

# Out-of-date datasets hamper conservation of species close to extinction

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## Brief Communication

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# Abstract

International databases and data aggregators on species conservation status are powerful tools supporting the efforts of conservation biologists and practitioners in reducing the loss of biodiversity. However, out-of-date information and poor interoperability of databases can hamper conservation of highly threatened species or in extreme cases can result in their removal from conservation frameworks. Lack of common standards for database updates, slow update timing and incongruencies among datasets result in confusing information that prevent proper conservation prioritisation and actions. A simple survey to update and solve incongruencies between the BGCI PlantSearch Database, the IUCN Red List and other datasets resulted in a change of status of sixteen plant species, including the “rehabilitation” of fourteen species thought to be extinct.

## Full Text

There are different ways a species previously thought to be extinct can be ‘rehabilitated’ or removed from the list of extinct taxa. First, it can be rediscovered in its native range as part of increased search efforts or simply by chance (1); second, it can be identified as a synonym with an extant species as a result of improved taxonomic knowledge (2); third it can be found alive in an ex situ facility, which allows for the species to be considered extinct in the wild (EW), according to the International Union for the Conservation of Nature (IUCN) Categories and Criteria (3).

The latter two cases are seen as non-genuine status changes, though the consequences for rehabilitated species can be extremely important: while extinct species are excluded from conservation frameworks, rehabilitated species can be the subject of conservation management plans (4). Information on the conservation status of extinct, extinct in the wild and possibly extinct species should therefore be as accurate as possible to avoid weakening our conservation efforts or directing them to the wrong targets.

Large databases such as the IUCN Species Information Service, PlantSearch, GBIF, etc. are very useful data aggregators providing important data for developing conservation programmes. However, most databases are characterised by a slow information turnover (e.g., red lists are revised every ten years; 3) or updates are made by reporting data from a source to another, with errors and inaccuracies that are often maintained over long periods (5, 6, 7). Moreover, inconsistencies among data sources can produce incongruencies in a species’ conservation status. For instance, in the IUCN Red List 2021, three species (*Astragalus nitidiflorus* Jiménez Mun. & Pau, *Euphrasia mendoncae* Samp. = *Euphrasia minima* DC., *Ornithogalum visianicum* ex Vis.= *Loncomelos visianicum* (Tomm. ex Vis.) Speta) out of four listed as extinct for Europe are currently extant, according to recent updates (2). The abovementioned issues hamper our ability to plan and prioritise conservation actions (both in situ and ex situ). Species that were declared extinct or extinct in the wild or are very close to extinction are particularly affected by such issues, as a single additional information may change their status to “nothing can be done” (extinct), or to “there is still some hope” (extinct in the wild or extant).

Botanic Garden Conservation International (BGCI)'s PlantSearch database provides information on the plant collections (living collections and seed banks) of botanic gardens around the world. It presently holds data from over 1,000 institutions, consisting of more than 1.5 million occurrence records, representing over 600,000 taxa. BGCI also maintains the ThreatSearch database which lists global, regional and national red list assessments for plants obtained from a range of sources, including the IUCN Red List. ThreatSearch currently includes over 300,000 conservation assessments, representing over 180,000 taxa.

Comparing data from these two databases showed that a number of taxa reported as extinct were also reported as being in cultivation ex situ in botanic garden collections. This demonstrates the clear incongruity of out-of-date information.

With the aim of assessing the impact of out-to-date information on species conservation, we therefore checked the status of 24 non-European species recorded as Extinct (according to the IUCN Red List and 5, 7) but were also recorded as present in BGCI's PlantSearch database in at least one ex situ collection. Synonyms for each species were identified using the World Checklist of Vascular Plants and the threat status for each species (using both accepted names and synonyms) was checked using BGCI's ThreatSearch database. In each case, where more than one assessment was available, the most recent assessment was used. Similarly, records for each species were checked against PlantSearch and the gardens recorded as cultivating any of the species were identified. Finally, updates for these species were obtained by contacting all the institutions identified to have them in collection. Therefore, species reported as EW in table 1 have at least a verified (this article) ex situ living collection in a botanic garden belonging to the BGCI network. Additional data have been collated by checking local floras or by contacting local experts for those species still extant in their native range (see notes to Table 1). For four species we could not get any updates as the institutions involved were uncontactable (*Delissea subcordata* Gaudich., *D. undulata* Gaudich, *Grevillea divaricata* R.Br., *Proboscidea spicata* Correll).

In summary, Table 1 shows that 14 species deemed to be extinct are extinct in the wild or extant (with overlaps among sources): three species listed in the IUCN Red List as EX are EW and one (*Pimpinella schweinfurthii*) is still present in its native range in the Arabian Peninsula; four out of fourteen species declared extinct by (5) are actually extinct (plus one possibly extinct), four species are EW and five are still extant; two species reported as EX by (6) and (7) should be reclassified as EW.

