CHAPTER 8 - GROWTH MODELS

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The development of yield equations and growth models for eucalypt species has assisted the development of silvicultural regimes for the production of pulp wood or appearance grade sawn timber from butt logs in pruned and thinned stands. Growth and yield models have been developed for some of the eucalypt species grown in New Zealand. Growth models are available for *E. saligna* and *E. nitens*, although *E. saligna* is no longer used in large scale plantations in this country. Although pulpwood and sawlog regimes have been devised for *E. nitens*, without validation datasets predictions of growth rate and yield for this species need to be treated with caution because of the wide regional variation in growth patterns and the influence of pests and disease.

Growth and yield models have been developed for *E. fastigata* and a group of four species known as stringybarks. Present models are based on data derived mainly from young stands that have not been re-measured many times. Data from the very few existing older stands may or may not be representative of the types of sites and seedlots being planted more recently. Predictions, especially for *E. fastigata*, are therefore tentative until more information becomes available from older stands and the models can be refined. Most of the *E. fastigata* stands examined are less than 20 years old. Models for stringybarks are based on data collected from stands of the true stringybarks *E. eugenoides*, *E. globoidea*, and *E. muelleriana* as well as *E. pilularis* which appears to grow at a similar rate. Most of the stringybark information comes from stands younger than age 36 in Northland, Coromandel and Bay of Plenty.

Prototype *E. fastigata* growth and yield models

Used in combination to make predictions of productivity over a wide range of stockings, sites and ages, the models, even though they require refinement, do provide a tool which can be used to evaluate silvicultural regimes. They indicate trends in the effects that site quality, stocking and harvest age have on total standing volume and average tree size at harvest. Basic log grade recovery models can give some idea of the way in which the predicted total standing volume at harvest will be allocated to sawlogs, pulp and waste.

Second generation growth models have been developed by the Scion/industry eucalypt cooperative that has incorporated a much larger data set from central North Island forests.

Data used to develop the models has come from permanent sample plots, regime trials and MARVL (Method of Assessing Recoverable Volume by Log type) plots located between the Northland and Nelson/Marlborough regions (Table 17).

Table 17: Location, age and mean annual increment (MAI) of *E. fastigata* stands used to provide data for prototype growth and yield model.

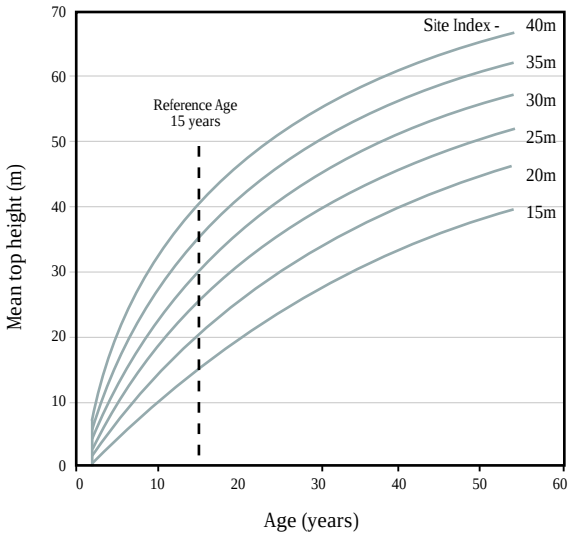
Region	Number of Permanent Sample Plots	Number of MARVL Plots	Total Number of Plots	Maximum Age (yr)	Maximum MAI (m^3/ha)
Northland	12		12	9.4	49.4
Bay of Plenty	18	1	19	18.2	41.2
Central North Island	34	27	61	66	38.6
East Coast		13	13	19	37.5
Wanganui/Manawatu		2	2	61	24.9
Nelson/Marlborough	2	2	4	60	19.4
All data	**66**	**45**	**111**		

A summary of the Site Index data derived from these plots for use in the model database is shown in Table 17.

