Briefing Paper 1:

The physical (peri)-urban forestry resource in Europe

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1. Introduction

1.1 Defining urban forestry

Over the past two decades, professionals and researchers from disciplines such as forestry, arboriculture, urban planning and design, landscape architecture and environmental management have contributed to the rapid development of urban forestry in Europe. Urban forestry is an interdisciplinary and integrative concept and Konijnendijk et al. (2006) highlight two widely accepted definitions of it. The Society of American Foresters sees it as 'the art, science and technology of managing trees and forest resources in and around urban community ecosystems for the physiological, sociological, economic, and aesthetic benefits trees provide society'.

More recently FAO have adopted the term 'Urban and Peri-Urban Forestry' (UPF), which sets urban forestry within a wider context of the urban green environment. UPF includes urban and peri-urban forest and other wooded land, as well as trees in parks, gardens, tree-lined streets and squares, undeveloped areas, transport and river corridors. This paper adopts both definitions but relies more heavily on the FAO concept of UPF, which is holistic and is linked to planning and design as well as to environmental science.

1.2 Three main types of location for UPF

Forest resources vary along the urban-rural gradient. The core areas of many major European cities are of medieval origin, where trees and parks rarely form a significant component, while the more modern city developments, have been planned and laid out with a structure of tree lined streets, formal squares and parks and woodlands have also often been incorporated into the newer urban landscape. This said, one urban forest element often leads into, is connected to or visually links with another to present an overall sense of a city-wide forest (Bell et al. 2005).

It has been suggested that the types of variety of locations in which trees can be found in (peri-)urban setting can be grouped into three main types (Randrup et al., 2005):

1. Trees in streets, squares, parking areas and other "grey spaces" with sealed surfaces.
2. Trees in parks and other green spaces such as yards, gardens, and commercial areas.
3. Stands of trees which are often referred to as "woodlands" or "woods" to distinguish between the wider urban forest resource and its components that have traditionally been defined as "forest".

The differences between the three types are not just in terms of where they are situated but Nilsson et al. (2001) highlight that there are also differences pertaining to:

- levels of planning and management hierarchy required
- stress experienced
- establishment techniques used
- average life times
- establishment and management costs.

Street trees, for example, are usually single trees with a low average lifetime due to a high stress level. Moreover, street trees generally involve the highest management costs. Park trees are also to be found individually or in small groups, with a medium or high average lifetime, medium stress level, and medium costs for establishment and management. Urban woodland trees are usually established in stands by means of seeding or planting of small trees, with a high average lifetime, low establishment cost, and relatively low management costs.

1.3 Purpose of this paper

The original purpose of this paper was to report on the structure, composition and quantity of the UPF resource in Europe. However, the ambitions of the authors have been frustrated by the lack of relevant empirical data at national and European level. The findings reported herein on the characteristics of the UPF resource in Europe, should, therefore, be interpreted with caution and be recognised as being based on partial and fragmented evidence. The main thrust of the paper is on information and data requirements and on the threats and constraints on UPF.

2. Characteristics of UPF resources in Europe

2.1 Trees in Streets and other paved areas

Trees in streets and other urban sites with sealed surfaces are an important component of UPF resources, as well as an important architectural element in the cityscape where they ameliorate aesthetic, social, and microclimatic conditions, as discussed in the briefing paper on the societal benefits of UPF. In many European cities the “web” of trees along streets, squares, etc. weaves through the city, creating ecological corridors and visual links between parks, woodlands and other open spaces. In the historical or commercial core of larger cities, streets and parking areas are often the only location available for trees.

Streets and other paved urban areas with sealed surfaces are generally complex stressed environments for tree growth, making trees vulnerable to diseases and attacks from pests as discussed in section 7 of this paper on the threats to the UPF resource..

2.2 Trees in parks and other green spaces

Parks, gardens and other urban spaces dominated by vegetation often contain a considerable number of trees, but actual forest stands are often limited or absent. Rather, trees are used to provide ornamental value as well as mass and structure and to define the character and scale of space. Many parks, gardens, cemeteries etc. are characterised by a large variety of native and exotic tree and shrub species used because of their ornamental value. The Trees in Towns II, national survey in England showed that species diversity is especially rich in residential areas and is lowest in commercial premises (Britt and Johnston, 2008).

Beautification has traditionally been one of the main arguments for greening cities with the addition of parks, gardens and other types of green spaces (Tyrväinen et al. 2005, Konijnendijk 2008). Yet, as evidence has mounted about the multiple functions urban green spaces provide, their design and management has gradually shifted to also reflect the environmental, conservation and economic benefits that they can provide (as discussed in the briefing paper on benefits), with the aim to develop functioning ecosystems as well as settings for cultural and social activity (Bell et al., 2005, Gustavsson et al., 2005).

Recognising the interconnection of natural resources and human resources, parks and other green spaces have become essential within the concept of sustainable urban ecosystems. This has resulted in a more restricted use of exotic species, which for centuries have been a predominant element in park design due to their ornamental value. The strength of the political discourses of sustainability and biodiversity conservation have resulted in the design and management of urban parks and woodlands increasingly being carried out as part of restoration programs which either concentrate on ecosystems functions or cultural history, or both (e.g. Gobster, 2007). One example is the *Isar Plan*, where the strongly regulated Isar river course in the inner-city of Munich, Germany has been redesigned as part of a program that combines flood protection with the restoration of a near-natural river bank forest landscape and the facilitation of nature-oriented leisure and recreational use by the urban population in the river bank zone (European Urban Knowledge Network 2010).

