The text that follows is a PREPRINT.

Please cite as:

Fearnside, P.M. 1989. The charcoal of Carajás: Pig-iron smelting threatens the forests of Brazil's Eastern Amazon Region. Ambio 18(2): 141-143.

ISSN: 0044-7447

The original publication is available at: <Ambio>

THE CHARCOAL OF CARAJÁS: PIG-IRON SMELTING THREATENS THE FORESTS OF BRAZIL'S EASTERN AMAZON REGION

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28 April 1988

ABSTRACT

Brazil's Grande Carajás Program threatens to consume large areas of tropical forest in the eastern Amazon region as raw material for charcoal used in smelting pig-iron. Special fiscal incentives have been granted to the smelters, the first of which began operation in January 1988. Plans for sustainable production of charcoal (either from management of native forests or from plantations) are unlikely to be implemented in practice. The term "forestry management" is being applied to clearcutting or near-clearcutting systems that are both environmentally damaging and unlikely to prove sustainable. The pig-iron scheme is made possible by the Carajás mine and railway that were financed by the World Bank. The events at Carajás suggest ways that environmental safeguards could be strengthened both by Brazilian government agencies and by the World Bank.

THE CARAJ°S PIG-IRON PLAN

A part of the ore from Carajás, the world's largest high-grade iron deposit, is to be transformed into pig-iron in a series of smelters planned or presently under construction, in accord with a massive plan under the Grande Carajás regional development program. The Grande Carajás Program (PGC) administers fiscal incentives and other developments in the eastern part of the Brazilian Amazon Region (1). The PGC area, with approximately 900 000 km^2, was expanded in 1985 from its previous 840 000 km^2 by including the full area of all municípios intercepted by the eighth parallel (which previously served as the southern boundary). The agricultural sector of the Grande Carajás program is described in a six-volume report known as "PGC-Agrícola" (2).

The agricultural portion of the Grande Carajás plan, when first announced in 1981, called for US$ 11.1 thousand million, US$ 1.3 thousand million of which were destined for silviculture. The scale of the investments proposed for the agriculture sector decreased in subsequent revisions of the plan. PGC-Agrícola of 1983 foresaw a total budget for direct investments of US$ 1.18 thousand million. Since 1983 many of the agriculture and ranching projects described in PGC-Agrícola have not materialized on the proposed scale due to the absence of the major international financing originally expected for the program. Even so, the silvicultural portion, whose purpose is to supply charcoal to the pig-iron smelters, is still going forward on a massive scale.

By May 1986 the Grande Carajás Interministerial Council had approved incentives for seven pig-iron plants, two iron alloy plants and two cement factories, all planned to function with charcoal. These 11 enterprises will demand 1.1 million metric tons of charcoal annually (3, 4). Francisco Sales Batista Ferreira, the present Executive Secretary of the Grande Carajás Program, stated in May 1986 that projects awaiting approval would bring the total number of pig-iron plants to 20, and that it had not yet been decided, even for those already approved, if the charcoal will be supplied by Eucalyptus plantations or from the native forest. PGC officials have reportedly also said that a total of 30 pig-iron plants are planned (5).

The PGC-Agrícola plan opens the possibility of the areas slated for charcoal production being greatly expanded at a future date. The document states that "with regard to the private sector, there is great expectation and interest in the field of charcoal brickette making for the export market," and admits that "in the future these numbers (for charcoal production) could increase either as a result of the installation of industrial plants that use firewood or charcoal... or by expanding the processing industries" (6).

The history of the Grande Carajás program illustrates a general pattern in development planning in Amazonia. The program has been presented to the public as an evolving series of trial balloons, in the form of "preliminary" reports and oral proposals. These have met a steady stream of criticism, but spokespersons for the plan can always respond to such criticisms by saying that the plan in question is no longer current, even though the basic structure of the Grande Carajás Program remains unchanged (7).

