ABSTRACT

AUSTIN, KELLY F. 'The Hamburger Connection' and Deforestation in Less Developed Countries: A Test of Ecologically Unequal Exchange Theory. (Under the direction of Dr. Andrew Jorgenson.)

This study explores Norman Myers's concept of the 'hamburger connection' as a form of ecologically unequal exchange, where more-developed nations are able to misappropriate the environmental costs of beef consumption to less-developed nations. OLS (ordinary least squares) regression is used to test if deforestation in less-developed nations is associated with the vertical flow of beef to more-developed nations. An interaction term is also used to test if this relationship is more pronounced for Latin American nations, as posited by Myers. The sample includes all non-desert, less-developed nations for which there is available data across all indicators and for either measure of deforestation, total forest change or natural forest change. Overall, the results confirm the tested hypotheses. The findings also provide unique contextual support for ecologically unequal exchange theory by analyzing the environmental impacts of export flows for a specific commodity type, beef.

‘The Hamburger Connection’ and Deforestation in Less Developed Countries:
A Test of Ecologically Unequal Exchange Theory

by
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DEDICATION

This paper is dedicated to my parents, whose love and support has instilled in me a desire for knowledge in the quest for social and environmental equality.

BIOGRAPHY

Kelly Austin was born and raised in the Santa Cruz Mountains of central California. There she enjoyed a childhood filled with hiking, camping, and exploring in the redwoods and large oaks with her parents and beloved dog, Roxy. During her high school years Kelly and her parents moved to Ashland, Oregon, where she graduated from high school in 2001.

Kelly attended college at Oregon State University, in Corvallis, Oregon. There she met her future husband, John Austin, who shared her love for family and the outdoors. In June of 2006 Kelly graduated from OSU with a B.S. in Human Development and Family Sciences and a B.A. in Sociology.

Kelly currently lives with her husband John and their two dogs, Duke and Bruno, in Raleigh, North Carolina. She is pursuing her doctorate degree in sociology at North Carolina State University.

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I am also deeply indebted to Edward Kick, Jerry Jacka, and Brett Clark for their insightful and helpful contributions on earlier drafts. I also want to thank Dr. Norman Myers, whose earlier research on the "hamburger connection" has served as a guiding light for this paper.

I also want to acknowledge my family and friends, whose support and encouragement I would not be here without. Thank you to my parents, Brad and Cris, for encouraging me to study hard and not lose sight of my goals. I also thank my husband John, who is there when I get home at night with a warm hug and words of appraisal. I am also deeply indebted to my colleague and best friend, Laura McKinney, who is always there for a good laugh and helpful advice. And lastly, I also thank my buddy Christopher Dick, who is willing to help whenever I call upon him for "just a quick question."

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INTRODUCTION

Few people today associate the hamburger with the eradication of tropical forests. Norman Myers was one of the first scholars to make "the hamburger connection" in the early 1980s; he argued that, "tropical deforestation…was due to North American demand for artificially cheap beef" (Myers 1981:3). Although Myers made this claim nearly 30 years ago, a new report issued by the Center for International Forestry Research (CIFOR) in 2004 shows that Brazil's growing success as an exporter of beef may be the single greatest cause of rising national deforestation rates. Other studies also link expansion of beef-export enterprises to increases in deforestation in Honduras, El Salvador, Costa Rica, Ecuador, and a variety of other nations (Kaimowitz 2004, DeWalt 1983, Myers 1981, Rudel et al. 2002, Koop and Tole 1997). Despite the overwhelming case-study evidence exposing the environmental consequences of the 'hamburger connection' in particular nations, the current literature lacks a quantitative, cross-national examination of this phenomenon.

Recent cross-national studies of deforestation focus on how deforestation in less-developed nations often takes place through processes of ecologically unequal exchange (Jorgenson 2006, Jorgenson, Dick and Austin *forthcoming*). The theory of ecologically unequal exchange asserts that more-developed nations are able to externalize their consumption-based environmental costs to less-developed nations through unequal trade relationships. Thus, the 'hamburger connection' could be considered as a form of ecologically unequal exchange, as the case studies mentioned above depict that the export of beef to affluent nations has been linked with increasing forest loss.

The concept of ecologically unequal exchange illustrates that historical and structural conditions have created a system in which more-developed nations are able to misappropriate the use of environmental space in less-developed nations to their benefit. The most recent cross-national research exposes how the vertical flow of goods up the world-system hierarchy is associated with increases in deforestation in less-developed nations (Jorgenson 2006, Jorgenson et al. *forthcoming*). This relationship is examined through the creation of a weighted export index, which is a measurement technique developed by Jorgenson (2006) that quantifies the relative extent to which exports of a given nation are sent to more-developed nations. To test the 'hamburger connection' as a form of ecologically unequal exchange in the subsequent analyses, I create and use a weighted export indictor for beef. OLS regression is employed to test the impact of the weighted beef export measure on deforestation for natural forested areas and total forested areas in less-developed nations. Regional effects of ecologically unequal exchange are also tested for in the use of a slope dummy interaction for Latin American nations and weighted export flows for beef. I now turn to a discussion of both the theory of ecologically unequal exchange and beef production in Latin America.

PRIOR LITERATURE

Ecologically Unequal Exchange:

Ecologically unequal exchange is a theoretical perspective grounded in world-systems theory and more classical perspectives on trade dependence (Frank 1967, Wallerstein 2004, Emmanuel 1972). The theory of ecologically unequal exchange highlights how historically structured trade relations allow more-developed countries to externalize their environmentally based costs to less-developed nations (Jorgensen 2003, Jorgenson 2006, Rice 2007b). As more-developed nations are advantageously situated at the top of the international stratification system, these countries have the power to secure more favorable terms of trade which promote greater access to natural resources and waste sinks that are located in less-developed nations. Thus, although the majority of consumption of natural resources takes place in core nations, many of the negative environmental costs of production and consumption are disproportionately felt within less-developed nations (Jorgenson 2003, Jorgenson and Rice 2005, Rice 2007a).

