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IMPORTATION OF BREEDING MATERIAL OF PINUS PINASTER AIT. FROM PORTUGAL.

by

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A report on activities associated with a visit to Portugal, France and Spain to further the tree improvement programme for *Pinus pinaster* in Australia.

FORESTS DEPARTMENT
PERTH
WESTERN AUSTRALIA

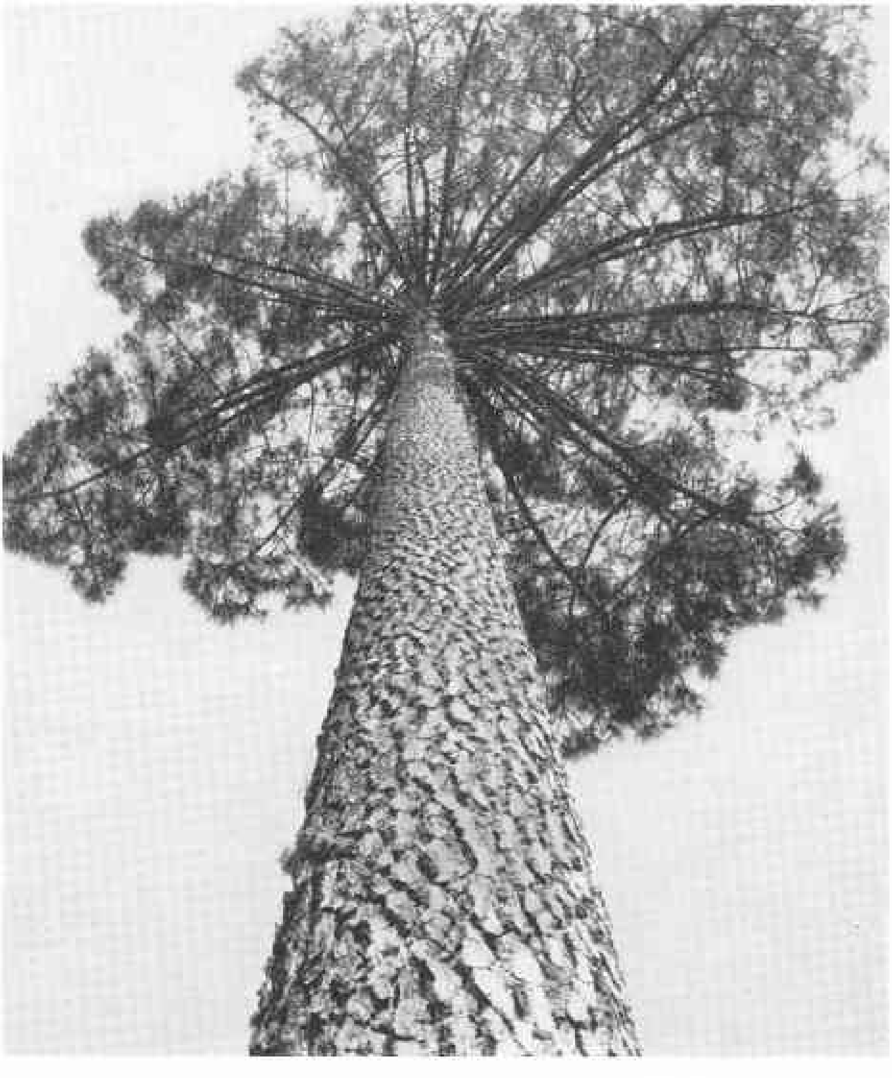

Figure 1.—*Pinus pinaster* plus phenotype E105. Forest of Leiria, Portugal.

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FOREWORD.

During visits to Portugal in 1959 and 1960 in connection with securing adequate supplies of *Pinus pinaster* seed for Australian Forest Services, I noted many trees in the Leirian Forests which appeared superior in form to representatives of this species in Australian plantations. Within Australia the species can still only be observed in the early rotation age and the final quality is still in doubt. Within Portugal the excellent form and vigour of trees within the final rotation stages at 60 to 80 years leaves no doubt of quality.

Difficulties in securing sufficient plus trees in the restricted stands of *Pinus pinaster* in Western Australia led me to the conclusion that the importation of scion material from Portugal was the best and quickest route to the improvement of this species in Australia.

An approach to other forest authorities in Australia and New Zealand resulted in an agreement to share the considerable expense of sending an officer to Portugal in 1964 to search for plus trees and despatch scion material, pollen and seeds to Australia.

Senior Forester D. H. Perry of the Western Australian Forest Service was unanimously chosen as the best man for the task. Mr. Perry had nearly 40 years experience of intensive work with the introduction of *Pinus pinaster* into Western Australia, and was an authority on the various provenances of the species.

Many difficulties had to be overcome by him in Portugal, and it is remarkable that so much was achieved so successfully in a two year period. Mrs. Perry, the daughter of a forester, accompanied her husband, worked incessantly with him throughout the project, and to her support and encouragement during a long stay in a strange land much credit must be given.

On my return to Portugal in June, 1966, at the close of the World Forestry Conference in Madrid. I was impressed by the high regard in which Mr. Perry was held by Portuguese and French foresters with whom he had worked. Their assistance and co-operation in the project is greatly appreciated. Particularly I wish to acknowledge the kindness and active help extended by Messieurs J. Guinaudeau and Georges Illy in France and D. P. Machado and Fernando Pessoa in Portugal. They have given signal service to Australian forestry in this field.

The success of the venture also depended on effective co-operation from other bodies. The British Forestry Commission, Qantas Air Service and the quarantine service of the Department of Agriculture, Western Australia were of great assistance. The staff of the Wanneroo Tree Breeding Station are to be commended on the job they did to guarantee success at the receiving end of the organization.

The programme has proved both unique and full of interest. It is with satisfaction that this Bulletin is published to report both the aim and procedures of the venture and the degree of success achieved.

A. C. HARRIS,
Conservator of Forests.

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IMPORTATION OF BREEDING MATERIAL OF PINUS PINASTER AIT. FROM PORTUGAL.

PART I—SELECTION, IMPORTATION AND PROPAGATION.

Introduction.

Pinus pinaster was first introduced into Western Australia, from Europe, near the beginning of this century. It has proved to be a desirable commercial forest species in this new habitat, providing a valuable softwood resource on infertile soils otherwise of limited economic potential.

Initial problems associated with provenance variation have been solved (4). Since 1942 only seed from the forests of Leiria in Portugal has been used in plantation establishment. Approximately 25,000 acres of the species have been established in Western Australia and the potential exists to increase this acreage to the vicinity of 150,000.

Acceptable total volume yields are produced from populations raised from Portuguese seed. These populations however, display tremendous variation in stem straightness and branching characteristics incurring extensive degrade in timber; particularly that obtained from early thinnings. To ameliorate this species defect a breeding programme was commenced within the State in 1957.

Initial progress has been rapid. By 1963 a seed orchard containing 2,250 grafts at a 22 foot square spacing had been established. The 16 most promising phenotypes selected from local stands older than 20 years of age were employed in the orchard.

Original plus tree selection was limited however, to approximately 3,000 acres of pine which were of known Portuguese origin and of acceptable age. This selection did serve to show that trees of the desirable qualities were present in the population. It failed to yield such trees in sufficient quantity to satisfy orchard rquirements. Only 5 of the 16 trees used in the orchard completely met the desired standard of phenotypic selection and none of the 16 trees have been proven by progeny testing. Screening for wood properties has not yet been undertaken.

The initial aim of 40 desirable plus phenotypes to commence the orchard programme could not be met. It will be years before the younger stands are sufficiently developed to yield further plus material in quantity. Rather than accept this unsatisfactory commencement and possible delay to the breeding programme it was decided to turn to the natural stands of the species.

From October 1963 to November 1965 an officer of the Western Australian Forests Department was stationed in Portugal to select plus material within the Forest of Leiria and to forward vegetative material to Australia for propagation.

The venture was an expensive one but is commendable for the faith shown in both the future of the species in Australia and in the value of tree breeding to commercial forestry. Financially the programme was assisted by the forest services of South Australia, Victoria and New Zealand and the Commonwealth Forestry and Timber Bureau. Foresters working closely with the species have no doubts that this initial expenditure will be handsomely repaid.

The present report covers the development of the programme up to January 1967, and is presented in three parts. Part I—reports details concerning the selection, importation and propagation of the plus material in Australia. Parts II— and III— report observations by Mr. Perry while in Portugal, France and Spain.

At the present stage the programme is not complete. Scion material is yet to be disseminated from Western Australia to all participating centres. This procedure can only be caried out within the time required to multiply shoots on the initial grafts. Several years will be involved. It can be said however, that the major aims of the venture have been satisfied at this time.

The Search Area.

Provenance trials in Western Australia clearly separate the Portuguese source of *Pinus pinaster* as the most suitable for tree improvement. The search for superior phenotypes during the European visit was hence restricted to Portugal. A reconnaissance of the forests in Portugal revealed that the best formed trees were to be found in the region of Leiria and all selections were made within the State Forest of Leiria. Within these forests certain areas were excluded from the intensive search for plus phenotypes. These exclusions included malformed protection forest along the Atlantic coast and other areas seriously affected by nutritional disorders. Stands under thirty years of age were also eliminated as being too young for selection purposes.

The balance of the forest was intensively searched to yield 85 plus phenotypes of acceptable standard. It is estimated that the selection intensity involved was of the order of one plus phenotype per quarter million trees.

Selection Standards.

The most pronounced weakness of the species is the inherent instability of the bole. It is subject to serious lean, butt sweep and bowing. Nodal swelling and heavy and irregular branching are also common faults.

In the search weight was given to favour the selection of trees in which the bole was straight, vertical, of circular cross section and with pronounced leader dominance. Only trees of dominant or co-dominant vigour were included in the final selection.

The basis of the selection standard is revealed in a point grading system included as Table 1. This grading was employed only after selection of the best trees available, to allocate priorities to individuals for future progeny test and seed orchard attention. Assessment of individual tree characteristics on this grading system is contained in Table 2.

TABLE 1.

SCORING SYSTEM EMPLOYED TO ASSOCIATE PRIORITIES TO SELECTED PHENOTYPES.

BOLE. Perfect score				100
Overall Straightness. Maximum			50	
Very slight bow	Deduct	5		
Slight bow	„	10		
Very slight butt sweep	„	10		
Slight butt sweep	„	15		
Very slight pistol butt	„	10		
Slight pistol butt	„	15		
Defects in excess of those mentioned	Reject			
Inter-Whorl Straightness. Maximum			5	
One very slight kink	Deduct	$2\frac{1}{2}$		
Two very slight kinks	„	5		
Defects in excess of those mentioned	Reject			
Verticality				
One degree of lean accepted as vertical			20	
For every degree of lean in excess of one	Deduct	5		
More than five degree lean	Reject			
Circularity. Maximum		5		
Boles not circular in section	Reject			
Nodal Swellings. Maximum			15	
Very slight nodal swellings	Deduct	5		
Slight nodal swellings	„	10		
Leader Dominance. Maximum			5	
Trees in which the leading shoot does not persist through the crown	Reject			
VIGOUR. Maximum				100
Predominant tree	Score	95		
Dominant tree	„	85		
Codominant tree	„	75		
CROWN. Maximum score				50
The crown required was symmetrical, compact and healthy. No deduction made when defect was obviously due to environmental factors.				
BRANCHING. Maximum score				50
All Portuguese trees were high pruned and no assessment was possible.				

TABLE 2.

DETAILS OF PLUS PHENOTYPES SELECTED IN PORTUGAL.

No. of Tree	Age in 1964, 1965	Site Quality	Canopy Class	Total Height in Feet	Height to Green Crown in Feet	Mean Bark Thickness in Inches	Diameter under Bark in Inches	Spiral Grain Measured B.H. at Two Points		POINTS RATING FOR VARIOUS QUALITIES								
										BOLE						Vigour	Crown	Total
								A	B	Overall Straightness	Inter-whorl Straightness	Verticality	Circularity	Nodal Swellings	Leader Dominance			
E101	135	2	Dominant	100′	68′	1.7″	30.8″	0°	2°	35	5	20	5	15	5	85	25	195
E102	133	3	Dominant	92′	48′	1.6″	26.9″	6°	6°	50	5	20	5	15	5	85	35	220
E103	86	2	Dominant	94′	65′	1.20″	21.78″	0°	1°	50	5	10	5	15	5	95	50	235
E104	84	1–2	Dominant	106′	76′	1.7″	22.1″	0°	0°	50	5	*nil*	5	15	5	95	40	215
E105	88	2–3	Dominant	91′	58′	1.7″	19.2″	1.5°	0°	50	5	20	5	15	5	95	50	245
E106	98	3	Dominant	86′	60′	1.66″	15.77″	0°	2°	30	5	10	5	15	5	*	40	....
E107	84	3	Dominant	80′	58′	1 3″	19.3″	0°	0°	50	5	20	5	15	5	*	30	....
E108	101	3	Dominant	84′	64′	1 66″	20.5″	0°	1.5°	35	5	15	5	15	5	*	40	....
E109	111	3	Dominant	87′	46′	1.47″	22.85″	0°	1.5°–2°	50	5	20	5	15	5	*	40	....
E110	102	3	Co-Dominant	82′	62′	1.2″	14.7″	2°	2.5°	50	5	20	5	15	5	*	45	....
E111	103	3	Dominant	84′	64′	1.87″	17.26″	2°	2°	30	5	13	5	15	5	*	50	....
E112	47	2	Dominant	78′	50′	1.43″	12 41″	0°	0°	45	5	20	5	15	5	75	50	220
E113	48	2	Dominant	78′	50′	1.73″	12.44″	0°	0°	35	5	17	5	15	5	75	50	207
E114	65	3	Dominant	71′	46′	1.56″	14.85″	0°	2°	40	5	20	5	15	5	75	50	215
E115	64	3	Dominant	76′	50′	2.2″	16.6″	0°	2°	45	5	20	5	15	5	95	50	240
E116	136	3	Dominant	93′	62′	1.23″	24.04″	0°	0°	45	5	*nil*	5	15	5	*	50	....
E117	52	2	Dominant	91′	54′	2.03″	19.32″	0°	0°	50	5	20	5	15	5	95	50	245
E118	67	2–3	Dominant	81′	56′	1.56″	13.81″	0°	0°	50	5	20	5	10	5	74	50	219

E119	67	2	Dominant	60′	88′	1.5″	16.1″	0°	1°	45	5	20	5	15	5	*	50	....
E120	134	2–3	Dominant	98′	68′	1.8″	23.6″	3°	4°	45	5	20	5	15	5	85	50	230
E121	136	2	Dominant	102′	71′	1.6″	26.7″	0°	0°	35	5	20	5	15	5	*	35	....
E122	63	2	Dominant	92′	68′	2.2″	18.8″	1°	0°	50	5	20	5	15	5	95	50	245
E123	53	2–3	Co-Dominant	82′	52′	1.9″	14.0″	1°	0°	45	5	20	5	15	5	74	50	219
E124	62	3	Dominant	65′	40′	1.2″	13.8″	0°	0°	50	5	20	5	15	5	95	50	245
E125	87	2	Dominant	99′	71′	1.8″	22.97″	0°	0°	40	5	*nil*	5	15	5	95	50	215
E126	93	2	Dominant	101′	68′	2.3″	19.9″	0°	0°	45	5	13	5	20	5	75	50	218
E127	109	2	Dominant	102′	76′	1.73″	19.92″	0°	0°	45	5	13	5	15	5	75	50	213
E128	108	2	Dominant	104′	68′	1.6″	22.89″	0°	6°	50	5	20	5	15	5	95	50	245
E129	35	2	Dominant	61′	32′	1.26″	11.00″	1	2°	50	5	20	5	5	5	95	50	235
E130	53	1	Dominant	100′	72′	2.16″	21.77″	0°	0°	45	5	20	5	15	5	95	50	240
E131	71	2	Dominant	96′	68′	1.6″	22.25″	0°	0°	50	5	20	5	15	5	95	50	245
E132	37	3	Dominant	60′	36′	1.43″	9.45″	0°	0°	50	5	20	5	15	5	75	50	225
E133	42	3	Co-Dominant	61′	32′	1.53″	10.46″	0°	0°	50	5	20	5	15	5	75	50	225
E134	93	2	Dominant	104′	74′	1.76″	22.25″	0°	1	40	5	20	5	5	5	90	50	220
E135	91	2	Dominant	95′	66′	1.46″	19.67″	1	2°	50	5	20	5	15	5	95	50	245
E136	86	2	Dominant	97′	74′	1.46″	18.08″	0°	0°	45	5	13	5	15	5	85	50	223
E137	87	2	Dominant	96′	72′	1.6″	19.7″	0°	0°	45	5	18	5	15	5	95	50	238
E138	86	3	Dominant	86′	62′	1.8″	17.1″	1°	1°	45	5	10	5	15	5	95	50	230
E139	43	3	Dominant	55′	33′	1.4″	10.6″	0°	0°	50	5	20	5	15	5	95	50	245
E140	45	3	Dominant	58′	30′	1.46″	9.33″	0°	2°	45	3	20	5	15	5	85	50	228
E141	43	3	Dominant	58′	33′	1.7″	10.6″	0°	0°	45	5	20	5	15	5	95	50	240
E142	43	3	Dominant	58′	32′	1.63″	10.26″	0°	0°	45	5	20	5	15	5	95	50	240
E143	44	3	Dominant	59′	38′	1.26″	10.04″	0°	0°	50	3	20	5	15	5	74	50	222

* Isolated trees. No basis for comparison.

