A World Flora Online by 2020: a discussion document on plans for the achievement of Target 1 of the Global Strategy for Plant Conservation by 2020

Presented to the Sixteenth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice of the Convention on Biological Diversity, Montreal, 30 April – 5 May 2012.

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1. Background to the Global Strategy for Plant Conservation and its targets for 2010

Recognizing the critical situation facing the world's plant diversity, and a particular responsibility to alert the global community, botanists at the XVI International Botanical Congress in Saint Louis, Missouri, United States in August 1999, called for plant conservation to be recognized as an outstanding global priority in biodiversity conservation.

Responding to the Congress resolution, an *ad hoc* group drawn from major international and national organizations, institutions, and other bodies involved in biodiversity conservation came together in Gran Canaria, Spain in April 2000 to consider the need for a global initiative for plant conservation. The group resolved that a Global Strategy for Plant Conservation (GSPC) and associated program for its implementation should be developed urgently, within the framework of the United Nations Convention on Biological Diversity (CBD).

In its decision VI/9, the CBD adopted the GSPC at its 6th Conference of the Parties held in the Hague, Netherlands in April 2002. The Strategy included 16 targets to be achieved by 2010. Target 1 called for the preparation of *"a widely accessible working list of known plant species, as a step towards a complete world flora."*

Following the adoption of the GSPC by the CBD in 2002, a Global Partnership for Plant Conservation (GPPC) was created in 2004 to help support the implementation of the Strategy worldwide. The GPPC brings together a range of major institutions and organizations active in plant conservation worldwide (http://www.plants2020.net/gppc).

The terms and technical rationale for GSPC Target 1 for 2010 were as follows:

> *A working list of known plant species is considered to be a fundamental requirement for plant conservation. The target is considered to be attainable by 2010, especially given that is to be a working rather than a definitive list, and it is*

limited to known organisms (currently about 270,000, which may increase by 10–20% by 2010). Some 900,000 scientific names are known for these 270,000 species. In effect the target will require the compilation and synthesis of existing knowledge, focusing on names and synonyms, and geographical distribution. Both national flora and compilations and international initiatives are important in this respect. The list could be made accessible through the World Wide Web, complemented by CD-ROM and printed versions. Further work on national and regional floras is necessary to lay the basis for the longer term aim of developing a complete world flora, including local and vernacular names.

Target 1 was achieved with the creation of The Plant List (http://www.theplantlist.org/), released in December 2010 by the Royal Botanic Gardens, Kew and the Missouri Botanical Garden.

2. A working list of all known plant species

The Plant List is a working list of all known plant species. Version 1, released in December 2010, aims to be comprehensive for species of vascular plants and bryophytes. It does not include algae or fungi. Version 1 contains 1,244,871 scientific plant names of which 298,900 are accepted species names. It includes no vernacular plant names.
Collaboration between the Royal Botanic Gardens, Kew, the Missouri Botanical Garden, and contributions from other partners enabled the creation of The Plant List by combining multiple checklist datasets held by these partners.

The Plant List was developed using an automated system that evaluates plant name data and provides an *accepted* scientific name for most species, with links to all *synonyms* by which a species has been known. It also includes *unresolved* names for which the contributing data sources did not contain sufficient evidence to decide whether names were accepted or synonyms.

Data were evaluated from Tropicos (http://www.tropicos.org/) and the World Checklist of Selected Plant Families (http://apps.kew.org/wcsp/home.do), in addition to other sources available for the project such as the International Plant Names Index (IPNI; http://www.ipni.org/), the International Legume Database & Information Service (ILDIS; http://www.ildis.org/), the International Organization for Plant Information (IOPI; http://plantnet.rbgsyd.nsw.gov.au/iopi/iopihome.htm), the Global Compositae Checklist (http://compositae.landcareresearch.co.nz/), GrassBase (http://www.kew.org/data/grasses-db.html), and iPlants (http://www.iplants.org/).

