, Latvia (https://gardensearch.bgci.org/garden/7267)	Custom
Kalsnava Arboretum, Latvia (https://gardensearch.bgci.org/garden/7048)	Custom (ArcMap/LVM Geo geodatabase (incomplete); MS Excel)

Notes:

Geografisk Have, Kolding, Denmark (since 1953):

Historically keeping data over the plant collection has been very sparse and unsystematically maybe due to the fact that the garden was not made as a scientific collection with the aim of natural preservation. But rather a public garden and collection of plants introduced to Denmark by Aksel Olsen. Therefore, many plants originate from nurseries and are not collected from nature. From 1968 to 2010 plants were not systematically registered when planted in the garden. In 1953 and 1981 an inventory of the old part of the collection 'Syvdalen' was made. In 1985 an inventory of the rest of the garden was made. From 2010 to 2025 the database was stored in Microsoft office access docs. From 2025 the database was moved to a Wordpress based homepage on the internet.

Only since 2018 data has been updated continuously and systematically and plants given a unique accession number when planted in the garden with data on where the plants have come from. The numbers are simply made from the year of planting and a following number starting from 1 new every year. For example, “Betula pendula 202601” is the first plant planted in 2026 and so on. Numbers starting with 100 are plants planted before 2016 and here the time of planting is not known exactly. In some cases the planting time can be narrowed down somewhat by looking through the old inventory lists.

Plants that arrive in the garden with an accession number get a new number and the existing number is written into the database under 'remarks'. Plants are usually not registered before they are planted in the garden. New arrivals may stand in the 'nursery' a year or two before being planted and registered.

When plants die they are taken out of the database and put on a separate list (since 2017).

Arboretum Mustila, Finland:

The plantations data that are in very diverse formats:

- Publications by A. F. Tigerstedt (1922, 1925, 1926, very comprehensive)
- Publication by P. M. A. Tigerstedt (editor; 1996): Arboretum Mustila -- Publications of the Finnish Dendrological Society, Vol. 2. Helsinki.
- Card index of forest plantations 1928-1954 (excluding woodland gardens)
- Semi-scientific guide books (very useful)
- Mixed old archive data (letters, delivery lists, inventories etc.)
- "Plantations register" Excel index (complete 1987-2010, the rest incomplete, but for some plantations, this is the only place where they are listed)
- "Seed register": Excel file of seed, plant & cutting accessions (complete 1989-2023, unpolished for 2024-2026, includes all handled material including many accessions never eventually planted in the collection)*
- Map/card/sheet files (1987-2025, incomprehensive, but ca. 6000-7000 plantations in these)
- Yearly planting reports/summaries (included in the index, except last few years)
- Private memo-aid drafts (must be deciphered by the persons behind them)
- Memorised information (only existing in the minds of old workers)
- A few plantations of 2021 are only mapped in our tentative QGIS map system, which is not currently in working condition

Beyond the main arboretum, there are satellite collections (important seed sources) in public lands outside Mustila.

*This is the data included in this analysis, representing all accessions currently available in digital form.

Appendix 2: Summary of the draft PlantSearch fields used for accession-level documentation, excluding name-based fields (which are covered by WFO), with equivalent DarwinCore field names where known. The 26 summarised in Table 3 do not include ‘collection’ (always implicit in a given dataset) or ‘germplasm type’ (we only looked at records of living plants).

Data category	Field Name	DarwinCore name	Description	Upload information
Source	Collection		Name of Garden/Arboretum	
Source	Accession Number	?catalogNumber	The unique ID given to material when it is registered and labeled on entry to the collection of the garden. The accession number tracks the genetic line and allows to link back to the original occurrence informatino if it is wild collected material. Accession: Plant material (individual or group) of a single taxon and propagule type with identical or closely similar parentage acquired from one source at the same time.	Separate values by commas for multiple donor Possible Values: Pedigree ID(s), UNKNOWN, WILD
Source	IPEN Number		Unique ID number assigned by the International Plant Exchange Network, if applicable.	
Source	External Source		Name of donor organisation or individual; or additional information about the original source of this accession.	
Source	External Number		If germplasm has been donated provide the Unique ID (accession number) provided by the donating garden.	
Source	Provenance Type		The type of source of this accession. Garden Origin (G): transferred from another garden, nursery, or commercial outfit. Wild Origin (W): obtained directly from a wild population. Wild-Derived (Z):	Uppercase, lowercase, and abbreviated values are acceptable. Possible Values: Wild (W), Wild

