Chapter 6

Carbon sequestration estimates of indigenous street trees in the City of Tshwane, South Africa

Abstract

Amelioration of global warming presents opportunities for urban forests to act as carbon sinks and thereby be accounted in the carbon trade industry. The City of Tshwane Metropolitan Municipality is planting 115 200 indigenous street trees in the period 2002 to 2008. These trees hold a carbon credit potential in their future growth. In order to calculate the carbon sequestration potential, the growth rate of *Combretum erythrophyllum*, *Rhus lancea* and *Rhus pendulina* were determined. Combined species growth regressions of *Combretum erythrophyllum* - *Rhus lancea* and *Rhus lancea* - *Rhus pendulina* are also presented. *Combretum erythrophyllum* has the fastest growth rate while that of *Rhus lancea* and *Rhus pendulina* are slower. The results from growth regression relationships were used in a generic allometric biomass regression to calculate the carbon sequestration rate of each species, which was extrapolated to determine the total quantity of carbon to be sequestrated by the street trees over a 30-year period (2002 to 2032). It is estimated that the tree planting will result in 200 492 tonne CO_2 equivalent reduction and that 54 630 tonne carbon will be sequestrated. The carbon dioxide reductions could be valued at more than US$2 million. This illustrates that carbon trade could become a valuable source of revenue for the urban forestry industry.

Keywords: allometry, carbon sequestration, growth rate, regression, stem diameter, street trees, trade, urban forestry

Introduction

Concern over global warming has resulted in an international investigation into methods of ameliorating the green house effect (IPCC, 2000). Because plants act as carbon sinks, fixing carbon through the process of photosynthesis, focus has been on terrestrial vegetation to facilitate carbon sinks (IPCC, 2000; Brown, 2002). A carbon sink is defined as the process or mechanism that removes carbon dioxide (greenhouse gas) from the atmosphere (IPCC, 2000). Carbon is sequestrated and stored in tree tissue at different rates and quantities depending on factors such as growth rate, tree species, size at maturity and life span (Nowak *et al.*, 2002a).

Urban trees and forests have a significant potential to act as carbon sinks (McPherson *et al.*, 1994; Freedman *et al.*, 1996; McPherson & Simpson, 1999; Nowak & Crane, 2002; Nowak *et al.*, 2002a; Nowak *et al.*, 2002b). However, compared to natural forests (Brown *et al.*, 1997; Ter-Milkaelian & Korzukhin, 1997; Brown, 2002), less research has been done on urban forest carbon dioxide sequestration and urban tree biomass allometry and there is a general lack of information on urban tree species in this regard (McPherson *et al.*, 1994; Peper & McPherson, 1998). A literature search revealed no information regarding urban forest carbon dioxide sequestration and urban tree biomass allometry in a South African context.

The City of Tshwane Metropolitan Municipality (Municipality), South Africa, is in a process of establishing 115 200 indigenous street trees in the urban areas of previously disadvantaged communities such as Atteridgeville, Ga-Rankuwa, Mabopane, Mamelodi, Soshanguve, Temba, and Winterveld (personal communication with S. Paul, City of Tshwane Metropolitan Municipality, 8 April 2002). The tree-planting programme commenced in 2002 and is due for completion in 2008. In an urban setting, the geographical areas of these previously disadvantaged communities are known as "Townships" (suburbs). As the legacy of historically politically motivated urban development strategies, they are mostly the habitation of the poor and are generally denuded of vegetation. Street trees hold the prospect of carbon sequestration and aesthetic transformation of these vegetation-impoverished areas.

In order to estimate carbon sequestration benefits it is necessary to calculate the quantities of carbon that can potentially be sequestrated by future growth. If sufficient quantities of carbon will be sequestrated, the Municipality may engage in carbon trade. In this process, the carbon sequestration potential of these trees are traded and the income thus generated could provide finances for further tree planting. The carbon trade industry could become an important source of revenue for urban forestry. Further information about carbon trading is available at www.pointcarbon.com , www.co2e.com , http://unfccc.int .

Current methods of modelling urban forest carbon sequestration often employ allometric equations from which tree biomass and consequently carbon sequestration may be derived (Peper & McPherson, 1998; McPherson & Simpson, 1999; Nowak & Crane, 2002; Nowak *et al.*, 2002b). Through allometric equations tree diameter, usually at breast height, or other easily measurable variables are related to standing volume of biomass (dry mass) (Haase & Haase, 1995; Nelson *et al.*, 1999; Keller *et al.*, 2001; Ketterings *et al.*, 2001). Approximately fifty percent of the biomass can be ascribed to carbon (Scholes & Walker, 1993; McPherson & Simpson, 1999; Gifford, 2000; McPherson *et al*., 2001; Nowak *et al*., 2002b).

When the street trees are young the standing carbon stock is not substantial. However, the growth of the trees represents a potential increase in biomass and hence carbon sequestration. The aim of this study was therefore to:

(1) develop generic combined species growth rate regressions based on the data captured from three indigenous street tree species,

(2) to estimate the potential rate of carbon sequestration of three indigenous street tree species as well as the potential rate of carbon sequestration of the generic combined species regressions and then,

(3) to calculate the total quantity of carbon that could be sequestrated by the 115 200 street trees after a 30-year growth period in the City of Tshwane's Townships.

The rate of carbon sequestration is dependent on the growth rate therefore these two aims of the study are closely related. Growth rates for the three indigenous species were determined in Chapter 3.

Methodology

Field data collection

The stem circumferences of street trees were measured in the winter and early spring (April - September) of 2002 in the Pretoria area in the City of Tshwane (25˚ 39' S - 25˚ 50' S; 28˚ 19' E - 28˚ 09' E), in the province of Gauteng. The stem circumference of the larger street trees (larger than approximately 90 mm diameter) was determined with a tape measure at 50 mm above ground level or just above the basal swelling. Diameter at breast height (DBH), which is measured at 1.37 m above ground level, was not an appropriate measurement since the biomass regression equation used requires stem diameter measurements at ground level. Also the Municipality often planted trees that still have branches below 1.37m. Furthermore, the African savanna species investigated tend to branch at a level lower than this height.

The diameters of small trees (smaller than approximately 90 mm diameter) were measured with callipers 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 and circumference.

Three species, *Combretum erythrophyllum* (river bushwillow), *Rhus lancea* (karee) and *Rhus pendulina* (white karee) were investigated. All the species are indigenous to South Africa and when fully grown are approximately 7 m to 12 m tall (Joffe, 1993; van Wyk & van Wyk, 1998). In total 282 trees were measured of which 105 were *Combretum erythrophyllum*, 107 *Rhus lancea* and 70 *Rhus pendulina*. The height of the trees when first planted in streets varied, but in general, is approximately two meters (personal communication with S. Paul, City of Tshwane Metropolitan Municipality, 8 April 2002).

The majority of the trees were growing in residential, non-irrigated, managed lawn environments. The average planting distance is 14 m. Driveways and road infrastructure often resulted in irregular planting distances. The irregular planting distances were not included in the calculation of an average planting distance. Mean tree to curb distance and road reserve width were 2.1 m and 6.5 m respectively.

With some exceptions ten trees were measured per street (see Chapter 3 and Chapter 4). Selection of the best individual street trees during data gathering for statistical analysis could result in biased data. As is the case with allometry (Clark & Clark, 2000) a biased selection of trees could artificially inflate predictive regression estimates. This problem was avoided by stratified random sampling - the streets were selected at random within the city; and the selection of trees in the streets was performed at random (see Chapter 3 and Chapter 4).

Determining growth rate

A literature search revealed no growth rate equations for any indigenous urban trees, therefore generic growth equations could not be used for carbon sequestration calculations. As a result the individual species' growth rates had to be determined. The trees were planted between 1955 and 2001 and their ages were derived from the planting dates which were obtained from the Municipality. The planting dates refer to the date at which the trees were physically planted in the streets. The ranges of minimum and maximum ages of the species are 1.2 years to 47.6 years, 1.3 years to 32.6 years and 3.4 years to 15.6 years for *Combretum erythrophyllum*, *Rhus lancea* and *Rhus pendulina* respectively. Hence, data for 46.4 years, 31.3 years and 12.2 years age range periods for *Combretum erythrophyllum*, *Rhus lancea* and *Rhus pendulina* respectively, was used in the calculations. Planting dates for trees planted prior to 1995 were obtained from aerial photographs and personal communication with botanical and horticultural staff since the Municipality did not keep planting date records prior to 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 *Rhus lancea* and *Rhus pendulina* with planting dates of 1970 and 1987 respectively.

Both stem diameter and stem circumference were regressed on age to compute the growth rate of each species. Two combined species regressions for a *Combretum erythrophyllum* - *Rhus lancea* combination and a *Rhus lancea* - *Rhus pendulina* combination are also presented. Several growth curve models were tested (see Chapter 2): exponential (Zhang, 1997), first degree logistic (Brewer *et al.*, 1985), Gompertz (du Toit, 1979), Lundqvist (Brewer *et al.*, 1985) and Richards family (du Toit, 1979). However, the logarithmic equation (Peper *et al.*, 2001a; Peper *et al.*, 2001b) was considered to provide the most appropriate fit (see Chapter 2) and was used to determine the growth rates for the individual and the combined species.

Age was used as independent variable and stem diameter or stem circumference was modelled using the following equation:

$$E(y_i) = a * [\log(x_i + 1)]^b \qquad (1)$$

where

y_i = observed response for the i^{th} tree, where i = 1,2,…, n;

n = number of observations

x_i = age of the i^{th} tree

a, b = parameters to be estimated

$E(\ )$ = expected values

A description of the statistical models and procedures are presented elsewhere (Peper *et al.*, 2001a; Peper *et al.*, 2001b) as well as in Chapter 3. An equation presented in the original publications by Peper *et al.* (2001a) and Peper *et al.* (2001b) has been corrected based on e-mail correspondence with P.J. Peper (pjpeper@ucdavis.edu, USDA Forest Service, Center for Urban Forest Research, c/o Dept. Env. Hort., Univ. of California, One Shields Avenue, Davis, CA 95616-8587, http://cufr.ucdavis.edu/, 23 April 2003). The altered equation is presented in Table 6.1. It is important to mention that a bias correction was applied (Baskerville, 1972). Statistical analysis was conducted using SAS (SAS® version 8.2, SAS Institute, SAS Campus Drive, Carry, NC 27513).

Carbon sequestration

Very few allometric biomass regressions exist for southern African tree species (Dayton, 1978; Rutherford, 1979; Scholes, 1987; Chidumayo, 1990; Goodman, 1990; Tietema, 1993; Shackleton, 1997) and no biomass allometry could be found for indigenous urban trees in the literature. The Municipality would not allow destructive harvesting and therefore species-specific biomass regressions could not be derived. Instead, the following generic equation presented by Shackleton (1997) for South African savanna trees was used for biomass calculations:

$$\log b = 2.397(\log c) - 2.441 \quad (2)$$

with $r^2 = 0.94$; $p < 0.00001$; $n = 94$

where *b* is the biomass (kg) and *c* the stem circumference (cm) at ground level.

The stem circumference and its upper and lower confidence intervals as calculated using equation (1), were used in the above biomass regression (equation (2)) to calculate the biomass for an individual tree. Because equation (1) gives an age - stem circumference relationship and equation (2) a stem circumference – biomass relationship, an age – biomass relationship could be obtained. Stem diameter, although not measured for the larger trees, could be incorporated in this relationship since it is a function of stem circumference.