Development of The Plant List has been a collaborative venture coordinated at the Royal Botanic Gardens, Kew and the Missouri Botanical Garden and relying on the generosity of many collaborators who manage significant taxonomic data resources. The purpose was to merge into a single consistent database the best of the nomenclatural information available in these diverse data resources through a defined and automated process. In summary, development of The Plant List involved merging many taxonomic data sources taking the accepted name and synonymy relationships from those that were global

checklist datasets, augmenting these and adding additional names and synonymy relationships from regional and national floristic datasets following a set of rules. Species names not accounted for in any of the previously incorporated data sets are added from nomenclatural resources, ensuring the list is comprehensive for all plant names. Finally a further set of rules are applied to the final data set to resolve inconsistencies, conflicting or overlapping statuses and to correct logical data errors.

The accumulated names were evaluated to produce the first inclusive list of the world's plants in over a century. The information is freely available on line at http://www.theplantlist.org/. The Plant List is considered a working list: it is not perfect and represents work in progress. The aim was to produce a "best effort" list by 2010 to demonstrate progress and stimulate further work. We acknowledge the many inconsistencies attributable to a lack of data or authoritative references. The List provides a significant new resource and a starting place for a World Flora Online.

The Plant List contains 1,244,871 scientific plant names: flowering plants, conifers, ferns and bryophytes, in 620 families and 16,167 genera. The total accepted species number is 298,900 species, almost an equal number of names currently unresolved and 477,601 synonyms. Given these figures and the ratios between them we could predict now a number around 400,000 accepted species in the World Flora.

3. Updated GSPC targets for 2020

In its decision X/17, the CBD adopted a consolidated update of the GSPC for the decade 2011–2020 at its 10th Conference of the Parties held in Nagoya, Japan in October 2010. The updated Strategy includes five Objectives and 16 targets to be achieved by 2020. The updated GSPC Target 1 aims to build on this success and complete the ambitious target of *"an online flora of all known plants"* by 2020. Such a widely accessible Flora of all known plant species is an essential tool for planning and implementation of comprehensive plant conservation efforts at all levels, and Target 1 is seen as a critical element in completing each of the other objectives and targets of the GSPC (see below). While some in the botanical community might consider this an unrealistic task, we believe there is a solid resource in the data already available, as well as the necessary expertise within the scientific community, to create a solid foundation for the World Flora Online and to identify and begin to fill the gaps.

The following terms and technical rationale for a World Flora Online are being considered at the Sixteenth meeting of the CBD's Subsidiary Body on Scientific, Technical and Technological Advice, Montreal, 30 April – 5 May 2012 (UNEP/CBD/SBSTTA/16/11)

> *Target 1: An online Flora of all known plants.*
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> *A widely accessible Flora of all known plant species is a fundamental requirement for plant conservation and provides a baseline for the achievement and monitoring of other targets of the Strategy. The previous (2010) target 1 aimed to develop "a widely accessible working list of known plant species as a step towards a complete world flora," and this target was achieved at the end of*

> *2010, as The Plant List (www.theplantlist.org). Drawing from the knowledge gained in producing The Plant List, an online World Flora of all known plant species is now projected for 2020. The structure of the Flora is yet to be determined, but it should be a framework capable of accommodating regional floristic information (at national or lower level) that can provide answers in both regional and global contexts. Enhancements should include more complete synonymy; geographic distributions to at least country level, drawing on national floras, checklists, and monographs; habitat data; identification tools, principally interactive keys, images, and descriptions; conservation status (with links to assessments being carried out under Target 2); and other enhancements as practicable, e.g., vernacular names. Much of these data already exist in digital or printed format, and they can be used to populate the Flora. This is much more than an information technology project, though, and plant taxonomists will play a crucial role in resolving taxonomy that differs between geographic regions and in generating new floristic and monographic work to update old information and fill in the considerable gaps that exist. Capacity-building in taxonomy, as outlined in the Global Taxonomy Initiative (GTI), and linkage between national, regional and global initiatives, will also be critically important to maintaining, improving, and updating the Online World Flora.*

The updated GSPC for 2020 was welcomed in Resolution 1 of the XVIII International Botanical Congress, held in Melbourne, Australia in July 2011, specifically mentioning the World Flora Online, calling for "*botanical institutions worldwide to collaborate to achieve a comprehensive and authoritative 'online flora of all known plants' by 2020*."

There is, therefore, a clear recognition that a World Flora Online is endorsed by the international botanical community, and that it would contribute significantly to the conservation of plant diversity worldwide.

With this background in mind, in January 2012 in Saint Louis, 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 GPPC—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 the World Flora Online, as well as a decision to form an international consortium of institutions and organizations to collaborate on providing that content. Preliminary ideas on the technical requirements for processing and delivering the data, and a tentative timetable for the next steps to be taken, were also reviewed.

