

Trees in Urban and City Environments: a review of the selection criteria with particular reference to nature conservation in New Zealand cities

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The overall aim of this research was to review the general criteria for selection of trees for urban environments and city environments. The reason for this research was to assess the extent to which criteria for tree selection can contribute to nature conservation in cities. We conducted an extensive review of the literature, looking for publications about the selection criteria. In particular, we looked for any previous published reviews of the criteria. With reference to the criteria used in New Zealand, we undertook an unstructured review of the practices adopted in most cities. A review of the literature revealed many publications about different criteria but only one publication in which there was a general review of the criteria used for selecting trees for urban environments. By way of contrast, lists of tree species deemed to be suitable (or unsuitable) for urban planting are widely available, and some include information about selection criteria, but often with little background explanation. Worldwide, commonly used criteria included commercial availability of species, compatibility with urban environments, landscape design, low maintenance, avoidance of nuisance factors and historical practice. The most common criteria are concerned with the concept of choosing species compatible with local climate and soils. Anecdotal evidence suggests that more and more cities are using a mix of criteria including those that may contribute to conservation and restoration of native biota. We suggest that there should be greater use of ecological, genetic and biogeographical criteria to meet the needs of nature conservation in New Zealand cities.

Urban development has been one of the major causes of loss of wildlife habitats and changes to natural ecosystems. In a review by McKinney (2002) of urbanisation and nature conservation, it is suggested that urban development has resulted in some of the greatest local extinction rates and that urbanisation frequently eliminates the large majority of native species. However, the value of plants in and around cities has been valued for many decades. For example, as long ago as 1830, 'A retired Officer' (the pseudonym used by the author) wrote about the design of towns in Australia:

All entrances to every town should be through a park, that is to say, a belt of park of about a mile or two in diameter, should entirely surround every town, save and excepting such sides as are washed by a river or lake. This would greatly contribute to the health of the inhabitants in more ways than one, as well as pleasure it would render the surrounding prospects beautiful and give a magnificent appearance to the town from whatever quarter viewed.

(A retired Officer (1830), *The Friend of Australia or a plan for exploring the interior and for carrying on a survey of the whole continent of Australia*, London: Hurst, Chance and Co.)

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RESEARCH

Why are there trees in cities? Are they there by accident or by design? It is probably true to say that for most cities and other urban areas around the world, there has long been a practice of planting trees in urban environments because of the perceived functions of trees or their benefits (including amenity and recreational values as well a range of social and economic values).

Trees for urban environments are generally selected on the basis of pragmatic criteria. The main categories under which the criteria have been grouped include suitability for the site, availability of the stock and the preferences of local people.

A great deal of research has been undertaken on specific criteria. That these categories and general criteria have been in practice for a long time has led us to suggest that it would be timely and useful to assess these criteria in a general manner. In particular, we were interested to know the extent to which trees are selected for reasons of nature conservation in cities. We thought that this would be timely because of the ever-increasing growth of cities and the fact that urbanisation is one of the main causes of biota loss and damage to ecosystems. At the same time, however, there have been some innovative ideas about how to conserve rare plant species in cities.

The overall aim of this research was to review the general criteria for selection of trees for urban environments and city environments. There were three objectives. The first objective was to review the literature on the general categories of criteria that are used to select trees for cities and other urban environments and to consider whether some general criteria could be added. There was also the possibility that some criteria could, in the future, be of less importance. We did not intend to assess any single ecological, aesthetic or design category, or any other category in particular. Rather, we were interested in a more general overview of the different categories. For example, trees for cities and other urban environments have long been selected, in particular, on the basis of their suitability to survive in certain climate and soil conditions. That is just one general category. Other categories include landscaping and aesthetic properties, and environmental benefits.

The second objective was to determine what criteria are used for tree selection in New Zealand cities. The reasons for this were because we have research and education interests in New Zealand urban ecology.

