



A PC-based yield model for forest management in Britain



Version 1.0



# User manual



forest management in Britain

Forestry Commission: Edinburgh In association with Forest Research

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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<sup>3</sup> ha<sup>-1</sup> yr<sup>-1</sup>). 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.

😋 🕞 📲 🕨 32 Bit Computer 🔹 Win7 32 (Ci) 🔹 Program Files 🔸 Forestry Commission Research Agency 🔸 Forest Yield 1.0										
File Edit View Tools Help										
Organize 👻 📓 Open 🛛 Burn New folder										
🔶 Eavonites	A Nan	ne		Date modified	Туре	Size				
E Desktop	12	quickhe	lp	26/09/2013 09:07	Adobe Acrobat D	128 KB				
Secent Places	-	ForestYi	eld	18/04/2016 14:22	Application	4,163 KB				
Downloads	1	🚳 Pre	Open	07/2013 11:20	Application extens	56 KB				
		TH 🤫	Run as administrator	09/2005 17:56	Application extens	268 KB				
📜 Libraries	- 🔬	De	Troubleshoot compatibility	03/2009 09:54	Bitmap image	36 KB				
Documents	<b>S</b>	Sp 📕	Scan with AVG	03/2016 13:36	Bitmap image	1,876 KB				
A Music		FO 💮	Permanently shred with AVG	06/2009 16:36	GID File	9 KB				
Pictures	0	FO	Pin to Taskbar	06/2008 02:35	Help file	404 KB				
Videos	- 5	140	Pin to Start Menu	04/2016 16:23	Icon	43 KB				
	- 🔺	Fo	Restore previous versions	04/2016 16:28	Icon	53 KB				
🚜 Homeoroup	8	BE	Condito	09/2005 17:55	Microsoft Excel C	7 KB				
	2	CP	Jenu to	09/2005 17:55	Microsoft Excel C	10 KB				

### 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<sup>®</sup> Control Panel. In Windows<sup>®</sup> 7 and Windows<sup>®</sup> 8, this can be done using **Open Control Panel**, or **Uninstall or change a program** via Windows<sup>®</sup> Explorer (My Computer).

To uninstall the program:

- 1. Press Start, or click the PC settings button in Windows<sup>®</sup> 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.

🕒 🗢 🖾 🕨 Control Panel 🔸	All Control Panel Items    Programs and Features											
File Edit View Tools Help	File Edit View Tools Help											
Control Panel Home	Uninstall or change a program											
View installed updates	To uninstall a program, select it from the list and then	click Uninstall, Change, or Repair.										
😗 Turn Windows features on or												
off	Organize 🔻 Uninstall Change Repair											
	Name	Publisher	Installed On	Size	Version							
	A Forest Yield 1.0	Forestry Commission Research	19/04/2016	7.16 MB	1.0.88							
	Garmin Express	Garmin Ltd or its subsidiaries	12/02/2016	153 MB	4.1.16.0							
	🐮 Garmin POI Loader	Garmin Ltd or its subsidiaries	16/06/2015	16.0 MB	2.7.3							
	🔁 Garmin USB Drivers	Garmin Ltd or its subsidiaries	16/06/2015	581 KB	2.3.1.0							
	📀 Google Chrome	Google Inc.	05/08/2014		49.0.2623.110							
	OO Google Toolbar for Internet Explorer	Google Inc.	23/12/2015		7.5.7210.1528							
	Intel(R) Network Connections Drivers	Intel	05/08/2014	916 KB	18.1							
	1 Intel® Management Engine Components	Intel Corporation	05/08/2014	20.4 MB	9.5.15.1730							
	Intel® PROSet/Wireless Software	Intel Corporation	05/08/2014	332 MB	16.1.1							

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 <u>Select yield table</u> 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).

🚯 Forest Yield													
<u>File E</u> dit <u>W</u> indow <u>H</u> elp													
🚯 Select yield table	Select yield table												
Species	—Initial sp	acing		Thinning t	reatment				veld table				
Yield class Estimate yield class Top height 0.00 m Stand are 0 yrs									C toggle order				
Month January													
	1st thin delay	1st thin type	1st thin age	2nd thin age	Max MAI age	Sub thin type	Late thin age	Late thin cycle					

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 Forest Yield 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). Forest Yield 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 Forest Yield 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.

Thinning treatment												
• Intermediate	yield table											
	wolume assortment											
C Line 10 year delay	for age											
C Line 5 year delay												
C (ins(1.2))	order											
( Line(1:5)												
C No Thinning												
n 2nd thin Max MAI Sub thin Late thin Late thin												
age age type age cycle												
s 22 years 42 years INTERMED N/A N/A												
	Thinning treatment         © Intermediate											

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<sup>2</sup> resulting from the inputs illustrated in Figure 7.

\land Displ	ay yiel	d table (Jl	- YC 10	) - 1.7m	- IT - IT	)										
Species			Yield	class		Thinning I	treatme	nt			Initial s	pacing	Sta	nd area		
Japanese	e larch			10		Intermed	iate					1.7	1.0	0		🔁 export
1st thin o	lelay	1st thin typ	e	1st thi	1st thin age 2nd thin a			age Max MAI age Sub thin type				Late thin a	age Lat	e thin cyc	le	print
0 years		INTERMEDI	ATE	17 yea	irs	22 years	42	years	INTER	MEDIAT	E	N/A	N/#	4		
		٩	AIN CR	OP after	thinnin	g	Yield from THINNINGS						ATIVE	MAI	^	assortment
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³/h	BA m²/ha	¥ol m³/ha	Vol m³/ha /yr		
12	7.26	0 2861	8.990	18.160	0.014	39.200	(	0.000	0.000	0.000	0.00	0 18.160	39.200	3.267		
17	10.16	0 1340	12.080	15.358	0.045	60.900	1263	11.100	12.222	0.028	35.00	0 27.580	95.900	5.641		
22	12.77	0 886	15.640	17.027	0.107	94.800	454	13.670	6.668	0.077	35.00	0 35.917	164.80	7.491		
27	15.06	0 666	19.020	18.917	0.197	131.00	221	17.100	5.064	0.159	35.00	0 42.871	236.00	8.741		
32	17.03	0 529	22.050	20.201	0.309	163.40	137	20.200	4.384	0.256	35.00	0 48.538	303.40	9.481		
37	18.71	.0 435	24.760	20.926	0.436	189.70	94	22.990	3.919	0.371	35.00	0 53.182	364.70	9.857		
42	20.14	0 372	27.220	21.624	0.573	213.00	63	25.530	3.225	0.502	31.60	0 57.106	419.60	9.990		
47	21.37	0 328	29.470	22.393	0.715	234.80	43	27.860	2.634	0.641	27.70	0 60.508	469.10	9.981		
52	22.43	0 296	31.520	23.136	0.859	254.80	32	29.990	2.246	0.780	24.80	0 63.497	513.90	9.883		
57	23.39	0 271	33.410	23.767	1.007	272.90	25	31.960	2.030	0.913	23.10	0 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.

<sup>2</sup>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, Forest Yield can alternatively be set to display annual values via the **Preferences** sub-window (see the *Preferences* section below).

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

🐥 Displ	🖗 Display volume assortment (JL - YC 10 - 1.7m - IT - IT)															
Species			Yield c	lass	Thinning	treatme	nt		Initial s	pacir	ig !	Stan	nd area			
Japanese	larch			10	Intermedia	ite				1.7		1.00				export
1st thin	delay	1st thin type		1st thin a	ge 2nd thin	2nd thin age Max MAI age Sub thin type Late thin age Late thin cycle							orint			
0 years		INTERMEDIATE		17 years	22 years	22 years 42 years INTERMEDIATE						N/A		_	-8-	print
	MAIN Volun By to	CROP after t ne in m³/ha p diameter r	hinnin ange	g		Yield from THINNINGS Yolume in m³/ha By top diameter range										
Age yrs	Mear dbh cm	1 7 - 14cm	14	- 18cm	18cm+	Stem tip <7cm	Mean dbh cm	7 - 14cm	14 - 18ci	m	18cm+	Stem tip <7cm				
12	8.99	90 39.2	00	0.000	0.000	18.582	2 0.000	0.000	0	.000	0.0	000	0.000			
17	12.08	30 52.0	53	8.847	0.000	11.944	11.100	32.567	2	433	0.	000	8.908			
22	15.64	10 55.8	20	28.792	10.187	6.891	l 13.670	26.939	8	.061 0		000	3.880			
27	19.02	20 42.4	24	43.920	44.656	5.120	) 17.100	16.200	11	.611	511 7.18		1.919			
32	22.05	50 28.2	95	46.876	88.229	3.982	20.200	8.947	11	275	14.	778	1.129			
37	24.76	50 18.0	67	42.167	129.466	129.466 3.188		4.940	9	280	20.	780	0.746			
42	27.22	20 11.5	94	35.409	165.997	2.641	L 25.530	2.529	6	.445	22.	625	0.481			
47	29.47	70 7.6	02	28.968	198.229	2.255	5 27.860	1.301	4	242	22.	157	0.319			
52	31.52	20 5.1	19	23.512	226.169	1.971	L 29.990	0.712	2	.847	21.	242	0.225			
57	33.41	10 3.5	24	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 Forest Yield 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 Forest Yield. 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, Forest Yield 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. Forest Yield 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, Forest Yield forces the minimum top diameter of the smallest 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.

-Top diameter classes, in cm over ba	rk	
Min	top diameter	Max top diameter
	7	14
Number of top diameter	14	18
classes (Max 5)	18	

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

The default categories for stand volume assortments reported by Forest Yield 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 Forest Yield 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+.

Top diameter classes, in cm over bark										
Min to	Max top diameter									
	7	14								
Number of top diameter	14	18								
classes (Max 5)	18	24								
	24	30								
	30									

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).





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<sup>3</sup> 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<sup>3</sup> 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.

