Proceedings of the EuroGard VII Congress

EUROPEAN BOTANIC GARDENS IN THE DECADE ON BIODIVERSITY
CHALLENGES AND RESPONSABILITIES IN THE COUNT-DOWN TOWARDS 2020

Editor
Denis Larpin

MUSÉUM NATIONAL D'HISTOIRE NATURELLE

Thanking Botanic Gardens Conservation International and the European Botanic Gardens Consortium for hosting these proceedings on their websites

Front page: *Eryngium alpinum* dans le Vallon du Fournel et inclus dans le site Natura 2000 Vallon des Bans - Vallée du Fournel (https://inpn.mnhn.fr/site/natura2000/FR9301505), ***Doug Evans***

Graphic design : **Amaya Delmas**

SUMMARY

Part I.

The EuroGard VII Congress

The European Botanic Gardens Congress, EuroGard VII, was held in Paris from July 6-10, 2015 at the National Natural History Museum. It was organised in partnership with the European Botanic Gardens Consortium (EBGC), Botanic Gardens Conservation international (BGCI), and Jardins botaniques de France et des pays francophones (JBF).

EuroGard VII brought together representatives from botanic gardens across Europe. The scientific programme focused around the new version of the European Botanic Gardens Action Plan. The conference addressed the issues and challenges facing botanic gardens in the Decade on Biodiversity and will consider opportunities and prospects for the community of botanic gardens.

Jardins botaniques de France et des pays francophones

The Association of Botanical Gardens of France and Francophone countries has linked botanical gardens in France since 1979. Since 1994, it opened its membership to botanic gardens in French-speaking countries and now counts members in Belgium, Cambodia (in progress), Canada, Luxembourg, Madagascar, Morocco, Senegal (in progress), Switzerland and Vietnam. The members of the Association are developing, each according to their means, plant conservation programmes through research, integrated conservation, education and public awareness to ensure the preservation of biological diversity and the sustainable management of the planet's resources. In France, the Association provides support to its members, old or new, organizing, each year, technical sessions that bring together the different actors. The association issued in 1996 a Charter for botanical gardens which defines the areas of work of contemporary botanical gardens, "institutions that hold documented plant collections for the purpose of scientific research, conservation, exhibition and education". The gardens that have chosen to follow the ethics of this charter confirm their willingness to join European and international actors working towards the implementation of international strategies for the conservation of biological diversity.

European Botanic Gardens Consortium

There are around 800 botanic gardens in Europe and in most countries these are linked through national botanic garden networks. Representatives of the national networks come together in the European Botanic Gardens Consortium. The Consortium was established in 1994 to plan Europe-wide initiatives for botanic gardens, especially within the context of implementation of the Convention on Biological Diversity and other European biodiversity policies and strategies. The Consortium acts as a valuable conduit for information flow and co-operation between the national associations of botanic gardens as well as between individual institutions. As well as organising regular European Botanic Gardens Congresses (EuroGard), the Consortium has also promoted and helped to lead other significant international initiatives, such as the IPEN - the International Plant Exchange Network.

Botanic Gardens Conservation International

Botanic Gardens Conservation International (BGCI) provides a global voice for all botanic gardens, championing and celebrating their inspiring work. BGCI is the world's largest plant conservation network, active in over 100 countries. Its mission is "to mobilize botanic gardens and engage partners in securing plant diversity for the well-being of people and the planet". BGCI plays a leading role in the implementation of the UN's Global Strategy for Plant Conservation. It has helped to establish many new botanic gardens and provides training in all aspects of the work of botanic gardens. BGCI documents and provides information on the great diversity of plants held in the world's botanic gardens and supports conservation and education programmes around the world.

EUROGARD VII

EUROPEAN BOTANIC GARDENS IN THE DECADE ON BIODIVERSITY
CHALLENGES AND RESPONSIBILITIES IN THE COUNTDOWN TOWARDS 2020

In support of The United Nations Decade on Biodiversity

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Paris quadrifolia L., Herb Paris or True Lover's Knot, was chosen as the emblem for the EuroGard VII congress in Paris

The Herb Paris is a small rhizomatous geophyte in the Melanthiaceae family. It is remarkable for its leaves and floral parts all whorled in 4. Its inconspicuous flowers are wind- or self-pollinated.

It is found in moist woodlands on calcareous soils, across the temperate and boreal regions of Europe, including the Paris Basin.

The species is in decline due to the aggressive methods of modern forestry. Regeneration is mainly by vegetative spread because seed dispersal is limited. Since the species colonizes new forest stands very slowly, management should focus mainly on conservation of ancient forest stands.

Its current name comes from the medieval name *Herba Paris*.

According to interpretations, it evokes Paris the mythological hero, or more probably comes from the Latin *par*, equal, in reference to its regular morphology.

EUROGARD VII
PARIS

> IMAGE 1

F. Perriat / CBNBP

> IMAGE 2

F. Perriat / CBNBP

The European Botanic Gardens Congress, EuroGard VII (European Botanic Gardens in the Decade on Biodiversity - Challenges and responsibilities in the countdown towards 2020), was held in Paris from July 6 -10, 2015 at the Muséum national d'Histoire naturelle. It was organised in partnership with the European Botanic Gardens Consortium (EBGC), Botanic Gardens Conservation international (BGCI), and Jardins botaniques de France et des pays francophones (JBF).

> IMAGE 1 AND 2

Left : Oral presentation, F-G Grandin MNHN
Right : The round table "European botanic gardens and North-South partnerships"

The congress attracted **269 delegates** from **41 countries**.
The congress included **14 keynote presentations**, **102 oral presentations**, **5 workshops**, **2 panels** and **45 posters**.

A Pre-Congress Workshop on the Global Strategy for Plant conservation was organized by MNHN, BGCI and the Secretariat of the Convention on Biological Diversity on July 3 and 4. It was attended by **25 participants** among which 14 participants from West and Central Africa, the Indian Ocean and Haiti.

> IMAGE 3

The launch of the french capacity building initiative "Sud Expert Plantes Developement Durable", F-G Grandin MNHN

During the Welcome ceremony, the Aide Française au développement, l'Institut de Recherche pour le Développement, le Muséum national d'Histoire naturelle, le Fonds Français pour l'Environnement Mondial, the Ministry of Foreign Affairs and the Ambassadeur délégué à l'environnement officially launched the French capacity building initiative "Sud Expert Plantes Developpement Durable".

The scientific programme was based on the European Botanic Gardens Action Plan which has been updated following the conference conclusions.

The conference addressed the issues and challenges facing botanic gardens in the Decade on Biodiversity and considered opportunities and prospects for the community of botanic gardens.

> IMAGE 4

The posters, F-G Grandin MNHN

From 6 to 10 July 2015, the Jardin des Plantes, the historic botanical garden of Paris has hosted the 7th European Botanic Gardens Congress. This exceptional site, with 4 centuries of history, is recognised as a historical monument and is also a listed site.

> IMAGE 1

The Herbarium

The Jardin des Plantes is at the heart of a large national institution with a scientific, cultural and professional remit, the National Museum of Natural History. It is a public institution under the supervision of the Ministry of Higher Education and Research and the Ministry of Ecology, Sustainable Development and Energy.

On 26 hectares in the heart of Paris, it houses, in one location, research laboratories, part of the Museum's botanical and zoological gardens and exhibition galleries. It is a place of recreation and education for the 6 million visitors who discover the diversity of its botanical collections and horticultural presentations every year. It is also a very active center for the dissemination of knowledge on plants, animals and nature, welcoming more than 35,000 children each year. It includes the Menagerie, the second oldest zoo in the world opened in 1794.

About 8,000 plant species, part of the living plant collections of the National Museum of Natural History, are on display at the Jardin des Plantes in its thematic gardens and its historic glasshouses. A rich tree heritage tells the history of botany in France with specimens planted over the years since the seventeenth century. The Arboretum of Chèvreloup, a 200 hectare site near Versailles, the exotic garden of Menton, the alpine garden of Samoens and the domain of Harmas de Fabre complement the living collections with an additional 12,000 species.

For more information visit: www.mnhn.fr

> IMAGE 2

J. Munier MNHN

LOCATION OF CONGRESS/CONFERENCE ROOMS

Seventh European Botanic Gardens Congress - July 6-10, 2015
7e congrès des Jardins botaniques européens - 6-10 Juillet 2015

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Theme A

STRATEGIC FRAMEWORKS AND BEST PRACTICE FOR BOTANIC GARDENS /
CADRES STRATÉGIQUES ET BONNES PRATIQUES POUR LES JARDINS BOTANIQUES

A1: Cultivating our connections, building support and influence for Botanic Gardens / *Exploiter ses réseaux pour la promotion des jardins botaniques*

A2: Living collections: the essence of botanic gardens horticulture / *Les collections vivantes, raison d'être du jardin botanique*

A3: Access to genetic resources and benefit-sharing: International, European and national legislative approaches and their implications for Botanic Gardens / *Accès aux ressources génétiques et partage des avantages : approches législatives internationales, européennes et nationales et leurs implications pour les jardins botaniques*

A4: Databases and biodiversity information management / *Bases de données et gestion de l'information sur la diversité végétale*

A4A: Plant collection management systems / *Bases de données sur la gestion des collections*

A4B: Managing information on biological diversity at all levels / *Gestion de l'information sur la diversité végétale*

Theme B

SCIENCE

B5: Ethnobotany and botanic gardens / *Ethnobotanique et jardins botaniques*

B6: Plant science and innovation / *Science du végétal et innovation*

B7: Invasive species, research, management and control / *Espèces exotiques envahissantes : recherche, gestion et contrôle*

Theme C

HERITAGE, CULTURE AND TOURISM /
PATRIMOINE, CULTURE ET TOURISME

C8A & C8B: Contemporary importance of historic gardens / *Rôles contemporains des jardins botaniques historiques*

C9: Impact and potential of botanic gardens in tourism / *Impact et potentiel des jardins botaniques pour l'économie touristique*

Theme D

CONSERVATION

D10: Conservation in the garden and in the wild, part 1 / *Conserver au jardin et dans la nature, 1ère partie*

D11: Conservation in the garden and in the wild part, 2 / *Conserver au jardin et dans la nature 2ème partie*

Theme E

BOTANIC GARDENS AND CLIMATE CHANGE /
JARDINS BOTANIQUES ET CHANGEMENT CLIMATIQUE

E12: Sustainable practices within the botanic garden / *Pratiques durables au jardin botanique*

E13: Climate change research in botanic gardens / *Recherche sur les changements climatiques dans les jardins botaniques*

Theme F

EDUCATION

F14: Social roles of botanic gardens / *Rôle social des jardins botaniques*
F15: Connecting people to plants / *Sensibiliser l'homme au végétal*
F16: Teaching botany / *Enseigner la botanique*

Theme G

NETWORKING, COOPERATION AND CAPACITY BUILDING / RÉSEAUX, COOPÉRATION ET PARTENARIATS

G17: International partnerships for botanic gardens / *Partenariats internationaux pour les jardins botaniques*
G18: Social networking for connecting people to plants / *Réseaux sociaux et jardins botaniques*
G19: Fundraising Instruments for botanic gardens projects / *Trouver des financements pour les jardins botaniques*
G20A & G20B: Global tree conservation / *Conservation des espèces ligneuses au niveau mondial*

PLANNING PRE-CONGRESS AND CONGRESS

Eurogard VII - Planning Pre-congress et Congress - July, 3-10 2015

at the Muséum national d'Histoire naturelle, 57 rue Cuvier, 75005 Paris

Invitation only

GSPC WORKSHOP

Friday 3/07	9:00-10:30	10:30-11:00	11:00-13:00	13:00-14:00	14:00-16:00	16:00-16:30	16:30-17:30
	Welcome - Introduction	Coffee Break	Role of the main stakeholders	Lunch	Implementation of the GSPC	Coffee Break	Implementation of the GSPC

Saturday 4/07	9:00-10:00	10:00-10:45	10:45-11:15	11:15-12:00	12:00-13:00	13:00-14:00	14:00-16:30	15:30-16:00	16:00-16:30	16:30-17:30
	Presentation CBD	Work groups	Coffee Break	Work groups	General discussion	Lunch	Work groups	Coffee Break	Work groups	General discussion, conclusions

CONSORTIUM

Saturday 4/07	19h30
	EBGC Dinner

Sunday 5/07	9:00-10:45	10:45-11:05	11:05-13:00	13:00 - 14:30	14:30-16:00	16:00-16:20	16:20-18:00
	EBGC meeting	Coffee Break	EBGC meeting	Lunch	EBGC meeting	Coffee Break	EBGC meeting

EUROGARD

Sunday 5/07	14:00-18:00
	Welcome, registration, posters installation.

Monday 6/07	8:00-9:00	9:00 - 9:50	9:50-12:45	10:50-11:15	11:15-12:45	12:45-14:15	14:15-15:50	15:50-16:15	16:15-18:00	19:00-21:30
	Welcome, registration, posters installation.	Opening of the Congress	Oral presentations	Coffee Break	Oral presentations	Lunch	Oral presentations	Coffee Break	Oral presentations	Welcome reception and lauch of the SEP2D Programme, 13th Arrondissement Townhall
							Option : 14:30-15:30 Visit of the Children's Gallery upon registration			

Tuesday 7/07	8:30-9:00	9:00-10:50	10:55-11:20	11:15-12:30	12:45-14:15	14:00-16:00	16:00-16:25	16:25-18:00
	Welcome	Oral presentations	Coffee Break	Oral presentations	Lunch	Oral presentations	Coffee Break	Oral presentations
					Presentation by the designer Alexis Tricoire of his work previously exhibited at the Jardin des Plantes			17:30-18:30 Guided tour of Paris Herbarium (Upon registration)

Wednesday 8/07	8:30 - 18:30		
	Visits in Paris and Ile de France (upon registration)		
	Excursion 1: Field Trip to the Fontainebleau Forest	Excursion 2: Chevreloup National Arboretum and Gardens of the Versailles Estate	Excursion 3: Zoological Park of Paris and Botanic Gardens of the city of Paris (Parc Floral and Arboretum)

Invitation only

Parallel session - Fifth Liaison Group meeting

Wednesday 8/07	9:00-10:55	10:45-11:05	11:20-12:30	12:30-14:00	14:00-16:00	16:00-16:20	16:20-18:00	19:30
	Liaison Group meeting	Coffee Break	Liaison Group meeting	Lunch	Liaison Group meeting	Coffee Break	Liaison Group meeting	Dinner

Thursday 9/07	8:30-9:00	9:00-10: 55	10:55-11:30	11:30-12:45	12:45-14:00	14:00-16:10	16:10-16:35	16:35-18:00	20:30-23:00
	Welcome	Oral presentations	Coffee Break	Oral presentations	Lunch	Oral presentations	Coffee Break	Oral presentations	Gala dinner

Friday 10/07	8:30-9:00	9:00-10:50	10:50-11:10	11:30-12:00	12:45-14:00	13:30-16:00		
						Guided tours (upon registration)		
	Welcome	Oral presentations and conclusions	Coffee Break	Oral presentations and conclusions	Lunch	13:30-14:30 Paris Herbarium	13:30-15:30 Tropical Greenhouses and Alpine Garden	13:30-16:00 Ecole de Botanique (systematic garden) and Ecological garden

DETAILED PROGRAMME

EuroGardVII Detailed Programme

	Day 1 – Sunday, July 5th, 2015	
09:00 – 18:00	**European Botanic Gardens Consortium meeting**	**Salle des Conseils**
14:00 – 18:00	**EUROGARD Welcome and registration**	**Direction des relations européennes et internationales (DREI)**
	Poster installation	**Orangerie**
	Day 2 – Monday, July 6th, 2015	
08:00 – 09:00	**Welcome, registration and poster installation**	**Grand Amphi du Muséum (GAM)**
09:00 – 09:50	**Congress Opening Ceremony**	**Grand Amphi du Muséum (GAM)**
	MNHN/BGCI/JBF	**Chair: Jean-Patrick Le Duc**
	Introduction to the Congress	
	K01 Ferreira de Souza Dias, Braulio	
	Enhancing implementation of the Global Strategy for Plant Conservation – the role of botanic gardens	
09:50 – 10:50	**Keynote Addresses**	
	K02 Smith Paul	
	The role of BGCI in building a botanic garden-centred global system for the conservation of all plant diversity	
	K03 Richard Dominique	
	Biodiversity in Europe: between risks and opportunities	
	K04 Maloupa Eleni	
	From the first to the seventh Eurogard: reflections on the development and changing roles in botanic gardens	
10:50 – 11:10	**Coffee Break**	**Foyer du GAM**
	Theme A - Strategic frameworks and best practice for botanic gardens / Cadres stratégiques et bonnes pratiques pour les jardins botaniques	**Grand Amphi du Muséum (GAM)**
11:10 – 11:30	**Keynote Address**	**Chair: Philippe Richard**
	A/K05 Jebb Matthew	
	Science, Showmanship and Salad-growing	
11:30 – 12:40	**Introduction**	
	A/O01 Joly Eric	
	Les Jardins et les zoos du MNHN : des outils de recherche et de reconnexion à la nature réactualisés	
	Oral presentations	
	A1: Cultivating our connections, building support and influence for Botanic Gardens / Exploiter ses réseaux pour la promotion des jardins botaniques	
	A1/O02 Sharrock Suzanne, Hird A., Jones M.	
	Networking botanic gardens for conservation - The role of BGCI's databases	
	A1/O03 Bray Laurent	
	Le Jardin Botanique de Paris, opérateur et accompagnateur de politique municipale parisienne	
	A1/O04 Koja Pawel	
	Measuring synergy within botanical gardens: using morphological analysis to evaluate the coherence of environmental, economic and social activities	
12:45 – 14:15	**Lunch Break / Poster Session**	**Orangerie**
	Theme A - Strategic frameworks and best practice for botanic gardens / Cadres stratégiques et bonnes pratiques pour les jardins botaniques	
14:15 – 14:35	**Keynote Address**	**Grand Amphi du Muséum (GAM)**
	A4: Databases and Biodiversity information management / Bases de données et gestion de l'information sur la diversité végétale	
	A4/K06 Guiraud Michel	
	The virtual herbarium: a recent output of renovating the collections at the MNHN	
14:35 – 15:50	**Parallel Session 1 – Oral presentations**	**Grand Amphi du Muséum (GAM)**
	A3: Access to genetic resources and benefit-sharing: international, European and national legislative approaches and their implications for Botanic Gardens / Accès aux ressources génétiques et partage des avantages : approches législatives internationales, européennes et nationales et leurs implications pour les jardins botaniques	**Chairs: Michael Kiehn and Conny Löhne, Task Force IPEN**
	A3/O10 Löhne Cornelia, Kiehn Michael	
	The Nagoya Protocol and the EU Regulation on Access and Benefit-Sharing – challenges and open questions for botanic gardens	
	A3/O11 Kozlowska Alicja	
	The role of collections in the European approach on ABS	
	A3/O12 Leroy Anca	
	Clés de lecture des obligations du Protocole de Nagoya	
	A3/O13 Kiehn Michael, Löhne Cornelia	
	Botanic Gardens in Europe – ready for ABS?	
	A3/O14 Biber-Klemm Susette	
	Do botanic gardens comply with the Nagoya Protocol? – An external view	
15:50 – 16:10	**Coffee Break**	**Foyer du GAM**
16:10 – 16:40	**Parallel Session 1 – Oral presentations (continued)**	**Grand Amphi du Muséum (GAM)**
	A3/O15 Van den Wollenberg Bert	
	Where living collections and convention regulations meet. A need for strengthening networking within the botanic garden community	
	A3/O15bis Williams China, Sharrock Suzanne	
	Implementing the Nagoya Protocol: Developing a Toolkit for your Botanic Garden	
16:40 – 17:00	**Final discussion**	

14:40 – 15:35	**Parallel Session 2 – Oral presentations**	**Amphi Rouelle**
	Theme A - Strategic frameworks and best practice for botanic gardens / Cadres stratégiques et bonnes pratiques pour les jardins botaniques	**Chair: Costantino Bonomi**
	A4: Databases and Biodiversity information management / Bases de données et gestion de l'information sur la diversité végétale	
	A4A: Plant collection management systems /Bases de données sur la gestion des collections	
	A4/O16 Havinga Reinout, Ostgaard Havard	
	Learning from the retail industry – Collection management with barcodes	
	A4/O17 Bollat C., Bray Laurent, Lipa V., Loizeau P.-A., Palese R., Tropé M.	
	BOTALISTA, un outil de gestion opérationnel et décisionnel pour répondre aux nouvelles missions des jardins botaniques	
	A4/O18 Rainer Heimo, Knickmann B., Koller W.	
	JACQ – a botanical collection management system	
	A4/O19 Ek Renske	
	What does the public want? Lessons learned from using modern technology in transferring plant knowledge from the scientific community to the wider audience	
	A4/O20 Wyatt Andrew	
	Advances in Plant Records Databases supporting Conservation	
15:35 – 16:10	**Coffee Break**	**Foyer du GAM**
16:10 – 18:00	**Parallel Session 2 – Oral presentations (continued)**	**Amphi Rouelle**
	A4B: Managing information on biological diversity at all levels / Gestion de l'information sur la diversité végétale	**Chair: Dominique Richard**
	A4/O21 Archambeau Anne-Sophie, Chenin E., Vignes-Lebbe R., Lecoq M.-E., Pamerlon Sophie	
	The global biodiversity information facility (GBIF): free and open access to biodiversity data	
	A4/O22 Loizeau Pierre-André, Wyse Jackson Peter	
	World Flora Online for 2020 / Flora mondiale en ligne pour 2020	
	A4/O23 Dadashova Aida, Ali-zade V., Salimov R.	
	Supporting the conservation of plant diversity by database and information management	
	A4/O24 Gourvil J., Just Anais, Milon T., Millet J.	
	SI-FLORE, an information system on the flora of France to provide expertise to policy makers on the management and conservation	
	A4/O25 Oulès Emeline, Robert S., Poncet L., Tercerie S.	
	The INPN (National Inventory of Natural Heritage), a mangement tool for French biodiversity knowledge dissemination and conservation	
	A4/O26 Felpete J. Ignacio Alonso, Bueno A., Porras C.	
	OpenREDBAG: accessing data of threathened and protected flora conserved in Spanish's germplasm banks	
14:40 – 18:10	**Parallel Session 3 – Oral presentations**	**Salle d'Entomologie**
	Theme A - Strategic frameworks and best practice for botanic gardens / Cadres stratégiques et bonnes pratiques pour les jardins botaniques	**Chair: Denis Larpin**
	A2: Living collections: the essence of botanic gardens horticulture / Les collections vivantes, raison d'être du jardin botanique	
	A2/O05 Bour A., Aztafioff Katia	
	The Scientific and Cultural Project in the tropical collections of Nancy Botanical Garden	
	A2/O06 Petitt Sally	
	Nurturing botanical horticulturists of the future: Horticultural Training at Cambridge University Botanic Garden	
	A2/O07 Bellefroid Elke, Ausloos G., Swaerts D., Reynders M., Leyman V., Billet F., Aplin D., Vanderborght T., Dessein S.	
	Two decades of landscaping the plant palace: linking plant collections and education	
	A2/O08 Reynders Marc, Bellefroid E., De Meyere D., Vanderborght T., Dessein S.	
	How to use ecological data to optimize horticulture in large ex-situ plant collections	
	A2/O09 Burkart Michael, Lauterbach D.	
	Ex situ plant species conservation in Germany: current issues and international options	
19:15 - 22:00	**Welcome ceremony**	**Mairie du 13ème arrondissement (Paris)**
	Day 3 – Tuesday, July 7th, 2015	
08:30 – 09:00	**Welcome, registration**	**Grand Amphi du Muséum (GAM)**
09:00 – 10:00	**Keynote Addresses**	**Chair: Thomas Haevermans**
	Theme C: Heritage, Culture and Tourism / Patrimoine, Culture et Tourisme	
	C/K08 Deverell Richard	
	Heritage, Tourism and Science – an Impossible Mix?	
	Theme B: Science	
	B/K07 Caujapé-Castells Juli	
	Bridging the gap between population genetics and conservation practise: science facts or science fiction?	
	Theme G: Networking, cooperation and capacity building / Réseaux, coopération et partenariats	
	G/K14 Qunli Han	
	Networks, cooperation and capacity building	

10:00 – 11:00	Parallel Session 1 – Panel	Grand Amphi du Muséum (GAM)
	Theme G: Networking, cooperation and capacity building / Réseaux, coopération et partenariats	Chair: Fanch le Hir
	G17: International partnerships for botanic gardens / Partenariats internationaux pour les jardins botaniques	
	G17/Pa03	
	European botanic gardens and North-South partnerships - A round table discussion	
	G17/O91 Lanata Francesca, Dessein Steven, de Merode Emmanuel	
	Landscape development in educational and touristic sites in and around Virunga Park, and in particular in the site of hydroelectric plants of Rutshuru	
11:00 – 11:20	Coffee Break	Foyer du GAM
11:20 – 12:10	G17/Pa03 Panel (continued)	Grand Amphi du Muséum (GAM)
09:45 – 10:55	Parallel Session 2 – Oral presentations	Amphi Rouelle
	Theme C: Heritage, Culture and Tourism/ Patrimoine, Culture et Tourisme	Chair: Laurent Bray
	C9: Impact and potential of botanic gardens in tourism / Impact et potentiel des jardins botaniques pour l'économie touristique	
	C9/O50 Perrocheau Romaric	
	Touristic development in Nantes botanical garden	
	C9/O51 Koen Es	
	Botanic gardens as tourist attractions	
	C9/O52 Gouveia António C., Gonçalves L., Schreck Reis C., Azevedo C., Moreira A., Trincão P.	
	The botanic garden of the University of Coimbra, Portugal: paths to and from a UNESCO World Heritage Site	
	C9/O53 Monteiro, Luis Carlos Neto	
	A combined system to monitor and manage visitor use at World Heritage Sites: a case-study from the Průhonice Park, Czech Republic	
10:55 – 11:15	Coffee Break	Foyer du GAM
09:45 – 10:55	Parallel Session 3 – Oral presentations	Salle d'Entomologie
	Theme C: Heritage, Culture and Tourism / Patrimoine, Culture et Tourisme	Chair: Dalila Espirito-Santo
	C8A: Contemporary importance of historic gardens / Rôles contemporains des jardins botaniques historiques	
	C8/O42 Lavabre-Bertrand Thierry, Jarry D.-M., Spicq E.	
	The botanic garden of Montpellier and the School of Medecine, France	
	C8/O43 Felismino David	
	The botanical garden of the Polytechnic School of Lisbon, Portugal: origins and formation of its plants collection	
	C8/O44 van Uffelen, Gerda A.	
	Hortus botanicus Leiden: 425 years of plants and people	
	C8/O45 Juretić Biserka, Kovačić S., Mihelj D., Sandev D., Stamenković V.	
	The oldest university botanical garden in Croatia celebrating 125th anniversary	
10:55 – 11:15	Coffee Break	Foyer du GAM
11:15 – 12:25	Parallel Session 3 – Oral presentations (continued)	Salle d'Entomologie
	C8B: Contemporary importance of historic gardens / Rôles contemporains des jardins botaniques historiques	Chair: Dalila Espirito-Santo
	C8/O46 Kosev Krasimir, Dyankova V., Pencheva L.	
	Can a historic garden become a botanic one?	
	C8/O47 Rautenberg Anja	
	"The Rise of Systematic Biology": a potential nomination to the World Heritage List?	
	C8/O48 Gouveia António C., Schreck Reis C., Azevedo C., Gonçalves L., Trincão P.	
	Histories behind the glass: the greenhouses of the botanic garden of the University of Coimbra, Portugal	
	C8/O49 Hernández Bermejo J. Esteban, Hilgert N., Pochettino M.-L., Stampella P.	
	Towards an historical and ethnobotanical garden in Misiones, Argentina	
11:15 – 12:45	Parallel Session 4 – Panel	Salle Baleine 4
	Theme C: Heritage, Culture and Tourism/ Patrimoine, Culture et Tourisme	Chairs: Partridge Alison and Barley Richard
	C9: Impact and potential of botanic gardens in tourism / Impact et potentiel des jardins botaniques pour l'économie touristique	
	C9/Pa01 Partridge Alison, Barley Richard	
	Be careful what you wish for - Tourism readiness for botanic gardens	
09:00 – 12:00	Parallel Session 5 – Sponsored Workshop	Salle de Géologie
	Havard Ostgaard (IrisBG)	
	Getting more out of your botanical collections using IrisBG	
12:45 – 14:15	Lunch Break / Poster Session	Orangerie
	Theme G: Networking, cooperation and capacity building / Réseaux, coopération et partenariats	Grand Amphi du Muséum (GAM)
14:15 – 14:35	Keynote Address	Chair: Noëline Raondry Rakotoarisoa
	G20/K15 Oldfield Sara	
	Saving trees from extinction - Progress at European and global levels	

14:35 – 16:05	Parallel Session 1 – Oral presentations	Grand Amphi du Muséum (GAM)
	G20A: Global tree conservation / Conservation des espèces ligneuses au niveau mondial	
	G20/O95 Shaw Kirsty, Gratzfeld J., Rivers M., Magin G., Gill D.	
	The Global Trees Campaign – Safeguarding the world's threatened trees from extinction	
	G20/O96 Westwood Murphy, Cavender N.	
	What's your tree species? Prioritizing threatened taxa through a comprehensive conservation strategy	
	G20/O97 Lamant Thierry, Bénard L., Berthon S., Bimont S., Blaison L., Castagnio J.-P., Diaz E., Fauveau M., Grannet A.-M., Guardia G., Le Roi J.-P., Levannier P., Loho P., Mazoyer P., Monzo G., Pasqualini M., Perrette N., Savajols G., Simonnet F., Triolo J., Vandaele J., Vial C., Musch B.	
	ONF's arboreta of national interest	
	G20/O98 Arnet M., Santos B., Clemens John, Pelser P., Brockerhoff E.	
	How could an antipodean network of small arboreta contribute to the conservation of threatened Northern hemisphere trees?	
	G20/O99 Gratzfeld Joachim, Kozlowski Gregor, Fazan L., Christe C., Bétrisey S., Buord S., Garfì G., Pasta S., Gotsiou P., Fournaraki C., Dimitriou D., Sklavaki P., Naciri Y., Dadashova A., Selimov R., Davitashvili N., Song Y.	
	Relict trees driving international cooperation, research and conservation – The example of Zelkova spp. (Ulmaceae)	
16:05 – 16:25	Coffee Break	Foyer du GAM
16:25 – 17:25	Parallel Session 1 – Oral presentations (continued)	Grand Amphi du Muséum (GAM)
	G20B: Global tree conservation / Conservation des espèces ligneuses au niveau mondial	Chair: Kirsty Shaw
	G20/O100 Cavender Nicole, Westwood M., Bechtoldt C., Donnelly G., Oldfield S., Gardner M., Rae D., McNamara W.	
	Strengthening the conservation value of ex situ tree collections	
	G20/O101 Le Hir Fanch, Desmarattes Elie, Bordenave B., Mézard C., Gautier C., Cueff E., Bodin M.	
	Sauvetage du genévrier d'Ekman et conservation de la flore de la Forêt des Pins (Haïti)	
	G20/O102 Fromageot Claude	
	L'arbre, itinéraire d'un acteur passe-frontières	
From 17:30	Poster Session	Orangerie
14:30 – 16:05	Parallel Session 2 – Oral presentations	Amphi Rouelle
	Theme B: Science	Chair: Serge Muller
	B7: Invasive species, research, management and control / Espèces exotiques envahissantes : recherche, gestion et contrôle	
	Introduction - Serge Muller	
	B7/O37 Flevaris Spyridon	
	EU Regulation on invasive alien species – Presentation of the legislation and of progress in its implementation	
	B7/O38 Heywood Vernon	
	Invasive alien species - A challenge for botanic gardens	
	B7/O39 Barham Ellie, Sharrock S., Lane C., Baker R.	
	An international plant sentinel network	
	B7/O40 Ronse Anne C.M.	
	Monitoring of collection escapes in Botanic Garden Meise, Belgium	
	B7/O41 Ducatillion Catherine, Bellanger R., Chevallier J., Mellerin Y., Zboralski A.	
	Early evaluation of invasion risks of exotic species introduced at the Villa Thuret Botanical Garden, France	
16:05 – 16:25	Coffee Break	Foyer du GAM
16:25 – 17:55	Parallel Session 2 – Workshop	Amphi Rouelle
	Theme A - Strategic frameworks and best practice for botanic gardens / Cadres stratégiques et bonnes pratiques pour les jardins botaniques	
	A3: Access to genetic resources and benefit-sharing: international, European and national legislative approaches and their implications for Botanic Gardens / Accès aux ressources génétiques et partage des avantages : approches législatives internationales, européennes et nationales et leurs implications pour les jardins botaniques	
	A3/W03	
	Convenor: IPEN Task Force - Facilitator: Van den Wollenberg, Bert	
	How to adjust the International Plant Exchange Network (IPEN) to the new challenges of the Nagoya Protocol of the Convention on Biological Diversity	
14:30 – 16:00	Parallel Session 3 – Oral presentations	Salle d'Entomologie
	Theme B: Science	Chair: Serge Bahuchet
	B5: Ethnobotany and botanic gardens / Ethnobotanique et jardins botaniques	
	B5/O27 Bavcon Jože, Ravnjak B.	
	Traditional plant use in Slovenia	
	B5/O28 Ursem Bob, Gard W.F.	
	Solving the quest of an amphora near 2.000 years old Dead Sea scrolls, found in Qumram	
	B5/O29 Hernández Bermejo J. Esteban, Herrera-Molina F.	
	ICEBS (1992-2018): a consolidated international framework for ethnobotany	
	B5/O30 Wyse Jackson, Peter	
	Building an appreciation of native plants through ethnobotany and traditional knowledge, an example from Ireland	
	B5/O31 Salick Jan	
	Museum of biocultural collections to feature science	

16:00 – 16:20	**Coffee Break**	Foyer du GAM
16:20 – 17:30	**Parallel Session 3 – Oral presentations (continued)**	Salle d'Entomologie
	B6: Plant science and innovation / Science du végétal et innovation	Chair: Juli Caujapé-Castells
	B6/O33 Caperta Ana D, Róis A. S., Cortinhas A., Paes A.P., Espírito-Santo Dalila	
	Morphological and ecological aspects of *Limonium* spp. occuring in Portugal	
	B6/O34 Ursem Bob	
	Plants and its electrical phenomena and responses	
	B6/O35 Rucińska Anna, Puchalski J.	
	Molecular studies on conservation efficiency of *ex situ* collection for genetic diversity conservation of relict species *Dendranthema zawadzkii* (Herb.) Tzvelev	
	B6/O36 Mulhauser Blaise, Mitchell E.A.D., Mulot M.	
	Creation of a raised bog in the Botanical Garden of Neuchâtel: research, collections and public information	
14:15 – 17:15	**Parallel Session 5 – Sponsored Workshop (continued)**	Salle de Géologie
	Havard Ostgaard (IrisBG)	
	Getting more out of your botanical collections using IrisBG	
	Day 4 – Wednesday, July 8th, 2015	
	Excursions	
	Day 5 – Thursday, July 9th, 2015	
08:30 – 09:00	**Welcome, registration**	Grand Amphi du Muséum (GAM)
09:00 – 09:40	**Keynote Addresses**	Chair : Matthew Jebb
	Theme F: Education	
	F/K13 Richard Philippe	
	Educational and social role of botanical gardens: new tracks?	
	Theme D: Conservation	
	D/K09 Bardin Philippe	
	Moving towards success in Conservation: background informations and the example of French Conservatoires Botaniques Nationaux network	
09:40 – 09:55	**Introduction**	
	D10/O64 Le Duc Jean-Patrick	
	Le commerce des plantes vivantes : une activité économique importante et une source de fraudes conséquente	
09:55 – 11:00	**Parallel Session 1 – Oral presentations**	Grand Amphi du Muséum (GAM)
	D10: Conservation in the garden and in the wild, part 1 / Conserver au jardin et dans la nature, 1ère partie	
	D10/O65 Godefroid Sandrine, Le Pajolec S., Van Rossum F.	
	Reintroductions and population reinforcements of critically endangered plant species in restored grassland habitats from Belgium	
	D10/O66 Bonomi Costantino	
	NASSTEC: a training network on native seed science and use for plant conservation and grassland restoration in Europe	
	D10/O67 Papineau Christian	
	The dry forests of New Caledonia: assessment and perspectives after more than 13 years of action in aim to conserve and restore these threatened spaces and species	
11:00 – 11:20	**Coffee Break**	Foyer du GAM
11:20 – 12:20	**Parallel Session 1 – Oral presentations (continued)**	Grand Amphi du Muséum (GAM)
	D10/O68 Malaval S., Bischoff A., Provendier D., Boutaud M., Dao J., Bardin Philippe, Millet J.	
	VEGETAL LOCAL: a national French label for the conservation of the native flora	
	D10/O69 Evans Douglas, Richard D., Gaudilla-Sipkova Z., Bailly-Maitre J.	
	Progress in plant and habitats conservation across the European Union	
	D10/O32 Timoshyna Anastasiya	
	Towards conservation and sustainable use of wild plants: experiences with the implementation of the FairWild Standard	
09:40 – 11:10	**Parallel Session 2 – Oral presentations**	Amphi Rouelle
	Theme F: Education	Chair : Eleni Maloupa
	F15: Connecting people to plants / Sensibiliser l'homme au végétal	
	F15/O78 't Hart Joke, van Dijk D.	
	Striking a new balance between plant-focus and people-focus in Dutch botanic gardens	
	F15/O79 Salazar M. L., Oliveira C., Soares A. L., Soares F., Espírito-Santo Dalila	
	The use of phytosociology in the project of gardens - Practical application in the Ajuda Botanical Garden, Portugal	
	F15/O80 Mathieu Daniel, Tocco A., Carré J., Schäfer V.	
	Sciences citoyennes et participatives, l'expérience de Tela Botanica	
	F15/O81 Barata Raquel	
	Engaging for plant conservation: inquiry-based learning at the Botanic Garden of the University of Lisbon, Portugal	
	F15/O82 Gadzińska J., Wiland-Szymańska Justyna	
	Music of nature in the botanical garden	
11:10 – 11:30	**Coffee Break**	Foyer du GAM
11:30 – 12:30	**Parallel Session 2 – Oral presentations (continued)**	Amphi Rouelle
	F15/O83 De Schrijver Jolle, Dugardin C., Goetghebeur P.	
	Dare to think! Educating about the nature of science in The Ghent University Museum and Botanical Garden	
	F15/O84 Fontaine Benoît, Machon N., Martin G.	
	Production of indicators of biodiversity from data generated by general public of citizen science programs - The example of "Sauvages de ma rue" from Vigie-Nature	
	F15/O85 Ravnjak Blanka, Bavcon J.	
	Urban hobby gardening and botanic gardens	
09:40 – 11:10	**Parallel Session 3 – Workshop**	Salle d'Entomologie
	Theme F: Education	
	F15: Connecting people to plants / Sensibiliser l'homme au végétal	
	F15/W04 Derewnicka Liliana, Vergou Asimina, Julliard Romain, Machon Nathalie	
	Convenor: Derewnicka Liliana	
	Let it grow: Botanic gardens, museums and zoos campaigning for biodiversity across Europe ä	
11:10 – 11:30	**Coffee Break**	Foyer du GAM

11:30 – 12:30	**Parallel Session 3 – Oral presentations**	Salle d'Entomologie
	Theme G: Networking, cooperation and capacity building / Réseaux, coopération et partenariats	Chair: Suzanne Sharrock
	G19: Fundraising instruments for botanic gardens projects / Trouver des financements pour les jardins botaniques	
	G19/O92 Michel Didier	
	Horizon2020 – Science with and for society, responsable research and innovation, some news projects to build!	
	G19/O93 Felismino D., Barata Raquel	
	Local fundraising opportunities and public awareness: voting for sustainability at the Botanic Garden of the University of Lisbon (MUHNAC)	
	G19/O94 Anastasiadis Foivos, Maloupa E., Papanastasi K.	
	Sustainable development of botanical gardens: the case of Balkan Botanic Garden of Kroussia, Greece	
12:45 – 14:00	**Lunch Break / Poster Session**	Orangerie
14:00 – 14:20	**Keynote Address**	Grand Amphi du Muséum (GAM)
	Theme D: Conservation	Chair: Paul Smith
	D/K10 Wyse Jackson, Peter	
	The Global Strategy for Plant Conservation – A framework for botanic garden conservation action and the World's 2020 Plant Challenge	
14:20 – 16:10	**Parallel Session 1 – Oral presentations**	Grand Amphi du Muséum (GAM)
	D11: Conservation in the garden and in the wild, part 2 / Conserver au jardin et dans la nature, 2ème partie	
	D11/O60 Sandev Dubravka, Kovačić S.	
	Research on germination ecology of Croatian statutorily strictly protected species in the Botanical Garden of the Faculty of Science, University of Zagreb, Croatia	
	D11/O61 Kojs Paweł, Puchalski J., Wiland-Szymańska J., Szymczak G., Galej K., Matynia D.	
	The seed bank network in Poland as a result of Flomatur Robia Project	
	D11/O62 Essalouh L., Molina James, Prosperi J.-M., Pham J.-L., Khadari Bouchaib	
	From the *ex situ* conservation in seed banks to understanding the evolution of life history and phylogeography of rare and threatened flora: partnership and involvement of national botanical conservatoires (CBN) with ARCAD project	
	D11/O63 Breman Elinor, Way M.	
	Safe for the future: seed conservation standards developed for the Millenium Seed Bank partnership	
	D11/O64 O'Donnell Katherine, Sharrock Suzanne	
	Seed banking in botanic gardens around the world WORLD	
	D11/O65 Herrera-Molina Francisca, Prados Ligero J., Hernández Bermejo J. E.	
	New tools and commitments in the conservation of the Mediterranean flora and Andalusian agrodiversity (Spain): the Andalusian Germplasm Bank	
16:10 – 16:30	**Coffee Break**	Foyer du GAM
From 16:30	**Poster Session**	Orangerie
14:30 – 16:10	**Parallel Session 2 – Oral presentations**	Amphi Rouelle
	Theme F: Education	Chair : Liliana Derewnicka
	F14: Social roles of botanic gardens / Rôle social des jardins botaniques	
	F14/O72 Maloupa Eleni, Dalampira E.S., Papanastasi K., Oikonomou A., Krigas N.	
	A new area for education and awareness raising in the Balkan Botanic Garden of Kroussia, Greece: following up environmental, social and economic demand	
	F14/O73 Astafieff Katia	
	How to engage new audiences in Nancy Botanical Garden? Two original and unifying new projects	
	F14/O74 Vicentini Renzo, Bonomi C., Tava M.	
	The tropical greenhouse of Muse-An opportunity for social inclusion	
	F14/O75 Mouly Arnaud, Dupouët C., Vignot A., Diana-Mathé I., Jacquot G., Laithier M.-L., Milhan F., Perret N., Baudiquez B.	
	New aims and scopes to support a botanical garden in need to move in Besançon, France	
	F14/O77 Jelles J.D., Vandecasteele P.G.M., Keßler Paul J.A.	
	Generations linked with the green collectionsin botanics gardens	
16:15 – 16:35	**Coffee Break**	Foyer du GAM
16:35 – 18:05	**Parallel Session 2 – Oral presentations (continued)**	Amphi Rouelle
	F16: Teaching botany / Enseigner la botanique	Chair : Marc-André Selosse
	F16/O86 Mouly Arnaud	
	Future teachers in France: their representations of botanical gardens and plants	
	F16/O87 Chosson E., Dupont Frédéric	
	Entrée du numérique dans les jardins botaniques des Facultés de Pharmacie	
	F16/O88 Elster Doris	
	The potential of the botanic garden for inquiry-based teacher education	
	F16/O89 Marinček Alenka	
	Teaching botany through guided tours and various workshops	
	F16/O90 Andreeva Alla, Korneva-Chaeva I.	
	Using artistic heritage in contemporary education to study plant life	
14:40 – 16:10	**Parallel Session 3 – Workshop**	Salle d'Entomologie
	Theme A - Strategic frameworks and best practice for botanic gardens / Cadres stratégiques et bonnes pratiques pour les jardins botaniques	
	A2: Living collections: the essence of botanic gardens horticulture / Les collections vivantes, raison d'être du jardin botanique	
	A2/W01 Richard Philippe and the council members of Jardins botaniques de France et des pays francophones	
	The association for French-speaking botanical gardens: a charter to strengthen their action in the 21[st] century	
16:10 – 16:30	**Coffee Break**	Foyer du GAM

16:30 – 18:00	**Parallel Session 3 – Workshop**	Salle d'Entomologie
	A2/W02 Havinga Reinout, Kool Anneleen	
	The Index Seminum: a market place without time or venue?	
21:15	**Gala Reception**	"Capitaine Fracasse" Boat
	Day 6 – Friday July 10th, 2015	
08:00 – 09:00	**Welcome, registration**	Grand Amphi du Muséum (GAM)
	Theme E - Botanic Gardens and Climate Change / Jardins botaniques et changement climatique	Chair :
09:00 – 09:40	**Keynote Addresses**	
	E/K11 Le Treut Hervé	
	attente titre	
	E/K12 Hyvärinen Marko	
	Should botanic gardens revise their living collection policies to facilitate adaptation to climate change?	
09:40 – 10:50	**Parallel Session 1 – Oral presentations**	Grand Amphi du Muséum (GAM)
	E13: Climate change research in botanic gardens / Recherche sur les changements climatiques dans les jardins botaniques	
	E13/O68 Lehtimäki Iida, Hällfors M.H., Lehvävirta S., Schulman L.E., Hyvärinen M.	
	Translocation experiments with Siberian primrose in six botanic gardens – practical experiences and preliminary results	
	E13/O69 Marquis Frédéric, Abdulhak S.	
	Studying garden plant species phenology: a tool for observation of climate change	
	E13/O70 Ducatillion Catherine, Bellanger Richard, Charron Tristan, Chevallier Joëlle, Mellerin Yannick, Heinz Christine, Caraglio Yves, Ameglio Thierry	
	Growth phenology monitoring to study drought trees adaptation at the Villa Thuret Botanic Garden	
	E13/O71 Lamant Thierry, Bastien Jean-Charles, Bellanger Richard, Ducatillion Catherine, Musch Brigitte	
	Scientific arboreta under climatic changes	
10:50 – 11:15	**Coffee Break**	Foyer du GAM
9:45 – 10:50	**Parallel Session 2 – Oral presentations**	Amphi Rouelle
	E12: Sustainable practices within the botanic gardens / Pratiques durables au jardin botanique	Chair : Peter Wyse Jackson
	E12/O66 Benkhelifa Karim, Rémy Marc, Astafieff Katia	
	Differentiated management and practices in Nancy botanical garden (France): retrospective and evolutions	
	E12/O67 Freyre Nicolas, Loizeau Pierre-André	
	Les Conservatoire et Jardin botaniques de la Ville de Genève au régime Bio	
10:50 – 11:15	**Coffee Break**	Foyer du GAM
9:20 – 10:50	**Parallel Session 3 – Panel**	Salle d'Entomologie
	Theme F: Education	
	F14: Social roles of botanic gardens / Rôle social des jardins botaniques	
	F14/Pa02 Derewnicka Liliana, Vergou Asimina	
	Rolling with the changes: what is the role of university botanic gardens?	
10:50 – 11:15	**Coffee Break**	Foyer du GAM
11:15	**EuroGardVII Congress Conclusion**	Grand Amphi du Muséum (GAM)
	Loizeau Pierre-André	
12:15	**EuroGardVIII Congress Presentation**	
	Espirito Santo Dalila	
12:45 – 14:15	**Lunch Break / Poster Session**	Orangerie
14:30 – 17:00	**Guided Tours of the Jardin des Plantes**	Meeting at Greenhouse entrance

KEYNOTE SPEAKERS

Braulio Ferreira de Souza Dias

Executive Secretary of the Convention on Biological Diversity

Dominique Richard

Director, European Topic Center on Biological Diversity

Paul Smith

Secretary General, Botanic Gardens Conservation International

Eleni Maloupa

Director, Hellenic Agricultural Organization, Thessaloniki

Qunli Han

Director, Division des Sciences Ecologiques et de la Terre, UNESCO

Sara Oldfield

IUCN/SSC Global Tree Specialist Group

Juli Caujapé Castells

Director, Botanic Garden Las Palmas

Matthew Jebb

Director, National Botanic Garden Glasnevin

Michel Guiraud

Direction des collections, Muséum national d'Histoire naturelle

Philippe Richard

Directeur, Jardin Botanique de Bordeaux

Philippe Bardin

Conservatoire Botanique National du Bassin Parisien

Peter Wyse Jackson

Chair of the Global Partnership for Plant conservation

Hervé Le Treut

Director, Institut Pierre Simon Laplace, Climatologist, Member of IPCC

Marko Hyvärinen

Director, Helsinki Botanic Garden

RESOLUTIONS, CONCLUSIONS AND SYNTHESIS

General Resolution (1/3)

Recognising the importance that botanic gardens need to place in protecting and conserving the world's flora, and noting that we are at the mid-term stage in the countdown to 2020 for the Global Strategy for Plant Conservation, as well as other conservation targets, the Congress urges botanic gardens to:

- be purposeful and effective in building the knowledge base, establishing projects and promoting the GSPC in their institutes;
- participate in updating national actions in support of the Global Strategy for Plant Conservation as well as the CBD's Strategic Plan for Biodiversity 2011-2020;

General Resolution (2/3)

Emphasising the importance that botanic gardens need to place in managing their collections in accordance with the articles covering Access and Benefit Sharing under the Convention on Biological Diversity, and complying with the principles of the recently enacted Nagoya Protocol, the Congress recommends that botanic gardens and networks:

- Become fully engaged and familiar with the Nagoya Protocol and its implementation in their country.
- Submit case-studies to their national networks that exemplify both the tangible and intangible benefits shared by BGs with provider countries;
- always act in a manner that builds trust and transparency and enhances the willingness of provider countries to engage in collaborative conservation programmes;
- support and use the International Plant Exchange Network (IPEN) in the exchange of materials between institutions.

General Resolution (3/3)

Recognising the dedication, support and guidance provided over the past 20 years, as well as the remarkable advances and improvements in garden management, organisation and engagement that have taken place in that time, the Congress wishes to record its gratitude to:

- the European Botanic Gardens Consortium, national networks, botanic gardens, and especially the many hard-working individuals who have supported and enhanced the work of gardens throughout Europe;
- Botanic Gardens Conservation International, and all its staff over the years for its invaluable support; and
- those individuals who have organised the past seven congresses for their dedication to the success and achievements of EuroGard.

EuroGard VII Congress Conclusions

THEME A **Cadres stratégiques et bonnes pratiques pour les jardins botaniques. Strategic frameworks and best practice for botanic gardens**

Noting the significant progress that has been made in garden management across Europe; *Recognising* the quality of horticultural knowledge that has been built over many centuries in European gardens; and *Aware* of the challenge of accurate identification of material, the documentation of collections and the regulation burden; The Congress calls upon botanic gardens to:

- Engage with BGCI's GardenSearch and PlantSearch databases so that indicators of GSPC targets can be measured and networking enhanced;

EuroGard VII Congress Conclusions

- Continue to seek ways to record, preserve and share horticultural knowledge as widely as possible;
- Enhance the quality of data and record keeping, including ecological data recording;
- Develop means to store and maintain regulatory and other necessary documentation and share their experiences with gardens in their networks.

The Congress further calls upon national and regional networks to:

- Continue working together to raise standards of curation, recordkeeping, data-handling and compliance across all gardens in their networks;
- Cultivate connections and engagement with civil and political society to build support and influence for botanic gardens.

THEME B **Science du végétal, ethnobotanique et les espèces exotiques envahissantes. Plant Science, Ethnobotany and invasive species**

Aware of the upcoming regulation on Invasive Alien Species in the EU and of the work already undertaken on invasive species by many gardens and the European Botanic Garden Consortium; and *Mindful* of the excellent work already being undertaken in botanic gardens to promote an interest in our native floras; The Congress encourages botanic gardens to:

- Continue to raise awareness on invasive alien species in their collections and always label these appropriately;
- Promote traditional knowledge on plants to their visitors and use this as an proven tool for engaging interest in plants locally and generally;
- Develop displays that encourage an appreciation for our native flora and the role of botanic gardens in its conservation;
- Help to set up identification and early warning systems for plant diseases and harmful animals.

THEME C **Patrimoine, Culture et Tourisme. Heritage, Culture and Tourism.**

Recognising that botanic gardens are often major tourism destinations; and *Mindful* that many have historic constraints on their ability to adapt; The Congress recommends that botanic gardens:

- Raise awareness of the history of science and botanic gardens through innovative displays and events;
- Take part in the annual Fascination of Plants Day (May 18) and other biodiversity related days;
- Develop a marketing strategy and ensure that they are able to measure the impact of this strategy in terms of the needs and perceptions of their visitors.

THEME D **Conserver au jardin et dans la nature, Conservation in the garden and in the wild**

Mindful that there is no technical reason why species should become extinct in these days of micro-propagation, cryopreservation and seed banking skills; *Appreciating* the remarkable progress that botanic gardens have already made in developing integrated *in-situ / ex-situ* projects with expanding work in translocations, transplantations, native seed science and studies on population genetics; and *Aware* of the serious conservation concerns raised by the over-exploitation of horticultural and medicinal plants; the Congress calls upon botanic gardens to:

- Be mindful that all conservation work should be undertaken using the best possible techniques, scientific knowledge and understanding;
- Ensure that work is well documented and shared where appropriate;
- Engage with and promote where possible the work of IUCN, CITES, TRAFFIC and others in ensuring legal, sustainable and appropriate use of wild plants including through the promotion of the FairWild standard.

EuroGard VII Congress Conclusions

THEME E **Jardins botaniques et changement climatique. Botanic Gardens and Climate Change**

Recognising that some botanic gardens across Europe are already part of the International Phenological Gardens network; *Mindful* of the Baltic experiences with a network of gardens trialling plant clones across climatic zones; and *Noting* that the conservation community is lacking evidence and understanding of the effects of climate change; the Congress asks gardens and networks to:

- Encourage the gathering of phenological and climate related data;
- Promote climatic change related studies across networks of gardens;

THEME F **Sensibiliser l'homme au végétal / Enseigner la botanique. Connecting people to plants / Teaching botany**

Acknowledging the important role that botanic gardens continue to play in connecting people to nature; *Recognising* the importance of education, activities and engagement with civil society; The Congress encourages gardens to:

- Explore innovative ways of engaging new audiences within their gardens;
- To find ways of bringing plant education outside the botanic gardens and promoting nature, especially in urban settings.

THEME G **Réseaux, coopération et partenariats. Networking, cooperation and capacity building**

Acknowledging the work of the European Botanic Gardens Consortium in developing strong co-operation amongst botanic Gardens across Europe; *Recognising* the value of developing charters or codes of practice that provide a roadmap and help gardens to achieve greater standards, capacities as well as political and societal recognition; *Noting* the establishment of the Ecological Restoration Alliance (ERA) and the unique expertise botanic gardens have to offer to restoration; The Congress encourages botanic gardens to:

- Develop and participate in national partnerships linking botanic gardens with other sectors;
- Develop principles and targets in order to raise standards of horticulture, data management and public engagement;
- Reach out to botanic gardens and partners in developing countries, and countries with economies in transition, to develop mentoring, support and capacity-building projects;
- Consider how their work might contribute to the (ERA) in order to scale up restoration action.

Thanks to the host, organisers, and sponsors

The Congress congratulates our hosts, Le Muséum national d'Histoire naturelle (MNHN), and extends its thanks to its director Eric Joly and JeanPatrick le Duc, Maïté Delmas, Michel Guiraud and all their staff for the warm welcome and organisation of a successful meeting.

We further commend our hosts on the remarkable transformation and improvements that they have brought about at the Museum, in particular the redevelopment, reconditioning and digitisation of the herbarium, a laudable contribution to the understanding of the world's plant diversity and testament to their status as one of the world's premier institutions.

Thanks to the host, organisers, and sponsors

We extend our thanks to the Organising committee: Eric Joly, Jean-Patrick Le Duc, Maïté Delmas, Frédéric Achille, Pedro Saiz, Nelly Huguet, Brigitte Carmine, Chantal Grizard (MNHN); Fanch le Hir, Romaric Perrocheau, Renée Buzy Debat, Pascale Gueguen (JBF); Suzanne Sharrock and Joachim Gratzfeld (BGCI); Eleni Maloupa (EBGC); Peter Wyse Jackson (GPPC); Philippe Bardin (CBN); Noéline Raondry Rakotoarisoa (UNESCO); and Robert Hoft (CBD).

We recognise the special work of the Scientific committee in delivering such an excellent programme of talks: Denis Larpin, Serge Bahuchet, Stephen Blackmore, Laurent Bray, Michel Cambornac, Jean-Marc Drouin, Frédéric Dupont, Thomas Haevermans, Frédéric Hendoux, Anca Leroy, Pierre-André Loizeau, Serge Muller, Jan Plesnik, Dominique Richard, Philippe Richard, Bernard Riera et Marc-André Selosse.

We have been delighted to have had the opportunity of meeting colleagues from beyond Europe in particular from west and central Africa, the Indian Ocean and Haiti and we commend the MNHN and BGCI for their initiative in inviting these partners, and on the signing of the “Sud Expert Plantes Developpement Durable” programme.

We gratefully acknowledge la Mairie de Paris, les Conservatoire et Jardin Botaniques de la Ville de Genève, la Fondation IRIS, IRIS BG, la Fondation Yves Rocher et la Société Botanique de France for their generous assistance.

Synthesis of the congress

BY PIERRE-ANDRE LOIZEAU, DIRECTOR OF CONSERVATORY AND BOTANIC GARDENS OF THE CITY OF GENEVA / PAR PIERRE-ANDRÉ LOIZEAU, DIRECTEUR DES CONSERVATOIRE ET JARDIN BOTANIQUES DE LA VILLE DE GENÈVE

Chers collègues,

Bien que je sois le seul mentionné dans le programme pour présenter cette conclusion, j'aimerais commencer par remercier Suzanne Sharrock et Matthew Jebb qui ont préparé la partie de cette intervention relative au Consortium des jardins botaniques européens et aux résolutions de ce congrès.

Tout d'abord j'aimerais vous faire partager le plaisir que j'ai eu à participer à ce congrès EuroGard VII. La chaleur qui s'est abattue sur une grande partie de l'Europe n'a pas trop perturbé nos discussions, n'a pas échauffé les esprits. Les débats ont été sereins et constructifs, les conférences plénières passionnantes.

Je résumerais les axes principaux de ces conférences plénières en quatre points : importance d'un cadre législatif, responsabilité en termes de conservation, travail collaboratif et enfin maintien du lien à la nature.

IMPORTANCE D'UN CADRE LÉGISLATIF

Concernant l'importance du cadre législatif, Braulio Ferreira de Souza Dias ouvre les feux et rappelle l'importance de la Stratégie Mondiale pour la Conservation des Plantes en tant que cadre d'action pour la sauvegarde de la biodiversité. Dominique Richard rapporte que l'Union Européenne a défini des objectifs dans le cadre de l'élaboration de sa Stratégie pour la Biodiversité pour 2020. A l'autre bout du congrès, Peter Wyse Jackson en fait de même et affirme que la Stratégie Mondiale pour la Conservation des Plantes constitue un cadre qui oriente les activités des jardins botaniques. Si la moitié des objectifs est couverte par ceux-ci, on peut trouver des Jardins botaniques pour tous les objectifs restants.

Mais la législation peut devenir lourde et contraignante, bien que les objectifs qu'elle poursuive soient déontologiquement incontournables et encouragés par les jardins botaniques. Ainsi concernant l'introduction du Protocole de Nagoya, Braulio Ferreira de Souza Dias constate qu'il s'agit d'une législation novatrice, qui introduit la reconnaissance de la souveraineté des pays sur leurs ressources naturelles. Pourtant Matthew Jebb et Michel Guiraud observent que d'une manière générale les contraintes législatives sont de plus en plus lourdes et risquent de devenir des surcharges difficiles à surmonter pour les instituts scientifiques. L'introduction du Protocole de Nagoya pourrait conduire à une situation paradoxale, à savoir qu'il risque de fermer l'accès aux ressources génétiques des pays qui ont besoin d'une meilleure connaissance de la biodiversité de leur territoire. Sans prendre position sur ce problème administratif, Braulio Ferreira de Souza Dias affirme que la recherche nécessite l'accès aux ressources génétiques afin de mettre en valeur la richesse de la biodiversité. Les pays en voie de développement ont donc

Synthesis of the congress

besoin de ces travaux pour donner de la valeur à leur biodiversité. Michel Guiraud dans ce contexte souligne un avantage possible des collections virtuelles par le fait qu'elles pourraient constituer une réponse à la complexité de la législation qui se met en place. Sur un plan plus général, Jean-Patrick Le Duc décortique le commerce illégal des plantes. Il attribue aux jardins botaniques un rôle important en tant que partenaire des douanes afin que les jardins botaniques prennent en charge dans de bonnes conditions les plantes saisies ou confisquées.

RESPONSABILITÉ EN TERMES DE CONSERVATION

Paul Smith observe que les jardins botaniques ont les outils et les compétences pour conserver la diversité végétale, grâce aux herbiers, aux banques de semences, aux activités de conservation in et ex situ, aux actions de restauration d'habitats.

Han Qunli montre tout l'intérêt des Réserves de la Biosphères de l'UNESCO. 651 réserves dans 120 pays couvrent plus de 10 millions de km2 incluant plus de 170 millions de personnes. Ces Réserves représentent des laboratoires très importants pour l'étude de l'équilibre entre nature et population humaine. Les Jardins botaniques peuvent aider à comprendre ces interactions.

Pourtant Braulio Ferreira de Souza Dias fait le constat amer que nous avons échoué dans la diminution de la perte de biodiversité, que celle-ci continue. Il observe que les raisons de cet échec sont dues au fait que nous n'avons pas mis l'accent sur les causes sous-jacentes. Il faut montrer à la société comment elle peut tirer les bénéfices de la biodiversité. On trouve là tout le discours tournant autour des services écosystémiques.

Pour Dominique Richard, la complexité des systèmes environnementaux peut être la cause d'un temps important avant que les actions ne prennent effet.

Juli Caujapé Castells observe que nous ne savons souvent pas quelle stratégie utiliser pour la conservation. Nous donnons l'impression d'un manque de coordination, d'un manque de clarté des actions du fait que certains concepts sont difficiles à cerner. Il démontre que la fragmentation, souvent cause de la perte de biodiversité, peut aussi être à l'origine de l'apparition de nouvelles espèces sous une forme première d'haplotypes. Il propose que la notion de population, plutôt que celle d'espèce, devienne l'unité officielle de la conservation.

Philippe Bardin dresse lui aussi quelques constats autour de la conservation des espèces menacées au sein de la Fédération des conservatoires botaniques nationaux de France. Dubitatif sur la probabilité d'atteindre les objectifs de la Stratégie mondiale pour la conservation de plantes à l'échéance de 2020, et bien que les résultats actuels soient déjà relativement satisfaisants, il montre que les espèces menacées sont relativement peu présentes dans les territoires placés sous protection. Il observe qu'il est nécessaire d'inventer de nouveaux outils de hiérarchisation pour augmenter l'efficacité des mesures de protection, et par exemple, d'ajouter aux critères de l'UICN la responsabilité patrimoniale, l'originalité phylogénétique du taxon et son évolution historique si les données existent.

Enfin Hervé le Treut et Marko Hyvärinen évoquent la problématique des changements climatiques sur la répartition de plantes. Marko Hyvärinen propose d'accompagner ces migrations par des cultures ex situ et in situ

Synthesis of the congress

appropriées au niveau des jardins botaniques. Cependant il pose de nombreuses questions : Comment évaluer la sensibilité d'une espèce au changement climatique, comment choisir les espèces, comment les déplacer, comment gérer les risques de développer des plantes envahissantes, comment s'assurer de la légalité de ce qu'on fait, comment en faire un travail quotidien pour les jardins botaniques ?

TRAVAIL COLLABORATIF

Plus que le travail en réseau, les vraies collaborations durables apparaissent comme un moyen de renforcer la force d'action des jardins botaniques. Braulio Ferreira de Souza Dias observe que les jardins botaniques ont la capacité de participer à l'effort global, mais que d'une manière générale il faut intensifier le travail en réseau, et les contacts avec les politiques. Il faut placer la sauvegarde de l'environnement dans le contexte du développement durable, en s'appuyant aussi sur l'économie et le social.

Sur ce thème Pawel Kojs présente une méthode permettant de rester cohérent au sein des jardins botaniques dans le respect des trois piliers du développement durable : environnement, économie et activités sociales.

Eleni Maloupa, en retraçant l'histoire des réunions EuroGard, a donné l'image d'une « famille » des jardins botaniques qui communique, échange et construit son avenir lors de ces réunions. Ce point de vue est partagé par Matthew Jebb, qui constate que tout le monde ne peut pas tout faire, qu'il faut travailler en réseau et définir des priorités. Les réunions comme celles d'EuroGard nous aident à définir ces priorités.

Suzanne Sharrock rappelle que le réseau des jardins botaniques, à travers leur affiliation au BGCI, représente une force de frappe importante, avec près de 3000 jardins botaniques fréquentés par une estimation de 500 millions de visiteurs par an.

Les bases de données centralisées comme PlantSearch et GardenSearch apportent des informations très utiles à l'orientation des plans d'action des jardins botaniques et à la justification de leur soutien par les autorités politiques ou les financiers.

MAINTIEN DU LIEN À LA NATURE

Paul Smith rappelle que la nature dont nous avons besoin pour nous alimenter ne vient pas du réfrigérateur. C'est la nécessité de conserver le lien avec la Nature, vitale pour la survie de notre espèce, qu'il exprime dans le contexte d'une société où plus de la moitié de la population mondiale habite dans des espaces urbains, souvent déconnectée de la vie sauvage.

Eric Joly insiste sur le rôle des zoos et jardins botaniques comme vecteur du maintien du lien à la nature, mais aussi en tant qu'outil pour la recherche, et pour la conservation *in* et *ex situ*.

De son côté Philippe Richard constate que dans la mesure où 75-80% de la population européenne habite dans des villes, il est normal que les jardins botaniques soient situés à proximité de celles-ci, et qu'ils jouent un rôle important dans le maintien du lien à la Nature. Il redéfinit la mission principale des jardins botaniques, à savoir « rendre la nature accessible et compréhensible au public ».

Synthesis of the congress

Dans un autre registre, Laurent Bray met en évidence le travail important de la Ville de Paris pour l'augmentation de la végétalisation en zone urbaine, et le rôle du Jardin botanique dans le maintien du lien à la nature à travers la plantation d'espèces de plantes provenant du Bassin parisien.

DISCUSSION

Pour terminer, j'aimerais reprendre la redéfinition des tâches principales des Jardins botaniques proposée par Peter Wyse Jackson : 1) assumer des tâches de conservation dans un cadre planifié, justifié et effectif, 2) construire une base de connaissance, 3) documenter plutôt trois fois qu'une, 4) Diffuser, transmettre, éduquer, 5) Sortir de sa zone de confort, 6) Définir la politique du futur, 7) Changer la vie des gens. En effet, les jardins botaniques doivent à la fois sauvegarder la variété de la vie, contribuer au bien-être humain et participer à la diminution de la pauvreté. Pour terminer, permettez-moi un point de vue personnel concernant le cadre législatif. Je pense que la signature de la Convention sur la Diversité Biologique constitue l'acte fondateur des nations autour de la prise de conscience de la nécessité de considérer la nature comme une ressource nécessaire à la survie de l'espèce humaine.

Le contexte régional, national et international est paradoxal en termes de biodiversité. Alors que la disparition des espèces semble s'accélérer, que les atteintes à l'environnement augmentent, que les mesures contre les problèmes climatiques tardent à être prises, que personne ne sait comment aborder la crise démographique, lorsqu'elle n'est pas niée, des avancées significatives au niveau législatif nous font espérer en des jours meilleurs.

Si je prends l'exemple de la Suisse que je connais bien, ne me demandez pas pourquoi, on peut observer une transcription de concepts fondamentaux dans la législation, correspondant aux valeurs que nous attribuons à la nature. Ainsi, suivant les impulsions données par la Stratégie mondiale pour la biodiversité et la Stratégie mondiale pour la conservation des plantes, le Conseil Fédéral adopte-t-il la Stratégie Biodiversité Suisse le 25 avril 2012 définissant 10 objectifs stratégiques (encourager une utilisation durable des ressources naturelles, assurer une infrastructure écologique, favoriser la survie des espèces, préserver la diversité génétique, etc.). Un plan d'action est en cours d'élaboration au niveau national.

La Stratégie Biodiversité Suisse introduit dans la législation le concept fondamental de dépendance de l'être humain par rapport aux services rendus par la nature. Elle érige en principe le fait que la nature rend des services écosystémiques. Elle place l'être humain dans ce système, ce qui a des conséquences sur sa façon d'évoluer dans celui-ci. On échappe de la sorte à la vision déconnectée des plantes et des animaux qui a prévalu jusqu'à maintenant. L'isolation des territoires pour les mettre sous protection n'est plus le seul outil qui permette de ménager la nature. C'est l'intégralité du territoire qui est considérée pour conserver la Biodiversité.

D'un sujet périphérique, la biodiversité devient une préoccupation centrale et est considérée avec cette loi comme un cadre à respecter dans lequel l'humain doit inscrire son action.

LA BIODIVERSITÉ EST UNE RESSOURCE, ELLE N'EST PAS UN LUXE.

Ces avancées législatives importantes, issues du travail de certaines personnes présentes dans cette salle, et que je remercie ici discrètement, mais sincèrement, nous montrent que les jardins botaniques représentent une force de frappe en faveur de la biodiversité. En s'alliant les uns aux autres, en

Synthesis of the congress

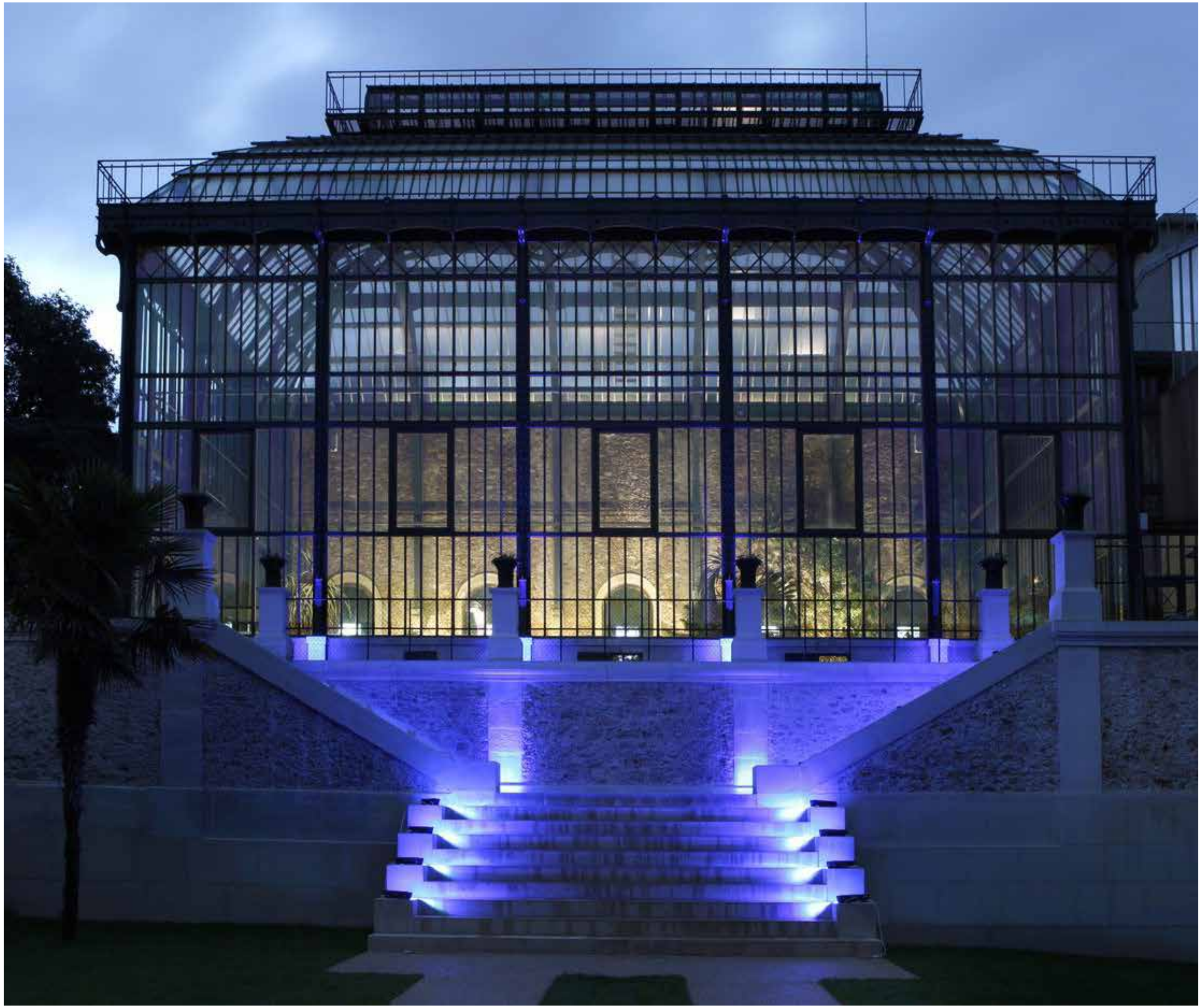
mettant en commun nos ressources, en nous rapprochant des politiques, en agissant localement avec une vision globale, en collaborant, en échangeant, nous avons les moyens de faire changer les choses, par l'addition de tous nos petits efforts.

Personne mieux que les botanistes et les jardiniers-botanistes, les floristes, les systématiciens, les écologues et les biologistes, ne peuvent parler aussi bien de la nature et du monde végétal. Nous avons la responsabilité face à la société d'informer et de chercher à convaincre sur les points qui nous paraissent vitaux pour la survie de notre espèce et de toutes les espèces dont nous avons la responsabilité. La Terre nous est prêtée, rendons la complète et en bon état à nos enfants.

Ces actions impliquent non seulement de la rigueur dans notre travail, mais aussi de la générosité dans nos actions, et le partage des connaissances le plus largement possible.

Base législative, travail collaboratif, conservation et lien à la nature, voilà pour moi les axes forts qui apparaissent à l'issue de ce congrès EuroGard VII et qui vont guider la plupart de mes actions en tant que directeur des Conservatoire et Jardin botaniques de la Ville de Genève et organisateur du 6 è Congrès mondial des jardins botaniques en Juin 2017.

Credit photo: The New Caledonian Greenhouse © *M. Cohen / MNHN*



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Part II.

The Full Papers

TABLE OF CONTENTS

THEME A

STRATEGIC FRAMEWORKS AND BEST PRACTICE FOR BOTANIC GARDENS

TABLE OF CONTENTS

THEME A

STRATEGIC FRAMEWORKS AND BEST PRACTICE FOR BOTANIC GARDENS

THEME B

SCIENCE

TABLE OF CONTENTS

THEME B
SCIENCE

THEME C
HERITAGE, CULTURE & TOURISM

THEME D

CONSERVATION

TABLE OF CONTENTS

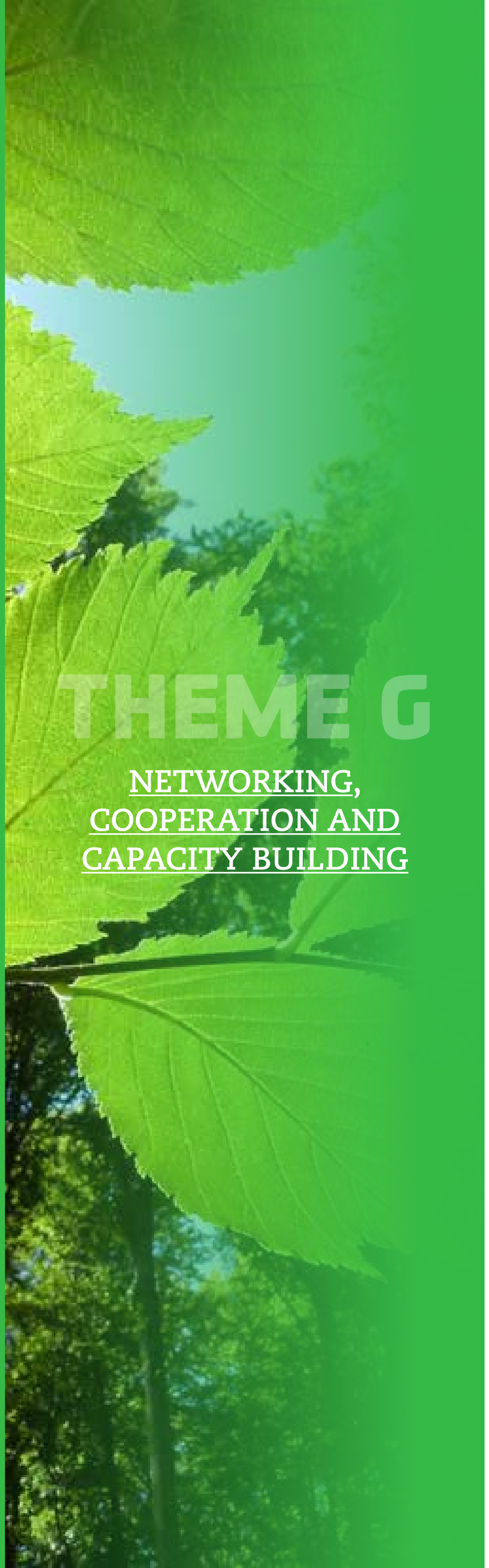
THEME D
CONSERVATION

THEME E
BOTANIC GARDENS AND CLIMATE CHANGE

THEME F
EDUCATION

THEME F
EDUCATION

TABLE OF CONTENTS



THEME G

NETWORKING, COOPERATION AND CAPACITY BUILDING

TABLE OF CONTENTS

EUROGARD VII
PARIS

THEME A:

STRATEGIC FRAMEWORKS AND BEST PRACTICE FOR BOTANIC GARDENS

01.

THEME A

STRATEGIC FRAMEWORKS AND BEST PRACTICE FOR BOTANIC GARDENS

THEME A

STRATEGIC FRAMEWORKS AND BEST PRACTICE FOR BOTANIC GARDENS

LE PROJET SCIENTIFIQUE ET CULTUREL (PSC) DANS LES COLLECTIONS TROPICALES DES CONSERVATOIRE ET JARDINS BOTANIQUES DE NANCY (CJBN)

Photo credit : *Pierre-François Valk / CJBM*

Bour Aurélien & Astafieff Katia

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> Mots-clefs PSC SERRES TROPICALES COLLECTIONS VÉGÉTALES VIVANTES CJBN COLLECTIONS SPÉCIALISÉES

01. Résumé

• *Bour Aurélien*
• *Astafieff Katia*

LES CONSERVATOIRE ET JARDINS BOTANIQUES DE NANCY (CJBN) ONT ENTREPRIS EN 2009 L'ÉLABORATION D'UN PROJET SCIENTIFIQUE ET CULTUREL (PSC), DÉMARCHE INSPIRÉE DES MUSÉES (LOI RELATIVE AUX MUSÉES DE FRANCE). L'OBJECTIF ÉTAIT DE FAIRE UN BILAN DE LA SITUATION EXISTANTE SUR LE FONCTIONNEMENT DU JARDIN BOTANIQUE, À TOUS LES NIVEAUX : HISTORIQUE, GESTION, TERRAINS ET BÂTIMENTS, PERSONNEL, PUBLICS, MUSÉOGRAPHIE, ACTIVITÉS SCIENTIFIQUES ET CULTURELLES, PROGRAMMATION, PARTENARIATS, COMMUNICATION ET BIEN-SÛR AVANT TOUT COLLECTIONS.

L'étape suivante dans la démarche PSC a consisté en la rédaction d'un document définissant les orientations, les actions et moyens à mettre en œuvre pour réaliser les objectifs de l'établissement.

Concernant les collections, le travail s'est porté sur les collections de pleine terre, les collections tropicales, les collections du jardin d'altitude du Haut Chitelet, ainsi que les collections patrimoniales (herbiers et bibliothèques). Au niveau des collections tropicales, au bout de plus de 30 ans de fonctionnement, les serres des CJBN ont rassemblé plus de 6 000 accessions de plantes en culture. Une réflexion a donc été engagée pour déterminer l'intérêt de ces collections, en lien avec d'autres grands jardins botaniques français, et cibler des groupes particuliers qui font la spécificité des CJBN.

> Mots-clefs PSC SERRES TROPICALES
COLLECTIONS VÉGÉTALES VIVANTES
CJBN COLLECTIONS SPÉCIALISÉES

01. Introduction

• *Bour Aurélien*
• *Astafieff Katia*

Photo credit : *Pierre-François Valk / CJBN*

UNE COLLECTION PEUT SE DÉFINIR COMME UN GROUPEMENT THÉMATIQUE DE PLANTES AYANT UNE VOCATION PARTICULIÈRE : SCIENTIFIQUE, PÉDAGOGIQUE, CULTURELLE, ESTHÉTIQUE, DE CONSERVATION OU SERVANT DE RÉSERVES POUR L'ENSEIGNEMENT OU LES EXPOSITIONS.

Chaque collection doit avoir une raison d'être précise, et doit être en accord avec les missions du jardin botanique. Il ne s'agit pas en effet d'avoir le plus grand nombre d'espèces possibles d'une même famille pour avoir une collection complète.

Nous nous sommes basés sur les critères proposés par le BGCI (Botanic Gardens Conservation International), qui doivent être remplis par une institution pour être considérée comme jardin botanique :

• un degré de permanence des collections raisonnable
• une base scientifique pour les collections
• une documentation précise sur les collections
• un suivi des plantes en collections
• un étiquetage adapté
• une ouverture au public
• la communication des informations aux autres jardins botaniques, institutions ou au public
• des échanges de graines et de matériels avec d'autres jardins botaniques ou institutions de recherche
• des recherches réalisées à partir des plantes en collection
• des programmes de recherche sur la taxonomie, grâce aux herbiers

Nous nous sommes également basés sur les niveaux de reconnaissance du CCVS (Conservatoire français des Collections Végétales Spécialisées) qui présente l'avantage de réaliser un recensement des collections importantes dans les différents jardins botaniques.

Etat des lieux

Trente-sept collections, d'importance variable, ont été initialement répertoriées, correspondant soit à des familles de plantes (Marantacées, Broméliacées, etc.), soit à des thématiques particulières (plantes des îles de l'océan indien, plantes insectivores, etc).

01. Etat des lieux

• Bour Aurélien
• Astafieff Katia

Nous avons aussi identifié :

- LES COLLECTIONS SPÉCIALISÉES, de nature à être reconnues à l'échelle internationale. Elles sont centrales pour le jardin et susceptibles de servir pour des projets de recherches. Pour celles-ci, l'exhaustivité est un objectif, et la maintenance de la collection est une priorité.

- LES COLLECTIONS NON SPÉCIALISÉES, qui possèdent un nombre de taxons plus réduit. Elles contribuent à la diversité du matériel végétal disponible pour la pédagogie, la scénographie et les expositions.

- LES COLLECTIONS THÉMATIQUES OU TRANSVERSALES. Elles sont alimentées par les taxons issus des deux autres types de collection et constituent l'ossature des expositions permanentes et des parcours thématiques.

Points forts et points faibles des collections

Le bilan a permis de déterminer les points forts et les points faibles de collections. Les collections spécialisées sont les collections suivantes :

- Les Aracées
- Les Pélargoniums
- Les fougères tropicales et les plantes alliées (sélaginelles)
- Les plantes des îles Mascareignes et des Seychelles
- Les Fuchsias Lemoine (inclus dans la collection des Obtenteurs lorrains)

Ces collections sont en elles-mêmes des points forts pour le jardin botanique. Elles sont originales, riches et remarquables et ont un intérêt scientifique, pédagogique ou patrimonial important.

Ces collections ont cependant parfois été insuffisamment mises en valeur auprès du public. Si certaines actions ponctuelles ont été réalisées (exposition Pélargoniums ou présentation d'Aracées), les collections ne sont pas clairement identifiées auprès du public, faute de médiation spécifique à leur sujet. L'intérêt scientifique de certaines collections est encore à définir. Si un travail important a été réalisé au niveau des Aracées, les autres thématiques nécessitent encore une réflexion. La problématique de la conservation des espèces particulièrement rares est aussi à approfondir.

Les collections thématiques sont les suivantes :
- Les épiphytes
- Les plantes utiles à l'homme
- L'évolution des plantes terrestres
- Les relations plantes-insectes.

Ces collections constituent les piliers du jardin botanique. Leur potentiel pédagogique et scientifique nécessite d'être développé.
Si les plantes utilitaires sont régulièrement utilisées à des fins pédagogiques, les autres thématiques sont encore sous-exploitées.

Les collections non spécialisées sont les Bégonias, les Marantacées, ainsi que les plantes succulentes et les Cactacées. Elles contribuent à la diversité des plantes cultivées au jardin botanique. Elles ont notamment un intérêt pédagogique et attractif pour le public (plantes des milieux arides).

01. Actions

• Bour Aurélien
• Astafieff Katia

Ce bilan a permis de réaliser un tri important dans les collections.
Près de 1 500 accessions de collections non spécialisées ont été confiées à d'autres jardins botaniques dont le travail portait sur ces collections.
Ce tri a permis aux CJBN de consacrer l'espace des serres et le temps de travail aux thèmes phares. Ainsi, depuis ce délai, plus de 1 000 nouveaux taxons ont enrichi les collections spécialisées et thèmes transversaux depuis 2009. Ce travail a été récompensé par la distinction du CCVS, qui a agréé 5 collections présentes dans les serres, dont deux en 2013 (les Aracées, les fougères tropicales, les plantes carnivores, les plantes myrmécophiles et le patrimoine horticole lorrain).

Par ailleurs, la reconnaissance de ces collections spécialisées à l'international a valu aux CJBN d'être sélectionnés pour accueillir le congrès de l'International Aroid Society (IAS) en 2009 et l'European carnivorous plants Exhibit and Exchanges (EEE) en 2013, deux événements majeurs dans les domaines concernés au niveau mondial.

Conclusions

Un effort important de communication doit être fait sur ces collections (site web, catalogues). Un ouvrage sur les plantes carnivores a été publié en 2014. D'autres efforts sont encore à réaliser pour mieux faire connaître les collections remarquables auprès du public.

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THE CULTIVATION METHOD OF *WELWITSCHIA MIRABILIS* HOOK.F. IN RHIZOBOXES

Photo credit : The 11-years old plant XI of *Welwitschia mirabilis* with male inflorescences (2014), ***Ewa Kazmierczak-Grygiel***

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> Keywords WELWITSCHIA MIRABILIS CULTIVATION REPLANTING RHIZOBOXES

01. Abstract

• *Kazimierczak-Grygiel Ewa*

WELWITSCHIA MIRABILIS HOOK.F. (_WELWITSCHIACEAE, GYMNOSPERMS_) IS AN ENDANGERED AND STRICTLY PROTECTED SPECIES. IT IS A RARE PLANT IN BOTANICAL GARDENS.

Among other things, it has low tolerance to transplanting. In the literature, it was recommended to sow seeds in a permanent place and to cultivate *Welwitschia* in a drain-pipe. This system makes repotting very difficult or impossible.

Seeds of *Welwitschia mirabilis* were collected *ex situ* in botanical gardens and sown from 2003 to 2004. For sowing seeds special containers made out of transparent plastic (rhizoboxes) and having inner pots out of metal net were used. This facilitates bedding the seedling out to the next container. For sowing we used porous soil of similar composition as for repotting seedling or young plants, with a defined amount of micro and macro elements.

Seedlings were kept in a labolatory condition in artificial light (photoperiod 12h/day), at temperature between 25-30oC, and 25-45% humidity. Older plants were grown in glasshouse conditions with lamplight. The plants were regularly watered. Depending on the season, one has to take care of high air humidity, sufficient ventilation and fertilization.

Seedlings, as well as older plants, of *Welwitschia*, were replanted at different stages. A few plants were cultivated in the same pot for a long period of time.

The growth and development of plants after repotting proceeded without disruption. This applied system of containers allowed us to transplant older plants. Our study shows that with this well-adapted method, *Welwitschia mirabilis* has a high tolerance to transplanting.

> Keywords WELWITSCHIA MIRABILIS CULTIVATION REPLANTING RHIZOBOXES

01. Introduction

• *Kazimierczak-Grygiel Ewa*

Photo credit : The 11-years old plant XI of *Welwitschia mirabilis* with male inflorescences (2014), ***Ewa Kazmierczak-Grygiel***

WELWITSCHIA MIRABILIS HOOK.F. (_WELWITSCHIACEAE, GYMNOSPERMS_) IS AN ENDANGERED AND STRICTLY PROTECTED SPECIES. ITS DISTRIBUTION IS CONFINED TO A NARROW COASTAL STRIP IN THE NAMIB DESERT FROM KUISEB IN SOUTH WEST AFRICA TO CABO NEGRO IN ANGOLA (KERS 1967).

Welwitschia is rare in botanical gardens, because it is a difficult plant to grow. Among other things, it exhibits low tolerance to transplanting. In the literature, it was recommended to sow seeds into their permanent location and to cultivate *Welwitschia* in a drain-pipe (Herre, 1954; Jaarsveld, 1992). This system makes repotting very difficult or even impossible.

Materials & methods

Seeds of *Welwitschia mirabilis* were collected ex situ in botanical gardens and sown from 2003 to 2004. For sowing seeds, special containers made out of transparent plastic sized 60 x 200 x 400 mm and equipped with inner pots out of metal net with dimensions of 50 x 70 x 100 mm were used. Seedlings were repotted in the same rhizoboxes, and small plants in rhizoboxes with dimensions of 115 x 260 x 400 mm (**Photo 1**). For sowing we used porous soil of similar composition as for repotting seeds, with a defined amount of micro and macro elements. The soil consisted of fine gravel and fine sand, seramis, acid peat and leaf-litter earth and was sterilized via soil steaming and fungicide treated just before repotting.

Seedlings were kept in a labolatory condition in artificial light (photoperiod 12h/day), at temperature between 25-30oC, and 25-45% humidity. Older plants were grown in glasshouse conditions with lamplight. The plants were regularly watered. High air humidity, sufficient ventilation and fertilization need to be taken care of, depending on the season. Within the first days after repotting, the plants were put in diffused light.

Data regarding morphological development of seedlings have been gathered systematically by measuring length and width of cotyledons and leaves within 12 months and root growth within 2 months after sowing.

For repotting, seedlings at various development stages were chosen, i.e. between the 50th and 517th day after sprouting.

> Keywords WELWITSCHIA MIRABILIS CULTIVATION REPLANTING RHIZOBOXES

01. Materials & methods

• *Kazimierczak-Grygiel Ewa*

The four stages of plant development were set on the basis of the ratio of leaf length to cotyledon length (**Tab. 1**). A movable front wall and an internal container made it possible to transplant plants with little harm to the upper part of the root ball.

> PHOTO 1

Rhizoboxes made of transparent plastic. One or two transparent walls screw together

Results

The seedlings exhibited important root growth in length, i.e. from 2,6 cm to 4,8 cm before cotyledons appeared on the soil surface (**Photo 2**). When leaf primordia appeared, the root length amounted from 3,3 cm to 6,7 cm. Within 60 days the seedlings' roots reached the bottom of the containers. At this time, some seedlings started to produce lateral roots. The average root growth in length for all observed plants amounted to 0,29 cm/day.

Replanting of the first three plants ended with success despite various age and development stage of these plants. Therefore, we have decided to transplant remaining plants in the same way. Observations of the seedlings' development allowed us to distinguish growth stages of juvenile plants based on the proportion of length of their cotyledons and leaves: L<Li, L=Li, L=2Li, L>3Li (L – leaves, Li – cotyledons; **Tab. 1**). We removed the bigger part of the root prior to placing the plant in a new container and left only less than 18 cm long, regardless of the original length of the root and age of the plant. Shortening of roots did not cause dieback or even noticeable slower growth of plants.

Four plants of *Welwitschia mirabilis*, were repotted as oldest plants (VII, VIII, X, XI; **Tab. 1**), i.e. from 8 to 10 years after sprouting. The growth and development of plants after transplanting proceeded without disruption.

Two plants were cultivated in the same pot for a long period of time i.e. over 7 years (plant IV and XII; **Tab. 1**). In this case, the growth of the root system and the leaf weight were limited (**Photo 3**). The applied system of containers allowed us to transplant older plants without problems.

> PHOTO 2

Left: Seedling „II" - 2 days after germination (2003). ***Right:*** The young seedling „V" - repotted in 2003. Leaves longer than cotyledons (L=2Li), the root about 30 cm long

> Keywords WELWITSCHIA MIRABILIS CULTIVATION REPLANTING RHIZOBOXES

01. Results

• *Kazimierczak-Grygiel Ewa*

> PHOTO 3

Left: The main root of plant „XII" (2004) during first repotting (7 years old, 2012). ***Right:*** The dense root system with soil protected with the net

Marking of the plant	Date of sowing	Date of germination	Date of 1st repotting	Ratio of leaf / cotyledon	Plant's age [days]	Date of 2d repotting	Plant's age [years]
III	2003-04-04	2003-04-22	2003-06-11	L<Li	50	-	-
X	2004-05-14	2004-06-13	2004-08-11	L<Li	59	2013-08-20	9
IX	2004-05-14	2004-06-08	2004-09-15	L<Li	99	-	-
V	2003-04-04	2003-04-25	2003-09-01	L=2Li	129	-	-
VIII	2003-11-20	2004-01-01	2004-07-21	L=2Li	202	2012-07-12	8
XI	2004-05-14	2004-06-16	2004-09-15	L=Li	91	2013-10-17	9
VII	2003-04-04	2003-04-25	2003-07-17	L=Li	83	2013-11-06	10
VI	2003-04-04	2003-04-23	2003-09-20	L>3Li	150	-	-
II	2003-04-04	2003-04-25	2004-09-23	L>3Li	517	-	-
XII	2004-09-29	2004-10-18	2012-08-08		2851	-	> 7-
IV	2003-04-04	2003-04-22	2012-08-22		3410	-	> 9-

> TABLE 1

Date of plant's age and repotting stage

Discussion

In the literature, there are not detailed descriptions available of *Welwitschia mirabilis* seedlings or plant replanting. Any information on the use of rhizoboxes in the cultivation of this plant cannot be found either. Experiments in various botanical gardens show that the first eight months are critical as far as the cultivation of *W. mirabilis* is concerned (Jaarsveld, 1992). Due to the tap root system, repotting is possible only within the first weeks or not until several years have passed, when plants are older.

The pace of root growth in length of *W. mirabilis* in in situ research amounted initially to 0,5-1 cm/day, reaching 1 m within 8 months. Such pace of root development facilitates reaching wet stratum in soil (Eller *et al.*, 1983; von Willert, 1994; Henschel & Seely, 2000). In the described experiment, the average root growth for 5 plants amounted to 0,29 cm/day. The taproot early formed lateral roots, which intercrossed and formed natural grafts with one another (Rowley, 1972).

In the AMU Botanical Garden first seedlings sown in the years 1998-2002 were cultivated successfully in traditional ceramic or plastic pots. It was, however, technically difficult to transplant them. For sowing seeds and transplanting plants of *W. mirabilis* from 2003 to 2004 special rhizoboxes were used, which allowed us to observe the development of the tap root system and eliminate the necessity for repotting seedlings within the first years (Kazimierczak-Grygiel, 2002) (**Photo 4**).

Statistical presentation of obtained results was limited due to small sample size. Experiments obtained at the Adam Mickiewicz Botanical Garden

> Keywords WELWITSCHIA MIRABILIS CULTIVATION REPLANTING RHIZOBOXES

01.

• *Kazimierczak-Grygiel Ewa*

show that cultivation of *W. mirabilis* plants, including replanting of seedlings and juvenile plants, does not cause any problems.

> **PHOTO 4**

Bottom: The comparison of the growth of 5 seedlings (2003) growing in rhizoboxes: „II", „VI", „IV", „III", „VII". ***Above:*** The comparison of the growth of 3 plants (2003) in 2013: „II", „VI", „III"

Conclusions

1. The described method enabled repotting of *Welwitschia* plants at various development stages,
2. The application of rhizoboxes with an inner pot facilitates repotting and limits the damage to the root system during repotting,
3. *Welwitschia* plants cultivated in containers require regular watering, fertilization and light exposure,
4. Rhizoboxes ensure successful growth of *Welwitschia* plants for even up to twenty years,
5. *Welwitschia mirabilis* exhibits high tolerance to transplanting.

> Keywords WELWITSCHIA MIRABILIS CULTIVATION REPLANTING RHIZOBOXES

01.

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THE INTERNATIONAL PLANT EXCHANGE NETWORK (IPEN) AND THE NAGOYA PROTOCOL

Photo credit : Seeds of *Richardia brasiliensis* Gomes (Rubiaceae), ***Rudolf Hromniak***

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> Keywords ACCESS AND BENEFIT-SHARING
NAGOYA PROTOCOL PLANT MATERIAL EXCHANGE

01. Introduction

• *Kiehn Michael*
• *Löhne Conny*

Photo credit : Seeds of *Richardia brasiliensis* Gomes (Rubiaceae), ***Rudolf Hromniak***

THE *INTERNATIONAL PLANT EXCHANGE NETWORK* (IPEN) WAS ESTABLISHED IN 1998 AS A SYSTEM FOR BOTANIC GARDENS TO FACILITATE THE TRADITIONAL EXCHANGE OF LIVING PLANT MATERIAL FOR RESEARCH, CONSERVATION, EDUCATION AND FOR RAISING PUBLIC AWARENESS ON BIODIVERSITY (LOBIN *ET AL.*, 2004, VON DEN DRIESCH *ET AL.*, 2005).

IPEN endorses the principles of regulating access to genetic resources and a fair and equitable sharing of benefits arising from their utilization (in short: Access and Benefit-sharing, ABS) laid down in Article 15 of the *Convention on Biological Diversity* (CBD). Therefore, IPEN is designed to be transparent and trustworthy to providers of plant genetic resources. At the same time it intends to mitigate negative effects for Botanic Gardens potentially caused by additional bureaucracy related to material transfer or documentation. IPEN has received recognition as a best practice model and as an instrument for implementing the ABS principles of the CBD (e.g., IEEP *et al.*, 2012, Greiber *et al.*, 2012 and CBD, 2013). IPEN is open to botanic gardens worldwide and today has 191 members from 33 countries[1].

With its focus on the ABS, the IPEN system was well prepared for the new, legally binding aspects of the "*Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention of Biological Diversity*" (NP). With the coming into force of the NP on 12th October 2014, IPEN had to formally incorporate the elements of the NP into its regulations. The present paper intends to inform about the general principles of IPEN and the recent steps taken to ensure the ongoing functionality of the IPEN in the age of the Nagoya Protocol. The adapted IPEN Code of Conduct has now been opened for signature by new members, but also by current members, as IPEN requires the renewal of memberships after 5 years.

IPEN coordination group (formerly called IPEN task force) and secretariat

The day-to-day work of IPEN, which includes answering questions of IPEN members and non-members about the CBD- and NP-consequences for Botanic Gardens or the scope and intentions of IPEN, is carried out by the IPEN Coordination Group. This group of botanic gardens network representatives (actual composition see **footnote 1**) are nominated by botanic gardens net-

1 www.bgci.org/policy/ipen/

> Keywords ACCESS AND BENEFIT-SHARING NAGOYA PROTOCOL PLANT MATERIAL EXCHANGE

01. IPEN coordination group (formerly called IPEN task force) and secretariat

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works in consultation with the *European Botanic Gardens Consortium*[2] (for Europe) and with BGCI[3] or IABG[4] (for non-European gardens). To support the IPEN Coordination Group in handling the expected additional work in the context of the NP-obligations, an IPEN Secretariat was established in 2017. The Secretariat is hosted by the Botanical Garden of the University of Vienna, (contact address: Rennweg 14, 1030 Vienna, Austria, ipen@univie.ac.at).

Major tasks of the Secretariat and the Coordination Group are the development and update of the IPEN in accord with the developments of the international biodiversity conventions, especially the CBD and the NP, and the promotion of IPEN activities and member interests in the national and international context. In consultation with national botanic gardens networks, the IPEN Coordination Group also assesses if applicants meet the IPEN criteria, and deals with IPEN registrations at the IPEN website (http://www.bgci.org/resources/ipen/). All applications and questions to the IPEN Coordination Group shall be directed to the Secretariat. The Secretariat is also in charge of keeping an updated list of IPEN-members and of relevant contacts. In the future, it is intend to set up a regular information tool for IPEN members related to new developments in ABS and NP regulations and their relevance for Botanic Gardens.

IPEN membership

In order to become an IPEN member, an applicant must be a botanic garden in the definition outlined in the International Agenda for Botanic Gardens (BGCI, 2012, see also http://www.bgci.org/ourwork/1528). It must be registered by BGCI (in BGCI's Garden Search database: http://www.bgci.org/garden_search.php) in order to have a Garden Institution Code necessary for issuing IPEN numbers (**see below**). Private individuals are not eligible for membership. The applicant has to be a legal entity or part of a larger legal entity, e.g., of a university.

An application for IPEN-membership has to be sent to the IPEN Secretariat, following the instructions outlined on the IPEN website (http://www.bgci.org/policy/Criteria_for_IPEN_membership_and_registration/). This includes a commitment to implement the "main principles of the IPEN" as described in the Code of Conduct. The IPEN Coordination Group handles the application and, if appropriate, seeks advice about the application from the respective national or regional networks, BGCI or IABG.

The IPEN code of conduct

The IPEN Code of Conduct[5] is the core element for the functionality and understanding of the IPEN. This document has to be endorsed by every garden applying to join the network as a commitment to act in accord with the IPEN requirements. It contains rules and regulations related to the acquisition, documentation, maintenance and supply of living plant material within and beyond the IPEN system as well as on benefit-sharing. It also provides a standardized template for Material Transfer Agreements (MTA) to be used for exchanges with institutions that are not member of the IPEN. A key aspect of the IPEN Code of Conduct is that plant material transferred within the network may only be used for non-commercial purposes of scientific research, education, conservation, raising public awareness and display.

2 www.botanicgardens.eu

3 Botanic Gardens Conservation International (www.bgci.org)

4 International Association of Botanic Gardens (http://iabg.scbg.cas.cn/)

5 Available on the BGCI webpage (http://www.bgci.org/files/ABS/IPEN/IPEN%20Code%20of%20Conduct.doc).

> Keywords ACCESS AND BENEFIT-SHARING
NAGOYA PROTOCOL PLANT MATERIAL EXCHANGE

01. The IPEN code of conduct

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In 2017, the wording of the Code of Conduct has been adjusted in order to make full reference to the Nagoya Protocol and to ensure compliance with its provisions. No substantial changes to the Code of Conduct were necessary, since the original version was designed for compliance with the ABS regulations of the CBD, which were specified but not altered by the NP. The new version of the Code of Conduct now includes explicit references to the NP at the appropriate positions and exemplifies its implications. It also provides clearer guidance how material can leave IPEN (including commercialisation).

The IPEN number: basis for documentation and material transfer

Every plant accession transferred within the IPEN must carry an IPEN number. This number serves as a unique identifier of the plant material. It therefore must be created by the first garden that introduces an accession to the IPEN, and it has to remain connected to the accession and all its descendants through all generations to come, including any further transfer within IPEN. The IPEN number is a code identifying the garden which created the number, the country of origin, and the presence or absence of restrictions regarding the use of the material (**details see below**). Thus it allows the tracing of the origin of the plant genetic resource at every stage of the plant exchange within the network. This creates transparency for the country of origin and ensures that its interests do not get lost along the chain of transfers within IPEN.

The full set of information relevant for this accession, e.g., complete taxonomic data, type of material, source, permits related to the acquisition or use, and any conditions or terms of the country of origin, including original PIC and MAT[6] documents, stay at the garden which entered the material into the IPEN and created the IPEN number. This garden is immediately identifiable by the IPEN number. For all other gardens, only the IPEN number (and in case of any transfer or use restrictions details on such restrictions) is needed as documentation. This is easily manageable and secures the interests of provider countries.

The IPEN number is composed of four elements. They are presented and explained here with an example from the Botanical Garden of the University of Vienna, taken from its seed catalogue for 2010:

AT-0-WU-CAR100208 is the IPEN number connected to an accession of *Heliospermum pusillum* (Waldst. & Kit.) Rchb.

"AT" (for Austria) is the code for the country of origin (two positions in the IPEN number, abbreviation according to ISO 3166-1-alpha-2; if the origin is unknown: "XX"). "0" indicates: no restrictions on transfer or non-commercial use of the material exist (one position in the IPEN number, "1" would indicate that there are restrictions). "WU" (= University of Vienna) is the unique Garden code of the institution that first introduces the material to the IPEN. Those garden codes can be found on the BGCI website under "Garden Search". "CAR100208" is the specific identification number (accession number) used by the Botanical Garden of the University of Vienna. Any other IPEN member receiving material with such an IPEN number material might use their own accession number for internal purposes, but are obliged to keep the origi-

6 PIC = Prior Informed Consent issued by the providing country's authorities. MAT = Mutually Agreed Terms between provider and user of the respective genetic resources.

> Keywords ACCESS AND BENEFIT-SHARING
NAGOYA PROTOCOL PLANT MATERIAL EXCHANGE

01. The IPEN number: basis for documentation and material transfer

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nal IPEN number and to forward it with any future transfer of this material to third parties. As already reported by Kiehn (2015) the traceability within the IPEN system has already been proven for this IPEN number: the *Index Seminum* 2012 of the Botanic Garden of the University of Münster (Germany) offers seeds of *Silene pusilla* Waldst. & Kit. The IPEN number connected with this position (AT-0-WU-CAR100208) clearly indicates that the seeds offered here represent offspring of material from the 2010 catalogue of the Botanical Garden of the University of Vienna; in spite of different scientific names.

Immediate minimum obligations regarding documentation

An IPEN member does not immediately have to put all its collections into the IPEN documentation system (i.e. adding IPEN numbers to all accessions). The minimum obligation is to include those accessions which are offered for exchange/transfer within the IPEN system. At least for those plant genetic resources an IPEN number must be issued by the member garden, and documentation must be stored to be made available upon request. Ideally (and depending on infrastructural, personal and financial resources), other accessions can also be included into the IPEN system (on a voluntary basis).

Material transfer to institutions outside of IPEN

The IPEN Code of Conduct clearly describes the procedures to be followed by member gardens if plant genetic resources are requested by an institution that is not a member of IPEN. In such a case, the potential recipient will have to sign, at minimum, an IPEN Material Transfer Agreement, which will bind him to the same terms and conditions as applicable within IPEN (i.e. non-commercial purposes of scientific research, education, conservation, raising public awareness and display). The recipient has to keep the full documentation for that material. Depending on the conditions defined by the providing country for the material in question, such a transfer might also require additional *a priori* steps by the potential recipient, i.e., obtaining of a PIC or MAT for the intended uses. This secures ABS and NP compliance for material leaving the IPEN.

Commercialization

The traceability of the source of plant genetic resources in the IPEN system also provides a sound basis for every step necessary for an intended commercial use of plant genetic resources in accord with the CBD and the NP. Anyone who intends to use material transferred under the IPEN system has to check first if the providing country of this material regulates access to and use of its genetic resources.

If so, the potential commercial user has to seek PIC and MAT for the intended use from this country's authorities. Only then and in accord with the obligations stated there, this material, now element of separate agreements, can become subject of commercial utilization. This holds true independent of the question whether an IPEN member or a third party intends to use the material for a commercial purpose.

> Keywords ACCESS AND BENEFIT-SHARING NAGOYA PROTOCOL PLANT MATERIAL EXCHANGE

01. IPEN and benefit-sharing

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IPEN members, through their endorsement of the IPEN Code of Conduct, express their commitment for a fair and equitable sharing of benefits arising from utilisation of genetic resources. The IPEN system has been established in order to facilitate material exchange for non-commercial purposes in botanic gardens, but it also provides options and clear guidelines for commercial use of such material. Nevertheless, misperceptions of IPEN in this regard were expressed, e.g., by Kamau *et al.* (2010: 257): "*Networks of ex situ collections exist that exchange biological material among themselves and with researchers fostering taxonomic research, but excluding commercialisation and, in consequence, the regulation of benefit sharing*". Such misunderstanding needs to be actively counteracted, e.g. by better communicating IPEN activities in benefit-sharing like joint excursions or projects with institutions in countries of origin, sharing of research results, knowledge and know-how transfers, training, staff exchanges, donation of equipment and educational material, community development activities and monetary benefits from commercialisation projects (von den Driesch *et al.*, 2005: 39, IEEP 2012).

Outlook

The IPEN framework has proven to reduce the administrative burden for its member gardens when exchanging plant material. IPEN has been recognized as best practice model for ABS-compliance, and it was stated that IPEN deserves support for these efforts (see, e.g., Godt, 2013: 261). The IPEN Code of Conduct has been adjusted to fully comply with the provisions of the Nagoya Protocol. The IPEN Coordination Group continues to inform botanic gardens about the developments connected with the NP. Its members will stay in contact with CBD authorities to further raise awareness on the work and the needs of botanic gardens, allowing botanic gardens to continue their efforts related to conservation, research and public outreach. They also will continue to promote botanic gardens` ideas and the corresponding needs towards relevant (political) stakeholders on national, regional and international levels. Ideally, the implementation of the NP could even lead to a harmonized accession and documentation policy for non-commercial purposes with standardized procedures for PICs and MTAs. Strengthening IPEN (by increasing the number of members and the number of countries represented) also strengthens the position of the IPEN Coordination Group in such negotiations. There is still some doubt about the functionality of IPEN in securing the transparency of transfers of plant genetic resources for provider countries (Godt, 2013: 260f.). As such a functionality is a requirement for the acceptance and credibility of the system, IPEN structures and operations needs to be further promoted and proven by best practice examples.

> Keywords ACCESS AND BENEFIT-SHARING NAGOYA PROTOCOL PLANT MATERIAL EXCHANGE

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WHERE LIVING COLLECTIONS AND CONVENTION REGULATIONS MEET. A NEED FOR STRENGTHENING NETWORKING WITHIN THE BOTANIC GARDEN COMMUNITY

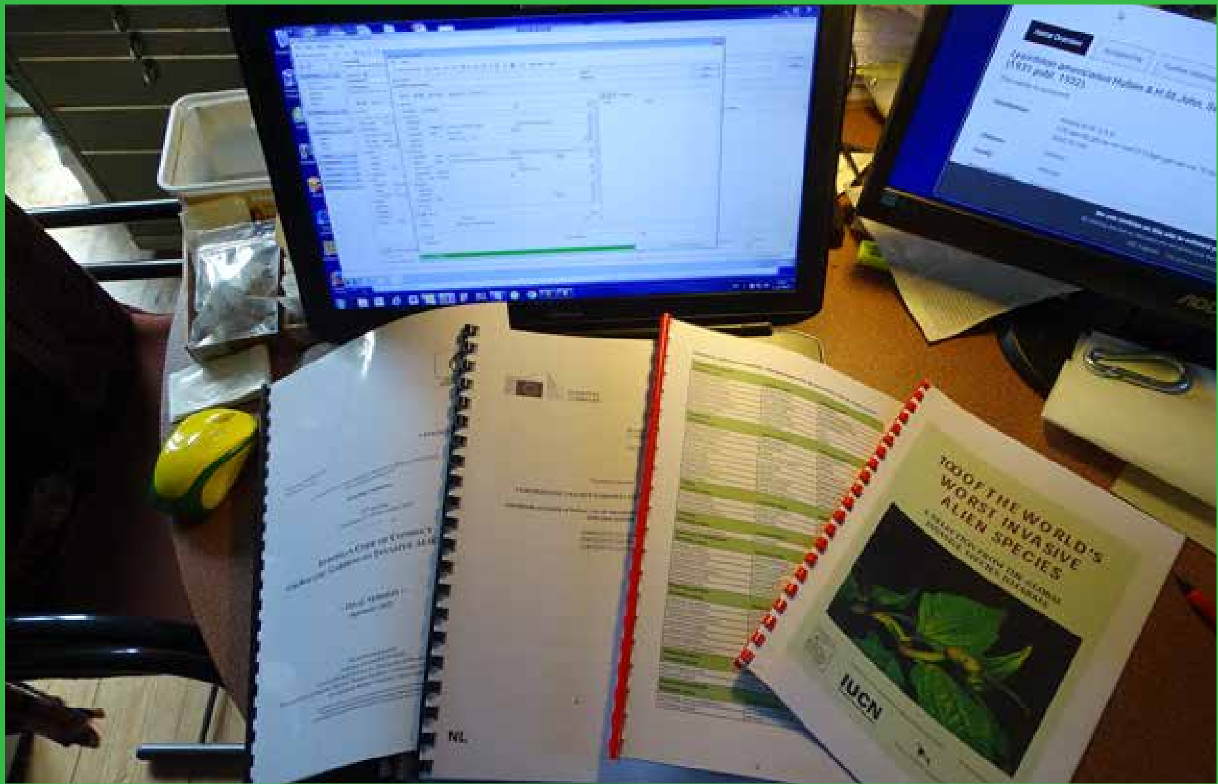

Photo credit : The pile of documents of important regulations, on top of which the four most recent ones regarding invasive alien species, ***Bert van den Wollenberg***

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> Keywords IMPLEMENTATION OF REGULATIONS CITES INVASIVE PLANTS ACCESS BIOSAFETY NATIONAL / INTERNATIONAL NETWORKS

01. Abstract

• *van den Wollenberg Bert*

WE SEE BOTANIC GARDENS AS PLACES OF QUIET CONTEMPLATION. BEHIND THE SCENES HOWEVER, BOTANIC GARDENS HAVE TO INCREASINGLY QUICKLY ADDRESS INTERNATIONAL LAW, AND KEEP UP WITH ANY CHANGES. WITH INCREASING URGENCY AND SPEED, BOTANIC GARDENS HAVE TO ADDRESS NEW LEGAL REQUIREMENTS.

In the past CITES was the most notable convention to reckon with, but now there's the Nagoya Protocol, invasive species, biosafety, and safety requirements regarding visitors and staff.

At the same time, individual botanic gardens are increasingly facing budget restrictions, leading to less garden staff, where more garden staff would be the necessary development. Apart from knowing how to propagate plants, we now also have to know the laws pertaining to them.

Unless the botanic garden community develops mechanisms to deal more efficiently with the challenges posed by these conventions and their resulting national laws, they increasingly run the risk of legal enforcement. A well-known example is CITES, where any plant of which the name needs to be changed, either for nomenclatural or taxonomic reasons, or following proper identification, may lead to a name that features on the CITES appendix 1/ EU annex A list, for which a permit is required to have plants of that species in the collection. Legal staffs have a more fixed perception of names than we do. For the Nagoya Protocol, and the overarching CBD, proper names are also vitally important.

It is not by lack of interest or commitment, that botanic gardens run the risk of violating such regulations, but by lack of efficient mechanisms and protocols within botanic gardens, whereby they unknowingly may make mistakes. This is an even bigger challenge for the smaller gardens, where specialised staff is often lacking. Where individual gardens cannot keep up, networks can be the key to new solutions that renders international law manageable to individual botanic gardens.

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01. Introduction

• *van den Wollenberg Bert*

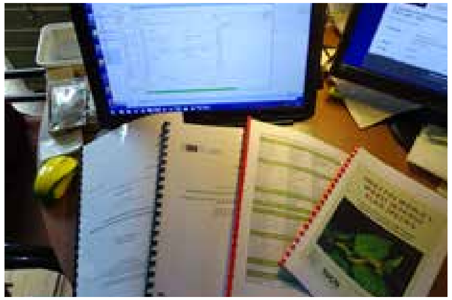

Photo credit : The pile of documents of important regulations, on top of which the four most recent ones regarding invasive alien species, *Bert van den Wollenberg*

IN THIS DAY AND AGE BOTANIC GARDENS ACROSS THE GLOBE ARE INCREASINGLY CHALLENGED TO MANAGE THEIR PLANT COLLECTIONS IN SYNC WITH A STEADILY GROWING NUMBER OF EUROPEAN AND INTERNATIONAL REGULATIONS, INCLUDING OCCASIONAL EMERGENCY MEASURES ISSUED BY THE EU WHICH REQUIRE A QUICK RESPONSE.

At the same time botanic gardens in general are facing stricter budgets rendering employment of more staff, in particular specialised staff, difficult if not impossible. Since implementation of legal requirements must be a priority, it follows that botanic gardens individually, but also the respective networks at various levels should explore possibilities of increasing efficiency in the current *modus operandus* to free up time.

Since many important regulations pertain to the plant collection, it is obvious that senior staff involved in the plant collection management, such as curators, collection administrators and scientific staff will be somehow involved in addressing the relevant legal requirements. An obvious efficiency effort should therefore be directed towards the collection management. This paper will focus on some major regulations, their respective collection management relevance, and their current problems to keep up. Finally, conclusions will be drawn and suggestions made on which level the respective issues could best be resolved, and how.

Relevant issues

For all conventions, regulations, and laws pertaining to plants individual botanic gardens need to know to which plants these pertain, and/or under what circumstances. Finding this out is not at all simple, and very time consuming. In addition to this, much if not all revolves around the proper names of the plants. Awareness of the currently accepted names, differences in the names used by various sources for plant names or regulations, different taxonomies used, and proper identification of the plants themselves all work towards confusion and as a result, potential non-compliance, despite the good intentions botanic gardens generally have. Some of the major conventions and regulations are discussed here. Each convention or regulation poses its own challenges for the collection managers to face, challenges which are discussed from the perspective of the collection management at an individual botanic garden.

> Keywords IMPLEMENTATION OF REGULATIONS
CITES INVASIVE PLANTS
ACCESS BIOSAFETY
NATIONAL / INTERNATIONAL NETWORKS

01. Relevant issues

• *van den Wollenberg Bert*

CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES OF WILD FAUNA AND FLORA (CITES)

Nowadays botanic gardens in the EU may need permits for plant in their collection which are listed in CITES appendix I / EU annex A to possess them legally. In the EU, CITES is implemented via a series of EU regulations, known as the EU Wildlife Trade Regulations. The basic regulation is the *Council Regulation (EC) No 338/97 on the protection of species of wild fauna and flora by regulating trade therein*. In addition, there are regulations on implementation, permits, and suspension (to suspend import of a particular species into the EU). The EU Annexes A-D are not quite the same as the CITES appendices I-III, some species are "upgraded" in the EU annexes in comparison to their CITES pendant to accommodate stricter policies when deemed necessary. EU Annex D has no CITES pendant but exists of some CITES Appendix III-listed species and some non-CITES-listed species.

Since there is no "EU-law", all EU regulations are implemented via national legislation in all EU Member States. Each Member State has the prerogative to apply stricter conditions than agreed within the Council of Europe. This means that botanic gardens within the EU must check the relevant laws of their own country, not the EU regulation or the CITES convention.

Whether or not a permit is needed also depends on whether such plants originate from the wild, and whether they were obtained after the coming into force of CITES in the country where the garden is situated. If such plants originated from cultivation, this would not be the case, and then such plants would be treated as if occurring on CITES appendix II / EU annex B. However, such a cultivated origin would still have to be substantiated with evidence, requiring quite a detailed documentation. Equally, plants acquired prior to the coming into force of CITES in the country of the given botanic garden exempts these plants from needing a permit to underpin their legal possession. In addition to the above, the actual detection of the collection plants that are listed as CITES appendix I / EU annex A is less straightforward then it seems. The use of synonyms instead of the currently accepted name, and misspellings may lead to the non-detection of CITES appendix I / EU annex A specimens in the plant collection.

By uploading the plant collection data to BGCI's Plant Search Database, the plant collection data of a given botanic garden are amongst others cross-checked with the IUCN Red List and CITES databases. As a result, a botanic garden that uploads its plant collection data BGCI's Plant Search Database receives a "list of hits" of plant names which emerged on either database. This is very convenient, since by employing this procedure, a given botanic garden can quickly detect which plants in the collection are of the CITES appendix I / EU annex A category, since a separate column identifies the CITES-category (if any). CITES appendix I / EU annex A plants may require permits just to maintain them in the collection. The relevant accessions can then be checked as to whether a permit is indeed required, and if so, whether it is or is not present, in which latter case a follow-up is needed.

Data comparisons can be advantageous over cross-checking all records manually, which is a time-consuming affair. The potential advantage of data cross-checking is even greater when the data of taxa in the collection of CITES appendix I / EU annex A can be updated automatically. This does of course require more advanced software to be used for plant collection management, and a report of all living accessions of these CITES appendix

> Keywords IMPLEMENTATION OF REGULATIONS CITES INVASIVE PLANTS ACCESS BIOSAFETY NATIONAL / INTERNATIONAL NETWORKS

01. Relevant issues

• van den Wollenberg Bert

I / EU annex A can make this work much easier. The disadvantage of data cross-checking, when this is done alphanumerically, so specific strings of characters, is that small misspellings will lead to non-matching, and in this particular case regarding CITES, potentially to non-detection of plants listed as CITES appendix I / EU annex A taxa. More fundamentally, this cross checking through the upload to BGCI's Plant Search Database, at least before 2015, would not lead to the desired detection when synonym names were used, since the names check was run past the International Plant Names Index (IPNI) Database, which does not distinguish between synonym and accepted names, since it is a database of published names only, which is quite useful in itself, but not for this particular purpose.

Recently BGCI has changed the names check, and BGCI can now check the uploaded plant names against The Plant List Database, which does recognize current and synonym names, allowing for a better check. The following example is based on the experiences before this change took place:

> PHOTO 1

Euphorbia capsaintemariensis Rauh vs. *Euphorbia decaryi* var. *cap-saintemariensis* (Rauh) Cremers

In Delft we have this taxon recorded as *Euphorbia decaryi* var. *cap-saintemariensis* (Rauh) Cremers, in conformity with the Kew World Checklist of Selected Plant Families which we use as primary source to identify currently correct names. Under this name, it did not show up on BGCI's returned file of hits against the IUCN and CITES databases. Checking this name directly on the CITES checklist (http://checklist.cites.org/#/en) by performing the search using the name *Euphorbia decaryi* var. *cap-saintemariensis* came back as "Your search did not match any taxa". The search using the name *Euphorbia cap-saintemariensis* suffered the same fate.

Only when the dash ("-") character was removed, and the name Euphorbia decaryi var. capsaintemariensis or *Euphorbia capsaintemariensis* was used, was the taxon found and the CITES ranking (appendix 1) clarified.

In this case, the presence or absence of the "-" character resulted in failure or success in discovering the CITES ranking.

> Keywords IMPLEMENTATION OF REGULATIONS CITES INVASIVE PLANTS ACCESS BIOSAFETY NATIONAL / INTERNATIONAL NETWORKS

01. Relevant issues

• van den Wollenberg Bert

Another example:
We have a plant recorded as *Euphorbia capsaintemariensis* var. *tulearensis*. Again, this plant does not show up on the CITES checklist as having a CITES listing. Searching for *Euphorbia tulearensis* however again reveals this to be a CITES appendix 1 taxon. In this case, the synonym name (or correct name as you would have it) of *Euphorbia capsaintemariensis* var. *tulearensis* is simply not recorded or recognized as a synonym of *Euphorbia tulearensis*. Such anomalies prevent efficient and effective searches, whether done by data comparison as when uploading data to BGCI's Plant Search Database, or searching for specific names directly at the CITES checklist page.

