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Ecologically Unequal Exchange and Deforestation: A Cross-National Analysis of Forestry Export Flows

John M. Shandra,[1] Christopher Leckband,[1] and Bruce London[2]

Abstract

The theory of ecologically unequal exchange suggests that rich nations are able to externalize their resource demands and environmental degradation onto the poor nations of the world through the vertical flow of exports. However, there has been no cross-national research that examines if forestry export flows from poor to rich nations is associated with higher rates of deforestation in poor nations. As such, we seek to address this gap in the literature by constructing cross-national regression models of forest loss from 1990 to 2005 for a sample of 60 poor nations. In doing so, we find substantial support for ecologically unequal exchange theory that poor nations with higher levels of forestry export flows to rich nations tend to have higher rates of deforestation. We also find that a number of other factors are related to deforestation. These include international nongovernmental organizations, democracy, total forestry production, total population growth, rural population growth, and tropical climate. We conclude with a discussion of the findings, theoretical implications, methodological implications, policy suggestions, and possible directions for future research.

Keywords

deforestation, unequal exchange, cross-national

In recent years, a number of cross-national studies (e.g., Allen & Barnes, 1985; Ehrhardt-Martinez, 1998; Ehrhardt-Martinez, Crenshaw, & Jenkins, 2002; Jorgenson, 2006, 2008; Kahn & McDonald, 1994; Marquart-Pyatt, 2004; Rock, 1996; Rudel, 1989; Rudel & Roper, 1997; Shandra, 2007c; Shandra, Restivo, & London, 2008; Shandra, Shandra, & London, 2008) on deforestation have been published. This volume is not surprising given that deforestation is particularly salient for study by sociologists for a few reasons. First, forest loss is associated with other environmental problems. In particular, forests play an important role in mitigating climate change (Rock, 1996). They are also home to more than half

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of all living plants and animals (Ehrlich & Ehrlich, 2004). Thus, destruction of forests greatly reduces biodiversity of the planet. The removal of trees also exacerbates soil erosion, flooding, and desertification (Hurst, 1990). Second, forest loss often results in a variety of social problems (Rich, 1994). These include eradicating indigenous cultures, spreading disease, and increasing rural violence (Homer-Dixon, 1999). Third, forest loss is largely the result of anthropogenic activities and, thus, can be modeled using cross-national data (Jorgenson, 2008).

One possible anthropogenic cause of deforestation that can be modeled with cross-national data is the export of forestry products. In fact, there has been a substantial amount of case study evidence that suggests forest exports contribute to forest loss (e.g., Barbosa, 2001; Hurst, 1990; Rich, 1994). However, cross-national research on the topic has been largely inconclusive. For example, Shandra (2007b), Marquart-Pyatt (2004), Ehrhardt-Martinez et al. (2002), Ehrhardt-Martinez (1998), and Rudel (1989) find no statistical relationship between level of total forestry exports and deforestation. Given the environmental and social costs of deforestation, these contradictory findings suggest a need for additional study.

Thus, we begin this study with the goal of reexamining the relationship between forestry exports and deforestation. However, we expand on previous cross-national research in a novel way, which may help to explain the largely inconclusive findings noted above. In particular, we draw on the theory of ecologically unequal exchange to test the ideas that (a) rich nations externalize their forest loss onto the poor nations of the world by importing forestry resources from poor nations and (b) that this process of externalize contributes to higher rates of forest loss in poor nations. In doing so, we conduct the first cross-national study that seeks to determine if higher levels of forestry exports sent from poor to rich nations are associated with increased deforestation in poor nations. In other words, unlike previous cross-national research, which focuses on total levels of forestry exports, we use a more nuanced, theoretically grounded, and relational measure of forestry exports.

We now turn to a detailed review of ecologically unequal exchange theory and its prediction regarding forest loss. We then elaborate on the reasons for including other theoretically relevant predictors in our cross-national models. We describe the model in more detail below when we discuss our independent variables. We conclude with a discussion of the findings, theoretical implications, methodological implications, policy suggestions, and possible directions for future research.

Ecologically Unequal Exchange Theory

In recent years, there has been a surge in theory and empirical research concerning how the structure of international trade contributes to various forms of environmental degradation (e.g., Frey, 2003; Jorgenson, 2003, 2009a; Rice, 2007a; Shandra, 2007a; Shandra, Shor, & London, 2008; York, 2007). The theory of ecologically unequal exchange is one of the main orientations in this burgeoning area of inquiry. Given its focus on trade relationships between rich and poor nations, this perspective has its origins in the dependency and world-systems traditions (e.g., Chase-Dunn, Kawano, & Brewer, 2000; Emmanuel, 1972; Frank, 1967; Galtung, 1971; Prebisch 1950; Wallerstein, 1974). However, it was Stephen Bunker (1985) in his book titled *Underdeveloping the Amazon: Extraction, Unequal Exchange, and the Failure of the Modern State* who first described how exports sent from poor to rich nations tend to affect adversely the natural environment of poor nations.

Why may this be the case? Generally, wealthy nations tend to be advantageously situated within the global economy and are more likely to secure favorable terms of trade (Bunker, 1985; Hornborg, 2003). This is because the prices of exports from poor nations (largely natural resources) seem to consistently fall relative to the prices of items exported by wealthy nations (largely manufactured goods) because of a weak income elasticity of demand for natural resources, an abundant supply of cheap labor, and a lack of union organization in poor nations (Emmanuel, 1972; Prebisch, 1950; Roberts & Parks, 2007).