The last objective was to use the results of the first two objectives to try and identify tree selection criteria that could possibly contribute to nature conservation in cities. We chose this objective because we were well aware that much of the lowland flora of New Zealand has been destroyed. We reasoned that urban ecology has a role to play in addressing nature conservation in New Zealand.

The specific objectives of this research were therefore to address the following:

- In general, what are the criteria for selection of trees in urban environments?
- In New Zealand, what is current practice, in terms of criteria, used for tree selection?
- Are there other categories of criteria that could usefully be used to advance nature conservation in New Zealand cities?

METHODS

The first task was a literature search. This was needed to help us identify the general categories or groups of criteria. It was also an opportunity to see whether anyone else had undertaken an assessment or reappraisal of the different categories of criteria as applied in general to tree selection. Consequently, the urban ecology journals and books, ecological journals, horticultural journals and arboricultural journals were searched for papers on criteria for tree selection in urban environments. All issues of all the following journals were searched for papers on criteria for selecting trees for urban environments:

- *Journal of Arboriculture*
- *Journal of Horticulture*
- *Journal of the Royal New Zealand Institute of Horticulture*
- *Landscape & Urban Planning*
- *Urban Ecology*
- *Urban Forestry & Urban Greening*

We also contacted colleagues from around the world who we knew had interests in this area of research. Relevant web sites were also searched.

With respect to the second objective, we wrote to 15 city councils throughout New Zealand and asked if there were written guidelines with criteria for tree selection. We received 11 detailed replies and, where appropriate, these were followed up with telephone calls and meetings with city arboriculturalists. Our assessment of the categories and criteria used for selecting trees in New Zealand was therefore based on the tree planting guidelines and information gleaned from conversations with city arboriculturalists.

RESULTS

Survey of the literature

We found many papers in journals and books that discuss the role of trees in urban environments, including a growing literature on the values of trees in cities. The values include long-standing tree valuation in dollar terms, but also more subjective amenity and design values (see, for example, Amir and Misgav, 1990; Arnold, 1993; Bradshaw, et al, 1995; Miller, 1996; Trowbridge and Bassuk, 2004). The value of societal health outcomes in tree-dominated urban landscapes is also starting to be recognised (Breslav, et al, 2000).

Robinette classified the 'functions' of urban trees into several categories including architectural, engineering, climatic and aesthetic. We could add social values or functions to those categories. Research on this topic has shown that the quality of life in urban areas can be improved with trees (Dwyer, et al, 2003; Kuo, 2003; Westphal, 2003). There are also publications about the role of trees

in helping to improve air quality and other environmental parameters. Trees can modify local climates, and strategically placed trees can help save energy, reduce heating and cooling costs, and act as carbon sinks (Beckett, et al, 2000; Nowak and Dwyer, 2000; Rich, 1970; Scott, et al, 1998; Yang, et al, 2005).

Trees cost money and there are tree management costs. Some researchers have therefore looked at the benefits of trees in urban environments against the costs (Maco and McPherson, 2003; McPherson, 2003). Research on cost-benefit analysis of urban forestry has been extended to include the role of trees in consumer/environment interactions and has been focused on public goods provided by urban tree planting (Wolf, 2003). There has also been related research on the monetary compensatory value of trees (Nowak, et al, 2002). Contemporary methods of assigning monetary values to trees suggest that the asset value of urban tree plantings may be comparable to the asset value of hard structures such as buildings. As an example, the value of municipal trees planted in Christchurch (population 345,000) in New Zealand by the city council, is estimated to be worth about US\$207 million (Dieter Steinegg, pers. com. Nov 2006).

