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FARM FORESTRY IN BRAZIL

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ABSTRACT

Relatively recently initiated, but rapidly growing, small-farm forestry programs are augmenting the supply of wood from large-scale plantations to consumers in Brazil. Most private-sector forestry companies have started such programs, as have governments in several states. For some forestry companies, farm forest areas are equivalent to as much as 20% of the company's own plantation area. Farm yields are close to those for large company-owned plantations. Farm forestry programs are helping to provide local wood supplies at reasonable costs, while providing farmers with a new revenue source. Intercropping of annual crops with trees (agroforestry) is increasing in most farm-forest programs. Because farm forestry is relatively new in Brazil, there is a significant scope for improving and expanding such programs.

INTRODUCTION

The development of plantation forestry began in earnest in Brazil in 1966, when federal tax incentives were introduced to encourage tree planting. The area of plantations grew from 470,000 hectares in 1966 to some 6.2 million hectares in 1992 [Couto and Betters, 1994]. Until the mid-1980s, Brazilian forestry companies, especially those associated with pulp and steel production, expanded tree production exclusively by purchasing land and establishing new plantations. Since the mid-1980s,

such companies have pursued a different strategy--increasingly contracting with private farmers as a means for expanding their wood supply. Fig. 1 shows this trend for Minas Gerais [Oliveira, 1991], one of Brazil's major wood consuming states. Small and medium-sized wood consumers have also begun mobilizing themselves to assist farmers in tree planting in an effort to insure the availability of wood locally for the long term.

While the idea of farm-forestry is not new in Brazil--having been promoted as long ago as the early 1960s [Grodzki, 1963], three relatively recent developments are accelerating the implementation of the idea: *(a)* the federal tax incentives introduced in 1966 to encourage tree planting were eliminated in 1988, making it much less attractive for forestry companies to expand their own plantation areas; *(b)* in regions where natural forests were being cut for wood (especially the states of Minas Gerais and Sao Paulo), natural forests within reasonable transportation distances have essentially been completely cut, with insufficient replanting to meet local needs; and *(c)* objections of environmentalists and others to "over-planting" of trees have discouraged expansion of large tracts of company-owned plantations. (In the state of Espirito Santo, for example, Aracruz Florestal is now prohibited by law from purchasing additional land for eucalyptus planting.)

In farm-forestry programs, the forestry company or another organization provides the material inputs and technical know-how for establishing the trees on a farmer's land and contracts with the farmer to buy some or all of the first-cut harvest for an agreed upon price that incorporates repayment for the initial inputs and services. The inputs include saplings (usually some species of eucalyptus), fertilizers (applied at planting), herbicides (applied at some point after planting), and pesticides. The company samples the farmer's soil and provides fertilizers and sapling species "tuned" to that farmer's soil.

Today, farmer-owned plantations account for as much as 20% of some forestry companies' total planted area. Some companies have a goal of raising this fraction to 50% or more. This paper discusses some of the characteristics of farm-forestry in Brazil, some of the implications for farmers

and for forestry companies, and briefly discusses the trend toward agroforestry as part of farmer-forestry programs.

FARM-FORESTRY CHARACTERISTICS

Corporate Programs

Table 1 gives some characteristics of farm forestry programs operated by 8 forestry companies in Brazil today. The information in this table was collected through direct contacts with the companies. It is not a comprehensive picture of private-sector farm forestry in Brazil today. However, some important features can be gleaned from this limited information.

Of the programs indicated in Table 1, the largest are operated by Aracruz (30,000 hectares currently under contract), Champion (13,000 ha), and Cenibra (8,500 ha). The farmer-owned areas are 10 to 20% of the size of the company-owned areas planted with trees. These percentages can be expected to grow in the future. For example, the Pains company has indicated a target of 50% farmer-contracted area. Despite the large total areas that are starting to be contracted from farmers, the per-farm area contracted is relatively small, ranging from less than 2 ha (Riocell) up to about 50 ha (Bahia Sul) for the companies listed in Table 1. The average per-farm area planted with trees represents from 10 to 30% of the average total farm area where these figures have been reported (Table 1). In the cases of Champion, Riocell, Ripasa, Inpacel, and Bahia Sul, few if any of the participating farmers intend to commit their total farm area to trees. In the case of Cenibra, 27% of farmers under contract intend to commit their total farm area to trees--a relatively high percentage among forest-farm programs at present.

