Table 6.11. *Economic and financial analysis of government assisted cattle ranches in the Brazilian Amazon*

	Net present value (U.S. dollars)	Total investment outlay (U.S. dollars)	NPV/investment outlay
I. Economic analysis			
A. Base case	−2,824,000	5,143,700	−0.55
B. Sensitivity analysis			
1. Cattle prices assumed doubled	511,380	5,143,700	+0.10
2. Land prices assumed rising 5%/year more than general inflation rate	−2,300,370	5,143,700	−0.45
II. Financial analysis			
A. Reflecting all investor incentives: tax credits, deductions, and subsidized loans	1,875,400	753,650	+2.49
B. Sensitivity analysis			
1. Interest rate subsidies eliminated	849,000	753,650	+1.13
2. Deductibility of losses against other taxable income eliminated	−658,500	753,650	−0.87

ing costs, every other year. Fixed assets other than land, under Brazilian tax codes, are depreciated by the straight-line method over a six-year period. Tax losses (operating revenues less operating costs, interest charges, and depreciation) are assumed to be fully deducted against other income taxable at the marginal corporate income tax rate of 40 percent. Since the project never generates a taxable income itself, its eligibility for income tax holiday is irrelevant.

The investor's financial analysis examines the discounted present value of all cash flows to the investor over the project life, at a real discount rate of 5 percent. Expenditures financed from outside tax liabilities, therefore, are not costs to the investor, and the availability of credit financing tied to the project at negative real interest rates adds substantially to the investment's profitability from the private investor's perspective.

In the base case, the present value of the investor's own equity input is only $0.75 million, less than 15 percent of total project investment costs, because the investor can defer his own contribution and use tax credits and government loans instead. As Table 6.11 shows, despite the project's intrinsic unprofitability, the discounted present value of net cash flows to the investor is $1.87 million. This represents a return of 2.5 times the

investor's equity, despite the fact that, from a national perspective, the project loses more than half the capital invested in it. This is a strong indication of the distortions created by these incentive programs, and their effect of drawing private and – even more – public resources into uneconomic and environmentally damaging activities.

Sensitivity analyses explored how much this perverse incentive to private investors would be reduced by removing particular subsidies. First, it was assumed that interest rate subsidies were withdrawn by charging a nominal interest rate of 31 percent, 6 percent above the general inflation rate, the same rate used for discount present-value analysis. The net present value of the project to the private investor is reduced by over half, to $0.85 million, but still represents a 13 percent return on the investor's equity input. A further sensitivity test found that without deductibility of tax losses against other taxable income and without credit subsidies, the discounted present value of the investor's returns becomes a net loss of $0.65 million, nearly equal to his entire investment. Only government subsidies make such livestock investments attractive to private entrepreneurs.

The fiscal cost to the government of these subsidies and incentives is heavy, because they offset the intrinsic losses incurred in the project and provide generous returns to the private investor as well. In fact, in the base case financial analysis, the net present value of foregone tax revenues and concessionary credits is $5.6 million dollars, which is $0.5 million more than the total investment costs of the project itself. In other words, had the government invested directly in these ranches rather than stimulating private investment, it would have lost $2.8 million per ranch, the economic loss estimated in Table 6.11. Its actual loss per ranch is twice that, most accruing to private investors as profits. Such policies are fiscally burdensome as well as economically and environmentally costly.

In addition to the economic and fiscal costs of subsidized loans to cattle ranches, a complete analysis would also consider the opportunity costs of marketable roundwood destroyed in pasture formation. The author's survey found that only 18 percent of the SUDAM ranches recovered merchantable timber in clearing forests. Most ranchers simply destroyed the timber. Although it is conceivable that, given transport costs, such timber might have little stumpage value, government livestock sector development policies have given ranchers little incentive to make full use of forest resources. In contrast to the SUDAM-subsidized ranches, 42 percent of the non-SUDAM ranches surveyed had marketed timber. Two reasons for this divergence are likely. First, government subsidies substitute for private capital that would undoubtedly be raised in part from

more extensive timber sales. Second, large SUDAM-subsidized landowners clear forest quickly to demonstrate tenancy and prevent intrusions by land-grabbers and landless peasants, and to demonstrate to SUDAM inspectors that tax-credit subsidies are at work.

The opportunity costs of marketable roundwood destroyed in the process of ranch implantation may be large. On an average SUDAM ranch of 23,600 hectares (Gasques and C. Yokomizo 1985), where about 11,600 hectares could legally be converted from forest to pasture, at an average density of "merchantable" roundwood of 43.17 cubic meters per hectare (IBDF 1978), the total volume of merchantable timber that could be cut would be 500,772 cubic meters per ranch. By September 1985 there were 527 SUDAM-supported ranches, giving an estimated total marketable timber cut of 263,907,000 cubic meters. Since only 18 percent of these ranches marketed timber (generously presumed to be all marketable timber, i.e., 43.17 cubic meters per hectare), then 432 ranches marketed no timber, a potential loss of 216,333,500 cubic meters. Taking a conservative estimate of average current (1985) stumpage values for commonly extracted Amazon timber species other than mahogany, a range of $5–$10 per cubic meter as the social value of timber recovery, then the social opportunity cost of forest destruction reaches $1–2 billion on the SUDAM-supported ranches alone. This is roughly equal to the amount of SUDAM tax credits allocated to the livestock sector between 1966 and 1983.[19]

Small farmer settlement policy and the forest sector

While Brazilian Amazon development policy has emphasized the expansion of large-scale capitalist enterprises, settlement by small farmers also has been significant in regional development efforts and an important cause of tropical forest conversion. Colonization programs have been motivated by four national concerns: a growing landless peasant class, idled by drought and agro-industrial land consolidation (mainly in the Northeast and South); seasonal labor shortages in the Amazon's growing extractive industries; agricultural subsidies to stimulate domestic and export food crop production; and the military regime's desire to secure national sovereignty in a frontier region sharing undefended borders with seven neighboring nations.

The PIN Transamazon directed colonization program

The idea that the Amazon could be an agricultural frontier capable of absorbing the marginalized rural masses of the Brazilian *sertão* was

embodied in Decreto Lei 1.106/1970, establishing the National Integration Program (PIN). This program's foundation was an ambitious highway-building program to integrate the Amazon with the "economic mainland" of Brazil. The east-west Transamazon Highway and north-south Cuiabá-Santarém Highway projects were planned to bisect the region. The Transamazon Highway was intended to connect the Belém-Brasília Highway with the town of Humaitá in Amazonas, a distance of 2,322 kilometers, and eventually to complete a line of roads from the Atlantic coast at Recife to the Peruvian border at Cruzeiro do Sul, a total distance of 5,560 kilometers. The areas adjacent to these roads were initially reserved for small farmers, most of whom were to be drawn from the populous, drought-beleaguered Northeast.

Colonization along the highway was to take place in a pattern of "rural urbanism," with a three-tier system of central places: agrovilas (small villages of 48 to 66 dwellings) spaced at 10-kilometer intervals, agropoli (settlements of 600 families serving 8 to 22 agrovilas with banking and postal facilities, public schools, and farm cooperatives), and ruropoli (cities of up to 20,000 with communication, medical, and administrative services and agro-industries) at 140-kilometer intervals.