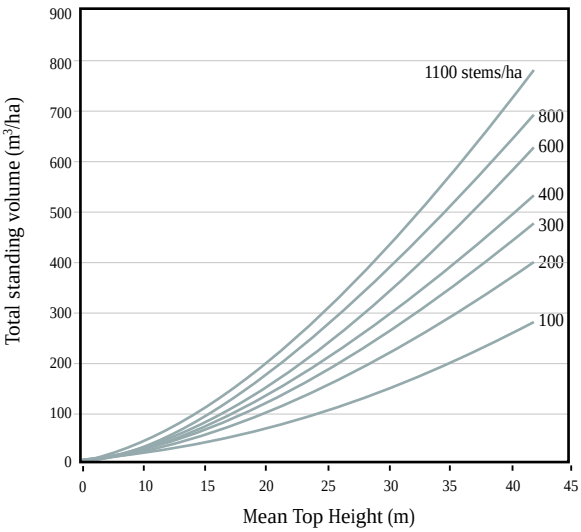
Table 18: Site Index data (mean top height at age 15) used in the development of prototype *E. fastigata* growth and yield models.

Region	Total no. of plots	Average	Minimum	Maximum	Standard deviation
Northland	12	34.2	32.0	38.5	2.2
Bay of Plenty	19	30.2	26.3	36.5	2.8
Central North Island	61	25.1	19.7	30.7	2.4
East Coast	13	23.7	17.8	26.9	3.3
Wanganui/Manawatu	2	18.5	17.8	19.2	1.0
Nelson/Marlborough	4	22.1	19.2	25.7	3.0
All data	**111**	**26.6**	**17.8**	**38.5**	**4.4**

Current model prediction curves for volume yield of *E. fastigata*

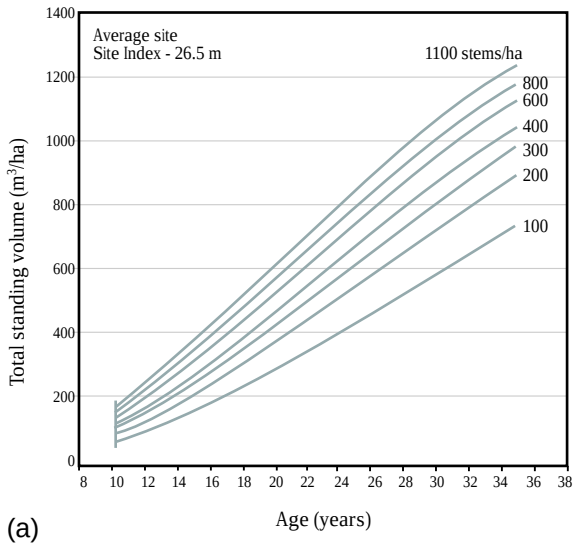


Prediction curves for Mean Top Height derived from plot data

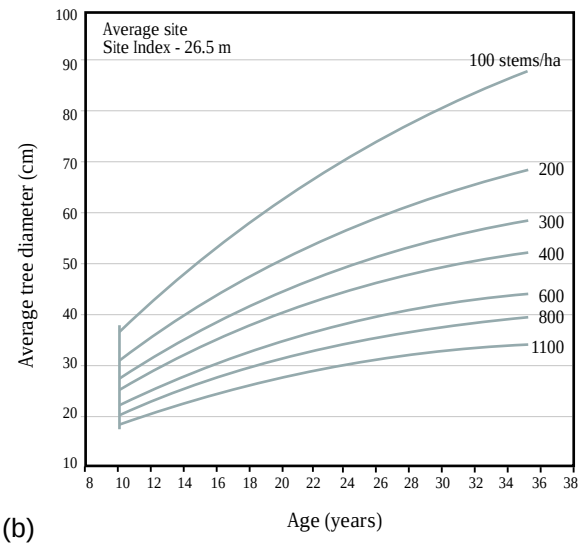


Values for Mean Top Height in the database were used to generate curves predicting total standing volume for a range of stocking rates

A volume growth model has also been developed to predict stand growth beyond the range shown.