Since eucalyptus grows on 5 to 7 year rotations and most farmer-forestry programs were only started in the mid-to-late 1980s, harvesting of the first farmer-planted land is only just now starting. Based on a few such harvests and on projections of yields based on the initial tree growth rates for three of the companies listed in Table 1, it appears that annual per-hectare yields from the farmer-

contracted areas are presently slightly below the yields obtained from large plantations on company-owned lands. Farmer yields can be expected to increase in the future, as both farmers and their contracting companies learn improved methods and approaches. At present, technical assistence to farmers is not always adequate, e.g. in selecting appropriate areas for planting. Also, in some areas, there are difficulties with seedling and fertilizer distribution, with the taking of environmental precautions, and with preventing fires [Capitani, 1992].

Off-setting any yields are substantially lower costs to companies for establishing farmer-contracted plantations. For the companies in Table 1 that reported establishment costs, the cost-per-hectare for establishing farmer-contracted plantations ranged from 2 to 42% of the establishment cost for company-owned plantations.

Companies use different approaches for engaging farmers in forestry programs. The Pains Company puts on "Field Days" at their research site. Farmers spend the day seeing experimental results and talking with Pains staff. The farmers tend to be convinced by the Field Day activities about the merits of tree growing, but have neither the capital nor the confidence to proceed on their own. They seek Pains backing on both counts. A key element in the success of the Pains program has been their staff of extension agents, who interact directly with the farmers. The farmers often come to rely on the agents for information and advice since most of the farmers are able to read little if at all. (Some 85% of the farmers have a maximum of 3 years schooling in the region around the city of Divinopolis, where Pains is located in Minas Gerais state.)

Other Programs

In addition to farm-forestry programs run by forestry companies, other programs include efforts initiated in the public sector, as well as those run by "timber replacement associations" (TRAs).

State-Initiated Programs. Several states have initiated programs to increase farm forestry. Minas Gerais accounts for 90% of total charcoal consumption in Brazil. As recently as 1980,

Minas Gerais was self-sufficient in wood production for its charcoal needs. By 1990, it was importing 50% of its charcoal needs from other states [Castro Filho, 1991]. Potential shortages in local wood availability were recognized by the state as long ago as 1970, at which time the Extension Service of Minas Gerais State (EMATER) started a farm-forestry program called PRODEMATA that resulted in some 25,000 hectares of tree farms by 1976. Subsequently, the State Forest Institute (IEF) of Minas Gerais launched a series of farm-forestry programs, the most recent of which was initiated in 1989 [Oliveira, 1991]. This program, PRO-FLORESTA, is being financed by a loan in excess of $90 million from the World Bank. Among its goals are the establishment of 165,000 hectares of farmer forests [Castro Filho, 1991]. By 1990, over 55,000 hectares of farm forests were established under the various public-sector programs in Minas Gerais.

In Sao Paulo state in 1989, the Secretary for Environment and Agriculture signed an agreement with eight companies (pulp and paper: Champion, Suzano, de Zorzi, Simao, and Ripasa; particle board: Eucatex and Duratex; and mining: Serrana) in Sao Paulo, the goal of which was to distribute 1.2 million seedlings among some 260 farmers, each of whom would plant an area no larger than 5 hectares [Fujihara, 1991]. Saplings are donated by the companies and funding is collected to pay for their distribution and assistance given in planting. These funds, coming primarily from the private sector, are placed in a fund (Fundo Florestal) managed by the Forest Foundation of Sao Paulo (Fundacao para a Conservacao e a Producao Florestal do Estado de Sao Paulo). A side effect of this modest initiative was the drawing up of the 1993 Sustainable Forest Development Plan for Sao Paulo state [Fundacao Florestal, 1993]. The plan's target is to increase native forest cover from 3.1 million hectares today to 4.7 million within 25 years, and increase plantation area from 0.73 to 2.8 million hectares. The plan depends heavily on farm forestry.