Searching for "*Euphorbia*" is not advisable since it leads to 36 pages to browse. In this case, downloading the search results may be more efficient, but this does imply manual searches, and will not be effective when synonym/correct names are searched for which are not connected to the names on the CITES checklist. The problematic recognition of CITES appendix I / EU annex A is challenge nr. 1.

Apart from synonyms which may complicate the identification of CITES appendix I / EU annex A taxa in the plant collection, the proper identification of the plants is yet another challenge with direct relevance. A further complication may be that a botanic garden may not have the proper keys and descriptions to its disposal to perform a proper identification. Smaller gardens usually also have a smaller library, and less access to scientific journals than the larger gardens.

When proper identification is possible since the necessary keys and descriptions are available, it may occur that a non-CITES listed species or CITES appendix II / Annex B listed species turns out to be a CITES appendix I / EU Annex A species. Depending on other aspects this may then mean that all of a sudden a permit is required, but this is only evident when all CITES Appendix I / EU Annex A species are recorded in the database of that particular botanic garden, or is immediately checked on http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014R1320. On this website, there are links for every EU Member State and the official publication where the national legislation was published, after each individual EU Member State passed the national legislation to implement the EU regulation.

In short:
- Plant of CITES appendix I / EU annex A species identified to be CITES appendix II / EU annex B species: no problem.
- Plant of CITES appendix II / EU annex B species identified to be CITES appendix I / EU annex A species: **a permit may be required!**

The presence or absence of keys and descriptions to check the identity of CITES listed species, and this applies more generally to all plant identification, is our second challenge.

INVASIVE EXOTIC SPECIES (EU REGULATION NO 1143/2014)

In September 2012 the European Code of Conduct for Botanic Gardens on Invasive Alien Species was submitted to the Council of Europe (Heywood 2012). Subsequently, an illustrated version of this document was published in June 2013 (Heywood with Sharrock).

EU Regulation no 1143/2014 of the European Parliament and of the Council on the prevention and management of the introduction and spread of inva-

> Keywords IMPLEMENTATION OF REGULATIONS
CITES INVASIVE PLANTS
ACCESS BIOSAFETY
NATIONAL / INTERNATIONAL NETWORKS

01. Relevant issues

• *van den Wollenberg Bert*

sive alien species was published 22 October 2014. A EU blacklist of banned species, deemed of "Union Concern" is expected to be published at the end of 2015 or early 2016.

In the mean time, after this paper was presented in July 2015, the first EU list of 37 invasive alien species was adopted on July 13, 2016, and came into force on August 3 of the same year.

As is the case with CITES, for the EU Member States national legislation has been passed. E.g. in The Netherlands, this regulation has come into force on January 1, 2015.

At this point, no current list of banned species exists in The Netherlands, but a list of 7 aquatic plants no longer available from horticulture, based upon a voluntary Agreement on Aquatic Plants established in 2010 between the Ministry of Agriculture, the Association of Regional Water Authorities (Unie van Waterschappen), and the relevant horticultural organisations:

- *Crassula helmsii*
- *Hydrilla verticillata*
- *Hydrocotyle ranunculoides*
- *Ludwigia grandiflora*
- *Ludwigia peploides*
- *Myriophyllum aquaticum*
- Added in 2012: *Myriophyllum heterophyllum*

Other EU Member States may also have some national legislation regarding particular invasive species already, if these are of particular concern.

While CITES has had decades to become familiar to the botanic gardens community, the fast-developing national and international regulations are quite often unknown to individual botanic gardens. As a result of the EU regulation 1143/2014, and indeed in the onset to its development, the EU Consortium of Botanic Gardens has discussed this issue as early as June 2007, when Matthew Jebb (current director of the National Botanic Garden Glasnevin, Dublin, Ireland) presented the first results of a questionnaire sent to all the Consortium members, in order to obtain a more coherent picture of the presence of invasive plants in natural habitats, with the intention to monitor all the exotic plants in plant collections and when necessary add their potential for invasiveness in botanic gardens in separate columns.
In the meantime botanic gardens are in general well aware of this issue, as with the voluntary Code of Conduct for botanic gardens. However, on an operational level, when it comes to identifying the individual invasive plant species, this is less straightforward. The EU regulation reports that some 12,000 species in the environment of the Union and in other European countries are alien, of which roughly 10 to 15 % are estimated to be invasive. The fact that these are still estimates means that more research is needed in quite a few cases. Of course, the European botanic gardens hold many more alien species than the 12,000 species referred to in the EU regulation. It is for this group of plant species that the Consortium project on invasive plants gathers information on the suspected or potential invasiveness in plant collection, as an "early warning system" for botanic gardens, to ensure that botanic gardens do not contribute to the problem that invasive plant species pose already.

Again, the big issue for botanic gardens is to locate the source of information on known invasive plants in natural habitats. Alien species may behave

> Keywords IMPLEMENTATION OF REGULATIONS
CITES INVASIVE PLANTS
ACCESS BIOSAFETY
NATIONAL / INTERNATIONAL NETWORKS

01. Relevant issues

• *van den Wollenberg Bert*

differently in different countries. E.g., *Alliaria petiolata*. This species has been introduced to New Zealand, Canada and the United States. It is native to Europe, ranging from England to Sweden to Turkestan, northwestern-Himalayas, India and Sri Lanka. In Finland however, it is an introduced species, although it has been recorded in Finland for several hundred years. In Finland, it is not considered to be invasive (*pers. comm.* Leif Schulman). It is important to have a precise understanding of the process and genetics of the invasive species to distinguish between alien plants which are not invasive, and alien plants which are. Some species which in the past were assumed to be native plants now turn out to be archaeophytes, aliens that colonized or were introduced many centuries ago. The process of colonisation in itself is a natural phenomenon, leading locally to a changing –though be it slowly- ecosystem. Stacey & Crawly (2015) argue that the current flora in the British Isles largely originates from refugia from southern and southeastern Europe, after the last glaciation ended some 128,000 years ago, leaving the British Isles largely devoid of plants at that time. Neophytes are distinguished from archaeophytes as plants to have arrived starting at a time where mankind significantly increased its influence on the composition of the native flora. For the British Isles, this pivotal date is 1500 AD.

It is not the alien plants that pose the problems, but those that invade our current ecosystems and change them to the detriment of the native flora. This is particularly noticeable when these invasive aliens also cause economic of health damage to man. Alien plants arrive in new territories either naturally, through natural vectors, or through introduction by man, deliberately or by accident. Understanding and differentiating between these requires new terminology and clear definitions, which are vital in order to effectively address the problems with invasive aliens effectively and proportionally. From an evolutionary perspective, it is undesirable to put a ban on all neophytes, since adaptation to changes in the biotic or abiotic environment is a natural phenomenon, which does require the influx of neophytes that may be better adapted to the new situation than the extant flora. Neophytes may range from being surviving plants, not reproducing at all, to plants of casual occurrence, not reproducing every year, to naturalized plants, which are present for 5 or 10 years, to be called naturalised. When naturalised are to be considered invasive also requires clear circumscription in order to avoid confusion. Stace and Crawley (2015) define invasive plant species as naturalised species that form a substantial proportion of the biomass of the invaded community. However, when this occurs in man-made or highly disturbed habitats, they would not use the word invasive for such a species. A precise distinction between invasive species and the archaeophytes and the remainder of the neophytes is necessary for effective policies. However, it should be noted that in order to prevent outbreaks of invasions, we cannot afford to wait until the invasion is evident, since at that point, it may have become impossible to counter the invasion with effective measures. And such measures would also invariably mean a huge cost to contain or eradicate the particular invasive species. Therefore we would like to know in advance which alien plant species may become invasive in a particular area, in order for eradication or containment measures to be both effective and cost-effective.

Most of the botanic gardens in Europe maintain large numbers of exotic plants in their collections, and have done so for decades if not centuries. In addition to the voluntary code of conduct for botanic gardens on invasive plant species (Heywood 2012, Heywood with Sharrock 2013), the EU now also has adopted a regulation (No 1143/2014), and the first EU list of 37 invasive alien species was adopted on July 13, 2016. On June 19, 2017, another 12 spe-

> Keywords IMPLEMENTATION OF REGULATIONS
CITES INVASIVE PLANTS
ACCESS BIOSAFETY
NATIONAL / INTERNATIONAL NETWORKS

01. Relevant issues

• van den Wollenberg Bert

cies of plants and animals were added tot he first list, and currently (November 2017), an addition of another 11 species is under consideration.

For all the species on the first list and subsequent additions, a number of measures will apply, such as a ban on import and export, transport, propagation, and presence within a collection without a permit.

For individual European botanic gardens the EU list will be straightforward, but it is less straightforward to identify the information source to check all the exotic plants in their collection for their invasive or potential invasiveness in their particular geographic situation. Delivering Alien Invasive Species Inventories for Europe (DAISIE)[1], North European and Baltic Network on Invasive Species (NOBANIS)[2] and European Plant Protection Organisation (EPPO)[3], as well as National Initiatives, do provide detailed databases. However, these are not complete, nor is it easy for botanic gardens to obtain summary lists of problem taxa. It can be difficult for Garden managers and curators to obtain summary lists that provide at a glance indications of problem taxa, especially when it comes to such lists pertaining to their specific country. Again, checking the plant collection data against a good Invasive Species database would be very helpful to help focus attention on the specific exotic plants in that particular collection which are or potentially may become invasive. We are still far from that option, and for now, the challenge remains for botanic gardens to become aware of the known invasive and potential invasive plants in our plant collections. The first EU list of banned species only shows the most problematic of the invasive species, and subsequent additions to the list will address other species of concern for which the risk analysis was not ready at the time of publication of the first list.

The absence of a summary list of all invasive plant species for botanic gardens to check their holdings against is the 3rd challenge.

Botanic gardens can share information about exotic plant species which in their opinion may have a potential of invasiveness. It should be clear however, that in those cases, we need to ensure that more detailed information is gathered before such species are declared to be invasive, to ensure that such species actually behave invasive as defined, and are not confused with weediness in an artificial environment.

NAGOYA PROTOCOL

The Nagoya Protocol itself, and the EU regulation pertaining to it, have been discussed in another presentation, and therefore are not discussed here. However, there is a significant misunderstanding among many botanic gardens in Europe, as to the access to biodiversity within Europe. While the Nagoya protocol has paragraphs on access, the EU regulation lacks an access pillar. The reason for this is that several EU Member States do not intend to use the right to restrict access in order to ensure that benefits are shared equitably, as stipulated by the Nagoya Protocol. At this moment only Bulgaria and Spain have access restrictions, although other countries are considering it, or are in the process of implementation (e.g. France). The national absence of access regulation in relation to the Nagoya Protocol does not mean however, that access is free. This misunderstanding turned up at a discussion within the EU Consortium of Botanic Gardens at the first biannual meeting in Dublin, February 2015. Subsequently a questionnaire was sent to its members by the author. This preliminary assessment showed that in some countries species which are not protected by law, or growing in protected areas or private land, may be collected in some countries, while in others permits

1 www.europe-aliens.org/index.jsp

2 www.nobanis.org/

3 www.eppo.int/INVASIVE_PLANTS/ias_lists.htm

> Keywords IMPLEMENTATION OF REGULATIONS
CITES INVASIVE PLANTS
ACCESS BIOSAFETY
NATIONAL / INTERNATIONAL NETWORKS

01. Relevant issues

• van den Wollenberg Bert

are required. Since the questionnaire was not completed by all, no further details are provided here. A more detailed study will be necessary if the level of detail desired is to be achieved.

However, it should be clear that plant collecting in the wild may be subjected to other national legislation than the legislation pertaining to the EU regulation of the Nagoya Protocol. This means that when collecting is contemplated, botanic gardens should first find out about the legitimacy of such collecting. This, however, is far from easy. The information websites are not always joined in one national "clearing house", and often the language other than English is used, or initial information pages are in English, but when more details are referred to on other sits, the language changes from English to the national language. A further complication arises in federal states, where part or most of the legislation is issued by the individual states or cantons, as is the case respectively for Austria and Switzerland.

This constitutes the 4th challenge to botanic gardens: to find the proper information sites for each country where plant collecting is considered, in order to respect the national laws of that country.

PHYTOSANITARY REGULATIONS

The European directive from May 2000 (Council Directive 2000/29/EC) addresses the protective measures against the introduction of organisms which may be harmful to plants or plant products, and the measures intended to contain, restrict or prevent the spread of these organisms in the European Community. The extent to which this directive applies to botanic gardens varies with the various organisms to be contained. As a result, the familiarity with this directive is less well developed as compared to e.g. CITES or invasive species. The occurrence of *Anoplophora chinensis* (the Citrus Long-horned Beetle) triggered an emergency measure following outbreaks of this beetle in 2010 in Germany, the Netherlands, Italy and the United Kingdom (notified under document C (2012) 1310) lead to quite profound containment measures. This beetle occurs naturally in China, and is known to travel via imports of plants and wood. Although the beetles are most harmful to *Citrus*, a wide range of host plants can consolidate its presence within the EU: *Acer, Aesculus hippocastanum, Alnus, Betula, Carpinus, Cornus, Corylus, Cotoneaster, Crataegus, Fagus, Lagerstroemia, Malus, Platanus, Populus, Prunus laurocerasus, Pyrus, Rosa, Salix and Ulmus.* Since the listed genera and species of host plants also frequently occur in botanic gardens, a real concern rose among the botanic gardens of the countries in question. As woody plant imports from China do not occur regularly amongst European botanic gardens, and such imports would easily be noticed by the customs departments, botanic gardens were not perceived as a significant vector.

In May 2015 another EU emergency measure was issued concerning the bacterial disease caused by *Xylella fastidiosa*. This time, the bacterial outbreak had already infected large stands of olive trees in Lecce Province, Italy. This time, 7 pages of host plants were identified, amongst others also 25 entire genera: *Acer, Aesculus, Brassica, Carex, Citrus, Coffea, Erodium, Hemerocallis, Juglans, Malva, Melilotus, Morus, Platanus, Portulaca, Prunus, Quercus, Rubus, Salix, Sambucus, Sonchus, Sorghum, Vaccinium, Veronica, Vinca, and Vitis.*

Again, many of the potential host species and genera concern plants that are well-represented in collections of botanic gardens. However, since the origin of the infestation is within the European boundaries, where botanic gar-

> Keywords IMPLEMENTATION OF REGULATIONS
CITES INVASIVE PLANTS
ACCESS BIOSAFETY
NATIONAL / INTERNATIONAL NETWORKS

01. Relevant issues

• van den Wollenberg Bert

dens have a well-developed exchange of plants and seeds, the potential risks are higher. In the Netherlands, news about this emergency measure reached one botanic garden, and fortunately was shared almost immediately with the other gardens in the Dutch national network of botanic gardens (NVBT). At that point at least one botanic garden did intend to import *Citrus* plants from Italy, but upon hearing from this emergency measure, decided against it just to be on the safe side. This example shows that it is imperative to be informed about such measures, in order to ensure the proper follow-up by all relevant stakeholders. A faltering communication could potentially lead to undesirable imports which may again lead to new infestations. The 5th challenge for botanic gardens is not only to stay informed about conditions, restrictions, and changes therein of the standing phytosanitary regulation as implemented by national law, but even more challenging, to be aware of EU emergency measures, and their potential significance to each individual botanic garden.

Discussion

In the past decades, new regulations in the EU pertaining to plants, and therefore to botanic gardens with their living plant collections, have increased in number. In addition, in some cases the EU has issued emergency measures on short notice to contain potential acute damage to the economy, biodiversity or health. Since the legal measures issued are relevant to all individuals and organisations, in this case within the EU, this also affects botanic gardens. Increasingly therefore, botanic gardens are facing these issues with their legal aspects, while generally no additional staff is made available, nor does the staff in most cases possess sufficient legal knowledge. A commonly heard complaint is that when such policies are issued, these should also include increase of staff amongst the stakeholder organisations. Be that as it may, the current fact of life is that the burden of making ends meet between the currently available staff and existing workload on the one hand, and the duty to abide by the law on the other, is placed on all stakeholder organisations.

This inescapably means that botanic gardens have to reconsider their *modus operandus*. Yet botanic gardens do not all individually have to re-invent the wheel. The global botanic garden community is known to be a benevolent network with a strong sense of community feeling. The international seed exchange system which has existed for centuries and runs without mutual billing or assessment of gains and costs, is a good example of that. This community can and should try its best to address these challenges jointly as a community, where specific issues are addressed at the proper level where it can most efficiently be addressed, be it at the level of the individual gardens, their national networks, their international networks, or the international interdisciplinary cooperation with e.g. the international plant taxonomy community. The latter is usually addressed via the many larger botanic gardens that are part of more encompassing institutions with e.g. herbaria and or other plant research departments.

ACTIONS/RESPONSES FROM THE BOTANIC GARDENS COMMUNITY

The actions and responses of the botanic garden community should ensure that we are and remain fit for purpose. The alternative would be that individual botanic gardens might become side-tracked, as a result of which the many challenges, including support for the Global Strategy for Plant Conservation (GSPC), would come to rest on fewer botanic gardens.

> Keywords IMPLEMENTATION OF REGULATIONS
CITES INVASIVE PLANTS
ACCESS BIOSAFETY
NATIONAL / INTERNATIONAL NETWORKS

01. Discussion

• *van den Wollenberg Bert*

The possible actions to consider are split here into the various levels, starting with the level of the individual gardens, up to the interdisciplinary level. Some actions may turn out to be easier to resolve at another level. This can happen when botanic gardens or their institutes team up to address a particular issue. The division as proposed here is therefore to some extent arbitrary, yet it can be very useful in setting the stage in our thinking. Also, this listing may be incomplete, and time will tell what other initiatives or approaches can be added.

I. THE INDIVIDUAL LEVEL

- Ensure that the data on plant species in relation to regulations, i.e. CITES, invasive aliens, etc. can be consolidated within the botanic garden, preferably within the collection administration. This may in time affect the type of software used. Timely recognition of the needs but also new technological developments may help prepare for necessary changes. Prioritise also on the implementation of the more general aspects of conventions and regulations.
- Prioritise the efforts for plant identification. It is one of the most important activities in relation to the management of a plant collection, but due to various obstacles, such as the absence of the necessary tools (keys, descriptions, etc.) is often the least practiced. Setting targets may help, if only to direct more attention and effort in this direction.
- Check the plant names against the use of synonyms. A simple approach that will provide much insight is to use the facility of BGCI's Plant Search database. By uploading the names of the plants in the plant collection, these data are now checked against relevant databases such as The Plant List, the CITES -, and IUCN Red List databases. In return BGCI emails back lists that show which of your plants have a CITES and/or IUCN listing, as well as any names not accepted as the currently correct name against The Plant List as the default authority for currently correct names. Names not verifiable by The Plant List are rejected and therefore possibly incorrect. This feature is extremely useful as a fast and elaborate names check. When your software cannot process the returned data file, this file will have to be processed manually, but much time is gained by the automated check. These are all direct benefits from uploading the data to BGCI's Plant Search database.
- The garden's plant collection data, when uploaded BGCI's Plant Search database, are added to the list of taxa known to be represented in at least one botanic garden in the world. This helps BGCI to demonstrate the role that botanic gardens jointly play in the ex situ conservation of plant species, and the threatened species represented therein. This is of particular relevance to article 8 of the GSPC, which is now part of the Convention on Biological Diversity (CBD). The list which is returned to the garden by BGCI also reveals the uniqueness of individual taxa, since in a separate column the total number of gardens known to maintain that particular taxon is listed in a separate column. A "1" means to only your garden is known to maintain that taxon. Of course, not all botanic gardens of the world have uploaded their data yet, but the more gardens do so, the more accurate and reliable this uniqueness indication becomes.
- Ensure that any plant collecting is done according to the relevant national legislation, and ensure that relevant documents are archived and linked to the plants collected, to underpin their legality as part of the botanic garden plant collection.
- Read and use, handbooks, manuals and protocols of best practice on the various issues in relation to plant collections, and regulations. BGCI has

> Keywords IMPLEMENTATION OF REGULATIONS
CITES INVASIVE PLANTS
ACCESS BIOSAFETY
NATIONAL / INTERNATIONAL NETWORKS

01. Discussion

• van den Wollenberg Bert

produced handbooks on various issues in the past, to aid botanic gardens.

- Consider to join forces and adopt e.g the European Code of Conduct for Botanic Gardens on Invasive alien species, and consider joining the International Plant Exchange Network (IPEN), which is developed to help botanic gardens to address the requirements of the CBD.
- Consider to become member of BGCI, and thus strengthen BGCI's capacity to represent botanic gardens internationally amongst the policy-makers.

II. THE NATIONAL LEVEL

The national networks of botanic gardens can play a significant role to assist their member gardens to address the many challenges.

- Ensure that the national network is known in circles of the relevant ministries of the national government. Try to achieve that relevant information regarding national legislation that implements international conventions and European regulations and directives is communicated to the network as the representative of the specific stakeholder group that botanic gardens are. This can be achieved e.g. by designating a contact person or contact group for each relevant ministry.
- Contact the ministry responsible for CITES, in order to ensure that it is clear to all member gardens for which plants permits are required, and assist in the process of acquiring these where necessary. In addition, make sure that protocols or procedures are developed and agreed with the relevant ministry to ensure timely renewal (permits expire after five years) and the procedure when new permits need to be issued. E.g., a CITES flow chart will be developed in line with the procedural views of the ministry for the Dutch network to clarify in each individual accession if a permit is required.
- Ensure close contact with the relevant ministry regarding their monitoring of the implementation of the Nagoya Protocol / its EU regulation. Ensure that the member gardens know under which conditions the NP is applicable, and how to comply in such cases.
- Ensure that the conventions and their EU regulations are discussed on a regular basis, e.g. every 2-3 years. The members can be informed about changes in the legislation if and when these occur, but in addition, it is very useful to discuss the practicalities jointly to learn from each other, and keep the issues high on the agenda of the individual members.
- Develop an overview of tools for identification (keys, floras monographs etc.) within the network, to help each garden in accessing such tools when not in the possession of that garden. The Dutch network (NVBT) is developing such a repository for its members, who jointly have far more available than the members have individually. This repository will be available for members only, to ensure that issues such as copyright are not violated.

III. THE INTERNATIONAL LEVEL

Since the issues at the international level may be addressed at regional level as well (e.g. for the EU by the European Consortium of Botanic Gardens), as well as interdisciplinary, a sharp divide of the issues between them would be very arbitrary and artificial.

- A major issue on this level is the further development of data cross-checking of plant collections with taxonomic databases, as well as CITES- and IUCN databases. In particular, a "smart search" approach is needed such as internet search engines use nowadays, to ensure that small typing errors do not result in data mismatches, but instead are recognised when they should be.

> Keywords IMPLEMENTATION OF REGULATIONS CITES INVASIVE PLANTS ACCESS BIOSAFETY NATIONAL / INTERNATIONAL NETWORKS

01. Discussion

• van den Wollenberg Bert

- The World Flora Online initiative is a hugely important and useful feature to the botanic garden community once it is up and running. The project also intends to provide keys and descriptions for the taxa listed. It would be hugely beneficial if such information would become available as soon as possible, even if the database is still in the development phase.
- Strive towards taxonomic publications to be published in open access journals rather than journals from publishers. Too often publications are not available unless paid for, or a subscription is taken, and this is a significant impediment for the smaller gardens or those with otherwise very limited budgets. It is a positive development that the EU recommends to its Member States that there should be open access to publications resulting from publicly funded research as soon as possible.
- Encouragement of the policy-makers to also include a more specific communication mechanism to contact the relevant stakeholder-groups more directly. Current policies tend to assume too much that stakeholders will be informed somehow, but in practice, this is not always the case, and in particular with important EU emergency measures, such communication seems to depend more on chance than on well-organised communication.
- Better access to relevant publications to a wider audience of stakeholders. Too often important publications are published in journals with copyright restrictions. In addition, quite often such journals are too expensive for the smaller botanic gardens with only small budgets. E.g. the ambition of the Dutch government is that in November 2018 60 percent of the scientific publications are published in open access journals, to increase to 100 percent in 2024. This is strongly supported by the Association of Dutch Universities.
- When topical manuals, handbooks or guidelines are developed, these would benefit from a stronger focus on the practical implementation, since it is the practicalities that botanic gardens have to deal with. Especially in relation with the CBD and the Nagoya Protocol, the publications have been rather vague in this respect.

Botanic gardens are facing an ever-growing number of regulations, their documents and lists, the latter often being augmented irregularly. Individually, botanic gardens in general are facing an increasing administrative and legal challenge in order to secure the obligatory, often detailed, requirements. This would require dedicated staff that handles the legal obligations by turning these into the proper procedures and documentation within the existing garden administration. Some botanic gardens, mostly the large gardens with many staff members, actually do have such dedicated staff. For the smaller botanic gardens, and without opportunities to hire additional staff, the increasing legal obligations will only add to the weight of the existing overhead. As an overall conclusion to the growing demands, it seems clear that networking more strongly is the obvious solution for botanic gardens in order to cope with such increasing demands and expectations. Networking can provide the structural backbone for more and more detailed communication about all relevant issues that affect botanic gardens today. Such issues could be better handled by the existing networks of botanic gardens, ideally with staff formally allocated to dedicate sufficient time to keep up with the number of relevant regulations and the expanding scope of each regulation. Such dedicated staff could turn the many challenges from regulations into practical approaches for implementation that each member garden can incorporate into the daily routine. Some national networks of botanic gardens in Europe are already well-developed and up to the challenge, but other networks are still developing their *modus operandus*, while yet other networks are still in the process of establishment.

> Keywords IMPLEMENTATION OF REGULATIONS CITES INVASIVE PLANTS ACCESS BIOSAFETY NATIONAL / INTERNATIONAL NETWORKS

01. Discussion

• van den Wollenberg Bert

Other approaches, e.g. emanating from the European Consortium of Botanic Gardens, might be necessary to deal with the current non-level playing field of national networks of botanic gardens in Europe.

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IMPLEMENTING THE NAGOYA PROTOCOL: DEVELOPING A TOOLKIT FOR YOUR BOTANIC GARDEN

Photo credit : Raising awareness of ABS issues with collection holders in Ethiopia, *Suzanne Sharrock*

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> Keywords ACCESS AND BENEFIT SHARING NAGOYA PROTOCOL TOOLKIT BEST PRACTICE BOTANIC GARDEN MANAGEMENT

01. Abstract

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THE NAGOYA PROTOCOL ON ACCESS AND BENEFIT SHARING (ABS) IS A LEGALLY BINDING INTERNATIONAL INSTRUMENT THAT CAME INTO FORCE IN OCTOBER 2014.

While a significant motive for developing the new ABS regime is the fair and equitable sharing of monetary benefits arising from commercial exploitation of genetic resources, valuable non-monetary benefits that contribute significantly to conservation and sustainable use are also generated and shared in various ways. The Nagoya Protocol also establishes a compliance regime that means penalties will be imposed if genetic resources are utilised illegally. The European Union is a Party to the NP and has adopted Regulations on ABS that apply to all users of genetic resources in the Union.

Botanic gardens can be users and are suppliers of plant genetic material and it is therefore vital that they are aware of the new ABS framework being developed at both the EU and national level. This new framework is likely to have significant implications for botanic gardens and the way they work in the future.

BGCI and the Royal Botanic Gardens Kew have been working together to develop a set of training modules on ABS and the Nagoya Protocol for botanic gardens. These include guidelines for setting up an institutional ABS implementation toolkit, including the development of codes of conduct, best practice guidance and model agreements.

This paper will introduce the toolkit for botanic gardens implementing the Nagoya Protocol, followed by a case study from RBG, Kew. Both the NP and the EU Regulations encourage the adoption of sectoral codes of conduct, best practices and model agreements to assist implementation and several initiatives have begun in the botanic garden community. This paper will also provide an introduction to some of these initiatives.

> Keywords ACCESS AND BENEFIT SHARING NAGOYA PROTOCOL TOOLKIT BEST PRACTICE BOTANIC GARDEN MANAGEMENT

01. Introduction

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Photo credit : Raising awareness of ABS issues with collection holders in Ethiopia, *Suzanne Sharrock*

THE NAGOYA PROTOCOL ON ACCESS AND BENEFIT SHARING UNDER THE CONVENTION ON BIOLOGICAL DIVERSITY (NAGOYA PROTOCOL) ENTERED INTO FORCE ON 12 OCTOBER 2014 (WWW.CBD.INT/ABS/).

At the time of writing, it had been ratified by 68 Parties, including the European Union. The Nagoya Protocol, when implemented at a national level, will govern the way genetic resources are accessed (in countries where the organisms carrying them are found) and used (by both researchers and commercial entities), and how any benefits arising out of their utilisation should be shared. The Protocol is a legally binding instrument and requires Parties to implement compliance mechanisms to ensure genetic resources are used legally, and to institute penalties if they are not.

The European Union ratified the Nagoya Protocol in June 2014 and passed the EU Regulation on Access and Benefit Sharing which came into force from October 2014 (http://ec.europa.eu/environment/nature/biodiversity/international/abs/index_en.htm), and is directly applicable in EU member states. Articles 4 (Obligations of Users), 7 (Monitoring User Compliance) and 9 (Checks on User Compliance) came into force one year later (October 2015). The EU Regulations focus on compliance measures for users of genetic resources in the EU. The Regulations apply to 'utilisation of genetic resources' in the EU that were accessed *after* the Nagoya Protocol came into force, and *from a Party* to the Protocol that has clear access legislation. 'Utilisation of genetic resources' is defined, in Article 3(5) of the Regulations, as in the Nagoya Protocol Article 2(c): 'to conduct research and development on the genetic and/or biochemical composition of genetic resources'. It requires users to exercise 'due diligence' that genetic resources have been legally accessed.

The Regulations establish two checkpoints:

- On receipt of funding for utilisation projects
- At the final stage of development of a product in the EU

Competent authorities in each Member State will carry out checks on user compliance (Article 9) which will include spot checks and Member States will introduce penalties for non-compliance. The Regulations encourage the development of sectoral codes, best practices and model contractual clauses, and will be implemented through further guidance that is currently being developed.

> Keywords ACCESS AND BENEFIT SHARING NAGOYA PROTOCOL TOOLKIT BEST PRACTICE BOTANIC GARDEN MANAGEMENT

01. Botanic gardens and ABS

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Botanic gardens acquire, use and exchange plants for a range of scientific, conservation, economic and cultural purposes. In these activities, it is important that botanic gardens comply with national laws and observe the terms under which the genetic resources in their collections have been provided. With the entry into force of the Nagoya Protocol, there is greater pressure on botanic gardens to monitor the use[1] of materials in their collection.

A global survey of botanic gardens was conducted in 2012 by Botanic Gardens Conservation International (BGCI) and the American Public Gardens Association (APGA) to assess awareness of access and benefit-sharing issues and potential preparedness for Nagoya Protocol requirements. Representatives of 222 gardens from 46 countries responded. Results indicated that many respondents were not yet familiar with access and benefit-sharing or the Nagoya Protocol. Exchange of plant material was common, but many gardens did not track transfers to third parties, use material transfer agreements, or link permits or restrictions to collection records. The survey demonstrated the need for capacity-building initiatives and practical tools to enable gardens and their networks to understand access and benefit-sharing, comply with new legislation, build trust and safeguard their role in conservation (Davis et al.., 2015).

An ABS learning tool

In response to the survey, BGCI in partnership with the Royal Botanic Gardens, Kew, and with the financial support of the Japan Biodiversity Fund, has developed a set of ABS self-learning modules. These modules aim to address the lack of awareness about the Convention on Biological Diversity, and ABS issues in particular, amongst the botanic garden community. The modules are available on the BGCI website (www.bgci.org/policy/abs_learning/).

The modules take a step-by-step approach, with a module covering each of the following elements:

- Introduction to the CBD
- History of the Nagoya Protocol
- Key articles of the Protocol
- Practical implementation by botanic gardens
- Developing a checklist / toolkit
- Developing contracts and agreements

Each module consists of a set of slides which can be read directly on-line, or can be downloaded for off-line consultation. At the end of each module, a set of quiz questions tests the users' understanding of the issues covered in that module. A comprehensive list of resources and references for additional information is also provided. At the time of the EuroGard conference, the modules were available in English only. However, they have subsequently been translated and are available in French, Spanish and Chinese.

Case study: developing an ABS toolkit at the Royal Botanic Gardens, Kew

The Royal Botanic Gardens, Kew was founded in 1759 by Princess Augusta, the mother of King George III. For over 250 years it has focused on plant and

1 It should be noted that 'use' or 'utilization' in the context of the Nagoya Protocol has a specific meaning, which is: 'to conduct research and development on the genetic and/or biochemical composition of genetic resources, including through the application of biotechnology'.

> Keywords ACCESS AND BENEFIT SHARING NAGOYA PROTOCOL TOOLKIT BEST PRACTICE BOTANIC GARDEN MANAGEMENT

01. Case study: developing an ABS toolkit at the Royal Botanic Gardens, Kew

• *Williams China*
• *Sharrock Suzanne*

fungal discovery, identification and naming. As a botanic garden it is open to the public, with over 1.7 million visitors a year, and employs approximately 700 staff in science and horticulture. It was designated a UNESCO World Heritage Site in 2003. Kew is a non-departmental public body, part funded by the UK Department for the Environment and Rural Affairs (Defra) and is answerable to a Board of Trustees (Kew's Science Strategy).

Kew holds nineteen major collections including preserved plant and fungal collections (the Herbarium), living material (The Seed Bank and Living Plant collections) and extensive visual reference collections (library, art and archives, as well as on-line resources including databases). Kew has an active fieldwork collecting programme, with scientists going on more than 60 fieldwork trips each year, bringing back thousands of new specimens. Kew's work involves an extensive international network of overseas partners – over 400 collaborating institutes worldwide in over 110 countries.

Kew's Collections in Numbers
Herbarium (7.5 M) & **Fungarium** (1.25 M)
Living collections (+30,000 species)
Millennium Seed Bank (+30,000 species; c. 2 billion seeds)
DNA and tissue bank (+42,000 accessions)
DNA C-value (+7,000 species)
Slide collections (+100,000 slides)
Library (> 750,000 volumes), **archives** (250,000), **artwork** (> 175,000), **paintings, prints and drawings**
Over 300 **international scientists visit** each year
More than 60 **overseas plant collecting trips** annually
Exchange over 60,000 **herbarium specimens** and 10,000 **live plants and seeds** each year
Working with 400 **collaborating institutes**
In over 110 **countries worldwide**

Kew has been proactive in ensuring that it works closely with partners to ensure plants are collected legally, according to national law, and that research taking place at Kew is in line with national and international legislation and conservation priorities, both in the UK and in the countries where it works. In 1992, with negotiations of the Rio Convention taking place, Kew saw that action was required to maintain the trust of partners to continue to develop its collections and research. In consultation with staff and Trustees Kew's first 'benefit-sharing' policy was introduced, outlining Kew's commitment to sharing benefits with countries of origin.

Since then Kew has been active in following the development of the Convention on Biological Diversity (CBD) and working to develop a policy in ABS and streamline this with other botanical research institutes in the UK and worldwide. In 1994, a CBD Officer post was established, and a CBD Unit created. Between 1997 and 2000 Kew coordinated a UK Department for International Development (DFID) funded project involving 28 botanical institutions from 21 countries, to develop best practice ABS guidelines for botanical institutions. The resulting 'Principles on Access to Genetic Resources and Benefit-Sharing' (*www.bgci.org/policy/abs_principles/*) cover best practice in acquisition, curation, use and the supply of material, and associated benefit-sharing. The Principles have been endorsed by over 25 botanical institutions worldwide and were used to form the basis of Kew's current ABS policy. This approach is the basis of the way Kew works in this area today.

The Principles and Kew's own ABS Policy (including model agreements) have been influential. They have been widely cited by the CBD Secretariat, the EU and by the UK Department for Food and Rural Affairs (Defra) as examples of best practice and have influenced the development of the CBD's

> Keywords ACCESS AND BENEFIT SHARING NAGOYA PROTOCOL TOOLKIT BEST PRACTICE BOTANIC GARDEN MANAGEMENT

01. Case study: developing an ABS toolkit at the Royal Botanic Gardens, Kew

• Williams China
• Sharrock Suzanne

Bonn Guidelines as well as that of national legislation in countries as diverse as India and Australia.

As well as influencing international and national legislation and policy on genetic resources, Kew's ABS policy has also been a vital tool for working transparently with partners and stakeholders. Kew's current Policy on ABS (Kew's Policy on ABS) was approved by the Director and Board of Trustees and has been effective since December 2004. Kew's policy is designed to ensure that all material brought into Kew (either collected on fieldwork, or from other institutions and individuals) has been legally acquired on mutually agreed terms, that it is used and supplied by Kew on terms and conditions consistent with those under which it was acquired, and that benefits arising from the use of genetic resources by Kew are shared fairly and equitably as agreed with partners in the country of origin of the material.

In order to implement the ABS Policy Kew has, over the years, developed and put in place a suite of practical measures and tools so that staff are supported and given the tools to ensure that material in the collections is used according to terms and conditions under which it was acquired. This institutional ABS Toolkit (submitted to the CBD Secretariat by the EU as an information document: *www.cbd.int/abs/submissions/icnp-3/EU-Kew-letter.pdf*) governs the way Kew manages its plant collections, addresses issues related to Access and Benefit Sharing (ABS) under the Convention on Biological Diversity and national legislation, keeps track of Kew's bilateral contracts and obligations, and supports Kew's vital conservation partnerships.

THIS TOOLKIT INCLUDES:

- KEW'S POLICY ON ABS (*www.kew.org/sites/default/files/ABSPolicy.pdf*) that includes a commercialisation policy. The policy was written in 1993 and revised in 2004.
- A DEDICATED CBD UNIT (currently 1 full time member of staff) working with a wider cross-departmental group of approximately 20 scientist and horticulturalist to develop and update Kew's policies, processes and model agreements, in line with ABS regulations and institutional requirements.
- AN INTERACTIVE INTERNET-BASED STAFF GUIDE ON ABS setting out best practice for collecting, use and supply of genetic resources, links to documents and policies, and up to date guidelines for staff working with Traditional Knowledge (TK) and Indigenous and Local Communities (ILCs).
- A CROSS-DEPARTMENTAL 'OVERSEAS FIELDWORK COMMITTEE' (OFC) which is responsible for monitoring all overseas fieldwork collecting trips by Kew staff (approximately 60 overseas collecting trips per year). The team is comprised of staff representatives in all departments and corresponds through email. The procedure for planning overseas fieldwork ensures that national laws and legislation are followed, appropriate permissions from all relevant stakeholders are obtained and kept, and benefits are agreed and shared fairly. It also ensures that collections are curated appropriately afterwards, and any terms and conditions are linked to permits and terms of use. In addition the OFC ensures that staff work according to sectoral best practice standards and models that a record is kept of the countries in which Kew is working, and that they are working safely following government safety advice.
- A SUITE OF TEMPLATE AGREEMENTS. These include Access and Benefit Sharing Agreements (for governmental partners) and Memoranda of Un-

> Keywords ACCESS AND BENEFIT SHARING NAGOYA PROTOCOL TOOLKIT BEST PRACTICE BOTANIC GARDEN MANAGEMENT

01. Case study: developing an ABS toolkit at the Royal Botanic Gardens, Kew

• *Williams China*
• *Sharrock Suzanne*

derstanding (for institutional partners) to outline the terms of long term collaborative projects with partners institutions (in 2015 there are over 70 active agreements). In addition Kew has developed a standard set of Material Supply Agreements for different types of material, and a donation letter to ensure that material donated to Kew has been legally collected and transferred, and that any additional terms of use are recorded.

- POLICIES FOR VISITING RESEARCHERS in all departments ensure that the hundreds of scientists, students consulting the collections each year are aware of terms under which this material can be used. Kew has also developed policies for DNA data, images and information harvesting (https://www.kew.org/science/data-and-resources/science-terms-and-conditions).
- STAFF TRAINING AND AWARENESS-RAISING SESSIONS. The CBD Unit offers a daylong session to all Kew staff to outline Kew's policies and best practice guidance. The course runs at least once per year and is attended by over 30 staff per session.

Kew's existing records management systems have been adapted and amended to ensure that they keep track of key ABS information:

- PIC/MAT documents (agreements, permits, certificates of compliance)
- the date of legal extraction of the material from the country of origin
- the country of origin and the provider of the material
- terms of use, including any restrictions and benefit-sharing
- any unique identifiers supplied with the material

Records management systems at Kew include databases, logbooks and both paper and digital systems. Staff training is essential to ensure that key information is held and passed between departments and, crucially, to any third party user.

Collaboration and information sharing with colleagues in the non-commercial research community to build a harmonised sectoral approach to ABS (for instance work with the international botanic gardens community through BGCI, with the UK plant community through PlantNetwork, the Common Policy Guidelines and Principles on ABS (www.bgci.org/resources/abs/) and the Consortium of European Taxonomic Facilities (CETAF) ongoing work (www.cetaf.org/).

Having an existing ABS toolkit has meant that Kew was in a strong position to respond to the new framework of the Nagoya Protocol and the reporting requirements of the EU Regulations on ABS. Following the coming into force of the Nagoya Protocol, Kew is reviewing the existing ABS Toolkit to ensure it is able to comply both with the due diligence and reporting requirements of the EU Regulation, and also any changes in the national ABS legislation in countries where they have partnerships and access genetic resources. Kew continues to work with others in the non-commercial research sector, at the UK, EU and International level to develop best practice implementation tools and resources for our sector.

Kew worked with partners and others in the botanic garden sector to come up with a sector approved approach and to review and upgrade procedures in all departments in the following areas:

- Ensure that all new accessions are collected or transferred to Kew legally, according to the national law of the provider country.
- Record the date of accession into Kew, and also, where possible, the date of legal extraction of the genetic resource from the country of origin.

> Keywords ACCESS AND BENEFIT SHARING NAGOYA PROTOCOL TOOLKIT BEST PRACTICE BOTANIC GARDEN MANAGEMENT

01. Case study: developing an ABS toolkit at the Royal Botanic Gardens, Kew

• *Williams China*
• *Sharrock Suzanne*

- Review databases in all departments to ensure that they have fields for this information and that they are secure from tampering and have a clear audit trail for any changes made.
- Review staff procedure in all departments to ensure that material is always used and supplied in line with terms and conditions under which it was acquired.
- Develop and review our ABS policy and specifically Model Supply Agreements. Ensure agreements with third parties clarify that material is being supplied on non- commercial terms only and that if a change of use is intended they need to inform us so that new PIC and MAT can be negotiated with the Provider.

Conclusion

Since the entry into force of the Nagoya Protocol and in particular the introduction of the EU Regulations, the level of awareness of ABS issues amongst botanic gardens, especially in the EU, has increased significantly. However, there is still a need for further capacity building and training in this area. The ABS learning modules discussed here are being seen as a useful tool to help guide the development of botanic garden policies on ABS. Botanic gardens are clearly keen to comply with the NP, but lack of capacity can be an issue especially for smaller gardens. Botanic gardens welcome simple step by step guidance that helps them navigate different policy areas, and for smaller more local gardens this guidance needs to be simple to follow and in a local language. BGCI is continually looking for opportunities to work with the botanic gardens community to build capacity in this area.

While the focus within Europe tends to be on access issues, there is a need to demonstrate and document best practice in benefit sharing as well. Further work is planned in this area and BGCI will be looking to develop practical case studies, models and examples to continue to support botanic garden implementation.

> Keywords ACCESS AND BENEFIT SHARING NAGOYA PROTOCOL TOOLKIT BEST PRACTICE BOTANIC GARDEN MANAGEMENT

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• *Williams China*
• *Sharrock Suzanne*

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WORLD FLORA ONLINE MID-TERM UPDATE : FLORE MONDIALE EN LIGNE POUR 2020

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> Mots-clefs BIODIVERSITÉ TAXONOMIE CONSERVATION FLORE DU MONDE

01. Résumé

• Loizeau Pierre-André
• Wyse Jackson Peter

ON ESTIME QU'IL EXISTE SUR TERRE 400'000 ESPÈCES DE PLANTES VASCULAIRES, DONT 10% RESTENT ENCORE À DÉCOUVRIR. CES PLANTES, TANT CONNUES QU'INCONNUES, PEUVENT DÉTENIR LES RÉPONSES À DE NOMBREUX PROBLÈMES DE SANTÉ, SOCIAUX, ENVIRONNEMENTAUX ET ÉCONOMIQUES DANS LE MONDE.

Un inventaire complet du monde végétal est vital pour que de nombreuses espèces menacées soient protégées et que leur potentiel soit réalisé avant que ces espèces, et les possibilités qu'elles offrent, ne disparaissent.

En 2010, la Stratégie Mondiale pour la Conservation des Plantes, SMCP (*Global Strategy for Plant Conservation*, GSPC) de la Convention sur la Diversité Biologique des Nations Unies désignait comme son premier objectif (Objectif 1) le besoin d'avoir « Une flore en ligne de toutes les plantes connues ». Avec cette idée derrière la tête, en janvier 2012 à St Louis, Missouri, USA, les représentants de quatre institutions : le *Missouri Botanical Garden, le New York Botanical Garden, le Royal Botanic Garden Edinburgh, et le Royal Botanic Gardens, Kew* – tous membres du *Global Partnership for Plant Conservation* (GPPC) – prirent l'initiative de se rencontrer et de discuter des moyens permettant d'atteindre cet objectif 1 de la SMCP à l'échéance de 2020. La réunion a abouti à la proposition d'une esquisse de l'étendue et du contenu d'une Flore du Monde en Ligne (World Flora Online, WFO), ainsi qu'à la décision de créer un consortium international d'institutions et d'organisations afin de collaborer à sa réalisation. Le projet de WFO a par la suite été lancé en Inde, à l'occasion d'un événement qui s'est tenu pendant la 11ème Conférence des Parties à la Convention (COP) sur la Diversité Biologique en octobre 2012, pendant laquelle la COP adopta par ailleurs cette initiative de la WFO. En janvier 2013, un Protocole d'Accord (*Memorandum of Understanding*) fut proposé à des signatures. A la fin juillet 2014, 34 institutions ont signé ce Protocole d'Accord. Une série d'autres institutions et organisations dans le monde entier est également invité à participer au Consortium de la WFO.

La WFO sera un compendium libre d'accès des espèces de plantes du monde entier, basé sur le Web. Elle sera un projet international, collaboratif, construit à partir des flores publiées et des connaissances existantes, des check-lists et des révisions, mais requerra aussi des collectes et l'acquisition de nouvelles informations sur des groupes de plantes peu connues et des plantes venant de régions inexplorées.

Le projet représente une étape décisive vers un service fournissant des informations globales consolidées sur la flore du monde.

> Keywords BIODIVERSITY TAXONOMY CONSERVATION WORLD FLORA

01. Abstract

• *Loizeau Pierre-André*
• *Wyse Jackson Peter*

THERE ARE AN ESTIMATED 400,000 SPECIES OF VASCULAR PLANTS ON EARTH, WITH SOME 10 PERCENT MORE YET 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 U.N. Convention on Biological Diversity included as its first target (Target 1) the need for "An online flora of all known plants." With this background 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* (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 a World Flora Online, as well as a decision to form an international consortium of institutions and organizations to collaborate on providing that content.

The World Flora Online project was subsequently launched in India, at an event held during the 11th Conference of the Parties to the Convention on Biological Diversity in October, 2012 where the COP also adopted a decision welcoming the World Flora Online initiative. In January, 2013 a Memorandum of Understanding on the World Flora Online, was opened for signature. Up to the end of July 2016, 34 institutions and organizations had signed the MOU. A range of other institutions and organizations worldwide is also being invited to participate in the WFO Consortium.

The World Flora Online 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 revisions but will also require the collection and generation of new information on poorly know 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.

> Mots-clefs BIODIVERSITÉ TAXONOMIE CONSERVATION FLORE DU MONDE

01. Introduction

• Loizeau Pierre-André
• Wyse Jackson Peter

LA STRATÉGIE MONDIALE POUR LA CONSERVATION DES PLANTES (SMCP, *GLOBAL STRATEGY FOR PLANT CONSERVATION*, GSPC, EN ANGLAIS) A ÉTÉ ADOPTÉE PAR 193 GOUVERNEMENTS LORS DE LA CONFÉRENCE DES PARTIES (COP) DE LA CONVENTION SUR LA DIVERSITÉ BIOLOGIQUE (CDB) EN AVRIL 2002 (SECRÉTARIAT DE LA CONVENTION SUR LA DIVERSITÉ BIOLOGIQUE 2002).

Elle constitue une importante avancée mettant en évidence la prise de conscience de la menace qui pèse sur les plantes dans le monde entier, tout en proposant, pour la première fois, un cadre cohérent pour une politique et des actions nécessaires à la diminution de l'appauvrissement continu de la diversité végétale. Elle a été réévaluée pour une seconde phase le 29 octobre 2010 par décision X/17 de la COP en proposant 16 objectifs (Convention sur la diversité biologique. Conférence des parties 2010). Ceux-ci visent l'objectif ultime de diminuer la perte de biodiversité des plantes en 2020. Ils contribuent par ailleurs au Plan Stratégique pour la Biodiversité 2011-2020 (Convention on Biological Diversity 2012).

Le 1er objectif de la Stratégie Mondiale pour la Conservation des Plantes définit que pour 2020, la diversité des plantes devrait être comprise, documentée et reconnue. Les objectifs de ce but (Convention sur la diversité biologique. Conférence des parties 2010) sont :

• l'établissement d'une flore en ligne de toutes les plantes connues
• l'évaluation de l'état de conservation de toutes les espèces végétales connues
• les informations, la recherche et les produits associés sont développés et partagés

En effet, il faut comprendre que d'une part la nature au sens large subit une pression anthropique insupportable et certainement non durable, et que d'autre part les informations permettant de la décrire et de la protéger sont éclatées dans toute la littérature scientifique. La SMCP dans son ensemble, et son premier objectif, la création d'une Flore du Monde en Ligne (World Flora Online, WFO, www.worldfloraonline.org), ont pour but de faire prendre conscience de la nécessité de conserver le monde végétal pour le bien de l'humanité et de réunir la documentation de référence afin d'en faciliter l'utilisation et d'améliorer le travail de conservation (Wyse Jackson & Miller 2015).

01. Un inventaire du monde végétal

• *Loizeau Pierre-André*
• *Wyse Jackson Peter*

On estime à 400'000 le nombre d'espèces de plantes vasculaires sur Terre, dont environ 10 à 20% de celles-ci sont encore à découvrir (Joppa *et al.* 2011). Ces plantes, connues ou inconnues, peuvent répondre à certaines questions posées par les problèmes de santé, sociaux et économiques du monde. Un inventaire complet du vivant est vital si l'on veut pouvoir bénéficier de leur potentiel complet avant que de nombreuses espèces, et les possibilités qu'elles offrent, ne disparaissent. C'est en effet en connaissant et en nommant les plantes que des programmes de conservation qui leur sont destinés peuvent être élaborés.

La Stratégie Mondiale pour la Conservation des Plantes (SMCP) de 2002 avait comme objectif premier l'établissement d'une liste de toutes les espèces connues. Grâce à une collaboration entre les institutions mondiales ayant constitué les plus importantes bases de données de noms de taxons, et notamment grâce au travail du Jardin botanique de Kew et du Jardin botanique du Missouri, cette liste a vu le jour en 2010 . Elle a été mise à jour en septembre 2013 dans une version 1.1.

The Plant List (www.theplantlist.org) est une liste de travail de toutes les espèces végétales connues . Elle vise à être globale pour les espèces de plantes vasculaires (plantes à fleurs, conifères, fougères et de leurs alliés) et des bryophytes (mousses et hépatiques). Pour chaque nom au niveau de l'espèce, les informations comprennent le ou les auteur(s) du nom, le lieu de publication de l'article, et un statut du nom en accepté, synonyme ou non-résolu dans son utilisation taxonomique actuelle. Pour chaque nom inclus, chaque fois que c'est possible, des liens sont également fournis sur l'enregistrement d'une base de données en ligne, sur l'entrée correspondante dans IPNI, et sur la source d'information sur ce taxon. Pour chaque enregistrement de nom, *The Plant List* indique le niveau de confiance relatif à l'exactitude du statut du nom ; les évaluations de confiance sont basées principalement sur la nature et l'intégrité taxonomique de la source de données (Paton 2013).

World Flora Online

Le projet World Flora Online (WFO) a été créé en réponse à l'objectif 1 de la Stratégie Mondiale pour la Conservation des Plantes (SMCP) dans sa version actualisée de 2010 (Convention sur la diversité biologique. Conférence des parties 2010; Convention on Biological Diversity 2012). En janvier 2012 à St Louis, Missouri, USA, les représentants de quatre institutions : le *Missouri Botanical Garden*, le *New York Botanical Garden*, le *Royal Botanic Garden* Edinburgh, et le *Royal Botanic Gardens, Kew* – tous membres du *Global Partnership for Plant Conservation* (GPPC) – prirent l'initiative de se rencontrer et de discuter des moyens permettant d'atteindre cet objectif 1 de la SMCP à l'échéance de 2020. La réunion a abouti à la proposition d'une esquisse de l'étendue et du contenu d'une Flore du Monde en Ligne (World Flora Online, WFO), ainsi qu'à la décision de créer un consortium international d'institutions et d'organisations afin de collaborer à sa réalisation.

Le projet de WFO a par la suite été lancé en Inde, à l'occasion d'un événement qui s'est tenu pendant la 11ème Conférence des Parties à la Convention (COP) sur la Diversité Biologique en octobre 2012, pendant laquelle la COP adopta par ailleurs cette initiative de la WFO.

Les termes et les justifications techniques pour le but 1 suggèrent que la flore devrait inclure les noms acceptés et une synonymie complète, en con-

01. World Flora Online

• *Loizeau Pierre-André*
• *Wyse Jackson Peter*

struisant cette taxonomie sur les résultats des objectifs précédents pour le but 1 (période allant de 2002 à 2010), visant à développer " une liste de travail, largement accessible des espèces végétales connues constituant un pas vers une flore mondiale complète " (Convention on Biological Diversity 2012). De nouvelles connaissances devraient également être incorporées dès qu'elles seront disponibles.

Le projet est basé sur l'observation que de nombreuses institutions mettent en œuvre des projets de flore numériques au niveau national, et qu'il serait intéressant de réunir ces informations en un seul point afin d'en faciliter la consultation et la synthèse. La WFO devrait devenir sur internet la ressource fondamentale et vérifiée, documentant toutes les plantes connues dans le monde. Elle offrira des capacités de recherche sur des informations vérifiées ainsi que de nouvelles données, et établira des liens avec les espèces d'autres bases de données et catalogues existants.

La WFO couvre l'ensemble du monde végétal en partant des bryophytes jusqu'au angiospermes. Elle sera libre d'accès sur internet.

En échange de l'attribution et de l'implication dans le projet, le Consortium de la WFO demande que les organisations contribuent en :

- déterminant les noms des espèces acceptées, et les synonymes de chaque nom accepté
- identifiant les sources et fournissant des traitements précis de chaque espèce provenant à la fois de flores et de monographies

Un référentiel taxonomique consensuel

Comme on l'a vu plus haut, le projet est basé sur une liste préliminaire de toutes les espèces végétales connues, qui est disponible sur le site internet *The Plant List* (www.theplantlist.org), constituant le référentiel taxonomique auquel les descriptions d'espèces et d'autres informations spécifiques doivent être rattachées. Cependant, *The Plant List* étant une liste statique, celle-ci ne suffit pas à représenter l'évolution des concepts taxonomiques au fur et à mesure que les groupes de recherche de par le monde les établissent. Aussi il est apparu assez rapidement que le référentiel taxonomique de la WFO devait devenir un outil dynamique de l'état de la connaissance de la systématique mondiale pour être utile. Ceci est rendu possible par la mise en base de données de ce référentiel et par le développement d'un outil de gestion collaboratif, ou d'ingestion de taxonomies partielles. Le Consortium de la WFO travaille actuellement à la mise en place d'un outil informatique performant de gestion de la taxonomie.

Sans rejeter la possibilité de taxonomies alternatives, la World Flora Online présentera un consensus au niveau de la classification, ce qui devrait faciliter la compréhension du monde végétal par des non-botanistes. Pour atteindre cet objectif, le projet a besoin de l'expertise de réseaux collaboratifs et de taxonomistes individuels afin de développer une classification consensuelle.

01. Un outil pour la conservation, mais pas que...

• *Loizeau Pierre-André*
• *Wyse Jackson Peter*

L'objectif est de fournir des informations qui contribuent à une bonne compréhension de la situation du monde végétal dans un environnement en évolution constante, soumis à la pression humaine.

En premier lieu, ce sont les personnes qui s'occupent de conservation qui devraient bénéficier des informations du site internet, mais aussi les taxonomistes et tous les scientifiques utilisant des informations venant du monde végétal (par exemple les écologistes, les anthropologues, les archéologues ou les pharmacologues).

Les personnes appelées à contribuer au projet sont les fournisseurs de données primaires, les conservateurs dans les herbiers, les systématiciens, les informaticiens ou autres gestionnaires de données.

Un important travail de réflexion a été mené par les participants au projet, afin de définir les informations qui doivent apparaître dans le site internet. Ainsi les bénéficiaires doivent avoir un accès libre aux données depuis de multiples plateformes internet, pouvoir imprimer ou télécharger des données, indépendamment de leur dimension, rechercher des taxons par nom scientifique et/ou par pays ou région, être informé du nom scientifique retenu pour chaque taxon, être informé de la synonymie relative, ainsi que de la classification adoptée tant par le fournisseur de données que par la classification consensuelle adoptée par WFO, et surtout voir affiché la description des taxons pour chacune des flores les ayant décrits.

Par ailleurs le site devrait pouvoir afficher des photos ou des dessins des taxons, ou au minimum des liens internet externes sur ces informations, proposer des outils d'identification (clés) des plantes d'un pays ou d'une région ou des liens internet sur de tels outils, informer sur la distribution des taxons enregistrés dans la WFO, informer de la source des données et de leur fiabilité, etc.

Un soutien très large de la communauté

Le projet de WFO est soutenu par le *Global Partnership for Plant Conservation* depuis 2011 dont l'objectif principal est de favoriser la mise en œuvre de la Stratégie Mondiale pour la Conservation des Plantes en facilitant la communication entre initiatives poursuivant le même but (Wyse Jackson 2013). Le projet a aussi été considéré comme prioritaire lors du Congrès International de Botanique à Melbourne en 2011.

A l'issue de la conférence internationale organisée conjointement par l'UNESCO et le Muséum National d'Histoires Naturelle de Paris en septembre 2014, avec pour thème « Quels botanistes pour le 21e siècle? Métiers, enjeux et opportunités » (Rakotoarisoa et al. 2016), la déclaration finale appelle toute la communauté des botanistes et des scientifiques travaillant avec le monde végétal, ainsi que leurs institutions, à augmenter leurs efforts afin d'atteindre les objectifs et les buts due la SMCP, notamment ceux dont la charge incombe aux botanistes, y compris l'achèvement de la WFO pour 2020 permettant de fournir un référentiel essentiel à la connaissance des plantes du monde entier.

> Mots-clefs BIODIVERSITÉ TAXONOMIE CONSERVATION FLORE DU MONDE

01. Un soutien très large de la communauté

• *Loizeau Pierre-André*
• *Wyse Jackson Peter*

La WFO est organisée dans le cadre d'un Consortium d'institutions, qui ont toutes signés un accord de partenariat (*Memorandum of Understanding*). Ouvert aux signatures en janvier 2013, le Consortium de la WFO comptait, en juillet 2015, 29 institutions partenaires. *Une année après, il compte 34 institutions* (**Tableau 1**).

Etabli principalement autour d'institutions européennes et nord-américaines, ce Consortium recherche toutefois des partenariats dans le monde entier.

Un consortium actif et dynamique

Après une réunion de lancement à St-Louis, USA, en janvier 2012, suivie d'une réunion d'organisation en juillet de la même année toujours à St-Louis, le Consortium de la WFO s'était réuni à trois reprises au moment de la tenue de la conférence Eurogard VII, en novembre 2013 à Edimbourg, en juin 2014 à St-Pétersbourg, et en janvier 2015 à Genève. *Deux réunions ont eu lieu ensuite, à Rio de Janeiro en octobre 2015 et à New York en avril 2016.*

Le Consortium est organisé en quatre entités : le Conseil réunit tous les membres du Consortium et décide des options stratégiques. Il est appuyé par un secrétariat. Deux sous-groupes travaillent pendant l'année au développement du projet : le «Groupe de travail Taxonomique» fait des propositions concernant la classification, la taxonomie et l'appel aux experts, et le «Groupe de travail Technique» travaille sur l'architecture de la base de données, sur le contenu du site internet, et sur les outils à développer.

> **TABLE 1**

Membres du Consortium de la WFO, état en juillet 2016

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, Netherlands**
Flora of North America Association	**US & 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, USA**
Muséum National d'Histoire Naturelle	**Paris, France**
National Biodiversity Institute (INBio) of Costa Rica	**Santo Domingo de Heredia, Costa Rica**
Natural History Museum	**London, UK**
Naturalis Biodiversity Center	**Leiden, Netherlands**
Royal Botanic Garden	**Edinburgh, Edinburgh, UK**
Royal Botanic Gardens	**Kew, London, UK**
Smithsonian National Museum of Natural History	**Washington, DC, USA**
South African National Biodiversity Institute	**Pretoria, South Africa**
The New York Botanical Garden	**New York, NY, USA**
Tsitsin Main Botanical Garden	**Moscow, Russia**
UNESCO Chair in Plant Conservation and Biodiversity in Macaronesia and in Western Africa	**Gran Canaria, Spain**

01. Un projet collaboratif

• *Loizeau Pierre-André*
• *Wyse Jackson Peter*

Deux prototypes de portail fonctionnels ont été développés au Missouri Botanical Garden et au Royal Botanic Gardens de Kew. Le premier développé par le Missouri Botanical Garden avait surtout travaillé le design, s'attachant à mettre en évidence les résultats utiles au public cible. Le second portail était basé sur le travail fait par Kew pour afficher les données du groupe *eMonocot* (www.emonocot.org).

Finalement le Consortium a décidé d'adapter le logiciel proposé par Kew, et a remercié le Missouri Botanical Garden pour sa proposition d'en assurer le développement. On retrouve dans ce portail des éléments tels que le nom scientifique, le protologue, quelques images, des descriptions provenant de plusieurs sources, le positionnement dans la classification adoptée, une phylogénie, un statut UICN. La description de l'habitat est aussi affichée en fonction des sources, comme la distribution, la conservation et les usages. Le matériel Type est aussi mentionné, ainsi qu'une carte de distribution. Enfin on pourra afficher la synonymie, la bibliographie et les copyrights en fonction des sources. A propos de la synonymie, la WFO devrait proposer des classifications alternatives en fonction de différents projets, l'une d'elles étant la classification consensuelle proposée par la communauté des taxonomistes participants au projet WFO.

La réunion de Genève au début 2015 a apporté par ailleurs de nouvelles réjouissantes. Ainsi par exemple le New York Botanical Garden a obtenu de Google un financement permettant de placer le projet dans le *cloud* sur des serveurs mis à disposition par cette entreprise. Le Jardin botanique de Rio a mis à disposition du temps d'informaticien permettant de travailler le design en général. Les Conservatoire et Jardin botaniques de la Ville de Genève ont proposé leur logiciel de gestion de la nomenclature comme un des outils pouvant gérer le référentiel taxonomique. On notera que ce logiciel permet une gestion « par projet », permettant ainsi de visualiser sur une base de noms valides plusieurs taxonomies en parallèle, l'une d'elle étant la taxonomie consensuelle proposée pour la WFO. Ce ne sont que quelques exemples de l'investissement consenti par les partenaires de ce projet, chaque membre du Consortium apportant son expertise et des moyens en fonction de ses possibilités, mais dans tous les cas avec un désir profond d'aboutir à un résultat utile et enthousiasmant.

L'éternel problème des moyens financiers

La WFO fonctionne sur les moyens mis à dispositions par les partenaires, ou les moyens financiers que ceux-ci ont pu trouver pour assurer leur participation. On aurait pu s'attendre à un soutien plus fort de la part des gouvernements, dans la mesure où la SMCP est soutenue par les signataires de la Convention sur la Diversité Biologique. Malgré cela, ce soutien est appréciable dans la mesure où il permet d'orienter et de justifier la participation des institutions partenaires actuelles et futures à cet important projet. Par ailleurs il permet de solliciter des sponsors.

01.

Conclusion

• *Loizeau Pierre-André*
• *Wyse Jackson Peter*

L'effort consenti de manière volontaire par les institutions est un point très encourageant, qui démontre l'importance de ce projet pour le développement futur non seulement de la conservation, mais aussi de la taxonomie et de la publication de flores. En effet, ce projet collaboratif met en commun les moyens des institutions partenaires afin de partager les données de référence utiles à tous. Ceci est rendu possible par l'évolution impressionnante de la communication à travers internet. Bien qu'il existe encore des points du globe qui restent peu ou difficilement accessibles à l'information électronique, la communication est intense dans la majorité des lieux actifs en botanique et en conservation. Les informations que la WFO mettra à disposition de tous vont certainement accélérer tous les processus liés à la nomenclature et à la taxonomie, et apporter des informations et des aides à la décision concernant les problèmes globaux de conservation. On notera par ailleurs que la plupart des objectifs de la Stratégie Mondiale pour la Conservation des Plantes ne pourront se réaliser que si ce premier objectif d'une Flore du Monde en Ligne est réalisé.

Contacts

Toutes les institutions intéressées sont cordialement invitées à participer à ce projet collaboratif. Les personnes de contact sont Peter Wyse Jackson (*peter.wysejackson@mobot.org*) et Pierre-André Loizeau (*pierre-andre.loizeau@ville-ge.ch.*), co-présidents de la WFO.

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THE INPN (NATIONAL INVENTORY OF NATURAL HERITAGE), A MANAGEMENT TOOL FOR FRENCH BIODIVERSITY KNOWLEDGE DISSEMINATION AND CONSERVATION: THE EXAMPLE OF FLORA AND HABITAT

Photo credit : Composition extraite de l'Inventaire National du Patrimoine Naturel, https://inpn.mnhn.fr. Muséum national d'Histoire naturelle [Ed].2003-2018., ***Solène Robert et Emeline Oulès, 2018***

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01. Abstract

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A ROBUST KNOWLEDGE BASE IS THE FIRST STEP IN SUCCESSFUL NATURE CONSERVATION.

The “Inventaire National du Patrimoine Naturel” (INPN), a National Inventory of Natural Heritage, was created in 2003 using data managed by the Natural Heritage Department (UMS 2006 Patrimoine Naturel) of the French Natural History Museum (MNHN). The development and management of the INPN by the Museum is enshrined in national legislation (the Environmental Code L411-5) and funded by the French Ministry of Environment. More than a simple inventory, the INPN is a national programme of management, consolidation and dissemination of biodiversity knowledge, underpinning the broader “Information System on Nature and Landscapes” (SINP) within France. As a national information platform, the INPN provides data about marine and continental fauna, flora and fungi across the mainland France, Corsica and its overseas territories, as well as information on protected areas (their features, boundaries and distribution). This remit has been recently extended to natural habitats and geological heritage (INPG). The INPN provides information on species distribution (national reference layers) and status (taxonomy, associated regulations, and IUCN Red List status) for more than 160,000 species, including 34,766 floristic species [1]. In Europe, Flora databases are very often managed by universities and enhanced thanks to expert botanists. With regard to data on flora, the main partners are: Federation of National Botanic Conservancies (FCBN), French Society of Orchidophily (SFO), French Forests Office (ONF), MNHN, National Geographical and Forest Information Institute (IGN), Botanical Society from Alsace (SBA), Institute of research for development, Global Biodiversity Information Facility (GBIF) and private organisations.

Collected data are often heterogeneous, and therefore pass through a formal process of standardisation, control and scientific validation. Common standards are key to the interoperability of information systems. The MNHN holds the scientific responsibility to implement the national taxonomic repository called TAXREF. This register is the backbone of the species information system which allows to manage and share data.

In 2015, the national “Flora” data in the INPN have nearly reached 30 million (species occurrence data), thanks to partnerships, and in particular with the FCBN and the Ministry of Environment. Data processing is currently underway, this is why this number might actually evolve. Over the next years, the completion of national survey data layers, will help define (and fill) knowledge gaps. In combination, these INPN programmes help to set public conservation policy for natural heritage, and reinforce the importance of consistency in knowledge acquisition for biodiversity management and conservation.

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01. Introduction

• *Oulès Emeline*
• *Robert Solène*
• *Poncet Laurenr*
• *Tercerie Sandrine*

Photo credit : Composition extraite de l'Inventaire National du Patrimoine Naturel, https://inpn.mnhn.fr. Muséum national d'Histoire naturelle [Ed].2003-2018. , *Solène Robert et Emeline Oulès, 2018*

BEING A BOTANIST IS A PASSION, WE COLLECT LIST OF PLANTS ON PAPER SHEETS OR COMPUTERS, WE PRESERVE PLANT SPECIMENS IN *HERBARIA*, AND TAKE NUMBERS OF PICTURES. WE EVEN MAKE MAPS TO LOCATE THEM, AND THEIR HABITATS.

This is a worldwide phenomenon and it has been so for centuries. So many data, but still, how do we use those precious information? How do we share this knowledge in order to improve nature conservation?

This is why, every data collector, professional or skilled observer, have been developing solutions to store all their information in one place. It all began in the 1980ies, together with computer development, and in the 1990ies with the World Wide Web. Since the beginning of the new century, public organisations and associations, created big databases, collecting all the information on biodiversity. In an attempt for all to speak the same language, and to use the same informatics codes, data are now more homogeneous and, as a consequence more useful. The Museum (MNHN), is one of those public organisations, which works on data compilation and dissemination at the national level. Thus, the MNHN was mandated by the French Ministry of Environment for this task.

Background

EUROPEAN LEGISLATION FOR A NATIONAL REFERENCE BANK OF FRENCH BIODIVERSITY

Officially launched in 2005, the INPN is a national information platform, which provides data about marine and terrestrial fauna, fungi, flora and habitat across metropolitan France and its overseas territories (species distribution and status), as well as information on protected areas. The platform is constantly evolving, and will soon include geological, mineralogical, and palaeontological resources. The INPN is kept up to data via naturalist networks, scientific expertise, collections, biodiversity conservation/research programmes, as well as conventions with the private sector.

The State ensures and organises data exchange between biodiversity actors thanks to the Information System on Nature and Landscape (SINP). As specified in the European INSPIRE Directive and in the Aarhus International

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01. Background

• *Oulès Emeline*
• *Robert Solène*
• *Poncet Laurenr*
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Convention, environmental knowledge must be made available to the greatest number of people.

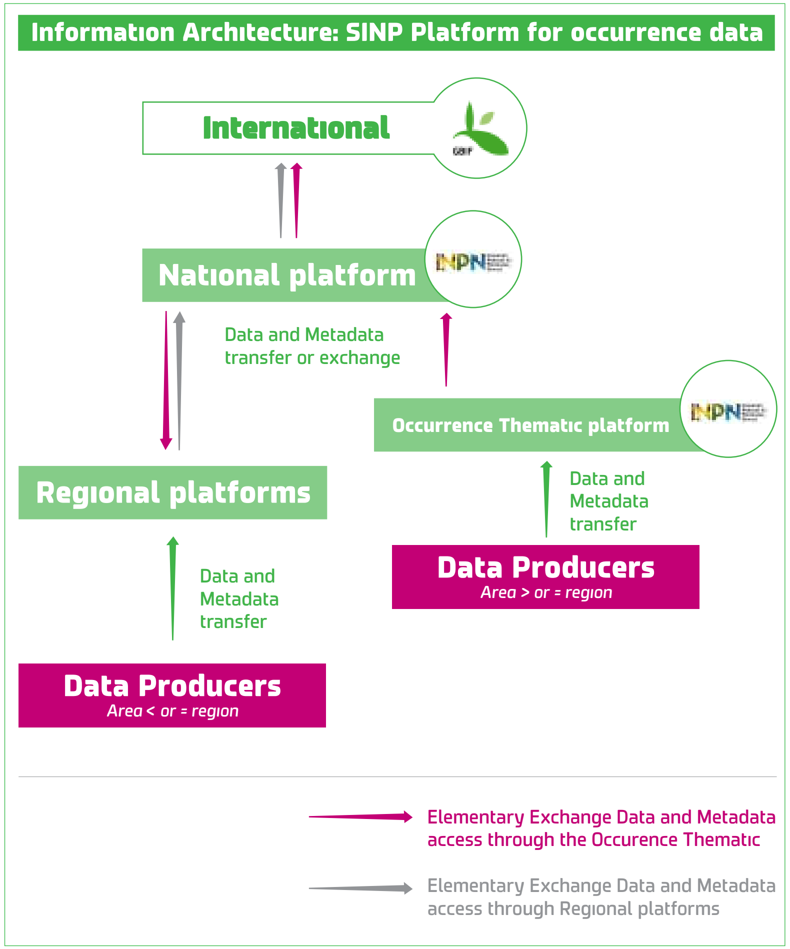
Indeed the State, through the SINP, ensures the design, animation and assessment, at the regional and national levels, while the Museum (UMS2006/MNHN) ensures the scientific responsibility of the inventories led within this framework.

NATIONAL REPOSITORIES (TAXREF, HABREF)

The prerequisite to manage and disseminate biodiversity knowledge is the use of standards to speak a common language. Those standards are then used to produce robust data through a formalised process.

Here is an overview of those national standards:
- taxonomic repository TAXREF,
- laws and regulation, in conjunction with TAXREF,
- Habitats repository HABREF.

TAXREF is the keystone of the species information system. It lists valid scientific names and their synonyms, reflecting the taxonomic knowledge at a given time to ensure the use of the same valid name for a species in all French territories. The current version was released in December 2015, it is already the 9th version.



> FIGURE 1

Information architecture, Information System on Nature and Landscape (SINP), platforms for occurrence data. Robert S., 2015

The number of floristic taxa in France (metropolitan and overseas territories) is 32,705 (Gargominy *et al.*, 2015), which includes 26,489 taxa only for the Tracheophyte branch (vascular plants). Regarding metropolitan France, the taxonomic register of vascular plants is implemented within the framework

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01. Background

• Oulès Emeline
• Robert Solène
• Poncet Laurenr
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of a four-party convention between the French Ministry of Environment, the FCBN, the Tela Botanica association and the MNHN.

HABREF is a national repository comprising the official reference versions of the typologies of habitats or vegetation covering marine and/or continental environments in France (metropolitan and overseas territories) (Clair *et al.*, 2015). It includes 19 typologies representing 18,600 units (habitat types) and comprised correspondences (~16,000) and connections between habitats and species (20,000).

The legal protection and the regulation of wildlife species and natural areas, is one of the cornerstones of the policy of biodiversity conservation.
'Laws and regulation', concerns both species (associated regulations) and natural or protected areas (National parks or reserves, Natura 2000 areas, Natural Areas of Ecological Fauna and Flora Interest…). Concerning natural or regulated areas, the platform provides mainly descriptive data such as site name, date of creation, renewal or modification, region(s), official text, fauna-flora-habitat data, and geographical information (GIS layers).
Concerning species status, for instance, the number of texts and the taxonomic shift between these texts and scientific expertise make them difficult to use. The Museum (UMS2006/MNHN) produced tables of species in conjunction with the national taxonomic repository TAXREF that can be used by policy makers.

DATA COLLECTION AND DISSEMINATION

In 2015, the national "Flora" data in the INPN have reached nearly 30 million (species occurrence data). Data processing is currently underway, this is why this number might actually evolve. Those occurrence data mainly concerns Vascular plants.

Distribution across the French mainland and Corsica, is available for more than 7,000 floristic species, and is updated as often as possible. This digital atlas of species per department is called the Atlas of the Departmental Biodiversity and Marine Sectors (ABDSM) (Haffner *et al.*, 2012). The department was chosen, as a relevant administrative entity which has the advantage of being a rather thin inventory unit to provide an acceptable level of biogeographical information on species distribution but requires an effort on data acquisition sufficiently reduced to consider frequent updates.
The summary information presented on these cards are based on expert opinion (likely presence or absence of the species), recent observations from botanists, and scientific papers. An innovative aspect lies in the estimation of absence of the species clearly differentiated from a simple lack of information. It is a starting point to initiate national inventories.

The French plant biodiversity is assessed throughout the country, thanks to the work of scientists, and skilled observers from public or private organisations and associations. Data are collected and monitored thanks to field work, scientific literature and collections. It is of a great interest to know precisely when and where the data was collected, this is why data sources appears on each species search (Metadata).

The main sources for plant occurrence data are: National Botanic Conservancies (CBN) and their Federation (FCBN), French Society of Orchidophily (SFO), French Forests Office (ONF), MNHN, associations, Natural Reserves (RNN), National and regional nature parks, natural areas conservancies, In-

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01. Background

• *Oulès Emeline*
• *Robert Solène*
• *Poncet Laurenr*
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stitute of research for development (IRD), Global Biodiversity Information Facility (GBIF) and private organisations.

Collections are a significant source of data, collected throughout centuries, they sometimes become a tool, which helps us to understand the evolution in plant distribution, or to establish links between human activities and species decline.
The Museum of Natural History preserves the national Herbarium, with around 8 million specimens from all over the world. Some of the specimens hosted in Paris are or will be part of the information available on the INPN.

Participatory sciences are now spreading and are of a great help to monitor ordinary biodiversity, through national inventories. There are three ongoing projects at the Museum, concerning this subject, which will soon be part of the INPN:

- "Vigie Flore" and "Sauvages de ma rue", held together with the French association Tela Botanica. Citizens can be involved in those projects, and increase information on common and urban vascular plants.
- "Les Herbonautes", which is a digital herbarium. Skilled observers can fill the gaps from the Paris herbarium missing information.

> FIGURE 2

Wild plants of high natural heritage value, found inside the Botanical Garden in Paris (O. Delzons, 2014)

Focus on monitoring programmes from the UMS2006/MNHN & Botanical Garden

Biodiversity is also assessed at the Botanical Garden from Paris.
The Natural Heritage Department from the Museum (UMS2006/MNHN) defined an Ecological Quality Index (IQE, Indicateur de Qualité Ecologique) for site management (Delzons *et al.*, 2013). This Environmental Quality Index is a standardised assessment tool based on a six day inventory of biodiversity. It aims to provide information on three key aspects of biodiversity, i) diversity, ii) wildlife and natural heritage value and iii) ecological functionality, and to propose management measures to preserve biodiversity. In order to create this indicator, inventories were conducted on 29 sites over a four-year period, and compared with published literature and expert knowledge. This approach uses composite indicators and is continually evolving thanks to experience feedbacks and a community of practice created for the purpose.

The IQE was similarly conducted inside the Botanical Garden in 2014. We are currently working together with the managers of the garden in order to help this nature to grow, and to inform our visitors, without disturbing their habits or this historic place.

Outcomes and perspectives

Besides clustering data in one place, the INPN, is a tool for biodiversity actors. In order to illustrate this fact, here are some important outcomes and partnerships connected with the INPN and flora/habitat conservation.

ATLASES

The production of atlases, is one of the first outcomes. Digital atlases, such as the Atlas of the Departmental Biodiversity and Marine Sectors, are now spreading. However available and exhaustive paper plant atlases covering

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01. Outcomes and perspectives

• *Oulès Emeline*
• *Robert Solène*
• *Poncet Laurenr*
• *Tercerie Sandrine*

French mainland and Corsica have not been updated for all plants. In 2008 the French Society of Orchidophily (SFO) transferred more than 420,000 data on orchid's observations to the INPN. As a consequence, in 2010, the Atlas for wild orchids, from mainland France and Corsica, which was coordinated by the SFO, was released as a scientific publication from the Museum. This work is also related to the assessment of the French orchid Red List from mainland France and Corsica, in partnership with the federation of botanic conservancies (FCBN), the International Union for Conservation of Nature (IUCN) and the SFO. The next step would be a national vascular plant Atlas for mainland France and Corsica.

WORK ON RED LISTS AND NATURA 2000

IUCN's Red Lists of threatened species is a global assessment of the risk of extinction of species or subspecies of plants and animals. The list of floristic species to be assessed is established consistently with the national taxonomic repository. Once confirmed, the results are published and disseminated on the sites of IUCN France and the INPN.

Reporting on Natura 2000, concerns all countries of the European Union, as enshrined in the Fauna, Flora, and Habitats European Directive (1992). France led a systematic assessment for the European Commission on the conservation status of wild fauna, flora and habitats of community interests on its territory. The last report, from the Natural Heritage Department (UMS2006/MNHN), covers the years 2007-2012 and concerns 100 plant, 7 lichen and 205 animal species in France, as well as 132 types of habitats in both terrestrial and maritime ecosystems (Bensettiti & Puissauve, 2015).

DEFINE INVENTORY NEEDS AND HELP ENVIRONMENTAL POLICY DECISION MAKING PROCESS

Finally, with 30 Million occurrence data on flora, the completion of national survey data layers will help define inventory needs and fill knowledge gaps.

Moreover, numbers of analyses can be done thanks to those available information, and can improve or guide environmental policy:

- studies on the evolution in plant diversity or distribution. This evolution can be compared to data on climate change, land use evolution, anthropic pressures…,
- studies on the evolution of flora hotspots,
- improvement of conservation planning, using flora atlases,
- update knowledge gaps on natural areas, related to the national Strategy of Creation of Protected Areas (SCAP).

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01. References

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https://inpn.mnhn.fr/espece/cd_nom/87933?lg=en https://inpn.mnhn.fr/programme/referentiel-habitats

EUROGARD VII
PARIS

THEME B:

SCIENCE

02.


THEME B
SCIENCE

SOME TRADITIONAL PLANT USES IN SLOVENIA

Photo credit : *Lycopodium clavatum L.* using with the equipmet for cleaning the oven before puting bread inside , ***Jože Bavcon***

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> Keywords ETHNOBOTANY BOTANIC GARDENS SLOVENIA

02. Abstract

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IN THE PAST SLOVENIA WAS A RATHER RURAL COUNTRY. PEOPLE WERE LIVING CONNECTED WITH NATURE AND MANY PLANTS WERE USED FOR VARIOUS PURPOSES. HOWEVER A LOT OF KNOWLEDGE ABOUT PLANTS WENT FORGOTTEN DUE TO CHANGES IN THE LIFE-STYLE.

In the University Botanic Gardens Ljubljana besides our field work in various parts of Slovenia we also collect the oral history of our plants. Once the use of wild plants was namely very diverse and due to their massive collection and harvesting, many of them had to be protected. With the changes in life-style also the need for their protection has changed. Today some among them actually do not need a protection anymore while others, mostly medicinal plants, are more and more endangered, especially due to returning back to natural way of living. To the visitors of our botanic garden we like to point out their often forgotten role in order to broaden the awareness about the importance of ethnobotany also in our home area. Among the plants used for various purposes in the past definitely *Ruscus aculeatus* L. is worth mentioning. It was used for funerary wreaths, brooms, in Istria it was put onto the barrels filled with water, as the plant layer prevented water from splashing over the barrel edge. Common ivy was used for making Easter bundles, and for making decorative wreaths in churches. It was also used for ceremonial purposes, which today still can be seen during the ceremony of warding off the winter by "laufarji" in Cerklje, where one among them is wearing clothes made of ivy. *Lycopodium clavatum* L. was once used as a broom for cleaning the ovens before bread baking or for filtering the milk in the mountains. Tufts of different ferns were hanged in the stables to catch flies. Dogwood (*Cornus mas* L.) has a very hard wood and for this reason it was used as teeth for hay-rakes. Also the hop-hornbeam (*Ostrya carpinifolia* Scop.) has a very hard wood and was used for making wooden hammers for wood-chopping or for central parts of the wooden wheels. The bushes of *Euonymus europaeus* L. were often present between the fields and in times of hand-seeding for convenience their shoots were used for marking the already seeded areas. However the most commonly used plant was the common hazel (*Corylus avellana* L.). Its fruits represented food, sticks from its shrubs were used as basket harnesses. Kids were using hazel for making bows and dogwood for making arrows. Among medicinal plants nowadays already almost forgotten species *Inula hirta* L. should be mentioned. Once it was so important in popular medicine that it was given even a popular scientific name *Astra montana*. According to tradition it was able to heal everything even snake bites. Today only seldom it is being collected. The knowledge about past uses of the plants is getting forgotten and for this reason in the Botanic garden of University of Ljubljana we try to preserve it by recording this oral history.

> Keywords ETHNOBOTANY BOTANIC GARDENS SLOVENIA

02. Introduction

• *Bavcon Jože*
• *Ravnjak Blanka*

Photo credit : *Lycopodium clavatum* L. using with the equipmet for cleaning the oven before puting bread inside, ***Jože Bavcon***

HISTORY OF PLANT USE IS AS OLD AS CIVILISATION ITSELF. USE OF PLANTS IN ANCIENT EGYPT IS ALREADY WELL-KNOWN (OGRIN, 1993). IT HAS BEEN ESTABLISHED THAT CONQUERORS OF NEW TERRITORIES ALWAYS BROUGHT ALONG PEOPLE THAT HAD KNOWLEDGE OF PLANTS.

Some even had renowned teachers that taught natural sciences. Aristotle (384–322 BC) taught Alexander the Great (356–323 BC), who introduced citruses to Europe from India (Curtius & Rufus, 1809, Martin & Blackwell, 2012). Theophrastus (371–287 BC) already described around 500 plant species and varieties, especially medicinal and useful plants. (https://www.tcd.ie/Botany/tercentenary/origins/theophrastus).

Dioscorides (40–90 AD), a Greek physician that treated Roman legionnaires, wrote a famous book on plants (http://www.greekmedicine). Pliny the Elder (23–79 AD) also wrote about plants (Jones, 1966). Later on, knowledge of plants was passed on through monasteries from antiquity into the Middle-Ages, and then into cities and newly formed universities. Mathioli (1570), Clusius (1583), brothers Bauhin (1596), and much later Linnaeus (1753), who is considered the founder of ethnobotany, thus wrote about plants. The latter's Expedition to Lapland is especially famous, as it is considered the pioneering work of ethnobotany (Cox, 1999). Botanic gardens also began paying attention to ethnobotany, thus bringing the world of plants even closer to the people (Balick & Cox, 1996a, b).

In the territory of present-day Slovenia, the first to start studying botany was a physician for the miners of Idrija – Scopoli. In 1760 and 1772, he published his works – Flora Carniolica (Petkovšek, 1977). Hacquet, who also studied alpine flora, came to Idrija because of Scopoli (Hacquet, 1782; Praprotnik, 2014, 2015). He was followed by other researchers, who, in addition to botany, also wrote about the use of plants for different purposes. Pharmacists gathered plants and made tinctures out of them. Among them was also Freyer, the first curator of the Provincial Museum (Predin, 2002). Hladnik, the founder of the Botanic Garden, also wrote about the use of plants (Voss, 1884, 1885; Praprotnik, 2012), whereas his student, Andrej Fleischmann, studied the use of plants extensively (Voss, 1884, 1885; Praprotnik 1993, 2015). The latter wrote about the healing power of downy elecampane (*Inula hirta*), locally known as *Astra montana*, which cures all diseases, even snake bites (Praprotnik, 1993).

As in days past, interest in use of plants is today quite high (Lewington, 1990; Schultes & Reis, 1995; Balick & Cox, 1996 a, b; Minter, 1999; Milliken &

> Keywords ETHNOBOTANY BOTANIC GARDENS SLOVENIA

02. Introduction

• Bavcon Jože
• Ravnjak Blanka

Bridgewater, 2013). However, this knowledge is disappearing rapidly (Wyse Jackson, 2014), as our research has also shown. In the past, knowledge of plants was necessary for survival. In the countryside of Slovenia, it was impossible to buy flowers for a bouquet. People therefore gathered plants in meadows, forest edges, and in forests, and used them to decorate houses, chapels, and churches. Various plants were thus always present in the vicinity of human dwellings, and lived inside farm houses or on windowsills throughout winters. Of course, only plants that weren't sensitive to lower temperatures, as houses were not heated properly. It was the change of heating methods – central heating, which had started becoming widespread in countryside houses during the 1970s – that represented the change for plants on windowsills. Many plants disappeared from badly heated rooms and remained only in the warmer region of Slovenia along the coast. In that region, there is no great need for heating, and many of these plants survive outside during normal winters.

Methods

We collected material on the use of plants for various purposes for many years. We used the interview method for data collection, interviewing older people during various traditional gatherings. In the past, in the 1970s and 1980s, many tasks were performed with traditional farming tools. In this way, some of us could see these tasks in real life. However, other customs were disappearing and were preserved only in stories of the elderly. Not so long ago, in 2011, tools for sweeping the furnace were still in use in one village. Even though we noticed this by coincidence, we oftentimes notice a truly traditional use of plants while conducting fieldwork for the research of plant biodiversity in Slovenia. Ethnobotanical traditions were also collected by attending traditional gatherings, were various tasks are carried out in traditional ways. This has become extremely popular in Slovenia during the last decade. Various local books, wherein older authors reminisce on certain tasks and customs, also include many notes on the use of plants. Even today, certain plants are still being used in traditional ways. In addition to the aforementioned methods of data collection, we also collected data with reviews of old literature in individual regions of Slovenia. We reviewed ethnological collections in individual museums and read literary works by certain authors that described plants. Lately, there have been numerous notes in local chronicles that present the history of individual towns. During the 1970s and 1980s, there were quite a lot of studies conducted with primary school pupils from various schools in Slovenia. These studies were later used for further detailed collection of data in the field.

Results

Below, we present a few plant species that were traditionally used in Slovenia in the past. Ground pine (*Lycopodium clavatum* L.) is classified in the family *Lycopodiaceae* and is, in the wider sense, a fern. The plant can be over one metre long. From a prostrate stem, branches grow upwards and, at the end of summer, may develop spore spikes, which grow on intermediate stems with less leaves than light green-yellow spikes. Leaves are narrow and gentle, spirally arranged, and tapered to a fine hair-like point. The plant grows in forests with abundant sunlight, but will start to disappear quickly if tree canopy

> Keywords ETHNOBOTANY BOTANIC GARDENS SLOVENIA

02. Results

• Bavcon Jože
• Ravnjak Blanka

becomes too dense. We therefore most often find it on forest edges, and even more frequently on meadows or on once-mowed grass meadows. The plant prefers acidic soil, and can often be found near common heather (*Calluna vulgaris* Salisb.). The plant is very flexible and can be simply pulled out of the ground with a single pull. It is sparsely rooted, as it most often covers weak grass turf or dead leaves. Because of these very characteristics and its evergreen nature, we can still find it during late autumn and winter, as long as there is no snow. This may have contributed to its use. In autumn, when people were raking leaves for bedding, the plant kept getting stuck on the rakes. The use of plants was just a step away. In the western part of Slovenia, primarily in hilly regions, houses were equipped with tiled farmhouse stoves that were used for baking bread, drying fruit, walnuts, and, of course, resting on top of them during winter evenings. To prepare the stoves for baking, they had to be heated first and then swept. This was done with a simple broom that was locally known as *uadla* or *pometovnca*. They fastened the ground pine into a wrought-iron hook attached to a wooden handle. Gathered in a bunch, it was a very good broom with no immediate fire risk.

If there was no ground pine, they used other plants (various species of fern, among them also eagle fern – *Pteridium aquilinum* (L.) Kuhn). Eagle fern was mowed during autumn on meadows or in forests, and used as protection against snow for hayracks for storing hay. During spring, it was then used for bedding. In one region of Slovenia (White Carniola), some forests were called *steljniki* (literally, bedding forest), as the ferns mowed each year in these forests were used for bedding.

Common hazel (*Corylus avellana* L.) grew everywhere as a bush where mowing was not done regularly. In Slovenia, the common hazel and the people were in constant contact. Every few years, the common hazel – which grew as a bush on forest margins – was cut down to make bundles of firewood. They were tied together with a branch from a common hazel or traveller's joy (*Clematis vitalba* L.), and used as firewood, for distilling brandy, cooking in livestock cauldrons, and for drying fruit in special drying rooms. Bushes of common hazel were occasionally left in meadows for shadow or for making a simple sled, which they loaded with hay and then pulled downhill to the hayracks. During autumn, the common hazel yielded hazelnuts, which were used for preparing potica, a special type of nut roll. As common hazel branches were oftentimes bent in an arch, they were used for many things, i.e. handles. Oftentimes, they bent the branches themselves, so they grew in the desired shape. The common hazel was thus oftentimes used for hooks on ropes with which they tied the hay. The common hazel might have been an apparent nuisance for a farmer, but was also extremely useful, and man and common hazel got along quite well with one another. During autumn, squirrels made a kind of "baskets" from hazelnuts, as they quite often gnawed on nuts only from one side. These baskets – sometimes they even had handles – were quite a fun toy for children. When a basket harness tore off, a straight two or three-year-old hazel branch was the perfect thing to make a new one. If it tore while walking, a replacement part could be found immediately in the nearby bush, and the walk home could continue. A hazel branch had to be suitably hydrated, so it could be nicely bent when you stepped on it with a shoe and started slowly winding it around its axis. It cracked a bit along the length, but only enough so it could be split apart somewhat to complete the weave of the thinner end. If there was enough time, people gathered straight two to four-your-old hazel branches with as little side branches as possible. These were placed in a warm spot in a barn, and after a few days, when the wood became hydrated, wrapped into new baskets. The common hazel

> Keywords ETHNOBOTANY BOTANIC GARDENS SLOVENIA

02. Results

• *Bavcon Jože*
• *Ravnjak Blanka*

didn't just serve as fuel for a fire, but was used for weaving as well. They cut straight and erect common hazel branches, splitting them by pulling them between two knives stuck in a hazel trestle. This way, they made four wide and equally thick strips. Young, straight, or even slightly arched shoots were peeled white, placed into the holes in the basket bottom, and weaving with *vitre* – as these strips were called in certain places – could begin. If the weaver was skilful, the basket was weaved so thick that not even one grain of wheat could fall out. In some places, these baskets were called *zahmašni koši* (literal translation: "baskets for the Mass"), as they were really only used when they want shopping in larger villages. Other baskets were for more everyday use, e.g. for hay and leaves. The latter were especially large and wide. They were also used for carrying manure. Farmers also used the common hazel to weave so-called *berače*, baskets with handles for picking up potatoes and other crops, for carrying lunch, etc. In some places, they used the common hazel to weave baskets for waggons and other uses. A late-winter bouquet on a farmhouse table always included hazel branches with male hazel catkins.

European cornel or dogwood (*Cornus mas* L.), as one of the harder woods in Slovenia, was always used for rake teeth. Forked boughs were used for rope hooks to tie hay stacks or loaded waggons. In Police, on the edge of Šentviška Gora Plateau, common dogwood (*C. sanguinea* L.) was used for *bergle*, which they filled with hay and then carried from higher or lower areas home to the plateau. .

In the past, traveller's joy (*Clematis vitalba* L.) was useful for tying things together. They made harnesses for baskets from branches of thumb thickness. In hilly regions in the spring, with this kind of baskets they carried the soil from the lower end of the field to the top end. Traveller's joy could handle all that with ease. It was also used to tie together a thatched roof. Like the roof itself, which could last over thirty years in sunny locations, traveller's joy held the planks that were holding the straw in place all this time. Many simple fences were also tied with it. Side planks were tied to handles on waggons with traveller's joy. As a weaving material, it was used for baskets and many other things. Much of this has been lost, as access to other tying materials has become easier and primarily cheaper. The value of traveller's joy, a nature-friendly material that could ultimately be used as an extremely flammable fuel, has been forgotten.

Common ivy (*Hedera helix* L.) is categorised in the ivy family (*Araliaceae*). It is a woody, clinging, climbing plant. It climbs on any surface – walls, trees – and can reach up to 30 metres in height and 20 centimetres and more in width by older plants. Or it can simply cling to and cover the ground. It grows slowly and has a very long life, so it can reach a few hundred years. The epidermis of the later woody stem is ashy grey. Because it was evergreen, ivy was one of the most traditionally used plants. It was used to make wreaths for church decorations. These wreaths were very diverse. The leaves could be rolled and attached to a string two or three at a time. Between such tufts, they attached parts of wheat straws. Another options was to attach one leaf at a time, thus making long wreaths that could be hung inside the church. On Palm Sunday, ivy branches with fruits were used in many parts of Slovenia to make bundles. These bundles were large and were used by boys to show off. Ivy was used for other ritual purposes. In some places, they used ivy branches or leaves for Shrovetide. The traditional *Cerkljanska laufarija* (literally, the running in Cerkno) includes, among the 25 costumes, an ivy costume as the character of spring. Its entire attire, including the hat, is covered with ivy leaves, which are arranged as fish scales, causing the water to flow over

> Keywords ETHNOBOTANY BOTANIC GARDENS SLOVENIA

02. Results

• Bavcon Jože
• Ravnjak Blanka

them. Each year, they used about 10.000 of the nicest and largest leaves for such a costume. Nice ivy offshoots must be collected each year anew. The leaves are then plucked off the offshoots and sown to the costume from the bottom up. Not a single patch of clothing can be visible under the ivy leaves. The leaves must also nicely fit on all folds and ends of the costume, so the whole costume looks perfect. This work is, of course, very precise, and the ivy costume was therefore always made by someone skilful, most of the time a woman. Each year, the ivy costume shows how much effort was invested by the festival organisers in the making of the costumes. The character holds in his hand an ivy branch with fruit. With a smiling mask from lime wood, green clothing, always friendly gestures, and a beautiful companion, the daisy, he invites spring back to the country. Including this costume, three characters are made from plants: the main character *Pust* (literally translation, Shrovetide) is made from moss and carries a spruce, and his brother is made entirely from spruce branches and bast made of corn. In Karst, a plucked ivy branch placed on a crossroad symbolised the number eight, eight days, when every winemaker could sell wine at home without paying taxes. The branch led you to the farmhouse where the wine and local delicacies were sold. During Saint George's Day (24 April), the retinue of the Green Saint George wears costumes of birch twigs or ivy leaves and walks from house to house. The Green Saint George represents the reawakened nature and new life.

In Karst, on the Sunday before the St John's Eve (24 June), they make wreaths from plants for ritual purposes. The tradition has been revived. Most often, these are small wreaths from goldmoss stonecrop (*Sedum acre*), which can remain fresh for very long in a wreath. The wreaths are then hung above house entrances, where they can protect the house throughout the year. Other Karst species are also used for weaving, e.g. smoke bush (*Cotinus coggygria*, Scop.), rock knapweed (*Centaurea rupestris* L.), St John's wort (*Hypericum perforatum* L.), feather grass (*Stipa pennata*), and others. A very versatile plant species growing on Karst and Slovenian Istria was the naturally occurring butcher's broom (*Ruscus aculeatus* L.) (Bavcon, 1992). During the 1970s, it was still used to make funeral wreaths. It has phylloclades, stems transformed into leaves, which, in addition to its woody characteristics, provide it with increased firmness. Wreaths on graves therefore lasted a very long time. It was also used for sweeping chimneys. They made a tuft of offshoots, which was then pulled through the chimney. Offshoots were used to make brooms, which were very good for sweeping courtyards in Karst. In this region, water was scarce, so it was often transported with donkeys in special, open bushels. They prevented spillage from these bushels by placing cut butcher's broom offshoots on the surface. They could thus transport as much water as possible. When moving, only small ripples formed, which did not cause enough splashing for water to spill out. Nowadays, butcher's broom is mostly used for bouquets during the winter, as female plants have very nice, shiny red berries, which remain on the plant for a very long time.

Of course, the most famous use of plants is for medicinal purposes. In Slovenia, one of such plants is the downy elecampane (*Inula hirta* L.). Primarily in the Dinarides, it was known over 150 years ago in the folk tradition as *Astra montana*, the plant that cures everything. People gathered inflorescences, soaked them in alcohol, and used them for tea (Fleischmann 1848). In addition to medicinal plants, farmhouse tables were always, and especially in spring, decorated by bouquets of natural species. The first were usually hellebores, which flowered during the winter. They were followed by common snowdrops (*Galanthus nivalis*) and spring snowflakes (*Leucojum vernum*), hazel branches, larch branches with female inflorescences, lungwort (*Pulmonarila*

> Keywords ETHNOBOTANY BOTANIC GARDENS SLOVENIA

02. Results

• Bavcon Jože
• Ravnjak Blanka

officinalis), forget-me-not (*Myosotis arvensis*), and lilies of the valley (*Convallaria majalis*). Lilies of the valley were an especially nice home decoration. Plucked lilies of the valley were arranged in a ray pattern on a deep plate, covered with a gravel-stone, and then watered. Through the night, the lilies of the valley rose up, and the bouquets looked like a tuft of lilies among the grasses. A farmhouse table was therefore never without a flower bouquet on Sundays until late spring. Bouquets were also used to decorate chapels, markers, and churches. Later one, these natural species were joined by those growing on the home garden.

Discussion

Even though knowledge of plants is disappearing rapidly, Slovenia, as a very traditional society, recently still held on to quite a bit. During the 1970s and 1980s, this knowledge was still abundant. At that time, interest in such knowledge was slightly renewed, and for this reason quite a lot of it has persevered. Some of it was passed on with oral tradition, and even more is written in local books, which were written relatively late (Prezelj, 1997; Komac, 2003; Čemažar, 2009; Rihter *et al.*, 2014). A lot of them were written predominantly in the last 15 years. Almost every somewhat larger town has its own local chronicle. These, of course, vary in quality, but quite often they hold some interesting facts on the use of plants, which represents an additional impetus for research in that area. A lot of this has re-emerged due to a renewed interest in preserving old traditions (Kuret, 1989), which are oftentimes related to plants and their use. In the past, many traditions have begun to disappear, while others persevered unchanged until today (Kuret, 1989, http://www.stanjel.eu/dogajanje/etnologija/; www.rutars.net/kazalo/index2.htm). Various museums and societies strive to reawaken in these towns some aspects of the past. Photographs depicting traditions have been preserved, a lot is written in old works, and even more in newer ones. But the newer the work, the higher the chance that it includes mistakes, as oral tradition was passed on indirectly. Even though much of the knowledge on use of plants in the past (Cilenšek, 1892) has been forgotten, as some authors conclude (Ramirez, 2007; Turner & Turner, 2008; Wyse Jackson, 2014), much of it has been preserved until today in Slovenia (Kuret, 1989). Reason for this lies in the fact that Slovenia was a very traditional and quite a rural society. Even though many of the old traditions were abandoned or were unwanted after the Second World War due to the social system changes (Kuret, 1989), a lot of such knowledge was preserved in the oral tradition or writing. With new trends and awareness of the cultural heritage, old traditional knowledge, and with it ethnobotany, is beginning to be revived. Old traditions have once again become modern, and various societies in different parts of Slovenia have started bringing back former traditions. These are mostly related to seasons, and almost all related to plants. Today, one of the main problems is a lack of knowledge of plants. Various authors came to this conclusion (Akeroyd, 1997; Balick, 2007; Vandebroek & Balick, 2012), and Slovenia is no exception. Even more so: sometimes, there is even less of this general knowledge. Nowadays, there is no more difference between the countryside and a city, since the traditional method of managing the land has more or less ended (Bavcon, 2013). Modern agriculture is conceptualised completely differently, causing the knowledge on primarily natural species to slowly disappear. The school system also doesn't offer such education; knowledge of plants is therefore vanishing. This is something we wish to rectify in the Botanic Garden with various activities (Bavcon, 2010; Bavcon *et al.*, 2015).

> Keywords ETHNOBOTANY BOTANIC GARDENS SLOVENIA

02. Conclusion

• *Bavcon Jože*
• *Ravnjak Blanka*

People in Slovenia used plants for various purposes. Use of some was widespread, whereas others were only used in a small area (Bavcon, 2004, 2013). Plants were used for consumption (Mlakar, 2006, 2007a), as medicine, as well as for making various tools and equipment (Komac, 2003; Dular, 2007; Mlakar, 2007b; Čemažar, 2009). Use of some plants is described only in oral tradition (Bavcon, 2004, 2013). Therefore, such use had to be tested with experiments. This helped us determine the actual use of specific plants. In the Botanic Garden, we're attempting to conduct tests of various uses of plants on the basis of collected materials, stories, and traditions, and on this basis determine if such use was possible in the described manner. The test with the butcher's broom, forget-me-nots, and the ground pine showed that the use of plants is even simpler than it seems. During various workshops that we organise in the Botanic Garden for the general public, we pass on this use of plants to younger generations. We have thus presented the tradition of weaving with plants, making whistles, small ships for the *Gregorjevo* (literal translation: George's day), dolls and slippers from bast, and much more (Bavcon *et al.*, 2015).

> Keywords ETHNOBOTANY BOTANIC GARDENS SLOVENIA

02. References

• Bavcon Jože
• Ravnjak Blanka

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SOLVING THE QUEST OF AN AMPHORA NEAR 2.000 YEARS OLD DEAD SEA SCROLLS, FOUND IN QUMRAN

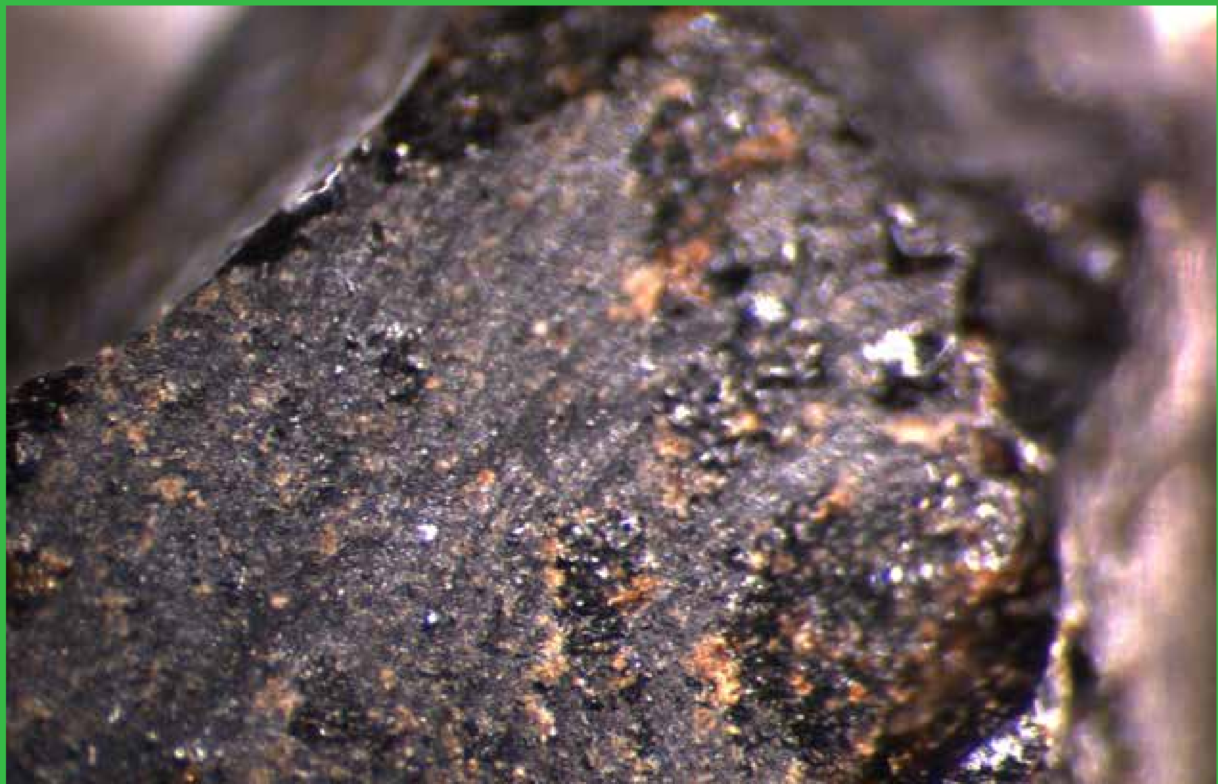

Photo credit : Remnant piece of the inner edge of the jar or amphora, *Bob Ursem & Wolfgang F. Gard*

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> Keywords AMPHORA DEAD SEA SCROLLS DATE PALM SEEDS SOFT SOAP

02. Introduction

• *Ursem Bob*
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Photo credit : Remnant piece of the inner edge of the jar or amphora, ***Bob Ursem & Wolfgang F. Gard***

THE ESSENES SETTLED CIRCA 150 YEARS BEFORE CHRIST AT QUMRAN AND REMAINED THERE UNTIL THE ROMANS DESTROYED THE CITY IN 68 AFTER CHRIST. THE PEOPLE WERE KNOWN FOR THEIR HIGH INTELLIGENCE AND SKILLS IN MANUFACTURING GOODS AND CLOTHING.

They wrote on papyrus paper and copper plates and possessed a huge scroll library. In addition they had the knowledge of farming, cattle breeding and keeping goats and sheep (Magnes, 2003). Inhabitants of Qumran cultivated several crops and date palms near the spring at Ein Fehkha at the southern edge of the settlement (Magnes, 2003).

Furthermore they are known to wear white clothes, which was quite exceptional in those days and the whole area. White clothing means a knowledge of fibre cleaning with a deep penetration with strong cleaning materials. Normal clothes are brown coloured, because only surface areas could be cleaned and thus the inner fibre textures remain untouched and appear as brown fabrics.

The current knowledge of the people of Qumran could only be traced now by scroll readings and excavation of artefacts. The Romans destroyed in 68 the whole khirbet or city and most of all the treasured library, except for a significant number of over 900 documents and a small amount of amphorae discovered in 11 caves (between 1947-1956: 5 by Beduin; 6 by archaeologists). Amphora number two at Qumran cave is a special one. This amphora has been made without a bottom part, and it contains a remnant piece at its inner edge of 4 X 5 millimetre. This remnant piece was studied without destruction at the Hebrew University, University of Jordan and many others. Dr. Jan Gunneweg, nuclear chemist and material scientist of the Archaeometry Task-Force Unit of the Hebrew University, send it on instigation to Delft University for further investigation. So far nobody has a clue what it was and why the amphora had been made on purpose without a bottom part. The quest remain unsolved for nearly 2000 years.

Methods

Old 2000 year old material of the inner edge of an amphora or jar number two was first analysed by hand lens, then in a sequence of non-destructive methods, ESEM analysis, chemical component optical analysis, Infra-Red mi-

> Keywords AMPHORA DEAD SEA SCROLLS DATE PALM SEEDS SOFT SOAP

02. Methods

• Ursem Bob
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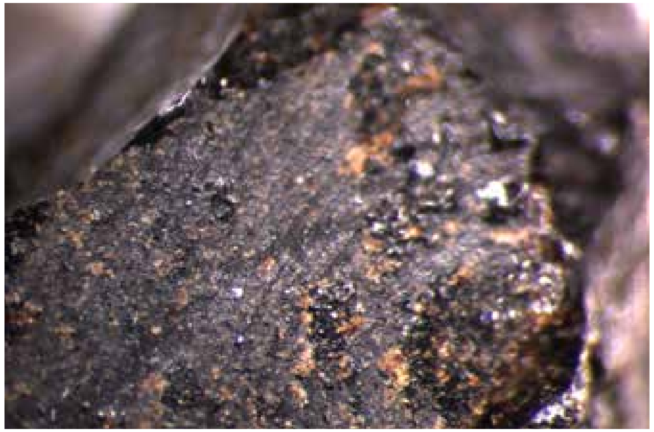
croscopy analysis. After literature studies fresh date palm seeds were burned in an enclosed heating process till potash. The potash remain material was analysed by ESEM, chemical component optical analysis and Infra-Red microscopy analysis and matched with data gathered from the 2000 year old material.

The content of the remnant piece in amphora number two

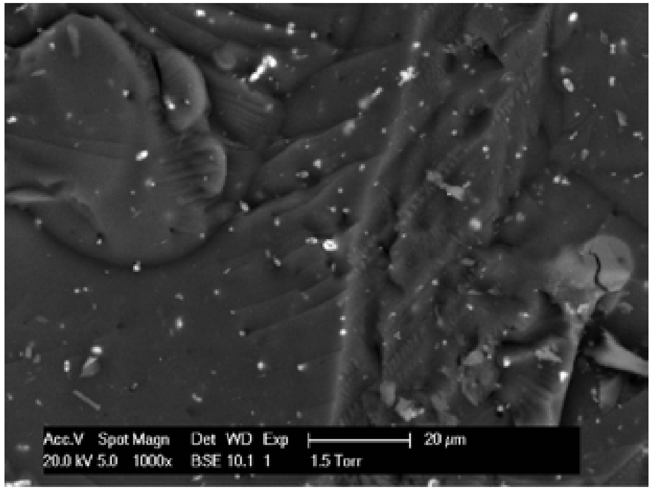
The primary question was: What is the content of amphora or jar number two? First, an hand lens analysis proof a structural pattern of diverse materials. An uniform core area and a partly rough outer area with a linear fine surface pattern as depicted in **Figure 1**. The overall colour dark grey up to almost black with small remnants of brown oxygenated iron.



> FIGURE 1.

Photo of remnant piece of the inner edge of the jar or amphora (photo by authors)

A deeper and non-destructive analysis with an ESEM to get a structural insight as given in Figure 2. The remnant material showed clearly collapse plant cell wall fragments as can be observed at the green indicated arrow points in this figure. Collapsed plant cell structures show a distinct thick cell wall and that differs very much from animal cell membrane structures, and when collapsed a double cell wall could be seen as a distinct white line of two cell walls. Next to Collapsing cell structures, also cell wall fragments can be seen in **Figure 2**. It is obvious that this material has been heated while processing.



> FIGURE 2.

ESEM photo showing collapsed cell structures in a sample of the remnant piece of the inner edge of the jar or amphora (photo by authors)

The quest continued with a possible list of plant species from the area that could resist high temperatures and still show such a distinct collapsed structure, like woody shrubs, trees, seeds or carpels. The Essenes were known for

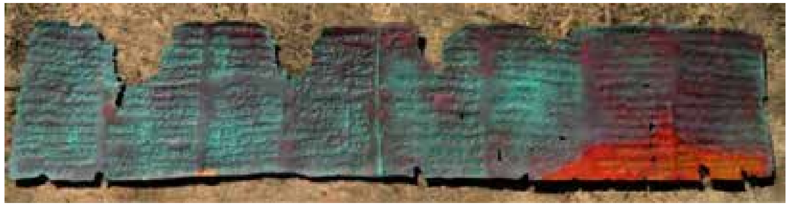
> Keywords AMPHORA DEAD SEA SCROLLS DATE PALM SEEDS SOFT SOAP

02. The content of the remnant piece in amphora number two

• Ursem Bob
• Gard WolfgangF.

their agriculture of crops, like barley, date palm wood or fruit, olive wood or seed, wild peach seed, and also for their gathering of native plant species like Sodom apple seed, acacia wood, common caper bush, tamarisk wood, rose of Jericho and many others. A needle in a hay stack puzzle at a first glance.

Back to literature of Dead Sea scroll translations and publications. The most important information was given in the translation of the Great Isaiah scroll, discovered at two kilometres distance of khirbet Qumran by Bedouins together with the French archaeologist Henri de Contenson in March 1952 (**Figure 3**). They found two lumps of what is now known as the famous Copper Scroll. This highly oxidized scroll was broken into two separate rolled up sections. In its original state it measured 0.3 m in width, 2.4 m in length, and was about 1 mm thick. No one knew quite how to open it up without damaging the text. One lunatic suggestion was to try to reduce the copper oxides with hydrogen, or even electrolysis, to recover the copper! After considerable preparatory research for three years by John Allegro of Oxford University, and in 1955 the first piece of scroll was finally 'opened' by Professor H. Wright Baker at *Manchester College of Science and Technology* (now UMIST), followed by the second piece in 1956. In 1991 the world was astonished to hear that one of the unpublished scrolls included incredible references to a "Messiah" who suffered crucifixion for the sins of men. The scroll was translated by Dr. Robert Eisenman, Professor of Middle East Religions of California State University. He declared, "The text is of the most far-reaching significance because it shows that whatever group was responsible for these writings was operating in the same general scriptural and Messianic framework of early Christianity." Because of this translation we also know something about the daily habits of the Essenes, like frequent bath taking, wearing white clothes, and evidence of a tannery or date press. In 1993 carbonized dates were found by the Israeli archaeologist Yitzak Magan that apparently could be associated with a date press at the southern edge of the settlement Qumran. This suggests that the inhabitants of Qumran cultivated date palms by the spring at Ein Fehkha. It is likely they cultivated other crops as well, and they undoubtedly raised herds of sheep, goats, and cattle, as could be traced by animal bone deposits in the same area. So this limits the quest to the focus on date palms.



> FIGURE 3.

The Great Isaiah scroll (photo Alexander Schick)

Date palm seeds and wood have been collected at the vicinity of the khirbet Qumran and also on other areas around the Dead Sea, Qumran, in the south near En Gedi, Massada and furthermore two locations in Jordan (**Figure 4**).

> FIGURE 4.

Dead Sea area depicting Qumran and with red star markings seed collection sites of date palm by Ursem

> Keywords AMPHORA DEAD SEA SCROLLS DATE PALM SEEDS SOFT SOAP

02. The content of the remnant piece in amphora number two

• *Ursem Bob*
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Fresh date palm seeds were burned in an enclosed manner in order to create potash. The potash material was sampled and analysed by gas chromatography and mass spectroscopy, with a focus on traces of potassium and sodium. With this focus on potassium and sodium, we could make the connection to soap manufacturing. Sodium with animal fat will form a solid block of soap, while potassium combined with animal fat will turn out in a liquid soap. Because of evidence in literature on the Dead Sea scroll 'Great Isaiah' describes the significance of Essenes wearing white clothes. Soap as a block could not deep penetrate the fibres as liquid soap and thus stay more brown or brown in colour. Liquid soap purifies the fibre structure as a whole and thus results in a white performance.

The Dead Sea has been used since ancient time for harvesting minerals. The first scientist to analyse the seawater content of the Dead Sea was the famous French chemist Antoine Laurent de Lavoisier in 1776. Lavoisier already noted a high content of magnesium-chloride, calcium-chloride, sodium-chloride and magnesium-bromide, but overlooked the presence of potassium. In 1817 the French famous chemist Joseph Louis Gay Lussac also analysed the seawater of the Dead Sea and tried to find the presence of small microorganisms, but no 'microscopic animals' were found. Arie Nissenbaum discussed the results of all published paper on the Dead Sea seawater so far known to the chemical analysis and clearly show how the industrial chemical potential could be used for industrial production of commodities and products like soap manufacturing (Nissenbaum, 1979). The unique seawater content makes the Dead Sea to the world's saltiest natural lake of the world. The average salinity is 280 grams per kilo water and compared to the average salinity in oceans is about 35 grams per kilo water. In addition, especially in the northern part of the lake, it has a high content of potassium and bromine, so nowadays known for potash making en bromine open air mining (Nissenbaum, 1993). The Dead Sea has no outlets to balance between precipitation, runoff, and evaporation, except in northern part where the Jordan River and the Arnon River supply large amounts of fresh water in conjunction with the presence of water springs in the vicinity of Qumran and due to the annual runoff and floods in the rainy winter season. In addition, the water intake various considerably, which result in the late 1950s in an annual discharge of 1.200 X 10^6 cubic metre and an intake of 1.600 X 10^6 cubic metre, and a decline of the water level and higher rate of salinity. The annual renewed water of the Dead Sea is a little more than one percent of its total, because of agricultural water use of the Jordan River in mainly Israel and Jordan. The water is rich in chloride and an unusually high content of magnesium and bromine, and an unusually low sulphate and carbonate content. The seawater of the Dead Sea has an extreme high content of calcium (15,75 %). Still no trace of potassium could be noted in literature and be explained. The German, Israeli scholar in Law, Linguistics, Physics and Geology Yaakov Bentor (1961), was the first scientist that unravel the geological history of the Dead Sea. At the end of the Mesozoic times tectonic disturbances frequently occured and fault formation resulted in the sinking part of the Jordan-Arava rift, followed by a lacustrine deposition, leaving deposited sediments behind as a result of natural drainage, evaporation or other geophysical processes. Although there is evidence found of an open sea connection in the Pliocene age based on traces of marine micro fauna in the upper tertiary Sodom formation of Mount Sodom. Later, the Jordan River filled the inland depression with fresh water that eventually turned salty and known as the Lisan Lake. After several hundred thousand years the Lisan Lake started to shrink til its present level as Dead Sea in the late Pleistocene. According to Bentor the Lisan Lake only contributed in a very small part to the total salts content in

> Keywords AMPHORA DEAD SEA SCROLLS DATE PALM SEEDS SOFT SOAP

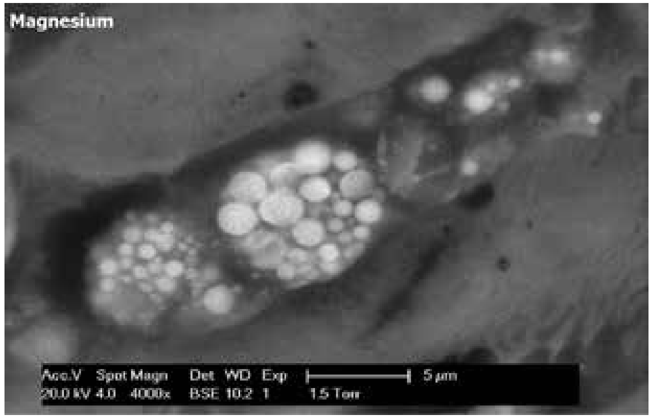
02. The content of the remnant piece in amphora number two

• Ursem Bob
• Gard WolfgangF.

present-day Dead Sea. The presence of the bromine enrichment may lead to the existence of organic life forms, similar to oil waters that carry considerable amounts of bromine and iodine elsewhere in the world. Life forms were never found until the Israeli microbiologist Benjamin Elazari Volcani or Benjamin Wilkansky showed that bacterial organisms could grow in water taken from the sea at depth up to seven metres as phytoflagellates. He also discovered the presence of halo-obligatory bacteria next to green algae *Dunaliella* species in the Dead Sea (Wilkansky, 1936). *Dunaliella* algae solved the problem of differences in osmotic pressure by developing a special metabolic pathway of producing large amounts of intracellular glycerol, that could feed the *Halobacterium*. The *Halobacterium* incorporates potassium up to a high intercellular concentration (up to 4.8 m) and extraordinary specificity for potassium ions (K^+) over sodium ions (Na^+). The biota microorganisms exert a critical influence on some biogeochemical processes that occur in the Dead Sea and as a result it explains the extreme high levels of potassium near Qumran. This has most likely never changed since the late Pleistocene and give evidence that date palm growth near the shore in Ein Fehkha were planted in potassium rich soil and water environment. Date palms, like many other plant species, do have a tendency to store secondary metabolites in their seeds. This explains also the high content of potassium in the fresh seeds. Conditions as we encounter today didn't differ very much in compare to the Essenes existence. Potash making, like today, was clearly a special skill of the Essenes and could only exist on potassium rich environment that happen to be optimal at Qumran and its vicinity.

