

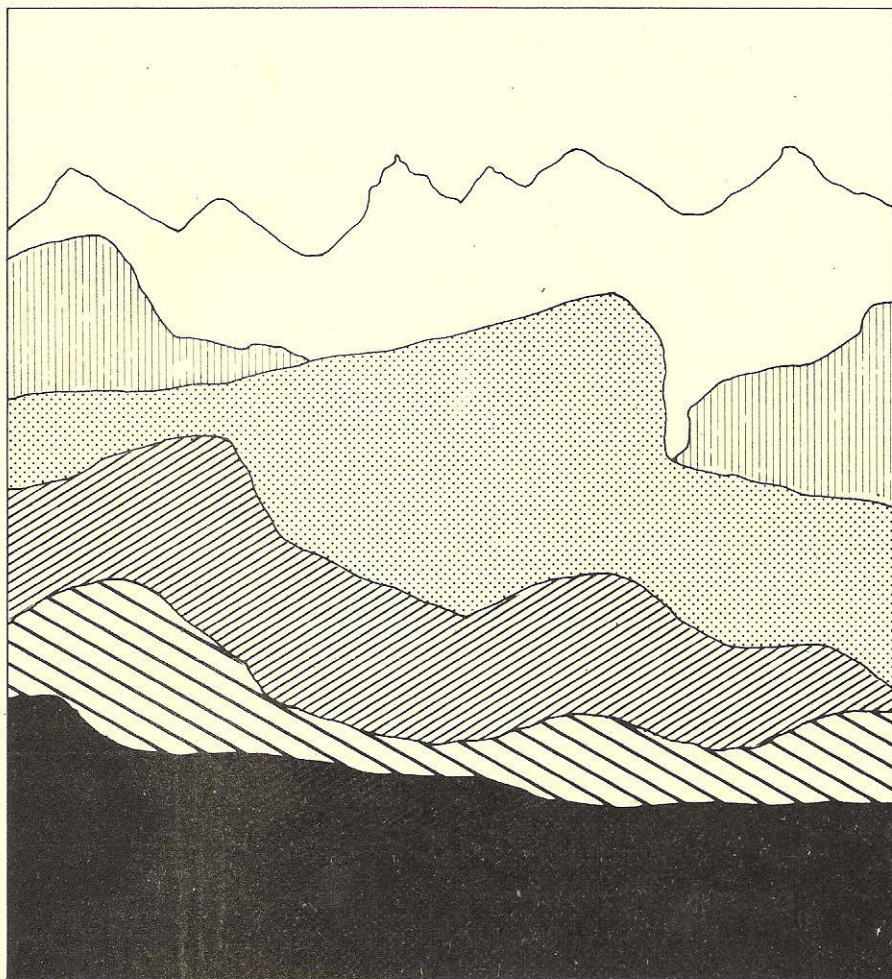


MOUNTAIN SILVICULTURE

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FIRST RESULTS OF A THINNING EXPERIMENT ON A *Pinus sylvestris* L. MAN-MADE FOREST IN THE SISTEMA CENTRAL RANGE.

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ABSTRACT

Preliminary results of a thinning experiment carried out on 39 years old *Pinus sylvestris* L. planted stands are presented. Assayed treatments are described and characterized in relation to stand variables, and yields obtained are quantified in m³/Ha of wood and in Kg/Ha of total aerial biomass. The evolution of diameter, height and volumen with age, and the variation of mean and current increments are presented for each diameter class.

1. INTRODUCTION

Data in the 1989 Anuario de Estadística Agraria indicate that 53% of the 922.495 Ha covered by *Pinus sylvestris* L. in Spain corresponds to man-made stands. The high density with which these forests are created leads, when they are not thinned, to a great biomass loss by natural mortality due to strong competition and to a slowing of growth and vigor of every tree (HAWLEY & SMITH, 1982). Besides, a very high proportion of these plantations are currently ready for a first or second thinning, so it becomes necessary to study what is the proper timing for these silvicultural operations, retrieving a good deal of wood resources, promoting stand growth and concentrating yield in the best trees.