These fourteen species are therefore back into a conservation framework.

Some inaccuracies are surprisingly coarse, like for instance, the case of *Micranthemum micranthemoides*, declared extinct but very common in the market of commercial plants. In that case, despite its EW status, the conservation of *M. micranthemoides* may deserve a lower conservation priority than other EW species cultivated in a single botanic garden and with very small populations. A more subtle example of the confusion generated by out-of-date datasets is the case of *Cynometra beddomei* Prain, that was declared EX in 1998 (9), a status still reported in the PlantSearch database despite the indication that an ex situ collection exists. The extinct status was confirmed by (5), but a more recent IUCN assessment indicates

that the species is not extinct at all, and it occurs in the wild and it is classified as Endangered (10). Interestingly, three specimens of this species grow at Nehru Tropical Botanic Garden & Research Institute, India (A. Dyhani pers. comm.), which is not the same BGCI institution where the unique ex situ collection reported in PlantSearch was thought to be. In such a case, the perception of conservation needs for this species differs greatly depending on which dataset is considered. A further example of confusion due to out-of-date dataset is the case of *Trochetiopsis melanoxydon* s. str., a species already extinct at the time of its description by (11). The latter author split *T. melanoxydon* s.l. into two species *T. melanoxydon* s. str. and *T. ebenus* Cronk. Since collections of the putative *T. melanoxydon* were made before 1995, this species is still reported as cultivated ex situ, while current living specimens belong to *T. ebenus*.

Looking at the data turnover of PlantSearch, it emerges that many institutions do not consider updating datasets as an important task, and do not refresh their data regularly; for example, there are 257 plant lists in PlantSearch, from European gardens, mostly provided since 2010 but a few are from earlier. Most of these lists have not been updated since they were first submitted. Seventy-seven gardens have uploaded plant lists since January 2019 and of these, only 14 have subsequently been updated, despite regular requests for updates at European meetings.

In the specific case, one of the most serious consequences of out-to-date information is the underestimation of the collection value. For instance, despite *Trochetiopsis melanoxydon* was originally cultivated in six botanic gardens, our survey suggests that only one BGCI garden currently hosts verified living specimens of this species (Table 1). It follows that the only institution hosting the last individuals of *T. melanoxydon* may be unaware of the role and responsibility it has in the conservation of this species. More generally, a clear perception of a collection value achieved through fresh and accurate information is key to proper ex situ population management, like for example material duplication and exchange (see the case of *T. melanoxydon*; 12). This work shows how periodical updates of species databases and data aggregators can contribute to species conservation by excluding species that do not need conservation anymore (i.e., extinct species) or that deserve high conservation attention like the thirteen species here rehabilitated. Updates should involve several aspects such as the taxonomy, for which we need a definitive taxonomic backbone to link datasets such as the World Flora Online (13), the critical review of historical information, the scientific literature on species phylogenesis (14) and distribution (e.g., 15, 16), and for databases like PlantSearch a simple periodical physical check of collections. An increased consideration of validated citizen science datasets (e.g., iNaturalist; [www.iNaturalist.com](http://www.iNaturalist.com)) would also benefit the retrieval of new data, especially on species distribution.

Guidelines on what, when, how to update datasets should be developed to better integrate data management into conservation practice. In this perspective, new approaches deriving from other fields such as medicine and data management should be applied to obtain a more efficient system of data gathering with links among institutions, and datasets interoperability (17-19).

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## Table 1

Table 1

Update of status for 20 extinct species with at least an ex situ collection in BGCI PlantSearch database.

