

# Reincorporation of deteriorated and abandoned forestry areas using an enrichment method in Paraná, Brazil<sup>1/</sup>—————

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## COMPENDIO

*El presente trabajo analiza cuatro especies autóctonas de valor comercial. Lafoensia pacari St Hil ssp petiolata Koebne, Prunus brasiliensis Schott ex. Spreng, Ocotea porosa (Nees) L Barroso, y Balfourodendron riedelianum Engl, con el propósito de elaborar alternativas técnicas para la reforestación y utilización de áreas abandonadas por la agricultura nómada en Paraná-Brasil. Las cuatro especies fueron plantadas tanto en campo abierto como bajo dosel a través del método de enriquecimiento en líneas. La finalidad del trabajo fue determinar el crecimiento en general de tales especies y su resistencia a las heladas. Después de 2 años de observación es posible concluir que el P. brasiliensis se destaca por su buen desarrollo y resistencia a las heladas en campo abierto; en cuanto a L. pacari, O. porosa y B. riedelianum conviene que sean plantados bajo dosel, que permita intensidades de luz de 50 - 75%*

### Introduction

**B**RAZIL, formerly covered nearly totally with broadleaved and coniferous forests, began to feel serious problems during this decade in some of its regions on provisioning their own wood and pulp and paper industries and those industries, which consume charcoal and firewood.

Even though great forest areas exploited with the target of supplying lumber and veneer industries, the massive deforestation process was mainly forced by agriculture (sugar cane, wheat, soybean, coffee, corn, etc), cattle raising, railroad companies (firewood and charcoal) and industries (firewood and charcoal). Even today, about 80 per cent of the exploited wood is destined for the production of energy or as thermo-reducing agent (Table I) Until today Brazil does not dispose of important coal beds and oil fields. For that reason the forest has and will have the task of supplying fuel for industries in order to reduce as much as possible the import of fossil fuel

The Federal State of Paraná serves, because of its trustworthy data, as a sad example of how the natural forest can be decimated. Paraná (20 120,300

ha), a State qualified for forestry, was originally covered over 84 per cent of its area (16 842,200 ha) with dense forests (10) On the last inventory on 1973 the forest covering enclosed only 11.80 per cent. Today the forest covering is estimated merely at 8 per cent (Fig 1) This fast deforestation (in Paraná about 370,000 ha/year) can be explained if we consider that in addition to the already enumerated reasons, the agriculture still uses today, over vast areas, the technique of shifting cultivation. This shifting cultivation becomes more important the nearer to the tropics agriculture is practiced. This characteristic is particular of countries of the tropical and subtropical regions of the world and had been already analysed by several authors (2, 5, 6, 18). According to Hesmer (5) this way of cultivation is probably the proper technique of land use, if we consider the ecological and socio-economic aspects of these regions, which definitely can not follow European patterns of agricultural utilization.

Due to the fast reduction of forested areas the government began in 1966 to offer incentives for reforestation by the reduction of tax payments. According to Victor (17) the government incentivated, through this reforestation program, about 2.6 mill ha spending more or less 1,700 mil US\$. Table 2 shows that the greater part of the reforested area was established with exotics (*Pinus* spp and *Eucalyptus* spp), in Paraná mainly with pines, developing homogenous stands and only 8.7 per cent with a

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Table 1.—Projected demand of wood raw material for the main wood processing sectors.

Year	Mechanical processed wood	Pulp and paper	Firewood and charcoal	%	Total
	mill m <sup>3</sup> r.	mill m <sup>3</sup> r.	mill m <sup>3</sup> r.		
1975	17.31	11.20	141.70	83.3	170.21
1980	23.09	18.82	156.70	78.9	198.61
1985	29.44	29.05	157.60	72.9	216.09
1990	36.43	43.09	164.10	67.1	244.52
1995	44.15	63.31	173.10	61.7	280.56
2000	53.38	89.10	182.40	56.1	324.88

Source: Instituto Brasileiro de Desenvolvimento Florestal, (7).

