Growth and Yield Estimation of the Stand of *Cupressus lusitanica*

Negash Mamo

Technical Manual 17

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Ethiopian Institute of Agricultural Research

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Introduction

Cupressus lusitanica was introduced to Ethiopia before 1950 (Pukkala and Pohjonen, 1993; Negash et. al, 1995) and it has been planted in different parts of the country through reforestation programs. Munesa Shashemene forest is among the plantation where this species has been planted widely as timber tree. Currently, it accounts for 61.67% of the total plantation area of 6101 ha. *Cupressus* is the most important and fast growing exotic tree species in Ethiopia, suitable for construction and making of furniture, doors, windows etc (Web et al. 1984).

Availability of growth and yield models is among the important forest management tools that give required information for planning. Predicting future growth and yield of plantations is absolutely essential in forest management. Adequate documented empirical models or yield tables of exotic as well indigenous species that help to estimate growth and yield of plantation forests of the country are lacking. As a result, foresters frequently try to make best guess and subjective estimates of growth and yield or use models of neighbouring countries.

Therefore, this manual is meant to give insight on the basic concepts and definition of growth and yield and then look at the meaning and measurement of growth in the context of plantation forest managed under even-aged silvicultural system at Munesa Shashemene.

Stand growth is a change in a stand attributes such as volume, and basal area, over some specified time. Yield is the amount of wood that can be harvested and removed per period or the total amount of wood that could be removed at any time. Growth and yield can be explained in physical units such as volume (m^3/ha) and basal area (m^2/ha). Naturally, trees accumulate growth over many years. Woody growth occurs in branches diameter, height, and roots. Commonly only the bole to some merchantable top is removed from the forest.

The models presented in this manual give the quantitative relationship between measured growth characters, which are helpful to predict quadratic mean diameter, total height, tree volume, growth, and yield of *C. lusitanica* stands growing at Munesa Shashemene.

Yield tables, which are simplified representations of the reality, are used for getting replies to question like: where, how much, and when to cut. These permit managers to understand the present and future status of the plantation and to make decision based on predicted yield.

Therefore, models as well as yield tables presented in this manual helps for management planning of *C. lusitanica* growing at Munesa Shashemene and could be used to estimate growth of *C. lusitanica* growing in other similar agro ecology.

Tree Characteristics

The most commonly measured tree characters in forest inventory are breast height diameter and total height. The different dimension of trees is called tree characteristics.

Diameter Measurements

The thickness of the bole is mostly described as the diameter at breast height (dbh). Diameter at breast height is measured at the height of 1.3 meters above the ground using a forest calliper or diameter tape. When calliper is used, hold it horizontally and do not squeeze the calliper's arms on the trunk tightly. For a better precision do a second measurement at perpendicular direction and take the average. Measure the diameter on the upper side of the sloppy terrain. If the tree is forked below 1.3 meter, then the tree should be considered as a tree composed of two stems and the diameter is measured for both of them (figure 1.)

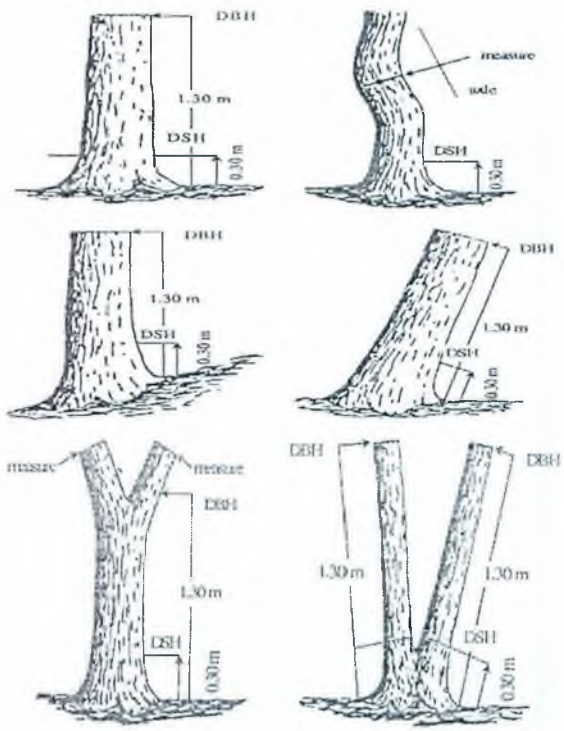

Figure 1. Diameter measurements

Height Measurements

The total height of a tree is the length of straight line connecting the base of the tree with the extremity of terminal bud of the stem. For forked trees, there is one height if the fork is above 1.30 m and, as many heights as there are stems if the fork is below 1.30 m. Measuring height is time consuming and is subjected to error due to over stocking, human error and precision of the instrument (FAO, 1980).

A height is measured by optical procedure using Sunnto hypsometer, Blume Leiss, Haga and others. Often, Sunnto hypsometer is used to measure the height of standing tree. When measuring tree height using Sunnto hypsometer, it is always important to decide at which distance from the tree the measurement should be taken. To do this, it is possible to use range finder, which is delivered with the instrument that has four distances to choose from15, 20, 30, and 40). The other option is to use tape meter and use the same distances as those of the range finder. When using range finder, choose one of the distances and arrange the range finder accordingly and hung or fix it vertically at visible spot on the trunk of the tree to be measured, look to the range finder through the prism or eyepiece on the hypsometer and move backward and forward until the white band on the range finder overlaps completely and then take the measurement.

Place the instrument to the eye and move it in a vertical arc until the horizontal index line, viewed through the lens, is aligned with the tip and bottom of the tree, i.e. the desired object. Look simultaneously, with both eyes open, one should look into the lens and read the graduated measurement corresponding to measured distance, while the other eye should look to the tip and bottom of the tree. If the measurement is made on flat terrain, add the reading from the tip (h_1) and reading from bottom (h_2) to get the height of the tree (Fig 2). If the measurement is made from down slope subtract the reading from tip of the tree (h_1) from the reading obtained at the base of the tree (h_2), and if the measurement is made down slope, the reading obtained from the tip of tree be subtracted from the reading taken from the base of the tree.

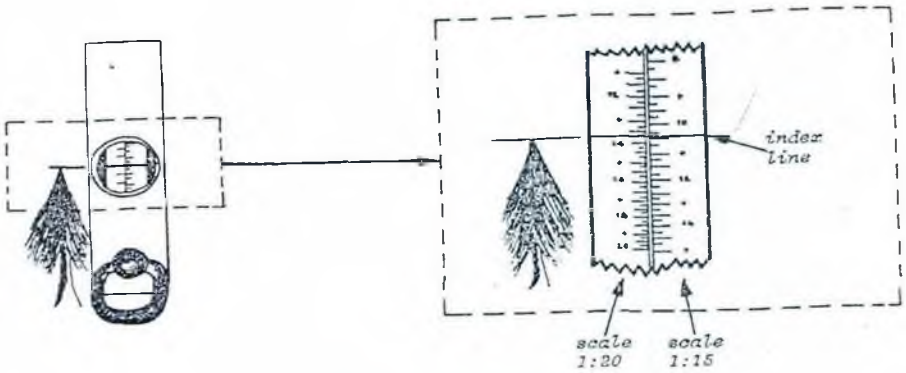

Figure 2. Sunto hypsometer

Diameter–Height Relationship

Measuring tree height is one the difficult and time-consuming tasks in forest inventory. Therefore, the use of diameter and height relationship is essential to make forest inventory easier and less time consuming. The diameter height curve equations of *Cupressus lusitanica* presented in tables 1-6 for site indices 19, 20, 21, 22, 23, 25 and 26 at different ages of the stand can be used to predict the total height of trees. To obtain the total height of the required trees measuring diameter at breast height is adequate. And insert the diameter measured in the equation in order to determine the total height of the tree.

