EUROGARD VII
PARIS

THEME G:

NETWORKING, COOPERATION AND CAPACITY BUILDING

07.

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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

• *Shaw Kirsty*
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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.

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07. Introduction

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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.

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07. Identifying and prioritising the tree species of greatest conservation concern

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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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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.

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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).

References

Oldfield, S., Lusty, C. & MacKinven, A., 1998. *The World List of Threatened Trees*. World Conservation Monitoring Centre. Cambridge, UK.

Rivers, M., Shaw, K., Beech, E. & Jones, M., 2015. *Conserving the World's Most Threatened Trees: a global survey of* ex situ *collections*. Botanic Gardens Conservation International. Richmond, UK.

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

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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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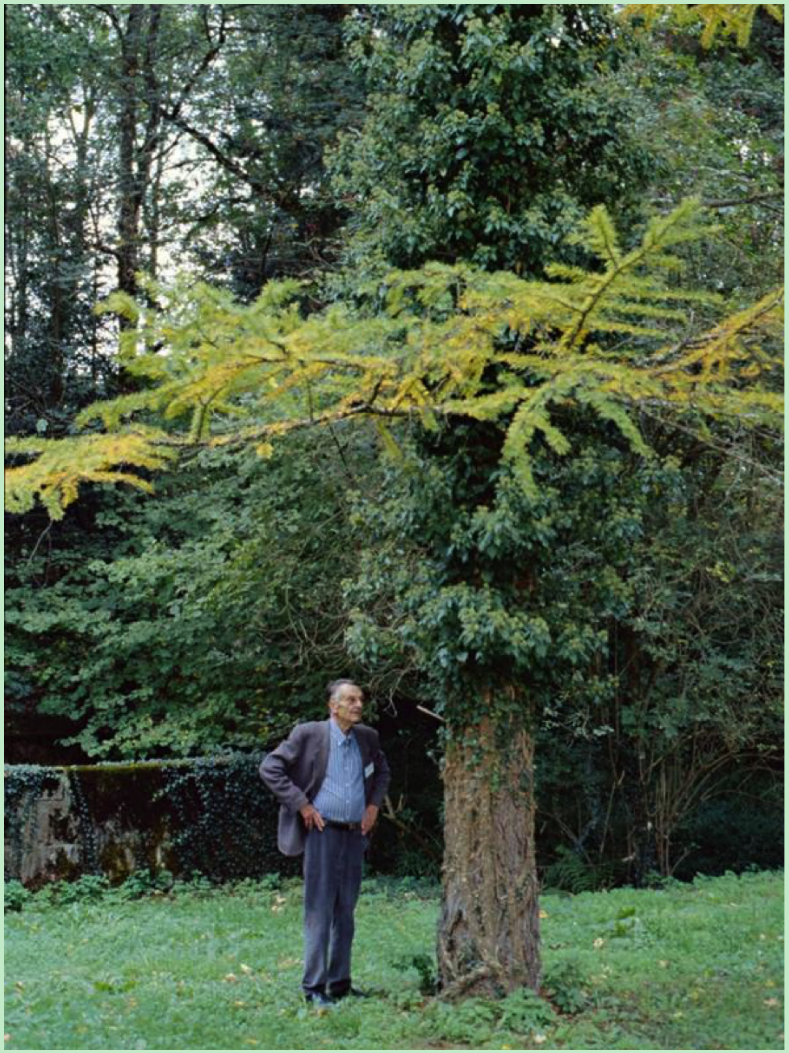

> FIGURE 1

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).