One of the most prominent thinkers in the ecologically unequal exchange literature is Stephen Bunker. In his book, *Underdeveloping the Amazon* (1985), Bunker theorizes that ecologically unequal exchange involves a process of energy and material loss as extractive materials are harvested from less-developed nations for use in productive economies of more-developed nations. Unbalanced energy flows from less-developed nations also increase the rate of consumption capacity in developed nations (Bunker 1985). Bunker is careful to point out that it is not simply the flow of energy from less-developed to more-developed nations that causes ecologically unequal exchange, but the social organization that accompanies this process (Bunker 1985). Extractive economies in less-developed nations and productive economies in more-developed nations facilitate an international division of labor, which is characterized by the coordination of specialized tasks acting upon a continual flow of undervalued raw materials from less-developed nations (Bunker 1985). This inevitably leads to "underdevelopment" as less-developed nations are drained of their energy and matter, which damages the local ecology, social organization, and infrastructure (Bunker 1985, Frank 1967).

The theory of ecologically unequal exchange is often illustrated in what has commonly been referred to as the consumption/degradation paradox. Many recent cross-national studies show that the differential outcomes of environmental burdens are non-linear and are based on contingent dynamics (e.g. Rice 2007b, Burns et al. 2003). For example, forest product consumption is highest in more-developed countries, but these nations tend to have the lowest deforestation rates; and in fact most more-developed nations are experiencing increases in total forest size (Earth Trends Data). More specifically, nations with the lowest consumption of forest products experience the greatest rates of deforestation within their borders (Earth Trends Data).

The consumption/degradation paradox is also highlighted in studies using the ecological footprint, which measures the biologically productive area required to support the consumption of natural resources and assimilation of waste products for a given population (e.g. Jorgenson 2003, Jorgenson and Rice 2005). This measure is useful when looking at the complexities of environmental costs, as it is a measure of consumption-based societal demand upon domestic and global environmental resources. Research using per capita footprints shows that more-developed nations tend to have higher footprint demand than less-developed countries, and that many more-developed nations have an ecological footprint that is greater than their domestic resource availability (Jorgenson 2003). Thus, the use of natural resources to support populations in more-developed nations must be appropriated from somewhere else. This line of research suggests that more-developed nations use environmental space in less-developed nations as resource taps to subsidize for their own consumption, and new research also demonstrates that these structural relations have become more ecologically unequal in recent decades (Jorgenson et al. *forthcoming*, Jorgenson 2003, Rice 2007a). Research by Jorgenson and Rice also shows that this process tends to reduce or limit consumption in less-developed countries (Jorgenson and Rice 2005, Rice 2007a). Trade between nations facilitates these types of relationships, as less developed countries with high levels of exports to more developed nations tend to have lower per capita ecological footprints. Thus, trade relations at least partly structure the use of environmental space between nations as well as consumption patterns within nations.

Some researchers use the "Netherlands Fallacy" analogy to illustrate this point. The Netherlands Fallacy is based on the observation that the Dutch population has a very affluent standard of living, which is only made possible through the import of resources and the export of waste. This example highlights how domestic environmental conditions are not necessarily an accurate depiction of the environmental burdens that a population creates; the negative consequences of one nation's demands are displaced on others (Rice 2007a, York and Rosa 2003). According to Hornborg (1998), the example of the Netherlands Fallacy also depicts how international trade creates a zero-sum game: growth and development in some parts of the world are inextricably linked to under-development and environmental degradation in others.

Contributing to the complexity of cross-national environmental degradation, recent studies also show that there is likely to be an emerging process of 'recursive exploitation,' where developing nations (semi-peripheral nations) as well as more-developed nations are able to secure trade advantages with less-developed nations, which increases forms of environmental degradation in the latter (Burns et al. 2003). Thus, the externalization of environmental burdens is not simply a pattern between more-developed nations and those below them, but between the middle and lower strata within the world-system as well. This process is evidenced in current deforestation research (see Burns et al. 2003). For example, studies of previous decades find that deforestation rates were highest in developing nations, but recent data show that deforestation has become more pronounced within the least-developed nations (Burns et al. 2003). Burns et al. (2003) speculate that this is attributed to an increase in logging businesses that are based in semi-peripheral nations which are able to facilitate timber harvest in the least-developed or peripheral nations.

Jorgenson highlights how trade or export-dependent relationships are a mechanism of ecologically unequal exchange. More specifically, in a recent study the creation of a weighted export indicator demonstrates that the amount of goods sent to more-developed nations is positively associated with deforestation rates in less-developed nations (Jorgenson 2006). The weighted export measure involves both relational and attributional measures to more directly test ecologically unequal exchange relationships. Relational measures are included in the amount of exports sent between a host nation and a receiving nation and attributional measures are included in the level of economic development of the receiving countries. Use of this indicator by Jorgenson (2006) depicts that the vertical flow of goods from less-developed nations up the world-system hierarchy increases forms of environmental degradation within these countries.

In a more recent study by Jorgenson, Dick, and Austin (*forthcoming*), ecologically unequal exchange is tested using a weighted export indicator that is restricted to primary sector goods. This slightly more refined use of the weighted export indicator has a strong theoretical basis and is particularly relevant to this study as forest degradation is closely linked to primary-sector activities, like livestock farming. The results of this study confirm that relatively higher levels of primary sector exports sent to more-developed nations increases both total and natural deforestation within less-developed nations, net of other factors (Jorgenson et al. *forthcoming*).

