The distribution, abundance and composition of street trees in selected towns of the Eastern Cape, South Africa

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Abstract

Street trees are an important component of the urban forest as they provide critical ecosystem services which contribute to human health and environmental quality. However, little is known about the distribution, diversity and density of street trees, particularly in the developing world where urbanisation is most rapid. Thus, the aim of this paper was to assess the distribution, composition and abundance of street trees across three towns along an environmental gradient in the Eastern Cape of South Africa, and identify the key challenges faced by local officials concerned with the provision of street trees. In each town, streets were randomly sampled in the commercial, affluent residential, township settlement and low cost housing areas under the Reconstruction and Development Program (RDP). Attributes recorded per tree were species, circumference, height and health, while semi-structured interviews were conducted with the municipal officials involved in the establishment and maintenance of street trees. A total of 1,485 trees were encountered, comprising 61 species. The majority (56%) of trees were alien species. Noticeable differences in tree density and species richness were evident across suburbs, being highest in the more affluent suburbs and poorly represented in the low income township and RDP areas. There was a decreasing mean tree height and health score along the environmental gradient from the coastal town to the inland town. Although awareness of the benefits of street trees was high, as was the need to reduce the proportion of alien species, the primary constraint to establishment and maintenance of street trees in the three towns was limited budget and human resources.

Keywords

- Alien;
- Diversity;
- Developing world;
- Indigenous;
- Wealth

Introduction

The proportion of the world's population living in urban areas is increasing rapidly such that by 2030 almost two-thirds of the world's population will reside in cities (United Nations, 2007). Consequently, the sustainability of towns and cities is becoming an environmental issue of increasing concern. In this regard, urban greening is of primary interest because it provides numerous ecosystem goods and services which benefit humankind (Colding et al., 2006), a key one of which is biodiversity because it underpins many other ecosystem goods and services (Jim and Chen, 2009). The urban biodiversity also enables urban inhabitants to interact with nature, thereby enhancing appreciation and understanding of the important ecological, social and psychological functions green areas perform.

The urban forest includes vegetation along streets, in parks, woodlots, remnant sites and residential areas, all of which may constitute a significant proportion of a nation's tree canopy (Alvey, 2006). Street trees, the focus of this article, play a vital role in the enhancement of human well-being given the social benefits and recreational opportunities they offer for inhabitants (Tyrväinen et al., 2005). They also promote economic benefits as it is well established that trees increase the value of houses that are in close proximity (Georgi and Dimitriou, 2010), as well as through the promotion of tourism and economic development by contributing to the quality and aesthetics of residential and working environments ([Tyrväinen et al., 2005] and [Chaudhry and Tewari, 2010]). From an aesthetic perspective, tree-lined streets are frequently regarded as important in providing “visual relief in concretized city settings” (Nagendra and Gopal, 2010). Street trees are also beneficial to street vendors through the provision of shade and thereby some protection from the sun and rain (Nagendra and Gopal, 2010). Although Nagendra and Gopal (2010) highlighted the critical role of street trees in urban environments, they also commented how they are often undervalued by urban planners and managers alike.

Securing the biodiversity, ecological, social and economic benefits offered by street trees is particularly challenging in developing countries because of rapid development and urbanisation (Jim and Chen, 2009). Investigation of the species diversity, abundance and distribution of street trees can be an important step towards biodiversity conservation within the urban setting (Jim and Chen, 2009). A recent study in Bangalore, India, suggested that data on tree distribution including species composition, size and age structure, and spatial inventories are essential to allow for more effective management of street trees and the biodiversity they represent (Nagendra and Gopal, 2010). The authors recorded 108 different species of street trees in Bangalore. While the diversity of species was higher than in most developing countries, the density was lower. This emphasises the potentially significant contribution of street trees to urban biodiversity.

Despite the growing acknowledgement of the importance of green spaces and trees in the urban environment, most of the research into, and understanding of, urban greening is centred on examples from the developed world, predominantly from European and North American countries. In the developing world, there is an unfortunate dearth of work, perhaps with the exception of China, with studies from urban areas such as Beijing (Li et al., 2005), and Guangzhou (Jim, 2004). The latter assessed the species composition of both urban and heritage trees, revealing the urgent need for better management and conservation thereof (Jim, 2004).

The situation in southern Africa is no different from the rest of the developing world. There is limited literature on urban greening, and even less on urban forestry, including street trees ([Stoffberg et al., 2008] and [Stoffberg et al., 2010]). McConnachie et al. (2008) assessed the extent of green space and alien plant species across ten small towns and found that there was a significant correlation between income levels and public green space provision. While Stoffberg et al. (2010) recently investigated the contribution of street trees to carbon sequestration in Tshwane, they did not comment on or assess the distribution or diversity of the trees involved. Despite the fact that South Africa celebrates Arbor Week each year, when individuals and institutions are encouraged to plant trees (Guthrie and Shackleton, 2006) there is no data on the extent, species diversity and contribution to habitability of towns.

