DEFORESTATION, LAND DEGRADATION AND RURAL POVERTY IN LATIN AMERICA: EXAMINING THE EVIDENCE*

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Abstract

The following paper examines aggregate evidence of a link between rural poverty, land degradation and deforestation in Latin America. Overall trends in land degradation and deforestation are discussed, as well as the geographical 'location' of the rural poor. The paper also compares and contrasts three statistical analyses of the factors influencing deforestation across the region, and finds evidence of potential rural poverty-resource degradation linkages given the negative relationship between income per capita as well as agricultural yields and deforestation, as well as the positive relationship between rural

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population density and forest clearance. However, policies aimed at increasing economic growth are not sufficient on their own to reverse the rural poverty-resource degradation linkage in Latin America. Instead, these need to be supported by more targeted policies and investments to raise the comparative returns to existing agricultural lands, improve the access of poor rural households to land and credit markets, extend key infrastructure, extension and marketing services to the rural poor, and remove tax and pricing distortions that benefit mainly wealthier farmers and landowners.

1 Introduction

The main purpose of this paper is to provide an overview of aggregate empirical evidence of the potential links between rural poverty and resource degradation in Latin America. Recent studies suggest that there are two overall aspects of poverty-environment linkages that are critical to this relationship in developing countries (see Barbier (1997) for a review).

First, poverty may not be a direct cause of environmental degradation but instead may operate as a constraining factor on poorer rural households' ability to avoid resource degradation or to invest in mitigating strategies. Empirical evidence suggests that poorer households in rural Latin America are more constrained in their access to credit , inputs and research and extension services necessary for investments in improved resource management (Barbier 1998; López and Valdés 1998). Poverty, imperfect capital markets and insecure land tenure may reinforce the tendency towards short-term time horizons in production decisions, which may bias land use decisions against long-term resource management strategies. Consequently, a rational strategy for poor rural households with limited access to capital and alternative economic opportunities may be to extract short-term rents through resource conversion and degradation, so long as there are sufficient additional resources available in frontier areas to exploit relatively cheaply and the cost of access remains low.

Second, poverty may severely constrain poor households ability to compete for resource access. In periods of commodity booms and land speculation, wealthier households generally take advantage of their superior political and market power to ensure initial access to better quality resources in order to capture a larger share of the resource rents. Poorer households are either confined to marginal environmental areas where resource rents are limited or only have access to higher quality resources once resources are degraded and rents are dissipated. This relationship between poverty, resource access and resource degradation is perhaps less well-documented for Latin America but may be significant, particularly in frontier areas characterized by open access resource exploitation (Barbier 1998; Schneider 1994; Mahar and Schneider 1994; Sunderlin and Rodrigez 1996).

The outline of the paper is as follows. The next section examines overall trends in land degradation and deforestation in Latin America, as well as the geographical 'location' of the rural poor. The evidence suggests that there might be a 'cumulative causation' link between rural poverty, deforestation and land degradation: poor rural household abandoning degraded land for 'frontier' forested lands, which results in deforestation and cropping of poor soils leading to erosion, which is in turn followed by land abandonment and additional conversion further into the forest frontier, and so on. If such an aggregate relationship exists, then cross-country statistical analyses of deforestation and land expansion should provide some evidence of this linkage. In Section 3, three statistical analyses of the factors affecting deforestation are examined, and the results are interpreted in light of potential rural poverty-resource degradation linkages. Finally, the conclusion to this paper discusses briefly the implications for policy of the overview of aggregate evidence of a 'cumulative causation' link between rural poverty, deforestation and land degradation in Latin America.

2 Land Degradation and Deforestation in Latin America: an Overview

The 1990 global forest resource assessment of tropical deforestation indicated that the annual deforestation rate across tropical Latin America over 1981-90 was approximately 0.8%, which is par with the global average (see Table 1). However, the area of tropical forests cleared on average each year in Latin America, 7.4 million hectares (ha), is almost as much as the first area cleared in Asia and Africa put together. Although most of the deforestation is currently occurring in tropical South America (6.4 million ha), the highest rate of deforestation is being experienced in Central America and Mexico (1.5% annually).

Table 2 compares global and Latin American trends in human-induced soil erosion over the 1945-90. Over 15% of the world's degraded land is located in Latin American countries. Central America and Mexico have the highest proportion of degraded area to all vegetated land of any region in the world. Much of the degradation in this region appears to be moderate, severe or extreme. South America also has a significant amount of human-induced soil degradation, although much of it is light degradation. Agricultural activities cause the most degradation in Central America and Mexico, with deforestation also a significant factor. In South America, deforestation is the main cause of human-induced degradation, although over-grazing and agricultural activities are also significant.

Together Tables 1 and 2 suggest that in recent years the major rural resource use trends in Latin America have resulted in both processes of deforestation and land degradation. Moreover these two processes are clearly linked, as deforestation appears to be a major source of human-induced soil degradation in the region. Underlying both recent deforestation and land degradation trends in Latin America has been rapid changes in land use patterns. This is illustrated in Table 3.

Virtually all Latin American countries have experienced an expansion in cropland area since 1979-81, while at the same time forest and woodland area has declined substantially (see Table 3).[1] Permanent pasture has also increased in most Latin American countries. Continued conversion of forest and woodland to other uses is perhaps inevitable given the

[1] The few countries in Table 3 which show an expansion of forest area over 1981-90, include Chile, Cuba and Uruguay, all of which have expanded plantation and/or reforestation efforts.

pressures of population density and the high proportion of forested land in Latin America.

