
WORLD FLORA ONLINE MID-TERM UPDATE

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ABSTRACT

There are an estimated 400,000 species of vascular plants on Earth, out of which 10% are still to be discovered. These plants, both known and unknown, may hold answers to many of the world's health, social, environmental, and economic problems. A full inventory of plant life is vital if many threatened species are to be protected and if their full potential is to be realized before many of these species, and the possibilities they offer, become extinct. In 2010, the updated Global Strategy for Plant Conservation (GSPC) of the United Nation's Convention on Biological Diversity (CBD) included as its first target (Target 1) the need for "an online flora of all known plants." Bearing this in mind, in January 2012 in St. Louis, Missouri, U.S.A., representatives from four institutions—the Missouri Botanical Garden, the New York Botanical Garden, the Royal Botanic Garden Edinburgh, and the Royal Botanic Gardens, Kew, all members of the Global Partnership for Plant Conservation—took the initiative to meet and discuss how to achieve GSPC Target 1 by 2020. The meeting resulted in a proposed outline of the scope and content of a World Flora Online (WFO), as well as a decision to create an international consortium of institutions and organizations to collaborate on providing its content. The WFO project was subsequently launched in October 2012 in India, at an event held during the 11th Conference of the Parties (COP) to the CBD, where the COP also adopted a decision welcoming the WFO initiative. In January 2013, a memorandum of understanding on the WFO was open to signature. By the end of July 2016, 34 institutions and organizations had signed it. Other institutions and organizations worldwide are also invited to participate in the WFO Consortium. The WFO will be an open-access, web-based compendium of the world's plant species. It will be a collaborative, international project, building upon existing knowledge and published floras, checklists, and taxonomic and other revisions. It will also require the collection and generation of new information on poorly known plant groups and plants in unexplored regions. The project represents a major step forward in developing a consolidated global information service on the world's flora.

Key words: Biodiversity, conservation, taxonomy, world flora.

This publication and its corresponding presentation, given during the Global Partnership for Plant Conservation (GPPC) Congress at St. Louis in June 2016, provide an updated English version of the speech we gave at the Eurogard VII Congress, which took place in Paris in July 2015.

The Global Strategy for Plant Conservation (GSPC) was adopted by 193 countries during the Conference of the Parties (COP) of the United Nation's Convention on Biological Diversity (CBD) in April 2002 (Convention on Biological Diversity, 2002). The GSPC represents an important step forward, emphasizing awareness-raising about the threats to plants worldwide. It also proposes the first coherent framework for the policies and the consequential actions necessary to reduce the continuous loss of biological diversity, and most notably of plants. It was revised and updated for a second phase on 29 October 2010, by decision X/17 of the COP, proposing 16 targets (Convention on Biological Diversity, 2012a). These objectives ultimately aim at halting the loss of plant diversity by 2020. They also contribute to the achievement of the Strategic Plan for Biodiversity 2011–2020 and the related

Aichi Targets (Convention on Biological Diversity, 2012b).

GSPC Objective I seeks to establish that, by 2020, "plant diversity should be understood, documented and recognized" (Convention on Biological Diversity, 2012a). The targets within this objective are as follows:

- Target 1: An online flora of all known plants.
- Target 2: An assessment of the conservation status of all known plant species, as far as possible, to guide conservation action.
- Target 3: Information, research and associated outputs, and methods necessary to implement the strategy developed and shared.

Indeed, it is important to understand, first, that nature is currently facing untenable and unsustainable human pressure, and second, that information helping to describe it and protect it is spread across the scientific literature. The GSPC as a whole, and its Target 1, the creation of a World Flora Online (WFO, <www.worldfloraonline.org>), aims to raise awareness about the necessity to protect the world's plants for the sake of humanity, and to collect and make

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available all relevant documentation on plant species diversity worldwide to facilitate its use and to help advance conservation work (Wyse Jackson & Miller, 2015).