🕭 Foi	est Yiel	d																			
jile E	dit <u>W</u> indo	w I	Help																		
1=																					
🀥 D	Display yield table (SP - YC 8 - 1.4m - IT - IT)																				
species Yield class Thinning treatment Initial spacing Stand area																					
Scot	s pine				8		Intermed	iate					1.4	1.0	)		export				
1st t	hin delay	15	t thin type	e	1st th	in age	2nd thin a	ige Ma	ix MAI ag	e Subth	nin type		Late thin a	ige Lat	e thin cyc	le	print				
0 ye	rs INTERMEDIATE 29 years 34 years 79 years INTERMEDIATE N/A N/A																				
			М	AIN CR	OP after	r thinnin	g		Yield fr	om THI	NNINGS	S CUMULATIVE PRODUCTION			IVE MAI		VE MAI On		VE MAI 🛆 DN		assortmen
Ag yr	e To s hi m	p t	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³/ha	BA m²/ha	¥ol m³/ha	Vol m³/ha /yr						
	39 1	3.2	1258	15	22	0.10	127	402	13	5	0.07	28	8 45	211	5.4		1				
	40 1	3.5	1258	15	23	0.11	138	0	0	0	0.00	(	) 46	222	5.6						
	41 1	3.8	1258	16	25	0.12	150	0	0	0	0.00	(	48	234	5.7						
	42 1	4.1	1258	16	26	0.13	161	0	0	0	0.00	(	9 49	245	5.8						
	43 1	4.4	1258	17	27	0.14	173	0	0	0	0.00	(	50	257	6.0						
	44 1	4.7	1007	17	24	0.16	157	251	15	4	0.11	28	3 52	269	6.1						
	45 1	4.9	1007	18	25	0.17	168	0	0	0	0.00	(	53	280	6.2						
	46 1	5.2	1007	18	27	0.18	180	0	0	0	0.00	(	54	292	6.3						
	47 1	5.5	1007	19	28	0.19	192	0	0	0	0.00	(	55	304	6.5						
	48 1	5.7	1007	19	29	0.20	203	0	0	0	0.00	(	56	315	6.6	¥					

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

 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'.

Preferences	×
Display selection screen on startup	
Yield table	
C General Yield Class curves	
C None	
Yield model version	
C Original models for all species	New models for sitka Spruce
Yield table display frequency	
C Standard	• Annual
Display yield table main crop values	
<ul> <li>After thinning</li> </ul>	C Before thinning
Yield table rounding convention	
Standard	C No rounding
Top diameter classes, in cm over bark	
Min top diameter	Max top diameter
17	14
Number of top diameter 3 14 classes (Max 5) 18	18
$\checkmark$	×

- 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).

Forest Yield (using new Sitka spruce yield tables)												
Eile Edit <u>W</u> indow <u>H</u> elp												
Select yield table (using new Sitka spruce yield tables)												
	Initial spacing Thinning treatment											
Scots pine	○ 0.9m			Interm	ediate				yield table			
Mapped Species	€ 1.4m			C Interm	ediate, 10	Year delay	r		volume assortment			
1	○ 1.8m			O Interm	ediate, 5 Y	'ear delay			values for age			
Yield class 10 🜩	C 2.0m			C Line 10	i vear dela	w			r clear			
Estimate yield class	C 2.4m				,	,			🕋 toggle			
Top height 0.00 m	C 2.5m			C Line 5	year delay				v order			
Stand age 0 yrs												
Month January 💌	C 3.0m			C Line(1:3)								
	C 4.5m			C No Thir	ning							
	1st thin delay	1st thin type	1st thin age	2nd thin age Sub thin Late thin Late thin cycle				Late thin cycle	-			
	0 years	INTERMED	25 years	30 years	70 years	INTERMED	N/A	N/A				

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

\land Displa	Display yield table (SP - YC 10 - 1.4m - IT - IT)     Sector Vield class Thisping treatment Total spacing Stand area															
Species			Yield	class		Thinning (	treatme	nt			Initial s	pacing	Sta	nd area		
Scots pir	ne			10		Intermed	iate					1.4	1.00	)		ᢇ export
1st thin o	ielay 1	1st thin typ	e	1st thi	n age	2nd thin a	ige M	ax MAI ag	e Subti	nin type		Late thin a	ige Late	e thin cyc	le	print
0 years	1	INTERMEDI	ATE	25 yea	ars	30 years	70	lyears	INTER		E	N/A	N/A			
		1	IAIN CR	OP after	thinnin	g		Yield fr	om THI	NNINGS			ATIVE	MAI	^	assortment
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³/ha	BA m²/ha	¥ol m³/ha	Vol m³/ha /yr		
39	15.	2 1056	18	28	0.18	188		) 0	0	0.00	(	54	293	7.5		
40	15.	.6 831	19	25	0.20	167	22	5 16	5	0.16	35	5 55	307	7.7		
41	15.	9 831	20	26	0.22	182		0 0	0	0.00	(	57	322	7.8		
42	16.	2 831	21	27	0.24	196		0 0	0	0.00	(	58	336	8.0		
43	16.	5 831	21	29	0.25	210		0 0	0	0.00		) 60	350	8.1		
44	16.	8 831	22	30	0.27	224		) 0	0	0.00	(	) 61	364	8.3		
45	17.	1 681	23	27	0.30	204	15	) 19	4	0.23	35	5 63	379	8.4		
46	17.	4 681	23	29	0.32	218		) 0	0	0.00	(	) 64	393	8.5		
47	17.	6 681	24	30	0.34	232		) 0	0	0.00	(	) 65	407	8.7		
48	17.	9 681	24	31	0.36	246		) 0	0	0.00		) 66	421	8.8	¥	

**Figure 18** The modelled cumulative volume production (397 m<sup>3</sup> 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<sup>3</sup> per hectare).

Forest	Yield (I	using new	/ Sitka s	pruce yie	eld table	s)											
ile <u>E</u> dit	Mindow	Help															
🐥 Displ	ay yield	l table (SP	P - YC 1	2 - 1.4m	- IT - IT	)											
Species			Yield	class		Thinning t	reatme	nt			Initial s	pacing	Sta	nd area			
Scots pir	e			12		Intermed	iate					1.4	1.0	)		export	
1st thin o	lelay 1	st thin typ	e	1st thi	n age	2nd thin a	ige Ma	ax MAI ag	2 Sub th	in type	1	Late thin a	ige Lat	e thin cyc	le		
																La print	
0 years	I	NTERMEDI	ATE	23 yea	irs	28 years	68	years	INTER	MEDIATE		N/A	N/A	1		🔚 volume	
		٩	1AIN CR	OP after	thinnin	g		Yield fr	om THI	NINGS		PRODU	ATIVE	MAI	^	assortment	
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³/ha	Trees /ha	Mean dbh cm	BA m²∕ha	Mean vol m³	¥ol m³∕ha	BA m²/ha	¥ol m³/ha	Vol m³/ha /yr			
39	17.1	1 723	22	28	0.29	212	C	0	0	0.00	0	) 61	380	9.8			
40	17.4	4 723	23	29	0.32	229	0	0	0	0.00	(	) 62	397	9.9			
41	17.8	3 723	23	31	0.34	246	C	0	0	0.00	0	64	414	10.1			
42	18.1	1 723	24	32	0.36	263	0	0	0	0.00	0	65	431	10.3			
43	18.4	4 588	25	29	0.40	237	134	22	5	0.31	42	2 67	447	10.4			
44	18.7	7 588	26	30	0.43	254	0	0	0	0.00	0	68	464	10.5			
45	19.1	1 588	26	32	0.46	270	0	0	0	0.00	0	0 70	480	10.7			
46	19.4	4 588	27	33	0.49	287	0	0	0	0.00	0	71	497	10.8			
47	19.7	7 588	27	35	0.52	303	0	0	0	0.00	0	73	513	10.9			
48	20.0	0 494	28	31	0.56	278	94	25	5	0.45	42	2 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<sup>3</sup> 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<sup>3</sup> per hectare) is higher than the observed cumulative volume production (425 m<sup>3</sup> per hectare) at the appropriate age.

🕨 Forest	Yield	(using nev	w Sitka s	spruce yi	ield tabl	es)										
jle <u>E</u> dit	₩indow	Help														
Å Displa	ay yield	l table (SF	P - YC 14	4 - 1.4m	- IT - IT	)										
Species			Yield	class		Thinning I	treatmen	t			Initial s	pacing	Sta	nd area		_
Scots pir	e			14		Intermed	iate					1.4	1.0	0		export
1st thin o	lelay 1	st thin typ	e	1st thi	n age	2nd thin a	ige Ma	x MAI age	sub th	nin type		Late thin a	ige Lat	e thin cyc	le	print
0 years	I	NTERMEDI	ATE	21 yea	ars	26 years	66	years	INTER	MEDIATE		N/A	N/4	4		
		1	1AIN CR	OP after	thinnin	g		Yield fr	om THI	NNINGS		CUMUL	ATIVE CTION	MAI	^	assortment
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²∕ha	Mean vol m³	¥ol m³/ha	Trees /ha	Mean dbh cm	BA m²∕ha	Mean vol m³	¥ol m³/ha	BA m²/ha	¥ol m³/ha	¥ol m³/ha /yr		
39	18.8	3 634	25	32	0.43	270	0	0	0	0.00	(	0 70	466	11.9	١	
40	19.1	1 634	26	34	0.45	289	0	0	0	0.00	(	71	485	12.1		
41	19.5	5 512	27	30	0.50	258	122	24	5	0.40	49	9 73	503	12.3		
42	19.8	3 512	28	31	0.54	277	0	0	0	0.00	(	75	522	12.4		
43	20.1	1 512	29	33	0.58	296	0	0	0	0.00	(	76	541	. 12.6		
44	20.5	5 512	29	34	0.61	314	0	0	0	0.00	(	78	559	12.7		
45	20.8	8 512	30	36	0.65	333	0	0	0	0.00	(	) 79	578	12.8		
46	21.1	1 428	31	32	0.71	302	85	28	5	0.58	49	9 81	596	13.0		
47	21.5	5 428	32	34	0.75	320	0	0	0	0.00	(	82	614	13.1		
48	21.8	3 428	32	35	0.79	338	0	0	0	0.00	(	84	632	13.2	~	

- 5. The modelled cumulative volume production illustrated in Figure 19 is greater than that recorded for the stand (425 m<sup>3</sup> per hectare). It is therefore appropriate to assume that the Local Yield Class of the stand is lower than 14 m<sup>3</sup> per hectare per annum. The best estimate of Local Yield Class for this particular stand is therefore 12 m<sup>3</sup> 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<sup>3</sup> ha<sup>-1</sup> yr<sup>-1</sup>, 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 Forest Yield 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<sup>3</sup> ha<sup>-1</sup> yr<sup>-1</sup> greater than the assessed General Yield Class (see Table 3 on page 11 of the Forest Yield 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 Forest Yield 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'.

Preferences	
Display selection screen on startup	
<ul> <li>Yield table</li> </ul>	
C General Yield Class curves	
C None	
Yield model version	
Original models for all species	New models for sitka Spruce
Yield table display frequency	
O Standard	Annual
Display yield table main crop values	
<ul> <li>After thinning</li> </ul>	C Before thinning
Yield table rounding convention	
Standard	C No rounding
Top diameter classes, in cm over bark	
Min top diameter	Max top diameter
1	14
Number of top diameter 3	18
$\checkmark$	×

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).