A program similar to that in Sao Paulo has been ongoing since 1989 in Rio Grande do Sul [Ferro, 1992]. The program is based on an agreement reached between Riocell, a major pulp and paper company, the state's Secretary of Agriculture, and the state extension service, EMATER/RS-

Ascar, and it includes the participation of local governments. Any farmer interested in planting trees in areas of 0.5 to 10 ha/year can request seedlings, the planting, fertilization, and tending of which are done with the advice from EMATER specialists. The farmers are obliged to give 10% of the first harvest to Riocell as payment for the seedlings and are free to sell or use the remainder of the harvest as they choose.

Timber Replacement Associations. TRAs developed beginning in the late 1980s as a result of stipulations in the 1965 Forestry Code requiring wood and charcoal consumers in Brazil to replace their wood consumption. To satisfy the Forestry Code, biomass consumers must either directly plant trees (after having their tree-planting plan approved by IBAMA, the Brazilian Institute for the Environment and Natural Resources), or pay a "replacement tax" to IBAMA. Small consumers--sawmills, bakeries, potters, brick makers, barbecue restaurants, etc.--typically paid the replacement tax, which today is roughly $0.6 to $0.7 per solid cubic meter of wood consumed.

By the mid-1980s, it became clear that IBAMA was not effectively using the replacement taxes, because sufficient replanting close to consumption centers was not being carried out. In 1988, a group of wood consumers in the state of Sao Paulo initiated a civil disobedience movement to replace IBAMA as the collector of the replacement tax. Without formal legal recognition, they created an association that began collecting the replacement taxes and took responsibility for replacing locally their own consumption. Since then, other similar associations have been created. After four years of successful, but "illegal" replanting activities, these associations were officially recognized by the Sao Paulo Department for the Protection of Natural Resources. Finally, in 1993, they were also recognized by IBAMA and officially authorized to collect the replacement tax. There are currently 18 TRAs distributed throughout Sao Paulo state, and TRAs have been initiated in other states as well.

In Sao Paulo, a TRA's membership consists of wood consumers using up to 12,000 m^3 of raw material per year. The TRAs produce and distribute seedlings to small and medium-sized farmers and provide the necessary technical support in planting and forest management. FLORESPI (Table 2) is

one such TRA. It was created in 1989, covers 80 cities in an area of 200,000 km^2, works with 3,000 registered farmers, and has established 450 reforestation areas. FLORESPI's own nursery is able to produce 600,000 seedlings per year. FARESP, also shown in Table 2, is a federation whose membership includes all 18 of the TRAs operating in Sao Paulo state.

For wood consumers, one advantage of the TRAs is the effective replanting of trees locally, which reduces wood prices due to lower transportation costs. For example, in the northwestern region of Sao Paulo, home of many ceramics producers, natural forests have disappeared, and firewood is shipped from neighboring Mato Grosso do Sul over distances as great as 350 km. In such cases, wood consumers have paid up to six times higher prices than for locally produced wood [Andrews, 1990]. In addition to reduced cost, local environmental conditions are also improved by the reduced pressure to cut natural forests, as well as the environmental awareness-training provided by the TRAs to farmers. The main advantages for farmers in working with a TRA (rather than a forestry company) are low planting costs, free technical advice, and no commercial obligations at production time.

MOTIVATION FOR PARTICIPATING IN FARMER FORESTRY

Farmers' Perspective

Farmers have several motivations for participating in tree farming programs [Capitani et al., 1992], including additional income from a certain market, productive use of marginal areas, stimulus for cooperation with their fellow farmers, and availability of wood for on-farm use.

The case of one farmer contracted by Pains Florestal is probably not untypical.[1] This particular farmer has 13 hectares of eucalyptus trees, in addition to which he grows some sugarcane (for cattle fodder), rice, beans, citrus fruit, chickens, and others. Some 90% of his non-tree production is for self consumption. He had land available to plant trees because it is difficult for him to expand

[1] This information is based on a personal interview (April 27, 1994) with the farmer at his farm.

his conventional farming activities in a profitable way: he doesn't have access to capital to invest in expanding area (or improving productivities), in addition to which there is no profitable market for production in excess of his own needs, because middlemen who control access to markets pay poor prices.