Table 1. Diameter–height curve equation for site indices at Munesa Shashemene Site index 25-26

Age (years)	Equation (model)	Coefficient determination
Beseko site 1		
8	H=2.7325 ln(d)+7.2688	R^2=0.99
9	H=5.27 ln(d)+ 1.0055	R^2=0.98
11	H=5.3613 ln(d)+ 2.7825	R^2=0.98
12	H=6.0946 ln(d)+ 0.8529	R^2=0.98
14	H=8.3238ln(d)-4.4086	R^2=0.99
15	H=7.581ln(d)-1.7458	R^2=0.99
16	H=8.2269ln(d)+-2.9966	R^2=0.99
18	H=9.2835ln(d) –5.139	R^2=0.99
Beseko site 2		
7	H=5.1887 ln(d) –1.4209	R^2=0.97
9	H=3.937 ln(d)+ 3.9319	R^2=0.96
10	H=5.0116 ln(d)+ 1.5311	R^2=0.97
12	H=5.2767 ln(d)+1.8629	R^2=0.97
13	H=6.0619ln(d)+0.3673	R^2=0.97
14	H=6.6555ln(d)-0.7156	R^2=0.98
16	H=6.4662ln(d)+0.4159	R^2=0.98
Borena site		
12	H=3.626ln(d) +7.3659	R^2=0.98
14	H=2.335ln(d)+ 13.628	R^2=0.98
15	H=2.4303ln(d)+ 14.111	R^2=0.98
16	H=4.7382ln(d)+8.341	R^2=0.98
18	H=8.1148ln(d)-1.8385	R^2=0.99
Ashoka site		
7	H=5.9994 ln(d) –3.1066	R^2=0.98
9	H=7.1354 ln(d) –3.9637	R^2=0.99
10	H=10.278 ln(d) –12.923	R^2=0.96
12	H=8.5565 ln(d) –6.3859	R^2=0.98
13	H=9.042 ln(d)- 7.0324	R^2=0.98
14	H=9.051 ln(d)-7.0236	R^2=0.98
16	H=9.0567 ln(d) – 5.9119	R^2=0.98

Table 2. Site index 23

Age (years)	Equation (model)	Coefficient determination
Boye site		
7	H=4.3873 ln(d) –0.0119	R^2=0.96
9	H=5.9229 ln(d) –1..932	R^2=0.97
10	H=3.6577 ln(d)+ 5.3207	R^2=0.96
12	H=5.3531 ln (d)+1.4929	R^2=0.99
13	H=6.108 ln(d)+ 0.223	R^2=0.99
14	H=6.4839 ln(d)+0.238	R^2=0.99
16	H=5.9259 ln(d)+ 3.0128	R^2=0.99
Sire Bake site		
7	H=3.247 ln(d) +1.1712	R^2=0.97
9	H=4.7567 ln(d) – 0.5988	R^2=0.96
10	H= 5.2643 ln(d) –1.4209	R^2=0.96
12	H=3.0949 ln(d)+ 7.3846	R^2=0.99
13	H= 4.2054 n(d)+4.9336	R^2=0.99
14	H= 4.4934 ln(d)+ 5.4776	R^2=0.98
16	H= 4.2264 ln(d)+7.3908	R^2=0.99
Liye Lepis site		
7	H= 5.1528ln(d) -2.6317	R^2=0.98
8	H=6.8735 ln(d) - 4.9592	R^2=0.98
10	H=7.8462 ln(d) - 4.989	R^2=0.98
11	H=6.7595 ln(d) - 1.125	R^2=0.98
13	H=7.3113 ln(d) - 2.0967	R^2=0.99
14	H=4.4927 ln(d) + 7.1843	R^2=0.98
15	H= 6.927 ln(d) –0.3744	R^2=0.99
17	H=7.3073 ln(d)+ 0.293	R^2=0.99

Table 3. Site index 22

Age (years)	Equation (model)	Coefficient determination
Reji site		
8	H=5.5676 ln(d) –2.6892	R^2=0.98
10	H=5.7891 ln(d) –0.6215	R^2=0.99
11	H=6.438 ln(d) – 2.3689	R^2=0.99
13	H=7.2189 ln (d) –3.3269	R^2=0.97
14	H=6.512 ln(d)-0.5049	R^2=0.98
15	H=7.844 ln(d) –3.9706	R^2=0.98
17	H=9.114 ln(d) –7.1697	R^2=0.98
Dalele site		
10	H=3.324 ln(d) + 1.9822	R^2=0.97
12	H=3.9199 ln(d) +3.4946	R^2=0.97
13	H= 3.9492 ln(d)+4.4495	R^2=0.97
14	H=4.5554 ln(d)+ 4.2852	R^2=0.97
16	H= 6.0019 ln(d)+0.9794	R^2=0.98

Table 4. Site index 21

Age (years)	Equation (model)	Coefficient determination
Shoba site		
11	H=8.2872 ln(d) –8.1285	R^2=0.98
13	H=7.493 ln(d) –4.1966	R^2=0.99
14	H=7.733 ln(d) – 3.9725	R^2=0.99
15	H=7.9009 ln (d) –3.4762	R^2=0.97
17	H=9.0466 ln(d)-6.5436	R^2=0.98
Keta Sardo site		
8	H=4.5434 ln(d) - 1.7813	R^2=0.97
10	H=4.5 ln(d) –0.1416	R^2=0.95
11	H=4.9729ln(d)+0.1026	R^2=0.95
13	H=3.7652 ln(d)+ 5.2756	R^2=0.95
14	H=5.5236 ln(d)+1.1029	R^2=0.97
15	H=4.8452 ln(d)+3.8697	R^2=0.98
17	H=5.5803 ln(d)+2.8662	R^2=0.98

Table 5. Site index 20

Age (years)	Equation (model)	Coefficient determination
Wondo Genet site		
7	H=2.9628 ln(d) +1.7293	R^2=0.97
9	H=2.2288 ln(d) +7.79	R^2=0.87
10	H=4.219 ln(d) +2.8669	R^2=0.98
12	H=7.2872 ln (d) –4.2318	R^2=0.98
13	H=5.1882 ln(d) +2.4712	R^2=0.98
14	H=5.5748 ln(d)+2.1917	R^2=0.98
16	H=6.4769 ln(d) – 0.4965	R^2=0.98

Table 6. Site index 19

Age (years)	Equation (model)	Coefficient determination
Kuke site		
12	H=5.139 ln(d)-0.6711	R^2=0.97
14	H=5.457 ln(d)+ 0.1194	R^2=0.98
15	H=5.2698 ln(d)+ 1.6852	R^2=0.98
16	H=5.7994 ln(d)+ 1.222	R^2=0.98
18	H=7.3738 ln(d)-2.7239	R^2=0.98
Bojitu site		
12	H=4.4133 ln(d) - 0.522	R^2=0.98
14	H=4.683 ln(d)+ 1.1126	R^2=0.98
15	H=6.7117 ln(d) - 3.8575	R^2=0.98
17	H=5.5126 ln(d)+1.6597	R^2=0.99
18	H=5.4779 ln(d)+2.1013	R^2=0.99
19	H=6.5242 ln(d)-0.1413	R^2=0.99
21	H=4.2264 ln(d)+7.3908	R^2=0.98
Wandere site		
7	H=3.9279 ln(d) +0.3411	R^2=0.97
9	H=3.766 ln(d)+ 2.7853	R^2=0.98
10	H=3.731 ln(d)+ 3.303	R^2=0.98
12	H=4.6431 ln(d)+1.9321	R^2=0.98
13	H=4.4684 ln(d)+3.1492	R^2=0.98
14	H=6.73 ln(d) +2.3099	R^2=0.98
16	H=5.0213 ln(d)+2.6957	R^2=0.99

Volume Equation

Volume is the measure of solid content or capacity usually expressed in cubes units, such as cubic meter; cubic decimeter and cubic feet. Volume is the most widely used measure of wood quantity. Estimating volume of standing trees is difficult and time consuming unless tree volume equation is used or the volume of cut trees are determined using either Huber's, Smalian's or Newton's formula. In this manual the volume equation (1) that was developed by Orlander (1986) was used to estimate the volume of standing trees.

$$Lnv=-3.2161+1.8096\ Ln\ (d)+1.1492 Ln\ (h), \quad (1)$$

Where (d) is breast height diameter and (h) is total height of the tree. To make volume estimation easier, the above volume equation is presented in the form of volume table. The volume of a single tree can be obtained directly from volume table (4) using the diameter at breast height and height as input parameter; the table provides volume in terms of cubic decimetre (dm^3).

