Artigos

Economic activities and deforestation in Brazil's Carajás region. Examining production deforestation linkages

Maria José Willumsen*
Robert D. Cruz†
Annick Trottier§

ABSTRACT

This paper assesses the impacts of productive activities on macroeconomic conditions and deforestation using a two-region CGE model. The object of study is the interaction between productive sectors (especially agriculture, livestock, timber and pig iron) and deforestation in the Eastern Amazon region of Brazil. This region, also known as the Carajás Corridor, has experienced rapid growth and settlement over the last three decades. Over this same period a significant portion of its natural resources (particularly forest) has been depleted.

The growth simulations reveal that expansion and development of the metals sector only indirectly result in higher levels of deforestation by stimulating the expansion of agriculture and livestock production. The expansion of agricultural activities results in sufficient wood by-products to meet the greater demand for charcoal production caused by development of the metals sector.

Key words: Carajás, Carajás metallurgy complex, deforestation, regional growth.

RESUMO

Esse artigo avalia os impactos das atividades produtivas nas condições macroeconômicas e no desmatamento usando um modelo CGE para duas regiões. O objeto de estudo é a interação entre os setores produtivos (especialmente agricultura, pecuária, madeira e ferro gusa) e desmatamento na região leste da Amazônia brasileira. Essa região, também conhecida como o Corredor de Carajás, experimentou um rápido crescimento e povoamento nas últimas três décadas. Nesse mesmo perídoo, uma parcela significativa de seus recursos naturais, florestas em particular, foi exaurida.

As simulações realizadas revelam que o desenvolvimento da metalurgia só indiretamente conduz a um nível mais elevado de desmatamento ao estimular a expansão da agricultura e da pecuária. A expansão das atividades agrícolas gera como sub-produto madeira suficiente para atender a demanda crescente da produção de carvão causada pelo crescimento da metalurgia.

Palavras-chave: Carajás, complexo metalúrgico de Carajás, desmatamento, crescimento regional.

* Department of Economics - Florida International University, Miami, FL 33199.

† Andreas School of Business - Barry University, Miami Shores, Florida

§ Department of Economics - Florida International University, Miami, FL 33199.

Introduction

Public opinion, governments and world organizations have become increasingly concerned with the links between economic activity and environmental quality, and various studies attempting to model this issue have recently appeared in the academic literature Persson and Munasinghe (1995), Gibson (1996), Panayotou and Sungsuwan (1989), Southgate, *et al* (1991) and Osório and Campari (1995)). This has been particularly true in the case of the Brazilian Carajás Corridor. International investment spending has also become increasingly sensitive to long run environmental impacts, potential changes in government policies, the potential reactions of environmentally conscious consumers, and their implications for the overall risk to capital. While transnational firms have shown considerable interest in investing in the Carajás Corridor, much of that investment has not been realized in part because of uncertainty over the direct and indirect environmental impacts of such investment.

In 1967 U.S. Steel discovered the world's second largest deposit of strategic minerals (iron, manganese, copper, tin, nickel, aluminum and others) in the Carajás highlands of Pará, Brazil, in the eastern portion of the Brazilian Amazon region. The mine was later sold to Companhia Vale do Rio Doce (CVRD), at the time a state-owned steel company but recently privatized. Soon after its acquisition, CVRD planned the construction of a US$3.5 billion project composed of: 1) urban and mining infrastructure in the Carajás area; 2) a large capacity and modern deep-water (300,000 tdw) harbor, located at São Luís, 560 miles away from the mines; and 3) a railroad connecting the mines to the harbor, providing cheap transportation for minerals, essential to secure CVRD's international competitiveness. This project was called *Projeto Ferro Carajás*, or simply *Projeto Carajás*, PC (The Carajás Project), and its construction began in the early 1980s.

In the mid-1980s, with the completion of the Carajás Project, the Government created the *Programa Grande Carajás* (Greater Carajás Program) for the planning of the region's development. Between 1985 and 1987 thirteen independent pig iron firms received government authorization to operate. The first of these firms began operations in 1988. Six plants are currently in operation, with a total production capacity of 750,000 tons per year. A 100,000 ton per year plant is to begin operation in 1997. Five other plants received authorization to operate, but could not meet the deadline for their installation and had their licenses rescinded in 1990. Another plant was ordered closed for not complying with the current environmental legislation. Since then, no other plants have been licensed.

Environmental assessments of the Carajás Iron Ore Project focused mainly on its direct effect within the area under the control of CVRD. While these analyses were careful and the resulting mitigating measures generally effective, they did not extend beyond the immediate project area.

As a result, they failed to anticipate much of the substantial induced development caused by the project which, through the Carajás railway and road investments, greatly improved physical access to extensive parts of the region. This and other factors led to intensified in-migration by loggers, ranchers, prospectors, small farmers, land speculators, urban settlers, and other groups, with significant environmental and social impacts including rapid deforestation.[1]

After 1987 the international community began to express strong concern over the impacts of the Carajás project on the region's deforestation, especially the impact of the pig-iron industry. The Carajás metallurgicy complex became the "culprit" for deforestation in the Amazon. The industry's environmental reputation played a major role in the failure to complete the planned metallurgical complex. Foreign capital shied away from financing activities related to the expansion of the industrial complex. Moreover, the Brazilian government, through the Greater Carajás Program, prohibited the expansion of pig-iron production by firms that could not prove self-sufficiency in charcoal production originating in cultivated forests. Since reforestation has not yet been tested in the region on a commercial scale, pig-iron production continues to be restricted and to rely primarily on charcoal produced from agriculture and lumber industry residues.

Iron-ore production continues to be primarily exported, precluding the emergence of inter-industry linkages and the diversification of the regional economy in ways that would support the region's economic growth.

By 1991 the population of the Carajás Corridor reached 7.3 million, more than 50 per cent under the age of 14 (IBGE, 1993). Approximately 57 per cent of the population live in rural areas, in contrast with 25 per cent at the national level. This high level of rural population underscores the importance of agriculture. Annual rates of population growth are still high (4.6 per cent per year), even by Brazilian standards. Population projections put the region's population at 11 million by the year 2010 (Sawyer, 1994).

The process of settlement and economic growth was accompanied by deforestation of large areas. In the 1980s, deforestation reached alarming proportions. Data collected by Brazil's National Institute for Space Research (INPE, various issues) reports that the total surface area deforested between 1978 and 1987 increased sharply. An area of 54,600 km^2 had been deforested in the Legal Amazon in 1978, while in 1988 the area of deforestation reached 280,000 km^2. In the states of Maranhão, Pará and Tocantins, which make up the Carajás Corridor, the extent of deforestation jumped from 128,000 km^2 in 1978 to 253,000 km^2 in 1988. An average of 12,500 km^2 per year of forest was lost in this region alone. Annual rates of gross deforestation seem to have reached their peak in the second half of the 1980s and have tapered off since then. In 1970

[1] A.Ozório de Almeida and J.S. Campari (1995) provide an extensive description of population and economic shifts in this area during the 1980s and explores the factors determining the decision of settlers to deforest the land.

approximately 12 per cent of the region's forest areas had been cleared, but by 1985 this proportion had reached just over 25 per cent. Some progress has been made in controlling the rate of deforestation. In the period 1990-91, the gross rate of deforestation was 0.3 per cent per year, well below the 0.54 average rate observed during the 1978-88 period. The pace of deforestation in the Carajás Corridor fell to an annual average of 6,200 km^2 between 1988 and 1994. The rate of deforestationis still alarmingly high, however.

Deforestation of Tropical Forests in the Carajás Corridor
Area in thousands of Km^2

State	Total Area	Original Forest Area	Forest in 1994	Pace of Deforestation			
				Prior to 1978	1978 to 1988	1988 to 1994	Total to 1994
Maranhão	325	155	38	80	34	3	117
Pará	223	213	85	24	74	30	128
Tocantins	277	58	13	24	17	4	45
Total	825	426	136	128	125	37	290