Consequently, it takes more and more natural resource (e.g., forestry) or other primary product (e.g., agriculture and mining) exports to buy imports from rich nations (Muradian & Martinez-Alier, 2001). A poor nation can be very successful at exporting more natural resources, but, in return for the sale of those natural resources, it gets fewer, not more, imports from wealthy nations (Giljum & Eisenmenger, 2004). This often translates into to extensive degradation within the boundaries of poor nations (e.g., forest loss, water pollution, and air pollution) as they expand export production just to maintain current levels of imports (Roberts & Parks, 2007).

It is also important to note that ecologically unequal exchange leads to other problems in poor nations, especially poverty and inequality (Bunker, 1985). Significantly, these problems have also been associated with deforestation. First, a focus on raw material exports prevents increases in the sort of value-added industries that have the potential to employ the people in poor nations (e.g., manufacturing, industry, and services; Mohan, 2001). By slowing the creation of jobs in sectors other than agriculture, fewer jobs are available to workers who, lacking alternatives, put more pressure on forests (Ehrhardt-Martinez, 1998). Second, poor nations that focus on exporting mainly natural resources often lack the revenue to provide subsidies and credits for agricultural inputs to help maintain crop yields. This may increase incursions into forests as people extract resources to supplement their incomes (George & Sabelli, 1994). For example, Rudel (1993) describes how Ecuador reduced and eliminated government subsidies and credits for fertilizers and pesticides because of a lack of government revenues. These cuts increased deforestation because small-scale farmers expanded production into nearby forests in order to maintain crop yields (Rudel, 1993). Thus, ecologically unequal exchange also contributes to forest loss by limiting economic and employment opportunities thereby perpetuating poverty, which leads large numbers of poor people to exploit forest resources.

The exchange of exports from poor to rich nations tends to be organized around multinational corporations or partnerships between elites in poor nations and import firms in rich nations (Anderson & Lindroth, 2001; Evans 1979; Frank 1967; Frey, 2003). The International Monetary Fund and World Bank also facilitate this process through their structural adjustment loans (Peet, 2003; Rich, 1994). These loans require poor nations to boost exports of natural resources by devaluing currency and providing various regulatory concessions (e.g. environmental law waivers) and financial incentives (e.g., tax holidays) to foreign investors in return for the money (George, 1992; Shandra, Shandra, et al., 2008; Shandra, Shor, et al., 2008).

The empirical analysis of ecologically unequal exchange theory has become quite popular among ecological economists, who examine material flows (e.g., Fischer-Kowalski & Amann, 2001; Giljum, 2004). These scholars have developed detailed natural capital accounting frameworks for measuring flows of biomass and other resources. However, this work tends to focus on single nations (e.g., Giljum, 2004). To apply the approach cross-nationally, Jorgenson (2006) created a more comprehensive measure of "weighted export flows," which allows researchers to test insights of ecologically unequal exchange using data for a large sample of nations. Jorgenson's (2006) weighted export flow measure quantifies the extent to which the exports of a given nation are sent to wealthier nations. A higher value on this measure indicates that a nation sends a larger percentage of its total exports to wealthier nations—see also Jorgenson and Rice (2005) for a discussion of this variable.

The existing cross-national research supports ideas of ecologically unequal exchange theory. For instance, Jorgenson (2006) finds that a higher levels of total exports sent from poorer to wealthier nations is associated with increased rates of deforestation in poorer nations. Shandra et al. (2009) find that higher levels of total exports sent from poor to rich nations is related to increased rates of industrial organic water pollution in poor nations. Rice (2007b) shows that poor nations with a higher proportion of exports sent to the rich nations exhibit relatively lower overall per capita ecological footprints. Jorgenson (2009b) extends this line of research by using longitudinal data to demonstrate that the vertical flow of total exports to wealthier nations is associated with a widening gap over time in the resource consumption levels of rich and poor nations as measured by the ecological footprint.

Although these studies of total export flows generally support hypotheses from ecologically unequal exchange theory, they can be refined and extended. It would seem that if ecologically unequal exchange contributes to forest loss in poor nations then it may be occurring through the vertical flow of *forestry* exports from poor to rich nations. However, this hypothesis has yet to be empirically evaluated despite theory that suggests this is the case and ample anecdotal evidence that illustrates this point. Let us now consider some of this case study evidence.

The flow of forestry exports to wealthy nations has led to extensive deforestation in Asia (Rudel, 2005). It was from the Philippines that Japan first imported timber, beginning in 1945 (Hurst, 1990). The firms involved in the trade included such well-known corporations as Mitsubishi, Sumitomo, Mitsui, and C. Itoh (Madeley, 1999). The exports from the Philippines peaked during the late 1960s and went into a steady decline thereafter. By 1990, only 1 million out of 17 million hectares of forest remained in the Philippines (Madeley, 1999). Declining forestry exports from the Philippines led Japanese companies to expand logging elsewhere in Asia during the 1970s and 1980s (Rudel, 2005). In Indonesia, for example, President Suharto spurred on forestry exports by offering foreign companies a range of official incentives, especially 5- and 6-year tax holidays (Dauvergne, 1994). The activities of these firms enabled Indonesia to become the world leader in timber exports with a total harvest of 25 million cubic meters in 1979, which were mainly destined to Japan (Bryant & Bailey, 1997). This represented a 10-fold increase in production since 1960 and translated into a 14% decline in Indonesia's forest cover. A similar process played out in the forests of Malaysia (Rudel, 2005).

