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The nature and composition of urban plant diversity in the Mediterranean*

Abstract

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Mediterranean urban areas house substantial amounts of biodiversity – both plant and animal. Urban green spaces include (a) areas of natural or semi-natural vegetation such as ecosystem fragments, reserves, nature parks, forests, and river banks, which house varying amounts of native species; (b) urban agriculture and horticulture; (c) managed spaces with cultivated vegetation such as parks and gardens; and (d) informal urban green spaces such as wastelands or brown field sites which are largely colonized by weeds, ruderal plants and invasive species. Considerable attention has been paid to the biodiversity values of the first two categories but the last category which includes areas such as industrial wastelands, roadside verges, river and canal banks, railway line embankments, has been largely neglected. The benign climate of the Mediterranean region has permitted the cultivation of a wide range of both temperate and semitropical trees, shrubs and herbaceous plants in parks, gardens and other urban settings. The main managed elements are public parks, private and domestic gardens, botanic gardens, zoological parks, glasshouses and shade houses, planted urban forests, street trees, landscaping of office blocks, residential apartment blocks, public buildings, university and college campuses, business parks, golf courses, nurseries, garden centres, and more recently green roofs and living walls. While the diversity of species grown in urban botanic gardens is usually well documented, we have little detailed information on the overall range of species grown in public parks and gardens and, with some exceptions, even less of those grown in private gardens. Street trees are an important component of urban diversity with more than 55% of streets in a city like Madrid populated with trees, totalling altogether 300,000 specimens. Many cities have published guides to their urban street trees but there is no overall compilation. Overall, it is likely that altogether several tens of thousands of plant species are grown in Mediterranean urban areas, representing a very substantial source of biodiversity. The inventory of urban plant diversity is very uneven: for some cities such as Ioannina, Jerusalem, Montpellier, Naples, Patras, Rome, Sousse, fairly comprehensive inventories have been compiled but for most our knowledge is incomplete. Given the large growing percentage of city dwellers in the Mediterranean, it is important that much more attention should be paid to understanding and maintaining urban plant diversity which contributes substantially to human health and wellbeing.

Key words: urban biodiversity, Mediterranean, urban agriculture, green spaces.

* Extended and enriched version of the introductory oral presentation given at the XV OPTIMA meeting in Montpellier, 6-11 June 2016.

Introduction

Ours has become a planet of urban dwellers in a very short time. Already, over half of humanity lives in urban areas. Two thirds will do so in the lifetimes of most people now living on Earth. T. Trzyna (2014)

With already half of the world population living in towns and cities, the biodiversity that they house is now widely recognized as playing an important role in enhancing the quality of life of their inhabitants whose opportunities of experience of wild nature is becoming more restricted. Although many Mediterranean cities suffer from a lack of green space for their growing populations, urban areas do house substantial amounts of biodiversity – both plant and animal. Urban green spaces are remarkably diverse (Heywood 1996) but can be grouped into the following main categories:

- areas of natural or semi-natural vegetation;
- managed spaces with cultivated vegetation such as parks and gardens;
- urban agriculture and horticulture; and informal urban green spaces such as wastelands or brown field sites which are largely colonized by weeds, ruderal plants and invasive species.

'While intact natural ecosystems harbor the richest biodiversity, remnants of pristine natural landscapes (e.g. relicts of primeval forests), traditional agricultural landscapes (e.g. meadows and satoyama), restored landscapes, and managed and industrial landscapes (e.g. industrial parks, railway tracks, residential and city centers, parks, gardens, and brownfields) are increasingly becoming refugia for biodiversity in cities'. Secretariat of the Convention on Biological Diversity (2012)

Historical perspective

The vegetation of the Mediterranean region has undergone massive changes over the past few thousand years, with much of the forest cover of oaks and pines replaced by subseral communities of various types of scrubland such as maquis, garrigue, phrygana, matorral, which today form a conspicuous part of the Mediterranean landscapes. Successive waves of civilization have not only shaped the past and present landscapes through clearing of the land for crops, the use of fire, and the felling of forests to provide timber for shipbuilding but by through their introduction of numerous plants for agriculture, horticulture and ornament. The period of Al Andalus had a major influence on gardens as well as horticulture and agriculture (Heywood 2012) and the wide range of plant introductions included several ornamentals such as *Melia azedarach* (García Sánchez & Hernández Bermejo 2007). Later the introduction of ornamental shrubs, trees, palms and climbers, from many parts of the world, notably from the neotropics, has transformed the urban landscapes of the Mediterranean.

Inventory of urban plant diversity

Although urban spaces lose biodiversity, as measured by numbers of species, as urbanization expands and destroys habitats, many plant [and animal species], including threat-

ened and endangered species, are able to grow and flourish in cities. Overall, it is likely that altogether several tens of thousands of plant species are grown in Mediterranean urban and periurban areas, representing a very substantial source of biodiversity.

Most research on urban biodiversity has focused on the inventory and composition of plant diversity within individual cities. The inventory of urban plant diversity in the Mediterranean is very uneven: for some cities such as Ioannina, Jerusalem, Montpellier, Naples, Patras, Rome, Sousse, fairly comprehensive inventories have been compiled but for most our knowledge is incomplete. This lack of inventory prevents making a proper assessment of the consequences of urbanization on changing patterns of biodiversity in the Mediterranean region and differences between east and west and north and south.

