Forestry Commission

ForestYield

A PC-based yield model for forest management in Britain

Version 1.0

Forest Research

Forestry Commission

User manual

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A PC-based yield model for forest management in Britain

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ForestYield project team:
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Introduction

Yield models are one of the foundations of forest management. They provide essential information about the patterns of tree growth and potential productivity that can be expected in forest stands of different tree species, with varying growth rates, when managed in different ways. Yield models are essential for demonstrating that ongoing and intended management is consistent with the principles of sustainable forestry. The outputs of yield models support many other calculations and models relevant to the evaluation of forests and forestry. These include analyses of the development of forest structure at the stand and landscape scales, the modelling of timber and wood properties, the estimation of forest biomass and carbon stocks, the modelling of forest greenhouse gas balances and the economic evaluation of forest policies and forest management options.

Forest Yield is a software tool for displaying and applying forest yield tables, mainly those originally published in the Forestry Commission Booklet *Yield models for forest management*. Forest Yield provides access to these yield tables in digital form. This user manual describes how to use the software. It provides an introduction to the software, how to install it and a guide to the software's features and applications. The software and this user manual are supported by a handbook, *Forest Yield: a handbook on forest growth and yield tables for British forestry*, for those who would like to know more about the theory underpinning the development and application of the yield tables.

Forest Yield: a handbook on forest growth and yield tables for British forestry provides an introduction to the essential theory of forest growth and yield, with emphasis on the implications for its practical application and the interpretation of results presented in yield tables. It also includes a comprehensive description of the specific yield tables included in Forest Yield in terms of the tree species, growth rates and management prescriptions represented. Many of the yield models contained in Forest Yield were developed some decades ago but they are still highly relevant to forest planning and management in Britain.

Forest Yield tables

The yield tables in Forest Yield have been developed for use in British forestry. Individual yield tables are specified by a combination of:

- tree species
- yield class
- management prescription

Tree species

The yield tables in Forest Yield can be applied to around 150 tree species currently growing in the British Isles (see Appendix 1). Species that were historically considered to be 'commercial' generally have their own set of yield tables. Other species listed in Appendix 1, for which models have not been developed, are mapped to these more 'commercial' species on the basis of growth and silvicultural characteristics. The software also includes this mapping to permit the application of yield tables to tree species for which specific models have not been developed.

Forest Yield also includes new yield tables for Sitka spruce, which can be used as an alternative to the originals. These are based on the preliminary outputs of a dynamic growth and yield model which is being developed by the Forestry Commission and is currently in use as a research tool. The new tables may be particularly useful for application to Sitka spruce stands managed according to prescriptions not covered in the original yield tables, and in providing improved predictions for unthinned stands.

Yield class

Yield class is an index used in Britain of the potential productivity of even-aged stands of trees. It is based on the maximum mean annual increment of cumulative timber volume achieved by a given tree species growing on a given site and managed according to a standard management prescription. It is measured in units of cubic metres per hectare per year ($m^3\ ha^{-1}\ yr^{-1}$). Yield class is discussed in detail in *Forest Yield: a handbook on forest growth and yield tables for British forestry*.

Management prescription

In general, the Forest Yield tables represent one silvicultural system: even-aged, single-species stand management. Within this system, a range of management prescriptions is considered. The management prescriptions are defined in terms of a combination of assumed initial tree spacing and a programme of thinnings. This is used to represent stands planted or established at different densities and thinned in various ways, including initial line thinnings, as well as stands that are left unthinned. A full description of the management prescriptions covered by the yield tables included in the Forest Yield software is provided in *Forest Yield: a handbook on forest growth and yield tables for British forestry.*

It is possible for a user to manipulate yield table outputs outside the Forest Yield software to represent other silvicultural systems, such as mixed-species stands, or to take account of specific situations such as the changes in growth rate associated with check or application of fertiliser in a stand of trees. These sorts of adjustments are discussed in more detail in examples provided in this user manual.

Installing Forest Yield

System requirements

- Windows® operating system (major versions of Windows).
- 100 MB of available hard-disk space.

The system requirements are minimal for Forest Yield. In Windows® 7 and 8 there may be some issues installing and running Forest Yield due to security settings.

A self extracting zip file containing the Forest Yield v1.0 software with Yield Lookup v4.3 (the database of yield tables) and all supporting files can be downloaded from the Forest Yield website (www.forestry.gov.uk/forestyield).

How to install Forest Yield

Forest Yield can be installed in two ways, depending on your computer's security settings.

Method 1

This method should work on most computers:

➔ Run the installation file called ForestYield-1.0-Install.exe

The installation has two parts:

- The underpinning Yield Lookup yield table database must be installed first. By default the program will be installed into the folder C:\Program Files\Forestry Commission Research Agency\Yield Lookup 4.3. However, it can be located elsewhere if required during the installation process. The installation program will automatically place all the files where they are needed. It is recommended that the default installation folder is used.

- The Forest Yield software can now be installed. By default the program will be installed into the directory C:\Program Files\Forestry Commission Research Agency\Forest Yield 1.0. However, it can be located elsewhere if required during the installation process. The installation program will automatically place all the files where they are needed (including associated files). It is recommended that the default installation folder is used.

Method 2

Try this if Method 1 does not work:

➔ Manually unzip the self-extracting file ForestYield-1.0-Install.exe

This file can be put anywhere on your hard disc. The only difference from Option 1 above is that after unzipping the file the user needs to manually install the file Setup.exe. This will start the installation process as with method 1.

Administration privileges in Windows® 7 and 8

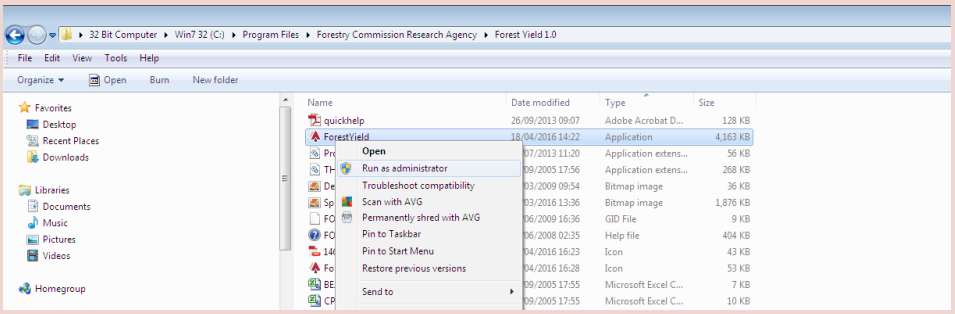
The level of security has increased in Windows® 7 and 8 compared with previous versions. This means that there can be problems in installing, running or saving files if Windows® requires administrator rights. The installation program described in Method 1 above has been set up to try to minimise these problems and give the user control over all the files in the installation file space. However, if you have any problems with lack of privileges you have three options:

1. Install the program to an area of the hard disc where you know you have read, write and execute privileges.

2. Install the self-extracting version (Method 2 above) to an area of the hard disc where you know there are no requirements for administrator privileges (the desktop is a good location). This should avoid most security issues.

3. Try running the installation file or Forest Yield as an administrator. Right mouse-click on the executable file and choose Run as administrator from the menu (Figure 1).

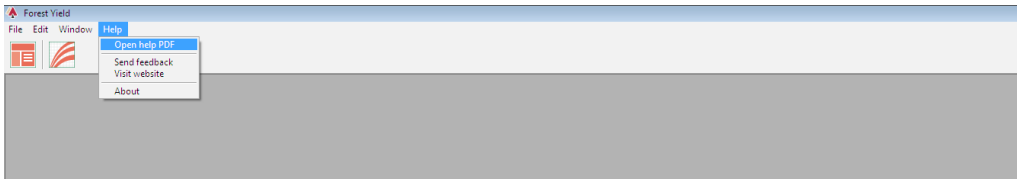
Figure 1 Running as administrator.



Help files

Forest Yield accesses all Help information from the file quickhelp.pdf. This file can be accessed directly from Forest Yield under the Help drop-down menu in the Main Window (Figure 2).

Figure 2 Accessing Help in Forest Yield.



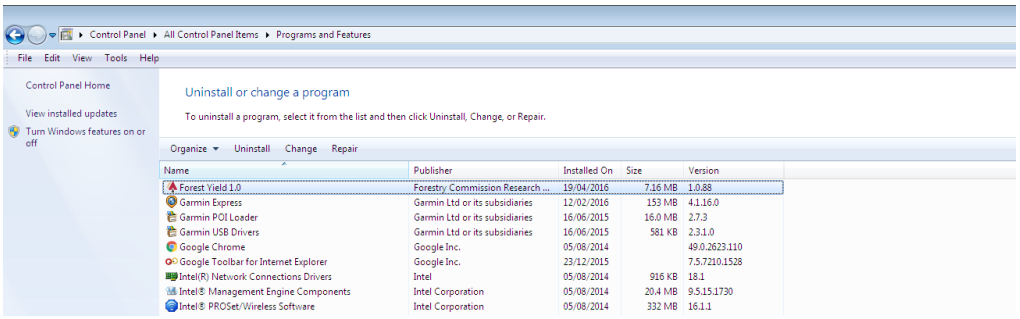
Uninstalling Forest Yield

Forest Yield is uninstalled via the Windows® Control Panel. In Windows® 7 and Windows® 8, this can be done using Open Control Panel, or Uninstall or change a program via Windows® Explorer (My Computer).

To uninstall the program:

1. Press Start, or click the PC settings button in Windows® 8.
2. Choose Control panel.
3. Choose Programs: Uninstall a program (or put Control Panel\Programs\Programs and Features into Windows® Explorer).
4. Select Forest Yield 1.0 from the list of programs (Figure 3).
5. Left click on Uninstall in the banner above the list of programs.

Figure 3 Uninstalling Forest Yield.



This will remove all the components of Forest Yield apart from the underpinning yield table database Yield Lookup.

To uninstall Yield Lookup follow the instructions above but select Yield Lookup 4.3 in Step 4. This will remove all the components of Yield Lookup.

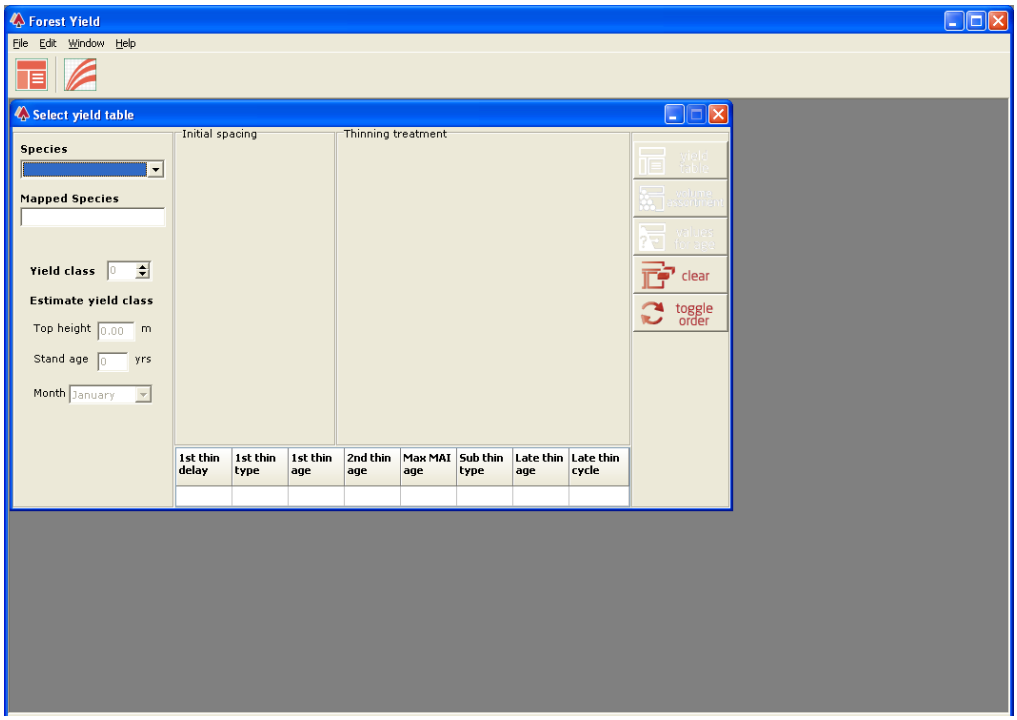
Using Forest Yield

Getting started

Double click the Forest Yield icon on the desktop to launch the software.

The first screen (Figure 4) presents a menu and two toolbar icons (Figure 5), which are used to select between the different ways of using Forest Yield.

Figure 4 The Forest Yield default start-up screen showing the default Select yield table sub-window (see the *Preferences* section below). Note also, at the top left corner of the main window, the toolbar icons (buttons) for selecting a yield table to display and for showing General Yield Class curves (Figure 5).



To adjust settings, including the format of yield tables, see the Preferences section below.

Forest Yield can be used in two main ways:

1. To estimate the General Yield Class of a stand of trees.
2. To access and display yield table information and volume assortments.

Figure 5 The toolbar icons for launching the Select yield table (left) and Display General Yield Class curves (right) sub-windows.

Basic help in using the program can be found within the Help option on the menu bar on the main window of Forest Yield (Help > Open help PDF).

Estimating the General Yield Class of a stand of trees

General Yield Class for a stand of a particular tree species can be estimated from an assessment of stand top height at a specified age (see also the 'General Yield Class' section of the Forest Yield handbook, page 26).

Click on the Display General Yield Class icon to display a new sub-window where values for species, top height and stand age can be entered.

Start by selecting the tree species from the species drop-down menu (top left) on the Display General Yield Class sub-window (Figure 6). Forest Yield will automatically display mapped species, where these are relevant (see below).

Mapped species

Forest Yield includes yield tables for all the main forestry tree species grown in Britain (see Appendix 1). The drop-down list also includes species for which there is no directly available yield table; however, Forest Yield will use the nearest suitable yield table for another species – referred to as the 'mapped species'.

For example, selecting Serbian spruce – which has no specific yield table – will result in General Yield Class being estimated from the yield table for Norway spruce, the mapped species.

The top height and age for the stand (see the box on stand age) should be entered into the relevant text boxes in the Display General Yield Class sub-window. If appropriate, the month in the year when the assessment of top height and age was made can also be entered (this information is optional and typically will only be of interest for research purposes).

Stand age

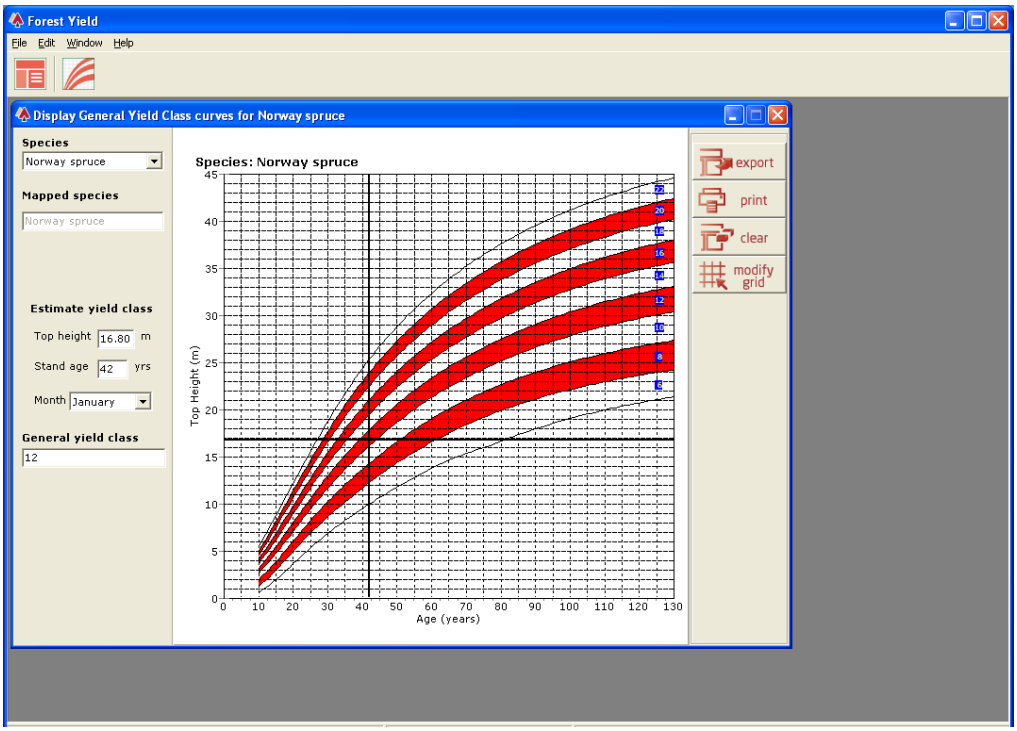
Stand age represents the number of growing seasons a stand has experienced since planting or establishment. The month in the year in which the top height was assessed has a small but significant effect on the total number of growing seasons and hence the effective age of a stand. Suppose a stand recorded as planted in 1950 was assessed in October 2007. In this example the stand age at time of assessment would be calculated as 2007 – 1950 = 57 years. Now suppose that the stand was assessed in March 2008. This is in the period following the end of the 2007 growing season and before the start of the 2008 growing season, so the stand age would still be calculated as 2007 – 1950 = 57 years. However, if the stand was assessed in October 2008 then the stand age would be calculated as 2008 – 1950 = 58 years. Assessments made between March 2008 and October 2008 would be assumed to have taken place during the growing season and a fractional adjustment might be made to the stand age of 57 years as follows:

January to March: add 0.0 year
April: add 0.2 year
May: add 0.4 year
June: add 0.6 year
July: add 0.8 year
August: add 0.9 year
September to December: add 1.0 year

If a month is selected from the drop-down list in Forest Yield, the above adjustments will be automatically applied to the stand age already entered.

The General Yield Class value is now displayed – this is rounded to the nearest even whole number.

Figure 6 The General Yield Class curves for Norway spruce, showing a yield class assessment for a 42-year-old stand with a top height of 16.8 m and which was measured in January.



When both top height and stand age have been entered, cross hairs will mark the position of the assessment on the General Yield Class chart.

Gridlines can be added to the chart using the modify grid button.

The chart can be exported as a bitmap (picture) file using the export button.

Accessing information from a yield table

A yield table can be accessed by selecting a species, yield class and management regime – the latter defined in terms of initial spacing and thinning treatment. All these parameters are defined and explained in detail in the ForestYield handbook.

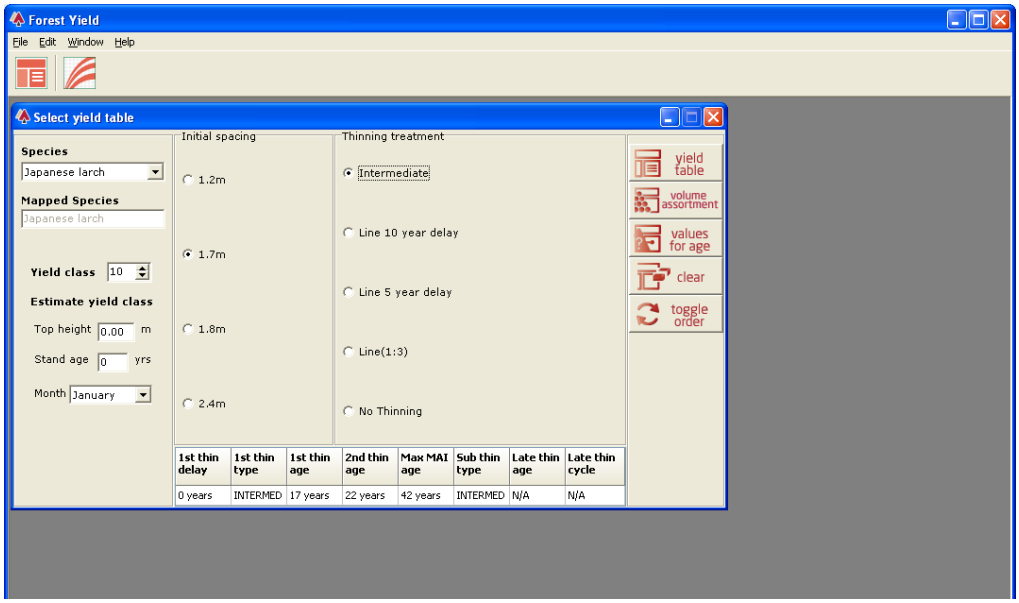
Click on the Select yield table icon to display the sub-window where values for species, yield class, initial spacing and thinning treatment can be entered (Figure 7).

Start by selecting the tree species from the drop-down menu (top left of the sub-window). ForestYield will automatically display the mapped species (see the box describing mapped species on page 3).

The yield class for the species of interest is automatically set by ForestYield to the lowest available value in the range of yield tables. This value can be changed, in steps of two, up to the maximum available yield class for the species.

If the yield class of interest is outside of the range represented in the yield tables for the tree

Figure 7 Selecting the yield table for Japanese larch, yield class 10, intermediate thinning. Note that some stand-specific operational information is already displayed at the foot of the sub-window.



species, reference should be made to the yield table for the lowest or highest available yield class, as appropriate – see 'Selecting a yield table' in the Forest Yield handbook. If yield class is not known, this can be estimated by entering values for top height and age – see the section on 'Estimating the General Yield Class of a stand of trees' above.

Management regime is specified by choosing either the initial spacing first or the thinning treatment first – as appropriate to the species and yield class. For each tree species, yield tables are available for only certain selected combinations of spacing and thinning treatment, see 'Management regimes' in the Forest Yield handbook. It may be useful to toggle between both options using the toggle order button in order to explore what management regimes are available for a given species and yield class – especially if there is likely to be a limited range of yield tables available (see also the 'Selecting a yield table' section of the Forest Yield handbook, page 63).

Having selected a yield table, there are three ways of accessing yield information:

1 Display yield table.
2 Display volume assortment.
3 Display yield values for a specified stand age.

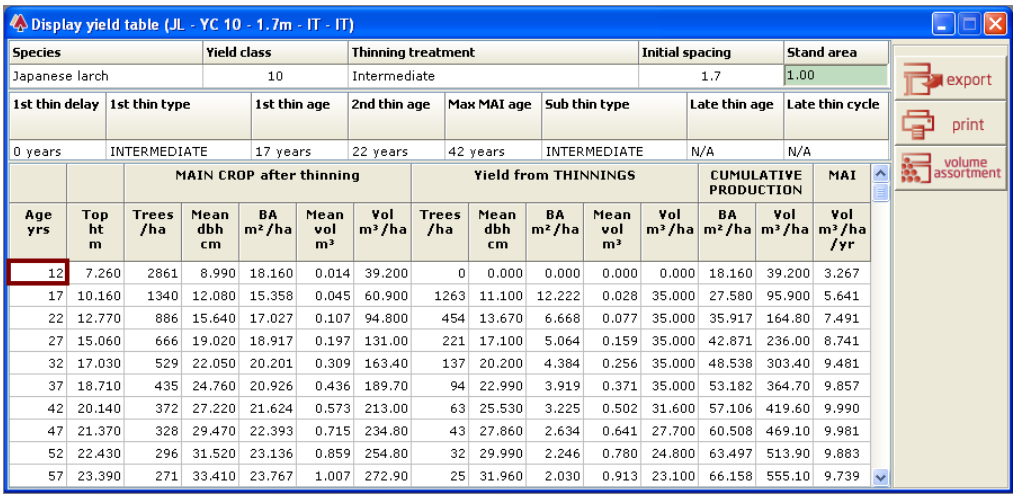
The on-screen buttons giving access to these functions are shown at the top right of the Select yield table sub-window illustrated in Figure 7.

Displaying yield tables

Click on the yield table button.

The yield table is displayed in a new sub-window (Figure 8). An explanation of the information shown in a yield table is given in Appendix 2. Results are given for a default stand area of 1 hectare. If tabulated values are required for a known stand area, rather than for a default of 1 hectare, the tabulated values can be recalculated by entering the stand area, in hectares, into the box labelled Stand area (at the top right-hand side of the sub-window). This is the only thing that can be changed in the sub-window.

Figure 8 The standard yield table[2] resulting from the inputs illustrated in Figure 7.



Species	Yield class	Thinning treatment	Initial spacing	Stand area
Japanese larch	10	Intermediate	1.7	1.00

1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle
0 years	INTERMEDIATE	17 years	22 years	42 years	INTERMEDIATE	N/A	N/A

		MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha	Vol m³/ha	Vol m³/ha /yr
12	7.260	2861	8.990	18.160	0.014	39.200	0	0.000	0.000	0.000	0.000	18.160	39.200	3.267
17	10.160	1340	12.080	15.358	0.045	60.900	1263	11.100	12.222	0.028	35.000	27.580	95.900	5.641
22	12.770	886	15.640	17.027	0.107	94.800	454	13.670	6.668	0.077	35.000	35.917	164.80	7.491
27	15.060	666	19.020	18.917	0.197	131.00	221	17.100	5.064	0.159	35.000	42.871	236.00	8.741
32	17.030	529	22.050	20.201	0.309	163.40	137	20.200	4.384	0.256	35.000	48.538	303.40	9.481
37	18.710	435	24.760	20.926	0.436	189.70	94	22.990	3.919	0.371	35.000	53.182	364.70	9.857
42	20.140	372	27.220	21.624	0.573	213.00	63	25.530	3.225	0.502	31.600	57.106	419.60	9.990
47	21.370	328	29.470	22.393	0.715	234.80	43	27.860	2.634	0.641	27.700	60.508	469.10	9.981
52	22.430	296	31.520	23.136	0.859	254.80	32	29.990	2.246	0.780	24.800	63.497	513.90	9.883
57	23.390	271	33.410	23.767	1.007	272.90	25	31.960	2.030	0.913	23.100	66.158	555.10	9.739

Yield table information can be exported using the export button on the right-hand side of the sub-window. Available export formats are:

- Microsoft Excel® Spreadsheet (.xls)
- Rich Text Document File (.rtf)
- Comma Separated File (.csv)
- Text File (.txt)

Displaying yield values for a specified stand age

Click on the values for age button in the Select yield table sub-window.