The Transamazon region was divided into three Integrated Colonization Project (PIC) areas headquartered at Marabá, Altamira, and Itaituba. The ambitious plan projected the settlement of 100,000 families on 100-hectare lots by 1976. By mid-1974 only 3,700 families had received title from the National Colonization and Land Reform Institute (INCRA) (Katzman 1977). These numbers increased to 5,717 by the end of 1974 and about 7,000 by the end of 1975 (Moran 1982). By mid-1978 only 7,900 families owned titled farm lots on the Transamazon (Skillings and Tcheyan 1979). Including families with temporary land occupancy permits, no more than 12,800 families were settled through PIN in the Transamazon area (Bunker 1985). In the Marabá and Itaituba PIC areas, colonization plans were curtailed by malaria (Marabá) and poor soils (Itaituba). Because of its more fertile soils, PIC Altamira became the showcase of Transamazon colonization. The rural urbanism plan also fell short of initial objectives. Of the 66 agrovilas planned for the Altamira project, 27 were actually built and most lacked the promised amenities. Only 3 of the 15 agropoli planned for the Marabá-Itaituba segment of the highway were finally constructed and only one ruropolis was built. Maintenance of the Transamazon Highway, a continuous problem, has been minimal, leaving many stretches impassable during the rainy season, so that food often must be airlifted to settlements. Complex and often contradictory bureaucratic policies and procedures, as well as bad planning,

played a large part in the failure of the program (Pompermayer 1979; Bunker 1985). Yet, underlying these shortcomings was a major policy shift away from small-farmer settlement toward a renewed emphasis on large-scale land development (mainly cattle ranching) that followed from the lobbying of the Association of Amazon Entrepreneurs, a São Paulo-based livestock interest group, and led to the POLOAMAZONIA program in 1974 (Pompermayer 1979).

The costs of the National Integration Program are difficult to measure. About $1 billion was allocated for fiscal years 1971–1974, mostly for road-building, but it is doubtful that more than $500 million was actually spent (Smith 1981). It has been estimated that highway construction costs were about $120 million.[20] The agrovilas cost about $425,000 each ($11.5 million overall), and the direct cost of relocating and settling farmers was about $13,000 per family ($103 million overall).

POLONOROESTE and semi-directed colonization in Rondônia

Colonization efforts in Rondônia have had more far-reaching social and forest sector consequences than those in the Transamazon. After nearly three decades of spontaneous settlement, the first federal initiative to bring order to the population explosion in Rondônia began in 1968. Shortly thereafter, INCRA was charged with rationalizing the distribution of land titles and planning the occupation of new frontier zones in the territory. By the end of 1980, 22,650 families had received land titles from INCRA in eight different areas of Rondônia (SEPLAN/Ro 1985). Many others were squatting on public land awaiting titles. The number of title holders increased to 24,748 by 1983. By July 1985, INCRA had deeded 29,944 properties to small farmers (SEPLAN/Ro 1985: 23), most of which were 100 hectares in size.

In 1981 a full-scale regional development program was established for Rondônia and western Mato Grosso. As in the PIN, the Northwest Brazil Integrated Development Program (POLONOROESTE) was predicated on massive investments in highway improvements. About $568 million (1981) was budgeted to reconstruct and pave the 1,500-kilometer Cuibá–Pôrto Velho highway. Another $520 million was budgeted for land settlement, agricultural development, and feeder roads. About $36 million was allocated for environmental protection and support of Indian communities (World Bank 1981: 1). While both PIN and POLONORESTE were based on an exaggerated conception of the importance of interregional transport, they differed in noteworthy ways. Unlike PIN in the Transamazon, INCRA's role in Rondônia has been limited to the demarcation of lots in project areas and issuing of land titles. Although the State Secretariat of Planning prepared urban plans for specific settlement sites, the rural urbanism scheme was not replicated in Rondônia. In the Transamazon, INCRA paid colonists relocation expenses and gave farmers up to eight months of salary (at about $40 per month) (Moran 1976: 18). Adding housing, local social overhead facilities, and administration, the total per capita cost of PIN was about $39,000 per colonist. In Rondônia, colonists receive no stipend; in fact, they pay nominal administrative fees for their land titles, and are expected to amortize their moving and groundbreaking costs by marketing timber from their lots. Total POLONOROESTE costs for land settlement alone come to about $10,000 per household.

A second noteworthy difference is the productivity of the soils in the two areas. In neither area are soil conditions ideal for either annual or perennial crops. However, while only about 3 percent of the Transamazon transect has agriculturally desirable soils, 33 percent of Rondônia's soils were classified as "good" for perennial agriculture (Fundação João Pinheiro 1975).

Planners of the Transamazon Highway exhibited little regard for protecting either indigenous communities or biologically rich refugia along the highway's path. While it cannot be said that POLONOROESTE planners have spared no expense to guarantee Indian land rights or conserve pristine wilderness areas in Rondônia (indeed the Brazilian government and the World Bank have been severely criticized for their sponsorship of environmental destruction in this region [Rich 1985]), it is noteworthy that in the POLONOROESTE program the government has supported initiatives to protect 46 different bounded areas (Indian reserves, biological reserves, and protected forest areas). These areas total 5.1 million hectares, or 21 percent of the total area of a state that has one of the world's richest and most diverse tropical ecosystems.

Forest sector impacts

It is virtually impossible to estimate the total forest area that has been converted by small farmer settlement in the Transamazon and Rondônia. However, the direct forest impacts of PIN in the Transamazon were probably substantial. Most of the migrants have stayed in the region, but many have sold their original lots and moved to nearby towns (Moran, in press). Assuming that by 1983 each family had cleared 50 hectares of land from their original 100-hectare lots (the maximum allowed by law), then 640,000 hectares of converted forest can be directly attributed to these settlers. This amount is equal to 14.9 percent of the area reported converted in the state of Pará (where most of the PIN settlement was

centered) and only 4.3 percent of the total conversion in the Legal Amazon. Since the government effectively abandoned PIN in 1975, the program probably had no direct effect on deforestation beyond 1983.

In Rondônia, INCRA had granted 51,361 families farm lots by 1983 (SEPLAN/Ro 1985: 20).[21] Based on the author's 1985 research on forest clearance by farmers in the Rolim de Moura sector of the Gi-Paraná Settlement Project Area of Rondônia, by 1983 the typical farmer had cleared an average of 19.3 hectares. Assuming that Rolim de Moura is typical, then at the state level INCRA beneficiaries had converted 991,267 hectares, about 71.0 percent of the total area of Rondônia reported deforested by 1983. Throughout the Amazon region, where 14.8 million hectares were reported deforested by 1983, direct government colonization in Rondônia would account for only 6.7 percent of the regional total.

The direct forest conversion impacts associated with sponsored small farmer settlement in both the Transamazon and Rondônia projects totaled 11 percent of the Amazonian forest alteration detected by Landsat monitoring by 1983.