TABLE 1

Global Tropical Deforestation Trends

Region	Number of countries	Land area (million ha)	Forest cover		Annual deforestation 1981-90	
			1980 (million ha)	1990 (million ha)	million ha	% per annum
Africa	**40**	**2,236.1**	**568.6**	**527.6**	**4.1**	**0.7**
West Sahelian Africa	6	528.0	43.7	40.8	0.3	0.7
East Sahelian Africa	9	489.7	71.4	65.5	0.6	0.9
West Africa	8	203.8	61.5	55.6	0.6	1.0
Central Africa	6	398.3	215.5	204.1	1.1	0.5
Trop. Southern Africa	10	558.1	159.3	145.9	1.3	0.9
Insular Africa	1	58.2	17.1	15.8	0.1	0.8
Asia & Pacific	**17**	**892.1**	**349.6**	**310.6**	**3.9**	**1.2**
South Asia	6	412.2	69.4	63.9	0.6	0.8
Continental S.E. Asia	5	190.2	88.4	75.2	1.3	1.6
Insular S.E. Asia	5	244.4	154.7	135.4	1.9	1.3
Pacific	1	45.3	37.1	36.0	0.1	0.3
Latin America & Caribbean	**33**	**1,650.1**	**992.2**	**918.1**	**7.4**	**0.8**
C. America & Mexico	7	239.6	79.2	68.1	1.1	1.5
Caribbean	19	69.0	48.3	47.1	0.1	0.3
Trop. South America	7	1,341.6	864.6	802.9	6.2	0.7
Total	**90**	**4,778.3**	**1,910.4**	**1,756.3**	**15.4**	**0.8**

Source: FAO (1993).

TABLE 2

Global Trends in Human-Induced Soil Degradation, 1945-90

Region	Total Degraded Area (million ha)	Degraded Area as a % of Vegetated Land	Causes of Soil Degradation (%)				
			Deforestation	Over-Exploitation a/	Over-Grazing	Agricultural Activties	**Industrialization b/**
World	**1,964.4**	**17.0**	**30**	**7**	**35**	**28**	**1**
Moderate, severe	1,215.4	10.5					
and extreme c/	749.0	6.5					
Light d/							
Europe	**218.9**	**23.1**	**38**	**--**	**23**	**29**	**9**
Moderate, severe	158.3	16.7					
and extreme	60.6	6.4					
Light							
Africa	**494.2**	**22.1**	**14**	**13**	**49**	**24**	**--**
Moderate, severe	320.6	14.4					
and extreme	173.6	7.8					
Light							
Asia	**747.0**	**19.8**	**40**	**6**	**26**	**27**	**--**
Moderate, severe		12.0					
and extreme	452.5	7.8					
Light	294.5						
Oceania	**102.9**	**13.1**	**12**	**--**	**80**	**8**	**--**
Moderate, severe	6.2	0.8					
and extreme	96.6	12.3					
Light							
North America	**95.5**	**5.3**	**4**	**--**	**30**	**66**	**--**
Moderate, severe	78.7						
and extreme	16.8	4.4					
Light		0.9					
Central America	**62.8**	**24.8**	**22**	**18**	**15**	**45**	**--**
and Mexico	60.9	24.1					
Moderate, severe	1.9	0.7					
and extreme							
Light							
South America	**243.4**	**14.0**	**41**	**5**	**28**	**26**	**--**
Moderate, severe	138.5	8.0					
and extreme	104.8	6.0					
Light							

Sources: Oldeman, van Engelen and Pulles (1990) and WRI (1992).

Notes and Sources

Notes: -- represents less than 1 percent contribution.

a/ *Over-exploitation* refers to over-exploitation for fuelwood use

b/ *Industrialization* includes industrial and waste accumulation, excessive pesticide use and acidification by airborne pollutants.

c/ *Extreme degradation* - degradation has occurred on poor soils and restoration is impossible. *Severe degradation* - degradation involves severe nutrient depletion and deeper, more frequent gullies and hollows; extensie restoration is required, involving physical structures, drainage works, terraces, mechanized deep plowing, and reseeding. *Moderate degradation* – degradation that involves loss of topsoil from water and wind erosion, nutrient decline, some salinization and soil compaction, all of which contribute to loss of potential productivity; restoration is essential to reverse productivity declines, and requires both soil conservation practices and major structural interventions, such as drainage for waterlogging or salinity, contour ridging, bunds, etc.

d/ *Light degradation* - degradation on good soils that shows signs of dgradation – some topsoil loss, nutrient decline and increased salinity – which can be restored through standard conservation practices, such as crop rotation, minimum tillage, and other on-farm practices.