The first step was the agreement and signing of, at the end of February 2012, a Memorandum of Understanding between the four institutions. They agreed to provide members of an Organizing Committee charged with facilitating and assisting in the organization and coordination of the international Consortium of relevant organizations and institutions that may contribute to the achievement of the World Flora Online by 2020.

The next step is to invite relevant institutions and organizations representing a wide coverage of geographical regions and centers of plant diversity to join the consortium that will provide the content of the World Flora Online and collaborate in the ongoing and urgent efforts to document plant diversity in parts of the world and amongst specific plant groups were there are significant gaps in knowledge.

4. What is a vision for the World Flora Online?

Firstly, it is probably useful to define what the World Flora Online is *not*. It is not a critical, monographic revision of each of the world's plant species. Nor is it a detailed local Flora with vouchered distributional data. Initially it will be a synoptic Flora with a defined, descriptive data set containing largely pre-existing data on the world's plant species. A restrictive timeline and limited resources, by and large, make it unrealistic to develop new or collated descriptions. Although these may well be required in the future, it will first be necessary to collect and make available existing data. Once the foundation is available, new technologies can be employed to analyse, manipulate, and enhance the Flora. As this work proceeds it will be important to explore mechanisms, including capacity-building at national level, to fill the gaps in existing knowledge.

Initially, it is suggested that the following data types are both available and necessary to produce a World Flora Online that will promote scientific research and conservation as well as support the other GSPC targets for 2020. It is proposed that these data types be prioritized as (a) core fields and (b) supplementary fields, but it is expected that the content will grow as information, resources, and technology improve.

(a) Core fields:

- Scientific names – accepted name and synonyms, by direct input from a revised and updated version of The Plant List, with options for showing alternative classifications, not just the consensus one
- Links to higher-level taxa – genera, families, etc., based on consensus and optional alternative classifications
- Descriptions – an option for multiple descriptions with full attribution reflecting regional and taxonomic differences or alternatives
- Images – photographs and drawings showing a full range of characteristics from the whole organism to microscopic details
- Identification keys – initially available text (dichotomous keys), but moving to random access and other options as technology, markup, and data parsing become available. Inclusion of keys may be facilitated by linkages to existing sources such as http://www.identifylife.org/ or online Flora projects.
- Distribution – national-level geographic distribution
- References – attribution of sources of data included in the Flora

(b) Supplementary fields:

- Native status – at national level, flagging endemic taxa
- Habitats – general categories to provide gross sorting of plant species
- Altitude – general altitudinal range for species
- Conservation assessments – an opportunity to increase the assessments of plant species and support GSPC Target 2
- Web links – to external data about the species, e.g. barcodes
- Vernacular names – to be included if available

Attribution will be a critical element for all data used whether a full description from a Flora or the publication used to interpret the habit or altitudinal properties of a species. This will be a community resource built on the work of a great many individuals throughout the world, and their contributions to the Flora and its influence on GSPC Targets will be documented.

It is envisaged that information in the World Flora Online will be presented in a variety of languages. For example, descriptions written in a particular language will be presented in the language in which they are currently available. In some instances, translations into a variety of languages are possible too and it is expected that, in due course, different language versions will be presented as and when resources allow.

5. The way forward: compilation of existing data, gap-identifying, gap-filling

Essentially, the strategy employed to take forward the compilation of the World Flora Online will be initially to combine and synthesize existing electronic datasets and incorporate regional and national Floras and monographs. The World Flora Online will also further improve and build upon the work already achieved in The Plant List, by using as its taxonomic "backbone" a revised version of The Plant List.

Recent electronic Floras and monographs will be the easiest targets, and they will form the initial content of the Flora. It is estimated that about 50% of the Flora can be compiled in this way. This is the "easy part." Less easy will be the incorporation of data from recent hard-copy Floras and monographs (which are not currently available in digital form). These will be electronically captured and, with emerging markup software, added to the reservoir of data. It will be possible to determine the remaining gaps in the data. The "hard part" will then entail filling these gaps. It is planned to invite and facilitate participants from the world's botanical community to fill these gaps for whole taxa or missing data elements from their unique knowledge and holdings. It will also be important to support much-needed new taxonomic work to fill the identified gaps.