With a ban on log exports from the devastated forests of Indonesia in 1985, Japanese companies, often in partnership with Malaysian firms, expanded logging operations into Cambodia, Papua New Guinea, and Myanmar (Rudel, 2005). For example, Madeley (1999), writing in the Thai paper, *The Nation*, notes Cambodia had 17 million hectares of forest before 1970, which covered 70% of the country's total land area. However, forest cover had fallen to approximately 10 million hectares by 1990 because of logging by companies exporting forestry products to Japan, Australia, New Zealand, and South Korea (Madeley, 1999). Fawthrop (1995) concludes, "The Cambodian government has signed all the remaining forests to foreign logging companies—even perhaps down to the last tree outside of national parks" (quoted in Madeley, 1999, p. 73). Simultaneously, despite the ban on exporting logs, forest loss has continued at an alarming pace in Indonesia. From 1990 to 2005, 28 million hectares of forest were cleared, largely by foreign companies partnered with domestic firms, to meet increased demand abroad for plywood, mainly from Japan and South Korea (Madeley, 1999).

This process has also contributed to deforestation in Latin America. In Brazil, Mitsubishi owns Eidai do Brazil Madieras, one of the largest logging operations in the Amazon, and exports mahogany mainly to the United States and Europe (Madeley, 1999). According to Bryant and Bailey (1997), Mitsubishi is one of the largest contributors to forest loss in the Brazilian state of Para where Eidai do Brazil Madieras's operations are located. Mitsubishi also exports mahogany to the United States and Europe from operations in Ecuador, Chile, and Bolivia (Karliner, 1997).

Other types of forestry exports sent to rich nations also contribute to deforestation in Latin America. For instance, Aracruz Celulose, a joint venture between Norwegian-based Lorentzen and Brazilian-based Souza Cruz, is the world's largest exporter of hardwood bleached pulp and has its biggest operation in the Brazilian state of Espirito Santo (Madeley, 1999). The annual exports are valued at approximately $330 million of which 70% are sent to the United States, Canada, Europe, and Japan. However, Madeley (1999) notes that 80,000 hectares of natural forest area have been cleared in production of the bleached pulp exports since 1990.

Similarly, forestry export flows to rich nations contribute to deforestation in Africa. Rudel (2005) describes how European-based firms after World War II realized the proximity of forests in Mauritania, Gambia, Guinea-Bissau, Guinea, and Sierra Leone to the coast for export to Europe. Today, Cameroon is the largest African exporter of unprocessed logs to Europe, which contributes to Cameroon losing about 200,000 hectares of forest annually (Madeley, 1999). Meanwhile, Gabon has become Africa's leading exporter of plywood and rough sawn timber to Europe because of a slump in oil prices that reduced revenues so sharply that the nation was left with the second largest debt in Africa (Tockman, 2001). Consequently, Gabon parceled out most of its forests to 50 foreign timber companies, which log 965 square miles of forest annually (Madeley, 1999). Furthermore, French timber giant Isoroy has recently been granted a 1,930 square mile concession to log in Gabon's biologically rich Lope Reserve, which will triple the amount of forest being cleared.

The theory of ecologically unequal exchange hypothesizes that higher levels of forestry exports sent to rich nations should be associated with increased forest loss in poor nations. This assertion is further supported by case study evidence from several different regions of the world. However, this line of reasoning has yet to be tested in a cross-national context. We seek to evaluate this hypothesis below, but we also note that it is likely other independent variables help to explain forest loss in poor nations. We discuss these factors when we elaborate on our model specifications below.

Methodology

Dependent Variable

Deforestation. The dependent variable for our analysis is the average annual percentage change in natural forest area from 1990 to 2005. Please note that deforestation is signified by a positive value for interpretation purposes. The data may be obtained from the Food and Agriculture Organization (2005). This measure includes land greater than half a hectare in size with trees higher than 5 meters and a canopy cover of more than 10%. A natural forest consists only of native forest species with the possible exception of small areas of natural regeneration or assisted natural regeneration. This measure excludes forest plantations, which are areas established through planting or seeding (Food and Agricultural Organization, 2005). Most cross-national research (e.g., Burns, Kick, & Davis 2003; Jorgenson, 2006; Shandra, 2007b) examines the average annual percentage change in total forest area, which includes natural forest areas as well as forest plantations. A forest plantation often involves relative homogeneity in the types of species grown for commercial purposes (World Resources Institute, 2005). We use natural forest area data because we are interested in the potential effects of forest export flows to rich nations on land that is not already being intensively managed for commercial production (e.g., forest plantations). We provide descriptive statistics and a bivariate correlation matrix in Table 1. The mean annual rate of deforestation for the entire sample of nations is equal to 0.631%. The mean forest loss is 0.822% in Asia, 0.771% in Africa, 0.602% in Latin America, 0.200% in Middle East, and –0.283% in Eastern Europe.

Independent Variables

Forestry export flows. We include the flows of forestry exports from rich to poor nations to test ecologically unequal exchange theory. In particular, this variable measures a nation's forestry exports sent to Organization for Economic Cooperation and Development nations as a percentage of a nation's total forestry exports. The data may be obtained from the United Nations (2008) *Commodity Trade Statistics Database*. This database reports import and export statistics in Untied States dollars for nations by commodity and trading partner. We use the first revision of the Standard International Trade Classification to identify forestry sector exports. Some of the commodity groupings include wood, lumber, and cork (Code 24) as well as pulp and paper (Code 25). For some poor nations, there is incomplete information on forestry exports. To deal with this potential limitation, we follow Moore, Teixeira, and Schiell's (2006) practice of using import data from trading partners to reconstruct missing export data. We log this variable to deal with its skewed distribution. From the discussion of ecologically unequal exchange theory above, we hypothesize that higher levels of forestry exports sent from poor to rich nations should be associated with higher rates of deforestation in poor nations.

