Tree Diversity

A Guide to achieving tree diversity in urban tree populations

Barcham
The Tree Specialists

Don't always believe what you see. Take a closer look at the windows.

Introduction

At the time of writing there is an increasing appreciation of the benefits trees provide, especially in the urban environment. It is generally accepted that more trees need to be planted. Ambitious numeric targets for tree planting coupled with equally ambitious targets to increase canopy cover by a certain number of percentage points emerge on an almost daily basis.

Such initiatives at both local and national level are to be welcomed and, some would argue, long overdue. Yet, more often than not, there is a lack of any evidence base to support the achievability of such targets. The question, 'what have we got' remains largely unanswered and the question, 'where do we want to be', rarely asked or defined in any sort of long-term strategic management plan for the urban forests of the UK.

It is true that urban tree populations, at a time when more planting is being encouraged, face increasing pressures the most notable being the accelerated introduction of imported pest and or disease and the affects of climate change on urban environments both now and into the future.

The purpose of this manual is to introduce readers, where necessary, to the concept of resilience to these and other challenges through planned and managed diversity within urban tree populations.

A widely accepted framework for urban forest management involves four stages. These are:

- What have we got?
- What do we want?
- How do we get there?
- How do we know whether we are succeeding?

This manual will use the above questions as headings to examine the question and hopefully provide suggestions and answers as to how resilience through diversity might be achieved through strategic management.

The manual will draw on research, commentary and the personal experience of the author. It is not intended to be a complete academic work but more as a guide to the subject. Full references where appropriate are included as well as sources of further information where considered useful.

I hope you the reader will find its contents useful.

Keith

Keith Sacre

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Poste Centrale
Thiers (souterrain)

Magnificent Oriental Plane photographed in Brive, France.

1.0

Diversity

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1.0 Tree Diversity

Why is diversity in our tree populations so important, what does diversity mean and how can such diversity be achieved? It is the purpose of this manual to attempt to provide some answers to these questions.

DIVERSITY = RESILIENCE = SUSTAINABLE URBAN FOREST
A commonly agreed position........

When considering sustainable urban forest management, maintenance, and development there are again commonly agreed elements which constitute a diversely populated urban forest.

- **Diversity of species**.
- **Diversity of age.**
- **Diversity of size.**
- **Diversity of genetics.**
- **Diversity of public good.**

Diversity of Species

This refers to the proportions of any given family, genus, species, and cultivar which make up the tree population in its entirety.

Diversity of Age

While size and age are inextricably linked with many species it is not a generic truth. For example, an old, Field Maple (Acer campestre) will not necessarily be as large as a Tulip Tree (Liriodendron tulipifera) of the same age but may be significantly old for its species. Age is associated with increased biodiversity with many flora and fauna building relationships with trees as they get older.

Diversity of Size

The link between tree size and the public goods delivered is widely accepted and can be represented graphically as shown in this diagram (right). Smaller trees provide many public goods and ecosystem service benefits but the larger the tree the larger the biomass available and the greater the potential.

Tree Diversity

Diversity of Genetics

There is very little in the literature which deals adequately with the question of genetic diversity within tree populations. Certainly, in the urban environment many of the more successful tree species are in fact clonal selections which have been propagated vegetatively either through cuttings or budding. The consequence is that all these selections are genetically identical. Only trees raised directly from seed can display genetic variation. The consequence of clonal selection is that being genetically identical they are equally, universally, vulnerable to stresses and strains all be it from climate change, pest and disease or other threats.

Pyrus calleryana Chanticleer here seen lined out on the nursery is an excellent urban tree and is widely used. However, all the trees are genetically identical. This is not to say that the tree should not be planted but an awareness of its vulnerability should be acknowledged.

Diversity of public good

Six public goods have been identified and outlined by the UK Government, at the time of writing.

- Clean and plentiful water.
- Clean air.
- Thriving plants and wildlife.
- Reduction in and protection from environmental hazards.
- Adaption to and mitigation of climate change.
- Beauty, heritage, and engagement with the environment.

It is obvious that the urban forest contributes to each of these public goods with the benefits trees provide contributing to all of them. Yet each individual genus, species and cultivar has its own characteristics. There is a vast range of shape and form, height, breadth and leaf density and intrinsic tolerances and genetic capacity. Each of these characteristics will influence the capacity of each, genus, species, and cultivar to deliver a particular public good. Diversity in the population facilitates and maximises the potential of the urban forest to deliver the whole range of public goods.

1.1 Diverse Populations

What should a diverse tree population look like?

There are several theoretical models, with regard, to genus, species, cultivar percentages, which have been referred to over the years.

- **Santamour 1990**

No urban tree population should comprise more than 10% of any given species, no more than 20% of any genus and no more than 30% of any given family.

