

ECOLOGY AND DISTRIBUTION OF *PINUS LAGUNAE*,
IN THE SIERRA DE LA LAGUNA,
BAJA CALIFORNIA SUR, MEXICO

MARIE-FRANÇOISE PASSINI and NICOLE PINEL
Laboratoire de Botanique Tropicale,
Université Pierre et Marie Curie,
12 rue Cuvier, 75005, Paris, France

ABSTRACT

Pinus lagunae extends from 1200 to 2000 m only on the Sierra de la Laguna, Baja California Sur, Mexico. This study provides descriptions of habitat, soil characteristics, composition and cover of herbaceous vegetation, and physiography. Three forest types are described: one of *Pinus lagunae* only, the others with *Pinus lagunae* and *Quercus devia*.

RESUMEN

Pinus lagunae se encuentra unicamente entre los 1200 y 2000 m en la Sierra de la Laguna, Baja California Sur, México. Este estudio se propone descripciones del habitat, característicos del suelo, composición y cubierta de la vegetación herbacea, y fisiografía. Tres bosques han sido descritos: uno exclusivamente formado por *Pinus lagunae* y los otros formados con *Pinus lagunae* y *Quercus devia*.

Pinus lagunae (Robert-Passini) M.-F. Passini is found in a limited area in the Sierra de la Laguna at the southern end of the Baja California peninsula (Baja California Sur, Mexico). In 1981, Robert-Passini described it as a variety of *Pinus cembroides* Zucc. In 1983, D. K. Bailey gave it subspecific rank and in 1987, M.-F. Passini raised it to specific level. This article describes the ecology and floristic composition of *Pinus lagunae* communities.

METHODS

Ecological and floristic surveys (Tables 1, 2) were made at the summit of Sierra de la Laguna (Figs. 1, 2) along three transects: north to south between La Victoria and San Francisquito (Fig. 2, transect 1-1'), northwest to southeast between Cerro el Picacho and Cañon de la Zorra, and west to east between Cañon de la Burrera and Cañon de la Zorra. Ecological variables and floristic composition were noted in samples of 25 × 20 m². The ecological variables include geographic sites, altitude, topographic exposure, slope and substrate, surface percentage of hard stone, loose gravel, fine soil, and litter, and variation in vegetation: trees, shrubs and herbaceous layer density (Godron et al. 1968; Passini 1982).

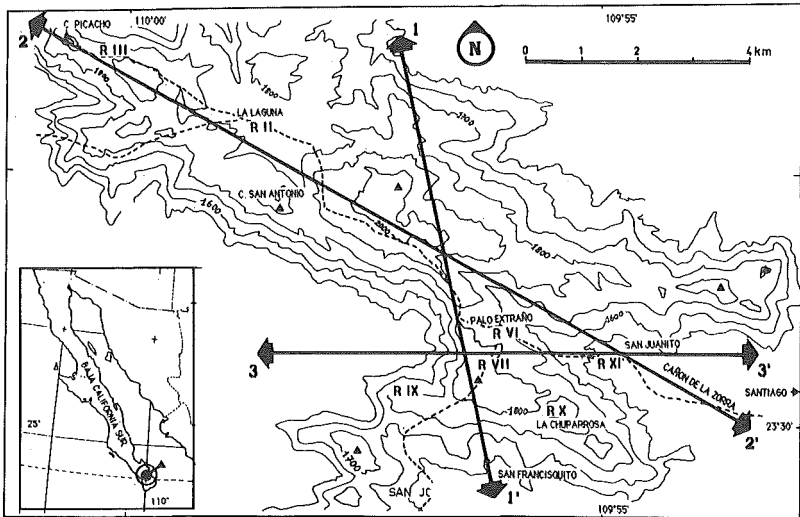


FIG. 1. The Sierra de la Laguna. Lines 1-1', 2-2', and 3-3' are transects discussed in text and illustrated in Fig. 2.

