

## PROGRESS IN THE *PINUS CARIBAEA* MORELET AND *PINUS OOCARPA* SCHIEDE INTERNATIONAL PROVENANCE TRIALS.\*

By A. GREAVES†

### SUMMARY

The selection of suitable provenances is essential for achieving maximum productivity in forest plantations. As few countries have the resources for provenance testing over a wide range of sites, a thorough appraisal of the relative merits of different provenances can only be achieved through international cooperation and exchange of information. The establishment of the *Pinus caribaea* Morelet and *Pinus oocarpa* Schiede international provenance trials under the coordination of the Commonwealth Forestry Institute, Oxford, led to the creation of a provenance assessment data base which revealed that certain provenances grew well in a wide range of environments across countries.

### RESUME

La sélection de provenances appropriées est essentielle pour obtenir une productivité maximale dans les plantations forestières. Etant donné que peu de pays ont les ressources nécessaires pour tester les provenances sur un large échantillon de sites, une approche minutieuse des mérites relatifs des différentes provenances peut seulement être réalisée grâce à la coopération internationale et à l'échange d'informations. La mise en place des tests de provenance internationaux de *Pinus caribaea* Morelet et de *Pinus oocarpa* Schiede coordonnée par le Commonwealth Forestry Institute, Oxford a conduit à la création d'une base de données d'évaluation des provenances qui a révélé que certaines des provenances ont une croissance satisfaisante dans une large gamme d'environnements à travers le monde.

### RESUMEN

La selección de procedencias adecuadas es esencial para la obtención de una productividad máxima en plantaciones forestales. Como pocos países tienen los recursos para pruebas de procedencias sobre un amplio rango de sitios, una prueba cabal de los méritos relativos de diferentes procedencias puede obtenerse solamente a través de la cooperación internacional e intercambio de información. El establecimiento de ensayos internacionales de procedencias de *Pinus caribaea* Morelet y *Pinus oocarpa* Schiede bajo la coordinación del Commonwealth Forestry Institute, Oxford, llevó a la creación de una base de datos de valoración de procedencias los cuales revelaron que ciertas procedencias crecieron bien en un amplio rango de ambientes a través de países.

### Introduction

Diverse environments are encountered within the natural populations of many potentially valuable plantation species which, from past experience with exotic introductions, is a strong indication that there may be genetic adaptations to local

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† Research Officer, Department of Agriculture and Forest Science, Commonwealth Forestry Institute, University of Oxford.

conditions (Callaham, 1964). Consequently provenance (seed source) trials are necessary to determine which provenances within a species are best adapted for growing in new environments.

The acquisition of range-wide provenance seed collections is often a tedious enterprise that requires continuity of effort over several successive seed collection seasons, a venture that is frequently beyond the resources of the developing countries that it stands to benefit most. Moreover, the mounting of expeditions by several countries for collecting the seed of the same species involves much duplication of effort and may lead to competition for the acquisition of limited seed resources. A more satisfactory approach is for a single organisation that has the capability for developing and sustaining a seed collection programme to undertake the work and distribute the seed among the countries that wish to implement provenance testing. This has the added advantage that the same set of provenances are tested over a far greater range of environments than would be possible in individual national programmes, thus paving the way for a more thorough evaluation of the species through international cooperation and exchange of information (Burley and Kemp, 1973).

The Commonwealth Forestry Institute (CFI), through projects funded by the UK Overseas Development Administration and with additional financial assistance from the Commonwealth and FAO, adopted this approach for the evaluation of *Pinus caribaea* Morelet and *Pinus oocarpa* Schiede provenances as part of its contribution to the Global Programme for Improved Use of Forest Genetic Resources (FAO, 1975; 1977). These species were the first to receive attention by the CFI because of their excellent potential for the economic afforestation of many degraded or naturally infertile sites at low to medium altitudes throughout the tropics and subtropics which, if successfully implemented, will relieve some of the pressures on the world's fast-declining natural forest reserves.