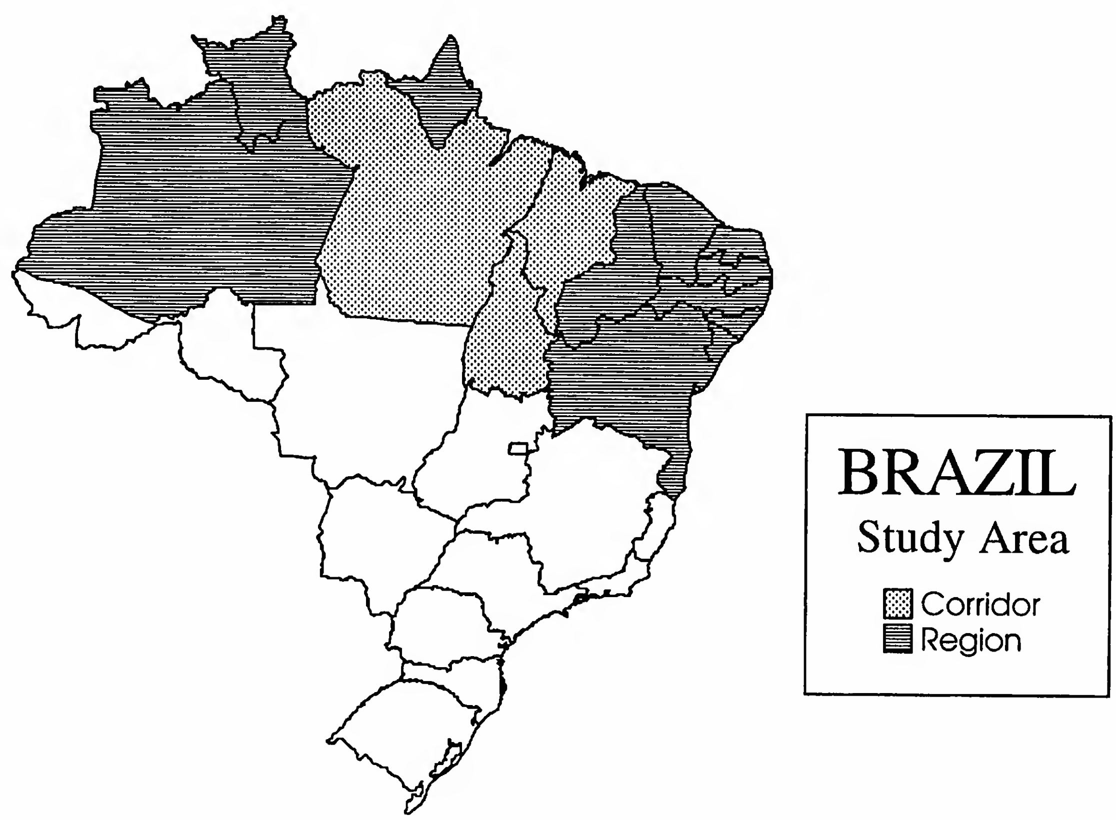
Source: INPE, Instituto de Pesquisas Espaciais. "*Deforestation in Brazilian Amazonia*", several bulletins (1992, 1993, 1994).

The purpose of this study is to construct a two-region general equilibrium model to assess the effect of production activities on macroeconomic conditions and deforestation using a two-region CGE model. The area considered in this study represents the regions most affected by the Carajás project. The model permits the examination of the economic interaction among productive sectors, and the direct and indirect demand for commodities that result in deforestation. The design of the model was driven by the objective of evaluating the macroeconomic and deforestation effects of expanding and diversifying the production of metals within the region most directly affected by the Carajás railway. The simulations performed reveal the impact of alternative external demand shocks (changes in regional exports) and the impact of an alternative development strategy on the rate of deforestation.

Description of the economic/deforestation model

The model was built to represent the basic economic interactions between two regions in the North/Northeast of Brazil. The main region of interest is the Carajás Corridor, also referred as the

Corridor, made up of the most immediate area of influence of the Carajás Project. This is the area in which the Carajás project is located. It encompasses not only the smaller and more directly affected area around the Carajás railroad, but also a broader area under this project's influence. The totality of the states of Maranhão, Pará and Tocantins are included in this region. The other region is called Macro Region (also referred to as Region), and is composed of the remaining states of the North and Northeast regions. The CGE model is based on an inter-regional input-output model built by the authors. Economic output in the model is disaggregated into 47 industries: 8 agricultural sectors, 3 mining sectors, 22 manufacturing sectors, a construction sector, two public utilities (electricity and water) and 11 service sectors. It is assumed that the regions trade goods and services with one another and with the rest of Brazil and the rest of the world. The inter-regional export equations link the two regions' economies.



The variables appearing in the equations are defined as follows:

X_i^h, output of industry "I" in region "h"

I_i^h, investment spending

E_i^{hk}, exports of good "I" from region "h" to region "k"

G_i^h, government spending

E_i^{hB}, exports of good "I" from region "h" to the rest of Brazil

E_i^{hW}, exports of good "I" from region "h" to the rest of the world

T^h, transfer payments to households

C_i^{hk}, consumption of good "I" produced in region "h" and consumed in "k"

Y^k, household disposable income in region "k"

The parameters of the model are defined as,

a_{ij}^{hk}, intermediate input requirement - good "I" produced in h purchased by industry "j" in region "k"

λ_i^h, labor value added per unit of output in region "h" for industry "I"

κ_i^h, capital value added per unit of output in region "h" for industry "I"

τ_i^h, indirect tax rate for good "I" in region "h"

π^h, personal tax rate for households in region "h"

δ_i^h, share of capital income generated in industry "I" and retainedby region "h"

β_i^{hk}, propensity to consume good "I" produced in region "h" by households in region "k"

The core model is described by the following set of equations.

Industry output is demand determined in each sector according to the following equations.

$$X_i^h = \sum_j a_{ij}^{hh} X_j^h + E_i^{hk} + E_i^{hB} + E_i^{hW} + G_i^h + I_i^h + C_i^h$$

where h = {Macro Region, Carajás Corridor}

The endogenous expenditure components are inter-regional exports and household consumption. The inter-regional export equations are

$$E_i^{hk} = \sum_j a_{ij}^{hk} X_j^k + \beta_i^{hk} Y^k$$

where h = {Macro Region, Carajás Corridor}; k = {Macro Region, Carajás Corridor}; and h ≠ k. Intra-regional household consumer expenditures are determined by a set of simple expenditure functions:

$$C_i^h = \beta_i^{hh} Y^h$$

The household disposable income and regional GDP, respectively, are given by the following identities:

$$Y^h = (1 - \pi^h)(\sum_i \lambda_i^h X_i^h + \sum_i \delta_i^h \kappa_i^h X_i^h) + T^h$$

and

$$GDP^h \equiv \sum_i \lambda_i^h X_i^h + \sum_i \kappa_i^h X_i^h + \sum_i \tau_i^h X_i^h$$

The first extension to the core model is the addition of a set of equations that reflect deforestation activity. The production of charcoal requires wood inputs that are available from four sources. For each hectare of land area under forestry management approximately 10 m^3 of charcoal could be produced. The forestry sector produces wood for charcoal production as a by-product of its own activities. For each US$1,000,000 of sales from logging, enough wood by-product is produced to allow the production of 8,400 m^3 of charcoal (Rezende and Sampaio (1994)). The third source of material input for charcoal production originates from the clearing of land for the expansion of agricultural goods and livestock production. Each hectare of land area cleared for agriculture or livestock generates the material wood inputs necessary to support the production of 160 m^3 of charcoal production. If the material inputs necessary to produce the amount of charcoal demanded is not sufficient, then the fourth source of wood input is illegal deforestation. Approximately 100,000 m^3 of charcoal are produced for each US$1,000,000 of charcoal industry sales.

$$CHCAP = 10\ AREAMGT + 0.0084444(X_{xv}/e) + 160\,(DAGR + DLIV)$$

The amount of charcoal (in million m^3) that can be produced from legal sources of wood inputs is given by where AREAMGT represents the land area under forestry management in million hectares; X_{xv} is total output in wod by-products; "e" represents the exchange rate in 1993; DAGR is land cleared to support expansion of agriculture (in million ha); and DLIV is land cleared to support expansion of livestock production (in million ha). No wood for charcoal is currently produced under managed areas (AREAMGT = 0), but it remains a potentially important future source if necessary.

Historical data on land use patterns and agricultural and livestock output in the Carajás Corridor suggest that 7 km^2 of land is required to produce US$1 million of agricultural output, while 63.1 km^2 are needed to produce US$1 million of output in the livestock industry. The same data reveals that farmers and ranchers keep a considerable amount of idle land relative to the area of land actually utilized in production (Mueller, 1994). For each km^2 used in production, another 0.62 km^2 are left idle. As output in agriculture and livestock expands, more land is cleared and inputs for charcoal production are generated as part of this process. In the absence of changes in land productivity and the ratio of idle to utilized land area, the land cleared to support expansion of agricultural and livestock production is given by the following functions.

$$DAGR = 11.34\,(X^{t}_{AG} - X^{t-1}_{AG})/e$$

$$DLIV = 102.222(X^{t}_{LS} - X^{t-1}_{LS})/e$$

The amount of charcoal that cannot be produced from these legal sources of material inputs is given by the identity:

$$CHGAP = (X_{c} /e) - CHCAP$$

where X_c is the actual output of the charcoal industry and CHGAP$\geq$ 0. Approximately 110 km2 of forest is consumed for each million cubic meters of charcoal produced, and approximately 0.9 km^2 of forest area is consumed for each US$ million of output produced in the timber industry.