The carbon calculations are based on the whole tree biomass estimates, which include both below and above ground biomass. However, 5.4% leaf biomass was subtracted from the total above ground biomass (Rutherford, 1982) as calculated by equation (2). In calculating root biomass a root : shoot ratio of 0.78 is assumed (Scholes & Walker, 1993). A conservative carbon content of the above ground biomass is assumed as 45 % and root carbon as 42% of root biomass (Scholes & Walker, 1993).

Carbon sequestration estimates, stem circumference and stem diameter were regressed on tree age (Appendix A). The estimates in Appendix A were calculated based on 0.25 year (3 months) intervals. These small age intervals were used so that the interpolation of the derived variables (sequestrated carbon, stem circumference, stem diameter) could also be determined with intervals smaller than one year. This makes deductions from the tables (Appendix A) more accurate and makes it more user-friendly for general use than had one year intervals been used. The confidence intervals are also provided.

Tshwane' s carbon sequestration

Tree age - carbon relationships were used to calculate the total quantity of carbon that could be sequestrated by the 115 200 street trees after a 30 year period (2002 - 2032). No growth or biomass regressions could be found in the literature, therefore the calculated growth rate and carbon regression equations presented were applied to the nine additional species that are being planted in the Townships (Table 6.2). *Combretum erythrophyllum* and *Rhus lancea* combined species regression was used to calculate growth rates and carbon sequestration rates for species of intermediate size (*Galpinia transvaalica*, *Olea europaea* subsp. *africana*, *Warburgia salutaris*) (van Wyk, 1984; Joffe, 1993). *Combretum* *erythrophyllum* equation was applied for larger trees (*Combretum krausii*, *Ekebergia capensis*) (van Wyk, 1984; Joffe, 1993) and *Rhus lancea* equation was applied to this species only.

The oldest trees in the *Rhus pendulina* data set were 15.6 years and could therefore not be used for 30 year projections, consequently *Rhus lancea* and *Rhus pendulina* combined species regression was used to determine the carbon sequestration for *Rhus pendulina* as well as for that of *Acacia caffra*, *Heteropyxis natalensis*, *Rhus leptodictya*, and *Vepris lanceolata*. In some instances, the growth rates determined for the three species investigated as well as that of the combined species growth rate regressions correlated with the natural growth rates of the nine species that were not investigated and for which carbon values were determined (van Wyk, 1984; Joffe, 1993). Annual carbon gain is calculated as the quantity of carbon fixed per year (kg C yr^{-1}) over a 30-year period (2002 - 2032) (Table 6.2).

Results and discussion

Growth rate

Stem diameters ranged from 26 mm to 685 mm, 26 mm to 507 mm and 36 mm to 352 mm for *Combretum erythrophyllum*, *Rhus lancea* and *Rhus pendulina* respectively. The regression coefficients and coefficients of determination (r^2) to predict stem diameter and stem circumference growth by age are presented in Table 6.1. The coefficients of determination are 0.76, 0.84 and 0.75 for *Combretum erythrophyllum*, *Rhus lancea* and *Rhus pendulina* respectively (Table 6.1). For the *Combretum erythrophyllum* - *Rhus lancea* and *Rhus lancea* - *Rhus* *pendulina* combined species regressions the coefficients of determination are 0.77 and 0.80 respectively. The logarithmic regression models fitted to the data are shown in Figure 6.1 to Figure 6.3.

In Figure 6.3 all the curves presented make a visual growth rate comparison possible. In general *Combretum erythrophyllum* has the highest growth rate, thereafter the combined species regression of C*ombretum erythrophyllum* - *Rhus lancea*, then *Rhus lancea*, *Rhus pendulina* and lastly that of the *Rhus lancea* - *Rhus pendulina* combined species regression. The growth rate of the combined species regression of *Rhus lancea* and *Rhus pendulina* is lower than both that of the two species individually. This can be attributed to the nature of the logarithmic equation's fit to the combined data set. Initially *Rhus pendulina* has the lowest growth rate but it equals the growth rate of *Rhus lancea* towards the upper end of the curve. Visual consideration of the slope of its ascent, may lead one to conjecture that it will have a faster growth rate than *Rhus lancea* beyond the range of the data.

Carbon sequestration rate is related to growth rate. Therefore the faster a tree grows, the faster it fixes carbon from the atmosphere into plant tissue. As a consequence, the growth rate comparison is an important indicator as to which species sequestrates carbon the fastest.

The statistical model used to fit the data, accounted for the variability within the data values. It can be noticed that the confidence bounds expand with the increase in tree age (Figure 6.1 and Figure 6.2). This is a common tendency for all the species and reflects the variability within the species due to effects of differences in genotype, culture, site conditions, biotic, and abiotic factors that influence the health and growth of a tree (Peper *et al.*, 2001a).

The regression equations presented are only valid within the range of ages and stem circumferences of the data collected in this study. Extrapolation with the aim of obtaining data beyond the collected data range is, therefore, not recommended. This point was made by Haase & Haase (1995) in determining biomass through the use of allometry and should also be observed when calculating growth rate.

Table 6.1. Sample size (n), estimated regression coefficients (A, b) and mean standard error (MSE) values for predicting stem diameter growth as well as coefficients of determination. Stem diameter can be predicted by $\hat{y}_i = EXP\{MSE/2 + (\hat{A} + \hat{b}\log(\log(x_i + 1)))\}$, where $\hat{y}_i$ = the stem diameter to be estimated , $\log$ is the natural logarithm of the argument and EXP = the inverse of the natural logarithm and x_i = age, stem circumferences or stem diameter

Species	Stem circumference vs. age					Stem diameter vs. age			
	n	A	b	MSE	r^2	A	b	MSE	r^2
Combretum erythrophyllum	105	4.58352	2.44085	0.14804	0.76	3.43879	2.44085	0.14804	0.76
Rhus lancea	107	4.92616	1.74761	0.057522	0.84	3.78143	1.74761	0.057522	0.84
Rhus pendulina	70	4.53425	2.21533	0.051892	0.75	3.38952	2.21533	0.051892	0.75
Combined *C. erythrophyllum R. lancea*	212	4.76982	2.05338	0.11204	0.77	3.62509	2.05338	0.11204	0.77
Combined *R. lancea R. pendulina*	177	4.87405	1.78049	0.059088	0.80	3.72932	1.78049	0.059088	0.80

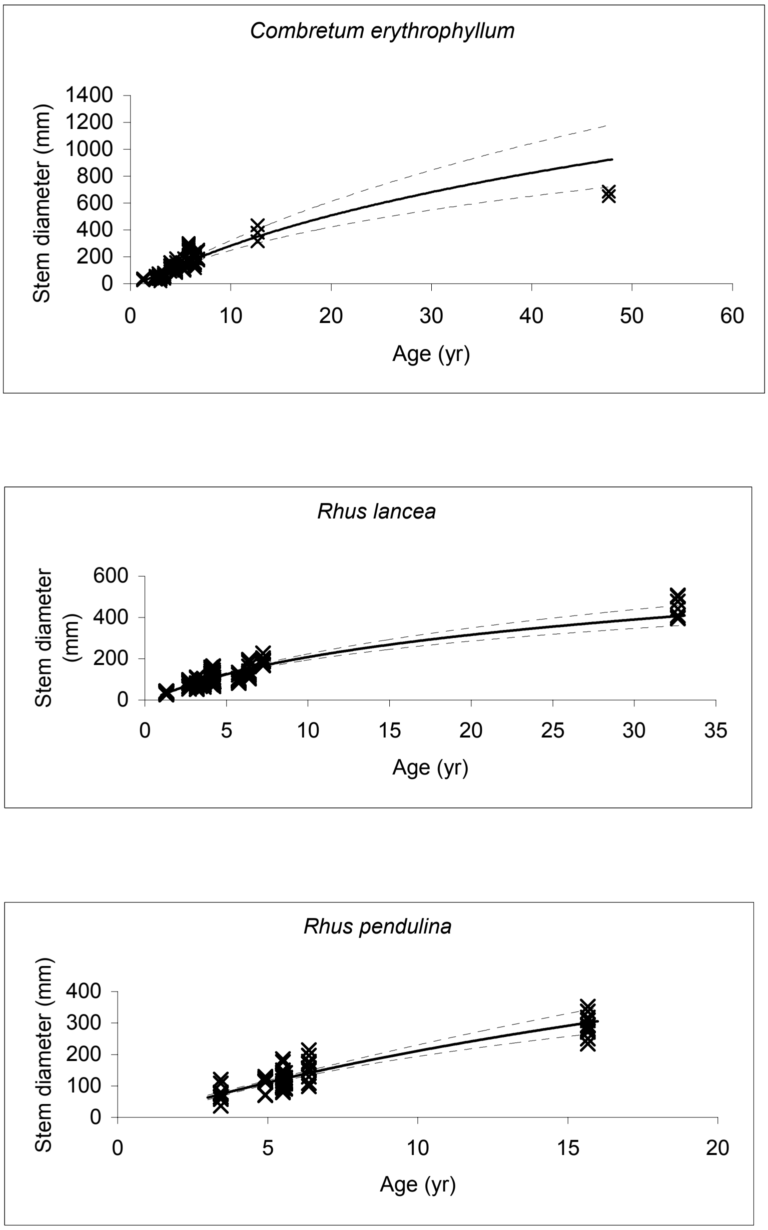
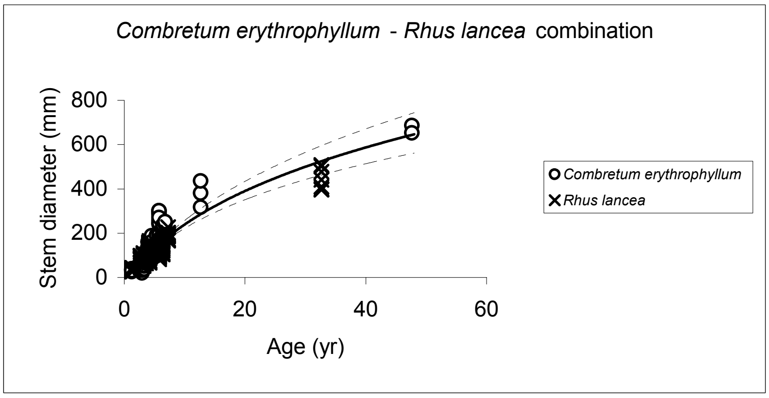


Figure 6.1. Stem diameter logarithmically regressed against tree age (years) (Table 6.1) for *Combretum erythrophyllum*, *Rhus lancea* and *Rhus pendulina*. The dotted lines represent the confidence intervals at a level of 95% to the estimated means.



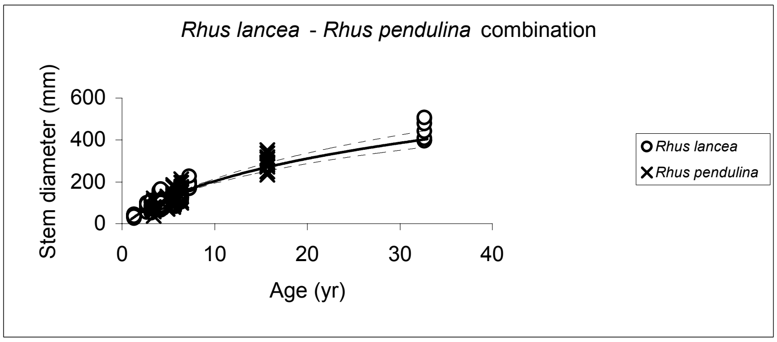


Figure 6.2. Stem diameter logarithmically regressed against tree age (years) (Table 6.1) for *Combretum erythrophyllum* - *Rhus lancea* and *Rhus lancea* - *Rhus pendulina* combinations. The dotted lines represent the confidence intervals at a level of 95% to the estimated means.