When it comes to selecting trees for urban environments, there is a wealth of literature on what factors or criteria should be considered (Miller, 1997; Phillips, 1993; Rego and Castel-Branco, 1998; Saebo, et al, 2003; Saebo, et al, 2005; Stoecklein, 2001). The most important and general question is, of course, will the tree grow and flourish in the physical and biotic conditions (soil, climate, aspect and so forth) present? Underlying that question is a vast amount of research. That research includes work on stress-tolerant landscape plants (Widrechner, 1994; Wray and Mize, 1985), phenotypic selection for landscaping (Lagerstrom and Eriksson, 1996), air pollution resistance (Barnes, et al, 1999) and transgenic plants for insect resistance (Jouanin, et al, 1997). This question about what factors need to be considered to ensure a tree will survive has resulted in many city authorities producing lists of trees that are suitable, and not suitable, for the local conditions.

However, it is not all about tree fitness and survival. This has been well illustrated by the content of many conferences that have taken place on the topic. A good example is the proceedings of the seventh conference of the Metropolitan Tree Improvement Alliance (Metria 7: Trees for the nineties: Landscape tree selection, testing, evaluation and introduction). In those proceedings there are papers about tree fitness and survival, but also other papers that demonstrate the range of categories that may be used for tree selection. Selection of cultivars plays a very important role in ensuring the success of tree plantings in terms of both physical conditions and biotic conditions (such as susceptibility to pests). At that conference, Gerhold (1990) presented information about the development and testing of cultivars for street trees. Bassuk (1990) drew attention to the fact that the urban environment includes many physical variables (drainage, soil fertility, pH, salt, and amount of root space) and that it is a series of heterogeneous microclimates. However, it is relevant to note that papers at that conference did not focus only on the question of what trees are suitable for particular physical conditions. The

papers also demonstrated the range of criteria that may be used for selecting trees. For example, Wandell (1990) presented material about searching for the perfect shade tree. Santamour (1990) advocated the need for a broader diversity of trees in urban landscapes to guard against possible large-scale devastation by pests (the importance of maintaining diversity of tree species has been researched elsewhere by Galvin (1999)). Other categories could include the role of trees as habitats or food sources for animals, aesthetic properties of trees (their form, branching, leaves, fruits and flowers), nuisance factors and also how trees respond to pruning (such as branching and wound closure).

Although many books about trees in the urban landscape include criteria (grouped into several categories) for tree selection (for example, Arnold, 1993; Bradshaw, et al, 1995; Gilbert, 1989; Miller, 1996; Trowbridge and Bassuk, 2004), there appears to be little research on the categories themselves. Many papers addressed the topic of how trees are selected but we could find no papers in journals that specifically and critically discussed reasons for any particular categories being used as a basis for selection. Few papers discussed the ecological basis for selecting urban trees (those that did included Saebo, et al, 2003; Ware, 1994). Of particular importance was the fact that we found no published papers that advocated nature conservation as a category.

We have used the literature to develop tree selection categories and criteria for urban environments. The categories and criteria are presented here in no particular order of priority:

- Suitability in terms of general site conditions: This includes soil type, local climate, and specific factors such as frost tolerance, salt tolerance or drought tolerance. Such criteria generally tend to be used in localities that have one or more dominant ecological parameters such as coastal influence, nutrient-poor soils, severe winter climate and high wind frequency.
- Suitability in terms of foundation materials used for adjacent roads, canals and so forth: This includes road foundations and effects of different road aggregates adjacent to the planting sites for trees and is especially used for avenue, boulevard and roadside plantings.
- Availability: Sometimes the choice of species is limited by availability, particularly when there is mass planting of hundreds of trees. This can become an overriding factor, or where a tree-planting budget must be spent in a short period and a local authority simply has to take what trees are available.
- Safety and avoidance of structural problems: This includes the selection of trees that have life forms that will not cause hazards to traffic, pedestrians and infrastructure (for example, underground piping and cables); avoidance of using trees which have far extending surface roots or suckering habits.
- Avoidance of nuisance factors: This includes avoiding trees that are poisonous or have fruits with unpleasant odours and trees that shed large amounts of bark or limbs.