The deforestation identity (km^2) is given by

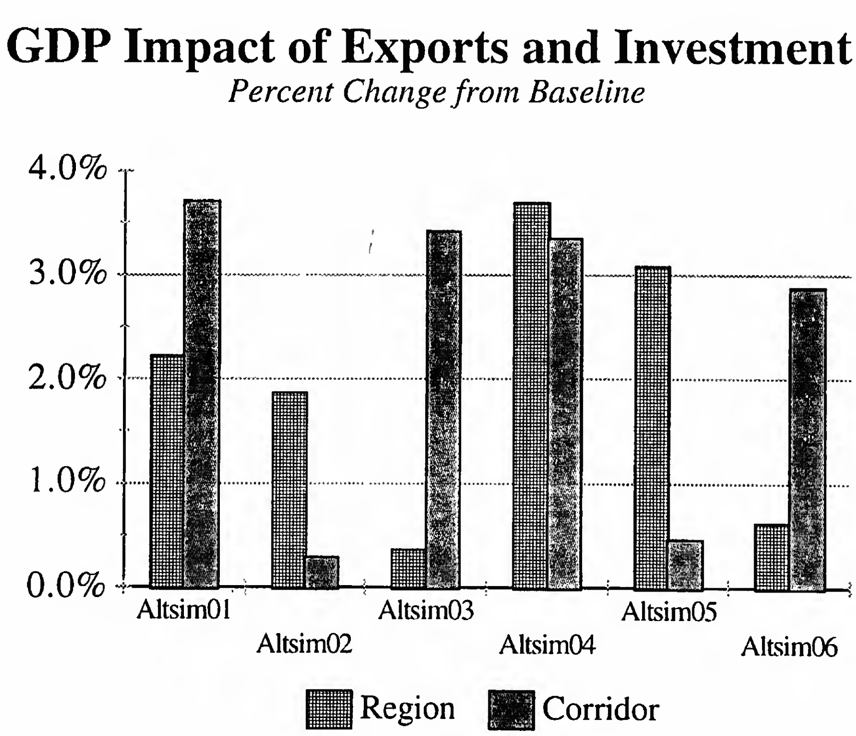
$$DEF = 0.89\,(X_{xv}/e) + DAGR + DLIV + 109.649\ \ CHGAP$$

Additional land area must be cleared as economic activities in the logging and agricultural sectors expand without a concomitant increase in land productivity. Similarly, economic growth leads to an increase in the demand for charcoal, and, unless the material inputs necessary for charcoal production are available from the clearing of land, forest management and by-products from the logging industry, additional forest must be cleared to satisfy the demand for charcoal.

Two sets of simulations were performed. The six simulation exercises were conducted in the first set to gauge the responsiveness of regional economies and regional deforestation to exogenous changes in final demand. The second set of simulations examine the marginal impact of alternative scenarios for the development of a metallurgical complex.

Sensitivity Analysis

Three simulations were performed to examine the effect of changes in regional exports. The first of those simulations (Altsim01 in the tables) examines the impact of an *across-the-board*, ten percent increase in exports to the rest of Brazil and the rest of the world. Gross regional product (regionally generated value added) increases by 2.3 percent in the Macro Region and by 3.5 percent in the Carajás Corridor The Carajás Corridor is a more export oriented economy than the Macro Region, hence the larger relative impact.[2] Household income increases by 2.1 percent in the Macro Region and by 3.4 percent in the Carajás Corridor (Table 1).



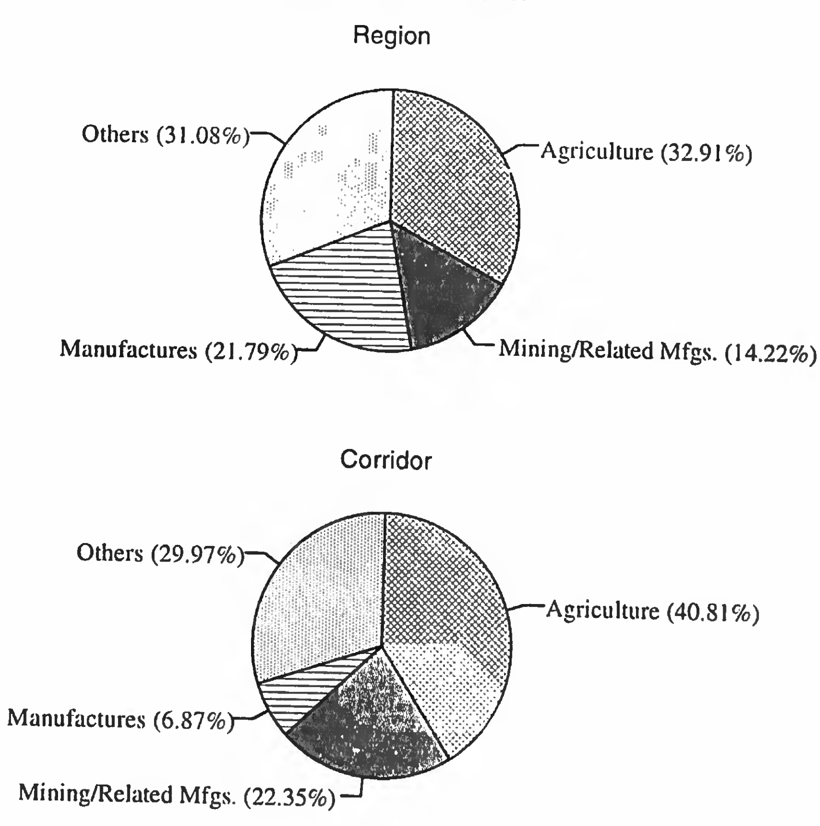
[2] The ratio of exports to GDP is 0.22 in the Macro Region and 0.62 in the Carajás Corridor.

In the baseline simulation nearly 17,400 km² of land area is deforested per year in both the Macro Region and the Carajás Corridor combined (Table 3). This area is consistent with the pace of deforestation witnessed in the late 1980s and early 1990s. In both the Macro Region and the Carajás Corridor the greatest amount of deforestation results from agricultural activities. The production of livestock accounts for between 70 and 80 per cent of the total area deforested. The residual by-products from these activities are more than sufficient to meet the needs of charcoal production activities that take place. This result is very sensitive, however, to the pace of economic growth in the agriculture and livestock sectors. The clearing of land originates from an expansion of economic activity in these sectors, rather than from the level of activity itself. That is, it is the growth of output that leads to additional clearing of land. Once production in these sectors stabilizes, there is no further need to clear land (provided land productivity does not decline).

The baseline simulation corresponds to 1993. In the early part of the 1990s the level and pace of economic growth in these sectors slowed considerably from the rates observed in the early to mid-1980s. In the absence of any growth in agricultural and livestock production, nearly 2.800 km² of forest would have needed to have been cleared in order to meet the needs of charcoal production in the baseline simulation. That rate of deforestation represents approximately one half the rate most recently observed. This last result highlights the need to develop either alternative energy sources to charcoal or a renewable supply of wood for charcoal once the region's agricultural and livestock sectors stabilize.

Composition of Exports

Baseline Data



When the economies experience a "balanced" increase in export demand, the resulting stimulus to the logging, agriculture and livestock sectors leads to an increase in the amount of land area cleared by these activities. The wood by-products from this land clearing process are then sufficient to meet the input requirements of charcoal production, even though the production (and export) of pig iron also increases by almost the same percentage. This result is obtained for both the Macro Region and the Carajás Corridor. In the Carajás Corridor the production capacity of charcoal from wood by-products increases by approximately 75 percent, while the actual demand for charcoal increases by nearly 8 percent. This result is due, in large measure, to the composition of exports which is highly skewed towards the exports of agricultural products, minerals and the manufacture of mineral related products (mainly metals).

Exports of agricultural products, minerals and related manufactures accounted for nearly one-half of the Macro Region's total exports and for approximately two-thirds of total exports from the Carajás Corridor. Exports of agricultural products alone accounted for one-third of the Macro Region's exports and 40 per cent of the Carajás Corridor's exports. Consequently, an increase in exports is largely directed towards exports of agricultural products, leading to an expansion of land under cultivation and deforestation. The residual by-products from the expansion of agriculture more than satisfy the input needs of the charcoal sector even in the face of increased production of pig iron.

An across the board increase in exports has a significant impact on deforestation. A 10 percent increase in exports from 1993 levels in both the Macro Region and Carajás Corridor results in an additional 28,400 km^2 of area deforested in the Macro Region and an additional 19,900 km^2 of area deforested in the Carajás Corridor. For each additional US$1 million of exports (at constant 1993 prices) 43 km^2 of forest is lost in the Macro Region. An increase in exports of US$1 million leads to the loss of 39 km^2 of forest in the Carajás Corridor.

