VARIATION
IN THE GROWTH RATE AND QUALITY
OF *PINUS PINASTER* AIT,
IN WESTERN AUSTRALIA

by

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Conservator of Forests

PERTH
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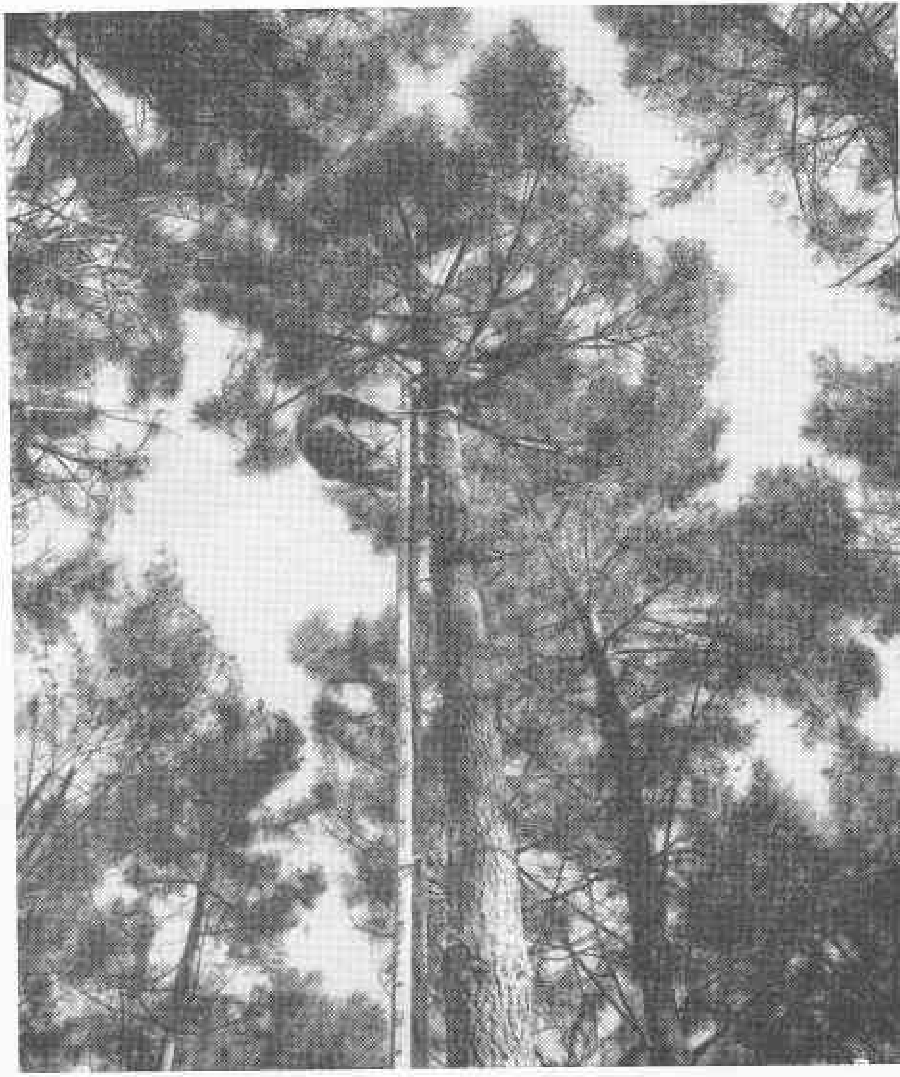

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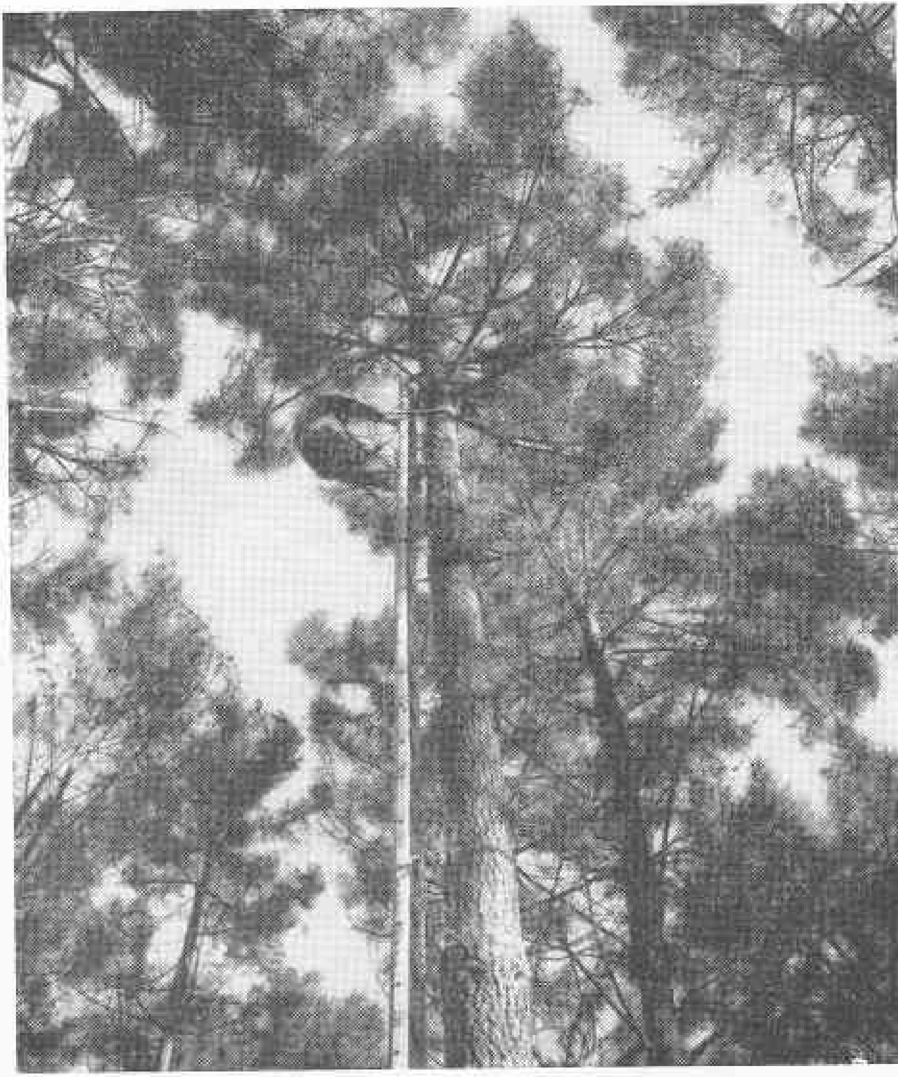
Climbing a superior tree of Portuguese origin to collect scions for grafting. This tree is 23 years old, 68 feet high and 11.8 inches diameter over bark at breast height.



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The Portuguese race is the most suitable and is markedly superior from the viewpoint of total height, merchantable volume and volume of the pruned section. Landes, Corsican and Esterel, in that order of importance, follow the Portuguese race in these aspects.

Form assessments comparing the percentages of quality stems in the four populations favour the Corsican race with approximately double the number of acceptable crop stems per unit area of the Landes and Esterel. Portuguese stem quality is intermediate between Corsican and the better Landes percentages. Stem taper of the mean acceptable crop stem is similar for all races with the exception of the Esterel in which it is significantly greater.

Information on wood properties for the species is limited and indicates little variation between races. From the point of view of high specific gravity, the Portuguese wood quality may be slightly superior.

For breeding purposes, Portuguese stock offers the most potential. Selection should improve the percentage of quality stems and reduce the high tendency for forking within the present population. The maximum degree of tree improvement for the species should be achieved by combining the vigour of the Portuguese population with the superior form of the Corsican population, provided resultant wood quality does not deteriorate in the process. At present the Landes and Esterel races do not appear to have anything further to contribute to the breeding programme.

INTRODUCTION

Pinus pinaster Ait., the maritime pine of southern and south-eastern Europe, was introduced into Western Australia in 1896 with the object of establishing softwood plantations on undeveloped coastal plain sands in the south-western portion of the State.

This introduction, undoubtedly prompted by the precedent of extensive afforestation with the species under similar climatic conditions and over a broad range of poorer soils in France and South Africa, has since proved to be a wise one. Extensive species trials over the past 40 years have now proved that maritime pine is the only softwood that can be seriously considered for commercial plantation use on the sandy soils of the Swan Coastal Plain.

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Between the years 1900 and 1930, numerous attempts were made by the Forests Department of Western Australia to establish plantations of maritime pine. Most work up to 1920 involved the direct sowing methods employed in Europe and generally resulted in failure. After 1920, establishment efforts were mainly concerned with seedling stock raised in nurseries, and by 1927 suitable techniques of site preparation, stock raising and planting out had been developed to allow establishment to be continued with confidence. Since 1930, the total planted area of maritime pine within the State has increased gradually to 20,500 acres in 1960.

Up to 1927, seed obtained from the French and, possibly, the Italian forests, was used exclusively in local work. No deliberate efforts were made to keep records of seed source or to separate the stock raised from different seed batches in the field. With the increase in tempo of establishment, after 1927, came the planning for provenance testing to determine if any particular source of seed was most suited to local plantation requirements. In 1929, the first trials comparing stock raised from seed of different geographic origins were established and since that date all seed of any species planted within the State has been recorded on a serial system whereby stock from any seed batch can be traced from the field, through the nursery and back to its place of origin and authority of collection.

It should be noted that although attempts to compare the characteristics of maritime pine provenance under Western Australian conditions was not commenced until 1929, at least one visiting forester had previously brought to notice the possible importance of using seed of origin other than French. In 1916, Hutchins, in his book "A Discussion of Australian Forestry," mentions ". . . In speaking of the supply of cluster pine seed, I have drawn special attention to the fact that the Portuguese Forests Department has offered to supply seed at the same price as the Paris quotations. This is of importance since Lisbon seed represents the exact climate of south Western Australia and the cluster pine at Leiria is the finest strain of cluster pine known to me."

From 1929 to 1939, provenance trials comparing stock from forest centres scattered over the natural range of the species were established annually and until 1948 careful measurement and uniform treatment were maintained for all trials. At this stage the results obtained from the project were considered to be conclusive and measurement was discontinued. As a result of this investigation all seed used in the State plantation programme since 1940 has been of Portuguese origin.

The publication of a detailed account of provenance investigations in South Africa by Rycroft and Wicht in 1947 confirmed and added to local findings and is possibly the reason why no previous effort has been made to write up a complete account of the local activity in this field.

In 1957, on commencing a breeding programme for maritime pine in Western Australia it was necessary to review the provenance information accumulated by previous workers. Measurement data was checked and collated and, where necessary, further work was commenced to provide as clear an indication as possible of the local variation within the species as a basis for selection studies. The information obtained from this review, and recent studies are incorporated in this bulletin.

THE SEPARATION OF GEOGRAPHIC RACES

The first comprehensive report clearly outlining the fact that the species *Pinus pinaster* embraced several geographic races was published by Duff (1928). Duff, following a study of the species over its natural range and a review of the available literature, distinguished three principal races. These races, the Corsican, the Atlantic (Landes) and the Esterel were separated on the basis of their variability in growth rate, stem form and crown and branching characteristics. He also suggested that at least two other races, of Italian origin, probably existed. Duff was able to identify the first two races and possibly an Italian race in South African stands of known seed origin.

