Debt, Structural Adjustment, and Biodiversity Loss: A Cross-National Analysis of Threatened Mammals and Birds

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Abstract

There has been increasing interest by social scientists in the cross-national determinants of environmental problems. One area of inquiry that has received little attention is biodiversity loss. We seek to address this gap in the literature by conducting a cross-national study of threatened mammals and birds in 2005. In doing so, we use negative binomial regression models for a sample of 65 nations to evaluate hypotheses drawn from several theoretical perspectives. We find substantial support for dependency theory that higher levels of debt service, structural adjustment, and primary sector exports are associated with higher numbers of threatened mammals and birds. We also find support for world polity theory that higher levels of non-governmental organizations are associated with lower numbers of threatened mammals and birds. We conclude with a discussion of the findings, some policy implications, and possible directions for future research.

Keywords: *debt service, biodiversity loss, dependency theory*

Introduction

According to the International Union for the Conservation of Nature, an "extinction crisis" is under way in which 1 in 4 mammals and 1 in 10 birds are in danger of disappearing (Sample 2008). There are several reasons why social scientists should be concerned with the loss of mammals and birds. First, they provide humans with important resources (e.g., food, medicines, etc.) (Tuxill 1997). Second, birds and mammals perform vital ecosystem services (Eldredge 1998). Third, they ensure nature's ability to reproduce the necessary resources upon which humans depend (Donohoe 2003). Fourth, preservation of biodiversity is important for historical, cultural, and aesthetic reasons (Takacs 1996). These factors (discussed in detail below) underscore the need for a better understanding of the forces that shape biodiversity loss of mammals and birds. Nevertheless, there has been little cross-national research on the topic — see Shandra et al. (2009), McKinney, Fulkerson, and Kick (2009), and Hoffmann (2004) as notable exceptions.

Consequently, we carry out a cross-national study that examines how various anthropogenic factors are correlated with biodiversity loss of mammals and birds. We pay special attention to dependency theory's hypotheses that debt and structural adjustment lending may be associated with increased numbers of threatened mammals and birds in a nation. We now turn to a review of the importance of studying biodiversity loss as well as dependency theory's predictions regarding it. We also elaborate upon the reasons for including other theoretically relevant predictors in our cross-national models. We conclude with a discussion of the findings, some policy suggestions, and possible directions for future research.

Why Study Biodiversity Loss of Mammals and Birds?

As noted briefly above, there are several reasons why sociologists should be concerned with biodiversity loss of mammals and birds. First, mammals and birds provide humans with food, medicines, and other commercially valuable substances (Tuxill 1997). However, they are particularly essential for the proper functioning of different types of ecosystems (Beattie and Ehrlich 2001). Many mammals play an important role in ensuring the survival of plant species, serve as a key source of protein in the food supply, and provide essential pest control (Eldredge 1998). Similarly, birds are invaluable given their roles in pollination, seed dispersal, and pest management (Clout and Hay 1989).

Second, while performing these essential ecological services, mammals and birds maintain biologically diverse ecosystems that are productive, stable, and responsive to disruption (Beattie and Ehrlich 2001). In doing so, they enhance nature's ability to produce food and other vital resources (Donohoe 2003). For example, birds are responsible for the vast majority of pollination and seed dispersal for crops (Clout and Hay 1989). Further, without pollination and seed dispersal by birds, many plants and trees would suffer, thereby jeopardizing an indispensable resource for humans, oxygen. Bird and mammals also serve as predators to insects and other pests. As such, their absence could be devastating for forests as well as crops, which may be unable to survive infestations (Pfannmuller and Green 1999). This is especially relevant to populations in poor nations that depend upon forests for the food, fiber, and medicines that forests provide. At the same time, such pest control lessens the need to use artificial pesticides and fertilizers, which have been linked to adverse impacts in humans (Jorgenson and Kuykendall 2008).

Third, preserving biodiversity of birds and mammals is important for reasons beyond the economic and ecological services they provide (Takacs 1996). The biodiversity of the planet is a meaningful source of mystery and beauty to many people. These reasons transcend viewing the world in anthropocentric terms — sources and sinks related to human use of the earth and its creatures (Wilson 1990). Similarly, there are strong moral arguments that the rights of non-human animal species should be respected and protected (Franklin 1999). Although these arguments range from greater or lesser protection of these rights vis-à-vis the rights of humans, a common theme is that humans should consistently consider the lives of other animal species when undertaking projects that may impact the natural environment.

Fourth, variation in the number of threatened mammals and birds is largely the result of human activities (Hoffmann 2004). The factors that may threaten birds and mammals may include agriculture, natural resource extraction, and population growth among others (Mozumder and Berrens 2006). The availability of cross-national data on both the number of threatened mammals and birds as well as the anthropogenic drivers of biodiversity loss makes this analysis possible. We now turn to a discussion of how anthropogenic factors suggested by dependency theory are hypothesized to affect the number of threatened mammals and birds in poor nations.

Dependency Theory

The dependency perspective argues that international economic exchanges and unequal power relationships between rich and poor nations are detrimental to the poor nations of the world. In essence, rich nations become wealthy by exploiting the cheap labor and resources of poor nations (e.g., Evans 1979; Amin 1976; Frank 1967). In recent years, a substantial body of cross-national research has been produced in an attempt to provide empirical tests of propositions drawn from dependency theory. This research has noted the changing nature of these economic exchange relationships. The earliest studies tended to incorporate measures of "classical" trade dependence such as commodity concentration or export partner concentration (i.e. Moon and Dixon 1985). Research focusing on a later period, roughly the 1980s, tended to focus on multinational corporate penetration or foreign direct investment (i.e., London and Williams 1990; London and Williams 1988; Bornschier and Chase-Dunn 1985). Another more recent strand of studies, dealing with the period from the mid-1980s onward, shifts the focus to debt dependence — the impact of the "debt crisis" and concomitant structural adjustment loans (i.e., Schafer 1999; Bradshaw and Wahl 1991; Walton and Ragin 1990). Our study follows in this last tradition.