It is remarkable that the area of Qumran has this high content, which differs very much from other location around the Dead Sea. It is known in Dead Sea scroll analysis that most people at that time weared brown clothes, except in khirbet Qumran and its vicinity.

In addition, analysis was made with ESEM on optical observation of chemicals. The 2000 year old material shows evident traces of magnesium, which gives substantive information that this material is definitely of plant origin. Magnesium is the metal component of chlorophyll (**Figure 5**).



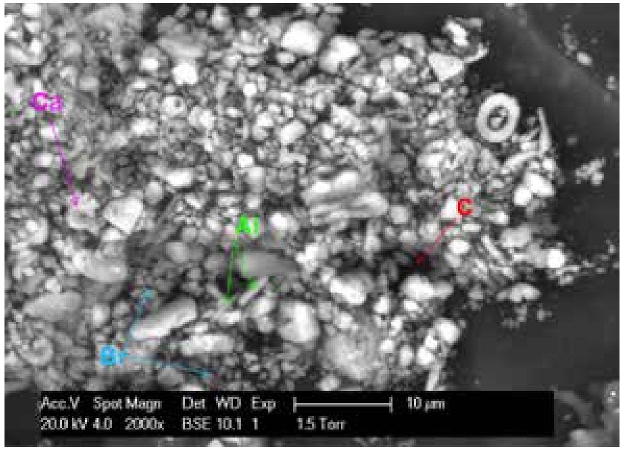
> **FIGURE 5.**
Magnesium in 2000 year old material of the inner edge of the jar (photo by authors)

Furthermore, the analysis of the 2000 year old material shows also other components that contribute to match chemically this material to the present produced potash of fresh date palm seeds, like carbon, calcium and trace elements such as aluminium and bromine. ESEM analysis in samples of the 2000 years old material and the sample material taken from fresh seed potash show a clear match of other aggregates like carbon, calcium and aluminium and bromine as can be seen in **Figures 6** and **7**.

> Keywords AMPHORA DEAD SEA SCROLLS DATE PALM SEEDS SOFT SOAP

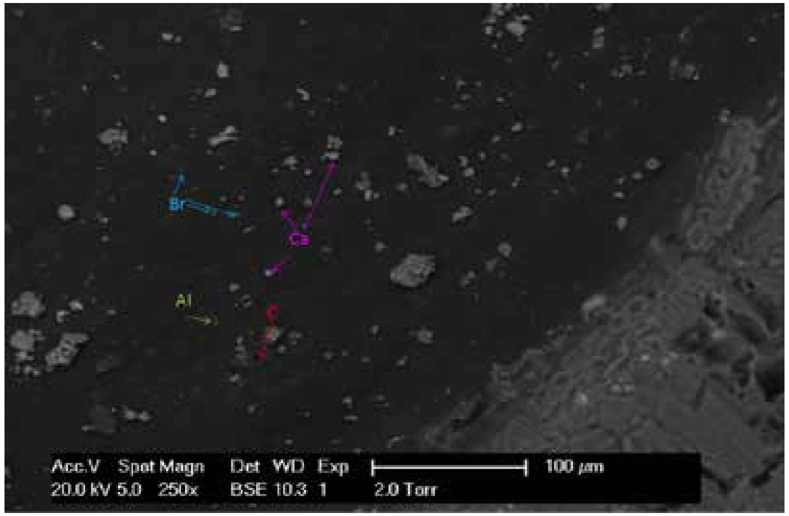
02. The content of the remnant piece in amphora number two

• *Ursem Bob*
• *Gard WolfgangF.*



> FIGURE 6.

Carbon, Calcium, Aluminium and bromine in 2000 year old material of the inner edge of the jar. Carbon is the black area indicated in red with C, Calcium given in pink as Ca, Aluminium given in green as Al and Bromine indicated in blue as Br. (photo by authors)

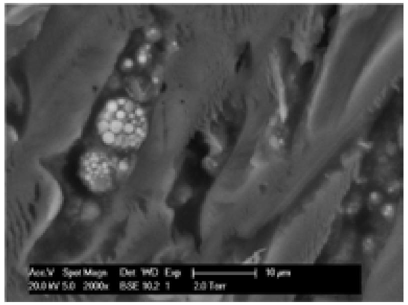


> FIGURE 7

Carbon, Calcium, Aluminium and bromine in potash material of fresh date palm seeds. Carbon is the black area indicated in red with C, Calcium given in pink as Ca, Aluminium given in green as Al and Bromine indicated in blue as Br. (photo by authors)

This evidence, especially the trace elements Aluminium and Bromine, indicates that the palm trees in the area of Qumran do still give the same chemical composition in present time as it could be traced in the period of the Essenes before the destruction in 68 after Christ. Conditions of date palm growth didn't change so much in almost 2000 years as a remarkable finding.

The investigation on traces of magnesium in the potash of fresh date palm seeds has been carried out and evidently shows a similar distribution as the old potash remnant of the inner edge of the jar. ESEM analysis show the same clustering and proof of magnesium traces in this new made potash as shown in **Figure 8**.



> FIGURE 8.

Magnesium traces as seen in typical clusters in potash made of fresh date palm seeds (photo by authors)

In addition, the potash material of fresh date palm seeds do shows collapsed cell structures and proofs that the potash making could have taken place in the same manner as we did and presumed (see **Figure 9**). It could be made, like in many other places in the world, in an enclosed burning stove, but that is of course still a speculation. The principle process of potash making could not be very different, according to the similarity of the chemical analysis so far.

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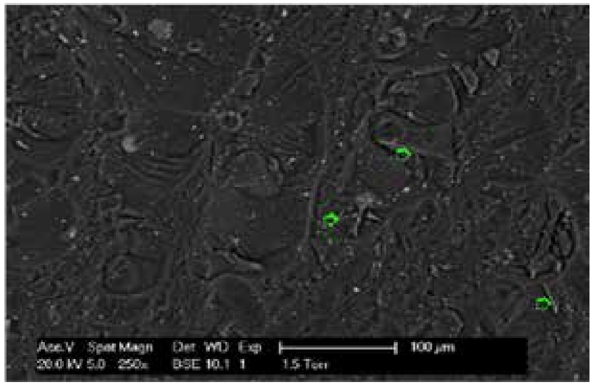
• Gard WolfgangF.

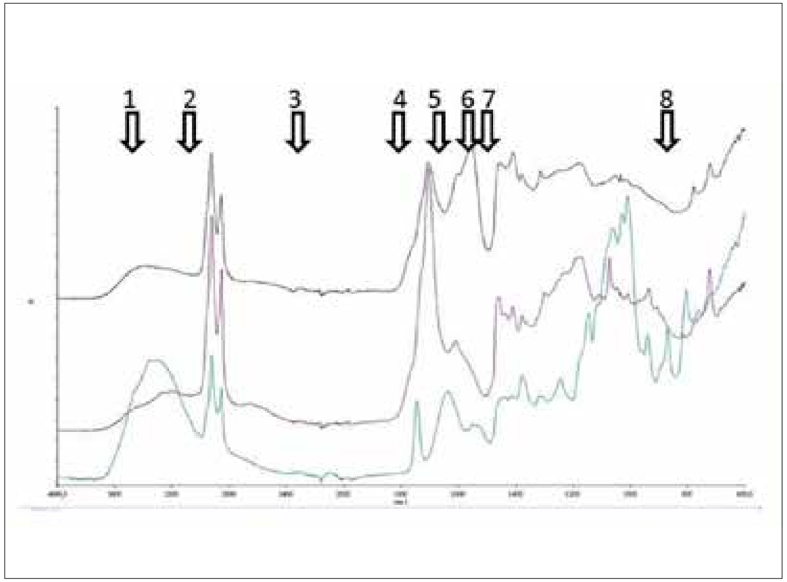


> FIGURE 9.

ESEM photo showing collapsed cell structures of a sample taken from potash of fresh date palm seeds. Green arrows indicate collapsed cell structures (photo by authors)

So far we know that the Essenes used date palm seeds for food production and, in addition, also known is the use potash in an unique Essenes method of leather production. Chemical analysis of the sediment in the tannery basin at Ain Feshka at Qumran area revealed no traces of tannin, which was usually indispensable for the production of leather, but instead, calcium carbonate was found as evidence of potash use for a better quality of leather and as a proof of a completely different kind of manufacturing from that was in use elsewhere (Stegeman, 1993). In our sample is also no sodium been traced. The connection of the use of date palm seeds and potash production is so far never been seen as a correlation.

An Infra-Red microscopy analysis followed on the 2000 year old material of the inner edge of the jar and the potash samples of fresh date palm seeds to possibly match it with the results of the chemical analysis. The potash of fresh seeds were taken from two different origins. The first sample was taken from potash of the outer seed skins only and the second samples were taken from exclusive inner core material of the fresh date palm seeds. The result shows a distinct match of peaks, to give equal evidence as the chemical ESEM analysis (see **Graph 1**). The blue curve is the old remnant material of the inner edge of the jar number two and the purple curve is of the exclusive inner core material, while the black curve represents the potash sample of the outer skin material of fresh date palm seeds. A little hump, distinct peaks of two thousand year old material and new materials show a very well distinct correlation given in Graph 1 at eight given arrows. However, the graph of potash taken from old and inner edge origin shows two extra distinct peaks that didn't correlate, but can be an influence of decay over time or external aging effects.



> GRAPH 1.

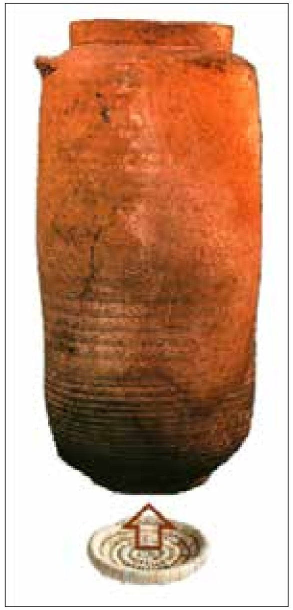
I-R analysis of 2000 year old potash taken from the inner edge of jar two (blue curve), and combined with potash taken from fresh date palm seed skins (black curve) and samples taken from potash made of the inner core material of fresh date palm seeds (purple curve). Every arrow above indicates similar peak locations in all given graphs (left to right: hump 1), peaks (2), turbulence (3), peak (4), area near peak (5), peak (6), peak (7) and inclination area (8)

> Keywords AMPHORA DEAD SEA SCROLLS DATE PALM SEEDS SOFT SOAP

02. The quest of amphora number two: what is it?

• *Ursem Bob*
• *Gard WolfgangF.*

The amphora number two was conscious made without a bottom part, and also without a lid. Reference was not given in the transcription of the Great Isaiah scroll. The Dead Sea Scrolls were buried in Qumran at 68 AD most possibly by the Essenes themselves. The Essenes are also known to take at least one or more daily baths before community dinners and of wearing white clothing. Soap making was essential at that time and it must be an important part or role of their social and spiritual culture. Other communities covered themselves in more brown coloured fibres. The expectation was that the Essenes were the very first in their world of soft soap making, instead of hard soap blocks based on sodium for only cleaning surface areas.



> FIGURE 10.

Amphora number two of Qumran with a present traditional flat basket weaving filter of date palm leaves as possible filter bedding. Photo amphora: The SchØyen Collection MS 1655/1; photo traditional basket weaving: B. Ursem

The amphora number two of Qumran must been enclosed underneath and filled with potash and operates as a filter system as shown in **Figure 10**. If water washes through, the effluent will be a potassium hydroxide solvent and the residue will be potassium poor, but could be in the top of the amphora, and especially hidden underneath the inner edge still enriched with potassium as remainder. Potassium hydroxide solvent can easily be condensed by sun radiation to a syrupy but still a viscose liquid pasta. This pasta product can be mixed with goat fat or sheep fat and through an esterification process into soft soap.

Soft soap making was very unusual in the early century and before the date counting according to the Christian calendar. The function of the jar had to be an early manufacturing filter for soft soap industries of the Essenes. The feature of soft soap is a deep penetration into the fibre structure and because of that a better cleaning effect on clothes. The result is the famous bright white clothes as can be seen in any image of the Essenes, even in all depicting of Jesus Christ. It is well accepted to believe that Jesus at his time must have been educated by the Essenes. The Essenes did have an exceptional practical and spiritual knowledge and wrote down over 900 scrolls, thus can be seen as one of or the largest library in the whole region. Archaeological evidence indicates the settlement of Essenes in the khirbet Qumran since about 150 B.C.E. At the late time period of the Essenes, it has been noted that the Essenes were inter related with a Jewish sect, an intensely messianic, apocalyptic, baptist, wilderness, new covenant group, led by a priest they called the "Teacher of Righteousness" who was opposed and possibly killed by the establishment priesthood in Jerusalem or most possible the people that could be associated to the followers in the circumference of the figure of Jesus. It is also noted that at time of the outbreak of the Jewish-Roman

> Keywords AMPHORA DEAD SEA SCROLLS DATE PALM SEEDS SOFT SOAP

02. The quest of amphora number two: what is it?

• *Ursem Bob*
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War (66 C.E.) the scrolls were already hidden in caves near the khirbet. The library represents over 900 documents in 350 separate works in multiple copies. Cave four alone contained the most, 520 texts in a total number of over 15.000 papyrus fragments. Copper scrolls, like the Isaiah scroll, was an non-canonical book, known as Enoch, and the holy writings, rules of faith, commentaries on scriptures and other fascinating writings were found in cave three. In addition, Cave 3 contains a list of 64 hiding places where gold, silver, sacred objects and other more valuable scrolls were hidden. The amphora was one of the item among these treasures. The bulk of the scrolls were in Jordanian control and were placed with a team of mostly Catholic and non-Jewish scholars who published till now eight volumes of material and still it needs decades to unravel all Essenes writings. Overall it contains many important parallels to the Jesus movement, or could collide with the life of Jesus at that time. Time will tell. Next to the Qumran discovered scrolls are also scrolls found at Masada in the south, the Herodian fortress taken over by Jewish Zealots after the fall of Jerusalem in 70 C.E. and finally taken by the Romans in 73 C.E. Remarkable to note is the discovery of an ostracon or inscribed pottery shred that contains only 16 line letters and obviously has been written before 68 C.E. that concerns a property transfer of an individual to the community of Qumran. So date palm and crop 'orchards' were present and lively transferred in ownership as well at the Essenes period. The knowledge of leather making via potash by Essenes and the clear match in several distinct similar results of old and new materials in the Infra-Red-analysis, and the fact that the old material was left over inside the amphora, indicates a high skilled and knowledgeable society. It also proofs that the Essenes used these special prepared amphora's for an unique manufacturing of potash for leather preparations and for cleaning their original brown tainted fabrics. Essenes are exclusively known for trading the best white fashion, as well as the best documented library at that time in the area.

So this indicates that the Essenes can be seen as the very first soft soap manufacturing industries in the world, a remarkable thought after answering the quest of amphora number two and its content.

> Keywords AMPHORA DEAD SEA SCROLLS DATE PALM SEEDS SOFT SOAP

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PLANTS AND ITS ELECTRICAL PHENOMENA AND RESPONSES

Photo credit : *Populus X canadensis* with electric transpiration damages due to high Voltage charges as seen below in the silvery discoloration of the leaf tip and above of the carbonized petioles, *Ursem Bob*

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> Keywords PLANT ELECTRICITY NATURAL PHENOMENON UTILIZATION

02. Abstract

• *Ursem Bob*

PLANTS DO REACT TO ELECTRICAL CHARGES AS A NATURAL PHENOMENON, LIKE AN EXTREME INCREASE OF TRANSPIRATION STARTING ALREADY AT FOUR HOUR BEFORE A THUNDERSTORM GENERALLY APPEARS.

As a possible result it shows a silvery discoloration of leaves, especially at the tip, or a physical-chemical reaction in the vascular phloem and converts the sugar content into caramel or a typical transformation of the wood into an orange colour. Furthermore i.e. in high altitude studies it shows readings of a potential field strength of $E = 5000\ Vm^{-1}$ measured at the top of Alpine plants and thus shaping it into a cushion growth pattern while the same species shows a more widespread carpeting genetic growth pattern at low altitudes in the Netherlands. Until recent research at the Botanic Garden of Delft University of Technology, growth responses to electrical field charges were so far hardly studied and understood in plants. Next to different observations in nature and measured experiments in the Botanic Garden in addition and due to this study also a total new insight on electrical plant responses and applications in studies of transpiration and contribution to humidity, cloud formation and precipitation patterns could be understood in another viewpoint and provide a novel insight on current available scientific knowledge. This possibly remarkable research leads to transpiration calculations of trees and shrubs and provides a contribution to a more complete insight of the hydrological cycle.

In addition, electrical responses of plants can be applied in technologies like data logged plant transpiration measurements and satellite programmes, ultrafine dust removal for indoor and outdoor air purification, electrical milking of secondary plant metabolites for food and pharmaceutical properties, new pesticide crop control systems and many more.

> Keywords PLANT ELECTRICITY NATURAL PHENOMENON UTILIZATION

02. Electricity seen as a natural phenomenon

• *Ursem Bob*

Photo credit : *Populus X canadensis* with electric transpiration damages due to high Voltage charges as seen below in the silvery discoloration of the leaf tip and above of the carbonized petioles, *Ursem Bob*

ELECTRICITY AND PLANTS IS A TOPIC THAT NEED TO BE FIRST EXPLAINED IN NATURE'S PHENOMENON AS A WHOLE. THE PRINCIPLE OF NATURAL ELECTRICAL CHARGING STARTS WITH SOLAR RADIATION ON EARTH AND EARTH'S ATMOSPHERE.

The sun radiates the earth, and in electrical terms bombards the globe with negatively charged electrons, positively charged protons and neutrally charged neutrons. The protons are relatively large and can be thus intercepted at the outer atmosphere layers of the electrosphere, charging positively at approximately at a height of 50 kilometres. In addition protons activate the effect of photoionization in the ionosphere belt and results in a splitting of several chemical air-borne components.

Photo-ionization, where photons act on atoms, ions and molecules became activated and results in the ejection of electrons which join other electrons travelling on the solar wind to earth. The electrons are extremely small and faster in speed than protons, impacting on earth, particularly on the poles due to the effect of the earth's magnetic field.

A sun-flame outburst during a sunspot causes an intensive corona discharge with currents that reach an amperage of 20 million coulomb per second at 50.000 volts and, in addition, in an enormous ionizing of oxygen and nitrogen by electrons above the electrophori altitude and in the upper stratosphere. This results in an aurora borealis in the Northern Hemisphere and an aurora australis in the Southern Hemisphere at an approximate height in the atmosphere of between 30 and 200 km.

This natural electrical phenomenon correlates with the sunspot activity in an 11 year cycle of the sun. At a sunspot, solar winds move at a speed of 1.5 million kilometres per hour and electrons reach the earth's atmosphere about 40 hours after the corona discharge at the sun, and follow the lines of magnetic force generated by the earth's core.

First the electrons ionize atoms of nitrogen, from an altitude of 200 kms downwards. This shows as green and blue colourations in the following image taken from personal observation in Kakslauttanen (Lapland, Finland) on March 1st, 2013. Secondly, the electrons ionize atoms of oxygen (at an approximate altitude of 30-100 kms) showing a yellow or a red colouration (above a height of about 60 kms and at lower altitudes) as a blue aurora moving con-

> Keywords PLANT ELECTRICITY NATURAL PHENOMENON UTILIZATION

02. Electricity seen as a natural phenomenon

• Ursem Bob

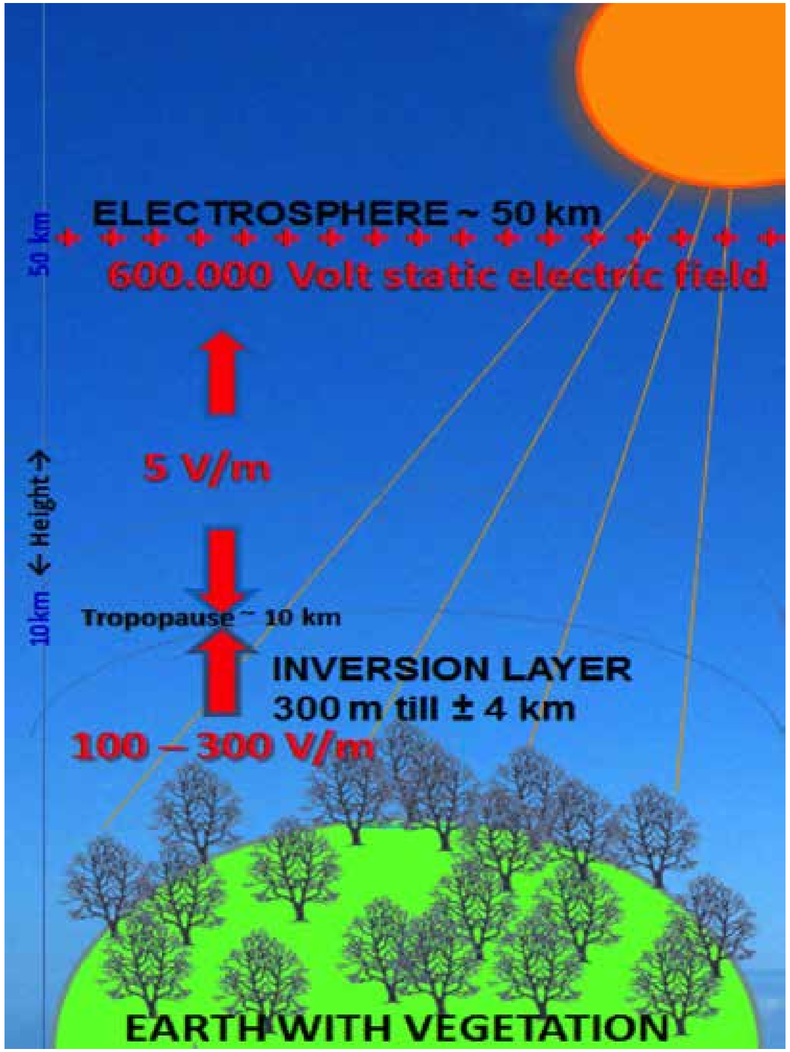
stantly, shifting combinations of clouds in a dance as captured in the frozen moment of **Image 1** (Brekke, 1994).

> IMAGE 1.

Aurora borealis at Kakslauttanen, Lapland (Finland) showing ionizing oxygen (Photo: author)

Normally electrons pass unhindered through the electrosphere and impact on the earth, charging the earth's surface negatively. All biological life, connected to the earth or plants rooted in the soil are therefore, in principle, negatively charged, while the atmosphere is, by definition, positively charged due to proton impaction at the electrosphere altitude. The result is an electric field between earth and all its connected biological life and the atmosphere.

Near the earth's surface the field strength is approximately E=100Vm-1 up to E=300Vm-1, depending on air humidity and temperature (Brillouin, 1897; Le Cadet, 1898).



> IMAGE 2

Electric field pattern in the atmosphere (Source: author)

> Keywords PLANT ELECTRICITY NATURAL PHENOMENON UTILIZATION

02. Electricity seen as a natural phenomenon

• Ursem Bob

It changes at the inversion or boundary layer, where thermals of warm and less dense air rise into cold air as a result of convection and condensation, thus producing a reversed temperature profile with a stable mass of dense cold air positioned below a lighter warm air.

At lower levels of the inversion layer, there remains the normal pattern of air warmed by solar radiation on the surface of the earth, below a steadier cold air caused by the adiabatic processes of increasing height. Above the boundary layer, however, temperature rises due to extremely low humidity and the insignificance of the impact of solar radiation.

This results in a weaker electric field strength of V=5Vm-1 with a static electric field charge of 600.000 volts at the 50 km electrosphere in the stratosphere as seen in **Image 2**. The increase of electric field charges is according to the measurements of Burke field data, measured with a balloon (Burke, 1975).

At troposphere level, between the tropopause and the earth's surface, electric field strength can vary between approximately E=100Vm-1 to E=300Vm-1, but could increase significantly in thunderstorm conditions which in a flash, could exceed up to 660 million volts per second as also measured in data of Burke's field studies (Burke, 1975). In the vicinity of a thunderstorm, even 4 hours before lightning starts, the electric field strength can increase to a value of over 1.000 volts per metre. The impact on plant life is huge.

In nature the static electric field increases the electrical transpiration of plants. This is evident in strong local earth electric field areas during a thunderstorm discharge. A spectacular example of this can be seen in Broceliande Forest in the Brittany region, France where old, large beech trees grow downwards as depicted in **Image 3**. Plants are generally shaped according in reference to the existing natural electric field, despite their genetic growth pattern and the way of growing in tree stands of just a single species or as in a forest resource of several different species, they do grow all rooted in the ground and normally erect in upward directions, which is very much in contrast to the trees as observed in Broceliande Forest.

This phenomenon of extreme twisted bendy growth of trees can be also observed in high mountain altitudes where all herbal plants and also very small shrubs grow in a fully electrical spherical cushion shape, while the lowland equivalent species grow undisrupted by electrical field charges in a flowerbed arrangement.

> IMAGE 3

Broceliande Forest (Source: author)

Normally, plant transpiration depends on temperature and humidity, strongly influenced by solar radiation. If we consider the impact of electricity,

> Keywords PLANT ELECTRICITY NATURAL PHENOMENON UTILIZATION

02. Electricity seen as a natural phenomenon

• Ursem Bob

we may observe the increased responses of plants and the effects on growth patterns (**Image 3**) and heat or joule responses in the vascular system (**Image 4**).

Plant responses on electric field charges in nature

All plants, except epiphytes, grow normally, rooted in the soil and are thus negatively charged. They transpire water in balance with their root uptake. Transpiration will become unbalanced if the temperature or exposure to direct solar radiation induces a greater water loss due to transpiration, but also when nearby lightning causes an increase in the electric field, as can be observed from photographs (**Image 4**) of a silver or a warty birch tree (*Betula pendula*) in the Botanic Gardens of Delft University in the summer of 2005.

Here we can clearly see an orange discolouration as a result of caramelization of all sugars in the phloem underneath the bark. The recent scientific botanical discovery of conversion of sugar into caramel can only possibly be explained by friction in the vascular phloem system, causing extreme transpiration due to the proximity of a thunderstorm creating a massively strong electric field. Caramel can be easily detected by its characteristic smell and its chemical reaction in solution with hydrochloric acid as black flocculation (Schweizer, 1937).

Similar data in sapwood are obtained as a measuring tool for data-logging the transpiration of trees. This can be done with 2 steel pins that cover the whole sapwood in a radial direction at a pre-determined distance. Both steel pins are connected and charged with a high voltage. When both pins are equally charged, it results in a difference in temperature. These readings can be correlated with the ions and transportation of sugar inside the vascular phloem of a living tree.

Another method of measurement is that of stem compression, causing friction in the vascular phloem system, which provides an equally accurate transpiration reading. A whole tree trunk embracement would result in the total transpiration figure for the whole tree canopy. Thus we can measure tree transpiration in a 24 hour data log system, or even extrapolate these transpiration figures for individual tree stands and even whole forests.

Rainfall interception experiments using stem compression are novel approaches for understanding the contribution of transpiration to the hydrological cycle in tree stands and forests (Friesen, 2008; Friesen *et al.*, 2008).

> IMAGE 4

Betula pendula with caramel in phloem (Photos: author)

> Keywords PLANT ELECTRICITY NATURAL PHENOMENON UTILIZATION

02. Plant responses on electric field charges in nature

• Ursem Bob

Another natural electric response to a thunderstorm in close proximity is observed in leaves of the hybrid black poplar (*Populus* X *canadensis*) in the Botanic Garden of Delft University of Technology. It shows a very clear silvery discolouration of the leaf tip due to extreme transpiration. Carbonisation of the narrowed part of the petioles has also been observed as in **Image 5**.

> IMAGE 5.

Populus X canadensis with electric transpiration damages due to high Voltage charges as seen below in the silvery discoloration of the leaf tip and above of the carbonized petioles (Photo: author)

The electrical response as a natural phenomenon has also been tested in the yew tree (*Taxus baccata* CV *dovastoniana*) branches in laboratory conditions with a controlled mimicked set-up of a high voltage and micro amperage electric field charging environment as shown in **Image 6**.

The branch was exposed to alternating voltages of V1=8KVs and V2=11KVs with a correlated current of I1=0.002mA and I2=0.017mA. The result is a circular pattern of deposition of Baccatine III, 10-Deacyctylbaccatine III or Docetaxel, Cephalomannine and Paclitaxel as given in graph 1 of the yield in Autumn 2006, Spring 2007 and Summer 2007, taken from the branches of a specimen (Botanic Garden of Delft University of Technology). Paclitaxel, and other taxanes (baccatine III, 10-deacettylbaccatine III or docetaxel, cephalomannine) will be esterifiable converted into the anti-cancer treatment medicine.

> IMAGE 6

Taxus baccata CV *dovastoniana* in laboratory experiment exposed to a 10 kVolt and 40 micro-Ampere pulse charged aluminium sheet and deposition of secondary metabolites (taxanes, taxoteres, and paclitaxel) and brown discoloration of the needle tips (Photo: Caner Yurteri)

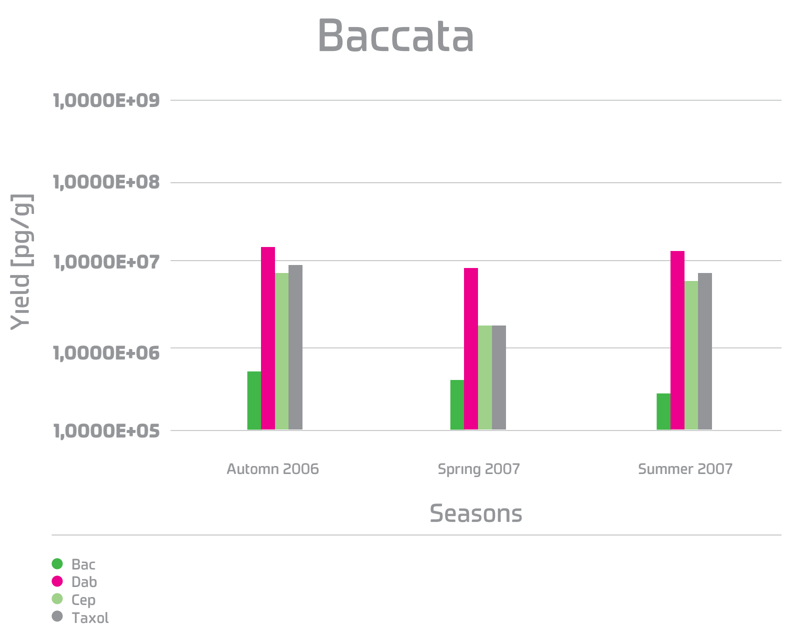
As well as these distinct extracted secondary metabolites as shown in **graph 1**, we also observed a brown discolouration of the needle tips. This brown colour is the result of a high flow extraction in a powerful field charge. This burning of the tips can also be seen in some needles in **Image 6** as a result of electro-spraying.

> Keywords PLANT ELECTRICITY NATURAL PHENOMENON UTILIZATION

02. Plant responses on electric field charges in nature

• *Ursem Bob*

Streamlining of field lines concentrates the most at needle tips as shown in Image 7 of the empiric field line results. Due to this field line density, the electro-transpiration is highest at the tip. Transpiration droplets at the needle tip are forced into a Taylor cone mode when electro-spraying is active. At higher voltage exposure total brown and even black discolouration due to burning of a needle has been recorded. If the needles are not damaged by burning, they can recuperate and be re-harvested after a few months. This applied technique doesn't harvest any sugar, only distinct secondary metabolites.



> GRAPH 1.

Yield of Baccatine III, 10-Deactylbaccatin III, Cephalomannine and Paclitaxel (=Taxol) as a result of electrospraying from branches of *Taxus baccata* CV *dovastoniana* in autumn 2006, spring 2007 and summer 2007 in picogram secondary metabolite to dry weight in gram (Source: Sylvia Widjaja, 2009)

In addition to experimental observation of needle burning, other electro-spraying extractions have been conducted showing tissue variation due to high voltage exposure (Vance *et al.*, 1994; Wheeler *et al.*, 1992). The secondary metabolite extraction of taxoteres via electrospraying was a discovery made at Delft, by Jan Marijnissen and Rein Roos, which focused only on the extraction or 'electric milking' itself and not on the associated natural phenomena as described in the article (Marijnissen *et al.*, 2001).

These phenomena in high voltage exposure, observed in the Botanic Garden in Delft, can be seen elsewhere in nature. An example of this, is a scent of terpenes from pine trees, as a transpiration reaction of high electric air charges which occurs, in the author's observation, about 4 hours before actual lightning occurs. Another personally observed phenomenon, is the inversion of lime tree leaves, in the same time period and conditions. The reversal of lime leaves is consistent with the closing of the stomata to reduce transpiration, and manifests itself in the silver lime (*Tilia tomentosa*) in particular, which has leaves with a whitish waxy layer, silvery pubescent leaves underneath and a green top surface. Turning over of leaves closes the stomata almost automatically, because there is more exposure to wind, radiation and immediate reduction of humidity in the leaf surface. Stomata are normally found under the leaf, and it is a fact that humidity happens at a slightly higher rate than in a more exposed leaf surface without stomata. These observations on the silver leaf lime tree phenomenon have not been published in any scientific papers to date other than by the author.

The strength of electric field also shapes plant growth, as clearly indicated in **Image 3**. In normal conditions, plant follow their genetic pattern. However, they can often be disturbed and shaped by a combination of predominant

> Keywords PLANT ELECTRICITY NATURAL PHENOMENON UTILIZATION

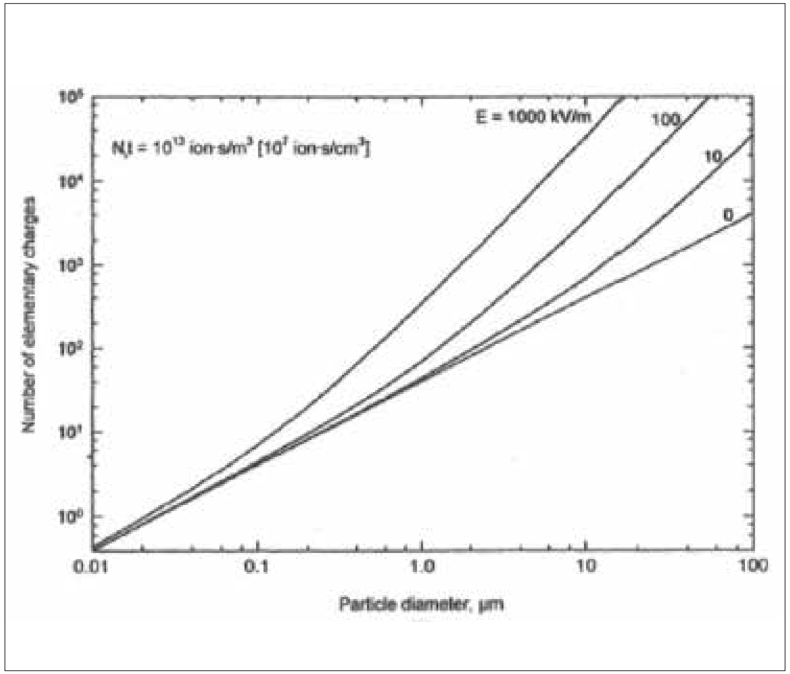
02. Plant responses on electric field charges in nature

• Ursem Bob

meteorological and electric winds and increased electrical field charge exposure due to high altitude or solitary growth e.g. trees in an open field. The combined effects of these winds in coastal areas can be seen in the bending of trees depending on the predominant wind direction or fixed in a bent position as a result of electric transpiration. If the sugar in the vascular phloem can convert into caramel, it can also fixate a tree into a fully bent position. Naval builders in particular have, historically, used this bent wood in ship manufacturing using steam to ensure that the wood holds its curved shape. It is interesting that in nature, the combined forces of meteorological and electric winds also cause extreme transpiration and bending.

Electric wind has its origins in earth or in biological matter which starts out as negatively charged airborne particles carried on meteorological wind or by convection becoming fully negatively charged due to friction in the air. Both effects result in a total negatively charged flow of particulate matter in the air which also drifts in full coherence on the meteorological wind. In this situation, the wind velocity accelerates to gale force and locally, extreme gusts of wind. This can be seen during forest fires, where inflammable particles, ejected by fire and heat are released. Polyphenols, in particular, found in eucalyptus trees increase wind speed, resulting in devastating conflagrations.

The same high altitude alpine plant species were studied in lowland areas at the Botanic Garden of Delft University. Plants in high altitudes are exposed to a huge increase in electrical field charge in comparison to those species growing in lowland areas. This results in a pincushion-shaped growth in high alpine areas, whereas in lowland areas, specimens of the same plant species grow in a multi directional scattering pattern. This phenomenon can be fully explained by an increase in field line density and electric charge thereafter.



> GRAPH 2

Field and diffusion charging with the number of charges acquired versus particle diameter for field strength of 0, 100, 100 and 10.000 V/cm at $N_i t$ = 10^{13} s/m³ [10^7 s/cm³] and $\varepsilon = 5.1\ C^2N^{-1}m^{-2}$ (Source: Hinds)

As can be seen in the Hinds' experiment graph, a discharge from a point results in a spherical pattern of field lines with a single fully charged 0.1 um particle diameter with 4 elementary charges or a charge (Q=6.4x10/19 Coulomb) in standard conditions, meaning field and diffusion charging according to **Graph 2**, and its stream line electric field of the empiric study in **image 7** (Hinds, 1999). The maximum charge on solid particles is reached when the self-generated field at the surface, due to the field strength in that given position, reaches the value requiring a spontaneous emission of electrons at the surface. When the number of electrons or elementary charges exceed

02. Plant responses on electric field charges in nature

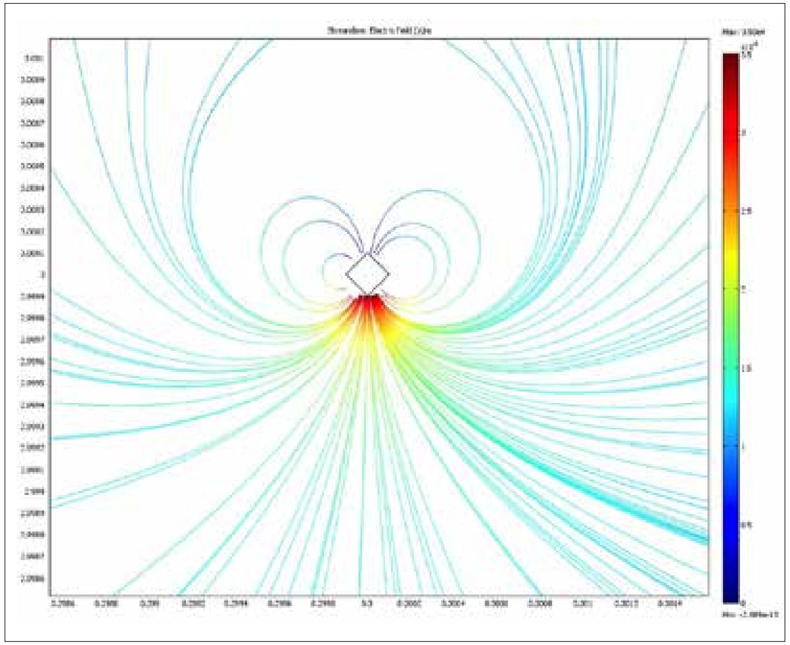
• *Ursem Bob*

this equilibrium, it results in ejection of the crowded electrons at the surface. If, on the other hand, it fails to reach this equilibrium, electrons can still be added to the charging of a particulate.

On study of **Image 7**, it is an empiric fact that the indicated pattern of field lines from a spatial sphere and a field line density near a particle or any pointed object will increase in such a spatial sphere. Therefore, a plant that grows with just a single branch outside a spatial sphere pattern will face another set of its own spatial sphere pattern on the tip of this branch, as opposed to the first spatial sphere of lower positioned round shaped branches which have a strong density and another set of their own field lines at the protruding exposed branch tips.

Every single point, in this case the sharp end of a leaf tip or thorn will act like a solitary electrical discharge point. This results in higher electric transpiration than with lower branches and provides an extra stress effect. It is preferable, therefore, that plants grow according to the natural electric field pattern, become a round-shaped growth and don't follow a genetic growth pattern at the outer canopy under relatively high charged electric field conditions.

In high altitudes, which generally have a higher electric field than lowland areas, the result is a dominant growth of herbal plants in pincushion patterns. However, in lowland areas it is only clearly visible in the spherical dome-like growth of a free-standing tree group. Measurements with a hand-held field strength meter at the top of a dwarf- growth pincushion plant (moss campion or cushion pink - *Silene acaulis*) show a reading of nearly E =5000V/n at an altitude of approximately 2200m in the Alps.



> IMAGE 7

A single fully charged 0.1 μm particle and its streamline electric field (Vm^{-1}) with a maximum value of $E = 3.50 \times 10^4$ V/m in red near the particle and decline in distance up to $E = 1.5 \times 10^4$ V/m in light blue (Source: author)

The natural electric field charge of a single fir tree has been measured in low mist conditions to ensure a natural isolation layer just above ground level. In these conditions measurements were taken with a hand- held field strength meter at the top of a Greek fir (*Abies cephalonica*) which has been growing since 1932. Measurements in the Botanic Garden showed a reading of nearly E=20.000V/m consisting of pure static electricity.

Mist is in fact only drifting micro-sized droplets in the atmosphere. In low or wind-free conditions, they can be charged in the same way as nearly all

> Keywords PLANT ELECTRICITY NATURAL PHENOMENON UTILIZATION

02. Plant responses on electric field charges in nature

• Ursem Bob

particulate matter and may have maximum negative charge. Because of this increase in negative charge, they may in time become larger droplets due to water adhesion and so easily convert to a dense fog. Fog and mist always take the form of low lying drifting droplets because both equal charges cancel each other out. Mist is lifted by its own electrical force and stabilizes at a few decimetres above water or earth, balanced by the downward force of gravity. This natural phenomenon is a very useful application because we can utilise fog lights positioned low on our vehicles to enhance vision in foggy or misty conditions.

The final example of plant response can be found in electric field charges in the wind dispersion of pollen and spores. Pollen is released at 17 degrees Celsius or higher as observed by the author in the Botanic Garden. Pollen releases as negative particulate in the air and drifts on the wind to the stamens of other flowers of the same species to pollinate them. Pollen drifts downwards during solar radiation but remains at the same level in al dry-weather conditions. Spores are released at the moment of maturity regardless of temperature.

That both natural dispersions show a negative charge due to friction in the air on particulates, is in fact a generic principle of nature. The uplifting electrical force on pollen or spores is in balance with the downward pull of gravity and so results in a very effective system to ensure optimal pollination or sporulation by the wind. The digressive effect on pollen and spores during drifts of solar radiation could be explained by photovoltaic effects. Solar radiation affects the pollen and spores with photons that diminish the negative charge. If the negative charge declines due to existing electrons absorbing the photon energy, gravity takes over and pollen are forced towards the ground.

When electrons absorb photon energy they become excited and jump to the conduction band or outer surface of the pollen or spore and become free (Becquerel, 1839). This results in a momentum in which pollen and spores are forced down by gravity. Near the stigma are the field lines closer together, similar to image 7, and thus become electrical attracted to stigma. Pulled on to the stigma, grounded added electrons discharge the pollen and convert it into a chemical bonding retained by the strongest physical Van Der Waals forces.

Applications of nature's plant electricity

Plant electricity can be directly utilized in the earlier mentioned secondary metabolite harvesting, and applied in space engineering programmes, crop protection methods, and in a peculiar plant correlated discovery and unique application of an air purification system as the ultra-fine dust removal system which will be discussed in a separate and more detailed part hereafter. Plant electricity applied in space engineering programmes has its origin in the electrical joule effect on the vascular system of trees and its plant transpiration by the author and the rainfall interception experiments of using stem compression as a novel approach in understanding the contribution of transpiration to the hydrological cycle in tree stands and forests by Jan Friesen (Friesen, 2008). Both combined approaches on plant electrical responses result in a novel programme of Mirjam Gerrits dissertation research (2010) at Mount Kilimanjaro and in addition the successor satellite readings on the older advanced high resolution raiometre satellite to measure tree

> Keywords PLANT ELECTRICITY NATURAL PHENOMENON UTILIZATION

02. Applications of nature's plant electricity

• Ursem Bob

transpiration on top of the earlier noted infrared global vegetation index. The PhD thesis research of Mirjam Gerrits shows a clear relation between the annual forest depletion at the foot of Mount Kilimanjaro and the retreat of the glacier on the summit. Her findings underlines the importance of a forest belt as also given by Fresen, that 50 percent of the precipitation recirculates in the hydrological cycle. Mount Kilimanjaro forests at its lowland belt captures circa 50 percent of its precipitation to recirculate into the hydrological cycle, while only 8 percent additional precipitation is contributed by atmospheric influx. The remaining precipitated water is circa 40 percent of the hydrological cycle, which has its origin in evaporation and adiabatic cooling during rising effects along the mountain slope. As side effect, these findings are very perpendicular to the general opinion that climate change could cause the glacier depletion of Mount Kilimanjaro.

Another and entirely different application of electricity and plants can be found in a similar technical way given in secondary metabolite harvesting of plants, but in a reversed setting. In the process of 'electric milking' droplets are charged and directed towards a high voltage charged plate, but in the process for crop protection the opposite can be utilized by charging micro-droplets with the use of a grounded connected plant as receptor. If pest control chemicals dissolve in water and get dispersed via a Taylor cone by a positive high voltage as air borne charged micro-droplets, these can only move to the grounded plants. First a charged micro-droplet will get fixed. The following charged droplet will settle next to the first fixed micro-droplet, because the area is more opposite (negative) charged than the covered adjacent droplet surface. As a result, a nanostructured film layer of solvent pesticides will cover and protect the whole plant. Traditional pest control is sprayed in clusters of insecticides and will cover never the entire plant. Furthermore this novel approach of nanostructured film pesticide technology only needs 200 times less pest control material in compare to the same plant coverage.

The discovery of the phenomenon of electric field charge that results in the ultra fine dust reduction principle

Knowledge and understanding of the phenomenon of field charges and the natural electric field, is the first step to the single observation of particulate matter, for example, salt and biological particles, solar radiation drifting from seashore to hinterland, tiny particles seen with the naked eye lifting above sea buckthorn (*Hippophae rhamnoides*) up to a higher level and continuing in the airflow. Relevant characteristics of seabuckthorn are its woody spines and narrow pointed leaf tips as pictured in **Image 8**.

> IMAGE 8

Hippophae rhamnoides with woody thorns and narrow pointed leaves (Photo: author)

> Keywords PLANT ELECTRICITY NATURAL PHENOMENON UTILIZATION

02. The discovery of the phenomenon of electric field charge that results in the ultra fine dust reduction principle

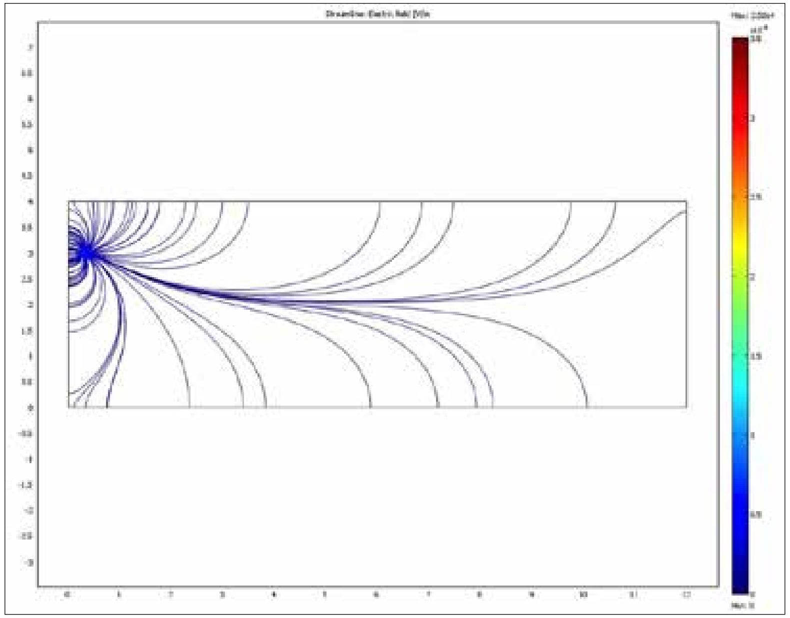
• *Ursem Bob*

The lifting of these large particles above the spiny, narrow, pointed leaves would be an unusual phenomenon in nature without electrical friction charging. Particles are normally only pulled downwards by gravity, unless due to friction, they are equally charged by pollen drift. The clear lift of particles which remain at the same height above seabuckthorn bushes whilst still drifting on the meteorological wind can only be explained by the fact that negative charging of particulates cannot suddenly become higher, but their response is due to the very pointed structure of the seabuckthorn leaves.

As shown in **Image 7**, a number of pointed ends contribute to a larger field effect on equally charged particles and thus facilitate a lift to a higher level until there is once again a balance with gravity. If various negative points are arranged in close proximity, the electric field will be directed upwards with an increase in the total electric field as seen in **Image 9**.

This image represents an empiric streamline electric effect of a fully charged 0.1µm particle with 4 elementary charges or a charge (Q = 6.4x10-19 Coulomb) in standard conditions (Hinds, 1999) in an enclosed setting with an equally negative field charge on both sides. Thus, it can be seen as an overall lower intensity of electric field strength, but a more enlarged field in one direction when compared with a fully charged particulate of 0.1 um in a free-ranging environment as shown in **image 7**.

If a number of these fields, as shown in **Image 8**, are formed by a cluster of thorns or distinctly pointed leaf tips in close proximity to each other, the result is a larger impact of the electrical force and this acts as an unidirectional uplifting vector. This summative effect of parallel unidirectional vectors of each spiny point or sharp leaf tip, results also in a total lift of equally



> IMAGE 9

A single fully charged 0.1 µm particle influenced at both sides with an equal charged field and its streamline electric field (Vm^{-1}) with a value of approximately E = 0.50 x 10^4 V/m in blue (Source: author)

charged airborne particulates just above these shrubs. Because of this larger electric repellent force and the fact that it opposes the downward pull if gravity, eventually an airborne particle gains further uplift. The field strength diminishes in distance until a new equilibrium between the electrical force and gravity has been attained.

As observation of nature explains, the concept of airborne particulate matter with positive high voltage charging and the capturing of particulates can only be optimally processed by the use of opposite electric poles. At the high voltage pole, a corona discharge ensures that charges of all airborne

> Keywords PLANT ELECTRICITY NATURAL PHENOMENON UTILIZATION

02. The discovery of the phenomenon of electric field charge that results in the ultra fine dust reduction principle

• Ursem Bob

particulates are captured and affixed to the conductive receptor. The reason for a positive high voltage charge is that it works together with gravity, and positive charging of particulates also creates a healthy human environment, for instance mountainous areas (Elster & Geitel, 1900), with an additional incidental of extremely low ozone production (King, 1963; Mittler *et al.*, 1957).

A corona discharge with a positive high voltage and a micro-amperage or higher strength of current, turns nearly all various sized particles uniformly positive, except for particles of less than 10 nms in diameter. A 10 nm particle is fully charged with one elementary charge, whereas a smaller sized particle cannot keep this elementary charge because of its own Brownian movement. All particles larger than 10 nms in diameter will become positively charged due to electron expulsion, or jump off to the conduction board or outside the surface area of the particulate. As a result positive particles drift off in ionic, molecular or particle wind from the corona discharge, following the electric field lines towards to a grounded conductive receptor. The lacking of electrons of each particulate will be added from the earth as soon as it connects the grounded conductive receptor, and thus fixate this discharging air borne particle with a chemical covalent bonding.

These particles will add electrons via the grounded or negative charged receptor and become affixed with a covalent bonding fastened by Van der Waals forces, or as electrostatic molecular interactions with a total effect by a super adhesive force. Because of conductivity, other particles can be added to earlier depositions and eventually grow into fluffy structures, remaining strongly bonded together and preventing fixed particles from rising into the air.

The principle of the Ultra Fine Dust Reduction System (UFDRS) relies very much on principles which can be observed in nature. The only difference can be found in the addition of a very small current, in the magnitude of micro-amperage. Current is lacking in static electric fields in nature. This low current can be viewed as the loss of electrons by discharge on ejecting other excited particle electrons or, as impelled by the electronic jump to the conduction board or the outset surface of particulate matter of 10 nms or more that become free.

> Keywords PLANT ELECTRICITY NATURAL PHENOMENON UTILIZATION

02. References

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CREATION OF A RAISED BOG IN THE BOTANICAL GARDEN OF NEUCHÂTEL: A TOOL FOR RESEARCH, COLLECTIONS AND PUBLIC INFORMATION

Photo credit : The raised bog of the Botanical Garden of Neuchâtel at the beginning of the growing season (march 2016), *Blaise Mulhauser*

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> Keywords
PEATLAND'S PLANT COLLECTION
EX SITU CONSERVATION
CLIMATIC EFFECTS ON VEGETATION

02. Abstract

• *Mulhauser Blaise*
• *Mulot Matthieu*
• *Tritz Jérémy*
• *Gueniat Sylvian*
• *Koenig Isabelle*
• *D'inverno Mirko*
• *Mitchell Edward A.D.*

IN SEPTEMBER 2014 WE CREATED A SMALL RAISED BOG OF CA. 100M² IN THE BOTANICAL GARDEN OF NEUCHÂTEL. THE MATERIAL (MARL AND PEAT) WAS COLLECTED FROM A DEGRADED PEATLAND IN AN INDUSTRIAL AREA OF THE REGION. THE BOG WAS PLANTED WITH OVER 30 SPECIES OF MOSSES AND VASCULAR PLANTS COLLECTED FROM BOGS IN THE JURA MOUNTAINS AND FROM EXISTING COLLECTIONS.

This object corresponds to the three missions of the garden : 1) to inform the public as well as students about these unusual, fragile and threatened ecosystems, 2) to present characteristic peatland plants from the Jura Mountains (*Sphagnum, Drosera, Eriophorum, Betula nana,* etc.), and 3) to conduct research projects.

During the winter 2014-15, the snow remained longer on the peatbog that on the adjacent path and meadow, thus providing evidence for a microclimatic effect of the bog. The excessively dry and hot summer 2015 allowed testing the resistance of the newly established bog vegetation. Most plants resisted well, including graminoids *Eriophorum vaginatum, Trichophorum cespitosum* or *Carex* sp., *ericaceous* (*Vaccinium oxycoccos, myrtillus* and *vitis-idea*) and mosses (especially *Sphagnum*). This living laboratory provides a unique opportunity to inform the public about the characteristics and functions of these ecosystems and the challenges of conserving and restoring them in a warmer world.

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Photo credit : The raised bog of the Botanical Garden of Neuchâtel at the beginning of the growing season (march 2016), *Blaise Mulhauser*

PEATLANDS PLAY A MAJOR ROLE IN THE GLOBAL CARBON CYCLE AS THEY STORE CA. 1/3 (CA. 600 GIGATONS) OF ALL SOIL CARBON DESPITE THE FACT THAT THEY ONLY COVER 3% OF THE TOTAL LAND AREA (YU *ET AL.* 2011, MOORE 2002, LIMPENS *ET AL.* 2008).

Regionally they also control hydrology and climate (Mitsch & Gosselink 2000). However in many developed regions peatland have been almost totally destroyed through conversion to agricultural land or peat harvesting. Switzerland is a typical example with a loss of ca. 90% of its initial raised bog surfaces, mostly between the 19th and 20th centuries (Grünig 1994, Joosten & Clarke 2002). For example the 400 km^2 of lowland peatlands (fens) located in the « three lakes » region (between the lakes of Neuchâtel, Biel and Morat) have been converted to agricultural land (Grünig 1994). In 1987 a popular initiative aiming to protect the remaining peatlands of Switzerland - including the largest ones in the Jura Mountains - was accepted by the people.

The challenge today is to preserve the remaining peatlands and to restore damaged ones. Indeed a monitoring program has shown that even the protected bogs are on average suffering from degradation such as reduced moisture, increased nutrient load, encroachment by bushes (Graf *et al.* 2010, Klaus 2007). The main challenges for successful peatland recovery include restoring an appropriate hydrology, hydrochemistry, and microclimate, introducing diaspores of target species and avoiding unwanted invading species (e.g. *Betula, Molinia*) (Gorham & Rochefort 2003, Rochefort & Bastien 1998).

Climate change and especially extreme climatic event represent a threat to the maintenance of existing peatlands (Bragazza 2008, Pastor *et al.* 2003) as well as to their restoration (Samaritani *et al.* 2011, de Jong *et al.* 2010). Climate-induced lowering of the water table is recognised as a key factor in controlling vegetation changes (Breeuwer et al. 2009), CO_2 balance (Bubier *et al.* 2003, Strack *et al.* 2009) and peat decomposition (Freeman *et al.* 2001).

A further challenge for the conservation and restoration of peatlands is public perception. Peatlands are often considered as useless land and their drainage and conversion to agricultural land is referred to as "improvement". There is therefore a need to educate the general public about the roles of these ecosystems in global climate regulation, local hydrology and climate, as habitat for rare species and as precious archives of past environmental changes and history of human activities (Barber 1993, Warner & Asada 2006,

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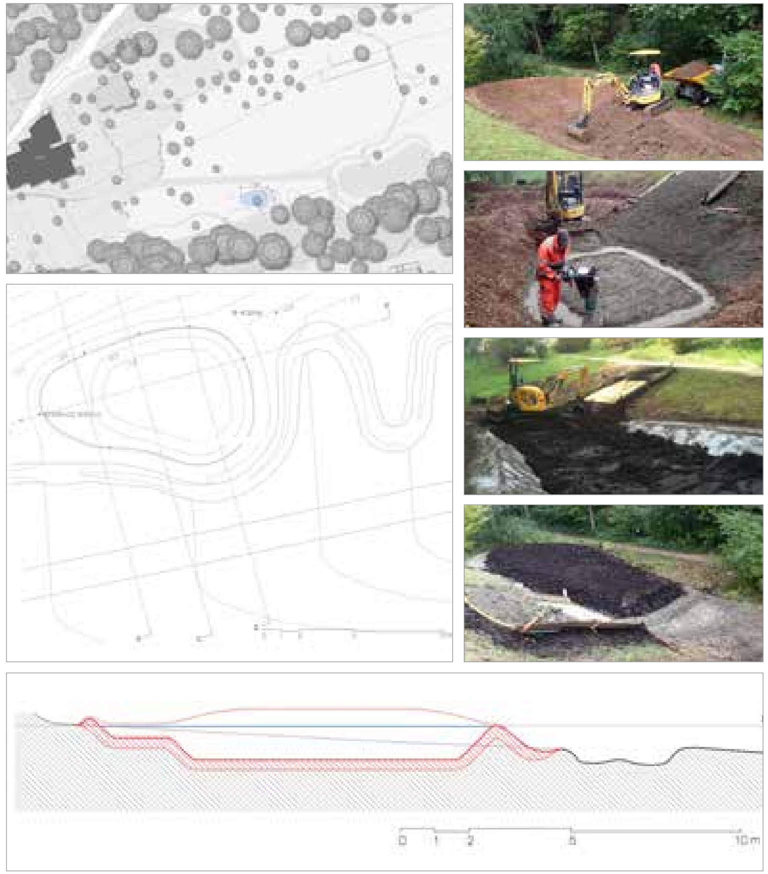
Buckland 1993). The construction in September 2014 of a small raised bog in the botanical garden of Neuchâtel, corresponds to the three missions of the garden: 1) to inform the public as well as students about these unusual, fragile and threatened ecosystems, 2) to present characteristic plants from the Jura Mountains (*Sphagnum, Drosera, Eriophorum, Betula nana*, etc.), and 3) to conduct research projects.

Materials & methods

At the beginning of September 2014 we created a small raised bog of ca. 100m^2 in the botanical garden of Neuchâtel. The map showing the location of the bog and the different stages of construction of the peatland are illustrated in **Figure 1**. First a large (ca. 100m^2) hole was dug. The hole had a maximum depth of 210cm, with one half being deeper and the other shallower gradually reaching the surface of the natural terrain. Then ca. 60m^3 of marl was delivered and brought to the site. This material was distributed homogenously over the surface to produce a 60cm thick impermeable layer over which the peat (also ca. 60m^3) was then deposited. The peat thickness reaches 160cm at the deepest part. The material (marl and peat) was collected from a degraded peatland in an industrial area of the region (town of Le Locle).

The bog is divided into two parts, with shallow (30-100cm) and deep (100-160cm) peat. A shallow pool was dug in the centre of each part. Around each pool the surface was divided in six slices half of which were planted (at low density) with over 30 species of mosses and vascular plants collected from bogs in the Jura Mountains and from existing collections (**Table 1**), and the other half left bare to study colonisation. The two treatments are referred to as "planted" and "non-planted". Plants from the surrounding meadow and forest provide ample sources of seeds, which germinate on the bog. In one half of the 12 surfaces (randomly selected) these plants are left to develop naturally while in the other six surfaces non-bog plants are removed. These two treatments are referred to as "weeded" and "non-weeded". There is thus four combination of these 2x2 treatments and three replicates of each.



> FIGURE 1.

Map of the botanical garden of Neuchâtel and construction of the peatland.

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EX SITU CONSERVATION
CLIMATIC EFFECTS ON VEGETATION

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The surface of the peatbog was marked with wooden sticks every meter along perpendicular lines, to delineate ca. 100 plots of 1m^2. The vegetation of each of these plots is monitored three times a year, in spring, mid-summer and autumn using semi-quantitative estimation of the percentage cover of each species (Londo scale) and with aerial photography done by a drone (**Fig. 2**). A picture is taken from each plot at the time of each vegetation survey. Following this the alien (i.e. "non bog") species are removed in the surfaces corresponding to this treatment. Alien shrubs and tree seedlings which have very successfully germinated on the bare peat (e.g. *Salix*) are also removed from all plots as their development would have excessively large impacts on the bog vegetation in relation to the size of the overall peatland.

> **FIGURE 2.**

Map of the peatland and pictures taken on 15.06.2015 and 15.09.2015 by a drone.

A dense network of sensors in being installed to monitor micro-environmental conditions (temperature, water table depth, moisture, etc., **Fig. 2**) and will also do regular measurements of other factors including hydrochemistry (pH, macro-nutrients, etc.) and functioning (soil respiration, decomposition, photosynthesis, methane emissions). One of our goals is to assess to what extent such a lowland bog exposed to hot and dry summers is capable to develop a typical bog vegetation and act as a carbon sink. This research ties in with several research projects conducted in Switzerland and other countries in Europe and beyond to which the University of Neuchâtel collaborates.

> **TABLE 1.**

List of plant species introduced on the peatland of the botanical garden of Neuchâtel

Sampling site - Name of the peatland	Bois-des-Lattes	Bois-des-Lattes	Le Cachot	Le Cachot	Le Cachot	
Place / Lieu-dit	Ancienne zone exploitée	Drain bouché	Gouille du centre	Fossé Pochon	Partie NO	
Sampling date / Date d'échantillage	07/10/14	07/10/14	07/10/14	07/10/14	01/04/12	
Coord N	46'58'21.94''N	46'58'22.02''N	47'0'19.52''N	47'0'16.71''N	47'0'21.63''N	
Coord E	6'42'20.35''E	6'42'45.13''E	6'39'56.20''E	6'39'52.44''E	6'39'50.57''E	
Vascular plants / Plantes vasculaires						**Code IPEN**
Andromeda polifolia L.	●					CHINEU20140200
Andromeda polifolia L.					●	CHINEU20140201
Betula nana L.					●	CHINEU20140202
Calluna vulgaris (L.) Hull	●					CHINEU20140203
Carex rostrata Stokes			●			CHINEU20140204
Carex nigra (L.) Reichard*						CHINEU20140205
Carex rostrata Stokes		●				CHINEU20140206
Carex rostrata Stokes				●		CHINEU20140207
Comarum palustre L. (*Potentilla palustris*)				●		CHINEU20140208
Drosera rotundifolia L.					●	CHINEU20140209
Dryopteris cristata (L.) A. Gray*						CHINEU20140235
Eriophorum angustifolium Honck	●					CHONEU20140210
Eriophorum vaginatum L.	●					CHONEU20140211
Eriophorum vaginatum L.					●	CHONEU20140212
Filipendula ulmaria (L.) Maxim.*						CHONEU20140213
Pinus mugo subsp. *uncinata* (DC.) Domin	●					CHONEU20140214
Trichophorum cespitosum (L.) Hartm. (s.str.prov)	●					CHONEU20140215
Vaccinium myrtillus L.	●					CHONEU20140216
Vaccinium oxycoccos L.					●	CHONEU20140217
Vaccinium uliginosum L.	●					CHONEU20140218
Vaccinium uliginosum L.					●	CHONEU20140219
Vaccinium vitis-idaea L.	●					CHONEU20140220
Mosses / Bryophytes						
Aulacomnium palustre (Hedw.) Schwägr	●					CHONEU20140221
Hylocomnium splendens (Hedw.) Schimp	●					CHONEU20140250
Pleurozium schreberi (Brid.) Mitt.	●					CHONEU20140222
Polytrichum alpinum Hedw. (=P.strictum)	●					CHONEU20140223
Sphagnum angustifolium (Russow) C.E.O.Jensen	○					CHONEU20140224
Sphagnum capillifolium (Ehrh.) Hedw	○					CHONEU20140225
Sphagnum cuspidatum Hoffm			●			CHONEU20140226
Sphagnum fallax (H.Klinggr.) H.Klinggr		●				CHONEU20140227
Sphagnum fallax (H.Klinggr.) H.Klinggr				●		CHONEU20140228
Sphagnum fuscum (schimp.) H.Klinggr					●	CHONEU20140229
Sphagnum magellanicum Brid.	●					CHONEU20140230
Sphagnum magellanicum Brid.					●	CHONEU20140231
Sphagnum rubellum Wilson	●					CHONEU20140232
Sphagnum rubellum Wilson					●	CHONEU20140233
Sphagnum squarrosum Crome*						CHONEU20140234

* *In the botanical garden of Neuchâtel before 2012, from "vallée des Ponts-de-Martel" (Bois-des-Lattes or Marais rouge)*

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PEATLAND'S PLANT COLLECTION
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CLIMATIC EFFECTS ON VEGETATION

02. Results

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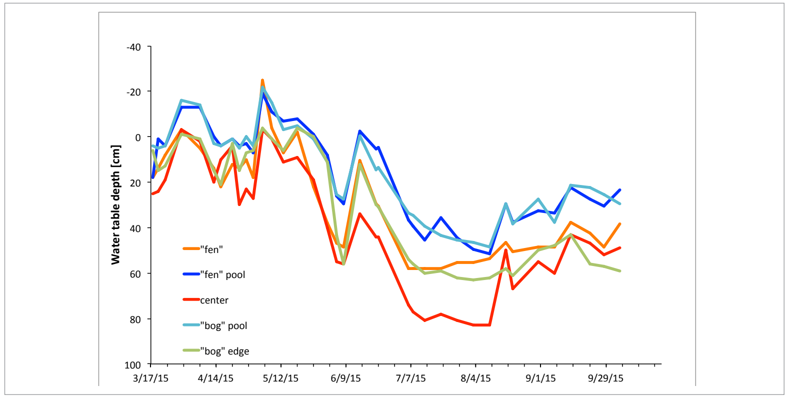
After one year of development some preliminary results can already be shown, including the thermal inertia of the peatland, the resistance of the plants to the heat wave and drought of the summer 2015 and the colonisation of herbaceous plants on the bare peat surface.

> **FIGURE 3.**

The peatland on 24.02.2015 with snow still on the surface.

1. THERMAL INERTIA

The first observation is the thermal inertia of the peat body relative to the surrounding mineral soil. This was very obvious during the winter after a period of snowfall. The thickness of the snow and the duration of snow cover were measured from November to March on the peatland and on the adjacent path and meadow. The water-saturated peat body froze during the winter and the snow remained longer than on the adjacent well-drained mineral soil that heated up much faster as soon as air temperature increased (**Fig. 3**). Thus once the peat body has cooled it remains colder than the surrounding land. These temperature patterns will be more precisely monitored in the future once temperature loggers are installed.

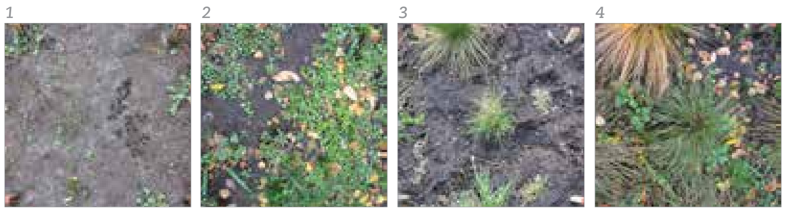


> **FIGURE 4.**

Patterns of water table depth [cm] measured in five spots on the bog (colors are the same than Piezometer of Fig. 2).

2. RESISTANCE OF THE BOG VEGETATION TO THE HOT AND DRY SUMMER 2015

The summer 2015 was especially hot and dry. We therefore feared that the newly planted bog vegetation would not survive such extreme conditions. However we observed that almost all plants survived. Deep rooted vascular plants such as *Carex* ssp., *Eriophorum* ssp., *Trichophorum caespitosum* and ericaceous shrubs all survived well (see especially difference between pictures of **Fig. 2**). Likewise the mosses including *Sphagnum* were still mostly alive. The only exception was the bog pool species *Sphagnum cuspidatum* that died in the dried out pools. This general good resistance of bog plants may be explained by the fact that, although the summer was indeed especially hot and dry the spring had been quite wet, with high water table recorded from March to June (**Fig. 4**). The development if the vegetation in two 1m² plots representative for two of the four treatments is illustrated in **Figure 5**.



> **FIGURE 5.**

Vegetation development of two 1m² plots of the bog corresponding to two treatments: **1:** non-planted & non-weeded (plot C-6). **2**: planted & non-weeded (plot B-8). **3**: July 8th 2015. **4:** October 16th 2015.

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3. DEVELOPMENT OF PLANTS ON OPEN PEAT SURFACES

We left 50% of the bog surface totally bare to study the primary colonisation by diaspores from the surrounding plants. Given the extreme climatic conditions of the summer we wondered how successful this colonisation would be. Interestingly a high number of plants germinated on the peat. These were however mostly plants from the adjacent meadow and forest while bog plants seemed to have colonised these surfaces from vegetative lateral growth (especially clear for *Vaccinium oxycoccos*, **fig. 6**).

> FIGURE 6.

Development of *Vaccinium oxycoccos* on the bare peat surface from an adjacent vegetation patch during the summer 2015. (Grey pieces are IPEN labels with name of plants introduced)

Discussion

The peatbog of the Botanical Garden of Neuchâtel, created at low elevation (ca. 500m) and in a region with moderate rainfall (ca. 900mm/yr) is primarily useful to understand the evolution of such an ecosystem under apparently unfavourable climatic conditions. After only one year of observations it is clearly too early to draw any firm conclusions on the long-term development of this peatland. However the drought and heat wave that lasted from May to September 2015 already provided the opportunity to evaluate how the plants reacted to a long-lasting hydric stress. We were pleasantly surprised to see how well the vegetation had survived and indeed the comparison of the two aerial images (**fig. 2**) and the images of the two plots (**fig. 5**) clearly show the strong growth of the vascular plants. The mosses may not have grown much but mostly seem to have survived as well. The exceptions are the smallest patches or isolated moss plants and the characteristic *Sphagnum* species of bog pools (*S. cuspidatum*) that died in the dried up pools. The peatland therefore already represents an invaluable object for scientific research.

The second advantage of this peatland is that the characteristic plants of this unusual ecosystem can now be present in their "natural" context rather than in suboptimal small surfaces. Having these plants growing on a massive peat body also offers a higher chance of maintaining these plants over a long period, as attested by their good survival during the stressful conditions of the summer of 2015. This peatland already is proving very useful to the public inform about the value and fragility of peatland ecosystems. The peatland thus also clearly serves educational purposes.

This peatland also offers opportunities to test the growth conditions of rare and endangered peatland plants, of multiplying them with the goal of re-introducing them in some newly restored peatlands in the region without having to samples in fragile natural populations. As 90% of the remaining peatlands in Switzerland have been damaged directly or indirectly by human activities there is now a good potential for conducting ecological restoration projects and indeed many ambitious projects are in progress. In many cases

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CLIMATIC EFFECTS ON VEGETATION

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• Tritz Jérémy
• Gueniat Sylvian
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it would be desirable to re-introduce the characteristic plants of these ecosystems and here the peatland of the Botanical Garden of Neuchâtel can be useful both to experiment growth conditions and to multiply characteristic plants. The peatland thus also serves conservational purposes.

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AN INTERNATIONAL PLANT SENTINEL NETWORK

Photo credit : Mealy bug infestation, *Suzanne Sharrock*

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> Keywords PEST DISEASES SENTINEL PLANTS INVASIVE MONITORING CAPACITY BUILDING

02. Abstract

- *Barham Ellie*
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- *Lane Charles*
- *Baker Richard*

INVASIVE PESTS AND DISEASES CAN HAVE A DEVASTATING IMPACT ON PLANT LIFE AND THEIR ASSOCIATED ECOSYSTEMS. IN RECENT YEARS, THE WORLD HAS SEEN A SHARP RISE IN THE NUMBER OF THESE HARMFUL INVASIVE ORGANISMS WHICH CAUSE LARGE SCALE ENVIRONMENTAL AND ECONOMIC DAMAGE.

This rise is a result of the increased globalisation of trade in plants and plant material, an ever-growing industry. A major issue in addressing this increasing threat is that the majority of organisms that have caused outbreaks in temperate forests were either not known to be damaging or were unknown to science before their introduction.

Most European countries utilise a process called Pest Risk Analysis (PRA) to regulate risk within trade which focuses on known threats. As a result, damaging unknown organisms ('unknowns') are often left unregulated, increasing the chances of their introduction into new countries. Botanic gardens and arboreta are in a unique position to aid in the identification of such unknowns; within their collections they play host to expatriate plants that can act as sentinels for these potentially invasive and damaging organisms.

The International Plant Sentinel Network (IPSN) aims to generate information valuable to global plant health in order to safeguard against the threat of [such organisms] / [new introductions]. The developing network consists of gardens and diagnostic institutes who work together to provide an early-warning system for new and emerging plant pests and diseases. The IPSN focuses on increasing knowledge and awareness among garden staff, seeking best practise, developing standardised approaches and providing training materials and methodologies for monitoring and surveying. Established as part of a European-funded (EUPHRESCO) project the IPSN is led by the UK's Food and Environment Research Agency (FERA) in collaboration with Botanic Gardens Conservation International (BGCI) and partners in Europe (Julius Kühn-Institut, Germany; National Plant Protection Organisation, Netherlands; DiBAF, Italy; Forest Research, UK and CABI: Centre for Agriculture and Biosciences International). Although a European project, the network aims to be truly international as the issue of invasive organisms needs to be tackled on a global scale.

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02. Introduction

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Photo credit : Mealy bug infestation, ***Suzanne Sharrock***

INVASIVE ALIEN PESTS AND DISEASES OF PLANTS HAVE DEVASTATING ENVIRONMENTAL, ECONOMIC AND SOCIO-CULTURAL EFFECTS AND THUS ARE A PROMINENT CONCERN OF INDUSTRIES, THE PUBLIC AND GOVERNMENTS AROUND THE WORLD.

They are particularly worrying for botanic gardens and arboreta that care for extensive collections of diverse, valuable and rare plant species. This threat is ever-growing, largely as a result of the globalisation of trade in plants and plant material, used by unwanted organisms to hitchhike into a new region (Aukema *et al.*, 2011, Tomoshevich *et al.*, 2013). This concern is amplified by issues surrounding the prediction of future threats. The majority of temperate forest pests and diseases in recent years were either not known to be damaging or were unknown to science before outbreaks (Kenis *et al.*, 2011). This is because invasive organisms are often not considered significant pests in their native region, largely due to evolved resistance by natural host species and population control by natural enemies.

In order to manage threats, countries need to know of their existence. Pest Risk Analysis (PRA) is used by many European countries to regulate risk within trade; it is used to decide if an organism should be recognised as a pest of concern and subsequently regulated. It also aids decision-making regarding the strength of any phytosanitary measures (Baker *et al.*, 2009). However, PRA is reliant on known organisms with sufficient levels of information available. Therefore, it leaves many organisms unregulated and able to move into a new region freely; e.g. the 'unknowns' or organisms lacking enough information to complete PRAs. Sentinel plants offer a unique opportunity to address this issue.

Sentinel plants

Monitoring plants maintained outside of their natural ranges, so-called plant sentinels, that are exposed to pests and diseases in their adopted region can help to detect potential future threats (Britton *et al.*, 2010). In this way damaging organisms can be initially identified which can guide research to determine if they pose a significant threat to plant species in native regions. In turn, sentinels can also be used to collect information in order to address knowledge gaps for organisms suspected to be potential threats to

> Keywords PEST DISEASES SENTINEL PLANTS INVASIVE MONITORING CAPACITY BUILDING

02. Sentinel plants

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plant health (e.g. for PRAs). Studying invasive species in their natural regions, or where they have already been introduced, can be used to increase our understanding of the pest including life history and interactions with natural predators, e.g. potential biological controls. Importantly, using plant sentinel within these regions can help identify further pest-host associations, categorise and describe the type of damage they cause and the susceptibility of plant species. All of this information is vital for assessing the risk an organism poses, particularly for PRAs. In addition, information can be used in the creation of robust eradication, containment or, preferably, prevention management programmes.

Botanic gardens and arboreta

There are over 2,500 botanic gardens and arboreta globally, playing host to an estimated 30-40% of known plant species (Kramer and Hird, 2011). Importantly for plant sentinel research, gardens contain exotic plant species from countries around the world. This presents a significant opportunity to carry out sentinel research on a large and global scale.

In return, contributing gardens receive significant benefits for their role in carrying out sentinel research and being part of the network. Firstly, it will help ensure staff are hyper-vigilant for new outbreaks. Detecting damaging organisms quickly greatly increases the chances of management programmes working, thus mitigating damage caused and protecting the rest of the collection. It will enable contact with local diagnosticians and experts, establishing good links to professional help at a local level and beyond. It offers an opportunity for botanic gardens and arboreta to showcase the research and scientific potential that their living collections have to offer. It offers professional development opportunities to staff. Finally, it provides networking opportunities and increased communication on a local, regional and global scale, not just with plant health scientists but also with staff from other gardens working in the area.

The International Plant Sentinel Network

The International Plant Sentinel Network (IPSN) is a developing network of botanic gardens, arboreta, government organisations and plant health scientists. The IPSN aims to provide key information on plant pests and diseases that can be used by plant health scientists and National and Regional Plant Protection Organisations (NPPO & RPPO) in order to conserve global plant health. The network supports botanic gardens and arboreta in carrying out such important research by providing key training and coordination. This includes developing and providing links to resources, identifying potential collaborations, facilitating surveys and research, and sharing information. In this way, it is hoped these institutes, supported and coordinated by the IPSN, will work collaboratively to provide an early warning system for new and emerging plant pests and diseases.

The IPSN provides a centralised platform for communication, dissemination of information and coordination of efforts for carrying out sentinel research. This includes surveying tools and training materials which can be

> Keywords PEST DISEASES SENTINEL PLANTS INVASIVE MONITORING CAPACITY BUILDING

02. The International Plant Sentinel Network

• Barham Ellie
• Sharrock Suzanne
• Lane Charles
• Baker Richard

used to promote awareness and train and support staff in the areas of plant health, identification and biosecurity. The IPSN website (www.plantsentinel.org) includes various resource materials from comprehensive guides to pest and disease identification and surveying tools to good biosecurity practise guides, examples of best practise and posters. It also provides links to forums and external databases, resources and information.

All IPSN materials have been developed in collaboration with leading diagnostic scientists alongside botanic garden staff. This includes the Yorkshire Arboretum (UK), the Core Facility Botanical Garden at the University of Vienna (Austria), the Royal Botanic Gardens, Kew (UK), the Royal Botanic Gardens Edinburgh (UK) and Botanischer Garten der Universitat Potsdam (Germany).

As part of its role in providing training, the IPSN runs workshops in order to provide on the ground training for garden staff. These workshops are also a great opportunity for participants to network with individuals working within horticulture, plant health and government organisations, from within their country and further afield. So far workshops have been held at Shenzhen Fairy Lake Botanical Gardens (China), Huntington Botanical Gardens (U.S.), Royal Botanic Gardens, Kew (UK) and the Yorkshire Arboretum (UK). All hosting gardens have experience in the area of plant health from surveying to identification and were able to share examples of best practises with attendees.

A global network

The IPSN is funded through EUPHRESCO, an ERA-NET project; the UK's participation is led by Fera and funded by the Department for Environment, Food and Rural Affairs (Defra). Other current EUPHRESCO partners are the Julius Kühn-Institut (Germany), the Plant Protection Services (Netherlands), the Department for Innovation in Biological, Agro-food and Forest systems (Italy), CABI (UK) and Forest Research (UK). The network is guided by an International Advisory Group comprising leading experts from organisations around the world. This includes representatives from the European and Mediterranean Plant Protection Organisation (EPPO), the American Public Garden Association, the South African National Biodiversity Institute (SANBI) and Centre of Invasive Biology (CIB), the New Zealand Better Border Biosecurity (B3) consortium and the Food and Agriculture Organization (FAO) among others. A full list is available at www.plantsentinel.org/international-advisory-group

The IPSN is coordinated by Botanic Gardens Conservation International (BGCI). BGCI have extensive links to the botanical gardens and arboreta community, and are leading authorities in the area of plant conservation. Their two unique databases, GardenSearch and PlantSearch, are exceptional resources which can be utilised to facilitate and support research. GardenSearch lists all known gardens and includes key information such as location (country, region) and contact details. PlantSearch catalogues living plant, seed and tissue collections in gardens around the world and can be used to identify the gardens which hold a specific plant species. This not only lets the IPSN identify gardens in areas where the pest or disease is present, but also helps to pinpoint those institutes that house host plants of interest.

> Keywords PEST DISEASES SENTINEL PLANTS INVASIVE MONITORING CAPACITY BUILDING

02. The future

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- Baker Richard

The IPSN has been running for nearly 3 years, and is soon to start the next phase of its development; using the network to provide meaningful data to plant health regulators. This information will be used to prevent and/or mitigate the impact of pest and disease outbreaks, to help conserve plant species around the world. The IPSN will facilitate and coordinate research projects as well as continue to provide support, guidance and training.

Currently, in collaboration with CABI, the IPSN is in the pilot phase of developing an online reporting system and front-facing database. CABI are a not-for-profit research and publishing organisation that has much experience in this area having previously developed various databases. It is hoped this new reporting system will simplify and ease data collection and will provide data storage for results. This will help garden staff to manage their surveying work and track the progress of any damage.

The IPSN is working to create a viable and robust network that meets the needs of its key stakeholders; botanic gardens, arboreta, National Plant Protection Organisations, Regional Plant Protection Organisations and plant health scientists. It is hoped the network will become an established and important tool that will be championed by these stakeholders and supported by BGCI.

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MONITORING OF COLLECTION ESCAPES IN THE BOTANIC GARDEN MEISE

Photo credit : *Ranunculus parviflorus* growing along a wall of the old Boechout castle, ***Anne Ronse***

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> Keywords GARDEN ESCAPES BOTANIC GARDEN SURVEY NEOPHYTES INVASIVE HYBRIDIZATION

02. Abstract

• *Ronse Anne C.M.*

A MONITORING PROGRAMME OF COLLECTION ESCAPES HAS BEEN INITIATED IN THE DOMAIN (92 HA) OF THE BOTANIC GARDEN MEISE. FIRST, A NINE-YEAR VEGETATION SURVEY OF THE (SUB) SPONTANEOUS VASCULAR PLANTS WAS CARRIED OUT FROM 2002 TO 2010; IT WAS FOLLOWED BY A SYSTEMATIC MONITORING OF THE ESCAPED NEOPHYTES DURING 5 YEARS FROM 2012 ON, RECORDING SEVERAL PARAMETERS SUCH AS THEIR NUMBER AND PERSISTENCE.

Up to 2014, a number of 202 species of collection escapes has been observed, which amounts to 2,5% of the taxa in open air collections. Of these, 57 species have not been reported before as a neophyte in Belgium. Some neophytes with invasive tendencies appear to come from outside sources rather than from the plants in the collections. A recent spreading of several thermophilic species has also been observed, some of which subsist long after the species have disappeared from the collections. Most of the escapes are ephemeral but some display strong invasive behaviour. The botanic collections seem to favour the appearance of escapes in some cases, such as the co-occurrence of both sexes of dioecious plants, and also by the presence of cultivated native species coming from colder areas than the local representatives. The hybridization and back-crossing of cultivated taxa with native species is an ongoing process which appears to occur simultaneously both in the botanic garden and on outside locations.

> Keywords GARDEN ESCAPES BOTANIC GARDEN SURVEY NEOPHYTES INVASIVE HYBRIDIZATION

02. Introduction

• Ronse Anne C.M.

Photo credit : *Ranunculus parviflorus* growing along a wall of the old Boechout castle, ***Anne Ronse***

THE MAIN SOURCE FOR ALIEN INVASIVE PLANT SPECIES IN SEVERAL PARTS OF THE WORLD CONSISTS OF PLANTS THAT HAVE BEEN INTRODUCED FOR HORTICULTURAL USE BY NURSERIES, BOTANICAL GARDENS AND INDIVIDUALS (E.G. DEHNEN-SCHMUTZ *ET AL.* 2007; GROVES *ET AL.* 2005; REICHARD & WHITE 2001).

Some of the cultivated species are able to escape from cultivation and become established or naturalized; they are called garden escapes. In order to minimize the risks of invasive garden escapes, codes of conducts for horticulture have been developed in several countries (Heywood & Brunel 2011). However, several invasive species have originated from collections of botanic gardens, which have been reported as biased towards invasive species (Hulme 2011). That is the reason why voluntary codes of conduct on invasive alien species have also been developed for botanic gardens and arboreta in different parts of the world (e.g. Heywood & Sharrock 2013; *http://www.centerforplantconservation.org/invasives/DownloadPDF/bga.pdf*). One of the recommendations included in these documents is to carry out a monitoring of the escapes from the collections (called collection escapes) on the garden site. This can yield valuable information about the invasive potential of species in a certain area and climate, which may especially be useful as many of the species are not (yet) available in commerce. The importance for alien plant research of listing the species naturalizing in botanic gardens was already stressed in the 19th century by Martins (1856) and by Devos (1870).

For these reasons a programme was started for the monitoring of collection escapes in the Botanic Garden Meise, with the aim to evaluate the invasive potential of plant species in the collections and to prevent them from spreading in- and outside the garden.

Materials & methods

The Botanic Garden Meise (formerly called National Botanic Garden of Belgium) is located at a distance of about 10 km to the north of Brussels. It contains large collections of about 18000 taxa, of which 8000 are grown in the open in a domain of 92 ha. This old castle domain contains diverse habitats such as greenhouses, open air collections, buildings, roads, woodlands, grasslands, lawns, and ponds. Some of them are (semi-)natural areas with a high conservation status, such as petrifying springs with *Cratoneurion* (habi-

> Keywords GARDEN ESCAPES BOTANIC GARDEN SURVEY NEOPHYTES INVASIVE HYBRIDIZATION

02. Materials & methods

tat type H7220) (Oosterlynck & Van Landuyt 2012). Several studies have been made on the (sub)spontaneous flora of the domain, including plants but also lichens, fungi, myxomycetes and other organisms (Hoste 2011).

For the vascular plants, a nine-year vegetation survey was carried out from 2002 to 2010. During that first survey period, all subunits of the domain (called sectors) were visited at least twice, once in spring and once in summer or in early autumn, and a list of species was made for each sector. In a second phase, from 2012 on, all plant species are again recorded by sector, following a schedule aiming at visiting each sector within 5 years. Moreover, a systematic monitoring of the escaped neophytes is done, and several parameters are noted in order to characterize their invasive potential: the number of plants, their age, their distance from the mother plants in collection, and the habitat type where they are found. Several species traits will be considered for further analysis, such as the means of dispersal, the type of propagation and the original geographical range.

Results & discussion

The first survey revealed the presence of 586 (sub)spontaneous species of vascular plants in the domain, of which 156 species (26%) were neophytes that had probably escaped from the collections (Ronse 2011a). Of these, 38 species were recorded for the first time as a neophyte in Belgium (Ronse 2011b). The ongoing monitoring of the second phase has already resulted in a further increasing number of species that have been found escaping outside the collections, as more sectors are visited. From 2012 to 2014, 64 new plant species were recorded, of which 46 (72%) are collection escapes: the proportion of escapes in the new discovered species has strongly increased in the second phase. This brings the (provisional) total number of escaped species in Meise to 202, of which 57 have not been reported before as a neophyte in Belgium (Verloove 2006a).

However, it is not always easy to distinguish between species that have escaped from the collections and neophytes that have spread from outside sources. One of these examples is *Duchesnea indica* (Andrews) Teschem. (Rosaceae), a creeping plant that is called Indian strawberry or Mock strawberry. In the domain a steady expansion of the species has been observed between 2002 and 2014. This is shown in **table 1**, which displays the number of sectors in which this species was found per year (as averaged over time periods of 1or 2 years), as well as the number of sectors per year in which the species was first recorded (new occurrences per year).

Time period	Average n° of sectors/year	Average n° of new sectors/year
2002-2003	3	3
2004-2005	2,5	2,5
2006-2007	1,5	0,5
2008	9	9
2009	11	6
2010	7	4
2011	3	0
2012	11	5
2013	6	0
2014	4	0

> TABLE 1.

Number of sectors of the domain in which *Duchesnea indica* was found annually

> Keywords GARDEN ESCAPES BOTANIC GARDEN SURVEY NEOPHYTES INVASIVE HYBRIDIZATION

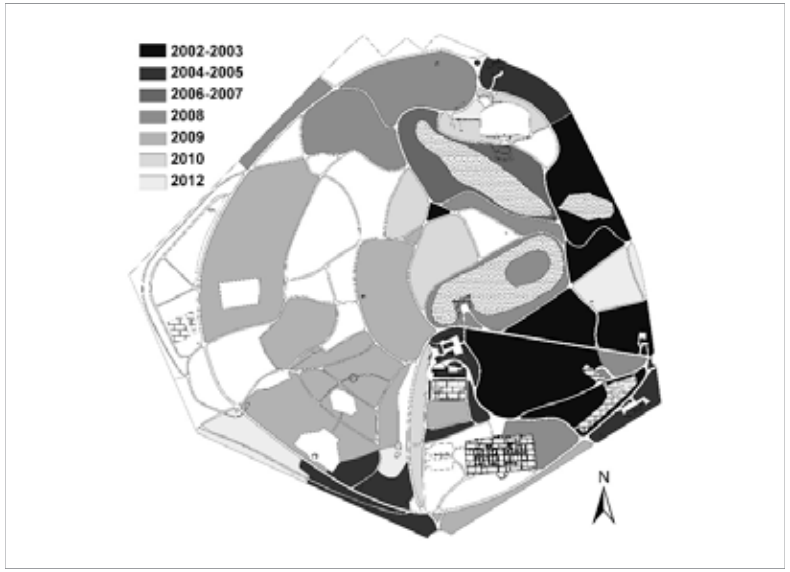
02. Results & discussion

• Ronse Anne C.M.

The latter shows clearly that a very strong increase of the species has been recorded between 2008 and 2010, especially in 2008 and 2009. The low occurrence in 2011 might seem erratic, as compared to the occurrence of 2010 and of 2012, but it is due to the fact that only sporadic observations were made in that year, as the first survey had already been completed then, and the second had not started yet.

Duchesnea indica has been placed in the watch list of invasive species in Belgium (Branquart 2015), and it is known that this species had gone through a significant expansion in parks in the Brussels area since 1990 (Saintenoy-Simon et al. 1995). This is why I suspected that the source of the invading plants in the domain lied outside, even if the species was cultivated in the garden. In order to investigate this hypothesis, a spatial analysis was made of the progression in time of the species in the domain (**Figure 1**). This displays an initial presence that is largely restricted to the eastern side of the domain, close to the main visitor entrance. Gradually the species has expanded to the other parts of the domain, and it still had not been found in a number of sectors by 2014, mainly in the western part. The cultivated plants of D. *indica* are located in the central and the southern part, while one former location was close to the eastern entrance, but the plants there had died since several years. This seems to confirm the hypothesis that the spontaneously occurring plants of D. *indica* in the domain have come from an outside source, and that they have entered the domain by the main entrance. Other neophytes, such as *Senecio inaequidens* DC. (Asteraceae), have also been observed to enter the domain by this entrance.

On the other hand, many species in the domain are obviously collection escapes, as they are not present in the surroundings outside. Some of them don't show invasive behaviour and are restricted to one or a few sites, where they remain present year after year, only reproducing locally. This is the case for instance for some wall-dwelling species, such as *Asarina procumbens* Mill., a decorative member of the Plantaginaceae that grows on the outer sides of greenhouse walls. More surprisingly, I also found a cactus, probably *Mammillaria* sp., which has subsisted for at least ten years on the outer wall of a greenhouse. But other collection escapes clearly display invasive behaviour. One such species in Meise is *Nothoscordum gracile* (Aiton) Stearn (Amaryllidaceae), which has been cultivated until the summer of 2010, when it was removed from the collections. It was present within its flower beds, but also outside at distances up to several tens of meters. The attempt to eradicate has not worked well, as in 2015 still many tens of plants were present. This should not surprise, as the species is naturalized in parts of the United States, and in scattered locations of Europe, Asia, Africa, Australia, and various oceanic islands (https://en.wikipedia.org/wiki/Nothoscordum), even if the species was not known as a neophyte in Belgium (Verloove 2006a).



> FIGURE 1.

Progression of *Duchesnea indica* from 2002 to 2012 in the domain of the Botanic Garden Meise

> Keywords GARDEN ESCAPES BOTANIC GARDEN SURVEY NEOPHYTES INVASIVE HYBRIDIZATION

02. Results & discussion

• Ronse Anne C.M.

Another escape displaying invasive tendencies is *Juglans mandshurica* Maxim. (Juglandaceae), a species of walnut that is very hardy. Seedlings of this species are found in several sectors of the domain, and we assume that the nuts may be disseminated by birds. The seedlings often remain unspotted as they grow in the woody areas, which are not regularly weeded, and as they look much like *J. regia*, a cultivated tree that is increasingly found naturalized in the northern part of Belgium (Verloove 2006b). A few of the seedlings in the domain have become mature trees that are reproducing. *J. mandshurica* is mentioned as introduced and potentially invasive in Central Russia by the EPPO Global Database (https://gd.eppo.int/taxon/IUGMN), and the related Japanese species J. ailantifolia Carr., that is also known as *J. mandshurica var. sachalinensis*, shows invasive behaviour in some areas of New Zealand (http://whangareiflora.weebly.com/invasive-plants.html).

Some escapes in Meise have been found surviving long after the mother plants in the collections have disappeared. This is the case for *Mentha pulegium* L., a mint species that is a very rare native species in Belgium; recently some new sites have been discovered, where the species is probably present as a neophyte (Ronse 2012). It has been cultivated in the botanic garden from 1987 to 1991 and then died, but it is increasingly found in lawns in the domain. A second example of escapes surviving the mother plants is the thermophilic *Ranunculus parviflorus* L., which has been cultivated between 1974 and 1992, and then disappeared from the collections; it is now increasingly found as a weed in disturbed or weeded parts (Ronse 2011c).

A special case of neophytes that are not strictly speaking collection escapes are hitch-hiking weeds that are introduced in botanical collections together with cultivated plants, and that can spread from there. One such example in Meise is *Euphorbia humifusa* Willd., a small annual spurge from south-eastern Asia that has naturalized in several parts of Europe and south-western Asia. It is known to have grown around 1900 in the systematic garden at the former Botanic Garden location in Brussels, from where it has been brought to Meise together with the collections (Ronse 2011d). It has been rapidly increasing since 2010, and maybe the recent increase of this thermophilic species has also been triggered by global warming, as is also suspected for *Mentha pulegium* and for *Ranunculus parviflorus*.

The provisory results of the monitoring of escapes have allowed us to identify some mechanisms going on in botanic gardens that seem to favour the escape of cultivated species. The first concerns dioecious (tree) species, of which plants of both sexes are present in each other's vicinity in botanic gardens, whereas this is not so often the case in private gardens or parks. This means that in botanic gardens they produce seedlings that are often not found elsewhere. One example of this is *Cercidiphyllum japonicum* Siebold & Zucc. (Cercidiphyllaceae), a tree from eastern Asia that is frequently grown in European parks but that had not been recorded as a neophyte in Belgium yet (Verloove 2006a). In Meise many tens of seedlings grow in several locations. Another example is *Diospyros lotus* L. (Ebenaceae), a dioecious tree from south-eastern Europe and south-western Asia that produces edible fruits called date plums. In Meise it shows invasive behaviour, and hundreds of seedlings have been found up to one kilometre away from cultivated trees (Groom et al. 2011).

A second mechanism is the escape of native species that are cultivated from a non-local provenance in the collections. In some cases they are better adapted than the locally native plants, for example when the latter are on

> Keywords GARDEN ESCAPES BOTANIC GARDEN SURVEY NEOPHYTES INVASIVE HYBRIDIZATION

02. Results & discussion

the edge of their distribution area because of climatic constraints, while the cultivated plants are adapted to colder climates. In Meise, plants of *Oenanthe pimpinelloides* L. (Apiaceae) show expansive behaviour, whereas this species is very rare in Belgium and is included in the Red List of vascular plants in Flanders (Ronse 2005). However, the cultivated plants come from Bulgaria, with hardiness zone 6 or 7, whereas the garden is located in hardiness zone 8.

A third mechanism that I found in the botanic garden at Meise is spontaneous hybridization of a native species with a cultivated alien species. The hybrid often displays invasive tendencies and gradually replaces the native parent; sometimes further introgression occurs by back-crossing. One such example is *Hyacinthoides* x *massartiana Geerinck* (Asparagaceae), the hybrid of the native H. *non-scripta* (L.) Chouard ex Rothm. And of the cultivated *H. hispanica* (Mill.) Rothm. Plants with intermediate characters invade flower beds in the vicinity of the flower beds of both parents in the collection, and pop up at different locations throughout the domain as well. A similar process also occurs elsewhere in northern Belgium, where hybrid plants have increasingly been found growing both in forests and in gardens (Verloove 2006c). Within the garden it seems that the hybrid plants originate from the cultivated plants, rather than come from the outside, given their location.

Another example is *Ilex x altaclerensis* (hort. ex Loud.) Dallim., a man-made cross between *Ilex perado* Ait., a non-hardy species in Belgium, with the native Holly (*Ilex aquifolium* L.) as male parent. Several cultivars of *I. x altaclerensis* have been planted in gardens and in public places. Within the Botanic Garden Meise many plants with intermediate characteristics between the primary crosses and Holly are growing in woodland; further investigation has shown that similar back-crossing is occurring in several other locations in northern Belgium (Ronse, in preparation).

Conclusion

Since 2002 more than 200 species have been found to escape from the collections in the botanical garden Meise, and this number is steadily increasing. This represents one third of all vascular plant species that were found growing (sub)spontaneously in the domain. Compared to the 8000 taxa grown in the open air collections, the number of escapes represents 2.5 percent, which may seem a low proportion. However it should be kept in mind that probably a large number of escapes is not recorded, due to the frequent weeding in the collections, and due to the fact that the monitoring of the collection escapes has only been done for a few years. Yet more than one quarter of the collection escapes concern species that have not been reported as a neophyte in Belgium before. This shows the importance of monitoring in botanic gardens as an information source about invasive behaviour of alien species. However, it is not always easy to discern whether a species that is spreading in the domain originates from the collections or from outside, when it is present in the collections but also occurs as a neophyte in the area around the garden. A spatial analysis of the progression in time of the species within the garden domain can give indications for this.

> Keywords GARDEN ESCAPES BOTANIC GARDEN SURVEY NEOPHYTES INVASIVE HYBRIDIZATION

02. Conclusion

Most of the collection escapes occur in low numbers and are ephemeral, as the areas in the vicinity of the collections are frequently weeded. Some of them show strong invasive behaviour and are very difficult to eradicate from the collections, in some cases also for species that have not been reported as a neophyte in our country before, such as for *Nothoscordum gracile*. Several species that have been observed to spread during the last decade(s) are thermophilic species or species that are on the northern edge of their distribution, so it is well possible that global warming is involved. Some species even survive as escapes after having died in the collections. A few mechanisms or processes that take place in the botanic garden turn out to favour the appearance of taxa with invasive properties, such as the co-occurrence of both sexes of dioecious plants. The cultivation of native species with a provenance from colder areas than the local conditions has led to frequent escapes, as found for the rare *Oenanthe pimpinelloides*. This phenomenon of escape and aggressive behaviour of native species from a non-local provenance might be more common than visible at first glance. Indeed, this is easy to monitor in the case of locally rare plants, but it is more difficult to discern for more common species, and it would require genetic analyses to prove this. Another ongoing process is the hybridization and back-crossing of cultivated taxa with native species, and this has been found to take place more or less simultaneously in the botanic garden as well as on other locations outside the garden.

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STUDY OF EXOTIC PLANTS' NATURAL REGENERATION IN THE VILLA THURET BOTANIC GARDEN: AN EARLY EVALUATION OF THE BIOLOGICAL INVASION RISKS

Photo credit : Arbres exotiques acclimatés au jardin botanique de la Villa Thuret, *C. Ducatillion*

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> Keywords BOTANICAL GARDEN INVASIVE SPECIES EXOTIC SPECIES RISK ASSESSMENT INVASION MONITORING ACCLIMATION NATURALIZATION DISPERSAL

02. Abstract

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- *Chevallier Joëlle*
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- *Ducatillion Catherine*

MANY EXOTIC PLANT SPECIES HAVE BEEN - AND STILL ARE - INTRODUCED IN BOTANIC GARDENS AS BIOLOGICAL RESOURCES AND OBJECT OF STUDY.

These resources could become acclimatized to provide services, especially in the situation of climate change. However, some species may become invasive. The Villa Thuret botanic garden is located on the coastline of the Mediterranean area, considered as a biodiversity hotspot. As soon as the 19th century, its director Charles Naudin identified the risk of plant invasion. Nowadays, scientists and gardeners have set an experimental design in order to assess the naturalisation's ability of introduced species and to prevent any invasion. The protocol aims at studying the species fecundity and dispersal as well as the survival of the potential spontaneous seedlings of these plants. Besides the seedlings inventory and monitoring by the maintenance staff of the garden, this survey will also consist in installing and monitoring representative unmaintained observation plots. Their size and number are limited by technical issues and by the acceptability of the staff and of the visitors. Ten 16m²-plots have been set in the garden in summer 2014. A phytosociological census was achieved for each one to precisely assess the spontaneous or planted plant species growing. Every six months, an inventory of the regenerating exotic species' seedlings is performed to identify the impact of rainfall, cold and drought through the germination, the seedlings' survival and the height growth. There will also be an estimation of the species fertility by seed collection and germination tests. This study will result in a list of species able to spontaneously regenerate within the botanic garden, but also in the characteristics of the regeneration: dispersal distance, seedlings' survival and growth rate and habitats propitious for germination. Here are the first identified plants: *Acacia* spp., *Ailanthus altissima* (Mill.) Swingle, *Albizia polyphylla* E.Fourn., *Araucaria bidwillii* Hook., *Arbutus* x *thuretiana* Dem. Nothosp. Nov., *Celtis* spp., *Cocculus laurifolius* DC., *Cotoneaster divaricatus* Rehder & E.H.Wilson, *Diospyros whyteana* (Hiern) F. White, *Elaeagnus macrophylla* Thunb., *Jubaea chilensis* (Mol.) Baill., *Phoenix* spp., *Koelreuteria bipinnata* Franch., *Pistacia* spp., *Pittosporum* spp., *Prunus ilicifolia* (Nutt. ex Hook. & Arn.) D.Dietr., *Quercus* spp., *Sapindus* spp., *Syzygium paniculatum* Gaertn., *Umbellularia californica* (Hook. & Arn.) Nutt., *Xylosma congesta* (Lour.) Merr., *Zanthoxylum simulans* Hance and *Zelkova serrata* (Thunb.) Makino. This experiment is planned for five years. The collected data will be processed with risk analysis tools already applied on forestry arboreta. This experimental design could be tested in other local botanic gardens to confirm its efficiency. It would be a valuable tool to precociously assess the risks and to warn against the escape and the proliferation of the concerned species.

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02. Introduction

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• Ducatillion Catherine

Photo credit : Arbres exotiques acclimatés au jardin botanique de la Villa Thuret, ***C. Ducatillion***

INVASIVE EXOTIC SPECIES ARE ONE OF THE MAIN CAUSES OF BIODIVERSITY LOSS WORLDWIDE, ALONG WITH HABITATS DESTRUCTION (SIMBERLOFF *ET AL.*, 2003). THESE SPECIES TEND TO DEVELOP IN THE NATURAL, SEMI-NATURAL AND MAN-MADE ENVIRONMENT OF THEIR INTRODUCTION AREA.

They compete with native species, seizing available resources. This leads to a weakening of native species' populations and, in the long run, to biodiversity loss and ecosystems disturbance (Hulme *et al.*, 2009). Thus, ecosystem services are disrupted (Cardinale *et al.*, 2012), damaging human health and economic activities (Pimentel *et al.*, 2000; Díaz *et al.*, 2006). In the European Union, the annual cost of exotic invasive species has indeed been estimated at 12 billion euros (Genovesi, 2014).

The invasion process has been thoroughly documented and discussed, especially by Richardson *et al.* (2000), Colautti & MacIsaac (2004) and Blackburn *et al.* (2011). It has been defined as the crossing of different barriers by a species: geographical, environmental and reproductive barriers. Each crossing refers to different processes: introduction, naturalisation and invasion, respectively. This terminology has been controversial and is still discussed (see Blackburn *et al.*, 2011 for a review). Richardson *et al.* (2011) proposed a glossary to precisely define the different concepts involved in invasion Ecology. According to this glossary, a species is considered native in a given area if it has evolved in this area or if it arrived by natural means. Besides, a species is considered exotic in a given area if its presence is due to human intentional or accidental actions that spread it out of its native range. Here we consider that a species introduced by human actions in a region before 1500 is native. A species is invasive when it is able to reproduce over several life cycles in large numbers and to spread at considerable distance from the parents. This definition does not take into account the potential environmental, economic and health effects of such species. It only relies on ecological and biogeographical criteria. Few exotic species become invasive in a given area. According to the probabilistic "ten rules" (Williamson & Fitter, 1996), 10% of imported species would escape cultivation or captivity. Then 10% of these escaped species would naturalize. Finally, 10% of naturalized species would become invasive. Thus, one imported species out of a thousand would become invasive.

Amongst the identified invasive exotic species responsible for the most harmful consequences, plants represent one of the main groups (Vilà *et al.*,

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02. Introduction

• *Zboralski Antoine*
• *Bellanger Richard*
• *Chevallier Joëlle*
• *Mellerin Yannick*
• *Ducatillion Catherine*

2009). The ecological success of an exotic plant species in its range of introduction depends on its own characteristics, but also on its interactions with the ecosystem it has been introduced in (Meerts *et al.*, 2004). Several hypotheses have been suggested to explain the ecological success of invasive exotic plant species (Hierro *et al.*, 2005), such as the propagule pressure, the enemy release or the disturbance hypotheses. These have been put into practice on some case studies of exotic plant species invasion, such as *Lantana camara* L. (Sharma *et al.*, 2005) or *Acacia dealbata* Link (Lorenzo *et al.*, 2010), bringing a better understanding of the underlying invasion mechanisms. Given the available knowledge, some risk assessment methods and good practices guidelines have been developed to prevent the introduction and the expansion of invasive species in susceptible ecosystems (Pheloung *et al.*, 1999; Weber & Gut, 2004; Branquard, 2009; Heywood & Brunel, 2009; Brunel *et al.*, 2010).

Exotic plant species introductions are known to occur through botanic gardens (Hulme, 2011). These have been implicated in the import of multiple invasive species, considered harmful according to the International Union for the Conservation of Nature (Lowe *et al.*, 2000). At the moment, risk assessment tools and good practices guidelines are not widely employed within botanic gardens (Hulme, 2015), paving the way to new potentially invasive plant species' introductions. The introduction and acclimatization roles of botanic gardens are indeed far from being obsolete. In a context of global climate change, botanic gardens represent a unique plant germplasm acclimatized to local environmental conditions that can be used to find new species of economic relevance (Heywood, 2011). They could also be used to identify potential pests and pathogens native to the gardens' area, susceptible to attack exotic plant species (Britton *et al.*, 2010). This could provide information on potential future invasive pests and pathogens in the countries from which the plant species originate.

In this context, the Villa Thuret botanic garden is willing to set up an invasive plant species policy. This garden is located in Antibes, France, on the coastline of the Mediterranean basin. This basin is considered as one of the main biodiversity hotspots worldwide (Myers *et al.*, 2000), with about 13,000 endemic plant species. As other hotspots, it is threatened by invasive species (Muller, 2004; Underwood, 2009). At a regional scale, an invasive plant species management strategy has already been set up in France (Terrin *et al.*, 2014). Nonetheless, an early detection of these species in introduction areas such as the Villa Thuret botanic garden could make the management easier and cheaper. The garden counts more than 1,000 exotic species divided into 140 families and 450 genera, originating from diverse regions of the world and potentially able to regenerate.

To early assess the invasion potential of these species, a field experiment has been set up in the botanic garden itself. This study aims at (i) detecting the exotic plant species able to regenerate and spread, (ii) determining the likely death causes of the spontaneous seedlings and (iii) knowing the key factors allowing the species at risk to reproduce in the garden.

Materials & methods

1. STUDY SITE

The study site is the Villa Thuret botanic garden, located on a peninsula in Antibes (France) at the coordinates 43°33'50"N, 07°07'27"E (NTF system).

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02. Materials & methods

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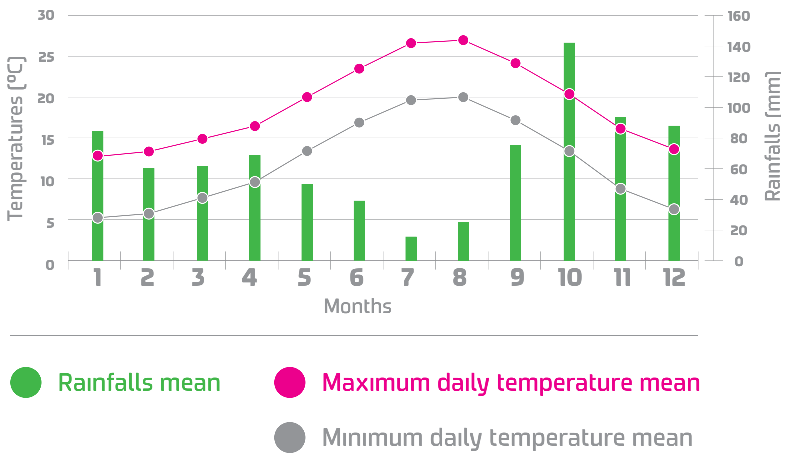
This is a 3.5ha-garden created in 1857 on a basic soil made of volcanic clay. The climate is Mediterranean, consisting of fall and winter rainfall, as shown on **fig. 1**, and a hot and dry summer. The average annual rainfall and temperature are respectively 803 mm and 15.6°C. The garden is not watered and does not receive neither amendments nor chemical treatments. Every species planted in the garden is taxonomically identified at least to the genus.

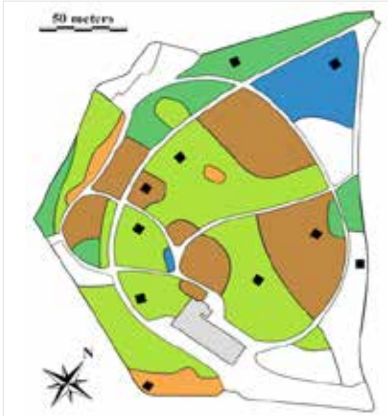


> FIGURE 1.

Monthly rainfalls, maximum and minimum daily temperatures at the botanic garden; means of the period 2004-2013.

2. SEEDLINGS INVENTORY AND CREATION OF A SEEDLINGS HERBARIUM

In order to list the plant species able to reproduce, a seedlings inventory is conducted on a regular basis, namely during the garden maintenance operations. The number of seedlings of each spotted species is not determined, only the names of the genus and of the species are ascertained. Since the seedlings' morphology may not be similar to the adult plants' morphology, the taxonomic identification may be problematic. Thus, a seedlings herbarium has been created to facilitate the identification process.



Type	*Characteristics of the micro-habitats* *Ground cover*	*Tree cover (%)*	*Drainage*	*Surface (m²)*
1	gr.	< 5	+	9900
2	gr.	25-50	+	3800
3	d.l.	25-50	+	1100
4	d.l.	50-75	+	7100
5	d.l.	> 75	-	2200
	Not characterised			4800

> FIGURE 2.

Left: Distribution of the observation plots in the different micro-habitats of the garden; *Right:* characteristics of the micro-habitats regarding the chosen criteria ("gr." = grassland; "d.l." = litter of dead leaves; "+" = no stagnant water; "-" = stagnant water).

3. OBSERVATION PLOTS MONITORING

One of the main constraints of the botanic garden is the maintenance, which aims especially at removing weeds and at keeping the garden clean and safe for the visitors. In this context, the development of natural seedlings may be impaired, preventing any study. Hence, ten 16m²-plots without any maintenance operation have been set up in the garden. Their number and size arise from a compromise between scientific issues and the acceptability of the staff and of the visitors. To prevent any edge effect, an additional one meter wide strip without maintenance is established around each plot.

To distribute these plots, a characterisation of the different micro-habitats of the garden has been carried out, based on three qualitative criteria possibly impacting the seedlings development: ground cover (grassland or litter of dead leaves), tree cover (determined as classes of percentage of covering) and drainage (stagnant water after rainfall or not). It is presented on **fig. 2**. The plots have been distributed across the different micro-habitats according to the total surface of each one in the garden. Furthermore, they did not contain any planted individuals. Some areas of the garden did not display the chosen characteristics. They were not taken into account for this study, except for one area with conifers, where an additional plot was set up.

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02. Materials & methods

• Zboralski Antoine
• Bellanger Richard
• Chevallier Joëlle
• Mellerin Yannick
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At the beginning of the monitoring, a phytosociological census has been performed to determine the different species growing in each plot. Afterwards, inventories of the exotic species' natural seedlings have been planned every six months for each plot. More precisely, these inventories take place between the rainy season and the dry season, in order to assess the impact of rainfall, cold and drought. Several variables are measured: species, new seedlings germination, distance from the presumed parent plant, seedlings survival and seedlings height. The presumed parent plant of a seedling is the closest adult plant of the same species known to produce seeds. This monitoring has been planned for five years and started in April 2014.

Results

1. SEEDLINGS INVENTORY

At the presentation date, this study was not completed. Thus, only the first results are available. To date, 29 different exotic species have been identified among the detected seedlings in the garden (**table 1**), representing 19 families. The precisely identified species are all represented by planted individuals in the garden. For some seedlings, only the genus has been determined: the species could not be differentiated at the seedling's stage.

Family	Genus	Species	Area of origin
Anacardiaceae	Pistacia	spp.	-
Araucariaceae	Araucaria	*bidwillii* Hook	Australia
Arecaceae	Jubaea	*chilensis* (Mol) Baill.	South America
Berberidaceae	Berberis	sp.	-
Ebenaceae	Diospyros	*whyteana* (Hiern) F.White	Africa
Elaeagnaceae	Elaeagnus	*macrophylla* Thunb.	China, Japan
Ericaceae	Arbutus	*x thuretiana* Dem. Nothosp. Nov,	France (hybrid)
	Arbutus	spp.	-
Fabaceae	Acacia	*implexa* Benth.	Australia
		iteaphylla F.Muell. ex Benth.	Australia
		melanoxylon R.Br.	Australia
		paramattensis Tindale	Australia
	Albizia	*polyphylla* E.Fourn	Africa
	Vachellia	*nilotica* (L.) P.J.H.Hurter & Mabb.	Africa, Asia
Fabaceae	Quercus	spp.	-
Lauraceae	Umbellularia	*californica* (Hook. & Arn.) Nutt.	North America
Menispermaceae	Cocculus	*laurifolius* DC.	Asia
Myrtaceae	Eucalyptus	sp.	Asutralia
	Syzygium	*paniculatum* Gaertn	Australia
Pittosporaceae	Pittosporum	spp.	-
Rosaceae	Cotoneaster	*divaricatus* Rehder & E.H.Wilson	China
	Prunus	*ilicifolia* (Nutt. ex Hook. & Arn.) D.Dietr.	North America
Rutaceae	Zanthoxylum	*simulans* Hance	Asia
Salicaceae	Xylosma	*congesta* (Lour.) Merr.	Asia
Sapindaceae	Koelreuteria	*bipinnata* Franch.	China
	Sapindus	spp.	-
Simaroubaceae	Ailanthus	*altissima* (Mill.) Swingle	China
Ulmaceae	Celtis	sp.	-
	Zelkova	*serrata* (Thunb) Makino	Asia

> TABLE 1.

Inventory of exotic species able to produce seedlings. The areas of origin have been ascertained with the GRIN database (Taxonomy Germplasm Resource Information Network – Global Web v.1.9.4.2.; available at: https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysimple.aspx)

2. OTHER EXPECTED RESULTS

Besides a list of the exotic species able to produce seedlings, this experiment is expected to provide knowledge about the average dispersal distance from the presumed parent plants, the seedlings' growth and survival rates and the germination conditions depending on environmental parameters.

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02. Discussion

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This experiment aims at detecting potentially invasive exotic plant species before they escape the botanic garden. It also aims at identifying key factors allowing these species to reproduce within the garden and at determining the likely death causes of spontaneous seedlings. Since it has been planned for five years and started in 2014, it is premature to draw clear conclusions from the first obtained results. Nonetheless, it seems that at least 29 exotic plant species were able to cross the reproductive barrier and started the naturalisation process, leading to sustainable populations on multiple lifecycles (Richardson *et al.*, 2000). If they succeed, they would eventually be able to spread into their new environment. To better assess this ability, the collected data could be processed with risk analysis tools, such as those used for forestry arboreta (Ducatillion *et al.,* 2015). Amongst these species, some have already been identified in the botanic garden region as invasive or potentially invasive exotic species, such as *Acacia melanoxylon* or *Ailanthus altissima* (Terrin *et al.*, 2014). Others belong to the same genus as identified invasive exotic species or with high invasion risk, such as *Pittosporum* spp., Elaeagnus spp. or *Eucalyptus* spp. This is considered as an invasion factor in the risk analysis method proposed by Weber & Gut (2004). Hence, a tightened monitoring of these species in the garden should be performed.

To better assess the efficiency of this experimental design to detect potentially invasive exotic plant species, it could be applied in other botanic gardens of the region. Even if each garden has its own singularities, the characterisation used for the Villa Thuret botanic garden is based on general criteria that can be adapted to other gardens. The collected data would provide a valuable source of information on future potential threats regarding invasive exotic plant species.

A stumbling block remains regarding the taxonomic identification of the detected seedlings. Although a seedlings herbarium helps identifying the species, some seedlings do not display enough morphological characteristics to be specifically identified. Thus, it would be interesting to use molecular techniques to address this issue, such as barcoding methods (Kress *et al.*, 2005).

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02. References

• Zboralski Antoine
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THEME C:

HERITAGE, CULTURE & TOURISM

03.


THEME C
HERITAGE, CULTURE & TOURISM

CAN A HISTORIC GARDEN BECOME A BOTANIC ONE?

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> Keywords HISTORIC GARDEN BOTANIC GARDEN CHANGE OF THE FUNCTION CONSERVATION RESTORATION ADAPTATION PLANT COLLECTIONS

03. Introduction

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WHAT IS A GARDEN?

THE ETYMOLOGY OF THE WORD “*GARDEN*”, BEING OF GERMANIC ORIGIN, MEANS “*YARD*” OR “*ENCLOSURE*” AND DENOTES SOME WAYS OF ORGANIZING LAND, WATER AND PLANTS (WWW.ENCYCLOPEDIA.COM/TOPIC/GARDEN.ASPX).

According to Lucio Morrica (1994) the term “*garden*” refers to “*non-industrial developed land (in economic terms), in which people can perform a wide range of activities in contact with nature, such as rest, leisure, play, walk, plant cultivation*”. Creating a garden is putting together ingenious structure of geometric or fantastic shapes, in order to achieve a purely aesthetic result.

WHAT IS A HISTORIC GARDEN?

According to the Florence Charter, a historic garden is “*an architectural and horticultural composition of interest to the public from the historical or artistic point of view. As such, it is to be considered as a monument.*

The historic garden is an architectural composition whose constituents are primarily vegetal and therefore living, which means that they are perishable and renewable. Thus its appearance reflects the perpetual balance between the cycle of the seasons, the growth and decay of nature and the desire of the artist and craftsman to keep it permanently unchanged.” (Icomos, 1981).

WHAT IS A BOTANIC GARDEN?

Bulgarian legislation determines the botanic garden as “*an institution, which supports collections of living plants for the needs of experimental botanical research, natural science and environmental conservation education, and is open to visitors for more than five months a year.*”

BGCI has considered what makes a botanic garden different from a public park or pleasure gardens: “*Botanic gardens are institutions holding documented collections of living plants for the purposes of scientific research, conservation, display and education.*” (BGCI, 2000).

The aim of the presented paper is to study the possibility of raising the rank of a historic garden to a botanic garden – i.e. garden of special function. In order to achieve the above mentioned aim the following objectives are put forward:

• Trace the development

> Keywords HISTORIC GARDEN
BOTANIC GARDEN CHANGE OF THE FUNCTION
CONSERVATION RESTORATION ADAPTATION
PLANT COLLECTIONS

03. Introduction

• *Kosev Krasimir*
• *Dyankova Vera*
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- Explore the change of the function of a Bulgarian historic park into a botanic garden
- Discuss the possibility of re-functionalization by the method of induction.

The University Botanic Garden in Sofia

What are the possible answers to the question "Can a historic garden become a botanic one?" The answer is 'yes', if the garden is a historic one by its origin. An example of such a garden in Bulgaria is the University Botanic Garden in Sofia, which is also a historic one from the point of view of history of botany and science and being the first Botanic Garden established during the Third Bulgarian Kingdom. It was founded by the first Bulgarian professor of botany – Dr. Stefan Georgiev, in the yard of the School of Higher Education, which is nowadays the University of Sofia "St. Kliment Ohridski". The Botanic Garden was established in 1892. It has a conservatory which holds exotic and other plants and a rockery with a rich variety of alpine species. The University students studying Botany have their activities in the garden. According to the definitions, this is a typical historic botanic garden.

Case study: the University Botanic Garden in Balchik

Another answer to the above question is 'yes' it can, depending on its relevant adaptation. A proof of this is our present case study: the University Botanic Garden in Balchik.

HISTORY

A summer residence of the Romanian Queen was built in the beginning of the XXth century in Southern Dobrudzha, Bulgarian territory occupied by Romania. This was a place for recreation of a particular royalty and her entourage. A terraced park, which now has status of historic garden, was built. After 16 years of seasonal use, the political situation changed. The Treaty of Craiova was signed in 1940. Romania returned Southern Dobrudzha to Bulgaria, so the residence gained new status. A few years later, the political situation changed again and both countries became republics.