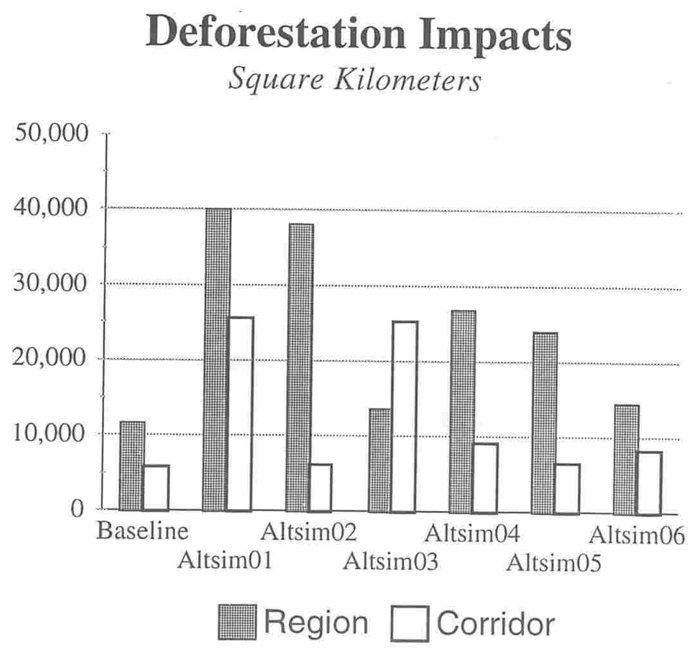
Alternative simulations 2 and 3 illustrate the economic inter-relationship between the two regions (Table 1). "Altsim02" simulates the exogenous growth of external demand in the Macro Region only. Under this simulation the Macro Region's GDP rises by 1.9 percent, while household income rises by 1.8 percent. Since the Macro Region buys goods from the Carajás Corridor, the resulting economic stimulus in the Macro Region leads to increased economic activity in the Carajás Corridor. The Macro Region's propensity to import from the Carajás Corridor is not strong, however, and gross regional product in the Carajás Corridor rises by only 0.3 percent.

The economic stimulus to the Macro Region increases the pace of deforestation, as production in the "forest consuming sectors" increases. A 10 percent increase in the Macro Region's exports results in an additional loss of 26,600 km^2 of forest. The stimulus to economic activity in the

Carajás Corridor also increases the area of land under cultivation and logging activity, and results in an additional 1,500 km^2 of area deforested.

When only the Carajás Corridor witnesses a 10 percent increase in exogenous exports (Altsim03), gross regional product in the Carajás Corridor increases by 3.4 percent, and GDP in the Macro Region rises by 0.4 percent. The increase in production in the Carajás Corridor's logging, agriculture and livestock leads to an increase in the area deforested. This increase in exports results in an additional 19,400 km^2 of forest area lost in the Carajás Corridor. The Carajás Corridor's purchases of goods from the Macro Region positively stimulate economic activity in the Macro Region's forest consuming sectors. An additional 1,900 km^2 is lost in the Macro Region as a result of export led expansion in the Carajás Corridor economy (Table 4).

The remaining multiplier simulations look at the impact from an exogenous increase in investment spending. Although the results are qualitatively similar to the results of an increase in exports, the economic and deforestation effects are different because of differences in the composition of investment spending. Changes in investment demand have less direct and indirect impact on the forest consuming sector than the impact that results from a change in exports. The effects are also different in the Carajás Corridor because investment goods are less likely to be produced within the Carajás Corridor itself. Consequently, increases in investment demand have less stimulatory, short run macroeconomic impact in the Carajás Corridor.



The Macro Region's economy is more affected by investment spending than by exports. The macroeconomic stimulus from a 10 percent increase in investment, however, is greater than the stimulus from export growth, while the deforestation impacts are smaller. The Macro Region's GDP increases by 3.7 percent as a result of a 10 percent increase in both the Macro Region and the Carajás Corridor (*Altsim04* in the Table 1 and graphs). Household income increases by 3.6 percent. This increase in investment spending leads to 15,100 km^2 of forest being cleared in the Macro Region.

GDP in the Carajás Corridor increases by 3.3 percent under this simulation, measurably lower than the 3.7 percent growth under a 10 percent increase in exports. Household income increases 3.2 percent as a result of the increase in investment demand, while an additional 3,500 km^2 of forest is cleared (Table 3).

Altsim05 represents a 10 percent increase in investment spending in the Macro Region alone, while*Altsim06* represents the same percentage increase in investment spending only in the Carajás Corridor. The pattern of effects is similar to the simulations involving exports: 1) an economic stimulus to the Macro Region has a much larger effect on the Carajás Corridor than the same stimulus in the Carajás Corridor has on the Macro Region; 2) economic and deforestation impacts are smaller when only one region is growing than when both are growing; and 3) the effects on deforestation occur as the forest consuming sectors adjust to a higher level of production, but once the new "equilibrium" production level is reached, the effects on deforestation are significantly muted.

Developing the metallurgical pole: alternative scenarios

The development scenario examined in the following set of simulations is based on those elaborated by the Master Plan for Integrated Development of the Carajás Railway Corridor (Plano Diretor de Desenvolvimento Integrado do Corredor da Estrada de Ferro Carajás,SEPLAN/PGC, 1989), revised in view of anticipated contingencies, prospects and limitations of the regional metals sector. More specifically, the scenarios for the years 2000 and 2010 were revised in light of considerations regarding the prospects for future development of this regional industry and its integration with the national and international market for metallurgical products.

The plan considered an analysis of current conditions in the world market for steel products. Current trends indicate a tendency towards stagnation of world demand and few possibilities of globalization of markets for higher value-added products, especially steel. The analysis also found that Brazilian industries, particularly those located in the Center-West, Southeast and South of Brazil, were operating with excess capacity. Although general market conditions do not warrant expectations of booming growth, it is important to differentiate the prospects for the production of primary iron (pig iron and pre-reduced iron), semi-processed steel (billets, blooms, and slabs), and other metallurgic products.

An analysis of the pig iron market indicates the strong potential for exports of this product and of pre-reduced iron to foreign steel producers. According to Rezende and Sampaio (1994), there is a potential market for primary iron of at least 30 million tons per year. Under appropriate conditions (including environmental conditions), the Carajás Corridor area could supply about 10 per cent of this demand, representing exports of about 3 million tons per year for the region.

The outlook for the international market in semi-processed steel (billets, blooms, and slabs) is positive, although profitability may not be favorable to the construction of large, export oriented plants within the Carajás Corridor. For this reason it was estimated that the region's production potential would be around 450,000 tons per year, mainly dedicated to exports. This production, however, can gradually be diverted to consumers of construction materials in the Carajás Corridor. The same conditions and restrictions apply to the production of rolled steel (plate, hot rolled sheet and coil, cold rolled sheet and coil, coated sheet and coil), and specialty steel.

The growth scenarios we examined considered the initial expansion of metals production within the Carajás Corridor to have the external market as its destination, since the processing industries located in the area lack capacity to absorb the output levels considered in these scenarios. The vertical integration and diversification of production capacity in the area is being gradually implemented so that the region can internalize the benefits of further processing of its primary and intermediate production in an orderly manner.

Although there are significant constraints to the establishment of a metallurgical complex — lack of capital, poor quality of labor, lack of entrepreneurship, etc.—it is expected that these obstacles can be overcome in the near future and that joint ventures between national and foreign firms will be established. In the growth strategy simulated in this study, the potential level of steel production in the Carajás Corridor is maintained at much lower levels than those established by the Master Plan. We believe, however, that the scenarios utilized in the present simulations are more consistent with the possibilities afforded by domestic and international markets, as well as with the supply of inputs in the Carajás area.

Two future growth scenarios were simulated. The first serves as a benchmark for comparison withthe strategy for expansion and diversification of the Carajás Corridor metals sector. The first scenario, referred to as the reference scenario, assumes that present market trends will continue. The international market for primary iron (including pig iron) is favorable and possibilities for exports to steel processing facilities in the Northern Hemisphere are good. On the other hand, the price of steel will remain low due to excess capacity at the world level. It is assumed that entrepreneurship will not change significantly within the Carajás Corridor. That is, local business culture will limit the expansion of investments in vertical integration of the steel industry and production of charcoal. Environmental conditions remain unchanged and production takes place within the parameters established by laws and current enforcement practices.

Growth scenario simulation export assumptions: millions of US $

Product	1993 Actual	Reference Scenario		Potential Development Scenario	
		2000	2010	2000	2010
Primary Iron	97.1	129.5	108.5	116.3	330.0
Semi-processed Steel	0.0	0.0	103.5	103.5	103.5
Laminated Steel	0.0	0.0	0.0	0.0	263.5
Special Steel	0.0	0.0	0.0	0.0	472.4
Iron Alloys	0.0	29.6	64.0	29.6	186.4
Cast Iron	0.0	0.0	48.0	30.0	60.0
Other Metals	30.0	48.0	48.0	48.0	48.0
Paper (Cellulose)	0.0	0.0	210.0	210.0	210.0

Source: Rezende and Sampaio, 1994, p.248.