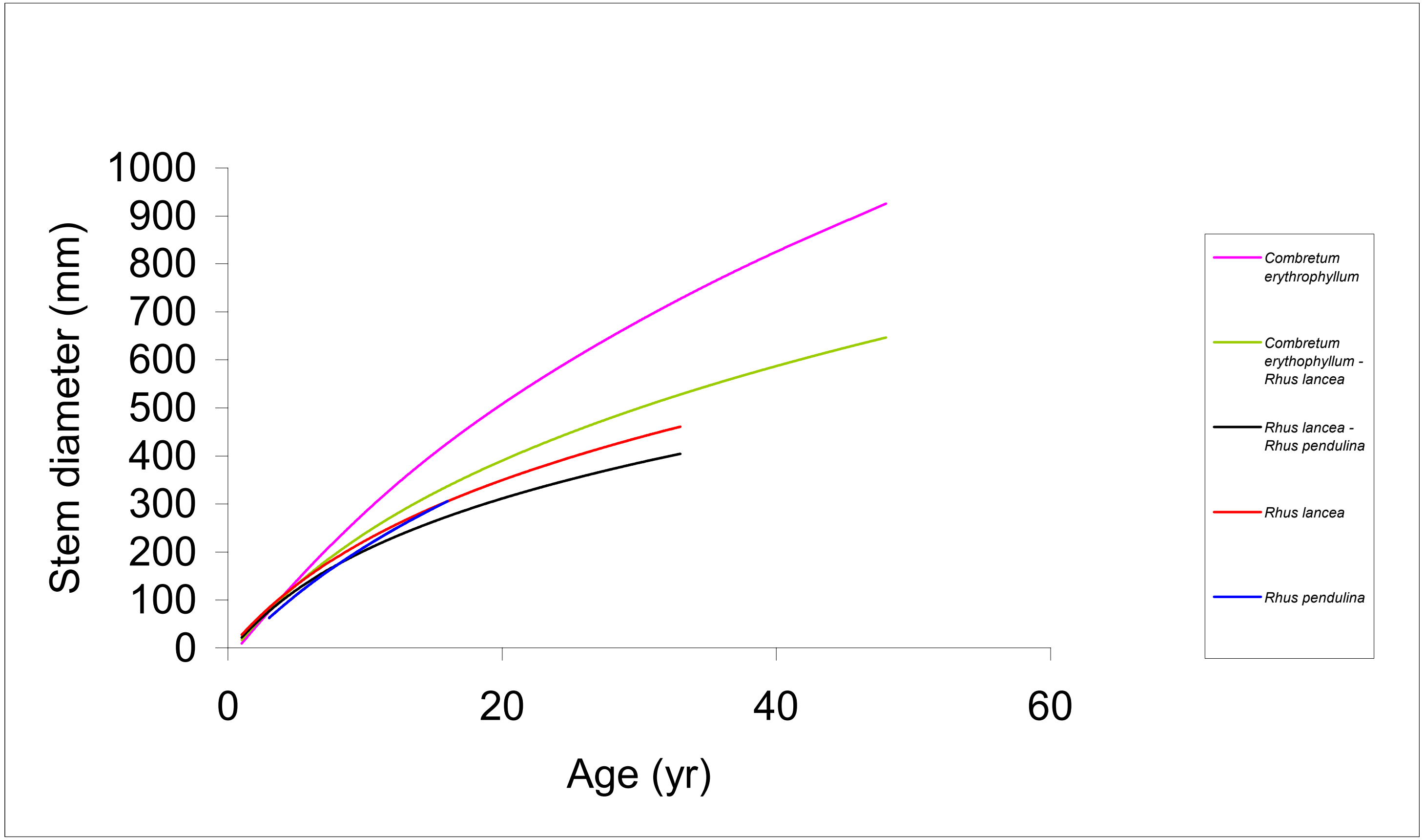


Figure 6.3. Stem diameter logarithmically regressed against tree age (years) for *Combretum erythrophyllum*, *Rhus lancea* and *Rhus pendulina* as well as the *Combretum erythrophyllum* - *Rhus lancea* and *Rhus lancea* - *Rhus pendulina* combined species regressions to enable growth rate comparisons between the species and the combined species regressions.

Carbon sequestration

The carbon sequestration results are presented in table format in Appendix A. Both circumference and stem diameter are provided for ease of use and to avoid conversion errors. Although tree age is the explanatory (independent) variable, stem diameter and circumference may also be used to determine carbon sequestration or tree age and *vice versa*.

Sequestration rates derived from the regressions show that the *Combretum erythrophyllum* and *Rhus lancea* combination sequestrates carbon at a faster rate (14 kg C yr^{-1}) than the *Rhus lancea* and *Rhus pendulina* combination (8 kg C yr^{-1}) but has a slower sequestration rate than *Combretum erythrophyllum* (29 kg C yr^{-1}) (Table 6.2). The *Rhus lancea* and *Rhus pendulina* combination sequestration rate is the same as that of *Rhus lancea* and *Rhus pendulina* respectively (8 kg C yr^{-1}).

The Municipality selected 12 indigenous species for the tree planting program, which forms part of its 2002 to 2008 urban forestry plan for the Townships (Table 6.2). *Combretum erythrophyllum* and *Ekebergia capensis* each represent 11 % of the total number of trees to be planted this program and *Combretum krausii* 8 %, and they sequestrate 20.1 %, 19.4 % and 14.5 % of the total amount of carbon respectively (Table 6.2). Thus they have relatively high sequestration percentages in relation to their proportional representation of the total number of trees. On the other hand *Rhus lancea*, *Rhus leptodictya*, *Rhus pendulina* and *Olea europaea* subsp. *africana* represent 16 %, 10 %, 12 %, and 16 % of the total population respectively. They in turn sequestrate 8.0 %, 5.1 %, 6.0 % and 14.6 % of the total amount of carbon respectively. Their sequestration proportion is less than their proportional representation of the total population. This can be attributed to the size of the mature trees and their growth rate (McPherson *et al.*, 1994; Nowak *et al.*, 2002a)

Combretum erythrophyllum is a relatively large tree in natural environments with a higher growth rate than *Rhus lancea* and *Rhus pendulina*, which are trees of medium size and of moderate growth rate that will therefore sequestrate less carbon and at a lower rate than the larger tree (*Combretum erythrophyllum*).One may therefore safely deduce that larger trees with higher growth rates will be more beneficial to ameliorate global warming since they sequestrate larger quantities of carbon faster.

Table 6.2. The species that are being planted and the regression equations used to calculate the estimated carbon sequestration The total number of trees planted per species by 2008, as well as the percentage (rounded) of each species represented in the total number of trees. The rate of carbon gain over a 30-year period and the total quantity of carbon sequestrated by 2032 as well as the percentage (rounded) carbon that each species sequestrates, are shown.

Species planted	Regression equation used	Number of trees to be planted by 2008	Percentage of total number of trees	Carbon sequestrated by 2032 (ton carbon)	Rate of carbon gain per individual tree (kg carbon yr^{-1})	Percentage of total carbon
Acacia caffra	*Rhus* spp. combined	5200	5	1189	8	2.2
Combretum erythrophyllum	*Combretum erythrophyllum*	12600	11	10984	29	20.1
Combretum krausii	*Combretum erythrophyllum*	9000	8	7932	29	14.5
Ekebergia capensis	*Combretum erythrophyllum*	12100	11	10589	29	19.4
Galpinia transvaalica	*Combretum erythrophyllum- Rhus lancea* combined	9500	8	4096	14	7.5
Heteropyxis natalensis	*Rhus* spp. combined	1200	1	279	8	0.5
Rhus lancea	*Rhus lancea*	18350	16	4363	8	8.0
Rhus leptodictya	*Rhus* spp. combined	11700	10	2764	8	5.1
Rhus pendulina	*Rhus* spp. combined	13600	12	3283	8	6.0
Olea europaea ssp africana	*Combretum erythrophyllum- Rhus lancea* combined	18950	16	7988	14	14.6
Vepris lanceolata	*Rhus* spp. combined	600	1	140	8	0.3
Warburgia salutaris	*Combretum erythrophyllum- Rhus lancea* combined	2400	2	1023	14	1.9
Total		115200	101*	54630		100.1*

*Total rounded percentages

When considering the threat of global warming, one may argue that it is best to revise the Municipality's planting schedule and plant all the streets with larger and faster growing trees. However, there is ecological safety in the use of a diversity of urban forestry species since it minimizes the risk of catastrophic loss resulting from insects, disease or other harmful agents (McPherson & Rowntree, 1987). An example of the destructive magnitude of pests is that of the urban forest of Brooklyn (New York, United States of America), where 51% of the tree population is infested with the Asian longhorn beetle. This infestation could lead to a US$390 million compensatory or replacement value loss in urban forest infrastructure (Nowak *et al.*, 2002b). A diversity of species also allows for the creation of a variety of habitats. As with natural forests, unique microclimates and environs are created by each individual tree species, which enables different understory plant compositions and arrangements. Furthermore, all the species are indigenous and will therefore enhance bird life (Joffe, 1993) in the Townships that should aid in transforming the aesthetic and environmental qualities of these biodiversity impoverished areas. From a landscape architectural point of view, diversity is also important for the creation of an aesthetically pleasing environment. Although planting a large diversity of fast growing large trees will address both the diversity and the carbon sequestration issues it will be inappropriate for urban environments which also necessitate the use of a diversity of tree sizes.

Tshwane' s carbon sequestration

Calculations show that by 2032 a quantity of 54 630 tonne carbon could be sequestrated by the 115 200 street trees. Often emission reductions are reported as the full molecular mass of CO_2 rather than the atomic mass of carbon. The molecular mass of CO_2 can be obtained by multiplying the atomic mass of carbon by 3.67 (McPherson & Simpson, 1999). In applying this conversion factor the abovementioned trees will result in an estimated 200 492 tonne CO_2 equivalent reduction. Assuming a market related price of US$10 tonne CO_2 (www.pointcarbon.com accessed 31 May 2005), the carbon dioxide could be valued US$2 004 920. This calculation does not include carbon dioxide costs due to tree propagation, tree planting and maintenance as well as tree mortalities.

This study only accounts for carbon sequestration as environmental benefit related to street trees. However, there are numerous other advantages that urban trees hold, amongst others storm water runoff reductions, pollution reduction and climate amelioration, (Akbari *et al.*, 2001; Akbari, 2002; Nowak *et al.*, 2002b; Maco & McPherson, 2003) (see Chapter 7). These and other benefits as well as costs involved with street tree maintenance (Nowak *et al.*, 2002a) for example, need to be considered when calculating the monetary benefit or cost of street trees (Nowak *et al.*, 2002b; McPherson, 2003).

Conclusion

The aim of this study was to develop generic combined species growth rate regressions, to estimate the potential rate of carbon sequestration of three indigenous street tree species as well as that of the combined species' regressions and thirdly to determine the total quantity of carbon that could be sequestrated by future street tree planting over a 30 year period in the City of Tshwane.

Combretum erythrophyllum has the highest growth rate, thereafter the combined species regression of *Combretum erythrophyllum* - *Rhus lancea*, then *Rhus lancea*, *Rhus pendulina* and lastly that of the *Rhus lancea* - *Rhus pendulina* combined species regression.