Vascular flora of Rome

Of the total 1581 spontaneous vascular plant species that make up the flora of Rome at present, 1300 species were recorded in the urban sector and 1294 species in the suburban sector. There are 228 non-native species, of which 161 are neophytes and 67 are archaeophytes. The number of species shared by the urban and suburban floristic pools are 1013, accounting for 64% of the total municipal species pool. The species that occur exclusively in the urban sector are 287 (163 native and 124 non-native) while those that occur exclusively in the suburban sector are 281 (273 native and 8 non-native).
Source: Capotorti & al. (2013)

Urban areas of natural or semi-natural vegetation

A wide array of **natural or semi-natural vegetation** which houses varying amounts of native species is found in Mediterranean cities:
- ecosystem fragments,
- urban protected areas and reserves,
- nature parks,
- urban and peri-urban forests, and
- river banks,

Some cities in the Mediterranean have invested in planning structures that preserve the biodiversity at landscape level such as the Infraestructura Verde del Área Metropolitana de Valencia: Corredor del Rio Turia, Huerta, Albufera y Mar Mediterráneo which a vast green space between eight municipalities bordering the sea. The aim is to avoid fragmentation of the ecosystems, both natural and agricultural, and the urban barriers around the river Turia, improving access to the landscape (Cantó López 2014). 'Lisbon Biodiversity 2020' aims to protect and enhance Lisbon's biodiversity. 18% of the city's area is covered with semi-natural vegetation. Of the 2,800 plant species recorded in the metropolitan area, fewer than 10 percent are native. Lisbon is also part of the 'Green Surge' project on urban green infrastructure planning and governance in 20 European cities (Box 1).

Box 1. Green Surge

Green Surge is a transnational research project funded through the European Union's Seventh Framework Programme. GREEN SURGE is an acronym for Green Infrastructure and Urban Biodiversity for Sustainable Urban Development and the Green Economy.
The project is identifying. developing and testing ways of connecting green spaces, biodi-

versity, people and the green economy, so as to meet the major urban challenges related to land use conflicts, climate change adaptation, demographic changes, and human health and well-being.
Of the 20 countries included in the project, five were Mediterranean: Bari and Milan (Italy), Barcelona (Spain), and Lisbon and Almada (Portugal).

Source: http://greensurge.eu/filer/GREEN_SURGE_Report_of_City_Portraits.pdf

Fig. 1. Canal vegetation, Nervi, near Genova, Italy (Photo V. H. Heywood).

Urban protected areas

Urban protected areas are defined by IUCN as 'protected areas situated in or at the edge of larger population centres'. They meet IUCN's definition of a protected area and can be in any of its six Management Categories. They do not include conventional urban parks with lawns, flowerbeds and sports fields (Trzyna 2014). Urban protected areas have no formal recognition as such internationally, nor is there a global inventory of urban protected areas and they are not identified separately in the World Database of Protected Areas. Most urban protected areas are recognized either as Category II (national park) or Category V (protected landscape or seascape). However, there are urban protected areas in all categories.

Urban protected areas can be managed by national governments, state or provincial governments in federal systems, local governments, nongovernmental organizations, local community groups, or businesses.

Box 2. Urban protected areas

Urban protected areas are distinctive in several ways. They:

— Receive large numbers of visitors, including many who visit frequently, even daily. Many of these visitors lack experience of wilder forms of nature. They tend to be much more diverse ethnically and economically than visitors to more remote protected areas.

— Relate to numerous actors in the urban arena, including government decision-makers, communications media, opinion leaders, and key educational and cultural institutions.

— Are threatened by urban sprawl and intensification of urban development.

— Are disproportionately affected by crime, vandalism, littering, dumping, and light and noise pollution.

— Are subject to such urban edge effects as more frequent and more severe fires, air and water pollution, and introduction of invasive alien species.

Source: Trzyna (2014).

Examples of urban protected areas are the Calanques National Park (Category II, 8,500 ha of land and 43,500 ha of the Mediterranean Sea, plus buffer zones) located on the outskirts of Marseilles. It was created in 2012 as France's tenth national park and may be the only national park in Europe that adjoins a city and is both terrestrial and marine. Rocky inlets, headlands, and islands heavily influenced by human activity over millennia. Managed by an administrative council composed of representatives of national and regional agencies and local governments, various interest groups, residents of the park, and park staff.

At the edge of the city are the Ljubljana marshes in the Ljubljana Marsh Nature Park, located in the area of Ljubljansko barje, in Central Slovenia, in the southernmost part of the Ljubljana Basin. It has a protected area of some13,505 ha. The Park covers Slovenia's largest complex of wet grasslands with hedges and forests, shrubs and watercourses. The area is well-known for its rich biodiversity, which is the result of specific cultivation practices (extensively-mowed meadows).
http://www.ljubljanskobarje.si/?lang=en

The Parco Nazionale delle Cinque Terre, with its 3,868 hectares wide surface, is one of Italy's smallest National Parks and the most populated at the same time, with about 4,000 inhabitants distributed in five small towns. For more than a 1000 years humans have modified the natural environment by cutting into the steep slopes of the hills to obtain stretches of land and cultivate them, the so called "ciàn", supported by kilometers-long dry-stone walls. They are the most characteristic feature of the Cinque Terre that has recognized by UNESCO as a World Heritage site as a cultural landscape[i].

Fig. 2. Ljubljana marshes (Slovenia).

Natural Parks and Nature Parks

The terms National Park and Nature Park are frequently used in some Mediterranean countries to describe landscapes protected through long-term planning, use and agriculture. They are maintained in their present state and may be promoted for the purposes of tourism. They are often subject to varying degrees of local or national legislation. Their formal definition varies from country to country. In France, a Regional Nature Park (*parc naturel régional*) is a body under the aegis of the local and the national government, covering an inhabited rural area of outstanding beauty, established in order to protect the scenery and heritage as well as setting up sustainable economic development in the area[ii]. In Spain, a natural park(*parque natural*) is a natural space protected for its biology, geology, or landscape, with ecological, aesthetic, educational, or scientific value whose preservation merits preferential attention on the part of public administration. The regulation of the activities that may occur there attempts to assure its protection[iii].

Natural and Nature parks are not National Parks although some of them may achieve such a designation. In Europe, they come under the **'**EUROPARC Federation', the network for Europe's natural and cultural heritage which was established in 1973. 'the collective voice for all nature and landscape areas'.

Examples of Mediterranean Natural Parks that are urban or peri-urban are:

- Collserola Natural Park in Spain, which has been called the 'World's biggest urban Natural Park', Comprising more than 8.000 ha of Mediterranean forest, it has 10 million trees, 1,000 species of plants and almost 190 species of animals. The park forms Barcelona's natural border to the west.
- The vast Regional Natural Park of Narbonne in Mediterranean France (Parc naturel régional de la Narbonnaise en Méditerranée) covers 80,000 hectares. It includes a diver-

sity of features and landscapes, from lagoons and fine sandy beaches on the Mediterranean coast, to vineyards and garrigue[iv].