Subsidy effects

The social overhead investments in both settlement programs ($1.5 billion to $2.5 billion) tend to overshadow the substantial implicit subsidies to colonists represented by the land grants conferred in both programs. The official value of the land given to colonists was set by INCRA at about $1 per hectare. However, the market value of the land, $31.70 per hectare (based on the author's survey data, Table 6.8), indicates an implicit land subsidy of $163 million in Rondônia, or about $3,200 per colonist.

More important, land title has allowed many colonists to borrow subsidized money under various government rural credit programs. In Rondônia by 1985, an estimated 48.6 percent of the nearly 30,000 colonists with titles had borrowed money under one program or another at least once. Although the amounts, interest rates, and terms of these loans varied widely in the sample of 70 colonists in the Gi-Paraná colonization project area, most of these loans were tied to the cultivation of a certain cash crop over a specific area (e.g., seven hectares of coffee) or the purchase of livestock, either of which would involve new forest conversion. Interestingly, nearly one-fourth (23.5 percent) of the loans to these colonists were used, in part, to purchase chainsaws.

In the Transamazon, unlike Rondônia, one researcher found that "lumber operations" (i.e., forest resources) did not provide significant income to settlers and that credit programs, while contributing up to 30 percent of farmer income (in the case of upland rice subsidies), had encouraged production distortions through inappropriate crop selection and forest clearance (Smith 1981). Banks were more willing to loan for the production of specific cash crop varieties approved by INCRA and EMATER (Brazil's agricultural extension service) on the basis of experimental trials undertaken in nontropical conditions outside the Amazon. Sustaining production required expensive pesticides and fertilizers. Banks were also more willing to lend to farmers for first-year plantings in newly cleared fields, which produce higher crop yields than older fields. This practice may have encouraged farmers to cut new forest more often than necessary.

That cheap financing would encourage forest conversion is almost obvious. In Rondônia, the mean value of the area cleared by farmers by 1985 was 22.3 hectares. However, 60.9 percent of the sub-sample who were recipients of subsidized financing had cleared more than that. Farmers in Rondônia who receive rural credit tend to clear about 25 percent more forest area than those who do not receive such financing.

Small farmer settlement has been a feature of Amazon development policy since 1970 and has promoted deforestation in the Transamazon and Rondônia. Migration to the Amazon is likely to continue, even intensify, under economic conditions of austerity. Small farmer settlement is closely linked to large social overhead investments, especially in transport improvements. The regularization of land titles has enabled many titled farmers to borrow from the government's rural credit programs, further exacerbating deforestation. Although it accounts for less than half the deforestation attributable to cattle ranching, small farmer settlement clearly has been a significant cause. Finally, it should be noted that there are several private colonization projects in Amazônia, some supported by government subsidy programs. Most of these projects are relatively new and small compared to the Transamazon or Rondônia colonization programs.

Conclusions and recommendations

The Amazon is the world's largest tropical moist forest region, believed to be home to a tenth of the earth's 5 million to 10 million plant and animal species. The forests of the Brazilian Amazon alone may contain nearly a third of the world's volume of tropical broadleafed timbers: between 48 billion and 78 billion cubic meters. Yet, in spite of their enor-

mous economic value and essential environmental functions, the rain forests of the Brazilian Amazon are being destroyed at rates that appear to be accelerating exponentially in some areas.

Nearly half the rain forest destruction in the Brazilian Amazon thus far is directly attributable to four government subsidy programs: the SUDAM program for developing the Brazilian Amazon, the Brazilian Central Bank's rural credit program, the National Integration Program in the Transamazon, and the semi-directed program of small farmer settlement in the state of Rondônia. The numbers of beneficiaries, the subsidies, and the forest impacts are summarized in Table 6.12.

Livestock production, expanded largely through government fiscal incentives, has been responsible for the largest proportion – 30 percent – of the forest conversion in the region. While it has been asserted that forest destruction may be justified if alternative uses of forest land bring large and unambiguous benefits, large-scale cattle ranching, without enormous subsidies, is economically untenable in the Amazon, its income covering only about 45 percent of costs. Regardless of the harmful environmental effects of cattle ranching on the Amazon, this activity can be discredited on economic grounds alone.

Yet the Brazilian government, during the bureaucratic authoritarian regime (1964–1985), vigorously pursued expansion of the livestock sector in the Amazon. The explanation for this apparently irrational behavior may be found in Brazil's political economy during this period. Anxious to ensure its legitimacy by appeasing powerful corporate interest groups, the government used the Amazon development program to transfer vast sums of public capital into private hands. Cattle ranching became the pretext for the appropriation of public capital by the large corporations to which the government's policies were, in the main, directed. Although ranches were inherently unprofitable as production operations, their corporate owners could nonetheless obtain large profits through government subsidies. In essence, the SUDAM livestock program has subsidized corporate profits at the considerable expense of the Brazilian taxpayer and the Amazon's forests.

Fearing social unrest in the rural backlands of the Brazilian Northeast and South, where land tenure regimes are highly unequal, the government sponsored two massive colonization programs initially directed toward small farmers with large families. The National Integration Program (PIN) of the early 1970s ambitiously sought to transplant 100,000 farmers to the Transamazon. Hastily conceived and without regard for variable soils, topographical constraints, preexisting indigenous populations, or public health problems, PIN was doomed to fail. Fewer than 15,000 farmers participated directly.

The enormously expensive Transamazon Highway, conceived partly to open up the region, is in a perpetual state of disrepair, although still in use. Most of the area along the highway cleared by small farmers is now in marginal use as pasture. Weary of trying to survive in a world they did not understand, many of the original farmers have abandoned their farms and moved to nearby towns and cities (the Amazon is the most rapidly urbanizing region of Brazil). Others, faced with tired soils or threats of intimidation by armed land-grabbers, have moved further into the Amazon to clear new forest areas.

The spontaneous settlement of Rondônia has been a different experience from that of the Transamazon, although both were predicated on the highway-based development model. In the Transamazon, colonization was directed by government planners and bureaucrats who selected the farmers to be relocated and determined the design and organization of life in the communities they would live in. In Rondônia, the government races to keep up with the droves of migrants who arrive on their own initiative. By 1985, nearly 30,000 migrants to Rondônia had received definitive land titles. Perhaps a comparable number are squatting on land in anticipation of titles. During the 1970s, as the rural population of Brazil actually declined, Rondônia's rural population exploded at an annual rate of 34 percent. The effects of this population explosion on Rondônia's forest are shocking: in 1975, only 0.5 percent of the area had been deforested; by 1980, 3.1 percent had been converted; by 1983, 5.7 percent; by 1985, over 11 percent.