Combretum erythrophyllum and *Rhus lancea* combination regression sequestrates carbon at a faster rate (14 kg C yr^{-1}) than the *Rhus lancea* and *Rhus pendulina* combination (8 kg C yr^{-1}). *Combretum erythrophyllum* and *Rhus lancea* combination regression has, however, a slower sequestration rate than *Combretum erythrophyllum* (29 kg C yr^{-1}) (Table 6.2). The *Rhus lancea* and *Rhus pendulina* individual species sequestration rates are the same as that of *Rhus lancea* and *Rhus pendulina* combination (8 kg C yr^{-1}).

Calculations show that by 2032 a quantity of 54 630 ton carbon could be sequestrated by the 115 200 street trees. This will result in an estimated 200 492 ton CO_2 equivalent reduction. Assuming a market related price of US$10 ton^{-1} CO_2 the carbon dioxide could be valued at US$2 004 920. This calculation does not include carbon dioxide costs due to tree propagation, tree planting and maintenance as well as tree mortalities.

Although urban forests are smaller in scale than natural forest systems, they still offer carbon sequestration benefits. The Townships of South Africa render themselves as opportune environs for the establishment of new trees. These are zero carbon credit and debit baseline environs from which carbon sequestration can be calculated based on the growth of newly planted trees. Furthermore, carbon trade could provide valuable resources for the maintenance and establishment of such urban forests (personal communication with B. Dry, City of Tshwane Metropolitan Municipality, February 2003).

Limited research has been done on the growth rate and carbon sequestration rate of urban street trees and no literature could be found pertaining to the issues discussed for the species investigated in a South African context which renders additional significance to the research presented.

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Appendix A

The tree age (years) and its correlated sequestrated carbon (kg), stem circumference (mm) and stem diameter (mm) is presented. Lower (L) and upper (U) confidence intervals at a level of 95% to the estimated means, are also provided. The following tables show the results for *Combretum erythrophyllum* (Table Appendix A 6.1a), *Rhus lancea* (Table Appendix A 6.1b), *Rhus pendulina* (Table Appendix A 6.1c), and the *Combretum erythrophyllum* - *Rhus lancea* (Table Appendix A 6.2), and *Rhus lancea* - *Rhus pendulina* (Table Appendix A 6.3) combined species regressions. The results show the predictions from age 1 year till the oldest tree measured by 0.25 year (3 month) intervals.

Table Appendix A 6.1a. Species: *Combretum erythrophyllum*

Combretum erythrophyllum									
Age (years)	**Sequestrated carbon (kg)**			**Stem circumference (mm)**			**Stem diameter (mm)**		
	Mean	**L**	**U**	**Mean**	**L**	**U**	**Mean**	**L**	**U**
1.00	0.09	0.05	0.16	43	34	54	14	11	17
1.25	0.23	0.14	0.36	63	52	77	20	17	24
1.50	0.46	0.31	0.69	85	72	100	27	23	32
1.75	0.83	0.59	1.16	108	94	125	35	30	40
2.00	1.34	0.99	1.80	133	117	150	42	37	48
2.25	2.02	1.55	2.63	157	141	176	50	45	56
2.50	2.88	2.28	3.65	183	166	202	58	53	64
2.75	3.95	3.18	4.90	208	190	228	66	61	73
3.00	5.22	4.27	6.37	234	215	254	74	68	81
3.25	6.70	5.55	8.10	260	240	281	83	76	89
3.50	8.41	7.00	10.09	285	264	308	91	84	98
3.75	10.34	8.64	12.37	311	289	335	99	92	107
4.00	12.49	10.45	14.94	337	313	363	107	99	115
4.25	14.88	12.43	17.81	362	336	390	115	107	124
4.50	17.49	14.57	21.01	387	359	418	123	114	133
4.75	20.34	16.86	24.53	413	382	446	131	121	142
5.00	23.41	19.31	28.38	437	404	474	139	129	151
5.25	26.70	21.90	32.56	462	426	502	147	135	160
5.50	30.23	24.64	37.09	487	447	530	155	142	169
5.75	33.97	27.51	41.95	511	468	558	163	149	178
6.00	37.94	30.52	47.16	535	489	586	170	156	187
6.25	42.12	33.66	52.71	559	509	614	178	162	195
6.50	46.51	36.92	58.60	583	529	642	185	168	204

Combretum erythrophyllum									
Age	Sequestrated carbon (kg)			Stem circumference (mm)			Stem diameter (mm)		
(years)	Mean	L	U	Mean	L	U	Mean	L	U
6.75	51.12	40.31	64.83	606	549	669	193	175	213
7.00	55.94	43.82	71.40	629	568	697	200	181	222
7.25	60.96	47.45	78.31	652	587	724	208	187	230
7.50	66.18	51.19	85.56	675	606	751	215	193	239
7.75	71.60	55.04	93.15	697	625	778	222	199	248
8.00	77.21	58.99	101.06	720	643	805	229	205	256
8.25	83.02	63.05	109.31	742	661	832	236	211	265
8.50	89.01	67.22	117.88	764	679	859	243	216	273
8.75	95.19	71.48	126.78	785	697	885	250	222	282
9.00	101.56	75.83	136.00	807	714	912	257	227	290
9.25	108.10	80.28	145.54	828	732	938	264	233	298
9.50	114.81	84.82	155.40	849	749	964	270	238	307
9.75	121.70	89.45	165.57	870	765	990	277	244	315
10.00	128.75	94.17	176.05	891	782	1015	284	249	323
10.25	135.98	98.96	186.83	911	798	1041	290	254	331
10.50	143.36	103.84	197.92	932	815	1066	297	259	339
10.75	150.91	108.80	209.30	952	831	1091	303	264	347
11.00	158.61	113.84	220.99	972	846	1116	309	269	355
11.25	166.47	118.95	232.96	992	862	1141	316	274	363
11.50	174.47	124.13	245.23	1011	877	1166	322	279	371
11.75	182.63	129.39	257.78	1031	893	1190	328	284	379
12.00	190.94	134.71	270.62	1050	908	1215	334	289	387
12.25	199.38	140.11	283.74	1069	923	1239	340	294	394
12.50	207.97	145.56	297.13	1088	938	1263	346	298	402
12.75	216.70	151.09	310.80	1107	952	1287	352	303	410
13.00	225.56	156.67	324.73	1126	967	1311	358	308	417
13.25	234.55	162.32	338.94	1144	981	1334	364	312	425
13.50	243.68	168.02	353.41	1163	996	1358	370	317	432
13.75	252.94	173.79	368.14	1181	1010	1381	376	321	440
14.00	262.32	179.61	383.12	1199	1024	1404	382	326	447
14.25	271.83	185.49	398.36	1217	1038	1427	387	330	454
14.50	281.46	191.42	413.86	1235	1051	1450	393	335	462
14.75	291.21	197.40	429.60	1252	1065	1473	399	339	469
15.00	301.08	203.43	445.59	1270	1078	1496	404	343	476
15.25	311.06	209.52	461.82	1287	1092	1518	410	347	483
15.50	321.16	215.65	478.29	1305	1105	1540	415	352	490
15.75	331.37	221.84	495.00	1322	1118	1563	421	356	497
16.00	341.70	228.06	511.94	1339	1131	1585	426	360	504
16.25	352.13	234.34	529.12	1356	1144	1607	432	364	511
16.50	362.66	240.66	546.52	1372	1157	1628	437	368	518
16.75	373.31	247.02	564.15	1389	1169	1650	442	372	525
17.00	384.05	253.43	582.01	1406	1182	1672	447	376	532
17.25	394.90	259.88	600.08	1422	1194	1693	453	380	539
17.50	405.85	266.36	618.37	1438	1207	1715	458	384	546
17.75	416.90	272.89	636.88	1455	1219	1736	463	388	553
18.00	428.04	279.46	655.61	1471	1231	1757	468	392	559
18.25	439.28	286.07	674.54	1487	1243	1778	473	396	566
18.50	450.61	292.71	693.68	1503	1255	1799	478	399	573
18.75	462.03	299.39	713.03	1518	1267	1820	483	403	579
19.00	473.55	306.11	732.59	1534	1279	1840	488	407	586
19.25	485.15	312.86	752.34	1550	1290	1861	493	411	592

Combretum erythrophyllum									
Age	Sequestrated carbon (kg)			Stem circumference (mm)			Stem diameter (mm)		
(years)	Mean	L	U	Mean	L	U	Mean	L	U
19.50	496.85	319.64	772.29	1565	1302	1881	498	414	599
19.75	508.63	326.46	792.44	1580	1313	1902	503	418	605
20.00	520.49	333.31	812.79	1596	1325	1922	508	422	612
20.25	532.44	340.20	833.33	1611	1336	1942	513	425	618
20.50	544.48	347.11	854.06	1626	1348	1962	518	429	624
20.75	556.59	354.06	874.97	1641	1359	1982	522	432	631
21.00	568.78	361.03	896.08	1656	1370	2002	527	436	637
21.25	581.06	368.04	917.36	1671	1381	2021	532	440	643
21.50	593.41	375.07	938.83	1685	1392	2041	536	443	650
21.75	605.84	382.14	960.48	1700	1403	2060	541	446	656
22.00	618.34	389.23	982.31	1715	1413	2080	546	450	662
22.25	630.92	396.35	1004.32	1729	1424	2099	550	453	668
22.50	643.57	403.49	1026.50	1743	1435	2118	555	457	674
22.75	656.29	410.66	1048.85	1758	1445	2137	559	460	680
23.00	669.09	417.86	1071.37	1772	1456	2156	564	463	686
23.25	681.96	425.08	1094.06	1786	1466	2175	569	467	692
23.50	694.89	432.33	1116.92	1800	1477	2194	573	470	698
23.75	707.89	439.60	1139.94	1814	1487	2213	577	473	704
24.00	720.97	446.89	1163.13	1828	1497	2232	582	477	710
24.25	734.10	454.21	1186.48	1842	1508	2250	586	480	716
24.50	747.31	461.55	1209.99	1856	1518	2269	591	483	722
24.75	760.57	468.91	1233.65	1869	1528	2287	595	486	728
25.00	773.91	476.29	1257.48	1883	1538	2305	599	489	734
25.25	787.30	483.70	1281.46	1896	1548	2324	604	493	740
25.50	800.76	491.13	1305.59	1910	1557	2342	608	496	745
25.75	814.27	498.57	1329.88	1923	1567	2360	612	499	751
26.00	827.85	506.04	1354.31	1937	1577	2378	616	502	757
26.25	841.49	513.53	1378.90	1950	1587	2396	621	505	763
26.50	855.18	521.03	1403.63	1963	1596	2414	625	508	768
26.75	868.94	528.56	1428.50	1976	1606	2431	629	511	774
27.00	882.75	536.10	1453.53	1989	1615	2449	633	514	780
27.25	896.61	543.67	1478.69	2002	1625	2467	637	517	785
27.50	910.54	551.25	1504.00	2015	1634	2484	641	520	791
27.75	924.51	558.84	1529.45	2028	1644	2502	645	523	796
28.00	938.54	566.46	1555.03	2041	1653	2519	650	526	802
28.25	952.63	574.09	1580.75	2053	1662	2536	654	529	807
28.50	966.77	581.74	1606.61	2066	1671	2554	658	532	813
28.75	980.95	589.41	1632.61	2079	1681	2571	662	535	818
29.00	995.20	597.09	1658.74	2091	1690	2588	666	538	824
29.25	1009.49	604.79	1684.99	2104	1699	2605	670	541	829
29.50	1023.83	612.50	1711.39	2116	1708	2622	674	544	835
29.75	1038.22	620.23	1737.91	2128	1717	2639	677	546	840
30.00	1052.66	627.97	1764.55	2141	1726	2655	681	549	845
30.25	1067.15	635.73	1791.33	2153	1735	2672	685	552	851
30.50	1081.68	643.50	1818.23	2165	1743	2689	689	555	856
30.75	1096.26	651.29	1845.26	2177	1752	2705	693	558	861
31.00	1110.89	659.09	1872.41	2189	1761	2722	697	560	866
31.25	1125.56	666.90	1899.68	2201	1769	2738	701	563	872
31.50	1140.28	674.73	1927.07	2213	1778	2755	705	566	877
31.75	1155.05	682.57	1954.58	2225	1787	2771	708	569	882
32.00	1169.86	690.42	1982.22	2237	1795	2788	712	571	887

