The Botany, Ecology, Distribution and Conservation status of *Pinus patula* ssp. *tecunumanii* in the Republic of Honduras

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ABSTRACT

Although *Pinus patula* subsp. *tecunumanii* is the latest pine to be discovered in Honduras, its geographical distribution within the country is much wider than hitherto realized, and its altitudinal range has also proved to be greater than that of any other pine in Central America. Populations at low, middle and upper elevations have been demarcated, but it is those at the middle altitudes, where population pressures are greatest, that conservation measures need to be implemented immediately. Strategies are recommended in terms of both *in* and *ex situ* conservation stands for preserving the best phenotypes which cover all three zones.

The botany, ecology and complicated nomenclature of the taxon are also fully discussed and a Key is provided to distinguish it from the six other native species. This pine's magnificent silvicultural features and ecological preferences are given as the reasons for its over exploitation.

INTRODUCTION

Although *Pinus patula* ssp. *tecunumanii* was the last species of pine to be discovered in Honduras, its silvicultural characteristics and especially its fast growth and magnificent form suggest it may prove to be one of the most important of all pines for plantation

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forestry. In this paper we discuss the interesting historical background of the taxon, its complicated nomenclatural history, its distribution and the reasons why it is in need of conservation in some parts of its range.

CLASSIFICATION

Pinus patula ssp. *tecunumanii* is one of the seven species of pine native to the Republic of Honduras (Styles and Hughes, 1983; Hernández, 1984). These are listed below according to the classification of Little and Critchfield (1969).

Pinus section Strobus ('white or soft' pines)

Subsection Strobus
Pinus ayacahuite Ehrenberg

Pinus section Pinus ('hard' pines)

Subsection Australes
Pinus caribaea Morelet var. *hondurensis* (Sénécl.) Barrett & Golfari

Subsection Ponderosae
Pinus maximinoi H.E. Moore
Pinus pseudostrobus Lindley ssp. *pseudostrobus*
Pinus hartwegii Lindley

Subsection Oocarpae
Pinus oocarpa Schiede ssp. *oocarpa*
Pinus patula Schiede & Deppe ssp. *tecunumanii* (Eguiluz & Perry) Styles.

BOTANICAL DESCRIPTION

Pinus patula Schiede & Deppe ssp. *tecunumanii* (Eguiluz & Perry) Styles

Synonymy: *P. tecunumanii* Eguiluz & Perry (1983)
P. tecumumanii Schwerdtfeger (illegitimate name) (1953)
P. oocarpa var. *tecumumanii* (Schwerdtf.) Aguilar (illegitimate name) (1962).
P. oocarpa var. *ochoterenae* Martínez (1948).

Large, straight-boled tree up to 50 m tall and 150 cm dbh, more usually to 30-40 m high and 50-90 cm dbh. Bole sometimes with nodal swellings. Crown light, with a few thin, more or less ascending or lateral branches; young branchlets with a pruinose bloom. Bark reddish grey, rough and fissured at the base of the bole, smoother and thinner above, exfoliating in papery scales, flakes or strips, leaving reddish-orange patches beneath. Foliage slender, light green, spreading, or more or less pendulous. Needles usually 4 per fascicle, sometimes 3 or 5, 12-25 cm long. Needle-sheaths papery, smooth, reddish-brown or grey, 10-22 mm long. Resin canals 2-3, almost always medial, rarely internal. Cones persistent, small, hard, brown, varnished, narrowly conoidal, pointed at apex, rounded and asymmetrical at the base; 4-8 cm long by 3-5 cm broad; borne singly or in pairs or occasionally in whorled clusters of 6 or more on peduncles up to 2.0 cm long; more rarely sessile or subsessile; cone scales narrow, with raised apophyses, sometimes with a forward-projecting prickle. Cones mature in January and February (Figure 1).

The Tecun Uman pine may be distinguished from the other 6 species of pine which occur in Honduras by the following key.

1. Sheaths of needle-fascicles deciduous, absent from mature fascicles; cone-scales with flat or reflexed apophyses; umbo terminal; very resinous ..... *P. ayacahuite*

   Sheaths of needle-fascicles persistent; cone-scales with prominent apophyses; umbo dorsal; non resinous 2

2. Needles in fascicles of 3, rarely 4 (5); held stiffly erect, cones early deciduous, falling from the tree without the peduncle as soon as seeds are shed; cone-scales with a persistent apical prickle; (sea level to 700 m, occasionally 900 m alt.) .... *P. caribaea* var. *hondurensis*

   Needles in fascicles of 4 or 5, rarely 3 or 6; erect, spreading or pendulous; cones persistent or semi-persistent, falling from tree with or without, peduncle, cone-scales with or without an apical prickle at maturity; (uplands from 650 m) 3

3. Cones sessile (or with a peduncle less than 0.5 cm long); leaving a few basal scales on branchlet on falling; (uplands and high mountains above 2000 m) 4

