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THEME C:

HERITAGE, CULTURE & TOURISM

03.

THEME C

HERITAGE, CULTURE & TOURISM

CAN A HISTORIC GARDEN BECOME A BOTANIC ONE?

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

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WHAT IS A GARDEN?

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

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

WHAT IS A HISTORIC GARDEN?

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

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

WHAT IS A BOTANIC GARDEN?

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

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

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

• Trace the development

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- Explore the change of the function of a Bulgarian historic park into a botanic garden
- Discuss the possibility of re-functionalization by the method of induction.

The University Botanic Garden in Sofia

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

Case study: the University Botanic Garden in Balchik

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

HISTORY

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

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

PRESERVATION OF GARDEN AND PARK ART

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

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

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

PLAN AND TOPOGRAPHY

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

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

> FIGURE 1.
The historic part of the Botanic Garden

> FIGURE 2.
The Botanic Garden after 2005

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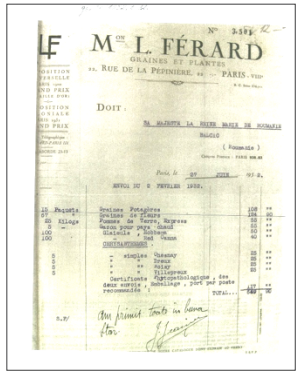
VEGETATION

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

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

> FIGURE 3

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

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

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

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

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

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

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year	1955	1968	2015
Cacti and succulent species	0	250	3450

> TABLE 1

Evolution of the Cacti and succulent species collection

STRUCTURAL AND DECORATIVE CHARACTERISTICS

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

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

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

WATER EFFECTS

At the beginning of the last century, the abundance of water in the area was an important natural resource. There was a network of shallow waterways, and water designed mirrors. They had not only decorative function but

> FIGURE 4

The Cacti conservatory

they created favorable microclimate conditions for the vegetation in terms of air moisture. Some of the waterways were used for irrigation too. The water sources and soil were allocated in view of the overall visual concept.

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

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

FUNCTION AND ACCESS

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

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

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

> TABLE 2
Palace garden and Botanic garden: comparative table

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

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

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

Discussion

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

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

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

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

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Can a historic garden become a botanic one?

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

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

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> Keywords HISTORY OF SCIENCE
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03. Abstract

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

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

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

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

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

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

> FIGURE 1.

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

> Keywords HISTORY OF SCIENCE
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03. A global network

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

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

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

> FIGURE 2.

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

Bio-cultural heritage

Persons, publications, collections, other movable objects and immaterial heritage like knowledge cannot be inscribed on the World Heritage List, as there are other conventions and programmes for such kinds of heritage. The material, immovable heritage from systematic biology is present in buildings, garden structures, landscape elements and other remnants of scientific

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activities. For a science such as systematic biology, the organisms themselves are also important: individual specimens that were studied by 18th century scientists and still survive in botanical gardens, descendants to these specimens and extant plant and animal populations. These plants and animals, in gardens or in nature, form a living bio-cultural heritage, which in some cases also have a unique scientific value. Modern DNA analyses may even link herbarium material to these living specimens.

Extant plants in historical excursion areas can be used to resolve nomenclatural issues. Examples from Linnaeus' excursion areas around Uppsala include modern collections used as conserved types of *Polygala vulgaris* (Applequist 2014), *Potentilla verna* (**Figure 3**; Brummitt 2011), *Mespilus cotoneaster* (Thulin & Ryman 2003), and epitypes of *Salix* x *fragilis* (Belyaeva 2009) and *Lycopodium complanatum* (Thulin *et al.* 2009).

Collections by Joseph Bank and Linnaeus' student Daniel Solander from Botany Bay near Sydney have been used to study changes in vegetation since 1770 and to suggest rehabilitation of remnants of the original vegetation in the area (Benson & Eldershaw 2007).

In a genetic study of Siberian crab apple, *Malus baccata*, the type material in Linnaeus' herbarium was compared with extant garden specimens and wild material (Andreasen *et al.* 2014).

The Franklin tree, *Franklinia alatamaha,* was first discovered in Georgia in 1765, collected by William Bartram in 1770 and is extinct in the wild since the early 19th century. All living specimens today are descendants to those cultivated in Bartram's Garden (Merkle 2013).

> FIGURE 3

Collecting of conserved type of *Potentilla verna* L. in Uppsala 2010. Photo: Anders Larsson

> Keywords HISTORY OF SCIENCE
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03. Conclusions

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Systematic biology, Linnaeus, Buffon or other important scientists cannot be inscribed on the World Heritage List. But, it could be possible to nominate sites for inscription, if they carry a material heritage from scientific activities.

The gardens and excursion areas mentioned in this paper together illustrate various aspects of the history of systematic biology in the 18th century. The sites carry a heritage in the form of garden structures, buildings, bio-cultural heritage and other remnants of scientific activities.

Scientific work is a kind of cultural activity that is currently represented in relatively few World Heritage Properties. Inscribing more sites that carry a heritage from various scientific developments, could therefore contribute towards enriching the World Heritage List. A network of collaborating partner sites in several countries can contribute to a global perspective on our understanding of the history of science and the importance of biological diversity. An increased recognition of bio-cultural heritage could facilitate the linking of nature and culture conservation efforts.

More information on the nomination initiative can be found on: http://www.lansstyrelsen.se/uppsala/varldsarv/

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LISBON'S HISTORIC GARDENS AND THEIR TREES COLLECTIONS OF VARIOUS ORIGIN AND THREAT

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HISTORIC GARDENS
DIVERSITY CONSERVATION

03. Abstract

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• *Azambuja Sónia Talhé*
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LISBON'S MEDITERRANEAN CLIMATE ALLOWS THE COEXISTENCE OF DIFFERENT TREE SPECIES, FROM NORTHERN EUROPE TO SUBTROPICAL CLIMATES.

