A COPPICE WITH STANDARDS SYSTEM ADAPTED TO EUCALYPTUS PLANTATIONS FOR RURAL COMMUNITIES

M. Reynders

State University, Faculty of Agricultural Sciences, Department of General and Comparative Silviculture.
Research Centre for Silviculture, Forest Management and Forest Policy.

Abstract

Coppice with standards might be the most appropriate management system for Eucalyptus plantations established to fulfil the needs of rural communities in developing countries.
In Rwanda trials were established comparing pure coppice and high forest to coppice with standards with different densities of standards. The analysis was made of the production of the coppice, the production of the reserves and the total production of each treatment. The lack of significant difference between the total production of treatments allows a great freedom of action to the silviculturist and the choice of the management system should depend on the valorization possibilities of the thinning products.

INTRODUCTION

Ninety per cent of the population of developing countries uses fuelwood as energy for domestic use. There are presently approximately 100 million people living in areas where the minimum energy need can not be satisfied, while one billion people live in regions with a growing deficit of fuelwood and where the minimum need can only be satisfied by overcutting existing forests.

In the developing countries, in the tropics and subtropics, mainly eucalypts are used for fuelwood plantations, because they are fast growing and coppice easily. The great majority of the 4 million hectares of eucalypt plantations in the world are or will be managed as coppice crops, as the objective of the management is quantity rather than quality.
The advantages of the coppice system are mainly that the management does not require much silvicultural knowledge and that the strong growth of the coppice allows short rotations. The disadvantages however are those proper to a clear felling and the production of small timber.

The coppice with standards system is a management system aiming at the simultaneous production of small sized timber from the coppice and big sized timber from the standards. The forest consists of two elements, the coppice constitutes the lower story and the standards or reserves form the upper story. This management system aims at a multiple use and both coppice and standards have an economical function.
The simultaneous use of two essentially different regeneration methods is typical for the coppice with standards system. The coppice regenerates vegetatively from the stumps while the standards regenerate generatively by natural seeding, although sometimes use is made of planting and recruitment of standards can be done by reserving good coppice shoots from young stumps.

The starting point of the management is the coppice which is clear felled with regular intervals.
In the classical, european, coppice with standards system, at the occasion of the felling of the coppice there is a selective cutting of the standards and further recruitments are made to their number. The standards are varying in age and size according to multiples of the coppice rotation.

There are thus several age classes in well defined proportions in order to assure the continuity of growth and stock and mixtures of species are normally used.

In the selection of a management system for Eucalyptus plantations for rural communities in developing countries the following criteria have to be considered :

- The immediate and short term needs are the production of firewood and small sized timber. These prodcucts can be obtained from coppice.
- Taking into account the evolution of the population and a beginning of industrialization it is imperative to create a timber reserve. The standards can fulfil this need.
- Furthermore, the management system has to be simple of conception as well as of its application in order to allow its implementation by little qualified personnel.

The classical conception of coppice with standards cannot be considered as too much importance is given to the reserve and its application supposes the availability of qualified personnel.

Information on management of Eucalyptus plantations with the coppice with standards system is very scarce.
In 1954 FAO published the first edition of " Eucalyptus for Planting ", written by André METRO. This book was constantly used by foresters in many countries. Because of developments in the area of eucalypt plantations as well as in technics of planting, work on a second edition was started in 1974 and a " Draft " for the second edition of " Eucalyptus for Planting " was ready in 1976. In this draft approximately one page was dedicated to " The use of coppice with standards with eucalypts ". The information provided was very summary and was in fact nothing more than a short historical review of the classical european coppice with standards forests. The final sentence of the paragraph was however - " Owners of eucalypt coppice crops might well look at coppice with standards as a method of improving the value of part of their investments, but would be advised to approach the matter cautiously as the eucalypts do not tolerate competition with each other very well ".
The new edition of " Eucalypts for Planting " was then published by FAO in 1979 as N° 11 of the FAO Forestry Series. However there was not one word about coppice with standards in the new text. The one page which was in the draft had been omitted, probably because it did not provide factual information, and no reaction had come forward from the readers of the draft.
This leads one to believe that the management of the 4 million hectares of Eucalyptus plantations in the world does not include coppice with standards.

DESCRIPTION OF THE EXPERIMENT

This present situation is in fact not different from the situation I knew when working in Rwanda and Burundi as a silvicultural research officer of INEAC (Institut National pour l'Etude Agronomique au Congo).
I then established trials to study the coppice with standards system in Eucalyptus plantations for rural communities.
In these trials the reserve was created at the first thinning which practically consisted of a clear felling with reservation of some standards.
The second intervention consisted in the clear felling of the coppice and a selective thinning of the standards reducing the overhead canopy in order to permit the sustained growth of the coppice.
The following interventions are of the same nature as the second intervention, that is a clear felling of the coppice and a thinning of the standards.

At the occasion of these interventions there is no recruitment of trees from the coppice for the standards, the standards being selected at the first intervention and thinned at each passage in order to obtain finally a density of a fifty standards per hectare which are maintained till maturity.