Government programs to develop the Amazon are leading to its destruction. What can be done to alter this course? Numerous areas of the Amazon are known to be particularly rich in biological diversity. Other areas belong to Indians who have a moral right to live undisturbed by modern development in the lands they have conserved and cultivated for centuries. The natural integrity of such areas should be ruthlessly and tirelessly defended. However, the strictly protectionist approach to the Amazon overall is, in the author's opinion, doomed to fail. Conservation of the Amazon's rain forests must begin with an appreciation of their value as an economic asset, endowed by nature. Like any fund, with responsible stewardship, the Amazon can generate benefits in perpetuity for humans. In accordance with this "use it or lose it" philosophy, which is by no means universally shared among students of the Amazon, the following general policy recommendations are offered:

Table 6.12. *Subsidy and forest impacts of selected government programs*

Program	Total estimated subsidy (U.S. dollars)	Estimated subsidy rate (percent)	Number of direct beneficiaries	Subsidy per beneficiary (U.S. dollars)	Area deforested (hectares)	Percent of total deforested area in Brazil[a]
Livestock						
SUDAM livestock tax credits	597,710,000[b]	54[c]	469[d]	1,274,000[e]	4,432,050[f]	30.0
Rural credit for pasture formation[g]	65,072,000[h]	49[i]	3,511[j]	18,500[k]	880,000[l]	5.9
Settlement						
PIN	500,000,000[m]	n.a.	12,800	39,062[n]	640,000[o]	4.3
Rondônia						
• POLONOROESTE	520,000,000[p]	n.a.	51,361[q]	10,124[r]	991,267[s]	6.7
• Implicit land subsidy	162,800,000[t]	100	51,361	3,170[u]	—	—
• Implicit timber subsidy	150,399,000–306,779,000[v]	100	27,889[w]	550–1,100[x]	—	—

[a]Total area deforested by 1983 = 14,837,294 hectares (IBDF/PMCF).

[b]Total SUDAM tax credit assistance to the livestock sector from 1965 through September 1983 expressed in nominal U.S. dollars.

[c]Average tax credit share of total capital costs of a sample of 18 SUDAM-supported cattle ranches.

[d]Number of cattle ranches receiving SUDAM tax credit financing from 1965 through September 1983.

[e]Total estimated subsidy divided by beneficiaries.

[f]In mid-1985, the average SUDAM ranch was 11 years old and had cleared 9,450 hectares, which, multiplied by 469 ranches, is 4,432,050 hectares.

[g]"Rural credit" refers to Permanent Pasture formation loans only. Numerous other credit lines were used for deforestation as well, but these are not trackable. Hence, rural credit data given represent the minimum.

[h]$65,072,000 = total disbursements of $132.8 million from 1969 to 1982 to ranchers in the "North Region" under Permanent Pasture credit program multiplied by the nominal subsidy rate of 49 percent effective in 1975 (assumed median rate for period), as indicated in Table 6.6.

[i]1975 subsidy rate embodied in rural credit loans as specified in Table 6.6.

[j]Complete data are not available. From 1977 through 1983, 3,511 Permanent Pasture loans were executed to cattle ranchers in the North Region.

[k]Average nominal U.S. dollar value of per capita Permanent Pasture loans, adjusted by subsidy rates given in Table 6.6, from 1977 through 1981.

[l]Derived from total Permanent Pasture loan disbursements of $132.8 million (nominal) made from 1969 through 1983 to cattle ranchers in the North Region divided by average forest clearance and pasture formation costs of $150.95 per hectare as indicated in Table 6.8.

[m]Approximate total expenditures of PIN Transamazon program.

[n]Total PIN expenditures divided by maximum number of known beneficiaries.

[o]Assumes that by 1983 each of the 12,800 PIN beneficiaries cleared a total of 50 hectares of forest, the legal limit on a 100-hectare lot (12,800 × 50).

[p]Portion of POLONOROESTE budget for 1981–86 for land settlement, agricultural development, and feeder roads.

[q]Number of families receiving permanent and provisional titles to 100-hectare lots in seven colonization areas of Rondônia by 1983 as indicated by SEPLAN/Ro (1985: 20).

[r]$520 million (land settlement, agricultural development, feeder roads) of total POLONOROESTE budget divided by 51,361 INCRA beneficiaries in Rondônia.

[s]Based on author's 1985 survey of 70 colonists in Gi-Paraná PIC of Rondônia in which the typical colonist had cleared 19.3 hectares by 1983 multiplied by total 1983 beneficiaries (51,361).

[t]Implied subsidy equivalent to $31.70 per hectare (average 1984 market price for unimproved Amazon land indicated in Table 6.8) multiplied by 100 hectares per beneficiary and 51,361 beneficiaries.

[u]$31.70 per hectare land subsidy multiplied by 100 hectares per beneficiary.

[v]Implied subsidy equivalent to $550–1,100 per beneficiary of a 100-hectare lot multiplied by 27,889 beneficiaries (54.3 percent of 51,361 total beneficiaries) who marketed an average of 110 cubic meters of timber with an estimated stumpage value of $5–10 per cubic meter through 1984 as reported by 70 colonists surveyed by author in 1985.

[w]Number of colonists who marketed timber occurring on their 100-hectare lots in Rondônia through 1984.

[x]Based on an average of 110 cubic meters marketed per beneficiary multiplied by $5–10 per cubic meter (range of stumpage values from 1978 to 1984) expressed in nominal U.S. dollars.

1. No new livestock projects should be approved for tax credit financing by SUDAM. For existing cattle projects in the Amazon, all fiscal incentives (i.e., tax credit financing and income tax deductions) should be phased out over a five-year period.
2. Similarly, the various rural credit programs should be amended by the Central Bank to prohibit new lending for fixed and semi-fixed investment on ranches in the tropical zones of the Amazon.
3. Instead, it is recommended that priority SUDAM financing be given to four categories of projects: (a) those that would reclaim and make economic use of degraded clearings in the terra firma areas; (b) large-scale agroforestry projects; (c) industrial wood projects that are based on sustained-yield cropping and selective reforestation of appropriate commercial timber species (i.e., "forest enrichment"), especially when those projects are directly linked to Brazilian-based final wood product manufacturing enterprises; and (d) projects that would promote the self-sustaining economic utilization of the Amazon's fertile *várzea* floodplains.
4. Any project that would involve the conversion of more than 50 hectares of dense or transition forest should be subjected to certain requirements for SUDAM financing that ensure the maximum possible recovery of forest resources. After the ratio of public-to-private matching shares of SUDAM projects has been determined, the private share should be adjusted upward in an amount equal to the estimated present market value and replacement cost value of the forest resources that would be destroyed by the project. Theoretically, this would provide corporations with an incentive to maximize the salvage of forest resources (timber, fuelwood) or minimize the forest area they would convert.

The development model of the Amazon region has been largely based on "growth pole" theory, which holds that investment in a leading sector propels development in other related sectors. In the Amazon, livestock was selected as the leading sector. Yet, after more than 20 years of public investment, the livestock sector has absorbed more in subsidies than it has generated in revenues and has contributed little to permanent regional employment. It has not stimulated collateral development, except in the slaughterhouse and meat-packing industries. Nor has it obviated the shortages of beef and dairy products that periodically beleaguer Brazilian consumer markets. Moreover, it has been the principal engine of destruction of the Amazon's rain forests. The growth pole approach, based on the livestock sector, has been tested in the Amazon for more than 20 years, and it has failed. Now it is time to try something new.

Acknowledgments

The author wishes to acknowledge the valuable assistance provided to him by the National Science Foundation, the Organization of American States, the Núcleo de Altos Estudos Amazônicos–Universidade Federal do Pará, the Instituto de Florestas–Universidade Federal Rural do Rio de Janeiro, and the Instituto Brasileiro de Desenvolvimento Florestál (Brasília and Pôrto Velho), whose generous financial and logistical support made possible the field research leading to this report. The preparation of this report was made possible by the World Resources Institute.