TABLE 3

Latin America - Land Area and Use, 1979-91

	Land Area (000 ha)	1993 Population Density (per 000 ha)	Cropland and Pasture as % of Land Area	Forest as % of Land Area	Cropland 1989-91 (000 ha)	Cropland % Change since 1979-81	Permanent Pasture 1989-91 (000 ha)	Permanent Pasture % Change since 1979-81
Central America and Mexico	**262.005**	**1.219**	**50,3**	**23,9**	**37.730**	**4,5**	**94.164**	**5,2**
Belize	2.280	89	4,6	44,4	56	9,0	48	9,1
Costa Rica	5.106	640	55,9	32,1	529	4,5	2.327	15,6
Cuba	10.982	993	57,4	25,1	3.330	4,0	2.970	15,3
Dominican Republic	4.838	1.575	73,1	12,7	1.446	2,4	2.092	0,0
El Salvador	2.072	2.663	64,8	5,0	733	1,1	610	0,0
Guatemala	10.843	925	30,3	34,6	1.882	7,9	1.400	7,7
Haiti	2.756	2.501	50,9	1,4	905	1,7	497	-2,4
Honduras	11.189	503	39,2	29,1	1.824	3,7	2.560	6,2
Jamaica	1.083	2.304	42,5	17,1	270	1,8	190	-8,1
Mexico	190.869	472	52,0	22,2	24.713	0,7	74.499	0,0
Nicaragua	11.875	346	56,2	28,5	1.273	2,1	5.400	10,7
Panama	7.599	337	29,1	43,4	649	16,7	1.560	13,9
Trinidad & Tobago	513	2.493	25,5	42,9	120	3,4	11	0,0
South America	**1.742.693**	**173**	**34,8**	**47,2**	**113.697**	**10**	**492.730**	**6,8**
Argentina	273.669	122	61,9	21,6	27.200	0,0	142.200	-0,7
Bolivia	108.438	71	26,7	51,3	2.328	12,9	26.600	-1,7
Brazil	845.651	185	28,9	58,3	59.933	23,1	184.200	7,5
Chile	74.880	184	23,9	11,8	4.400	3,9	13.500	3,8
Columbia	103.670	327	44,2	48,5	5.410	4,1	40.400	5,8
Ecuador	27.684	409	28,4	39,4	2.732	9,4	5.140	29,2
Guyana	19.685	41	8,8	6,2	495	0,1	1.230	0,8
Paraguay	39.730	117	58,6	34,7	2.199	26,7	21.100	33,5
Peru	128.000	179	24,1	53,4	3.730	6,1	27.120	0,0
Suriname	15.600	29	0,6	95,2	68	39,7	20	1,7
Uruguay	17.481	180	84,8	3,8	1.304	-9,5	13.520	-0,8
Venezuela	88.205	234	24,5	34,2	3.898	4,3	17.700	2,9
All Countries	**2.004.698**	**717**	**36,8**	**44,1**	**151.427**	**7,2**	**586.894**	**6,0**

(cont...)

(continued)

	Forest and Woodland		Other Land		Annual Logging of Closed Broadleaved Forest, 1981-90	
	1989-919 (000 ha)	% Change since 1979-81	1989-91 (000 ha)	% Change since 1979-81	Extent (000 ha)	% of Closed Forest
Central America and Mexico	**62.724**	**-12,8**	**67.388**	**7,1**	**102**	**1,1**
Belize	1.012	0,0	1.164	-0,7	3	0,2
Costa Rica	1.640	-9,9	611	-20,3	34	2,6
Cuba	2.760	9,1	1.922	-28,1	3	0,2
Dominican Republic	615	-3,1	685	-2,0	0	0,0
El Salvador	104	-25,7	625	4,7	na	na
Guatemala	3.750	-17,6	3.811	17,3	3	0,1
Haiti	38	-34,1	1.316	1,3	1	7,7
Honduras	3.260	-18,8	3.545	17,9	2	0,1
Jamaica	185	-5,1	438	5,3	1	0,4
Mexico	42.460	-11,4	49.197	12,1	4	0,0
Nicaragua	3.380	-24,7	1.822	44,6	45	0,9
Panama	3.300	-20,4	2.090	36,9	3	0,1
Trinidad & Tobago	220	-4,3	162	3,8	3	1,8
South America	**822.086**	**-5,9**	**314.379**	**8,1**	**2.466**	**0,3**
Argentina	59.200	-1,4	45.069	4,3	na	na
Bolivia	55.590	-1,1	23.920	3,4	12	0,0
Brazil	493.030	-4,9	108.488	1,2	1.982	0,5
Chile	8.800	1,3	48.180	-1,6	na	na
Columbia	50.300	-5,6	7.760	7,8	108	0,2
Ecuador	10.900	-21,9	8.912	22,8	152	1,3
Guyana	16.369	0,0	1.591	-0,6	9	0,0
Paraguay	13.800	-31,6	2.631	30,3	49	1,8
Peru	68.400	-3,5	28.750	8,6	89	0,1
Suriname	14.853	-0,2	658	2,7	11	0,1
Uruguay	669	6,8	1.988	11,4	na	na
Venezuela	30.175	-8,8	36.432	6,6	54	0,1
All Countries	**884.810**	**-9,5**	**381.767**	**7,6**	**2.568**	**0,7**

Source: WRI (1994).

