

THE SOCIAL COSTS OF RAIN FOREST DESTRUCTION: A Critique and Economic Analysis of the "Hamburger Debate"

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In their 1979 monograph on the economic development of the Brazilian Amazon, Robert Skillings and Nils Tcheyan offer an important insight into the economics of public policies that promote beef cattle production in this region: "The present system of fiscal incentives," they assert, "creates a major difference between the social costs and benefits of livestock projects and the private costs and benefits." (Skillings and Tcheyan, 1979, p. 68). This statement underscores a critical dimension of the problem of rain forest destruction that was alluded to, but not directly addressed by Uhl and Parker in their provocative and illuminating editorial "Is a One-Quarter Pound Hamburger Worth a Half-Ton of Rain Forest," (*Interciencia*, September-October, 1986), and by two respondents (Matteucci and Segal, in separate letters to the editor, *Interciencia*, January-February, 1987).

This paper addresses two questions: Is there a difference between the private and social costs and benefits of converting rain forest to pasture? What relevance is the difference, if any, to the causes of large scale tropical deforestation? In addition to various secondary sources, the analysis of these questions draws upon my 1984-85 economic survey of 73 Brazilian Amazon beef cattle ranches.

Amazon Rain Forests and Hamburgers

But first, I believe it is necessary to question the now reified notion that tropical rain forests in general, and Amazonian rain forests in particular, are being converted mainly to produce hamburgers. Moreover, the debate has emphasized hamburger consumption in the United States which implies a second erroneous conclusion: the U.S. demand for hamburgers is an important factor propelling rain forest destruction in Latin America.

According to one researcher, about 7.6% of all beef consumed in the United States during the 1970s was imported (Shane, 1986, p. 85). By 1982, however, the U.S. imported 662,300 metric tons of beef from suppliers world-wide representing only 2.7% of the total tonnage of beef marketed in the U.S. (24,249,000 metric tons) (Shane, 1986, p. 89 and USDA, 1984). Of this amount only 86,960 metric tons (0.35% of total U.S. consumption) originated from beef suppliers in Latin American countries with tropical rain forests. Brazil, the largest tropical rain forest country in the world, sold 21,400 metric tons of beef to the U.S. (0.09% of total U.S. consumption), of which approximately 1,700 tons originated from the Brazilian Amazon North region and Mato Gros-

so.¹ Thus the Brazilian Legal Amazon (excluding Goias and Maranhao) supplied the U.S. with 0.007 percent (seven one-thousands of one percent) of its apparent beef consumption in 1982; a quantity that is impressive only by virtue of its insignificance.

It is significant to the "hamburger debate," however, that since 1965 no fresh uncooked beef from Brazil has been legally imported to the United States due to public health concerns relating to aftosa (hoof-and-mouth disease) (USDC, various years). In other words, it is highly doubtful that even a single Brazilian Amazon rain forest hamburger has ever been consumed in the United States. There are, of course, other tropical Latin American countries, mainly in Central America, where rain forest destruction is more closely correlated to export beef production (Shane, 1986). Yet, it is also important to recognize that beef imports to the U.S. have been declining relative to domestic production since the 1970s, and that a very small portion of those imports are processed into hamburgers.²

It is unfortunate that the much maligned hamburger was adopted as the relevant unit for analysis in this debate. Clearly Uhl, Parker, and Matteucci recognize the hamburger has only figurative meaning in the discussion of tropical deforestation. The demand for

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other beef products in the growing consumer markets of Latin America, and public policies seeking to satisfy that demand, account for most of the expansion in the region's livestock sector and the concomitant destruction of tropical forests. Given these reservations, the hamburger unit is reluctantly used in the following analysis only to emphasize the important distinctions between private and social costs and benefits of tropical beef production in terms that are consistent with the discussion so far.

The Private Costs and Benefits

Based on an 1984-85 analysis of the financial performance of a small sample of beef cattle birthing and fattening operations in the Brazilian Amazon, I estimate that the total unit cost of establishing and operating a typical Amazon cattle ranch for five years is about US\$ 415 per hectare.³ Taking what Uhl and Parker (1986) tentatively calculate to be the approximate land factor requirement of 6.25 square meters (0.000625 hectares) to produce a single typical 125 gram (about one-quarter pound), 100% beef hamburger, then the cost to the rancher of producing a quarter-pound unit of beef would be about US\$ 0.26. By the time a quarter-pound unit of beef, from whatever source, reaches the take-out counter of a North American fast-food restaurant in the United States, say Burger King, its price to the U.S. consumer is US\$ 1.59 (June 1987). Depending on various factors such as location and size, the U.S. fast-food franchise restaurant may obtain a profit margin ranging from 10% to 18% on the quarter-pound hamburger.⁴ Given the large volume of sales enjoyed by such restaurants (US\$47.7 billion in 1985),⁵ hamburgers, wherever they originate, are an important part of an immensely lucrative business. Do Latin American cattle ranchers benefit from their capital investment in the production of Amazon beef? And, more importantly, do they fully absorb the costs associated with their beef production?