Combretum erythrophyllum									
Age	Sequestrated carbon (kg)			Stem circumference (mm)			Stem diameter (mm)		
(years)	Mean	L	U	Mean	L	U	Mean	L	U
32.25	1184.71	698.28	2009.97	2249	1804	2804	716	574	892
32.50	1199.60	706.16	2037.83	2261	1812	2820	720	577	898
32.75	1214.54	714.05	2065.82	2272	1821	2836	723	580	903
33.00	1229.52	721.95	2093.91	2284	1829	2852	727	582	908
33.25	1244.54	729.87	2122.13	2296	1837	2868	731	585	913
33.50	1259.60	737.79	2150.45	2307	1846	2884	734	587	918
33.75	1274.70	745.73	2178.88	2319	1854	2900	738	590	923
34.00	1289.84	753.68	2207.43	2330	1862	2916	742	593	928
34.25	1305.02	761.64	2236.09	2341	1870	2931	745	595	933
34.50	1320.24	769.60	2264.85	2353	1878	2947	749	598	938
34.75	1335.50	777.58	2293.72	2364	1887	2963	753	601	943
35.00	1350.80	785.57	2322.70	2375	1895	2978	756	603	948
35.25	1366.13	793.57	2351.78	2387	1903	2994	760	606	953
35.50	1381.50	801.58	2380.97	2398	1911	3009	763	608	958
35.75	1396.91	809.60	2410.26	2409	1919	3024	767	611	963
36.00	1412.35	817.63	2439.66	2420	1927	3040	770	613	968
36.25	1427.83	825.67	2469.16	2431	1934	3055	774	616	972
36.50	1443.35	833.72	2498.75	2442	1942	3070	777	618	977
36.75	1458.90	841.77	2528.45	2453	1950	3085	781	621	982
37.00	1474.48	849.84	2558.25	2464	1958	3101	784	623	987
37.25	1490.10	857.92	2588.15	2475	1966	3116	788	626	992
37.50	1505.76	866.00	2618.14	2485	1973	3131	791	628	997
37.75	1521.44	874.09	2648.23	2496	1981	3146	795	631	1001
38.00	1537.16	882.19	2678.42	2507	1989	3160	798	633	1006
38.25	1552.92	890.30	2708.70	2518	1996	3175	801	635	1011
38.50	1568.70	898.41	2739.08	2528	2004	3190	805	638	1015
38.75	1584.52	906.54	2769.55	2539	2011	3205	808	640	1020
39.00	1600.37	914.67	2800.11	2549	2019	3220	812	643	1025
39.25	1616.25	922.81	2830.77	2560	2026	3234	815	645	1030
39.50	1632.16	930.95	2861.51	2570	2034	3249	818	647	1034
39.75	1648.10	939.11	2892.35	2581	2041	3263	822	650	1039
40.00	1664.07	947.27	2923.28	2591	2048	3278	825	652	1043
40.25	1680.07	955.43	2954.29	2602	2056	3292	828	654	1048
40.50	1696.10	963.61	2985.40	2612	2063	3307	831	657	1053
40.75	1712.16	971.79	3016.59	2622	2070	3321	835	659	1057
41.00	1728.25	979.98	3047.87	2633	2078	3336	838	661	1062
41.25	1744.37	988.17	3079.23	2643	2085	3350	841	664	1066
41.50	1760.51	996.37	3110.68	2653	2092	3364	844	666	1071
41.75	1776.68	1004.58	3142.22	2663	2099	3378	848	668	1075
42.00	1792.89	1012.79	3173.83	2673	2106	3392	851	671	1080
42.25	1809.11	1021.01	3205.54	2683	2114	3406	854	673	1084
42.50	1825.37	1029.24	3237.32	2693	2121	3421	857	675	1089
42.75	1841.65	1037.47	3269.19	2703	2128	3435	860	677	1093
43.00	1857.96	1045.70	3301.14	2713	2135	3448	864	680	1098
43.25	1874.29	1053.95	3333.16	2723	2142	3462	867	682	1102
43.50	1890.65	1062.19	3365.27	2733	2149	3476	870	684	1107
43.75	1907.04	1070.45	3397.46	2743	2156	3490	873	686	1111
44.00	1923.45	1078.71	3429.73	2753	2163	3504	876	688	1115
44.25	1939.89	1086.97	3462.07	2763	2169	3518	879	691	1120
44.50	1956.35	1095.24	3494.49	2772	2176	3531	882	693	1124
44.75	1972.83	1103.51	3526.99	2782	2183	3545	886	695	1128

Combretum erythrophyllum									
Age	**Sequestrated carbon (kg)**			**Stem circumference (mm)**			**Stem diameter (mm)**		
(years)	**Mean**	**L**	**U**	**Mean**	**L**	**U**	**Mean**	**L**	**U**
45.00	1989.34	1111.79	3559.57	2792	2190	3559	889	697	1133
45.25	2005.88	1120.07	3592.22	2801	2197	3572	892	699	1137
45.50	2022.43	1128.36	3624.95	2811	2204	3586	895	701	1141
45.75	2039.02	1136.65	3657.75	2821	2210	3599	898	704	1146
46.00	2055.62	1144.95	3690.62	2830	2217	3613	901	706	1150
46.25	2072.25	1153.25	3723.57	2840	2224	3626	904	708	1154
46.50	2088.90	1161.55	3756.59	2849	2230	3640	907	710	1159
46.75	2105.57	1169.86	3789.69	2859	2237	3653	910	712	1163
47.00	2122.26	1178.18	3822.85	2868	2244	3666	913	714	1167
47.25	2138.98	1186.50	3856.09	2877	2250	3679	916	716	1171
47.50	2155.72	1194.82	3889.40	2887	2257	3693	919	718	1175

Table Appendix A 6.1b. Species: *Rhus lancea*

Rhus lancea									
Age (years)	Sequestrated carbon (kg)			Stem circumference (mm)			Stem diameter (mm)		
	Mean	L	U	Mean	L	U	Mean	L	U
1.00	0.34	0.25	0.47	75	65	86	24	21	27
1.25	0.65	0.50	0.86	98	88	110	31	28	35
1.50	1.09	0.87	1.38	122	111	134	39	35	43
1.75	1.65	1.35	2.02	145	133	158	46	42	50
2.00	2.33	1.95	2.79	167	155	180	53	49	57
2.25	3.13	2.67	3.68	189	177	202	60	56	64
2.50	4.05	3.50	4.68	210	198	224	67	63	71
2.75	5.07	4.43	5.79	231	218	244	74	70	78
3.00	6.18	5.46	7.01	251	238	265	80	76	84
3.25	7.40	6.57	8.33	271	257	284	86	82	91
3.50	8.70	7.76	9.76	290	276	304	92	88	97
3.75	10.09	9.02	11.28	308	294	323	98	94	103
4.00	11.56	10.35	12.91	326	311	341	104	99	109
4.25	13.10	11.73	14.62	343	328	360	109	104	114
4.50	14.71	13.16	16.43	360	344	377	115	110	120
4.75	16.38	14.64	18.33	377	360	395	120	114	126
5.00	18.12	16.16	20.31	393	375	412	125	119	131
5.25	19.91	17.72	22.37	409	390	429	130	124	137
5.50	21.76	19.31	24.51	424	404	446	135	129	142
5.75	23.65	20.94	26.72	439	418	462	140	133	147
6.00	25.60	22.59	29.01	454	431	478	145	137	152
6.25	27.59	24.27	31.36	469	444	494	149	141	157
6.50	29.62	25.98	33.77	483	457	510	154	145	162
6.75	31.69	27.71	36.25	496	469	525	158	149	167
7.00	33.80	29.46	38.79	510	482	540	162	153	172
7.25	35.95	31.23	41.38	523	493	555	167	157	177
7.50	38.13	33.02	44.02	536	505	569	171	161	181
7.75	40.34	34.83	46.72	549	516	584	175	164	186
8.00	42.58	36.65	49.46	562	527	598	179	168	190
8.25	44.85	38.49	52.25	574	538	612	183	171	195
8.50	47.14	40.34	55.09	586	549	625	186	175	199
8.75	49.46	42.21	57.97	598	559	639	190	178	203
9.00	51.81	44.08	60.89	609	570	652	194	181	207
9.25	54.18	45.97	63.84	621	580	665	198	185	212
9.50	56.56	47.87	66.84	632	590	678	201	188	216
9.75	58.97	49.78	69.87	643	599	690	205	191	220
10.00	61.40	51.69	72.93	654	609	703	208	194	224
10.25	63.85	53.62	76.03	665	618	715	212	197	228
10.50	66.31	55.55	79.16	676	627	727	215	200	232
10.75	68.79	57.49	82.32	686	636	739	218	203	235
11.00	71.29	59.43	85.51	696	645	751	222	205	239
11.25	73.80	61.38	88.73	706	654	763	225	208	243
11.50	76.33	63.34	91.97	716	663	774	228	211	246
11.75	78.86	65.30	95.24	726	671	786	231	214	250
12.00	81.41	67.27	98.54	736	680	797	234	216	254
12.25	83.98	69.24	101.85	745	688	808	237	219	257
12.50	86.55	71.21	105.19	755	696	819	240	222	261
12.75	89.14	73.19	108.56	764	704	830	243	224	264