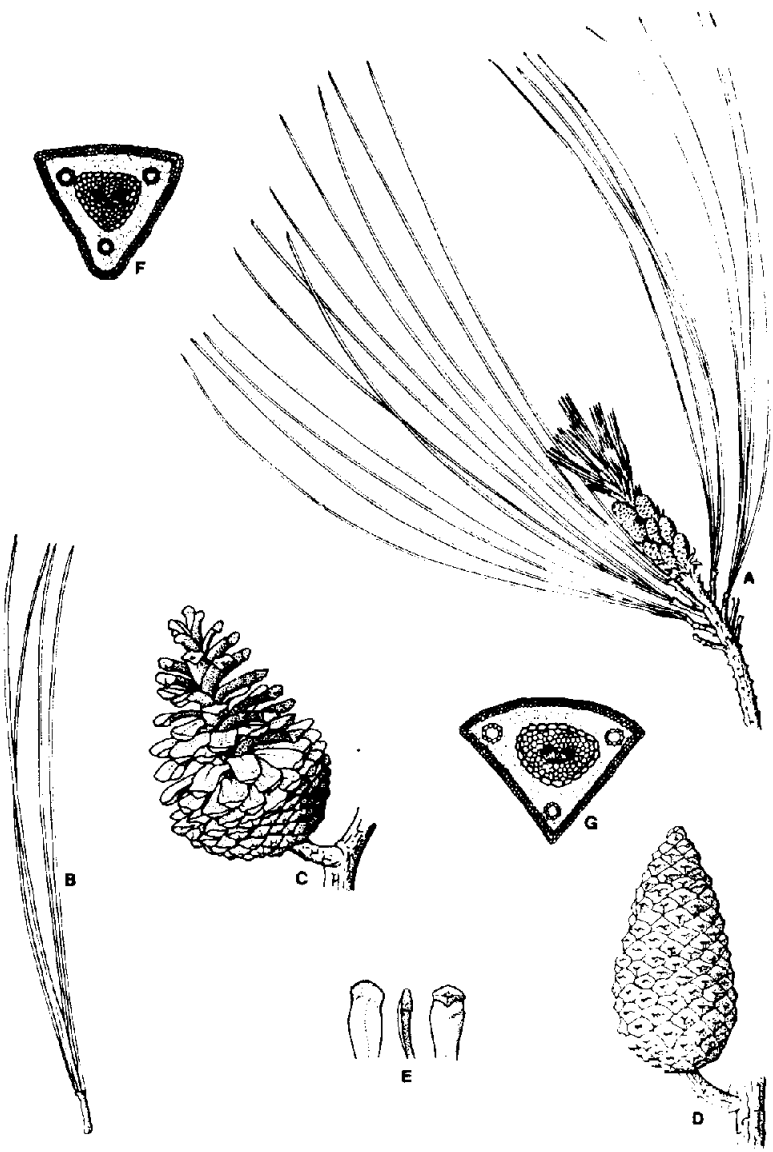


FIGURE 1. Legend to illustration of *Pinus patula* subsp. *tecunumanii*.

A. Branchlet with male strobili;B. Needle fascicle; C. Mature female cone; D. Unopened female cone; E. Cone scales; F. & G. Needle sections showing positions of resin canals.

Cones generally pedunculate; peduncle up to 3 cm long, falling with peduncle attached; (900 to 1800 m) 5

4. Cones dark brown or almost black; needles erect, short, 10-16 cm long; apophyses of cone-scales flat or only slightly raised; (high mountains above 2400 m) ..... *P. hartwegii*

Cones brown, shining; needles pendulous, coarse, 10-18 cm long; apophyses of cone-scales raised, sometimes very prominent; (upland areas above 2000 m) ..... *P. pseudostrobus* ssp. *pseudostrobus*

5. Needles conspicuously pendulous, very slender; cones soft with thin scales; needle sections showing 1-3 hypodermal intrusions ..... *P. maximinoi*

Needles erect, spreading or pendulous; cones hard with thick scales; hypodermal intrusions absent 6

6. Needles mostly in fascicles of 5, very rarely 6; erect or spreading, coarse, with thick blackish or dark brown sheaths; cones broadly ovoid (egg-shaped), ± as long as broad, forming a rosette when fully open; needle sections with some septal resin canals always present; bark on upper bole rough, dark grey or blackish, deeply fissured and furrowed, exfoliating in thick plates ..... *P. oocarpa* ssp. *oocarpa.*

Needles mostly in fascicles of 4, sometimes 3 or 5; spreading or pendulous; very slender; sheaths smooth, brownish; cones narrowly conoidal, distinctly longer than broad when open; needle sections with 1-3 resin canals, usually medial; bark on upper bole light grey, exfoliating in thin scales, flakes or strips leaving a distinctly orange or reddish inner bark beneath ..... *P. patula* ssp. *tecunumanii*

TAXONOMIC HISTORY AND NOMENCLATURE

The correct taxonomic rank of *P. patula* ssp. *tecunumanii* has been, and still is, the subject of considerable debate, and will probably remain so, depending on the taxonomic importance attributed to individual botanical characters and the breadth or narrowness of the species concept maintained by different specialists. Both the history and nomenclature of this taxon has been fully

researched by Styles (1985) and only a brief resumé will be repeated here.

The taxon was first described in 1953 by a German forest entomologist, F. Schwerdtfeger, who had been appointed by FAO to investigate an epidemic of *Dendroctonus* sp. beetle which was devastating the pine forests of Guatemala. On arrival he found his work hampered by the lack of information on the taxonomy and distribution of the natural pine forests of the region, and was therefore forced to study the systematics of the local pines before commencing his entomological work. The Tecun Uman pine was the only species he encountered that he could not fit into the then existing classification systems. In 1953 Schwerdtfeger published a very full account of his new pine as *P. 'tecumumanii'* (naming it after the last leader of the Quiché Indians in Guatemala who was killed in 1524 by Pedro de Alvarado of Spain during the conquest of the American Isthmus), clearly differentiating it from all the other local species. The Rules of Botanical Nomenclature state, however, that in order for a new species name to be validly published, the first description of it must (since 1935) be in the Latin language. All new species must also have one single specimen designated as a holotype, that is herbarium material to which the new name is permanently attached and which is kept in an accessible, recognised forestry/botanical herbarium or other institution (museum). There it can be studied by others when necessary. Since Schwerdtfeger's description was published in Spanish and no holotype was designated among his botanical collections of *P. tecumumanii,* his original name is therefore considered invalidly published.

More recently, Equiluz & Perry (1983) studied Schwerdtfeger's pine again. Using only local material from Guatemala they came to the conclusion that it does form a distinct species and legitimised the specific name with a slight change in the spelling of the epithet to *P. tecunumanii,* considering it most closely related to *P. oocarpa.* It is unfortunate that these authors chose to study *only* Guatemalan material of this taxon when arriving at their decision. In order to assess total variation, a group must be studied over the entire geographical range of its distribution. It should be compared also with the other likely relatives (in this case members of the subgroup Oocarpae). These authors also placed great emphasis on the chemical composition of certain terpenes in the resin. In 1976 Styles produced evidence to show that a variety of *P. oocarpa* (var. *ochoterenae* Martínez) from southern Mexico had, in his opinion,

been wrongly classified and really belonged to *P. patula*. This he allied to another variety of *P. patula* (var. *longepedunculata* Loock), also described from southern Mexico. Eguiluz & Perry maintain both these taxa as separate entities.

On reading Schwerdtfeger's description and examining material from over the entire range of distribution and comparing this with both *P. patula* from throughout Mexico and *P. oocarpa* from both Mexico and Central America, Styles (1985) concluded that this taxon is no more than an extension of the range of *P. patula* into southern Mexico and Central America, demonstrating a typical example of clinical variation. In reaching his decision, Styles not only used evidence from morphological traits on herbarium specimens but also ecological information and observations on trees in the forest. The alliance of Schwerdtfeger's taxon with *P. patula* is further supported by the work of McCarter and Birks (1985), who used linear discriminant and canonical variable analyses of 15 gross morphological and micro-anatomical characters to separate populations of *P. oocarpa* from *P. patula* ssp. *tecunumanii*. The inclusion of populations of *P. patula* ssp. *patula* and its variety *longepedunculata* in these analyses showed clearly that the morphological variation expressed by *P. patula* ssp. *tecunumanii* is similar to these two taxa but quite distinct from *P. oocarpa*.