This botanical richness is due in large part to the Portuguese Discoveries and contact with other cultures that meant plant species from around the world came to Portugal, particularly to Lisbon. These plants from all over the world, cultivated in public and private gardens and parks, were a challenge for naturalists, gardeners and horticulturists. In addition to its aesthetical value, this botanical diversity plays a central role in increasing biodiversity and promoting urban ecological sustainability. Within the framework of the project "LX GARDENS - Lisbon's Historic Gardens and Parks: Study and Landscape Heritage Inventory" (financed by FCT: PTDC/EAT-EAT/110826/2009) an historical, artistic and botanical study of Lisbon's Public Gardens (from the 18th century up to the 1960's) has been conducted. This research studied the historic and botanical components of 60 Lisbon's historic gardens as part of the city's Cultural Heritage. One of the aims of this study was to contribute to the identification and evaluation of Lisbon's historic gardens botanical diversity. However, the distinctiveness of each garden, its heritage importance and its use as a public space were also factors in determining its overall value. City gardens contribute significantly to the well-being of all those who live there and contribute to a sustainable city. The botanical study in question included a plants survey (height > 2 m) of each garden that identified and placed the plants on a map with GIS localization tools. This study made it possible to identify and quantify up to 26,000 trees in 64 gardens. Many of the taxa are singular such as *Curtisia dentata* (Burm.f.) C.A.Sm.; *Harpullia pendula* Planch. ex F. Muell.; *Melaleuca styphelioides* Sm.; *Pinus ayacahuite* Ehrenb. ex Schltdl.; *P. torreyana* Parry ex Carrière; *Schinus latifolius* (Gillies ex Lindl.) Engl.; *S. lentiscifolius* Marchand; *Taxodium huegelii* C.Lawson; *Trichilia havanensis* Jacq.; *Trochodendron aralioides* Siebold & Zucc.. Some are threatened cultivated plants such as: *Afrocarpus mannii* (Hook.f.) C.N.Page; *Araucaria angustifolia* (Bertol.) Kuntze; A. heterophylla (Salisb.) Franco; *Austrocedrus chilensis* (D.Don) Pic.Serm. & Bizzarri; *Caesalpinia paraguariensis* (Parodi) Burkart; *Cedrus libani* A.Rich.; *Chamaecyparis formosensis* Matsum; *Chrysophyllum imperiale* (Linden ex K.Koch & Fintelm.) Benth. & Hook.f.; *Cupressus bakeri* Jeps.; *C. goveniana* Gordon; *Dracaena draco* (L.) L.; *Metasequoia glyptostroboides* Hu & W.C.Cheng; *Pinus radiata* D.Don. Some of the trees inventoried stand out because of their size, structure, age, rarity or for historic and cultural reasons, and as a result have been classified by the Institute for Nature Conservation and Forests, thus adding to Lisbon's ecological, landscape, cultural and historic heritage.

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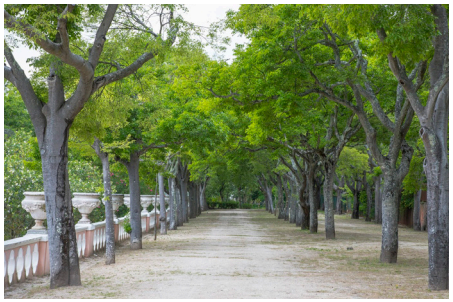

© Tapada Necessidades with *Celtis australis* subsp. *australis* e *C. australis* subsp. *caucasica*, ***Jorge de Sousa***

THIS STUDY THAT IS PART OF THE PROJECT ENTITLED "LX GARDENS - LISBON'S HISTORIC GARDENS AND PARKS: STUDY AND LANDSCAPE HERITAGE INVENTORY" [...]

[...] (financed by FCT: PTDC/EAT-EAT/110826/2009), was undertaken by an interdisciplinary team (botany, landscape architecture, history of art, etc.) which conducted an historical-artistic and botanical analysis of historical gardens, estates and parks in the city of Lisbon from the 18th century up to the 1960's.

The project studied the history of 70 public and private gardens in Lisbon, from the city's first public garden, *Passeio Público* (the Public Walk) which was created in 1764 and is now *Avenida da Liberdade*, up to the Modernist period, represented by the Calouste Gulbenkian Foundation Garden (dating from the 1960's). This research led to greater knowledge of Lisbon's landscape heritage and has helped enhance the value and profile of that heritage, as well as promote cultural tourism.

This paper delivers the taxonomic study of the specimens (height > 2 m) to be found in Lisbon's historic parks and gardens. The species which have been growing in these man-made ecosystems are intended to facilitate the conservation of urban biodiversity, and contribute to their aesthetic and biological value, while stressing the historical value of all these spaces.

Materials & methods

The study area that accounts to 3% of the total area of the city of Lisbon (100 km^2) consists of 64 historical gardens and parks (59 gardens with an inventory of existing trees and their location; 1 garden with a list of species, but not the trees location; and 4 gardens with both types of inventory). Of the 64 gardens studied (**Fig. 1**), 62 inventories were taken by the LX Gardens project team and 2 (Tropical Botanical Garden and the Calouste Gulbenkian Foundation Garden) were provided by the managing bodies.

The botanical study adopted the following methodology: taking of inventory, placing within the geographic information systems and specimen identification. All data collected were entered in a relational database built on a SQL

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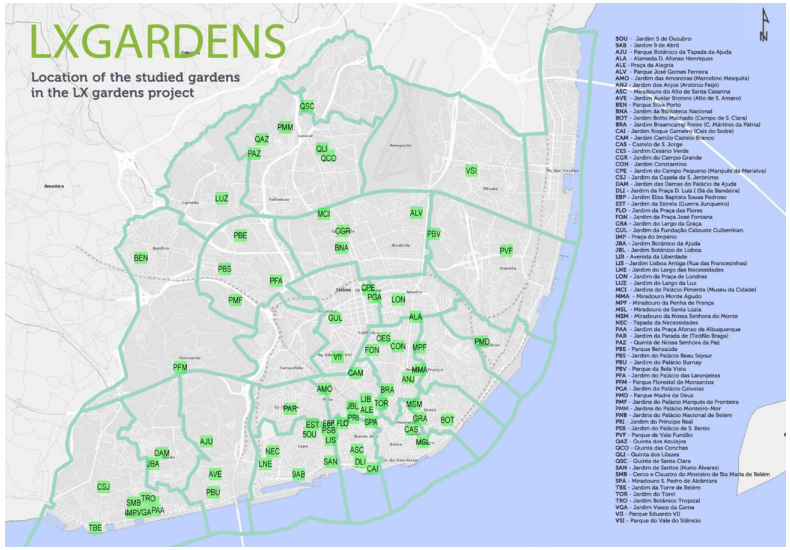
server 2014. The data were processed through a simple statistical analysis which allowed us to determine, for instance, the most frequent species and those found in the largest quantities.

The data entered into the SIG from 2011 to 2014, included the following items: (1) Specimen ID number; (2) Garden code; (3) Type of green space (Garden, Park, Botanical Garden, Enclosure and Hunting Ground or Recreation Ground); (4) Species code; (5) Family; (6) Genus; (7) Species; (8) Species classifier; (9) Geographic origin of the *taxa*; (10) Status of the region's plants life: native to mainland Portugal, non-native and/or invasive); (11) Growth form – Plant physiognomy; (12) ETRS 1989 coordinates; (13) Classified as being of public interest; (14) Legislation classifying the tree.