2.3 Urban and peri-urban woodlands

Urban and peri-urban woodlands are managed for a variety of purposes. Originally, provision of timber and fuel wood was the main reasons for cities and towns to own and manage forests, but this function is presently only of secondary importance

(Konijnendijk, 2008). Recreation and nature protection are typically the main functionalities of urban woodlands today (Bell et al., 2005, Tyrväinen et al., 2005).

Previously commercial production plantations in urban and peri-urban areas have developed over time. They mainly consist of even-aged monoculture types with interiors resembling the 'pillared hall'. However, canopy trees, undergrowth and the main characteristics of the ground flora are all of importance for biodiversity and help define the scale, character and atmosphere of the place for human experiences of forest interiors (Gustavsson et al., 2005). From a silvicultural perspective, the importance of urban woodlands has been widely overlooked for years, although city authorities throughout Europe are increasingly applying a variety of management techniques to achieve different structures of vegetation and atmospheres within individual woodlands as well as across woodland areas (Gundersen et al., 2005, Nielsen et al., 2010).

Compared to commercial forests where the management regime is aimed at wood production, and where the stand is the functional unit, the higher functional level – i.e. the woodland landscape – is of equal importance when it comes to developing recreational and ecological functionalities in urban woodlands (Gustavsson et al., 2005). Variation between wooded areas and open habitats and recreational areas is a common characteristic for many of the most appreciated and well-known urban woodland landscapes in Europe, such as Amsterdamse Bos, the Netherlands, Helsinki's Central Park, Finland, and Jægersborg Deer Garden, north of Copenhagen, Denmark. The mosaic of interiors under closed canopies, intimate glades and canopy openings, semi-open savannah-like areas with scattered trees, open spaces of varying size and type and a diversity of edges along the boundary of forested and open parts are mutually supportive for multi-purpose uses (Bell et al., 2005), while they also create habitat diversity, something which is of the utmost importance for biodiversity conservation.

2.3.1 Urban growth and woodland fragmentation

When talking about urban woodlands most people think of the long-established and well known recreational woodland landscapes such as Belvoir Park Forest in Belfast, Djurgården in Stockholm, Grunewald in Berlin, Bois de Boulogne in Paris, and the Amsterdamse Bos in Amsterdam. These areas however, only account for a limited share of the woodland resource in and around European cities. As urban structures have grown, so too has the area of woodland that has been integrated into the urban matrix. Urbanisation has, in many cases, led to the fragmentation of woodlands into more or less isolated patches of varying size, ranging from small wooded lots to large woodland landscapes.

However, despite this phenomena, management methods are seldom differentiated between woodlands of different size and silvicultural systems designed for large woods generally prevail. Therefore, professionals, as well as researchers may need to reconsider management methods for small woodlands (Gundersen et al., 2005).

3. State of knowledge on UPF resources in Europe

3.1 How much do we know?

The starting point for any resource management is a basic understanding of the resource being managed and some idea of the outcomes that stakeholders seek, expressed as management objectives. In forestry this requires firstly an inventory with a data collection framework that informs decision-making relevant to the intended objectives and, secondly, allows changes to be measured, monitoring and evaluation to be undertaken and management to be adapted as changes are identified.

There is little data on the composition and characteristics of urban forests available at national or European levels. There are, on the other hand, many examples of high quality municipal urban forest working plans and a number of larger cities and municipalities have well developed inventory and management systems for trees in public spaces (although conversely, many do not). However, even where such plans, systems and inventories exist, trees in private or commercial spaces such as gardens and business premises are rarely included despite the fact that they represent a significant proportion of the urban tree population. Although it is difficult to control how trees on private land are used and managed, urban foresters are becoming increasingly aware of the need to include them in inventories of the complete urban forest resource.

The scientific literature contains a multitude of locationally specific studies on different aspects of urban forestry which are important supplements to inventories by national and local authorities. However, this research is still fragmented and does not yet constitute a coherent evidence base sufficient to support a rigorous overview of the UPF resource and a related strategic approach at the transnational or pan-European level. Thus, whilst there is an extensive planning literature and there are excellent inventory systems being applied to urban green space at a European level, integrative and harmonised inventory systems for the UPF resource are lacking.

Possibly the sole exception to the deficit in comprehensive data on UPF at a national level is the *Trees in Towns II* (TTII) national survey of England (Britt and Johnston, 2008), a government study which explores in depth the entire urban forest resource across the country, including woodlands as well as trees outside woodlands, and including both public and privately owned land. It is highly detailed, reporting on numerous aspects of the national resource, including numbers and densities of trees, location, species composition, sizes, canopy cover, age and maturity and trees condition. This survey also builds on a previous study, *Trees in Towns*, published in 1993, and as such is able to give some indication of trends through comparison.