Fieschi (1932) and Fieschi and Gaussen (1932) following up Duff's lead, reported on investigations of the variation in leaf anatomy of the species. They claimed that two separate species could be distinguished from Duff's racial grouping on the basis of the number and distribution of the resin ducts in the basal portion of the leaf. Similar studies by Marsh (1939) in South Africa and Perry (unpublished data) in Western Australia could not confirm this claim.

Perry (1940) identified Duff's three races in Western Australian plantations and suggested further that sufficient difference existed under local conditions between the Atlantic stock from France and the Atlantic stock from Portugal to constitute two separate races. Four geographic races, the Landes and Portuguese from the Atlantic seaboard forests of France and Portugal respectively, the Corsican from maritime pine forests in Corsica and the Esterel from the French Esterel, Le Maure and possibly Italian forests were considered to be clearly defined in Western Australian stands. The characters used for classification purposes by Perry were similar to those of Duff with the exception that Perry included time of flowering.

In 1947 Rycroft and Wicht published a detailed account of provenance trials in South Africa confirming the identity of the four races of Perry. Two new races, a Moroccan and a Luccan were also separated. This latter, arising from seed imported from the Italian forests of Lucca, had been suggested as a possibility by both Duff and Perry and was previously included in the Esterel race. The descriptions of the main characteristics of the four races occurring in both plantation areas were more or less identical with that of Perry, with the omission of time of flowering.

Rycroft and Wicht also provided data to illustrate the differences in rate of growth, stem form factors and wood density between provenances from the Landes, Portuguese, Esterel and Corsican forests.

Perry (1949) further classified the species variation in Western Australian plantations. He was able to identify all of the races of Rycroft and Wicht with the exception of the Moroccan which has never been planted locally.

The racial grouping at present recognised for Western Australian use may be summarised as follows:—

A.—*Origin—Atlantic Region:*

(a) Landes Race.—Seed received from the French forests of the Landes region.

(b) Portuguese Race.—Seed received from the Portuguese forests of Leiria and Marinha Grande.

B.—*Origin—Mediterranean Region:*

(a) Esterel Race.—Seed received from the French forests of Esterel or Le Maures.

(b) Corsican Race.—Seed received from the forests of Corsica.

(c) Luccan Race.—Seed received from the Italian forests surrounding the town of Lucca.

In the present bulletin discussion is restricted to four races: Portuguese, Landes, Corsican and Esterel. Isolated trees of Luccan origin are planted within the State but have never been included in organised provenance trials. The race has no promise of forest potentiality in southern Australia. Several thousand acres of plantation raised from seed received from the South African, French Hoek plantation are also established in this State. Rycroft and Wicht (1947) infer that this seed probably originated in the Landes area and do not distinguish the provenance as a separate race. South African seed (as the French Hoek provenance is known locally) appears to be an undesirable form of the Landes race and has little plantation value in Western Australia.

The morphological definition of races accepted is that of Rycroft and Wicht (1947) and Perry (1949).

Characters discussed in this bulletin are those of height growth, basal area growth, taper, branching and general stand quality. These factors are important to the utilization value of the species and provide readily distinguishable features for breeding selection purposes. They are not necessarily considered as the major factors required to define the racial groupings and until further detailed work on *Pinus pinaster*, similar to that of Critchfield (1957) for *Pinus contorta* is carried out, present definitions must be accepted.

RACIAL VARIATION IN NEEDLE ANATOMY

Fieschi (1932) and Fieschi and Gaussen (1932) in two papers reported on investigations of the needle anatomy of the maritime pine races separated by Duff (1928). They claimed that sections cut at the base of the leaf fascicle, within the region of the basal sheath, never have more than two resin canals in the mesophyll in the case of the Atlantic race (which included the Landes and Portuguese types) and generally more than two canals in the Mediterranean races. On this basis it was considered that the Atlantic race should be regarded as one species and the Mediterranean races as another with the Maures and Esterel race as one variety and the Corsican race as the other variety of the second species.

These publications stimulated interest in both South Africa and Western Australia where it was hoped anatomical differences would provide a rapid and decisive means of identifying the correct origin of plantation stock at an early age.

Marsh (1939) in reviewing these publications firstly questioned the validity "of establishing a species on a difference for which no more could be claimed than it generally occurs." Secondly, he stated that an examination of material of known origin grown in South Africa could not confirm the claims. He found that in sections cut from the basal portion of the fascicle in the region where the individual leaves just begin to be differentiated, two resin canals predominated in the mesophyll of all races. Also, more than two resin canals predominated in all races when the section was taken at a point where the individual leaves had completely separated from one another. The latter sections were all taken well within the lower half of the basal sheath. The reviewer concluded that the conclusions reached by Fieschi and Fieschi and Gaussen had no validity whatsoever.

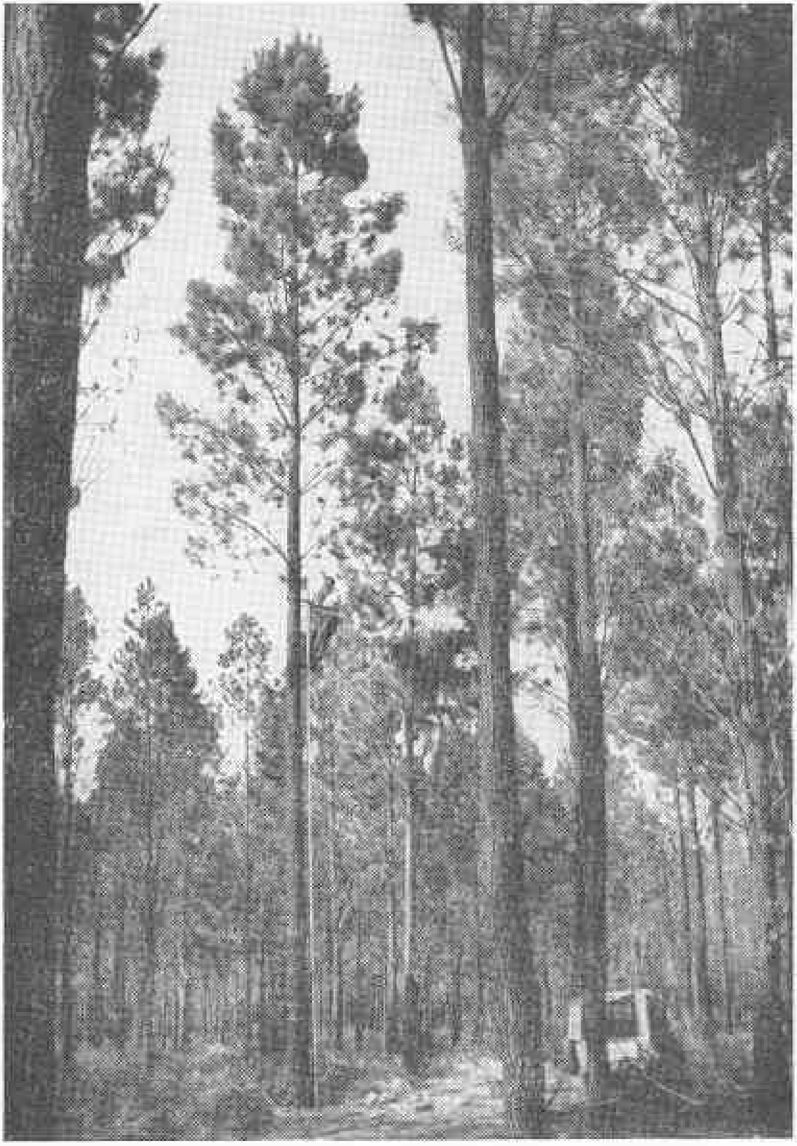
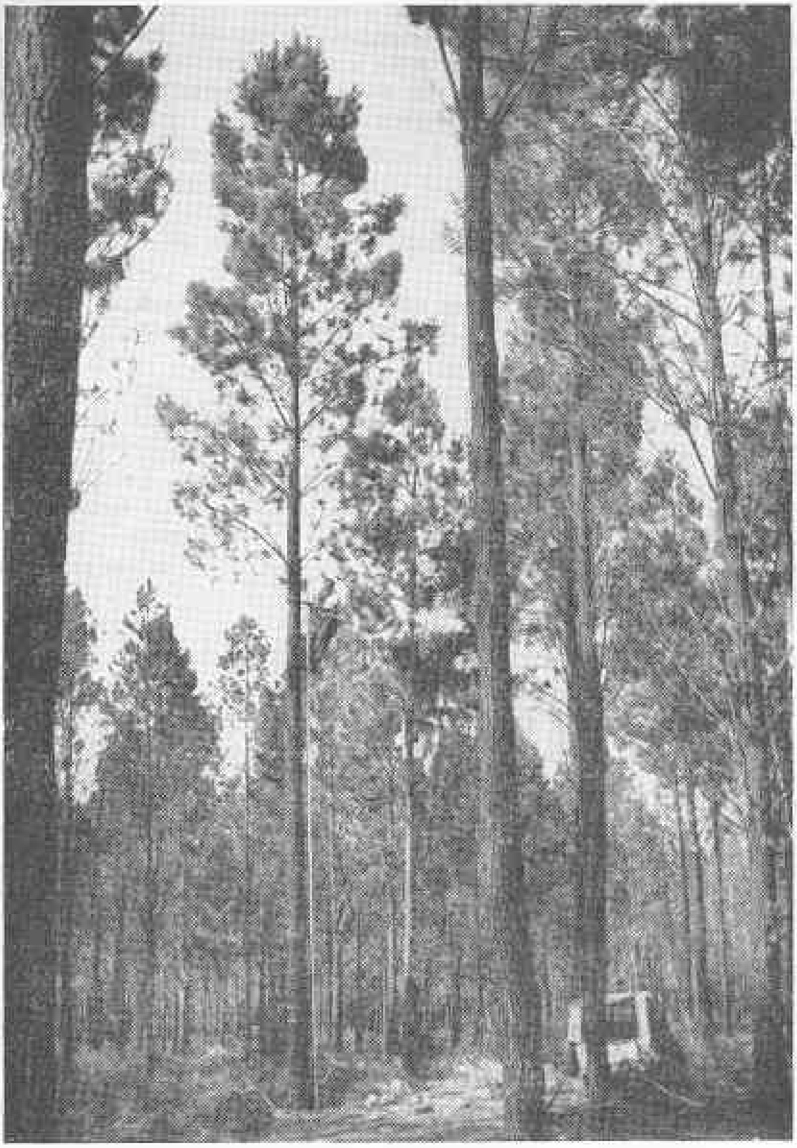


Plate 2.

A superior Portuguese tree in C.19 Gnangara. Thirty feet of ladder is set against the stem. Background trees are Corsican of the same age as the Portuguese

In Western Australia, Perry carried out independent investigations attempting to assess the diagnostic value of needle anatomical variation for racial separation in maritime pine. His work, completed in 1950, confirmed Marsh's statements generally and was never published. A summary of the work is included here as a further guide to future intensive investigations into racial separation within the species.