The different treatments which were executed and compared were : (first intervention)

- 1. clear felling : pure coppice
- 2. felling with a reserve of 100 trees per hectare : coppice with standards.
- 3. felling with a reserve of 150 trees per hectare : coppice with standards.
- 4. felling with a reserve of 200 trees per hectare : coppice with standards.
- 5. felling with a reserve of 250 trees per hectare : coppice with standards.
- 6. felling with a reserve of 350 to 400 trees per hectare : coppice with standards.
- 7. Control : high forest, with a density of approximately 2000 trees per hectare. This was the standard procedure for Eucalyptus plantations managed by the Forest Service, i.e. at the first intervention reduce the stand to approximately one half of the number of trees planted (planting was 1.5 m by 1.5 m or 4444 trees per hectare).

The trial was established in Forest Service plantation in Rwasave, near Butare in Rwanda at an altitude of 1750 m, mean temperature of 19°C, annual rainfall 1139 mm and a dry season of three months (June, July and August.
The Eucalyptus maïdeni plots were on a slope of 15 to 20 % and the Eucalyptus saligna plots on a slope of 5 to 10 %, both exposed to the south-east. The soil grosso-modo corresponds to a sandy clay.
Treatments were applied on net plots of 25 ares, and randomized.
The first intervention was done at age 5 years 3 months of the plantation (January 1956) and the second at age 10 years (October 1960).

RESULTS OF MEASUREMENTS

The following tables give the data of the different measurements.

Table I. Data for the starting point of the trial, after the 1st intervention. Age : 5 years 3 months.

Number of colums		1	2		3	4	5
Plot Nr.	Species and treatments	Number of trees per hectare	Mean tree		Basal area/ha	Volume/ha	Dominant Height
			Girth (cm)	Volume (dm^3)	(m^2)	(m^3)	(m)
	Eucalyptus saligna						
1	- coppice	0	-	-	-	-	-
2	- coppice with standards	100	46.80	135,04	1,74	13,5	18
3	- coppice with standards	152	49,74	158,55	2,99	24,1	18
4	- coppice with standards	200	44,60	132,90	3,16	26,5	18
5	- coppice with standards	248	40,56	90,10	3,24	22,3	16
6	- coppice with standards	375	41,32	95,55	5,10	35,9	17
7	- high forest	1.648	24,08	29,96	7,60	49,4	17
	Eucalyptus maïdeni						
1	- coppice	0	-	-	-	-	-
2	- coppice with standards	100	41,80	101,57	1,39	10,1	16
3	- coppice with standards	152	35,52	63,46	1,52	9,7	15
4	- coppice with standards	196	37,95	83,59	2,24	16,3	15
5	- coppice with standards	248	34,43	62,93	2,34	15,6	15
6	- coppice with standards	472	34,87	70,31	4,56	33,1	16
7	- high forest	2.480	22,01	24,37	0,56	60,4	16

Table II. Thinning at age 10 years : Results of the measurements of the reserves.

Number of columns		1	2	3	4	5	6	7	8	9	10	11	12	13
Plot	Species and treatments	Before thinning					After thinning					Production of the felling (m^3)	Volume increment per hect. (m^3)	Total heigt of dominant trees (m)
		Number of the trees/ha	Mean tree		Basal area/ha (m^2)	Volume/ha (m^3)	Number of the trees/ha	Mean tree		Basal area/ha (m^2)	Vol./ha (m^3)			
			Girth (cm)	Volume (dm^3)				Girth (cm)	Vol (dm^3)					
	Eucalyptus saligna													
2	Coppice with standards	100	99,60	899,15	7,89	89,9	80	102,50	955,56	6,69	76,4	13,5	76,4	28
3	" " "	152	108,02	1.067,43	14,11	162,2	100	112,20	1155,98	10,02	115,5	46,7	138,1	28
4	" " "	200	92,30	764,29	13,56	152,8	132	95,45	821,22	9,57	108,4	44,4	126,3	28
5	" " "	248	83,54	616,00	13,77	160,2	124	88,22	693,38	7,68	85,9	74,3	137,9	27
6	" " "	368	80,32	626,77	18,89	230,6	164	86,70	737,10	9,81	120,8	109,8	194,7	27
7	High forest	1.432	43,25	151,68	21,32	217,2	232	70,08	447,40	9,07	103,8	113,4	167,8	24
	Eucalyptus maïdeni													
2	Coppice with standards	100	87,60	621,63	6,11	62,1	76	90,78	669,13	4,98	50,8	11,3	52,0	23
3	" " "	152	72,76	422,35	6,40	64,1	100	73,40	430,17	4,28	43,0	21,1	54,4	24
4	" " "	196	72,65	421,01	8,23	82,5	112	72,85	423,44	4,73	47,4	35,1	66,2	24
5	" " "	248	65,48	338,07	8,46	83,8	136	69,26	380,72	5,19	51,7	32,1	68,2	24
6	" " "	464	60,60	322,12	13,56	149,4	224	64,28	366,33	7,36	82,0	67,4	116,3	26
7	High forest	2.408	34,01	88,17	22,17	212,3	316	53,35	265,38	7,16	83,8	126,5	151,9	26