Table 4. Volume table of *Cupressus lusitanica*

Figures refer to stem volume (cm^3) over bark between stump and top

	Diameter at breast height (cm)																			
	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0
5.0	4.7	6.5	8.6	11.0	12.6	16.4	19.5													
6.0	5.2	8.0	10.6	13.5	14.1	20.3	24.1	28.2												
7.0	7.3	9.6	12.7	16.2	21.0	24.2	28.8	33.7	38.9											
8.0	8.1	11.2	14.8	18.9	23.5	28.2	33.5	39.3	45.4	51.9										
9.0	9.2	12.8	17.0	21.6	27.5	32.3	38.4	45.0	52.0	59.4	67.3									
10.0	10.4	14.5	19.1	24.4	31.6	55.8	91.4	50.7	58.6	67.1	76.0	85.4								
11.0		16.2	21.3	27.2	33.6	40.7	48.4	56.6	65.4	74.8	84.8	95.3	106.3							
12.0			23.6	30.0	37.2	45.0	53.5	62.6	72.3	82.7	93.7	105.3	117.5							
13.0				32.9	40.8	49.3	58.6	68.6	79.3	90.7	102.7	115.4	128.8	142.9						
14.0					44.4	53.7	63.8	74.7	86.3	98.7	111.9	125.7	140.3	155.6	171.6					
15.0						58.1	69.1	80.9	93.5	106.9	121.1	136.1	151.9	168.4	185.7	203.8				
16.0							74.4	87.1	100.7	115.1	130.4	146.6	163.6	181.4	200.0	219.5	239.7			
17.0								93.4	107.9	123.4	139.8	157.1	175.4	194.5	214.5	235.3	257.0	279.6		
18.0									115.2	131.8	149.3	167.8	187.3	207.7	229.0	251.3	274.5	298.6	323.6	
19.0										140.2	158.9	178.6	199.3	221.0	243.7	267.4	292.1	317.7	344.3	371.9
20.0											168.5	189.4	211.4	234.4	258.5	283.6	309.8	337.0	365.3	394.5
21.0												200.3	223.6	247.9	273.4	300.0	327.7	356.5	386.3	417.2
22.0													235.8	261.5	288.4	316.5	345.7	376.0	407.5	440.2
23.0														275.2	303.5	333.0	363.8	395.7	428.9	463.2
24.0															318.7	349.7	382.0	415.6	450.4	486.4
25.0																366.5	400.4	435.5	472.0	509.8
26.0																383.4	418.8	455.6	493.8	533.3
27.0																400.4	437.4	475.8	515.7	557.0

Stand Characteristics

Stand characteristics such as number of trees, basal area, and volume, are used to describe tree populations in sample plots or stands. To characterize the existing stand, adequate number of sample plots or trees over the range of site variability should be sampled. The size of the plots is preferred to be 20 m by 20 m. The breast height diameter of trees in sample plots should be measured to determine mean diameter of trees in the stand. For stand characterization the quadratic mean diameter is more preferred than arithmetic mean diameter. The quadratic mean diameter (dg) should be calculated for each sample plot and this can be calculated by applying equation (2). The calculation could be done easily using Microsoft Excel.

$$dg = \sqrt{\frac{\sum_{i=1}^{n} dbh_i^2}{n}} \quad (2)$$

Where (dbh) is the breast height diameter and n is the number of trees in the sample plots.

A basal area is expressed in the form of equation (3). This gives us basal area of a single tree in terms of square meter (m^2). If basal area per hectare is required, then multiply the plot mean of basal area by the number of tree per hectare. Number of trees per hectare could be estimated as number of tree in sample plots (20m by 20 m) multiplied by 25. The basal area of a single tree is explained in mathematical formula as:

$$g = \frac{d^2 .3.14}{40000} \quad (3)$$

Where d is breast height diameter and 3.14 is value of "pie". The basal area of the stand can also be estimated using Spiegel relascope.

Mostly the height of tree in sample plots is measured using 4\psometer. Lorey's mean height is preferable than arithmetic mean height. Use equation (4) to determine the Lorey's mean height of the plots. In the equation h_l is Lorey's mean height, h_i is height of a single tree and g_i is basal area of a single tree.

$$h_l = \frac{\sum_{i=1}^{n} h_i \cdot g_i}{\sum_{i=1}^{n} g_i} \quad (4)$$

Growth and Yield Prediction

Site Classification

Site classification is an important part of growth and yield estimation and is used to determine site productivity. Site index can be also used to determine land value and land taxation. The initial and almost crucial step in growth and yield prediction is to quantify differences in site productivity. In the perspective of plantation management, site productivity can be explained as the production potential of a given site for particular tree species at a given age. Of all indirect measures that have been investigated, the dominant height of trees appears the most practical, consistent and useful indicator of site quality. Therefore, site index system is a useful tool in forest management planning as it serves as input parameters in predicting the potential growth and yield of a forest.

To determine site index, first, examine trees in a stand visually select representative trees with full crowns in the upper canopy that appear vigoros and strongly competitive for light, moisture, and nutrients. Next, measure four largest trees in the sample (20 m x 20 m) and calculate the average dominant height and then obtain information about the age of the stand from management plan. To determine the site index of the sample plots, insert the mean dominant height and the age of the stand in site index models (6) for Gambo-Shashemene (Woyna Dega) and site index model (8) for Munesa (Dega) (Negash and Hubert 2006). To make site determination easy figures 1 and 2 can be used instead.

Site index model for Gambo-Shashemene (Woyena Dega)

$$H = SI \cdot \left(\frac{1 - \exp(-0.0793 \cdot A)}{1 - \exp(-0.0793 \cdot 15)} \right) \quad (5)$$

SI= H/((1-exp(-0.0793*A))/(1-exp(-0.0793*15))) (6)

Site index model for Munesa (Dega)

$$H = SI \cdot \left(\frac{1 - \exp(-0366 \cdot A)}{1 - \exp(-0.0366 \cdot 15)} \right) \quad (7)$$

SI= H/((1-exp(-0.0366*A))/(1-exp(-0.0366*15))) (8)

Where H is dominant height at the age A_1, SI is site index at the base age 15; 0.0793 and 0.0366 are estimated parameters for Gambo-Shashemene and Munesa respectively. The site index values of sample plots are then averaged to estimate the value of the stand. For instance site index 26 means that the dominant height of the stand is 26 meter at the age of 15 years.

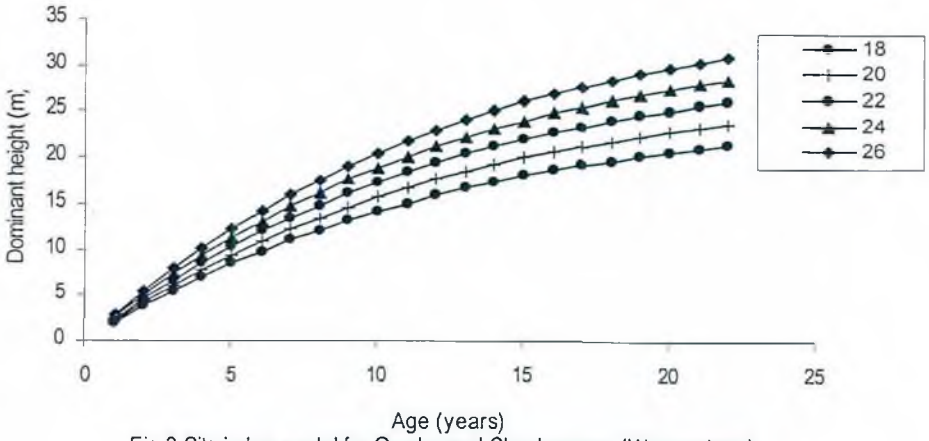

Fig.3.Site index model for Gambo and Shashemene (Woyna dega)

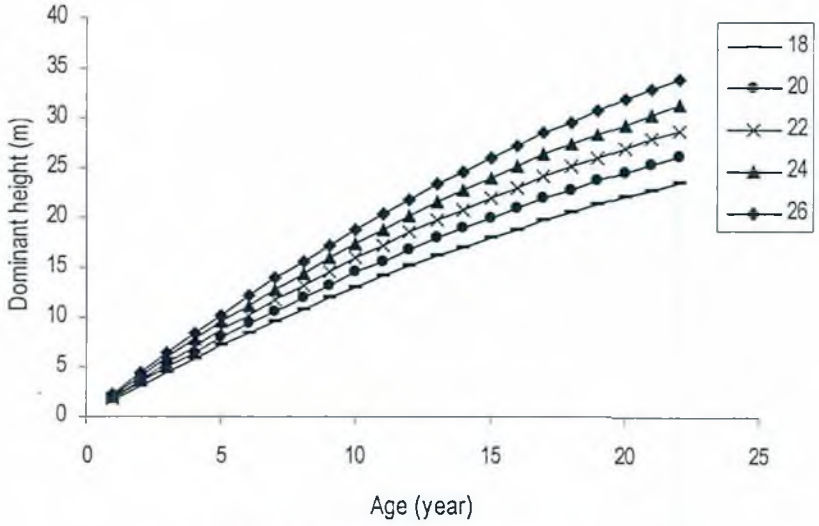

Fig. 4. Site index model for Munesa (dega)

Methods of Growth and Yield Predictions

Yield Tables

There are several methods be used to predict the growth and yield and future development of the stand. One of these methods is yield table. Yield tables are summaries of expected yields tabulated by stand age and site indexes. A yield table shows the development of the most important characteristics of the stand, such as dominant height (H_d), quadratic mean diameter (DG), Loryes mean height (HL), stocking (N/ha), standing volume (V_{st}), total volume (V), mean annual increment (MAI), current annual increment (CAI) and rotation age or maximum production age. The rotation age or maximum production age is the age at which mean and current annual increment intersect. The yield of Gambo-Shashemene and Munesa presented tables (1-16) show the average stand development of *C. lusitanica*. Thus they give the picture of the actual average stand conditions in different site indices.