No. of Tree	Age in 1964, 1965	Site Quality	Canopy Class	Total Height in Feet	Height to Green Crown in Feet	Mean Bark Thickness in Inches	Diameter under Bark in Inches	Spiral Grain Measured B.H. at Two Points		POINTS RATING FOR VARIOUS QUALITIES								
										BOLE								
								A	B	Overall Straightness	Inter-whorl Straightness	Verticality	Circularity	Nodal Swellings	Leader Dominance	Vigour	Crown	Total
E144	35	2	Dominant	61′	31′	1.83″	11.61″	0°	1°	50	5	20	5	15	5	95	50	245
E145	35	2	Dominant	64′	36′	1.13″	12.85″	0°	1°	45	3	20	5	15	5	95	50	238
E146	35	2–3	Dominant	60′	30′	1.3″	10.28″	0°	1.5°	50	5	20	5	10	5	74	50	219
E147	32	2	Dominant	60′	28′	1.43″	12.57″	0°	2°	50	5	20	5	15	5	95	50	245
E148	30	2–3	Dominant	57′	30′	1.13″	10.30″	0°	0°	50	5	20	5	15	5	75	50	225
E149	30	2	Dominant	64′	32′	1.53″	10.62″	0°	0°	45	5	20	5	15	5	95	50	240
E150	33	2	Dominant	68′	36′	1.73″	9.9″	0°	0°	50	5	20	5	15	5	85	50	235
E151	31	2	Dominant	63′	32′	1.33″	10.86″	0°	0°	50	5	20	5	10	5	75	50	220
E152	88	2	Dominant	90′	72′	1.36″	18.9″	0°	0°	40	5	20	5	15	5	75	50	215
E153	86	2	Dominant	89′	61′	1.7″	21.73″	0°	0°	40	5	15	5	15	5	95	50	230
E154	95	2	Dominant	94′	66′	2.06″	20.06″	0°	0°	45	5	20	5	15	5	95	50	240
E155	44	2	Dominant	74′	46′	1.73″	11.33″	0°	1.5°	50	5	20	5	15	5	75	50	225
E156	45	2	Dominant	79′	51′	1.8″	14.53″	0°	1°	50	5	20	5	15	5	95	50	245
E157	48	2	Dominant	83′	53′	1.7″	12.82″	3°	4°	50	5	20	5	15	5	85	50	235
E158	90	2–3	Dominant	94′	70′	1.46″	19.67″	0°	0°	50	5	20	5	10	5	95	50	240
E159	75	2	Dominant	92′	69′	1.66″	16.56″	0°	2°	40	5	20	5	15	5	85	50	225
E160	95	2–3	Dominant	89′	68′	1.70″	17.60″	2°	2°	45	5	15	5	15	5	85	50	225
E161	95	2	Dominant	96′	72′	1.8″	20.60″	0°	0°	50	5	10	5	15	5	95	50	235
E162	87	2	Dominant	96′	78′	1.13″	18.11″	0°	1°	50	5	20	5	15	5	85	50	235
E163	86	2	Dominant	96′	70′	1.16″	21.22″	0°	1.5°	45	5	nil	5	20	5	95	50	225
E164	60	2–3	Dominant	82′	50′	1.46″	15.85″	0°	0°	50	5	20	5	15	5	85	50	235

E165	62	2–3	Dominant	83′	57′	1.36″	15.73″	0°	2°	50	2.5	20	5	15	5	85	50	232.5
E166	61	3	Dominant	75′	50′	1.5″	16.24″	0°	0°	50	5	20	5	15	5	95	50	245
E167	61	2–3	Dominant	78′	52′	1.33″	16.90″	0°	0°	50	*nil*	15	5	15	5	95	50	235
E168	61	2–3	Dominant	79′	51′	1.9″	15.92″	0°	0°	50	5	15	5	20	5	95	50	245
E169	42	3	Dominant	51′	31′	1.46″	8.85″	0°	1°	50	5	20	5	15	5	100	50	250
E170	43	3	Dominant	49′	26′	1.23″	9.31″	1°	1°	50	5	20	5	15	5	85	50	235
E171	52	2	Dominant	81′	56′	1.90″	14.33″	0°	1°	50	5	15	5	20	5	100	50	250
E172	51	2	Dominant	76′	46′	1.76″	15.09″	0°	0°	40	5	15	5	20	5	100	50	240
E173	66	2	Dominant	93′	59′	1.73″	17.54″	0°	0°	50	5	10	5	15	5	100	50	240
E174	64	2	Dominant	87′	53′	1.66″	14.81″	0°	0°	40	5	20	5	15	5	85–100	50	225–240
E175	61	2–3	Dominant	78′	48′	1.83″	14.47″	6°	6°	50	5	20	5	15	5	100	50	250
E176	62	2–3	Dominant	80′	54′	1.73″	17.57″	1°	0°	45	5	10	5	15	5	100	50	235
E177	58	2	Dominant	84′	52′	1.8″	18.03″	1°	1°	45	5	10	5	15	5	95	50	230
E178	39	3	Dominant	53′	34′	1.63″	10.10″	2°	2°	45	5	20	5	15	5	95	50	240
E179	53	3	Dominant	68′	40′	2.03″	12.64″	0°	1°	50	5	20	5	15	5	95	50	245
E180	55	2	Dominant	79′	50′	1.6″	16.20″	0°	0°	50	2.5	20	5	15	5	85	50	232.5
E181	55	2–3	Dominant	76′	48′	1.73″	15.31″	1°	1.5°	50	5	20	5	15	5	85	50	235
E182	57	2	Dominant	89′	59′	0.96″	17.35″	3°	4°	45	5	20	5	15	5	85	50	230
E183	41	2	Dominant	82′	44′	1.5″	13.22″	0°	1°	50	5	20	5	15	5	85–95	50	235–245
E184	Protection Forest Tree included as a Control for Grafting Studies only.								....	....	....	....	....	....	....	....	....	....
E185	61	3	Dominant	70′	45′	1.46″	13.92″	0°	1°	50	5	20	5	15	5	85	50	235
E186	49	2	Dominant	70′	41′	1.4″	13.7″	0°	0°	50	5	20	5	15	5	95	50	245

Vertically and lean were gauged against a plumb bob line. Vigor was assessed by comparison with the height and girth (breast height) of the largest trees within a radius of one chain of the possible phenotype. On steep slopes these comparisons were restricted to stems within a distance of 20 feet up and down slope. Allowance was also made for any obvious variation in soil type within the radius of 66 feet.

It has been mentioned that both dominant and co-dominant stems were considered for selection. To receive a full score for vigour a tree had to be both taller and of greater girth than any other tree within the comparison area. Although it is theoretically desirable to have all selections of top vigour, in practice it is not feasible while maintainng the prime selection criteria of near perfect stem characteristics. In the ratings in Table 2 it will be noted that several of the selections do approach a perfect score.

Bole selections, on which the emphasis was placed, required that the stem must be straight, vertical, smooth, round in section while passing straight and unbroken through the crown to the leading shoot. Nodal swellings and bends or kinks between whorls were completely rejected wherever feasible.

Spiral grain measurements and 12 mm cores were obtained for each tree following the procedure of Wheeler (19). All trees were accurately located, permanently marked for identification, measured, sampled and described. All trees were photographed.

Scions were collected from each final selection and forwarded to Australia for propagation. Where possible half sib seed and pollen was also collected and forwarded to Western Australia.

The 85 trees selected range in age from 30 to 136 years with the majority falling within the 50 to 80 year age interval.

Importation.

Scions from 85 plus phenotypes and one specimen from the poor form protection forest (see Table 3) were imported into Western Australia within four main introduction periods—September 1964, March and April 1965, May 1965 and September 1965.

Details concerning the date of arrival, number of clones imported, storage method used in transit and the number and type of grafts involved for each shipment are set out in Table 3.

Up to September 1964, 53 trees had been located. Scions from these trees were included in the first three shipments in September 1964. Scions from the 33 further trees were introduced in Autumn and Spring 1965. These latter shipments also included further scions from trees which had failed in the initial propagations in September 1964.

Scions were inspected in Portugal prior to despatch. Any buds with obvious insect damage were discarded. For shipment the buds were enclosed in polythene bags packed in cardboard travelling cases. Each shipment was airfreighted from Lisbon to Perth via London in the pressurized freight compartments available in the aircraft.

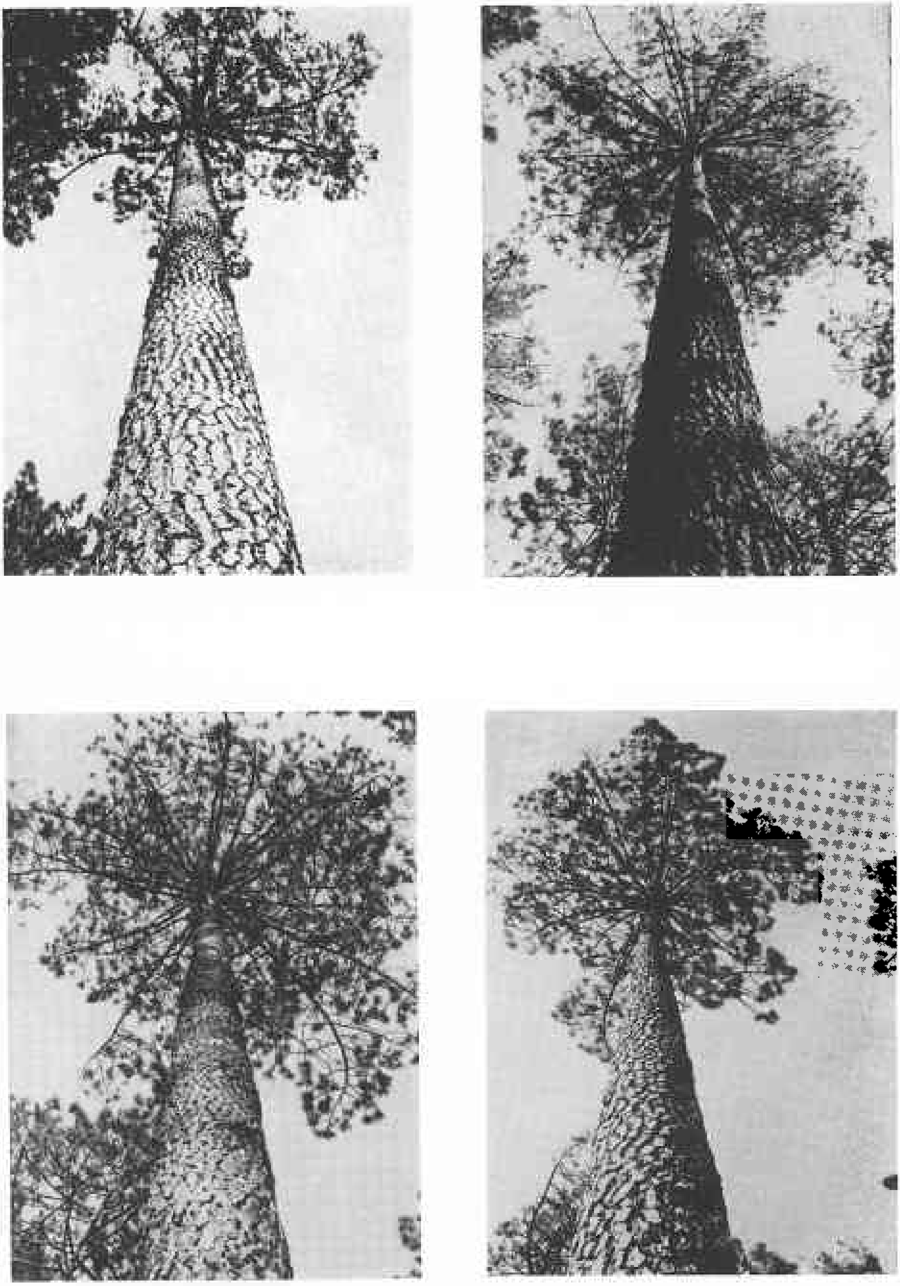

Figure 2.—Examples of plus phenotypes selected. From left to right at the top E135 and E117, below E164 and E160.

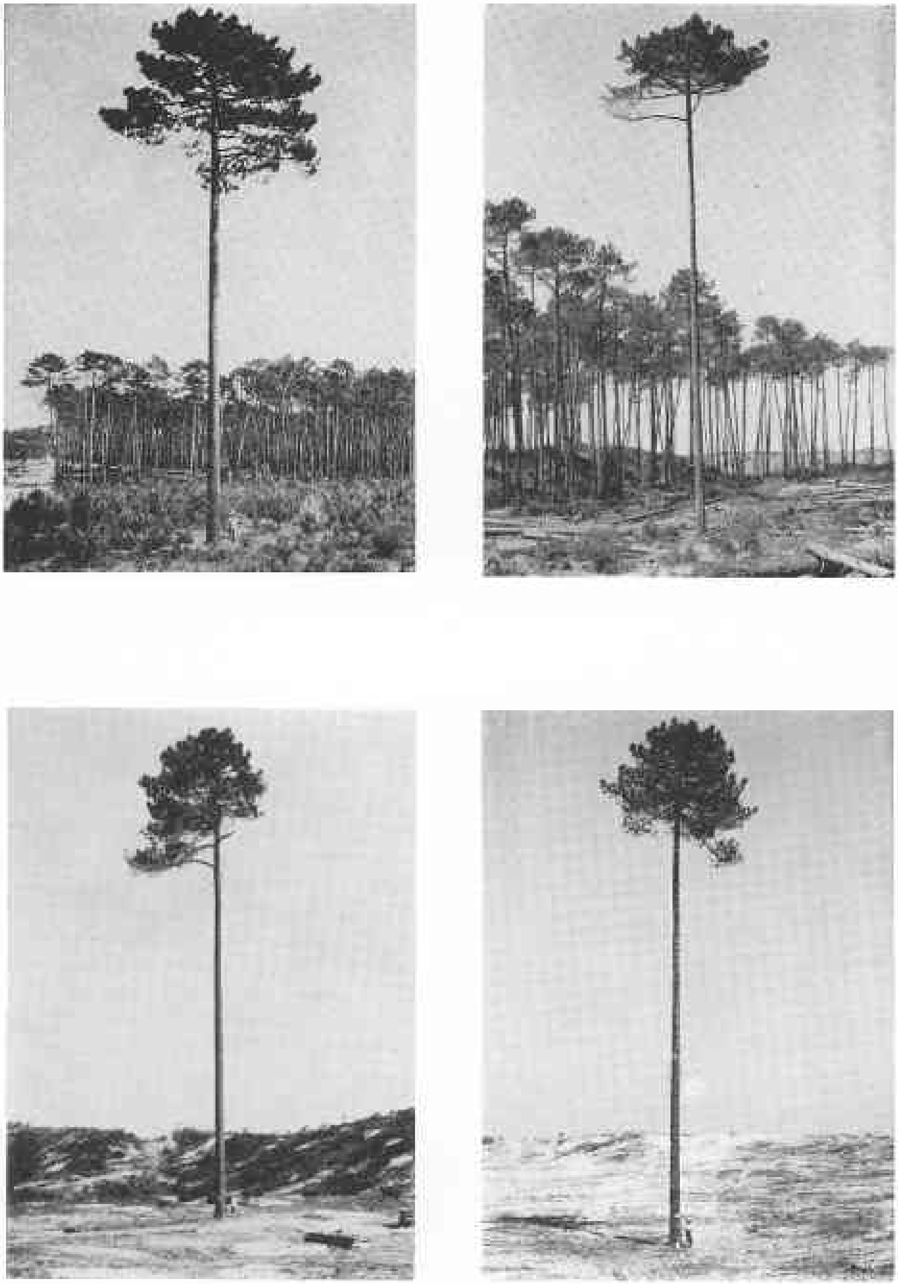

Figure 3.—Examples of plus phenotypes selected. From left to right at the top E105 and E162, below E104 and E137.