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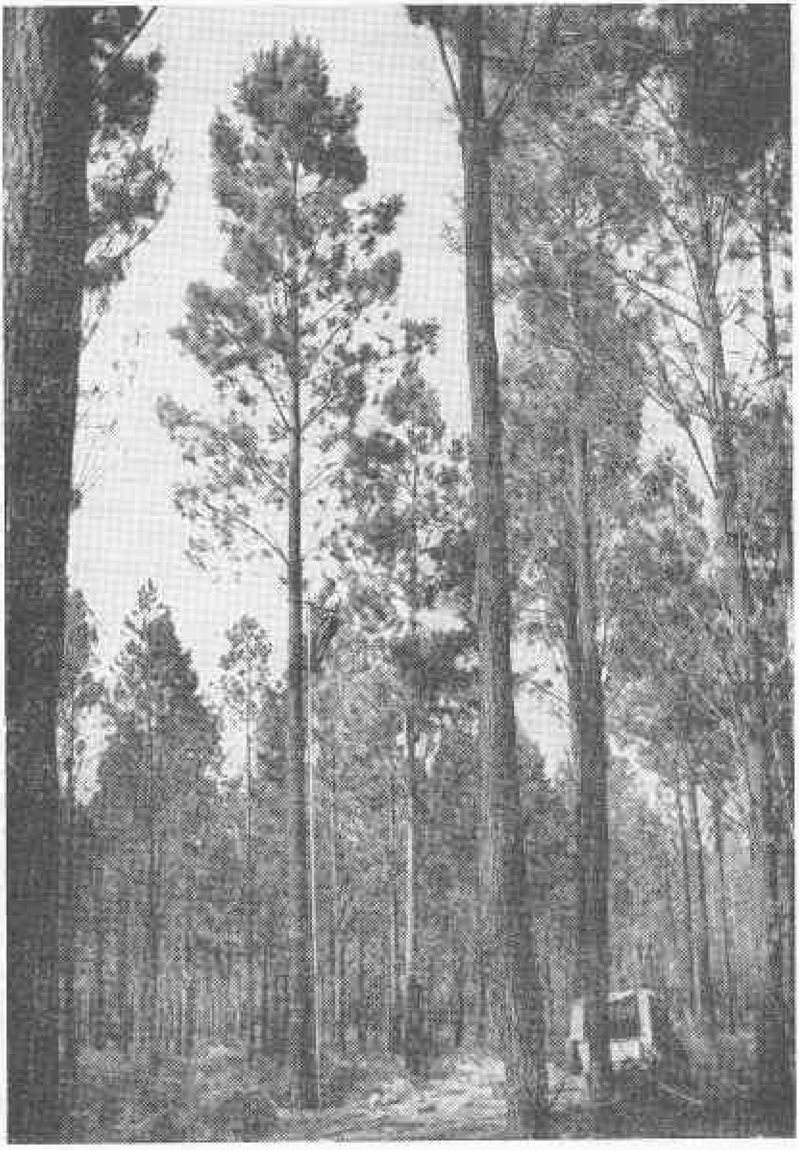

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Perry examined some 7,000 needles obtained from stands of known origin in Western Australia and from material supplied by the French and Portuguese Forest Services. Each needle was sectioned at a point three-quarters of an inch from the base and examined under a microscope. A record was made of both the total number of resin canals within the mesophyll of each needle and their exact position around the periphery.

The following conclusions were made from the study:—

(1) Needles with only two resin canals may be found in all races in trees of all ages up to 35 years.

(2) Needles from younger trees of all races have a lower number of resin canals than older trees.

(3) Young trees of all races have resin canals predominantly on their rounded or outer needle surfaces, while older trees generally have canals on both sides of their needles.

(4) Fieschi's statement that the Atlantic race had always two canals per needle and the Mediterranean races generally contained more than two canals per needle cannot be substantiated.

(5) Although needles of the Atlantic races generally had a lower canal count than the Mediterranean races, no constant features in the leaf anatomy could be found to distinguish any one race from the others.

Following an examination of Marsh's review, Perry agreed that Fieschi's claim has no validity.

PROVENANCE TRIALS

As a result of extensive trial establishment carried out in the period 1929 to 1930 it is possible to compare the relative characteristics of different provenances over the entire area considered for planting maritime pine within Western Australia. Many of these trials include Portuguese and Landes stock only, but in the four main plantation centres at Gnangara, Somerville, Myalup and Ludlow, at least one trial incorporates the provenances from the Portuguese, Landes, Corsican and Esterel Forests. For each centre, with the exception of Ludlow, reliable growth measurement data is available for comparative purposes.

For trial purposes individual provenances were planted in adjacent blocks each of four acres or more in extent. Within each provenance block a plot consisting of a row of 30 trees was selected, several years after establishment, for measurement. Plot selection was not random but so aimed to ensure that the samples in each trial were of comparable site quality while at the same time representative of the stand to be sampled.

Height and girth measurements for each plot tree were carried out periodically up to 1948 for the Somerville and Myalup plots and up to 1952 at Gnangara.

Throughout all stages of establishment and stand maintenance, treatment within each trial was identical. Thinning was not carried out until 1952 when periodic measurement was discontinued.

All seed employed for trial purposes was obtained through reputable seed firms or Forest Services on the direct request that each batch should be collected from a specific area. In most cases the British Forestry Commission acted as an intermediary to supply the seed.

Trial design does not permit sound statistical interpretation of the measurement data obtained. There is sufficient replication of trials both within plantations and between plantation centres, however, to permit data to be interpreted with confidence. Results to be presented were obtained from Gnangara, Somerville and Myalup. Details of races represented, seed used, date of establishment and number of sample trees measured are set out in Table 1.

TABLE 1.

Provenance Trials Measured for Racial Comparison in Western Australia.

Plantation	Compartment	Provenance	Serial No.	Date Planted	Number of Sample Trees
Gnangara	19	Portuguese	40	1931	30
	19	Landes	38	1931	30
	19	Corsican	39	1931	30
	19	Esterel	53	1931	30
Gnangara	12	Portuguese	253	1936	30
	12	Landes	297	1936	30
	12	Corsican	266	1936	30
	12	Esterel	231	1936	30
Myalup	21	Portuguese	40	1931	55
	16	Landes	B.C.	1929	50
	16	Landes	B.C.	1929	50
	21	Corsican	39	1931	50
	21	Esterel	53	1931	50
Somerville	26	Portuguese	54	1931	30
	27	Portuguese	54	1931	30
	26	Portuguese	40	1931	30
	27	Corsican	39	1931	30
	5A	Portuguese	54	1932	30
	5B	Landes	60	1932	30
	17	Portuguese	54	1933	30
	24	Landes	201	1933	30
	22	Landes	219	1934	30
	36	Landes	244	1935	30
	36	Corsican	246	1935	30
	36	Esterel	241	1935	30
	32	Portuguese	253	1936	30
	32	Landes	273	1936	30
	32	Corsican	266	1936	28
	34	Landes	273	1936	30
	11	Portuguese	B.B.	1929	30

Mean height and mean basal area values obtained from periodic plot measurements are illustrated in Figures 1 and 2.

For Gnangara C.19 and Gnangara C.12 a row of 30 trees in each provenance was used as the basis for measurement. Two rows totalling 50 trees were periodically measured in each block at Myalup while at Somerville plantation the Portuguese data was obtained from six separate plots containing a total of 180 trees, the Landes measurement includes three plots embracing 88 trees and the Corsican and Esterel data covers 3 plots with a total of 60 trees and one plot of 30 trees respectively as shown in Table 1.

The scatter of individual plot means for height and basal area at Somerville plantation were plotted before calculating the grouped means contained in Figures 1 and 2. This was to ensure that the unequal number of plots for each provenance and the wide distribution of trials over the plantation area could be suitably represented by a single set of data. The height age scatter is included as Appendix I.

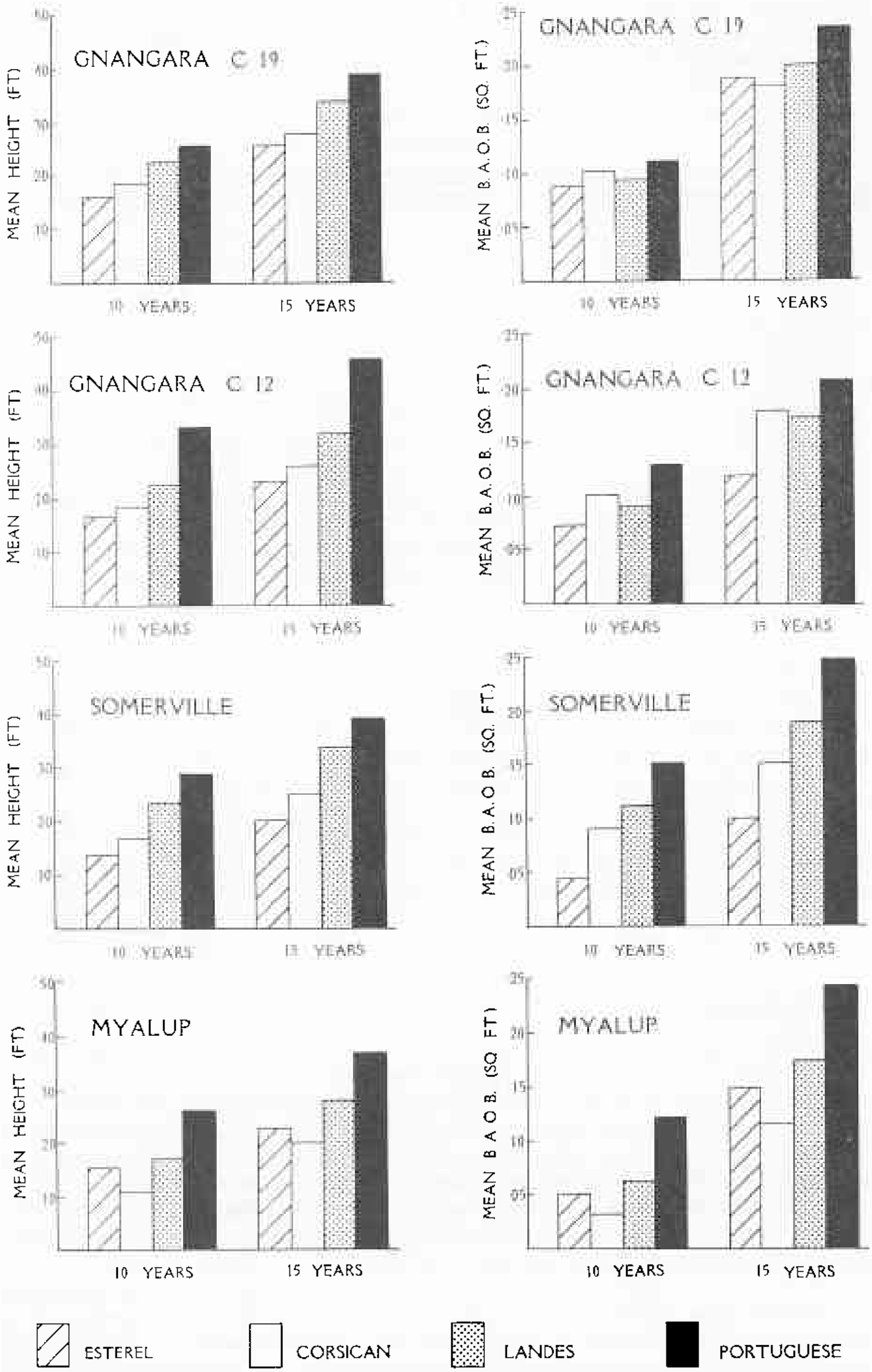


Fig. 1.

