World-Economic Integration, Supply Depots, and Environmental Degradation: A Study of Ecologically Unequal Exchange, Foreign Investment Dependence, and Deforestation in Less Developed Countries

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World-Economic Integration, Supply Depots, and Environmental Degradation: A Study of Ecologically Unequal Exchange, Foreign Investment Dependence, and Deforestation in Less Developed Countries

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Abstract
This article engages multiple perspectives to consider how forms of world-economic integration allow for developed countries to treat less developed countries as supply depots to satisfy their unsustainable resource consumption levels. Particular attention is paid to the role of ecologically unequal exchange relationships in the mode of the vertical flow of exports and the transnational organization of extraction and production in the context of foreign investment dependence. It is argued that these interrelationships in the primary sector contribute to deforestation in less developed countries. Following theoretical discussions, regression analyses are conducted to assess the validity of the proposed relationships. Results suggest that both types of integration do contribute to deforestation in less developed countries, net of other factors. Ultimately, this research suggests that the structure of the world-economy allows for developed countries to externalize their consumption-based environmental costs, which often leads to increased environmental degradation in many less developed countries.

Keywords
deforestation, environmental sociology, foreign investment, political-economy, trade

Introduction

This study focuses on structural mechanisms that allow for less developed countries and especially the resources within their borders to be treated as supply depots to help satisfy the increasingly unsustainable levels of consumption by the populations of developed countries. As I argue below, such interrelationships ultimately lead to environmental

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degradation within many less developed countries as well as concomitant human suffering for the marginalized segments of local communities. Primarily drawing from two emergent critical orientations at the intersections of environmental sociology and political-economic sociology, I posit that ecologically unequal exchange relationships in the context of the vertical flow of exports and the transnational organization of extraction and production in the mode of foreign investment dependence both partially shape these forms of global environmental injustice. To evaluate the theoretical propositions, relatively nuanced primary sector and forest cover measurements are employed in cross-national regression analyses of deforestation for a sample of less developed countries during the 1990 to 2005 period. The results lend support to key aspects of both analytical perspectives, and illustrate the utility in using such methods and data to study different types of society/nature relationships in macro-comparative contexts.

The rest of the article proceeds in the following steps. In the next section I consider the resource consumption levels of populations throughout the world, with a focus on the per capita ecological footprints of nations.[1] Besides reviewing the general distribution of per capita footprints, I describe the consumption/degradation paradox, which refers to a noticeable inverse relationship between the consumption-based environmental impacts of nations and particular forms of environmental degradation within their borders. Here I explicitly focus on per capita ecological footprints relative to deforestation rates. This is followed by discussions of ecologically unequal exchange theory and the 'ecostructural' formulation of foreign investment dependence theory. I summarize the most relevant characteristics of the two perspectives as well as the findings for related studies conducted by environmental sociologists and other environmental social scientists. Next, I describe the methods, data, and sample employed in the multivariate regression analyses of deforestation, which is followed by the presentation and discussion of the results. I conclude by summarizing the analytical and empirical contributions of the current study, and discuss how forms of political and civil society integration have the potential to mitigate or counteract the environmental harms of world-economic integration for less developed countries.

The Consumption/Degradation Paradox: Where Are the Supply Depots?

Over the past few years, a great deal of macro-comparative research has focused on the structural determinants of resource consumption. In this body of work, sociologists and other social scientists commonly use the ecological footprint as an indicator of the consumption-based environmental impacts of a nation's population (e.g. Hornborg 2006; Jorgenson 2005; Jorgenson and Burns 2007; Rice 2007b; York et al. 2003). The ecological footprint was primarily developed by Mathis Wackernagel and William Rees (1996), and quantifies the amount of biologically productive land required to support the consumption of renewable natural resources and assimilation of carbon dioxide waste products of a given population. National footprints are measures of societal consumption-based demand upon domestic as well as global natural resources, and they allow for comparisons

of a nation's environmental demand relative to available domestic and global 'natural capital'.[2] The recently updated national footprints measure the bio-productive area required to support consumption levels of a given population from cropland (food, animal feed, fibre, and oil); grassland and pasture (grazing of animals for meat, hides, wool, and milk); fishing grounds (fish and seafood); and forest (wood, wood fibre, pulp, and fuel wood) (Global Footprint Network 2006). They also include the area required to absorb the carbon dioxide released when fossil fuels are burned, and the amount of area required for built infrastructure. Regarding the former, the carbon dioxide portion of the footprint deals explicitly with natural sequestration, which involves the biocapacity required to absorb and store the emissions not sequestered by humans, less the amount absorbed by the oceans.[3] The ecological footprint is measured and reported in global hectares, and is calculated by adding imports to, and subtracting exports from, domestic production. In mathematical terms, consumption = (production + imports) - exports. This balance is calculated for more than 600 products, including both primary resources (e.g. wheat, milk, raw timber) and manufactured products that are derived from them (e.g. cereal, cheese, paper, plywood).

The most common finding for quantitative comparative research in this tradition is a positive association between per capita footprints and level of economic development (measured as GDP per capita).[4] Indeed, this positive association is very strong in relative magnitude in all the multivariate studies cited above, and when assessing only the bivariate association between the two measures (per capita footprints and GDP per capita) for the majority of nations in the world, we see that they are almost always correlated at or above .850 (e.g. Jorgenson 2005; Jorgenson and Burns 2007; Rice 2007b). Thus, it appears that resource use and consumption is fundamentally tied to affluence and economic development.