TABLE 3.

SUMMARY OF THE IMPORTATION AND GRAFTING PROGRAMME.

Date Received	Phenotypes Represented	Storage Method	Number and Type of Graft			
			Tip	Bottle	Side	Total
9/9/64	117, 123, 129, 130, 132, 133, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151	Wet In Moss	411	186	....	597
15/9/64	101, 102, 103, 104, 112, 113, 114, 115, 116, 118, 119, 120, 121, 122, 124, 125, 126, 127, 128	Wet In Moss	295	172	—	467
22/9/64	105, 106, 107, 108, 109, 110, 111, 115, 123, 131, 133, 134, 135, 136, 137, 138, 139, 142, 152, 153	Wet No Moss	268	197	—	465
	Total for Season	....	974	555	0	1,529
11/3/65	113, 129, 146, 149, 150, 151, 155, 156, 157, 164, 165, 166, 167, 184	Dry	162	141	9	312
18/3/65	132, 140, 143, 155, 157, 168, 171, 172, 173, 174, 175, 176, 178, 180, 181, 184	Dry	163	159	16	338
25/3/65	103, 153, 154, 155, 157, 158, 159, 160, 162, 163, 183, 184	Dry	126	115	1	242
1/4/65	104, 109, 110, 117, 125, 128, 136, 155, 157, 161, 169, 170, 177, 179, 182, 184	Dry	199	148	2	349
	Total for Season	....	650	563	28	1,241
23/5/65	105, 118, 119, 152, 153, 161, 162, 163, 177	—	211	....	....	211
	Total for Season	—	211	0	0	211
8/9/65 8/9/65	101, 128, 179, 181, 182, 185, 186 Grafted in Portugal	— —	135	....	— —	135 169
	Total for Season	—	135	....	—	135
	Total Grafted Locally	—	1,970	1,118	28	3,116

A period of six to 10 days elapsed between picking the scions from the parent tree and grafting at the Wanneroo Breeding Centre in Western Australia. During much of this period the material was subjected to the fluctuating temperatures normal to the aircraft hold and fumigation treatment. Wherever possible however, the scions were held in refrigerated storage at 38 to 40 degrees Fahrenheit.

In the initial three shipments received in September 1964, the scions were packed in damp moss. Remaining shipments carried the scions in the air dry conditions which pertained at time of collection.

Quarantine.

Vegetative material was imported from Portugal to Australia subject to the following conditions set by plant quarantine authorities.

1. The number of scions imported was to be kept to the minimum from which successful introduction of the clone could be expected.
2. On arrival in Australia all vegetative material had to be fumigated with methyl bromide for two hours at 70°F under a concentration of three pounds of methyl bromide per 100 cubic feet.
3. All vegetative material had to be dipped in a fungicidal solution (zineb) prior to grafting.
4. All grafting was to be carried out in an insect proof shelter.
5. All successfully grafted material was to be maintained in an insect proof shelter for at least 12 months following importation.
6. Frequent inspections were to be made in the glasshouse by both a pathologist and an entomologist.
7. Clearance from the insect proof shelter could only be obtained following a satisfactory report from the pathologist, the entomologist and the Commonwealth and State Quarantine officials.

Arrangements were also made for the material in the glasshouse to receive frequent insecticidal sprays. Malathion and white oil, metasystox, or white oil alone, were sprayed at least at monthly intervals. The frequency of spraying was stepped up to fortnightly or weekly intervals depending on growth rate and or seasonal conditions.

Apart from two shipments of scions despatched direct to Canberra and New Zealand, all fumigation and grafting was carried out in Western Australia. A special insect proof glasshouse was constructed at the Forests Department centre at Wanneroo to hold the grafts. Fumigation was carried out by the Department of Agriculture in the standard facilities at Fremantle.

Half sib seed and a small quantity of pollen were also imported. This material was inspected by quarantine officials but not fumigated.

In the final shipment in September 1965, completed grafts were imported. These received the standard quarantine treatment set for scions with the added provision that all soil was to be removed from the plant roots prior to despatch from Portugal.

Propagation.

Both the bottle and tip cleft grafting methods were employed in propagation.

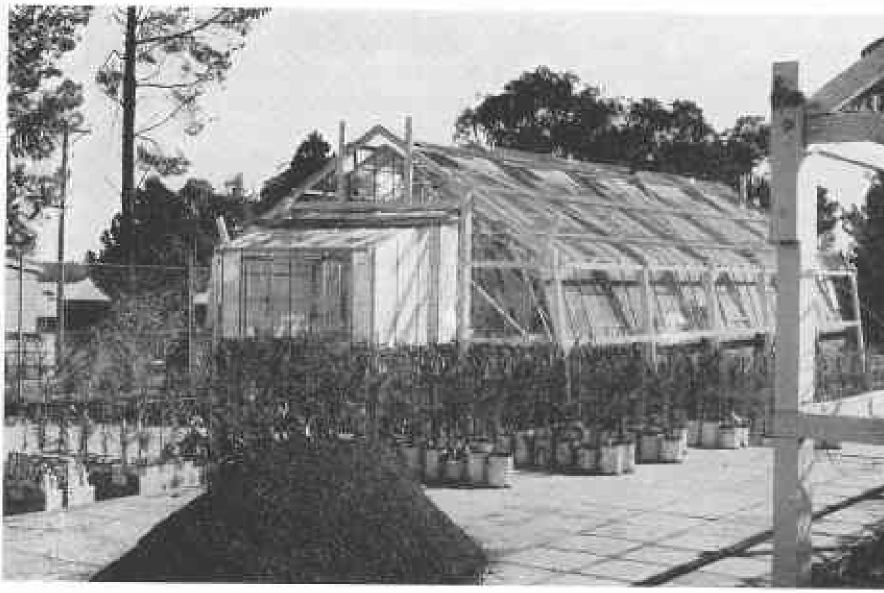

Figure 4.—The insect proof glasshouse at the Forests Department Tree Improvement Centre at Wanneroo. Imported grafts were held under quarantine for at least twelve months.

With scions of decreased vigour from older trees collected locally, the bottle technique has always provided the highest survival rates. Under the above conditions survival values of 50 to 80 per cent. have been obtained while tip grafts yielded from 30 to 50 per cent. success.

An estimate of the average number of scions to import was based on these values, allowing a further 20 per cent. loss due to unknown contingencies associated with storage in transit, seasonal differences in the stock and scions and fumigation effects. An average survival of 30 per cent. was estimated and at least 20 grafts of each clone was considered to be the minimum desirable import quota.

This estimate was strengthened by information obtained from a controlled trial run to investigate the influences of certain of the above coningencies on mortality (5). Results of this work indicated that for maximum survival in the importation venture, the following requirements should be considered.

(1) The time between collection and grafting should be minimised.

(2) Scions should be stored dry in transit.

(3) Grafting should be carried out within 24 hours of fumigation.

(4) The maximum use should be made of the bottle grafting technique.

In practice, the September 1964 shipments were received before the above information was available and were packed in a moist medium. Also, bottle grafting imported material proved to be almost a complete failure.

Failure of the bottle graft to the extent experienced was without precedence in Western Australia. It was found to result from the presence of a soft bacterial rot on the old wood of the scions. When the woody shank to the bud was immersed in the bottle of water the bacteria developed, entered the vascular system and caused death of the bud.

With the tip grafting technique, all of the old wood is removed from the scion prior to grafting. The source of the rot is hence removed and no real problem from disease was presented in subsequent development. The presence of this pathogen was unpredictable and unfortunate. The numerous bottle grafts manipulated had taken well before they were eventually killed.

Stocks for grafting were raised in 9 x 7 inch cans and brought to the required high state of vigour by watering and fertilizing. Prior to grafting a 4 week flushing period in the glasshouse was provided. By this means, stocks were equally successful in both spring and autumn grafting.

During propagation, two grafting teams of two men each were employed. To minimise influences of operator technique and clone storage time, each team completed at least 10 grafts for each clone in any one day before returning to any one clone.

Budding on.

Any lateral buds produced on successful grafts during the quarantine period in the glasshouse were grafted on to new stock. This practice was followed in any month of the year and yielded takes of 70 per cent or higher. By this means the survival numbers of many of the clones were greatly increased during the quarantine period.

Survivals.

In Table 4 the average percentages of survivals for each importation period are shown. These values are re-arranged in Table 5 to show the differences obtained between bottle and tip grafts.

TABLE 4.

SURVIVAL VALUES FROM DIRECT GRAFTING.

Grafting Period	Number Grafted	Number Survived	Per Cent. Survival	Graft Type
September, 1964	1,529	86	5.6	Bottle and Tip
March, 1965	892	263	29.6	Bottle and Tip
April, 1965	349	35	10.0	Bottle and Tip
May, 1965	211	83	39.3	Tip only
September, 1965	135	52	38.6	Tip only
Total	3,116	519	16.6	

Survival numbers for each clone at time of planting out are presented in Appendix I.

The main feature of the survival results is that all except six of the 86 trees introduced as scions have been successfully grafted. Seventy nine of the trees are represented by two or more grafts in Western Australia (Table 6) and are considered to be successfully introduced. Of the trees which failed to establish, none rate top priority for seed orchard and pollination work when assessed on the phenotypic scoring system. Essentially, the trees of most promise have been introduced successfully and, with the large number of trees of lower priority also established, the six failures are considered to be of no serious concern.

TABLE 5.

AVERAGE SURVIVAL PERCENTAGES FOR GRAFT TYPES.

Season in Southern Hemisphere	Bottle Graft	Tip Graft
Spring	0.0	12
Autumn	2.0	37

The overall propagaton venture is a complete success within the aims of the programme. There are moreover a number of interesting observations, made during the programme, which increase understanding of the problems involved.

Storage Method.

In Table 3 it will be seen that all shipments apart from the three in September 1964 were packed without added moisture. There is little doubt that this modification proved beneficial although a quantitative expression of the degree of improvement is not possible.

With limitations due to both the number of scions to be imported and local collection problems in Portugal it was not possible to import test material in a manner permitting analysis of storage effects.

It should be noted however, that storage method was not all important. In September 1964 batches of scions in the air dry condition were imported direct into New Zealand and the Australian Capital Territory. Zero survival resulted. Scions of the same clones picked at the same time but packed in moistened moss and imported into Western Australia did produce some survivors. Here it is obvious that condition of the stock material and grafting technique were more important than storage means.

Grafting Method.

The bottle grafting technique was employed on a little less than 50 per cent. of the scions imported prior to May 1965. The virtual complete failure, due to the introduced bacterial contaminant, seriously reduced the overall survival percentage. This cause of failure could no be anticipated.

TABLE 6.

SURVIVAL CLASSES FOR INTRODUCED PHENOTYPES AS AT JANUARY, 1967.

No. of Survivals	Phenotypes Represented in Class	No. of Clones
0	E110, 116, 120, 125, 136, 153	6
1	E101, 102, 155	3
2	E121, 126, 140, 141	4
3	E103, 106, 108, 109, 128, 142	6
4	E104, 132, 135, 150	4
5	E137, 138	2
6	E115, 163, 179	3
7	E112, E114	2
8	E124	1
9	E105, 113, 131, 147, 181	5
10	E107, 111, 130, 144, 170	5
11	E117	1
12	E127, 139, 177, 182	4
13	E165	1
14	E143, 172	2
15	E154, 161, 173, 183	4
15+	E118, 119, 122, 123, 129, 133, 134, 145, 146, 148, 149, 151, 152, 156, 157, 158, 159, 160, 162, 164, 166, 167, 168, 169, 171, 174, 175, 176, 178, 180, 184, 185, 186	33

The fact that all was not lost, due to the diversity of techniques employed on all imported batches, favours a conservative approach in such ventures where few of the contingencies can be precisely evaluated or controlled.

Results from tip grafting, even where scion and stock diameters matched poorly, provided survival values of 30 per cent. These results were not far below those which have been obtained from grafting some local material of low vigour in Western Australia.

It was most noticeable that the largest, most vigourous buds, provided the highest survival; even when poorly matched to stocks.

Clonal Variation.

Variation in survival due to clonal origin can be appreciated from data in Appendix I. Clone E153 was imported in September 1964, March 1965, and May 1965 with zero success on grafting. Similarly clones E110 and E136 were imported in both September 1964 and April 1965 with no success. Other clones such as E154, E156, E174, E175, E176, E178, E180, E185 and E186 produced up to and in excess of fifty per cent. survival from tip grafting in only one introduction.

Clonal variation in survival can be expected to have a genetic component which cannot be equated to environment and grafting technique (5).

Seasonal Influences.

Certain clones such as E103, E105, E106, E125, E136, E146, E153 (Appendix I) showed no obvious relationship between survival and season of grafting. Other clones (E118, E119, E129, E130, E161, E162, E163 etc.) reveal a very definite relationship between survival percentage and season of grafting.

Grafting scions collected in spring in Portugal onto stocks flushed in autumn in Western Australia proved to be the most successful procedure. Apart from results of this present venture no other data on the effects of opposite seasonal influences on stock and scion compatability are known.

In both instances in which scions picked in the autumn dormant condition were grafted onto stocks responding to the spring environment, subsequent shoot growth predominated in the lammas, long bud type with little or no needle development. (Figure 5). Bud extension was slow to start but vigorous under these conditions. Deaths resulted in the following summer from these needle free, long buds. Of 135 initial survivors from the September 1964 programme, only 80 were surviving in March 1966. Many of the survivors were in poor condition.

The exact cause of these late deaths is not known. It is believed however, that they resulted from translocation difficulties due to a weak graft union. This condition was common to many late summer mortalities which were dissected and is obviously associated with the dormant condition of the scion when grafted.

Summer deaths in local grafting programmes with imported scions grafted in autumn amounted to less than one per cent of the initial survivors. The scions grafted in autumn in this project grew vigorously and normally to produce a sturdy shoot with abundant needle development.

These results revealed for the first time recorded the nature of a condition of bud dormancy which exists in *Pinus pinaster*. Future importation ventures of the present nature should consider chilling and or light treatments to increase graft survival when summer dormant buds are utilized.

Introduced Grafts.

The final shipment included 173 grafts made in Portugal for trees which had propagated poorly in Western Australia.

The decision to import grafted material was based on the desire to successfully introduce all plus phenotypes selected in Portugal. The decision acknowledged the possibility that survival, following fumigation, would probably be poor.

On arrival at the Wanneroo Centre the material was in very poor condition and most plants were dead before repotting. Only one graft survived. This result can be expected in future as fumigation (in particular) and transport conditions are very harsh on exposed roots.

The Introduction of Seed.

Wherever possible cones were picked from the selected trees. Seed was extracted and forwarded to Australia. Depending on the natural occurrence of cones the number of seeds per tree varied greatly.

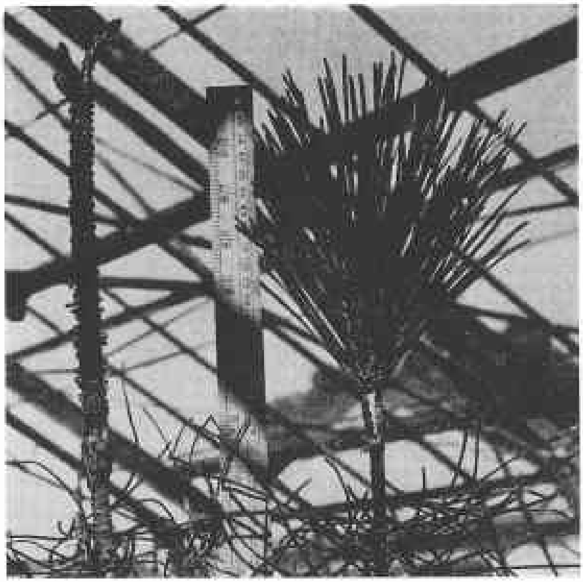

Figure 5.—Long bud development from dormant scions (left) compared to normal growth (right). The grafting position can be identified.

