NATURAL REGENERATION OF ABIES X BORISSII-REGIS MATTF. IN PERTOULI FOREST (GREECE)

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INTRODUCTION

The forest of Pertouli, situated at an altitude of 1100-1800 m above sea level in the Pindus mountain area of Thessalia (Greece), covers about 3 297 ha. It is in possession of and administrated by the Aristotelion University of Saloniki.

From a phytosociological point of view it belongs to the Fagion-illyrcum ass. Abietetum borissii-regis (Mayer, 1980) on an acid brown forest soil. The bastard fir, Abies x borissii-regis Mattf., is the principal tree species in Pertouli, where recently, also some pine was planted.
In this forest research on the establishment of bastard fir regeneration was undertaken by Oekonomopoulos (1937), Bassiotis (1956), Graikiotis (1960), Makris (1962), Pauly (1962), Moulopoulos (1956) and Panagiotidis (1965).
Studies on further development of established regenerations are rather scarce (Bassiotis, 1956 ; Panagiotidis, 1965 ; Dafis, 1969). Therefore many aspects concerning structure and structuration of regeneration groups, social differentiation, the significance of early and retarded regeneration, the quality of surviving dominants and the influence of exposure reps. the presence of an older forest canopy remain unclear.

The present study tries to answer some of these questions. In doing so it recognizes a number of diversified explanations, given for the abscence, the irregular dispersion and the slow establishment of natural regeneration.

METHODOLOGY

Natural regeneration of bastard fir was studied between july and september 1982, in the sections 209 (14.7 ha) and 210 (17.3 ha) of the Wathi-division.

In both sections a humus layer of the moder type prevails. Natural regeneration of bastard fir was obtained over a fairly large area using an adapted system of group selection cuttings.

Two regeneration units in section 209 and one regeneration unit belonging to section 210 were analyzed.
All units were situated on a N- to W-esposed slope.

Section 210

Regeneration introduced about 30 years ago. Completely enclosed to prevent damage by grazing cattle. Silvicultural intervention every 3 years to eleminate dominating seedlings of poor quality.

Regeneration unit R1

1.55 ha. Production class 2-3 (Wiedemann, 1957). Slope 8-13°. Group regeneration completed.

Regeneration unit R2

0.69 ha. Production class 3 (Wiedemann, 1957). Slope 8-13°. Incomplete regeneration in groups.

Section 209

More recent natural regenerations. Not enclosed. Influence of frequent grazing. Superficial silvicultural intervention every 10 years.

Regeneration unit R3

1.24 ha. Production class 3 (Wiedemann, 1957). Variable slope. Incomplete group regeneration.

In these 3 units a total of 45 sample plots (Pn) of 2 m x 5 m each, were laid out, 19 in R1, 8 in R2 and 18 in R3.
In each unit, a maximal bilateral distance of 25 m between plots was observed. Measurements in all plots of a given unit were used to calculate the average situation for the unit, converted, if necessary, into quantity/ha.
(Symbols and definitions of terminology : add. 1).

REGENERATION RESEARCH IN PERTOULI

Different explanations are given to explain the absence, the irregular dispersion or the slow establishment of natural regeneration.

Oekonomopoulos (1937) holds the opinion that, in Pertouli, a direct relationship exists between the phytosociological forest type and the potential for stand regeneration.
Graikiotis (1960) and Pauly (1962) are convinced that chronic lack of moisture and soil drought are the main obstacles to natural regeneration.
Spontaneous sowing and seed germination are usually good to abundant, but most seedlings start drying out during the first weeks of August. This is a generalized phenomen in Greece : most forests

are extremely difficult to regenerate and pass through a critical phase of variable length at the end of each rotation, or whenever space becomes available following death of older dominant trees.

Moulopoulos (1956), Bassiotis (1956) and Makris (1962) they explain the absence of regeneration by a combination of factors : the absence of cover of a forest canopy protecting the young seedlings, the low degree of atmospheric moisture and high soil temperature. Experiments by Moulopoulos (1956) indicate that seedlings can survive, when they remain in the shadow at noon or are growing inside the forest at a distance to the edge of at least 1 to 1, 5 x the average height of dominant trees.

When no protecting cover or canopy is available, two phenomens are observed :

- Regeneration of the chloroplasts in the recently formed needles of seedlings, less than 1 year old (Makris, 1962) ;

- Burns at the base of the stem, causing deterioration of the cambium, after which swellings appear, due to the accumulation of non-movable masses of nutrients.
  Combined with soil temperature as high as 69°C, they ultimately cause death of the seedling (Moulopoulos, 1956).

Panagiotidis (1965), on the other hand, is convinced that the maintenance of a growing stock, too high for the site, is the principal reason for regeneration difficulties. This concurs with the opinion of Dafis (s.d.) that forest treatment as been aiming too much at the increase of growing stock and the concentration of increment in a restricted number of elite-trees instead of optimalizing the forest structures, with subsequent regeneration, at the right moment, as a direct consequence (Schädelin, 1942).

It seems evident that, although drought and high summer temperatures are the main stress factors, acting upon the establishment of a new forest generation, other influences, especially in the field of silvicultural treatment and forest management, are to be reckoned with.
It is not the aim of this study to analyze the process of establishment of regeneration, but to evaluate structure and structuration of established regeneration groups with the basic information on the difficulties of establishment as a background.

1. The structure of regeneration groups

Moulopoulos (1956) is convinced that the bastard fir needs a protecting cover or canopy during at least 5 to 6 years. Therefore the presence, in a regeneration group, of seedlings, less than 6 years old, is of restricted importance as their survival is not assured.

Equally meaningful to analysis is the statement by Panagiotidis (1965) that gregarious regeneration is typical for bastard fir, whereas silver fir (Abies alba Mill.) tends more to individualized regeneration.
Irregular dispersion of seedlings is stimulated by the adopted system of group regeneration. Under marginal ecological conditions, the heterogeneity of regeneration increases with the extension of the group (Leibundgut, 1981). These restrictions are considered in evaluating and relativating the importance of average numbers of seedlings.

1.1. Number of seedlings

The number of seedlings is fairly high, the age of the seedlings considered, and attains an average of 25 880/ha (limits between 21 570 for R1 and 29 500 for R3) over the three regeneration units, 68 % of which or 16 240/ha are more than 5 years old (tab. 1).

Table 1 : Average number of seedlings per sample plot of 10 m².

Regeneration unit	Total number of seedlings				Seedlings > 5 year	
	N	Limits	s	Number of plots	N_5	In % of N
R1	21.57	0 - 43	16.1	19	20.64	96
R2	25.13	0 - 75	23.1	8	15.88	63
R3	29.50	1 - 72	18.9	18	14.94	51
R	25.88	0 - 75	18.8	45	16.24	68

The total average number of seedlings is higher in the unit, containing more recent regeneration (R3), but for the total number of seedlings older than 5 year a reverse order is observed (↑ R1 → R3). These differences indicate only a tendency and are, statistically, not very significant.

The number of seedlings is satisfactory in a general way, laying within the limits, set by Panagiotidis (1965) for the end of the regeneration period (37 000 to 19 500/ha). They also concur with the observations of Eckhart and Rachoy (1973) in N.Austria, Tirol and Vorarlberg, who found 14 000 to 82 000 seedlings/ha of less than 25 cm in mixed fir-spruce regenerations.

The presence of a fern cover, thought to have a positive influence on regeneration by Moulopoulos (1956), does not seem to be beneficient ; a negative exponential correlation, highly significated in each of the fern cover (x = % of soil covered and the number of seedlings per sample plot (y).

Regeneration unit	Equation	Limits	Pn	r	F-value
R1	$y = 24.35^{-0.04x}$	0 - 100	19	- 0.80	31.178***
R2	$y = 36.01^{-0.04x}$	0 - 100	8	- 0.89	23.631***
R3	$y = 24.59^{-0.03x}$	0 - 90	18	- 0.58	7.948**

Especially in R1, the relationship between the fern cover (FC = % of surface covered) and the average number of seedlings per sample plot of 10 m² is clearly illustrated.

FC	$\overline{N}$/P	Pn
0	23.4	5
5	23.8	5
10	39.5	2
10-50	7.3	3
50-75	5.5	2
> 75	0.5	2

On the other hand, the presence of a protective forest canopy has, up to a certain point, a positive effect (tab. 2). The effect of the forest canopy is more clearly observable in the older generation units (R1 and R2).

Table 2 : Average number of seedlings per sample plot of 10 m² in relation to % of soil covered by forest canopy (cc).

Cover Class	R1		R2		R3		Tot.	
	$\overline{N}$	Pn	$\overline{N}$	Pn	$\overline{N}$	Pn	$\overline{N}$	Pn
0 - 10	0.33	3	-	1	21.83	6	13.60	10
10 - 25	4.00	3	-	-	12.00	2	7.20	5
25 - 50	10.50	2	4.00	1	33.00	3	20.67	6
50 - 100	23.40	5	46.00	2	42.75	4	34.55	11
> 100	33.00	6	26.50	4	35.33	3	31.54	13

A relatively better consolidation of regeneration in R2 and, especially, in R1 is indicated by the higher absolute number of seedlings older than 5 years, as well as by their more important relative share in the total number of seedlings (tab. 1).

A fern cover may have a positive effect if it is not too dense. The influence of a forest canopy is quite different. It starts to have negative effects at a sensibly higher level as the fern cover.

The negative correlation between the density of a fern cover and the number of seedlings, explains, at any case, the irregular dispersion of regeneration as well as differences in quality.
Group regeneration under a not too dense forest canopy seems to be a good solution. Great attention should be paid to the first stages of regeneration (pre-regeneration) or advanced regeneration. Considering the difficulties of establishment and slow growth of the seedlings, the advantages of a longer regeneration period must be recognized.

1.2. Distribution of seedlings according to social class

For social classification the system, proposed by Mayer (1976) is adopted (add. 1).
Between 1/5 to 2/5 of all seedlings grow up isolated (SC1 + SC2) or in a dominant position (SC3). This corresponds to an average for the classes together of 0.435 seedlings/m² in R1, 0.413/m² in R2 and 0.639/m² in R3 of which only 0.271/m² to 0.383/m² really dominate (tab. 3). The absolute number of seedlings, belonging to these three classes, is roughly the same in R1 and R2, but a little higher in R3.
Inversely, the greater part (3/5 to 4/5) of all seedlings are more or less dominated and belong to the classes 4 and 5.
The relative number of dominated elements is highest in the units, where regeneration is most advanced (79 % in R1 and 74 % in R2) ; it is lowest in the unit with more recent regeneration (57 % in R3).
It is also remarkable that the absolute and relative number of suppressed elements, whatever the cause for their retardement, is high in the older units and fairly low in R3 (1.071 seedlings/m² or 52 % in R1 against 0.528/m² or 35 % in R3).
In the three units the number of co-dominant seedlings (SC4) is fairly low, but the ratio N_3/N_4 changes from 1.17 in R3 to 0.79 in R2 and even 0.49 in R1, indicating a loss of elements from SC3 in favour of SC4 as regeneration develops progressively in time and a more advanced splitting up or social differentiation in the older units (R1 and R2), whereas differentiation has progressed less in the younger unit R3.
Roughly the same results are obtained, if the dominant height h_d of each unit is used as a base to define stratification, considering an upper stratum (US = $h > 2/3\ h_d$), a middle stratum (MS = $1/3\ h_h < h < 2/3\ h_d$) and a lower stratum (LS = $h < 1/3\ h_d$) (tab.4).

Table 3 : Distribution of seedlings, older than 5 years, according to the social classes (SC) of Mayer.

(1 = Isolated. Under cover ; 2 = Isolated. Exposed ; 3 = Gregarious. Dominant ; 4 = Gregarius. Co-dominant ; 5 = Gregarious. Suppressed).