### The Natural Populations

*P. caribaea* and *P. oocarpa* are indigenous to the Central American and Caribbean region and have the same approximate latitudinal limits of 12°N and 27°N, but whereas *P. oocarpa* is entirely restricted to the mountainous uplands of Central America and Mexico between 600 m and 2,400 m, *P. caribaea* is mostly found on the Central American coastal lowlands and several islands in the Caribbean region. It comprises three distinctly separate territorial distributions. *P. caribaea* var. *caribaea* Barrett and Golfari occurs in western Cuba, *P. caribaea* var. *bahamensis* Barrett and Golfari is found on several islands in the Bahamas and Turks and Caicos Islands, and *P. caribaea* var. *hondurensis* Barrett and Golfari forms discontinuous stands in Central America extending from north-eastern Nicaragua, through north and central Honduras, and eastern Guatemala to northern Belize. Although the distribution of *P. caribaea* var. *hondurensis* is predominantly coastal some populations are found in inland locations, mostly spreading from the coastal lowlands along valleys up to 800 m altitude and merging in places with the lower limits of the *P. oocarpa* distribution.

The natural populations of *P. caribaea* were described in detail by Lamb (1973) and Greaves (1978), and those of *P. oocarpa* by Greaves (1979).

## Collection of Provenance Material

### *Seed samples*

The success of provenance research is dependent on the extent to which the selected provenances are representative of the genetic diversity within the natural populations. Indications of the pattern of genetic variation may be detected through taxonomic studies, but to complete such studies normally takes many years, and whilst an accurate taxonomic classification provides a useful framework its absence does not prevent the implementation of effective investigations. In this context, descriptions of the precise locations of the seed sources are more important than the labels attached to them.

A practical approach to sampling natural populations is to assume that there is clinal variation as an adaptive response to latitude and climate with superimposed ecotypic variation brought about by geographical isolation and different soil types. Stands at the limits of a species' distribution merit special attention as these provenances may have the genetic adaptations that will extend the range of conditions into which the species can be successfully introduced. The CFI adopted these principles for the planning of provenance seed collections that were representative of the entire *P. caribaea* range and the Central American *P. oocarpa* populations (Kemp, 1973; Greaves, 1978; 1979).

### *Herbarium and oleoresin samples*

The term "provenance" refers to a geographical location of plant material or to the plants of a species derived from that location. It does not refer to a broad region. Consequently the conclusions reached from provenance research apply only to sampling locations which by necessity are of limited extent. If several provenances are shown to have desirable qualities it may be necessary to seek means of identifying other occurrences of the same ecotypes to expand the seed collection base to useful proportions. This is especially true in regions where once-extensive forests have been reduced to scattered remnants. Where clinal genetic variation is evident interpolation and extrapolation from the provenance locations may be a reliable means of defining the boundaries of the desirable populations, but this procedure is unsatisfactory when pronounced ecotypic variation occurs. Further provenance trials would provide the answers but only after several years.

Alternatively, if a provenance is shown to have unique taxonomic characteristics these will serve as an efficient and rapid means of identifying other provenances of the same ecotype. Herbarium specimens for conventional taxonomic studies and oleoresin samples for chemo-taxonomic investigations (Burley and Lever, 1973) were therefore collected in addition to the provenance seed samples.

## Seed Distribution

Seed distribution for the international trials of *P. caribaea* provenances and Central American *P. oocarpa* provenances commenced in 1971 and has continued to the present day. This was undertaken without seeking commitments from the recipients, but many recognised the advantages of a standardised experimental design and opted to use the field layouts that were available from the CFI on request.

The large number of available provenances and the limited quantities of seed precluded the testing of all the provenances on all sites, hence it was necessary to

select a suitable range of provenances for each trial. Whenever possible several provenances from native environments similar to the trial site were chosen, but since the most favourable provenance x environment interaction is not necessarily produced by a homoclinal introduction other provenances from contrasting environments were also incorporated.

The seed distributed to date comprises 36 provenances of *P. caribaea* and 46 provenances of *P. oocarpa* with 53 countries participating in the *P. caribaea* trial and 44 in the *P. oocarpa* trial (see Appendix 1).

In 1979 the Instituto Nacional de Investigaciones Forestales (INIF), Mexico, made available 27 seed collections of Mexican *P. oocarpa* provenances for a further international provenance trial. In response to a questionnaire 14 countries requested to be included in this investigation and subsequently each received a selection of 20 provenances, including four of the most promising provenances from the earlier trial of Central American seed sources so providing a link between the two trials. The coordination of the programme is under the joint supervision of INIF and the CFI, with INIF distributing seed to Latin America and the CFI distributing seed to Africa and Asia.