Enter stand age to display yield values – the default is the first age in the relevant yield table. However, this can be changed by using the age buttons at the bottom right-hand side of the sub-window.

Yield information can be exported using the export button option on the right-hand side of the sub-window. Export formats are:

- Microsoft Excel® Spreadsheet (.xls)
- Rich Text Document File (.rtf)
- Comma Separated File (.csv)
- Text File (.txt)

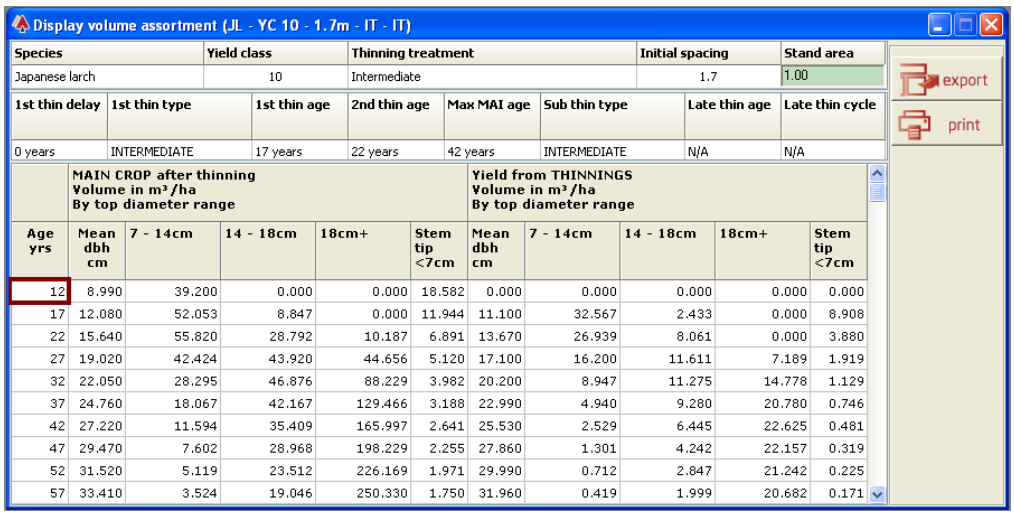
Displaying volume assortments

Click on the Volume assortment button in the Select yield table sub-window.

The volume assortment table is displayed in a new sub-window (Figure 8). Results are given for a default stand area of 1 hectare. The assortment volumes are separately displayed for the main crop and for thinnings along with stand age and mean dbh from the selected yield table. The different assortment categories, in terms of selected top diameters, can be specified via the Preferences sub-window (see the section below on 'Preferences, Assortment specification'). A category representing stem tips (i.e. stemwood with diameter less than 7 cm overbark) is always included in the results for volume assortments.

[2] The standard yield table presents values for a stand of trees, generally at 5-year intervals, starting 5 years before the notional age of first thinning. However, ForestYield can alternatively be set to display annual values via the Preferences sub-window (see the *Preferences* section below).

Figure 9 The ForestYield Display volume assortment sub-window based on the inputs illustrated in Figure 7.



Display volume assortment (JL - YC 10 - 1.7m - IT - IT)

Species	Yield class	Thinning treatment	Initial spacing	Stand area
Japanese larch	10	Intermediate	1.7	1.00

export

print

1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle
0 years	INTERMEDIATE	17 years	22 years	42 years	INTERMEDIATE	N/A	N/A

	MAIN CROP after thinning Volume in m³/ha By top diameter range					Yield from THINNINGS Volume in m³/ha By top diameter range				
Age yrs	Mean dbh cm	7 - 14cm	14 - 18cm	18cm+	Stem tip <7cm	Mean dbh cm	7 - 14cm	14 - 18cm	18cm+	Stem tip <7cm
12	8.990	39.200	0.000	0.000	18.582	0.000	0.000	0.000	0.000	0.000
17	12.080	52.053	8.847	0.000	11.944	11.100	32.567	2.433	0.000	8.908
22	15.640	55.820	28.792	10.187	6.891	13.670	26.939	8.061	0.000	3.880
27	19.020	42.424	43.920	44.656	5.120	17.100	16.200	11.611	7.189	1.919
32	22.050	28.295	46.876	88.229	3.982	20.200	8.947	11.275	14.778	1.129
37	24.760	18.067	42.167	129.466	3.188	22.990	4.940	9.280	20.780	0.746
42	27.220	11.594	35.409	165.997	2.641	25.530	2.529	6.445	22.625	0.481
47	29.470	7.602	28.968	198.229	2.255	27.860	1.301	4.242	22.157	0.319
52	31.520	5.119	23.512	226.169	1.971	29.990	0.712	2.847	21.242	0.225
57	33.410	3.524	19.046	250.330	1.750	31.960	0.419	1.999	20.682	0.171

Preferences

The options available via Preferences (under the Edit menu) can be used to set the preferred settings for the appearance and display formats of ForestYield as well as the top diameter classes for volume assortments. Options can be set for:

- Start-up appearance
- Model version
- Display format
- Assortment specification.

Start-up appearance

The Display selection screen on startup section of the Preferences sub-window can be used to customise the start-up screen of ForestYield. The default is for the Select yield table sub-window to be displayed on start-up. This can be kept as the default or, alternatively, ForestYield can be started so that it displays the General Yield Class curves sub-window or simply the menu bar and icons for the two main functions.

Yield model version

The Yield model version section of the Preferences sub-window can be used to select which set of yield tables to use for Sitka spruce. The original set of yield tables was previously published by the Forestry Commission as *Yield models for forest management* (Booklet 48). For Sitka spruce, an alternative set is now available – produced using a new dynamic yield model. Whether the original or new tables are selected for Sitka spruce, tables for all other species are based on the original Booklet 48 models.

Display format

The display section of the Preferences sub-window can be used to customise the detailed display of yield tables and is composed of three parts.

Yield table display frequency is used to select the preferred age intervals. Conventionally, yield table results are only displayed for defined ages – usually 5 years apart. Yield tables can be displayed using these standard intervals or as an annual sequence.

Display yield table main crop values is used to select how the main crop results are displayed. Conventionally, yield table results for the main crop take into account the removal of thinnings. The main crop results can be displayed either before or after thinning.

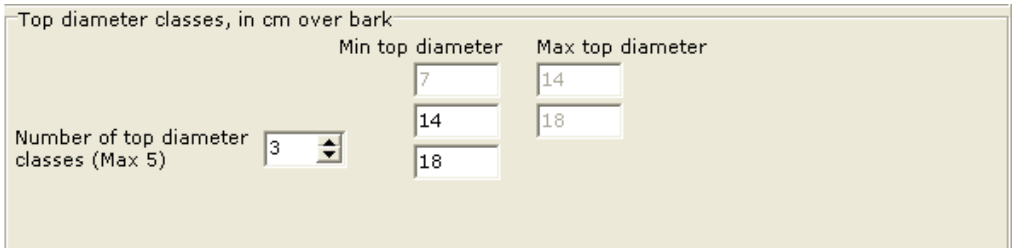
Yield table rounding convention is used to select the rounding conventions for yield table results. Standard conventions round results to a fixed number of decimal places. ForestYield can be set to display unrounded results (more strictly, results to three decimal places), if required.

Assortment specification

The assortment specification section of the Preferences sub-window (illustrated in Figure 10) can be used to specify up to five categories of roundwood by setting minimum and maximum top diameters for each desired category. The categories cannot overlap and must be continuous (i.e. there must be no gaps between adjacent categories). In addition, the minimum top diameter of the smallest category must be 7 cm. To ensure these conditions are met, ForestYield forces the minimum top diameter of the smallest category to be 7 cm, while it requires the minimum for any other categories to be specified, and then automatically sets the maximum values for the categories. Once the required volume assortment categories have been specified, press Save which will save these category preferences and close the Preferences sub-window.

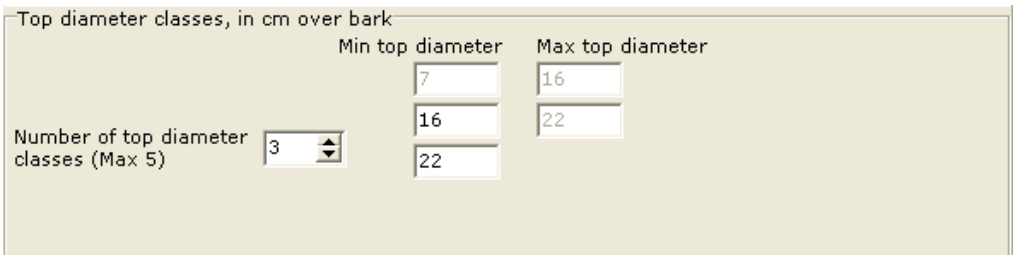
The default stand volume assortment categories are 7–14 cm, 14–18 cm and 18+ cm top diameter overbark (see Figure 10). These default categories can be changed using the volume assortment specification sub-window.

Figure 10 The default top diameter settings for the volume assortment function in ForestYield.



The default categories for stand volume assortments reported by ForestYield can be changed by entering the desired minimum top diameter limits into the appropriate text boxes (as illustrated in Figure 11).

Figure 11 The default top diameter settings for the volume assortment function in ForestYield can be changed by the user, as illustrated in this example. The greyed-out maximum top diameter values are updated by the software when new values for minimum top diameter are entered.

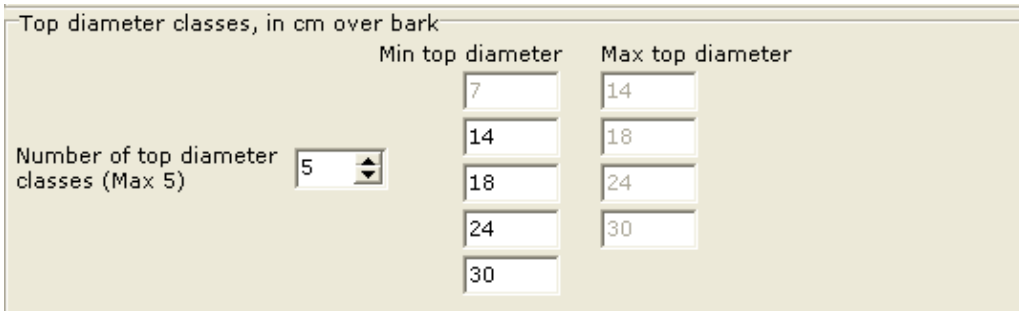


The number of top diameter classes can be set using the selector at the left-hand side of the assortment specification section in Preferences. The minimum number of top diameter classes is 1 and the maximum number is 5 (the default setting is 3, as illustrated in Figure 11). If selecting only one top diameter class, then all that will be displayed in the Display volume assortments sub-window is the full stem volume to 7 cm overbark and, in addition, the volume of stem tips (i.e. main stem volume less than 7 cm top diameter overbark).

Except for the first and final categories, the minimum top diameter set in any row will be used as the maximum top diameter in the previous row. In the example illustrated in Figure 12, two additional top diameter categories have been added by setting the selector to '5' and entering '24' and '30' as the minimum top diameters (in centimetres, overbark) for the next two classes.

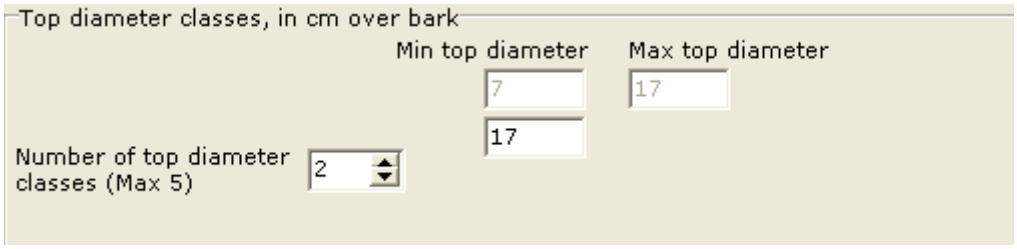
The five top diameter classes specified in Figure 12 are therefore: 7 cm–14 cm; 14 cm–18 cm; 18 cm–24 cm; 24 cm–30 cm; 30 cm+.

Figure 12 Two additional top diameter assortment categories have been set by the user.



To reduce the number of top diameter classes, simply adjust the selector to indicate the desired number of classes and enter the desired minimum top diameter values (see illustration in Figure 13).

Figure 13 The number of top diameter assortment categories has been changed to 2.



Pressing the Save preferences button will register and save your changes. 

In every case, the final top diameter class will always have no upper limit.

Manipulating yield table results

There will always be some differences between the growth predicted by yield tables and the actual growth of a stand of trees. The key reason is that the yield tables reflect the average growth of trees across Great Britain. In most cases, it is assumed that such differences will tend to 'average out' over a whole forest.

However, occasionally, and for a variety of reasons, a standard yield table may depart significantly from the past and (by implication) future growth of a stand. In such circumstances, it may be possible to make systematic adjustments to the values in the table in order to better predict future stand-level growth. The following worked examples include dealing with variations in tree growth rate due to local site conditions and using the yield tables in situations for which they were not originally designed, such as predicting tree growth in mixed-species stands.

Example 1 – Estimating the production class of a stand

The yield tables in Forest Yield assume that General Yield Class is a precise indicator of timber volume production – however, this is not always the case. As explained in more detail in the sections of the Forest Yield handbook on Local Yield Class (page 26) and production class (page 33), General Yield Class is an *estimate* of volume production, based on assessments of top height and age. A true assessment of yield class based on a direct assessment of volume production is known as Local Yield Class.

Production class is a measure of the agreement or disagreement between General Yield Class and Local Yield Class for a stand (or group of stands). If the Local Yield Class is in fact greater than the estimate based on General Yield Class, the stand is given a production class of A, A+ etc., depending on the extent of the difference. Similarly, if the Local Yield Class is Lower, production class takes values C, C- etc. If the Local Yield Class and the estimate based on General Yield Class are in agreement, then the stand is given a production class of B.

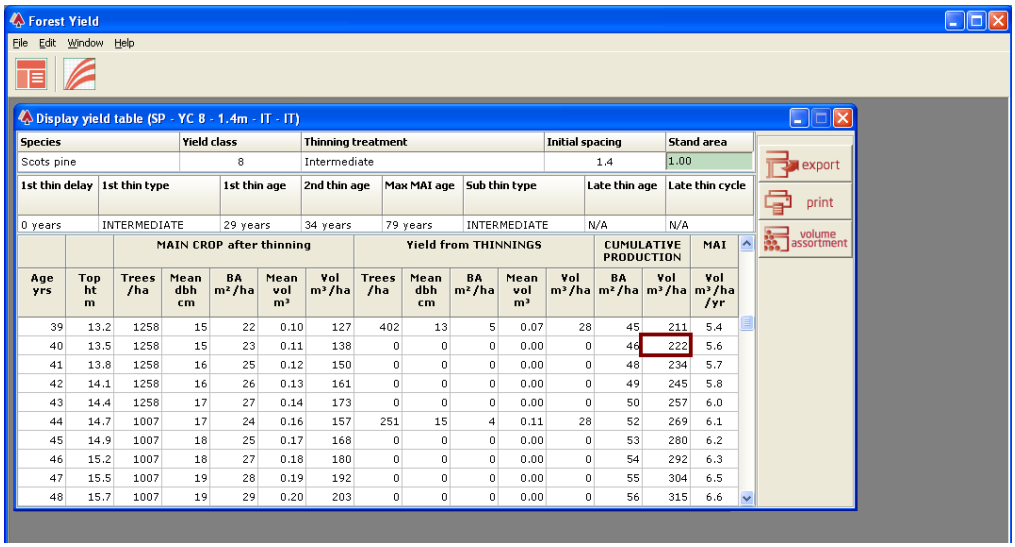
All yield tables – irrespective of spacing and treatment – are based on production class B (i.e. Local Yield Class and General Yield Class are in agreement).

If the Local Yield Class of a stand (or group of stands) is known as well as the General Yield Class (hence, production class is also known), then it is possible to construct a local yield table to more accurately reflect the growth patterns in the stand(s).

The following example is based on a well-managed stand for which good thinning records exist. If records of cumulative production have not been kept, then production class should only be estimated for young stands which have not been thinned.

Suppose that records have been collected for a thinned 40-year-old stand of Scots pine, General Yield Class 8 and initially planted at 1.4 m equivalent square spacing (5316 stems per hectare, see Table 5 of the Forest Yield handbook). The records indicate that the cumulative volume production is 425 m^3 per hectare (see the sections on 'Volume' and 'Measuring volume productivity' in the Forest Yield handbook, starting on pages 18 and 22 respectively). The yield table value for cumulative volume is 222 m^3 per hectare (Figure 14). The value from the records is very much larger than the value in the yield table, indicating that the production class of the stand is significantly higher than standard (i.e. greater than production class B) and that the Local Yield Class of the stand is consequently higher than the assessed General Yield Class.

Figure 14 The modelled cumulative volume production for a thinned 40-year-old stand of Scots pine, General Yield Class 8 and initially planted at 1.4 m equivalent square spacing.



Species	Yield class	Thinning treatment	Initial spacing	Stand area
Scots pine	8	Intermediate	1.4	1.00

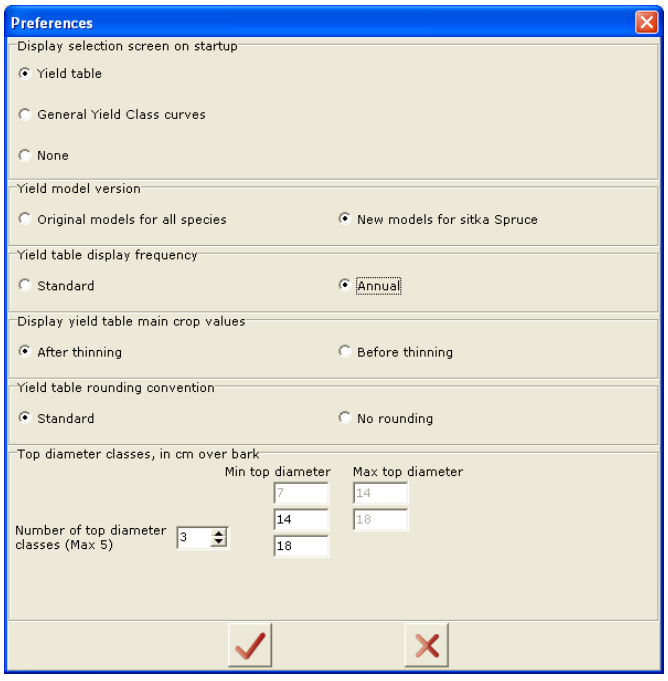
1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle
0 years	INTERMEDIATE	29 years	34 years	79 years	INTERMEDIATE	N/A	N/A

		MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha	Vol m³/ha	Vol m³/ha /yr
39	13.2	1258	15	22	0.10	127	402	13	5	0.07	28	45	211	5.4
40	13.5	1258	15	23	0.11	138	0	0	0	0.00	0	46	222	5.6
41	13.8	1258	16	25	0.12	150	0	0	0	0.00	0	48	234	5.7
42	14.1	1258	16	26	0.13	161	0	0	0	0.00	0	49	245	5.8
43	14.4	1258	17	27	0.14	173	0	0	0	0.00	0	50	257	6.0
44	14.7	1007	17	24	0.16	157	251	15	4	0.11	28	52	269	6.1
45	14.9	1007	18	25	0.17	168	0	0	0	0.00	0	53	280	6.2
46	15.2	1007	18	27	0.18	180	0	0	0	0.00	0	54	292	6.3
47	15.5	1007	19	28	0.19	192	0	0	0	0.00	0	55	304	6.5
48	15.7	1007	19	29	0.20	203	0	0	0	0.00	0	56	315	6.6

The steps for assessing the production class of this stand are as follows:

1. Open the Preferences sub-window and set the Yield table display frequency to 'Annual' (Figure 15). This is to ensure that the necessary values can always be compared between yield tables, irrespective of the ages at which the standard yield tables start.

Figure 15 Set the Yield table display frequency to 'Annual'.



2. Because, in this instance, observed cumulative volume production is greater than that indicated in the General Yield Class table, select (Figure 16) and display (Figure 17) the yield table for one yield class greater than the General Yield Class, keeping all other stand parameters the same.

3. Because observed cumulative volume production is still greater than that indicated in the General Yield Class table, select and display the yield table for one yield class greater than in the previous step, keeping all other stand parameters the same (Figure 18).

Figure 16 Select the yield table for one yield class higher than indicated by the standard top height on age relationship (in this example, 10 rather than 8).

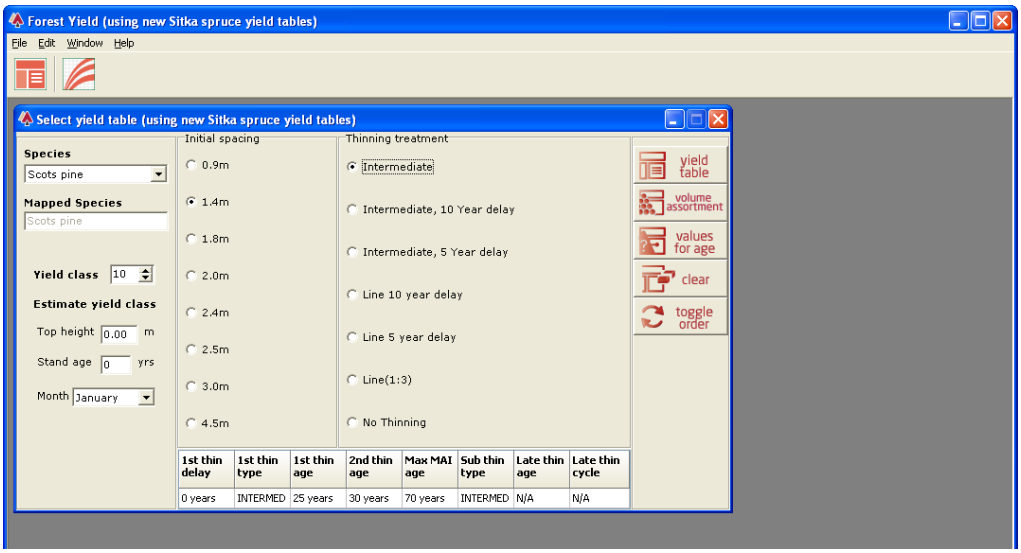


Figure 17 The modelled cumulative volume production (307 m^3 per hectare) at the appropriate stand age is still lower than the observed cumulative volume production for the stand in question (425 m^3 per hectare).

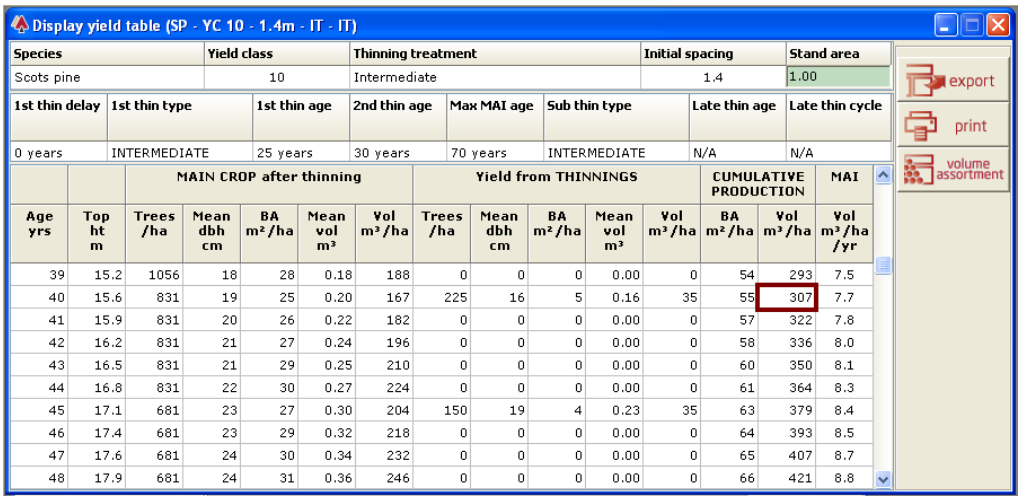
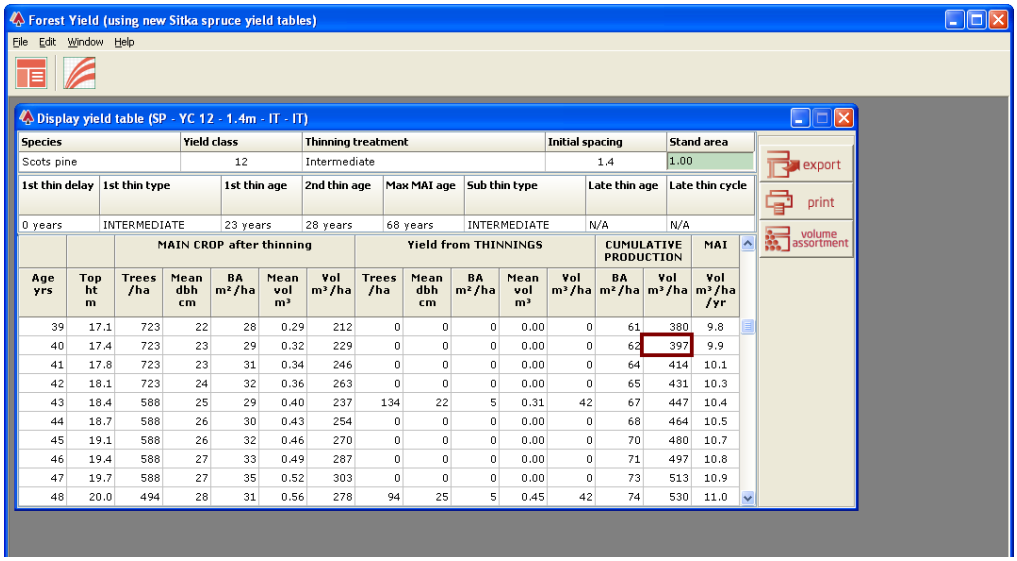


Figure 18 The modelled cumulative volume production (397 m^3 per hectare) for yield class 12 Scots pine at the appropriate stand age is still lower than the observed cumulative volume production for the stand in question (425 m^3 per hectare).