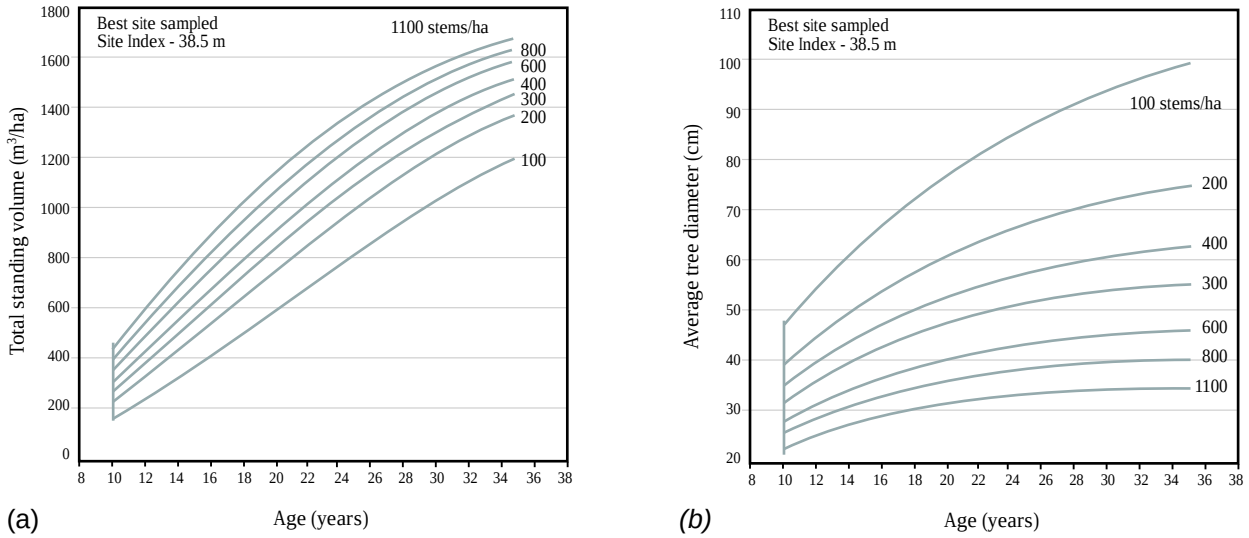


(a)

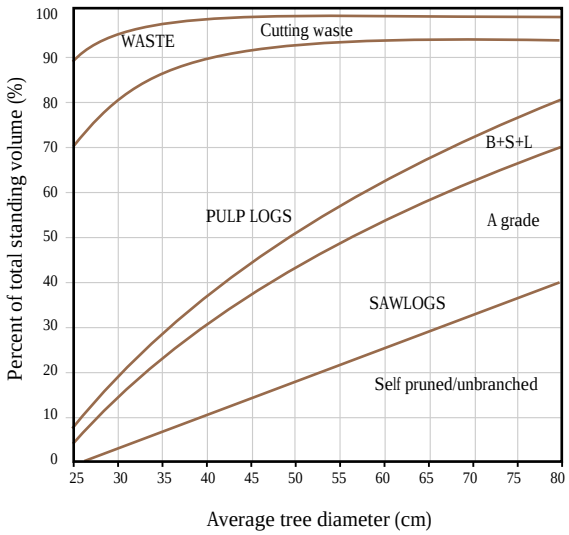


(b)

Current model prediction curves for (a) total standing timber volume and (b) mean tree diameter of E. fastigata grown on sites with an average (Site Index = 26.5 m)



Current model prediction curves for (a) total standing timber volume and (b) mean tree diameter of E. fastigata grown on high-quality sites (Site Index = 38.5m)



Current model prediction curves for log grade recovery from *E. fastigata* stands.

Log grade recovery models for *E. fastigata*, as shown in the graph above demonstrate the strong influence of average stem diameter on predicted results. For example, the total standing timber volume in stands with a mean stem diameter of 40 cm can be expected to contain 35% sawlog material and 55% pulpwood. The ratio for stands with mean stem diameter of 60 cm is 60% sawlogs and 33% pulpwood.

The recovery model curves shown can be used to divide predicted total standing volume into basic log grades. The results will be indicative only, because the models are based on data from 45 stands, most of which were young, with relatively high stockings. Over prediction of the recovery of sawlog volumes could be expected if trees are grown at wide spacings.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Current (2008) stringybark growth and yield models

Stringybark models are based on a smaller dataset than the *E. fastigata* models. They include information from stands of *E. eugenoides*, *E. globoidea*, *E. muelleriana* and also *E. pilularis*, a species that is similar to the true stringybarks. Although predictions may be unreliable for a given site, the indication of trends in growth and yield should be useful for general evaluation of silvicultural regimes.

Data used to develop the current stringybark models has come from permanent sample plots and MARVL plots scattered around Northland and the Coromandel/Bay of Plenty regions (Table 19).