Growth Models

Quadratic mean diameter

Quadratic mean diameter can be expressed as the plot mean diameter estimated using equation (2). The quadratic mean diameter model is developed, as quadratic mean diameter is a function of dominant height and number of trees per hectare. Therefore, the quadratic mean diameter of the stand can be also obtained using Equations 9 and10 (Negash and Hubert 2006). This models also help to optimize the number of trees per hectare in relation to the required size of quadratic mean diameter (dg).

Quadratic mean diameter model of Gambo-/Shashemene (Woyna Dega)

$$dg_{cm} = \frac{1}{(0.00000248 \cdot Hd_{(m)}^{(0.493499)} \cdot N + 0.43428 \cdot Hd_{(m)}^{-0.8137})} \quad (9)$$

Quadratic mean diameter model of Munesa (Dega)

$$dg_{(m)} = \frac{1}{(0.000001582 \cdot Hd_{(m)}^{(0.608449)} \cdot N + 0.8226 \cdot Hd_{(m)}^{-1.0057})} \quad (10)$$

Where dg is quadratic mean diameter, Hd is dominant height and N is number of trees per hectare

Lorey's mean height and dominant height relationship

The relationship between Lorey's mean height and dominant height of *C. lusitanca* stand at Gambo-Shashemene and Munesa can be determined using equations 11 and 12 respectively (Negash and Hubert, 2006). The input parameters are dominant height (H_d,) and number of trees per hectare (N). Lorey's mean height (h_l) can be obtained by subtracting ΔH from dominant height (H_d,).

Lorey'S mean height model of Gambo-/Shashemene (Woyna dega)

$$\Delta H = H_d - h_l = 0.21277 \ln\left(\frac{H_d}{1.3}\right) \cdot \ln\left(\frac{N}{100}\right) \quad (11)$$

Lorey'S mean height model of Munesa (Dega)

$$\Delta H = H_d - h_l = 0.24875 \ln\left(\frac{H_d}{1.3}\right) \cdot \ln\left(\frac{N}{100}\right) \quad (12)$$

Stand density index

Stand density index (SDI) is the umber of trees per hectare that a stand would have at a standard average breast height diameter (dbh). In this case the standard average breast height diameter is taken as 25 cm (Husch et al, 1982). The stand density index for Gambo-Shashemene and Munesa are as follows:

Gambo-Shashemene (Woyna dega) stand density index

$$SDI = \exp(9.715 - 1.647 \cdot \ln SI + 0.22155 \cdot \ln SI \cdot \ln H_d) \quad (12)$$

Munesa (dega) stand density index

$$SDI = \exp(9.402 - 1.809 \cdot \ln SI + 0.29565 \cdot \ln SI \cdot \ln H_d) \quad (13)$$

Where SI is site index and H_d is dominant height.

Volume yield equation

To determine the volume yield for Gambo-Shashemene and Munesa, use the following equation developed by Negash and Hubert (2006).

Volume equation of Gambo-Shashemene (Woyna dega)

$$V = \exp(0.56567 + 0.00096254 \cdot SDI - 0.03156 \cdot SI + 1.70372 \cdot \ln H_d) \quad (14)$$

Volume equation of Munesa (dega)

$$V = \exp(-0.50185 + 0.00103 \cdot SDI + 0.01864 \cdot SI + 1.66943 \cdot \ln H_d) \quad (15)$$

Where SDI is stand density index, SI is site index and H_d is dominant height.

Mean annual increment (MAI) is the average annual volume increment of the stand since its establishment. Current annual increment (CAI) is the total volume growth of all trees in one year.

How to Use the Yield Tables

- Establish a sample plot of 20m x20m
- Take dominant height measurements of four trees in the sample plots
- Determine the average dominant heights from the sample plots
- Obtain the information of the stand age from the management plan
- Determine the site index or site quality for Woyna dega using equation (6) for dega equation (8) or using figures 3 and 4.
- Then using the site index and the age obtained as input to select appropriate yield tables, you can have the stand characters for required stand age and site index

Yield table 1.Yield tables for *Cupresus lusitanca* stand for different site indices and initial stem number at Munesa (Degaga)

Site index = 19 **Initial stem number=1600-2500**

Age (years)	H_d (m)	HL (m)	N/ha	SDI	DG (m)	BA (m^2ha^{-1})	V_{st} (m^3ha^{-1})	V (m^3ha^{-1})	MAI ($m^3ha^{-1}y^{-1}$)	CAI ($m^3ha^{-1}Y^{-1}$)
7	10.165	8.73	1645	443.37	11.05	15.75	61.91	64.1009	9.16	
8	11.416	9.93	1548	490.51	12.22	18.14	81.11	83.3085	10.41	19.21
9	12.622	11.10	1474	535.32	13.31	20.49	102.35	104.549	11.62	21.24
10	13.784	12.23	1414	578.00	14.32	22.76	125.26	125.261	12.53	20.71
11	14.905	13.32	1367	618.71	15.26	24.98	149.73	149.733	13.61	24.47
12	15.986	14.37	1328	657.58	16.13	27.12	175.40	175.401	14.62	25.67
13	17.027	15.39	1299	694.73	16.93	29.23	202.36	202.363	15.57	26.96
14	18.032	16.37	1274	730.27	17.67	31.23	230.05	230.049	16.43	27.69
15	19	17.31	1256	764.29	18.35	33.20	258.66	258.656	17.24	28.61
16	19.933	18.22	1239	796.87	18.98	35.05	287.46	289.654	18.10	31.00
17	20.833	19.10	1228	828.10	19.56	36.87	316.94	322.005	18.94	32.35
18	21.701	19.95	1220	858.04	20.08	38.62	346.66	355.496	19.75	33.49
19	22.537	20.77	1214	886.76	20.56	40.28	376.42	390.031	20.53	34.53
20	23.344	21.55	1210	914.31	21	41.87	406.13	425.511	21.28	35.48
21	24.121	22.31	1209	941.11	21.39	43.41	435.84	462.006	22.00	36.50
22	24.87	23.04	1209	966.38	21.74	44.87	465.22	499.037	22.68	37.03
23	25.593	23.75	1209	989.91	22.07	46.24	494.04	536.318	23.32	37.28
24	26.289	24.43	1209	1011.83	22.38	47.52	522.25	573.716	23.90	37.40
25	26.961	25.08	1209	1032.26	22.66	48.71	549.80	611.11	24.44	37.39

Yield table 2 Site index =20 Initial number =1600-2500

Age (years)	H_d (m)	HL (m)	N/ha	SDI	DG (cm)	BA (m^2ha^{-1})	V_{st} (m^3ha^{-1})	V (m^3ha^{-1})	MAI ($m^3ha^{-1}y^{-1}$)	CAI ($m^3ha^{-1}Y^{-1}$)
7.00	10.7	9.28	1500	439.99	11.64	15.96	66.66	71.034	10.15	
8.00	12.016	10.56	1400	483.82	12.9	18.28	86.82	90.5491	11.32	19.52
9.00	13.286	11.79	1335	529.12	14.04	20.67	109.65	112.498	12.50	21.95
10.00	14.51	12.98	1285	572.65	15.11	23.03	134.48	136.575	13.66	24.06
11.00	15.69	14.12	1250	615.89	16.08	25.39	161.36	162.946	14.81	26.37
12.00	16.827	15.24	1215	654.43	17	27.57	189.05	190.777	15.90	27.83
13.00	17.924	16.31	1190	692.55	17.84	29.74	218.24	220.669	16.97	29.89
14.00	18.981	17.34	1170	728.96	18.62	31.83	248.40	252.287	18.02	31.62
15.00	20	18.34	1151	762.41	19.34	33.80	278.93	285.124	19.01	32.84
16.00	20.983	19.30	1139	795.83	20	35.75	310.46	319.863	19.99	34.74
17.00	21.93	20.23	1129	827.38	20.6	37.60	342.27	355.85	20.93	35.99
18.00	22.843	21.12	1120	856.85	21.16	39.36	374.07	392.804	21.82	36.95
19.00	23.723	21.98	1116	886.27	21.66	41.08	406.39	431.4	22.71	38.60
20.00	24.572	22.81	1113	914.01	22.11	42.72	438.52	470.849	23.54	39.45
21.00	25.39	23.61	1113	941.14	22.52	44.31	470.72	511.517	24.36	40.67
22.00	26.179	24.38	1113	966.41	22.89	45.79	502.40	552.62	25.12	41.10
23.00	26.94	25.12	1113	989.94	23.24	47.19	533.48	593.999	25.83	41.38
24.00	27.673	25.84	1113	1011.86	23.56	48.49	563.89	635.508	26.48	41.51
25.00	28.38	26.53	1113	1032.29	23.85	49.72	593.58	677.012	27.08	41.50