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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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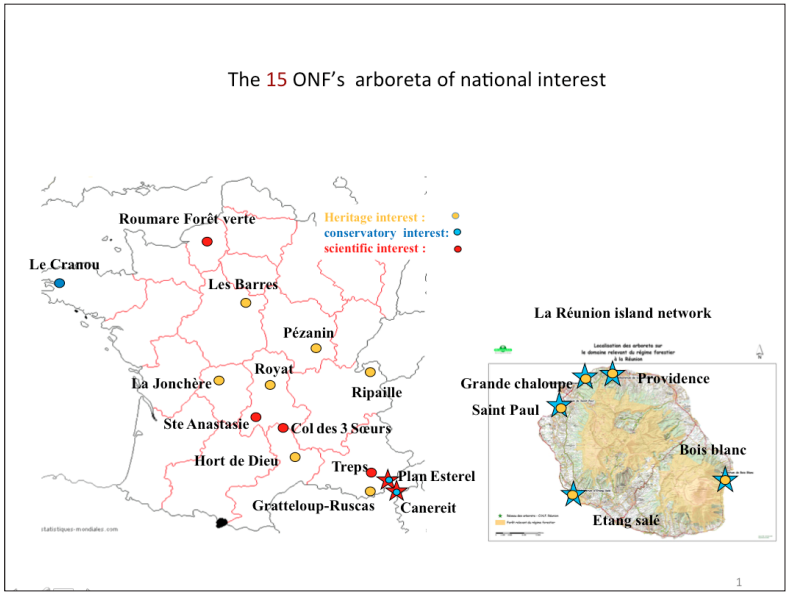

> FIGURE 2

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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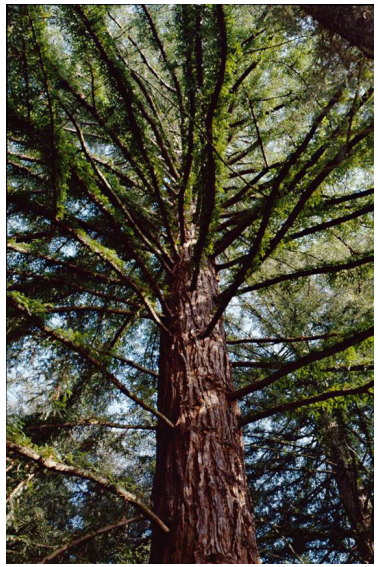
in Europe. Its initial goal was acclimatization, forestry, ornamental and description of new species introduced but now, we wish to enrich the *Fruticetum Vilmorinianum* (shrub arboretum) and the oldest parts after the 1999 storm and the 2003 dry hot summer.



> 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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It owns 105 taxa and its initial goal was acclimatizing exotic taxa (Grateloup) 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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• Simonnet F.
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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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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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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.

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References

Allemand, P. *et al.*, 1989. Espèces exotiques utilisables pour la reconstitution du couvert végétal en région méditerranéenne : Bilan des Arboretums forestiers d'élimination. *INRA, Techniques et Pratiques.*

Blandin, N. & Steiner, F., 1996. *Arboretums de RFV, bilan de la période 1975-1995* – INRA et ONF : juin 1996.

Imbert, P., 1988. *Choix des espèces de reboisement en Haute-Margeride, premier bilan de l'arboretum Curie (Lozère, col des 3 sœurs, altitude 1470 m). Rapport de stage de BTS,* INRA.

Mons, D., 1993. *Bilan de trois arboretums d'altitude dans le Massif Central.* Rapport de stage de BTS, INRA & ONF.

Pestour, J.-L., 1984. *Choix des espèces de reboisement en région méditerranéenne.* Premier bilan des arboretums d'élimination. Mémoire de troisième année, ENGREF & INRA.

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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> Keywords RELICT TREES ZELKOVA GEOGRAPHIC ISOLATION CLIMATE CHANGE INTEGRATED *EX* AND *IN SITU* CONSERVATION CLONAL POPULATION GENETIC DIVERSITY INTERNATIONAL COOPERATION GLOBAL TREES CAMPAIGN

07. Abstract

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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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Photo credit : ***left*** : Collection of *Zelkova abelicea* seeds, Kedros, Crete, ***Gregor Kozlowski ; right*** : Introduction of *Zelkova sicula* saplings, Bosco Ficuzza, Sicily, ***Giuseppe Garfì***

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; Garfì & 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 (Garfì, 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., Garfì & 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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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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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 (Garfì *et al.*, 2011; Garfì & 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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(>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

> Keywords RELICT TREES ZELKOVA GEOGRAPHIC ISOLATION CLIMATE CHANGE INTEGRATED *EX* AND *IN SITU* CONSERVATION CLONAL POPULATION GENETIC DIVERSITY INTERNATIONAL COOPERATION GLOBAL TREES CAMPAIGN