Table 19: Location, age and mean annual increment (MAI) of stringybark stands used to provide data for current growth and yield models

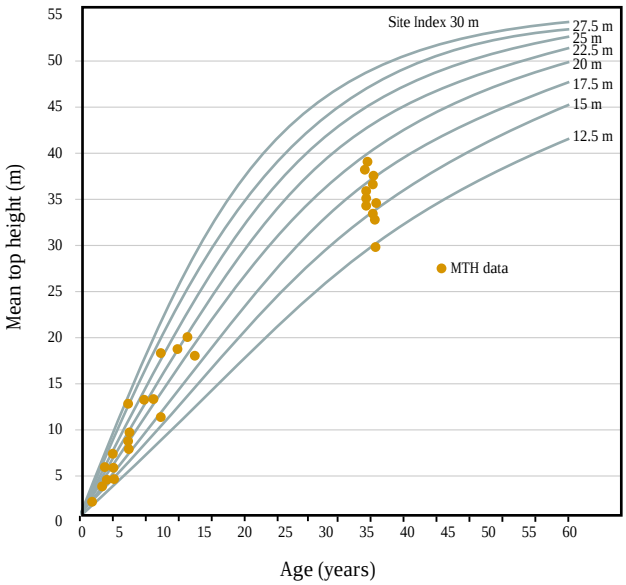
Region	Species	Number of Permanent Sample Plots	Number of MARVL Plots	Tree age (yr)		Maximum MAI (m^3/ha)
				Mean	Range	
Northland	*E. pilularis*	9	1	8.4	3 - 60	35.4
	E. muelleriana	6		6.6	3 - 14	9.7
	E. globoidea	4		4.4	3 - 6	6.3
Coromandel and Bay of Plenty	*E. pilularis*		3	35.3	35 - 36	11.8
	E. muelleriana		8	35.4	35 - 36	33.2
	E. globoidea/E. eugenoides		4	36.0	36 - 36	18.8
All data		**19**	**16**	**14.5**	**3 - 60**	**35.4**

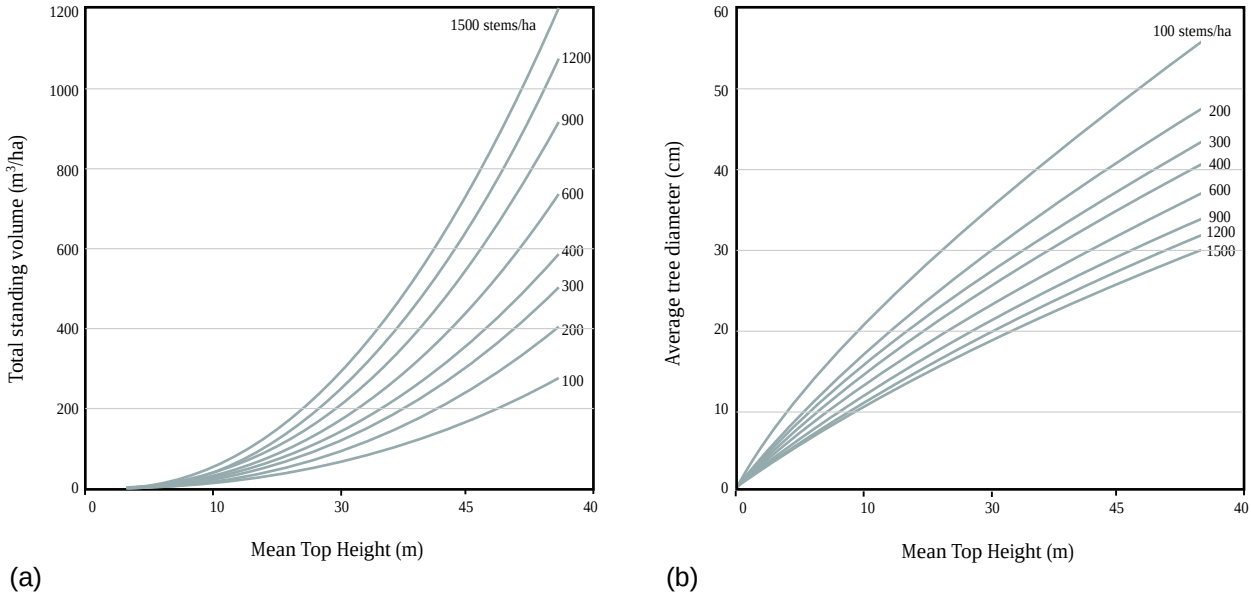
A summary of the Site Index data derived from these plots for use in the model database is shown in Table 20.