Several recent studies suggest that beef cattle ranching in the Amazon may be profitable only with government subsidies (Hecht 1985, Fearnside 1986, Shane 1986, Norgaard *et al.* manuscript). My analysis partially supports this conclusion. Over a five-year period, the typical ranch in my survey sample earns gross revenues from fattened steer sales equivalent to about US\$ 136.95 per hectare of pasture.⁶

TABLE I
OPPORTUNITY COSTS OF SUDAM DISBURSEMENTS TO THE LIVESTOCK
SECTOR BASED ON AVERAGE U.S. INVESTMENT RETURNS
(1966-1983)

Year	Disbursements		Average Rate of Return (c)	Accumulated Opportunity Cost (US\$000)
	Current Cr\$ (000) (a)	Current US\$ (000) (b)		
1966	1,170	527	-.0036	525
1967	10,828	4,057	.0351	4,743
1968	28,696	8,485	.0464	13,686
1969	73,373	18,001	-.0377	30,686
1970	154,501	33,631	.1025	70,909
1971	149,844	28,337	.1073	109,895
1972	167,492	28,226	.0894	150,469
1973	157,957	25,789	-.0194	172,904
1974	211,724	31,182	-.0429	195,691
1975	424,607	52,247	.1671	289,368
1976	522,697	48,974	.1608	392,748
1977	750,071	53,031	-.0025	444,667
1978	952,106	52,690	.0313	512,925
1979	1,093,761	40,594	.0585	585,899
1980	2,132,056	40,447	.0927	684,409
1981	3,536,434	37,975	.0267	741,671
1982	8,372,432	49,319	.2902	1,020,536
1983	19,184,539	44,202	.0917	1,162,374
TOTAL	37,924,291	597,714		1,162,374

NOTES:

- Incentivos Fiscais Liberados pela SUDAM (Anualmente) ate o Mes Setembro 1983; "Setor Agropecuario."* Internal SUDAM project summary tables, p. 5. Excludes SUDAM program administration and livestock administrative support services.
- Current U.S. Dollars converted at official annual exchange rates (source: World Bank, *World Tables*, various years). One effect of converting to U.S. Dollars at the generally over-valued Brazilian exchange rates is to understate the true value of the SUDAM disbursements. Therefore, the dollar values given reflect a conservative estimate of the opportunity cost in current dollar terms.
- Based on average returns on equivalent investments in common stocks, long-term corporate bonds, long-term U.S. government securities, and U.S. Treasury Bills taken from "Basic Series: Year-by-Year Total Returns, 1926-1985," prepared by Ibbotson Associates, Chicago. The decision to use these U.S. series returns instead of a Brazilian index (e.g. Brazilian Treasury Notes) to estimate opportunity cost reflects the author's intention to represent a relatively conservative long-term investment option. Accordingly, this choice may not reflect actual investment portfolio performance, which if better than the Ibbotson composite would understate opportunity costs. The author does not intend to suggest that the Brazilian government should invest Amazon regional development funds in U.S. capital markets. Although the effects of inflation are largely accounted for in the conversion of Cruzeiros to Dollars the current values expressed only fail to account for the difference between the actual and expected rates of inflation in the U.S.

Given the Uhl-Parker land-hamburger coefficient, although based on a slightly longer (8 years) pasture life-span, these revenues are equivalent to only US\$ 0.085 per hamburger unit of beef that costs US\$ 0.26 to produce. Without subsidies my analysis indicates that beef cattle ranching covers less than one-third of its total-year cost.