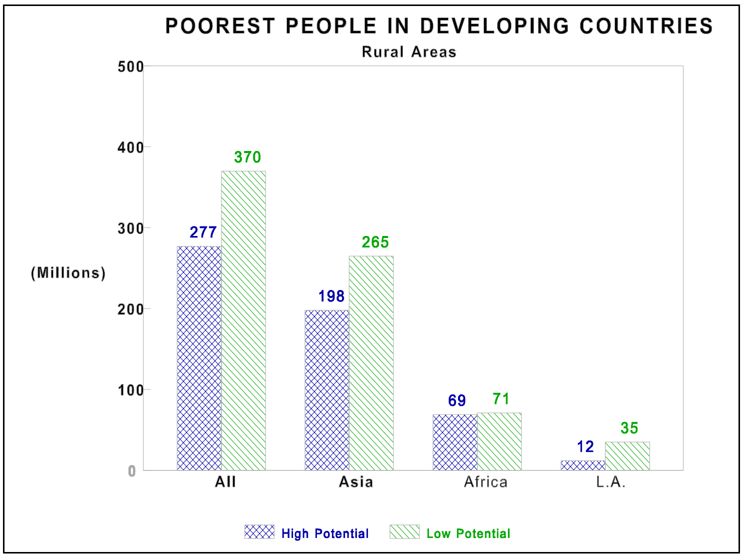
For example, although in Central America and Mexico approximately 50% of the land area is already either cropland or pasture, just under 25% of the remaining land is still forest and woodland. Population density is on average over 1,200 people per square kilometre (km^2). With the exception of Costa Rica and Nicaragua, timber production appears to be relatively insignificant at present across the region. It is not surprising that population pressure in particular may be forcing further expansion of cropland and permanent pasture at the expense of forest and woodlands.

In comparison, South America still retains vast areas of forest and woodlands, with just under 50% of its total land area still forested. Timber production also seems more significant in the region, although Brazil is clearly the dominant timber producer of the region. However, in South America cropland and permanent pasture are also expanding rapidly at the expense of forest and woodlands, particularly the tropical forests.

It is extremely difficult to find aggregate statistics linking rural resource poverty to land degradation and deforestation trends in Latin America. However, an analysis by Leonard *et al.* (1989) attempted to determine how the poorest 20 percent of the rural population in developing countries were distributed across ‘high’ and ‘low potential’ lands. The latter are defined as resource-poor or marginal agricultural lands, where inadequate or unreliable rainfall, adverse soil conditions, fertility and topography limit agricultural productivity and increase the risk of chronic land degradation. The results are indicated in Figure 1. Although the rural areas of Latin America have a much lower total number of extreme poor than Asia or Africa, a higher proportion of Latin America’s poorest people are concentrated on low potential lands. Almost three quarters of the poorest 20% of the rural population in Latin America can be found on low potential lands, as opposed to 51% and 57% in Africa and Asia respectively. One factor explaining the larger share of the rural poor on ‘low’ potential lands in Latin America is that this region has a greater amount of high-yield and mechanized commercial agriculture than either Africa or Asia.

FIGURE 1

The Rural Poor and Ecologically Fragile Areas



Source: Leonard *et al.* (1989).

Notes: High Potential = High potential agricultural lands; i.e., highly productive, favourable agricultural lands that are either irrigated or have reliable and adequate rainfall, as well as generally high or potentially high soil fertility.

Low Potential = Low potential lands; i.e., resource-poor or marginal agricultural lands. where inadequate or unreliable rainfall, adverse soil conditions, fertility and topography limit agricultural productivity and increase the risk of chronic land degradation.

The 'poorest people' are defined as the poorest 20 percent of the population in developing countries.

As low potential lands are considered to be prone to chronic land degradation, then clearly the problems of rural poverty and human-induced soil degradation are linked in Latin America. Moreover, given that in Latin America many marginal and resource-poor lands are also likely to have been previously forested lands, then a strong rural poverty-deforestation link may also exist. Finally, as depicted in Table 2, deforestation may itself may be an important cause of human-induced soil degradation across Latin America. This raises the possibility of a ‘cumulative causation’ link between rural poverty, deforestation and land degradation: poor rural household abandoning degraded land for 'frontier' forested lands, deforestation and cropping of poor soils lead to further degradation, which in turn lead to land abandonment and additional forest land conversion, and so on.

If there is a linkage between aggregate levels of rural poverty, land degradation and deforestation in Latin America, then cross-country statistical analyses of the regions should provide some evidence of this linkage. The next section looks at three recent statistical analyses of the factors underlying deforestation across Latin America, and discusses whether their findings provide evidence of a relationship between rural poverty and resource degradation.

3 Statistical Analysis of Deforestation in Latin America

Several recent studies have conducted statistical analysis of deforestation in Latin America, especially emphasizing role of agricultural conversion. Although most studies have focussed on individual countries, a few have attempted to elicit regional trends. In this section, two regional analyses of relevance to this paper are examined, and an additional analysis conducted for this study is also discussed.

Data on closed forest area and annual deforestation rates are notoriously unreliable across Latin American countries. A common approach is to assume that expansion of agricultural land or permanent pasture is a proxy measure for forest land conversion. As discussed in the previous section, this is not an unreasonable assumption for Latin America.

For example, Southgate (1994) employs data from 24 Latin American countries to explore the causes of agricultural frontier expansion and thus forest clearance. The dependent variable used in the analysis is average annual agricultural land (i.e. permanent pasture and cropland) growth over 1982-87. The results are indicated in Table 4, and suggest that the expansion of agricultural land across Latin America - and thus by proxy deforestation - are causally related to a number of key growth variables. Population growth appears to be positively correlated with agricultural frontier expansion, reflecting perhaps both the direct demand for agricultural land as populations increase as well as the indirect demand as increasing numbers of consumers raises the demand for agricultural commodities and production. Agricultural export growth also appears to be positively related to agricultural land expansion, again most likely indicating the influence of a strong export performance on the demand for land. In contrast, growth in agricultural yields across Latin American countries seems to reduce agricultural land expansion. Yield increases appear to be offsetting the demand for converting and bringing new agricultural land into production. Finally, Southgate also includes a 'land constraint' variable, reflecting the physical constraints of the land. The negative coefficient on this variable indicates that, where there is little appropriate land available for additional conversion, then the growth in arable land is significantly reduced.