TableIII.Results of mensurations of girths during the second rotation

Number of columns		1	2	3	4	5	6	7	8	9	10
Plot	Species and treatments	Number of trees per hectare		Annual measurements Girth of the mean tree (cm)						Increment of girth of the mean tree (cm)	
		January 1956	October 1960	January 1056	January 1957	December 1957	January 1959	January 1960	October 1960	Total increment in the period january 1956-october 1960	Mean annual increment for the period january 1956-october 1960
	Eucalyptus saligna										
2	Coppice with standards	100	100	46,80	61,40	70,60	83,60	95,80	99,60	52,80	11,11
3	" " "	151	152	49,74	67,63	77,89	90,78	101,84	108,02	58,28	12,27
4	" " "	200	200	44,60	60,00	67,60	78,30	88,00	92,30	47,70	10,04
5	" " "	248	248	40,56	54,03	62,33	72,17	81,12	83,54	42,98	9,05
6	" " "	376	368	41,32	54,41	61,96	70,86	78,47	80,32	39,00	8,21
7	High forest	1.648	1.432	24,08	29,72	33,18	37,83	42,70	43,25	19,17	4,03
	Eucalyptus maïdeni										
2	Coppice with standards	100	100	41,80	57,40	64,80	75,60	82,60	87,60	45,80	9,64
3	" " "	152	152	35,52	48,02	54,86	63,42	69,34	72,76	37,24	7,84
4	" " "	196	196	37,95	50,71	56,12	64,08	69,59	72,65	34,70	7,30
5	" " "	248	248	34,43	45,48	51,37	58,79	63,70	65,48	31,05	6,54
6	" " "	472	464	34,87	44,61	49,27	54,87	59,00	60,00	25,73	5,42
7	High forest	2?480	2?416	22,01	26,59	28,66	31,01	32,96	34,01	12,00	2,53

Table IV? Measurement and volume determination of the coppice at the occasion of the intervention of october 1960.

Number of columns		1	2	3	4	5	6	7	8	9	10
Plot	Species and treatments	Number of trees per hectare	Production of coppice				Stacking factor	Total height of dominant coppice shoots	Standing volume before thinning at age of 10 years		
			Per Stump	Per hectare	Mean annual increment for the period january 1956-october 1960				Reserve	Coppice	Total
			(m^3)	(m^3)	(m^3)	steres		(m)	(m^3)	(m^3)	(m^3)
	Eucalyptus saligna										
1	Coppice	0	0,13	340	70	98	0,72	18	0	340	340
2	Coppice with standards	100	0,13	216	44	62	0,71	18	90	216	306
3	Coppice with standards	152	0,12	198	41	57	0,71	17	162	198	360
4	Coppice with standards	200	0,09	173	35	50	0,70	17	153	173	326
5	Coppice with standards	248	0,08	150	31	44	0,70	16	160	150	310
6	Coppice with standards	368	0,04	103	21	30	0,70	13	231	103	334
7	High forest	1.432	0,01	17	3	4	0,70	8	217	17	234
	Eucalyptus maïdeni										
1	Coppice with standards	0	0,10	298	61	84	0,73	19	0	298	298
2	Coppice with standards	100	0,10	222	46	63	0,72	17	62	222	284
3	Coppice with standards	152	0,09	179	37	52	0,71	16	64	179	243
4	Coppice with standards	196	0,08	156	32	45	0,71	14	82	156	238
5	Coppice with standards	248	0,05	100	20	30	0,69	14	84	100	184
6	Coppice with standards	464	0,04	78	16	23	0,69	13	149	78	227
7	High forest	2.408	0,01	13	2	3	0,69	10	212	13	225

ANALYSIS OF PRODUCTION DATA

The analysis was made of the following data :

- the production of the coppice of each treatment,
- the production of the reserve (standards) of each treatment.
- the total production (coppice + standards) of each treatment.

Calculations were at the 5 percent level, and the analysis was an analysis of variance and the Duncan New Multiple Range Test.

The production of the coppice of each treatment

The calculations are based on the production of the coppice in cubic metres per hectare before the thinning at age 10 years (october 1960), see column 9 of table IV. :

The results of the analysis can be graphically summarized as follows (figure 1). Treatments underscored by the same line are not significantly different.

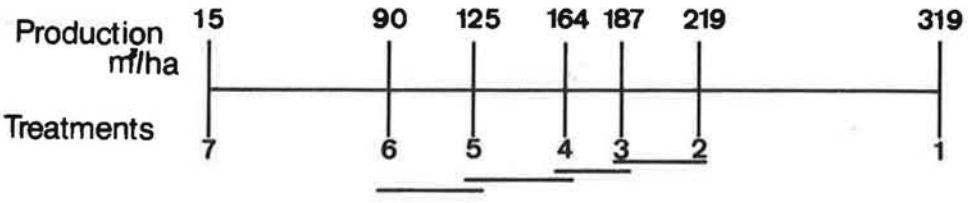


Fig.1

From these results the following conclusions can be made :

- The production of treatment N° 1 (coppice) is significantly different and superior to the coppice production of all other treatments.

- In the coppice with standards treatments, the coppice production of the treatments with reserves of 100 trees per hectare (treatment N°2) and with reserves of 150 trees per hectare (treatment N° 3) are significantly different of the coppice production of the treatments with reserves of 250 trees per hectare (treatment N° 5) and reserves of 400 trees per hectare (treatment N° 6).

- The coppice production of the treatment with a reserve of 200 trees per hectare (treatment N°4) is not significantly different from treatments N°3 and N°5.

The production of the reserve (standards) of each treatment.

The calculations are based on the volume increment per hectare during the period january 1956 - october 1960, see column 12 table II.
The results of the analysis are graphically summarized in figure 2.