In terms of specimen identification, the study was conducted on the basis of external morphological features, using works of reference specific to the field – Bailey (1975), Bailey & Bailey (1976), Eggli (2003), Franco (1971, 1984); Franco & Afonso (1994, 1998, 1993), Huxley *et al.* (1992) and Walters *et al.* (1986, 1984, 1989, 1995, 1997) – and by comparison to specimens to be found in the João Carvalho e Vasconcellos herbarium (LISI) at Lisbon University's School of Agronomy.

Works of reference were used to check the names of families [Kubitzki, (1990, 1993, 1998a, b)], the names of species [The Plant List - version 1.1.] and the respective names of the authors of species [Brummitt & Powell, (1992)]. The geographic origin (Brummit, 2001) of each of the *taxa* was studied, as well as its conservation status under the IUCN categories of Walter & Gillett (1998).



> FIGURE 1.

Green areas inventoried by the "LX GARDENS - Lisbon's Historic Gardens and Parks" team project

Results & discussion

Across the 64 green spaces studied the inventory recorded 27.610 trees from 99 different species, belonging to 103 families. A preliminary analysis of the geographic origin of the existing species showed that of the 799 species ≈ 90% were non-native (720 species), ≈ 8% are native to mainland Portugal (66 species) and ≈ 2% are species deemed invasive under Decree-law no. 565/99 of 21 December (13 species). As for the quantity of plants covered by the inventory, we found that of the 27.610 trees present some 62% are non-native species (17.198 trees); 35% are native to the mainland (9.591 trees) and 3% are invasive species (821 trees).

The most frequent species are: *Celtis australis* L.; *Olea europaea* L.; *Pinus pinea* L.; *Fraxinus angustifolia* Vahl subsp. *angustifolia*; *Phillyrea latifolia* L.; *Cupressus*

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sempervirens L.; *Platanus* x *hispanica* Mill. ex Münchh.; *Cercis siliquastrum* L.; *Ligustrum lucidum* W.T.Aiton; *Phoenix canariensis* Chabaud; *Cupressus lusitanica* Mill.; *Jacaranda mimosifolia* D. Don.

However many of the taxa studies are singular such as *Curtisia dentata* (Burm.f.) C.A.Sm.; *Harpullia pendula* Planch. ex F.Muell.; *Melaleuca styphelioides* Sm.; *Pinus ayacahuite* Ehrenb. ex Schltdl.; P. *torreyana* Parry ex Carrière; *Schinus latifolius* (Gillies ex Lindl.) Engl.; S. *lentiscifolius* Marchand; *Taxodium huegelii* C.Lawson; *Trichilia havanensis* Jacq.; *Trochodendron aralioides* Siebold & Zucc.

Species	Status of the region's plants life	Presence
Celtis australis	Native	46
Cupressus sempervirens	Non-native	37
Jacaranda mimosifolia	Non-native	36
Ligustrum lucidum	Non-native	36
Cercis siliquastrum	Non-native	33
Olea europaea	Native	32
Punica granatum	Non-native	32
Platanus x hispanica	Non-native	31
Magnolia grandiflora	Non-native	31
Phoenix canariensis	Non-native	31
Pinus pinea	Native	29
Fraxinus angustifolia subsp. angustifolia	Native	26

> TABLE 1

The twelve tree species that are most frequent in the 64 gardens studied (LX Gardens 2011/14 survey)

Species	Status of the region's plants life	Trees nº
Celtis australis	Native	2 530
Olea europaea	Nnative	2 255
Cupressus sempervirens	Non-native	1 146
Platanus x hispanica	Non-native	1 022
Pinus pinea	Native	983
Fraxinus angustifolia subsp. angustifolia	Native	960
Cercis siliquastrum	Non-native	927
Ligustrum lucidum	Non-native	833
Phillyrea latifolia	Native	716
Phoenix canariensis	Non-native	589
Cupressus lusitanica	Non-native	482
Jacaranda mimosifolia	Non-native	460

> TABLE 2.

The twelve tree species with the largest number of plants to be found in the 64 gardens studied (LX Gardens 2011/14 survey)

Some are threatened cultivated plants such as: *Afrocarpus mannii* (Hook.f.) C.N.Page; *Araucaria angustifolia* (Bertol.) Kuntze; A. *heterophylla* (Salisb.) Franco; *Austrocedrus chilensis* (D.Don) Pic.Serm. & Bizzarri; *Caesalpinia paraguariensis* (Parodi) Burkart; *Cedrus libani* A.Rich.; *Chamaecyparis formosensis* Matsum; *Chrysophyllum imperiale* (Linden ex K.Koch & Fintelm.) Benth. & Hook.f.; *Cupressus bakeri* Jeps.; C. *goveniana* Gordon; *Dracaena draco* (L.) L.; *Metasequoia glyptostroboides* Hu & W.C.Cheng; *Pinus radiata* D.Don.

Based on these results we draw up two tables: **Table 1** refers to the 12 tree species that are most frequent in the 64 gardens studied, while **Table 2** contains the 12 tree species with the largest number of plants to be found in the 64 gardens studied.

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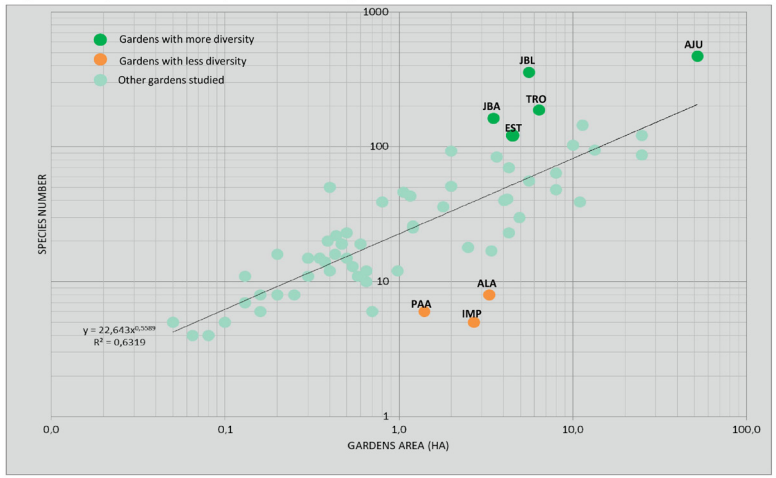
It should be noted that *Celtis australis* is both the most frequent and the most abundant species in the green spaces studied, as we can find 2.530 examples of this species in 46 of the 64 gardens studied. Among the 12 most populous species, five (42%) are species native to mainland Portugal - *Celtis australis* L.; *Olea europaea* L.; *Pinus pinea* L.; *Fraxinus angustifolia* Vahl subsp. *angustifolia*; *Phillyrea latifolia* L. – while the other seven (58%) are species that were non-native - *Cupressus sempervirens* L.; *Platanus* x *hispanica* Mill.ex Münchh.; *Cercis siliquastrum* L.; *Ligustrum lucidum* W.T.Aiton; *Phoenix canariensis* Chabaud; *Cupressus lusitanica* Mill.; *Jacaranda mimosifolia* D. Don.