AN INVENTORY OF THE WORLD'S PLANTS

It is estimated that there are 400,000 species of vascular plants on Earth, out of which 10% are still to be discovered (Joppa et al., 2011). These plants, whether they are known yet or not, could answer key questions about health, social, and economic problems of the world. A complete inventory of plants is crucial for us to benefit from their full potential before many species disappear, together with the possibilities they offer. Furthermore, it is only after knowing and describing plants that conservation programs can be designed to protect them.

It is important to mention that the publication of a global list of the world's known plants has happened only three times in the whole botanical history of the world. In 1753, Carl von Linné (Linnaeus) published the *Species Plantarum* (Linnaeus, 1753), in which he described 6000 species, which represented all known plant species in the world at that time. The founder of the Conservatory and Botanic Garden of the City of Geneva, Augustin Pyramus de Candolle, began to describe all the known plants of the world in 1821, in his *Prodromus Systematis Naturalis Regni Vegetabilis*. After his death, he was followed in this work by his son until 1870. The 17 volumes provided the treatment for 60,000 species, with father and son themselves publishing 6000 species new to science (de Candolle & de Candolle, 1824–1873). After Linnaeus and de Candolle, no one was again able to build such a list, until the 21st century.

When first adopted in 2002, the GSPC first aimed to establish a list of all known species. Thanks to the collaboration between a range of international institutions that had created the most important databases of taxon names, especially the Royal Botanic Gardens, Kew, and the Missouri Botanical Garden, this list, called “The Plant List,” was created in 2010 and made available online (<www.theplantlist.org>). It was updated (version 1.1) in September 2013.

The Plant List provides a working list of all known plant species. It aims to be comprehensive for species of vascular plants (flowering plants, conifers, and their allies) and of bryophytes (mosses and liverworts). For each species name, information is given about the name author(s), the place of publication of the description article, and the status of the name (whether it is accepted, a synonym, or unresolved in its current taxonomic use). For each name, each time

it is possible, links are also given, pointing toward the corresponding entry in an online database, in the International Plant Names Index (IPNI), and in any other available relevant information about the taxon. For each registered name, The Plant List indicates the level of confidence relative to the status of the name; the confidence evaluation is based principally on the nature and taxonomic integrity of the data source (Paton, 2013).

WORLD FLORA ONLINE

The WFO project was created to respond to and achieve Target 1 of the updated 2010 version of the GSPC (Convention on Biological Diversity, 2012a, 2012b). In January 2012 in St. Louis, representatives of four institutions—the Missouri Botanical Garden, the New York Botanical Garden, the Royal Botanic Garden Edinburgh, and the Royal Botanic Gardens, Kew—met and discussed how to reach GSPC Target 1 by 2020. The meeting led to a draft description of the scope and content of the WFO, and to the decision to create an international consortium of institutions and organizations to better collaborate on the implementation of the WFO.

The WFO project was then launched in India, during an event that took place in parallel with the 11th COP of the CBD in October 2012. This 11th COP also endorsed and welcomed the WFO initiative.

The terms and technical justifications for Target 1 suggest that this flora should include accepted names as well as a comprehensive synonymy, building the taxonomy based on the results of the earlier GSPC Target 1 (from 2002 to 2010), aiming to develop a “a widely accessible working list of known plant species, as a step towards a complete world flora” (Convention on Biological Diversity, 2012b). New knowledge should also be incorporated as soon as it is available.

The feasibility of the project has been based on the observation that numerous institutions are now implementing projects on the preparation of digital floras at national and other levels and the increasing availability of digital data from previously published floras and monographs. By combining these efforts and using the WFO as a central, moderated and verified, and regularly updated global source of information on the world's plants, it has huge potential to provide a unique resource to support the conservation and management of the world's plant resources. The WFO should therefore become the fundamental authoritative and verified web resource, documenting all known plants in the world. It will offer research capacity on verified information and on

new data, and will establish links with other existing databases and catalogs.

The WFO covers the whole range of the plant world, from bryophytes to angiosperms. It will be freely accessible on the web.

In exchange for the attribution and inclusion in the project, the WFO Consortium asks the organizations to contribute by:

- determining the names of accepted species and synonyms of each accepted name; and
- identifying the sources and providing precise treatments for each species from floras and monographs, including where possible, descriptions and geographical distributions.