Histograms comparing height and basal area means at ages 10 and 15 years of four provenances of maritime pine tested under Western Australian conditions.

VARIATION IN RACIAL VIGOUR

Measurement data expressed in Figures 1 and 2 includes all trees dominant to suppressed, of variable stem form and health as they occur in the 30 to 50 tree sample rows. Data therefore concerns the mean tree of the planted population and represents the inherent vigour of the seed of each provenance.

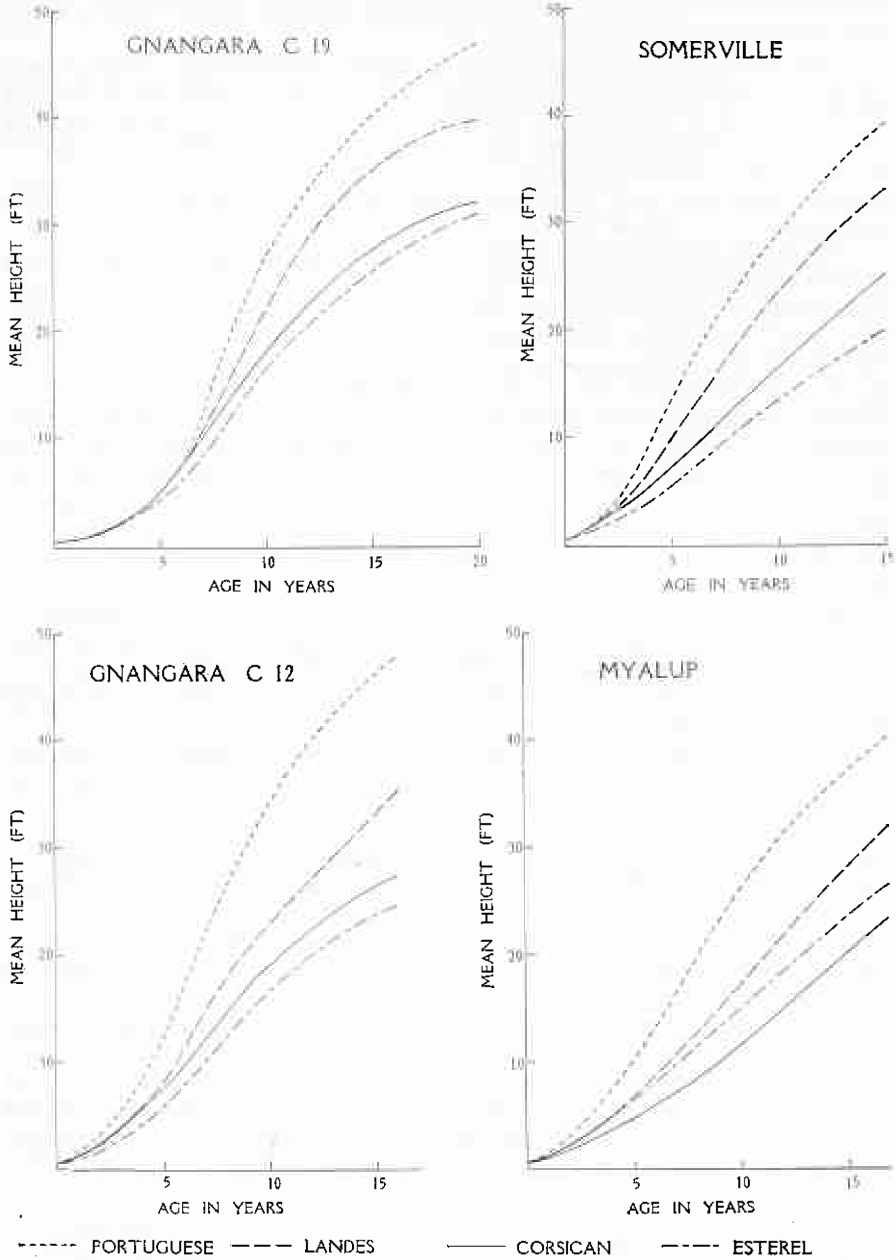


Fig. 2.
Curves showing mean height growth for different maritime pine provenances tested at three separate plantation centres.

The Portuguese provenance is obviously the better from the viewpoint of height and basal area development. This superiority has consistently been established in all plantations where Portuguese seed is planted adjacent to other provenances. Landes is clearly superior to Corsican and Esterel and data in Figure 1 indicates that Corsican may be slightly superior to Esterel in these two characters. The latter fact cannot be definitely established from trials available from study in Western Australia.

Rycroft and Wicht (1947) obtained similar comparisons for height and diameter growth in South African trials. The Portuguese race proved superior on all sites tested; Landes was consistently in second place and significantly less than the Portuguese from the viewpoint of diameter, while the relative merits of the provenances from Corsica and the French Esterel varied with different trials but were always less than the value attained by the Landes provenance.

From the viewpoint of inherent vigour under plantation conditions tested in the southern hemisphere, the Portuguese race of maritime pine is markedly superior to all others tested to date.

VARIATION IN THE ACCEPTABLE CROP TREE

The results expressed in Section V refer to the mean tree of an unimproved stand. As such they provide an estimate of the vigour of a particular provenance and, if converted to volume estimates, would indicate the capacity of a particular provenance to produce raw wood material. This information provides little indication of the actual utilisation value of the species or the range of tree quality present of interest for breeding purposes.

Recent work has aimed at defining both quantitative and qualitative aspects of wood production at an age when the major properties of the final crop should be suitably expressed. The sampling method employed was based on a system used for progeny assessment purposes by the Queensland Forest Service. (Priv. Com.).

One single strata of the range of tree vigour and form present in unthinned stands was sampled. This strata, termed the acceptable crop tree, consists of those trees of desirable vigor, stem straightness, symmetry of cross section and branching habit to be of high value for present utilization and hence final crop purposes. Essentially the acceptable crop tree is one which will produce logs of optimum value for milling or peeling purposes and, as such, will receive a higher price through quality consideration by the market.

The acceptable crop tree has been defined to facilitate stand assessment for breeding purposes. It is not necessarily the final crop tree marked in commercial plantation practice.

Present pine treemarking prescriptions in Western Australia maintain 100 trees per acre to form the final crop. These trees receive the full benefit of cultural treatment carried out during the rotation and comprise the best selection of 100 trees, scattered at a reasonably uniform spacing over the acre, available from the initial stocking. In certain instances trees of defective form and relatively low vigour are included in the final crop selection either to facilitate spacing or to make up the required number of trees.

The acceptable crop tree is not limited by spacing or numerical definition. The numbers per acre depend entirely on the capacity of the seed and site to produce trees of a suitable vigour and form standard. A stand of malformed stems raised from inferior seed may contain only 1 or 2 acceptable crop trees out of an initial stocking of 1,000 per acre. It may have, however, 100 trees per acre marked for final crop purposes as a matter of necessity. It is also possible that some stands may contain more than 100 acceptable crop trees per acre but, due to poor distribution over the area, may not provide 100 final crop trees of acceptable standard.

The theoretical ideal of the tree breeder is to produce seed which will provide populations of 100 per cent. acceptable crop trees so that all stems removed during the rotation will be of high value for utilization purposes.

The definition of the type of acceptable crop tree present in a stand, the capacity of this stand to produce wood material and the number of acceptable crop stems per acre provides both qualitative and quantitative information for the particular stand.

Sampling to Define the Acceptable Crop Stem.

The provenance trial in Compartment 19, Gnangara, was sampled at an age of 28 years to provide information on further aspects of racial variation.

This trial extends over an area of 16 acres with approximately 4 acres of each provenance represented. Site variation was mapped for the whole compartment and little difference occurred between large selected sampling areas within adjacent blocks. Treatment within the trial was kept uniform, including a light thinning, up to 1952. The Portuguese stand was, however, further thinned, in 1955. This difference was not considered sufficiently important to prevent sampling as the thinning response up to early 1959 (when sampled) has been small as a result of the poor crown condition accruing from a stagnation period of three years prior to the first thinning.

Two separate sampling procedures were involved:

(i) *To Define the Acceptable Crop Tree.*

Within each provenance block 25 to 30 acceptable trees of the dominant final crop were selected from areas of comparable site quality. This was arranged by dividing each area into four and selecting trees from the whole four sections.

For each tree, total height and diameters over bark and under bark at stem heights of 4 ft. 3 in., 5 ft. and 15 ft. were measured. Table 2 sets out the mean tree values calculated from the measurement.

TABLE 2

Mean Values for Acceptable Crop Trees Measured in C. 19 Gnangara

Race	Mean D.B.H. (In.)		Mean Height	Mean Taper U.B.	Mean Volume to 20 ft. (Cubic ft.)			Mean O.B. Vol. to 4 in. D.u.b.	Number of Trees
	O.B.	U.B.	ft.		O.B.	U.B.	Bark %		
Portuguese	11·7	8·0	63	0·91	12·1	7·8	35·4	19·6	31
Landes	10·4	8·3	55	0·88	9·6	6·5	32·4	13·9	25
Corsican	10·4	8·2	45	0·91	9·4	6·3	32·6	12·5	27
Esterel	10·0	7·9	43	1·17	8·3	5·5	33·5	11·3	25

Comparisons of total height, over bark merchantable volume, volume under bark to a stem height of 20 ft. and taper are illustrated in Figure 3. Results of an analysis carried out for the differences in these means are included as Table 3.

TABLE 3

Significance of Acceptable Crop Tree Means of Four Provenances Sampled

Character	Provenances Compared	Difference in Means			Significance
		Calculated		Actual	
		0·05	0·01		
Height	Portuguese-Landes	1·6	2·2	8·0	at 0·01
	Landes-Corsican	1·5	2·0	10·1	at 0·01
	Corsican-Esterel	1·8	2·4	1·8	at 0·05
Taper U.B.	Portuguese-Landes	0·14	0·19	0·03	*Nil*
	Landes-Corsican	0·15	0·20	0·03	*Nil*
	Corsican-Esterel	0·20	0·27	0·26	at 0·05
	Portuguese-Esterel	0·19	0·25	0·26	at 0·01
Volume U.B. to 20 ft.	Portuguese-Landes	0·8	1·0	1·3	at 0·01
	Landes-Corsican	0·7	1·0	0·2	*Nil*
	Portuguese-Corsican	1·0	1·3	1·5	at 0·01
	Landes-Esterel	0·5	0·7	1·0	at 0·01
	Corsican-Esterel	0·8	1·1	0·8	at 0·05

(ii) *Basal Area Distribution Per Acre.*

Within each of the four uniform sampling areas, three 0.1 acre plots were selected, enumerated and indexed for predominant height by measuring the height of the five tallest trees scattered over each plot. Table 4 sets out the results of the measurement.

TABLE 4

Mean Basal Area Over Bark and Stem Distribution Per Acre for Sampled Provenance Stands in Compartment 19, Gnangara

Diameter Class Over Bark (in.)	Portuguese		Landes		Corsican		Esterel	
	Basal Area	No. of Stems	Basal Area	No. of Stems	Basal Area	No. of Stems	Basal Area	No. of Stems
0– 6	3·3	30	16·3	130	12·6	113	22·3	160
6– 7	2·4	10	10·7	47	2·1	10	11·6	50
7– 8	8·5	27	10·5	33	19·9	63	19·0	63
8– 9	7·9	20	19·6	50	22·5	53	35·6	90
9–10	17·9	37	26·1	53	20·3	60	20·2	40
10–11	33·6	57	29·2	50	21·9	36	9·9	16
11–12	14·3	20	7·1	10	9·4	13	2·3	3
12–13	22·8	27	2·8	3	....	....	....	....
13–14	13·1	13	3·1	3	....	....	....	....
14+	7·7	7	....	....	....	....	....	....
Total	131·5	250	125·3	380	117·8	350	121·8	423
Mean Predom Height	64 Ft.		55 Ft.		42 Ft.		41 Ft.	