- Maintenance: There is an increasing effort to ensure that selected trees have minimal maintenance requirements, including little need for spraying and pruning.
- Design and aesthetic properties: Especially for new peri-urban developments and revitalisation projects, the contribution of particular trees to landscape design often becomes important, hopefully providing shade and shelter and adding value to property, although many modern housing developments appear to avoid the use of large trees significantly higher than rooflines.
- Maintaining historical selection: For many local residents, familiarity of landscape is important and so often selection of tree species is put into an historical context; effectively meaning that previously utilised species will continue to be used despite when there may be some disadvantages.
- Environmental function: A more recent criterion for some local authorities has been the functional aspects of trees, the role of trees in helping to reduce pollution and noise, helping to ameliorate environments and contributing to both wildlife and land use values.
- Socioeconomic functions: The contribution that urban forestry makes to the social environment and the role trees play in land values.

Criteria used in New Zealand cities

The response from city councils to our inquiries revealed that ten have lists of suitable (or unsuitable) trees but, in some cases, there are no specific criteria. Six are currently developing 'tree plans' or 'tree planting guides', but the remainder do not have general categories or even specific criteria for selecting trees.

In New Zealand – over and above safety considerations and avoidance of structural problems – the selection of trees appears to have often been determined primarily by very generalised and broad ideas about suitability (to local physical conditions) and by current availability, and secondarily by aiming to maintain past planting patterns and selections. The following extracts from recent council discussion documents about street trees appear typical of past practice:

While suggestions from residents should be considered, the final decision on the choice of tree rests with the arboriculturist. Criteria include soil type, drainage, local climate, width of footpath and road, proximity to buildings and infrastructure, types of trees in the vicinity and availability.

A key factor is past practice. The present predominant large growing deciduous trees are the major component in Christchurch central city. For this reason, the recommended core species consists of solely deciduous northern hemisphere trees.

Apparently recent discussions have taken place in New Zealand about the environmental value of trees. Examples include the amelioration of environmental factors such as stormwater interception and take-up of pollutants. Another category that is becoming recognised is the contribution of open space and trees to societal health and well-being (Spellerberg, 2006).



New plantings of locally sourced native plants as part of a housing estate in Christchurch.



Maturing native plantings on the outskirts of Christchurch.

Our personal observations have shown that there appears to be a growing realisation that trees can be selected, at least in part, on the basis of their potential contribution to nature conservation. We believe that more and more cities in New Zealand are beginning to give priority both to species that are characteristic of the local ecology, and to trees that support indigenous wildlife. However, such attempts are frequently the target of considerable opposition. The opposition stems from the claim that exotic trees are part of New Zealand's heritage. There is a lively exotic versus natives debate (in the media) that includes the use of terms such as 'ecological racist', 'eco-Nazis', 'pathetic political correctness', and 'anti-exotic tree phobia' (Spellerberg, 2006).

Historically in New Zealand, horticulturalists or arboriculturalists have been responsible for choosing trees for planting in cities. Many of these people would have gained some experience from the United Kingdom and in particular would have been influenced by practice in Europe. This is not surprising because of the wealth of knowledge in Europe about suitable trees (usually from the northern hemisphere) for cities. Consequently, there has been a common and longstanding practice of using northern hemisphere tree species in New Zealand cities. The same applies to 'British colonial cities' in Australia, South Africa and elsewhere.

DISCUSSION

The specific objectives of this research were to determine the criteria for tree selection in urban environments. What is the current practice used for tree selection in New Zealand cities and what tree selection criteria could be beneficial to advance nature conservation in New Zealand cities?



Oak trees along a main avenue in Ashburton.

Tree selection criteria in general

Worldwide, the most important criteria for selecting trees for urban environments would appear to have been pragmatic. Suitability for local conditions, low maintenance and avoidance of structural problems are further considerations. Criteria that contribute to landscape design appear to be next in importance. It was surprising to find that there have been very few published reviews about the categories of tree selection criteria, particularly in respect to what criteria may or may not be useful in terms of nature conservation in cities.