Table 1. Descriptive Statistics and Bivariate Correlation Matrix (N = 60)

	Mean	Standard Deviation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Deforestation, 1990-2005	0.631	0.861	1.000															
2. Total forestry exports, 1990	0.545	0.351	–.052	1.000														
3. Forest export flows, 1990	0.019	0.034	.039	.066	1.000													
4. Nongovernmental organizations, 1990	0.813	1.092	–.153	.253	–.039	1.000												
5. Environmental ministry, 1990	0.383	0.490	.022	.005	.002	.064	1.000											
6. Democracy, 1990	–4.22	1.652	–.091	.128	–.247	.471	–.031	1.000										
7. Gross domestic product, 1990	7.688	0.795	–.033	.096	–.131	.089	.028	–.650	1.000									
8. Economic growth rate, 1980-1990	2.083	4.511	.272	–.051	–.044	.162	–.068	–.059	–.245	1.000								
9. Domestic forestry production, 1990	0.001	0.001	.397	–.290	–.070	.111	.017	.061	–.044	.219	1.000							
10. Total population growth, 1980-1990	0.263	0.106	.254	–.021	.326	.119	.066	.320	–.046	.193	–.147	1.000						
11. Nondependent population growth, 1980-1990	0.294	0.108	.134	.021	.122	.089	.031	.192	–.258	.322	–.134	.872	1.000					
12. Rural population growth, 1980-1990	0.133	0.152	.289	–.063	.246	.061	–.003	.512	–.618	.019	.064	.776	.638	1.000				
13. Urban population growth, 1980-1990	0.494	0.250	.181	–.091	.041	.018	.177	.360	–.558	.353	–.113	.647	.552	.327	1.000			
14. Natural forest stocks, 1990	8.859	1.776	.045	.178	.153	–.376	–.039	.170	–.079	.061	–.443	.132	.216	.027	.110	1.000		
15. Data quality, 1990	0.687	0.490	–.009	.032	–.151	.231	–.083	–.324	.209	.168	–.011	–.278	–.185	–.126	–.287	–.017	1.000	
16. Tropical climate, 1990	0.766	0.426	.448	–.005	.143	.223	–.051	.109	–.044	.336	.237	.397	.212	.368	.318	–.053	.029	1.000

Total forestry exports. We also consider the total amount of forestry exports in our models. This variable is measured as a percentage of total exports. The data are measured in 1990. The forestry data may be obtained from the United Nations *Commodity Trade Statistics Database*. The data on total exports comes from the World Bank (2003). We hypothesize that higher levels of total forestry export should be associated with higher rates of deforestation.

Nongovernmental organizations. Based on insights from world polity theory (Boli & Thomas 1999; Frank, 1999; Frank, Hironaka, & Schofer 2000; Schofer & Hironaka, 2005), we include the number of international nongovernmental organizations working on "environmental" and "animal rights" issues in a nation per capita for 1990. The data were collected by Smith (2004) from the *Yearbook of International Associations*. It is important to note that the data exclude labor unions, institutes, and foundations (Smith & Wiest, 2005). Note, too, that a measure of international nongovernmental organizations per capita is, in effect, a density measure. The population data, used to standardize this measure for comparison across nations, may be obtained from the World Bank (2003). Recently, Shandra (2007b, 2007c) find that higher levels of nongovernmental organizations per capita are associated with decreased rates of deforestation. This may be the case because nongovernmental organizations finance local conservation projects, support social movement activity around environmental issues, shape the language of environmental agreements, and write codes of conduct (Keck & Sikkink, 1998). As such, we hypothesize that higher levels of nongovernmental organizations per capita should be associated with lower rates of deforestation.

Environmental ministry. We also include a dummy variable that measures whether or not a nation had an environmental ministry. We code nations that had an environmental ministry in 1990 with a value of 1. All other nations serve as the reference category and are coded with a value of 0. The data may be obtained from Frank (1999). We hypothesize that nations with an environmental ministry should be associated with lower rates of deforestation than nations without an environmental ministry. This is because environmental ministries tend to implement programs that may reduce deforestation. These may include demarcating protected areas, monitoring of forests for illegal logging, and monitoring compliance with forestry regulations (Hurst 1990; Rich, 1994).

Democracy. We use the average of Freedom House's (1997) political rights and civil liberties scales to measure democracy. Political rights reflect the degree to which a nation is governed by democratically elected representatives and has fair, open, and inclusive elections. Civil liberties reflect whether within a nation there is freedom of press, freedom of assembly, general personal freedom, freedom of private organizations, and freedom of private property (Freedom House, 1997). Both variables have a 7-point scale with the following codes: 1-2 (*free*), 3-5 (*partially free*), and 6-7 (*not free*). We multiply our index by negative one so that high scores correspond with high democracy. According to Li and Reuveny (2006), democracy should be associated with lower rates of deforestation, because democratic nations have higher levels of political activism than repressive nations. This is a result of democracies guaranteeing certain rights to their citizens including freedoms of speech, press, and assembly. Furthermore, leaders in a democracy must be responsive to such activism because of electoral accountability (Midlarsky, 1998). Furthermore, greater freedom of the press and assembly leads to a wider diffusion of information, which, in turn, raises public awareness especially around environmental issues (Ehrhardt-Martinez et al., 2002).

Gross domestic product. As is standard in such analyses, it is incumbent on us to take into account a nation's level of development in order to make sure that any effects discovered are independent of a nation's level of wealth (London & Ross, 1995). In this regard, we employ a measure of gross domestic product per capita at parity purchasing power for 1990. These data may be obtained from the World Bank (2003). We log this variable to correct for its skewed distribution. Shandra (2007b) and Jorgenson (2006) find that higher levels of economic development are associated with lower rates of deforestation. Burns, Kick, and Davis (2003), writing in the world system tradition, attribute this finding to wealthier nations "externalizing" their environmental costs by importing natural resources from poorer nations. We expect to find a similar inverse relationship in this study.