The basal area distribution in 1 in. diameter classes for the four provenances is illustrated in Figure 4. Figure 5 breaks up the basal area and stem distribution for each provenance into similar diameter classes to indicate the possible influence of the unequal thinning.

TABLE 3

Significance of Acceptable Crop Tree Means of Four Provenances Sampled

Character	Provenances Compared	Difference in Means			Significance
		Calculated		Actual	
		0·05	0·01		
Height	Portuguese-Landes	1·6	2·2	8·0	at 0·01
	Landes-Corsican	1·5	2·0	10·1	at 0·01
	Corsican-Esterel	1·8	2·4	1·8	at 0·05
Taper U.B.	Portuguese-Landes	0·14	0·19	0·03	*Nil*
	Landes-Corsican	0·15	0·20	0·03	*Nil*
	Corsican-Esterel	0·20	0·27	0·26	at 0·05
	Portuguese-Esterel	0·19	0·25	0·26	at 0·01
Volume U.B. to 20 ft.	Portuguese-Landes	0·8	1·0	1·3	at 0·01
	Landes-Corsican	0·7	1·0	0·2	*Nil*
	Portuguese-Corsican	1·0	1·3	1·5	at 0·01
	Landes-Esterel	0·5	0·7	1·0	at 0·01
	Corsican-Esterel	0·8	1·1	0·8	at 0·05

(ii) *Basal Area Distribution Per Acre.*

Within each of the four uniform sampling areas, three 0.1 acre plots were selected, enumerated and indexed for predominant height by measuring the height of the five tallest trees scattered over each plot. Table 4 sets out the results of the measurement.

TABLE 4

Mean Basal Area Over Bark and Stem Distribution Per Acre for Sampled Provenance Stands in Compartment 19, Gnangara

Diameter Class Over Bark (in.)	Portuguese		Landes		Corsican		Esterel	
	Basal Area	No. of Stems	Basal Area	No. of Stems	Basal Area	No. of Stems	Basal Area	No. of Stems
0– 6	3·3	30	16·3	130	12·6	113	22·3	160
6– 7	2·4	10	10·7	47	2·1	10	11·6	50
7– 8	8·5	27	10·5	33	19·9	63	19·9	63
8– 9	7·9	20	19·6	50	22·5	53	35·6	90
9–10	17·9	37	26·1	53	29·3	60	20·2	40
10–11	33·6	57	29·2	50	21·9	36	9·9	16
11–12	14·3	20	7·1	10	9·4	13	2·3	3
12–13	22·8	27	2·8	3	—	—	—	—
13–14	13·1	13	3·1	3	—	—	—	—
14+	7·7	7	....	—	—	—	—	—
Total	131·5	250	125·3	380	117·8	350	121·8	423
Mean Predom Height	64 Ft.		55 Ft.		42 Ft.		41 Ft.	

The basal area distribution in 1 in. diameter classes for the four provenances is illustrated in Figure 4. Figure 5 breaks up the basal area and stem distribution for each provenance into similar diameter classes to indicate the possible influence of the unequal thinning.

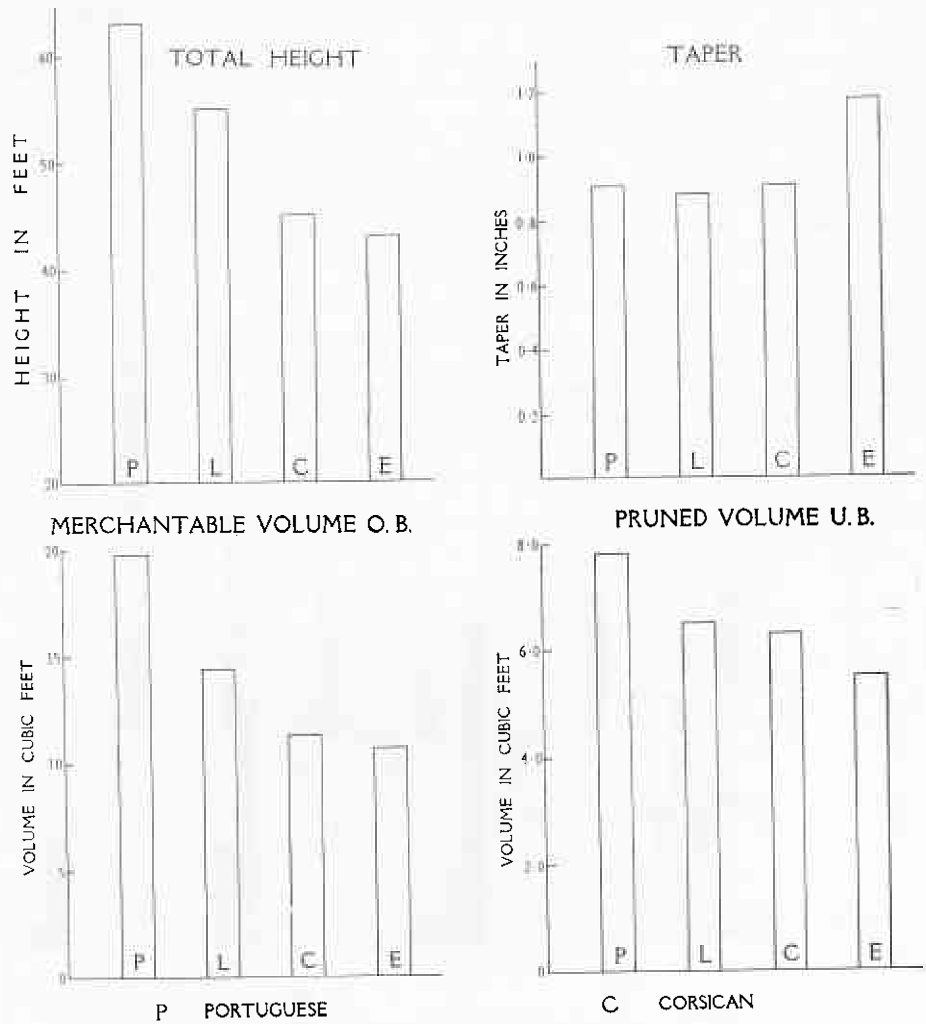
Height Variation.

The height of the mean acceptable crop tree varied considerably between the four provenances with the order of superiority favouring Portuguese, Landes, Corsican and Esterel respectively. Significant differences (at 0.01 level) were found between the Portuguese-Landes and Landes-Corsican means but not between the Corsican-Esterel means.

This order was to be expected from the vigour results set out previously in Figures 1 and 2.

Volume Variation.

The comparisons for over bark merchantable volume to a 4 in. under bark diameter limit and the under bark volume to a stem height of 20 ft. again shows the superiority of the Portuguese race. This superiority was significantly greater when tested for the under bark volume to 20 ft.



P PORTUGUESE

L LANDES

C CORSICAN

E ESTEREL

Fig. 3.

Total height, taper, merchantable volume over bark and pruned volume under bark means for acceptable crop trees of 28 years of age compared in the Gnangara C.19 provenance trial.

The Landes acceptable crop tree has a greater merchantable volume than either the Corsican or Esterel provenances, but has a significant advantage over the Esterel race only, if considered from the viewpoint of volume under bark to height 20 ft.

Under bark volume to 20 ft. stem height represents the stem section pruned under present plantation prescriptions. It includes those logs which will produce high class lumber and plywood and, as such, is a measure of the production of quality wood.

Taper Variation.

No significant difference could be determined between the mean taper of the Portuguese, Landes, and Corsican acceptable crop tree. Esterel taper was significantly greater than that of these three provenances.

This result was unexpected. It has always been taken for granted that the Corsican race tapered much more rapidly than both the Portuguese and Landes races.

Rycroft and Wicht (1947) found that there was a very evident inverse correlation between the size of the tree and form factor for the four races, but were unable to state whether these observed variations were due to the differences in size of tree or to inherent differences in form between stocks. Taper studies illustrated here appear to indicate that tree size was the cause of the observed form factor differences with the exception of the Esterel race.

The value used to express taper in all cases is the difference between under bark diameters at stem heights of 5 ft. and 15 ft.

Variation in Basal Area Distribution.

From Figure 4 it can be seen that the Portuguese stand has a far greater proportion of its basal area distributed in the larger diameter classes (10 in. plus) than any other provenance. Figure 5 comparing the basal area distribution and stem distribution further shows that even though the additional thinning in the Portuguese stand has reduced stem numbers to 65 per cent. of the Landes, total basal areas are more or less equal.

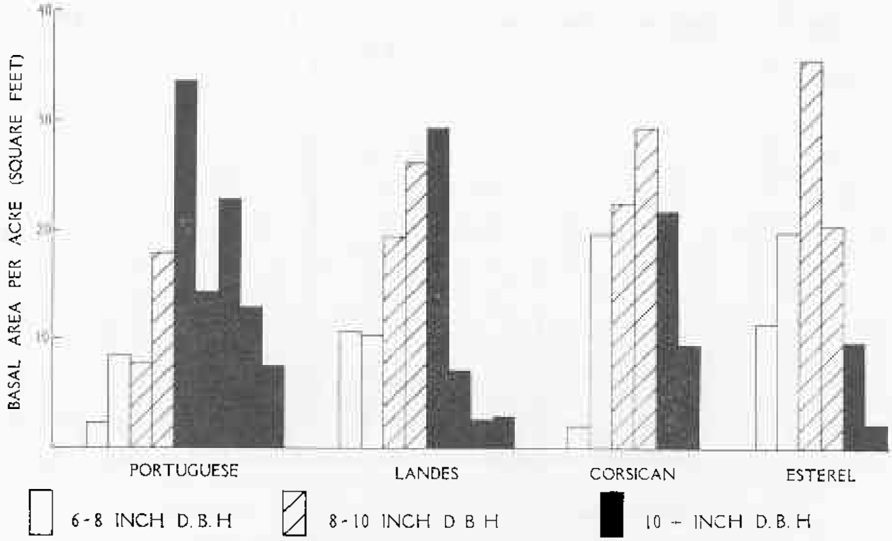


Fig. 4.

Basal area distribution at age 28 years for thinned stands of the four provenances tested in the Gnangara C.19 trial.

The only apparent unnatural advantage the Portuguese stand may have had over the other three could be due to the additional thinning in 1955. This advantage is considered to be more apparent than real.

Increment core samples taken prior to sampling distinguished a slight improvement in growth in the Portuguese stand over the four years since the 1955 thinning. This improvement could not be expected to assist the greater diameter class distribution of the Portuguese race to any important degree.

It should be noted that by preventing any thinning in the trial up to the year 1952, the Portuguese race was handicapped. The greater vigour of this provenance resulted in a very marked stagnation of the stand. Crown condition deteriorated badly in the three years before thinning and response to treatment was so poor that the second thinning in 1955 was made to try and rectify the matter.