Trees were defined as plants more than 2 m high, having a definite trunk and nonramified at the base. Stand density was calculated according to Robert (1973), who considered forests to be highly dense if the distance "d" between trunks is less than 3 m, dense if d is between 3 and 8 m, and open if d is between 8 and 15 m.

Each species was given an abundance coefficient from 1 to 5. Specimens of plant collections were placed at the Herbaria at the Department of Terrestrial Biology of Centro de Investigaciones Biológicas (Comitán), La Paz, Baja California Sur, and the Laboratoire de Botanique Tropicale in Paris.

GEOGRAPHY AND ECOLOGICAL CONDITIONS

The Sierra de la Laguna, situated between 23°35' and 23°25'N, 105°50' and 110°W, is a deeply dissected range with coarse granitic soil derived from batholithic bedrock dating to the Cretaceous period (Durham and Allison 1969). These mountains appeared in the Tertiary period when the peninsula separated from the American continent. Faulting brought about an eastward tilt to the mountain block with a steep escarpment on the west flank and gentler slopes toward the Gulf of California. The soils, derived from granite parent rock, are slightly acid (pH varying from 5 to 7) and have an alluvial-sandy texture throughout the Sierra.

Annual rainfall varies from 200 mm to 800 mm, mostly between July and October with a mean of 580 mm (Reygadas and Velazquez

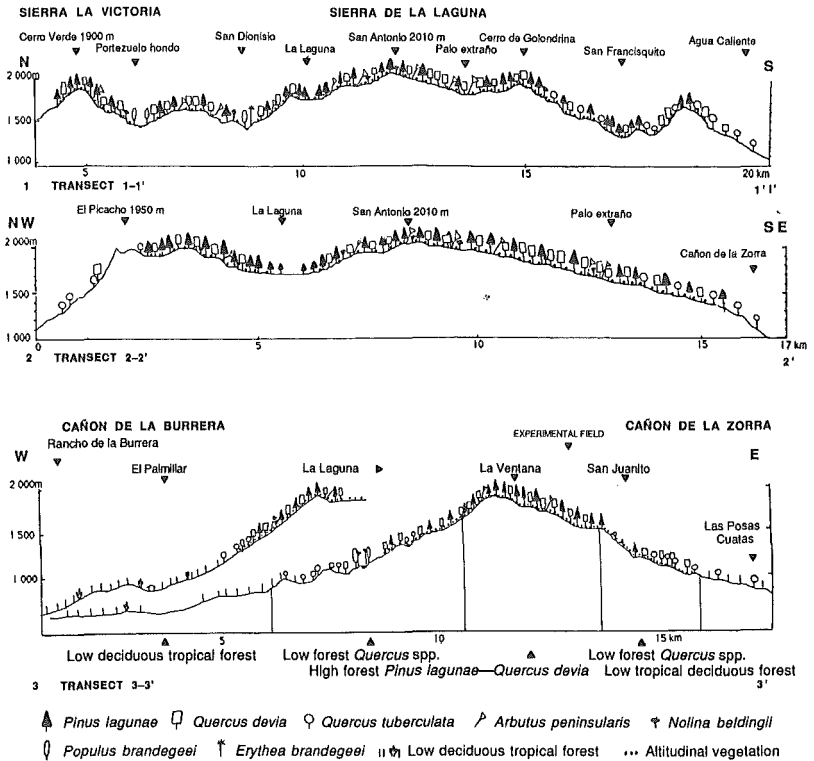


FIG. 2. Altitudinal distribution of *Pinus lagunae* and *Quercus devia* along three transects (see Fig. 1).

1981). Annual amounts are much greater when there are hurricanes. Extremely violent rainfalls during such storms (70 mm per hour in 1979) wash away earth, rocks, sand, and vegetation, leaving little water for vegetation. Slight rainfall during January and February accounts for 5% of the annual rainfall. Winter fog is frequent on the Sierra summit.

The average annual temperature is 18.9°C (Reygadas and Velazquez 1981) ranging from 25°C in July to 11.9°C in January. Temperatures occasionally drop below 0°C in December, January, and February. The daily average temperature is 29°C in January, and 14°C in September and October.