07. *Zelkova abelicea* – a plant of exceptional diversity

• *Gratzfeld Joachim*
• *Kozlowski Gregor*
• *Buord S.*
• *Fazan L.*
• *Christe C.*
• *Bétrisey S.*
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• *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*
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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*
• *Kozlowski Gregor*
• *Buord S.*
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• *Bétrisey S.*
• *Garfì G.*
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• *Fournaraki C.*
• *Dimitriou D.*
• *Sklavaki P.*
• *Naciri Y.*
• *Dadashova A.*
• *Selimov R.*
• *Davitashvili N.*
• *Song Y.*

Bonga, J.M. & von Aderkas, P., 2013. In vitro *culture of trees.* Springer Science+Business Media, 238 pages.

Brooker, R., Britton, A., Gimona, A., Lennon, J. & Littlewood, N., 2011. *Literature review: species translocations as a tool for biodiversity conservation during climate change.* Scottish Natural Heritage Commissioned Report No.440, 68 pages.

Christe, C., Kozlowski, G., Frey, D., Bétrisey, S., Maharramova, E., Garfì, G., Pirintsos, S. & Naciri, Y., 2014a. Footprints of past intensive diversification and structuring in the genus Zelkova (Ulmaceae) in south-western Eurasia. *Journal of Biogeography* 41: 1081-1093.

Christe, C., Kozlowski, G., Frey, D., Fazan, L., Bétrisey, S., Pirintsos, S., Gratzfeld, J. & Naciri, Y., 2014b. Do botanic garden collections capture the genetic variation of wild populations? A molecular analysis of two relict tree species *Zelkova abelicea and Z. carpinifolia*. *Biodiversity and Conservation* 23: 2945-2959.

De Paola, M., Franco, A., Macchia, F. & Forte, L., 1997. Plant macrofossils in Pleistocenic volcanoclastic deposit near Tursi (Basilicata). In: Atti Giornata di Studi in ricordo di Daria Bertolani Marchetti (Formigine, 18 maggio 1996), *Aedes Muratoriana*, Modena: 319-327.

Di Pasquale, G., Garfì, G. & Quézel, P., 1992. Sur la présence d'un *Zelkova* nouveau en Sicile sudorientale (*Ulmaceae*). *Biocosme Mésogéen* 8-9: 401-409.

Egli, B., 1997. A project for the preservation of *Zelkova abelicea* (Ulmaceae), a threatened endemic tree species from the mountains of Crete. *Bocconea* 5(2): 505-510.

Fazan, L., Stoffel, M., Frey, D.J., Pirintsos, S. & Kozlowski, G., 2012. Small does not mean young: age estimation of severely browsed trees in anthropogenic Mediterranean landscapes. *Biological Conservation* 153: 97-100.

Fineschi, S., Anzidei, M., Cafasso, D., Cozzolino, S., Garfì, G., Pastorelli, R., Salvini, D., Taurchini, D. & Vendramin, G.G., 2002. Molecular markers reveal a strong genetic differentiation between two European relic tree species: *Zelkova abelicea* (Lam.) Boissier and *Z. sicula* Di Pasquale, Garfì & Quezel (Ulmaceae). *Conservation Genetics* 3: 145-153.

Fineschi, S., Cozzolino, S., Migliaccio, M. & Vendramin, G.G., 2004. Genetic variation of relic tree species: the case of Mediterranean *Zelkova abelicea* (Lam.) Boissier and Z. sicula Di Pasquale, Garfì and Quézel (Ulmaceae). *Forest Ecology and Management* 197: 273-278.

Follieri, M., Magri, D. & Sadori, L., 1986. Late Pleistocene *Zelkova* extinction in central Italy. *New Phytologist* 103: 269-273.

Fournaraki, C. & Thanos, C.A., 2002. Seeds of *Zelkova abelicea*, an endemic tree of Crete. TREE SEEDS 2002, Annual Meeting of IUFRO "Research Group for Seed Physiology and Technology", 11-15 September 2002, MAICh, Chania, Crete. *Book of proceedings*: 83-84.

Fournaraki, C. & Thanos, C.A., 2006. *Zelkova abelicea*, the unique endemic tree of Crete and its conservation. *ENSCONEWS* 1: 14-16.