It will be necessary to identify a "consensus taxonomy" in situations where the same taxa are currently treated differently in different regions and/or by different authors. It will also be important to present alternative treatments, with references, so as not to obscure taxonomic disagreement where such exists. This will serve the needs of plant systematists, who are among the Flora's primary stakeholders. We also recognize the

need of stakeholders who wish to know a single, accepted name for a species. In most cases this will not be controversial, but, when controversy exists, a consensus opinion must be identified and provided. This need will be met by The Plant List, updated as necessary to form the taxonomic backbone for the World Flora Online as described above.

Another essential component of the World Flora Online, responding to criticisms of the first version of The Plant List, released at the end of 2010, will be an efficient system that enables specialists to submit feedback that can be included or acted upon to correct, improve, and augment the content.

The internet will provide a means to promote participation and gather information from across the range of each species. The development of an open, community-wide display, editing, feedback/comment, and review system will not be an easy task, but it is feasible today and is a practicable way to complete a World Flora Online within the very limited time constraints.

6. Technical challenges in delivering the World Flora Online

The primary technical challenge is to develop an open and transparent, Web-based data collection, manipulation, and storage facility. This must be easily employed by contributors worldwide for data capture while maintaining an agreed standard, permitting targeted editorial access to specialists, and facilitating the use of a wide variety of external hardware and software options.

Secondarily, the system must provide open access to this accumulated data resource for the scientific community and other users of botanical data. The system will be required to support research and conservation as an authoritative information system to facilitate the implementation of the Convention.

We see the World Flora Online as a critical resource for the direct conservation of plants by providing the information necessary to provide a baseline on the plant diversity of each region or country, as well as to identify the organisms under study effectively, evaluate their distributions, and help improve both regional and global estimates of status of threatened or endangered taxa supporting GSPC Target 2.

An open Web site will provide access to the recorded information on the world's plants and tailor output for national or regional context for selected plant groups, specific kinds of organisms or identifying groups of endangered taxa; and thus be designed to support the other GSPC 2020 targets.

7. How is the World Flora Online relevant at a national level?

Although it will primarily provide a global overview of the diversity of plant species on the planet, the World Flora Online will become an essential tool for conservation planners, policy makers and practitioners at all levels. For example, countries without a

national Flora, or without a recent one, will benefit from being able to draw upon the floristic treatments that will be included in the World Flora Online.

With the inclusion of geographical information on the distribution of all species, at least in principle, users will be able to prepare comprehensive overviews, including checklists, of the plant diversity of particular countries and regions, whether or not specific Floras exist for those countries and regions.

Efforts to produce national Floras can also complement the World Flora Online, and vice versa. We also hope that collaboration on, and the results from, the World Flora Online will help stimulate plant systematic work in parts of the world and on particular plant groups where it has hitherto been less active. With slightly more than half the world's plants estimated to be endemic to a single country, the expertise of national institutions will be critical to the long-term sustainability of the World Flora Online.

The World Flora Online can also be used as part of national plant conservation strategies and programs to:

- Help identify species threatened within national boundaries
- Compile lists of priority species requiring conservation action
- Provide identification tools (keys, photographs, descriptions etc) to plant conservation practitioners
- Indicate the distribution of species in other countries
- Provide guidance on potential invasive species
- Provide a baseline and framework for the compilation of information on plants (including traditional and other knowledge) being conserved or in need of conservation (for example for the achievement of Targets 5,7,8, 9, 10 and 11).

It is expected that the World Flora Online will become a fundamental resource for many sectors and in particular those working on the conservation and sustainable use of biological resources.

National-level capacity-building activities will be required in some parts of the world if the GSPC Targets are to be achieved. Such efforts may be most effectively undertaken within the context of the capacity-building strategy of the CBD's Global Taxonomy Initiative[1] (GTI) (UNEP/CBD/SBSTTA/15/5/Annex).

8. Which of the other GSPC Targets for 2020 will the World Flora Online support?

[1] See UNEP/CBD/SBSTTA/16/12. Revised Draft Capacity-Building Strategy for the Global Taxonomy Initiative: http://www.cbd.int/doc/meetings/sbstta/sbstta-16/official/sbstta-16-12-en.pdf

The achievement of Target 1 provides a valuable baseline against which many of the GSPC targets can be monitored. Some specific examples of how it can support particular targets are given below.