Yield table 3 Site index =21 Initial stem number= 1600-2500

Age (years)	H_d (m)	HL (m)	N/ha	SDI	DG (cm)	BA (m^2ha^{-1})	V_{sl} (m^3ha^{-1})	V (m^3ha^{-1})	MAI ($m^3ha^{-1}y^{-1}$)	CAI ($m^3ha^{-1}Y^{-1}$)
7.00	11.234	9.83	1363	433.93	12.25	16.06	71.08	78.1499	11.16	15.93
8.00	12.617	11.16	1320	461.65	12.99	17.49	87.82	97.9248	12.24	17.93
9.00	13.95	12.46	1255	504.34	14.17	19.77	110.83	121.307	13.48	19.86
10.00	15.235	13.71	1205	545.50	15.26	22.02	135.87	146.885	14.69	21.72
11.00	16.474	14.92	1170	586.67	16.26	24.29	163.06	174.854	15.90	23.50
12.00	17.668	16.09	1135	623.29	17.21	26.39	191.07	204.294	17.02	25.21
13.00	18.82	17.22	1111	660.20	18.08	28.50	220.81	235.995	18.15	26.82
14.00	19.93	18.31	1092	695.68	18.88	30.55	251.64	269.535	19.25	28.34
15.00	21	19.36	1074	728.38	19.63	32.48	282.91	304.37	20.29	29.78
16.00	22.032	20.37	1062	760.90	20.31	34.39	315.22	341.126	21.32	31.11
17.00	23.026	21.34	1052	791.72	20.94	36.22	347.88	379.21	22.31	32.35
18.00	23.985	22.28	1045	821.57	21.52	37.99	380.96	418.746	23.26	33.49
19.00	24.91	23.19	1038	849.20	22.06	39.66	413.84	459.032	24.16	34.53
20.00	25.801	24.06	1036	877.23	22.54	41.31	447.35	501.151	25.06	35.48
21.00	26.66	24.90	1035	903.86	22.98	42.89	480.67	544.148	25.91	36.48
22.00	27.488	25.72	1034	928.71	23.38	44.38	513.51	587.614	26.71	37.48
23.00	28.287	26.50	1034	952.40	23.75	45.79	546.00	631.708	27.47	38.48
24.00	29.057	27.25	1034	974.54	24.09	47.12	577.85	675.998	28.17	39.48
25.00	29.799	27.98	1034	995.23	24.41	48.37	609.02	720.341	28.81	40.48

Yield table 4 Site index =22 Initial stem number=1600-2500

Age (years)	H_d (m)	HL (m)	N/ha	SDI	DG (cm)	BA (m^2ha^{-1})	V_{st} (m^3ha^{-1})	V (m^3ha^{-1})	MAI ($m^3ha^{-1}y^{-1}$)	CAI ($m^3ha^{-1}Y^{-1}$)
7.00	11.769	10.39	1250	429.90	12.86	16.22	75.80	85.8166	12.26	
8.00	13.218	11.79	1185	478.90	14.22	18.80	99.76	109.912	13.74	24.10
9.00	14.614	13.15	1133	524.97	15.48	21.31	126.16	136.598	15.18	26.69
10.00	15.961	14.47	1088	567.28	16.66	23.71	154.41	165.563	16.56	28.97
11.00	17.259	15.74	1068	614.32	17.71	26.30	186.26	198.261	18.02	32.70
12.00	18.51	16.97	1034	650.98	18.74	28.50	217.60	231.624	19.30	33.36
13.00	19.716	18.15	1012	688.65	19.67	30.73	251.02	267.753	20.60	36.13
14.00	20.879	19.29	1000	727.42	20.5	33.00	286.44	306.823	21.92	39.07
15.00	22	20.39	985	761.47	21.3	35.07	321.76	346.937	23.13	40.11
16.00	23.081	21.45	975	795.02	22.02	37.09	358.08	389.225	24.33	42.29
17.00	24.123	22.47	970	828.43	22.66	39.10	395.36	433.817	25.52	44.59
18.00	25.127	23.46	965	859.35	23.26	40.98	432.53	479.558	26.64	45.74
19.00	26.096	24.40	965	890.62	23.78	42.84	470.49	527.655	27.77	48.10
20.00	27.029	25.32	965	919.74	24.26	44.59	508.07	576.704	28.84	49.05
21.00	27.929	26.20	965	946.86	24.71	46.24	545.15	626.483	29.83	49.78
22.00	28.797	27.05	965	972.10	25.11	47.78	581.61	676.784	30.76	50.30
23.00	29.634	27.87	965	995.60	25.49	49.22	617.35	727.413	31.63	50.63
24.00	30.44	28.66	965	1017.48	25.84	50.57	652.31	778.19	32.42	50.78
25.00	31.218	29.43	965	1037.85	26.16	51.84	686.43	828.951	33.16	50.76

Yield table 5 Site index =23 Initial Number=1600-2500

Age (years)	H_d (m)	HL (m)	N/ha	SDI	DG (cm)	BA (m^2ha^{-1})	V_{st} (m^3ha^{-1})	V (m^3ha^{-1})	MAI ($m^3ha^{-1}y^{-1}$)	CAI ($m^3ha^{-1}Y^{-1}$)
7.00	12.304	10.94	1155	427.34	13.46	16.42	80.79	94.0395	13.43	
8.00	13.819	12.41	1100	477.88	14.87	19.10	106.64	120.602	15.08	26.56
9.00	15.279	13.84	1045	521.29	16.21	21.55	134.23	149.44	16.60	28.84
10.00	16.686	15.22	1012	566.99	17.43	24.12	165.17	181.743	18.17	32.30
11.00	18.043	16.55	980	607.96	18.57	26.52	197.51	216.248	19.66	34.50
12.00	19.351	17.83	960	649.82	19.6	28.96	232.40	253.981	21.17	37.73
13.00	20.612	19.07	940	687.68	20.58	31.24	268.12	293.632	22.59	39.65
14.00	21.828	20.26	930	727.02	21.44	33.57	306.13	336.662	24.05	43.03
15.00	23	21.41	920	763.20	22.25	35.76	344.61	381.498	25.43	44.84
16.00	24.13	22.53	910	796.40	23.01	37.81	383.28	427.832	26.74	46.33
17.00	25.219	23.59	907	830.76	23.67	39.89	423.48	477.3	28.08	49.47
18.00	26.269	24.62	904	862.65	24.28	41.84	463.59	528.137	29.34	50.84
19.00	27.282	25.61	904	893.93	24.83	43.74	504.15	581.101	30.58	52.96
20.00	28.258	26.57	904	923.05	25.33	45.52	544.30	635.107	31.76	54.01
21.00	29.199	27.49	904	950.16	25.79	47.19	583.89	689.91	32.85	54.80
22.00	30.106	28.39	904	975.39	26.21	48.76	622.81	745.282	33.88	55.37
23.00	30.981	29.24	904	998.87	26.60	50.23	660.96	801.008	34.83	55.73
24.00	31.824	30.07	904	1020.72	26.96	51.60	698.26	856.89	35.70	55.88
25.00	32.637	30.87	904	1041.07	27.30	52.88	734.66	912.747	36.51	55.86