- The 1,600 hectare Regional Park of Molentargius Park (Parco Regionale Naturale Molentargius-Saline)[v], located in the urban area of Cagliari, the capital of Sardinia , Italy. The abandoned industrial landscape of a former salt works has been transformed into an urban park, due to the intervention of environmental organizations and after a civil mobilization (Ruju 1998: 952).

Urban and peri-urban forests (UPF)

It is a long-standing tradition in many European towns and cities to maintain forests or woodlands in or around the inhabited area. **Urban and peri-urban forestry** (UPF) is the practice of managing forests, groups of trees or even individual trees in and around urban areas so as to maximise their economic livelihood social, cultural environmental and biodiversity values (Davies & al. 2017; Jorgensen 1986). Although long established in the USA and Europe (Kenney 2014) it is a relatively novel discipline especially in Mediterranean countries.

Although there is a diversity of definitions of what constitutes an urban forest (Calvo & al. 2914; Kenney 2014), **Urban forests** are defined by FAO (2016) as 'networks or systems comprising all woodlands, groups of trees, and individual trees located in urban and peri-urban areas; they include, therefore, forests, street trees, trees in parks and gardens, and trees in derelict corners. Urban forests are the backbone of the green infrastructure, bridging rural and urban areas and ameliorating a city's environmental footprint'. They divide then into four main types (Table 1) although some of these such as city parks and street trees overlap with other typologies and are covered separately in this paper. Thus, urban forests may be components of urban protected areas, nature and natural parks, municipal parks and gardens and private gardens.

A first attempt to develop a State of Mediterranean Urban and Peri-urban Forestry was carried out by a Working Group and published as part of the 'State of Mediterranean Forests' compiled by FAO (2013). It recognizes four approaches to Urban and peri-urban forestry (UPF) forestry:

- **Focus on management-oriented woodlands in and around towns** (central-northern European approach)
  Slovenia, Croatia, Romania & Turkey; to some extent: Israel & Morocco
- **Focus on less management-oriented urban parks and gardens**
  Algeria, Bulgaria, Cyprus, France, Lebanon, Malta, Spain & Tunisia; to some extent: Egypt, Greece and Morocco
- **Focus on the development of an ecological network of protected areas**
  Croatia, France, Greece, Italy, Portugal, Slovenia & Spain
- **Focus on the integration of all UPF approaches and related disciplines**
  France, Italy & Portugal; to some extent: Croatia, Greece, Slovenia & Turkey

It noted that 'the diversity of cultures, languages, societies, histories and policies in the Mediterranean region suggests that it will be challenging to find a common definition of urban forest and to amplify the concept to include peri-urban woodlands and open

spaces. Moreover, on the one hand there are many studies on UPF in Mediterranean countries, and on the other there is a reluctance to adopt UPF as a scientific discipline and as a strategic factor in the future development of cities. To date there is no up-to-date regional overview of the experiences gained and expertise acquired; no action plans or national strategies for meeting the long-term challenges of cities that take into account the potential contributions of forests and trees; and no specialized UPF network focusing on the Mediterranean region'.

It also found that quantitative data on urban and peri-urban forests in the Mediterranean are generally very poor. For example, data on the area of green space per person (the "per capita green space provision") is highly incomplete but from the evidence available, the lowest values in Europe were found in the south and east (Fuller & Gaston 2009). A survey of 75 urban forests in major cities in Turkey reported an average size of 377 hectares with a very wide range (from 1 hectare to more than 11 000 hectares) while the Guides des forets urbaines et périurbaines (Haut Commissariat aux Eaux et Forêts et à la Lutte Contre la Désertification 2010) reported an area of 2.5 m2 of green space per inhabitant in Moroccan cities.

This guide defined urban forest as a "forest inside the urban texture", and peri-urban forest as a "forest area influenced by an urban context" (according to a range of requested services, especially recreation and tourism) located less than 30 km from the urban area.

Table 1. Main types of urban forest

Peri-urban forests and woodlands.
Forests and woodlands surrounding towns and cities that can provide goods and services such as wood, fibre, fruit, other non-wood forest products, clean water, recreation and tourism.
City parks and urban forests (>0.5 ha).
Large urban or district parks with a variety of land cover and at least partly equipped with facilities for leisure and recreation.
Pocket parks and gardens with trees (<0.5 ha).
Small district parks equipped with facilities for recreation/leisure, and private gardens and green spaces.
Trees on streets or in public squares.
Linear tree populations, small groups of trees, and individual trees in squares and parking lots and on streets.
Source: FAO (2016)

An assessment of urban and peri-urban forests in Greece, is given by Christopoulou & al. (2007). They describe the various historical stages in the development of these forests, from numerous reforestation programmes on most of the mountainous terrain around the Greek capital by the end of the 19th century, initially planted on aesthetic, health or protection grounds or on a combination of the above and subsequently, declared as 'protective' forests, an institution that was spread nationwide to encompass also forests and is still in operation today. Later, between 1973 and 1980, 19 woodland areas were declared 'Aesthetic Forests' (forests with special natural beauty) such as the Mount Hymettus Aesthetic Forest (Such is the Vai Palm Forest in eastern Crete, the Aesthetic Forest in Rodopi Mountains in Thrace and the Kaisariani Forest in Athens.

The role of urban and peri-urban forests on the provision of ecosystem services is gradually being recognized, as in the Barcelona Green Infrastructure and Biodiversity Plan 2020 (Hàbitat Urbà 2013). This notes that Barcelona has 3,611 hectares of green infrastructure covering 35.3% of the city land (according to 2009 data). Of this area, 1,076 hectares are strictly urban greenery, 1,795 pertain to the municipal district within Collserola Nature Park and 740 are private greenery generally in the highest part of the city.

Fig. 3. Genova, Italy, wildland-urban interface (Photo V. H. Heywood).