DEVELOPING A CONSENSUS TAXONOMY

As seen above, the project has been based on the development of a preliminary list of all known plant species, The Plant List, based on, as far as possible, a consensus taxonomy to which species descriptions and other specific information can be attached. However, The Plant List is a static list and is not sufficient to represent the ongoing and often rapid evolution of taxonomic concepts as research groups around the world elaborate them. Therefore, we rapidly realized that, in order to be useful, the core taxonomic referential (“the taxonomic backbone”) of the WFO should become a dynamic tool on the current state of systematic knowledge. This becomes possible if the taxonomic backbone is structured in a database, and with the development of a collaborative tool for its management, or for the integration of partial taxonomies. The WFO Consortium is currently working on the implementation of a digital tool for taxonomy management.

Without rejecting the possibility of including in the WFO alternative taxonomies, the WFO will provide a consensus about the classification of the world’s plants, which should facilitate greater understanding of the plant world by non-botanists. To reach this goal, the project needs to draw in the expertise of collaborative networks and individual taxonomists in order to develop a consensus classification.

A TOOL FOR CONSERVATION, AND MORE

The objective of the WFO is to provide comprehensive and authoritative information that contributes to a sound understanding of the status of the world’s plants, thereby assisting plant conservation efforts in an environment that is constantly evolving due to human pressure.

People involved in biodiversity conservation will be the first to benefit from the information available on the website (the WFO portal), but others are also expected to use it: taxonomists and other scientific researchers using information about plants (e.g., ecologists, anthropologists, archaeologists, ethnobotanists, and pharmacologists).

The people who will be contributing to the project will be the providers of primary data, such as herbarium conservators, plant systematic experts, information technology experts, and other data managers.

Important work has been undertaken by the project participants in order to define the information that should appear on the website. Beneficiaries should have free access to the data on various web platforms; be able to print and download data, regardless of its dimensions; be able to search taxa by scientific name and/or by country or region; be informed of the accepted scientific name currently in use for each taxon; be informed of any related synonymy, as well as the consensus classification adopted by the WFO; and, most importantly, see the display of the taxon descriptions for each of the floras that described it.

In addition, the website should also allow the display of photographs or drawings of the taxa, or at the very least, display web links to external websites which contain this information. It should also propose and provide access and links to identification tools (including keys) for plants of a country or a region. Finally, the website should give information about the distribution of taxa included in the WFO and provide, together with the data source, an assessment of its reliability.

It is also expected and anticipated that the WFO will support the achievement of GSPC Target 2, “an assessment of the conservation status of all known plant species, as far as possible, to guide conservation action” (Convention on Biological Diversity, 2012b), and provide information on the current conservation status of each species, as far as it is known. It remains to be determined whether providing information on the conservation status of each taxon will be provided in the WFO website or achieved through web links.

LARGE SUPPORT FROM THE COMMUNITY

Since 2011, the WFO project has been supported by the GPPC, which has the main goal of helping to implement the GSPC and facilitates communication between initiatives aiming at similar goals (Wyse Jackson, 2013).

This project was also considered a priority during the 2011 International Botanical Congress at Mel-

Table 1. Members of the World Flora Online Consortium, as of July 2016.