In 1964 and 1965 all batches with sufficient seed numbers were raised in the Wanneroo nursery and incorporated in field progeny trials planted out in 1965 and 1966.

A total of 62 plus phenotypes are represented in these trials. Trees not introducd in this manner are E116, E119, E133, E139, E142, E144, E147, E148, E150, E151, E155, E159, E163, E166, E167, E169, E170, E175, E176, E179, E185, E186.

Pollen Introduction.

It was hoped to import pollen from a large number of the selections for direct crossing against local clones. This process would have speeded up the progeny testing programme by at least three years.

In practice it was found that limitations in time within Portugal, climbing difficulties and the prime necessity to provide suitable quantities of scions to guarantee successful introduction, limited pollen collection. Pollen of two trees E154 and E182 was imported successfully and has been used in crossing work at Wanneroo in 1965 and 1966. The first cones from these pollinations will be collected in 1967.

Wood Sampling of Plus Phenotypes.

Twelve millimetre cores extending from bark to pith were extracted from opposite radii of each tree. These were dipped in a solution of pentachlorphenol, wrapped in polythene and airfreighted to the Forest Products Division of the C.S.I.R.O. in Melbourne, Australia, for evaluation. Results are contained in Appendix II.

Two readings for spiral grain were made at opposite radii at approximately breast high on each tree. The equipment and methods used for sampling and spiral grain measurement is described by Wheeler (19).

Conclusions.

This introduction programme was planned to fulfil an urgent need for a suitable range of plus phenotypes of *Pinus pinaster* within Australia. The contents of this report leave no doubt that the programme has been carried out with a degree of success which exceeded initial expectations.

Numerous difficulties arose during the programme. These have not been emphasized within this report but the statements of initial grafting results provided will convey to those familiar with vegetatve propagation the earlier disappointments involved. Considering the previously unexplored contingencies—fumigation effects, storage and transport facilities, clonal variation, bud dormancy and seasonal influences—the officers involved in the programme are completely satisfied with the final, if not some of the individual results.

Seventy-nine plus phenotypes from Portugal are now safely established in clonal arboreta in Western Australia. Of the six selected phenotypes which failed to establish, five are included in comprehensive half sib progeny trials within the State. It will hence be possible to evaluate all but one of the trees under local conditions.

The selection standard of the Portuguese trees was very high. Within the standard determined from initial selection work within Western Australian Plantations, at least half of the imported trees are as good or better than the five best local selections. The remainder generally promise superiority to other trees currently employed in the local seed orchard.

Understandably the Portuguese selections remain to be proven under Australian conditions. It is believed however, that the major attribute selected for, stem straightness and form, should perform well under the new environment. Even if half of the Portuguese selections are ultimately rejected on the basis of progeny test results, a completely adequate range and selection for seed orchard establishment will remain. It should be noted that the importations will supplement, and not replace selections from internal stands in the overall breeding programme in Western Australia. The admixture is expected to greatly improve stem characteristics of the future population while at least maintaining the minimum standard of vigour acceptable.

Pinus pinaster in its improved form will play a highly significant role in forest production in many parts of the southern hemisphere as well as Western Australia. The current venture was partly sponsored by forest services in South Australia, Victoria, the Australian Capital Territory and New Zealand. The next stage in the programme is to disseminate the selection material to these centres for their use. This process is straightforward but will take some time. Following 12 months in quarantine and budding on, the grafts have a limited supply of buds available for scion removal at this stage. Within two years supplies will be adequate for all concerned.

Due to this need to build up a scion reserve, it is not planned to use the Portuguese selections in Western Australian seed orchards until 1969. Controlled pollinations for progeny test purposes will, however, commence in 1967 in certain instances. The new seed orchard will incorporate most imported clones plus the best local clones with provisions for culling at least half as progeny test data comes to hand.

The commercial results of the introduction venture are still at least 10 years into the future. The introduction will ensure however, that at that time, the maximum improvement possible, for the species, has been achieved.

In the remainder of this report it will be appreciated that the expense involved in having an officer in south eastern Europe for a period of two years has additional benefits. Our knowledge of the species in its natural habitat has been greatly increased. In particular it is possible to appreciate what the latter stages of rotations in Western Australia can offer. Further provenances of seed from Portugal, Spain and France were secured and have been established in Western Australia. Seed supplies were checked and secured. And last but not least, an effective liaison has been established between Western Australia and the countries visited.

PART II—PINUS PINASTER IN PORTUGAL.

1. *Introduction.*

The total area of *Pinus pinaster* forests in Portugal is reputed to be about 3,200,000 acres.

Pinus pinaster has contributed greatly to the economy of Portugal for some hundreds of years, and will continue to do so on an increasing scale. The species is extremely hardy and adaptable, and is easily established there by direct sowing of the seed.

The species may now be seen growing on a variety of soils from sands to clays, at elevation from 20 feet to 4,000 feet above sea level and within rainfall limits of 15 inches to 120 inches per annum. It reaches optimum development on the more fertile of the sandy soils of the coastal region between Nazare and the river Minho, and on the sandy loams in the region of Leiria and Coimbra. Providing there is no free lime in the soil, the species appears to do quite well on terra rossa soils over limestone. It is being used as a pioneer in afforestation on the more exposed and eroded sites where rainfall is adequate. Large forests of the species can now be found growing in regions originally forested with hardwoods.

The tree is so much a part of the Portuguese landscape north of the Tagus that it is known as the "Pinheiro bravo" or the wild pine tree.

2. *The Origin of the Leirian Population.*

The widely held belief amongst Portuguese foresters is that *Pinus pinaster* is not indigenous to their country, being introduced from France during the reign of King Denis (1297-1325 A.D.). Arala Pinto in his work "O Pinhal do Rei" (12) states that *Pinus pinea* is endemic to the forest of Leiria, and bases this opinion on the fact that lignite unearthed in the forest was identified as an original fragment of *Pinus pinea*. Assuming that this identification is correct it does not necessarily follow that *Pinus pinaster* was not indigenous also.

Arala Pinto further states that the winged seeds of *Pinus pinaster* were brought from France by seamen and sailors in the 14th century. These seeds when sown on the sandy soils of the forest of Leiria were able to achieve optimum development. So adaptable was the species that *Pinus pinea,* unable to compete, was gradually eliminated, and pure forests of *Pinus pinaster* developed in its place.

In presenting these views Pinto fails to produce any real evidence to support them. One gains the impression that they are largely conjecture.

Dr. Tabarda de Morais (7) is also of the opinion that *Pinus pinaster* was introduced into Portugal from Gascony within recent historical times. This conclusion was influenced by the fact that no fossilised remains of the species had been found in Portugal up to that time.

Whilst it is quite possible that seed of the species may have been imported from France at some stage, it is considered that if this is the case, then the provenance has been absorbed into an indigenous population of *Pinus pinaster.*

The following points appear to substantiate an alternative theory that *Pinus pinaster* has been endemic to Portugal for a very long period of time:—

(i) There is a most striking resemblance between the soils and the vegetation of the Landes region in France, and those in the vicinity of the forest of Leiria. Many species of plants other than *Pinus pinaster* are common to both regions. The following is by no means a complete list:—

Calluna vulgaris.	*Rhamnus frangula.*
Erica cineria.	*Hypocheris radicata.*
Erica scoparia.	*Scorzonera humilis.*
Erica tetralix.	*Agropyrum junceum.*
Erica ciliaris.	*Ammophila arenarium.*
Ulex europaeus.	*Euphorbia paralias.*
Ulex nanus.	*Cakile maritima.*
Arrhenatherum thorei.	*Salix repens.*
Molina caerulea.	*Sarothamnus scoparius.*
Pteris aquilina.	*Rubia peregrina.*
Schoenus nigricans.	*Helianthemum guttatum.*
Arbutus unedo.	*Craetaegus monogyna.*
Simaethus planifolia.	*Hydrocotyle vulgaris.*

The great similarity between the two ecosystems strongly suggests a similar evolutionary history. Reasons for the exclusion of *Pinus pinaster* from the Portuguese region do not appear to exist.

(ii) French experience demonstrates that when the Leirian provenance is grown in the Landes region in Gascony, it is very susceptible to frost damage. The local provenance is resistant to frost.

(iii) The Landes provenance in its own habitat does not commence to shed pollen before early April (6) whilst the Leirian race in the forest of Leiria commences pollen shed in early March. When grown in comparative trials in Western Australia, the same pattern is evident. The Leirian provenance commences pollen shed some three weeks before the Landes, indicating that this factor is under genetic control.

(iv) Wood analyses of the two provenances indicate that the Leirian origin has a significantly higher specific gravity and a lower incidence of spiral grain (8, 13).

(v) In all provenance trials in Australia and South Africa to date (4, 10, 13) the rate of growth of the Leirian provenance has proved to be significantly greater than that of the Landes. New Zealand studies however, indicate that the Landes provenance may equal the Leirian in this regard (15).

Western Australian experience with seed batches reputably obtained from the Landes region reveals considerable variation in form and rate of growth of the species within the region. In no instance however, has the combination of time of flowering, rate of growth and branching characteristics approached the pattern consistent for the Portuguese provenance under comparable environment.

(vi) An important paper by Dr. Carlos Teixeira (17), apparently overlooked by Portuguese foresters, throws some interesting light on this matter. He describes the finding of fossilised remains of a conifer closely related to *Pinus pinaster,* in Pliocene beds at Rio Maior. Teixeira named these specimens *Pinus praepinaster.* This pine had fascicles of three needles as opposed to only two in *Pinus pinaster.* Apart from this the cones and pollen were indistinguishable from those of the present day species. In this connection it should be noted that *Pinus pinaster* frequently develops fascicles of three needles when young, and almost invariably does so if the leading shoot is damaged or removed.

An examination of the fossil specimens in the Lisbon Geological Museum showed them to be beautifully preserved. Some of the scales on one of the cones have actually opened since excavation and the seeds and wings could be plainly seen. It requires very little imagination to realise that *Pinus pinaster* as we know it could have evolved from *Pinus praepinaster* in the long geological period involved.

3. *Variation within Portugal.*

Assuming that *Pinus pinaster* is indigenous to Portugal, it then follows that there should be some variation within the species, induced by climatic and elevational changes in the environment. Unfortunately it is not now possible to trace the boundaries of the original distribution. Within the last thirty years huge areas of new forest have been established, mostly by broadcasting seed collected in the central coastal region. The species now extends to the Spanish frontier all over Portugal north of the Tagus. Small plantations, isolated plots and scattered trees are to be seen in the southern part of the country but these generally have the appearance of being established by man.

It is possible that a provenance of separate identity exists in the vicinity of Viseu and northwards to Vila Real. Here the older trees form a very dense crown and the needles are a darker green than the Leirian trees. The younger trees in the 3 to 15 year age class, are however indistinguishable from trees of the Leirian provenance of the same age.

The opportunity was taken to collect seeds from several sources in Portugal for trials in Western Australia. All collections were made from trees older than thirty years or from young trees positively known to be the natural regeneration of an earlier stand. With the future study of this range of seed batches under uniform environment conditions, precise information of species variation within Portugal will be available.

4. *Some Notes on Pollen Shed—Time of Flowering.*

The results of Western Australian provenance trials have demonstrated that while the time of flowering for each of the major provenances varies considerably, it is constant for each provenance and is under genetic control (10). Experience in Portgual has shown that environment also has a marked effect on this factor. The species flowers progressively later from west to east of the country and is further delayed by an increase in altitude. There is also a between-tree variation in flowering time within the forests of Leiria, and this can be as much as three weeks.

Large areas of the Serra Estrela, the highest mountain range in Portugal, (6,500 feet), have been afforested with *Pinus pinaster*. Seed was obtained from other centres for this purpose. Much of it came from the region of Leiria, but unfortunately it is not possible to relate any stand to its seed origin. An examination of these forests on the 10th and 11th of April 1965 showed that the time of flowering for *Pinus pinaster* on both sides of the range varied with elevation in all stands inspected. At about 4,000 feet the terminal buds were just becoming active and beginning to break winter dormancy. With decreasing elevation the buds were more advanced and active, until at about 1,000 feet pollen was just commencing to shed. It was estimated that pollen shed would not take place at 4,000 feet until May.

Within the forest of Leiria in 1964 pollen shed commenced on or about the 8th March, and in 1965 on the 15th March. Pollen ripens and begins to shed close to the ocean in the vicinity of Sao Pedro de Moel a few days earlier than on the eastern side of the forest, some five miles inland.

5. *Insect and Fungal Pests.*

Sirex sp. occurs in Portugal and specimens have been captured and recorded at intervals over the past 50 years. It occurs rarely, only attacks weak and dying trees, and is of little economic importance.

Ips spp. also occurs but is of no economic importance. The forest floor is generally kept free of all debris by the local people who remove everything for fuel. This in addition to the activities of its natural predators, keeps the insect well under control.

The processionary moth, *Thaumetopoea pityocampa* causes considerable damage by defoliating the trees. Whilst this must result in loss of increment, trees appear to recover satisfactorily.

Insect attack to female stroboli and developing cones greatly reduces seed yields but little is known about this at present. This factor will become more important as the production of high quality seed develops.

Some loss of timber production is caused by wood rotting fungi which gain entry through dead branch stubs and along the scars left by old resin tapping operations.

Generally it can be said that although *Pinus pinaster* has been grown in Portugal as pure forest for some hundreds of years, it is singularly free from serious pests. There is no doubt however, that some of the insects which prey on this pine could be potentially very dangerous, if introduced into Australia where they would be free of biological control.

Capacity for Survival.

One of the outstanding qualities of *Pinus pinaster* is its capacity to survive adverse conditions. This has been amply demonstrated in Western Australia and is most noticeable in Portugal. Provided only that there is sufficient moisture in the soil profile to maintain life in the tree, it will tolerate a wide range of climatic conditions and almost any soil deficiency. Stands exist on the dunes in the Forest of Leiria which are 86 years old and only 8 ft. to 10 ft. high (Fig. 6). Such tenacity is an admirable characteristic in a forest tree as it gives the forester time to rectify errors of siting. It has been possible in Western Australia to improve failed areas to site quality 1 and 2 by addition of fertilisers.

Figure 6.—*Pinus pinaster* protection forest on the coastal dunes. Age is 84 years. Forest of Leiria.

THE FOREST OF LEIRIA.

1. *Brief History and Description.*

This famous forest was created by royal decree promulgated by King Denis who reigned from 1279 to 1325 AD. It has been part of the royal estate and of the Republic ever since, and subject to regulation and some form of management since its creation. The dunes along the Atlantic coast in this region are very unstable and large areas of drifting sands must have existed from early times. These have practically all been stabilised now by the Forest Service and largely afforested with *Pinus pinaster*. Very large areas of this protection forest are making little growth and present an interesting challenge to Portuguese foresters. The solution of the nutrition problems associated with the afforesting of these dunes could lead to greatly increased yields.

The present area of the forest is approximately 28,500 acres. An estimated one quarter of this, at least, is non-productive protection forest.

The Forest of Leiria is situated between latitude 39° 42′ 2″ and 39° 52′ 49″ on the Atlantic coast immediately west of the town of Leiria, after which it takes its names. Administrative headquarters are situated in Marinha Grande on the eastern edge of the forest. This town was probably not in existence when the forest was created, or at best would be only a tiny village. The nearby town or small city of Leiria dates back to Roman times and probably earlier.

Figure 7.—Sixty years old *Pinus pinaster*. Forest of Leiria.

The forest is divided into some 342 compartments by straight more or less north-south and east-west fire lines; the corner of each compartment being marked by a stone survey peg. The north-south lines are numbered and the east-west lines lettered. These references are cut into the stone markers.

Specimen trees of *Pinus pinaster* up to 150 years old are still preserved in the forest. One of the oldest and a magnificient specimen is to be seen in Compartment 118. Its height is 108 feet, height to the first branch is 74 feet and the girth at breast height is 9 ft. 10½ in.