Aimed to these goals, and with the cooperation of the Agencia del Medio Ambiente in the Madrid Autonomous Community, the Departamento de Sistemas Forestales at CIT-INIA established during 1991 the experimental site M-3, within a network of silvicultural experimental sites for the study of thinning in *Pinus sylvestris* L. planted forests, managed by this Department since 1968. Data and results presented below refer to this experiment.

2. STUDY AREA

The plantation under study, established in 1953 by pit planting in ox formed terraces, is located in the forest M-1.020 "La Morcuera", of 2.042 Ha ranging from 1400 to 2200 m in

altitude and belonging to the municipality of Rascafría (Madrid).

Mean stand values in the study site M-3 are the following : 39 years old (in 1991, year to which all the figures are referred); 2.254 trees/Ha; 11.2 m dominant height; 9.8 m mean height; 147 mm mean squared diameter; 38 m²/Ha basal area; Hart's index = 19; 172.2 m³/Ha stem volume; 76.4 dm³ mean tree volume and 4.42 m³/Ha mean annual increment. The experimental site consisted of 9 treatments replicated 3 times, thus 27 (9 x 3) plots were established.

The soil in the area is of the humic cambisol type, rich in organic matter but generally poorly humified, developing over acid rocks (gneiss). Texture of upper layer is median, being in general somewhat stony soils in their profile with very good permeability (MONTURIOL Y ALCALA DEL OLMO, 1990).

Characteristic vegetation belongs to the supramediterranean carpetano - iberian - alcarreña subhumid siliceus series typical of *Quercus pyrenaica* or pyrenean oak (*Luzulo forsteri-Querceto pyrenaicae sigmetum*)(RIVAS, 1988).

Climate can be classified within phytoclimatic subtype VIII(VI), subnemoral oroborealoid (ALLUE, 1990).

3. TREATMENTS

For the diverse silvicultural techniques to be applied on the forest plantations, it becomes necessary to measure the effect on the stand of different thinning intensities, combined with pruning carried out at several heights. To gain knowledge on the stand responses to these silvicultural operations, the following treatments were assayed:

Treatment A (Control): None intervention is carried out. Only dead or dying trees are removed.

Treatment D/SP: Low thinning without pruning.

Treatment D/P3: Low thinning with pruning to 3 m height of every tree in the plot.

Treatment E/SP: Mixed thinning, strong, without pruning.

Treatment E/P3: Mixed thinning, strong, with pruning to 3 m height of every tree.

Treatment E/P5: Mixed thinning, strong, with pruning to 5 m height of every tree.

Treatment E/Pap: Mixed thinning, strong, with pruning to 5 m height of likely "future trees" (trees reaching the end of rotation, 300 - 350 trees/Ha).

Treatment C.Alta: High thinning, strong, without pruning.

Treatment S/Pap: Selective thinning, strong, addressed to eliminate trees in competition with "future trees", with pruning to 5 m height of "future trees" (300 - 350 trees/Ha).

4. DATA COLLECTION

Once the experimental units (plots) of 1.000 m² were established and delimited, trees were individualized by identifying them with a number painted white in the bark.

For each plot the following data were recorded:

- Normal crossed diameter of every tree.
- Height in a sample of 30 trees selected proportionally to the diameter distribution in the plot, and complemented with other sample consisting of the 100 thickest trees per Ha, chosen to determine the dominant height.

Also, 134 sample trees were felled down and measured; these were selected proportionally to the diameter distribution in the stand and were taken from the stand outside the thinning plots to avoid interferences in the plots. The following measurements were recorded from these trees :

- Total height, of the stem (7 cm in top) and to the first green branch.
- For each tree, length between recognizable whorls, to accurately determine the development of annual height increments.
- Normal diameter, and also diameter and bark thickness to 1 m intervals from the base, used to calculate stem volume by Huber's formula.
- For each tree, a slice was taken from the base to measure on it the annual diameter increments, thus allowing to know exactly the evolution of this variable and the age of the tree.
- For each tree, its green biomass was weighed, differentiating among the following components:
 - . Weight of branches with diameter lesser than 2 cm.
 - . Weight of branches 2 - 7 cm in diameter.
 - . Proportions of the biomass components: wood, needles and bark, were determined by means of a sample.