After all, the park was neglected and abandoned. In 1955 it was decided by the Bulgarian government to ask the Bulgarian botanist, Academician Daki Yordanov, who was Rector of Sofia University from 1956 to 1962, to establish a botanic garden on this place. The royal park with seasonal use became a botanic garden of the Sofia University dedicated to "*educational and scientific purposes*" (Bulgarian legislations) open to public for year-round visits.

PRESERVATION OF GARDEN AND PARK ART

The activities for the preservation of a historic garden are defined in the Florence Charter and include maintenance, conservation and restoration (Icomos, 1981). In reliance with the implementation of these activities, a team of specialists from University Botanic Gardens carried out a historical research of the Balchik palace gardens.

The comparative analysis of the managing of the park during different historic periods with respect to different function is based on the data from various historical studies and archives. The components of a historic garden

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03. Case study: the University Botanic Garden in Balchik

• Kosev Krasimir
• Dyankova Vera
• Pencheva Lyuba

were compared with the components of the park studied, following the Article 4 of the Florence Charter (1981). The changes of the function of the site were traced back.

PLAN AND TOPOGRAPHY

The historic park has an area of 6.45 ha, located in northeastern Bulgaria, about 2 km Southwest of the town of Balchik. It covers land at the seashore at an altitude from 0 to 35 m. The characteristic which is typical of the site is its location along the Black Sea in East – West direction but facing South. The park consists of different geometrically shaped gardens. The landscape is the main structural factor, which determines the positioning of the gardens on terraces. "*There are nine terraces at different altitudes, five of which are truly gardens*" (Boia, 2014). In some parts of the garden, the steep terrain necessitated the building of numerous stone walls, between which there are lanes and tunnel-like arches.

Today, the Botanic Garden covers a bigger area of 19.4 ha (**Figs 1** and **2**).

> **FIGURE 1.**
The historic part of the Botanic Garden

> **FIGURE 2.**
The Botanic Garden after 2005

> Keywords HISTORIC GARDEN BOTANIC GARDEN CHANGE OF THE FUNCTION CONSERVATION RESTORATION ADAPTATION PLANT COLLECTIONS

03. Case study: the University Botanic Garden in Balchik

• Kosev Krasimir
• Dyankova Vera
• Pencheva Lyuba

VEGETATION

The Romanian Queen Maria, being a granddaughter of Her Majesty Queen Victoria, adhered to the English tradition of gardening and selection of plant species in the park. The vegetation is a component that follows its biological life cycles, so its look in the past is evidenced by archival and photographic materials.

The present research confirmed the conclusion that a huge variety of ornamental species definitely with seasonal aspect were grown on the spot (**Fig. 3**). Some of the most popular flowers planted in the garden were different varieties of: irises, petunias, larkspurs, dahlias, tulips, lupines, godetias, nasturtiums as well as roses, moss roses, asters and daffodils and the lilies – flowers that are related to the English gardening. "*But although a whole lifetime lies between that lily walk in far Dobrodzha and those first lilies I ever saw, in papa's little garden plot, the scent of the Madonna lily always carries me back to the Swiss Cottage on the Isle of Wight*" *says Maria in "The Story of My Life*" (Marie, Queen of Romania, 1934).

> FIGURE 3

Seed lists and orders justify the seasonal character of the plant display

The autochthonous tree vegetation of this place consisted mainly of willows and poplar trees that are typical of the waterside habitats "*... many acacias and a special kind of lilac trees with a nice wine color blossoms.*" (Неделчев, 1943).

Apart from the park area, approximately 1/3 of the land was occupied by orchards, vegetable gardens and vineyards.

The Botanic Garden was created in 1955. The plant biodiversity was enriched by transferring plants from the University Botanic Garden - Sofia. The first arrivals were evergreen trees and shrubs that added color during the year-round use of the site. The enrichment of the plant biodiversity is an activity related to the change of the function of the garden, i.e. its transformation into a botanic garden.

"*The micro-climate is favorable for various foreign plant species – the sunny days during the year are more plentiful, and the humidity – quite high. The area is located on the very seacoast, in a deep bay facing southeast. It is sheltered from the cold northern winds. This is another favorable prerequisite for the successful cultivation of many species that could not thrive anywhere else. The autumn by the sea is long and dry, which favors the complete maturation of the seeds, particularly for species that have a longer growing season. The soil is very chalky and is not suitable for many plants...*" (Минчев, 1968).

Due to the specific environmental, climatic and topographic characteristics of the First Black Sea botanic garden in Bulgaria, a collection of exotic plant species was created. The expansion of the cacti and succulent species collection throughout the years is presented in **Table 1**. A Cacti conservatory was opened to the public in 2012 (**Fig. 4**).

> Keywords HISTORIC GARDEN BOTANIC GARDEN CHANGE OF THE FUNCTION CONSERVATION RESTORATION ADAPTATION PLANT COLLECTIONS

03. Case study: the University Botanic Garden in Balchik

• Kosev Krasimir
• Dyankova Vera
• Pencheva Lyuba

year	1955	1968	2015
Cacti and succulent species	0	250	3450

> TABLE 1

Evolution of the Cacti and succulent species collection

> FIGURE 4

The Cacti conservatory

STRUCTURAL AND DECORATIVE CHARACTERISTICS

The historic park was developed on a steep terrain with natural landslides, which was the reason for the terraced structure. Currently, the maintenance of the historic part is associated with regular strengthening of the specific support elements, in accordance with their original architectural appearance.

Numerous architectural park elements give the park its distinctive appearance. Some of these elements are pots, crosses, thrones etc. originating from Turkey (Istanbul), Dalmatia, Spain, Morocco, Moldova, Bessarabia, Bulgaria. The research revealed that some of them have disappeared over the years.

The conservation and adaptation of the historic garden requires new architectural park elements, such as park lighting, benches, signs, etc., to be compatible with the old ones.

WATER EFFECTS

At the beginning of the last century, the abundance of water in the area was an important natural resource. There was a network of shallow waterways, and water designed mirrors. They had not only decorative function but they created favorable microclimate conditions for the vegetation in terms of air moisture. Some of the waterways were used for irrigation too. The water sources and soil were allocated in view of the overall visual concept.

Today, along the coastline there is a shore strengthening facility “Damba” that changes the microclimate conditions in particular with the water bal-

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03. Case study: the University Botanic Garden in Balchik

• Kosev Krasimir
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• Pencheva Lyuba

ance. It also affects the vegetation by minimising the sea vapor and moisture. At present, the amount of available natural water is reduced. Partial restoration of the waterways is in progress.

FUNCTION AND ACCESS

The palace park is categorized as a park with limited access and seasonal character with respect to its function.

In 1955, the Minister of Culture being Principal of the Higher education ordered the establishment of a botanic garden in the palace park. The executive authorities changed the function of the historic park and that's how the site was opened to the public. In 2002, the main part of the palace garden (6.45 ha) was legally declared as a "*monument of garden and park art*" (Bulgarian legislation). In 2005, 17.4 ha of the territory of the Botanic Garden were declared Protected Area under the Protected Areas Act. In the same year, a garden of 0.7 ha for persons with disabilities was opened. In 2012 a new Con-

Period	1924-1940	1941-1954	1955 till now
Property	Romanian Royal	Special status	Bulgarian State
Function	**Royal garden**: recreation place of a royalty	Holiday residence	**Botanic garden**: Scientific, educational and social functions
Access	Limited	Limited	Public
Display	Spring - summer	Summer	All year round
Plant species diversity	Natural vegetation Spring and summer display orchard, vineyards and vegetables	The garden was neglected	Botanical collections containing more than 4 600 species incl. outdoor exposition of large-size cacti and succulents. Successfully introduced exotic species as ancient ginkgo, the metasequoia, the Japanese raisin tree and the rubber tree, the holm oak, the evergreen magnolia; rare and endangered species

> TABLE 2

Palace garden and Botanic garden: comparative table

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03. Case study: the University Botanic Garden in Balchik

• Kosev Krasimir
• Dyankova Vera
• Pencheva Lyuba

servatory of 800 sq. m. was opened. It holds a permanent exhibition of cacti and succulent species, and is the largest one of its kind on the Balkans.

The **Table 2** presents the change of the function of the garden with the time.

Today the University Botanic Garden - Balchik is one of the most visited tourist sites at Bulgarian Black Sea coast, a place for student practices, educational programs and different social activities, open to the public all year round.

Discussion

In Bulgaria there are gardens designed in the past and used for the royal family that over the time and according to the Florence charter definition now have the status of historic ones. These are: Park "Vrana" and Park "Euxinograde" – both with recreational functions till now.

The present research shows that a historic garden can become a botanic one if there is a scientific and policy makers' goodwill. This process includes historical research, professional conservation, restoration and adaptation as well as creating and development of plant collections in according to re-functionalisation.

The developing of a botanic garden from an historic garden is not an innate process. This change of the function is associated with intentional efforts. The categories "historic" and "botanic" garden are not mutually exclusive definitions of an object but the categories of different rank.

The comparison between the characteristics of the palace gardens, based on the historical research (Дянкова *et al.*, 2012) and the newly created ones in the same location – University Botanic Garden – Balchik, shows a successful change of one function of the garden, and adaptation of another of its functions. The preservation of the historic value of some major landscape and architectural elements creates conditions for the increase of the share of one of them – the vegetation. It has become a subject of scientific research and educational activity targeted at the preservation of plant biodiversity. Moreover, in this way a new social role has been achieved.

> Keywords HISTORIC GARDEN BOTANIC GARDEN CHANGE OF THE FUNCTION CONSERVATION RESTORATION ADAPTATION PLANT COLLECTIONS

03. Conclusion

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Can a historic garden become a botanic one?

Yes, following the Bulgarian example. The change of the function of the historic park into a botanic garden could be used as an approach for ***ex situ*** conservation of the plant biodiversity. This is possible only in compliance with the recommendations of BGCI and Global Strategy for Plant Conservation.

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www.encyclopedia.com/topic/garden.aspx

"THE RISE OF SYSTEMATIC BIOLOGY": A POTENTIAL NOMINATION TO THE WORLD HERITAGE LIST?

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> Keywords HISTORY OF SCIENCE
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HISTORY OF NOMENCLATURE
BIO-CULTURAL HERITAGE

03. Abstract

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"THE RISE OF SYSTEMATIC BIOLOGY" IS A SWEDISH INITIATIVE FOR A TRANSNATIONAL SERIAL NOMINATION TO THE UNESCO WORLD HERITAGE LIST. THE PROPOSED NOMINATION CONSISTS OF BOTANICAL GARDENS AND EXCURSION AREAS THAT WERE IMPORTANT FOR THE DEVELOPMENT OF SYSTEMATIC BIOLOGY IN THE 18TH CENTURY.

Botanical gardens potentially to be included in the nomination are: The Linnaeus Garden and Linnaeus' Hammarby (Uppsala, Sweden), Hortus botanicus Leiden (Leiden, the Netherlands), Chelsea Physic Garden (London, United Kingdom), Jardin des Plantes (Paris, France) and Bartram's Garden (Philadelphia, USA). Excursion areas that could potentially contribute to the nomination are Table Mountain National Park (Cape Town, South Africa), Kamay Botany Bay National Park (Sydney, Australia), Herbationes Upsalienses (Uppsala, Sweden), Råshult Curate's Residence Culture Reserve (Älmhult, Sweden) and areas near Nagasaki and Hakone (Japan).

These gardens and excursion areas together illustrate various aspects of the history of systematic biology in the 18th century. The sites carry a heritage present not only in garden structures, buildings and other remnants of scientific activities, but also in the form of remaining individuals and descendants to the collected specimens that once were essential for the scientific development. These extant plants and animals form a living bio-cultural heritage, which in some cases also have a unique scientific value.

> Keywords HISTORY OF SCIENCE
SYSTEMATIC BIOLOGY
HISTORY OF NOMENCLATURE
BIO-CULTURAL HERITAGE

03. Introduction

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"THE RISE OF SYSTEMATIC BIOLOGY" IS A SWEDISH INITIATIVE FOR A TRANSNATIONAL SERIAL NOMINATION TO THE UNESCO WORLD HERITAGE LIST (FIGURE 1).

The proposed nomination consists of some of the botanical gardens and excursion areas that were most important for the development of systematic biology in the 18th century.

Exploration activities all around the world and the promotion of natural sciences in many countries during the 18th century led to increasing knowledge of the global flora and fauna, and a need to develop the methods for identifying, naming, classifying and describing living things. Carl Linnaeus in Sweden introduced a binomial nomenclature (Linnaeus 1753, Linnaeus 1758), which later became a new standard way to communicate species names (McNeill & *al.* 2012; International Commission on Zoological Nomenclature 2000). Linnaeus also introduced a radical but artificial system to classify plants based on their sexual organs (Linnaeus 1735), and a fragment of a natural system (Linnaeus 1751). More comprehensive natural systems soon followed, e.g. in the works by the Paris botanists Michel Adanson (Familles des plantes, 1763) and Antoine-Laurent de Jussieu (Genera plantarum, 1789).

> FIGURE 1.

The symbol of "The Rise of Systematic Biology". ***Clockwise, from the top***: Hammarby Houseleek, Jovibarba globifera, at Linnaeus' Natural History Museum in Hammarby, Uppsala, Sweden – Sazanka, Camellia sasanqua, in Japan, described by Linnaeus' disciple Carl Peter Thunberg – Old Man Banksia, Banksia serrata, in Australia, collected by Joseph Banks and Linnaeus' disciple Daniel Solander and described by Carl Linnaeus the Younger – Cape Sugarbird, Promerops cafer, on King Protea, Protea cynaroides, both described by Linnaeus, the latter collected by Thunberg – Coco de Mono, Lecythis ollaria, in Venezuela, the genus described by Linnaeus' disciple Pehr Loefling and the species name published by Linnaeus based on Loefling's notes – Raccoon, Procyon lotor, in Delaware, USA, described by Linnaeus and further observed by Linnaeus' disciple Pehr Kalm. Illustration: Jonas Lundin

> Keywords HISTORY OF SCIENCE
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HISTORY OF NOMENCLATURE
BIO-CULTURAL HERITAGE

03. A global network

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Research facilities such as botanical gardens were the base of the 18th century scientists who cultivated, exchanged, studied and described newly discovered plants (and some animals), developed new theories and garden methods and educated new generations of scientists. The Linnaeus Garden (Uppsala, Sweden) was designed to illustrate, among other things, a new plant classification system. Linnaeus complemented this official academic garden by creating a private summer estate and private research facility outside of town (Linnaeus' Hammarby, Uppsala, Sweden). Jardin des Plantes (Paris, France) illustrates the scientific environment where some of the first natural systems of plant classification were developed. Bartram's Garden (Philadelphia, USA) was developed to facilitate plant exchange between North America and Europe. Chelsea Physic Garden (London, United Kingdom) was the first botanical garden in London, designed to display herbal, medicinal and "useful plants" and became one of the leading gardens in developing new garden techniques. The Hortus Botanicus Leiden (the Netherlands) was a centre of knowledge on non-European plants during the 17th and early 18th centuries, and attracted students from all over Europe.

In excursion areas around the world, scientists and explorers studied plants and animals and collected material that illustrated the diversity of life from different continents: Herbationes Upsalienses (Uppsala) and Råshult (Älmhult, Sweden) are directly linked to Linnaeus' works that are the starting points of scientific nomenclature of plants. Kamay Botany Bay National Park (Sydney, Australia) is the place of one of the first major scientific collections from Australia. Table Mountain National Park (Cape Town, South Africa) was frequently studied by scientists on passing ships. Hakone Mountains and Nagasaki (Japan) were the first sites in Japan visited by international botanists.

The Swedish sites mentioned above are included on Sweden's tentative list of future nominations to the World Heritage List. Discussions have been initiated with botanical gardens and excursion areas in other countries that could potentially also contribute to the nomination in the future (**Figure 2**).

> FIGURE 2.

Location of sites potentially to be included in the serial nomination. Basemap © US National Park Service

Bio-cultural heritage

Persons, publications, collections, other movable objects and immaterial heritage like knowledge cannot be inscribed on the World Heritage List, as there are other conventions and programmes for such kinds of heritage. The material, immovable heritage from systematic biology is present in buildings, garden structures, landscape elements and other remnants of scientific

> Keywords
HISTORY OF SCIENCE
SYSTEMATIC BIOLOGY
HISTORY OF NOMENCLATURE
BIO-CULTURAL HERITAGE

03. Bio-cultural heritage

activities. For a science such as systematic biology, the organisms themselves are also important: individual specimens that were studied by 18th century scientists and still survive in botanical gardens, descendants to these specimens and extant plant and animal populations. These plants and animals, in gardens or in nature, form a living bio-cultural heritage, which in some cases also have a unique scientific value. Modern DNA analyses may even link herbarium material to these living specimens.

Extant plants in historical excursion areas can be used to resolve nomenclatural issues. Examples from Linnaeus' excursion areas around Uppsala include modern collections used as conserved types of *Polygala vulgaris* (Applequist 2014), *Potentilla verna* (**Figure 3**; Brummitt 2011), *Mespilus cotoneaster* (Thulin & Ryman 2003), and epitypes of *Salix* x *fragilis* (Belyaeva 2009) and *Lycopodium complanatum* (Thulin *et al.* 2009).

Collections by Joseph Bank and Linnaeus' student Daniel Solander from Botany Bay near Sydney have been used to study changes in vegetation since 1770 and to suggest rehabilitation of remnants of the original vegetation in the area (Benson & Eldershaw 2007).

In a genetic study of Siberian crab apple, *Malus baccata*, the type material in Linnaeus' herbarium was compared with extant garden specimens and wild material (Andreasen *et al.* 2014).

The Franklin tree, *Franklinia alatamaha,* was first discovered in Georgia in 1765, collected by William Bartram in 1770 and is extinct in the wild since the early 19th century. All living specimens today are descendants to those cultivated in Bartram's Garden (Merkle 2013).

> FIGURE 3

Collecting of conserved type of *Potentilla verna* L. in Uppsala 2010. Photo: Anders Larsson

> Keywords HISTORY OF SCIENCE
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HISTORY OF NOMENCLATURE
BIO-CULTURAL HERITAGE

03. Conclusions

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Systematic biology, Linnaeus, Buffon or other important scientists cannot be inscribed on the World Heritage List. But, it could be possible to nominate sites for inscription, if they carry a material heritage from scientific activities.

The gardens and excursion areas mentioned in this paper together illustrate various aspects of the history of systematic biology in the 18th century. The sites carry a heritage in the form of garden structures, buildings, bio-cultural heritage and other remnants of scientific activities.

Scientific work is a kind of cultural activity that is currently represented in relatively few World Heritage Properties. Inscribing more sites that carry a heritage from various scientific developments, could therefore contribute towards enriching the World Heritage List. A network of collaborating partner sites in several countries can contribute to a global perspective on our understanding of the history of science and the importance of biological diversity. An increased recognition of bio-cultural heritage could facilitate the linking of nature and culture conservation efforts.

More information on the nomination initiative can be found on: http://www.lansstyrelsen.se/uppsala/varldsarv/

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LISBON'S HISTORIC GARDENS AND THEIR TREES COLLECTIONS OF VARIOUS ORIGIN AND THREAT

© Tapada Necessidades with *Celtis australis* subsp. *australis* e *C. australis* subsp. *caucasica*, *Jorge de Sousa*

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03. Abstract

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LISBON'S MEDITERRANEAN CLIMATE ALLOWS THE COEXISTENCE OF DIFFERENT TREE SPECIES, FROM NORTHERN EUROPE TO SUBTROPICAL CLIMATES.

This botanical richness is due in large part to the Portuguese Discoveries and contact with other cultures that meant plant species from around the world came to Portugal, particularly to Lisbon. These plants from all over the world, cultivated in public and private gardens and parks, were a challenge for naturalists, gardeners and horticulturists. In addition to its aesthetical value, this botanical diversity plays a central role in increasing biodiversity and promoting urban ecological sustainability. Within the framework of the project "LX GARDENS - Lisbon's Historic Gardens and Parks: Study and Landscape Heritage Inventory" (financed by FCT: PTDC/EAT-EAT/110826/2009) an historical, artistic and botanical study of Lisbon's Public Gardens (from the 18th century up to the 1960's) has been conducted. This research studied the historic and botanical components of 60 Lisbon's historic gardens as part of the city's Cultural Heritage. One of the aims of this study was to contribute to the identification and evaluation of Lisbon's historic gardens botanical diversity. However, the distinctiveness of each garden, its heritage importance and its use as a public space were also factors in determining its overall value. City gardens contribute significantly to the well-being of all those who live there and contribute to a sustainable city. The botanical study in question included a plants survey (height > 2 m) of each garden that identified and placed the plants on a map with GIS localization tools. This study made it possible to identify and quantify up to 26,000 trees in 64 gardens. Many of the taxa are singular such as *Curtisia dentata* (Burm.f.) C.A.Sm.; *Harpullia pendula* Planch. ex F. Muell.; *Melaleuca styphelioides* Sm.; *Pinus ayacahuite* Ehrenb. ex Schltdl.; P. *torreyana* Parry ex Carrière; *Schinus latifolius* (Gillies ex Lindl.) Engl.; S. *lentiscifolius* Marchand; *Taxodium huegelii* C.Lawson; *Trichilia havanensis* Jacq.; *Trochodendron aralioides* Siebold & Zucc.. Some are threatened cultivated plants such as: *Afrocarpus mannii* (Hook.f.) C.N.Page; *Araucaria angustifolia* (Bertol.) Kuntze; A. heterophylla (Salisb.) Franco; *Austrocedrus chilensis* (D.Don) Pic.Serm. & Bizzarri; *Caesalpinia paraguariensis* (Parodi) Burkart; *Cedrus libani* A.Rich.; *Chamaecyparis formosensis* Matsum; *Chrysophyllum imperiale* (Linden ex K.Koch & Fintelm.) Benth. & Hook.f.; *Cupressus bakeri* Jeps.; C. *goveniana* Gordon; *Dracaena draco* (L.) L.; *Metasequoia glyptostroboides* Hu & W.C.Cheng; *Pinus radiata* D.Don. Some of the trees inventoried stand out because of their size, structure, age, rarity or for historic and cultural reasons, and as a result have been classified by the Institute for Nature Conservation and Forests, thus adding to Lisbon's ecological, landscape, cultural and historic heritage.

> Keywords TREE SPECIES LISBON PORTUGAL HISTORIC GARDENS DIVERSITY CONSERVATION

03. Introduction

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© Tapada Necessidades with *Celtis australis* subsp. *australis* e *C. australis* subsp. *caucasica*, ***Jorge de Sousa***

THIS STUDY THAT IS PART OF THE PROJECT ENTITLED "LX GARDENS - LISBON'S HISTORIC GARDENS AND PARKS: STUDY AND LANDSCAPE HERITAGE INVENTORY" [...]

[...] (financed by FCT: PTDC/EAT-EAT/110826/2009), was undertaken by an interdisciplinary team (botany, landscape architecture, history of art, etc.) which conducted an historical-artistic and botanical analysis of historical gardens, estates and parks in the city of Lisbon from the 18th century up to the 1960's.

The project studied the history of 70 public and private gardens in Lisbon, from the city's first public garden, *Passeio Público* (the Public Walk) which was created in 1764 and is now *Avenida da Liberdade*, up to the Modernist period, represented by the Calouste Gulbenkian Foundation Garden (dating from the 1960's). This research led to greater knowledge of Lisbon's landscape heritage and has helped enhance the value and profile of that heritage, as well as promote cultural tourism.

This paper delivers the taxonomic study of the specimens (height > 2 m) to be found in Lisbon's historic parks and gardens. The species which have been growing in these man-made ecosystems are intended to facilitate the conservation of urban biodiversity, and contribute to their aesthetic and biological value, while stressing the historical value of all these spaces.

Materials & methods

The study area that accounts to 3% of the total area of the city of Lisbon (100 km^2) consists of 64 historical gardens and parks (59 gardens with an inventory of existing trees and their location; 1 garden with a list of species, but not the trees location; and 4 gardens with both types of inventory). Of the 64 gardens studied (**Fig. 1**), 62 inventories were taken by the LX Gardens project team and 2 (Tropical Botanical Garden and the Calouste Gulbenkian Foundation Garden) were provided by the managing bodies.

The botanical study adopted the following methodology: taking of inventory, placing within the geographic information systems and specimen identification. All data collected were entered in a relational database built on a SQL

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03. Materials & methods

• Vasconcelos Teresa
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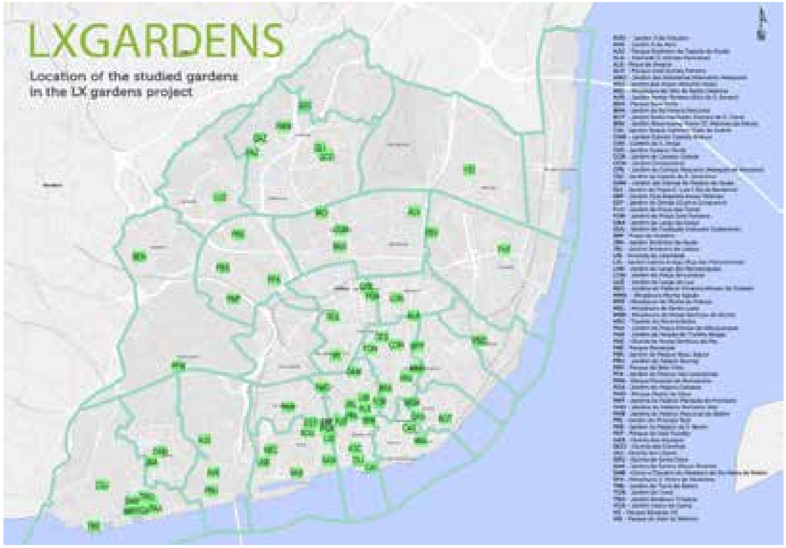
• Arsénio Pedro Forte Paulo

server 2014. The data were processed through a simple statistical analysis which allowed us to determine, for instance, the most frequent species and those found in the largest quantities.

The data entered into the SIG from 2011 to 2014, included the following items: (1) Specimen ID number; (2) Garden code; (3) Type of green space (Garden, Park, Botanical Garden, Enclosure and Hunting Ground or Recreation Ground); (4) Species code; (5) Family; (6) Genus; (7) Species; (8) Species classifier; (9) Geographic origin of the *taxa*; (10) Status of the region's plants life: native to mainland Portugal, non-native and/or invasive); (11) Growth form – Plant physiognomy; (12) ETRS 1989 coordinates; (13) Classified as being of public interest; (14) Legislation classifying the tree.

In terms of specimen identification, the study was conducted on the basis of external morphological features, using works of reference specific to the field – Bailey (1975), Bailey & Bailey (1976), Eggli (2003), Franco (1971, 1984); Franco & Afonso (1994, 1998, 1993), Huxley *et al.* (1992) and Walters *et al.* (1986, 1984, 1989, 1995, 1997) – and by comparison to specimens to be found in the João Carvalho e Vasconcellos herbarium (LISI) at Lisbon University's School of Agronomy.

Works of reference were used to check the names of families [Kubitzki, (1990, 1993, 1998a, b)], the names of species [The Plant List - version 1.1.] and the respective names of the authors of species [Brummitt & Powell, (1992)]. The geographic origin (Brummit, 2001) of each of the *taxa* was studied, as well as its conservation status under the IUCN categories of Walter & Gillett (1998).



> FIGURE 1.

Green areas inventoried by the "LX GARDENS - Lisbon's Historic Gardens and Parks" team project

Results & discussion

Across the 64 green spaces studied the inventory recorded 27.610 trees from 99 different species, belonging to 103 families. A preliminary analysis of the geographic origin of the existing species showed that of the 799 species ≈ 90% were non-native (720 species), ≈ 8% are native to mainland Portugal (66 species) and ≈ 2% are species deemed invasive under Decree-law no. 565/99 of 21 December (13 species). As for the quantity of plants covered by the inventory, we found that of the 27.610 trees present some 62% are non-native species (17.198 trees); 35% are native to the mainland (9.591 trees) and 3% are invasive species (821 trees).

The most frequent species are: *Celtis australis* L.; *Olea europaea* L.; *Pinus pinea* L.; *Fraxinus angustifolia* Vahl subsp. *angustifolia*; *Phillyrea latifolia* L.; *Cupressus*

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03. Results & discussion

• Vasconcelos Teresa
• Cunha Ana Raquel
• Soares Ana Luísa
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sempervirens L.; *Platanus* x *hispanica* Mill. ex Münchh.; *Cercis siliquastrum* L.; *Ligustrum lucidum* W.T.Aiton; *Phoenix canariensis* Chabaud; *Cupressus lusitanica* Mill.; *Jacaranda mimosifolia* D. Don.

However many of the taxa studies are singular such as *Curtisia dentata* (Burm.f.) C.A.Sm.; *Harpullia pendula* Planch. ex F.Muell.; *Melaleuca styphelioides* Sm.; *Pinus ayacahuite* Ehrenb. ex Schltdl.; *P. torreyana* Parry ex Carrière; *Schinus latifolius* (Gillies ex Lindl.) Engl.; *S. lentiscifolius* Marchand; *Taxodium huegelii* C.Lawson; *Trichilia havanensis* Jacq.; *Trochodendron aralioides* Siebold & Zucc.

Species	Status of the region's plants life	Presence
Celtis australis	Native	46
Cupressus sempervirens	Non-native	37
Jacaranda mimosifolia	Non-native	36
Ligustrum lucidum	Non-native	36
Cercis siliquastrum	Non-native	33
Olea europaea	Native	32
Punica granatum	Non-native	32
Platanus x hispanica	Non-native	31
Magnolia grandiflora	Non-native	31
Phoenix canariensis	Non-native	31
Pinus pinea	Native	29
Fraxinus angustifolia subsp. angustifolia	Native	26

> TABLE 1

The twelve tree species that are most frequent in the 64 gardens studied (LX Gardens 2011/14 survey)

Species	Status of the region's plants life	Trees nº
Celtis australis	Native	2 530
Olea europaea	Nnative	2 255
Cupressus sempervirens	Non-native	1 146
Platanus x hispanica	Non-native	1 022
Pinus pinea	Native	983
Fraxinus angustifolia subsp. angustifolia	Native	960
Cercis siliquastrum	Non-native	927
Ligustrum lucidum	Non-native	833
Phillyrea latifolia	Native	716
Phoenix canariensis	Non-native	589
Cupressus lusitanica	Non-native	482
Jacaranda mimosifolia	Non-native	460

> TABLE 2.

The twelve tree species with the largest number of plants to be found in the 64 gardens studied (LX Gardens 2011/14 survey)

Some are threatened cultivated plants such as: *Afrocarpus mannii* (Hook.f.) C.N.Page; *Araucaria angustifolia* (Bertol.) Kuntze; *A. heterophylla* (Salisb.) Franco; *Austrocedrus chilensis* (D.Don) Pic.Serm. & Bizzarri; *Caesalpinia paraguariensis* (Parodi) Burkart; *Cedrus libani* A.Rich.; *Chamaecyparis formosensis* Matsum; *Chrysophyllum imperiale* (Linden ex K.Koch & Fintelm.) Benth. & Hook.f.; *Cupressus bakeri* Jeps.; *C. goveniana* Gordon; *Dracaena draco* (L.) L.; *Metasequoia glyptostroboides* Hu & W.C.Cheng; *Pinus radiata* D.Don.

Based on these results we draw up two tables: **Table 1** refers to the 12 tree species that are most frequent in the 64 gardens studied, while **Table 2** contains the 12 tree species with the largest number of plants to be found in the 64 gardens studied.

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03. Results & discussion

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• Cunha Ana Raquel
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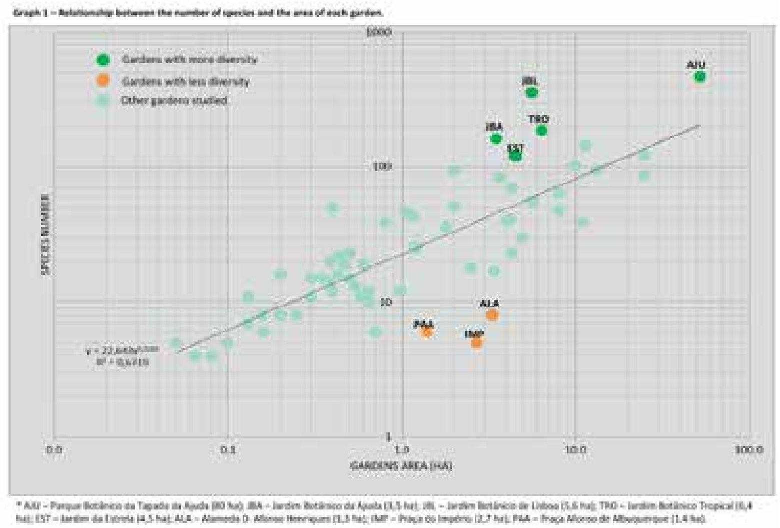
It should be noted that *Celtis australis* is both the most frequent and the most abundant species in the green spaces studied, as we can find 2.530 examples of this species in 46 of the 64 gardens studied. Among the 12 most populous species, five (42%) are species native to mainland Portugal - *Celtis australis* L.; *Olea europaea* L.; *Pinus pinea* L.; *Fraxinus angustifolia* Vahl subsp. *angustifolia*; *Phillyrea latifolia* L. – while the other seven (58%) are species that were non-native - *Cupressus sempervirens* L.; *Platanus* x *hispanica* Mill.ex Münchh.; *Cercis siliquastrum* L.; *Ligustrum lucidum* W.T.Aiton; *Phoenix canariensis* Chabaud; *Cupressus lusitanica* Mill.; *Jacaranda mimosifolia* D. Don.

Following the taxonomic study, **Graph 1** was drawn up which establishes a relationship between the number of species in each green space and its respective area. We draw attention to the following conclusions: 1) *Tapada da Ajuda* (AJU) is the green space that has the greatest botanical diversity, and also the largest area (100 ha). 2) Next come the botanical gardens (JBA, JBL, TRO) which are green spaces with greater species diversity. 3) Mention must be made of *Jardim da Estrela* (EST) due to its enormous botanical diversity, and the *Praça do Império* (IMP), *Praça Afonso de Albuquerque* (PAA) and *Vasco da Gama* (VGA) gardens because of the relatively low level of botanical diversity given their size.



> GRAPH 1

Relationship between the number of species and the area of each garden

Conclusion

Lisbon's climate allows the coexistence of various native and non-native tree species, from the North of Europe to subtropical climates. In addition to its inestimable aesthetic value, that botanical diversity provides a habitat for fauna, thus playing a critical role in the increase in biodiversity as well as in the sustainability of the urban ecological structure. That floral wealth is also due to the Portuguese Discoveries and to contact with other cultures that brought to Portugal, especially Lisbon, plant species from all over the world.

Across the areas studied, plant taxa were found from all over the world. Some of the trees inventoried stand out because of their size, structure, age, rarity or for historic and cultural reasons, and

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• Soares Ana Luísa
• Azambuja Sónia Talhé
• Arsénio Pedro Forte Paulo

03. Conclusion

as a result have been classified by the Institute for Nature Conservation and Forests, thus adding to Lisbon's ecological, landscape, cultural and historic heritage. In general the existing botanical gardens and parks are special places for preserving biodiversity ex situ and may also act as a host location for threatened cultivated trees.

Acknowledgements

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SIX HISTORICAL GARDENS AND THEIR CONTRIBUTIONS TO THE RISE OF SYSTEMATIC BIOLOGY

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03. Abstract

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CAN A SELECTION OF SIX BOTANICAL GARDENS FROM EUROPE AND NORTH AMERICA ILLUSTRATE SOME PARTS OF THE 18TH CENTURY HISTORY OF SYSTEMATIC BIOLOGY?

The science systematic biology developed rapidly in the 18th century, thanks to international collaboration. Some of the gardens that were important for the development of systematic biology in the 18th century, and still carry a preserved material heritage, have been preliminary identified and connected in an informal network:

The Hortus botanicus Leiden (the Netherlands) was a centre of knowledge on non-European plants during the 17th and early 18th centuries, and attracted students from all over Europe.

In 1683 the Hortus botanicus Leiden started a seed exchange program with Chelsea Physic Garden (London, UK). Chelsea Physic Garden was created in 1673 by the Society of Apothecaries of London for the training of apprentices about medicinal plants and their uses. The Physic Garden contained one of the first heated greenhouses.

In the 1740s, Carl Linnaeus re-designed the almost 100 years old academy garden in Uppsala (Linnaeus Garden, Sweden) in order to illustrate his new plant classification system. Linnaeus also created a private research facility at his estate Hammarby, to complement the academy garden.

The Jardin des Plantes (Paris, France) illustrates the scientific environment where some of the first natural systems of plant classification were developed. Founded in 1635 as a medicinal garden, it became an important scientific centre in the 18th century.

Bartram's Garden (Philadelphia, USA) was founded in 1728 and facilitated plant exchange between North America and Europe. It is the oldest preserved botanical garden in the Unites States.

Sweden is exploring if some, or all, of these gardens could be included in a future nomination to the UNESCO World Heritage List, together with excursion areas from around the world where important scientific collections were made.

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SYSTEMATIC BIOLOGY

03. Introduction

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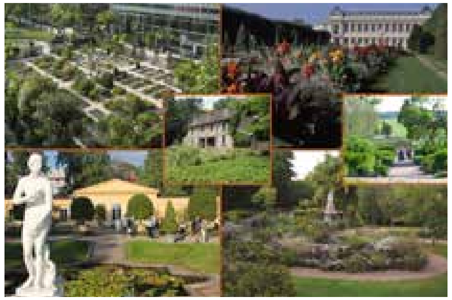

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BOTANICAL GARDENS AROUND THE WORLD CARRY A HERITAGE FROM THE LONG HISTORY OF BOTANICAL, AND OTHER, SCIENCES.

The field of science that is now known as systematic biology developed rapidly in the 18th century, thanks to international collaboration between botanical gardens in several countries. More and more scientifically undescribed plants were collected around the world. This massive influx of new species increased the need of better methods to grow, describe, name and classify the world's flora and fauna.

Some of the gardens that were important for the development of systematic biology in general and systematic botany in particular in the 18th century, and still carry a preserved material heritage, have been preliminary identified and connected in an informal network. This selection of gardens covers gardens important for classification (exemplified by the Linnaeus garden in Uppsala and Jardin des Plantes in Paris), and parts of a plant and information exchange network connecting, among others, London (Chelsea Physic Garden) with plants from North America (via Bartram's Garden in Philadelphia) and East India (via Hortus botanicus Leiden). The history of systematic biology is also related to the development of gardening methods, as exemplified by the works of Philip Miller in the Chelsea Physic Garden.

The Linnaeus garden and Linnaeus' Hammarby

Carl Linnaeus was responsible for several important developments within systematic biology during the 18th century. His most long-lasting contribution is a convenient naming system (the binomial system) and later scientists have established some of Linnaeus's works as the starting points for scientific names of several organism groups. Linnaeus also contributed to

> IMAGE 1

The Linnaeus Garden.
Photo: © Jesper Kårehed

> Keywords HISTORY OF SCIENCE
SYSTEMATIC BIOLOGY

03. The Linnaeus garden and Linnaeus' Hammarby

• *Rautenberg Anja*
• *van Uffelen Gerda*
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• *Achille Frédéric*
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the field of systematic biology through his attempts to classify the world's all plants and animals and by proposing standardized methods and terminology.

The garden that is today known as the Linnaeus Garden (Uppsala, Sweden) was created in 1655. In the 1740s, it was re-designed by Carl Linnaeus to illustrate his new plant classification system. Today, the Linnaeus Garden is an 18th century oasis in central Uppsala that gives excellent opportunities to learn about botany, 18th century or modern, and of past and present uses of plants. The former professor's residence now houses the Linnaeus Museum.

Linnaeus also created a private research facility at his beloved summer estate Hammarby, to complement the academic garden. At Linnaeus' Hammarby, about forty plant species still remain from Linnaeus's own plantations.

> IMAGE 2

Linnaeus' Hammarby. Photo: © Lennart Swanström, Länsstyrelsen i Uppsala län

> IMAGE 3

Jardin des Plantes. Photo: © M.N.H.N. / O. Borderie

Jardin des Plantes

The Jardin des Plantes (Paris, France) illustrates the scientific environment where some of the first natural systems of plant classification were developed by Bernard and Antoine Laurent de Jussieu and Michel Adanson. Founded in 1635 as the king's medicinal garden, it developed as an important scientific centre during the 18th century, to finally become the Muséum National d'Histoire Naturelle.

The 18th century structure of the garden has been largely preserved. It still hosts historical specimens of trees, introduced for the first time in continental Europe and studied by important botanists, such as Jospeh Pitton de Tournefort, or the Jussieus. One historical specimen is the pistacio tree (Pistacia vera) that was used by Sebastien Vaillant to demonstrate the sexuality of the plants in 1716, which in turn inspired Linnaeus's classification of plants. The plant collections are distributed in alpine, medicinal, phytosociological gardens, formal flower beds, glasshouses... The core of the Jardin des Plantes is the systematic garden which was reorganised six times according to the progress of the botanical classifications between 1683 and 2009. It is still a prominent place for discovering natural sciences and botany.

> Keywords HISTORY OF SCIENCE
SYSTEMATIC BIOLOGY

03. Chelsea Physic garden

• Rautenberg Anja
• van Uffelen Gerda
• Kårehed Jesper
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Chelsea Physic Garden (London, the United Kingdom) was an important node for plant exchange and a centre for development of garden methods in the 18th century. The garden was created in 1673 by the Society of Apothecaries of London for the purpose of training apprentices in how to recognise medicinal plants and study their uses. It is associated with many of the leading gardeners including Philip Miller (the author of the very popular Gardeners Dictionary, in several editions), William Aiton (who later became the first gardener at Kew), and William Forsyth (a Scottish botanist who went on to found the Royal Horticultural Society). Seeds and plants were being exchanged as early as 1683 with four seedlings of Cedrus libani exchanged between John Watts and Paul Hermann (from Hortus botanicus Leiden). This early exchange programme has become the Index Seminum an international seed exchange programme with more than 350 botanical gardens swapping seeds to each other annually. The Physic Garden also contained the first (in the United Kingdom) stove houses or heated greenhouses, built in 1680, and later in 1773 one of the first purpose built rock gardens.

Today the mission of the garden is to demonstrate the medicinal, economic, cultural and environmental importance of plants to the survival and well-being of humankind. It grows and maintains a collection of herbal and medical plants in documented labelled and interpreted displays in a historic botanic garden. It has education activities and events and it continues to demonstrate the development of the science and practice of horticulture, botany and related disciplines through the historic role of the garden.

> IMAGE 4

Chelsea Physic Garden. Photo: © Charlie Hopkinson

Bartram's garden

Bartram's Garden (Philadelphia, USA) served as a centre for the exchange of plants and natural history knowledge between North America and Europe in the 18th and early 19th centuries. Bartram's Garden was founded in 1728 by botanist John Bartram. In founding the garden, John Bartram cultivated and studied plants collected from his many travels in the British colonies in North America. Bartram corresponded extensively with European and American scientists and amateurs, channelling information on his explorations, collections and discoveries through Peter Collinson in London. Other scientific correspondents included Sir Hans Sloane and Philip Miller in London Johann Frederik Gronovius in Leiden, and Carl Linnaeus in Uppsala.

John Bartram in turn received most of the early Linnaean publications from his correspondents, and beginning in the 1730s directed specimens and botanic information on North American plant species to the systematic publication projects of Linnaeus and his collaborators. Bartram also made extensive collections of cryptogams and medicinal plants. The Bartrams funded their garden, and their travels and scientific research with a retail trade to Europe in new North American plants. More than 200 North American woody

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SYSTEMATIC BIOLOGY

03.

• *Rautenberg Anja*
• *van Uffelen Gerda*
• *Kårehed Jesper*
• *Achille Frédéric*
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plants were introduced into cultivation by the Bartrams, including the Franklin tree, *Franklinia alatamaha*, now extinct in the wild.

The botanic garden was continued and enlarged over three generations of the Bartram family. John Bartram's son, William Bartram continued his father's work to collect, describe and illustrate new American species. With the establishment of the new U.S. national government in Philadelphia in 1776, Bartram's Garden served as a de facto national botanic garden for several decades, serving as a place for new research, and a site of pilgrimage for its earlier botanic heritage. John Bartram's house and garden, and his 1760 greenhouse are preserved as a park in Philadelphia, part of the city Parks & Recreation system, and operated by the John Bartram Association. Bartram's Garden is the oldest preserved botanical garden in the Unites States and remains a vivid place for learning and inspiration.

> IMAGE 5

Bartram's Garden. Photo: © Joel Fry

> IMAGE 6

Hortus Botanicus Leiden. Photo: © Wim Sonius

Hortus Botanicus Leiden

The Hortus botanicus Leiden (the Netherlands) was a centre of knowledge on non-European plants during the 17th and early 18th centuries, through the import of plants from Far East Asia and the Cape via the Dutch East India Company. The garden was founded in 1590 by Leiden University for teaching and research purposes, but was also intended to be a public garden right from the start. The Hortus was visited by students from all over Europe, many of them attracted by the medicine lectures of Herman Boerhaave (director of the garden 1709–1730).

Today, the Orangery building from 1740–1744 and several plants (e.g. a tulip tree, *Liriodendron tulipifera* from the 1710s) remain from the long history of Hortus botanicus Leiden, in which the garden grew from 1,400 m^2 to three hectares. The tropical greenhouses, built in 1938, and restored in 2013, contain large research collections.

> Keywords HISTORY OF SCIENCE
SYSTEMATIC BIOLOGY

03. Conclusion

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- van Uffelen Gerda
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- Achille Frédéric
- Medway Susan
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A network of historical botanical gardens in several countries can contribute to a more global perspective on the history of science, by illustrating how collaboration and exchange has fuelled the scientific development for centuries. In such a network, experiences can also be shared about how to balance between the preservation of historical heritage and the need to develop the garden to reflect modern botany, research and public outreach.

There is potential to enrich the World Heritage List by inscribing more properties that carry a heritage from scientific developments. Sweden is exploring if some, or all, of these gardens could be included in a future nomination to the UNESCO World Heritage List, together with excursion areas from around the world where important scientific collections were made.

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http://www.lansstyrelsen.se/uppsala/varldsarv/

THURET GARDEN IN ANTIBES, FROM 1857 TO 1875: A BRANCH OF THE BOTANICAL GARDEN OF PARIS, FOR ACCLIMATIZATION

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> Keywords ACCLIMATIZATION ARCHIVES TRACE OF PLANTS INTRODUCTION BOTANICAL GARDEN NETWORK

03. Abstract

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BOTANIST GUSTAVE THURET CREATED A BOTANICAL GARDEN IN ANTIBES IN THE SOUTH OF FRANCE IN 1857. THE GARDEN WAS ORIGINALLY PRIVATE BUT WAS DONATED TO THE FRENCH STATE IN 1877.

It is now managed by INRA (French national institute for agricultural research) and is behind the introduction of thousands of exotic species in the Mediterranean climate, species that it has helped study and promote. Analysis of the extensive archives covering the period from 1857 to 1875 demonstrate the importance of the links forged with the Jardin des Plantes in Paris and the exchange of plants between the two institutions.

As part of reflections into the improvement of acclimatization processes, this study looks at several questions. Which species were first introduced at Jardin Thuret, bearing mind that some have now become commonplace in our region? Can we trace back the history of these introductions? Which trees are still alive today? Can we improve the methods for choosing, introducing and experimenting with new species adapted to cope with current climate changes on the basis of the results obtained over the last century and a half? Can the archives help us answer these questions and develop a plan for the future? Although it is too early to answer, the study of the flow of plants between Paris and Antibes reveals complementarities between the two institutions and the vital role played by Jardin Thuret in 1) cultivating new species in the French Mediterranean region, 2) botanical and horticultural knowledge of these species and 3) the production and dissemination of seeds.

Villa Thuret is still run as a scientific institution and acclimatization center for new species. The archives studied during this exploratory work show that in the 19th century, it was closely connected to the natural history museum in Paris (MNHN), which was in turn connected to the rest of the world; the Villa had in fact become a kind of Mediterranean branch of the MNHN. Several thousand species were introduced at Jardin Thuret between 1857 and 1875. At the end of this period, new plants able to live outdoors in Antibes accounted for some 2,691 taxa, 29% of which came from the Jardin des Plantes in Paris. In exchange, 1,871 seed batches collected at Jardin Thuret were added to the *Index Seminum* in Paris.

> Keywords ACCLIMATIZATION ARCHIVES TRACE OF PLANTS INTRODUCTION BOTANICAL GARDEN NETWORK

03. Introduction

• *Thévenet Jean*
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© La Villa Thuret au XIXème siècle, In : *La nature* n°1362 (1899)

THE EFFECTS OF CLIMATE CHANGE OCCURRING NOW ARE BEING FELT IN THE FOREST STANDS, WITH EXTENSIVE DIEBACK (DAVI, 2015), FIRES AND WIDESPREAD HEALTH ISSUES (DUPUY *ET AL.*, 2015).

If measures to adjust our current lifestyles are not taken soon, minimum annual average temperature will reach 3°C above the pre-industrial average by 2100 (IPCC, 2014). The commitments made in Paris during COP21 in December 2015 set the goal of a 2°C increase, or even 1.5°C if possible (COP21, 2015). We have already reached a 0.85°C rise (IPCC, 2014) and we can see the impact that this is having on certain landscapes. We can therefore expect much more severe upheavals and the strategic thing to do would be to anticipate them.

The time required for species and plant communities to adapt to these changes is much longer than the time it takes for the expected changes to occur, so one avenue of research currently be explored is assisted migration. (Lehtimäki *et al.*, 2015). To respond to new social and economic requirements such as the production of wood and other commodities, another avenue is the introduction and acclimatization of exotic species which would replace other species in biomes that the latter are no longer able to withstand. However, the scientific community often has a negative view of acclimatization due to the combination of concepts involved in the different phases of the overall process covered by the generic term acclimatization. However, the concept is regaining interest due to the possibilities it implies for the adaptation of plants to climate change (Heywood, 2011). It is therefore an area worth exploring as long as the different processes are defined, from the introduction and accommodation phases (Collin, 2001) to the adaptation and command of the technical and legal requirements and the biological risks.

The other issue is time: we do not have time to apply the same approach as our predecessors in the botanical gardens and ecological arboretums, a large number of which were created by INRA in France over the 20th century (Ducatillion *et al.*, 2015; Lamant *et al.*, 2015). Things need to move much faster! As such, we need to improve the methods and techniques used for the selection, introduction and experimentation with new species that show high potential, making use of historical documents. The Villa Thuret archives – those kept on site and those of its counterparts such as the Jardin des Plantes in Paris – could provide us with vital information and help us select species

> Keywords ACCLIMATIZATION ARCHIVES TRACE OF PLANTS INTRODUCTION BOTANICAL GARDEN NETWORK

03. Introduction

• *Thévenet Jean*
• *Gili Aurore*
• *Ducatillion Catherine*

adapted to the new challenges, on the basis of biogeographical or taxonomical criteria.

These goals of this exploratory work are 1) to present the wealth of historical documents available in both institutions, 2) demonstrate the diversity, complementarity and value of the data available and 3) retrace the flow of species introduced into the Mediterranean climate during the 19th century.

Materials & methods

During the 18th and 19th centuries, botany and horticulture combined their power to increase the number of cultivated exotic plants within gardens by massively introducing exotic species on our territory (Drouin, 1995). Acclimatization takes part in the plant domestication by incorporating the travel (Haudricourt *et al.*, 1987). Plants resulting from this complex process show different statuses from acclimatized species to naturalized species; some of these plants may even become invasive (Thevenot, 2013).

1. DÉFINITION

Regarding the purposeful introduction of a species outside of its natural distribution area, it can be deemed acclimatized if it can occasionally reproduce outside of its cultivation area but ends up withering without human intervention (Naudin *et al.*, 1887; Williamson et al., 1996; Richardson *et al.*, 2000; Pysek *et al.*, 2004).

type of documents	location
Thuret-Decaisne correspondence **1856-1875**	Library of the Institut de France, *Paris*
Naudin-Thuret correspondence **1858-1875**	Villa Thuret, *Antibes*
Naudin-Bornet correspondence **1858-1899**	Villa Thuret, *Antibes*
Index Seminum from Jardin des Plantes **1856-1900**	Library of the Service des cultures, *Museum Paris*
Descaine correspondence **1859-1883**	Library of the Service des cultures, *Museum Paris*
Registers input of seeds and plants **1831-1901**	Library of the Service des cultures, *Museum Paris*
Registers output of seeds and plants **1843-1900**	Library of the Service des cultures, *Museum Paris*
Archives of the Service des cultures **1823-1874**	Library of the Service des cultures, *Museum Paris*
Archives of the Service des cultures **1846-1860**	Library of the Service des cultures, *Museum Paris*
Archives of the Service des cultures **1861-1879**	Library of the Service des cultures, *Museum Paris*
Archives of the Service des cultures **1870-1907**	Library of the Service des cultures, *Museum Paris*
Open living plants **1859-1907**	Library of the Service des cultures, *Museum Paris*
Thuret, Bornet correspondence and notes **1857-1878**	Villa Thuret, *Antibes*
Naudin correspondence and notes **1878-1899**	Villa Thuret, *Antibes*

> TABLE 1

List of historical records used for this study

Acclimatization refers in this text only to the introduction and cultivation of small samples of wild species propagules (seeds or potted plants), whose natural area lies in a different geographical zone from that in which it is being cultivated. Here, these samples are called accessions.

2. TYPES OF DOCUMENTS

The material used includes all the historical documents (**Table 1**) providing information (or data) on the flow of exotic plants introduced at Villa Thuret between 1857 and 1875, or on the behavior of those plants (growth, flowering, fruiting, tolerance to cold weather incidents or drought). These are publications or unpublished documents, the originals of which are stored in Villa Thuret's historical library or the library of the culture department in the natural history museum in Paris (MNHN). Correspondence between Gustave Thuret and Joseph Decaisne is stored at the Institut de France. Copies of the original documents have been acquired with copies of photographs

> Keywords ACCLIMATIZATION ARCHIVES TRACE OF PLANTS INTRODUCTION BOTANICAL GARDEN NETWORK

03.

• Thévenet Jean
• Gili Aurore
• Ducatillion Catherine

produced by the authors, with permission from the institutions concerned. Although there are some gaps in certain sources, others make up for these shortfalls and help piece together the puzzle.

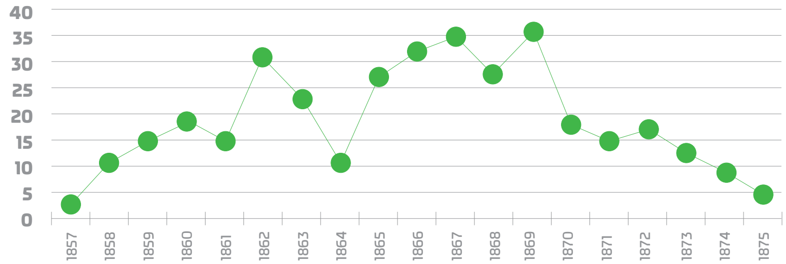
3. WORKING METHOD

Initial work involves identifying documents in the archives and accessing the documents and data. As the documents are read, raw data is systematically entered and scanned into a spreadsheet. The following information is recorded: archive reference, name of the author of the data, date of the data, name of the data entry operator, date of entry, Latin binomial of the plants, type of propagule (seed or plant), accession, origin where known, name of the correspondent or supplier, accession flow (batch received or batch sent), comments, observations and anecdotes (free text field on growth of the species, meteorological information, etc.), personalities mentioned, etc. This data is then cleaned up, updated (nomenclature) and completed with the bibliographical data characterizing the natural area of the species.

Results

1. BIRTH THURET GARDEN AND INTRODUCTION OF NEW SPECIES

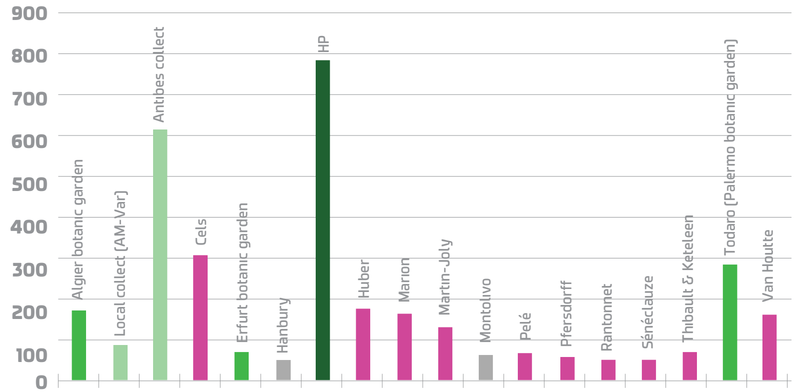
When Gustave Thuret moved to Cap d'Antibes in 1857, Joseph Decaisne held the culture chair at the MNHN in Paris. The two men had long worked together, as shown by the abundant correspondence between them, enabling us to trace the origins of the garden. The first plants arrived in autumn that year, and planting began in spring 1858. However, Thuret had great trouble finding horticulturalists locally. On 12 November 1857, he wrote to Decaisne: "*...Paris feels a long way away and there must be horticulturalists closer by [...]. There is no point trying to obtain anything here. The southerners' total neglect for horticulture is unthinkable...*" This forced him to develop a supply network stretching much further than just Antibes. In the early years, the MNHN became the main supplier of Jardin Thuret. Then the network expanded to include 36 French and foreign suppliers by 1869; this figure dropped off again, probably due to saturation in the garden and decreasing requirements (**Figure 1**).



> FIGURE 1

Total plant suppliers known versus time (1857-1875)

The suppliers were nursery owners, botanists and other botanical gardens. The most significant are shown in **figure 2**.



> FIGURE 2

Main suppliers from 1857 to 1875. * Plant Nurseries in pink, botanists worldwide ** in grey, Botanical Garden of Paris (HP) in dark green, other botanical gardens in green, local harvests in pale green.

> Keywords ACCLIMATIZATION ARCHIVES TRACE OF PLANTS INTRODUCTION BOTANICAL GARDEN NETWORK

03. Results

• Thévenet Jean
• Gili Aurore
• Ducatillion Catherine

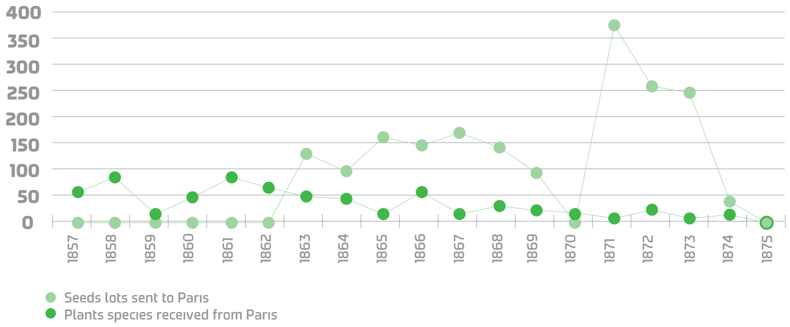
The data collected lets us trace the flow of accessions over time (**Figure 3**). The results are enlightening: in 1875, 2,691 taxa were listed at Jardin Thuret in a register drawn up in 1872 and added to until 1875: *Enumeratio Plantarum in horto Thuretiano cultarum*. In this inventory, 767 species living at Cap d'Antibes come from deliveries from the Jardin des Plantes. Each taxon may have been subject to several accessions which reached the total number of 4,290 in less than two decades. There is information to complete the list of living species, characterizing the accessions (potted plants or seeds) and plant growth (flowering, fruiting, seed production).

> FIGURE 3

Annual number of accessions across all suppliers and annual number of accessions from the Museum of Paris (HP) from 1857 to 1875 (ND= no date)

2. COLLECTION AND DISSEMINATION OF SEEDS

Gustave Thuret systematically harvested the seeds produced outdoors in his garden. From 1863 onwards, the flow of plants between Paris and Antibes was reversed (**Figure 4**). While we have not yet found the Index seminum for Jardin Thuret for that period, we have proof of its existence: In a letter to Joseph Decaisne dated December 1871, Gustave Thuret confirms that *"[he] will not produce a catalogue on [his] behalf this year and [he] will send him all his harvests from 1870 to 1871"*. The seeds harvested at Villa Thuret are therefore disseminated via the Index seminum of Paris. 1,871 seed batches were added to the MNHN's Index seminum between 1863 and 1875, including 372 taxa for 1871 alone.



> FIGURE 4

Number of accessions exchanged as a function of time (1857 to 1875)

The gardens at Villa Thuret in Antibes during the Thuret period (1857-1875) had become a "subsidiary" of the Jardin des Plantes in Paris, as subsequently mentioned in a handwritten archive dated December 1880: "*Naudin (Ch.) Director of Villa Thuret, the MNHN's branch in Antibes*".

3. SYNTHESIS OF EXISTING RAW DATA

The numerical data obtained to date for this period is as follows:

- Number of known suppliers: **36**
- Total number of accessions: **unknown**

> Keywords ACCLIMATIZATION ARCHIVES TRACE OF PLANTS INTRODUCTION BOTANICAL GARDEN NETWORK

03. Results

• *Thévenet Jean*
• *Gili Aurore*
• *Ducatillion Catherine*

- Total number of taxa introduced: **unknown**
- Number of accessions leading to a plant able to live outdoors at Jardin Thuret: **4,290** (2,905 in potted plant form and 1,286 in seed form), only 30% of plants were introduced in seed form
- Number of living taxa at Jardin Thuret in 1875: **2,691**
- Number of seed batches harvested at Jardin Thuret and sent to Paris: **1,871**
- Maximum number of taxa whose seeds were harvested the same year and sent to Paris: **372**, or 14% of taxa whose introduction was successful

Discussion

The archives collected and used for this study provide us with information on the methods used to create collections in a botanical garden in 19th-century France. The garden at Villa Thuret benefited from the extensive network of correspondents of the Jardin des Plantes in Paris, completing Gustave Thuret's already wide personal network. However, there are some uncertainties as to the exact bio-geographical origin of the seed batches or plants introduced, rarely specified by the supplier.

Jardin Thuret was designed to facilitate understanding of exotic species and this study shows the extent of the introduction efforts required for a garden like this to take form in less than 20 years and become a powerful force in acclimatization. The garden helped to diversify the range of plants used and contributed to economic growth on the Mediterranean coast, while leading to long-term changes to the landscapes. The introduction of palm trees in the second half of the 19th century and its consequences is one example that can be seen today (Ducatillion, 2013).

Only 30% of accessions were in seed form; this means that G. Thuret introduced thousands of potted plants. If we were to continue with this kind of introduction work, it would be neither possible nor recommended to use similar resources today, mainly for economic and phytosanitary reasons.

The current raw data shows that seeds were harvested from 14% of living taxa. However, this does not mean that the other species did not produce seeds.

The compilation of this first set of archives has helped characterize and quantify the flow of plants between Paris and Antibes. To improve the likelihood of success for future introductions, we would need to compare the full list of taxa introduced with the list of taxa that adapted to environmental conditions in Antibes. We are now aware of the taxa that were successfully introduced and of the efforts made for those taxa (in terms of number of accessions); however, we do not yet know the full introduction effort, in number of accessions and number of taxa. We cannot therefore characterize the successes and failures of introduction at this stage.

This study also shows the richness and quality of the historical archives. Not all of them have been made use of yet and certain sources have not yet been looked at (at suppliers other than the MNHN in Paris, for example). We can suppose that the sources are likely to increase, which would expand the data available for the period already covered and for the following decades – the "post-Thuret" period – from the end of the 19th century to the 20th century.

> Keywords ACCLIMATIZATION ARCHIVES TRACE OF PLANTS INTRODUCTION BOTANICAL GARDEN NETWORK

03. Conclusion

• *Thévenet Jean*
• *Gili Aurore*
• *Ducatillion Catherine*

The changes underway, especially in terms of climate change, are reigniting interest in the acclimatization of adapted species. This exploratory work has been done so that we can avoid introducing species doomed to failure and improve the success rate of introductions. To this end, we would like to compare the list of species introduced at Jardin Thuret and the list of species that have successfully developed in this host environment, in order to identify the criteria for success.

It has been possible to find and reunite a set of archive documents covering the Thuret period, from 1857 to 1875. An initial analysis of these archives demonstrates the introduction drive at the garden, which covered 5 hectares at that time, with 4,290 known accessions in fewer than two decades. These accessions led to a total 2,691 living taxa listed in 1875. We also have proof that at least 1,871 seed batches were sent to Paris. These batches reached a volume 372 different taxa harvested and sent in 1871, i.e. 14 years after the garden's creation. We can deduce that at least 14% of the plants introduced and growing outdoors in the garden reached sexual maturity.

This analysis shows the significance of the exchanges between the natural history museum in Paris (MNHN) and Jardin Thuret at that time. The MNHN was the main plant supplier for Thuret. After 5 years of existence, Jardin Thuret produced seeds that could be disseminated across the world via the MNHN. Jardin Thuret was then a branch of the MNHN in Paris.

Some of the accessions were registered on both sides, so it is now possible to piece together their history, trace certain seed flows and accurately date the arrival of species that thrived at Cap d'Antibes. With current biological resource conservation methods and efforts to understand the mechanisms behind biological invasions, this information is attracting much interest from the scientific community.

> Keywords ACCLIMATIZATION ARCHIVES TRACE OF PLANTS INTRODUCTION BOTANICAL GARDEN NETWORK

• *Thévenet Jean*
• *Gili Aurore*
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03. Acknowledgements

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THEME D:

CONSERVATION

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THEME D

CONSERVATION

BIODIVERSITY IN EUROPE: BETWEEN RISKS AND OPPORTUNITIES

Photo credit : Old olive orchard, Agistri island, Greece, *Dominique Richard*

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> Keywords BIODIVERSITY LOSS EUROPE BIODIVERSITY POLICIES NATURE-BASED SOLUTIONS GREEN INFRASTRUCTURE BOTANICAL GARDENS

04. Abstract

• *Richard Dominique*

THE COMMITMENT TO HALT BIODIVERSITY LOSS AND ECOSYSTEM DEGRADATION IN EUROPE WAS REITERATED IN 2010, BOTH BY EUROPEAN COUNTRIES AS CONTRACTING PARTIES TO THE CONVENTION ON BIOLOGICAL DIVERSITY, AND THE EUROPEAN UNION WITH ITS 2020 BIODIVERSITY STRATEGY.

Yet, environmental assessments and reports produced by the European Environment Agency with support from its European Topic Centres (ETCs) – among which the ETC on Biological Diversity – show that biodiversity in Europe continues to face multiple and increasing pressures which affect ecosystem resilience and jeopardize nature conservation efforts engaged since more than 30 years. In addition Europe's footprint on other regions of the world is severe. In these conditions, halting biodiversity loss is a collective challenge to be shared among decision makers and citizens, users and managers of the land, scientists and amateurs, people leaving in rural and in urban environments, each one with its own contribution. Because of their specificity and their large distribution across the continent, botanical gardens also have an important role to play, even more if they are well organized within a network, sharing common short and long term objectives.

> Keywords BIODIVERSITY LOSS EUROPE BIODIVERSITY POLICIES NATURE-BASED SOLUTIONS GREEN INFRASTRUCTURE BOTANICAL GARDENS

04. Better knowledge for better policy implementation

• *Richard Dominique*

Photo crédit : Old olive orchard, Agistri island, Greece, *Dominique Richard*

THE GLOBAL CHALLENGES POSED BY THE CONTINUOUS LOSS OF BIODIVERSITY REQUIRE THE MOBILIZATION OF A WIDE RANGE OF ACTORS AT ALL LEVELS OF ACTION AND DECISION, EACH WITHIN ITS OWN SCOPE OF INTERVENTION.

Out of the large spectrum of actions needed, building a solid and targeted knowledge base is necessary to guide the implementation of biodiversity-related policies and assess their effectiveness.

In Europe, the European Environment Agency (EEA), based in Copenhagen has the specific mandate to '*support sustainable development and to help achieve significant and measurable improvement in Europe's environment through the provision of timely, targeted, relevant and reliable information to policy making agents and the public*', in partnership with 33 European member countries (i.e. EU countries, Norway, Liechtenstein, Iceland, Switzerland and Turkey) and collaborating countries (five West Balkans countries) (EEA, 2015a). One of the most recent achievements of the EEA is the publication of the "European environment – state and outlook 2015 report" (EEA, 2015b), a comprehensive assessment of the European environment's state, trends and prospects, in a global context.

To build the knowledge base needed for the implementation of policies such as the EC Nature Directives, the Bern Convention on the conservation of European wildlife and natural habitats or the EU 2020 Biodiversity Strategy, the EEA is supported by the 'European Topic Centre on Biological Diversity' (ETC/BD, 2016), a consortium of scientific bodies and national agencies from twelve European countries, coordinated by the 'Muséum national d'Histoire naturelle' in Paris.

European ecosystems are under pressure and their underlying biodiversity is at risk

Main drivers and impacts on Europe's ecosystems as well their trends are addressed by the EEA State and outlook report 2015 on Europe's environment. According to EEA, a variety of factors explain the uneven progress towards ensuring long-term ecosystem resilience:

• The complexity of environment systems can cause a considerable time

> Keywords BIODIVERSITY LOSS EUROPE BIODIVERSITY POLICIES NATURE-BASED SOLUTIONS GREEN INFRASTRUCTURE BOTANICAL GARDENS

04. European ecosystems are under pressure and their underlying biodiversity is at risk

• *Richard Dominique*

lag between reduced pressures and changes in environmental impacts and status

- Pressures on ecosystems remain substantial despite recent reductions. Thus while impacts from habitat change and overexploitation have stabilized or even decreased in forest, freshwater and wetlands ecosystems (and even pollution for the two latter), they remain high and rapidly increasing in urban, agricultural- including grassland – and marine ecosystems. The impact of invasive alien species is already obvious in urban and marine ecosystems and will rapidly increase in all types of ecosystems.
- External pressures (including global megatrends) can counteract the effects of specific policy measures and local management efforts. Exported environmental impacts can return to Europe in the form of global and regional environmental problems such as air pollution, biodiversity loss and climate change. Although the influence of climate change has not yet severely affected European ecosystems, its impacts are expected to very rapidly increase in the coming decades.

As a result of past and present pressures on ecosystems, biodiversity in Europe is at risk. Various sources of information provide evidence of status and trends of species and habitats across the continent and, more specifically, in countries member of the European Union, so-called EU Member States:

- An analysis of land-cover change during the period 2000-2006, based on CORINE Land-Cover data, thus shows that, in 23 EU Member States artificial surfaces have increased by almost 8%, water bodies by 4,5% (partly due to new dams) while wetlands have continued to decrease by almost 3% and grasslands by 1,2%.
- A number of European red lists of species have been published by IUCN since 2007 (IUCN, 2015). To date 9,735 species have been assessed on the European Red List including all vertebrate species (mammals, amphibians, reptiles, birds and fishes), freshwater molluscs, medicinal plants, dragonflies, butterflies, bees and a selection of terrestrial molluscs, saproxylic beetles and plants. All grasshopers and crickets will be assessed in 2016. The assessment of all bryophytes, ferns, and trees, a selection of shrubs, saproxylic beetles and all remaining terrestrial molluscs will be finalized in 2018. Some of the findings are that:
    - Out of 591 crop wild relative plant species assessed at least 11.5 % are threatened at European level, with another 4.5 % that are Near Threatened (Bilz & *al*, 2011).
    - At least 6.6 % of the aquatic plant species in Europe are threatened with extinction. Moreover, 7.4 % are Near Threatened (Bilz & *al*, 2011)
    - Out of the 400 medicinal vascular plants from ninety families assessed, the proportion of threatened species could lie between 2.3 % (if all Data Deficient species are indeed not threatened) and 8.5 % (if all Data Deficient species are indeed threatened) (Allen & *al*, 2014)
    - Out of about 2,000 European bee species, 9.2 % are threatened with extinction, out of which 20 % endemic to Europe. Another 5.2 % are likely to be threatened in the near future. But more than 55 % of the species are data deficient (Nieto & *al*, 2014).
- A major source of information for EU Member States is provided by the regular reporting (now planned every six years) under Article 12 of the EC

> Keywords BIODIVERSITY LOSS EUROPE BIODIVERSITY POLICIES NATURE-BASED SOLUTIONS GREEN INFRASTRUCTURE BOTANICAL GARDENS

04. European ecosystems are under pressure and their underlying biodiversity is at risk

• *Richard Dominique*

Birds Directive and Article 17 of the Habitats Directive which gives an insight on respectively the population status and trends of all wild bird species occurring in the EU - i.e. 450 species -, and the conservation status of 230 habitat-types and more than 1 200 species other than birds (i.e. mammals, amphibians, reptiles, fishes, freshwater molluscs, dragonflies, butterflies, saproxylic beetles and plants). The reporting cycle covering the period 2008-2012 for birds and the period 2007-2012 for habitats and other species shows that (EEA, 2015c):

- Whilst the majority of Europe's birds are secure, there are still a significant number that are threatened, declining or depleted, including once common farmland species like the Skylark, *Alauda arvensis*, and the Black-tailed Godwit, *Limosa limosa*. Looking at the short-term population trends, these indicate that some 4% of all bird species are still not secure but increasing and 6% are stable. However a further 20% are declining.
- Concerning the 1200 species covered by the Habitats Directive, 23 % of the EU-level species assessments indicate a favourable status. On the other hand, 60 % are unfavourable, of which 42 % are considered to be unfavourable – inadequate and 18 % are unfavourable – bad. More than one-sixth (17 %) of species assessments have an unknown status. In relation to conservation trends, 4 % of species assessments are unfavourable but improving, 20 % are stable, but 22 % are deteriorating and 14 % are without a known trend.
- Assessments of habitats protected under the Habitats Directive show that only around one sixth have a favourable conservation status. The overwhelming majority of habitats have an unfavourable conservation status, with 47 % of the assessments being unfavourable - inadequate and 30 % being unfavourable – bad. Looking at trends, a third of the habitat types are unfavourable but stable (33 %). However a further 30 % are still deteriorating, which is a serious cause for concern. Only 4 % are showing improvements so far.

In addition Europe's footprint on other regions of the world remains severe.

Action is needed and may take place at all scales

The commitment to halt biodiversity loss and ecosystem degradation in Europe was reiterated in 2010, both by European countries as Contracting Parties to the Convention on Biological Diversity, and the European Union with its 2020 Biodiversity Strategy which is developed around 6 targets, i.e.: **1)** Fully implement the Nature Directives (including the completion of the so-called Natura 2000 network of designated sites, both in the terrestrial and the marine environment), **2)** Restore and maintain ecosystems and their services, **3)** Increase the contribution of forestry and agriculture to maintaining and enhancing biodiversity, **4)** Ensure the sustainable use of fisheries resources and the good environmental status of the marine environment, **5)** Combat invasive alien species and **6)** Help advert global biodiversity loss (EC, 2011).

A report on a mid-term review of the EU 2020 Biodiversity Strategy (EC, 2015) was published by the European Commission in October 2015 and is

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04. Action is needed and may take place at all scales

• *Richard Dominique*

available through the Biodiversity Information System for Europe (BISE) portal, jointly developed by the European Environment Agency and the European Commission (EEA-EC, 2016). Information on the implementation of national biodiversity strategies is also available from the 'Country' pages of BISE. The Mid-Term review report of the Strategy concludes in particular that "*Achieving the 2020 objectives will (also) require more effective integration with a wide range of policies, by setting coherent priorities underpinned by adequate funding – in particular in the sectors of agriculture and forestry which together account for 80% of land use in the EU, as well as marine, fisheries and regional development. EU financing instruments can assist in the process. Achieving biodiversity objectives will also contribute to the growth and jobs agenda, food and water security, and to quality of life, as well as to the implementation of sustainable development goals globally and in the EU.*

The biodiversity policy framework is thus in place at global and EU level but much depends on its effective implementation through national and local policies, as well as proper financing. However halting biodiversity loss is a collective challenge and beyond the role of decision makers, taking action has to be shared with citizens, users and managers of the land, scientists and amateurs, people leaving in rural and in urban environments, each one with its own contribution.

Many successful and innovative initiatives involving in-situ and ex-situ conservation, restoration projects, communication or capacity building are taking place across Europe, often supported, since 1992, by the EU LIFE funding instrument (EC, 2016a). Since 2014, a pan-European prize, the Natura 2000 award (EC, 2016b), is awarded every year by the European Commission as a tribute to initiatives of excellence in the management of Natura 2000 designated sites and conservation achievements, showcasing the added value of the network for local economies, and increasing public awareness about Europe's valuable natural heritage.

Green infrastructure and nature-based solutions as emerging concepts

In the context of climate change and of an increasingly urbanized European continent, emerging concepts such as 'Green Infrastructure' (GI) and 'Nature-Based Solutions' (NBS) are being addressed in the policy agenda. Thus, a 'Green Infrastructure Strategy' (EC, 2013) was adopted by the European Commission in 2013 '*to promote the deployment of green infrastructure in the EU in urban and rural areas*'. The EU Research and Innovation policy agenda 'Horizon 2020' on Nature-Based Solutions and Re-Naturing Cities (EC, 2016c) aims to position the EU as leader in 'Innovating with nature' for more sustainable and resilient societies.

Looking at the wider countryside, including cities, these concepts provide guiding principles for sustainable management and use of nature for tackling societal challenges such as climate change mitigation and adaptation, water and food security, public health provision, and disaster risk management. The basic idea is that nature can help provide viable solutions that use and deploy the properties of natural ecosystems and their associated services in a smart, 'engineered' way, acting as 'natural infrastructures', as opposed to 'grey infrastructure' (which refers to conventional piped drainage

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04. Green infrastructure and nature-based solutions as emerging concepts

• *Richard Dominique*

and water treatment systems). Thus, peri-urban forests can prevent pollutants from entering streams that supply fresh water to cities and businesses downstream. Upstream landscape conservation and restoration measures can act as natural water filtration plants, as an alternative to more conventional water treatment technologies (EEA, 2015d).

Botanical gardens have their own role to play

Because of their specificity and their large distribution across the continent, botanical gardens have an important role to play, even more if they are well organized within a network, sharing common short and long term objectives. As stated by Magdol and Pomerol (2015), “The literature on botanical gardens is limited and their application to green infrastructure undervalued. Botanical gardens are traditionally viewed as vibrant plant habitats for the purpose of human enjoyment but they should also be viewed as opportunities for green infrastructure implementation… botanical gardens can be designed and managed to provide the traditional amenities (e.g., biodiversity, education) along with improving the urban environment (e.g., runoff filtration, heat island reduction)”.

> Keywords BIODIVERSITY LOSS EUROPE BIODIVERSITY POLICIES NATURE-BASED SOLUTIONS GREEN INFRASTRUCTURE BOTANICAL GARDENS

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NASSTEC: A TRAINING NETWORK ON NATIVE SEED SCIENCE AND USE FOR PLANT CONSERVATION AND GRASSLAND RESTORATION IN EUROPE

Photo credit : NASSTEC - Restoring native grasslands - restoring ski slopes in the Alps - alpine seed mixture - flower rich grassland in the Dolomites , *C. Bonomi - Arc. MUSE*

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> Keywords NATIVE SEEDS NATIVE SEED PRODUCTION STANDARDS RESTORATION SEED-BASED RESTORATION TRAINING

04. Abstract

• *Bonomi Costantino*

GRASSLANDS ARE ONE OF THE MOST ENDANGERED BIOMES IN THE WORLD, WHICH HAVE BECOME FRAGMENTED AND DEGRADED, BOTH BEING HEAVILY CONVERTED FOR HUMAN USE, AND WITH LITTLE CONSERVATION PROTECTION.

Seed legislation, regulations and policies exist for agricultural and horticultural purposes in Europe, but not for native grassland species used in restoration practices. Restoration efforts are often made with non-native plant species with the absence of seed quality protocols, policies and adequate training for restoration practitioners. EU initiatives to tackle this issue are currently disjointed and isolated operations, while networking is strategic to attain significant impact. An EU initiative called NASSTEC (the NAtive Seed Science, TEchnology and Conservation Initial Training Network) has been funded under FP7 as a Marie Curie Action - Initial Training Network (ITN). The aim of this network is to promote better understanding of native seed science and the use of native seeds for restoration connecting academia to industry, and informing policy. The network includes 7 full partners and 7 associate partners with 12 researchers trained in the network and based at the 7 partners and ideally positioned to support the developing native seed industry across Europe. The training programme focus on three important bio-regions across Europe including the Atlantic, Alpine and Mediterranean grasslands. Research investigates bio-geography, seedling phenomics, stress-tolerance, and seed quality protocols in germination, dormancy, longevity, and establishment. Communication between academia and industry will be enhanced by this project, thus NASSTEC integrates commercial and research priorities in order to recommend a certification scheme in Europe based on the findings of NASSTEC, promoting an European seed producers' association and meeting the grower's needs.

> Keywords NATIVE SEEDS NATIVE SEED PRODUCTION STANDARDS RESTORATION SEED-BASED RESTORATION TRAINING

04. Introduction

• *Bonomi Costantino*

Photo credit : NASSTEC - Restoring native grasslands - flower rich grassland in the Dolomites , *C. Bonomi - Arc. MUSE*

GRASSLANDS ARE ONE OF THE MOST ENDANGERED BIOMES IN THE WORLD, WHICH HAVE BECOME FRAGMENTED AND DEGRADED, BOTH BEING HEAVILY CONVERTED FOR HUMAN USE, AND WITH VERY FEW CONSERVATION PROTECTIONS.

They are widely recognised in the literature as having extreme value in terms of biodiversity, threatened species, habitat provision, and ecosystem services. European grasslands are often anthropogenic landscapes, resulting from a positive interaction between natural processes and traditional human activities. However, regular land use over the past 100 years and the urban sprawl have led to irreversible degradation of biodiverse grasslands such as dry meadows and alpine meadows. Seed legislation, regulations and policies exist for agricultural and horticultural purposes in Europe, but not for native grassland species used in restoration practices. Restoration efforts are often made with non-native plant species with the absence of seed quality protocols, policies and adequate training for restoration practitioners. EU initiatives to tackle this issue are currently disjointed and isolated operations, while networking is strategic to attain significant impact. Existing producer's associations are only present in the UK (Flora locale), in Germany (VWW) and Austria (REWISA).

In the European context, the native seed industry has a large unexpressed potential, facing an increasing demand for native seeds for grassland restoration, which it is not capable to meet. The native seed companies are mostly disconnected from the academic sector and often lack key knowledge on critical aspect of seed biology. In the US and Australia the native seed industry is much more developed supporting a multi-million dollar market.

> FIGURE 1.

Native plants display in Scotland

> Keywords NATIVE SEEDS NATIVE SEED PRODUCTION STANDARDS RESTORATION SEED-BASED RESTORATION TRAINING

04. NASSTEC structure

• Bonomi Costantino

An EU initiative called NASSTEC (the NAtive Seed Science, TEchnology and Conservation Initial Training Network) has recently been funded by the European Union under the 7th Framework Programme for Research and Technological Development (FP7) as a Marie Curie Action (MCA) and in particular as an Initial Training Network (ITN). The aim of this network is to promote better understanding of native seed science and the use of native seeds for restoration connecting academia to industry, and informing policy. The network includes 7 full partners and 7 associate partners - four are academic institutions: MUSE - Trento Science Museum and the University of Pavia in Italy, the Royal Botanic Gardens Kew and the James Hutton Institute in the UK; the remaining three are native seed companies: Scotia Seeds in the UK, Semillas Silvestres in Spain and Syngenta seeds in the Netherlands.

NASSTEC ultimate goal is to promote a more effective industry-academia interaction and technology transfer aiming at facilitating the development of a stronger European market.

The NASSTEC consortium recruited synchronously 11 ESRs (Early Stage Researchers) among 225 applicants and 1 ER (Experienced Researcher) among 22 applicants. The recruiting procedure enforced the European Code of Conduct for Recruitment of Researchers with a transparent and impartial procedure. The 12 successful applicants have a gender balance of 4 male and 8 female, originating from 7 different countries: 3 Spanish and 3 Italians, two Canadians, one American, one Croatian, one Portuguese and one Sri-Lankan.

These twelve researchers have been trained in the network, based across the various partners, ideally positioned to support the developing native seed industry across Europe. The training programme focused on three important bio-regions across Europe including the Atlantic, Alpine and Mediterranean grasslands. Research investigated bio-geography, seedling phenomics, stress-tolerance, and seed quality protocols in germination, dormancy, longevity, and establishment. The scientific and training programmes embraced 12 research topics, clustered under three sub programmes: A) *In situ* seed sampling; B) Seed biology characterisation; and C) Production and deployment of seed.

NASSTEC implemented a strong training programme with three Annual General Meetings, one University Induction Course, three specialist workshops on Molecular Ecology, Business Models, Outreach and two summer school on Seed Collecting and Seed Germination. And in the end a final conference held in Kew Gardens in September 2017: "Seed Quality of Native Species: ecology, production & policy" that enjoyed the participation of 123 delegates from 20 countries. The conference gave a preview of NASSTEC outputs and paved the way for future developments at European level.

A parallel outreach programme engaged all key stakeholders and the public; the fellows jointly contributed to 3 demonstrative pilot project restoring grasslands in 3 sites in each biogeographical region covered by the project. Strategically located sites have been selected in Italy, Spain and the UK, sown in autumn 2015, and monitored since that date, with many native plants actively growing.

The fellows enjoyed mobility throughout the network, spending on average 25% of their time across the network or at conferences.

> Keywords NATIVE SEEDS NATIVE SEED PRODUCTION STANDARDS RESTORATION SEED-BASED RESTORATION TRAINING

04. NASSTEC structure

• Bonomi
Costantino

> FIGURE 2.

The NASSTEC third Annual Meeting in held in Cordoba, 31.1-3.2.2017

NASSTEC outputs

To date NASSTEC awarded nine PhDs in native seed science delivering the human resources required by the nascent native seed industry in Europe, ensuring high quality seed sourcing and production. This will help identify, consolidate and improve existing technology platforms across Europe. Thanks to its multidisciplinary approach, NASSTEC developed joint network products, including a species selection tool, a germination information database, guidelines for the production and use of native seeds and a proposal for a quality certification scheme that are being collated in a final project manual that will be published shortly. Updates on the project website www.nasstec.eu.

To date the project produced a total of 6 publications (Abbandonato *et al*., 2017; De Vitis *et al.*, 2017; Ladouceur *et al*., 2017; Lopez Del Egido *et al*., 2017; Marin *et al*., 2017; Paparella *et al*., 2015; Tudela-Isanta *et al*., 2017), 2 workshops, 1 panel discussion, 13 oral presentations, 26 poster presentations and 3 stands delivered at 22 conferences and courses plus 2 TV and 1 radio interview. This dissemination effort involved 64 individual contributions. As far as outreach is concerned, 6 IBSE (Inquiry Based Science Education) activities have been designed to promote NASSTEC in schools and 8 ESRs manned a NASSTEC info point at 3 events.

On a more global level the project was presented to a selection of key audiences, arguing for the need of a global networking initiative for native seeds, at the US Native Seed Conferences held in Santa Fe (USA) in April 2015 and in Washington DC (USA) in February 2017. This idea gained the support of key scientists from all continents and was formalised at the SER2015 held in Manchester in August 2015 with the official launch of the International Network for Seed-based Restoration (INSR - http://ser-insr.org) where NASSTEC fellow Stephanie Frischie covers the key position of network Secretary.

New opportunities emerged during the project and were discussed at meeting and congresses. Among the others, the development of a European wide seed zoning system based on a regional biogeographical scale rather than on a national basis, a joint European native seeds quality certification scheme and a joint database of native seed producers and species in production available on-line as a global hub where producers and users alike could refer.

NASSTEC also contributed to develop a stronger European trade association, cultivating active interconnections between EU native seed producers that will benefit for a wider European perspective. A new seed-collecting app

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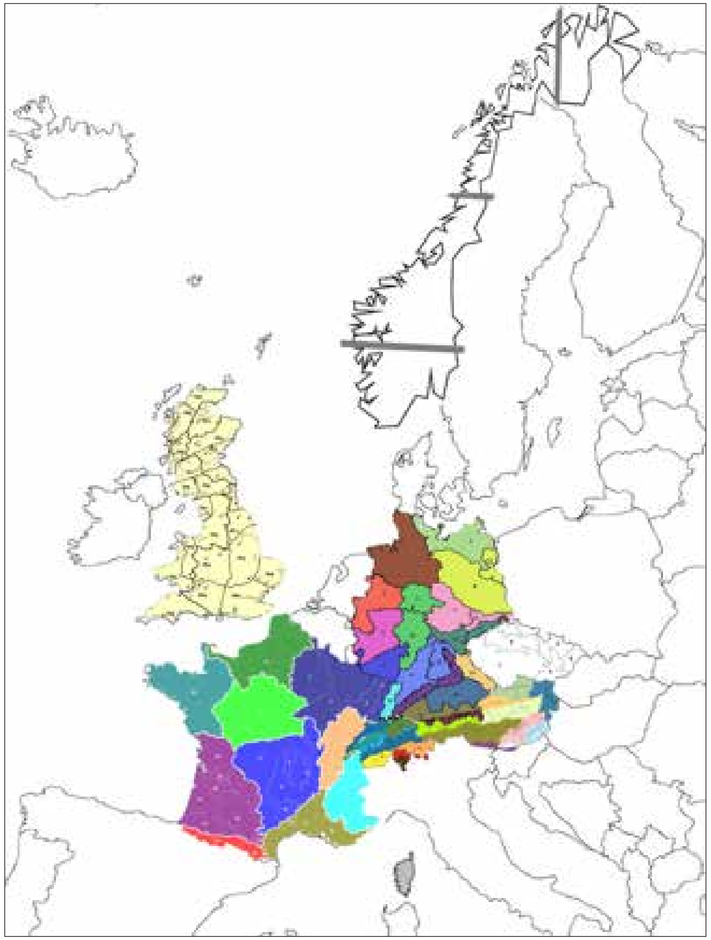
04. NASSTEC outputs

• Bonomi
Costantino

for producers and a new European producers' association website are now being developed.



> FIGURE 3.

National seed zones currently available in Europe. Sources: Austria [24]; Czech Republic [25]; France [26]; Germany [27]; Great Britain [28]; Norway [8]; Switzerland [29] from De Vitis *et al.* (2017)

Conclusion

NASSTEC provided a forum for native seed producers, from many European countries such as Germany, Austria, France, Norway, The Netherlands, Sweden, the UK, Italy and Spain that came together in Kew in September 2017 to discuss the needs of the native seed industry and the outlook in the European market.

With Germany going native by 2020 for grassland restoration activities (thanks to a new national legislation), other European countries are likely to pass similar regulations in the future, creating a favourable context and many new opportunities for native seed producers and in this context NASSTEC outputs will play a key contribution to drive a knowledge-based development of native seed producers. In this context, NASSTEC has played and will play a pivotal role in harmonising the native seed industry at European level, ensuring industry-academia integration and driving a wider uptake of the use of native seeds in Environmental restoration. Ultimately contributing to a win-win situation, facilitating the development of a larger market for native seeds, fostering the development of new companies, new jobs and at the same time protecting the environment and enhancing ecosystem services.

> Keywords NATIVE SEEDS NATIVE SEED PRODUCTION STANDARDS RESTORATION SEED-BASED RESTORATION TRAINING

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VÉGÉTAL LOCAL : UNE MARQUE FRANÇAISE POUR LA CONSERVATION DE LA FLORE INDIGÈNE

Photo credit : Récolte de graines en milieu naturel dans le cadre de la marque Végétal local, ***CBNPMP/S.Malaval***

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04. Abstract

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- *Millet Jerôme*

THE FRENCH GOVERNMENT HAS DEVELOPED A NATIONAL STRATEGY FOR BIODIVERSITY CONSERVATION TO IMPLEMENT THE CONVENTION ON BIOLOGICAL DIVERSITY (1992 RIO EARTH SUMMIT). THE NATIONAL STRATEGY AIMS AT THE CONSERVATION OF INDIGENOUS PLANT SPECIES AND PARTICULARLY THEIR GENETIC DIVERSITY.

This diversity is an insurance to survive and evolve in dynamic ecosystems (under changing conditions). In this framework, the French government intended to change the common restoration and revegetation practice involving the use of plant material with unknown or non-local origin.

In 2015, two collective trademarks were created, “Végétal local” and “Vraies messicoles”, in order to promote the use of local plant provenances. Three years after creation, already 48 seed suppliers and tree nurseries produce seeds according to the trademark guidelines including sustainable practices for collection in natural plant populations and local propagation of seeds and tree saplings.

End users such as land managers can today obtain seeds or tree sapling with the trademark for restoration and revegetation projects guaranteeing a positive effect on biodiversity.

> Mots-clefs RÉGIONS D'ORIGINE BIOGÉOGRAPHIE MESSICOLES FLORE SAUVAGE VÉGÉTAL LOCAL RESTAURATION ÉCOLOGIQUE RÉHABILITATION CONSERVATION DE LA BIODIVERSITÉ ADAPTATIONS LOCALES DIVERSITÉ GÉNÉTIQUE

04. Résumé

- *Malaval Sandra*
- *Bischoff Armin*
- *Hédont Marianne*
- *Provendier Damien*
- *Boutaud Michel*
- *Dao Jerôme*
- *Bardin Philippe*
- *Dixon Lara*
- *Millet Jerôme*

LA FRANCE, EN TANT QUE PARTIE À LA CONVENTION SUR LA DIVERSITÉ BIOLOGIQUE A ÉLABORÉ UNE STRATÉGIE NATIONALE POUR LA BIODIVERSITÉ AU DÉBUT DES ANNÉES 2010, PORTANT NOTAMMENT SUR LA CONSERVATION DES ESPÈCES VÉGÉTALES INDIGÈNES, ET EN PARTICULIER LA DIVERSITÉ GÉNÉTIQUE DE CES ESPÈCES.

Cette diversité est un moyen de survie pour les êtres vivants dans l'équilibre et l'évolution de la dynamique des écosystèmes. Le constat était fait que de nombreux travaux d'aménagement étaient conduits avec des végétaux sauvages dont l'origine était inconnue ou non garantie et très souvent éloignée du site de l'utilisation.

En 2015, ont été créées deux marques collectives, « Végétal local » et « Vraies messicoles », dont l'objectif est de garantir l'origine bio-géographique locale des végétaux sauvages proposés sur le marché. Trois ans après leur création, ces deux marques ont déjà 48 bénéficiaires, qui collectent en milieu naturel des végétaux sauvages, via des pratiques durables, et les multiplient ou élèvent pour une commercialisation des semences et des plants dans leur région d'origine.

Les utilisateurs, gestionnaires de sites ou maîtres d'ouvrage d'aménagements, peuvent aujourd'hui disposer d'une garantie d'action positive sur la biodiversité lors de l'utilisation en revégétalisation, semis ou plantation des végétaux labellisés dans les sites considérés.

> Mots-clefs RÉGIONS D'ORIGINE BIOGÉOGRAPHIE MESSICOLES FLORE SAUVAGE VÉGÉTAL LOCAL RESTAURATION ÉCOLOGIQUE RÉHABILITATION CONSERVATION DE LA BIODIVERSITÉ ADAPTATIONS LOCALES DIVERSITÉ GÉNÉTIQUE

04. Introduction

• *Malaval Sandra*
• *Bischoff Armin*
• *Hédont Marianne*
• *Provendier Damien*
• *Boutaud Michel*
• *Dao Jerôme*
• *Bardin Philippe*
• *Dixon Lara*
• *Millet Jerôme*

Photo credit : Récolte de graines en milieu naturel dans le cadre de la marque Végétal local, ***CBNPMP/S.Malaval***

LA RESTAURATION DES ÉCOSYSTÈMES DEVIENT UNE NÉCESSITÉ APRÈS LA DÉGRADATION DES TERRAINS INDUITE PAR LES ACTIVITÉS HUMAINES, DIRECTEMENT OU INDIRECTEMENT (BRADSHAW, 2002).

Elle nécessite généralement la réalisation de semis ou de plantations afin de retrouver une communauté végétale semblable à la communauté initiale. Pour cela, il est nécessaire de disposer de matériel végétal indigène, qu'il s'agisse d'herbacées, d'arbustes ou d'arbres originaires de la zone de restauration afin de retrouver les fonctions de l'écosystème (Thomas *et al.*, 2014 ; Van der Mijnsbrugge *et al.*, 2010). Cependant les professionnels de la production et de la commercialisation des végétaux et les acteurs de la protection de l'environnement se heurtaient jusqu'alors à l'absence sur le marché français de végétaux d'origine sauvage dont la provenance locale pouvait être garantie. Les informations disponibles lors de l'achat de matériel végétal précisent rarement l'origine de la plante. Les termes « provenance » ou « origine géographique » peuvent indiquer soit l'emplacement de la pépinière, soit l'aire de répartition naturelle de l'espèce. Dans la majorité des cas il était donc difficile voire impossible de connaître l'origine du lieu de récolte. La loi française n'oblige pas non plus à inscrire la provenance géographique sur le matériel végétal sauvage disponible sur le marché. La France avait donc besoin d'une garantie sur l'origine du matériel végétal, comme d'autres pays européens qui ont déjà développé des filières d'approvisionnement en végétaux d'origine sauvage et des signes garantissant l'origine géographique.

En Europe de nombreuses espèces de plantes messicoles sont au bord de l'extinction. Une stratégie nationale pour les espèces messicoles a été élaborée entre 2012 et 2017 pour mettre en place des actions de conservation des espèces messicoles (Cambecèdes *et al.*, 2012). L'objectif de cette stratégie est de préserver les populations sauvages qui existent encore et de restaurer la biodiversité en semant des graines de provenance locale pour maintenir le rôle fonctionnel de ces espèces ainsi que les services écosystémiques qu'elles permettent dans les champs. Il était donc nécessaire d'avoir sur le marché une marque qui garantisse la provenance locale des espèces messicoles.

> Mots-clefs RÉGIONS D'ORIGINE BIOGÉOGRAPHIE MESSICOLES FLORE SAUVAGE VÉGÉTAL LOCAL RESTAURATION ÉCOLOGIQUE RÉHABILITATION CONSERVATION DE LA BIODIVERSITÉ ADAPTATIONS LOCALES DIVERSITÉ GÉNÉTIQUE

04. Les marques : des outils scientifiques

- *Malaval Sandra*
- *Bischoff Armin*
- *Hédont Marianne*
- *Provendier Damien*
- *Boutaud Michel*
- *Dao Jerôme*
- *Bardin Philippe*
- *Dixon Lara*
- *Millet Jerôme*

En réponse à cette demande croissante, en 2011, le Ministère français de l'écologie a lancé un appel à propositions visant à créer un cadre pour la production de matériel végétal indigène et local, dans le cadre de sa stratégie nationale pour la biodiversité (Ministère de l'Ecologie, du Développement Durable, des Transports et du Logement, 2011). Un consortium rassemblant la Fédération des Conservatoires botaniques nationaux (FCBN) et deux associations (Plante & Cité et l'Afac-Agroforesteries) a permis la création en janvier 2015 de deux marques collectives consacrées à la production de matériel végétal local et autochtone : « Végétal local » et « Vraies messicoles ». Ces marques garantissent l'origine de plantes indigènes et la préservation de la diversité génétique. L'ampleur géographique de l'origine locale de ces plantes a été définie par des experts scientifiques, sur la base de données bio-géographiques et a abouti à la définition de 11 régions d'origine pour la France métropolitaine. En outre, sur la base de la littérature et des discussions scientifiques entre experts, des règles ont été définies sur la collecte de semences ou de plantes dans la nature, sur la multiplication des stocks, sur la traçabilité et le contrôle de toutes ces étapes, permettant de conserver au maximum la diversité génétique des plantes collectées et la conservation de la ressource dans le milieu naturel. Les premiers végétaux labellisés ont été produits à l'automne 2015. « Végétal local » se consacre à l'ensemble de la flore sauvage indigène tandis que « Vraies messicoles » cible les espèces messicoles et dont l'objectif est de conserver les populations ayant subi une forte régression depuis l'intensification de l'agriculture.

L'USAGE DE PLANTES INDIGÈNES EST PRÉCONISÉ PAR EXEMPLE DANS LES CAS SUIVANTS :

- Restauration écologique des milieux aménagés tels que les pistes de ski, berges de rivières,
- Stabilisation des milieux, végétalisation de talus routiers ou ferroviaires,
- Restauration écologique de milieux naturels,
- Utilisation ornementale dans les espaces verts des villes dédiés à la biodiversité ou les friches.

Ces marques ne concernent que les espèces indigènes sauvages, excluant les espèces exotiques, les variétés horticoles ou les plantes sélectionnées (par exemple variétés fourragères issues de la sélection). Déposées en Janvier 2015 à l'INPI (Institut National de la Propriété Industrielle), elles sont aujourd'hui la propriété de l'Agence Française pour la Biodiversité (AFB), qui a repris les missions de la FCBN.

CES MARQUES SONT CONSTRUITES SUR DES PRINCIPES GÉNÉRAUX S'APPLIQUANT À L'ENSEMBLE DE LA FLORE SAUVAGE HERBACÉE ET LIGNEUSE, NOTAMMENT :

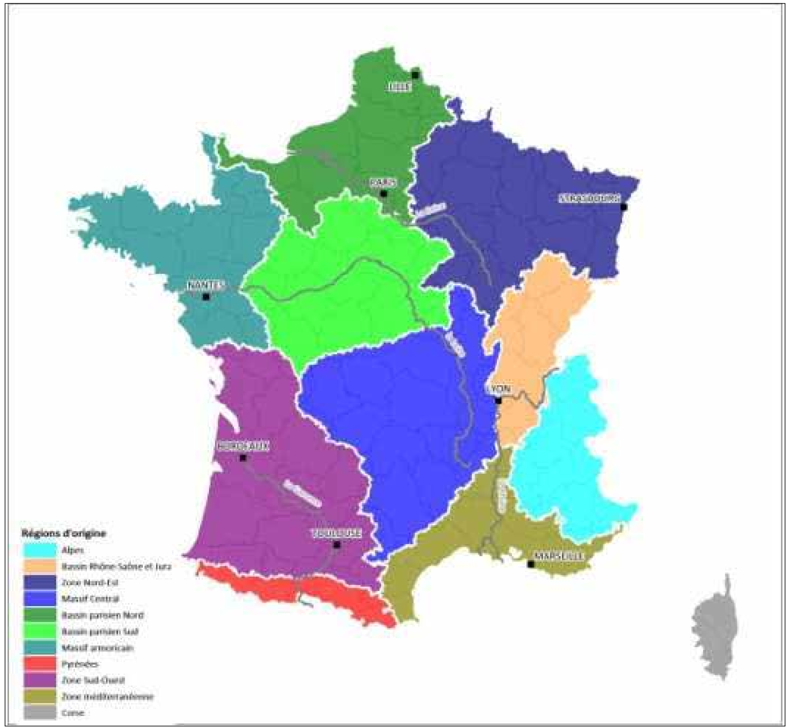
- 11 grandes régions d'origine de production et d'utilisation des végétaux locaux, qui ont été délimitées sur la base de critères écologiques et bio-géographiques (type de milieux, géologie, hydrologie, etc.).
- Un découpage de ces régions d'origine en unités naturelles pour les secteurs où la flore est soumise à des influences pédoclimatiques particulières (sans que ce découpage en unité naturelle ne soit obligatoire dans le cadre des marques).
- Des règles de collecte dans le milieu naturel et de production de ces espèces qui ont été définies afin d'éviter une perte de diversité génétique.
- Un système d'audit organisé chez les candidats afin de vérifier si les pratiques de collecte, production et gestion des stocks sont conformes aux règles des marques.

> Mots-clefs RÉGIONS D'ORIGINE BIOGÉOGRAPHIE MESSICOLES FLORE SAUVAGE VÉGÉTAL LOCAL RESTAURATION ÉCOLOGIQUE RÉHABILITATION CONSERVATION DE LA BIODIVERSITÉ ADAPTATIONS LOCALES DIVERSITÉ GÉNÉTIQUE

04. Les marques : des outils scientifiques

• *Malaval Sandra*
• *Bischoff Armin*
• *Hédont Marianne*
• *Provendier Damien*
• *Boutaud Michel*
• *Dao Jerôme*
• *Bardin Philippe*
• *Dixon Lara*
• *Millet Jerôme*

Ces deux marques sont gérées par un comité de marque qui est l'organe central de gestion, se réunissant deux fois par an et ayant pour objectif d'étudier les dossiers des candidats à la labellisation et d'apporter les éléments à l'AFB pour les labellisations. Il prend appui sur les résultats des contrôles réguliers réalisés par les auditeurs chez les candidats et les bénéficiaires.



> FIGURE 1.

Les onze régions françaises d'origine biogéographique

Ces marques sont applicables dans des régions d'origine biogéographique. Ces onze régions métropolitaines ont été délimitées pour la récolte, la multiplication et l'utilisation privilégiées des végétaux dans le cadre de ces marques (**Fig. 1**). Elles sont délimitées sur la base des limites administratives communales et représentent les secteurs où le matériel végétal peut-être utilisé sans dommage sur le patrimoine génétique local et où ces espèces sont le mieux adaptées aux conditions environnementales, ce qui favorise la réussite des semis et des plantations. En effet, les caractéristiques génétiques acquises localement par la flore sauvage au cours du temps lui permettent d'avoir un avantage lorsque celle-ci est utilisée dans son territoire d'origine.

Ces deux marques nationales possèdent chacune un règlement d'usage précisant les conditions d'accès et les méthodes d'audit spécifiques et un référentiel technique précisant les règles de conduite des collecteurs et producteurs de matériel végétal labellisé. En résumé, les principales règles concernent :

- La collecte dans le milieu naturel (taille des populations, méthode d'échantillonnage, etc.),
- La multiplication des espèces (nombre de générations limité pour éviter une sélection, etc.),
- La réalisation d'audits pour vérifier la conformité des cultures aux exigences des marques.

Pour l'attribution des marques, des dossiers de candidatures peuvent être déposés tout au long de l'année. Ces dossiers doivent contenir la liste des espèces ciblées pour la labellisation, les zones de collectes et production des semences et des plants, ainsi que le projet pour la multiplication et la description des capacités du candidat à produire ces espèces. Lors du comité

> Mots-clefs RÉGIONS D'ORIGINE BIOGÉOGRAPHIE MESSICOLES FLORE SAUVAGE VÉGÉTAL LOCAL RESTAURATION ÉCOLOGIQUE RÉHABILITATION CONSERVATION DE LA BIODIVERSITÉ ADAPTATIONS LOCALES DIVERSITÉ GÉNÉTIQUE

04. Les marques : des outils scientifiques

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- Bischoff Armin
- Hédont Marianne
- Provendier Damien
- Boutaud Michel
- Dao Jerôme
- Bardin Philippe
- Dixon Lara
- Millet Jerôme

de marque réuni deux fois par an, les dossiers sont étudiés afin de définir si la marque est attribuée aux espèces proposées par le candidat. La marque est attribuée aux espèces qui sont conformes aux attentes du règlement et du référentiel technique chez des candidats aptes à remplir les exigences de ces cahiers des charges. Le candidat fera alors l'objet de plusieurs audits au cours de sa période de labellisation. Depuis 2015, ce sont déjà 48 candidats qui ont reçu le droit d'exploiter l'une ou l'autre des marques, qu'ils soient collecteurs et ou producteurs de végétaux locaux, herbacés ou ligneux.

Un relais technique et scientifique pour le développement de filières locales de production de plantes indigènes labellisées est en place. Il est constitué des membres du réseau des Conservatoires botaniques nationaux pour chaque région d'origine et de membres de Plante & Cité et de l'Afac-Agroforesteries. Ce réseau permet un accompagnement dans l'utilisation des végétaux locaux lors d'aménagements sur le territoire et sert de relais entre producteurs et utilisateurs.

L'année 2015 a été marquée par plusieurs événements clés. En avril, les 13 premières candidatures pour la labellisation ont été reçues. En juin, le premier comité de marque a eu lieu afin d'étudier ces premières candidatures. Suite au dépôt des candidatures, les audits ont eu lieu dans le courant de l'été. Les premières labellisations ont été attribuées en novembre 2015. Ces deux marques sont présentées sur le site internet *http://www.fcbn.fr/vegetal-local-vraies-messicoles* (bientôt *www.vegetal-local.fr*) et des lettres d'informations sont publiées régulièrement depuis Janvier 2015, elles reprennent les évènements marquants et permettent leur diffusion.

Conclusion

Les deux marques créées apportent une garantie aux utilisateurs de végétaux sauvages qui souhaitent bénéficier de végétaux d'origine locale. Ces marques ont également permis l'émergence de nouvelles filières de production dans différents territoires français, afin de rendre disponibles des végétaux pour la restauration écologique, le génie végétal ou encore des aménagements en faveur de la biodiversité. Le nombre croissant de structures bénéficiaires des marques fait écho à la préoccupation croissante des acteurs et gestionnaires sur la conservation de nos ressources naturelles, par la conservation de la diversité génétiques des espèces de la flore commune. Ces marques servent également d'outil de développement d'activités économiques non délocalisables, telles que la collecte et la production de ces végétaux locaux.

> Mots-clefs RÉGIONS D'ORIGINE BIOGÉOGRAPHIE MESSICOLES FLORE SAUVAGE VÉGÉTAL LOCAL RESTAURATION ÉCOLOGIQUE RÉHABILITATION CONSERVATION DE LA BIODIVERSITÉ ADAPTATIONS LOCALES DIVERSITÉ GÉNÉTIQUE

04. Références

- *Malaval Sandra*
- *Bischoff Armin*
- *Hédont Marianne*
- *Provendier Damien*
- *Boutaud Michel*
- *Dao Jerôme*
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PROGRESS IN PLANT AND HABITAT CONSERVATION ACROSS THE EUROPEAN UNION

Photo credit : Eryngium alpinum dans le Vallon du Fournel et inclus dans le site Natura 2000 Vallon des Bans - Vallée du Fournel (https://inpn.mnhn.fr/site/natura2000/FR9301505), *Doug Evans*

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> Keywords HABITATS DIRECTIVE NATURA 2000 CONSERVATION STATUS PLANT SPECIES HABITATS

04. Abstract

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THE EUROPEAN UNION'S HABITATS DIRECTIVE, ADOPTED IN 1992, IMPLEMENTS THE 1979 BERN CONVENTION BY PROTECTING A SELECTION OF HABITATS AND SPECIES. PROTECTION IS BY BOTH STRICT PROTECTION OF SPECIES LISTED ON ANNEX IV - INCLUDING PLANT TAXA -, AND PROTECTED AREAS FOR HABITATS AND SPECIES LISTED RESPECTIVELY ON ANNEXES I & II.

Together with sites designated under the 1979 Birds Directive these protected areas form the Natura 2000 network. The Habitats Directive also has requirements for regular monitoring and reporting with assessments of conservation status produced at six yearly intervals. The proportion of assessments as Favourable in 2013 is variable across taxonomic groups but always below 30%, however the species and habitats listed in the annexes were selected as they were considered to be rare and /or threatened. Implementation of the Habitats Directive requires action from a wide range of actors, and botanic gardens have been important in many countries, both for their knowledge and skills.

> Keywords HABITATS DIRECTIVE NATURA 2000 CONSERVATION STATUS PLANT SPECIES HABITATS

04. Introduction

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• *Richard Dominique*
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Photo credit : Eryngium alpinum dans le Vallon du Fournel et inclus dans le site Natura 2000 Vallon des Bans - Vallée du Fournel (https://inpn.mnhn.fr/site/natura2000/FR9301505), *Doug Evans*

THERE WAS A GROWING AWARENESS OF ENVIRONMENTAL PROBLEMS IN THE SECOND HALF OF THE TWENTIETH CENTURY, MARKED BY PUBLICATIONS SUCH AS SILENT SPRING (CARSON 1962) [...]

[...] and the first Red Books of threatened species (Scott 1965) together with international meetings such as the 1972 United Nations Conference on the Human Environment in Stockholm (which led to the creation of the United Nations Environment Programme) and the Convention on Biological Diversity in Rio de Janeiro in 1992.

This led to both national and international actions such as the Ramsar Convention (1971), the Bern Convention on the Conservation of European Wildlife and Natural Habitats (1979), and the Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention, 1979).

Although prior to the single European Act of 1987, the European Union[1] had no clear competence for environmental issues, a directive to protect all wild birds in the EU was adopted unanimously by the then nine member states in 1979.

European action to conserve nature

The Bern Convention protects plant species listed in Annex I and animal species Annexes II (strictly protected) and III (protected). The Emerald network of protected areas was created by Recommendation No. 16 of the Standing Committee to the Bern Convention in 1989 but due to the political changes in central Europe in the early 1990s there was little action and the process was relaunched in 1996 (Jaffeux 2004). There are currently 37 Emerald sites in Switzerland with lists of sites under development in several other non-EU countries.

The 1992 EU Habitats Directive was conceived as an EU implementation of the Bern Convention (Evans 2012) and has two major elements, site protection for the habitats listed on Annex I and species (sometimes subspecies) listed on Annex II (as part of the Natura 2000 network) together with strict protection for species (sometimes species groups) listed on Annex IV. There

1 The term European Union is used for convenience and also refers to its predecessors such as the European Economic Community.

> Keywords HABITATS DIRECTIVE NATURA 2000 CONSERVATION STATUS PLANT SPECIES HABITATS

04. European action to conserve nature

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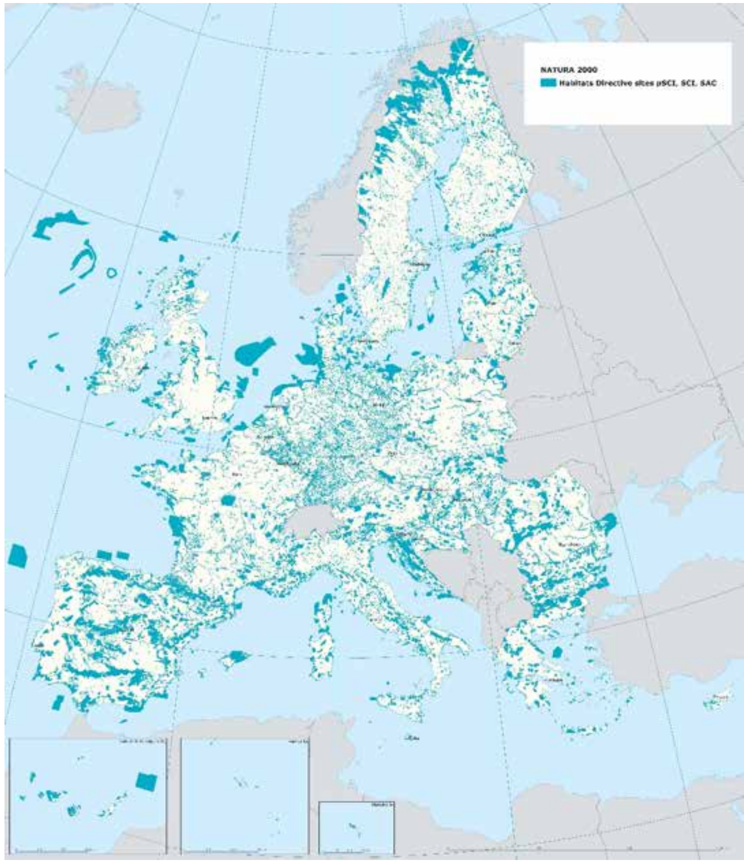
also measures on methods of hunting and sustainable use. As a result of European enlargement from 12 to 28 countries since the directive was adopted extra habitats and species have been added to the annexes (Evans *et al.* 2013). **Table 1** summarises the number of habitats and species protected by the Habitats Directive, the annexes list a large number of plant species, including some ferns and bryophytes.

There are now over 28 000 sites covering some 18% of the EU's terrestrial area and some 5% the EU's seas (see **Fig. 1**).

> TABLE 1

The number of habitats and taxa protected by the EU's Habitats Directive. Note that a taxon may be listed on more than one annex and that taxa include groups such as 'all Cetacea' and '*Sphagnum*'

	Annex I	Annex II	Annex IV	Annex V
Habitats	233			
Species & other taxa		932	977	85
Vascular plants		578	636	27
Non-vascular plants		32	0	5



> FIGURE 1.

Sites designated or proposed for Natura 2000 under the Habitats Directive by the end of 2014 (source EEA)

Conservation status of EU species

The aim of the directive is to maintain, or if necessary, restore habitats and species to 'Favourable Conservation Status' (FCS). Favourable Conservation Status effectively describes the situation where the habitat type or species can be expected to prosper without any change to existing management or policies (EEA 2015; Epstein, López-Boa & Chapron 2015). As the habitat types and species were selected because they were thought to be threatened and or rare it should not be a surprise that most habitat types and species listed in the Annexes of the Directive are not at FCS. Given the time required

> Keywords HABITATS DIRECTIVE NATURA 2000 CONSERVATION STATUS PLANT SPECIES HABITATS

04. Conservation status of EU species

• Evans Douglas
• Richard Dominique
• Gaudillat Zelmira
• Bailly-Maitre Jerôme

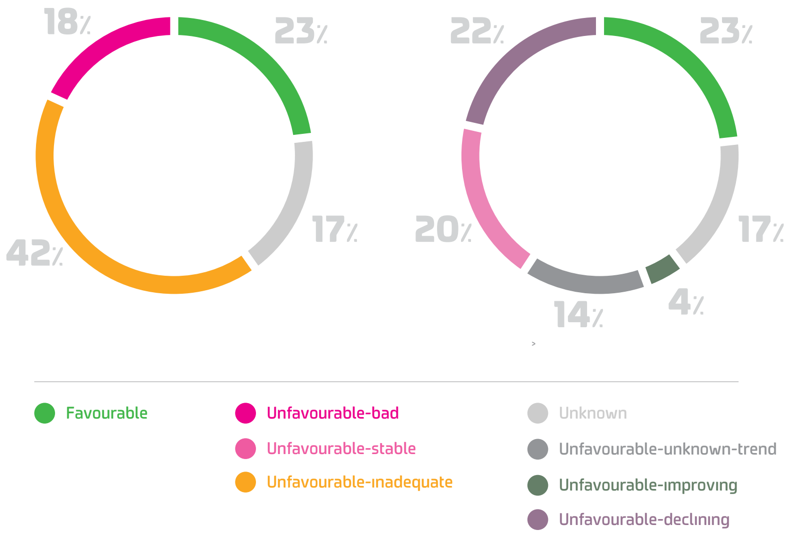
to restore many habitat types and species to recover from an unfavourable conservation status this is likely to remain true for some time even if the appropriate conservation measures are in place.

Under the habitats directive the Member States have an obligation to report on the conservation status every six years using an agreed methodology, The most recent reports cover the period 2007-12 and give an overview of the state of the species and habitats protected by the directive (EEA 2015). Conservation Status under Article 17 reporting is the overall assessment of the status of a habitat type or species at the scale of a biogeographical or marine region. It is first assessed by each Member State using a methodology based on four parameters (see **Table 2**) to give an assessment for each biogeographical or marine region within its territory. These assessments are then combined to give an assessment of the Conservation Status at the whole biogeographical or marine region (i.e. including all Member States within it). The Conservation Status assessments for Article 17 concern the Conservation Status across all of a biogeographical or marine region within a Member State, i.e. not just within the Natura 2000 network.

> TABLE 2

The parameters for assessing Conservation Status of habitats and species

Species	Habitats
Range	Range
Population	Area
Suitable habitat	Structure and functions
Future prospects	Future prospects



> FIGURE 2.

Proportion of species assessments in each conservation status class (2007-12) (left) and their trends (right) (Source EEA 2015)

Assessments of Conservation Status are given as one of four classes ‘Favourable’, ‘Unfavourable-inadequate’, ‘Unfavourable-bad’ and ‘Unknown’. The unfavourable category has been split into two classes to allow improvements or deterioration to be reported: ‘Unfavourable-Inadequate’ for situations where a change in management or policy is required to return the habitat type or species to FCS, but there is no danger of loss of the habitat type or extinction of the species in the foreseeable future and ‘Unfavourable-Bad’ is for habitats or species in serious danger of becoming lost or extinct, respectively (at least regionally). ‘Unknown’ should be used where there is insufficient information available to allow an assessment.

Figure 2 shows the conservation status for all species assessments and their trends in conservation status. Twenty three per cent of assessments are Favourable while a further four per cent, although unfavourable, are improving. Unfortunately information is not available for 17% of assessments which have been reported as unknown.

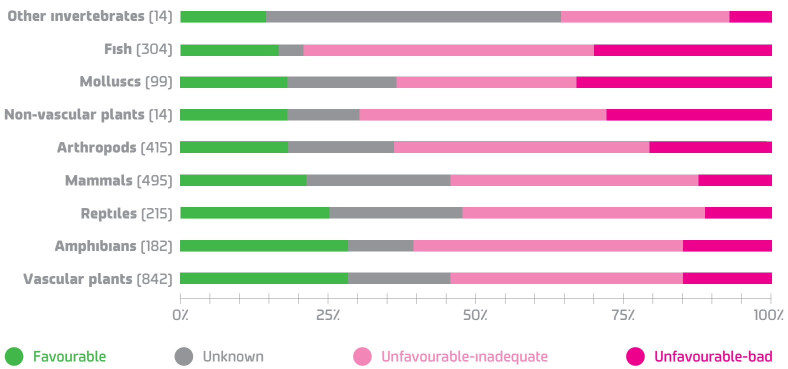
> Keywords HABITATS DIRECTIVE NATURA 2000 CONSERVATION STATUS PLANT SPECIES HABITATS

04. Conservation status of EU species

• Evans Douglas
• Richard Dominique
• Gaudillat Zelmira
• Bailly-Maitre Jerôme

Figure 3 shows how the taxonomic groups compare and it is clear that vascular plants have a higher percentage of reports as 'Favourable' than other taxonomic groups. This is likely to be due to the large number of localized endemics listed on the annexes; of the 86 taxa whose distribution is one grid cell (10 km x 10km), 60 are plants.

Although it is difficult to evaluate the effectiveness of networks of protected areas and other measures the evidence suggests that appropriate conservation measures such as appropriately managed Natura 2000 sites leads to improvement in conservation status (EEA 2015).



> FIGURE 3

Proportion of species assessments in each conservation class per taxonomic group (2007-12) (Source EEA 2015)

A role for botanic gardens?

Many botanic gardens across Europe have been involved in implementing the habitats directive, either by giving advice to government agencies or by more direct action including site management. At least one garden is part of the Natura 2000 network - The Troodos Botanic Garden in Cyprus. More commonly gardens are involved in site selection as this requires information on the distribution of the plants listed on Annex II and in many countries this is coordinated by botanic gardens. Similarly monitoring of plant populations and sometimes of habitats can also involve botanic gardens and their staff. Gardens can also play an important role in education and public awareness, for example in 2010 the Villa Thuret botanical garden in southern France held an exhibition on 'Biodiversité sans frontière: Natura 2000 dans les Alpes de la mer' (Biodiversity without frontiers: Natura 2000 in the coastal Alps).