Managed spaces with cultivated vegetation

The main managed elements of cultivated vegetation in Mediterranean cities are remarkably diverse and house large amounts of plant and animal diversity (Heywood 1996), notably :

- Urban and peri-urban parks
- Municipal/public parks and gardens
- Private and domestic gardens
- Botanic gardens and arboreta
- Zoological parks and gardens
- Landscaping of office blocks, residential apartment blocks, public buildings, university and college campuses, business parks,
- Golf courses
- Cemeteries
- Nurseries, garden centres
- Street trees
- Green roofs and living walls.

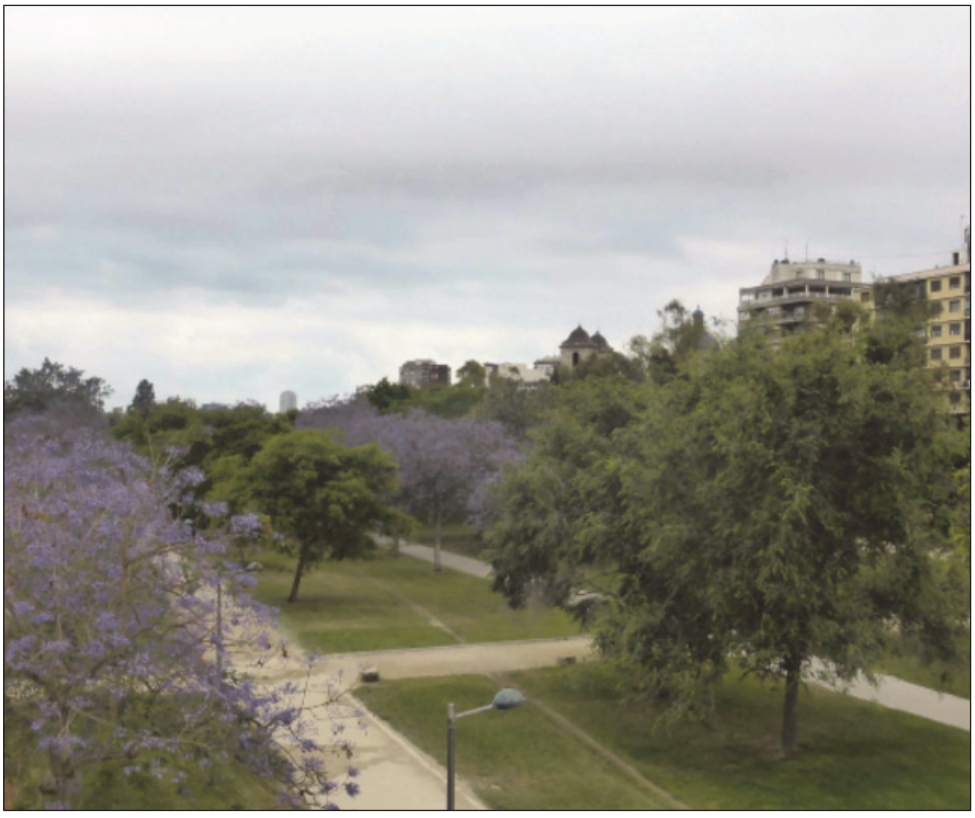

Fig. 4. River bed Jardines del Turia, Valencia, Spain (Photo V. H. Heywood).

Urban and peri-urban parks

As Mediterranean towns and cities have expanded, the role of urban parks in providing areas for culture, recreation, community development, heritage, health and wellbeing, economic development, connecting people to nature, conserving biodiversity, natural environment, education has been increasingly recognized. A wide diversity of such parks may be found, ranging from traditional urban municipal parks and gardens to vast areas of green space including both natural and seminatural vegetation and landscaped and cultivated areas, such as the Bois de Vincennes (995 ha) and the Bois de Boulogne (845 ha), in Paris the Casa de Campo in Madrid (1,722 ha) and the Parc de Collserola in Barcelona which has an area of 84.65 km², the largest metropolitan park in the world.

In Marseilles, half of the city's area is made up of natural spaces, with over 400 hectares of public parks and gardens, including 54 parks with an area greater than 1 ha and 15, five of them over 15ha. These are complemented by a network of 270 squares and gardens. Montpellier has 954 ha of public green spaces and parks. Madrid has 3300 ha of parks and gardens, distributed throughout more than 40 parks within the urban limits, including the Casa de Campo, the 120 ha Parque del Buen Retiro on the centre of the city, the Parque del Oeste, the Campo del Moro and the Jardines de Sabatini, the 60 ha Parque de la Dehesa de la Villa.

In addition to these parks, there are countless smaller gardens and green spaces in virtually all Mediterranean towns and cities.

Several Mediterranean countries, such as Greece, France, Italy, Spain and Portugal are members of a European federation of urban parks (Fedenatur). There are 28 such parks in the Mediterranean, most of them in Spain.

Peri-urban parks

The peri-urban space represents a transition between the city and the countryside and parks located in such areas are a key element of the green infrastructures system associated with urban areas and play a key role in the provision of ecosystem services. Peri-urban parks may be defined as:

'areas of ecological, landscape and cultural interest located on the outskirts of or in close proximity to urban settlements, but inherently interwoven with the urban environment, where environmental protection, recreational, cultural, educational, economic and development related functions can coexist, with the support of public policies, plans and actions and with full citizen involvement' (Junta de Andalucía 2012)

The Interreg 4c Periurban Project – Periurban Parks Improving Environmental Conditions in Suburban Areas[vi] identified four typologies:

a. Protected Nature Park

This type of park consists of areas with a high natural, biological and landscape or cultural related values. Generally, these parks are characterised by a high level of plant and animal biodiversity. Regulations and restrictions for the use of this type of territory exist at European level (NATURA 2000), at national level and / or at regional and local level. Legislation on nature protection often provides direct rules and frameworks for activities. The prohibition of certain uses can have significant impact on the development process.

b. Semi-Natural Agro-Ecological Park

This type of park is composed of a mixture of natural and artificially created lands, which may include ecological areas, such as green corridors, or agricultural lands, such as crop fields, woods and wetlands. This type of park is not subject to particular European regulation (though it has been taken into consideration at EU level, particularly in the 2004 EESC commentary on Agriculture in Periurban Areas), but is subject to a range of legislation and policies at national and local level.

c. Green City Park

This type of park represents a green area located in very close proximity to or within the urban area, with a series of functions related to local use and addressed to local residents. Given that it can express various forms of environmental features and values, it is subject to a range of legislations and policies at national and local level (e.g. Forest Management Plans, Local Plans on Green Spaces, Urban Development Plans).

d. Re-naturalised Park

This type of park represents a landscape, which had previously been artificially denatured or deteriorated to some extent, including ex-industrial areas, or dumping grounds, but has now been partly or fully recovered.