A Forest Yield (using new Sitka spruce yield tables)												
<u> E</u> ile <u>E</u> dit <u>W</u> indow <u>H</u> elp												
A Select yield table (using	new Sitka	a spruce y	rield tabl	es)								
	Initial sp	acing		Thinning t	reatment							
Scots pine	C 0.9m									yield table		
Mapped Species	C 1.4m			G Tatara	adistal				<b>.</b>	volume ssortment		
Iscuts pine	€ 1.8m			- unterm	eulatej				?7	values for age		
Yield class 10 🜩	C 2.0m								F	clear		
Estimate yield class	C 2.4m								3	toggle order		
Stand age of vrs	C 2.5m											
Month January	C 3.0m			C No Thir	nning							
	C 4.5m											
	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	INTERMED	26 years	31 years	71 years	INTERMED	N/A	N/A				
L		1	1			,			1			

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.

Forest	Yield Window	(using nev Help	w Sitka s	pruce yi	ield tabl	es)											
		Terb															
À Displ	ay yield	l table (SF	- YC 10	) - 1.8m	- IT - IT	)											
Species			Yield	class		Thinning	treatmer	nt			Initial sp	pacing	Sta	nd area			
Scots pir	e			10		Intermed	iate					1.8	1.0	0		export	
1st thin o	lelay 1	st thin typ	e	1st thi	n age	2nd thin a	ige Ma	x MAI age	sub th	in type	ľ	Late thin a	nge Lat	e thin cyc	le	print	
0 years	I	NTERMEDI	ATE	26 yea	irs	31 years	71	years	INTER	MEDIATE	:	N/A	N/4	1			
		•	IAIN CR	OP after	thinnin	g		Yield fr	om THIM	NINGS			LATIVE	MAI	^	assortment	
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha	¥ol m³∕ha	Vol m³/ha /yr			
21	8.3	3 2580	10	22	0.03	65	0	0	0	0.00	0	22	65	3.1			
22	8.8	3 2545	11	23	0.03	75	0	0	0	0.00	C	23	75	3.4			
23	9.2	2 2511	11	24	0.03	84	0	0	0	0.00	C	24	84	3.7			
24	9.6	5 2476	11	25	0.04	94	0	0	0	0.00	C	25	94	3.9			
25	10.0	2442	12	27	0.04	104	0	0	0	0.00	0	27	104	4.1			
26	10.4	1553	13	19	0.05	78	855	11	9	0.04	35	5 28	113	4.4			
27	10.8	3 1553	13	21	0.06	90	0	0	0	0.00	0	29	125	4.6			
28	11.2	2 1553	14	22	0.07	102	0	0	0	0.00	0	31	137	4.9			
29	11.5	5 1553	14	24	0.07	114	0	0	0	0.00	0	33	149	5.1			
30	11.9	1553	15	26	0.08	126	0	0	0	0.00	6	34	161	5.4	~		

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.

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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.

🐥 Forest Yield (using new S	itka sprud	e yield ta	bles)								
<u>File E</u> dit <u>W</u> indow <u>H</u> elp											
Select yield table (using	, new Sitk	a spruce y	ield tabl	es)							
	Initial sp	acing	1	Thinning t	reatment				1		
Scots pine	C 0.9m			Gatana	- 41-4-1				yield table		
Mapped Species				(e interni	eulatej				volume assortment		
Scots pine	C 1.4m								values		
Yield class 🖇 🜩	• 1.8m			C Interm	ediate, 10	Year dela	ŕ				
Estimate yield class	_										
Top height 0.00 m	© 2.0m			C Interm	ediate, 5 Y	′ear delay			v order		
Stand age 0 yrs	C 2.4m										
Month January 💌	C 3.0m			C No Thir	ning						
	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	INTERMED	30 years	35 years	80 years	INTERMED	N/A	N/A			

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

Fores	t Yield	(using n	w Sitk	a spr	ruce yie	ld table	s)										
le <u>E</u> dit	Window	Help															
🐥 Disp	lay yie	ld table	SP - YC	C 8 -	1.8m -	IT - IT)											
Species			Yi	ield c	lass		Thinning	treatme	ent			Initial s	pacing	Sta	nd area		
Scots p	ine				8		Intermed	iate					1.8	1.00	)		export
1st thin	delay	1st thin t	/pe		1st thi	n age	2nd thin a	ige M	lax MAI age	Sub ti	nin type		Late thin a	age Lati	e thin cyc	le	print
0 years		INTERME	DIATE		30 vea	rs	35 vears	8	0 vears	INTER		E	N/A	N/A			<u> </u>
			MAIN	CRO	P after	thinnin	g		Yield fro	m THI	NNINGS			ATIVE	MAI	^	volume assortment
Age yrs	Top ht m	Tree /ha	5 Mea db cn	an hi n	BA m²∕ha	Mean vol m³	¥ol m³∕ha	Trees /ha	i Mean dbh cm	BA m²∕ha	Mean vol m³	¥ol m³/ha	BA m²/ha	¥ol m³∕ha	Vol m³/ha /yr		
20	6	.4 27:	0	8	15	0.01	33		0 0	0	0.00	(	) 15	33	1.7		
2	. 6	.8 268	4	9	17	0.01	39		0 0	0	0.00	(	) 17	39	1.9		
23	2 7	.2 265	8	9	18	0.02	46		0 0	0	0.00	(	18	46	2.1		
23	3 7	.6 263	3	10	19	0.02	52		0 0	0	0.00	(	) 19	52	2.2		
24	7	.9 260	7	10	20	0.02	58		0 0	0	0.00	(	20	58	2.4		
25	5 8	.3 258	2	10	21	0.02	64		0 0	0	0.00	(	21	64	2.5		
26	5 8	.7 254	3	11	22	0.03	72		0 0	0	0.00	(	22	72	2.8		
23	9	.0 250	4	11	23	0.03	80		0 0	0	0.00	(	23	80	3.0		
28	3 9	.4 246	5	11	25	0.04	89		0 0	0	0.00	(	25	89	3.2		
29	9 9	.7 242	7	12	26	0.04	97		0 0	0	0.00	1 0	1 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.

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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<sup>3</sup> 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 ir	n the General	Yield Cla	ass yield t	able have b	peen selected
prior to co	pying.							

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Species	Yield class	Thinning treatment	Initial spacing	Stand area		9			J	ĸ	L	IVI	IN	
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	Late thin							
						age	cycle							
0 years	INTERMEDIATE	30 years	35 years	80 years	INTERMEDIATE	N/A	N/A							
			MAIN CROP after t	hinning			Yield	from T	HINNIN	IGS		CUMUL/ PRODUC	TIVE	MA
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m²	Vol m²/ha	Trees / ha	dbh n cm	BA n²/ha v	Mean vol m³ m	vol >/ha n	BA n²/ha r	Vol n³/ha	Vo m <sup>3</sup> /
20	6.4	2710	8	15	0.0	01 3	3 0	0	0	0	0	15	33	1.
21	6.8	2684	9	17	0.0	01 3	9 0	0	0	0	0	17	39	1
22	2 7.2	2658	9	18	0.0	02 4	6 0	0	0	0	0	18	46	2
23	3 7.6	2633	10	19	0.0	02 5	2 0	0	0	0	0	19	52	2
24	4 7.9	2607	10	20	0.0	02 5	8 0	0	0	0	0	20	58	2
25	5 8.3	2584	10	21	0.0	02 5	4 0	0	0	0	0	21	54	- 2
27	7 9	2545	11	22	0.0	03 8	0 0	0	0	0	0	22	80	-
28	3 9.4	2465	11	25	0.0	04 8	9 0	0	0	0	0	25	89	3
29	9 9.7	2427	12	26	0.0	04 9	7 0	0	0	0	0	26	97	3
30	0 10.1	1693	11	20	0.0	05 7	7 696	11	7	0.04	28	27	105	3
31	1 10.4	1693	13	21	0.0	05 8	7 0	0	0	0	0	28	115	3
32	2 10.8	1693	12	23	0.0	9	7 0	0	0	0	0	30	125	3
34	4 11.4	1693	14	25	0.0	07 11	7 0	0	0	0	0	32	145	-
35	5 11.8	1219	15	21	0.0	08 9	9 474	13	6	0.06	28	34	155	4
36	5 12.1	1219	15	22	0.0	09 11	0 0	0	0	0	0	35	166	- 4
37	7 12.4	1219	16	6 23	. 0	.1 12	1 0	0	0	0	0	37	177	- 4
38	8 12.7	1219	16	25	0.	11 13	2 0	0	0	0	0	38	188	
39	y 13 1 13 3	1219	10	26	0.	12 14	5 0	15	5	0.11	28	39	210	
40	1 13.6	953	16	24	0.1	14 13	8 0	0	0	0	0	41	222	5
42	2 13.9	953	18	26	0.:	16 14	9 0	0	0	0	0	43	233	5
43	3 14.2	953	19	27	0.:	17 16	1 0	0	0	0	0	45	245	5
44	4 14.5	953	15	28	0.:	18 17	2 0	0	0	0	0	46	256	5
45	5 14.7	782	20	25	0	.2 15	6 172	17	4	0.16	28	47	268	5
46	5 15	782	21	27	0.	21 16	7 0	0	0	0	0	49	279	6
4/	15.3	782	21	28	0.1	23 1/	· · ·	0	0	0	0	50	291	6
49	9 15.8	782	22	30	0.3	26 20	2 0	0	0	0	0	52	314	6.
50	16.1	661	23	28	0.3	28 18	6 121	20	4	0.23	28	53	326	6.
51	1 16.3	661	. 24	29	0	.3 19	7 0	0	0	0	0	54	337	6.
52	2 16.5	661	. 24	30	0.3	32 20	8 0	0	0	0	0	56	348	6.
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<sup>3</sup>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.