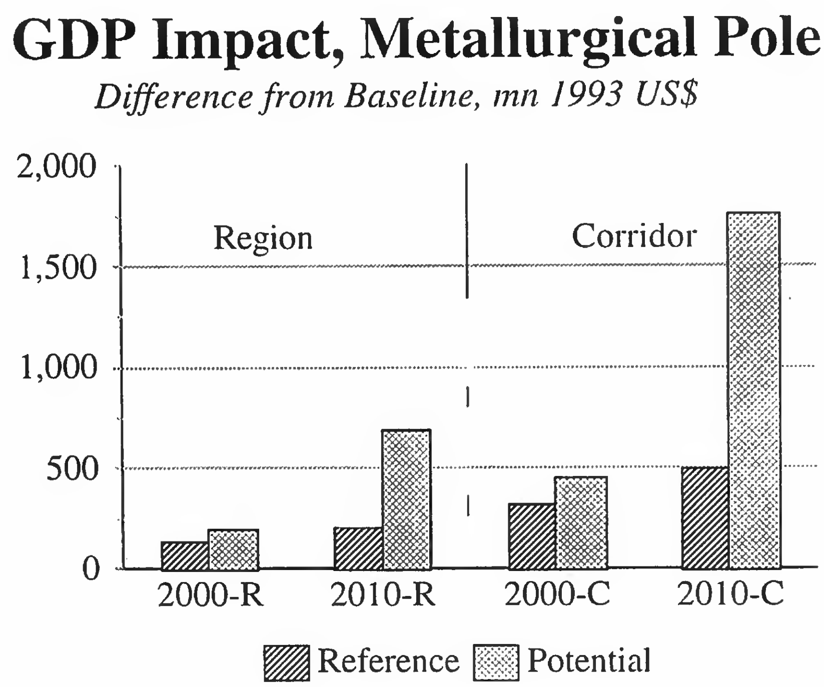
The second scenario is referred to as the potential scenario and is based on conditions that will allow higher production levels, stricter environmental laws and criteria for sustainability of natural resources, especially wood from native forests. Vertical integration of the metallurgical industry would be gradual and would follow the consolidation of regional demand. The specific assumptions regarding the regional export of metal products are given in the following table.

The simulation of alternative growth scenarios reflects the marginal contribution to economic activity and deforestation resulting from the development of a metallurgical complex as described in each scenario. Thus the simulations do not represent a forecast but represent an analysis of the marginal impacts under each scenario.

The reference scenario for the year 2000 results in a positive marginal impact on the Carajás Corridor's gross regional product (GDP) of 1.7 per cent[3] when compared to the 1993 baseline

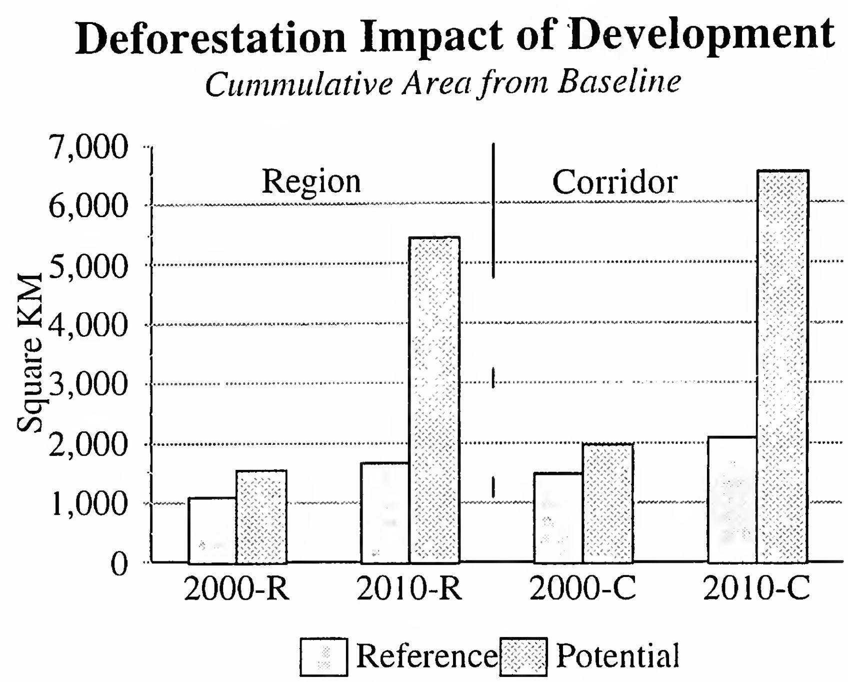
[3] The impacts on output, expenditures and income are all measured in inflation adjusted (real) terms.

simulation (Table 5). Under this scenario regional exports are 2.9 per cent higher, while regional consumption and household income increase by about 1.4 per cent over the baseline. The economic stimulus from higher exports of iron ore and pig iron continues through the year 2010 under this scenario. By this year, the growth of iron and related industries (as described in the reference scenario) leads to a growth of 2.6 per cent in the Carajás Corridor's GDP. Exports grow 4.4 per cent when compared to their levels in the baseline, while household consumption and income are each higher by 2.1 per cent. The Carajás Corridor's GDP in 2000 is US$321 million higher than its baseline level By 2010, Carajás Corridor GDP is up by US$496 million.



The Macro Region's economy is stimulated by expansion in the Carajás Corridor economy. The Macro Region's GDP is up by 0.2 per cent from the baseline in 2000 and by 0.4 per cent in 2010 (Table 5). Macro Region exports are up by 1.3 per cent in 2000 and by 1.8 per cent in 2010. This increase in exports represents additional sales for the Carajás Corridor.

The economic stimulus of an expanding metals industry in the Carajás Corridor leads to an expansion in forest consuming activities. Between 1993 and 2000, agricultural output increases by 0.8 percent over baseline values (see Table 6), while livestock production increases by 0.5 per cent under the reference scenario. By 2010, agricultural activity in the Carajás Corridor is 1.1 per cent greater than in 1993 as an indirect result of an expanding metals sector. Livestock production is up by 0.7 per cent. The production of timber is up by 1.6 per cent in 2000 and by 1.8 per cent in 2010 under this scenario. To accommodate this expansion in production among the forest consuming sectors, nearly 2,100 km^2 of forest in the Carajás Corridor will be cleared, in the absence of improvements in land productivity or the ratio of idle land to land utilized in production.[4] While the production of charcoal increases by 4.1 per cent by the year 2000 and by 4.4 per cent by the year 2010, these levels of production can be accomodated by the wood by-products of the forest consuming sectors.



Under the potential scenario, a larger proportion of iron ore is processed into steel and other metals rather than exported as ore or pig iron. The regional economic impact of higher levels of processing before ultimately being exported enhance the stimulatory effect on the Carajás Corridor's economy. The process of increasing "forward linkages" among economic sectors increases the economic multiplier effect of production.[5] The impact on deforestation, however, is also greater to the extent that this development strategy succeeds in increasing output in agriculture and similar forest consuming sectors. In this simulation it is also assumed that no increase in land productivity occurs and that the proportion of idle land remains as in the baseline case.

GDP within the Carajás Corridor increases by 2.4 per cent over the baseline simulation by the year 2000 in the potential scenario (Table 5). By 2010 Carajás Corridor GDP is 9.3 per cent higher than the baseline under this scenario, for an increase of US$1.760 billion compared with 1993. Carajás Corridor exports are nearly 15 per cent higher by 2010, while household income is up by 7.1 percent. Household income in 2010 is about US$960 million higher than the baseline (Table 7). In comparison to the reference scenario, the potential scenario represents US$133 million in additional GDP by the year 2000 and US$1.260 billion in additional GDP by 2010.

[4] Another 1,650 km² of forest in the Macro Region will also be cleared to accomodate economic expansion.

[5] The energy requirements of this development strategy have been examine in the previously cited study of Rezende and Sampaio.

Household income in 2010 under the potential scenario is US$670 million greater than under the reference scenario.

The effects on the Macro Region's GDP are also larger in the potential scenario. By 2010 the Macro Region's GDP is larger by 1.4 per cent over the baseline (Table 5).

Even though the potential scenario is based on using coke as an imported alternative energy source to charcoal by 2010, the amount of deforestation is greater than under the reference scenario. The higher impact on the output of forest consuming sectors results in greater deforestation. The potential scenario represents an additional loss of 4,500 km^2 of Carajás Corridor forest area in comparison to the reference scenario. (See Table 8.) Additional deforestation of 3,800 km^2 also occurs in the Macro Region.

Conclusions

Advocates of the expansion of pig iron production and the development of related industries (such as steel) suggest that the production of pig iron and the resulting demand for charcoal are not the root causes of the region's deforestation. They argue that population growth, farming, ranching and logging are the root causes of deforestation and that the production of charcoal is made possible by the use of residual by-products of these activities.[6] The simulations presented in this study support this view. When the regional economies expand (especially when their agriculture and livestock sectors expand), sufficient wood by-products are generated to meet the input requirements of charcoal production. The demand for charcoal production comes mainly from the need to supply the pig iron industry with a low-cost source of energy. These simulations also show, however, that in the absence of both land clearing activities to satisfy the expansion of agriculture and the cultivation of wood to meet charcoal production needs, the annual rate of deforestation that would result from the energy needs of pig iron production would be equivalent to approximately 50 per cent of the rate witnessed during the early 1990's. That is, maintaining or increasing pig iron production without growth of output in forest consuming sectors, an increase in the productivity of land in these activities, or an effort to grow the inputs needed to produce charcoal would lead to continued deforestation of natural areas at about one-half the rate currently observed.