Cropper and Griffiths (1994) used pooled cross-section and time-series data over the period 1961-88 for Latin America, Asia and Africa separately to determine the effects of both income and population pressure on annual deforestation rates. Developing countries roughly in the tropical belt and containing forest area of over one million ha were included in the analysis. The purpose of examining the income relationships was to test for the environmental Kuznets curve or 'inverted U' hypothesis; i.e., to what extent does deforestation first rise, even out and then fall with increases in per capita income across developing regions. In addition, the authors wanted to determine the additional influence of population pressure on tropical deforestation.

TABLE 4

Analysis of Agricultural Frontier Expansion in Latin America

Dependent variable: Annual Agricultural Land Growth, 1982-87	
Explanatory variable	Estimated coefficients (t statistic)
constant	0.463
	(2.876)
POPGRO (Annual population growth, 1980-88)	0.249
	(3.773)
EXPGRO (Annual agricultural export growth, 1984-88)	0.031
	(2.214)
YLDGRO (Annual increase in crop production per unit area of crop land, 1982-89)	- 0.198
	(- 6.000)
NOLAND (Land constraint dummy)	- 0.641
	(- 3.127)
Adjusted R^2: 0.511	F Statistic: 12.098
Sum of Squared Residuals: 0.062	Durbin-Watson: 2.065

Source: Southgate (1994).

In order to conduct a pooled analysis of deforestation from 1961-88, Cropper and Griffiths use the percentage change in forest area in each developing country during each year of this time period. This calculation is based on the time series for forests and woodlands provided by the FAO's *Production Yearbook*. Although as the authors note this time series is consistent, for many developing countries the annual statistics for forests and woodland are in themselves estimates derived from annualized deforestation rates derived from more periodic surveys and assessments of the status of forest resources.[2] These surveys are generally frequent and

[2] *That is, the usual procedure is for a country to survey (at best) its forest resources every five years, say 1975, 1980 and 1985, and to use these periodic surveys to calculate the annual average rate of deforestation for the intervening years. Estimates of the forest resource base for these intervening years are adjusted accordingly. For many developing countries, the gap between accurate surveying of their forest stock and measurements of rates of deforestation has been much longer, particularly before 1980. Thus the most recent global assessment of tropical forest resources conducted by FAO (1993) has concluded: "So far a statistically designed pan-tropical forest*

intermittent, and usually only conducted in accordance with the FAO's own ten-yearly global assessments of tropical forest resources (FAO and UNEP 1982; FAO 1993). In addition, for most tropical forest countries, estimates of both forest resources and annual rates of deforestation are notoriously unreliable before the 1980 FAO tropical forest resource assessment.

Table 5 displays the results of Cropper and Griffiths' analysis for Latin America. The overall results suggest that an inverted-U shaped relationship between income and deforestation does exist in Latin American countries. However, the level of income at which rates of deforestation peaks in the region is US$5,420, and Cropper and Griffiths note that most countries are at income levels below this threshold. Thus the authors interpret these results to imply that the increase in the rate of deforestation in Latin America tends to level off as income rises. Income growth also appears to have a negative influence on deforestation, although the magnitude of this effect is small. In Latin America, increasing the rate of growth of per capita income by 8 percent reduces the rate of deforestation by one-tenth of a percentage point.

A surprising result of Cropper and Griffiths' analysis is that, although both population growth and rural population density are positively correlated with tropical deforestation in Latin America, neither variable is highly significant (see Table 5). The authors do find a significant positive relationship between (border-equivalent) prices for tropical logs and deforestation in Latin America. This may suggest a strong correlation between logging activities and deforestation, both directly

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survey has not been attempted....There is considerable variation among regions with respect to completeness and quality of the information, with Asia faring better than tropical America and the latter better than tropical Africa....It is unlikely that the state and change information on forest cover area and biomass could be made available on a statistically reliable basis at the regional or global levels within the next ten or twenty years unless a concerted effort is made to enhance the country capacity in forest inventory and monitoring."

through 'unsustainable' extraction and indirectly through the process of 'opening up' previously inaccessible forest areas for agricultural settlement and conversion (Amelung and Diehl 1991; Barbier *et al.* 1994; Schneider 1994; Mahar and Schneider 1994).

TABLE 5

Pooled Analysis of Tropical Deforestation in Latin America

Dependent variable: Annual rate of deforestation, 1961-88	
Explanatory variable	Estimated coefficients (t statistic)
Per capita income (US$ millions)	6.03 (1.93)
Per capita income squared	- 556.29 (- 1.54)
Percentage change in per capita income	- 0.0123 (- 3.23)
Price of tropical logs (US$ thousands)	0.000192 (2.41)
Percentage change in population	0.0196 (0.39)
Rural population density	0.0363 (1.08)
Time trend	- 0.0000063 (- 0.05)
R^2 : 0.47 No of observations: 450	Turning point: $5,420

Source: Cropper and Griffiths (1994).