- **Miller and Miller 1991**

Proven species should not exceed more than 10% of the population.

- **Moll 1989**

No species should exceed 5% of a city's tree population and no genus should exceed 10%

- **Grey and Denke 1986**

One species should not amount to more than 10-15% of the total population.

- **Barker 1975**

Communities should establish maximum population densities for each species as a percentage of the entire street tree and no more than 5% of any one species is used.

This avenue of London Plane (Platanus hispanica) does not meet any of the percentage requirements outlined above but does it mean that the tree population, when taken in entirety, is lacking in diversity.

Diverse Populations

1.1

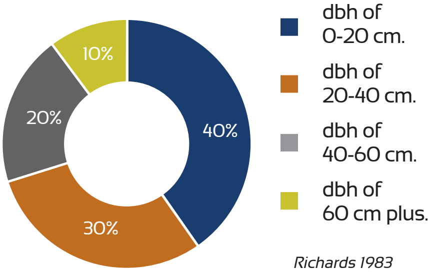
Tree and park populations

The most often used percentage expression of size diversity is that of Richards in 1983.

At the time of writing there is little guidance or research to express, in terms of percentages, diversity of age, diversity of genetics or diversity of public good.

All of the above are idealised percentages and useful but it is hard to find an evidence base to support any of them. They are guidelines, and in that sense valuable but they are not absolutes and should not be treated as such.

Tree and park populations should be comprised of trees of approximately:



Richards 1983

All of the above guidelines, in addition to not having a verifiable evidence base, focus on the composition of the tree population and do not have a specific focus on the many benefits provided by the urban forest.

3-30-300 Rule

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- **THREE trees from your window.**
- **THIRTY percent tree cover.**
- **THREE HUNDRED metres to the nearest park**

Introduced by the Nature Based Solutions Institute in Barcelona the 3-30-30 rule focuses on the benefits provided by the whole urban forest and considers the importance of 'green' to human physical and mental health.

The first element of the rule is that every citizen should be able to see at least three trees (of a decent size) from their home and refers to recent research which demonstrates the importance of nearby, especially visible green for mental health and well- being.

The second element again refers to research which has shown an association between urban forest canopy and cooling, better micro-climates, mental and physical health, air pollution and noise reduction. Research from Australia has repeatedly found that 30% is an important threshold and names cities such as Barcelona, Bristol, Canberra, Seattle, and Vancouver who have set targets to achieve 30% tree canopy cover.

The third element is a recommendation of the European Regional Office of the World Health Organisation where the provision of green space of at least one hectare within 300 metres encourages the recreational use of green space with positive impacts for both physical and mental health.

1.2 Diverse Populations

How diverse are urban tree populations now in comparison to the aforementioned models?

Trees in Towns II the last comprehensive review of trees in urban areas in England reported that six species accounted for 37% of all trees and shrubs planted in England's cities.
(Britt and Johnson 2008).

Recent work carried out by Forest Research examining 12 i-Tree studies in the UK confirmed this perception reporting that in total 110 different genus were identified across all locations, of which 218 species were identified and concluded that locations were typically dominated by a small number of species.
(Monteiro 2019).

It has been reported that although there are a wide range of tree species used in central and northwestern European countries, approximately 250 woody species are used across central European parks and gardens.
(Roloff et al 2009)

Usually only three to five genera account for 50-70% of all street trees planted with lime, maple, plane, horse chestnut, oak and ash being the most popular.
(Pauleit 2013)

A measurement of 108 cities around the world for species diversity found that on average 20% of trees in the urban forest were of the same species, 26% were of the same genus and 32% were of the same family.
(Morgenroth et al 2016)

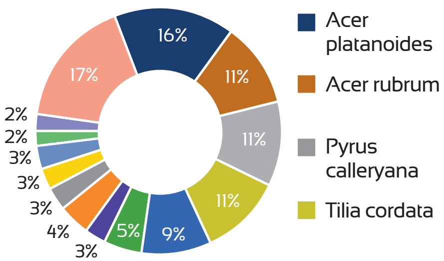
A historic Jacaranda mimosifolia avenue in Funchal, Madeira . The entire avenue is composed of one species and one age class.

Diverse Populations 1.2

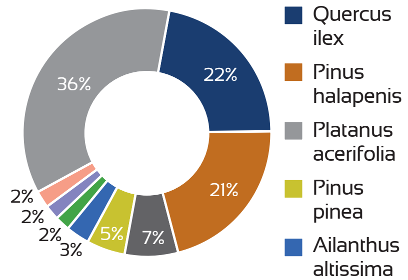
International comparisons:

It can be seen from the pie charts below that each of the tree populations described is heavily dependent on a limited number of tree species.