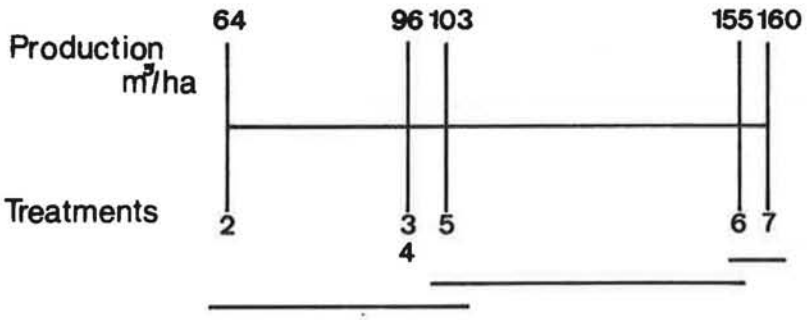


Fig.2

From the results the following conclusions can be made :

- There is no significant difference between the increments of the reserves of the coppice with standards treatments with a low density of reserves (from 100 to 250 trees per hectare, treatments N°2, N°3, N°4 and N°5).

- There is no significant difference between the increment of the reserves of treatment N°6 (coppice with standards with a reserve density of ± 400 trees per hectare) and treatment N°7 (high forest).

- The increments of the reserves of treatments N°6 and N°7 are significantly different and superior to the increments of the reserves of the coppice with standards treatments with reserves of 100,150 and 200 trees per hectare (treatments N°2, N°3 and N°4).

The total production of each treatment

The total production includes :

- the standing volume of the reserves before the thinning at age 10 years (see column 8, table IV),
- and the volume of the coppice before the thinning at age 10 years (see column 9, table IV).

The results of the analysis are graphically summarized below (figure 3).

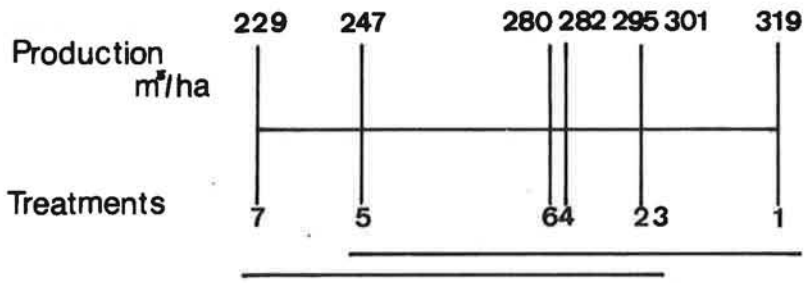


Fig.3

The Duncan Test shows very clearly the lack of significant differences between the production of the different treatments, only the pure coppice is superior to the high forest.

Cumulated frequency distributions of girth

At the occasion of the intervention and at each yearly measurement cumulated frequency distributions of girths have been made.

The aspect of the curves and their displacement allow the study of the stand.
In the following graphs, the x-axis shows the values of the girth at breast height (1.50 m from ground level), and the y-axis the deciles.
The letters and figures in the graphs stand for :

a - cumulated frequency distribution before the thinning of january 1956, at age 5 years 3 months,

1 - cumulated frequency distribution after the thinning of january 1956 at age 5 years 3 months,

2 - cumulated frequency distribution in january 1957,at age 6 years 3 months, 1 year after the thinning,

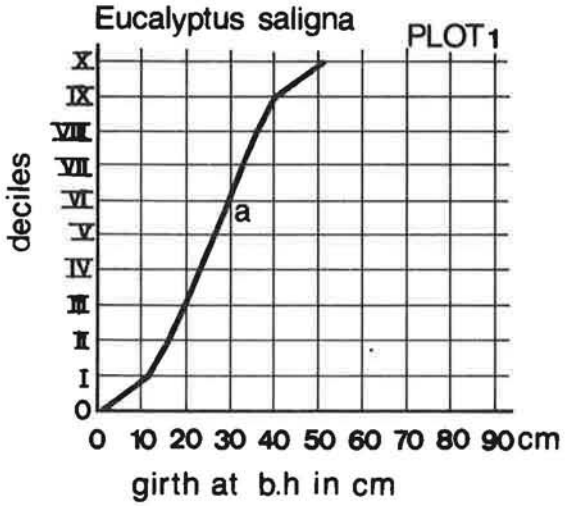
3 - cumulated frequency distribution in de-ember 1957, at age 7 years 2 months, approximately 2 years after the thinning,

4 - cumulated, frequency distribution in january 1959, at age 8 years 3 months, 3 years after the thinning,

5 - cumulated frequency distribution in january 1960, at age 9 years 3 months, 4 years after the thinning,

6 - cumulated frequency distribution in october 1960, at age 10 years, 4 years 9 months after the thinning,

b - cumulated frequency distribution after the thinning of october 1960, at age 10 years.