Private and domestic gardens

The benign climate of the Mediterranean permits the cultivation of a wide array of plants from around the world and this has encouraged the development of garden creation by private individuals. In most countries on the northern shores, there are many important private gardens, especially in Italy, France and Spain, some of which hold important collections of plants, a tradition that goes back at least to the days of Cosimo I de Medici (Heywood 2015). In 16th century Italy, many of the most important plant collections were to be found in private gardens in Rome which became a leading centre of botanical study and research (Attlee 2006).

Some of these private villa gardens were built by wealthy families, nobility or the crown. Examples include the Boboli gardens in Florence, the Villa d'Este, Tivoli, near Rome, the Giardino Giusti, Verona, in Italy, the Jardins du château de Versailles, in France, and the Jardin del Palacio de Aranjuez and the Parque de Maria Luisa, Sevilla, in Spain. A useful account of some of the main villa gardens in the Mediterranean is given by Bradley Hole (2006). In addition, there are numerous accounts of the parks and gardens of the Mediterranean, especially in France, Italy, Spain and Portugal that may be consulted. The tradition of creating gardens in the region continues and there are many innovative examples in the northern shores of the Mediterranean and to a lesser extent in some North African cities such as Rabat and Marrakesh.

Botanic gardens and arboreta

Urban botanic gardens are unique green spaces with high concentrations of plant diversity. They play a major role in plant conservation, education and public outreach. The Mediterranean was the birthplace of botanic gardens of the western tradition, and from 16th century onwards in Italy and other countries the first academic university

botanic gardens were founded such as those of Pisa (1544), Padua (1545), Firenze (1545), Bologna (1547), Ferrara (?1577), Zurich (1560), Leiden (1577), Paris (1579), Leipzig (1597), Montpellier (1598) and Valencia (1567). Many further botanic gardens were created in the European Mediterranean zone in the following centuries.

In a recent review of Mediterranean botanic gardens (Heywood 2015), I noted that today, the Mediterranean region houses a large number of botanic gardens but their distribution across the region and their range of facilities are very uneven. The total number is approximately 170 of only those gardens that occur in the Mediterranean climate zone of the countries concerned are included. By far the largest number (57) are found in Italy where most of the country occurs in the Mediterranean climate zone and although France as a whole has as many if not more botanic gardens than Italy, most of them are in the non-Mediterranean zones where only some 20 occur. In Spain, most botanic gardens occur in the Mediterranean zone which covers much of the country: 21 out of a total number of 29. In contrast, with few exceptions, botanic gardens have not played an important role in the countries of the southern and eastern Mediterranean: the number of botanic gardens in North Africa and the Levant is relatively small, and often with limited resources and facilities and with species- poor living collections; and in the countries of SW Asia, with few exceptions, botanic gardens have not been developed either as scientific or educational establishments. More than half of the countries have one or two botanic gardens or none and most of those that do exist are small and report few activities (Heywood 2015).

In most cases, the plants accessions grown in botanic garden are recorded in catalogues and/or databases. Mediterranean botanic gardens house collectively some tens of thousands of species and innumerable cultivars.

A range of structures to enable a wide range of exotic species to be grown successfully and survive the winter cold is found in Mediterranean gardens, especially in botanic gardens. These include cold frames, stanzone per i cidri, limonaie and orangeries, greenhouses and shade houses (umbracula). There has also been a trend to construct biodomes or biospheres and similar glass structures to grow a diversity of plants and simulate natural habitats for the benefit of the local population and children (Fig. 5).

Inventory of plants diversity in Mediterranean parks and gardens.

It is evident that the estate of Mediterranean parks and contains an enormous diversity of plant species but we have little detailed information on the overall range of species grown in them and, with some exceptions, even less of those grown in private gardens. Some of them have been inventoried such as the Parc de Collserola, where over a thousand higher plants and around thirty plant communities have been catalogued, but most of them do not have a complete or even partial inventory of the plants they house. Overall, we can say some tens of thousands of species are grown in these parks and gardens and collectively they represent a vast but often overlooked and neglected treasure house of plant riches.

Fig.5. Biosphere, Genoa, Italy (Photo V. H. Heywood).

Fig. 6. Jardin Exotique, Monaco (Photo V. H. Heywood).

Urban biodiversity and tourism

The Mediterranean is the world's leading tourist destination, with the twenty countries bordering the Mediterranean Sea attracting over 30% of world tourism. The 46,000 km long coastal zone is visited by about 183 million tourists during the 3-month summer season. 25,000 km of this total are already urbanized and have already exceeded a critical limit. An additional 100 million domestic tourists bring the total up to about 280 million visitors a year. Over 12 million tourists visit the Mediterranean islands each year.

The increase of tourism has led to massive urban and tourist development with accompanying infrastructural effects. This is especially accentuated in coastal areas such as in parts of the Mediterranean and on islands, leading to the phenomenon known as 'coastalization'[vii] . This has inevitably led to an impoverishment of biodiversity, loss or fragmentation of habitats but on the other hand has been instrumental in increasing the amount of cultivated plant biodiversity.