Following the taxonomic study, **Graph 1** was drawn up which establishes a relationship between the number of species in each green space and its respective area. We draw attention to the following conclusions: 1) *Tapada da Ajuda* (AJU) is the green space that has the greatest botanical diversity, and also the largest area (100 ha). 2) Next come the botanical gardens (JBA, JBL, TRO) which are green spaces with greater species diversity. 3) Mention must be made of *Jardim da Estrela* (EST) due to its enormous botanical diversity, and the *Praça do Império* (IMP), *Praça Afonso de Albuquerque* (PAA) and *Vasco da Gama* (VGA) gardens because of the relatively low level of botanical diversity given their size.

Graph 1 – Relationship between the number of species and the area of each garden.



* AJU – Parque Botânico da Tapada da Ajuda (80 ha); JBA – Jardim Botânico da Ajuda (3,5 ha); JBL – Jardim Botânico de Lisboa (5,6 ha); TRO – Jardim Botânico Tropical (6,4 ha); EST – Jardim da Estrela (4,5 ha); ALA – Alameda D. Afonso Henriques (3,3 ha); IMP – Praça do Império (2,7 ha); PAA – Praça Afonso de Albuquerque (1,4 ha).

> GRAPH 1

Relationship between the number of species and the area of each garden

Conclusion

Lisbon's climate allows the coexistence of various native and non-native tree species, from the North of Europe to subtropical climates. In addition to its inestimable aesthetic value, that botanical diversity provides a habitat for fauna, thus playing a critical role in the increase in biodiversity as well as in the sustainability of the urban ecological structure. That floral wealth is also due to the Portuguese Discoveries and to contact with other cultures that brought to Portugal, especially Lisbon, plant species from all over the world.

Across the areas studied, plant taxa were found from all over the world. Some of the trees inventoried stand out because of their size, structure, age, rarity or for historic and cultural reasons, and

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as a result have been classified by the Institute for Nature Conservation and Forests, thus adding to Lisbon's ecological, landscape, cultural and historic heritage. In general the existing botanical gardens and parks are special places for preserving biodiversity ex situ and may also act as a host location for threatened cultivated trees.

Acknowledgements

The authors would like to thank the Fundação para a Ciência e Tecnologia (FCT PTDC/EAT-EAT/110826/2009) for financial support during the development of this study and the Lisbon Municipality for their support and extend special thanks to Mafalda Farmhouse. The authors are also grateful to Teresa Antunes (MUHNAC/ULisboa), Maria Cristina Duarte (FC/ ULisboa), Francisco Castro Rego (ISA/ ULisboa), Andreia Fernandes Cunha and Jorge de Sousa for their support during the work.

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SIX HISTORICAL GARDENS AND THEIR CONTRIBUTIONS TO THE RISE OF SYSTEMATIC BIOLOGY

© Wim Sonius, M.N.H.N. /O. Borderie, Jesper Kårehed, Charlie Hopkinson, Joel Fry, Lennart Swanström, (Collage, images are cropped)

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> Keywords HISTORY OF SCIENCE
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03. Abstract

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CAN A SELECTION OF SIX BOTANICAL GARDENS FROM EUROPE AND NORTH AMERICA ILLUSTRATE SOME PARTS OF THE 18TH CENTURY HISTORY OF SYSTEMATIC BIOLOGY?

The science systematic biology developed rapidly in the 18th century, thanks to international collaboration. Some of the gardens that were important for the development of systematic biology in the 18th century, and still carry a preserved material heritage, have been preliminary identified and connected in an informal network:

The Hortus botanicus Leiden (the Netherlands) was a centre of knowledge on non-European plants during the 17th and early 18th centuries, and attracted students from all over Europe.

In 1683 the Hortus botanicus Leiden started a seed exchange program with Chelsea Physic Garden (London, UK). Chelsea Physic Garden was created in 1673 by the Society of Apothecaries of London for the training of apprentices about medicinal plants and their uses. The Physic Garden contained one of the first heated greenhouses.

In the 1740s, Carl Linnaeus re-designed the almost 100 years old academy garden in Uppsala (Linnaeus Garden, Sweden) in order to illustrate his new plant classification system. Linnaeus also created a private research facility at his estate Hammarby, to complement the academy garden.

The Jardin des Plantes (Paris, France) illustrates the scientific environment where some of the first natural systems of plant classification were developed. Founded in 1635 as a medicinal garden, it became an important scientific centre in the 18th century.

Bartram's Garden (Philadelphia, USA) was founded in 1728 and facilitated plant exchange between North America and Europe. It is the oldest preserved botanical garden in the Unites States.

Sweden is exploring if some, or all, of these gardens could be included in a future nomination to the UNESCO World Heritage List, together with excursion areas from around the world where important scientific collections were made.

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(Collage, images are cropped)

BOTANICAL GARDENS AROUND THE WORLD CARRY A HERITAGE FROM THE LONG HISTORY OF BOTANICAL, AND OTHER, SCIENCES.

The field of science that is now known as systematic biology developed rapidly in the 18th century, thanks to international collaboration between botanical gardens in several countries. More and more scientifically undescribed plants were collected around the world. This massive influx of new species increased the need of better methods to grow, describe, name and classify the world's flora and fauna.

Some of the gardens that were important for the development of systematic biology in general and systematic botany in particular in the 18th century, and still carry a preserved material heritage, have been preliminary identified and connected in an informal network. This selection of gardens covers gardens important for classification (exemplified by the Linnaeus garden in Uppsala and Jardin des Plantes in Paris), and parts of a plant and information exchange network connecting, among others, London (Chelsea Physic Garden) with plants from North America (via Bartram's Garden in Philadelphia) and East India (via Hortus botanicus Leiden). The history of systematic biology is also related to the development of gardening methods, as exemplified by the works of Philip Miller in the Chelsea Physic Garden.

The Linnaeus garden and Linnaeus' Hammarby

Carl Linnaeus was responsible for several important developments within systematic biology during the 18th century. His most long-lasting contribution is a convenient naming system (the binomial system) and later scientists have established some of Linnaeus's works as the starting points for scientific names of several organism groups. Linnaeus also contributed to

> IMAGE 1

The Linnaeus Garden.
Photo: © Jesper Kårehed

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the field of systematic biology through his attempts to classify the world's all plants and animals and by proposing standardized methods and terminology.