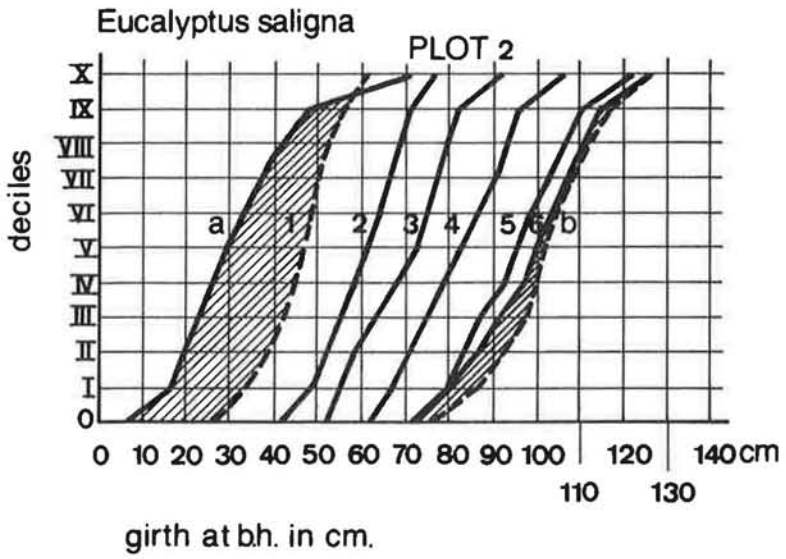


Pure Coppice

Cumulated frequency distribution

before the clear felling of january 1956.

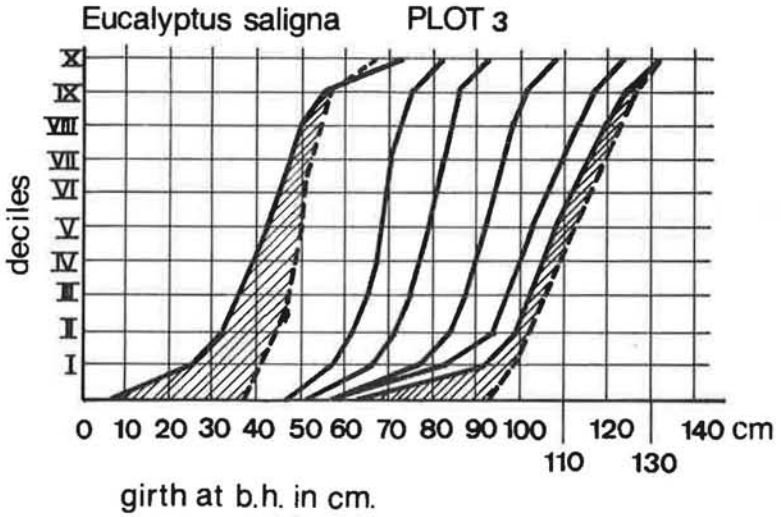
a - 2012 trees per hectare



Coppice with standards

Density of the reserve

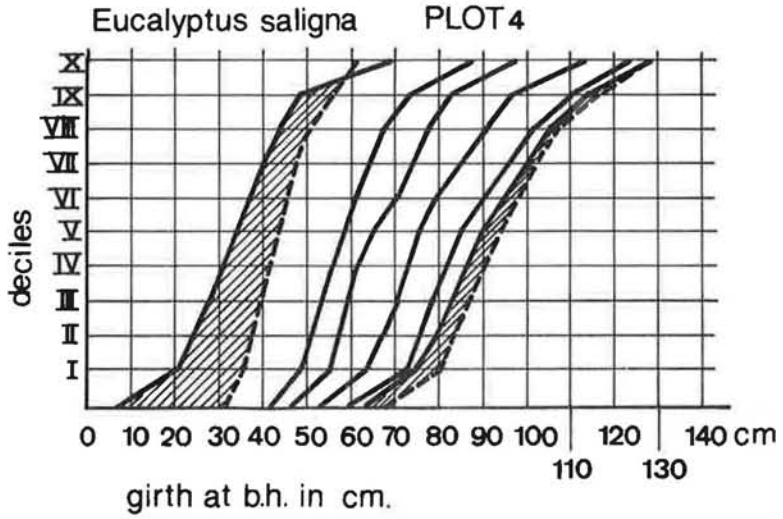
a- 1760 trees per ha
1- 100 trees per ha
2- 100 trees per ha
3- 100 trees per ha
4- 100 trees per ha
5- 100 trees per ha
6- 100 trees per ha
b- 80 trees per ha



Coppice with standards

Density of the reserve

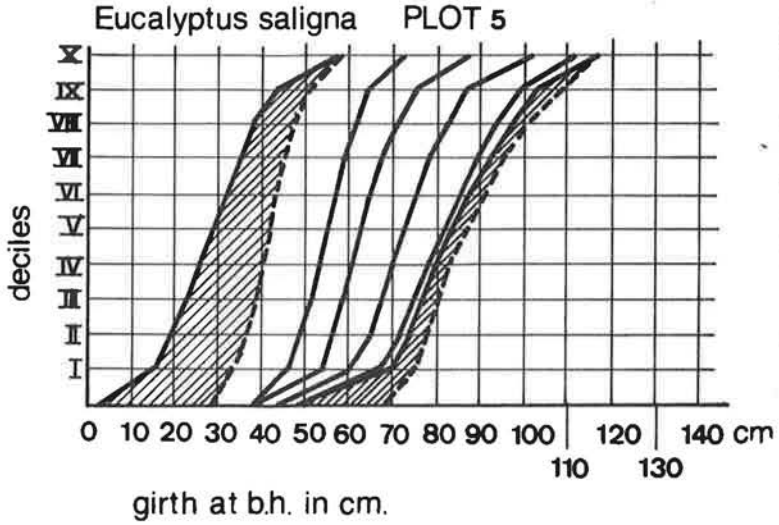
a- 1080 trees per ha
1- 152 trees per ha
2- 152 trees per ha
3- 152 trees per ha
4- 152 trees per ha
5- 152 trees per ha
6- 152 trees per ha
b- 100 trees per ha