City landscapes are human dominated and hence regarded by many as being artificial. We would suggest that in most cities, public spaces have been designed primarily with humans in mind and consequently there are artificial mixes of tree species. That is, the mixes of species are typically often dominated by non-native species. However, there have been exceptions. For example, Warrington New Town in the United Kingdom where emphasis was given to the importance of native plant species appropriate to the area, soil and topography, so as to provide a diversity of landscapes that appears as natural as possible (Scott, et al, 1986; Scott, 1991). More and more so there appears to be more reference to indigenous vegetation when selecting trees for cities (see Breuste, 2004; Florgård, 2004). The 'naturalistic movement' in the United Kingdom is adapting ideas for urban redesign that have previously been implemented in continental Europe. In Adelaide, Australia, there is the 'Urban Forest - One Million Trees Programme' where the aim is to redress the loss of local native species across metropolitan Adelaide (<http://www.urbanecology.org.au/articles/onemilliontrees>). Also in Australia, there is the 'Growing Green' programme for Melbourne where European tree species are progressively being replaced by indigenous species.

This trend (if it is a trend) must surely have come from a growing realisation that urbanisation has had, and continues to have, a detrimental effect on nature with the results being habitat degradation, habitat loss and species extinction.

Tree selection for cities in New Zealand

In our opinion, the selection of trees in New Zealand cities appears to have been determined first by suitability (to local physical conditions) and availability, and secondly, by continuation of past planting patterns and selections. Exotic tree species are very common in New Zealand cities.

We conclude that the disciplines of ecology and biogeography have not played a significant role in the selection and location of trees in New Zealand cities. We feel that this needs to be addressed. There are many reasons for doing so. For example, native trees can be important habitats for many native animal species such as birds. There are many opportunities to plan mixes of tree species in cities that can attract and benefit wildlife. We would also argue that there is a compelling argument to try to compensate for the extent of destruction of native lowland flora that has taken place over the last few hundred years. This is New Zealand, and the native flora is our natural heritage. Planting exotic tree species was considered to be acceptable

100 years ago but values change. Today there is surely a growing recognition that use of native plants in cities is part of being sustainable.

It seems that there is increasing discussion about 'the natural look' and it also appears that the literature is now starting to include publications about planting and design that are based on ecological and biogeographical principles. There is talk about sustainable urban landscapes, the conservation of indigenous vegetation within urban developments and the restoration of habitat for indigenous taxa within cities. In line with this, Stewart, et al (2004) and Stewart and Woods (1995) discuss the potential trend or the growing establishment of indigenous flora in the City of Christchurch, New Zealand. Evidence for the growing demand for native plant species in New Zealand is described in Spellerberg and Given (2004). One good example of the extensive use of indigenous species in an urban park setting is Matawai Park in Rangiora, North Canterbury (Henderson, 2003).

Tree selection criteria for cities in New Zealand (with nature conservation in mind)

We suggest that there are several criteria that could usefully be used for selection of trees for cities, particularly where there is an interest in nature conservation. The following are suggested as a basis for discussion and are in no particular order of importance.

Planning ahead

Urban planting of trees is a long-term exercise. When one plants a tree it should be in the context of the useful life of the tree, which may be 100 years or more. This means that tree selection should not be decided on the spur of the moment. Yet, too often tree selection may be done in a hurry, using only what is available at that time, either because there is political or community pressure to plant immediately, or because the money for planting must be spent urgently. The time for debate and decisions on tree planting, whether first generation or replacement, is not when tree planting is about to take place but several years earlier. This not only allows rational and informed decisions to be made but also allows time for sourcing, propagating and growing on the best stocks of suitable (native) species to an appropriate and (if necessary) uniform size.

Genetic and cultivar considerations

In New Zealand, there appears to be a lack of widely available knowledge about native trees species suitable for urban planting and certainly a lack of deliberate trials and genotype selection of indigenous species that are candidates for widespread urban planting, even after 150 years or more of European settlement.