Recent ecologically unequal exchange research clearly implies that much of the consumption that takes place in core nations is possible through the exploitation of environmental space in less-developed nations. Thus, the vertical flow of goods up the world system creates global assembly lines with a clear division of labor between nations (Jorgenson & Kick 2006). As a result of neoliberal and colonial legacies, many less-developed nations became export-dependent, often on primary sector goods. These processes make these nations more vulnerable to world-economic market forces and produce uneven patterns of consumption and degradation (Jorgenson & Kick 2006). Other scholars have argued that export-dependence on a narrow export base enables nations to harness their "comparative advantage" and effectively produce and trade more efficiently (Findlay 1987). However, while comparative advantage might enable nations to focus on producing their most competitive products, a narrow export base (especially in primary sector goods) can undermine a nation's most vital natural resource base (McMichael 2004).

An Emphasis on Latin America:

When Norman Myers first posited the 'hamburger connection' in the early 1980s, he argued that "the cattle ranchers' impact….is by far the major factor in forest destruction in tropical Latin America" (Myers 1981:3). Likewise, case studies on the 'hamburger connection' have primarily been conducted in Central and South American nations, including Brazil, Honduras, Costa Rica, Ecuador, and El Salvador (see Kaimowitz 2004, DeWalt 1983, Myers 1981, Rudel et al. 2002, Koop & Tole 1997). The popularity of cattle ranching in these areas is also explored by Rudel in *Tropical Forests: Regional Paths of Destruction and Regeneration in the Late Twentieth Century* (2005). In this text, Rudel uses meta-analyses of existing case-studies to examine similarities in the causes of deforestation across regions. He finds that cattle ranching plays an important role in fueling deforestation in Latin American nations, but not necessarily elsewhere (Rudel 2005).

Rudel (2005) argues that the prominence of the beef industry in Latin America as compared to other regions is rooted in historical legacies of colonialism, which have influenced the structure of trade, external markets, politics, social networks, and the new global demand for beef. Colonial relationships had facilitated large export economies of tropical fruit, sugar, coffee, and cotton during the 16th -19th centuries in Latin America. Cattle ranching became popular in the post-WWII era, as increases in the demand for beef, particularly by rapidly expanding fast-food chains in the United States, provided a new export market for Latin American farmers. This shift from farming to cattle ranching was facilitated by national governments and public programs which built roads to sea ports from the new cattle producing regions, provided refrigeration technologies, and granted land holdings for pasture conversion (Rudel 2005).

The United States also played a critical role in facilitating beef-export operations in Latin America. Rudel argues that the American government feared revolution in Latin American states as had taken place in Cuba; thus bi-lateral aid programs were created which provided funds for land settlement schemes that helped landless peasants convert rainforest into pasture (Rudel 2005). Enclave beef-export economies developed in rural areas with ties to consumers in affluent nations. Indeed, core governments and international organizations encouraged less-developed states to find 'competitive advantages' that would increase the efficiency and profitability of exports. However, by following this method of development, less-developed nations become dependent on a narrow export base, which can increase forms of environmental degradation, including deforestation. These geo-political forces were supplemented by overall increases in the demand for beef- not just in the United States, but globally, during the late 1900s (Rudel 2005).

The historical, geo-political trends that Rudel describes are consistent with findings from other 'hamburger connection' studies in Latin America. Much of this research points to the role of both foreign and domestic capital in facilitating the creation of cattle enterprises. For example, Nations and Komer (1983) argue that international bank loans from organizations like the World Bank and the IMF are one of the main drivers for development in the cattle industry throughout Central America. Demand from affluent nations also plays a role in the success of foreign investment, as Nations and Komer (1983:17) maintain that, "international lending agencies willingly support beef production because they know that the U.S. market for imported beef will produce funds to pay back their loans." For example, DeWalt (1983) finds that nearly three-quarters of meat-packing plants in Honduras were built by transnational corporations with the assistance of U.S. capital.

Many researchers also assert that national policies (which are supported by the international development agencies mentioned above) have spurred growth in the cattle industry (Hecht 1992, Moran 1996, Nations and Komer 1983). Not only do many Latin American countries fail to conserve nationally owned forest lands, but many governments also provide legal and financial incentives to peasant farmers and cattle ranchers to colonize and clear forests (Hecht 1992, Moran 1996, Nations and Komer 1983). For example, Moran's work in Brazil (1996) revealed that regional development agencies have created policies which favor land speculation, such as tax-free capital gains on "improved land." Many areas of the Brazilian Amazon have unclear or invalid ownership property rights, and because cleared forest is considered land that has been "improved" by the Brazilian government, who ever clears it gains legal right to sell "the improvements." This has lead to a "frenzy of deforestation and real estate speculation" according to Moran (1996:154). He reports that it is possible to net the equivalent of $9,000 U.S. dollars from clearing 14 hectares of forest. And along with the tax breaks on capital gains, this is more that 5 times what a farm laborer would hope to make under ideal conditions over a two-year period (Moran 1996).

Many other nations also host similar policies, making cattle ranching the easiest and cheapest way to gain rights to land for both large and small holders alike. These incentives to convert forest into pasture make it more economical to deforest new areas rather than using exiting or fallow crop lands for pasture (Hecht 1992). "Since those who clear land have a stronger legal claim to the parcel than those who do not, there is ample incentive to clear as much land as possible" (Hecht 1992:15). Given the role of tax benefits and other policies which encourage the conversion of forest land into pasture, Moran asserts that, "Clearly, deforestation rates in Latin America would have been much lower without the subsidies" (1996:153).