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1	Species	Yield class	Thinning treatment	Init	ial spacing	Stand area											
2	Scots pine	10	Intermediate	2.4	1.8	1			1 - 1 - 11								
3	1st thin delay	1st thin type	1st thin age	2nd	thin age	Max MAI ag	e Sub thi	in type	Late thin age	cycle							
4	0 years	INTERMEDIATE	26 years	31 y	ears	71 years	INTERM	EDIATE	N/A	N/A							
5				MA	N CROP after t	hinning				Yie	eld fror	n THINN	NGS			TION	MAI
	Age yrs	Top ht m	Trees /ha	4	lean dbh cm	BA m²/ha	Mea	n vol m²	Vol m²/ha	Trees /ha	Mean dbh	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha i	Vol n³/ha	Vol m³/ha
6		21 0	2	2590	10	-									22	65	2.1
8		22 8	8	2545	11		3		0.03 7	5 0		0 0	0	0	23	75	3.4
9		23 9	2	2511	11	2	4	0	.03 8	4 0	)	0 0	0	0	24	84	3.7
10		24 9	6	2476	11	2	15	0	0.04 9	4 0		0 0	0	0	25	94	3.9
11		25 1	0	2442	12	2	:7	C	0.04 10	4 0	) (	0 0	0	0	27	104	4.1
12		26 10	4	1553	13	1	9	C	0.05 7	8 855	5 1	1 9	0.04	35	28	113	4.4
13		27 10	8	1553	13	2	1	0	0.06 9	0 0		0 0	0	0	29	125	4.6
14		28 11	2	1553	14	2	2	0	0.07 10	2 0		0 0	0	0	31	137	4.9
15		29 11	5	1553	14		4		10 11	4 U		0 0	0	0	33	149	5.1
10		31 12	3	1069	15		0		0.1 10	3 484	1	4 7	0.07	35	36	173	5.6
18		32 12	6	1069	16		2	c	0.11 11	6 0		0 0	0	0	38	186	5.8
19		33 1	3	1069	17	2	4	C	0.12 12	9 0		0 0	0	0	39	199	6
20		34 13	3	1069	17		5	C	0.13 14	2 0	)	0 0	0	0	41	212	6.2
21		35 13	7	1069	18	2	7	C	0.15 15	6 0	)	0 0	0	0	42	226	6.4
22		36 1	4	814	19	2	13	C	0.16 13	4 254	1	6 5	0.14	35	44	239	6.6
23		3/ 14	4	814	20	2	5	c	.18 14	8 0		0 0	0	0	45	253	5.8
24		39 14	5	814	20	4	8		1.22 17	6 0		0 0	0	0	4/	281	7.2
26		40 15	3	814	21	2	9	0	0.23 19	0 0		0 0	0	0	50	295	7.4
27		41 15	7	657	23	2	:6	0	0.26 16	8 158	1	9 4	0.22	35	51	308	7.5
28		42 1	6	657	23	2	8	C	.28 18	3 0	)	0 0	0	0	53	323	7.7
29		43 16	3	657	24	2	9		0.3 19	7 0		0 0	0	0	54	337	7.8
30		44 16	6	657	24	3	10	C	0.32 21	1 0		0 0	0	0	56	351	8
31		45 16	2	657	25	3	12	0	.34 22	5 0		0 0	0	0	57	365	8.1
32		40 1/	4	549	26	2		L.	0.4 21	• 108	2	- 4 0 0	0.32	35	50	303	0.2
33		48 17	7	549	20		1		0.42 23	2 0		0 0	0	0	61	407	8.5
35		49 1	8	549	28	3	13	0	0.45 24	6 0		0 0	0	0	62	421	8.6
36		50 18	3	549	28	3	14	C	.47 26	0 0		0 0	0	0	63	435	8.7
37		51 18	6	470	29	3	1	C	0.51 23	9 79	2	5 4	0.44	35	65	449	8.8
38		52 18	8	470	30	3	13	C	0.54 25	2 0	)	0 0	0	0	66	462	8.9
39	( ) N Charts ( )	53 19	1	470	30	3	14	C	).57 26	6 0		0 0	0	0	67	476	9
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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.

Tore       Dark       Part land       Dark       Part land       Dark       North       All North       North       All North       North       All North       Nort	X	🛃 🦈 🤊 - (" -  =					SP-L)	YC10-1.8m	n-IT-IT.xls [C	ompatibil	ity Mo	de] - M	icrosoft I	Excel											83
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Fot         Agenerit         Barner         Barner         Barner         Barner         Barner         Barner         Cit         Barner         Cit         Barner           A         B         C         D         E         F         Q         H         J         K         M         M         N         O         P           B         Social         Timing carner         Initial social         Social         Social         Eate thin MA         Late thin MA         Late thin MA         A         H         J         J         K         M         N <th>Pi</th> <th>aste</th> <th>ΒI</th> <th>u -   🖽 -   🎂 -</th> <th><u>A</u>· ≡ ≡</th> <th>建建</th> <th>Merge &amp; C</th> <th>enter +</th> <th><u> </u></th> <th>00. 0.* 0.* 00.</th> <th>Cont</th> <th>ditional</th> <th>Format</th> <th>Goo</th> <th>d</th> <th>Neutral</th> <th></th> <th>÷ i</th> <th>nsert De</th> <th>lete Form</th> <th>at 🧕</th> <th>ill - Ilear -</th> <th>Sort &amp;</th> <th>Find &amp;</th> <th></th>	Pi	aste	ΒI	u -   🖽 -   🎂 -	<u>A</u> · ≡ ≡	建建	Merge & C	enter +	<u> </u>	00. 0.* 0.* 00.	Cont	ditional	Format	Goo	d	Neutral		÷ i	nsert De	lete Form	at 🧕	ill - Ilear -	Sort &	Find &	
A         B         C         D         E         F         G         H         I         J         K         L         M         N         O           Scotp ine         10         Triend case         Initial spacing         Stand area         I <th></th> <th>Clipboard G</th> <th></th> <th>Font</th> <th>6</th> <th>Alignm</th> <th>ent</th> <th>G</th> <th>Number</th> <th>6</th> <th>1 Onia</th> <th>atting - t</th> <th>is tuble -</th> <th></th> <th>Styles</th> <th></th> <th></th> <th></th> <th>Ce</th> <th>ells</th> <th>-</th> <th>E</th> <th>diting</th> <th>Juccu</th> <th></th>		Clipboard G		Font	6	Alignm	ent	G	Number	6	1 Onia	atting - t	is tuble -		Styles				Ce	ells	-	E	diting	Juccu	
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1         Decks         Tree class         Hinding treatment         And is space of the class         Hinding treatment         L2         L3         L4	- 4	A		В	-	С			D	E			F		G	H		1	J	K	L	M	N	0	-
2         Dot         Minimuzation         D         Mark         Dot         D <thd< th=""></thd<>	1	Species	Yi	ield class	Thinning treat	nent		Initial s	pacing	Stand a	rea														
is turn user         is turn user<	2	Scots pine		10	Intermediate			and this	1.0	Max MA	1 200	Sub th	in tune		Late this	Late this									
i       9 years       INTERMEDIAT       NA       NA </th <th>3</th> <th>TSC CIIII GEIBY</th> <th></th> <th>se chin type</th> <th>rst tim age</th> <th></th> <th></th> <th>2110 (1111</th> <th>aye</th> <th>HIGA HIA</th> <th>rage</th> <th>300 (1)</th> <th>in type</th> <th></th> <th>age</th> <th>cycle</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th>	3	TSC CIIII GEIBY		se chin type	rst tim age			2110 (1111	aye	HIGA HIA	rage	300 (1)	in type		age	cycle									
Age vrs         Top hr         Trees ha         Man dbc         Man vb         Man vb         Val vb / vb         Tes h         No         No        No         No         No </th <th>4</th> <th>0 years</th> <th>IN</th> <th>TERMEDIATE</th> <th>26 years</th> <th></th> <th></th> <th>31 years</th> <th></th> <th>71 years</th> <th></th> <th>INTERM</th> <th>EDIATE</th> <th></th> <th>N/A</th> <th>N/A</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th>	4	0 years	IN	TERMEDIATE	26 years			31 years		71 years		INTERM	EDIATE		N/A	N/A									
Age vrs         Top h m         Toes /ha         Mean dbh m         Pan v/n         Pan v/n         Pres /ha         m <sup>2</sup> /n         m <sup>2</sup> /n	5							MAIN C	ROP after t	hinning							Yiel	d from	THINN	NGS		CUMU	ATIVE	MAI	
0         0		Age yrs		Top ht m		frees /ha		Mean	dbh cm	BA m <sup>2</sup>	/ha	Mea	in vol m	3	Vol m³/ha	Trees /	(ha	Mean dbh	BA m²/ha	Mean vol m <sup>3</sup>	Vol m³/ha	BA m²/ha	Vol m³/ha	Vol m³/ha	
1         1         25         11         12         003         55         0 </th <th>6</th> <th></th> <th>21</th> <th>6.0</th> <th></th> <th></th> <th>2590</th> <th></th> <th></th> <th></th> <th>22</th> <th></th> <th></th> <th>0.03</th> <th></th> <th></th> <th>0</th> <th>cm</th> <th></th> <th></th> <th></th> <th></th> <th>65</th> <th>791</th> <th>_</th>	6		21	6.0			2590				22			0.03			0	cm					65	791	_
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10       24       7.0       2476       11       25       0.04       94       0	9		23	7.6			2511		11		24			0.03	8	4	0	0	0 0	0	0	24	84	3.7	
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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.

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		68	19.9			329	38		38		1.06	34	9	0	0	0	0	0	82	661	9.7
		70	20			329	39		40		1.09	35	9	0	0	0	0	0	84	693	9.7
-		70	20.2			329	40		38		1.13	37	2	29	37	3	1.03	29	85	694	9.0
		72	20.5			300	40		38		1.2	36	1	0	0	0	0	0	85	703	9.8
		73	20.7			300	41		39		1.24	37	1	0	0	0	0	0	86	713	9.8
		74	20.8			300	41		40		1.27	38	1	0	0	0	0	0	87	723	9.8
		75	21			300	41		41		1.3	39	0	0	0	0	0	0	88	733	9.8
		76	21.1			279	42		39		1.34	37	4	21	39	3	1.24	26	88	742	9.8
		77	21.3			279	42		39		1.37	38	3	0	0	0	0	0	89	751	9.8
		78	21.4			279	43		40		1.4	39	1	0	0	0	0	0	90	759	9.7
		79	21.5			279	43		41		1.43	40	0	0	0	0	0	0	90	768	9.7
		80	21.7			279	43		41		1.46	40	8	0	0	0	0	0	91	777	9.7
		81	21.8			263	44		40		1.5	39	4	1/	41	2	1.38	23	91	785	9.7
		02	21.9			203	44		40		1.55	40	2	0	0	0	0	0	92	793	9.7
		84	22			263	45		41		1.50	40	7	0	0	0	0	0	93	808	9.6
		85	22.3			263	45		42		1.62	42	4	0	0	0	0	0	94	816	9.6
		86	22.4			250	46		41		1.65	41	2	13	43	2	1.51	20	94	823	9.6
		87	22.5			250	46		41		1.68	41	9	0	0	0	0	0	95	830	9.5
		88	22.6			250	46		42		1.7	42	5	0	0	0	0	0	95	836	9.5
		89	22.7			250	46		42		1.73	43	2	0	0	0	0	0	96	843	9.5
		90	22.8			250	47		43		1.76	43	8	0	0	0	0	0	96	849	9.4
		91	22.9			239	47		41		1.79	42	8	10	44	2	1.66	17	97	856	9.4
		92	23			239	47		42		1.81	43	4	0	0	0	0	0	97	862	9.4
		93	23			239	47		42		1.84	43	9	0	0	0	0	0	97	867	9.3
		94	23.1			239	48		43		1.86	44		0	0	0	0	0	98	873	9.3
		95	23.2			239	48		40		1.00	45	2	8	46	0	1.8	14	98	884	9.2
		90	23.3			231	48		43		1.93	44	7	0	-+0		1.0	1.4	99	889	9.2
		98	23.4			231	49		43		1.95	45	2	0	0	0	0	0	99	894	9,1
		99	23.5			231	49		43		1.98	45	7	0	0	0	0	0	100	899	9.1
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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'<sup>4</sup> can be used in order to produce a bespoke yield table.