Unit	Social class	$\bar{N}$/10 m²	%
R1	1	0.71	3
	2	0.94	5
	3	2.71	13
	4	5.57	27
	5	10.71	52
	Total	20.64	100
R2	1	1.00	6
	2	0.25	2
	3	2.88	18
	4	3.63	23
	5	8.13	51
	Total	15.88	100
R3	1	2.28	15
	2	0.28	2
	3	3.83	26
	4	3.28	22
	5	5.28	35
	Total	14.94	100

Allthough the values for the dominant height are significantly different from each other, a great analogy in the three units is observed as far as stratification, distribution of seedlings and function of the strata are concerned :

- The mean absolute number of seedlings in the upper stratum is nearly the same in the three units. It varies between 21 to 36 seedlings pro are, representing no more than 8 to 16 % of all seedlings.

- No direct relation seems to exist between the total number of seedlings and the number of dominant seedlings (upper stratum). Otherwise, the total number of seedlings in the understory increases as the total number of seedlings also increases. It is, therefore, higher in more recent regeneration.

- The fundamental difference between the 3 units is to be found in the number of suppressed or retarded seedlings (LS), reaching the highest level in the younger regenera-

Table 4 : Stratification of seedlings ($\overline{N}$/10 m²) with the dominant height of each unit as a reference.

Unit		US		MS		LS		Total		Pn
		$\overline{N}$	%	$\overline{N}$	%	$\overline{N}$	%	$\overline{N}$	%	
R1	$\overline{N}$	3.06	15	4.94	21	12.53	64	20.53	100	17
h_d = 232.88	$\not{s}$ ±	1.75		2.13		3.11				
R2	$\overline{N}$	2.14	8	2.86	17	23.71	75	28.86	100	7
h_d = 424.43	$\not{s}$ ±	1.19		1.55		4.75				
R3	$\overline{N}$	3.56	16	3.22	10	22.72	74	29.50	100	18
h_d = 133.82	$\not{s}$ ±	2.34		1.94		4.13				

t-value on differences in h_d between units :

R1/R2 = 3.125** R2/R3 = 4.470*** R1/R3 = 2.708*

tion unit, where ultimate elemination following suppression is less advanced.

- The relatively feeble representation of the middle story, projected against the low number of seedlings in the upper story, clearly indicates that, in all cases, stratification is well advanced.

Further research must bring an answer to the question if the number of dominant seedlings is directly related or not to ecological site conditions. On the other hand, actual stratification show that the upper story must be accepted as the main object of treatment at an early age and that the possibilities of the middle stratum to furnish elite-material are restricted.

1.3. Distribution of seedlings over h-classes and d-classes

A highly significant linear correlation exist between height (h) and diameter (d) (measured at the base of the seedling) (tab. 5). These correlations indicate the relatively greater importance of diametergrowth vs heigth-growth in R3, the intermediate position in this regard of R1 and the relatively greater importance of h-growth in R2 : 100 cm in heigth corresponds with a diameter of 3.13 cm in R3, 2.80 cm in R1 and only 2.42 in R2.
Maximal seedling height is also more important in R2 and the unit is characterized by relatively sharper competition and higher stand density.

Table 5 : Linear regression between height of seedling/cm (x) and its diameter/cm (y) pro unit and pro social class.

Unit/class	Equation	n	r	Limits for x
R1	y = 0.025x + 0.30	133	0.92***	13 - 420
R2	y = 0.02x + 0.42	35	0.94***	15 - 600
R3	y = 0.03x + 0.13	63	0.95***	11 - 160
SC 1	y = 0.02x + 1.28	9	0.65	30 - 150
SC 2	y = 0.04x - 0.24	13	0.94***	15 - 120
SC 3	y = 0.02x + 0.75	37	0.91***	20 - 420
SC 4	y = 0.03x + 0.14	38	0.87***	40 - 270
SC 5	y = 0.02x - 0.02	36	0.90***	13 - 100

Analogous phenomens are observed by comparing dominant with co-dominant and suppressed seedlings : in the suppressed group diameter growth is more strongly inhibited than height growth ; in the dominant group height growth is relatively more important than is the case for co-dominant and suppressed elements, using equal diameters as a reference.
Thus, previous constatations are confirmed that increasing stand density and a closer upper canopy inhibit diameter growth more strongly than height growth (Van Miegroet, 1956). Such a constatation stresses the importance of early silvicultural intervention, as individual stability and growth of retarded elements and even of co-dominants, as well as their potential to furnish elite-material rapidly decrease with the passing of time (Fig. 1 ; Fig. 2).

As to distribution of seedlings over d-classes and h-classes, a certain analogy between the three units exists, to be expected as a certain analogy in social structuration and differentiation was already observed before.

The general pattern of distribution reveals the following characteristics :

- concentration of a high number of seedlings in the lower h- and d-classes ;
- a regularly decreasing number of seedlings with increasing classvalue ;
- relatively weak representation of seedlings higher than 2 m or with a diameter of more than 5 cm, but they are, absolutely and relatively, more numerous in the more advanced units R1 and 2.

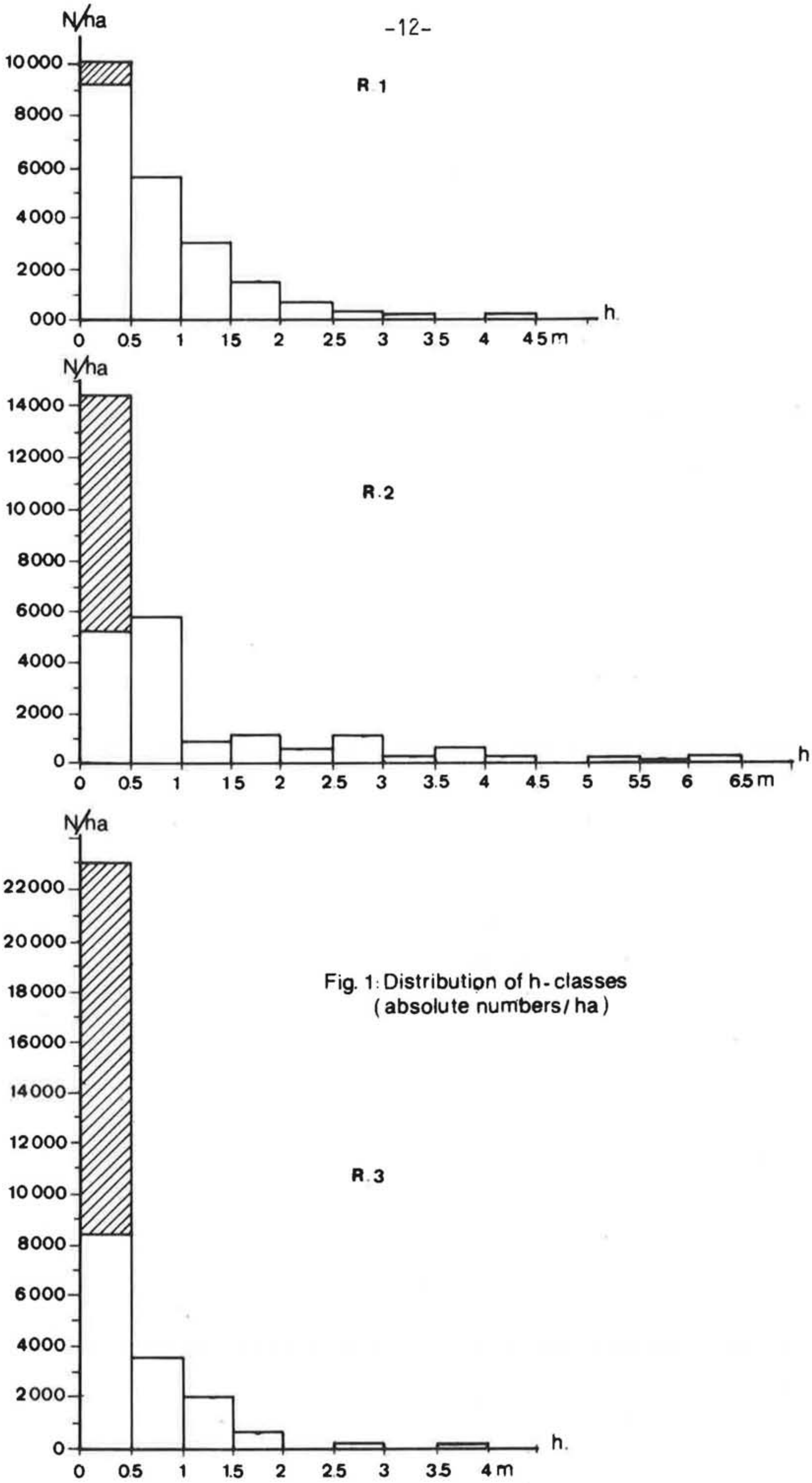
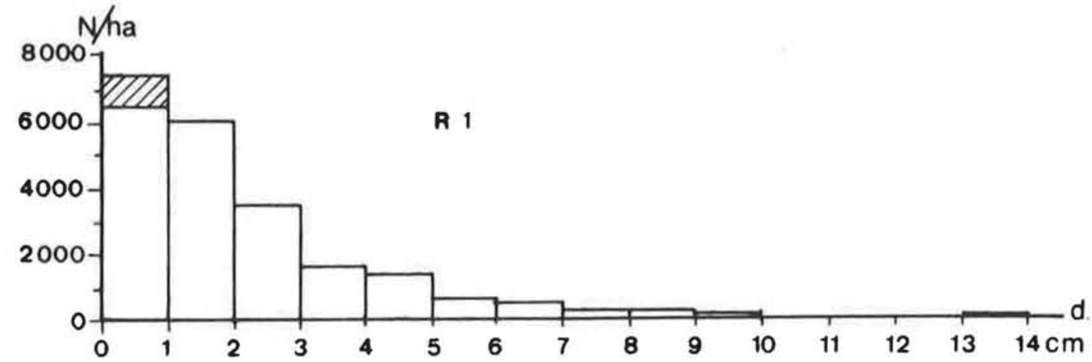
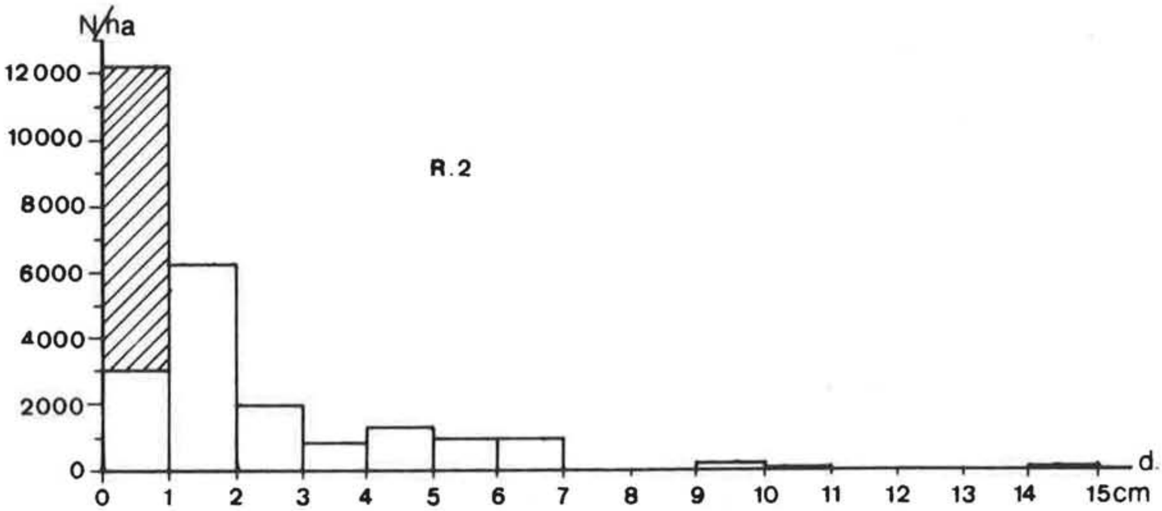