The garden that is today known as the Linnaeus Garden (Uppsala, Sweden) was created in 1655. In the 1740s, it was re-designed by Carl Linnaeus to illustrate his new plant classification system. Today, the Linnaeus Garden is an 18th century oasis in central Uppsala that gives excellent opportunities to learn about botany, 18th century or modern, and of past and present uses of plants. The former professor's residence now houses the Linnaeus Museum.

Linnaeus also created a private research facility at his beloved summer estate Hammarby, to complement the academic garden. At Linnaeus' Hammarby, about forty plant species still remain from Linnaeus's own plantations.

> IMAGE 2

Linnaeus' Hammarby. Photo: © Lennart Swanström, Länsstyrelsen i Uppsala län

> IMAGE 3

Jardin des Plantes. Photo: © M.N.H.N. / O. Borderie

Jardin des Plantes

The Jardin des Plantes (Paris, France) illustrates the scientific environment where some of the first natural systems of plant classification were developed by Bernard and Antoine Laurent de Jussieu and Michel Adanson. Founded in 1635 as the king's medicinal garden, it developed as an important scientific centre during the 18th century, to finally become the Muséum National d'Histoire Naturelle.

The 18th century structure of the garden has been largely preserved. It still hosts historical specimens of trees, introduced for the first time in continental Europe and studied by important botanists, such as Jospeh Pitton de Tournefort, or the Jussieus. One historical specimen is the pistacio tree (Pistacia vera) that was used by Sebastien Vaillant to demonstrate the sexuality of the plants in 1716, which in turn inspired Linnaeus's classification of plants. The plant collections are distributed in alpine, medicinal, phytosociological gardens, formal flower beds, glasshouses... The core of the Jardin des Plantes is the systematic garden which was reorganised six times according to the progress of the botanical classifications between 1683 and 2009. It is still a prominent place for discovering natural sciences and botany.

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03. Chelsea Physic garden

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Chelsea Physic Garden (London, the United Kingdom) was an important node for plant exchange and a centre for development of garden methods in the 18th century. The garden was created in 1673 by the Society of Apothecaries of London for the purpose of training apprentices in how to recognise medicinal plants and study their uses. It is associated with many of the leading gardeners including Philip Miller (the author of the very popular Gardeners Dictionary, in several editions), William Aiton (who later became the first gardener at Kew), and William Forsyth (a Scottish botanist who went on to found the Royal Horticultural Society). Seeds and plants were being exchanged as early as 1683 with four seedlings of Cedrus libani exchanged between John Watts and Paul Hermann (from Hortus botanicus Leiden). This early exchange programme has become the Index Seminum an international seed exchange programme with more than 350 botanical gardens swapping seeds to each other annually. The Physic Garden also contained the first (in the United Kingdom) stove houses or heated greenhouses, built in 1680, and later in 1773 one of the first purpose built rock gardens.

Today the mission of the garden is to demonstrate the medicinal, economic, cultural and environmental importance of plants to the survival and well-being of humankind. It grows and maintains a collection of herbal and medical plants in documented labelled and interpreted displays in a historic botanic garden. It has education activities and events and it continues to demonstrate the development of the science and practice of horticulture, botany and related disciplines through the historic role of the garden.

> IMAGE 4

Chelsea Physic Garden. Photo: © Charlie Hopkinson

Bartram's garden

Bartram's Garden (Philadelphia, USA) served as a centre for the exchange of plants and natural history knowledge between North America and Europe in the 18th and early 19th centuries. Bartram's Garden was founded in 1728 by botanist John Bartram. In founding the garden, John Bartram cultivated and studied plants collected from his many travels in the British colonies in North America. Bartram corresponded extensively with European and American scientists and amateurs, channelling information on his explorations, collections and discoveries through Peter Collinson in London. Other scientific correspondents included Sir Hans Sloane and Philip Miller in London Johann Frederik Gronovius in Leiden, and Carl Linnaeus in Uppsala.

John Bartram in turn received most of the early Linnaean publications from his correspondents, and beginning in the 1730s directed specimens and botanic information on North American plant species to the systematic publication projects of Linnaeus and his collaborators. Bartram also made extensive collections of cryptogams and medicinal plants. The Bartrams funded their garden, and their travels and scientific research with a retail trade to Europe in new North American plants. More than 200 North American woody

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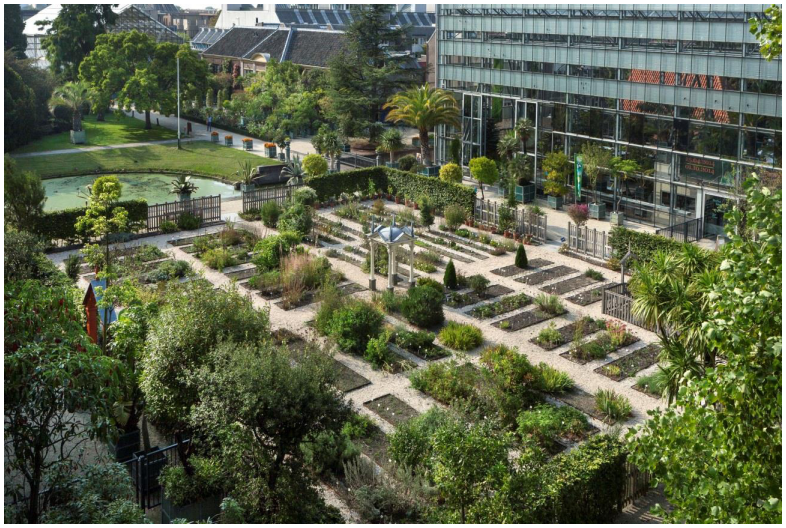
• *Fry Joël T.*

plants were introduced into cultivation by the Bartrams, including the Franklin tree, *Franklinia alatamaha*, now extinct in the wild.

The botanic garden was continued and enlarged over three generations of the Bartram family. John Bartram's son, William Bartram continued his father's work to collect, describe and illustrate new American species. With the establishment of the new U.S. national government in Philadelphia in 1776, Bartram's Garden served as a de facto national botanic garden for several decades, serving as a place for new research, and a site of pilgrimage for its earlier botanic heritage. John Bartram's house and garden, and his 1760 greenhouse are preserved as a park in Philadelphia, part of the city Parks & Recreation system, and operated by the John Bartram Association. Bartram's Garden is the oldest preserved botanical garden in the Unites States and remains a vivid place for learning and inspiration.

> IMAGE 5

Bartram's Garden. Photo: © Joel Fry



> IMAGE 6

Hortus Botanicus Leiden. Photo: © Wim Sonius

Hortus Botanicus Leiden

The Hortus botanicus Leiden (the Netherlands) was a centre of knowledge on non-European plants during the 17th and early 18th centuries, through the import of plants from Far East Asia and the Cape via the Dutch East India Company. The garden was founded in 1590 by Leiden University for teaching and research purposes, but was also intended to be a public garden right from the start. The Hortus was visited by students from all over Europe, many of them attracted by the medicine lectures of Herman Boerhaave (director of the garden 1709–1730).