Urban forestry practice in Europe is highly advanced. Trees and woodlands can be established on the most difficult sites and managed to meet a wide range of purposes. Whether the aim is economic regeneration, extensive land reclamation or social inclusion in a small community the skills to deliver these aims are readily available. However, the adaptation of data collection and inventory systems in the component disciplines has not kept pace. Furthermore, there has been little integration of data collection and inventory systems across disciplines and across organisations at different levels, from the local to the national.

3.2 National Forest Inventories

In 1997, the European Commission reported on forest inventory processes in Europe. Following this, members of the European National Forest Inventory Network

(ENFIN) established COST Action E43, *Harmonisation of Forest Inventories Europe: Techniques for common reporting.* 37 countries participated, 27 from Europe. Of the 37 countries reporting on their National Forest Inventory (NFI) processes only two, the UK and Ireland, indicated that they specifically identify and sample trees on urban land (Tomppo et al., 2010).

Most countries have 'other land' categories that might be expected to include urban trees. However, a common approach is to sample only those areas that exceed a specific minimum size and carry species that have a minimum height (usually 5m) when mature. The most commonly used approach is that of the United Nations Economic Commission for Europe/FAO (UNECE/FAO, 1997) where 'forest land' is categorised as exceeding 0.5 ha in extent with a canopy cover of at least 10% of species exceeding 5m on maturity. 'Other land' is categorised as 0.5 ha minimum area, 5 – 10% crown cover of tree species or at least 10% shrub coverage. Whilst some countries use different filters, for example Luxembourg and Latvia include areas down to 0.1 ha, the overall result is that a significant part of the UPF resource is unrecorded. This applies especially to single trees.

3.3 Factors contributing to the lack of available data

The lack of data available on UPF at the national level has partly been the result of the different levels of planning and management hierarchy as well as the variety of agencies and owner structures related to the urban tree resource.

Another contributing factor is that despite its importance to the urban environment, UPF is at present largely overlooked in international forestry processes. This impacts at the national level so that national forest programmes in Europe, which share a common root in the UNCED 1992 Proposals for Action, make little or no mention of UPF (Humphreys, 2004), (Gislerud and Neven, 2002)

Another reason for the lack of national level data is because the definitions, terminology and the practices used in national forest inventories are not yet adapted to meet the information needs of urban forestry (perhaps partly as a result of weak political support).

The lack of empirical data at a scale larger than city or city-region extends not only to inventory but also to the products and services delivered by UPF. Unless this is addressed, so that these attributes are identified and measured, Europe will lose the opportunity to maximise the benefits of UPF. The discipline will have continuing difficulty competing with urban land uses where such quantitative data is readily available.

3.4 How do we move forward?

We suggest that the lack of information and development of harmonised inventory methods could be addressed through minor changes to existing data collection systems. Recommendations and guidance on this would be a valuable output from the workshop to which this paper contributes.

There is scope for the European Commission to encourage and assist the scientific community to identify the key research questions and research themes and to develop a common European terminology. The lack of uniform standards and protocols has been recognised by the International Union of Forest Research Organizations (IUFRO) and by the Food and Agriculture Organization (FAO) of the United Nations, both of whom have processes currently underway to examine the issues.

Although division 4 of IUFRO on *Forest Assessment, Modelling and Management*, is not actively pursuing inventory of UPF, the Urban Forestry research group is currently developing Urban Forestry Data Standards. We suggest that there is an opportunity at the EU level, in collaboration with IUFRO, to revisit NFI guidance to include procedures for assessing the scale and nature of the UPF resource.

We also suggest that the TTII survey is a major advance and that the techniques and methods applied in undertaking the survey could be adapted to meet the needs of UPF inventory in other European countries.

Within Europe the European Environment Agency's (EEA) *CORINE* land-cover data has a 'green urban' category that provides useful information, especially on designations, but not at the level (1:100,000) of detail or with the categories required for UPF resource management. If the opportunity arises to include UPF data in future *CORINE* exercises then this would be a valuable addition.

FAO is concerned to develop systematic approaches in UPF in developing countries. However, their guidance on National Forest Monitoring and Assessment (NFMA) http://www.fao.org/forestry/nfma/en/ (FAO, 2008) is silent on recording the UPF resource, indicating a possibility for their participation in any EU/IUFRO collaboration. FAO have recognised the problem of poor data and recently wrote to countries asking for assistance in identifying sources of data on trees outside forests (TOF). The FAO Global Forest Resources Assessment (FRA) 2010 is preparing a thematic report on TOF to be available for the next FRA expert consultation meeting in August 2011. FAO reports that the Institut de Recherche et Développement (IRD) is assisting FAO in preparing the report, in collaboration with other partner institutions including inter alia ICRAF and CATIE. The report will be ready by April 2011. It is also noteworthy that researchers in the US have undertaken extensive UPF inventories and their expertise should not be overlooked.

Modern ICT and remote sensing technologies also mean that these gaps in data should be less difficult to fill than has historically been the case. Furthermore, we suggest that comparative assessments of city-level urban tree data bases would be one approach towards developing empirical data at a scale larger than city or city-region.

The US Department of Agriculture has developed a software suite called i-tree which allows for not only analysis of urban forestry resources but also for benefits assessment and can link urban forest management activities with environmental quality and community value. Pilot work on adapting and applying the system is currently ongoing in the UK and this may prove a valuable tool for use across other countries in Europe.