A further analysis of tropical deforestation in Latin America was conducted by Barbier (1998). The analysis was estimated for 21 tropical countries in Latin America over the 1980-85 period, examining the relationship between forest clearance and several key influences on deforestation identified by Southgate (1994), Cropper and Griffiths (1994) and individual country studies in Latin America: population pressure, agricultural yields, logging and income.[3] The

[3] *Tropical counties are taken to be those countries with the majority of their land mass lying between the tropics. This definition does not distinguish between moist and dry forests that lie between the tropics. The 21 tropical Latin American countries used in the analysis include all the countries listed in Table 3, with the exceptions of Argentina, Chile and Uruguay (considered predominantly temperate) and Cuba (data limitations).*

approach of the analysis was similar to that for all tropical developing countries undertaken by Barbier and Burgess (1997).

TABLE 6

Analysis of Forest Clearance in Tropical Latin American Countries, 1980-85

Dependent variable: Five-year change in closed forest area (log forest area 1985 - log forest area 1980) a/		
Explanatory variable	Estimated coefficients (t statistic)	Estimated elasticities
constant	- 0.1340	-0.0363
X1 Rural population density 1980	(- 3.267)	-0.0380
X2 Roundwood production per capita 1980	- 0.0001	0.1161
X3 Agricultural yield 1980	(- 3.195)	
	- 0.1923	
	(- 2.965)	
	0.0578	
	(2.891)	
R^2 (adjusted R^2) : 0.511 (0.425)	F Statistic:	5.926
S.E of Regression: 0.062	No of observations:	21

Source: Barbier (1998).

Notes: a/ As the dependent variable is negative, the positive coefficient for X3 indicates that forest conversion is decreasing with a unit change in this variable, whereas the negative coefficients for X1 and X2 indicate that forest conversion is increasing with a unit change in these variables.

Once again, a critical issue in the deforestation analysis is the choice of dependent variable. Sufficient data now exist on forest cover in Latin America so that it is not necessary to follow the approach of Southgate (1994) and use changes in arable land as a proxy for changes in forest cover. On the other hand, as discussed above, estimating annual changes in forest cover from the FAO time series used by Cropper and Griffiths (1994) is probably too inaccurate a measure of yearly deforestation rates. The most reliable data on changes in tropical forest area are currently derived from the global Forest Resource Assessment exercise conducted every ten years by the FAO and supplemented by interim assessments (FAO and UNEP 1982; FAO 1988 and 1993; Schmidt 1990). Unfortunately, changes in forest area in the 1990 Assessment for many tropical countries were estimated from population growth rates over the 1980-90 period, which as argued by Cropper and Griffiths (1994), makes it impossible to employ such data in an empirical analysis of deforestation if population or population density are considered to be important explanatory variables of changing forest cover. However, FAO data on forest area (in 000 ha) for 1980 and 1985 can be used to estimate a five-yearly change in forest cover for tropical countries. The change in forest cover over 1980-85 was therefore chosen as the dependent variable for forest conversion in the analysis conducted by Barbier (1998).

The results of the analysis are shown in Table 6. The five-year change in forest cover is represented by the logarithm of the forest area in 1985 minus the logarithm of the forest area in 1980. This leads to a semi-logarithmic specification of the regression, as the explanatory variables are based on the initial period (1980) data.[4] Three explanatory variables

[4] *A second version of the regression model was also run, representing the five yearly change in forest cover by the ratio of forest area in 1985 to forest area in 1980. This leads to a linear specification of the model. Although the second linear version is not shown here, it yields similar elasticities for the explanatory variables and overall explanatory power as the semi-log version depicted in Table 6. As a check on these two versions of the model, another linear specification of the regression equation was run using the percentage change in forest area (i.e. the change in closed forest area from 1980 to 1985 divided by closed forest area in 1980) as an alternative dependent variable. This third regression yielded virtually the same results as the linear regression with the ratio of 1985 to 1980 closed forest areas as the dependent variable. Thus it appears that using the latter ratio as the dependent variable is a good approximation of the half-decade rate of*

proved to be significant: industrial roundwood production per capita, agricultural yields and rural population density. Income per capita proved not to be correlated with change in forest cover across tropical Latin America, and was omitted from the regression results.[5]

The analysis indicates that industrial roundwood production and rural population pressure are positively associated with forest clearance in tropical Latin America for the 1980-85 period, i.e. increasing levels of industrial roundwood production per capita and population density lead to higher rates of forest loss. These factors seemed to have about equal impacts. A 1% increase in rural population density across Latin America in 1980 increased the level of tropical forest area converted over the 1980-85 period by around 0.036%. Similarly, a 1% increase in logging per capita led to a 0.038% rise in forest clearance.[6] The positive influence of

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deforestation. It follows that the log of this ratio will also serve as a good approximation.

[5] *The t-statistic for real income per capita was 1.2258; however, inclusion of the variable also reduced the significance of agricultural yields in the regression (t = 1.295) as well as the overall explanatory power of the regression. In addition, the sample size was reduced to 19 countries, as observations on income were not available in 1980 for Belize and Surinam. The data for industrial non-coniferous roundwood production are taken from FAO* Yearbook of Forest Products *(FAO 1992b), and were expressed in per capita terms (m^3/total population) in the model. Real gross national product per capita in 1980 (in US$/1000) and population density in 1980 (people/1000 ha) are derived from World Bank (1992). The indicator for agricultural yield is approximated by cereal output per unit of cereal production area in 1980 (mt/ha) and is based on data from FAO (1992a).*