HISTORY OF THE TAXON IN THE REPUBLIC OF HONDURAS

Although some populations of pine collected in Nicaragua as *P. oocarpa* (Greaves, 1979) have subsequently proved to be *P. patula* ssp. *tecunumanii* (the provenances of Yucul and San Rafael del Norte), this does not appear to have been the case in Honduras. During the years 1970-74 provenance seed collections were made at 15 different sites by Oxford Forestry Institute staff in Honduras, but all have since proved to be correctly identified as *P. oocarpa*, after examination of the parental botanical material gathered at the same time as seed collections were made. In the worldwide provenance trials being conducted by OFI, none of the progeny of any of these provenances has shown the considerable spectacular growth and form over a wide range of environments which is characteristic of *P. patula* ssp. *tecunumanii*.

It is of interest to consider briefly just why this taxon remained undiscovered for so long in Honduras.

1. In the early 1970s, it was generally considered that *P. oocarpa* did not grow above 1500 m or below 800 m altitude. Thus populations of *P. patula* ssp. *tecunumanii* in the southwest of Honduras growing above these altitudes were never encountered. All the seed collections of *P. oocarpa* were made between 800 and 1450 m (Greaves, 1979).

2. In the north-east and east of Honduras (in the Departments of Yoro and Olancho) where *P. patula* ssp. *tecunumanii* descends to altitudes as low as 500 m, vehicular access has, until comparatively recently, been very difficult and it was not until 1983 that the explorations of McCarter and Hughes revealed the occurrence and full extent of this lowland distribution.

3. There is no doubt that in parts of their sympatric ranges *P. patula* spp. *tecunumanii* and *P. oocarpa* are confusingly similar, even with the benefit of knowing where and what to look for. The greatest problems occur at middle elevations (900-1600 m) on sites where the two species occur together (for example in Yoro and western Olancho). These, since the former does not occur on the shallow and infertile soils derived from ignimbrites or rhyolitic tuffs (see section on Ecology and Distribution below), tend to be sites which are much superior to those on which *P. oocarpa* is normally found. For this reason the development of the latter species here very much better than normal: tree form and branching habit are vastly improved and bark characteristics tend to become deceptively similar to those of *P. patula* ssp. *tecunumanii*. Needles and needle sheaths lose the coarseness which is a hallmark of *P. oocarpa* on drier and more infertile sites.

4. Finally, where the two taxa occur together, hybridization is almost certainly a further complicating factor giving rise to progeny with intermediate morphological characteristics. *P. patula* ssp. *tecunumanii* has also been shown to hybridize with *P. caribaea* var. *hondurensis* in Australia (controlled artificial crosses) (Nikles 1981), and in South Africa, van der Syde (1955, 1958, 1959) has shown that *P. patula* readily out-crosses with *P. oocarpa*. Houkal *(pers. comm.)* and Styles *et al.* (1982) have shown by artificial cross pollination and under natural conditions that *P. oocarpa* hybridizes with *P. caribaea* var. *hondurensis*. Seed of the latter cross made by Houkal has since been examined by isoenzyme analysis at Berkeley, California, and hybridity confirmed (Critchfield, *pers. comm.*).

This pine was in fact first discovered in Honduras in the mid-1970s by an FAO forestry officer, J. Troensegaard, whilst visiting Cerro Cusuco in the Sierra de Omoa, (Dept. of Cortés). He reported seeing a pine tree growing there with *P. maximinoi* at 1650 m, similar in appearance to *P. oocarpa* but with a striking flaking, reddish-orange bark and smaller cones. Herbarium specimens and bark of trees were subsequently collected by Chaplin in 1976 and sent to Oxford for examination. Styles confirmed that they appeared different from typical *P. oocarpa,* notably in the character of the bark, but more especially in the resin canal pattern as seen in a cross section of the needles. *P. oocarpa* needles almost always possess from 3-6 (8) resin canals of which the majority are in the septal position (now acknowledged as a consistent feature of the species), whereas the unknown tree had 2-3 resin canals in the medial position (Figure 1, Appendix 2).

It must be admitted, however, that at the time, resin canal number and particularly position in the needle section as useful stable taxonomic characters were a subject of considerable debate. Subsequent collections of the same taxon from similar habitats in Guatemala by Stead, Styles and Mittak confirmed that this was the same tree as that first described by Schwerdtfeger in 1953 and that few, medial resin canals are a characteristic of this species. This strongly allies its taxonomic position with *P. patula* and not with *P. oocarpa.*

Once the occurrence of this taxon was firmly established in Honduras, further explorations, particularly by Hughes and McCarter found it to be fairly widely distributed in the country (Appendix 1), and it yet may still be shown to occur in other more inaccessible areas.

ECOLOGY AND DISTRIBUTION

Pinus patula ssp. *tecunumanii* has an extensive but fairly scattered and disjunct distribution from southern Mexico - in the States of Oaxaca and Chiapas (and probably to the south-west into Guerrero) - through Guatemala, El Salvador, Belize and Honduras into the north-western Departments of Nicaragua: a latitudinal range of just over 4° (*cf* 6° for *P. caribaea* var. *hondurensis* and 15° for *P. oocarpa*).

Pinus patula ssp. *patula* has a much more restricted distribution in northern and central Mexico from the State of Nuevo León to

Appendix 1. List of botanical collections of *Pinus patula* ssp. *tecunumanii* in Honduras (*Sites of OFI provenance seed collections).