Coppice with standards

Density of the reserve

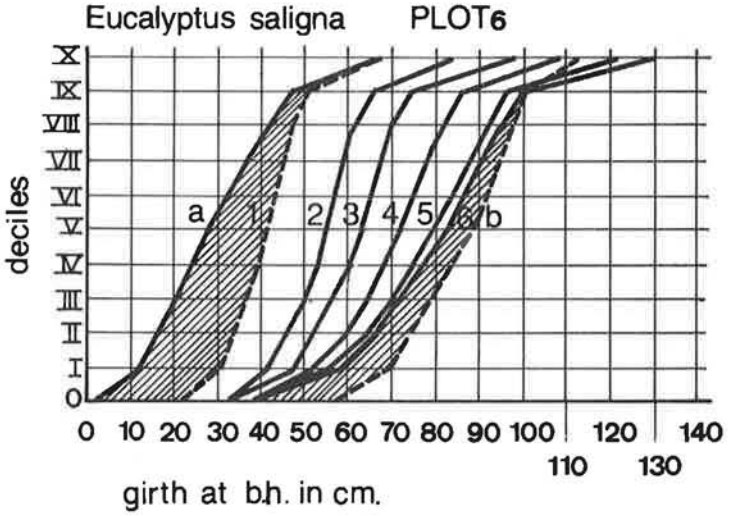
a- 1420 trees per ha
1- 200 trees per ha
2- 200 trees per ha
3- 200 trees per ha
4- 200 trees per ha
5- 200 trees per ha
6- 200 trees per ha
b- 132 trees per ha



Coppice with standards

Density of the reserve

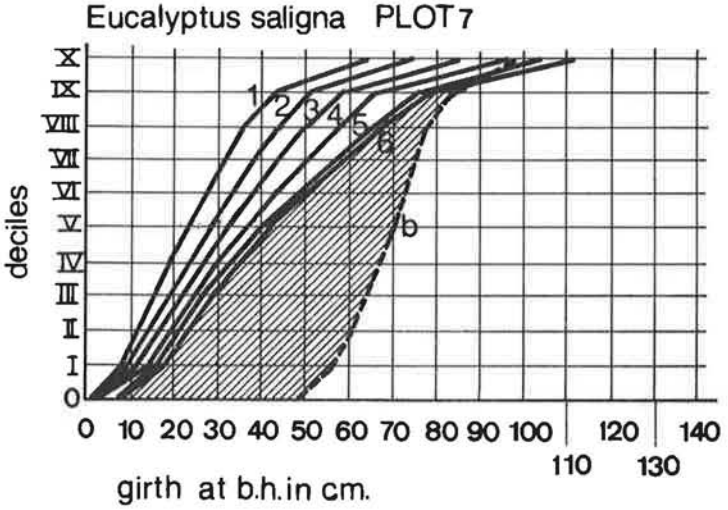
a- 2188 trees per ha
1- 248 trees per ha
2- 248 trees per ha
3- 248 trees per ha
4- 248 trees per ha
5- 248 trees per ha
5- 248 trees per ha
6- 248 trees per ha
b- 124 trees per ha



Coppice with standards

Density of the reserve

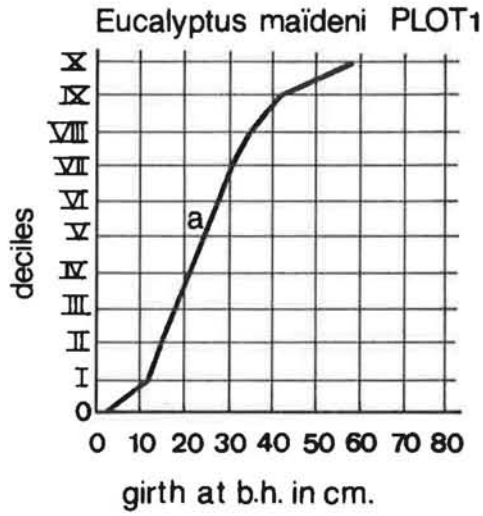
a- 1536 trees per ha
1- 376 trees per ha
2- 376 trees per ha
3- 376 trees per ha
4- 368 trees per ha
5- 368 trees per ha
6- 368 trees per ha
b- 164 trees per ha



High forest

Density of the reserve

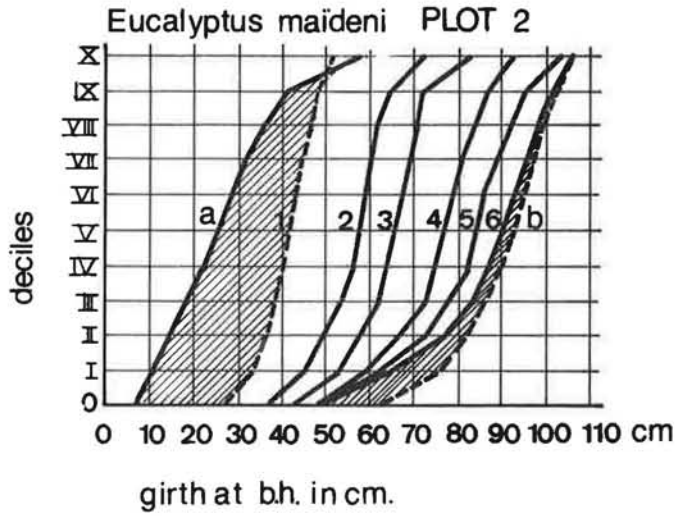
1- 1648 trees per ha
2- 1608 trees per ha
3- 1576 trees per ha
4- 1488 trees per ha
5- 1448 trees per ha
6- 1432 trees per ha
b- 232 trees per ha



Pure coppice

Cumulated frequency distribution before the clear felling of january 1956.