SILVICULTURE

One important area of vagueness in the Grande Carajás plan is the extent to which the program will carry out the grandiose plans declared for charcoal production from native forests and from silvicultural plantations. In 1982, at a meeting of the Brazilian Society for the Progress of Science (SBPC) in Campinas, SΓo Paulo, a plan was announced by Nestor Jost, then Executive Secretary of the Grande Carajás Program. The plan called for 2.4 million hectares of Eucalyptus plantations along the Carajás-Ponta da Madeira (SΓo Luis) railway route. The plantations would be distributed in a series of properties of 10 000 ha each. In addition to silviculture, charcoal would be obtained from native forest throughout the Grande Carajás zone. The charcoal would purchased from local residents, including caboclos and even indigenous groups, in a network of collection points spread over the PGC region, according to the plan announced by Nestor Jost (8). Technical reports of the current plan specify collection from small farmers, but do not mention indigenous groups (3, 9).

Prior to the current PGC-Agrícola document, a report of the charcoal plan written by the Ministry of Mines and Energy in 1981 declared that 180 000 ha of trees would be planted anually for eight years, which would give a total plantation area of 1 440 000 ha (rounded to 1.5 million hectares in the report). PGC-Agrícola's plans for silvicultural plantations are not clear, but since the original budget of 1981 of US$ 1.36 thousand million for silviculture is larger than the entire budget for PGC-Agrícola in the 1983 document, one can infer that the 3.6 million hectares designated for "charcoal" in the PGC-Agrícola plan of 1983 would not be utilized to accomodate the 1.5 million hectare Eucalyptus project described in the original proposal (1).

The present plans imply an area of Eucalyptus unprecedented in the tropics. To feed the 20 pig-iron plants planned plus the other types of industrial projects already approved would require annually 2 396 230 metric tons of charcoal (Table 1). Assuming the mean yields obtained in commercial plantations of Eucalyptus deglupta in the Jari Project, one can calculate that over 700 000 hectares of Eucalyptus would be necessary, or almost ten times the area of managed plantations at Jari (Table 2). Just the projects already approved represent 323 000 ha or 4.3 times Jari's managed plantations. Silviculture on this scale would be subject to substantial risks of diseases, insects and soil degradation, as is the case at Jari (10-13).

Because of the high cost of silvicultural plantations, it is likely that charcoal will come from cutting native forest as long as accessible forests exist. A map of the areas zoned for supplying charcoal (Figure 3) indicates the vast extent of areas potentially affected. Using the conversion factor adopted by SEPLAN/PGC/CODEBAR/SUDAM for "steres" (units of firewood equivalent to piles of 1 · 1 · 1 m of wood in the form of logs) of 420 kg (for dry native wood), the 10 418 390 metric tons of dry wood to be used annually (Table 1) would represent a pile of native forest logs occupying 24 805 690 m^3. If this were in the form of a building with a base of 100 · 100 m, it would be 2481 m high, or 620 stories! If this wood were obtained from clearcutting dense forests only, it would consume 50 000 ha · $year^{-1}$; 72 000 ha would be consumed yearly if all of the forest types present in the Grande Carajás Program area were cut in the proportions in which they occur (Table 3). Just the 11 industries already approved would consume annually a pile of logs equivalent to a 281 story building--requiring 23 000 ha of dense forests or 33 000 ha of forests of all types. Although

the Grande Carajás zone's forests are now much reduced from the areas of the early 1970s shown in Table 3, many years would still be required to convert them all to charcoal. Nevertheless, the pig-iron plan would add a new and particularly relentless force to those already driving deforestation in the region.

FORESTRY MANAGEMENT

The PGC-Agrícola document states that the "implantation of charcoal-making facilities in a 40 km strip along the Serra dos Carajás-Ponta da Madeira railway would encompass an area of 3.6 million hectares" (14). It is unclear how much of this area would be composed of silvicultural plantations and how much of "forestry management."