Fig. 1: Distribution of h-classes
(absolute numbers/ha)





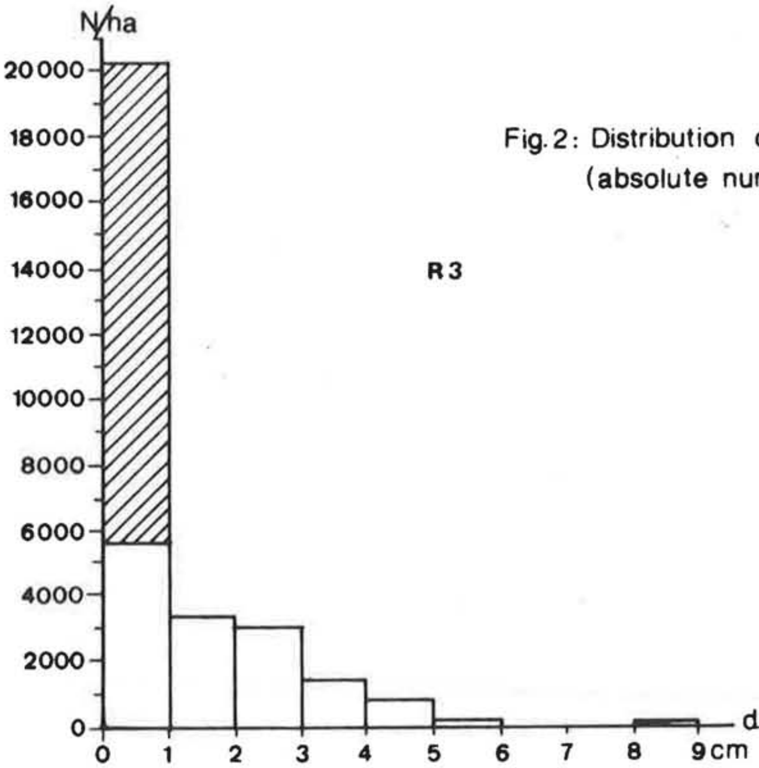


Fig. 2: Distribution of d-classes
(absolute numbers/ha)

The concentration of seedlings in the lower classes is more pronounced in R3 (23 000/ha or 78 %), less important in R2 (14 500/ha or 58 %) and lowest in R1 (10 070/ha or 40 %).

All younger seedlings (5 years old or less) are concentrated in the lowest d- and h-class. Their absolute and relative numbers are very important in R3, less important in R2 and nearly negligible in R3. Considering the high total number of older, surviving seedlings, the value of this juvenil 0-5 yr.-class as a reservoir, from which future dominants might arise, is extremely restricted. The differences which in this respect exist between the 3 units, also illustrate how the process of establishment changes in the course of time, affecting, in turn, the pattern of seedling distribution.
The distribution of seedlings is more equilibrated in older and more advanced regenerations, because a more stable relationship between surviving competitors has arisen and less concentration in the lower classes is observed, due to the double effect of increased elimination of weaker seedlings and reduction of recent establishment (post-regeneration).
In younger, less advanced regenerations, recent establishments are more conspicuous and the impact of post-regeneration is greater. This more important recent establishment, combined with less-advanced competition, due to lower seedling height and reduced crown development, produces a rather irregular pattern of distribution of seedlings. It is typical for intense dynamical development and the breaking-up of uneven-aged populations.
In planning and executing silvicultural treatment of natural regenerations these facts should be kept in mind.
It is especially useful to remember that the lowest d- and h-classes contain, as a matter of fact, two sub-populations :

- seedlings, belonging to the age-class 0-5 yr, and representing recent establishment ;

- seedlings of 6 years and older, representing a sub-population of suppressed, retarded and less vital, but still surviving elements, and a result of social demotion.

In R1 the first sub-population is weakly represented, but the products of social demotion are numerous.
In R3 quite a different situation is observed : the absolute and relative importance of recent establishment is great, whereas the product of social degradation is weakly represented as a direct consequence of less advanced structuration and less stronger competition.
R2 takes an intermediate position between R1 and R3.

From a practical point of view it thus becomes more evident that treatment of young stands must be, necessarily, individualized at an early stage. It is advisable to study the age-class composition of the lower d- and h-classes as it can give an important clue to the state of actual development.

A high share of older elements in the lowest d- or h-class, as in the case of R1, makes this class worthless as a real reservoir of potential dominants. A high share of recent seedlings, as in the case of R3, can make the lower d- or h-class more valuable as a reservoir, however total dependant upon the actual structural situation and, especially, the number of seedlings of good quality, already growing in dominant position.

1.4. Relation between social position and height

Whereas the relation between seedling height and stratification is evident, the question remains whether the social classes of Mayer's scheme are purely arbitrary or also related to height in a general way, and whether or not, real differences in height between these social classes exist.
This is really important because social classification is based on the comparison of seedlings within an extremely restricted area, where variation in site conditions on a small scale may easily interfere with the height-growth of seedlings, belonging to all social classes. It is also necessary to have better knowledge about the relationship between dominant and co-dominant seedlings (SC3/SC4).

In this respect the analysis of R1 and R3, representing different phases of development and quite unequal regarding height and diameter of the seedlings, globally and for each social class separately, (Tab.6) indicates that the relationship between the social classes and eventual differences between them are of the same nature in both cases (Tab. 7).
This applies to differences in height as well as to differences in diameter, to be expected as a result of the established linear relation between h and d (Tab. 5).

Table 6 : t-test on the differences in height and diameter of the seedlings between R1 and R3.

Social class	$\bar{h}$/cm			$\bar{d}$/cm			n	
	R1	R3	t	R1	R3	t	R1	R3
1	66.80	28.07	3.619***	2.42	0.91	4.836***	10	41
2	44.31	27.20	1.065	1.38	0.74	1.073	13	5
3	137.74	93.67	2.820**	4.01	2.78	3.030***	38	69
4	136.08	93.22	3.916***	3.53	2.59	3.275**	78	59
5	45.74	31.85	4.164***	1.03	0.90	1.437	150	95
Total	85.00	60.51	4.747***	2.26	1.75	3.585***	289	269

Table 7 : t-test on the differences in h/cm between social classes in R1 and R3.

Social class	Reference	R1		R3	
		t-value	Df	t-value	Df
Dominants SC 3	SC 1	2.109*	46	6.762***	108
	SC 2	3.189**	49	2.508*	72
	SC 4	0.108	114	0.041	126
	SC 5	9.740***	186	9.361***	162
Co-dominants SC 4	SC 1	3.447***	86	5.989***	98
	SC 2	5.247***	89	2.211*	62
	SC 5	15.401***	226	8.312***	152

The classes of dominants and co-dominants are clearly different from all other social classes, but between SC 3 and SC 4 no significant differences in mean height and mean diameter of the seedlings exist.
As a consequence present constatations permits to draw some provisional conclusions :

1° Seedlings-height determines social differentiation and relative dominance.

2° No real differences between dominant and co-dominant seedlings exist, indicating that the sub-population, to which they belong, has not yet completely splitted up.

3° The class of suppressed seedlings is clearly distinguishible. Retarded seedlings or recent establishments, belonging to this class not really build a reserve of potential dominants, because the differences with SC 3 and SC 4 are too great.

4° Isolated seedlings (SC 1 and SC 2) are unequivocally differentiated from all other classes. Their potential for growth is restricted. They, however, must be considered as valuable reserve on marginal spots, where establishment is difficult.

The striking differences between R1 and R3 on the whole and in each social class separately, indicate that social differences increase with progressing development of regenerations. Structuration is all the more a function of relative height-growth. The value of seedlings as structural elements is therefore increasingly determined by their height and, consequently, their diameter compared to seedlings growing immediately next to them. It suggests the opportunity of early individualization of treatment.

2. The Dynamics of Development

If it is accepted that the height of the seedling determines its social position and its value as a structural element, it is worthwhile to try to detect the main causes for differences in height between seedlings. They are, in fact, the driving force behind social differentiation and structuration, as such not to be neglected by adequate silvicultural treatment.
Three possible reasons for height differences can be considered : age differences, unequal individual vitality and a high potential for dominance.

2.1. Age and age-differences

2.1.1. The Regeneration period RP.

Establishment is not completely terminated in each of the units. The regeneration period is fairly long and covers, up to now, 30 to 35 years in R1 and R2 and even 24 to 29 years in R3 (Tab. 8). However, in R1 seedlings from 0-5 yrs. represent no more than 4.3 % of the total number, against 37.0 % in R2 and even 49.3 % in R3.
The total number of seedlings, corresponding to the regeneration period as recognized post-facto, increases from R1 over R2 to R3, but the differences are not very important.

Principal regeneration phase

Although regeneration is spread out over a fairly high number of years, concentration of seedlings in a restricted principal regeneration period can be observed in each unit. This principal regeneration period covers 18 years in R1 (seedlings between 6 and 23 years old) and R2 (seedlings between 12 and 29 years. Whereas establishment of a new generation has nearly come to an end in R2 and especially in R1, it still goes on very intensively in R3, probably because grazing continually liberates space for new seedlings. Within the principal regeneration period the highest concentration of dominants (SC 3) is found

- for R1 in the age class 12-17 yr.with 42 % of the total number of dominants and 5.3 % of the total number of seedlings ;
- for R2 in the age class 18-23 yr. (35 % of all dominants ; 4.0 of total number of seedlings) ;
- for R3 also in the age class 12-17 yr. (47 % of all dominants ; 6.6 % of total number of seedlings).

Table 8 : Age-class distribution according to social class.

	Unit	SC	Age-classes in years							Total
			0/5	6/11	12/17	18/23	24/29	30/35	> 35	
N/ha	R1	1	857	500	143	71	-	-	-	1 571
		2	-	572	357	-	-	-	-	929
		3	-	572	1 142	715	214	71	-	2 714
		4	-	500	3 356	1 358	286	71	-	5 571
		5	71	4 072	5 143	1 429	71	-	-	10 786
		Tot.	928	6 216	10 141	3 573	571	142	-	21 571
	R2	1	3 625	-	374	252	126	-	125	4 502
		2	-	251	-	-	-	-	-	251
		3	-	249	749	998	874	-	-	2 870
		4	-	126	251	1 373	1 623	248	-	3 621
		5	5 625	499	1 501	3 752	2 252	127	-	13 756
		Tot.	9 250	1 125	2 875	6 375	4 875	375	125	25 000
	R3	1	8 944	1 055	722	501	-	-	-	11 222
		2	389	168	112	-	-	-	-	669
		3	278	166	1 944	1 666	55	-	-	4 109
		4	111	223	2 111	944	-	-	-	3 389
		5	4 833	1 333	2 778	1 111	56	-	-	10 111
		Tot.	14 555	2 945	7 667	4 222	111	-	-	29 500
In %	R1	1	92.3	8.0	1.4	2.0	-	-	-	7.3
		↓2	-	9.2	3.5	-	-	-	-	4.3
		3	-	9.2	11.3	20.2	37.5	50.0	-	12.6
		4	-	8.0	33.1	38.0	50.1	50.0	-	25.8
		5	7.3	65.6	50.7	40.0	12.4	-	-	50.0
		→	4.3	28.8	47.0	16.6	2.6	0.7	-	↓ 100 →
	R2	1	39.2	-	13.0	3.9	2.6	-	100.0	18.0
		↓2	-	22.3	-	-	-	-	-	1.0
		3	-	22.1	26.1	15.7	17.9	-	-	11.5
		4	-	11.2	8.7	21.5	33.3	66.1	-	14.5
		5	60.8	44.4	52.2	58.9	46.2	33.9	-	55.0
		→	37.0	4.5	11.5	25.5	19.5	1.5	0.5	↓ 100 →
	R3	1	61.4	35.8	9.4	11.9	-	-	-	38.0
		↓2	2.7	5.7	1.5	-	-	-	-	2.3
		3	1.9	5.6	25.4	39.5	49.5	-	-	13.9
		4	0.8	7.6	27.5	22.3	-	-	-	11.5
		5	32.2	45.3	36.2	26.3	50.5	-	-	34.3
		→	49.3	10.0	26.0	14.3	0.4	-	-	↓ 100 →

This kind of concentration indicates that the social position of a seedling and especially its eventual dominant character is, for a large part, determined by its age.