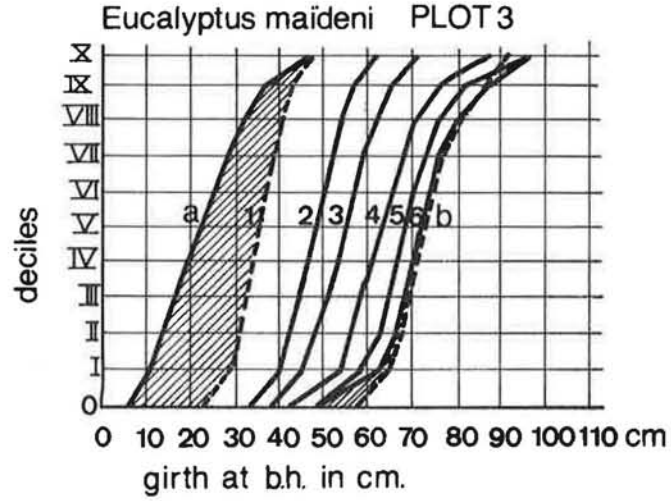
a- 2356 trees per hectare



Coppice with standards

Density of the reserve

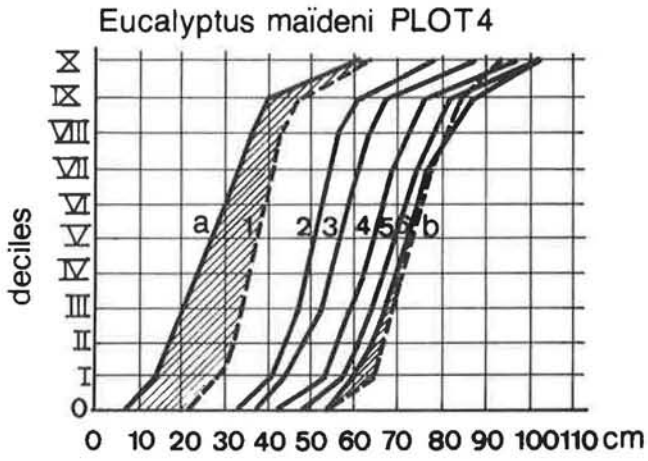
a- 1564 trees per ha
1- 100 trees per ha
2- 100 trees per ha
3- 100 trees per ha
4- 100 trees per ha
5- 100 trees per ha
6- 100 trees per ha
b- 76 trees per ha



Coppice with standards

Density of the reserve

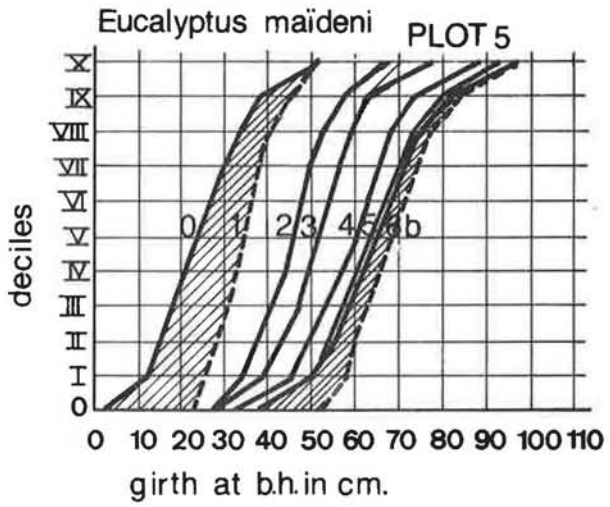
a- 1552 trees per ha
1- 152 trees per ha
2- 152 trees per ha
3- 152 trees per ha
4- 152 trees per ha
5- 152 trees per ha
6- 152 trees per ha
b- 100 trees per ha



Coppice with standards

Density of the reserve

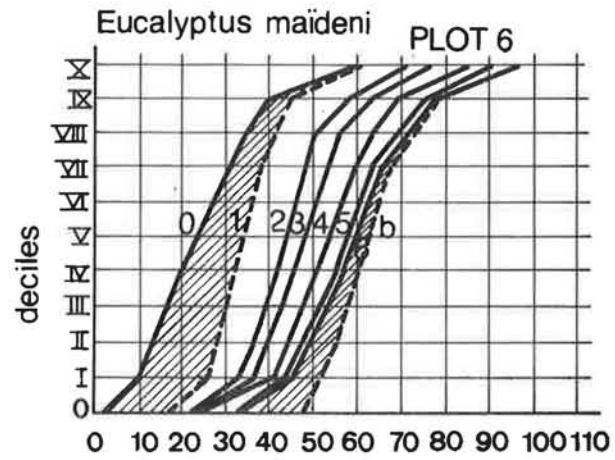
a-1480 trees per ha
1- 196 trees per ha
2- 196 trees per ha
3- 196 trees per ha
4- 196 trees per ha
5- 196 trees per ha
b- 112 trees per ha



