Urban Forestry & Urban Greening 9 (2010) 129–137

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.de/ufug

Street trees in Bangalore: Density, diversity, composition and distribution

Harini Nagendra [a,b,*], Divya Gopal [a]

[a] Ashoka Trust for Research in Ecology and the Environment (ATREE), Royal Enclave, Srirampura, Bangalore 560064, Karnataka, India
[b] Center for the Study of Institutions, Population, and Environmental Change (CIPEC), Indiana University, 408 N. Indiana Ave., Bloomington, IN 47408, USA

ARTICLE INFO

Keywords:
Avenue trees
Cities
Green spaces
India
Urban biodiversity
Urban ecology

ABSTRACT

Once renowned as India's ''garden city'', the fast growing southern Indian city of Bangalore is rapidly losing tree cover in public spaces including on roads. This study aims to study the distribution of street trees in Bangalore, to assess differences in tree density, size and species composition across roads of different widths, and to investigate changes in planting practices over time. A spatially stratified approach was used for sampling with 152 transects of 200 m length distributed across wide roads (with a width of 24 m or greater), medium sized roads (12–24 m) and narrow roads (less than 12 m). We find the density of street trees in Bangalore to be lower than many other Asian cities. Species diversity is high, with the most dominant species accounting for less than 10% of the overall population. Narrow roads, usually in congested residential neighborhoods, have fewer trees, smaller sized tree species, and a lower species diversity compared to wide roads. Since wide roads are being felled of trees across the city for road widening, this implies that Bangalore's street tree population is being selectively denuded of its largest trees. Older trees have a more diverse distribution with several large sized species, while young trees come from a less diverse species set, largely dominated by small statured species with narrow canopies, which have a lower capacity to absorb atmospheric pollutants, mitigate urban heat island effects, stabilize soil, prevent ground water runoff, and sequester carbon. This has serious implications for the city's environmental and ecological health. These results highlight the need to protect large street trees on wide roads from tree felling, and to select an appropriate and diverse mix of large and small sized tree species for new planting.

Introduction

There is increasing recognition of the fact that cities constitute a new type of environment with species compositions and habitats peculiar to urban-industrial areas. City residents interact with trees in diverse ways, and trees are found to be located in parks, along streets, near waterways, planted in home gardens, commercial zones, and protected in sacred locations. Of these, tree lined avenues have come to constitute one of the most significant visual features of green space in urban landscapes, becoming a standard feature in most European cities and those colonized by European settlers, by the mid-19th century (Lawrence, 1994).

The list of benefits provided by street trees is long and diverse. Tree lined streets provide much-welcomed aesthetic beauty and visual relief in concretized city settings, and supply a range of psychological, social and economic benefits for residents and businesses including reductions in domestic violence, lowering of obesity, higher property values, reductions in asthma levels, traffic speeds, and auto accidents, and overall improvements in human well-being and community vitality (Wetter et al., 2001; Maco and McPherson, 2003; Dumbaugh, 2005; Wolf, 2005). Especially critical in sub-tropical and tropical climates, street trees protect pedestrians from the sun and the rain, and provide critical spaces and shelter for street vendors. While street trees may constitute only a small fraction of green cover in most cities, wooded streets constitute the most accessible green spaces for the vast majority of low to medium income city dwellers who lack access to other green spaces in residential and commercial areas (Heynen et al., 2006), thus playing an extremely significant and irreplaceable role in urban lives.

Other, equally significant ecological and environmental benefits are provided by street trees. Wooded streets constitute important habitats for birds and other urban taxa in urban landscapes, and provide critical landscape connectivity by acting as corridors between urban parks (Fernandez-Juricic, 2000). Street trees and other urban trees play a significant role in lowering urban temperatures and mitigating the intensity of urban heat island effects (Chow and Roth, 2006), thereby providing significant savings in electricity (McPherson et al., 1997; Maco and

* Corresponding author at: Ashoka Trust for Research in Ecology and the Environment (ATREE), Royal Enclave, Srirampura, Bangalore 560064, Karnataka, India. Tel.: +91 80 23636555; fax: +91 80 23530070.
E-mail address: nagendra@indiana.edu (H. Nagendra).

1618-8667/$ - see front matter © 2009 Elsevier GmbH. All rights reserved.
doi:10.1016/j.ufug.2009.12.005

McPherson, 2003). These trees help in reducing storm water runoff, thus reducing the likelihood of flooding and damage to urban properties (McPherson et al., 1997). They act as noise filters, purify air and sequester carbon. Further, due to their proximity to traffic and consequently to higher loads of atmospheric pollutants, street trees are likely to capture higher amounts of particulate matter, carbon dioxide, ozone and other air pollutants than trees located in parks and green spaces distant from traffic, thus contributing more significantly in reducing atmospheric pollution in the city (McPherson et al., 1997; Beckett et al., 2000).