Pittsburgh, USA

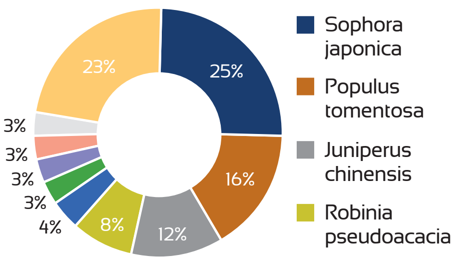


Barcelona, Spain

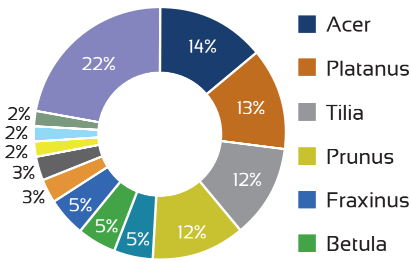


Courtesy Sjoman et al

Beijing, China



Camden, London, UK



From the above it is possible to conclude that cities and towns internationally lack a diversity within their urban forest and that there is generally a reliance on a few tried and tested species. Data from the continually emerging i-tree studies confirm this.

In the UK at the time of writing the evidence base is fragmented but what information exists suggests that while diverse at an individual species level, the number of species present in a population, tree populations are highly dependent on relatively few species.

1.3 Diverse Populations

This suggests that health and well-being benefits are not being maximised and that tree populations in general remain vulnerable and lack resilience. There are several examples from recent history where urban tree populations heavily reliant on one or more species have been decimated through external change primarily through the introduction of invasive pest and or disease. This is coupled with the ever- present challenge of climate change and the resilience of urban tree populations.

- **Dutch Elm Disease (DED)**

In the late 1960's a second and more virulent form of was imported into the UK. Within a decade approximately twenty million Elms were dead.

- **Chestnut Blight**

It is estimated that between 3-4 billion American chestnut trees were destroyed in the first half of the 20th Century by the blight.

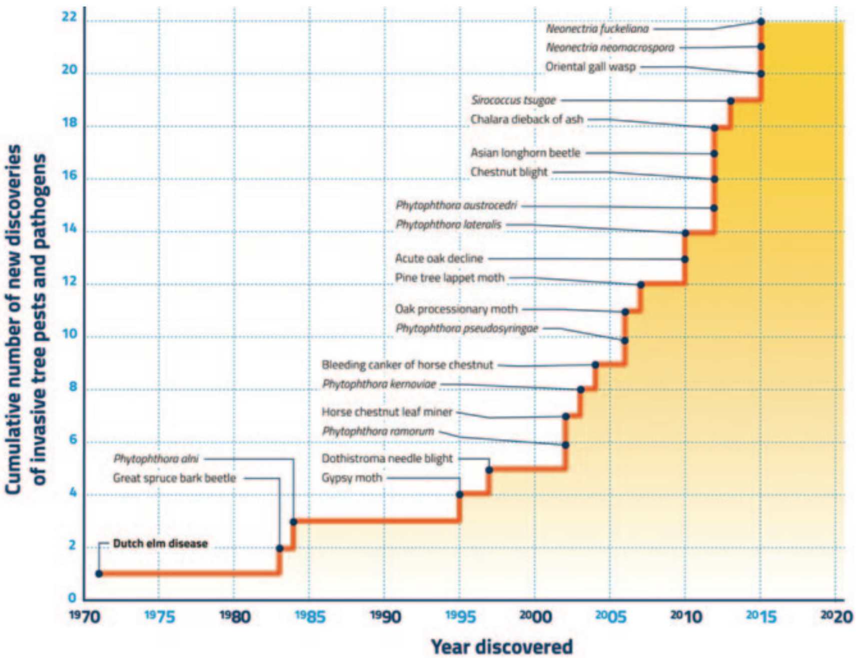
- **Emerald Ash Borer**

Emerald Ash Borer *(Agrilus planipennis)* has killed tens of millions of ash trees so far and threatens to kill most of the 8.7 billion ash trees through North America.

- **Ash Dieback**

It is predicted that Ash dieback *(Hymenoscyphus fraxineus)* will kill up to 95% of ash trees across the UK (Woodland Trust website)

The table below illustrates quite clearly the increased incidence of new, imported pest and disease in the UK



Courtesy of the Arboricultural Association.

Diverse Populations 1.3

Mixed species avenue in Ithaca USA.

Pterocarya fraxinifolia

2.0

Climate Change

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2.0 Climate Change

It is suggested that climate change is likely to directly affect trees in urban and suburban areas. The occurrence of temperature fluctuations, wildfires, extreme weather events and species invasions threaten the stability and productivity of urban forests

(Ordonez and Duinker 2012).