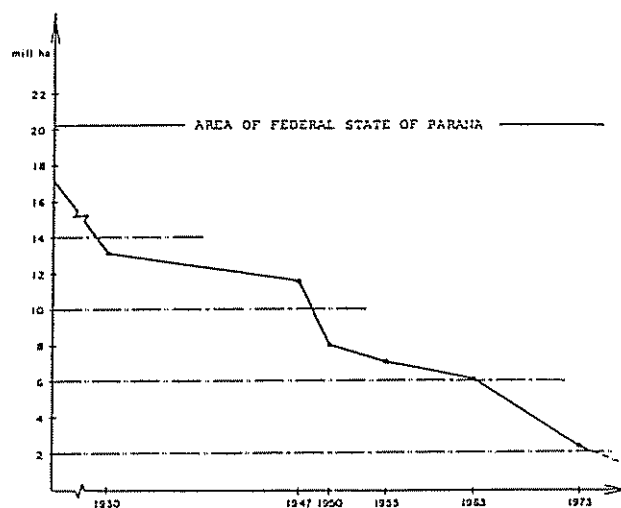


Fig. 1.—Deforestation process of the Federal State of Paraná

Table 2.—Annual reforestation as result of government incentives (ha)

Year	Brasil	Federal State of Paraná				
		Total	<i>A. angustifolia</i> <sup>1</sup>	<i>Pinus spp.</i> <sup>2</sup>	<i>Eucalyptus spp.</i> <sup>3</sup>	Palms and <sup>4</sup> fruit trees
1966		221	3	156	50	12
1967	34,759	6,157	1,513	3,809	747	88
1968	102,909	19,841	3,065	15,925	550	301
1969	162,383	38,934	4,774	32,712	795	653
1970	222,005	57,443	5,336	48,042	2,167	1,698
1971	248,467	54,165	3,669	40,889	6,914	2,693
1972	304,356	54,115	5,352	30,442	9,080	9,271
1973	294,203	58,753	6,301	27,946	3,097	21,409
1974	324,378	66,080	5,551	30,320	7,254	22,950
1975	398,239	85,570	5,124	29,804	3,854	46,788
1976	469,199	86,500	5,220	31,950	4,900	41,430
TOTAL	2 560,898	527,809	45,908	294,995	39,713	147,193
%	100	20,1	—	—	—	—
	—	100	8,7	55,9	7,5	27,9

<sup>1</sup> *Araucaria angustifolia*<sup>2</sup> *Pinus elliottii*, *P. taeda*, *P. patula* and others.<sup>3</sup> *Eucalyptus riminalis*, *E. saligna*, *E. alba*, *E. grandis* and others<sup>4</sup> *Euterpe edulis* (Palmaceae) and fruit trees

Source: Instituto Brasileiro de Desenvolvimento Florestal (1977a, 1977b)

native species (*Araucaria angustifolia*). The preference for exotics is owed to their fast growth and rusticity, which began their wood production on the 7th or 8th year and exhibit increments of 30-60 m<sup>3</sup>r/ha/a for eucalyptus (13) and 20-40 m<sup>3</sup>r/ha/a for pines (12).

*Object of the present study*

Besides the native species present smaller volumetric increments\* they also demand good knowledge about their autoecology, if plantation with them has to be successful. Unfortunately, this last reason made the reforestation with native species excepting *Araucaria angustifolia* impracticable (9). According to Carvalho (3), 80 per cent of the forest species of Parana are sensitive to frost during their juvenile stage. The majority of them prefer a light shadow. Due to this reason all attempts to reforest with autochthonous species on previously cleaned areas following the model of reforestation with exotics failed in their majority.

Based on that recognition and on the fact that there exist in Paraná important areas abandoned by the shifting cultivation and mostly covered today by brush and scrub growth, we decided to install a trial using the line-enrichment method and prove its applicability.

