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Applications of the crown diameter–stem diameter relationship for different species of broadleaved trees

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Abstract

There is a well known but comparatively little-studied relationship between crown diameters (*K*) and stem diameters (*d*) of trees. Between about 20 and 50 cm dbh the relationship is very close to being linear, with an r^2 value higher than 0.8. The investigation described in this paper was conducted to establish the relationships for 11 broadleaved species that are commonly grown in Britain.

The results indicated that all species have higher *K*/*d* ratios when they are young, but the ratio reduces as stem diameter increases, beginning to stabilize around 30 cm dbh. Of the species investigated, walnut (*Juglans regia*) had by far the highest ratio when young, but other strongly light-demanding species, such as birch (*Betula pendula*), had very low ratios. There was no strong suggestion that the *K*/*d* ratio could be used to predict the tolerance of species, with high ratios for the more shade tolerant species, as indicated by Shallenberger et al. (1986).

The possible applications and uses of a knowledge of the *K*/*d* ratio are discussed, including implications for decisions on spacings, basal areas per hectare, the prediction of desirable stocking levels for any given mean stem diameter, and thinning regimes. Also discussed, are spacings that might be appropriate in mixed species stands, the management of overstories in shelterwood systems, genetic selection in breeding programmes and prediction of volumes of branchwood for fuel.

Keywords: Crown diameter; Stem diameter; *K*/*d* relationship; Broadleaved trees; Thinning regimes; Tree spacing

1. Introduction

The crowns of trees have been subjected to much less mensurational study than their stems, primarily due to their lower marketable value. However, crown size, being closely related to the photosynthetic capacity of a tree, is an important parameter in studies of the growth of individual trees. It is also very

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relevant in studies of the growth of stands due to the close correlation between crown size and stem diameter, and the 'packing' or density of trees in a stand.

Forest trees usually exhibit a significant relationship between their crown diameters (*K*) and stem diameters (*d*). Duchaufour (1903) was one of the first authors to identify this in a study of *Fagus* (Fig. 1). Subsequently workers have identified the *K*/*d* relationship for many species, temperate and tropical, coniferous and broad-leaved. The true relationship between *K* and *d* may actually he sigmoid due to the distortion of the line at the lower end because *d* is usually measured at breast height, and the possible depression of the upper end due to senility. However, Dawkins (1963) suggested that for the common range of forest tree sizes, between 0.2 and 0.5 m dbh, there would be a negligible distortion of the linear relationship.

Knowledge of the *K*/*d* relationship of a species can be applied to indicate the tolerance of a species to variations in stand density (Dawkins, 1963), for predicting basal areas, devising thinning regimes and, given the inclusion of height data, for developing stand volume estimates. *K*/*d* relationships have been used to calculate maximum basal areas for species, such as beech (Colette, 1951) and Douglas fir (Briegleb, 1952), and for predicting desirable spacings or stocking rates for other species such as ash, cherry and sycamore (Thill, 1980).

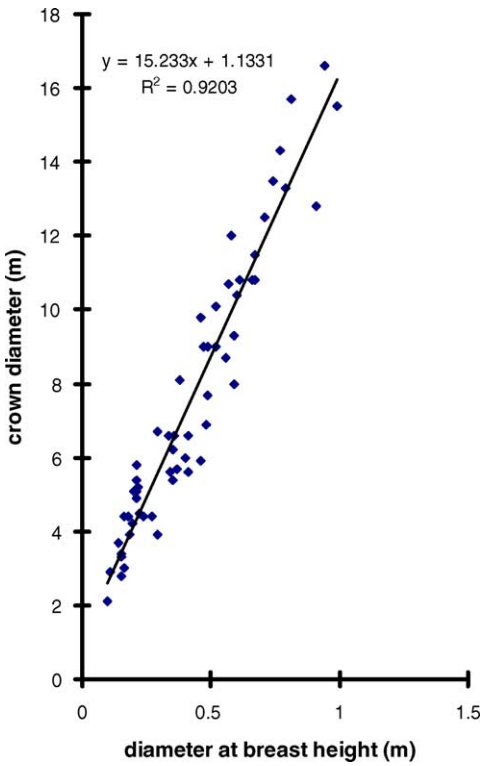

Fig. 1. Crown diameter–stem diameter (*K*/*d*) relationship for beech.

Stand density indices (e.g. Curtin, 1964) and crown competition factors (e.g. Krajicek et al., 1961) have been calculated for a number of species. These estimates supply an indication of the area available to trees for stands at any particular density. Many workers, e.g. Ilvessalo (1950), Ayhan (1974) and Gering and May (1995), have used the *K*/*d* relationship of a species for estimating dbh or basal area from crown diameters measured from aerial photographs or other methods of remote sensing. Investigation of the *K*/*d* ratio also provides a useful means of checking the validity of yield tables and other growth models (Philip, 1994).

The crown size of only one of the major British broadleaved species, oak, has been studied (Jobling and Pearce, 1977), and there has been little published work on other species. This paper presents crown diameter–stem diameter relationship data of several broadleaved species and discusses its application potential. The two key aims of this work were:

1. To improve the knowledge of the growth habit of some of the minor species. The form of the *K*/*d* relationship should indicate appropriate thinning regimes for the species, depending upon whether they are plastic or intolerant (Dawkins, 1963).
2. The ability to predict crown diameters would assist in decisions on the spacing of hardwood rows in conifer–hardwood mixtures, and on the density of overstorey to leave in shelterwood regeneration fellings and when underplanting. It would also be helpful in arboriculture, when planning the spacing of single trees and tree avenues.

2. Methods

Some data were collected specifically for this study, and some had already been collected by the authors, as shown in the footnote to Table 1.