Tree species that are adapted to warmer climates will tolerate increasing temperatures and as such may become more common in urban environments that also experience the urban heat island effect.

(Leichenko and Solecki 2013).

The table below, adapted from the Met Office website (2020) outlines current changes and offers predictions for the UK.

	Changes in intensity or frequency so far	Is this linked to climate change?	What is expected in the future?
UK Warm Spells	Increase	Yes	Increase
UK Cold Spells	Decrease	Yes	Decrease
UK Heavy Rain	Increase	Inconclusive	Increase
UK Dry Spells	No trend detected	Inconclusive	Increase (Summer)
UK Wind Storms	No trend detected	Inconclusive	Inconclusive

It is obvious that the above will impact on the growth, suitability, and resilience of trees growing in the already harsh urban environment.

Climate Change 2.0

The table below outlines the impacts of climate change on forest trees. It is probable that these impacts will be equally great on urban trees and possibly exacerbated.

Forest responses to climate change

- Increased CO^2, inc. temperature, rainfall variability

	FAST	SLOW	
INDIRECT	Fire frequency/intensity More disease More insect pests More invasives Water quality	Habitat compostion and structure Wood supply Erosion Water yield	Ecosystem goods and services
DIRECT	Photosynthesis Water use/transp. Flowering/phenology Regeneration Wood density/quality Growth and mortality Frost/storm damage	Decomposition Tree nutrient status Genetic change Species distribution/ local extinction	

THE UNIVERSITY OF MELBOURNE

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Given that urban tree populations are facing severe external challenges and that they generally exhibit a lack of diversity leading to a corresponding lack of resilience the question arises as what to do.

3.0

Native or Exotic?

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3.0 Native versus exotic species

Discussion of species diversity in the urban environment invariably polarises into whether the planting of native species is preferable to the use of, so called exotic species. Some argue that native is best, some argue for a mixture some prefer the use of exotics. Perhaps the real question is whether true diversity is achievable using native species alone.

Foliage of Acer campestre (Field Maple) commonly accepted as a species truly native to the UK.

Foliage of Celtis orientalis (Nettle Tree) a resilient and hardy tree native to the Mediterranean region which is used widely as a street tree throughout Europe but is certainly not a native to the UK.

'Given that research has demonstrated the urban environment is already a diverse one regarding tree species it is perhaps surprising to find that other research indicates that many practices orientated publications, research papers and governmental websites in the fields of urban planning, urban forestry and urban ecology argue for the use of native species and the avoidance of introduced species'

(Sjoman et al date)

It has been argued that Urban landscapes represent the most complex mosaic of vegetative land cover and multiple land uses of any landscape and are characterised by a diverse range of site conditions, not found in the surrounding countryside. Urban areas can accommodate a surprisingly varied flora.

(Morgenroth et al 2016).

Nature Vs Exotic

Native versus exotic species 3.0

If any of the theoretical positions outlined previously are to be applied, then the question, must, be asked as to whether true diversity and resilience can be achieved in the urban environment using native species alone.

Styphnolobium japonicum (Japanese Pagoda Tree) in full flower. A native of China it is used extensively as a very successful urban tree throughout Europe.

3.1 Native versus exotic species

According to the Royal Horticultural Society's website 18 genus are native to the UK. These are Acer, Carpinus, Fagus, Fraxinus, Ilex, Malus, Pinus, Populus, Prunus, Pyrus, Quercus, Salix, Sorbus, Tilia, Ulmus. However, many of these are limited to a relatively few species as can be seen below.

GENUS	SPECIES NATIVE TO UK
Acer	*Acer campestre*
Alnus	*Alnus glutinosa*
Betula	*Betula pendula* *Betula pubescens*
Carpinus	*Carpinus betulus*
Fagus	*Fagus sylvatica*
Fraxinus	*Fraxinus excelsior*
Ilex	*Ilex aquifolium*
Malus	*Malus sylvestris*
Pinus	*Pinus sylvestris*
Populus	*Populus nigra subsp Betulifolia*
Prunus	*Prunus avium* *Prunus padus* *Prunus spinosa*
Pyrus	*Pyrus cordata*
Quercus	*Quercus petrea* *Quercus robur*
Taxus	*Taxus baccata*
Tilia	*Tilia cordata* *Tilia platyphyllos*
Ulmus	*Ulmus glabra* *Ulmus minor*

Native versus exotic species

The two genus remaining are Sorbus and Salix. These are represented by several species.