Table 20: Site Index data (mean top height at age 15) used in the development of current stringybark growth and yield models

Region	Species	Total no. plots	Average site index (m)	s.d. (m)	Min. (m)	Max. (m)
Northland	*E. pilularis*	10	25.2	4.8	18.8	32.6
	E. muelleriana	6	22.4	3.2	17.6	27.6
	E. globoidea	4	23.8	3.8	21.1	29.3
Coromandel and Bay of Plenty	*E. pilularis*	3	16.6	0.7	16.0	17.5
	E. muelleriana	8	17.9	1.4	15.6	19.6
	E. globoidea	4	14.1	1.1	12.5	14.8
All data		**35**	**20.9**	**5.0**	**12.5**	**32.6**

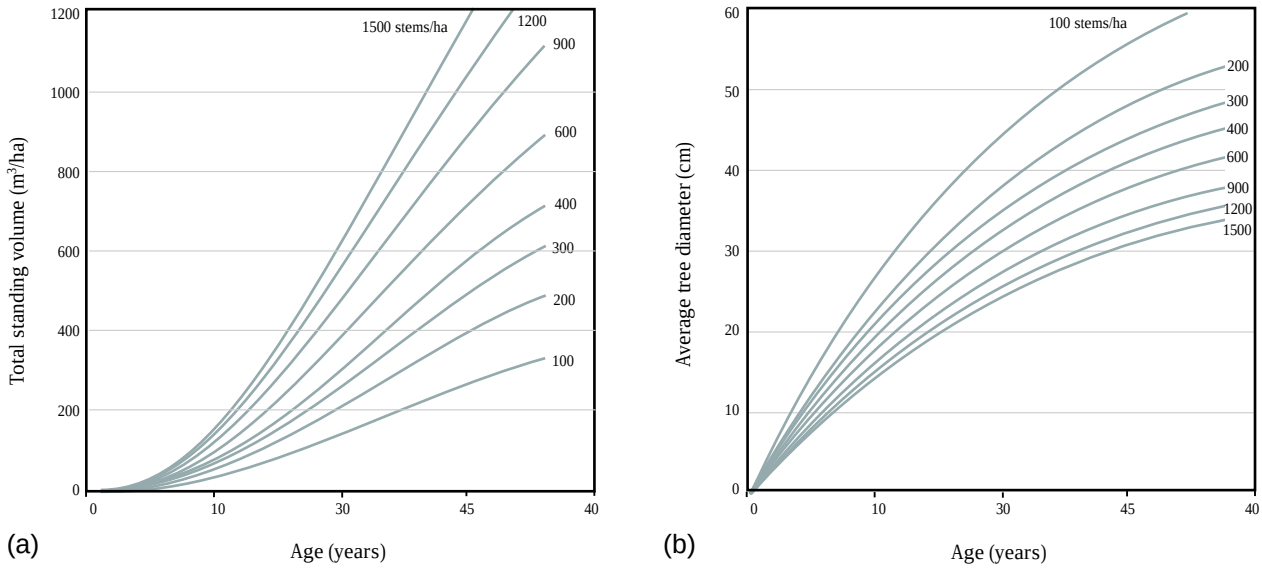
Current model prediction curves for Mean Top Height of stringybarks derived from plot data