The Subsidy Factor in Amazon Beef Cattle Production

Several subsidy streams flow into the Amazon's livestock sector,

both directly and indirectly. Two direct subsidy programs warrant special consideration. First, Brazil's regional development program for the Amazon, administered by the Superintendency for Amazon Development (SUDAM), enables corporations to convert income tax liability into venture capital dedicated to government approved corporate livestock projects. This program has been amply described elsewhere (Cavalcanti 1967, Mahar 1979, SUDAM 1982, Nascimento 1985). Between 1966 and 1983, 469 Amazon livestock projects received tax credit financing of Cr\$ 37.9 billion

TABLE II
OPPORTUNITY COSTS OF CENTRAL BANK RURAL CREDIT LOANS
TO AMAZON LIVESTOCK PRODUCERS BASED ON AVERAGE U.S.
INVESTMENT RETURNS (1977-1983)

Year	Current Cr\$ (000 (a))	Subsidy Rate (b)	Subsidy (Cr\$ 000)	Subsidy (US\$ 000)	Average Rate of Return (c)	Accumulated Opportunity Cost (US\$ 000)
1977	3,920,730	.707	2,771,956	195,981	-.0025	195,491
1978	2,048,113	.670	1,372,236	75,940	.0313	279,927
1979	7,664,279	.732	5,610,252	208,211	.0585	516,694
1980	5,442,861	.798	4,343,403	82,396	.0927	654,626
1981	10,771,801	.845	9,102,172	97,741	.0267	772,455
1982	25,948,148	.864	22,419,199	132,064	.2902	1,167,010
1983	41,108,680	.926	38,066,637	87,707	.0917	1,369,775
TOTAL	96,904,612		83,685,855	880,040		1,369,775

NOTES:

- (a) *Financiamentos Concedidos a Produtores e Cooperativas por Região Geoeconômica e Unidade da Federação, Número e Valor dos Contratos, Atividade: Pecuária.* Brasília: Banco Central do Brasil, Departamento do Crédito Rural, *Dados Estatísticos* various years. Only years 1977 to 1983 rural credit data could be obtained from the Central Bank.
- (b) Subsidy rate is calculated as percentage of commercial rate subsidized given real commercial interest rates ranging from 35% (1975) to 78% (1981) as noted in the International Monetary Fund (1983) rural credit interest rates of 12% per year with an 8-year grace-period on amortization of principle as derived from Banco Central do Brasil, *Documentos Normativos*, various years.
- (c) Based on average returns on equivalent investments in common stocks, long-term corporate bonds, long term U.S. government securities, and U.S. Treasury Bills taken from "Basic Series: Year-by-Year Total Returns, 1926-1985," prepared by Ibbotson Associates, Chicago. The decision to use these U.S. series returns instead of a Brazilian index (e.g. Brazilian Treasury Notes) to estimate opportunity cost reflects the author's intention to represent a relatively conservative long-term investment option. Accordingly, this choice may not reflect actual investment portfolio performance, which if better than the Ibbotson composite would understate actual opportunity costs. The author does not intend to suggest that the Brazilian government should invest Amazon regional development funds in U.S. capital markets. Although the effects of inflation are largely accounted for in the conversion of Cruzeiros to Dollars, the current values expressed only fail to account for the difference between the actual and expected rates of inflation in the U.S.

(US\$ 598 million). The estimated opportunity cost associated with these tax credit subsidies was US\$ 1,162 billion, representing a private benefit of about US\$ 2.5 million to each of these 469 corporate livestock project sponsors (Table I).⁷ Given an average pasture area of 11,600 hectares per project, then the total social value of the SUDAM subsidies enjoyed by these private corporations was about US\$ 215 per hectare or US\$ 0.135 per hamburger equivalent (given the Uhl-Parker coefficient).

A second subsidy stream enjoyed by Amazon ranchers emanates from the Brazilian Central Bank's Rural Credit program initiated in 1965. Between 1977 and 1983 minimally 13,900 Amazon livestock producers secured one or more loans under the Rural Credit program mainly for the expansion of beef cattle production. The total value of the subsidy portion of these loans was Cr\$ 83.7 billion (US\$ 880 million in nominal terms). The estimated opportunity cost associated with these rural credit

subsidies is US\$ 1,370 billion during this period, or US\$ 98,500 per ranch (Table II).

Between these two programs, subsidies to Amazon beef cattle ranchers represent a total social cost of approximately US\$ 2.5 billion over the respective periods analyzed. Assuming that the shrewd SUDAM-subsidized rancher is able to secure rural credit financing, then the total present value of the private benefit obtained would be US\$ 2.6 million per ranch project, or US\$ 224 per hectare of pasture, or US\$ 0.14 per hamburger equivalent. Adding gross sales revenues of US\$ 0.085 per hamburger equivalent, then the total private benefit (subsidies and sales revenues) to the corporate rancher is only about US\$ 0.225 per hamburger equivalent, while production costs are US\$ 0.26 per unit. Thus, even with socially expensive subsidies, the Amazon beef producers in my survey recovered only 86% of their estimated total 5-year costs. To compensate for the difference be-

tween costs and revenues, ranchers must either accelerate herd off-take or overstock pastures to unsustainable levels. Alternatively, as some researchers assert, they might try to sell their ranches for a windfall profit from rapidly inflated land values.