Yield table 6 Site index =24 Initial stem number=1600-2500

Age (years)	H_d (m)	HL (m)	N/ha	SDI	DG (cm)	BA (m^2ha^{-1})	V_{st} (m^3ha^{-1})	V (m^3ha^{-1})	MAI ($m^3ha^{-1}y^{-1}$)	CAI ($m^3ha^{-1}Y^{-1}$)
7.00	12.839	11.49	1070	424.64	14.06	16.60	85.80	102.694	14.67	
8.00	14.42	13.03	1016	473.81	15.54	19.27	112.99	131.482	16.44	28.79
9.00	15.943	14.52	975	521.03	16.92	21.91	143.19	163.539	18.17	32.06
10.00	17.412	15.97	940	564.82	18.2	24.45	175.63	198.47	19.85	34.93
11.00	18.827	17.35	918	609.45	19.37	27.03	211.11	237.025	21.55	38.56
12.00	20.192	18.70	895	649.17	20.47	29.43	247.61	277.746	23.15	40.72
13.00	21.508	19.99	881	689.52	21.46	31.85	286.50	321.918	24.76	44.17
14.00	22.777	21.24	870	728.00	22.37	34.18	326.68	368.745	26.34	46.83
15.00	24	22.44	860	763.82	23.22	36.40	367.53	417.684	27.85	48.94
16.00	25.179	23.60	855	799.60	23.98	38.59	409.76	469.646	29.35	51.96
17.00	26.316	24.71	850	832.69	24.68	40.65	452.06	523.247	30.78	53.60
18.00	27.412	25.79	850	866.28	25.3	42.70	495.54	579.987	32.22	56.74
19.00	28.468	26.83	850	897.57	25.86	44.63	538.76	638.146	33.59	58.16
20.00	29.487	27.82	850	926.70	26.38	46.44	581.52	697.441	34.87	59.30
21.00	30.469	28.79	850	953.80	26.86	48.14	623.68	757.605	36.08	60.16
22.00	31.415	29.72	850	979.01	27.30	49.73	665.11	818.386	37.20	60.78
23.00	32.328	30.62	850	1002.46	27.71	51.22	705.71	879.546	38.24	61.16
24.00	33.207	31.48	850	1024.29	28.08	52.61	745.40	940.869	39.20	61.32
25.00	34.056	32.32	850	1044.59	28.43	53.92	784.11	1002.16	40.09	61.29

Yield table 7 Site index=25 Initial stem numbers=1600-2500

Age (years)	H_d (m)	HL (m)	N/ha	SDI	DG (cm)	BA (m^2ha^{-1})	V_{st} (m^3ha^{-1})	V (m^3ha^{-1})	MAI ($m^3ha^{-1}y^{-1}$)	CAI ($m^3ha^{-1}Y^{-1}$)
7.00	13.374	12.04	996	422.63	14.65	16.79	90.99	109.797	15.69	
8.00	15.02	13.65	948	472.54	16.2	19.53	119.99	140.659	17.58	30.86
9.00	16.607	15.21	910	519.78	17.64	22.22	152.05	174.937	19.44	34.28
10.00	18.137	16.71	882	565.76	18.96	24.88	187.11	212.764	21.28	37.83
11.00	19.612	18.16	858	608.70	20.19	27.44	224.29	253.633	23.06	40.87
12.00	21.034	19.56	840	650.31	21.31	29.96	263.69	297.776	24.81	44.14
13.00	22.405	20.91	828	691.35	22.34	32.45	305.27	345.364	26.57	47.59
14.00	23.726	22.21	817	729.48	23.3	34.81	347.84	395.445	28.25	50.08
15.00	25	23.46	811	767.41	24.15	37.14	392.13	448.893	29.93	53.45
16.00	26.228	24.67	805	802.44	24.95	39.34	436.71	504.333	31.52	55.44
17.00	27.412	25.83	803	837.27	25.66	41.50	482.46	562.897	33.11	58.56
18.00	28.554	26.95	803	870.90	26.3	43.59	528.70	623.945	34.66	61.05
19.00	29.654	28.03	803	902.20	26.88	45.55	574.64	686.51	36.13	62.57
20.00	30.715	29.08	803	931.32	27.42	47.39	620.08	750.289	37.51	63.78
21.00	31.738	30.08	803	958.41	27.91	49.11	664.86	814.992	38.81	64.70
22.00	32.724	31.05	803	983.59	28.37	50.73	708.85	880.347	40.02	65.35
23.00	33.675	31.99	803	1007.02	28.79	52.24	751.95	946.098	41.13	65.75
24.00	34.591	32.89	803	1028.80	29.17	53.65	794.06	1012.01	42.17	65.91
25.00	35.475	33.76	803	1049.06	29.53	54.97	835.12	1077.88	43.12	65.86

Yield table 8 Site index =26 Initial stem number =1600-2500

Age (years)	H_d (m)	HL (m)	N/ha	SDI	DG (cm)	BA (m^2ha^{-1})	V_{st} (m^3ha^{-1})	V (m^3ha^{-1})	MAI ($m^3ha^{-1}y^{-1}$)	CAI ($m^3ha^{-1}Y^{-1}$)
7.00	13.909	12.59	933	421.93	15.25	17.03	96.49	117.227	16.75	
8.00	15.621	14.27	887	471.33	16.86	19.79	127.11	150.075	18.76	32.85
9.00	17.272	15.89	854	519.70	18.35	22.56	161.36	186.845	20.76	36.77
10.00	18.863	17.46	827	565.30	19.72	25.26	198.40	227.139	22.71	40.29
11.00	20.396	18.97	807	609.60	20.99	27.91	238.24	271.135	24.65	44.00
12.00	21.875	20.42	792	652.37	22.15	30.52	280.43	318.691	26.56	47.56
13.00	23.301	21.83	781	693.67	23.22	33.05	324.64	369.706	28.44	51.01
14.00	24.675	23.18	772	732.73	24.2	35.49	370.18	423.709	30.26	54.00
15.00	26	24.48	766	770.50	25.09	37.86	417.09	480.889	32.06	57.18
16.00	27.277	25.74	762	806.68	25.9	40.14	464.90	540.91	33.81	60.02
17.00	28.509	26.95	760	841.48	26.64	42.33	513.41	603.691	35.51	62.78
18.00	29.696	28.12	760	875.13	27.3	44.45	562.46	669.171	37.18	65.48
19.00	30.84	29.24	760	906.44	27.9	46.44	611.16	736.269	38.75	67.10
20.00	31.944	30.33	760	935.56	28.46	48.31	659.33	804.66	40.23	68.39
21.00	33.008	31.38	760	962.63	28.97	50.06	706.77	874.031	41.62	69.37
22.00	34.033	32.39	760	987.80	29.44	51.69	753.37	944.089	42.91	70.06
23.00	35.022	33.36	760	1011.19	29.87	53.22	798.99	1014.56	44.11	70.47
24.00	35.975	34.30	760	1032.93	30.27	54.65	843.57	1085.2	45.22	70.64
25.00	36.894	35.21	760	1053.15	30.63	55.99	887.02	1155.77	46.23	70.57

Yield table 9. Yield tables for *Cupresus lusitanca* stand for different site indices and initial stem number at Gambo – Shashemene

Site index =26 Initial stem number =1600-2500

Age (years)	H_d (m)	HL (m)	N/ha	SDI	DG (cm)	BA (m^2ha^{-1})	V_{st} (m^3ha^{-1})	V (m^3ha^{-1})	MAI ($m^3ha^{-1}y^{-1}$)	CAI ($m^3ha^{-1}Y^{-1}$)
7.00	11.02	9.69	1860.00	658.72	13.09	25.02	106.96	112.21	16.03	
8.00	12.16	10.78	1798.00	701.29	13.91	27.30	130.62	138.10	17.26	25.89
9.00	13.20	11.79	1750.00	739.36	14.61	29.34	154.24	164.89	18.32	26.79
10.00	14.17	12.72	1715.00	773.58	15.22	31.19	177.63	192.20	19.22	27.31
11.00	15.06	13.59	1690.00	804.44	15.75	32.89	200.58	219.72	19.97	27.52
12.00	15.88	14.39	1670.00	832.38	16.20	34.41	222.75	247.16	20.60	27.44
13.00	16.65	15.12	1655.00	857.72	16.60	35.80	244.09	274.30	21.10	27.14
14.00	17.35	15.81	1644.00	880.76	16.94	37.05	264.51	300.95	21.50	26.65
15.00	18.00	16.44	1636.00	901.75	17.24	38.19	283.96	326.95	21.80	26.00
16.00	18.60	17.02	1632.00	920.90	17.50	39.24	302.52	352.18	22.01	25.23
17.00	19.16	17.56	1630.00	938.39	17.72	40.20	320.09	376.55	22.15	24.37
18.00	19.67	18.05	1628.00	954.39	17.92	41.06	336.54	399.98	22.22	23.43
19.00	20.14	18.51	1628.00	969.04	18.09	41.84	352.07	422.43	22.23	22.45
20.00	20.58	18.94	1628.00	982.46	18.25	42.55	366.57	443.87	22.19	21.44
21.00	20.98	19.33	1628.00	812.17	20.56	54.00	467.53	464.28	22.11	20.41
22.00	21.36	19.69	1628.00	823.26	20.73	54.92	484.70	483.66	21.98	19.38
23.00	21.70	20.03	1628.00	833.35	20.89	55.76	500.75	502.02	21.83	18.36
24.00	22.02	20.34	1628.00	1034.29	18.55	43.97	408.41	519.37	21.64	17.35
25.00	22.31	20.62	1628.00	1030.66	18.80	45.19	425.30	535.74	21.43	16.37