Pre-regeneration phase

Surviving pre-regeneration is rather unimportant, suggesting that regeneration either starts explosively at a certain, but rather advanced moment or that destruction of seedlings was during establishment extremely high over a period of unknown length, during which seedlings had great difficulty to colonize the site.
Nevertheless, pre-regeneration has a certain importance in R1 : it comprises 713 surviving seedlings/ha (3.3 % of total number), 284 of which are dominants or 10.5 % of all seedlings belonging to SC 3.
Remaining pre-regeneration is really unimportant in R2 with 500 seedlings/ha or 2 % of the total number of seedlings. None of this surviving seedling is dominant.

In R3 pre-regeneration is also nearly negligible with only 111 seedlings/ha (0.4 % of N), 55 of which or 1.3 % of the number of surviving seedlings belonging to SC 3 are dominant.

Post-regeneration phase

A post-regeneration phase can not be distinguished in R3.

Post-regeneration is fairly unimportant in R1, comprising only 928 recent seedlings of 0-5 yr., mostly isolated and none of them belonging to the dominant or co-dominant class.
On the other hand, post-regeneration is rather important in R2, but difficult to evaluate at the moment. It comprises 10 375 seedlings/ha or more than 2/5 of the total number of surviving seedlings, 240 of which are dominants or 8.7 % of the number of seedlings belonging to SC 3.
A fair number of seedlings from the post-regeneration phase belong to SC 1 and, as such, are of great value. A still greater number belonging to SC 5. It is nearly impossible to correctly evaluate their actual and potential value.

Provisional conclusions

The characteristics of the pre- and post-regeneration phases as well as the position and length of the principal regeneration phase indicate that regeneration does not progress in quite the same way in the 3 units. The consequences of intensive care in R1 and of grazing in R3 are evident, where establishment is a continuity. But R2 rather follows some kind of a ware-pattern.

In all cases the surviving seedlings, that colonized the site during the principal regeneration phase are the principal potential components of the future stand. This phase covers a period of nearly 20 years, as a subdivision of a much longer total regeneration period of no less than 30 to 35 years.

2.1.2. Age class distribution according to social class

Age class distribution is quite different within each social class, but the main age characteristics are the same in all units.

SC 1 : Isolated seedlings under cover

The range of age classes is rather restricted. Seedlings are clearly concentrated in the 1st age class (0-5 yr.) with between 55 % (R1) and 80 % (R2 ; R3) of all seedlings, belonging to SC 1.

SC 2 : Isolated seedlings not under cover

Rather unimportant sub-population, representing not more than 1 to 4 % of the total number of seedlings. They belong, nearly exclusively, to the lower age classes, which illustrates their small chances for survival (Moulopoulos, 1956).

SC 3 : Dominant seedlings

Dominant seedlings show a wide range of age distribution, although the greater part belongs to the principal regeneration phase (cfr. Supra). Very few elements established during the post-regeneration phase are still survive : none in R1, 8.7 % of the total number of seedlings belonging to SC 3 in R2 and a little more in R3 (10.8 %), where current establishment is still going on and the regeneration period is lengthened by the impact of frequent cattle-grazing.

SC 4 : Co-dominant seedlings

The analogy with SC 3 is striking :

- About the same range of age class distribution.

- Concentration of seedlings in age classes corresponding to the principal regeneration phase.

- Weak representation of age classes corresponding to post-regeneration phase : none in R1, 3.5 % of number of seedlings belonging to SC 4 in R2 and no more than 9.9 % in R3.

SC 5 : Suppressed seedlings

This class has a wide range, covering nearly all age classes, although concentration of seedlings in the age classes, corresponding to the principal regeneration phase can be observed, however less pronounced as in the case of SC 3 and SC 4.

Seedlings of less than 12 years (age class 1 and 2) are strongly represented : 38.4 % of the number of seedlings belonging to SC 5 in R1, 44.5 % in R2 and even 61.0 % in R3.
In this class two sub-populations are present :

- A sub-population with older elements, which still survive although they suffered social demotion along the line SC 3 - SC 4 - SC 5.
  The sub-population, resulting from, social degradation is most prominent in R1.

- A sub-population with younger elements established at the end of the principal regeneration phase and during the post-regeneration phase, typical for R2 and, especially, for R3, where active establishment is still in progress.

The age characteristics of the social classes strengthen the conviction that early silvicultural intervention is needed if the promotion to dominant status of retarted or younger elements is, for some reason, though advisable.

2.1.3. Relationship between social classes

The classes SC 1 and SC 2 are to be considered as independent entities within the regeneration groups and units : they have no direct contact with the other classes. The dominant, co-dominant and suppressed classes are in direct physical and physiological contact with each other, as a result of the nature of their distribution in time and space. The ratio of the number of seedlings in SC 3 (N3), SC 4 (N4) and SC 5 (N5), illustrates the variability of the relationship between classes with the passing of time (Tab. 9).
The ratio N3/N4 increases from R1 over R2 to R3 : as far as their numbers are concerned, co-dominants are relatively more important than dominants in the older and better consolidated regeneration groups. Also in absolute terms co-dominants are better represented than dominants in the older units (R1 and R2), but in R3 the dominants are more numerous.

Table 9 : Ratio of the number of seedlings in social classes (Age classes corresponding to the principal regeneration phase).

Ratio	Unit	Age-class					Mean ratio	
		0/5	6/11	12/17	18/23	24/29	PRF	RP
N3/N4	R1		1.14	0.34	0.54		0.47	0.49
	R2			0.98	0.73	0.54	0.81	0.79
	R3	2.50	0.74	0.92	1.76		1.20	1.21
N3/N5	R1		0.14	0.22	0.50		0.23	0.25
	R2			0.50	0.27	0.39	0.35	0.21
	R3	0.06	0.12	0.70	1.50		0.40	0.41
N4/N5	R1		0.12	0.65	0.95		0.49	0.52
	R2			0.17	0.37	0.72	0.43	0.26
	R3	0.02	0.17	0.75	0.85		0.34	0.34

With increasing seedling-age the N3/N4-ratio also increases in R1 and R2, but not in R3.
From this state of affair can be deduced that the relative number of dominant seedlings diminishes in the course of time, that time is an active factor in structuration and that SC 4 functions as a collector for demoted elements, descending from SC 3.
The result of this transition is good perceptible in R1 and R2, but less in R3, where structuration is still in full progress.

The relationship between SC 3 and SC 5 is less evident, but in all cases the relative importance of suppressed elements decreases with increasing age of the seedlings, as well as from R1 to R3. This situation is to explained by increasing mortality with the passing of time, slow transition from SC 3 to SC 5 and the fact that younger seedlings represent an important portion of SC 5.

The ratio N4/N5 also decreases from R1 to R3, but, whitin each unit, it increases with the age of the seedlings. The relative increase in importance of N4 in relation to N5 with the passing of time is due, partly to the transitions from SC 3 to SC 4, partly to the high mortality-rate for suppressed elements.

As a base for treatment of regenerations or young stands three facts should be kept in mind :

- Structural development is characterized by the transition of components following the line SC 3 - SC 4 - SC 5 elimination.

- Dominant and co-dominant elements arise from the splitting up of the same basic sub-population.

- Suppressed elements have a double origin : descent from a higher social class and more recent establishment.

2.1.4. Age differences between social classes

The determination of the mean age of the seedlings pro social class confirms precious constatations (Tab. 10).
The mean age of the isolated seedlings, whether under cover or not, is significantly lower than the mean seedlings age in all other social classes. They are the result of recent establishment on parts of the site where the mortality rate is probably high.

Table 10 : Average age of the seedlings pro social class (in years).

Unit	Social class	Age	s	n
R1	1	5.8	5.31	17
	2	10.3	3.41	11
	3	16.2	5.51	40
	4	16.5	4.29	78
	5	13.4	3.80	149
	3 + 4	16.4	4.72	118
	Tot.	14.0	5.16	295
R2	1	6.2	6.14	36
	2	8.5	2.12	2
	3	19.4	5.18	24
	4	23.1	4.90	29
	5	14.0	9.25	109
	3 + 4	21.3	5.33	53
	Tot.	14.5	9.32	200
R3	1	5.0	4.73	199
	2	7.0	4.45	11
	3	15.3	5.63	75
	4	15.4	3.88	61
	5	8.9	6.68	181
	3 + 4	15.4	4.91	136
	Tot.	9.0	6.88	527

No age differences between dominant and co-dominant seedlings exist in R1 and R3, but in R2 seedlings belonging to SC 4 are significantly older as those belonging to SC 3.

t-test on age differences between SC 3 and SC 4

R1	0.399	for	n = 40 + 78
R2	2.710**	for	n = 24 + 29
R3	0.150	for	n = 75 + 61

The common origin of both classes is thus confirmed, as well as the fact that SC 4 consists of elements in social descent.

The mean age of suppressed seedlings is a little lower than the mean age of dominants and co-dominants. The differences are well-pronounced in R2 and R3, but less in R1.

In less developed regeneration groups recent establishment determine the composition of SC 5. In more developed regeneration groups the composition of SC 5 is more confused, by the lower survival rate of recent establishments and the presence of older seedlings, whether retarded in growth but still vital, or resulting from social descent.

2.2. Vitality (V)

Vitality is a slightly subjective notion, judged visually by global evaluation of health, intensity of growth, needle or leaf biomass, appearance of leaves or needles, resilience and resistance of the seedling to negative external influences and internal pressure. This assessments can be completed by the acceptance of three conventional vitality classes (high ; medium ; low).

The absolute and relative number of highly vital elements (class 1) diminishes with progressive development of the regeneration. This observation applies to each unit, particularly to the dominants class in each unit. The difference between R3 and the older units R1 and R2 is striking, illustrating that structural development is accompanied by loss of vitality suffered by a number of dominant components and thus furthers the descending evolutive movement (Tab. 11, Fig. 3).

In all units, SC 4 comprises a great number of elements belonging to vitality class 1. This number is even more important than for SC 3 in R1 and R2, but lower in R3.
These findings confirm the double function of SC 4 as a reserve of valuable elements and as the collector of demoted seedlings. It implies that the effective use by silvicultural treatment of co-dominants as a real quality reserve requires early intervention.
The significance of social descent is otherwhise indicated by the stronger representation of vitality class 2 in SC 4 compared to SC 3.

Table 11 : Distribution of seedlings, older than 5 years, over 3 conventional vitality-classes (N/ha).