<sup>4</sup>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<sup>3</sup> ha<sup>-1</sup> yr<sup>-1</sup>.

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<sup>1</sup>), 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.

Fores	st Yield	(using nev	v Sitka s	pruce yi	eld tabl	es)										
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Coorier	-	tu table ma	ipped in	olli olika	spruce	Thinning I	uer) (ss	fiaem illo	ueij - ro	. 14 - 21	Toitial co	)) Desing	Shar	d area		
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510kd 5	pruce (i			14		Intermed	late					2.0	12.00		•	
1st thin	n delay	1st thin typ	e	1st thi	n age	2nd thin a	ige Ma	ix MAI age	sub th	in type	Ľ	ate thin a	ige Late	thin cyc	le	📑 print
0 years	5	INTERMEDI	ATE	26 yea	ars	31 years	61	years	INTER	MEDIATE	: P	I∕A	N/A			
		1	1AIN CR	OP after	thinnin	g		Yield fr	om THIM	NNINGS			ATIVE	MAI	^	assortment
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²∕ha	Mean vol m³	¥ol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³/ha	BA m²∕ha	¥ol m³∕ha	¥ol m³/ha /yr		
23	7 12	.7 1445	17	33	0.14	195	0	0	0	0.00	0	43	244	9.0		
28	8 13	.2 1439	18	35	0.15	215	0	0	0	0.00	0	45	264	9.4		
29	9 13	.8 1434	18	37	0.16	235	0	0	0	0.00	0	47	284	9.8		
30	0 14	.3 1428	19	39	0.18	256	0	0	0	0.00	0	49	305	10.2		
33	1 14	.9 1009	20	33	0.23	229	414	16	8	0.12	49	51	328	10.6		
32	2 15	.4 1005	21	35	0.25	248	0	0	0	0.00	0	53	347	10.8		
30	3 16	.0 1001	21	36	0.27	268	0	0	0	0.00	0	54	366	11.1		
34	4 16	.5 997	22	38	0.29	288	0	0	0	0.00	0	56	387	11.4		
		.0 993	23	40	0.31	309	0	0	0	0.00	0	57	407	11.6		
35	5 17							1.0		0.04	40		400	11.0		

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

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**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).

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2	Sitka spruce (New Model)	14 Let this tune	Intermediate	2 Ond this are	1 May MAT ago	Cub this has	Late this	Lata this								
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F	Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m <sup>3</sup>	Vol m³/ha	Trees /ha	Mean	BA	Mean	Vol	BA	Vol	Vol	
6									dbh i cm	m²/ha	vol m <sup>3</sup> r	,13/ha	m²/ha n	,13/ha	m³/ha /yr	
7	15	5 5.9	9 2134	11	19	0	1.02 3	8 0	0	0	0	0	19	38	2.5	
8	16	6.5	5 2155	5 11	. 21	. 0	1.02 4	9 0	0	0	0	0	21	49	3.1	
9	17	7 7	7 2175	5 11	23	0	1.03 6	2 0	0	0	0	0	23	62	3.6	
10	10	9 8.2	2109	1 12	2	· ·	1.03 7	0 0	0	0	0	0	25	90	4.2	
13	20	0 8.7	7 2200	13	25	0 0	.05 10	6 0	0	0	0	0	29	106	5.3	
13	3 21	1 9.3	3 2206	5 13	31	. 0	.06 12	4 0	0	0	0	0	31	124	5.9	
14	4 22	2 9.8	3 2202	2 14	4 31	8 0	1.06 14	2 0	0	0	0	0	33	142	6.5	
1	5 23	3 10.4	4 2199	14	35	5 0	.07 16	1 0	0	0	0	0	35	161	7	
10	5 24	4 11	1 2197	1	37	0	1.08 18	2 0	0	0	0	0	37	182	7.6	
11	23	5 12.1	1 1451	11	3	· · ·	1.09 20	5 744	13	10	0.07	49	47	203	8.7	
10	27	7 12.7	7 1445	17	33	3 0	.14 19	5 0	0	0	0	0	43	244	9	
20	28	8 13.2	2 1439	18	35	5 0	.15 21	5 0	0	0	0	0	45	264	9.4	
21	1 29	9 13.8	8 1434	18	37	r 0	.16 23	5 0	0	0	0	0	47	284	9.8	
22	2 30	14.3	3 1428	19	31	0	.18 25	6 0	0	0	0	0	49	305	10.2	
23	3 31	1 14.9	9 1009	20	33	s 0	1.23 22	9 414	16	8	0.12	49	51	328	10.6	
22	32	3 16.4	5 1005	21	31	. 0	.27 26	8 0	0	0	0	0	54	347	11.1	÷.
26	34	4 16.5	5 997	22	38	. 0	.29 28	8 0	0	0	0	0	56	387	11.4	
21	7 35	5 17	7 993	3 23	40	0 0	.31 30	9 0	0	0	0	0	57	407	11.6	
28	36	5 17.5	5 753	3 24	35	5 0	.37 28	1 237	19	6	0.21	49	59	429	11.9	
29	9 37	7 18	3 750	25	36	5	0.4 30	0 0	0	0	0	0	60	447	12.1	
30	38	8 18.5	5 /4/	25	30	5 0	.43 31	9 0	0	0	0	0	62	467	12.3	-
3	35	19	7 /44	26	41		1.40 33	9 0	0	0	0	0	65	487	12.5	+
3	41	1 20	589	28	36	5 0	1.56 33	0 149	22	6	0.33	49	66	527	12.9	
34	42	2 20.5	5 587	29	33	· 0	1.59 34	9 0	0	0	0	0	67	545	13	
35	5 43	3 20.9	585	5 25	31	0	1.63 36	7 0	0	0	0	0	69	564	13.1	
36	5 44	4 21.4	4 582	2 30	40	0 0	1.66 38	6 0	0	0	0	0	70	583	13.2	
31	7 45	5 21.8	580	30	41		0.7 40	5 0	0	0	0	0	71	602	13.4	1
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**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.

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-	Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m <sup>3</sup>	Vol m³/ha	Trees /ha	Mean	BA	Mean	Vol	BA	Vol	Vol	
									dbh	m²/ha	vol m²	m²/ha	m²/ha	m²/ha	m²/ha	
6									cm						/yr	
7	15	5.9	2134	11	. 19	0.02	38	0	0	0	0	0	19	38	2.5	
8	16	6.5	2155	11	. 21	0.02	49	0	0	0	0	0	21	49	3.1	
9	17	7	2175	11	23	0.03	62	0	0	0	0	0	23	62	3.6	
10	18	7.6	2189	12	25	0.03	/5	0	0	0	0	0	25	/5	4.2	
11	19	8.2	2 2194	12	2/	0.04	90	0	0	0	0	0	2/	90	4.8	
12	20	0.7	2200	12	20	0.05	100	0		0	0	0	29	100	5.5	
13	21	9.5	2200	1/	33	0.00	142	0		0			33	142	6.5	
14	23	10.4	1 2199	14	35	0.07	161	0	0	0	0	0	35	161	7	
16	24	11	2197	15	37	0.08	182	0	0	0	0	0	37	182	7.6	
17	25	11.6	2195	15	39	0.09	203	0	0	0	0	0	39	203	8.1	
18	26	12.1	1451	17	32	0.12	176	744	13	10	0.07	49	42	226	8.7	
19	27	12.7	7 1445	17	33	0.14	195	0	0	0	0	0	43	244	9	
20	28	13.2	2 1439	18	35	0.15	215	0	0	0	0	0	45	264	9.4	
21	29	13.8	3 1434	18	37	0.16	235	0	0	0	0	0	47	284	9.8	
22	30	14.3	3 1428	19	39	0.18	256	0	0	0	0	0	49	305	10.2	
23	31	14.9	9 1009	20	33	0.23	229	414	16	8	0.12	49	51	328	10.6	
24	. 32	15.4	1005	21	35	5 0.25	248	0	0	0	0	0	53	347	10.8	
25	33	16	5 1001	21	. 36	5 0.27	268	0	0	0	0	0	54	366	11.1	
26	34	16.5	997	22	38	0.29	288	U	0	0	0	0	56	387	11.4	-
21	40	17.5	753	22	40	0.31	281	237	19	6	0.21	49	59	420	11.0	
28	41	18	750	25	36	0.5/	300	237	19	0	0.21	49	60	447	12.1	
30	43	18.5	747	25	38	0.43	319	0	0	0	0	0	62	467	12.3	÷.
31	44	19	744	26	39	0.46	339	0	0	0	0	0	63	487	12.5	
32	45	19.5	741	26	40	0.48	359	0	0	0	0	0	65	507	12.7	Τ.
33	46	20	589	28	36	0.56	330	149	22	6	0.33	49	66	527	12.9	
34	47	20.5	5 587	29	37	0.59	349	0	0	0	0	0	67	545	13	
35	48	20.9	585	25	39	0.63	367	0	0	0	0	0	69	564	13.1	
36	49	21.4	\$ 582	30	40	0.66	386	0	0	0	0	0	70	583	13.2	
37	50	21.8	3 580	30	41	0.7	405	0	0	0	0	0	71	602	13.4	
38	51	22.3	477	32	37	0.79	375	101	25	5	0.49	49	73	621	13.5	11
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### 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<sup>-1</sup>; a growth rate equivalent to at least yield class 22 (from Table A1.5 on page 82 of the Forest Yield 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.