Many authors also assert that cattle ranching has become so popular in Latin America because of price ceilings on other agricultural products. Beef is simply more profitable than other crops as it is a more highly valued commodity (DeWalt 1983, Fearnside 2005). Compared to other crops, cattle ranching also requires very little labor and capital (equipment), which lowers production costs and increases profits (DeWalt 1983, Kaimowitz et al. 2004, Fearnside 2005). Beef production is also a good investment for rural peoples as they have the flexibility to "cash in" when they so choose (Hecht 1992). Cattle ranching does require large tracts of land, however, but compared to other regions land tends to be cheaper and more abundant in Latin America (Myers 1981, DeWalt 1983, Kaimowitz et al. 2004). And, given the overall increase in the demand for beef, in the United States and globally, profits from beef are high and risks are relatively low (Myers 1981, Nations and Komer 1983).

Another major factor that has increased the intensity of beef export in Latin America is the recent outbreak of meat diseases, such as hoof and mouth disease and mad cow disease. Latin American meat has historically been disease-free, causing even greater demand for beef produced in Central and South America (Fearnside 2005, Kaimowitz et al. 2004, Nations and Komer 1983). Many countries have banned beef imports from other beef-producing nations, such as those in Asia and Europe, in an effort to reduce the likelihood of exposure to these diseases. These changes have increased prices in beef from Latin America, making this lucrative market even more profitable (Kaimowitz et al. 2004).

Many case studies also point to cultural factors in explaining the prominence of cattle enterprises in Latin America. DeWalt argues that cattle ranches have occupied the large valleys and costal plains of Central America since colonial times (DeWalt 1983). Walker and Moran (2000) argue that cattle ranching has played a developmental role throughout Latin American history, and that land granting for the creation of pastures began in New Spain in as early as the 16th century. Hispanic cultures traditionally view cattle ranching as a prestige activity, where possession of cattle herds historically represents social standing and political power (Myers 1981, Walker and Moran 2000). These cultural values have often been upheld and supported by early national governments; pasture conversion is consistent with the Latin American frontier "ethic," as the claiming and preparation of land was historically viewed as a heroic act (Walker and Moran 2000).

Overall, the case studies summarized above and the meta-analysis conducted by Rudel suggest that the greater prominence of cattle ranching in Latin America as compared to other nations is partly due to a host of geo-political and cultural forces that are rooted in historical and structural relationships. All of these studies are consistent in highlighting that demand for beef from affluent nations is a driving force behind deforestation in Latin American nations. The 'hamburger connection' can clearly be seen as a form of ecologically unequal exchange throughout these case studies, as the environmental costs of beef consumption are argued to be disproportionately placed on Latin American nations.

The findings from the ecologically unequal exchange literature and the 'hamburger connection' case studies point to the examination of two empirical questions. First, is the hamburger connection a form of ecologically unequal exchange, where the vertical flow of beef up the world-system hierarchy is associated with deforestation in less-developed nations cross-nationally? And second, is this relationship more pronounced for Latin American nations? These questions yield the hypotheses outlined below:

Hypotheses:

H_1: Deforestation in less-developed countries is positively associated with the relative extent to which beef exports are sent to more-developed nations.

H_2: The impact of the vertical flow of beef exports on deforestation in Latin American nations is more pronounced relative to other less-developed nations.

DATA & METHODS

I employ ordinary least squares (OLS) regression to examine the effect of weighted beef export flows on deforestation, as is consistent with current cross-national deforestation research. Two measures of deforestation are used: deforestation of total forest areas and deforestation of natural forest areas, due to the limited data availability on forest cover change. The use of both of the measures of deforestation yields the creation of two samples.

Samples:

The countries researched in the analyses include all less-developed, non-desert nations for which there are available data for (at least one of) the dependent variables and all independent variables.[1] Less-developed countries are defined as nations in the bottom three quartiles of the World Bank Income Classification of Countries, which is based on per capita GDP (2007). The sample sizes across the two dependent variables (deforestation rate of total forest area and deforestation rate of natural forest area) are severely limited due to a lack of data availability across the key independent variable, the weighted export flow for beef, and the second dependent variable, deforestation of natural forest area. These restrictions result in a sample of 32 countries for deforestation

[1] Egypt and Oman were omitted from the sample(s) as desert countries. Uruguay and Samoa were omitted from the sample(s) as influential cases due to extremely high reforestation rates.

analyses of total forests and a sample of 26 countries for deforestation analyses of natural forests. For a complete list of countries included in the analyses, see Appendix 1. Although imputation could have been used to substitute for missing values, more conservative estimates are preferred and thus listwise deletion is employed.[2]

Dependent Variables:

Two measures of deforestation are used. The *total deforestation rate* reflects the annual percent change in total forest cover, which includes natural forest areas as well as forest plantations used for forestry or other related purposes. The *natural deforestation rate* reflects the annual percent change in natural forest cover, which only includes native forest species only, with the possible exception of small areas of natural regeneration or assisted natural regeneration. Both the total and natural deforestation rates were created from point estimates measured in thousand square hectares for 1990 and 2005, which were obtained from Earth Trends data base of the World Resources Institute (2005). These data were collected for the *Global Forest Resource Assessment* of the Food and Agricultural Organization. The forest area measures include land area that is more than 0.5 hectares which contains trees higher than 5 meters and a canopy cover of more than 10 percent. Although conducting deforestation analyses of natural forests is most appropriate for this study, analyses of both measures of deforestation will be used as there is limited data availability of natural forest change, and as total forest area is the most common measure used in related research. A positive score indicates that

[2] Listwise deletion is considered a more 'conservative' method for dealing with missing data as decreased sample size may inflate the standard error estimates.

deforestation is taking place while a negative score indicates that reforestation or aforestation is taking place.[3]

Key Independent Variable:

A weighted export indicator was created for beef to measure export transactions in the year 1990. This indicator quantifies the relative extent to which beef exports are sent to more-developed countries from an exporting country. This indicator is an appropriate measure to test hypotheses derived from ecologically unequal exchange theory as it includes both *relational measures* in taking into account the amount of beef that is exported from a sending country to receiving countries, as well as *attributional* measures in taking into account the level of economic development for the receiving countries in the form of per capita GDP. The beef exports data, which include all forms of beef and veal meat, were obtained from the United Nations COMTRADE database and reported in 1990 U.S. dollars (UN 2007).[4] The weighted index is calculated as:

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

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

[3] Aforestation 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.
[4] The SITC classification for this commodity in the UN Comtrade data base is 001.