Whether one should grow exotic or native trees has a further level of debate. The question is, even within a native species, should we be growing only trees and plants that are sourced from local stock? In other words, Christchurch City would grow native trees sourced only from mid-Canterbury generic stock and Auckland City would grow trees sourced from the Auckland region. A problem is that with



Above and below: Two photographs of Matawai Park, Rangiora. It is one of the largest planted areas in New Zealand dedicated to native plants.



some genera, such as *Sophora* in New Zealand, native stocks in gardens are highly mixed, often growing species that do not occur in the region or growing forms of local species that have been sourced from elsewhere in New Zealand. Already, urban stocks of *Sophora* and a number of other native New Zealand genera are probably well contaminated in a genetic sense. Genetic origins are also an important consideration for exotic species when attempting to use the most appropriate material to ensure planting success.

Horticultural aspects

It is often overlooked that many of the favoured trees for urban planting in New Zealand cities are species that have gone through centuries of selection and trials that have both eliminated the species and genetic strains that are less appropriate and singled out those species that are best suited to cope with the stresses of the urban environment (R. Rowe, pers com 2005). This process of horticulturalisation means that there is a selection of species and cultivars that have stood the test of time. Notwithstanding, there is need to trial new candidate species, especially indigenous species. It is one thing to plant a species such as totara (*Podocarpus totara*) but do we know we are planting those particular genotypes which are best suited to the urban and city environment?

Health problems

Some trees may be the cause of some health problems. Often, this seems to be poorly understood. For example, silver birch (*Betula pendula*) is a very popular tree for urban environments, especially around schools, yet the pollen of silver birch is a potent allergen and a major contributor to seasonal hay fever, asthma and oral food allergies (oral allergy syndrome). Health problems associated with silver birch are well documented in the research literature (Spellerberg, et al, 2006).

Use of a community ecology biogeographical approach

It is a relatively simple matter to identify suitable trees for each set of urban environments. But this approach typically does not include reference to historical plant community structure and plant assemblages, let alone past biogeographical patterns. It is not possible to recreate the original plant assemblages; however there may be merit in adopting an entire regional approach (Williams, 2005) or a whole city approach to indigenous planting. This could be based on what is known about the original vegetation assemblages (mixes of species and age classes) of the region and city concerned. A preliminary use of this approach in Christchurch has been developed from natural area surveys of the city (Meurk, et al, 1993). These have led to recognition of four original habitat types within the city and plant lists have been developed for each of these (Lucas Associates, 1997). Another example is the 'Sustainable Landscapes' project in Adelaide, South Australia. This is a partnership between developers, a waste water management authority and the Botanic Gardens of Adelaide (S. Pitman pers com.).

What this implies is that there should be a selection of locally sourced (biogeographical) indigenous trees for specific sites and that this should be

undertaken with reference to the local representation of indigenous species and mixes of species and mixes of age classes for individual species (community ecology). We suggest that it may be possible to establish mosaics of various urban-wide assemblages of indigenous species and age classes and thus encourage greater species richness, beta species diversity and structural diversity. For example, this could include:

- establishing plant assemblages of tree species at the scale of the whole city; and
- establishing continuity between discrete green areas by linear habitats.

Such an approach requires several operational tools. It needs a suitably detailed database or inventory of tree species (preferably GPS-based), good location information, knowledge of the suitability of particular native trees for planting in cities and locally sourced material.

In conclusion, we suggest that more sustainable tree planting in cities in the future could be based on both horticultural and on ecological and biogeographical principles. This would address the impacts of cities on native vegetation and would benefit nature conservation. The benefits of such an approach could include potentially lower maintenance costs and avoidance of longer-term nuisance and health-related problems, by ensuring that the right tree is planted in the right site – an increasing contribution of the urban treescapes to the conservation of indigenous wildlife and the increasing recognition of natural heritage.

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