Yield table 10 Site index 19 Initial number of trees 1600-2500

Age (years)	H_d (m)	HL (m)	N/ha	SDI	DG (cm)	BA (m^2ha^{-1})	V_{st} (m^3ha^{-1})	V (m^3ha^{-1})	MAI ($m^3ha^{-1}y^{-1}$)	CAI ($m^3ha^{-1}Y^{-1}$)
7.00	11.635	10.32	1670	642.00	13.78	24.89	113.39	117.36	16.77	
8.00	12.83	11.48	1615	684.66	14.65	27.20	138.50	144.40	18.05	27.04
9.00	13.935	12.53	1615	734.79	15.31	29.70	166.01	172.38	19.15	27.98
10.00	14.955	13.53	1541	756.28	16.05	31.14	188.44	200.91	20.09	28.53
11.00	15.897	14.45	1520	787.82	16.60	32.88	212.95	229.65	20.88	28.74
12.00	16.767	15.29	1501	815.24	17.09	34.42	236.48	258.32	21.53	28.67
13.00	17.571	16.08	1488	840.57	17.51	35.83	259.25	286.68	22.05	28.35
14.00	18.314	16.80	1479	863.77	17.88	37.12	281.10	314.52	22.47	27.84
15.00	19	17.47	1470	884.02	18.21	38.27	301.70	341.68	22.78	27.17
16.00	19.634	18.08	1465	903.02	18.49	39.33	321.40	368.04	23.00	26.36
17.00	20.219	18.65	1465	921.44	18.73	40.33	340.35	393.51	23.15	25.46
18.00	20.76	19.18	1465	937.91	18.94	41.23	358.12	418.00	23.22	24.49
19.00	21.26	19.66	1465	952.67	19.12	42.04	374.74	441.46	23.23	23.47
20.00	21.721	20.11	1465	965.92	19.29	42.77	390.27	463.87	23.19	22.41
21.00	22.148	20.53	1465	977.83	19.43	43.43	404.75	485.21	23.11	21.34
22.00	22.541	20.91	1465	988.57	19.57	44.03	418.23	505.47	22.98	20.26
23.00	22.905	21.27	1465	998.26	19.69	44.57	430.77	524.66	22.81	19.19
24.00	23.241	21.59	1465	1007.02	19.79	45.05	442.43	542.81	22.62	18.14
25.00	23.552	21.90	1465	1014.96	19.89	45.50	453.26	559.93	22.40	17.12

Yield table 11 Site index 21 Initial number of trees 1600-2500

Age (years)	H_d (m)	HL (m)	N/ha	SDI	DG (cm)	BA (m^2ha^{-1})	V_{st} (m^3ha^{-1})	V (m^3ha^{-1})	MAI ($m^3ha^{-1}y^{-1}$)	CAI ($m^3ha^{-1}Y^{-1}$)
7.00	12.248	10.95	1512	627.75	14.46	24.81	119.95	122.40	17.49	
8.00	13.506	12.17	1464	670.53	15.37	27.15	146.61	150.57	18.82	28.17
9.00	14.668	13.30	1424	707.40	16.17	29.22	173.07	179.72	19.97	29.15
10.00	15.742	14.34	1400	742.68	16.84	31.17	199.74	209.45	20.94	29.73
11.00	16.733	15.31	1376	772.37	17.45	32.87	225.35	239.40	21.76	29.95
12.00	17.65	16.20	1360	800.13	17.96	34.45	250.41	269.27	22.44	29.87
13.00	18.496	17.03	1348	825.32	18.42	35.89	274.57	298.82	22.99	29.55
14.00	19.278	17.79	1339	848.2	18.81	37.19	297.71	327.84	23.42	29.02
15.00	20	18.49	1334	869.61	19.15	38.40	319.95	356.15	23.74	28.32
16.00	20.667	19.14	1328	888.12	19.46	39.47	340.76	383.63	23.98	27.48
17.00	21.283	19.75	1328	906.59	19.71	40.49	360.95	410.18	24.13	26.55
18.00	21.853	20.30	1328	923.13	19.93	41.41	379.89	435.72	24.21	25.53
19.00	22.379	20.81	1328	937.96	20.13	42.24	397.63	460.19	24.22	24.47
20.00	22.864	21.29	1328	951.29	20.31	42.99	414.20	483.56	24.18	23.37
21.00	23.313	21.72	1328	963.29	20.47	43.67	429.65	505.81	24.09	22.25
22.00	23.728	22.13	1328	974.12	20.61	44.28	444.05	526.94	23.95	21.13
23.00	24.111	22.50	1328	983.89	20.74	44.84	457.45	546.97	23.78	20.02
24.00	24.465	22.85	1328	992.74	20.85	45.34	469.90	565.89	23.58	18.93
25.00	24.791	23.17	1328	1000.8	20.96	45.80	481.47	583.75	23.35	17.86

Yield table 12 Site index 21 Initial number of trees 1600-2500

Age (years)	H_d (m)	HL m)	N/ha	SDI	DG (cm)	BA (m^2ha^{-1})	V_{st} (m^3ha^{-1})	V (m^3ha^{-1})	MAI ($m^3ha^{-1}y^{-1}$)	CAI ($m^3ha^{-1}Y^{-1}$)
7.00	12.86	11.58	1380	615.73	15.12	24.77	126.69	127.32	18.19	
8.00	14.181	12.86	1335	657.72	16.08	27.11	154.75	156.59	19.57	29.28
9.00	15.401	14.05	1300	694.82	16.92	29.22	182.82	186.89	20.77	30.30
10	16.529	15.15	1273	728.02	17.65	31.13	210.55	217.79	21.78	30.90
11	17.57	16.17	1256	759.37	18.27	32.92	238.08	248.92	22.63	31.13
12	18.532	17.11	1242	787.26	18.82	34.53	264.67	279.98	23.33	31.06
13	19.421	17.98	1232	812.77	19.29	36.00	290.38	310.70	23.90	30.72
14	20.242	18.78	1223	835.32	19.71	37.31	314.82	340.88	24.35	30.17
15	21	19.52	1217	856.15	20.08	38.52	338.23	370.33	24.69	29.45
16	21.701	20.21	1214	875.66	20.4	39.64	360.64	398.91	24.93	28.59
17	22.348	20.84	1212	893.38	20.67	40.66	381.82	426.53	25.09	27.62
18	22.945	21.42	1212	909.96	20.91	41.60	401.95	453.09	25.17	26.57
19	23.498	21.96	1212	924.85	21.12	42.45	420.80	478.55	25.19	25.46
20	24.008	22.46	1212	938.24	21.31	43.22	438.42	502.87	25.14	24.32
21	24.479	22.92	1212	950.31	21.48	43.92	454.86	526.03	25.05	23.16
22	24.914	23.35	1212	961.2	21.64	44.54	470.18	548.03	24.91	22.00
23	25.316	23.74	1212	971.04	21.78	45.11	484.44	568.87	24.73	20.84
24	25.688	24.10	1212	979.96	21.9	45.63	497.71	588.57	24.52	19.70
25	26.031	24.44	1212	988.03	22.01	46.10	510.03	607.16	24.29	18.59