- *Target 2: An assessment of the conservation status of all known plant species, as far as possible, to guide conservation action.*

A sound taxonomic basis for plant species is required before conservation assessments can be meaningful. The achievement of Target 1 will help to indicate, for example, assessments of supposedly threatened entities that are, in fact, conspecific with widespread and common species.

- *Target 3: Information, research and associated outputs, and methods necessary to implement the Strategy developed and shared.*

The World Flora Online will be freely available via the World Wide Web.

- *Target 5: At least 75 per cent of the most important areas for plant diversity of each ecological region protected with effective management in place for conserving plants and their genetic diversity.*

Regional distributional information included in the World Flora Online will help to identify and highlight particular areas of great and important plant diversity.

- *Target 7: At least 75 per cent of known threatened plant species conserved in situ.*
- *Target 8: At least 75 per cent of threatened plant species in ex situ collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes.*

Country-level occurrence data will assist national-level implantation. Information on the endemic and conservation status (Target 2) included in the World Flora Online will provide a means to identify priorities and monitor the achievement of Targets 7 and 8.

- *Target 9: 70 per cent of the genetic diversity of crops including their wild relatives and other socio-economically valuable plant species conserved, while respecting, preserving and maintaining associated indigenous and local knowledge.*

The World Flora Online can provide a reference point for the compilation of national, regional and global lists of plants of socio-economical importance.

- *Target 10: Effective management plans in place to prevent new biological invasions and to manage important areas for plant diversity that are invaded.*
- *Target 11: No species of wild flora endangered by international trade.*

Distribution information contained in the World Flora Online will be particularly valuable to help in monitoring the achievement of this target and for the work of related Conventions, e.g. CITES.

The global perspective of all plant species provided by the World Flora Online, including the taxonomy, distribution, native status, and habitats of the species, will facilitate the efforts to achieve Targets 5–11.

- *Target 14: The importance of plant diversity and the need for its conservation incorporated into communication, education and public awareness programmes.*

The publicity generated for the World Flora Online will increase awareness of the world's plants and the issues of their conservation among the public, as well as increasing knowledge among both the public and special interest groups such as plant systematists, conservationists, and ecologists.

- *Target 16: Institutions, networks and partnerships for plant conservation established or strengthened at national, regional and international levels to achieve the targets of this Strategy.*

Developing the international consortium that will provide the content of the World Flora Online will contribute to the achievement of Target 16.

9. Institutions and organizations that have agreed, in principle, to collaborate

As this document was being prepared, a range of leading institutions involved in plant systematics around the world was invited to participate in the preparation of the World Flora Online. The brief list presented here includes only those institutions and organizations that have confirmed their participation, in principle, at the time this paper was communicated to the Secretariat of the Convention on Biological Diversity on 23 April 2012. It is expected that many more institutions will join in this international collaborative effort.

- Conservatoire et Jardin botaniques de la Ville de Genève, Switzerland
- Forest Herbarium, Department of National Parks, Wildlife and Plant Conservation, Thailand
- Forest Research Institute Malaysia
- Institut de Recherche pour le Développement, New Caledonia
- Missouri Botanical Garden, United States
- National Herbarium, Addis Ababa University, Ethiopia
- New York Botanical Garden, United States
- Royal Botanic Garden Edinburgh, United Kingdom

- Royal Botanic Gardens, Kew, United Kingdom
- South African National Biodiversity Institute (SANBI)
- Species Plantarum Programme (SPP)

10. Conclusions

The adoption of Target 1 for the development of a World Flora Online by 2020 by the international community, as part of the CBD's Global Strategy for Plant Conservation, presents a serious and daunting challenge to the global botanical community. In essence, it is a request to collate, compile, develop, organize and disseminate information on as many as 400,000 known plant species in only eight years. A great deal of the required information is already available in a usable form, and the technology to develop a world-accessible system to support the task is available. The first steps, outlined in this paper have now been put together to create the plan for providing this new resource for plant conservation. The support of the botanical community is urgently needed through participation in this task to provide a critical resource necessary for the successful completion of the GSPC 2020 targets. The support of national governments, the international community and the private sector will also be needed to provide resources (financial and other resources, including capacity-building) to help facilitate this important project over the next eight years.