Organization	Location
Academy of Sciences	St. Petersburg, Russia
Allen Herbarium, Landcare Research	Lincoln, New Zealand
Australian Biological Resources Study	Canberra, Australia
Botanic Garden and Botanical Museum Berlin-Dahlem, Dahlem Centre of Plant Science (DCPS)	Berlin, Germany
Botanic Garden Meise	Meise, Belgium
Botany Department of Trinity College Dublin	Dublin, Ireland
Conservatoire et Jardin botaniques de la Ville de Genève	Geneva, Switzerland
Core Facility Botanical Garden of the University of Vienna	Vienna, Austria
Euro+Med Plantbase	Berlin, Germany
Flora Iberica Project	Madrid, Spain
Flora Malesiana Foundation	Leiden, The Netherlands
Flora of North America Association	U.S.A. and Canada
Forest Research Institute Malaysia	Kuala Lumpur, Malaysia
Global Biodiversity Information Facility	Copenhagen, Denmark
Institute of Botany, Academy of Sciences of the Czech Republic	Prague, Czech Republic
Institute of Botany, Azerbaijan National Academy of Sciences	Baku, Azerbaijan
Institute of Botany, Chinese Academy of Sciences	Beijing, China
Institute of Botany, Slovak Academy of Sciences	Bratislava, Slovakia
Instituto de Botánica Darwinion	Buenos Aires, Argentina
Instituto de Ecología A.C.	Veracruz, Mexico
Instituto de Pesquisas Jardim Botânico do Rio de Janeiro	Rio de Janeiro, Brazil
Komarov Institute of Botany	St. Petersburg, Russia
Kunming Institute of Botany, Chinese Academy of Sciences	Kunming, China
Missouri Botanical Garden	St. Louis, Missouri, U.S.A.
Muséum National d'Histoire Naturelle	Paris, France
National Biodiversity Institute of Costa Rica	Santo Domingo de Heredia, Costa Rica
Natural History Museum	London, U.K.
Naturalis Biodiversity Center	Leiden, The Netherlands
New York Botanical Garden	Bronx, New York, U.S.A.
Royal Botanic Garden Edinburgh	Edinburgh, U.K.
Royal Botanic Gardens, Kew	London, U.K.
Smithsonian National Museum of Natural History	Washington, D.C., U.S.A.
South African National Biodiversity Institute	Pretoria, South Africa
Tsitsin Main Botanical Garden	Moscow, Russia
UNESCO Chair in Plant Conservation and Biodiversity in Macaronesia and Western Africa	Gran Canaria, Spain

bourne, which endorsed the project through one of its resolutions.

In September 2014, UNESCO and the National Museum of Natural History of Paris organized an international conference on the theme “Botanists of the twenty-first century: Roles, challenges and opportunities” (Rakotoarisoa et al., 2016). The final declaration of this conference called for the community of botanists and scientific researchers working with plants in general, as well as their institutions, to make a special effort in order to reach the objectives and targets of the GSPC, especially when implementation relies on botanists, including the finalization of the WFO by 2020, which they recognized would provide an essential reference to knowledge on plants from the whole world.

The WFO is driven and managed by a consortium of institutions and organizations, all of which have signed a memorandum of understanding. It opened to signature in January 2013 and had 29 partner institutions by July 2015. One year later, it had 34 institutions (see Table 1).

While most of the institutions involved are based in Europe or North America, the consortium is keen to include more partners from around the globe.

AN ACTIVE AND DYNAMIC CONSORTIUM

After a kick-off meeting in St. Louis, in January 2012, followed by an organizational meeting in July of the same year, also in St. Louis, the WFO Consortium met five times: Edinburgh (November 2013); St. Petersburg (June 2014); Geneva (January

2015); Rio de Janeiro (October 2015); and New York (April 2016).

The consortium is constituted of five bodies. Representatives of all members of the consortium meet at the Council to take decisions on strategic options. The Council is helped by a Secretariat. Three standing subgroups work to develop the project. The Taxonomic Working Group develops and elaborates proposals and plans regarding classification, taxonomy, and calls for taxonomic experts to become involved in the project. The Technical Working Group works on the database architecture, the website content, and tools for its development. The third working group, Communications, was created at the WFO Council meeting held in October 2015, to consider options for publicizing the project and increasing awareness of its content, role, and importance.

A COLLABORATIVE PROJECT

Two functioning prototypes for an online WFO portal were developed at the Missouri Botanical Garden and at the Royal Botanic Gardens, Kew. The first portal, developed by the Missouri Botanical Garden, focused on design, to show how useful results of a world flora could be provided to the targeted public. The second portal was based on the work developed by Kew and its partners to display data relative to the group eMonocot (<www.emonocot.org>).