The debt crisis highlighted the inability of many poor nations to generate enough revenue to make payments on their foreign debt. The International Monetary Fund and World Bank responded to the debt crisis by rescheduling loan payments and providing new loans known as structural adjustment (McMichael 2004). These structural adjustment loans required indebted nations to institute a variety of macro-economic policy reforms in return for the money (Rich 1994). The policy reforms include devaluing currency, reducing government spending, liberalizing trade, and privatizing government assets (Peet 2003). Ostensibly, the underlying logic behind structural adjustment is to stimulate economic growth and generate currency for debt repayment by increasing revenue from exports and reducing government spending. While this "earn more" and "spend less" model may facilitate debt repayment, it has been shown to be correlated with higher levels of poverty (Bradshaw and Schafer 2000), higher levels of political protests (Walton and Ragin 1990), and lower levels of educational attainment (Buchman 1996). It has also been linked to various environmental problems including deforestation (Shandra et al. 2008) and organic water pollution (Shandra, Shor, and London 2008). To date, this insight has yet to be applied to a study of biodiversity loss. However, there are several different reasons why structural adjustment may be associated with higher numbers of threatened mammals and birds in poor nations. We elaborate upon four possible reasons in the following paragraphs.

First, structural adjustment programs require that governments promote economic activity consonant with their "comparative advantage" (Peet 2003). This often involves the export of whatever available natural resources and agricultural goods are in demand on the world market (Rich 1994). Put differently, nations attempt to increase export earnings in order to finance interest and principal payments (McMichael 2004). The most common way to achieve this is currency devaluation, which creates a demand for a nation's exports on the world market (Mohan 2001). In general, poor nations meet increased demand by expanding production and extraction of agricultural goods and natural resources for export (Rich 1994). The export sectors that may be related to increased numbers of threatened birds and mammals in a nation include large-scale agriculture, cattle ranching, mining, and logging (George 1992). This is because these activities tend to completely destroy the habitats of mammals and birds (Cuaron 2000).

Similarly, road building that often accompanies export agriculture and natural resource extraction tends to lead to habitat fragmentation especially of forests (Rudel and Roper 1997). One consequence of fragmentation is the subdivision of bird and mammals populations, which may reduce conservation prospects because they may be subject to heightened demographic, environmental and genetic pressures (Caughley 1994). For example, Chiarello examines differences in population density and size of five large mammal species in fragments of the Brazilian Atlantic Forest. The conclusion of the study is that only a small portion of these large mammal species would be able to sustain themselves even in the largest fragments, whose area measured 20,000 hectares (Chiarello 2000). Further, roads encourage migration to and colonization of frontier areas, which accelerates habitat destruction and fragmentation (Peres 2000). Roads also have been shown to result in bushmeat hunting because they increase access to wildlife populations and lower costs of transporting bushmeat to market (Trombuluk and Frissell 2000). On a related note, Lopes and Ferrari (2000) examine the effects of colonization on mammals in the eastern Brazilian Amazon. The authors find that logging, hunting, and slash and burn agriculture by colonists adversely affects mammal abundance and diversity in the region.

Export-oriented agribusiness may threaten birds and mammals in other ways. This type of agriculture tends to rely upon large quantities of pesticides and fertilizers to maintain high crop yields. However, many pesticides (e.g., dieldrin, heptachlor, organophosphate, and carbamate) are acutely toxic, which means that exposure to small amounts can cause severe poisoning and, consequently, death (Eldredge 1998). However, pesticides also affect birds and mammals through the process of "bioaccumulation" or the building up of toxins in the fatty tissue of organisms (Picone and Van Tassel 2002). Many chemicals in pesticides tend to be taken up by fish, plants, and insects. The toxins are then passed on to birds and mammals that eat them with the toxins becoming increasingly concentrated at higher levels in the food chain (Rapport, Costanza, and McMichael 1998). In birds, the toxins have been linked to abnormal embryos, eggshell thinning, slower nestling rates, suppressed appetites, reduced territorial defenses, and decreased parental attentiveness. In mammals, pesticides have been linked to reproductive and immunity suppression problems (Piccone and Van Tassel 2002). All of these problems may be associated with higher levels of threatened birds and mammals.

The second reason why structural adjustment loans may be associated with higher numbers of threatened mammals and birds is that governments must liberalize trade by removing barriers to foreign investment when undergoing adjustment. This involves a variety of regulatory concessions and financial incentives as well as privatizing government assets (Walton and Ragin 1990). Regulatory concessions may include exemptions on corporate activities including logging harvest quotas, exporting raw logs, logging protected species, logging in protected areas, proper disposal of tailings used in mining, and installing pollution abatement technology (Hurst 1990). The most notable financial incentives are "tax holidays" that involve exemptions of export duties, import duties, and corporate income taxes (Leonard 1988). The purpose of the regulatory concessions and financial incentives is to stimulate foreign direct investment within a nation to generate currency to make debt payments (Clapp 1998). However, they may also lead to higher numbers of threatened mammals and birds in a nation because tax cuts and environmental law exemptions make export agriculture and other extractive ventures more profitable. Thus, investment in these areas tends to increase and, consequently, biodiversity loss of mammals and birds increases for the reasons described previously (Mohan 2001). In fact, a number of cross-national studies have been published that demonstrate multinational corporate investment contributes to environmental problems often linked to biodiversity loss. For example, Jorgenson (2008) finds that primary sector foreign investment is associated with higher rates of forest loss, while Jorgenson (2006a) finds that secondary sector foreign investment (e.g. manufacturing) is related to increased organic water pollution.

Some case study evidence that demonstrates this process comes from Latin America. Tockman (2001) describes how an International Monetary Fund structural adjustment loan required the government of Ecuador to increase revenues from oil exports by providing corporations with various tax breaks. Additionally, oil corporations were exempted from carrying out an environmental impact assessment when building a new pipeline. According to Tockman (2001), these macro-economic policy reforms paved the way for Occidental Petroleum and Alberta Energy to construct a crude oil pipeline through 11 protected areas, including the pristine cloud forests of the Mindo Valley in the northwest part of Ecuador. The 95 mile long pipeline is planned to transport oil from the Amazon Forest to the Pacific Coast. However, the valley provides habitat to many endangered animals. It has also been designated by Bird Life International as South America's first Important Bird Area. This is because a Bird Life International study found that the area is a major breeding ground for the endangered black-breasted puffleg hummingbird. Further, Bird Life International has identified 45 Mindo Valley birds as threatened with extinction (Tockman 2001).