From a private cost and benefit perspective, beef cattle production in the Brazilian Amazon is only financially sensible given the government subsidies that support it and the possibility of cannibalizing ranch fixed and semi-fixed assets which those subsidies sought to permanently develop. Extensive deforestation in the Amazon attributed to cattle ranching cannot be separated from the public policies that subsidize this activity.⁸

The Social Costs of Rain Forest Destruction

Subsidies entail social costs. However, the total social cost of producing rain forest hamburgers is not

limited to the opportunity cost of public funds embodied in various government subsidy programs. There are other social costs as well, e. g. the opportunity costs of the cattle ranching versus other more productive agricultural or extractive land uses. The largest social cost, however, may derive from the destruction of the forest itself and the timber resources it produces.

The Amazon's forests represent an enormous capital endowment from nature, the market value of which is incalculable. In terms of potential industrial roundwood alone, the 1984 stumpage value of the Amazon's marketable timber resources is roughly appraised at US\$ 800 billion.⁹ Yet the economic utilization of this endowment has been minimal. Less than one-half of all Amazon ranchers have ever extracted commercial timbers from their properties, and among SUDAM-subsidized ranches only 18% have done so.¹⁰ The magnitude of the waste left behind in the conversion of forest to pasture is staggering in both ecological and economic terms. Between 1966 and 1983, the ranches subsidized through SUDAM alone destroyed an estimated 192.8 million cubic meters of marketable roundwood (about 48 million trees) in their haste to transform forest to pasture.¹¹ This amount is more than four times the total volume of industrial roundwood that was extracted from the North region between 1975 and 1980.¹² Assuming that just one-half of this marketable timber could have been economically salvaged, then the opportunity cost associated with the destruction of marketable timber on SUDAM ranches alone would represent the most expensive item in the social cost structure of livestock production in the Brazilian Amazon, about US\$ 2,283 billion between 1966 and 1983, or US\$ 511 per hectare, or US\$ 0.319 per hamburger equivalent.¹³

Brazil's two major programs that subsidize beef cattle production in the Amazon, combined with the destruction of forest resources those programs encourage, represent a total social cost of approximately US\$ 4.8 billion, as summarized in Table III below:

For every quarter-pound unit of Amazon beef that costs US\$ 0.26 to produce, Brazil absorbs at least US\$ 0.46 in social costs. Stated differently, one metric ton of Amazon beef (before processing) embodies about US\$ 4,000 in social costs. In stark contrast, between 1971 and 1982, Brazil paid, on average, US\$ 1,086 per metric ton for imported foreign produced and processed beef

TABLE III
 TOTAL ESTIMATED SOCIAL COSTS OF RAIN FOREST DESTRUCTION
 ATTRIBUTABLE TO PUBLIC POLICIES SUPPORTING LIVESTOCK
 PRODUCTION IN THE BRAZILIAN AMAZON

Item	Social Cost (US\$ Billions)	Cost per Hamburger (US\$)
SUDAM Tax Credits:	1,162	0.135
Central Bank Rural Credits:	1,370	0.005
Timber Destruction:	2,283	0.319
TOTAL SOCIAL COSTS	4,815	0.459

(IBGE, annually). In other words, the Brazilian government could have acquired nearly four metric tons of foreign beef for the same cost it absorbed subsidizing the production of one metric ton of Amazon beef.¹⁴

The divergence between the private and social costs and benefits of beef cattle production in the Amazon is apparent. Subsidized Amazon beef producers obtain a positive return on investment only with subsidies and the liquidation of productive assets. From the private perspective government subsidies enable investors to benefit from the Amazon's livestock sector regardless of its social utility. Without such subsidies producing rain forest beef would be a financial impossibility.

From a social point of view, cattle ranching in the Amazon is a losing proposition, the subsidization of which has diverted scarce resources away from Brazil's pressing social needs, has undoubtedly worsened Brazil's internal and external debts, and has been responsible for most of the destruction visited upon the Amazon's fragile environment. The subsidization of rain forest beef is not worth the social and environmental costs it embodies.