Urban trees

Trees, and notably street trees, are an important component of urban diversity and trees often give them a special character such as the pines of Rome (*Pinus pinea*), the plane trees (*Platanus* of the Ramblas in Barcelona, the bitter orange trees (*Citrus* × *aurantium*) in many Mediterranean towns and cities such as Athens, Rome, Sevilla, Marrakesh, Tel Aviv, Valencia. When in flower they often produce spectacular shows at certain times of the year such as the Jacaranda (*Jacaranda mimosifolia*) in Athens (Photo 1), the Judas tree (*Cercis siliquastrum*) in Rome.

Azahar – orange blossom in Spain

In Spain, the term Azahar (or Flor de Azahar) refers to various white flowers and by anastomasia to those of the orange, lemon and citron. It is popularly associated with the intensely perfumed orange blossom that is found in the streets, squares and patios of many towns and cities, especially in Andalucía and the Levant. Valencia is often known as the Ciudad del Azahar (City of orange blossom) and the name Costa del Azahar (coast of orange blossom) is refers to a 120 km stretch of the coast in the province of Castellón. The name comes from the hispanic Arabic azzahár, which in turn derives from the classic Arabic az-zahr (which means flowers). In April, the city of Córdoba celebrates the coming into flower of the orange blossom, as 'Córdoba en Azahar', with a series of events.

A wide range of tree species is grown in Mediterranean towns and cities, including many tropical and subtropical trees that are able to flourish in the benign climate of the Mediterranean, such as the Brazilian pepper tree (*Schinus terebinthifolius*), Pagoda tree (*Styphnolobium japonicum*), Indian bead tree (*Melia azedarach*), Jacaranda (*Jacaranda mimosifolia*), Rosewood (*Tipuana tipu*), and various palm species such as the Canary date palm (*Phoenix canariensis*), Hemp palm (*Trachycarpus fortunei*), Mexican Washingtonia (*Washingtonia robusta*), Date palm (*Phoenix dactylifera),* Californian Washingtonia (*Washingtonia filifera*). However, only a small number of trees dominate the urban street plantings, such as elms (*Ulmus* spp.), planes (*Platanus* spp.), Holm oak (*Quercus ilex*), black locust *(Robinia pseudacacia*), hackberry (*Celtis australis*, *C. occidentalis*), Japanese pagoda tree (*Sophora japonica*), *Albizzia julibrissin*, mulberry

(*Morus* sp.), poplar (*Populus* spp.), curtain (*Ficus microcarpa*), cypress (*Cupressus sempervirens*), Lime (*Tilia platyphyllos*).

Mediterranean cities vary both in the actual numbers of trees planted and the number of different species they represent. More than 55% of streets in Madrid are populated with trees, totalling altogether 300,000 specimens belonging to 220 species, while there are 153,000 trees in the streets of Barcelona, including over 150 different species. In 1998 Rome had 120,00 street trees belonging to 58 species. Madrid is, in fact the European capital with most street trees and second only to Tokyo globally.

Many Mediterranean cities such as Barcelona, Madrid, Valencia, have published guides to their urban street trees but there is no overall compilation. The city of Lucca, Italy, prepared an inventory of the 1 452 trees within its 15th-century city walls to optimize investments in adaptive management and the conservation of the city's historical urban forest.

The Barcelona Charter, the 'Declaration of the Rights of Trees in the City' was drawn up and signed in Barcelona on the occasion of the first congress of the Spanish Association of Arboriculture. This Charter establishes the rights of trees in the urban environment (Box aa).

Box aa :Commitments contained in the Declaration of the Rights of Trees in the City

– To situate trees in their basic role as one of the city's principal heritage resources.
– Comprehensive and continuous preparation and promotion of information, inventories, management techniques, practices, procedures, products, services and standards that facilitate the introduction of trees in the city in fitting and decent conditions
– To disseminate information: to inform and educate the general public, the various professional groups, the industrial and service sectors, schools, colleges and universities, about the basic importance of trees for life in the city.
– To establish policies, rules, regulations and practices in city government and administration that ensure optimal conditions for the life of trees.
– To reconsider all the elements that currently make up urban space and think ahead from the standpoint of the requirements and potential of the urban tree network as regards the conception, planning, creation, management, use and reuse of this public space.

Parameters such as the number of street trees per inhabitant indicate the street tree density per population. According to an EU COST working group, a survey between 1999 and 2001 to study tree establishment practice in European towns and cities (Pauleit & al. 2002), while most central European cities had a ratio of 50–80 street trees per 1000 inhabitants, although there was a wide variation between urban areas within a single country, and the tree density was as low as 20 street trees per 1000 inhabitants for Nice. A more recent study (Forman 2014) showed the number of trees varies from 2–22 per 100 people, and that in the Mediterranean cities sampled, Athens has the most trees per capita while Nice and Marseilles have the fewest.

Street trees play an important role in the ways cities function and provide a series of environmental and social benefits such as improved air quality, reduction of noise pollution, moderating the urban microclimate, improving the quality of life and by providing shade not only make circulating through the city more pleasant but also reduce air conditioning costs (Hàbitat Urbà 2011).

Survival rates for street trees vary considerably, from a few years to several decades or longer. The average survival rate in Barcelona is 50 years. The species of tree planted vary over time, responding to social, arboricultural and even political factors. In recent years, there has been a tendency for large trees to be replaced by smaller ones.

The street tree environment is both artificial and heavily managed and the rate of natural regeneration is negligible, so the main source of new trees is planting. As Roman (2014) puts it this 'makes tree-lined streets more akin to an orchard: a cultivated landscape, stewarded by humans, and grown for human benefit.' Marseille has published a Guide to Greening the Streets (Guide de végétalisation des rues)[viii]

Fig. 7. Jacaranda in flower in an Athens street (Photo V. H. Heywood).

Urban agriculture and horticulture

Urban agriculture[ix] has become a more common feature of European and Mediterranean cities in recent years. It can be defined briefly as the growing of plants and the raising of animals within and around cities but the critical difference from rural agriculture, is not location but the fact that it is integrated into the urban economic and ecological system (Mougeot 2001). It is extremely diverse and different typologies have been proposed. Although it is not the aim of urban agriculture, nor would it be desirable, to make cities sustainable in terms of food supply, it can provide a substantial proportion of food products

from different types of crops (grains, root crops, vegetables, mushrooms, fruits) (Box 2), as well as non-food products (e.g. aromatic and medicinal herbs, ornamental plants, tree products). Urban and periurban agriculture also includes trees that are managed for producing fruit and fuelwood, as agroforestry) and small-scale aquaculture.