To create this measure, beef export values are first converted from dollar amounts to proportional scores for each sending nation. This score reflects the total proportion of beef that is sent to a specific receiving country from a sending country. Each proportion score is then multiplied by the receiving nations' GDP per capita (which is taken from the World Bank and measured in constant 2000 U.S. dollars). These products are then summed, and this final measure quantifies a nation's relative level of beef exports to more-developed nations.

Additional Independent Variables:

Forest Stock, 1990 (ln): is measured as the total square hectares of total forest area or natural forest area (World Resources Institute 2005). These measures were logged to correct for excessive skewness. Controlling for levels of forest stock is important in cross-national research as deforestation could occur at different rates due to the abundance or scarcity of forests.

Gross Domestic Product [GDP] per capita, 1990 (ln): is measured in constant (2000) U.S. dollars (World Resources Institute 2005). This measure was logged to correct for excessive skewness. GDP per capita is included in cross-national deforestation analyses as an important measure of economic development. As described earlier, most current deforestation research shows a negative relationship between economic development and deforestation rates due to processes of recursive exploitation (e.g. Burns et al 2003).

Total Population Change: is measured as the annual percent change in total population from 1990 to 2005. This measure was calculated from levels of total population, measured in thousands of people, which were transformed into percent change scores

(World Resources Institute 2005). Population dynamics are very important to control for as much of the current deforestation research shows that increases in population are associated with increases in deforestation in less-developed nations; overall, a larger population puts more strain on natural resources (Kick et al. 2006, Rudel & Roper 1997).

Rural Population Change: is measured as the annual percent change in rural population, from 1990 to 2005. This measure was calculated from levels of rural population, measured in thousands of people, which were transformed into percent change scores (World Resources Institute 2005). Much of the current deforestation literature asserts a positive relationship between rural encroachment and deforestation, as rural populations often cut down, burn, or damage forested areas for subsistence farming activities (Burns et al 1994; Jorgenson & Burns 2007).

GDP per capita Change: is measured as the annual percent change is gross domestic product (GDP) per capita from 1990 to 2005. This measure was calculated from GDP per capita values in constant (2000) U.S. dollars, and transformed into percent change scores (World Resources Institute 2005). In addition to controlling for level of economic development, controlling for change in economic development is also shown to be a significant predictor of deforestation; current literature reports a negative relationship between economic growth and deforestation (Jorgenson & Burns 2007).

Beef Exports as Percent of GDP, 1990 (ln): is measured by dividing the total amount of beef exports by GDP and quantifies the relative level of a country's beef exports in the year 1990. Both the beef export data described above and total GDP were used to calculate this measure (UN 2007, World Bank 2007). This measure was logged to correct for excessive skewness. It is important to control for the level of overall beef exports when testing for processes of ecologically unequal exchange as this theory asserts that it is not the amount of exports per say that is important, but where the exports are going. Thus, controlling for this measure allows for more rigorous testing of how the structure of international trade contributes to deforestation.

Meat Production per capita, 1990: is measured by dividing the total amount of meat production, measured in metric tons, by total population for 1990 (World Resources Institute).

Meat Consumption per capita, 1990: is measured by dividing the total amount of meat consumption, measured in metric tons, by total population for 1990 (World Resources Institute). Controlling for overall levels of meat production and consumption is important as domestic demand for beef is also likely to impact deforestation rates. Once again, controlling for these measures allows for more valid hypothesis testing.

Interaction Term:

To test the second hypothesis, that the effect of the vertical flow of beef up the world-system is a significantly greater problem in Latin American nations as compared to other less-developed countries, an interaction term is created. The interaction term is generated by creating a dummy variable for region between Latin American nations (coded as 1) and all other nations (coded as 0). This dummy variable is then multiplied by the weighted beef export indicator. By including this interaction term as a predictor for the two measures of deforestation, heterogeneity of slopes is tested for by region.[5] A significant positive coefficient for this indicator would indicate that the effect of the weighted beef export flow on deforestation in Latin America is significantly greater than the other less-developed nations included in the analyses.

RESULTS

Descriptive statistics for the two samples are presented in Tables 1 and 2.[6] These results reveal that deforestation is taking place in the majority of less-developed nations in the sample as mean deforestation rate across the two measures for deforestation are positive. More specifically, the average annual deforestation rate of natural forested areas is .61% and the average annual deforestation rate of total forest areas is .50%. Univariate statistics for the key indicator, weighted beef export flows, reveal that this measure varied substantially across cases given the high standard deviations for this measure across the two samples. For the sample of nations with measures on natural deforestation, the average value of the weighted export indicator for beef was 11497.25 units and for the sample of nations with measures on total deforestation, the average value for the weighted beef export indicator was 11992.11 units. In the sample of nations with natural forest deforestation rates, about 37% of the less-developed countries are Latin American, and for the sample for total forest deforestation rates, about 44% of the less-developed countries are Latin American.

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[5] For other studies that have used this method, see York and Gossard 2004; Burns, Kick, & Davis 2003.
[6] Bi-variate correlations are also available from the author upon request.