4. Geographical differences in the provision of UPF in Europe

As already discussed, there is little systematic, robust evidence available on the provision of UPF across Europe. However, in terms of urban woodland specifically, in a review of developments in urban forestry in Europe, Konijnendijk (2003) concluded that the evidence available, although limited, indicated that in the more urbanised areas of Western Europe the percentage of total woodland cover which is assessed as urban woodland is considerably higher than the share attributed to urban areas in the Nordic and Central European countries. Field testing would be needed to assess whether this difference is an artefact of different systems of data classification or actually reflects differences in levels of canopy cover.

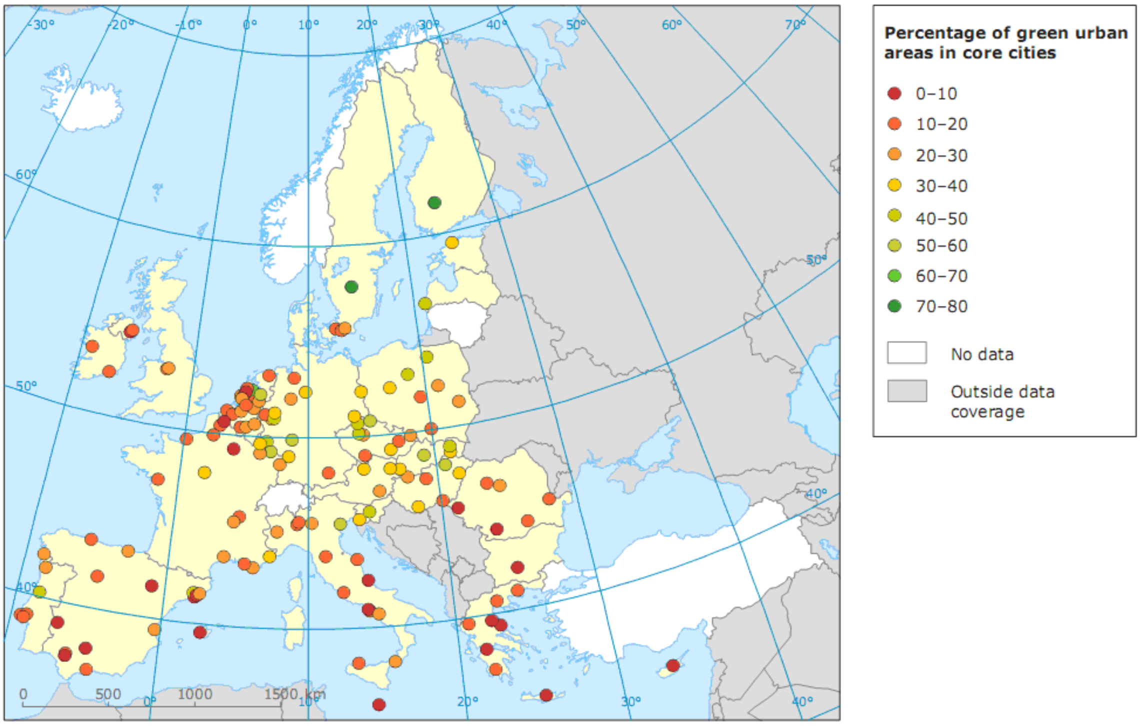
City administrations often have a good overview of their woodlands in terms of information about size, while more comprehensive overviews at national or international level are generally missing (Pauleit et al., 2005). A noticeable exception is a comparative study of the size distribution of woodlands situated within and in direct contact with the borders of cities in 18 municipalities in the forest poor Denmark, (harbouring 33 % of the Danish population) and in 30 larger cities in the forest dominated Sweden (harbouring 31 % of the Swedish population) (Nielsen et al., 2010). Based on this study it has been estimated that wooded lots of only 0.5 to 1.9 ha in size constitute more than half of all urban and urban fringe woodlands in Sweden (54,7 %), and more than three out of four woods are less than 5 ha in size (76,1 %), the average woodland size being 6.9 ha (Nielsen et al., 2010). In comparison, wooded lots of 0.5 to 2 and 2-5 ha jointly constitute one third of the urban and urban fringe woodland resource in Denmark (33.1 %), the average woodland being 23.3 ha in size.

The woodland size distribution in Denmark is likely to reflect the situation in other forest poor countries in North-west Europe, such as Holland, England, Ireland and Belgium. Likewise, other North and East European countries with high forest cover, such as Norway, Finland, Estonia and Slovenia are likely to experience a more similar scenario to that demonstrated by Sweden. This assumption is supported by studies of urban woodland size distribution elsewhere. For example, a study in London, England found that 40% of urban woodland was between 2 to 5 ha in size (wooded lots less than 2 ha were not included in the statistics) (Harrison et al., 1995). Similarly, a study in Ljubljana, Slovenia found that 79 % of urban woodland patches were between 1-5 ha in size (Pinat, 2005).