In addition to augmenting land use patterns, tax breaks and selling off of public enterprises yield additional reductions in public spending by eroding the tax base because there is little new revenue being collected by the government (George 1992). This hampers the regulatory capacity of governments to enforce environmental regulations and implement conservation projects, which are already limited by the mandated cuts — see below (Deacon 1994). Further, small-scale producers, who are thrown off the land when export agriculture is expanded by large corporations, often turn to growing subsistence crops on marginal lands that are home to many threatened mammals and birds (Culas 2006).

Third, compounding the effects of diminished government revenue, structural adjustment loans usually require deep cuts in government spending to correct for budgetary imbalances (Barbosa 2001). The nature of the cuts has varied from nation to nation, but a common theme has been the reduction in the budgets and staffs of environment and conservation departments (Tockman 2001). These cuts often hamper enforcement of environmental regulations, impede efforts to prevent hunting of threatened species, and hinder demarcation of protected areas — all factors that may help to explain why higher levels of structural adjustment are associated with higher numbers of threatened mammals and birds (Rich 1994). In other words, structural adjustment reduces the regulatory capacity of governments to deal with causes of biodiversity loss. For example, Wood, Stedman-Edwards, and Mang (2000) describe how an International Monetary Fund structural adjustment loan required Cameroon to decrease government expenditures, which resulted in substantial cuts at the Ministry of Environment and Forests. The Ministry has had to contend with reduced personnel, salary cuts of 40 percent, poor working conditions, and an absence of equipment. In fact, one of the first government actions adopted by the government in Cameroon was to sell off all official vehicles. Consequently, Wood, Stedman-Edwards, and Mang (2000) write, "Guards whose function is to control forest exploitation are forced, if they want to do their job, to beg lifts from the very people they are supposed to monitor" (139).

The fourth reason why structural adjustment may be associated with higher numbers of threatened mammals and birds is that these loans tend to exacerbate poverty (Rudel 2005). In this regard, a focus on agricultural and natural resource exports prevent increases in the sort of value-added industries that employ the poor (i.e., manufacturing and services) (Mohan 2001). By slowing the creation of jobs in sectors other than agriculture, fewer jobs are available to urban workers who, lacking alternatives, put more pressure on forests and other lands that are home to mammals and birds (Ehrhardt-Martinez 1998). It is also important to note that budgetary cuts reduce or eliminate government subsidies and credit for agricultural inputs (Rudel 1993). Rudel (2005) discusses how such cuts forced Ecuador to cut subsidies for fertilizers and pesticides in return for structural adjustment loans. These cuts forced small-scale farmers, who were unable to afford the unsubsidized fertilizer and pesticide, to expand production into marginal areas, especially forests that are home to many threatened birds and mammals, in order to maintain crop yields (Rudel 2005).

In general, dependency theory suggests that debt service and structural adjustment should be related to environmental degradation in poor nations. More specifically, we hypothesize that higher levels of debt service and structural adjustment should be associated with higher numbers of threatened mammals and birds in poor nations. We test this line of reasoning below. Of course, it is quite likely that a number of additional independent variables suggested by other theoretical perspectives are correlated with biodiversity loss. We discuss these as we introduce additional independent variables below.

Methodology

Nations Included

We include nations located in Asia, Africa, Caribbean, Europe, and Latin America that are not classified as "high" income according to the World Bank's (2003) income quartile scheme (Jorgenson 2006b; Jorgenson 2006c). We exclude high income nations because they are not recipients of structural adjustment loans. We also do not include nations formed following the collapse of the Soviet Union because there are no data for these nations in 1990. This yields a sample of 65 nations for which complete data are available after listwise deletion of missing data.[2]

Dependent Variables

Number of Threatened Mammals. The first dependent variable for the analysis is the number of mammal species listed as threatened in the World Conservation Union's *Red List of Threatened Animals*. The *Red List*, a comprehensive inventory of threatened species, is the most widely used source on endangered animals (Hoffmann 2004; Pearman 2002; Cole, Reeder, and Wilson 1994). It is based on information provided by a network of more than seven thousand conservation experts and their associated organizations from almost every nation on the planet. The data may be accessed online through the World Resources Institute's *Earth Trends* database. We use the data on threatened mammal species for 2005 because a different classification system was used in earlier years, rendering earlier data incomparable (Hoffmann 2004). We acknowledge that this drawback prevents the examination of difference score and cross-lagged effects models and limits conclusions we can make about change over time (Finkel 1995). Such analyses should be conducted when comparable time series data become available. Note, however, that we measure the independent variables in 1990. This is done for a couple of reasons. First, we want to avoid potential problems with simultaneity bias that may arise if we measured all our variables at one time point (e.g., 2005). Second, Abouhard and Cingranelli (2009) argue that it takes a nation five years on average to implement fully the conditions attached to a structural adjustment loan and it will take at least an additional five years for the effects of a structural adjustment loan to become apparent. Ideally, we would examine the effect of our independent variables with a ten year lag on the number of threatened mammals and birds. How-

Table 1 Descriptive Statistics and Bivariate Correlation Matrix (N = 65)

	Mean	Standard Deviation	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Threatened Mammals, 2005	26.093	24.343	1.000						
(2) Threatened Birds, 2005	27.476	20.064	.832	1.000					
(3) Structural Adjustment, 1990	1.952	4.419	.066	.145	1.000				
(4) Total Debt Service, 1990	22.968	13.204	.195	.174	.066	1.000			
(5) Multilateral Debt Service, 1990	20.845	12.800	.116	.113	.074	.953	1.000		
(6) Primary Sector Exports, 1990	.199	.169	-.191	-.137	-.021	.223	.182	1.000	
(7) Non-Governmental Organizations, 1990	.485	.410	-.310	-.319	.056	.053	.002	.325	1.000
(8) Protected Land Area, 1990	10.210	9.551	-.023	.082	.046	.032	.011	-.025	.046
(9) Democracy, 1990	-0.384	7.085	.065	.325	.061	.023	-.016	-.057	.237
(10) Gross Domestic Product, 1990	7.588	.800	.026	.239	.043	-.062	-.069	-.132	.036
(11) Total Population Size, 1990	50600000	169000000	.559	.470	-.104	-.013	-.007	-.153	-.283
(12) Non-Dependent Population Size, 1990	55.492	5.184	.256	.403	-.039	-.127	-.134	-.265	-.055
(13) Total Mammals, 2005	238.861	134.202	.790	.799	.101	.204	.110	-.067	-.181
(14) Total Birds, 2005	771.153	373.145	.598	.761	.064	.173	.091	-.036	-.117
(15) Endemic Mammals, 2005	21.092	40.650	.880	.794	.274	.189	.112	-.132	-.227
(16) Endemic Birds, 2005	32.031	69.036	.858	.803	.163	.170	.085	-.123	-.217
(17) Land Area, 1990	17.346	1.446	.529	.540	.199	.123	.068	-.358	-.515
(18) Tropical Climate, 1990	.769	.424	-.049	-.032	-.011	.018	-.004	.303	.214
(18) Asian Dummy	.169	.377	.553	.429	-.201	-.012	-.018	-.229	-.178
(19) African Dummy	.446	.500	-.276	-.464	-.007	.016	-.002	.230	.085
(20) European Dummy	.061	.242	-.178	-.139	-.121	-.158	-.131	-.133	-.085