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7	-	15	5.9		2134	11	1	1	0.02	38	0	0	0	0	0	21	38	2.5	
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10		18	7.6		2189	12	2!	5	0.03	75	0	0	0	0	0	25	75	4.2	
11	1	19	8.2		2194	12	2	7	0.04	90	0	0	0	0	0	27	90	4.8	
12	1	20	8.7		2200	13	2	9	0.05	106	0	0	0	0	0	29	106	5.3	
13	1	21	9.3		2206	13	3	1	0.06	124	0	0	0	0	0	31	124	5.9	
14		23	10.4		2199	14	3	5	0.07	161	ő	ŏ	ő	ő	0	35	161	7	
16		24	11		2197	15	3	7	0.08	182	0	0	0	0	0	37	182	7.6	
17	1	25	11.6		2195	15	3	9	0.09	203	0	0	0	0	0	39	203	8.1	
18	1	26	12.1		1451	17	31	2	0.12	176	744	13	10	0.07	49	42	226	8.7	
19		27	12.7		1445	1/	3.	5	0.14	215	0	0	0	0	0	43	244	94	
20	1	29	13.8		1434	18	3	7	0.16	235	Ő	ŏ	0	ō	ō	47	284	9.8	
22	1	30	14.3		1428	19	3	9	0.18	256	0	0	0	0	0	49	305	10.2	
23	1	31	14.9		1009	20	3	3	0.23	229	414	16	8	0.12	49	51	328	10.6	
24		32	15.4		1005	21	3	5	0.25	248	0	0	0	0	0	53	347	10.8	
25	1	34	16.5		997	21	31	3	0.29	288	0	0	0	0	0	56	387	11.4	
27	· ·	30	17	1	993	23	41	0	0.31	309	0	0	0	0	0	57	407	11.6	-
28		31	17.5		753	24	3	5	0.37	281	237	19	6	0.21	49	59	429	11.9	
29	1	32	18		750	25	3	5	0.4	300	0	0	0	0	0	60	447	12.1	
30		33	18.5		747	25	3	5	0.43	319	0	0	0	0	0	62	467	12.3	
32		35	19.5		741	26	4	2	0.48	359	0	0	0	0	0	65	507	12.7	
33	1	36	20		589	28	31	5	0.56	330	149	22	6	0.33	49	66	527	12.9	
34		37	20.5		587	29	3	7	0.59	349	0	0	0	0	0	67	545	13	
35		38	20.9		585	29	3	9	0.63	367	0	0	0	0	0	69	564	13.1	
36		39	21.4		582	30	4		0.7	405	0	0	0	0	0	70	583	13.2	-
38		40	22.3		477	32	3	7	0.79	375	101	25	5	0.49	49	73	621	13.5	
39		42	22.7	1	475	32	3	9	0.83	393	0	0	0	0	0	74	638	13.6	Ŧ
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### Example 5 - Mixed-species stands

The yield tables in Forest Yield were developed primarily to represent single-species, evenaged 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<sup>3</sup> ha<sup>-1</sup> (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<sup>3</sup> ha<sup>-1</sup> (Figure 41).

The total volume of the stand is therefore:

(2.6 ha × 566 m<sup>3</sup> ha<sup>-1</sup>) + (3.3 ha × 437 m<sup>3</sup> ha<sup>-1</sup>) = 1471.6 m<sup>3</sup> + 1442.1 m<sup>3</sup> = 2913.7 m<sup>3</sup>

or

2913.7 m<sup>3</sup> ÷ 5.9 ha = 493.8 m<sup>3</sup> ha<sup>-1</sup>.

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

🚸 Forest Yield (using new S	iitka spru	ce yield ta	bles)								
<u>File E</u> dit <u>W</u> indow <u>H</u> elp											
🐥 Select yield table (using	, new Sitk	a spruce y	rield table	es)							
	Initial sp	acing		Thinning t	reatment						
Species Douglas fir				Crown					yield table		
Mapped Species									volume assortment		
Douglas fir				C Line 10	) year dela	ıy			values for age		
Yield class 22 보									r clear		
Estimate yield class	(* 1.7m			C Line 5	year delay				toggle		
Top height 0.00 m									- order		
Stand age 0 yrs				C Line(1:	3)						
Month January 💌				🔿 No Thir	nning						
	1 st 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			
										,	

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

🐥 Displ	ay yiel	d table (Di	F - YC 22	2 - 1.7m	- CT - C	T)											×
Species			Yield	class		Thinning (	treatme	nt			Initial s	pacing	Sta	nd area			
Douglas	fir			22		Crown						1.7	1.0	D		🚽 🚽 export	:
1st thin	delay	Lst thin typ	e	1st thi	n age	2nd thin a	ige Ma	ax MAI ag	e Subth	nin type		Late thin a	ige Lat	e thin cyc	le	print	
0 years		CROWN		17 yea	ars	22 years	52	years	CROW	٧N		N/A	N/A			volume	_
	ge Top Trees Mirs ht /ha d		1AIN CR	OP after	thinnin	g		Yield fi	om THI	NNINGS		CUMUL	ATIVE	MAI	^	assortme	nt
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³∕ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha	¥ol m³/ha	¥ol m³/ha /yr			
47	32	4 200	49	38	2.48	498	33	8 46	5	2.12	7:	L 102	1031	21.9			
48	32	7 200	50	39	2.60	521	(	) 0	0	0.00		104	1053	21.9			
49	33	1 200	50	40	2.71	543	(	) 0	0	0.00		105	1076	22.0			
50	33	4 200	51	41	2.82	566	(	) 0	0	0.00		106	1099	22.0			
51	33	7 200	52	43	2.94	589		) 0	0	0.00		108	1121	22.0			
52	34	1 180	53	40	3.08	553	21	. 51	4	2.80	5	9 109	1144	22.0			
53	34	4 180	54	41	3.19	574	(	) 0	0	0.00		110	1165	22.0			
54	34	6 180	55	42	3.31	594	(	) 0	0	0.00		111	1186	22.0			
55	34	9 180	55	43	3.43	615	(	) 0	0	0.00	I	112	1206	21.9			
56	35	2 180	56	44	3.54	636	(	) 0	0	0.00		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).

🐥 Forest Yield (using new S	iitka spru	ce <mark>yi</mark> eld ta	bles)								
<u>File Edit Window H</u> elp											
A Select yield table (using	, new Sitk	a spruce y	ield tabl	es)							
	Initial sp	acing	Ĩ	Thinning t	reatment						
Species Corsican pine	○ 1.4m								yield table		
Mapped Species	@ 2.0m			Interm	ediate				volume assortment		
Corsican pine	C 2.5m								values		
Yield class 16 🚖	○ 3.0m								clear		
Estimate yield class	C 4.5m			C Line(1:	3)						
Top height 0.00 m	○ 2.0×3	.0m W/rov	30						v order		
Stand age 🛛 yrs	○ 2.0x3	.0m W/rov	40								
Month January 💌	○ 2.0×3	.0m W/rov	50	O No Thir	ning						
	C 2.0×3	.0m W/rov	60								
	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	INTERMED	21 years	26 years	56 years	INTERMED	N/A	N/A			

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

\land Displ	ay yiel	d table (Cl	- YC 1	6 - 2m -	IT - IT)											
Species			Yield	class		Thinning I	treatme	Int			Initial s	pacing	Sta	nd area		
Corsican	pine			16		Intermed	iate					2.0	1.0	0		🚽 export
1st thin o	lelay 🗄	Lst thin typ	e	1st thi	n age	2nd thin a	ige M	ax MAI ag	e Subti	nin type		Late thin a	nge Lat	e thin cyc	le	
0 vears			ATE	21 vez	ars	26 vears	5	6 vears	INTER	MEDIAT	E	N/A	N/A	<u>،</u>		
		1	1AIN CR	OP after	thinnin	ng Yield from THINNINGS						ATIVE	MAI	^	volume assortment	
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²∕ha	Mean vol m³	¥ol m³∕ha	Trees /ha	Mean dbh cm	BA m²∕ha	Mean vol m³	¥ol m³/ha	BA m²/ha	¥ol m³∕ha	Vol m³/ha /yr		
46	22.	5 352	35	34	1.04	366	5:	8 31	4	0.93	5:	3 80	700	15.2		
47	22.	8 352	36	35	1.09	384		0 0	0	0.00	1	81	717	15.3		
48	23.	2 352	36	36	1.14	402		0 0	0	0.00	1	82	735	5 15.3		
49	23.	5 352	37	37	1.19	419		0 0	0	0.00	1	) 83	753	15.4		
50	23.	8 352	37	38	1.24	437		0 0	0	0.00	1	84	770	15.4		
51	24	1 313	38	35	1.30	407	4	0 34	4	1.20	41	8 85	788	15.5		
52	24	4 313	38	36	1.35	423		0 0	0	0.00	1	86	804	15.5		
53	24	7 313	39	37	1.41	440		0 0	0	0.00	1	87	821	15.5		
54	25.	0 313	39	38	1.46	456		0 0	0	0.00	1	88 0	837	15.5		
55	25.	3 313	40	39	1.51	472		0 0	0	0.00	1	88 (1	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 (m² 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 <sup>2</sup> ha <sup>-1</sup> ÷ 39.1 m <sup>2</sup> ha <sup>-1</sup> = 0.42
Lodgepole pine	13.7 m <sup>2</sup> ha <sup>-1</sup> ÷ 39.1 m <sup>2</sup> ha <sup>-1</sup> = 0.35
Birch	9.0 m <sup>2</sup> ha <sup>-1</sup> ÷ 39.1 m <sup>2</sup> ha <sup>-1</sup> = 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 Forest Yield 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  $287 \text{ m}^3 \text{ ha}^{-1}$  (Figure 43).

The closest yield table in Forest Yield 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<sup>3</sup> ha<sup>-1</sup> (Figure 45).

The closest yield table in Forest Yield 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<sup>3</sup> ha<sup>-1</sup> (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).

🐥 Forest Yield												
<u>File E</u> dit <u>W</u> indow <u>H</u> elp												
Select yield table										3		
	Initial sp	acing		Thinning t	reatment							
Sitka spruce	C 0.9m			<ul> <li>Interm</li> </ul>	ediate				yield table			
Mapped Species	○ 1.4m								volume assortmen	it		
Sitka spruce	C 1.7m			C Line(1:	3)				values			
Yield class 16 🜩	C 1.8m								Tor age			
Estimate yield class	€ 2.0m			🔿 No Thir	nning					-		
Top height 0.00 m	C 2.1m								order	_		
Stand age 0 yrs	C 2.4m			C Solitar	y Line							
Month January 💌	C 2.6m											
	○ 3.0m			C Solitar	y Line, 5 y	ear delay						
	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	INTERMED	22 years	27 years	57 years	INTERMED	N/A	N/A	1			

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

\land Displa	ay yiel	d table (S	5 - YC 1	6 - 2m - I	IT - IT)											
Species			Yield	class		Thinning	treatme	nt			Initial s	pacing	Sta	nd area		
Sitka spr	ruce			16		Intermed	liate					2.0	1.0	0		🔁 export
1st thin o	jelay	1st thin ty	e	1st thi	n age	2nd thin a	age M	ax MAI ag	e Subtl	nin type		Late thin a	age Lat	e thin cyc	le	print
0 years		INTERMED	IATE	22 yea	ars	27 years	57	'years	INTER	MEDIAT	E	N/A	N//	4		volume
			1AIN CR	OP after	thinnin	g	Yield from THINNINGS						LATIVE	MAI	^	assortment
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³/ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/h	BA m²/ha	¥ol m³/ha	¥ol m³/ha ∕yr		
31	16	.3 855	23	36	0.29	246	(	) 0	0	0.00	1	0 57	358	8 11.5		
32	16	.8 651	25	32	0.33	214	204	1 20	7	0.27	5	6 60	382	2 11.9		
33	17	.4 651	26	34	0.37	238	(	) 0	0	0.00		0 61	406	5 12.3		
34	17	.9 651	26	35	0.40	262	(	) 0	0	0.00		0 63	430	12.7		
35	18	.5 651	27	37	0.44	287		) 0	0	0.00		0 65	455	5 13.0		
36	19	.0 651	28	39	0.48	311	(	) 0	0	0.00		0 67	479	9 13.3		
37	19	.6 525	29	35	0.53	280	120	i 24	6	0.45	5	6 69	504	13.6		
38	20	.0 525	30	37	0.58	303	(	) 0	0	0.00		0 70	523	/ 13.9		
39	20	.5 525	30	38	0.62	326	(	) 0	0	0.00		0 72	550	14.1		
40	21	.0 525	31	40	0.66	349		) 0	0	0.00		0 73	573	3 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).