Botanic gardens have a particularly important role in restoration projects for endangered plants and habitats as they often have both the technical knowledge required (e.g. appropriate propagation techniques) and living material to use for reintroduction into the wild. In some cases material from several collections can be brought together to ensure genetic diversity of the reintroduced plants.

For example, the British population of the orchid Cypripedium calceolus had been reduced to a single individual by collecting but techniques developed by the Royal Botanic Gardens, Kew (London) have led to the establishment of several new populations in appropriate habitats (Fay & Taylor 2015). Similarly, in an international project, expertise at the botanic garden in Brest (France) has helped a project to reinforce the wild populations of the Critically Endangered tree Zelkova sicula in its native Sicily (Magnanon, 2015).

In some instances habitat types listed on Annex I have dominant or key species which are themselves also threatened. One example is habitat '4080 Sub-Arctic *Salix* spp scrub' formed by a range of *Salix* species including

> Keywords HABITATS DIRECTIVE NATURA 2000 CONSERVATION STATUS PLANT SPECIES HABITATS

04. A role for botanic gardens?

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• *Richard Dominique*
• *Gaudillat Zelmira*
• *Bailly-Maitre Jerôme*

S lapponum, *S lanata*, *S arbuscula*, *S myrsinites*, *S glauca*, *S helvetica* and *S bicolor* which are frequently also threatened as species. In Scotland both the habitat and some of its component species are very rare with a total habitat area reported under Article 17 as 23ha while both *S lanata* and *S lapponum* are considered Vulnerable and *S mysinities* as Endangered on the UK red list of vascular plants (Cheffings. & Farrell 2005). As a result, there have been a series of projects to restore the habitat over the past 20 years in which the Royal Botanic Gardens Edinburgh has been an important partner (Rae 2015). This has involved both research to better understand the ecology of the habitat and its component species and practical work to reinforce willow populations on existing sites and to create additional stands.

Acknowledgments

The ETC/BD and its work to support the European Commission in the implementation of the Habitats Directive and the Bern Convention is funded by the European Environment Agency and the French Ministère de l'Écologie, du Développement durable et de l'Énergie.

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PEATBOG AND WET MEADOW ON A MICRO-SCALE IN THE ADAM MICKIEWICZ UNIVERSITY BOTANICAL GARDEN IN POZNAŃ

Photo credit : *Iris sibirica* L., *Alicja Kolasińska*

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> Keywords EX SITU CONSERVATION PEATBOG WET MEADOW BOTANICAL GARDEN

04. Abstract

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• *Jaskulska Joanna*

THIS PAPER PRESENTS A PROJECT ON HOW TO CREATE A NEW HABITAT FOR PEATBOG AND VARIABLE HUMIDITY GRASSLAND SPECIES. THE PROJECT'S MAIN AIMS ARE TO:

- create favourable ex situ conditions for peatbog species found in the Sand Mine „Kotlarnia" S.A., a site which is planned to be filled with water;
- enlarge the current collection of rare and endangered plant species from peatbogs and variable humidity grasslands (Target 8 of the GSPC; Sharrock, 2012);
- present to the wider public rare and endangered species of little known and hard-to-reach habitats such as peatbogs (Target 14 of the GSPC; Sharrock, 2012).

The new subsection in the botanic garden was created between 2010-2013 over an area of almost 800 m^2. The site offers new habitat of varying degrees of acidity for peatbog plants. In 2013, 23 species were introduced into the new site. Plant material was transferred from the wild, i.e. from the peatbog in the Sand Mine „Kotlarnia" S.A. Plant material of taxa of well-known origin cultivated in the conservation collections of the Adam Mickiewicz University (AMU) Botanical Garden and of species naturally growing from the Arboretum in Syców was introduced as well. Monitoring in 2015 revealed that all species had survived except for *Vaccinium myrtillus* and *Rynchospora alba*. Twelve taxa have established well and have generated new shoots or clumps, i.e. *Drosera rotundifolia*, *Sphagnum* sp. and *Calluna vulgaris*. In 2015, a further batch of species were planted.

Thanks to the project, the amount of rare and endangered species characteristic of peatbogs and variable humidity grasslands in the collection of the AMU Botanical Garden grew by 10 species. Creating the new subsection of these habitats as well as establishing a trail and visual information materials (interpretational board, plant labels), enhanced the educational role of the Garden.

> Keywords *EX SITU* CONSERVATION PEATBOG WET MEADOW BOTANICAL GARDEN

04. Introduction

• *Kolasińska Alicja*
• *Jaskulska Joanna*

Photo credit : *Iris sibirica* L., ***Alicja Kolasińska***

IN POLAND, PEATBOGS ARE ENDANGERED AND UNDER CONSTANT AND HEAVY ANTHROPOGENIC PRESSURE. THE MAJORITY OF PEATBOG TYPES ARE PROTECTED UNDER 'NATURA 2000'.

Many species growing in these habitats are legally protected or have been put on both the National and IUCN European Red List of Threatened Species. *Ex situ* collections of peatbog plants are very occasionally established in Polish botanic gardens due to cultivation challenges. A rare example of such a collection is located in the Alpine Botanical Garden in Zakopane.

In this paper a project is presented on how to build a subsection in the Adam Mickiewicz University (AMU) Botanical Garden for plants of peatbogs and variable humidity grasslands thereby creating new habitats for this horticulturally very demanding group of plants. These activities support the provisions of Target 8 of the Global Strategy for Plant Conservation (GSPC), according to which botanic gardens should enhance *ex situ* collections of rare and endangered species of a given country until 2020 by at least 75% (Kolasińska *et al.*, 2012; Sharrock, 2012).

The aims of this project are to:

- create favourable *ex situ* conditions for peatbog species found in the Sand Mine „Kotlarnia" S.A., a site which is planned to be filled with water;
- enlarge the current collection of rare and endangered plant species from peatbogs and variable humidity grasslands (Target 8 of the GSPC; Sharrock, 2012);
- present to the wider public rare and endangered species of little known and hard-to-reach habitats such as peatbogs (Target 14 of the GSPC; Sharrock, 2012).

Materials & methods

Wild plant material, i.e. from the peatbog in the Sand Mine „Kotlarnia" S.A. (Nowak & Nowak, 2006) was transferred to AMU Botanical Garden. Altogether, 7m^2 of marshy meadows with clumps of *Drosera rotundifolia* L., *Lycopodiella inundata* (L.) Holub and *Sphagnum* sp. were collected. The plants were collected with the help from Silesian Botanical Garden. Plant material of taxa

> Keywords EX SITU CONSERVATION PEATBOG WET MEADOW BOTANICAL GARDEN

04. Materials & methods

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of well-known origin cultivated in the conservation collections of the AMU Botanical Garden and of species naturally growing from the Arboretum in Syców was introduced as well.

The new subsection is located in the lowest part of the Garden, where high groundwater levels can occur spontaneously. However, in case of longer periods without rain when the water table sinks, water is replenished from the nearby pond. To maintain the required pH level, the added water is acidified with citric acid. Owing to this procedure the pH stays at 5,5.

Work to create the new subsection in AMU Botanical Garden started in 2010. Technical interventions began in 2012 and the first planting was carried out in autumn 2013. The realization of the first stage started with deepening and structuring the already existing small water body. It was then divided into different zones by means of fascines and filled with peat of varying acidity, allowing the establishment of sectors of highmoor, transitional moor and lowmoor plants (**Fig. 1**). Moreover, sandy embankments separate the peatbog from the alkaline and eutrophic water seeping through from the surrounding grassland section. In 2013, a trail was created to facilitate closer observations of the plants (Jaskulska *et al.*, 2014).

The final construction work and the majority of the planting activities are planned to be completed by the end of 2015. Ultimately, the site will cover almost 800m^2 (**Fig. 2**).
The establishment of a special area is planned where chosen taxa will be presented in a system of plots and in clusters marked with labels. Material for future planting in the site will be obtained as before, namely from the resources of the AMU Botanical Garden as well as from the wild following agreement with branches of the Regional Management of Environment Protection. Some species were accessioned via seeds from various botanical gardens through the *Index Seminum*.

Fig. 1a.

Fig. 1b.

Fig. 1c.

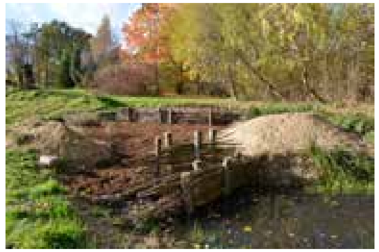
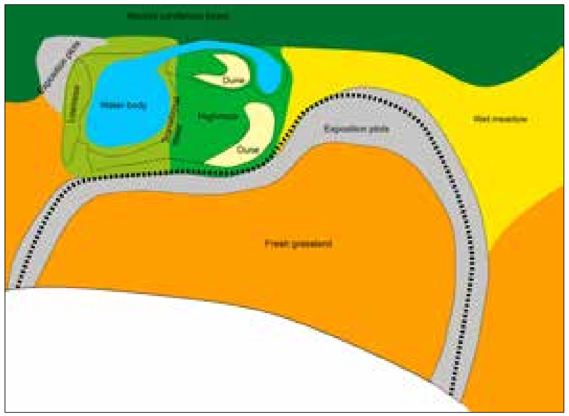


Fig. 1d.

> FIGURE 1.

Stages of construction of the subsection (© A. Kolasińska, except Fig. 1b: © M. Jędrzejczak)

Fig. 1a. Delimitation of the peatbog area
Fig. 1b. Construction of water ponds
Fig. 1c. Water ponds with the fascine
Fig. 1d. The peatbog before planting



> FIGURE 2.

Plan of the peatbog and wet meadow

> Keywords EX SITU CONSERVATION PEATBOG WET MEADOW BOTANICAL GARDEN

04. Results

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In 2013, 23 species were planted in the created habitats (**Tab. 1**). Horticulturally most demanding taxa include *Andromeda polifolia*, *Betula humilis*, *Betula nana*, *Carex pulicaris*, *Chamaedaphne calyculata*, *Drosera rotundifolia*, *Eriophorum angustifolium*, *E. vaginatum*, *Ledum palustre*, *Lycopodiella inundata*, *Oxycoccus palustris*, *Salix lapponum*, *Saxifraga hirculus* and *Sphagnum* sp.

Monitoring in 2015 revealed that all species had survived except for *Vaccinium myrtillus* and *Rynchospora alba*. Twelve species have established well and have produced new shoots or clumps. Self-seeding and spreading of horticulturally demanding plants such as *Drosera rotundifolia* was observed (**Fig. 3**). New rosettes were found even 5m from the mother plant. Similar observations were made for *Sphagnum* sp. and *Calluna vulgaris*. Growth deterioration was recorded only for *Ledum palustre* and *Lycopodiella inundata*.

> FIGURE 3.

Drosera rotundifolia L.
(© A. Kolasińska)

Taxa name	Planted in 2013	Condition in 2015	Planted or to be planted in 2015
Andromeda polifolia L.	+	+	
Arnica montana L.			+
Betula humilis Schrank	+	++	
Betula nana L.	+	++	
Butula pubescens Ehrh.	+	++	
Calla palustris L.			+
Calluna vulgaris (L.) Hull	+	++	
Caltha palustris L.			+
Carex arenaria L.			+
Carex pulicaris L.	+	++	
Chamaedaphne calyculata (L.) Moench	+	+	
Cirsium canum (L.) All.			+
Cladium mariscus (L.) Pohl			+
Colchicum autumnale L.			+
Comarum palustre L.	+	++	
Cornus suecica L.			+
Drosera rotundifolia L.	+	++	
Empetrum nigrum L.			+
Equisetum palustre L.	+	++	
Eriophorum angustifolium Honck.	+	++	
Eriophorum vaginatum L.	+	+	
Euphorbia palustris L.			+
Euphorbia villosa Waldst. et Kit. ex Willd.			+
Festuca valesiaca Schleich.	+	++	
Geranium sanguineum L.			+
Gladiolus imbricatus L.			+
Gladiolus palustris Gaud.			+
Inula salicina L.			+
Iris sibirica L.			+
Ledum palustre L.	+	-	
Lycopodiella inundata (L.) Holub	+	-	
Lysimachia thyrsiflora L.			+
Menyanthes trifoliata L.			+
Myrica gale L.			+
Osmunda regalis L.			+
Oxycoccus palustris Pers.	+	++	
Pinus sylvestris L.			+
Polemonium caeruleum L.			+
Polytrichum commune Hedw.	+	++	
Primula farinosa L.			+
Pulsatilla patens L.			+
Rhynchospora alba (L.) Vahl.	+	0	
Salix lapponum L.	+	+	
Saxifraga hirculus (L.) Scop.	+	+	
Schoenus nigricans L.			+
Senecio macrophyllus M.Bieb.			+
Sphagnum sp.	+	+	
Swertia perennis L.			+
Trollius europaeus L.			+
Vaccinium myrtillus L.	+	0	
Vaccinium uliginosum L.	+	+	

> TABLE 1.

List of species introduced or foreseen to be planted in the peatbog and variable humidity grassland subsection
\+ condition similar to the one observed in 2013
\+ + the species grows better, is self-seeding and gets shoots or clumps
\- condition worse than in 2013
0 species not observed (probable absence)

> Keywords **EX SITU CONSERVATION** **PEATBOG** **WET MEADOW** **BOTANICAL GARDEN**

04. Results

• *Kolasińska Alicja*
• *Jaskulska Joanna*

The majority of the next batch of the new 28 species planned for introduction were planted in spring of the year 2015 including *Calla palustris*, *Cladium mariscus*, *Menyanthes trifoliata* and *Senecio macrophyllus* (**Tab.1**).

Further, an interpretational trail was created. Information panels about peatbog and grassland species, their ecology as well as their typical plant communities were installed and labels with basic botanical information were placed next to the target species.

> **FIGURE 4**

Clumps of plant material transferred from the peatbog in the Sand Mine „Kotlarnia" S.A. (© A. Kolasińska)

Discussion

Establishing the new habitat subsection in the lowest part of the Garden where high level of ground water occurs spontaneously, and dividing it into several parts with varying acidity, created favourable conditions for the acclimatization of horticulturally demanding plants such as peatbog species. Some plants were transferred with larger turf fragments to enhance survival rates (**Fig. 4**). These measures as well as the size of the peatbog section together with the surrounding meadow (altogether ca. 800m^2) increase the chances of maintaining a stable ecosystem with growing success of establishing peatbog species in the future. Within the last three years of research, stabilization or growth in number and improving condition of the cultivated plants were observed. In line with the original project idea, the plant collection is steadily increased with new species. Owing to these measures, the provisions of Targets 8 and 14 of the GSPC are supported.

> Keywords EX SITU CONSERVATION PEATBOG WET MEADOW BOTANICAL GARDEN

04. Conclusion

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Thanks to this project, the amount of rare and endangered species characteristic of peatbog and variable humidity grassland habitats in the collection of the AMU Botanical Garden has grown by 10 species in 2013 and the next 28 species in 2015.

Creating the new subsection, and building a path through the site, which, besides facilitating research studies enables public outreach, has also enhanced the educational role of the Garden, supporting GSPC Target 14.

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SEED BANKS AND THE CBN-ARCAD PARTNERSHIP: TOWARDS UNDERSTANDING THE EVOLUTION OF THE LIFE TRAITS AND PHYLOGEOGRAPHY OF RARE AND THREATENED FRENCH WILD FLORA

Photo credit : *Consolida ajacis* is propagated for horticultural purposes. Genetic introgression can occur between wild and domesticated plants (horticultural forms), thus raising the question on the importance of preserving populations considered as naturalized populations. Genetic studies on these populations using the ARCAD technical genotyping platform will help identify introgressed forms among wild populations, ***F. Andrieu & V. Noble (CBNMed)***

Consolida ajacis

Wild form

Horticultural form

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> Keywords *EX SITU* CONSERVATION OF WILD PLANT
SEED CHARACTERIZATION
DNA BANKS
POPULATION GENETICS
PHYLOGENY
MEDITERRANEAN FRENCH FLORA

04. Abstract

- *Essalouh Laila*
- *Molina James*
- *Prosperi Jean-Marie*
- *Pham Jean-Louis*
- *Khadari Bouchaïb*

FRENCH NATIONAL BOTANICAL CONSERVATORIES (CBN) HAVE THE LONG-STANDING EXPERIENCE IN THE CONSERVATION OF RARE AND THREATENED WILD SPECIES THROUGH THEIR CONSERVATION IN SEED BANKS (SB).

Ex-situ conservation consists of collecting seeds for medium- and long-term conservation by regularly checking their germination ability in order to re-introduce and/or enhance wild threatened plant populations. This approach is reinforced by database networking between French CBN, but also via data exchanges with bordering botanical gardens.

Beyond this work on SB conservation of rare and highly threatened taxa, studies on the evolution of life history traits and/or phylogeography are essential to optimize the wild flora management strategies.

As partners within the Agropolis Resource Center for Crop Conservation, Adaptation and Diversity consortium (ARCAD: < www.arcad-project.org >), CBN and the Federation of National Botanical Conservatories (FCBN) will be able to carry out such studies. The main goal of this consortium is to develop a national *ex-situ* conservation center sharing facilities, technological platforms and Plant Biological Resource Centers (CRBV) for: i) *ex-situ* SB conservation, ii) seed characterization (morphometry, chemical composition, etc.), iii) cryoconservation of non-orthodox seeds, iv) DNA banks and genotyping, and v) information systems and databases.

ARCAD aims to strengthen scientific dynamics on genetic resource management and conservation. The CBN partnership within ARCAD aims to:

- integrate and contribute to the scientific and technical dynamics of the ARCAD consortium on plant conservation,
- contribute to the creation of a CRBV of wild flora and wild relatives of agronomic species,
- contribute to a new portal for the conservation of flora with international scope.

In the paper the criteria used for the selection of CBN wild taxa to be stored in the ARCAD seed bank (ARCAD-CBN SB) are presented.

> Keywords *EX SITU* CONSERVATION OF WILD PLANT, SEED CHARACTERIZATION, DNA BANKS, POPULATION GENETICS, PHYLOGENY, MEDITERRANEAN FRENCH FLORA

04. Introduction

• *Essalouh Laila*
• *Molina James*
• *Prosperi Jean-Marie*
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• *Khadari Bouchaïb*

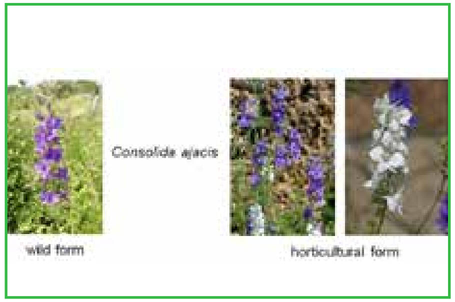

Photo credit : *Consolida ajacis* is propagated for horticultural purposes. Genetic introgression can occur between wild and domesticated plants (horticultural forms), thus raising the question on the importance of preserving populations considered as naturalized populations. Genetic studies on these populations using the ARCAD technical genotyping platform will help identify introgressed forms among wild populations, ***F. Andrieu & V. Noble (CBNMed)***

CBN ARE INVOLVED IN NATIONAL POLICIES ON BIODIVERSITY CONSERVATION AS THEY ARE OBSERVATORIES FOR PLANT EVOLUTION IN A SETTING OF CLIMATE CHANGE AND HUMAN ACTIVITIES. THEY HAVE FOUR MAIN TASKS:

1. Boosting knowledge on the status and evolution of wild plants and natural and semi-natural habitats,
2. Identification and conservation of rare and endangered wild plants and natural and semi-natural habitats,
3. Providing scientific and technical expertise on wild plants and habitats for public services and local authorities,
4. Public awareness and education on plant diversity knowledge and conservation.

CBN are highly involved in *in-situ* and *ex-situ* conservation of rare and endangered plant species and the SBs are important tools for *ex-situ* conservation. Seeds are collected and preserved in the medium or long-term storage. They are regularly checked for their viability and seedling emergency for the purpose of carrying out reintroductions and/or creating new populations. These practices are supported by the networking of CBN seed bank (CBN-SB) databases (DB).

Scientific knowledge on these plants (adaptive functional traits to climate change and human activity pressure, structure of genetic patterns, etc.) are highly expected by CBN to preserve rare and endangered plants with high efficiency. This challenge can be facilitated by the support of laboratories specialized in seed characterization (morphometric and morphological characters, biochemical analysis) and genetic analysis (phylogeny and phylogeography).

The ARCAD partnership is an opportunity for CBN to optimize *ex-situ* methods and conservation tools of rare and endangered plant species. ARCAD is a consortium involving several research institutes within Agropolis International (INRA, CIRAD, IRD and Montpellier Supagro) with the aim of becoming the main French center for the management and conservation of plant genetic resources.

What links should CBN develop with ARCAD in order to integrate and contribute to the scientific and technical dynamics regarding *ex-situ* conser-

> Keywords *EX SITU* CONSERVATION OF WILD PLANT SEED CHARACTERIZATION DNA BANKS POPULATION GENETICS PHYLOGENY MEDITERRANEAN FRENCH FLORA

04. Introduction

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• Molina James
• Prosperi Jean-Marie
• Pham Jean-Louis
• Khadari Bouchaïb

vation, seed characterization and genetic diversity studies? This is the main question of this partnership and it will be examined in the present study. Here we describe the ARCAD consortium and the objectives defined by the CBN in partnership with ARCAD. We then examine the selection criteria and describe the taxon groups proposed for ARCAD-CBN SB. Finally, we discuss the features of this ARCAD-CBN partnership and describe the prospects for the conservation of French wild flora (FWF).

ARCAD consortium and CBN objectives for the ARCAD partnership

ARCAD aims to make Montpellier a French hub for plant genetic resource management and conservation via the involvement of the institutions (INRA, CIRAD, Montpellier Supagro and IRD) and research structures (UMR AGAP and UMR DIADE) working on plant genetics that are already present. Supported by research institutions, the European Union and the French Languedoc-Roussillon region, the ARCAD consortium will have a building and facilities by late 2019 to bring together SBs, technical platforms, technical and engineering staff and scientists focusing on plant genetic resource management and conservation. ARCAD includes four technical platforms that offer innovative approaches for seed conservation and characterization, and genetic diversity analysis. Within the CRBV framework, seeds are conserved in medium and maintained under medium or long-term storage in secured conditions with robotic management under quality of assurance procedures. Non-orthodox seeds and clonally-propagated plants may be conserved using a technical cryopreservation platform. The third technical platform on seed phenotyping offers several innovative methods using robotic procedures such as automatic image analysis and non-invasive analysis using near-infrared spectroscopy (NIRS) for morphological and morphometric characterization, biochemical analysis (e.g. the fatty acid nature) and determination of the germination ability and potential. The fourth platform is devoted to the DNA bank and molecular marker genotyping using, for instance, microsatellite markers, as well as markers generated by next-generation sequencing (NGS) tools, e.g. single nucleotide polymorphism (SNP) markers. The ultimate objective is to establish links between DNA and the SB accessions. In addition to the involvement of research institutes and units, the ARCAD consortium aims to: **I)** offer training activities by hosting foreign personal staff, and **II)** provide biological resource reception capacities and develop partnerships with CBN, etc.

Through this partnership, CBN aim to: **I)** integrate and contribute to the scientific and technical dynamics of the ARCAD program on ex-situ conservation, seed characterization and genetic diversity studies, **II)** work towards creating a CRBV of FWF, and **III)** develop a portal for FWF conservation with international scope so as to establish and promote scientific collaborations. Beyond long-term secure seed conservation, the first objective is to propose an ARCAD-CBN SB to support studies and scientific collaborations on the evolution of life history traits (seed characterization) and the genetic diversity structure (DNA bank and genotyping). Such studies are crucial to gain insight into the biology of species and develop appropriate conservation strategies. The second objective is to establish a complementary link between CBN SB and the common CBN-ARCAD SB (**Fig. 1**). This strategy requires taxa selection according to criteria that should be tailored to CBN objectives through their ARCAD partnership.

> Keywords EX SITU CONSERVATION OF WILD PLANT
SEED CHARACTERIZATION
DNA BANKS POPULATION GENETICS
PHYLOGENY MEDITERRANEAN FRENCH FLORA

04. Selection criteria and taxon groups proposed for the CBN-ARCAD SB

• *Essalouh Laila*
• *Molina James*
• *Prosperi Jean-Marie*
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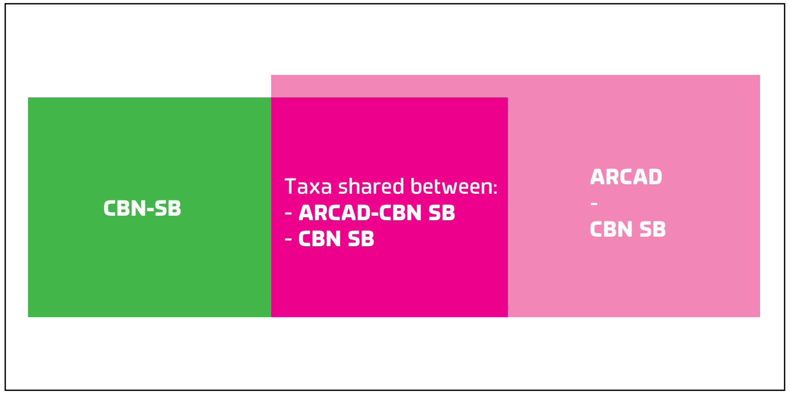
• *Khadari Bouchaïb*

Selection criteria were examined by consulting CBN botanic gardens involved in the Mediterranean biogeographical area (MBA) while taking the following characteristics into account:

i) Taxon status and issues (protected and IUCN Red List species),
ii) Environmental issues and threats (species impacted by urban development, global change, agricultural activities),
iii) Phylogenetic (monophyletic species) and biogeographic (endemic species and species in Mediterranean hotspots) aspects,
iv) Genetic pools related to wild relatives of cultivated species.

Three criteria were defined to select taxon for ARCAD-CBN SB: **i)** The rarity and threats, **ii)** phylogenetic and biogeographical representation of wild flora, and **iii)** links with agroecosystems and cultivated species.
Five taxon groups were identified for ARCAD-CBN SB by examining *in-situ* Mediterranean FWF using these criteria.



> FIGURE 1.

Complementary links between CBN SB and ARCAD-CBN SB. Taxa to be conserved in CBN-ARCAD SB for two targets: i) doubly secure conservation of rare and threatened species, and ii) studies on the evolution of life history traits and phylogeography

1. PROTECTED AND THREATENED TAXA

This includes protected taxa according to the national and regional lists and taxa on the IUCN Red List of endangered flora in France and on the regional red lists. They represent a substantial challenge for FWF management and conservation. Several approaches, including taxa and habitat inventories, public awareness campaigns and promotion of the legislation framework, are used to avoid or limit the impacts of urban development and agricultural practices. When no other alternative is possible for saving plants *in-situ*, restoration programs for habitats or impacted species are undertaken. Boosting scientific knowledge on these plants and habitats is crucial for their efficient conservation. This can be facilitated by the support of laboratories specialized on seed characterization as well as on phylogenetic and phylogeographic analysis.

2. TAXON GROUPS LINKED TO AGROECOSYSTEMS

Crop weed taxa can provide ecosystem services as hosting crop pest predators while also providing ideal refuges for some pollinators (Jauzein, 2011). These taxa include “messicoles” (annual cereal weed species), weed species preferentially associated with crops, which are the main interest of a national action program (PNA) supported by the French Ministry of Ecology, Sustainable Development and Energy and coordinated by FCBN and CBNMPM (Cambecèdes *et al.*, 2012). A French list of annual cereal weed species, corresponding to 102 taxa, was drawn up in the framework of this PNA program. A comparison of annual cereal weed taxa (messicoles) lists of the four Mediterranean CBN areas (CBNMed, CBNA, CBNMC, CBNPMP) revealed 12 common taxa (**Tables 1 and 2**). Seed samples from populations of these different French MBA are suitable for studying spatiotemporal evolution of functional traits of seeds linked to the genetic structure.

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04. Selection criteria and taxon groups proposed for the CBN-ARCAD SB

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> TABLE 1

Inventory of "messicole" species present in Mediterranean biogeographic regions corresponding to the area encompassed by Mediterranean CBN (CBNMed), including part of CBNPMP (*Pyrénées Midi Pyrénées* region), CBNA (alpine region), CBNMC (*Massif Central* region) and CBNC (Corsica, *missing data for CBNC)

CBN	CBNMed	CBNPMP	CBNA	CBNMC	CBNC
Taxon number	69	125	33	28	*

> TABLE 2

List of 12 " messicole" annual cereal weed species common for CBNMed, CBNA, CBNMC end CBNPMP areas

1. *Adonis aestivalis* L.	7. *Conringia orientalis* (L.) Dumort.
2. *Adonis flammea* Jacq.	8. *Galium tricornutum* Dandy
3. *Agrostemma githago* L.	9. *Gladiolus italicus* Mill.
4. *Androsace maxima* L.	10. *Legousia speculum-veneris* (L.) Chaix
5. *Bupleurum rotundifolium* L.	11. *Myagrum perfoliatum* L.
6. *Caucalis platycarpos* L. [1753]	12. *Vaccaria hispanica* (Mill.) Rauschert

Moreover, some weed species preferentially associated with crops, likewise *Ajuga chamaepitys*, are also present in semi-natural areas. As the selection pressures are likely different, comparing functional traits such as the seed mass of these taxa between agroecosystems and semi-natural habitats can be interesting for studying the adaptive traits and drawing up appropriate conservation strategies.

Other taxa, likewise *Consolida ajacis*, are propagated for horticultural purposes. Genetic introgression can occur between wild and domesticated plants (horticultural forms), thus raising the question on the importance of preserving populations considered as archaeophytes – or naturalized populations – in comparison to cultivated forms. Genetic studies on these populations using the ARCAD technical genotyping platform will help to identify introgressed forms among wild populations.

3. WILD TAXA RELATED TO CROP SPECIES

A list of wild taxa related to crop species has been drawn up at the national level, including about 600 wild taxa related to 258 crop species (food, forage, horticultural and medicinal crops). Seed collecting of these taxa may be organized in the framework of specific project in partnership with ARCAD. The sampling strategy should take into account the French biogeographical zones outlined in the *Flore Locale* program.

4. TAXON GROUP REPRESENTATIVE OF THE PHYLOGENY AND BIOGEOGRAPHY OF WILD FRENCH MEDITERRANEAN FLORA

Focusing only on rare and threatened taxa is not sufficient to gain further insight into the vulnerability factors and adaptive strategies involved because of difficult distinguishing between the effects of human and biological factors. Comparative studies between these taxa and common taxa, according to phylogenetic and biogeographic patterns, would enhance assessment of the consequences of vulnerability related to anthropogenic pressures (Lavergne *et al.*, 2004). In this context, taxa should be selected according to their representativeness of Mediterranean FWF (phylogenetic level), but also according to their endemic status (biogeographical level).

Continental Mediterranean FWF consists of about 1,217 genera, including 917 native and 300 non-native species. Each native genus may be represented by one or two species so as to represent the phylogenetic diversity of the entire flora community. One or two batches of seeds sampled from several individual plants are necessary to represent each concerned taxon. For these 917 native taxa, leaves will be sampled from one to three individual plants per taxon in order to establish the DNA bank for Mediterranean FWF. CBN-ARCAD SB aims to have representative samples of endemic species

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SEED CHARACTERIZATION
DNA BANKS POPULATION GENETICS
PHYLOGENY MEDITERRANEAN FRENCH FLORA

04. Selection criteria and taxon groups proposed for the CBN-ARCAD SB

• *Essalouh Laila*
• *Molina James*
• *Prosperi Jean-Marie*
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(range restricted to French MBA) to benefit from their strong heritage value but also to support the development of analyses combining genetic studies (diversity, genetic structure, phylogeographic patterns, etc.) and taxa spatial distribution studies (e.g. hotspot-based analysis), which are key tools for designing natural conservation area networks.

5. TAXON GROUPS WITH CONFUSING TAXONOMICAL RELATIONSHIPS

Some taxa, such as *Allium polyanthum, Bromus commutatus, Campanula rotundifolia, Chaerophyllum hirsutum* and *Limonium cuspidatum,* have yet to be defined for their taxonomical relationships, often leading to erroneous identifications. Phylogenetic studies wherein morphological traits are compared to DNA polymorphism through the use of genetic markers are essential to clarify the taxonomy and classification of these taxa. A list of more than 80 taxa is proposed for the collection of seeds for CBN-ARCAD SB (about 5-10 batches per taxon). For these taxa, leaves will be sampled (about 1-3 individuals per taxon) for the Mediterranean FWF DNA bank.

Building the CBN-ARCAD seed bank

In addition to secure long-term conservation in CBN-ARCAD SB, sampling of selected taxa should meet the following conditions so as to facilitate studies on the evolution of functional traits (such as seed mass) and genetic structure (Albert et al., 2012): **i)** sampling sites should be representative for their biogeographical distribution, and **ii)** seeds should be collected preferably from individual plants which are representative for the sampled population. It is hard to assess the number of seed samples required for all taxa since the sampling protocol dependents on the biology and ecology of each taxon. Our aim is to propose a sampling size range while keeping in mind that substantial sampling may be necessary for some taxa (5-10 populations per taxon; collection of seeds from 20-30 individuals per population in order to capture the highest genetic diversity). While taking all selected taxon groups into account, the number of seed accessions for ARCAD-CBN SB could be estimated as 10,000 to 25,000 accessions.

With 10,570 accessions (seed batches) and 1,730 taxa, the CBNMed SB is the largest SB within the CBN network (CBNA, CBNC, CBNMC, CBNPMP), including 567 (33%) protected and threatened taxa (http://banques-de-graines-alpes-mediterranee.eu). Quantities in the set of 686 accessions, corresponding to 312 taxa, are sufficient (see **Table 3**). These seed accessions could be used for studies on the evolution of functional traits.

> TABLE 3.

Classification of accessions according to seed, taxon and family quantities, after a CBNMed SB inventory. Two major group categories, i.e. E4 and E5, could be used for studies on the evolution of functional traits

Category of groups	Seed quantity	Accession number	Percentage / total accessions	Taxa number	Family number
E4	1,001 - 10,000	586	5,46%	274	56
E5	>10,000	100	0,96%	69	28
E4 + E5		686	6,42%	341	84

These 312 taxa are classified in three groups selected for CBN-ARCAD SB (protected and threatened taxa, annual cereal weeds and wild taxa related to crop species, representative of Mediterranean FWF). For each of these taxa, seeds were collected 10, 20 or even 30 years ago, generally at one site, but sometimes at two or more. These seed accessions, complemented by new samples collected at the same sites using SI Flore SILENE (http://flore.silene.eu), will be used to conduct comparative studies on the evolution of life his-

> Keywords *EX SITU* CONSERVATION OF WILD PLANT
SEED CHARACTERIZATION
DNA BANKS
POPULATION GENETICS
PHYLOGENY
MEDITERRANEAN FRENCH FLORA

04. Building the CBN-ARCAD seed bank

• *Essalouh Laila*
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• *Prosperi Jean-Marie*
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tory traits based on the seed phenotyping and genetic analysis using the ARCAD technical platforms.

Following a detailed inventory, CBNMed SB seems to be a valuable tool for studying of the evolution of life history traits. This strategy would require new seed collections at previously sampled sites for comparative studies regarding these sites or populations. It is therefore essential to adopt this approach as a real complementary and synergistic link between CBN SBs such as CBNMed and the future CBN-ARCAD.

Conclusion & prospects

The CBN-ARCAD partnership is a quite unique experience in France as the challenge is to establish collaborations between the agrobiodiversity research community (ARCAD consortium) and the wild flora research community (CBN). Based on the ARCAD-CBN SB, the adopted approach has been achieved to seek complementary and synergistic linkages at two levels (see Fig. 1): i) between the CBN and the ARCAD consortium, and ii) between CBN SBs and the CBN-ARCAD SB. The ARCAD partnership is illustrated by the involvement and contribution of the CBN to scientific and technical dynamics within the ARCAD consortium (long-term storage, availability of seed samples of Mediterranean FWF representative taxa, taxa linked to agroecosystems and wild taxa related to crop species) in order to conduct the studies on the evolution of life history traits and to optimize knowledge on flora management and conservation (wild taxa and wild taxa related to crop species). Links between CBN SB and CBN-ARCAD SB offer the possibility of conducting studies on the evolution of taxa life history traits with seeds collected 10, 20 or even 30 years ago (Franks *et al.*, 2008; Franks & Weiss, 2008).

CBN involved in ARCAD project should share the following objectives: i) long-term seed storage of accessions in CBN-ARCAD SB for rare and threatened taxa, including non-orthodox seeds and clonally-propagated plants; ii) propose rare and threatened crop weeds such as annual cereal weeds (messicoles) related to PNA (Cambecèdes *et al.*, 2012) for conservation and studies on the evolution of life history traits and genetic patterns.

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04. Conclusion & prospects

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CBNMed also has other objectives, some of which can be shared by other CBN:

i) To study life history traits through the characterization (shape, mass, biochemical composition, etc.) of seeds of protected and threatened taxa, along with other taxon groups selected for the CBN-ARCAD SB, so as to establish descriptive reference standards of seed traits,

ii) To study and clarify phylogenetic relationships of taxa with a not clear taxonomy (e.g. Limonium cuspidatum on the Languedoc plain, Camargue, southern France),

iii) To study and understand the evolution of life history traits and gene flow for taxa linked to agroecosystems, including crop weed taxa,

iv) To study and understand the adaptive strategies and vulnerability factors based on a phylogenetic and biogeographical representativeness of common taxa of Mediterranean FWF, and rare and threatened taxa (Lavergne *et al.*, 2004),

v) To identify, collect seeds and conduct studies on the genetic relationships of wild taxa related to crop species.

In agreement with FCBN (http://www.fcbn.fr), work carried out as a part of this study was focused solely on the Mediterranean FWF. The CBN-ARCAD partnership is expected to expand its contribution to FWF, including other CBN. In order to continue developing this CBN-ARCAD partnership, it is essential to promote this work by setting up seed collection strategies for taxon groups proposed for CBN-ARCAD SB. Wild plant seed collection strategies and storage can be different according to taxon groups but they should share a common goal of representing the biogeographical distribution of each taxon (several sites or populations; Albert *et al.*, 2012) and the diversity within the same site or population. Seed collection for taxa selected for CBN-ARCAD SB will be organized over the next 5 years with the aim of gathering 10,000 to 25,000 seed accessions.

> Keywords *EX SITU* CONSERVATION OF WILD PLANT, SEED CHARACTERIZATION, DNA BANKS, POPULATION GENETICS, PHYLOGENY, MEDITERRANEAN FRENCH FLORA

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SAFE FOR THE FUTURE: SEED CONSERVATION STANDARDS DEVELOPED FOR THE MILLENNIUM SEED BANK PARTNERSHIP

Photo credit : MSBP Seed Conservation Standards review at the Finnish Museum of Natural History LUOMUS, *Paula Havas-Matilainen*

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> Keywords SEED CONSERVATION STANDARDS SEED BANKS LONG-TERM CONSERVATION ORTHODOX SEEDS

04. Abstract

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FOR CONSERVATION SEED COLLECTIONS TO BE RECOGNISED AS A GLOBAL RESOURCE AND SATISFY THE NEEDS OF ANTICIPATED USERS, COLLECTIONS AND ASSOCIATED DATA MUST BE OF HIGH QUALITY.

The Millennium Seed Bank Partnership (MSBP) Seed Conservation Standards provide a framework within which member organisations cooperate to ensure the quality of their collections.

Making conservation seed collections from wild populations faces very different challenges from banking agricultural collections, highlighting the need for Standards tailored to such collections. The Seed Conservation Standards developed for the MSBP represent current best practice for long-term conservation of orthodox seeds from wild plants. They draw on and reference various existing protocols and guidelines and can be applied and monitored at an international scale.

We provide an introduction to the Standards, which cover all aspects of long-term seed conservation, from collection to seed bank management. In addition to ensuring the quality of the collections, the Standards also provide a basis for technology transfer amongst partners and capacity development within the MSBP network as a whole. The ability of the Standards to improve facilities across the network is discussed. Up to 50% of the indicators used to monitor the Standards can be assessed by routine collection data exchange, such as through the MSBP Data Warehouse, a BRAHMS database containing seed collection data from across the MSBP. The remainder are assessed as part of regular partnership cooperation visits.

An annual questionnaire records developments across the MSBP, and has been used to gauge response to the Standards. Eighty five percent of respondents to the 2014 survey supported the development and implementation of the Standards. Standards which were deemed easiest to meet included those associated with collecting, processing and data management, while ‘viability and monitoring’ was seen as the hardest group of Standards to meet, followed by ‘distribution’, ‘storage and duplication’, and ‘seed bank management’. In 2015, 40% of respondents to a survey felt ready for a Standards review, while 33% preferred to defer for a year.

> Keywords SEED CONSERVATION STANDARDS SEED BANKS LONG-TERM CONSERVATION ORTHODOX SEEDS

04. Introduction

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Photo credit : MSBP Seed Conservation Standards review at the Finnish Museum of Natural History LUOMUS, *Paula Havas-Matilainen*

THE PRESSING NEED TO CONSERVE PLANT DIVERSITY IS WELL KNOWN AND UNDERSTOOD (MEA, 2005; CBD, 2012).

Ex situ conservation in the form of seed banks is going a long way to address this need by conserving genetic material from the world's wild, uncultivated plants, with a focus on those that are endangered, endemic or of economic importance. By making the seed material available to bona fide researchers and restoration practitioners an integrated conservation strategy emerges, with *ex situ* conservation of seed supporting in situ conservation actions.

Since the 1970s, seed-banking has been used as a routine conservation measure by Royal Botanic Gardens, Kew (Kew). Following the completion of the Kew's Millennium Seed Bank (MSB) in 2000 at Kew's Wakehurst campus, a worldwide network of partner institutes was developed for the purpose of conserving plant diversity across the globe (**Fig. 1**). The Millennium Seed Bank Partnership (MSBP) has involved more than 95 countries and territories and seeds from over 180 countries and territories have been banked as duplicates at the MSB, making the MSBP the largest wild plant conservation programme in the world.

> FIGURE 1.

Map showing the global extent of the Millennium Seed Bank Partnership, 2000-2015

The current target of the MSBP is to bank seed from 25% of the world's plant species by 2020. That is a quarter of all plants that bear orthodox seeds which can withstand drying to 15% relative humidity (RH) and storage at -20°C, about 75,000 species. There are currently 40,000 species in MSBP seed banks with associated collection data available for review. A further 11,000 species have been reported by partners, but have yet to be assessed in detail.

> Keywords SEED CONSERVATION STANDARDS SEED BANKS LONG-TERM CONSERVATION ORTHODOX SEEDS

04. Introduction

• *Breman Elinor*
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The MSBP includes almost 200 organisations across the partnership (130 of which are overseas), and has active seed collection programmes in 80 countries and territories. Some of the partnerships have been running for 15 years, some are just starting up; a range of seed banking facilities, meeting the needs of the partner's seed banking programme are covered, from high to low tech.; and while the majority of partners duplicate their seed collections at the MSB for safe storage, collections are increasingly being duplicated in-country or in regional networks.

To be recognised as a global resource and satisfy the needs of anticipated users of collections and associated data, MSBP seed collections must be of high quality. Previous guidelines for the banking of plant germplasm have addressed crop species, their wild relatives and other wild plants that are used for nutrition, shelter or fuel (FAO, 2014; ISTA, 2011). They did not focus on the long-term conservation of wild plant species, or those wild plants which are of high conservation value. The MSBP Seed Conservation Standards provide a framework to recognise MSBP collection quality, including material not duplicated at the MSB. The standards assure users of the utility of the collections and also provide a basis for technology transfer amongst partners and capacity development within the MSBP network as a whole.

Materials & methods

Kew has created an active research methodology for the conservation of seeds from wild plants, which informs all aspects of the seed banking process from collection in the field through to germination testing (Smith *et al.*, 2003). The MSBP Seed Conservation Standards were developed by Kew in 2014 using global best practice (e.g. FAO, 2014; ISTA, 2011) and more than 30 years of seed banking experience at Kew. Drafts were sent out across the MSBP for consultation and the Standards were adapted accordingly. The final Seed Conservation Standards were published in February 2015 (Kew, 2015a). The MSBP annual questionnaire in 2014 and 2015 was used to gauge uptake and response to the Standards.

A system for monitoring the Standards across the MSBP was developed by Kew. The system needed to be comprehensive and able to capture detail, yet not be a burden on busy colleagues. Monitoring involves the completion of a Standards review form, 50% of which can be calculated automatically using seed collection data provided by a partner to the MSBP Data Warehouse (a BRAHMS database containing seed collection data from across the partnership, *http://brahmsonline.kew.org/msbp/SeedData/DW*). The remainder can be completed by the partner, either during a visit to/from the MSB, or remotely with help available electronically. Joint fieldwork and planning is also required, enabling those Standards relating to the collection of seed samples to be monitored.

A ranking system was developed for the Standards, consisting of high, medium and low priority. Those considered high priority are listed in **Table 1.** A ranking system was also devised to chart partners' advances towards meeting a given Standard: no significant concerns; some potential gains (non-priority); high potential gains (medium priority); and priority area for development.

> Keywords SEED CONSERVATION STANDARDS SEED BANKS LONG-TERM CONSERVATION ORTHODOX SEEDS

04. Materials & methods

• *Breman Elinor*
• *Way Michael*

> TABLE 1

Standards with the highest priority ranking

1.1	**Genetic materials, including traditional knowledge, legally collected and conserved**
1.2	**Collection names verified (ideally with reference to a voucher)**
1.5	**Survival of source population not compromised**
2.1	**Unique accession reference number is assigned to all incoming material**
2.2	**Collections are placed in cool/ambient drying conditions of 15% eRH ± 3% within 4 weeks of collection** (Immature seeds are ripened before drying; microscopic seeds (e.g. orchids) are dried for a maximum of 1 week)
3.1	**Collections are held in air-tight (hermetic) containers**
3.3	**Collections are stored at -20°C ± 3°C**
3.5	**Collections are duplicated at -20°C ± 3°C and 15% eRH ± 3% at a second, geographically-separate, facility or reason for non-duplication recorded** (reasons include: low seed number, accession being regenerated and/or on priority list for recollection)
5.1	**A data management system, using recognised seed bank data standards, is in use and capable of export in standard format**
6.2	**A distribution policy, with appropriate risk management for pests, diseases and potentially invasive species, is in place and applied**

> FIGURE 2

The seven categories covered by the MSBP Seed Conservation Standards

Results

The MSBP Seed Conservation Standards (Kew, 2015a) consist of 20 standards split across seven categories relating to all aspects of seed conservation (**Fig 2**). The Standards are voluntary and based on broad statements of best practice, allowing partner institutes to meet them using existing internal protocols where possible.

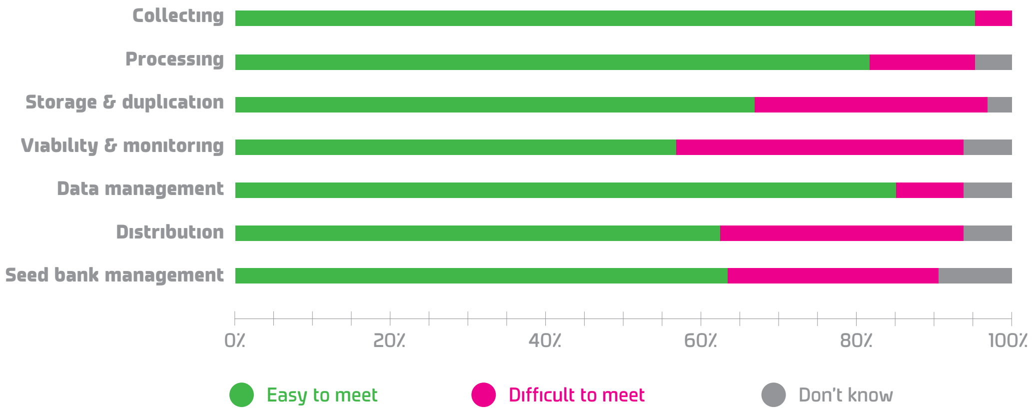
The MSBP annual questionnaire was used to gauge interest in and monitoring of the Standards in 2014. The ease with which an institute could meet the proposed Standards was assessed (**Fig. 3**). The majority of partners felt that most standards would be easy to meet, the easiest being collection standards, the hardest being 'viability and monitoring'. Interest in involvement

> Keywords SEED CONSERVATION STANDARDS SEED BANKS LONG-TERM CONSERVATION ORTHODOX SEEDS

04. Results

• Breman Elinor
• Way Michael

in the development and monitoring of the Standards was also gauged, and received 86% positive response rate.



> FIGURE 3

How easy would the following standards be for your institute to meet? 99 responses, representing 80 organisations from 44 countries

The 2015 MSBP questionnaire asked in more detail about some of the facilities that partners have at their institutes which have a bearing on meeting the standards (**Fig. 4**). For drying, the majority have purpose-built drying rooms or are using silica gel or other desiccants to dry their seed collections. Those responding 'other' tended to use a mixture of drying options depending on seed type. For storage, the majority are storing between -11°C and -20°C. Those who answered 'other' were not storing seeds long-term but using refrigerators or ambient conditions to store seed. Of the 79% who store their seeds long term (>5 years), 80% bank at -11 to -20 °C, and all except one use tri-laminate foil bags or glass to store their seeds.

This information gives us a good idea of how close a particular institute is to meeting the standards on seed drying (to 15 ±3 %RH) and seed banking temperature (-20 ±3 °C) for long-term conservation collections. It also provides a valuable baseline on which to develop technology transfer and capacity building. Of those who responded, 73% felt ready for Standards review in 2015-16.

Discussion

The need for standardisation of procedure and practice across seed banking networks in relation to the long-term conservation of wild species has been recognised and answered by the MSBP Seed Conservation Standards. Despite being a voluntary code, there has been enthusiastic uptake of the Standards across the MSBP network, with 86% of respondents to the 2014 MSBP questionnaire wishing to be involved in their development, and 73% of respondents to the 2015 MSBP questionnaire requesting a Standards review within two years. Data from the 2015 questionnaire is also encouraging as it suggests that the majority of institutes who responded would meet the key standards on drying and freezing conditions with ease, supporting the assertion in the 2014 questionnaire that these Standards would be easy to meet.

Trial reviews of the Standards were carried out for the MSB and for LUOMOS in Finland in 2014 to help develop the monitoring procedures. Since then Standards reviews have been carried out for the New Zealand Plant Conservation Network, and are planned with a host of MSB partners in the coming months. These reviews can take the form of visits of Kew staff to the

> Keywords SEED CONSERVATION STANDARDS SEED BANKS LONG-TERM CONSERVATION ORTHODOX SEEDS

04. Discussion

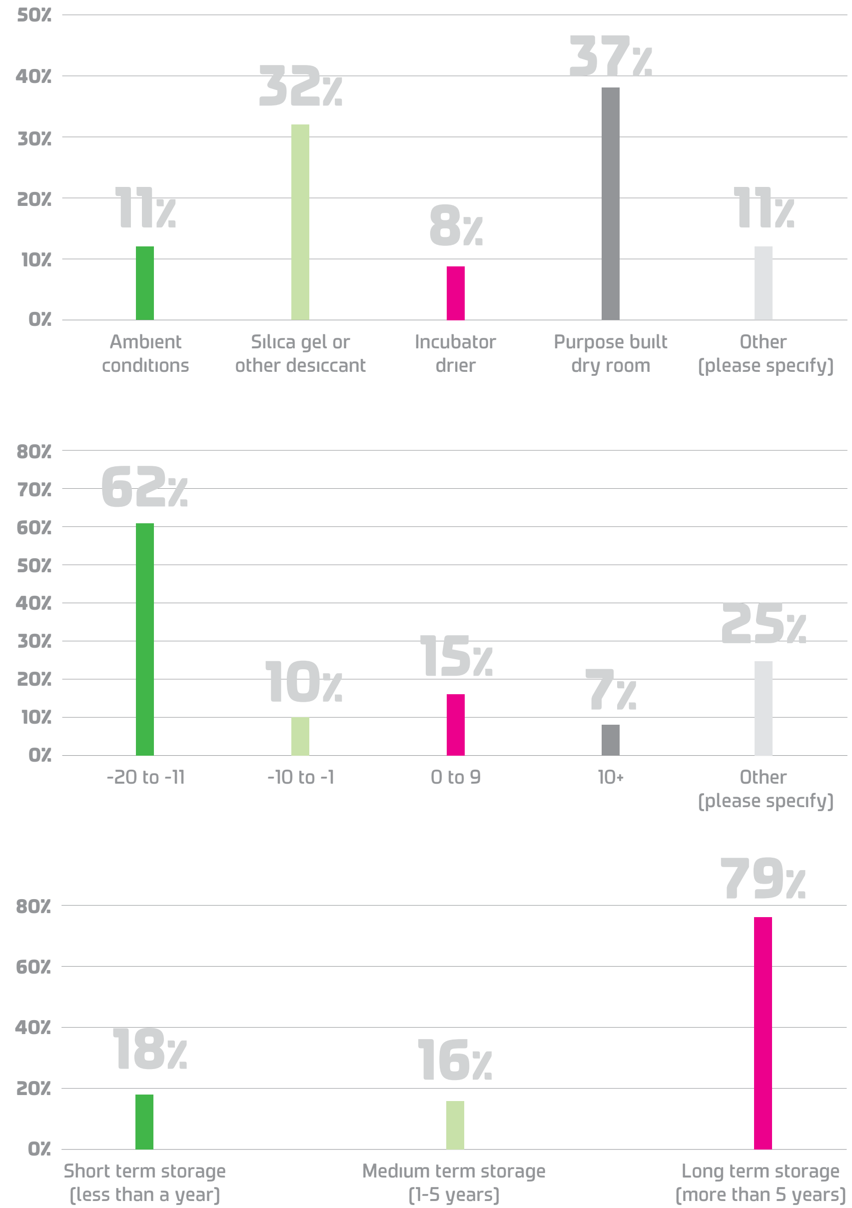
• Breman Elinor
• Way Michael

partner's facilities, or vice versa, or can be carried out remotely with data sharing.

Across the MSBP there is a strong focus on capacity building and mentoring. As well as assuring the quality of the seed collections held across the network, the Standards are helping members of the MSBP to work together to build capacity and improve facilities and procedures to raise the quality of wild species seed conservation globally. An initial Standards review provides a baseline against which seed banks can mark their progress in relation to procedures and facilities. The traffic light ranking in reviews allows seed banks to easily identify areas where improvements could be made and focus on these. A wide range of help is available from Kew to enable capacity building and technology transfer, examples include regular training opportunities, help with database management issues (e.g. through the MSBP Data Warehouse), advice on seed bank design and seed banking equipment, and technical information sheets covering all aspects of the seed banking process (Kew, 2015b).

Conclusion

The MSBP Seed Conservation Standards represent an important step forward for *ex situ* plant conservation. They are an integral part of the MSBP target of banking 25% of the world's plants by 2020, as using Standards in seed banks around the world is key to assuring high quality global seed conservation at the scale required by current targets.



> FIGURE 4

Upper panel shows conditions used for drying seed collections (n=61), middle panel shows conditions used for banking seed collections (n=59), lower panel shows length of seed storage (n=56)

> Keywords SEED CONSERVATION STANDARDS SEED BANKS LONG-TERM CONSERVATION ORTHODOX SEEDS

04. References

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• Way Michael

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BGCI SUPPORTING SEED BANKING IN BOTANIC GARDENS AROUND THE WORLD

Photo credit : Participants collecting seed and data as part of GSCC training in Argentina, *Katherine O'Donnell*

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> Keywords GSPC *EX SITU* CONSERVATION SEEDBANKING NETWORK

04. Abstract

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TARGET 8 OF THE GLOBAL STRATEGY FOR PLANT CONSERVATION CALLS FOR '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 BY 2020'.

A recent review of global progress suggests that less than 30% of threatened plant species are in *ex situ* collections. More needs to be done if the 2020 targets are to be achieved.

A global review of the role of botanic gardens in seed banking was carried out by BGCI. Survey results, together with existing information available from the Millennium Seed Bank Partnership (MSBP) and BGCI's databases were used to define the baseline situation of botanic gardens in seed banking and to determine where the gaps exist. Over 420 institutions are involved in seed banking in 97 countries. Nearly 80% of these bank seed at their own institutions. The majority of botanic gardens involved in seed banking are located in Europe and the United States. Based on analysis of geographic patterns of plant diversity the major gaps exist in South America, Central Africa and South East Asia. Of the survey respondents the majority use institutionally specific protocols for collecting and banking. Priority is given to the conservation of endemic and threatened species with banking of economic species less important. Analysis of seed accession data in PlantSearch suggests that 38,000 taxa are in ex situ collections. In addition over 50 botanic gardens have collected and banked seed accessions for 17,000 wild taxa, which are not currently documented in PlantSearch.

Over 60 gardens that are currently collecting seed but not banking it have expressed interest in becoming involved in seed banking at their institution but cited lack of funding, trained available staff and infrastructure as the most important limiting factors to seed conservation. In order to monitor global progress towards Target 8 of the GSPC, seed collections need to be well documented in BGCI's PlantSearch database. Botanic gardens with seed collection information not already in PlantSearch are encouraged to add their data. PlantSearch records could be used alongside information on plant diversity and the number of orthodox species per country to determine gaps and prioritise collecting.

> Keywords GSPC *EX SITU* CONSERVATION SEEDBANKING NETWORK

04. Introduction

• *O'Donnell Katherine*
• *Sharrock Suzanne*

Photo credit : Participants collecting seed and data as part of GSCC training in Argentina, *Katherine O'Donnell*

IT HAS RECENTLY BEEN REPORTED THAT ONLY 29% OF PLANT SPECIES ON THE IUCN RED LIST OF THREATENED SPECIES™ ARE IN *EX SITU* COLLECTIONS (SHARROCK *ET AL.*, 2014).

Target 8 of the GSPC calls for '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' by 2020.

With less than 6% of the estimated 400,000 species of plants formally assessed at the global level using IUCN criteria, monitoring progress of *ex situ* conservation is difficult. However it is clear that more needs to be done if this GSPC target is to be realised.

Orthodox seeds can be collected from plants, dried and stored in cool conditions until they are required for research, restoration or reintroduction. Seed banking is increasingly being used as a method of *ex situ* conservation for a variety of reasons:

- It is the most cost effective method of *ex situ* conservation;
- A higher genetic diversity can be sampled when collecting than for living collections;
- Seeds take up less room than living plant collections;
- Seeds can survive for hundreds of years in conditions of low humidity and low temperature.

Methods

In order to identify the gaps in seed banking it is essential to determine the baseline situation. BGCI has therefore recently carried out a global review of the role of botanic gardens in seed conservation.

This review was based on information from BGCI's GardenSearch and PlantSearch databases along with data on Millennium Seed Bank partners and the results from a recent BGCI survey on seed banking in botanic gardens. The survey was sent to GardenSearch contributors in over 700 institutions. 271 individual institutions responded from 65 countries. The questions in the survey aimed to determine:

> Keywords GSPC *EX SITU* CONSERVATION SEEDBANKING NETWORK

04.

• O'Donnell Katherine
• Sharrock Suzanne

Methods

- Which institutions are involved in seed collecting and banking;
- What protocols are being used for collecting and banking;
- Seed storage facilities and conditions available in botanic gardens;
- Institutional reasons for seed conservation;
- The limitations preventing gardens becoming involved in or doing more seed conservation;
- Data management of accessions and use of PlantSearch to share data.

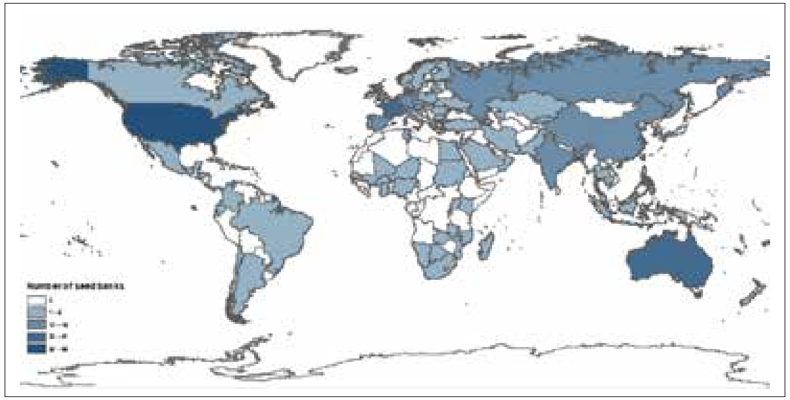
Results

Nearly 80% of the institutions that responded to the survey collect seed as part of their work. The main reasons for collecting seed include conservation and back up/replacement of the living collections. There is a strong emphasis on collecting seed of threatened or endemic taxa within these gardens.

A number of gardens (74) that collect seed do not presently bank this seed. This is due to several factors, including lack of trained and available staff, lack of infrastructure, insufficient funding and lack of institutional priority. Of these institutions more than 80% would be interested in banking the seed they collect. This includes institutions in nine countries where there are currently no botanic gardens involved in seed banking.

SEED BANKING: THE GLOBAL OVERVIEW

It is recognised that many institutions in a wide range of countries collect and bank seed. However in many cases, seed banking focuses on agricultural crops and falls within the remit of agricultural institutes and agencies. The focus of our survey was to identify institutions involved in seed banking of wild plants, and particularly threatened species, which are generally not included in agricultural seed banks.



> FIGURE 1

Number of seed banks per country

The results of the survey allowed us to identify over 50 institutions involved in such seed banking on which we previously had no data. In order to determine a global overview, this information was combined with that of MSBP project partners and information from GardenSearch.

The analysis revealed that at least 421 institutions are involved in seed banking of wild plants in 97 countries (**Fig.1**.). Botanic gardens are the main institutions involved in such seed banking, however a variety of different types of institution were also identified, including arboreta, universities, natural history museums, forestry and tree seed centres, science institutes and even zoos.

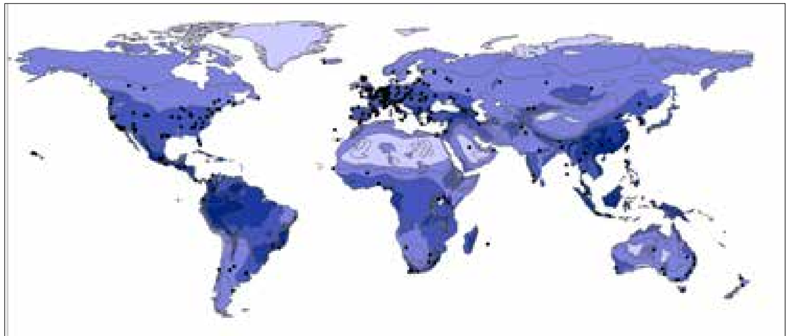
As expected, the number of seed banks per country is not even. Several countries including the United States, Australia, and France have more than 20 institutions involved in seed conservation. However, for the majority of countries, we have so far identified only 1 or 2 institutions involved in seed banking for wild plants.

> Keywords GSPC *EX SITU* CONSERVATION SEEDBANKING NETWORK

04. Results

• *O'Donnell Katherine*
• *Sharrock Suzanne*

Information on countries where few or no wild plant seed banks exist was analysed against patterns of plant diversity to determine gaps in seed banking (**Fig.2.**). Central Africa, South America and South East Asia were highlighted as the main regions with high plant diversity but limited seed banking activity.



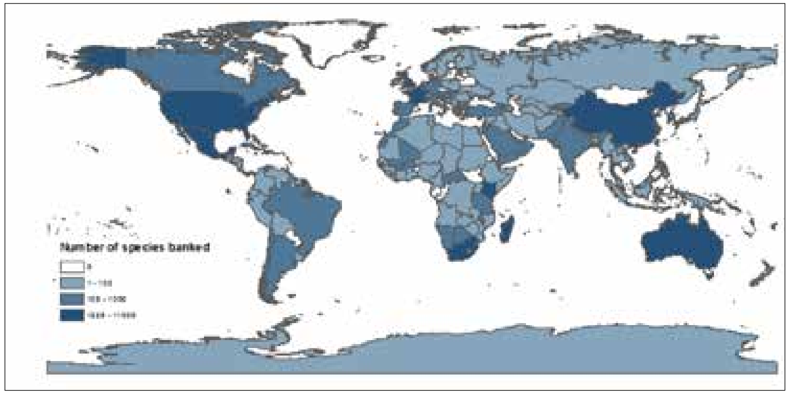
> FIGURE 2

The location of seed banking institutes with relation to plant diversity

The survey also revealed that the majority of institutions involved in seed conservation, bank seed at their own institutions. Those that don't have their own institutional facilities are either involved in the Millennium Seed Bank Partnership and store seed at the MSB seed bank in the UK or bank their seed at another institution in-country.

NUMBER OF SPECIES CONSERVED

BGCI's PlantSearch database acts as an essential tool for monitoring progress towards Target 8 of the GSPC. Gardens are able to upload their living plant, seed and tissue collection data to this global database.



> FIGURE 3

The number of wild taxa banked per country

Of the survey respondents that collect and bank seed, the majority do not upload their seed collections data to PlantSearch. Of those that do the majority upload their seed collections data under a different institutional profile to that of the 'parent' botanic garden. This is then listed as institution type 'Gene/Seedbank' and the accession data can be distinguished from that of living plant collections.

Using PlantSearch data, we are only able to identify 37,937 distinct taxa in seed banks around the world. The majority of these are from the MSBP which has approximately 34,000 taxa in its seed bank. However, recipients of the survey were asked how many wild collected species/taxa their seed banks held. Analysis of this data suggests that at least a further 17,000 taxa are being banked by botanic gardens around the world. For MSBP data the country of origin of the collections is known. For additional collections highlighted by the survey, it was assumed that the seed banking country was the country of origin. This data was analysed at the country level to show the number of banked taxa globally (**Fig.3**). There are several countries where we are not aware of any seed collections of wild plant species. A high number of species have been banked in the United Kingdom, United States, Australia, China, South Africa and France.

> Keywords GSPC *EX SITU* CONSERVATION SEEDBANKING NETWORK

04. Results

• *O'Donnell Katherine*
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SEED BANKING STANDARDS

The protocols used for collecting and banking seed are important in order to ensure high quality seed of conservation value. When conserving seed it is essential to aim for high genetic diversity and maximum viability.

Seeds should be collected from a large number of individuals within a population in order to capture the most genetic diversity. In order for seed to have a high viability, efforts must be made at the time of collection to gather mature and viable seed.

There are a variety of protocols used by institutions involved in seed conservation including those developed by the MSBP, ENSCONET (European Native Seed Conservation Network) and the Seeds of Success. The majority of institutions however collect and bank seed using their own institutional protocols.

Drying seed increases its longevity and is essential for long term storage. For every 1% decrease in moisture content the life of a seed is doubled (Harrington, 1963). Based on the results of the survey, 65% of the institutions that collect and bank seeds have drying facilities which range from the use of desiccants such as silica gel to more costly incubator driers and drying rooms. 26% don't have any drying facilities and 9% did not respond. Nearly all of the institutions that do have drying facilities bank for the medium (1 to 5 years) or long-term (more than 5 years).

Once dried, seed should be placed in hermetically sealed containers in order to keep moisture out. The most efficient containers are trilaminate foil which can be heat sealed and glass jars with air tight lids (Gold & Manger, 2014). Paper packets were found to be the most commonly used containers that seed collections were stored in.

Correctly identifying seed collections is essential if the seeds are to be utilised. Voucher material such as herbarium specimens should be collected at the time of seed collection in order to accurately identify seeds to a particular species. A third of the respondent institutions do not use voucher specimens to verify collection names.

It is advisable to store a duplicate accession of banked seed at another institution as an insurance against loss. Nearly two thirds of the institutions that answered this question do duplicate their collections.

NETWORKING

Only half of the survey respondents reported being part of a seed banking network (57%). These included international networks such as the MSBP; regional networks such as ENSCONET and national networks, such as the French Conservatoires Botaniques Nationaux, the Center for Plant Conservation (US) and the Red Argentina de Bancos de Germoplasma de Especies Vegetales Nativas (Argentina). Of the institutions that are not part of a seed banking network, 90% agreed that they would benefit from being involved in one.

OBJECTIVES AND LIMITATIONS

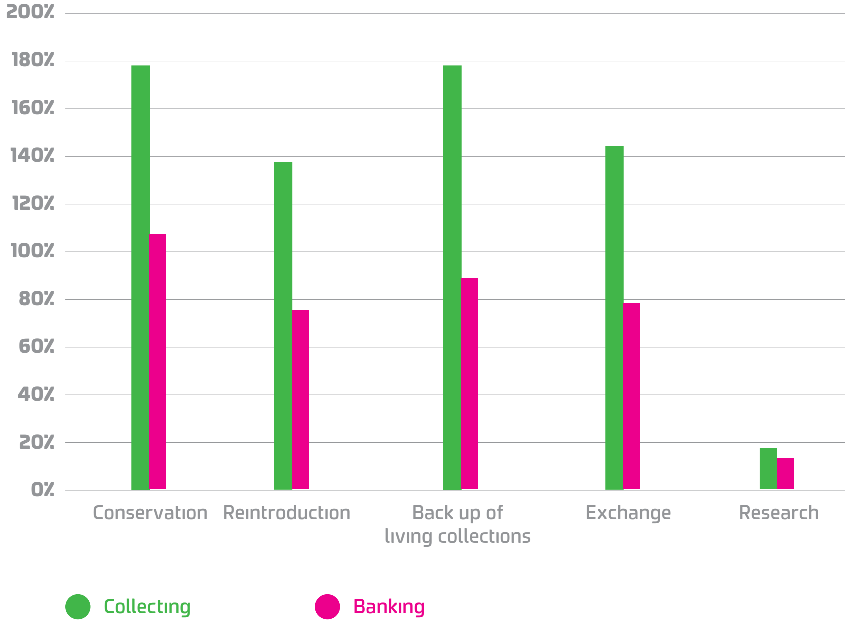
The main objectives for survey respondents to collect and bank seed are generally the same. Most collect and bank seed for conservation and as a backup or to replace living collections. Reintroduction and exchange (*index seminum*) are also important. Several institutions collect and bank seed for research purposes (**Fig 4**).

> Keywords GSPC *EX SITU* CONSERVATION SEEDBANKING NETWORK

04. Results

• *O'Donnell Katherine*
• *Sharrock Suzanne*

What is the main objective to collecting and banking seed in your institution?

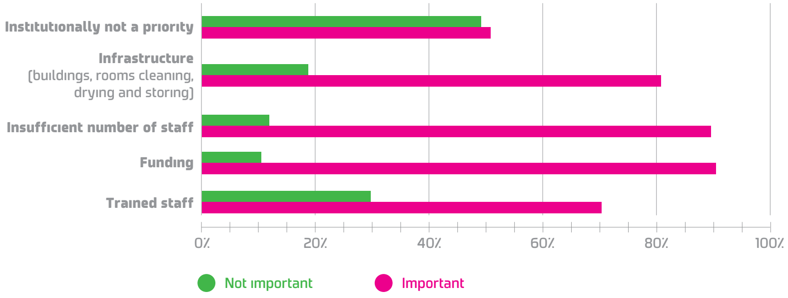


> FIGURE 4

Number of institutions collecting and banking for various different objectives

For institutions that are already banking seed there are several limitations to increasing this activity. These include factors such as infrastructure, human resources and funding. Lack of institutional priority was generally less of a limitation (**Fig 5**).

How important are each of these limitations in preventing seed banking?

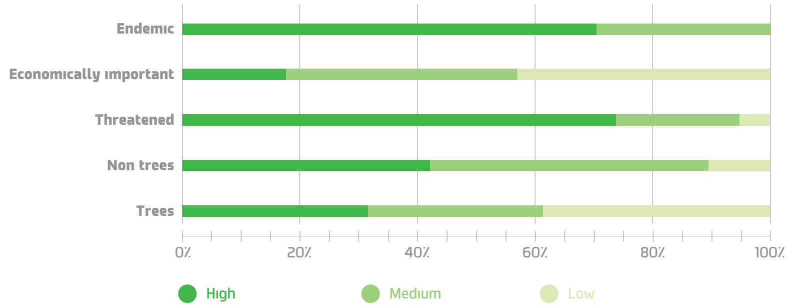


> FIGURE 5

The importance of limitations in preventing seed banking

Botanic gardens that collect and bank seed prioritise endemic and threatened species which are not trees. There is less emphasis on conserving trees and economically important taxa. This is not surprising as tree species usually require specialist equipment for seed collection (**Fig 6**).

Which species do you prioritise for banking?



> FIGURE 6

Species prioritised for banking

> Keywords GSPC *EX SITU* CONSERVATION SEEDBANKING NETWORK

04. Discussion

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Through the survey, we have identified a number of institutions involved in seed banking that were not previously documented in BGCI's databases. In order to be able to accurately monitor and measure the botanic garden community's extensive contribution to Target 8 of the GSPC, *ex situ* seed collections must be well reported.

The results of the survey suggest that at least a further 17,000 taxa are being conserved as seed in botanic gardens around the world than we were previously aware of. We cannot currently determine whether or not these accessions are unique taxa as information is not available in BGCI's databases.

Incorporating this data into PlantSearch would be the first step to determining which threatened and orthodox species are not in *ex situ* seed collections. Currently only a limited number of institutions that are involved in seed banking upload their seed collection data to PlantSearch. By uploading seed collection data, progress can be reported and priorities set.

Documentation is important not just for monitoring progress against targets but it is also essential for ensuring *ex situ* collections are available for research, reintroduction and restoration.

If seed collections are to be of conservation value, the protocols used for banking must be of a high standard. The survey indicates that some gardens could benefit from implementing higher standards for post-harvest seed handling in order to ensure that the viability of their seed is maintained. Drying and storing seed in air tight containers is important as damp seed quickly loses viability. Furthermore, if seed collections are not verified with a herbarium voucher, their use for reintroduction, restoration and research is limited. Duplication of accessions is also important for safeguarding the collections.

Finally, we can say that through the survey, we have identified a number of strengths and a number of weaknesses in relation to seed banking in botanic gardens. Our aim now is to build on the strengths and address the weaknesses as we engage the whole community in the Global Seed Conservation Challenge.

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WILD PLANT SEED BANKING ACTIVITIES IN THE BOTANICAL GARDEN GRAZ (STYRIA & CARINTHIA, AUSTRIA)

Photo credit : Ideally seeds are collected at the time of dispersal.
Here, a picture of Heracleum austriacum, an Eastern Alps endemic species

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> Keywords SEED BANKING *EX SITU* CONSERVATION ENDEMICS THREATENED PLANT SPECIES HERBARIUM

04. Abstract

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• *Berg Christian*

IN 2008, THE BOTANICAL GARDEN OF GRAZ UNIVERSITY (GZU, INSTITUTE FOR PLANT SCIENCE) ESTABLISHED A LONG-TERM SEED BANK FOR WILD PLANTS GROWING WITHIN THE AUSTRIAN PROVINCE OF STYRIA (STEIERMARK).

It is the first such seed bank to be established at a provincial level in Austria. The main objective of the seed bank is to collect and store diaspores of all of Styria's wild vascular plants together with herbarium voucher specimens and location and habitat data. The creation of a broader collection of wild plants, including both common and introduced plants, is of additional value for related scientific purposes. Herbarium specimens provide the opportunity to validate the determination of the collected taxa as well as providing opportunities for further scientific investigations. All seeds and spores have been preserved using ultra-drying methods, and have been stored in cold conditions (-15° C) - a simple and cost effective method of preservation. Every individual collection meets ENSCONET standards. A record of the stored species is published every year in the *Index Seminum* of the Graz Botanical Garden. Our garden is well connected within national and international networks, and is a member of the Austrian workgroup of botanical gardens, BGCI and IPEN. The activities are approved and financially supported by the Styrian government.

In 2012, we began collaborating with the Millennium Seed Bank Partnership, RBG Kew. Since 2013, 519 diaspore samples and herbarium specimens have been collected, including a high proportion of Eastern Alps endemics.

Our initial field trips were focused on the main fruiting period in September and October and were strongly subject to chance; as a result we collected from every species with mature seed material available in the field at that time. Since 2013 our search has become more specific and we have focused on special target species (e.g. Eastern Alps endemics). However, the search for specific taxa poses a number of challenges such as the fluctuating conditions which occur annually over the course of the vegetation period.

> Keywords SEED BANKING *EX SITU* CONSERVATION ENDEMICS THREATENED PLANT SPECIES HERBARIUM

04. Introduction

• *Schwager Patrick*
• *Berg Christian*

Photo credit : Ideally seeds are collected at the time of dispersal. Here, a picture of Heracleum austriacum, an Eastern Alps endemic species

AS A PART OF THE AUSTRIAN BIODIVERSITY STRATEGY (BUJF 1998) THE GRAZ SEED BANK WAS FOUNDED IN 2008 AT THE BOTANICAL GARDEN OF GRAZ UNIVERSITY (GZU) AS A LONG-TERM SEED BANK OF WILD PLANTS GROWING WITHIN THE AUSTRIAN PROVINCE OF STYRIA / STEIERMARK (GOSCH & BERG 2008).

The Graz Seed Bank is, therefore, acknowledged as the first seed bank at a provincial level in Austria, and thus represents a milestone in achieving Austria's Biodiversity Strategy objectives.

With regards to the Millennium Seed Bank Partnership, the aim of the project was to collect species of the Austrian vascular plant flora not yet included in the Millennium Seed Bank. In 2013, our collecting activity was limited to Styria. In 2014, we were able to expand the project to include the area of Carinthia / Kärnten. Over the last three years we spent 70 days in the field collecting diaspores from 145 species. We collected plants from 36 families, at 50 different locations.

In this article we wish to provide a short overview of the project over the last three years, detail our experiences in preparing for the collecting season, and explain our collection strategies for targeting populations in mountain landscapes.

Materials & methods

The major collecting period in all three years extends from May to September. The diaspores are collected in the field using paper bags, or plastic bags if the fruits have to be fermented for cleaning. The collection, preparation and preservation of the fruits, seeds and spores follows ENSCONET standards. Hence, for every collected species a herbarium specimen has been collected too. Thus the possibility to validate the determination of the collected taxa is guaranteed and the specimen also provides the opportunity for further scientific investigations. Additional field data is also collected. Standard location data (country, state, city and an exact description of the locality) is noted, providing prior information about where the material has been collected. Further geographic localizations are carried out using in-field-measurement with a GPS (Garmin eTrex Vista HCx, eTrex 30, GPSMap 64s). According to ENSCONET standards the chosen collection area can be quite large (10 m^2 to 50 ha) and depends on the species. However, mixing diaspores collected from

> Keywords SEED BANKING *EX SITU* CONSERVATION ENDEMICS THREATENED PLANT SPECIES HERBARIUM

04. Materials & methods

• Schwager Patrick
• Berg Christian

populations at different sites should be avoided. We collected geomorphological data (geology, aspect, slope) and land management information. We also gathered data on the population (total size, percentage plants that have formed seeds, total number of plants collected from and size of the collecting area) which supplies knowledge about the conditions of the population and fruit set in individual years.

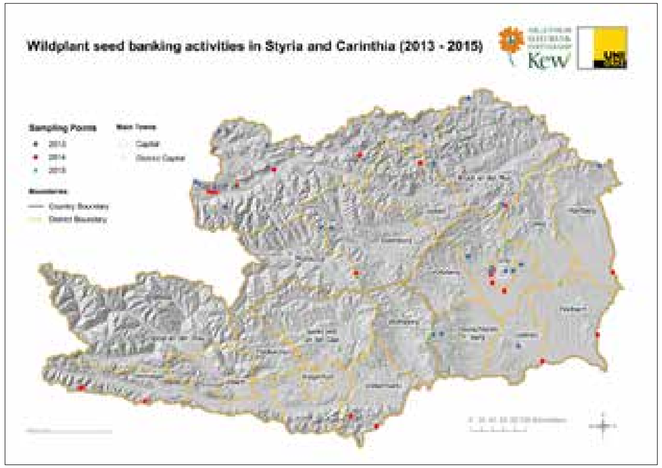
During one collecting period it is useful to map suitable populations of target species during their flowering period for collecting the following year. Many species seem to disappear during their fruiting time, and can only be found when flowering earlier in the season or with exact occurrence data. Marking populations when in flower is sometimes the only way to find them in fruit.

All the fruits, seeds and spores for the Millennium Seed Bank have been slowly dried under cool room temperatures before cleaning and are sent together with the herbarium specimen and the collected field data to the Millennium Seed Bank at the end of every year.

The material for the Styria seed bank has been preserved using the ultra-drying method (Gomes-Campo 2006, Peres-Garcia *et al.* 2007) and has been stored for long term preservation at sub-zero temperatures (-15 °C) in the Graz Seed Bank. This provides a simple and cost effective method of preservation.

Results

Since the implementation of the Graz Seed Bank project in 2008, 519 samples and herbarium specimen have been collected. During the last three years, while collaborating with the Millennium Seed Bank partnership, we spent 70 days in the field, collecting diaspores from 145 species from 36 families. We collected at 50 different locations in Styria and Carinthia which are located both in the mountainous areas as well as in the valleys regions (**Figure 1**).



> FIGURE 1

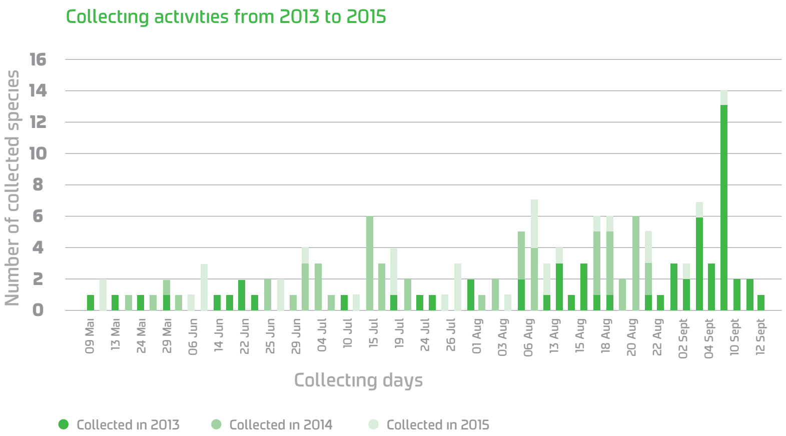
Map of Styria and Carinthia with sampling points of the years 2013 to 2015. Datasource (CC-BY-3.0 licence): Land Steiermark - data.steiermark.gv.at; Land Kärnten - data.ktn.gv.at; Umweltbundesamt GmbH - data.umweltbundesamt.at

The collecting period starts in May for early spring flowering plants and lasts until September (**Figure 2**). Particularly early fruiting species include *Anemone nemorosa*, *Isopyrum thalictroides*, *Erythronium dens-canis*, *Potentilla micrantha*, *Petasites paradoxus* or *Helleborus niger* followed by *Cyclamen purpurascens* fruiting in early summer and *Crocus albiflorus* in summer.

> Keywords SEED BANKING *EX SITU* CONSERVATION ENDEMICS THREATENED PLANT SPECIES HERBARIUM

04. Results

• Schwager Patrick
• Berg Christian



> FIGURE 2

Collecting activities in the years 2013 to 2015. The bars indicate the number of species collected within a one-day period (y-axis). The distinction of the collection years is by different colours

Since 2013, our search has been focused on special target species according to the Millennium Seed Bank partnership e. g. Eastern Alps endemics or endangered species: 45 species are listed in the Austria's red list (Nikelfald 1999), 13 species are listed as regionally threatened in Styria (Zimmermann *et al.* 1989) and 29 species are listed as regionally threatened in Carinthia (Kniely *et al.* 1995). Some of Austria's most endangered species are *Gentiana froelichii*, *Alyssum ovirense*, *Kanutia carinthiaca*, *Veronica fruticulosa* or *Alyssum repens* subsp. *transsilvanicum* or *Saxifraga paradoxa*. Many of these species also have endemic status in Austria (**Table 1**). A total of 13 species have either endemic or sub-endemic status for Austria (Fischer *et al.* 2008).

Family	Full name	Threatened in Austria	Endemic in Austria
Anthirinaceae	*Veronica fruticulosa*	4	
Apiaceae	*Heracleum austriacum*		Sub-endemic in the North Eastern Alps
Asteraceae	*Cirsium carniolicum*		South Eastern of the Eastern Alps
Asteroideae	*Erigeron atticus*	3	
Brassicaceae	*Noccea crantzii*		Endemic in the North Eastern limestone Alps
Brassicaceae	*Alyssum ovirense*	4	
Brassicaceae	*Alyssum repens ssp. transsilvanicum*	4	
Caryophyllaceae	*Cerastium sylvaticum*	3	
Dipsacaceae	*Knautia carinthiaca*	4	
Ericaceae	*Rhodothamnus chamaecistus*		Estern Alps
Gentianaceae	*Gentiana froelichii*	4	South Eastern Alps
Poaceae	*Helictotrichon parlatorei*		Alps
Poaceae	*Festuca eggleri*	3	
Primulaceae	*Primula wulfeniana*		South Eastern limestone Alps
Primulaceae	*Androsace wulfeniana*		Eastern Alps; sub-endemic for Austria
Ranunculaceae	*Ranunculus graecensis*	4	
Ranunculaceae	*Thalictrum lucidum*	3r!	
Rosaceae	*Potentilla micrantha*	3	
Rubiaceae	*Galium aristatum*	3	
Saxifragaceae	*Saxifraga paradoxa*	3	Sub-endemic in Austria (Eastern Central Alps)
Scrophulariaceae	*Wulfenia carinthiaca*	3	South Eastern limestone Alps
Valerianaceae	*Valeriana supina*		Estern Alps

> TABLE 1

Particularly threatened and (sub-) endemic species in Austria that we collected for the Millennium Seed Bank partnership. 3: threatened, 3r!: regionally higher threatened, 4: potentially endangered

Discussion

In the early years of our project, our field trips were characterized by collecting seeds from every species with mature seed material available in the field. We focused primarily on the main fruiting period in September and October as our core timeframe for collection. The selection of species was strongly dependent on chance.

A targeted search for specific taxa poses a number of risks, in particular, estimating the best collection time in the mountains for specific species. After long and arduous journeys to the collection site we were often either too early or too late for the target species.

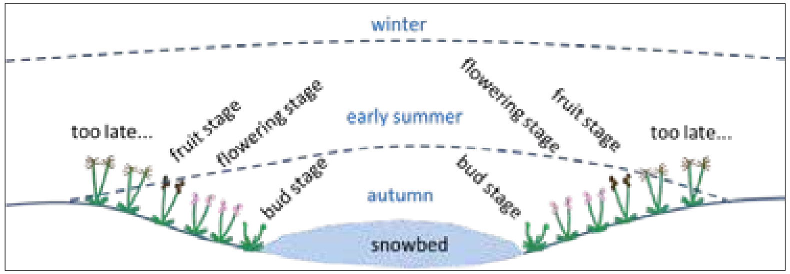
> Keywords SEED BANKING *EX SITU* CONSERVATION ENDEMICS THREATENED PLANT SPECIES HERBARIUM

04. Discussion

• *Schwager Patrick*
• *Berg Christian*

Due to annual fluctuating conditions during the vegetation period it is particularly difficult to plan the ideal time for collecting montane and alpine species. We compensate for this by finding the optimal altitude or correct fruiting stage within the micro relief. A good example is the vegetation around snow patches (**Figure 3**) where we have often found concentric circles of different flowering stages. Hence these sites are particularly interesting at different times. Typical snow patch species we collected are *Ranunculus alpestris*, *Potentilla brauneana*, *Veronica aphylla*, *Noccaea crantzii* or *Primula clusiana*. We also paid particular attention to the particular state of the seed maturity and considered this for the next year.

> FIGURE 3



Schematic drawing of an alpine snow patch in August / September at approximately 1900 m above sea level. Blue dotted line indicates snow cover at different seasons. The fruiting stage of plants is depended on the number of snow free summer days

In order to insure the coverage of a broad range of species the period of collecting must begin as early as May.

Difficult to access areas need a special collection strategy. A literature review and the consultation of experts for specific taxa or regions constitute the first steps in planning the field work. Additionally, mapping of plants during their flowering time can improve success in the following collecting period, especially for rare species. Problems with fluctuations in optimal maturity can be reduced by collecting at different altitudes and by using differences between populations or individuals of different microhabitats.

The creation of a broader collection of wild plants is of additional value for other related scientific purposes (e. g. systematics, plant microbiome).

Conclusion

Seed banks are part of Austria's Biodiversity Strategy. Thus, our activities greatly contribute to the *ex-situ* species conservation activities required by the Convention on Biological Diversity.

> Keywords SEED BANKING *EX SITU* CONSERVATION ENDEMICS THREATENED PLANT SPECIES HERBARIUM

04. References

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• *Berg Christian*

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EX SITU CONSERVATION OF NATIVE PLANT SPECIES IN EUROPE: THE ENSCONET CONSORTIUM

Photo credit : Seed collection in Lapland, Finland, *Aino Anttila*

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> Keywords SEED BANKING SEED CONSERVATION NETWORK RESEARCH COLLECTION AND CURATION MANUALS ENSCOBASE

04. Abstract

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- *Kiehn Michael*
- *Miranto Mari*

HIGH-STANDARD SEED COLLECTING AND STORAGE ACTIVITIES ARE IMPORTANT ELEMENTS OF *EX SITU* CONSERVATION AND, IDEALLY, SHOULD BE FULLY INTEGRATED INTO OVERARCHING CONSERVATION ACTIONS.

Consequently, European seed banks and other bodies with an interest in seed banking and conservation of Europe's native flora started the European Native Seed Conservation NETwork (ENSCONET) Consortium (2010-present), an extension of the FP6 funded ENSCONET project (2004-2009). Its aims are to improve quality, co-ordination and integration of European seed conservation practice, policy and research for native plant species. It also intends to enable the exchange of information, equipment and staff, the sharing of data, collaborations at the European level and interactions with *in situ* conservation initiatives.

> Keywords SEED BANKING SEED CONSERVATION NETWORK RESEARCH COLLECTION AND CURATION MANUALS ENSCOBASE

04. Introduction

• *Breman Elinor*
• *Carta Angelino*
• *Kiehn Michael*
• *Miranto Mari*

Photo credit : Seed collection in Lapland, Finland,
Aino Anttila

THE EUROPEAN NATIVE SEED CONSERVATION NETWORK (ENSCONET) WAS CONCEIVED AND DEVELOPED IN RESPONSE TO THE GROWING RECOGNITION OF THE IMPORTANCE OF WELL-COORDINATED, MANAGED AND SCIENTIFICALLY SOUND SEED COLLECTING AND STORAGE ACTIVITIES FOR THE CONSERVATION OF THE EUROPEAN NATIVE FLORA (E.G., EXPRESSED BY TARGETS 8 AND 9 OF THE GLOBAL STRATEGY FOR PLANT CONSERVATION, CONVENTION ON BIOLOGICAL DIVERSITY 2012).

ENSCONET was initiated by the Royal Botanic Gardens, Kew, also in recognition of the growing contribution of European seed banks to the Millennium Seed Bank Partnership.

Between 1st November 2004 and 31st October 2009 the ENSCONET project received funding from the European Community's Sixth Framework Programme (FP6) as an Integrated Activity implemented as a Co-ordination Action (Müller *et al.* 2012). After the successful closure of the project and the end of the FP6 funding, it was the desire of the ENSCONET members to continue their successful joint European seed conservation activities. Since 2010 ENSCONET has continued to improve quality, co-ordination and integration of European seed conservation practice, policy and research for native plant species under the name of ENSCONET Consortium. This collaboration ensures an ongoing exchange of information, equipment and staff, the sharing of data, and collaboration at the European level. RBG Kew provides the Secretariat for the ENSCONET Consortium and is represented on its Steering Committee together with three elected members from the ENSCONET Consortium.

ENSCONET Consortium members are committed to implementing the letter and the spirit of the 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the 1992 Convention on Biological Diversity (CBD), the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGFRA) and all regional and national laws and regulations concerning biodiversity.

The initial ENSCONET project (2004-2009) comprised 29 institutions from 19 countries, while the current ENSCONET Consortium consists of 31 institutes from 14 countries (**Table 1**). Members include seed banks, botanical gardens and other institutes involved in plant conservation and research covering all the biogeographic regions of Europe. They work together in four activity areas: collecting, curation, data management and dissemination.

During the first five years the FP6 funding enabled a number of activities to take place which furthered the aims of ENSCONET, namely promoting seed conservation across Europe and strengthening ties between member insti-

> Keywords SEED BANKING SEED CONSERVATION NETWORK RESEARCH COLLECTION AND CURATION MANUALS ENSCOBASE

04. Introduction

• *Breman Elinor*
• *Carta Angelino*
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• *Miranto Mari*

tutes. Since 2010, the ENSCONET Consortium has continued to undertake joint activities despite no central funding

Collecting and curation

DEVELOPMENT OF SEED BANKING PROTOCOLS

During the ENSCONET project members published two manuals to help the European seed conservation community follow standard procedures meeting international standards. The first dealt with seed collection of wild species (ENSCONET 2009a), the second with curation protocols and recommendations (ENSCONET 2009b). Both of these documents are available in eight languages (*http://www.ensconetconsortium.eu/*).

SEED COLLECTION

Member organisations undertake seed conservation work as part of the network, and meet to work together in the field and share experience and best practice in seed collection for long-term conservation. To date several joint seed collection expeditions have taken place, including Asturias 2011, Central Slovakia 2011 and Hungary 2012. A number of seed conservation workshops have also taken place e.g. in Austria 2013 and Finland 2014, and a specialised workshop on forest seed treatment was organized and hosted by the Forest Gene Bank Kostrzyca in 2012.

CAPACITY BUILDING

As a direct result of involvement in ENSCONET new seed banks have been developed e.g. Oslo, Helsinki, and new national networks of seed banks and botanic gardens have been established e.g. in Austria, Germany and Poland.

Data management

One of the most important outputs of ENSCONET was the establishment of an online database where members and other seed banking institutes in Europe could host their seed conservation data. ENSCOBASE (*http://enscobase.maich.gr/*), hosted by Mediterranean Agronomic Institute of Chania (MAICH) in Crete, is updated regularly by data contributors using individual organisation logins. The members who contribute data to ENSCOBASE are listed in **Table 1**.

ENSCOBASE enables analysis of progress towards international conservation aims, such as the Global Strategy for Plant Conservation (GSPC), at the European level. Progress towards GSPC Targets 8a and 8b (75% of threatened taxa conserved ex situ by 2020 and at least 20% available for use) and 9 (70% of crop wild relatives conserved ex situ by 2020) has been analysed based on seed bank holdings across Europe, as uploaded to ENSCOBASE (Rivière & Müller 2017). They found that 62.7% of European threatened species are conserved ex situ, indicating the potential for European seed banks to meet the target 8 by 2020. This led to the development of a European-wide seed conservation strategy, providing target lists for each country of threatened taxa that will need collecting in order to meet target 8 (Rivière *et al.* submitted). In addition, Rivière & Müller (2017) found that GSPC targets 8b and 9 had already been met.

> Keywords SEED BANKING SEED CONSERVATION NETWORK RESEARCH COLLECTION AND CURATION MANUALS ENSCOBASE

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• *Miranto Mari*

04. Dissemination

During the ENSCONET project an annual newsletter was produced (ENSCONews) and widely circulated. A website was also developed outlining the project and its activities, and this is still maintained today by MAICh in Crete (http://ensconet.maich.gr/About.htm, www.ensconetconsortium.eu or www.seedbanks.eu).

The ENSCONET Consortium not only works in conserving native plants ex situ and in situ, and in managing the associated data, but also promotes the importance of conservation. Research work has been supported throughout the existence of ENSCONET and the ENSCONET Consortium, a recent example being work on photoinhibition of seed germination (Carta. 2017; Vandelook *et al.*, in press).

Members of the Consortium continue to present their research findings at conferences and through scientific publications. Most recently the Consortium has been the subject of oral and poster presentations at the 6th Global Botanic Gardens Congress in Geneva (June 2017) and at the EastCentGard conference in Budapest (October 2017).

Looking to the future

A new Steering Committee was elected in 2017 who have the stated aims of:

- Improving communication between members
- Strengthening links with conservation and plant biology related institutions
- Ensuring that ENSCOBASE is maintained and updated with collection data from partner seed banks

> TABLE 1

Members of the ENSCONET project (2004-2009) and Consortium (2010-present) with their acronym in ENSCOBASE

Country	Member institute	Institution's acronym as shown in ENSCOBASE[1]	Member of ENSCONET project 2004-2009	Member of ENSCONET Consortium since 2010
Austria	University of Natural Resources and Applied Life Sciences Vienna	BOKU	Yes	Yes
Austria	University of Vienna		Yes	Yes
Belgium	Botanic Garden Meise	BGM	Yes	Yes
Cyprus	Agricultural Research Institute Cyprus	CYARI	Yes	Yes
Cyprus	Nature Conservation Unit, Frederick University Cyprus	NCU	Yes	Yes
Finland	Finnish Museum of Natural History LUOMUS	LUOMUS	Yes	Yes
France	National Natural History Museum, Paris	MNHN	Yes	Yes
Germany	Botanischer Garten und Botanisches Museum Berlin-Dahlem, FU Berlin	BGBM	Yes	Yes
Germany	Institute of Botany, University of Regensburg		No	Yes
Greece	Mediterranean Agronomic Institute Chania (Crete)	MAICh	Yes	Yes
Greece	National and Kapodistrian University of Athens	NKUA	Yes	Yes
Hungary	Budapest Zoo and Botanical Garden		Yes	Yes
Ireland	Provost Fellows and Scholars of the College of the Holy and Undivided Trinity of Queen Elizabeth near Dublin	TCD	Yes	No
Italy	Centro per la Conservazione della Biodiversità, Università di Cagliari	CCB	No	Yes
Italy	Università di Pavia	PAVIA	Yes	Yes
Italy	Department of Biology, Università di Pisa	PISA	Yes	Yes
Italy	MUSE - Museo delle scienze, Trento		Yes	Yes
Italy	Rete Italiana Banche del Germoplasma per le Pianti Spontanee Minacciate		No	Yes
Luxembourg	Musée national d'histoire naturelle Luxembourg	Luxembourg	Yes	Yes
Norway	Natural History Museum, University of Oslo	UOBG	Yes	Yes
Poland	Botanical Garden - Center for Biological Diversity Conservation of the Polish Academy of Sciences	BG-CBDC PAS	Yes	Yes
Poland	Forest Gene Bank Kostrzyca	Kostrzyca	Yes	Yes
Portugal	Jardim Botânico - MUHNAC, Universidade de Lisboa	MUHNAC	Yes	Yes
Slovakia	Plant Science and Biodiversity Center, Institute of Botany, Slovak Academy of Sciences	SARC-RIPP	Yes	Yes
Spain	Jardin Botanico Viera y Clavijo del Cabildo de Gran Canaria	Canario	Yes	Yes
Spain	Fundacion Publica Municipal Jardin Botanico de Cordoba	Cordoba	Yes	No
Spain	Jardín Botánico Atlántico de Gijón, Universidad de Oviedo	GIJON	Yes	Yes
Spain	Fundació Jardí Botànic de Sóller	Sóller	Yes	Yes
Spain	Universidad Politécnica de Madrid	UPM	Yes	Yes
Spain	Universitat de València	UVEG	Yes	Yes
Spain	Sociedad de Ciencias Aranzadi		No	Yes
Switzerland	Conservatoire et jardin botaniques de la ville de Genève	Geneva	Yes	Yes
United Kingdom	Royal Botanic Gardens, Kew	RBGK	Yes	Yes

> Keywords SEED BANKING SEED CONSERVATION NETWORK RESEARCH COLLECTION AND CURATION MANUALS ENSCOBASE

04. Looking to the future

• *Breman Elinor*
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• *Miranto Mari*

- Creating interactions between ENSCOBASE and other seed conservation databases
- Promoting seed research activities
- Establishing opportunities for the exchange of seed conservation related knowledge, best practices and experiences

At the ENSCONET Consortium's last general meeting at the 6th Global Botanic Gardens Conference in Geneva (June, 2017), the work of the Consortium for the near future was prioritized as follows:

1) Contributing to GSPC targets 8 and 9 in Europe by encouraging the upload of data about seeds stored in European seed banks to ENSCOBASE and by using these data for national and regional gap analyses and collection plans;
2) Strengthening communication and links within the network and with other conservation and plant biology related institutions and stakeholders in addition to raising public awareness of the importance of seed conservation of native wild species;
3) Integration of seed conservation activities into other fields of ex situ and in situ conservation, including international conventions (e.g. the UN Sustainable Development Goals) and linking with other national and international activities on seed conservation;
4) Promoting seed research activities and the exchange of seed conservation related knowledge, best practices and experiences; thus ensuring that seed collections are suitable and available for conservation projects including seed-based restoration activities;
5) Encouraging and supporting joint national and regional activities (especially related to biogeographical regions);
6) Seeking funding opportunities, especially on national and regional levels, to enable the Consortium to carry out these tasks.

Membership

Membership is restricted to facilities devoted to promoting native seed conservation in Europe. Any institution with an interest in joining the ENSCONET Consortium should apply in writing to the Secretariat (address details under author[1]).

1 Not all ENSCONET members have acronyms as not all contribute data to ENSCOBASE. In addition, there are institutes not listed here who contribute data to ENSCOBASE but are not members of ENSCONET.

> Keywords SEED BANKING SEED CONSERVATION NETWORK RESEARCH COLLECTION AND CURATION MANUALS ENSCOBASE

04. Conclusion

• *Breman Elinor*
• *Carta Angelino*
• *Kiehn Michael*
• *Miranto Mari*

The activities of ENSCONET and the ENSCONET Consortium have considerably improved the standards of seed collecting and storage in Europe. They have resulted in closer collaboration between the project partners, but also with organisations outside of the "seed bank community". In order to further improve the utility of seed banking for the conservation of the European native flora, the ENSCONET Consortium seeks to link with the relevant organisations in Europe. Given an adequate financial background, the initiative is optimistic to continue to provide valuable contributions for this overarching goal.

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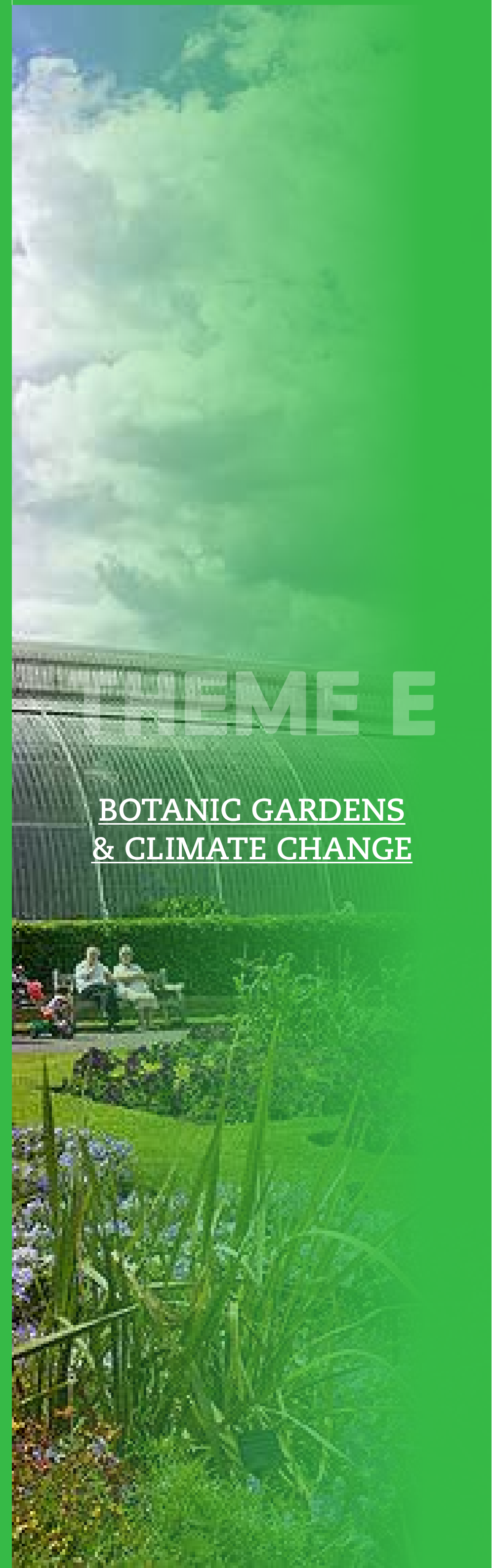
EUROGARD VII
PARIS

THEME E:

BOTANIC GARDENS & CLIMATE CHANGE

05.



THEME E

BOTANIC GARDENS & CLIMATE CHANGE

GESTION DIFFÉRENCIÉE AUX CONSERVATOIRE ET JARDINS BOTANIQUES DE NANCY : RÉTROSPECTIVE ET ÉVOLUTIONS

Photo credit : Gestion différenciée au jardin botanique, *Karim Benkhelifa / JBN*

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> Mots-clefs CJBN GESTION DIFFÉRENCIÉE FAUCHAGE TARDIF ARRÊT DES PESTICIDES VALORISATION DE COLLECTIONS PBI CHAUFFAGE PAR INCINÉRATION DE DÉCHETS

05. Résumé

- *Benkhelifa Karim*
- *Rémy Marc*
- *Astafieff Katia*

LES CONSERVATOIRE ET JARDINS BOTANIQUES DE NANCY (CJBN) ONT RÉALISÉ DE NOMBREUX EFFORTS POUR UNE ASSURER UNE GESTION DES COLLECTIONS PLUS RESPECTUEUSE DE L'ENVIRONNEMENT, AUSSI BIEN DANS LES SERRES TROPICALES QUE DANS LES COLLECTIONS TEMPÉRÉES. CELA SE TRADUIT NOTAMMENT PAR L'ÉLIMINATION DES PESTICIDES, DES ACTIONS VISANT À AUGMENTER LA BIODIVERSITÉ DANS LE JARDIN, LA MISE EN PLACE DE LA PROTECTION BIOLOGIQUE INTÉGRÉE ET MÊME UN PROJET DE PHÉNOLOGIE POUR ÉTUDIER LES CHANGEMENTS CLIMATIQUES.

> Mots-clefs CJBN GESTION DIFFÉRENCIÉE FAUCHAGE TARDIF ARRÊT DES PESTICIDES VALORISATION DE COLLECTIONS PBI CHAUFFAGE PAR INCINÉRATION DE DÉCHETS

05. Collections de pleine-terre

• *Benkhelifa Karim*
• *Rémy Marc*
• *Astafieff Katia*

Photo credit : Gestion différenciée au jardin botanique,
Karim Benkhelifa / JBN

CONCERNANT LES COLLECTIONS DE PLEINE-TERRE, CETTE DÉMARCHE, MISE EN PLACE PROGRESSIVEMENT, A MODIFIÉ LES HABITUDES DE NOMBREUX AGENTS AINSI QUE CELLES DES VISITEURS.

Sur l'ensemble des 32 ha, certaines parcelles précédemment tondues sont maintenant gérées en fauche tardive. Les pesticides ne sont plus utilisés, le désherbage manuel s'est intensifié. Des plantes vivaces ont été plantées aux pieds des arbres et arbustes plutôt que d'épandre des désherbants sur sols nus.

Après plusieurs années, nous constatons une augmentation de la diversité faunistique et floristique locale. Les prairies et les vivaces plantées, en plus d'être ornementales, hébergent les auxiliaires de culture. Des sentiers sinueux tondus dans les hautes herbes guident et invitent les visiteurs vers les collections les plus éloignées de l'entrée du jardin. Enfin, cette démarche écologique est aussi économiquement avantageuse. Depuis quelques années, nous utilisons également de nouvelles tondeuses écologiques pour les plus grands espaces herbacés : des moutons ! Des ruches ont également été installés, afin d'introduire des pollinisateurs, de même que des nichoirs à insectes pour les espèces solitaires.

LILASCOPE : ÉTUDE DES CHANGEMENTS CLIMATIQUES

Les changements climatiques deviennent une réelle problématique des jardins botaniques. En dehors des méthodes de gestion des collections plus respectueuses de l'environnement, un nouveau projet a été mis en place en 2012 : *Lilascope*, un outil de suivi de la phénologie des lilas comme sentinelle du réchauffement climatique.

Ce projet est la traduction de la volonté affirmée par l'Université de Lorraine de mobiliser les atouts des Conservatoire et Jardins Botanique de Nancy (CJBN) sur des projets de recherches portant sur des thématiques liées aux changements globaux (climats, biodiversité, …). Ce projet a été mis en place par le laboratoire d'Ecologie et Ecophysiologie Forestières (UMR INRA-Université de Lorraine). Il vise à caractériser la variabilité interannuelle et la variabilité génétique de la phénologie de différents cultivars de Lilas (2 cultivars suivis), une des collections emblématiques des CJBN, pour en faire un outil de monitoring à long terme des fluctuations du climat local et régional. Il s'appuie sur l'implémentation de technique moderne de capture et

> Mots-clefs CJBN GESTION DIFFÉRENCIÉE FAUCHAGE TARDIF ARRÊT DES PESTICIDES VALORISATION DE COLLECTIONS PBI CHAUFFAGE PAR INCINÉRATION DE DÉCHETS

05. Collections de pleine-terre

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• *Astafieff Katia*

d'analyse d'image vidéo dont la retransmission en ligne sera également un outil de diffusion de culture scientifique et technique à destination du public. Le matériel utilisé est le suivant : 4 webcams de type CAM-SEC à 5 méga pixels (trois installées et une en réserve pour éviter les pertes de données en cas de panne) avec support de fixation et boitier de protection étanche, une micro station météo avec capteurs pour le rayonnement, la température de l'air et du sol, l'humidité de l'air, les précipitations et la teneur en eau du sol, une centrale d'acquisition de données avec transmission wifi et boîtier de protection étanche pour station météo type CR3000 Campbell, un mat de 10 m de haut pour supporter les caméras et le panneau solaire et un Serveur dédié. L'installation sert à repérer les différents stades phénologiques d'une plante (feuillaison, floraison, fructification, défeuillaison ...) et de disposer de séries temporelles d'indices de végétation qui peuvent être confrontées aux principaux facteurs météorologiques.

Collections tropicales

Les serres tropicales des CJBN ont été parmi les premières en France à appliquer la Protection Biologique Intégrée (PBI), technique à présent courante dans les jardins botaniques. Les CJBN entament en effet la 15e année de PBI, et disposent actuellement d'un certain recul sur cette pratique. Cette durée, alliée à un volume de serres important (2 500 m²), a amené des observations pertinentes sur l'équilibre biologique et l'efficacité de l'utilisation d'auxiliaires de culture. On constate par exemple que dans la serre de grand volume (serre palmarium) il n'y a pas eu besoin d'apporter d'auxiliaires depuis plus de cinq années. En effet, les auxiliaires tels que les *Cryptolaemus montrouzieri* sont présents d'une année à l'autre et l'équilibre ravageurs/auxiliaires s'autorégule seul.

La PBI a, par ailleurs, été accompagnée dès ses débuts par une réduction non négligeable des intrants chimiques, muée à partir de 2010 par l'arrêt de l'utilisation de pesticides, démarche qu'il convient aujourd'hui d'appeler « zéro phyto ».

De plus, si l'utilisation de produits chimiques pour la culture est un aspect particulièrement visible des effets néfastes de l'horticulture sur l'environnement, la consommation de carburants pour le chauffage des serres en représente un autre. Ainsi, les serres des CJBN qui étaient chauffées à partir d'une chaufferie gaz, sont depuis 2010 chauffées par le réseau de chauffage urbain de l'agglomération de Nancy qui utilise l'incinération de déchets ménagers et une chaudière à bois. Ce système présente le double avantage de valoriser des déchets dont le recyclage est impossible, et de supprimer la consommation de carburants fossiles. Cette démarche a permis de diminuer nettement l'empreinte carbone des serres.

Les bâtiments

On peut ajouter aussi, au niveau des pratiques durables, la construction de nouveaux bâtiments plus respectueux de l'environnement. Ainsi, le pavillon d'accueil, construit en 2005, et le nouveau bâtiment technique, dont la construction vient de commencer, sont conçus dans un esprit durable, tant au niveau des matériaux que de l'utilisation énergétique.

> Mots-clefs CJBN GESTION DIFFÉRENCIÉE FAUCHAGE TARDIF ARRÊT DES PESTICIDES VALORISATION DE COLLECTIONS PBI CHAUFFAGE PAR INCINÉRATION DE DÉCHETS

05. Conclusion

• *Benkhelifa Karim*
• *Rémy Marc*
• *Astafieff Katia*

Les Conservatoire et jardins botaniques de Nancy ont donc réalisés de nombreux progrès dans la gestion de leurs collections, tant au niveau des collections tempérées (fauche tardive, plantation de vivaces qui abritent des auxiliaires de culture, etc.) que des collections tropicales (lutte intégrée, nouveau mode de chauffage, etc.). Ces pratiques permettent de s'inscrire dans une démarche de développement durable, qui prend en compte la problématique des changements climatiques avec un projet de recherche sur ce sujet (Lilascope).

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LES CONSERVATOIRE ET JARDIN BOTANIQUES DE LA VILLE DE GENEVE AU REGIME BIO

Photo credit : Un Jardin BIO favorise le vivant. Pollinisation de *Borago officinalis* L., ***Bernard Renaud, CJBG.***

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> Mots-clefs LUTTE BIOLOGIQUE BIODIVERSITÉ DÉVELOPPEMENT DURABLE HORTICULTURE BIOLOGIQUE, PRATIQUES HORTICOLES JARDIN BOTANIQUE

05. Résumé

- *Freyre Nicolas*
- *Loizeau Pierre-André*

DEPUIS LE 1ER JANVIER 2015, LES CONSERVATOIRE ET JARDIN BOTANIQUES DE LA VILLE DE GENÈVE CULTIVENT UN JARDIN « 100% BIO ». PLUSIEURS ANNÉES D'EXPÉRIMENTATION, D'ÉTUDES ET DE RECHERCHES DE SOLUTIONS ONT ÉTÉ NÉCESSAIRES POUR RÉALISER CE PROJET AMBITIEUX ET UNIQUE EN SUISSE ROMANDE. LA RESPONSABILITÉ D'UN PATRIMOINE DE PLUS DE 9'000 TAXONS DIFFÉRENTS EN COLLECTIONS VIVANTES NE LAISSE PAS LE DROIT À L'ERREUR DANS LA MISE EN ŒUVRE DE NOUVELLES TECHNIQUES DE CULTURES. LA VOLONTÉ D'OUVRIR LA VOIE À PLUS D'ÉCOLOGIE ET DE BONNES PRATIQUES DANS L'ART DE CULTIVER LES PLANTES NOUS A POUSSÉS À FAIRE LE PAS. AUJOURD'HUI, LES VISITEURS PROFITENT D'UN JARDIN ENTRETENU SELON LES EXIGENCES DU CAHIER DES CHARGES DE BIOSUISSE, UNE GRANDE PREMIÈRE POUR UNE COLLECTIVITÉ PUBLIQUE!

> Mots-clefs LUTTE BIOLOGIQUE BIODIVERSITÉ DÉVELOPPEMENT DURABLE HORTICULTURE BIOLOGIQUE, PRATIQUES HORTICOLES JARDIN BOTANIQUE

05. Introduction

• *Freyre Nicolas*
• *Loizeau Pierre-André*

Photo credit : Un Jardin BIO favorise le vivant. Pollinisation de *Borago officinalis* L., ***Bernard Renaud, CJBG.***

BIOSUISSE EST L'ORGANISATION FAÎTIÈRE DES PRODUCTEURS BIO DE NOTRE PAYS DEPUIS 1981. ELLE EST PROPRIÉTAIRE DU LABEL BOURGEON, LE PLUS LARGEMENT RÉPANDU ET RECONNU PAR LES CONSOMMATEURS SUISSES.

À ce jour, plus de 5700 exploitants agricoles et horticoles travaillent dans le respect des directives de BIOSUISSE, une des normes les plus exigeantes au monde en matière d'agriculture biologique. Le Jardin botanique de la Ville de Genève bénéficiera de ce label de qualité après une période dite de reconversion, d'une durée de 2 ans, durant laquelle les règles de BIOSUISSE sont strictement identiques à celles qui prévaudront ensuite.

Ce projet répond à plusieurs objectifs. Le premier et le plus important est bien sûr l'enjeu écologique. En abandonnant complètement et strictement tous les produits chimiques de synthèse utilisés dans l'entretien des espaces verts, nous respectons d'autant mieux l'écosystème qui nous entoure. Travailler en BIO, c'est respecter les cycles de la vie. C'est assumer la finitude de nos ressources naturelles et agir en conséquence, à notre échelle. Le deuxième enjeu est celui de la santé. Se conformer aux exigences du BIO améliore nettement les conditions de travail des jardiniers. Les pratiques écologiques sont en effet bien plus favorables et respectueuses de la santé humaine que les méthodes conventionnelles utilisées jusqu'à aujourd'hui. Le troisième objectif est de faire évoluer la pratique de l'horticulture et de le faire reconnaître. En effet, le cahier des charges de BIOSUISSE s'adresse principalement à l'agriculture, soit la production de denrées alimentaires animales ou végétales. La démarche des Conservatoire et Jardin botaniques de la Ville de Genève est pionnière en ce sens qu'elle s'applique à des collections de plantes et des espaces verts publics.

BIOSUISSE

> IMAGE 1

Logo BIOSUISSE

> Mots-clefs LUTTE BIOLOGIQUE BIODIVERSITÉ DÉVELOPPEMENT DURABLE HORTICULTURE BIOLOGIQUE, PRATIQUES HORTICOLES JARDIN BOTANIQUE

05. Matériel et méthodes

• *Freyre Nicolas*
• *Loizeau Pierre-André*

La démarche de reconversion vers des techniques de culture biologique est le résultat de plus d'une année d'étude de faisabilité. Il y a d'abord un constat de départ : en 2014, le Jardin botanique de la Ville de Genève est « presque » BIO. Pour mesurer avec rigueur et précision le vide à combler vers la certification BIO, nous avons rédigé et soumis un sujet de travail de bachelor à la Haute école du paysage, d'ingénierie et d'architecture de Genève (hepia). Un étudiant de la filière Gestion de la Nature s'est saisi du sujet et a travaillé pendant 3 mois au contact du terrain et des jardiniers. L'objectif était de clarifier la procédure administrative vers la certification, et de mesurer l'impact technique et financier d'une telle opération (Irschingler, 2014).

L'étude a consisté à faire un inventaire le plus exhaustif possible de tous les intrants utilisés au Jardin (engrais, produits phytosanitaires, semences, substrats de culture, alimentation et soins aux animaux, etc…) et de vérifier la compatibilité avec les règles de BIOSUISSE. Pour tous les produits non autorisés, l'objectif était de proposer une ou plusieurs solutions techniques alternatives, de manière à pouvoir assurer une transition vers le BIO sans prétériter la santé des plantes et des animaux. Toutes les pratiques de culture ont également fait l'objet d'une évaluation relative au cahier des charges de BIOSUISSE. La deuxième partie de l'étude a porté sur l'évaluation des coûts et la charge administrative engendrés par un tel processus. La procédure à suivre pour une reconversion BIO a également été clarifiée.

À la suite des résultats de cette étude, nous avons pris toutes les mesures nécessaires pour nous mettre en conformité avec les exigences de BIOSUISSE avant le 1er janvier 2015. Techniquement, la méthode a consisté à faire un tri complet des intrants du Jardin, acquérir des fournitures nouvelles, et mettre en place des procédures pour assurer une traçabilité parfaite de toutes les opérations liées à l'utilisation de ces intrants (traitements phytosanitaires, soins animaliers, travaux d'apiculture, etc…). Administrativement, la démarche a consisté à affilier l'institution à BIOSUISSE ainsi qu'aux différents organismes de contrôle et de représentation professionnelle. Après cette étape importante, nous nous sommes soumis à un contrôle à blanc de l'ensemble du Jardin botanique effectué par un organisme indépendant de certification.

La dernière étape, et probablement la plus sensible, a été de convaincre l'ensemble du personnel du secteur Jardin (42 collaborateurs) du bienfondé de cette démarche vers le BIO. En effet, la réussite de ce projet tient beaucoup dans la capacité des jardiniers à accepter le changement et à s'y adapter.

Résultats

Une des principales difficultés a été de se familiariser avec la liste contraignante des intrants de l'Institut de recherche de l'agriculture biologique (FiBL,2014). La règle veut que tous les intrants de l'exploitation doivent figurer dans cette liste; nous avons dû ainsi bouleverser de nombreuses habitudes et rechercher des nouveaux fournisseurs à qualité de produits égale, voire supérieure. Par exemple, la fumure minérale des plantes a été complètement revue et remplacée par des engrais organiques. Avec des temps de réaction parfois plus longs, l'utilisation de ces engrais nécessite une adaptation des pratiques culturales de la part des jardiniers. Les substrats de culture ont été également reconsidérés, avec pour objectif de travailler sans tourbe pour la production, ce qui correspond à une exigence supplémentaire par rapport aux normes de BIOSUISSE. C'est peut-être l'aspect phytosanitaire qui nous

05. Résultats

• *Freyre Nicolas*
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a posé le moins de problème, dans la mesure où nous utilisions déjà la lutte BIO (auxiliaires de culture) depuis plusieurs années. Le fait de travailler avec des plantes sauvages et de cultiver une extraordinaire biodiversité (plus de 9000 taxons différents) est en soit une grande aide pour limiter les attaques qui restent très localisées. L'alimentation des animaux d'élevage (ovins et caprins) ainsi que les protocoles de soins vétérinaires ont été par contre entièrement revus et corrigés pour se conformer au cahier des charges de l'agriculture biologique. Des solutions alternatives ont finalement été trouvées pour l'ensemble des produits non autorisés par BIOSUISSE (voir annexe). L'intégralité de ces résultats est présentée dans le travail de bachelor de V. Irschlinger (2014).

En plus des restrictions concernant les intrants, certaines mesures contraignantes relatives aux pratiques de culture sont décrites dans le cahier des charges de BIOSUISSE. Il est dit par exemple que « la régulation des mauvaises herbes doit être effectuée uniquement par les techniques de culture et par des moyens mécaniques. Le désherbage thermique est autorisé. […] La stérilisation du sol à la vapeur est interdite en plein air » (BIOSUISSE, 2014). L'unique solution et la plus efficace reste donc le désherbage manuel, qui était déjà largement pratiqué au Jardin botanique compte tenu de la spécificité et de la diversité des cultures. De manière générale, une très grande importance est donnée au respect de la vie du sol. « À long terme, seuls les sols vivants continueront de fournir des récoltes » (BIOSUISSE, 2014). C'est pourquoi la conservation et l'amélioration de la fertilité naturelle des sols revêt une importance centrale en agriculture biologique et doit être obtenue par des techniques de culture adéquates. Tout ce qui contredit cet objectif primordial doit être abandonné. Il est en particulier « formellement interdit d'utiliser des engrais chimiques de synthèse et des produits phytosanitaires chimiques de synthèse ou fabriqués à l'aide de l'ingénierie génétique » (BIOSUISSE, 2014). Au-delà de l'interdiction, c'est le principe de respect de la vie qui est mis en avant, comme postulat central de l'agriculture biologique.