Frederik, A.W. Noack, Manthey, M., Ruitenbeek, J.H. & Mohadjer, M.M., 2010. Separate or mixed production of timber, livestock and biodiversity in the Caspian Forest. *Ecological Economics* 70: 67-76.

Garfì, G., 1997a. On the flowering of *Zelkova sicula* (Ulmaceae): additional description and comments. *Plant Biosystems* 131(2): 137-142.

Garfì, G., 1997b. *Première contibution à l'étude de Zelkova sicula (Ulmaceae), une relique de la flore tertiaire, endémique de la Sicile Sud-Orientale (Systématique - Caryologie - Dynamique de la croissance - Dendroécologie).* PhD Thesis, Fac. Sci. Techn., Univ. Aix-Marseille III, 235 pages + annexes.

Garfì, G., Barbero, M. & Tessier, L., 2002. Architecture and growth patterns of *Zelkova sicula* (Ulmaceae) in South-East Sicily as a response to environmental conditions. *Journal of Mediterranean Ecology* 3(2-3): 65-76.

Garfì, G., 2006. *Zelkova sicula*. *The IUCN Red List of Threatened Species* 2006. dx.doi.org/10.2305/IUCN.UK.2006.RLTS.T61678A12522379.en

Garfì, G., Carimi, F., Pasta, S., Rühl, J. & Trigila, S., 2011. Additional insights on the ecology of the relic tree *Zelkova sicula* di Pasquale, Garfì et Quézel (Ulmaceae) after the finding of new population. *Flora* 206: 407-417.

Garfì, G. & Buord, S., 2012. Relict species and the challenges for conservation: the emblematic case of *Zelkova sicula* Di Pasquale, Garfì et Quézel and the efforts to save it from extinction. *Biodiversity Journal* 3(4): 281-296.

Hoshino, Y., 1990. Fruiting shoot as a wind-dispersed diaspore assisting the fruit dispersal of *Zelkova serrata* (Thunb.) Makino. *Japanese Journal of Ecology* 40: 35-41.

Ito, N., 1981. Wood as a material for Japanese buildings. *In: Proceedings of the 6th ICOMOS General Assembly and International Symposium "Nessun futuro senza passato"*, ICOMOS, Rome: 391-402.

Kozlowski, G., Gibbs, D., Huan, F., Frey, D. & Gratzfeld, J., 2012b. Conservation of threatened relict trees through living *ex situ* collections: lessons from the global survey of the genus *Zelkova* (Ulmaceae). *Biodiversity and Conservation* 21: 671-685.

Kozlowski, G. & Gratzfeld, J., 2013. *Zelkova – an ancient tree. Global status and conservation action.* Natural History Museum Fribourg, Switzerland, 60 pages.

Kozlowski, G., Frey, D., Fazan, L., Egli, B., Bétrisey, S., Gratzfeld, J., Garfì, G. & Pirintsos, S., 2014. Tertiary relict tree *Zelkova abelicea* (Ulmaceae): distribution, population structure and conservation status. *Oryx* 48: 80-87.

Kozlowski G., Frey D., Fazan L., Egli B., Pirintsos S., 2012a. Zelkova abelicea. *The IUCN Red List of Threatened Species 2012.* dx.doi.org/10.2305/IUCN.UK.2012.RLTS.T30319A17701987.en

Kvavadze, E.V. & Connor, S.E., 2005. *Zelkova carpinifolia* (Pallas) K. Koch in Holocene sediments of Georgia – an indicator of climatic optima. *Review of Palaeobotany and Palynology* 133: 69-89.

Lynch, A.J.J., Barnes, R.W., Cambecèdes, J. & Vaillancourt, R.E., 1998. Genetic evidence that *Lomatia tasmanica* (Proteaceae) is an ancient clone. *Australian Journal of Botany* 46: 25-33.

Maharramova, E., Muller, L.A., Korotkova, N. & Borsch, T., 2014. Development of nuclear microsatellites for the Arcto-Tertiary tree *Zelkova carpinifolia* (Ulmaceae) using 454 pyrosequencing. *Applications in Plant Sciences* 2(3) 1300072.