The findings for the regression analyses are presented in Tables 3, 4, and 5. In total, eight models are reported for each of the two outcomes, deforestation rate for total forest areas and deforestation rate for natural forest areas. Each model includes the simple baseline, presented in Model 1; it includes the weighted beef export indicator, and controls for forest stock and GDP per capita. Due to extremely limited samples sizes, only one other indicator is included at a time in subsequent models with the baseline indicators. Analyses in Tables 3 and 4 primarily test the first hypothesis, that less-developed countries with higher levels of beef export to more-developed countries experience greater deforestation rates than countries with low levels of beef export to developed nations. Analyses in Table 5 test the second proposed hypothesis, that the impact of the weight beef export indicator on deforestation is predicted to be more pronounced for Latin American countries relative to other less-developed nations.

Standardized regression coefficients are reported and flagged for statistical significance. Unstandardized regression coefficients, standard errors, and variance inflation factors are also reported. Other appropriate regression diagnostics were employed to confirm adherence to OLS regression assumptions (eg. residual plots, Breuch-Pagan Test, White Test). All VIFs in the models are well within conventional standards, with the highest VIF reported at 2.68 (Model 3, natural forest analysis). Of particular relevance, the VIFs for the key independent variable, weighted beef export flows, do not exceed 2.00 in any model across the two outcomes.

Overall, the findings support the tested hypotheses. Results in Tables 3 and 4 show that the weighted export indicator for beef is positively associated with both natural deforestation rates and total deforestation rates in less-developed countries, net of other factors. This effect is statistically significant at the .01 level in models 1-6 across both outcomes and when predicting natural deforestation rates in model 7; it is statistically significant at the .05 level when predicting total deforestation rates in model 7. As is shown by the value of the standardized regression coefficients, the magnitude of the relationship between the weighted beef export indicator and deforestation rates is also quite strong; it is the strongest predictor of deforestation in all of the models except in model 4 for total deforestation rates, where GDP per capita change has a stronger impact on total forest change.

The findings from Tables 3 and 4 therefore depict that the vertical flow of beef exports up the world-system hierarchy is associated with increases in deforestation in less-developed countries. Thus, developed nations are able to externalize the consumption-based environmental costs associated with beef production, namely deforestation, to less-developed nations. Besides providing support for the first hypothesis, these results clearly demonstrate that 'the hamburger connection' is a form of ecologically unequal exchange. These findings also suggest that 'the hamburger connection' is an unequal trade relationship that is associated with increases in deforestation all less-developed nations, not just countries in Central and South America.

The findings for the second tested hypothesis (that the impact of the weight beef export indicator is more pronounced for Latin American countries relative to other less developed nations) are presented in Table 5. The interaction term is tested with the predictors in the baseline model, as in the other models. The main effect (dummy coded region indicator) is excluded from this model as is consistent with cross-national studies that test for contextual effects like region.[7] These models are often referred to as contextual models and are ideal for testing for the heterogeneity of slopes across categories. The interaction term was significant at the .0840 level for total forest change and at the .0685 level for natural forest change. Although these values are slightly outside conventional standards ($p<.05$), their extremely close proximity to this threshold shows that this relationship still warrants close inspection.[8]

Despite being slightly outside of conventional guidelines, the findings in Table 5 do support the tested hypothesis, net of other factors. More specifically, the contextual effects demonstrate that in Latin America, the effect of the weighted beef export flow on both measures of deforestation is greater than in other regions. Thus, these findings demonstrate that the assumption of homogeneity of slopes is violated, and that the slopes of the weighted beef export flow on deforestation differ significantly for Latin American nations and other less-developed nations. These results suggest that the vertical flow of beef up the world-system spurs Latin American nations to deforest considerably more compared with other regions, as is consistent with case study findings.

Tables 3-4 also take into account the effects of the other predictors. These results show that level of forest stock is negatively associated with deforestation rates in Model 2 for natural deforestation, and Models 5 and 8 for both measures of deforestation, at the .05 level. In the other models, forest stock was not a significant predictor of

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[7] See York and Gossard 2004; Burns, Kick, & Davis 2003.
[8] Inflated SE are also likely to have biased p-value estimates due to limited sample sizes.

deforestation. GDP per capita only proved to be a significant predictor of deforestation in Model 4 for natural forest change and Model 8 for both natural and total forest change. In these models, GDP per capita is negatively associated with deforestation, which is consistent with prior research discussed earlier.

Total population change is positively associated with both measures of deforestation rates at the .01 level (Model 2). Rural population change is positively associated with deforestation rates when predicting natural forest change at the .05 level (Model 3). A negative relationship between GDP per capita change and both deforestation measures reveals that increases in GDP are associated with increases in natural and total forest size; this relationship was statistically significant for both outcomes at the .01 level (Model 4). Beef exports as percent of GDP, meat production per capita and meat consumption per capita were not significant predictors for either measure of deforestation.[9]

Although the findings from Tables 3 and 4 show that many of the theoretically important statistical controls, such as GDP, did not have any significant effect on deforestation in many of the models, this is likely to be a result of decreased variability in these indicators due to such limited sample sizes. A fully saturated model was also tested for both outcomes, which included all relevant indicators; while not presented here, the effect of the weighted export indicator for beef remained statistically significant at the .05 level.

[9] Urban population growth, democratization, and EINGO intensity were also controlled for; these predictors had no significant effect on deforestation and did not influence the effect of the weighted export indicator on deforestation.

CONCLUSION

This study adds to the growing body of literature on ecologically unequal exchange[10]. In comparison to other cross-national research using weighted export indicators, this study uses a much more nuanced form of the measure. Prior research using this measure has combined all types of exports or all primary sector exports (see Jorgenson 2006; Jorgenson et al. *forthcoming*). Creating this index with such a specific commodity type is not only distinct from previous studies, but it also provides more contextual evidence for testing ecologically unequal exchange theory. Thus, using such a nuanced weighted export indicator provides strong empirical support for ecologically unequal exchange theory as the results demonstrate that unequal trade relationships operate for very specific commodity types.