ever, data availability issues prevent us from doing so. We only have data on the structural adjustment variable in 1990.[3] In Table 1, we provide bivariate correlations and descriptive statistics for the variables used in the analysis.

Number of Threatened Birds. The second dependent variable is the number of threatened bird species. The data are also taken from the World Conservation Union's Red List of Threatened Species provided in accordance to the International Union for Conservation of Nature and Natural Resources. The data are accessible online through the World Resource Institute's *Earth Trends* database. The data used in this treatment are for 2005.

Independent Variables

Structural Adjustment. To capture the effects of structural adjustment, pressure, and conditionality required by the International Monetary Fund and other multilateral lenders, Walton and Ragin (1990) developed a conditionality index. It has been used previously by Bradshaw and Schafer (2000), Schafer (1999), and Buchman (1996) among others. This index is the sum of four variables which include: (1) the number of debt renegotiations between a country and an international financial body, (2) the number of debt restructurings experienced by an indebted nation, (3) the number of times a country utilized the International Monetary Fund Extended Fund Facility, and (4) the total International Monetary Fund loans received by a country as a percentage of its allocated quota. The variables are measured in 1990. The four components of the index are converted to z-scores and summed.[4] The index effectively approximates structural adjustment because the International Monetary Fund and other multilateral lenders impose conditions in each of its negotiations and renegotiations with indebted nations (Walton and Ragin 1990). Dependency theory hypothesizes that structural adjustment should be associated with higher numbers of threatened mammals and birds.

Total Debt Service Ratio. In addition to the pressure to adjust their economies under structural adjustment, indebted nations must continually service their foreign debts (George 1992). Therefore, it is also important to control for debt service as well as structural adjustment. This approach has been used previously by Bradshaw and Schafer (2000), Schafer (1999), and Buchman (1996). Thus, we also include the sum of principal and interest payments in foreign currency, goods, or services on long-term public, publicly guaranteed private debt with maturity of one year or longer, short-term debt, and repayments and charges to the International Monetary Fund

(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	
1.000													
.063	1.000												
-.055	.653	1.000											
-.034	.006	-.055	1.000										
-.047	.607	.671	.311	1.000									
.296	.067	.031	.399	.081	1.000								
.368	.189	.058	.278	.064	.893	1.000							
-.050	.109	.158	.311	.235	.718	.498	1.000						
-.014	.146	.136	.263	.243	.662	.530	.931	1.000					
.105	-.096	.039	.421	.040	.554	.487	.461	.384	1.000				
.231	-.23	-.389	-.155	-.543	.153	.259	-.066	.028	-.103	1.000			
-.092	.211	-.044	.467	.315	.226	.113	.341	.389	.141	-.142	1.000		
.021	-.778	.691	-.212	-.729	-.148	-.183	-.282	-.306	-.04	.491	-.405	1.000	
-.061	.232	.324	-.056	.473	-.278	-.278	-.132	-.115	-.226	-.467	-.115	-.229	1.000

(World Bank 2003). It is measured as a percentage of goods and services exports for 1990. The data come from the World Bank (2003). According to dependency theory, total debt service should be correlated with higher numbers of threatened mammal and bird species. This is because governments, in an attempt to increase earnings to meet debt payment obligations, expand exports in sectors including agriculture, forestry, and mining (York 2007).

Multilateral Debt Service. As an alternative measure of debt dependency, we also include the debt service ratio that covers the sum of principal repayments and interest actually paid in foreign currency, goods, or services on long-term obligations to only the International Monetary Fund and World Bank (World Bank 2003). The data are measured as a percentage of exports of goods and services for 1990. They may be obtained from the World Bank (2003). Like total debt service, we expect multilateral debt service to be associated with higher numbers of threatened mammals and birds.

Primary Sector Exports. We also include exports of primary sector goods as a percentage of total exports in the models. The data are measured in 1990 and may be obtained from the United Nations *Commodity Trade Statistics Database*. This database reports import and export statistics in United States dollars for nations by commodity and trading partner. We use the first revision of the Standard International Trade Classification to identify primary sector exports. Some of the commodity groupings include: live animals (Code 00); meat and meat preparations (Code 01); dairy products and eggs (Code 02); cereals and cereal preparations (Code 04); fruit and vegetables (Code 05); sugar, sugar preparations and honey (Code 06); coffee, tea, cocoa, spices and manufactures thereof (Code 07); feed stuff for animals excluding unmilled cereals (Code 08); miscellaneous food preparations (Code 09); unmanufactured tobacco (Code 21); wood, lumber and cork (Code 24); pulp and paper (Code 25); and crude animal and vegetable materials (Code 29). For some nations, there is incomplete information on exports. To deal with this potential problem, we follow Moore, Teixeira, and Schiell's (2006) practice of using import data from trading partners to reconstruct missing export data. From above, we hypothesize that higher levels of primary sector exports should be associated with more threatened mammals and birds.