🚸 Forest Yield											
<u>Eile E</u> dit <u>W</u> indow <u>H</u> elp											
A Select yield table											
Enocios	Initial sp	acing		Thinning t	reatment						
Lodgepole pine	C 1.5m			<ul> <li>Interm</li> </ul>	ediate				yield table		
Mapped Species	C 1.8m								volume assortment		
	@ 2.0m			C Line(1:	:3)				for age		
Yield class 10 🔶	C 2.2m			C No Thi	nning				r clear		
Top height 0.00 m	C 2.4m								C toggle order		
Stand age 0 yrs	C 2.6m			C Solitar	y Line						
Month January 💌	C 3.0m			🔿 Solitar	y Line, 5 y	ear delay					
	0.011										
	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	INTERMED	25 years	30 years	60 years	INTERMED	N/A	N/A			
·											

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

🚸 Displ	ay yiel	d table (LF	- YC 10	) - 2m -	IT - IT)											[	_ 🗆 🛛
Species			Yield	class		Thinning	treatme	nt			Initial s	pacing	Sta	nd area			
Lodgepo	le pine			10		Intermed	iate					2.0	1.0	D		R	export
1st thin o	delay 1	1st thin typ	2	1st thi	n age	2nd thin a	ige Ma	ax MAI ag	e Subth	nin type		Late thin a	age Lat	e thin cyc	le	Ģ	print
0 years	1	INTERMEDI	ATE	25 yea	ars	30 years 60 years INTERMEDIA			MEDIAT	E	N/A	N/A				volume	
		~	AIN CR	DP after	thinnin	g	Yield from THINNINGS						LATIVE	MAI	^	<b>;;;</b> ];	assortment
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²∕ha	Mean vol m³	¥ol m³∕ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³/ha	BA m²/ha	¥ol m³/ha	Vol m³/ha /yr			
31	14.	2 1128	18	28	0.15	168	(	0	0	0.00		) 42	238	7.7			
32	14.	6 1128	18	29	0.16	182	(	0	0	0.00		43	252	7.9			
33	15.	0 1128	18	30	0.17	196	(	0	0	0.00		3 44	266	8.1			
34	15.	4 1128	19	31	0.19	210	(	0	0	0.00		0 46	280	8.2			
35	15.	8 884	20	27	0.21	189	244	17	5	0.14	3	5 47	294	8.4			
36	16.	2 884	20	28	0.23	202	(	0	0	0.00		48	307	8.5			
37	16.	.6 884	21	30	0.24	215	(	0	0	0.00		9 49	320	8.6			
38	16.	9 884	21	31	0.26	228	(	0	0	0.00		50 50	333	8.8			
39	17.	3 884	21	32	0.27	241	(	0	0	0.00		51	346	8.9			
40	17.	7 726	22	28	0.30	219	159	19	4	0.22	3	5 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).

🐥 Forest Yield											(	
<u>Eile E</u> dit <u>W</u> indow <u>H</u> elp												
A Select yield table												
Species Birch ▼ Mapped Species Sycamore Yield class 8 ‡ Estimate yield class Top height 0.00 m Stand age 0 yrs Month January ▼	⊂Initial sp € 1.5m	acing		Thinning t	ediate				volume assortment volues volues volues clear clear clear			
	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	INTERMED	15 years	20 years	45 years	INTERMED	N/A	N/A				

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

\land Displa	ay yiel	d table ma	pped fr	om Birch	i (SY - Y	C 8 - 1.5	im - IT -	IT)								
Species			Yield	class		Thinning	treatme	nt			Initial s	pacing	Sta	nd area		
Sycamor	e			8		Intermed	liate					1.5	1.0	D		ᢇ export
1st thin d	ielay 🗄	lst thin typ	e	1st thi	n age	2nd thin a	age Ma	ax MAI ag	e Subt	hin type		Late thin a	nge Lat	e thin cyc	le	
																Carl print
0 years	:	INTERMEDI	ATE	15 yea	ars	20 years	45	i years	INTER	RMEDIAT	E	N/A	N/A			volume
		1	IAIN CR	OP after	thinnin	g	Yield from THINNINGS					CUMUI	ATIVE	MAI	^	assortment
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³∕ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³/ha	BA m²/ha	¥ol m³∕ha	Vol m³/ha /yr		
31	16.	6 454	22	18	0.28	129	(	0 0	0	0.00	(	0 40	228	7.4		
32	16.	9 454	23	19	0.31	140	(	) 0	0	0.00	(	) 41	239	7.5		
33	17.	2 454	24	21	0.33	151	0	0 0	0	0.00		42	250	7.6		
34	17	5 454	25	22	0.36	162	0	0 0	0	0.00		) 44	261	7.7		
35	17.	8 357	26	19	0.40	144	97	7 23	4	0.29	21	3 45	272	7.8		
36	18.	0 357	27	20	0.43	154		0 0	0	0.00		) 46	281	7.8		
37	18.	2 357	28	21	0.46	163	(	0 0	0	0.00		) 47	290	7.8		
38	18.	4 357	28	22	0.48	173	0	0 0	0	0.00	(	) 48	300	7.9		
39	18.	6 357	29	23	0.51	182	(	0 0	0	0.00	(	) 49	309	7.9		
40	18.	9 294	30	21	0.56	164	64	1 27	4	0.44	21	3 50	319	8.0	¥	

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

 $0.42 \times 287 \text{ m}^3 \text{ ha}^{-1} = 120.54 \text{ m}^3 \text{ ha}^{-1}$  of Sitka spruce (121 m<sup>3</sup> ha<sup>-1</sup>, rounded);  $0.35 \times 189 \text{ m}^3 \text{ ha}^{-1} = 66.15 \text{ m}^3 \text{ ha}^{-1}$  of lodgepole pine (66 m<sup>3</sup> ha<sup>-1</sup>, rounded);  $0.23 \times 144 \text{ m}^3 \text{ ha}^{-1} = 33.12 \text{ m}^3 \text{ ha}^{-1}$  of birch (33 m<sup>3</sup> ha<sup>-1</sup>, rounded).

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

Forest Yield 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.

\land Displ	ay yiel	d table (S	6 - YC 16	- 2m - I	IT - IT) f	ior net sta	and area	a = 0.42	ha							
Species			Yield	class		Thinning	treatme	nt			Initial s	pacing	Sta	nd area		
Sitka spr	ruce			16		Intermed	iate					2.0	0.43	2		n export
1st thin o	delay 🗄	1st thin typ	e	1st thi	n age	2nd thin a	age Ma	ix MAI agi	e Sub th	nin type		Late thin a	ige Lati	e thin cyc	ie	print
0 years	:	INTERMED:	ATE	22 yea	ars	27 years	57	years	INTER	MEDIAT	E	N/A	N/A			
		1	1AIN CRO	)P after	thinnin	ıg	Yield from THINNINGS					CUMUL	ATIVE	MAI	^	assortment
Age yrs	Top ht m	Trees	Mean dbh cm	BA m²	Mean vol m³	¥ol m³	Trees	Mean dbh cm	BA M²	Mean vol m³	¥ol m³	BA m²	¥ol m³	¥ol m³/yr		
32	16.	.8 273	25	13	0.33	3 90	86	20	3	0.27	2	4 25	160	5.0		
33	17.	.4 273	26	14	0.37	7 100	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	3 131	0	0	0	0.00		0 28	201	5.6		
37	19.	.6 221	29	15	0.53	118	53	24	2	0.45	2	4 29	212	5.7		
38	20.	.0 221	30	15	0.58	3 127	0	0	0	0.00		0 30	221	5.8		
39	20.	.5 221	30	16	0.62	2 137	0	0	0	0.00		0 30	231	5.9		
40	21	.0 221	31	17	0.66	5 147	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.

\land Displ	ay yiel	d table (LF	- YC 10	- 2m - I	T - IT) f	or net st	and area	a = 0.35	ha							(	
Species			Yield e	lass		Thinning (	reatme	nt			Initial s	al spacing Stand area					
Lodgepo	le pine			10		Intermediate					2.0 0.			35			export
1st thin o	delay	1st thin typ	e	1st thi	n age	2nd thin a	ige Ma	x MAI age	sub th	nin type		Late thin a	ige Lati	e thin cyc	ie	ģ	print
0 years	:	INTERMEDI	ATE	25 yea	irs	30 years 60 years INTERMED			MEDIAT	E	N/A N/A				-	volumo	
		٩	IAIN CRO	IP after	thinnin	g		Yield fr	om THI	NNINGS		CUMUL PRODU				ä.	assortment
Age yrs	Top ht m	Trees	Mean dbh cm	BA m²	Mean vol m³	¥ol m³	Trees	Mean dbh cm	BA m²	Mean vol m³	¥ol m³	BA m²	¥ol m³	Vol m³/yr			
31	14.	2 395	18	10	0.15	59	0	0	0	0.00	1	0 15	83	2.7			
32	14.	6 395	18	10	0.16	64	0	0	0	0.00	1	0 15	88	2.8			
33	15.	0 395	18	11	0.17	69	0	0	0	0.00	1	0 16	93	2.8			
34	15.	4 395	19	11	0.19	73	0	0	0	0.00	1	0 16	98	2.9			
35	15.	8 309	20	10	0.21	66	85	17	2	0.14	1	2 16	103	2.9			
36	16.	2 309	20	10	0.23	71	0	0	0	0.00	1	0 17	107	3.0			
37	16.	6 309	21	10	0.24	75	0	0	0	0.00	1	0 17	112	3.0			
38	16.	9 309	21	11	0.26	80	0	0	0	0.00	1	0 18	117	3.1			
39	17.	3 309	21	11	0.27	84	0	0	0	0.00	1	0 18	121	3.1			
40	17.	7 254	22	10	0.30	77	56	19	2	0.22	1	2 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.