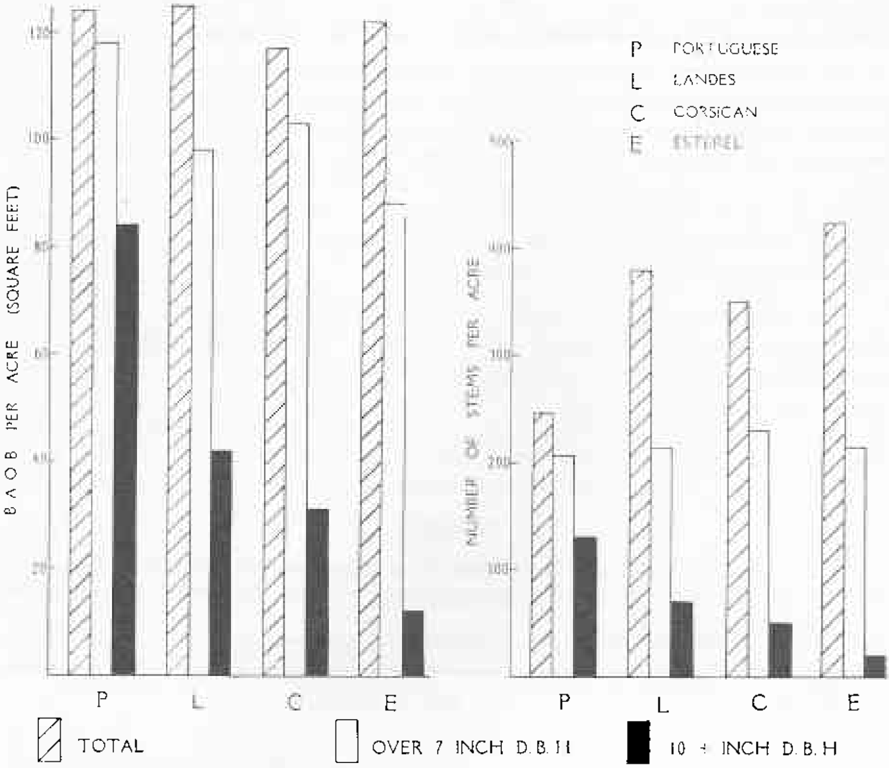


Figure 5.

Comparisons between numbers of stems and the basal area assortment in equal diameter intervals for the provenances in the Gnangara C.19 trial. Stand age is 28 years in each case and the Portuguese provenance has received thinning treatment additional to that of the other three provenances.

To offset possible bias due to the unequal treatment it was decided, prior to sampling, that if the statistical results were to be considered they should only be accepted at the 0.01 probability level.

VARIATION IN THE DISTRIBUTION OF QUALITY STEMS

Previously it was suggested that useful quantitative values for a particular stand could be obtained by defining—

(i) the capacity of the stand to produce wood material (vigour);

(ii) the mean acceptable crop tree present;

(iii) the number of acceptable crop trees per unit area.

Following the definition of the first two factors for the four provenances and the establishment of the superiority of the Portuguese race in all characters tested, the necessity arose for an overall stand quality index. This value, to indicate the proportion of quality stems present, was specificially required to compare form properties of the different racial populations.

The fact that one stand is of a higher quality that another is generally not difficult for a forester to observe. The point always in question, however, is the degree of quality difference which may exist in any comparison.

Of recent years, stand assessment systems have been developed for progeny testing purposes in forest tree breeding programmes. Different systems vary in detail depending on the intensity of assessment required but all are generally based on the principle of awarding points for individual tree factors such as vigour, stem straightness, stem symmetry of cross section, type and angle of branching, crown density and crown symmetry. The intensity of the system depends on the number of points weighted to each character and through the treatment of characters singly or in group.

The assessment method employed in Western Australia was based on one devised for use in Queensland (Priv. Com.) and the major details of the points system for martime pine are set out in Table 5.

TABLE 5.

Points System Used for Individual Tree Classification in Stand Form Assessments.

A.—Vigour—Maximum number of points awarded = 5

No. of Points	Tree Characteristics
5	Outstanding dominant; excellent height, girth and volume growth
4	Dominant stem; crown well up in the general canopy level; above plot average in volume
3	Co-dominant to subdominant tree; volume approaching the average for the stand
2	Subdominant stem; crown below the general canopy level or diameter low to give below average volume
1	Suppressed stems or those that are becoming ineffective

B.—Form—Maximum number of points awarded = 5

No. of Points	Tree Characteristics
5	Straight tree with small wide angle branches and a healthy crown ; circular cross section
4	Slight irregularities in the stem which will not affect the utilization value of the tree. Some peeler logs present in the stem
3	Defects present in the stem but not serious—includes mild bends, sweep or slight lean. Also may be less desirable in other characteristics such as branch size, branch angle ; no quality peeler logs in the stem
2	Defects becoming serious—sweep, bends, lean, double leader above 20 ft., etc. Suitable only for low grade utilization
1	Defects in all or some characters serious
0	Hopeless form

In this classification, form is a term used to cover all visual characteristics of the tree with the exception of diameter growth and total height. As such, its interpretation calls for both a knowledge of the range of characters which may be experienced and also, of those factors of form that are the most important. Inconsistencies of interpretations must occur.

These difficulties are not important provided assessments are of reconnaissance value only and against them must be considered the advantages of speed of assessment, ability to replicate plots and the general experience obtained by using the classification for the construction and application of a more rigid system for detailed work.

For assessment purposes temporary plots, 0.1 acre in extent, were established in the stand to be sampled. Each plot tree was girthed and a mean and maximum girth determined for the plot. With these limits as a guide each tree was then awarded up to five points for vigour and up to five points for form. The principle of breaking up the assessment data into strata to permit comparisons between plots is outlined in Table 6.

TABLE 6.

Separation of Plot Trees Into Tree Classes.

Tree Class (Strata)	Points Awarded	
	Vigour	Form
Plus stems	5 5 4	5 4 5
Acceptable stems	5 5 4 4	5 4 5 4
Marginal stems	5 4 3	3 3 4

B.—Form—Maximum number of points awarded = 5

No. of Points	Tree Characteristics
5	Straight tree with small wide angle branches and a healthy crown ; circular cross section
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Marginal stems	5 4 3	3 3 4

Sampling carried out has mainly been restricted to portions of stands of site quality II to remove possible interpretation defects due to site changes.

Results obtained for a form assessment at the 0.1 acre sample plots in the Gnangara C.19 provenance trial sampling are set out in Table 7.

TABLE 7.

Mean Stem Classification on a per Acre Basis for Provenance Sample Plots in C.19 Gnangara.

Seed Source	Stem Classification						No. of Plots
	Total		Acceptable		Plus		
	Number	Per cent.	Number	Per cent.	Number	Per cent.	
Portuguese S.40	550	100	46	8	10	2	3
Landes S.40	550	100	33	6	10	2	3
Corsican S.30	550	100	86	16	23	4	3
Esterel S.53	550	100	33	7	0	0	3

The results in Table 7 indicate that the percentage of acceptable crop trees and plus trees in the Corsican population is double that of the other three races of which the Portuguese may have a slight superiority. Foresters familiar with these stands would readily accept the fact that the data provides a true comparison for the Corsican population but could not agree that it adequately expresses the marked form superiority of the Portuguese stand over that of either the Landes or Esterel.

The Portuguese population has a high proportion of double leaders (approximately 25 per cent. of initial stocking). These would not be seriously considered by many foresters if the forking occurred above 20 ft. of good bole. In the assessment, however, a double leader tree cannot accrue more than two points for form and hence cannot be of acceptable crop standard.

Mean values for the assessment of 19 Portuguese plots, eight Landes Plots, four Corsican plots and three Esterel plots are set out in Table 8.

TABLE 8.

Mean Stem Quality Values Obtained for Stand Assessments for Four Races of Maritime Pine. Data Expressed on a Per Acre Basis.

Seed Source	Stem Classification						No. of Plots
	Total		Acceptable		Plus		
	Number	Per cent.	Number	Per cent.	Number	Per cent.	
Portuguese	894	100	120	13	15	2	19
Landes	691	100	54	8	9	1	8
Corsican	550	100	90	16	27	5	4
Esterel	550	100	33	7	0	0	3

Individual plot values are included in Appendix II to show the degree of variation experienced within stock raised from a single seed batch of a given race.

In the assessment project, the Portuguese race was of most concern and both the poorest and best stands were measured in an effort to identify differences attributed to seed collection. With the Landes race only the best stands (serial No. 60) were sampled in any detail to indicate the highest quality level that could be expected from the race.

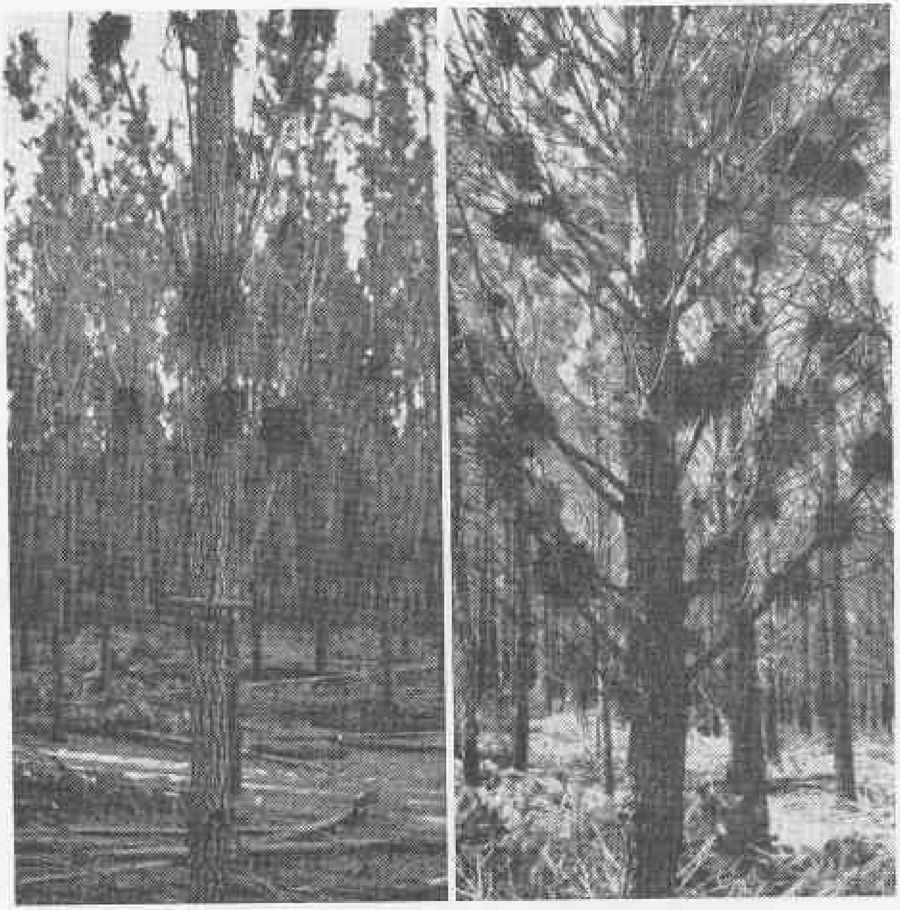


Plate 3.
Extremes of branching in maritime pine. Left: Portuguese. Right: Esterel.