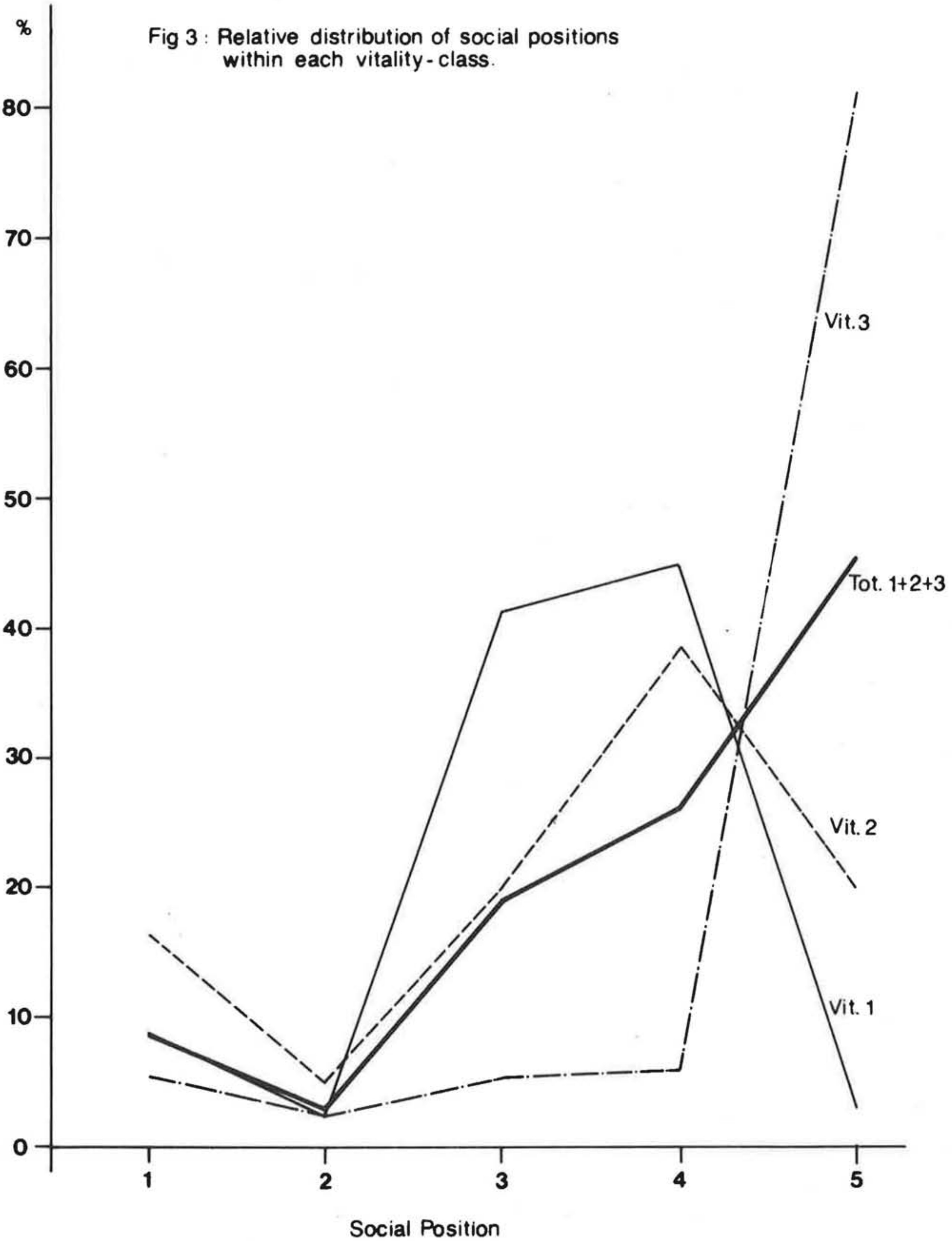
Unit	Social class	Vitality-class			Total
		1	2	3	
R1 14 plots	1	143	357	214	714
	2	143	214	571	928
	3	1 571	857	286	2 714
	4	2 857	1 786	929	5 572
	5	72	786	9 857	10 715
	Tot.	4 786	4 000	11 857	20 643
R2 5 plots	1	124	251	625	1 000
	2	250	-	-	250
	3	1 247	627	1 002	2 876
	4	2 628	874	124	3 626
	5	126	1 124	6 873	8 123
	Tot.	4 375	2 876	8 624	15 875
R3	1	833	889	556	2 278
	2	56	222	-	278
	3	2 889	611	332	3 832
	4	1 722	1 223	334	3 279
	5	222	444	4 611	5 277
	Tot.	5 722	3 389	5 833	14 944

Equally important is the fact that the presence of highly vital elements in SC 5 is negligible even in R3, although in this unit the relative number of seedlings belonging to vitality class 3 is as high as for R1 or R2.
It is therefore evident that, even in more recent regeneration, suppressed elements should not be considered as a real reserve. They only provide soil cover.

Not less important as a base for treatment is the fact that 3-seedlings are fairly rare in the class of dominants and co-dominants but over abundant in SC 5. It is even possible to prove an inverse correlation between the relative number (%) of elements with "high" and "low" vitality indicating that "medium vitality" is but a transition phase :

y = low vitality	x = high vitality	
$\bar{y} = 28.5533$	$\bar{x} = 39.8933$	df1 = 1 df2 = 13
$y = 55.24 - 0.67\,x$	$r = 0.7265$	F-value = 14.5292**

With relation to the classes of isolated seedlings (SC 1 and SC 2) can be observed that the absolute number of vital elements they con-


%
Fig 3 : Relative distribution of social positions
within each vitality-class.
80
70
60
50
40
30
20
10
0
1
2
3
4
5
Social Position
Vit. 3
Tot. 1+2+3
Vit. 2
Vit. 1

tain is extremely low and decreases as structural development progresses (R3 > R2 > R1).
However, the conservation of isolated seedlings is absolute necessary and requires early and repeated protective intervention.

These relationship permit to learn that the vitality of a seedling is a not negligible factor as it co-determines its social status. Most vital elements are concentrated in SC 3 and SC 4. Therefore the regulation of the relationship between dominants and co-dominants is one of the basic missions of early silvicultural treatment. Contrary to the opinion, expressed by Schädelin (1946), no proof exists that the ascent of co-dominants to dominant status can be arranged by silvicultural intervention in the dominant class. On the other hand early intervention can prevent or delay the descent of dominants to a lower social class.

As to the unterstory, it clearly acts as a collector of less vital components, due to their retarded establishment or to the social degradation they suffered. It therefore has a minor structural value, but its ecological value can be important.

2.3. Developmental tendency (DT)

To assess the developmental tendency of a seedling, a confrontation with its most immediate neighbour is needed, comparing the length of the leading shoots (external relation) and the lenght of each actual leader to extension growth during the previous year (internal relation).
Subsequent classification is based on the acceptance of three fundamental situations of an otherwhise really complex relationship :

- The position of the seedling improves compared to its immediate neighbour = ascending movement (DT-class 1).
- The position of the seedling remains unchanged compared to its immediate neighbour = stationary situation (DT-class 2).
- The position of the seedling worsens compared to its immediate neighbour = descending movement (DT-class 3).

2.3.1. DT in relation to social position

It is irrelevant to try to determine the developmental tendency of isolated seedlings, not in direct physical contact with others.

The class of the dominants (SC 3) possesses the highest relative number of ascending elements (55 to 74 % of all dominants). The relative number of stationary elements is fairly high, but descending elements are few (10 to 12 % of all seedlings belonging to SC 3) (Tab. 12).

Table 12 : Distribution of seedlings (N/ha), older than 5 years, according to social class and developmental tendency.

Social class	SC 3 = dominant				SC 4 = co-dominant				SC 5 = suppressed				Total SC 3 + SC 4			
Developmental tendency	1	2	3	Tot.	1	2	3	Tot.	1	2	3	Tot.	1	2	3	Tot.
R1 N/ha	1502	929	284	2715	1498	2072	2002	5572	71	143	10572	10786	3000	3001	2286	8287
% of SC	55.3	34.2	10.5	100	26.9	37.2	35.9	100	0.7	1.3	98.0	100	36.2	36.2	27.6	100
% of Σ SC 3 + SC 4	18.1	11.2	3.4		18.1	25.0	24.2									100
R2 N/ha	874	187	124	1185	1752	751	1126	3629	250	4624	9375	14249	2626	938	1250	4814
% of SC	73.7	15.8	10.5	100	48.3	20.7	31.0	100	1.7	32.5	65.8	100	54.5	19.5	26.0	100
% of Σ SC 3 + SC 4	18.1	3.9	2.6		36.4	15.6	23.4									100
R3 N/ha	2943	667	501	4111	833	944	1611	3388	1778	1056	7279	10113	3776	1611	2112	749
% of SC	71.6	16.2	12.2	100	24.6	27.9	47.5	100	17.6	10.4	72.0	100	50.3	21.5	28.2	100
% of Σ SC 3 + SC 4	39.2	8.9	6.7		11.1	12.6	21.5									100

The relative number of ascending dominants decreases with progressive development of the regeneration and reaches the lowest level in R1 : the splitting up of the sub-population of seedlings, composing SC 3, is more advanced as structuration has also farther progressed.
In the co-dominant class the situation is not quite the same :

- The three developmental tendencies are present with fairly little variation in relative and absolute numbers.

- The relative number of ascending elements is much lower as in the corresponding dominant class.

- The absolute and relative number of stationary elements is highest in the most advanced unit. In each unit separately it is higher than for the dominant class SC 3.

- The numbers (absolute and relative) of descending elements are many times higher as in the corresponding dominant class.

- The relative number of descending elements is highest in the more recent regeneration unit R3.

It is quite evident that the dynamics of change are most active in the co-dominant class.

If the social classes 3 and 4 are put together, the lowest relative number of ascending elements is also found in R1 but the highest number of stationary seedlings. The relative number of descending elements is nearly equal in all units.
In the understory (SC 5) seedlings with descending tendency clearly dominate, but most strongly in R1. Ascending elements are rare in older regeneration units, but still fairly well represented in less developed regeneration groups (R3).

Globally, the absolute number of ascending elements, belonging to the dominant and co-dominant classes is fairly high and varies between 2 626 and 3 776/ha. This could be sufficient to make of stand of fair quality if the seedlings with an ascending tendency, are also of good quality.
These assessments show that a very intense dynamic for change exists, with a general preponderance for a descending developmental movement.

The descending elements are concentrated in SC 5, which, in no case, can be considered as a reserve of potential dominants.
From the moment the absolute number of dominants is thought to be sufficient, considering age and developmental stage of a regeneration, silvicultural treatment must endeavour to regulate competition between dominants and has but little chances to promote codominants to dominant status.
If, on the other hand, the absolute number of dominant seedlings

is insufficient or if a great part of the dominants are of poor quality, silvicultural intervention must try to promote co-dominants with a stationary or ascending tendency to dominant status, by liberating them from direct competition by less valuable dominants in their immediate neighbourhood. Such a measure implies strong and repeated interventions.

2.3.2. DT in relation to age

The absolute and relative total number of ascending seedlings attains the lowest level in the more advanced regenerations (R1 and R2). For the relative total number of descending elements the reverser is observed.
The highest percentage is to be found in R1, the lowest in R3. Stationary elements are a minority in all units (tab. 13).
A direct correlation exists between DT-classes 1 and 3 proving the nearly direct evolution from ascent to descent.

y = descent (relative numbers)	x = ascent (relative numbers)	
$\bar{y} = 58.5778$	$\bar{x} = 23.5056$	df1 = 1 df2 = 16
$y = 76.61 - 0.77\ x$	$r = 0.7410$	F-value = 19.4844***

Also in this respect it is shown that the stationary position is a transition phase of restricted importance or duration in an evolutive movement, characterized, in a general way, by continual social degradation. As a matter of fact, the limited importance of the stationary element can be noticed in all age classes of all units.

Curious enough, but not contrary to the general characteristics of development, is the fact that the relative number of ascending elements increases from the lower toward the higher age classes, especially remarkable in R3, in full dynamic development, where the intensity of transition is better felt.
This movement is understandably not accompanied by an increase in absolute numbers of ascending and descending elements :

- The older surviving seedlings block more and more space with the progression of time.