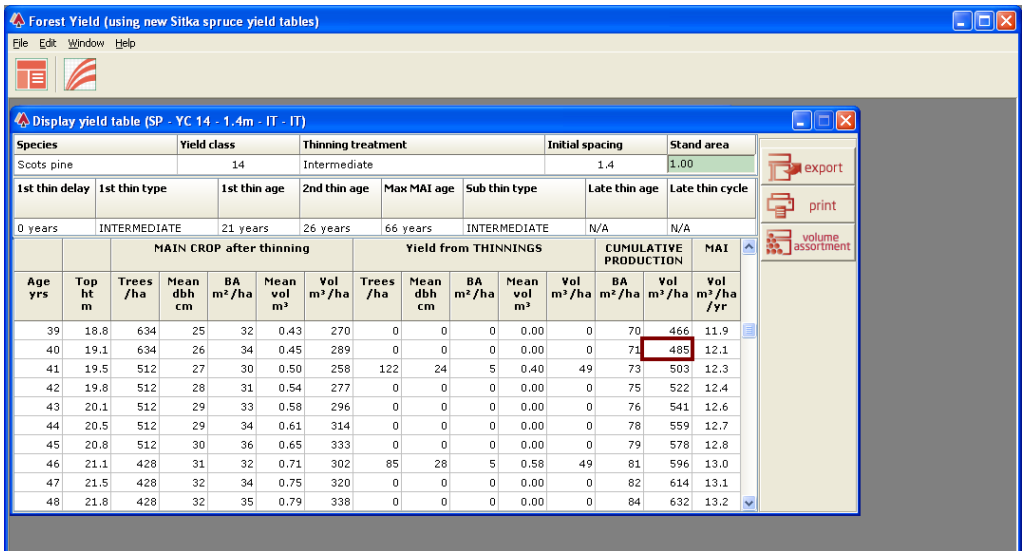
Species	Yield class	Thinning treatment	Initial spacing	Stand area
Scots pine	12	Intermediate	1.4	1.00

1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle
0 years	INTERMEDIATE	23 years	28 years	68 years	INTERMEDIATE	N/A	N/A

		MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m^2/ha	Mean vol m^3	Vol m^3/ha	Trees /ha	Mean dbh cm	BA m^2/ha	Mean vol m^3	Vol m^3/ha	BA m^2/ha	Vol m^3/ha	Vol m^3/ha/yr
39	17.1	723	22	28	0.29	212	0	0	0	0.00	0	61	380	9.8
40	17.4	723	23	29	0.32	229	0	0	0	0.00	0	62	397	9.9
41	17.8	723	23	31	0.34	246	0	0	0	0.00	0	64	414	10.1
42	18.1	723	24	32	0.36	263	0	0	0	0.00	0	65	431	10.3
43	18.4	588	25	29	0.40	237	134	22	5	0.31	42	67	447	10.4
44	18.7	588	26	30	0.43	254	0	0	0	0.00	0	68	464	10.5
45	19.1	588	26	32	0.46	270	0	0	0	0.00	0	70	480	10.7
46	19.4	588	27	33	0.49	287	0	0	0	0.00	0	71	497	10.8
47	19.7	588	27	35	0.52	303	0	0	0	0.00	0	73	513	10.9
48	20.0	494	28	31	0.56	278	94	25	5	0.45	42	74	530	11.0

4. The modelled cumulative volume production illustrated in Figure 18 is still less than that recorded for the stand (425 m^3 per hectare), so select and display the yield table for one yield class greater than in the previous step, keeping all other stand parameters the same (see Figure 19).

Figure 19 The modelled cumulative volume production (485 m^3 per hectare) is higher than the observed cumulative volume production (425 m^3 per hectare) at the appropriate age.



Species	Yield class	Thinning treatment	Initial spacing	Stand area
Scots pine	14	Intermediate	1.4	1.00

1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle
0 years	INTERMEDIATE	21 years	26 years	66 years	INTERMEDIATE	N/A	N/A

		MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m^2/ha	Mean vol m^3	Vol m^3/ha	Trees /ha	Mean dbh cm	BA m^2/ha	Mean vol m^3	Vol m^3/ha	BA m^2/ha	Vol m^3/ha	Vol m^3/ha/yr
39	18.8	634	25	32	0.43	270	0	0	0	0.00	0	70	466	11.9
40	19.1	634	26	34	0.45	289	0	0	0	0.00	0	71	485	12.1
41	19.5	512	27	30	0.50	258	122	24	5	0.40	49	73	503	12.3
42	19.8	512	28	31	0.54	277	0	0	0	0.00	0	75	522	12.4
43	20.1	512	29	33	0.58	296	0	0	0	0.00	0	76	541	12.6
44	20.5	512	29	34	0.61	314	0	0	0	0.00	0	78	559	12.7
45	20.8	512	30	36	0.65	333	0	0	0	0.00	0	79	578	12.8
46	21.1	428	31	32	0.71	302	85	28	5	0.58	49	81	596	13.0
47	21.5	428	32	34	0.75	320	0	0	0	0.00	0	82	614	13.1
48	21.8	428	32	35	0.79	338	0	0	0	0.00	0	84	632	13.2

5. The modelled cumulative volume production illustrated in Figure 19 is greater than that recorded for the stand (425 m^3 per hectare). It is therefore appropriate to assume that the Local Yield Class of the stand is lower than 14 m^3 per hectare per annum. The best estimate of Local Yield Class for this particular stand is therefore 12 m^3 per hectare per annum, two yield classes greater than the General Yield Class derived from top height and age.

6. Refer to Table 3 on page 11 of the Forest Yield handbook. The difference between Local Yield Class and General Yield Class is 4 $m^3\ ha^{-1}\ yr^{-1}$, so this stand of Scots pine is production class A+.

Example 2 – Constructing yield tables for production classes A or C

In this example, it is assumed that the production class (see page 33 of the ForestYield handbook) of a stand is known and the user wishes to produce a local yield table. The method given here can be used for production classes A++, A+, A, C, C– and C–– of any tabulated species.

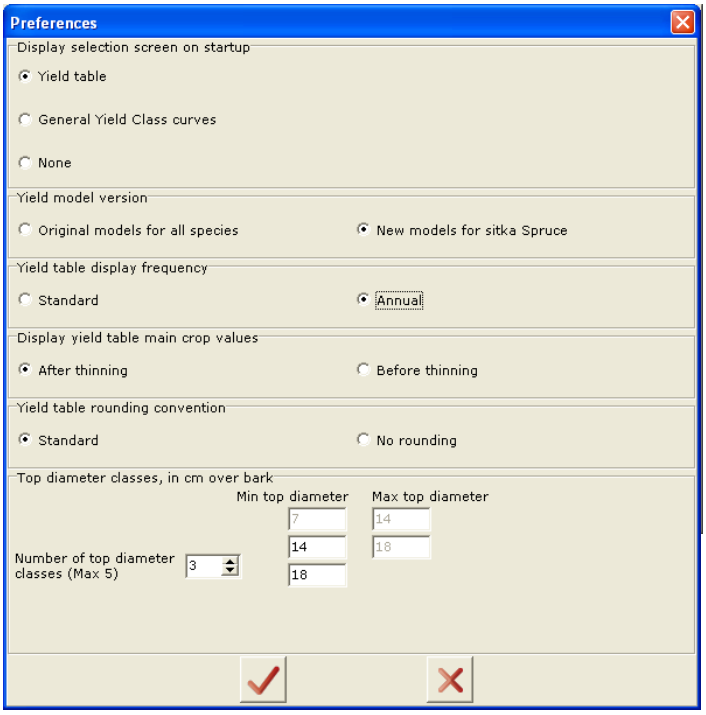
Assume that a stand of Scots pine, General Yield Class 8, has been assessed as being production class A. The Local Yield Class of the stand is therefore 2 m^3 ha^{-1} yr^{-1} greater than the assessed General Yield Class (see Table 3 on page 11 of the ForestYield handbook), i.e. the Local Yield Class is 10. Cumulative volume production from this stand is therefore greater than that given by the yield table for the General Yield Class and a local adjustment needs to be made to a standard ForestYield table in order to accurately forecast production.

To produce a suitably adjusted yield table, the yield table for the Local Yield Class of the stand should be selected, but the top height should be replaced with values taken from the yield table based on General Yield Class for the stand. This gives a table which reflects the currently observed patterns of cumulative volume production, top height development and other associated stand attributes (e.g. basal area). The resultant local yield table will be more representative of the stand attributes for each age of stand development for that particular stand.

The local yield table is constructed by carrying out the following steps:

1. Open the Preferences sub-window and set the Yield table display frequency to 'Annual' (Figure 20). This is to ensure that the necessary top height values can always be copied between yield tables, irrespective of the ages at which the standard yield tables start.

Figure 20 Set the Yield table display frequency to 'Annual'.



2. Select and display the yield table appropriate for the Local Yield Class indicated by the production class of the stand; in this worked example General Yield Class 8 production class A gives Local Yield Class 10 (Figures 21 and 22).

Figure 21 Select the correct yield table for the Local Yield Class of the selected stand.

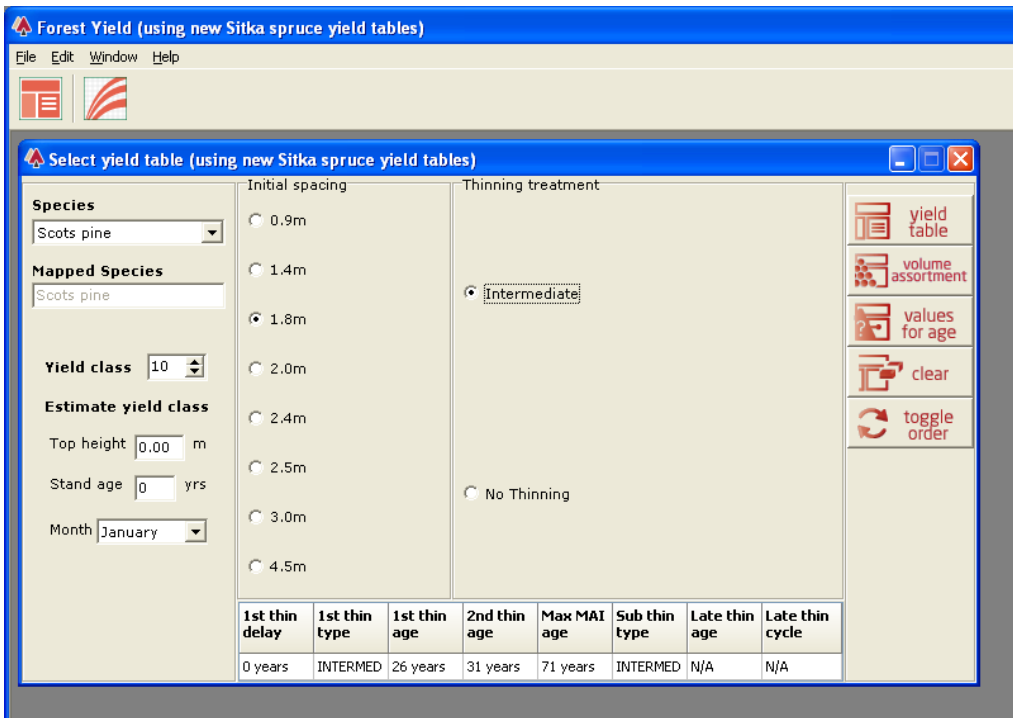
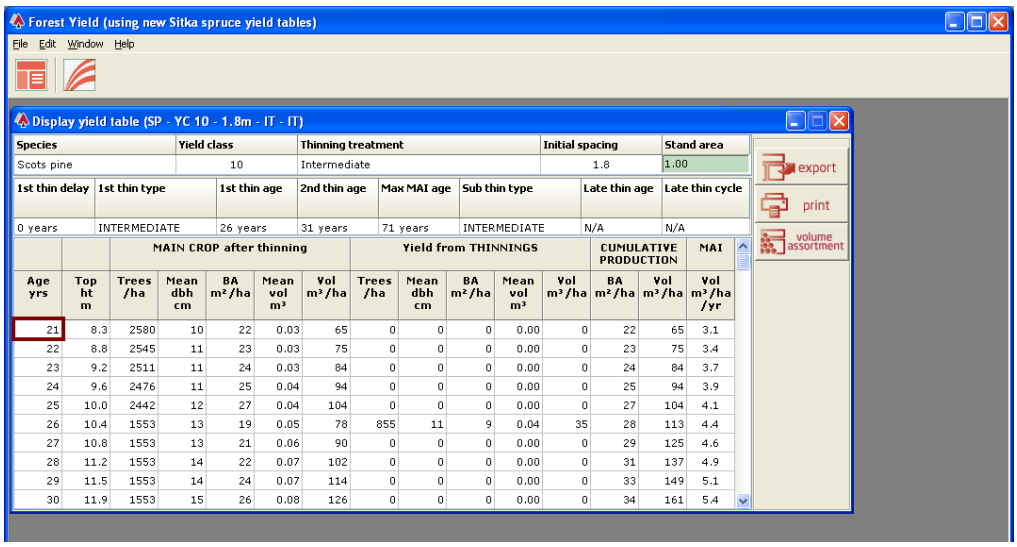
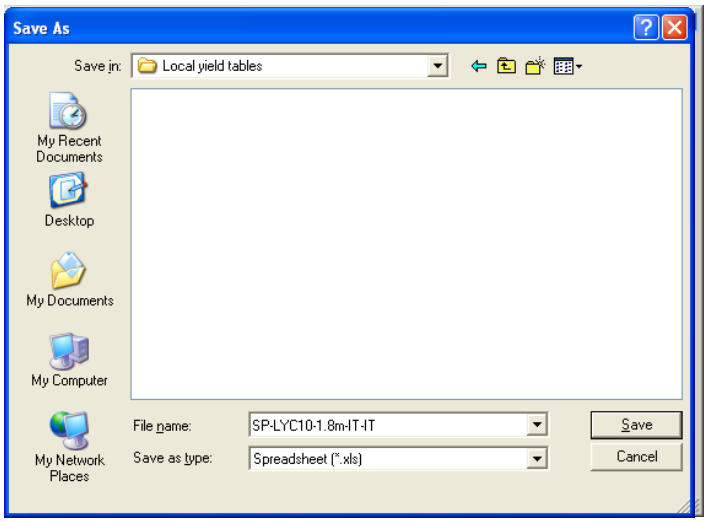


Figure 22 Display the yield table appropriate to the Local Yield Class.



3. Make a note of the first age displayed in the yield table (21 years in this example) and export the output to a spreadsheet file (Figure 23).

Figure 23 Save the export file with an appropriate name.



4. Select and display the yield table appropriate for the General Yield Class indicated by the current top height and age of the selected stand (Figures 24 and 25).

Figure 24 Select the correct yield table for the General Yield Class of the selected stand.

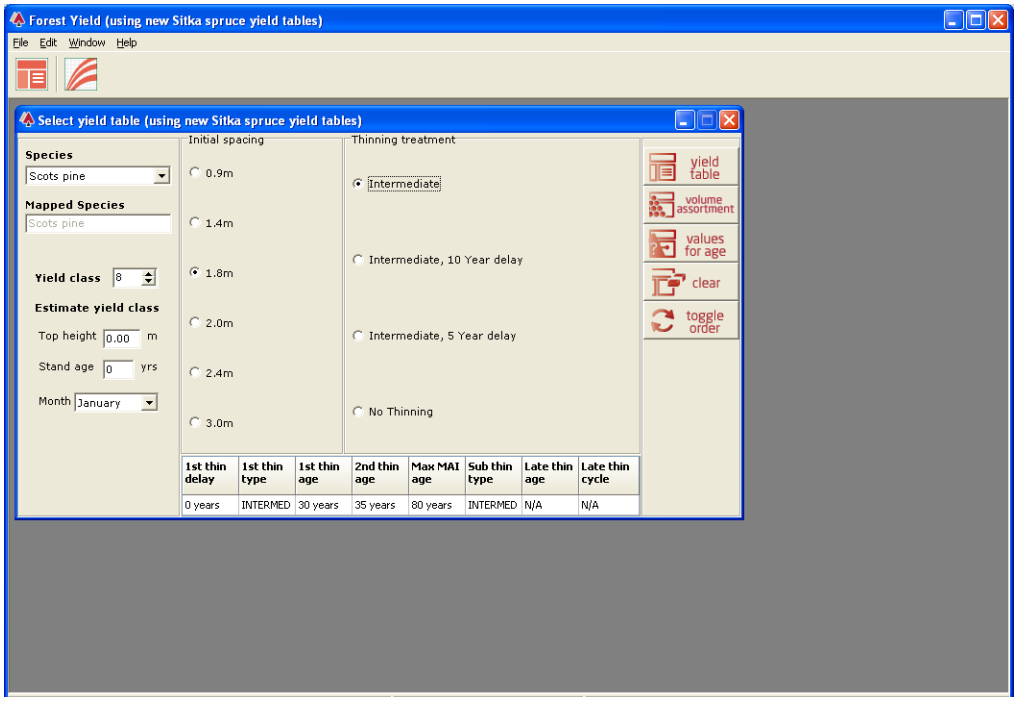
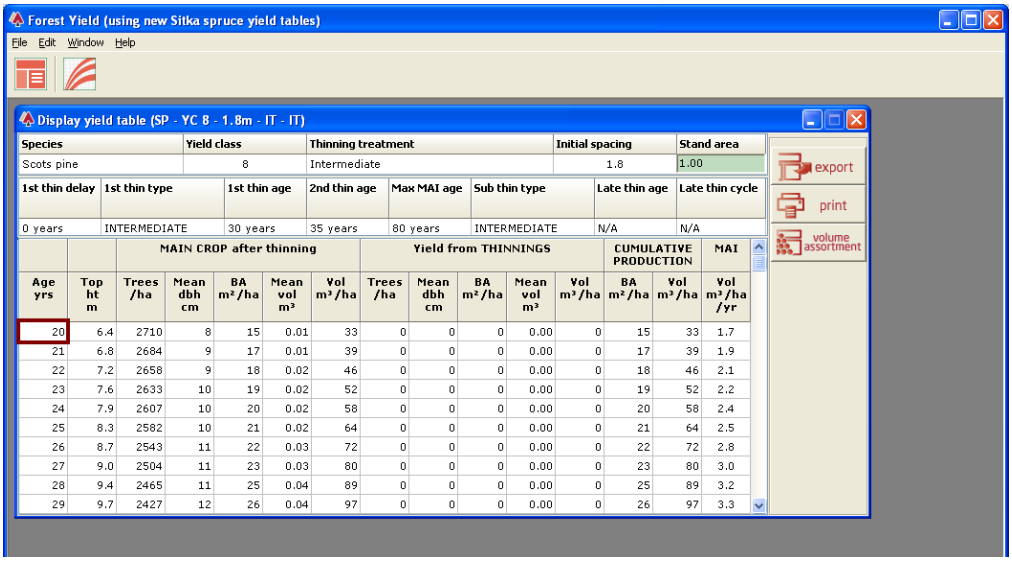


Figure 25 Display the yield table appropriate to the General Yield Class.



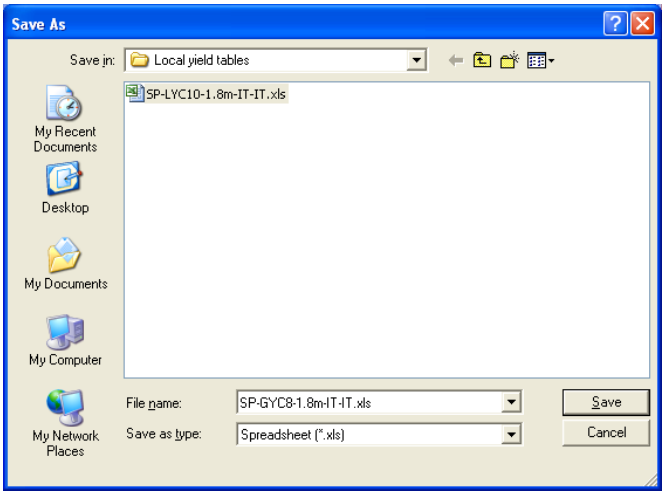
Species	Yield class	Thinning treatment	Initial spacing	Stand area
Scots pine	8	Intermediate	1.8	1.00

1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle
0 years	INTERMEDIATE	30 years	35 years	80 years	INTERMEDIATE	N/A	N/A

		MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha	Vol m³/ha	Vol m³/ha/yr
20	6.4	2710	8	15	0.01	33	0	0	0	0.00	0	15	33	1.7
21	6.8	2684	9	17	0.01	39	0	0	0	0.00	0	17	39	1.9
22	7.2	2658	9	18	0.02	46	0	0	0	0.00	0	18	46	2.1
23	7.6	2633	10	19	0.02	52	0	0	0	0.00	0	19	52	2.2
24	7.9	2607	10	20	0.02	58	0	0	0	0.00	0	20	58	2.4
25	8.3	2582	10	21	0.02	64	0	0	0	0.00	0	21	64	2.5
26	8.7	2543	11	22	0.03	72	0	0	0	0.00	0	22	72	2.8
27	9.0	2504	11	23	0.03	80	0	0	0	0.00	0	23	80	3.0
28	9.4	2465	11	25	0.04	89	0	0	0	0.00	0	25	89	3.2
29	9.7	2427	12	26	0.04	97	0	0	0	0.00	0	26	97	3.3

5. Export the displayed General Yield Class yield table to a spreadsheet file (Figure 26).

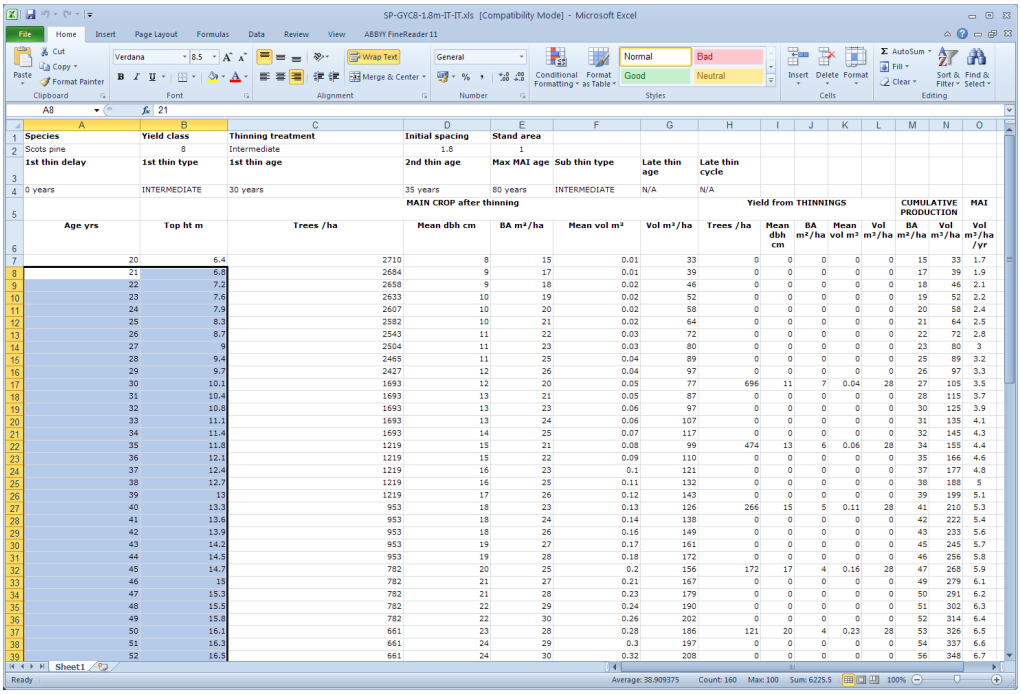
Figure 26 Save the export file with an appropriate name.