With the loan of inputs and know-how from Pains, the farmer has been able to establish a healthy tree crop, 20% of the first harvest of which will be given to Pains as repayment for the initial loan. The farmer can sell the remaining 80% on the open market at market prices. (Pains would, in all likelihood, be willing to purchase additional wood from the farmer, but an agreement to do so would be negotiated between Pains and the farmer.) The contract with Pains stipulates that Pains will harvest their 20% share so that the farmer does not need to invest in harvesting equipment. The farmer's first harvest of trees will generate a sizeable revenue, which the farmer can then invest as he pleases, e.g. in technology to increase the productivity of his food crop production.

Forestry Companies' Perspective

The economic motivation for forestry companies to contract farmers is relatively clear. Again, the example of the Pains company is illustrative. Pains operates its own tree plantations in an area around the relatively large town of Divinopolis, the site of the Pains charcoal-based steel factory. The average transport distance for charcoal produced on or near Pains' own plantations is 485 km. After the federal tree-planting incentives were ended, Pains essentially stopped expanding their own plantations around Divinopolis. Instead they purchased additional charcoal from the nearest source they could find, which was in the state of Mato Grosso do Sul. The average transport distance is 1100 km, making this charcoal very expensive.

Aware that reliance on charcoal from Mato Grosso do Sul was not an acceptable source over the long term for meeting their charcoal needs, Pains also initiated its farmer forestry program. The lower capital investment per hectare required for Pains to establish farmer-owned plantations, zero

maintenance costs to Pains, and the average transport distance of only 45 km from farmer-forests to the Divinopolis steel mill, combine to make the farmer-forestry program financially attractive to Pains.

Also, Pains is assisting the farmers in the area to form cooperatives, through which Pains can contract for larger volumes of wood with less administrative costs. The cooperatives also permit farmers to further raise productivities, e.g. by sharing the use of costly machinery, and the cooperatives can provide bargaining power to the farmers in their efforts to sell crop harvests that are in excess of their self-consumption needs.

SOCIAL BENEFITS

There are also societal benefits of farmer-forestry programs. Farmers can increase their revenues, which in turn can encourage economic development in rural areas and reduced migration to urban areas. (Pains indicated that migration to Divinopolis, the regional urban center, had slowed significantly since their farmer forestry program was started.) Also, the concentration of land ownership by forestry companies is reduced. Finally, the lower cost for wood production makes the final product (steel, pulp, etc.) more competitive, which implies macro-economic benefits for the region and/or country.

FUTURE FARMER-FORESTRY: AGROFORESTRY

Because of farmers' concern that tree planting would divert land away from other crops, there is growing interest in the idea of intercropping trees and food crops. The interest comes originally from the farmers, since growing food crops could provide an annual revenue stream from tree-planted areas, in addition to the less-frequent tree-derived revenue. For this reason, most forest companies in Brazil today are encouraging agroforestry within their farmer-forestry programs [Couto and Betters, 1994]. Companies are also interested because it appears that under some conditions, higher yields of wood are achievable from intercropped areas.

Pains Florestal is one company that launched an agroforestry research program in an effort to better understand and to improve agroforestry technologies for the benefit of both farmers and the company.[2] Pains began their research program in part because they observed that trees intercropped by farmers on their own with food crops apparently were growing better than when planted as a mono-crop. Beginning in 1991, Pains conducted a series of trials with different combinations of *Eucalyptus camaldulensis* or *Eucalyptus urophylla* with beans, corn, cassava, rice, and sorghum. *E. camaldulensis* was found to be preferable because of its more vertical canopy, which leads to less shading of the annual crop planted between rows of the trees.