🚸 Displa	Display yield table mapped from Birch (SY - YC 8 - 1.5m - IT - IT) for net stand area = 0.23 ha															
Species			Yield	class		Thinning I	treatmer	nt			Initial spacing			nd area		
Sycamor	re			8		Intermediate					1.5			3		ᢇ export
1st thin o	ielay	1st thin typ	st thin type 1st thin age		n age	2nd thin age Max MAI age		Sub ti	Sub thin type		Late thin a	ige Late	Late thin cycle		print	
0 years	0 years INTERMEDIATE 15 years				ars	20 years	45	years	INTER	MEDIAT	E	N/A	N/A			
		1	1AIN CR	OP after	thinnin	g		Yield fro	om THI	NNINGS		CUMUL PRODU	ATIVE	E MAI 📥		assortment
Age yrs	Top ht m	Trees	Mean dbh cm	BA m²	Mean vol m³	¥ol m³	Trees	Mean dbh cm	BA m²	Mean vol m³	¥ol m³	BA m²	¥ol m³	¥ol 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<sup>2</sup> ha<sup>-1</sup> basal area and 530 m<sup>3</sup> ha<sup>-1</sup> 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 Forest Yield, 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 Forest Yield 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).

Correst Yield File Edit Window Help											(	_   0 [
🐥 Select yield table												
Species Douglas fir ▼ Mapped Species Douglas fir Yield class 20 ♀ Estimate yield class Top height 0.00 m Stand age 0 yrs Month January ▼	⊂ Initial sp (€ 1.7m	acing		Thinning t C Crown C Line 10 C Line 5 C Line(1: C No Thir	reatment ) year dela year delay 3)	y			values values clear clear corder			
	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				

**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).

🐥 Displ	Display yield table (DF - YC 20 - 1.7m - CT - CT)															
Species			Yield	class		Thinning (	treatme	nt			Initial spacing		Sta	Stand area		
Douglas	fir			20		Crown					1.7			1.00		🔁 export
1st thin (	st thin delay 1st thin type 1st thin age		n age	2nd thin age Max MAI age Sub thin t			in type	Late thin age			Late thin cycle		print			
0 years		CROWN		17 yea	irs	22 years 52 years CROWN		/N		N/A	N/#	N/A				
		۲	AIN CR	OP after	thinnin	g		Yield fr	om THI	NNINGS			LATIVE	MAI	^	assortment
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³∕ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	Vol m³/ha	BA m²/ha	¥ol m³/ha	Vol m³/ha /yr		
48	31.25	2 212	47.359	37.345	2.195	465.34	(	0.000	0.000	0.000	0.00	97.896	955.34	19.903		
49	31.58	4 212	48.154	38.609	2.295	486.48	(	0.000	0.000	0.000	0.00	99.161	976.48	3 19.928		
50	31.91	.6 212	48.936	39.874	2.394	507.62	(	0.000	0.000	0.000	0.00	100.42	997.62	2 19.952		
51	32.24	8 212	49.706	41.139	2.494	528.76	(	0.000	0.000	0.000	0.00	0 101.69	1018.3	7 19.976		
52	32.58	0 188	50.790	38.150	2.626	494.40	24	47.800	4.253	2.342	55.50	0 102.95	1039.9	9 19.998		
53	32.86	6 188	51.540	39.285	2.729	513.92	(	0.000	0.000	0.000	0.00	104.09	1059.4	19.989		
54	33.15	2 188	52.279	40.420	2.833	533.44	(	0.000	0.000	0.000	0.00	105.22	1078.9	9 19.980		
55	33.43	8 188	53.008	41.555	2.937	552.96	(	0.000	0.000	0.000	0.00	106.36	1098.4	19.972		
56	33.72	4 188	53.727	42.690	3.040	572.48	(	0.000	0.000	0.000	0.00	0 107.49	1117.9	9 19.964		
57	34.01	0 172	54.640	40.425	3.153	543.60	16	52.020	3.401	3.025	48.40	108.63	1137.5	5 19.956	¥	

It is apparent from Forest Yield 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<sup>2</sup> ha<sup>-1</sup> - 99.161 m<sup>2</sup> ha<sup>-1</sup> = 3.789 m<sup>2</sup> ha<sup>-1</sup>

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

1039.9 m<sup>3</sup> ha<sup>-1</sup> - 976.48 m<sup>3</sup> ha<sup>-1</sup> = 63.42 m<sup>3</sup> ha<sup>-1</sup>

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

and

standing volume (52 years) = 530 m<sup>3</sup> ha<sup>-1</sup> + 63.42 m<sup>3</sup> ha<sup>-1</sup> = 593.42 m<sup>3</sup> ha<sup>-1</sup> = 593 m<sup>3</sup> ha<sup>-1</sup>, 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<sup>2</sup> ha<sup>-1</sup> ÷ 253 = 0.18098 m<sup>2</sup>

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 Forest Yield 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 Forest Yield **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 Forest Yield 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	B Displaying the relevant part of the unrounded annual yield table	e for oak, yield class 6,
1.2 m initia	ial spacing, intermediate thinning.	

\land Displ	Display yield table (OK - YC 6 - 1.2m - IT - IT)																
Species			Yield	class		Thinning (	treatme	nt			Initial s	pacing	St	and area			
Oak				6		Intermediate					1.2 1.0			00	00		export
1st thin o	1st thin delay 1st thin type 1st thin age		n age	2nd thin age Max MAI age			e Subti	Sub thin type Late thin age			age La	ite thin cyc	le	- C	print		
0 years		INTERMEDI	ATE	25 yea	ars	30 years 80 years INTERMEDIAT				MEDIAT	E	N/A N/A				-	volumo
		1	IAIN CR	OP after	thinnin	g		Yield fr	om THI	NNINGS						<b></b>	assortment
Age yrs	Top ht m	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³∕ha	Trees /ha	Mean dbh cm	BA m²/ha	Mean vol m³	¥ol m³/h	BA m²/ha	¥ol m³/h	a <sup>Vol</sup> m³/ha /yr			
78	23.06	0 279	33.548	24.679	0.893	249.40	(	0.000	0.000	0.000	0.00	0 64.736	467.8	0 5.997			
79	23.18	0 279	33.851	25.127	0.915	255.40	(	0.000	0.000	0.000	0.00	0 65.185	473.8	0 5.997			
80	23.30	0 246	34.900	23.523	0.978	240.40	33	28.100	2.053	0.634	21.00	0 65.634	479.8	5.998			
81	23.42	0 246	35.209	23.942	1.001	246.08	(	0.000	0.000	0.000	0.00	0 66.052	485.4	8 5.994			
82	23.54	0 246	35.516	24.361	1.024	251.76	(	0.000	0.000	0.000	0.00	0 66.471	491.1	.6 5.990			
83	23.66	0 246	35.820	24.780	1.047	257.44	(	0.000	0.000	0.000	0.00	0 66.890	496.8	4 5.986			
84	23.78	0 246	36.122	25.199	1.070	263.12	(	0.000	0.000	0.000	0.00	0 67.309	502.5	5.982			
85	23.90	0 218	37.170	23.601	1.139	247.80	28	30.230	2.017	0.747	21.00	0 67.728	508.2	0 5.979			
86	24.00	0 218	37.479	23.995	1.164	253.18	(	0.000	0.000	0.000	0.00	0 68.122	513.5	8 5.972			
87	24.10	0 218	37.785	24.389	1.189	258.56	(	0.000	0.000	0.000	0.00	0 68.516	518.9	6 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<sup>3</sup>.

The biomass of the average oak stem is calculated as  $0.56 \times 1.024$  m<sup>3</sup> = 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:* 

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 Forest Yield (see Figure 53) as the input into this equation. Hence:

crown biomass  $_{(7 \text{ cm} \le dbh \le 50 \text{ cm})} = 0.0000168513 \times (35.516^{2.4767})$ = 0.11657 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*:

root biomass (dbh > 30 cm) = -0.174882004 + (0.009559391 × dbh)

where dbh is diameter at breast height in centimetres.

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

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

#### Step 4

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

stem biomass + crown biomass + root biomass = 0.57344 + 0.11657 + 0.16463 = 0.85464 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  $210.2 \times 0.5 = 105.1$  tonnes C ha<sup>-1</sup> in this hypothetical stand.

# Appendix 1 Tree species in Forest Yield

**Table A1.1** The 61 conifer tree species included in Forest Yield, 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	СР
Bhutan pine	Pinus wallichiana	-	SP
Bishop pine	Pinus muricata	BIP	СР
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	<b>Pinus nigra ssp. laricio</b> (syn. Pinus nigra var. maritima)	СР	СР
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	-	СР
Lodgepole pine	Pinus contorta var. latifolia	LP	LP
Macedonian pine	Pinus peuce	МСР	СР
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	СР
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	-	СР
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 Forest Yield, 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	Mapped to species
Ach	Freedom encoloion	ALL	cv
Asn	Praxirius excession	АН	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	-	ОК
Cider gum	Eucalyptus gunnii	-	SY
Common alder	Alnus glutinosa	AR	SY
Common lime	Tilia × europaea	LI	SY
Common walnut	Juglans regia	-	ОК
Cork oak	Quercus suber	-	OK
Crab/wild apple	Malus sylvestris	-	ОК
Crack willow	Salix fragilis	-	ОК
Downy birch	Betula pubescens	BI	SY
Downy oak	Quercus pubescens	-	ОК
Eastern cottonwood	Populus deltoides	-	PO
English elm	Ulmus procera	-	BE
Field maple	Acer campestre	FM	SY
Goat willow	Salix caprea	-	ОК
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	-	ОК
Hazel	Corylus avellana	-	SY
Holly	Ilex aquifolium	-	ОК
Holm oak	Quercus ilex	-	ОК
Hornbeam	Carpinus betulus	HBM	BE
Horse-chestnut	Aesculus hippocastanum	-	SY
Hungarian oak	Quercus frainetto	-	ОК
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.	ОК	ОК

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	ХВ	SY
Other cherry	Prunus spp.	-	ОК
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	РО
Other walnut	Juglans spp.	-	ОК
Other willow	Salix spp.	-	ОК
Paper birch	Betula papyrifera	-	SY
Pedunculate oak	Quercus robur	-	ОК
Pin oak	Quercus palustris	-	ОК
Pyrenean oak	Quercus pyrenaica	-	ОК
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	-	ОК
Service-tree	Sorbus domestica	-	ОК
Sessile oak	Quercus petraea	-	ОК
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	ТОК	ОК
White ash	Fraxinus americana	-	SY
White oak	Quercus alba	-	ОК
White poplar	Populus alba	-	PO
White willow	Salix alba	-	ОК
Whitebeam	Sorbus aria	-	ОК
Wild cherry/gean	Prunus avium	-	ОК
Wild service-tree	Sorbus torminalis	-	ОК
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  $100 \text{ m} \times 100 \text{ m} = 10000 \text{ m}^2$  (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.

Forest Yield 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 Forest Yield software is supported by a comprehensive user manual and this booklet, which sets out the essential principles of forest mensuration, growth and yield. Forest Yield will be of use to forest and woodland managers and practitioners, researchers and students.



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