6. Using a suitable spreadsheet application, open both of the spreadsheets generated above (in Steps 3 and 5).

7. Select and copy the ages and top heights[3] from the General Yield Class yield table (saved in Step 5), starting no earlier than the age recorded in Step 3 (Figure 27).

Figure 27 The required ages and top heights in the General Yield Class yield table have been selected prior to copying.

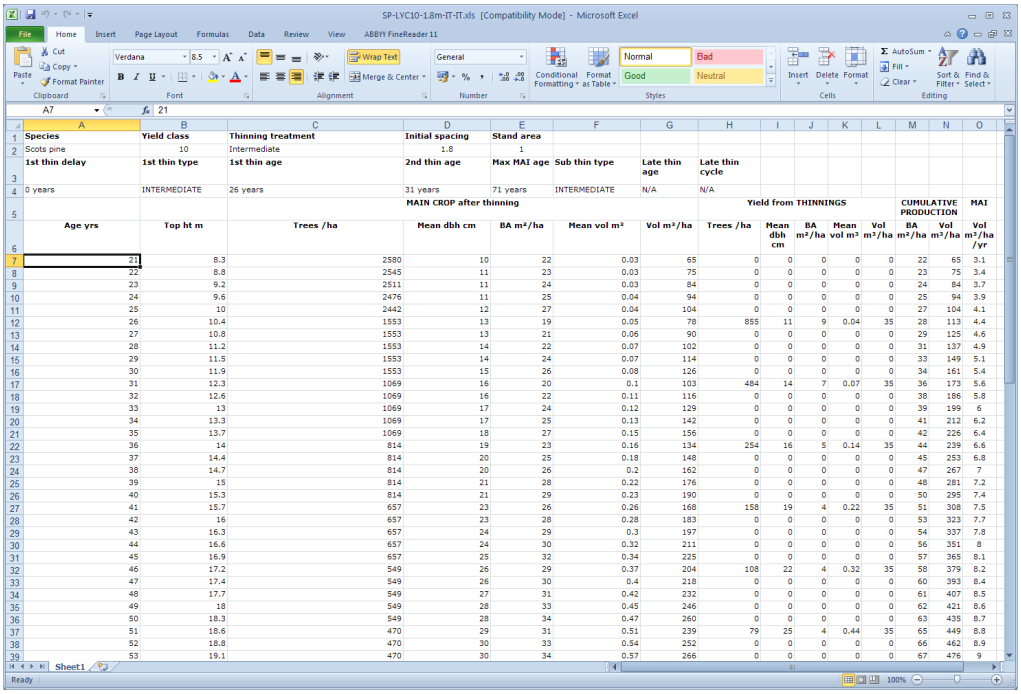


Species	Yield class	Thinning treatment	Initial spacing	Stand area									
Scots pine	8	Intermediate	1.8	1									
1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle						
0 years	INTERMEDIATE	30 years	35 years	80 years	INTERMEDIATE	N/A	N/A						
			MAIN CROP after thinning					Yield from THINNINGS				CUMULATIVE PRODUCTION	MAI
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha	Vol m³/ha	Vol m³/ha /yr
20	6.4	2710	8	15	0.01	33	0	0	0	0	0	15	33	1.7
21	6.8	2684	9	17	0.01	39	0	0	0	0	0	17	39	1.9
22	7.2	2658	9	18	0.02	46	0	0	0	0	0	18	46	2.1
23	7.6	2633	10	19	0.02	52	0	0	0	0	0	19	52	2.2
24	7.9	2607	10	20	0.02	58	0	0	0	0	0	20	58	2.4
25	8.3	2582	10	21	0.02	64	0	0	0	0	0	21	64	2.5
26	8.7	2543	11	22	0.03	72	0	0	0	0	0	22	72	2.8
27	9	2504	11	23	0.03	80	0	0	0	0	0	23	80	3
28	9.4	2465	11	25	0.04	89	0	0	0	0	0	25	89	3.2
29	9.7	2427	12	26	0.04	97	0	0	0	0	0	26	97	3.3
30	10.1	1693	12	20	0.05	77	696	11	7	0.04	28	27	105	3.5
31	10.4	1693	13	21	0.05	87	0	0	0	0	0	28	115	3.7
32	10.8	1693	13	23	0.06	97	0	0	0	0	0	30	125	3.9
33	11.1	1693	13	24	0.06	107	0	0	0	0	0	31	135	4.1
34	11.4	1693	14	25	0.07	117	0	0	0	0	0	32	145	4.3
35	11.8	1219	15	21	0.08	99	474	13	6	0.06	28	34	155	4.4
36	12.1	1219	15	22	0.09	110	0	0	0	0	0	35	166	4.6
37	12.4	1219	16	23	0.1	121	0	0	0	0	0	37	177	4.8
38	12.7	1219	16	25	0.11	132	0	0	0	0	0	38	188	5
39	13	1219	17	26	0.12	143	0	0	0	0	0	39	199	5.1
40	13.3	953	18	23	0.13	126	266	15	5	0.11	28	41	210	5.3
41	13.6	953	18	24	0.14	138	0	0	0	0	0	42	222	5.4
42	13.9	953	18	26	0.16	149	0	0	0	0	0	43	233	5.6
43	14.2	953	19	27	0.17	161	0	0	0	0	0	45	245	5.7
44	14.5	953	19	28	0.18	172	0	0	0	0	0	46	256	5.8
45	14.7	782	20	25	0.2	156	172	17	4	0.16	28	47	268	5.9
46	15	782	21	27	0.21	167	0	0	0	0	0	49	279	6.1
47	15.3	782	21	28	0.23	179	0	0	0	0	0	50	291	6.2
48	15.5	782	22	29	0.24	190	0	0	0	0	0	51	302	6.3
49	15.8	782	22	30	0.26	202	0	0	0	0	0	52	314	6.4
50	16.1	661	23	28	0.28	186	121	20	4	0.23	28	53	326	6.5
51	16.3	661	24	29	0.3	197	0	0	0	0	0	54	337	6.6
52	16.5	661	24	30	0.32	208	0	0	0	0	0	56	348	6.7

[3]Although only the requisite top heights are required in practice, copying the ages as well should allow any inconsistencies to be spotted when pasting these values into the yield table for the Local Yield Class; particularly where the first age of this table is lower than the first age in the yield table for the General Yield Class.

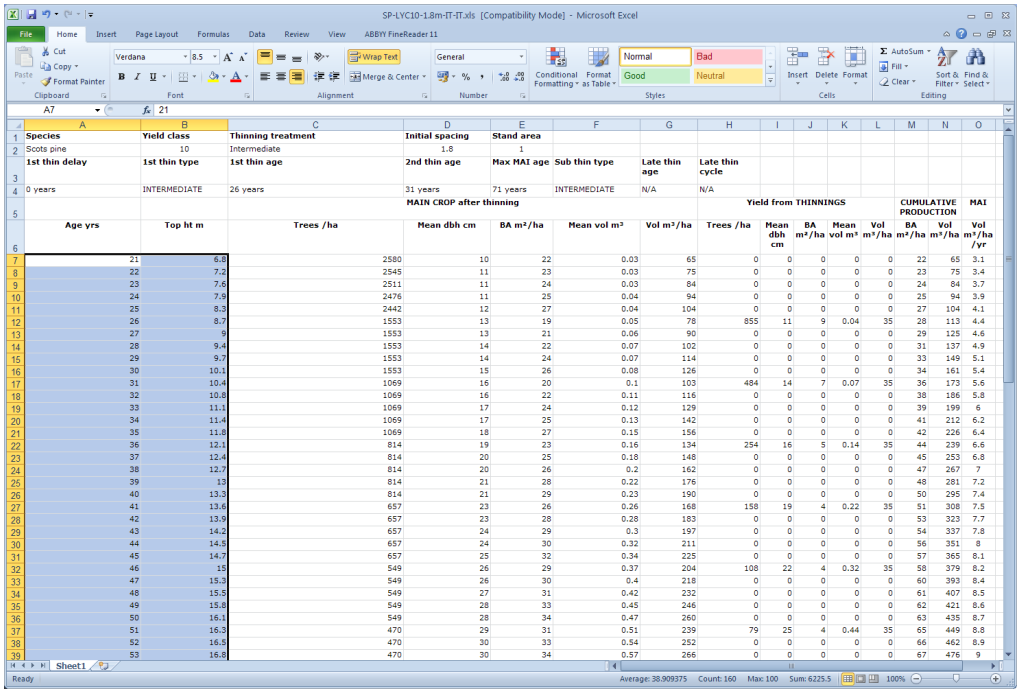
8. Starting at the correct age, paste the ages and top heights copied in the step above into the spreadsheet of the yield table generated using the indicated Local Yield Class of the stand (saved in Step 3, Figures 28 and 29).

Figure 28 The unmodified yield table relating to the observed Local Yield Class of the stand. Note that the cell selected in the above illustration reflects the first age selected and copied in Step 7.



Species	Yield class	Thinning treatment	Initial spacing	Stand area												
Scots pine	10	Intermediate	1.8	1												
1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle									
0 years	INTERMEDIATE	26 years	31 years	71 years	INTERMEDIATE	N/A	N/A									
			MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI	
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m²/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m²/ha		BA m²/ha	Vol m³/ha	Vol m³/ha /yr	
21	8.3	2580	10	22	0.03	65	0	0	0	0	0		22	65	3.1	
22	8.8	2545	11	23	0.03	75	0	0	0	0	0		23	75	3.4	
23	9.2	2511	11	24	0.03	84	0	0	0	0	0		24	84	3.7	
24	9.6	2476	11	25	0.04	94	0	0	0	0	0		25	94	3.9	
25	10	2442	12	27	0.04	104	0	0	0	0	0		27	104	4.1	
26	10.4	1553	13	19	0.05	78	855	11	9	0.04	35		28	113	4.4	
27	10.8	1553	13	21	0.06	90	0	0	0	0	0		29	125	4.6	
28	11.2	1553	14	22	0.07	102	0	0	0	0	0		31	137	4.9	
29	11.5	1553	14	24	0.07	114	0	0	0	0	0		33	149	5.1	
30	11.9	1553	15	26	0.08	126	0	0	0	0	0		34	161	5.4	
31	12.3	1069	16	20	0.1	103	484	14	7	0.07	35		36	173	5.6	
32	12.6	1069	16	22	0.11	116	0	0	0	0	0		38	186	5.8	
33	13	1069	17	24	0.12	129	0	0	0	0	0		39	199	6	
34	13.3	1069	17	25	0.13	142	0	0	0	0	0		41	212	6.2	
35	13.7	1069	18	27	0.15	156	0	0	0	0	0		42	226	6.4	
36	14	814	19	23	0.16	134	254	16	5	0.14	35		44	239	6.6	
37	14.4	814	20	25	0.18	148	0	0	0	0	0		45	253	6.8	
38	14.7	814	20	26	0.2	162	0	0	0	0	0		47	267	7	
39	15	814	21	28	0.22	176	0	0	0	0	0		48	281	7.2	
40	15.3	814	21	29	0.23	190	0	0	0	0	0		50	295	7.4	
41	15.7	657	23	26	0.26	168	158	19	4	0.22	35		51	308	7.5	
42	16	657	23	28	0.28	183	0	0	0	0	0		53	323	7.7	
43	16.3	657	24	29	0.3	197	0	0	0	0	0		54	337	7.8	
44	16.6	657	24	30	0.32	211	0	0	0	0	0		56	351	8	
45	16.9	657	25	32	0.34	225	0	0	0	0	0		57	365	8.1	
46	17.2	549	26	29	0.37	204	108	22	4	0.32	35		58	379	8.2	
47	17.4	549	26	30	0.4	218	0	0	0	0	0		60	393	8.4	
48	17.7	549	27	31	0.42	232	0	0	0	0	0		61	407	8.5	
49	18	549	28	33	0.45	246	0	0	0	0	0		62	421	8.6	
50	18.3	549	28	34	0.47	260	0	0	0	0	0		63	435	8.7	
51	18.6	470	29	31	0.51	239	79	25	4	0.44	35		65	449	8.8	
52	18.8	470	30	33	0.54	252	0	0	0	0	0		66	462	8.9	
53	19.1	470	30	34	0.57	266	0	0	0	0	0		67	476	9	

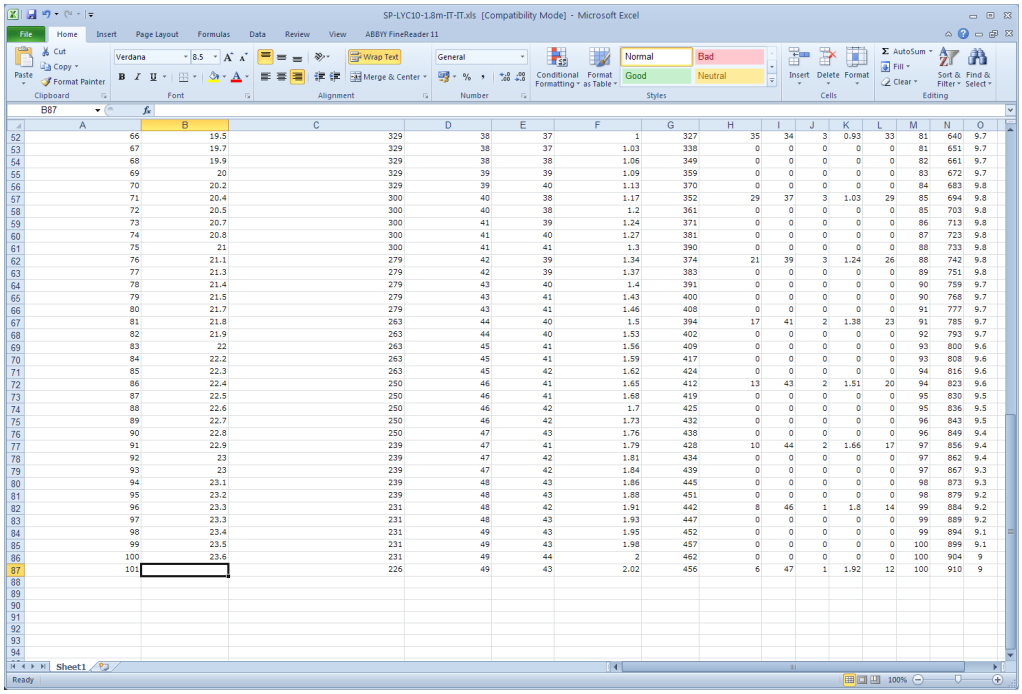
Figure 29 The yield table for the Local Yield Class with the General Yield Class ages and top heights pasted in over the Local Yield Class figures.



Species	Yield class	Thinning treatment	Initial spacing	Stand area												
Scots pine	10	Intermediate	1.8	1												
1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle									
0 years	INTERMEDIATE	26 years	31 years	71 years	INTERMEDIATE	N/A	N/A									
			MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI	
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m²/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m²/ha		BA m²/ha	Vol m³/ha	Vol m³/ha /yr	
21	6.8	2580	10	22	0.03	65	0	0	0	0	0		22	65	3.1	
22	7.2	2545	11	23	0.03	75	0	0	0	0	0		23	75	3.4	
23	7.6	2511	11	24	0.03	84	0	0	0	0	0		24	84	3.7	
24	7.9	2476	11	25	0.04	94	0	0	0	0	0		25	94	3.9	
25	8.3	2442	12	27	0.04	104	0	0	0	0	0		27	104	4.1	
26	8.7	1553	13	19	0.05	78	855	11	9	0.04	35		28	113	4.4	
27	9	1553	13	21	0.06	90	0	0	0	0	0		29	125	4.6	
28	9.4	1553	14	22	0.07	102	0	0	0	0	0		31	137	4.9	
29	9.7	1553	14	24	0.07	114	0	0	0	0	0		33	149	5.1	
30	10.1	1553	15	26	0.08	126	0	0	0	0	0		34	161	5.4	
31	10.4	1069	16	20	0.1	103	484	14	7	0.07	35		36	173	5.6	
32	10.8	1069	16	22	0.11	116	0	0	0	0	0		38	186	5.8	
33	11.1	1069	17	24	0.12	129	0	0	0	0	0		39	199	6	
34	11.4	1069	17	25	0.13	142	0	0	0	0	0		41	212	6.2	
35	11.8	1069	18	27	0.15	156	0	0	0	0	0		42	226	6.4	
36	12.1	814	19	23	0.16	134	254	16	5	0.14	35		44	239	6.6	
37	12.4	814	20	25	0.18	148	0	0	0	0	0		45	253	6.8	
38	12.7	814	20	26	0.2	162	0	0	0	0	0		47	267	7	
39	13	814	21	28	0.22	176	0	0	0	0	0		48	281	7.2	
40	13.3	814	21	29	0.23	190	0	0	0	0	0		50	295	7.4	
41	13.6	657	23	26	0.26	168	158	19	4	0.22	35		51	308	7.5	
42	13.9	657	23	28	0.28	183	0	0	0	0	0		53	323	7.7	
43	14.2	657	24	29	0.3	197	0	0	0	0	0		54	337	7.8	
44	14.5	657	24	30	0.32	211	0	0	0	0	0		56	351	8	
45	14.7	657	25	32	0.34	225	0	0	0	0	0		57	365	8.1	
46	15	549	26	29	0.37	204	108	22	4	0.32	35		58	379	8.2	
47	15.3	549	26	30	0.4	218	0	0	0	0	0		60	393	8.4	
48	15.5	549	27	31	0.42	232	0	0	0	0	0		61	407	8.5	
49	15.8	549	28	33	0.45	246	0	0	0	0	0		62	421	8.6	
50	16.1	549	28	34	0.47	260	0	0	0	0	0		63	435	8.7	
51	16.3	470	29	31	0.51	239	79	25	4	0.44	35		65	449	8.8	
52	16.5	470	30	33	0.54	252	0	0	0	0	0		66	462	8.9	
53	16.8	470	30	34	0.57	266	0	0	0	0	0		67	476	9	

9. Delete any top heights that were not replaced in step 8 (26.3 m at age 101 years in this example, Figure 30). The rest of the figures on those rows of the spreadsheet will correctly reflect the stand parameters at those ages, even though top height is no longer shown.

Figure 30 Delete any top height values that were not replaced by the newly pasted figures.



10. Save the spreadsheet with an appropriate name. This is now a suitable local yield table for the stand where cumulative volume and related stand attributes should be representative for any assessed top height and age.

Examples 3 and 4 – Modelling the effect of variations in growth rate

As yield classes are used for production forecasting, it is extremely important that the recorded yield class allows the most accurate possible estimate of future growth. Yield classes are not intended as a method for describing the past development of a stand, the rate of growth of which may have been affected by a number of factors with the result that an individual stand will not always follow the growth rate predicted by a particular yield class.

For part of its life, a stand may grow faster than its yield class predicts, and at other times it may grow slower. For example, a particular stand may suffer from growth check for a number of years after planting, during which period it may grow very slowly. However, once the stand has grown out of the check phase, its growth rate, and hence yield class, will increase. Another situation that can cause a variation in growth rate is fertiliser application, which will usually cause the rate of growth of a stand to increase for a limited number of years if the treatment is not repeated.

In both these situations, the use of current top height and stand age for assessing yield class may not be very helpful as these reflect the average height growth to date, which is unlikely to be a good predictor of future growth. In a stand which has recovered from an initial period of check, the predicted growth rate based on the average growth rate to date will usually be less than the actual future growth rate. Conversely, once the stand has grown out of the check phase, its current growth rate combined with its true age will tend to lead to an overestimate of future growth.

Changes in growth rate can be allowed for by combining the current growth rate with an 'adjusted age'. The current growth rate and the measured top height are used to derive the yield class using top height increment tables (Appendix 1, Tables A1.1 to A1.7 of the Forest Yield handbook). The 'adjusted age' is then derived from the top height/age curves, using this yield class and the measured top height. A description of the use of top height increment tables is outlined in Examples 3 and 4 of this user manual, and is explained in more detail in 'Allowing for changes in growth rate' in the Forest Yield handbook.

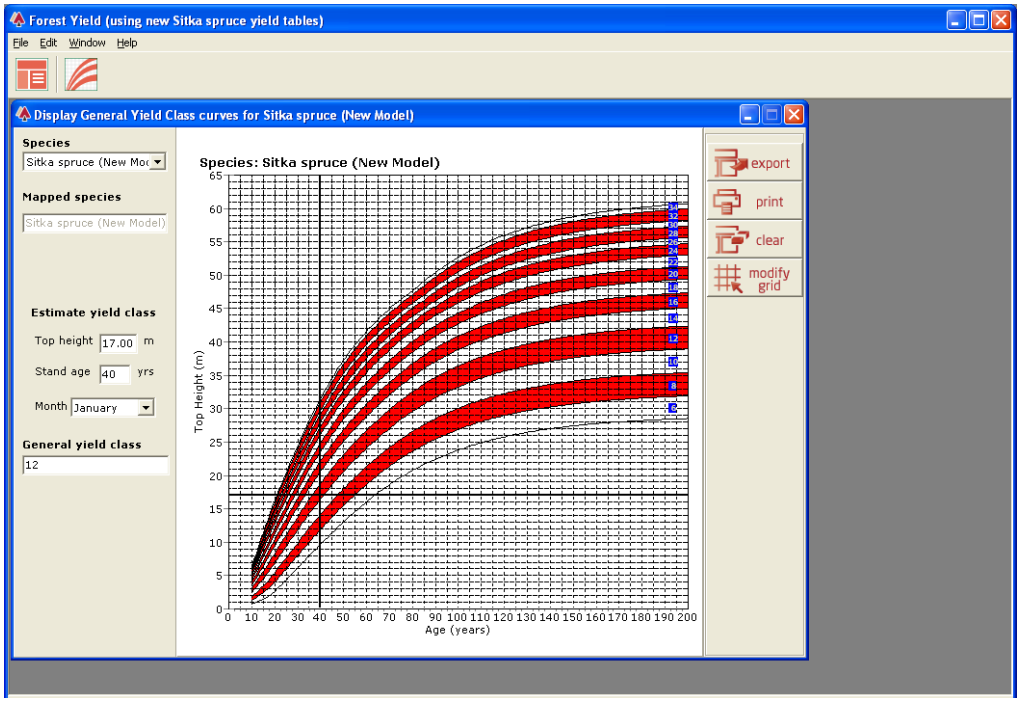
In situations, such as those described above, where growth rate has varied in the past and will affect the estimation of correct yield class, the 'adjusted age'[4] can be used in order to produce a bespoke yield table.

[4] Note: Where growth rate has slowed for a number of years, the 'adjusted age' will tend to be lower than the true age of the stand. On the other hand, where there has been a temporary growth spurt, 'adjusted age' will tend to be greater than the true age of the stand.

Example 3 – Allowing for growth check

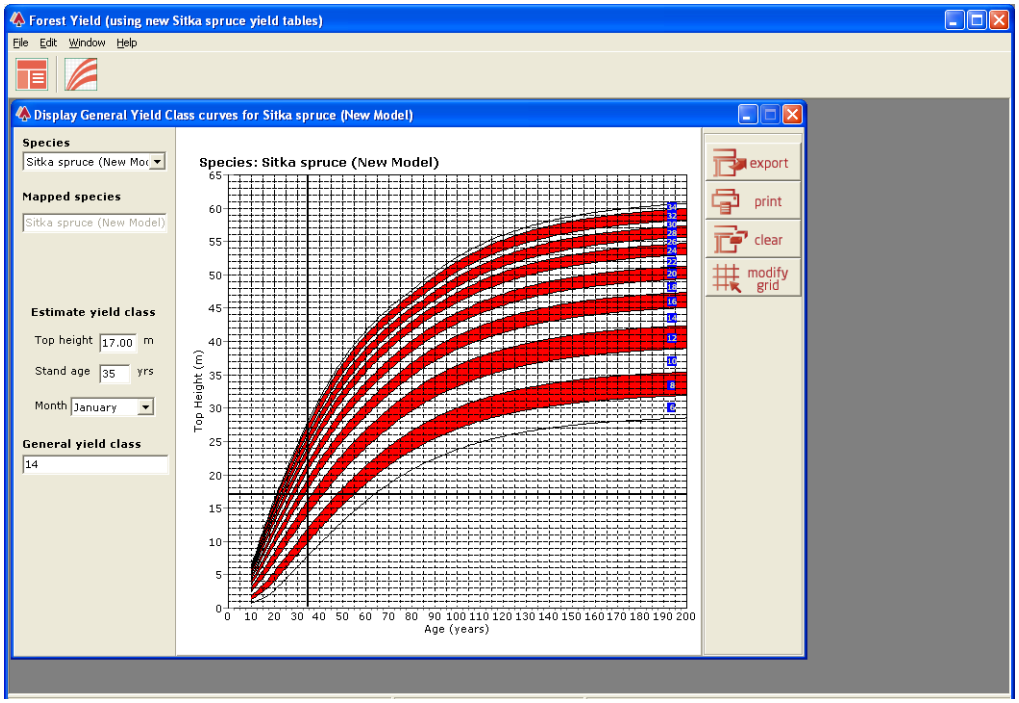
A 40-year-old Sitka spruce stand, which had previously experienced heather check, now has a top height of 17 m. This suggests a yield class of 12 (Figure 31).

Figure 31 A stand top height of 17 m at age 40 years in Sitka spruce indicates a yield class of 12 m^3 ha^{-1} yr^{-1}.