Within most cities of the world wealthier neighbourhoods are contrasted by poorer ones which may also coincide with ethnic and other socio-economic differences. This is the case in South Africa (Lubbe et al., 2010), exacerbated by the legacy of the colonial and apartheid eras under which land ownership and occupation was racially segregated (McConnachie and Shackleton, 2010). Black Africans were restricted to living in racially defined suburbs locally termed ‘townships’ (Wilkinson, 1998), which were poorly serviced and dominated by relatively small, high-density ‘erven’ (lots). Poverty levels were high due to restrictions on employment opportunities. In contrast, whites resided in leafy, low density suburbs with adequate infrastructure. With the demise of the apartheid regime in the early 1990s the new government sought to address the severe backlogs created under apartheid (Wilkinson, 1998). There is now a vigorous program to deliver large numbers of low cost houses consisting of a single storey on a 40 m^2 foundation (Gilbert, 2004). This was part of the immediate post-apartheid national Reconstruction and Development Program (RDP), and hence these housing developments are locally termed ‘RDP houses’. In the last 10 years approximately two million RDP houses have been constructed (Dept of Housing, 2007), but large backlogs remain because of the high rates of influx of new urban migrants (Gilbert, 2004). Occupancy of RDP housing is reserved for the poor and indigent, with lists of eligible households maintained by local municipal housing departments.

In the broader context of urban greening, studies have revealed that in South Africa affluent suburbs generally have more public green spaces than poorer ones (McConnachie and Shackleton, 2010), as well as larger and more biodiverse gardens (Lubbe et al., 2010). This paper sought to ascertain whether such a pattern exists with regard to street trees, and if so, why. Consequently, the aim of this study was to determine and contrast the distribution, composition and abundance of street trees within selected Eastern Cape towns, and to understand the challenges and constraints faced by local municipal and town planning officials in providing for street trees.

Study sites

Situated in the south-eastern seaboard of South Africa, the Eastern Cape is the second largest province and occupies about 14% of the country (Statistics South Africa, 2004). The sites selected for this study were the towns of Port Alfred (33°36′S; 26°53′E), Grahamstown (33°18′S; 26°32′E) and Somerset East (32°43′S; 25°35′E) which are coastal, intermediate and inland towns of the Eastern Cape, respectively. The selection of these towns enabled a comparison of street trees with increasing distance from the coast with its associated declines in mean annual rainfall and increasing mean annual temperature. In other words, the three towns represent a gradient of potentially decreasing habitat congeniality for tree growth.

The climate within towns of the Eastern Cape varies with distance from the ocean. Coastal areas such as Port Alfred typically enjoy mild temperate conditions, with seasonal temperatures ranging between 14 and 23 °C; while inland areas such as Somerset East experience more extreme conditions, with seasonal temperatures ranging from 5 to 35 °C (State of the Environment in South Africa, 2004). Grahamstown and its surrounds have a moderate climate, with seasonal temperatures ranging from 9 to 23 °C. The hottest months are December to March while the coldest months are June and July. While most rainfall occurs in the summer months (October–April) the number of months with rains declines with increasing distance from the coast. The mean annual rainfall at Port Alfred is 688 mm, for Grahamstown 669 mm and 574 mm at Somerset East.

Grahamstown is the largest of the three towns with a total population of approximately 65,000, of which 77% reside in the township areas which are characterised by high-density low-cost housing as well as informal settlements. Port Alfred and Somerset East are smaller with total populations of approximately 20,000–25,000. Within each of the study towns there are clear socio-economic demarcations, partially a result of South Africa's apartheid past. Thus, there are affluent suburbs which were formally reserved for occupation by residents of European descent, townships previously designated for people of African descent and low-cost RDP suburbs developed by the post-apartheid, democratic government for poor communities (McConnachie and Shackleton, 2010). As one of the poorest provinces in the country (Statistics South Africa, 2004), the Eastern Cape is characterised by relatively high unemployment (>35%), low literacy rates and a high proportion of poorly paid employees (State of the Environment in South Africa, 2004).

Furthermore, there are marked differences in the primary economic bases of the selected towns. Port Alfred, situated on the coast, is a growing tourism centre, Somerset East is largely an agricultural service centre and Grahamstown is a historical and educational city and home to the local municipal offices.