Endnotes

1. The Brazilian Amazon region (BAR) is commonly defined in two ways. The "North Region" (defined by IBGE, the Brazilian census agency) includes the states of Pará, Amazonas, Acre, Rondônia, and Amapá and the federal territory of Roraima. The "Legal Amazon" (the definition used by SUDAM, the Superintendência do Desenvolvimento da Amazônia) includes the North Region plus Mato Grosso state and large parts of Goiás and Maranhão states. Since information in this paper is drawn from both IBGE and SUDAM, both definitions are used in the text, as necessary.

2. This estimate (84.3 percent of tree species represented by less than one individual per hectare) is based on an inventory of 36 hectares of natural "high forest" (*alta floresta*) in the Tapajós National Forest area of central Amazônia in which 134 different species of trees (15 cm. d.b.h. or more were found). Mercado (UFRRJ 1985b: 139) in an inventory of the Jamari National Forest in Rondônia (southern Amazônia) indicates that 90 percent of the species in this so-called "transition forest" (*floresta aberta*) occur in densities of less than 1 tree (10–35 cm. d.b.h.) per hectare.

3. The $1.7 trillion estimate is based on Knowles' (1966) estimate of 78.3 billion cubic meters multiplied by the average cost of roundwood production, estimated by Browder (1986: 232) at $21.87 per cubic meter. The author does not suggest that this entire stock of biomass should be auctioned off or quickly harvested to meet pressing national economic exigencies (e.g., foreign debt). Brazil's Amazon forest resource must be regarded as a capital endowment fund from which substantial annual interest income may be earned if responsible sustained-yield cropping practices are followed. In any case, the world's capacity to absorb the entirety of the region's tropical timbers in the short term (e.g., 5–10 years) is too limited for this notion to be practical.

4. "Industrial wood" includes sawnwood and pulp at various stages of processing, used as inputs to final demand manufacturing processes (excluding industrial fuelwood). In the Amazon, the sector mainly consists of lumber mills.

5. Fearnside (1985a) gives three reasons for believing that Landsat-based estimates of deforested areas are low. First, 1978–1983 data for three of the nine federal units of the Legal Amazon (Amapá, Roraima, and Amazonas), totaling nearly 40 percent of the region's area, were not included in the 1983 estimates. Second, evidently the Landsat technology has difficulty distinguishing primary (virgin) forest from secondary growth. Third, Fearnside maintains that Landsat is handicapped in detecting small forest clearings. In spite of these legitimate criticisms, most researchers, including Fearnside, use the Landsat information as the only available standard, regularly updated measure of deforestation in the Bra-

zilian Amazon. Furthermore, some of the apparent technical deficiencies in Landsat image interpretation are being resolved, according to IBDF consultants.

6. It is conceivable that as government resources become strained in the current economic crisis in Brazil, subsidies for Amazon development projects might be reduced. In this case, recent trends in deforestation rates may not continue their apparently exponential upward spiral. While general economic difficulties may constrain the pace of deforestation due to cattle ranching, it is likely to aggravate deforestation due to frontier migration and small farmer settlement as "push factors" become more intense.

7. The assertion that "deforestation is linked to longstanding economic patterns in Brazil, such as high inflation rates" and several other points made in this section of the text are abstracted from Fearnside (1985a).

8. For an excellent discussion of the preference given to the livestock sector by Amazon development policy-makers, and the role of foreign markets, see Hecht (1985).

9. The estimated value of corporate income tax exemption declared by Amazon industrial wood producers between 1970 and 1984 is $1.2 billion (1984). See Browder (1986: 139–40, fn.).

10. Personal communication from Dr. Fabio Monteiro de Barros, Senior Partner, Castro and Barros, São Paulo, Brazil, and Robert Repetto, World Resources Institute, Washington, D.C.

11. Given the proliferation of rural credit programs during the 1970s (over 100 specific credit lines), estimating with exactitude the volume of disbursements to the livestock sector in the Brazilian Amazon is difficult. The $730.5 million includes both SUDAM indirect tax credits ($598 million) and rural credit disbursements ($132.5 million). The latter is clearly a minimal estimate derived from one credit line (permanent pastures) and excludes the various special credit programs for which disbursements are not trackable. A more likely estimate of the total use of rural credit disbursements for pasture formation would be about $691 million [$147.1 billion (total disbursements) × 0.196 (share to the livestock sector nationwide) × 0.024 (share of total disbursements to North Region)]. If this amount ($691 million) was spent only on forest clearance and pasture formation, then rural credit programs to the livestock sector were responsible for conversion of 4.6 million hectares (31 percent of the total area reported deforested by Landsat) by 1983 ($691 million divided by $150.95 per hectare). These estimates seem realistic given that total rural credit disbursements to the Amazon's livestock sector between 1976 and 1983 were US$987 million in nominal terms.

12. This estimate, 29.99 percent of the total area deforested by 1983, is a direct extrapolation from the author's sample of 8.5 percent of all 469 SUDAM-subsidized cattle ranchers (by September 1983). At the microregional level, the livestock factor is a considerably more important determinant of deforestation. For instance, Tardim et al. (n.d.), in an exhaustive study of 760,000 hectares in Barra de Garcas area of northern Mato Grosso, found that SUDAM ranches were responsible for 38 percent of the area deforested.

13. Other estimates of the average area of SUDAM livestock projects range from 18,126 (SUDAM 1983) to 28,860 hectares (Pompermayer 1979). For the traditional IBGE North Region and Mato Grosso, the average size of establishment listed in livestock production (*pecuária*) has been estimated at 872 hectares (IBGE, Censo Agropecuária, 1980).

14. Personal communication from Alberto Oliveira Lima Filho in 1984, based on his 1980 market study for the Atlas Meat Processing Company.

15. The statement "Deforestation is justified only when the economic benefits to be obtained therefrom are large and unambiguous" was made by Robert F. Skillings, former chief of the Brazil Division, World Bank, and proponent of the POLONOROESTE program in Rondônia. Cited in Hemming (1985).

16. For a general review of the major environmental issues involving tropical deforestation, see Goodland (1975), Myers (1980), Lugo and Brown (1982), Guppy (1984), the Sioli and Fearnside chapters of Hemming (1985), Tangley (1986), and Buschbacher (1986). More detailed studies have focused on nutrient cycling and soil productivity (Herrera et al. 1978; Falesi 1976, 1980; Seubert et al. 1977; Alvim 1977; Serrão et al. 1979; Fearnside 1980a; Hecht 1982); soil porosity and erosion (Daubenmire 1972; Fearnside 1980b; Abreu Sa Diniz et al. 1980); hydrologic cycles and rainfall (Molion 1975; Villa Nova et al. 1976; Marques et al. 1977; Friedman 1977; Salati 1980; Gentry and Lopez-Parodi 1980); atmospheric-climatic effects (Sioli 1978; Woodwell 1978; Salati 1980; Kuklas and Gavin 1981; Woodwell et al. 1983); species extinction (Gomez-Pompa et al. 1972; Pires and Prance 1977; Prance 1982; Lovejoy and Oren 1981; Lovejoy and Salati 1983; Lovejoy et al. 1983; Myers 1985); and threats to native populations (Davis 1977; Posey 1983).