However, the average height growth of top height sample trees has been in the region of 2.0 m in the last 4 years (an average of 50 cm yr^{-1}), which suggests that the yield class is now 14 (from Table A1.5 on page 82 of the Forest Yield handbook). The adjusted age of the stand is therefore about 35 years (yield class 14, top height 17 m), as illustrated in Figure 32. It is important to note that this yield class assessment assumes that the stand will continue growing at the current rate, which is quite likely now that the crop has recovered from check.

Figure 32 A top height of 17 m would be achieved by approximately 35 years in yield class 14 Sitka spruce.



In order to construct a bespoke yield table for this stand, the age column will need to be changed by replacing the entry for age 35 (the 'adjusted age' of the stand) with 40 (the actual age of the stand) and incrementing the subsequent ages accordingly.

A suitable local yield table can be constructed by carrying out the following steps:

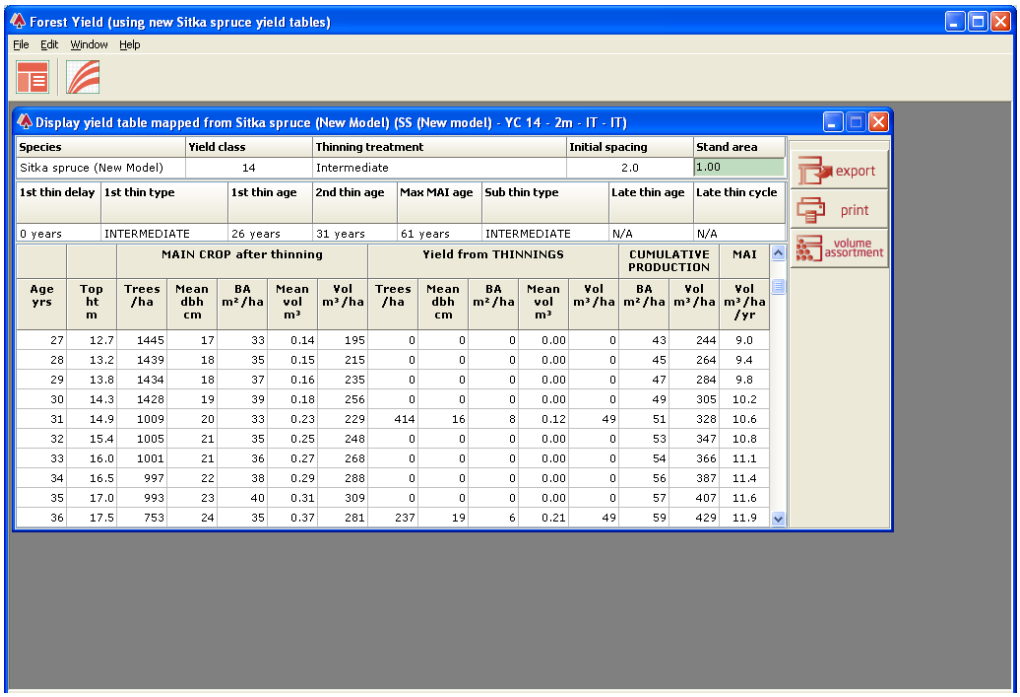
1. Load (Figure 33) and export as a spreadsheet file (Figure 34) the appropriate yield table for the stand.

2. Using a suitable spreadsheet application, open the file saved in the above step (Figure 35).

3. Replace the 'adjusted age' (35 years) with the actual age (40 years) of the stand, and increment successive years accordingly (Figure 36).

4. Delete any rows relating to stand ages earlier than the current true age of the stand (Figure 36) and save the file. This is now a suitable local yield table for the stand where cumulative volume and related stand attributes should be representative for any assessed top height and age.

Figure 33 The yield table for Sitka spruce yield class 14, 2.0 m initial spacing, intermediate thinning regime.



Species	Yield class	Thinning treatment	Initial spacing	Stand area
Sitka spruce (New Model)	14	Intermediate	2.0	1.00

1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle
0 years	INTERMEDIATE	26 years	31 years	61 years	INTERMEDIATE	N/A	N/A

		MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha	Vol m³/ha	Vol m³/ha/yr
27	12.7	1445	17	33	0.14	195	0	0	0	0.00	0	43	244	9.0
28	13.2	1439	18	35	0.15	215	0	0	0	0.00	0	45	264	9.4
29	13.8	1434	18	37	0.16	235	0	0	0	0.00	0	47	284	9.8
30	14.3	1428	19	39	0.18	256	0	0	0	0.00	0	49	305	10.2
31	14.9	1009	20	33	0.23	229	414	16	8	0.12	49	51	328	10.6
32	15.4	1005	21	35	0.25	248	0	0	0	0.00	0	53	347	10.8
33	16.0	1001	21	36	0.27	268	0	0	0	0.00	0	54	366	11.1
34	16.5	997	22	38	0.29	288	0	0	0	0.00	0	56	387	11.4
35	17.0	993	23	40	0.31	309	0	0	0	0.00	0	57	407	11.6
36	17.5	753	24	35	0.37	281	237	19	6	0.21	49	59	429	11.9

Figure 34 Export the yield table as a spreadsheet file, giving it an appropriate name.

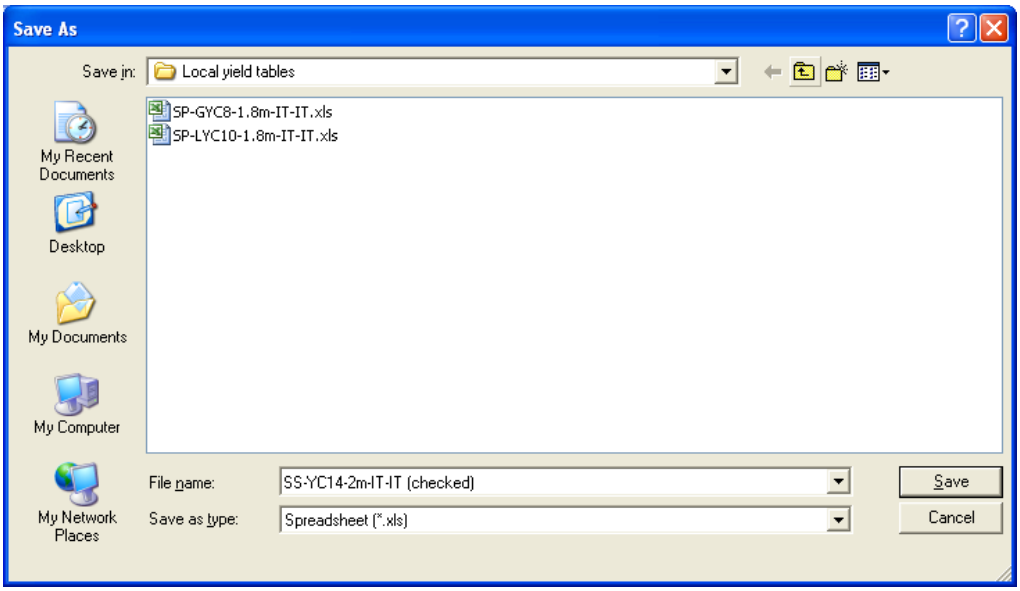
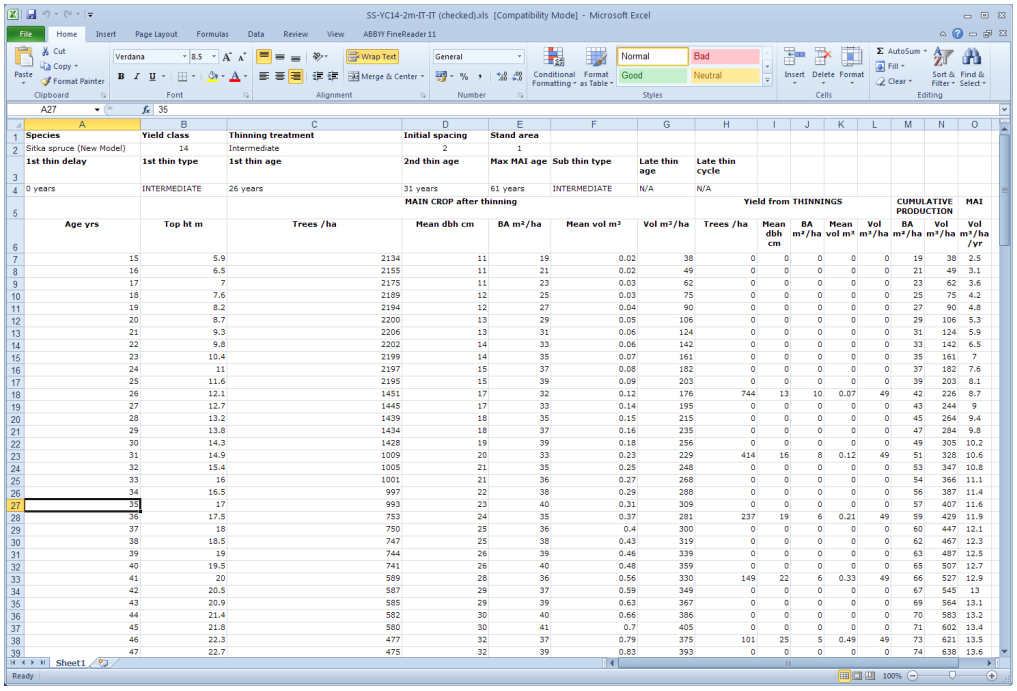
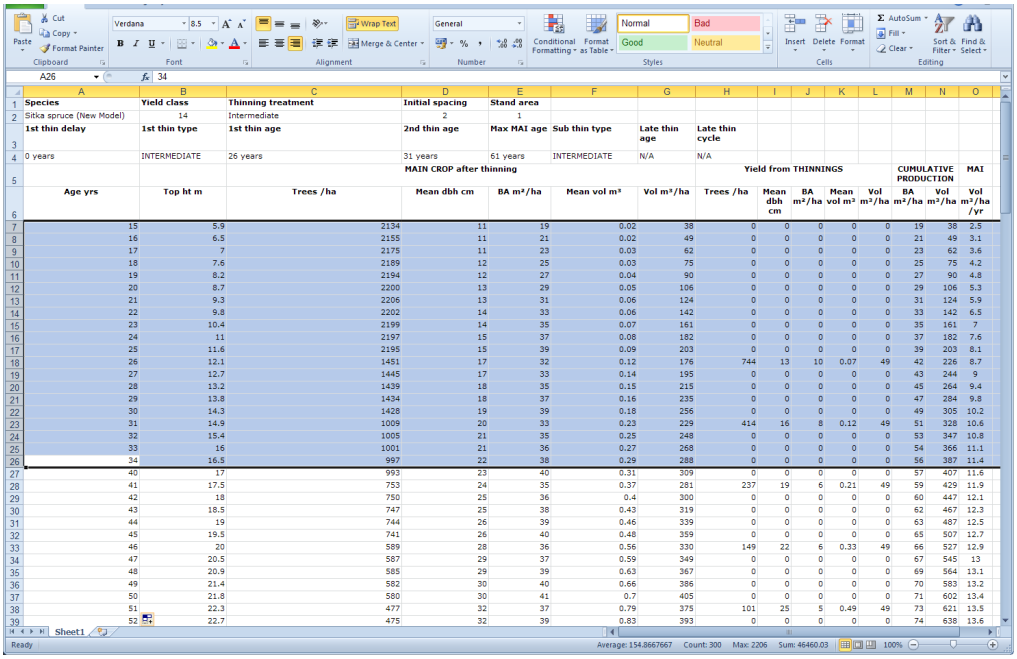


Figure 35 The unadjusted yield table for Sitka spruce, yield class 14. Note that the normal age at which a top height of 17 m would be expected is 35 years (the 'adjusted age' of the stand in the current example).



Species	Yield class	Thinning treatment	Initial spacing	Stand area												
Sitka spruce (New Model)	14	Intermediate	2	1												
1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle									
0 years	INTERMEDIATE	26 years	31 years	61 years	INTERMEDIATE	N/A	N/A									
			MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI	
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha	Vol m³/ha	m³/ha /yr
15	5.9	2134	11	19	0.02	38	0	0	0	0	0	19	38	2.5
16	6.5	2155	11	21	0.02	49	0	0	0	0	0	21	49	3.1
17	7	2175	11	23	0.03	62	0	0	0	0	0	23	62	3.6
18	7.6	2189	12	25	0.03	75	0	0	0	0	0	25	75	4.2
19	8.2	2194	12	27	0.04	90	0	0	0	0	0	27	90	4.8
20	8.7	2200	13	29	0.05	106	0	0	0	0	0	29	106	5.3
21	9.3	2206	13	31	0.06	124	0	0	0	0	0	31	124	5.9
22	9.8	2202	14	33	0.06	142	0	0	0	0	0	33	142	6.5
23	10.4	2199	14	35	0.07	161	0	0	0	0	0	35	161	7
24	11	2197	15	37	0.08	182	0	0	0	0	0	37	182	7.6
25	11.6	2195	15	39	0.09	203	0	0	0	0	0	39	203	8.1
26	12.1	1451	17	32	0.12	176	744	13	10	0.07	49	42	226	8.7
27	12.7	1445	17	33	0.14	195	0	0	0	0	0	43	244	9
28	13.2	1439	18	35	0.15	215	0	0	0	0	0	45	264	9.4
29	13.8	1434	18	37	0.16	235	0	0	0	0	0	47	284	9.8
30	14.3	1428	19	39	0.18	256	0	0	0	0	0	49	305	10.2
31	14.9	1009	20	33	0.23	229	414	16	8	0.12	49	51	328	10.6
32	15.4	1005	21	35	0.25	248	0	0	0	0	0	53	347	10.8
33	16	1001	21	36	0.27	268	0	0	0	0	0	54	366	11.1
34	16.5	997	22	38	0.29	288	0	0	0	0	0	56	387	11.4
35	17	993	23	40	0.31	309	0	0	0	0	0	57	407	11.6
36	17.5	753	24	35	0.37	281	237	19	6	0.21	49	59	429	11.9
37	18	750	25	36	0.4	300	0	0	0	0	0	60	447	12.1
38	18.5	747	25	38	0.43	319	0	0	0	0	0	62	467	12.3
39	19	744	26	39	0.46	339	0	0	0	0	0	63	487	12.5
40	19.5	741	26	40	0.48	359	0	0	0	0	0	65	507	12.7
41	20	589	28	36	0.56	330	149	22	6	0.33	49	66	527	12.9
42	20.5	587	29	37	0.59	349	0	0	0	0	0	67	545	13
43	20.9	585	29	39	0.63	367	0	0	0	0	0	69	564	13.1
44	21.4	582	30	40	0.66	386	0	0	0	0	0	70	583	13.2
45	21.8	580	30	41	0.7	405	0	0	0	0	0	71	602	13.4
46	22.3	477	32	37	0.79	375	101	25	5	0.49	49	73	621	13.5
47	22.7	475	32	39	0.83	393	0	0	0	0	0	74	638	13.6

Figure 36 The modified yield table for Sitka spruce, yield class 14, in which the current stand age (40 years) has been assigned to the currently assessed top height of 17 m. Subsequent ages have been incremented to reflect this change. Note that the rows highlighted above can safely be deleted from the table as the earlier growth of the stand is not being modelled.



Species	Yield class	Thinning treatment	Initial spacing	Stand area												
Sitka spruce (New Model)	14	Intermediate	2	1												
1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle									
0 years	INTERMEDIATE	26 years	31 years	61 years	INTERMEDIATE	N/A	N/A									
			MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI	
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha	Vol m³/ha	m³/ha /yr
15	5.9	2134	11	19	0.02	38	0	0	0	0	0	19	38	2.5
16	6.5	2155	11	21	0.02	49	0	0	0	0	0	21	49	3.1
17	7	2175	11	23	0.03	62	0	0	0	0	0	23	62	3.6
18	7.6	2189	12	25	0.03	75	0	0	0	0	0	25	75	4.2
19	8.2	2194	12	27	0.04	90	0	0	0	0	0	27	90	4.8
20	8.7	2200	13	29	0.05	106	0	0	0	0	0	29	106	5.3
21	9.3	2206	13	31	0.06	124	0	0	0	0	0	31	124	5.9
22	9.8	2202	14	33	0.06	142	0	0	0	0	0	33	142	6.5
23	10.4	2199	14	35	0.07	161	0	0	0	0	0	35	161	7
24	11	2197	15	37	0.08	182	0	0	0	0	0	37	182	7.6
25	11.6	2195	15	39	0.09	203	0	0	0	0	0	39	203	8.1
26	12.1	1451	17	32	0.12	176	744	13	10	0.07	49	42	226	8.7
27	12.7	1445	17	33	0.14	195	0	0	0	0	0	43	244	9
28	13.2	1439	18	35	0.15	215	0	0	0	0	0	45	264	9.4
29	13.8	1434	18	37	0.16	235	0	0	0	0	0	47	284	9.8
30	14.3	1428	19	39	0.18	256	0	0	0	0	0	49	305	10.2
31	14.9	1009	20	33	0.23	229	414	16	8	0.12	49	51	328	10.6
32	15.4	1005	21	35	0.25	248	0	0	0	0	0	53	347	10.8
33	16	1001	21	36	0.27	268	0	0	0	0	0	54	366	11.1
34	16.5	997	22	38	0.29	288	0	0	0	0	0	56	387	11.4
40	17	993	23	40	0.31	309	0	0	0	0	0	57	407	11.6
41	17.5	753	24	35	0.37	281	237	19	6	0.21	49	59	429	11.9
42	18	750	25	36	0.4	300	0	0	0	0	0	60	447	12.1
43	18.5	747	25	38	0.43	319	0	0	0	0	0	62	467	12.3
44	19	744	26	39	0.46	339	0	0	0	0	0	63	487	12.5
45	19.5	741	26	40	0.48	359	0	0	0	0	0	65	507	12.7
46	20	589	28	36	0.56	330	149	22	6	0.33	49	66	527	12.9
47	20.5	587	29	37	0.59	349	0	0	0	0	0	67	545	13
48	20.9	585	29	39	0.63	367	0	0	0	0	0	69	564	13.1
49	21.4	582	30	40	0.66	386	0	0	0	0	0	70	583	13.2
50	21.8	580	30	41	0.7	405	0	0	0	0	0	71	602	13.4
51	22.3	477	32	37	0.79	375	101	25	5	0.49	49	73	621	13.5
52	22.7	475	32	39	0.83	393	0	0	0	0	0	74	638	13.6

Example 4 – Allowing for fertiliser application

A Sitka spruce stand was fertilised 10 years ago at age 20, when its top height was 9 m, indicating yield class 14. Its top height is now 17 m which means that the average height growth over the past 10 years has been 80 cm yr^{-1}; a growth rate equivalent to at least yield class 22 (from Table A1.5 on page 82 of the ForestYield handbook) and meaning that the stand is now assessed at yield class 18 on the basis of top height and age. A yield class 14 stand would have taken 35 years to achieve a top height of 17 m (Figure 32).

If there is no further application of fertiliser, and unless there is evidence to the contrary (i.e. no apparent decline in leader and recent internodal growth), there may be no reason to assume that the stand will continue to grow at the higher rate, and it may be more accurate to assume that it will instead grow at the pre-fertilisation rate of yield class 14.

In this hypothetical example, fertilising the stand at age 20 can be considered to have saved 5 years (35–30) on the planned rotation length, and the stand could be recorded as yield class 14 with an adjusted age of 35 years.

However, as in Example 3, a bespoke yield table will be constructed for this particular stand. The age column will again need to be changed, this time replacing the entry for age 35 (the 'adjusted age' of the stand) with 30 (the actual age of the stand) and incrementing the subsequent ages accordingly.

A suitable local yield table can be constructed by carrying out the following steps:

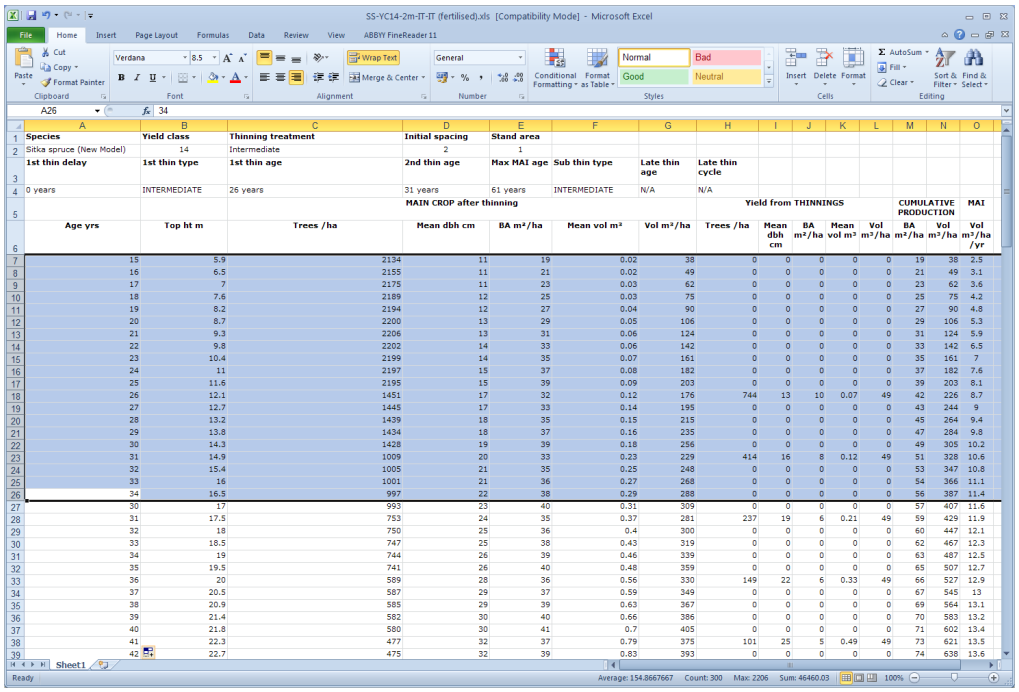
1. Load the appropriate yield table for the stand (as illustrated in Figure 33) and export as a spreadsheet file (as illustrated in Figure 34).

2. Using a suitable spreadsheet application, open the file saved in the above step.

3. Replace the 'adjusted age' (35 years) with the actual age (30 years) of the stand, and increment successive years accordingly (Figure 37).

4. Delete any rows relating to stand ages earlier than the current true age of the stand (Figure 37) and save the file. This is now a suitable local yield table for the stand where cumulative volume and related stand attributes should be representative for any assessed top height and age.

Figure 37 The modified yield table in which the current stand age (30 years) has been assigned to the currently assessed top height of 17 m. Subsequent ages have been incremented to reflect this change. Note that, as in Example 3, the rows highlighted above can safely be deleted from the table.



SS-YC14-2m-IT-IT (fertilised).xls [Compatibility Mode] - Microsoft Excel

Species	Yield class	Thinning treatment	Initial spacing	Stand area											
Sitka spruce (New Model)	14	Intermediate	2	1											
1st thin delay	**1st thin type**	**1st thin age**	**2nd thin age**	**Max MAI age**	**Sub thin type**	**Late thin age**	**Late thin cycle**								
0 years	INTERMEDIATE	26 years	31 years	61 years	INTERMEDIATE	N/A	N/A								
			MAIN CROP after thinning					**Yield from THINNINGS**					**CUMULATIVE PRODUCTION**		**MAI**
Age yrs	**Top ht m**	**Trees /ha**	**Mean dbh cm**	**BA m²/ha**	**Mean vol m³**	**Vol m³/ha**	**Trees /ha**	**Mean dbh cm**	**BA m²/ha**	**Mean vol m³**	**Vol m³/ha**	**BA m²/ha**	**Vol m³/ha**	**Vol m³/ha /yr**
15	5.9	2134	11	19	0.02	38	0	0	0	0	0	19	38	2.5
16	6.5	2155	11	21	0.02	49	0	0	0	0	0	21	49	3.1
17	7	2175	11	23	0.03	62	0	0	0	0	0	23	62	3.6
18	7.6	2189	12	25	0.03	75	0	0	0	0	0	25	75	4.2
19	8.2	2194	12	27	0.04	90	0	0	0	0	0	27	90	4.8
20	8.7	2200	13	29	0.05	106	0	0	0	0	0	29	106	5.3
21	9.3	2206	13	31	0.06	124	0	0	0	0	0	31	124	5.9
22	9.8	2202	14	33	0.06	142	0	0	0	0	0	33	142	6.5
23	10.4	2199	14	35	0.07	161	0	0	0	0	0	35	161	7
24	11	2197	15	37	0.08	182	0	0	0	0	0	37	182	7.6
25	11.6	2195	15	39	0.09	203	0	0	0	0	0	39	203	8.1
26	12.1	1451	17	32	0.12	176	744	13	10	0.07	49	42	226	8.7
27	12.7	1445	17	33	0.14	195	0	0	0	0	0	43	244	9
28	13.2	1439	18	35	0.15	215	0	0	0	0	0	45	264	9.4
29	13.8	1434	18	37	0.16	235	0	0	0	0	0	47	284	9.8
30	14.3	1428	19	39	0.18	256	0	0	0	0	0	49	305	10.2
31	14.9	1009	20	33	0.23	229	414	16	8	0.12	49	51	328	10.6
32	15.4	1005	21	35	0.25	248	0	0	0	0	0	53	347	10.8
33	16	1001	21	36	0.27	268	0	0	0	0	0	54	366	11.1
34	16.5	997	22	38	0.29	288	0	0	0	0	0	56	387	11.4
30	17	993	23	40	0.31	309	0	0	0	0	0	57	407	11.6
31	17.5	753	24	35	0.37	281	237	19	6	0.21	49	59	429	11.9
32	18	750	25	36	0.4	300	0	0	0	0	0	60	447	12.1
33	18.5	747	25	38	0.43	319	0	0	0	0	0	62	467	12.3
34	19	744	26	39	0.46	339	0	0	0	0	0	63	487	12.5
35	19.5	741	26	40	0.48	359	0	0	0	0	0	65	507	12.7
36	20	589	28	36	0.56	330	149	22	6	0.33	49	66	527	12.9
37	20.5	587	29	37	0.59	349	0	0	0	0	0	67	545	13
38	20.9	585	29	39	0.63	367	0	0	0	0	0	69	564	13.1
39	21.4	582	30	40	0.66	386	0	0	0	0	0	70	583	13.2
40	21.8	580	30	41	0.7	405	0	0	0	0	0	71	602	13.4
41	22.3	477	32	37	0.79	375	101	25	5	0.49	49	73	621	13.5
42	22.7	475	32	39	0.83	393	0	0	0	0	0	74	638	13.6

Example 5 – Mixed-species stands

The yield tables in Forest Yield were developed primarily to represent single-species, even-aged stands. There may, however, be occasions when a forest manager wishes to predict the likely growth and yield from a mixed-species stand. There are two forms of mixtures, 'discrete mixtures' and 'intimate mixtures', which are dealt with slightly differently, and an example relating to each mixture type is given below.