Economic growth. We also include the economic growth rate from 1980 to 1990. These data may be obtained from the World Bank (2003). It is generally thought that economic growth should be associated with higher rates of deforestation. This is because there are large amounts of capital available for investment in activities that accelerate forest loss during periods of economic expansion (Rudel, 1989).

Total forestry production. We also include total forestry production per capita for 1990 in the models. This variable includes all wood in the rough destined for either industrial or fuelwood uses. Commodities included in this classification are sawlogs, veneer logs, pulpwood, fuelwood, and other industrial round wood. The data may be obtained from the World Resources Institute's *Earth Trends Database*. The population data may be obtained from the World Bank (2003). We include this measure because we want to know the effects of forestry export flows while controlling for total forestry production within a nation. We expect total forestry production to be associated with increased rates of deforestation.

Total population growth. The neo-Malthusian perspective suggests that demographic factors shape deforestation. Therefore, we include percentage change in population growth from 1980 to 1990 in the analysis. The population growth rate data come from the World Bank (2003). Many cross-national studies find that population growth increases deforestation (e.g., Allen & Barnes, 1985; Ehrhardt-Martinez, 1998; Jorgenson, 2006; Rudel, 1989; Shandra, 2007c). The general argument suggests that "geometric" growth in population outstrips "arithmetic" growth in the means of subsistence, leading to "carrying capacity" problems and ensuing environmental problems (Ehrlich & Ehrlich, 2004). Rudel and Roper (1997) provide a detailed discussion of the reasons why population growth should be correlated with higher rates of deforestation in poor nations.

Nondependent population growth. York, Rosa, and Dietz (2003) argue that it is important to "decompose" demographic factors in cross-national studies. That is, researchers should examine not just overall growth rates per se but also the impact of population growth in different contexts. A key finding in York et al.'s (2003) study pertains to the detrimental impact of the level of a nation's nondependent population (i.e., population aged 15-64 years) on its ecological footprint. Thus, we decompose the total population growth in our analysis and include the percentage change of a nation's nondependent population from 1980 to 1990 in the regression models. These data may also be obtained from the World Bank (2003). We expect that nondependent population growth should be correlated with higher rates of deforestation.

Rural and urban population growth. Jorgenson and Burns (2007) demonstrate the utility of decomposing population by geographical context. They find that rural population growth tends to increase deforestation whereas urban population growth tends to decrease it. Jorgenson and Burns (2007) argue that expanding urban centers often create economic opportunities other than agricultural ones, which attract people to cities. This process relieves pressure on forest and, thus, reduces deforestation (Rudel & Roper, 1997). Therefore, we also decompose population in this analysis and examine the differential effects of rural and urban population growth. To do so, we include the percentage changes in rural and urban populations from 1980 to 1990 in our models. The data may be obtained from the World Bank (2003). We would expect that higher rural population growth rates should be associated with higher deforestation rates, whereas higher urban population growth rates should be associated with lower deforestation rates.

Natural forest stocks. It is necessary to include a measure that controls for the potentially biasing effects of relative abundance or scarcity of forest resources (Rudel, 1989). Therefore, we include natural forest area in a nation for 1990. We log this variable to control for its skewed distribution. The data may be obtained from the Food and Agricultural Organizations (2005).

Tropical climate. We also include a dummy variable to capture if a nation's predominant climate is tropical (York et al., 2003). The World Resources Institute (2005) classifies a nation as being tropical if more than half its land area has a mean monthly temperature that exceeds 18°C. We code tropical nations with a value of 1. All other nations serve as the reference category and are coded with a value of 0. We hypothesize that tropical nations should have higher rates of deforestation because these nations tend to have more valuable tree species that are in demand on the world market (Rudel, 1989).

Data quality. We also take into account the data quality of the deforestation estimates. The data may be obtained from the Food and Agriculture Organization (2005). We classify forestry statistics as being highly reliable if they are based on remote sensing survey or current national field sampling estimates (Shandra, 2007a). We classify forestry statistics as having low reliability if they are based on expert estimates, which often involves extrapolation from an outdated national inventory. As such, we include a dummy variable to measure the reliability of deforestation, identifying those nations in which forest cover measures are based on remote sensing surveys or current national field sampling estimates and should, therefore, be of higher quality (1 = *high data quality*). The reference category includes nations whose forestry estimates are based on expert estimates or an outdated inventory (0 = *low data quality*).

Sample

We include all nations that are not classified as "high" income according to the World Bank's (2003) income quartile classification system. We exclude high-income nations because the theory of unequal exchange is concerned with how flows of forestry exports from poor to rich nations affect the environment in poor nations. We also do not include nations formed following the collapse of the Soviet Union because there are no data for them in 1990. This yields a sample of 60 poor nations for which complete data are available.[1] We follow the standard practice of checking for influential cases with Cooks *D* statistics and outliers with standardized residuals. There do not appear to be any potential problems with influential cases or outliers in the analysis.

Findings

In Table 2, we present the ordinary least squares estimates of deforestation. The main independent variable included in every equation is the flow of forestry exports from poor to rich nations. We also include the following theoretically relevant control variables: total forest exports, nongovernmental organizations, environmental ministry presence, democracy, gross domestic product, economic growth, total forestry production, measures of population growth, forest stocks, tropical climate, and data quality. In Models 2.1 and 2.2, we include the total population growth rate. We decompose population growth in the remaining equations. In Equations 2.3 and 2.4, we examine the impact of nondependent population growth. In Equations 2.5 and 2.6, we include the rural and urban population growth rates. We use multiple indicators of similar theoretical constructs to help guard against potential problems with measurement error (Paxton, 2002). We also use "cognate" but "distinct" indicators to increase the reliability of the findings (London & Ross, 1995). Finally, we remove non-significant independent variables in even-numbered equations to ensure the results are not an artifact of including too many predictors for a sample of 60 nations.