Non-Governmental Organizations. We include the number of international non-governmental organizations working on *environmental* and *animal rights* issues in a nation per capita for 1990. The data were collected by Smith and Wiest (2005) from the *Yearbook of International Associations*. It is important to note that the data exclude labor unions, institutes, and foundations (Smith and Wiest 2005). Note, too, that a measure of non-governmental organizations per capita is, in effect, a density measure. The population data, used to standardize this measure for comparison across nations, may be obtained from the World Bank (2003). A number of cross-national studies in the world polity tradition demonstrate the beneficial impact of non-governmental organizations on the natural environment (e.g., Shandra 2007a; Schofer and Hironaka 2005; Frank, Hironaka, and Schofer 2000; Frank 1999). This is most likely the result of non-governmental organizations funding local conservation projects (Bradshaw and Schafer 2000), supporting social movement activity around biodiversity issues (Keck and Sikkink 1998), helping to shape the language of international treaties (Frank 1999), and monitoring compliance with treaties when there are no formal enforcement mechanisms (Shandra 2007b). Nevertheless, this insight has not yet been applied to a study of threatened mammals and birds. Thus, we test the world polity theory hypothesis that higher levels of non-governmental organizations per capita should be associated with lower numbers of threatened mammals and birds.

Protected Land Area. We include the percentage of protected land area in a nation to measure a government's commitment to conservation and environmental protection (Frank 1999). The data are measured in 1990 and may be obtained from the United Nations (2004). It is generally thought that protected land area should help protect biodiversity in a nation (Bates and Rudel 2000). Thus, we expect to find an inverse relationship between this variable and the number of threatened mammals and birds.

Democracy. We also account for a nation's level of democracy or autocracy in our models. The data come from the Polity IV Project (2005). This measure ranges from -10 (autocracy) to 10 (democracy). We hypothesize that democracy should be inversely related to the number of threatened mammals and birds. According to Liu and Reuveny (2006), democratic nations have higher levels of political activism than repressive nations because democracies guarantee certain rights including freedoms of speech, press, and assembly. Leaders in a democracy must be responsive to such activism because of electoral accountability (Midlarsky 1998). Further, greater freedom of the press and assembly leads to wider diffusion of information, which, in turn, raises public awareness regarding conservation issues (Ehrhardt-Martinez, Crenshaw, and Jenkins 2002). Therefore, environmental groups are often more successful at informing people and organizing them to act in democratic rather than in repressive nations (Li and Reuveny 2006). In this regard, Brockington (2007) demonstrates the importance of democratic governance in successful conservation and preservation efforts, including programs that aim to enhance species diversity. We hypothesize that higher levels of democracy should be correlated with lower numbers of threatened mammals and birds.

Gross Domestic Product. As is standard in cross-national analyses, it is incumbent on us to take into account a nation's level of development in order to make sure that any effects discovered are independent of a nation's level of wealth (London and Ross 1995). In this regard, we employ a measure of gross domestic product per capita at parity purchasing power for 1990. These data may be obtained from the World Bank (2003). We log this variable to correct for its skewed distribution. Recently, Jorgenson (2006a) finds that gross domestic product is correlated with lower rates of deforestation. Burns, Kick, and Davis (2003) attribute this finding to wealthier nations "externalizing" their environmental costs by importing natural resources and agricultural goods from poorer nations. The effects of gross domestic product on biodiversity loss have resulted in somewhat mixed findings. Clausen and York (2008a) find increases in this variable are associated with greater aquatic biodiversity loss. However, Hoffmann (2004) finds high levels of gross domestic product per capita are associated with lower numbers of endangered bird and mammal species. McKinney, Fulkerson, and Kick (2009) find no statistically significant relationship between this measure and the number of threatened birds. Clearly, additional research is needed in this area.

Total Population Size. It is also important to take into account demographic factors in cross-national research on environment issues (e.g., Shandra 2007a; Jorgenson and Burns 2007; Rudel 1989). This idea is rooted in Malthus's (1826) well-known assertion that "geometric" growth in population outstrips "arithmetic" growth in the means of subsistence. Put simply, nations with larger populations should create higher levels of various forms of environmental degradation because they consume more resources and create more waste (e.g., York, Rosa, and Dietz 2003; Ehrhardt-Martinez 1998). The loss of biodiversity is no exception (Pletscher and Schwartz 2000; Meffe, Ehrlich, and Ehrenfeld 1993; Machlis 1992). As such, we hypothesize that a higher level of population should be associated with higher numbers of threatened birds and mammals increase. Thus, we include in a nation's total population size in our models. The data may be obtained from the World Bank (2003).

Non-Dependent Population Size. York (2007) and York, Rosa, and Dietz (2003) argue that it is important to "decompose" demographic factors in cross-national studies. That is, researchers should examine not just total population size per se but also the impact of population dynamics in different contexts. A key finding in York, Rosa, and Dietz's (2003) study pertains to the detrimental impact of nation's non-dependent population (i.e., percentage of population aged 15-64) on its ecological footprint because adults tend to consume greater amounts of resources and generate more waste than other portions of the population (e.g. children and elderly). Thus, we decompose the total population size in our analysis and include the percentage of a nation's population that is non-dependent in 1990. These data may also be obtained from the World Bank (2003). We expect that non-dependent population should be associated with higher numbers of threatened birds and mammals.

Total and Endemic Mammals and Birds. To accurately specify our models, a number of biophysical control variables must also be included to reflect the cross-national variability of bird and mammals ecosystems (Clausen and York 2008a). The number of threatened species in each nation is obviously related to the total number of bird or mammals species. McKinney, Fulkerson, and Kick (2009) find support for this hypothesis in their cross-national study of threatened birds. Therefore, we include the total number of birds in a nation in the models of threatened birds and the total number of mammals in the models of threatened mammals. We also include the number of endemic birds or endemic mammals in each nation as another biophysical parameter. Endemic birds and mammals refer to the number of bird and mammals species that occur exclusively within national boundaries. Noos and Cooperrider (1994) suggest that higher levels of endeminism within a nation are related to higher levels of biodiversity loss due to specific niches required for species resiliency. Hoffmann (2004) and Zurlini, Grossi and Rossi (2002) find support for this hypothesis. The data on the number of total and endemic birds are measured for 2005. They may be obtained online from the World Resources Institute's *Earth Trends* database.

Land Area. Another important bio-physical control that must be taken into account in cross-national research on biodiversity is the size of a nation's landmass. This is because nations with larger land areas have the potential to contain more species (Forester and Machlis 1996). Smith, Horning, and Moore (1997) demonstrate that land area is an important control when predicting number of threatened species. Therefore, we also include the land area in square kilometers of each nation in the models. We log this variable to correct for its skewed distribution. The data may be obtained from the World Bank (2003).