The per capita footprints of nations can be compared to the global biocapacity per capita. This is calculated by dividing all the biologically productive land and sea on earth by the total world population, which provides an estimate of the globally sustainable level of consumption per person.[5] For example, in 2003, which is the most recent year for which data are available for these measures, the global biocapacity per capita was 1.780 global hectares, while out of the 140 nations assessed in Figure 1 below, 63 had per capita footprints above this globally sustainable level. Thus, a large proportion of nations appear to have globally unsustainable consumption habits, and these nations are those with relatively higher levels of economic development. What is more, a common observation in this literature is the consumption/degradation paradox (e.g. Jorgenson 2003; Princen et al. 2002; Rice 2007a, 2007b), which refers to noticeable inverse relationships between the resource consumption levels of a given nation and particular forms of environmental degradation within their borders. Figure 1 provides an example of this paradox.

In Figure 1 we see that nations with higher per capita footprints in 2003 tend to have relatively lower levels of deforestation within their borders from 1990 to 2005.[6] For these countries, the two measures are correlated at -.533. Furthermore, nations that experienced some rate of reforestation or afforestation[7] within their borders during the same

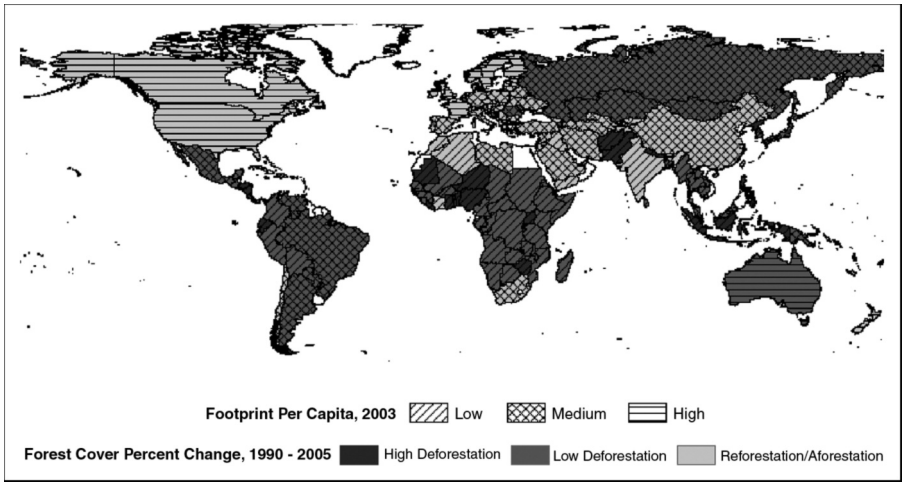

Figure 1 The consumption/degradation paradox

15-year period had either high or medium per capita footprints in 2003. There is also a noticeable 'global North/global South' pattern as well, meaning that the less developed countries of the global South tend to have relatively lower per capita footprints and higher rates of deforestation. How could higher consuming nations have the lowest levels of deforestation within their borders while we generally see the opposite in lower consuming nations? Where are the supply depots (Dunlap 1993; Dunlap and Catton 2002) for the highly consumptive populations of the developed countries? As I argue below, at least two types of world-economy integration allow for more developed countries to externalize portions of the 'environmental costs' to less developed countries. In other words, I posit that ecologically unequal exchange relationships and foreign investment dependence are structural mechanisms that enable developed countries to treat less developed countries as supply depots. While suppressing domestic levels of resource consumption, it is argued that these relationships also lead to higher levels of deforestation (and other forms of environmental harms) within the borders of less developed countries.

Ecologically Unequal Exchange

Comparative sociology has experienced a recent surge in theory and empirical analyses concerning how the structure of international trade contributes to environmental degradation and other related outcomes, especially within less developed countries. A primary orientation in this body of social science inquiry is the theory of ecologically unequal exchange, which has much of its ancestry in the classical unequal exchange, trade dependence, and world-systems traditions in political-economic sociology (e.g. Chase-Dunn 1998; Emmanuel 1972; Frank 1967; Galtung 1971; Hirschman 1980[1945];

Wallerstein 1974) as well as strands of work in ecological economics (e.g. Hornborg 1998; Muradian and Martinez-Alier 2001) and material flows analysis (e.g. Giljum 2004; Giljum and Eisenmenger 2004). However, it is important to note that sociologists interested in associations between economic underdevelopment and environmental harms, particularly Stephen Bunker, were pushing for this form of theoretical architecture and related inquiries in prior decades. As highlighted by others as well (e.g. Jorgenson 2006a, 2009b; Rice 2007a; Roberts and Parks 2007), in his path breaking work on the Amazon, Bunker (1984, 1985) forcefully argued that theoretical articulations and corresponding empirical assessments had failed to address how and the extent to which the extraction and export of natural resources from less developed, peripheral countries involve a vertical flow of value embodied in energy and matter to developed countries, and could greatly influence the demographic, environmental, and structural contexts in which subsequent development efforts unfold. Further, the latter will likely complicate future value-added extractive activities and thus negatively impact the quality of life for domestic populations. As Bunker (1984, 1985) and later Hornborg (1998, 2001) poignantly assert, such dynamics in extractive peripheral nations are underdevelopmental and environmentally damaging in the extreme, yet they foster further developmental processes and increased resource consumption in the developed core countries.

Likewise, many other environmental social scientists, especially a number of ecological economists and international relations scholars, argue that international trade blurs the responsibility of more affluent nations for their outsourced or distanced environmental impacts of production and consumption (e.g. Anderrson and Lindroth 2001; Lofdahl 2002; Rothman 1998). In other words, the structure of trade, especially the flow of resources from less developed countries to more-developed countries, provides a means by which patterns of production and consumption become disassociated within a nation, particularly in regard to concomitant environmental impacts (Rothman 1998). Moreover, developed countries possess the economic capital, geopolitical power, and institutional capacity to achieve improvements in domestic environmental conditions while continuing to impose negative externalities (Princen et al. 2002).