ALTITUDINAL DISTRIBUTION OF *PINUS LAGUNAE*

On the western slope of Sierra de La Laguna (Fig. 2, transect 3-3'), isolated pines occur at 1300 m, in the Cañon de la Burrera,

TABLE 1. CHARACTERISTICS OF SEVEN SAMPLE SITES IN THE SIERRA DE LA LAGUNA, BAJA CALIFORNIA SUR. ¹ Soil pH was measured at a depth of 0–10 cm with a Hellige pH meter.

	Site number						
	II	III	VI	VII	IX	X	XI
Date	12 Oct 1984	2 May 1985	14 Oct 1984	8 Nov 1985	29 Mar 1985	10 May 1985	7 May 1985
Location	La Laguna	El Picacho	Palo-Extraño	Experimental	San Francisquito	La Chuparrosa	San Juanito
Elevation (m) ⁵	1700	1950	1650	1750	1700	1725	1400
Topography	open bowl	main ridge	moderate slope	high ridge	slope		slope
Exposure	all	SE	E	NW	S	all	SE
Slope inclination	0%	10%	10%	10%	30%	0%	30%
pH ¹	5	6	5	5	7	4.5	5
Dominance 1	<i>Pinus lagunae</i>	<i>Quercus devia</i>	<i>Quercus devia</i>	<i>Quercus devia</i>	<i>Quercus devia</i>	<i>Pinus lagunae</i>	<i>Quercus tuberculata</i>
Dominance 2	<i>Quercus devia</i>	<i>Rumfordia connata</i>	<i>Arbutus peninsularis</i>	<i>Pinus lagunae</i>	<i>Quercus tuberculata</i>	<i>Quercus devia</i>	<i>Pinus lagunae</i>
Percent cover by vegetation types							
Trees	25	0	60	60	80	30	50
Shrubs	60	80	80	30	20	20	10
Grasses	80	30	60	20	60	80	90

TABLE 2. PLANTS ENCOUNTERED IN THE TWO PRINCIPAL FOREST TYPES OF THE SIERRA DE LA LAGUNA, BAJA CALIFORNIA SUR. Abundance was estimated on a scale of 1 to 5 with 5 the most abundant.

Height class	Tall open forest of <i>Pinus lagunae</i>	Abundance	Tall dense forest of <i>P. lagunae</i> and <i>Quercus devia</i>	Abundance
> 12 m	<i>Pinus lagunae</i> (Robert-Passini) M.-F. Passini	2	<i>Pinus lagunae</i>	1
8-12 m	—	—	<i>Quercus devia</i> Goldman	2
			<i>Pinus lagunae</i>	3
4-8 m	<i>Arbutus peninsularis</i> Rose & Goldman	1	—	
2-4 m	—	—	<i>Garrya salicifolia</i> Eastw.	1
			<i>Nolina beldingii</i> Brandegee	1
1-2 m	—	—	<i>Lepechinia hastata</i> (A. Gray) Epling	4
			<i>Rumfordia connata</i> Brandegee	3
			<i>Tagetes lacera</i> Brandegee	3
0.5-1 m	<i>Lepechinia hastata</i>	3	<i>Muhlenbergia microsperma</i> (DC.) Kunth	3
	<i>Arracacia brandegeei</i> J. Coulter & Rose	1	<i>Stachys coccinea</i> Jacq.	2
	<i>Calliandra brandegeei</i> (Britton & Rose) Gentry	1	<i>Bromus anomalus</i> Rupr. ex Fourn.	2
	<i>Erythea brandegeei</i> Purpus	1	<i>Acalypha comoduana</i> Millsp.	1
	<i>Muhlenbergia rigida</i> (Kunth) Kunth	1	—	—
	<i>Opuntia lagunae</i> K. Brandegee	1		
	<i>Rhus integrifolia</i> (Nutt.) Benth. & Hook.	1		
	<i>Tagetes lacera</i>	1		
25-50 cm	<i>Bidens nudata</i> Brandegee	4	<i>Calliandra brandegeei</i>	2
	<i>Tagetes lacera</i>	3	—	—
	<i>Piptochaetium fimbriatum</i> (Kunth.) Hitchc.	2		
	<i>Brachypodium mexicanum</i> (Roemer & Schultes) Link	1		

TABLE 2. CONTINUED.