17. Land purchase price ($31.70 per hectare) applies to entire ranch (49,000 hectares), while all other capital and operating costs ($383.12 per hectare) apply only to area in pasture (11,600 hectares).

18. More recent SUDAM policy is to limit the value of the land to 10 percent of the private investor's equity contribution.

19. For an additional discussion of the social costs of timber destruction in the Brazilian Amazon, see Browder (in press) and Mahar (1979: 128–129).

20. Derived from Moran (1976: 81), who obtained a Transamazon unit road-building cost of $53,710 per kilometer.

21. This number includes 24,748 families with titles and 26,613 families who had received temporary land occupation licenses from INCRA in anticipation of definitive titles and who should be considered beneficiaries of the Rondônia settlement program. Twenty-nine percent of the colonists surveyed in the author's sample did not have definitive land titles.

References

Abreu Sa Diniz, Tatiana Deane, and Therezinha X. Bastos. 1980. Efeito do Desmatamento na Temperatura do Solo em Região Equatorial Úmida. *Boletim de Pesquisa No. 7*. Belém: EMBRAPA/CPATU.

Alvim, Paulo de Tarso. 1977. Agricultura nos Trópicos Úmidos: Potencialidades e Limitações. *In Trabalhos Apresentados no Primeiro Seminário Regional de Desenvolvimento Rural Integrado*, Vol. 2, January 24–26. Manaus: SUDAM/Fundação Getúlio Vargas.

Banco Central do Brasíl. 1985. *Manual de Normas e Instruções*. MCR No. 199, Circular 1292, Capitulo 5. Brasília.

Banco Central do Brasíl. *Dados Estatísticos* (Brasília), various years.

Binswanger, Hans P. 1987. Fiscal and Legal Incentives with Environmental

Effects on the Brazilian Amazon. Unpublished discussion paper, Agriculture and Rural Development Department, World Bank. Washington, D.C., May.
Browder, John O. 1984. Tomando Conhecimento dos Importadores Norteamericanos de Madeira Amazônica Brasileira. *Infoc Madeireiro*, Edição Especial 3 (20). Brasília: IBDF.
Browder, John O. 1985. Subsidies, Deforestation and the Forest Sector in the Brazilian Amazon. A report to the World Resources Institute. Washington, D.C.
Browder, John O. 1986. Logging the Rainforest: A Political Economy of Timber Extraction and Unequal Exchange in the Brazilian Amazon. Ph.D. diss. University of Pennsylvania.
Browder, John O. In press. The Social Costs of Rain Forest Destruction: A Critique and Economic Analysis of the Hamburger Debate. *Interciencia*.
Bruce, Richard W. 1976. Produção e Distribuição da Madeira Amazônica. Série Estudos No. 4. Brasília: IBDF.
Bunker, Stephen G. 1985. *Underdeveloping the Amazon: Extraction, Unequal Exchange, and the Failure of the Modern State*. Urbana: University of Illinois Press.
Buschbacher, Robert J. 1986. Tropical Deforestation and Pasture Development. *Bioscience*, Vol. 36, No. 1: 22–28.
Caulfield, Catherine. 1984. *In the Rainforest*. University of Chicago Press.
Correa de Lima, J. P., and R. S. Mercado. 1985. The Brazilian Amazon Region: Forestry Industry Opportunities and Aspirations. *Commonwealth Forestry Review*, Vol. 64, No. 2: 151–156.
Daubenmire, R. 1972. Some Ecological Consequences of Converting Forest to Savanna in Northwestern Costa Rica. *Tropical Ecology*, Vol. 13, No. 1: 31–51.
Davis, Sheldon H. 1977. *Victims of the Miracle*. London: Cambridge University Press.
Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA). 1981. Distribuição Diamétrica de Espécies Comerciais e Potenciais em Floresta Tropical Úmida Natural na Amazônica. Boletim de Pesquisa No. 23. Prepared by João Olegário Pereira de Carvalho. Belém: EMBRAPA/CPATU.
Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA). 1984. *Amazônia: Meio Ambiente e Technologia Agrícola*. Prepared by Cristo Nascimento and Alfredo Homma. Belém: EMBRAPA/CPATU.
Erfurth, Th. 1974. International Trade and Trade Flows of Tropical Forest Products. *Properties, Uses, and Marketing of Tropical Timber*, Vol. 1. Final report, FAO, Rome.
Falesi, I. C. 1976. *Ecosistema de Pastagem Cultivada na Amazônia Brasileira*. Boletim Técnico No. 1. Belém: EMBRAPA/CPATU.
Falesi, I. C. 1980. O Solo na Amazônia e sua Relação com a Definicão de Sistemas de Produção Agrícola. *Reunião do Grupo Interdisciplinar de Trabalho sobre Diretrizes de Pesquisa Agrícola para a Amazônia*, Vol. 1. May 6–10, 1974. Brasília: EMBRAPA.
FAO. *See* United Nations Food and Agriculture Organization.
Fearnside, Philip M. 1980a. Effects of Cattle Pasture on Soil Fertility in the Brazilian Amazon: Consequences for Beef Production Sustainability. *Tropical Ecology*, Vol. 21, No. 1: 125–137.
Fearnside, Philip M. 1980b. The Prediction of Soil Erosion Losses under

Various Land Uses in the Transamazon Highway Colonization Area of Brasil. In *Tropical Ecology and Development: Proceedings of the Fifth International Symposium of Tropical Ecology*, ed. J. I. Furtado, April 16–21. Kuala Lumpur: International Society of Tropical Ecology.
Fearnside, Philip M. 1984. A Floresta Pode Acabar? *Ciencia Hoje*, Vol. 2, No. 10 (Janeiro/Fevereiro): 34–41.
Fearnside, Philip M. 1985a. The Causes of Deforestation in the Brazilian Amazon. Paper presented at the United Nations University International Conference on Climatic, Biotic and Human Interactions in the Humid Tropics: Vegetation and Climate Interactions in Amazônia. February 25–March 1. São Paulo, São José dos Campos.
Fearnside, Philip M. 1985b. Environmental Change and Deforestation in the Brazilian Amazon. In *Change in the Amazon Basin: Man's Impact on Forests and Rivers*, ed. John Hemming, pp. 236–40. Manchester: Manchester University Press.
Fearnside, Philip M. 1986. Agricultural Plans for Brazil's Grande Carajas Program: Lost Opportunity for Sustainable Local Development? *World Development*, Vol. 14, No. 3: 385–409.
Friedman, I. 1977. The Amazon Basin: Another Sahel. *Science*, Vol. 197: 7.
Fundação João Pinheiro. 1975. Levantamento de Reconhecimento de Solos da Aptidão Agropastoril, das Formações Vegetais, e do Uso da Terra em Área do Terrritório Federal de Rondônia. Belo Horizonte: MI/SUDECO/FJP.
Gasques, J. B., and C. Yokomizo. 1985. Resultados de 20 Anos de Incentivos Fiscais na Agropecuária da Amazônia. Unpublished paper, Instituto de Planejamento Economico e Social, Brazil.
Gentry, A., and J. Lopez-Parodi. 1980. Deforestation and Decreased Flooding in the Upper Amazon. *Science*, Vol. 201: 1354–1356.
Gomez-Pompa, A., C. Vasquez-Yanes, and C. Guevara. 1972. The Tropical Rainforest: A Non-Renewable Resource. *Science*, Vol. 177: 762–765.
Goodland, Robert. 1985. Brazil's Environmental Progress in Amazonian Development. In *Change in the Amazon Basin: Man's Impact on Forests and Rivers*, ed. John Hemming, pp. 5–35. Manchester: Manchester University Press.
Guppy, Nicolas. 1984. Tropical Deforestation: A Global View. *Foreign Affairs*, Spring: 928–965.
Hecht, Susanna B. 1982. Cattle Ranching Development in the Eastern Amazon: Evaluation of a Development Strategy. Ph.D. diss., University of California, Berkeley.
Hecht, Susanna B. 1985. Environment, Development and Politics: Capital Accumulation and the Livestock Sector in Eastern Amazônia. *World Development*, Vol. 13, No. 6: 663–684.
Hecht, Susanna B. 1986. Development and Deforestation in the Amazon. Unpublished report to the World Resources Institute. Washington, D.C., January.
Hecht, Susanna B. 1985. The Economics of Cattle Ranching in Eastern Amazônia. Unpublished manuscript.
Hemming, John, ed. 1985. *Change in the Amazon Basin: Man's Impact on Forests and Rivers*. Manchester: Manchester University Press.
Herrera, R., C. Jordan, H. Klinge, and E. Medina. 1978. Amazon Ecosystems:

Their Structure and Functioning with Particular Emphasis on Nutrients. *Interciencia*, Vol. 3: 223–231.
Instituto Brasileiro de Desenvolvimento Florestál (IBDF). 1978. *Informes Sobre a Comercialização da Madeira Amazônica.* Coleção: Desenvolvimento e Planejamento Florestál, Série Técnica 7. Brasília: COPLAN.
Instituto Brasileiro de Desenvolvimento Florestál (IBDF). 1985. *O Sector Florestál Brasileiro: 79/85.* Brasília.
Instituto Brasileiro de Geografia e Estatística (IBGE), various years. *Anuário Estatístico. Censo Agropecuária. Censo Industrial.*
Instituto de Pesquisa Tecnológica de São Paulo (IPT). 1985. Estabelecimento de Estratégia de Comercialização Nacional de Madeiras Tropicais Brasileiras. Resumo do Relatório, No. 21.824. São Paulo.
International Monetary Fund. 1983. *Interest Rate Policies in Developing Countries.* Occasional Paper No. 22. Washington, D.C., October.
Katzman, Martin T. 1977. *Cities and Frontiers in Brazil.* Cambridge: Harvard University Press.
Knowles, O. H. 1966. Relatorio ao Governo do Brasíl Sobre a Producão e Mercado de Madeira na Amazônia. Projecto do Fundo Especial No. 52. MI/SUDAM/FAO.
Knowles, O. H. 1969. *Investment and Business Opportunities in Forest Industrial Development of the Brazilian Amazon.* SF/BR4, Technical Report 1. Rome: FAO/UNDP/FD.
Kuklas, G., and J. Gavin. 1981. Summer Ice and Carbon Dioxide. *Science*, Vol. 214: 497–503.
Lovejoy, Thomas E., and David C. Oren. 1981. The Minimum Critical Size of Ecosystems. In Ecological Studies 41: *Forest Island Dynamics in Man-Dominated Landscapes*, ed. Robert L. Burgess and David M. Sharpe. New York: Springer-Verlag.
Lovejoy, Thomas E., and Eneas Salati. 1983. Precipitating Change in Amazônia. In *The Dilemma of Amazonian Development*, ed. Emilio Moran. Boulder, Colo.: Westview Press.
Lovejoy, Thomas E., et al. 1983. Ecological Dynamics of Tropical Forest Fragments. In *Tropical Rainforests: Ecology and Management.* Oxford: Blackwell Scientific Publications.
Lugo, Ariel E., and Sandra Brown. 1982. Conversion of Tropical Moist Forests: A Critique. *Interciencia*, Vol. 7, No. 2: 89–93.
Mahar, Dennis J. 1979. *Frontier Development Policy in Brazil: A Study of Amazônia.* New York: Praeger.
Marques, J., J. M. Sanots, N. A. Villa Nova, and E. Salati. 1977. Precipitable Water and Water Vapor Flux Between Belém and Manaus. *Acta Amazônia*, Vol. 7, No. 3: 355–362.
Mercado, Roberto Samanez. 1980. A Indústria Madeireira da Amazônia: Estrutura, Produção, e Mercados. Ph.D. diss., Michigan State University.
Mitchell, J. 1984. *Workshop on the Global Effects of Carbon Dioxide from Fossil Fuels.* Washington, D.C.: U.S. Department of Energy.
Molion, L.C.B. 1975. A Climatonomic Study of the Energy and Moisture Fluxes of the Amazonas Basin with Consideration of Deforestation Effects. Ph.D. diss., University of Wisconsin.

Moran, Emilio F. 1976. Agricultural Development in the Transamazon Highway. Latin American Studies Working Papers. Bloomington: Indiana University.
Moran, Emilio F. 1982. Colonization in the Transamazon and Rondônia. Paper presented at the 31st Annual Latin American Conference on Frontier Expansion in Amazônia, February 8–11, University of Florida, Gainesville.
Moran, Emilio F. In press. Resettlement in the Amazon Forests. In *People of the Rain Forest*, ed. Julie S. Denslow and Christine Padoch. Berkeley: University of California Press.
Myers, Norman. 1980. *Conversion of Tropical Moist Forests.* Washington, D.C.: National Academy of Sciences.
Myers, Norman. 1981. The Present Status and Future Prospects of Tropical Moist Forest. *Environmental Conservation*, Vol. 7, No. 2: 101–114.
Myers, Norman. 1985. The End of the Lines. *Natural History*, Vol. 2: 2–12.
Pires, J. M., and G. T. Prance. 1977. The Amazon Forest: A Natural Heritage to Be Preserved. In *Extinction Is Forever*, ed. G. T. Prance and T. Elias. Bronx: New York Botanical Gardens.
Pompermayer, Malori Jose. 1979. The State and the Frontier in Brazil: A Case Study of the Amazon. Ph.D. diss., Stanford University.
Posey, Darrell A. 1983. Indigenous Ecological Knowledge and Development of the Amazon. In *The Dilemma of Amazonian Development*, ed. Emilio Moran. Boulder, Colo.: Westview Press.
Prance, Ghillean T. 1982. *Biological Diversity in the Tropics.* New York: Columbia University Press.
Pringle, S. L. 1976. Recycling of Water in the Amazon Basin: An Isotope Study. *Water Resources Research*, Vol. 15, No. 5: 1250–1258.
Rich, Bruce M. 1985. The Multilateral Development Bank's Environmental Policy and the United States. *Ecology Law Quarterly*, Vol. 12: 681–745.
Salati, Eneas. 1980. Um Deserto no Futuro da Amazônia. Rio Branco *O Jornal*, March 31.
Secretaria de Planejamento do Rondônia (SEPLAN/Ro). 1985. *Anuário Estatístico de Rondônia, 1983.* Pôrto Velho.
Serrão, A., I. Falesi, J. B. Vega, and J. F. Teixeira. 1979. Productivity of Cultivated Pastures on Low Fertility Soils of the Brazilian Amazon. In *Pasture Production in Acid Soils of the Tropics*, ed. P. A. Sanchez and L. E. Tergas. Cali, Colombia: CIAT.
Seubert, C. E., P. A. Sanchez, and C. Valverde. 1977. Effects of Land Clearing Methods on Soil Properties and Crop Performances on a Utisol of the Amazon Jungle of Peru. *Tropical Agriculture*, Vol. 54: 307–321.
Shane, Douglas R. 1986. *Hoofprints on the Rainforest.* Philadelphia: Institute for the Study of Human Issues.
Silva, José Natalino Macedo. 1983. Influência de Duas Intensidades de Exploração no Crescimento da Floresta Residual. *Pesquisa em Andamento, No. 129.* Belém: EMBRAPA.
Sioli, Harald. 1978. Destruição da Amazônia Pode Ameaçar o Mundo. Quoted in the *Folha de São Paulo*, December 12.
Sioli, Harald. 1985. The Effects of Deforestation in Amazônia. In *Change in the*