Salix	*Salix alba* *Salix caprea* *Salix cinerea* *Salix fragilis* *Salix pentandra* *Salix triandra* *Salix viminalis*

Sorbus	*Sorbus arranensis* *Sorbus aucuparia* *Sorbus bristoliensis* *Sorbus devoniensis* *Sorbus domestica* *Sorbus eminens* *Sorbus hibernica* *Sorbus lancastriensis* *Sorbus porrigentiformis* *Sorbus psuedofennica* *Sorbus rupicola* *Sorbus subcuneata* *Sorbus torminalis* *Sorbus vexans* *Sorbus wilmottiana*

Genus which are currently affected adversely by a known pest or disease where planting is restricted or banned.
Genus where native species would not be suitable for extensive use as trees, particularly street trees in the urban environment either because of size, form or availability. It is to be noted that S. aucuparia, S. domestica and S. torminalis are used but normally they are represented by cultivars.

The above is the interpretation of the author and is likely to be contested by some, but it is readily apparent that the choice, which at first seems ample to meet diversity criteria is limited. The native versus exotic discussion is not going to be resolved here and is going to continue to be, in some instances controversial, but the palette of trees which can be used in the urban environment is vast. It is certain that stresses and strains caused by either climate change or imported pest and disease is only going to increase and it is at the very least, questionable as to whether the palette of available native trees can deliver the resilience necessary.

4.0

Can diversity be achieved?

Koelruteria paniculata

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4.0 Can diversity be achieved?

Perhaps the simplest way to answer the question is to offer a case study. The story of Greater Lyon in France is well documented but remains an exemplary example of what can be achieved.

Tree Population In Greater Lyon In 1994 (% By Genus)		Tree Population In Greater Lyon In 2013 (% By Genus)	
Platanus	53%	Platanus	26%
Acer	13%	Acer	11%
Tilia	9%	Tilia	8%
Robinia	7%	Celtis	7%
Aesculus	3%	Fraxinus	6%
Prunus	3%	Quercus	5%
Celtis	2%	Prunus	5%
Populus	1%	Pyrus	5%
Other	9%	Sophora	3%
		Corylus	3%
		Gleditsia	2%
		Aesculus	2%
		Ulmus	2%
		Malus	1%
		Zelkova	1%
		Other	15%

In the mid-1990s, plane trees represented over 50% of the tree population managed by the Greater Lyon Authority (GLA). In 2013, this had been brought down to 26%, while the overall number of species found in hard landscapes in the Lyon area had increased by 68%, with over 260 different species and 70 genres represented. This stark increase is a result of a strategic commitment to diversification. (TDAG 2014)

Can diversity be achieved? 4.0

A riverside avenue of Platanus photographed in Lyon, France. The percentage of this genus in the population was reduced from over 50% to 26%

4.1 Words of caution

There would appear to be general agreement in the literature that increasing the diversity of species present in urban tree populations is both positive and necessary if the challenges of climate change and imported pest and disease are to be met both now and into the future.

There are however those who urge caution when considering planting for diversity alone. Managing only for diversity has its dangers.

It has been suggested that the problems associated with invasive exotic species, the emission of volatile compounds, allergen production and the potential for infrastructure damage all, must, be considered when introducing new species into the urban environment. Species selection for planting must be undertaken strategically to optimise the desired ecosystem services and limit ecosystem disservices.

Morgenroth et al (2016)

It is reasonable to suggest that the possibility of introducing inadvertently an invasive species is a real one but there is a need to consider the trade -offs between the positive and negative effects of introduced and in particular invasive tree species where environmental context is of vital importance and due consideration given to the fact that a species can be invasive in a specific climate or environment does not mean that it is invasive in a whole region or under other environmental conditions.

Sjoman et al (2016)

It has also been suggested that the distribution of biomass in the urban forest may be more important than species richness in terms of the ecosystem services delivered and that at any proportion of a local population a species may be regarded as overused if it is often planted where other proven species could do better.

Morgenroth et al (2016)

It is argued that the search for diversity, while desirable should not preclude the substantial use of a proven species in local locations where it is judged to be the best- known choice and that increasing diversity beyond the proven adapted species requires the use of un-proven or less adapted species.

Richards (1993)

Words of caution 4.1

The questions raised about invasive species and ecosystem disservices are real and should not be dismissed and it is true that the introduction of a new species does significantly increase the chance of the introduction of an invasive species particularly with a changing climate and other localised conditions prevalent in a particular environment.

> Other research differentiates between introduced and invasive species and argues that not all introduced species are invasive and that the two terms should not be confused. Introduced species are those species which have been introduced to northern Europe since the last ice age with invasive species, a sub- group, which spread and maintain populations without human intervention.
>
> *Sjoman (2012)*

While the above views urge caution and introduce sensible discussion points the fundamental proposition that diversity in a tree population will increase resilience is not challenged.

Maakia amurensisis

5.0

Species selection for diversity

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5.0 Species selection

Diversity in the urban forest

When discussing diversity in the urban forest two questions which are always asked are, which species should be planted and will species selected be available from the nursery when needed.