Building from these bodies of work, the contemporary theory of ecologically unequal exchange posits that through the vertical flow of exports from less developed countries, more developed countries partially externalize their consumption-based and production-based environmental costs.[8] This in turn increases forms of environmental degradation in the former while suppressing levels of resource consumption within their borders (e.g. Hornborg 1998, 2001; Hornborg et al. 2007; Jorgenson 2006a; Rice 2007a). In general, the populations of more developed countries are positioned advantageously in the world-economy, and thus more likely to secure and maintain favorable terms of trade allowing for greater access to the natural resources and sink capacities within less developed countries. This greater access facilitates the externalization of environmental and human well-being consequences of extraction, which contributes to heightened resource depletion and concomitant environmental degradation (e.g. deforestation, soil erosion, water pollution) within the borders of less developed countries (e.g. Jorgenson 2006a; Shandra et al. 2009). These structural processes also help create conditions where more developed

countries are able to misappropriate global 'environmental space', which encompasses the stocks of natural resources and waste assimilation properties of ecological systems supporting human social organization (Rice 2007b). Further, the misappropriation of environmental space suppresses resource use and consumption opportunities for less developed countries – often well below globally sustainable thresholds, which hinders prospects to increase the overall quality of life for domestic populations (e.g. Hornborg 1998; Jorgenson 2009b; Rice 2008). Put differently, the externalization of social and ecological burdens of extraction, production, and consumption by developed countries to less developed countries are characteristic of environmental costs shifting through ecologically unequal exchange relationships (Rice 2007a).

Unlike earlier historical periods that were largely characterized by more direct unequal exchanges (Chase-Dunn and Hall 1997; Chew 2001), the dynamics and consequences of ecologically unequal exchange in the contemporary era are embedded in a more intensified world-economy where 'middle developed' countries experience relatively reduced consumption levels and enhanced environmental degradation associated with consumption in more developed countries, while also outsourcing part of their environmental costs to the least developed countries, which suppresses domestic levels of consumption in the latter while further increasing forms of environmental degradation within their borders. Thus, in the modern world-economy, which is characterized by an upswing in different forms of structural economic globalization (Chase-Dunn and Jorgenson 2007; Chase-Dunn et al. 2000), unequal exchanges are not simply characteristic of core/periphery relationships: 'semiperipheral' nations are exploited by 'core' nations, while simultaneously exploiting more 'peripheral' nations (e.g. Chase-Dunn 1998; Roberts and Grimes 2002). In addition to being illustrative of the potential consequences of ecologically unequal exchanges, the above processes and their uneven impacts are also characteristic of what Burns et al. (2006) refer to as a relatively new form of 'recursive exploitation', nested within the contemporary international stratification system.

A spate of studies in environmental sociology lends support to the preceding arguments of ecologically unequal exchange theory concerning how the vertical flow of exports is a structural mechanism that leads to environmental degradation and suppressed resource consumption in less developed countries. For example, Jorgenson (2006a) creates a weighted index that measures the relative extent to which the exports of a given country are sent to more developed countries. This index is then employed in a series of regression analyses of deforestation in less developed countries, and the results do indeed suggest that less developed countries with relatively higher levels of exports sent to more developed countries exhibit higher levels of deforestation, net of other factors. In a follow-up study, Jorgenson et al. (forthcoming) conduct a more nuanced analysis, which involves the creation of the same sort of weighted index, but for only primary sector exports. Indeed, prior sociological research on deforestation highlights the relevance of exports in this sector (e.g. Kick et al. 1996; Rudel 2005). Jorgenson et al. (forthcoming) find that deforestation in less developed countries is largely a function of the extent to which the primary sector exports of a given nation are sent to more developed countries. Similarly, ecological economists have shown that the perceived comparative

advantage in primary sector exports for the global South can lead to severe environmental degradation over time (e.g. Muradian and Martinez-Alier 2001). Combined, these studies provide support for the environmental degradation side of the resource consumption/environmental degradation 'coin' in the context of ecologically unequal exchange relationships.

Regarding the other side of the consumption/degradation coin, in a series of cross-sectional analyses, Rice (2007a) shows that less developed countries with a higher proportion of exports sent to the highest income countries exhibit relatively lower per capita ecological footprints.[9] Similarly, in a recent panel study, Jorgenson (2009b) finds that less developed countries with relatively higher levels of exports sent to more developed countries exhibit suppressed domestic levels of consumption, well below globally sustainable levels for many nations. More importantly, further results indicate that structural relationships between more developed countries and less developed countries have become more ecologically unequal through recent decades. In other words, the vertical flow of exports has contributed to a widening gap between the resource consumption levels of 'the haves' in the global North and the 'have nots' in the global South. Overall, this growing body of research helps to explain the disparities between consumption-based environmental demand (i.e. per capita footprints) and actual forms of environmental degradation (i.e. deforestation) as illustrated in Figure 1. These disparities are partly a function of ecologically unequal exchange relationships via the vertical flow of exports, which help more developed countries treat less developed countries as supply depots.

To further assess the validity of the preceding theorization, in the subsequent analyses I investigate the extent to which the vertical flow of primary sector exports contributes to deforestation in less developed countries. In the analyses I also consider the role of another form of world-economic integration – primary sector foreign investment dependence – which I discuss in the following section.

Foreign Investment and the Environment

The longstanding sociological theory of foreign investment dependence (e.g. Bornschier and Chase-Dunn 1985; Chase-Dunn 1975) asserts that the accumulated stocks of foreign investment generally make a less developed country more vulnerable to different transnational and global political-economic conditions, which often leads to a variety of negative consequences for domestic populations, including suppressed economic development (e.g. Dixon and Boswell 1996; Kentor 1998; cf. Firebaugh 1996), increased domestic income inequality (e.g. Alderson and Nielsen 1999; Bornschier et al. 1978), and problems with food security and human health (e.g. Jenkins and Scanlan 2001; Wimberley and Bello 1992). As discussed below, sociologists have recently advanced an 'ecostructural'[10] formulation of foreign investment dependence theory (e.g. Jorgenson 2007; Jorgenson and Kuykendall 2008; Jorgenson et al. 2007). It is argued that this newer approach helps explain how the transnational organization of extraction and production in the context of foreign investment dependence partially allows for more developed countries

and the transnational firms headquartered within them to treat less developed countries as supply depots as well as sinks for waste.