5. RESULTS

Characteristics of thinning and pruning types

In TABLE 1 each of the nine assayed treatments are characterized in relation to the stand variables. Mean values of each variable before thinning, mean values of the stand removed and mean values of the stand left after thinning are quantified.

Quantification of total biomass removed

TABLE 2 has been compiled with data of biomass obtained from sample trees. This quantification of the biomass removed is interesting due to its energetic value and because it allows to know the amount of total biomass extracted from the ecosystem when a thinning treatment is carried out.

TABLE 3 has been constructed by applying the modular values (referred to each diameter class) expressed in TABLE 2 to the diameter distributions of the stand before thinning, of the extracted stand by the thinning and of the crop trees left after thinning. In this table, total aerial biomass before thinning, thinned and left after thinning are quantified averaging the three plots for each treatment. To draw a better picture of the total aerial biomass distribution

TABLE 1
Thinning intensity related to the stand variables for each treatment

Stand variable	T R E A T M E N T S											
	A			D/SP			D/P3			E/SP		
	Before Thinning	Thinning	After Thinning	Before Thinning	Thinning	After Thinning	Before Thinning	Thinning	After Thinning	Before Thinning	Thinning	After Thinning
Age	39	39	39	39	39	39	39	39	39	39	39	39
N/ha	2233	57	2177	2350	1117	1233	2457	1230	1227	2043	843	1200
Ho (m)	11,1	-	11,1	11,5	-	11,5	13,2	-	13,2	11,2	-	11,2
Hg (m)	9,4	7,7	9,4	10,0	9,6	10,4	11,5	11,1	11,9	9,2	8,1	9,7
dg (cm)	14,7	8,5	14,9	15,4	11,9	16,6	15,6	12,1	18,3	14,7	11,9	16,4
G (m ² /ha)	38,1	0,2	37,9	39,6	12,2	27,4	46,6	14,1	32,5	34,6	9,3	25,3
Vol. m ³ /ha	168	1,0	167	181	50	131	242	64	178	146	32	114
HART index	19	-	19	18	-	25	15	-	22	20	-	26
Residuary G (%)	-	-	100	-	-	72	-	-	85	-	-	66

Control.

D/SP: Low thinning without pruning.

D/P3: Low thinning with pruning to 3 m height of every tree.

E/SP: Mixed thinning without pruning.

E/P3: Mixed thinning with pruning to 3 m height of every tree.

E/P5: Mixed thinning with pruning to 5 m height of every tree.

E/PaP: Mixed thinning with pruning to 5 m height of likely "future trees" (trees reaching the end of rotation - 300-350 trees/ha).

C/Alia: High thinning without pruning.

S/PaP: Selective thinning addressed to eliminate trees in competition with "future trees".

Pruning to 5 m height of "future trees".

TABLE 1. Thinning intensity related to the stand variables for each treatment. (Continuation)

Stand variable	T R E A T M E N T S											
	E/P3			E/P5			E/PaP			C. Alta		
	Before Thinning	Thinning	After Thinning	Before Thinning	Thinning	After Thinning	Before Thinning	Thinning	After Thinning	Before Thinning	Thinning	After Thinning
Age	39	39	39	39	39	39	39	39	39	39	39	39
N/ha	2400	1100	1300	1983	1010	973	2147	1104	1043	2150	780	1370
Ho (m)	10,3	-	10,3	11,7	-	11,7	11,8	-	11,8	9,7	-	9,7
Hg (m)	9,0	8,0	9,6	10,5	10,3	10,8	10,1	9,3	10,7	8,9	8,9	8,9
dg (cm)	13,7	11,1	15,7	15,7	12,9	17,9	14,9	11,9	17,5	14,0	14,5	13,7
G (m ² /ha)	35,6	10,7	24,9	36,9	12,8	24,1	38,5	12,9	25,6	32,8	12,5	20,3
Vol. m ³ /ha	150	42	108	175	56	119	183	55	128	135	52	83
HART index	20	-	27	19	-	27	18	-	26	22	-	28
Residuary G (%)	-	-	65	-	-	63	-	-	67	-	-	53

A: Control.