### Results from Provenance Trial Assessments

Many of the participants in the international provenance trials have published the results of their assessments, some in technical notes and scientific journals but mostly in the proceedings of the joint meetings of IUFRO Working Parties S2.01.08 (Tropical Species Provenances) and S2.03.01 (Breeding of Tropical Species) (Burley and Nikles, 1973; Nikles, Burley and Barnes; 1978). Others have made summaries of unpublished data available to the CFI where all the information on the provenance trials is processed and collated with the aid of a purpose-designed computerised data storage system. The accumulated data base amounts to 205 assessments from 113 trials in 26 countries for the *P. caribaea* investigations, and 166 assessments from 77 trials in 24 countries for the *P. oocarpa* studies (see Appendices 2 and 3).

An appraisal of the data base revealed that several provenances of both species showed consistent trends over a wide range of sites when ranked according to vigour and crown and stem form traits. The three varieties of *P. caribaea* occurred in the order var. *caribaea*, var. *bahamensis*, var. *hondurensis* when ranked according to increasing height growth, and in the reverse order for improving stem and crown form. Differences among provenances within varieties were only apparent for *P. caribaea* var. *hondurensis*. The coastal lowland provenances showed no signs of early flowering, but on some sites the provenances from higher and drier inland locations were flowering by age 3.5 years. A similar division was observed in the occurrence of needleless shoots and die-back which occurred in inland provenances but not in coastal provenances on humid lowland trial sites close to the equator. At age 5 years the most vigorous and wind-firm provenances were from southern coastal regions in Honduras and Nicaragua, but some of these provenances had high frequencies of foxtails.

Highly distinctive differences in vigour and stem and crown form were apparent among several *P. oocarpa* provenances within one year of planting. Foxtails were only a characteristic of the Mountain Pine Ridge provenance from Belize which, together with several provenances from Nicaragua at the southern limit of the species' range, was conspicuous for its rapid growth rate and a high proportion of well-formed trees. A detailed review of the *P. caribaea* and *P. oocarpa* provenance trials was given by Greaves (1980).

### Results from Taxonomic Studies

Chemo-taxonomy showed promise as a useful tool for determining population limits. Forty terpenes were examined in the *P. caribaea* and *P. oocarpa* stem xylem oleoresin, six of which appeared to be sufficient for discriminating among provenances (Burley and Green, 1977). Further studies are now in progress to ascertain if this can be applied to the mapping of ecotype boundaries.

The anatomical and morphological studies of the herbarium specimens has not been completed, but the widespread use of the varietal name "*Pinus oocarpa* var. *ochoterenai* Martinez" has been shown to be incorrect (Styles, 1976). This variety was first described in 1940 following studies of trees in Chiapas, Mexico, that have a distinctive and superior form to the typical *P. oocarpa*. In recent years the name has frequently been applied without adequate scientific foundation to any better-formed *P. oocarpa*. Styles concluded that the trees in Chiapas with which Martinez was concerned should be referred to *Pinus patula* var. *longipedunculata* Loock ex Martinez. Elsewhere the specific name *P. oocarpa* is still appropriate but the use of the varietal term *ochoterenai* should be discontinued.

### International Cooperation

The substantial progress that has been achieved in the evaluation of the genetic resources of *P. caribaea* and *P. oocarpa* is directly attributable to the admirable cooperation that has prevailed among the collaborators in the international provenance trials of these species. The accumulated data base is of value not only for making periodic broad appraisals of the relative merits of the provenances, but also as a source of information to researchers who may wish to make comparisons of the results of their own trials with those of other trials in similar environments elsewhere thus substantiating their conclusions. The assessment data for specified trials, or for trials within specified ranges of latitude and altitude, are available on request to contributors of data. However much information of relevance to the programme is not compatible with computerised data storage and this is issued as publications. Thus details of the provenance seed collections were compiled for *P. caribaea* (Greaves, 1978) and *P. oocarpa* (Greaves, 1979) and the first summary and review of the data base (Greaves, 1980) was distributed to all collaborators. Bibliographies of the published papers relating to the international provenance trials are also available.

The achievements of this programme demonstrate the advantages of international cooperation through exchange of information when supported by a multi-discipline team that is able to guarantee long term continuity of effort. This applies not only to the acquisition and distribution of experimental material, but also to the collation of research results from many sources, and the dissemination of information arising out of it concerning the appropriate choice of seed source for achieving improved plantation productivity.