To date, the agroforestry trials have been most promising with intercropping of beans and *E. camaldulensis*. Figure 2 shows the height and diameter of the eucalypts at one-year of age when planted as a monoculture or when intercropped with rice or beans. The improved growth of the trees is attributed primarily to the more frequent attention (e.g., weeding) given them by the farmer (compared to a monoculture of trees) as a byproduct of the necessary attention given to the annual crop. Also, the tree roots evidently capture much of the fertilizer applied to, but leached away from, the annual crop.

Pains found that intercropped corn and rice do poorly compared to monocultures of these crops, though tree growth would be enhanced. On the other hand, some variety of beans appear to give significantly higher yields when intercropped than when planted in monocultures. Figure 3 summarizes some of the results for beans in terms of effective productivities.[3] The two left-most bars are the average productivities for monoculture beans in Brazil and in the Pains region. The right four bars are results from Pains' experiments: the first two of these bars are the average and best-plot

[2] The information here on the Pains agroforestry research activities is based on personal communication with Eliane Ceccon, Director of Agroforestry Research Station, "Fazenda D. Rosa," Pains Florestal S.A., Divinopolis, Minas Gerais, April 1994. Pains Florestal was recently purchased by another company, as a result of which the agroforestry research effort has been terminated.

[3] Effective productivity is defined as the tonnage yield divided by the area planted with beans, which excludes the area planted with trees in the case of intercropping.

productivities for the year in which the trees were planted. The second two of these bars are the average and best-plot productivities for the second annual crop of beans after planting of the trees. The reasons for the success of the beans in intercropping is thought to be due to the fact that, as C_3 crops, they prefer some shade: shade promotes leaf area enhancement, which leads to greater carbon fixing.

CONCLUSIONS

Small-scale forest farming (1 to 50 hectares per farm) is growing rapidly in Brazil with encouragement from the private sector, from federal, state, and local governments, and from farmers. A small sample of farm forestry programs is described in this paper, based on which it appears that significant areas of tree plantations can be established relatively rapidly through such programs. Yields obtained by farmers appear to be not much lower than those achieved on very large-scale plantations owned and operated by forestry companies. Farm forestry programs are still relatively new in Brazil, so there is scope for improvement in many aspects of such programs.

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Table 1. Some corporate farmer forestry programs in Brazil, based on information provided by individual companies.

Company →	Aracruz	Champion	Cenibra	Riocell	Pains	Ripasa	Inpacel	Bahia Sul
Location (state)	Espirito Santo	Sao Paulo	Minas Gerais	R. Grande do Sul	Minas Gerais	Sao Paulo	Parana	Bahia, E. Santo
Company-Owned Land								
Total area (hectares)	200,000	n.a.	156,194	71,751	85,073	69,942	47,874	115,138
Area planted (hectares)	131,000	n.a.	87,935	52,487	51,467	50,365	25,768	66,902
Average establishment cost for new plantings[a] ($/ha)	1,250	n.a.	1,670	960	n.a.	917	712	427
Average productivity of planted area (dry tonnes/ha/year)[b]	22.3[c]	n.a.	17.8[d]	19.2[d]	n.a.	17.3[d]	19.8[d]	21.8[d]
Average delivered cost of wood ($/dry tonne)[e]	39	n.a.	48	30	n.a.	n.a.	22	16
Farmer-Forestry Program								
Year program was started	1989	1960	1985	1989	1988	1991	1991	1992
Total number of farmers	2000	328	500	3098	314	85	110	16
Average total farm size (ha)	n.a.	n.a.	100	16	63	90	n.a.	300
Primary activity of farm	n.a.	cattle,corn, coffee,citrus	cattle	n.a.	n.a.	cattle	cattle, crops	cattle
Total area contracted for trees (ha)	30,000	13,000	8,500	4,985	2,431[f]	2,425	1,575	850
Average per-farm area planted with trees (ha)	15	40	17	1.6	7.7	29	14	53
Average productivity of planted area (dry tonnes/ha/year)	n.a.	15[d]	12.7[d]	15[d]	n.a.	15.8[d]	n.a.	n.a.
Average establishment cost to company ($/ha)	n.a.	430	240	23	n.a.	130	266	180
Average delivered cost of wood to company ($/dry tonne)[e]	n.a.	16	42	n.a.	n.a.	n.a.	n.a.	n.a.
Percent of farms intending to commit total area to trees	n.a.	8	27	0	n.a.	6	2	0

(a) Includes land rent, sapling production, land preparation, planting, fertilizers, herbicides.