Tropical Climate. We also include a dummy variable for nations with a tropical climate. We classify a nation as being tropical if more than half of its land area has a mean monthly temperature that exceeds eighteen degrees Celsius (York, Rosa, and Dietz 2003). The data may be obtained from the World Resources Institute (2005). We hypothesize that poor nations with a tropical climate should have larger numbers of threatened mammals and birds.

Geographical Location. It is also important to account for findings that may arise out of geographical and historical circumstances of nations that cannot be explained by the other independent variables in the model (Shandra, Shor, and London 2000; York, Rosa, and Dietz 2003). McKinney, Fulkerson, and Kick (2009) find such geographical classifications are important determinants of threatened bird species. Therefore, we include a control for the geographical location of nations in the models. In particular, we include a series of dummy variables coded with a value of 1 for nations that are located in Asia, Africa, or Europe. The reference category includes Latin American and Caribbean nations. They are coded with a value of 0.

Negative Binomial Regression

The dependent variables in this analysis, number of threatened bird or mammal species, are non-negative and have rapidly descending upper tails. The use of ordinary least squares regression in this instance may result in inefficient tests of statistical significance and biased coefficients (Cameron and Trivedi 1998). However, there are two different types of count data models that can be estimated to deal with these problems — Poisson and negative binomial regression. The choice of model depends on assumptions about the distribution of the dependent variable. In a Poisson regression model, the dependent variable is the number of times an event occurs based on the assumption that the events are both constant and independent (Hoffmann 2004). This is quite a restrictive assumption and rarely fits in practice because overdispersion exists in most situations (i.e., the conditional variance does not equal the conditional mean, violating the error assumption of the Poisson distribution). Overdispersion is due to heterogeneity within the sample causing events to lose independence (Clausen and York 2008a).

Table 2 Negative Binomial Regression Estimates of Threatened Mammals and Birds Including Debt Service and Structural Adjustment

	Equation 2.1 Threatened Mammals	Equation 2.2 Threatened Birds	Equation 2.3 Threatened Mammals	Equation 2.4 Threatened Birds
International Variables				
Structural Adjustment, 1990	.016* 1.016 (.009)	.028* 1.028 (.014)	.014 1.014 (.009)	.025* 1.026 (.014)
Total Debt Service 1990	.007** 1.007 (.003)	.010* 1.010 (.004)		
Multilateral Debt Service, 1990	.007* 1.007 (.003)	.011* 1.011 (.004)		
Primary Sector Exports, 1990	.601* 1.823 (.369)	.689* 1.992 (.374)	-.163 .849 (.226)	.742* 2.101 (.392)
Non-Governmental Organizations, 1990	-.284* .752 (.118)	-.414* .661 (.174)	-.261* .769 (.119)	-.387* .678 (.173)
National Variables				
Protected Land Area, 1990	-.006 .993 (.004)	-.003 .996 (.006)	-.006 .993 (.004)	-.003 .996 (.006)
Democracy, 1990	.020* 1.020 (.009)	.007 1.007 (.015)	.022* 1.023 (.009)	.010 1.010 (.014)
Gross Domestic Product, 1990	-.060 .941 (.081)	-.043 .957 (.125)	-.062 .939 (.081)	-.043 .957 (.124)
Total Population, 1990	-.001 1.000 (.001)	-.001 1.000 (.001)	-.001 1.000 (.001)	-.001 1.000 (.001)
Non-Dependent Population, 1990	.022* 1.003 (.012)	.044* 1.045 (.020)	.023* 1.023 (.014)	.045* 1.046 (.020)

In the case of our dependent variables, the event of having one bird or mammal species become threatened should not be independent from the status of other bird or mammal species. This is likely due to the interconnected relationships among birds and mammals in the ecosystem (Clausen and York 2008a). In fact, our dependent variables do not meet the assumptions of a Poisson regression model for two reasons. First, the variances of our dependent variables are several times larger than their means, signaling overdispersion. Second, likelihood ratio tests indicate statistically significant overdispersion in the models. We report the results of the overdispersion tests for each of our models in Table 2. Given these considerations, we present negative binomial regression models instead of Poisson regression models.

Since the link function for a negative binomial regression model is the log-link, its coefficients may be exponentiated into odds ratios and used to estimate predicted change in the outcome variable that is associated with the independent variables. An odds ratio greater than one indicates an increase in the dependent variable, while an odds ratio less than one indicates a decrease in the dependent variable (Smith and Wiest 2005; Long 1997). Finally, to determine the overall fit of the models, Akaike's Information Criterion and McFadden's pseudo R^2 measures are computed based on the models' deviance statistics (Cameron and Trivedi 1988; Hoffmann 2003). A key property of Akaike's Information Criterion is that it may be used to compare non-nested models to determine which provides the best fit to the data. A smaller value of the Akaike's Information Criterion indicates a better model fit (Clausen and York 2008b).

Control Variables:				
Total Mammal Species, 2005	.003*** 1.003 (.001)	.003*** 1.003 (.001)		
Total Bird Species, 2005	.003*** 1.003 (.001)	.003*** 1.003 (.001)		
Endemic Mammal Species, 2005	.002* 1.002 (.001)	.002* 1.002 (.001)		
Endemic Bird Species, 2005	.001 1.001 (.001)	.001 1.001 (.001)		
Land Area, 1990	.026 1.026 (.043)	.095 1.100 (.068)	.035 1.036 (.043)	.107 1.113 (.178)
Tropical Climate, 1990 (1 = Yes)	-.133 .874 (.105)	-.021 .978 (.180)	-.150 .860 (.106)	.046 .954 (.178)
Asian Nation, (1 = Yes)	.682*** 1.979 (.132)	.660*** 1.935 (.210)	.691*** 1.997 (.134)	.660*** 1.936 (.209)
African Nation, (1 = Yes)	.483** 1.621 (.181)	-.226 .797 (.280)	.521** 1.684 (.184)	-.160 .851 (.281)
European Nation, (1 = Yes)	-.382* .682 (.239)	-.195 .822 (.320)	-.384* .680 (.239)	-.213 .807 (.320)
Akaike? Information Criterion	441.251	485.424	441.785	485.256
McFadden's Pseudo R-Square	.252	.197	.251	.197
Likelihood Ratio Test of Overdispersion	8.031**	55.558***	8.999***	52.893***
Number of Cases	65	65	65	65

Notes:

a) * indicates p < .05, ** indicates p < .01, and *** indicates p < .001 for a one-tailed test.

b) The first number reported is the unstandardized coefficient, the second number is the odds ratio, and the third number in parentheses is the standard error.

c) A statistically significant likelihood ratio test indicates overdispersion in the Poisson regression model. To deal with this potential problem, we present negative binomial regression models.