Table 3 —Systematic classification of the 4 species studied

Family	Genus	Species	Sub-species	Author	Common name
Lythraceae	Lafoensia	<i>L. parani</i>	<i>petiolata</i>	Koehne	dedaleiro
Rosaceae	Prunus	<i>P. brasiliensis</i>	—	Schott ex Spreng	pessegueiro bravo
Lauraceae	Ocotea	<i>O. porosa</i>	—	(Nees) I. Barroso	imbuia
Rutaceae	Balfourodendron	<i>B.riedelianum</i>	—	Eng	pau marfim

lity. If we compare the enrichment method with the traditional reforestation model with exotics appears the advantage of no necessity of eliminating all vegetation and reduce on this way implantation costs and subsequent ecological disturbance because this method requires only the opening of straight (tight) strips alternated with wider strips where vegetation is maintained. In this way, it is possible to get the reincorporation of abandoned areas and susceptible of erosion to a productive activity without losing part of the soil. According to Brünig (1) this damage can reach in the tropics really high erosion ratios: 32-50 t/ha/a when an even terrain is cultivated and 600-1.200 t/ha/a when shifting cultivation is done on steep terrain

\* *Araucaria angustifolia* : 15-18 m<sup>3</sup>r/ha/a (P. Com. Wakasugi)  
*Prunus brasiliensis* : 11.88 m<sup>3</sup>r/ha/a (SPELIZ. 1968)  
*Lafoensia pacári* : 7.11 m<sup>3</sup>r/ha/a (SPELIZ. 1968)

*Materials and Methods*

*Species*

For the trial were selected 4 autochthonous species of the 2nd plateau of Paraná of the region of Irati which present moderate increments 5-12 m<sup>3</sup>r/ha/a and have wood appropriate for lumber: *Lafoensia pacari*, *Prunus brasiliensis*, *Ocotea porosa* and *Balfourodendron riedelianum* (Table 3)

*Place of the trial*

The trial was installed in the National Forest of Irati (Floresta Nacional de Irati) owned by the Instituto Brasileiro de Desenvolvimento Florestal (IBDF) which characteristics are (3):

- Country : Brazil
- Federal State: Paraná
- County : Teixeira Soares
- Altitude : 885 m a s l.
- Latitude : 25°26' Lat. S
- Longitude : 50°51' Long. W.
- Climate : — subtropical humid without dry season
- classification of Koeppen: Cfb mean temperature hottest month: 22°C.

- Soils : — mean temperature coldest month: 10 °C.
- number of frosts: more than 5 per year
- red-yellow podsolic var Piracicaba
- dark red dystrofic latosol
- Vegetation : — rainy subtropical forest type High Parana
- Araucaria forest

*Method*

- 1 *Installation* two silvicultural systems were selected and installed according to following distinctives:
  - plantation under open field conditions, and
  - plantation under canopy conditions (enrichment method)
- a) *Plantation under open field conditions:* This trial was established in an area which

was previously cleaned with the shield of a tractor.

Statistic outline: — model: randomized blocks  
— nº of species: 4  
— replication: 4  
— nº of plants/plot:  
25 (5 x 5)  
— nº of plants/species:  
100 (4 x 25)  
— spacing: 2 x 2 m

b) Plantation under canopy conditions (enrichment method):

This trial was established on deteriorated second growth forests, where pioneer species *Mimosa scabrella* dominated. The stand had originally a density of 1 000 trees per hectare and a mean height of 14 m. The strips opened in this stand were 1 m width, 30 m long and separated by strips with vegetation of 2 m width.

Statistic outline: — model: linear plots  
— nº of species: 4 (the same of a))  
— replication: 4  
— nº of plants/plot: 7  
— nº of plants/species:  
(4 x 7)  
— spacing: on the line 1 m between lines 3 m.  
— light intensity on the lines:  $\pm 75\%$  of open field conditions.