Collector(s)	No.	Dept.	Locality	Grid Ref. °N °W	Altitude (m)
Chaplin, C.E. & Troensegaard, J.	C 264	Cortés	Cusuco, Sierra de Omoa	15° 24' 88° 09'	1650
Cox & Guzmán	1326	Francisco Morazán	Guaimaca	14° 36' 86° 48'	?
Eilers, L.J.	865	El Paraíso	Monserrat, between Yuscarán & Oropolí	13° 56' 86° 52'	1000
ESNACIFOR	sn	Olancho	Sierra de Agalta	15° 01' 85° 48'	nr
Hernández, D. & Cornejo, L.	sn	Comayagua	La Danta	14° 32' 87° 28'	1400
Hughes, C.E.	1	Cortés	10 km of Buenos Aires, Cusuco, Sierra de Omoa	15° 30' 88° 11'	1500
Hughes, C.E.	3	Olancho	15 km E of Culmí	15° 06' 85° 21'	600
*Hughes, C.E.	2, 54-68	Comayagua	El Achiote above Siguatepeque	14° 33' 87° 50'	1600
Hughes, C.E.	10-16, 66	La Paz	Buena Vista	14° 07' 87° 59'	1875-2000
Hughes, C.E.	17	Lempira	Montaña de Celaque	14° 32' 88° 42'	1600-2000
*Hughes, C.E.	39 46-53	Comayagua	Las Botijas Zambrano	14° 22' 87° 25'	1550
Hughes, C.E.	43	Intibucá	Peña Nariz, La Esperanza	14° 18' 88° 11'	1590
Hughes, C. E.	45	Intibucá	Between La Esperanza & Marcala	14° 18' 88° 11'	1700
*Hughes, C. E.	69-75	Comayagua	Ocote Rancado, 10 km Corretera de Meambar, 10 km N of Siguatepeque	14° 36' 87° 50'	1450
Hughes, C. E.	76-83	Comayagua	Montaña la Germania, NW of Siguatepeque	14° 36' 87° 50'	1280
Hughes, C. E.	85,223	La Paz	14 km S of San Pedro Tutule, towards Opatoro	14° 15' 87° 51'	2000-2150
Hughes, C. E.	212	El Paraíso	12 km N of Las Cruces towards Tempesent	13° 50' 87° 51'	1270
Hughes, C.E.	348	Yoro	Cerro de la Cubebra, 30km W of Olanchito	15° 30' 86° 34'	790
Hughes, C.E.	470	Olancho	10 km S of Gualaco N slopes of Sierra Agalta	14° 54' 86° 12'	900
Kemp, R.H.	s.n.	Olancho	Culmí	15° 02' 85° 30'	600
*McCarter, P.S.	1-50	El Paraíso	Villa Santa	14° 11' 86° 20'	850-950
*McCarter, P.S.	54-78	Olancho	Culmí	15° 06' 85° 21'	550-750
*McCarter, P.S.	79-109	Olancho	La Colonia	15° 11' 85° 25'	550-700
McCarter, P.S.	110	Intibucá	Between Masguara & La Esperanza	14° 20' 88° 05'	1560
McCarter, P.S.	112	Intibucá	30 km N of La Esperanza, between Río Colorado & San Nicolás	14° 18' 88° 11'	1470
McCarter P.S.	117	Ocotepeque	Between Plan del Rancho & Jocotan	14° 26' 89° 11'	2240

Collector(s)	No.	Dept.	Locality	Grid Ref. °N °W	Altitude (m)
McCarter, P.S.	118	Ocotepeque	2 km N of Jocotan, Montaña Sumpul	14° 22' 89° 03'	2050
*McCarter, P.S.	152-176	Ocotepeque	Montaña Sumpul	14° 24' 89° 08'	1950-2050
*McCarter, P.S.	177, 190, 192-214	Cortés	Cusuco, Sierra de Omoa	15° 30' 88° 11'	1500-1650
*McCarter, P.S.	215-224	Lempira	Montaña Celaque	14° 34' 88° 39'	1600-1800
*McCarter, P.S.	226-255, 325-364	Olancho	San Esteban	15° 15' 85° 37'	700-800
*McCarter, P.S.	365-394	Olancho	San Francisco de La Paz	14° 55' 86° 09'	870-1100
*McCarter, P.S.	460-499	Yoro	Jocon	15° 18' 86° 53'	850-1100
McCarter, P.S.	554	Intibucá	6 km SW of La Esperanza on road to Azacualpa	14° 18' 88° 11'	1900
McCarter, P.S.	556	Comayagua	Cerro Granadilla, Montaña Comayagua	14° 28' 87° 33'	1850
McCarter, P.S.	559, 560	Comayagua	San José de los Planes, Cerro los Obingos, Montaña Meambar Azul	14° 48' 87° 51'	1350-1650
McCarter, P.S.	570	Olancho	N slopes of Sierra de Agalta	14° 56' 85° 58'	1200
McCarter, P.S.	574	Lempira	N slopes of Cerro del Cielo, south of Moaga	14° 22' 88° 47'	2100
McCarter, P.S. & Hughes, C.E.	6	Olancho	10 km NE of San Francisco de la Paz on rd to Gualaco	14° 54' 86° 12'	890
McCarter, P.S. & Hughes, C.E.	8	Olancho	5 km N of Gualaco	15° 03' 86° 03'	790
McCarter, P.S. & Hughes, C.E.	12	Olancho	20 km NE San Esteban valley of Rio Grande	15° 15' 85° 37'	900
McCarter, P.S. & Hughes, C.E.	14	Olancho	15 km S of Juticalpa, N slopes Montaña Azacualpa	14° 45' 86° 12'	800
McCarter, P.S. & Hughes, C.E.	18	Comayagua	Los Alpes, 1 km N of rd to Jesus Otoro	14° 33' 87° 50'	1280
*McCarter, P.S. & Styles, B.T.	1-50	La Paz	Guajiquiro, 20 km SE of San Pedro Tutulée	14° 11' 87° 50'	1835-2250
*McCarter, P.S. & Styles, B.T.	54-93	La Paz	Finca Los Reyes, between La Paz & San Pedro Tutulée	14° 19' 87° 45'	1750 - 2000
McCarter, P.S. & Styles, B.T.	104, 105	Olancho	Culmi	15° 02' 85° 30'	550
McCarter, P.S. & Styles, B.T.	106-107	Olancho	La Colonia	15° 11' 85° 25'	550-590
McCarter, P.S. & Styles, B.T.	113	Olancho	Corinto	15° 19' 87° 08'	1200
McCarter, P.S. & Styles, B.T.	114-115	Francisco Morazán	Agua Fria, Cerro Catichón	14° 25' 86° 51'	1080
McCarter, P.S. & Styles, B.T.	119	Yoro	Pimencito, on rd, Yoro to Jocon	15° 12' 87° 03'	780
McCarter, P.S. & Styles, B.T.	393	Francisco Morazán	Sanquin, Guaimaca	14° 36' 86° 48'	1140
McCarter, P.S. & Styles, B.T.	395	Olancho	Las Bayotas, 20 km N of Gualaco	15° 12' 86° 15'	850
McCarter, P.S. & Styles, B.T.	397	Yoro	N of Las Trojas, Montaña Palo Bonito	15° 16' 87° 05'	1200