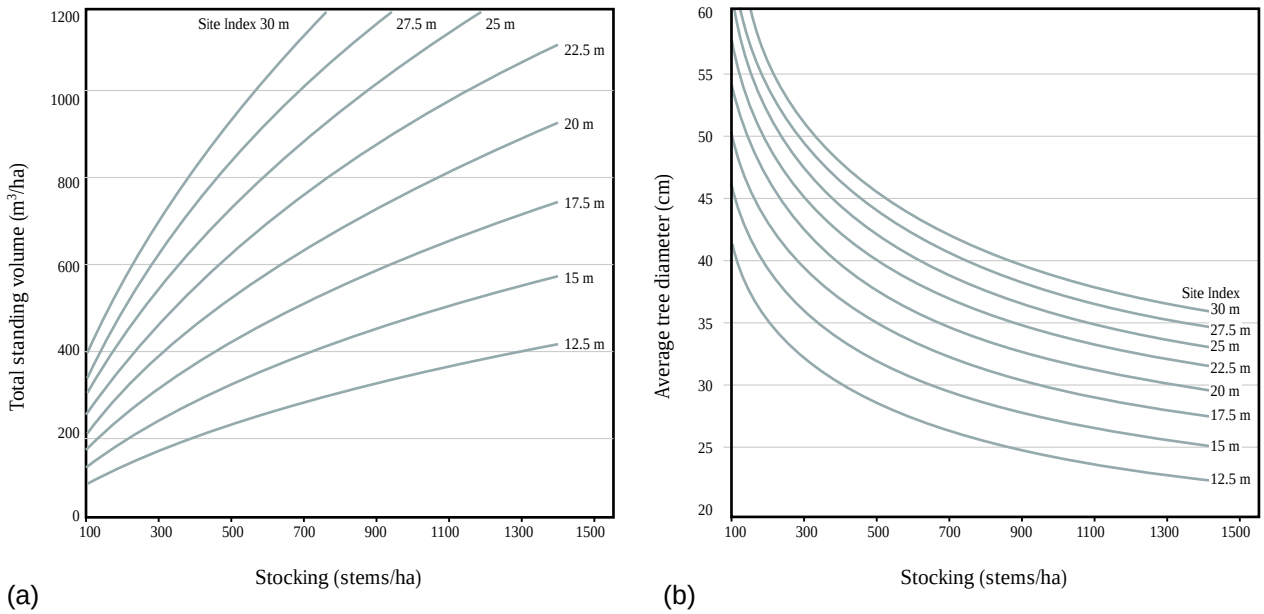


(a) Volume and (b) stem diameter prediction curves for stringybarks over a range of stocking rates. Testing has indicated that errors of 20-50% can be expected from these unrefined models.

Volume yield models and tree size models were used in combination with the height growth model to predict Total Standing Volume and average stem diameter for sites of average quality and also for a range of Site Index estimates and stocking rates at tree age 30.



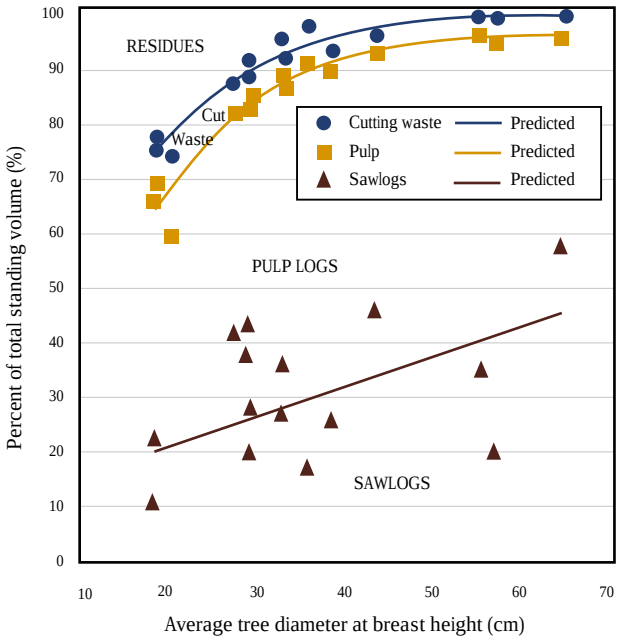
Current model prediction curves for (a) total standing volume and (b) mean tree diameter of stringybarks over a range of final crop stockings on average sites (Site Index = 21 m)



Current model prediction curves for (a) Total Standing Volume and (b) mean tree diameter of stringybarks over a range of Site Index estimates and stocking rates at tree age 30.

Log grade recovery models again demonstrate the influence of average stem diameter on predicted results. For example, the total standing timber volume in stands with a mean stem diameter of 40 cm can be expected to contain 30% of sawlog material and 60% pulpwood. The ratio for stands with mean stem diameter of 60 cm is 45% sawlogs and 50% pulpwood.

Predictions from recovery models in the graph shown below can be used to divide up the total standing volume predictions into basic log grades. The results will be indicative only, because the models are based on data from only 16 stands. Values for sawlog recovery vary widely between plots. More growth and yield data are needed to test and improve the models presented here.



Current model prediction curves for log grade recovery from stringybark stands.

Key Points

- Growth and yield models are available for *E. nitens* and *E. saligna*. Regional variation in growth patterns means that without validation datasets at a regional level current *E. nitens* models need to be treated with caution.
- Models have being developed for *E. fastigata* with second generation models developed by the Scion/ industry eucalypt cooperative (now in FFR).
- Models have been developed for a group of species consisting of *E. eugenoides, E. globoidea, E. muelleriana* and *E. pilularis* (stringybarks). Current databases for these species do not cover the complete age range. Until the models can be refined, they indicate trends rather than reliable predictions of the effects of silvicultural procedures.

Suggested reading:

Berrill & Hay 2006

Candy 1997

Deadman & Goulding 1979

Fry 1983

McKenzie & Hay 1996