The forest to-day is almost pure *Pinus pinaster*, with some very small areas of *Pinus pinea* and *Eucalyptus globulus*. It is serviced by an excellent system of sealed roads which are kept in a very good state of repair.

2. *Climate.*

The climate is cool and wet in winter, warm and dry in summer. Light frosts are experienced at ground level in winter and are rarely severe. The summer dryness is alleviated to some extent by the frequent fogs which drift in from the Atlantic at night, and often do not clear away before ten o'clock in the morning. The strongest winds and the big winter storms usually come from the north west.

Tables 7, 8 and 9 providing details of the temperatures and rainfall for the forest of Leiria for a period of ten years, have been extracted from Arala Pinto's work "O Pinhal do Rei" (12). The recording station of Engenho is situated on the eastern edge of the forest adjoining Marinha Grande, Mioteira is in the north eastern part of the forest and Vieira in the north west corner near the Atlantic.

TABLE 7.

TEN YEAR TEMPERATURE AND RAINFALL AVERAGES FOR THE FOREST OF LEIRIA.

	Engenho	Moiteira	Vieira
Mean Annual Temperature, Fah.	59.00°	59.18°	59.54°
Temperature Mean for Hottest Month, Fah.	81.14°	77.18°	76.64°
Temperature Mean for Coldest Month, Fah.	40.46°	40.64°	42.80°
Annual Rainfall, in inches	34.07"	34.54"	35.25"

TABLE 8.

MONTHLY TEMPERATURE MEANS FOR THE FOREST OF LEIRIA.

Maximum Temperatures (Fah.)

Month	Mean Maximum			Mean Minimum			Monthly Mean		
	Engenho	Mioteira	Vieira	Engenho	Mioteira	Vieira	Engenho	Mioteira	Vieira
January	69.9	68.0	68.4	46.6	47.3	46.8	57.0	55.2	57.2
February	77.1	79.7	74.7	44.6	46.4	48.8	59.0	57.0	58.8
March	80.0	81.0	80.9	48.6	49.3	50.2	62.4	59.7	61.9
April	87.9	90.3	87.8	51.9	51.6	53.6	65.5	62.6	64.2
May	92.8	92.3	92.1	50.9	55.4	55.8	69.4	65.7	67.8
June	103.3	95.0	95.6	57.7	63.5	61.2	73.9	60.3	71.6
July	103.3	102.7	103.5	55.9	57.2	66.2	78.8	61.0	75.7
August	105.9	103.1	102.6	66.7	60.8	66.6	81.1	70.2	77.5
September	99.7	100.4	101.7	62.7	63.5	61.2	78.8	68.0	75.9
October	93.4	92.3	90.9	57.3	59.0	57.6	71.9	65.3	70.5
November	78.9	82.4	80.0	50.9	53.6	61.3	61.9	56.8	62.0
December	73.6	78.8	78.3	43.9	47.8	45.9	58.3	53.4	58.6

Minimum Temperatures (Fah.)

Month	Mean Maximum			Mean Minimum			Monthly Mean		
	Engenho	Mioteira	Vieira	Engenho	Mioteira	Vieira	Engenho	Mioteira	Vieira
January	57.3	59.0	57.6	24.4	24.3	26.4	40.5	39.9	42.0
February	60.4	59.0	58.8	23.0	22.6	23.7	41.4	40.5	42.9
March	71.9	59.4	60.6	32.0	29.7	32.8	46.0	45.7	48.0
April	65.5	59.4	67.5	33.3	33.8	35.2	47.5	46.2	49.8
May	64.5	63.9	72.9	39.4	40.5	42.6	50.5	49.8	55.4
June	67.3	63.9	72.9	42.9	41.9	43.5	55.4	53.4	57.7
July	78.1	68.0	86.4	47.5	45.3	47.7	57.9	52.4	60.4
August	68.2	68.4	80.9	45.7	45.9	48.0	57.9	52.3	60.6
September	71.8	70.8	85.5	40.3	41.4	42.6	56.1	41.0	59.0
October	66.4	67.5	70.2	33.1	33.8	37.8	51.6	46.0	53.9
November	62.9	59.4	65.7	—3.5	—0.8	—1.8	45.1	41.2	47.7
December	65.8	67.8	60.3	—4.3	—3.8	—2.4	41.7	38.8	43.7

TABLE 9.

MONTHLY MEAN PRECIPITATION FOR THE FOREST OF LEIRIA.

Month	Monthly Precipitation (Inches)		
	Engenho	Mioteira	Vieira
January	3.80	4.09	4.15
February	3.29	3.33	3.08
March	5.14	5.37	5.14
April	3.21	3.40	2.87
May	1.91	2.34	3.44
June	0.96	1.34	1.17
July	0.34	0.51	0.36
August	0.25	0.29	0.22
September	1.17	1.39	1.14
October	3.37	2.55	2.54
November	5.03	4.19	5.79
December	5.06	5.74	5.35
	34.69	34.54	35.25

3. *Soils.*

The soils in this forest are mainly sandy acidpodsols, the "B" horizon often consisting of a layer of coffee rock. This consists of sand, cemented in varying degrees with iron and other salts leached down through the profile. French foresters call this deposition horizon "alios" and the Portuguese "surraipa". The western side of the forest is mainly made up of dunes of recent aeolian origin. The balance of the forest covers old formations interspersed with extensive, and in some cases, badly drained flats.

The depth of the water table varies greatly, being deep on the dunes and near the surface on some of the more low lying of the flats.

Apart from some of the more recently formed dunes, the soils are fertile by Western Australian standards. However in view of the responses obtained to NPK in experimental work, the soil nutrients are not readily avaliable to the trees.

It has not been possible to relate site quality in the forest to the amounts of major nutrients calculated to be present in the soils (9).

There is unfortunately, little or no information available to indicate what effect this forest has had on its soils. It is considered locally that the trees have influenced the formation of surraipa.

4. *Establishment Practice.*

Prior to about 1930 the forest was renewed by encouraging the natural regeneration following the final cut. Since then it has been the practice to sow *Pinus pinaster* seed broadcast after varying degrees of soil preparation.

Present practice, following the clear felling, is to remove all the debris, This is usually done by the local people who cart away everything for fuel.

Figure 8.—*Pinus pinaster* branchwood fuel. Forest of Leiria.

Figure 9.—Transporting firewood *(Pinus pinaster)* to the glass factories in Marinha Grande.

The stumps are then removed, generally by hand labour, although a bulldozer is now used when available. The stumps are split and sold to the glass factories in Marinha Grande for fuel. It will be noted that every vestige of organic debris is removed from the site. When to this is added the cumulative effect of the peasants raking up and carting away the pine needles for hundreds of years, it would be strange indeed if the soils were not deteriorating.

Figure 10.—Small branchwood harvested as fuel. Forest of Leiria.

The right to remove the needles was granted to the peasants by royal charter when the forest was created and has never been revoked. They are used as bedding for stock and are eventually carted out on to the fields for fertiliser. Restriction of the practice at this stage would inflict considerable hardship on the poorer people who cannot afford to buy chemical fertilisers.

When the site has been completely cleared it is rotary hoed and fifteen pounds of seed per acre is broadcast sown by hand.

Results from recent experiments testing responses to NPK fertilisers have been most encouraging. Tests are also being made to determine if growth responses can be obtained by ripping and breaking up of the coffee rock layer where it is within two or three feet of the surface. Results are promising.

More recently, experiments have been carried out to test the spot sowing of seed in an attempt to lower initial costs involved in fertiliser application and to economise when using seed of better genetic entity. Results are promising and it is also anticipated that the cost of early uneconomic thinnings will be reduced. Labour for this latter operation is becoming increasingly scarce and more costly as Portugal develops industrially.

5. *Seed Collection.*

Cones are collected from both felled and standing trees for a fixed price per cubic metre. They are taken from trees felled in thinnings at all levels, from final crop fallings, from the protection forest along the coast and from private forests in the region. There is no restriction on the source of the cones, but all must be sound and free of all insect damage.

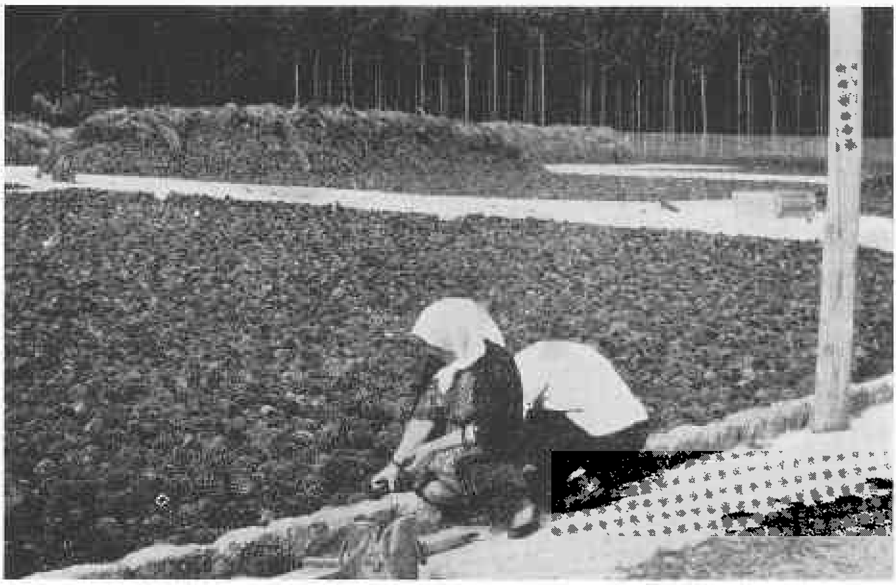

Figure 11.—*Pinus pinaster* cones drying in the sun. Forest of Leiria.

Collection takes place from about January to April. The cones are stored in heaps in the open, on concrete and stone paved drying floors. A covering of pine branches is used to protect the cones from the sun and prevent premature opening. In June and July they are spread out to dry and open in the sun. Girls are employed to remove the seeds by knocking one cone against another. The seeds are swept up and bagged. De-winging is not practised and is not necessary when broadcast sowing. No attempt is made to separate seed of different origins and the whole season's collection is mixed into a single parcel.

6. *Varation Within the Species in the Forest of Leiria.*

The stands of *Pinus pinaster* in the forest of Leiria, gauged on the basis of form and rate of growth on the better sites, are undoubtedly some of the best, if not indeed the very best in Portugal. Little adulteration, if any, has

Figure 12.—Eighty years old *Pinus pinaster*. Forest of Leiria.

occurred through the introduction of seed from other sources. Indeed it can be said that the reverse is the case and seed tends to flow away from this forest, rather than towards it. As mentioned, earlier, until very recent times the system of fostering natural regeneration was relied upon to renew the forest. During the last thirty years or so regeneration has been accomplished by broadcast sowing. The seed for this operation has always been collected from within and immediately around the forest. In support of the contention that seed tends to flow away from this forest rather than towards it, large quantities have been and still are collected every year and distributed indiscriminately all over Portugal for the creation of new forests and the regeneration of old ones. The reason for this is entirely economic, as seed of this species can be collected more cheaply and with greater facility in the vicinity of Leiria than elsewhere.

There is considerable variation in form and rate of growth within the boundaries of the forest. Most of this can be related to the effect of site.

The recent intensive search for plus phenotypes revealed that the form of the trees in some compartments is better than others if judged by the yield of plus trees. This variation is independent of site quality. It is usually noticeable that compartments which produce one or more plus phenotypes, generally contain other trees of high quality and the general form of the compartment is better than average. This suggests, in view of the fact that all compartments are separated by an artificially straight line which ignores the terrain, that there are variations within the local population. The differences noted above are solely variations in bole form and nothing has been seen that might suggest that there are differences of racial origin.

It is not possible to indicate whether these differences are genetically controlled or the effect of some variation in management.

Figure 13.—Forest of Leiria, Compartment 116. Eighty year old trees showing bowing due to the influence of slope.

7. *Management.*

It has been the practice in the past to grow the trees at high densities, particularly in the first half of the eighty to ninety year rotation. In Table 10 some idea of the stocking rates for site qualities 3, 4 and 5 is provided. The data, extracted from the work of Jose Caetano Velez (18), reveals considerable variation between compartments of the same age and site quality.

Shortage of labour, rising costs and the loss of merchantable volume are now directing attention to the necessity for revising thinning schedules. Reductions in the stocking rates particularly in the first half of the rotation have already been introduced (Fig. 14.)

TABLE 10.

STOCKING RATES FOR SELECTED COMPARTMENTS IN THE FOREST OF LEIRIA.

Site Quality	Compt No.	10 Years		50 Years		60 Years		80 Years	
		No. Trees		No. Trees		No. Trees		No. Trees	
		/hect.	/acre	/hect.	/acre	/hect.	/acre	/hect.	/acre
3	14	840	340	490	198	460	186	380	154
3	60	940	381	599	243	490	198	240	97
3	101	1,280	518	860	348	640	259	270	109
4	114	620	251	520	211	490	198	320	129
4	98	720	292	580	235	480	194	290	117
4	99	1,100	445	630	255	500	202	200	81
4	33	1,010	409	830	336	670	271	220	89
4	8	1,060	429	930	377	900	365	310	126
4	7	1,160	469	940	381	900	365	310	126
4	100	1,250	506	830	336	710	288	250	101
4	34	1,380	559	1,140	462	850	344	260	105
4	51	2,060	834	2,040	826	1,540	624	320	130
5	9	1,490	603	1,170	474	780	316	400	162
5	73	1,710	693	1,610	642	1,400	567	340	138
5	51	1,810	733	1,770	717	1,500	607	300	126

It should be appreciated, however, that these changes in establishment and management practises are only taking place within the forest of Leiria. The resistance to change is tremendous, both within the Forest Service, and in private forestry. The private owner of a small area of woodland is concerned with the necessity to draw funds from it to meet living and emergency needs. A funeral or a dowry is paid for by falling and selling some trees, and the best formed and most vigorous are usually the first to go. In addition, to keep some funds coming in, the owner taps the trees for resin from an early age. State practice taps only during the final two or three years of the life of the tree.

The length of the rotation within the forest of Leiria is set at eighty years. In practice it often exceeds this, possibly due to an imbalance of age classes and the influence of ruling economic conditions on demand.

Thinnings are scheduled for every five years, but are not strictly enforced. The trees are green pruned in their early years (Fig. 15), often commencing with the first thinning at from three to five years.

In later years all branches, as they die, are removed, from the trees by the local people. This wood is used for fuel (Fig. 10).

It is very noticeable in the forest that the trees are slow to respond to thinnings. Apart from the fact that all thinnings in the past have been light, and the release from competition therefore not great, it is considered that the

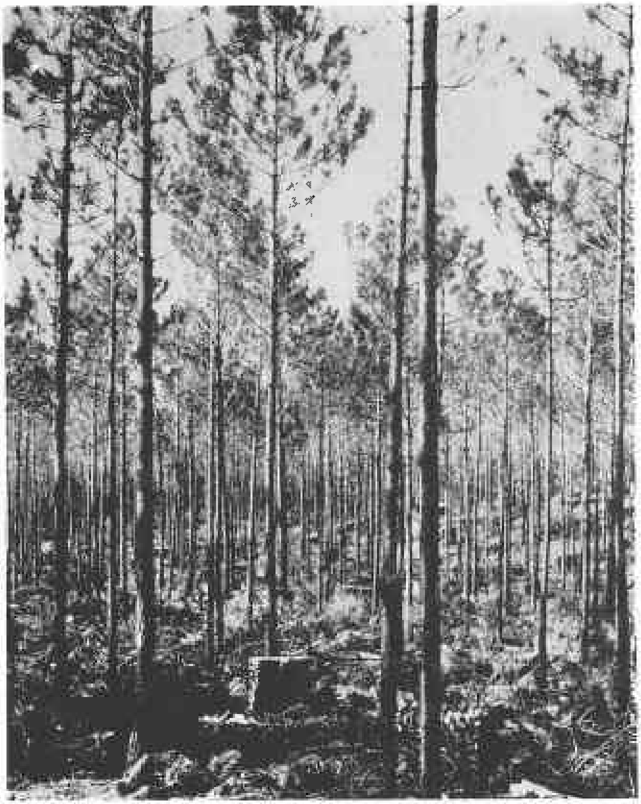

Figure 14.—Thinning in a 28 year old stand to the new prescription. Trees have been reduced from 650 to 300 per acre. Forest of Leiria.

systematic removal of all the stumps of felled trees could be a factor in depressing the response of the remaining trees. It is well known that in a pure forest of this type, a great many of the roots become grafted after reaching an age of fifteen or twenty years. The removal of stumps would sever many of these connections and so slow down the response of the remaining trees to the increased growing space. The royalties received for the stumps may offset this loss in increment.