Rhus lancea									
Age	Sequestrated carbon (kg)			Stem circumference (mm)			Stem diameter (mm)		
(years)	Mean	L	U	Mean	L	U	Mean	L	U
13.00	91.73	75.17	111.94	773	712	840	246	227	268
13.25	94.34	77.16	115.34	783	720	851	249	229	271
13.50	96.95	79.14	118.77	792	727	861	252	231	274
13.75	99.57	81.13	122.21	800	735	872	255	234	277
14.00	102.20	83.12	125.67	809	742	882	258	236	281
14.25	104.84	85.11	129.15	818	750	892	260	239	284
14.50	107.49	87.11	132.64	826	757	902	263	241	287
14.75	110.14	89.10	136.15	835	764	912	266	243	290
15.00	112.80	91.10	139.68	843	771	922	268	245	293
15.25	115.47	93.09	143.22	851	778	931	271	248	296
15.50	118.14	95.09	146.78	860	785	941	274	250	300
15.75	120.82	97.09	150.35	868	792	950	276	252	303
16.00	123.50	99.09	153.93	876	799	960	279	254	306
16.25	126.19	101.09	157.53	883	805	969	281	256	308
16.50	128.88	103.08	161.13	891	812	978	284	258	311
16.75	131.58	105.08	164.75	899	819	987	286	261	314
17.00	134.28	107.08	168.39	907	825	996	289	263	317
17.25	136.98	109.08	172.03	914	831	1005	291	265	320
17.50	139.69	111.08	175.68	922	838	1014	293	267	323
17.75	142.40	113.07	179.34	929	844	1023	296	269	326
18.00	145.12	115.07	183.02	937	850	1032	298	271	328
18.25	147.84	117.06	186.70	944	856	1040	300	273	331
18.50	150.56	119.06	190.39	951	862	1049	303	274	334
18.75	153.28	121.05	194.09	958	868	1057	305	276	337
19.00	156.01	123.04	197.80	965	874	1066	307	278	339
19.25	158.73	125.03	201.52	972	880	1074	309	280	342
19.50	161.46	127.02	205.25	979	886	1082	312	282	344
19.75	164.20	129.01	208.98	986	892	1090	314	284	347
20.00	166.93	131.00	212.72	993	897	1099	316	286	350
20.25	169.67	132.98	216.47	1000	903	1107	318	287	352
20.50	172.40	134.96	220.22	1006	909	1115	320	289	355
20.75	175.14	136.95	223.98	1013	914	1122	322	291	357
21.00	177.88	138.93	227.75	1020	920	1130	325	293	360
21.25	180.62	140.90	231.52	1026	925	1138	327	294	362
21.50	183.36	142.88	235.30	1033	930	1146	329	296	365
21.75	186.10	144.86	239.09	1039	936	1153	331	298	367
22.00	188.84	146.83	242.88	1045	941	1161	333	300	370
22.25	191.58	148.80	246.67	1052	946	1169	335	301	372
22.50	194.33	150.77	250.47	1058	952	1176	337	303	374
22.75	197.07	152.74	254.28	1064	957	1183	339	305	377
23.00	199.81	154.70	258.08	1070	962	1191	341	306	379
23.25	202.56	156.66	261.90	1076	967	1198	343	308	381
23.50	205.30	158.62	265.72	1082	972	1205	345	309	384
23.75	208.04	160.58	269.54	1088	977	1213	346	311	386
24.00	210.79	162.54	273.36	1094	982	1220	348	313	388
24.25	213.53	164.49	277.19	1100	987	1227	350	314	391
24.50	216.27	166.44	281.02	1106	992	1234	352	316	393
24.75	219.02	168.39	284.86	1112	997	1241	354	317	395
25.00	221.76	170.34	288.70	1118	1001	1248	356	319	397
25.25	224.50	172.28	292.54	1124	1006	1255	358	320	399
25.50	227.24	174.23	296.39	1129	1011	1262	359	322	402

Rhus lancea									
Age (years)	Sequestrated carbon (kg)			Stem circumference (mm)			Stem diameter (mm)		
	Mean	L	U	Mean	L	U	Mean	L	U
25.75	229.98	176.17	300.23	1135	1015	1268	361	323	404
26.00	232.72	178.10	304.08	1141	1020	1275	363	325	406
26.25	235.46	180.04	307.94	1146	1025	1282	365	326	408
26.50	238.19	181.97	311.79	1152	1029	1289	367	328	410
26.75	240.93	183.90	315.65	1157	1034	1295	368	329	412
27.00	243.67	185.83	319.51	1163	1038	1302	370	331	414
27.25	246.40	187.75	323.37	1168	1043	1308	372	332	416
27.50	249.13	189.68	327.23	1173	1047	1315	374	333	419
27.75	251.87	191.60	331.10	1179	1052	1321	375	335	421
28.00	254.60	193.51	334.96	1184	1056	1328	377	336	423
28.25	257.33	195.43	338.83	1189	1060	1334	379	338	425
28.50	260.06	197.34	342.70	1195	1065	1340	380	339	427
28.75	262.78	199.25	346.57	1200	1069	1347	382	340	429
29.00	265.51	201.16	350.45	1205	1073	1353	384	342	431
29.25	268.23	203.06	354.32	1210	1077	1359	385	343	433
29.50	270.96	204.96	358.19	1215	1082	1365	387	344	435
29.75	273.68	206.86	362.07	1220	1086	1371	388	346	437
30.00	276.40	208.76	365.95	1225	1090	1378	390	347	438
30.25	279.12	210.66	369.82	1230	1094	1384	392	348	440
30.50	281.83	212.55	373.70	1235	1098	1390	393	350	442
30.75	284.55	214.44	377.58	1240	1102	1396	395	351	444
31.00	287.26	216.32	381.46	1245	1106	1402	396	352	446
31.25	289.97	218.21	385.34	1250	1110	1408	398	353	448
31.50	292.68	220.09	389.22	1255	1114	1413	399	355	450
31.75	295.39	221.97	393.10	1260	1118	1419	401	356	452
32.00	298.10	223.84	396.98	1265	1122	1425	403	357	454
32.25	300.80	225.72	400.87	1269	1126	1431	404	358	455
32.50	303.50	227.59	404.75	1274	1130	1437	406	360	457

Table Appendix A 6.1c. Species: *Rhus pendulina*

Rhus pendulina									
Age	Carbon sequestrated (kg)			Stem circumference (mm)			Stem diameter (mm)		
(years)	Mean	L	U	Mean	L	U	Mean	L	U
1.00	0.09	0.04	0.19	42	31	58	14	10	19
1.25	0.20	0.11	0.39	60	46	79	19	15	25
1.50	0.38	0.22	0.67	79	62	100	25	20	32
1.75	0.65	0.40	1.06	98	80	120	31	25	38
2.00	1.01	0.65	1.55	118	98	141	37	31	45
2.25	1.46	1.00	2.15	138	117	162	44	37	51
2.50	2.02	1.44	2.85	158	137	182	50	43	58
2.75	2.69	1.98	3.65	177	156	202	56	50	64
3.00	3.46	2.63	4.56	197	176	221	63	56	70
3.25	4.35	3.39	5.57	217	195	240	69	62	76
3.50	5.34	4.27	6.68	236	215	259	75	68	83
3.75	6.44	5.26	7.89	255	235	278	81	75	88
4.00	7.65	6.35	9.21	274	254	296	87	81	94
4.25	8.96	7.56	10.63	293	273	315	93	87	100
4.50	10.38	8.86	12.16	312	292	333	99	93	106
4.75	11.90	10.26	13.81	330	310	351	105	99	112
5.00	13.52	11.75	15.57	348	328	369	111	104	117
5.25	15.24	13.31	17.45	366	346	387	116	110	123
5.50	17.06	14.95	19.46	383	363	405	122	115	129
5.75	18.96	16.65	21.61	401	379	423	128	121	135
6.00	20.96	18.40	23.88	418	396	441	133	126	140
6.25	23.05	20.20	26.30	435	411	459	138	131	146
6.50	25.22	22.05	28.85	451	427	477	144	136	152
6.75	27.48	23.94	31.54	468	442	495	149	141	158
7.00	29.82	25.88	34.36	484	456	513	154	145	163
7.25	32.24	27.85	37.32	500	470	531	159	150	169
7.50	34.74	29.85	40.42	516	484	549	164	154	175
7.75	37.31	31.90	43.64	531	498	567	169	158	181
8.00	39.95	33.97	46.99	547	511	585	174	163	186
8.25	42.67	36.08	50.47	562	524	603	179	167	192
8.50	45.46	38.22	54.07	577	537	620	184	171	197
8.75	48.31	40.39	57.79	592	549	638	188	175	203
9.00	51.24	42.59	61.64	607	562	655	193	179	209
9.25	54.22	44.82	65.60	621	574	672	198	183	214
9.50	57.27	47.07	69.68	635	586	690	202	186	220
9.75	60.38	49.35	73.87	650	597	707	207	190	225
10.00	63.55	51.66	78.17	664	609	724	211	194	230
10.25	66.78	53.99	82.58	677	620	740	216	197	236
10.50	70.06	56.35	87.10	691	631	757	220	201	241
10.75	73.40	58.73	91.73	705	642	773	224	204	246
11.00	76.79	61.13	96.46	718	653	790	229	208	251
11.25	80.23	63.55	101.30	731	664	806	233	211	257
11.50	83.73	65.99	106.23	745	674	822	237	215	262
11.75	87.28	68.46	111.27	758	685	838	241	218	267
12.00	90.87	70.94	116.40	770	695	854	245	221	272
12.25	94.51	73.44	121.63	783	705	870	249	224	277
12.50	98.20	75.96	126.95	796	715	886	253	228	282
12.75	101.93	78.49	132.36	808	725	901	257	231	287
13.00	105.71	81.05	137.87	821	734	917	261	234	292

Rhus pendulina									
Age	**Carbon sequestrated (kg)**			**Stem circumference (mm)**			**Stem diameter (mm)**		
(years)	**Mean**	**L**	**U**	**Mean**	**L**	**U**	**Mean**	**L**	**U**
13.25	109.53	83.61	143.47	833	744	932	265	237	297
13.50	113.39	86.20	149.15	845	754	947	269	240	302
13.75	117.29	88.80	154.93	857	763	962	273	243	306
14.00	121.23	91.41	160.78	869	772	977	277	246	311
14.25	125.21	94.04	166.73	881	781	992	280	249	316
14.50	129.23	96.68	172.75	892	791	1007	284	252	321
14.75	133.29	99.33	178.86	904	800	1022	288	255	325
15.00	137.38	102.00	185.05	915	808	1037	291	257	330
15.25	141.51	104.67	191.32	927	817	1051	295	260	335
15.50	145.68	107.36	197.66	938	826	1065	299	263	339

Table Appendix A 6.2. *Combretum erythrophyllum* - *Rhus lancea* combination

***Combretum erythrophyllum* and *Rhus lancea* combination**									
Age	**Sequestrated carbon (kg)**			**Stem circumference (mm)**			**Stem diameter (mm)**		
(years)	**Mean**	**L**	**U**	**Mean**	**L**	**U**	**Mean**	**L**	**U**
1.00	0.19	0.14	0.26	59	51	67	19	16	21
1.25	0.41	0.31	0.54	81	72	91	26	23	29
1.50	0.75	0.59	0.95	104	95	115	33	30	37
1.75	1.22	1.00	1.50	128	117	139	41	37	44
2.00	1.84	1.54	2.19	151	140	163	48	45	52
2.25	2.59	2.21	3.04	175	164	187	56	52	59
2.50	3.50	3.03	4.04	198	187	210	63	59	67
2.75	4.56	4.00	5.20	221	209	234	70	67	74
3.00	5.77	5.10	6.52	244	232	257	78	74	82
3.25	7.12	6.34	8.00	266	254	279	85	81	89
3.50	8.61	7.70	9.64	288	275	302	92	88	96
3.75	10.25	9.19	11.44	310	296	324	99	94	103
4.00	12.02	10.78	13.40	331	317	347	105	101	110
4.25	13.92	12.49	15.53	352	337	369	112	107	117
4.50	15.96	14.29	17.81	373	356	390	119	113	124
4.75	18.11	16.19	20.26	393	375	412	125	119	131
5.00	20.39	18.18	22.86	413	394	433	131	125	138
5.25	22.78	20.25	25.61	433	412	454	138	131	145
5.50	25.28	22.41	28.51	452	430	475	144	137	151
5.75	27.89	24.64	31.56	471	447	496	150	142	158
6.00	30.60	26.95	34.75	489	464	516	156	148	164
6.25	33.42	29.32	38.08	508	481	536	162	153	171
6.50	36.33	31.76	41.54	526	497	556	167	158	177
6.75	39.33	34.27	45.14	543	513	575	173	163	183
7.00	42.42	36.83	48.86	561	529	595	178	168	189
7.25	45.60	39.46	52.71	578	544	614	184	173	195
7.50	48.87	42.14	56.67	595	559	633	189	178	201
7.75	52.22	44.87	60.76	611	574	651	195	183	207
8.00	55.64	47.66	64.96	628	589	670	200	187	213
8.25	59.14	50.49	69.27	644	603	688	205	192	219
8.50	62.71	53.37	73.68	660	617	706	210	196	225
8.75	66.35	56.30	78.21	676	631	724	215	201	230
9.00	70.06	59.26	82.83	691	645	741	220	205	236
9.25	73.84	62.27	87.56	707	658	759	225	209	241
9.50	77.68	65.32	92.38	722	671	776	230	214	247
9.75	81.58	68.41	97.29	737	684	793	234	218	252
10.00	85.55	71.53	102.30	751	697	809	239	222	258
10.25	89.56	74.69	107.40	766	710	826	244	226	263
10.50	93.64	77.88	112.58	780	722	842	248	230	268
10.75	97.77	81.11	117.85	794	735	859	253	234	273
11.00	101.95	84.36	123.20	808	747	875	257	238	278
11.25	106.18	87.65	128.63	822	759	891	262	242	283
11.50	110.46	90.96	134.14	836	771	906	266	245	288
11.75	114.79	94.30	139.73	849	782	922	270	249	293
12.00	119.17	97.67	145.39	863	794	937	275	253	298