During earlier decades, many less developed countries experienced a deepening of foreign debt, which resulted in austerity measures developed by global finance and governance institutions. These austerity measures, such as structural adjustment programs, often encourage the governments of indebted countries to create more appealing conditions for transnational corporations and foreign capital (McMichael 2004; Stiglitz 2002).[11] Thus, in an effort to attract foreign investment and transnational enterprises, many less developed countries have attempted to establish more favorable business conditions, including tax reductions (if not tax exemptions), relaxed labor laws, and exemptions to environmental regulations designed to protect the environment from primary and secondary sector activities (e.g. Clapp and Dauvergne 2005; Leonard 1988). The perceived or real threat of capital flight could also be viewed as an incentive for less developed countries to offer regulatory concessions to transnational firms and foreign capital (Wallerstein 2005). Further, Roberts and Parks (2007) show that many less developed countries are less likely to ratify international environmental treaties, some of which deal with extractive and productive activities that are common practices for transnational corporations. At least partly resulting from these unfolding political-economic processes, the relative presence of foreign investment stocks for all economic sectors combined within less developed countries increased from roughly 4 percent of their overall GDP in 1980 to approximately 28 percent in 2000 (United Nations 1992, 1994, 1996, 2000, 2003). This increase for less developed countries is much more pronounced than the recent upsurge in the structural globalization of foreign investment for the world-economy as a whole (Chase-Dunn and Jorgenson 2007).

With the above structural conditions in mind, some macro-sociologists (e.g. Jorgenson et al. 2007) argue that a large proportion of secondary (i.e. manufacturing) sector foreign direct investment (FDI) in less developed countries finances highly polluting and ecologically inefficient manufacturing processes and facilities, many of which are outsourced from developed countries. A growing body of empirical research on less developed countries supports these arguments. For example, Jorgenson (2007), Grimes and Kentor (2003), Kentor and Grimes (2006), Shandra et al. (2004), and York (2008) find that secondary sector foreign investment and total foreign investment contribute to growth in total anthropogenic carbon dioxide emissions, while Jorgenson (2009a) shows that secondary sector foreign investment contributes to higher levels of carbon dioxide emissions per unit of production. What is more, Jorgenson (2006b) and Jorgenson et al. (2007) find that growth in the per capita emissions of various air pollutants and greenhouse gases are tied to the transnational organization of production in the context of foreign investment dependence. Put differently, transnationally controlled manufacturing firms appear to be relatively highly polluting in scale and intensity as well as relatively less 'eco-efficient'. Similarly, increasing levels of industrial organic water pollutants are at least partly a function of foreign investment in manufacturing (Jorgenson 2007). This form of industrial waste is highly detrimental to regional aquatic ecosystems and human health.[12]

Turning to the focus of the current article, it is argued that foreign investment in the primary sector commonly finances agricultural activities, forestry operations, and extractive enterprises that contribute to deforestation in less developed countries (see also Bunker and Ciccantell 2005; Jorgenson 2008). In the following paragraphs I describe how transnationally controlled operations in each of these primary sector activities contribute to the degradation of forested areas.

Like the manufacturing sector, the production of agricultural goods has become globally distributed and largely controlled by transnational corporations headquartered in developed countries (McMichael 2004; Magdoff et al. 2000). According to the global agricultural systems literature in sociology, as agriculture enterprises are integrated into the world-economy, especially those owned by transnational firms, the intensity and scale of their production both tend to increase substantially (e.g. Harper and Le Beau 2003). To boost production, forested areas are cleared in multiple ways, including the use of tractors and other types of machinery as well as by the burning of biomass. Forested areas are also cleared for large-scale and intensive livestock operations, many of which are controlled by foreign capital (e.g. Burns et al. 1994; DeWalt 1983). For example, besides a growing focus on mono-agricultural exports, the foreign-controlled segment of the cattle industry in Honduras and El Salvador is a primary contributor to deforestation (Koop and Tole 1997), and the majority of the livestock products are exported to higher-consuming, more affluent societies (e.g. Rice 2007b). Furthermore, forms of capital-intensive agriculture, which is common practice among foreign-owned facilities in less developed countries (Jorgenson and Kuykendall 2008), can deplete the soil of nutrients, which often leads to further expansion and concomitant forest degradation (Magdoff et al. 2000).

Many less developed countries, especially those with relatively larger and more accessible forests, are prime locations for logging operations (Kick et al. 1996), and indebted countries are often encouraged to utilize their natural resources, including forested areas, as a form of comparative advantage to attract foreign investment (McMichael 2004). After the Second World War, for example, logging firms headquartered in Europe realized the propinquity of West African forests to coastal outlets for export purposes. These firms also gained access to and logged forested regions in Cameroon, the Ivory Coast, and Ghana, with the majority of wood exported to and consumed by the urban populations in southern and western Europe (Rudel 2005). Thus, within less developed countries, logging operations have become increasingly controlled by foreign capital and transnational firms, and much of the wood is transformed into commodities for the articulated markets in more developed nations (Burns et al. 2006; Chew 2001; Lofdahl 2002).