Methods

Data collection

Street tree counts involved physical visits to each town to assess composition, size, health and diversity. Sample streets within each town were randomly selected by means of geographical information system (GIS). The surface area of each town was divided into the four zones, i.e. central business district (CBD), affluent residential, township and RDP, which allowed for a stratified sampling approach. Digitally ortho-rectified aerial photographs (1:30,000) were used to spatially capture the four zones in a GIS (ArcGIS 9.3). A master grid (100 m × 100 m) was created over each town. For each of the four zones, a subset was selected, from which a given sampling size (e.g. 20%) was randomly chosen. In each town, 30 transects were sampled per affluent residential and township area, and 10 per CBD. Fewer streets were sampled in the CBD due to the limited number of streets in each given their small size. Regarding the RDP streets, 30 transects were sampled in Grahamstown and Somerset East, however, only 15 were sampled in Port Alfred because of difficulties in differentiating between the township and RDP zones.

Within each of the randomly selected streets a 200 m sample transect (as used by Nagendra and Gopal, 2010) was denoted by a waypoint in ArcMap. The starting point for each transect within the sample street was the nearest road intersection to the relevant waypoint. For the 200 m transect all the trees on either side of the street were identified and assessed. Unknown species were assigned an interim name and a specimen collected and photograph taken for later identification at the Selmar Schonland herbarium (GRA, Grahamstown). Names of indigenous species follow Germishuizen et al. (2006) and alien species follow Glen (2002). Stem circumference was recorded at a height of 50 cm above ground level to accommodate younger or smaller trees. Tree health was recorded into one of five classes using a simple scale that was robust and with low operator variability which can be used by municipal officials in future (Table 1).

Table 1. Health score used in rating street trees in three Eastern Cape (South Africa) towns.

Score	Description
1	Tree is in near perfect health without any visible damage
2	Tree is reasonably healthy with 1 or 2 broken or damaged branches
3	Tree has a few branches that are broken or damaged but is still relatively healthy
4	Several branches are broken or damaged and the tree is clearly unhealthy
5	Tree is severely damaged and/or dying

Key informant interviews

A number of semi-structured, key informant interviews were conducted with the responsible municipal officials in each town to determine their views and perceptions on the manner in which street trees are selected and accommodated in the urban landscape, and the challenges they face in their establishment and maintenance. A range of questions were asked such as what type of street trees had been planted, whether sufficient consideration was given to urban greening by senior municipal officials and elected councillors, and what they felt were the biggest threats to the urban forest.

Data analysis

Preliminary data analysis was carried out using Microsoft Excel to calculate mean street tree density, circumference, height and health scores in each town. Species richness (the number of tree species per town and per 200 m transect) as well as the Shannon diversity index at the species level was calculated. The Shannon index is commonly used to characterise species diversity and accounts for both abundance and relative evenness of the species present. The Shannon index ranges from zero to infinity, increasing as the number of species increases, but typical values range from 1.5 to 3.5. The interview information was largely qualitative as there were relatively few planners and municipal officials per town. This qualitative data was summarised and used to help interpret the quantitative tree data.

All statistical data analysis was executed in Statistica 9 (Statsoft, Tulsa, OK, USA). A non-parametric Kruskal–Wallis test was undertaken to determine whether there were significant differences between the three town and suburbs with reference to mean tree density, size and state of health score. Where differences were observed post hoc tests using the least significant difference were performed.

Results

Distribution of street trees per town

Within the 285 sample transects a total of 1,485 street trees were enumerated, with 292 in Port Alfred, 616 in Grahamstown and 577 in Somerset East. A total of 61 species were encountered, of which 46 were identified to the species level. Certain alien trees were only identified to the genus level, namely *Acacia*, *Bauhinia*, *Eucalyptus*, *Euphorbia*, *Melia* and *Pinus* sp., with two species identified to the family level (*Fabaceae* and *Palmaceae*). The highest number of street trees encountered in a single 200 m transect was 38 in Port Alfred, 50 in Grahamstown and 36 in Somerset East. Many transects had no street trees; 22% in the affluent residential, 40%o f the CBD transects and 90% of sample transects in the township and RDP suburbs.

Attributes of street trees between towns

There was no significant difference ($H = 1.60$; $p = 0.4487$) in the mean density of street trees per transect between the three towns, ranging from 3.3 ± 6.6 at Port Alfred to 6.2 ± 11.0 in Grahamstown (Table 2). Mean tree height was relatively uniform across the three towns, being just over 6 m. There was a significant difference, however, in mean stem circumference ($H = 29.02$; $p < 0.0001$), with trees in Somerset East having significantly narrower stems than at either of the other two towns, which were not significantly different to one another. Somerset East also fared the worst with respect to mean health score being significantly lower than the mean score in Port Alfred, but not Grahamstown. In general, the mean health score indicated that most of the trees were in a reasonably healthy condition.