			derived from wild-origin, second generation or more. Unknown (U): unknown origin.	Derived (Z), Garden (G), Unknown (U)
Wild origin	Collection Date	dwc:Event:eventDate	Date this accession was collected in the wild.	For estimated date, either omit month or day, or indicate estimate level in “Collection Date Estimate Level” field. Acceptable Formats: YYYY-MM-DD, YYYYMMDD, YYYY-MM, YYYYMM, YYYY
Wild origin	Collector	dwc:Occurrence:recordedBy	A list of names of people, groups, or organisations responsible for collecting this accession.	
Wild origin	Collector Number	dwc:Occurrence:recordNumber OR dwc:Event:fieldNumber	Identifier(s) assigned by the collector(s) at the time this accession was originally collected.	
Wild origin	Locality	locality	Details of the specific location of the original wild collection of this accession.	
Wild origin	Municipality	municipality	The name of the next smaller administrative region than county (city, municipality, etc.) of the location where this accession originated.	
Wild origin	County	county	The name of the next smaller administrative region than State/Province (county, shire, department, etc.) of the location where this accession originated.	
Wild origin	State/Province	stateprovince	The name of the next smaller administrative region than country (state, province, canton, department, region, etc.) of the location where this accession originated.	
Wild origin	Country	country	The name of the country or major administrative unit of the location where this accession originated.	Country name, 2-digit, or 3-digit ISO country codes are acceptable.
Wild origin	Latitude	decimalLatitude	The geographic latitude of the location where this accession originated.	In decimal degrees, ideally to 5-digit precision, WGS-84/NAD-83 datum.

			Positive values are north of the Equator, negative values are south of it. Legal values lie between -90 and 90, inclusive.	Entries in degrees/minutes format will be converted to decimal degrees. Latitude will be masked to 2-digit precision for public view. Possible Values: Between -90 and 90, inclusive
Wild origin	Longitude	decimalLongitude	The geographic longitude of the location where this accession originated. Positive values are east of the Greenwich Meridian, negative values are west of it. Legal values lie between -180 and 180, inclusive.	In decimal degrees, ideally to 5-digit precision, WGS-84/NAD-83 datum. Entries in degrees/minutes format will be converted to decimal degrees. Longitude will be masked to 2-digit precision for public view. Possible Values: Between -180 and 180, inclusive
*Wild origin	Elevation	m	Useful to cross-check locality	
Wild origin	Wild Occurrence Restriction		wild locations of poaching concern can be withheld	Possible values: ?
Wild origin	Sampling Protocol Used	dwc:Event:samplingProtocol	The method used for collecting this accession from the wild, whether propagules were separated by individual maternal lines, or collected by combining more than one maternal lines together (bulking).	Possible values: bulk collection, maternal lines, not known
Check status	Taxon Determined By	identifiedBy	The type of verification recorded for a previous identification or taxon name assigned for this living/viable material.	Possible Values: Comparison, A Taxonomist, A Taxonomic Specialist, Breeder
Check status	Specimen Number		A unique number/letter to indicate the number of specimens (sometimes called qualifiers, items, plantings) under one accession number. This could	If omitted, number 1 will be assigned automatically.

			be one or more specimens labelled with or known by at the garden.	
Check status	Number of Individuals		Number of living individual plants or seeds in this Specimen.	Current number of individuals representing this single specimen record. The default is 1. Tick MASS for a group of individuals such as a mass planting or seed lot where you are not able to count individuals.
Check status	Garden location (change name of field) [Environment]- Type		Where in the garden is this specimen.	Possible values: Display Greenhouse (or covered environment), Outdoors all year round, Propagation Nursery
Check status	Accessioned - Date		For estimated dates, leave month and/or day field blank.	
Check status	Status Check Condition - Date		For estimated dates, leave month and/or day field blank.	
Check status	Status Check Condition			Possible values: alive, dead, dormant
Check status	Died - Reason			(blank text field)
Plant, seed etc.	Germplasm type			Possible Values: Plant, Seed, Pollen, Explant