Finally, the consortium decided to adapt the program developed by Kew, and thanked the Missouri Botanical Garden for its willingness to develop the existing eMonocot software as a functional WFO portal. Much of the work being undertaken by the Missouri Botanical Garden on this project has been supported by a generous grant from the Monsanto Company, which has provided substantial support for this purpose over a 5-year period. In the WFO portal, numerous elements are displayed: the scientific name, the protologue, a few images, descriptions from different sources, the position of each taxon in the adopted classification, a phylogeny, and the currently available IUCN Red List category. Depending on the sources, some extra information is displayed, such as habitat descriptions, species distributions, and other conservation ratings and use. The type material is also mentioned. A distribution map can also be attached. Finally, depending on the sources, it is possible to display the synonymy, the bibliography, including author attributions and credits, and the copyrights. Regarding synonymy, the WFO also proposes to include alternative classifications, depending on those in-

cluded in different projects, one of which will be accepted as the consensus classification proposed by the community of taxonomists taking part in the WFO project.

The meeting that took place in Geneva at the beginning of 2015 brought great news for the project. For example, the New York Botanical Garden had obtained funding from Google to put the project on the cloud, using servers provided by this company. The Botanic Garden of Rio provided work time of its information technology expert to develop the general design. The Conservatory and Botanical Garden of the City of Geneva proposed to provide their management program for nomenclature, as a tool to manage the taxonomic backbone. This program allows an independent management for each "project," allowing the user to visualize, on a basis of valid names, different taxonomies in parallel, one of these taxonomies being the consensus taxonomy proposed by the WFO. These were just some examples of the substantial and generous investments brought to the project by its partners. Each member of the consortium brings its expertise and resources, depending on its capacity, but always with the profound desire to obtain a useful and enthusiastic outcome for the achievement of this vital GSPC target by 2020.

THE ETERNAL FUNDING PROBLEM

The WFO relies on funds and other resources provided by its partners, or on funds that its partners have raised from other sources in order to allow their participation. It had been hoped, since the GSPC is a key agreed initiative of the CBD, and supported by each of the signatory parties of the CBD, that specific resources and support would have become available from governments. However, this has not been the case to date, although it should be acknowledged that many of the partner institutions are government-supported. Nevertheless, the endorsement of the GSPC, and specifically of the WFO, allows partner institutions in the consortium to justify and promote their participation in the project and to undertake fundraising efforts for this important project.

CONCLUSION

The efforts made by the WFO Consortium and its member institutions are very encouraging and demonstrate the importance of this global project. It points to and highlights the importance of further future development of plant taxonomy and floristic publications, to support many purposes, not just plant conservation. Indeed, this collaborative project has been important in linking and joining the resources of

partner institutions in order to share knowledge about the world's plants, which is useful to all. This is made possible by the impressive evolution of communications via the internet. Although some places in the world remain hardly accessible to electronic information, communication is intense in the great majority of active sites of botany and conservation. The information that the WFO will provide to all will certainly accelerate all processes linked to nomenclature and taxonomy, and will give vital information and deliver important decision-making tools about global conservation issues. Besides, monitoring the achievement of many of the targets of the GSPC becomes achievable only when Target 1, "an online flora of all known plants," has been reached.

Plans are being made to launch a public WFO portal at the International Botanical Congress in China in July 2017. This portal will include extensive but representative data on the plants of many parts of the world, provided by a range of partners in the WFO Consortium. Following that, efforts will continue to be made to populate the WFO database with information on tens of thousands more species, with the aim of having as comprehensive and authoritative a WFO as possible by 2020. In the meantime, contributions from a range of taxonomic experts and specialist taxonomic networks will be incorporated too, to further enhance the quality of data in the core taxonomic reference system in the flora (the "taxonomic backbone"). A major issue that remains to be resolved is how to ensure that data currently available only in printed (non-digital) formats can be digitized and incorporated into the WFO. Such a project as the WFO will never be complete and future work of the consortium will focus on what arrangements need to be made to ensure that the project continues after 2020 and is updated and enhanced as further data become available.

CONTACTS

Any interested institution is cordially invited to participate in this collaborative project. Contact

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