Furthermore, surveys also exist which examine greenspace cover in particular cities and towns across the continent, although these are often not reliable or comparable. For example, some surveys are based on administrative units which may be largely urban but which may also include areas of countryside, while others do not make it clear the types of green area that have been included (Konijnendijk, 2003). Pauleit et al. (2005) discuss two studies by the EEA (one from 1999 and one from 2002), both of which examined green space cover in European urban areas. These studies show that greenspace cover varies dramatically across the continent. For example, the 1999 study found that the total amount of greenspace in European areas can range from as little as 4% in Athens to as much as 53% in Budapest (EEA, 1999 cited in Pauleit et al., 2005: 52). Map 1 below illustrates more recent findings from the EEA (2010), which again demonstrate that the share of green urban areas in cities varies considerably across Europe but, in addition, provides evidence that a lower share of public green areas is more common in Southern and Western European cities.

Map 1: Share of green urban areas in European cities, 2006

Source: EEA, 2010



Note: The term ‘core city’ refers to the administrative city defined in the Urban Audit (http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/city_urban/)

Pauleit et al. (2005: 52) cite the first Environmental Assessment for Europe in the 1990s which found that in most European cities, more than half of the population live within fifteen minutes walking distance to greenspace (this was used as an indicator of environmental quality). More recently, the Urban Ecosystem Europe Report (Bono et al., 2006) used surveys to determine the sustainability of cities in Europe against a selection of indicators. Some of its findings are illustrated below in figures 1 and 2. The report’s analysis of greenspace utilised two categories, parks and other greenspace. Whilst this study cannot be used as a UPF measure, it illustrates, nevertheless, an inverse correlation between the size of an urban area and the proportion of greenspace; big towns tend to have less green area relative to the built area (Bono et al., 2006).

Figure 1: Area of parks and gardens per inhabitant (m^2).

Source: Bono et al., 2006

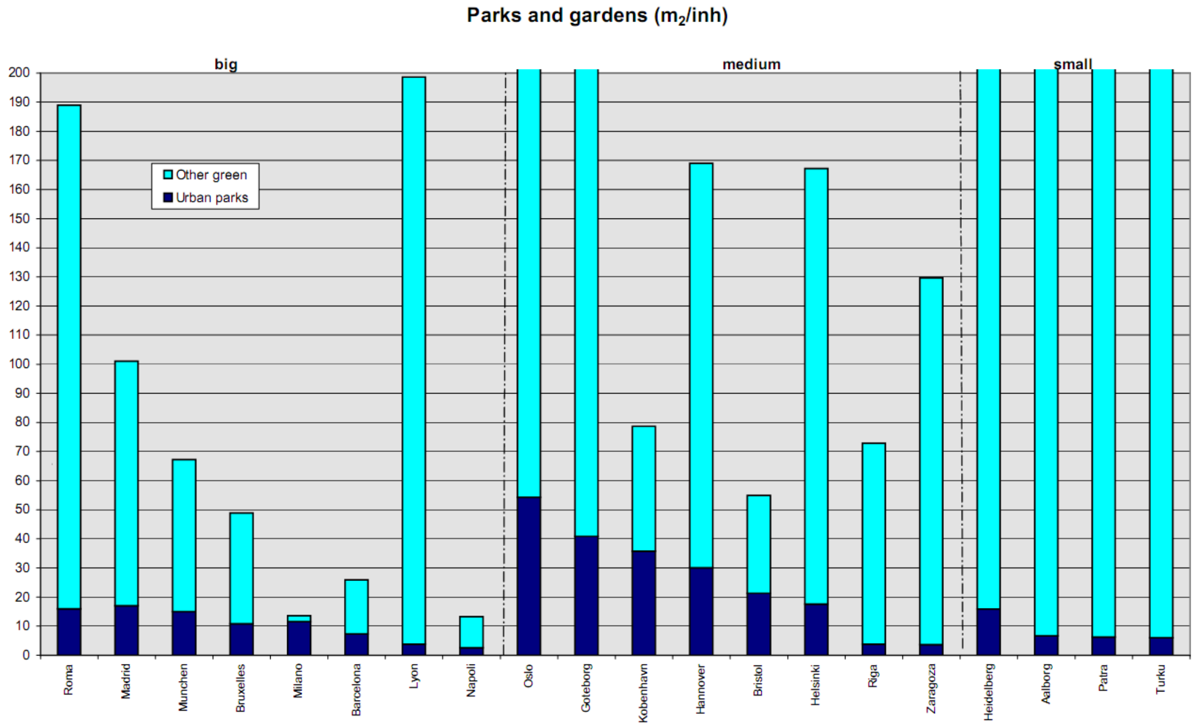
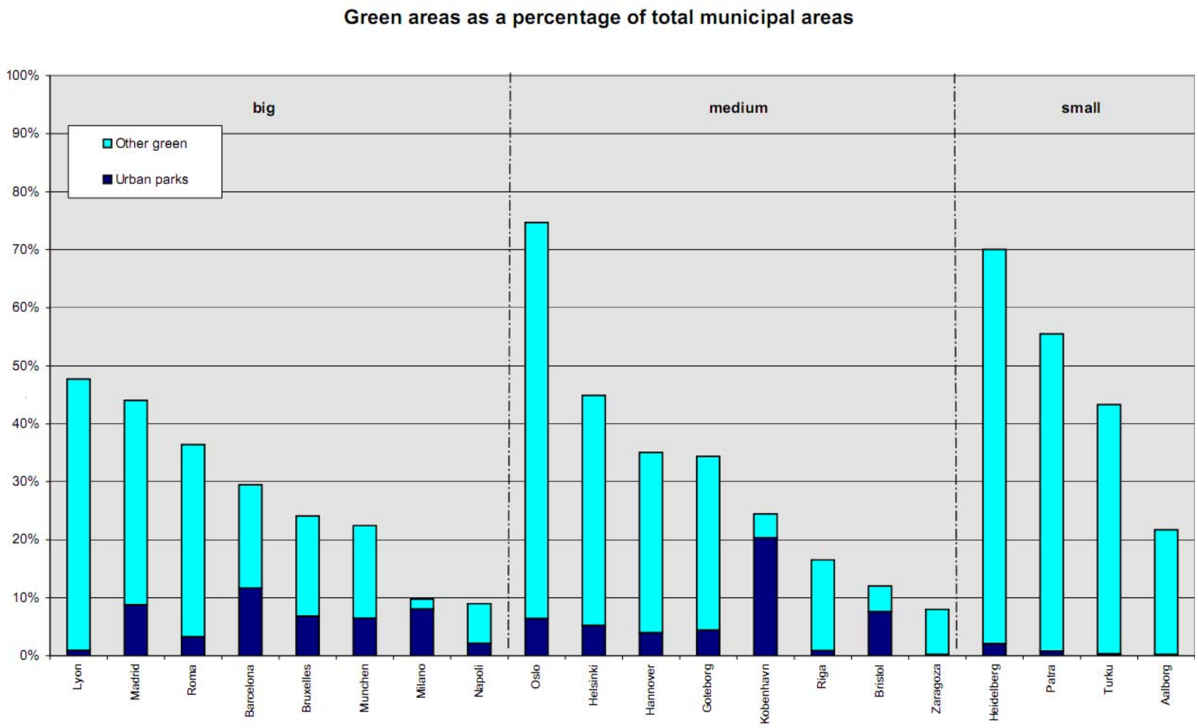