Collector(s)	No.	Dept.	Locality	Grid Ref. °N °W	Altitude (m)
McCarter, P.S. & Styles, B.T.	402	Olancho	Just beyond Mangulile towards La Unión	15° 09' 86° 50'	800
McCarter, P.S. & Styles, B.T.	403	Olancho	Between Salama & La Guata	14° 55' 86° 32'	800
McCarter, P.S. & Styles, B.T.	404	Yoro	Between Mangulile & Sabana Afuera	15° 09' 86° 53'	900
McCarter, P.S. & Styles, B.T.	405	Yoro	Cabeza de Vaca, above Loco Mapa, Cordillera Nombre de Dios.	15° 25' 87° 21	1400
McCarter, P.S. & Styles, B.T.	409	Francisco Morazán	Between Marale & Orica	14° 53' 87° 06'	1100
McCarter, P.S. & Styles, B.T.	413	La Paz	Las Trancas, between Guajiquiro and Opatoro	14° 08' 87° 52'	2000
McCarter, P.S. & Styles, B.T.	414	Intibucá	6 km SW of La Esperanza on road to Marcala	14° 18' 88° 07'	1700
McCarter, P.S. & Styles, B.T.	416	Comayagua	Above Las Botijas, Zambrano	14° 24' 87° 25'	1700
Stead, J.W.	187, 189, 191	Cortés	Cerro de Cusuco above Colradia Sierra de Omoa	15° 24' 88° 09'	1460
Stead, J.W. & Styles, B.T.	258 259	Cortés	20 km from Colradia on rd to Buenos Aires	15° 24' 88° 09'	1300
Valerio, J.	2131	Francisco Morazán	Montaña Uyuca	14° 01' 87° 05'	1000
Wilkinson, K.	11-24	Olancho	Culmi, highlands east of Río Wampú	15° 06' 85° 21'	500-700

Oaxaca. In the latter state both subspecies occur in an area of morphological transition. It is in Honduras, however, that the distribution of *P. patula* ssp. *tecunumanii* is most extensive, occurring in at least 10 of the 17 Departments in the country (Appendix 1). The species is found over a wide altitudinal range, from 600 m in the eastern Departments of Olancho and Yoro through to 2400 m in the highlands of the south-west (Departments of Lempira and Ocotepeque). Altitude of occurrence is largely determined by geology and rainfall, with the distribution being restricted to those sites where soils are moderately deep and fertile, slightly acid and free draining and which have a mean annual rainfall in the range 1400 to 2000 mm. The relative distributions of *P. oocarpa* and *P. patula* ssp. *tecunumanii* are mainly determined by these same factors - with the former largely restricted to the shallow and infertile soils derived from ignimbrites and rhyolitic tuffs and/or areas where rainfall is less than 1400 mm.

Became of the great altitudinal range, *P. patula* ssp. *tecunumanii* can be found in association with all the other species

Appendix 2 Table of characters which might be used to differentiate between typical specimens of *P. oocarpa* ssp. *oocarpa* and *P. patula* ssp. *tecunumanii*.

	P. oocarpa	**P. patula** ssp. **tecunumanii**
Tree form	Variable, sometimes heavily branched and with large crown	Generally good or excellent; bole straight with light branching and crown; occasional nodal swellings
Bark	Thick, blackish-brown, deeply fissured, exfoliating in thick plates	Thin, reddish-grey, reddish orange beneath, smooth exfoliating in thin scales, flakes or strips
Branchlets	Brown or grey	Pruinose "bloom"
Needles	Thick, coarse, erect or spreading	Slender, light, spreading or slightly pendulous
Needles/fascicle	Predominantly 5 rarely 3	Mainly 4, sometimes 3 or 5
Needle sheath	Scaly, rough, blackish	Paper, smooth, reddishbrown or grey
Resin canals	Several (up to 8), of which several are septal	Few, 1-3; usually all medial
Cones	Larger, up to 10 x 7.5 cm dark brown; flattened and rosette-shaped when fully open; ± symmetrical and flat at the base	Smaller, up to 7 x 3.5 cm, shiny, with varnished appearance; pointed or conoidal when open; rounded and asymmetrical at the base
Peduncle	Short or long, cones borne singly or in whorls of up to 3	Long or short, cones borne singly or in pairs, occasionally in whorled clusters of 6 or more
Seeds/kg	50-60,000	70-110,000
Habitat/ecology	Dry shallow infertile soils often on volcanic tufa. Rainfall from 700-1300mm pa. **Liquidambar** rarely present; sparse understorey.	Deeper moister fertile soils, not on volcanic tufa. Rainfall > 1400mm. **Liquidambar** often present. Rich understorey of herbs and shrubs.
Coppicing	Frequent; strong	Rarely; weak
Young trees	Branches straight	Branches curve upwards, like a candelabra.
Altitudinal range	800-1700 m	600-2200 m