The extraction of minerals and other raw materials are the starting points for a large proportion of global production systems, and transnational firms who invest in less developed countries are key actors in these primary sector activities (Bunker and Ciccantell 2005). The mining of different materials is often carried out in a series of stages, each of which involves possible environmental impacts, most of which are potentially detrimental to forested areas (e.g. Bunker 1984). For example, the prospecting and exploration stages,

the building of facilities, the opening of pits and trenches, and the establishment of access via transportation routes (e.g. rails, roads) all contribute to the degradation of forests (Peterson and Heemskerk 2001).

Transportation infrastructures – particularly roads for mining operations – can also indirectly contribute to deforestation since they increase access to forest areas for illegal loggers and settlers (Burns et al. 1994). Opencast mining and strip mining are common methods of extraction in the exploitation phase, and both are known to increase harm to forested areas (Beynon et al. 2000). Extractive activities in this context also create waste in the form of tailings, and leftover tailings can accumulate as large mounds that impact vegetation as well as water tables. What is more, many forms of mining operations and their related transportation systems (i.e. rails) require large quantities of wood for their construction, maintenance, and energy generation (Chew 2001).

Considering the ways in which different primary sector activities in less developed countries – many of which are increasingly controlled by foreign capital – are known to degrade forested areas, in the analyses that follow, I evaluate the assertion of the preceding theorization concerning the positive effect of primary sector foreign direct investment on deforestation.

The Multivariate Analyses

In the subsequent regression analyses I examine the extent to which deforestation in less developed countries is a function of both ecologically unequal exchange in the context of vertical export flows and foreign investment dependence. Investigating the impacts of both on environmental degradation simultaneously is an important advance in this tradition of inquiry, and considering the dependent variable, I focus on primary sector export flows and primary sector foreign investment while including relevant controls, which are described below.

While a variety of dependent variables could be used in the current study, deforestation is quite pragmatic considering

1) how various primary sector activities can contribute to this form of environmental degradation, and more importantly,
2) how the over-consumption of different natural resources (captured by primary sector measurements) by the populations in developed countries might contribute to deforestation through the two investigated forms of world economic integration.

More generally, it is my hope that this research illustrates the utility in using such quantitative comparative methods and measurements to conduct sociological investigations of global environmental injustices. In the analyses I employ ordinary least squares [OLS] regression, which is the most commonly used method in cross-national research on deforestation (e.g. Ehrhardt-Martinez 1998; Jorgenson 2006a; Kick et al. 1996; Rudel 1989; Schofer and Hironaka 2005; Shandra 2007).

Dependent Variable

The dependent variable is a measure of *deforestation* in the form of percent change, which is calculated using point estimates measured in hectares for 1990 and 2005. Forest size point estimates for 1990 and 2005 are obtained from the World Resources Institute (2005), who gathered these data from the *Global Forest Resource Assessment* of the Food and Agricultural Organization. These are the most recent estimates available on a comparative cross-national basis. Positive values for the dependent variable correspond with deforestation, and negative values correspond with increased levels of forest area (i.e. afforestation or reforestation). Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds, are considered forests. These data include natural forest areas as well as forest plantations used for forestry or other related purposes (e.g. cork and oak stands, rubberwood plantations). While it could be considered problematic to use measures that include forest plantations, it is important to note that measures of deforestation derived from these data are correlated with deforestation measures derived from only natural forest estimates at approximately .950 (see Jorgenson 2008), and the availability of data for the latter is relatively lacking (World Resources Institute 2005).[13]

Key Independent Variables

I calculate and employ a weighted index that quantifies the relative extent to which a country's primary sector exports are sent to more developed countries for the year 1990. Like previous studies (Jorgenson 2006a; Jorgenson et al. forthcoming; Shandra et al. 2009), here I refer to this measure as *weighted export flows*. I log [ln] these data as well as other variables in the analyses to minimize skewness. Data required for the construction of the index include

1) relational measures in the form of primary sector exports between sending and receiving countries, and
2) attributional measures of economic development or affluence for receiving countries in the form of per capita gross domestic product (GDP), which are taken from the World Bank (2007) and measured in constant 2000 US dollars.

Exports data are obtained from the United Nations COMTRADE database (United Nations 2007), and are reported in 1990 US dollars. The primary sector exports data consist of export flows of goods in the Food and Live Animals, Beverages and Tobacco, and the Crude Materials aggregates of the Standard International Trade Classification (SITC) Revision 1 system. More specifically, these commodity groups include: live animals; meat and meat preparations; dairy products and eggs; cereals and cereal preparations; fruit and vegetables; sugar, sugar preparations and honey; coffee, tea, cocoa, spices and manufactures thereof; feed stuff for animals excluding unmilled cereals; miscellaneous

food preparations; unmanufactured tobacco; oil seeds, oil nuts and oil kernels; wood, lumber and cork; pulp and paper; and crude animal and vegetable materials.
The weighted index is calculated as:

$$W_i = \sum_{j=1}^{N} p_{ij} a_j$$

Where:
W_i = weighted primary sector export flows for country i
p_{ij} = proportion of country i's primary sector exports sent to receiving country j
a_j = GDP per capita of receiving country j

The first step is to convert the flows of primary sector exports to receiving countries into proportional scores. More specifically, exports to each receiving country are transformed into the proportion of the sending country's total amount of primary sector exports. The second step involves multiplying each proportion by the receiving country's per capita GDP. The third step is to sum the products of the calculations in step two. The sum of these products quantifies a nation's relative level of primary sector exports sent to more developed countries.

The second key independent variable for the analyses is *accumulated stocks of primary sector foreign direct investment as percentage of total GDP,* 1990 [ln], which includes stocks of foreign direct investment in agriculture and forestry as well as mining and quarrying. The foreign investment data are obtained from the United Nations *World Investment Directories* (United Nations 1992, 1994, 1996, 2000, 2003) and the Organisation for Economic Co-Operation and Development's *International Direct Investment Statistics Yearbook* (OECD 2001). Total GDP data are measured in 2000 US dollars (World Bank 2007). These data are used in previous studies of environmental degradation (e.g. Jorgenson 2008; Jorgenson and Kuykendall 2008).