Coppice with standards

Density of the reserve

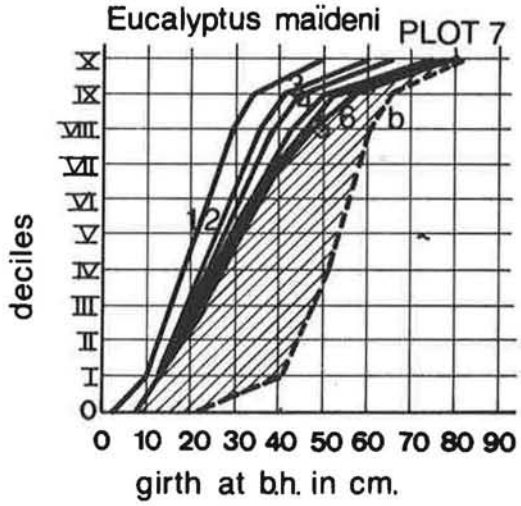
a- 1512 trees per ha
1- 248 trees per ha
2- 248 trees per ha
3- 248 trees per ha
4- 248 trees per ha
5- 248 trees per ha
6- 248 trees per ha
b- 136 trees per ha



Coppice with standards

Density of the reserve

a- 1716 trees per ha
1- 472 trees per ha
2- 472 trees per ha
3- 472 trees per ha
4- 472 trees per ha
5- 464 trees per ha
6- 464 trees per ha
b- 224 trees per ha



High forest

Density of the reserve

1- 2480 trees per ha
2- 2464 trees per ha
3- 2444 trees per ha
4- 2444 trees per ha
5- 2416 trees per ha
6- 2408 trees per ha
b- 316 trees per ha

The displacement of the curve from (a) to (1) is the result of the thinning of january 1956 and has a technical origin. The displacement from (6) to (b) is te result of the thinning in october 1960, the displacement of the curve has also a technical origin. In the graphs the hatched surfaces represent these periods.

The displacements from (1) to (6) result from the girth increments during the period january 1956 - october 1960, and have thus a biological origin. Curves 2,3,4,5 and 6 show the composition of the population respectively at 1 year, 2 years, 3 years, 4 years and 4 years and 9 months after the first thinning of january 1956, curve 1 giving the composition of the population immediately after that thinning.

Interpretation of the graphs

Plots (treatments) 7, high forest with a great density of reserves, show only small displacements of the succesive curves, especially for the lower deciles. The curve becomes more and more inclined. In this stand only the dominant trees show increments, while codominants and dominated trees vegetate.

For plots 6, coppice with standards with a density or reserves of approximately 400 trees per hectare, the displacement of thecurve is almost normal although there is a decrease in increment of the lower deciles starting at the third year after thinning. This decrease corresponds with the time of canopy closure.

Plots 2,3,4 and 5, coppice with standards, show almost parallel annual curves. The lesser the density of the reserve, the more the curves are parallel. It is only in the last year of the rotation that the two or three lower deciles do not follow the general movement which means that the smallest trees are suffering from the competition of the others.

In conclusion it can be said that the graphs represent the plots fairly accurately and give the forester a valuable tool for the evaluation and control of the stands.

CONCLUSIONS

The lack of significant difference between the total production of treatments allows the silviculturist a great freedom of action.

The choice of the management system should depend on the valorization possibilities of the thinning products.
At the second thinning, the coppice with standards system give a range of products which may satisfy different categories of consumers. This range of products is more varied when the initial reserve is greater.

The coppice system

This simple management system, easy to apply with lowly qualified forestry personnel, responds to the immediate needs of rural populations and small owners.
Nevertheless, the coppice system does not take into account the evolution of the market as it only provides firewood and small service and farm timber.
This system should only be applied when a uniform produce is wanted, as f.i. the production of wood for paper manufacture.

The high forest

This management system is not recommended as its production is lowest, and its production at the first thinning was also low compared to the other treatments.

The coppice with standards with a low density of reserves

Low density of reserves includes densities from 100 to 250 trees per hectare after the first thinning.
These treatments allow the coppice to attain an exploitable size during the rotation period as well as allowing a high increment of the reserves.

The coppice shoots reach the lower part of the canopy of the standards and this helps their natural pruning.
When the objective is to obtain quality trees, it is advised to have densities of reserves of at least 200 trees per hectare after the first thinning, thus allowing a progressive selection.

The coppice with standards with a great density of reserves

In this mixed treatment with reserves of approximately 400 trees per hectare, preference is given to the standards, the coppice being of secondary importance.
This system is the most complete forestry system, having a dominant, codominant and dominated strata and a lower shrub stratum consisting of the coppice.
The density of the reserves must be about 400 trees per hectare after the first thinning in order to allow sustained increment and natural pruning while obtaining dominants of good form. The coppice production is less important, mainly small firewood, the basis of the production being obtained from the thinning of the standards, which delivers a great variety of products (telephone poles, posts, mine timber, big firewood, ..). The system permits also the progressive selection of the standards with the objective of saw timber production.