Let us begin our discussion of the findings by considering the forestry variables. First, we find little support for the prediction that total forest exports are associated with higher rates of deforestation. The coefficients for this variable are not statistically significant in Equations 2.1, 2.3, and 2.5. In sharp contrast, we do find substantial support for the theory of ecologically unequal exchange. The coefficients for the forestry export flow variable are positive and significant in every equation of Table 2. Put differently, we confirm the findings of previous cross-national research that total forestry exports do not explain significant variation in forest loss. However, our relational measure of forestry export flows clearly explains significant variation in forest loss. We should note that these finding remain stable and consistent despite the inclusion of a measure that gauges total forestry production within a nation. The coefficients for this variable are positive and significant in every equation of Table 2.[2] We should note, however, that total forestry production measure maintains a stronger effect on deforestation than the forestry export flow measure. The standardized regression

Table 2. Estimates of Deforestation (1990-2005), Including Total Forestry Exports and Forestry Flows Exports

Type of Variables	Equation 2.1	Equation 2.2	Equation 2.3	Equation 2.4	Equation 2.5	Equation 2.6
International variables						
Forestry export flows,	.572*	.618*	.480*	.471*	.542*	.520*
1990	.233	.252	.196	.192	.221	.212
	(.262)	(.253)	(.273)	(.263)	(.271)	(.255)
Total forestry exports,	1.138		1.690		1.289	
1990	.005		.068		.051	
	(2.551)		(2.622)		(2.594)	
Nongovernmental	−.487***	−.473***	−.440***	−.403***	−.484***	−.467***
organizations, 1990	−.688	−.600	−.558	−.511	−.615	−.593
	(.109)	(.098)	(.114)	(.098)	(.113)	(.099)
National variables						
Environmental ministry,	.146		.174		.149	
1990	.093		.099		.085	
(1 = *yes*)	(.166)		(.175)		(.177)	
Democracy, 1990	.314***	.349***	.295***	.260***	.342***	.326***
	.604	.671	.567	.500	.657	.625
	(.084)	(.079)	(.089)	(.082)	(.090)	(.084)
Gross domestic	−.490**	−.582**	−.548	−.523**	−.393*	−.431**
product, 1990	−.452	−.537	−.506	−.483	−.360	−.398
	(.163)	(.098)	(.170)	(.166)	(.182)	(.165)
Economic growth rate,	−.001		.001		.008	
1980-1990	−.001		.001		.043	
	(.020)		(.022)		(.023)	
Total forestry production,	.119***	.123***	.115***	.121***	.106***	.124***
1990	.592	.612	.525	.449	.527	.466
	(.025)	(.020)	(.026)	(.022)	(.015)	(.028)
Total population growth	2.863**	3.135***				
rate, 1980-1990	.254	.387				
	(1.045)	(.906)				
Nondependent population			1.328			
growth rate, 1980-1990			.167			
			(.926)			
Rural population growth					1.669*	1.626*
rate, 1980-1990					.295	.288
					(.762)	(.731)
Urban population growth					.436	
rate, 1980-1990					.126	
					(.498)	
Control variables						
Natural forest stocks,	.032		.032		.038	
1990	.072		.066		.078	
	(.058)		(.062)		(.059)	
Tropical climate, 1990	.321		.514*	.503*	.433*	.521*
(1 = *tropical*)	.184		.254	.298	.214	.257
	(.245)		(.251)	(.238)	(.248)	(.232)
Data quality, 1990	.256		.177		−.148	
(1 = *high reliability*)	.145		.100		−.084	
	(.186)		(.193)		(.194)	
Constant	3.940*	5.228***	4.591*	3.942**	3.512*	3.433**
	(1.691)	(1.439)	(1.766)	(1.614)	(1.842)	(1.580)

(continued)

Table 2. (continued)

Type of Variables	Equation 2.1	Equation 2.2	Equation 2.3	Equation 2.4	Equation 2.5	Equation 2.6
R^2	.592	.540	.546	.497	.577	.541
Adjusted R^2	.488	.488	.431	.441	.457	.479
Number of cases	60	60	60	60	60	60
Highest variance inflation factor score	3.038	2.650	3.056	2.622	3.295	2.972
Mean variance inflation factor score	1.765	1.684	1.774	1.659	1.900	1.701

Note: The first number reported is the unstandardized coefficient, the second number is the standardized coefficient, and the third number in parentheses is the standard error.
*$p < .05$, one-tailed. **$p < .01$, one-tailed. ***$p < .001$, one-tailed.

coefficients for total forestry production are about twice the size of the standardized regression coefficients for the forestry export flow variable. For instance, the standardized coefficient for total forestry production variable is equal to .604 in Equation 2.1, whereas the standardized coefficient for forestry export flow variable is equal to .233 in Equation 2.1. A similar pattern can be observed in the remaining equations of Table 2. This finding should not be surprising given that total forestry production includes forestry products being produced for both domestic and international markets.