There are many publications and catalogues which offer advice and suggestions. The most recent, at the time of writing and certainly one of the most comprehensive, is the Trees and Design Action Group's 'Tree Species Selection for Green Infrastructure, A Guide for Specifiers,' researched and authored by Dr Andrew Hirons and Dr Henrik Sjoman. This document, which is freely available as a download from the TDAG web site provides profiles for over 280 species supported with explanatory guidance. (www.tdag.org.uk).

Much can be learned from Dr. Sjöman's thought provoking work. His research work has included a selection of natural habitats across the world which currently replicate, as far as is possible, the environmental conditions likely to be found in Scandinavian cities in the 2050's as a result, of climate change.

'The aim was to identify promising tree species and genotypes for urban environments in the CNE-region through dendrological studies in natural habitats.' (Sjoman 2012)

In his doctoral thesis published in 2012 he lists tree species identified from case studies as specialists for warm dry habitats which have never been grown or grown to a limited extent, in the CNE-region. This list is reproduced below:

Carpinus orientalis	*Quercus baronii*
Carpinus turczaninowii	*Quercus dalechampii*
Celtis bungeana	*Quercus pubescens*
Fraxinus chinensis	*Quercus wutaishanica*
Morus mongolica	*Sorbus folgneri*
Ostrya japonica	*Syringa pekinensis*
Quercus aliena var acuteserrata	*Ulmus glaucescens*
	Ulmus pumila

Species selection 5.0

Ostrya japonica Kew Gardens

In Germany the Institute of Forest Botany and Forest Zoology has produced a Climate-Species-Matrix attempting, based on reliable publications, to extensively classify and assess tree species with regards to their usability after predicted climate change. Working on the hypothesis that in the near future trees will become more important in the urban environment but will have to cope with increasingly extreme climatic conditions, especially an increase in the frequency and severity of summer drought and heat waves. (Roloff 2006).

The analysis categorised trees according to their suitability, with regard, to drought tolerance and hardiness. The table reproduced below is representative of the total work and is not the work in its entirety. This cannot, because of space be reproduced in full in this manual but focuses only on trees and shrubs which were considered suitable based on two assessment categories (drought tolerance and hardiness) taller than 10 metres.

Acer zoeschense	Zoeschen maple
Cladrastis sinensis	Chinese yellowwood
Fraxinus pallisiae	Pallis' ash
Ostrya carpinifolia	European hop-hornbeam
Phellodendron sachalinense	Amur corktree
Pinus heldreichii	Bosnian pine
Quercus bicolor	Swamp white oak
Quercus macrocarpa	Bur oak
Robinia viscosa	Clammy locust

5.1 Species selection

There are many aids to species selection and information as to how diversity can be achieved. The range of species which could enhance diversity in our tree populations is plentiful but it is worth referring to CITREE a web based species selection programme produced by the Technische Universität in Dresden, Germany, which makes recommendations as to species choice based on constraints criteria and required design characteristics. (www.citree.com)

The 2009 publication recommended Urban Trees: Site Assessment and Tree Selection for Stress Tolerance (Bassuk at al) remains a worthwhile and useful reference.

However, the challenge is to encourage designers, specifiers and tree managers to step outside their comfort zone and move beyond the, often narrow, range of species and cultivars they are familiar with and perhaps use rather formulaically.

Ostrya carpinifolia at Kew Gardens

Nursery Supply:

Of course, even if the challenge of the above paragraph is met then there is the question of availability within the nursery industry. It is obvious from the species list used as examples above that many would not be available should they be specified.

In an article published in Arboriculture News August 2018 Dr Gary Watson a lead researcher from the Morton Arboretum, Chicago, USA summarises the dilemma as he sees it drawing attention to substantially increased production necessary, the likelihood that the production costs of previously underused species being considerably higher and the need for growers to develop the confidence that the trees would be purchased if they were prepared to invest in the growing of them.

He concludes, 'Arborists and Foresters would have to learn how to match each species with appropriate sites, be willing to pay more and to commit to using a wider variety of more challenging species.'

Species selection

Will nurseries respond and grow the range of species required?

Dr Watson's points are well made but the articulate and educated matching of species to site should surely be a prerequisite of all urban plantings (BS 8545: Trees from Nursery to Independence in the Landscape 2014).

The grower's reluctance to invest is related to market uncertainty. This uncertainty is related to the lack of long -term strategic planning. With long-term strategic planning comes certainty and the prospect of more contract growing. This method was successfully used in the delivery of New York City's million trees campaign completed in the autumn of 2016.

The Barcham Trees method of production.

Spathodea campanulata

6.0

Achieving Diversity

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6.0 Achieving Diversity

It is widely accepted that sustainable strategic management of the urban forest can be summarised under four headings or questions.