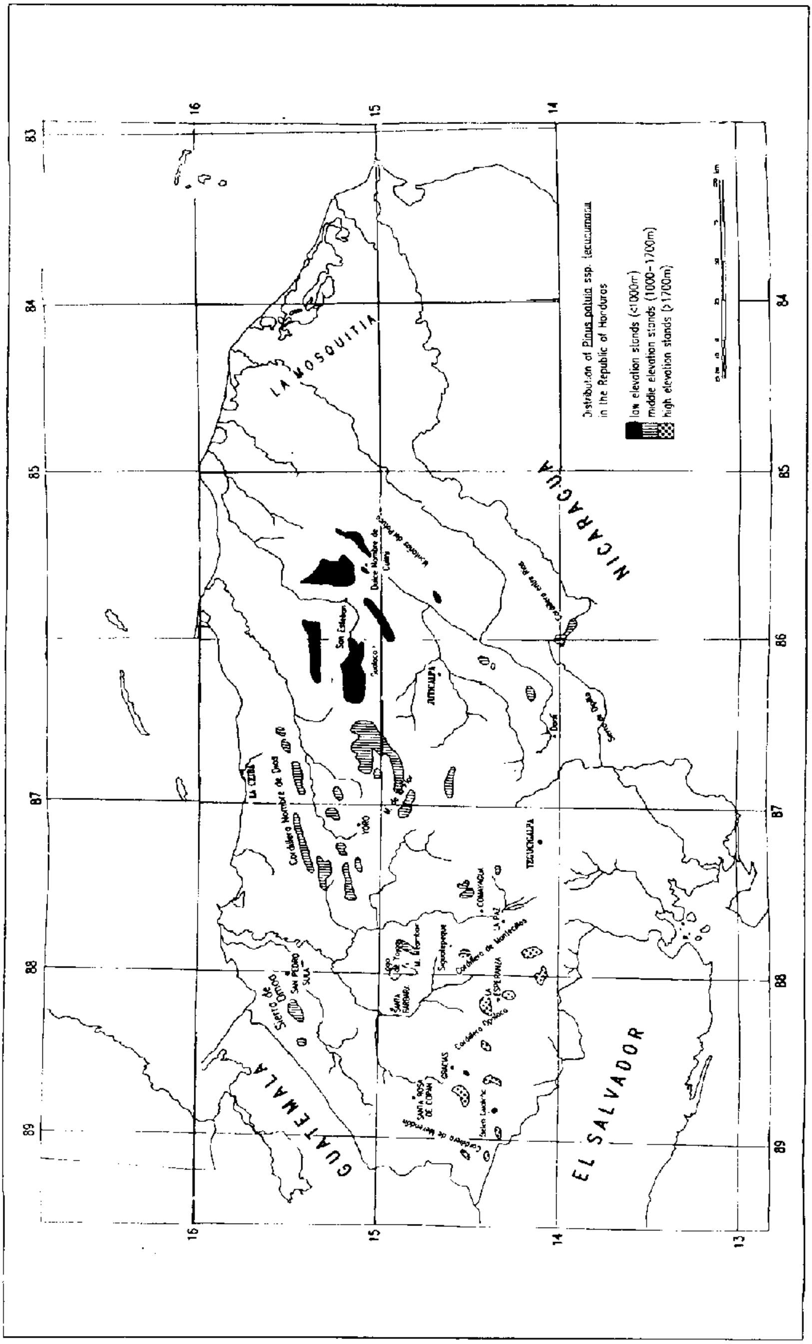
of pine that occur in Honduras. At and above 1800 m altitude (*eg* Las Trancas, Guajiquiro [La Paz], Belén Gualcho, Montaña de Celaque [Lempira]), it occurs with *P. pseudostrobus* and/or *P. ayacahuite*. To the south of Belen Gualcho at altitudes of around 2400 m it even occurs with *P. hartwegii*. From 800-1800 m (*eg* Cusuco, Sierra de Omoa [Cortés], San José de los Planes, Montana Meambar Azul [Comayagua], Villa Santa [El Paraíso]), it may be found with *P. oocarpa*, and/or *P. maximinoi*, whilst at lower elevations, 500-800 m, (*eg* Culmí, San Esteban, Gualaco [Olancho]) it grows alongside (but rarely in mixture with) *P. caribaea*. At many of these localities and certainly those below 1900 m, *Liquidambar styraciflua* is a commonly associated broadleaved species. So similar are its site requirements to those of *P. patula* ssp. *tecunumanii* (*ie* a relatively moist, acid and fertile soil with a reasonably high rainfall) that its presence may be safely taken as a marker for the type of habitat favoured by the pine (Map 1).

Understorey vegetation, especially on the middle and high elevation sites, is typically quite dense and luxuriant, reflecting the more fertile and wetter conditions. Species commonly occurring are many in the Melastomaceae, the ferns *Pteridium aquilinum* and *Dicranopteris pectinata, Mimosa albida, Salvia* spp., and grasses such as *Andropogon bicornis*. Almost always *P. patula* ssp. *tecunumanii* integrades above with montane broadleaved forest and rarely (unlike *P. oocarpa*) through transition forest dominated by *Quercus* spp.

As with all species of pine in the country, fire plays an integral part and indeed is an overriding influence on the distribution and regeneration of *P. patula* ssp. *tecunumanii*. Compared with typical *P. oocarpa*, forest fires are less common but are probably an even more important element in the regeneration of this species. On the moister and more fertile sites invasion and subsequent growth of broadleaved species is all the more rapid. Although *P. patula* ssp. *tecunumanii* has an early growth as rapid as any of the invading species (with the exception of, possibly, *L. styraciflua)* and can compete with them on bare ground, the presence of a dense herb or shrub layer will preclude the later establishment of the shade intolerant pine.

SILVICULTURAL ASPECTS

Became of its genetic potential, *P. patula* ssp. *tecunumanii* is probably the most important species of pine in Honduras. Mature,


Distribution of Pinus patula ssp. tecunumanii
in the Republic of Honduras
low elevation stands (<1000m)
middle elevation stands (1000-1700m)
high elevation stands (>1700m)
LA MOSQUITIA
NICARAGUA
EL SALVADOR
GUATEMALA
TEGUCIGALPA
COMAYAGUA
LA CEIBA
YORO
JUTICALPA
SAN PEDRO SULA
SANTA ROSA DE COPAN
GRACIAS
SANTA BARBARA
LA ESPERANZA
LA PAZ
Sierra de Omoa
Cordillera Nombre de Dios
San Esteban
Dulce Nombre de Culmi
Cordillera de Montecillos
Cordillera de Merendón
Cordillera Opalaca

naturally occurring stands possess phenotypes of magnificent form, with straight, clear boles and light, narrow crowns. Diameters exceeding 1 m at breast height are not infrequent on good sites, making this one of the largest of any of the tropical pines.

The few provenances of *P. patula* ssp. *tecunumanii*, included through misidentification in the OFI-coordinated international provenance trial series of *P. oocarpa*, established in the 1970s (Yucul and San Rafael del Norte from Nicaragua and Mountain Pine Ridge from Belize) have consistently outperformed all the true *P. oocarpa* provenances in terms of growth rate and form, when planted on a wide range of sites and under different climatic conditions. On some lowland tropical sites they have grown better than the best provenances of *P. caribaea* (Gibson, 1987).

It seems reasonable to expect that *P. patula* ssp. *tecunumanii* in Honduras will show a considerable degree of provenance variation in its adaptability and the expression of silvicultural traits, given the disjunct nature of its distribution and the wide altitudinal range over which it occurs. Seed lots for provenance/progeny trials of the species (including 13 provenances from Honduras) have been distributed over the last two years (1986-87), but the trials are as yet too young to provide meaningful information on genetic variation.

More direct evidence of genetic variation within and between Honduran provenances is already available from a limited study of the allele frequencies of isozyme systems in 203 trees from seven provenances (McCarter, 1985; Lockhart, 1986). Analyses carried out on these data show the provenances of Guajiquiro, La Paz and Cusuco to be of similar identity and distinct from the provenances of Siguatepeque and Zambrano (Las Botijas), which in turn are separated from the provenance of Villa Santa. These groupings are, conveniently, related to the altitudinal bands discussed below.

CONSERVATION STATUS

After *P. oocarpa* and *P. caribaea*, *P. patula* ssp. *tecunumanii* is the third most common species of pine in Honduras. Given this fact, it seems all the more remarkable that it was scarcely known to exist in the country before 1980. Fifty years ago it would have been even more common, for large tracts of the pine forest,

where today only remnant stands - or in extreme cases, only a few trees - remain, have been cleared for agriculture. Extreme examples of this are on Montaña Comayagua above 1600 m, between La Sampedrana and Las Botijas, or on the Cordillera de Montecillos above Siguatepeque, where stands from which seed collections of the species were made as recently as 1982 no longer exist.