Forestry management applies to an area much larger than the 3.6 million hectares mentioned in the charcoal plan along the railway. The term "forestry management" appears to be employed by the authors of PGC-Agrícola merely as a euphemism for using the biomass of the forests as they are clearcut, instead of any sustainable management system that maintains the forest canopy intact. The document states: "Forestry management for energy production will be executed primarily along the Serra dos Carajás-Ponta da Madeira railway and in the areas designated for mining and ranching, with use of the woody material coming from removal of the forest cover, covering about 15 million hectares" (15).

General statements in the PGC-Agrícola document that "timber exploitation should be conducted in the direction of sustained management of the forest" (16) appear to have few corresponding specific plans for implementation and no allocation in the budget included in the report. An especially difficult problem in implanting sustained forestry management systems is that the discount rates used in financial calculations are much higher than the biological rates that limit the growth of forest trees. In the case of PGC-Agrícola, the opportunity cost of capital of 6% per year, in real terms, is used as the basis for evaluating internal rates of return computed for the agricultural production systems in the program (17). Native forests can only grow at much less than the critical level of one-half of this rate, indicating that some modification of the system of economic rewards would have to be invented if sustainable management is to become attractive to landowners (18).

Like plantations, managed forests will also lose nutrients in the exported biomass and through leakage from the system. These nutrients must either be replaced through inputs of fertilizers or the system will become unproductive. One calculation of nutrient exports concludes that a maximum of three rotations could be had, limiting the time period for use without fertilizer inputs to 40 years (19). The cost of replacing lost nutrients is not included in the management plans.

Florestas Rio Doce--the forestry subsidiary of the Companhia Vale do Rio Doce (CVRD) mining company undertaking the Carajás iron project--initiated a forestry management experiment for charcoal production in 1983 at Buriticupu, MaranhΓo. The scheme involves removing the smaller trees (better for making charcoal), together with the understory, in plots exploited at varying intensities (20-24). The experiments include treatments with clearcutting and with heavy exploitation that leaves only a few scattered trees in an otherwise clearcut field. Carlos Eugenio Thibau, president of Florestas Rio Doce and

designer of the study points with enthusiasm to rapid growth of secondary vegetation in the clearcut and near-clearcut treatments. The propriety of considering as "forestry management" a practice that removes all of the forest is questionable.

The Buriticupu forestry management experiments have great potential impact on deforestation in the region because of legal and semantic questions regarding "forestry management," plus the tremendous demand for charcoal implicit in pig-iron production schemes being implanted for processing ore from Carajás. Brazil's 1965 Forestry Code (Decree Law 4771, Article 44) requiring that 50% of any property remain under natural forest cover has been reinterpreted by IBDF (Normative Instruction 302 of 3 July 1984) to allow clearing for annual crops or pasture in 20% of each property and "forestry management" in the remaining 80% (Decree Law 7511 of 7 July 1986 modified this by prohibiting deforestation completely, but allows "forestry management"). If "forestry management" is interpreted to include clearcutting followed by leaving the area to secondary vegetation, even if (at least theoretically) with a view to subsequent harvests, then the legal obstacles will be removed to rapid deforestation for charcoal production in private lands and in concessions granted to firms exploiting Brazil's national forests. The possibility of carrying out "forestry management" for charcoal production, patterned after the Buriticupu trials, has been considered for the Gurupé National Forest. Adopting the term "forestry management" as a euphemism for clearcutting would speed this process (24).

Because no decision has been made on the source of charcoal for industries already approved, it is clear that a prior evaluation of environmental impacts was not a prerequisite for approval. Once the investment has been made in an expensive installation such as a pig-iron plant, the plant will play a role similar to a cuckoo in the nest. When a cuckoo lays an egg in another bird's nest, the unfortunate host soon finds itself diverting all of its efforts to providing food for the enormous cuckoo chick. In the same way, the forests and the entire economy of the areas around the pig-iron smelters will be irresistibly drawn into feeding these plants with charcoal, regardless of the local population's own interests (7).