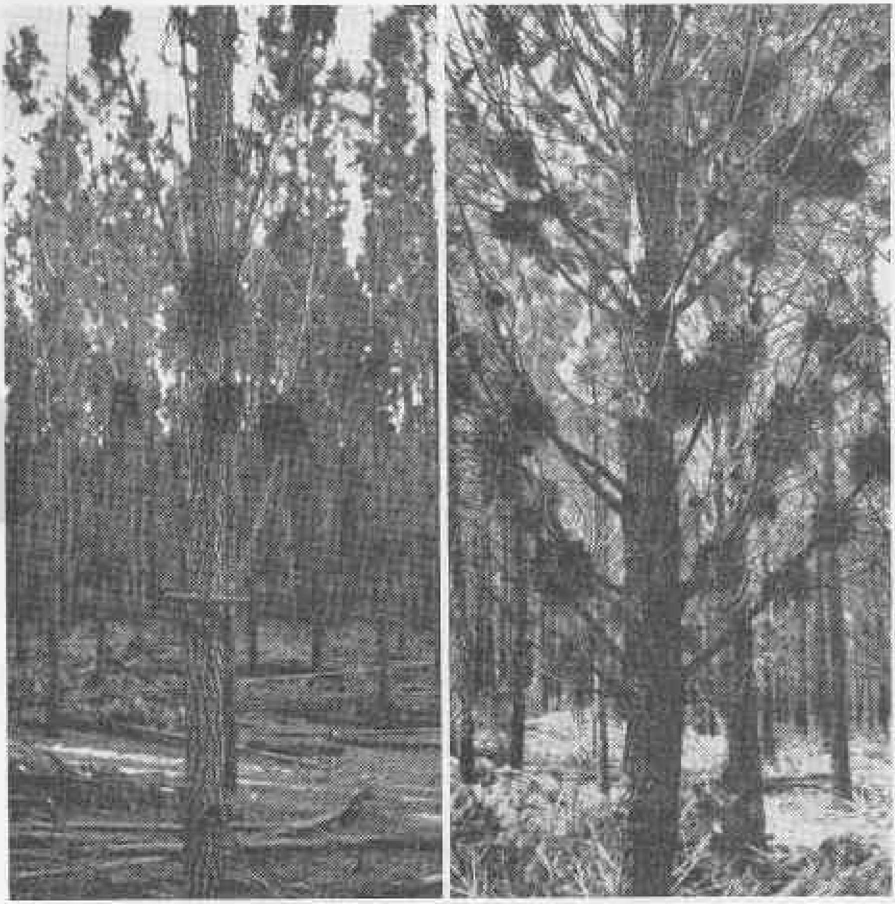
Average values for the percentage of acceptable stems and plus stems place the Corsican provenance with the highest quality stem density; Portuguese is second in importance and the Landes and Esterel races follow in that order. The Corsican population is far superior to any other from the viewpoint of density of plus stems and offers a good source of form for breeding work in maritime pine. In local plantations this advantage is offset somewhat by the limited area of the provenance available for selecting elite trees.

Appraisal of the Form Assessment Method.

An evaluation of the cause of variation of plot data set out in Appendix III is difficult even though stands of uniform site quality, comparable spacings and similar ages were sampled wherever possible. It is believed that the results bring out the following points:—

(i) Stand age is a major factor which can cause incongruencies in form appraisal. Generally, stems are considered of better form the older they are through the smoothing out of bends and whorl scars by increased diameter growth.

(ii) Spacing variation does influence the assessment of form. Wider spaced plots will generally receive lower points than close spaced plots of the



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(ii) Spacing variation does influence the assessment of form. Wider spaced plots will generally receive lower points than close spaced plots of the same age, mainly due to larger branch size and often more accentuated stem bending.

(iii) Variation due to site quality does not appear to have as much effect on form assessment as was previously supposed. Vigour is classified relative to the surrounding stand and is not affected by site quality change. A previous consideration that the form on slower growing trees would be higher than that of fast grown trees may not be of great significance in assessment appraisal.

(iv) At least five plots of 0.1 acre are required to give a reasonable indication of the form—vigour relations of any single seed batch. The Portuguese S.371, Corsican S.39 and Landes S.60 plots in Appendix II were, for each race, in stands of the same age and spacing, of the same plantation history and on similar site qualities. Variation within each serial, as indicated by the plot data, is accredited to variation within the populations.

For local purposes it is considered the project has satisfactorily covered the following points required from the reconnaissance assessment:—

(a) Information on the variation in stem quality between separate provenances has been obtained.

(b) A definition of the form—vigour properties of existing maritime pine populations has been made to provide a basis for estimating both the potential of tree breeding work and the progress of tree breeding work with the species.

(c) The application of assessment procedure has provided an idea of the range of tree variation present and the relative importance of the different characters attributed to form and vigour. This will enable a satisfactory assessment procedure to be compiled for future progency testing.

(d) Further to (c) the minimum requirements of the elite phenotype for breeding selection in the different races have been obtained.

(e) As far as form and vigour are concerned, the obtained information permits the breeding programme to be concentrated on the Portuguese and Corsican populations present within the State.

INDIVIDUAL ASPECTS OF FORM

The form appraisal attempted has been on the basis of establishing a quality stem index by grouping the individual aspects of form in any one tree. This quality index separates the better trees of the population and concerns primarily those trees without stem defect rather than the defective stems in the population.

This approach has been necessary due to the removal in certain instances of some stand abnormality in pruning and cleaning treatments. Under these conditions any procedure to assess the proportion of abnormal trees in a particular stand may be very conservative. It is certain, however, that all the better class stems still remain intact in the areas sampled.

The two approaches to the problem provide the same information in that relative quality between populations can be compared.

The quality index does not, however, illustrate the major form defects which occur in the species and the relative importance of each in determining the final estimate of quality. To cover this aspect the following observations and photographs are included:—

(i) *Butt Sweep or Bowing of the Stem.*—The worst feature of maritime pine from the utilization viewpoint is butt sweep or bending of the stem from ground level to a height of 6 to 10 feet. This feature is typical of the Landes and Esterel races, occurs in certain instances in Portuguese stock and is very infrequent in Corsican stands.

Duff (1928) suggested that although there is evidence that butt sweep is inherited in the French races there also seems to be a good correlation between bowed stems and environment. He considered that even if the tendency to bowing is inherited it seems reasonable that the bend in the stem is largely due to lack of balance between a relatively big crown and a relatively small root system. Observations in Western Australia affirm this statement.

The Portuguese stock planted locally is normally not affected to any important degree by the butt sweep general in Landes stands. Extreme butt sweep does occur on occasions in Portuguese stands, however, and in all instances this occurrence is associated with swampy, excessively moist planting sites or very loose sands. On such sites the weight of the crown or wind action would be most likely to cause the seedling to topple over during the early stages of establishment as suggested by Duff.

Local assessments indicate that butt sweep is inherent in the French races, but is largely the result of environmental influences in the Portuguese and Corsican races.

(ii) *Shepherd's Crooks or Stem Kinking.*—The development of sudden stem kinks or crook like bends (Plate 4) is a reasonably common feature in many stands of Portuguese origin.

Plate 4.
Stem kinking common in Portuguese stands.

Very few of these stem defects can be ascribed to mechanical damage as is the case with pine tip moth attacks in Great Britain (Forestry Commission Leaflet No. 40) and investigations of developing kinks reveal no detectable internal abnormalities. The occurrence of kinks is patchy rather than general and usually appears at the same growth stage on all stems affected in an area. Most trees, after resuming vertical growth, continue so without further abnormalities.

In the Spring of certain years, the leaders of many stems of the faster growing Portuguese race will droop, supposedly as a result of a moisture deficit. Leader wilting due to either drought stress or unseasonal frosts is apparently

Plate 5.
The branching disorder locally referred to as "twisting disease." This is considered to be the result of *Chermes* attack.

the cause of much kink or crook formation. Birds alighting on young stems may also contribute to kink formation in certain instances.

(iii) *Branch Twisting.*—Plate 5 shows the extreme erratic twisting and bending of maritime pine branches locally referred to as the "twisting disorder." Branch twisting is uncommon, occurs in isolated patches within a healthy crop and has also been observed in *Pinus radiata* plantations on rare occasions. Trees affected are all disordered at the same growing stage and generally grow out of the abnormality within one or two years. Stem kinking or shepherd's crook formation is not necessarily associated with branch twisting.

Investigations of branch material early in the twisting stage have revealed a general association between the disorder and *Chermes* attack. It is considered that the insect is the causative agent. This explanation is more acceptable than that of nutrient deficiencies suggested earlier, as twisting can be found on both high quality *Pinus radiata* sites and on the poorest *Pinus pinaster* sites.

The disorder is of rare occurrence, generally only affects the branching for one to two years, and is of little economic importance.

(iv) *Double Leadering.*—Double leaders or stem forks are associated with all Portuguese stands planted in Western Australia and normally occur in 20 to 30 per cent. of the trees of the initial stocking. Forking is relatively uncommon in other provenances planted.

This must be considered as the major defect of present Portuguese stock. From all indications it is an inherent disorder which must be improved by selective breeding.

(v) *Branching.*—Duff (1928) Perry (1949) and Rycroft and Wicht (1947) have defined features of branch angles, whorl pattern and internodal length which are characteristic for the separate races of maritime pine.

The Corsican tree with its flat branching, regular whorl and even internodes is the most desirable from the utilization point of view. The other extreme is the acute angled branching and long internodes of the Portuguese tree (see Plate 3) which, however, generally has regular branch arrangement within the whorls. Esterel branching is undesirable from all aspects while Landes is intermediate between the Corsican and Portuguese.

Multinodal trees do not occur in the Portuguese stock and the instances where branch angle in the lower 20 feet of stem flatten to any degree are extremely rare. Any marked improvement to this racial character can only be expected if a satisfactory cross with the Corsican stock can be achieved.

Branch size does not vary to any great extent between races with the exception of Esterel which in local stands has heavy irregular branching. Fine branched phenotypes of the Portuguese race are present in the population for selection consideration.

(vi) *Stem Straightness.*—The descending order of stem straightness of the four races is Corsican, Portuguese, Landes and Esterel respectively.

The Corsican stem has a desirable degree of straightness and lean is a rare feature in this provenance. The taller Portuguese stem is subject to slight bends, sweeps and lean in a comparable degree to *Pinus radiata.*

(vii) *Brooming.*—Brooming in the crown is often detected on individual trees in Landes stands. The entire crown, a single branch or portion of a branch may be affected.

This disorder is of little economic importance, has not often been detected in Portuguese stock and is of unknown causes.

Similar phenomena are mentioned for Douglas fir and other species by Buckland and Kuit (1957).

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These major defects of tree form found in maritime pine populations are common to most pine species. Progeny testing information is not yet available for maritime pine, but sufficient work has been carried out with other pines to indicate that many factors of form such as stem straightness, branch angle, branch size and stem forking are genetically controlled and that population defects in these characters can be decreased by breeding manipulation.

VARIATION IN WOOD QUALITY

One of the most important considerations in any forest tree breeding programme is that of the wood quality of the selected elite parent trees and the effects of breeding on this quality. Most breeding programmes aim to improve wood quality in the species: All programmes allow that in breeding to increase the usable volume, the present timber standard in the population must be at least maintained.