Figure 2: Green areas as a percentage of total municipal area.

Source: Bono et al., 2006



5. Geographical differences in the make-up of the UPF resource in Europe

The lack of inventory data makes quantitative analysis of geographical differences in UPF in Europe impossible. Clearly within Europe there are differences in species make-up in forests in different climatic and edaphic zones. There are indications that this is reflected in UPF resources although Pauleit et al. (2005: 54) argue that the selection of urban tree species also varies considerably as a result of local planting policies.

A study (Woodall et al., 2010) in the US indicated that 42% of urban trees matched the top ten forest-land trees in their surrounding hinterland. 30–50% of the tree species representing the majority of tree biomass in the cities studied could be found in surrounding forestland. The remaining tree species were either 'purely ornamentals' or infrequent native tree species. Over 75% of the native tree species in cities were within the latitudinal range of their respective forestland range. Only a few (native) tree species in urban areas were found to be north of their forestland ranges. From this study (Woodall et al., 2010), which gives some valuable insights on native species in UPF, we can deduce that non-native ornamental trees comprise about 50% of the 'tree biomass' in these US cities.

Few similar studies have been found in relation to European cities, although it would be possible to extract information on native and non-native species from the data gathered for the TTII survey (Britt and Johnston, 2008) on urban forest resources in England. In respect to species composition in general, the TTII survey found that large broadleaved tree species comprise around 31% of all urban trees in England, small broadleaved trees account for 42% and conifers made up 27% of the total, with the dominant species being Leyland cypress (*x Cuprocyparis leylandii*).

Beyond this, a survey of European tree selection and establishment practice demonstrated that, in general, Northern European cities, in comparison with those in Central and North-West Europe, have a low diversity of tree species and genera because of the prevailing harsh climatic conditions in this region and due to a 'traditionally narrow choice of species' (Pauleit et al., 2005: 54). However, although overall there is a broad selection of species in Central and North-Western European cities, at least 50% of street trees usually belong to between three and five genera (Pauleit et al., 2005: 54).

Another study (Attorre et al., 2000 cited in Pauleit et al., 2005: 55) explored the change in species composition of street trees in Rome over 100 years and found that there was a trend towards smaller tree species, a trend which Pauleit et al. (2005: 55) argue is likely to also be evident in other European regions.

6. Threats to the UPF resource

6.1 Climate change

The single biggest uncertainty identified in the literature is the impact of climate change on existing urban trees, both through increased damaging incidents such as drought or storm and also by chronic effects. This raises questions of how managers might respond with new species and different management regimes.

Urban areas are usually considerably warmer than rural areas, can be relatively more humid and as a result suffer the impacts of what has been termed the 'urban heat island effect'. Observations that cities tend to be warmer than rural areas began to be recorded around two hundred years ago by weather watchers and the existence of the urban heat island effect is now a recognised phenomenon (Arnfield, 2003; Bornstein, 1968; Chen and Jim, 2008: 57; Oke, 1982). It is caused by heat radiated by buildings, from sealed surfaces and from heat produced by vehicles and air conditioning, for example. This effect can make urban areas hotter during the day in summer but it means cities may also retain heat at night, making it uncomfortable to live there, although it also reduces the effect of cold winters.