[6] *Several alternatives were also tried for these two explanatory variables. For example, following Cropper and Griffiths (1994), industrial roundwood export unit values expressed in terms of domestic currencies were used as an alternative to per capita industrial roundwood production. The former proved to reduce the overall significance of the regression by one half, and in itself was not significant (t = 0.163516). Using border-equivalent log export prices may be inappropriate in this analysis because only just under 0.2% of industrial roundwood production in tropical Central and South America is exported, the widespread prevalence of price distortions and policy interventions in the forestry industry of the region has probably meant that there is little relationship between border-equivalent log prices and actual domestic prices faced by loggers. Total population and total population*

rural population density on tropical deforestation suggests that population pressure is correlated with forest clearance in Latin America. As noted above, the direct correlation between log production and deforestation over 1980-85 would confirm the results of Cropper and Griffiths (1994) that recent forestry practices and policies in Latin America have directly and indirectly encouraged forest conversion, as many studies have suggested (Amelung and Diehl 1991; Barbier *et al.* 1994; Repetto and Gilles 1988).

The analysis by Barbier (1998) also indicates that agricultural yields are negatively associated with tropical forest conversion in Latin America, i.e. improvements in overall agricultural performance appear to reduce the demand for more forest clearance (see Table 6). The influence of agricultural yields is the strongest of all the explanatory variables. A 1% increase in agricultural yields across tropical Latin America in 1980 reduces the level of forest conversion by almost 0.12% over the 1980-85 period, which is double the effect of the other two variables put together. This confirms the result of Southgate (1994) that yield increases on existing arable land in Latin America appears to offset the demand for converting and bringing new agricultural land into production, thus counteracting deforestation.

Putting together the results of the above three statistical analyses of deforestation across Latin America can provide some interesting insights into the possible relationships between rural poverty and resource degradation.

First, although an indicator for rural poverty was not included in any of the analyses, it is probably reasonable to assume that over the long term the aggregate level of rural poverty in Latin America would decline with increases in per capita income. If deforestation is negatively affected by rising per capita income in the long run as indicated by the analyses of Cropper and Griffiths (1994) and Southgate (1994), then it

density were also used as alternative variables for rural population density in the analysis, but these alternatives again proved to be less significant.

follows that overall economic development and thus rural poverty alleviation would act to reduce forest clearance, if not rural resource degradation generally. The converse may also be true: increasing rural resource poverty across Latin America may be positively correlated with deforestation and resource degradation. However, as pointed out by Kaimowitz (1996), rising per capita income in Latin American countries may also generate higher demand for agricultural products and provide resources for large, capital intensive projects and subsidies to agriculture, all of which may increase deforestation. Kaimowitz found that the latter two factors may be particularly relevant in Bolivia for explaining its relatively low deforestation rates, as the country is one of the poorest in Latin America and has suffered sluggish economic growth for some time. In contrast, for a relatively wealthier country such as Mexico, the positive correlation between state-level rises in per capita income and expansion of livestock numbers and thus deforestation in is largely attributable to the effect of rising incomes on the demand for beef and other livestock prices (Barbier and Burgess 1996).

Second, the counteracting effect of increasing agricultural yields on deforestation and the positive correlation of rural population density on forest clearance may actually be related to the overall process of frontier agricultural expansion in Latin America, particularly with regard to the migration of poor rural households to frontier forested areas. Such households are generally dependent on their land holdings as their main income-earning assets. If yields are increasing on existing agricultural land, then there is less incentive for poor households to abandon these holdings, migrate to frontier areas and convert new land. However, as noted in the previous Section and as illustrated particularly by Figure 1, a substantial proportion of Latin America’s rural poor are located on marginal lands. As these lands are degraded and yields decrease, then poor households will have an incentive to migrate to the frontier and clear forest lands. The positive relationship between rural population density and deforestation may in fact be picking up on the trend of increased forest conversion by migrating poor rural households in many parts of Latin America.

Finally, it was suggested that the positive relationship between logging and deforestation in Latin America could be reflecting both the direct and indirect impact of timber production on forest clearance. However, as shown in Table 3, the total area of closed forest currently being logged in most Latin American countries is still relatively small. Even if this logging is unsustainable or involves substantial clear cutting, the contribution of this direct deforestation impact is probably small relative to the conversion of forest land by other activities, such as agriculture. A recent review of deforestation models has concluded that logging is generally not directly related to deforestation in Latin America (Kaimowitz and Angelsen 1998). The direct impact of logging on deforestation may also be limited to certain regions within Latin American countries. For example, only in the Southeast of Brazil is there evidence that logging alone is the main cause of deforestation of native forests; in the Amazon and other regions, wood extraction is mainly associated with clearing forests for agriculture (Serôa da Motta 1997).

Nevertheless, several analysts have pointed out that in Latin America timber production may have a more important indirect role in deforestation by 'opening up' previously inaccessible forest lands, particularly through the construction of roads (Amelung and Diehl 1991; Chomitz and Gray 1994; Reis and Guzmán 1994; Schneider *et al.* 1990). Reducing the costs of access to frontier forest lands may again be an important factor in encouraging migration of poor rural households who are sensitive to such costs to these frontier areas. As Serôa da Motta (1997) has shown, in the Brazilian Amazon land conversion for agriculture and wood production are actually part of the same process. Wood extraction from frontier forests finances their clearance, and licenses obtained for agricultural clearing effectively legalises timber harvesting. In addition, by agreeing in advance to purchase wood harvested from cleared forest land, saw mills obtain wood supplies cheaply while at the same time providing up-front capital for land conversion.