D/SP: Low thinning without pruning.

D/P3: Low thinning with pruning to 3 m height of every tree.

E/SP: Mixed thinning without pruning.

E/P3: Mixed thinning with pruning to 3 m height of every tree.

E/P5: Mixed thinning with pruning to 5 m height of every tree.

E/PaP: Mixed thinning with pruning to 5 m height of likely "future trees" (trees reaching the end of rotation - 300-350 trees/ha).

C. Alta: High thinning without pruning.

S/Pap: Selective thinning addressed to eliminate trees in competition with "future trees".

Pruning to 5 m height of "future trees".

in the *Pinus sylvestris* L. plantation, it has been split in the seven fractions presented in TABLE 3.

TABLE 2
Aereal biomass (in kg of dry matter) in different parts
of the tree, by diametric classes.

DIAMETRIC CLASSES (cm)	Stem		Branches 2-7 cm ϕ		Branches < 2 cm ϕ			TOTAL
	Wood	Bark	Wood	Bark	Wood	Bark	Needles	
5-10	6,7	3,7	1,3	0,2	2,3	0,9	2,4	17,5
10-15	20,0	6,2	2,5	0,4	3,6	1,4	3,8	37,9
15-20	41,2	9,8	7,6	1,1	6,6	2,6	6,9	75,8
20-25	66,5	14,0	14,2	2,1	9,1	3,5	9,5	118,9
25-30	112,0	22,0	25,1	3,7	13,3	5,2	13,9	195,2

Age evolution of height and diameter

Using data recorded from sample trees, age evolution of height, diameter and mean tree volume have been obtained for each diameter class (FIGURES 1, 2 and 3). The evolution of normal diameter and height normal and current increments, for each diameter class, is represented in FIGURES 4 and 5.

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TABLE 3
Aereal biomass variation (in kg/ha) at different intensity of thinning

	T R E A T M E N T S								
	A	D/SP	D/P3	E/SP	E/P3	E/P5	E/PaP	C/Alta	S/PaP
BEFORE THINNING									
STEM									
- Wood	64133	65722	72616	56769	58370	58929	63465	49659	65802
- Bark	17159	17614	18908	15219	16526	15313	16679	14078	18116
BRANCHES 2-7 cm Ø									
- Wood	10943	11244	12962	9674	9435	10370	11108	8053	10992
- Bark	1630	1678	1928	1445	1419	1542	1651	1208	1648
BRANCHES < 2 cm Ø									
- Wood	10897	11150	12013	9606	10332	9735	10626	8839	11379
- Bark	4263	4358	4692	3755	4042	3805	4155	3461	4447
- Needles	11424	11690	12586	10073	10843	10202	11135	9274	11936
TOTAL	120449	123456	135705	106541	110967	109896	118819	94572	124320
THINNED									
STEM									
- Wood	268	20114	22364	14573	17287	19625	21137	17422	22625
- Bark	148	6436	7112	4783	5911	5987	6645	4896	6932
BRANCHES 2-7 cm Ø									
- Wood	52	3033	3440	2161	2516	3019	3196	2990	3475
- Bark	8	466	526	334	392	460	490	443	531
BRANCHES < 2 cm Ø									
- Wood	92	3922	4360	2897	3555	3681	4057	3140	4247
- Bark	36	1532	1704	1131	1387	1439	1585	1232	1659
- Needles	96	4120	4578	3044	3736	3866	4262	3289	4461
TOTAL	700	39623	44084	28923	34784	38077	41372	33412	43300
AFTER THINNING									
STEM									
- Wood	63865	45608	50252	42196	41083	39304	42328	32237	43178
- Bark	17011	11178	11796	10436	10615	9326	10034	9182	11184
BRANCHES 2-7 cm Ø									
- Wood	10891	8211	9522	7513	6919	7351	7912	5063	7516
- Bark	1622	1212	1402	1111	1027	1082	1161	765	1117
BRANCHES < 2 cm Ø									
- Wood	10805	7228	7653	6709	6777	6054	6569	5699	7132
- Bark	4227	2826	2998	2624	2655	2366	2570	2229	2788
- Needles	11328	7570	8008	7029	7107	6336	6873	5985	7475
TOTAL	119749	83833	91621	77618	76183	71819	77447	61160	80390