Today, the Orangery building from 1740–1744 and several plants (e.g. a tulip tree, *Liriodendron tulipifera* from the 1710s) remain from the long history of Hortus botanicus Leiden, in which the garden grew from 1,400 m^2 to three hectares. The tropical greenhouses, built in 1938, and restored in 2013, contain large research collections.

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A network of historical botanical gardens in several countries can contribute to a more global perspective on the history of science, by illustrating how collaboration and exchange has fuelled the scientific development for centuries. In such a network, experiences can also be shared about how to balance between the preservation of historical heritage and the need to develop the garden to reflect modern botany, research and public outreach.

There is potential to enrich the World Heritage List by inscribing more properties that carry a heritage from scientific developments. Sweden is exploring if some, or all, of these gardens could be included in a future nomination to the UNESCO World Heritage List, together with excursion areas from around the world where important scientific collections were made.

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http://www.lansstyrelsen.se/uppsala/varldsarv/

THURET GARDEN IN ANTIBES, FROM 1857 TO 1875: A BRANCH OF THE BOTANICAL GARDEN OF PARIS, FOR ACCLIMATIZATION

© La Villa Thuret au XIXème siècle, In : *La nature* n°1362 (1899)

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03. Abstract

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BOTANIST GUSTAVE THURET CREATED A BOTANICAL GARDEN IN ANTIBES IN THE SOUTH OF FRANCE IN 1857. THE GARDEN WAS ORIGINALLY PRIVATE BUT WAS DONATED TO THE FRENCH STATE IN 1877.

It is now managed by INRA (French national institute for agricultural research) and is behind the introduction of thousands of exotic species in the Mediterranean climate, species that it has helped study and promote. Analysis of the extensive archives covering the period from 1857 to 1875 demonstrate the importance of the links forged with the Jardin des Plantes in Paris and the exchange of plants between the two institutions.

As part of reflections into the improvement of acclimatization processes, this study looks at several questions. Which species were first introduced at Jardin Thuret, bearing mind that some have now become commonplace in our region? Can we trace back the history of these introductions? Which trees are still alive today? Can we improve the methods for choosing, introducing and experimenting with new species adapted to cope with current climate changes on the basis of the results obtained over the last century and a half? Can the archives help us answer these questions and develop a plan for the future? Although it is too early to answer, the study of the flow of plants between Paris and Antibes reveals complementarities between the two institutions and the vital role played by Jardin Thuret in 1) cultivating new species in the French Mediterranean region, 2) botanical and horticultural knowledge of these species and 3) the production and dissemination of seeds.

Villa Thuret is still run as a scientific institution and acclimatization center for new species. The archives studied during this exploratory work show that in the 19th century, it was closely connected to the natural history museum in Paris (MNHN), which was in turn connected to the rest of the world; the Villa had in fact become a kind of Mediterranean branch of the MNHN. Several thousand species were introduced at Jardin Thuret between 1857 and 1875. At the end of this period, new plants able to live outdoors in Antibes accounted for some 2,691 taxa, 29% of which came from the Jardin des Plantes in Paris. In exchange, 1,871 seed batches collected at Jardin Thuret were added to the *Index Seminum* in Paris.

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THE EFFECTS OF CLIMATE CHANGE OCCURRING NOW ARE BEING FELT IN THE FOREST STANDS, WITH EXTENSIVE DIEBACK (DAVI, 2015), FIRES AND WIDESPREAD HEALTH ISSUES (DUPUY *ET AL.*, 2015).

If measures to adjust our current lifestyles are not taken soon, minimum annual average temperature will reach 3°C above the pre-industrial average by 2100 (IPCC, 2014). The commitments made in Paris during COP21 in December 2015 set the goal of a 2°C increase, or even 1.5°C if possible (COP21, 2015). We have already reached a 0.85°C rise (IPCC, 2014) and we can see the impact that this is having on certain landscapes. We can therefore expect much more severe upheavals and the strategic thing to do would be to anticipate them.

The time required for species and plant communities to adapt to these changes is much longer than the time it takes for the expected changes to occur, so one avenue of research currently be explored is assisted migration. (Lehtimäki *et al.*, 2015). To respond to new social and economic requirements such as the production of wood and other commodities, another avenue is the introduction and acclimatization of exotic species which would replace other species in biomes that the latter are no longer able to withstand. However, the scientific community often has a negative view of acclimatization due to the combination of concepts involved in the different phases of the overall process covered by the generic term acclimatization. However, the concept is regaining interest due to the possibilities it implies for the adaptation of plants to climate change (Heywood, 2011). It is therefore an area worth exploring as long as the different processes are defined, from the introduction and accommodation phases (Collin, 2001) to the adaptation and command of the technical and legal requirements and the biological risks.

The other issue is time: we do not have time to apply the same approach as our predecessors in the botanical gardens and ecological arboretums, a large number of which were created by INRA in France over the 20th century (Ducatillion *et al.*, 2015; Lamant *et al.*, 2015). Things need to move much faster! As such, we need to improve the methods and techniques used for the selection, introduction and experimentation with new species that show high potential, making use of historical documents. The Villa Thuret archives – those kept on site and those of its counterparts such as the Jardin des Plantes in Paris – could provide us with vital information and help us select species

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adapted to the new challenges, on the basis of biogeographical or taxonomical criteria.

These goals of this exploratory work are 1) to present the wealth of historical documents available in both institutions, 2) demonstrate the diversity, complementarity and value of the data available and 3) retrace the flow of species introduced into the Mediterranean climate during the 19th century.

Materials & methods

During the 18th and 19th centuries, botany and horticulture combined their power to increase the number of cultivated exotic plants within gardens by massively introducing exotic species on our territory (Drouin, 1995). Acclimatization takes part in the plant domestication by incorporating the travel (Haudricourt *et al.*, 1987). Plants resulting from this complex process show different statuses from acclimatized species to naturalized species; some of these plants may even become invasive (Thevenot, 2013).