Example 5a – Discrete mixtures

A discrete mixture is defined as one where two or more species are established in clearly identifiable single-species blocks. The growth and yield of each species is predicted separately and is bulked-up using the relative planimetric (map) areas of the block(s) of each tree species. For example, a sloping area of land was planted with two species – Douglas fir on the lower, flatter parts (where the soils are deeper, moister and more fertile) and Corsican pine on the upper parts (where the soils are typically less deep and drier). Both species were planted at the same time, 50 years ago, and have been thinned. Planting records suggest that both species were planted at 1.8 m equivalent square spacing. The Douglas fir was last assessed as being yield class 22 and the Corsican pine is recorded as being yield class 16. The total planimetric area occupied by the Douglas fir is 2.6 hectares and the total planimetric area occupied by the Corsican pine is 3.3 hectares.

The proportion of stand area occupied by each species is therefore:

Douglas fir 2.6 ha ÷ (2.6 ha + 3.3 ha) = 2.6 ha ÷ 5.9 ha = 0.44
Corsican pine 3.3 ha ÷ (2.6 ha + 3.3 ha) = 3.3 ha ÷ 5.9 ha = 0.56

The closest yield table in Forest Yield for the Douglas fir component is that for yield class 22, 1.7 m initial spacing, and modelled on the assumption that a crown thinning treatment has been carried out (Figures 38 and 39).

The tabulated volume per hectare of Douglas fir at age 50 years is 566 m^3 ha^{-1} (Figure 39).

The closest yield table in Forest Yield for the Corsican pine component is that for yield class 16, 2.0 m initial spacing, and modelled on the assumption that an intermediate thinning treatment has been carried out (Figures 40 and 41).

The tabulated volume per hectare of Corsican pine at age 50 years is 437 m^3 ha^{-1} (Figure 41).

The total volume of the stand is therefore:

(2.6 ha × 566 m^3 ha^{-1}) + (3.3 ha × 437 m^3 ha^{-1}) = 1471.6 m^3 + 1442.1 m^3 = 2913.7 m^3

or

2913.7 m^3 ÷ 5.9 ha = 493.8 m^3 ha^{-1}.

Figure 38 Selecting the closest appropriate yield table (Douglas fir, yield class 22, 1.7 m initial spacing, crown thinning).

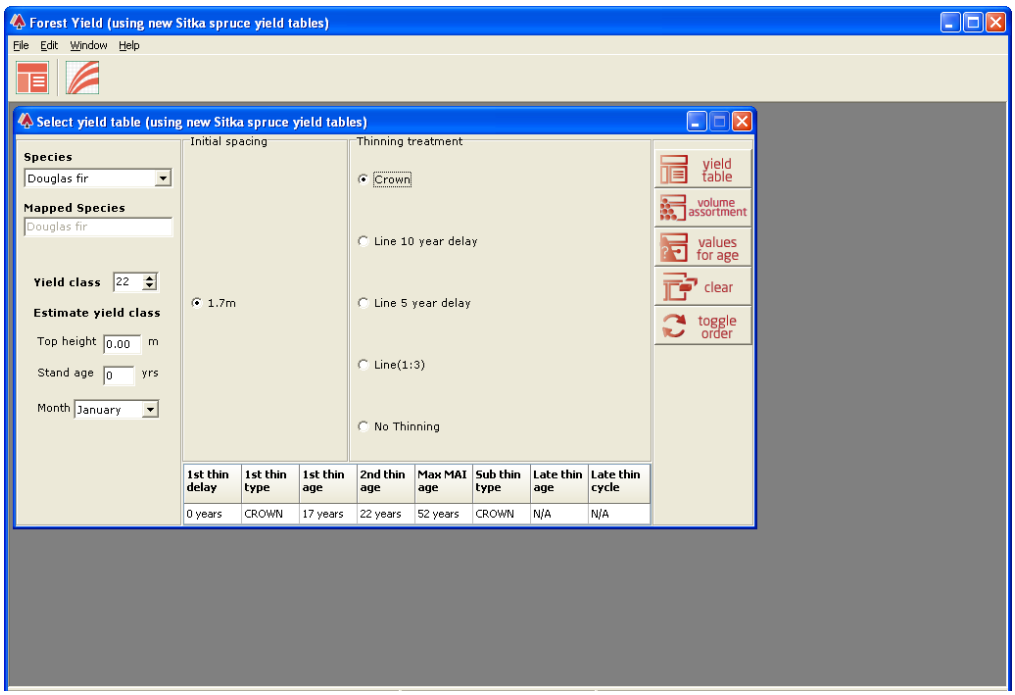
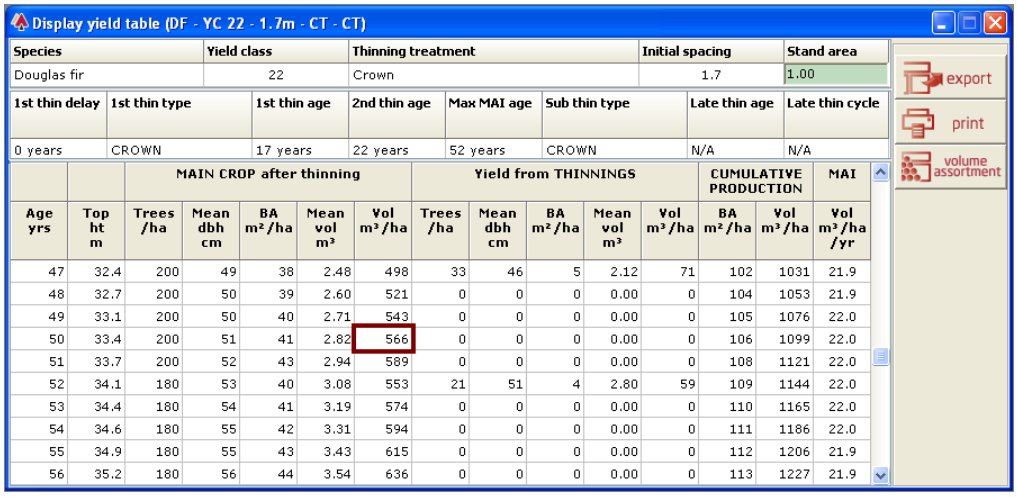


Figure 39 Displaying the yield table for Douglas fir, yield class 22, 1.7 m initial spacing, crown thinning (as selected in Figure 35).



Species	Yield class	Thinning treatment	Initial spacing	Stand area
Douglas fir	22	Crown	1.7	1.00

1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle
0 years	CROWN	17 years	22 years	52 years	CROWN	N/A	N/A

		MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha	Vol m³/ha	Vol m³/ha/yr
47	32.4	200	49	38	2.48	498	33	46	5	2.12	71	102	1031	21.9
48	32.7	200	50	39	2.60	521	0	0	0	0.00	0	104	1053	21.9
49	33.1	200	50	40	2.71	543	0	0	0	0.00	0	105	1076	22.0
50	33.4	200	51	41	2.82	566	0	0	0	0.00	0	106	1099	22.0
51	33.7	200	52	43	2.94	589	0	0	0	0.00	0	108	1121	22.0
52	34.1	180	53	40	3.08	553	21	51	4	2.80	59	109	1144	22.0
53	34.4	180	54	41	3.19	574	0	0	0	0.00	0	110	1165	22.0
54	34.6	180	55	42	3.31	594	0	0	0	0.00	0	111	1186	22.0
55	34.9	180	55	43	3.43	615	0	0	0	0.00	0	112	1206	21.9
56	35.2	180	56	44	3.54	636	0	0	0	0.00	0	113	1227	21.9

Figure 40 Selecting the closest appropriate yield table for the second mixture component (Corsican pine, yield class 16, 2.0 m initial spacing, intermediate thinning).

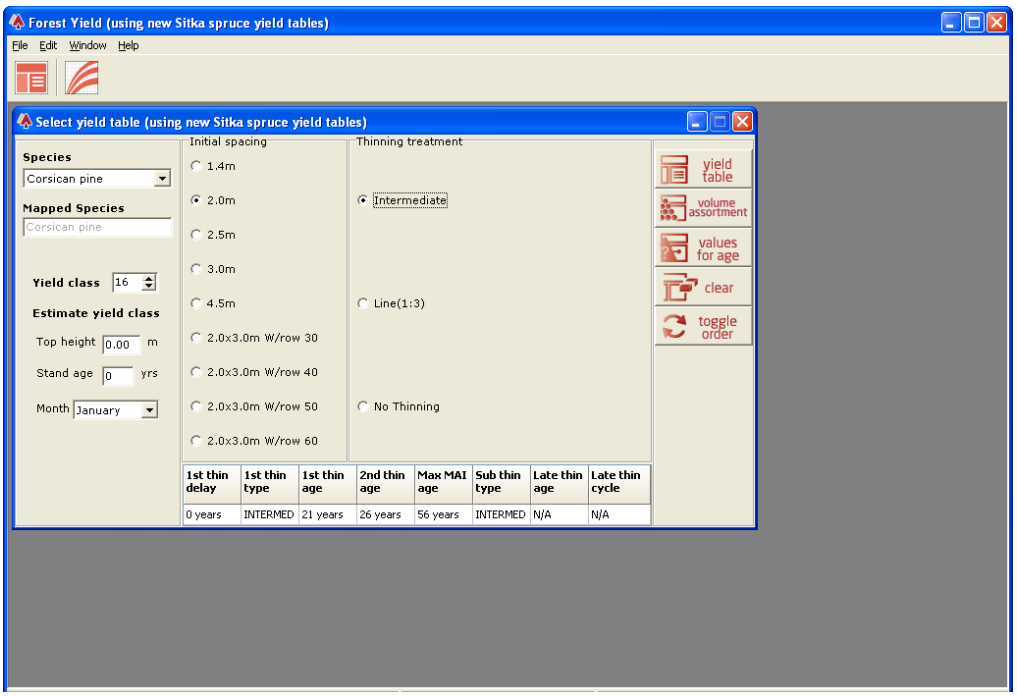
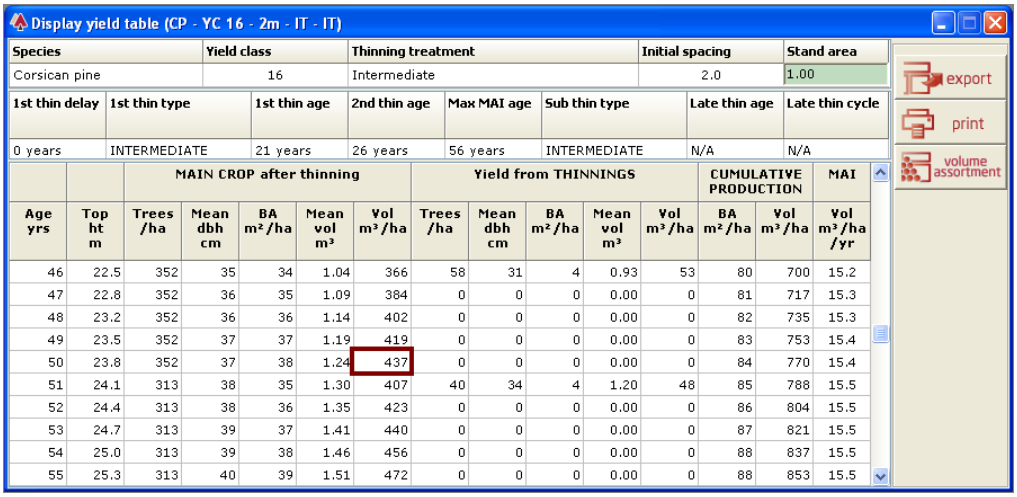


Figure 41 Displaying the yield table for Corsican pine, yield class 16, 2.0 m initial spacing, intermediate thinning (as selected in Figure 37).



Species	Yield class	Thinning treatment	Initial spacing	Stand area
Corsican pine	16	Intermediate	2.0	1.00

1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle
0 years	INTERMEDIATE	21 years	26 years	56 years	INTERMEDIATE	N/A	N/A

		MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha	Vol m³/ha	Vol m³/ha/yr
46	22.5	352	35	34	1.04	366	58	31	4	0.93	53	80	700	15.2
47	22.8	352	36	35	1.09	384	0	0	0	0.00	0	81	717	15.3
48	23.2	352	36	36	1.14	402	0	0	0	0.00	0	82	735	15.3
49	23.5	352	37	37	1.19	419	0	0	0	0.00	0	83	753	15.4
50	23.8	352	37	38	1.24	437	0	0	0	0.00	0	84	770	15.4
51	24.1	313	38	35	1.30	407	40	34	4	1.20	48	85	788	15.5
52	24.4	313	38	36	1.35	423	0	0	0	0.00	0	86	804	15.5
53	24.7	313	39	37	1.41	440	0	0	0	0.00	0	87	821	15.5
54	25.0	313	39	38	1.46	456	0	0	0	0.00	0	88	837	15.5
55	25.3	313	40	39	1.51	472	0	0	0	0.00	0	88	853	15.5

Example 5b – Intimate mixtures

An intimate mixture is defined as one where two or more species are intermingled on an area of land such that it is impossible to identify discrete areas occupied by a single species. Nevertheless, as for discrete mixtures (see Example 5a, above) the growth and yield of each species is predicted separately and is bulked-up according to an estimate of the relative proportions of stand occupancy by each species. The proportions of stand occupancy are usually estimated using either the proportion of crown occupancy or proportion of total basal area of each species. It is important to note that this approach will not allow for potential interactions between different tree species growing in intimate mixtures.

The following example considers an area of land planted 35 years ago at 2.0 m equivalent square spacing with an intimate mixture of two species – Sitka spruce and lodgepole pine. Immediately following planting, a significant quantity of birch regeneration naturally appeared

across the whole stand and has also now established. The stand has subsequently been managed to maintain the tree-species mixture and has been subjected to an intermediate thinning regime. Because the birch regenerated so close to the date of planting of the conifers, all trees in the stand are taken to be the same age.

A recent stand assessment gave the information in Table 1.

Table 1 Results of an assessment in a mixed stand.

Species	Top height (m)	Basal area (m^2 ha^{-1})
Sitka spruce	18.5	16.4
Lodgepole pine	16.4	13.7
Birch	17.1	9.0
	Total basal area of stand	**39.1**

There is no information on crown occupancy. Therefore, on the basis of basal area, the proportion of stand area occupied by each species is estimated as:

Sitka spruce 16.4 m^2 ha^{-1} ÷ 39.1 m^2 ha^{-1} = 0.42
Lodgepole pine 13.7 m^2 ha^{-1} ÷ 39.1 m^2 ha^{-1} = 0.35
Birch 9.0 m^2 ha^{-1} ÷ 39.1 m^2 ha^{-1} = 0.23

Using the top height data, and assuming a stand age of 35 years, the Sitka spruce is yield class 16, the lodgepole pine is yield class 10 and the birch is yield class 8.

The closest yield table in ForestYield for the Sitka spruce component is that for yield class 16, 2.0 m initial spacing, and modelled on the assumption that an intermediate thinning treatment has been carried out (Figures 42 and 43).

The tabulated volume per hectare of Sitka spruce at age 35 years is 287 m^3 ha^{-1} (Figure 43).

The closest yield table in ForestYield for the lodgepole pine component is that for yield class 10, 2.0 m initial spacing, and modelled on the assumption that an intermediate thinning treatment has been carried out (Figures 44 and 45).

The tabulated volume per hectare of lodgepole pine at age 35 years is 189 m^3 ha^{-1} (Figure 45).

The closest yield table in ForestYield for the intruded birch component is that for yield class 8, 1.5 m initial spacing, and modelled on the assumption that an intermediate thinning treatment has been carried out (Figures 46 and 47).

The tabulated volume per hectare of birch at age 35 years is 144 m^3 ha^{-1} (Figure 47).

Figure 42 Selecting the closest appropriate yield table for the first component (Sitka spruce, yield class 16, 2.0 m initial spacing, intermediate thinning).

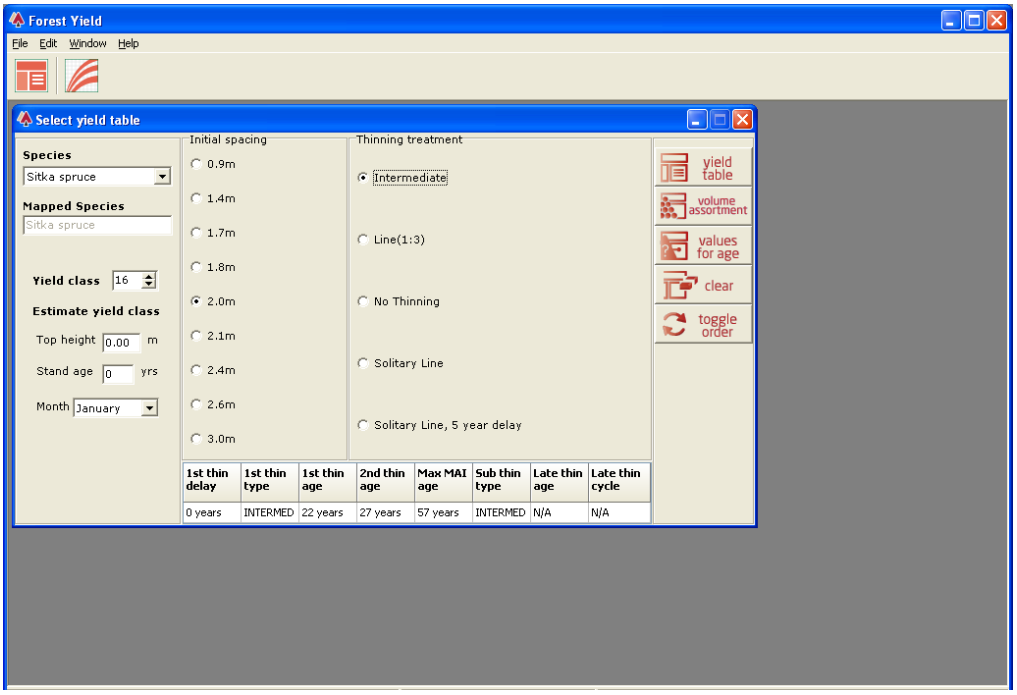
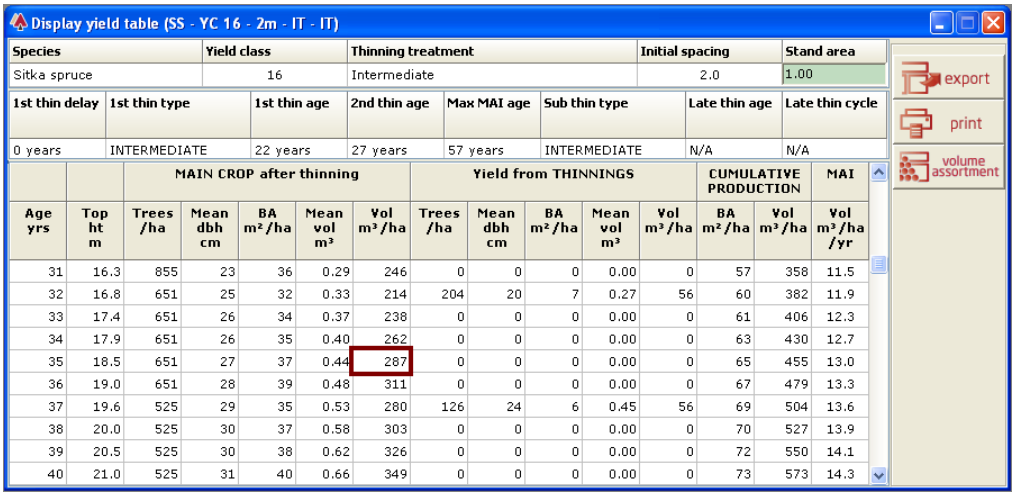


Figure 43 Displaying the yield table for Sitka spruce, yield class 16, 2.0 m initial spacing, intermediate thinning (as selected in Figure 42).



Species	Yield class	Thinning treatment	Initial spacing	Stand area
Sitka spruce	16	Intermediate	2.0	1.00

1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle
0 years	INTERMEDIATE	22 years	27 years	57 years	INTERMEDIATE	N/A	N/A

		MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha	Vol m³/ha	Vol m³/ha/yr
31	16.3	855	23	36	0.29	246	0	0	0	0.00	0	57	358	11.5
32	16.8	651	25	32	0.33	214	204	20	7	0.27	56	60	382	11.9
33	17.4	651	26	34	0.37	238	0	0	0	0.00	0	61	406	12.3
34	17.9	651	26	35	0.40	262	0	0	0	0.00	0	63	430	12.7
35	18.5	651	27	37	0.44	287	0	0	0	0.00	0	65	455	13.0
36	19.0	651	28	39	0.48	311	0	0	0	0.00	0	67	479	13.3
37	19.6	525	29	35	0.53	280	126	24	6	0.45	56	69	504	13.6
38	20.0	525	30	37	0.58	303	0	0	0	0.00	0	70	527	13.9
39	20.5	525	30	38	0.62	326	0	0	0	0.00	0	72	550	14.1
40	21.0	525	31	40	0.66	349	0	0	0	0.00	0	73	573	14.3

Figure 44 Selecting the closest appropriate yield table for the second component (lodgepole pine, yield class 10, 2.0 m initial spacing, intermediate thinning).

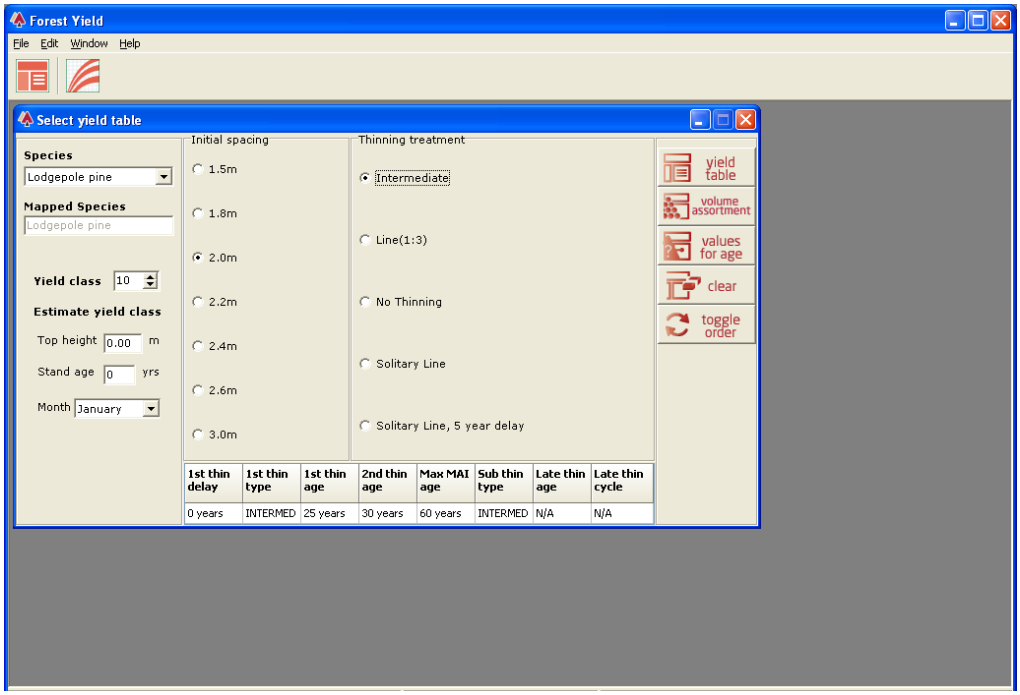
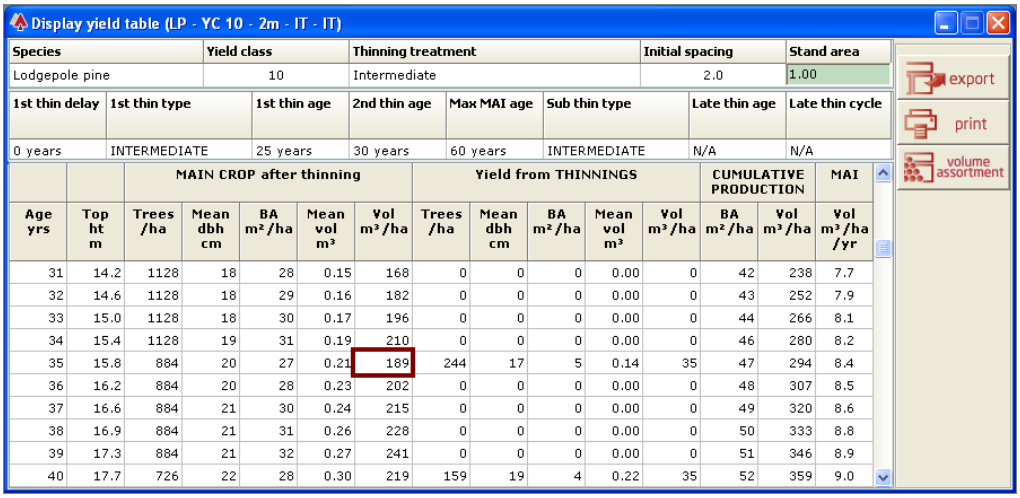


Figure 45 Displaying the yield table for lodgepole pine, yield class 10, 2.0 m initial spacing, intermediate thinning (as selected in Figure 44).