Taxon	IUCN Red List	Humphreys et al. 2019	Knapp et al. 2020	Ex situ accession	New status
<i>Argyroxiphium virescens</i> Hillebr.	EX	EX		No <sup>1</sup>	EX
<i>Begonia trullifolia</i> Guillaumin		EX		Yes <sup>2</sup>	EW
<i>Beyeria lepidopetala</i> F.Muell.		EX			Extant <sup>3</sup>
<i>Boechera fruticosa</i> (A.Nelson) Al-Shehbaz			EX	Yes? <sup>4</sup>	EW?
<i>Castilleja uliginosa</i> Eastw.			EX	Yes <sup>5</sup>	EW
<i>Cynometra beddomei</i> Prain	EN	EX		Yes <sup>6</sup>	EN <sup>7</sup>
<i>Dypsis linearis</i> Jum.	EN	EX		Yes <sup>8</sup>	EN
<i>Grevillea divaricata</i> R.Br.	CR(PE)	EX		No <sup>9</sup>	CR(PE)
<i>Hemigenia exilis</i> S.Moore		EX		Yes	Extant <sup>10</sup>
<i>Isolepis bulbifera</i> (Boeckeler) Muasya				No <sup>11</sup>	EX
<i>Lepidium obtusatum</i> Kirk	EX	EX		No <sup>12</sup>	EX
<i>Marshallia grandiflora</i> Beadle & F.E.Boynton			EX	Yes <sup>13</sup>	EW
<i>Micranthemum micranthemoides</i> (Nutt.) Wettst. ex Wettst.			EX	No	EW <sup>14</sup>
<i>Ormosia howii</i> L.Chen	EX				Extant <sup>15</sup>
<i>Ozothamnus selaginoides</i> Sond. & F.Muell.		EX		Yes <sup>16</sup>	EW
<i>Phyllanthus comptonii</i> S.Moore	EX	EX		No <sup>17</sup>	EX
<i>Pimpinella schweinfurthii</i> Asch.	EX	EX		No	Extant <sup>18</sup>
<i>Psychotria cadigensis</i> Merr.	EX	EX		Yes <sup>19</sup>	EW
<i>Psychotria ilocana</i> (Merr.) Merr.	EX	EX		Yes <sup>20</sup>	EW

Taxon	IUCN Red List	Humphreys et al. 2019	Knapp et al. 2020	Ex situ accession	New status
Trochetiopsis melanoxylon (Sol. ex Sims) Marais	EX	EX		No <sup>21</sup>	EX
<p>Notes:</p> <p><sup>1</sup> Accession thought to be <i>A. virescens</i> at National Tropical Botanical Garden, Kauai, Hawaii, US is now thought to be of hybrid origin</p> <p><sup>2</sup> Cultivated at: Jardin Botanique de la Ville de Lyon, Lyon, France</p> <p><sup>3</sup> At least a wild population is alive in Kalbarry Natinal Park, Western Australia (pers. comm. Alanna Chant, Johanna Human, Parks and Wildlife Service, October 2021)</p> <p><sup>4</sup> Cultivated at: Royal Botanic Garden Edinburgh, Edinburgh, UK. There are taxonomic issues related to the specimen that need to be solved</p> <p><sup>5</sup> Cultivated at: University of California Botanical Garden, Berkeley, US</p> <p><sup>6</sup> Cultivated at: Jawaharlal Nehru Tropical Botanic Garden &amp; Research Institute, Thiruvananthapuram, India (3 specimens; pers. comm. A. Dhyani); a non-verified specimen present at Malabar Botanic Garden, Olavanna, India</p> <p><sup>7</sup> Recently assessed as Endangerd (EN) in the Western Ghats, India</p> <p><sup>8</sup> Cultivated at: Royal Botanic Gardens Sydney, Sydney, Australia</p> <p><sup>9</sup> Lost from: Myall Park Botanic Garden, Glenmorgan, Australia, but still occurring in the wild</p> <p><sup>10</sup> Rediscovered</p> <p><sup>11</sup> Lost from hosting institution (non-disclosable)</p> <p><sup>12</sup> Not in cultivation. Germination attempted in 1993, but seedlings died soon (8).</p> <p><sup>13</sup> Cultivated at: Royal Botanic Gardens Kew, Richmond, UK</p> <p><sup>14</sup> Available in the market as ornamental plant</p> <p><sup>15</sup> The species is still extant and threatened according to Threatened Species List of China plants</p> <p><sup>16</sup> Cultivated at: St. Andrews Botanic Garden, Fife, UK</p> <p><sup>17</sup> Specimens cultivated at Lyon Arboretum, Honolulu, Hawaii were identified as belonging to <i>Diospyros parvifolia</i></p> <p><sup>18</sup> Present in Arabia and Oman (Source: Plants of the World online)</p> <p><sup>19</sup> Cultivated at: Honolulu Botanical Gardens, Honolulu, Hawaii</p> <p><sup>20</sup> Cultivated at: Northwestern University Ecological Park and Botanic Gardens, Laoag City, Philippines</p> <p><sup>21</sup> <i>Trochetiopsis melanoxylon</i> s. str. has never been in ex situ cultivation. All accessions labelled as <i>T. melanoxylon</i> should be re-labelled as <i>T. ebenus</i> Cronk. The latter is present at Cambridge University Botanic Garden, Cambridge, Glasgow Botanic Gardens, Glasgow, Royal Kew Gardens, Kew, UK, at Conservatoire Botanique National du Brest, Brest, France and at a second Institution in France (name not disclosable). Lost from: San Diego Botanic Garden, San Diego, US, St. Andrews Botanic Garden, Fife, UK.</p>					