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07. References

• *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.*

Manchester, S.R., 1989. Systematics and fossil history of the Ulmaceae. In: Crane, P.R. & Blackmore, S. (eds.): *Evolution, systematics, and fossil history of the Hamamelidae, Volume 2: 'Higher' Hamamelidae*. Systematics Association, Special Volume No. 40B, Clarendon Press, Oxford: 221-251.

Ostrom, E., 2009. A general framework for analyzing sustainability of social-ecological systems. *Science* 325(5939): 419-422.

van Riper III, C., Powell, R.B., Machlis, G., van Wagtendonk, J.W., van Riper, C.J., von Ruschkowski, E., Schwarzbach, S.E. & Galipeau, R.E., 2012. Using integrated research and interdisciplinary science: Potential benefits and challenges to managers of parks and protected areas. *The George Wright Forum* 29(2): 216-226.

Søndergaard, P. & Egli, B.R., 2006. *Zelkova abelicea* (Ulmaceae) in Crete: floristics, ecology, propagation and threats. *Willdenowia* 36: 317-322.

Stahl, U., Reu, B. & Wirth, C., 2013. Predicting species' range limits from functional traits for the tree flora of North America. *Proceedings of the National Academy of Sciences of the United States of America* (PNAS) 111(38): 13739-13744.

Tanai, T. & Wolfe, J.A., 1977. *Revisions of* Ulmus *and* Zelkova *in the middle and late Tertiary of western North America*. Geological Survey Professional Paper 1026. United States Government Printing Office, Washington, 28 pages.

Thanos, C.A., Fournaraki, C., Tsiroukis, A. & Panayiotopoulos, P., 2010. Timing of seed germination and life history of trees: case studies from Greece. *In*: Chien, C.-T. & Chen, F.-H. (Eds.) '*Symposium Proceedings*', TFRI Extension Series No. 212: 103-111; IUFRO Tree Seed Symposium: Recent Advances in Seed Research and *Ex Situ* Conservation, Taipei, Taiwan.

Thomas, C.D., 2011. Translocation of species, climate change, and the end of trying to recreate past ecological communities. *Trends in Ecology & Evolution* 26(5): 216-221.

Wang, Y.F., Ferguson, D.K., Zetter, R., Denk, T. & Garfi, G., 2001. Leaf architecture and epidermal characters in *Zelkova*, Ulmaceae. *Botanical Journal of the Linnean Society* 136: 255-265.

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
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TREE CONSERVATION

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
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07. Prioritization

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• *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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07. Recommendations

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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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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.

> Keywords EX SITU
GLOBAL STRATEGY FOR PLANT CONSERVATION
GLOBAL TREES CAMPAIGN
INTEGRATED CONSERVATION MANAGEMENT
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
GLOBAL STRATEGY FOR PLANT CONSERVATION
GLOBAL TREES CAMPAIGN
INTEGRATED CONSERVATION MANAGEMENT
TREE CONSERVATION

07. References

• *Cavender Nicole*
• *Westwood Murphy*

Cavender, N., Westwood, M., Bechtoldt, C., Donnelly, G., Oldfield, S., Gardner, M., Rae, D. & McNamarav, W., 2015. Strengthening the conservation value of *ex situ* tree collections. *Oryx* 49, 416–424

CDB (Convention on Biological Diversity), 2012. *Global Strategy for Plant Conservation 2011–2020*. Botanic Gardens Conservation International, Richmond, UK.

IDIGBIO (Integrated Digitized BioCollections), 2011. https://www.idigbio.org/ [accessed 25 November 2014].

Maunder, M., Guerrant Jr, E.O., Havens, K. & Dixon, K., 2004. Realizing the full potential of ex situ contributions to global plant conservation. *In*: Ex situ *Plant Conservation: Supporting Species Survival in the Wild* (eds E.O. Guerrant Jr, K. Havens & M. Maunder). Island Press, Washington, DC, USA.

Pence, V.C., 2013. *In vitro* methods and the challenge of exceptional species for Target 8 of the Global Strategy for Plant Conservation. *Annals of the Missouri Botanical Garden*, 99, 214–220.

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

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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.

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07. Contexte du projet

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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.