Species	Yield class	Thinning treatment	Initial spacing	Stand area
Lodgepole pine	10	Intermediate	2.0	1.00

1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle
0 years	INTERMEDIATE	25 years	30 years	60 years	INTERMEDIATE	N/A	N/A

		MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha	Vol m³/ha	Vol m³/ha/yr
31	14.2	1128	18	28	0.15	168	0	0	0	0.00	0	42	238	7.7
32	14.6	1128	18	29	0.16	182	0	0	0	0.00	0	43	252	7.9
33	15.0	1128	18	30	0.17	196	0	0	0	0.00	0	44	266	8.1
34	15.4	1128	19	31	0.19	210	0	0	0	0.00	0	46	280	8.2
35	15.8	884	20	27	0.21	189	244	17	5	0.14	35	47	294	8.4
36	16.2	884	20	28	0.23	202	0	0	0	0.00	0	48	307	8.5
37	16.6	884	21	30	0.24	215	0	0	0	0.00	0	49	320	8.6
38	16.9	884	21	31	0.26	228	0	0	0	0.00	0	50	333	8.8
39	17.3	884	21	32	0.27	241	0	0	0	0.00	0	51	346	8.9
40	17.7	726	22	28	0.30	219	159	19	4	0.22	35	52	359	9.0

Figure 46 Selecting the closest appropriate yield table for the third component (birch, yield class 8, 1.5 m initial spacing, intermediate thinning).

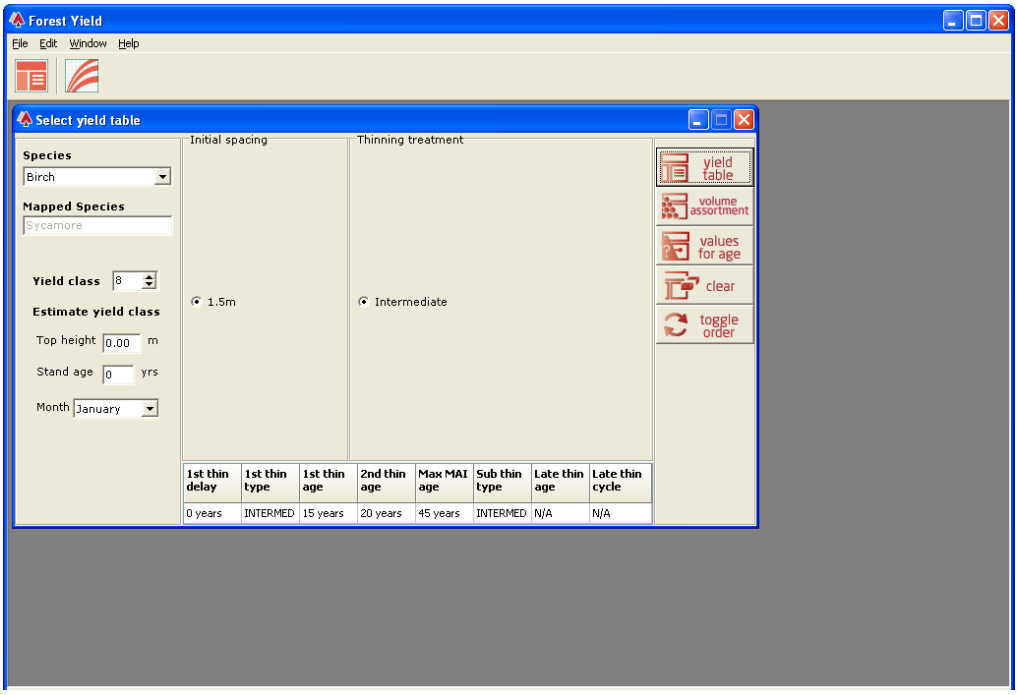
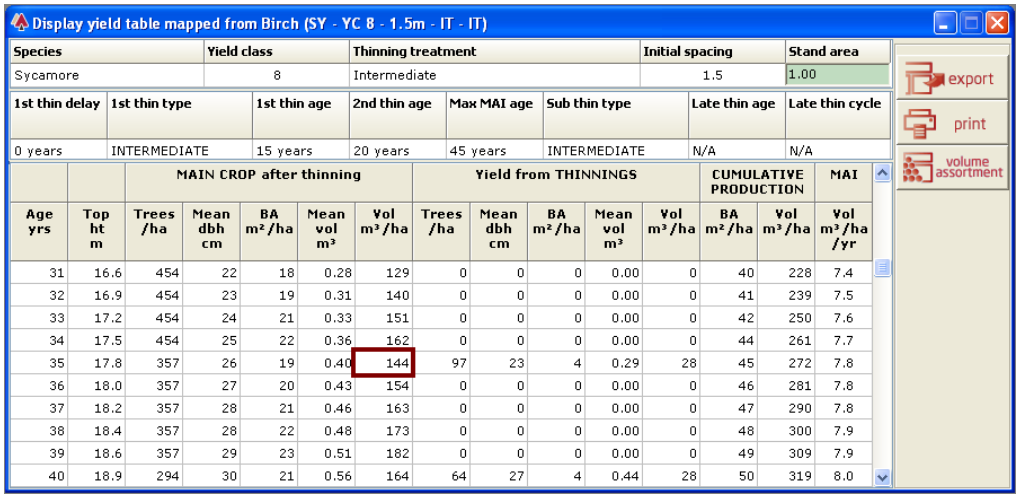


Figure 47 Displaying the yield table for birch, yield class 8, 1.5 m initial spacing, intermediate thinning (as selected in Figure 46).



The estimated total volume per hectare of the stand is therefore made up of:

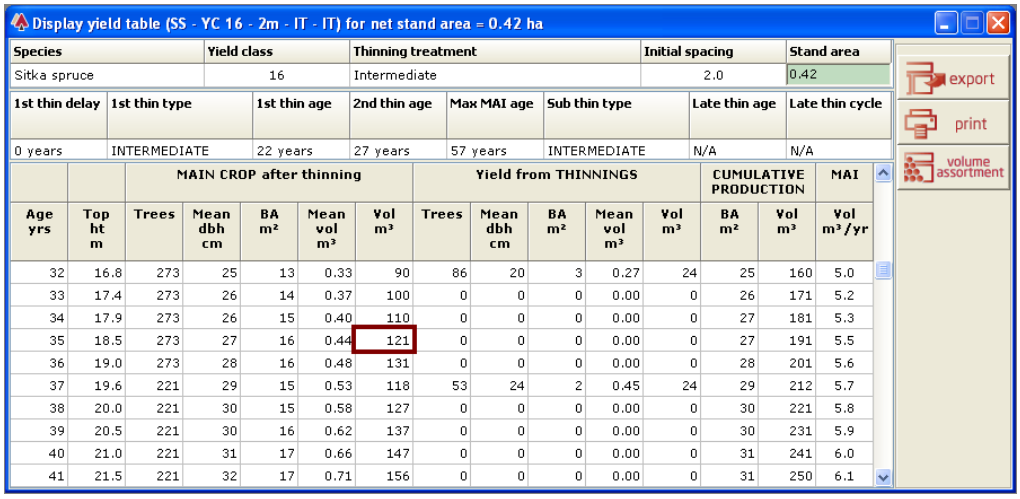
0.42 × 287 m^3 ha^{-1} = 120.54 m^3 ha^{-1} of Sitka spruce (121 m^3 ha^{-1}, rounded);
0.35 × 189 m^3 ha^{-1} = 66.15 m^3 ha^{-1} of lodgepole pine (66 m^3 ha^{-1}, rounded);
0.23 × 144 m^3 ha^{-1} = 33.12 m^3 ha^{-1} of birch (33 m^3 ha^{-1} , rounded).

That is a total of 120.54 + 66.15 + 33.12 = 219.81 m^3 ha^{-1} for the mixture (220 m^3 ha^{-1}, rounded).

ForestYield can be used to estimate species-specific per hectare values by entering the proportion of area occupied in the relevant **Stand area** box (see Figures 48 to 49, below).

It is important to recognise that, over a large area, there will be variations in the total volume and the volumes contributed by the component species, so that the results calculated in this example strictly apply on average over a stand.

Figure 48 Displaying the per hectare values for Sitka spruce (yield class 16, 2.0 m initial spacing, intermediate thinning, as selected in Figure 42) making up a proportion of 0.42 of a mixture.

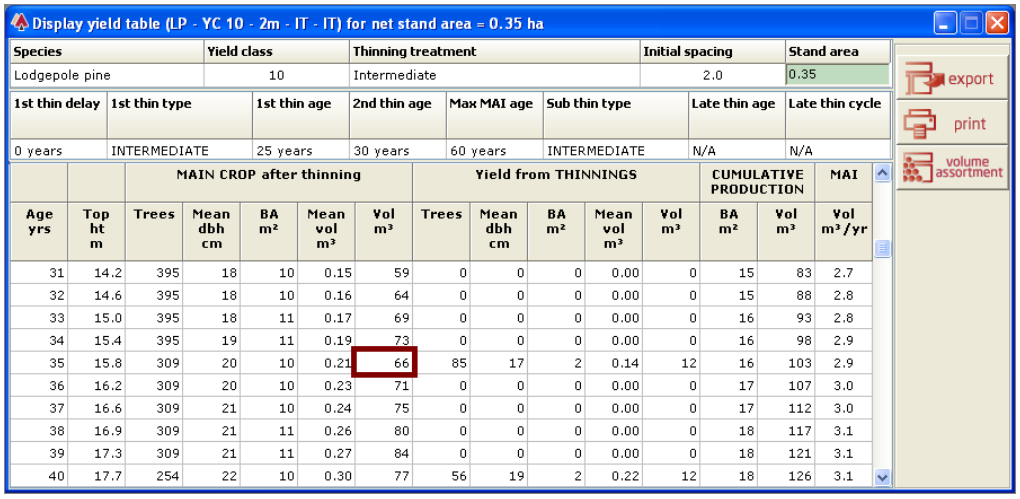


Species	Yield class	Thinning treatment	Initial spacing	Stand area
Sitka spruce	16	Intermediate	2.0	0.42

1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle
0 years	INTERMEDIATE	22 years	27 years	57 years	INTERMEDIATE	N/A	N/A

		MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI
Age yrs	Top ht m	Trees	Mean dbh cm	BA m²	Mean vol m³	Vol m³	Trees	Mean dbh cm	BA m²	Mean vol m³	Vol m³	BA m²	Vol m³	Vol m³/yr
32	16.8	273	25	13	0.33	90	86	20	3	0.27	24	25	160	5.0
33	17.4	273	26	14	0.37	100	0	0	0	0.00	0	26	171	5.2
34	17.9	273	26	15	0.40	110	0	0	0	0.00	0	27	181	5.3
35	18.5	273	27	16	0.44	121	0	0	0	0.00	0	27	191	5.5
36	19.0	273	28	16	0.48	131	0	0	0	0.00	0	28	201	5.6
37	19.6	221	29	15	0.53	118	53	24	2	0.45	24	29	212	5.7
38	20.0	221	30	15	0.58	127	0	0	0	0.00	0	30	221	5.8
39	20.5	221	30	16	0.62	137	0	0	0	0.00	0	30	231	5.9
40	21.0	221	31	17	0.66	147	0	0	0	0.00	0	31	241	6.0
41	21.5	221	32	17	0.71	156	0	0	0	0.00	0	31	250	6.1

Figure 49 Displaying the per hectare values for lodgepole pine (yield class 10, 2.0 m initial spacing, intermediate thinning, as selected in Figure 44) making up a proportion of 0.35 of a mixture.

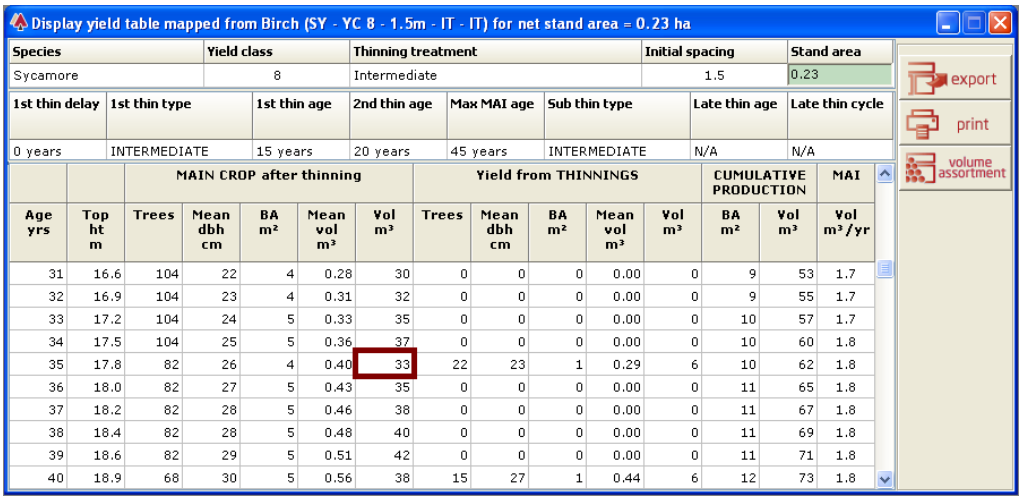


Species	Yield class	Thinning treatment	Initial spacing	Stand area
Lodgepole pine	10	Intermediate	2.0	0.35

1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle
0 years	INTERMEDIATE	25 years	30 years	60 years	INTERMEDIATE	N/A	N/A

		MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI
Age yrs	Top ht m	Trees	Mean dbh cm	BA m²	Mean vol m³	Vol m³	Trees	Mean dbh cm	BA m²	Mean vol m³	Vol m³	BA m²	Vol m³	Vol m³/yr
31	14.2	395	18	10	0.15	59	0	0	0	0.00	0	15	83	2.7
32	14.6	395	18	10	0.16	64	0	0	0	0.00	0	15	88	2.8
33	15.0	395	18	11	0.17	69	0	0	0	0.00	0	16	93	2.8
34	15.4	395	19	11	0.19	73	0	0	0	0.00	0	16	98	2.9
35	15.8	309	20	10	0.21	66	85	17	2	0.14	12	16	103	2.9
36	16.2	309	20	10	0.23	71	0	0	0	0.00	0	17	107	3.0
37	16.6	309	21	10	0.24	75	0	0	0	0.00	0	17	112	3.0
38	16.9	309	21	11	0.26	80	0	0	0	0.00	0	18	117	3.1
39	17.3	309	21	11	0.27	84	0	0	0	0.00	0	18	121	3.1
40	17.7	254	22	10	0.30	77	56	19	2	0.22	12	18	126	3.1

Figure 50 Displaying the per hectare values for birch (yield class 8, 1.5 m initial spacing, intermediate thinning, as selected in Figure 46) making up a proportion of 0.23 of a mixture.



Display yield table mapped from Birch (SY - YC 8 - 1.5m - IT - IT) for net stand area = 0.23 ha

Species	Yield class	Thinning treatment	Initial spacing	Stand area
Sycamore	8	Intermediate	1.5	0.23

1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle
0 years	INTERMEDIATE	15 years	20 years	45 years	INTERMEDIATE	N/A	N/A

export print volume assortment

		MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI
Age yrs	Top ht m	Trees	Mean dbh cm	BA m²	Mean vol m³	Vol m³	Trees	Mean dbh cm	BA m²	Mean vol m³	Vol m³	BA m²	Vol m³	Vol m³/yr
31	16.6	104	22	4	0.28	30	0	0	0	0.00	0	9	53	1.7
32	16.9	104	23	4	0.31	32	0	0	0	0.00	0	9	55	1.7
33	17.2	104	24	5	0.33	35	0	0	0	0.00	0	10	57	1.7
34	17.5	104	25	5	0.36	37	0	0	0	0.00	0	10	60	1.8
35	17.8	82	26	4	0.40	33	22	23	1	0.29	6	10	62	1.8
36	18.0	82	27	5	0.43	35	0	0	0	0.00	0	11	65	1.8
37	18.2	82	28	5	0.46	38	0	0	0	0.00	0	11	67	1.8
38	18.4	82	28	5	0.48	40	0	0	0	0.00	0	11	69	1.8
39	18.6	82	29	5	0.51	42	0	0	0	0.00	0	11	71	1.8
40	18.9	68	30	5	0.56	38	15	27	1	0.44	6	12	73	1.8

Example 6 – Adding increment to an assessment of standing volume

A plot-based assessment of growing stock was undertaken 3 years ago on a stand of yield class 20 Douglas fir, when it was 49 years old. This assessment gave estimates of 253 stems per hectare, 42 m^2 ha^{-1} basal area and 530 m^3 ha^{-1} volume.

The stand is due to be felled this year and, rather than commission another plot-based survey, the forest manager wishes to estimate the current standing volume and basal area from the values obtained 3 years ago.

The easiest mechanism by which this may be achieved is to add the growth increment, modelled in ForestYield, to the estimates obtained 3 years ago from the field survey.

The stand has previously been selectively thinned, although not in the past 3 years, and the initial planting spacing is believed to be 1.8 m.

The closest yield table in ForestYield is for Douglas fir, yield class 20, 1.7 m initial spacing, and modelled on the assumption that a crown thinning treatment has been carried out (Figures 51 and 52).

Figure 51 Selecting the closest appropriate yield table (Douglas fir, yield class 20, 1.7 m initial spacing, crown thinning).

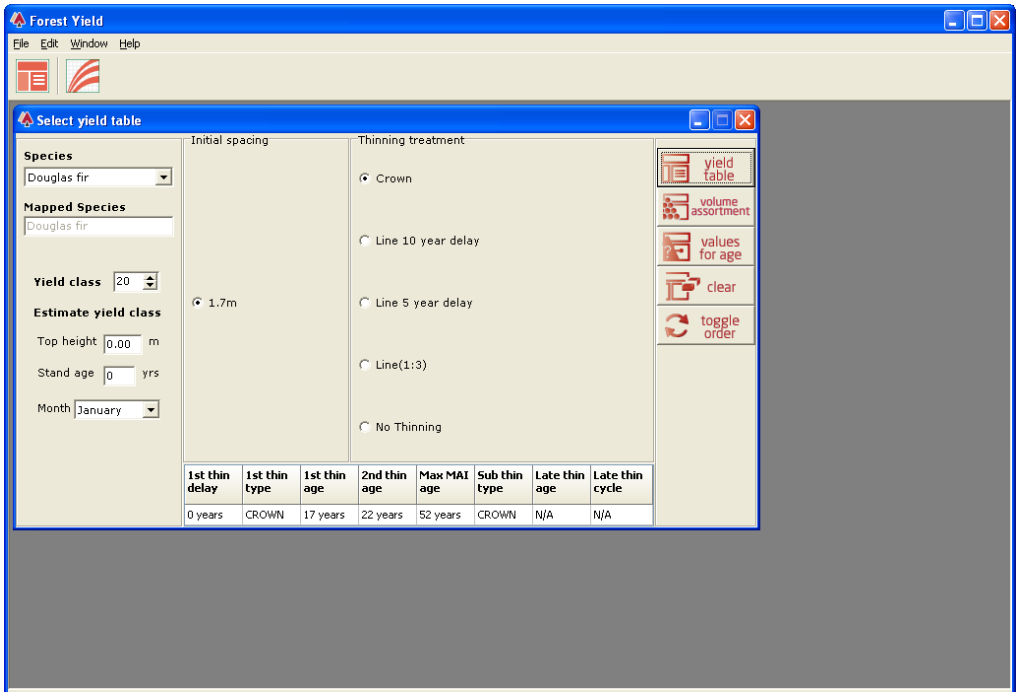
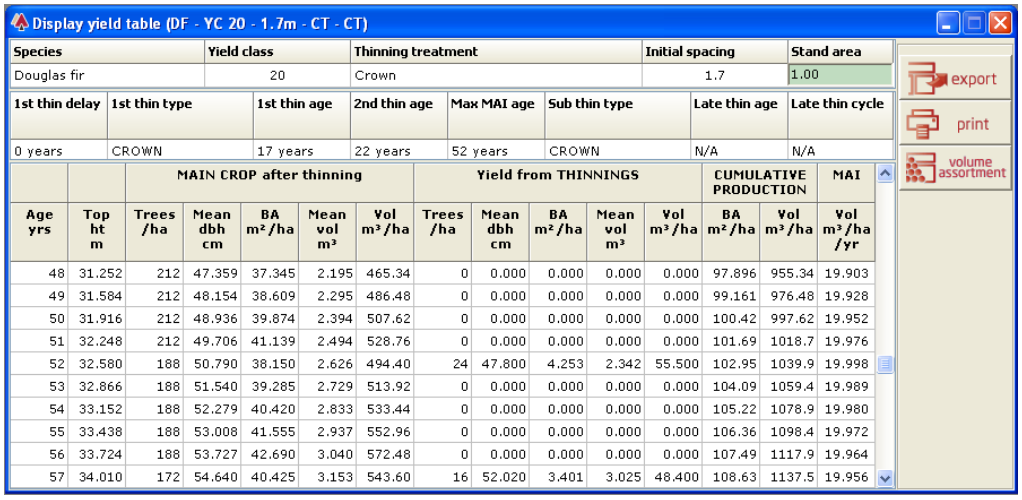


Figure 52 Displaying the unrounded annual yield table for Douglas fir, yield class 20, 1.7 m initial spacing, crown thinning (as selected in Figure 51).



Species	Yield class	Thinning treatment	Initial spacing	Stand area
Douglas fir	20	Crown	1.7	1.00

1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle
0 years	CROWN	17 years	22 years	52 years	CROWN	N/A	N/A

		MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha	Vol m³/ha	Vol m³/ha /yr
48	31.252	212	47.359	37.345	2.195	465.34	0	0.000	0.000	0.000	0.000	97.896	955.34	19.903
49	31.584	212	48.154	38.609	2.295	486.48	0	0.000	0.000	0.000	0.000	99.161	976.48	19.928
50	31.916	212	48.936	39.874	2.394	507.62	0	0.000	0.000	0.000	0.000	100.42	997.62	19.952
51	32.248	212	49.706	41.139	2.494	528.76	0	0.000	0.000	0.000	0.000	101.69	1018.7	19.976
52	32.580	188	50.790	38.150	2.626	494.40	24	47.800	4.253	2.342	55.500	102.95	1039.9	19.998
53	32.866	188	51.540	39.285	2.729	513.92	0	0.000	0.000	0.000	0.000	104.09	1059.4	19.989
54	33.152	188	52.279	40.420	2.833	533.44	0	0.000	0.000	0.000	0.000	105.22	1078.9	19.980
55	33.438	188	53.008	41.555	2.937	552.96	0	0.000	0.000	0.000	0.000	106.36	1098.4	19.972
56	33.724	188	53.727	42.690	3.040	572.48	0	0.000	0.000	0.000	0.000	107.49	1117.9	19.964
57	34.010	172	54.640	40.425	3.153	543.60	16	52.020	3.401	3.025	48.400	108.63	1137.5	19.956

It is apparent from ForestYield that the assessments of basal area and standing volume made 3 years ago (at stand age 49 years) are both higher than the average tabulated values illustrated in Figure 52. Irrespective of this, an estimate of the likely growth increment can be obtained from the cumulative production columns of the yield table.

The GB average 3-year increment for an equivalent stand is estimated to be the relevant tabulated value for cumulative production at 52 years (now) minus the equivalent tabulated value for cumulative production at 49 years (i.e. at the age the stand was when last assessed).

So, for basal area, the likely 3-year increment for a stand of this age is estimated as:

102.95 $m^2\ ha^{-1}$ – 99.161 $m^2\ ha^{-1}$ = 3.789 $m^2\ ha^{-1}$

and, for standing volume, the equivalent increment is estimated as:

1039.9 m^3 ha^{-1} – 976.48 m^3 ha^{-1} = 63.42 m^3 ha^{-1}

The current values of stand basal area and standing volume can therefore be estimated as:

basal area (52 years) = 42 m^2 ha^{-1} + 3.789 = 45.789 m^2 ha^{-1}
= 46 m^2 ha^{-1}, rounded

and

standing volume (52 years) = 530 m^3 ha^{-1} + 63.42 m^3 ha^{-1} = 593.42 m^3 ha^{-1}
= 593 m^3 ha^{-1}, rounded.