Control Variables

Forest stock, 1990 [ln] is calculated as the total size of forested areas (World Resources Institute 2005). This controls for the possibility that either scarcity or abundance of forest areas influences rates of deforestation.

Gross domestic product per capita [GDP], 1990 [ln] is included in nearly all cross-national studies of deforestation, and measures a country's level of economic development. These data are taken from the World Bank (2007) and are reported in 2000 US dollars.

Total population change is defined as the percent change in a country's total population from 1990 to 2005. Levels of total population for 1990 and 2005 are obtained from the World Bank (2007).

Gross domestic product per capita change controls for a country's percent change in their level of economic development from 1990 to 2005. Percent change scores are calculated using the World Bank (2007) data. In addition to level of development, recent studies (e.g. Burns et al. 2006; Jorgenson 2006a) also find that deforestation is negatively associated with change in level of development.

Table 1 Descriptive statistics and bivariate correlations

	Mean	SD		1.	2.	3.	4.	5.	6.	7.	8.
Deforestation	4.380	16.738	**1.**								
Primary sector weighted export flows (ln)	9.860	.278	**2.**	.235							
Primary sector FDI as % GDP (ln)	.937	.748	**3.**	.288	−.010						
Forest stock (ln)	8.933	1.898	**4.**	.201	.057	.102					
GDP per capita (ln)	7.128	.977	**5.**	−.290	.061	−.091	−.068				
Total population change	28.759	15.055	**6.**	.378	.149	.191	.154	−.455			
GDP per capital change	33.720	43.797	**7.**	−.302	−.064	−.111	.182	.023	−.276		
Primary sector activities as % GDP (ln)	2.772	.566	**8.**	.240	−.027	.056	−.006	−.820	.450	−.065	
Primary sector exports as % GDP (ln)	.829	1.377	**9.**	.237	.284	.304	−.012	−.079	.162	−.054	.188

Note: N = 49

Primary sector activities as percentage total GDP, 1990 [ln] controls for the extent to which a domestic economy is primary sector-based. This measure comprises value added from forestry, hunting, and fishing as well as cultivation of crops and livestock production. These data are obtained from the World Bank (2007).

Primary sector exports as percentage total GDP, 1990 [ln], quantifies the relative level of a country's primary sector exports in the year 1990. To calculate this variable, I use the same primary sector export flows data used for the weighted export flows measure described above (United Nations 2007) as well as total GDP estimates measured in 2000 US Dollars (World Bank 2007). Using these data allows us to consider the extent to which

1) ecologically unequal exchange dynamics in the context of the vertical flow of primary sector exports and
2) dependence on primary sector foreign direct investment contribute to deforestation in less developed countries, net of the effects of the overall level of primary sector exports.

Descriptive Statistics

Table 1 provides descriptive statistics and bivariate correlations for all variables included in the reported regression models. The correlations between both key independent variables

Table 2 Countries included in the analyses

Algeria	Haiti	Peru
Angola	Honduras	Philippines
Argentina	Hungary	Poland
Bangladesh	India	Romania
Belize	Indonesia	Samoa
Bolivia	Jamaica	Senegal
Brazil	Kenya	Sri Lanka
Cameroon	Madagascar	Suriname
Chile	Malawi	Thailand
China	Malaysia	Trinidad & Tobago
Colombia	Mexico	Turkey
Costa Rica	Morocco	Uruguay
Czech Republic	Nicaragua	Vanuatu
Ecuador	Pakistan	Venezuela
El Salvador	Panama	Zimbabwe
Ethiopia	Papua New Guinea	
Guatemala	Paraguay	

and the dependent variable are positive and moderate in strength, while the correlation for the two key independent variables is virtually null, suggesting that each captures a relatively unique form of world-economic integration for the less developed countries in the dataset.

Countries Included in the Analyses

The sample includes all less developed countries on which data are available for the dependent variable and key independent variables as well as the statistical controls in the reported models. Less developed countries are identified as those falling below the upper quartile of the World Bank's (2007) income quartile classification of countries. Restricting the analyses to less developed countries is very common in this area of research in general, and studies of deforestation in particular. With these set parameters, the result is a sample of 49 less developed countries, which are listed in Table 2. Diagnostics available upon request indicate that the sample does not include any overly influential cases or those with standardized residuals greater than three (absolute values).

Results

The findings for the regression analyses are reported in Table 3.[14] I test seven models, all of which include forest stock and GDP per capita as statistical controls. Besides the two controls, model 1 includes primary sector weighted export flows, and primary sector

FDI is the independent variable of interest in model 2. These two models allow us to examine the effects of the two key independent variables separately. Besides forest stock and per capita GDP, model 3 consists of the weighted export flows and FDI measures. Models 4 through 7 include both of the key independent variables as well as forest stock, per capita GDP, and one additional statistical control. Total population change is the additional control in model 4, while model 5 also consists of GDP per capita change. Primary sector activities as percent GDP is the additional control in model 6, while model 7 also consists of primary sector exports as percent GDP. Considering the limited sample size, I include no more than five predictors in any reported model. I report standardized regression coefficients, which are flagged for statistical significance. I also provide unstandardized coefficients, standard errors, and variance inflation factors [VIFs] as well as r-square values and the constants for each model. The relatively low VIFs for all coefficients indicate that none of the reported models are unstable due to multicollinearity.