These relationships are also supported by recent statistical analyses of deforestation in individual Latin American countries. Population pressure combined with tenure insecurity and road expansion were found to be the main factors influencing forest land clearance for agriculture in Ecuador (Southgate, Sierra and Brown 1991). Population pressure was also found to increase agricultural land expansion in Mexico, whereas rising state-level per capita income appears to reduce forest clearance for agriculture (Barbier and Burgess 1996). Road building was also discovered to be highly correlated with deforestation in Belize (Chomitz and Gray 1994) and Brazil (Reis and Guzmán 1994).

4 Conclusion

This paper has reviewed recent evidence of linkages between rural poverty and resource degradation in Latin America. Three regional statistical analyses of the factors contributing to deforestation across the region were also examined, and the possible influence of rural poverty on these relationships were discussed.

A major problem in examining empirically poverty-environment linkages in Latin America is the difficulty in obtaining reliable data on rural poverty rates across countries and geographical areas in the region. Nevertheless, the negative impacts of aggregate per capita income on deforestation in statistical studies across Latin America may provide some evidence that over the long term land conversion and degradation is correlated with persistent rural poverty. In addition, the counteracting effect of increasing agricultural yields on deforestation and the positive correlation of rural population density on forest clearance may actually be related to the overall process of frontier agricultural expansion in Latin America, particularly with regard to the migration of poor rural households to frontier forested areas.

However, one should not be overly optimistic in drawing policy conclusions from this evidence. Although it is fair to argue that empirical studies indicate that overall economic development and thus rural poverty alleviation would act to reduce forest clearance, if not rural resource degradation generally, it is certainly not reasonable to conclude that policies that encourage greater economic growth and rising per capita income are alone sufficient to break the rural poverty-resource degradation linkage in Latin America.

First, as the analysis by Cropper and Griffiths (1994) shows, per capita income may have to rise a great deal before deforestation in Latin America starts to level off and fall with increasing income. For example, their analysis indicates that the average regional level of income at which rates of deforestation peaks is US$5,420, and Cropper and Griffiths note that most countries are at income levels well below this threshold. Moreover, given the highly skewed distribution of income across much of Latin America, it is entirely possible that a country could reach this threshold income level and still have substantial numbers of rural poor. As noted in Section 2, the rural poor seem to be geographically concentrated on fragile and degradable land, including forest frontier regions.

Second, as stressed throughout this paper, the rural poverty-resource degradation linkage in Latin America appears to be highly dynamic, and possibly more complex than a direct causal relationship. For example, poverty may not be a direct cause of environmental degradation but instead may operate as a constraining factor on poorer rural households' ability to avoid resource degradation or to invest in mitigating strategies. Consequently, a rational strategy for poor rural households with limited access to capital and alternative economic opportunities may be to extract short-term rents through resource conversion and degradation, so long as there are sufficient additional resources available in frontier areas to exploit relatively cheaply and the cost of access remains low. An important ‘push’ factor in this dynamic may be the inability of poor rural households to compete with wealthier households in existing land, credit and resource markets in established and productive rural areas. An equally important ‘pull’ factor is likely to be the ‘opening up’ of previously inaccessible forest areas by major mining, timber and agricultural mining investments.

What appears to drive the dynamic of this rural poverty-resource degradation linkage is the pervailing set of economic institutions and incentives in Latin America, which are in turn a product of the existing policy structure (Barbier 1998). As Heath and Binswanger (1996) have observed in Colombia, “rural poverty, inefficient resource allocation and natural resource degradation are joint phenomena, often induced by a common nexus of policy failures,” which leads to “the concentration of impoverished populations with few investment resources on marginal lands, at tropical forest frontiers and on erodible hillsides.”

As argued by Barbier (1998), current policy distortions in Latin America reinforce this “joint phenomena” through three principal mechanisms:

- repressing the economic returns to farming on existing agricultural land relative to the price of land in markets, so that this land is effectively ‘overpriced’;

- making relatively cheap and abundant frontier and marginal land more accessible for poor farmers to exploit at even low rates of economic returns, leading to effectively ‘underpriced’ frontier and marginal land; and

- distorting the comparative economic returns from the existing and frontier or marginal land opportunities faced by poor rural households, thus encouraging land abandonment and migration by these households to the forest frontier and onto other marginal lands.

Clearly, these three processes are not peripheral to economic development in Latin America but represent major structural imbalances in the rural economy. Poverty alleviation in Latin America will not succeed without addressing these imbalances. This in turn implies that policy reform can no longer afford to ignore rural poverty-resource degradation linkages, and focus solely on overall macroeconomic and development policies in the hope that eventually there may be some ‘trickle down’ effect on reducing both rural poverty and resource degradation.

Instead, policy makers in Latin America must begin to recognize that the economic incentives determining the resource management decisions of households lie at the heart of the poverty problem, and thus must be a key focus in the design of policies to alleviate rural poverty. Existing reforms aimed at economic liberalization and removing policy distortions in agriculture may reduce some of the incentives that have led to excessive land degradation and forest conversion. However, more targeted policies and investment are required to raise the comparative returns to existing agricultural lands, improve the access of poor rural households to land and credit markets, extend key infrastructure, extension and marketing services to the rural poor, and remove tax and pricing distortions that benefit mainly wealthier farmers and landowners.

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