Height class	Tall open forest of <i>Pinus lagunae</i>	Abundance	Tall dense forest of <i>P. lagunae</i> and <i>Quercus devia</i>	Abundance	
2-25 cm	<i>Agrostis</i> sp.	4	<i>Arracacia brandegeei</i>	3	
	<i>Aristida schiediana</i> Trin. & Rupr.	4	<i>Lupinus</i> sp.	2	
	<i>Bidens nudata</i>	3	<i>Asplenium blepharodes</i> D. Eaton	1	
	<i>Heterosperma xantii</i> A. Gray	3	<i>Phaseolus</i> sp.	1	
	<i>Lycurus phleoides</i> Kunth	3	—	—	
	<i>Aegopogon tenellus</i> (DC.) Trin.	2			
	<i>Bidens lemmonii</i> A. Gray	2			
	<i>Desmodium neomexicanum</i> A. Gray	2			
	<i>Gnaphalium</i> sp.	2			
	<i>Helianthemum glomeratum</i> Lagasca ex DC.	2			
	<i>Hypericum peninsulare</i> Eastw.	2			
	<i>Muhlenbergia microsperma</i>	2			
	<i>Arracacia brandegeei</i>	1			
	<i>Opuntia lagunae</i>	1			
	<i>Quercus devia</i>	1			
	0-5 cm	<i>Piptochaetium fimbriatum</i>	2	<i>Arracacia brandegeei</i>	1
		<i>Cyclanthera tamnoides</i> Cogn.	1		
<i>Oenothera</i> sp.		1			
<i>Pinus lagunae</i>		1			
<i>Prunus</i> sp.		1			



FIG. 3. Tall dense forest of *Pinus lagunae* and *Quercus devia*. 1, *Pinus lagunae*; 2, *Quercus devia*; 3, *Arbutus peninsularis*; 4, *Nolina beldingii*; 5, *Lepechinia hastata*; 6, *Rumfordia connata*; 7, *Acacia peninsularis*; 8, *Muhlenbergia* sp.

growing with *Erythea brandegeei*, *Populus brandegeei*, and *Salix* sp., in an association similar to the "bosque en galeria" described by Rzedowski (1978). Two-hundred-year-old pines are found at 1500 m with low, open stands of *Quercus tuberculata* and *Dodonaea viscosa*. On the east slope, small *Pinus lagunae* (<5 m) grow in isolated groves between 1200 and 1500 m. Extensive forests grow with *Quercus devia* above 1600 m.

The southern limit of pine is near Cañon San Jorge at 1700 m. *Pinus lagunae* is absent from *Quercus devia* stands, on open, sunny southern exposures from Cañon de Agua Caliente (Fig. 2, transect 1-1'). It is also absent from southern exposures in the Sierra San Lazaro and San Lorenzo at 1700 m. *Quercus devia* may withstand more xeric conditions than *Pinus lagunae*.

PINUS LAGUNAE FOREST TYPES

Ecologic (Table 1) and floristic surveys (Table 2) show *Pinus lagunae* vegetation to consist of 1) tall, open *Pinus lagunae* forests; 2) tall, dense *Pinus lagunae* forests with *Quercus devia*; and 3) low,

open *Pinus lagunae* forests with understory of *Quercus devia* and *Quercus tuberculata*.