Le cahier des charges de BIOSUISSE prévoit également des mesures obligatoires d'encouragement de la biodiversité. « Les producteurs Bourgeon cultivent l'ensemble de leur domaine de manière à ménager le plus possible l'environnement et les plantes, animaux et microorganismes présents. Ils s'efforcent d'avoir un domaine aussi diversifié que possible qui laisse de la place à divers êtres vivants et habitats aussi bien dans les surfaces cultivées qu'à leurs abords. Les producteurs Bourgeon complètent avec des mesures supplémentaires les déjà grandes prestations systémiques de l'agriculture biologique pour la biodiversité » (BIOSUISSE, 2014). De par sa diversité en terme de nombre d'espèces cultivées, mais aussi paysagère, le Jardin botanique respecte déjà ces principes sans mesure supplémentaire. Il est toutefois intéressant de noter que les principes de BIOSUISSE ne s'arrêtent pas uniquement à la culture elle-même, et accordent une place importante à la notion de services écosystémiques.

Les principaux problèmes que nous avons rencontré sont liés à l'acquisition de matériel végétal de multiplication (semences, boutures, plants, etc…), l'offre en qualité BIO étant très faible en production ornementale. Il y a aujourd'hui en Suisse très peu de fournisseurs qui proposent des semences de plantes ornementales (annuelles, bisannuelles et bulbes) certifiées BIO. Le choix et la diversité sont ainsi très faibles, et la qualité germinative n'est pas toujours optimale. Il paraît évident que si la demande émanant des professionnels de l'horticulture augmente, le nombre de fournisseurs, la qualité et la disponibilité des produits, ainsi que la diversité de formes et de couleurs

> Mots-clefs LUTTE BIOLOGIQUE BIODIVERSITÉ DÉVELOPPEMENT DURABLE HORTICULTURE BIOLOGIQUE, PRATIQUES HORTICOLES JARDIN BOTANIQUE

05. Résultats

• Freyre Nicolas
• Loizeau Pierre-André

augmentera en conséquence. Conscient de cette réalité, BIOSUISSE n'exige pas, pour le moment, des semences certifiées, pour autant que le producteur prouve l'absence de disponibilité sur le marché. Tout prétraitement phytosanitaire (graines enrobées) est par contre bien évidemment proscrit.

Administrativement, nous avons dû mettre en place plusieurs actions pour se mettre en conformité. D'abord, toutes les opérations techniques (traitements phytosanitaires, traitements vétérinaires, achats d'intrants, opérations d'apiculture et d'élevage, etc...) doivent être strictement documentées et archivées pour assurer un suivi complet de l'exploitation. « Les exploitations doivent rendre compte de leurs achats d'engrais, d'amendements, de fourrages, d'additifs fourragers et de produits phytosanitaires, et de l'emploi qui en est fait. La présence de tout intrant non autorisé par le présent Cahier des charges est formellement interdite dans toute l'exploitation » (BIOSUISSE, 2014). Ces exigences de traçabilité demandent la tenue à jour d'un certain nombre de registres consultables en tout temps sur l'exploitation.

Ensuite, le Jardin botanique de la Ville de Genève a formellement signé un contrat de production avec BIOSUISSE, l'organe fédérateur des agriculteurs BIO. Nous avons également mandaté la société indépendante BioInspecta, qui est l'organisme de contrôle des exploitants BIO. Enfin, nous sommes devenus membres de BioGenève, l'association cantonale des producteurs BIO. L'ensemble des cotisations obligatoires et des émoluments de contrôle s'élève aux alentours de 1000.-CHF par année. Le Jardinier-chef a également dû suivre une formation obligatoire de 2 jours sur les principes de l'Agriculture biologique.

Au 1er janvier 2015, le Jardin botanique a ainsi officiellement commencé une période de 2 ans de reconversion dans l'objectif d'obtenir le label BIO en 2017. Nous nous sommes soumis avec succès au premier contrôle de BioInspecta en mars 2016, ce qui est loin d'être anodin dans l'approche de notre métier. Accepter de faire contrôler son travail par une entreprise extérieure, c'est une manière de s'exposer à un jugement. C'est pourtant l'outil incontournable qui permet de certifier la qualité des exploitations BIO en Suisse. Le contrôle a lieu chaque année entre mars et septembre. En plus de cet exercice obligatoire (et annoncé), 10% des exploitations suisses sont visitées une deuxième fois de manière aléatoire.

Discussion

Toutes les solutions techniques trouvées dans le cadre de cette recherche ont été proposées aux jardiniers comme une alternative positive. Cette approche « solution » a été la clé de la réussite du processus vers le BIO. Il est en effet nécessaire d'accompagner le changement au lieu de l'imposer. Un agriculteur peut prendre seul la décision d'une reconversion BIO. Par contre, une institution aussi complexe que la Jardin botanique de Genève, qui compte 42 collaborateurs et plus de 9000 taxons, doit nécessairement passer par un processus d'acceptation. Pour les jardiniers, il s'agit de réinventer son métier, d'oser expérimenter, déconstruire des principes établis depuis de nombreuses années.

Dans le contexte actuel de l'agriculture biologique, le chemin pris par le Jardin botanique de Genève est bien évidemment une exception. Cette démarche est pionnière, puisqu'à priori, le cahier des charges de BIOSUISSE

> Mots-clefs LUTTE BIOLOGIQUE BIODIVERSITÉ DÉVELOPPEMENT DURABLE HORTICULTURE BIOLOGIQUE, PRATIQUES HORTICOLES JARDIN BOTANIQUE

05. Discussion

• Freyre Nicolas
• Loizeau Pierre-André

s'adresse au secteur agricole, et principalement à la production alimentaire. Le processus de reconversion BIO du Jardin botanique a été possible, il faut le reconnaître, grâce au bon sens des instances de certification. Plusieurs aspects de notre métier si spécifique ne sont en effet pas décrits dans les règles du jeu, personne jusque-là n'ayant soulevé la problématique. Est-il possible de recevoir des plantes rares de collection d'autres Instituts botaniques qui ne sont pas certifiés BIO ? Comment nourrir des animaux d'ornement si l'aliment n'existe pas en qualité BIO ? Faut-il renoncer aux traditions d'échanges de graines à travers les *Index seminum* ? Autant de questions qui ont été soulevées et résolues par des compromis, grâce à la bienveillance de BIOSUISSE qui est conscient de ses limites, et qui a souhaité encourager notre démarche.

La suite logique serait de faire évoluer le cahier des charges de BIOSUISSE, vers la prise en considération des spécificités des métiers de l'horticulture, de la botanique et des espaces verts. Il semble nécessaire d'avoir une masse critique d'entreprises et de jardins botaniques assez importante pour pouvoir stimuler ce changement.

Conclusion

Au niveau national, le Jardin botanique de la Ville de Genève est la première collectivité publique à respecter formellement les normes de BIOSUISSE. Les espaces verts urbains en Suisse étant majoritairement gérés et entretenus par le secteur public, l'objectif est d'inciter et d'encourager d'autres municipalités à faire de même en s'appuyant sur cette expérience. La portée de ce projet prendrait alors une dimension supplémentaire avec un impact démultiplié.

La réussite de ce projet tient essentiellement dans la capacité des jardiniers à accepter le changement. Concrètement, le passage en BIO ne demande pas nécessairement plus de travail, mais oblige à réaliser plusieurs adaptations. L'enjeu a été de trouver ensemble des solutions techniques (engrais, traitements, substrats, etc…) qui soient favorables et parfois même meilleures qu'auparavant. La responsabilité des collections vivantes du Jardin botanique de la Ville de Genève (plus de 15 000 plantes de collections) ne laisse en effet pas le droit à l'erreur ou à l'approximation !

> Mots-clefs LUTTE BIOLOGIQUE BIODIVERSITÉ DÉVELOPPEMENT DURABLE HORTICULTURE BIOLOGIQUE, PRATIQUES HORTICOLES JARDIN BOTANIQUE

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SIBERIAN FIR SEED PRODUCTIVITY IN V.N. SUKACHEV INSTITUTE OF FOREST ARBORETUM, RUSSIA

Photo credit : Siberian firs at Forest Arboretum, *R.I. Loskutov*

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> Keywords
EX SITU CONSERVATION
SEED FORMATION
SEEDS PRODUCTIVITY

05. Abstract

• *Bazhina Elena*

THE DEVELOPMENTAL ASPECTS OF SEXUAL REPRODUCTION OF SIBERIAN FIR (*ABIES SIBIRICA* LEDEB.) GROWING AT THE SUKACHEV INSTITUTE OF FOREST ARBORETUM WERE ANALYZED. SIBERIAN FIR SEED-CONE BUD, PRE-FERTILIZATION OVULE DEVELOPMENT, POLLINATION, FERTILIZATION AND EMBRYO DEVELOPMENT WERE HISTOLOGICALLY INVESTIGATED. SEED PRODUCTIVITY OF CONES AND SEEDS IS VERY LOW AT THE ARBORETUM. THE RESULTS OBTAINED IN THIS STUDY CONTRIBUTE TO UNDERSTANDING THE EFFECTS OF CLIMATE CHANGE ON THE REPRODUCTION OF *A. SIBIRICA*; SUCH INFORMATION MAY CONSTITUTE THE BASIS FOR THE CONSERVATION OF THIS PLANT.

> Keywords
EX SITU CONSERVATION
SEED FORMATION
SEEDS PRODUCTIVITY

05. Introduction

• *Bazhina Elena*

Photo credit : Siberian firs at Forest Arboretum, ***R.I. Loskutov***

IN A MODERN ERA OF ENVIRONMENTAL CHANGE, THE DETERMINATION OF PLANTS HARVESTING IS IMPORTANT FOR THE DEVELOPMENT OF MODELS WITH PROTOCOLS FOR PLANT CONSERVATION.

However, gaps in fundamental biological information for threatened plants are one of the challenges for global plant conservation. *Ex situ* plant collections provide valuable means for researching of climate change (Firsov, 2012; Shaw & Hird, 2014). When forest plants are grown artificially in arboreta, botanical gardens and on plantations, they have to, like in the case of climatic changes, and adapt themselves to new environmental conditions. Target 8 of the Global Strategy for Plant Conservation (GSPC) is directly aimed using *ex situ* collections to support conservation, and enabling supply of *ex situ* material for recovery and restoration programs (Secretariat of the Convention on Biological Diversity, 2009). Botanical gardens and arboreta are important in terms of improving our understanding of *ex situ* conservation of plants, climatic change effects on plants and of mechanisms of their adaptation to these changes (Owens & Blake, 1985; Westwood & Cavender, 2015).

Plant conservation requires broadening our knowledge of plant reproductive biology, especially of how seeds develop in the plants being grown. It was shown that climatic changes at introduction induce reproductive phenology shift and different types of disturbances in planted trees (Owens *et al.*, 1991; Beuker *et al.*, 1998; Skrøppa *et al.,* 2007; Bazhina, 2014; Bazhina *et al.,* 2011). And viewed in that light, studying the characteristics of the seed production of the fir trees (*Abies sibirica* Ledeb.) growing in the arboretum may contribute significantly to our understanding of how to conserve woody species.

The purpose of this study was to investigate female gametophyte and seed development in the Siberian fir (*Abies sibirica* Ledeb.) cultures in the Arboretum of the V.N. Sukachev Institute of Forest (Krasnoyarsk, Russia).

Materials & methods

GENERAL INFORMATION

V.N. Sukachev's Forest Arboretum was originally established in 1977, in the wildland/Krasnoyarsk interface (Akademgorodok) in an area of 15.15 ha.

> Keywords
EX SITU CONSERVATION
SEED FORMATION
SEEDS PRODUCTIVITY

05. Materials & methods

• *Bazhina Elena*

The aims of the arboretum are conservation, investigations of introduction and acclimatization and education. The arboretum displays many elements of the Siberian- and Far-Eastern-type ecosystems. This is essentially an islet of mountain steppe with soil characterized by thick sod layer and ground vegetation dominated by tall grasses (Mamaev *et al.*, 1993). Notwithstanding its proximity to Krasnoyarsk, the arboretum is almost not polluted, because it is situated outside the zone of the prevalent industrial emission transfer (Varpholomeev & Maltsev, 2006). The arboretum is a member of the Botanic Gardens Conservation International (BGCI).

GEOGRAPHICAL AND TOPOGRAPHICAL CHARACTERISTICS

The arboretum is situated on a terrace (275m a.s.l.) of the left bank of Yenisei River (Lat. 55°59', Long. 92°45').

CLIMATIC AND SOIL CHARACTERISTICS

The arboretum is considered to be an East-Siberian version of the Southern taiga subzone. The climatic conditions of the arboretum according to Spravochnik po klimatu (1967) are the following: extremely continental climate with cold winter (up to -53°C in January) and short hot summer (up to +38°C in July). The mean annual precipitation is 485mm. The length of the vegetation is 154 days; the period of freeze-free is 120 days and the period with snowpack is 165 days. The arboretum is supported by sod-carbonate, weakly alkaline (pH is close to neutral 7.01±0.08) soil containing little humus (2.55±0.13%) and mobile nitrogen (Loskutov, 1991).

DATASET

Siberian fir saplings were grown from seeds collected in natural fir stands of Altai region found in moderately continental climate and were brought to the arboretum from the nursery of the Research Siberian Institute of Fruit Growing (Barnaul, Altai) in 1977 (Loskutov, 1993).

Developing seed buds and cones were collected every 1 or 2 weeks from late April through August from several 50-year-old Siberian fir trees growing at the arboretum. They were collected in the upper parts of crowns of trees, brought to the laboratory, and fixed. Ovuliferous scales or separate ovules were removed from large cones. The ovulate cones were fixed in Navashin's solution or in alcohol mixed with acetic acid to a ratio of 3 : 1 for one day, dehydrated through the tertiary ethyl alcohol series (Pausheva, 1988) and embedded to paraffin. Serial sections were cut at 8μm, stained for anatomical study by iron-hematoxilin and procion red and blue dyes (Ivanov, 1982).

DATA ANALYSIS

A 10-15 ovule and developing seeds per stage were analyzed using a Micromed-2 microscope. Seed productivity was measured as a quantity of seed scales producing seeds during 2010-2012. Since, under each seed scale 2 ovules developed, then the seed productivity was calculated according to the formula: $A=n/2N100$ (%), where n- seed number is, N- total number of seed scales is (Minina & Tretyakova, 1983). Seed quality was tested by X-rays method (Scherbakova, 1965). Quantity of full, empty and damaged by insect's seeds was calculated (in %). Results were statistically analyzed using standard statistical methods STATISTICA 7.0 (StatSoft, Inc. STATISTICA, 2001).

> Keywords
EX SITU CONSERVATION
SEED FORMATION
SEEDS PRODUCTIVITY

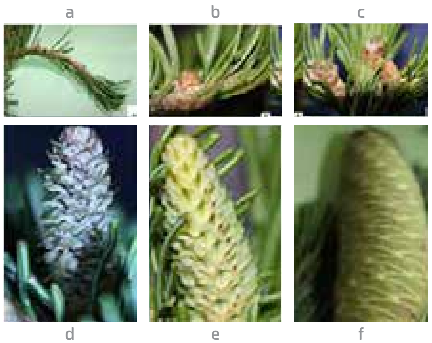
05. Results

• *Bazhina Elena*

SEED-CONE BUD DEVELOPMENT

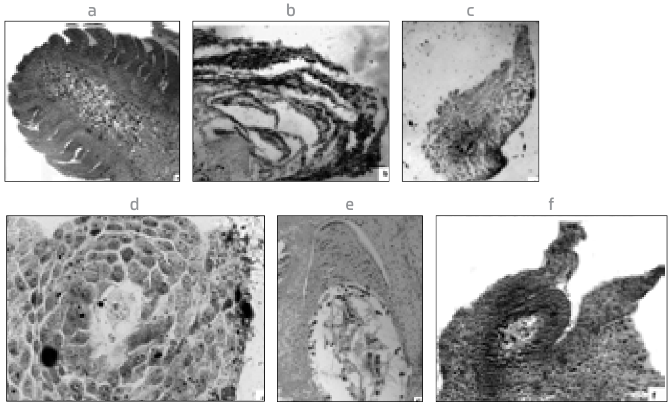
The developmental aspects of sexual reproduction of the Siberian fir growing at the arboretum and in natural populations are essentially the same. Seed-cone buds develop only on shoots in the upper region of the crown. They differentiated nearly all axillary primordia on the upper surface of twigs in early-July (**Fig. 1a**). In late July, a differentiation begins in macrostrobiles: bract scale primordia become notable on the apex flanks. In mid-to-late August, swellings occur at the bract scale bases that later develop into a small ovuliferous scale (**Fig. 2a**). Only bracts at the very base and tip of the cone do not develop ovuliferous scales. Part of buds will become latent or form small vegetative buds (**Fig. 2b**). When conditions are unfavorable for seed-cone differentiation, part of latent buds makes up to 80-90%.

Fertile ovuliferous scales initiate two ovule primordia before winter dormancy. Ovules are on the upper surface of ovuliferous scale and consist of a megasporangium (nucellus). At the late-August ovuliferous scale increased up to 254x296mkm, nucellus increased up to 128x85mkm. A ring of meristematic cells develops around the nucellus. Seed-cone buds overwinter at this stage.



> FIGURE 1

Seed cones development: a – seed-cone buds initiation (mid-July); b – dormant seed-cone bud (early September); c - seed-cone after dormancy (late April); d – seed cone at pollination (May) showing pointed bracts; e, f – branch and matured cone (late August)



> FIGURE 2

Median longitudinal sections of: a - a dormant seed cone bud: bracts have a broad base and point tip, a small ovuliferous scale forms in its axil (late August); b – a latent bud in spring; c - a post dormant seed cone: developing bracts and ovuliferous scale demonstrate mitotic divisions (late April); d – an ovule from seed cone after dormancy showing one large megaspore mother cell in the nucellus; e,f – ovule at pollination: free-nuclear female gametophyte, integument is already funnel-shaped and female gametophyte show free nuclei

PRE-FERTILIZATION OVULE DEVELOPMENT

In dormant seed cones the ovular areas showed a discrete epidermis and one or two isodiametric hypodermal archesporial cells and subjacent cells were aligned in concentric arcs. In the post dormancy stages seed-cone buds become very long, bracts, ovuliferous scale and ovules developed rapidly (Fig. 2c), the ring meristematic cells formed the integument. Each archesporial cell divided to form an inner sporogenous cell and an outer primary parietal cell, which further divided periclinally to form the parietal tissue. One of the sporogenous cells elongated considerably, became prominent, and functioned as the megaspore mother cell (MMC) (**Fig. 2d**). After the MMC formed (late-May), the cells of the nucellar epidermis divided periclinally forming a thick nucellar cap and integument differentiated. Meiosis of MMC was not followed by wall formation and megaspore went through free-nuclear divisions. Tapetal cell became more irregular and flattened on the inner surface of the nucellus as the nucellar cavity enlarged and became spherical (**Fig. 2e**). At pollination time integument overgrew the nucellus, extended beyond the edge of the ovuliferous scale, and developed a wide flangelike structure and a wide open micropyle (**Fig. 2f**).

> Keywords
EX SITU CONSERVATION
SEED FORMATION
SEEDS PRODUCTIVITY

05. Results

• *Bazhina Elena*

The haploid female gametophyte cells divided, except for several cells at the micropylar end, each of which elongated, formed a large basal vacuole and functioned as an archegonial initial. At the arboretum usually two to four initials per ovule formed as in a natural population. Cells around each archegonial initial divided, forming small isodiameric archegonial jacket cells with densely staining cytoplasm and large nuclei. Then archegonial initials divided unequally and form a small primary neck cell to the outside and a large, vacuolated central cell to the inside, which enlarged and developed many clear vacuoles (**Fig. 3a**). Archegonial jacket cells remained small, isodiametric, and densely staining. Female gametophyte cells continued to divided, forming a large egg nucleus (**Fig 3b, c**). The matured gametophyte was slightly irregular and nearly filled the nucellar cavity; the 2 archegonia were surrounded by a single layer of jacket cells, which were smaller than the surrounding gametophytic cells.

POLLINATION AND FERTILIZATION

The period of pollination varies with the location and the weather. Pollination is usually occurring earlier at the arboretum (in the second decade of May) than in natural populations growing in vicinity of Krasnoyarsk where pollination usually occurs in late May but may occur a week later - early June depending on weather conditions. At the time of pollination the scales of the female cones become slightly separated from each other, thus allowing easy access for the pollen to the micropyles (**Fig. 1d**). However, no germinating pollen grains were found on the nucellar tip of ovules at the arboretum. Because of the failure of cones to be pollinated, many stages from fertilization through the early embryonic stage were represented by few specimens and are not illustrated photographically. However, a few adequate specimens were available to describe embryo development.

EMBRYO DEVELOPMENT

The 16-celled pro-embryo was formed 1-2 week after fertilization, by mid-July (**Fig. 3d**). It was a very transient phase before suspensor elongation which lasts in true fir only a few days (Owens & Molder, 1977; Singh & Owens 1981, 1982). During the next stage, cells of the embryo tier divide to form distal apical cells and basal embryonal tubes, which elongated and force the apical cells further into the female gametophyte. The apical cells divided to form a club-shaped embryonal mass (**Fig. 3e**). The proximal cells of the embryonal mass elongated unequally to form a massive secondary suspensor, which pushed the embryonal cells into the corrosion cavity of gametophyte (**Fig. 3f**).

In some ovules occurs “cleavage polyembryony” when the suspensor tier elongates and embryonal tubes form. Cleavage refers to the separation of the apical cells into four files of cell. One of these embryos resulting from cleavage are more vigorous and other soon degenerate (**Fig. 3g**). Matured *Abies* seeds seldom have more than one matured embryo. All other embryos stop development at a very early stage, degenerate and are reabsorbed.

Cells at the distal end of the embryo formed several cotyledons (embryonal leaves) around small shoot apical meristem (**Fig. 4a, b**), cells of central portion of the embryo formed root apical meristem and the basal cells formed a thick secondary suspensor. During the next week embryos and seed matured, the remaining female gametophyte cells contain stored food in the form of starch and lipo-protein (Owens & Molder, 1977; Singh & Owens 1981, 1982). Differentiation in the club-shaped embryonal mass to initiate root meristem and a ring of cotyledon primordial occurred in the 4th week of July and embryo matured by the 1th week of September. Seed development

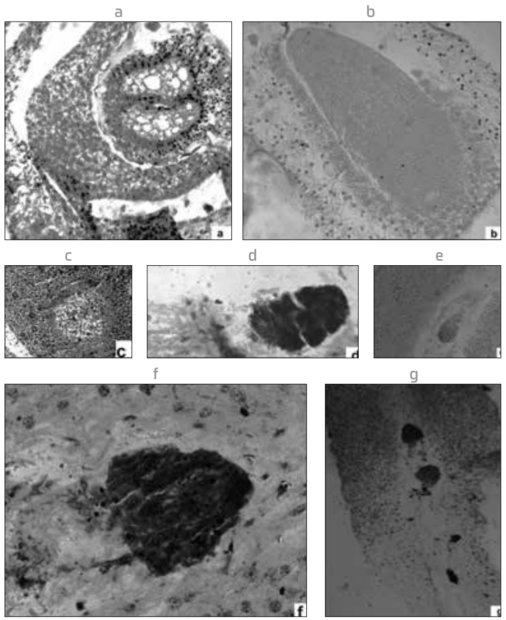
> Keywords
EX SITU CONSERVATION
SEED FORMATION
SEEDS PRODUCTIVITY

05. Results

• *Bazhina Elena*

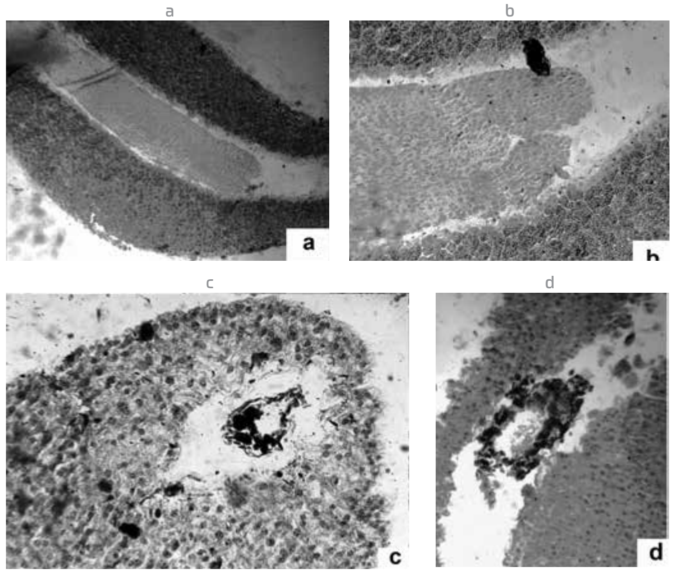
is completed in late-August - early-September. This is about three months after pollination as in alpine (*Abies lasiocarpa* (Hook.) Nutt.) and *amabilis* (*A. amabilis* (Dougl.) Forbes) firs (Owens & Molder, 1985).

In most ovules there is absence of pollination, no further seed development was possible and female gametophytes were finally aborted (**Fig. 4c**). We noted that gametophytes wereaborted only if, five to six weeks after pollination, fertilization had not occurred. In this case, gametophytes collapsed and their contents became absorbed by the surrounding tissues. Lack of fertilization is very common in true firs and female gametophyte will degenerate leaving a normal-appearing but empty seed.



> FIGURE 3

Longisections of ovules to show the development of the archegonium and embryo: a – young archegonia surrounded by a layer of a jacket cells; the central cells are highly vacuolated; b, c – later stage: b - central cell cytoplasm is dense and nucleoli of jacket cells are hypertrophied; c – matured archegonium showing dense cytoplasm with numerous large and small inclusions and large egg nucleus; d – 16-celled proembryo consisting of four ties of cell: apical, suspensor, rosette and open (mid-July); e – club-shaped embryo in corrosion cavity just before meristematic zone appear. The suspensor cells and embryonal tubes elongate and become coiled as they push the distal embryo tier through the archegonial jacket into the female gametophyte tissue; f – torpedo-shaped embryo. Inner female gametophyte cells are collapsing next to corrosion cavity; g – cleavage polyembryony: one embryo (torpedo-shaped) is more vigorous and the others soon degenerate



> FIGURE 4

Longisections of an ovule in mid-summer: a, b - the embryo within corrosion cavity at time of cotyledon initiation and formation (late-July); c - collapsed female gametophyte; d - *Megastigmus* egg in corrosion cavity

SEED PRODUCTIVITY OF CONES

The Siberian fir trees growing in the Institute of Forest Arboretum have generally low production of cones and seeds, with cone amounts varying from none to twenty in a tree. Generally seed productivity of cones ranged 45% to 87% during the years covered by our studies. However, these seeds showed an extremely low viability, containing developed embryos making up only 1-9.8%. Empty seeds were morphologically similar to full ones.

Unlike the natural populations of the species found in the low-mountain areas of Eastern Siberia, in which the seed buds damaged by seed chalcids (*Megastigmus*) amounted to a considerable number, the insect larval infestations were negligible (less than 1% of the seeds were damaged) at the arboretum. Few *Megastigmus* eggs observed during archegonium formation. The eggs were located at the embryo sac ends opposite that where archegonia are, as well as between the nucellus tips and embryo sacs (**Fig. 4d**).

> Keywords *EX SITU* CONSERVATION
SEED FORMATION
SEEDS PRODUCTIVITY

05. Discussion

• *Bazhina Elena*

According to the 2009 Assessment Report on Climate Change and Its Impacts (IPCC), Eastern Siberia is a region where air temperature has been observed to increase remarkably over the past several decades. The most considerable air temperature changes have occurred in the montane ecosystems dominated by mixed fir-Siberian pine forest stands. For conservation and reforestation in new environmental conditions, woody species have to adapt their reproductive systems to these changes. The main and sometimes the only way of reproduction of Siberian fir are by seeds (Hekrasova & Ryabinkov 1978). Understanding of the mechanisms of seed development in moved Siberian fir trees, as well as research of the mechanism disturbances, are crucially important to succeed in controlling the species cone and seed production during its adaptation to new microclimatic conditions.

Abies sibirica shows a 1-year type of reproductive cycle similar to the other true fir (Powell, 1970; Singh & Owens, 1982; Arista & Talavera, 1994; Politi *et al.*, 2011). The seed cones show only rudimentary ovules containing archesporial cells during winter dormancy, and their differentiation are post-dormance phenomena. A considerable part of seed buds aborted before or during dormancy, and became dry hard, and pitched. Cones abortion can seriously reduce potential crop at the arboretum.

The phenology of events occurring during spring and summer differs at the arboretum and in natural populations. Climatic changes appeared to be responsible for physiological disturbances in the planted fir individuals, which disturbances were particularly evident during meiosis or during pollen formation (Bazhina *et al.,* 2011; Bazhina, 2014). Because of inadequate pollination is the low number of filled seeds found at the arboretum. The development of the pollen tube and ovule is more highly synchronized in true fir than in most other conifers and the brief period of pollen tube development happens during the few days while female gametophyte is maturing (Owens & Molder, 1985). Any asynchrony in development or frequent low pollen production may then prevent fertilization and reduce the number of filled seed.

The Siberian fir trees growing in Forest Arboretum have generally low production of cones and seeds. The cone development might be blocked at certain stages by a number of factors (Colangeli *et. al.*, 1989; Owens & Morris, 1998), and in particular climatic conditions, which probably caused abortion of buds before their bursting or of cones at early stages of their development. Siberian fir cone morphogenesis is remarkable for the fact that the processes of both megasporogenesis and female gametophyte development do not depend on seed pollination (Nekrasova & Ryabinkov, 1978). However, the major factors accounting for sterile seed occurrence are insufficiency and low quality of pollen. It is due to certain specificity of fir sexual reproduction that the fir trees at the arboretum are unable to realize their high reproduction potential. In other words, this specificity causes such a low adaptation of the fir reproduction system to the environmental conditions found in the arboretum.

> Keywords
EX SITU CONSERVATION
SEED FORMATION
SEEDS PRODUCTIVITY

05. Conclusion

• *Bazhina Elena*

Thus, acquiring understanding of how Siberian fir seed formation occurs and what disturbs this process in plantations is an important step towards effective control and management of cone and seed production of the fir trees during their adaptation to new microclimatic conditions. In the context of ongoing climate changes, these disturbances have become research priorities. For artificial forest growth to be successful, it is crucial to carefully select parent trees. *Ex situ* collections must involve enough material (the number of individuals) to be suitable for reproduction and reintroduction (Anonymous, 1995). Besides, for effective *ex situ* conservation of woody species, seeds should be collected from local natural populations, and subsequently tested for quality using cytological and genetic techniques prior to planting.

> Keywords EX SITU CONSERVATION
SEED FORMATION
SEEDS PRODUCTIVITY

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STUDY OF THE ADAPTABILITY OF TREES TO DROUGHT: PHENOLOGICAL MONITORING OF ASSISTED GROWTH SENSORS, IN THE BOTANICAL GARDEN OF VILLA THURET

Photo credit : PepiPiaf sensor on Eucalyptus dorrigoensis tree, *Inra PACA Villa Thuret*

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> Keywords PHENOLOGY DIAMETER GROWTH DLVDT SENSOR MICRO-DENDROMETER ABIOTIC STRESS

05. Abstract

- *Ducatillion Catherine*
- *Bellanger Richard*
- *Charron Tristan*
- *Chevallier Joëlle*
- *Heinz Christine*
- *Marchal Cécilia*
- *Mellerin Yannick*
- *Caraglio Yves*
- *Ameglio Thierry*

THE ADAPTING OF TREES TO CLIMATE CHANGE IS ONE OF THE BIGGEST CHALLENGES WE FACE PRESENTLY. THE GOAL OF THE PHENOTOOLS PROGRAMME IS TO MEASURE THE IMPACT OF CLIMATE ON THE PHENOLOGY OF GROWTH OF A SAMPLE OF EXOTIC TREES INTRODUCED AT THE VILLA THURET BOTANICAL GARDEN IN A MEDITERRANEAN CLIMATE.

These trees are from very diverse taxonomic groups, biogeographic origins and have different growth patterns. They are deciduous or conifer species, with rhythmic or perennial growth. The method used lets us observe and compare their primary growth and their secondary growth simultaneously. The approach requires the use of autonomous micro-dendrometers to record and continuously monitor micro-variations in trunk or branch diameter. The initial results highlight contrasted growth and drought-adaptation strategies at the same site.

> Keywords PHENOLOGY DIAMETER GROWTH DLVDT SENSOR MICRO-DENDROMETER ABIOTIC STRESS

05. Introduction

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Photo credit : PepiPiaf sensor on Eucalyptus dorrigoensis tree,
Inra PACA Villa Thuret

THE ADAPTING OF TREES TO CLIMATE CHANGE IS ONE OF THE BIGGEST CHALLENGES WE FACE PRESENTLY. IN ORDER TO SURVIVE, THESE LIVING ORGANISMS, THAT GENERALLY HAVE A LONG LIFESPAN, MUST BE ABLE TO WITHSTAND INCREASINGLY FREQUENT AND MORE INTENSE CLIMATIC EVENTS.

Climate changes affect the phenology of species and have consequences on the growth and reproduction of trees. The question of which species to plant is one faced by forestry, orchard and urban landscape managers.

In the Mediterranean climate, water resources are highly fluctuating, with a variation coefficient of 30% (Rambal, 2002). Over the decades to come, we will see an increase in more intense droughts around the Mediterranean and a reduction in rainfall events, which will become more unpredictable and violent. Will the flora be able to withstand more and more pronounced drought conditions? Some species are able to limit water loss by reducing their leaf surfaces, the number of stomata or conditions for transpiration from stomata (leaf hairs, waxes, etc.). Others have greater capacity to access groundwater, i.e. deep root systems. On a physiological level, transpiration, which is a vital process for tree growth and its temperature regulation, is heavily affected by the water shortages linked to edaphic drought. The higher the deficit, the slower growth. In an extreme drought, even if the stomata are fully closed, dehydration continues and can cause xylem vessel embolism and eventually death of the tree (Cruiziat *et al.,* 2001, 2003).

One of the findings we made at the Villa Thuret, located in southeast France, is that many exotic trees can withstand the excesses of the Mediterranean climate (proven in the fact that they have continued to thrive in the garden for several decades, some for a century or more), apparently irrespective of their phylogenetic positioning or biogeographic origin. However, they demonstrate diverse –indeed contradictory – phenologies: some grow while others are “paused”, they flow once or several times depending on year, stop growing in some winters or some summers but not others, etc. Some retain their original phenology (e.g. southern hemisphere) while others adapt to the seasons in the host country, according to conditions that have yet to be explained.

Due to the influence of climate on phenology, the plants’ exposure to environmental fluctuations and the taking into account of global chang-

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• Ameglio Thierry

es, studies on phenology have increased in number over the last ten years (Gordo & Sanz, 2010). In 2005, Rathgeber et al. put forward a hypothesis on the influence of global change (climate and CO_2 increases) on forest ecosystem production. Some studies have demonstrated a correlation between the earlier appearance of the first phenological stages in spring and rising temperatures over recent years (Cleland *et al.*, 2007), which is consistent with an increase in the length of the vegetation period. Current changes lead to modifications in plant phenology and, due to high temperatures and drought conditions in summer (Cleland *et al.*, 2007), this can lead to a reduction in radial growth and hence in forest productivity (Michelot *et al.*, 2012). Among the studies into the impact of climate on plant phenology, some focus on primary meristem events that lead to longer stems (Cleland *et al.* 2007; Gordo & Sanz, 2010), while others deal with the modulation of secondary meristem functioning and the consequences on thickness growth (Rathgeber *et al.*, 2000; Rossi *et al.*, 2011; Cuny *et al.*, 2012; Klein *et al.*, 2013; Michelot *et al.*, 2012). These results may appear contradictory and raise the question of the relationship between these types of growth. Furthermore, in the Mediterranean region, the climate creates growth conditions that alternate frequently between two winter dormancy phases and two vegetation phases: we refer to this as bimodal growth (Camarero *et al.*, 2010).

The methods currently applied in studies into the impact of climate change on phenology come up against some methodological limitations. For example, knowledge about the development and growth of some species, in particular Mediterranean and/or exotic species in a Mediterranean climate, which varies from one year to another, remains underdeveloped at this stage and lacks hindsight (some permanent sites exist in the natural environment: Puechabon, Fontblanche, St Michel de l'Observatoire). To benefit from historical data and diverse situations, it is therefore necessary to set up robust, automated methodological tools to supply the databases and phenological models, and also help us understand the development phases of these species and assess their capacity for adaptation in relation to this characteristic (phenology), which has not been the subject of extensive study so far.

Since 2013, in the framework of the "Perpheclim" (Perennial fruit crops and forest phenology evolution facing climatic change - Database, Modelling and Observatory network) project of the ACCAF metaprogramme (Adaptation of agriculture and forest to climate change) run by INRA (French national institute for agricultural research), we have set up a primary and secondary growth phenology monitoring system at Jardin Thuret, on a diversified sample of trees to highlight and characterise the underlying physiological and morphological processes. What is the impact of climate and its excesses on growth and what are the long-term effects. What morphological, phenological and physiological determiners can we observe and monitor? Can we pinpoint growth strategies when faced with the risk of edaphic drought for these species? These are some of the questions that our study will endeavour to answer.

Materials & methods

The sample currently comprises 68 adult trees belonging to 17 taxa with forestry potential. The selection criteria are as follows: taxonomic and biogeographic diversity, primary growth mode diversity, growth phenology diversity, exoticism and acclimatisation (the trees are all adult and have well accommodated to the pedoclimatic conditions at Jardin Thuret), presence of control

> Keywords PHENOLOGY DIAMETER GROWTH DLVDT SENSOR MICRO-DENDROMETER ABIOTIC STRESS

05. Materials & methods

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species (native taxa, some of which belong to the same genus as the exotic taxa), trees enabling testing of a new phenological criterion: sudden bark shedding. The exotic species belong to the *Arbutus*, *Corymbia*, *Eucalyptus* and *Quercus* genera and the native species to the *Arbutus*, *Ostrya* and *Quercus* genera. The trees form three groups: deciduous species with rhythmic growth and evergreen species with rhythmic or perennial growth.

1. PRIMARY GROWTH MONITORING

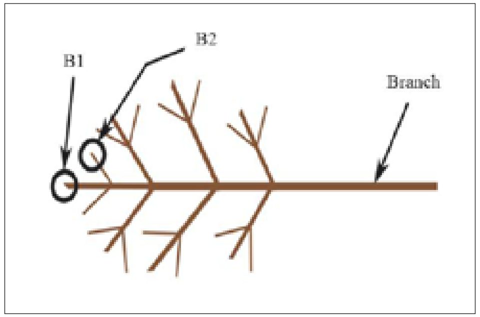
The weekly monitoring is inspired by the BBCH scale, with a universal decimal code for the phenological stages of the plants grown (**Table 1**) (Meier, 2001).

> TABLE 1.

Phenological stages

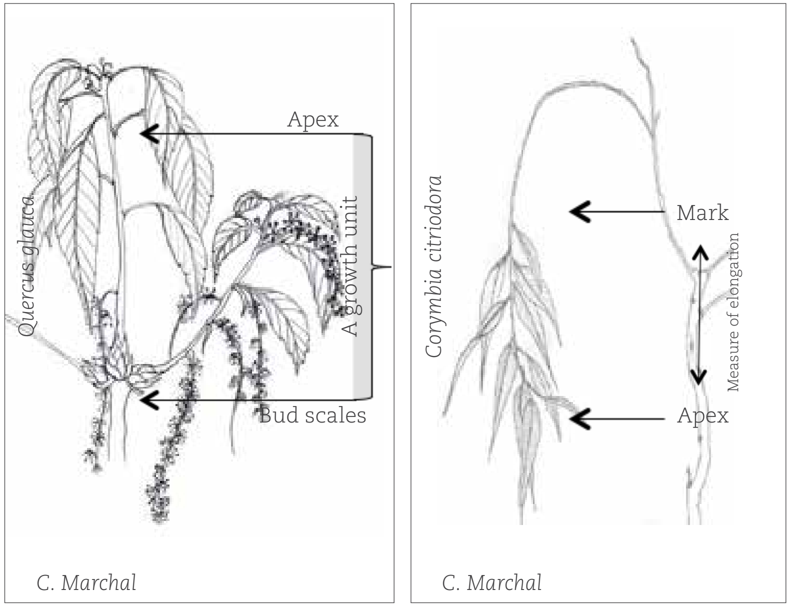
Code	Stage	Stage description
9	Leaves	The end of the first leaves extends beyond the end of bud scales
11	Leaves	The first leaves are plated on about 10% of the crown
15	Leaves	The first leaves are plated on about 50% of the crown
51	Flowers	The majority of flower buds began to swell
52	Flowers	The majority of flower buds began to open
61	Flowers	10% of the flowers or kittens are anthesis
65	Flowers	50% of the flowers or kittens are anthesis
69	Flowers	90% of the flowers or kittens are anthesis
71	Fruits	10% of fruit have reached their maximum size
85	Fruits	50% of fruit is ripe (changed color, or are dried and dehiscent, or fell)
91	Senescence	10% of the leaves have turned color or fell
95	Senescence	50% of the leaves have turned color or fell

The elongation of branches is also measured weekly along at least two axes per tree: a main B1 axis and a secondary B2 axis (**fig. 1** and **2**).



> FIGURE 1

Measured up branches



> FIGURE 2

Elongation measurement techniques for rhythmic or aperiodic growth

2. SECONDARY GROWTH MONITORING

Dendrochronology has been used for several decades to analyse year-on-year variations in tree diameter growth and the effects of age, cultural practices and climate variations. Variations in the diameter of a trunk, branch or fruit are continuously monitored with LVDT (Linear Variable Differential

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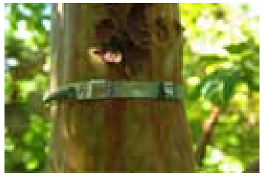
05. Materials & methods

> PHOTO 1 & 2

Left: PepiPIAF sensor
Right: Micro dendrometer

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Transformer) type sensors of sufficient resolution (1 µm), and reflect the action of four factors: 1) irreversible cell growth, reversible swelling or contracting of the organ in relation to 2) the moisture level and 3) thermal expansion of the organ (Kozlowski, 1971; Klepper *et al.*, 1971; McBurney & Costigan, 1984; Améglio & Cruiziat, 1992; Simonneau *et al.*, 1993; Zweifel *et al.*, 2000; Cochard *et al.*, 2001; Daudet *et al.*, 2005) and 4) the contraction or expansion of conductive elements under the impact of internal pressure related to water status of those conductive parts (Irvine & Grace, 1997; Offenthaler *et al.*, 2001; Sevanto *et al.*, 2002). We have used PépiPIAF sensors (Améglio *et al.*, 2010) which give very accurate (sensitivity to microns) continuous measurements of the diameter of an organ and memorise the data (diameter and temperature) without disrupting its functioning, using wireless technology (**Photo 1**).

Micro-dendrometers are used for twice-weekly trunk diameter measurements (**Photo 2**). We have taken weekly micro-core samples to track cambium/cork cambium activity. Finally, we monitored bark shedding in the species concerned, the objective being to explore a new simple phenological character for use in looking at cork cambium functioning (Ducatillion *et al.*, 2013). The entire device is on the **Table 2**.

Latin name	Family	Native	Primary growth	Fall leaves	Fall bark	Flowers season	Place of flowering	Trees number	Sensors PépiPiaf number	Growth measure	BBCH stages	Micro-coring	Microwave dendrometers	Followed bark fall
Aesculus californica	Hippocastanaceae	California	R	D	PG	P	T	2	1	2	2	1	2	0
Arbutus andrachne	Ericaceae	Eastern Mediterranean	R	E	S	H	T	4	0	2	3	1	1	4
Arbutus canariensis	Ericaceae	Canary Islands	R	E	S	W	T	1	1	1	1	1	1	1
Arbutus glandulosa	Ericaceae	Central America	R	E	S	W	T	1	0	0	0	0	0	
Arbutus menziesii	Ericaceae	South of North America	R	E	S	W	T	1	0	1	1	0	1	0
Arbutus unedo	Ericaceae	Western Mediterranean	R	E	PG	W	T	2	1	2	2	0	2	2
Arbutus x andrachnoides	Ericaceae	Greece	R	E	PG	W	T	3	0	2	3	1	2	3
Arbutus x thuretiana	Ericaceae	Hybrid	R	E	S	W	T	2	2	2	2	2	2	2
Corymbia citriodora	Myrtaceae	North East Australia	A	E	S	S, E	T	2	2		2	2	2	2
Corymbia maculata	Myrtaceae	Australia : Q, NSW, V	A	E	S	E	T	1	0	0	0	1	1	1
Eucalyptus dorrigoensis	Myrtaceae	Eastern Australia	A	E	S	E	T	2	1	1	1	1	1	1
Ostrya carpinifolia	Betulaceae	Mediterranean	R	D	P	S	A	3	0	1	3	1	1	0
Quercus glauca	Fagaceae	East and South Asia	R	E	P	S	A	4	0	2	4	0	2	0
Quercus ilex	Fagaceae	Mediterranean	R	E	P	S	A	10	2	2	10	2	6	0

> TABLE 2

Synthesis device.

Primary growth: rhythmic (R), aperiodic (A). Fall leaves: deciduous (D), evergreen (E). Fall bark: progressive (PG), sudden (S), persistent (P). Flower season: spring (S), summer (E), autumn (A), winter (W). Place of flowering: terminal (T), axillary (A)

> Keywords PHENOLOGY DIAMETER GROWTH DLVDT SENSOR MICRO-DENDROMETER ABIOTIC STRESS

05. Results and discussion

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For each of these species, measurements in diameter variations have been set against climate data, elongation periods, different phenophases and bark shedding. We now have eight years' worth of phenophase observations for several species, but only two and a half years with the use of sensors and bark shed observation. The initial results nonetheless reveal some significant trends. The effect of climate on the growth of the three initial tree categories is compared in **Table 3**.

Group 1, illustrated by *Arbutus* x *thuretiana* (a hybrid between A. *canariensis* and A. *andrachne* naturalised at Jardin Thuret), reveal a number of axes in the growth or flowering phase, between autumn and early summer. Normal winter temperatures do not affect growth. However, environmental conditions affect the phenophase dates. Growth stops during the summer period.

Trees in group 2, illustrated by *Eucalyptus dorrigoensis*, show pretty regular, opportunist growth throughout the year. In the *Aesculus californica* (group 3), budburst is very early (February) with brief primary growth. Leaves cease their activity earlier at the end of spring and fall in summer middle while it normally should shed in autumn for deciduous trees.

Under the same Mediterranean climate, the trees measured in the Botanical Garden in Villa Thuret demonstrate very contrasted primary and secondary growth depending on species, with variable sensitivity to climate factors (i.e. winter temperatures: e.g. *Eucalyptus dorrigoensis* vs. *Aesculus californica* or summer rainfall and drought; *Aesculus californica* vs. *Quercus ilex*)). Some species as *Aesculus californica* seem to avoid potential summer drought, regardless of the year's rainfall, with early leaf fall with no apparent link to

Climate action on 3 tree types. Some examples

Type of growth	Species example	Bud break and primary growth	Secondary growth	Climate action on growth
1 - Evergreen. Rhythmic growth	*Arbutus x thuretiana*	All the time except in summer.	Spring and beginning of summer	Impact on the phenophases and impact of extreme events
	Quercus ilex	Short and rapid growth in spring. Sometimes growth in autumn	Spring and summer	Impact of temperature on bud break
2 - Evergreen. Aperiodic growth	*Eucalyptus dorrigoensis*	Long growing with at least two short stops (winter and summer)	Only a stop in summer	Impact of extreme events
3 - Deciduous. Rhythmic growth	*Aesculus californica*	From late winter to late spring	Spring and summer	Slight impact on phenophases

> TABLE 3

Climate action on three tree types. Some examples

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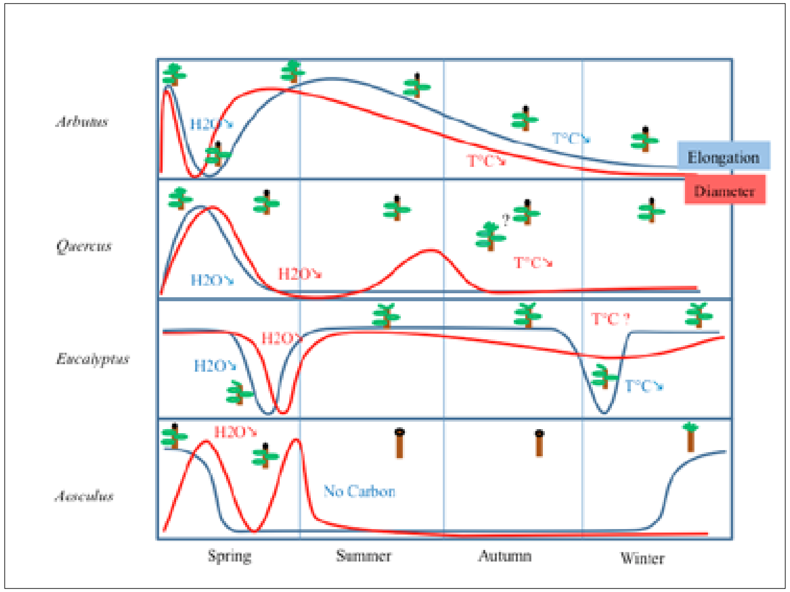
a climatic factor (no marked water stress). The physiology of these species in terms of phenophases, water flows and carbon management may thus be approached through the continual analysis of diameter variations and shows high diversity in functioning under the same climate. The annual phenological cycles of the four species groups are shown in **Fig. 3.**



> FIGURE 3

Diagram of the phenological cycles of 4 groups of species, according to the seasons. The curve in blue gives the average elongation for the 4 group of species independently of the climate. The red curve gives the same average for the diameter growth. For each season, we indicated the effect of the main climatic factor on elongation (in blue) or diameter growth (in red). For example, the diameter growth of the Eucalyptus is greatly attenuated by water stress (H2O) in late spring and early summer in comparison with the average diameter growth for this site at this period. For this species, diameter growth was also impacted in winter in response to the colder temperatures (T°C) of one year in comparison to the average temperature during winter for this site.

For example for *Eucalyptus*, when you measure diameter growth, you can observe an almost constant rate of growth decreased in late spring and early summer only by the soil water reserve (rainfall during this period) and during winter if the temperature decreased below +10°C. For *Aesculus californica*, the pattern of growth diameter appears the same as that measured in its original area in California (Mooney & Hays, 1973) but our continuous diameter measurements indicate that the fall of the leaves in this species is not related to water stress (no more shrinkage during the day indicated no strong mobilization of water reserves in the bark). Here we have a typical adaptation to the Mediterranean climate by an avoidance of drought stress by leaves fall with no stress and a drastic reduction of transpiration.

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05. Conclusion

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By monitoring both primary growth and secondary growth, we can obtain an overall view of the effect of climate on a plant's functioning. At the same site, the three groups of trees show contrasting growth modes, responding or not to climate conditions. The choice and positioning of the axes monitored, within the tree's architecture, provides more realistic information on the tree's behaviour in response to climate variations.

Thus, the study over a few years on the same site of primary or secondary growth dynamics can quickly permits to extract the phenophase of these growths for different species, but also to conclude on climatic factors (water or temperature) affecting them.

Thus observation of the bark phenology through the continuous acquisition of micrometric variations of branch or trunk diameter measurements using the PépiPIAF sensors therefore makes it possible to track not only secondary growth (resumption of cambial activity, growth rhythm) but also leaf phenology (budburst, leaf growth and senescence) by providing new information on the physiology of species which are little or so far unknown. This new tool therefore allows for the acquisition of phenology measurements in numerous situations (isolated tree, arboretum, acclimatisation gardens, orchards, forests, vines, trees in towns, etc.) while contextualising the different phenophases observed in the climatic environment (e.g. heat conditions), but also the physiological environment (e.g. water constraints), both of which can be addressed using the same measurement.

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INTRODUCTION OF EXOTIC TREE SPECIES IN FRENCH ELIMINATION ARBORETA: LESSONS OF THE PAST AND IDENTIFICATION OF VALUABLE FOREST REPRODUCTIVE MATERIALS FOR THE FUTURE

Photo credit : *Abies procera* à l'arboretum de Sainte Anastasie, *T. Lamant*

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> Keywords ARBORETUM EXOTIC FOREST TREES CLIMATIC CHANGE

05. Abstract

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- *Musch Brigitte*

ADAPTING FRENCH FOREST TO CLIMATIC CHANGES IS ONE OF THE IMPORTANT CHALLENGES THAT INRA[1] AND ONF[2] HAVE TO RAISE. IN ORDER TO REACH PART OF THIS GOAL, BOTH INSTITUTES HAVE REVISITED 6 ARBORETA PLANTED, FOR MOST OF THEM, FORTY YEARS AGO.

Their initial goal was to identify species, able to resist to pollution or to be an alternative to species endangered by pathogen problems. These arboreta are located in three different climates: oceanic, mountainous and Mediterranean. Numerous species are present at least in two different arboreta enabling comparison of their behavior under contrasted climates. In this project, we have measured survival and diameter on 254 taxa (17835 individuals). Moreover, total height of the three biggest trees per plots has also been measured. Thus, we can compare oldest results obtained in these arboreta in terms of growth and survival with those after several climatic accidents (drought, heat). We also have recorded the temperature and precipitations in order to identify years which are the most different from the average. We lastly began a study of chronodendrometry in view to determine the reactions (in terms of radial growth) of different species under climate stresses. The ultimate goal of the project is to identify species offering the best compromise between overall growth and growth to stress during extreme years.

These studies have showed that species which were the best thirty years ago are not the best nowadays. For example, in 1989, in the Mediterranean arboreta, the best choice for broadleaves was, species of genus *Fraxinus*, *Alnus* or *Arbutus*. Presently, the best species belong to the genus *Eucalyptus* spp. in spite of 1985's intensive frost. Arboreta also provide information on the invasive character of non-native species such as *Hakea* spp. Moreover, native species are not always better adapted in terms of growth and climate adaptation. It is for example the case in the arboreta under oceanic climate for *Pinus sylvestris* L., worse than *Sequoia sempervirens* (D. Don) Endl. or *Abies grandis* (Douglas ex D. Don) Lindl.. We have also shown that arboreta could be very interesting places to educate forest managers on the interest of new species under climatic changes. Indeed, in managed forest the number of species is low, and generally forest manager badly know or ignore non-native species' autecology. Arboreta are suitable places where they could increase their knowledge and thus discover the potentiality for forest purposes of more than hundred species in real forest conditions like *Alnus rubra* or *Nothofagus* or still *Chamaecyparis* and *Thuya* spp.

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05. Introduction

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Photo credit : *Abies procera* à l'arboretum de Sainte Anastasie, ***T. Lamant***

IN APRIL 1967, INRA PUBLISHED A REPORT ENTITLED "EXPERIMENTATION ON ECOLOGICAL ARBORETUMS" PROPOSING THE FOUNDATION FOR A PROGRAM TO PREDICT THE BEHAVIOR OF A SPECIES OR A PROVENANCE IN A GIVEN ENVIRONMENT (LACAZE, 1967).

This report led to the establishment of experimentation sites of a new genre and unique concept in the world of dendrology and forestry: "the elimination arboreta". The two main questions addressed by these experiments were:

(1) to find species able to grow in areas without forest vegetation (e.g. Massif Central's high moors, wetlands) generally considered as "forest production deserts",

(2) to provide alternative to species traditionally used in reforestation; but being unsuitable for various causes (insect attacks, air pollution, potential problems inherent in large-scale monocultures, etc.). These arboreta were established in public forests between 1969 and 1982 and almost all in national forests. Several reports have been published on the arboreta (Pestour, 1984; Imbert, 1988; Allemand, 1989; Blandin & Steiner, 1996; Mons, 1993). Today, trees planted in these arboreta have been selected by local conditions, that are sometimes very stressful (drought heat, short vegetation period, extreme frosts, etc.) and could be considered as adapted to their environment. The question now is: are some species known enough to be promoted as potential productive forest reproductive material? To try to answer that question, INRA and ONF, merged their inventories and data tables. The important results and conclusions of this study are presented here after.

Materials & methods

GEOGRAPHY

The six arboreta used to support this study were created by INRA. They are now managed by ONF as arboreta of scientific interest (Lamant *et al.*, in press) and are also included in the French multipartner public arboretum network (Ducatillion *et al.*, in press).

These arboreta are located in 3 different climates as oceanic (Basse Seine), mountainous (Sainte Anastasie and Col des 3 soeurs) and Mediterranean (Caneiret, Plan Esterel, and Treps) (see location in **fig. 1** and metadata in **fig. 2**).

> Keywords ARBORETUM EXOTIC FOREST TREES CLIMATIC CHANGE

05. Materials & methods

• Lamant Thierry
• Bastien Jean-Charles
• Bellanger Richard
• Ducatillion Catherine
• Musch Brigitte

> FIGURE 1

Map of the six scientific arboreta

Despite their geo-climatic distribution, and although some sources are common to several of them, these arboreta were not installed with the aim to build a network.

TREE SPECIES

At the beginning, 779 taxa (species and subspecies) belonging to 64 botanic families and 188 genera have been introduced in the 1970s. A significant proportion (43%) of the conifers taxa is present in two different climates and 2% only in 3 different climates. Moreover, 6% of the hardwoods taxa are present in two different climates. The main genera are *Abies* (19 species), *Betula* (7 species), *Cupressus* (20 species), *Eucalyptus* (58 species), *Fraxinus* (8 species), *Picea* (12 species), *Pinus* (45 species) and *Quercus* (11 species).

PROVENANCES

Most seed lots come from wild collection in the natural range of the species, and rarely from planted forests or botanic gardens. Most species are represented by several origins (see as an example in **fig. 3** below the distribution of the provenances representative of *Abies procera* Rehder in the species' native range).

As a result of an easy seed supply and a good bioclimatic match, arboreta include a high proportion of species native from the western part of the United States and Southwestern Canada.

Arboretum name	Location	Year birth	Area (ha)	Elevation (m)	Soil	Climate	Average rainfall (mm/yr)	Extremes (°C.)	Previous nbr of taxa	Current nbr of taxa	Previous nbr of provenances	Current nbr of provenances
Canereit	Var, SE	1973	4	260-320	Ryolith	Mediterranean	820	-12 to 38	398	151	587	230
Plan Estérel	Var, SE	1974	3	400-420	Ryolith	Mediterranean	820	-12 to 38	327	111	512	191
Treps	Var, SE	1975	1,8	600	Gneiss	Mediterranean	690	-14 to 38,7	108	48	139	74
Col des 3 Sœurs	Lozère, center mountain	1973	5	1390-1480	Granitic sand	Mountain	980	-30 to 34	71	47	339	330
Sainte Anastasie	Lozère, center mountain	1969	5,3	1200	Silt	Mountain	1300	-30 to 30	44	39	130	118
Basse Seine	Seine-Maritime, NW	1975	15	100-140	Silt & flint clay	Oceanic	800	-17 to 38	101	93	253	249

> FIGURE 2

Synthetic characteristics of the 6 scientific arboreta

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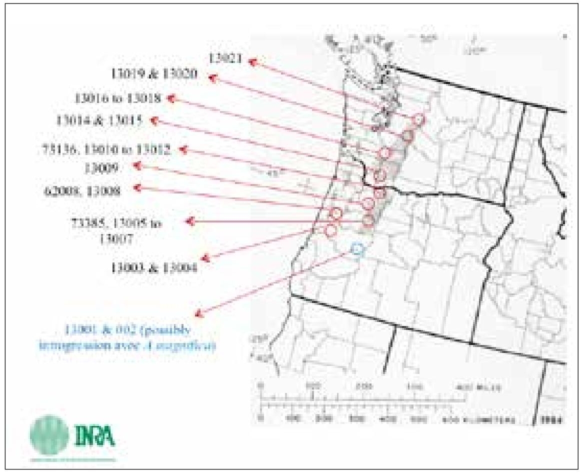


> FIGURE 3

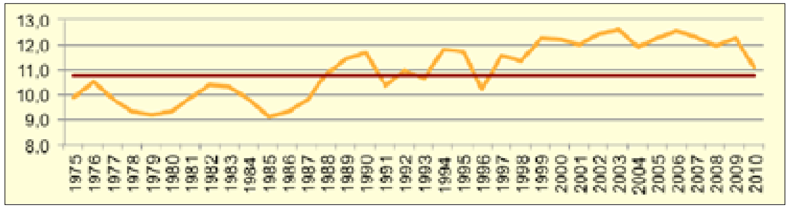
Noble fir's (*Abies procera*) native range in the USA and planted provenances (with their access number): most seed lots are characterized with the geographic coordinates of their harvesting site (latitude, longitude, elevation)

DESIGN

Each arboretum consists of several hundred rectangular plots of 90 m² each (for most of them), consisting of 30 trees of the same provenance, at a planting spacing of 2 m x 1 m.

OBSERVATIONS AND MEASUREMENTS

Depending of the arboreta, observations and measurements were carried out at different periodicities: e.g. 10 and 15 years after plantations in Mediterranean area, after 15 and 20 years in Massif Central and after 20 years in Normandy. Each subsequent report proposed a selection of interesting species, which resulted in other experimental plantations with more provenances and plants per species in order to explore their quality performances on a larger number of trees.



> FIGURE 4

Average annual temperature collected on 5 different weather stations around Basse Seine arboretum

About 20 years after the first studies (between 2010 and 2012) we undertook a new series of measurements and observations (health rating). The current objective was to find productive forest species. Therefore the 56 shrubs taxa have not been considered. Survival and circumference of 17835 trees (254 taxa from 68 genera) have been recorded. In order to compare species on the basis of dominant tree performances, total height of the three biggest trees per plot has also been measured.

Furthermore, we have also collected wood increment cores to check the possible impact on ring width of exceptional climatic years (for temperature and rainfall). As an example **fig. 4** below shows that, between 1978 and 2006, the Basse Seine arboretum experienced a temperature rise of 3 °C and the average temperature rise of 1° in 35 years.

Finally, we began an inventory of species able to naturalize in the Caneiret and Plan Esterel arboreta (south of France).

First results

Data are heterogeneous and complex. Nearly 40 years after their installation, the objectives of these arboreta have changed to shift towards the species adaptation to climate change. Currently and under the influence of climate changes (for example the scenario A2A shows the extension of thermo-Mediterranean climate and especially the meso-Mediterranean) we are trying to find solutions

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05. First results

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• *Bastien Jean-Charles*
• *Bellanger Richard*
• *Ducatillion Catherine*
• *Musch Brigitte*

from these arboreta or at least proposals for new adapted species to complete the indigenous species. First synthetic results drawn from the survival growth measurement are given here as an example.

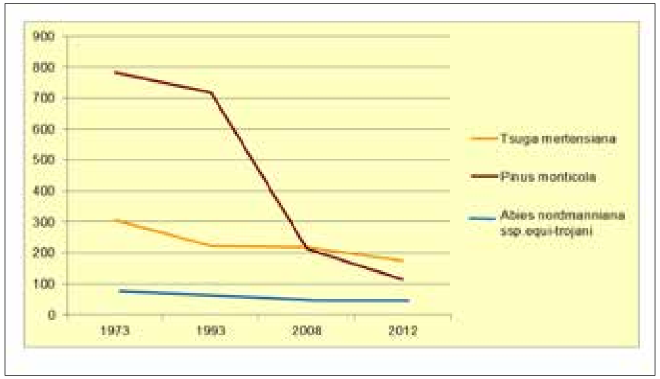
SURVIVAL

Arbitrarily, the raw survival is given here as the number of species of which at least one tree is still alive. Out of 3719 initial plots, there are 2365 plots where at least one tree is surviving. Out of 779 initial taxa, 355 present at least one survivor (hence 424 taxa are completely dead).

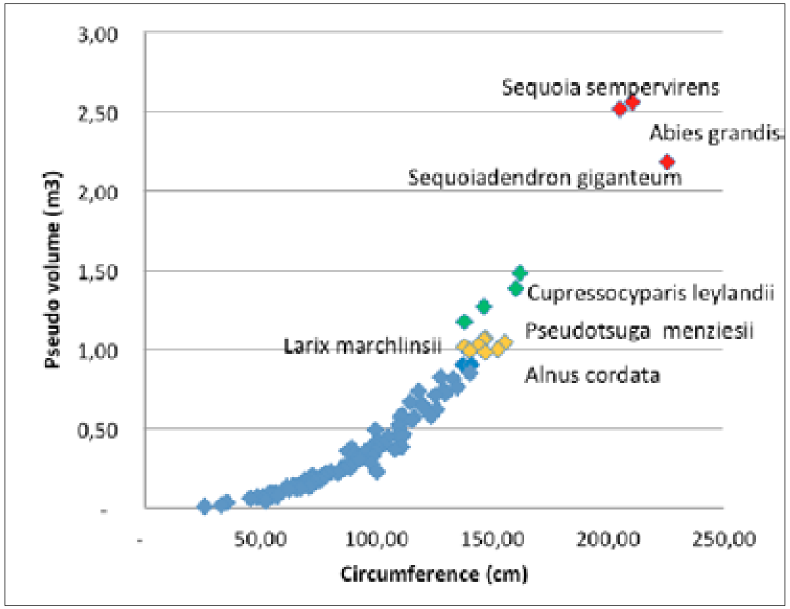
On the basis of successive inventories, we observed that survival of some species gradually decreases, which would demonstrate their total inadequacy. Others species suddenly disappeared in the first few years following their installation, which may be explained by uncommon factors, incidental, or humans (frost, drought, wild animals and lack of adequate maintenance). We also observe trees whose numbers even if they decline, remain relatively constant since planting (example of 3 species in **fig. 5**).

> FIGURE 5

Survival evolution according to time in number of trees. Example of 3 species at the Col des 3 Sœurs arboretum (*Tsuga mertensiana* (Bong.) Carrière, *Pinus monticola* Douglas ex D. Don, *Abies nordmanniana* subsp. *equi-trojani* (Asch. & Sint. ex Boiss.) Coode & Cullen)



GROWTH AND DENDROCHRONOLOGY



> FIGURE 6

Basse Seine arboretum (35 years old). Regression circumference – pseudo volume (m_3) of trunk of the 3 biggest trees per plot

EVOLUTION OF SPECIES GROWTH RANKING ALONG TIME

One of the most striking teachings of these arboreta is that species recommendations evolved significantly with time. In 1993 (20 years after plantation) in the Massif Central arboreta (mountain climate), one of the best conifers was *Pinus monticola* Douglas ex D. Don. Since 2000, the presence of *Cronartium ribicola* J.C. Fisch on American 5 needles-pines killed most of the *Pinus monticola* trees. Today, *Pinus peuce* Griseb. is one of the best performing pine species and *Abies homolepis* Siebold & Zucc. is the best fir species.

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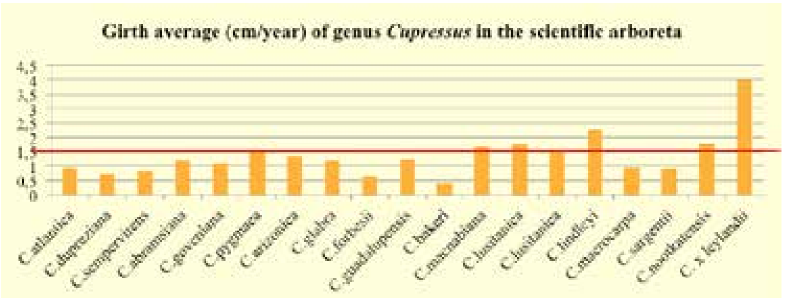
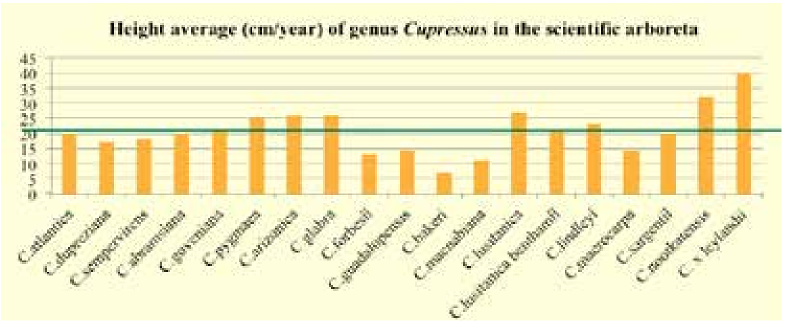
Under Mediterranean climate, in 1989 (16 years after plantation), in the Mediterranean arboreta, the best broadleaves were species of genus *Alnus*, *Arbutus* or *Fraxinus* because most of the *Eucalyptus* spp. froze. Now *Eucalyptus* spp. sprouts are taller than all the other species in spite of 1985's intensive winter frost.

The second teaching is that native species are not always best suited in terms of growth and adaptation to climate as in Basse Seine arboretum (under oceanic climate) with *Pinus sylvestris* L. (native) vs. *Sequoia sempervirens* (D. Don) Endl. or *Abies grandis* (Douglas ex D. Don) Lindl. and *Fagus sylvatica* L. (native) vs. *Nothofagus obliqua* (Mirb.) Blume.





> FIGURE 7

Compared growth of the species of *Cupressus* spp. in the whole of arboreta in cm a year, between 1973 and 2012.

Average circumference is 1,1 cm/year. Average height is 21 cm/year

DENDROCHRONOLOGY

We have made a selection of the best trade-off between growth and their reaction during difficult years. One of these studies was conducted in the arboretum of Basse Seine: *Cedrus atlantica* (Endl.) G. Manetti ex Carrière, *Cryptomeria japonica* (L. f.) D. Don, *Pinus sylvestris* L. and *Nothofagus obliqua* (Mirb.) Blume have greatly reduced their annual ring width during both dry and hot years and then normally grows the following years. This reaction suggests they are able to withstand water shortages without suffering the consequences in the long term. This should means that the lack of water does not affect (or a little) the growth of these taxa.

NATURALIZATION AND INVASIVE SPECIES

In Mediterranean arboreta, we find some invasive species to be eliminated such as *Hakea sericea* Schrad. and *Hakea salicifolia* (Vent.) B. L. Burtt. (Ducatillion *et al.*, 2015).

GENERAL RESULTS

Non exhaustive list of tree species with good potentialities of survival and growth, according to the climate:

- Mediterranean climate : *Genera Cupressus* and *Eucalyptus*
- Mountain climate: *Abies homolepis* Siebold & Zucc. and *Pinus peuce* Griseb.
- Oceanic climate: *Sequoia sempervirens* (D. Don) Endl. and *Nothofagus obliqua,* (Mirb.) Blume.
- *Abies nordmanniana* subsp. *equi-trojani* (Asch. & Sint. ex Boiss.) Coode & Cullen resists as well to the cold as the relative summer drought and could adapt to a wide climatic range, except the Mediterranean region.

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05. Discussion

SURVIVAL

The survival is a complex criterion: we know how many species are still represented by at least some individuals today, but we do not still know the cause of the mortality of others: biotic, abiotic or accidental factors? The tree accommodation can depend on constraints other than the climate. The survival expresses in a different way in time according to the species. The current result does not augur future results. Certain trees (species–provenance) can present a low rate of survival in a given time, but some surviving trees present a good quality potential. On the contrary, certain species present a high survival, but trees are in poor condition, or weakly productive. Three types of climate are representative of the French climate, except the continental climate, which gives a wide range of possibilities. On the other hand, it is not possible to define a wide gradient of survival, the species common to these three kinds of climatic arboreta being practically non-existent.

GROWTH

Growth varies over time and according to the species (example of fir trees with usually slow early growth, then faster). We need some growth observations along a good proportion of trees life before choosing an appropriate species. The environmental conditions of certain arboreta do not represent the usual forest area: the environment of Lower Seine is exceptionally fertile; on the contrary the ground in Caneiret is so poor and draining (dry) that even the native species have difficulty to develop. Even survival is an accomplishment.

Ackgnowledgments

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Conclusion & perspectives

Six elimination arboreta were planted in the 1970s, in 3 French climatic regions. 779 exotic taxa were introduced, represented by often several provenances. A large number of tree species comes from North America, but also from Australia, South America, South Africa or Mediterranean Basin. Every couple species-provenance is represented by several plots (about 30 trees per plot). Since their plantation in arboreta, these trees were selected by severe environmental conditions. The living trees are today more than 40-year-old and are regularly inventoried and measured (height and trunk circumference). First results give 355 living taxa.

But survival is heterogeneous: in some species all the trees are alive; in some another only one tree is alive. Besides, their growth is not always representative of forest potentialities, because of excessive constraints of local environment, or because the measurement age, or because biotic or abiotic accidents are not identified. It is thus necessary to refine analyses, in particular to cross all the methods of measure and analysis illustrated here, completed by thorough qualitative site's analysis to identify causes of tree death. Nevertheless the performance of some species seems already promising, according to sites and expectations, and for the current climate. We can include for example *Cupressus* spp. and *Eucalyptus* spp. such as *Eucalyptus cephalocarpa* Blakely in the Southeast of France, *Sequoia sempervirens* (D. Don) Endl. in the West, *Abies homolepis* Siebold & Zucc. in mountain or *Abies nordmanniana* subsp. *equi-trojani* (Asch. & Sint. ex Boiss.) Coode & Cullen in the 3 regions.

> Keywords ARBORETUM EXOTIC FOREST TREES CLIMATIC CHANGE

05. References

• *Lamant Thierry*
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• *Bellanger Richard*
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THEME F:

EDUCATION

06.


THEME F
EDUCATION

THEME F
EDUCATION

COMMENT MOBILISER DES NOUVEAUX PUBLICS AUX CONSERVATOIRE ET JARDINS BOTANIQUES DE NANCY ? DEUX PROJETS ORIGINAUX ET FÉDÉRATEURS

Photo credit : Le mouton géant recouvert de laine au Jardin Botanique de Nancy, *Katia Astafieff*

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> Mots-clefs PUBLICS DÉFAVORISÉS NON PUBLIC MÉDIATION CULTURELLE KNITTING GRAFFITI TRICOT URBAIN PROJET TRANSGÉNÉRATIONNEL LIEN SOCIAL DROGUES SANTÉ EXPOSITION CONFÉRENCE ADOLESCENTS

06. Résumé

• *Astafieff Katia*

LES CONSERVATOIRE ET JARDINS BOTANIQUES DE NANCY SONT UN ÉTABLISSEMENT DE CULTURE SCIENTIFIQUE ET TECHNIQUE COGÉRÉ PAR LA COMMUNAUTÉ URBAINE DU GRAND NANCY ET L'UNIVERSITÉ DE LORRAINE.

Avec un parc de 35 hectares, 2500 m^2 de serres tropicales et un jardin alpin dans les Vosges, ils attirent chaque année un large public venus découvrir quelques-unes des 14 500 espèces en culture. Ils assurent les missions de conservation du patrimoine végétal, de soutien à la recherche scientifique, d'expertise et d'éducation du public à la biodiversité.

Les missions des jardins botaniques évoluent. Centrés sur la conservation des végétaux, ils élargissent aujourd'hui leurs activités pour ancrer leurs projets dans la société, au plus près des problématiques actuelles pouvant toucher les citoyens. Pourtant, tous ne viennent pas forcément dans ces institutions, pour des raisons diverses. Dans une volonté d'élargir leurs publics, les Conservatoire et jardins botaniques de Nancy ont entrepris en 2014 deux projets pour toucher ceux qui fréquentent peu l'établissement : les personnes des quartiers socialement défavorisés (publics empêchés ayant peu d'accès à la culture) et les adolescents.

Les obstacles à la fréquentation des jardins botaniques, comme à celle des musées, sont de natures variées : barrières géographiques, culturelles, sociales, financières, physiques. On pourrait même ajouter parfois la barrière de l'âge. Si les enfants sont nombreux à venir et apprécier les visites au jardin botanique, les adolescents sont souvent peu présents. L'offre éducative proposée aux petits est souvent assez riche dans les institutions de culture scientifique, alors que les plus grands sont parfois laissés de côté. En dehors de la visite parfois obligatoire au collège ou au lycée, ils franchissent plus rarement les portes des institutions culturelles.

De même, les populations de certains quartiers, quelques soient leur âge, sont parfois difficiles à toucher. Même si des efforts tarifaires sont réalisés, la barrière est avant tout culturelle.

Les Conservatoire et jardins botaniques ont donc développé en 2014 deux projets nouveaux pour élargir les publics et faire venir ceux qui ne viennent habituellement pas.

> Mots-clefs PUBLICS DÉFAVORISÉS NON PUBLIC MÉDIATION CULTURELLE KNITTING GRAFFITI TRICOT URBAIN PROJET TRANSGÉNÉRATIONNEL LIEN SOCIAL DROGUES SANTÉ EXPOSITION CONFÉRENCE ADOLESCENTS

06. Knitting graffiti

• *Astafieff Katia*

Photo credit : Le mouton géant recouvert de laine au Jardin Botanique de Nancy, ***Katia Astafieff***

COMMENT FAIRE VENIR LES PERSONNES DE QUARTIERS MOINS FAVORISÉS, POUR QUI LE JARDIN BOTANIQUE EST UNE INSTITUTION CULTURELLE MÉCONNUE, DANS LAQUELLE LES ACTIVITÉS POURSUIVIES, À CARACTÈRE SCIENTIFIQUE, PEUVENT ÊTRE PARFOIS DES FREINS PSYCHOLOGIQUES OU SOCIOLOGIQUES ? EN PROPOSANT DES ACTIONS LUDIQUES ET ORIGINALES.

Le jardin botanique s'est ainsi rapproché de la mission cohésion sociale du Grand Nancy (l'une des tutelles de l'établissement avec l'Université de Lorraine), pour mettre en place un projet autour du tricot urbain, pour réaliser du Knitting graffiti au jardin, une mouvance artistique proche du Street Art. Il s'agit d'habiller de tricot ou de crochet des éléments de l'espace urbain (arbres, bancs, poubelles, statues, etc.), pour réaliser des installations éphémères. L'intérêt est de s'approprier l'espace public et d'investir son environnement de manière décalée et poétique. Les visiteurs portent ainsi un nouveau regard sur leur environnement.

Les CJBN ont donc proposé de réaliser ce type de projet au sein du jardin botanique.

Les habitants de l'agglomération, qu'ils soient des particuliers ou des associations, ont été invité à tricoter des carrés de laine qui ont servi à habiller un mouton géant ainsi que des éléments du jardin botanique (arbres, barrières…). Les réseaux sociaux (Facebook) ont été utilisés pour diffuser un appel à laine et à tricoteurs et l'information a été largement partagée.

L'opération a permis à la fois de mettre en valeur le jardin botanique autrement, en permettant de porter un autre regard sur les collections, de toucher d'autres publics, de développer des partenariats inhabituels et d'impliquer les visiteurs dans un projet différent, transgénérationnel et collaboratif.

LES OBJECTIFS ET INTÉRÊTS DU PROJET :

- attirer de nouveaux publics (associations de quartiers, classes de jeunes adultes en difficultés, personnes âgées en maison de retraite)
- un projet fédérateur et participatif, à la fois avec le public et les équipes du jardin botanique
- un projet transgénérationnel : retraités et jeunes adultes ont tricoté ensemble
- une démarche amusante et conviviale
- un projet « tendance » (le tricot est redevenu très à la mode !)
- un contexte économique particulier avec la tendance « Do it yourself »
- un faible budget
- de nouveaux partenariats (mission cohésion sociale, Bergère de France)
- une démarche nouvelle au jardin botanique

> Mots-clefs PUBLICS DÉFAVORISÉS NON PUBLIC MÉDIATION CULTURELLE KNITTING GRAFFITI TRICOT URBAIN PROJET TRANSGÉNÉRATIONNEL LIEN SOCIAL DROGUES SANTÉ EXPOSITION CONFÉRENCE ADOLESCENTS

06. Knitting graffiti

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- une mise en valeur originale des espaces du jardin botanique
- l'occasion également de mettre à l'honneur les moutons du jardin botanique qui entretiennent les espaces herbacés
- un lien avec les Conf'curieuses, cycle de conférences organisées par les CJBN, le Muséum-Aquarium de Nancy et l'Université de Lorraine (thématique 2012 : le mouton). Deux conférences étaient programmées au jardin : sur la gestion des milieux naturels par les herbivores et sur la teinture de la laine.

L'opération a été un succès. L'appel à laine a été bien relayé, notamment par les réseaux sociaux. Le public a été invité à rapporter des restes de pelotes de laine inutilisées à l'accueil du jardin botanique. De même, les visiteurs pouvaient venir récupérer de la laine pour tricoter des petits carrés de laine. Des bénévoles sont venues assembler les morceaux lors de différentes séances pour habiller un mouton géant. Pendant l'été, les visiteurs étaient également invités à venir compléter l'habillage du mouton en ajoutant leur petit carré de laine directement sur la structure.

Le personnel du jardin botanique s'est également fortement impliqué dans le projet (même les jardiniers tricotaient pendant les pauses !). L'installation s'est déroulée dans le parc ; mais des éléments ont également été installés dans les serres tropicales.

Plantes et drogues

Les adolescents ne constituent souvent pas un public important des jardins botaniques ou des musées. Pour toucher les jeunes et aborder des thématiques transdisciplinaires (botanique et santé), les Conservatoire et jardins botaniques de Nancy ont proposé un projet sur les plantes et les drogues, une problématique forte et d'actualité, en s'inspirant d'ateliers réalisés aux Espaces botaniques de l'Université de Liège.

En effet, les Conservatoire et jardins botaniques de Nancy, lieu de culture scientifique et technique, souhaitent aborder des sujets plus ambitieux, autour de problématiques de société.

Le projet était centré autour de l'exposition « Plantes et drogues », qui s'est déroulée du 26 mai au 31 octobre 2014, contenant une présentation des principales espèces sources de drogues (cocaïer, cannabis, absinthe, plantes à alcool, caféier, etc.), des panneaux d'informations sur la problématique des drogues (définition des drogues, lien entre drogues et médicaments, et, dans les serres tropicales, aspects ethnobotaniques et usages traditionnels des drogues), ainsi que des objets prêtés par la faculté de pharmacie.

Rencontres et conférences ont aussi été réalisées, en développant des partenariats avec la maison des addictions du CHU de Nancy et la police nationale. Evidemment, sur une telle thématique, une large part a été consacrée aux aspects liés à la santé.

Le projet a été l'occasion d'établir des collaborations inhabituelles, avec la police municipale, la maison des addictions du Centre hospitalier ou un ethnologue. C'est surtout la programmation annexe qui a permis de se rapprocher des publics, grâce à des interventions variées : animations avec la police ou cycle de conférences avec des médecins ou scientifiques. Par exemple, étaient au programme :

> Mots-clefs PUBLICS DÉFAVORISÉS NON PUBLIC MÉDIATION CULTURELLE KNITTING GRAFFITI TRICOT URBAIN PROJET TRANSGÉNÉRATIONNEL LIEN SOCIAL DROGUES SANTÉ EXPOSITION CONFÉRENCE ADOLESCENTS

06. Plantes et drogues

• *Astafieff Katia*

DANGEROSITÉ DES DROGUES : COMMENT S'Y RETROUVER ?

Par le docteur Laprevote, médecin, spécialiste des addictions, CHU de Nancy.

> LUNDI 26 MAI 2014 À 20H.

AYAHUASCA ET AUTRES PLANTES UTILISÉES PAR LES CHAMANS D'AMAZONIE

Par Sébastien Baud, ethnologue, Université de Strasbourg.

> MARDI 3 JUIN À 18H30.

PLANTES MAGIQUES ET THÉRAPEUTIQUES

Par Jacques Fleurentin, pharmacien et ethnopharmacologue.

> SAMEDI 21 JUIN À 14H30.

REGARD SUR LES DROGUES ET LES ADDICTIONS

Par Laurent Graillot, formateur anti-drogues, Police nationale.

> LES SAMEDIS 14 ET 28 JUIN 2014 À 14H30.

DROGUES ET CERVEAU : CONNAISSANCES ACTUELLES ET NOUVEAUX DÉFIS

Par le docteur Vincent Laprévote.

> MARDI 30 SEPTEMBRE 2014 À 18H30.

DROGUES ET MÉDICAMENTS

Par les Dr Valérie Gibaja et Dr Mickaël Bisch, CHU de Nancy

> MARDI 9 OCTOBRE 2014 À 18H30.

STUPÉFIANT ! DROGUES ET ADDICTIONS

Par Laurent Graillot, formateur anti-drogues, Police nationale.

> JEUDI 23 OCTOBRE À 18H30.

La plupart des conférences se sont déroulées dans l'amphithéâtre du Muséum-Aquarium de Nancy, qui a des capacités d'accueil supérieures à celles du jardin botanique, et ont accueilli un public important (entre 100 et 200 personnes par conférence).

La démarche a permis d'aborder la botanique par une entrée santé, et réciproquement, de parler d'un sujet délicat avec les jeunes par une entrée plantes, inhabituelle pour les médecins et pour la police.

Conclusion

Ces deux projets ont donc permis d'attirer des publics inhabituels au jardin botanique - jeunes ou personnes ayant un accès à la culture limité – et ont montré qu'il est à la fois possible d'aborder des thèmes ludiques et créatifs impliquant les visiteurs d'une part, et des problématiques complexes liées à la santé d'autre part.

> Mots-clefs PUBLICS DÉFAVORISÉS NON PUBLIC MÉDIATION CULTURELLE KNITTING GRAFFITI TRICOT URBAIN PROJET TRANSGÉNÉRATIONNEL LIEN SOCIAL DROGUES SANTÉ EXPOSITION CONFÉRENCE ADOLESCENTS

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GENERATIONS LINKED WITH THE GREEN COLLECTIONS IN BOTANIC GARDENS

Photo credit : Fern garden in Hortus botanicus Leiden, *Hanneke Jelles*

Keßler Paul J.A., Jelles J.D. & Vandecasteele P.G.M.

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> Keywords FERNS DRAWING GRAPHIC TECHNIQUES AWAKENING INTEREST

06. Abstract

- *Keßler Paul J.A.*
- *Jelles J.D.*
- *Vandecasteele P.G.M.*

'PREHISTORIC PLANTS' WERE IN THE LIMELIGHT IN THE LEIDEN HORTUS IN 2014, TO MARK THE 25TH ANNIVERSARY OF THE NETHERLANDS FERN SOCIETY (*NEDERLANDSE VARENVERENIGING*). IN THIS PROJECT THE EYES OF THE PUBLIC WERE OPENED TO THE BEAUTY OF FERNS USING A COMBINATION OF DRAWING AND GRAPHIC TECHNIQUES, AWAKENING THEIR INTEREST IN THIS GROUP OF PLANTS. THIS COMBINATION OF THE HORTUS COLLECTION WITH USE OF ART AND ARTISTS IS IN KEEPING WITH THE GARDEN'S APPROACH AND IS A USEFUL WAY TO COMBAT 'PLANT BLINDNESS'. IT IS AN ADDED BONUS IF THE INSTRUCTOR IS KNOWLEDGEABLE ABOUT BOTH DRAWING AND PLANTS, SO THAT INFORMATION AND DRAWING INSTRUCTION FORM A NATURAL ENTITY.

> Keywords FERNS DRAWING GRAPHIC TECHNIQUES AWAKENING INTEREST

06. Introduction

• *Keßler Paul J.A.*
• *Jelles J.D.*
• *Vandecasteele P.G.M.*

Photo credit : Fern garden in Hortus botanicus Leiden, *Hanneke Jelles*

DURING THE CONGRESS PAUL KESSLER REPORTED ON A SUCCESSFUL EXPERIMENT IN THE HORTUS BOTANICUS LEIDEN. IN THIS PROJECT THE EYES OF THE PUBLIC WERE OPENED TO THE BEAUTY OF FERNS USING A COMBINATION OF DRAWING AND GRAPHIC TECHNIQUES, AWAKENING THEIR INTEREST IN THIS GROUP OF PLANTS.

'Prehistoric plants' were in the limelight in the Leiden Hortus in 2014, to mark the 25th anniversary of the Netherlands Fern Society (*Nederlandse Varenvereniging*). The Hortus used graphic techniques to open the eyes of a broad sector of the public to this group of plants. Groups of participants were asked to make accurate illustrations of fern leaves, under the guidance of artists. The groups were formed of participants from all age groups: people brought along family members or acquaintances from different generations or, if the participant did not know any one, the Hortus found a younger or older participant.

THIS APPROACH HAD A NUMBER OF ADVANTAGES :

- Leiden is a student city. Students in their twenties could bring along their parents or, as was more often the case, their grandparents and do something fun and informative together.
- The mixed age groups created a harmonious atmosphere; they all worked enthusiastically, but also talked quietly and looked at each other's work.
- The participants had no previous knowledge of plants. Before the morning's course they regarded ferns as rather boring green plants. They were allowed to choose 'their' fern from a bucket of assorted ferns – a difficult choice to make because of the great differences between the plants.
- As they were drawing the participants discovered details, and someone explained what they were seeing. Binoculars were available, and the participants studied the ferns through these with great wonder. Some people spontaneously took photos through the binoculars with their mobile phones, so that they could add details to their own drawings
- After they had been drawing for two hours they were given a short tour of the fern garden. Where the average group of visitors chats their way through this, a group of course participants almost had to be dragged away from the fern garden because there was so much to see.

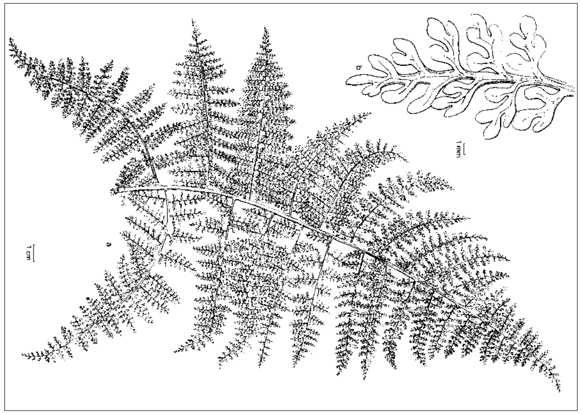
A contribution from the Cultural Participation Fund (*Fonds voor de Cultuurparticipatie*) enabled us to carry out this project, and meant that the Hortus could offer this course to participants for a low price, and direct recruitment towards both older people and students.

> Keywords FERNS DRAWING GRAPHIC TECHNIQUES AWAKENING INTEREST

06. Materials & methods

• *Keßler Paul J.A.*
• *Jelles J.D.*
• *Vandecasteele P.G.M.*

Patricia Vandecasteele is Head of Public Affairs at the Hortus botanicus Leiden (for this project involved in fund-raising), Hanneke Jelles is Head of Education (for this project involved in content and implementation). Together with various Leiden artists they assisted Paul Keßler with this project.



> IMAGE 1

Ink drawing of a tropical fern, *Monachosorum subdigitatum*; drawing Hanneke Jelles

Results and discussion

As a result of this successful project the Hortus has started up a new series of workshops; 2/3 of the group are students and 1/3 are other adults. The financial contribution made by the second group means that we have been able to offer the course free to students. These workshops have the same relaxed atmosphere of cooperation between different generations, and combine learning about plants with drawing skills. This series has now been going for more than a year and there is another planned for 2017.

Drawing requires concentration, and gives participants a welcome opportunity to 'go with the flow' in what is for many people a very busy modern world.

Bringing together two or three generations of adults fulfils a need. It is a way of combatting loneliness for the very oldest, and everyone experienced this short time together as highly valuable. There is a good chance that the participants will return to the Hortus.

Conclusion

This combination of the Hortus collection with use of art and artists is in keeping with the garden's approach and is a useful way to combat 'plant blindness'.

Apart from observation with the naked eye, the participants may have applied ways of observation new to them, with the help of binoculars, a microscope, and by way of detailed photographs. Receiving help with drawing alongside an explanation of what is being drawn is extremely beneficial. It is an added bonus if the instructor is knowledgeable about both drawing and plants, so that information and drawing instruction form a natural entity. Young and old, science and art, united at the Hortus botanicus Leiden.

> Keywords FERNS DRAWING GRAPHIC TECHNIQUES AWAKENING INTEREST

06. References

• *Keßler Paul J.A.*
• *Jelles J.D.*
• *Vandecasteele P.G.M.*

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Students of all generations study and draw fern leafs


Etching techniques are both surprising and exact


Participants discover all kinds of interesting details while drawing fern leafs


People of three generations joined the workshops


Ferns are a good subject to practice observation and drawing


Botanical artist Esmée Winkel teaching during a workshop


Botanical artist Esmée Winkel points out details after the workshop

A NEW BALANCE BETWEEN PLANT-FOCUS AND PEOPLE-FOCUS IN DUTCH BOTANIC GARDENS

Photo credit : Collaboration, *Wendeline van den Nagel*

't Hart Joke[1] & Van Dijk Dick[2]

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> Keywords COLLABORATION OF ALL DUTCH BOTANIC GARDENS CO-CREATION NEW AUDIENCES FOCUS ON PEOPLE AND PLANTS

06. Abstract

• *'t Hart Joke*
• *Van Dijk Dick*

THIS PAPER INTRODUCES THE PROJECT PLANTING THE FUTURE, INCLUDING RESULTS AND EXPERIENCES GAINED FROM THE COLLABORATION OF 24 DUTCH BOTANIC GARDENS, AND CONCLUDES WITH LEARNING POINTS AND IMPROVEMENTS.

The 24 botanic gardens are all under the auspices of the NVBT, the Dutch Association of Botanic Gardens. Main focus of the project is on creating new collaborative structures between the gardens and on developing new public programming through co-creation with both existing and potential new visitors based on the knowledge of the plants. The five year project is now half way. As a result of the work so far the gardens have begun to work more closely together, inside and outside the project. Many learning's relate to changing the manner in which the gardens have worked together and the need to be more externally focused whilst at the same time trying to maintain the essence that lies at the heart of being a botanic garden. The NVBT has proclaimed 2017 the year of the Dutch Botanic Garden complete with an extensive presentation aimed at the wider public, and events that will include the launch of a new jointly developed application. Project partners of NVBT are media lab Waag Society and Dutch funding body National Postcode Lottery.

> Keywords COLLABORATION OF ALL DUTCH BOTANIC GARDENS CO-CREATION NEW AUDIENCES FOCUS ON PEOPLE AND PLANTS

06. Introduction

• *'t Hart Joke*
• *Van Dijk Dick*

Photo credit : Collaboration, *Wendeline van den Nagel*

IN 2013 THE DUTCH ASSOCIATION OF BOTANIC GARDENS (NVBT) STARTED THE PROJECT PLANTING THE FUTURE TO HELP INDIVIDUAL GARDENS INNOVATE BY MOBILIZING THE COLLABORATIVE POTENTIAL.

The NVBT is an umbrella organization which consists of 24 gardens across the Netherlands. Their mission is to contribute to the conservation of plant biodiversity in the context of a sustainable world. The gardens constitute important Dutch heritage sites, with a living collection. The central concept of the Botanic Garden - stemming from the encyclopaedic tradition of the Renaissance - that all knowledge is collectible, as well as the form of a beautiful and lush garden, often in the inner city, and the collections themselves - both 'natural' and cultured species – are a representation of historic and contemporary society. The gardens are very diverse, some are academic, some are connected to large park areas, some are connected to zoos, etc.

The main reason to start a collaborative project involving all 24 Dutch botanic gardens was the decline of financial support the gardens were receiving from governments and universities. The gardens had little time to think about long term opportunities, they were mostly survival driven. The board of the NVBT decided to make funds available to formulate a combined proposal that would secure the future of all 24 botanic gardens. The proposal was awarded a grant of 2 million euro from the Dutch National Postcode Lottery and started the collaborative Planting the Future project that will run for 5 years.

Project aims

THE AIMS THAT WERE DEFINED FOR THE PLANTING THE FUTURE PROJECT ARE :

- Initiating dialogue with the public about the importance of plants from a shared and accessible (web based) database.
- Strengthening cooperation between participating gardens
- Rejuvenation of- and widening the target audience

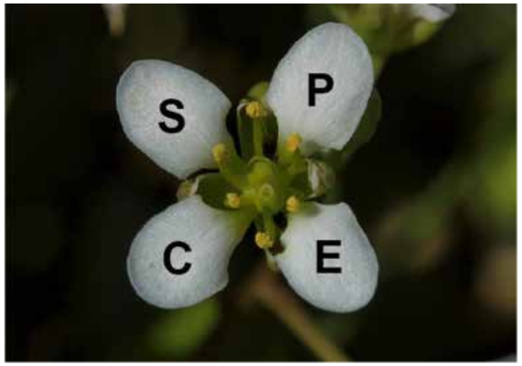
To work from a shared identity, the gardens started with the BGCI definition of a botanic garden, namely 'botanic gardens hold documented collections of living plants for the purposes of scientific research, conservation, public display and education'. It was agreed that not all the NVBT gardens needed to meet all of these four aims, but together the gardens do fulfil the criteria required by this definition. In reality it transpired that most of the botanic

> Keywords COLLABORATION OF ALL DUTCH BOTANIC GARDENS CO-CREATION NEW AUDIENCES FOCUS ON PEOPLE AND PLANTS

06. Project aims

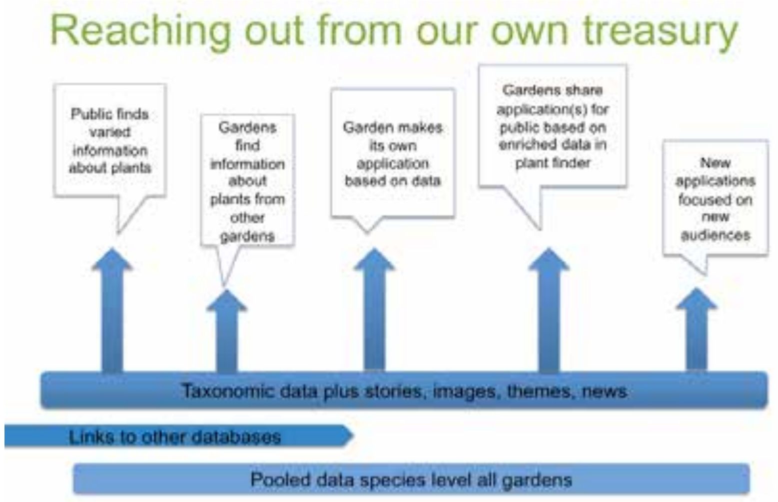
• 't Hart Joke
• Van Dijk Dick

gardens in the Netherlands are using their plant collections for communication, through public display, and also for educational purposes. The symbol of a flower with four leaves was chosen to illustrate this collaboration (see **Fig. 1**). SPEC (like species!) stands for Scientific research, Public display, Education and Conservation.



> FIGURE 1

Symbol of a flower as a representation of the collaboration



> FIGURE 2

Facilitating a dialogue with audiences from a shared database

From the outset making the data pertaining to all 24 botanic gardens public was one of the most important aims of the project. New technological infrastructure is currently being designed to enable this information to be accessible by the wider public. The gardens are amalgamating the collection data from each garden to make this wealth of information accessible via the NVBT website. The first pilot of a public application can be viewed at www.botanischetuinen.nl/en/plant-search. See also paper Renske Ek, *What does the public want? Lessons learned from using modern technology in transferring plant knowledge from scientific community to the wider audience.*

Co-creation labs

At the start of the project, collaboration between the Dutch Botanic Gardens was very limited. Critical to kick start the collaboration was the implementation of the co-creation labs under the leadership of Waag Society. Waag Society is a media lab that uses creative methods that stem from 'design thinking' and centre on 'learning by doing'. These methods focus on the creation of a new type of dialogue between people with different knowledge and backgrounds to get started.

> Keywords COLLABORATION OF ALL DUTCH BOTANIC GARDENS CO-CREATION NEW AUDIENCES FOCUS ON PEOPLE AND PLANTS

06. Co-creation labs

• 't Hart Joke
• Van Dijk Dick

The approach during these labs was not about "coming up with the single right idea" but about generating the broadest range of possibilities, and this proved to be critical. The focus of the three co-creation labs was on:

- Connecting a diverse set of representatives of the 24 very diverse gardens
- Collecting stories
- Connecting with existing and new audiences
- Exploring new technologies

The exploratory co-creative phase finished January 2015. The first two sessions consisted of six days each, and ran over a period of six weeks each. They involved 20 people in each lab from all ranks of the organisations, with alternating involvement of visitors of the gardens. The aim of these sessions was to find new ways to connect the knowledge about plants and biodiversity to the needs of diverse audiences. Participants of the sessions explored which stories from the botanic gardens are important and relevant to the public, identified who their current visitors and new target audiences are, and designed new storytelling methods that can be used to reach these new audiences.

In addition the participants explored which technology might be interesting and which infrastructure (in terms of collaboration and technology, national and international) is future proof. The added value of media/ICT in the context of the gardens is to open up their processes: to linked open data initiatives, opening up their collections to others, but also incorporating crowd sourced materials ('citizen science'); to creative re-use of materials (connecting to Do It Yourself and maker movements); to new locations and channels outside their own physical and geographical location.

> FIGURE 3

Prototyping and testing a route application in the 1st co-creation session

As an example of the method(s) used: the participants prepared for the sessions with a set activities from a 'sensitizing toolkit' that makes them look at their own garden with different eyes: 'where's the hidden treasure in my garden', 'what does my public enjoy least'?, 'what type of behaviour does my audience have'? The first session started with each garden sharing those findings and was followed by an activity in the garden with a set of 'ambiguous prototypes': objects that have no purpose in themselves, but designed to let them imagine what these objects could do in their garden. A free format explorative activity, which gets the participants in a specific mindset and also lets them get to know each other better. Towards the end of the six week activities they designed a number of specific interaction scenarios and prototypes, including a Physical Storytelling tool for grandparents and grandchildren, a Talking Tree and an Urban Gardeners programme, ideas that will be developed further. Among the learnings from the first two labs are:

- Kick starting the dialogue transfers to all topics and domains, education, communication, exhibition design; big spin off in informal connections
- Focus of the gardens is very much on broadcasting and not too much on

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06. Co-creation labs

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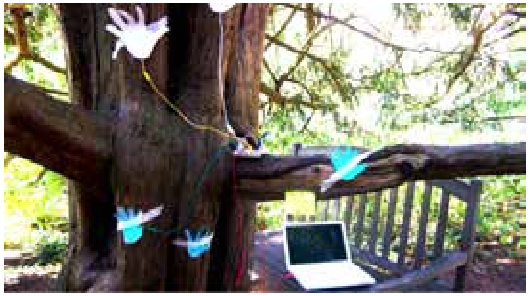
listening, bridging the gap to (new) audiences is challenging and terrifying for them

- Varied and lively content is the biggest hurdle to take, yes they do have stories but not verified and not accessible



> FIGURE 4

Prototyping and testing a user application responding to touch

The third lab was aimed at convergence of ideas and was limited to two-days, involving the decision makers of the individual gardens to gain support for the ideas developed. From the 20 proposals that had been developed by the participants, the most viable were developed into scenarios by Waag Society and put forward to an ad hoc decision making body in the third Lab.

> FIGURE 5

Prototyping and testing a user application using augmented reality

Experiences after two years

1. Sharing of individual knowledge and experience amongst the other botanic gardens has greatly increased the opportunities for each individual garden not only to survive but also to grow. There is now an on-going exchange in exhibits and educational material amongst the gardens. And perhaps more importantly, employees of the gardens regard each other as colleagues who can be called on for advice and who will be there to give advice.

2. Good collaboration requires an understanding of what your colleagues are doing both in your own botanic garden, as well as in each of the other gardens. To give an example: It is possible that within a particular garden the communications officer does not know what the collection manager does, and so the collection manager is not consulted when choices regarding programming are being made. Moreover the collection manager might be purchasing plants that do not conform to the aims outlined in the overall policy for the garden. Using the missions of the co-creation labs, surprising insights into the potential for collaborative and coordinated endeavours has become evident.

3. From the outset informing and involving all employees has increased support for collaboration. For example, the exhibition Protecting Plants, highlighting 240 Red List species in 24 botanic gardens: the exhibition was a success because all the gardens were involved from the outset, and all gardens agreed on the aims. There was a central organisation and the arrangement of the final exhibition is in such a way that leaves room for personal interpretation.

> Keywords COLLABORATION OF ALL DUTCH BOTANIC GARDENS CO-CREATION NEW AUDIENCES FOCUS ON PEOPLE AND PLANTS

06. Experiences after two years

• 't Hart Joke
• Van Dijk Dick

4. Communal information about the plants and events held by the NVBT gardens through the website, on facebook and twitter are not only important for the visitors but also for the employees working in the gardens.

> FIGURE 6

First shared exhibition on red list species: list means also frame-work in dutch: plants are not only on but also in red list during the exhibition

Lessons learned

ANECDOTES BELONGING TO THE PLANTS

If we want to share a large variety of anecdotes about the plants in the gardens with the wider public, it was of great importance that the anecdotes are linked both to the plant concerned and to the taxonomic information held in the collection management system. Again close collaboration between different employees is therefore important. Collection managers oversee taxonomic data, whilst guides recount anecdotes about the plants to the public. Information alignment is therefore of utmost importance.

Up until now the data and the anecdotes in the Dutch Botanic Gardens are not directly linked. Moreover, the anecdotes regarding the plants are not precisely documented. As part of the Planting the Future project, this is now changing: in the plant finder on the NVBT website the anecdotes and taxonomic information have been linked and made available to the general public. However, collecting the anecdotes and checking their reliability proved to be a huge undertaking.

TARGET-ORIENTATED WORK BEGINS BY KNOWING YOUR AUDIENCE

Bringing botanic garden employees together is a fertile ground for unleashing anecdotes about plants, and these are told effortlessly. But what happens when we suddenly have to recount these anecdotes to members of the local gardening club, or the Christian Women's Association? From working with the co-creation labs it became apparent that the level of experience in doing this within the participating gardens, was very low. Therefore if we want to focus on new target groups, we need to know who they are and where they are interested in. This proved to be an important learning point – regardless of how trivial it initially seemed. Knowing them and asking what they want For example during specific exercises in the co-creation labs series, a number of people were allocated the task of collecting anecdotes about carnivorous plants for the target group grandparents and children, the anecdotes were basically alright but the children understood virtually nothing.

REACHING NEW TARGET AUDIENCES MEANS BEING VISIBLE TO THE OUTSIDE WORLD

Actively spreading the word about what we do and why we do it, outside the gardens increases interest and attracts new audiences for the plants themselves. It is naïve to think that the visitor's self-motivation alone will be enough to draw him or her into the botanic garden.

> Keywords COLLABORATION OF ALL DUTCH BOTANIC GARDENS CO-CREATION NEW AUDIENCES FOCUS ON PEOPLE AND PLANTS

06. Lessons learned

• 't Hart Joke
• Van Dijk Dick

INTERNAL ORGANISATION OF THE BOTANIC GARDENS

The majority of the botanic gardens in the Netherlands have only a small number of staff who are responsible for a large number of different functions and tasks and they share them with a large number of volunteers. We all know that the botanic garden staff are both highly dedicated and extremely committed. However, the effectiveness of internal collaboration does have room for improvement, especially with regard to the alignment between those employees focused on the plant collections on the one hand and those employees concerned with communication and education on the other. In the botanic gardens the level of internal collaboration between these two groups left much to be desired. Plant-focused and people-focused groups need to work more closely- and become more in tune with one another.

Discussion

We present 10 key points that can contribute to the increasing success of the botanic gardens. As highlighted earlier, these points need to be regarded in the context of a change in working practices, especially with regard to collaboration, with more focus on the outside world, and not forgetting of course the importance in preserving each garden's own identity.

1. Work jointly, in co-creation
2. Search for shared identity and create 'ownership' of that identity
3. Ensure proper alignment of all the working groups within the organisation
4. Involve all employees including volunteers
5. Keep training and learning so that they are appropriately equipped for their (potential) new role
6. Communicate with the intended audience clearly in mind
7. Combine taxonomic data with plant anecdotes that the public find interesting and disseminate the information as pictures and stories
8. Be more outward looking, meet your audience
9. Be prepared to experiment to find new relevance for society
10. Build strong networks - don't try to do everything yourself

Conclusion

After a successful start in which the gardens explored new ways of working together, the next year, 2016, is the year of sharing and learning through workshops and lectures, as the process needs to continue to truly transform the organisations. Being both plant-focused and people-focused will make the Dutch botanic gardens more future proof. 2017 is the final year of the project and proclaimed to be the year of the Dutch botanic gardens. Current initiatives need not to end in 2017 but new ways (including funding) need to be explored further now to ensure continuity after 2017.

> Keywords COLLABORATION OF ALL DUTCH BOTANIC GARDENS CO-CREATION NEW AUDIENCES FOCUS ON PEOPLE AND PLANTS

06. References

• *'t Hart Joke*
• *Van Dijk Dick*

www.botanischetuinen.nl

www.waag.org

www.bgci.org

THE USE OF PHYTOSOCIOLOGY IN THE GARDEN PROJECTS. PRACTICAL APPLICATION UNDER MEDITERRANEAN CONDITIONS

Photo credit : The aspect of the *Olisiponense* Garden in the Jardim Botanico da Ajuda, Lisbon, after three years of plantation

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> Keywords NATIVE SPECIES NATURAL VEGETATION LANDSCAPE ARCHITECTURE BIODIVERSITY CONSERVATION

06. Abstract

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THE IMPORTANCE OF USING NATIVE SPECIES IN GARDENS AND LANDSCAPE RECOVERY ACTIONS IS A TOPIC THAT HAS BEEN STUDIED FOR ITS NUMEROUS ADVANTAGES, FOR THE ENVIRONMENTAL PERFORMANCE BEST SUITED TO PRESERVE, ENHANCE AND CONSERVE BIODIVERSITY, FOR GREATER ABILITY TO ADAPT TO NATURAL CONDITIONS, AND FOR ITS LOW WATER REQUIREMENTS, FERTILIZATION, AND MAINTENANCE.

There are generally many accepted reasons, why the use of native plants in gardens privileges the identity of the Green Design and Landscape Unit and is an important contributor to the sustainability of green spaces. However, there are still some obstacles to its practical implementation, including the shortage of available technical information on these native plants characteristics and proper use, their slower growth, the insufficient supply of certified native species in Portugal, but above all the lack of awareness of the difference between the native species and alien and invasive species, at the level of executive positions, technicians, designers and the public in general.

Motivated by the importance of this subject, a research project appeared in 2011, *Phytosociology, Landscape and Sustainable Gardens*, a partnership between Arqout (Landscape Architects) - Sigmetum (native plants nursery) - Instituto Superior de Agronomia/ISA (science), for the survey, characterization, testing, production, and dissemination of indigenous species. This project, financed by the rural development program PRODER (Programa de Desenvolvimento Rural, Portugal), is supported by a strong research component and field work, where the main series of vegetation and characteristic species are identified, as well as their potential for production in nurseries and use in landscape architecture projects and recovery of the landscape. The interpretation of the landscape, based on scientific concepts and procedures in the areas of Botany, Phytosociology and Phytogeography, enables compliance with the principles of sustainability and implements the concept for outdoor spaces.

In parallel with the research work an outreach strategy, with dissemination and promotion of indigenous species is underway. The disclosure is twofold. On the one hand the construction of a site where the scientific content is being processed and interpreted on a native flora (and vegetation)

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06. Abstract

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- *Oliveira Cristina*
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database as well as its presence in the national market. On the other hand, the highlighting of building garden models, examples of the application of the defined methodology and subsequent increase in use. Two examples are given: an ECOgarden in Ajuda Botanic Garden (Lisbon) and another in a private house at Melides (Alentejo). The aim of Ajuda Botanic Garden was the recovery of the forest zone that always was intended to be composed of native species, in order to be an example of a built garden with native plants, recreating the phytosociological environment of the region. This ECOgarden will allow visitors to see the indigenous flora of the Lisbon region that have a high ornamental value and the consequences of combining this methodology with previously known environmental gains. The Ajuda Botanic Garden gains a new point of interest, which is also important because of its educational panels that were associated with posters identifying the project and species. The aim is to show technical people and the general public that we have native species that have very considerable ornamental value, for any botanical collection that can be easily found in the market. The private house project in Melides is an example of applying the methodology under study to a landscape architecture project in a private garden, where the garden matches the surrounding landscape both in terms of the type of plants and their layout.

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06. Introduction

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Photo credit : The aspect of the *Olisiponense* Garden in the Jardim Botanico da Ajuda, Lisbon, after three years of plantation

AT THE PRESENT TIME AS THE CLIMATE IS CHANGING, THE PRESERVATION AND UPGRADING OF THE LANDSCAPE, ALONG WITH THE SCARCITY OF RESOURCES AND THE CURRENT ENVIRONMENTAL INSTABILITY LEAD US TO RETHINK THE WAY WE ACT ON THE LANDSCAPE AT THE VARIOUS LEVELS.

In this way the new environmental challenges in terms of green spaces are mainly focused on a decline in water consumption, reduced soil erosion and minimum use of exotic species, which often become invasive and harm the landscape balance. We seek to increase the use of native plants as an intrinsic feature of contemporary green space projects by disseminating information and making it available, and through growth in native species production via specialist methods adapted to their use in nature.

Landscape architecture projects should be designed as a living ecosystem, enhancing biodiversity and favoring balanced resource management. Thus, the selection of plant material becomes a determining factor in the creation of a truly sustainable garden, in terms of water management and use of fertilizers, as well as in terms of pest and disease control treatments. The specialist production methods have low production costs, no acclimatization expenses and require less fertilizer and water, which impact on the building of new green spaces, and, above all, their maintenance requires water consumption levels very similar to the natural situation, as close as possible to the average rainfall at each location. It is essential that each project is inspired by the actual location and materials, that plants and typologies be selected to favor local trade and production and at the same time reduce the costs of each project.

The project "*Phytosociology, Landscape and Sustainable Gardens*", financed by PRODER (Programa de Desenvolvimento Rural, Portugal), formed a partnership to study, research, design, produce, deliver and market native species. The parties concerned intend to promote a greater awareness of the importance and benefits of preserving the natural landscape and its biodiversity, which is based on assessment, knowledge and application of indigenous species in Portugal. At the research level a great deal of work has been undertaken in this field, especially as regards botany and phytosociology (reflecting the importance of ISA as a partner and the support of Lusitanian Association of Phytosociology - ALFA). This project was innovative to the extent that it focuses on interpreting the science in terms of landscape architecture, that is to say it promotes and disseminates biodiversity by means of a multidisciplinary understanding of landscape projects that has practical applications.

> Keywords NATIVE SPECIES NATURAL VEGETATION LANDSCAPE ARCHITECTURE BIODIVERSITY CONSERVATION

06. Introduction

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• Oliveira Cristina
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• Espírito-Santo Dalila

By disseminating information and raising awareness among the general public we seek to consolidate the ecological, aesthetical and economic components and above all make the use of native species "fashionable". This type of work makes it possible to design green spaces that are aesthetically appealing yet have a strong social and educational component, since this philosophy is a concept that awakens interest in and curiosity about Portuguese flora, and consequently raises awareness about the importance of the landscape and habitats. The software platform will allow producers to advertise the native species they produce and will bring the sector up-to-date in terms of new technology, acting as a driving force to its commercial presence and to the economic sustainability of this new niche market.

The specific objectives of this operation include: integration and synthesis of a base of knowledge about native species; identification, characterization and recognition of the main series of vegetation; research, demands and behavioral trends of native species; introduction of an increasing variety of indigenous species into the market with the development and implementation of a specialized nursery; definition and dissemination of new methods of intervention in the landscape; development of a platform for awareness, dissemination and promotion of native species in landscaping.

One of the major foreseeable consequence is the strengthening of the national identity by means of native plants. The spirit of each location, the essence of each landscape will be the design guidelines that will impact on tourism, production and society's relationship with the landscape and the environment generally.

Concerns about the environment and the benefits of using native species produced nationally and suited to the particular location will become effective when the general population is properly aware of this reality.

Methodology

Motivated by the importance of this subject, a research project appeared in 2011, *Phytosociology, Landscape and Sustainable Gardens*, a partnership between Arqout (Landscape Architects) - Sigmetum (native plants nursery) - Instituto Superior de Agronomia (ISA), for the survey, characterization, testing, production, and dissemination of indigenous species. The Project is supported by a strong research component and field work, where the main series of vegetation and characteristic species are identified, as well as their potential for production in nurseries and use in landscape architecture projects and the recovery of the landscape. All the project work, landscape planning and layout, along with the production and respective processes and methods, are based on technical and scientific concepts and procedures that have previously been studied and developed by specialists in the fields of Botany, Geography, Geology and Landscape Architecture.

Thus the project sets out to study and interpret previously developed contents, so as to provide for their practical application and subsequent disclosure, so that the methodology proposed may be used by those working in the fields in question.

In accordance with the concepts put forward by Capelo (2003), vegetation is a fundamental structuring element in landscapes. Not only does it

> Keywords NATIVE SPECIES NATURAL VEGETATION LANDSCAPE ARCHITECTURE BIODIVERSITY CONSERVATION

06. Methodology

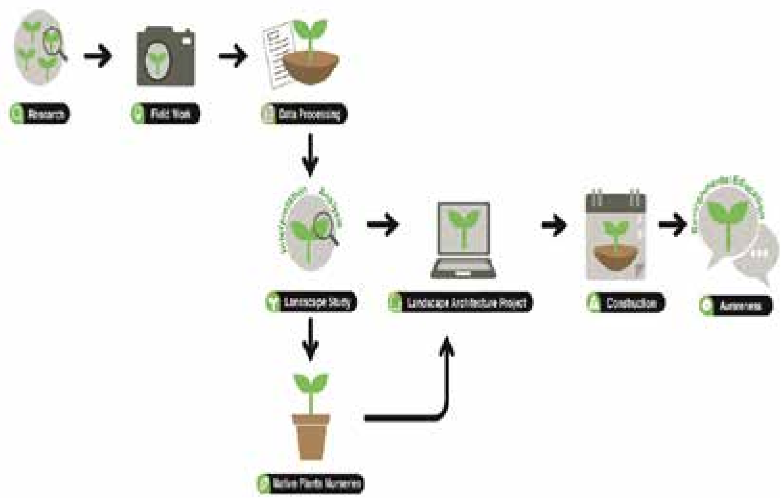
• Salazar Marta L.
• Oliveira Cristina
• Soares Ana Luisa
• Soares Filipe
• Espírito-Santo Dalila

dominate most land ecosystems through its biomass, it also constitutes the habitat for animal populations and is at the heart of the majority of human productive and cultural activities. It is also the element that best integrates a landscape's biological response to environmental factors (physical, biological and anthropic). In that sense it is also of enormous diagnostic and landscape systemization value.

The new science of landscapes was given the name of *Symphytosociology*. Géhu & Rivas-Martínez (1980) consolidate and promote the use of this term, definitively characterising the sigma associations as the stages of the same ecological succession (vegetation series) subordinated to the same climax and distinguishing the successional stage from the catenal stage (zoning), in the genesis of association complexes in a landscape. They also set up the basis for Integrated Chorology that establishes a territory's hierarchical bio-geographical typology, based on the Landscape Phytosociology units (Costa *et al.*, 1998).

The notions of dynamic-catenal phytosociology defined as the basis for Landscape Phytosociology are summarised in an article by Rivas-Martínez in 2005, where he defines the most important units – vegetation series, ge-oseries, permaseries and geopermaseries. A map of the vegetation series in continental Portugal with a scale of 1:400 000 was presented by Capelo (2007).

In parallel with the research work an outreach strategy, with dissemination and promotion of native species is underway. The disclosure is twofold. On the one hand the construction of a site where the scientific content is being processed and interpreted on a native flora (and vegetation) database, as well as its presence in the national market. On the other hand the challenge of



> FIGURE 1

Scheme for the methodology employed

designing landscape architects' projects with native species in order to be a living ecosystem, enhancing biodiversity and favoring balanced resource management (e.g., ECOgarden in Ajuda Botanical Garden and a private house at Melides).

SO, THE METHODOLOGY ADOPTED WAS AS FOLLOWS (**Fig. 1**):

- To identify and classify the major Portuguese plant series;
- To classify the Portuguese native species, based on knowledge from the fields of Botany;
- Phytosociology and Phytogeography, combined with data acquired from field work;
- To identify sites for collecting seeds and selecting species with the potential to be produced in the nursery and used in Landscape Architecture projects, considering the legislation for species and habitats;
- Experimentation on and production of native species by seminal means;
- To devise new methods of working on landscapes and outdoor spaces;
- To build up a data base containing up-to-date information on native plants and on their availability in the Portuguese market.

> Keywords NATIVE SPECIES NATURAL VEGETATION LANDSCAPE ARCHITECTURE BIODIVERSITY CONSERVATION

06. Results

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• Oliveira Cristina
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• Espírito-Santo Dalila

The current project bases all research and experimentation on thorough field work performed nationally (Costa *et al.*, 1998) that includes plant inventories (**Fig. 2**), landscape interpretation (**Fig. 3**) and the collecting of seeds in relation to landscape architecture and botany, as well as the production of many of these species in nurseries to ensure they are available for projects.

The gardens projected following this methodology were registered by ARQOUT with the name *ECOJardim* (EcoGarden). The project was awarded the ECOFLORA 2012 prize for a winning idea.

Tour n°	Itinerary	Date	Participants
1	APOSTIÇA/MECO/ARRÀBIDA	9/03/2012	Sigmetum (Filipe Soares, Joao, Tino), Argout (Mrata Salazar Leite), ISA (Dalila Espirito-Santos)

Stage		Coordinate	Vegetation series		
Woodland	**Pre-forest**	**High shrub**	**Perennial grassland**	**Low shrub**	**Annual grassland**
Oleo-Quercetum suberis (residual)	Junipero navicularae-Quercetum lusitanica	Thymo capitellati-Stauracanthetum genistoidis (residual)	Euphorbio transtaganae-Celticetum giganteae	Erico umbellatae-Ulicetum welwitschiani	Corynephoro macrantheri-Arenarietum algarbiensis
Quercus suber	Juniperus navicularis	Thymus capitellatus	Celtica gigantea (=Stipa gigantea)	Ulex australis subsp. welwitschianus	Tuberaria guttata
Phillyrea angistifolia	Daphne gnidium	Helichrysum italicum subsp. serotinum	Asphodelus lusitanicus	Erica umbellata	Aira caryophyllea
Phillyrea latifolia	Quercus lusitanica	Halimium calycinum	Brachypodium phoenicoides	Calluna vulgaris	Iberis contracta subsp. welwitschii
Asparagus aphyllus	Quesrcu coccifera		Agrostis curtisii	Lythodora prostrata subsp. lusitanica	Anemone palmata
Asparagus acutifolius			Carlina corymbosa	Lavandula luisieri	Scilla monophyllos
			Pimpinela villosa	Cistus salviifolius	Linaria spartea
			Thapsia dissecta	Genista triacanthos	Corynephorus macrantherus

> FIGURE 2

Example of a field survey form

Case study

Efforts on building ECOgarden models, and application examples to define methodology were implemented in several gardens. Landscape architects' projects were designed including the principles of sustainability mainly focused on a decline in water consumption, reduced soil erosion and minimum use of exotic species always attending to the aesthetical component.

In this paper we'll present two examples: Ajuda Botanic Garden, with the name of Olisiponensis Garden (**Fig. 4**) and a private garden at Grandola Hills, Melides (**Fig. 7**).

AJUDA BOTANIC GARDEN

In this Botanic Garden the aim was to recover the forest zone which was always intended to house native species, in order to be a sample of a built garden with native plants, recreating the phytosociological environment of the region (**Fig. 5**).