1. DÉFINITION

Regarding the purposeful introduction of a species outside of its natural distribution area, it can be deemed acclimatized if it can occasionally reproduce outside of its cultivation area but ends up withering without human intervention (Naudin *et al.*, 1887; Williamson et al., 1996; Richardson *et al.*, 2000; Pysek *et al.*, 2004).

type of documents	location
Thuret-Decaisne correspondence **1856-1875**	Library of the Institut de France, *Paris*
Naudin-Thuret correspondence **1858-1875**	Villa Thuret, *Antibes*
Naudin-Bornet correspondence **1858-1899**	Villa Thuret, *Antibes*
Index Seminum from Jardin des Plantes **1856-1900**	Library of the Service des cultures, *Museum Paris*
Descaine correspondence **1859-1883**	Library of the Service des cultures, *Museum Paris*
Registers input of seeds and plants **1831-1901**	Library of the Service des cultures, *Museum Paris*
Registers output of seeds and plants **1843-1900**	Library of the Service des cultures, *Museum Paris*
Archives of the Service des cultures **1823-1874**	Library of the Service des cultures, *Museum Paris*
Archives of the Service des cultures **1846-1860**	Library of the Service des cultures, *Museum Paris*
Archives of the Service des cultures **1861-1879**	Library of the Service des cultures, *Museum Paris*
Archives of the Service des cultures **1870-1907**	Library of the Service des cultures, *Museum Paris*
Open living plants **1859-1907**	Library of the Service des cultures, *Museum Paris*
Thuret, Bornet correspondence and notes **1857-1878**	Villa Thuret, *Antibes*
Naudin correspondence and notes **1878-1899**	Villa Thuret, *Antibes*

> TABLE 1

List of historical records used for this study

Acclimatization refers in this text only to the introduction and cultivation of small samples of wild species propagules (seeds or potted plants), whose natural area lies in a different geographical zone from that in which it is being cultivated. Here, these samples are called accessions.

2. TYPES OF DOCUMENTS

The material used includes all the historical documents (**Table 1**) providing information (or data) on the flow of exotic plants introduced at Villa Thuret between 1857 and 1875, or on the behavior of those plants (growth, flowering, fruiting, tolerance to cold weather incidents or drought). These are publications or unpublished documents, the originals of which are stored in Villa Thuret's historical library or the library of the culture department in the natural history museum in Paris (MNHN). Correspondence between Gustave Thuret and Joseph Decaisne is stored at the Institut de France. Copies of the original documents have been acquired with copies of photographs

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produced by the authors, with permission from the institutions concerned. Although there are some gaps in certain sources, others make up for these shortfalls and help piece together the puzzle.

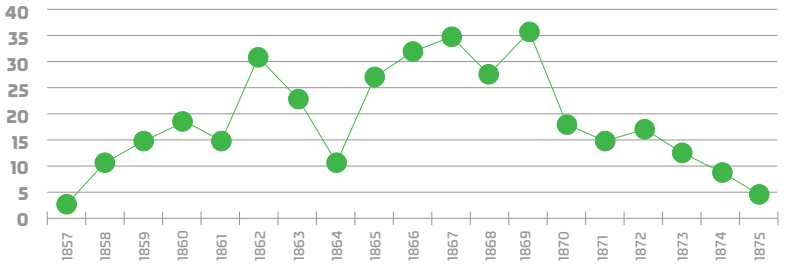
3. WORKING METHOD

Initial work involves identifying documents in the archives and accessing the documents and data. As the documents are read, raw data is systematically entered and scanned into a spreadsheet. The following information is recorded: archive reference, name of the author of the data, date of the data, name of the data entry operator, date of entry, Latin binomial of the plants, type of propagule (seed or plant), accession, origin where known, name of the correspondent or supplier, accession flow (batch received or batch sent), comments, observations and anecdotes (free text field on growth of the species, meteorological information, etc.), personalities mentioned, etc. This data is then cleaned up, updated (nomenclature) and completed with the bibliographical data characterizing the natural area of the species.

Results

1. BIRTH THURET GARDEN AND INTRODUCTION OF NEW SPECIES

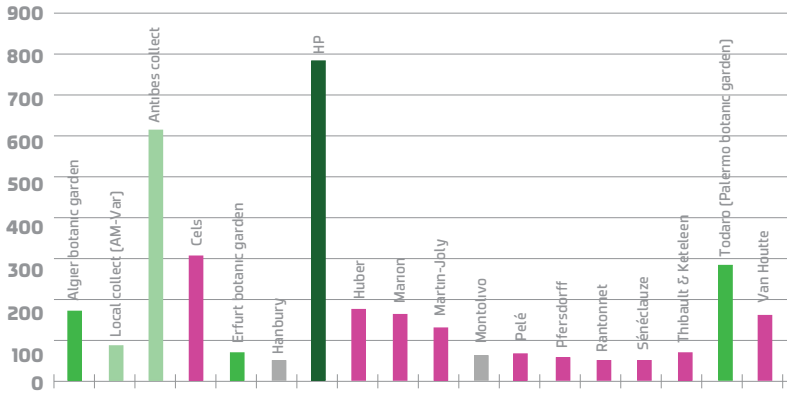
When Gustave Thuret moved to Cap d'Antibes in 1857, Joseph Decaisne held the culture chair at the MNHN in Paris. The two men had long worked together, as shown by the abundant correspondence between them, enabling us to trace the origins of the garden. The first plants arrived in autumn that year, and planting began in spring 1858. However, Thuret had great trouble finding horticulturalists locally. On 12 November 1857, he wrote to Decaisne: "…*Paris feels a long way away and there must be horticulturalists closer by […]. There is no point trying to obtain anything here. The southerners' total neglect for horticulture is unthinkable…*" This forced him to develop a supply network stretching much further than just Antibes. In the early years, the MNHN became the main supplier of Jardin Thuret. Then the network expanded to include 36 French and foreign suppliers by 1869; this figure dropped off again, probably due to saturation in the garden and decreasing requirements (**Figure 1**).



> FIGURE 1

Total plant suppliers known versus time (1857-1875)

The suppliers were nursery owners, botanists and other botanical gardens. The most significant are shown in **figure 2**.



> FIGURE 2

Main suppliers from 1857 to 1875. * Plant Nurseries in pink, botanists worldwide ** in grey, Botanical Garden of Paris (HP) in dark green, other botanical gardens in green, local harvests in pale green.

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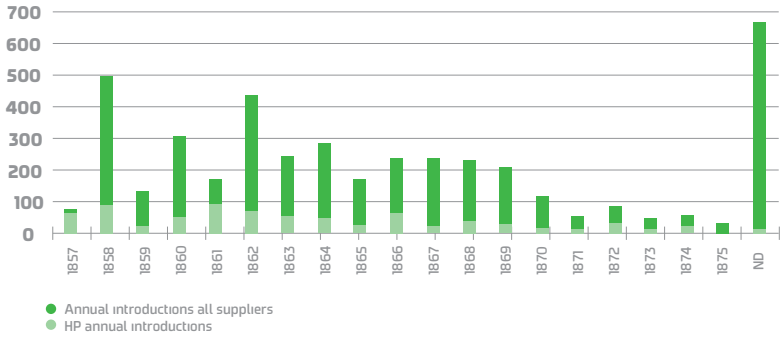
The data collected lets us trace the flow of accessions over time (**Figure 3**). The results are enlightening: in 1875, 2,691 taxa were listed at Jardin Thuret in a register drawn up in 1872 and added to until 1875: *Enumeratio Plantarum in horto Thuretiano cultarum*. In this inventory, 767 species living at Cap d'Antibes come from deliveries from the Jardin des Plantes. Each taxon may have been subject to several accessions which reached the total number of 4,290 in less than two decades. There is information to complete the list of living species, characterizing the accessions (potted plants or seeds) and plant growth (flowering, fruiting, seed production).