(b) Yield data were originally provided in solid cubic meters. Typical species of eucalyptus in Brazil have a density of about 0.5 dry tonnes per solid cubic meter.

(c) Includes only stem wood with diameter 7 cm or larger.

(d) Starting from the total yield at harvest (in solid m^3/ha) provided by the company, this has been calculated assuming a 6-year rotation and a wood density of 0.5 dry tonnes/m^3.

(e) Calculated from costs in $/solid m^3, assuming a wood density of 0.5 dry tonnes per cubic meter.

(f) Pains has a goal of contracting over 56,000 hectares under their farmer forestry program, which would involve some 4,000 farmers.

Table 2. Two timber replacement associations in Sao Paulo state, Brazil.

Company →	FARESP[a]	Florespi[b]
Farmer-Forestry Program		
Year program was started	1987-93	1989
Total number of farmers	2755	450
Average total farm size (ha)	n.a.	5
Primary activity of farm	n.a.	cane,cattle
Total area contracted for trees (ha)	8,251	2,500
Average per-farm area planted with trees (ha)	3.0	5.5
Average productivity of planted area (dry tonnes/ha/year)	n.a.	n.a.
Average establishment cost to TRA ($/ha)	333	241
Average delivered cost of wood ($/dry tonne)	n.a.	n.a.

(a) Federation of Reforestation Associations, representing all 18 timber replacement associations in Sao Paulo state.

(b) Forest Recuperation of the Piracicaba River Watershed Association, one of the 18 TRAs in Sao Paulo state.