Yet, despite extensive evidence of the critical role played by street trees in city environments, urban planners and managers have often undervalued the role played by street trees. Street-side trees are often the first to be sacrificed when infrastructural developments such as road widening take place, especially in fast growing cities. City managers are concerned about the possible hazards posed by street trees to traffic management and pedestrian safety, and often unwilling to spend money on the maintenance and renewal of trees on city streets (Pauleit, 2003; Dumbaugh, 2005). Roadside trees are also especially subject to stresses due to their proximity to atmospheric pollutants, poor drainage, inhospitable soil, and lack of space for growth (Ware, 1994; Jim, 1999; Thaiutsa et al., 2008).

For more effective long term management of street trees, it is essential to have data on tree distribution including species composition, size and age structure, and spatial inventories. Such information is also useful for urban managers seeking to maximize the environmental benefits provided by street trees, as factors such as species composition, size, canopy, and age structure critically impact the environmental functions of these trees (Maco and McPherson, 2003). Yet, in many developing countries, forest managers in charge of maintaining urban tree populations do not have the knowledge necessary for appropriate species selection, care and maintenance (Chacalo et al., 1994), and lack information on street trees including basic data such as city street surveys (Escobedo et al., 2006; Alvey, 2006; Jim and Chen, 2008). This is especially true, sadly, of many Asian cities despite the fact that these constitute some of the most densely populated parts of the world (Jim and Chen, 2008). The few Asian cities that have been studied in this regard mostly come from South East and East Asia, with little published research from South Asia.

This study aims to fill a critical gap by surveying street tree distribution in the fast growing southern Indian city of Bangalore. Embodying concepts of both "high-tech" and "green", the garden city of Bangalore – which can trace its history as far back as 900 AD – is now the second fastest growing city in India, with a growth rate of 38% between 1991 and 2001 and a population of over 7 million (Sudhira et al., 2007). Once known as the garden city of India, the city was famous for its tree lined avenues, but these have come increasingly under threat, with large sections of roads having been cleared in recent years for road widening, amongst numerous protests by local citizens (Nair, 2005; Sudhira et al., 2007). One preliminary study by Sudha and Ravindranath (2000) on the diversity of the urban forest in Bangalore provides some initial information indicating that there appear to be visual differences in the street tree species planted in different socio-economic parts of the city. More detailed information on the diversity and distribution of street trees can be significant for urban managers.

The objectives of this study are four-fold. Our first goal is to provide basic information on the diversity and distribution of street trees in Bangalore. Second, we examine differences in the distribution of trees in different parts of the city, specifically, we look at wide, medium width and narrow roads to examine if there are differences in tree density, species distribution and age/girth distributions across road categories, while narrow streets are located in areas that are primarily residential, with greater pedestrian traffic and low hanging electric and telephone poles. The criteria used for selection of trees for planting, as well as the management practices, can be quite different in differently sized roads. Wide roads tend to be located away from residential areas, and have fewer obstacles such as overhanging electrical or cable wires, are not as close to residential homes, and have lower densities of pedestrian traffic, all of which can lead to frequent tree pruning. These roads tend to be planted on both sides and in the median. In contrast, narrow roads tend to be located in residential areas, where there may be less space available on already narrow sidewalks for trees, and a preference for smaller sized fruiting or flowering species, with greater pruning of tree branches that create obstructions for overhanging wires, nearby houses, and pedestrian traffic.

Thus, different road categories can be expected to differ in the density, diversity, distribution and composition of street trees. Third, we investigate whether planting practices have changed over time, by examining the size distributions of the ten most dominant tree species as a proxy for age. Finally, the information gathered on tree distribution, diversity and density is compared with the information from other cities, and used to provide reccomendations for urban managers and planners.

This study is part of a larger project on urban biodiversity in Bangalore, which includes ongoing studies on biodiversity in parks, home gardens, religious institutions, educational institutions and other parts of the city with extensive green cover. All data will eventually be provided to the interested public including city planners and urban researchers, but also urban activists, students, educators, and the interested public in a publicly accessible spatial database that overlays biodiversity information onto high resolution satellite imagery.

Methods

Field studies of street tree diversity and distribution were conducted from November 2007 to April 2008. The data was collected with the assistance of students from St. Josephs College of Arts and Science, one of the city's oldest undergraduate colleges. The Outer Ring Road, a large road that circumscribes the majority of the city's roads was used to define the limits of the area within which sampling was conducted. A 1:50,000 scale 2002 Bangalore Guide Map prepared by the Survey of India was used to spatially distribute sampling locations. The map was divided into 1 km^2 grids, with each alternate grid selected for sampling. Given the rapidity at which urban land use and history are changing in the city, such a spatially distributed approach to sampling enables us to cover a range of localities with different urban histories, land uses and planting conditions, to the extent that these differences are present in the city.

A wide road (24 m or greater width), a medium road (between 12 and 24 m) and a narrow road (less than 12 m) were randomly selected for sampling within each grid using the following procedure. Within each grid, a random point was generated for each category of road width. The road junction corresponding to a road of the specified width that was located nearest to the randomly generated point was identified with reference to a Bangalore city map. From this junction, in a randomly selected direction, a transect of 200 m in length was identified. If the road did not extend for 200 m at this point, the next junction located closest to the random point was then selected, and the above procedure was repeated to identify an alternate transect for sampling.