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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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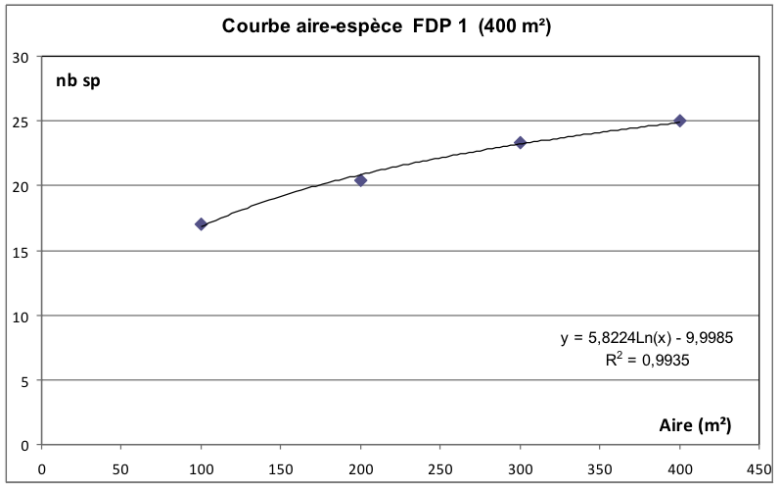
Ekman de la Faculté d'Agronomie de Port-au-Prince. Ces spécimens font actuellement l'objet d'identifications par de nombreux spécialistes. Toutes les planches d'herbiers ont été scannées et seront mises en ligne sur le site de Tela Botanica (PictoFlora). Concernant le genévrier d'Ekman, la HELVETAS Haïti 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.

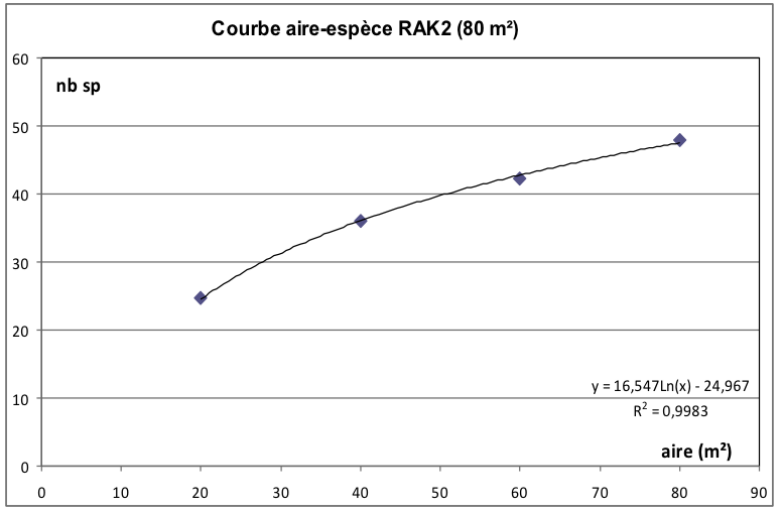
Des inventaires botaniques ont été réalisés dans différentes milieux afin d'analyser la structure et la diversité spécifique de la forêt de feuillus (rak), et de la forêt à base de *Pinus occidentalis*. Ces inventaires démontrent une plus grande richesse dans les forêts de feuillus (**Figs 1** et **2**).

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)

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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-

> Mots-clefs HAÏTI FORÊTS DES PINS *JUNIPERUS GRACILIOR* VAR. EKMANII GENÉVRIER D'EKMAN CONSERVATION *EX-SITU* MULTIPLICATION *IN VITRO*

07. Le projet

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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.

> Mots-clefs HAÏTI FORÊTS DES PINS *JUNIPERUS GRACILIOR* VAR. EKMANII GENÉVRIER D'EKMAN CONSERVATION *EX-SITU* MULTIPLICATION *IN VITRO*

07. Remerciements

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• *Mézard Claudy*
• *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.

Références

Adams, R.P., 1995. Revisionary study of Caribbean species of *Juniperus* (Cupressaceae). *Phytologia* 78(2): 134-150.

Adams, R.P., Morris, J.A. & Schwarzbach, A.E., 2008. The evolution of Caribbean *Juniperus* (Cupressaceae): Terpenoids, RAPDs and DNA SNPs Data. *Phytologia* 90 (1).

Adams, R.P., 2011. *Junipers of the World: The genus* Juniperus. Trafford Publishing Co., Bloomington, Indiana.