Conclusion

Figuratively speaking, it is true, as Uhl and Parker assert, that "we must acknowledge that consuming rain forest beef is tantamount to consuming rain forest." But it is also much more than that. Converting rain forests to cattle pastures is tremendously expensive and nonremunerative in social and economic terms. Ironically, by encouraging the production of beef cattle in the tropics, a biotope eminently unsuited for such production, international development lend-

ers (e.g. the World Bank, the Inter-American Development Bank, the Organization of American States) and regional development agencies like SUDAM, have impeded development by adding more weight to the already onerous financial debt burdens that tropical beef producing countries like Brazil must service. The case against tropical deforestation can and should be founded on economic grounds.

Professor Matteucci is equally correct in her analogy of rain forests as a "golden stew" which, of course, cannot be eaten. Moreover, as she implies, even the conversion of all tropical rain forests to pasture and the reduction in North American hamburger consumption would not satisfy the ever-growing protein needs of the Third World's burgeoning population. Accordingly, deforestation cannot be justified altruistically.

Professor Segal's assertion that forest conservation alone would be ineffectual and unacceptably costly is also valid. We must recognize the fact that in 1980 there were over 7 million people living in the Brazilian Amazon (probably over 10 million today), and most of these people are there to stay. Saving the rain forests means using them to meet human needs. Subsidized corporate cattle ranching does neither.

As stewards of this vast but fragile endowment from Nature, it is the primary responsibility of the governments presiding over the Amazon, and other imperiled forestlands, to re-direct development priorities toward non-destructive and economically responsible programs for the use of rain forests and their diverse natural products. The tragedy of tropical deforestation is a menacing problem which has an underlying solution, albeit a complex one. However promising certain "sustainable" alterna-

tives to deforestation may now appear to be. the solution, like the problem, is ultimately a question of political choice and public policy.

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NOTES

1. Derived from *Anuario Estatístico do Brasil*, 1983 p. 431 in which it is assumed that the Amazon's contribution to Brazil's 1982 beef exports is directly proportionate to the Amazon's share of Brazil's 1981 beef cattle herd. Since 1983 Brazilian census tables do not present aggregate data for the "Legal Amazon," in this paper the Brazilian Amazon is defined as the "North" region and the state of Mato Grosso.
2. There are over a dozen categories of imported beef products of which only one includes meat destined to become hamburgers. In 1982 hamburger-bound beef from 9 Latin American countries represented only 1.2% of all U.S. beef imports (Shane 1985, p. 89 and USDC, various years).
3. The author's analysis is based on his 1984-85 interviews (base-year: 1983) of 34 (7.2%) of the 469 corporate Amazon cattle ranchers that received tax credit subsidies through the Superintendency for Amazon Development by September 1983. Another 39 ranchers that did not receive SUDAM funding were also interviewed as a separate control group. The survey sample represent ranches in four Amazon states. In the author's analysis, estimates were derived for the investment costs of fixed and semi fixed assets and the operating costs over a five-year period (average economic life of a typical pasture, as assumed by Hecht 1982, Shane 1986, and others). Average capital asset costs were US\$ 241.82 per hectare of pasture while 5-year operating costs were US\$ 172.96 per hectare. Total estimated five-year costs, therefore, were US\$ 414.78 per hectare.
4. Personal communication from Mr. Thomas Strienk, Editor, *Restaurant Business* (New York), on June 5, 1987. A wide range of factors condition franchise profitability in the fast-food restaurant business. A profit rate range of 10% to 18% would apply to 60% to 80% of such establishments in the United States.
5. US\$ 47.7 billion in gross 1985 sales includes all U.S. franchise restaurants. Source: "Statistical Appendix" to *Food Service Trends* (New York: National Restaurant Association, March 1987).
6. Based on an average herd size of 6,000 animal units, an annual herd off-take rate of 17.1%, an average fattened steer price of US\$ 254.37 per animal, and a total pasture area of 11,600 hectares developed

over a five year period, as derived from the author's 1984-85 survey of SUDAM-subsidized ranches. As with unit costs, the nominal annual return of US\$ 22.50 per hectare is compounded at an average annual interest rate of 6.6% (see fn. 7) to give a 5-year total return of US\$ 136.95 per hectare or US\$ 0.085 per hamburger equivalent.