Urban agriculture has long been practised in east Mediterranean and North African Mediterranean cities although often not formally structured or officially recognized (Tawk & al. 2011). In the last decade or so, various innovative initiatives in North African cities have been developed such as the approach called 'Connecting Urban-Rural Spheres in Casablanca' (Giseke & al. 2015) in which urban open space and agriculture can be linked to a productive green infrastructure, forming new urban-rural linkages. There have also been any innovative developments in European Mediterranean cities in recent years, as in Greece (Morán & Fernández de Casadevante, 2014), France (Simón Rojo 2014; Scheromm 2015) , Italy (Antonelli & Lamberti 2012; Corrado 2013), Spain (de Felipe & Briz 2015; Romero. & Melo 2015).

Box 2. Urban farming

Vegetables have a short production cycle; some can be harvested within 60 days of planting, so are well suited for urban farming.

Garden plots can be up to 15 times more productive than rural holdings. An area of just one square metre can provide 20 kg of food a year.

Urban vegetable growers spend less on transport, packaging and storage, and can sell directly through street food stands and market stalls. More income goes to them instead of middlemen.

Urban agriculture provides employment and incomes for poor women and other disadvantaged groups.

Horticulture can generate one job every 100 sq m garden in production, input supply, marketing and value-addition from producer to consumer.

Source: http://www.fao.org/urban-agriculture/en/

Urban allotments and community gardens

Allotment gardens are a key feature of the urban landscape, providing numerous benefits beyond those of food production. These include ecosystem services such as local climate modification, pollination, and providing a pleasant location for socialising. The biodiversity of flora underpins many of these ecosystem services (Borysiak & al. 2016). As well as their various economic, social and cultural roles, allotments maintain a considerable diversity of plants and contribute increasingly to preserving traditional species, old cultivars and their genetic sources.

The term 'allotment' originates in the British usage of 'allotting' a parcel of land to an individual or family for non-commercial use as land to grow plants – mainly vegetables and ornamentals[x]. It is not widely used or translated into other languages in continental Europe although similar types of terrain are used there for growing plants for the same purposes, subject to their own particular form of regulation, such as the *jardins familiaux* in France, the *orti urbani* in Italy, and the *horts familiars*.

The tradition of providing allotments began in western and central Europe in the 19th century (Weirch, 2016) while in Mediterranean countries, allotments and community gardens other forms of urban gardening are a more recent development (Keshavarz & Bell 2016) and mainly found in large industrial cities such as Barcelona, Genoa and Marseille (Consales 2003) although there is now a growing interest in the concept. In fact, since 2008, there was a substantial growth in urban gardening, allotments and community gardens in countries all around the Mediterranean Sea, such as Cyprus, Greece Spain and Portugal, 'in response to the austerity policies in many countries, because of the recent economic crisis, together with high unemployment rates, food poverty or difficulties in maintaining public spaces' (Fox-Kämper 2016). More recently, the motivation has also come from the urban greening and sustainable living movements.

In Greece, there has been a remarkable development in recent years of community and urban agriculture in many cities, including allotment gardens 2014), merging food production, urban ecology, food sovereignty, social links and novel ways of thinking and inhabiting the cities (Morán & Fernández de Casadevante 2014). The first public policies to promote allotment gardens in Greece date from 2012, by developing social gardens for self-consumption for vulnerable groups. Although they began in medium-sized cities, these programmes spread quickly across the whole country – in Thermi, Kalamata, Tripoli, Larissa, Veria, Edesa, Lesbos and Crete as well as in metropolitan districts of Athens.

> In the face of 'the great socio-economic uncertainty the cities of the 21st century, the emergence of urban green commons (collectively managed green spaces) within the urban fabric responds to a contemporary need of urban resilience. As a form of "commons", the urban community gardens can be seen, except for productive landscapes and "foodscapes", as grounds of a new kind of urbanity, giving space to spontaneity, social coexistence, activism, bottom-up decision making and self-awareness around the role of the metropolis citizen'.
>
> Gavriilidou & Ritou (2016)

In France, according to Rubino (2007), in the aftermath of WWII, the term *jardins ouvriers* (so called because they were aimed at the disadvantaged working class) was replaced by *jardins familiaux*, shifting the attention from the users to their social characteristics, hence the term 'family gardens' that is also widely used.

So far, the plant diversity of allotments has been little studied or appreciated, especially in the Mediterranean. A study of the vascular flora of 11 allotment gardens in Poznań, Poland, in 3105 individual plots created between 1924 and 1982, totalling 150ha in area showed that the total vascular flora was 358 species with individual estates having a range of 182–248. Of these, 257 were native species and 101 were anthropophytes (Borysiak & al. 2016). Comparable data are not available for any Mediterranean allotments.

Community gardens

Community gardens (Jardins communautaires, orti/ giardini comunitari) are a new type of urban garden that has arisen more recently in Mediterranean towns and cities, often as a response to economic crises that lead to food poverty. In Greece, for example, community gardens have appeared within a context of social protest movements (Morán &

Fernández de Casadevante 2014). They are organized collectively by a group of people using individual or shared plots on private or public land, sometimes illegally, and may in some cases receive support from local government agencies or NGOs.

Micro-gardening

In addition to urban domestic vegetable gardens and allotments, a wide range of small-scale often highly innovative and *ad hoc* ways of growing both vegetables, herbs and ornamental plants can be found in and around many Mediterranean towns and cities. This is sometimes known as 'micro-gardening' (Box 3). With support from an FAO project, Cairo residents have grown an estimated 6 000 sq m of micro-gardens on the city's rooftops (FAO 2010)

Box 3. Micro-gardening

'Micro-gardening' is the intensive cultivation of a wide range of vegetables, roots and tubers, and herbs in small spaces, such as balconies, patios and rooftops. While urban residents have long grown vegetables in backyard plots, modern micro-gardening makes use of containers such as plastic lined wooden crates, custom-built tables and even old car tyres. It integrates horticulture production techniques with environmentally friendly technologies suited to cities, such as rainwater harvesting and household waste management. Micro-gardens allow low-income families to meet their needs for vitamins, minerals and plant protein by providing direct access to fresh, nutritious vegetables every day. They also offer a source of extra income from the sale of small surpluses.