Overall, the findings demonstrate that the vertical flow of beef up the world-system is positively associated with deforestation rates in less-developed countries. This relationship is also more pronounced for Latin American nations, as was tested using the interaction term. Thus, the 'hamburger connection' can clearly be conceptualized as a form of ecologically unequal exchange which increases deforestation in less-developed nations, and particularly so in Latin American nations.

This research provides clear policy implications. Beef production is one of the most biologically damaging forms of food production (Hecht 1992), and trade or

[10] While this study adds to the growing body of literature, I acknowledge that my analyses are conducted at one point in time with a restricted set of causal relationships. Despite these necessary limitations, I argue that this study represents a building block in a foundation of scholarly literature on unequal exchange.

movement of beef up the world-system is shown here to have detrimental effects for forests in less-developed regions. Building off of this research and prior case-study work on the 'hamburger connection,' I suggest that policy should be directed towards providing other economic opportunities for rural populations, as well as alternative means to gaining ownership of land (besides pasture conversion). Bank credits and other types of loans for cattle ranching should be limited to enterprises that use land that has already been deforested, such as abandoned crop land. Interest rates could also be raised on cattle credit, and land undergoing speculation through pasture conversion should not be given tax breaks of any sort. All of these suggestions must be combined with providing alternative economic opportunities for rural peoples or they will not be successful as many depend on cattle ranching for their livelihood. The proposed policies speak to an overarching theme of redefining the comparative advantage of cattle ranching in Latin America. Although implementation of these policies would clearly violate strategies that have been in place since colonization, these changes need to be addressed before environmental degradation puts Latin American nations at more of a comparative disadvantage than they already are. These policy suggestions also do not address the larger structural hierarchy of the world-systems which facilitates unequal trade relationships between states; however it is still important to consider how to tackle these inequities at the community or regional level.

Besides major policy implications, this study also points to future research questions. Given the contextual evidence for ecologically unequal exchange acquired by the use of a more nuanced weighted export measure, this type of indicator should be used to measure relative exports of other products, including other agricultural products or manufactured goods. Use of a weighted export indicator could also be implemented to explore the effects of unequal trade relationships on other environmental outcomes, such as water pollution or soil degradation.

The principle limitation of this study is sample size. Small sample size was attributed to limited data availability on the key predictor, weighted export flows for beef, and one of the dependent variables, natural deforestation rate. Many relevant control indicators were not statistically significant in the models, and this is likely due to such reduced samples sizes. Despite these limitations, the evidence for the effect of weighted export flows for beef on deforestation remained strong throughout the models.

Overall, the results of this study point to the growing complexity in structural relationships between nations. The theory of ecologically unequal exchange maintains that through inherent disparities in the world-system, developed nations are able to maintain favorable terms of trade which allows them to misappropriate the environmental costs of their consumption to less-developed nations. Processes of ecologically unequal exchange therefore take place as goods move up the world-system from less-developed nations to more-developed nations. The results of this study not only provide empirical support for this perspective, but also demonstrate that the unequal effects of exchange may be felt disproportionately across certain regions, as in the case of Latin America.

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Table 1: Univariate Statistics for Total Deforestation Sample: (N=32)

	Mean	**SD**	**Minimum**	**Maximum**	**Skewness**
Deforestation (annual % change)	0.504	0.784	-1.703	2.471	-0.048
Weighted Beef Export Flow	11992.110	10379.440	23.420	31717.370	0.589
Forest Stock (ln)	9.137	1.943	3.664	13.162	-0.542
GDP per capita (ln)	7.243	0.892	5.602	8.669	-0.261
Total Population Change	1.984	0.958	-0.430	3.631	-0.490
Rural Population Change	0.774	1.511	-2.913	3.646	0.012
GDP per capita Change	2.621	3.475	-2.208	17.976	1.683
Beef Exports as % of GDP (ln)	-4.504	2.954	-10.495	0.869	-0.179
Meat Production per capita	0.032	0.025	0.003	0.114	1.536
Meat Consumption per capita	0.032	0.023	0.003	0.100	1.107
Latin America (LA=1, other=0)	0.438	0.504	0	1	-

Table 2: Univariate Statistics for Natural Deforestation Sample: (N=26)

	Mean	**SD**	**Minimum**	**Maximum**	**Skewness**
Deforestation (annual % change)	0.614	0.811	-1.310	2.480	0.241
Weighted Beef Export Flow	11497.250	9841.739	23.420	31717.370	0.585
Forest Stock (ln)	9.006	2.058	3.135	13.152	-0.658
GDP per capita (ln)	7.120	0.857	5.602	8.629	-0.235
Total Population Change	1.887	0.999	-0.430	3.631	-0.289
Rural Population Change	0.827	1.412	-1.460	3.646	0.440
GDP per capita Change	2.826	3.694	-2.208	17.976	1.543
Beef Exports as % of GDP (ln)	-4.305	2.849	-10.495	0.869	-0.159
Meat Production per capita	0.031	0.026	0.003	0.114	1.571
Meat Consumption per capita	0.031	0.024	0.003	0.100	1.214
Latin America (LA=1, other=0)	0.370	0.492	0	1	-

Table 3: OLS Regression Predicting both Total Forest Change and Natural Forest Change