The force of the charcoal market created by installing the pig-iron plants is likely to be strong enough to motivate destroying the native forest in a wide radius around the smelters, but not so strong as to justify the inputs needed to produce the charcoal sustainably. In order to make production from plantations financially attractive, the price of pig-iron would have to increase substantially, probably at least doubling. The pig-iron firms could write off their investments over the period when the native forest is being felled, and abandon the area thereafter. The first smelter to operate (Siderúrgica Vale do Pindaré, in Açailândia, MaranhΓo) cost US$ 7 million to install. The most expensive item is the concrete foundation. The above-ground parts wear out after relatively short useful lifespans: from three years for the refractory brick structures to seven years for the furnace itself. The possibility of the pig-iron entrepreneurs in Carajás moving elsewhere after exhausting the cheap native wood source is suggested by the history of pig-iron plants in the Brazil's state of Minas Gerais: establishment and closing down of plants has followed a cyclic pattern in response to fluctuations in pig-iron prices.

The challenge of implanting sustainable production systems for charcoal supply is much more difficult than that of simply smelting pig-iron. The importance of tax and other

incentives from the Grande Carajás Program can be expected to attract firms with little competence or desire to take on plantation or forest management schemes that are technically complex, uncertain, costly and slow. Many of the firms have no experience in pig-iron or charcoal production: they are companies that have had construction or other contracts in the Carajás area and had thereby found themselves in the position to enter the lucrative Grande Carajás fiscal incentives program. The inexperience of the first firm to begin operations (Siderúrgica Vale do Pindaré, a subsidiary of Construtora Brasil S.A., also known as E.C.B.: Empresa de ConstruçΓo Brasil), which had paved the streets of Marabá and had done construction work for CVRD, is indicated by a costly mistake: the first crucible full of pig-iron was allowed to cool and solidify before pouring into the ingots.

The pig-iron firms and the government agencies that regulate them appear to accord a low priority to assuring the long-term supply of charcoal to the smelters. The coordinator of planning for the Grande Carajás Program says that the pig-iron firms are required to produce 25% of their charcoal needs beginning in the sixth year of operation, and 50% beginning in the tenth year (25). The plantations or forestry management areas that would supply even this fraction of the demand are not being implanted in practice. Apparently none of the firms are seriously considering plantations. A plan for forestry management, approved by the Brazilian Institute for Forestry Development (IBDF), is a requirement for startup. The first pig-iron smelter --Siderúrgica Vale do Pindaré--began operation on 8 January 1988 in Açailândia. The firm had an approved forestry management plan, but had not yet purchased a tract of forest on which to implement it. The sustainability of any management scheme is questionable if the plans are so general that information on the forest and other features of a specific location are unnecessary.

The beginning of pig-iron production in January 1988 represents a blow to Brazil's fledgling efforts to regulate development projects so that environmental damage is avoided. Incentives from the Grande Carajás Program were approved for the smelters after 23 January 1986 when Brazil's National Council of the Environment (CONAMA) established resolution No. 001 to operationalize Federal Law No. 6938 of 31 August 1981 by requiring environmental impact statements (RIMAs). No RIMA had been approved for any of the smelters when operation began (26).

THE ROLE OF INTERNATIONAL LENDING AGENCIES

The World Bank viewed its participation in CVRD's Carajás Iron Project as a model of "environmental progress" (27). The charcoal scheme that has been made possible by the iron project's infrastructure has recently become the focus of intense criticism (28, 29). The scheme illustrates four problems in controlling the environmental impact of development projects:

1.) The environmental safeguards of the World Bank-financed iron project apply to a "zone of influence" that is much more limited than the zone really affected by the undertaking and its offshoots. The CVRD iron project applies only to the 489 000 ha area around the mine, a 40 km strip along the Carajás-Ponta da Madeira Railway and a small area around the port near SΓo Luis; most of the Grande Carajás Program (PGC) that the mine and railway made possible lies outside of this zone.