Amazon Basin: Man's Impact on Forests and Rivers, ed. John Hemming: 58–65. Manchester: Manchester University Press.

Skillings, Robert F. 1985. Economic Development of the Brazilian Amazon: Opportunities and Constraints. In *Change in the Amazon Basin: Man's Impact on Forests and Rivers*, ed. John Hemming: 36–43. Manchester: Manchester University Press.

Skillings, Robert F., and Nils O. Tcheyan. 1979. *Economic Development Prospects of the Amazon Region of Brazil.* Monograph, School of Advanced International Studies. Washington, D.C.: Johns Hopkins University Press.

Smith, Nigel J.H. 1977. Transamazon Highway: A Cultural-Ecological Analysis of Colonization in the Humid Tropics. Ph.D. diss., University of California, Berkeley.

Smith, Nigel J.H. 1981. Colonization Lessons from a Tropical Forest. *Science*, Vol. 214, No. 4522: 744–61.

Superintendência do Desenvolvimento da Amazônia (SUDAM). 1983a. Incentivos Fiscais Liberados Pela SUDAM (Anualmente), Distribuição Setorial até o Mês de Setembro/83. Spreadsheets. Belém: SUDAM/DPO/DAI.

Superintendência do Desenvolvimento da Amazônia (SUDAM). 1983b. Relacão de Projetos Aprovados. Unpublished report. Belém.

Tangley, Laura. 1986. Saving Tropical Forests. *Bioscience*, Vol. 36, No. 1: 4–8.

Tardim, Antonio T., et al. n.d. Relatório das Atividades do Projeto. No. 1034. SUDAM/INPE.

United Nations Food and Agriculture Organization (FAO). 1978. *1977 Yearbook of Forestry Products.* Rome.

United Nations Industrial Development Organization (UNIDO). 1983. *First World-Wide Study of the Wood and Wood Processing Industries.* Sectoral Studies Series No. 2. Vienna.

United States Congress. 1984. Multilateral Development Bank Activity and the Environment. Report of the Subcommittee on International Development Institutions and Finance, Committee on Banking, Finance and Urban Affairs, U.S. House of Representatives (98th Congress, 2nd Session).

United States Department of State. 1978. Tropical Deforestation. Proceedings of the U.S. Strategy Conference Sponsored by the U.S. Department of State and the U.S. Agency for International Development, June 12–14, Washington, D.C. Washington, D.C.: U.S. Government Printing Office.

United States Interagency Task Force on Tropical Forests. 1980. *The World's Tropical Forests: A Policy Strategy and Program for the United States.* U.S. Department of State Publication No. 9117. Washington, D.C.: U.S. Government Printing Office.

Universidade Federal Rural do Rio de Janeiro (UFRRJ). 1983. *Diagnóstico da Indústria Madeireira do Estado de Rondônia.* Rio de Janeiro: MA/IBDF/DIC/UFRRJ.

Universidade Federal Rural do Rio de Janeiro (UFRRJ). 1985a. *Contribuição de Mercado Madeireiro no Desenvolvimento Regional: Rondônia.* Rio de Janeiro: MA/IBDF/DIC/UFRRJ.

Universidade Federal Rural do Rio de Janeiro (UFRRJ). 1985b. *Proposta para o Plano de Manejo da Floresta Nacional do Jamari.* Rio de Janeiro: MA/IBDF/DEF/UFRRJ.

Villa Nova, N. A., E. Salati, and E. Matsui. 1976. Estimativa da Evapotranspiração na Bacia Amazônico. *Acta Amazônica*, Vol. 6: 215–228.

Woodwell, George. 1978. Carbon Dioxide-Deforestation Relationships. *Proceedings of the U.S. Strategy Conference on Tropical Deforestation.* U.S. Department of State and the U.S. Agency for International Development, June 12–14, Washington, D.C.

Woodwell, George, et al. 1983. Global Deforestation: Contribution to Atmospheric Carbon Dioxide. *Science*, Vol. 222 (4628): 1081–1086.

World Bank (International Bank for Reconstruction and Development). *World Tables* (various years).

World Bank. 1981. *Brazil: Integrated Development of the Northwest Frontier.* A World Bank Country Study, June 1981. Washington, D.C.

Published by the Press Syndicate of the University of Cambridge
The Pitt Building, Trumpington Street, Cambridge CB2 1RP
32 East 57th Street, New York, NY 10022, USA
10 Stamford Road, Oakleigh, Melbourne 3166, Australia

First published 1988

Printed in the United States of America

Library of Congress Cataloging-in-Publication Data
Public policies and the misuse of forest resources.

"A World Resources Institute book."
Includes index.
1. Forest policy – Developing countries – Case studies.
2. Deforestation – Environmental aspects – Developing countries – Case studies. I. Repetto, Robert C.
II. Gillis, Malcolm. III. World Resources Institute.
HD9768.D44P82 1988
333.75'09172'4 87-33815

British Library Cataloguing in Publication Data
Public policies and the misuse of forest resources. – (A World Resources Institute book).
1. Natural resources. Forests. Exploitation. Policies of governments
I. Repetto, Robert II. Gillis, Malcolm
III. Series
333.75

ISBN 0-521-34022-5 hard covers
ISBN 0-521-33574-4 paperback

For Rachel and Sar
R.

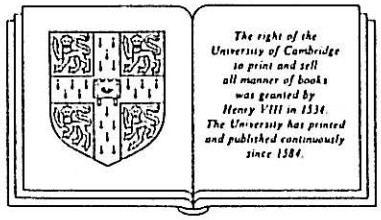
For Bill, Elsie, Lillianette,

Public policies and the misuse of forest resources

A World Resources Institute Book

Edited by
Robert Repetto
World Resources Institute

Malcolm Gillis
Duke University



CAMBRIDGE UNIVERSITY PRESS
Cambridge
New York New Rochelle Melbourne Sydney