8. Utilisation and Yields.

All thinnings after the age of about 5 years are removed from the forest. The smallest sizes are used for fuel and vineyard stakes, and the larger trees for fuel, pulpwood, cellulose, chipboard, electricity and telephone poles, mining timber, peeler logs and mill logs. Axes and handsaws are in use alongside the latest model chainsaws. Until recently the logs were hauled to landings in

Figure 15.—Eight years old *Pinus pinaster* after thinning and pruning. Present stocking is 1,800 trees per acre. Forest of Leiria, Compartment 340.

the forest and then transported on light narrow gauge railways out of the forest. This system has given way to modern motor trucks, some of which are fitted with cranes and winches for loading. An excellent system of sealed roads traversing the forest is still being extended.

Tree marking for thinning is done with a small tomahawk by making a single blaze in the bark on one side of the tree. Forest Guards usually work in teams of three or four men doing this work, one man booking and the rest marking. Each tree marked is tallied but not measured. After the trees have been felled they are measured and given a separate serial number which, together with the measurements, is engraved with a special tool into the wood of the butt. The logs, sold in parcels by tender or auction as they lie in the forest, are removed by the purchaser.

The felling at rotation age is carried out on a face, the whole coupe being felled in one operation. The trees fall in all directions and some loss by shattering results. A team then moves in to remove the branches and

Fig. 16.—Logs ready for sale following the final cut. Forest of Leiria.

dock the boles at the 20 cm. mark (approx. 8 in.). Each log is given a serial number and this together with its measurements are engraved on the butt as before. By the time the logs are ready for removal the tops and branchwood have all been removed. This greatly simplifies the operation (Fig. 16).

Current prices for the logs as they lie in the forest are as follows:—

Tree B.H.D.O.B. 4 in. to 6 in.—9.5 cents c.ft. or $4.78 Aust. per load.

Tree B.H.D.O.B. 8 in. to 10 in.—19.0 cents c.ft. or $9.58 Aust. per load.

Tree B.H.D.O.B. 12 in. to 14 in.—40.0 cents c.ft. or $19.08 Aust. per load.

Tree B.H.D.O.B. 16 in. plus—49.0 cents c.ft. or $24.50 Aust. per load.

The logs take a considerable time to remove if the parcel is large. Some of them may lie on the ground for five or six months before they are picked up. Little or no deterioration, either from bark beetles or blue mould, takes place in that time. Most felling is carried out in the winter and spring.

Pinus pinaster is used for almost everything that wood can be used for in Portugal. For service in the ground it is pressure treated with preservatives. Some of the uses noted are as follows:—

Ribs, planking and superstructure in shipbuilding.

Building construction including roofing timber, scantling, joists, flooring (both boards and parquetry).

Figure 17.—*Pinus pinaster* poles for the Post Office Department. Air seasoning prior to Tanalith treatment.

Joinery, furniture and internal fittings, pulp and cellulose, poles, posts, sleepers and mining timber.

Boxes and crates of all kinds.

With reference to yield tables for the forest of Leiria, a considerable amount of work was done on this by Santos Hall some years ago. Unfortunately the work was never published and the tables are not now available. His height and volume curves have been preserved and were revised and adjusted by Velez (18). These are reproduced in Appendices III and IV. The volumes shown in this report represent all marketable timber including fuel, down to 5 cm. (2 inches). The calculated volumes include the bark.

Table 11 extracted from the work of Velez, is the production table on which he based his adjustments to the height and volume curves of Santos Hall.

9. *Some Notes on* Pinus pinaster *Based on Observations Made in the Forest of Leiria.*

1. The species is very sensitive to light and the tree marker should fully appreciate this when marking for thinning. If the trees are left too close together they grow away from each other and towards any nearby opening

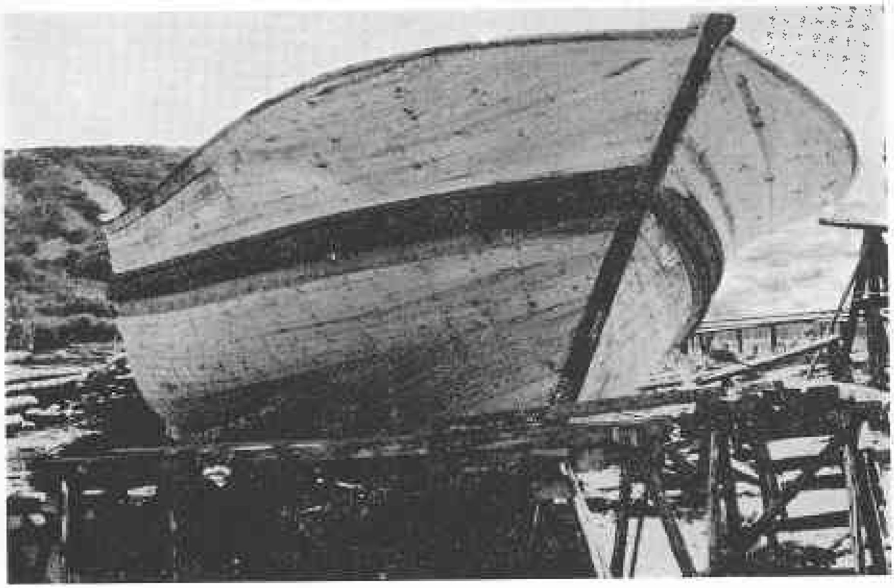

Figure 18.—A 35 foot long fishing boat at Nazare. Construction is entirely of *Pinus pinaster*.

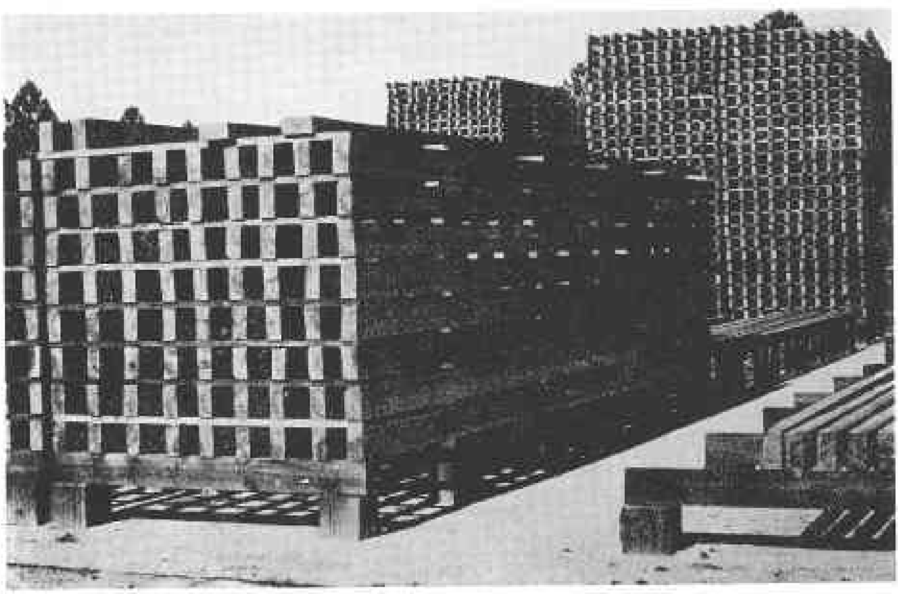

Figure 19.—Thirty feet by eight inches by three inches sawn *Pinus pinaster* stacked for seasoning at Marinha Grande.

TABLE 11.

YIELD TABLE FOR THE FOREST OF LEIRIA.
VOLUMES ARE EXPRESSED IN CUBIC FEET PER ACRE. QUALITY CLASS REFERS TO MEAN DOMINANT HEIGHT AT AGE 50 YEARS.

Age	Quality Class				
	(10M) 32.81 ft	(15M) 49.22 ft	(20M) 65.62 ft	(25M) 82.03 ft	(30M) 98.43 ft
20	2,140.79	2,525.48	3,147.55	3,821.11	4,727.76
30	2,775.74	3,254.81	4,031.325	4,872.19	6,001.95
40	3,326.31	3,884.03	4,789.25	5,767.41	7,084.49
50	3,796.80	4,317.44	5,422.76	6,511.03	7,975.42
60	4,182.91	4,850.75	5,931.87	7,100.22	8,673.29
70	4,488.84	5,185.38	6,313.69	7,534.96	9,178.09
80	4,712.06	5,421.34	6,572.53	7,816.68	9,491.27
90	4,850.75	5,557.19	6,704.09	7,943.96	9,611.40
100	4,505.81	5,597.23	6,711.25	7,915.36	9,535.61
110	4,482.93	5,538.60	6,593.98	7,735.17	9,272.47
120	4,779.24	5,377.01	6,349.44	7,399.09	8,822.00

in the canopy. The crown tends to develop vigorously on the free or open side and is severely restricted where there is insufficient space available for it to develop normally. This further influences the tendency of the trees to lean away from each other and results in a bowed and leaning bole with considerable compression wood.

There is little doubt that *Pinus pinaster* has an inherently unstable bole and very little outside influence is required to aggravate this. It is hoped eventually to correct this weakness by selective breeding, using parent stock with a strongly developed tendency to produce a straight and vertical bole. Fortunately such trees do exist in the forest of Leiria and a number have been located. These trees have maintained a vertical habit despite very strong pressure from nearby dominants and it is believed that this factor is under genetic control.

2. The crowns of *Pinus pinaster* never inter-lace or inter-mingle with one another but remain separate and distinct entities throughout their lives. Not even in the most sheltered valleys is it possible to find an exception to this.

3. Butt sweep is a term used in Western Australia to describe a bend or bow in the bole between ground level and breast height. This defect leads to considerable loss in milling or peeling recoveries from the largest log in

Figure 20.—Pine needles being removed from the forest for use as stock bedding. Forest of Leiria.

the tree and causes considerable degrade from compression wood development. Observation indicates that this fault can be aggravated by unfavourable external influences such as steeply sloping terrain (Fig. 13), very strong prevailing winds, wet and badly drained soils and from sandblasting. It is common to see all trees on steep slopes affected by butt sweep, the convex side of the curve facing down hill. Many trees also have a pronounced lean down the hill in addition. Strong and persistent winds cause butt sweep and malformation, particularly if the site is rather exposed (Fig. 21) and the defect is also very pronounced on wet badly drained sites.

The effect of sand blasting is to damage the very soft leading shoot at the height of its activity in spring. Trees higher than about two feet are rarely damaged. A whole compartment of about eighty acres was damaged in this way in 1964 and hardly a tree was unaffected. They were all injured on the north west side, the direction from which all the worst storms come. As a result the little trees developed a decided bow with the concave side to the north west.

4. Many trees have a tendency to develop pronounced nodal swellings. This fault is very persistent, being evident in trees of eighty years of age or more.

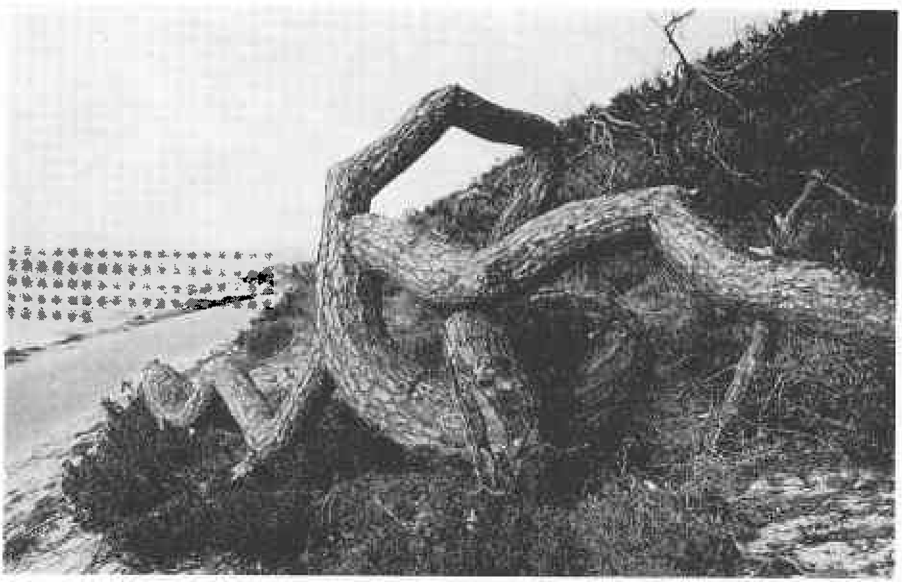

Figure 21.—Distorted tree form in the protection forest on the Atlantic coast. Age is about 80 years. Forest of Leiria.

5. Cone persistence and time of seed shed varies considerably within the species. Some trees are capable of carrying their cones for many years although the seed sheds every year. Other trees were found which not only carry persistent cones but also fail to shed their seed in the first summer, after ripening, but carry them into the second summer. Such a tree is E186, from which it was possible to collect many unopened cones at the end of a hot dry summer in 1965. Generally the cones open on the trees the first summer after the seed ripens. Many of the cones also fall off and continue to do so through the following winter and summer. In attempting to assess the seed producing capacity of a tree it is necessary to fully appreciate these factors as the observer on the ground could be misled by a tree that appears to carry a very few cones.

6. The colour of the wings of the seeds varies greatly between individual trees but is constant for the individual itself. The colour can vary from a pale fawn as in plus phenotype E162 to almost black as in plus phenotype E153. Seed size is largely governed by cone size, the large cones producing large seeds and the small cones small seeds. Cone size appears to be influenced by age, the largest cones being produced by the trees in the 10 to 40 year age group.

7. The time interval between commencement and cessation of pollen shed is about three weeks. It is improbable that the trees which flower at the beginning and end of this period fertilise one another. The time interval between pollen ripening and complete shedding is about ten days in any one tree.

8. *Pinus pinaster* bark is usually extremely persistent and durable. As a result the majority of trees are thick barked. Thin barked trees do occur however, and an example is plus phenotype E182. In such trees the bark appears to weather and shed more rapidly than is normal.

9. Plantations established in Western Australia from seed originating from the region of Leiria in Portugal, produce a very high percentage of trees with a forking habit. This propensity to fork is not evident in the trees of the Leiria region where forked trees are quite rare. It is possible that establishment and management practices in Portugal suppress this tendency as the forests are grown at high stocking rates, by Australian standards at all ages.

PRESENT STATUS OF TREE IMPROVEMENT WITH *PINUS PINASTER* IN PORTUGAL.

Prior to 1964 some experimental work had been done to test the possibility of grafting *Pinus pinaster* and to propagate it from cuttings. Some success was achieved in raising cuttings. Unfortunately the root system developed by this type of plant was inadequate to maintain stability and in later years all but one tree were blown down.

Following the recent location of the 85 plus phenotypes in the forest of Leiria, the Forest Service established a scion orchard in Compartment 151 by field grafting scions on to two year old seedlings already established by broadcast sowing. The following clones were successfully established to the end of 1965.

E—101, 110, 112, 113, 114, 118, 119, 123, 124, 128, 129, 132, 133, 139, 140, 141, 142, 143, 144, 145, 148, 149, 151, 152, 153, 155, 156, 157, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 183.

It was intended to graft the balance of the 85 plus phenotypes in 1966.

A small breeding station is in course of establishment at the forest station of Engenho at Marinha Grande. A glasshouse has been built, water laid on etc. A field laboratory has been set up also at Engenho.

Two tentative sites have been selected for seed orchards, one near the Spanish border at Monsaraz east of Evora and the other near Idanha a Nova north east of Castelo Branco. The location of suitable sites for orchards in Portugal is a problem with this species, as *Pinus pinaster* is grown almost everywhere.