> Keywords NATIVE SPECIES NATURAL VEGETATION LANDSCAPE ARCHITECTURE BIODIVERSITY CONSERVATION

06. Case study

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- Oliveira Cristina
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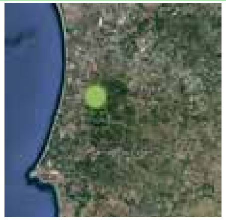
Tour sheet

MELIDES/SERRA DE GRÂNDOLA

arqOUT arquitectura paisagista	Sigmetum	Instituto Superior de Agronomia
Investigação/Projecto	*Investigação/Produção*	*Investigação/Consultoria*
Cristina Oliveira, Marta Salazar Leite	*Filipe Soares, João Paulo Gomes*	*Ana Luísa Soares, Dalila Espírito-Santo*

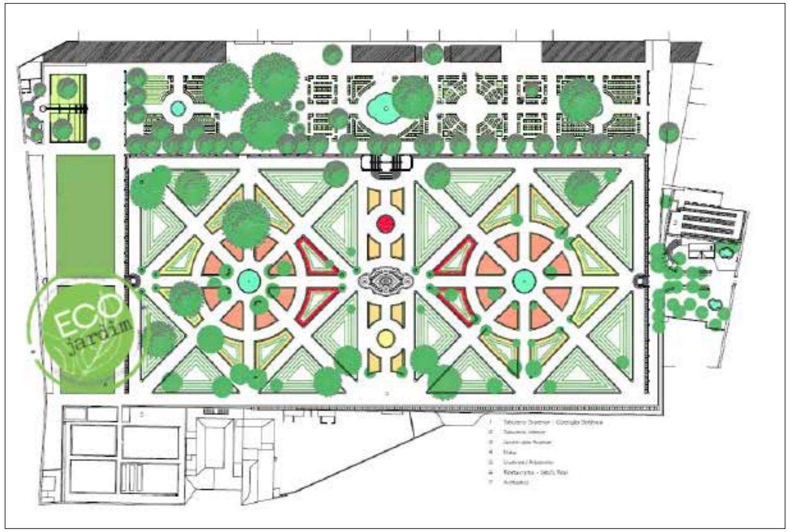
LOCAL	LANDSCAPE	PHYTOSOCIOLOGY
	The place is located in Serra de Grândola, predominant formation of shale, exposed to dry weather with little rain in summer and climate sub-humid with low temperatures in winter. The diagnosis was confirmed by the landscape phytosociological framework in a 500m radius, which were carried out several inventories and photographic surveys.	*Asparago aphylli-Quercetum suberis*

NATIVE WITH POTENTIAL FOR USE IN GARDEN

WOODLAND	HIGH SHRUB	LOW SHRUB	CLEARING/HEDGE
Arbutus unedo	*Erica scoparia*	*Asparagus aphyllus*	*Brachypodium phoenicoides*
Crataegus monogyna subsp brevispina	*Myrtus communis*	*Calluna vulgaris*	*Gladiolus reuteri*
Olea europaea var. sylvestris	*Phillyrea angustifolia*	*Cistus crispus*	*Origanum vulgare*
Pyrus bourgaeana	*Pistacia lentiscus*	*Cistus salviifolius*	*Stipa gigantea*
Quercus suber	*Quercus coccifera*	*Daphne gnidium*	*Thymus capitellatus*
	Rhamnus alaternus	*Erica australis*	
		Juniperus navicularis	
		Lavandula stoechas subsp. luisieri	
		Lonicera etrusca	
		Quercus lusitanica	
		Rhamnus oleoides	
		Rosmarinus officinalis	
		Rosa sempervirens	

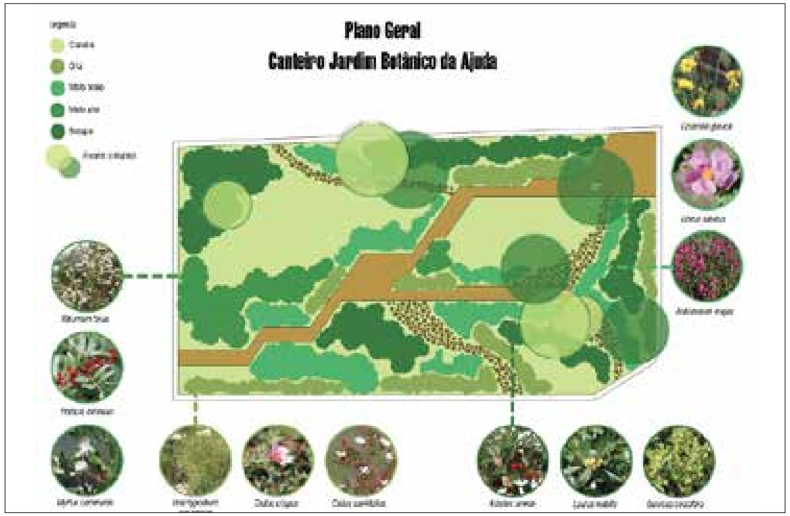
> FIGURE 3

Example of a field landscape interpretation (Tour sheet)



>> FIGURE 4

Localization of *Olisiponensis* Garden (ECOjardim) in Ajuda Botanic Garden



>> FIGURE 5

General Plan of *Olisiponensis* Garden - Ajuda Botanic Garden

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06. Case study

• Salazar Marta L.
• Oliveira Cristina
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• Soares Filipe
• Espírito-Santo Dalila

This ECOgarden will allow visitors to see the indigenous flora of Lisbon region and the combinations of high ornamental value that result of this methodology, associated with environmental gains already known.

A total of 300 plants were planted and the species used are presented in **Table 1** with their survival rate past one year. A mortality rate of 27% was observed in total. Species like *Cistus crispus, C. salviifolius, Coronilla glauca, Lavandula stoechas* subsp. *luisieri* and *Helichrysum stoechas* need sunny places and were planted down old trees where there was too much shadow. Cistus psilosepalus, on the contrary, prefer shadow places, and was planted in a very sunny place. Trees like *Quercus pyrenaica* and *Q. rotundifolia*, so frequent around Lisbon also died, possibly because they need water in the installation phase, and summer was very warm.

> FIGURE 6

Educational panel of *Olisiponensis* Garden

The Ajuda Botanic Garden gains a new point of interest, which is also important because of the educational panels that were associated with posters identifying the project and species (**Fig. 6**). It is intended to show to the technical persons and to the general public that we have native species with very considerable ornamental value, worth for any botanical collection that can be easily found in the market.

WOODLAND	Survival rate	HIGH SHRUB	Survival rate	LOW SHRUB	Survival rate	CLEARING/HEDGE	Survival rate
Olea europaea var. *sylvestris*	100%	*Viburnum tinus*	100%	*Helichrysum stoechas*	10%	*Brachypodium phoenicoides*	10%
Ceratonia siliqua	100%	*Phillyrea angustifolia*	100%	*Cistus albidus*	100%	*Centranthus ruber*	100%
Quercus pyrenaica	0%	*Phillyrea latifolia*	100%	*Cistus crispus*	75%	*Euphorbia characias*	75%
Arbutus unedo	50%	*Pistacia lentiscus*	100%	*Cistus monspeliensis*	100%	*Sedum sediforme*	100%
Quercus rivasmartinezii	100%	*Quercus coccifera*	100%	*Cistus psilosepalus*	80%		
Quercus rotundifolia	0%	*Rhamnus alaternus*	90%	*Cistus salviifolius*	80%		
Laurus nobilis	100%			*Coronilla glauca*	0%		
				Cytisus scoparius	0%		
				Lavandula stoechas subsp. *luisieri*	50%		
				Rosmarinus officinalis	50%		

> TABLE 1

Plants used in *Olisiponensis* Garden and survival rate

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06. Case study

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Private garden at Grandola Hills (Melides)

In the heart of the Grandola Hills, Melides, there is a family house designed by the architect Manuel Aires Mateus for which an ECOgarden was designed that would be a natural space, integrating the house and the pathways, that called for little maintenance and water consumption.

The project (**Fig. 7**) was conceived so as to interact with the local ecosystem and create a welcoming garden where the colours, textures and shapes of the plants would make them part of the surroundings, while encouraging walking and the outdoor life.

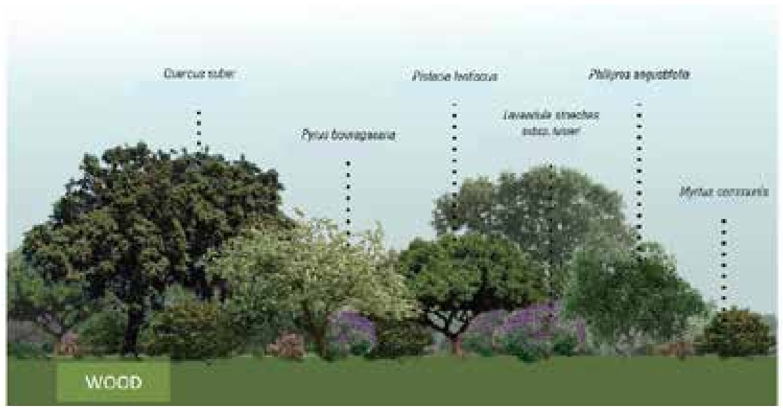
The first stages of the project focussed on the analysis and interpretation of the site. The region's main vegetation was classified and the groups of species having the ideal characteristics, resistance and development for this area were identified.

The species used are presented in **Table 2**, tree species like *Quercus suber, Arbutus unedo, Pinus pinea, Olea europaea* var. *sylvestris*, shrubs species like *Rhamnus alaternus, Phillyrea angustifolia, Pistacia lentiscus, Viburnum tinus* and smaller shrubs like *Cistus crispus, Calluna vulgaris, Lavandula pedunculata, Lavandula stoechas* subsp. *luisieri, Myrtus comunis, Daphne gnidium* and other grasses and climbing plants. The criterion for distributing the species was their placement according to exposure to sunlight and aesthetic effects (**Figs. 8** to **10**). As for watering needs during the early installation phase and in the summer, watering was guaranteed.

The garden was built in May 2013. It was inspired on the neighbor Landscape and based on its scientific components and the uses of local materials and the region's native plants (**Figs. 11** to **12**). It is classified as an ECOgarden, a registered trademark created by Arqout in the context of the research project in partnership with ISA and *Sigmetum*, funded by PRODER.

> FIGURE 7

Project master plan - ECOgarden in the Melides garden – Grandola Hills, Portugal (ARQOUT)



> FIGURE 8

The criterion for distributing the higher ligneous species

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06. Case study

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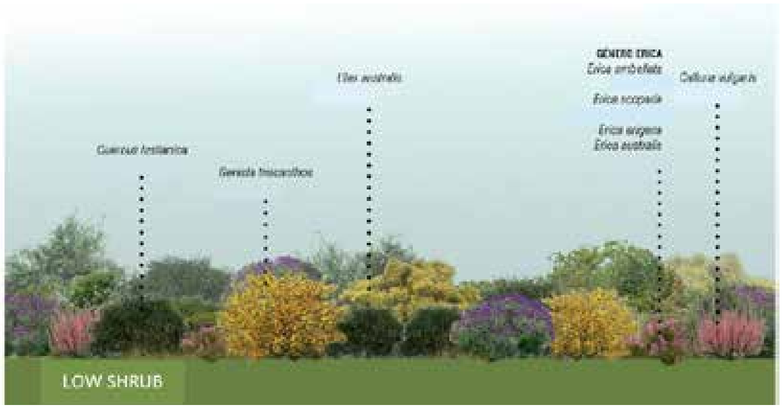
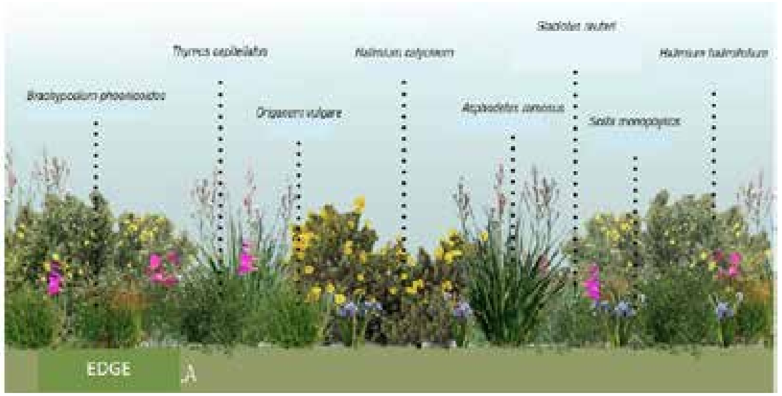


> FIGURE 9

The criterion for distributing the lower ligneous species



> FIGURE 10

The criterion for distributing the species (mainly herbs and shrubs)

TREES	HIGH SHRUBS	LOW SHRUBS	GRASSES	HERBS	GROUND COVER
Quercus suber	Rhamnus alaternus	Cistus crispus	Brachypodium phoenicoides	Muscari comosum	Lonicera etrusca
Arbutus unedo	Phillyrea angustifolia	Cistus monspeliensis	Stipa gigantea	Lithodora prostrata subsp. lusitanica	Rosa sempervirens
Pinus pinea	Pistacia lentiscus	Calluna vulgaris		Anagallis monelli	
Olea europaea var. sylvestris	Quercus lusitanica	Lavandula pedunculata		Linaria amethystea	
	Viburnum tinus	Lavandula stoechas subsp. luisieri		Origanum virens	
	Erica arborea	Myrtus communis		Calamintha baetica	
	Ulex welwitschianus	Daphne gnidium			

> TABLE 2

Plants used in Melides garden - Grandola Hills

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06. Case study

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> FIGURE 11

The garden finished (May 2015)

> FIGURE 12

The garden finished (May 2015)

Conclusion

In landscape architecture naturalist planting plans should be inspired by the aesthetics of spontaneous plant associations in the landscape. This naturalist vision covers not only planting plans consisting solely of native plants but also those including exotic plants. Piet Oudolf (1944-) is one of the architects who has made the largest contribution to the dissemination of naturalist planting plans through works such as *Planting the Natural Garden* (Oudolf, 2003) and projects such as *High Line Park* in New York.

Thus the selection of plant material becomes a determining factor in the creation of a truly sustainable garden, in terms of water management and the use of fertilisers, as well as in terms of pest and disease control treatments. It is very important that these plants be available through commercial nurseries. The use of phytosociology in the garden projects should also attend the aesthetical principles and the functional role of the green spaces. It is essential that each project is inspired by the actual location and materials, and that plants and typologies be selected to favor local trade and production and at the same time reduce the costs of each project. The make-up of planting plans should take into account and emphasize the project's ecological, aesthetic and functional components.

> Keywords NATIVE SPECIES NATURAL VEGETATION LANDSCAPE ARCHITECTURE BIODIVERSITY CONSERVATION

06. Conclusion

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With the present project we intend to increase the use of native plants as an intrinsic feature of contemporary green space projects by disseminating and making information available, and through the growth of native species production via specialist methods adapted to their use in nature. Reminding that mortality rate in the suited gardens shows us that being a plant of the vegetation series is not everything for the success of a plantation. The ecology of each plant and the respect for its needs in light are decisive for this success. All the plants placed in half shade grew without problems. The software platform will allow producers to advertise the native species they produce and will bring the sector up-to-date in terms of new technology, act as a driving force to its commercial presence and to the economic sustainability of this new market. The two case studies presented in this paper are a practical application under Mediterranean conditions and we intend to apply the methodology developed to other landscape architects' projects.

Acknowledgments

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> Keywords NATIVE SPECIES NATURAL VEGETATION LANDSCAPE ARCHITECTURE BIODIVERSITY CONSERVATION

06. Annex

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• Oliveira Cristina
• Soares Ana Luisa
• Soares Filipe
• Espírito-Santo Dalila

TAXA NOMENCLATURE AND USUAL NAMES

ANACARDIACEAE
Pistacia lentiscus L. **(mastic)**

APIACEAE
Pimpinella villosa Schousb.
Thapsia dissecta (Boiss.) Arán & Mateo

ASPARAGACEAE
Asparagus aphyllus L. **(wild asparagus)**
Asparagus acutifolius L. **(wild asparagus)**
Muscari comosum (L.) Mill. (= *Leopoldia comosa* (L.) Parl.) **(tassel hyacinth)**
Scilla monophyllos Link

ASTERACEAE
Carlina corymbosa L. **(clustered carline thistle)**
Helichrysum italicum (Roth) G.Don subsp. *serotinum* (Boiss.) P.Fourn. **(curry plant)**

BORAGINACEAE
Lithodora prostrata subsp. *lusitanica* (Samp.) Valdés (=*Glandora prostrata* subsp. *lusitanica* (Samp.) D.C.Thomas)

BRASSICACEAE
Iberis contracta Pers. subsp. *welwitschii* (Boiss.) Moreno **(white assemblies)**

CAPRIFOLIACEAE
Centranthus ruber (L.) DC. **(red valerian)**
Viburnum tinus L. **(laurustinus)**

CISTACEAE
Cistus albidus L. **(grey-leaved cistus)**
Cistus crispus L.
Cistus monspeliensis L. **(Montpellier cistus)**
Cistus psilosepalus Sweet
Cistus salviifolius L. **(sage-leaved rock-rose)**
Halimium calycinum (L.) K.Koch
Tuberaria guttata (L.) Fourr. **(spotted rock-rose)**

CRASSULACEAE
Sedum sediforme (Jacq.) Pau

CUPRESSACEAE
Juniperus navicularis Gand. **(juniper)**

ERICACEAE
Arbutus unedo L. **(strawberry tree)**
Calluna vulgaris (L.) Hull **(common heather)**
Erica australis L.
Erica scoparia L.
Erica umbellata L. **(heather)**

EUPHORBIACEAE
Euphorbia characias L. **(Mediterranean spurge)**

FAGACEAE
Quercus coccifera L. **(kermes oak)**
Quercus lusitanica Lam. **(Lusitanian oak)**
Quercus pyrenaica Willd. **(Pyrenean oak)**
Quercus rivasmartinezii (Capelo & J.C.Costa) Capelo & J.C.Costa **(kermes oak tree)**
Quercus suber L. **(cork oak)**

IRIDACEAE
Gladyolus reuteri Boiss. (= *Gladiolus communis* L.)

LAMIACEAE
Calamintha baetica Boiss. & Reut. (=*Clinopodium nepeta* subsp. *glandulosum* (Req.) Govaerts)
Lavandula pedunculata (Mill.) Cav. subsp. *pedunculata* **(French lavender)**
Lavandula stoechas L. subsp. luisieri **(Rozeira)** Rozeira
Origanum vulgare L. subsp. virens (Hoffmanns. & Link) Ietsw. **(oregano)**
Rosmarinus officinalis L. **(rosemary)**
Thymus capitellatus Hoffmanns. & Link **(tyme)**

LAURACEAE
Laurus nobilis L. **(bay laurel)**

LEGUMINOSAE
Ceratonia siliqua L. **(carob tree)**
Coronilla valentina L. subsp. *glauca* (L.) Batt.
Cytisus scoparius (L.) Link **(common broom)**
Genista triacanthos Brot.
Ulex australis Clemente subsp. *welwitschianus* (Planch.) Espírito Santo & al. **(gorse)**

MYRTACEAE
Myrtus communis L. **(myrtle)**

OLEACEAE
Olea europaea L. var. *sylvestris* (Mill.) Lehr.
Phillyrea angustifolia L. **(false olive)**
Phillyrea latifolia L. **(mock privet)**

PINACEAE
Pinus pinea L. **(umbrella pine)**

PLANTAGINACEAE
Linaria amethystea (Vent.) Hoffmanns. & Link
Linaria spartea (L.) Willd.

POACEAE
Agrostis curtisii Kerguélen **(bristle bent)**
Aira caryophyllea L. **(silver hairgrass)**
Brachypodium phoenicoides (L.) Roem. & Schult. **(perennial green grass)**
Corynephorus macrantherus Boiss. & Reut.
Stipa gigantea Link **(giant feather grass)**

PRIMULACEAE
Anagallis monelli L. **(blue pimpernel)**

RANUNCULACEAE
Anemone palmata L. **(yellow anemone)**

RHAMNACEAE
Rhamnus alaternus L. **(Mediterranean buckthorn)**

ROSACEAE
Crataegus monogyna var. *brevispina* (Kunze) Dippel **(common hawthorn)**
Pyrus bourgaeana Decne. **(Iberian pear)**
Rosa sempervirens L. **(evergreen rose)**

THYMELAEACEAE
Daphne gnidium L. **(flax-leaved daphne)**

XANTHORRHOEACEAE
Asphodelus lusitanicus Cout

DARE TO THINK! EDUCATING ABOUT THE NATURE OF SCIENCE IN THE GHENT UNIVERSITY MUSEUM AND BOTANICAL GARDEN

Photo credit : Students re-enact historic experiments of Van Helmont, Priestley and Sachs revealing the central nutrients of plant metabolism. Afterwards, students participate in a discussion about the nature of science, ***Tim Vanhove***

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> Keywords SCIENCE EDUCATION NATURE OF SCIENCE SCIENCE MUSEUM SCIENTIFIC LITERACY

06. Abstract

- *De Schrijver Jelle*
- *Dugardin Chantal*
- *Goetghebeur Paul*

TO INCREASE SCIENTIFIC LITERACY AMONG HIGH SCHOOL STUDENTS AND STIMULATE THEIR CRITICAL REFLECTION ABOUT SCIENCE, EDUCATING ABOUT THE NATURE OF SCIENCE (NOS) IS CONSIDERED CRUCIAL. NOS ENTAILS A FOCUS ON THE CENTRAL EPISTEMOLOGICAL UNDERPINNINGS OF SCIENCE, SUCH AS ITS REALM AND LIMITS, ITS LEVELS OF UNCERTAINTY, ITS BIASES AND THE REASONS FOR ITS RELIABILITY. AS BOTANICAL GARDENS AND SCIENCE MUSEUMS PROVIDE PROOF OF THE SCIENTIFIC PRACTICE AS SUCH, THEY ARE A FERTILE SOIL TO FOSTER UNDERSTANDING OF THE NOS AMONG A WIDE RANGE OF VISITORS AND CONTRIBUTE TO THE SCIENTIFIC LITERACY OF STUDENTS. IN THIS PAPER, WE EXPLORE HOW NOS CAN BE ADDRESSED IN SCIENCE MUSEUMS AND BOTANICAL GARDENS, REPORT ON AN EDUCATION RESEARCH DESIGN-STUDY TACKLING NOS AND DISCUSS THE IMPORTANCE OF TRAINING THE EDUCATIVE PERSONNEL TO OBTAIN A FOCUS ON THE NOS.

> Keywords SCIENCE EDUCATION NATURE OF SCIENCE SCIENCE MUSEUM SCIENTIFIC LITERACY

06. Introduction

• De Schrijver Jelle
• Dugardin Chantal
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Photo credit : Students re-enact historic experiments of Van Helmont, Priestley and Sachs revealing the central nutrients of plant metabolism. Afterwards, students participate in a discussion about the nature of science.

PHYLOGENIC CLASSIFICATION IS CONSTANTLY REFINED, THEORIES ABOUT SUBATOMIC PARTICLES ARE DISCUSSED AND CERTAIN PHYSIOLOGICAL PROCESSES REMAIN UNCERTAIN. BUT STILL, MANY PEOPLE AND MOST HIGH SCHOOL STUDENTS CONSIDER THE DOMAIN OF SCIENCE AS A COLLECTION OF UNQUESTIONABLE FACTS.

Students harbour a range of misconceptions with regard to the scientific process and the role of the scientist. Misconceptions such as “scientific ideas are permanent and unchanging”, or “if scientific ideas are tentative and subject to change, they cannot be trusted”, a “scientist is not creative” (Quigley, Pongsanon & Akerson, 2010).

Some of these misconceptions have probably been acquired in the regular science classes at school where teachers often propagate a purely objectified and disembodied view of science. Indeed, the scientific curriculum in secondary education often only focuses on the scientific content to be acquired by students, such as Newton’s laws or the anatomy of plants. Yet, science education can also play a key role in developing the scientific literacy of citizens. A scientifically literate citizen should be able to participate in or at least take stance in discussions about sensitive scientific issues such as nuclear energy, genetic modification or biodiversity. To become scientifically literate, the phenomenon of science in itself, as a method to obtain reliable knowledge with its own pitfalls and opportunities, should be addressed. This means that students need to understand ‘the nature of science’.

The nature of science (NoS) is concerned with the basic underpinnings of science as a way of knowing and the characteristics of scientific knowledge. It entails several interconnected aspects : **(1)** scientific knowledge is empirically-based implying that it is derived from observations of the natural world. **(2)** There is a distinction between observations and interpretations by inferring on these data. **(3)** Since the practice of science involves human inference, it is a process that relies on the imagination and creativity of the scientist. **(4)** Although scientific knowledge is the product of a process of observation and interpretation, scientific knowledge remains tentative. As scientists continue testing and challenging previous interpretations, answers are only seldom final. After all, science is a human endeavour and the human perspective is fallible. In other words: “The only consistent characteristic of scientific knowledge across the disciplines is that scientific knowledge itself is open to revision in light of new evidence.” (NGSS, 2013).

Thus far, the NoS is not explicitly addressed in Flemish science education, nor does it receive a lot of attention in Flemish science museums or botanical gardens. Many science education experts claim for many years now that

> Keywords SCIENCE EDUCATION NATURE OF SCIENCE SCIENCE MUSEUM SCIENTIFIC LITERACY

06. Introduction

• De Schrijver Jelle
• Dugardin Chantal
• Goetghebeur Paul

NoS should be addressed more broadly during science class (Akerson & Donenelly, 2010; Lederman, 2006; Abd-El-Khalick, Bell & Lederman; 1998). All of them underscore the conclusion that the integration of the NoS in the educational curriculum is a most promising endeavour. As botanical gardens and science museums provide proof of the scientific practice as such, they are a fertile soil to foster understanding of the NoS among a wide range of visitors and contribute to the scientific literacy of students. In this paper, we explore how NoS can be addressed in science museums and botanical gardens, report on an education research design-study tackling NoS and discuss the importance of training the educative personnel to obtain a focus on the NoS.

Materials & methods

In this paper we report on a small educational design research study carried out at the Ghent University Museum and botanical garden aimed at stimulating reflection about science. Educational design research (EDR) provides a methodology to create, evaluate and optimize the educative strategies and material (Plomp & Nieveen, 2007). It entails the study of developing and assessing educational interventions to solve everyday problems encountered by teachers and educators. This kind of research probes for principles to optimize the educational practice and bridge the gap between the educational practice and pedagogical research (Van Braak *et al.*, 2008). EDR is cyclical by nature, implying that it should be envisioned as a spiralling approach where the educative material of the educative intervention is developed, tested, evaluated, improved and then redeveloped, retested, re-evaluated again (Barab & Squire, 2004; Brown, 1992).

In order to tackle the problematic knowledge about the NoS among high school students, a series of workshops is developed at the Ghent University Museum for 12 to 15 year old high school students. 62 students were involved in this study. Interviews with students, teachers and qualitative observation during the educative intervention allows for assessing the learning process of the students. The workshops are developed by the educational staff of the science museum in collaboration with the collections of the botanical garden, the collection of scientific instruments and zoology. The educational personnel provides coaching for the high school students during the workshop.

Results

DESIGN PRINCIPLES

In developing the learning material following design principles were kept in mind:

1. As historic scientific cases provide an excellent context to reflect upon the NoS (Höttecke, 2000), it is important to integrate the histories of scientific discoveries in the learning material to be developed. In this regard different historic collections of the university museum can be used to provide the context to elicit understanding of the NoS.
2. As inquiry-based learning is a successful approach to enhance the motivation and commitment of students (Barnett, 2005), the learning material should allow students to discover and experience the scientific content through hands-on activities. This way, "inquiry-based exhibit methods about the processes of science can provide exemplary experiences with

> Keywords SCIENCE EDUCATION NATURE OF SCIENCE SCIENCE MUSEUM SCIENTIFIC LITERACY

06. Results

• *De Schrijver Jelle*
• *Dugardin Chantal*
• *Goetghebeur Paul*

inductive learning which can influence school methods." (Dolin *et al.*, 2008).

3. As understanding NoS is more than acquiring scientific knowledge, also involving reflection about scientific practice, students should be engaged in a dialogue and thinking activities throughout the learning process (Abd-El-Khalick, Bell & Lederman, 1998). In this regard a philosophical dialogue provides an interesting approach as it aims at eliciting critical reflection (Lafortune *et al.* 2002; Sigurdardottir & Nelson, 1999). This technique entails a conversation of a group of students who are discussing a central question. The coach only facilitates the dialogue by asking for explanations and arguments. The coach takes what is known as the Socratic stance, this means that he or she does not intervene with regard to the content of the discussion, but only stimulates the dialogue (Lipman, 1991; Schjelderup, 2009; Anthone & Mortier, 1997).

LEARNING MATERIAL

The use of three different collections at the Ghent University Museum (a botanical, zoological and scientific historic collection) enables an interdisciplinary approach, allowing students to discover recurring methods of science in distinct domains. The topic of 'energy' is chosen to develop the NoS learning material, as 'energy' plays a key role in the metabolism of plants and animals, but can also be addressed in the domain of physics in the study of historic scientific instruments.

In the botanical garden a workshop addressed the key historic steps in the development of the theory of photosynthesis. Students re-enact historic experiments of Van Helmont, Priestley and Sachs revealing the central nutrients of plant metabolism and the key role of solar energy for the production of organic matter. In the zoological collection, students studied the energy transfer in ecological pyramids by comparing differences in tooth structures between herbivores, carnivores and omnivores. In the collection of historic instruments, we used the experiment of Joule investigating the relation between mechanical energy and warmth as a tool to uncover the conceptual change with regard to warmth and energy.

In the workshops mentioned above, students participated in hands-on scientific experiments. In between and after these activities, students are guided in a discussion about the tentative nature of scientific knowledge, the difference between observation and inference, the creative role of the scientist and the empirical nature of the scientific practice. In a so-called "Salon scientifique", students investigated in a philosophical dialogue questions such as "How does a scientist proceed?", "Is a discovery absolutely true?" or "What makes a good scientist?"

Discussion

Observation reveals that students are highly motivated when hands-on and minds-on activities are alternated. Citations of students participating in the workshops anecdotally illustrate how understanding of NoS is stimulated. A 14-year-old answered: "*Most ideas change, but some remain the same for a long time. We will never know for sure whether what we know is absolutely correct*". A 13-year-old claimed: "*Last year I thought that a scientist only checks what others discovered. Now I realize that there are many new things to be discovered.*"

> Keywords SCIENCE EDUCATION NATURE OF SCIENCE SCIENCE MUSEUM SCIENTIFIC LITERACY

• *De Schrijver Jelle*
• *Dugardin Chantal*
• *Goetghebeur Paul*

06. Discussion

We noted in our study that it was particularly girls who were involved in the discussions. Teachers reported that some of the students who participated in the dialogue at the museum are students that do not participate in science classes at school. It is apparent that the use of the philosophical dialogue stimulates a student population that is not triggered in regular science classes. This corresponds to findings of a study stimulating dialogue and discussion in primary school science demonstrating that this approach elicits interest and motivation in science in a different population (Mant *et al.*, 2007; Hanley *et al.*, 2015). In this case, mainly girls and non-native speakers seem to benefit from this approach.

Observations also show that the coach plays a key role to induce reflection among students in the workshops. Not only does the coach need to find time to question students about NoS, he/she also needs enough time and training to learn the dialogical method. It is especially hard to acquire 'the Socratic stance', which implies the coach questions more than he answers.

As the educational personnel indicated that they were not trained well enough to address the NoS through philosophical dialogue, a training program was set up to overcome this problem. The training program included different sessions focused on science, inquiry-based learning, workshop didactics, dialogical teaching and philosophical dialogue. Key in this approach is the idea that educators in the NoS workshops are to be trained to ask questions rather than answer them.

In future, new cross-disciplinary workshops addressing the nature of science in botanical gardens will be necessary to follow up what was already accomplished.

Conclusion

As products of scientific enterprise, botanical gardens are not only pivotal in biodiversity education, they also play a central role with regards to the education about scientific thinking and science. The collaboration with science museums and university museums provides opportunities to discuss and focus on the NoS. What is more: the century old (academic) traditions of enquiry and investigation embodied in the university museum and botanical garden can be disclosed. As the academic heritage provides tactile evidence of this tradition it may allow students to deepen their understanding of the phenomenon of science as such. However, in order to stimulate this understanding, one needs to focus on the thinking processes underlying the development or collection of the objects in university museums and gardens. This shows why the philosophical dialogue is a promising educational instrument to stimulate active discussion and reflection among students. The case study suggests that using the Socratic dialogue to stimulate understanding of the nature of science is most promising. Though further research is necessary, it seems that using this type of dialogue to induce reflection about the nature of science may allow for a happy marriage between the university as a research centre and the university as a locus of scientific heritage. For botanical gardens this implies that these tranquil places can be transformed into spaces filled with the murmur of thought and reflection upon the very fabric of science.

> Keywords SCIENCE EDUCATION NATURE OF SCIENCE SCIENCE MUSEUM SCIENTIFIC LITERACY

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URBAN HOBBY GARDENING AND BOTANIC GARDENS

Photo credit : Urban gardens near University Botanic Gardens Ljubljana (Slovenia), *Jože Bavcon*

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> Keywords BOTANIC GARDENS URBAN GARDENING SOCIAL ROLE SUSTAINABLE DEVELOPMENT VEGETABLE GARDENING

06. Abstract

• *Blanka Ravnjak*
• *Bavcon Jože*

URBAN AREAS AND CITY POPULATION ARE INCREASING. AT THE SAME TIME THE CONSCIOUSNESS ABOUT THE IMPORTANCE AND QUALITY OF HOME PRODUCED VEGETABLES IS RISING. IN MANY CITIES THERE ARE AREAS, WHERE CITIZENS CAN GROW THEIR OWN VEGETABLES.

However, due to many generations of urban city-living, the knowledge about gardening, plants and their use, was forgotten by many people. That is why people are eager to receive knowledge and help, to enable them finding a primeval connection with the nature. This is where botanic gardens can play a very important role. Besides the fact, that they are scientific and research institutions and present living plant collections, they also hold a treasury of knowledge about gardening and play a significant social role. At the University Botanic Gardens Ljubljana we attach a particular importance to develop these new botanic gardens roles. In 2013, together with the Municipality of Ljubljana, the National Television of Slovenia (RTV SLO) and Ljubljana citizens, we developed an urban hobby gardening activity. To support this initiative, the Municipality of Ljubljana offered a degraded land, near our botanic garden devoted to the creation of gardens by citizens. The land was divided in several plots that were attributed to several citizens while the staff of our botanical garden helped, during planning and creation phase by giving professional advice and support for physical work. The whole action was well supported by the media. Once a week, professional advices about plants and gardening was given in TV broadcasts, live from the abovementioned gardens. The audience was able to follow at regular intervals the work progress on the gardens, observe the growth of the crops and ask questions. Thus, a once useless, abandoned piece of land was converted into a cultivated land and it also helped connect the botanical garden with citizens through gardening. With the help of the media, the botanic garden's knowledge and good practices were also presented to the broader population. This helped create a small gardening community, which is now actively sharing experiences and good practice as well as contributing to the learning land sustainable management. This project also increased the visibility and recognition of our botanic garden in Slovenia.

> Keywords BOTANIC GARDENS URBAN GARDENING SOCIAL ROLE SUSTAINABLE DEVELOPMENT VEGETABLE GARDENING

06. Introduction

• Blanka Ravnjak
• Bavcon Jože

Photo credit : Urban gardens near University Botanic Gardens Ljubljana (Slovenia), *Jože Bavcon*

NOWADAYS, BOTANIC GARDENS HAVE MANY DIFFERENT FUNCTIONS (CHENEY *ET AL.* 2000), IN ADDITION TO THE OLDEST, SCIENTIFIC AND RESEARCH ROLES, THERE IS ALSO THE EQUALLY OLD EDUCATIONAL ROLE (YOUNG 1987, MONEM 2007, OLDFIELD 2010).

Today, the educational role is ubiquitous. We're not only talking about an educational role in terms of teaching botanical sciences and showcasing plant collections to the experts and general public, but in terms of teaching the public about the usage and cultivation of plants. In large cities, citizens have lost gardening knowledge and know how; therefore, botanical gardens become essential knowledge centres, and provide a connecting link between the experts and the general public. In a botanic garden, knowledge can also be disseminated through lectures, workshops, educational courses, and larger projects. At the Denver Botanic Gardens, gardeners are available every day to give advice to the visitors on gardening issues (http://www.botanicgardens.org). The Brooklyn Botanic Garden organises an 8-week programme (http://www.bbg.org/greenbridge/bug), teaching the participants the basis of urban gardening and planting in urban communal areas. Participants that complete the course are awarded a "Brooklyn Urban Gardener" certificate. With this acquired knowledge, they then volunteer in various planting projects, help in school gardens or in gardening communities. In a poorer district of the city, the Chicago Botanic Garden created a green oasis of urban gardens, where the youth and those with significant barriers to employment are taught gardening and self-sufficient supply of produce http://www.chicagobotanic.org/urbanagriculture. The urban agriculture apprenticeship programme teaches students the theoretical and practical aspects of agriculture and management of agricultural systems. In addition to the listed examples in the United States, many other botanic gardens organise similar programmes, thus transforming parts of the urban environment into green gardens and teaching urban residents about gardening and thus provide self-sufficient supply of produce. Even in the Alhambra complex of palaces and gardens of Granada (Spain), a UNESCO world heritage city, a section of the land was dedicated to vegetable gardens for the citizens of the city.

The Botanic Garden of the University of Ljubljana also organised similar activities in the past. Between 1834 and 1867, as Fleischmann (a gardener and later also a head of the Botanic Garden) was gaining in importance, finally taking over the Garden in 1850, fruit cultivation and gardening were heavily promoted (Praprotnik 1993, 2015). Fleischmann helped farmers throughout Carniola (one of the regions of the former Habsburg Monarchy) with his advice and participated in agricultural fairs (Praprotnik 2015). In his lecture, he

> Keywords BOTANIC GARDENS URBAN GARDENING SOCIAL ROLE SUSTAINABLE DEVELOPMENT VEGETABLE GARDENING

06. Introduction

• *Blanka Ravnjak*
• *Bavcon Jože*

wrote, "Many a young lady knows the foreign Camellia, but not the domestic parsley" (Fleischmann 1849, 1850; Praprotnik 1993). After 1850, an entire fruit tree nursery was established, which operated until 1894 (Voss 1884, 1885; Paulin 1912, Bavcon 2010). After 1867, this work was continued, so that the later head of the Garden, Paulin, wrote that the Garden has strayed too far towards fruit and vegetable cultivation, and failed to retain its original purpose (Paulin 1912). Nevertheless, even Paulin, who at the time criticised this direction, cooperated intensively in the management and planning of school gardens (Wraber 2010). In the 1980s, school gardens, even those with useful plants for consumption, were an intensive subject – both in articles and in practice – for Strgar, the head of the Garden at the time (Strgar 1984–1988, 1990). Because of this past history, the transition to today's very popular gardening subjects was anything but difficult for the Botanic Garden of the University of Ljubljana.

Lately, the Botanic Garden of the University of Ljubljana organises various lectures and workshops to try and present the plant world, its biodiversity and usefulness to as many people as possible (Bavcon *et al*. 2004; Bavcon 2010; Bavcon *et al*. 2015). In a time of increasing awareness of the importance of home-grown food, we have further increased our active participation in communication with the amateur gardeners. Despite the fact that Slovenia has a relatively lower proportion of urban population compared to other European countries, the 1960s saw a significant growth of urban population, thereby causing the slow disappearance of gardening knowledge which was no longer passed from one generation to the next. In the past, individuals often asked for advice about gardening in the Botanic Garden. With time, the number of requests increased. So, we decided to develop urban gardens together with urban residents with the support of media. Therefore, in 2013, the Botanic Garden of the University of Ljubljana, the national broadcaster RTV SLO and the City of Ljubljana began the urban gardens project.

Methods

THE URBAN GARDENS PROJECT WAS IMPLEMENTED IN FIVE PHASES.

In the first phase, we selected the most suitable locations for urban gardens. We selected a location that was close enough to the Botanic Garden and at the same time owned by the City of Ljubljana, since the latter approved unlimited use of this land for gardening. The chosen location is located along a railway line, slightly inclined, and with a southern exposure. The location has been named "Gardens behind the railway line". This land plot has a ruderal and degraded character, and was home to invasive plant species and bushes.
Along with selecting the location, we also selected the candidates – lessees of gardens – with the help of RTV SLO.

In the second phase, during early spring in 2013, we thoroughly cleaned the land plot of all bushes, removed the large stones and the remains of construction material, and ploughed the soil. We then divided the land plot into 6-by-5-metre gardens (30 m^2). Such a plot had a size sufficient to provide enough food for a family of four.

In the third phase, we began planting vegetables, and attributed to each garden owner a mentor from the Botanic Garden. All the gardeners selected signed a statement, whereby they agreed to care for the gardens on a regular basis and only use natural materials (wood, hay, homemade compost) in

> Keywords BOTANIC GARDENS URBAN GARDENING SOCIAL ROLE SUSTAINABLE DEVELOPMENT VEGETABLE GARDENING

Methods

• Blanka Ravnjak
• Bavcon Jože

their gardens. Following our suggestions, they also agreed to only use natural agents against any potential pests, so the produce grown in the gardens will be truly natural and healthy. Furthermore, we initiated an on-line discussion group for notifications, gardening-related questions, and opinion-sharing. Gardeners were also provided with some saplings cultivated in the Botanic Garden, whereas the purchase of seeds was made possible with the financial support of the broadcaster. In the selection of vegetables, we promoted autochthonous Slovenian species.

The fourth phase was devoted to the development of the area around the gardens (paths, lawn), during which the staff of the Botanic Garden also consulted a landscape architect. A rock garden was created using the dug-up rocks. We also built a composter at the edge of the gardens and the Society Knof (a non-governmental public society) used recycled wooden boxes to build a common area for socialising, decorating it with flowerbeds (for varied flowering plants). Along the edge where the gardens border the railway line, we weaved a wicker fence. Finally, Semenarna Ljubljana (a local seed shop company) donated a water collector.

In the final and fifth phase, we carried out an evaluation of the gardens, of their production and the different gardening practices used. All activities were closely followed by the national broadcaster by means of weekly live shows. This allowed the audience to submit gardening questions to experts

Results

During the first year of the project, we helped develop four gardens; they were tended by a very diverse group of users: a three-generation family, an old retired couple, a single retired woman, and a younger employed woman. In the following years, they were joined by two young families, two retired couples, and two retired women. Crops grew nicely in the gardens, as the soil was not used intensively before and the gardens exposed in full sun. With intensive care for the garden and the development of the surrounding environment, we successfully exterminated the invasive plants from the area, such as the Canada goldenrod and the giant goldenrod (*Solidago canadensis, Solidago gigantea*). As already mentioned, we tested and presented various gardening practices in the gardens. In one of the gardens, we planted diverse crops in combination with decorative plants and herbs. The combination proved to be effective, as the herbs, such as basil (*Ocimum basilicum*) and summer savory (*Satureja hortensis*) successfully repelled aphids and prevented mould on tomatoes. Decorative flowers, such as marigolds (*Tagetes* sp.), common marigold (*Calendula officinalis*), and monks cress (*Tropaeolum majus*) repelled potatoes underground pests and brassica aphids. We also tested the usage of varied types of mulch. These proved to be effective especially in the dry summer months, as they retained moisture in the soil around the crops. We also built a smaller greenhouse in one of the gardens, where the gardeners successfully grew lettuce and carrots, as well as some vegetable seedlings for the next season. Since the start of the project, decorative plants flourished along the edges of the gardens, additionally attracting pollinators that are important for a good yield. Employees of the Botanic Garden presented the development and growth of the gardens, along with relevant advice, in 70 television live shows, whereas the project was featured in 3 printed publications (Katja 2015; Pirnat 2013; Fišer 2015).

> Keywords BOTANIC GARDENS URBAN GARDENING SOCIAL ROLE SUSTAINABLE DEVELOPMENT VEGETABLE GARDENING

06. Discussion

• Blanka Ravnjak
• Bavcon Jože

Even though Ljubljana, as the capital of Slovenia, is relatively close to the countryside, the proportion of population living in apartments in the city is relatively high. These residents do not own land plots, and therefore do not have the option to grow their own fruit and vegetables. Nowadays, many citizens cultivate vegetables on their balconies and terraces, but even that is most often insufficient, to provide enough food. The City of Ljubljana decided to help out by developing gardening areas, primarily in the vicinity of the larger residential communities. The City of Ljubljana started allocating areas in 1995, and in 2009, after an almost uncontrollable exploitation of space, whereby gardens started tarnishing the image of the city, a more serious development of gardening areas was initiated, with an ordinance on allocation of gardens (ordinances UL RS, št. 28/09). Two sample areas were developed, including a shed and composters for every garden, as well as a common playground. This garden development turned out to be quite costly and the decision was made to postpone the preparation of the areas for the gardens and land allotment in the following years. In 2014 and 2015, the City of Ljubljana passed new ordinances regarding the development and lease of land plots for garden use (ordinance UL RS, št. 8/2014). Any person with a permanent residence in Ljubljana and not in ownership of a land plot suitable to create a garden is entitled to rent a garden. A person renting such a garden pays a rent of 1€/m^2 per year. There are some additional operating costs, increasing the cost to about 30€ per year. Since the City of Ljubljana aims for every district community to have an area with gardens and a sample orchard, in 2015, a plan was prepared for the development of 442 gardens, of sizes varying between 25 to 30m^2. It was decided that abandoned and undeveloped city areas would thus be transformed into areas for production and self-sufficient supply of food. The goal of the municipal administration is to increase by 10% the number of garden projects that include self-sufficient supply for residents before 2020. The municipal administration also offers expert assistance to owners of already allocated gardens, in the form of lectures and workshops. Interest for self-production of fruit and vegetables is growing every day, as the city residents wish to consume healthy and ecologically produced vegetables with the smallest burden on the environment possible. This conscientiousness is even more present in countries with large urban surfaces, where botanic gardens in particular can instruct the local population – with workshops and various projects – regarding gardening and self-sufficient supply of food (Botanic Gardens Conservations International 2011).

Interest for gardens is quite high in the municipality of Ljubljana, it is therefore not surprising that support by the municipal administration is significant. For this reason, the Municipal Administration Board was happy to adopt the proposal by the Botanic Garden to develop gardens on the abandoned plots. Even more so, as the Botanic Garden helped create a positive story by connecting experts with city residents, and present the knowledge and joint practice to the general Slovenian public with the help of the media. When developing the “Gardens behind the railway line” project, we considered current and traditional practices, as well as the wishes of the individuals. Our garden development and planting programme was in no way fixed; we adapted to our audience, who could submit requests on what they wanted to see or learn in the popular TV live broadcast. By answering questions sent by our audience to the editorial board of the broadcasting company, we constantly followed current gardening subjects. Another positive outcome of the project is that a community also formed among the gardeners – a community of retirees, young families, and other peoples. Before the planting season, they exchanged saplings and seeds, and after the growing sea-

> Keywords BOTANIC GARDENS URBAN GARDENING SOCIAL ROLE SUSTAINABLE DEVELOPMENT VEGETABLE GARDENING

06. Discussion

• Blanka Ravnjak
• Bavcon Jože

son – crops. These crops were truly grown naturally (without pesticides and phytopharmacological agents), and were therefore of high quality. We also taught the gardeners how to eliminate pests from the garden using natural preparations and planting a combination of plants. With the popularisation and supply of domestic species of cultivated plants for the gardeners, we contributed to the preservation of local cultivars. We were able to explain to the gardeners that autochthonous species have the best adaptations for growing in our environment, and will grow more successfully with less care. Other botanic gardens throughout the world are also promoting the autochthonous plant species of their regions. Namely, this increases the genetic diversity of plants and promotes sustainable supply of locally grown cultivated plants characteristic of each individual countries (Taylor & Straley 1988; CBD 2012; Sharrock 2012). There was another positive outcome of the project as the gardeners did not only take care of their own garden, but also cared for the surroundings environment. Occasionally, meetings were organised in the Botanic Garden, where each gardener presented their current gardening difficulties, whereupon the experts attempted to find a solution. An intergenerational community was thus formed, where the experts of the Botanic Garden helped city residents to produce natural food by teaching them sustainable development methods for growing cultivated plants. But gardeners of the "Gardens behind the railway line" were not the only ones with a thirst for gardening knowledge; there were many others, who had sufficient surface to develop a garden next to their house, but lacked the know-how and knowledge. For this reason, the botanic garden organised a gardening course in 2014. It began during spring and lasted until the end of June. Thirty participants attended the course. The participants completed a 20-hours course, where they were primarily taught how to create a vegetable garden and how to grow high-quality vegetables at home. They learned how to suitably prepare the soil, when and how to plant or sow vegetables, what care is needed during the growing season, how to protect plants against pests, and when to harvest the crops. Furthermore, the staff of the botanic garden taught them how to collect the seeds of vegetable plants and how to manage cultivated plants in a sustainable manner. Our experience is not unique, the experts from the Denver Botanic Garden in the United States instructed the local population in a similar way by encouraging them to grow their own plant products and promote a healthy lifestyle (Derewnicka *et al*. 2015). Promotion of health food production was also implemented in the Auckland Botanic Gardens in New Zealand (Benham 2005).

For the city residents that own a garden and have already a basic gardening knowledge, we organised a workshop in the Botanic Garden of the University of Ljubljana, entitled "From seed to seed". During the workshop, we encouraged the participants to create their own seed bank. We taught them how to identify seeds of various plant species and the maturity state. During the practical exercises, we familiarised them with proper collection of seeds and seed cleaning. We also taught them how to properly store the seeds so that they retain their germination ability for as long as possible – as well as stratification procedures. During the workshop we also showed them the seed bank of our botanic garden and explained the importance of seed banks for preserving of biodiversity, as well as promoting sustainable development when considering the preservation of cultivated plants and their wild relatives.

Naturally, new methods and new cultivated plants are constantly arising in gardening, leading even experienced gardeners into uncharted waters. In the Botanic Garden of the University of Ljubljana, we aim at accompanying

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06. Discussion

• Blanka Ravnjak
• Bavcon Jože

these trends and help answer current questions. We therefore organise every fortnight the so-called "gardening hours". We organise afternoon short lectures on gardening and answer any potential questions participants may have, thus providing expert assistance.

Conclusion

Botanic gardens, with their extensive plant collections and know how centres, are important centres for disseminating knowledge on gardening to the general public. With urban expansion and the increase of urban population, the general public has almost lost the knowledge on home-grown food. Today, the demand for healthy food, sustainable development, and reconnection with nature awake in people a genuine interest for gardening and caring for their own gardens. In the way, botanic gardens, through workshops, lectures, or projects – individually or with the assistance of the city authorities – help people grow healthy food, promote autochthonous species and their wild related species, search for new varieties of cultivated plants, and protect nature and biodiversity (Sharrock 2013; Gough & Accordino 2012). In the Botanic Garden of the University of Ljubljana, where we developed urban gardens together with the City of Ljubljana and the Slovenian Radio and Televisions in 2013, we strive to reach the same goals. We taught the owners of these gardens about gardening and provided expert assistance throughout the year. A gardening community developed on these gardens, encouraging members to help each other and exchange crops and seeds. Furthermore, by developing the gardens we gave the area, which used to be degraded and overgrown by invasive species, an added value. And the city got a new managed green area. Considering the success of this project in other parts of the country, other Slovenian cities followed the Ljubljana example and began developing their own urban gardens.

> Keywords BOTANIC GARDENS URBAN GARDENING SOCIAL ROLE SUSTAINABLE DEVELOPMENT VEGETABLE GARDENING

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LET IT GROW: BOTANIC GARDENS, MUSEUMS AND ZOOS CAMPAIGNING FOR BIODIVERSITY ACROSS EUROPE

Photo credit : An exhibition developed by Copenhagen Zoo as part of Let it Grow about what visitors can do to attract biodiversity at home. It includes three experimental patches (grass, weeds and meadow flowers); set aside for local biodiversity. *Copenhagen Zoo*

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> Keywords CITIZEN SCIENCE PUBLIC ENGAGEMENT LOCAL BIODIVERSITY CAMPAIGN COLLABORATION BOTANIC GARDENS ZOOS AQUARIA

06. Abstract

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- *Bonacquisti Sandro*
- *Irwin Zoe*

HOW CAN WE HARNESS THE POWER OF CITIZEN SCIENCE AND ACTION TO INCREASE AND ENHANCE THE VALUE OF OUR LOCAL SPACES FOR EUROPE'S BIODIVERSITY?

This workshop will be an opportunity to learn about projects focused on local biodiversity running in botanic gardens across Europe, to share your own experiences and to envision how botanic gardens can partner with zoos and museums to maximize their impact for safeguarding the future of European Biodiversity. BGCI will open this session by presenting the *Let it grow* campaign which will run, in collaboration with EAZA and ECSITE, the European Zoo and Museum Networks, between 2016-2017. The campaign will not only aim to raise awareness of biodiversity issues but engage European citizens in practical research and conservation activities in their local environments. This campaign has the potential to reach millions of Europeans who are already engaged with museums, zoos and botanic gardens as well as attracting new audiences. In order to do so, this workshop will brainstorm with delegates, ideas for projects and activities that can be run locally as well as scaled, across many sites and countries. The Botanic Garden of Rome will also present its vision of developing botanic gardens in Europe as citizen science centres. Both of these concepts will act as inspiration for discussing new ideas for projects that botanic gardens can run in collaboration with zoos and museums. Based on recent Eurobarometer surveys, biodiversity is a concept that is hard to communicate and many people are not able to fully understand its meaning. Join us to re-imagine how we could contribute to biodiversity conservation by actively engaging the people of Europe. This paper presents the results of a workshop held as part of the 2015 Eurogard Congress, which was attended by around 15 participants, under the topic of education. Two introductory presentations outlined the "Let it grow campaign" led by BGCI and on the CSMON-Life project led by the Botanic garden of Rome which was followed by group discussions. One of the main outcomes of the workshop was to suggest two areas where collaborative citizen projects could be developed.

> Keywords CITIZEN SCIENCE PUBLIC ENGAGEMENT LOCAL BIODIVERSITY CAMPAIGN COLLABORATION BOTANIC GARDENS ZOOS AQUARIA

06. Introduction

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Photo credit : An exhibition developed by Copenhagen Zoo as part of Let it Grow about what visitors can do to attract biodiversity at home. It includes three experimental patches (grass, weeds and meadow flowers); set aside for local biodiversity, ***Copenhagen Zoo***

WHEN DISCUSSING CONSERVATION, THE TOPIC OF BIODIVERSITY IS MOST LIKELY TO ARISE, HOWEVER THE TERM IS RELATIVELY NEW AND ALTHOUGH SCIENTIFIC UNDERSTANDING ON THE SUBJECT IS BECOMING MORE SUBSTANTIAL, THE GENERAL PUBLIC'S KNOWLEDGE IS STILL LACKING.

The topic is important as it not only considers species but also necessitates the consideration of the health and function of whole genetic families and ecosystems. Biodiversity is vast and inclusive and, therefore its protection is an essential part of future conservation, which is why it needs to be conveyed to the public effectively to ensure their understanding and support (McKinney, 2002).

From an educational perspective, biodiversity can be a problematic topic. It is difficult to summarise and conceptualise clearly and therefore is difficult to convey to non-specialists (Wals, 2001). When searching for current education resources on biodiversity the results are numerous, with varying definitions of the term. Therefore it is not surprising that the public has only basic knowledge of the topic and little engagement. For biodiversity education to be successful it needs to be clear and relatable. There is also a necessity for active participation as previous citizen science projects have shown, having the public conduct science improves their understanding drastically (Bonney *et al.*, 2009).

The projects presented within this workshop aim to cover both of these factors. The 'Let it Grow campaign' will be based on local biodiversity projects focusing on a few, key identifier species. The Botanic Garden of Rome's CSMON-LIFE project is also localised and seeks to get the public actively engaged in biodiversity conservation. The workshop also provided an arena to discuss the potential for future work on behalf of botanic gardens in this area. Participants discussed the logistics and potential of citizen science as a form of engagement with biodiversity as well as ideas for future citizen science projects. Thereby this paper presents examples of how to make biodiversity education; clear, by targeting specific species; relatable, by focusing on localised issues; and engaging, by allowing the public to be actively involved.

Why focus on local biodiversity?

Biodiversity, across Europe is under threat. According to the European Environment Agency: "Europe's biodiversity continues to be eroded resulting in

> Keywords CITIZEN SCIENCE PUBLIC ENGAGEMENT LOCAL BIODIVERSITY CAMPAIGN COLLABORATION BOTANIC GARDENS ZOOS AQUARIA

06. Why focus on local biodiversity?

• *Derewnicka Liliana*
• *Attorre Fabio*
• *Bonacquisti Sandro*
• *Irwin Zoe*

ecosystem degradation. Recent data showed that 60% of species assessments and 77% of habitat assessments continue to be in unfavorable conservation status." (EEA, 2015, p.1). This is not only problematic for the environment but is having huge impacts on the economy. Rapporteur, Gerben-Jan Gerbrandy, states that: "The services that nature provides us with, like clean water, clean air, fertile soil and food, are not only crucial for the well-being of human kind, they also represent an astronomical economic value. According to economists, each year we lose 3% of GDP due to the loss of biodiversity. That costs the EU €450 billion year after year." (European Commission, 2015). At the same time, there is a general lack of interest and understanding of biodiversity amongst the European public. According to the Flash Eurobarometer on biodiversity, a survey conducted through ad hoc telephone interviews, in 2013, there is definite under appreciation of the term biodiversity. "… slightly less than half of Europeans have heard of the term "**biodiversity**" and know what it means (44%). Three in ten have heard of it but don't know what it means (30%) and slightly more than a quarter have never heard of it (26%)." (European Commission, 2013, p.4).

Yet that does not mean people are not concerned about the concept since, "Nine in ten Europeans believe that the decline of forests, climate change, the endangering and disappearance of animals, the decline of natural habitats and the endangering of some plants are all serious problems." (European Commission, 2013, p.5). Furthermore, there is a discrepancy between those who are concerned and those who actively and knowingly participate in conserving biodiversity. i.e. "Respondents were asked whether they make a personal effort to protect biodiversity. Roughly four in ten respondents (38%) say that they do make such an effort…" (European Commission, 2013, p.79).

Taken all together this indicates that there is need for improvement in both public understanding and action, but that projects which focus on European biodiversity could have great potential. This is supported by a recent summary of progress towards the Aichi Targets. Aichi Target one states that: "by 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably" (CBD, n.d.). The Secretariat of the Convention on Biological Diversity found that although, there is evidence of improvement we are currently not making sufficient progress towards achieving target one.

The "Let it grow" campaign

The European 'Let it Grow Campaign' seeks to address the deficit in progress on Aichi Target one (Secretariat of the Convention on Biological Diversity, 2014).

'Let it Grow' is a collaborative campaign between Botanical Gardens Conservation International (BCGI), the European Association of Zoos and Aquaria (EAZA) and Ecsite – a European organization representing science centres, museums and institutes. The campaign will be launched in January 2016 and run until December 2017. The aim is to promote public awareness and involvement with local biodiversity. The two year campaign will harness the power of citizen science to increase the value of our local spaces for Europe's biodiversity.

The campaign will exploit varying levels of engagement ranging from awareness raising to active participation in the measurement of biodiversity.

> Keywords CITIZEN SCIENCE PUBLIC ENGAGEMENT LOCAL BIODIVERSITY CAMPAIGN COLLABORATION BOTANIC GARDENS ZOOS AQUARIA

06. The "Let it grow" campaign

• *Derewnicka Liliana*
• *Attorre Fabio*
• *Bonacquisti Sandro*
• *Irwin Zoe*

The campaign will also support communities to preserve a portion of their green space for local biodiversity. Flagship species will be used to illustrate the challenges facing our wildlife with explanations on how these challenges have arisen. The partnership began on 11th September last year with the signing of a Memorandum of understanding between EAZA, ECSITE and BGCI. Going forward, these institutions will oversee and disseminate the campaign, share educational resources and recruit and support other partners who will fundraise; design and run activities and citizen science projects focused on local biodiversity in their area and publicize the importance of biodiversity.

Let it Grow is based on EAZA's model of biodiversity campaigns; it produces branding and activities at Zoos in Europe to raise money in order to fund biodiversity conservation projects.

The model has proved successful in European zoos and aquaria. For example, in 10 years, the EAZA biodiversity campaigns have raised over €3.3 million for conservation projects around the world, created new links between EAZA and other conservation organisations, been the catalyst for regulatory change, as well as raising awareness and offering funding to over 100 hundred conservation projects (EAZA Executive Office, 2010).

Specifically, in 2006, they launched their 6th campaign: the EAZA Madagascar Campaign. The aim was to:

- raise awareness of one of the world's most important reservoirs of natural history, using the unique fauna and flora found on Madagascar; promote the idea of biodiversity;
- promote ecotourism to Madagascar;
- raise funds for specific conservation projects;
- highlight ways in which the public can make positive contributions towards conservation through their daily lives;
- raise awareness for Malagasy endemic species amongst EAZA members and thereby influence future collection planning;
- promote the concept of "twinning" between EAZA members and National Parks and protected reserves (EAZA Executive Office, 2010).

Many of the aims of the Madagascar project and the lessons learnt through their other campaigns, are akin to the objectives of 'Let it Grow'. In particular, the ability to raise public awareness and create collaborations and partnerships between institutions within and out with EAZA. However, 'Let it Grow' seeks to take this further. Events and projects associated with the campaign will be run as partnerships between botanic gardens, zoos and science centres. The rationale behind this is that by getting together botanic gardens, museums, science centres and zoos they can maximize their impact through broadening their reach by combining audiences, as well as sharing expertise in different aspects of biodiversity, education and public engagement, in addition to offering a more holistic view of biodiversity by considering animals and plants together. Besides merely raising awareness, this campaign also seeks to be the spark for developing projects which inspire and facilitate participation in conservation on the part of the public through collaboration and citizen science.

The first step in developing the campaign is to *collect resources*, such as lesson plans or field guides, and activities related to local biodiversity that can be adapted and used by institutions across. As part of the campaign preparations, EAZA, Ecsite and BGCI are putting together *working groups* to develop and execute the strategy.

> Keywords CITIZEN SCIENCE PUBLIC ENGAGEMENT LOCAL BIODIVERSITY CAMPAIGN COLLABORATION BOTANIC GARDENS ZOOS AQUARIA

06. The "Let it grow" campaign

• *Derewnicka Liliana*
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WORKING GROUPS

Education: This group will review existing educational resources and adapt them for use across our networks of science centres, botanical gardens, zoos and aquariums.

Scientific: This group will advise on the scientific aspects of the campaign, defining what biodiversity means and what a biodiverse environment will look like.

Communications: This group will ensure smooth communications with all campaign participants and develop and execute a strategy for external communications to the media.

Citizen Science: This group will develop the tools and partnerships needed to allow members of the public to measure biodiversity as accurately as possible.

Fundraising: This group will develop a framework for raising funds for worthy local biodiversity causes at our institutions, and how that money will be awarded.

Assessment group: This group will design the measurement criteria for the campaign, working out how well we have done in raising awareness of biodiversity and getting people involved in measuring and creating it.

To join a working group e-mail *Liliana.derewnicka@bgci.org*

Botanic gardens as citizen science centres

To enhance public engagement and encourage participation in conservation, there is need for expertise and shared experience in contemporary techniques, one example is citizen science, which can be defined as the participation of citizens in research activities in several forms, often focused on the collection of field data (Miller-Rushing et al. 2012). There are a number of citizen science projects aiming at preserving biodiversity across Europe and the world which are strictly related to botanic gardens, and zoos. Some examples are:

- The New York Botanical Garden Citizen Science Service has developed several projects involving citizen scientists in collecting data about forest phenology, water quality (by monitoring invertebrates) and observations of birds. The most recent project is "Listening to the trees", which aims at engaging citizens for monitoring the impact of climate change on natural forests. (NYBG, n.d.).
- The Chicago Botanic Garden has several ongoing citizen science initiatives together with several partner institutions in the US. Two examples are Budburst, in which citizens are asked to observe how plant communities change with seasons (National Ecological Observatory Network, 2015), and project Plant of Concern, aimed at monitoring rare plants (Chicago Botanic Garden, 2015).

In Europe, citizen science has been fostered mostly by Universities and Museums, especially in northern countries. A new project that has the potential to encourage and enhance participation in conservation and thus raise awareness of the importance of local biodiversity is CSMON-LIFE.

> Keywords CITIZEN SCIENCE PUBLIC ENGAGEMENT LOCAL BIODIVERSITY CAMPAIGN COLLABORATION BOTANIC GARDENS ZOOS AQUARIA

06. Botanic gardens as citizen science centres

• *Derewnicka Liliana*
• *Attorre Fabio*
• *Bonacquisti Sandro*
• *Irwin Zoe*

THE CSMON-LIFE PROJECT

The LIFE+ funded, CSMON-LIFE (**Citizen Science Monitoring**), takes place within the Rome area. The project aims to develop simple Apps for smartphones to activate citizen science campaigns, which will be focused on environmental issues, such as:

- Loss of biodiversity because of the presence of alien species
- Effects of climate change
- Conservation of rare species
- Impact of human activities on the environment

During these campaigns citizens monitor targeted animal and plant species, which are indicators of such environmental issues. The data, once validated, will feed the National Biodiversity Network (NNB) portal of the Italian Ministry for the Environment. The project, following other positive experiences from the United States and in other European countries, will also involve several Bio-blitzes in specific survey areas. For example:

- Species campaigns: Lichens and air quality, and Good and Bad Squirrels
- Rare species / climate change
- Alien species monitoring (identified by picture and location, GPS)

CALL FOR CITIZEN SCIENCE CENTRES AT BOTANIC GARDENS

Botanic gardens are skilled in scientific research and public engagement and therefore have great potential in the area of local biodiversity and citizen science. To encourage support of botanic gardens and similar institutions to carryout work of this nature, effective examples and sharing of best practice is required. Dedicated centres for citizen science, located in botanic gardens, could provide hubs for citizen science to achieve these goals. This would have benefits for both public engagement with local biodiversity, and other environmental topics, as well as for the botanic gardens themselves. Although this would require that botanic gardens adapt to rapidly developing technologies and environmental needs, these centers would: :

- Provide a new function to BGs and increase their visibility.
- Facilitate the spread of knowledge about the CS and related initiatives.
- Increase the capacity of BGs when dealing with biodiversity and environmental issues.
- Support the networking on common methodologies, approaches, exchange of good practices.
- Help BGs with low skills and capacities.

Discussion points during the workshop

- People need to be rewarded for their contribution to citizen science: Acknowledgement in published paper (name or group name).
- Arguably, in citizen science projects which merely focus on the production of big data, the public are not ‘doing science’. There needs to be a real question for it to be science. Not just monitoring for the sake of it. The public must be aware of the intended use for the data. When we consider the idea that citizen science aims to engage people with the scientific process as well as content, collaborative/extreme citizen science is the best way to meet this end as the public are involved from the start. But, there can be different engagement levels in one project, i.e. some groups can be involved in project design and others only in monitoring.

> Keywords CITIZEN SCIENCE PUBLIC ENGAGEMENT LOCAL BIODIVERSITY CAMPAIGN COLLABORATION BOTANIC GARDENS ZOOS AQUARIA

• *Derewnicka Liliana*
• *Attorre Fabio*
• *Bonacquisti Sandro*
• *Irwin Zoe*

06. Discussion points during the workshop

- Experienced botanic gardens could be used as professional development hubs for other gardens to visit.
- The design of the project needs to be audience specific.
- Scientific verification tools are required: partner with universities or natural history museums.
- Engaging the public with the concept of biodiversity is not easy. According to the Flash Eurobarometer on biodiversity, conducted in 2013, “Nine in ten Europeans believe that the decline of forests, climate change, the endangering and disappearance of animals, the decline of natural habitats and the endangering of some plants are all serious problems.” (European Commission, 2013, p.5) therefore they are generally aware of the issue, yet not actively engaged. Creating links between plants and animals/birds/bees can be an effective engagement method, especially with children. This is also an effective way of illustrating the interdependence of global biodiversity. On the other hand, asking societal questions can make science relevant to people.

Ideas suggested for collaborative citizen science projects

PROJECT IDEA 1: BIODIVERSITY FOR WELLBEING

Question: What affect does biodiversity have on wellbeing?

Rationale: Horizon 2020 funding looks for a strong social element. Biodiversity to people’s wellbeing highlights the importance of biodiversity and its relevance to human existence. Links to the COHAB initiative that seeks to “address the gap in awareness, policy and action on the links between biodiversity and human health and well-being.” (COHAB, n.d.).

Public involvement: Monitoring their own wellbeing in various settings.

PROJECT IDEA 2: ORNAMENTAL PLANTS

Rationale: There is a lot of public knowledge and interest in this area, but not a lot of scientific research. Using ornamental plants as a hook will lead into questions of native vs non-native plants, hardiness in the face of climate change, monitoring for potential invasiveness and public engagement with the implications of this, etc.

Public involvement: Monitoring ornamental plants in public or private gardens.

> Keywords CITIZEN SCIENCE PUBLIC ENGAGEMENT LOCAL BIODIVERSITY CAMPAIGN COLLABORATION BOTANIC GARDENS ZOOS AQUARIA

06. References

• *Derewnicka Liliana*
• *Attorre Fabio*
• *Bonacquisti Sandro*
• *Irwin Zoe*

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ENTRÉE DU NUMÉRIQUE DANS LES JARDINS BOTANIQUES DES FACULTÉS DE PHARMACIE : LE PROJET SMARTJARDIN

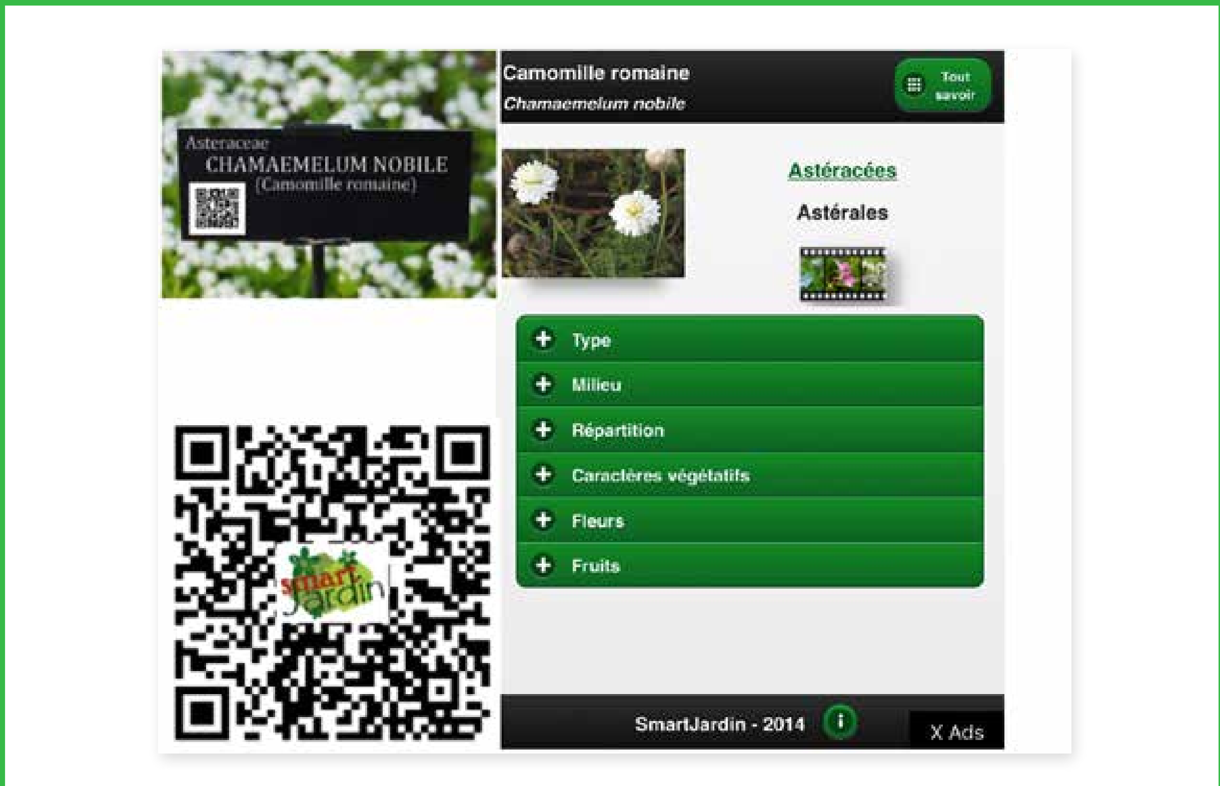

Photo credit : Smartjardin : les éléments majeurs de l'étiquetage connecté, ***Frédéric Dupont et Elisabeth Chosson***

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> Mots-clefs JARDIN BOTANIQUE JARDIN CONNECTÉ QR CODE ÉTIQUETAGE

06. Résumé

• *Chosson Elizabeth*
• *Dupont Frédéric*

SUITE À DEUX APPELS À PROJETS SUCCESSIFS, LE PROJET *SMARTJARDIN* (HTTPS://SMARTJARDIN.UNIV-ROUEN.FR) A VU LE JOUR DANS UNE PREMIÈRE VERSION EN 2012 ET DANS SA VERSION ACTUELLE EN 2014.

Ce projet s'est construit autour de l'élaboration de 100 fiches numériques illustrées de plantes médicinales ou toxiques par des enseignants-chercheurs en botanique de différentes facultés de pharmacie françaises. Par ailleurs, une application web a été développée pour permettre la consultation des fiches sur des appareils mobiles (smartphones) ; cette application est liée à un espace collaboratif performant, permettant aux auteurs de saisir leurs données (*http://smartjardin.univ-rouen.fr/admin*).

Les fiches signalétiques de chaque plante sont accessibles par le décodage d'un QR Code que les responsables de jardin peuvent directement générer sur la page de présentation du projet et placer sur les étiquettes des plantes. Les fiches sont également valorisées et consultables chez soi sur un ordinateur fixe au travers d'une autre application, jardins botaniques virtuels (*http://jbv.univ-rouen.fr*).

Une troisième version du projet pourrait être multilingue, adaptée à une diffusion et une collaboration au niveau européen.

> Mots-clefs JARDIN BOTANIQUE JARDIN CONNECTÉ QR CODE ÉTIQUETAGE

06. Introduction

• *Chosson Elizabeth*
• *Dupont Frédéric*

Photo credit : Smartjardin : les éléments majeurs de l'étiquetage connecté, *Frédéric Dupont et Elisabeth Chosson*

C'EST EN JANVIER 2012 QUE LE PROJET *SMARTJARDIN* A ÉTÉ LAURÉAT DE L'APPEL À PROJET ANNUEL DE L'UNIVERSITÉ NUMÉRIQUE DES SCIENCES DE LA SANTÉ ET DU SPORT, (UNF3S, HTTP://WWW.UNF3S.ORG) ET A PU OBTENIR SON PREMIER FINANCEMENT.

De mars à juin 2012, après une conférence du Dr Jean de Vaugelas, océanographe à l'université de Nice-Sophia Antipolis, pionnier dans l'utilisation des QR-codes et de la réalité augmentée, les auteurs et contributeurs se sont réunis en groupes de travail.

Le groupe « pédagogie » a travaillé sur le choix des plantes et la rédaction des fiches ; le groupe « ingénierie informatique » s'est penché sur la conception de l'application et la mise en forme des bases de données.

De juillet à août 2012 ces mêmes groupes ont assuré des corrections croisées des fiches, la recherche de l'iconographie et la saisie des données dans l'application en pré-production. Ces premiers travaux ont débouché en août 2012 sur l'inauguration du premier *Smartjardin* à l'UFR de pharmacie de Paris Descartes lors des journées scientifiques STOLON (association nationale des enseignants-chercheurs de sciences végétales et fongiques des facultés de pharmacie francophones). Enfin, en octobre 2012, la mise en production de l'application « *Smartjardin* », version 1, a été réalisée.

L'application Smartjardin, version 1

La première version de *Smartjardin* a été financée par l'UNF3S. Cinq universités partenaires ont travaillé sur le projet : Angers, Lille 2, Paris Descartes, Paris Sud et Rouen. L'application web et la base de données ont mobilisé un ingénieur pédagogique, un développeur et un stagiaire en informatique. La rédaction et l'illustration des fiches ont été réalisées par 6 auteurs des 5 universités suscitées et 2 contributeurs (relecture et iconographie), tous enseignants-chercheurs dans des facultés de pharmacie.

Une page web de présentation du projet a été créée à l'adresse : http://smartjardin.univ-rouen.fr (adresse de contact : smartjardin@univ-rouen.fr).

50 fiches de plantes médicinales ont été rédigées. Chaque fiche comporte une page d'accueil avec les principaux caractères botaniques de la plante, un lien vers la description de la famille, une rubrique « tout savoir » avec les

> Mots-clefs JARDIN BOTANIQUE JARDIN CONNECTÉ QR CODE ÉTIQUETAGE

06. L'application Smartjardin, version 1

• Chosson Elizabeth
• Dupont Frédéric

confusions, les usages… Des liens dans les textes de cette fiche renvoient vers une image ou vers un carrousel d'images (ex : http://smartjardin.univ-rouen.fr/fiche.php?id=46).

Les fiches ont été conçues pour être accessibles sur dispositifs mobiles (smartphone et tablette connectés à l'Internet à travers le Wifi, le 3G ou le 4G) ; l'accès se fait par décodage d'un QR code (http://qrcode.fr) directement placé sur l'étiquette de la plante dans les jardins botaniques grâce à l'utilisation d'applications nombreuses et gratuites de décodage (ex : http://www.beetagg.com/fr/).

Evolution de l'application : *Smartjardin* version 2

En janvier 2013 : la seconde version a été de nouveau lauréate de l'appel à projets annuel de l'UNF3S.

De nouveaux partenaires sont venus renforcer le groupe des auteurs : 3 enseignants-chercheurs des Universités de Rennes 1, Lorraine et Bourgogne. 50 nouvelles fiches concernant les plantes toxiques ont été élaborées.

En juin 2013 a eu lieu l'inauguration d'un nouveau Smartjardin en présence des autorités régionales et universitaires : le jardin botanique de la faculté de pharmacie d'Angers dont l'étiquetage présente désormais des QR code intégrés.

Une plateforme collaborative gérée par une équipe d'administrateurs et de gestionnaires : http://smartjardin.univ-rouen.fr/admin a été mise en place pour intégrer des contributions soumises à authentification et validation ; de juillet à août 2013, les groupes de travail se sont attelés aux corrections croisées des fiches, à la recherche de l'iconographie et à la saisie des données. Enfin, en septembre 2013, l'application *Smartjardin* V2 a été mise en production. De nouveaux jardins ont mis en place *Smartjardin* en 2014 : le jardin botanique de la faculté de pharmacie de Lille 2 et le Jardin botanique « Dominique Villars » de la faculté de pharmacie de Grenoble.

Les jardins botaniques virtuels

La base de données de Smartjardin sert également à une nouvelle application : « jardins botaniques virtuels » (http://jbv.univ-rouen.fr), qui permet aux étudiants de revoir chez eux sur leur ordinateur de bureau les fiches des plantes vues dans les jardins botaniques. En outre, l'application propose une série de questions de façon ludique par l'intermédiaire de personnages déambulant dans le jardin virtuel, pour en faciliter l'apprentissage.

Utilisation de *Smartjardin*

Pour les visiteurs des jardins un dispositif mobile connecté 3G, 4G ou WiFi (ce qui facilite le chargement des images) est nécessaire : tablette, téléphone (sous Android ou iPhone). Il faut, en outre, télécharger une application (gratuite) permettant de décoder des QR codes comme Beetag QR Reader, Kairos Flash QR Reader, etc…Au travers de l'objectif du dispositif mobile, le QR code

06. Utilisation de Smartjardin

• Chosson Elizabeth
• Dupont Frédéric

est transformé en adresse Internet, ce qui renvoie automatiquement le visiteur sur le site Internet porteur des informations.

L'utilisation des fiches et des illustrations est gratuite sous licence creative commons CC BY-NC-SA 3.0 FR (Attribution-pas d'utilisation commerciale-partage dans les mêmes conditions 3.0 France, *https://creativecommons.org/licenses/by-nc-sa/3.0/fr/*). La consultation régulière du site permet de connaître les nouvelles fiches disponibles créées par les jardins botaniques souhaitant présenter de nouvelles espèces, avec de nouveaux QR-codes qui peuvent être générés en se rendant à l'adresse *https://smartjardin.univ-rouen.fr/admin/qrcodes/qrcode_index.php*, lien que l'on retrouve sur le site en cliquant sur « Générer d'autres QR codes ».

Contribution à *Smartjardin*

Chaque jardin ou chaque botaniste peut contribuer à enrichir la banque de données de Smartjardin par la rédaction de nouvelles fiches, le partage d'illustrations ou en suggérant de nouvelles idées.

Les nouvelles idées peuvent être transmises à l'adresse de contact *smartjardin@univ-rouen.fr.* Pour devenir contributeur, il suffit de se rendre à la rubrique « Comment contribuer » du site et de remplir un petit formulaire qui sera soumis aux gestionnaires du site.

Conclusion

Ce projet a été le premier du genre en France. En Europe, des projets similaires commencent à se développer dans certaines présentations des jardins botaniques de Kew (Royaume-Uni), Vienne (Autriche), Meise (Belgique). Pour *Smartjardin*, il s'agit désormais d'enrichir la banque de données, d'ajouter de nouvelles fiches, tels des projets actuels de composition de fiches de plantes toxiques d'appartement, rédigées dans le cadre de projets d'unités d'enseignement libres d'étudiants en pharmacie ou de rédaction de fiches de plantes médicinales et toxiques méditerranéennes dans le cadre de thèses de doctorat d'exercice pharmaceutique.

Parmi les nouveaux jardins on comptera de 2015 à 2017 le Jardin de la Faculté de pharmacie de Toulouse 3, le Jardin Botanique « Jean-Marie Pelt » de Nancy, le Jardin de l'Arquebuse de Dijon, le Jardin de plantes médicinales du Musée Flaubert et d'histoire de la médecine de Rouen et le Jardin Massart de l'Université Libre de Bruxelles.

Une troisième version de *Smartjardin* pourrait devenir multilingue, favorisant ainsi les contributions hors du territoire français.

06. Remerciements

• *Chosson Elizabeth*
• *Dupont Frédéric*

Différents enseignants-chercheurs de faculté de pharmacie doivent être remerciés ici, soit pour leur implication scientifique dans la composition, la rédaction et l'illustration des fiches, au travers de nombreux échanges collaboratifs, soit pour leur aide dans la mise en place matériel de l'étiquetage spécifique dans les jardins botaniques respectifs :

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- Université de Bourgogne : Nathalie Séguy (auteur)
- Université de Lille 2 : Luc Dubreuil (ancien doyen)
- Université de Lorraine : Marie-Paule Sauder (auteur), Francine Paulus (doyen)
- Université Paris Descartes : Florence Leclerc (auteur), Gwenaël Ruprich-Robert (auteur), Annie Brulfert (contributeur), Martine Aïache (ancien doyen)
- Université de Paris-Sud : Annick Simon (auteur), Dominique Porquet (ancien doyen)
- Université de Rennes1 : Françoise Le Dévéhat (auteur).

THE POTENTIAL OF THE BOTANIC GARDEN FOR INQUIRY-BASED TEACHER EDUCATION

Photo credit : On photo-safari in the botanic garden Bremen, **Doris Elster**

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> Keywords SCIENCE EDUCATION GARDEN EDUCATION TEACHER TRAINING BOTANY BIODIVERSITY

06. Abstract

• *Elster Doris*

BASED ON THEORETICAL CONSIDERATIONS ABOUT THE LOW INTEREST OF ADOLESCENT IN BOTANY AND PLANTS A PATHWAY TO OVERCOME THE SO-CALLED PLANT BLINDNESS WITH METHODS OF INQUIRY-BASED SCIENCE EDUCATION (IBSE) IS GIVEN: *THE INQUIRE FOR TEACHER STUDENT PROGRAM* DEVELOPED AT THE UNIVERSITY OF BREMEN.

The program aims in the developing of IBSE activities to promote the awareness and interest in plants using the botanic garden and the green houses as authentic learning environment. The research focuses on the professional growth of the participants and on the demonstration of good practice examples, content and contexts, to raise the awareness of the green biodiversity. In addition, insights of the IBSE activity *Photo-Safari in the Botanic Garden* are given and results about pupils' learning within the program are reported. In the conclusion the potential of the botanic garden as an authentic learning environment for IBSE activities is discussed.

> Keywords SCIENCE EDUCATION GARDEN EDUCATION TEACHER TRAINING BOTANY BIODIVERSITY

06. Introduction

• *Elster Doris*

Photo credit : On photo-safari in the botanic garden Bremen, *Doris Elster*

INTERNATIONAL EDUCATIONAL RESEARCH DEMONSTRATES THAT THE INTEREST IN BOTANY OF ADOLESCENTS IS VERY LOW (SCHREINER & SJÖBERG, 2006; ELSTER, 2007).

Based on the ROSE survey (The Relevance of Science) Elster (2007) reports an increase of interest if the botanical content is connected with a student relevant context. But which contexts are relevant for the young generation? What are the challenges for biology teacher education to promote the interest in plants and botany? What is the potential of the botanic gardens to promote relevance and interest in botany?

THE IMPORTANCE OF BOTANIC GARDENS AS AN OUT-OF-SCHOOL LEARNING LOCATIONS

According to Rauer *et al.* (Rauer *et al.*, 2000) *'Botanic gardens are institutions that cultivate a documented living collection of plants to fullfil tasks in the field of scientific research and teaching, of education and the protection of species and nature.'* (Rauer *et al.*, 2000, p.5). In addition, botanic gardens offers visitors the original encounter with plants and any other living being and phenomena. The direct contact with plants allows the visitor the perception of life with all his/her senses (Fischbeck-Eysholdt, 2001).

In the view of the environmental educators, botanic gardens are excellent learning locations for the following thematical domains (Fischbeck-Eysholdt, 2001, p. 37):

- The complex relationship of plants to their environment
- The economic, cultural and aesthetical importance of plants in our life
- The connection between plants and the indigenous population
- The local environment and its global connection
- The global threat of the plant kingdom and the consequences of its destruction

According to Killermann (2005) the importance of the botanic garden is based on the original encounter of the green biodiversity in a multifaceted manner. Learners are allowed to make experiences with plants which are otherwise only possible via media. So they get to know and to value the diversity of plant spieces (Killermann, 2005).

> Keywords SCIENCE EDUCATION GARDEN EDUCATION TEACHER TRAINING BOTANY BIODIVERSITY

06. Introduction

• Elster Doris

PLANT BLINDNESS AS A PROBLEM OF THE HUMAN BRAIN?

According to Wandersee and Schussler (Wandersee & Schussler, 1999) plant blindness is defined as ‘*the inability to see or notice the plants in one's own environment, leading to the inability to recognize the importance of plants in the biosphere and in human affairs.*’ *Further on,* plant blindness also comprises an ‘*inability to appreciate the aesthetic and unique biological features of plants and the misguided, anthropocentric ranking of plants as inferior to animals, leading to the erroneous conclusion that they are unworthy of human consideration.*’ (Wandersee & Schussler, 1999, p. 82).

Most people don't pay attention to the fundamental role of plants and the effect on their life. But what causes plant blindness? Wandersee and Schussler (Wandersee & Schussler, 2001) argued that the primary contributor to plant blindness is the nature of the human visual information-processing system. People don't see all their surroundings by just opening their eyes. Their perception is connected with the knowledge about the object. As soon as people generally know more, for example about animals than about plants, they will pay more attention to the fauna than to the flora. In addition, chromatic homogeneity as well as the fact that plants are not moving at all, it can be seen as one of the parameters for the low interest in plants. The human brain is a detector of differences that needs changes in the patterns of space, time and/or colours. Plants don't show many differences and may therefore easily be overlooked.

VALORIZATION OF PLANTS – A CHALLENGE

According to Lindemann-Matthies (Lindemann-Matthies, 2009) the conservation of the diversity of plants mainly depends on their valorization and awareness. If nature is considered to be valuable, the readiness to protect endangered species is higher. Based on empirical results, a strong connection between the knowledge about and the valorization of plants can be observed. Therefore, it is an essential task of biology education not only to promote subject knowledge but perception, responsibilty and awareness as well in respect to nature and all living beings too (Weber, 2010).

Beside knowledge-based factors, emotional and experience based factors influence the awareness towards plants (Gebhard, 2013). Nature experiences are closely connected with the valorization towards specific nature experience. If the learners know the plants by name and context in their natural habitat, or have learned in the school about them, they appreciate their beauty and provide a deeper interest of their growing environment (Weber, 2010).

Interest is a decisive factor for the learning process (Krapp, 1998). If a learner is interested, than he or she builds a relationship to the the study object. In turn, this enables development of knowledge and competence in new situations. There are two major points of view from which interest can be approached: interest as a characteristic of a person (personal interest) and interest aroused by specific characteristics of the learning environment (situational interest).

Content and context of a learning object can steer the development of the situational interest or circumstances in which one can find a deepened interest (Krapp, 1998). Based on the ROSE survey (The Relevance of Science) conducted with 8th Graders in Germany and Austria, Elster (Elster, 2007) reports that the following three content items are in respect of relevance among the ten less interesting themes: *Structures and patterns of leaves and flowers; How*

> Keywords SCIENCE EDUCATION GARDEN EDUCATION TEACHER TRAINING BOTANY BIODIVERSITY

06. Introduction

• *Elster Doris*

plants grow and reproduce; Plants in their environment. Elster (Elster, 2007) reported an increased interest as soon as the botanical content is connected with a student's relevant context. But what are such contexts? According to Gilbert (Gilbert, 2006) *'A context must provide a coherent structural meaning for something new that is set within an broader perspective.' And further on: 'Students should be able to provide meaning to the learning; they should experience their learning as relevant to some aspects of the lives and be able to construct coherent "mental maps" of the subject.'* (Gilbert, 2006, p. 960).

Based on the ROSE survey (Elster, 2007) such relevant contexts with regard to plants and botany are medicine and health, nutrition, drugs and mysteries, environmental education (ESD) and socio-scientific contexts (STS).

THE PROGRAM INQUIRE FOR TEACHER STUDENTS

INQUIRE for Teacher Students is a program in pre-service biology teacher education at the University of Bremen (Elster, 2013). The program is based on the European project INQUIRE (Inquiry-based teacher training for a sustainable future; INQUIRE Consortium, 2011). Science educators, teacher students and teachers work together in a Community of Practice (Wenger *et al.*, 2002). The goal is to raise the awareness of the plant diversity by developing inquiry-based teacher units in a range of student relevant contexts. The content of these teaching units is about botany, biodiversity loss and climate change, the major global issues of the 21st century. The program is based on a broad understanding of Inquiry Based Science Education (IBSE). We define scientific inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already understood; planning investigations; reviewing what is already known in the framework of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations and predictions, and to communicate these results (INQUIRE Consortium, 2011). In summary, inquiry based learning is not about to memorize facts – it is about many activities, such as working with living organisms (mainly plants), observing natural phenomena, formulating questions, linking evidence to explanations and finding appropriate solutions to explain observations and to address questions and problems. There may be simple tasks or complex undertakings to be carried out, but they always do lead to learners experience and the excitement of solving a question or a problem of their own, usually in the setting of a team (INQUIRE Consortium 2011; Elster, 2013).

In the program *INQUIRE for Teacher Students* teacher students and teachers organize and built school teams. They exchange learnings about the scientific background of biodiversity loss, climate change and the methods of IBSE in several locations, such as the Botanic Garden, the glass houses and the labs of the Department of Biology Education. They get support of science educators and professional botanists in the development of IBSE activities and of course also in pupil relevant context. All these require an agreement on the working process, shared goals of the participants, as well as a critical rethinking of each personal practice. Next, teacher students and teachers invite all participant school classes to reflect and evaluate the IBSE school projects. Teacher students evaluate the pupils' learned results and their gained increase of knowledge and interest in regard to *green biodiversity and inquiry-based learning*. In addition, the teacher students reflect on their own Professional Development (PD) and Pedagogical Content Knowledge (PCK) according to Park and Oliver (Park & Oliver, 2008). The outcome of the most recent given program results in a further development of the study in IBSE

> Keywords SCIENCE EDUCATION GARDEN EDUCATION TEACHER TRAINING BOTANY BIODIVERSITY

06. Introduction

• Elster Doris

Teaching, and twelve teacher students made a MEd thesis on IBSE training programme and pupils'learning.

In this paper, the author reports on teacher students learning in respect to the *INQUIRE for Teacher Student* Program. In addition, the content and methods of nine IBSE teaching units (Master Theses) are proposed and discussed. A special focus could be given by one of these IBSE units, *Photo-Safari in the Botanic Garden*. It shows how effective this learning programme can operate in detail and as useful tool in your Botanic Garden.

Materials & methods

This study reports the professional growth of teacher students (N=42) and teachers (N=12) within the *INQUIRE for Teacher Students Program*. To gather data we analyzed questionnaires (pre-post) with open-ended questions and the research diaries of the teacher students and teachers according to the paradigm of the Qualitative Content Analysis (Mayring, 1998). In addition, an overview will be given on master theses based on the *INQUIRE for Teacher Students Program*. This paper analyses the content and methods of IBSE activities that were used to promote the awareness of plants (**Table 1**).

As *a best practice example* for learning botany in a student-relevant context, the IBSE teaching unit *Photo-Safari in the Botanic Garden* and its effect on pupils' learning about plants and pupils' connectedness of nature will be given in this paper. The teaching unit *Photo-Safari* was originally developed and conducted in the *INQUIRE for Teacher Student* Course in the summer semester 2013 and later on further developed within a master thesis. The special focus of the evaluation is on the effectiveness of the program regarding the prevention of *plant blindness* described by Wandersee and Schussler (Wandersee & Schussler, 1999). Furthermore, the teaching unit gives insights in the effects on pupils' valorization of plants and their interest in plants in general, as well as their subject knowledge of a neophyte. According to these goals the following main research questions are selected:

1) How does the teaching unit *Photo-Safari* influence the awareness of plants and the interest in plants?
2) What do participating pupils learn in respect to subject specific content knowledge?
3) What are the effects of the *Photo-Safari* on the participant connectedness to nature?

The data of this teaching unit is based on pupils' questionnaires (N=25; 11th Graders) in a pre-post- design and based on interviews with both the participants (five group interviews) and the teaching staff (N=5). The data analysis of the closed items is based on cluster analysis. The open questions and the interviews are analyzed based on the paradigm of the Qualitative Content Analysis (Mayring, 1998).

Results

IMPACT OF THE PROGRAM INQUIRE FOR TEACHER STUDENTS

The participating student teachers and teachers reported an increase of subject-specific Content Knowledge (CP) and the Pedagogical Content

> Keywords SCIENCE EDUCATION GARDEN EDUCATION TEACHER TRAINING BOTANY BIODIVERSITY

06. Results

Knowledge (PCK) in the field of biodiversity and climate change. They gained knowledge about the pupil attitudes, knowledge and interest, and also on knowledge about planning and conducting IBSE activities. Furthermore on knowledge about the curriculum, as well as knowledge about unconventional assessment techniques, like concept cartoons and concept maps.

'Today we learned a lot about biodiversity. The different plant species and their morphological adaptation to climate factors – that was new for me.' (diary_teacher student_C1).

Based on the questionnaire survey (pre-test) this paper indicates that the teacher students have only a little prior knowledge about biodiversity. During the course the teacher students gained a more differentiated picture about the dimensions of biodiversity.

'[…]biodiversity, I knew before that it is about the different plant and animal species, different habitats and genetic diversity, I caught up on the meaning of the word "biodiversity" by reading, but I did not know how to implement this contents into my lessons before.' (diary_teacher).

The participants reported a constant increase in their level of knowledge about plants species. They gathered detailed information about plants and their survival in the winter, their pollinators, and the diversity of certain plant families, in example *Bromeliaceae, Orchidaceae,* and *Ericaceae* (i.e. *Rhododendron*).

An increase of the self-estimation of the teacher students about their own IBSE competences could be noticed at all times. Based on the novice-expert-paradigm (Dreyfus & Dreyfus, 1987), the teacher students moved from mainly "beginners" to "advanced" or "experienced" with regard to their competences in IBSE.

The participants reported an increase in practical knowledge on how to initiate and how to conduct IBSE processes. That led to a readiness to use inquiry-based teaching and learning approaches. The self-estimation of IBSE competences and the willingness to teach in this way arose as well.

The Botanic Garden offered an authentic learning environment to discuss the importance of plants, aspects of endangered biodiversity and the responsibility of human beings for the natural environment.

An overview of Master theses promoting the awareness of the importance of plants

Table 1 gives an overview about teaching units (MEd theses) which include IBSE activities. They all use a student-relevant context in the domain of Botany and Biodiversity to raise the awareness of the importance of plants in this respect. It should recognize that the connection of hands-on activities and mind-on activities will be crucial to promote pupils' learning. Socio-scientific contexts (STS) as well as contexts that aim in the Education of Sustainable Development (ESD) trigger also the interest of adolescent learners. Younger children like investigations, learning on stations, and outdoor activities. All programs listed in **Table 1** were evaluated within master theses. They all indicate a positive impact on pupils' awareness of green biodiversity.

> Keywords SCIENCE EDUCATION GARDEN EDUCATION TEACHER TRAINING BOTANY BIODIVERSITY

06.

• Elster Doris

Title	Graders	Subject content to promote the awareness of plants	Methods to promote the awareness of plants
Pineapples at all costs?	8-10	Rain forests in Costa Rica, diversity of Bromeliaceae and Pineapples industry	Simulation game with IBSE activities; socio-scientific context
Foodstuffs and climate change	7-8	Plants and their importance for nutrition; foodstuffs and trade	Learning on Stations; inquiry learning; health context
A ring-highway for Tenerife?	8-10	Nature conservation area at Tenerife and the possible destruction; impact on living beings and danger of erosion	Simulation game according to the syndrome approach; decision making in a socio-scientific context (STS)
Renewable resources	7-8	Which plant/field crop shall farmer Max plant to act sustainable?	Learning on Stations; inquiry learning; context is Education for Sustainable Development (ESD)
Hibernation of plants	5-6	Local plants, their stress resistance regarding freezing	Learning on Stations; IBSE activities about plants' mechanism to overwinter
Geocaching in the Botanic Garden	5-6	Discovering plants in and around the botanic garden; put them in order; invasive species	Outdoor-Activity; scavenger hunt; context is ESD
Thorns of roses	10-12	International rose farming (Africa) and trade; local and global impact; rose growing	Mystery with integrated IBSE activities; syndrome approach; STS context
Expedition to the Mount Kinabalu	7-8	Trail through the rain forests of Borneo till the 4000 meter high top; investigation of plants at different stages	Simulation game and inquiry learning; context ESD-adventure
Photo-Safari in the Botanic Garden	8-10	Classification of local plants and bio-invasive species; specialist - generalist	IBSE activity with focus on self-directed learning and communication; context ESD

> TABLE 1.

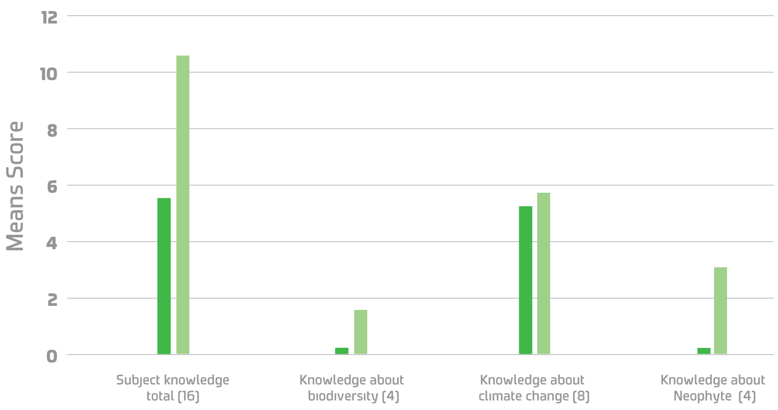
List of teaching units (Master Theses) to promote the awareness of plants. All activities are conducted in the botanic garden, the green houses and labs of the University Bremen in the years 2012-2015.

LEARNING EFFECTIVENESS OF THE IBSE TEACHING UNIT PHOTO-SAFARI IN THE BOTANIC GARDEN

The findings (**Fig. 1**) demonstrate that the participants could obviously expand their content knowledge regarding plants, their important role in the carbon cycle and the connection to neophytes, biodiversity loss and change in respect to climate change (significant increase). The participants score their subject knowledge developed within the Photo-Safari as important or very important.

Furthermore, the program *Photo-Safari* has a positive impact on the awareness of plants as well as the avoidance of *plant blindness*, as also recorded and in coherence concluded by Wandersee and Schussler in previous studies (Wandersee & Schussler, 1999). **Fig. 2** demonstrates that all factors to prevent *Plant Blindness* could be increased (e.g. Knowledge about Plants, Interest in

Learning Progress Subject Knowledge



	Subject knowledge total (16)	Knowledge about biodiversity (4)	Knowledge about climate change (8)	Knowledge about Neophyte (4)
Pretest	5,44	0,06	5,22	0,17
Postest	10,89	1,89	5,78	3,22

> FIGURE 1.

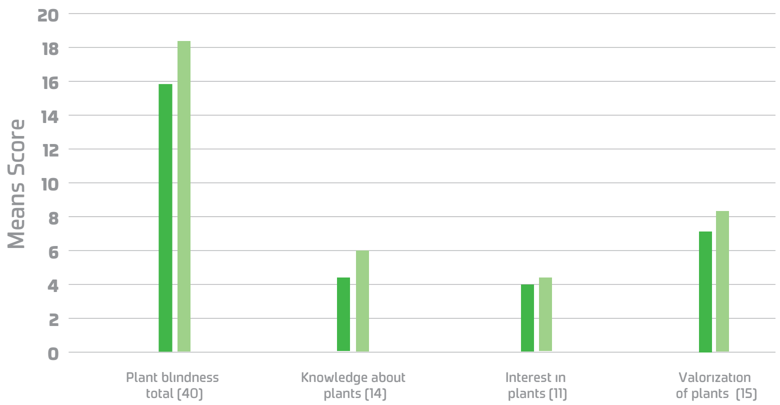
Means of the sum-scores of all participants regarding *Subject Knowledge*. The numbers in brackets are the maximal possible sum-score of the specific domain.

> Keywords SCIENCE EDUCATION GARDEN EDUCATION TEACHER TRAINING BOTANY BIODIVERSITY

06. Results

Plants, and Valorization of Plants). The findings are based on the questionnaire survey and are not statistically seen as significant. But the qualitative findings of the interviews support these positive results. In addition, the teachers agreed in the estimation, that the *Photo-Safari* could be useful as a very effective method to prevent plant blindness (Feldman-Bethe, 2014).

Impact on Plant Blindness, Interest, Valorization of Plants



	Plant blindness total (40)	Knowledge about plants (14)	Interest in plants (11)	Valorization of plants (15)
Pretest	15,78	4,56	4	7,11
Postest	18,17	6	4,22	8,56

> FIGURE 2.

Means of the sum-scores of all participants regarding *factors influencing Plant Blindness, Knowledge about Plants, Interest in Plants, and Valorization of Plants*. The numbers in brackets are the maximal possible sum-score of the specific domain.

The participants valued the importance of plants higher after taking part in the Photo-Safari. They argue that they have learned 'important issues'. It was not possible to increase their interest in plants. They only reported a high interest in the activity itself. Finally, the programme has a positive influence regarding their connectedness to nature.

Discussion & conclusion

The potential of botanic gardens for teacher education lies first of all in the multifaceted authentic learning environment. There are places for subject-content learning suitable for biology teachers and including in addition experiences with all senses. One of the students remarks in an interview: *'Visiting the botanic garden is like coming to an island within the city. It starts with the smell of fresh soil as the floor is not sealed. Watching the nature is like an ever changing adventure. I am fascinated about these changes. It allows me a deep insight in the processes of life.'* (group_interview3_students).

Another student points out *'the botanic garden allows outdoor experiences and helps learning the diversity of species.'* (group_interview2_students). Most of students state that – although the INQUIRE course is at the end of their academic study – they never have visited the Botanic Garden and the glass houses of the University Bremen before. They agree in following statements about the potential of the Botanic Garden:

- The Botanic Garden is an authentic learning environment that promotes fascination for living beings and life processes.
- The Botanic Garden offers possibilities for (guided) subject-content learning and direct observation of the diversity and plants.
- In dependence of age, sex and culture the contexts of interest about dealing with/learning about plants are different.
- Fascination and subject knowledge are essential preconditions to prevent plant blindness and supports awareness of plants and the interest in plants.

> Keywords SCIENCE EDUCATION GARDEN EDUCATION TEACHER TRAINING BOTANY BIODIVERSITY

06. Discussion & conclusion

• *Elster Doris*

- In addition, inquiry-based learning with hands-on and minds-on experiments supports positive attitudes about the diversity of plants.

To sum up, the integration of visits of the botanic garden in the teacher education program is important. If ongoing teacher value the Botanic Garden as learning environment, and if they recognize the fascination on the multifaceted possibilities, they may as ambassadors promote this fascination on the diversity of plants in the future. This paper show that the readiness to integrate a visit of the Botanic Garden with the given IBSE programme and INQUIRE course of the future school classes will be of great benefit to all other botanic gardens as well and can be seen as a prosperous future educational example.

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> Keywords SCIENCE EDUCATION GARDEN EDUCATION TEACHER TRAINING BOTANY BIODIVERSITY

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THE BOTANIC GARDEN OF THE UNIVERSITY OF MÁLAGA, A MEETING POINT FOR TEACHING AND AWARENESS


Photo credit : From left to right: Marta Recio (alone ; © ***Elena Bañares***), Antonio J. Jiménez-Lara, Guillermo Thode, Alfredo Asensi, Blanca Díez-Garretas, Elena Bañares, Antonio Heredia, José María Senciales, Manuel Marí-Beffa, José María Nieto-Caldera (© ***unknown visitor***)

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> Keywords BOTANIC GARDEN AWARENESS COLLABORATIVE TEACHING MULTIDISCIPLINARY RESEARCH WORKGROUP COOPERATIVE LEARNING SECONDARY SCHOOL UNIVERSITY

06. Abstract

- *Marí-Beffa Manuel*
- *Asensi Alfredo*
- *Bañares Elena*
- *Díez-Garretas Blanca*
- *Heredia Antonio*
- *Jiménez-Lara Antonio*
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SINCE 2007, THE DEPARTMENT OF PLANT BIOLOGY OF THE UNIVERSITY OF MÁLAGA, SPAIN, HAS BEEN DEVELOPING A NUMBER OF TEACHING APPROACHES IN COLLABORATION WITH OTHER UNIVERSITY DEPARTMENTS AND HIGH SCHOOLS OF THE CITY. THESE MULTIDISCIPLINARY ACTIVITIES HAVE BEEN GROUPED IN SEVERAL WORKGROUPS AND ANNUAL DISCUSSION PLATFORMS.

The workgroups are focused on topics such as histology, genetics, biochemistry, taxonomy, palynology, phenology, biogeography, ecology, ethnobotany, management of botanic gardens, or high school visits.

Amongst many other results, the book entitled “Plants of the Botanic Garden of the University of Malaga (UMA); Gymnosperms” has been edited and educational material for several degrees generated. Students of high schools have been guided during visits to the Botanic Garden and taught plant histology at a workshop in the garden facilities.

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06. Introduction

- *Marí-Beffa Manuel*
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IN THIS INNOVATIVE EDUCATIONAL PROJECT, THE ACTIVITY OF SEVERAL PROFESSORS OF THE UNIVERSITIES OF MÁLAGA (UMA, FIGURE 1), MEMBERS OF THE SPANISH NATIONAL RESEARCH COUNCIL (SPANISH: CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS, CSIC), TEACHERS OF HIGH SCHOOLS IN MALAGA AND A GROUP OF VOLUNTEER STUDENTS HAVE JOINED THEIR EFFORTS IN A CO-OPERATIVE-EDUCATION ACTIVITY.

The group, supported by the Málaga University has been accumulating an important data bank of the UMA botanic garden. Educational materials have been generated from the information stored in this bank, that have been used in various degrees offered by UMA and high schools. Teaching in these degrees has been improved and a number of final degree projects, a web site, and a book on the UMA botanic garden have been edited. This experience is similar to teaching experiences in other Spanish cities or cities from other countries.

> FIGURE 1

Overview of the Botanic Garden and the Faculty of Sciences of the University of Málaga. Image of the Botanic Garden from the Cactus and Succulent families sector. Observe the hemispheric Umbracle terrace characteristic of this garden

Teaching context

The project involves different subjects of several degrees of the Málaga University, such as Biology, Geography and Environmental Sciences. Some of these subjects are “Botany”, “Phytogeography and vegetation mapping”, “Evolutionary genetics”, “Developmental Biology”, “Cell Biology and Genetics”, “Cell Biology I”, “Computing for Biologists”, which share a similar plant biology teaching and involve about 700 students.

Objectives

THE GENERAL OBJECTIVES OF THIS PROJECT ARE :

a) Collaborative preparation of slides, posters or histological preparations from the botanic garden plants in UMA,

b) Preparation of end-of-degree works by volunteer students,

> Keywords BOTANIC GARDEN AWARENESS COLLABORATIVE TEACHING MULTIDISCIPLINARY RESEARCH WORKGROUP COOPERATIVE LEARNING SECONDARY SCHOOL UNIVERSITY

06. Objectives

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c) Application of educational material to the above-mentioned degrees,
d) Promotion of botanic gardens as a teaching tool in University degrees and Masters and in high Schools by the elaboration of a teaching book,
e) Development of a co-operative-education activity between teacher-researchers and students.

Teaching and research methodology

The method adopted by the project comprises a cooperative student-teacher activity which uses teaching material obtained from the Málaga University botanic garden. This teaching material is the result of an eight-year old teaching experience under grants from UMA. The material includes glossaries of garden plants, a book published by SPICUM (Publications Center at the University of Malaga), histological and photographic data from leaves of about 50 plants, and various experiences with students from high schools and UMA. This material has been used in the classroom in order to stimulate the study, visit and preservation of plants in the garden and the entry of students into research groups.

Satisfaction surveys have been conducted to obtain information about the objectives of the experience, this awareness of continuous learning of teachers and interaction between teachers and students. Students have been selected during class to explain this experience to their companions, opening a critical revision. All students have enjoyed this enriching experience. This strategy generates a multidisciplinary workgroup of teachers and students that reinforces learning skills and strengthens the knowledge of previous subjects. Results are stored in a Virtual platform of the Project at a section on formation of teachers: "*Jardín Botánico UMA, fichas bot. e histoteca* (PIE08-071)". Each group is assigned a Scrypt where the method is clearly explained. Each student uploads at a wiki the information and photographs obtained by the group. Debates, commentaries or clarifications are shared at a Forum. The workgroups can be ordered in three main topics: Cell Biology, Biochemistry and Genetics; Phytogeography and Human Geography; and Botanic teaching. While the first two workgroups are focused in both teaching and research, the third is almost exclusively dedicated to botanic teaching.

The teaching and scientific methodologies used are described:

1) CELL BIOLOGY, BIOCHEMISTRY AND GENETIC WORKGROUPS

Leaf histology: Ethanol fixation, agarose embedding, vibratome sectioning and Picro-fuchsin-Toluidine blue staining method were used for light microscopy histology of leafs. Glutaraldehyde fixation, Critical point drying and Metalizing by Sputtering methods were performed to obtain Scanning Electron Microscopy images (Pathan et al., 2010). Marí-Beffa M. and Jiménez-Lara A.J. are teachers in this workgroup.

Epicuticular waxes: Fixation, Critical point drying and Sputtering methods for Scanning Electron Microscopy were performed after Casado and Heredia (2001). Heredia A. is a teacher in this workgroup.

Genetics: Amino acidic sequences of proteins from angiosperm species belonging to families present in the botanic garden were compared with an APG classification of the garden species. Proteins were screened from ge-

> Keywords BOTANIC GARDEN AWARENESS COLLABORATIVE TEACHING MULTIDISCIPLINARY RESEARCH WORKGROUP COOPERATIVE LEARNING SECONDARY SCHOOL UNIVERSITY

06. Teaching and research methodology

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nomic (nuclear, mitochondrial and plastid) sequences (Genbank-PIR-Genomes-Organelle, NCBI; EMBL-Uniprot, EBI, GOLD, Doe Joint Genome Institute). Sequence variation and syntenies were considered using distances, NJ, parsimony, maximum likelihood methods by SeaView v4.25 software (Gouy et al., 2010). Thode G. is a teacher in this workgroup.

2) Phytogeography and Human Geography workgroups

Phytogeography: Small team of students were taught appropriate scales, and coordinate reference system (SRC) of each GIS project and reference orthophotograph (year/graphic resolution) and chronograms. Vectorial information layers were elaborated to provide scientific names, biotypes, stem diameters and locations. All groups collaborated at the UNION Geoprocess program fusing their Vectorial layers in each parcel to obtain a final design of the garden with the definition of the pathway network from google map views. Students are from first course of Biology degree with the same competences for plant species identification. Nieto-Caldera J.M. is a teacher in this workgroup.

Human Geography: Students from the last course of Geography were assigned several Garden sectors to geolocalize each plant and to provide UTM coordinates to them. Morphological, cartographic, bibliographic and general informative data were also assigned to each plant. Market prices of 50 plant species at garden centers were screened on the internet. Use prices were also estimated to refer added values of products: bonsais, wood, handicraft, cooking use, pharmacy, cosmetics or other uses, price and production by hectare. Local prices are annotated and errors by homonymies are prevented. Senciales J.M. is a teacher in this workgroup.

3) Botanic teaching workgroups

Glossary and File cards: Students from several courses of biology degree elaborated a botanic glossary of the garden using an online platform as a practice of Botany (Recio, 2008). File cards of each species were obtained following a methodology described in Recio et al. (2012). Recio M., Díez-Garretas B. and Asensi A. are teachers in this workgroup. Silva-Sánchez P. is a student in this workgroup.

Phenology: Phenology tables were obtained after Orskan (1989). Data from monthly visits to plants, phenophase photographs, and herbarium sheets were organized in an intranet databank. Recio M. is a teacher in this workgroup. Silva-Sánchez P. is a student in this workgroup.

Visits: In order to bring science closer to non-university level students, a private (Colegio Sagrado Corazón; CSC) and a public Secondary School (IES Politécnico Jesús Marín; PJM) were invited to bring some students to visit the Botanic Garden. This experience would allow us to check the interest and the "permeability" of these groups to botanical information. Depending on groups and student ages, a variety of teaching materials were produced. Before the beginning of the activity, the students received two brief talks related to the Project and the Botanic Gardens by Dr. Marí-Beffa and Dr. Recio, respectively. Student ages were comprised between 17 to 19 and 13 to 15 years old, for the private and the public secondary school, respectively. For this reason, the activity design was different in both groups. The first group (CSC) were divided into two sub-groups, older students attended a leaf histology workshop and youngest students conducted a visit tour through the garden to describe morphological characters of plants, previously explained

> Keywords BOTANIC GARDEN AWARENESS COLLABORATIVE TEACHING MULTIDISCIPLINARY RESEARCH WORKGROUP COOPERATIVE LEARNING SECONDARY SCHOOL UNIVERSITY

06. Teaching and research methodology

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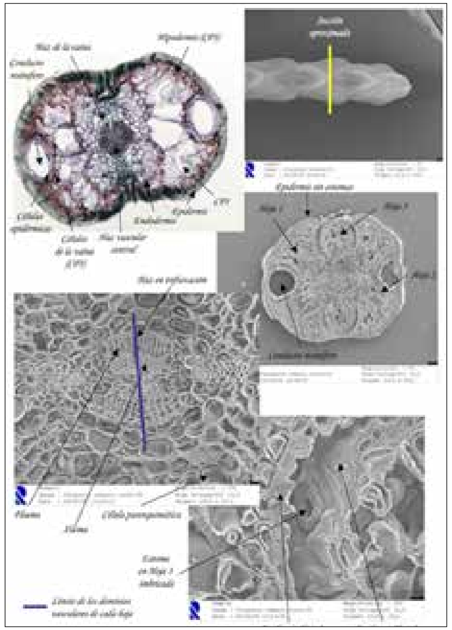
in a brief talk. The PJM students also performed a visit tour through the garden and they were provided with a small handbook with information, illustrations and location of 6 of the most representative specimens of the Botanic Garden. The handbook also contained a plant jigsaw that students had to solve at the end of the visit and some warnings on material recycling and good practice of water supply. Finally, they also red poems related to plants under the Umbracle. Moreover, visiting students took photographs of the garden and answered self-evaluation questionnaires on teachers and themselves. Recio M. and Bañares-España E. are teachers in this workgroup. Silva-Sánchez P. is a student in this workgroup.

Workgroup results and discussion

1. CELL BIOLOGY, BIOCHEMISTRY AND GENETIC WORKGROUPS

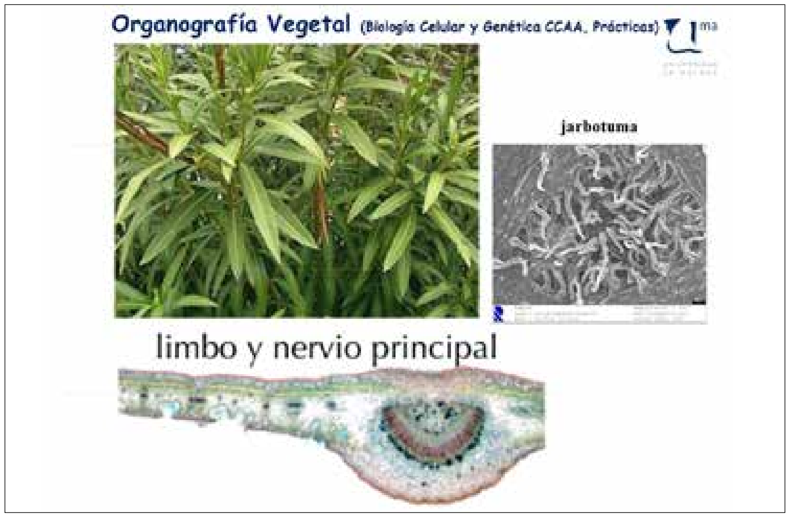
Leaf histology workgroup: This group generated histological preparations of leaves to obtain light and electron microscopy images of many species of the UMA Botanic Garden. Nineteen students in this group obtained images from 33 species to generate a histological collection of the botanic garden. Posters (see **Figure 2**) were also obtained from these images.

These results have been presented in several Teaching Congresses: The V Symposium of the Ibero-Macaronesian Association of Botanic Gardens, the Fourth Conference on Educational Innovation and virtual teaching at the University of Málaga, Málaga, Spain and a Congress on Cell Biology Teaching at Lleida, Spain; and several teaching slides of Plant Cell Biology subjects in Cell Biology I course of the Biology degree have incorporated material from this histological collection (see **Figure 3**):



> FIGURE 2

Histological results from *Juniperus phoenicea* L. subsp. *phoenicea* leafs. Poster with an optical image of a stained section and SEM images of leafs and leaf sections showing the main features of the leafs of this species. The figure is part of the book in figure 10



> FIGURE 3

Slide on *Nerium oleander* leaf used in practice of Cell Biology I course. Several images are used in theory and practice of Plan Cell Biology subjects at Cell Biology I course (second course of Biology degree). This slide shows a SEM image of a crypt in the oleander leaf (left) from histology workgroup (A.J. Jiménez-Lara, M. Marí-Beffa, J.M. Fernández-Figares, J. Ruiz-Sánchez)

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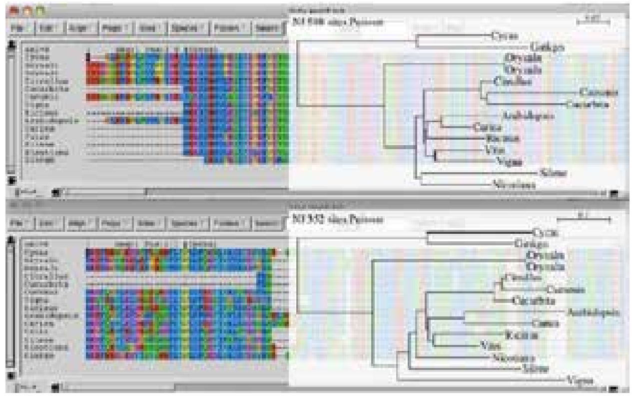
Epicuticular waxes workgroup: Three students have studied gymnosperm epicuticular waxes. They used SEM to revise the morphology of epicuticular waxes in leaves from 27 plants (**Figure 4**). According to morphology the molecular content of these waxes can be estimated. This has served as a collaborative teaching-learning experience and a screening for potential model species for chemical and biochemical research of epicuticular waxes.

> FIGURE 4

Material, collaborators and results of the epicuticular waxes workgroup. (Left) Scanning Electron Microscopy at the Central Service of Research Support. (Centre) Student of biology degree preparing samples. (Right) SEM image of epicuticular waxes from a leaf sample (A. Heredia)

Genetics workgroup: This group has analyzed mitochondrial and nuclear genes phylogenetic trees to assess plant diversity in the botanic garden. Students of evolutionary genetics and G. Thode have studied phylogenetic trees of proteins encoded by nuclear, mitochondrial and chloroplast genomes. Among these genomes, nuclear genes show the highest similarity with APG phylogeny (see matR and matK in **Figure 5**). Some of the characters used in "APG" system may be polyphyletic, such as number of chromosomes (2n), genome size, number of genes, mitochondrial genome size... Comparison of genomes revealed point mutation rates in mitochondria during the last 300 Myriads appropriate for the establishment of a coherent phylogenetic tree (**Figure 5**). Also synteny groups may also be useful for establishing taxonomic hierarchies (**Figure 6**). This data has been used during teaching of Evolutionary genetics (Biology degree) and Bioinformatics (Advanced Biotechnology Master) courses.



> FIGURE 5

Phylogenies of mitochondrial and nuclear proteins from plant families in the Botanic Garden. Sequence alignments and phylogenetic trees of mitochondrial (up) and chloroplast (bottom) proteins (Genetic workgroup, G. Thode)

> FIGURE 6

Mitochondrial genes (boxes) from 12 species of Angiosperms (columns) reveal a certain degree of 'synteny'. Colors must be used to clarify the study. For instance, non-coding rybosomal RNA genes are in black

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2. Phytogeography and Human Geography workgroups

Phytogeography workgroup: Three students and a teacher have positioned plant species in UMA Botanic Garden (http://www.jardinbotanico.uma.es/jardin-botanico/index.php) using the **Geographic Information System** (GIS). During the study, collaborators identified each plant using a GPS. As a result of this collaborative study a map (**Figure 7**) is obtained in which each sector is identified providing information on the plants in it.

> FIGURE 7

Satellite image of the UMA Botanic Garden of the University of Málaga. Sectors are numbered. A list of species names in each sector is provided after this study (A. Asensi and B. Diez-Garretas)

Two other students have compared this information with that provided by other Botanic Garden in Spain and the world writing a Revision on Management and Quality System (62 pages). This text has been given to the University of Málaga for further development of the garden.