2.) The total impact of many relatively small operations, such as the pig-iron smelters, may be tremendous even though each one is smaller than the undertakings usually considered in World Bank loan agreements.

3.) While the environmental program and procedures established by CVRD are designed to minimize the damage caused directly by the company, the many impacts of third parties are often not covered by these safeguards. Because the smelters will be located within the strip along the Carajás-Ponta da Madeira Railway, environmental requirements in the World Bank loan agreement for the CVRD Iron Project may apply to these third parties. While the issue remains unresolved as to whether the letter of the agreement has been violated, its spirit has undeniably been flaunted.

4.) The World Bank's procedures so far give it little leverage in inducing compliance with the environmental clauses in its loan agreements. As long as the maximum penalty for noncompliance remains the threat of suspending disbursements of the loan in question, the consequences of noncompliance dwindle rapidly as completion of loan disbursements approaches and evaporate virtually completely after the last installment is received. Environmental safeguards would be taken much more seriously if noncompliance for any given loan resulted in loss of other unrelated projects throughout the country.

The Brazilian government now hopes to secure World Bank funding for construction of the North-South Railway (30). The planned 1600 km railway linking Açailândia with Anápolis in the state of Goiás poses a formidable obstacle to having a genuine analysis of the costs and benefits of the Carajás charcoal scheme because preparations for the government to sign contracts with construction firms are going forward at all possible speed. After spending an estimated US$ 2.4 thousand million on building the railway (31), pressure will be virtually irresistible to forget about any environmental or even agronomic problems associated with the charcoal plans. It is clear that Brazil's requirement of an Environmental Impact Report (RIMA) has not been an impediment to steps that will soon make the railway a fait accompli. These developments have likewise been unimpeded by the lack of studies on the sustainability and impacts of producing the fundamental input for processing any pig-iron that might be transported: the charcoal of Carajás (39).

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39. An abbreviated version of this paper is to appear in Portuguese (32). Portions of the text have been adapted from (1, 7, 24). I thank Summer Wilson for comments on the manuscript.

TABLE 1: CHARCOAL DEMAND IN THE PROJECTS APPROVED IN CARAJÁS

Activity	Location	Company	Nominal demand (metric tons $year^{-1}$)
Pig-iron	Marabá	Construtora Beter, S/A[a]	5 000
		Itaminas Siderúrgica de Carajás, Ltda.	240 000
	Açailândia	Construtora Brasil, S/A	50 000
		Serveng Servisan, S/A	70 000
		Viena Siderúrgica do Maranhão, S/A	30 000
		Gusa Nordeste, S.A. (Florice)	40 000
		Itaminas Siderurgica do Carajás, Ltda.	240 000
SUBTOTAL FOR PIG-IRON:			705 000
Iron alloy	Parao-pebas	Prometal-Produtos Metalúrgicos, S/A	250 000
	Marabá	Ferro Ligas do Norte, S/A[a]	50 000
SUBTOTAL FOR IRON ALLOY:			300 000
Cement[b]	Cod'	Itapicuru Agroindustrial, S/A	26 000
	Capanema	CIBRASA, S/A	56 000
SUBTOTAL FOR CEMENT:			82 000
TOTAL FOR APPROVED PROJECTS:			1 087 000
ADDITIONAL DEMAND IF THE NUMBER OF PIG-IRON PLANTS IS INCREASED TO 20, IN ACCORD WITH THE PLAN:			1 309 230
TOTAL DEMAND:			2 396 230

(a) Construtora Beter pulled out of the pig-iron plan in 1987. Ferro Liga Norte may also have pulled out of the plan (not yet confirmed). These two withdrawals, totalling 85 000 metric tons of charcoal demand per year, would be more than compensated for by the demand of Companhia Siderúrgica do Pará (COSIPAR), a ferro-gusa smelter in Marabá not listed in the table. COSIPAR's initial demand of approximately 115 200 metric tons of charcoal per year will increase to approximately 576 000 metric tons·$year^{-1}$ if a second-phase plan is implemented (33; demands estimated using 3.2 m^3

charcoal·metric ton^{-1} of pig-iron; 0.30 metric ton charcoal·m^{-3} of charcoal). COSIPAR began smelting in March 1988.