The simulations involving anticipated growth in the metals sector based on the current structure of production versus the growth strategy proposed show considerable differences in impact. The

[6] Certainly the ability to sell wood from land cleared for agricultural use reduces the effective cost of forest clearing and thereby encourages more land intensive farming and ranching techniques. Such cost reductions, however, are minor and not likely to be a major factor in the optimal land clearing decision.

growth strategy presented as the potential scenario represents much faster regional economic growth for the area. Without public policies or market forces to change the current practice of land utilization in agriculture, the resulting economic stimulus increases the level of deforestation. This result occurs despite the reduction in the use of charcoal prescribed under that development strategy. The simulations analyzing alternative strategies for developing a metallurgical complex, as well as the multiplier simulations, suggest that deforestation in Carajás is more affected by land use practices in agriculture than by the production of pig iron or other metals. Increasing the productivity of land in agriculture and livestock production is more effective for stopping or reducing the rate of deforestation than curtailing the use of charcoal as a source of energy alone.

The analysis presented here in does not directly incorporate the dynamic element of population growth and endogenous investment demand, or the presence of agglomeration economies that would further stimulate regional growth. The analysis is consequently limited. An important extension of the general equilibrium model will be the incorporation of a labor market and the inter-regional migration of persons, since households are also consumers of charcoal. More importantly, agricultural activities expand to meet the needs of a growing population. Population pressures during periods of economic slowdowns increase the political pressure to develop new jobs through the promotion of new (or expanded) industries.

References

Alfsen, K. H. "Environmental Economics Based on General Equilibrium Models: the Norwegian Experience" Swiss Journal of Economics and Statistics, v. 127. n. 2 pp. 225-243.

Amelung, R. and M. Diehl. "Deforestation of Tropical Rain Forests: Economic Causes and Impact on Development", Kieler Studien, 241. Tübingen: J. C. B. Mohr, 1992.

Bergman, L. "Energy and Environmental Constraints on Growth: a CGE Modeling Approach", Journal of Policy Modeling, v. 12, n. 4, pp. 671-691, 1990.

Bojö, J., K.-G. Mäler, and L. Inemo. Environment and Development: An Economic Approach. Dordrecht: Kluwer Academic Publishers, 1990.

Cagnin, J. U. Impacto Ambiental do Projeto Ferro-Carajás, in Anais do Seminário "Impacto dos Grandes Projetos Financiados pelo BIRD no Brasil" SEPLAN, 1993.

Costa, R. A. et al. "Carvão Vegetal Ameaça Pequena Produção de Alimentos" Revista Pará Desenvolvimento, n. 22. July 1987.

CVRD - Companhia Vale do Rio Doce. Cenários do Mercado Internacional de Gusa no Ano 2000

SUFER-GITEV. Rio de Janeiro: Companhia Vale do Rio Doce: December 1992.

Informações Básicas acerca da Produção de Ferro-Gusa na Área do Programa Grande Carajás. Rio de Janeiro: Companhia Vale do Rio Doce: May, 1992.

Plano Preliminar de Desenvolvimento da Amazônia Oriental, Rio de Janeiro: CompanhiaVale do Rio Doce: 1981.

Dee, P. S. "Modelling Steady State Forestry in a Computable General Equilibrium Context" National Centre for Development Studies, Working Paper Series, n. 91/7 Camberra, 1991.

Gibson, Bill, "The Environmental Consequences of Stagnation in Nicaragua" World Development (forthcoming 1996).

Horta, M. H., and Souza, C. F. (1996). "O Brasil e a Iniciativa Amazônica: Níveis Atuais de Intercâmbio e Perspectivas de sua Ampliação," in A Economia Brasileira em Perspectiva, 1996, Vol. 1. Rio de Janeiro: Instituto de Pesquisa Econômica Aplicada- IPEA.

IBS, Instituto Brasileiro de Siderurgia. A Siderurgia em Números: 1993. Rio de Janeiro, 1993.

Anuário Estatístico da Indústria Siderúrgica Brasielira: 1992. Rio de Janeiro, 1992

IISI, International Iron and Steel Institute. Steel Statistics of Developing Countries: 1993. Brussels, October 1993.

INPE- Instituto de Pesquisas Espaciais. "Deforestation in the Brazilian Amazonia". Several Bulletins (1992, 1993, 1994).

Jankauskis, J. Avaliação de Técnicas de Manejo Florestal. SUDAM, Superintendência de Desenvolvimento da Amazônia/MEC, Ministério de Educação e Cultura, 1990.

Jorgenson, D. WW. and P. J. Wilcosen. "Intertemporal General Equilibrium Modeling of U. S. Environmental Regulation", Journal of Policy Modeling, v. 12, n. 4, pp. 715-7144, 1990.

Leslie, A. J. A Second Look of the Economics of Natural Management Systems in Tropical Mixed Forest. FAO, 1986.

Loureiro, V. R. "Amazônia: História e Perspectivas - Reflexões sobre a Questão" Revista Pará Desenvolvimento, n. 26, Jan./June, 1990.

Martini, A. M. et al. "Espécies Madeireiras- Primeira Tentativa de Avaliar a Resistência aos Impactos da Exploração, Ciência Hoje, August 1993

Motta, R. S. and Mendes, F. E. (1996) "Instrumentos Econômicos na Gestão Ambiental: Aspectos Teóricos e de Implementação," in A Economia Brasileira em Perspectiva, 1996, Vol. 1. Rio de Janeiro: Instituto de Pesquisa Econômica Aplicada- IPEA.

Mueller, C. "Evolução da Agropecuária na Região do Projeto Carajás" Brasília, 1994.

NATRON. Bases para o Relatório Final do Plano diretor de Desenvolvimento Integrado do Corredor da Estrada de Ferro Carajás, Vol. 1 and 2. November, 1988.

Nguyen, D. "Environmental Services and the Optimal Rotation Problem in forest Management" Journal of Environmental Management, v. 8, pp. 127-136, 1979.

Ozório de Almeida, A. and Campari, J., Sustainable Settlement in the Brazilian Amazon, Oxford University Press: New York. (1995).

Panayotou, S. and Sungsuwan, "An Econometric Study of the Causes of Tropical Deforestation: The Case of Northeast Thailand," Discussion Paper No. 284, Harvard Institute of International Development, Cambridge, MA (1989).

Pearce, D. and E. Barbier, A. Markandya. Sustainable Development: Economics and Environment in the Third World. Aldershot: Elgar, 1990.

Pearce, D. and R. K. Turner. Economics of Natural Resources and the Environment. New York: Harvester Wheatsheaf, 1990.

Perrings, C. A. et al. Biodiversity Conservation: Problems and Policies. Hingham, MA: Kluwer Academic Publishers, 1996.

Persson, A. and Munasinghe, M., "Natural Resource Management and Economy Wide Policies in Costa Rica: A Computable General Equilibrium (CGE) Modeling Approach," The World Bank Economic Review, v.9, no. 2: 259-285 (1995).

Reis, E. J. 1996. "Os Impactos do Pólo Siderúrgico de Carajás no Desflorestamento da Amazônia Brasileira, in A Economia Brasileira em Perspectiva, 1996, Vol. 1. Rio de Janeiro: Instituto de Pesquisa Econômica Aplicada- IPEA.

Reis, E. and S. Margulis. "Perspectivas Econômicas do Desflorestamento da Amazônia" Discussion Papers, n. 215. Rio de Janeiro: IPEA, 1991.

Reppeto, R. The Forest for the Trees? Government Policies and the Misuse of Forest Resources. Washington, D.C.: World Resource Institute, 1988.

"Economic Incentives for Sustainable Production" in G. Schramm, J. J. Warford (eds.), Envi ronmental Management and Economic Development. Baltimore: Johns Hopkins University Press, 1989.

Rezende, M. E. et al. "Produção Comercial de Carvão Vegetal para a Siderurgia" 1993. Mimeo.

Rezende, M. E., A. Lessa and F. Carazza. 1994. "Questões Ambientais e a Carbonização em Fornos de Alvenaria" 1994. Mimeo.

Rezende, M. E. and R. Santos Sampaio. Estudo de Alternativas Energéticas para o Polo Siderúrgico do Programa Grande Carajás - Componente Siderúrgico. Belo Horizonte, 1994.

Sawyer, D. and M. Willumsen. 1995. "Estudo de Alternativas Energéticas para o Pólo Metalúrgico do Programa Grande Carajás, Componente Regional" 1995.