Source: http://www.fao.org/ag/agp/greenercities/en/microgardens/index.html

Fig. 8. Street scape, Ortigia, Siracuse, Italy (Photo V. H. Heywood).

Informal urban green spaces

Informal green spaces, such as wastelands or brown field sites and abandoned industrial sites, tend to be overlooked as a source of valuable biodiversity. Although they tend to be colonized by weeds, ruderal plants and invasive species, they may also house considerable numbers of native plants. Some Mediterranean cities, such as Montpellier, France, have developed wasteland valorisation plans whereby such sites are inventoried and efforts made raise awareness of their importance and potential to change the perception of these areas from abandoned to added-value zones, leading to the integration of the wastelands into the urban green network. Another unusual example is transformation of an urban salt works into a public park in the urban area of Cagliari, Sardinia, Italy, following the suspension of production because of pollution from urban sewage (Lai 2013).

Flilibeck & al. (2016) caution that Mediterranean urban wastelands that are 'saved' with the aim of creating public green spaces are particularly at risk of being managed inappropriately from an ecological perspective and cites the example of a disused demolition waste landfill in Rome (Italy) where natural revegetation led to a very high vascular plant species density (269 species in 0.2 km^2). However, when local activists successfully campaigned to save the site from development, resulting in its designation as an Urban Nature Reserve, it was basically managed as a conventional neighbourhood park and as consequence, the number of vascular plants decreased by 50%.

Green roofs and living walls

A recent development has been the widespread adoption of green roofs and living walls as part of the urban greening system. Although green roofs may also be used for growing herbs and vegetables, they are primarily aimed at providing environmental benefits such as cooling.

Fig. 9. Jardin Vertical Caixaforum, Madrid, Spain (Photo V. H. Heywood).

Alien Invasive plants

One of the common consequences of urbanization is an increase in the number and extent of non-native invasive species by creating areas of disturbed habitat for non-native species to become established. While this is partly a result of increased invasion events, it can also be a consequence of the use of known alien invasive species in urban horticulture, including green roofs and living walls. Great care should be taken in the choice of species for urban greening to avoid such invasive elements. The guidelines given in codes of conduct on IAS for horticulture and botanic gardens should be followed (Heywood & Brunel 2009; Heywood 2013).

Conclusions

The rapid growth of urbanization in the Mediterranean region has thrown into focus the need for improving the quality of life of urban dwellers by providing green spaces so that contact with nature is not lost. As a response, many Mediterranean cities are engaged in urban green infrastructure projects, preserving remnants of natural vegetation, creating new reserves, urban forests and parks, encouraging informal local food projects such as allotments and community gardens, and reclaiming wastelands. The diversity of plant life in and around Mediterranean urban areas is remarkably complex and varied and is of enormous economic, social and cultural value, although there is a general lack of data on the biodiversity growing in the parks, gardens, forests, and streets of Mediterranean towns and cities. Conservation biologists have tended to ignore the extraordinary richness of this resource and strenuous efforts are needed to inventory, evaluate, conserve and exploit it for the benefit of those who live in these urban and peri-urban areas.

Fig. 10. *Ipomoea indica*, invasive in Sóller, Mallorca, Spain (Photo V. H. Heywood).

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Notes:

[i] http://www.parks.it/parco.nazionale.cinque.terre/Econtatti.php

[ii] http://www.parcs-naturels-regionaux.fr/article/missions

[iii] Ley 4/1989, de 27 de marzo, de conservación de los espacios naturales y de la flora y fauna silvestre.". – Bol. Oficial del Estado **74:** 8262-8269. 1989-03-28.

[iv] http://www.parcomolentargius.it/

[v] http://www.parcomolentargius.it/

[vi] Présentation des parcs et jardins http://environnement.marseille.fr/presentation

[vii] http://www.interreg4c.eu/projects/project-details/index-project=60-periurban-parks-improving-environmental-conditions-in-suburban-areas&.html

[viii] Described as 'Linear and nuclear concentrations along the coast […] phenomena that are directly linked with intensive housing development, indiscriminate land occupation, and the possession of large reserves of land which it is possible to build on' in the conclusions of the International Congress, 'Sustainable Tourism in the Mediterranean: The Participation of Civil Society', 1998. MED Project ULIXES 21. For Sustainable Tourism in the Mediterranean.

[ix] http://environnement.marseille.fr/sites/default/files/contenu/environnement/PDF/guide-vegetalisation-des-rues.pdf

[x] Also often referred to as Urban and Periurban Agriculture (UPA) although peri-urban is normally understood to be included in Urban agriculture.

[xi] The socioeconomic role of the allotment has been described by the *Office International des Coins de Terre et des Jardins Familiaux*, the most important, European non-profit making union of national allotment and leisure garden federations with more than 2,000,000 affiliated leisure gardeners and leisure garden families, as:

- for the "community" a better quality of urban life through the reduction of noise, the binding of dust, the establishment of open green spaces in densely populated areas;
- for the "environment" the conservation of biotopes and the creation of linked biotopes;
- for "families" a meaningful leisure activity and the personal experience of sowing, growing, cultivating and harvesting healthy vegetables amidst high-rise buildings and the concrete jungle;
- for "children and adolescents" a place to play, communicate and to discover nature and its wonders;
- for "working people" relaxation from the stress of work;
- for the "unemployed" the feeling of being useful and not excluded as well as a supply of fresh vegetables at minimum cost;
- for "immigrant families" a possibility of communication and better integration in their host country;
- for "disabled persons" a place enabling them to participate in social life, to establish contacts and overcome loneliness;
- for "senior citizens" a place of communication with persons having the same interests as well as an opportunity of self-fulfillment during the period of retirement.