Table 2. Attributes of street trees in Port Alfred, Grahamstown and Somerset East (Eastern Cape, South Africa).

Street tree attributes	Port Alfred	Grahamstown	Somerset East	Significance
Mean tree density (per 200 m transect) ± SD	3.3 ± 6.6	6.2 ± 11.0	5.8 ± 9.7	$p > 0.05$
Range of tree density (per 200 m transect)	0–38	0–50	0–36	–
Mean circumference (cm) ± SD	158.4 ± 103.3	144.3 ± 75.7	124.6 ± 43.9	$p < 0.0001$
Mean height (m) ± SD	6.4 ± 2.0	6.4 ± 2.0	6.5 ± 1.4	$p > 0.05$
Mean health score ± SD	2.5 ± 0.7	2.4 ± 0.6	2.3 ± 0.6	$p < 0.0001$
Species richness (no. of species per town)	25	39	27	–
Shannon diversity index	2.1	2.9	2.3	–

Composition of street trees per town

Species richness was highest in Grahamstown, with a total of 39 different species recorded, compared to 25 in Port Alfred and 27 in Somerset East (Table 3). In Port Alfred, the most common tree species was *Erythrina caffra* (coastal coral), representing 43% of the total sample. The most common species in Grahamstown was *Grevillea robusta* (silky oak), representing 16% of the total sample, and in Somerset East it was *Jacaranda mimosifolia* (jacaranda), representing 33% of the total sample. The greater density and species richness in Grahamstown resulted in a higher Shannon diversity index than in Port Alfred or Somerset East.

Table 3. Street trees species encountered in three Eastern Cape (South Africa) towns.

Scientific name	Indigenous/alien	Port Alfred	Grahamstown	Somerset East
Acacia karroo Hayne	i	–	0.8	2.4
Acacia sp.	a	–	1.5	–
Acacia xanthophloea Benth.	i	1.4	–	0.2
Araucaria heterophylla (salisb.) Franco	a	1.7	0.2	–
Bauhinia sp.	a	0.3	0.2	0.2
Brachychiton acerifolium (A.Cunn.) F. Muell.	a	–	11.5	–
Brachychiton populneum (Schott & Endl.) R.Br.	a	–	2.9	0.3
Brachylaena discolour DC.	i	1.7	–	0.2
Calodendrum capense (L.f.) Thunb.	i	–	1.0	–
Calpurnia aurea (Ait.) Benth.	i	–	0.2	–
Celtis africana Burm.f.	i	–	3.6	0.7
Celtis sinensis Pers.	a	–	–	0.3
Ceratonia siliqua L.	a	–	1.8	0.2

Scientific name	Indigenous/alien	Port Alfred	Grahamstown	Somerset East
Clerodendrum glabrum E.Mey.	i	0.3	–	–
Dais cotinifolia L.	i	–	0.3	–
Diospyros dichrophylla (Gand.) De Wint	i	0.3	–	–
Erythrina caffra Thunb.	i	42.6	5.4	0.5
Eucalyptus sp.	a	–	1.1	–
Eucalyptus X	a	0.7	3.3	3.1
Eugenia myrtifolia (Gaertn.) Britt.	a	0.3	–	–
Euphorbia sp.	a	0.7	–	–
Fabaceae	a	–		1.6
Ficus burtt-davyi Hutch.	i	0.3	0.2	–
Ficus cf. nitida Thunb.	a	–	0.7	–
Grevillea robusta A. Cunn.	a	–	15.8	–
Harpephyllum caffrum Bernh.	i	5.2	4.2	8.1
Jacaranda mimosifolia D.Don	a	0.3	12.5	33.4
Kiggelaria africana L.	i	–	0.3	–
Lagunaria patersonii (Andr.) G.Don	a	–	0.3	0.7
Ligustrum lucidum Ait.	a	0.7	–	0.7
Liquidumbar styraciflua L.	a	–	0.2	–
Melia azedarach L.	a	5.2	5.7	0.5
Melia sp.	a	0.3	0.2	–
Olea europaea subsp. *africana* Mill.	i	–	0.2	9.9
Palmaceae	a	0.3	–	–
Pinus sp.	a	8.9	1.0	0.3
Platanus occidentalis L.	a	–	1.1	9.0
Podocarpus falcatus (Thunb.) R.Br. ex Mirb	i	–	8.0	–
Podocarpus latifolius (Thunb.) R.Br. ex Mirb	i	–	0.2	–
Populus deltoids Bart. ex. Marsh	a	–	0.2	–
Quercus palustris Muenchh.	a	–	0.2	–
Quercus robur L.	a	–	6.3	4.2
Rhus lancea L.f.	i	0.3	2.1	0.7
Rhus lucida L.	i	–	0.3	–
Schinus molle L.	a	–	0.5	0.5
Schinus terebinthifolius Raddi.	a	10.0	4.6	0.3
Schotia brachypetala Sond.	i	–	0.2	–
Schotia latifolia Jacq.	i	6.2	–	–
Sideroxylon inerme L.	i	7.2	–	–
Syzygium cordatum Hochst.	i	3.1	–	–
Thuja occidentalis L.	a	–	–	0.3
Tipuana tipu (Benth.) Kuntze	a	–	0.2	2.9
Trichilia dregeana Sond.	i	0.3	–	–
Ulmus parvifolia Jacq.	a	–	–	14.9