FIG. 1: D.B.H. DEVELOPMENT IN EACH DIAMETER CLASS

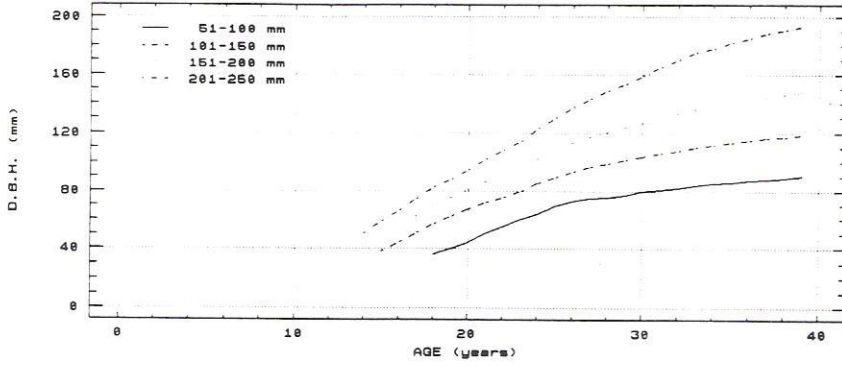


FIG. 2: TOTAL HEIGHT DEVELOPMENT IN EACH DIAMETER CLASS

