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Predicting the growth in tree height and crown size of three street tree species in the City of Tshwane, South Africa

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Abstract

The aim of the study was to determine the relationships between tree age and various parameters of tree size in order to develop models to predict the growth of street trees. Three indigenous species, *Combretum erythrophyllum, Searsia lancea* and *Searsia pendulina* commonly used as street trees in South Africa were the focus of this study. The relationship between tree height and age, crown height and age, as well as crown diameter and age for all three species were investigated. The logarithmic function provided a good fit to the data on age against tree height ($r^2 = 0.73$, 0.66 and 0.67 for the three species) and age against crown diameter ($r^2 = 0.74$, 0.75 and 0.69 for the three species) whereas the fit for age against crown height was slightly poorer ($r^2 = 0.74$, 0.54 and 0.59 for the three species). The logarithmic equations derived for the three species were applied to predict tree height at different ages and growth rates for different time intervals. A comparison between the species revealed that *C. erythrophyllum* starts with a mean annual tree height growth rate of 912 mm yr^{-1} for the first 5 years of growth while that of *S. lancea* is 786 mm yr^{-1} and *S. pendulina* 894 mm yr^{-1}. However, *S. pendulina* and *C. erythrophyllum* have the same mean annual growth rate for the 5–10 years (467 mm yr^{-1}) and 10–15 years periods (315–317 mm yr^{-1}). Both mean annual crown height and crown diameter growth rate consistently ranked the species in the order of *C. erythrophyllum* > *S. lancea* > *S. pendulina*.

Keywords: Allometry; Tree dimensions; Urban forests

Introduction

Available information on dimensional relationships of commonly propagated urban trees is usually based on personal observations and often lacks extensive scientific validation. The observations are based on perceptions of rates at which trees grow (Kirsten and Meyer, 1992; Joffe, 1993). Subjective terms such as *slow*, *moderate*, *quick* or *fast* are used to describe tree growth without these terms being substantiated with quantitative values. In contrast, the results presented here may be used to model dimensional growth of three street tree species with statistical methods and were derived from measurements of 282 street trees.

Apart from the urban ecological functions that urban trees fulfill, they are also used in a landscape architectural context to derive spatial and aesthetic functions (Grey and Deneke, 1978; Arnold, 1980; Larsen and Kristoffersen, 2002). Urban and landscape architectural tree planting demands knowledge of *inter alia* tree height and crown growth. Planning tree spacing and tree positioning in relation to structures can be improved

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with more accurate information on tree growth. Furthermore, accurate information of tree crown growth may provide more realistic and better landscape architectural planting designs (Larsen and Kristoffersen, 2002).

Qualitative growth information on South African indigenous trees that are suitable for urban forestry is exceptionally limited. The aim of the research presented here was therefore to determine the relationships between tree height and age, crown height and age, crown diameter and age as well as that of crown base height and age for three commonly used street trees and to use these relationships to predict tree growth.

The three species that were selected for this study, *Combretum erythrophyllum* (Burch.) Sond., *Searsia lancea* (L.f.) F.A.Barkley and *Searsia pendulina* (Jacq.) Moffett, are all indigenous to South Africa (Joffe, 1993; Van Wyk and Van Wyk, 1998) and commonly used as street trees in the City of Tshwane. A literature search revealed no information pertaining to these species' dimensional growth over time in an urban *or even* natural setting, which renders additional significance to the research presented.

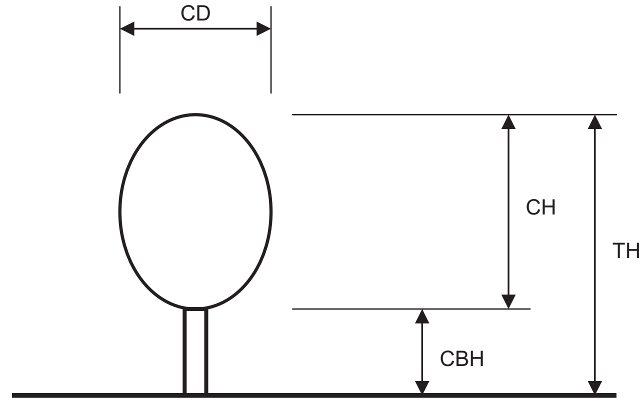

Fig. 1. The dimensions measured for each tree: tree height (TH), crown height (CH), crown base height (CBH) and crown diameter (CD).

Methods

The street trees were measured in the winter and early spring (April–September) of 2002 in the City of Tshwane (previously Pretoria), Gauteng Province, South Africa. The measurements were made between the suburbs Doornpoort (Ovenbush Street: 25°39′08.7″S–28°15′21.7″E) in the north and Erasmuskloof (Piering Street: 25°50′04.7″S–28°14′58.3″E) in the south, as well as between Pretorius Park (Pretoria East Cemetery: 25°49′36.2″S–28′19′20.8″E) in the east and Pretoria North (Brits Street: 25°40′40.8″S–28°09′05.4″E) to the west of the city. The tree height, crown base height (height from the ground to the lowest leaves of the crown) and crown diameter were measured with a graduated 3 m range pole (Fig. 1). Crown diameter measurements were taken in two directions, one parallel and the other perpendicular to the centre line of the road. The mean of the two measurements was used to calculate the diameter.

The measured trees were planted between 1955 and 2001 and their ages were derived from the planting dates obtained from the City of Tshwane Metropolitan Municipality (Municipality). The planting dates refer to the date at which the trees were physically planted in the streets. Planting dates for trees planted prior to 1995 were obtained from aerial photographs and personal communication with botanical and horticultural staff, since the Municipality kept planting date records only from 1995. In the past, the policy was to plant mostly exotic street trees. This rendered it difficult to find old individuals, of the species investigated, of which the age was known. Therefore, two sets of trees from parking lots were incorporated into this study. They are tree sets measured for *S. lancea* and *S. pendulina* with planting dates of 1970 and 1987, respectively. The tree age distribution of a species depended on the planting strategy of the Municipality. This strategy did not dictate a definite number per species to be planted each year within the city, which resulted in data that were not evenly distributed per tree age.

The selection of the largest individual street trees during data gathering for statistical analysis can easily result in biased data, which could artificially inflate predictive regression estimates (Clark and Clark, 2000). The problem was avoided in the current study by stratified random sampling. Apart from the necessary stratified age distribution, the streets were selected at random within each age group and the selection of trees in the streets was also performed at random. Trees with obvious defects that could have hampered growth or trees with growth abnormalities were not measured.

The aim was to collect data for 10 individual trees per street, which also results in 10 measurements per age group since all the trees in a street were planted at the same time. Of the 282 trees measured, 105 were *C. erythrophyllum* (river bushwillow) covering an age range from 1 to 47 years, 107 *S. lancea* (karee) with an age range from 1 to 32 years and 70 *S. pendulina* (white karee) with an age range of 3–15 years. Tree ages are taken in years since they were planted in the streets, due to certain instances of uncertainty of the age of the saplings when planted in the streets.

The majority of the measured street trees grew in non-irrigated, managed lawn residential environments. The average tree-to-curb distance and road reserve width were 2.1 and 6.5 m, respectively. The mean planting