Scientific name	Indigenous/alien	Port Alfred	Grahamstown	Somerset East
Unknown (7 species)		1.4	1.8	3.6

Table 4 shows the top five species per town, expressed as a percentage of the total number of trees sampled in each town. In Port Alfred, Grahamstown and Somerset East the five most common species accounted for 75%, 55% and 75%, respectively, of the total population of trees sampled. Overall, the majority (56%) of identified street trees encountered were alien in each town. The percentage of indigenous species was 42% in Port Alfred, 41% in Grahamstown and 26% in Somerset East. Three of the top five species in Port Alfred were indigenous, two at Somerset East and only one of the top five species in Grahamstown.

Table 4. The five most common street tree species in Port Alfred, Grahamstown and Somerset East (Eastern Cape, South Africa).

Town	Rank	Scientific Name	Indigenous/alien	%
Port Alfred	1	*Erythrina caffra* Thunb.	i	43
	2	*Schinus terebinthifolius* Raddi.	a	10
	3	*Pinus* sp.	a	9
	4	*Sideroxylon inerme* L.	i	7
	5	*Schotia latifolia* Jacq.	i	6
		Total		75
Grahamstown	1	*Grevillea robusta* A. Cunn.	a	16
	2	*Jacaranda mimosifolia* D.Don	a	13
	3	*Brachychiton acerifolium* (A.Cunn.) F. Muell.	a	12
	4	*Podocarpus falcatus* (Thunb.) R.Br. ex Mirb	i	8
	5	*Quercus robur* L.	a	6
		Total		55
Somerset East	1	*Jacaranda mimosifolia* D.Don	a	33
	2	*Ulmus parvifolia* Jacq.	a	15
	3	*Olea europaea* subsp. *africana* Mill.	i	10
	4	*Platanus occidentalis* L.	a	9
	5	*Harpephyllum caffrum* Bernh.	i	8
		Total		75

Distribution of street trees between suburbs

Of the 292 trees encountered in Port Alfred, 77% were located within the affluent residential areas. Similarly, in Grahamstown and Somerset East, 80% and 70% of trees, respectively, were located in the affluent residential areas. In all three towns, around 20% of trees sampled were found in the CBD. In contrast, with the exception of Somerset East, the township and RDP areas contained less than 5% of the encountered trees.

Attributes of street trees between suburbs

While differences in tree density, size and health were not significant between towns, this was not the case when comparing street trees between suburbs (Fig. 1). A key finding of this study was the virtual absence of street trees in the poorer township and RDP areas. Overall, there was a significant difference in tree density between suburbs ($H = 141.72$; $p < 0.0001$), with the CBD and affluent residential suburbs having a higher density than the township and RDP suburbs.