Appendix 3: Number of threatened taxa per garden 1. Taxa excluding *Rhododendron*, threat status from the IUCN (2026). 2. Threatened *Rhododendron* based on GCC *Rhododendron* working redlist. In both cases, comparing A. matched names and B. WFO 2026_06 taxonomically aligned names. *High numbers of EX and EW names at Bergen were not brought in as living material.

1 A. Matched Names.																						
	Babite	Bergen	Copenhagen	Eksolund	Frederiksberg	Göteborg	Greenland	Hørsholm	Kalsnava	Kolding	Latvia	Lund	Meilahti	Mustila	Niskala	Norr	Oslo	Oulu	Rogaland	Stavanger	Turku	Uppsala
CR	0	60	62	6	8	7	0	6	4	1	2	14	0	11	1	4	2	3	8	78	5	34
DD	2	117	82	12	53	28	0	30	16	12	8	22	3	24	8	9	19	9	22	116	26	58
EN	5	114	113	11	29	18	1	29	15	10	13	26	4	20	7	7	12	8	22	145	16	71
EX	0	97*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
EW	0	29*	4	0	1	0	0	0	0	0	1	1	0	1	0	0	1	0	0	4	0	1
LC	73	1897	1392	231	716	371	53	513	278	242	169	408	81	358	124	176	283	156	345	1659	360	876
NT	3	107	64	18	27	22	1	25	13	15	7	19	2	16	5	7	10	2	19	106	16	51
VU	2	113	128	9	30	24	1	27	14	9	3	34	0	18	1	4	10	1	23	130	15	65
1 B. Taxonomically Aligned.																						
	Babite	Bergen	Copenhagen	Eksolund	Frederiksberg	Göteborg	Greenland	Hørsholm	Kalsnava	Kolding	Latvia	Lund	Meilahti	Mustila	Niskala	Norr	Oslo	Oulu	Rogaland	Stavanger	Turku	Uppsala
CR	0	55	59	6	10	7	0	7	4	1	2	14	0	8	1	4	2	3	4	75	5	32
DD	3	114	83	13	56	26	0	32	18	14	10	26	4	22	9	10	21	10	22	114	25	56
EN	5	100	116	11	29	19	1	28	12	10	11	27	4	14	7	7	12	7	17	145	14	69
EX	0	84*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EW	0	26*	5	0	2	0	0	0	0	0	1	1	0	1	0	0	1	0	0	5	0	1
LC	75	1942	1450	231	734	375	54	525	281	252	176	414	79	366	128	172	284	160	355	1766	365	864
NT	3	110	60	18	25	21	1	26	13	16	7	19	2	16	6	7	10	2	19	100	16	49
VU	3	101	124	9	30	21	1	20	8	9	3	31	0	11	1	3	10	1	16	126	12	56