- In the lower social classes is to be reckoned with regular and definitive eliminations of suppressed weaker seedlings, whether the product of social demotion or of retarded establishment.

As a rule, the maximal absolute and relative number of ascending seedlings belongs to an age class in the first part of the principal regeneration phase.

Table 13 : Seedlings (> 5 years ; PRP), distributed according to age-class and developmental tendency.

Ref	Unit	DT \ Age	6-8	9-11	12-14	15-17	18-20	21-23	24-26	27-29	Tot.
N/ha	R1	1	71	571	786	1 000	571	214			3 213
		2	71	430	714	1 071	643	358			3 287
		3	929	4 144	2 787	3 785	1 356	429			13 430
		Tot.	1 071	5 145	4 287	5 856	2 570	1 001			19 930
	R2	1			874	126	123	377	748	252	2 500
		2			125	250	376	499	626	125	2 001
		3			376	1 123	2 501	2 624	2 376	749	9 749
		Tot.			1 375	1 499	3 000	3 500	3 750	1 126	14 250
	R3	1	333	223	944	1 389	1 443	500			4 832
		2	56	277	444	778	501	111			2 167
		3	889	1 167	1 723	2 389	1 334	333			7 835
		Tot.	1 278	1 667	3 111	4 556	3 278	944			14 834
% ↓	R1	1	6.6	11.1	18.3	17.1	22.2	21.4			16.1
		2	6.6	8.4	16.7	18.3	25.0	35.8			16.5
		3	86.8	80.5	65.0	64.6	52.8	42.8			67.4
	R2	1			63.6	8.4	4.1	10.8	19.9	22.4	17.6
		2			9.1	16.7	12.5	14.2	16.7	11.1	14.0
		3			27.3	74.9	83.4	75.0	63.4	66.5	68.4
	R3	1	26.0	13.4	30.3	30.5	44.0	53.0			32.6
		2	4.4	16.6	14.3	17.1	15.3	11.7			14.6
		3	69.6	70.0	55.4	52.4	40.7	35.3			52.8

R1 : 2 357 seedlings belonging to DT 1 and between 12 and 20 years old represent 10.9 % of the total number of seedlings, 11.8 % of surviving seedlings of PRP and 73.4 % of DT 1 seedlings belonging to PRP.

R2 : 1 377 seedlings belonging to DT 1 and between 21 and 29 years old, represent 5.5 % of the total number of seedlings, 9.7 % of surviving seedlings of PRP and 55.1 % of DT 1-seedlings belonging to PRP.

R3 : 2 832 seedlings belonging to DT 1 and between 15 and 20 years old represent 9.6 % of the total number of seedlings, 19.1 % of surviving seedlings of PRP and 58.6 % of DT 1-seedlings belonging to PRP.

2.4. Conclusion

The social structure of the fir regenerations at Pertouli forest is determined by the individual social position of the structural elements and by the relationship between social classes.
The social position of each element is determined, in the first place, by its age, meaning the moment at which the surviving seedlings established, and, secondly, by its genetically determined and ecologically influenced vitality.
The greater part of the dominant seedlings with an ascendant development tendency, belong to the highest age classes.
Retarded establishment offers the seedlings little chances for survival or ultimate ascent to dominant status, as they belong from the start, to the class of suppressed elements under the cover of vital dominants and in the company of high concentrations of demoted elements.
If structuration is to be influenced, early interventions are necessary.
Within a few years after establishment, selection must be restricted to a choice between individuals belonging to the dominant or co-dominant classes. The class of suppressed elements has only exceptionally a certain structural value or can be used as a reserve.

3. The quality of regenerations

By "quality Q of a regeneration" is to be understood its silvicultural value, meaning the potentiality it possesses and the posibilities it offers to create a forest stand with well-defined features, thought to be desirable at the moment in accordance with the provisionally fixed aims of management and treatment.
As such, the quality of a regeneration group is determined by quality and distribution of its composing elements.

As forest management and silvicultural treatment aims at maximal stability and optimal functionalization of the forest, it is reasonable to consider morphological characteristics, vitality, health, intensity of growth as the main quality parameters in evaluating seedlings.

3.1. Individual quality

3.1.1. Stem quality SQ

To be considered as "good", the stem of a seedling must be relatively straight, growing in a perfect vertical position, be undamaged and showing no signs of disease or attacks by parasites (Van Miegroet, 19). Slight imperfections degrade its quality to "medium" and great defaults or damage to "poor".

Only a fairly low number of seedlings has a perfect stem : only 444/ha or less than 3 % of the total number of seedlings in R3 against a maximum of 2 643/ha or 12.8 % of the total number of seedlings in R1 (Tab. 14).
It would be reckless to conclude from the higher quality reserve in more advanced regenerations, that the stem straightens out and improves with the passing of time. This would be entirely contrary to the expected cumulative effects of external influences. As a matter of fact, the poor stem quality in R3 is probably exclusively due to the influence of grazing,where as the better quality in R1 and R2 is a direct consequence of the presence of enclosures in these units.

Isolated seedlings, whether under cover (SC 1) or completely exposed (SC 2), never show a good stem quality. A best their stems are of medium value.

The real quality-carriers belong to the dominant and co-dominant classes : 1 643/ha for both classes in R1 (62 % of all seedlings belonging to SQ 1), 1 249/ha in R2 (71 % of all seedlings belonging to SQ 1), but only 390/ha in R3, although still representing 88 % of all seedlings belonging to SQ 1.
The differences between the older units and R3 are evident. They are not due to age differences but in different protective measures and thus to treatment.

In the understory SC 5 a high absolute number of seedlings with a good stem is present. However, this class can hardly be considered as a quality reserve because the SQ 1-seedlings make up only 1 to 9 % of the total number of seedlings in this class and are surrounded by a great majority of neighbours of poor quality.

The real stem quality reserve is to be found in SC 3 and SC 4, especially in R1 and R2, because of an evident concentration of good seedlings in these classes in comparison to the total distri-

Table 14 : Stem quality-classes (SQ) according to social class (seedlings > 5 years)

Ref	Unit	SQ \ SC	1	2	3	4	5	Tot.
N/ha	R1	1 good	-	-	571	1 072	1 000	2 643
		2 medium	143	143	714	2 071	2 643	5 714
		3 poor	571	785	1 429	2 429	7 072	12 286
		Tot.	714	928	2 714	5 572	10 715	20 643
	R2	1	-	-	125	1 124	501	1 750
		2	-	124	626	1 626	1 123	3 499
		3	1 000	127	2 123	874	6 502	10 626
		Tot.	1 000	251	2 874	3 624	8 126	15 875
	R3	1	-	-	279	111	54	444
		2	111	-	554	223	279	1 167
		3	2 167	278	3 000	2 944	4 944	13 333
		Tot.	2 278	278	3 833	3 278	5 277	14 944
% ↓ = 100	R1	1	-	-	21.0	19.2	9.3	12.8
		2	20.0	15.4	26.3	37.2	24.7	27.7
		3	80.0	84.6	52.7	43.6	66.0	59.5
	R2	1	-	-	4.3	31.0	6.2	11.0
		2	-	49.4	21.8	44.9	13.8	22.1
		3	100.0	50.6	73.9	24.1	80.0	66.9
	R3	1	-	-	7.3	3.4	1.0	3.0
		2	4.9	-	14.4	6.8	5.3	7.8
		3	95.1	100.0	78.3	89.8	93.7	89.2

bution of seedlings, whereas a high concentration of poor quality is found in SC 1, SC 2, SC 5 and in R3 as well (Tab. 15).

Table 15 : Distribution (in % of N) of quality-classes according to social class, compared to global distribution (in % of N) of all seedlings (↑ ; ↓ = quality class higher resp. lower percentage in social class as total number of seedlings belonging to this class).

Unit	% of N → = 100	Social class				
		1	2	3	4	5
R1	Total N	3.4	4.5	13.1	27.0	52.0
	N.SQ 1	-	-	21.6 ↑	40.6 ↑	37.8 ↓
	N.SQ 3	4.6 ↑	6.4 ↑	11.6 ↓	19.8 ↓	57.6 ↑
	N.CQ 1	4.0 ↑	4.0 ↓	68.0 ↑	20.0 ↓	4.0 ↓
	N.CQ 3	1.7 ↓	5.6 ↑	4.4 ↓	13.9 ↓	74.4 ↑
R2	Total N	6.3	1.6	18.1	22.8	51.2
	N.SQ 1	-	-	7.2 ↓	64.2 ↑	28.6 ↓
	N.SQ 3	9.4 ↑	1.2	20.0 ↑	8.2 ↓	61.2 ↑
	N.CQ 1	-	10.0 ↑	50.1 ↑	39.9 ↑	-
	N.CQ 3	2.8 ↓	-	4.1 ↓	10.9 ↓	82.2 ↑
R3	Total N	15.2	1.9	25.7	21.9	35.3
	N.SQ 1	-	-	62.8 ↑	25.0 ↑	12.2 ↓
	N.SQ 3	16.3 ↑	2.0	22.6 ↓	22.0	37.1 ↑
	N.CQ 1	16.2 ↑	-	61.2 ↑	16.2 ↓	6.4 ↓
	N.CQ 3	11.0 ↓	2.2	8.8 ↓	15.3 ↓	62.7 ↑

Isolated and suppressed seedlings, must be qualified as a poor quality reserve because the relative number of seedlings with good stem quality they contain is far below the relative number of seedlings belonging to these classes.
At any case, the best quality distribution is to be found in the dominant class, on account of the relatively important presence of seedlings with a good stem quality and the relatively weak presence of seedlings with a poor stem quality.

As to specific morphological features linked to social position, it is commonly accepted that seedlings under cover or suppressed seedlings are more slender than dominating or isolated seedlings (Van Miegroet, 1956 ; Mayer, 1976 ; Leibundgut, 1981).
That these morphological feature, especially the h/d-ratio, is of minor significance in evaluating stem-quality of seedlings (deformation, position and damages being more important), is shown by the comparison between R1 (general good quality ; quality, concentration in SC 3 and SC 4) and R3 (general poor quality, quality concentration in SC 3 and SC 4 rather unimportant).

	R1		R3	
Social class	h/d	n	h/d	n
1	28.4	10	39.9	41
2	34.5	13	39.0	5
3	33.3	38	33.8	69
4	39.8	78	35.6	59
5	47.8	150	43.2	95
Total	41.6	335	38.5	269

The global differences between R1 and R3 are rather unimportant (t = 2.000* on mean h/d-value for each unit). In both cases the level of h/d-value is indicative for a regular (slow) growth on a marginal site.
Statistically significant, but irrelevant from a silvicultural point of view are the differences R1/R3 concerning h/d-value for co-dominant (t = 3.011**) and for suppressed seedlings (t = 2.000*).
The differences between social classes within each unit are also restricted and only in R1 a significant difference in h/d between SC 3 and SC 4 exists (t = 3.748***). The co-dominants are more slender in this unit than the dominants : the negative influence of cover and stand density on d-growth is greater than on h-growth (Tab. 16).

Table 16 : Average annual increment h/cm and d mm according to social class and for seedlings older than 5 years in R1 and R3.

Social class	I_h				I_d			
	R1		R3		R1		R3	
	cm	%	cm	%	mm	%	mm	%
1	11.5	135	5.6	93	4.17	168	1.82	102
2	4.3	62	3.9	65	1.34	54	1.06	59
3	8.5	100	6.0	100	2.48	100	1.79	100
4	8.2	96	6.1	102	2.14	86	1.68	94
5	3.4	40	3.6	60	0.77	31	1.01	56

3.1.2. Crown quality

The quality of the crown of a seedling depends upon its symmetry, dept (at least 2/3 of total seedling length)for superior quality, the biomass and color of needles or leaves, damages and signs of disease or attacks by parasites.
As for stem quality, three arbitrary crown quality classes (CQC) can be distinguished : 1 = good ; 2 = medium ; 3 = poor.