It is likely that if climate change will lead to increased ambient temperatures in urban areas and this will mean that the urban heat island effect will grow, leading to increased thermal stress and drought problems for urban and peri-urban trees. This will have impacts on species suitability and choice. Roloff et al. (2009) have developed a Climate-Species-Matrix for the Central European region. The matrix contains 250 woody species used in Central European green spaces. Based on drought tolerance and winter robustness each species is assessed and classified with regards to usability after predicted changes in climate.

Another problem relates to air quality. The 2006 Urban Ecosystem Europe Survey (Bono et al., 2006) found that only 3 out of 26 EU cities surveyed complied with EU air-quality standards. Urban transport was the greatest contributing factor to poor air quality, and as high temperatures intensify the problem, Southern cities showed significantly lower air quality levels. Ozone and oxides of nitrogen, typical of transport-derived gaseous pollution, significantly affect the growth of trees.

6.2 Pests and Diseases

In addition to NFIs a further inventory process undertaken by most countries is a survey of forest and tree health. Again, similar categorisations to those used in NFIs make it impossible to identify data that is specific to UPF.

If this lack of data is an indication that the health of UPF is not being assessed then we believe that it represents a significant risk to forestry in Europe. Howe (2007) highlighted the problem, noting that an increasing proportion of horticultural material is grown in Asian countries and imported in to the EU and that although 'The urban interface is the most likely first point of contact between new pests and suitable host', 'this 'jumping off' point currently receives scant attention in relation to bio-security issues'.

The risk of pests and diseases affecting UPF is amplified by three factors:

1. Lack of genetic diversity
2. Global trade in horticultural and forest products
3. Climate change

6.2.1 Lack of genetic diversity

Laćan and McBride (2008) attempted to model the risk of mass mortality of trees and shrubs from insects and disease, based on two case studies of Northern Californian cities. A particular risk they identified was a tendency for a small number of tree species to predominate in any particular location e.g. *Ulmus* and *Fraxinus spp*. in the US Midwest that suffered wide-scale mortality from single pathogens.

Whilst there is some evidence that a significant proportion of UPF species are likely to reflect the locally indigenous vegetation (e.g. 50% found in Woodall et al., 2010 study in the USA discussed above) this still leaves a large proportion of species that are derived from distant areas. Also, the proportion of cloned material or material collected from plants with a very narrow genetic origin is not known, or is not reported in current academic writing. Such material is at a higher risk of catastrophic attack by pathogens.

6.2.2 Global trade in horticulture and forest products

Responsibility for regulating horticulture often lies in institutions different to those responsible for forestry. The trade includes not only plants but also soil and is a known source of forest pathogens e.g. phytophthora spp. affecting oak, alder, rhododendron, larch and other tree species in European countries.

6.2.3 Climate change

As discussed above, if the heat island effect intensifies as a result of climate change, the increased stress that this will cause to many urban trees is also a factor in increased susceptibility to pathogens, whilst the higher ambient temperature also has implications for the viability of pathogens, for example allowing southern tree-pests carried on transport or in horticultural products to survive in northern cities.

6.2.4 Current experiences of these factors

An illustration of the potential damage that can arise from a reliance on trees from a narrow genetic origin is given by Dutch Elm Disease which destroyed a large proportion of the Elm population of Northern Europe. The Elm populations that suffered greatest losses were those that are thought to have been propagated in pre-historic times by vegetative reproduction. Drawing on this experience, a growing number of experts emphasise the need for a broad range of species to be used to ensure the resilience of the urban tree stock against reoccurring outbreaks of disease (Tello et al., 2005; Bassuk et al., 2009).

The possibility of diseases and pests extending their ranges, either because of climate change or as a result of increased global movement of pathogens, is not a hypothetical risk but is currently being experienced in Europe on a large scale. Pests and diseases are moving into areas where resistance among host organisms is low and natural biological controls do not yet exist, leading to extensive damage.

For example, Forest Research (2010a) report that in the UK, Horse Chestnuts (Aesculus hippocastanum) are being attacked both by an invertebrate pest, the Horse Chestnut Leaf Miner, Cameraria ohridella, and a fungal pathogen causing stem bleeding, commonly known as bleeding canker, that were previously unreported.

The Horse Chestnut Leaf Miner was first observed in Macedonia in northern Greece in the late 1970's. In 1989, it appeared unexpectedly in Austria and has since spread throughout central and eastern Europe. It is currently spreading west through France and south through Italy. It was first found established in the UK in the London Borough of Wimbledon in July 2002. From this initial area of infestation, the moth has spread rapidly, and it is now present across most of south-central England, East Anglia and the Midlands.Over the past four or five years, the number of reports of Horse Chestnut trees with 'bleeding cankers' has increased markedly. The increased incidence of stem bleeding on Horse Chestnut is not just limited to the UK; the Netherlands, Belgium, France and Germany are also experiencing a similar upsurge. Whilst stem bleeding has previously been associated with Phytophthora spp. closer investigation of the bleeding cankers on Horse Chestnut has revealed that it is no longer the primary causal agent. Instead a completely different pathogen, Pseudomonas syringae pv aesculi, is responsible for the increase in these symptoms appearing on Horse Chestnut.