There are other statistically significant findings that should be discussed. First, we find that international nongovernmental organizations are associated with lower rates of forest loss. The coefficients for this variable are negative and significant in every equation of Table 2. These findings support world polity theory hypotheses about the potentially beneficial impact of nongovernmental organizations on the natural environment. Second, we find support for neo-Malthusian theory regarding the harmful effects of demographic factors on the forests. The coefficients for the total population growth are positive and significant in Equations 2.1 and 2.2. Furthermore, we confirm the importance of decomposing demographic factors in cross-national research (Jorgenson & Burns, 2007). We find that rural population growth is associated with higher rates of deforestation. The coefficients for this variable are positive and significant in Equations 2.5 and 2.6. Third, we find that economic development is related to deforestation. The coefficients for this variable are negative and significant in every equation of Table 2.[3] Fourth, we find that democracy is correlated with higher rates of deforestation. The coefficients for this variable are positive and significant in Equations 2.1 through 2.6.[4] Fifth, we find that it is important to include a control for the climate of a nation. The coefficients for tropical climate dummy variable are positive and significant in four of six equations of Table 2.[5]

We should also discuss the nonsignificant findings. First, we find little support that economic growth tends to increase deforestation. The coefficients for this variable fail to reach a level of statistical significance. This finding should not be surprising because ecologically unequal exchange theory suggests that when nations become wealthier they tend to rely less on their own forests and more on the forests of poorer nations (Jorgenson, 2006). Moreover, a focus on raw material exports such as forestry exports often prevents increases in the sort of value-added industries that help to stimulate economic growth within a poor nation. Second, we do not find support that the presence of an environmental ministry is associated with lower rates of forest loss.[6] The coefficients for the environmental ministry dummy variable are not statistically significant. Third, we do not find that other aspects of neo-Malthusian theory help explain deforestation. The coefficients for the nondependent and urban population growth rates do not reach a level of statistical significance.[7] Fourth, we do not find that the data quality dummy variable or forest stocks significantly predict deforestation. The coefficients for these variables are not statistically significant in any equation of Table 2.[8]

Discussion and Conclusion

This study extends our understanding of deforestation in a novel way. The previous cross-national research yielded some contradictory findings concerning how forestry exports influences deforestation. These studies tend to examine the impact of total forestry exports. However, they do not consider ideas from the theory of ecologically unequal exchange that higher levels of forestry exports from poor to rich nations are associated with increased deforestation in poor nations. We address this theoretical gap in the literature by conducting the first cross-national study that examines the simultaneous impacts of both factors. In doing so, we find substantial support for ecologically unequal exchange theory that higher levels of forestry export flows to rich nations are related to increased forest loss in poor nations. We find no support that total forestry exports predict deforestation. Specifically, the coefficients for the forestry export flow variable are positive and significant in every equation while the coefficients for total forestry exports do not reach a level of statistical significance in any equation in Table 2. We increase the reliability of these findings by demonstrating their statistical significance across several alternative model specifications (London & Ross, 1995).

An important theoretical implication can be taken from these findings. The results demonstrate that flows of forestry export from poor to rich nations are associated with increases deforestation in poor nations. Clearly, it is important to consider not only total levels of exports in cross-national research on the natural environment but also where exports are being sent (Jorgenson & Rice, 2005). Such analyses have the potential to lead to a more nuanced and in-depth understanding of how global economic forces shape environmental degradation in poor nations, encouraging us to focus specifically on trade relationships between nations. In fact, if we neglected this important insight, then our theoretical understanding of how forestry exports affect forests would be incomplete and offer at best a partial explanation.

There is a methodological implication that follows from the main findings as well. The results correspond with ideas put forth by Shandra et al. (2009). These authors find that both environmental and women's international nongovernmental organizations help to reduce forest loss and conclude it is important to consider different "types" of international nongovernmental organizations in cross-national research to more fully understand the role that these groups play in protecting the natural environment. We extend this line of reasoning here but in a slightly different way. We argue that it is necessary to move beyond examining the impact of total exports or total export flows. There should be greater attention paid by cross-national researchers to how specific sectors (e.g., forestry, agriculture, and mining) affect different types of environmental degradation. This approach should refine our thinking regarding how trade relationships affect the natural environment.

A number of other factors also help explain cross-national variation in deforestation. First, we find substantial support for world polity theory regarding the beneficial impact of international nongovernmental organizations on the natural environment. The coefficients for this variable are negative and significant in every equation of Table 2. Second, we find support for neo-Malthusian theory regarding the detrimental impact of total population growth. The coefficients for this variable are positive and significant in two equations. We also find utility in decomposing population dynamics (York et al., 2003). The coefficients for the rural population growth rate are positive and significant in Equations 2.5 and 2.6. This corresponds with findings by Jorgenson and Burns (2007). Third, we find that democracy is associated with higher rates of deforestation. This result contradicts our hypothesis regarding the beneficial impact of democracy on forest loss. However, Marquart-Pyatt (2004) and Ehrhardt-Martinez et al. (2002) find a similar relationship between democracy and deforestation. Midlarsky (1998) attributes this finding to freely elected leaders having to please competing interest groups (i.e., business and environment) to win as many votes as possible. Fourth, we find that it is important to include a control for tropical climate (Rudel, 1989). The coefficients for this variable are statistically significant in four of six equations in Table 2. Clearly, ecologically unequal exchange theory alone cannot explain cross-national variation in forest loss. Thus, it is essential for social scientists to draw on multiple theoretical perspectives to frame cross-national studies pertaining to the environment.