On the assumption that the number of trees has not changed since the assessment was made at age 49 years, when there were 253 trees per hectare, the quadratic mean dbh can be calculated as follows:

Average basal area = 45.789 m^2 ha^{-1} ÷ 253 = 0.18098 m^2

Equivalent diameter = $\sqrt{\frac{0.18098 \times 40000}{\pi}}$ = 48.004 cm

Note: This method of estimating increment should not be applied where the last assessment was carried out more than 5 years in the past.

Example 7 – Estimating biomass and carbon

Information from ForestYield can be used to generate estimates of biomass and carbon by following the methods outlined in Sections 5.3 and 6.3 of the Forestry Commission *Woodland Carbon Code*: *carbon assessment protocol* (www.forestry.gov.uk/wcc). Because of the nature of the allometric equations used in the estimation of biomass and carbon, it is appropriate to use unrounded values. The Yield table rounding convention in the ForestYield Preferences sub-window should therefore be set to 'No rounding' for biomass and carbon estimation.

In summary, the biomass of different parts of trees can be estimated by carrying out the following calculation steps:

1. The biomass of the average tree stem is estimated by multiplying mean total tree volume by the appropriate nominal specific gravity (from Table 5.3.1 in Section 5.3.1 of the Forestry Commission *Woodland Carbon Code: carbon assessment protocol*).

2. An estimate of the branch and foliage biomass of the average tree can be obtained using the relevant equation from Section 5.3.2 of the Forestry Commission *Woodland Carbon Code: carbon assessment protocol*.

3. The root biomass of the average tree can be estimated using the relevant equation from Section 5.3.3 of the Forestry Commission *Woodland Carbon Code: carbon assessment protocol*.

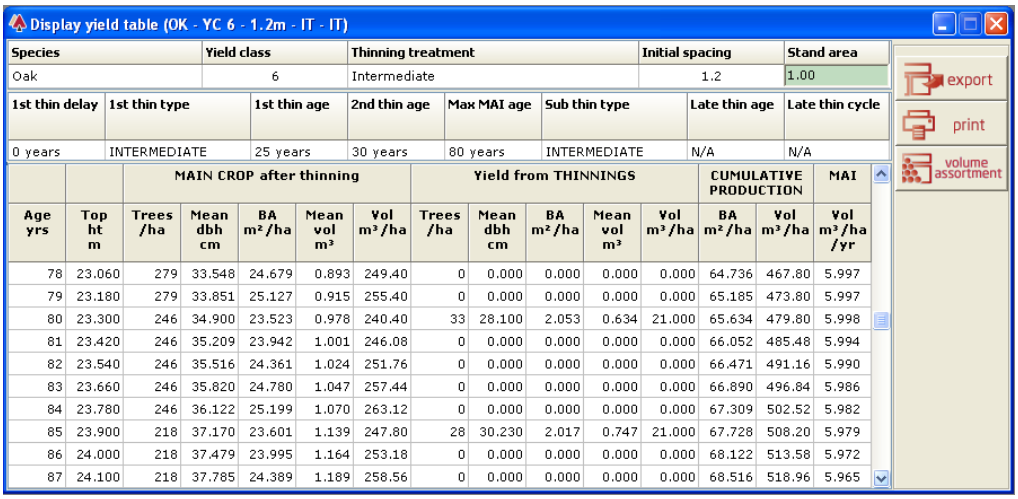
4. The biomass estimates from Steps 1 to 3 are added together to give an estimate of the total biomass for the average tree in the stand.

5. The estimate of biomass for the average tree from step 4 is multiplied by the estimated total

number of trees obtained from ForestYield in order to derive the total biomass (either per hectare or for the stand as a whole).

For example, a forest manager wishes to estimate the total biomass and carbon content of a thinned stand of 82-year-old oak, yield class 6. The information from the appropriate yield table is displayed in Figure 53.

Figure 53 Displaying the relevant part of the unrounded annual yield table for oak, yield class 6, 1.2 m initial spacing, intermediate thinning.



Species	Yield class	Thinning treatment	Initial spacing	Stand area
Oak	6	Intermediate	1.2	1.00

1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle
0 years	INTERMEDIATE	25 years	30 years	80 years	INTERMEDIATE	N/A	N/A

		MAIN CROP after thinning					Yield from THINNINGS					CUMULATIVE PRODUCTION		MAI
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha	Vol m³/ha	Vol m³/ha /yr
78	23.060	279	33.548	24.679	0.893	249.40	0	0.000	0.000	0.000	0.000	64.736	467.80	5.997
79	23.180	279	33.851	25.127	0.915	255.40	0	0.000	0.000	0.000	0.000	65.185	473.80	5.997
80	23.300	246	34.900	23.523	0.978	240.40	33	28.100	2.053	0.634	21.000	65.634	479.80	5.998
81	23.420	246	35.209	23.942	1.001	246.08	0	0.000	0.000	0.000	0.000	66.052	485.48	5.994
82	23.540	246	35.516	24.361	1.024	251.76	0	0.000	0.000	0.000	0.000	66.471	491.16	5.990
83	23.660	246	35.820	24.780	1.047	257.44	0	0.000	0.000	0.000	0.000	66.890	496.84	5.986
84	23.780	246	36.122	25.199	1.070	263.12	0	0.000	0.000	0.000	0.000	67.309	502.52	5.982
85	23.900	218	37.170	23.601	1.139	247.80	28	30.230	2.017	0.747	21.000	67.728	508.20	5.979
86	24.000	218	37.479	23.995	1.164	253.18	0	0.000	0.000	0.000	0.000	68.122	513.58	5.972
87	24.100	218	37.785	24.389	1.189	258.56	0	0.000	0.000	0.000	0.000	68.516	518.96	5.965

Step 1

The nominal specific gravity of oak, taken from Table 5.3.1 of the Forestry Commission *Woodland Carbon Code: carbon assessment protocol* is 0.56.

The estimated average stem volume of 82-year-old yield class 6 oak, from Figure 53, is 1.024 m^3.

The biomass of the average oak stem is calculated as 0.56 × 1.024 m^3 = 0.57344 oven-dry tonnes.

Step 2

The crown biomass of an oak tree with a dbh between 7 cm and 50 cm is estimated using the following equation from Table 5.3.2 of the Forestry Commission *Woodland Carbon Code: carbon assessment protocol*:

$$\text{crown biomass}_{(7\text{ cm} \le \text{dbh} \le 50\text{ cm})} = 0.0000168513 \times (\text{dbh}^{2.4767})$$

where dbh is diameter at breast height in centimetres.

We will use the mean dbh (35.516 cm) taken from ForestYield (see Figure 53) as the input into this equation. Hence:

$$\text{crown biomass}_{(7\text{ cm} \le \text{dbh} \le 50\text{ cm})} = 0.0000168513 \times (35.516^{2.4767})$$
$$= 0.11657 \text{ oven-dry tonnes.}$$

Step 3

The root biomass of oak trees with dbh greater than 30 cm is estimated using the following equation taken from Table 5.3.3 of the Forestry Commission *Woodland Carbon Code: carbon assessment protocol*:

$$\text{root biomass}_{(\text{dbh} > 30\text{ cm})} = -0.174882004 + (0.009559391 \times \text{dbh})$$

where dbh is diameter at breast height in centimetres.

We will use the mean dbh from ForestYield (see Figure 53) as the input into this equation, hence:

$$\text{root biomass}_{(\text{dbh} > 30\ \text{cm})} = -0.174882004 + (0.009559391 \times 35.516)$$
$$= 0.16463 \text{ oven-dry tonnes.}$$

Step 4

The total biomass of the average 82-year-old yield class 6 oak is:

$$\text{stem biomass} + \text{crown biomass} + \text{root biomass} = 0.57344 + 0.11657 + 0.16463$$
$$= 0.85464 \text{ oven-dry tonnes.}$$

Step 5

The total tree biomass per hectare is simply the value obtained in step 4, multiplied by the estimated number of tree stems per hectare taken from the yield table (see Figure 53). So, in this example:

0.85464 oven-dry tonnes × 246 stems per hectare = 210.2 oven-dry tonnes per hectare.

To estimate the carbon content, simply take the total biomass value and multiply it by 0.5 (see Forestry Commission Technical Paper 4, *The carbon content of trees*).

Thus, there is an estimated 210.2 × 0.5 = 105.1 tonnes C ha^{-1} in this hypothetical stand.

Appendix 1
Tree species in ForestYield

Table A1.1 The 61 conifer tree species included in ForestYield, listed alphabetically by common name. Names in bold indicate species directly represented in the yield tables. Note: Scientific names are subject to change and may therefore differ from those in previous Forestry Commission publications.

Common species name	Scientific name	FC species code	Mapped to species
Armand pine	*Pinus armandii*	–	SP
Atlas cedar	*Cedrus atlantica*	–	SP
Austrian pine	*Pinus nigra* ssp. *nigra*	AUP	CP
Bhutan pine	*Pinus wallichiana*	–	SP
Bishop pine	*Pinus muricata*	BIP	CP
Bornmuller fir	*Abies* ssp. *equi-trojani*	–	NF
Calabrian/Turkish pine	*Pinus brutia*	–	SP
Cedar-of-Lebanon	*Cedrus libani*	–	SP
Coastal redwood	*Sequoia sempervirens*	RSQ	GF
Colorado spruce	*Picea pungens*	–	NS
Common juniper	*Juniperus communis*	–	NS
Corsican pine	***Pinus nigra* ssp. *laricio*** (syn. *Pinus nigra* var. *maritima*)	**CP**	**CP**
Dawn redwood	*Metasequoia glyptostroboides*	–	EL
Deodar cedar	*Cedrus deodara*	–	SP
Douglas fir	***Pseudotsuga menziesii***	**DF**	**DF**
Engelmann spruce	*Picea engelmannii*	–	NS
European larch	***Larix decidua***	**EL**	**EL**
European silver fir	*Abies alba*	ESF	NF
Grand fir	***Abies grandis***	**GF**	**GF**
Greek fir	*Abies cephalonica*	–	NF
Hybrid larch	*Larix x marschlinsii*	HL	JL
Japanese larch	***Larix kaempferi***	**JL**	**JL**
Japanese red-cedar	*Cryptomeria japonica*	JCR	RC
Korean pine	*Pinus koraiensis*	–	SP
Lawson cypress	***Chamaecyparis lawsoniana***	**LC**	**RC**
Leyland cypress	*Cupressus leylandii*	LEC	RC
Loblolly pine	*Pinus taeda*	–	CP
Lodgepole pine	***Pinus contorta* var. *latifolia***	**LP**	**LP**
Macedonian pine	*Pinus peuce*	MCP	CP
Maritime pine	*Pinus pinaster*	MAP	LP
Mexican white pine	*Pinus ayacahuite*	–	SP
Mixed conifers	Mixed Pinidae (Coniferales)	MC	NS
Monterey cypress	*Cupressus macrocarpa*	–	RC
Monterey/radiata pine	*Pinus radiata*	RAP	CP
Mountain pine	*Pinus uncinata*	–	LP
Noble fir	***Abies procera***	**NF**	**NF**
Nootka cypress	*Cupressus nootkatensis*	–	RC
Nordmann/Caucasian fir	*Abies nordmanniana*	–	NF
Norway spruce	***Picea abies***	**NS**	**NS**

Common species name	Scientific name	FC species code	Mapped to species
Oriental/Caucasian spruce	*Picea orientalis*	–	NS
Other cedar	*Cedrus* spp.	XCD	SP
Other conifer	Other Pinidae (Coniferales)	XC	NS
Other larch	*Larix* spp.	XL	EL
Other pine	*Pinus* spp.	XP	SP
Other silver fir	*Abies* spp.	XF	NF
Other spruce	*Picea* spp.	XS	NS
Ponderosa pine	*Pinus ponderosa*	PDP	SP
Red/Pacific/beautiful fir	*Abies amabilis*	–	GF
Scots pine	***Pinus sylvestris***	**SP**	**SP**
Serbian spruce	*Picea omorika*	OMS	NS
Siberian fir	*Abies sibirica*	–	NF
Sitka spruce	***Picea sitchensis***	**SS**	**SS**
Slash pine	*Pinus elliottii*	–	LP
Wellingtonia	*Sequoiadendron giganteum*	WSQ	GF
Western hemlock	***Tsuga heterophylla***	**WH**	**WH**
Western red-cedar	***Thuja plicata***	**RC**	**RC**
Western white pine	*Pinus monticola*	–	CP
Weymouth pine	*Pinus strobus*	WEP	SP
White spruce	*Picea glauca*	–	NS
Yew	*Taxus baccata*	–	NS
Yunnan pine	*Pinus yunnanensis*	–	SP

Table A1.2 The 89 broadleaved tree species included in ForestYield, listed alphabetically by common name. Names in bold indicate species directly represented in the yield tables. Note: Scientific names are subject to change and may therefore differ from those in previous Forestry Commission publications.

Common species name	Scientific name	FC species code	Mapped to species
Ash	*Fraxinus excelsior*	AH	SY
Aspen	*Populus tremula*	–	PO
Beech	***Fagus sylvatica***	**BE**	**BE**
Big-leaved/Oregon maple	*Acer macrophyllum*	–	SY
Bird cherry	*Prunus padus*	–	OK
Black poplar	*Populus nigra*	–	PO
Black walnut	*Juglans nigra*	–	OK
Blackthorn	*Prunus spinosa*	–	OK
Box	*Buxus sempervirens*	–	OK
Cider gum	*Eucalyptus gunnii*	–	SY
Common alder	*Alnus glutinosa*	AR	SY
Common lime	*Tilia × europaea*	LI	SY
Common walnut	*Juglans regia*	–	OK
Cork oak	*Quercus suber*	–	OK
Crab/wild apple	*Malus sylvestris*	–	OK
Crack willow	*Salix fragilis*	–	OK
Downy birch	*Betula pubescens*	BI	SY
Downy oak	*Quercus pubescens*	–	OK
Eastern cottonwood	*Populus deltoides*	–	PO
English elm	*Ulmus procera*	–	BE
Field maple	*Acer campestre*	FM	SY
Goat willow	*Salix caprea*	–	OK
Green alder	*Alnus viridis*	–	SY
Green/red ash	*Fraxinus pennsylvanica*	–	SY
Grey alder	*Alnus incana*	–	SY
Grey poplar	*Populus × canescens*	–	PO
Grey willow	*Salix cinerea*	–	OK
Hawthorn	*Crataegus monogyna*	–	OK
Hazel	*Corylus avellana*	–	SY
Holly	*Ilex aquifolium*	–	OK
Holm oak	*Quercus ilex*	–	OK
Hornbeam	*Carpinus betulus*	HBM	BE
Horse-chestnut	*Aesculus hippocastanum*	–	SY
Hungarian oak	*Quercus frainetto*	–	OK
Hybrid black poplar	*Populus × canadensis*	–	PO
Italian alder	*Alnus cordata*	–	SY
Large-leaved lime	*Tilia platyphyllos*	–	SY
Lenga	*Nothofagus pumilio*	–	NO
London plane	*Platanus × acerifolia*	–	SY
Mixed broadleaves	Mixed Angiospermæ	MB	SY
Narrow-leaved ash	*Fraxinus angustifolia*	–	SY
Norway maple	*Acer platanoides*	NOM	SY
Oriental beech	*Fagus orientalis*	–	BE
Other oak	***Quercus* spp.**	**OK**	**OK**

Common species name	Scientific name	FC species code	Mapped to species
Other alder	*Alnus* spp.	AR	SY
Other birch	*Betula* spp.	XBI	SY
Other broadleaf	Other broadleaf	XB	SY
Other cherry	*Prunus* spp.	–	OK
Other elm	*Ulmus* spp.	EM	BE
Other eucalyptus	*Eucalyptus* spp.	–	PO
Other lime	*Tilia* spp.	LI	SY
Other Nothofagus	*Nothofagus* spp.	–	NO
Other plane	*Platanus* spp.	–	SY
Other poplar	***Populus* spp.**	**PO**	**PO**
Other walnut	*Juglans* spp.	–	OK
Other willow	*Salix* spp.	–	OK
Paper birch	*Betula papyrifera*	–	SY
Pedunculate oak	*Quercus robur*	–	OK
Pin oak	*Quercus palustris*	–	OK
Pyrenean oak	*Quercus pyrenaica*	–	OK
Rauli	*Nothofagus alpina* (syn. *Nothofagus procera*)	RAN	NO
Red alder	*Alnus rubra*	–	SY
Red oak	*Quercus rubra*	ROK	BE
Roble	***Nothofagus obliqua***	**RON**	**NO**
Rowan	*Sorbus aucuparia*	–	OK
Service-tree	*Sorbus domestica*	–	OK
Sessile oak	*Quercus petraea*	–	OK
Shagbark hickory	*Carya ovata*	–	BE
Shining gum	*Eucalyptus nitens*	–	PO
Silver birch	*Betula pendula*	–	SY
Silver maple	*Acer saccharinum*	–	SY
Sitka alder	*Alnus alnobetula* ssp. *sinuata*	–	SY
Small-leaved elm	*Ulmus minor* ssp. *minor*	–	BE
Small-leaved lime	*Tilia cordata*	–	SY
Sweet chestnut	*Castanea sativa*	SC	BE
Sycamore	***Acer pseudoplatanus***	SY	SY
Tulip tree/yellow poplar	*Liriodendron tulipifera*	–	PO
Turkey oak	*Quercus cerris*	TOK	OK
White ash	*Fraxinus americana*	–	SY
White oak	*Quercus alba*	–	OK
White poplar	*Populus alba*	–	PO
White willow	*Salix alba*	–	OK
Whitebeam	*Sorbus aria*	–	OK
Wild cherry/gean	*Prunus avium*	–	OK
Wild service-tree	*Sorbus torminalis*	–	OK
Wych elm	*Ulmus glabra*	–	BE

Appendix 2
Information given in yield tables

Table heading	Description
Age	Stand age in years. Typically, a yield table presents values at 5-year intervals, starting 5 years before the age of first thinning. However, this format may vary in individual tables, depending on the timing of thinnings. Forest Yield can also be set to display annual values.
Top height	Top height is the mean height, in metres, of the 100 trees of largest dbh per hectare. (See also 'Height' in the Forest Yield handbook which accompanies this software.)
Trees per ha	Number of measurable trees per hectare, i.e. only those with a dbh of at least 7 cm overbark. In yield tables for thinned stands, the numbers of trees per hectare are presented separately for trees comprising the main crop and for trees assumed to be removed in thinning operations. (See also 'Number of trees' in the Forest Yield handbook which accompanies this software.)
Mean dbh	Quadratic mean dbh (diameter at breast height), in centimetres, of the measurable trees. In yield tables for thinned stands, mean diameters are presented separately for trees comprising the main crop and for trees assumed to be removed in thinning operations. (See also 'Diameter' in the Forest Yield handbook which accompanies this software.)
BA	Basal area (BA) per hectare is the sum of the basal areas, in square metres, of the individual measurable trees, expressed on a per-hectare basis. (The basal area of an individual tree is the cross-sectional area of the tree at its breast height point.) In yield tables for thinned stands, values of basal area per hectare are presented separately for trees comprising the main crop and for trees assumed to be removed in thinning operations. In all yield tables, values are also given for cumulative basal area. (See also 'Basal area' in the Forest Yield handbook which accompanies this software.)
Mean vol	Mean volume per tree is the volume per hectare, in cubic metres, divided by the number of trees per hectare. In yield tables for thinned stands, values of mean volume per tree are presented separately for the trees comprising the main crop and for trees assumed to be removed in thinning operations. (See also 'Volume' in the Forest Yield handbook which accompanies this software.)
Vol	Volume per hectare is the sum of stem volumes, in cubic metres, for individual measurable trees to a top diameter of 7 cm overbark, expressed on a per-hectare basis. In yield tables for thinned stands, values of volume per hectare are presented separately for trees comprising the main crop and for trees assumed to be removed in thinning operations. In all yield tables, values are also given for cumulative volume. (See also the sections on 'Volume' and 'Measuring volume productivity' in the Forest Yield handbook which accompanies this software.)
Per cent mortality	Only applicable to yield tables for unthinned stands. Per cent mortality is defined as the cumulative volume lost due to mortality expressed as a percentage of the sum of stand cumulative volume production and cumulative volume lost due to mortality.
MAI	Mean Annual Increment (MAI) is the cumulative per hectare volume production divided by the stand age. It is the average rate of volume production achieved from time of planting up to a given stand age. (See 'Measuring volume productivity' in the Forest Yield handbook which accompanies this software.) However, for unthinned stands values for mean annual increment are based on standing volume rather than cumulative volume, i.e. they do not include volume effectively lost due to mortality.

Glossary

Basal area The cross-sectional area of the stem of an individual tree at its breast height point (1.3 m from ground level).

Basal area per hectare The sum of the basal areas of trees in an area of woodland expressed on a per hectare basis.

Biomass (of a tree) All of the material making up a tree or one of its components such as stem or branches.

Branch The woody material of trees excluding the stem, stump and roots.

Crown The branches and foliage of a tree.

Cumulative volume production An important measure of volume productivity in forestry that represents the total production of timber volume from a stand up to a given year in the stand's development. It is calculated as the standing volume per hectare attained by a forest stand in a given year plus the sum of per hectare volumes removed as thinnings up to that year.

Diameter at breast height (dbh) The diameter on the main stem of a tree at 'breast height', i.e. 1.3 m from ground level. See Section 3.1 of *Forest mensuration: a handbook for practitioners* for more details.

General Yield Class (GYC) An index used in Britain, derived from GB-level top height on age curves, for the potential productivity of even-aged stands of trees. See the section on 'Yield class', in the Forest Yield handbook starting on page 24, for more details.

Hectare (ha) Unit of area equivalent to 100 m x 100 m = 10 000 m^2 (1 ha = 2.47 acres).

Intermediate thinning A type of selective thinning which involves the removal of most of the suppressed and sub-dominant trees, and also the opening up of the canopy by breaking up groups of competing dominant and co-dominant trees. This encourages the development of the remaining trees and leaves an open and fairly uniform stand.

Local Yield Class (LYC) An index used in Britain, derived from direct assessments of cumulative volume production, of the potential productivity of even-aged stands of trees. See the section on 'Yield class' in the Forest Yield handbook.

Management prescription The combination of initial planting spacing, thinning regime and age of felling applied to a stand of trees.

Mean annual increment (MAI) A measure of the volume productivity of forest stands (usually even-aged). Mean annual increment is the average rate of cumulative volume production up to a given year. In even-aged stands, it is calculated by dividing cumulative volume production by age.

Mean dbh The dbh relating to the mean basal area of the trees in an area of woodland (i.e. quadratic mean dbh or root mean square dbh).

Numbers of trees per hectare The number of trees in an area of woodland expressed on a per hectare basis.

Oven-dry tonne (odt) Unit of mass. When applied to wood, it represents the mass of wood in tonnes, not including the mass due to the moisture content of the wood (which may vary considerably).

Overbark The volume or diameter of wood including the bark.

Planimetric area The area of a piece of land calculated based on the vertical projection of its boundaries, i.e. as commonly displayed on a map. A planimetric area for land on sloping ground is typically smaller than the true area based on distances measured along the slope(s).

Stand A distinct area of woodland, generally composed of a uniform group of trees in terms of species composition, spatial distribution, age class distribution and size class distribution.

Standing volume A measure of timber volume within standing trees. Usually expressed as cubic metres overbark standing.

Stem The woody material forming the above-ground main growing shoot of a tree. By convention, in Forest Yield, the stem is taken to include all woody volume above ground

with a diameter greater than 7 cm overbark. This may mean that significant 'straight' branches (i.e. more than 3 m length greater than 7 cm top diameter) are included as part of the main stem volume.

Thinning The periodic harvesting of trees in a woodland, involving the removal of some trees for commercial utilisation and the retention of others for future production or long-term retention. See the section on 'Thinning treatment' in the Forest Yield handbook, starting on page 47, for more details.

Top height The mean total height of the 100 trees of largest dbh in a hectare of woodland. Usually assessed on a sample of the trees of largest dbh in a series of circular plots of 0.01 ha in area.

Volume/volume per hectare The stem volume, expressed in cubic metres, to 7 cm top diameter overbark of an individual tree, group of trees or all the trees in a woodland. Volume can be expressed on an individual tree, per hectare or whole-group/stand basis.

Yield class An index used in Britain of the potential productivity of even-aged stands of trees. See the section on 'Yield class' in the Forest Yield handbook, starting on page 24 for more details.

ForestYield is a PC-based software tool that provides easy and flexible digital access to Forestry Commission yield tables for British forestry, based on those originally published in Forestry Commission Booklet 48, Yield models for forest management. These yield tables have underpinned forestry practice and supported day-to-day decision-making in British forestry since the 1950s, by providing users with estimates of various aspects of tree growth – including height, diameter and volume – based on information from the user for tree species, yield class and a selected management prescription. The ForestYield software is supported by a comprehensive user manual and this booklet, which sets out the essential principles of forest mensuration, growth and yield. ForestYield will be of use to forest and woodland managers and practitioners, researchers and students.

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