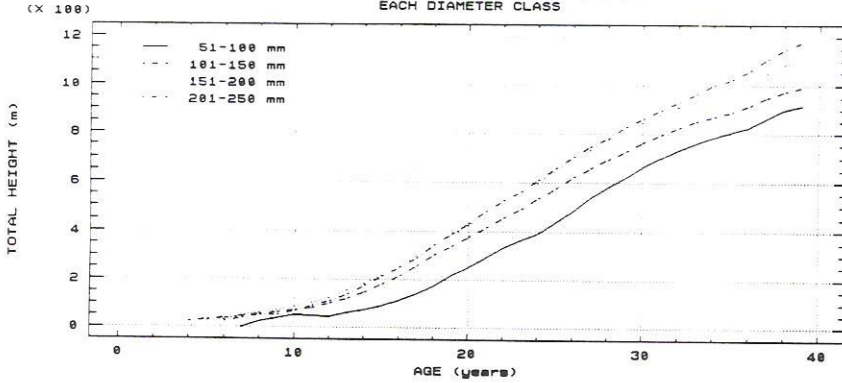
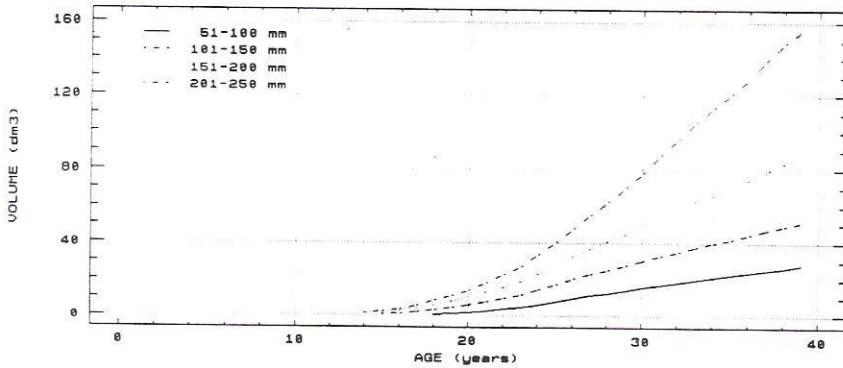
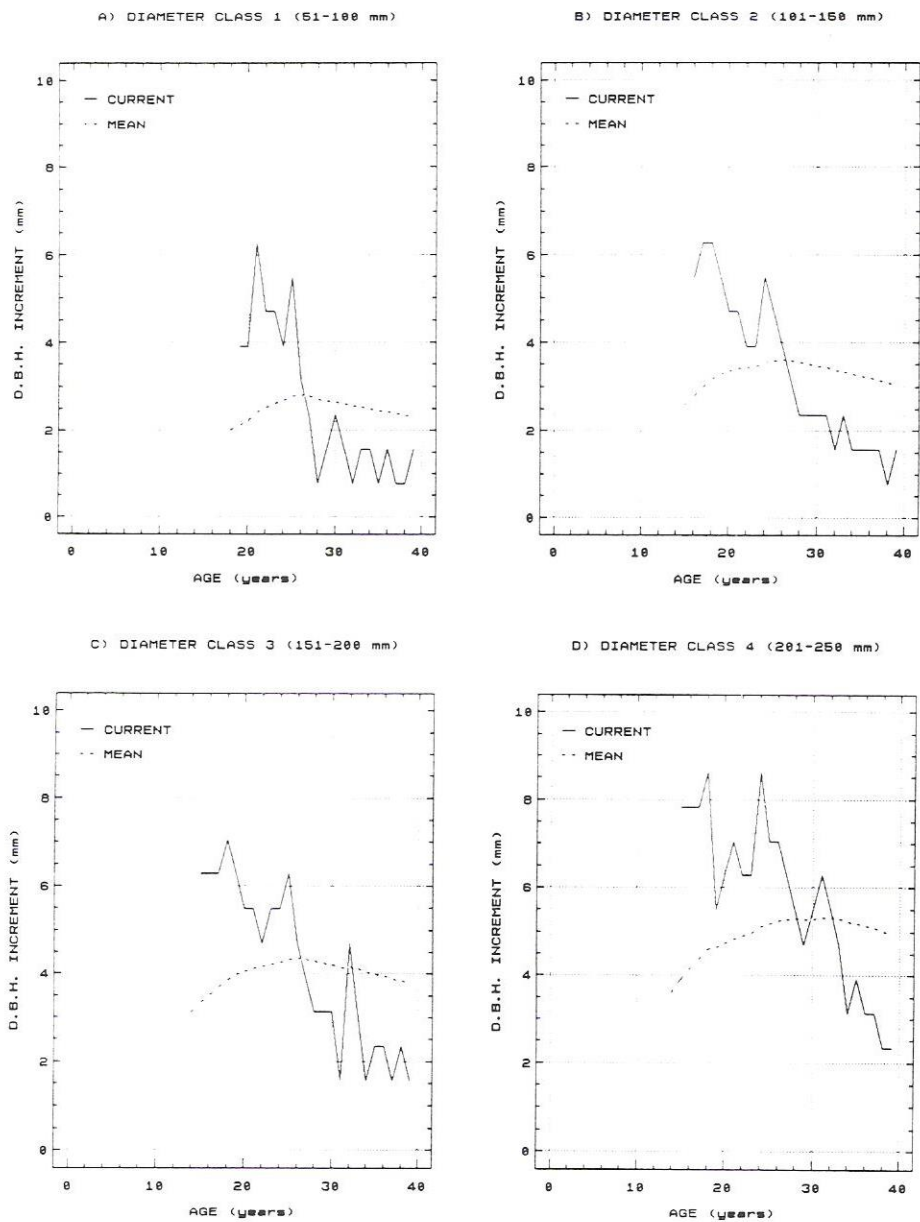