Combretum erythrophyllum and *Rhus lancea* combination									
Age	Sequestrated carbon (kg)			Stem circumference (mm)			Stem diameter (mm)		
(years)	Mean	L	U	Mean	L	U	Mean	L	U
12.25	123.59	101.07	151.12	876	805	953	279	256	303
12.50	128.05	104.49	156.93	889	817	968	283	260	308
12.75	132.55	107.93	162.80	902	828	983	287	263	313
13.00	137.10	111.39	168.74	915	839	997	291	267	317
13.25	141.69	114.88	174.75	927	850	1012	295	270	322
13.50	146.31	118.39	180.82	940	860	1027	299	274	327
13.75	150.97	121.92	186.95	952	871	1041	303	277	331
14.00	155.67	125.47	193.14	964	881	1055	307	281	336
14.25	160.40	129.03	199.40	977	892	1069	311	284	340
14.50	165.17	132.62	205.71	989	902	1083	315	287	345
14.75	169.97	136.22	212.08	1000	912	1097	318	290	349
15.00	174.80	139.84	218.50	1012	922	1111	322	294	354
15.25	179.67	143.48	224.98	1024	932	1125	326	297	358
15.50	184.56	147.13	231.51	1035	942	1138	330	300	362
15.75	189.49	150.80	238.10	1047	952	1151	333	303	367
16.00	194.44	154.48	244.73	1058	961	1165	337	306	371
16.25	199.42	158.18	251.42	1069	971	1178	340	309	375
16.50	204.43	161.89	258.15	1080	980	1191	344	312	379
16.75	209.47	165.61	264.93	1092	990	1204	347	315	383
17.00	214.53	169.35	271.75	1102	999	1217	351	318	387
17.25	219.61	173.10	278.63	1113	1008	1229	354	321	391
17.50	224.72	176.86	285.54	1124	1017	1242	358	324	395
17.75	229.86	180.63	292.50	1135	1026	1255	361	327	399
18.00	235.02	184.41	299.50	1145	1035	1267	365	329	403
18.25	240.20	188.21	306.55	1156	1044	1279	368	332	407
18.50	245.40	192.01	313.63	1166	1053	1292	371	335	411
18.75	250.62	195.82	320.75	1176	1061	1304	374	338	415
19.00	255.87	199.65	327.92	1187	1070	1316	378	341	419
19.25	261.13	203.48	335.12	1197	1078	1328	381	343	423
19.50	266.42	207.32	342.35	1207	1087	1340	384	346	426
19.75	271.72	211.17	349.63	1217	1095	1352	387	349	430
20.00	277.04	215.03	356.94	1227	1104	1363	390	351	434
20.25	282.38	218.90	364.28	1236	1112	1375	394	354	438
20.50	287.74	222.77	371.66	1246	1120	1387	397	356	441
20.75	293.12	226.65	379.08	1256	1128	1398	400	359	445
21.00	298.51	230.54	386.52	1265	1136	1409	403	362	449
21.25	303.92	234.44	394.00	1275	1144	1421	406	364	452
21.50	309.35	238.34	401.51	1284	1152	1432	409	367	456
21.75	314.79	242.25	409.05	1294	1160	1443	412	369	459
22.00	320.25	246.16	416.63	1303	1168	1454	415	372	463
22.25	325.72	250.08	424.23	1312	1175	1465	418	374	466
22.50	331.20	254.01	431.86	1321	1183	1476	421	377	470
22.75	336.70	257.94	439.52	1331	1191	1487	424	379	473
23.00	342.22	261.88	447.21	1340	1198	1498	426	381	477
23.25	347.75	265.82	454.92	1349	1206	1508	429	384	480
23.50	353.29	269.77	462.66	1357	1213	1519	432	386	484
23.75	358.84	273.72	470.43	1366	1220	1530	435	388	487
24.00	364.41	277.67	478.23	1375	1228	1540	438	391	490

Combretum erythrophyllum and *Rhus lancea* combination

Age	Sequestrated carbon (kg)			Stem circumference (mm)			Stem diameter (mm)		
(years)	Mean	L	U	Mean	L	U	Mean	L	U
24.25	369.98	281.63	486.05	1384	1235	1551	441	393	494
24.50	375.57	285.60	493.89	1393	1242	1561	443	395	497
24.75	381.17	289.57	501.76	1401	1249	1571	446	398	500
25.00	386.79	293.54	509.66	1410	1257	1582	449	400	503
25.25	392.41	297.52	517.58	1418	1264	1592	451	402	507
25.50	398.05	301.50	525.52	1427	1271	1602	454	404	510
25.75	403.69	305.48	533.48	1435	1278	1612	457	407	513
26.00	409.35	309.46	541.47	1444	1285	1622	459	409	516
26.25	415.01	313.45	549.47	1452	1291	1632	462	411	520
26.50	420.69	317.45	557.50	1460	1298	1642	465	413	523
26.75	426.37	321.44	565.55	1468	1305	1652	467	415	526
27.00	432.06	325.44	573.62	1476	1312	1662	470	418	529
27.25	437.77	329.44	581.72	1485	1318	1671	473	420	532
27.50	443.48	333.44	589.83	1493	1325	1681	475	422	535
27.75	449.20	337.45	597.96	1501	1332	1691	478	424	538
28.00	454.93	341.46	606.11	1509	1338	1700	480	426	541
28.25	460.66	345.47	614.28	1516	1345	1710	483	428	544
28.50	466.41	349.48	622.46	1524	1351	1719	485	430	547
28.75	472.16	353.49	630.67	1532	1358	1729	488	432	550
29.00	477.92	357.51	638.89	1540	1364	1738	490	434	553
29.25	483.69	361.52	647.13	1548	1371	1747	493	436	556
29.50	489.46	365.54	655.39	1555	1377	1757	495	438	559
29.75	495.24	369.56	663.67	1563	1383	1766	497	440	562
30.00	501.03	373.58	671.96	1570	1389	1775	500	442	565
30.25	506.83	377.60	680.27	1578	1396	1784	502	444	568
30.50	512.63	381.63	688.59	1586	1402	1793	505	446	571
30.75	518.43	385.65	696.93	1593	1408	1802	507	448	574
31.00	524.25	389.68	705.29	1600	1414	1811	509	450	577
31.25	530.07	393.70	713.66	1608	1420	1820	512	452	579
31.50	535.89	397.73	722.04	1615	1426	1829	514	454	582
31.75	541.72	401.76	730.44	1622	1432	1838	516	456	585
32.00	547.56	405.79	738.86	1630	1438	1847	519	458	588
32.25	553.40	409.82	747.29	1637	1444	1856	521	460	591
32.50	559.25	413.85	755.73	1644	1450	1864	523	462	593
32.75	565.10	417.88	764.19	1651	1456	1873	526	463	596
33.00	570.96	421.91	772.66	1658	1462	1882	528	465	599
33.25	576.82	425.94	781.14	1666	1468	1890	530	467	602
33.50	582.69	429.98	789.64	1673	1473	1899	532	469	604
33.75	588.56	434.01	798.14	1680	1479	1907	535	471	607
34.00	594.43	438.04	806.66	1687	1485	1916	537	473	610
34.25	600.32	442.07	815.20	1694	1491	1924	539	474	612
34.50	606.20	446.11	823.74	1700	1496	1932	541	476	615
34.75	612.09	450.14	832.30	1707	1502	1941	543	478	618
35.00	617.98	454.17	840.87	1714	1507	1949	546	480	620
35.25	623.88	458.20	849.45	1721	1513	1957	548	482	623
35.50	629.78	462.24	858.04	1728	1519	1966	550	483	626
35.75	635.68	466.27	866.64	1734	1524	1974	552	485	628
36.00	641.59	470.30	875.26	1741	1530	1982	554	487	631

Combretum erythrophyllum and *Rhus lancea* combination									
Age	Sequestrated carbon (kg)			Stem circumference (mm)			Stem diameter (mm)		
(years)	Mean	L	U	Mean	L	U	Mean	L	U
36.25	647.50	474.33	883.88	1748	1535	1990	556	489	633
36.50	653.41	478.36	892.52	1754	1540	1998	558	490	636
36.75	659.33	482.39	901.16	1761	1546	2006	561	492	639
37.00	665.25	486.42	909.82	1768	1551	2014	563	494	641
37.25	671.17	490.45	918.48	1774	1557	2022	565	495	644
37.50	677.10	494.48	927.16	1781	1562	2030	567	497	646
37.75	683.03	498.51	935.84	1787	1567	2038	569	499	649
38.00	688.96	502.54	944.54	1794	1572	2046	571	501	651
38.25	694.90	506.57	953.24	1800	1578	2054	573	502	654
38.50	700.83	510.60	961.95	1807	1583	2062	575	504	656
38.75	706.77	514.62	970.67	1813	1588	2069	577	506	659
39.00	712.72	518.65	979.40	1819	1593	2077	579	507	661
39.25	718.66	522.67	988.14	1826	1598	2085	581	509	664
39.50	724.61	526.69	996.89	1832	1604	2093	583	510	666
39.75	730.56	530.72	1005.64	1838	1609	2100	585	512	669
40.00	736.51	534.74	1014.41	1844	1614	2108	587	514	671
40.25	742.46	538.76	1023.18	1851	1619	2115	589	515	673
40.50	748.42	542.78	1031.96	1857	1624	2123	591	517	676
40.75	754.37	546.80	1040.75	1863	1629	2131	593	518	678
41.00	760.33	550.82	1049.54	1869	1634	2138	595	520	681
41.25	766.29	554.83	1058.34	1875	1639	2145	597	522	683
41.50	772.25	558.85	1067.15	1881	1644	2153	599	523	685
41.75	778.22	562.86	1075.97	1887	1649	2160	601	525	688
42.00	784.18	566.88	1084.80	1893	1654	2168	603	526	690
42.25	790.15	570.89	1093.63	1899	1658	2175	605	528	692
42.50	796.12	574.90	1102.46	1905	1663	2182	606	529	695
42.75	802.09	578.91	1111.31	1911	1668	2190	608	531	697
43.00	808.06	582.92	1120.16	1917	1673	2197	610	532	699
43.25	814.03	586.92	1129.02	1923	1678	2204	612	534	702
43.50	820.01	590.93	1137.88	1929	1682	2211	614	536	704
43.75	825.98	594.93	1146.75	1935	1687	2219	616	537	706
44.00	831.96	598.94	1155.63	1941	1692	2226	618	539	708
44.25	837.93	602.94	1164.51	1946	1697	2233	620	540	711
44.50	843.91	606.94	1173.40	1952	1701	2240	621	542	713
44.75	849.89	610.94	1182.30	1958	1706	2247	623	543	715
45.00	855.87	614.94	1191.20	1964	1711	2254	625	545	717
45.25	861.85	618.93	1200.10	1969	1715	2261	627	546	720
45.50	867.83	622.93	1209.02	1975	1720	2268	629	547	722
45.75	873.81	626.92	1217.93	1981	1724	2275	630	549	724
46.00	879.79	630.91	1226.85	1986	1729	2282	632	550	726
46.25	885.78	634.90	1235.78	1992	1734	2289	634	552	729
46.50	891.76	638.89	1244.71	1998	1738	2296	636	553	731
46.75	897.74	642.88	1253.65	2003	1743	2303	638	555	733
47.00	903.73	646.86	1262.59	2009	1747	2309	639	556	735
47.25	909.71	650.84	1271.54	2014	1752	2316	641	558	737
47.50	915.70	654.83	1280.49	2020	1756	2323	643	559	739