MEAN ANNUAL RAINFALL FOR FOUR CENTRES IN THE LANDES, 1953-1963

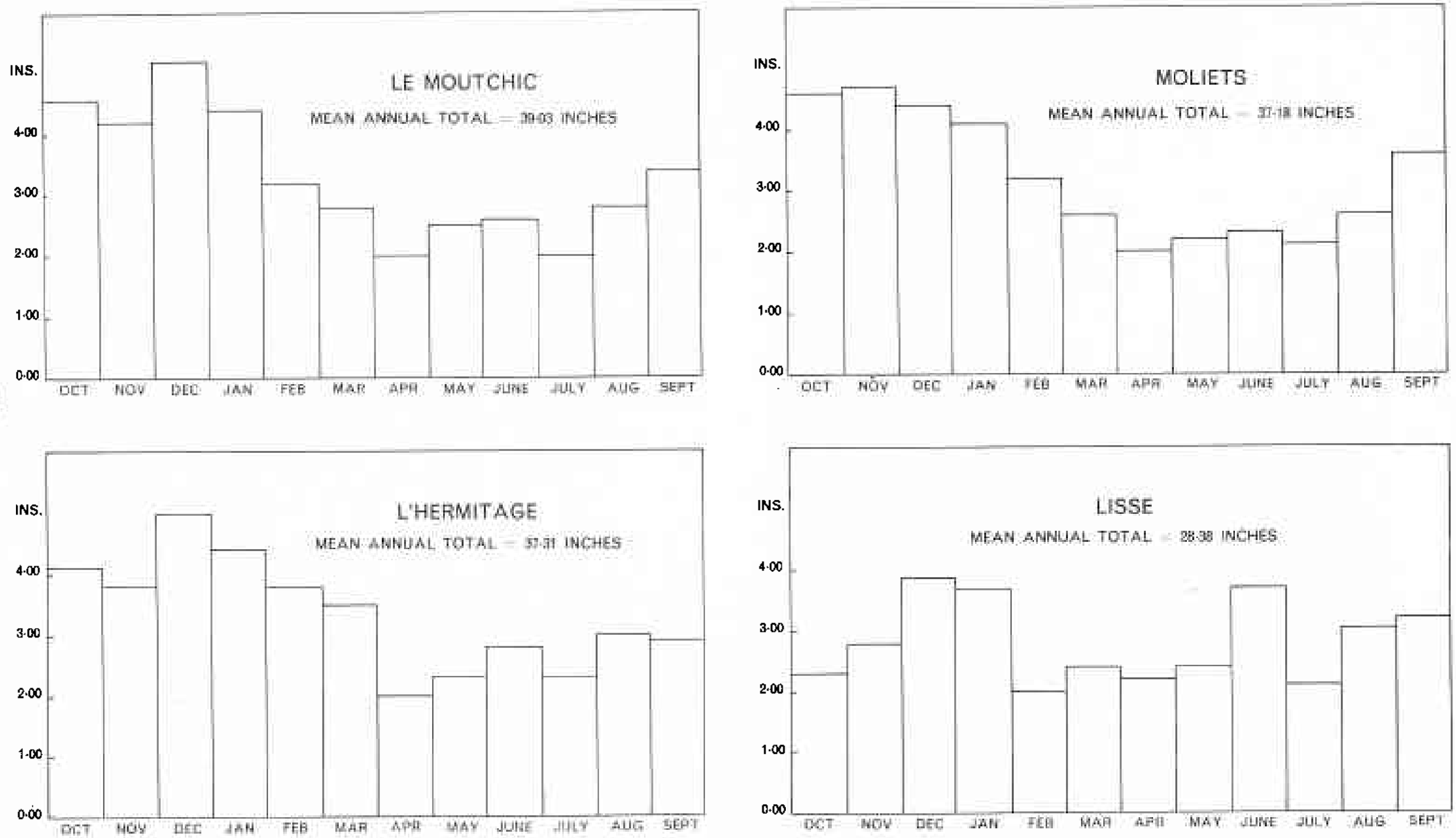

Figure 22.

PART III.—PINUS PINASTER IN THE LANDES REGION OF SOUTH WESTERN FRANCE AND IN NORTHERN SPAIN.

1. FRANCE.

Brief Description of the Landes.

The region known as the Landes is roughly triangular in shape, and is bounded on the west by the Atlantic ocean, on the east by the valleys of the Gironde and Garonne, and partly on the south by the Adour. The area contained within this region is approximately 2,000,000 acres, the greater part being forested with *Pinus pinaster*. It is mostly owned by private individuals and by local communes, the State holdings being largely confined to the unstable dune lands along the coast. The soils vary considerably in fertility but all are sandy (2). The water table is maintained at fairly shallow depths on the flats, but can be at considerable depth on the dunes. Alios, or coffee rock, commonly constitutes the "B" horizon under the flats. It is generally considered that the pines are responsible for the formation of this layer, but little is really known about it.

The rainfall varies from 38 inches per year in the coastal regions and diminishes to 28 inches per year at the Eastern apex of the regional triangle. The distribution throughout the year is good, the wettest months being September to January inclusive, but the remaining months appear to receive an average of 2 inches to $2\frac{1}{2}$ inches each (Fig. 22).

Temperatures (Table 12) range from —23°C to 42°C, the figures quoted being the extremes. The occasionally very low temperature registered may only occur once or twice in the rotation of 60 to 70 years; it is, however, a limiting factor for some of the provenances under test.

The summers are mild and cloudy with mist and frequent showers. It is difficult to imagine the forests of this region ever being under severe moisture stress. In the initial stages of establishment, some problems are encountered in this connection on certain soil types. These could be eliminated by thorough preparation of the soil and elimination of the scrubby ground cover.

The Forests of the Landes.

The huge area of forest established in this region is nearly all pure *Pinus pinaster*. Small sections contain a mixture of Cork and other Oaks and some broadleafed species but such areas are definitely limited. The fact that the pine has been able to flourish as pure forest, in this environment, for so long, is indicative of the adaptability, hardiness, and disease resistant qualities of the species.

TABLE 12.

TEMPERATURE DATA FOR THE LANDES REGION.
THE AVERAGES, IN DEGREES FAHRENHEIT, ARE MADE FOR THE PERIOD 1953-1964.

Year October-September inclusive	Locality							
	Le Moutchic		L'Hermitage		Moliets		Lisse	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1953–54	10.4°	92.6°	8.6°	95.9°	8.6°	104.0°	....	....
1954–55	23.0	102.2	15.8	94.5	23.0	104.0	14.0°	100.4°
1955–56	6.8	100.4	1.4	93.6	5.0	100.4	—9.4	99.5
1956–57	14.0	104.0	11.3	95.0	15.8	107.6	8.6	101.3
1957–58	20.3	100.4	17.6	91.4	24.8	102.2	19.4	96.8
1958–59	23.0	104.0	17.6	96.8	19.4	103.1	14.0	102.2
1959–60	19.4	100.4	14.0	93.6	19.4	100.4	12.2	97.7
1960–61	26.6	104.0	16.7	105.8	23.0	104.0	18.5	97.7
1961–62	6.26	100.76	12.2	96.8	....	105.8	10.4	101.3
1962–63	7.34	100.58	3.2	96.8	8.6	104.0	—0.4	95.0
1963–64	14.18	100.94	12.2	95.0	10.94	103.1	10.22	103.1

When examining these forests there is little difficulty in recognising that the greater part of it belongs to the Atlantic group of the species. There is, however, a great deal of variation, some of it obviously the effect of site. In other cases it is not possible to determine whether the variation is genetically controlled or the effect of environment. It is probable that originally the species did vary from north to south of its range, and this may still be so. The best stands seen were growing near Soustons in the south and many individual trees were indistinguishable from those of the Leirian provenance. Whether the appearance, good form and fast rate of growth of these stands can be duplicated elsewhere can only be determined by testing. Selecting parent stands or origins for provenance trials is, and will continue to become, increasingly difficult in this region. Massive quantities of seed have been brought in from other sources, including Portugal. Seed has also been collected in one part of the region, and transferred to another for sowing.

All this highlights the necessity, when collecting seed to establish provenance trials, to ensure that the collections originate from a sufficient number of individuals. This is necessary to ensure sufficient diversity on which to base any subsequent improvement programme. The possibility of obtaining further seed of identical genetic identity, by going back to the source, becomes more difficult as time goes on.

Fertilisers have been under test as a means of improving site quality and some highly significant results have been obtained (1).

Establishment is mainly by broadcast sowing and soil preparation varies with site and soil type (1) (2). Although difficulties have been experienced in establishing the trees only on certain soil types, it is considered that thorough soil preparation, using modern machinery, is essential on all sites. There is every indication that satisfactory subsequent growth can be obtained by the application of suitable fertilisers. If the coffee rock is found to be a serious hazard to growth, there would appear to be little difficulty in breaking it up with a big ripper, though little is known of the economics of the process at present. Portuguese experience indicates that whilst some benefit results from the breaking of the coffee rock layer, this is far outweighed by an application of suitable fertiliser.

Provenance Trials.

Two provenance trials were seen, one established between the years 1926 and 1938 at Place des Arrouilles, and the other established about 1952 at Malgaches arboretum.

The Arrouilles trial is not replicated and some of the provenances are actually progenies. The results are interesting and instructive for the opportunity they afford to study the appearance of the origins under trial in this environment. The Landes provenances appear to be best suited to this region and are superior to the Leirian. A severe cold wave experienced in 1956 damaged the Leirian stock but did not kill it. The Algerian provenance was wiped out completely. The Maures, Estorel, Corsican and inland Spanish provenances are not encouraging on this site.

The trial in the Malgaches arboretum has a randomised plot layout, with four replications. Again it is evident that the Landes provenances are doing the best. Some difficulty was experienced in recognising the Corsican provenance in this trial and it was stated that there are two and possibly three races of *Pinus pinaster* growing in Corsica. The Spanish inland race is very slow growing and is a heavy producer of persistent cones. The provenances of Maures and Estorel closely approximate their appearance in Australia.

The fact that the Leirian provenance does not thrive so well as the Landes in this region is considered to be a further indication that the two populations are quite distinct. Pollen shed in these Forests commences about the middle of April as opposed to early March in Portugal. This confirms Western Australian experience.

Tree Improvement.

An active programme of tree improvement for *Pinus pinaster* is well established and is based on the Research Station at Bordeaux. Plus phenotypes have been located and a clonal seed orchard established. The first half sib progeny trials were planted about five or six years ago and the first full sib trial was to be planted in 1966.

Plus Trees.—In selecting plus trees a great deal of emphasis has been placed on vigour and all trees seen are outstanding for this factor. Serious faults in form, such as for instance butt sweep, have been accepted in some of the earlier selections, but standards of perfection now closely approximate those in Western Australia. It was considered when selection commenced in France that, as the bulk of all logs are sold in short lengths and resin tapping led to serious degrade in the butt log, some degree of butt sweep was unimportant. It is now realised that the resin industry appears tc have a limited future unless some new and revolutionary process is devised for tapping the trees, and also that compression wood associated with butt sweep results in serious degrade.

When selecting plus trees the closest surrounding 30 trees are measured and their qualities assessed, as for the plus phenotype itself. This data is examined statistically and to make selection possible the plus tree must have a significant superiority over the population sample surrounding it. Girths are taken at breast height but considerable importance is given to mid-log or tree diameter as measured by a Barr and Stroud F.P.12 dendrometer or a pentaprism caliper. With the object of permitting the degree of genetic gain to be calculated, seed collected from the group of 30 surrounding trees is tested against the progeny of the plus phenotypes in the trial.

Some excellent plus phenotypes have now been located, of which the following rate highly:—4318, 4311, 4312, 4313, 5308.

Half sib seeds of the following plus phenotypes have been donated by the French Forest Service for trial in Australia:—

Tree No.	*Tree No.*	*Tree No.*	*Tree No.*
00.16	01.59	38.01	51.01
00.18	02.05	38.02	51.02
00.19	02.51	38.27	53.01
00.23	02.52	42.02	71.02
01.06	02.83	43.10	71.03
01.08	13.05	43.16	71.04
01.23	13.06	43.17	71.05
01.24	31.05	47.02	71.06

These have been received and sown and were planted out in trials in 1967.

Most of the plus phenotypes located to date are situated on other than State Forest and it is not likely that they will be preserved beyond their rotation age. All plus trees are in excess of forty years of age.

Progeny Trials.—Several half sib trials have been established and the oldest is aged about five years. The first full sib trial was to be planted out in 1966.

Seed Orchard.

The first clonal seed orchard has been established in the foothills of the Pyrenees near St. Pee sur Nivelle close to the Spanish border.

Pollen dispersal tests had shown that considerable separation from the region of the Landes was essential if contamination was to be kept down to an acceptable level (6). Planting cmmenced in 1962 and was to be completed in 1965. The area is about 8 acres and the espacement 16 ft. by 16 ft. The ramets are randomised, but as the planting commenced while the plus tree search was still in progress each clone is not represented over the whole area. The grafts are all growing very well and the orchard is regularly rotary hoed and has been given fertiliser treatment.

Breeding Station: Nursery and Grafting Technique.

The breeding station is located a short distance south of Bordeaux on the main road to Bayonne. Proposals are in hand to establish field laboratories and offices here and then to transfer the research station from the city to this site.

In raising stocks for grafting, the seeds are sown in open nursery beds and remain there for two years, by which time the plants are from 3 ft. to 4 ft. high. They are then transplanted into plastic bags of about 2 gallons capacity and set out in beds under lath shelters. Grafting is done in both autumn and spring. The method used is a side cleft graft, mating one year old wood into one year old wood. The scions are very large and usually comprise a whole primary or secondary branch terminal shoot with needles and side shoots intact. An average survival of 50 to 60 per cent. is claimed when grafting direct from the plus phenotype. Shoots from the scion orchard have not yet been grafted since the use of their current practice in which the whole of the terminal shoot is removed to make a single scion would greatly reduce the number of female flowers produced. Grafts are bound with a perishable rubber binding which falls off after some months. All grafts, when transferred to the seed orchard or clonal park, must be staked for some years to support their large size. No field grafting has been attempted so far.

Progenies are raised in tubes made of a stout cardboard-like material and are 9 in. long by 3 in. wide. These tubes are stacked vertically into concrete box forms about 30 ft. long by 3 ft. wide by 18 in. deep. Seeds are sown directly into the tubes. Each progeny is replicated four times and the plots are randomised within the frames. The frames are shaded on hot days by rolls of wired laths. Watering is effected by thin plastic hose, finely perforated in the upper surface and tied to light wooden strips for support and position over the frames. The lath shades can be rolled and unrolled over the hoses and it is not necessary to move them. A small centrifugal pump is used to boost the water pressure. The method is most effective, the water covering the area well and falling like light rain.


MAP of PORTUGAL, SPAIN
and
SOUTH-WESTERN FRANCE
FRANCE
BORDEAUX
Mimizan
LANDES
Soustons
OCEAN
ATLANTIC
44
42
38
36
Aviles
Santander
San Sebastian
Ribadeo
Gijon
Bilbao
Vitoria
Lugo
Lalin
Burgos
Pontevedra
Tuy
Valladolid
Alaejos
Vila Real
Salamanca
Porto
Viseu
Guarda
MADRID
SIERRA ESTRELA
Tagus
Pine Forest of Leiria
Nazare
Leiria
SPAIN
Rio Maior
PORTUGAL
LISBON
Cape St. Vincent
GIBRALTAR
MEDITERRANEAN SEA
20 10 0 20 40 60 80 100 120 MILES

Figure 23.

2. SPAIN.

In order to try and gain some idea of the potential value to Australia of any *Pinus pinaster* forest growing in the north of Spain, the following route from Lisbon to Bordeaux and return was traversed:—Lisbon and thence to Guarda, Salamanca, Valladolid, Burgos, Vitoria, San Sebastian and Biarritz, returning via Bilbao, Santander, Gijon, Ribedeo, Lugo, Lalin, Pontevedra, Tuy, Oporto to Lisbon (Fig. 23).

From the frontier to Burgos the route passes through Castile, a plateau from 1,000 to 2,000 feet high, very cold in winter and hot and dry in summer. This whole region is given over to the growing of cereals. The region resembles the Western Australian wheat region but the winters are much colder.

On the outward journey *Pinus pinaster* persisted to the vicinity of the Portuguese Spanish border, but was not seen again except as occasional single trees for nearly 100 miles in the vicinity of Alaejos, a small town between Salamanca and Valladolid. Here there were a few small man made plantations, even aged and in rows, but nothing remotely resembling a fragment of an old natural forest. Some old uneven aged stands of *Pinus pinea* were seen, giving the impression that this tree might be endemic to the region. *Pinus pinaster* hereabouts is extremely slow growing and branchy, the yearly increment in height being only about 6 in. Once past Valladolid very little *Pinus pinaster* was seen at all. The rainfall increases as the coast is approached and quite extensive stands of *Pinus radiata* and *Eucalyptus globulus* clothe the mountainsides. *Pinus pinaster* is a rare tree through all this region. There is a marked geological and soil change with the crossing of the Adour valley in France and a quite dramatic change in the forest. From this point onwards *Pinus pinaster* extends in an unbroken forest for some 120 miles.