Prior to discussing the results of particular interest for the study, I briefly summarize the correlates between deforestation and the variables that are treated as statistical controls. With the exception of model 4, deforestation is negatively associated with level of development (GDP per capita), which corresponds with most prior sociological investigations of this outcome.[15] Moreover, as revealed by model 5, rate of development (GDP per capita change) also negatively affects deforestation. Consistent with structural human ecology assertions (e.g. York et al. 2003), deforestation is positively associated with population growth. Thus, general economic and population factors both contribute to deforestation in less developed countries. Turning to models 6 and 7, the effects of both level of primary sector activities and level of primary sector exports on deforestation are non-significant, which I return to shortly.

The findings indicate that deforestation in less developed countries is partly a function of both ecologically unequal exchange relationships and foreign investment dependence in the primary sector. In particular, the effects of primary sector weighted export flows and primary sector FDI on deforestation are positive, statistically significant, and strikingly similar in magnitude. Combined with the non-significant effects of primary sector exports as percent GDP and primary sector activities as percent GDP, the results suggest that it is neither the relative scale of primary sector activities nor the level of primary sector exports that contributes to deforestation, but rather the structure of international trade via the vertical flow of primary sector exports and the transnational organization of primary sector activities in the context of FDI as percent GDP. What is more, it appears that both forms of world-economic integration are structural mechanisms which enable developed countries to use less developed countries as supply depots to satisfy their relatively high levels of resource consumption. Besides lending support to foreign investment dependence theory and ecologically unequal exchange theory, the key findings as well as the effects of population growth and economic development highlight the importance in considering how structural and human ecological factors at different scales affect how human societies impact the environment. In other words, local conditions and forms of macro-level integration both matter when considering society/nature relationships.

Table 3 Standardized coefficients for multivariate regression analyses of deforestation in 49 less-developed countries, 1990–2005

	1	2	3	4	5	6	7
Key Independent Variables							
Primary sector	.244**		.246**	.212*	.223**	.245**	.221*
Weighted export flows (ln)	(14.641)		(14.802)	(12.714)	(13.417)	(14.752)	(13.257)
	8.162		*7.939*	*8.027*	*7.612*	*8.037*	*8.411*
	[1.007]		[1.008]	[1.048]	[1.014]	[1.010]	[1.114]
Primary sector		.248**	.251**	.222**	.213**	.251**	.224*
FDI as % GDP (ln)		(5.552)	(5.611)	(4.968)	(4.757)	(5.620)	(5.013)
		3.049	*2.968*	*2.983*	*2.862*	*3.003*	*3.156*
		[1.018]	[1.018]	[1.046]	[1.036]	[1.018]	[1.134]
Control Variables							
Forest stock (ln)	.168	.159	.143	.123	.203*	.145	.149
	(1.478)	(1.399)	(1.263)	(1.087)	(1.787)	(1.281)	(1.313)
	1.198	*1.200*	*1.171*	*1.168*	*1.142*	*1.191*	*1.182*
	[1.008]	[1.014]	[1.018]	[1.031]	[1.061]	[1.030]	[1.023]
GDP per capita (ln)	−.293**	−.256**	−.272**	−.182	-.263**	−.246	−.266**
	(−5.022)	(−4.294)	(−4.664)	(−3.115)	(−4.512)	(−4.219)	(−4.554)
	2.329	*2.330*	*2.273*	*2.539*	*2.174*	*4.039*	*2.297*
	[1.009]	[1.012]	[1.016]	[1.289]	[1.017]	[3.136]	[1.023]
Total population change				.203#			
				(.225)			
				.170			
				[1.372]			

Table 3 *(Continued)*

	1	2	3	4	5	6	7
GDP per capita change					−.294** (−.113) *.049* [1.060]		
Primary sector Activities as % GDP (ln)						.031 (.928) *6.926* [3.099]	
Primary sector Exports as % GDP (ln)							.087 (1.058) *1.783* [1.225]
Constant	−117.389	18.007	−124.871	−119.621	−112.379	−130.290	−111.178
R^2	.176	.178	.238	.268	.320	.238	.244

Notes: **p<.05 *p<.075 #p<.10 (one-tailed tests); standardized coefficients flagged for statistical significance; unstandardized coefficients reported in parentheses; standard errors are in italics; VIFs reported in brackets; positive values for the dependent variable correspond with deforestation and negative values correspond with increased levels of forest area.

Conclusion

The purpose of this study was to consider how forms of world economic integration allow for more developed, higher consuming nations to treat less developed countries as supply depots, which ultimately leads to increased environmental degradation within their borders. As discussed in detail, ecologically unequal exchange relationships in the mode of the vertical flow of primary exports and the transnational organization of extraction and production in the context of primary sector foreign investment dependence are two such forms of integration that contribute to global environmental inequalities. Results of multivariate regression analyses of deforestation in less developed countries support key aspects of these arguments as well as their theoretical foundations. In particular, deforestation in less developed countries is positively associated with both the vertical flow of primary sector exports to developed countries and dependence on primary sector foreign direct investment. These results hold, net of population growth, level of development, and other factors. What is quite noteworthy is the similarity in the magnitude of their effects, which are quite moderate in strength and indeed far from trivial. Moreover, the non-significant effects of the levels of primary sector exports and primary sector activities, combined with the positive effects of foreign investment dependence and the vertical flow of exports for this sector, pointedly underscore the importance in considering how the transnational organization of extractive and productive activities as well as the structure of international trade contribute to environmental harms and injustices. Simply, this research indicates that examinations of the scale of activities or levels of exports for particular sectors are deeply inadequate by themselves. As the reported analyses and their theoretical foundations suggest, when investigating human-caused environmental degradation, it matters where natural resources come from and where they are sent, and it also matters who controls extractive and productive activities.