Yield table 13 Site index 22 Initial number of trees 1600-2500

Age (years)	H_d (m)	HL m)	N/ha	SDI	DG (cm)	BA (m^2ha^{-1})	V_{st} (m^3ha^{-1})	V (m^3ha^{-1})	MAI ($m^3ha^{-1}y^{-1}$)	CAI ($m^3ha^{-1}Y^{-1}$)
7	13.472	12.21	1265	604.42	15.78	24.73	133.40	132.10	18.87	.
8	14.856	13.56	1222	645.4	16.8	27.06	162.79	162.46	20.31	30.36
9	16.135	14.81	1194	683.74	17.66	29.25	192.71	193.88	21.54	31.42
10	17.316	15.96	1170	717.06	18.43	31.19	222.05	225.92	22.59	32.04
11	18.407	17.03	1152	747.3	19.09	32.96	250.83	258.21	23.47	32.29
12	19.415	18.01	1140	775.43	19.66	34.60	279.02	290.43	24.20	32.22
13	20.346	18.93	1132	801.37	20.16	36.11	306.34	322.31	24.79	31.88
14	21.206	19.77	1126	824.86	20.59	37.49	332.51	353.62	25.26	31.31
15	22	20.55	1120	845.47	20.98	38.71	357.21	384.18	25.61	30.56
16	22.734	21.27	1115	864.02	21.33	39.81	380.59	413.85	25.87	29.67
17	23.412	21.93	1113	881.69	21.62	40.85	403.00	442.51	26.03	28.67
18	24.038	22.54	1113	898.3	21.88	41.81	424.33	470.09	26.12	27.58
19	24.617	23.11	1112	912.8	22.11	42.66	444.14	496.53	26.13	26.43
20	25.151	23.63	1112	926.24	22.31	43.44	462.82	521.78	26.09	25.25
21	25.645	24.12	1112	938.36	22.49	44.15	480.26	545.83	25.99	24.05
22	26.101	24.56	1112	949.3	22.65	44.80	496.51	568.68	25.85	22.85
23	26.522	24.98	1112	959.2	22.8	45.38	511.64	590.32	25.67	21.65
24	26.911	25.36	1112	968.17	22.93	45.91	525.72	610.79	25.45	20.47
25	27.27	25.71	1112	976.3	23.05	46.39	538.80	630.11	25.20	19.31

Yield table 14 Site index 23 Initial number of trees 1600-2500

Age (years)	H_d (m)	HL (m)	N/ha	SDI	DG (cm)	BA (m^2ha^{-1})	V_{st} (m^3ha^{-1})	V (m^3ha^{-1})	MAI ($m^3ha^{-1}y^{-1}$)	CAI ($m^3ha^{-1}Y^{-1}$)
7	14.085	12.84	1165	594.05	16.43	24.69	140.13	136.74	19.53	
8	15.532	14.25	1128	635.69	17.49	27.08	171.24	168.15	21.02	31.41
9	16.868	15.56	1102	673.72	18.4	29.28	202.70	200.66	22.30	32.51
10	18.103	16.77	1082	707.77	19.19	31.28	233.84	233.82	23.38	33.16
11	19.243	17.89	1064	737.28	19.89	33.05	263.99	267.25	24.30	33.42
12	20.297	18.92	1054	765.8	20.49	34.73	293.86	300.60	25.05	33.35
13	21.27	19.88	1044	790.49	21.02	36.22	322.27	333.61	25.66	33.00
14	22.169	20.76	1040	814.64	21.47	37.64	350.12	366.03	26.14	32.42
15	23	21.57	1036	835.95	21.87	38.90	376.46	397.68	26.51	31.65
16	23.767	22.32	1032	854.79	22.23	40.04	401.26	428.41	26.78	30.73
17	24.476	23.02	1030	872.39	22.54	41.09	424.91	458.11	26.95	29.70
18	25.131	23.66	1028	888.09	22.82	42.03	447.09	486.68	27.04	28.57
19	25.735	24.26	1026	902.11	23.07	42.88	467.83	514.08	27.06	27.39
20	26.294	24.80	1026	915.59	23.29	43.68	487.58	540.25	27.01	26.17
21	26.81	25.31	1026	927.74	23.48	44.40	506.02	565.17	26.91	24.93
22	27.287	25.78	1026	938.73	23.65	45.06	523.21	588.85	26.77	23.68
23	27.727	26.21	1026	948.67	23.81	45.66	539.23	611.30	26.58	22.44
24	28.134	26.61	1026	957.68	23.95	46.20	554.13	632.52	26.35	21.22
25	28.51	26.98	1026	965.85	24.08	46.69	567.98	652.54	26.10	20.03

Yield table 15 Site index 24 Initial number of trees 1600-2500

Age (years)	H_d (m)	HL (m)	N/ha	SDI	DG (cm)	BA (m^2ha^{-1})	V_{st} (m^3ha^{-1})	V (m^3ha^{-1})	MAI ($m^3ha^{-1}y^{-1}$)	CAI ($m^3ha^{-1}Y^{-1}$)
7	14.697	13.44	1148	611.71	16.89	25.70	152.92	149.56	21.37	
8	16.207	14.91	1114	654.96	17.96	28.20	186.81	184.14	23.02	34.58
9	17.602	16.28	1088	693.35	18.88	30.45	220.77	219.99	24.44	35.84
10	18.89	17.54	1070	728.53	19.68	32.52	254.58	256.60	25.66	36.61
11	20.08	18.71	1055	759.57	20.37	34.37	287.46	293.53	26.68	36.94
12	21.18	19.79	1046	788.73	20.97	36.10	319.75	330.44	27.54	36.90
13	22.195	20.78	1038	814.44	21.49	37.64	350.61	366.98	28.23	36.55
14	23.133	21.70	1034	838.66	21.94	39.08	380.51	402.92	28.78	35.93
15	24	22.55	1030	860.00	22.34	40.36	408.74	438.03	29.20	35.11
16	24.801	23.34	1030	880.70	22.68	41.58	436.05	472.14	29.51	34.11
17	25.54	24.06	1030	899.19	22.97	42.67	461.74	505.12	29.71	32.98
18	26.223	24.73	1030	915.76	23.23	43.65	485.84	536.88	29.83	31.76
19	26.854	25.35	1030	930.63	23.47	44.53	508.40	567.34	29.86	30.46
20	27.437	25.92	1030	943.99	23.68	45.33	529.47	596.46	29.82	29.12
21	27.976	26.45	1030	956.03	23.87	46.05	549.13	624.20	29.72	27.75
22	28.473	26.94	1030	966.89	24.03	46.71	567.44	650.57	29.57	26.37
23	28.933	27.39	1030	976.71	24.19	47.30	584.48	675.57	29.37	25.00
24	29.357	27.81	1026	957.68	23.95	46.20	580.88	699.22	29.13	23.65
25	29.75	28.20	1026	965.85	24.08	46.69	595.36	721.54	28.86	22.32

Yield table 16 Site index 25 Initial number of trees 1600-2500

Age (years)	H_d (m)	HL (m)	N/ha	SDI	DG (cm)	BA (m^2ha^{-1})	V_{st} (m^3ha^{-1})	V (m^3ha^{-1})	MAI ($m^3ha^{-1}y^{-1}$)	CAI ($m^3ha^{-1}Y^{-1}$)
7	15.309	14.10	1004	577.29	17.71	24.72	154.06	163.07	23.30	
8	16.882	15.64	973	618.71	18.86	27.15	188.35	201.02	25.13	37.94
9	18.335	17.07	951	656.45	19.84	29.40	223.02	240.40	26.71	39.39
10	19.677	18.39	934	690.27	20.71	31.44	257.36	280.68	28.07	40.28
11	20.917	19.60	920	720.31	21.46	33.27	290.87	321.37	29.22	40.69
12	22.062	20.73	912	748.97	22.11	35.01	323.97	362.05	30.17	40.69
13	23.12	21.77	905	774.4	22.69	36.56	355.71	402.39	30.95	40.34
14	24.097	22.73	900	797.64	23.19	37.99	386.21	442.08	31.58	39.69
15	25	23.62	896	818.62	23.63	39.28	415.26	480.89	32.06	38.81
16	25.834	24.44	894	838.22	24.02	40.48	443.08	518.63	32.41	37.74
17	26.604	25.20	892	855.68	24.36	41.55	469.24	555.14	32.66	36.51
18	27.316	25.90	892	872.33	24.66	42.56	494.27	590.31	32.80	35.17
19	27.973	26.54	892	887.32	24.92	43.48	517.74	624.07	32.85	33.75
20	28.581	27.14	892	900.83	25.15	44.30	539.69	656.35	32.82	32.28
21	29.142	27.69	892	913.03	25.37	45.05	560.20	687.12	32.72	30.78
22	29.66	28.20	892	924.06	25.56	45.73	579.33	716.38	32.56	29.26
23	30.138	28.67	892	934.05	25.73	46.35	597.15	744.14	32.35	27.75
24	30.581	29.15	838	913.34	26.38	45.77	598.51	770.39	32.10	26.26
25	30.989	29.55	838	921.65	26.53	46.29	613.81	795.19	31.81	24.80

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