2. *Cultural treatments*: The plantation under open field conditions was only weeded in spring so that grass and weeds will protect the plants during the winter. The area of the enrichment method trial was weeded twice per year.
3. *Evaluation*: Every 3 months the basal diameter (on earth level) and height were measured. At the same time survival was determined.

### Results

After comparison of the results of both systems established (Table 4 and 5) we observed that the highest survival was obtained with *Lafoensia pacari* (89%) under field conditions and the lowest with *Balfourodendron riedelianum* also under field conditions. Even *L. pacari* presents a higher survival in the open field. If both systems are compared, that difference is not significant, but the increments of height and basal diameter are higher under canopy conditions, especially the differences in height increment are highly significant (see Table 6). This better growth can be explained with the frost damages happening to the plants under field conditions which lost after each frost a part of the stem. All height-increments under canopy conditions were better with the exception of *Prunus brasiliensis*. These differences were significant and, in one case, highly significant.

Table 4.—Mean development of height (H), basal diameter (BD) and survival (S) of 4 autochthonous species of the Federal State of Paraná planted under open field conditions.

Species	Year 0			Year 1			Year 2		
	H (m)	BD (mm)	S (%)	H (m)	BD (mm)	S (%)	H (m)	BD (mm)	S (%)
<i>L. pacari</i>	0.22	4.7	100	0.61	9.0	89	0.92	16.3	89
<i>P. brasiliensis</i>	0.22	1.9	100	0.79	7.4	86	1.65	18.0	80
<i>O. porosa</i>	0.14	2.8	100	0.17	5.0	63	0.53	9.1	55
<i>B. riedelianum</i>	0.12	2.1	100	0.20	5.6	60	0.60	10.6	50

*P. brasiliensis* grew in 2 years 1.43 m or 0.72 m/a under open field conditions. The other species (*L. pacari*, *O. porosa* and *B. riedelianum*) grew, however under canopy, respectively 0.58 m/a, 0.34 m/a and 0.38 m/a. *P. brasiliensis* demonstrated on this way to be a pioneer species, heliophil and frost-resistant, meanwhile *O. porosa* and *B. riedelianum* demonstrated to be very sensitive species to the direct exposition of frost and sunrays. Both species presented, when both systems were compared, significant differences in survival and in height growth.

### Conclusions

The enrichment method with lines showed to be the best alternative for *L. pacari*, *O. porosa* and *B. riedelianum* which also proved to be technically doable on those places where deteriorated forests exist after irrational exploitation or where shrub is growing as a result of abandonment after shifting cultivation. Only *P. brasiliensis* had better success when planted under open field conditions. What spacing concern, it seems to be more appropriate to use greater distances in the lines and between them, than that used in this trial. Even though there was no comparison done

Table 5.—Mean development of height (H), basal diameter (BD) and survival (S) of 4 autochthonous species of the Federal State of Paraná planted in lines under a canopy

Species	Year 0			Year 1			Year 2		
	H (m)	BD (mm)	S (%)	H (m)	BD (mm)	S (%)	H (m)	BD (mm)	S (%)
<i>L. pacari</i>	0.15	4.3	100	0.79	8.4	80	1.30	18.1	80
<i>P. brasiliensis</i>	0.22	2.0	100	0.79	6.9	85	1.33	14.1	78
<i>O. porosa</i>	0.17	4.0	100	0.49	6.4	80	0.80	10.5	80
<i>B. riedelianum</i>	0.12	2.2	100	0.38	7.9	90	0.88	12.5	75

Table 6.—Increment of height and basal diameter of 4 autochthonous species of the Federal State of Paraná under the 2 systems analysed.