- What have we got?
- What do we want?
- How do we get there?
- How are we doing?

These four questions were used in Trees in Towns II (Johnson and Britt 2008) as the stages of producing, developing and maintaining a comprehensive tree strategy.

It is suggested here that true diversity in a tree population cannot be achieved without a comprehensive tree strategy which provides a long term plan based on the above four questions. Diversity within the tree population will be just one of the many aims and objectives contained within the 'what do we want?' stage of planning and delivering a comprehensive tree strategy also often referred to as an Urban Forest Master Plan. In the authors view these are synonymous.

The Criteria and Indicators methodology for urban forest management was developed by Matheny and Clark (1997) and suggested that urban forest management can be divided into three principle areas, Vegetation Resource, Community Framework and Resource Management. It was further developed by Van Wassenaer and McKinney (2011) and elaborated on by Leff (2016). It was the method used in preparation of the Birmingham Urban Forest Master Plan (2021) with further elaborations (at the time of writing not yet published) produced in a collaboration between Birmingham Tree People, Birmingham City Council, The Nature Based Solutions Institute and Treeconomics.

The method begins with extensive consultation of stakeholders in the urban forest and develops a vision for the urban forest under consideration. This vision is broken down into a series of elements with each element assessed and prioritised. Progress is monitored for each of the elements. It is worth noting that the criteria and indicators will be different for each project and the vision and priorities localised.

Achieving Diversity

It is beyond the scope of this manual to discuss general urban forest management but as shown in the table below 'species diversity' is just one of the criteria. How this is prioritised will depend on the urban forest management programme in question.

Criteria and Indicators (C&I)

Vegetation Resource "The engine that drives urban forests"
Canopy cover
Uneven age distribution
Species diversity
Native vegetation

Community Framework "All parts of the community share a vision for their forest and act to realise that vision"
Public agency cooperation
Involvement of large private and institutional landholders
Neighbourhood action
General awareness of trees as a community resource

Resource Management Approach "The philosphy of management"
Funding
Protection of existing trees
Standards for tree care
Citizen safety

(criteria listed above are some examples from a larger list)

Criteria and Indicators (C&I)

Criteria	Performance Indicators				Key Objectives
	Low	Moderate	Good	Optimal	
Relative canopy cover	The existing canopy cover equals 0-25% of the potential or 0-13%	The existing canopy cover equals 25-50% of the potential or 13.1-26%	The existing canopy cover equals 50-75% of the potential or 26.1-39%	The existing canopy cover equals 75-100% of the potential or 39.1-52%	Achieve climate-appropriate degree of tree cover, community-wide
Condition of Publicly -owned Trees (trees managed intensively)	No tree maintenance or risk assessment Request based/ reactive system. The condition of the urban forest unknown	Sample-based inventory indicating tree condition and risk level is in place	Complete tree inventory which includes detailed tree condition ratings	Complete tree inventory which includes detailed tree condition and risk ratings	Detailed understanding of the condition and risk potential of all publicly-owned trees
Municipality-wide funding	Funding for reactive management	Funding to optimise existing urban forest	Funding to provide for net increase in urban forest benefits	Adequate private and public funding to sustain maximum urban forest benefits	Develop and maintain adequate funding to implement a city-wide urban forest management plan
Tree habitat suitability	Trees planted without consideration of site conditions	Tree species are considered in planting site selection	Community-wide guidelines are in place for the improvement of planting sites and the selection of suitable species	All trees planted in sites with adequate soil quality and growing space to achieve their generic potential	All publicly-owned trees are planted in habitats which will maximise current and future benefits provided to the site

Courtesy of Phillip van Wassenaer

6.1 Achieving Diversity

The search for diversity does not exclude the creation of single species avenues

Achieving Diversity 6.1

The Nordic Forest Research organisation has published a policy brief entitled 'Urban Tree Diversity for Sustainable Cities.'

- Understand your urban tree diversity.
- Determine locally relevant species diversity goals.
- Determine which species and cultivars are best suited to the local urban environment.
- Include local actors in the urban forest diversity action.
- Develop a locally relevant species prescription

The document recognises the need to promote tree diversity in urban forest strategic decision making, design and managements and makes the following recommendations for action.

A critical and essential element in achieving tree diversity, from the above, is understanding what you have got.

Understanding what you have got

There are many methods for assessing the urban forest and answering the question of 'what have you got? None of these are mutually exclusive and may be used independently of each other or combined to provide different layers of information. The depth of assessment will be entirely dependent on local needs and the resources available. An essential element in producing strategies for achieving diversity within a tree population is extensive consultation with stakeholders who are the users and beneficiaries of the urban forest.