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## APPENDIX 1

COUNTRIES PARTICIPATING IN THE CFI COORDINATED INTERNATIONAL  
PROVENANCE TRIALS OF TROPICAL PINES

<i>Country</i>	<i>P. caribaea</i>	<i>P. oocarpa</i>	<i>Country</i>	<i>P. caribaea</i>	<i>P. oocarpa</i>
Angola	*	*	Maldives Islands	*	
Argentina	*	*	Mauritius	*	
Australia	*	*	Mexico	*	*
Bangladesh	*	*	Mozambique	*	
Belize	*	*	Nepal	*	*
Bolivia	*		New Caledonia	*	
Brazil	*	*	New Hebrides	*	*
Cameroun	*	*	Nigeria	*	*
China	*	*	Pakistan	*	
Colombia	*	*	Papua New Guinea	*	*
Congo	*	*	Peru		*
Costa Rica	*	*	Philippines		*
Cuba	*	*	Puerto Rico	*	*
Ecuador	*	*	Sierra Leone	*	
Ethiopia		*	Solomon Islands	*	*
Fiji	*	*	South Africa	*	*
Ghana	*		Sri Lanka	*	*
Guyana	*	*	Surinam	*	
Honduras	*	*	Tanzania	*	*
India	*	*	Taiwan	*	
Indonesia	*	*	Thailand	*	*
Ivory Coast	*	*	Trinidad	*	
Jamaica	*	*	Uganda	*	*
Kenya	*	*	Venezuela	*	*
Liberia	*	*	Vietnam	*	*
Madagascar	*	*	Zaire	*	*
Malawi	*	*	Zambia	*	*
Malaysia	*	*	Zimbabwe	*	
			<b>Totals:</b>		
			56 countries	53	44

**STOP PRESS****URGENTLY REQUIRED****Photographs of Delegates of the XI COMMONWEALTH FORESTRY  
CONFERENCE**

It is regretted that we have not been able to get a copy of a photograph of the delegates from Port of Spain: if any member has a photograph, could he be kind enough to lend us one which we will return after it has been copied.

John Pitt (Ed.)

## APPENDIX 2

ASSESSMENT DATA AVAILABLE FROM THE CFI FOR THE  
*PINUS CARIBAEA* INTERNATIONAL PROVENANCE TRIAL

<i>Country</i>	<i>Trials</i>	<i>Assessments</i>
Australia	11	27
Brazil	17	28
Congo	2	2
Costa Rica	1	5
Ecuador	1	3
Fiji	8	8
Guayana	1	1
Honduras	1	4
India	3	1
Indonesia	12	16
Ivory Coast	1	2
Liberia	8	17
Malawi	4	10
Malaysia	5	7
New Caledonia	3	4
Nigeria	6	6
Puerto Rico	2	8
Sierra Leone	1	2
South Africa	2	4
Sri Lanka	6	6
Surinam	2	4
Tanzania	2	5
Thailand	5	17
Uganda	3	6
Vietnam	4	12
Zambia	4	4
<b>Totals:</b>		
26 countries	113	205

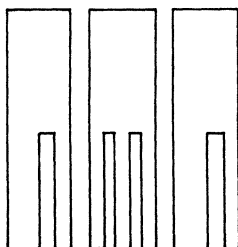


## APPENDIX 3

ASSESSMENT DATA AVAILABLE FROM THE CFI FOR THE  
*PINUS OOCARPA* INTERNATIONAL PROVENANCE TRIAL

<i>Country</i>	<i>Trials</i>	<i>Assessments</i>
Australia	3	10
Brazil	11	25
Colombia	2	2
Congo	4	10
Ecuador	1	1
Fiji	5	5
Honduras	1	3
India	1	2
Indonesia	3	3
Ivory Coast	1	2
Kenya	1	2
Liberia	6	11
Malaysia	3	4
Nepal	1	2
Nigeria	6	14
Puerto Rico	2	8
Solomon Islands	4	9
South Africa	5	9
Sri Lanka	2	4
Tanzania	1	4
Thailand	4	12
Uganda	3	7
Vietnam	4	12
Zambia	3	5
<b>Totals:</b>		
24 countries	77	166

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1334 St. Paul Street, Kelowna, British Columbia  
V1Y 2E1 Canada  
Telephone: (604) 763-4811  
Cable: Sylva  
Telex: 048-5123