Findings

In Table 2, we present the negative binomial regression estimates of the number of threatened mammal and bird species for 2005. The independent variables are measured in 1990. We organize the table in the following manner. The dependent variable in odd-numbered equations is the total number of threatened mammals while the dependent variable in even-numbered equations is the total number of threatened birds. In every model, we include structural adjustment, debt service, primary sector exports, non-governmental organizations, protected land area, democracy, gross domestic product per capita, total population size, non-dependent population size, total species, endemic species, land area, a tropical climate dummy variable, and geographical location dummy variables. We include total debt service in equations (2.1) and (2.2) and multilateral debt service in equations (2.3) and (2.4).

We organize the analysis in this way for a several reasons. First, we want to avoid potential problems with multicollinearity. If we include both debt service measures in the same model, then variance inflation factor scores exceed a value of ten. This is most likely due to the high bivariate correlations between these measures. Second, the sequential use of "cognate" but "distinct" indicators of more than one independent variable may shed considerable light on the complexities of dynamics involving the issue under investigation (London and Ross 1995). If the debt service measures maintain similar effects on threatened birds and mammals, for instance, then confidence in the general finding (i.e., higher levels of debt service are associated with higher numbers of threatened birds and mammals) is enhanced. If they produce different effects, then it highlights the utility of using refined indicators of debt. Third, multiple indicators help guard against potential problems associated with measurement error because one indicator may be imperfect but several measures are less likely to have the same error (Paxton 2002).

Let us now turn to a discussion of our dependency related variables. We find substantial support for ideas from this theory. Both debt service and structural adjustment are correlated with biodiversity loss. The coefficients for the structural adjustment variable are positive in all four equations and significant in three of four equations. Second, the coefficients for total debt service are positive and significant in equations (2.1) and (2.2). The coefficients for multilateral debt service are positive and significant in equations (2.3) and (2.4). We also find that primary sector exports are associated with higher numbers of threatened mammals and birds. The coefficients for this variable are positive and significant in equations (2.1), (2.2), and (2.4).

There are a number of other statistically significant findings that should also be mentioned. First, we find support for world polity theory that non-governmental organizations are associated with lower levels of biodiversity loss. The coefficients for this indicator are negative and significant in all equations. Second, we find great utility in decomposing demographic factors in our analysis. The coefficients for non-dependent population size are positive and significant in every equation of Table 2.[5] Third, we find that it is important to include a number of bio-physical control variables when examining biodiversity loss in cross-national research. The coefficients for total number of mammals are statistically significant in every odd-numbered equation. The coefficients for the total number of birds are statistically significant in every even-numbered equation. We also find that the number of endemic mammals tends to be associated with higher numbers of threatened mammals. The coefficients for this variable are positive and significant in equations (2.1) and (2.2). Finally, the coefficients for the geographical dummy variable for Asia are positive and significant in every equation. The findings indicate that nations located in Asia have larger numbers of threatened mammal and bird species than nations located in Latin America. This may be explained by large numbers of threatened species in the "mega-diverse" countries of China, India, Indonesia, Malaysia, and Papua New Guinea. We also find that it is important to include controls for Sub-Saharan Africa and Europe in the models of threatened mammals.

There are non-significant findings that also merit comment. First, we do not find that the level of economic development is related to the number of threatened mammals or birds. The coefficients for gross domestic product per capita are not statistically significant.[6] Second, we find mixed support that democracy is associated with threatened species. The coefficients for the variable are positive and significant in the threatened mammal models but not the threatened bird models.[7] Fourth, we find little support that the amount of protected land area is associated with lower number of threatened mammals and birds.8 The coefficients for this variable are negative but not statistically significant. Fifth, we do not find that a nation's total population is associated with the number of threatened mammals or birds.[8,9] The coefficients do not reach a level of statistical significance. Finally, we do not find that endemic bird species or land area are significantly related to the number of threatened species in a nation. The coefficients for these variables are not statistically significant.[10]

Discussion and Conclusion

This study extends cross-national research on biodiversity loss in a novel way. This is the first cross-national study that considers dependency theory hypotheses that debt service and structural adjustment are correlated with higher levels of biodiversity loss. In doing so, we find substantial support for this line of reasoning. The results indicate that both debt service and structural adjustment are significantly related to higher numbers of both threatened mammal and bird species. This is most likely the case because structural adjustment loans and large debt service burdens lead nations to increase exports of agricultural goods and natural resources in order to generate currency for debt repayment. In fact, the coefficients for primary sector exports are positive and significant in most equation of Table 2. We increase the reliability of these findings by demonstrating their statistical significance across several alternative model specifications and two different measures of biodiversity loss. Clearly, it is important to consider debt service and structural adjustment together when testing dependency theory hypotheses in a cross-national research regarding the natural environment (e.g., Shandra, Shor, and London 2009).

We also find that it is important to consider insights from other theoretical perspectives. First, we find substantial support for world polity theory that higher levels of non-governmental organizations per capita are associated with decreased numbers of threatened mammals and birds. The coefficients for this variable are negative and significant in every equation of Table 2. We would hypothesize that this is the case because non-governmental organizations finance conservation projects, support social movement activity around environmental protection, help shape the language of environmental treaties, and monitor compliance with environmental treaties in the absence of formal enforcement mechanisms. Second, we find that it is important to decompose demographic factors in cross-national research (York, Rosa, and Dietz 2003). In particular, we find that higher levels of non-dependent population are associated with higher numbers of both threatened mammals and birds. This is most likely the case because this segment of the population tends to consume more resources than other segments of the population. Third, we find that it is important to include a number of bio-physical control variables in cross-national models of threatened birds and mammals (Clausen and York 2008b). These controls include total number of species, endemic species, and a dummy variable for geography.