Table Appendix A 6.3. *Rhus lancea* - *Rhus pendulina* combination

***Rhus lancea* and *Rhus pendulina* combination**									
Age	**Sequestrated carbon (kg)**			**Stem circumference (mm)**			**Stem diameter (mm)**		
(years)	**Mean**	**L**	**U**	**Mean**	**L**	**U**	**Mean**	**L**	**U**
1.00	0.29	0.22	0.39	70	62	80	22	20	25
1.25	0.57	0.44	0.73	93	84	103	30	27	33
1.50	0.96	0.77	1.19	115	105	126	37	34	40
1.75	1.46	1.21	1.77	138	127	149	44	40	47
2.00	2.08	1.76	2.46	159	149	171	51	47	54
2.25	2.81	2.42	3.26	181	170	192	57	54	61
2.50	3.64	3.18	4.17	201	190	213	64	61	68
2.75	4.58	4.05	5.18	221	210	233	70	67	74
3.00	5.61	5.01	6.28	241	230	253	77	73	80
3.25	6.74	6.07	7.48	260	249	272	83	79	87
3.50	7.95	7.20	8.77	279	268	290	89	85	92
3.75	9.24	8.41	10.15	297	285	309	94	91	98
4.00	10.61	9.69	11.61	314	303	327	100	96	104
4.25	12.05	11.04	13.16	332	320	344	106	102	110
4.50	13.56	12.43	14.79	348	336	361	111	107	115
4.75	15.14	13.88	16.50	365	352	378	116	112	120
5.00	16.77	15.38	18.29	381	367	395	121	117	126
5.25	18.47	16.92	20.16	396	382	411	126	122	131
5.50	20.21	18.49	22.09	411	397	427	131	126	136
5.75	22.01	20.10	24.09	426	411	443	136	131	141
6.00	23.85	21.75	26.16	441	424	458	140	135	146
6.25	25.74	23.42	28.30	455	438	474	145	139	151
6.50	27.68	25.13	30.49	469	451	488	149	143	155
6.75	29.65	26.86	32.74	483	463	503	154	147	160
7.00	31.66	28.61	35.05	496	476	518	158	151	165
7.25	33.71	30.38	37.41	509	488	532	162	155	169
7.50	35.80	32.18	39.82	522	500	546	166	159	174
7.75	37.91	34.00	42.27	535	511	560	170	163	178
8.00	40.06	35.84	44.78	547	523	573	174	166	183
8.25	42.23	37.69	47.33	560	534	587	178	170	187
8.50	44.44	39.56	49.92	572	545	600	182	173	191
8.75	46.67	41.45	52.55	583	555	613	186	177	195
9.00	48.92	43.35	55.22	595	566	626	189	180	199
9.25	51.20	45.26	57.92	606	576	638	193	183	203
9.50	53.50	47.18	60.67	618	586	651	197	187	207
9.75	55.82	49.12	63.44	629	596	663	200	190	211
10.00	58.17	51.07	66.25	640	606	675	204	193	215
10.25	60.53	53.03	69.09	650	615	687	207	196	219
10.50	62.91	55.00	71.96	661	625	699	210	199	222
10.75	65.31	56.98	74.86	671	634	711	214	202	226
11.00	67.73	58.96	77.79	681	643	722	217	205	230
11.25	70.16	60.96	80.74	692	652	733	220	208	233
11.50	72.60	62.96	83.72	702	661	745	223	210	237
11.75	75.06	64.97	86.73	711	670	756	226	213	240
12.00	77.54	66.98	89.76	721	678	766	230	216	244

Rhus lancea and *Rhus pendulina* combination									
Age	Sequestrated carbon (kg)			Stem circumference (mm)			Stem diameter (mm)		
(years)	Mean	L	U	Mean	L	U	Mean	L	U
12.25	80.02	69.00	92.81	731	687	777	233	219	247
12.50	82.52	71.03	95.88	740	695	788	236	221	251
12.75	85.04	73.06	98.98	749	703	798	239	224	254
13.00	87.56	75.10	102.09	759	711	809	241	226	257
13.25	90.09	77.14	105.23	768	719	819	244	229	261
13.50	92.64	79.18	108.38	777	727	829	247	232	264
13.75	95.19	81.23	111.55	785	735	839	250	234	267
14.00	97.75	83.28	114.74	794	743	849	253	236	270
14.25	100.33	85.34	117.95	803	750	859	256	239	273
14.50	102.91	87.40	121.17	811	758	869	258	241	277
14.75	105.50	89.46	124.41	820	765	878	261	244	280
15.00	108.09	91.52	127.66	828	773	888	264	246	283
15.25	110.69	93.59	130.93	837	780	897	266	248	286
15.50	113.31	95.66	134.21	845	787	907	269	251	289
15.75	115.92	97.73	137.50	853	794	916	271	253	291
16.00	118.54	99.80	140.81	861	801	925	274	255	294
16.25	121.17	101.87	144.13	869	808	934	277	257	297
16.50	123.81	103.95	147.47	877	815	943	279	259	300
16.75	126.45	106.02	150.81	884	822	952	281	262	303
17.00	129.09	108.10	154.17	892	828	960	284	264	306
17.25	131.74	110.17	157.54	900	835	969	286	266	308
17.50	134.40	112.25	160.91	907	841	978	289	268	311
17.75	137.06	114.33	164.30	914	848	986	291	270	314
18.00	139.72	116.41	167.70	922	854	995	293	272	317
18.25	142.39	118.49	171.11	929	861	1003	296	274	319
18.50	145.06	120.56	174.52	936	867	1011	298	276	322
18.75	147.73	122.64	177.95	944	873	1020	300	278	325
19.00	150.41	124.72	181.38	951	879	1028	303	280	327
19.25	153.09	126.80	184.82	958	885	1036	305	282	330
19.50	155.77	128.88	188.27	965	891	1044	307	284	332
19.75	158.45	130.95	191.73	972	897	1052	309	286	335
20.00	161.14	133.03	195.19	978	903	1060	311	287	337
20.25	163.83	135.11	198.66	985	909	1068	314	289	340
20.50	166.53	137.18	202.14	992	915	1075	316	291	342
20.75	169.22	139.26	205.63	999	921	1083	318	293	345
21.00	171.92	141.33	209.12	1005	926	1091	320	295	347
21.25	174.61	143.40	212.62	1012	932	1098	322	297	350
21.50	177.31	145.48	216.12	1018	938	1106	324	298	352
21.75	180.02	147.55	219.63	1025	943	1113	326	300	354
22.00	182.72	149.62	223.14	1031	949	1121	328	302	357
22.25	185.42	151.68	226.66	1037	954	1128	330	304	359
22.50	188.13	153.75	230.19	1044	959	1135	332	305	361
22.75	190.83	155.82	233.72	1050	965	1143	334	307	364
23.00	193.54	157.88	237.25	1056	970	1150	336	309	366
23.25	196.25	159.94	240.79	1062	975	1157	338	310	368
23.50	198.96	162.01	244.33	1068	981	1164	340	312	370
23.75	201.67	164.07	247.88	1074	986	1171	342	314	373
24.00	204.37	166.12	251.43	1080	991	1178	344	315	375

Rhus lancea and *Rhus pendulina* combination									
Age	Sequestrated carbon (kg)			Stem circumference (mm)			Stem diameter (mm)		
(years)	Mean	L	U	Mean	L	U	Mean	L	U
24.25	207.08	168.18	254.99	1086	996	1185	346	317	377
24.50	209.79	170.24	258.55	1092	1001	1192	348	319	379
24.75	212.51	172.29	262.11	1098	1006	1199	350	320	382
25.00	215.22	174.34	265.67	1104	1011	1205	351	322	384
25.25	217.93	176.39	269.24	1110	1016	1212	353	323	386
25.50	220.64	178.44	272.81	1115	1021	1219	355	325	388
25.75	223.35	180.49	276.39	1121	1026	1225	357	327	390
26.00	226.06	182.53	279.97	1127	1031	1232	359	328	392
26.25	228.77	184.57	283.55	1132	1035	1238	360	330	394
26.50	231.48	186.61	287.13	1138	1040	1245	362	331	396
26.75	234.19	188.65	290.72	1144	1045	1251	364	333	398
27.00	236.90	190.69	294.31	1149	1050	1258	366	334	400
27.25	239.61	192.72	297.90	1154	1054	1264	367	336	402
27.50	242.32	194.76	301.49	1160	1059	1271	369	337	404
27.75	245.02	196.79	305.08	1165	1063	1277	371	339	406
28.00	247.73	198.82	308.68	1171	1068	1283	373	340	408
28.25	250.44	200.84	312.28	1176	1073	1289	374	341	410
28.50	253.14	202.87	315.88	1181	1077	1296	376	343	412
28.75	255.85	204.89	319.48	1186	1081	1302	378	344	414
29.00	258.55	206.91	323.08	1192	1086	1308	379	346	416
29.25	261.25	208.93	326.69	1197	1090	1314	381	347	418
29.50	263.96	210.94	330.29	1202	1095	1320	383	348	420
29.75	266.66	212.96	333.90	1207	1099	1326	384	350	422
30.00	269.36	214.97	337.51	1212	1103	1332	386	351	424
30.25	272.06	216.98	341.12	1217	1108	1338	387	353	426
30.50	274.75	218.98	344.73	1222	1112	1344	389	354	428
30.75	277.45	220.99	348.34	1227	1116	1350	391	355	430
31.00	280.15	222.99	351.95	1232	1120	1355	392	357	431
31.25	282.84	224.99	355.57	1237	1125	1361	394	358	433
31.50	285.54	226.99	359.18	1242	1129	1367	395	359	435
31.75	288.23	228.99	362.80	1247	1133	1373	397	361	437
32.00	290.92	230.98	366.41	1252	1137	1378	398	362	439
32.25	293.61	232.97	370.03	1257	1141	1384	400	363	441
32.50	296.30	234.96	373.64	1261	1145	1390	402	364	442