Species	Increments - 2 years - (1 year)							
	Height	Open field (m)	Basal	Diam (mm)	Height	Under canopy (m)	Basal	Diam (mm)
<i>L. pacari</i>	0.70	(0.35)	12.6	(6.3)	1.15**	(0.58)	13.8	(6.9)
<i>P. brasiliensis</i>	1.43**	(0.72)	16.1**	(8.1)	1.11	(0.56)	12.1	(6.1)
<i>O. porosa</i>	0.39	(0.20)	6.3*	(3.2)	0.63*	(0.32)	6.5	(3.3)
<i>B. riedelianum</i>	0.48	(0.24)	8.5	(4.3)	0.76*	(0.38)	10.5	(5.2)

\* Significant difference

\*\* High significant difference

Source: Carvalho (3)

in this trial about spacement it seems to be proper to suggest the utilization of strips with 1.5 to 2.0 m width separated by strips with vegetation of 4 to 5 m width. On the line we suggest a spacing of 2 m between the plants. The plants have to be a length of about 20 cm of aerial part.

If we consider that:

- there exist many abandoned areas by the shifting cultivation which represent a future reserve for a shifting cultivation activity after the present areas became worn out, and
- the pressure of population on the land for the utilization of food production is constantly growing

no traditional ways of land use, like agro-silviculture or cattle raising combined with forestry, seems to be a realistic alternative, because the best way of protecting the soil from erosion or lixiviation in the tropics and subtropics is by the maintenance of a light or dense canopy under which other cultivation can be done.

About this aspect it seems convenient to research the establishment of manioc cultivation on deteriorated soils without trees, associated with plantation of hardwood species like *L. pacari*, *O. porosa* or *B. riedelianum* in order to accelerate on one hand the alcohol production as substitute of gasoline (in Brazil alcohol is already used as substitute) and provide raw material for the production of food for men and animals and on the other hand establish hardwood forests for already installed lumber, plywood and veneer industries, which in the future will have increased difficulties on raw material supply. The manioc would protect the soil against erosion and the forest transplants during the first years against solar radiation and frost offering to the cultivator at the same time an income from the first year on.

### Summary

The present article analyses 4 forest autochthonous species of commercial value: *Lafoensia pacari*, St. Hil. Ssp. petiolata Koehne (dedaleiro), *Prunus brasiliensis* Schott ex. Spreng. (pessegueiro bravo), *Ocotea porosa* (Nees) L. Barroso (imbuia) and *Balfourodendron riedelianum* Engl. (pau marfim) with the target to offer aid to institutions and enterprises related to reforestation activities in order to give them technical alternatives on reforestation and on utilization of abandoned areas by the shifting cultivation in Paraná, Brazil.

The 4 species were planted under open field conditions and under canopy conditions using the enrichment method with lines, with the aim to analyze their frost-resistance and general growth. After 2 years of observation it is possible to conclude that *P. brasiliensis* has to be planted in open fields because of its frost-resistance and good development. Meanwhile, *L. pacari*, *O. porosa* and *B. riedelianum* is suggested to be planted under canopy that allow light intensities between 50 per cent and 75 per cent.

### Resumo

Analisam-se quatro espécies florestais autoctones do Paraná de valor comercial: *Lafoensia pacari* St. Hil. ssp. petiolata Koehne, *Prunus brasiliensis* Schott ex. Spreng, *Ocotea porosa* (Nees) L. Barroso e *Balfourodendron riedelianum* Engl. com a finalidade de estudar alternativas técnicas para o reflorestamento e sua utilização em áreas abandonadas pela agricultura migratória. As citadas espécies foram plantadas tanto a céu aberto como sob cobertura por enriquecimento em linhas para observar sua resistência às geadas e determinar seu desenvolvimento. Após 2 anos de ob-

servação é possível concluir que *P. brasiliensis* deve ser plantada, devido seu bom desenvolvimento e resistência às geadas, a céu aberto. As outras 3 espécies (*L. pacari*, *O. porosa* e *B. viedelianum*) no entanto, devem ser plantadas sob coberturas que permitam intensidade de luz de 50 - 75%

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