There are some policy suggestions that follow from our main findings regarding debt service, structural adjustment, and non-governmental organizations. First, it may serve non-governmental organizations well to focus their efforts on projects that decrease debt and protect land. A "debt-for-nature" swap is a very good example of such a project. The procedure usually entails an international non-governmental organization paying off a portion of a nation's debt in return for that nation setting aside a certain amount of land for complete protection (Cartwright 1989).

Nevertheless, debt-for-nature swaps can be criticized for being "reformist" in that the swaps do not address the underlying causes of increasing debt among poor nations (e.g., structural adjustment) (Shandra 2007b). Bryant and Bailey (1997) write, "If the argument is that fundamental change is the only way in which to solve the environmental crisis," then international non-governmental organizations "may be part of the problem and not part of the solution" (143). Consequently, international non-governmental organizations should also focus their efforts of lobbying leaders of the International Monetary Fund and World Bank to change or eliminate structural adjustment lending policies. This process could also include lobbying government officials in rich nations to withhold funding to the World Bank and International Monetary Fund until such changes occur.

These policy suggestions point to some promising avenues for future research. First, there has been no systematic research that examines the impact of debt-for-nature swaps on biodiversity loss. This is somewhat surprising given that there is adequate data available on when and where these swaps have been conducted. Thus, one potential avenue for research includes conducting a study along these lines. Second, it may be helpful to use a series of structural equation models to test the pathways by which structural adjustment is related to the number of threatened mammal and bird species (Clausen and York 2008b). This could involve examining the impact of structural adjustment on threatened mammals and birds through primary sector exports, protected land area, and level of development.

Endnotes

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2. The following 65 nations are included in the analysis after listwise deletion of missing data. They include Albania, Algeria, Angola, Argentina, Bangladesh, Benin, Bolivia, Brazil, Bulgaria, Burundi, Cameroon, Central African Republic, Chad, Chile, China, Columbia, Congo, Costa Rica, Democratic Republic of Congo, Ecuador, El Salvador, Gabon, Gambia, Ghana, Guatemala, Guinea, Guinea-Bissau, Honduras, Hungary, India, Indonesia, Kenya, Madagascar, Malawi, Malaysia, Mali, Mauritania, Mexico, Morocco, Mozambique, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Romania, Rwanda, Senegal, Sierra Leone, Somalia, Sri Lanka, Tanzania, Thailand, Tunisia, Uganda, Uruguay, Venezuela, Zambia, Zimbabwe.
3. We also rerun the analysis with all independent variables (except the structural adjustment variable due to data availability issues) with five and ten year lags. The results are similar to the findings presented here. We do not present them for sake of space.
4. We run a factor analysis on the four components of the conditionality index to determine if the variables are measuring different theoretical constructs. The results of the factor analysis indicate that all four variables load on one factor, providing no evidence that the index is

measuring different concepts. We also use the factor loadings from this analysis to construct a weighted conditionality index and then rerun our regression using this new index. These results are similar to the ones presented based here, which use the computationally simpler index of converting variables to z-scores and summing.

5. Jorgenson and Burns (2007) document the utility of decomposing population dynamics but stress the importance of considering different geographical contexts. Specifically, they find rural population growth is associated with increased deforestation while urban population growth is associated with decreased deforestation. This is because expanding urban centers often create economic opportunities other than agricultural ones, which attract people to cities. The process relieves the demand on forest resources and reduces deforestation. However, a growing rural population needs to clear additional land to meet its subsistence needs. See also Rudel and Roper's (1997) discussion of "frontier" and "immiseration" models for a treatment of how rural and urban population growth affects forests. Thus, we examine the impact of a nation's rural and urban population on the number of threatened mammals and birds. We expect that rural population size should be correlated with higher numbers of threatened species while urban population size should be correlated with lower numbers of threatened mammals and birds. Nevertheless, the coefficients for these variables do not reach a level of statistical significance. We do not show the results for sake of space, but they are available upon request.
6. Hoffmann (2004) finds an inverted u-shaped relationship (i.e., environmental Kuznets curve) exists between gross domestic product per capita and number of threatened mammals and birds. We test this hypothesis using a quadratic polynomial equation in which the gross domestic product per capita and its square are entered into the same model. If this relationship exists, the sign of the coefficient for the linear term should be positive and the sign of the coefficient for the squared term should be negative and statistically significant. To reduce problems of multicollinearity, we center the linear term around its mean. We then square the centered term. Finally, we include the centered linear term and squared term in the models (York, Rosa, and Dietz, 2003). The coefficients for the squared term are negative but fail to achieve statistical significance, providing no support for this hypothesis.
7. Bollen and Paxton (2000) argue that non-random measurement error arising from the subjective perceptions of judges affect all cross-national measures of democracy to some degree. This bias may distort comparisons across nations, undermining the empirical results that ignore it. Therefore, we also estimate our models using the average of Freedom House's (1997) political rights and civil liberties scales for 1990 as the measure of democracy. Political rights reflect the degree to which a nation is governed by democratically elected representatives and has fair, open, and inclusive elections. Civil liberties reflect whether within a nation there is freedom of press, freedom of assembly, general personal freedom, freedom of private organizations, and freedom of private property (Freedom House 1997). These variables are measured on a seven-point scale with the following codes: free (1-2), partially free (3-5), and not free (6-7). We multiply the index by negative one so that high scores correspond with high levels of democracy. The results are similar to the findings presented in Table 2. We do not show these findings for sake of space, but they are available upon request from the authors.
8. We also examine the impact of whether a nation had an environmental ministry in 1990. This is a dummy variable with nations that had an environmental ministry coded with a value of 1. All other nations serve as the reference category and are coded with a value of 0. The data have been used previously by Frank (1999). The coefficients for this variable are negative but fail to reach a level of statistical significance. The other findings are similar to the findings presented in Table 2.
9. Ehrhardt-Martinez (1998) finds an inverted u-shaped relationship (i.e., environmental Kuznets curve) exists between urbanization and deforestation. Urbanization may have a similar impact on the number of threatened birds and mammals. We use the procedure described in endnote 5 to test this hypothesis. The squared urbanization term is negative but fails to reach a level of statistical significance, indicating no support for an environmental Kuznets curve between urbanization and threatened mammal and bird species.
10. We attempt to increase the reliability of the findings by removing non-significant variables from our models and rerunning the models. All the variables maintain their sign and statistical significance in the new model specifications, indicating that the results are not affected by the ratio of independent variables to cases (Shandra et al. 2008).

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