> FIGURE 8

Slide elaborated by members of the Human Geography workgroup. Introductory slide of an oral presentation at three congresses on Geography or Botanic Garden Teaching

Human Geography workgroup: The analysis of the economic impact of the plants at the botanic garden searched for information in 2015 on the economic value of many plants in it. Three students of geography degree found data from 47 species. These data focused on reference prices and enterprises manufacturing them for different uses. Fluctuating prices depending on fashions (i.e. cosmetics) require continuous updating. An example is:

Pistacia terebinthus

- A 10g. envelope of terebinth seeds (terebinto or cornicabra in Spanish) costs 4,4€ (agroterra.com),
- First sap seedlings can be found to cost 0,48€ (turbepal.es), and 20-40 cm plants of 1,98€. A 250 cc. rooted plant costs 3,5€ (ceifraonline.com),
- Turpentine is traditional obtained from terebinth. Turpentine essence Titán (14,42€/l in ebay.es) is offered as a natural terebinthine,
- This is a native plant useful for *Pistacia vera* (Pistachio) grafts (15,01€/Kg. in especiaspedroza.es),
- Cornicabra must not be confused with cornicabra oil, a variety of olive oil.

This data was presented at three different Congresses: The V Symposium of the Ibero-Macaronesian Association of Botanic Gardens, the V Iberian Congress of Teaching Geography and the Fourth Conference on Educational Innovation and virtual teaching at the University of Málaga, Málaga, Spain. A slide from these oral presentations is shown in **Figure 8**.

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3. BOTANIC TEACHING WORKGROUPS

Phenology, glossary and file cards workgroup: Eight students and two teachers have been coordinated to study life cycles (**Figure 9**) of UMA botanic garden plants.

> FIGURE 9

Two students of the degree in biology of the phenology workgroup. The collaborators of this workgroup took notes and photographs periodically from plants in the garden (P. Silva-Sanchez)

The results of this group were compiled in species file cards. A total of 50 file cards with taxonomic information, geographical distribution, ecology and uses have been generated. A botany dictionary (185 words and 256 drawings), a photography-phenology database (654 images from 89 species), phenology, life tables (135 species) including gymnosperms (Recio, 2012) and angiosperm trees (Biology degree, 2014-15) to be issued at Acta Botanica Malacitana (2018) have been obtained. The continuous activity of these groups is providing an important database on the plants from the Botanic Garden of UMA (X Symposium of the Ibero-Macaronesian Association of Botanic Gardens, 2009). This effort has ended in the publishing of a teaching book by the Service of Publications and Scientific Exchange of the UMA (Spanish initials SPICUM) (**Figures 10-11**). This book authored by teachers and student volunteers summarize the results obtained by several workgroups to introduce students to the gymnosperm plants of the UMA botanic garden.

> FIGURE 10

Frontcover of the book "*Plants of the Botanic Garden of the University of Málaga. Gymnosperms*" edited by the SPICUM. This book on gymnosperms was presented in the Book Fair of Malaga in 2012 and it is sold at "Tienda-UMA" shop at the Campus and in bookshops in Málaga

In this book, file cards for each gymnosperm species are provided combining illustrations, phenology information, and histological descriptions. **Figure 11** shows an example of file cards about two *Araucaria* species.

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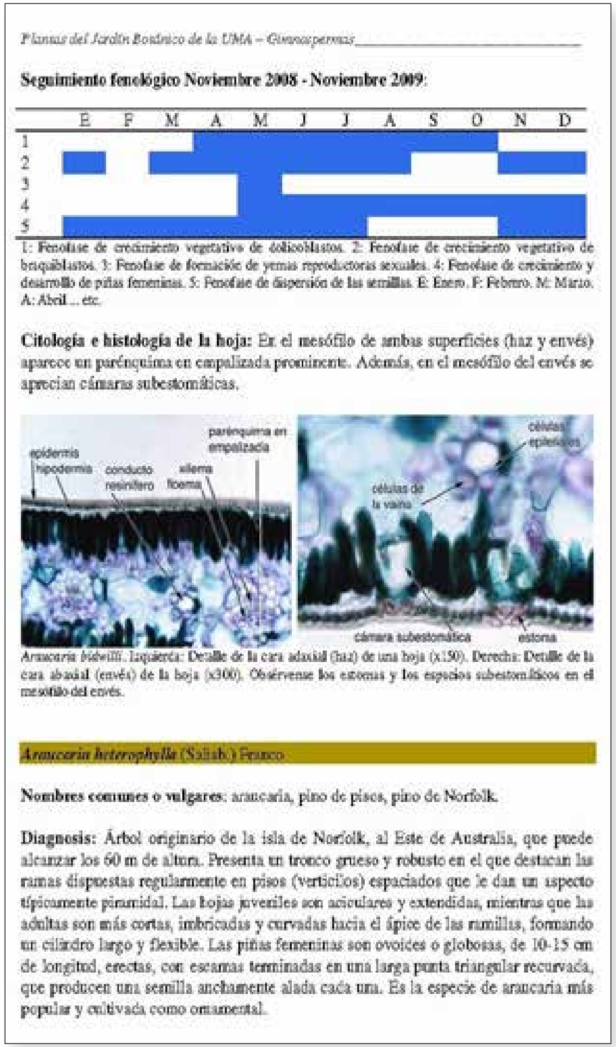

Planas del Jardín Botánico de la UMA – Gimnospermas

Seguimiento fenológico Noviembre 2008 - Noviembre 2009:

1: Fenofase de crecimiento vegetativo de dolicoblastos. 2: Fenofase de crecimiento vegetativo de braquiblastos. 3: Fenofase de formación de yemas reproductoras sexuales. 4: Fenofase de crecimiento y desarrollo de piñas femeninas. 5: Fenofase de dispersión de las semillas. E: Enero. F: Febrero. M: Marzo. A: Abril ... etc.

Citología e histología de la hoja: En el mesófilo de ambas superficies (haz y envés) aparece un parénquima en empalizada prominente. Además, en el mesófilo del envés se aprecian cámaras subestomáticas.

Araucaria bidwilli. Izquierda: Detalle de la cara adaxial (haz) de una hoja (x150). Derecha: Detalle de la cara abaxial (envés) de la hoja (x300). Obsérvense los estomas y los espacios subestomáticos en el mesófilo del envés.

Araucaria heterophylla (Salisb.) Franco

Nombres comunes o vulgares: araucaria, pino de pisos, pino de Norfolk.

Diagnosis: Árbol originario de la isla de Norfolk, al Este de Australia, que puede alcanzar los 60 m de altura. Presenta un tronco grueso y robusto en el que destacan las ramas dispuestas regularmente en pisos (verticilos) espaciados que le dan un aspecto típicamente piramidal. Las hojas juveniles son aciculares y extendidas, mientras que las adultas son más cortas, imbricadas y curvadas hacia el ápice de las ramillas, formando un cilindro largo y flexible. Las piñas femeninas son ovoides o globosas, de 10-15 cm de longitud, erectas, con escamas terminadas en una larga punta triangular recurvada, que producen una semilla anchamente alada cada una. Es la especie de araucaria más popular y cultivada como ornamental.

> FIGURE 11

File cards of *Araucaria bidwilli* (up) and *A. heterophylla* (botton) elaborated by the phenology workgroup. For each studied species, a file card is obtained to show general, phenological, histological, genetic or geographical data. We show a page of the book on gymnosperms (Figure 10) displaying file cards of species from *Araucaria genus*

Visits workgroup: After visits, the impact of the experience on students was evaluated by questionnaires. Questionnaires answered by Secondary School students have revealed their positive response to the visiting experience. Among all visitors, 19% considered the experience perfect, and most of them choose cactus and rose plants as their preferable plants. More than 60% understood every explanation and some of them provided interesting suggestions for improving the Botanic Garden. Suggestions were connected with the central pond, the need of a complete labeling of plants, guides and fountains of drinking water. This experience clearly raised awareness to ecological environment to visiting students.

Conclusions

- A Virtual platform has served to organize a variety of Workgroups for research and teaching of the botanic garden of UMA.
- This is the first step for a profound multidisciplinary knowledge of the UMA botanic garden and useful for its management.
- This teaching-learning experience provides an extensive database on ecological awareness to the Smart-Campus program of UMA (http://www.uma.es/smart-campus).
- Teaching material has been obtained and used in Biology and Environmental Sciences degrees to improve student competences.
- This high quality experience by volunteer students is a first contact with research in our University. Lab and bibliographical skills were developed by volunteers during this project.

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EUROGARD VII
PARIS

THEME G:

NETWORKING, COOPERATION AND CAPACITY BUILDING

07.

THEME G

NETWORKING, COOPERATION AND CAPACITY BUILDING

THE GLOBAL TREES CAMPAIGN – SAFEGUARDING THE WORLD'S THREATENED TREES FROM EXTINCTION

Photo credit : Critically Endangered *Karomia gigas* from Tanzania, *Kirsty Shaw / Global Trees Campaign*

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> Keywords GLOBAL TREES CAMPAIGN BUILD CAPACITY INTERNATIONAL NETWORK CONSERVATION BEST PRACTICE BOTANIC GARDENS ARBORETA

07. Abstract

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• *Rivers Malin*

THE GLOBAL TREES CAMPAIGN (GTC, WWW.GLOBALTREES.ORG) IS A JOINT INITIATIVE BETWEEN BOTANIC GARDENS CONSERVATION INTERNATIONAL (BGCI) AND FAUNA & FLORA INTERNATIONAL (FFI).

Our mission is to prevent all tree species extinctions in the wild, ensuring their benefits for people, wildlife and the wider environment. The GTC prioritises the trees of greatest conservation concern, carries out practical conservation projects for threatened trees in collaboration with partners, builds capacity for tree conservation and promotes the need for tree conservation.

Many of our GTC partners are botanic gardens and arboreta. The horticultural and research expertise, documented collections of living plants, seeds and herbarium specimens, and outreach potential of botanic gardens and arboreta make them excellent partners for spearheading innovative conservation programmes for the world's threatened tree species, for providing training to build the capacity of others to take action for the conservation of threatened trees, and raising awareness of the need for tree conservation.

The GTC provides a vehicle for promoting the tree conservation work of our international network of botanic gardens, arboreta, and in situ conservation partners, and for sharing best practice. The GTC has four objectives; **i)** to identify and prioritise the tree species of greatest conservation concern, **ii)** to ensure that the world's most threatened tree species are protected with populations recovering *in situ* through conservation action, **iii)** to empower partners and practitioners to undertake effective conservation for threatened trees and **iv)** to mobilise other groups to act for threatened trees.

> Keywords GLOBAL TREES CAMPAIGN BUILD CAPACITY INTERNATIONAL NETWORK CONSERVATION BEST PRACTICE BOTANIC GARDENS ARBORETA

07. Introduction

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• *Gratzfeld Joachim*
• *Rivers Malin*

Photo credit : Critically Endangered *Karomia gigas* from Tanzania, ***Kirsty Shaw / Global Trees Campaign***

THE GLOBAL TREES CAMPAIGN (GTC) IS A JOINT INITIATIVE BETWEEN BOTANIC GARDENS CONSERVATION INTERNATIONAL (BGCI) AND FAUNA & FLORA INTERNATIONAL (FFI).

The Campaign was launched in 1999, following the publication of *The World List of Threatened Trees* (Oldfield *et al.*, 1998) which provided conservation assessments for over 20,000 tree species, more than 7,000 of which were assessed as globally threatened with extinction. In response to this, GTC was initiated to take action to conserve the world's threatened trees. Our mission is to prevent all tree species extinctions in the wild, ensuring their benefits for people, wildlife and the wider environment.

BGCI became a joint partner of GTC in 2005. BGCI's international network adds strength to GTC and many of our key GTC partners are botanic gardens and arboreta. These institutions hold horticultural and research expertise, documented collections of living plants, seeds and herbarium specimens, and have great outreach potential. Botanic gardens and arboreta are able to lead innovative conservation programmes for threatened tree species, they can provide training to build the capacity of others to take action for the conservation of threatened trees, and they can act as hubs for raising awareness of the importance of tree conservation.

GTC provides a vehicle for promoting the tree conservation work of our international network of botanic gardens, arboreta, and *in situ* conservation partners, and for sharing best practice.

GTC HAS FOUR OBJECTIVES:

1. To identify and prioritise the tree species of greatest conservation concern;
2. To ensure that the world's most threatened tree species are protected with populations recovering *in situ* through conservation action;
3. To empower partners and practitioners to undertake effective conservation for threatened trees;
4. To mobilise other groups to act for threatened trees.

Many botanic gardens and arboreta around the world contribute to the four objectives of GTC.

> Keywords GLOBAL TREES CAMPAIGN BUILD CAPACITY INTERNATIONAL NETWORK CONSERVATION BEST PRACTICE BOTANIC GARDENS ARBORETA

07. Identifying and prioritising the tree species of greatest conservation concern

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• *Gratzfeld Joachim*
• *Rivers Malin*

In 2003, the IUCN Species Survival Commission (IUCN/SSC) Global Tree Specialist Group was formed with the mandate to lead red listing for trees and to act in an advisory capacity to GTC. The Global Tree Specialist Group now has over 80 members, each working within their own institution to carry out red listing of trees in specific regions or families. To date, GTC has published several regional or taxonomically focused Red List reports, including for *Magnoliaceae, Betulaceae, Rhododendrons,* Montane trees of the tropical Andes and Mexican cloud forest trees. All reports are open access on the BGCI and GTC websites and red list assessments are also published on to the IUCN Red List of Threatened Species (*www.iucnredlist.org*).

The Global Tree Specialist Group aims to carry out conservation assessments for all of the world's tree species by 2020 in the Global Tree Assessment. This will provide a useful resource for botanic gardens, arboreta and other conservation organisations, by prioritising which trees are in greatest need of conservation action. The first step in this process is producing a comprehensive list of the world's trees. GTC is currently compiling a list of the world's tree species with country level distribution information (GlobalTreeSearch), to be completed by the end of 2016.

In order to support botanic gardens and arboreta to further prioritise which threatened trees to focus their conservation efforts on, GTC uses BGCI's PlantSearch database (*www.bgci.org/plant_search.php*), which contains records of living plant collections held in more than 1,100 contributing institutions, to carry out analyses that identify which threatened species are currently absent from or lacking sufficient ex situ protection. In 2015, BGCI published *Conserving the World's Most Threatened Trees: A global survey of* ex situ *collections* (Rivers *et al.,* 2015). This report identified representation of Critically Endangered (CR) and Endangered (EN) trees in botanic garden and arboreta collections. Analysis of 9,641 identified CR and EN trees with PlantSearch records identified that only 1 in 4 of the world's most threatened trees are currently safeguarded in *ex situ* collections. The report and accompanying annex listing CR and EN tree species and their reported representation in collections can be used by botanic gardens and arboreta to guide their future collecting trips, prioritising CR and EN trees that are not yet well represented in *ex situ* collections. The report also provides recommendations on how these institutions can improve the conservation value of their *ex situ* collections including by sharing material among institutions and careful record keeping.

To ensure that the world's most threatened tree species are protected with populations recovering *in situ* through conservation action

Working in collaboration with partners around the world, GTC undertakes practical conservation projects for threatened trees. The projects aim to provide inspiration and models for replication that can be adopted by other conservation practitioners. A number of GTC projects led by botanic gardens and arboreta can be identified that provide good examples that European botanic gardens can replicate. For example, Bedgebury Pinetum in the UK worked on a GTC project with the Vietnamese Centre for Plant Conservation, to collect seed of the Endangered Golden Vietnamese Cypress, *Cupressus vietnamensis*. Efforts in Vietnam to propagate this species from seed had previously been unsuccessful. Previous *ex situ* collections of this species held in botanic gardens had been grown from cuttings and represented limited genetic diver-

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07. To ensure that the world's most threatened tree species are protected with populations recovering *in situ* through conservation action

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sity. Staff at Bedgebury Pinetum successfully propagated seedlings from the collected seed. Some of the propagated seedlings will be transported back to Vietnam to increase the remaining wild population. Training is being provided to the Centre for Plant Conservation, enabling them to propagate seedlings locally in future as well. A portion of the seedlings are planted in Bedgebury Pinetum, establishing an *ex situ* collection that represents more genetic diversity than previous collections, and providing an important opportunity to demonstrate to visitors the work that botanic gardens are undertaking to conserve the world's trees. Some of the collected seed is also stored in a back-up conservation collection at the Millennium Seed Bank.

Another example is the University of Oxford's Harcourt Arboretum in the UK, which is leading conservation efforts for the Critically Endangered *Betula chichibuensis* from Japan, working in collaboration with local botanic garden and university partners. Harcourt Arboretum also has a partnership with Wondo Genet College Arboretum in Ethiopia, working in collaboration with GTC to support Wondo Genet to expand and improve their conservation collection of indigenous and endangered trees.

These projects utilise the skills and knowledge of botanic gardens and arboreta to ensure sustainable conservation outcomes for threatened tree species, working in collaboration with local partners. Partnerships and international collaborations such as these can be facilitated through the BGCI and GTC networks, and all projects are promoted on our website, providing examples that additional botanic gardens, arboreta and other conservation institutions can replicate.

To empower partners and practitioners to undertake effective conservation for threatened trees

Another key aim of the GTC is to build capacity for tree conservation. GTC provides training courses and resources to enable practitioners to learn and improve skills for tree conservation. Many of our resources and courses are developed and delivered in collaboration with botanic gardens and arboreta. Resources are available on the GTC website in English, Spanish and French, enabling expert knowledge to reach a broad audience and empower other organisations and people to develop the skills required to carry out tree conservation. GTC welcomes suggestions of additional resources to add to our website and is keen to hear from experts interested in delivering training on GTC courses.

To mobilise other groups to act for threatened trees

GTC aims to achieve a broader recognition of the threats facing the world's trees, a wider appreciation of the importance of tree conservation and to encourage and enable increased action to save threatened trees. Through the GTC website, social media and publications, GTC reaches out to a wide audience, from policy makers to the public. In particular, GTC aims to encourage conservation organisations not currently focused on trees, including protected area managers and animal conservation institutions, to incorporate actions for threatened trees into their conservation work.

> Keywords GLOBAL TREES CAMPAIGN BUILD CAPACITY INTERNATIONAL NETWORK CONSERVATION BEST PRACTICE BOTANIC GARDENS ARBORETA

07. To mobilise other groups to act for threatened trees

• *Shaw Kirsty*
• *Gratzfeld Joachim*
• *Rivers Malin*

GTC also works to promote and share the tree conservation work of our partners. At EuroGard 2015, GTC coordinated a session on international tree conservation, providing a useful platform for botanic gardens and arboreta to share information about their own tree conservation programmes. GTC welcomes contributions from other European botanic gardens and arboreta to our blog and future conferences to inspire further participation in and support for tree conservation globally.

Conclusion

Through its four complementary objectives, GTC and our network of partners are taking action to prioritise and protect the world's threatened trees. Botanic gardens and arboreta participate in all four of GTC's objectives, both directly and indirectly. With only 1 in 4 of the world's most threatened trees currently protected in ex situ collections (Rivers *et al.*, 2015) there is clearly a lot of work still to do. The GTC provides a vehicle for promoting the tree conservation work of our international network of botanic gardens, arboreta, and in situ conservation partners, and for sharing best practice to scale up and improve contributions to tree conservation internationally. To find out more about our work please visit our website (www.globaltrees.org) or get in touch (globaltrees@bgci.org).

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ONF'S ARBORETA OF NATIONAL INTEREST

Photo credit : Arboretum de la Jonchère (Haute-Vienne), *Thierry Lamant*

Lamant Thierry[1], Bénard L., Berthon S., Bimont S., Blaison L., Castagnio J.-P., Diaz E., Fauveau M., Grannet A.-M., Guardia G., Le Rol J.-P., Levannier P., Loho P., Mazoyer P., Monzo G., Pasqualini M., Perrette N., Savajols G., Simonnet F., Triolo J., Vandaele J., Vial C. & Musch B.

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> Keywords ARBORETUM OFFICE NATIONAL DES FORÊTS (ONF) NETWORK HERITAGE INTEREST CONSERVATORY INTEREST SCIENTIFIC INTEREST

07. Abstract

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SINCE A LONG TIME, MANY ARBORETA HAVE BEEN SETTLED IN THE FRENCH TERRITORY. IN THE STATE FORESTS 144 ARBORETA HAVE BEEN REPORTED EITHER IN METROPOLE THAN IN OVERSEAS TERRITORIES. SINCE 2004 A WORK HAS BEEN CONDUCTED FOR A BETTER KNOWLEDGE OF THEIR RESOURCES. THREE DIFFERENT AXIS HAVE BEEN DEFINED: ARBORETA WITH PATRIMONIAL, SCIENTIFIC OR CONSERVATORY VOCATION.

For each axis, a set of criteria has been selected in order to sort all of the 144 arboreta. Then, different weights have been accorded to these criteria to select the best of this axis. Fifteen arboreta among the 144 have finally been selected as having a strong national interest.

The objectives of conservatory arboreta are the conservation of endangered species, in particular those listed on the IUCN Red List, with the increase of the number of endangered tree species and tree specimens.

Those with patrimonial purposes are selected for the presence a wide number of species. Their goal is to propose to a large public a view of the species diversity. Visits are proposed to raise public awareness on this species diversity.

The last group is represented by scientific arboreta. Their purpose is to detect species able to replace the autochtonous species which could resist to climate changes.

This network is managed by the research, development and innovation department of ONF (French National Forest Office) and aims to enrich the different arboreta according to its purposes. Some of these arboreta belong to the French national network too. All those taxa are introduced in the French

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• *Triolo J.*
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> FIGURE 1

. J.-F Lacaze, under a *Pseudolarix amabilis*, Pézanin Arboretum

database in order to allow researchers to work on allochtonous species. This network is also the support of different research projects. The objective of this presentation is to present the ONF's approaches and activities.

This paper is dedicated to the memory of Jean-François Lacaze (1929-2015) (**Fig. 1**) who was responsible of forest research at the National Institute for Agronomic Research (INRA).

> Keywords ARBORETUM OFFICE NATIONAL DES FORÊTS (ONF) NETWORK HERITAGE INTEREST CONSERVATORY INTEREST SCIENTIFIC INTEREST

07. Survey & evaluation results

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Photo credit : Arboretum de la Jonchère (Haute-Vienne), *Thierry Lamant*

THE CURRENT CONTEXT, WITH THE CLIMATE CHANGES, EXPLAINS THE RENEWED INTEREST IN ARBORETA. IN FRANCE, THE FIRST CENSUSES AND STATEMENTS OF ARBORETA WERE BASED IN PART OF A SURVEY (1976) BY THE DENDROLOGIST JEAN POURTET WHO WAS THE CURATOR OF LES BARRES NATIONAL ARBORETUM AT NOGENT SUR VERNISSON.

At the Office National des Forêts (ONF) we decided, first of all, to acquire all the necessary and useful knowledges about the arboreta under our management.

So, we needed to know:
- the exact number of arboreta because all was not not known
- their location
- their dendrologic content (few or not filled)
- their provenances (generally not known)
- some informations on the health status, maintenance, attendance...

A minimum information was required during a field survey between 2006 and 2008.
The results from the survey follows:
- number of arboreta (143)
- years of creation (from 1864 to 2003) and individual area (from 0.5 to 43 ha)
- number of taxa on whole sites (2654 in 2008, 3001 in 2015)
- number of taxa per main genera
- plants of phyto-pharmaceutical interest (at least 75)
- arboreta attendances (up to 26,000 people / year)

According to these results, three major interests were finally selected by onf:
- Heritage: 8 arboreta
- Conservatory: 4 arboreta
- Scientific: 6 arboreta

Fifteen national arboreta were selected (some have 2 different interests) (**Fig. 2**). For each of these retained interests, the criteria allowed lead to an assessment, then goals.

These 15 arboreta were designated in an ONF's administrative publication (n° 09-G-1544; january, 22th 1999) which sets the strategic direction and operating rules of the ONF arboreta.

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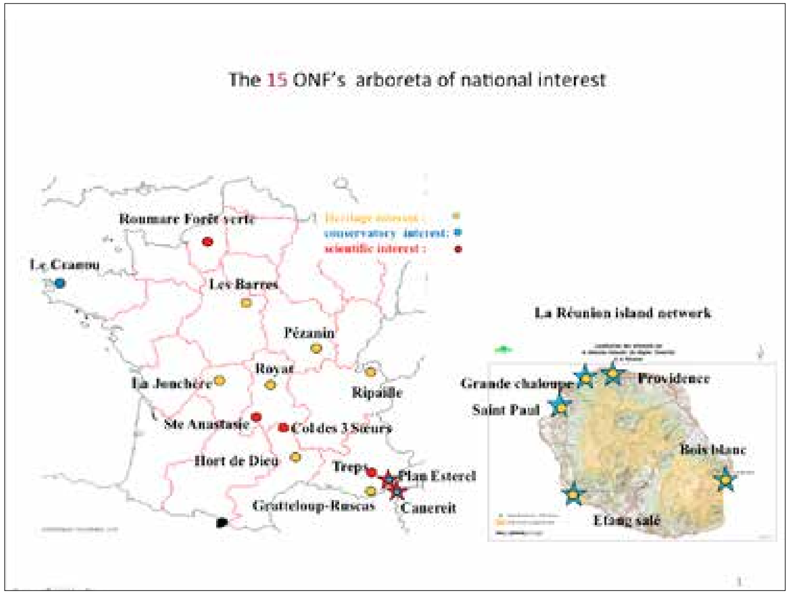

> FIGURE 2

The fifteen arboreta of national interest

The arboreta of national interest

THE ARBORETA OF HERITAGE INTEREST

The goal of the heritage interest arboreta is to show the global forest biodiversity for educational and economic purposes (nurseries, street trees…) with the help of guided tours documents.

The selection criteria (a rating of 20 points) are:

- Educational (7 criteria): parking, access road, marked trail, maintenance, labeling and graphic consistency, number of higher taxa equal or up to 100.
- Heritage (2 criteria): topics remarkable, site created by a dendrologist / forester historic figure.
- Landscape (4 criteria): trees / shrubs composition, topography, water, open space.
- Economic (7 criteria): national road nearby within 15 minutes driving, 100 000 inhabitants cities within 30 minutes driving, occasional animation on the arboretum (plants show), ONF staff available and / or motivated, tourist interest nearby or inside the arboretum, visitors annual number higher than 1000.

The maximum score was never been allocated and we decided to fixed the minimum objective at 15/20 (first criterion) and the number of visitors should be superior or equal to 10 000 (second decisive criterion).

The eight arboreta of heritage interest are in 4 different kind of climates:

- mediterranean : Gratteloup-Ruscas
- mountain : Hort de Dieu, La Jonchère, Pézanin, Royat
- plain (oceanic and continental) : Les Barres, Ripaille
- tropical : Réseau réunionnais

LES BARRES NATIONAL ARBORETUM

It is located in the North-East of the Loire valley (Loiret department) with an area of 35 hectares (**Fig. 3**). It was established in 1821, by Philippe-André de Vilmorin, the "father" of the modern forest genetics. Its elevation is 145 m above sea level under oceanic climate, on acidic sand / silt on flint clay. Its average annual rainfall is 690 mm per year with extreme temperatures from -21° to 38° C. It owns 2615 taxa and is one of the richest old arboreta

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07. The arboreta of national interest

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in Europe. Its initial goal was acclimatization, forestry, ornamental and description of new species introduced but now, we wish to enrich the *Fruticetum Vilmorinianum* (shrub arboretum) and the oldest parts after the 1999 storm and the 2003 dry hot summer.

> FIGURE 3

Sequoia sempervirens, Les Barres National Arboretum

PÉZANIN ARBORETUM

It is located in Saône-et-Loire department (Burgundy region) and its area is 26 ha (including 4 hectares of pond) (**Fig. 4**). It was established in 1903, by Maurice de Vilmorin, the same family present at Les Barres. Its elevation is 370 to 400 m above sea level under continental climate, on soil with porphyritic granite. Its rainfall average is around 810 mm per year with extreme temperatures from -25° to 36° C. It owns 565 taxa and its initial goal was acclimatization of forest and ornamental exotic species, forestry, ornamental and description of new species introduced but now, we wish to renew it with De Vilmorin's introductions (deciduous shrubs & trees, continental and mountain conifers.

> FIGURE 4

Pézanin Arboretum

LA JONCHÈRE ARBORETUM

This arboretum is located in Haute-Vienne department, Massif Central, and its area is 11 ha. It was established in 1885 respectively by dendrologist and nurseryman Henri Gerardin & André Laurent. Its elevation is 430 to 470 m above sea level on mountain under oceanic climate and on granite soil. Its average rainfall is around 1200 mm per year with extreme temperatures from -27° to 32° C. It owns 163 taxa and its initial goal was adaptation of exotic trees for timber production but now, we plan to renew it with enrichment in oceanic climate large conifers (in a very favorable ecologic conditions for them) and rhododendrons.

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ROYAT ARBORETUM

It is located in Puy-de-Dome department, Massif Central, with an area of 41 hectares. It was established in 1934 by French forestry service. Its elevation is 730 to 800 m above sea level on mountain under oceanic climate and on granite & volcanic deposits soil. Its average rainfall is around 850 mm per year with extreme temperatures from -20° to 38° C. It owns 153 taxa and its initial goal was a sylvetum (comparison tree species and provenances arboretum) to study the timber production forest species and now, there is an enrichment with deciduous hardwoods trees, shrubs and conifers growing together in the wild as geographic arboretum.

RIPAILLE ARBORETUM

This arboretum is located in Haute-Savoie department near the banks of the Geneva Lake, Northern Alps, and its area is 17 hectares. It was established in 1911 by a private forest owner. Its elevation is 950 m above sea level under continental climate, on moraine deposits. Its average rainfall is around 850 mm per year with extreme temperatures from -17° to 36° C. It owns 135 taxa and its initial goal was also a sylvetum with acclimatization of timber and ornamental exotic species. Its current goal is the enrichment with useful (medicinal, aromatic, food) and ornamental trees and shrubs. Just near the arboretum, the visitors can also see the Memorial of the "Justes", a site which honors the memory of those who helped to save Jews during the World War II.

L'HORT DE DIEU ARBORETUM

This historical arboretum is located in Gard department, South-East of France, with an area of 21 ha (**Fig. 5**). It was established in 1902 by the forester Georges Fabre and his friend the botanist Charles Flahault. Its elevation is 1250 to 1350 m above sea level under mountain climate, on schists. Its average rainfall is around 2000 mm per year with extreme temperatures from -28° to 30° C. It owns 105 taxa and its initial goal was to restore the mountain lands deforested during the nineteenth century. Its current goal is the enrichment from the genera and taxa tested by Fabre and Flahault. These two men have proved that we could completely restore deforested mountain areas.

> FIGURE 5
L'Hort de Dieu Arboretum

GRATTELOUP-RUSCAS ARBORETUM

This arboretum is located in Var department, near the French Riviera, formerly made up of two distinct parts: one arboretum (Gratteloup) and one experimental nursery (Ruscas) of the National Institute for Agronomic Research (INRA), established respectively in 1935 and 1962. Its total area is 9.7 ha. Its elevation is 100 to 120 m above sea level under mediterranean climate, on gneiss with an average rainfall of 690 mm per year with extreme temperatures from -14° to 38.7° C.

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• Vandaele J.
• Vial C.
• Musch B.

It owns 105 taxa and its initial goal was acclimatizing exotic taxa (Gratteloup) and experimental field of INRA in forest timber taxa (Ruscas). Its current goal is the enrichment with american / mexican semiarid altitude trees and shrubs.

THE ARBORETA OF CONSERVATORY INTEREST

Their goal is to increase the number of endangered and threatened taxa in their natural habitat (ex situ conservatory role). Our international reference is the IUCN (International Union for Conservation of Nature) Red List (with 172 taxa) including metropolitan arboreta (35) and Réunion Island arboreta (137). According the IUCN criteria, these sites keep respectively:

- Critically Endangered: 3 / 28 (31)
- Endangered: 9 / 28 (37)
- Vulnerable: 23 / 46 (69)

Their criteria are:

- Defined species endangered by the IUCN list
- Presence of at least 10 endangered species per arboretum
- Presence of at least 10 individuals of this species
- Well known origin of wild planted taxa

Four arboreta are concerned in three different kind of climates:

- mediterranean: Canereit and Plan Estérel
- oceanic : Le Cranou
- tropical: Réunion Island network arboreta

THE REUNION ISLAND ARBORETA NETWORK

It is located at Reunion Island, in Indian Ocean with 5 arboreta totalising 7.7 ha, established from 1996 to 2005. Its elevation is 100 to 120 m above sea level under tropical climate (dry / wet according to their situation on the island), on volcanic soil. The average rainfall is from no more 1000 to 4000 mm per year with extreme temperatures from 15° to 45° C. It owns 275 taxa. Its goal is the conservation of endangered species from the Mascarene Islands (in relation to its Botanical Conservatory and to the Brittany Botanic Conservatory at Brest, North-West of France).

LE CRANOU ARBORETUM

This arboretum is located in Finistère department (Brittany region) with an area of 14 ha (**Fig. 6**). It was established in 1979 by the National Institute for Agronomic Research (INRA). Its elevation is 180 to 200 m above sea level under oceanic climate, on granite, and the annual average rainfall is 1200 mm per year with extreme temperatures from -2° to 24° C. It owns 131 taxa and its initial goal was a sylvetum, a forest experiment for timber. Its current goal is the enrichment with metropolitan threatened flora.

> FIGURE 6

Embothrium coccineum, Le Cranou Arboretum

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• Vial C.
• Musch B.

SCIENTIFIC ARBORETA

The goals of these arboreta are to find taxa which could replace / complete native species in the context of climate changes (production of timber and biomass; related products as essential oils…).

Their criteria are:

- Well-known provenance for each taxon (latitude, longitude, elevation)
- At least 10 specimens by provenance
- 1 provenance must be present at least in 2 different arboreta

There are six arboreta in three different kind of climates:

- **oceanic climate:** Roumare-Forêt Verte
- **mountain climate:** Col des Trois Sœurs, Sainte Anastasie
- **mediterranean climate:** Canereit, Plan Esterel, Treps

These 6 arboreta belong to the public arboretum network (next chapter) and are managed by the research, development and innovation department of ONF.

CANEREIT ARBORETUM

It is located in Var department, Estérel Mountains, near French Riviera, and its area is 4 ha. It was established in 1973 by the National Institute for Agronomic Research (INRA). Its elevation is 260 to 320 m above sea level under mediterranean climate, on ryolitand and its annual average rainfall is 820 mm per year with extreme temperatures from -12° to 38° C. It owns 151 taxa (previously 398) with 230 different provenances (previously 587). The initial objective was to find substitutes for *Pinus pinaster* (*Matsucoccus feytaudii*), soil cover canopies against fire.

PLAN ESTEREL ARBORETUM

This arboretum is also located in Var department, with an area of 3 ha and it is located very close to the Canereit Arboretum. It was established in 1973 National Institute for Agronomic Research (INRA). Its elevation is 400 to 420 m above sea level under mediterranean climate, on ryolit. Its average rainfall is 820 mm per year with extreme temperatures from -12° to 38° C. It owns 111 taxa (previously 327) with 191 different provenances (previously 512). The initial objective was the same as the Canereit Arboretum.

TREPS ARBORETUM

It is also located in Var department in the Maures Mountains, with an area of 1.8 ha. It was established in 1975 by the National Institute for Agronomic Research (INRA). Its elevation is 400 to 420 m above sea level under mediterranean climate, on migmatite gneiss. Its average rainfall is 690 mm per year with extreme temperatures from -14° to 38.7° C and winter snow is frequent. It owns 48 taxa (previously 108) with 74 different provenances (previously 139). The initial objective was the same as the Canereit Arboretum.

COL DES TROIS SŒURS ARBORETUM

It is located in Lozère department, Massif Central, and its area is 7.2 ha (**Fig. 7**). It was established in 1973 by the National Institute for Agronomic Research (INRA). Its elevation is from 1390 to 1480 m above sea level under mountain climate, on porphyritic granite. Its average rainfall is 980 mm per year with extreme temperatures from -30° to 34° C. The climate is rough with 150 frost days per year and a short growing season from 2 to 2.5 months only. With the exception of the photoperiod, climatic conditions are similar to those of the North Cape in Norway and equipments for polar expeditions

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• Savajols G.
• Simonnet F.
• Triolo J.
• Vandaele J.
• Vial C.
• Musch B.

are frequently tested there. It owns 47 taxa (previously 71) with 330 different provenances (previously 339). Their initial objective was to find substitutes for *Picea abies* (destroyed by *Dendrochtonus micans*) and build windbreaks to shelter the summer pastures.

> FIGURE 7

Pinus sibirica, Col des Trois Sœurs Arboretum

SAINTE-ANASTASIE ARBORETUM

This arboretum is located in Cantal department, Massif Central, and its area is 5.7 ha. It was established in 1969 by the National Institute for Agronomic Research (INRA). Its elevation is 1300 m above sea level under mountain climate with oceanic influence, on silt under volcanic soil. Its average rainfall is 980 mm per year with extreme temperatures from -30° to 30° C.

It owns 39 taxa (previously 44) with 118 different provenances (previously 130). The initial objective was the same as the Col des Trois Sœurs Arboretum.

ROUMARE ARBORETUM – FORÊT VERTE

It is located in Seine-Maritime department, North-West of France and it consists of 3 sites in 2 peri-urban national forests over 15 ha. It was established in 1975 by the National Institute for Agronomic Research (INRA). Its elevation is from 100 to 140 m above sea level under oceanic climate, on silt on flint clay. Its average rainfall is 800 mm per year with extreme temperatures of -17° to 38 ° C. It owns 93 taxa (previously 101) with 249 different provenances (previously 253). The initial objective was to find air pollution resistant trees and shrubs. There is an additional objective since 2010 because 1 of the 3 sites is now open to the public.

The national ONF arboreta network

This network includes five public institutions (INRA, National Museum of Natural History-MNHN, Orsay and Grenoble Universities and ONF) who decided to create a public arboreta multipartner network). It includes 15 arboreta as the 6 ONF arboreta of scientific interest.

Its goal is to enrich the different arboreta according to their purposes. All those taxa are introduced in the French database in order to allow researchers to work on allochtonous species.

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• Vial C.
• Musch B.

This network is also the support of different research projects, managed by a special committee (animation of the network -21 people involved- technical support, annual coordination meeting, steering committee) with clearly specified objectives per arboretum, involvement in transversal projects (RMT-AForce), supervised internships (annual results of each arboretum, timber quality, invasive plants…) and communication (posters, conferences and other events).

These 15 arboreta managed by the ONF are a set of diverse vocations sites and are part of a national public network that will act together, particularly on the issue of climate changes.

Acknowledgements

Albert Dumas, Brigitte Fourier and Thomas Bouix.

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RELICT TREES DRIVING INTERNATIONAL COOPERATION, RESEARCH AND CONSERVATION – THE EXAMPLE OF *ZELKOVA* SPP. (ULMACEAE)

Photo credit : ***left*** : Collection of *Zelkova abelicea* seeds, Kedros, Crete, ***Gregor Kozlowski***
right : Introduction of *Zelkova sicula* saplings, Bosco Ficuzza, Sicily, ***Giuseppe Garfì***

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07. Abstract

• *Gratzfeld Joachim*
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• *Buord S.*
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THE TREE GENUS *ZELKOVA* FORMS PART OF THE ARCTO-TERTIARY RELICT FLORA THAT EXTENDED OVER LARGE PARTS OF THE NORTHERN HEMISPHERE DURING THE CENOZOIC ERA, SOME 55-2.5 MILLION YEARS AGO. THE HIGHLY DISJUNCT DISTRIBUTION OF THE SIX EXTANT SPECIES - *Z. SICULA, Z. ABELICEA, Z. CARPINIFOLIA, Z. SINICA, Z. SCHNEIDERIANA* AND *Z. SERRATA* - FROM THE MEDITERRANEAN TO THE CAUCASUS AND EAST ASIA, MAKES *ZELKOVA* A FASCINATING SUBJECT FOR PHYLOGENETIC AND BIOGEOGRAPHIC STUDIES TO ADVANCE THE UNDERSTANDING OF EVOLUTIONARY PROCESSES.

The rarity and extreme geographic isolation of some of the species and populations have attracted the attention of researchers, conservation practitioners and horticulturists in recent years, to conserve remaining genetic diversity in the wild and in *ex situ* collections. Inspired by this shared concern, since 2010 a highly interdisciplinary and international research group represented by partners from Europe, the Caucasus and East Asia have been participating in the development and implementation of Project *Zelkova* – an integrated conservation action plan for all the species in the genus (*zelkova.ch*).

This paper provides an overview of the key research findings gathered and pilot conservation activities initiated over the past five years, with a focus on the two Mediterranean species. As with other initiatives in the framework of the Global Trees Campaign (*globaltrees.org*) dedicated to saving the world's most threatened woody plants, it highlights the collaborative, multidisciplinary nature of the conservation efforts needed, to secure the values and benefits provided by rare, relict species for future generations.

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07. Introduction

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• *Kozlowski Gregor*
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• *Fournaraki C.*
• *Dimitriou D.*
• *Sklavaki P.*
• *Naciri Y.*
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Photo credit : ***left*** : Collection of *Zelkova abelicea* seeds, Kedros, Crete, ***Gregor Kozlowski*** ; ***right*** : Introduction of *Zelkova sicula* saplings, Bosco Ficuzza, Sicily, ***Giuseppe Garfi***

THE GENUS *ZELKOVA* BELONGS TO THE ARCTO-TERTIARY RELICT FLORA THAT COVERED LARGE PARTS OF THE NORTHERN HEMISPHERE DURING THE CENOZOIC ERA (I.E. 55-2.5 MILLION YEARS BEFORE PRESENT).

Fossil discoveries attributed to the genus, dating back more than 50 million years, give proof of the once circumboreal occurrence of the genus (Tanai & Wolfe, 1977; Manchester, 1989). Today, the highly disjunct distribution of the six extant species – *Z. sicula, Z. abelicea, Z. carpinifolia, Z. schneideriana, Z. sinica* and *Z. serrata* – from the Mediterranean to the Caucasus and East Asia, makes this genus a fascinating subject for phylogenetic and biogeographic studies and other international, collaborative research initiatives to further the knowledge of evolutionary processes.

As with the manifold interests to science, *Zelkova* trees have had long-standing, cultural and socio-economic functions. Specimens – some several hundred years old – planted as ornamentals in private and public venues, or found in places of worship and contemplation in eastern Asia, give evidence of the ancient and close relationship of people with these trees. Likewise, traditional herbal medicine, household items and other objects made from various parts of the plant, are testimony to the important values and customs associated with this genus (Ito, 1981; Kvavadze & Connor, 2005; Fournaraki & Thanos, 2006; Kozlowski & Gratzfeld, 2013).

The relict nature of the genus, however, is no recipe for survival in a rapidly transforming environment. As elsewhere in the world, habitat loss, fast changing climatic conditions and many other drivers of change, including overgrazing (Frederik *et al.*, 2010; Garfi & Buord, 2012; Kozlowski *et al.*, 2012a) and uncontrolled logging (Maharramova et al., 2014) exert high pressure on remaining natural *Zelkova* populations. Especially the two Mediterranean species, *Z. sicula* and *Z. abelicea* count among the most threatened in the genus (Garfi, 2006; Kozlowski *et al.*, 2012a). These species occur in exceptionally isolated and fragmented locations. Among the rarest trees in the world, they require specific management approaches combining a set of integrated in and *ex situ* conservation measures.

Zelkova sicula - one of a kind

Within the genus, *Zelkova sicula* Di Pasq., Garfi & Quézel has a particularly remarkable position. Discovered in 1991 (Di Pasquale *et al.*, 1992), this narrow endemic is known from only two locations, each with a single pop-

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07. *Zelkova sicula* - one of a kind

• Gratzfeld Joachim
• Kozlowski Gregor
• Buord S.
• Fazan L.
• Christe C.
• Bétrisey S.
• Garfi G.
• Pasta S.
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• Dimitriou D.
• Sklavaki P.
• Naciri Y.
• Dadashova A.
• Selimov R.
• Davitashvili N.
• Song Y.

ulation. Both populations cover an area of occupancy of less than one hectare and consist of a few hundred small trees each. Occurring between 320 and 520m above sea level on the north-eastern slopes of the Iblei mountains (south-eastern Sicily), the two populations are found in open forest communities with other tree species such as *Quercus suber, Q. virgiliana, Olea europaea var. sylvestris, Phillyrea latifolia, Pyrus spinosa* and *Calicotome infesta* (Garfì *et al.*, 2011).

STAYING ALIVE IN A CHANGING CLIMATE

Several of the morphological and life traits of *Z. sicula* can be interpreted as the result of a long-lasting process of adaptation to a rather suboptimal environment. Unlike the other *Zelkova* species, *Z. sicula* generally develops as a shrub or, at the most, grows into a small tree in its present locations (Garfì *et al.*, 2011). Characteristic for plants at the limit of their range (Stahl *et al.*, 2013), this habit likely is a response to water shortage (Garfì *et al.*, 2012). Ongoing investigations on plant-water relationships such as pressure-volume curves, leaf water potential and stomatal conductance, have highlighted a low plasticity as regards standard summer drought conditions in the current habitat (Oddo *et al.*, pers. comm.). The fact that both populations are restricted to the bottom of gullies or occur along narrow streams, suggests that these micro-habitats play a critical role in the species' ability to withstand water stress. Nonetheless, extreme environmental hazards, such as prolonged drought, can cause moderate to severe damage, ranging from withering of leaves to dieback of branches and stems. Rising habitat fragmentation and livestock grazing exert further pressure on both populations (Garfì & Buord, 2012). Due to these threat factors and the rarity of the species, *Z. sicula* has been included as Critically Endangered (CR) on the IUCN Red List of Threatened Species (Garfì, 2006).

TWO POPULATIONS, TWO CLONES - TWO INDIVIDUALS?

Recent studies suggest that *Z. sicula* has been subject to severe isolation and genetic impoverishment (Fineschi *et al.*, 2002, 2004; Christe *et al.*, 2014a). Fructification is irregular (Garfì, 1997a) and, as with other triploid species (Garfì, 1997b), seeds have always been found to be sterile (Bonga & von Aderkas, 2013). Regeneration occurs by means of vegetative mechanisms such as root suckering and layering. As a result, individuals in both genetically impoverished but distinct populations, are assumed to be of clonal origin; hence, each population could be regarded as a single individual. This, in addition to the extended geographic isolation with reduced potential gene flow, might be the reason for such a low intra-specific genetic variability (Fineschi *et al.*, 2004). On the other hand, clonality and vegetative reproduction are adding a further trait of uniqueness to this species; as with *Lomatia tasmanica* (*Proteaceae*) – known from a single, clonal population estimated to be several ten thousand years of age (Lynch *et al.*, 1998) – each *Z. sicula* population could potentially represent a many thousand year-old genetic unit.

RESCUE TRIALS IN PROGRESS

Since 2011, a major project funded through the European Commission EC Life Programme (*zelkovazione.eu*) has been implementing a range of integrated in and ex situ conservation actions in the areas of knowledge consolidation, population monitoring, active conservation, public outreach and communication. To date, a number of key milestones have been achieved, including the exclusion of the grazing pressure in both populations through fencing, the implementation of a sustainable management plan that involves formal agreements with local stakeholders, as well as the legal protection of the species through the enactment of a Councillor's Decree by the Regional Department of Environment (*zelkovazione.eu/node/4502*).

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07. *Zelkova sicula* - one of a kind

• Gratzfeld Joachim
• Kozlowski Gregor
• Buord S.
• Fazan L.
• Christe C.
• Bétrisey S.
• Garfi G.
• Pasta S.
• Gotsiou P.
• Fournaraki C.
• Dimitriou D.
• Sklavaki P.
• Naciri Y.
• Dadashova A.
• Selimov R.
• Davitashvili N.
• Song Y.

The recent successful development of protocols for in vitro and in vivo vegetative multiplication based on the expertise of researchers from the National Research Council, Italy and the Conservatoire Botanique National de Brest, France, is a further major step towards effective *ex* and *in situ* conservation. Indeed, the limited intra-specific variability in the species is facilitating the establishment of genetically representative conservation collections. Likewise, the possibility to generate plants without affecting the wild populations has opened a new, important perspective for *in situ* reinforcement programmes and introduction of the species to other ecosystems.

INTRODUCTION TO OTHER ECOSYSTEMS

In spite of the recent advances made, securing viable populations in situ remains a main conservation challenge given the vulnerability of the species in its current habitat. Introduction to other ecosystems has been studied to establish further populations in new locations. These have been identified using the guidelines for 'assisted colonisation' (Brooker *et al.*, 2011). Criteria for site selection are based on palaeo-ecological data including Follieri *et al.* (1986) and De Paola *et al.* (1997) and observations of specimens grown under different ex situ conditions. The latter have confirmed the potential of Z. sicula to mature into actual trees (Garfi *et al.*, 2011; Garfi & Buord, 2012) in contrast to the general habit of the plants in their present habitat. These findings suggest that more humid and cooler climatic conditions typical to montane mixed forests with *Fagus, Acer, deciduous Quercus, Ilex* or *Taxus*, may offer a better match for the ecological needs of *Z. sicula*. This conservation approach is applied as the 'last resort' for narrow endemics that are confined to very specific, ecological niches and exposed to changing, unfavourable environmental conditions (Brooker *et al.*, 2011; Thomas, 2011).

Zelkova abelicea - a plant of exceptional diversity

An endemic tree of the east-Mediterranean island of Crete, *Zelkova abelicea* (Lam.) Boiss. is found in open, mountain forest communities between 850 and 1,850 m above sea level. Occurring in association with *Acer sempervirens, Quercus coccifera* and occasionally *Cupressus sempervirens*, all of the four main mountain ranges of Crete, i.e. Levka Ori, Psiloritis, Dikti and Thripti, hold populations of *Z. abelicea*. Primarily, they occupy north-facing slopes, areas around dolines, summer-dry river banks, gullies and screes. Especially at higher altitudes (>1500 m above sea level) however, the species is also found on south-facing slopes with rock outcrops and often bare, thin soil (Egli, 1997; Søndergaard & Egli, 2006; Fazan *et al.,* 2012).

THREATENED AND FRAGMENTED POPULATIONS

More than 40 populations of *Z. abelicea* are known, mainly in the Levka Ori (ca. 30) and in the Dikti mountains (ca. 10). Two populations occur in the Psiloritis and one small population in the Thripti mountains (Kozlowski *et al.*, 2012a). While the distribution of the species according to the four mountain ranges is explained to be of ancient origin (Christe *et al.,* 2014a), it is not conclusively resolved whether the fragmented pattern of *Z. abelicea* stands within these locations is the result of natural processes or anthropogenic drivers of change (Kozlowski *et al.,* 2014). Nevertheless, in more recent history, overgrazing and browsing by goats and sheep, as well as soil erosion, drought and fire, present serious threats to all populations (Fazan *et al.,* 2012; Kozlowski *et al.*, 2012a). By and large, individuals are heavily browsed and exhibit a dwarfed habit, such as the population of Thripti, whereas large trees

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07. *Zelkova abelicea* - a plant of exceptional diversity

• Gratzfeld Joachim
• Kozlowski Gregor
• Buord S.
• Fazan L.
• Christe C.
• Bétrisey S.
• Garfi G.
• Pasta S.
• Gotsiou P.
• Fournaraki C.
• Dimitriou D.
• Sklavaki P.
• Naciri Y.
• Dadashova A.
• Selimov R.
• Davitashvili N.
• Song Y.

(>15 m) are rare and encountered especially in the Levka Ori mountains. To date, only fully developed trees have been observed to flower and produce viable seed (Fazan *et al.*, 2012; Kozlowski *et al.*, 2014). Given the level of threat to various populations, *Z. abelicea* has been included as Endangered (EN) on the IUCN Red List of Threatened Species (Kozlowski *et al.*, 2012a).

EACH MOUNTAIN CHAIN REPRESENTS A SEPARATE GENETIC AND CONSERVATION UNIT

Because of the limited seed dispersal capacity of *Zelkova* spp. (Hoshino, 1990; Wang *et al.*, 2001), gene flow between distant *Z. abelicea* populations is highly unlikely as confirmed by recent genetic studies (Christe *et al.*, 2014a). These demonstrate that the populations are genetically highly diverse within and between the four mountain ranges, and indicate that the colonization by *Z. abelicea* is very ancient (presumably before the early Miocene, over 25 million years ago). Each mountain chain should therefore be considered as a unique genetic entity, each of relevance for conservation.

EX SITU CONSERVATION CHALLENGES

In comparison with other *Zelkova* species, especially those from East Asia, *Z. abelicea* is underrepresented in botanic garden collections (Kozlowski *et al.*, 2012b). In addition, only a very small proportion of the genetic variability in natural populations is found in ex situ collections (Christe *et al.*, 2014b). All surveyed individuals cultivated in botanic gardens and arboreta originate from one single area in western Crete (Omalos Plateau, Levka Ori), while other populations do not appear to be represented in *ex situ* collections (Kozlowski *et al.*, 2012b; Christe *et al.*, 2014b). Future *ex situ* conservation approaches should consider the entire genetic diversity of the species, whilst avoiding genetic mixture of differentiated populations from the four mountain chains, especially when establishing field collections (Kozlowski *et al.*, 2012b, 2014). For heavily browsed and dwarfed populations with no observed or viable seed generation, vegetative propagation remains the only option to establish collections, which in turn enhances the complexity and costs of ex situ conservation.

IN SITU CONSERVATION CHALLENGES

Conventional approaches to protection and management, including methods to limit or completely prevent livestock grazing and browsing by means of fencing, should comprise the entire range of the genetic diversity of the species. Such measures require to be developed in close collaboration with shepherds and other local stakeholders (e.g. local administration, municipalities, national park administration), and accompanied by long-term scientific surveys to monitor progress and allow adaptive management.

ONGOING CONSERVATION ACTION

Based on the thorough research work undertaken in recent years, an international and interdisciplinary conservation programme for *Z. abelicea* has been initiated. The implementation of the project is assumed by the Mediterranean Agronomic Institute of Chania (MAICh) in collaboration with the four Forest Directorates of Crete (Chania, Rethymno, Heraklio, Lassithi). International collaboration and scientific support are assured by researchers and conservationists from the Universities of Fribourg (Switzerland) and Athens (Greece), Botanic Gardens Conservation International (BGCI, United Kingdom) and the Institute of Biosciences and BioResources of the National Research Council in Palermo (Sicily, Italy). *Ex situ* conservation efforts are progressing with seed stored in the seed bank of MAICh, capitalising also on studies carried out on germination requirements of the species since 2000

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07. *Zelkova abelicea* - a plant of exceptional diversity

• Gratzfeld Joachim
• Kozlowski Gregor
• Buord S.
• Fazan L.
• Christe C.
• Bétrisey S.
• Garfi G.
• Pasta S.
• Gotsiou P.
• Fournaraki C.
• Dimitriou D.
• Sklavaki P.
• Naciri Y.
• Dadashova A.
• Selimov R.
• Davitashvili N.
• Song Y.

(Fournaraki & Thanos, 2002; Thanos *et al.*, 2010). New and genetically representative *ex situ* collections (field as well as seed bank collections) are being established using seed and vegetative material sampled from all mountain regions. The experiences gained from the successful propagation of *Z. sicula* are of particular value for *ex situ* conservation of the genetically diverse *Z. abelicea* populations in which fruiting has not been observed to date (e.g. Thripti). In addition, selected pilot plots have been fenced throughout Crete and are regularly monitored by the team of MAICh as well as by the researchers and students of the University of Fribourg. Within the fenced plots, *Z. abelicea* dwarfed shrubs have responded immediately to the removal of the browsing pressure by producing new shoots up to 90 cm in length after one year of exclusion of browsing only. Moreover, a range of local and international campaigns and public outreach events have been realized, including scientific seminars, conferences and exhibitions, accompanied by a series of engaging public outreach materials.

Conclusions

The isolated occurrence and rarity of *Z. sicula* and *Z. abelicea* provide an ideal context to practise integrated conservation action and serve as a model for safeguarding other threatened species as pursued by the Global Trees Campaign. While the exclusion of grazing pressure such as through fencing is the most pragmatic measure for immediate protection in the wild, long-term in situ conservation efforts need to be implemented in close collaboration with local stakeholders and anchored in national legislation and policy. Systematic scientific evaluations to monitor progress and allow adaptive management will in turn inform the nature of population reinforcement programmes and options for potential introduction to other, analogous environments in situations where the original habitat has been lost, or no longer provides a viable option for the species' survival. This is especially crucial for *Z. sicula*, known from only two locations. The first attempt to establish three new populations will be carried out at elevations above 1000 m in the northern, mountainous ranges of Sicily in 2016.

As elsewhere in the world, *ex situ* conservation of *Zelkova* spp. faces the challenge of ensuring genetically representative collections, preferably in the countries of the species' natural distribution, where current *ex situ* holdings are still largely inadequate. The complexity of capturing the whole range of a species' genetic variation for *ex situ* conservation is well-illustrated by the distinct genetic diversity of *Z. abelicea* found in each of its four main areas of occurrence. While the remoteness and inaccessibility of some of the last remaining natural *Zelkova* populations prevent the broader public from appreciating their grandeur in the wild, *ex situ* collections at botanic gardens and associated scientific institutions, play a critical role in enhancing environmental awareness and education. Linking reports of fossil finds with their extant relatives and new population discoveries,

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07. Conclusions

• Gratzfeld Joachim
• Kozlowski Gregor
• Buord S.
• Fazan L.
• Christe C.
• Bétrisey S.
• Garfì G.
• Pasta S.
• Gotsiou P.
• Fournaraki C.
• Dimitriou D.
• Sklavaki P.
• Naciri Y.
• Dadashova A.
• Selimov R.
• Davitashvili N.
• Song Y.

Zelkova spp. and relict plants in general, can provide compelling stories to reach out to the wider society. Relict species from ancient times not only function as storehouses of information of the Earth's transformations over millions of years but also deliver a diverse range of ecosystem services. Though ultimately a matter of societal choice, their conservation therefore presents a vital element in the development of future ecosystem management approaches, especially in a period of unprecedented, rapid global change.

The conservation challenges of the species in the genus *Zelkova* have attracted the attention of researchers, conservation practitioners and horticulturalists in a joint endeavour to secure the remaining genetic diversity in the genus for future generations. Since 2010, this shared concern has brought together a highly interdisciplinary and international research group comprising of partners from Europe, the Caucasus and East Asia, to develop and implement Project *Zelkova* – an integrated conservation action plan for all the species in the genus (Kozlowski & Gratzfeld, 2013). Such multidisciplinary teams of researchers and conservation practitioners are essential to successfully conduct large-scale, complex initiatives that offer sustained management solutions and resonate with stakeholders (Ostrom, 2009; van Riper III *et al.*, 2012). Project *Zelkova* has had a unique ability to bring international partners together, mobilise financial resources, pool the collective expertise and encourage local stakeholders to participate in conservation actions.

By recognising that we live in a rapidly changing environment, and encouraging interdisciplinary science and action, this initiative offers a valuable model for replication in other threatened trees initiatives.

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07. References

• *Gratzfeld Joachim*
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• *Bétrisey S.*
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• *Fournaraki C.*
• *Dimitriou D.*
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STRENGTHENING THE CONSERVATION VALUE OF *EX SITU* TREE COLLECTIONS

Photo credit : Well curated, genetically diverse collections of many wild origin tree accessions is a priority step to ensuring that living collections contribute to collective conservation efforts of trees, *The Morton Arboretum*

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> Keywords EX SITU
GLOBAL STRATEGY FOR PLANT CONSERVATION
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07. Abstract

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• *Westwood Murphy*

WITH >10% OF TREES THREATENED WITH EXTINCTION THERE IS AN URGENT NEED FOR BOTANICAL GARDENS TO PROTECT THREATENED TREES IN DEDICATED CONSERVATION COLLECTIONS.

Species conservation is mentioned in the mission statements of most major botanical gardens, yet the actual conservation value of existing *ex situ* tree collections is low. We have been promoting an ongoing dialog with members of the global botanical garden community to identify ways to improve the conservation value of living *ex situ* tree collections. We have conducted dozens of interviews with garden colleagues and organized a symposium at the 5th Global Botanic Gardens Congress in October, 2013 (Dunedin, New Zealand) to discuss topics including the challenges of maintaining a conservation collection, how to prioritize tree species for conservation, how to measure the value of living collections, and strategies and recommendations to improve living conservation collections. We synthesized and evaluated this information to facilitate gardens becoming more effective agents for global tree conservation. Experts agree that gardens offer valuable strengths and assets for tree conservation. Some challenges exist, however, including a lack of strategic conservation focus, collection management limitations, gaps in fundamental biological information for trees, and a lack of global coordination. We offer solutions to facilitate gardens and arboreta of all sizes to participate more effectively in tree conservation. Prioritizing genetically diverse tree collections, participating in conservation networks, developing tree-specific conservation models and guidelines, and strengthening tree science research efforts are a few examples. Most importantly, a more coordinated global effort is needed to fill knowledge gaps, share information, and build conservation capacity in biodiversity hotspots to prevent the loss of tree species.

It is important to continue the dialog within the European botanical garden community on developing North/South partnerships, sharing knowledge, capacity building in gardens (especially in biodiversity hotspots), strengthening support for the Global Strategy for Plant Conservation, and forging networks and partnerships to work towards global tree conservation goals. Outcomes of these discussions are geared at **1)** the alignment and focus of conservation objectives and strategies for the European garden community, **2)** the identification of collaboration opportunities to catalyse conservation action, and **3)** the identification of model successful conservation partnerships and network building examples.

Results of interviews and discussions have been published in Oryx, 2015, 49(3), 416-424. Here the authors present adapted and abbreviated highlights.

> Keywords
EX SITU
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INTEGRATED CONSERVATION MANAGEMENT
TREE CONSERVATION

07. Prioritization

• Cavender Nicole
• Westwood Murphy

Photo credit : Well curated, genetically diverse collections of many wild origin tree accessions is a priority step to ensuring that living collections contribute to collective conservation efforts of trees, *The Morton Arboretum*

NO SINGLE GARDEN CAN PROTECT ALL OF THE >9,600 THREATENED TREE SPECIES. GARDENS MAY ONLY HAVE SUFFICIENT RESOURCES TO INVEST IN THE CONSERVATION OF A FEW OR ONLY ONE TARGET SPECIES AND A CAREFUL PROCESS FOR PRIORITIZATION SHOULD TAKE PLACE. THE FOLLOWING CRITERIA, *THE EIGHT ES*, CAN BE USED FOR PRIORITIZING TREE SPECIES FOR *EX SITU* CONSERVATION:

1. **Endangerment** (Maunder *et al.*, 2004). Arguably the most important consideration. Prioritize tree species based on regional, national and international threat lists (e.g. IUCN Red List, NatureServe).

2. **Endemism** (Maunder *et al.*, 2004). Tree species with extremely restricted ranges face a high risk of extinction. Protecting threatened plant species in ex situ collections, preferably in their country of origin, is Target 8 of the Global Strategy for Plant Conservation (CBD, 2012).

3. **Economically valuable** (Maunder *et al.,* 2004). Prioritize tree species that are sources of fibre, medicine, timber or food, or that are crop wild relatives (e.g. *Malus sieversii*). This contributes to Target 9 of the Global Strategy for Plant Conservation (CBD, 2012).

4. **Ecologically valuable** (Maunder *et al.*, 2004). Prioritize keystone tree species that provide significant ecosystem services, such as soil stabilization, restoring perennial stream flow, cleaning ground water & supporting biodiversity.

5. **Emblematic** (Maunder *et al.*, 2004). Promoting charismatic, flagship species for conservation purposes can be powerful tool to prevent extinction (e.g. *Sequoia sempervirens, Araucaria araucana, Adansonia* spp.).

6. **Exceptional species** (Cavender *et al.*, 2015). For living *ex situ* collections, prioritize tree species with seeds that cannot be viably seed banked using current technologies (e.g. *Quercus* spp.; Pence, 2013).

7. **Expert opinion** (Cavender *et al.*, 2015). Formal threat assessments such as the IUCN Red List require extensive & time-consuming data gathering & can take months, even years, to publish. When conservation measures are needed urgently, knowledgeable tree experts should push for action, & gardens should consult these experts to gather the necessary information to prioritize immediate conservation action.

8. **Evolutionary significance** (Cavender *et al.*, 2015). Species from monotypic genera or sparsely populated phylogenetic lineages represent valuable genetic diversity that should be protected (e.g. *Wollemia nobilis, Ginkgo biloba*).

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INTEGRATED CONSERVATION MANAGEMENT
TREE CONSERVATION

07. Recommendations

• *Cavender Nicole*
• *Westwood Murphy*

The following is a summary of practical recommendations that can be implemented by botanical gardens and arboreta to improve conservation efforts and increase the value of *ex situ* tree collections.

1. EVOLVE THE GARDEN MISSION & CURATION OF COLLECTIONS

Focus the garden mission and ensure that tree conservation is an explicitly stated component of the institutional mission. Align the institutional strategic plan, including well-developed & measurable conservation goals, with the targets & timeline of the Global Strategy for Plant Conservation. Make conservation a focus not only of living collections but also of databases, propagation strategies, education, interpretation & fundraising efforts.

Manage collections for conservation value. Advance the collection mentality from one of 'stamp collecting' to collecting for conservation purposes (i.e. many wild-collected, well-curated, genetically diverse individuals).Think beyond the collection towards an integrated conservation management strategy that includes reintroduction and in situ habitat protection, leading to recovery of healthy tree populations. Develop seed bank collections when viable. Prioritize threatened exceptional tree species (i.e. those that cannot be stored in a seed bank by using conventional methods) for living conservation collections. Be pragmatic & realistic in scope when developing conservation collection priorities. Replicate conservation collections (i.e. share accessions) across institutions as an insurance policy against natural disasters, disease & institutional closures. To ensure the long-term preservation of genetic diversity of *ex situ* conservation collections, propagate genetically valuable accessions, maintain an optimized age distribution & administer a strategic breeding programme. Maintain detailed records of living collections & share collections data through open-access databases.

Collect for tree conservation. When designing collecting strategies, maximize the number of wild-collected accessions & maternal lines from across the range of the species. Collect threatened trees opportunistically, keeping in mind the population genetic factors that influence collection quality. Ensure rigorous provenance documentation for every accession at the time of collection.

2. IMPROVE COORDINATION BETWEEN GARDENS

Use existing networks. Support Botanic Gardens Conservation International (*bgci.org*), the Global Trees Campaign (*globaltrees.org*) and ArbNet (*arbnet.org*) as mechanisms for unifying the garden community and building the global network. Establish or join a hub of conservation action, in which one organization or consortium takes responsibility for coordinating the conservation activities of a particular taxonomic group or geographical region. Lobby the Parties to CITES and the Convention on Biological Diversity to consider an exemption for non-profit gardens to export threatened tree species strictly for conservation & research purposes.

Establish new relationships. Initiate collaborations with gardens locally & globally to streamline conservation efforts, share ideas and resources, and exchange threatened plant material. Embrace opportunities to recognize & acknowledge colleagues and publicize collaborative efforts.

Improve communication. Join the conservation conversation by participating in a variety of communication channels, including social media, attending conferences and subscribing to professional organizations.

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INTEGRATED CONSERVATION MANAGEMENT
TREE CONSERVATION

07. Recommendations

• *Cavender Nicole*
• *Westwood Murphy*

Use established models. Learn from other organizational models, such as the American Zoological Association & the National Institute for Health, both of which have an explicit, unified purpose & manage centralized, well-organized, open-access databases of biological information.

3. EMPOWER SMALLER GARDENS TO CONSERVE TREES

What any garden can do. Prioritize seed sourced from wild populations & ensure thorough documentation of collections. Collaborate with leading gardens by volunteering land to grow threatened tree species (especially valuable when smaller gardens are in ecologically unique, valuable or threatened habitats). Leverage the expertise, resources & germplasm already available from leading gardens to support tree conservation programmes. Emphasize conservation to the public through education & interpretation. Act as local liaisons to facilitate collecting trips, monitor local threatened tree populations & support citizen science programmes.

How leading gardens can help. Develop complementary tree conservation programmes with smaller or less well-resourced gardens. Coordinate & facilitate conservation between many different institutions to streamline efforts. Recruit & support land owners of all types (e.g. city councils, universities, religious organizations, golf courses, cemeteries, private estates) to participate in tree conservation on their property. Build capacity for gardens in biodiversity hotspots through institutional partnering & developing models of conservation action that other gardens can adopt. Lobby for *in situ* conservation initiatives & habitat protection in areas of high biodiversity but that have low capacity for protecting threatened trees.

4. ADVANCE INFORMATION TECHNOLOGY & CLOSE GAPS IN KNOWLEDGE

Collaborate & share information. Strengthen ties with academia to enhance scientific rigour in tree research, improve access to scientific facilities & increase cross-disciplinary funding opportunities. Participate in researcher exchanges between institutions to share knowledge. Publicize research & conservation project results (both successes & failures) in traditional (e.g. peer-reviewed journals, conference proceedings) & non-traditional (e.g. social media, blogs, popular science articles, newsletters, podcasts) media channels.

Prioritize conservation-focused tree science research. Include funds for comparative genetic analysis of *ex situ* & *in situ* tree populations when applying for grant funding. Study living collections of threatened species to improve understanding of basic biology, reproduction, growth & disease resistance. Increase research on seed banks, cryopreservation, tissue culture, & micropropagation techniques for exceptional tree species, to improve efficiency & cost-effectiveness. Increase research on tree biology, taxonomy, phylogeny & reproductive ecology. Develop horticultural & propagation protocols for exceptional species.

Create tree-specific conservation models & guidelines. Develop scientifically informed models, based on specific life history traits, reproductive biology & distribution, for a range of tree taxa to predict the minimum necessary size for an ex situ living collection for conservation purposes. Develop standard protocols for maintaining & curating *ex situ* conservation collections of trees. Develop an industry-wide process for sharing collections information, including living trees, herbarium specimen data & genetic diversity data.

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TREE CONSERVATION

07. Recommendations

• *Cavender Nicole*
• *Westwood Murphy*

Contribute to conservation databases. Coordinate or contribute to efforts to evaluate extinction risk of tree species through the IUCN Red List assessment process. Employ best practices in database management & georeferencing (see guidelines at iDigBio, 2011). Share living collections & herbarium data with databases such as PlantSearch and the Global Biodiversity Information Facility.

5. PROMOTE CONSERVATION-FOCUSED EDUCATION, TRAINING & PUBLIC ENGAGEMENT

Create training opportunities. Train others in all aspects of tree science & care, especially students, & local people in biodiversity hotspots with threatened in situ tree populations. Promote botanical undergraduate & graduate programmes, ensuring the next generation of plant scientists, horticulturalists & collections curators is prepared. Support training programmes by mentoring students & interns.

Interpret & educate. Use living tree collections to create conservation-focused interpretation displays that are informative, engaging & innovative, & that inspire a call to action. Empower & educate the public on how they can contribute to tree conservation efforts, for example by choosing native or threatened woody species in their home landscaping. Incorporate conservation-focused fundraising opportunities into garden interpretation & public events (e.g. offer an adopt-a-tree programme for threatened species or highlight an ongoing in situ tree conservation programme to which the public can donate). Leverage existing outreach channels, such as public education programmes, summer camps & special events, to communicate the importance of tree conservation to the general public.

Involve the community. Develop citizen science programmes to engage the public in tree conservation & help generate valuable biodiversity data (e.g. collating information from digitized herbarium sheets, or documenting rare species sightings using specialized smartphone applications). Realize that prioritizing conservation is actually an asset, not an expense, which helps attract visitors & revenue streams to botanical gardens & arboreta.

Conclusions

Botanical Gardens and Arboreta have an important role to play in protecting the tree diversity of the planet. Improving the effectiveness of ex situ tree collections for conservation must be a priority if we are to confront the many challenges we face. We have offered many practical recommendations from a collective body of experts that if followed, could lead to a greater potential of promoting tree conservation and preventing impending extinction of many species. The most important step towards greater conservation effectiveness is to first prioritize well-curated, genetically diverse collections of many wild-origin accessions to maximize reintroduction potential. Even by taking small steps, such focusing efforts on one threatened tree species at a time or using living collections to educate the public about global tree conservation issues, gardens of all sizes can make a great contribution to collective conservation efforts.

> Keywords EX SITU
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TREE CONSERVATION

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• *Cavender Nicole*
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SAUVETAGE DU GENEVRIER D'EKMAN ET CONSERVATION DE LA FLORE DE LA FÔRET DES PINS (HAÏTI)

Photo credit : Le 2ème exemplaire connu de Juniperus gracilior var. eckmanii, avec des membres de l'association OPDFM (Haïti), ***Fanch LE HIR***

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> Mots-clefs HAÏTI FORÊTS DES PINS *JUNIPERUS GRACILIOR* VAR. *EKMANII* GENÉVRIER D'EKMAN CONSERVATION *EX-SITU* MULTIPLICATION *IN VITRO*

07. Résumé

• *Le Hir Fanch*
• *Desmarattes Elie*
• *Bordenave Bruno*
• *Mézard Claudy*
• *Gautier Catherine*
• *Cueff Estelle*
• *Bodin Manuelle*

LE CONSERVATOIRE BOTANIQUE NATIONAL DE BREST (CBNB) ŒUVRE DEPUIS QUARANTE ANNÉES POUR LA CONSERVATION DES ESPÈCES VÉGÉTALES MENACÉES À TRAVERS LE MONDE. IL INTERVIENT À UNE ÉCHELLE LOCALE (FLORE DU MASSIF ARMORICAIN) ET REÇOIT À CE TITRE L'AGRÉMENT «CONSERVATOIRE BOTANIQUE NATIONAL» DÉLIVRÉ PAR LE MINISTÈRE DE L'ENVIRONNEMENT FRANÇAIS.

Depuis sa création il mène des actions de sauvetage sur des espèces au bord de l'extinction totale (*Ruizia cordata* de l'île de la Réunion, *Normania triphylla* de Madère, *Zelkova sicula* de Sicile, *Cylindrocline lorencei* de l'île Maurice). Grâce à la fondation CEPF (Fonds de Partenariats pour les Ecosystèmes Critiques) le CBNB s'est allié en 2013 à l'OPDFM (Organisation Paysanne de la Forêt des Pins-Mare Rouge) d'Haïti pour conserver et valoriser la flore de cette aire protégée, située en altitude à proximité de la République dominicaine. Haïti est l'un des pays les plus déforestés de la planète (moins de 3% de forêts à l'heure actuelle) et la Forêt des Pins est l'un des seuls massifs forestiers encore existants dans l'île. Cet écosystème unique et menacé héberge de nombreuses espèces endémiques dont le rarissime genévrier d'Ekman (*Juniperus gracilior* var. *ekmanii*) connu, au début du programme, d'une seule station comportant un pied unique et âgé. Par la suite, grâce à la sensibilisation des populations locales, deux autres stations, hébergeant respectivement un et cinq spécimens, ont été découvertes. Comme le genévrier d'Ekman ne se régénère pas, un programme de multiplication *in vitro* a été mis en place en collaboration avec le laboratoire Vegenov, après la mise au point d'un protocole de culture. Les premières étapes (désinfection, introduction *in vitro*, maintien en culture) ont été franchies avec succès. Des difficultés sont apparues pour obtenir l'enracinement. L'objectif est de pouvoir rapatrier les plantules en Haïti et d'organiser des opérations de réintroduction avec les acteurs locaux.

Outre le sauvetage de cette espèce patrimoniale d'Haïti, le programme comporte d'autres volets complémentaires (amélioration de la connaissance de la flore, création d'un jardin de plantes endémiques, formation et sensibilisation). Ce programme se fait avec le soutien logistique d'HELVETAS Haïti.

> Keywords HAÏTI FORÊTS DES PINS *JUNIPERUS GRACILIOR* VAR. *EKMANII* EKMAN'S JUNIPER TREE *EX-SITU* CONSERVATION *IN VITRO* PROPAGATION

07. Abstract

- *Le Hir Fanch*
- *Desmarattes Elie*
- *Bordenave Bruno*
- *Mézard Claudy*
- *Gautier Catherine*
- *Cueff Estelle*
- *Bodin Manuelle*

SINCE 40 YEARS, BREST NATIONAL BOTANICAL CONSERVATORY (CBNB) DEDICATES EFFORTS OVER WORLDWIDE THREATENED PLANT SPECIES CONSERVATION. REGION SCALE PROGRAMS ARE ALSO CARRIED OUT IN THE ARMORICA RANGE IN BRITTANY, FRANCE, WITH THE MINISTRY OF ENVIRONMENT'S APPOINTMENT AS "NATIONAL PLANT CONSERVATORY".

Since its creation, priority actions have been carried out over critically endangered species such as the Reunion Island's Ruizia cordata, Madeira's *Normania triphylla*, Sicily's *Zelkova sicula* and Mauritius *Cylindrocline lorencei*. Thanks to support of the Critical Ecosystem Partnership Fund (CEPF), the CBNB works in Haïti since 2013 with the Mare Rouge Pine Forest farmer's association (OPDFM) to preserve and valuate the flora of this protected area, in the south-east Mountains, close to the Dominican Republic's border. Haiti is one of the world's most deforested countries with less than 3% of its forest speared, the Mare Rouge Pine Forest being one of the only significant remaining ones in the country. This unique and threatened ecosystem shelters a large set of endemic species, including the extremely rare Ekman's Juniper tree (*Juniperus gracilior* var. *ekmanii*). When this program began, the species was known from a unique site and a single aging tree. Thanks to the awareness of local people, two additional sites harbouring one and five other trees were discovered more recently. But since this species doesn't breed, a germplasm culture program has been initiated in partnership with the specialised Vegenov laboratory, with the aim of repatriating young plants and organising a reintroduction program with local partners. The first steps (disinfection and *in vitro* cultivation) were successfully achieved, with however some initial rooting challenges. In addition to safeguarding this Haiti's natural heritage with this high conservation value species, this program involves further shares such as increasing botanical knowledge, implementing a local endemic plants botanical garden, training and awareness rising. This program has received logistic support from HELVETAS-Haiti.

> Mots-clefs HAÏTI FORÊTS DES PINS *JUNIPERUS GRACILIOR* VAR. *EKMANII* GENÉVRIER D'EKMAN CONSERVATION *EX-SITU* MULTIPLICATION *IN VITRO*

07. Contexte du projet

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• *Desmarattes Elie*
• *Bordenave Bruno*
• *Mézard Claudy*
• *Gautier Catherine*
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Photo credit : Le 2ème exemplaire connu de Juniperus gracilior var. eckmanii, avec des membres de l'association OPDFM (Haïti), *Fanch LE HIR*

LA RÉPUBLIQUE D'HAÏTI FAIT PARTIE DU HOTSPOT DES CARAÏBES, QUI HÉBERGE UNE FLORE TRÈS RICHE COMPORTANT PRÈS DE 1 500 GENRES INDIGÈNES REPRÉSENTANT ENVIRON 11 000 ESPÈCES À FLEURS, DONT PRÈS DE 8 000 TAXONS ENDÉMIQUES.

Parmi les pays des Caraïbes, Haïti est certainement l'un des pays les plus déforestés, ayant perdu en quelques décennies la majorité de ses forêts. Aujourd'hui on considère que moins de 3% du territoire haïtien est couvert de forêts, alors qu'en 1923 sa couverture forestière était d'environ 60%. Cette déforestation a entrainé des phénomènes d'érosion majeure avec pour conséquence des catastrophes (inondations) régulières et un appauvrissement général des populations locales. Par ailleurs, cette réduction drastique des habitats risque de faire disparaitre un bon nombre d'espèces endémiques de ce hotspot inestimable. Parmi les espèces végétales menacées d'Haïti figure *Juniperus gracilior* Pilg. var. *ekmanii* (Florin) R.P. Adams, arbre emblématique au bord de l'extinction totale car il ne subsistait, au début du projet, qu'un seul exemplaire âgé dans la montagne de La Selle. Si rien n'est entrepris rapidement, cette espèce emblématique, mais aussi d'autres espèces patrimoniales peuvent disparaitre à tout jamais, privant ainsi Haïti et les populations locales de ce patrimoine unique.

Le genévrier d'Ekman n'est connu en Haïti que dans la Forêt des Pins (partie Ouest, appelée «Unité 2»), aire protégée de 16 000 ha, aujourd'hui Parc National Naturel. La Forêt des Pins se situe dans le Massif de la Selle qui fait partie du corridor prioritaire «Corridor binational du Massif de la Selle-Jaragua-Bahoruco-Enriquillo», à cheval sur Haïti et la République Dominicaine. Ce corridor héberge un habitat particulier à savoir les forêts subtropicales de montagne à majorité de *Pinus occidentalis* Sw. (espèce endémique d'Hispaniola), mais aussi de forêts de feuillus (appelés « raks » en créole haïtien) et hébergeant une biodiversité élevée. C'est, à Haïti, l'un des derniers espaces hébergeant des forêts naturelles abritant des espèces patrimoniales et endémiques comme le genévrier d'Ekman. Aujourd'hui protégée, la Forêt des Pins a fait l'objet par le passé d'une exploitation forestière. Les menaces actuelles sont les incendies et le prélèvement de «bois gras», partie basse des pins accumulant une grande quantité de résine et servant d'allume-feux. Des opérations de reboisement sur de grandes échelles sont réalisées annuellement par l'Organisation Paysanne De la Forêt des pins-Marne rouge (OPDFM), le Ministère de l'Agriculture, des Ressources Naturelles et du Développement Rural (MARND) et la coopération suisse par le biais de la HELVETAS Haïti.

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Le genévrier d'Ekman, autrefois plus commun en Haïti (des souches subsistent dans le Parc de la Visite) a fait l'objet de coupes pour la qualité de son bois rouge et imputrescible ce qui a entrainé sa disparition. Le genévrier d'Ekman est aussi présent en République dominicaine mais également dans très peu de stations (Sierra Baoruco). Il est classé CR (en danger critique) par l'UICN.

Les acteurs du projet

L'OPDFM

Créée en 2009, l'Organisation des Paysans pour le Développement de l'unité II de la Forêt des Pins, Mare Rouge (OPDFM) est composée des représentants du noyau central de la réserve ainsi que ceux de la zone tampon. Elle est constituée d'un conseil d'Administration de cinq membres et de cinq commissions techniques. Pour des besoins spécifiques en relation avec ses activités, elle sollicite l'appui technique auprès des Institutions avec lesquelles elle collabore : Ministère de l'Environnement (MDE), MARND, la HELVETAS Haïti.

La création de l'OPDFM répond à la nécessité d'organiser et de renforcer les acteurs de la société civile au niveau de la zone, afin d'identifier et de développer des actions pouvant leur permettre d'apporter des éléments de solution aux problèmes de dégradation de l'environnement et de la destruction des ressources naturelles ainsi que de l'inexistence quasi-totale des services sociaux de base (santé, éducation, etc.) auxquels est confrontée la zone de l'unité II de la Forêt des Pins.

LA HELVETAS HAÏTI

Fondée en 1995, HELVETAS Swiss Intercooperation (HSI), Organisation suisse de coopération au développement, travaille en Haïti et met en œuvre des projets en partenariat avec des ministères sectoriels et les acteurs locaux : CASEC (Conseil d'Administration de la Section Communale), ASEC (Assemblée de la Section communale) et OCB (Organisation Communautaire de Base). Ces projets sont localisés dans les départements de l'Ouest, du Sud-Est et de l'Artibonite. La HELVETAS gère avec l'OPDFM l'aire protégée de la Forêt des Pins (Unité 2) (récemment transformée en Parc National Naturel) et soutient des activités de développement dans la zone tampon de l'aire protégée.

LE CONSERVATOIRE BOTANIQUE NATIONAL DE BREST

Le Conservatoire botanique national de Brest (France), créé en 1975, est spécialisé dans la conservation des plantes menacées de disparition, à une échelle locale et internationale.

Les actions internationales de sauvetage, mais aussi de réintroduction, fondement historique de son action, ont conduit le Conservatoire botanique à intervenir en de nombreux endroits du monde avec une priorité accordée aux îles océaniques compte tenu de la fragilité de leur flore, souvent endémique. Le Conservatoire botanique dispose aujourd'hui d'une collection de plus de 4 500 espèces et variétés de plantes différentes dont plus de 1 900 sont menacées de disparition ou disparues en nature. Il abrite ainsi l'une des plus prestigieuses collections de plantes menacées.

Cette collection est située au sein d'un jardin de 30 hectares dédié à l'action du Conservatoire qui reçoit chaque année 300 000 à 400 000 visiteurs dont 10 000 pour les serres pédagogiques.

> Mots-clefs HAÏTI FORÊTS DES PINS *JUNIPERUS GRACILIOR* VAR. *EKMANII* GENÉVRIER D'EKMAN CONSERVATION *EX-SITU* MULTIPLICATION *IN VITRO*

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LE LABORATOIRE VEGENOV

Vegenov est un Centre de Ressources Technologiques spécialisé dans le végétal. Ses compétences techniques se déclinent en quatre domaines d'expertise : la santé des plantes, la qualité des produits végétaux et en particulier des légumes, les empreintes génétiques des plantes et de leurs pathogènes et la biologie cellulaire, dont la culture *in vitro*. Ces outils sont développés dans le cadre de projets de recherche appliquée à la création variétale et peuvent s'adapter aux besoins de sauvetage de plantes menacées d'extinction.

L'ARCHE AUX PLANTES

L'Arche aux Plantes est une association de type loi 1901, créée en 1986, qui regroupe des personnes passionnées par le monde végétal en général et s'intéressant à la conservation des espèces menacées en particulier. Elle apporte son soutien à différentes actions de conservation menées par le Conservatoire botanique national de Brest, notamment sur les espèces végétales en grand danger d'extinction. Elle organise chaque année deux fêtes des plantes dans le jardin du Conservatoire botanique national de Brest dans le but de collecter des fonds, ce qui lui a permis de créer en 1992 un fonds de sauvegarde dédié au financement ponctuel d'actions de sauvetage d'espèces végétales en danger de disparition et au démarrage de projets de coopération dans les pays émergents.

LE CEPF

Le CEPF (Critical Ecosystem Partnership Fund / Fonds de Partenariat pour les Ecosystèmes Critiques) est l'une des principales initiatives mondiales permettant à la société civile d'influencer et de participer à la conservation des écosystèmes parmi les plus critiques au monde. Ce mécanisme de financement unique est soutenu par sept grands bailleurs : l'Agence Française du Développement, Conservation International, l'Union Européenne, le Fonds pour l'Environnement Mondial, le Gouvernement Japonais, la Fondation Mac Arthur et la Banque Mondiale.

Le projet

Le projet a été focalisé sur le sauvetage du genévrier d'Ekman car il ne subsistait qu'un seul exemplaire connu en Haïti (Unité 2 la Forêt des Pins). Cet exemplaire ne développant pas de semences et la multiplication par bouturage classique ne marchant pas, il a été décidé de sa reproduction par culture *in vitro*. Mais ce projet, avec le genévrier d'Ekman comme « espèce-phare », comportait également d'autres composantes : amélioration des connaissances, formation des acteurs, conservation *in situ*, sensibilisation et communication…

AMÉLIORATION DES CONNAISSANCES

Il eut été très dommage de ne s'intéresser qu'à une espèce végétale menacée de disparition alors que la Forêt des Pins héberge une flore patrimoniale peu connue. Même si Haïti fait l'objet d'études floristiques de la part de botanistes haïtiens et internationaux, la connaissance de la flore haïtienne comporte de nombreuses lacunes. La Flore d'Haïti de H. D. Barker et de W. S. Dardeau date de 1930. Un herbier, créé par le botaniste suédois Ekman dans les années 1920, est hébergé à la Faculté d'Agronomie de l'Université d'Etat de Port-au-Prince, mais reste à développer.

Dans le cadre du projet plus de 150 spécimens d'herbiers ont pu être collectés dans la Forêt des Pins et dans la zone tampon entre octobre 2013 et septembre 2014. Un double de chaque spécimen a été confié à l'herbier

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07. Le projet

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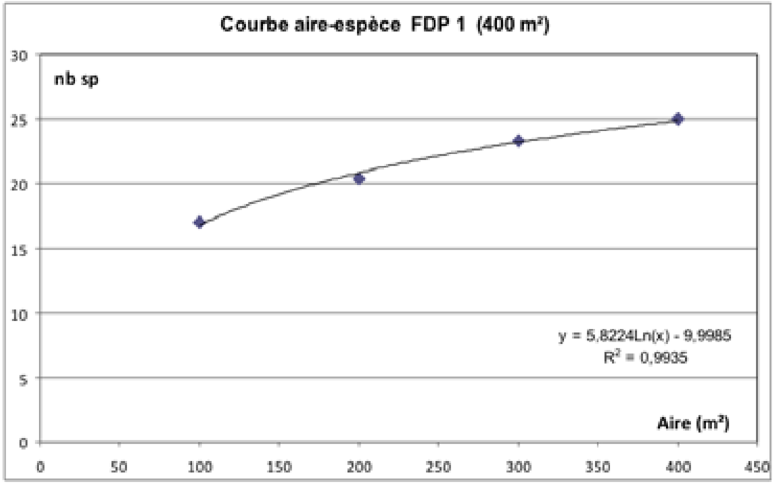
Ekman de la Faculté d'Agronomie de Port-au-Prince. Ces spécimens font actuellement l'objet d'identifications par de nombreux spécialistes. Toutes les planches d'herbiers ont été scannées et seront mises en ligne sur le site de Tela Botanica (PictoFlora). Concernant le genévrier d'Ekman, la HELVETAS Haïti et l'OPDFM ayant sensibilisé les populations locales sur l'importance de la conservation de cette espèce, deux nouvelles stations ont été découvertes : l'une par une villageoise dans un rak surplombant une ravine (un exemplaire unique), l'autre par les gardes de l'environnement dans une zone très déforestée, mais comportant 5 exemplaires, dont certains très âgés. La totalité de la population de genévrier d'Ekman en Haïti est de 7 exemplaires connus.

Une liste des espèces patrimoniales de la Forêt des Pins a été élaborée et parmi celles-ci nous pouvons citer : *Pinus occidentalis* Sw., *Fuchsia pringsheimii* Urb., *Fuchsia triphylla* L., *Schefflera tremula* (Krug & Urb.) Alain, *Podocarpus aristulatus* Parl., *Begonia domingensis* A. DC, *Salvia selleana* Urb., *Palicourea alpina* (Sw.) P. DC, *Juniperus gracilior* Pilg. subsp. *urbaniana* (Pilg. & Ekman) R.P. Adams, *Buddleja domingensis* Urb., *Arthrostylidium haitiense* (Pilg.) Hitchc. & Chase, Lobelia *ekmanii* Urb.

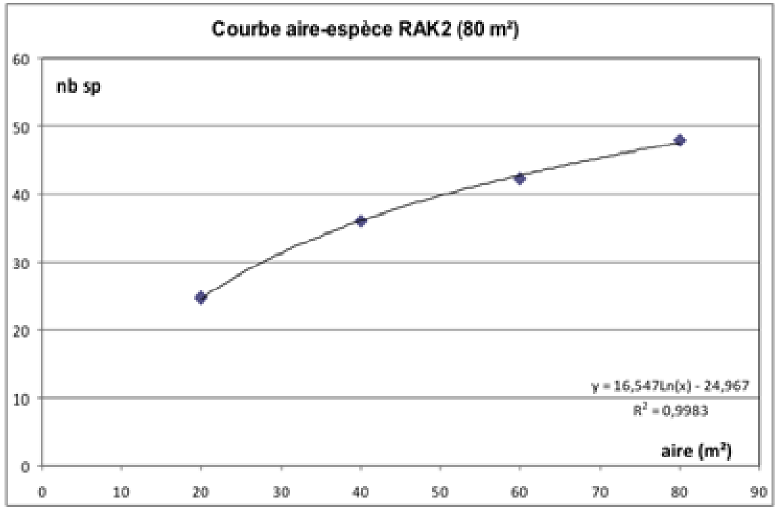
Des inventaires botaniques ont été réalisés dans différentes milieux afin d'analyser la structure et la diversité spécifique de la forêt de feuillus (rak), et de la forêt à base de *Pinus occidentalis*. Ces inventaires démontrent une plus grande richesse dans les forêts de feuillus (**Figs 1** et **2**).

En effet, si on compare la richesse spécifique mesurée dans les forêts de pins à celle relevée dans les raks, on peut estimer à une moyenne de 46 espèces pour une superficie de 1 hectare dans le premier cas (IRSFDP = 6,4 avec un coefficient de corrélation R^2 = 0.992) et de 112 dans le second (IRSRAK = 10,28 avec R^2 = 0.999). Compte tenu de la forte proportion d'espèces endémiques et de la présence d'espèces menacées de disparition dans ces deux types de végétation, cela représente, dans les deux cas, un patrimoine naturel considérable et irremplaçable, les végétations de rak étant à la



> FIGURE 1

Diversité de la forêt de pins



> FIGURE 2

Diversité de la forêt de feuillus (rak)

> Mots-clefs HAÏTI FORÊTS DES PINS *JUNIPERUS GRACILIOR* VAR. *EKMANII* GENÉVRIER D'EKMAN CONSERVATION *EX-SITU* MULTIPLICATION *IN VITRO*

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fois plus riches mais aussi certainement plus menacées encore que les forêts à *Pinus occidentalis*. Malheureusement la plupart des raks se trouvent dans la zone tampon de l'aire protégée et sont souvent défrichées pour les cultures vivrières par les populations locales. A l'avenir il importera de protéger ces milieux patrimoniaux.

Enfin, des enquêtes ethnobotaniques ont permis de dresser une liste de plus d'une centaine de plantes autochtones ou introduites utilisées pour soigner les maladies courantes des populations locales (celles-ci n'ayant pas accès à la médecine conventionnelle).

SAUVETAGE DU GENÉVRIER D'EKMAN

La multiplication *in vitro* ayant été programmée lors du début du projet, des essais de désinfection et de mise en milieu stérile ont été effectués par Vegenov et le CBNB sur différentes espèces de genévriers et de conifères proches du genévrier d'Ekman. De même un protocole de collecte, de conditionnement et de transport a été élaboré par le CBNB afin d'obtenir du matériel frais à l'arrivée au laboratoire. Enfin une demande d'autorisation de collecte et de transport de boutures de genévrier d'Ekman a été adressée au Ministère de l'Agriculture, des Ressources Naturelles et du Développement Rural (MARND).

Plusieurs séries de boutures ont pu être collectées lors de missions sur le terrain en 2014 et 2015 puis transportées jusqu'au laboratoire VEGENOV à Saint-Pol-de-Léon (Finistère). En tout 4 différents clones ont été mis en culture (les autres clones n'étant pas accessibles car poussant sur une falaise abrupte).

Au niveau des résultats, les phases de désinfection et de mise en culture en milieu stérile ont été couronnées de succès, même si le pourcentage de réussite n'est pas très élevé. Les micro-boutures ont été désinfectées, après rinçage à l'eau et au Mercryl, dans une solution d'hypochlorite de calcium à 10% pendant 15 minutes et ensuite introduites en condition stérile sur un milieu Woody Plant Medium (WPM) de McCown avec du saccharose à 30g/l et des hormones : BPA à 0,5mg/l et 2.4D à 0,5 mg/l. Les vitroplants ont été ensuite placés en chambre de culture à 25°C.

Quelques micro-boutures ont émis de nouvelles pousses qui ont été repiquées sur un milieu de multiplication identique au milieu d'introduction (WPM), avec uniquement l'hormone BPA testée à différents dosages entre 0,5 et 1,5 mg/l.

Au moment du congrès EurogardVII, le nombre de micro-boutures était d'une centaine. Quand elles seront enracinées et sorties des tubes, elles seront diffusées dans d'autres jardins botaniques pour des raisons de sécurité et réintroduites en milieu naturel au sein du Parc National Naturel de la Forêt des Pins.

En conclusion, on peut dire que cette espèce semble assez difficile à multiplier en culture *in vitro*, mais cela est souvent le cas au début de ce type de multiplication pour une nouvelle espèce.

FORMATION DES ACTEURS

Le projet comportait également un volet « renforcement des capacités », notamment dans le domaine de la multiplication des espèces patrimoniales, afin d'élever en pépinières d'autres espèces que Pinus occidentalis, aujo-

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urd'hui largement utilisé à des fins de reboisement dans la zone cœur et la zone périphérique de l'aire protégée. Outre des cours sur le terrain, un petit guide du pépiniériste a été conçu en français et en créole afin de transmettre de nouvelles techniques de multiplication aux pépiniéristes de l'OPDFM, l'objectif étant d'inclure des espèces patrimoniales dans les plans de reboisement.

CONSERVATION *IN SITU*

Si le projet était focalisé sur la conservation *ex situ* du genévrier d'Ekman, les actions de conservation *in situ* n'ont pas été oubliées. Grâce aux connaissances acquises lors des inventaires botaniques, des préconisations ont été apportées afin de mettre à jour le plan de gestion : mise en défens des nouvelles stations de genévrier d'Ekman, conservation des raks, protection de la station unique de Juniperus gracilior var. urbaniana, autre espèce endémique d'Hispaniola.

COMMUNICATION ET SENSIBILISATION

Deux conférences de presse ont été organisées en Haïti (Jacmel) et en France (Brest) afin de communiquer sur le projet et faire connaitre l'aire protégée de la Forêt des Pins. Des réunions avec les membres de l'OPDFM ont également permis de sensibiliser les populations locales. Un « jardin des plantes endémiques » est en cours de création dans la zone tampon. C'est en réalité un rak d'une quinzaine d'hectares qui sera valorisé grâce à un sentier d'interprétation botanique. D'autres espèces patrimoniales seront plantées dans ce jardin que l'on peut aussi appeler « réserve jardinée ». Des plantes médicinales seront également introduites sur le site qui accueillera diverses manifestations de sensibilisation à l'environnement.

Conclusions

Ce projet global réalisé avec le CEPF et d'une durée de 25 mois pour des raisons administratives a été clôturé fin septembre 2015. Malgré cette durée très courte, de nombreuses actions ont pu être entreprises (inventaires, formation, sensibilisation, multiplication *in vitro* du genévrier d'Ekman...). Le genévrier d'Ekman aura été une espèce « phare » pour le projet, permettant de mener des activités en parallèle dans le domaine de la connaissance et de la conservation. La découverte d'exemplaires supplémentaires de genévrier d'Ekman permettra peut-être d'obtenir des semences viables (le pied n°2 produit des cônes) et de garantir la diversité génétique de l'espèce. Ce projet aura en outre permis de constituer un groupe de spécialistes qui poursuivra le travail de détermination des espèces végétales de la Forêt des Pins et d'Haïti en général.

Le projet, et en particulier le jardin des plantes endémiques, pourra être intégré dans le réseau du futur jardin botanique national d'Haïti, actuellement en préparation avec le soutien du Comité national haïtien pour l'UNESCO, tout comme le jardin botanique associatif des Cayes, dans le Sud-Ouest d'Haïti. La Fondation « Yves Rocher » a décidé de financer la poursuite des travaux de multiplication *in vitro* du genévrier d'Ekman (phases d'enracinement et de sevrage) et sa réintroduction future en Haïti.

07. Remerciements

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• *Gautier Catherine*
• *Cueff Estelle*
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Nous tenons à remercier particulièrement le CEPF qui a financé ce projet, mais également tous les acteurs qui ont participé de près ou de loin aux différentes activités, l'OPDFM, Vegenov, le CBNB, la HELVETAS Haïti, l'Arche aux Plantes, l'Herbier Ekman, le Muséum National d'Histoire Naturelle de Paris, sans oublier la population locale de la Forêt des Pins Mare Rouge pour leur accueil et leur gentillesse.

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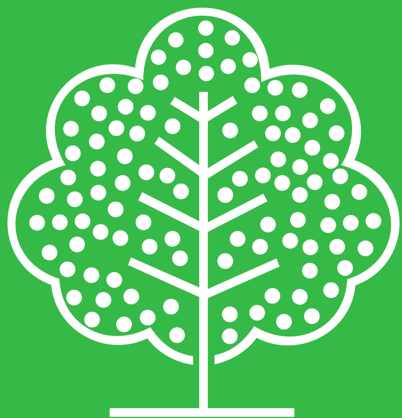
L'ARBRE, ITINERAIRE D'UN ACTEUR PASSE-FRONTIERES



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07. L'arbre, itinéraire d'un acteur passe-frontières

• *Fromageot Claude*

LE SÉDENTAIRE, LE POLITIQUE, LE PAYSAGISTE, L'URBANISTE, LE BOTANISTE, FONT ENTRER L'ARBRE DANS L'ESPACE PHYSIQUE DE LEUR ACTIVITÉ. AU XIX, L'ARBORETUM REPRÉSENTE L'IDÉAL DE LA RELATION À L'ARBRE MAGNIFIÉ.

Avec le développement industriel et médiatique, un hiatus se crée entre le paysage qui n'est plus nommé par ses arbres, et l'usage spécialisé de l'arbre pour ses intérêts spécifiques ou d'experts.

Cependant, à titre individuel, l'homme conserve encore souvent une relation symbolique forte à l'arbre.

Et si l'arbre était un nouvel acteur passe-frontière pour le XXI siècle ?

En raison de notre perception croissante des effets de la dérégulation climatique et des risques pour la biodiversité, les arbres, sous leurs formes diverses, forêts, haies, agréments, etc. nous invitent aujourd'hui, qui que nous soyons, et où que nous soyons, à revisiter notre rapport à la nature.

La Fondation Yves Rocher - Institut de France, soutenue par l'entreprise éponyme et par de nombreux donateurs, est un exemple de cette possible transformation sociétale. Avec les différents partenaires, la Fondation Yves Rocher aura permis la plantation de 50 millions d'arbres entre 2007 et fin 2015.

En France avec l'AFAC, Association Française des Haies et Arbres Champêtres, 25% des haies plantées chaque année sont concernées par ce soutien. Avec plus de 2 millions d'arbres plantés, plus de 4000 acteurs, agriculteurs, communes, écoles, sur plus de 60 départements de la métropole se sont engagés à réimplanter l'arbre et la haie au cœur de leur « monde ».

Au Mexique, avec le WWF (World Wildlife Fund / Fonds Mondial pour la Nature), des pins et cèdres plantés reconstituent les zones tampons et lieux d'hibernation des papillons monarques. Ce papillon migrateur démontre le lien entre biodiversité et climat. Pour les populations locales, ce choix de planter plus de 3 millions d'arbres est celui d'une économie durable basée sur leur savoir-faire.

Tous ces exemples montrent que l'arbre déclenche la transformation et surtout déclenche de nouvelles formes de collaboration entre les secteurs publics, privés, académiques, entrepreneuriaux.

Ces témoignages de relation à l'arbre démontrent la fierté des acteurs, la force de leur engagement et la réelle transformation du rapport à l'environnement.

LANDSCAPE OF PUBLIC ARBORETA IN FRANCE

Photo credit : Forest in winter, Caneiret arboretum, *C. Ducatillion, INRA, PACA, France*

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> Keywords ARBORETUMS
FRENCH NATIONAL NETWORK
EXOTIC TREES DATABASE

07. Abstract

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FRANCE LIES AT THE CROSSROADS OF SEVERAL BIOGEOGRAPHICAL REGIONS, WHICH MEANS IT IS THE HOME OF SOME RICH AND DIVERSE DENDROLOGICAL COLLECTIONS. THESE COLLECTIONS BELONG TO VARIOUS INSTITUTIONS AND NETWORKS.

A comprehensive list of exotic woody species found in the country has not been established, despite the level of interest in these biological resources, especially against the background of global changes. In 2004, several French public institutions set up a national network of arboretums to draw up an inventory of the biological resources available across the country and to promote them. The network currently comprises INRA (National Institution for Agricultural Research), the national natural history museum (MNHN), the French forestry commission (ONF), and Joseph Fourier University in Grenoble (UJF). The goal of the poster presented at Eurogard VII was to publicize this French network, the different types of arboretum, their content and activities.

Around fifteen arboretums have come together, with different botanical compositions and purposes depending on their history, status and location. They include both historical introduction arboretums, with collections of exotic trees, and forestry schemes. Like botanical gardens, the former served educational, horticultural, scientific and conservation purposes. The latter served mainly for scientific purposes, upstream of forestry production. The climate gradient covered by this network stretches from the Atlantic in the west to the Mediterranean in the south, taking in the mountains in the Centre-east and continental influences to the east.

With the aim of studying the abilities of species to adapt to new constraints and to respond to new production requirements, the inventory of metadata and the updating of data on these arboretums has become a priority. This work has been done using a collaborative platform known as Pl@ntNet, which now contains data from the scientific and historical arboretums managed by the ONF and INRA.

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07. Introduction

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Photo credit : Forest in winter, Caneiret arboretum, *C. Ducatillion, INRA, PACA, France*

FRANCE LIES AT THE CROSSROADS OF SEVERAL BIOGEOGRAPHICAL REGIONS, WHICH MEANS IT IS THE HOME OF SOME RICH AND DIVERSE DENDROLOGICAL COLLECTIONS. THESE COLLECTIONS ARE ADAPTED TO CLIMATE INFLUENCES RANGING FROM OCEANIC TO MEDITERRANEAN AND INCLUDING CONTINENTAL AND MOUNTAIN CLIMATES.

These biological resources are managed by various stakeholders within the network; they may be categorized according to their main objectives. For the conservation of plants or wild species, the main networks are the Association des Parcs Botaniques de France (APBF), the association des Jardins Botaniques de France et des pays francophones (JBF), the Conservatoire français des Collections Végétales Spécialisées (CCVS), the Comité des Parcs et Jardins de France (CPJF), the Fédération des Conservatoires Botaniques Nationaux (FCBN), the Groupe d'étude de l'arbre (GEA) and Tela Botanica (Tela). For landscape and ornamental horticulture, the main stakeholders are the nursery owners and landscape gardeners brought together within the Fédération Nationale des Producteurs Horticulteurs Pépiniéristes (FNPHP), the Association des Pépiniéristes Collectionneurs (ASPECO) and the Fédération française du Paysage (FFP). We can also mention the "Green spaces, nature and landscapes" working group of the Association des Ingénieurs Territoriaux de France (AITF), the Plante et Cité technical institutes and the Institut Technique de l'Horticulture (ASTREDHOR). Finally, the network brings together all tree collections with forestry objectives, including comparative arboretums, provenance tests, progeny tests and clonal trials, seed orchards and *ex situ* conservation collections.

A full list of the species present within these different networks has not been established. However, partial inventories have been published and grey literature is available. For example, several partial forestry arboretum reviews have been produced (Afxantidis, 1993; Allemand, 1989; Bastien, 1988; Mons, 1993).

In 2004, several French public institutions set up a national network of arboretums to draw up an inventory of the biological resources available across the country and to promote them. Network members wanted to pool their inventory data in a single database and work together on educational actions and a national phenological survey project. The poster presented at Eurogard VII was designed to present this national network of public arboretums, to characterize and locate the main sites, and present some joint actions.

> Keywords ARBORETUMS FRENCH NATIONAL NETWORK EXOTIC TREES DATABASE

07. Materials & methods

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DEFINITIONS

There are several definitions for the word arboretum. The most basic meaning is any place with a collection of trees. However, this definition is unclear and in reality covers some very different systems. Each institution in the network has its own vocabulary, depending on its resources and their use.

TYPE OF NETWORK ARBORETUMS

The inventory of systems in the network and their description has helped establish an initial typography as follows:

- Botanical gardens with interesting tree collections based on their history, their ornamental qualities, and the rarity of the taxa represented individually or in groups.
- Educational arboretums with tree collections with an educative purpose.
- Collection arboretums which are similar to botanical gardens but only contain tree collections that are interesting in their richness and taxonomic diversity.
- Comparative forestry arboretums that contain numerous taxa (more than 10) from very few different origins, the behavior of which is studied with a view to forestry objectives.

Experimental forestry systems are not included in the public arboretum network. These are, for example, comparative forestry arboretums with a low number of taxa of many different origins, seed orchards, conservation arboretums and nurseries.

DATABASES

To put together this database, it was necessary **1)** to find or develop the tool, **2)** gather the inventory data available at each institution to put together a complete a list as possible of the tree collections in the network, **3)** provide basic information on the taxa, origin, age, and the characteristics of the trees and the taxa, **4)** integrate the metadata on the sites and their institutional, historical and environmental context.

Results

ACTORS AND CURRENT DEVICES

The network initially comprised the following stakeholders: the French national institute for agricultural research (INRA), the national natural history museum (MNHN), the Ecole nationale du génie rural des eaux et forêts (ENGREF - national water and forestry engineering school), the national forestry commission (ONF) and Paris XI University (UPS), later followed by Joseph Fourier University (UJF). The aim of the partnership was to:

- provide mutual support for the scientific and/or educational promotion of the woody collections in the network,
- set up a coordinated renewal and enhancement program.

The arboretums concerned were the following:

- the national Barres arboretum at Nogent sur Vernisson (45), managed by the ENGREF
- the arboretums at Pézanin (71), La Jonchère (87) and Cardeilhac (31), managed by the ONF
- the forest gardens at Esterel (83) created by INRA and managed by the ONF

> Keywords ARBORETUMS FRENCH NATIONAL NETWORK EXOTIC TREES DATABASE

07. Materıals & methods

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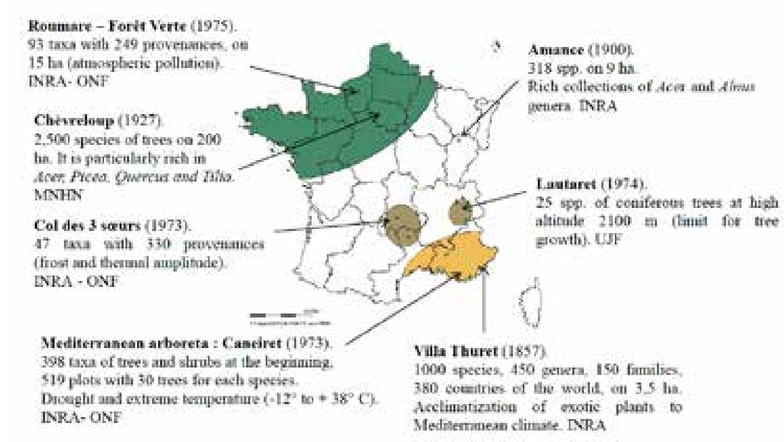
- the ecological arboretums at Roumare (76), Col des trois sœurs (48), Born (48) and Ste Anastasie (15), managed by INRA and the ONF
- the arboretums at Amance (54) and Villa Thuret d'Antibes (06) managed by INRA
- the Chèvreloup (78) arboretum managed by the MNHN
- the botanical garden on the Launay estate in Orsay (91), managed by Paris-Sud University

These different sites are home to arboretums whose richness varies depending on their status and location, ranging from several thousand taxa (2,600 at the Barres arboretum, 2,700 at Chèvreloup, 1,200 at Villa Thuret) to several dozen (47 at Col des trois soeurs), with the dominance of conifers that withstand lower temperatures in high-altitude areas or species (angiosperms and conifers) that withstand drought and heatwaves in the south of France. The ONF has its own typology which distinguishes between "scientific arboretums" and other systems (Lamant *et al.*, 2015). INRA has two networks: the comparative plant network (PlantaComp) and the network of arboretums that includes botanical gardens, collection arboretums and comparative forestry arboretums.

The national public arboretum network has been updated with the inclusion of the Lautaret arboretum managed by Joseph Fourier University at Grenoble. The main sites are shown with their summary characteristics on **figure 1.** They include:

- Historical arboretums having played an important role in the introduction of exotic species: Villa Thuret (1857), Les Barres (1870), Amance (1900) and Chèvreloup (1927),
- More recent forestry arboretums (from the 1960-70s) set up to test the tolerance of trees to extreme cold conditions (Col des trois soeurs in the Massif Central), drought (Caneiret in the Esterel), altitude (Col du Lautaret in the Alps), and pollution (Roumare-Forêt Vert in Normandy) These are forest gardens made up of comparative plots of several dozen trees of the same species and same origin. "Tree line" species were planted in the Le Lautaret arboretum at 2,100 m altitude.



> FIGURE 1

Location of the main public arboreta of the national network. The year of creation appears in brackets

DATABASE

The fields in the database were defined together and integrated in the Pl@ntNet collaborative platform. For its development and data transfer, INRA benefited for support from the UMR AMAP research unit[1]. Today, INRA and the ONF use this collaborative database, which contains inventory data and dendrological data for several thousand taxa distributed across French territory. The updating of the INRA/ONF forest arboretum inventories is currently in progress.

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COMMON ACTIONS FOR VALORIZATION

INRA and the ONF now account for the highest number of systems and biological resources and work closely together. The ONF manages the six scientific arboretums set up by INRA.

The French public arboretum network was involved in the national QDiv[2] project from 2006 to 2009, then, in the ACCAF Perpheclim[3] metaprogramme; several arboretums continue to provide phenological data to the Observatory of Seasons[4]. Some have been the object of studies for an early appraisal of invasive species (Ducatillion *et al.*, 2015) or on the measurement of survival rates among the species introduced in extreme conditions. Various data has been collected by scientists, such as phytosanitary, phenological or reproduction data.

Finally, the arboretums take part in national or international awareness-raising events such as the "Rendez-vous au jardin" events, the "European heritage" week, the "Fascination of plants days", etc.

Discussion

Since its creation in 2004, the main partner institutions of the public arboretum network have all upheld their membership, although there have been changes to the number of arboretums. However, the partnership has not been formally renewed, pending a legal formula adapted to the current context. It is now a question of reorganizing the operating conditions and network coordination. Concerning the joint database, the first attempt failed due to unforeseen institutional changes but most of the data has been saved and integrated in the Pl@ntNet collaborative platform under Data Manager; INRA and the ONF have been using this to pool resources since 2014. It has been opened to other partners to conduct a national inventory. To this end, each partner will be required to proceed with an inventory of their trees and taxa and to record their data on Pl@ntNet or send it to INRA for recording and pooling. The information will thus be collected and possibly compared, analyzed, published or used in joint programs. The main concerns at the current time are providing observation data on various issues related to phenology or invasive species, and identifying species likely to fulfil new requirements for assisted migration of species or for production, against the background of predicted climate change. Finally, one of the initial goals – coordinated renewal and enhancement – is still a priority, especially in the context of national reflection on acclimatization headed by INRA.

Conclusions

A French national public arboretum network was founded in 2004. It now brings together the three main institutions in charge of tree heritage: the national institute for agricultural research (INRA), the national natural history museum (MNHN) and the French forestry commission (ONF). Around fifteen arboretums are covered by this partnership. They are characterised by a typology according to the composition of their collections and their main activities. These arboretums are home to some rich dendrological collections and

1 AMAP: "Botanical and Bioinformatics of Plant Architecture" joint research unit

2 QDiv - Quantification of the effects of global changes on plant diversity

3 http://www6.inra.fr/projet-accaf-perpheclim

4 http://www.obs-saisons.fr/

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FRENCH NATIONAL NETWORK
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07. Conclusions

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are spread widely across several biogeographical regions, subject to different climatic influences (oceanic, continental, mountain and Mediterranean). The inventory data from them main ONF and INRA sites has already been collected and pooled in a collaborative database under Pl@ntNet Data Manager. The network has enabled the participation of several arboretums in 1) national scientific programs concerning phenology and climatic changes (QDiv, Perpheclim, Observatoire des saisons) and invasive species, 2) national and European events with an educational objective.

Today the network has evolved in line with the emergence of new requirements: it now has to formalize its operating procedures to develop resources and bring in other systems, in new programs linked to climate change.

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Annexes

Credit photo : *F.-G. Grandin MNHN*

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AMPHORA
AQUARIA
ARBORETA
ARBORETUM
ARBORETUMS
ARCHIVES
ARRÊT DES PESTICIDES
ATLAS
AWAKENING INTEREST
AWARENESS
BEST PRACTICE
BIO-CULTURAL HERITAGE
BIODIVERSITÉ
BIODIVERSITY
BIODIVERSITY CONSERVATION
BIODIVERSITY LOSS
BIODIVERSITY POLICIES
BIOGÉOGRAPHIE
BIOGEOGRAPHY
BIOSAFETY
BOTANIC GARDEN
BOTANIC GARDEN MANAGEMENT
BOTANIC GARDENS
BOTANICAL GARDEN
BOTANICAL GARDEN NETWORK
BOTANICAL GARDENS
BOTANY
BUILD CAPACITY
CAMPAIGN
CAPACITY BUILDING
CHANGE OF THE FUNCTION
CHAUFFAGE PAR INCINÉRATION DE DÉCHETS
CITES
CITIZEN SCIENCE
CJBN
CLIMATE CHANGE
CLIMATIC CHANGE
CLIMATIC EFFECTS ON VEGETATION
CLONAL POPULATION
CO-CREATION
COLLABORATION
COLLABORATION OF ALL DUTCH BOTANIC GARDENS
COLLABORATIVE TEACHING
COLLECTION AND CURATION MANUALS
COLLECTIONS SPÉCIALISÉES
COLLECTIONS VÉGÉTALES VIVANTES
CONFÉRENCE
CONSERVATION
CONSERVATION DE LA BIODIVERSITÉ
CONSERVATION *EX-SITU*
CONSERVATION STATUS
CONSERVATORY
COOPERATIVE LEARNING
CULTIVATION
DATABASE
DATE PALM SEEDS
DEAD SEA SCROLLS
DÉVELOPPEMENT DURABLE
DIAMETER GROWTH
DISEASES
DISPERSAL
DIVERSITÉ GÉNÉTIQUE
DIVERSITY
DLVDT SENSOR
DNA BANKS
DRAWING
DROGUES
ECOLOGICAL RESTORATION
EKMAN'S JUNIPER TREE
ELECTRICITY
ENDEMICS
ENSCOBASE
ETHNOBOTANY
ÉTIQUETAGE
EUROPE
EX SITU
EX SITU CONSERVATION
EX SITU CONSERVATION OF WILD PLANT
EXOTIC FOREST TREES
EXOTIC SPECIES
EXOTIC TREES
EXPOSITION
EX-SITU CONSERVATION
FAUCHAGE TARDIF
FERNS
FLORA
FLORE DU MONDE
FLORE SAUVAGE
FOCUS ON PEOPLE AND PLANTS
FORÊTS DES PINS
FRENCH NATIONAL NETWORK
GARDEN EDUCATION
GARDEN ESCAPES
GENETIC DIVERSITY
GENÉVRIER D'EKMAN
GEOGRAPHIC ISOLATION
GESTION DIFFÉRENCIÉE
GLOBAL STRATEGY FOR PLANT CONSERVATION
GLOBAL TREES CAMPAIGN
GRAPHIC TECHNIQUES
GREEN INFRASTRUCTURE
GSPC
HABITATS
HABITATS DIRECTIVE
HABREF
HAÏTI
HERBARIUM
HERITAGE INTEREST
HISTORIC GARDEN
HISTORIC GARDENS
HISTORY OF NOMENCLATURE
HISTORY OF SCIENCE
HORTICULTURE BIOLOGIQUE
HYBRIDIZATION
IMPLEMENTATION OF REGULATIONS
IN VITRO PROPAGATION
INFORMATION SYSTEM ON NATURE AND LANDSCAPES
INPN
INTEGRATED CONSERVATION MANAGEMENT
INTEGRATED *EX* AND *IN SITU* CONSERVATION
INTEREST
INTERNATIONAL COOPERATION
INTERNATIONAL NETWORK
INTEROPERABILITY
INVASION
INVASIVE
INVASIVE PLANTS
INVASIVE SPECIES
INVENTAIRE NATIONAL DU PATRIMOINE NATUREL
JARDIN BOTANIQUE
JARDIN CONNECTÉ
JUNIPERUS GRACILIOR VAR. *EKMANII*
KNITTING GRAFFITI
KNOWLEDGE
LANDSCAPE ARCHITECTURE
LIEN SOCIAL
LISBON
LOCAL ADAPTATION
LOCAL BIODIVERSITY
LONG-TERM CONSERVATION
LUTTE BIOLOGIQUE
MÉDIATION CULTURELLE
MEDITERRANEAN FRENCH FLORA
MESSICOLES
MICRO-DENDROMETER
MONITORING
MULTIDISCIPLINARY RESEARCH
MULTIPLICATION IN VITRO
NAGOYA PROTOCOL
NATIONAL / INTERNATIONAL NETWORKS
NATIONAL INVENTORY OF NATURAL HERITAGE
NATIVE SEED PRODUCTION
NATIVE SEEDS

LIST OF KEYWORDS USED IN CONTRIBUTING PAPERS

NATIVE SPECIES
NATURA 2000
NATURAL PHENOMENON
NATURAL VEGETATION
NATURALIZATION
NATURE OF SCIENCE
NATURE-BASED SOLUTIONS
NEOPHYTES
NETWORK
NEW AUDIENCES
NON PUBLIC
OFFICE NATIONAL DES FORÊTS (ONF)
ORTHODOX SEEDS
PBI
PEATBOG
PEATLAND'S PLANT COLLECTION
PEST
PHENOLOGY
PHYLOGENY
PLANT
PLANT COLLECTIONS
PLANT MATERIAL EXCHANGE
PLANT SPECIES
POPULATION GENETICS
PORTUGAL
PRATIQUES HORTICOLES
PROJET TRANSGÉNÉRATIONNEL
PSC
PUBLIC ENGAGEMENT
PUBLICS DÉFAVORISÉS
QR CODE
RÉGIONS D'ORIGINE
REHABILITATION
RELICT TREES
REPLANTING
RESEARCH
RESTAURATION ÉCOLOGIQUE
RESTORATION
RHIZOBOXES
RISK ASSESSMENT
SANTÉ
SCIENCE EDUCATION
SCIENCE MUSEUM
SCIENTIFIC INTEREST
SCIENTIFIC LITERACY
SECONDARY SCHOOL
SEED BANKING
SEED BANKS
SEED CHARACTERIZATION
SEED CONSERVATION
SEED CONSERVATION NETWORK
SEED FORMATION
SEED ZONES
SEEDBANKING
SEED-BASED RESTORATION
SEEDS PRODUCTIVITY
SEGETAL SPECIES
SENTINEL PLANTS
SERRES TROPICALES
SLOVENIA
SOCIAL ROLE
SOFT SOAP
STANDARD DATA
STANDARDS
SURVEY
SUSTAINABLE DEVELOPMENT
SYSTEMATIC BIOLOGY
TAXONOMIC REPOSITORY
TAXONOMIE
TAXONOMY
TAXREF
TEACHER TRAINING
THREATENED PLANT SPECIES
TOOLKIT
TRACE OF PLANTS INTRODUCTION
TRAINING
TREE CONSERVATION
TREE SPECIES
TRICOT URBAIN
UMS 2006 PATRIMOINE NATUREL (NATURAL HERITAGE DEPARTMENT)
UNIVERSITY
URBAN GARDENING
UTILIZATION
VALORISATION DE COLLECTIONS
VEGETABLE GARDENING
VÉGÉTAL LOCAL
WELWITSCHIA MIRABILIS
WET MEADOW
WILD FLORA
WORKGROUP
WORLD FLORA
ZELKOVA
ZOOS