Unfortunately studies into the variation of wood properties call for a greater degree of knowledge, skill and equipment than is generally available to personnel carrying out the reconnaissance phase of a breeding programme. Further, standards of cell length, micellar angle, basic density, ring width, percentage of late wood and longitudinal shrinkage and their inter-relations need to be known for the population. The lead in this direction has been given by work on *Pinus elloittii* in Australia (Dadswell and Nicholls, 1959).

Little information is available for maritime pine in this direction and local studies have had to be set aside until an officer could be suitably trained and equipment purchased. This has been a matter of necessity rather than one of priority.

Rycroft and Wicht (1947) included comparisons of wood specific gravity in their South African provenance investigations with maritime pine. They found that the specific gravity differences between the Portuguese, Landes, Corsican and Esterel stocks were slight but favoured the Portuguese in the two trials tested. The order of decreasing wood density closely followed that for diameter and height.

Bisset, Dadswell and Wardrop (1951) included samples from the four races in the Gnangara C.19 provenance trial in a study of tracheid lengths. They were able to show that the initial tracheid lengths varied from 1.2 to 1.68 mm. between the different trees. There was no great consistency in difference between the races although the Portuguese tended to have the highest initial tracheid length and the Corsican the lowest.

The small differences in specific gravity and tracheid length between the Portuguese and Corsican wood samples tested is promising and suggests that the inter-racial cross between these two stocks may be accomplished with satisfactory results.

DISCUSSIONS AND CONCLUSIONS

Maritime pine is a species with a high forest potential in Western Australia. Its adaptability to the undeveloped infertile coastal plain soils, the close proximity of these areas to the key market Perth and the future shortage of timber, particularly softwoods (Harris 1957), all favour its use in the State's afforestation programme. The scarcity of suitable land for establishing the fast growing *Pinus radiata* or any other desirable softwood makes maritime pine even more valuable.

These major defects of tree form found in maritime pine populations are common to most pine species. Progeny testing information is not yet available for maritime pine, but sufficient work has been carried out with other pines to indicate that many factors of form such as stem straightness, branch angle, branch size and stem forking are genetically controlled and that population defects in these characters can be decreased by breeding manipulation.

VARIATION IN WOOD QUALITY

One of the most important considerations in any forest tree breeding programme is that of the wood quality of the selected elite parent trees and the effects of breeding on this quality. Most breeding programmes aim to improve wood quality in the species: All programmes allow that in breeding to increase the usable volume, the present timber standard in the population must be at least maintained.

Unfortunately studies into the variation of wood properties call for a greater degree of knowledge, skill and equipment than is generally available to personnel carrying out the reconnaissance phase of a breeding programme. Further, standards of cell length, micellar angle, basic density, ring width, percentage of late wood and longitudinal shrinkage and their inter-relations need to be known for the population. The lead in this direction has been given by work on *Pinus elloittii* in Australia (Dadswell and Nicholls, 1959).

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Plate 6.
A stand of Portuguese maritime pine of age 17 years. Predominant height is 55 feet, and present stocking is 300 stems per acre. The stem selection resulting from close initial spacing and late thinning (16 years) is apparent.

Establishment on the coastal plain sands has the advantage of low clearing and planting costs and reduced haulage distances to the key market. Balanced against these must be the extreme infertility of site, high tending costs and the relatively low ultilizable volume of the species. All areas require manurial treatment for establishment and at least 50 per cent of the area will require one or more further such treatments to maintain a healthy, vigorous crop through a rotation of 60 years. This had always been considered a high possibility in contemplating pine plantations for the region and research indicates that soil fertilizer programmes may be carried out economically.

The major disadvantage with maritime pine as a commercial species, is the low percentage of quality trees that can be raised in any population. Total wood production per acre of the Portuguese race is acceptable provided fertilizer aid can be employed on poorer sites. Up to recently, however, it was standard practice to plant at 6 ft. by 6 ft. spacing largely to provide an adequate selection for final crop trees. This process guarantees 100 suitable final crop trees but is a costly one. To manage such initial stockings on sites which demand wide spacings, either early unmerchantable thinnings or delayed first thinnings in which a high proportion (approximately 30 per cent.) of the trees to be removed have no utilizeable value must be carried out. High quality pine crops such as *Pinus radiata* can carry such costs. With maritime pine where the very nature of the site makes any profit margin narrow, such costs can be used as a serious argument against planting the species.

The major objects of the tree breeding programme for *Pinus pinaster* in Western Australia are therefore:

(1) To improve stem quality in the population to allow increased spacing and lower establishment and tending costs.

(2) To increase utilizeable volume.

(3) To improve value increment of the species under plantation conditions.

(4) If possible to increase total volume production.

The programme emphasizes the improvement of form in the species and, through this, to increase utilizeable volume.

Provenance testing has shown that the Portuguese race is superior from the viewpoint of volume production, has good taper but is restricted by a high branch angle, crooked stems and forking. Within the population, however, acceptable stems and plus stems do occur to indicate that selection should decrease many of these defects.

Of the four races investigated the Corsican has the highest quality stem index with desirable characters of branching, crown symmetry and stem straightness. Its major disadvantage is its restricted vigour. This is not so serious when considered from the viewpoints of volume in the 20 ft. pruned section of the stem and taper.

Studies carried out to date indicate that the Landes and Esterel races at present having nothing to add to the species gene pool that is not already offered to a greater degree by the Portuguese and Corsican populations.

Present breeding policy is to carry out selection in the Portuguese population and eventually to combine the improved vigour and form characteristics obtained, with the form of the Corsican race by inter-racial crossing. This decision is subject to the verification of further wood quality and crossing studies. Present limited data available does not discredit the proposals.

It is considered that *Pinus pinaster* offers exceptionally high promise for breeding improvement and through such, will become a valuable species for use in southern Australia on soils unsuitable for agriculture and *Pinus radiata.*

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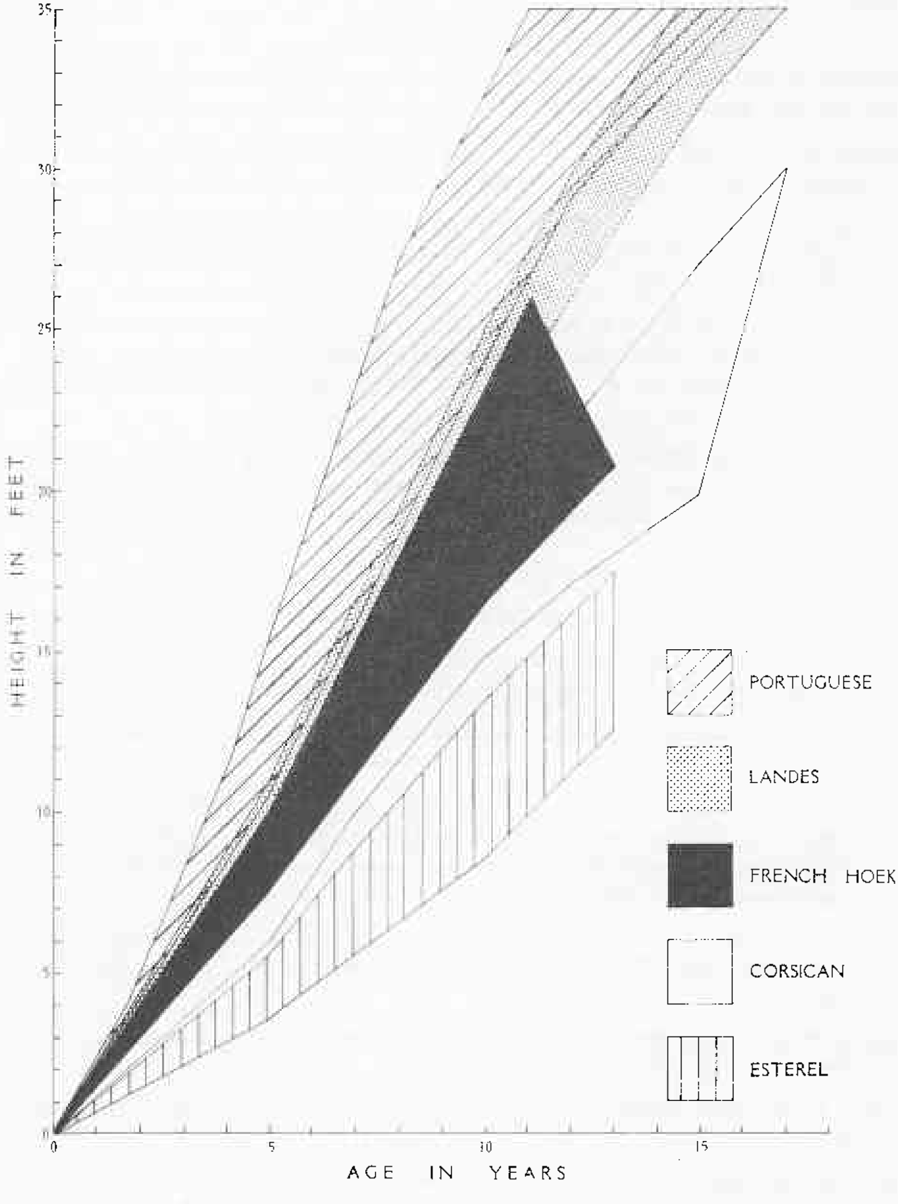

Appendix I.

Scatter diagram showing the height for age range of five provenances at Somerville plantations. All plots were established on similar flat sites. Table 1 provides the numbers of plots used to compile the scatter.

APPENDIX II.

Individual plot values obtained for stand form assessments. Data expressed for 0.1 acre plots.

Seed Source	Stem Classification						Number of Plots
	Total		Acceptable		Plus		
	Number	Per cent.	Number	Per cent.	Number	Per cent.	
Portuguese S.371	113	100	22	19	4	4	1
	107	100	18	17	3	3	1
	111	100	20	18	1	1	1
	111	100	17	15	2	2	1
	107	100	19	18	3	3	1
	106	100	9	9	3	3	1
	122	100	11	9	2	2	1
Mean	111	100	17	15	3	2	7
Portuguese S.711	74	100	7	10	0	0	1
	80	100	10	13	0	0	1
	89	100	13	15	0	0	1
Mean	81	100	10	12	0	0	3
Portuguese S.40	55	100	6	11	0	0	1
	55	100	3	6	2	4	1
	55	100	5	9	1	2	1
Mean	55	100	5	8	1	2	3
Portuguese S.356	82	100	8	10	1	1	1
S.356	70	100	10	14	1	1	1
S.253	57	100	5	9	3	5	1
S.358	122	100	13	11	0	0	1
S.375	107	100	23	21	1	1	1
S.385	79	100	9	11	1	1	1
Mean	86	100	11	13	2	1	6
Landes S.60	78	100	8	10	0	0	1
	78	100	7	9	1	1	1
	78	100	8	10	2	3	1
	79	100	5	6	1	1	1
	75	100	5	7	0	0	1
Mean	77	100	7	9	1	1	5
Landes S.40	55	100	1	2	1	2	1
	55	100	4	7	....	0	1
	55	100	5	9	2	4	1
Mean	55	100	3	6	1	2	3
Corsican S.39	55	100	9	16	4	7	1
	55	100	11	20	3	6	1
	55	100	9	16	3	6	1
	55	100	6	11	1	2	1
Mean	55	100	9	16	3	5	4
Esterel S.53	55	100	1	6	0	0	1
	55	100	4	7	0	0	1
	55	100	5	9	0	0	1
Mean	55	100	3	7	0	0	3

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