The same constatations apply to crown quality as to stem quality, but the differences are greater and the concentration of quality in the class of the dominants is still more pronounced (Tab. 17).

The number of seedlings with good crown quality is rather low. The relative importance of CQ 1 (% of total number of seedlings) even does not reach the level of SQ 1 in R1 (8.7 % against 12.8 %) and R2 (7.9 % against 11.0 %), although it attains a much higher level in R3 (11.6 % against 3.0 %). The situation in R3 proves that grazing severely affects the stem of the seedling and much less its crown.

Contrary to what was observed with regard to stem quality, the relative number of seedlings with a good crown is highest in the least developed regeneration unit R3. This fact proves that longer cohabitation of seedlings affects their crown in particular. It gives also an indication that crown-tending should start early. In the classes of isolated or individualized seedlings the number of seedlings with a good crown is rather high, but differences between SC 1 and SC 2 are not evident.

The real quality reserve, as far as the crown morphology of the seedling is concerned, is to be found in the class of the dominants (SC 3).
This class contains 50 to 68 % of all seedlings with good crown morphology and so its share in the number of seedlings with a good crown is 2 to 5 times higher than its share in the total number of seedlings (Tab. 15).
Seedlings with a real poor crown reach a level of only 13 to 21 % of all seedlings belonging to the class against 51 to 58 % for all classes together. Such an advantageous situation is found in all units.

Contrary to its position with regard to stem quality, the class of the co-dominants does not contain a great number of seedlings with an excellent crown : its share in the total number of CQ 1-seedlings is low to extremely low, especially if compared with the share of the class of the co-dominants in the total number of seedlings (Tab. 15).
But also the number of seedlings with a poor crown is low with the consequence that 50 to 60 % of all seedlings of SC 4 have a crown of medium quality. These facts illustrate the intensity of the dynamics of development, which is most strongly felt in this social class.

Table 17 : Crown quality classes (CQ) according to social class (seedlings > 5 years).

Ref	Unit	crown-class \ soc. class	1	2	3	4	5	Tot.
N/ha	R1	1 good	71	71	1 215	357	72	1 786
		2 medium	429	143	928	3 429	1 071	6 000
		3 poor	214	714	571	1 786	9 572	12 857
		Tot.	714	928	2 714	5 572	10 715	20 643
	R2	1	-	125	626	499	-	1 250
		2	749	126	1 874	2 127	624	5 500
		3	251	-	374	998	7 502	9 125
		Tot.	1 000	251	2 874	3 624	8 126	15 875
	R3	1	278	-	1 055	278	111	1 722
		2	1 167	111	2 111	1 833	389	5 611
		3	833	167	667	1 167	4 777	7 611
		Tot.	2 278	278	3 833	3 278	5 277	14 944
% ↓ = 100	R1	1	9.9	7.7	44.8	6.4	0.7	8.6
		2	60.1	15.4	34.2	61.5	10.0	29.1
		3	30.0	76.9	21.0	32.1	89.3	57.5
	R2	1	-	49.8	21.8	13.8	-	7.9
		2	74.9	50.2	65.2	58.7	7.7	34.6
		3	25.1	-	13.0	27.5	92.3	57.5
	R3	1	12.2	-	27.5	8.5	2.1	11.5
		2	51.2	39.9	55.1	55.9	7.4	37.6
		3	36.6	60.1	17.4	35.6	90.5	50.9

The descending developmental movement is clearly linked with sharp crown-competition, going out from dominant seedlings, but also effective between co-dominant seedlings.

Finally, it is shown again that, also from the point of view of crown development, SC 5 can not count as a quality reserve, as seedlings with a good crown make up less than 6.4 % of the number of suppressed seedlings and only 0.75 % of the total number of all seedlings.
The analysis of the distribution of crown quality classes thus clearly indicates that SC 3 is the real reserve from which to select.
For this reason it is the direct and principal object of treatment.
The total condition of all units further illustrates that positive intervention to promote growth and development of recognizable and dominant quality bearers, whatever the reason for their state, either genetically determined or as a consequence of beneficial influences, must start as early as possible.

The conviction that dominants of good quality and, up to a certain point in time and stand development, also the best co-dominants, should be the main object of silvicultural attention, care and selection is also based on the positive aspects of their physical features.
They distinguish themselves from seedlings, belonging to other social classes, by the characteristics of relative crown development as described by relative crown length (RL) and the D/d ratio.

Relative crown length RL

Social class	R1 : RL	n	R3 : RL	n
1	71.9	10	49.0	41
2	48.2	13	47.6	5
3	70.4	38	64.4	69
4	67.1	78	60.0	59
5	30.4	150	35.4	95
Total	55.4	289	50.6	269

The differences between R1 and R3 are not very big, but they exist : crown development is much better in R1.

t-value for RL-differences between R1 and R3

SC 1	3.798***
SC 3	2.185*
SC 4	3.533***
Tot.	2.847**

The differences are most pronounced in the classes that count most.

Within each unit no significant differences are found between dominants and co-dominants. Differences are restricted to a few cases of minor importance :

R1	Ref	t-value	
	SC 1 / SC 5	6.017***	No significant differences between all classes where seedlings have a deep crown. Restricted value of SC 5 as a reserve is confirmed.
	SC 3 / SC 5	10.868*	
	SC 4 / SC 5	3.249***	

R3	Ref	t-value	
	SC 1 / SC 5	4.644***	Poor crown development of isolated and of suppressed seedlings, which build a very poor quality reserve. No differences between dominants and co-dominants.
	SC 1 / SC 3	4.652***	
	SC 1 / SC 4	3.781***	
	SC 3 / SC 5	11.922***	
	SC 4 / SC 5	10.852***	

D/d-ratio

Social class	R1 :	D/d	n	R3 :	D/D	n
1		27.7	10		53.1	41
2		28.2	13		51.1	5
3		26.1	38		33.6	69
4		27.4	78		30.1	59
5		9.6	150		2.2	95
Total		19.2	289		25.0	269

Real and general differences between R1 and R3 exist : crown development is relatively stronger or stem development is relatively weaker in R3 compared to R1.

t-value for D/d-differences between R1 and R3.

SC 1	1.498
SC 2	2.678*
SC 3	4.963***
SC 4	2.109*
SC 5	4.092***
Tot.	3.198**

In R1 no significant differences between social classes exist. More advanced development seems to promote uniformity in relative development and produces a D/d-ratio comparable to the ration, typical for adult trees. The main reasons for this egalitarism could be the regularity of growth at a fairly slow pace, good spatial distribution and the advanced elimination of weaker seedlings.

In R3 three facts are remarkable

- The low values for SC 3 and SC 4, approaching the D/d-ratio for adults.
- The high values for the isolated seedlings (strong crown developments).
- The abscence of any difference between dominants and co-dominants.

3.1.3. Vitality

A general assessment of the vitality of the seedlings (Tab. 11) has directed attention toward two phenomens :

1° The decrease of the absolute and relative numbers of vital seedlings with progressing development of the regeneration, quite evident because the surviving most vital dominants require progressively more individual space and the social movement toward social demotion, from which suppressed, co-dominant and even dominant elements suffer, is accompanied by a decrease in vitality.

2° The most vital elements belong to the dominant and co-dominant classes (92.5 % of all seedlings with V1 in R2, 88.6 % in R2 and 80.6 % in R3).

This situation is greatly confirmed by the levels of increment (Tab. 16). The isolated seedlings under cover do extremely well on both counts (Id and Ih), even in comparison to the gregarious dominants.

They highly surpass even SC 3 in Id, which is relatively more important than Ih.
The differences between SC 3 and SC 4 are not very significant.
A certain tendency toward loss of position by SC 4 is most apparent in its Id and less in height growth.

The low vitality of suppressed seedlings and of isolated, exposed seedlings is illustrated, once more, by their low growth-rate.

3.2. Global quality

The assessment of the global quality of a regeneration, whether group or unit, arises from the determination and integration of individual characteristics in view of the conservation of the forest and/or the silvicultural aim.
The assessment of individual quality in the present study and the determination of its relative importance was based on three characteristics of the seedling : quality of the stem (SQ), crown quality (CQ) and vitality (V).
By accepting three arbitrary classes for each characteristic, roughly corresponding to the notions "good" (= 1) ; "medium" (= 2) and "poor" (= 3) 27 seedling types pro social class and a total of 135 seedling types could, theorethically, be considered. In this type of classification each seedling is characterized

a. by its social position

b. by a number with three digits, that consecutively, indicate the SQ-CQ- and V-classes to which the seedling belongs (111 to 333).

The experience, gathered in Pertouli forest, has indicated that only 2 out of a possible 27 seedling types are not found there :

213 : seedling with medium stem quality, good crown quality and low vitality.

313 : seedling with poor stem quality, good crown quality and low vitality.

A first approach indicates that really perfect seedlings are a rarety (Tab. 18).
The class 111 is, in fact, represented by only 334 to 571 seedlings/ha or between 2 and 3 % of the total number of seedlings.
There also is an all-over average of 426 near perfect seedlings pro ha (three units together), 41.0 % of which are dominants, 54.6 % co-dominants and 4.4 % belong to the understory. This again is a confirmation that SC 3 and SC 4 belong to the same sub-population, they are the real value or quality carriers, for the 112-, 121- and 211-types also are concentrated in the dominant and co-dominant classes.

Table 18 : Distribution of seedlings (N/ha) according to social class and individual quality.

Unit	SC \ SQ	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	Total
	CQ	1	1	1	2	2	2	3	3	3	1	1	1	2	2	2	3	3	3	1	1	1	2	2	2	3	3	3	
	V	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
R1	1										70				72								70	215	73		71	143	714
	2										72			71										69			145	571	928
	3	357		71	143						429			72	143			69		214	144		285	214	73	71	286	143	2714
	4	214	71		571	71		143			73			1072	429	70		359	73				643	500	68	142	358	715	5572
	5					72	214		71	643	70				142	144		215	2071					72	430		214	6357	10715
	Tot.	571	71	71	714	143	214	143	71	643	714			1215	786	214		643	2144	214	144		998	1070	644	213	1074	7929	20643
	%	2.8	0.3	0.3	3.5	0.7	1.0	0.7	0.3	3.1	3.5			5.9	3.8	1.0		3.1	10.5	1.0	0.7		4.8	5.2	3.1	1.0	5.1	38.5	100.0
R2	1																						123	122	499		127	129	1000
	2										122												129						251
	3				126						125	123		124		249				377			498	254	621		250	127	2874
	4	374			748						127			877	123		371	129					124	249			373	129	3624
	5					126			123	247						130		121	880				123	251			498	5627	8126
	Tot.	374			874	126			123	247	374	123		1001	123	379	371	250	880	377			997	876	1120		1248	6012	15875
	%	2.3			5.5	0.8			0.8	1.5	2.3	0.8		6.3	0.8	2.4	2.3	1.6	5.5	2.4			6.3	5.5	7.1		7.9	37.9	100.0
R3	1													55	57					276			443	556	58	56	278	499	2278
	2																							109		54	115		278
	3	167			111						279			281						612			1278	441		168	165	331	3833
	4	110												109	55		56			165			1001	671		278	498	335	3278
	5	57													56	53			167	58			56	224		57	167	4382	5277
	Tot.	334			111						279			455	168	53	56		167	1111			2778	2001	58	613	1223	5547	14944
	%	2.1			0.7						1.9			3.0	1.1	0.4	0.4		1.1	7.4			18.6	13.4	0.4	4.1	8.2	37.1	100.0

Relative distribution (%) of the sum of the 4 cited types over social classes (111, 112, 121, 211).