SEPLAN/PGC, Programa Grande Carajás. Plano Diretor do Corredor da Estrada de Ferro Carajás. 1989.

SINDIFER, Sindicato de Indústria do Ferro no Estado de Minas Gerais. A Indústria Não Integrada de Carvão Vegetal no Brasil - 1992. Belo Horizonte, Minas Gerais: December 1992.

Southgate, D. Serra, R. and Brown, L, "The Causes of Tropical Deforestation in Ecuador," World Development, v. 19, no. 9 (1991).

Thiele, R. and M. Wiebelt. "Policies to Reduce Tropical Deforestation and Degradation: A Computable General Equilibrium Analysis for Cameroon", Quarterly Journal of International Agriculture, v. 33, n. 2, pp. 162-178, 1994.

Vale, L. C. Cardoso, and M. B. Nascimento Filho. Estudo de Alternativas Energéticas para o Pólo Metalúrgico do Programa Grande Carajás, Componente Recursos Florestais. Belo Horizonte, 1994

Valverde, O. "Grande Carajás: Planejamento e Destruição" Rio de Janeiro, 1989. Mimeo.

"Sacrifício Verde", Ecologia e Desenvolvimento n. 33, November 1993.

Wadsworth F. H. A Time for Secondary Forestry in Tropical America. Institute of Tropical Forestry, 1986.

Wajsman, N. "The Use of Computable General Equilibrium Models in Evaluating Environmental Policy", Journal of Environmental Management, n. 44, pp. 127-143, 1995.

Table 1
Summary
Percent Change from Baseline (%)

	Baseline	Sim1	Sim2	Sim3	Sim4	Sim5	Sim6
Macro Region							
Tot.al Production		2.3	1.9	0.4	3.8	3.1	0.7
GDP		2.2	1.9	0.4	3.7	3.1	0.6
Consumption		2.1	1.8	0.3	3.6	3.0	0.6
Household Income		2.1	1.8	0.3	3.6	3.0	0.6
Labor		1.6	1.3	0.3	3.1	2.6	0.5
Capital		2.6	2.2	0.4	4.1	3.5	0.7
Transfers		0.0	0.0	0.0	0.0	0.0	0.0
Direct Taxes		2.1	1.8	0.3	3.6	3.0	0.6
Disposable Income		2.1	1.8	0.3	3.6	3.0	0.6
Savings		2.1	1.8	0.3	3.6	3.0	0.6
Savings Rate*		0.0	0.0	0.0	0.0	0.0	0.0
Carajás Corridor							
Tot.al Production		3.5	0.3	3.2	3.9	0.5	3.4
GDP		3.7	0.3	3.4	3.3	0.5	2.9
Consumption		3.4	0.3	3.1	3.2	0.4	2.8
Household Income		3.4	0.3	3.1	3.2	0.4	2.8
Labor		2.4	0.3	2.2	3.0	0.4	2.6
Capital		4.5	0.3	4.2	3.4	0.5	3.0
Transfers		0.0	0.0	0.0	0.0	0.0	0.0
Direct Taxes		3.4	0.3	3.2	3.2	0.4	2.8
Disposable Income		3.4	0.3	3.2	3.2	0.4	2.8
Savings		3.4	0.3	3.2	3.2	0.4	2.8
Savings Rate*		0.0	0.0	0.0	0.0	0.0	0.0

Table 2
Industry output - selected industries
Percent change from baseline (%)

	Baseline	Sim1	Sim2	Sim3	Sim4	Sim5	Sim6
Macro Region							
Extractive - Forestry		4.3	4.0	0.3	2.9	2.5	0.4
Charcoal		2.8	2.6	0.3	4.5	2.8	1.7
Soybean		8.9	8.8	0.1	0.5	0.4	0.1
Other Agriculture		3.2	2.7	0.6	3.2	2.5	0.7
Livestock		4.7	4.4	0.3	2.5	2.0	0.4
Extractive- Forest Management		2.8	2.6	0.3	4.5	2.8	1.7
Reforestation		2.9	2.5	0.5	4.2	3.6	0.6
Extractive: Iron Ore		2.9	2.5	0.5	4.2	3.6	0.6
Extractive - Other Metallic		5.9	5.6	0.3	2.4	1.9	0.5
Minerals		3.1	2.6	0.5	4.3	3.8	0.6
Alloys		2.9	2.5	0.5	4.2	3.6	0.6
Pig Iron		5.2	4.9	0.3	2.9	2.5	0.4
Steel		3.0	2.7	0.3	5.3	4.9	0.4
Lumber		2.0	1.4	0.6	4.2	3.4	0.7
Furniture		3.1	2.8	0.3	5.3	4.9	0.4
Total Industry Output		2.3	1.9	0.4	3.8	3.1	0.7
Carajás Corridor							
Extractive - Forestry		6.2	0.6	5.7	2.1	0.8	1.3
Charcoal		3.9	0.3	3.6	3.1	0.5	2.6
Soybean		8.6	0.1	8.6	0.7	0.1	0.6
Other Agriculture		6.9	0.2	6.7	1.5	0.3	1.2
Livestock		7.5	0.2	7.4	1.2	0.3	0.9
Extractive - Forest Management		3.9	0.3	3.6	3.1	0.5	2.6
Reforestation		10.0	0.0	10.0	0.0	0.0	0.0
Extractive - Iron Ore		10.0	0.0	10.0	0.0	0.0	0.0
Other Metallic Minerals		4.3	0.6	3.7	4.2	2.8	1.4
Alloys		2.6	0.9	1.7	4.5	104	3.1
Pig Iron		10.0	0.0	10.0	0.0	0.0	0.0
Steel		3.1	1.0	2.1	4.7	0.8	3.9
Lumber		2.9	0.2	2.7	6.2	0.2	5.9
Furniture		2.7	0.2	2.4	4.7	0.4	4.3
Total Industry Output		3.5	0.3	3.2	3.9	0.5	3.4

Table 3
Deforestation activity
Square kilometers (unless noted otherwise)

	Baseline	Sim1	Sim2	Sim3	Sim4	Sim5	Sim6
Macro Region							
Land Cleared by logging activity	332.6	346.8	345.9	333.5	342.3	340.9	334.0
Land Cleared for agriculture	1,923.0	5,233.6	4,911.7	2 244.9	3,984.3	3,574.0	2,333.3
Land Cleared for livestock	9,391.8	34,494	32,947.2	10,938.7	22,432.0	20,070.8	11,753.0
Land Cleared to meet charcoal needs	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total area deforested per year	11,647.4	40,074.5	38,204.8	13,517.1	26,758.5	23,985.7	14,420.2
Carajás Corridor							
Land Cleared by logging activity	638.4	678.1	642.0	674.6	651.5	643.2	646.7
Land Cleared for agriculture	1,003.5	3,568.1	1,104.4	3,467.2	1,682.9	1,161.5	1,24.9
Land Cleared for livestock	4,066.3	21,410.6	4,482.0	20,995.0	6,883.9	4,742.3	6,208.0
Land Cleared to meet charcoal needs	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total area deforested per year	5,708.3	25,656.8	6,228.4	25,136.7	9,218.3	6,547.0	8,379.6
Macro Region plus Carajás Corridor per year	17,355.6	65,731.3	44,433.2	38,653.8	35,976.8	31,532.8	22,799.7
Charcoal production potential[1]							
Macro Region (million cubic meters)	103.4	362.6	345.5	120.5	241.2	215.9	128.72
Carajás Corridor (million cubic meters)	46.76	228.4	50.5	223.4	78.7	54.4	71.1
Charcoal production less potential[2]							
Macro Region (million cubic meters)	-97.04	-356.0	-339.0	-114.1	-234.5	-209.3	-122.2
Carajás Corridor (million cubic meters)	-27.08	-207.9	-31.7	-203.3	-58.4	-34.6	-50.9
Land Cleared to accommodate charcoal production							
Macro Region (square kilometers)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carajás Corridor (square kilometers)	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes: 1 from logging and lumber mill byproduct and land cleared to accommodate agricultural sector expansion
2 negative values imply excess capacity