7. Constraints on UPF

Different in nature to such climatic and biological threats are a range of institutional and structural issues. For example, in the TTII survey on urban forest resources in England included a SWOT (strengths, weaknesses, opportunities, threats) analysis Britt and Johnston (2008: 303-316). Local authority tree-related officers, who are responsible for the management of a significant element of the UPF resource in England, were asked to list the five main strengths, weaknesses, opportunities and threats that they felt faced the urban forest and its management. This detailed analysis provides a fascinating insight into the challenges facing urban forest managers in England and many of the factors identified may well be typical to numerous other European countries. Constraints identified included:

- Lack of funding and resources
- Limited staff numbers
- Poor treescape quality
- Lack of data, records and surveys on the resource
- No tree strategy or weak strategy
- Lack of protective/planned tree programme
- Lack of political support
- Poor public support and awareness or negative perceptions
- Poor standards of management
- Lack of integrated management with the local authority and professional barriers impeding cross-disciplinary approaches

Other constraints may include:

- Ownership structures impacting on the capacity of managers to take action

- Removal of large trees and replacement with small ornamentals, for safety reasons
- Methodological weakness that impedes cost-benefit analysis
- Loss of land to development
- Damage from utility operators
- Vandalism

In many cases the authors suggest that the answer to these problems is a stronger evidence-base that would allow the value of UPF to be assessed within local and regional decision-making structures.

Since UPF is already overlooked in much forestry policy, there is a danger of it being also neglected in planning and environmental policy. To further political and policy backing for UPF, we believe that framing or aligning UPF research to the concept of green networks (or green structure/infrastructure as it sometimes termed) may also be beneficial. Green networks and infrastructure 'refers to the combined structure, position, connectivity and types of green spaces which together enable delivery of multiple benefits as goods and services' and which help combat habitat fragmentation (Forest Research, 2010b: 4). It should be considered 'holistically and at landscape as well as individual site scale' (Forest Research, 2010b: 4). The concept is growing in prominence across Europe and has been widely adopted in the language of urban planning and design. The fact that UPF is a means of creating green networks/infrastrucure links it directly to environmental discourses in urban planning and the concept could therefore be used to help demonstrate the relevance of UPF to wider environmental and urban planning policy.

8. Conclusions

8.1 Moving ahead with UPF resources

In the field of UPF Europe has professional and research skills in abundance and there are numerous examples where these skills have been applied to great effect. It has not been our aim to give a commentary on professional practice but rather to explore what is known about the European UPF resource and the main threats, constraints and challenges facing that resource. We have highlighted the fact that the management of UPF in Europe is hindered by a lack of good quality empirical data, by the need to develop common approaches to evaluation and to make methodological advances in cost-benefit analysis. These ambitions can be achieved through fairly minor amendments to existing processes and systems and this would help to ensure that UPF can contribute more fully to the wellbeing of Europeans and the sustainability not only of the urban environment but also the wider environment that is so strongly impacted by urban activities.

8.2 Evidence needs

Our overview has described the variety of circumstances that urban and peri-urban trees relate to and at the same time, has highlighted the lack of empirical data available on UPF resources beyond the city or city-region level. With a recognition of the need to respect and incorporate the rich diversity of climate, ecology, tradition and cultural heritage contained in, or experienced by the exiting resource across Europe, we draw attention to the following evidence needs:

8.2.1 Inventory and data

1. With current levels of empirical data on UPF resources across Europe being so poor, it is challenging to make transnational or pan-European overviews. More comparative studies that go beyond the city or city-region level are needed on the quantity, structure, composition and state of UPF resources. This in turn rests on the development of:

2. Common approaches to data collection and standards of measurement and evaluation within countries and across national boundaries. This will require a comprehensive overview to be undertaken of the types of data collected and existing and potential inventory systems. It also requires that:

3. Common definitions are used in data-gathering processes such as NFIs and *CORINE,* and that:

4. UPF resources are accounted for specifically in NFIs and related forest and tree health surveys.

5. More attention should be given to trees in non-public spaces such as private gardens and business premises.

6. Greater consideration should be given to small-scale sivilcultural systems.

8.2.2 Benefit valuation

1. At a strategic level and linking strongly with the conclusions of the briefing paper on the benefits of UPF, there is a need for common approaches to identification, quantification and valuation of the benefits or ecosystem services provided by UPF. This would allow cost benefit analysis to be undertaken and inform wider resource management, helping to provide backing and garner support for UPF initiatives and help to overcome many of the constraints facing the resource currently.

8.2.3 Risk Management

1. More needs to be understood about the implications of climate change for UPF, covering species choice, effects on existing resources and likelihood of catastrophic environmental events.

2. More research is needed to explore the risks posed by pests and diseases, covering institutional issues that impact on effective national-level control and regulation, levels of risk, implications of climate change, remedial measures and cost-benefit assessments.

3. There is a lack of understanding about the genetic make-up of UPF species, more knowledge of which would help us to determine the level of risk posed by pests and diseases. This links to the inventory related evidence needs above.

8.2.4 Cross Disciplinary

1. There is a need for landscape scale identification of opportunities for expansion and integration of UPF within new urban development

2. Integrative processes are required which give a profile to UPF in urban planning and design for a e.g. METREX

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