The listing overleaf is not intended to be a complete list of tools available and there are many others which provide valuable information. The choice of tools to be used have to fit local circumstances, aims and objectives and the resources available.

6.2 What you have got

Useful tools for understanding 'what you have got?'

Canopy assessment:	Varies in complexity and cost. One of the simplest methods is the use of i-Tree Canopy. Aerial photography provides more detail but can be costly. It must be remembered that canopy assessments are unlikely to give detail of the species mix with a population.
Inventory:	Operational inventories provide useful information about diversity within any given population. Data is usually limited to operational management and with information stored limited. The quality of inventories varies enormously and some major local authorities and landowners working with no inventory at all or partial inventories which exclude certain land use types. CAVAT is often used to provide an amenity value.
i-Tree Inventory Conversion:	Here the operational inventory is converted to an i-Tree study. Basic data, tree species, tree height and dbh are used to conduct an assessment which provides data on the ecosystem services provided by the trees in the inventory and the value in monetary terms of those services to the community. Further detailed information about urban forest structure and composition is gained. It must be remembered that the study will only include the trees contained on the inventory and excludes those trees which are not. In the case of local authorities this will not include those privately owned trees which invariably make up a significant percentage of the whole population.
i-Tree Eco Sample Study:	With this type of study a series of randomised plots are set out across the geographical area to be studied. Each of the plots is visited and core measurements and assessments taken. A comprehensive set of data is obtained which provides detailed and extensive information about the urban forest within the study area replicating and extending the information gained from the inventory conversion. Here the study includes both public and private trees, so a picture of the whole population is achieved but it is a sampling exercise and does not have the precision or detailed accuracy of the inventory conversion.
Urban Forest Master Plan or Comprehensive Tree Strategy:	This has been discussed above under Achieving Diversity.

The table opposite is not intended to be a complete list of tools available and there are many others which provide valuable information. The choice of tools to be used have to fit local circumstances, aims and objectives and the resources available.

Tree planting in Stockholm. A limited drive past inventory was used to stimulate the planting of trees in Stockholm and the use of the Stockholm structural soil method of planting. This emphasises how even the simplest inventory can be a stimulant for extensive urban forest development.

6.3 Conclusions

- The impacts of climate change and the increased risks to our urban tree populations by invasive pest and diseases are real and growing.
- It is generally accepted that the resilience of urban tree populations can be increased by the diversification of those populations. This diversity can be achieved through, species diversity, age and size diversity and genetic diversity.
- Metrics exist and are widely accepted to evaluate diversity within urban tree populations
- Evidence suggests that diversity in the urban tree populations of towns and cities is limited, not only in the UK but across the world.
- The foundation in planning to increase diversity is understanding fully the situation as it is currently, with a supporting evidence base, and answering the critical question, 'what have we got.'
- To succeed diversification needs to be part of an overall long-term visionary strategic management plan.
- Research has indicated that there are many species which are not currently used or infrequently used which have the capabilities to thrive in the urban environment.
- Specifiers need to be more adventurous in their species choice and relate that species choice to the overall diversity objectives.
- Diversity in the urban environment cannot be achieved using native species alone.
- Tree Nurseries must be part of the dialogue and be involved in discussions about species choice and be given the confidence to invest in producing an increased range of material with contract growing, made possible by long-term planning a possible solution.

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Watson. G. 2018. Are there practical limits to Urban Tree Species Diversity. Arborists News, August. 22-24.

6.5 Notes

Further Reading and Sources of useful material:

Websites:

www.treeconomics.co.uk

www.tdag.org.uk

www.citree.de

www.forestresearch.gov.uk

Books and other publications:

Routledge handbook of Urban Forestry. 2017. Edited by Francesco Ferrini, Cecil. C. Konijnendijk van den Bosch and Alessio Fini.

London Borough of Ealing i-tree report 2018.

Trees for Tough Urban Sites. Learning from Nature. Doctoral Thesis No 2012:7. Henrik Sjoman. Faculty of Landscape Planning, Horticulture and Agricultural Science. Alnarp, Sweden.

The Hidden Landscape. On fine scale green structure and its role in regulating ecosystem services in the urban environment. Doctoral Thesis No 2016:3. Johanna Deak Sjoman. Faculty of Landscape Architecture, Horticulture and Crop Production Science. Alnarp. Sweden.

Urban Forestry: Planning and Managing Urban Greenspaces. Third Edition. 2015. Robert W. Miller, Richard J. Hauer, Les P. Werner. Waveland Press, Inc.

If you have any difficulty in accessing any of the above or would like to discuss any of the contents of this manual then please contact keith@barchamtrees.co.uk

The aim of this manual has been to highlight the importance of the four stages of urban forest management and illustrate how they might be used in achieving resilience through diversity.

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