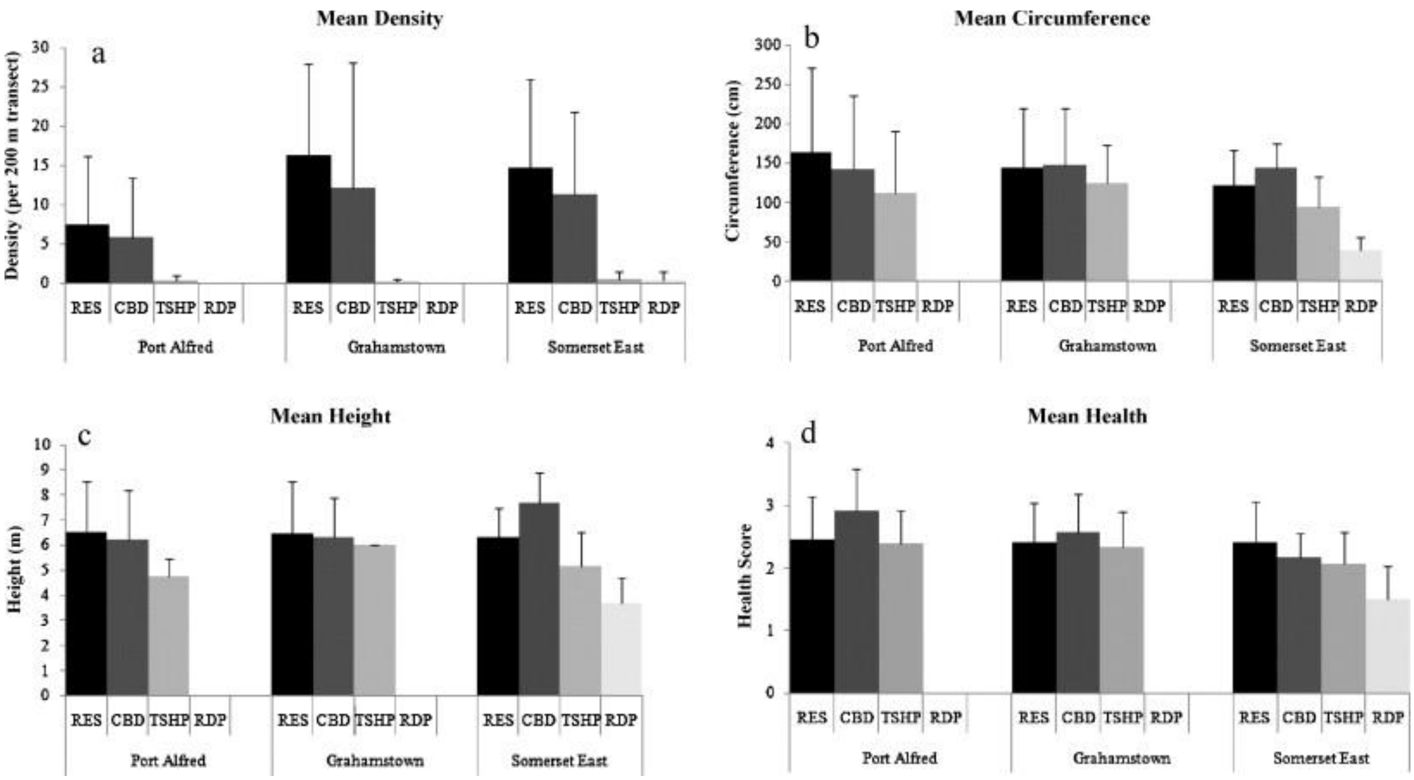

Fig. 1. Attributes of street trees per suburb in three Eastern Cape (South Africa) towns (RES = affluent residential; CDB = commercial; TSHP = township residential; RDP = Reconstruction and Development Program).

Differences in tree circumference were also significant ($H = 37.09$, $p < 0.0001$). In terms of size, the majority (58%) of trees encountered in the affluent residential and CBD had circumferences between 100 cm and 200 cm. In comparison, the majority (63%) of trees encountered in the township and RDP areas had circumferences less than 100 cm. There were also significant differences in tree height ($H = 55.02$, $p < 0.0001$) as well as health ($H = 22.05$, $p < 0.0001$) between suburbs.

In each suburb, the number of tree species within the 200 m transect varied considerably, with the greatest species richness in the affluent residential and CBD, with 3–6 species (Fig. 2). In contrast, the few roads with trees in the township and RDP areas tended to contain only one or two species.

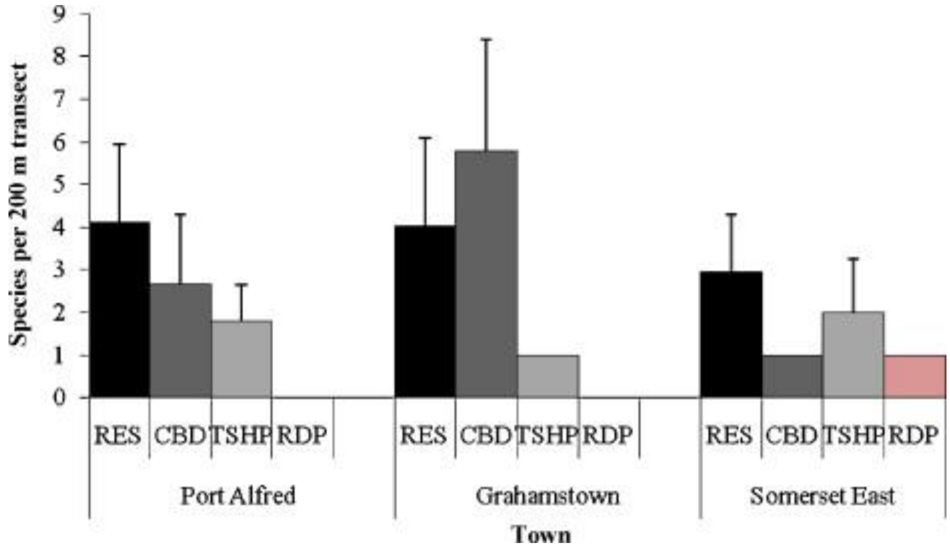

Fig. 2. Mean number of species per 200 m transect per suburb in three Eastern Cape (South Africa) towns.