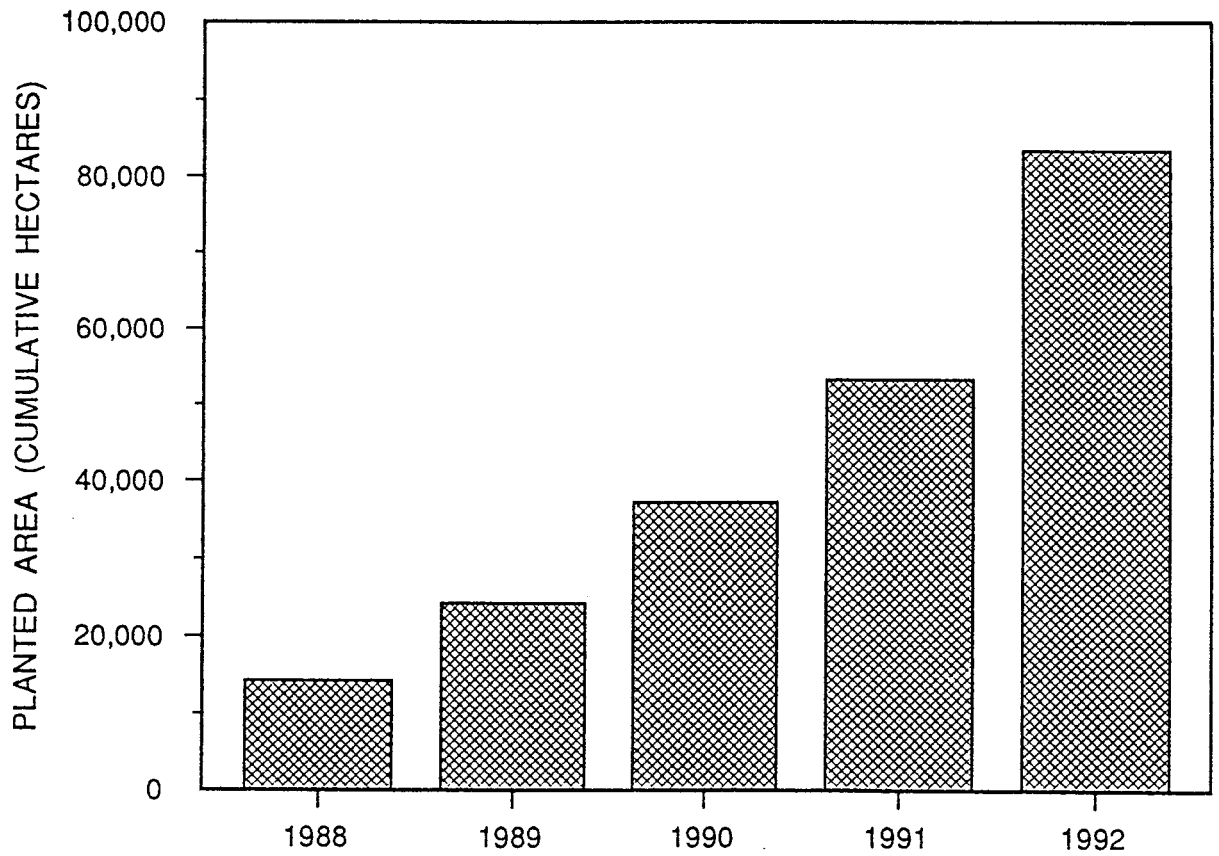

Figure 1. Small and medium-sized farm area planted with trees, 1988 through 1992, in Minas Gerais state and financed by private forestry companies [Oliveira, 1991]. The 1992 figure is a projection. The average growth rate from 1988 to 1992 is 35% per year. Farm area under trees established before 1988 is not shown. Also, planted areas established with public funding are not shown.