Barker, H. D. & Dardeau, W. S., 1930. *Flore d'Haïti.*

Farjon, A., 2013. *Juniperus gracilior* var. *ekmanii*. In: IUCN 2013. *IUCN Red List of Threatened Species.* Version 2013.1. www.iucnredlist.org

Mézard, C., 2013. *Contribution à la caractérisation de la biodiversité végétale à Mare-Rouge*, Mémoire pour l'obtention du diplôme d'ingénieur agronome, Université d'État d'Haïti.

Mézard, C., 2014. *Etude sur les plantes médicinales*, rapport interne.

Rousseau, J., 2000. *Plan de gestion et d'aménagement de la réserve de la Forêt des Pins,* Ministère de l'Agriculture, des Ressources Naturelles et de Développement Rural.

Zanoni, T.A., 1999. Regional Action Plan: Caribbean Conifers: current status. *In*: Farjon, A. and Page, C.N. (Editors), Conifers. *Status Survey and Conservation Action Plan. IUCN/SSC Conifer Specialist Group.* IUCN, Gland, Switzerland and Cambridge, UK. ix + 121 pp.

L'ARBRE, ITINERAIRE D'UN ACTEUR PASSE-FRONTIERES

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07. L'arbre, itinéraire d'un acteur passe-frontières

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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.

> Keywords ARBORETUMS
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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.

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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

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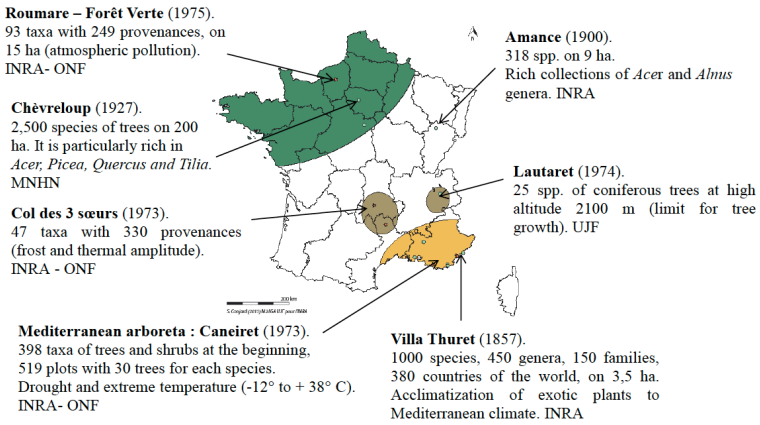
- the ecological arboretums at Roumare (76), Col des trois sœurs (48), Born (48) and Ste Anastasie (15), managed by INRA and the ONF
- the arboretums at Amance (54) and Villa Thuret d'Antibes (06) managed by INRA
- the Chèvreloup (78) arboretum managed by the MNHN
- the botanical garden on the Launay 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@nt-Net 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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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.

References

Afxantidis, D., 1993. Établir une liste des arboretums méditerranéens. Association Forêt méditerranéenne, *Compte rendu de séminaire sur les arboretums méditerranéens,* 2p.

Allemand, P., 1989. Espèce exotiques utilisables pour la reconstitution du couvert végétal en région méditerranéenne : bilan des *arboretums* forestiers d'élimination, *Techniques et pratiques INRA*, 147p.

Bastien, J.-C., 1988. Premiers enseignements des **arboretums** d'élimination de Basse-Seine, *Biologie et forêt,* p108 à 116.

Ducatillion, C., Badeau, V., Bellanger, R., Buchlin, S., Diadema, K., Gili, A. & Thévenet, J., 2015. Détection précoce du risque d'invasion par des espèces végétales exotiques introduites en arboretum forestier dans le sud-est de la France. Émergence des espèces du genre Hakea. Mesures de gestion *Revue d'Ecologie (Terre et Vie)*, Vol. 70 (suppt 12 « *Espèces invasives* »), 2015 : 139-150.

Lamant et al., 2015. *ONF's arboreta of national interest*. Eurogard VII, Paris.

Mons, D., 1993. *Bilan de trois arboretum d'altitude dans le massif central,* Rapport de stage de BTS, INRA – ONF, 185p.