Thus, the resource consumption/environmental degradation paradox in Figure 1 is at least partly a function of structural factors that allow for the more economically developed nations – primarily in the global North – to externalize portions of their consumption-based environmental costs to less developed countries, most of which are in the global South. In other words, forms of world-economic integration partially shape conditions in which the 'global haves' are able to treat the natural environment that surrounds the 'global have nots' as supply depots. The reported analyses focus on one type of environmental degradation with serious ecological and social consequences – deforestation. It is my hope that this work will encourage comparative sociologists to consider additional forms of environmental harms in future studies of ecologically unequal exchange, foreign investment dependence, and other related topics.

While forms of world-economic integration appear to help developed countries treat less developed countries as supply depots, which as shown here contributes to deforestation in the latter, recent studies suggest that types of political and civil society

integration in transnational and global contexts are able to directly suppress environmental degradation or mitigate the environmental harms of ecologically unequal exchange relationships and foreign investment dependence for less developed countries (e.g. Shandra et al. 2004, 2009; see also Pellow 2007). This body of work largely draws from world polity theory, which holds that international organizations play an important role in constituting and reinforcing world cultural norms (e.g. Meyer et al. 1998). From this perspective, international non-governmental organizations [INGOs] are characterized as carriers of world culture who diffuse progressive global models that are adopted by local actors (Meyer et al. 1999). Schofer and Hironaka (2005) argue that when environmental INGOs as well as other sorts of civil society groups are persistent they are likely to have a noticeable effect on material conditions. It seems likely that a stronger presence of environmental INGOs in less developed countries could lead to an enhanced persistence and thus beneficial outcomes for environmental conditions. In other words, through an assortment of mechanisms and strategies, environmental INGOs and other civil society groups – especially in nations where they have a greater collective presence – could successfully suppress the environmental harms of human activities, including the potential impacts of foreign investment dependence and ecologically unequal exchange relationships. Thus, while the focus of the current article was on forms of world economic integration that contribute to deforestation in less developed countries, I see forms of civil society integration and political integration in transnational and global contexts as critically important in resisting future environmental cost shifting between the global North and the global South while combating current global environmental injustices and concomitant human suffering, particularly in less developed countries.

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Notes

1 In this article the terms 'country' and 'nation' are used interchangeably.
2 Natural capital refers to the stock of natural assets, such as water and forest resources, producing a flow of services and resources for human societies.
3 A relatively new addition to the comprehensive footprint measure is the nuclear footprint subcomponent. Due to lack of conclusive and available data, the nuclear energy portion of the footprint is assumed to be and thus estimated as the same as the equivalent amount of electricity from fossil fuels. However, this subcomponent accounts for less than 4 percent of the total global footprint in the year 2000, and this percent is even lower for earlier years.

4 In studies of the total footprints of nations (e.g. York et al. 2003), once population size is controlled for we still see a positive [and relatively strong in magnitude] association between the footprints of nations and level of economic development.

5 This indicator of sustainable consumption was also developed by Wackernagel et al. (2000) and is available from the Global Footprint Network (e.g. 2006).

6 For Figure 1, the per capita footprint data are obtained directly from the Global Footprint Network (www.footprintnetwork.org), and the deforestation data were calculated from forest cover estimates obtained from the World Resources Institute (2005), which are described in more detail in the analyses section. In this figure, where I include all countries in which data are available for the two measures (N=140), the mean for per capita footprints is 2.416, with a standard deviation of 2.054, a minimum of .130, and a maximum of 11.870. For the forest cover percent change from 1990 to 2005, where positive values correspond with deforestation while negative values correspond with reforestation/afforestation, the mean is 3.312, with a standard deviation of 17.119, a minimum of -100.00, and a maximum of 47.400. For ease of interpretation, I collapse both measures into three categories. Nations with a per capita footprint between the minimum (.130) and 1.600 are classified as 'low', those with a per capita footprint of 1.610 to 5.470 are classified as 'medium', and nations with a per capita footprint from 5.480 to the maximum (11.870) are classified as 'high'. Nations with a deforestation rate from 20.010 to 47.400 percent are classified as 'high deforestation', those with a deforestation rate of .001 to 20.000 percent are classified as low deforestation, and nations with any rate of reforestation or afforestation (ranging from zero percent change to a net increase of 100.000%) are classified accordingly.

7 Afforestation usually refers to the artificial establishment of forests by planting or seeding in an area of non-forest land, and reforestation usually refers to the restocking of existing forests and woodlands which have been depleted, with native tree stock. The latter can occur naturally or artificially.

8 The global metabolic rift (e.g. Clark and York 2005) and treadmill of production (e.g. Gould et al. 2008) perspectives also suggest these sorts of society/nature relationships, given the structure of the world-economy and the ruptures in global ecosystems.

9 In his study, Rice uses a measure that quantifies the proportion of a nation's exports sent to nations in the high income category of the World Bank's (2007) income quartile classification of nations.

10 Grant et al. (2002) coined the term 'ecostructural', which refers to the growing body of sociological literature that attempts to highlight how and the extent to which macro-structural factors impact the environment.

11 Attracting foreign capital is often considered a means of stimulating economic development to assist in debt repayment while increasing the overall well-being for domestic populations (OECD 1999).

12 A recent study of less developed countries links infant mortality rates to levels of industrial organic water pollutants, net of the effects of health expenditures and other relevant factors (Jorgenson 2009c).

13 In a series of unreported analyses I instead use measures of deforestation for only natural forest areas. Due to data availability limitations, the sample size for these additional analyses is much smaller than the sample used for the reported analyses. However, the results of interest are substantively identical to the reported findings and available from the author upon request.

14 Elsewhere, I include measures of domestic investment, democratization, state strength, and data quality for the forest cover estimates. The effects of all additional controls are non-significant, and their inclusion does not substantively alter the reported findings of interest. Results of these additional analyses are available from the author upon request.

15 For thorough reviews of social scientific research on development and deforestation, see Burns et al. (2006), Rudel (2005), and Shandra (2007).

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