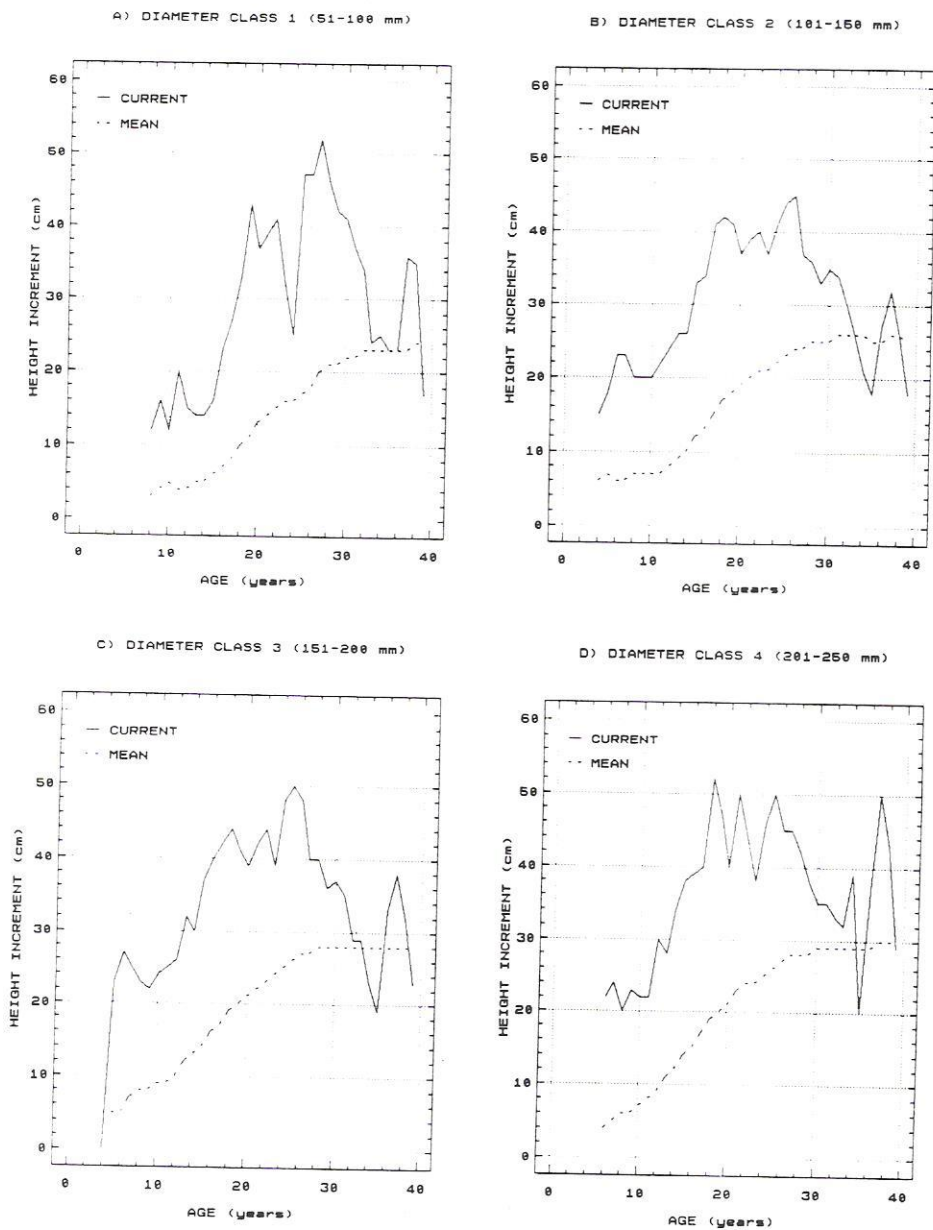


FIG. 3: VOLUME DEVELOPMENT IN EACH DIAMETER CLASS







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