7. In this analysis the opportunity cost rate varies each year in accordance with year-by-year average returns on equivalent investments in common stocks, long-term corporate bonds, long-term U.S. government securities, and U.S. Treasury Bills issued in the United States ("Basic Series: Year-by-Year Total Returns, 1926-1985, compiled by Ibbotson Associates, Chicago). The analysis of opportunity cost therefore assumes the conversion of Brazilian currency to U.S. Dollars in amounts equivalent to nominal SUDAM disbursements and the investment of these funds in the U.S. capital market. It is noteworthy that over the 18-year period in question, the average nominal return on these Basic Series stocks and bonds in the U.S. was 6.6%, considerably less than the opportunity cost rate of 11% recommended by Skillings and Tcheyan (1979, p. vii) for investments in Brazil. Therefore, the author's estimated opportunity cost is a conservative one.
8. Given that the typical SUDAM ranch in the author's survey cleared 11,600 hectares of natural vegetation cover by mid-1985 (an estimated 9,450 hectares by mid-1983), then the SUDAM's 469 ranches alone would be responsible for the conversion of 4.4 million hectares by 1983. The Brazilian government reported 14.8 million hectares of the Legal Amazon's natural vegetation cover had been altered by 1983 (IBDF, 1985). Accordingly, SUDAM's beef cattle program alone was responsible for approximately 30% of the total deforestation reported in the Legal Amazon region of Brazil. It should be noted that the IBDF forest conversion estimates, although widely used, understate the actual areal extent of vegetation cover destruction. For a brief critique see Fearnside, 1985.
9. The estimated "economic" value of the Brazilian Amazon's living timber stock (in terms of potential industrial roundwood alone) of US\$ 792 billion (1984) is derived from Knowles' (1966) calculation of 78.3 billion cubic meters of timber (DBH > 15 cm) for the region overall and an average roundwood price of US\$ 10.12 per cubic meter in 1984 (Browder, in press). Obviously this estimate includes many timber species which have no existing economic use. The author does not suggest that this dollar estimate represents the complete economic or social valuation of the Amazon's rain forests.
10. Derived from the author's 1984-85 survey which, for this question, resulted in 22 useable responses from SUDAM-subsidized ranchers and 34 useable responses from unsubsidized ranchers. The author does not intend to imply that the salvage of all marketable timber from SUDAM-subsidized ranches would have been financially or logistically viable. Nevertheless, these findings suggest that SUDAM subsidies have given ranchers a disincentive to more fully recover valuable timber resources.

11. Commercial timber densities vary widely over time and place in the Amazon in relation to diverse species distributions, market preferences, and transport costs. About 250 (of about 1,500) known Amazon timber species are marketed in Brazil (IBDF, 1985). Based on inventories undertaken by the Brazilian Forestry Institute sampling 33 different commercial species found in 15 different sub-regions of the Amazon an estimated average density of 43.17 cubic meters per hectare is obtained (IBDF, 1978). After 10 years of operation, the typical SUDAM-subsidized ranch in the authors survey sample converted approximately 11,600 hectares of forest by 1985. Extrapolating from the author's survey findings, then of the total 469 SUDAM-subsidized ranches, 385 (82%) salvaged no timber at all in the conversion of forest to pasture. Given the average density of commercial timber (43.17 m³/ha), then these SUDAM-subsidized ranches alone destroyed approximately 192.8 million cubic meters of marketable living timber, or about 48 million trees of commercial value (at 4 m³/mature tree individual). The author's estimate must be considered conservative. Mahar (1979, pp. 128-129) estimates the total loss of 432 million cubic meters by 1974 representing a total social cost of US\$ 1 billion or "more than twice the total investment realized by all livestock projects [by] 1975."

12. The total volume of roundwood extracted from the North region between 1975 and 1980 for industrial purposes was 44.7 million cubic meters (*Anuario Estatístico do Brasil*, various years).
13. These calculations are based on 385 SUDAM ranches not salvaging timber, each of which converts 11,600 hectares of forest, and 43.17 cubic meters of commercial timber per hectare, with an average stumpage price of US\$ 10.12 per cubic meter. The estimated volume of timber destroyed each year is based on the proportion of ranch projects approved by SUDAM each year. The annual nominal value of timber lost is factored by the Basic Series returns factor (see Note 7, above), to obtain the annual opportunity cost which is compounded each year from 1966 through 1983.
14. It is noteworthy that in spite of Brazil's costly subsidies to expand beef production in the Amazon, in 12 of the last years preceding 1984 Brazil has been a net importer of beef products (derived from *Anuario Estatístico do Brasil*, *Capítulo 37*, various years).

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