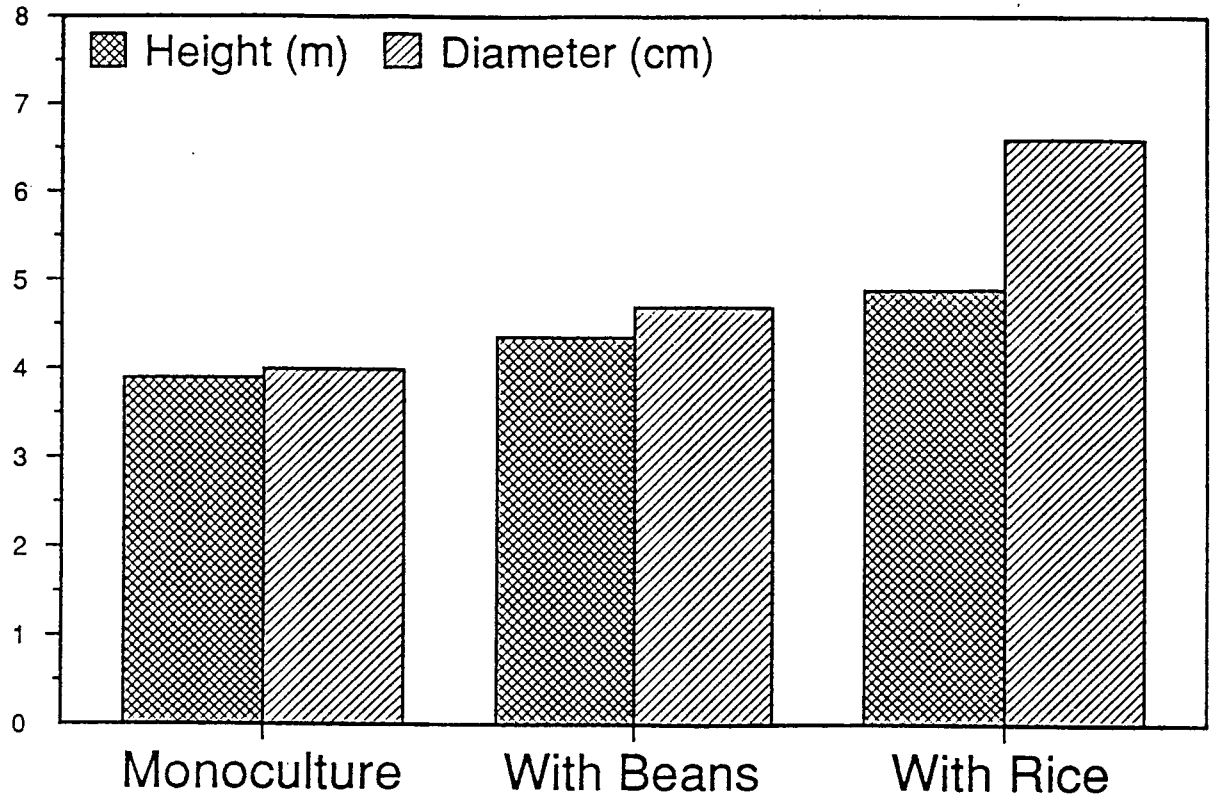

Figure 2. Height and diameter of *Eucalyptus camaldulensis* one year after planting in a monoculture and in agroforestry configurations with beans or rice in experiments of Pains Florestal. These are results of small-scale trials in central Minas Gerais state. Source: see footnote 2.

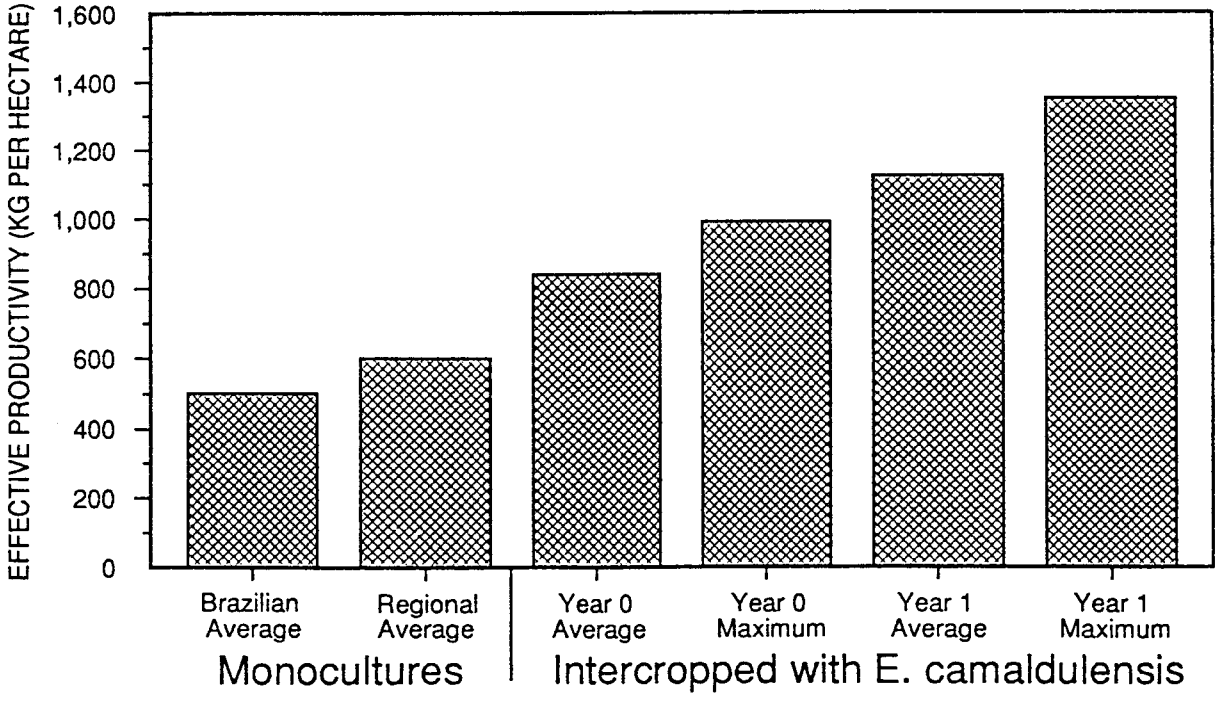

Figure 3. Comparison of effective yields (see footnote 3 for definition) of beans in monoculture and when intercropped with *Eucalyptus camaldulensis*. The monoculture yields are the average for Brazil and for the central Minas Gerais region. The intercropped results are from small-scale trials in central Minas Gerais state (see footnote 2). Year 0 refers to the year of planting of the *E. camaldulensis*. Year 1 refers to the year after planting.

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