2. Threatened *Rhododendron* based on GCC *Rhododendron* working redlist.

2 A. Matched Name.																						
	Babit e	Berge n	Cope nhage n	Eksol und	Frede riksbe rg	Göteb org	Green land	Hørsh olm	Kalsn ava	Koldi ng	Latvia	Lund	Meila hti	Mustil a	Niska la	Norr	Oslo	Oulu	Rogal and	Stava nger	Turku	Upps ala
CR	4	9	0	0	0	1	0	1	0	0	0	0	0	2	0	0	0	0	2	4	0	0
DD	6	40	9	0	0	4	0	5	0	1	6	2	0	7	0	0	1	0	8	14	3	0
EN	5	16	7	0	2	2	0	1	1	1	0	1	0	2	0	0	0	0	9	11	0	0
EW	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LC	84	222	82	4	37	52	0	72	31	32	36	14	1	42	11	5	30	7	93	146	53	13
NT	3	35	4	0	1	5	0	3	1	2	1	1	0	0	0	0	1	0	16	19	0	0
VU	15	126	27	0	5	25	0	18	1	7	4	10	0	7	0	0	3	0	34	62	11	0
2 B. Taxonomically Aligned.																						
	Babit e	Berge n	Cope nhage n	Eksol und	Frede riksbe rg	Göteb org	Green land	Hørsh olm	Kalsn ava	Koldi ng	Latvia	Lund	Meila hti	Mustil a	Niska la	Norr	Oslo	Oulu	Rogal and	Stava nger	Turku	Upps ala
CR	4	10	0	0	0	1	0	1	0	0	0	0	0	2	0	0	0	0	2	4	0	0
DD	6	42	11	0	0	7	0	8	2	2	6	2	0	9	0	0	1	0	10	18	3	0
EN	5	17	7	0	2	3	0	1	1	1	1	1	0	3	0	0	0	1	9	12	1	0
EW	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LC	84	232	84	4	39	53	0	72	35	33	36	16	1	46	11	5	29	10	97	153	54	13
NT	3	37	5	0	2	5	0	3	1	2	1	1	0	0	0	0	1	0	19	22	1	0
VU	17	132	29	0	8	24	0	18	2	8	5	10	0	7	0	0	4	1	40	67	11	0

Appendix 4: Data compiled from the 22 Botanic gardens and Arboreta that collaborated in the Nordic Arboreta Committee led development of a Nordic Metacollection.

Available as an open access data archive on Zenodo: <https://doi.org/10.5281/zenodo.23764541>

Includes:

Nordic_compiled_name_match - compiled list of plant names from each collection. The verbatim name, the best match to WFO and the current accepted name in WFO June 2026 release.

Nordic_accessions - priority list of accessions checked by collections.

Nordic_taxa_statments_of_facts - match WFO names, WFO rank, WFO taxonomic status, IUCN (2026_1) red list criteria, Global Conservation Consortia Rhododendron working redlist, lifeform and cited_appendix.

Nordic_appendix_5_full_list - Expanded appendix 5 table that includes all threatened rhododendron and the number of collections that they occur in.

Nordic_table_2_full_list - Expanded table 2 Threatened taxa and the number of collections that they occur in.

Nordic_fig_2_underlying_stats - compiled name stats that generated Fig. 2.

Nordic_garden_taxonomy_summary - summary of matched names, how they compared to the WFO June 2026 release, how each collection compared to each other in terms of shared and unique names.

Files are csv utf-8.

Nordic_arboreta_all_accessions_20261030.xlsx - Accessions-level data for threatened species included in a single spreadsheet based on an export from PlantSearch and including various summaries of the data as presented in the results.

Made in MS Excel.

Appendix 5: Most shared threatened *Rhododendron* taxa

Name	Number of gardens	Red List Status.
<i>Rhododendron insigne</i> Hemsl. & E.H.Wilson	11	Vulnerable
<i>Rhododendron williamsianum</i> Rehder & E.H.Wilson	10	Vulnerable
<i>Rhododendron lutescens</i> Franch.	9	Near Threatened
<i>Rhododendron makinoi</i> Tagg ex Nakai	8	Vulnerable
<i>Rhododendron rex</i> H.Lév.	8	Vulnerable
<i>Rhododendron proteoides</i> Balf.f. & W.W.Sm.	7	Vulnerable
<i>Rhododendron elegantulum</i> Tagg & Forrest	7	Vulnerable
<i>Rhododendron nakaharae</i> Hayata	7	Endangered
<i>Rhododendron galactinum</i> Balf.f. ex Tagg	6	Endangered
<i>Rhododendron taliense</i> Franch.	6	Vulnerable
<i>Rhododendron souliei</i> Franch.	6	Vulnerable
<i>Rhododendron auriculatum</i> Hemsl.	6	Vulnerable
<i>Rhododendron orbiculare</i> Decne.	6	Vulnerable