Table 4
Deforestation activity
Absolute change from baseline

	Baseline	Sim1	Sim2	Sim3	Sim4	Sim5	Sim6
Macro Region							
Land Cleared by logging activity		14.3	13.3	0.9	9.7	8.3	1.4
Land Cleared for agriculture		3,310.6	2,988.7	321.9	2,061.3	1,651.0	410.3
Land Cleared for livestock		25,102.3	23,555.4	1,546.9	13,040.2	10,679.0	2,361.2
Land Cleared to meet charcoal needs		0.0	0.0	0.0	0.0	0.0	0.0
Total area deforested per year		28,427.1	26,557.4	1,869.7	15,111.2	12,338.4	2,772.8
Carajás Corridor							
Land Cleared by logging activity		39.7	3.5	36.2	13.1	4.8	8.3
Land Cleared for agriculture		2,564.6	100.9	2,463.7	679.4	158.0	521.3
Land Cleared for livestock		17,344.3	415.7	16,928.6	2,817.6	675.9	2,141.7
Land Cleared to meet charcoal needs		0.0	0.0	0.0	0.0	0.0	0.0
Total area deforested per year		19,948.6	520.1	19,428.4	3,510.0	838.8	2,674.3
Macro Region plus Carajás Corridor per year		48,375.7	27,077.6	21,298.1	18,621.2	13,177.1	5,4444.1
Charcoal production potential[1]							
Macro Region (million cubic meters)		259.1	242.1	17.0	137.7	112.5	25.3
Carajás Corridor (million cubic meters)		181.6	4.7	176.9	31.9	7.6	24.3
Charcoal production less potential[2]							
Macro Region (million cubic meters)		-259.0	-241.9	-17.0	-137.4	-112.3	-25.2
Carajás Corridor (million cubic meters)		-180.8	-4.7	-176.2	-31.3	-7.5	-23.8
Land Cleared to accommodate charcoal production							
Macro Region (square kilometers)		0.0	0.0	0.0	0.0	0.0	0.0
Carajás Corridor (square kilometers)		0.0	0.0	0.0	0.0	0.0	0.0

Notes: 1 from logging and lumber mill byproduct and land cleared to accommodate agricultural sector expansion
2 negative values imply excess capacity

Table 5
Summary
Percent change from baseline

	Baseline	Ref 2000	Ref 2010	Pot 2000	Pot 2010
Macro Region					
Tot.al Production		0.27	0.42	0.38	1.37
GDP	-	0.24	0.37	0.34	1.23
Consumption		0.21	0.32	0.30	1.06
Exports		1.31	1.82	1.67	5.43
Household Income		0.21	0.32	0.30	1.06
Labor		0.19	0.29	0.27	0.97
Capital	-	0.24	0.36	0.34	1.19
Transfers	-	0.00	0.00	0.00	0.00
Direct Taxes	-	0.21	0.32	0.30	1.06
Disposable Income	-	0.21	0.32	0.30	1.06
Savings	-	0.21	0.32	0.30	1.06
Savings Rate*	-	0.00	0.00	0.00	0.00
Carajás Corridor					
Tot.al Production	-	2.31	3.50	3.21	12.06
GDP	-	1.69	2.61	2.39	9.26
Consumption		1.43	2.10	1.96	7.08
Exports	-	2.93	4.42	4.02	14.89
Household Income	-	1.43	2.10	1.96	7.08
Labor		1.58	2.37	2.20	7.92
Capital		1.29	1.85	1.73	6.31
Transfers	-	0.00	0.00	0.00	0.00
Direct Taxes	-	1.43	2.10	1.96	7.08
Disposable Income	-	1.43	2.10	1.96	7.08
Savings		1.43	2.10	1.96	7.08
Savings Rate*		0.00	0.00	0.00	0.00

Table 6
Industry output - selected industries
Percent change from baseline

	Baseline	Ref 2000	Ref 2010	Pot 2000	Pot 2010
Macro Region					
Extractive - Forestry		0.3	0.4	0.4	0.9
Charcoal		0.2	0.6	0.5	2.7
Soybean		0.1	0.1	0.1	0.3
Rice, Corn, Beans and Cassava		0.3	0.4	0.4	1.4
Other Agriculture		0.2	0.3	0.3	1.1
Livestock	-	0.2	0.3	0.2	0.9
Extractive- Forest Management		0.2	0.6	0.5	2.7
Reforestation		5.3	18.1	10.1	49.0
Extractive: Iron Ore		5.3	18.1	10.1	49.0
Extractive- Other Metallic Minerals		0.3	0.8	0.6	3.2
Alloys		1.7	7.9	5.0	23.7
Pig Iron		5.3	18.1	10.1	49.0
Steel		0.9	4.4	2.9	13.3
Lumber		0.2	0.3	0.2	0.9
Furniture		0.3	0.5	0.4	1.6
Paper and Cellulose		4.4	4.6	4.5	5.6
Total Industry Output		0.3	0.4	0.4	1.4
Carajás Corridor					
Extractive - Forestry		1.6	1.8	1.7	3.5
Charcoal		4.1	4.4	4.2	4.0
Soybean		0.3	0.4	0.4	1.4
Rice, Corn, Beans, Cassava		0.7	1.0	0.9	3.1
Other Agriculture		1.3	1.8	1.7	6.3
Livestock		0.5	0.7	0.7	2.2
Extractive - Forest Management		4.1	4.4	4.2	4.0
Reforestation		43.7	29.3	31.2	355.0
Extractive - Iron Ore		0.0	0.0	0.0	0.0
Extractive- Other Metallic Minerals	-	21.0	49.1	40.53	213.4
Alloys	-	3199.1	7148.5	3421.6	21146.5
Pig Iron		43.7	29.3	31.2	355.0
Steel		214.0	7401.2	7168.0	56673.5
Lumber		0.7	0.8	0.8	1.3
Furniture		1.0	1.6	1.5	5.5
Paper and Cellulose		287.9	288.2	288.1	290.2
Total Industry Output		2.3	3.5	3.2	12.1

Table 7
Summary
Billions of 1993 U.S. dollars

	Baseline	Ref 2000	Ref 2010	Pot 2000	Pot 2010
Macro Region					
Tot.al Production	89.9	90.2	90.4	90.3	91.2
GDP	55.7	55.9	55.9	55.9	56.4
Consumption	35.6	35.7	35.7	35.7	36.0
Exports	12.0	12.2	12.3	12.2	12.7
Household Income	44.3	44.5	44.5	44.5	44.8
Labor	21.1	21.2	21.2	21.2	21.4
Capital	22.4	22.4	22.5	22.5	22.6
Transfers	0.8	0.8	0.8	0.8	0.8
Direct Taxes	6.1	6.1	6.1	6.1	6.1
Disposable Income	38.3	38.4	38.4	38.4	38.7
Savings	2.7	2.7	2.7	2.7	2.7
Savings Rate*(%)	6.10	6.10	6.10	6.10	6.10
Carajás Corridor					
Tot.al Production	29.0	29.7	30.0	29.9	32.5
GDP	19.0	19.3	19.5	19.4	20.7
Consumption	10.3	10.5	10.6	11.0	11.1
Exports	11.9	12.2	12.4	12.3	13.6
Household Income	13.5	13.7	13.8	13.8	14.5
Labor	7.0	7.1	7.2	7.2	7.6
Capital	6.3	6.4	4.5	6.5	6.8
Transfers	0.1	0.1	0.1	0.1	0.1
Direct Taxes	1.7	1.8	1.8	1.8	1.9
Disposable Income	11.8	11.9	12.0	12.0	12.6
Savings	1.4	1.4	1.5	1.4	1.5
Savings Rate* (%)	10.51	10.51	10.51	10.51	10.51

Table 8
Deforestation activity
Square kilometers (unless noted otherwise)

	Baseline	Ref 2000	Ref 2010	Pot 2000	Pot2010
Macro Region					
Land Cleared by logging activity	332.6	333.5	333.8	333.8	335.7
Land Cleared for agriculture	1,923.0	2,096.3	2,183.0	2,165.1	2,785.6
Land Cleared for livestock	9,391.8	10,312.4	10,778.0	10680.2	13,941.3
Land Cleared to meet charcoal needs	0.0	0.0	.0.	0.0	0.0
Total area deforested per year	11,647.4	12,742.3	13,294.8	13079.1	17,062.0
Carajás Corridor					
Land Cleared by logging activity	638.4	648.4	649.8	649.5	661.0
Land Cleared for agriculture	1,003.5	1,311.5	1,432.3	1,407.0	2,17.3
Land Cleared for livestock	4,066.3	5,228.1	5,692.6	5,593.7	9,148.0
Land Cleared to meet charcoal needs	0.0	0.0	.0.	0.0	0.0
Total area deforested per year	5,708.3	7,188.0	7,774.6	7,650.2	12,226.3
Macro Region plus Carajás Corridor per year	17,355.6	19,930.0	21,069.4	20,829.3	29,288.9
Charcoal production potential[1]					
Macro Region (million cubic meters)	103.44	113.42	118.46	117.40	152.80
Carajás Corridor (million cubic meters)	46.76	60.17	65.51	64.38	106.01
Charcoal production less potential[2]					
Macro Region (million cubic meters)	-97.04	-107.01	-112.02	-110.97	-146.24
Carajás Corridor (million cubic meters)	-27.08	39.67	-44.96	-43086	-85.54
Land Cleared to accommodate charcoal production					
Macro Region (square kilometers)	0.00	0.00	0.00	0.00	0.00
Carajás Corridor (square kilometers)	0.00	0.00	0.00	0.00	0.00

Notes: 1 from logging and lumber mill byproduct and land cleared to accommodate agricultural sector expansion.

2 negative values imply excess capacity.