(b) This assumes that the cement factories will continue to use powdered charcoal as an energy source. The total demand may be slightly lower if the Carajás cement factories follow the example of the factories in Belém and Manaus that originally were designed to operate with charcoal but converted to oil when the price of this input fell to low levels in 1986-87. The eventual dwindling of global fossil fuel stocks should restore the attractiveness of charcoal at some future date.

TABLE 2: CHARCOAL DEMAND FOR GRANDE CARAJÁS COMPARED TO YIELDS AT JARI[a]

Information on Grande Carajás charcoal scheme:	
Number of pig-iron plants approved[b]	7
Annual charcoal demand for the pig-iron plants already approved (see Table 1):	705 000 metric tons
Mean charcoal demand per plant	100 710 metric tons
Total number of pig-iron plants planned:	20
Conversion efficiency of wood to charcoal (mean of 4 conventional methods)[c]	0.23 metric tons of charcoal metric ton^{-1} of dry wood
Information on the Jari Project:	
Mean yield of Eucalyptus deglupta at Jari (dry weight)	14.65 metric tons ha^{-1}.year^{-1}
Area of managed plantations at Jari	75 043 ha
One can calculate:	
Annual demand for charcoal (see Table 1)	2 396 230 metric tons
Annual demand for wood (dry weight)	10 418 390 metric tons
Area of Eucalyptus plantations required	711 152 ha
Number of times the area of the plantations at Jari necessary to supply approved and	9.5 times

planned plants

(a) Source: (10)

(b) These are the seven plants described in (3). The Executive Secretary of the Grande Carajás Program (PGC) stated in May 1986 that eight plants had already been approved (34). The eighth plant is probably Companhia Siderúrgica do Pará (COSIPAR) in Marabá.

(c) Circular metallic kilns (0.19), rear-fired ("hot-tail") ceramic kilns (0.20), and ceramic surface kilns with 5 m diameter (0.27) and 8 m diameter (0.24). Tunnel kilns still under development can reach an efficiency of 0.33, but they are not used commercially anywhere in Brazil--even by the steel companies in Minas Gerais that themselves manufacture the expensive metal plates used in the tunnel walls.

TABLE 3: FORESTS IN THE GRANDE CARAJÁS ZONE

Forest Type	Area present (km^2) (a)	Area present (% of forested area) (a)	Logs obtained on clearcutting (steres·ha^{-1}) (b)	Kg· $stere^{-1}$ dry weight (c)	Wood dry weight usable for charcoal (metric tons ha^{-1})
Dense forest	406 981	54.3	400	520	208.00
Open forest	96 688	12.9	245	487	119.32
High scrub cerradão)	28 648	3.8	195	420	81.90
Scrub forest (cerrado)	111 907	14.9	120	390	46.80
Secondary forest (capoeira)	105 014	14.0	105	385	40.43
Weighted mean for all forest types					144.17

(a) source: (35, based on 36). Uses 895 263 km^2 area approximating PGC zone prior to slight enlargement in 1985. Total forested area = 749 238 km^2; nonforested area = 146 025 km^2.

(b) source: (37). One "stere" = stacked logs occupying 1 m^3.

(c) source: (37); Value for native forests as a whole = 420 kg·stere^{-1} dry weight (38).

FIGURE LEGENDS

Figure 1 -- The Grande Carajás program zone.

Figure 2 -- The railways and charcoal project locations.

Figure 3 -- Zoning for charcoal production as a function of transportation (redrawn from: (38)). The potential for large-scale deforestation is evident.