There are some policy implications that follow from our main findings regarding forestry export flows and nongovernmental organizations. It may serve international nongovernmental organizations well to focus their efforts on projects that decrease consumption of forest resources in rich nations while supporting conservation of forests in poor nations. A good example involves the Climate Alliance of European Cities. This nongovernmental organization has convinced 200 municipalities in Germany and Austria to ban the use of tropical timber in government-financed projects and to reduce greenhouse gas emissions in the municipalities below national levels for 1990 (Rich, 1994). The Climate Alliance of European Cities also provides funding to the Instituto de Pre-Historia, Antropologia, e Ecologia, a Brazilian nongovernmental organization, to rehabilitate logged forests by replanting local tree species, to support farmers in raising tree crops, to demarcate extractive reserves, and to monitor protected areas for illegal forest extraction (Rich, 1994). Furthermore, policy makers may want to push for expanded use of the Forestry Stewardship Council's accreditation program. The program was established in 1993 with the hope of ensuring that all wood and wood products come from well-managed forests. The companies that participate in the program agree to nine principles of forestry management. A Forestry Stewardship Council logo signals to consumers that a product comes from an independently certified forest monitored by nongovernmental organizations, which meets the nine forestry management principles (Princen, 1994).

We conclude with some possible directions for future research. First, we examine only the impact of forestry export flows from poor to rich nations on forest loss. However, other types of export flows may also have a detrimental impact on forests. These include agricultural and mining exports sent from poor to rich nations. Thus, the first possible avenue for future research may be examining how these different types of export flows impact deforestation—see above. Second, we use cross-national data for a relatively short period of time to examine how ecologically unequal exchange affects forests. Unfortunately, comparable data on deforestation are limited to the past 15 years because of changes in data collection methodologies at the United Nations. It may well be that macrostructural changes occur over longer periods of time (Smith, 1996). Clearly, our effort to gauge processes from the most recent period are bound to miss such trends. Thus, researchers need more longitudinal data on forests to use fixed- or random-effects models to understand the long-term effects of ecologically unequal exchange on deforestation. The availability of longitudinal data would also allow researchers to use similar models to conduct separate analyses for each region of the world, thereby being able to determine how patterns of deforestation vary across the globe (York, 2007). Additionally, cross-national research of this sort should be supplemented with historical–comparative case study analysis (Rudel, 1993, 2005).

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Notes

1. The following 60 nations are included in the analysis after listwise deletion of missing data. They are Albania, Algeria, Angola, Argentina, Bolivia, Brazil, Bulgaria, Burkina Faso, Cambodia, Chile, China, Colombia, Congo, Cost Rica, Cote D'Ivoire, Ecuador, Egypt, Gabon, Gambia, Ghana, Guatemala, Guinea, Guinea-Bissau, Haiti, Honduras, Hungary, Indonesia, Jamaica, Kenya, Madagascar, Malawi, Malaysia, Mexico,

Mongolia, Morocco, Mozambique, Nicaragua, Niger, Nigeria, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Romania, Senegal, Sierra Leone, South Africa, Sri Lanka, Tanzania, Thailand, Trinidad, Turkey, Uganda, Uruguay, Vietnam, Zambia, Zimbabwe, Central African Republic, and El Salvador.

2. We also consider how other aspects of the domestic economy structure affect forest loss. It is thought that poor nations with larger service and manufacturing economies may have lower rates of deforestation because these types of activities are thought to put less pressure on forests (Shandra, 2007a). Therefore, we examined the impact of service-based economic activity and manufacturing-based economic activity in our models. The data may be obtained from the World Bank (2003) and are measured in 1990. The coefficients for both of these variables failed to reach a level of statistical significance.
3. Ehrhardt-Martinez et al. (2002) find that an inverted U-shaped relationship exists between gross domestic product per capita and deforestation. We test this hypothesis using a quadratic polynomial equation in which the gross domestic product per capita and its square are entered into the same model. If this relationship exists, the sign of the coefficient for the level of development should be positive and the sign of the coefficient for the squared term should be negative with this term being statistically significant. To reduce problems of multicollinearity we begin by centering the linear term around its mean. We then square the centered term. Finally, we include the centered linear term and squared term in our models (York et al., 2003). The coefficients for the squared term are negative but fail to achieve statistical significance.
4. Bollen and Paxton (2000) argue that nonrandom measurement error arising from the subjective perceptions of judges affects all cross-national measures of democracy to some degree. This bias may distort comparisons across nations, undermining the empirical results that ignore it. Therefore, we also estimate our models using the level of democracy or autocracy in a nation using data from the Polity IV Project (2005). This measure ranges from –10 (autocracy) to 10 (democracy). The results are similar to the results presented in Table 2.
5. We also include dummy variables for the region of the world in which a nation is located to deal with findings that may arise out of geographical circumstances, which cannot be accounted for by the independent variables in the model (Shandra, 2007a). These dummy variables identify a nation as being located in Latin America, Asia, Europe, and Africa. The reference category includes nations in Middle East. The coefficients for the geographical control variables failed to predict any significant variation in deforestation. The other findings remained similar to the results reported in Table 2. We do not present the results for sake of space, but they are available from the authors on request.
6. We also test the possibility that an interactive relationship may exist between the environmental ministry and nongovernmental organization variables. The coefficients for the interaction term between these variables fail to reach a level of statistical significance, indicating no support for this hypothesis.
7. Ehrhardt-Martinez (1998) finds an inverted U–shaped relationship exists between urbanization and deforestation. We use the procedure discussed in Note 3 to test this hypothesis. The squared urbanization term is negative but fails to predict any significant variation in deforestation, indicating no support for an environmental Kuznets curve between urbanization and deforestation. We do not present the findings, but they are available on request.
8. We also test for the possibility that there may be the effect of forestry export flows may vary by region. Therefore, we include interaction terms between the regional dummy variables and the forestry export flow measure discussed in Note 5 and the forestry export flow measure. The coefficients for the interaction terms are not statistically significant.

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