1. The tall, open *Pinus lagunae* forests can be seen above 1700 m, on level, sandy basins (Fig. 2, sec. 2) or on the rounded summits of Sierra de la Laguna. Trunks average 8 m apart. *Pinus lagunae* has a pyramid shaped crown, 12 to 18 m high; first branches are about 2 m above ground. There is little shrub growth but the herbaceous layer (0–1 m high) is diverse especially after the rainy season. Dominant species, including *Bidens* sp., *Castilleja bryantii*, *Dalea* sp., *Desmodium neomexicanum*, *Helianthemum glomeratum*, *Hypericum peninsulare*, *Linanthus nuttallii*, and *Stachys coccinea*, disappear between December and July. They are replaced by a "pastizal" of Gramineae, including *Agrostis exarata*, *Agrostis semiverticillata*, *Aegopogon tenellus*, *Aristida schiediana*, *Bouteloua hirsuta*, *Lycurus phleoides*, *Muhlenbergia microsperma*, *Muhlenbergia rigida*, and *Piptochaetium fimbriatum*.

2. The tall, dense *Pinus lagunae* and *Quercus devia* dominant formations prevail on steeper upper flanks of the Sierra de la Laguna (Fig. 3). Trunks average 5 m apart. Individual trees of *Pinus lagunae* have longer boles than in open forest areas on the summit. The first branches are at 3 to 7 m above ground. Pine diameters vary from 32 to 58 cm ($n = 50$; mean = 45 cm). Annual rings from wood samples taken by a Pressler auger show that 34-cm-diameter pines average 60 years of age. Numerous young 0.5–2-m trees can be seen in open spaces, 50–200 per hectare. *Quercus devia* has an average height of 10 m and an average diameter of 40 cm. Three hundred specimens form 35% coverage on the experimental site. Contiguous cover of this species protects shrub layer growth during the dry season. It sheds its leaves in late February, flowers in March, and is in full growth by the end of March. Acorns ripen in September. Other trees in this type include *Arbutus peninsularis* (madroño, 5 m) and *Nolina beldingii* (2 to 4 m). A dense shrub layer is dominated by *Lepechinia hastata*, *Rumfordia connata*, *Tagetes lacera*, *Calliandra brandegeei*, and *Acacia peninsularis*.

The herbaceous layer, though less dense and less rich than in the previous type, includes a number of Gramineae: *Agrostis* sp., *Aristida schiediana*, *Piptochaetium fimbriatum*, *Muhlenbergia emersleyi*, *Perilema crinitum*, *Schizachyrium* sp., and *Stipa* sp. Species other than the Gramineae are the same as those encountered in tall *Pinus lagunae* dominant forests.

3. Low open forests of *Pinus lagunae*, *Quercus devia*, and *Quercus tuberculata* are found on the lower edge of the previous type. It represents the ecotone between *Pinus lagunae* and *Quercus devia* forests. Pines have a more stunted habit, growing no higher than 12 m. The shrub layer includes *Croton* sp., *Dodonaea viscosa*, and *Rhus integrifolia*. The herbaceous layer is mainly made up of Gramineae.

SUMMARY

Pinus lagunae appears above 1200 m in Sierra de la Laguna which represents one of the lowest altitudinal limits observed among pines in the "cembroides group". *Pinus lagunae* stands fall into three types: a low thin forest of *Pinus lagunae* and *Quercus tuberculata* below 1500 m, a tall dense stand of *Pinus lagunae* and *Quercus devia*, found throughout the Sierra above 1500 m on the summit, and a tall open *Pinus lagunae* forest. *Pinus lagunae* display maximum growth rate and seed production in the latter type.

ACKNOWLEDGMENTS

This study was part of the research program on xeric pine formations led by Passini. Field studies were conducted by Nicole Pinel, from October 1984 until July 1985, in collaboration with the "Centro de Investigaciones Biologicas" de La Paz (C.I.B.) and the "Instituto Nacional de Investigaciones Forestales" (I.N.I.F.), Todos Santos (Baja California Sur). The authors are grateful to Annetta Carter, Richard A. Minnich, and David J. Keil, for their numerous helpful comments.

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(Received 4 Jan 1988; revision accepted 28 Oct 1988.)