The rate of disappearance of *P. patula* ssp. *tecunumanii* from such sites is largely a function of the species' occurrence on relatively fertile soils and the demands of a rapidly increasing rural population for agricultural land. But just as there are marked regional inequalities in population density, so also does the conservation status of the species vary considerably across its range.

The distribution of *P. patula* ssp. *tecunumanii* in Honduras can be divided into three major altitudinal bands: 1. the extensive lowland stands of Olancho and central and eastern Yoro (500-1000 m); 2. The middle elevation stands, mainly in the central parts of the country (Department of Comayagua, Francisco Morazán, northern Yoro, Intibucá, Cortés and El Paraíso), (1000-1700 m); and 3. the stands of the southwestern highlands in Ocotepeque, Lempira and La Paz (1700-2300 m) (Map 1).

The lowland stands of *P. patula* ssp. *tecunumanii* in Olancho and Yoro are the most extensive occurrences of the species anywhere in its natural range. Ecologically and silviculturally they are very similar to the stands on the Mountain Pine Ridge in Belize. Despite fairly large-scale commercial logging over recent years by CORFINO (Corporación Forestal Industrial de Olancho), in the San Estéban area (1983-87), and presently in the Montaña de Mora, north of Gualaco, these stands are, with few exceptions (*eg* between San Francisco de la Paz and Gualaco), under little threat. Seed trees have been left and, whilst natural regeneration could be improved upon with better fire management, it is on the whole adequate and in places very good. Population density in this part of Honduras is low (approximately five inhabitants per sq km of arable land (USAID, 1980)), so large-scale clearance for agriculture is unlikely.

The middle elevation sites are subject to much greater population pressure (approximately 200-300 inhabitants per sq km of arable land (estimated from USAID, 1980)). Since the soils, especially those below the *P. patula* ssp. *tecunumanii* zone, are

generally extremely poor the pressure on the better soils is greater. Traditional slash and burn cultivation systems are responsible for much of the forest clearance, although this is often preceded by heavy and largely uncontrolled logging (*eg* Montaña de la Flor, Montaña Comayagua).

The steeper slopes do not sustain long-term agricultural production and a sizeable proportion of the area of milpas (maize cultivations) is usually temporarily abandoned after several years. The fallow period is not long enough to allow regeneration of the pine and, indeed, so complete is the forest clearance that seldom are any stands left from which regeneration could occur. Even where regeneration does manage to become established, extensive livestock grazing practices on the abandoned lands effectively eliminate it. The regeneration of *L. styraciflua* on these sites is particularly notable and occasionally extensive, pure stands of the species can be seen where formerly *P. patula* ssp. *tecunumanii* was dominant.

In the absence of cultivation or grazing, however, regeneration following commercial logging can be excellent. The stands of *P. patula* ssp. *tecunumanii* above Cusuco on the Sierra de Omoa (Cortés), which were cut over some 30 years ago, are today impressive examples of the regenerative capacity and rapid growth rates of the species. Similarly, the stands on the leeward slopes of Montaña Meámbar Azul, above San José de Los Planes, were logged in the mid-1970s and here, too, in those areas where there has been no clearance for agriculture, natural regeneration has been excellent.

The high elevation stands of *P. patula* ssp. *tecunumanii* in the southwestern highlands of Honduras occur in the area of highest population density in the country (of the order of 1200 inhabitants per sq km of arable land (USAID, 1980)). With the exception of the extensive forests on Montaña Celaque, part of which is now a National Park and therefore to some degree protected from forest clearance, the upland pine and broadleaf forest is almost entirely composed of small, scattered stands (*eg* Las Trancas, Guajiquiro (La Paz), Cordillera de Merendón and Belén Gualcho (Ocotepeque)). Over much of this area the natural distribution of *P. patula* ssp. *tecunumanii* would have been fairly restricted on account of geology and rainfall, even without human interference.

This part of Honduras is inhabited principally by the Lenca

Indians, and there is a long history of settled agriculture. Forest clearance is once again by traditional slash and burn techniques but, once cleared, the land is kept under intensive cultivation. New incursions into the remaining forest area are prompted by population pressure rather than poor agricultural practice. In general, however, the rate of deforestation at these altitudes as shown by sequential aerial photographs taken in 1959 and 1981 has been comparatively low. Given the settled nature of agriculture here and the increasing awareness of the local population of wood scarcity, the prospects for conservation of these forests are better than for many of the middle elevation stands of *P. patula* ssp. *tecunumanii.*

RECOMMENDED CONSERVATION STRATEGIES

The *ex situ* conservation of many provenances of *P. patula* ssp. *tecunumanii* is already ensured by the collection of 420 individual family seed lots of some 13 Honduran provenances by OFI staff between 1982 and 1985 (McCarter, 1985; Styles, 1986) and their subsequent distribution during 1986/87 for the establishment of provenance/progeny trials in a number of other tropical and subtropical countries. These sites are indicated in Appendix 1. CAMCORE (Central America and Mexico Coniferous Resources Cooperative, based at North Carolina State University), over the same period, has also made collections of several of these provenances, again for provenance/progeny testing, but also for the establishment of *ex situ* gene conservation stands (Dvorak, 1985). In addition, the national seedbank at ESNACIFOR (Escuela Nacional de Ciencias Forestales), Siguatepeque, currently sells about 150 kg of *P. patula* ssp. *tecunumanii* seed annually to overseas purchasers (Ochoa, *pers. comm.*), although this is mainly from only a few provenances, in particular Villa Santa (El Paraíso), and San Esteban (Olancho). It is expected that when preliminary results from the provenance/progeny trials are known, say in 5-6 years time, and the full potential provenance variation of the species is revealed, this demand will increase substantially.

In the absence, however, of quantifiable information on the genetic variability both within and between provenances of *P. patula* ssp. *tecunumanii,* the development of an *in situ* conservation strategy *viz* the numbers, locations and size of stands is a matter largely of common sense rather than scientific certainty. As discussed above (Silvicultural Aspects), it is expected that there will be considerable variation between stands at different altitudinal ranges (low,

middle and high); within each of these bands, however, the genetic similarity or otherwise of the different constituent stands (*eg* between the stands at Culmi, San Esteban and Gualaco) is completely unknown.

McCarter (1988) lists several considerations, apart from genetic variation, which are of significance in determining the comparative conservation status of the various provenances. Chief of these are the extent and fragmentation of the stands which make up the provenance, the degree of human interference, the phenotypic quality of the stand and the likelihood of hybridisation with other pine species and in particular with *P. oocarpa*.