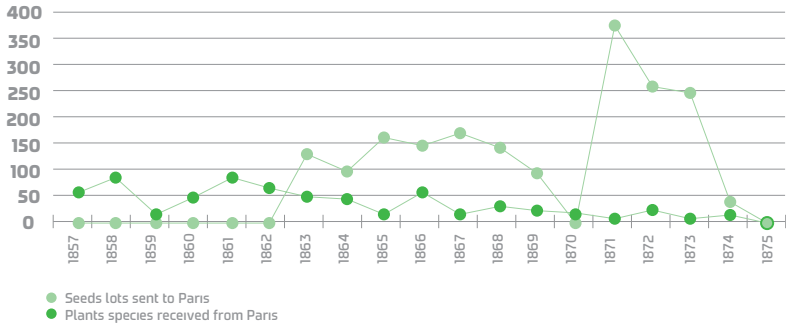


> FIGURE 3

Annual number of accessions across all suppliers and annual number of accessions from the Museum of Paris (HP) from 1857 to 1875 (ND= no date)

2. COLLECTION AND DISSEMINATION OF SEEDS

Gustave Thuret systematically harvested the seeds produced outdoors in his garden. From 1863 onwards, the flow of plants between Paris and Antibes was reversed (**Figure 4**). While we have not yet found the Index seminum for Jardin Thuret for that period, we have proof of its existence: In a letter to Joseph Decaisne dated December 1871, Gustave Thuret confirms that *"[he] will not produce a catalogue on [his] behalf this year and [he] will send him all his harvests from 1870 to 1871"*. The seeds harvested at Villa Thuret are therefore disseminated via the Index seminum of Paris. 1,871 seed batches were added to the MNHN's Index seminum between 1863 and 1875, including 372 taxa for 1871 alone.



> FIGURE 4

Number of accessions exchanged as a function of time (1857 to 1875)

The gardens at Villa Thuret in Antibes during the Thuret period (1857-1875) had become a "subsidiary" of the Jardin des Plantes in Paris, as subsequently mentioned in a handwritten archive dated December 1880: "*Naudin (Ch.) Director of Villa Thuret, the MNHN's branch in Antibes*".

3. SYNTHESIS OF EXISTING RAW DATA

The numerical data obtained to date for this period is as follows:

- Number of known suppliers: **36**
- Total number of accessions: **unknown**

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- Total number of taxa introduced: **unknown**
- Number of accessions leading to a plant able to live outdoors at Jardin Thuret: **4,290** (2,905 in potted plant form and 1,286 in seed form), only 30% of plants were introduced in seed form
- Number of living taxa at Jardin Thuret in 1875: **2,691**
- Number of seed batches harvested at Jardin Thuret and sent to Paris: **1,871**
- Maximum number of taxa whose seeds were harvested the same year and sent to Paris: **372**, or 14% of taxa whose introduction was successful

Discussion

The archives collected and used for this study provide us with information on the methods used to create collections in a botanical garden in 19th-century France. The garden at Villa Thuret benefited from the extensive network of correspondents of the Jardin des Plantes in Paris, completing Gustave Thuret's already wide personal network. However, there are some uncertainties as to the exact bio-geographical origin of the seed batches or plants introduced, rarely specified by the supplier.

Jardin Thuret was designed to facilitate understanding of exotic species and this study shows the extent of the introduction efforts required for a garden like this to take form in less than 20 years and become a powerful force in acclimatization. The garden helped to diversify the range of plants used and contributed to economic growth on the Mediterranean coast, while leading to long-term changes to the landscapes. The introduction of palm trees in the second half of the 19th century and its consequences is one example that can be seen today (Ducatillion, 2013).

Only 30% of accessions were in seed form; this means that G. Thuret introduced thousands of potted plants. If we were to continue with this kind of introduction work, it would be neither possible nor recommended to use similar resources today, mainly for economic and phytosanitary reasons.

The current raw data shows that seeds were harvested from 14% of living taxa. However, this does not mean that the other species did not produce seeds.

The compilation of this first set of archives has helped characterize and quantify the flow of plants between Paris and Antibes. To improve the likelihood of success for future introductions, we would need to compare the full list of taxa introduced with the list of taxa that adapted to environmental conditions in Antibes. We are now aware of the taxa that were successfully introduced and of the efforts made for those taxa (in terms of number of accessions); however, we do not yet know the full introduction effort, in number of accessions and number of taxa. We cannot therefore characterize the successes and failures of introduction at this stage.

This study also shows the richness and quality of the historical archives. Not all of them have been made use of yet and certain sources have not yet been looked at (at suppliers other than the MNHN in Paris, for example). We can suppose that the sources are likely to increase, which would expand the data available for the period already covered and for the following decades – the "post-Thuret" period – from the end of the 19th century to the 20th century.

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The changes underway, especially in terms of climate change, are reigniting interest in the acclimatization of adapted species. This exploratory work has been done so that we can avoid introducing species doomed to failure and improve the success rate of introductions. To this end, we would like to compare the list of species introduced at Jardin Thuret and the list of species that have successfully developed in this host environment, in order to identify the criteria for success.

It has been possible to find and reunite a set of archive documents covering the Thuret period, from 1857 to 1875. An initial analysis of these archives demonstrates the introduction drive at the garden, which covered 5 hectares at that time, with 4,290 known accessions in fewer than two decades. These accessions led to a total 2,691 living taxa listed in 1875. We also have proof that at least 1,871 seed batches were sent to Paris. These batches reached a volume 372 different taxa harvested and sent in 1871, i.e. 14 years after the garden's creation. We can deduce that at least 14% of the plants introduced and growing outdoors in the garden reached sexual maturity.

This analysis shows the significance of the exchanges between the natural history museum in Paris (MNHN) and Jardin Thuret at that time. The MNHN was the main plant supplier for Thuret. After 5 years of existence, Jardin Thuret produced seeds that could be disseminated across the world via the MNHN. Jardin Thuret was then a branch of the MNHN in Paris.

Some of the accessions were registered on both sides, so it is now possible to piece together their history, trace certain seed flows and accurately date the arrival of species that thrived at Cap d'Antibes. With current biological resource conservation methods and efforts to understand the mechanisms behind biological invasions, this information is attracting much interest from the scientific community.

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