SC	R1	R2	R3
1	4.7	-	-
2	4.8	9.8	-
3	38.1	20.1	100.0
4	47.8	70.1	-
5	4.7	-	-
Tot.	100	100	100

Presence of the 4 types within each class (in % number of seedling of the class)

SC	R1	R2	R3
1	9.8	-	-
2	7.8	48.6	-
3	21.1	8.7	10.2
4	12.8	24.1	-
5	0.7	-	-
Tot.	7.3	7.9	2.6

Although both, SC 3 and SC 4, contain a satisfactory number of good elements it nevertheless is evident that the good elements suffer less competition from elements belonging to lower quality classes in SC 3.
As to the presence of elements with poor quality, is to be observed that the 333-type (extremely low quality) is strongly represented (between 5 547 to 7 929 seedlings/ha, roughly corresponding to 37-38 % of the total number of seedlings).
This type is clearly dominant in SC 5. It is also moderately present in SC 3 and SC 4, although a little more in the latter class.

Relative distribution of 333-type over social classes

SC	R1	R2	R3
1	1.8	2.1	9.0
2	7.2	-	-
3	1.8	2.1	6.0
4	9.0	2.1	6.0
5	80.2	93.7	79.0
Tot.	100	100	100

Presence of 333-type within each class (% of number of seedlings belonging to the class)

SC	R1	R2	R3
1	20.0	12.9	21.9
2	61.5	0.0	0.0
3	5.3	4.4	8.6
4	12.8	3.6	10.2
5	59.3	69.2	83.0
Tot.	38.4	37.9	37.1

Although serious doubt could be cast upon the validity of the method it, nevertheless, is possible to consider the three parameter, used to assess the quality of the seedling (stem quality, crown quality, vitality) as equivalent and to consider the indices as a mathematical value.
By making the sum of the indices, 7 global quality classes are conceivable, ranging from 3 to 9. Consequently the mean quality-indices for different units can be calculated (Tab. 19).
These globalized quality indices greatly confirm earlier conclusions, arrived at by other methods.
They also teach that the three units are of medium quality and that the relative superiority of R1 is due

- to the higher absolute number of good seedlings (111 + 121 + 112 + 211) = 2 070/ha against 1 622/ha for R2 and 724/ha for R3.

- the concentration of this elements in the dominant and co-dominant class, where they find a relatively more advantageous competition environment in which to grow up : 1 859/ha or 22.4 % of all seedlings in this class are found in R1, 1 500/ha or 23.1 % in R2 and but 667/ha or 9.4 % in R3.

Table 19 : Distribution of seedlings (N/ha) according to social class (SC) and sum of indices (Σ i).

Unit	SC \ Σi	3	4	5	6	7	8	9	Tot.	$\frac{\Sigma i}{3 \cdot n}$
R1	1	-	70	-	142	215	144	143	714	2.3697
	2	-	72	71	-	69	145	571	928	2.6670
	3	357	572	357	572	354	359	143	2 714	1.8685
	4	214	715	1 286	1 072	1 071	499	715	5 572	2.0512
	5	-	70	72	427	1 074	2 715	6 357	10 715	2.7890
	Tot.	571	1 499	1 786	2 213	2 783	3 862	7 929	20 643	2.4489
	In %	2.8	7.3	8.6	10.7	13.5	18.7	38.4	100.0	
R2	1	-	-	-	123	122	626	129	1 000	2.5870
	2	-	122	-	129	-	-	-	251	1.6760
	3	-	251	624	498	503	871	127	2 874	2.1739
	4	374	875	877	618	378	373	129	3 624	1.7942
	5	-	-	126	246	749	1 378	5 627	8 126	2.8311
	Tot.	374	1 248	1 627	1 614	1 752	3 248	6 012	15 875	2.4418
	In %	2.4	7.9	10.2	10.1	11.0	20.5	37.9	100.0	
R3	1	-	-	331	500	612	336	499	2 278	2.3585
	2	-	-	-	-	163	115	-	278	2.4712
	3	167	390	893	1 278	609	165	331	3 833	1.9790
	4	110	-	274	1 112	949	498	335	3 278	2.0586
	5	57	-	58	112	334	334	4 382	5 277	2.8792
	Tot.	334	390	1 556	3 002	2 667	1 448	5 547	14 944	2.4208
	In %	2.2	2.6	10.4	20.1	17.9	9.7	37.1	100.0	

In all units real quality is concentrated in SC 3 ; SC 4 acts as a potential reserve ; the quality of SC 1 and SC 2 is low, but nevertheless much better than the quality of SC 5.

Seedling types, not or poorly represented are :

Absent in all units :

213	Average stem ; good crown ; low vitality.
313	Poor stem ; good crown ; low vitality.

Absent in two units :

112	Good stem ; good crown ; average vitality.
113	Good stem ; good crown ; low vitality.
123	Good stem ; average crown ; low vitality.
131	Good stem ; poor crown ; high vitality.
212	Average stem ; good crown ; average vitality.
312	Poor stem ; good crown ; average vitality.

Absent in one unit :

122	Good stem ; average crown ; average vitality.
132	Good stem ; poor crown ; average vitality.
133	Good stem ; poor crown ; low vitality.
232	Average stem ; poor crown ; average vitality.
331	Poor stem ; poor crown ; high vitality.

These constatations are interesting in itself. They incite to a critical approach to current methods of quality assessment. They indirectly indicate the direct linking between crown morphology and vitality of the seedling and stress the importance of early crown care as a means to promote equilibrated development.

As to the relationship between dominants and co-dominants and, more in particular, the determination of their potential value as a quality reserve and direct objects for silvicultural interest, three different approaches are possible on which to base a provisional judgment.

a. Evaluating the presence of valuable types (111, 121, 112, 211).

N/ha	SC 3	SC 4	Ratio N3/N4
R1	929	929	1.00
R2	251	1249	0.20
R3	390	-	-

b. Evaluating the presence of poor types (233, 323, 332, 333).

N/ha	SC 3	SC 4	Ratio N3/N4
R1	502	1214	0.41
R2	998	502	1.99
R3	496	833	0.60

c. Evaluating the ratio good types/bad types

	SC 3	SC 4
R1	1.85	0.77
R2	0.25	2.49
R3	0.78	-

Global quality indices suggest a certain degree of similarity between the 3 units. Detached analysis allow to observe differences with a direct impact on treatment :

- In R1 and R3 quality is concentrated in the dominant class, because the absolute number of good elements is high (R1) or because the relative number of poor elements is low (R1 and R3).
  No good elements are present in SC 4 (R3) or the good elements are dominated by poor elements in this class (R1).

- In R2 quite the opposite situation exists. Good quality is concentrated in the class of the co-dominants (very high number of good and low number of poor elements). The class of the dominants is relatively unimportant as quality reserve, because of the fairly low number of good elements in this class, against a high number of poor elements.

The latter constatations dictate prudence in formulating general conclusions on development and evolution of regenerations. They stress the importance of analysis and the necessity of an individualized treatment approach to each separate case.

CONCLUSIONS

In the forest of Pertouli in Thessalia (Greece) a very irregular distribution of natural regenerations of Abies x Borissi Regis Mattl. is observed.

This phenomen has different causes :

- The sensibility of young seedlings to direct solar radiation. Seedlings tend to disappear quickly if no protection is available, but also under too dense a cover. Therefore the maintenance of a suitable cover during the regeneration period and optimal regulation of stand density by adequate silvicultural intervention is of primary importance.

- The competition for water and nutrients between fir seedlings and a well developed herbaceous layer dominated by Pteridium aquilinum.

- The influence of grazing, especially by cattle, but also by different kinds of wildlife.

It is supposed that other factors influence the regeneration patterns, but their relative importance is not yet assessed.
The relatively low numbers of seedlings in regeneration groups, their poor quality and the low absolute number of excellent candidates are explained by the long suppression period, damage caused by exploitation of older trees, cattle grazing, excessive density of game populations and snow cover during severe winters. Fir however seems to recuperate fairly quickly. It is thought that 300 to 1200 dominant selection trees can be obtained in young stands if silvicultural treatment starts early.

SYMBOLS

R : Regeneration unit (R1, R2, R3).

P : Sample plot P_n : number of plots.

N : Number of seedlings/stems $\overline{N}$: average number of seedlings

N_5 : Number of seedlings more than 5 years old.

RP : Regeneration period : number of years between the establishment of surviving seedlings and culmination of the total number of seedlings.

FC : Fern cover = % of surface covered by ferns.

CC : Cover class = projection of forest canopy of soil, considering 5 classes

1	0 - 10 %
2	10 - 25 %
3	25 - 50 %
4	50 - 100 %
5	> 100 % (overlapping crowns).

s : Standard deviation.

AR : Advanced regeneration or pre-regeneration (-phase) = early stages of regeneration comprising, at given moment all surviving seedlings above the upper age limit for the principal regeneration phase PR.

PR : Principal regeneration (-phase) = period of uninterrupted establishment of seedlings, comprising, at a given moment, at least 50 % of all surviving seedlings, and for which no less than an average of 300 seedlings/ha/year are still present.

RR : Retarded or post-regeneration (-phase) = late stages of regeneration comprising, at a given moment, all surviving seedlings beneath the lower age-limit for the principal regeneration phase.

SC : Social class.
5 social classes are considered, following the classification system of Mayer (1976b) for regeneration in the selection forest :

Isolated seedlings :

Class 1 : Under cover
Class 2 : Uncovered

Gregarious seedlings :

Class 3 : Upper story. Dominants.
Class 4 : Middle story. Co-dominants.
Class 5 : Under story. Suppressed.

hd : Dominant height = average height, obtained by considering the highest seedling in each separate sample plot belonging to a given unit.

h : Tree height/cm.

$\overline{h}$: Average tree height.

US : Upper stratum. All seedlings with h > 2/3 hd.

MS : Middle stratum. All seedlings with 2/3 hd > h > 1/3 hd.

LS : Lower stratum. All seedlings with h < 1/3 hd.

Pn : Number of sample plots.

d : Diameter of seedlings, measured at stem-base.

Df : Degrees of freedom.

V : Vitality. Global assessment of health, growth intensity ; needle biomass, appearance of needles, resilience and resistance to negative external influences and internal pressure, assessed by accepting 3 conventional vitality classes (1 = high ; 2 = medium ; 3 = low).

Dt : Developmental tendency. Evolution of a seedling in comparison to its immediate neighbour. 3 classes are distinguished

DT 1 : ascending movement
DT 2 : stationary situation
DT 3 : descending movement.

Q : Quality of regeneration = potentiality it possesses and posibility it offers to create a stand with well-defined desirable features.

SQ : Stem quality, determined by straightness, vertical position, abscence of damage, disease or attack by parasites. Three stem quality classes are considered : 1 = good ; 2 = medium ; 3 = poor (SQC).

h/d-ratio : Ratio between height and diameter, both in cm, of seedling.

I : Increment Ih = height increment Id = diameter increment

CQ : Crown quality, determined by symmetry, depth, biomass of needles or leaves, color, damage, signs of disease or attacks by parasites.
Three crown quality classes (CQC) are considered : 1 = good ; 2 = medium ; 3 = poor.

RL : Relative crown length = $\frac{100 \cdot L}{h}$

L : Crown length.

D : Crown diameter.

D/d : Ratio crown diameter/stem diameter.

i : Index (1 ; 2 ; 3) for stem quality, crown quality and vitality.

Q-index : $\frac{i}{3 \cdot n}$ Average value of indices for crown quality, stem quality and vitality.

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