Challenges of street tree establishment and maintenance

In terms of the establishment and maintenance of street trees, the key challenges and constraints faced by municipal officials in each town varied but generally pertained to limited funds and a lack of skilled personnel. This was particularly pertinent in Port Alfred and Grahamstown, both of which are rapidly growing towns, but the budget allocation for greening and street trees does not keep apace. Additionally, most felt that the importance of street trees in ameliorating some of the effects of climate change was not receiving sufficient attention in their respective local councils. The biggest threats to the urban forest differed in each town but common threats identified were alien tree species, development and illegal removal of trees by residents.

In each of the towns, the street trees were mostly composed of mature individuals. Officials felt that the condition of trees, whether planted on sidewalks or in natural forests, had declined over the last couple of decades. Port Alfred is mostly characterised by coastal evergreen trees and few trees have been planted in recent years as there is more focus on maintaining existing trees, such as those outside of private residences or public buildings. In contrast, officials in Somerset East and Grahamstown reported that most of the street trees are deciduous; though in certain cases (e.g. Somerset East) small ornamental trees were planted. In all three towns, there was a strong preference for planting indigenous trees given the high percentage of alien species which were planted in the past.

All three towns had monitoring and maintenance program in place which involved watering of trees until they are well established, sweeping of leaves especially during autumn, pruning and trimming, and regular checking. Yet none had database systems capturing the monitoring data. The officials felt that citizens in their towns definitely valued street trees and were very aware of their aesthetic value.

Discussion

The objective of this study was to examine how various attributes of street trees compared between towns and suburbs. Recognising that the three towns were located along a gradient of decreasing congeniality for tree growth from the coast inland it was instructive that although street trees are largely established and maintained by human agency that the influence of the broader abiotic attributes were evident in the nature and size of trees. Somerset East had the smallest trees in terms of circumference and also a significantly lower health score than the other two towns. Port Alfred had the highest on both these measures, with Grahamstown being intermediate between the two. The harsher growing environment at Somerset East meant that there was a narrower range of indigenous species that could be planted there (only eight of the 34 species encountered), and consequently it had a markedly higher proportion of alien species relative to the other two towns. The total species number was highest in Grahamstown, probably a reflection of its longer history of settlement than the other two towns, as well as it being significantly larger, the seat of local government and perhaps also because it has a botanical garden which was established over 100 years ago.

The differences in street tree abundance and composition within towns were greater than those encountered between towns. The affluent residential areas and CBD had significantly higher tree densities than either of the poorer township or RDP suburbs. Most (90%) of the sampled streets in the township and RDP suburbs had no trees at all, compared to only 22% in the affluent residential and 40% in the CBD. On average, the streets sampled in the affluent and CBD areas had 4–6 species per transect compared to 0–2 in the township and RDP streets. Species richness in Bangalore, India, was around five species per 200 m transect (Nagendra and Gopal, 2010). The lower abundance of street trees in the poorer township and RDP areas mirrors the lower availability of public green space in general and per capita for these same towns as reported by McConnachie and Shackleton (2010). This is opposite to the findings of Barbosa et al. (2007) who reported that the more deprived groups and the elderly had better access to public green space in Sheffield (UK).

Thaiutsa et al. (2008) found that while there may be a large species richness of street and heritage trees in a specific city that typically only a few species dominate. The findings of our study indicate the same, with the five most abundant species contributing 75% of the trees at Port Alfred and Somerset East, and 55% in Grahamstown. Although the highest number of trees encountered in a single 200 m transect was 50 (in Grahamstown) there were only two species in that sample (*Brachychiton acerifolium* and *Jacaranda mimosifolia*). While Nagendra and Gopal's (2010) study suggested that low tree density can yield high diversity, the opposite is evident here since diversity was low and density was high. In the few instances where trees were encountered in the township and RDP areas, both density and diversity were low, which has also been found to be the case in private gardens in South Africa (Lubbe et al., 2010). For example, all of the trees encountered in the Somerset East RDP area were of a single species (*Acacia karroo*). Furthermore, their small size and sporadic location implied that they were relatively young, and were likely to have sprouted on their own, rather than directly planted by municipal workers.