	Model 1		Model 2		Model 3		Model 4	
	TFA	**NFA**	**TFA**	**NFA**	**TFA**	**NFA**	**TFA**	**NFA**
Weighted Beef	.473**	.565**	.490**	.596**	.467**	.613**	.522**	.598**
Export Flow	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
	.000	*.000*	*.000*	*.000*	*.000*	*.000*	*.000*	*.000*
	[1.06]	[1.04]	[1.06]	[1.05]	[1.07]	[1.06]	[1.07]	[1.04]
Forest Stock	-.239	-.272	-.241	-.277*	-.178	-.086	-.170	-.178
(ln)	(-.096)	(-.107)	(-.097)	(-.109)	(-.071)	(-.034)	(-.069)	(-.070)
	.067	*.067*	*.061*	*.058*	*.078*	*.072*	*.047*	*.050*
	[1.05]	[1.07]	[1.05]	[1.07]	[1.37]	[1.40]	[1.06]	[1.10]
GDP per capita	-.267	-.248	-.151	-.054	-.165	.147	-.340	-.274*
(ln)	(.234)	(-.235)	(-.133)	(-.051)	(-.145)	(.139)	(-.299)	(-.259)
	.145	*.159*	*.138*	*.150*	*.200*	*.233*	*.102*	*.117*
	[1.03]	[1.03]	[1.13]	[1.23]	[1.91]	[2.54]	[1.05]	[1.03]
Total			.396**	.473**				
Population			(.324)	(.384)				
Change			*.127*	*.127*				
			[1.10]	[1.21]				
Rural					.157	.527*		
Population					(.081)	(.303)		
Change					*.123*	*.146*		
					[2.08]	[2.68]		
GDP per capita							-.634**	-.563**
change							(-.143)	(-.124)
							.026	*.027*
							[1.04]	[1.04]
Constant	2.653*	2.715*	1.267	.674	1.724	-.906	3.196**	2.874**
R^2	.2636	.3692	.4060	.5534	.2754	.4729	.6524	.6743
Adjusted R^2	.1847	.2869	.3180	.4721	.1681	.3771	.6009	.6151

Notes: **p<.01 *p<.05 (one-tailed tests); standardized coefficients flagged for statistical significance; unstandardized coefficients reported in parentheses; standard errors reported in italics; VIFs reported in brackets

Table 4: OLS Regression Predicting both Total Forest Change and Natural Forest Change *continued*

	Model 5		Model 6		Model 7	
	TFA	**NFA**	**TFA**	**NFA**	**TFA**	**NFA**
Weighted Beef Export Flow	.469**	.565**	.457**	.552**	.413*	.511**
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
	.000	*.000*	*.000*	*.000*	*.000*	*.000*
	[1.06]	[1.04]	[1.09]	[1.07]	[1.14]	[1.10]
Forest Stock (ln)	-.232*	-.287*	-.206	-.225	-.196	-.186
	(-.093)	(-.113)	(.083)	(-.089)	(-.079)	(-.073)
	.068	*.065*	*.071*	*.077*	*.067*	*.071*
	[1.05]	[1.07]	[1.17]	[1.36]	[1.09]	[1.21]
GPD per capita (ln)	-.284	-.246	-.183	-.159	-.043	.014
	(-.249)	(-.232)	(-.160)	(-.150)	(-.038)	(.013)
	.149	*.153*	*.195*	*.231*	*.204*	*.238*
	[1.07]	[1.03]	[1.83]	[2.10]	[2.11]	[2.40]
Beef Exports as % of GDP (ln)	.096	.268				
	(.025)	(.356)				
	.045	*.213*				
	[1.04]	[1.00]				
Meat Production per capita			-.128	-.127		
			(-4.071)	(-3.910)		
			7.062	*7.630*		
			[1.83]	[2.17]		
Meat Consumption per capita					-.309	-.346
					(-10.528)	(-11.582)
					7.819	*8.400*
					[2.06]	[2.39]
Constant	2.851*	2.669*	2.140	2.083	1.464	1.056
R^2	.2724	.4406	.2726	.3766	.3100	.4193
Adjusted R^2	.1646	.3389	.1648	.2633	.2077	.3138

Notes: **p<.01 *p<.05 (one-tailed tests); standardized coefficients flagged for statistical significance; unstandardized coefficients reported in parentheses; standard errors reported in italics; VIFs reported in brackets

Table 5: Test of Different Slope for Latin American Countries

	TFA	**NFA**
Weighted Beef Export Flow	.255	.378*
	(.001)	(.001)
	.000	*.000*
	[2.00]	[1.61]
Forest Stock (ln)	-.208	-.235
	(-.084)	(-.093)
	.066	*.066*
	[1.07]	[1.09]
GDP per capita (ln)	-.347*	-.301*
	(-.304)	(-.285)
	.157	*.158*
	[1.16]	[1.07]
Latin America * Weighted Beef Export Flow	.330+	.315+
	(.001)	(.001)
	.000	*.000*
	[2.14]	[1.61]
P-value for interaction term	.0840	.0685
Constant	3.080**	2.972**
R^2	.3146	.4307
Adjusted R^2	.2130	.3272

Notes: **p<.01 *p<.05 +p<.10 (one-tailed tests); standardized coefficients flagged for statistical significance; unstandardized coefficients reported in parentheses; standard errors reported in italics; VIFs reported in brackets

APPENDIX

Nations Included in the Analyses:

Sample 1: Total Deforestation Rate
N = 32

Argentina
Belize
Brazil
Cameroon
Chile
China
Colombia
Costa Rica
El Salvador
Fiji
Guatemala
Honduras
India
Indonesia
Jamaica
Kenya
Madagascar
Malaysia
Mauritius
Mexico
Nicaragua
Pakistan
Panama
Paraguay
Poland
Romania
Senegal
Sri Lanka
Thailand
Turkey
Venezuela
Zimbabwe

Sample 2: Natural Deforestation Rate
N = 26

Argentina
Brazil
Chile
China
Colombia
El Salvador
Fiji
Guatemala
Honduras
India
Indonesia
Kenya
Jamaica
Madagascar
Malaysia
Mauritius
Nicaragua
Pakistan
Panama
Paraguay
Romania
Senegal
Sri Lanka
Thailand
Turkey
Zimbabwe