Returning along the northern coast of Spain, *Pinus pinaster* was not seen except as isolated specimens, until in the vicinity of Aviles, a short distance west of Gijon. From this point on the forests of this species increased steadily in extent. Most of it was even aged and had been established or renewed by man. The trees generally were of poor form and had only a moderate rate of growth. They resemble stands of the South African provenance known as French Hoek growing in Western Australia. As the western coast of Galicia is approached the species improves in form and in rate of growth, reaching optimum development in the region of Pontevedra. The trees hereabouts closely resemble the provenance of Leiria in appearance and rate of growth.

Pinus pinaster extends southwards from the northern coast of Galicia in a continuous belt as far south as Lisbon. Its range has been undoubtedly extended by man, mainly eastwards from the coastal regions and it is now extremely difficult, if not impossible, to determine the limits of the areas to which it was originally confined.

CONCLUSIONS.

There is sufficient diversity in appearance and growth rate to warrant further provenance testing of Landes origins in Western Australia.

The tree as seen in the vicinity of Pontevedra in Western Galicia in Spain also warrants testing under Western Australian conditions, and seeds were collected for this purpose. These were sown in August 1966.

Apart from these two origins it is not considered that any other provenance seen has the potential to compete with that of the forest of Leiria for timber production in the Western Australian environment.

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APPENDIX I.

INTRODUCTION OF PORTUGUESE TREES PROPAGATION SUMMARY TO MARCH, 1967.

Serial Nos.		Grafting Period										Total		Surviving Grafts " Budded On "	Total Survivals
		Sept., '64		Mar., '65		Apl., '65		May, '65		Sept., '65					
Pdl.	E.	G.	S.	G.	S.	G.	S.	G.	S.	G.	S.	G.	S.		
1	101	25	0	—	—	—	—	....	....	8	0	33	0	0	0
2	102	25	0	—	—	—	—	....	....	....	—	25	0	1	1
3	103	25	1	20	1	—	—	....	....	....	—	45	2	1	3
4	104	30	0	—	—	18	2	....	....	....	—	48	2	2	4
5	105	25	2	—	—	—	—	28	0	....	—	53	2	7	9
6	106	25	1	—	—	—	—	28	0	....	—	53	1	1	2
7	107	25	4	—	—	—	—	....	....	....	—	25	4	5	9
8	108	36	0	—	—	—	—	....	....	....	—	36	0	2	2
9	109	25	1	—	—	27	1	....	....	....	—	52	2	1	3
10	110	25	0	—	—	26	0	....	....	....	—	51	0	0	0
11	111	24	3	—	—	—	—	....	....	....	—	24	3	7	10
12	112	25	2	—	—	—	—	....	....	....	—	25	2	5	7
13	113	25	0	21	5	—	—	....	....	....	—	46	5	4	9
14	114	25	2	—	—	—	—	....	....	....	—	25	2	5	7
15	115	35	2	—	—	—	—	....	....	....	—	35	2	4	6
16	116	25	0	—	—	—	—	....	....	....	—	25	0	0	0
17	117	31	1	—	—	30	5	....	....	....	—	61	6	4	10
18	118	25	1	—	—	—	—	27	18	....	—	52	19	4	23
19	119	25	3	—	—	—	—	23	10	....	—	48	13	7	20
20	120	25	0	—	—	—	—	....	....	....	—	25	0	0	0
21	121	24	1	—	—	—	—	....	....	....	—	24	1	1	2
22	122	25	1	—	—	—	—	....	....	....	—	25	1	15	16
23	123	41	3	—	—	—	—	....	....	....	—	41	3	13	16
24	124	25	1	—	—	—	—	....	....	....	—	25	1	6	7
25	125	25	0	—	—	22	0	....	....	....	—	47	0	0	0
26	126	25	1	—	—	—	—	....	....	....	—	25	1	1	2
27	127	25	3	—	—	—	—	....	....	....	—	25	3	9	12
28	128	25	0	—	—	31	1	....	....	9	3	65	4	0	4
29	129	32	0	22	8	—	—	....	....	....	—	54	8	23	31
30	130	32	3	—	—	—	—	....	....	....	—	32	3	7	10
31	131	34	1	—	—	—	—	....	....	....	—	34	1	7	8
32	132	31	0	21	3	—	—	....	....	....	—	52	3	1	4
33	133	42	6	—	—	—	—	....	....	....	—	42	6	16	22
34	134	36	3	—	—	—	—	....	....	....	—	36	3	14	17
35	135	25	2	—	—	—	—	....	....	....	—	25	2	2	4
36	136	24	0	—	—	30	0	....	....	....	—	54	0	0	0
37	137	25	2	—	—	—	—	....	....	....	—	25	2	3	5
38	138	35	1	—	—	—	—	....	....	....	—	35	1	4	5
39	139	36	2	—	—	—	—	....	....	....	—	36	2	9	11
40	140	31	0	21	0	—	—	....	....	....	—	52	0	2	2
41	141	30	1	—	—	—	—	....	....	....	—	30	1	1	2
42	142	37	1	—	—	—	—	....	....	....	—	37	1	2	3
43	143	32	0	24	11	—	—	....	....	....	—	56	11	2	13
44	144	31	3	—	—	—	—	....	....	....	—	31	3	6	9
45	145	30	3	—	—	—	—	....	....	....	—	30	3	12	15
46	146	33	0	27	5	—	—	....	....	....	—	60	5	10	15
47	147	32	1	—	—	—	—	....	....	....	—	32	1	6	7
48	148	32	7	—	—	—	—	....	....	....	—	32	7	16	23
49	149	32	0	21	9	—	—	....	....	....	—	53	9	15	24
50	150	32	0	21	3	—	—	....	....	....	—	53	3	1	4
51	151	31	0	22	7	—	—	....	....	....	—	53	7	13	20
52	152	25	0	—	—	—	—	26	20	....	—	51	20	18	38
53	153	25	0	27	0	—	—	12	0	....	—	64	0	0	0
54	154	....	....	25	10	—	—	....	....	....	—	25	10	5	15
55	155	....	....	30	0	10	1	....	....	....	—	40	1	0	1
56	156	....	....	32	14	—	—	....	....	....	—	32	14	13	27
57	157	....	....	41	7	10	0	....	....	....	—	51	7	9	16
58	158	....	....	28	7	—	—	....	....	....	—	28	7	10	17
59	159	....	....	28	8	—	—	....	....	....	—	28	8	8	16
60	160	....	....	32	12	—	—	....	....	....	—	32	12	14	26
61	161	....	....	—	—	27	0	10	7	....	—	37	7	8	15
62	162	....	....	30	2	—	—	23	12	....	—	53	14	15	29
63	163	....	....	29	2	—	—	34	2	....	—	63	4	2	6
64	164	....	....	25	8	—	—	....	....	....	—	25	8	14	22
65	165	....	....	25	6	—	—	....	....	....	—	25	6	7	13
66	166	....	....	25	10	—	—	....	....	....	—	25	10	11	21
67	167	....	....	25	8	—	—	....	....	....	—	25	8	18	26
68	168	....	....	25	10	—	—	....	....	....	—	25	10	12	22
69	169	....	....	—	—	28	7	....	....	....	—	28	7	11	18

G. = No. Grafted. S. = No. of Survivals. " Budded On " = Buds Grafted from Ramets.

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INTRODUCTION OF PORTUGUESE TREES PROPAGATION SUMMARY TO MARCH, 1967.

Serial Nos.		Grafting Period										Total		Surviving Grafts "Budded On"	Total Survivals
		Sept., '64		Mar., '65		Apl., '65		May, '65		Sept., '65					
Pdl.	E.	G.	S.	G.	S.	G.	S.	G.	S.	G.	S.	G.	S.		
70	170	....	....	....	....	30	5	....	....	....	....	30	5	5	10
71	171	....	....	25	12	....	....	....	....	....	....	25	12	11	23
72	172	....	....	22	8	....	....	....	....	....	....	22	8	6	14
73	173	....	....	24	5	....	....	....	....	....	....	24	5	10	15
74	174	....	....	24	10	....	....	....	....	....	....	24	10	10	20
75	175	....	....	25	9	....	....	....	....	....	....	25	9	14	23
76	176	....	....	24	10	....	....	....	....	....	....	24	10	17	27
77	177	....	....	....	....	30	0	28	10	....	....	58	10	2	12
78	178	....	....	24	10	....	....	....	....	....	....	24	10	26	36
79	179	....	....	....	....	25	1	....	....	8	2	33	3	3	6
80	180	....	....	24	10	....	....	....	....	....	....	24	10	5	15
81	181	....	....	24	2	....	....	....	....	4	2	28	4	4	8
82	182	....	....	....	....	33	8	5	0	....	....	38	8	4	12
83	183	....	....	20	9	....	....	....	....	....	....	20	9	6	15
84	184	....	....	42	7	10	0	....	....	....	....	52	7	12	19
85	185	....	....	....	....	....	....	....	....	52	17	52	17	14	31
86	186	....	....	....	....	....	....	....	....	49	22	49	22	15	23

G. = No. Grafted. S. = No. of Survivals. "Budded On" = Buds Grafted from Ramets.

APPENDIX II.

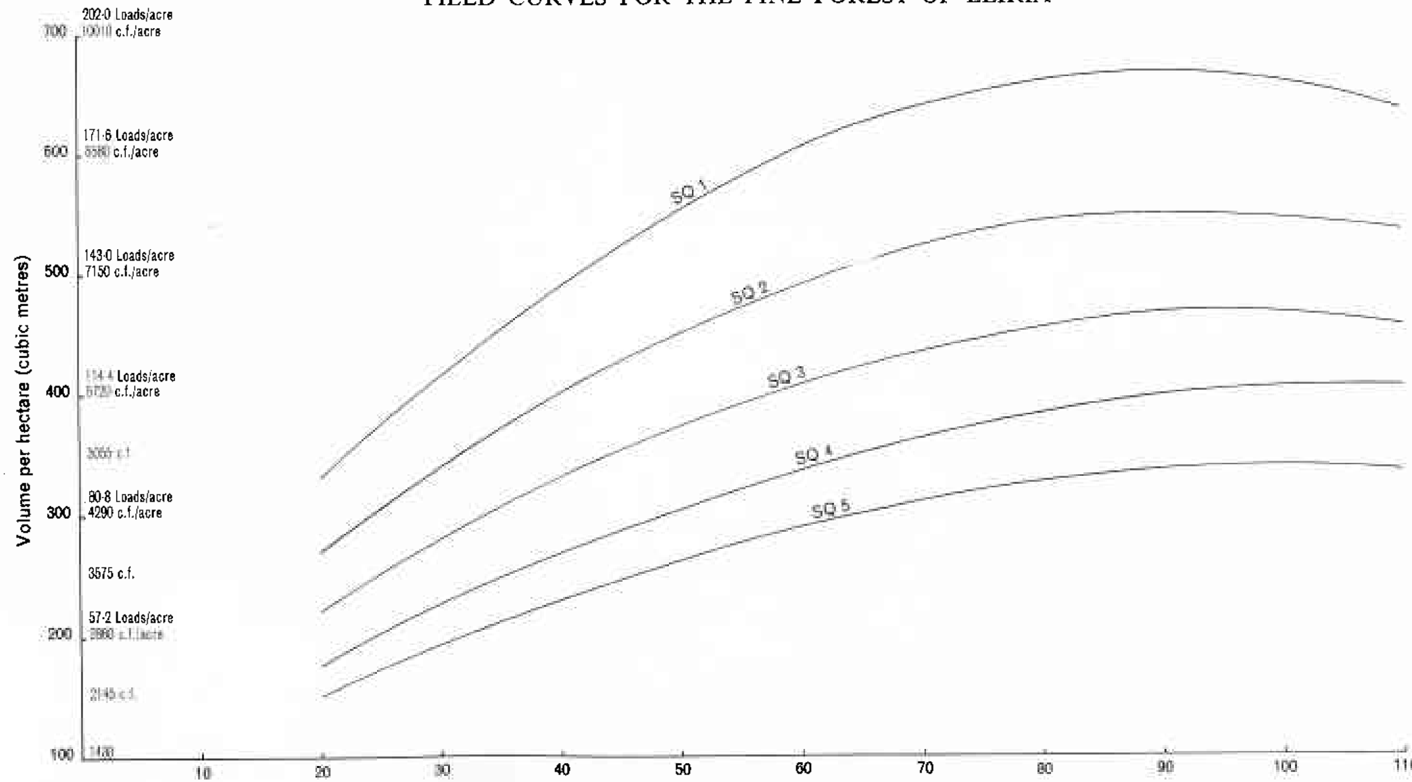
WOOD PROPERTIES OF THE SELECTED TREES.

Tree No.	Basic Density *	Fibre Length †	Grain Angle ‡	Tree No.	Basic Density	Fibre Length	Grain Angle	Tree No.	Basic Density	Fibre Length	Grain Angle
E101	.485	B.A.	0,2	E130	.504		0,0	E159	.521	B.A.	0,2
E102	.483		6,6	E131	.541	A.A.	0,0	E160	.558	B.A.	2,3
E103	.483	B.A.	0,1	E132	.531		0,0	E161	.455		0,0
E104	.464		0,0	E133	.508		0,0	E162	.517		0,1
E105	.519	B.A.	2,0	E134	.486	B.A.	0,1	E163	.522		0,2
E106	.454		0,2	E135	.534	B.A.	1,2	E164	.475		0,0
E107	.487		0,0	E136	.477		0,0	E165	.519		0,2
E108	.488	B.A.	0,2	E137	.491	A.A.	0,0	E166	.432		0,0
E109	.514	B.A.	0,2	E138	.523		1,1	E167	.501		0,0
E110	.514	B.A.	2,3	E139	.523	B.A.	0,0	E168	.502	A.A.	0,0
E111	.478	B.A.	2,2	E140	.493	B.A.	0,2	E169	.505	B.A.	0,1
E112	.487	A.A.	0,0	E141	.508		0,0	E170	.457		1,1
E113	.470	A.A.	0,0	E142	.516		0,0	E171	.496	B.A.	0,1
E114	.524		0,2	E143	.490	A.A.	0,0	E172	.489	B.A.	0,0
E115	.510	B.A.	0,2	E144	.465		0,1	E173	.478	B.A.	0,0
E116	.490		0,0	E145	.461		0,1	E174	.492		0,0
E117	.482		0,0	E146	.422	A.A.	0,2	E175	.467		6,3
E118	.563	A.A.	0,0	E147	.464		0,2	E176	.449	A.A.	0,1
E119	.533		0,1	E148	.460	A.A.	0,0	E177	.472		1,1
E120	.531	A.A.	3,4	E149	.501		0,2	E178	.493	A.A.	2,2
E121	.484		0,0	E150	.498	A.A.	0,0	E179	.471		0,1
E122	.461		1,0	E151	.514	A.A.	0,0	E180	.486		0,0
E123	.552		1,0	E152	.500		0,0	E181	.457		1,2
E124	.526	A.A.	0,0	E153	.539	A.A.	0,0	E182	.558		3,4
E125	.498		0,0	E154	.486		0,0	E183	.517		0,1
E126	.554		0,0	E155	.524		0,2	E185	.526		0,1
E127	.499	B.A.	0,0	E156	.519	A.A.	0,1	E186	.451		0,0
E128	.576	B.A.	0,6	E157	.522		3,4				
E129	.491	A.A.	1,2	E158	.549		0,0				

* Tree Mean for Mature Wood.
† A.A. = Above Average. B.A. = Below Average.
‡ Grain deviation in Degrees for last formed wood on two opposite radii.

APPENDIX III

YIELD CURVES FOR THE PINE FOREST OF LEIRIA



Curves of Santos Hall (Total wood production adjusted by Velez.)

APPENDIX IV

QUALITY CLASSES IN THE PINE FORESTS OF LEIRIA

Height Curves of Santos Hall adjusted by Velez.
Based on mean height of Dominants.