On the basis of this information for each provenance and the stratification of the natural distribution into the three main altitudinal bands, five provenances stand out as being suitable for and meriting conservation. These are:

1. the stands on the eastern slopes of Montaña Celaque (Lempira) above Gracias;

2. 'Belen Gualcho' - including the remaining stands around La Moaga and El Tuyal (Ocotepeque) and to the south of El Cutal, Cerro del Cleto etc. (Lempira);

3. 'San Esteban' - the stands to the north-east (Montaña de Coyolito);

4. the stands above Cusuco on the Sierra de Omoa (Cortés); and

5. 'San José de Los Planes' - the stands on the south-eastern slopes of Montaña Meámbar Azul (Comayagua).

The management of sizeable areas of each of these forests (a minimum area of 50-100 ha of each) as seed production stands is considered the best and most practical method of *in situ* conservation. Not only is a forest area which is seen to be actively managed less liable to agricultural encroachment but also seed stand establishment provides a means of obtaining seed of improved genetic quality (which commands a higher price) which is collectable at a lower unit cost (Hughes and Robbins, 1983). Hughes and Robbins (1983) cover very fully the necessary steps which are required to

Plate 1

Plate 2

Plate 1 & 2 Views of some of the magnificent trees in undisturbed natural stands of *P. patula* ssp. *tecunumanii* on Cerro del Cleto, south of Belen Gualcho, Department of Lempira 2100-2300 m (Photographs, R. D. Barnes).

Plate 3

Plate 3. Seed collection from a selected tree of *P. patula* ssp. *tecunumanii* at Villa Santa (El Paraíso) (Photograph, P.S. McCarter).

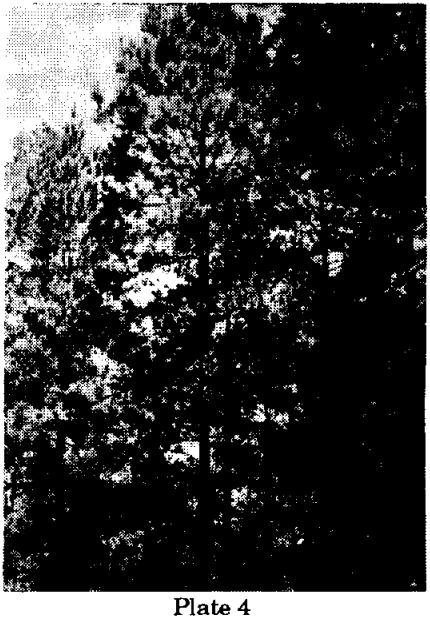


Plate 4

Plate 4. The excellent natural regeneration following the intensive logging of the mid 1960s (*ie* trees approximaterly 30 years old) have given rise to well stocked fairly even-aged stands of *P. patula* ssp. *tecunumanii* at Cusuco, Sierra de Omoa (Cortés) (Photograph, P. S. McCarter).

Plate 5

Plate 5. *P. patula* ssp. *tecunumanii* forest to the northeast of San Esteban (Olancho) immediately following a relatively low intensity commercial logging. Prescribed burning is now necessary to ensure full regeneration (Photograph, P.S. McCarter).

Plate 6

Plate 6. *P. patula* ssp. *tecunumanii* is characterized by its excellent stem form, light branching, small crown and self pruning capability (Photograph, C. E. Hughes).

Plate 7

Plate 8

Plate 7 & 8. Close up of bark of *P. patula* ssp. *tecunumanii*. Both pictures were taken at breast height (1.3 m). Plate 7 shows a large, old tree (dbh 90 cm); bark is 5-6 cm thick, grey and heavily plated. Plate 8 is of a younger tree (dbh 35 cm). Its bark is much more flaky and reddish in colour (Photographs, P. S. McCarter).

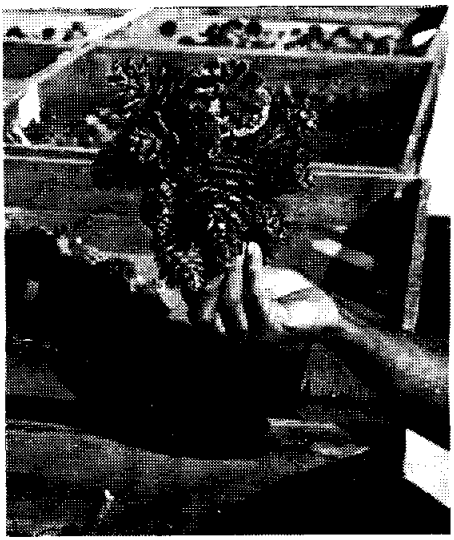


Plate 9

Plate 9. Cluster of 16 cones from *P. patula* ssp. *tecunumanii* collected at Villa Santa (El Paraíso). Such clustering, a phenomenon particularly associated with *P. patula* ssp. *patula*, is not infrequent in the Tecun Uman pine and is entirely absent from *P. oocarpa* (Photograph, P. S. McCarter).

convert areas of the natural pine forests of Honduras to improved seed production stands. These include silvicultural thinning/ "sanitary" fellings within the demarcated stands as well as of the isolation fringe around it (final crop density of about 150 trees/ha is suggested), together with adequate fire management *ie* regular prescribed burning. This will prevent the build up of heavy fuel loadings on the forest floor and allow the possible application of nitrogen and phosphorous fertiliser within the seed stand.

All five of the stands listed above lend themselves to such management: In particular the extensive stands on the Sierra de Omoa and San José de Los Planes, where the dense natural regeneration which has sprung up in the years since they were last commercially logged (30 and 11 years, respectively) are at a stage where prompt attention to a heavy crown thinning should optimise future seed production potential.

At Belen Gualcho it was recommended that forest conservation activities should form part of a larger, integrated rural development programme, which would include an element of reafforestation (using locally-collected seed only) on the steeper slopes.

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Our grateful thanks are also due to the many foresters and botanists who have studied and collected material of this important tree over the past few years, whether in the form of herbarium specimens or seed or both and who have all added greatly to our knowledge of its botany, ecology and distribution range throughout the Republic of Honduras.

We record especially the work of C. E. Hughes, who made significant discoveries during the early years of exploration. The staff of the seed bank at ESNACIFOR have also made considerable contributions, as has CAMCORE, based at the University of North Carolina, Raleigh, USA. A. Wolffsohn, MBE (Siguatepeque), was always available for discussion on the generalities of pine ecology, and we particularly appreciate the sharing of his profound knowledge and experience of the group gained over a long period of study and working in Honduras and Central America generally.

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