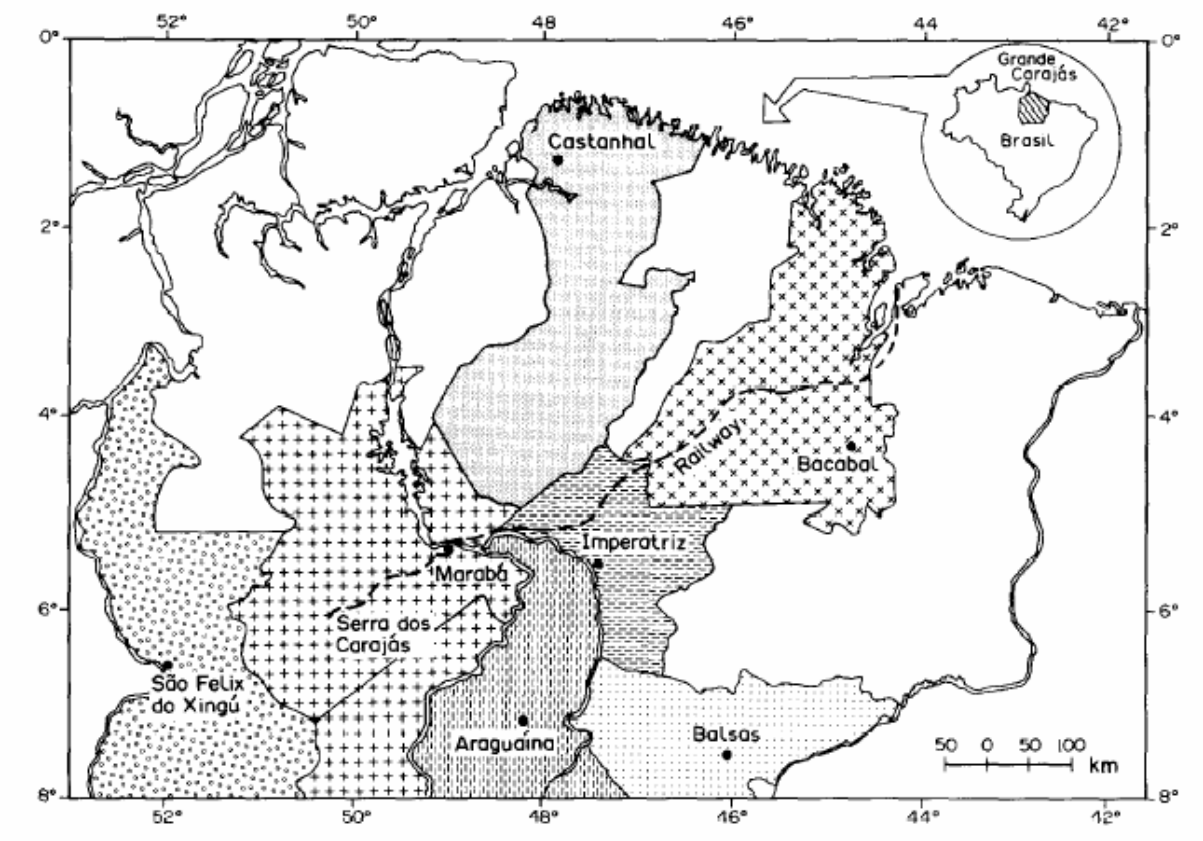
Photograph 1 -- Experimental kilns for charcoal making in Buriticupu, Maranhão.

Photograph 2 -- Kilns on a ranch in Açailândia supplying charcoal to the pig-iron smelters. Note that logs from the forest are being used, not sawmill scraps as claimed by the Grande Carajás Program.

Photographs 3-4 -- Pig-iron smelting in Açailândia began in January 1988, before environmental impact statements had been approved.

Photograph 5 -- Construction firms without experience in smelting have been attracted to the fiscal incentives program. The first batch of pig-iron cooled and solidified in the crucible --an expensive mistake. Firms attracted by fiscal incentives are unlikely to succeed in the more difficult task of managing the forest sustainably for wood production.

Fig. 1


52°
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Grande Carajás
Brasil
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Bacabal
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