The low abundance, and in many instances absence, of street trees in the township and RDP areas is cause for concern. Without a doubt, the legacy of South Africa's racially segregated apartheid era partially explains the apparent neglect of the township areas ([Lubbe et al., 2010] and [McConnachie and Shackleton, 2010]). In addressing the disparities between affluent and township areas, most studies have focused on aspects such as housing, sanitation, water and health. Few South African studies have dealt with the environmental dimensions of urban green space and forestry with respect to the low cost housing areas, therefore, this study sheds some light in this regard. Interestingly, one of the interviewed officials responded that there was no intentional neglect of township and RDP areas, but that newly planted trees were persistently vandalised. This claim requires further investigation, as does the possible damage by livestock in these areas. Nonetheless, officials in each town acknowledged the need to place more focus on greening the low income township and RDP suburbs. Greening programs in these suburbs also pose other challenges which are more acute than in more established and affluent suburbs, including higher rates of in-migration, the demand for new and upgraded infrastructure which can disrupt or totally replace planted trees, poverty and the presence of livestock. Many of these are common in developing nations (Ansari, 2008; also unpublished material by Shackleton), along with weak planning skills or implementation.

Almost 60% of the street trees encountered were alien species. Most of these alien species were mature trees, indicating that they were planted decades ago, before the concern with promoting indigenous biodiversity became mainstream. This is not uncommon in towns and cities of developing countries, especially in the older suburbs, as colonial officials actively introduced alien species between countries (Nagendra and Gopal, 2010). In Bangalore, India, Nagendra and Gopal (2010) reported that 67% of the street trees were alien to India. Melbourne in Australia had a lower proportion of alien species, but at 40% they are still a significant component of the local street tree composition (Frank et al., 2006). Municipal officials in each town were well aware of predominance of alien species and all were now promoting indigenous species when planting new street trees.

A bigger concern expressed by the planners and municipal officials was the lack of adequate resources for the establishment and maintenance of street trees, and that this rarely kept pace with growth of the town. It is clear that street habitats do not offer the most desirable conditions for plant life for a number of reasons including reduced rainfall infiltration due to the large area of paved surfaces, and limited soil volume which may confine and stifle root growth (Jim and Chen, 2008), both of which may lead to a greater probability of drought stress and reduced tree health (Milton Keynes Council, 2009). As a result, street trees may often require more frequent maintenance, highlighting the need for appropriate planning and management, which is difficult when financial resources are limited. For example, during the recent FIFA 2010 International Soccer World Cup hosted by South Africa, the national Department of Environmental Affairs promoted a greening of the World Cup campaign. Most municipalities were provided with approximately 500 indigenous trees to be planted in and along the approaches to each town. However, 6 months after the event municipal officials in Port Alfred reported that the trees were yet to be planted, due to the shortage of staff for maintenance. The trees that Grahamstown received were planted, but 8 months later a large proportion had died because they were not watered because the municipal water tanker had been diverted to other purposes.

Biodiversity in towns and cities provides various social and biological functions to residents, and may be regarded as one of the ecosystem services provided by green spaces (Alvey, 2006). Thus, the gathering of attribute data on street trees is useful because it can be fed into the broader context of biodiversity conservation in urban settings. Such information is essential for effective management of trees in urban areas. For example, the data can be used to make recommendations on the types of species that should or should not be selected in order to increase and maintain biodiversity and promote environmental sustainability within towns and cities. In order to ensure that biodiversity is maintained in an increasingly urbanised world, assessment of the distribution, composition and abundance of street trees, as well as those in urban parks, remnant patches and private gardens is a necessary and valuable exercise (Gaston et al., 2005). Thus, this study also sought to provide some insight into the contribution of street trees to urban biodiversity.

Conclusion

The valuable role played by urban green spaces and trees in terms of the ecological, social, aesthetic and psychological benefits they offer is well known. However, in the South African developing world context, represented by the three towns in this study, the establishment and maintenance of street trees currently cannot compete with pressing socio-economic demands for housing and infrastructure backlogs. This is most stark in the newer RDP areas, which focus on housing provision, but not the greater environment in which the houses are situated and the wellbeing of the residents living there. The disparities between the affluent residential suburbs and the disadvantaged township and RDP areas require urgent attention from policy makers and planners.

This study has shown that the macro-environmental context influences the size, health and diversity of the street trees, but management plans and actions can override these as demonstrated by the markedly different density and diversity in different suburbs, and the contrasting ratios of alien and indigenous species. The highest variety of species was recorded in Grahamstown, perhaps due to its greater size as well as its longer history.

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